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# Infestation of Parasites in Greenland Halibut in the Northwest Atlantic

by

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ABSTRACT.

As part of a stock identification study of Greenland halibut, the parasite fauna of Greenland halibut were analysed from six areas in the Northwest Atlantic in order to elucidate differences in parasite burden. Of the species found, three species of digeneans (*Brachyphallus crenatus, Steganoderma formosum* and *Stenakron vetustum*) and five species of nematodes (*Anisakis simplex. Ascarophis* sp., *Contracaecum* sp., *Hysterothylacium aduncum* and *Pseudoterranova decipiens*) show irregularities in distribution pattern. The prevalence of these species indicate that in most cases the southern fiords of West Greenland (Div. 1D,1F) were similar. However, there were some similarities between these samples and those from the Denmark Strait (ICES Subarea XIV). The sample from Newfoundland (Div. 3K) has a unique parasite fauna, but there seems to a cline from this sample to the Davis Strait (Div. 1C) and further onto the Denmark Strait.

## 1. INTRODUCTION.

### 1.1 Previous studies on Greenland halibut.

Greenland halibut (*Reinhardtius hippoglossoides* (Walbaum)) is widely distributed in the Northwest Atlantic. Spawning is supposed to take place in the deeper waters of the Davis Strait south of 67° N (Jensen, 1935 and Smidt, 1969). From there the larvae are dispersed by the currents to the west coast of Greenland as well as to the eastern Canadian coast (Templeman, 1973). While growing up, Greenland halibut in West Greenland are supposed to migrate either to the deeper parts of the fiords or to the deeper part of the Davis Strait (Riget and Boje, 1989b). Greenland halibut at the coasts of Newfoundland and Labrador are assumed to migrate towards the deep part of the Davis Strait (Bowering, 1984). When reaching maturity Greenland halibut in the Davis Strait area migrate to the spawning areas in the Davis Strait while Greenland halibut in the West Greenland fiords are assumed to stay in the fiords and to some extent spawn there (Riget and Boje 1989b).

In the East Greenland/Iceland area, spawning seems to occur on the continental slopes west of Iceland. Eggs and larvae are supposed to be carried either north-eastward along the northern Icelandic coast or more likely first north-westward and later south-westward towards East Greenland by the Irminger Current (Sigurdsson, 1980). Fish growing up in areas off Iceland are assumed to migrate to the spawning area when reaching maturity.

Several studies on stock identification of Greenland halibut in the Northwest Atlantic have been carried out. Templeman (1970), Misra & Bowering (1984) and Riget & Boje (1989a) have analysed meristic characters, Bowering (1988) analysed morphometric characters, Fairbairn (1981) and Boje *et al.* (1989) investigated frequencies of electrophoretically detectable protein loci, Khan et al. (1982) used blood protozoa as biological tags and Reimer & Ernst (1989) used the total parasite burden for stock discrimination. All authors suggest that Greenland halibut form a single interbreeding stock throughout the northwestern part of the Atlantic (the NAFO Convention Area), with the exception of the stocks in in the Gulf of St. Lawrence and Fortune Bay which seem to be somewhat isolated from the Davis Strait stock (Bowering, 1982). Further, there seem to be a connection between the spawning stock at West Iceland and the spawning stock in the Davis Strait (Boje *et al.* 1989, Riget & Boje 1989a).

Recently, Riget and Boje (1989b) summarized the present knowledge of the biology of Greenland halibut in West Greenland waters. They hypothesize that the populations in the southernmost fiords of West Greenland may be recruited from the spawning grounds west of Iceland and further that populations in the West Greenland fiords may be regarded as mainly stationary. To verify their hypothesis a stock identification study of Greenland halibut in the Northwest Atlantic was initiated in 1987 and for the first time Greenland halibut from the west Greenland fiords were included in such studies. The study include samples from the Denmark Strait, the Davis Strait, the inshore areas of West Greenland and an area off Newfoundland north of Grand Bank analyse genetic variation, meristic characters and the natural parasite fauna.

This paper presents the results of the analyses of the natural parasite fauna. The studies on meristic characters and genetic variations are reported in Boje et *al.* (1989) and Riget & Boje (1989a).

1.2 Biology of the parasites.

Using incidences of parasites to elucidate fish stock relations, demands certain criteria to be fullfilled for the parasites chosen (see Sindermann, 1983). First of all, the parasite do have to reveal differences in prevalence between the areas studied. The infestation of the parasite in the fish have to last for a while, not to reflect the food intake only. If the area of distribution of the parasite is limited, concerning its total host range, this limitation should be known. Following below a short review of the life-cycles of the parasite species found will be given.

Generally, the nematodes, and especially the larval forms, are very suitable as natural tags, because of their longevity in the host. The digeneans, on the other hand, using the criteria by Sindermann (1983), are limited in their use as natural tags, because of their short life span in the fish.

*Anisakis simplex* is known as a cosmopolitan, having a life cycle including a planktonic crustacean, mainly euphausiaceans. A wide range of fish may act as hosts. Whales are final hosts. *Anisakis* must be considered as a good natural tag, with no limitations in distribution and a life span in the fish of usually several years. As *Ascarophis* sp. has not been determined to a known species in present study, nothing specific is known of its distribution or life span. However, most species of the genus *Ascarophis* seem to have a sporadic and limited occurrence in the North Atlantic, with a broad range of fish as final hosts. With the sparse knowledge of the life cycle of this species, no conclusions should be drawn from its distribution alone. The *Contracaecum* sp., have seals as final host. Crustaceans are first intermediate hosts, and a broad range of fish species are second intermediate hosts. *Hysterothylacium aduncum* is a cosmopolitan, with crustacean as first intermediate host. Non-crustacean invertebrates may act as transport hosts. Fish usually act as both intermediate host, harbouring third larvae stage (L3), and final host with L4 or adults free in the alimentary system. Greenland halibut is assumed to be an unsuitable final host for this species, as only immature stages (larvae stages 3 and 4) were found in the intestine. No encapsulated L3 were found. *Pseudoterranova decipiens* has been recorded from the whole North Atlantic, except from the Greenland area. Its hosts include benthic crustaceans as first intermediate host, fish as second intermediate host and seals as final host. Like *Anisakis*, *P. decipiens* may probably survive for several years in the fish host. The grey seal, *Halichoerus grypus*, is the main final host. Thus, the species is very common in certain areas of Iceland and along the coast of Newfoundland and has formerly been used to elucidate cod stock relations (Platt, 1976).

*Brachyphallus crenatus* has a circumboreo-polar distribution. First intermediate host, a molluscan, is not known. Copepods are believed to be second intermediate host, and a broad range of fish can act as final hosts. The parasite is transferred from one fish host to another by predation. Both *Steganoderma formosum* and *Stenakron vetustum* have a circumpolar distribution, intermediate hosts are unknown and there seem to be a specificity for pleuronectid flatfish as final hosts.

## 2. MATERIALS AND METHODS.

### 2.1 Sampling.

Samples for the study were collected at the six sampling localities shown in Fig. 1. The sampling at Newfoundland (NAFO Div. 3K) was made in December 1987 by staff from Northwest Atlantic Fisheries Centre, St. John's, onboard the research vessel GADUS ATLANTICA. The samples from the Davis Strait (NAFO Div. 1C) and from the Denmark Strait (ICES Subarea XIVb) were taken in September 1988 and November 1987, respectively, by staff of the Greenland Fisheries Research Institute onboard the Japanese research vessel SHINKAI MARU. Samples from the inshore areas in West Greenland, Julianehaab (NAFO Div. 1F), Godthaab (Div. 1D) and Umanak (Div. 1A) were taken in January 1988, January 1987 and August 1987, respectively. Data on the sampling localities are given in Table 1.

Around 100 specimens of Greenland halibut in the length range 50-70 cm were sampled from each locality. Sex of all specimens was determined and length and weight measured. Otoliths were taken for age determination. From each specimen the intestinal system (i.e. stomach including lower part of oesophagus, pyloric caeca and intestine) and the right fillet were removed and frozen immediately. One thin smear wes prepared from each fish using blood from the heart, and dried in room temperature, fixed with 96% ethanol and stained with Giemsa stain. No smears and fillets were sampled in NAFO Div. 1D.

## 2.2 Procedure of examination.

From each locality 20 smears were examined microscopically for periods of 10 min with 40x and 100x objectives. Exterior of intestinal system was examined for nematodes without use of microscope, while the interior was examined microscopically. The fillets were skinned and cut into thin slices, which were examined over a candling table without use of a microscope.

Parasites from fillets and intestine were stored in 70% ethanol and cleared in lactophenol for determination. If necessary, parasites where mounted in glycerol-gelatine for microscopically examination.

## 3. RESULTS.

No blood protozoa were found in the examined smears. Incidence of observed species of parasites in the study is given in Table 2.

1 monogenean species, 12 species of digeneans, 1 cestod species, 2 species of acanthocephalans and 5 nematod species have been found in the samples. *Ascarophis* sp. has not been determined to any of the known species for the area. Anyhow, all specimens in the present material belong to the same species. Also *Contracaecum* has not been determined to species level. The specimens found were identical with those descriped by Smith & Wotten (1984). The digeneans *Genolinea laticauda* and *Gonocerca phycidis* and the nematode *Ascarophis* sp. are new recordings compared to previous investigations on parasites of Greenland halibut in the Northwest Atlantic (Brinkmann 1975, Reimer 1981, Reimer & Ernst 1989, Scott & Bray 1989 and Zubchenko 1980). All species in the present material are new recordings for Greenland halibut in the Greenland area, except for *Derogenes varicus, Steringophorus furciger* and *Entobdella hippoglossi*, also found by Brinkmann (1975).

Certain species have a sporadic occurrence in the area with low intensities e.g. *Entobdella hippoglossi, Anomalotrema koiae, Genolinea laticauda, Gonocerca phycidis, Hemiurus levinseni, Lecithophyllum* sp. and *Stephanostomum* sp., while others are more uniform distributed throughout the area, e.g. *Derogenes varicus, Lecithaster* sp. and *Steringophorus furciger*. However, some parasites distribute in an irregular manner with high variations in either prevalence or intensity between the localities, like *Brachyphallus crenatus, Steganoderma formosum, Stenakron vetustum, Anisakis simplex* larvae (in body cavity), *Ascarophis* sp., *Contracaecum* sp. larvae, *Hysterothylacium aduncum*, and *Pseudoterranova decipiens* larvae (in body cavity). The latter eight species are considered usable as natural tags and were selected for analyses.

## 3.1 Effect of sex.

The effect of sex on the prevalences and intensities of the eight chosen parasite species was analysed in order to elucidate bias in the material. The sex ratio (males/total) in the samples range from 0.23 (Denmark Strait) to 0.71 (Davis Strait). Kruskal-Wallis tests (Chi-square approximation) on pooled prevalences and intensities for all localities, respectively, did not show any significant differences between the sexes for any species.

## 3.2 Effect of age and area.

The prevalence and incidence of parasites in fish can be expected to depend on the age of the fish, the analyses are therefore done by age groups. As the counts on numbers of parasites are not normally distributed only nonparametric tests have been performed. (Kruskal-Wallis one-way analysis of variance by ranks).

### *Anisakis simplex*

Both intensities (I) and prevalences (P) pooled for all localities increased significantly in relation to age (I:$p<0.0001$, P:$p<0.0008$).

In order to elucidate differences between the localities, P was plotted against age for each locality (Fig.2). Prevalences of *Anisakis* in Newfoundland, Julianehaab and Denmark Strait seem to increase with age, in the Davis Strait P seem to decrease with age, while P in Umanak and Godthaabsfiord seem to vary without any trends. In order to eliminate the age effect when analysing the effect of the locality only age groups 8 and 9 years old were included in the analyses. In Table 3 is given the results of a Kruskal-Wallis one-way analysis on the prevalences. The localities formed two groups, where Godthaabsfiord, Julianehaab and Denmark Strait were not significantly different mutually, but have significantly higher prevalences than the three other localities.

### *Ascarophis* sp.

The prevalences (P) pooled for all localities increased significantly in relation to age ($p<0.0001$), while this was not the case for the intensities.

However, the relation of P versus age for each locality (Fig.3), does not seem to show any clear trends for any locality. Therefore all age groups within the range 7-12 years were used in analyses of effect of locality (Table 3). High prevalences were found in the inshore samples of Godthaabsfiord and Julianehaab, and they differed significantly from the other samples.

### *Brachyphallus crenatus*

This species was only found in the Julianehaab sample, which therefore differs significantly from the other localities (Table 3). The prevalence increased significantly ($p<0.0191$) with age.

### *Contracaecum* sp.

Both intensities (I) and prevalences (P) pooled for all localities decreased significantly in relation to age (I:$p<0.0001$, P:$p<0.0001$).

The relation of P versus age seem to differ strongly between the localities (Fig.4). The overall negative correlation are obvious for the Umanak sample and to a lesser degree the Davis Strait sample, while the relation is very constant in the Newfoundland sample. To avoid these differences in age effect, the age groups 8 and 9 years old were selected for further analysis. Godthaabsfiord and Julianehaab differ from the other samples in having very low prevalences, Davis Strait, Denmark

Strait and Umanak differ from Godthaabsfiord and Julianehaab as well as from Newfoundland in having intermediate levels of P, while Newfoundland differ from all other localities in having a high P (Table 3).

*Hysterothylacium aduncum*

There was no significant age effect on either I or P for all localities pooled.

*H. aduncum* is found in very low numbers except for the offshore localities, Newfoundland, Davis Strait and Denmark Strait with P levels of 6 to 15 showing no age effects for any locality (Table 2, Fig.5). Consequently, P values from the inshore localities differed significantly from P values from offshore localities (Table 3).

*Pseudoterranova decipiens*

There was no significant age effect of either I or P for all localities pooled.

*P. decipiens* is found in very low numbers and in the Davis Strait, Umanak, Julianehaab and Denmark Strait only. No age effects are seen for any locality. Julianehaab differs from the other localities in having a relatively high P (Table 3).

*Steganoderma formosum*

Both intensities (I) and prevalences (P) pooled for all localities decreased significantly in relation to age (I:$p<0.0068$, P:$p<0.0024$).

*S. formosum* show a decrease in P in relation to age in Umanak and in the Davis Strait, while the trend is unclear for the Newfoundland sample. The latter location has a higher P compared to the other locations (Table 3)

*Stenakron vetustum*

Only prevalences (P) pooled for all localities increased significantly in relation to age ($p<0.0012$).

Like *Steganoderma*, *S. vetustum* is found in adequate numbers to elucidate age effects in Newfoundland only. Consequently, the Newfoundland sample differs from the other samples in relation to prevalence.

## 3.3 Effect of locality on combined prevalences of selected parasites.

From Table 3 it seems as the prevalences of *Ascarophis*, *Contracaecum*, *Hysterothylacium*, *Brachyphallus and Pseudoterranova*, show the same trends in differences between locations. Therefore, a cluster analysis was performed on the prevalences of those species, in order to elucidate the origin of the six samples (clustering analysis on the basis of the nearest centroid sorting method, Anon 1985). In the analysis the number of allowed clusters is optional. In order to discriminate the locations, 3 clusters seem to give the best explaination of the counts of prevalences. In Table 4 is listed the characteristics of each of the four clusters. Table 5 gives the results of the analysis. The main representation of localities in the 3 clusters (hatched underscored figures) has been chosen subjectively.

Cluster 1 consist of 71% of the material. The locations, Newfoundland, Davis Strait, Umanak and Denmark Strait dominates the cluster and explains 92% of the counts. Cluster 2 consists of 5% of the total material, and is mainly represented (93%) by the localities Newfoundland, Davis Strait and Denmark Strait. Clusters 3 represent 24% of the total material, and the locations Godthaabsfiord and Julianehaab explain 95% of the cluster. Some locations are not fully explained in this grouping. This seems to be the case for especially Godthaabsfiord and Julianehaab, where only 75% and 83% of their counts are represented in the grouping.

In summary, Godthaabsfiord and Julianehaab seem to have a unique combination of prevalences of parasite species, separating them from the other localities. In most cases Umanak seems to be associated with Newfoundland, Davis Strait and Denmark Strait.

## 4. DISCUSSION.

### 4.1 Static relationships of parasite incidences.

Table 3 outlines the relations between the localities for each parasite species. Concerning prevalences of *Steganoderma*, *Stenakron* and *Contracaecum*, Newfoundland is isolated from the other localities. Also Julianehaab as well as Julianehaab and Godthaabsfiord combined, do isolate concerning prevalences of *Ascarophis*, *Contracaecum*, *Brachyphallus* and *Pseudoterranova*. Regarding localities as Davis Strait, Umanak and Denmark Strait there do not seem to be any obvious relationship.

For some parasite species, prevalence increase or decrease along a geographical gradient. *Steganoderma* and *Stenakron* decrease in the direction Newfoundland, Davis Strait, West Greenland fiords and Denmark Strait, while *Anisakis* show an increase in the same direction.

The cluster analysis (Table 5) reveal two main groupings in the material, in which the southern fiords of West Greenland compose one group and the other locations compose another group.

Thus, concerning parasite infestation, Greenland halibut in the Newfoundland area seem to be highly isolated from the West Greenland fiord populations. The Davis Strait area is partly related to Newfoundland and the Denmark Strait area. Anyhow, populations in Umanak in the northern West Greenland area, show tendencies for a relationship to the Davis Strait, and there seem to be some similarities with the populations in the southern fiords of West Greenland too. It is noteworthy, that the localities closest to each other, Davis Strait and Godthaabsfiord in most cases are very different from each other.

### 4.2 Dynamic relationships of parasite incidences.

When trying to make some considerations about the dynamics of the Greenland halibut populations in the Northwest Atlantic from the results of the present study of parasite infestation, it is necessary to take the size of the stock components and the assumed migration patterns as described in the introduction, into account.

*Anisakis simplex*, is considered the best natural tag in the present study and it displays a very distinct pattern of distribution (Fig.2), where Godthaabsfiord, Julianehaab and Denmark Strait differ from the other localities. However, a possible migration of Greenland halibut from Godthaabsfiord and Julianehaab to the Davis Strait area cannot be excluded, beceause the size of the stock in the Davis Strait is several times bigger than the stocks in the West Greenlad fiords, and migrated fish will only have a slight dilution effect on the prevalences of *Anisakis*. But a migration in the the opposite direction, as proposed by Atkinson & Bowering (1987), is in conflict with the prevalences of *Anisakis*. The generally assumed migration of Greenland halibut from Newfoundland and Labrador to the Davis Strait area, does fit well with the observed prevalences of *Anisakis*, as weel as migrations from the southwest Greenland fiords to the Denmark Strait area.

## 5. Conclusions.

The prevalence of the parasites found in the study seem to show some general tendencies. The parasite fauna found in the Newfoundland sample has a unique combination. However, there seems to be a cline in prevalence for several parasite species from Newfoundland to the Davis Strait and further to the other areas investigated. The southern fiords of West Greenland i.e. Godthaabsfiord and Julianehaab has a very similar parasite fauna. The fauna in those areas show some similarities with the Denmark Strait. The Umanak sample seems in most cases to be associated with the Davis Strait sample and resembles the southern fiords of West Greenland slightly.

The results of the investigations on the parasite fauna generally sustain the present knowledge on the relations between the populations of Greenland halibut in the Northwest Atlantic. The study outline the expected relation between Greenland halibut at Newfoundland and the Davis Strait as well as the connection between the populations in the Denmark Strait and the southern West Greenland fiords. However, the present material do not reveal any distinct relations between the West Greenland fiords and the Davis Strait. In many cases the greatest difference in prevalence is found between the closest situated localities, Godthaabsfiord and the Davis Strait.

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Table 1. Data on the samplings.

| Location | NAFO Division/ ICES Subarea | Date | Depth interval | No. | Age range |
|---|---|---|---|---|---|
| Newfoundland | 3K | Nov.-Dec. 1987 | 220- 835 m | 100 | 7-10 |
| Denmark Strait | XIVb | Oct. 1987 | 180- 930 m | 100 | 7-13 |
| Davis Strait | 1C | Sept. 1988 | 603- 869 m | 100 | 8-12 |
| West Greenland fiords | | | | | |
| Umanak | 1A | Aug. 1987 | 210-1080 m | 107 | 8-13 |
| Godthaabsfiord | 1D | Jan. 1987 | 140- 600 m | 101 | 6-15 |
| Julianehaab | 1F | Jan. 1988 | 330- 430 m | 101 | 8-15 |

Table 2. Incidence of parasites from Greenland halibut in samples from the Northwest Atlantic. Legends: i: intensity of infestation in the specimens infested, p: prevalence, -: missing incidence. * No fillets were sampled at Godthaab fiord.

| Locality | Newfound-land | | Davis Strait | | Umanak | | Godthaabs-fjord | | Juliane-haab | | Denmark Strait | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ICES Subarea/NAFO Division | 3K | | 1C | | 1A | | 1D | | 1F | | XIVb | |
| | p | i | p | i | p | i | p | i | p | i | p | i |
| **Monogenea:** | | | | | | | | | | | | |
| *Entobdella hippoglossi* | - | - | - | - | 1 | 1.0 | - | - | - | - | - | - |
| **Digenea:** | | | | | | | | | | | | |
| *Anomalotrema koiae* | - | - | 1 | 3.0 | - | - | - | - | - | - | - | - |
| *Brachyphallus crenatus* | - | - | - | - | - | - | - | - | 19 | 1.7 | - | - |
| *Derogenes varicus* | 22 | 2.7 | 51 | 5.5 | 84 | 10.2 | 41 | 1.9 | 58 | 2.7 | 20 | 1.8 |
| *Genolinea laticauda* | - | - | - | - | - | - | - | - | - | - | 1 | 1.0 |
| *Gonocerca phycidis* | - | - | 1 | 4.0 | - | - | - | - | - | - | - | - |
| *Hemiurus levinseni* | - | - | 1 | 2.0 | 2 | 1.0 | - | - | - | - | - | - |
| *Lecithaster* sp. | 33 | 3.2 | 21 | 2.4 | 2 | 1.0 | 22 | 4.2 | 35 | 2.6 | 3 | 1.0 |
| *Lecithophyllum* sp. | - | - | - | - | 1 | 1.0 | - | - | - | - | - | - |
| *Steganoderma formosum* | 24 | 2.5 | 3 | 1.3 | 1 | 1.0 | 1 | 2.0 | - | - | - | - |
| *Stenakron vetustum* | 29 | 2.9 | 3 | 2.0 | 1 | 1.0 | 2 | 3.5 | 1 | 3.0 | - | - |
| *Stephanostomum* sp. | - | - | - | - | 1 | 1.0 | - | - | - | - | - | - |
| *Steringophorus furciger* | 10 | 3.8 | 40 | 8.8 | 15 | 8.4 | 21 | 11.2 | 15 | 7.1 | 8 | 2.0 |
| **Cestoda:** | | | | | | | | | | | | |
| Cestode larvae sp. | - | - | - | - | - | - | - | - | - | - | 1 | 1.0 |
| **Acanthocephala:** | | | | | | | | | | | | |
| *Echinorhyncus gadi* | 11 | 3.4 | 7 | 3.1 | - | - | 18 | 1.5 | 10 | 4.2 | 15 | 2.0 |
| *Corynosoma* sp. | 2 | 1.0 | 1 | 2.0 | 18 | 1.6 | - | - | - | - | 4 | 1.0 |
| **Nematoda:** | | | | | | | | | | | | |
| *Anisakis* sp., l. (intestine) | 4 | 1.3 | 7 | 1.6 | 3 | 1.7 | 19 | 1.4 | 14 | 2.1 | 16 | 4.1 |
| *Anisakis* sp., l. (fillets,body cav.) | 26 | 1.8 | 20 | 2.0 | 15 | 1.2 | 50* | 2.2 | 76 | 3.2 | 72 | 4.2 |
| *Ascarophis* sp. adults | 1 | 4.0 | 2 | 4.0 | 7 | 4.3 | 68 | 30.8 | 84 | 51.8 | - | - |
| *Capillaria* sp. | - | - | - | - | 1 | 1.0 | 3 | 7.0 | 7 | 9.4 | - | - |
| *Contracaecum* sp., larvae | 90 | 9.4 | 53 | 2.8 | 49 | 2.0 | 6 | 1.0 | 27 | 1.5 | 49 | 2.4 |
| *Hysterothylacium aduncum* (L3+4) | 6 | 4.2 | 7 | 1.1 | - | - | 1 | 1.0 | 2 | 1.0 | 15 | 9.0 |
| *Pseudoterranova decipiens*, l.(int.) | - | - | - | - | 3 | 1.0 | - | - | 1 | 2.0 | 3 | 6.0 |
| *Pseudoterranova decipiens*, l.(fil.) | - | - | 1 | 1.0 | 1 | 1.0 | -* | - | 7 | 1.4 | 4 | 1.0 |
| Nematode sp. | 6 | 1.2 | 3 | 1.0 | - | - | 5 | 1.0 | 5 | 1.0 | 2 | 1.5 |

**Table 3.** Samples ordered in relation to difference in mean P value for each selected parasite species. Locations underscored by the same line are not significantly different from each other ($p<0.05$).

*Anisakis simplex* (in fillets and body cavity)

| Newfoundland | Davis Strait | Umanak | Godthaabsfjord | Julianehaab | Denmark Strait |
|---|---|---|---|---|---|
| 0.26 | 0.23 | 0.08 | 0.55 | 0.73 | 0.62 |

*Steganoderma formosum*

| Newfoundland | Davis Strait | Umanak | Godthaabsfjord | Julianehaab | Denmark Strait |
|---|---|---|---|---|---|
| 0.24 | 0.03 | 0.01 | 0.01 | 0.0 | 0.0 |

*Stenakron vetustum*

| Newfoundland | Davis Strait | Umanak | Godthaabsfjord | Julianehaab | Denmark Strait |
|---|---|---|---|---|---|
| 0.29 | 0.02 | 0.01 | 0.01 | 0.0 | 0.0 |

*Ascarophis* sp.

| Newfoundland | Davis Strait | Denmark Strait | Umanak | Godthaabsfjord | Julianehaab |
|---|---|---|---|---|---|
| 0.01 | 0.01 | 0.0 | 0.04 | 0.75 | 0.84 |

*Contracaecum* sp.

| Newfoundland | Davis Strait | Denmark Strait | Umanak | Godthaabsfjord | Julianehaab |
|---|---|---|---|---|---|
| 0.90 | 0.56 | 0.52 | 0.58 | 0.05 | 0.18 |

*Hysterothylacium aduncum*

| Newfoundland | Davis Strait | Denmark Strait | Umanak | Godthaabsfjord | Julianehaab |
|---|---|---|---|---|---|
| 0.06 | 0.08 | 0.13 | 0.0 | 0.01 | 0.02 |

*Brachyphallus crenatus*

| Newfoundland | Davis Strait | Denmark Strait | Umanak | Godthaabsfjord | Julianehaab |
|---|---|---|---|---|---|
| 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.18 |

*Pseudoterranova decipiens* (in fillets and body cavity)

| Newfoundland | Davis Strait | Denmark Strait | Umanak | Godthaabsfjord | Julianehaab |
|---|---|---|---|---|---|
| 0.0 | 0.01 | 0.02 | 0.0 | 0.0 | 0.08 |

**Table 4.** Results of a cluster analysis, on the basis of the nearest centroid sorting method (Anon, 1985). Mean prevalence of the parasites in each cluster.

| Cluster | *Ascarophis* | *Contracaecum* | *Hysterothylacium* | *Brachyphallus* | *Pseudoterranova* |
|---|---|---|---|---|---|
| 1 | 0.00 | 0.59 | 0.00 | 0.01 | 0.02 |
| 2 | 0.04 | 0.39 | 1.00 | 0.03 | 0.00 |
| 3 | 1.00 | 0.19 | 0.01 | 0.09 | 0.03 |

Table 5. Results of a cluster analysis, on the basis of the nearest centroid sorting method (Anon, 1985). The upper figure indicate numbers of counts of prevalences, the lower figure indicate row percent of counts. Locations chosen as representative for the cluster are underscored.

| | | Location | | | | | |
|---|---|---|---|---|---|---|---|
| Cluster No. | % of total | Newfoundland 3K | Davis Strait 1C | Umanak 1A | Godthaabsfjord 1D | Julianehaab 1F | Denmark Strait XIVb |
| 1 | 71 | 714<br>26 | 618<br>22 | 638<br>23 | 130<br>5 | 88<br>3 | 288<br>25 |
| 2 | 5 | 46<br>23 | 54<br>27 | 0 | 0 | 14<br>7 | 84<br>42 |
| 3 | 24 | 8<br>1 | 8<br>1 | 28<br>3 | 384<br>41 | 504<br>54 | 0 |
| Percentage explained by the hatched figures: | | 99 | 99 | 96 | 75 | 83 | 100 |

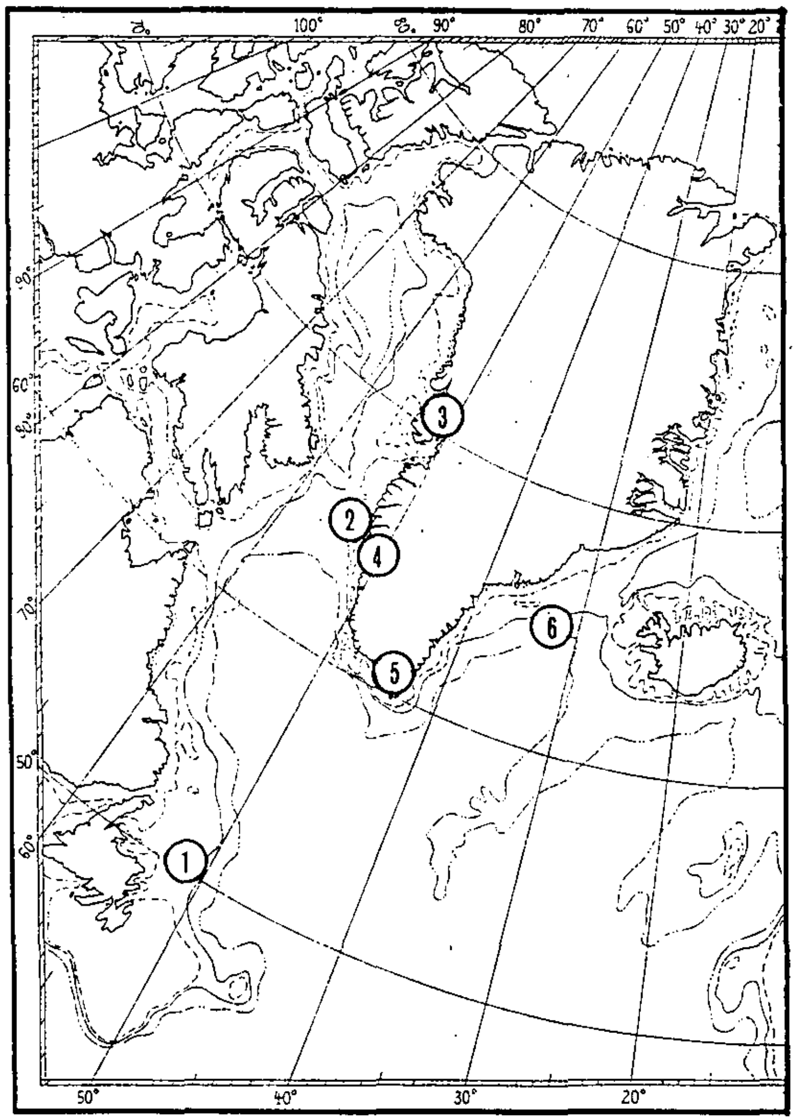
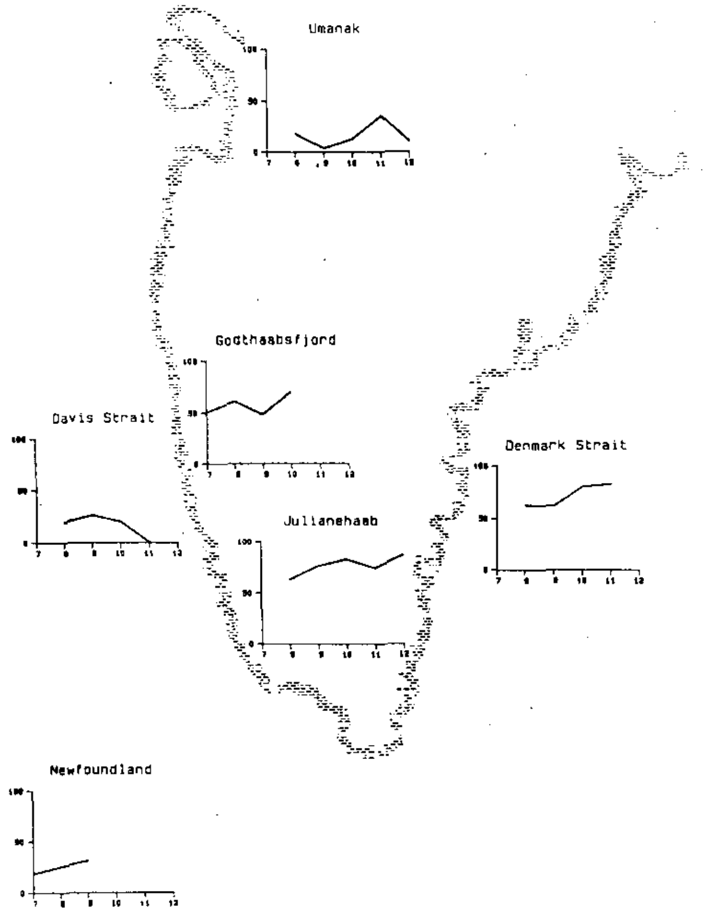



Fig. 1. Distribution of Greenland halibut samples in the Northwest Atlantic. 1: Newfoundland, 2: Davis Strait, 3: West Greenland , fjords Div. 1A, 4: West Greenland fjords, Div 1D, 5: West Greenland fjords, Div 1F, 6: Denmark Strait.




<u>Fig.2.</u> Relations between prevalences (%) and age of *Anisakis simplex* in Greenland halibut for the localities studied.

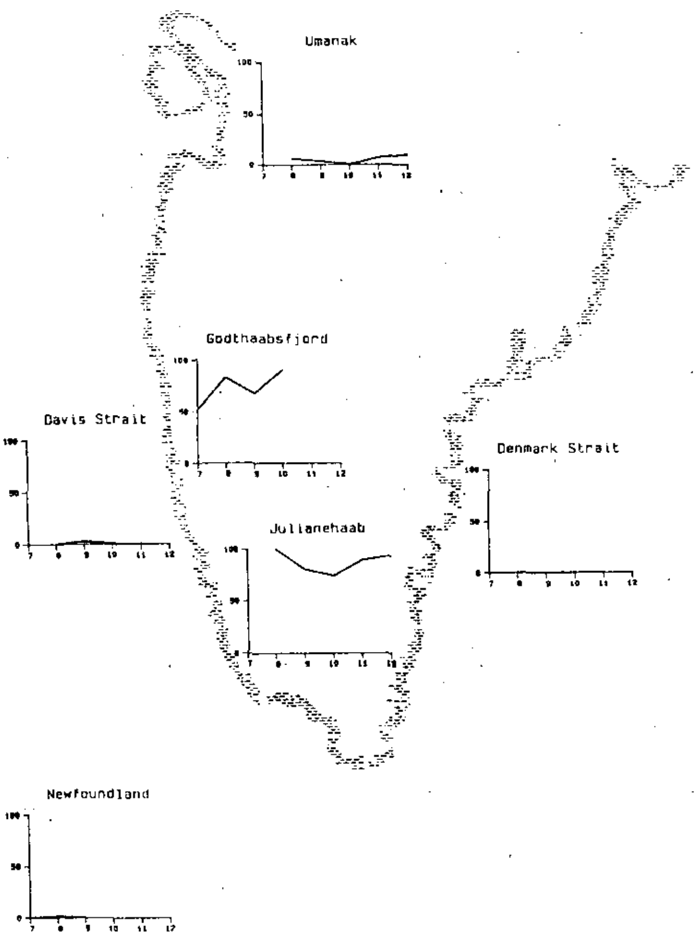



Fig.3. Relations between prevalences (%) and age of *Ascarophis* sp. in Greenland halibut for the localities studied.

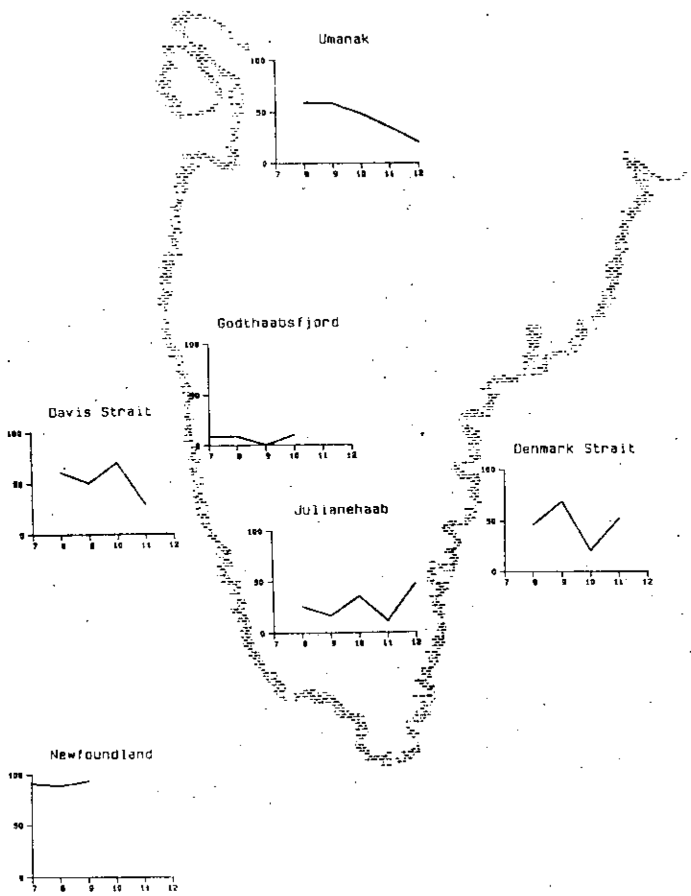



Fig.4. Relations between prevalences (%) and age of *Contracaecum* sp. in Greenland halibut for the localities studied.

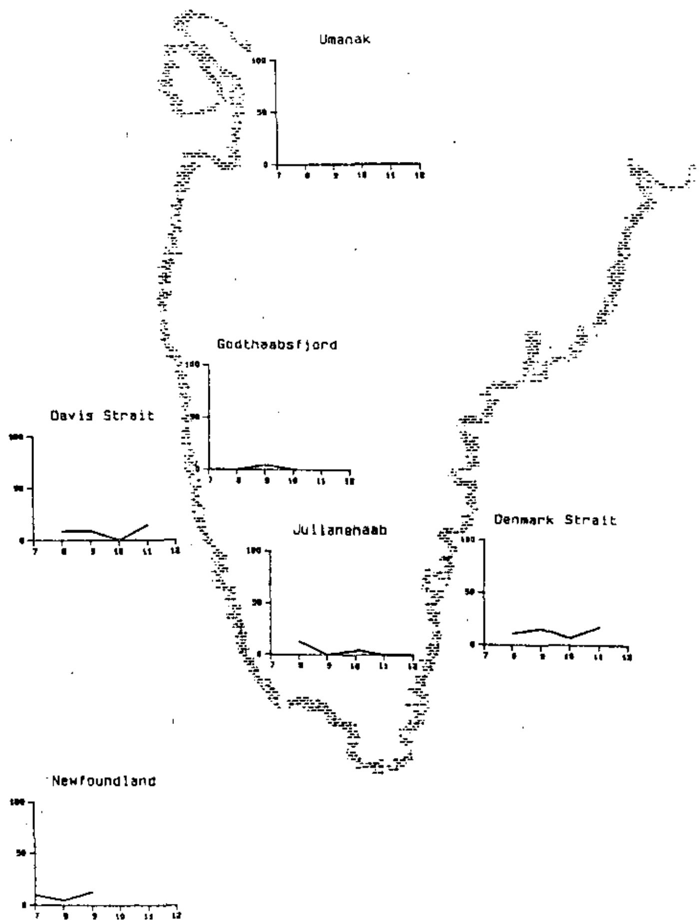



Fig.5. Relations between prevalences (%) and age of *Hysterothylacium aduncum* Greenland halibut for the localities studied.