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SCOTTISH SPRAT FISHERIES, WITH SOME NOTES ON THE BIOLOGY OF THE STOCKS

by

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Introduction

The last ten years have seen a large increase in landings of sprats Clupea sprattus at Scottish ports. The purpose of this paper is to document recent developments in the sprat fisheries and to provide information on the composition of the landings in each area. Articles covering one or two seasons within this period have been published at intervals in the Scottish Fisheries Bulletin.

The Scottish Sprat Fisheries

Annual landings of sprats in Scotland from 1921-1960 inclusive are shown in Table 1 (Scottish Sea Fisheries Statistical Tables: H.M.S.O.). During this period the principal fisheries were winter ring-net fisheries in the Firth of Forth, Firth of Tay, and intermittently in the Inverness Firth. Most of the sprats landed went for canning and landings were probably limited more by demand than by abundance.

The ring-net fishery culminated in the 1962-63 season when 22 930 t of sprats were caught in the Firth of Forth. Within another two seasons, however, this fishing method was almost completely superseded by pair-trawling (Tables 2 and 3), which began along the east coast of England a few years earlier (Johnson 1970). Pair-trawling is now the only fishing method regularly used in Scotland to catch sprats, except in the small Shetland fishery, where single-boat pelagic trawls are also used.

The pair-trawl fisheries for sprats began in the Firth of Forth and Moray Firth, later extending to other coastal areas around Scotland (Fig. 1). Owing to the mobility of the fishing fleets, the amount of fishing in each area changes from season to season and within seasons depending on the availability of sprats. There is also some interchange of vessels between the Scottish fisheries and that off the north-east coast of England (the North Shields fishery). The main Scottish fishing areas are the Firth of Forth, the south coast of the Moray Firth and sea lochs in the South Minch (Table 3). Smaller scale fisheries also take place from time to time in the outer Firth of Forth, off the coast of Aberdeenshire, in the North Minch and off the west coast of Shetland. A short-lived ring-net fishery in the Firth of Clyde ceased after the 1965-66 season (Table 2).

In most years sprat landings start in September or October, reach a peak sometime between December and February and decline rapidly thereafter. The Firth of Forth fishery tends to start later than that in the Moray Firth. The only important landings outside the period October-March were made off the coast of Aberdeenshire from July-September 1965, in the Moray Firth in

April 1966 and in the outer reaches of the Firth of Forth in April 1969. Average monthly catches per arrival in the two main fisheries are shown in Table 4. In both areas the catch per arrival tends to rise in October or November thereafter maintaining a fairly high level until the end of the season which often finishes abruptly. Since little fishing, however, takes place at times and in areas where sprats are scarce, the catch per arrival is probably not a reliable index of abundance. Furthermore, when total landings increase above a certain level, an artificial limit is set by the imposition of quotas to each boat landing. Since 1964-65 the average catch-rate over a whole season has ranged between 6.3 and 12.9 tons per arrival in the Firth of Forth, and between 5.2 and 15.4 tons per arrival in the Moray Firth, but this is probably not a reliable indication of the annual variation in abundance.

Composition of the Landings

Regular samples of sprats from the commercial landings have been analysed at the Marine Laboratory, Aberdeen. The fish in a sample of known weight were measured to the $\frac{1}{2}$ cm below, and for a stratified sub-sample the weight, sex, and stage of maturation were recorded, and the otoliths taken for age determination. In this paper only the length and age data are considered. For present purposes the birthday has been set arbitrarily at 1 July (approximately the peak of spawning in the northern North Sea), so that during their first winter after metamorphosis, they are termed 0-group, and in successive winters 1-, 2- group and etc. The possibility, suggested by Iles and Johnson (1962), that some sprats spend their first winter as larvae, and therefore form no hyaline layer in their otoliths at this time, has not yet been fully investigated.

From the weights of samples and landings it has been possible to calculate the number of sprats in each age group landed in each month and area. The results are summarised in Tables 5-9, together with the per-centage age compositions. In addition, overall length distributions for each area are shown in Table 10. Results from each fishery are summarised separately below.

Firth of Forth

Landings in the Firth of Forth have consisted mostly of 0- and 1-group sprats and only in the 1968-69 season did 2-group fish make an important contribution. The 1964 year-class appears to have been stronger than average, but after two further reasonable year-classes, those from 1967 to 1971 were average or poor. As 0-group the 1972 year-class was abundant.

Moray Firth

As in the case of the Firth of Forth, landings consisted mostly of 0- and 1-group fish with the 2-group making a significant contribution in the 1966-67 and 1968-69 seasons. The 1964 year-class was even stronger than in the Firth of Forth and after a gap of five seasons with poor or average year-classes, those of 1970, 1971 and 1972 appear to have been strong. The 1968 year-class, which was very scarce as 0-group, was quite strong as 1-group.

The distribution of each age group is not uniform in all parts of the area covered by the fishery. Table 11 shows comparisons between the inner and outer parts of the Moray Firth (a division is made for statistical purposes at 3°W). In four of the five seasons for which data are available,

the mean age of sprats caught in the eastern parts of the firth was higher than in the inner firth. This suggests that in this area the 0-group tend to move further west towards the true estuarine conditions.

West Coast

Landings of sprats off the Scottish west coast consistently show a different composition from those off the east coast. The most abundant age is the 2-group, 0-group sprats contributing a negligible percentage to the whole. Fish up to 4 years of age also occur in significant numbers. Most fish lie in the length range 11-15.5 cm.

Shetland

In most years the Shetland landings consist principally of 0-group fish.

Aberdeenshire Coast

In this area also 0-group sprats have been the most abundant, except in the 1965-66 season when 1-group fish predominated.

Catch per Unit Effort

For reasons stated above the number or weight of sprats per landing cannot be used as a reliable index of abundance. Statistics have also been kept of the amount of time spent fishing, and the numbers caught per hour are also shown for the Firth of Forth and Moray Firth fisheries in Tables 5 and 6. In the case of pair-trawling, which is aimed at particular shoals of fish, the abundance of sprats is likely to be as much a function of searching time as it is of fishing time. To increase searching power, vessels frequently work in units of three or more, two trawling while the other searches. If the extent to which sprats concentrate in shoals changes from year to year, then the catch per hour's fishing is also likely to give a spurious estimate of abundance. In partial rectification fishing effort is now being recorded in three ways: number of arrivals, days absent from port, and hours spent on the fishing grounds, whether fishing or searching. Data prior to 1974, however, are not available.

Despite the inadequacy of the measure of fishing effort, the possibility of predicting catch-rates from those obtained the previous season was tested by plotting the catch-rates of 1- and 2-group sprats against those of 0- and 1-group respectively in the previous season. No clear pattern was evident, although certain features stand out. The 1964 year-class, for example, was the strongest recorded in the Moray Firth in the first three years of its life; it was also prominent in the Firth of Forth and accounted for a large percentage of the sprats caught off the Aberdeenshire coast in the autumn and winter of 1965-66. In contrast the 1968 year-class was barely represented as 0-group in Moray Firth catches but was strongly represented as 1-group. The contrast suggests that not only the abundance but also the distribution and concentration of sprats varies from year to year, and no simple method of forecasting seems to be possible with present information.

Length at Age

Lengths-at-age of sprats caught in the three main fisheries are shown in Table 12. There is some annual variation but no evidence that this is related to year-class strength. Values for the Moray Firth and Firth of Forth fisheries are very similar, and are markedly lower than those recorded for the west coast fishery.

The high mean-length of the O-group sprats is probably due to the fact that this age group is only partially recruited to the fishery, both because of mesh selection (Johnson 1970) and differences in distribution of O-group and older fish (see above). Since the tendency to move inshore in the winter appears to decline with age (see also Johnson 1970), the mean lengths of older fish caught in the fishery may not be representative of the population from which they are drawn. As a result it is probably not valid to calculate growth-rates from the figures at present available. The difference in length-at-age between east and west coasts could also be due to the different pattern of recruitment to these fisheries.

Discussion

The Scottish sprat fisheries take place in the winter months when the fish concentrate inshore, often in very large shoals. In this respect they are similar to the English fisheries (Johnson 1966 *et seq.*, 1970). Off the east coast of Scotland the pattern of recruitment indicates that only a fraction of the O-group (i.e. those spawned only a few months before the fishery begins) are available to the fishery, and the proportion may vary from season to season. On average catch-rates of 1-group sprats are higher than those of the O-group. Differences between the catch-rates of 1-, 2- and 3-group fish indicate a high rate of loss from one season to the next (for the Moray Firth and Firth of Forth an average loss of ca 85% per year is indicated between 1 and 2 years of age). Since concentration inshore, however, may decline with age, this may not be entirely due to mortality.

The fact that prediction of catch-rates from those in the previous season is unreliable suggests that the availability of sprats in a given season is a function of both abundance and distribution. Over the past few seasons the location of shoals in the Moray Firth has varied considerably, possibly as a result of a change in climatic and hydrographic factors. Investigations are planned to investigate the factors affecting the distribution and concentration of sprats in this area.

The pattern of recruitment off the Scottish west coast is very different. The first two age-groups make a much smaller contribution to the landings. It seems likely that the O-group and 1-group fish are spatially separated from the older fish at this time, since de Silva (1973) has shown that O-group sprats can be found in winter in the inner reaches of some west coast sea lochs with the older fish further offshore.

References

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Table 1 Scottish landings of sprats in metric tons, 1921-1960

Year	District of Landing: Leith (Firth of Forth)	Arbroath (Firth of Tay)	Lossiemouth (Moray Firth)	Other Districts
1921	1 672	247	269	81
1922	574	0	109	0
1923	1 522	816	1 044	61
1924	4 731	1 476	1 309	5
1925	575	159	83	0
1926	140	418	11	0
1927	765	579	4	0
1928	331	265	12	4
1929	2 659	866	51	0
1930	861	1 375	0	0
1931	580	795	2	0
1932	251	1 151	130	0
1933	648	1 033	27	0
1934	396	785	<1	0
1935	126	1 007	0	0
1936	182	515	<1	0
1937	127	512	0	0
1938	558	68	0	0
1939	609	196	0	0
1940	39	8	0	0
1941	603	12	0	3
1942	282	52	0	3
1943	851	81	25	21
1944	1 368	85	25	0
1945	1 429	85	398	<1
1946	979	329	0	0
1947	524	<1	25	0
1948	1 318	474	8	22
1949	1 658	97	0	0
1950	427	285	0	0
1951	1 169	341	0	0
1952	7 652	1 129	0	0
1953	7 398	824	0	0
1954	2 649	61	0	36
1955	6 503	137	0	0
1956	2 277	98	0	<1
1957	2 760	289	202	134
1958	3 802	446	2	91
1959	4 350	20	0	1
1960	591	0	0	0

Table 2 Scottish ring-net landings of sprats in metric tons, 1960-1966

Fishing season	Fishing Area				
	Firth of Forth	Firth of Tay	Moray Firth	South Minch	Firth of Clyde
1960-61	71	0	0	0	0
1961-62	2 235	0	276	0	76
1962-63	22 930	265	119	515	2 541
1963-64	8 608	46	4 319	0	940
1964-65	7	0	1 990	0	1 979
1965-66	20	0	0	0	93

Table 3 Scottish pair trawl landings of sprats in metric tons, 1960-1973

	North Shields	Firth of Forth	East Coast Scotland	Moray Firth	Shetland	North Minch	South Minch
1962-63	0	561	0	94	0	0	0
1963-64	0	1 934	102	4 428	0	0	0
1964-65	7	9 819	4 409	7 777	0	0	0
1965-66	0	7 124	4 474	70 682	1 355	0	0
1966-67	64	1 405	1	19 699	875	0	0
1967-68	0	16 214	181	18 425	1	73	0
1968-69	685	20 474	580	3 464	42	421	6 185
1969-70	0	9 358	552	13 245	33	114	1 035
1970-71	1 761	3 808	2 937	5 201	19	63	4 505
1971-72	265	676	111	28 312	0	272	702
1972-73	248	2 509	3 261	40 516	14	2	6 569

Table 4 Average monthly weight of sprats per arrival 1963-73.

	Metric tons per landing	
	Firth of Forth	Moray Firth
September	4.2	1.5
October	3.8	6.1
November	9.2	7.7
December	8.6	8.0
January	8.2	8.0
February	6.9	8.0
March	7.2	6.3
April	10.1	4.4

Table 5 Numbers landed, percentage age composition of sprats and numbers caught per hour in the Firth of Forth 1964-1973.

Fishing season		Age-groups 0	1	2	3	4	5
1964-65	No landed $x10^{-6}$	1197.4	301.1	16.7	6.1	0	0
	%	78.7	19.8	1.1	0.4	0	0
	No per hour $x10^{-3}$	324	81.6	4.5	1.7	0	0
1965-66	No landed $x10^{-6}$	38.8	817.8	69.1	10.3	2.8	0
	%	4.1	87.1	7.4	1.1	0.3	0
	No per hour $x10^{-3}$	15.2	320	27.0	4.0	1.1	0
1966-67	No landed $x10^{-6}$	31.4	130.4	32.7	2.2	0.01	0
	%	16.0	66.3	16.6	1.1	0.007	0
	No per hour $x10^{-3}$	48.6	202	50.6	3.4	0.02	0
1967-68	No landed $x10^{-6}$	686.3	836.0	113.3	55.3	5.9	0
	%	40.4	49.3	6.7	3.3	0.4	0
	No per hour $x10^{-3}$	134	163	22.1	10.8	1.2	0
1968-69	No landed $x10^{-6}$	74.7	512.5	490.4	79.2	18.8	0
	%	6.4	43.6	41.7	6.7	1.6	0
	No per hour $x10^{-3}$	10.3	70.8	67.7	10.9	2.6	0
1969-70	No landed $x10^{-6}$	164.4	373.2	54.3	43.1	2.4	0.3
	%	25.8	58.5	8.5	6.8	0.4	0.05
	No per hour $x10^{-3}$	24.3	55.1	8.0	6.4	0.36	0.05
1970-71	No landed $x10^{-6}$	1318.6	102.7	11.2	6.5	1.1	0
	%	91.6	7.1	0.8	0.4	0.08	0
	No per hour $x10^{-3}$	475	37.0	4.0	2.3	0.4	0
1971-72	No landed $x10^{-6}$	12.6	60.9	2.8	1.2	0.07	0.06
	%	16.2	78.4	3.6	1.6	0.09	0.08
	No per hour $x10^{-3}$	25.1	121	5.5	2.4	0.14	0.12
1972-73	No landed $x10^{-6}$	436.1	155.1	11.6	0.6	0	0
	%	72.3	25.7	1.9	0.1	0	0
	No per hour $x10^{-3}$	484	172	12.8	0.70	0	0
Overall percentage 1964-1973		47.8	39.7	9.7	2.5	0.4	0.005

Table 6 Numbers landed, percentage age composition of sprats and numbers caught per hour in the Moray Firth 1964-1973.

Fishing Season		Age-groups 0	1	2	3	4	5
1964-65	No landed $x10^{-6}$	3223.4	47.8	0	0.09	0	0
	%	98.5	1.5	0	0.003	0	0
	No per hour $x10^{-3}$	775	11.5	0	0.02	0	0
1965-66	No landed $x10^{-6}$	1553.8	6769.1	368.3	26.3	4.6	0
	%	17.8	77.6	4.2	0.3	0.05	0
	No per hour $x10^{-3}$	57.2	249	13.6	0.97	0.17	0
1966-67	No landed $x10^{-6}$	309.3	374.6	598.9	66.7	15.9	1.6
	%	22.6	27.4	43.8	4.9	1.2	0.1
	No per hour $x10^{-3}$	15.4	18.6	29.8	3.3	0.8	0.08
1967-68	No landed $x10^{-6}$	291.8	1087.9	60.4	18.3	0.3	0
	%	20.0	74.6	4.1	1.2	0.02	0
	No per hour $x10^{-3}$	19.2	71.5	4.0	1.2	0.02	0
1968-69	No landed $x10^{-6}$	10.5	88.4	32.0	3.1	0.9	0
	%	7.8	65.5	23.8	2.3	0.7	0
	No per hour $x10^{-3}$	2.9	24.4	8.8	0.86	0.25	0
1969-70	No landed $x10^{-6}$	390.2	1233.1	17.7	11.8	1.0	0
	%	23.6	74.6	1.1	0.7	0.06	0
	No per hour $x10^{-3}$	28.3	89.3	1.3	0.85	0.07	0
1970-71	No landed $x10^{-6}$	923.7	255.4	27.9	1.0	0.09	0
	%	76.5	21.1	2.3	0.08	0.007	0
	No per hour $x10^{-3}$	118	32.5	3.5	0.12	0.01	0
1971-72	No landed $x10^{-6}$	2188.1	2000.2	74.6	18.2	0.3	0
	%	51.1	46.7	1.7	0.4	0.007	0
	No per hour $x10^{-3}$	88.5	80.9	3.0	0.73	0.01	0
1972-73	No landed $x10^{-6}$	3434.9	2326.4	453.9	5.5	0	0
	%	55.2	37.4	7.3	0.09	0	0
	No per hour $x10^{-3}$	206	140	27.3	0.33	0	0
Overall percentage 1964-1973		43.5	50.1	5.8	0.5	0.08	0.006

Table 7 Numbers landed and percentage age composition of sprats off the Scottish west coast, 1967-1973.

Fishing Season		Age-groups 0	1	2	3	4	5	6
1967-68	No landed $x10^{-6}$	0.007	4.4	0.2	0.8	0.02	0	0
	%	0.1	81.7	3.5	14.3	0.4	0	0
1968-69	No landed $x10^{-6}$	0.02	116.6	248.0	12.5	16.7	0	0
	%	0.004	29.6	63.0	3.2	4.2	0	0
1969-70	No landed $x10^{-6}$	2.6	89.7	4.6	3.5	0	0	0
	%	2.6	89.3	4.5	3.5	0	0	0
1970-71	No landed $x10^{-6}$	2.8	36.9	221.0	26.5	2.5	0	0
	%	1.0	12.7	76.3	9.1	0.9	0	0
1971-72	No landed $x10^{-6}$	0.2	20.5	10.3	14.5	2.6	0.4	0.2
	%	0.5	42.0	21.2	29.8	5.3	0.9	0.3
1972-73	No landed $x10^{-6}$	11.6	151.0	187.7	20.9	6.5	0	0
	%	3.1	40.0	49.7	5.5	1.7	0	0
Overall percentage 1967-1973		1.4	34.5	55.3	6.5	2.3	0.03	0.02

Table 8. Numbers landed and percentage age composition of sprats from Shetland waters 1965-1973.

Fishing Season		Age-groups 0	1	2	3	4
1965-66	No landed $x10^{-6}$	90.8	17.1	19.4	0	0
	%	71.3	13.4	15.2	0	0
1966-67	No landed $x10^{-6}$	270.1	1.4	1.9	0.3	0
	%	98.7	0.5	0.7	0.1	0
1968-69	No landed $x10^{-6}$	36.3	0.04	0	0	0
	%	99.9	0.1	0	0	0
1969-70	No landed $x10^{-6}$	3.4	2.9	0	0	0
	%	53.3	46.7	0	0	0
1971-72	No landed $x10^{-6}$	15.5	10.2	1.0	0.2	0.08
	%	57.6	38.0	3.6	0.6	0.3
1972-73	No landed $x10^{-6}$	6.2	0.3	0.2	0	0
	%	92.5	4.8	2.8	0	0
Overall percentage 1965-1973		88.5	6.7	4.7	0.1	0.02

Table 9 Numbers landed and percentage age composition of sprats off the Aberdeenshire coast 1964-1971.

Fishing Season		Age-groups 0	1	2	3	4
1964-65	No landed $x10^{-6}$	63.9	20.7	0	0	0
	%	75.5	24.5	0	0	0
1965-66 Jul-Sep	No landed $x10^{-6}$	12.7	491.0	14.0	2.7	1.1
	%	2.4	94.2	2.7	0.5	0.2
1965-66 Oct-Mar	No landed $x10^{-6}$	21.6	162.5	32.5	2.0	0.6
	%	9.8	74.1	14.8	0.9	0.3
1968-69 Mar-May	No landed $x10^{-6}$	8.6	31.2	21.3	0.2	0.2
	%	14.0	50.7	34.6	0.3	0.3
1969-70	No landed $x10^{-6}$	58.0	44.0	0.3	0.4	0
	%	56.5	42.9	0.3	0.4	0
1970-71 Dec-Mar	No landed $x10^{-6}$	1558.8	24.2	0	0	0
	%	98.5	1.5	0	0	0
Overall Percentage 1964-1971		67.0	30.1	2.6	0.2	0.07

Table 10 Percentage length distributions of sprats in the main Scottish fisheries 1964-1973.

Length to ½ cm below	Moray Firth	Firth of Forth	West Coast	Shetland
3.5		0.01		
4	0.003	0.10		0.06
	0.03	0.68		0.46
5	0.17	0.96		0.80
	0.96	1.42		1.97
6	2.34	2.72	0.008	4.58
	3.75	4.89	0.05	9.97
7	7.18	7.40	0.09	12.76
	6.94	9.33		17.94
8	9.73	10.27	0.39	18.82
	8.46	11.04	0.16	15.47
9	8.32	9.71	0.62	5.67
	5.54	7.80	0.08	1.11
10	6.01	5.26	0.14	1.83
	7.32	3.86	0.49	2.08
11	10.11	3.31	1.86	2.14
	9.39	3.13	4.68	1.68
12	8.06	4.04	12.58	1.43
	3.63	3.65	14.89	0.65
13	1.31	3.69	20.48	0.48
	0.39	2.83	16.80	0.08
14	0.22	2.28	15.27	0.02
	0.05	1.04	7.60	
15	0.04	0.46	2.69	
	0.02	0.10	0.95	
16			0.14	
			0.02	
17			0.008	

Table 11 Percentage age compositions of sprats caught in different areas of the Moray Firth.

Fishing Season	Area	Age-groups 0	1	2	3	4
1964-65	Inner	98.6	1.4	0	0	0
	Outer	98.4	1.6	0	0.009	0
1969-70	Inner	26.0	72.1	1.1	0.7	0.06
	Outer	14.2	84.1	1.0	0.6	0.04
1970-71	Inner	77.0	20.6	2.3	0.08	0.007
	Outer	54.5	41.7	3.8	0	0
1971-72	Inner	71.0	28.0	0.8	0.2	0
	Outer	35.3	61.6	2.4	0.6	0.01
1972-73	Inner	84.5	14.1	1.4	0	0
	Outer	35.7	52.9	11.2	0.2	0

Table 12 Mean lengths at age of sprats

Year-class	0	1	2	3	4	5
Moray Firth						
1961	-	-	-	13.2	14.2	14.4
1962	-	-	-	14.4	14.0	-
1963	-	10.1	11.4	13.0	14.5	-
1964	7.7	11.0	12.7	13.1	13.3	-
1965	7.7	10.6	12.2	13.7	14.2	-
1966	8.6	11.6	12.8	14.0	14.8	-
1967	9.1	11.6	13.0	14.4	14.2	-
1968	8.9	10.6	11.7	13.4	-	-
1969	7.3	10.4	12.2	14.3	-	-
1970	7.2	10.8	12.3	-	-	-
1971	8.0	11.4	-	-	-	-
1972	8.7	-	-	-	-	-
Mean	8.1	10.9	12.3	13.7	14.2	14.4
Firth of Forth						
1961	-	-	-	12.9	14.4	-
1962	-	-	11.2	13.8	14.8	-
1963	-	9.8	11.9	12.6	13.3	-
1964	8.0	9.7	10.6	14.0	14.4	15.2
1965	6.8	9.1	12.8	14.1	13.9	-
1966	8.1	10.9	13.3	14.4	15.2	15.2
1967	8.6	12.2	13.8	14.9	15.2	-
1968	7.5	10.4	13.7	13.2	-	-
1969	7.6	9.5	12.7	13.5	-	-
1970	7.0	10.2	11.2	-	-	-
1971	7.7	9.7	-	-	-	-
1972	7.5	-	-	-	-	-
Mean	7.6	10.2	12.4	13.7	14.5	15.2
West Coast						
1963	-	-	-	-	14.3	-
1964	-	-	-	13.7	13.5	-
1965	-	-	12.7	14.2	-	-
1966	-	12.6	14.0	14.2	14.8	15.9
1967	10.2	12.7	13.3	14.5	15.2	-
1968	8.2	12.1	13.3	14.6	15.1	-
1969	8.4	12.4	13.9	14.8	-	-
1970	9.0	12.4	13.5	-	-	-
1971	9.5	12.2	-	-	-	-
1972	8.7	-	-	-	-	-
Mean	9.0	12.4	13.4	14.3	14.6	15.9

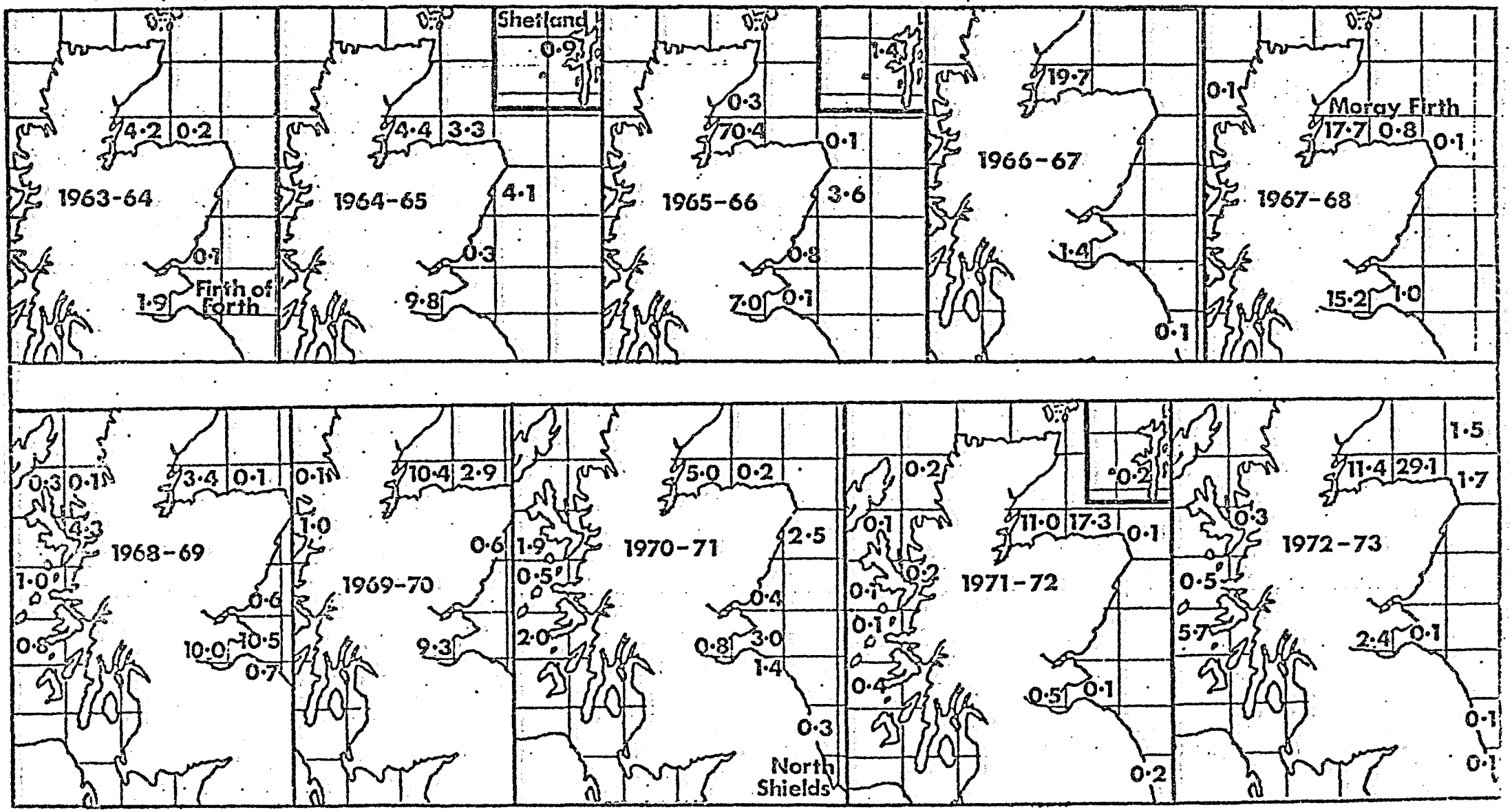

Figure 1 Pair-trawl landings of sprats in thousand metric tons from each statistical rectangle, 1963-1973.