# Quantitative Studies on the Helminth Fauna of Capelin *(Mallotus villosus* (Müller) *)* in the Northwest Atlantic For the Purpose of Stock Discrimination

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# QUANTITATIVE STUDIES ON THE HELMINTH FAUNA OF CAPELIN (*MALLOTUS VILLOSUS* (MÜLLER)) IN THE NORTHWEST ATLANTIC FOR THE PURPOSE OF STOCK DISCRIMINATION



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Pálsson, J. 1986. Quantitative studies on the helminth fauna of capelin (Mallotus villosus (Müller)) in the Northwest Atlantic for the purpose of stock discrimination. Can. Tech. Rep. Fish. Aquat. Sci. 1499: v + 21 p.

Capelin (Mallotus villosus) from the Northwest Atlantic were examined for parasitic helminths. Data on individual prevalence of three species of gyrodactylid Monogenea (Gyrodactyloides petruschewskii, G. andriaschewi, and Laminiscus gussevi) were not collected, but combined prevalence was high in NE and E Newfoundland water and low in western Newfoundland and Gaspé waters. Of the Digenea, Lecithaster gibbosus was relatively common, but Derogenes varicus and Hemiurus levinseni were only of sporadic occurrence. Eubothrium parvum (Cestoidea) was found, but prevalence was low. Third-stage larvae of Anisakis simplex, Contracaecum sp. and Hysterothylacium aduncum (Nematoda) were found in the body cavity. In N, NE and E Newfoundland waters Contracaecum sp. larvae were the most commonly occurring nematodes followed by A. simplex and H. aduncum. In contrast, in fish from the Gulf of St. Lawrence, H. aduncum was most common followed by A. simplex and Contracaecum sp.

Three species, L. gibbosus, Contracaecum sp. and H. aduncum were useful to differentiate capelin from Gulf of St. Lawrence, (L. gibbosus absent, abundance of H. aduncum higher that Contracaecum sp.) and those from N, NE and E Newfoundland waters (L. gibbosus present, abundance of Contracaecum sp. higher than H. aduncum). Helminth parasites of capelin from N, NE and E Newfoundland waters did not show qualitative or quantitative difference reflecting previously identified stocks of capelin in that area.

Larvae of the above three species of nematodes were found in samples of capelin from Barents Sea and Icelandic waters: prevalence of Contracaecum sp. was higher in fish from the Barents Sea than those from Icelandic waters.

## RÉSUMÉ

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Des capelans (Mallotus villosus) du nord-ouest de l'Atlantique ont fait l'objet d'un examen pour la recherche d'helminthes parasites. On n'a pas compilé de données distinctes sur l'incidence des trois espèces de monogènes gyrodactylidés (Gyrodactyloides petruschewskii, G. andriaschewi et Laminiscus gussevi), mais leur incidence globale était élevée dans les eaux du nord-est et de l'est de Terre-Neuve et faible dans celles de l'ouest de Terre-Neuve et de la péninsule de Gaspé. Quant aux digènes, Lecithaster gibbosus était

relativement commun, tandis que Derogenes varicus et Hemiurus levinseni étaient plutôt sporadiques. Des Eubothrium parvum (Cestoïdés) ont été décelés, mais leur incidence était faible. Des larves de troisième stade de Anisakis simplex, de Contracaecum sp. et de Hysterothylacium aduncum (Nématodes) ont été trouvées dans la cavité viscérale. Dans les eaux du nord, du nord-est et de l'est de Terre-Neuve, des larves de Contracaecum sp. constituaient les nématodes les plus courants, venaient ensuite celles de A. simplex et de H. aduncum. Chez les poissons du golfe St-Laurent l'order d'incidence décroissant était: H. aduncum, A. simplex et Contracaecum sp.

Trois espèces, L. gibbosus, Contracaecum sp. et H. aduncum se sont avérées utiles pour différencier les capelans du Golfe St-Laurent (L. gibbosus absent et H. aduncum plus abondant que Contracaecum sp.) de ceux des eaux du nord, du nord-est et de l'est de Terre-Neuve (L. gibbosus présent et Contracaecum sp. plus abondant que H. aduncum). Les helminthes parasites des eaux du nord, du nord-est et de l'est de Terre-Neuve ne présentaient pas d'écarts qualitatifs ou quantitatifs reflétant des différences entre les stocks du capelan déjà identifiés dans cette zone.

Les larves des trois espèces de nématodes mentionnées ci-dessus ont été décelées dans des échantillons de capelan provenant des eaux de la mer de Barents et de l'Islande et l'incidence de Contracaecum sp. était plus élevée chez les poissons de la mer de Barents.

## INTRODUCTION

Several, largely unsuccessful, attempts have been made to differentiate between Northwest Atlantic stocks of capelin (Mallotus villosus (Müller)) using various techniques e.g., geographic variation in vertebral number (Templeman 1948; Pitt 1958) electrophoretic analysis of liver and skeletal muscle esterases (Payne 1975, 1976) and multivariate discriminant function analysis of meristic and morphometric characters (Sharp et al. 1978). Based on known seasonal distribution patterns and stock movement records, Campbell and Winters (1973) suggested that there were four major stocks of capelin in the Canadian Atlantic but Carscadden and Misra (1980), using multivariate analysis of meristic characters, were able to identify only three. The reanalysis of Carscadden and Misra's able by Misra and Carscadden (1984) essentially substantiated their earlier findings.

Geographic variations in parasite fauna, both qualitative and quantitative, have proven useful in the study of fish populations and migrations (Margolis 1965; Kilambi and DeLacy 1967; Kalil 1969; Parsons and Hodder 1971; Gibson 1972; Platt 1976; Beverley-Burton and Pippy 1978; Bussmann and Enrich 1979: Siegel 1980). Therefore, it was suggested that the identification of capelin stocks might be possible using similar techniques. Palsson and Beverley-Burton (1984) identified the metazoan parasites of capelin in the North Atlantic and their potential as biological indicators of host stocks is herein investigated.

## MATERIALS AND METHODS

Samples of 100 mature male capelin were collected from various localities in the Northwest Atlantic (Fig. 1, Table 1) during the spawning season (May to July) of 1980 and 1981. Only males were examined in order to avoid possible effects of variation between sexes, and because larval nematodes in the body cavity are more easily overlooked in the ovarian mass of a gravid female. Offshore samples were taken from research vessels of Canada's Department of Fisheries and Oceans, using either a bottom or midwater trawl; inshore samples were taken in purse seines by local fishermen, from whom locality information was obtained, and beach spawning samples were also obtained from the North Atlantic (Icelandic waters) and the Barents Sea.

Capelin were frozen as soon and as fast as possible after capture: most samples (11) were frozen within 1 h; 9 by 5 h; 1 by 10 h; 1 by 15 h and 1 within 24 h. If fish could not be frozen immediately, samples were kept in insulated containers with crushed ice for transportation to the freezing facilities.

Prior to necropsy, fish were allowed to thaw and the total length (mm) (Templeman 1948) was measured and adjusted for shrinkage due to freezing (Winters 1980). Fish were examined using standard helminthological procedures. Helminths were collected and processed as noted in Palsson and Beverley-Burton (1984) for identification. Numbers of parasites found and location within the host were recorded.

Otoliths for age determination were removed, washed and mounted either with Permount (Fisher Scientific Company) on black cardboard or on special otolith-trays (Bourston 1968). All age discriminations were confirmed by technicians at the Northwest Atlantic Fisheries Centre, St. John's, Newfoundland.

Quantitative terms (prevalence and abundance) as defined by Margolis *et al*. 1982 are utilized.

Statistical analysis of data using Hartley's test, showed a significant ($P < 0.05$) variation between most samples in the variance of abundance of larval nematodes. It was found that the relationship between abundance and variance was approximately $\sigma^2 = k.\mu$, indicating the need for a square root transformation (Ott 1977). Because of the small number involved, the transformation $\sqrt{x + 0.05}$ was utilized prior to comparative analyses using analysis of variance and Duncan's test.

Samples collected in N, NE and E Newfoundland waters in 1980 were divided into two groups (differing significantly from each other in abundance of *Contracaecum* sp. larvae). These groups are referred to in the text as Group 1 and Group 2.

## RESULTS

The helminths found in the present survey were listed and , where pertinent, described by Palsson and Beverley-Burton (1984). The larval cestoideans and the single acanthocephalan species were of such infrequent occurrence, they are not mentioned herein.

### MONOGENEA

Abundance for each of the gyrodactylid species (*Gyrodactyloides petruschewskii*, Bykhovskii 1947; *G. andriaschewi*, Bykhovskii and Polyanskii 1953 and *Laminiscus gussevi* (Bykhovskii and Polanskii 1953); Palsson and Beverley-Burton 1983), was not recorded. However, the prevalence of 'gyrodactylids' on capelin in northeastern and eastern Newfoundland waters was 88-100% while from western Newfoundland and the Gaspé prevalence was 10-24%.

### DIGENEA

#### *Derogenes varicus* (Müller 1784) Looss 1901

*Derogenes varicus* was found in most samples from Newfoundland waters but prevalence was consistently low, only exceeding 6% in two samples. Mean intensity was also low at 1.0-2.7.

Hemiurus levinseni Odher 1904

Geographic variation: Hemiurus levinseni was of sporadic occurrence only in north and northeast Newfoundland waters where (with one exception of 16%) prevalence was 1-5%.

Potential as "biological tag": Neither D. varicus nor H. levinseni appears to have any potential as a "biological tag".

Lecithaster gibbosus (Rudolphi 1802) Lühe 1901

Geographic variation: L. gibbosus was found in all samples taken in north, northeastern and eastern Newfoundland waters. Prevalence varied between samples from 1% up to 51% and abundance ranged from 0.01 to 1.34 (Table 2). L. gibbosus was more common in samples taken in inshore waters than offshore waters, and prevalence in inshore waters increased as the spawning season progressed (Table 2, samples # S-102 vs S-103 and S-106 vs S-107). This parasite was absent in fish taken off the west coast of Newfoundland and Gaspé Peninsula. One specimen of L. gibbosus was found in samples from Icelandic waters, but none was found in the sample from the Barents Sea.

Annual variation: The prevalence of L. gibbosus in samples from north, northeast and east Newfoundland waters collected in 1980 (4-51%) and 1981 (1-40%) (Table 2) does not show annual variation.

Potential as "biological tag": L. gibbosus appeared to be useful as a biological indicator to distinguish capelin from the Gulf of St. Lawrence, where the parasite was absent, and those from the Atlantic waters of Newfoundland where it was found in all samples.

CESTOIDEA

Eubothrium parvum Nybelin, 1922

Geographic variation: Adults of E. parvum were found in all the 1980 samples of capelin from the Newfoundland area, except from the west coast. It was also found in the sample from the Gaspé Peninsula. Although there was some variation between samples, prevalence was consistently low (1-8%). One specimen of E. parvum was found in the sample from the Barents Sea.

Annual variation: Although present in almost all samples collected in 1980, E. parvum was found in only 3 of 12 samples collected in 1981. All three samples were from inshore waters where prevalence was 1-2%.

Potential as "biological tag": Because of its sporadic occurrence and annual variation, E. parvum does not appear to have any potential as a "biological tag".

NEMATODA

*Anisakis simplex* (Rudolphi 1809) Dujardin 1845

Geographic variation: For samples taken in 1980 statistical analysis indicated significant ($P < 0.01$) variation in the abundance of *Anisakis simplex* third-stage larvae (Table 3). However, Duncan's test did not allow any group of samples to be singled out as lines of similarity of abundance overlapped (Fig. 4). For samples taken in 1981, no statistically significant variation in the abundance of *A. simplex* was found between samples (Table 3). The prevalence of *A. simplex* in samples of capelin taken in Icelandic waters and the Barents Sea was similar (12 and 17%).

Annual variation: Prevalence of *A. simplex* was low (3-13%) in capelin taken in N, NE and E Newfoundland waters during 1980, but had increased (15-30%) in 1981 (Table 4). Similarly the abundance increased, ranging from 0.03 to 0.15 in 1980 and from 0.18 to 0.37 in 1981 (Table 4).

Variation with host size: Abundance of *A. simplex* did not increase with host length (Fig. 2 and 3).

Potential as "biological tag": As neither prevalence nor abundance of *A. simplex* could be used to single out any one sample or group of samples, this parasite was not considered useful as a biological indicator of host stocks.

*Contracaecum* sp.

Geographic variation: In N, NE and E Newfoundland waters third-stage larvae of *Contracaecum* sp. were the most commonly found nematodes. *Contracaecum* sp. showed significant variation ($P < 0.01$) in abundance between samples both in 1980 and 1981 (Table 3). For samples in 1980, Duncan's multiple range test (Fig. 4) indicated that 3 of the samples from north and east Newfoundland waters (Group 1, Fig. 2) differed significantly ($P < 0.05$) in abundance of *Contracaecum* sp. from the other three samples taken in that area (Group 2, Fig. 2). The samples from the Gulf of St. Lawrence (S-4 and S-14, Fig. 4) has the lowest abundance of *Contracaecum* sp. (S-4 though equal to S-12), but did not differ significantly from two of the samples from east Newfoundland waters (Fig. 4). The variation in abundance of *Contracaecum* sp. between samples collected in 1981 cannot be interpreted as geographic variation. The sample from the Barents Sea had a higher prevalence (63%) of *Contracaecum* sp. than the sample from Icelandic water (27 and 31%).

Annual variation: From N, NE and E Newfoundland waters the prevalence of *Contracaecum* sp. in 1980 ranged from 18 to 56% and abundance from 0.19 to 0.89; in 1981 prevalence ranged from 17 to 78% and abundance from 0.20 to 1.65 (Table 4). A sample collected in Middle Cove in 1980 (S-7) had a prevalence of 20% and abundance of 0.25, but in two samples from the same locality in 1981 (S-106 and S-107) the prevalence was 78 and 45% and the abundance 1.59 and 0.77 respectively (Table 4).

Variation with host size: In 1981, samples taken in inshore waters early in the spawning season were, on the average, older, longer and more heavily infected with Contracaecum sp. than samples taken later in the spawning season (Table 5). Thus, variation in abundance was related to the length of male capelin (Fig. 3).

Potential as "biological tag": Samples of male capelin from the Gulf of St. Lawrence were found to have a lower abundance of Contracaecum sp. than samples from N, NE and E Newfoundland waters.

Hysterothylacium aduncum (Rudolphi 1802) Deardorff and Overstreet 1981

Geographic variation: Hysterothylacium aduncum third-stage larvae were the most commonly found nematodes in two samples from the Gulf of St. Lawrence with 17 and 21% prevalence and 0.22 and 0.25 abundance (Table 4). The abundance of H. aduncum in samples from the Gulf of St. Lawrence was significantly higher ($P < 0.05$) than in samples from N, NE and E Newfoundland waters, with one exception (S-12, Fig. 4). No significant variation in abundance of H. aduncum was found between samples collected in N, NE and E Newfoundland waters in 1980 and 1981 (Table 3). Prevalence of H. aduncum was high (78%) in a sample taken off the southwest coast of Iceland, but low (13%) in a sample taken north of Iceland which is more similar to the prevalence observed in the sample from the Barents Sea (19%).

Annual variation: Prevalence of H. aduncum in samples from N, NE and E Newfoundland waters ranged from 1 to 13% in 1980 and from 3 to 8% in 1981 (Table 4), indicating little annual variation.

Variation with host size: Abundance of H. aduncum did not show increase with host length (Fig. 2 and 3).

Potential as "biological tag": Samples of male capelin from the Gulf of St. Lawrence were found to have a higher abundance of H. aduncum that samples from N, NE and E Newfoundland waters.

## DISCUSSION

Hunninen and Cable (1943) reported cercariae of Lecithaster confusus Odhner 1905 infect Acartia sp. (Copepoda) and Ching (1960) found metacercariae of Lecithaster sp. in cyclopoid copepods. It is known (Templeman 1948) that copepods form a large part of the diet of capelin thus, the increase in prevalence and abundance of L. gibbosus over the spawning season, and the difference between samples taken offshore and inshore may reflect the higher occurrence of infected copepods in shallow waters. Køie (1979) considered copepods were important intermediate hosts for Derogenes varicus and may be a source of infection to capelin. Hemiurus levinseni was rarely found and in considered to be of accidental/sporadic occurrence in capelin.

The low prevalence of Eubothrium parvum observed in the present study is probably related to the fact that only mature male capelin (3 years and older) were examined. Kennedy (1979) found prevalence of E. parvum in the Barents Sea reached its maximum in 1-year-old capelin; was reduced by 50% in 2-year-old and is still lower in older fish. Kennedy (1979) suggested that E. parvum utilizes a planktonic copepod as its intermediate host and associated the difference in prevalence with differences in selection of food items between age-classes. Templeman (1948) and Jangaard (1974) reported that young fish feed extensively on copepods while older fish consume more euphausiids. The difference in prevalence of E. parvum between 1980 and 1981 could be either the result of variation in the available food (copepods being a greater dietary component in 1980) or copepods were more likely infected with E. parvum in 1980.

Similarities in abundance of larval Anisakis simplex between samples of male capelin were too great for A. simplex to be useful as biological indicator of host stocks (Table 4, Fig. 4). The fact that abundance did not increase with average length of male capelin (Fig. 2 and 3) could be due to a slow transmission rate rather than transmission of A. simplex only occurring at an early age. An increase from 1980 to 1981 sampling season in the prevalence and abundance of A. simplex in samples of capelin taken in N, NE and E Newfoundland waters was observed (Table 4). Smith (1974) demonstrated experimentally the capability of larval A. simplex, fed to haddock (Melanogrammus aeglefinus (L.)) and whiting (Merlangius merlangus (L.)) in a 'food package', to penetrate through the stomach or pyloric caeca and to establish themselves in the body cavity of the new, paratenic host. This experiment indicated that A. simplex can be transferred from one host to another, becoming more common in the fish farther up the food chain.

The difference in abundance of Contracaecum sp. between samples taken in inshore waters early and late in the spawning season (Table 4) can be attributed to differences in age and size of the fish as early spawners are, on average, older and larger than late spawners (Table 5). The difference in size between early and late spawners was reported by Templeman (1948). Later, Atkinson and Carscadden (1979) found that this difference in mean size resulted from combined effects of difference in age-composition and mean length-at-age and stated "larger, faster-growing capelin spawn first followed by the slower-growing and later-maturing ones".

Adult H. aduncum have never been reported from capelin, although they have been found in the stomach and intestine of various marine teleosts of the NW Atlantic (Margolis and Arthur 1979). Polyanskii (1955) reported H. aduncum in the intestine of capelin in the Barents Sea, but did not distinguish larvae from adults.

As the three helminth species considered here as possible biological indicators of host stocks (L. gibbosus, Contracaecum sp. and H. aduncum) have been reported from a number of fishes and have complex life cycles, they do not fulfil Kabata's (1963) second condition - "Preferably, the parasite should include in its life cycle only the host species which is the object of the study." However, Kabata (1963) noted parasites with complex life cycles could be used as biological tags, but that their use required a wider study than in the case of parasites with simple life cycles. As for the third condition (the duration of the infection must be "reasonably long") the longevity of L. gibbosus is not known but larval anisakids probably persist in fish for several years, as is the case with larval A. simplex (Bishop and Margolis 1955). The common occurrences of these parasites in fishes of the Northwest Atlantic indicates that the area is within the physiological range of the parasites, thus fulfilling Kabata's fifth condition.

Based on qualitative and quantitative differences in the parasite fauna, capelin from the Gulf of St. Lawrence can be differentiated from capelin from N, NE and E Newfoundland waters as follows:

| | Prevalence % | Abundance |
|---|---|---|
| Gulf of St. Lawrence: | | |
| Lecithaster gibbosus | absent - 0 | |
| Contracaecum sp. | low - 7-15 | low - 0.07-0.19 |
| Hysterothylacium aduncum | high - 17-21 | high - 0.22-0.25 |
| N, NE and E Newfoundland waters: | | |
| Lecithaster gibbosus | present - 4-51 | |
| Contracaecum sp. | high - 17-78 | high - 0.19-1.65 |
| Hysterothylacium aduncum | low - 1-13 | low - 0.01-0.22 |

In samples collected in N, NE and E Newfoundland waters in 1980 (Table 1), significant difference in the abundance of Contracaecum sp. was observed (Table 3); an apparent relationship to capelin body length (Table 5) could not be substantiated (Fig. 2); however, Duncan's multiple range test (Fig. 4) indicated a correlation with sample distribution. Two groups are distinguished (Fig. 2 and 4). Of these two groups, the one with the lower abundance of Contracaecum sp. (Group 2, Fig. 2) possibly represents capelin that over-wintered in coastal waters. Winters (1970) found the abundance of nematode larvae in capelin over-wintering in Trinity Bay, Newfoundland, in March 1968, to be low (0.32-0.37). This is a somewhat lower level than found in a sample (S-10, Table 3) from this area in June 1980, in which the abundance was 0.52. The group of samples with the higher abundance (Group 1, Fig. 2) of Contracaecum sp. probably represents capelin that have migrated from offshore to spawn in inshore areas of N, NE and E Newfoundland and the southeast shoal of the Grand Banks (Campbell and Winters 1973).

Unfortunately samples collected in the above areas in 1981 could not be similarly divided into two distinct groups. In 1981, the abundance of Contracaecum sp. in samples of male capelin from N, NE and E Newfoundland waters increased with increasing average length of fish (Fig. 3) and the observed variation in abundance between samples of Contracaecum sp. can be attributed to this fact. In view of these differing results from two years of sampling, it is evident that data collected over any one year must be treated with caution and further study is necessary to test the validity of the suggested difference between capelin over-wintering in inshore and offshore waters.

The few samples of male capelin taken outside the Northwest Atlantic give somewhat limited information of general differences in parasite fauna between samples taken in Northwest Atlantic, Icelandic waters and Barents Sea. The most obvious difference is that Digenea were absent from samples taken in Barents Sea and practically absent from samples taken in Icelandic water, while L. gibbosus was relatively common in capelin taken in N, NE and E Newfoundland waters. The helminth fauna of male capelin from these geographic areas is, however, similar in that all three species of larval nematodes were present in all samples. This uniformity may reflect the fact that these particular larvae are non-host specific and are of common occurrence (Margolis and Arthur 1979, Polyanskii 1955). However, the relative prevalence and abundance of *Contracaecum* sp. and *H. aduncum* differed between areas: *Contracaecum* sp. was more common that *H. aduncum* in samples taken in N, NE and E Newfoundland waters (18-78% compared to 1-13%) (Table 4) and the Barents Sea (63% compared to 19%), while *Contracaecum* sp. was less common than *H. aduncum* in samples from the Gulf of St. Lawrence (7-15% compared to 17-21%) and in a sample from the SW coast of Iceland (31% compared to 78%). Thus, the difference, is quantitative but not qualitative.

As a practical tool for stock identification the qualitative and quantitative differences in the helminth fauna observed in the present study have led to a means to distinguish between stocks of capelin in the Gulf of St. Lawrence and in N, NE and E Newfoundland waters. However, the utilization of parasites to differentiate further between stocks of capelin in N, NE and E Newfoundland waters was unsuccessful.

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Table 1. Geographic locations of samples of mature male capelin (Mallotus villosus (Müller) taken in Northwest Atlantic (Newfoundland waters and Gulf of St. Lawrence) in 1980 and 1981, and samples taken in North Atlantic and Barents Sea in 1980 (N = 100 for each sample).

| Locality | | Date | Sample No. | Sampling gear |
|---|---|---|---|---|
| Northwest Atlantic | | | | |
| Middle Cove | 47°39'N 52°41'W | 80-06-27 | S-7 | Castnet |
| Plate Cove/Bonavista Bay | 48°31'N 53°30'W | 80-06-29 | S-8 | Castnet |
| Grand Banks | 44°22'N 49°57'W | 80-06-30 | S-9 | Bottom Trawl |
| Greens Harbour/Trinity Bay | 47°39'N 53°31'W | 80-07-01 | S-10 | Purse seine |
| Holyrood/Conception Bay | 47°24'N 53°08'W | 80-07-07 | S-12 | Purse seine |
| Twillingate/Notre Dame Bay | 49°40'N 54°46'W | 80-07-10 | S-13 | Castnet |
| West Coast of Newfoundland[a] | 49°15'N 58°25'W | 80-04-27 | S-4 | Bottom Trawl |
| Gaspê Peninsula[a] | 48°10'N 64°30'W | 80-06-05 | S-14 | Castnet |
| St. Mary's Bay | 46°50'N 53°45'W | 81-06-01 | S-101 | Purse seine |
| Bay Roberts/Conception Bay | 47°36'N 53°16'W | 81-06-17 | S-102 | Purse seine |
| Bay Roberts/Conception Bay | 47°36'N 53°16'W | 81-07-02 | S-103 | Purse seine |
| Blackhead Bay/Bonavista Bay | 48°35'N 53°16'W | 81-06-26 | S-104 | Castnet |
| New Harbour/Trinity Bay | 47°36'N 53°33'W | 81-06-17 | S-105 | Purse seine |
| Middle Cove | 47°39'N 52°41'W | 81-06-18 | S-106 | Castnet |
| Middle Cove | 47°39'N 52°41'W | 81-06-25 | S-107 | Castnet |
| Grand Banks | 47°20'N 52°22'W | 81-06-10 | S-108 | Bottom trawl |
| Grand Banks | 46°54'N 50°41'W | 81-06-12 | S-109 | Bottom trawl |
| Grand Banks | 46°41'N 51°56'W | 81-06-13 | S-111 | Bottom trawl |
| Grand Banks | 45°28'N 49°53'W | 81-06-19 | S-115 | Bottom trawl |
| Grand Banks | 44°08'N 49°40'W | 81-06-26 | S-112 | Bottom trawl |
| North Atlantic | | | | |
| Iceland SW-Coast | 63°40'N 22°30'W | 80-03-04 | S-3 | Purse seine |
| North of Iceland | 68°17'N 19°30'W | 80-10-20 | S-20 | Midwater trawl |
| Barents Sea | 74°27'N 39°00'E | 80-09-16 | S-17 | Midwater trawl |

[a]In the text west coast of Newfoundland and Gaspê Peninsula are noted together as Gulf of St. Lawrence.

Table 2. Lecithaster gibbosus (Rudolphi, 1802) Luhe, 1901: prevalence, abundance and intensity of infection in mature male capelin (Mallotus villosus (Müller)) taken during 1980 and 1981 in various localities within Newfoundland waters and the Gulf of St. Lawrence (N = 100 for each sample).

| Locality | Year | Sample No. | Prevalence (%) | Abundance | Intensity Mean | Intensity Range |
|---|---|---|---|---|---|---|
| N, NE, E Newfoundland waters: | | | | | | |
| Middle Cove | 1980 | S-7 | 11 | 0.12 | 1.1 | 1-2 |
| Plate Cove | 1980 | S-8 | 16 | 0.23 | 1.4 | 1-3 |
| 44°22'N 49°57.5'W | 1980 | S-9 | 43 | 0.93 | 1.9 | 1-8 |
| Greens Harbour | 1980 | S-10 | 4 | 0.08 | 2.0 | 1-3 |
| Holyrood | 1980 | S-12 | 51 | 1.34 | 2.6 | 1-18 |
| Twillingate | 1980 | S-13 | 39 | 0.76 | 1.9 | 1-6 |
| West coast of Newfoundland[a] | 1980 | S-4 | 0 | - | | |
| Gaspê Peninsula[a] | 1980 | S-14 | 0 | - | | |
| St. Mary's Bay | 1981 | S-101 | 40 | 0.93 | 2.3 | 1-19 |
| Bay Roberts | 1981 | S-102 | 18 | 0.35 | 1.9 | 1-5 |
| Bay Roberts | 1981 | S-103 | 39 | 0.78 | 2.0 | 1-6 |
| Blackhead Bay | 1981 | S-104 | 30 | 0.78 | 2.6 | 1-29 |
| New Harbour | 1981 | S-105 | 26 | 0.41 | 1.6 | 1-7 |
| Middle Cove | 1981 | S-106 | 7 | 0.13 | 1.9 | 1-6 |
| Middle Cove | 1981 | S-107 | 20 | 0.66 | 3.3 | 1-14 |
| Grand Banks: | | | | | | |
| 47°20'N 52°22'W | 1981 | S-108 | 2 | 0.02 | 1.0 | |
| 46°54'N 50°41'W | 1981 | S-109 | 7 | 0.08 | 1.1 | 1-2 |
| 46°41'N 51°56'W | 1981 | S-111 | 19 | 0.29 | 1.5 | 1-4 |
| 44°08'N 49°40'W | 1981 | S-112 | 5 | 0.06 | 1.2 | 1-2 |
| 45°28'N 49°53'W | 1981 | S-115 | 1 | 0.01 | 1.0 | |

[a]In the text, west coast of Newfoundland and Gaspê Peninsula are noted together as Gulf of St. Lawrence.

Table 3. F-values from analysis of variances of length of capelin (*Mallotus villosus* (Müller)), abundance of larval *Anisakis simplex* (Rudolphi, 1809) Dujardin, 1845, larval *Contracaecum* sp. and larval *Hysterothylacium aduncum* (Rudolphi, 1802) Deardorff and Overstreet, 1981, for samples of mature male capelin taken in N, NE and E Newfoundland waters and Gulf of St. Lawrence in 1980 and in N, NE and E Newfoundland waters in 1981.

| | | Computed F-values | | | |
|---|---|---|---|---|---|
| | | | Abundance | | |
| | Degrees of freedom | Length of capelin | *A. simplex* | *Contracaecum* sp. | *H. aduncum* |
| 1980 | | | | | |
| All samples | 7 and 792 | 49.53[b] | 3.40[b] | 22.44[b] | 6.13[b] |
| N, NE and E Newfoundland | 5 and 495 | 1.35[b] | 2.68[a] | 11.99[b] | 1.17 |
| 1981 | | | | | |
| All samples | 11 and 1188 | 90.11[b] | 1.20 | 16.88[b] | 1.17 |

[a] $P < 0.05$.

[b] $P < 0.01$.

Table 4. *Anisakis simplex* (Rudolphi, 1809) Dujardin, 1845, *Contracaecum* sp., and *Hysterothylacium aduncum* (Rudolphi, 1802) Deardorff and Overstreet, 1981, third stage larvae; prevalence, abundance and intensity of infection in mature male capelin (*Mallotus villosus* (Müller)) taken during 1980 and 1981 in various localities within Newfoundland waters and the Gulf of St. Lawrence (N = 100 for each sample).

| | | | *Anisakis simplex* | | | | *Contracaecum* sp. | | | | *Hysterothylacium aduncum* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Intensity | | | | Intensity | | | | Intensity | |
| | Year | Sample No. | Prevalence (%) | Abundance | Mean | Range | Prevalence (%) | Abundance | Mean | Range | Prevalence (%) | Abundance | Mean | Range |
| N, NE, E Newfoundland waters: | | | | | | | | | | | | | | |
| Middle Cove | 1980 | S-7 | 3 | 0.03 | 1.0 | | 20 | 0.25 | 1.2 | 1-4 | 1 | 0.01 | 1.0 | |
| Plate Cove | 1980 | S-8 | 12 | 0.12 | 1.0 | | 50 | 0.77 | 1.5 | 1-5 | 4 | 0.04 | 1.0 | |
| 44°22'N 49°57.5'W | 1980 | S-9 | 13 | 0.15 | 1.1 | 1-2 | 54 | 0.84 | 1.6 | 1-3 | 5 | 0.07 | 1.4 | 1-2 |
| Greens Harbour | 1980 | S-10 | 5 | 0.05 | 1.0 | | 30 | 0.41 | 1.4 | 1-3 | 6 | 0.06 | 1.0 | |
| Holyrood | 1980 | S-12 | 6 | 0.06 | 1.0 | | 18 | 0.19 | 1.1 | 1-2 | 13 | 0.15 | 1.2 | 1-2 |
| Twillingate | 1980 | S-13 | 7 | 0.07 | 1.0 | | 56 | 0.89 | 1.6 | 1-4 | 7 | 0.07 | 1.0 | |
| West coast of Newfoundland[a] | 1980 | S-4 | 13 | 0.14 | 1.1 | 1-2 | 15 | 0.19 | 1.3 | 1-4 | 17 | 0.22 | 1.3 | 1-4 |
| Gaspé Peninsula[a] | 1980 | S-14 | 18 | 0.21 | 1.2 | 1-2 | 7 | 0.07 | 1.0 | | 21 | 0.25 | 1.2 | 1-2 |
| St. Mary's Bay | 1981 | S-101 | 29 | 0.37 | 1.3 | 1-3 | 63 | 1.23 | 2.0 | 1-5 | 8 | 0.22 | 2.8 | 1-7 |
| Bay Roberts | 1981 | S-102 | 15 | 0.24 | 1.6 | 1-4 | 62 | 1.20 | 1.9 | 1-5 | 5 | 0.05 | 1.0 | |
| Bay Roberts | 1981 | S-103 | 17 | 0.24 | 1.4 | 1-3 | 32 | 0.51 | 1.6 | 1-4 | 4 | 0.04 | 1.0 | |
| Blackhead Bay | 1981 | S-104 | 20 | 0.24 | 1.2 | 1-2 | 61 | 1.12 | 1.8 | 1-5 | 3 | 0.03 | 1.0 | |
| New Harbour | 1981 | S-105 | 26 | 0.29 | 1.1 | 1-2 | 73 | 1.65 | 2.3 | 1-7 | 4 | 0.05 | 1.3 | 1-2 |
| Middle Cove | 1981 | S-106 | 29 | 0.34 | 1.2 | 1-3 | 78 | 1.59 | 2.0 | 1-5 | 5 | 0.05 | 1.0 | |
| Middle Cove | 1981 | S-107 | 20 | 0.24 | 1.2 | 1-3 | 45 | 0.77 | 1.7 | 1-6 | 6 | 0.07 | 1.2 | 1-2 |
| Grand Banks: | | | | | | | | | | | | | | |
| 47°20'N 52°22'W | 1981 | S-108 | 15 | 0.18 | 1.2 | 1-3 | 45 | 0.85 | 1.9 | 1-6 | 7 | 0.09 | 1.3 | 1-3 |
| 46°54'N 50°41'W | 1981 | S-109 | 24 | 0.30 | 1.3 | 1-3 | 26 | 0.47 | 1.8 | 1-6 | 10 | 0.12 | 1.2 | 1-2 |
| 46°41'N 51°56'W | 1981 | S-111 | 32 | 0.35 | 1.1 | 1-2 | 17 | 0.20 | 1.2 | 1-3 | 5 | 0.07 | 1.4 | 1-3 |
| 44°08'N 49°40'W | 1981 | S-112 | 21 | 0.31 | 1.5 | 1-5 | 41 | 0.65 | 1.6 | 1-5 | 6 | 0.07 | 1.2 | 1-2 |
| 45°28'N 49°53'W | 1981 | S-115 | 27 | 0.32 | 1.2 | 1-3 | 47 | 0.70 | 1.5 | 1-4 | 5 | 0.08 | 1.6 | 1-4 |

[a] In the text, west coast of Newfoundland and Gaspé Peninsula are noted together as Gulf of St. Lawrence.

Table 5. Comparison of number of fish in each age-class, mean length of fish and abundance of larval Contracaecum sp. between samples of male capelin (Mallotus villosus (Müller)) collected at different times in same localities in NE Newfoundland waters in 1981.

| Locality | Date | No. of fish in age-class 3 | 4 | 5 | 6 | Average length of capelin (mm) | Contracaecum sp. Abundance | Prevalence (%) |
|---|---|---|---|---|---|---|---|---|
| Middle Cove | 81-06-18 | 16 | 57 | 26 | 1 | 186 | 1.59 | 78 |
| Middle Cove | 81-06-25 | 69 | 21 | 10 | 0 | 176 | 0.77 | 45 |
| Bay Roberts | 81-06-17 | 38 | 33 | 27 | 2 | 183 | 1.20 | 62 |
| Bay Roberts | 81-07-02 | 63 | 27 | 9 | 1 | 175 | 0.51 | 32 |

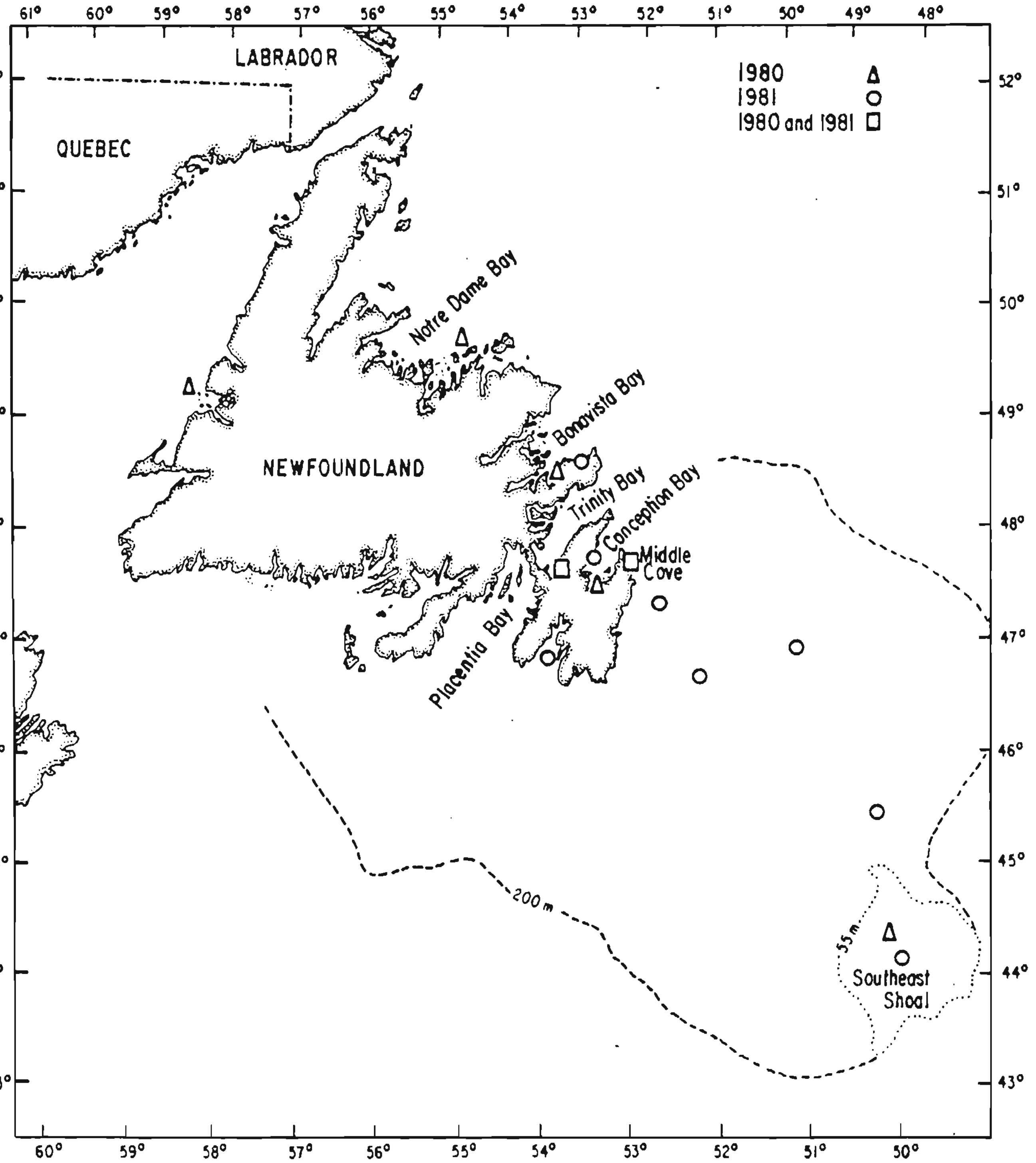


Fig. 1. Collection sites for male capelin (Mallotus villosus (Müller)) taken in Newfoundland waters in 1980 and 1981.

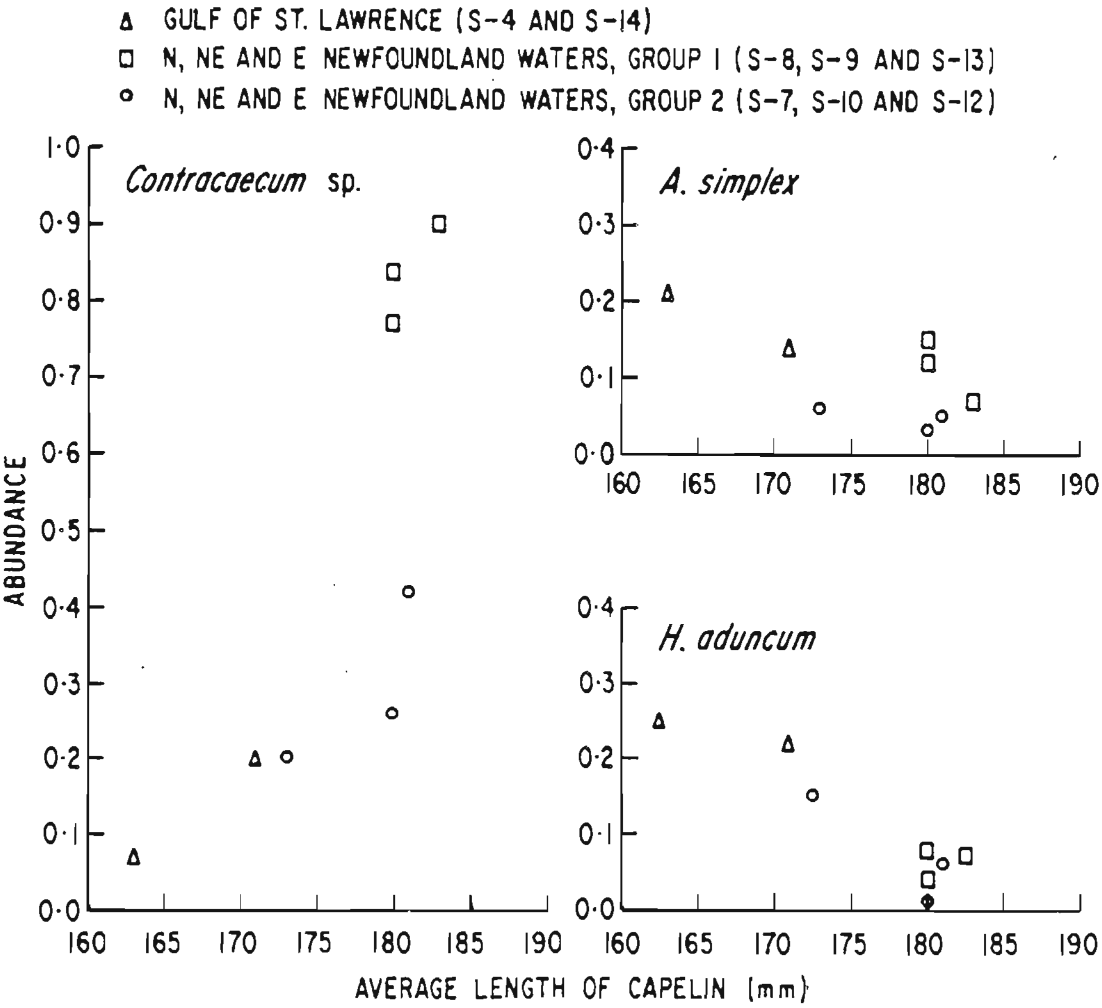


Fig. 2. Relationship between average length (mm) of male capelin (Mallotus villosus (Müller)) and abundance (transformed data) of larval Anisakis simplex (Rudolphi 1809) Dujardin 1845, larval Hysterothylacium aduncum (Rudolphi 1802) Deardorff and Overstreet 1981 and larval Contracaecum sp. in samples of male capelin taken in NW Atlantic and Gulf of St. Lawrence in 1980.

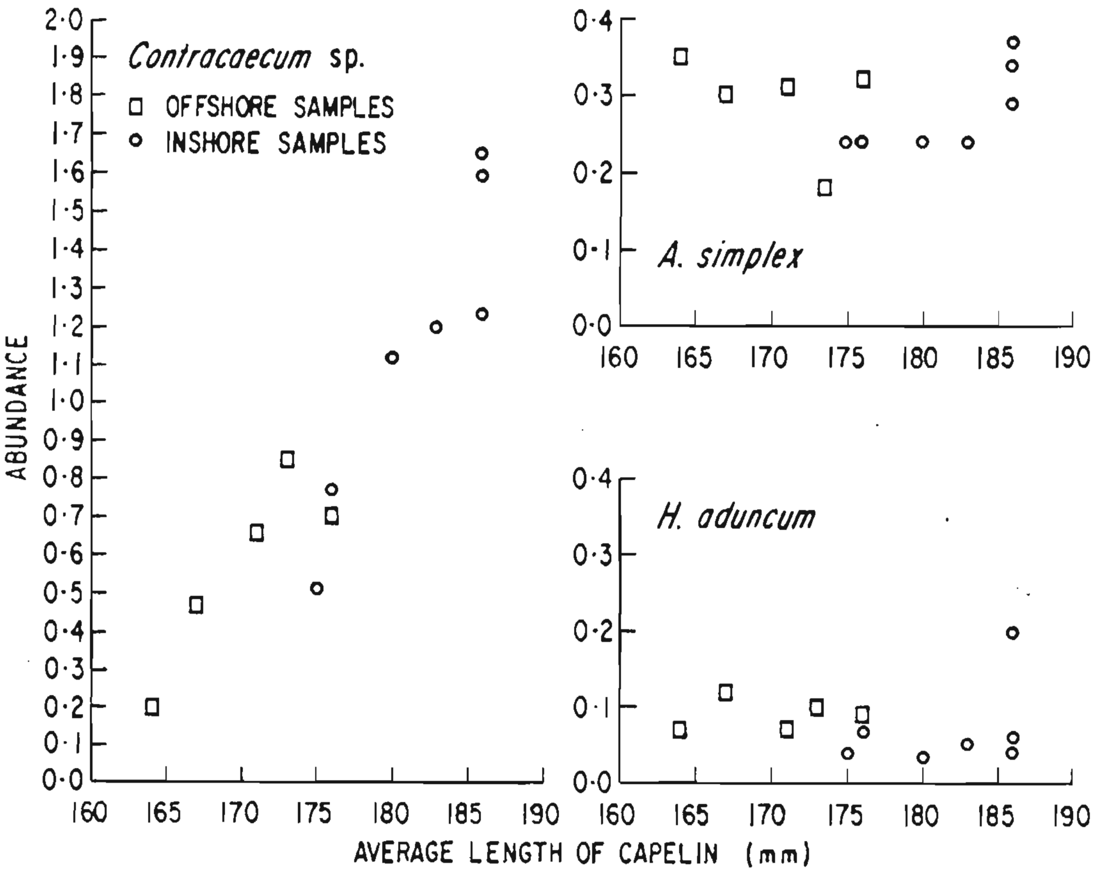


Fig. 3. Relationship between average length (mm) of male capelin (Mallotus villosus (Müller)) and abundance of larval Anisakis simplex (Rudolphi 1809) Dujardin 1845, larval Hysterothylacium aduncum (Rudolphi 1802) Deardorff and Overstreet 1981 and larval Contracaecum sp. in samples of capelin taken in N, NE and E Newfoundland waters in 1981.

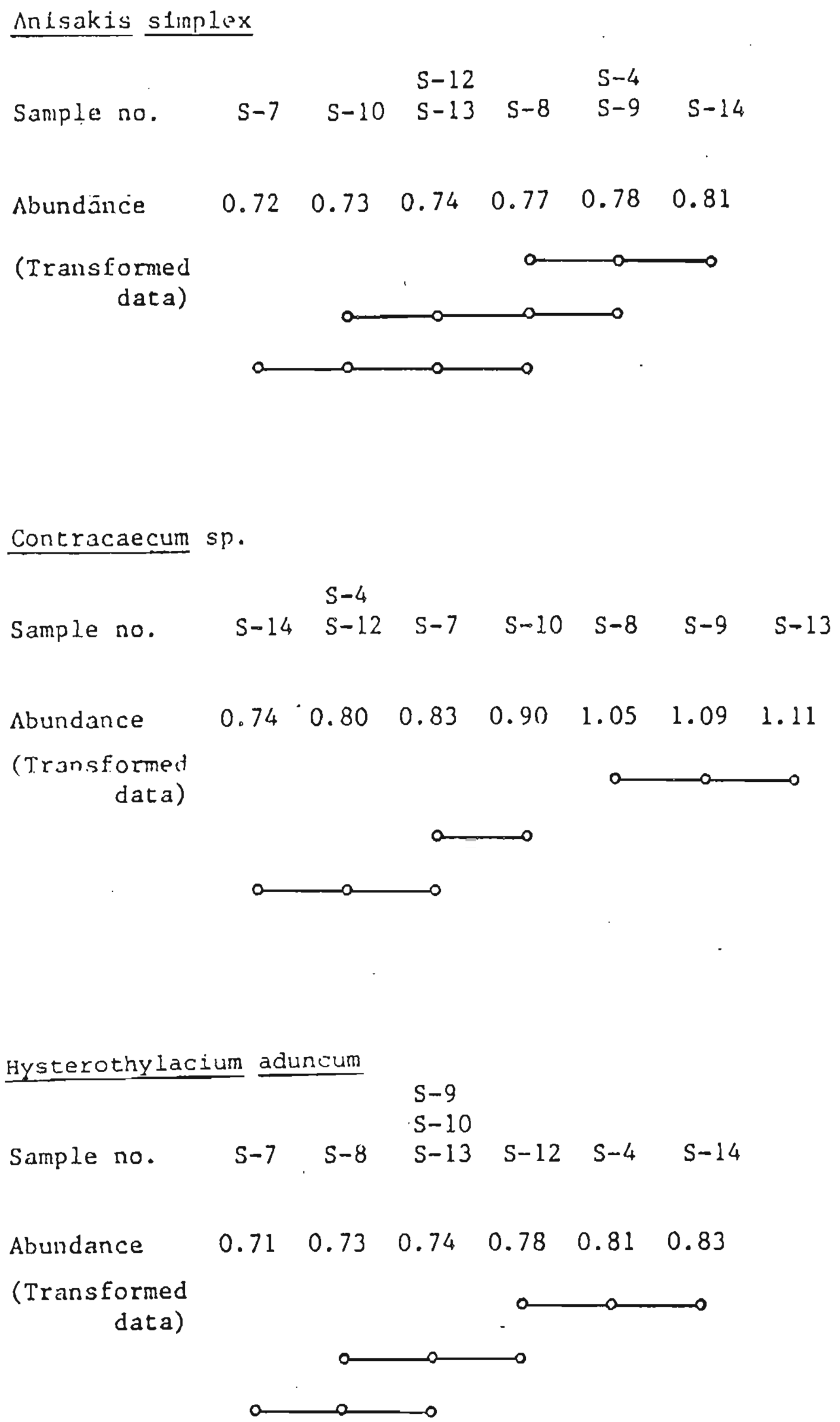


Figure 4. Comparison between samples of male capelin (Mallotus villosus (Müller)) taken in 1980 from various locations in the Northwest Atlantic and Gulf of St. Lawrence (Table 1) based on abundance of three species of larval nematodes (Anisakis simplex, Contracaecum sp. and Hysterothylacium aduncum), using Duncan's multiple range test. Samples with a common line do not differ significantly ($P < 0.05$).

Contracaecum sp.

| Sample no. | S-111 | S-109 | S-103 | S-112 | S-115 | S-107 | S-108 | S-104 | S-102 | S-101 | S-105 | S-106 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Abundance (Transformed data) | 0.81 | 0.91 | 0.94 | 1.00 | 1.03 | 1.04 | 1.07 | 1.19 | 1.21 | 1.22 | 1.36 | 1.37 |

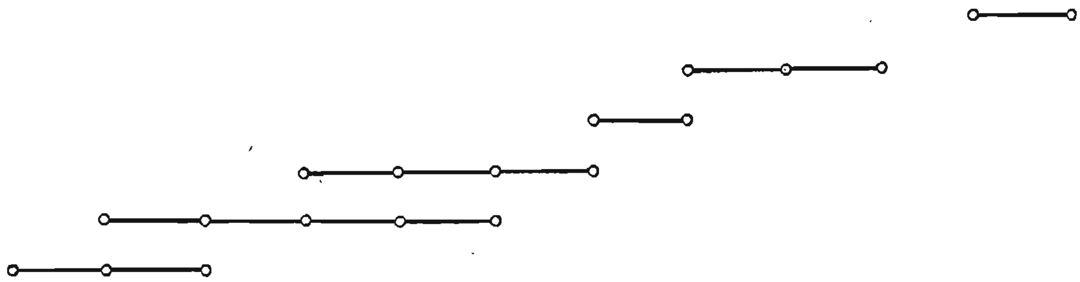

Figure 5. Comparison between samples of male capelin (*Mallotus villosus* (Müller) taken in 1981 from various locations in the Northwest Atlantic (Table 1) based on abundance of larval *Contracaecum* sp., using Duncan's multiple range test. Samples with a common line do not differ significantly ($P < 0.05$).