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## LARVAL NEMATODES IN COD FROM SCOTTISH WATERS 1958-73

by

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### Summary

Cod samples from five areas around Scotland and one in the northern North Sea were obtained from research vessel and commercial catches during 1958-73 and examined for larval nematodes in the musculature. Two genera of nematodes, Anisakis sp. and Porrocaecum sp. were found. There were considerable variations in the abundance of each nematode in the different areas. Between 1958-73, increases in the incidence and intensity of infection of one or both genera were evident in most areas.

### Introduction

The presence of larval nematodes in the musculature of cod and other fish from Scottish waters has been known for many years. In the last 15 years there is evidence of a large increase in the number of cod infected (Rae, 1963; 1972) and this has been associated with an increase in the populations of the grey seal around Scottish coasts.

Two genera of nematodes are known to parasitise the musculature of cod in Scottish waters; these are Porrocaecum and Anisakis. Both these nematodes are closely related but their life-cycles differ in several respects. Both genera have three hosts in their life-cycles, Anisakis has euphausiids, particularly Thysanoessa spp. as its first host, fish as the second host and cetaceans (and to a much lesser extent the grey seal) as the final host. The first host of Porrocaecum is unknown but is possibly a small benthic crustacean such as a gammarid or mysid; fish are again the second hosts while the grey seal is the only significant final host. Rae (1963) claimed that 88% of the nematodes examined from cod were Porrocaecum and only 3% were Anisakis; the remainder were unidentifiable.

However, recent work at this laboratory and in England (Young 1972) has shown that in some areas over 90% of the worms found are Anisakis although in other areas 100% of the worms are Porrocaecum.

### Materials and Methods

The results given in this report are taken directly from Rae (1963; 1972) for the period 1958-1970 and from our own examinations in 1971-72 and 1973. Some of Rae's original results from examinations of commercial catches of cod from 1963-1970 have been reanalysed in order to allow more direct comparisons to be made between this and our own data. Results from 1958-70 were taken from both research vessel and commercial catches of cod; subsequent results from commercial catches only. Cod from all sources have been examined

by candling or slicing of the musculature of the fillets and flaps. It should be noted that Rae did not distinguish between Anisakis and Porrocaecum during examination of fish; in 1971-72 and 1973 the presence of the two genera have been recorded separately.

Results from research vessel catches are given only as the incidence of infection, that is the percentage of fish infected; results from commercial catches are expressed as both the incidence and intensity (mean number of nematodes per fish) of infection.

This report deals with fish from the following geographical areas; Moray Firth, northern North Sea, north coast, North Minch, South Minch and Clyde (Fig. 1).

## Results

### 1. Moray Firth

Rae (1972) showed that there had been a marked increase in the incidence of infection of cod caught by research vessels between 1958 and 1970 (Table 1). The largest increase was between 1962-65 and 1966-70. However, results from commercial catches show no evidence of a consistent increase in incidence or intensity of infection in any size group of fish between 1965 and 1973 (Table 2). There has apparently been some increase in the overall infection of cod between 1971-72 and 1973 due to both Anisakis and Porrocaecum becoming more numerous. In 1971-73 the numbers of fish infected with Anisakis and Porrocaecum were very similar although over 60% of the total number of nematodes found were Porrocaecum (Table 2). Anisakis is more abundant than Porrocaecum in cod below 50 cm, but this situation is reversed in larger fish.

### 2. Northern North Sea

The incidence of infection of cod caught by research vessels has shown a dramatic increase between 1958 and 1970 (Table 3a). Commercial catches from Ling Bank area (Fig. 1) in 1971-73 showed a fairly high incidence and intensity of infection of cod with larval nematodes (Table 3b) which was comparable with the incidence figures from the whole northern North Sea in 1966-70. The great majority of nematodes found in Ling Bank cod were Anisakis (Table 3b). There is evidence of an increase in abundance of this genus in fish under 60 cm between 1971-72 and 1973.

### 3. North coast of Scotland

There is no evidence of any increase in the incidence of infection of cod from research vessel catches during the period 1958-70 (Table 4a). Examinations of commercial catches in 1971-73 have shown a rather higher incidence of infection than that of fish from research vessel during 1966-70. The intensity of infection of commercial catches was fairly low (Table 4b). In 1971-72 fish infected with Anisakis and Porrocaecum were found in almost equal numbers although Porrocaecum was numerically the most abundant worm (Table 4b). In 1973 although the infection with Anisakis had remained at the same level Porrocaecum had increased in abundance (Table 4b).

### 4. North Minch

The incidence of infection of cod from research vessel catches increased considerably from 1962-65 to 1966-70 (Table 5a) so that in the latter period the North Minch was the most heavily infected area in Scottish waters

according to Rae (1972). There is further evidence of an increase in incidence and intensity of infection of fish from commercial catches between 1963-65, 1969-70 and 1973. This increase is most marked in fish less than 60 cm in length. Both Anisakis and Porrocaecum were present in North Minch cod although the latter was by far the most abundant in all length groups of fish.

#### 5. South Minch

Examinations of cod from research vessel catches show no evidence of any increase in incidence of infection from 1958-61 to 1966-70 (Table 6a). However, these were substantial increases in both the incidence and intensity of infection of fish from commercial catches between 1968 and 1973 although as the numbers of fish examined were small these results must be treated with caution. The great majority of larval nematodes found in South Minch cod during 1973 were Porrocaecum.

#### 6. Clyde

There is no evidence from either research vessel catches (Table 7a) or commercial catches (Table 7b) of any increase in incidence or intensity of infection of cod from 1958-1972. Indeed commercial catches show a marked decline in infection between 1970 and 1971-72 particularly in fish 30-49 cm in length (Table 7b). We have found only Porrocaecum in fish from the Clyde.

#### Discussion

There is no doubt that there has been a considerable increase in the infection of cod from the northern North Sea with larval nematodes during 1958-1973 and this has certainly been due to an increase in the numbers of Anisakis only. The numbers of Porrocaecum found in cod from the Ling Bank area have been much too small to suggest that this genus has been responsible for any increase in infection over the northern North Sea. Work in this laboratory has also shown a great increase in the infection of whiting from the North Sea with Anisakis from 1962-63 to 1971-72 while Dutch workers have shown a considerable increase in the infection of herring from the North Sea between 1959 and 1965 (Roskam, 1966).

It seems probable that Anisakis is largely responsible for the increase in infection of cod in offshore southern North Sea areas as reported by Rae (1972). Anisakis may also be mainly responsible for increases in infection of cod around the Shetlands although Porrocaecum is also common in fish from these waters and could be partly or wholly responsible for the increase.

There is some evidence of an increase in infection of cod from the Moray Firth although results from research vessel and commercial catches are conflicting.

Both Anisakis and Porrocaecum are found in similar numbers in cod from this area and either or both could be responsible for an increase in infection. It should be noted that both genera of nematodes rarely occur together in the musculature of a single cod, infections usually being of one genus only. Thus an increase in one genus only could result in a considerable increase in overall infection. As Rae did not distinguish between the two genera of nematodes in the fish he examined between 1958 and 1970 it is not possible to determine with certainty if either or both genera have increased during this period in the Moray Firth or any other area in which both genera are presently common. It may be significant that whiting from the Moray Firth, and the east coast generally have shown a great increase in infection with Anisakis from 1962-63 to 1971-73.

Infection of cod from the North Minch has apparently increased considerably between 1962 and 1973 probably because both Anisakis and Porrocaecum have become more abundant in this period. In the South Minch results from commercial and research vessel catches are conflicting and in recent years there has not been any increase in infection. Fluctuations in infection in the South Minch must be due mainly to variations in the numbers of Porrocaecum as Anisakis is scarce in cod from this area.

There is some evidence of recent increasing infection of cod from off the north coast of Scotland due to an increase in the abundance of Porrocaecum. However, in all areas there are probably considerable fluctuations in infection of cod between different years and significant trends can only be reliably detected over a longer period.

References

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Young, P.C. 1973 The relationship between the presence of larval anisakine nematodes in cod and marine mammals in British home waters. J. Appl. Ecol. 9, 459-485.

Table 1. Moray Firth: Research Vessel Catches. Incidence of infection with larval nematodes.

	31-50 cm			51-70 cm			71+cm			Total		
	No.	W	%	No.	W	%	No.	W	%	No.	W	%
1958-61	322	20	6.2	184	38	20.7	75	21	28.0	581	79	13.6
1962-65	346	28	8.1	146	48	32.9	58	30	51.7	550	106	19.3
1966-70	147	24	16.3	60	37	61.7	37	30	81.1	244	91	37.3

No. = Number of fish examined

W. = Number of fish with nematodes

% = Incidence of infection (% of fish infected)

TABLE 2 MORAY FIRTH: COMMERCIAL CATCHES INCIDENCE AND INTENSITY OF INFECTION WITH LARVAL NEMATODES

	30-39cm					40-49cm					50-59cm					60-69cm					70+cm					Total				
	No.	W	%	N	I	No.	W	%	N	I	No.	W	%	N	I	No.	W	%	N	I	No.	W	%	N	I	No.	W	%	N	I
*1965	45	2	4.4	2	0.1	172	6	3.5	10	0.1	55	16	29.1	46	0.8	2	0	0.0	0	-	0	-	-	-	-	274	24	8.8	58	0.2
*1966	40	7	17.5	11	0.3	461	99	37.0	134	0.3	139	40	28.8	129	0.9	29	18	62.1	182	6.3	14	8	57.1	27	1.9	683	172	25.2	483	0.7
*1967	188	6	3.2	6	0.03	305	51	16.7	71	0.2	283	82	29.0	162	0.6	29	14	48.3	31	1.1	3	1	33.3	4	1.3	808	154	19.1	274	0.3
*1968	31	0	0.0	0	-	157	25	15.9	30	0.2	240	96	40.0	190	0.8	98	57	58.2	227	2.3	28	19	67.9	153	5.5	554	197	35.6	600	1.1
*1969	198	20	10.1	22	0.1	551	117	21.2	223	0.4	373	115	30.8	936	2.5	65	38	58.5	207	3.2	11	8	72.7	143	13.0	1 198	298	24.8	1 531	1.3
*1971-72	137	19	13.9	22	0.2	104	26	25.0	36	0.4	97	26	26.8	70	0.7	32	11	34.4	23	0.7	10	8	80.0	28	2.8	380	90	23.7	179	0.5
**1971-72	137	10	7.3	13	0.1	104	18	17.3	20	0.2	97	16	16.5	22	0.2	32	4	12.5	10	0.3	10	3	30.0	5	0.5	380	51	13.4	70	0.2
***1971-72	137	9	6.6	9	0.1	104	12	11.5	16	0.2	97	11	11.3	48	0.5	32	9	28.1	13	0.4	10	7	70.0	23	2.3	380	48	12.6	109	0.3
*1973	44	1	2.3	1	0.02	59	19	32.2	30	0.5	68	29	42.6	75	1.1	46	21	45.7	82	1.8	16	10	62.5	26	1.6	233	80	34.3	214	0.9
**1973	44	1	2.3	1	0.02	59	12	20.3	17	0.3	68	17	25.0	26	0.4	46	12	26.1	22	0.5	16	5	31.3	12	0.8	233	47	20.2	78	0.3
***1973	44	0	0.0	0	-	59	8	13.6	13	0.2	68	13	19.1	49	0.7	46	15	31.3	60	1.3	16	5	31.3	14	0.9	233	41	17.6	136	0.6

\* Includes Anisakis and Porrocaecum

\*\* Anisakis only

\*\*\* Porrocaecum only

No. = Number of fish examined

W = Number of fish with larval nematodes

% = Incidence of infection (% of fish infected)

N = Number of larval nematodes found

I = Intensity of infection (mean number of larval nematodes per fish examined)

Table 3a. Northern North Sea - Offshore: Research Vessel Catches. Incidence of infection with larval nematodes

	31-50cm			51-70cm			71+cm			Total		
	No.	W	%	No.	W	%	No.	W	%	No.	W	%
1958-61	389	2	0.5	167	8	4.8	128	15	11.7	684	25	3.7
1962-65	217	20	9.2	170	15	8.8	136	23	16.9	523	58	11.1
1966-70	225	84	37.3	138	77	55.8	66	39	59.1	429	200	46.6

No. = No of fish examined

W. = No of fish with nematodes

% = Incidence of infection (% of fish infected)

Table 3b. Ling Bank: Commercial Catches. Incidence and intensity of infection with Anisakis and Porrocaecum in 1971-72 (1973 figures in brackets).

Length in cm	No. fish	No. infected		c/o Incidence		No worms		Intensity	
		<u>Anisakis</u>	<u>Porrocaecum</u>	<u>Anisakis</u>	<u>Porrocaecum</u>	<u>Anisakis</u>	<u>Porrocaecum</u>	<u>Anisakis</u>	<u>Porrocaecum</u>
30-39	28 (44)	9 (22)	0 (0)	32.1 (50.0)	0.0 (0.0)	11 (50)	0 (0)	0.4 (1.1)	0 (0.0)
40-49	70 (64)	26 (33)	1 (0)	37.1 (51.6)	1.4 (0.0)	48 (101)	1 (0)	0.7 (1.6)	0.01 (0.0)
50-59	23 (45)	11 (39)	0 (1)	47.8 (86.7)	0.0 (2.2)	29 (140)	0 (1)	1.3 (3.1)	0 (0.02)
60-69	29 (47)	20 (27)	1 (0)	69.0 (57.4)	3.4 (0.0)	61 (58)	1 (0)	2.1 (1.2)	0.03 (0.0)
70+	81 (57)	51 (38)	9 (5)	63.0 (66.7)	11.1 (8.8)	330 (137)	21 (5)	4.1 (2.4)	0.3 (0.08)
Total	231 (257)	117 (159)	11 (6)	50.6 (61.9)	0.1 (2.3)	479 (486)	23 (6)	2.1 (1.9)	0.1 (0.02)

No. = Number of fish examined

W. = Number of fish with larval nematodes

c/o = Incidence of infection (% of fish infected)

N = Number of larval nematodes found

I = Intensity of infection (mean number of larval nematodes per fish examined).



Table 4a. North Coast; Research Vessel Catches. Incidence of infection with larval nematodes

	31-50cm			51-70cm			70+cm			Total		
	No.	W	%	No.	W	%	No.	W	%	No.	W	%
1958-61	180	23	12.8	84	13	15.5	54	20	37.0	318	56	17.6
1962-65	103	7	6.8	214	48	22.4	158	65	41.1	475	120	25.3
1966-70	83	7	8.4	76	24	31.6	27	7	25.9	186	38	20.4

No = No of fish examined

W = No of fish with nematodes

% = Incidence of infection (% of fish infected)

Table 4b. North Coast: Commercial Catches. Incidence and intensity of infection with Anisakis and Porrocaecum in 1971-72 (1973 figures in brackets).

Length in cm	No. fish	No. infected		°/o incidence		No. worms		Intensity	
		<u>Anisakis</u>	<u>Porrocaecum</u>	<u>Anisakis</u>	<u>Porrocaecum</u>	<u>Anisakis</u>	<u>Porrocaecum</u>	<u>Anisakis</u>	<u>Porrocaecum</u>
30-39	12 (24)	2 (3)	2 (5)	16.7 (12.5)	16.7 (20.8)	2 (4)	2 (5)	0.2 (0.2)	0.2 (0.2)
40-49	52 (30)	11 (2)	8 (12)	21.2 (6.7)	15.4 (40.0)	18 (3)	14 (26)	0.4 (0.6)	0.3 (0.9)
50-59	60 (62)	16 (24)	10 (19)	26.7 (38.7)	16.7 (30.6)	21 (50)	62 (60)	0.4 (0.8)	1.0 (1.0)
60-69	20 (52)	4 (10)	6 (18)	20.0 (19.2)	30.0 (34.6)	5 (14)	13 (77)	0.3 (0.3)	0.7 (1.5)
70+	16 (20)	1 (3)	9 (10)	6.3 (15.0)	56.3 (50.0)	2 (11)	27 (47)	0.1 (0.6)	1.7 (2.4)
Total	160 (188)	34 (42)	35 (64)	21.3 (22.3)	21.9 (34.0)	48 (82)	118 (215)	0.3 (0.7)	0.7 (1.1)

Table 5a. North Minch: Research Vessel Catches. Incidence of infection with larval nematodes

	31-50cm			51-70cm			71+cm			Total		
	No.	W	%	No.	W	%	No.	W	%	No.	W	%
1958-61	47	18	38.3	202	77	38.1	138	62	44.9	387	157	40.6
1962-65	66	6	9.1	151	52	34.4	111	61	55.0	328	119	36.3
1966-70	89	56	62.9	60	30	50.0	39	33	84.6	188	119	63.3

No = No of fish examined

W = No of fish with nematodes

% = Incidence of infection (% of fish infected)

Table 5b. North Minch: Commercial Catches. Incidence and infection with larval nematodes.

	30-39cm				40-49cm				50-59cm				60-69cm				70+cm				Total									
	No	W	%	N	I	No	W	%	N	I	No	W	%	N	I	No	W	%	N	I	No	W	%	N	I					
*1963-65	48	6	12.5	7	0.2	33	5	15.2	5	0.2	42	25	59.5	105	2.5	23	10	43.5	64	2.8	18	13	72.2	92	5.1	164	59	36.0	273	1.7
*1969-70	0	-	-	-	-	2	0	0.0	0	0.0	20	5	25.0	7	0.4	55	36	65.5	87	1.6	37	20	54.1	80	2.2	114	61	53.5	174	1.5
*1973	23	14	60.9	72	3.1	20	15	75.0	67	3.4	25	19	76.0	95	3.8	13	9	69.2	30	2.3	15	13	86.7	144	9.6	96	70	72.9	424	4.4
**1973	23	12	52.2	24	1.0	20	11	55.0	24	1.2	25	10	40.0	18	0.7	13	2	15.4	2	0.2	15	2	13.3	2	0.1	96	37	38.5	70	0.7
***1973	23	10	43.5	48	2.1	20	12	60.0	43	2.2	25	16	64.0	77	3.1	13	7	53.8	28	2.2	15	13	86.7	142	9.5	96	58	60.4	338	3.5

\* Includes both Anisakis and Porrocaecum

\*\* Anisakis only

\*\*\* Porrocaecum only

No. = Number of fish examined

W = Number of fish with larval nematodes

% = Incidence of infection (% of fish infected)

N = Number of larval nematodes found

I = Intensity of infection (mean number of larval nematodes per fish examined)

Table 6a. South Minch: Research Vessel Catches. Incidence of infection with larval nematodes

	31-50cm			51-70cm			70+cm			Total		
	No.	W	%	No.	W	%	No.	W	%	No.	W	%
1958-61	20	3	15.0	81	46	56.8	43	30	69.8	144	79	54.9
1962-65	19	2	10.5	71	43	60.6	33	27	81.8	123	72	58.5
1966-70	9	3	33.3	21	13	61.9	6	5	83.3	36	21	58.3

No = No of fish examined

W = No of fish with nematodes

% = Incidence of infection ( % of fish infected)

Table 6b. South Minch: Commercial Catches. Incidence and intensity of infection with larval nematodes.

	30-39cm					40-49cm					50-59cm					60-69cm					70+cm					Total				
	No	W	%	N	I	No	W	%	N	I	No	W	%	N	I	No	W	%	N	I	No	W	%	N	I	No	W	%	N	I
*1964-65	NONE					9	2	22.2	9	1.0	21	6	28.6	9	0.4	64	26	40.6	134	2.1	58	44	75.9	204	3.5	152	78	51.3	356	2.3
*1968	NONE					14	12	85.7	80	5.7	47	40	85.1	186	4.0	100	84	84.0	564	5.6	178	166	93.3	1833	10.3	339	302	89.1	2663	7.9
*1973	14	9	64.3	46	3.3	23	15	65.2	103	4.5	16	11	68.8	33	2.1	15	12	80.0	86	5.7	17	13	76.5	64	3.8	85	60	70.6	335	3.9
**1973	14	2	14.3	3	0.2	23	4	17.4	4	0.2	16	3	18.8	4	0.3	15	1	6.7	2	0.1	17	2	11.8	2	0.1	85	12	14.1	15	0.2
***1973	14	8	57.1	43	3.1	23	12	52.2	99	4.3	16	10	62.5	29	1.8	15	12	80.0	84	5.6	17	13	76.5	62	3.6	85	56	65.9	320	3.8

\* Includes both Anisakis and Porrocaecum

\*\* Anisakis only

\*\*\* Porrocaecum only

No. = Number of fish examined

W = Number of fish with larval nematodes

c/o = Incidence of infection (% of fish infected)

N = Number of larval nematodes found

I = Intensity of infection (mean number of larval nematodes found)

Table 7a. Clyde: Research Vessel Catches. Incidence of infection with larval nematodes.

	31-50cm			51-70cm			71+cm			Total		
	No.	W	%	No.	W	%	No.	W	%	No.	W	%
1958-61	98	45	45.9	74	35	47.3	25	14	56.0	197	94	47.7
1962-65	68	20	29.4	44	26	59.1	4	2	50.0	116	48	41.4
1966-70	35	17	48.6	23	9	39.1	4	2	50.0	62	28	45.2

No = No of fish examined

W = No of fish with nematodes

% = Incidence of infection (% of fish infected)

TABLE 7b. CLYDE: COMMERCIAL CATCHES INCIDENCE AND INTENSITY OF INFECTION WITH LARVAL NEMATODES

	30-39cm					40-49cm					50-59cm					60-69cm					70+cm					Total				
	No.	W	%	N	I	No.	W	%	N	I	No.	W	%	N	I	No.	W	%	N	I	No.	W	%	N	I	No.	W	%	N	I
1964	187	53	28.3	131	0.7	90	31	34.4	137	1.5	42	26	61.9	119	2.8	48	39	81.3	226	4.7	21	19	90.5	97	4.6	388	168	43.3	710	1.8
1965	198	71	35.9	199	1.0	244	125	51.2	328	1.3	156	90	57.7	265	1.7	114	76	66.7	249	2.2	70	49	70.0	262	3.7	782	411	52.6	1 303	1.7
1966	535	102	19.1	202	0.4	498	247	49.6	615	1.2	277	204	73.7	671	2.4	203	164	80.8	639	3.2	129	111	86.1	686	5.3	1 642	828	50.4	2 813	1.7
1968	256	40	15.6	60	0.2	206	80	38.8	216	1.1	119	67	56.3	204	1.7	95	69	72.6	253	2.7	45	37	82.2	162	3.6	721	293	40.6	895	1.2
1969	112	17	15.2	23	0.2	174	38	21.8	109	0.6	72	32	44.4	146	2.0	80	47	58.8	168	2.1	88	77	87.5	329	3.7	526	211	40.1	775	1.5
1970	152	14	26.9	38	0.7	184	71	38.6	258	1.4	248	120	48.4	404	1.6	199	113	56.8	488	2.5	159	123	77.4	671	3.9	942	441	46.8	1 809	1.9
1971-72	63	0	0.0	0	-	54	6	11.1	13	0.2	44	16	36.4	31	0.7	25	13	52.0	69	2.8	26	21	80.8	129	5.0	212	56	26.4	242	1.1

No. = Number of fish examined

W = Number of fish with larval nematodes

% = Incidence of infection (% of fish infected)

N = Number of larval nematodes found

I = Intensity of infection (mean number of larval nematodes per fish examined)



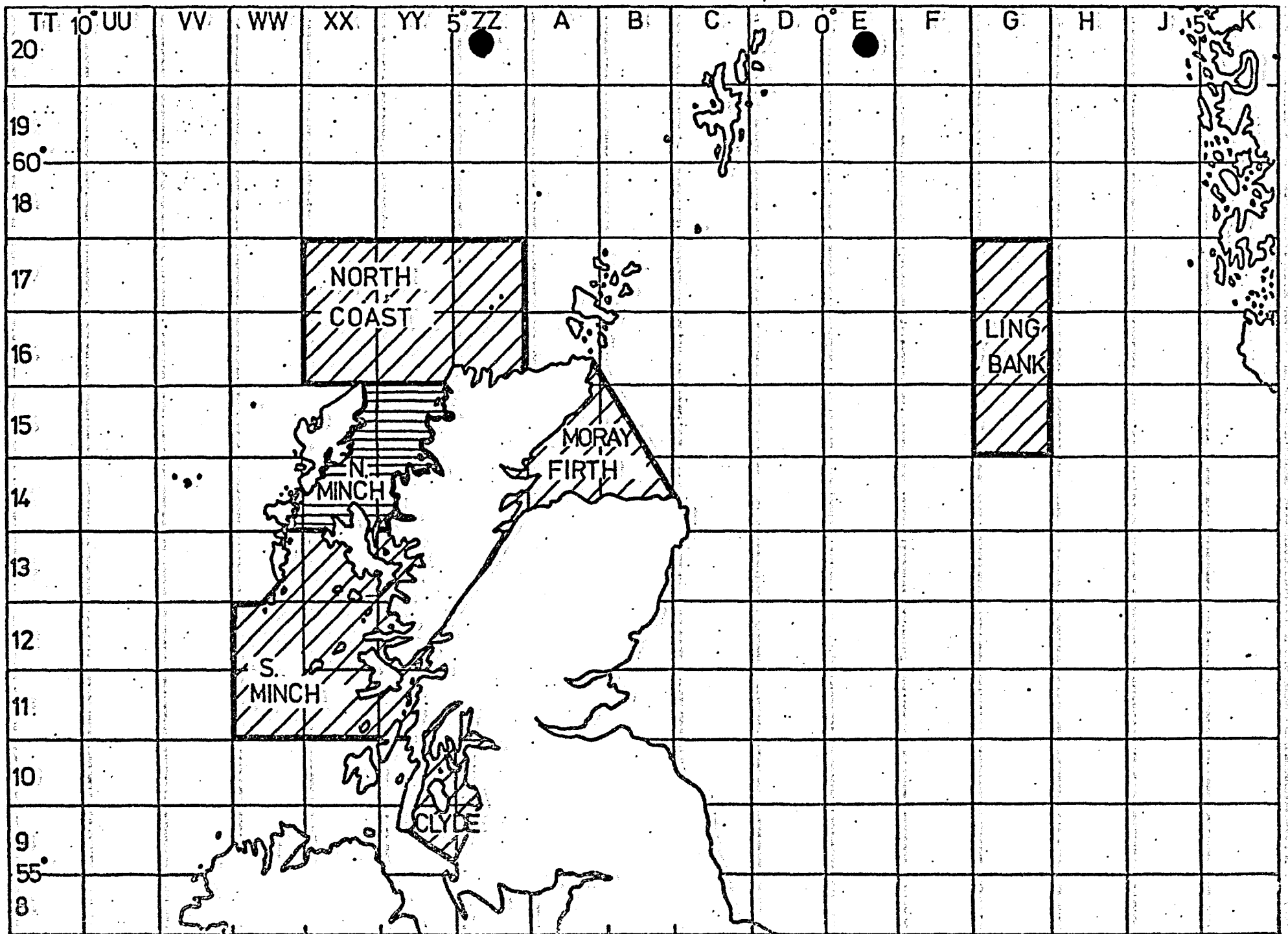


FIG 1. AREAS FROM WHICH CCD WERE SAMPLED FOR LARVAL NEMATODES, DURING 1971-1973.