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ANISAKIS LARVAE (NEMATODA: ASCARIDIDA) IN MACKEREL, (*SCOMBER SCOMBRUS* L.) IN ICES SUB-AREAS IV, VI. VII AND VIII IN 1970-1971 AND 1982-1984

by

A. Eltink
Netherlands Institute for Fishery Investigations
P.O. Box 68, 1970 AB IJmuiden
The Netherlands

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RESUME

En 1982-1984 des recherches ont été menées sur *Anisakis* en tant que marque biologique chez le maquereau pour déterminer l'origine et le trajet migratoire du maquereau du sud de la Mer du Nord. Les données partielles collectées à cette fin ont fait l'objet d'une précédente communication. Les résultats complets des recherches sur l'*Anisakis* dans les échantillons de maquereau récoltés dans les sous-zones CIEM IV, VI, VII et VIII ainsi que les résultats de recherches de la période antérieure 1970-1971 sont donnés dans la présente communication.

L'infestation est beaucoup moins liée à la longueur et à l'âge du poisson qu'on ne pourrait le prévoir en faisant l'hypothèse d'une infestation par *Anisakis* augmentant annuellement.

L'abondance d'*Anisakis* chez le maquereau atteint un niveau maximal dès l'âge de 3 à 5 ans. Ceci est probablement dû à une résistance accrue de l'hôte aux noevelles invasions par les larves d'*Anisakis* plutôt qu'à une perte de larves. La mortalité des hôtes moyennement et fortement infestés ne peut expliquer cette forte diminution des infestations annuelles par *Anisakis* chez les groupes d'âges les plus vieux. Le taux d'infestation au cours de la (ou des) première(s) année(s) de vie du maquereau détermine probablement le taux d'infestation des poissons âgés et détermine également le temps nécessaire au développement d'une résistance aux nouvelles invasions de larves. L'abondance d'*Anisakis* chez le maquereau de la Mer du Nord a approximativement doublé entre le début des années 70 et le début des années 80.

L'abondance d'*Anisakis* chez le maquereau du sud de la Mer du Nord a relativement moins progressé au cours de la même période. Dans la population de maquereau de l'ouest, on note un accroissement de l'infestation de sud au nord, entre mai et juillet.

En 1982-1984, la prévalence et l'abondance les plus grandes apparaissent dans la population de maquereau de la Mer de Nord tandis que prévalence et abondance les plus faibles apparaîssent chez le maquereau du sud de la Mer du Nord et du Golfe de Gascogne.

L'abondance de L'*Anisakis* dans la population de maquereau de l'ouest est à peu près moitié moindre que celle du maquereau de la Mer du Nord.

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ABSTRACT

In 1982-1984 investigations were carried out to investigate the origin and migration of the southern North Sea mackerel using Anisakis as a biological tag in mackerel for which purpose only part of the Anisakis data were presented earlier. All results of these investigations on Anisakis in mackerel samples, collected in ICES Subareas IV, VI, VII and VIII together with results of investigations in an earlier period 1970-1971, are presented in this paper. The infestation is much less related to the length and age of the fish than expected assuming an increasing yearly Anisakis infestation. The abundance of Anisakis in mackerel reaches as early as age 3 to 5 the highest level. This is probably due to an increased host resistance to newly invading Anisakis larvae rather than the loss of larvae. Mortality of the medium and high infestated hosts can not explain this sharp decrease in the yearly Anisakis infestations for the older age groups. The level of Anisakis infestation during the first year(s) of life of the mackerel determines probably the level of infestation when they are old fish and also determines the time needed to develop a resistance to newly invading larvae. The abundance of Anisakis in North Sea Mackerel doubled approximately from the early seventies till the early eighties. The abundance of Anisakis in the mackerel from the southern North Sea Mackerel increased relatively less during these time periods. Within the Western Mackerel population there is a gradual increase in the infestation from south to north from May to July. In 1982-1984 the highest prevalence and abundance occurs in North Sea Mackerel population. The lowest prevalence and abundance occurs in mackerel from the southern North Sea and the Bay of Biscay. The abundance of Anisakis in the Western Mackerel population is about half of the infestation in the North Sea Mackerel.

INTRODUCTION

Two mackerel (Scomber scombrus L.) populations occur in the northeast Atlantic: the Western Mackerel and the North Sea Mackerel stocks (Anon., 1988). The Western Mackerel spawn in the Celtic Sea and Bay of Biscay, while the North Sea Mackerel spawn in the central North Sea. After spawning the main part of both populations migrate to the same feeding grounds in the northern North Sea, which is a very important feeding area for the mackerel. Euphausiids, copepodes and fish are the most important food (Mehl and Westgaard, 1983 and Anon., 1984). The main infestation of mackerel with larvae of Anisakis simplex (Nematoda: Ascaridida) (Pippy and van Banning, 1975) takes place in the northern North Sea (Smith, 1983a).
The life cycle of Anisakis goes from the final host, which contains the adults, through an intermediate and a paratenic host, containing the larval stages and back to the final host again. Intermediate hosts are crustaceans, mainly euphausiids (Smith, 1983a and Smith 1983b). Paratenic hosts of Anisakis are in most cases Teleostei, like herring, horse mackerel and mackerel, eating these euphausiids. Final hosts of Anisakis are mainly Cetaceans (van Banning and Becker, 1978), feeding on these fish. In the final hosts the adult Anisakis produce eggs, which enter sea water along with the faeces of the marine mammalian final host.
In 1982-1984 investigations were carried out on Anisakis as a biological tag in mackerel to find out the origin and migration of the southern North Sea mackerel in relation to the North Sea and Western Mackerel populations for which purpose only part of the Anisakis data were presented earlier. The southern North Sea mackerel should be regarded as an overflow of mackerel of the Western Mackerel population to the North Sea Mackerel population (Eltink et al., 1986). This group of mackerel , which spawns in the North Sea, is born and has partly spent the juvenile phase in the western areas and probably does not feed in the northern North Sea and has therefore a characteristic low infestation of Anisakis. All results of these investigations on Anisakis in mackerel samples, collected in ICES Subareas IV, VI, VII and VIII together with results of investigations in an earlier period 1970-1971 (collected by dr P. van Banning) are listed in this paper. The prevalence, abundance, mean intensity and degree of infestation of Anisakis in mackerel by area and by length or age of the fish or only by area in ICES Sub-areas IV, VI, VII and VIII in the two time periods 1970-1971 and 1982-1984 are presented. Instead of by area this information is also given for the Western and North Sea Mackerel population and the mackerel from the southern North Sea. Furthermore, the Anisakis distributions by area and time within the western and North Sea area are examined. Infestation by sex was examined, because there was a suspect that the male sex would be more prone to infestation with Anisakis than the female sex, for males mature earlier and therefore migrate at a younger age to the feeding grounds in the northern North Sea. The degree of Anisakis infestation is investigated in relation to the loss of condition of the fish. Hypotheses are given for the mechanisms preventing an excessive infestation and the determination of the infestation level.

MATERIAL AND METHODS

During the period 1970-1971 1064 mackerel and during the period 1982-1984 3008 mackerel were examined for Anisakis larvae in ICES Subareas IV, VI, VII and VIII.
Table 1 shows the number of mackerel, which were examined for Anisakis and which were aged, by year and by ICES Division or Subdivision. These

sampled areas are shown for both time periods in respectively Figures 3 and 4 (the large ICES Divisions IVa, IVb and VIa have been divided in smaller Subdivisions, which have additions like e.g. 'SW' for southwest etc.).
In 1970 and 1971 aselect samples were taken from mackerel catches of commercial and research vessels in ICES Divisions IVa, VIa and VIIg (Table 1). All fish were examined for Anisakis larvae and of these fish sex, maturity, age, weight and length were estimated.
In 1982-1984 part of the samples of the market sampling programme were used for counting Anisakis together with samples from research vessels. These samples were representative for the length and age composition of the catches. These fish were examined for Anisakis larvae and the sex, maturity, age, weight and length were estimated. Of some additional samples of research and commercial vessels, being representative for the length distribution of the catch, only the length was estimated and the number of Anisakis counted.
Two methods of counting the number of Anisakis larvae were used:
* The 'Naked-eye' counting method. The visceral mass of each mackerel separately was examined very carefully for nematodes, which were then identified and counted. This method was used in 1982 and 1983, because also the plerocercus of Grillotia angeli (Cestoda: Trypanorhyncha) (MacKenzie, 1981) was counted then.
* The citric acid - pepsin digestion method (Roskam, 1966). Anisakis larvae were recovered by citric acid - pepsin digestion of the whole visceral mass of each mackerel separately during 24 hours at 37^{0}C, after which the digested mass was sieved over a black 1x1 mm metal-wire sieve. The nematodes remaining on the sieve were identified and counted. This method was used in 1970, 1971 and 1984.

All fish in Sub-area IV north of latitude 55^{0}N were assumed to belong to the North Sea Mackerel population, except those caught from July to October. All fish in Sub-area IV south off latitude 55^{0}N were assumed to belong to the mackerel from the southern North Sea. All fish in Sub-area VI, VII and VIII were assumed to belong to the Western Mackerel population, except those caught in VIa NE in November, December, January, February or March.
Fish of a certain age and length have been combined in groups in order to have enough fish per age or length group. The following age groups were used: 1-3, 4-6, 7-10, 11+(age 11 and older). The following length groups were used: 20.0-24.9 cm, 25.0-29.9 cm, 30.0-34.9 cm, 35.0-39.9 cm, 40.0-44.9 cm and 45.0-49.9 cm.
The following ecological terms in parasitology, recommended by an ad hoc committee of the American Society of Parasitologists (Margolis et al., 1982) are used in this paper:

PREVALENCE (%) =	Number of individuals of a host species infected with a particular parasite species * 100 / Number of hosts examined
ABUNDANCE =	Total number of individuals of a particular parasite species in a sample of hosts / Total number of individuals of the host species (infected + uninfected) in the sample. (= Mean number of individuals of a particular parasite species per host examined)
MEAN INTENSITY =	Total number of individuals of a particular parasite species in a sample of a host species / number of infected individuals of the host species in the sample. (= Mean number of individuals of a particular parasite species per infected host in a sample)

The infestated mackerel were divided in three categories for indicating the DEGREE OF INFESTATION:

1-15 Anisakis larvae per fish = LOW degree of infestation
16-45 Anisakis larvae per fish = MEDIUM degree of infestation
>45 Anisakis larvae per fish = HIGH degree of infestation

The percentage of fish with a HIGH, MEDIUM and LOW infestation in a certain area or for a certain population or for a certain age or length group add up to 100%. The calculation of these three degrees of infestation (%) is not presented in the Tables 3 - 8, when there were less than 5 infestated fish.

RESULTS

Individual worm burden ranged from 0 to 378. The frequency distributions of Anisakis larvae are skewed as is shown as an example for age group 5 of North Sea Mackerel in 1983-1984 in the text table below :

A./fish	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	>=50
Frequency	7	10	7	5	2	6	3	3	2	1	5

Table 2 shows the prevalence (%), mean intensity and abundance of Anisakis in mackerel and the number of fish, which were examined, by year, by ICES Division or by Subdivision, by month and by rectangle. Information on the assumed (sub)population identity is added in this Table 2. The information of this table is presented respectively in Figure 1 and 2 for the two time periods 1970-1971 and 1982-1984. These figures show the ICES statistical rectangles, which have been sampled during both periods. The abundance of Anisakis in mackerel increased in the northern North Sea from 1970-1971 to 1982-1984. The coverage of sampling in the western area was very limited during 1970-1971. The only sampling was done in Subdivision VIa NE, which is very near to the northern North Sea area, and in Division VIIg, which is more or less a nursery ground. Therefore, no information is available on the changes in the Anisakis infestation in the western areas.

Table 3 shows the total number of mackerel examined for Anisakis, the number uninfestated and infestated fish; the prevalence, the mean intensity, abundance and the degree of infestation in the infected fish (%) by Division or by Subdivision for two time periods 1970-1971 and 1982-1984. Figure 3 and 4 show the prevalence, the abundance of Anisakis in mackerel and number of fish examined by Division or Subdivision for respectively the two time periods 1970-1971 and 1982-1984. The highest abundance of Anisakis in mackerel occurred in 1970-1971 in Subdivisions IVa SE and NE and in 1982-1984, not only in IVa NE+SW+SE and IVb E+W, but also in Division VIIc.

Table 3 is combining all age and length groups, but Table 4 and 5 show the same information by length groups respectively by age groups in order to detect any relation between infestation and the length or age of the fish. The prevalence (%) increases with the length and age of the mackerel. The abundance and mean intensity increases with length and age of the mackerel, but seem to decrease often for the largest and oldest fish.

Table 6 and 7 show the total number of mackerel examined for Anisakis, the number uninfestated and infestated fish, the prevalence, the mean intensity, abundance and the degree of infestation in the infected fish (%) for the Western Mackerel, the North Sea Mackerel and the mackerel from the southern North Sea for the periods 1970-1971 and 1982-1984 by length group (Table 6)and by age group (Table 7). Figure 5 shows in most cases an increasing abundance of Anisakis in mackerel for each age group of the

North Sea Mackerel population and the mackerel from the southern North Sea from 1970-1971 to 1983-1984. The relative high abundance of Anisakis in 1-3 year old southern North Sea mackerel in 1970-1971 seems unrealistically high.
Figure 6 and 7 show the abundance of Anisakis in mackerel in the North Sea and Western Mackerel population and in the mackerel from the southern North Sea and the Bay of Biscay, by length group in 1982-1984 and by age group in 1983-1984. The smallest and youngest fish had the lowest infestation with Anisakis. The 4 year and older fish do not show a clear increasing abundance of Anisakis, but the abundance fluctuates more or less around a certain level. The abundance or mean intensity by age group do not show an increase as one would expect with an increasing food uptake of the mackerel, but a rapid increase for young fish, nearly no further increase for older fish and even a decrease for the oldest fish (Table 4 and 5 and Figures 5, 6 and 7). The prevalence rates increased for the Western and North Sea mackerel populations between 1970-1971 and 1982-1984 (Table 6 and 7). An unexpected high prevalence and abundance were estimated for the smallest and youngest mackerel from the southern North Sea in 1970-1971.
Table 8 shows the total number of mackerel examined for Anisakis, the number uninfestated and infestated fish, the prevalence, the mean intensity, abundance and the degree of infestation in the infected fish (%) for the Western Mackerel, the North Sea Mackerel and the mackerel from the southern North Sea by sex and sexes combined in 1983-1984. There is no clear difference between male and female mackerel in relation to Anisakis infestation, although the prevalence and abundance of Anisakis in Western Mackerel and mackerel from the southern North Sea is just a little higher for males than for females.
Figures 8, 9 and 10 demonstrate the differences in abundance of Anisakis in mackerel depending on the time and the area of sampling. Figure 8 shows the abundance of Anisakis in mackerel in the North Sea area from June to July in 1983 and 1984. The highest infestation of 1-3 year old mackerel occurs in the northern North Sea. Four year and older fish in the northern and central North Sea have a much higher infestation than those from the southern North Sea. The abundance of Anisakis decreases also often for the oldest and largest mackerel in these figures.
Figure 9 shows the abundance of Anisakis in the mackerel in the western area from May to July in 1983 and 1984 in three different areas. From north to south the abundance of Anisakis in each age group of mackerel decreases, especially the abundance of Anisakis in the juveniles (age 1-3).
The abundance of Anisakis in mackerel in Division VIIj decreases within each age group during (pre)spawning from March to May as is shown in Figure 10. The most remarkable change is the decrease in infestation of 1-3 year olds.
Figure 11, 12 and 13 show the cumulative percentage of mackerel having a low , medium and high Anisakis infestation by age group in 1983-1984 for respectively the North Sea and Western Mackerel and the mackerel from the southern North Sea. These figures demonstrate that the percentage distributions of the degrees of Anisakis infestation do not change any more after age 4 of the mackerel. These percentages do not include uninfected fish.

The mean condition factor ($K = 100 * \text{weight} / \text{length}^3$) of the Western Mackerel, North Sea Mackerel and the mackerel from the southern North Sea in 1983-1984 in relation to the number of Anisakis larvae present is shown in Table 9. There is no correlation between increasing degree of infestation and loss of condition of the fish. However, a positive correlation seems to exist between degree of infestation and the condition of the fish.

DISCUSSION

The skew frequency distributions of Anisakis in mackerel are also common in herring (van Banning and Becker, 1978) and blue whiting (Smith and Wootten, 1978). The overdispersion of Anisakis in mackerel is typical of almost all parasite frequency distributions studied in natural populations (Anderson, 1978).

Once the Anisakis larvae have entered the visceral cavity or musculature they quickly become encapsulated and remain immobile while fish is alive. Larvae do not penetrate the viscera but are encapsulated superficially. Thus, although the surface of the liver may be covered with larval nematodes its internal structure and functioning are probably unimpaired (Smith and Wootten, 1978).

For counting Anisakis larvae the pepsin digestion method is preferable to the naked-eye counting method, because inaccuracy may arise especially when the fish is not fresh-caught or when thawing after freezing causes 'deliquescence' in the body cavity (van Banning and Becker, 1978). As a consequence of counting only in the body cavity contents, nematodes in the musculature are missed. The tendency of each Anisakis to bore into the musculature of herring has shown to be constant in that approximately one in 130 larvae was found in this circumstance regardless of the age or the length of the host (Davey, 1972). Therefore, the number of Anisakis larvae, in the musculature of the mackerel missed by this method, is probably irrelevant.

Smith (1983b) stated that euphausiids in the North-East Atlantic and northern North Sea, and perhaps universaly, are major hosts of Anisakis simplex. The Anisakis larvae are found in the following euphausiids species in the northern North Sea: Thysanoessa inermis, T. longicaudata, T. raschii and Nyctiphanes couchii (Smith, 1983a) and probably also Meganyctiphanus norvegica (Smith, 1971), which is the most important species of the euphausiids in the mackerel diet (Mehl and Westgaard, 1983). Smith (1983a) had the impression that the infected euphausiids were most common in the offshore region at depth between 100 and 200m in the northern North Sea as shown in Figure 14. No individual euphausiid harboured more than one parasite. In the northern North Sea the distribution was extremely patchy; the prevalence rate for individual euphausiid species in individual samples was in T. inermis from 0 to 4.0%, in T. longicaudata from 0 to 1.0% and in T. raschii from 0 to 1.3%, but an exceptionally high rate of 78% was recorded. Larval Anisakis occurred in 0.42% of the examined euphausiids (109 individuals out of 26058 euphausiids of five species).

The abundance of Anisakis in mackerel doubled approximately in the North Sea Mackerel population from 1970-1971 to 1982-1984 (Figure 5 and Table 6 and 7). This increase was less in the mackerel from the southern North Sea. The infestation of Anisakis in 1-3 year old southern North Sea mackerel was relatively high in 1970-1971, because the last strong year class 1969 of the North Sea Mackerel population had an expanded distribution to the south. The sampling of mackerel during 1970-1971 was not adequate enough to describe any change in the abundance of Anisakis in mackerel in the western area or in the Western Mackerel population between both periods.

It appears that in June and July the southern part of the northern North Sea area the highest abundance of Anisakis in mackerel occurs, although the number of fish examined is rather low (Figure 8). The mackerel from the southern North Sea has a much lower abundance of Anisakis. The southern North Sea mackerel should be regarded as an overflow of mackerel of the Western Mackerel population to the North Sea Mackerel population (Eltink et al., 1986). This group of mackerel, which spawns in the North Sea,

is born and has partly spent the juvenile phase in the western areas, does not feed in the northern North Sea and has therefore a characteristic low infestation of Anisakis.
The juveniles of the Western Mackerel population, growing up in the western area, have a relatively high infestation compared with juveniles from the English Channel, the Bay of Biscay and southern North Sea. Along the edge of the continental shelf there is an increase in the infestation of juvenile fish from south to north from May to July (Figure 9). Probably the infestation of juvenile mackerel increases from south to north. In the eighties there has been a partial shift of western juvenile mackerel from the Western English Channel to the west of Scotland (Anon., 1988). The infestation of these juvenile Western Mackerel will probably increase, when more juveniles are growing up to west of Scotland, because the infestation in the western English Channel would be much lower.
During the (pre)spawning season (March-May) the abundance of Anisakis in Western Mackerel decreases (Figure 10) as a result of the age-size succession in spawning of the mackerel. The older and larger fish spawn earlier and within an age group the relatively large fish spawn earlier. After spawning they migrate to the northern North Sea for feeding. The largest fish within an age group mature earlier and therefore spawn earlier and migrate earlier to the feeding area in the northern North Sea, where they get a higher infestation compared with the relatively smaller fish of the same age group, remaining in the western areas or migrating northward later (Eltink, 1987). The relatively sharp decrease in infestation of the youngest fish from March to May is caused by an immigration of low infestated first time spawners in the spawning area.
In the Western Mackerel population seems to exist a positive correlation between the degree of Anisakis infestation and the condition factor of the fish as a result of the age-size succession in spawning and migration of mackerel (Eltink, 1987); the largest fish within an age group are probably those fish having the highest condition factor.
Males of the 2 year old mackerel mature at a smaller length than females, which causes a relatively higher abundance of Anisakis in these 2 year old males in the spawning area (Eltink, 1987). Therefore, one would expect a higher infestation in male Western Mackerel and male mackerel from the southern North Sea than for females, because these males start their feeding migration to the North Sea earlier compared to females. But there was only a slight higher infestation in these males.
Figure 5, 6 and 7 show that only the juvenile mackerel (age 1-3 and length class 20-24 and 25-29) of the North Sea Mackerel population have a very high abundance, which is nearly as high as the older and larger fish, because these juveniles grow up in the North Sea, which is the main infestation area. The juvenile North Sea Mackerel, growing up in an area with a risk of many infestations in a relatively short period, probably gets a high number of infestations before they even have been able to develop a presumptive resistance to newly invading larvae. The juvenile Western Mackerel, growing up in an area with a risk of much less infestations in the same period, probably gets a low number of infestations before they develop a presumptive resistance to newly invading larvae. It takes a longer period for the Western Mackerel to develop this presumptive resistance compared to the North Sea Mackerel. This implies that the abundance of Anisakis in adult mackerel is dependent on the Anisakis infestation pressure during the juvenile period. It is even possible then that within the population the abundance of Anisakis in mackerel decreases with the age of the fish. It implies that the older fish in the population have been spending their first years of live in an area, where they got a low infestation. According to Smith and Wootten (1978) there was an indication in some samples of blue whiting that the level of infestation decreased in older fish.

Also Gieds (1981) found that the infestation in the very large and old blue whiting was decreasing with the length of the fish. This decrease in the level of infestation for older fish can also be observed in mackerel (Tables 4 - 8 and Figures 5 - 10). The level of Anisakis infestation in mackerel in the early seventies was indeed about half of the recent level, which means that the hypothesis above is in agreement with the observations in blue whiting and mackerel. Therefore, the abundance of Anisakis in Western Mackerel increased from the early seventies till the early eighties, because the oldest (age 11+) fish have a lower infestation than the younger fish (age 4-10).
In the text table below is shown the growth in length and weight by year of the mackerel in the middle of the year. Mackerel eat about 2.5 times their own body weight each year (Anon., 1984) and about 1/3 of their diet in the northern North Sea consists of euphausiids (Mehl and Westgaard, 1983). Assuming only 70% of their food consumption is eaten in the northern North, the annual food intake of euphausiids in the northern North Sea can be estimated and is about 60% of their own body weight. The mean weight of an individual M. norvegica eaten by mackerel estimated during the stomach sampling programme (Anon., 1984) was 0.08 g and the mean weight of both T. inermis and T. raschii 0.02 g (pers. comm. Sigbjørn Mehl). The mean weight of an individual euphausiid was assumed to be 0.06 g, because the most important euphausiid in the diet of the mackerel was M. norvegica. This mean weight can be used for estimating roughly the number of euphausiids eaten each year by one individual mackerel in a certain age group from the weight of euphausiids eaten by each mackerel in a certain age group. The percentage of infected euphausiids eaten is assumed to be at least 0.5% of the total number of euphausiids eaten in the northern North Sea, because the prevalence rate was already 0.42% in all samples taken in the total area as shown in Figure 14 and because the biomass of Thysanoessa species is much lower to the west of Scotland than in the northern North Sea (Lindley, 1977). The theoretical cumulative infestation of Anisakis in mackerel can be estimated, assuming each infected euphausiid eaten accounts for one encapsulated Anisakis in the body cavity of the mackerel and assuming that Anisakis larvae live as long as their paratenic host (see text table below).

Age of mackerel	Length of fish	Weight of fish	Weight of Euphausiids eaten (g)	Number of Euphausiids eaten (N)	Infestations concerning year	Theoretical cumulative infestations
0	15.5	39	24	390	2	2
1	22.8	125	75	1250	6	8
2	27.7	225	135	2250	11	19
3	31.1	318	191	3180	16	35
4	33.4	394	237	3940	20	55
5	35.0	453	272	4530	23	78
6	36.1	497	298	4970	25	103
7	36.8	528	317	5280	26	129
8	37.3	550	330	5500	28	157
9	37.7	566	339	5660	28	185
10	37.9	576	346	5760	29	214

The number of theoretical cumulative infestations are compared to the observed values of the North Sea and Western Mackerel populations as is shown in Figure 15. The number of infestations each year is linear related to the food consumption of the mackerel, but the observed abundance of

Anisakis in both populations remain far below the expected values of the theoretical cumulative infestations and show evidence of nearly no more infestations after the age of 3 or 5. This much lower observed abundance can be explained by a possible increased host resistance to newly invading larvae as suggested earlier as the most likely possibility. This host resistance to newly invading larvae can be developed either by the fish itself or by the encapsulated Anisakis larvae themselves. Any change in the feeding habits of about 4 year and older mackerel should be excluded as possibility on account of the results of the stomach sampling project (Anon., 1984). Furthermore the mortality of the medium and high infected paratenic hosts should be considered as a possible cause of this much lower observed than expected abundance, but the number of Anisakis infestations did not have an apparent effect on the condition of the mackerel not even at very heavy infestation levels. Also Smith and Wootten (1978) did not find any correlation between the degree of infestation and the loss of condition of the blue whiting. Even, when a high degree of infestation would not affect the condition of the fish, one would expect that fish with a higher degree of infestation would suffer a higher mortality than those fish having a lower degree of infestation. This would imply that the cumulative percentage distribution (Figures 11, 12 and 13) would change to relatively more medium and less low infestated fish. However, these percentage distributions do practically not change for the 4 year and older fish, which supports the hypothesis of the host resistance. Furthermore the loss of previously established worms could also cause this much lower observed than expected abundance of Anisakis in mackerel. This would imply that the established larvae should live only 3 to 5 year in order to get a very slowly increasing abundance by age or length and that in older fish about 30 nematodes should degenerate each year (see text table above). Fish, examined with the naked-eye counting method, did not show evidence of degenerating Anisakis larvae in high numbers. Therefore, the host resistance is still the most plausible explanation for the observed characteristics of the Anisakis infestations in mackerel.

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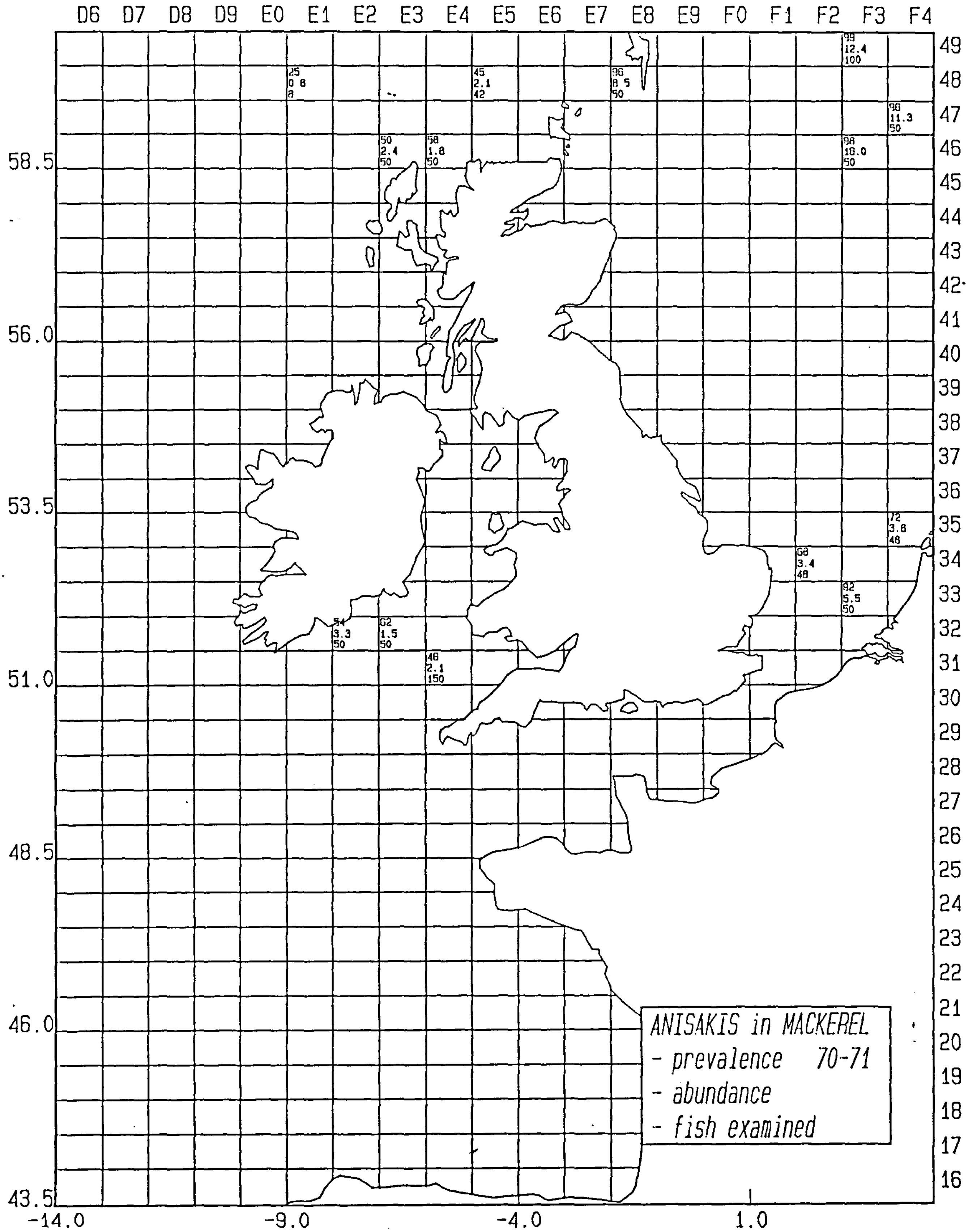

Figure 1. The prevalence (%) and abundance of Anisakis in mackerel and the number of mackerel, which were examined, by rectangle in 1970-1971.

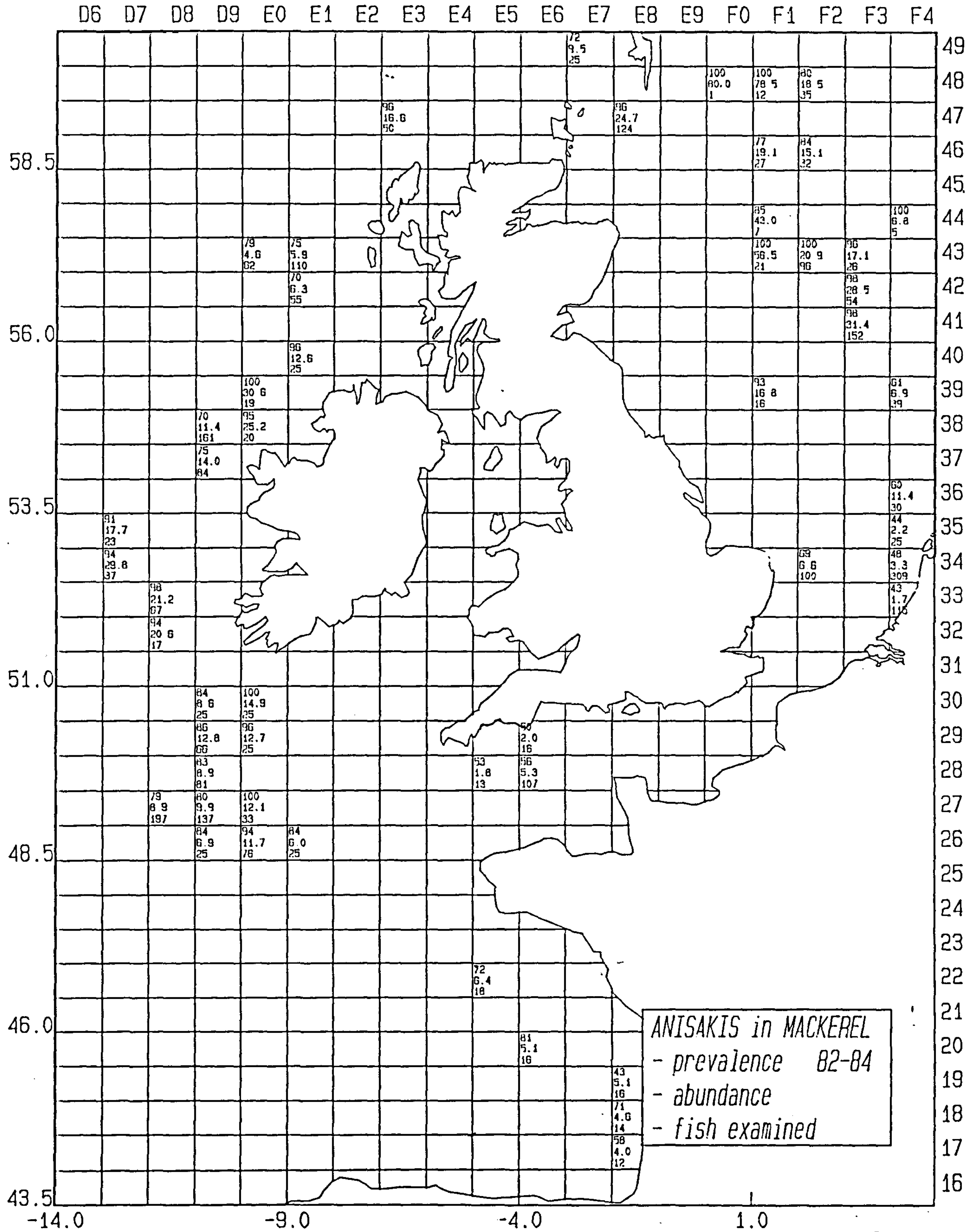

Figure 2. The prevalence (%) and abundance of Anisakis in mackerel and the number of mackerel, which were examined, by rectangle in 1982-1984.

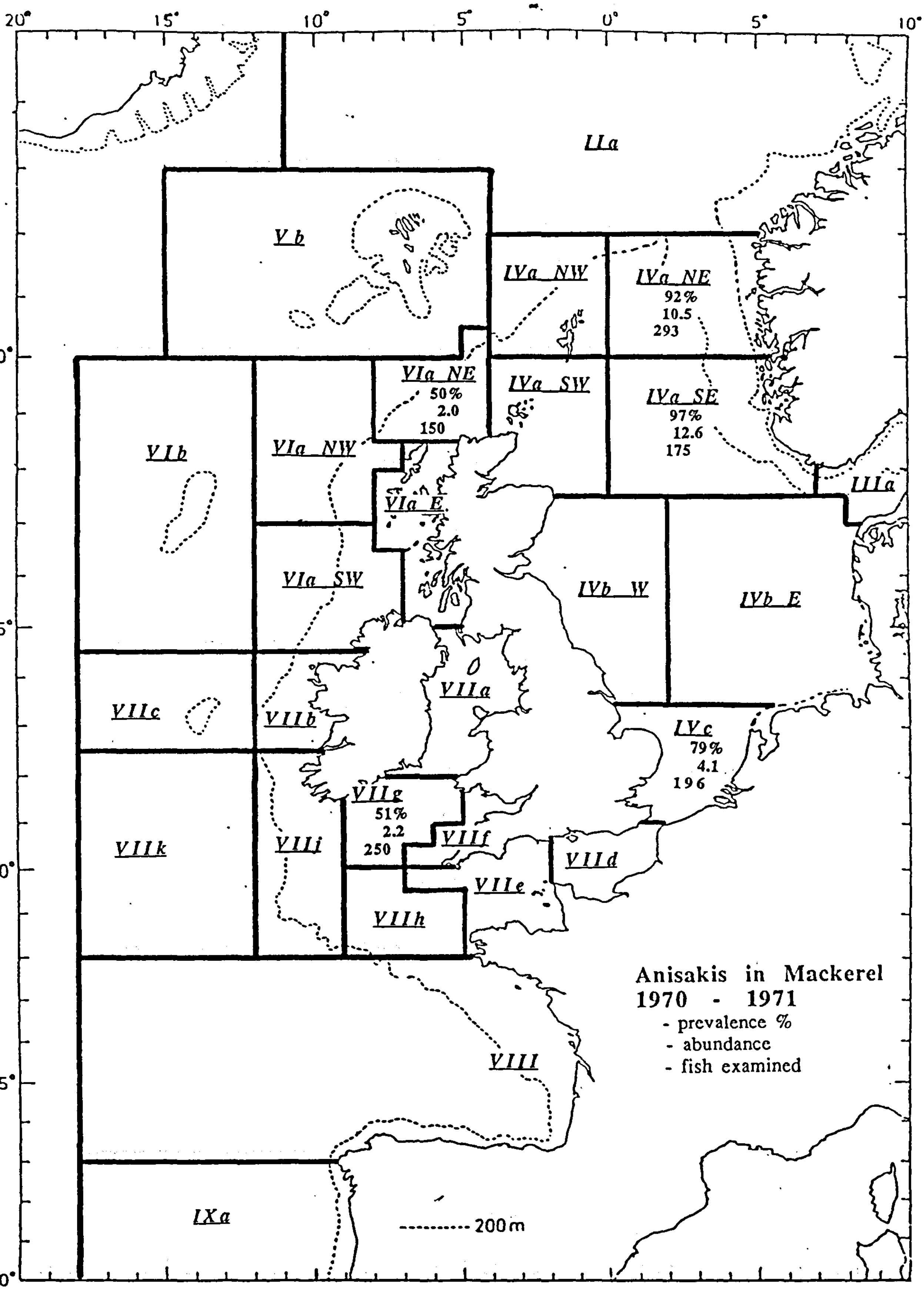

Figure 3. The prevalence (%) and abundance of Anisakis in mackerel and the number of mackerel, which were examined, by ICES Division or by Subdivision in 1970-1971.

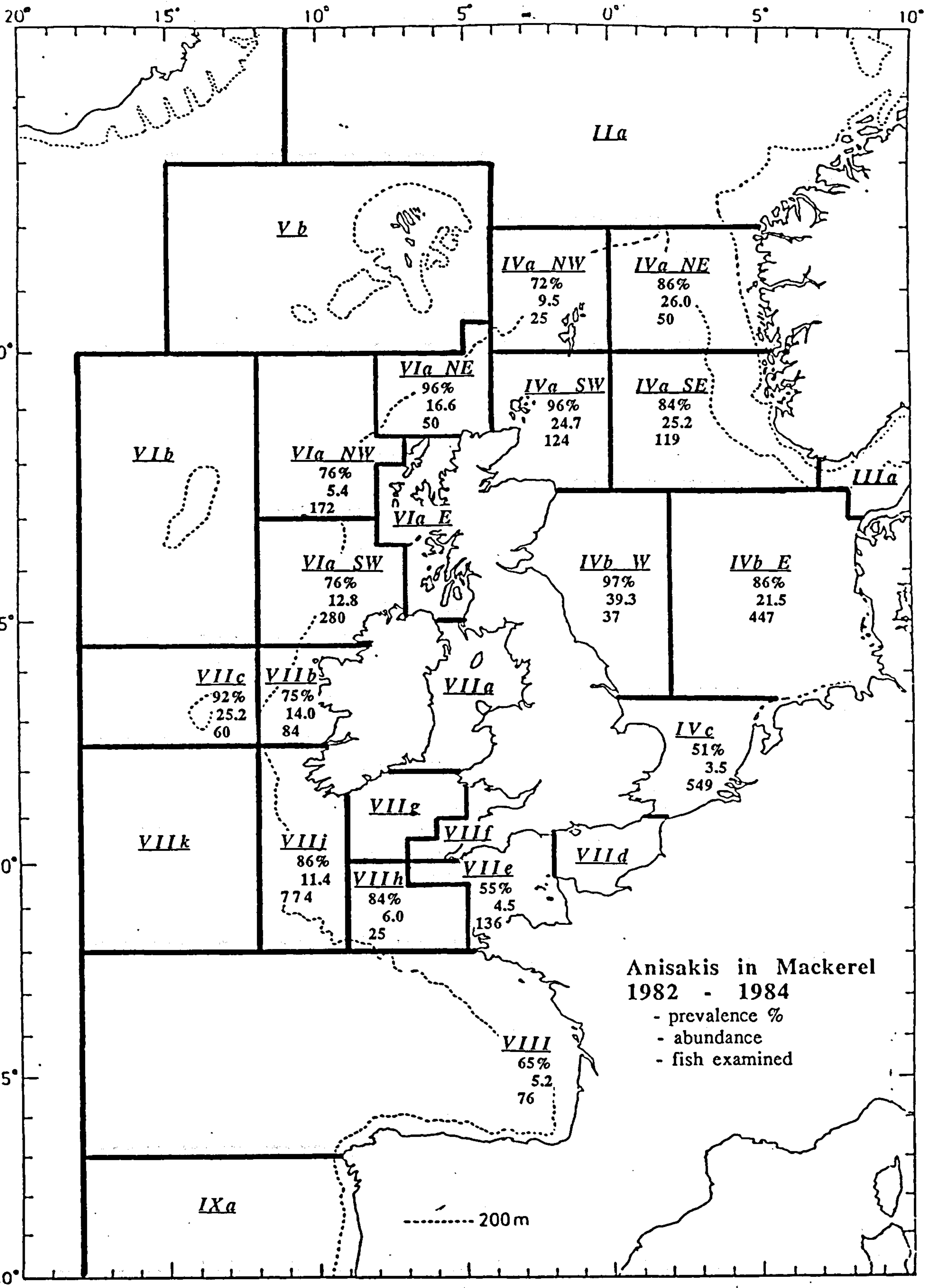

Figure 4. The prevalence (%) and abundance of Anisakis in mackerel and the number of mackerel, which were examined, by ICES Division or by Subdivision in 1982-1984.

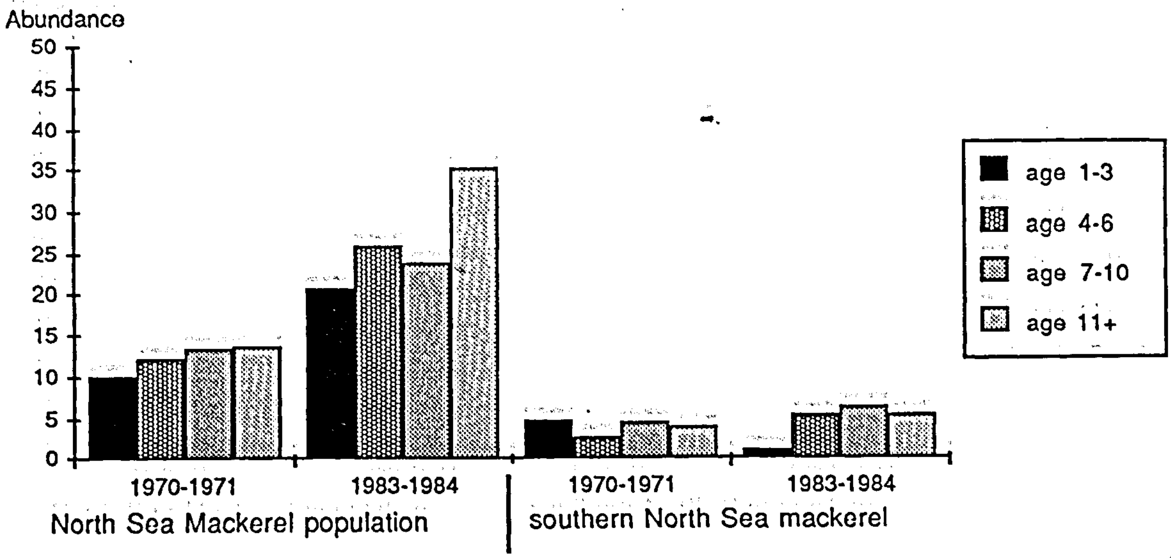

Figure 5. Abundance of Anisakis in mackerel in the North Sea Mackerel population and in the mackerel from the southern North Sea by age group in 1970-1971 and 1983-1984.

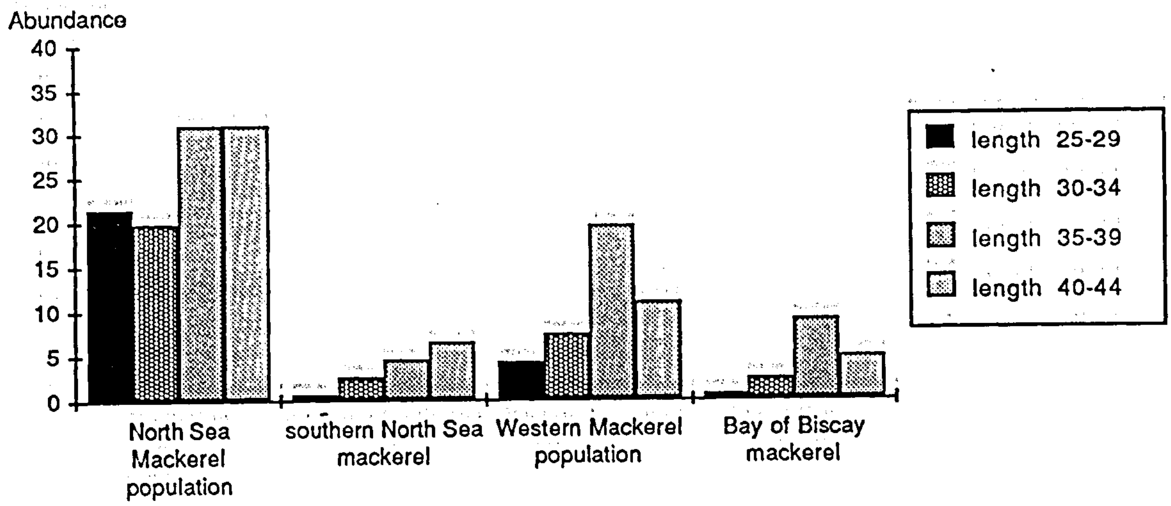

Figure 6. Abundance of Anisakis in mackerel in the North Sea and Western Mackerel population and in the mackerel from the southern North Sea and the Bay of Biscay by length group in 1982-1984.

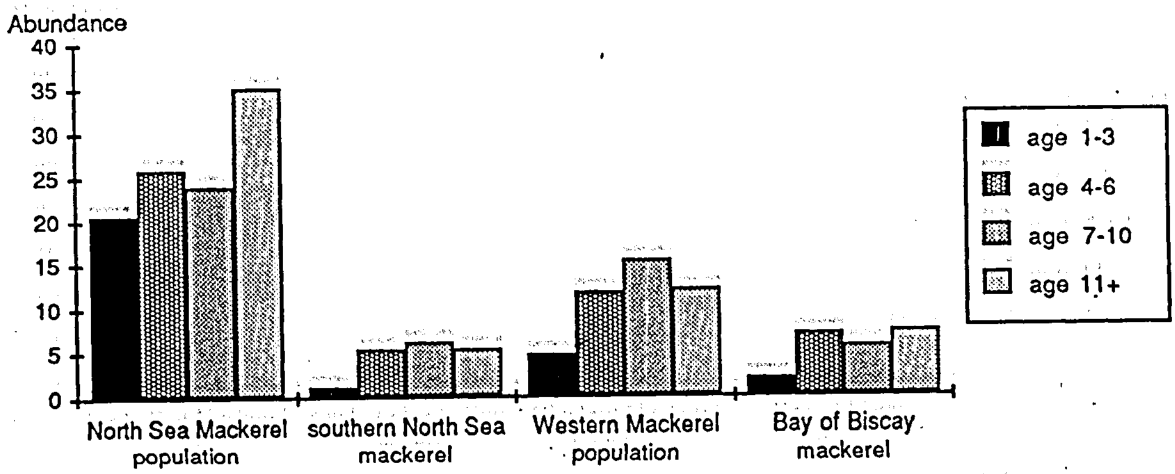

Figure 7. Abundance of Anisakis in mackerel in the North Sea and Western Mackerel population and in the mackerel from the southern North Sea and the Bay of Biscay by age group in 1983-1984.

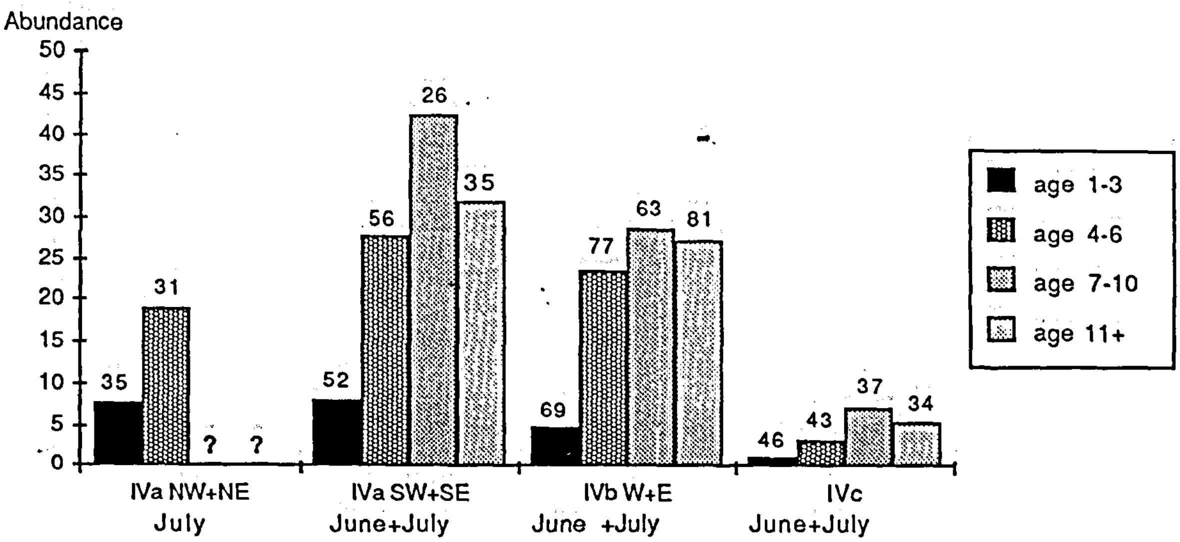

Figure 8. Abundance of Anisakis in mackerel in the North Sea by area and by age group in June and July in 1983-1984. The numbers indicate the number of mackerel examined.

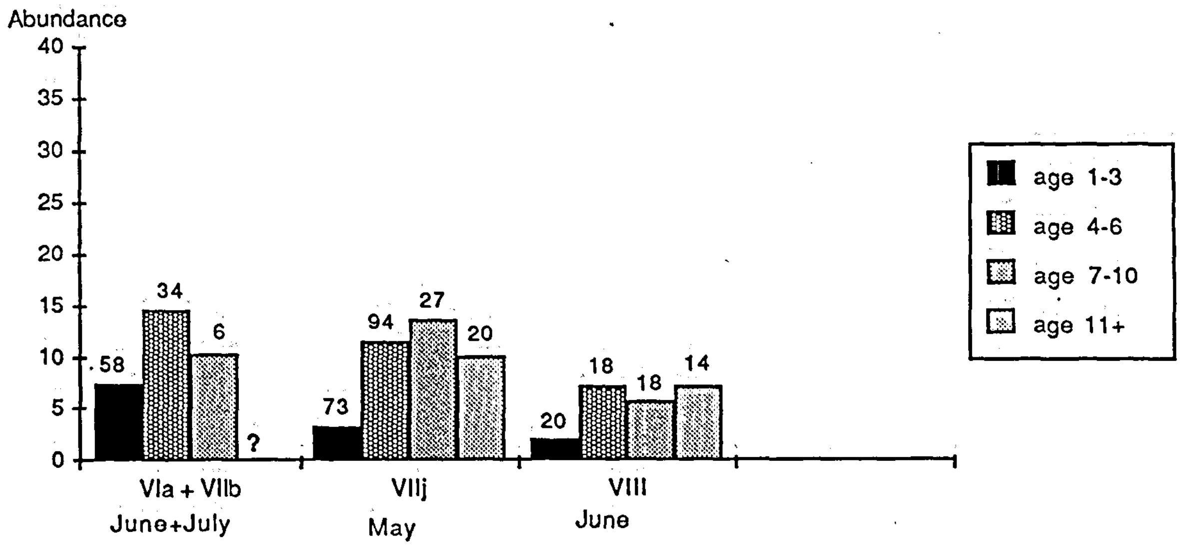

Figure 9. Abundance of Anisakis in mackerel in the western areas by area and by age group from May to July in 1983-1984. The numbers indicate the number of mackerel examined.

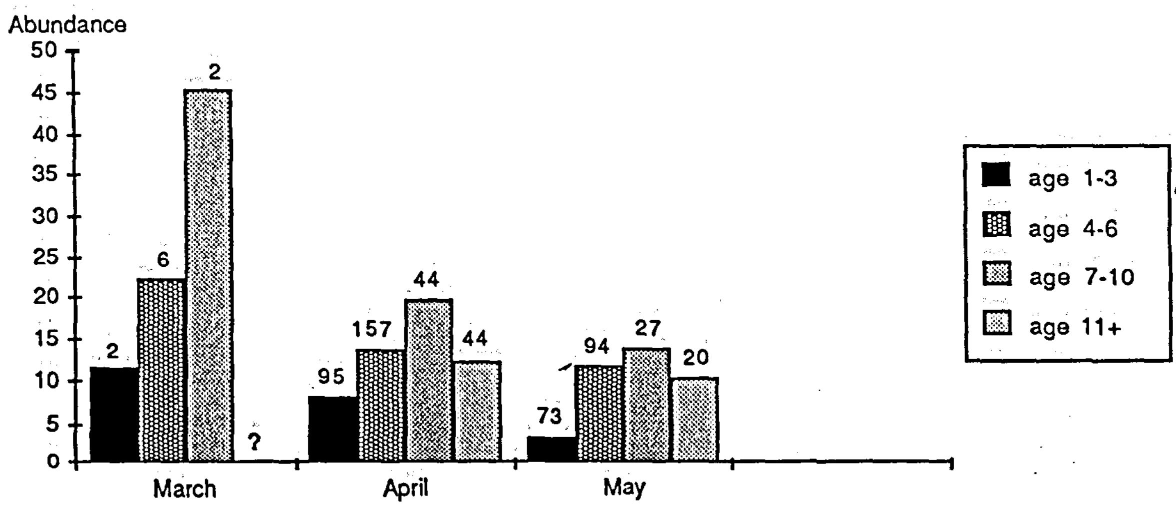

Figure 10. Abundance of Anisakis in mackerel in the mackerel spawning area Division VIIj by month and by age group from March to May in 1983-1984. The numbers indicate the number of mackerel examined.

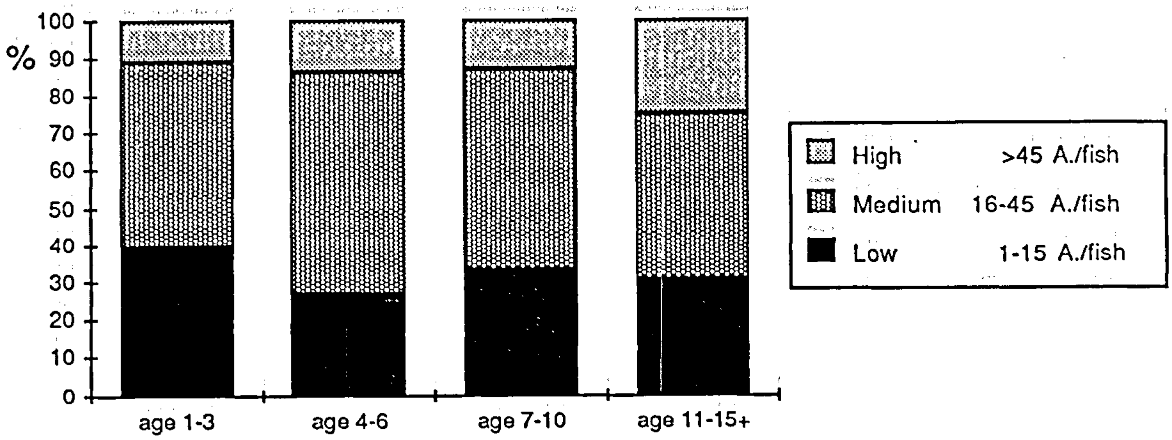

Figure 11. Cumulative percentage of mackerel having a low, medium and high Anisakis infestation in the North Sea Mackerel population by age group in 1983-1984.

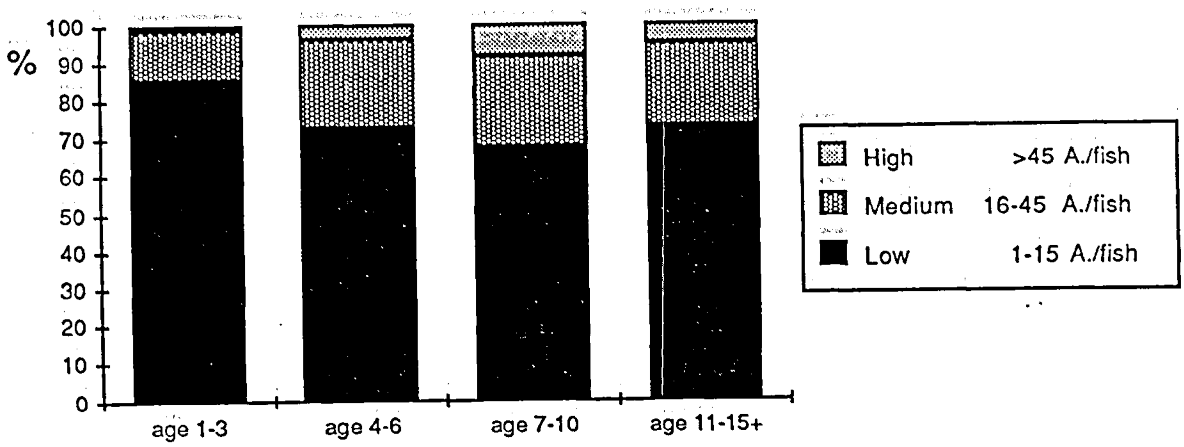

Figure 12. Cumulative percentage of mackerel having a low, medium and high Anisakis infestation in the Western Mackerel population by age group in 1983-1984.

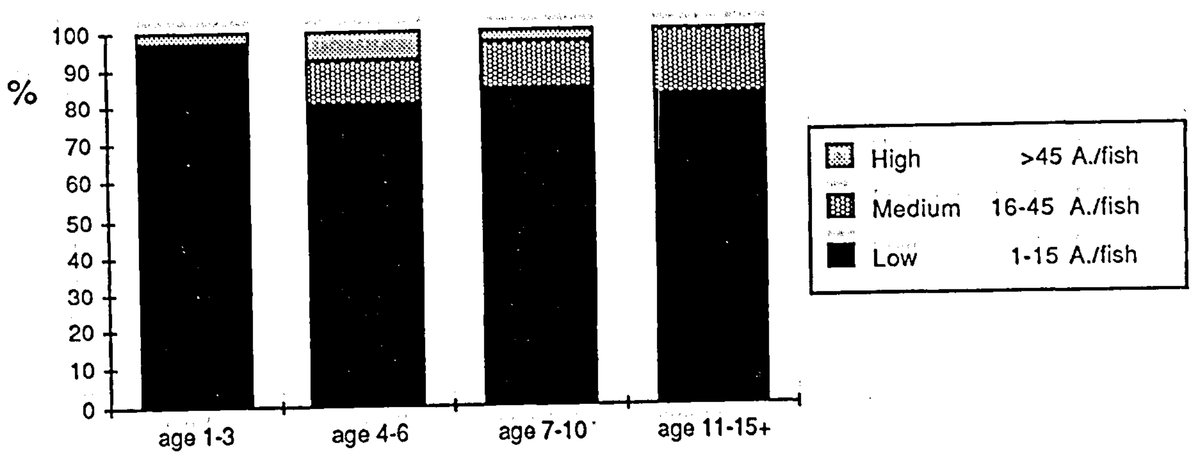

Figure 13. Cumulative percentage of mackerel having a low, medium and high Anisakis infestation in the mackerel from the southern North Sea by age group in 1983-1984.

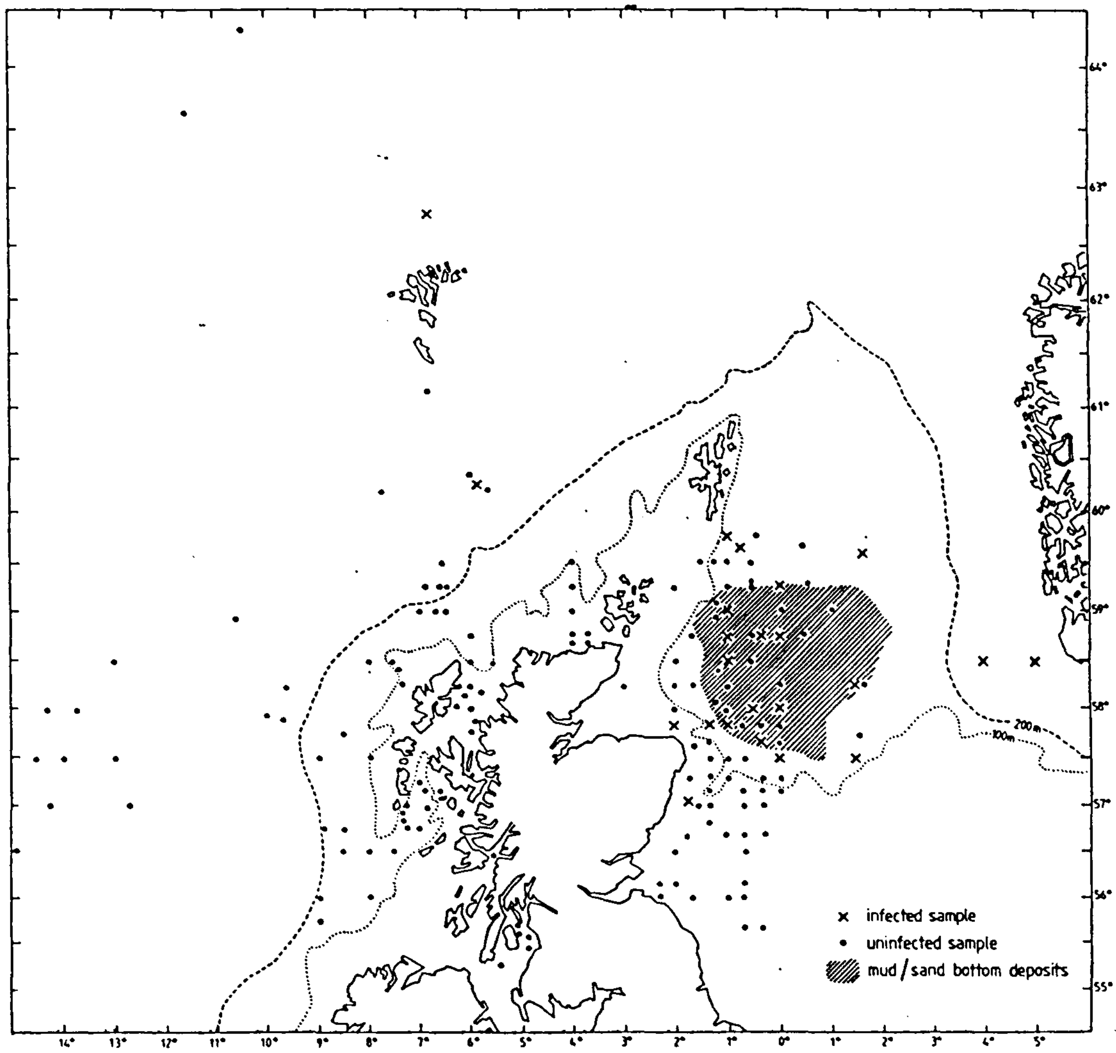

Figure 14. The distribution of euphausiid samples infected and uninfected with larval Anisakis simplex (After Smith, 1983a).

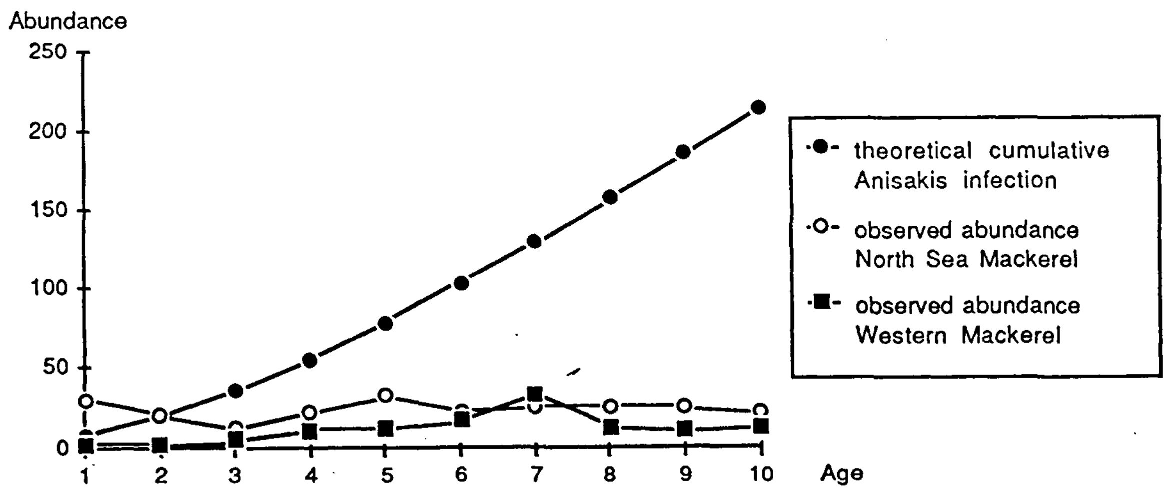

Figure 15. The theoretical cumulative Anisakis infection by age in mackerel in comparison to the abundance of Anisakis observed in the North Sea and Western Mackerel by age.

TABLE 1. The number of mackerel, which were examined for Anisakis, by year and by ICES Division or by Subdivision. Between brackets the number of mackerel of which the age was estimated.

Year	(Sub)Division	Number of mackerel examined	aged
1970	IVa NE	100	(100)
1970	IVa SE	125	(124)
1970	VIa NE	150	(150)
1970	VIIg	250	(250)
1970	Total	625	(624)
1971	IVa NE	193	(193)
1971	IVa SE	50	(50)
1971	IV c	196	(196)
1971	Total	439	(439)
1982	IVb E	39	(0)
1982	IVc	137	(0)
1982	Total	176	(0)
1983	IVb W	16	(16)
1983	IVc	60	(32)
1983	VIa NE	50	(50)
1983	VIa SW	39	(16)
1983	VIIc	60	(14)
1983	VIIe	136	(81)
1983	VIIj	152	(114)
1983	VIII	76	(70)
1983	Total	589	(393)
1984	IVa NE	50	(50)
1984	IVa NW	25	(25)
1984	IVa SE	119	(119)
1984	IVa SW	124	(50)
1984	IVb E	408	(392)
1984	IVb W	21	(21)
1984	IVc	352	(300)
1984	VIa NW	172	(25)
1984	VIa SW	241	(100)
1984	VIIb	84	(25)
1984	VIIh	25	(25)
1984	VIIj	622	(450)
1984	Total	2243	(1582)
1970-1984	TOTAL	4072	(3038)

TABLE 2. The prevalence (%), mean intensity and abundance of Anisakis in mackerel and the number of mackerel, which were examined, by year, by ICES Division or by Subdivision, by month and by rectangle. Between brackets the number of mackerel of which the age was estimated.

Year	(Sub)Division	Month	Rectangle	Number of mackerel examined	Number of mackerel aged	(%) Prevalence	Mean intensity	Abundance	Mackerel (Sub)population
1970	IVa NE	4	51F1	100	(100)	81	11.7	9.4	North Sea
1970	IVa SE	5	45F5	25	(25)	100	16.6	16.6	North Sea
1970	IVa SE	5	46F3	50	(49)	98	16.3	16.0	North Sea
1970	IVa SE	8	48E8	50	(50)	96	8.8	8.5	-
1970	VIa NE	8	46E3	50	(50)	50	4.8	2.4	Western
1970	VIa NE	8	46E4	50	(50)	58	3.2	1.8	Western
1970	VIa NE	8	48E5	50	(50)	42	4.4	1.9	Western
1970	VIIg	10	31E4	100	(100)	51	4.9	2.5	Western
1970	VIIg	11	31E4	50	(50)	38	3.2	1.2	Western
1970	VIIg	11	32E2	50	(50)	54	6.1	3.3	Western
1970	VIIg	11	32E3	50	(50)	62	2.4	1.5	Western
1971	IVa NE	4	49F3	100	(100)	9	12.6	12.4	Western
1971	IVa NE	4	50F3	50	(50)	96	10.9	10.5	North Sea
1971	IVa NE	5	50F2	43	(43)	97	8.8	8.6	North Sea
1971	IVa SE	5	47F4	50	(50)	96	11.7	11.3	North Sea
1971	IVc	4	53F2	50	(50)	82	4.7	3.8	southern North Sea
1971	IVc	5	34F2	48	(48)	68	4.9	3.4	southern North Sea
1971	IVc	5	35F3	7	(7)	71	3.8	2.7	southern North Sea
1971	IVc	5	35F4	41	(41)	73	5.4	4.0	southern North Sea
1971	IVc	10	34F3	50	(50)	92	5.9	5.5	southern North Sea
1982	IVb E	10	39F4	39	(0)	61	11.3	6.9	-
1982	IVc	10	33F4	90	(0)	45	4.4	2.0	southern North Sea
1982	IVc	10	34F4	47	(0)	38	6.2	2.4	southern North Sea
1983	IVb W	6	39F1	16	(16)	93	17.9	16.8	-
1983	IVc	4	34F4	29	(9)	55	7.1	3.9	southern North Sea
1983	IVc	5	34F4	21	(13)	61	14.6	9.0	southern North Sea
1983	IVc	6	34F4	10	(10)	70	8.9	6.2	southern North Sea
1983	VIa NE	2	47E3	50	(50)	96	17.3	16.6	-
1983	VIa SW	3	38E0	20	(8)	95	26.5	25.2	Western
1983	VIa SW	3	39E0	19	(8)	100	30.6	30.6	Western
1983	VIIc	3	34D7	37	(0)	94	31.5	29.8	Western
1983	VIIc	3	35D7	23	(14)	91	19.3	17.7	Western
1983	VIIe	1	28E6	24	(6)	54	21.9	11.9	Western
1983	VIIe	1	29E6	16	(16)	50	4.0	2.0	Western
1983	VIIe	2	28E6	83	(46)	56	5.9	3.3	Western
1983	VIIe	4	28E5	13	(13)	53	3.4	1.8	Western
1983	VIIj	3	32D8	10	(10)	100	24.8	24.8	Western
1983	VIIj	4	26E0	1	(1)	100	21.0	21.0	Western
1983	VIIj	4	27D9	12	(12)	91	6.9	6.3	Western
1983	VIIj	4	29D9	16	(16)	93	28.4	26.6	Western
1983	VIIj	4	33D8	67	(29)	98	21.5	21.2	Western
1983	VIIj	5	27D8	8	(8)	75	8.8	6.6	Western
1983	VIIj	5	27D9	17	(17)	82	10.7	8.8	Western
1983	VIIj	5	27E0	8	(8)	100	8.0	8.0	Western
1983	VIIj	5	28D9	6	(6)	100	10.8	10.8	Western
1983	VIII	6	17E8	12	(12)	58	6.9	4.0	Western
1983	VIII	6	18E8	14	(14)	71	6.5	4.6	Western
1983	VIII	6	19E8	16	(10)	43	11.7	5.1	Western
1983	VIII	6	20E6	16	(16)	81	6.2	5.1	Western
1983	VIII	6	22E5	18	(18)	72	8.9	6.4	Western

Year	(Sub)Division	Month	Rectangle	Number of mackerel examined	Number of mackerel aged	(%) Prevalence	Mean intensity	Abundance	Mackerel (Sub)population
1984	IVa NE	7	50F0	25	(25)	84	37.8	31.7	-
1984	IVa NE	7	51F0	25	(25)	88	23.0	20.3	-
1984	IVa NW	7	49E7	25	(25)	72	13.2	9.5	-
1984	IVa SE	7	44F1	7	(7)	85	50.2	43.0	-
1984	IVa SE	7	44F4	5	(5)	100	6.8	6.8	-
1984	IVa SE	7	46F1	27	(27)	77	24.5	19.1	-
1984	IVa SE	7	46F2	32	(32)	84	17.9	15.1	-
1984	IVa SE	7	48F0	1	(1)	100	80.0	80.0	-
1984	IVa SE	7	48F1	12	(12)	100	78.5	78.5	-
1984	IVa SE	7	48F2	35	(35)	80	23.1	18.5	-
1984	IVa SW	5	47E8	74	(0)	97	25.9	25.2	North Sea
1984	IVa SW	6	47E8	50	(50)	96	24.9	23.9	North Sea
1984	IVb E	5	41F3	148	(139)	98	30.5	30.0	North Sea
1984	IVb E	6	36F4	30	(25)	60	18.9	11.4	southern North Sea
1984	IVb E	6	36F5	50	(50)	38	13.2	5.0	southern North Sea
1984	IVb E	6	41F3	4	(4)	100	79.8	79.8	-
1984	IVb E	6	42F3	54	(54)	98	29.1	28.5	-
1984	IVb E	6	43F2	96	(94)	100	20.9	20.9	-
1984	IVb E	7	43F3	26	(26)	96	17.8	17.1	-
1984	IVb W	7	43F1	21	(21)	100	56.5	56.5	-
1984	IVc	4	34F4	25	(25)	36	2.3	0.8	southern North Sea
1984	IVc	5	33F4	25	(0)	36	1.6	0.6	southern North Sea
1984	IVc	5	34F2	25	(25)	84	12.6	10.6	southern North Sea
1984	IVc	5	34F4	100	(100)	48	5.9	2.8	southern North Sea
1984	IVc	6	34F2	50	(50)	76	7.3	5.5	southern North Sea
1984	IVc	6	34F4	50	(50)	60	7.2	4.3	southern North Sea
1984	IVc	6	35F4	25	(25)	44	4.9	2.2	southern North Sea
1984	IVc	7	34F4	27	(25)	37	2.4	0.9	southern North Sea
1984	IVc	8	34F2	25	(0)	40	12.1	4.8	southern North Sea
1984	VIa NW	5	43E0	62	(0)	79	5.8	4.6	Western
1984	VIa NW	5	43E1	25	(0)	80	6.6	5.3	Western
1984	VIa NW	7	43E1	35	(25)	71	11.0	7.9	Western
1984	VIa NW	8	43E1	50	(0)	76	6.5	4.9	Western
1984	VIa SW	5	38D9	133	(0)	67	16.0	10.8	Western
1984	VIa SW	6	38D9	28	(25)	82	17.4	14.3	Western
1984	VIa SW	6	40E1	25	(25)	96	13.1	12.6	Western
1984	VIa SW	6	42E1	30	(25)	76	9.4	7.2	Western
1984	VIa SW	8	42E1	25	(25)	64	8.0	5.1	Western
1984	VIIb	5	36D9	47	(0)	76	23.8	18.3	Western
1984	VIIb	6	37D9	37	(25)	72	11.9	8.7	Western
1984	VIIh	4	26E1	25	(25)	84	7.1	6.0	Western
1984	VIIj	4	26E0	75	(75)	94	12.2	11.6	Western
1984	VIIj	4	27D9	33	(25)	72	16.0	11.6	Western
1984	VIIj	4	27E0	25	(25)	100	13.4	13.4	Western
1984	VIIj	4	28D9	50	(50)	86	10.3	8.9	Western
1984	VIIj	4	29D9	25	(25)	88	8.5	7.5	Western
1984	VIIj	4	29E0	25	(25)	96	13.2	12.7	Western
1984	VIIj	4	30D9	25	(25)	84	10.3	8.6	Western
1984	VIIj	4	30E0	25	(25)	100	14.9	14.9	Western
1984	VIIj	5	26D9	25	(25)	84	8.2	6.9	Western
1984	VIIj	5	27D8	189	(25)	79	11.2	9.0	Western
1984	VIIj	5	27D9	75	(75)	81	12.1	9.9	Western
1984	VIIj	5	29D9	25	(25)	80	11.7	9.3	Western

TABLE 3. The total number of mackerel examined for Anisakis, the number uninfested and infested fish, the prevalence, the mean intensity, abundance and the degree of infestation in the infected fish (%) by area for two time periods 1970-1971 and 1982-1984.

								Degree of infestation (%)		
Period	Area	Total number examined	Number uninfested	Number infested	% Prevalence	Mean intensity	Abundance	1-15 A LOW	16-45 A MEDIUM	>46 Anisakis HIGH
1970-1971	IVa NE	293	23	270	92	11.4	10.5	74	24	2
1970-1971	IVa SE	175	5	170	97	13.0	12.6	71	28	2
1970-1971	IVc	196	41	155	79	5.2	4.1	96	4	1
1970-1971	VIa NE	150	75	75	50	4.1	2.0	96	4	0
1970-1971	VIIg	250	122	128	51	4.3	2.2	95	5	0
1982-1984	IVa NE	50	7	43	86	30.2	26.0	61	26	14
1982-1984	IVa NW	25	7	18	72	13.2	9.5	72	22	6
1982-1984	IVa SE	119	19	100	84	30.0	25.2	48	26	26
1982-1984	IVa SW	124	4	120	97	25.5	24.7	43	44	13
1982-1984	IVb E	447	62	385	86	25.0	21.5	49	37	14
1982-1984	IVb W	37	1	36	97	40.4	39.3	22	56	22
1982-1984	IVc	549	268	281	51	6.9	3.5	87	10	2
1982-1984	VIa NE	50	2	48	96	17.3	16.6	73	21	6
1982-1984	VIa NW	172	40	132	77	7.1	5.4	89	11	1
1982-1984	VIa SW	280	66	214	76	16.8	12.8	72	18	10
1982-1984	VIIb	84	21	63	75	18.7	14.0	70	21	10
1982-1984	VIIc	60	4	56	93	27.0	25.2	50	32	18
1982-1984	VIIe	136	61	75	55	8.2	4.5	88	9	3
1982-1984	VIIh	25	4	21	84	7.1	6.0	91	10	0
1982-1984	VIIj	774	104	670	87	13.1	11.4	75	21	5
1982-1984	VIII	76	26	50	66	7.8	5.2	82	18	0

TABLE 4. The total number of mackerel examined for Anisakis, the number uninfested and infested fish, the prevalence, the mean intensity, abundance and the degree of infestation in the infected fish (%) by area and by length class for two time periods 1970-1971 and 1982-1984. The months in which the mackerel samples were collected are listed below the name of the Division or Subdivision.

Period	Area & month	Length classes	Total number examined	Number uninfested	Number infested	% Prevalence	Mean intensity	Abundance	Degree of infestation (%) 1-15 A LOW	16-45 A MEDIUM	>46 Anisakis HIGH
1970-1971	IVa NE	25-29	50	2	48	96	11.1	10.6	75	23	2
	4+5	30-34	93	14	79	85	9.7	8.2	80	19	1
		35-39	125	7	118	94	12.6	11.9	70	27	3
		40-44	25	0	25	100	12.1	12.1	76	24	0
1970-1971	IVa SE	25-29	11	0	11	100	9.4	9.4	82	18	0
	5+8	30-34	52	3	49	94	9.3	8.8	78	22	0
		35-39	82	2	80	98	15.4	15.0	65	33	3
		40-44	30	0	30	100	13.7	13.7	70	27	3
1970-1971	IVc	20-24	2	0	2	100	4.0	4.0			
	4+5+10	25-29	106	13	93	88	5.5	4.8	97	2	1
		30-34	25	9	16	64	2.2	1.4	100	0	0
		35-39	47	14	33	70	6.1	4.3	91	9	0
		40-44	16	5	11	69	5.0	3.4	91	9	0
1970-1971	VIa NE	25-29	1	0	1	100	25.0	25.0			
	8	30-34	138	75	63	46	3.2	1.5	97	3	0
		35-39	10	0	10	100	6.9	6.9	100	0	0
		40-44	1	0	1	100	9.0	9.0			
1970-1971	VIIg	25-29	30	19	11	37	4.5	1.7	91	9	0
	10+11	30-34	150	87	63	42	3.2	1.3	98	2	0
		35-39	62	15	47	76	5.6	4.3	94	6	0
		40-44	8	1	7	88	5.1	4.5	86	14	0
1982-1984	IVa NE	30-34	37	7	30	81	15.1	12.3	73	23	3
	7	35-39	11	0	11	100	70.4	70.4	27	36	36
		40-44	2	0	2	100	36.0	36.0			
1982-1984	IVa NW	25-29	1	0	1	100	5.0	5.0			
	7	30-34	16	7	9	56	7.6	4.3	89	11	0
		35-39	8	0	8	100	20.6	20.6	50	38	12
1982-1984	IVa SE	30-34	64	18	46	72	13.3	9.6	76	13	11
	7	35-39	34	0	34	100	51.2	51.2	15	35	50
		40-44	19	1	18	95	32.9	31.2	39	39	22
		45-49	2	0	2	100	28.0	28.0			
1982-1984	IVa SW	20-24	2	0	2	100	6.5	6.5			
	6	25-29	2	0	2	100	20.0	20.0			
		30-34	34	0	34	100	24.4	24.4	41	44	15
		35-39	39	2	37	95	28.6	27.1	38	51	11
		40-44	39	1	38	97	26.2	25.6	42	40	18
		45-49	8	1	7	88	17.0	14.9	57	43	0
1982-1984	IVb E	20-24	13	0	13	100	33.6	33.6	8	69	23
	5+6+7	25-29	18	4	14	78	20.9	16.3	43	50	7
		30-34	111	29	82	74	13.4	9.9	71	26	4
		35-39	130	23	107	82	26.0	21.4	51	34	15
		40-44	153	5	148	97	29.5	28.5	43	39	19
		45-49	22	1	21	96	31.0	29.6	29	62	10
1982-1984	IVb W	30-34	1	0	1	100	3.0	3.0			
	6+7	35-39	27	1	26	96	49.9	48.0	12	58	31
		40-44	8	0	8	100	16.3	16.3	50	50	0
		45-49	1	0	1	100	25.0	25.0			
1982-1984	IVc	25-29	24	17	7	29	2.4	.7	100	0	0
	4+5+6+7	30-34	213	124	89	42	5.4	2.3	93	5	2
		35-39	187	91	96	51	6.0	3.1	88	10	2
		40-44	103	26	77	75	8.7	6.5	83	16	1
		45-49	22	10	12	55	15.4	8.4	75	17	8
1982-1984	VIa NE	25-29	10	0	10	100	7.7	7.7	90	10	0
	2	30-34	25	1	24	96	12.4	11.9	79	17	4
		35-39	10	1	9	90	19.4	17.5	44	56	0
		40-44	5	0	5	100	56.0	56.0	60	0	40
1982-1984	VIa NW	25-29	1	0	1	100	4.0	4.0			
	7	30-34	131	38	93	71	5.3	3.7	95	5	0
		35-39	29	1	28	97	14.4	13.9	64	32	4
		40-44	11	1	10	91	4.0	3.6	100	0	0
1982-1984	VIa SW	25-29	4	1	3	75	3.0	2.3			
	3+6+8	30-34	203	62	141	70	9.7	6.7	84	14	3
		35-39	59	1	58	98	31.2	30.7	48	26	26
		40-44	14	2	12	86	33.3	28.5	50	33	17
1982-1984	VIIb	30-34	46	19	27	59	11.0	6.5	74	26	0
	6	35-39	20	1	19	95	33.9	32.2	58	21	21
		40-44	17	0	17	100	14.1	14.1	77	12	12
		45-49	1	1	0	0					
1982-1984	VIIc	25-29	3	1	2	67	7.5	5.0			
	3	30-34	25	1	24	96	15.4	14.8	54	46	0
		35-39	21	1	20	95	44.1	42.0	35	25	40
		40-44	10	1	9	90	27.1	24.4	56	22	22
		45-49	1	0	1	100	1.0	1.0			
1982-1984	VIIe	25-29	75	38	37	49	10.0	4.9	89	8	3
	1+2+4	30-34	55	21	34	62	6.9	4.3	85	12	3
		35-39	6	2	4	67	3.3	2.2			
1982-1984	VIIh	25-29	1	0	1	100	2.0	2.0			
	4	30-34	16	2	14	88	5.1	4.5	100	0	0
		35-39	7	1	6	86	12.5	10.7	67	33	0
		40-44	1	1	0	0					
1982-1984	VIIj	25-29	17	6	11	65	3.5	2.2	100	0	0
	3+4+5	30-34	393	79	314	80	11.8	9.4	77	19	3
		35-39	244	8	236	97	16.8	16.2	66	26	8
		40-44	118	11	107	91	10.1	9.1	84	14	2
		45-49	2	0	2	100	9.0	9.0			
1982-1984	VIII	20-24	10	6	4	40	7.8	3.1			
	6	25-29	2	1	1	50	1.0	.5			
		30-34	19	11	8	42	5.6	2.4	88	13	0
		35-39	25	4	21	84	10.6	8.9	76	24	0
		40-44	19	3	16	84	5.8	4.9	88	13	0
		45-49	1	1	0	0					

TABLE 5. The total number of mackerel examined for Anisakis, the number uninfested and infested fish, the prevalence, the mean intensity, abundance and the degree of infestation in the infected fish (%) by area and by age groups for two time periods 1970-1971 and 1983-1984. The months in which the mackerel samples were collected are listed below the name of the Division or Subdivision.

Period	Area & month	Age	Total number examined	Number uninfested	Number infested	% Prevalence	Mean intensity	Abundance	Degree of infestation (%) 1-15 A LOW	16-45 A MEDIUM	>46 Anisakis HIGH
1970-1971	IVa NE	1-3	147	12	135	92	10.9	10.0	76	23	2
	4+5	4-6	115	9	106	92	11.5	10.6	75	24	2
		7-10	14	1	13	93	12.6	11.7	69	31	0
		11+	17	1	16	94	13.9	13.1	63	31	6
1970-1971	IVa SE	1-3	48	3	45	94	10.2	9.6	78	22	2
	5+8	4-6	70	1	69	99	14.3	14.1	68	30	1
		7-10	34	1	33	97	12.6	12.2	67	30	3
		11+	22	0	22	100	13.3	13.3	73	27	0
1970-1971	IVc	1-3	116	15	101	87	5.3	4.6	97	2	1
	4+5+10	4-6	35	13	22	63	4.2	2.7	96	5	0
		7-10	23	8	15	65	6.6	4.3	87	13	0
		11+	22	5	17	77	4.9	3.8	94	6	0
1970-1971	VIa NE	1-3	99	54	45	46	3.1	1.4	98	2	0
	8	4-6	43	21	22	51	4.8	2.5	96	5	0
		7-10	8	0	8	100	7.6	7.6	88	13	0
1970-1971	VIIg	1-3	118	74	44	37	3.7	1.4	96	5	0
	10+11	4-6	89	37	52	58	4.5	2.6	98	2	0
		7-10	41	11	30	73	5.0	3.6	90	10	0
		11+	2	0	2	100	1.5	1.5			
1983-1984	IVa NE	1-3	24	6	18	75	13.8	10.3	83	11	6
	7	4-6	20	1	19	95	25.9	24.6	47	42	11
		7-10	3	0	3	100	171.3	171.3			
		11+	3	0	3	100	15.3	15.3			
1983-1984	IVa NW	1-3	11	5	6	55	4.0	2.2	100	0	0
	7	4-6	11	2	9	82	10.7	8.7	67	33	0
		7-10	2	0	2	100	53.0	53.0			
		11+	1	0	1	100	12.0	12.0			
1983-1984	IVa SE	1-3	40	15	25	63	9.7	6.1	80	12	8
	7	4-6	43	3	40	93	27.8	25.9	50	28	23
		7-10	16	0	16	100	57.3	57.3	0	38	63
		11+	20	1	19	95	38.4	36.5	42	32	26
1983-1984	IVa SW	1-3	12	1	11	92	15.5	14.2	46	55	0
	6	4-6	13	0	13	100	33.8	33.8	23	54	23
		7-10	10	1	9	90	21.2	19.1	22	78	0
		11+	15	0	15	100	26.1	26.1	53	27	20
1983-1984	IVb E	1-3	101	25	76	75	14.1	10.6	67	26	7
	5+6+7	4-6	101	9	92	91	24.7	22.5	45	44	12
		7-10	72	8	64	89	30.0	26.7	44	36	20
		11+	118	4	114	97	30.8	29.8	38	46	17
1983-1984	IVb W	1-3	1	0	1	100	29.0	29.0			
	6+7	4-6	8	0	8	100	35.1	35.1	25	50	25
		7-10	12	1	11	92	40.9	37.5	9	73	18
		11+	16	0	16	100	43.4	43.4	31	44	25
1983-1984	IVc	1-3	84	59	25	30	2.5	.7	100	0	0
	4+5+6+7	4-6	93	41	52	56	8.4	4.7	85	10	6
		7-10	79	24	55	70	7.9	5.5	87	11	2
		11+	76	21	55	72	7.2	5.2	84	16	0
1983-1984	VIa NE	1-3	24	1	23	96	8.2	7.9	87	13	0
	2	4-6	16	1	15	94	18.5	17.4	60	33	7
		7-10	6	0	6	100	49.2	49.2	50	33	17
		11+	4	0	4	100	17.0	17.0			
1983-1984	VIa NW	1-3	9	5	4	44	8.8	3.9			
	7	4-6	11	3	8	73	7.5	5.5	88	13	0
		7-10	4	0	4	100	12.5	12.5			
		11+	1	0	1	100	8.0	8.0			
1983-1984	VIa SW	1-3	54	14	40	74	9.5	7.1	88	8	5
	3+6+8	4-6	52	7	45	87	13.8	11.9	78	18	4
		7-10	8	0	8	100	15.1	15.1	63	25	13
		11+	2	0	2	100	61.5	61.5			
1983-1984	VIIb	1-3	17	8	9	53	7.0	3.7	89	11	0
	6	4-6	5	2	3	60	22.3	13.4			
		7-10	2	0	2	100	13.5	13.5			
		11+	1	0	1	100	1.0	1.0			
1983-1984	VIIc	1-3	4	1	3	75	6.7	5.0			
	3	4-6	6	0	6	100	16.7	16.7	50	50	0
		7-10	3	0	3	100	36.3	36.3			
		11+	1	0	1	100	32.0	32.0			
1983-1984	VIIe	1-3	63	34	29	46	3.3	1.5	97	3	0
	1+2+4	4-6	15	8	7	47	1.6	.7	100	0	0
		7-10	3	0	3	100	7.3	7.3			
1983-1984	VIIh	1-3	11	1	10	91	5.8	5.3	90	10	0
	4	4-6	12	2	10	83	9.0	7.5	90	10	0
		7-10	2	1	1	50	1.0	.5			
1983-1984	VIIj	1-3	170	39	131	77	7.7	6.0	81	19	0
	3+4+5	4-6	257	22	235	91	14.4	13.2	72	24	4
		7-10	73	2	71	97	18.6	18.1	66	25	9
		11+	64	5	59	92	12.6	11.6	75	22	3
1983-1984	VIII	1-3	20	12	8	40	5.3	2.1	88	13	0
	6	4-6	18	4	14	78	9.1	7.1	71	29	0
		7-10	18	5	13	72	7.9	5.7	92	8	0
		11+	14	1	13	93	7.8	7.2	85	15	0

TABLE 6. The total number of mackerel examined for Anisakis, the number uninfested and infested fish, the prevalence, the mean intensity, abundance and the degree of infestation in the infected fish (%) for the Western Mackerel, the North Sea Mackerel and the mackerel from the southern North Sea and by length class for two time periods 1970-1971 and 1982-1984.

Population and Period	Length class	Total number examined	Number uninfested	Number infested	% Prevalence	Mean intensity	Abundance	Degree of infestation (%) 1-15 A LOW	16-45 A MEDIUM	>46 Anisakis HIGH
North Sea Mackerel 1970-1971	25-29	61	2	59	97	10.8	10.4	76	22	2
	30-34	111	15	96	87	10.0	8.6	78	21	1
	35-39	195	9	186	95	13.9	13.3	67	30	3
	40-44	51	0	51	100	13.4	13.4	73	26	2
	25-44	418	26	392	94	12.4	11.6	72	26	2
North Sea Mackerel 1982-1984	20-24	15	0	15	100	30.0	30.0	20	60	20
	25-29	15	1	14	93	23.1	21.5	36	57	7
	30-34	63	0	63	100	20.0	20.0	48	44	8
	35-39	61	2	59	97	32.0	31.0	31	53	17
	40-44	102	1	101	99	31.4	31.1	33	45	23
	45-49	16	2	14	88	29.0	25.4	43	50	7
	20-49	272	6	266	98	28.2	27.6	36	48	16
Western Mackerel 1970-1971	25-29	31	19	12	39	6.3	2.4	83	17	0
	30-34	288	162	126	44	3.2	1.4	98	2	0
	35-39	72	15	57	79	5.8	4.6	95	5	0
	40-44	9	1	8	89	5.6	5.0	88	13	0
	25-44	400	197	203	51	4.2	2.1	96	4	0
Western Mackerel 1982-1984	20-24	10	6	4	40	7.8	3.1			
	25-29	103	47	56	54	7.8	4.3	93	5	2
	30-34	888	233	655	74	10.0	7.4	81	17	2
	35-39	411	19	392	95	20.4	19.5	62	26	12
	40-44	190	19	171	90	12.2	11.0	81	15	5
	45-49	5	2	3	60	6.3	3.8			
	20-49	1607	326	1281	80	13.4	10.7	76	19	6
Southern North Sea Mackerel 1970-1971	20-24	2	0	2	100	4.0	4.0			
	25-29	106	13	93	88	5.5	4.8	97	2	1
	30-34	25	9	16	64	2.2	1.4	100	0	0
	35-39	47	14	33	70	6.1	4.3	91	9	0
	40-44	16	5	11	69	5.0	3.4	91	9	0
	20-44	196	41	155	79	5.2	4.1	96	4	1
Southern North Sea Mackerel 1982-1984	25-29	28	20	8	29	2.3	.6	100	0	0
	30-34	250	148	102	41	6.2	2.5	91	6	3
	35-39	213	103	110	52	8.5	4.4	85	11	5
	40-44	116	30	86	74	8.8	6.5	83	16	1
	45-49	22	10	12	55	15.4	8.4	75	17	8
	25-49	629	311	318	51	7.9	4.0	86	11	3

TABLE 7. The total number of mackerel examined for Anisakis, the number uninfested and infested fish, the prevalence, the mean intensity, abundance and the degree of infestation in the infected fish (%) for the Western Mackerel, the North Sea Mackerel and the mackerel from the southern North Sea and by age groups for two time periods 1970-1971 and 1983-1984.

Population and Period	Age	Total number examined	Number uninfested	Number infested	% Prevalence	Mean intensity	Abundance	Degree of infestation (%)		
								1-15 A LOW	16-45 A MEDIUM	>46 Anisakis HIGH
North Sea Mackerel 1970-1971	1-3	176	13	163	93	10.9	10.1	76	23	1
	4-6	173	10	163	94	13.0	12.2	71	28	2
	7-10	31	2	29	94	14.2	13.3	66	31	3
	11+	37	1	36	97	14.0	13.6	67	31	3
	1-11+	417	26	391	94	12.3	11.5	72	26	2
North Sea Mackerel 1983-1984	1-3	45	1	44	98	21.3	20.8	41	50	9
	4-6	45	1	44	98	26.5	25.9	27	59	14
	7-10	31	1	30	97	24.8	24.0	33	53	13
	11+	68	1	67	99	35.7	35.2	31	45	24
	1-11+	189	4	185	98	28.3	27.7	33	51	16
Western Mackerel 1970-1971	1-3	217	128	89	41	3.4	1.4	97	3	0
	4-6	132	58	74	56	4.6	2.6	97	3	0
	7-10	49	11	38	78	5.5	4.3	90	11	0
	11+	2	0	2	100	1.5	1.5			
	1-11+	400	197	203	51	4.2	2.1	96	4	0
Western Mackerel 1983-1984	1-3	348	114	234	67	7.3	4.9	86	14	1
	4-6	376	48	328	87	13.6	11.9	73	23	4
	7-10	113	8	105	93	16.7	15.5	68	24	9
	11+	83	6	77	93	13.1	12.1	74	22	4
	1-11+	920	176	744	81	12.0	9.7	76	20	4
Southern North Sea Mackerel 1970-1971	1-3	116	15	101	87	5.3	4.6	97	2	1
	4-6	35	13	22	63	4.2	2.7	96	5	0
	7-10	23	8	15	65	6.6	4.3	87	13	0
	11+	22	5	17	77	4.9	3.8	94	6	0
	1-11+	196	41	155	79	5.2	4.1	96	4	1
Southern North Sea Mackerel 1983-1984	1-3	116	83	33	28	4.1	1.2	97	0	3
	4-6	109	48	61	56	9.5	5.3	82	12	7
	7-10	95	32	63	66	9.3	6.2	84	13	3
	11+	87	24	63	72	7.5	5.4	83	18	0
	1-11+	407	187	220	54	8.0	4.3	85	12	3

TABLE 8. The total number of mackerel examined for Anisakis, the number uninfested and infested fish, the prevalence, the mean intensity, abundance and the degree of infestation in the infected fish (%) for the Western Mackerel, the North Sea Mackerel and the mackerel from the southern North Sea by sex and sexes combined in 1982-1984.

Population and Period	Sex	Total number examined	Number uninfested	Number infested	% Prevalence	Mean intensity	Abundance	Degree of infestation (%) 1-15 A LOW	16-45 A MEDIUM	>46 Anisakis HIGH
North Sea	Females	151	4	147	97	28.7	28.0	37	46	17
Mackerel	Males	118	2	116	98	27.9	27.5	34	51	16
1983-1984	Both	269	6	263	98	28.4	27.7	35	48	16
Western	Females	743	156	587	79	11.8	9.3	79	16	5
Mackerel	Males	654	132	522	80	12.4	9.9	77	19	4
1983-1984	Both	1397	288	1109	79	12.1	9.6	78	18	4
Southern North	Females	228	109	119	52	7.5	3.9	87	10	3
Sea Mackerel	Males	204	93	111	54	8.9	4.9	83	14	4
1983-1984	Both	432	202	230	53	8.2	4.4	85	·12	4

TABLE 9. The average condition factor of the Western Mackerel, North Sea Mackerel and the southern North Sea Mackerel in relation to the degree of Anisakis infestation in 1983 - 1984.

Degree of Anisakis infestation per mackerel		Western Mackerel Condition factor	Number of fish	North Sea Mackerel Condition factor	Number of fish	Southern NS Mackerel Condition factor	Number of fish
-	0 Anisakis	695	176	828	4	713	187
LOW	1 - 15 Anisakis	715	569	627	62	755	187
MEDIUM	16 - 45 Anisakis	721	149	617	99	800	26
HIGH	> 45 Anisakis	726	27	752	33	739	7