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THE MYXOSPORIDIAN PARASITE MYXOBOLUS AEGLEFINI AUERBACH, 1906, AND ITS USE AS PARASITOLOGICAL TAG FOR PLAICE OF THE EASTERN NORTH SEA.

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1. Introduction

The geographic variation in abundance of parasites of marine fishes and its usefulness as parasitological tag has already been applied with some succes to several fish species (Sindermann, 1961). To be useful as parasitological tag a parasite must fulfil some conditions, as is discussed by Kabata (1963):

1) the parasite should be common in one population and rare or absent in another population of the studied host species.
2) preferably, the parasite should include in its life cycle only the host species which is the object of the study.
3) the infestations or infections produced by the parasite must be of a reasonable long duration.
4) the incidence of the parasite must remain relatively stable.
5) the environmental conditions throughout the area studied should be, preferably, within the physiological range of the parasite intended as a tag.

In order to cope with the overfishing problems of the North Sea an international quota-regulation was set up in the different fishing areas. For the Dutch fisheries problems arose when identifying catches of sole (Solea solea L.) as originating from the area under quota regulations or from the free area of the Skagerak (Jammer Bay)*. It was found that the identification could be made possible by observation of the parasites and

* since April 1978 this area is also under a (separate) quota regulation.

origin of plaice (Pleuronectes platessa L.) landed as bycatch with the sole of the areas in question.
The protozoan parasite Myxobolus aeglefini occurring abundantly in plaice of the Skagerak fulfilled most of Kabata's conditions, and the findings of the survey pointed to this parasite as an useful parasitological tag to distinguish plaice of that area from plaice of adjacent areas exploited by the Dutch flat-fish fisheries. This survey was undertaken by the Netherlands Institute for Fishery Investigations since 1973.

2. General information of the myxosporidian parasite Myxobolus aeglefini.

Appearance: 1) microscopically: spores elliptical or almost round, with lenticular shape, length 10-12, width 8-12, thickness 5.9-9.0 µm. Two pyriform polar capsules length 3.5-6.8 µm. Massive sutural ridge (Fig. 1).
2) macroscopically: spores accumulated as a milk-white substance in subspherical cyst-like cavities or vain-like branching canals up to 3 mm in diameter and specifically situated in the cartilage and bones of the skull of the fish host. The skull of heavily infected fish shows a mottled appearance (Fig. 2).

Species affected: first observation and description by Auerbach, 1906, from the skull of haddock (Melanogrammus aeglefinus L.). In 1907 also by Auerbach observed in whiting (Merlangius merlangus L.) and cod (Gadus morhua L.), in 1912 added with the ling (Molva molva L.). Kabata (1957) described the occurrence in the cranial cartilage of plaice and viewed the occurrence observed by other authors in cod, ling, norway pout (Trisopterus esmarkii L.) and hake (Merluccius merluccius L.). Lom (1970) recorded also the lumpsucker (Cyclopterus lumpus L.). Prof. Christensen (Royal Veterinary and Agricultural University, Copenhagen, Denmark, pers. comm., 1976) observed infected plaice, flounder (Platichthys flesus L.) and dab (Limanda limanda L.).

Distribution and locations: Auerbach (1912) described locations along the Norway coast (Bergen, Abelvaer, Lödingen, Vardö). Kabata (1957) recorded St. Andrews Bay, Scotland. Bykhovsky (1962) the Western Baltic Sea. Lom (1970) mentioned the North Sea and Atlantic Ocean. Christensen (pers. comm., 1976) observed infestations in the Gyllingnaes area, east coast of Denmark. In our survey also infestations were found in the Eastern Irish Sea.
Locations are marked in figure 3.

Incidence: none of the authors cited have given exact informations of the incidence, except for Auerbach (1912) giving an incidence of 2.2% in haddock and cod from Abelvaer, Norway. Christensen (pers. comm. 1976) informed us about an incidence up to 51% for plaice, 59% for flounder and 44% for dab from the Danish Gyllingnaes area for 1976.

Effect on host: erosion and (in some instances) hypertrophy of head cartilage. Lom (1970) mentioned this effect especially for haddock and plaice. No clear data are found concerning mortality of the host species due to infestation by M. aeglefini. In our observations even heavily infected plaice showed no external signs of poor condition generally. However, frequently the otoliths were found

also affected and malformed, which may result in an abnormal behaviour of the plaice and mortality. More research on this topic is needed of heavily infected stocks of flatfish and gadoids.

3. Materials and methods

Samples of plaice were collected from commercial fisheries or by the Dutch research vessel "Tridens". With the latter the samples were not restricted to plaice of commercial size and the position of fishing stations was more detailed and fixed, offering better data for drawing annual comparisons.
Length and sex of the plaice were recorded, age determination by otolith reading was performed frequently. In heavily infected specimens the otoliths were sometimes affected by M. aeglefini in such a way that age determination was difficult.
The cranium was checked on white cyst-like spots using the opening cut to remove the otoliths for age-determination. In case of doubt also a check with light microscope was performed with squash preparation of fresh of formalin-fixed material taken from the whitish substance of spots in the cranium. The infestation of the cranium was divided in three classes: 1. single or very few spots; 2. roughly 6 or some more spots, but still scattered widely; 3. overcrowding of spots and vein-like branching canals, serious erosion and hypertrophy.
Concerning class 1 it is difficult to estimate with absolute certainty the absence of a single spot with the opening cut used. The chance is present to overlook very light infected specimens with a spot in the cranium too far from the opening cut for direct observation. Within this aspect it must be also considered that very young stages of the parasite, not producing spores or in such a minor mass that it is hardly visible with the naked eye, also are overlooked with the used method. Exact observation is also difficult in very young plaice with a thin cranium. These data must be considered therefore as minimum values.
The area searched is marked in figure 3.

4. Results

4.1. - Research ship data (RV "Tridens").

4.1.1. Since 1969 a prerecruit survey is carried out twice a year along 10 lines of stations in the eastern coastal area of the North Sea and since October 1973 along 15 lines including the Skagerak-northern Kattegat area. Fig. 4 gives the location and the names of these lines. In November 1973 the study of the incidence of Myxobolus aeglefini in plaice caught on these lines was initiated. Since then the occurrence of the parasite was followed during each prerecruit survey (with the exception of October 1974). Table I gives the percentage infestation of plaice per line for the cruises up to and including the April 1978 cruise.

The parasite is very rare on the lines from Scheveningen to Sylt. The Holmen Ground, Jammer Bay and Kattegat lines yield fairly high percentages and the Esbjerg-, Hvide Sande- and Thyborön lines show the intermediate zone between the most northern lines with percentages over 20% and the practically not-infested area south of 55°N.
The infestation level in the Esbjerg-line plaice remains low (< 5%) from November 1973 - April 1978, whereas those caught on the Hvide Sande stations show a higher level, generally around some 5%.
The average level of infestation on the Thyborön-line is higher and of the order of 15% with large variations. The Holmen Ground line shows an average infestation level of 31% and a large variation too. In the Jammer Bay the average level is 50% with varying incidences per cruise reaching 78%. The general picture from these data is that there exists a plaice stock in the Skagerak with a high incidence of infestation which does not mix much with the adjacent North Sea plaice stocks. The zone between the Skagerak plaice and the North Sea stock is rather limited and of the order or some 50 miles only.
The degree of infestation in the Skagerak-Holmen Ground stock may vary from year to year and the data collected in November 1973 suggest that the high degree of infestation has been reached only recently.

4.1.2. The degree of infestation as a function of the length for male and female plaice separately.

As mentioned in section 3 the degree of infestation has been assessed in a qualitative scale from 0 (not infested) to 3 heavily infested). Table II gives the numbers of plaice infested according to this scale for different length-classes and for male and female plaice separately. There is only a slight increase in % infestation with length and there is a small, significant (X^2 = 23.5 for 6 d.f.) difference between females and males.
Biologically it is however unlikely that this parasite behaves differently in respect to males and females, although no informations exist of the way in which plaice become infested with M. aeglefini. Therefore, in the following no distinction between data from the two sexes will be made.

4.1.3. The degree of infestation as a function of the length on the four lines: Hvide Sande, Thyborön, Holmen Ground and Skagerak.

The ratio of the plaice showing different degrees of infestation may put some light on the process of infestation. Stage 1 is a difficult one and must be considered as minimum estimates (see section 3). There is no difficulty with the stages 2 and 3. Table III gives the number of plaice in-

fested as a function of the length for the four lines in the transition zone and in the Skagerak area. At the bottom of the table the ratios between the degree of infestation stages 1,2 and 3 are given for the four lines. No significant differences exist between the four lines. The detailed information of the four lines indicate a similar built up of the infestation picture. The only difference is that in the Hvide Sande and the Thyborön lines no infestation seems to occur in the length category 6-10 cm. whereas this is the case in the Jammer Bay area. The numbers sampled are, however, much too low to make any conclusion. This is only possible when considering the percentage and degree of infestation as a function of the age.

4.1.4. The degree and percentage of infestation as a function of the age on the four lines.

Table IVa gives the degree and percentage of infestation for the Hvide Sande-, Thyborön-, Holmen Ground and Jammer Bay lines separately for all April-May cruises of RV "Tridens" combined. It is apparent that in all lines infestation can be observed already in the first age-group sampled (I-group) and that infestation occurs in all age-groups. Table IVb gives the same information for the combined September-October cruises. Figure 5 shows the % infestation per age-group for the four lines. In the Hvide Sande- and Thyborön lines the values of infestation percentages in April-May are higher than in September-October. In the Holmen Ground line there is no difference and in the Jammer Bay area the September-October data suggest higer values than in spring.

4.2. - Data from commercial ships.

4.2.1. Another source of information on M. aeglefini infestation is the regular sampling of landings of commercial ships in the Netherlands since 1957. Since 1976 all plaice collected in this sampling programme were included in the M. aeglefini study.
Figure 6 gives the percentage of plaice infested for 6 areas in the North Sea and for the Skagerak for 1976 and 1977 combined as a function of the seasons. For January, February and March, the spawning season of the plaice, monthly percentages are given as a result of the intensified sampling in the spawning season. For the rest of the year the data were grouped in the periods April-June and July-December. Inspection of the diagrams shows that the % infestation in all North Sea areas is highest in the plaice spawning season and drops considerably in the rest of the year. In the Skagerak, however, the reverse is true.
This is in agreement with our findings on the Tridens line fishery where the April-May percentages are higher than the September-October for the Hvide Sande and Thyborön lines and the reverse is true for the Jammer Bay line.

4.3. - Research ship data from the Irish Sea.

4.3.1. Table VI gives the results from the Irish Sea survey, which are restricted to the recent start in 1977 for the M. aeglefini study in this area (see fig. 3). The area is divided in four locations from A in the north to D in the south. It is interesting that only areas C and D were found infected and that only the year-classes 1973 and 1974 were involved. This may indicate a recent penetration of the parasite in this area of the Irish Sea, for example as result of the presence of some long distance migrants from the Skagerak area. (see section 5). These data are, however, much too few and not yet based on long-term information to make any conclusion.

5. Discussion

The observed characteristics of the occurrence of M. aeglefini in plaice offer several possibilities to learn more about the behaviour of plaice. It is known from tagging experiments that during the spawning season plaice from most of the sub-populations aggregate in the southern part of their area of distribution for spawning. Interesting for this N-S migration are the changing and reversing data of the percentage of plaice infested with M. aeglefini as a function of the seasons (see sections 4.1.4, 4.2.1 and figs. 5 and 6). This may be considered as a reflection of the migration pattern of the substocks sampled, which may temporarily bring infected specimens from the Skagerak to more southern positions in that period.
For making this supposition more acceptable, two basic questions are important:
a. Is it possible that the M. aeglefini infestation can be picked up in other areas than the Holmen Ground-Skagerak-Kattegat area? and b. The plaice found infested in the different substocks do they originate from these stocks or are they long distance migrants from the Skagerak area? Tables Va and Vb together with figure 7 gives a possible answer to these questions. As we have seen in section 4.1.4 and in figure 5 plaice of all age-groups included the youngest sampled (I-group) were infested. It is therefore quite possible too that the O-group will show infestation, but because of their smalness it is difficult to assess the degree of infestation through the otolith-cut method. Table Va for the spawning season shows the percentage infestation for the various areas as a function of age. From 1976 to 1977 there is generally an increase, in most cases in the younger age-groups. However, different from the picture in the Holmen Ground-Skagerak area, the other North Sea areas show no infestation in the two-year old plaice and a minor percentage in the three-year old fish and a steadily increasing percentage with increasing age. This is shown clearly in figure 7. Table Vb gives the same information for the April-December samples. Based on these data it can be assumed that the infestation takes place only in the Holmen Ground-Skagerak-Kattegat area. Therefore infested plaice from other areas do not belong to the sub-stock in which they have been found, but must be considered as long distance migrants (strays) from the Skagerak sub-stock. The degree of mixing with the various other sub-stocks in the North

Sea is low and may amount annually to some 1.5%. However, for a better understanding of the mixing process we should know the sizes of the various substocks and collect information for additional years to calculate the rate of mixing. Within this aspect it should be also very interesting to understand more about the origin of the infected plaice in the locations mentioned in the literature (Scotland, Norway, Baltic: see introduction). As far as indicated these locations showed a low infestation percentage and the question arises if this is also the result of migrating plaice from the Skagerak or are there more infected areas in the eastern North Atlantic Sea?

6. Conclusions

The data of the M aeglefini infestation in plaice have shown to be useful as characterostoc for the plaice of the Skagerak-Kattegat area. In this area the research during the period 1973-1978 showed a continuous high level of infestation and together with the other features observed with the parasite it can be stated that M. aeglefini can be valued as parasitological tag for plaice. In addition to characteristics such as width of the first annual ring on the otolith (de Veen and Boerema, 1959) and abnormal pigmentation (de Veen, 1969), the parasite can be useful for the study of the structure of the substocks of plaice in the North Seaand adjacent waters. However, to get a maximal information research must be continued for a longer period and extended over more areas, especially the Kattegat-Baltic area, together with more studies concerning the way of infestation and life-cycle of the parasite.

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TABLE I - % infestation with Myxobolus aeglefini Auerbach on the lines of stations fished by R.V. "TRIDENS" in the April-May and September-October cruises in the years 1973-1978.
(number of sampled plaice within brackets).

Line	1973	1974	1975		1976		1977		1978
	Nov.	April	April-May	Sept-Oct.	April-May	Sept.-Oct	April-May	Sept.-Oct.	April-May
Scheveningen	0 (26)		0 (67)	0 (22)	0 (33)	0 (40)	0 (67)	0 (80)	0 (50)
Ymuiden	0 (90)	0 (67)	0 (88)	0 (100)	0 (43)	0 (62)	0 (86)	0 (78)	0 (55)
Texel	0 (89)	0 (75)	0 (75)	0 (97)	0 (70)	0 (75)	0 (90)	0 (88)	
Cleaverbank	0 (65)	0 (13)	0 (22)	0 (26)	2.5 (40)	0 (1)	0 (21)	0 (33)	2.0 (50)
Terschelling	0 (56)	0 (170)	0 (86)	0 (71)	0 (50)	0 (44)	0 (73)	0 (98)	0 (91)
Borkum	0 (10)	0 (16)	0 (74)	0 (66)	0 (50)	0 (35)	0 (86)	2.0 (50)	0 (56)
Heligoland	0 (24)	0 (54)	0 (12)	0 (33)	0 (35)	0 (10)	0 (20)	0 (11)	0 (19)
Norderney	0 (140)	0 (90)	0 (58)	0 (70)	0 (18)	0 (52)	0 (53)	0 (61)	0 (67)
Sylt	0 (78)	0 (59)	0 (70)	0 (75)	0 (45)	0 (54)	0 (23)	0 (65)	0 (81)
Esbjerg	0 (170)	4.3 (281)	0.8 (118)	0 (63)	0 (90)	1.4 (289)	2.2 (89)	3.1 (149)	3.7 (162)
Hvide Sande	0 (56)	0.9 (215)	1.4 (72)	6.0 (67)	5.3 (75)	4.7 (169)	3.8 (79)	5.9 (303)	10.0 (409)
Thyborön	4.9 (123)	7.1 (73)	9.1 (22)	6.2 (97)	17.9 (67)	20.1 (433)	43.9 (66)	12.7 (197)	16.9 (496)
Holmen Ground	13.2 (68)	45.2 (73)	25.0 (16)		29.4 (102)	25.2 (107)	36.9 (65)	28.7 (43.5)	47.5 (59)
Jammer Bay	23.0 (174)	32.0 (244)	27.9 (62)		63.0 (100)	70.7 (348)	58.4 (125)	77.8 (853)	44.2 (837)
Kattegat	4.0 (45)				49.5 (93)				

TABLE II - Degree of infestation in four classes (see text) for male and female plaice separate and for all lines of stations combined, as a function of the length of the plaice.

Length class in cm	Male					Female				
	Degree of infestation				% infested	Degree of infestation				% infested
	0	1	2	3		0	1	2	3	
6-10	19	0	0	0	0	6	0	0	0	6
11-15	107	8	5	3	13.0	49	8	4	2	22.2
16-20	232	19	21	22	21.1	110	16	17	12	29.0
21-25	336	47	24	34	23.8	173	40	19	31	34.2
26-30	442	68	43	56	27.4	336	56	27	36	26.2
31-35	274	51	35	20	27.9	273	62	30	23	29.6
36-40	27	10	13	4	50.0	122	26	21	4	29.5
41-45	3	1	1	0	40.0	47	13	10	8	39.7
46-50						20	4	2	3	31.0
51-55						7	0	2	0	22.2
Total	1440	204	142	139	25.2	1143	225	132	119	29.4

TABLE III - Ration between the degrees of infestation as a function of the length for four lines of stations for sexes combined and all cruises combined.

HVIDE SANDE LINE						THYBORÖN LINE					
length in cm	degree of infestation				% infested	length in cm	degree of infestation				% infested
	0	1	2	3			0	1	2	3	
6-10	8	0	0	0	0	6-10	41	0	0	0	0
11-15	39	1	1	0	4.9	11-15	157	9	0	0	5.4
16-20	160	3	2	5	5.9	16-20	217	20	7	5	12.9
21-25	383	3	7	9	4.7	21-25	231	49	20	25	28.9
26-30	604	15	18	8	6.4	26-30	367	43	21	27	19.9
31-35	131	4	2	2	5.8	31-35	196	12	9	3	10.9
36-40	16	1	2	0	15.8	36-40	31	2	1	2	13.9
41-45	6	0	0	0	0	41-45	9	3	1	0	25.0
46-50	3	0	0	1	25.0	46-50	5	0	1	0	16.7
						51-55					
						56-60	1	1	0	0	50.0
Total	1350	27	32	25	5.9	Total	1255	139	60	62	17.2

HOLMEN GROUND LINE						JAMMER BAY LINE					
length in cm	degree of infestation				% infested	length in cm	degree of infestation				% infested
	0	1	2	3			0	1	2	3	
6-10						6-10	2	1	0	0	33.3
11-15						11-15	82	19	8	5	28.1
16-20						16-20	269	137	92	93	40.7
21-25	1	0	0	0	0	21-25	271	247	105	107	62.9
26-30	83	22	7	12	33.1	26-30	247	223	117	124	65.3
31-35	274	63	44	31	21.5	31-35	141	124	70	47	63.1
36-40	160	21	26	14	27.6	36-40	46	23	18	5	50.0
41-45	22	3	3	3	29.0	41-45	22	8	8	4	47.6
46-50	9	2	1	0	25.0	46-50	6	4	1	3	57.1
51-55	2	0	0	0	0	51-55	4	0	3	0	42.9
56-60						56-60	1	0	0	0	0
Total	551	111	81	60	25.5	Total	1091	786	422	388	57.2

Ratio's infestation class 1 : 2 : 3

Hvide Sande line	32.1 : 38.1 : 29.8 %
Thyborön line	53.3 : 23.0 : 23.8 %
Holmen Ground line	44.0 : 31.7 : 23.8 %
Jammer Bay line	49.2 : 26.4 : 24.3 %

TABLE IVa - Degree of infestation as a function of age for four lines of stations, all cruises and sexes combined, April - May.

HVIDE SANDE LINE						THYBORÖN LINE					
Age-group	degree of infestation				% infested	Age-group	degree of infestation				% infested
	0	1	2	3			0	1	2	3	
0	1	0	0	0	0	0					
1	14	0	0	3	17.6	1	4	1	1	0	33.3
2	52	0	1	0	1.9	2	17	8	6	0	45.2
3	81	0	4	1	5.8	3	37	13	1	2	30.2
4	52	0	0	0	0	4	46	4	1	0	9.8
5	16	0	0	0	0	5	4	1	0	0	20.0
6	2	0	0	0	0	6	1	2	0	0	66.7
7	0	0	0	1	100.0	7	0	0	0	1	100.0
8						8	0	1	0	0	100.0
9						9	1	0	0	0	0
10+						10+	2	0	0	0	0

HOLMEN GROUND LINE						JAMMER BAY LINE					
Age-group	degree of infestation				% infested	Age-group	degree of infestation				% infested
	0	1	2	3			0	1	2	3	
0						0					
1						1	12	4	2	1	36.8
2	0	0	1	0	100.0	2	39	10	7	12	42.6
3	30	11	6	5	42.3	3	41	27	28	16	63.4
4	74	14	8	2	20.7	4	20	14	5	7	56.5
5	9	3	3	0	40.0	5	2	3	2	2	77.8
6	5	0	1	0	16.7	6	5	0	0	0	0
7	4	1	1	0	33.3	7	4	2	1	0	42.9
8	0	1	0	0	100.0	8	2	2	0	0	50.0
9						9	4	1	1	0	33.3
10+	2	0	0	1	33.3	10+	3	0	2	0	40.0

TABLE IVb - Degree of infestation as a function of age for four lines of stations, all cruises and sexes combined, September - October.

HVIDE SANDE LINE						THYBORÖN LINE					
Age-group	degree of infestation				% infested	Age-group	degree of infestation				% infested
	0	1	2	3			0	1	2	3	
0						0	1	0	0	0	0
1	10	0	0	0	0	1	13	2	0	0	13.3
2	25	0	1	3	13.8	2	43	0	3	2	10.4
3	34	0	0	0	0	3	85	1	3	0	4.5
4	10	0	0	0	0	4	93	1	0	0	1.1
5	21	0	0	0	0	5	52	0	0	0	0
6						6					
7						7	1	0	0	0	0
8						8	1	0	0	0	0
9						9					
10+						10+					

HOLMEN GROUND LINE						JAMMER BAY LINE					
Age-group	degree of infestation				% infested	Age-group	degree of infestation				% infested
	0	1	2	3			0	1	2	3	
0						0					
1						1	2	1	1	1	60.0
2	0	1	1	0	100.0	2	6	5	4	5	70.0
3	14	4	4	2	41.7	3	16	20	14	16	75.8
4	70	5	7	5	21.3	4	14	16	11	12	73.6
5	14	2	4	3	39.1	5	1	2	0	0	66.7
6	1	0	1	0	50.0	6	1	0	0	0	0
7	0	0	1	0	100.0	7					
8						8					
9						9					
10+						10+					

TABLE Va - % infestation with Myxobolus aeglefini Auerbach as a function of age in commercial catches from different areas of the North Sea, sexes combined, for the first quarter (plaice spawning season) of 1976 and 1977.

Year-class	1976							1977						
	Southern Bight	Transition area	Flamborough	German Bight		Fisherbank	Average	Southern Bight	Transition area	Flamborough	German Bight		Fisherbank	Average
				west	east						west	east		
1975								0	0	0	0	0	0	0
1974	0	0	0	0	0	0	0	0	0	0.9	0	0.8	6.0	1.28
1973	0	0	0	0.5	2.0	7.0	1.58	1.3	0.7	0.4	4.2	4.1	13.0	3.95
1972	0	0.5	0	0.6	0.2	1.1	0.40	0.5	0.9	2.1	3.5	4.0	9.8	3.47
1971	0	0	3.9	2.1	1.7	14.3	3.67	2.2	2.6	1.9	8.2	5.6	12.3	5.47
1970	0	2.1	1.9	7.6	4.2	10.7	4.42	3.4	0.9	4.7	6.7	10.5	14.6	6.80
1969	0	0	1.8	9.6	7.4	19.1	6.32	1.4	3.4	2.0	6.8	10.0	14.3	6.32
1968	2.1	0	0	6.0	12.5	25.0	7.60	0	1.8	8.6	14.0	10.2	22.4	9.50
1967	0	3.3	0	16.3	10.7	18.5	8.13	7.4	2.4	0	0	26.1	23.3	9.87
1966	0	0	0	3.8	21.7	6.1	5.27	0	2.4	6.8	2.4	12.1	45.5	11.53
1965	3.3	0	0	7.7	20.8	7.7	6.58	0	2.3	0	6.1	9.5	24.2	7.02
1964	0	0	12.5	10.0	14.3	20.0	9.47	0	0	0	0	0	0	0
1963	0	3.4	0	7.1	10.0	11.1	5.27	0	1.3	4.6	4.5	4.0	10.6	4.17
1962+	0	0	0	0	11.1	7.1	3.03	0	0	0	0	0	0	0
Average	0.2	0.7	0.8	3.6	4.3	7.9	2.92	0.8	1.1	2.3	4.3	5.0	13.0	4.42

TABLE Vb - % infestation with Myxobolus aeglefini Auerbach as a function of age in commercial catches from different areas of the North Sea, sexes combined, for the second, third and fourth quarter of 1976 and 1977.

Year-class	1976							1977						
	Southern Bight	Transition area	Flamborough	German Bight		Fisherbank	Average	Southern Bight	Transition area	Flamborough	German Bight		Fisherbank	Average
				west	east						west	east		
1976								0	0	0	0	0		0
1975	0	0		0	0		0	0	0	0	0	0	0	0
1974	0	0.8	0	0	0.9	2.5	0.70	0	0	0	0	0	1.1	0.18
1973	0	0	1.8	0	0.7	2.4	0.82	0	0	0	2.0	1.4	4.3	1.28
1972	0.7	0	0.4	0	0	0.9	0.33	0	0	1.0	2.0	5.0	3.4	1.90
1971	0	0	1.5	0	0	0	0.25	0	0	0	0	8.3	13.3	3.60
1970	1.7	0	1.5	0	0	0	0.53	0	0	0	12.5	10.0	7.1	4.93
1969	0	0	1.7	3.2	0	10.7	2.60	0	0	0	0	0	0	0
1968	0	14.3	0	0	0	15.4	4.95	0	0	0	0	0	0	0
1967	6.3	0	4.0	18.2	0	10.0	6.41	25.0	0	0	0	28.6	11.1	10.78
1966	0	0	0	0	0	20.0	3.33	0	0	0	0	0	0	0
1965	0	0	0	0	0	0	0	0	11.1	0	0	0	0	1.85
1964	0	0	0	0	0	0	0			0			0	0
1963	0	0	0	0	0	0	0	0	0	0	0	25.1	11.1	6.02
1962+	0	0	0	0	0	14.3	2.38	0	0	0	0	0	0	0
Average	0.3	0.4	1.0	0.5	0.4	2.7	0.88	0.3	0.2	0.3	0.8	0.3	3.8	0.95

TABLE VI - Degree and % of infestation as a function of age for four areas (A - D) in the eastern Irish Sea, sexes combined for May 1977.

Area A (most northern)						Area B					
Year-class	degree of infestation				% infested	Year-class	degree of infestation				% infested
	0	1	2	3			0	1	2	3	
1976	1				0	1976	2				0
1975	7				0	1975	9				0
1974	21				0	1974	14				0
1973	17				0	1973	4				0
1972	8				0	1972	3				0
1971	1				0	1971	1				0
1970	5				0	1970	1				0
1969	1				0	1969					
1968	1				0	1968	1				0
1967	1				0	1967					
1966						1966	1				0
1965	3				0	1965					
1964						1964	1				0

Area C						Area D (most southern)					
Year-class	degree of infestation				% infested	Year-class	degree of infestation				% infested
	0	1	2	3			0	1	2	3	
1976	1				0	1976	7				0
1975	41				0	1975	101	1			1.0
1974	37	2	2		9.8	1974	56	1		2	5.1
1973	29	1	1		6.5	1973	17				0
1972	12				0	1972	8				0
1971	12				0	1971	9				0
1970	6	1			14.3	1970	9				0
1969	4				0	1969	6				0
1968	4				0	1968	2				0
1967						1967	2				0
1966	3				0	1966	1				0
1965	1				0	1965	2				0
1964						1964					

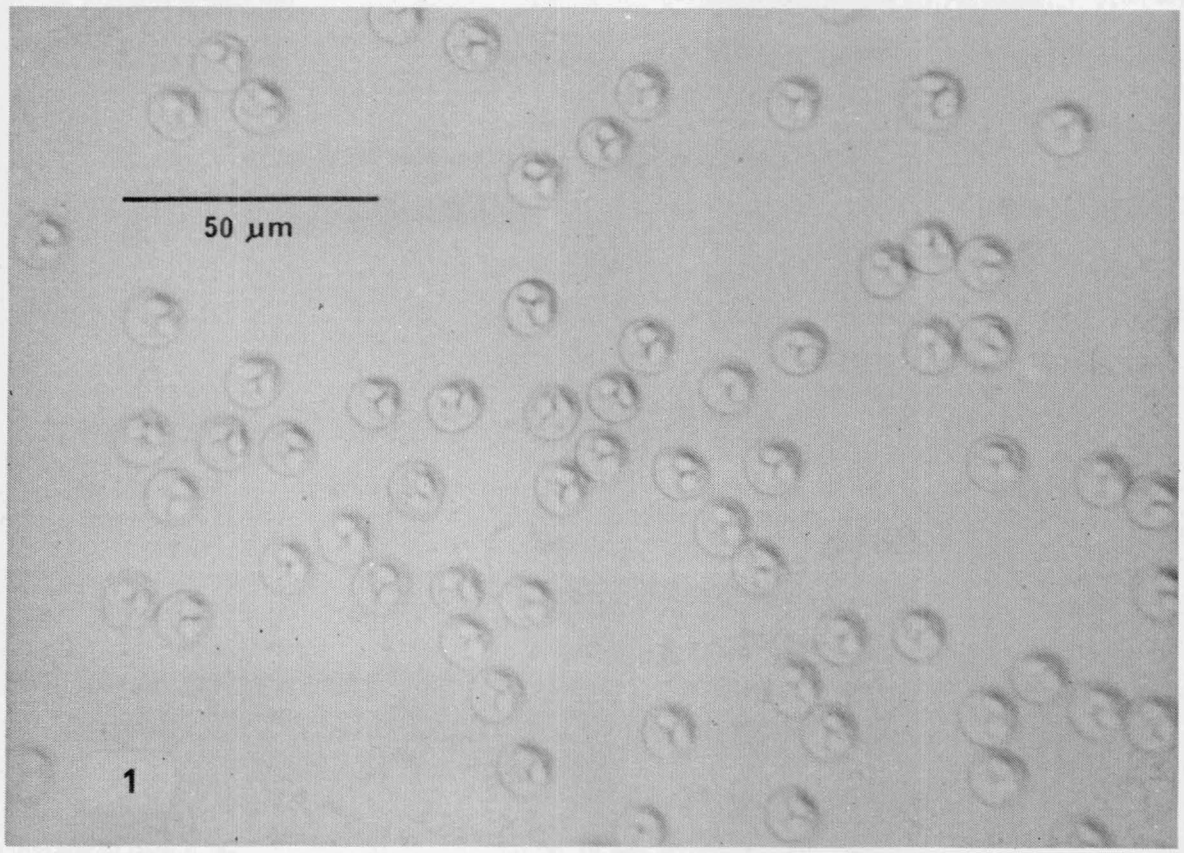


Fig. 1 Spores of Myxobolus aeglefini Averbach. Light microscope photograph; squash preparation of formaling-fixed material from head cartilage of plaice. Inside the spores the two pyriform polar capsules are clearly visible.

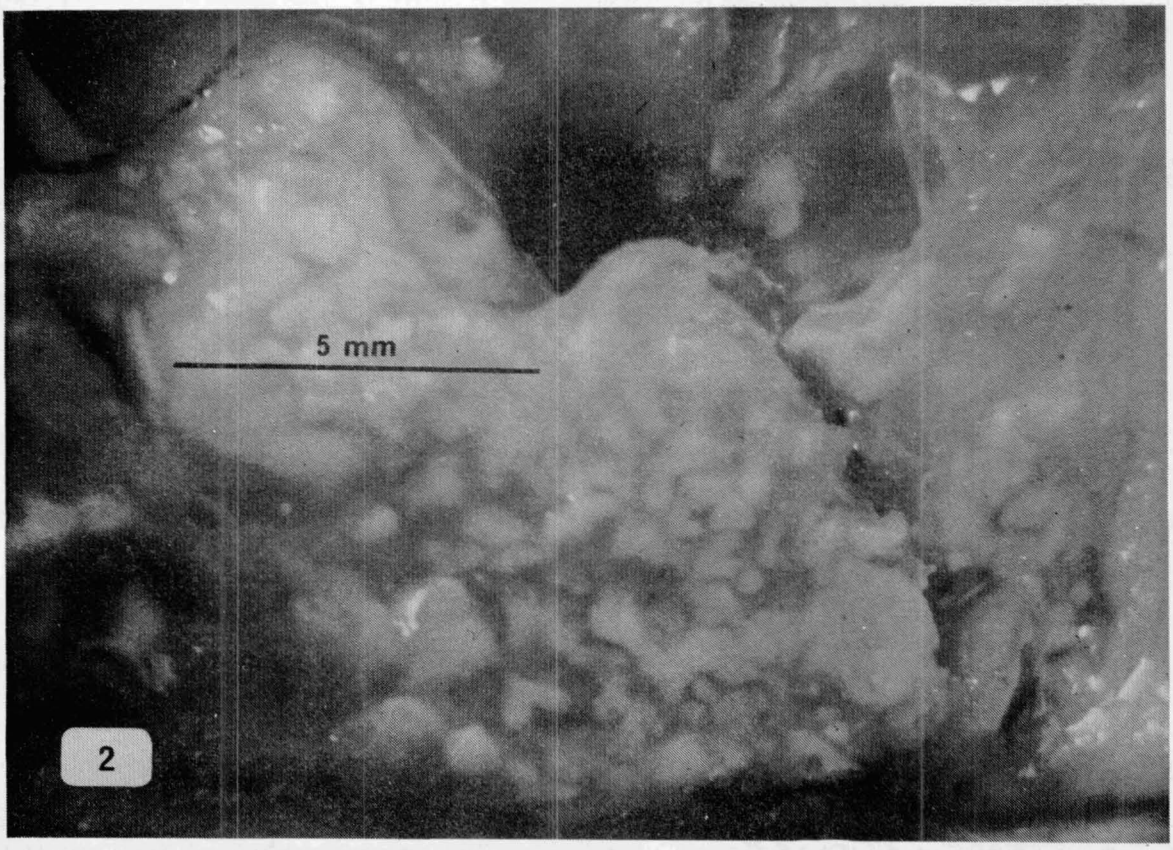


Fig. 2 Overerowding of white cyst-like spots and vein-like branching canals in head cartilage of plaice affected with Myxobolus aeglefini Averbach. Otolith removing cut level, class 3 infestation.

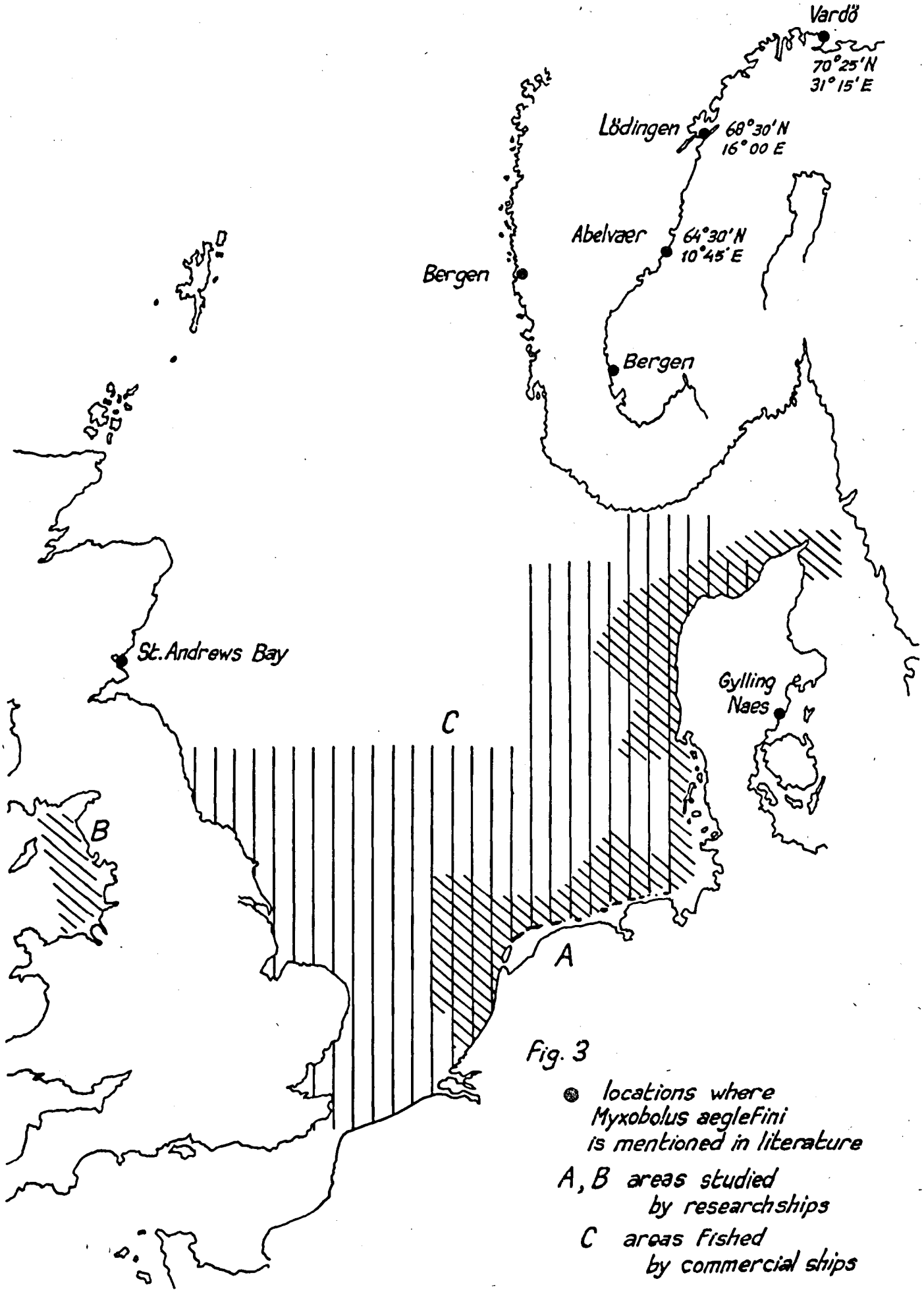


Fig. 3

● locations where Myxobolus aeglefini is mentioned in literature

A, B areas studied by researchships

C areas fished by commercial ships

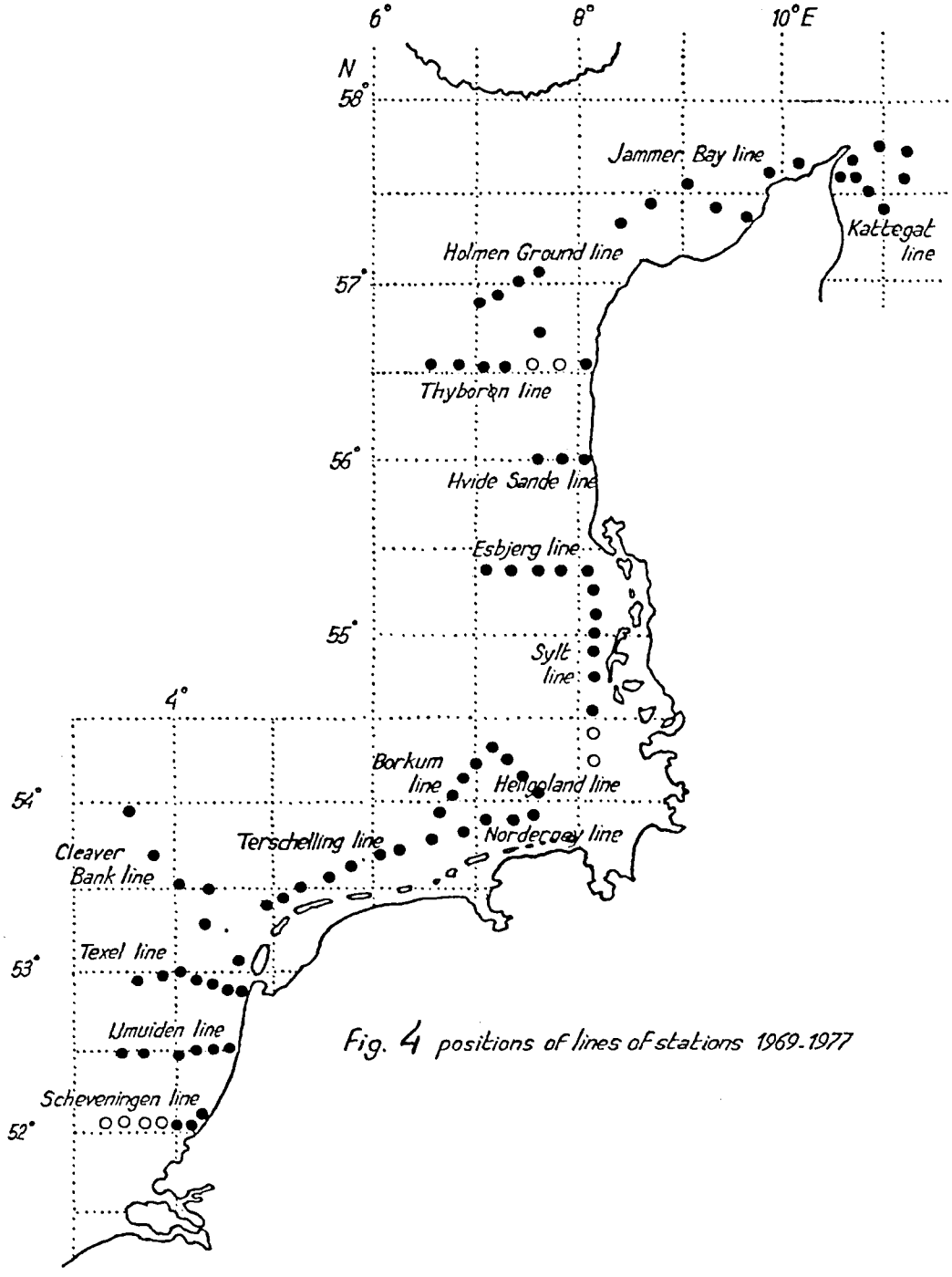
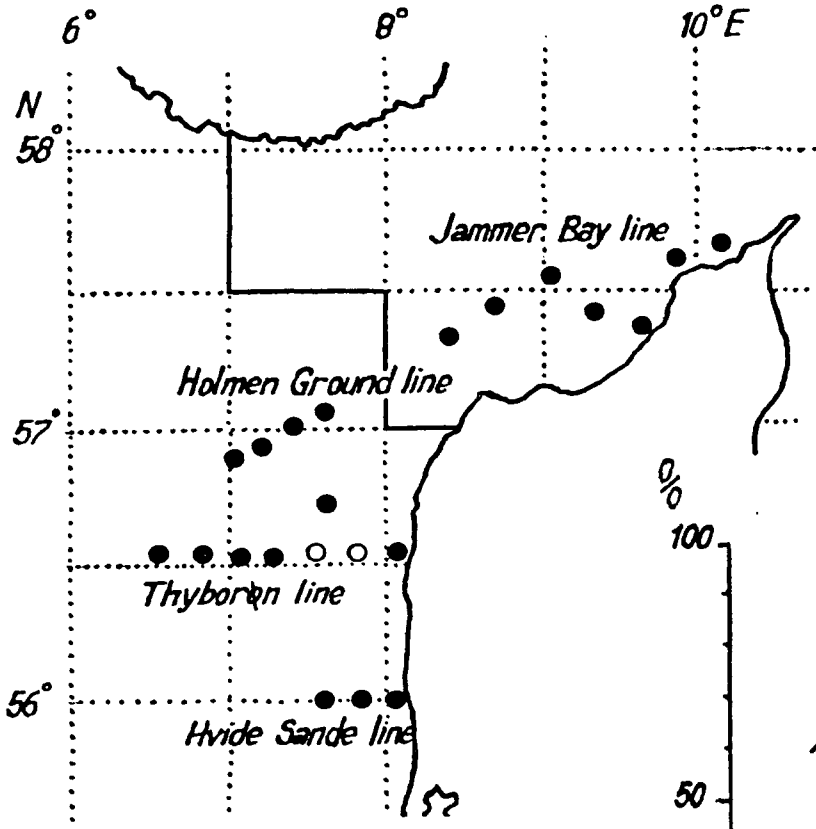
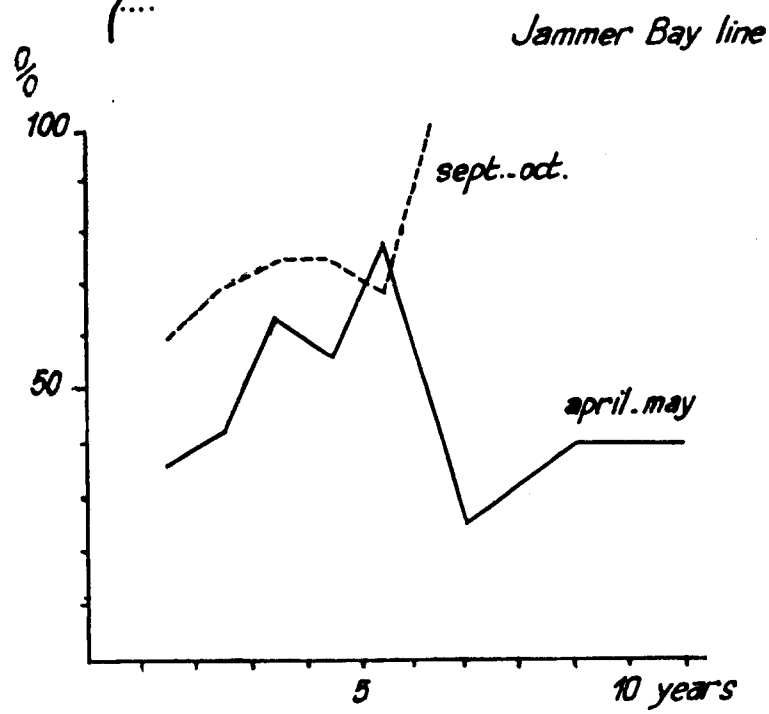
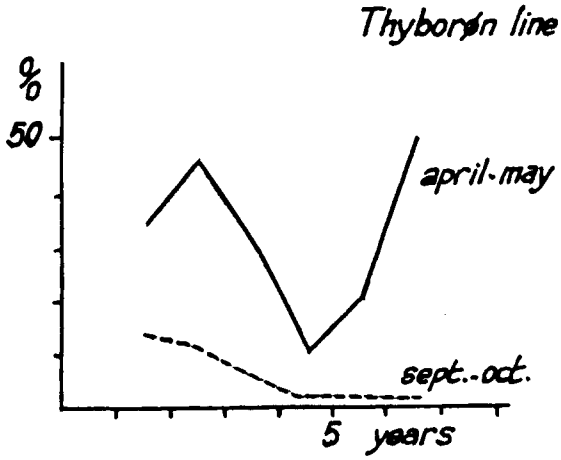
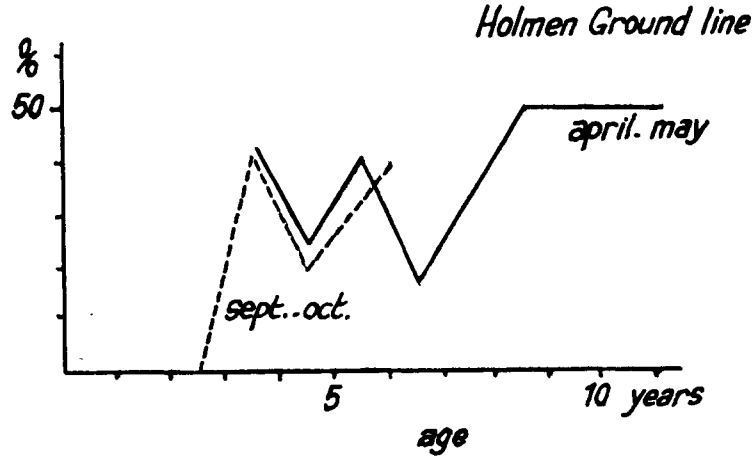


Fig. 4 positions of lines of stations 1969-1977









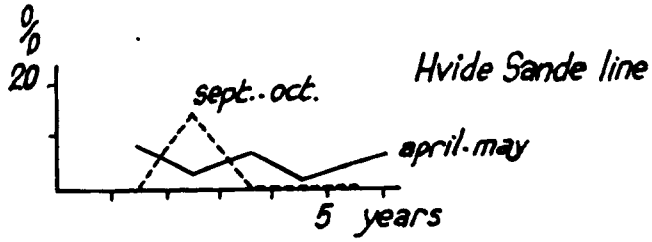


Fig. 5

% infestation with age for april-may and september-october (average 1975-1977) for four lines fished by RV Tridens

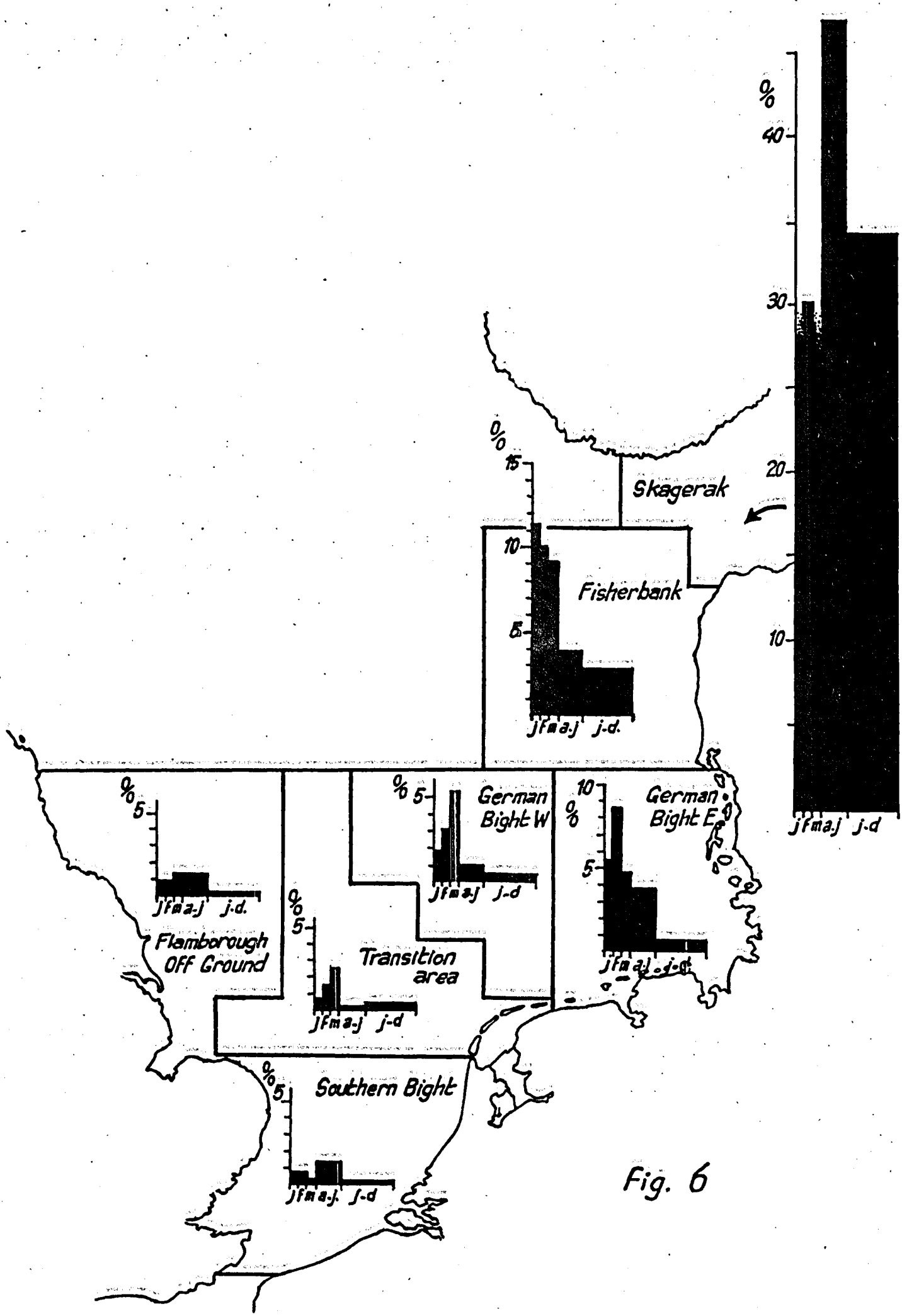

%
40
30
20
10
jfma.j j-d.
Skagerak
%
15
10
5
Fisherbank
jfma.j j-d.
%
5
jfma.j j-d.
Flamborough
Off Ground
%
5
German
Bight W
jfma.j j-d
%
10
5
German
Bight E
jfma.j j-d
%
5
Transition
area
jfma.j j-d
%
5
Southern Bight
jfma.j j-d

Fig. 6

Fig. 7 % infestation with age for the plaice spawning season and the rest of the year for 1976 and 1977 for all North Sea areas combined