PARASITIC FAUNA, DIET, AND LENGTH-WEIGHT-AGE RELATIONSHIPS OF COD STOCKS OFF COASTAL LABRADOR WITHIN NAFO DIVISIONS 2H AND 2J

EUGENE M. LEE

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Parasitic Fauna, Diet, and Length-Weight-Age Relationships of Cod Stocks off Coastal Labrador Within NAFO Divisions 2H and 2J.

by

Eugene M. Lee, B.Sc. Hon.

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ABSTRACT

Atlantic cod (*Gadus morhua* Linnaeus 1758) were sampled on coastal Labrador in August of 1985 at Makkovik (northern portion of NAFO (North Atlantic Fisheries Organization) division 2J) and at St. Lewis (southern portion of NAFO division 2J). A number of biological parameters were compared between the sample areas. These included length-weight-age relationships, diet, and parasitic fauna (nematodes, trematodes, acanthocephalans, and myxozoans). Cod from the two areas were significantly different from each other in prevalences and abundances of nematodes, an acanthocephalan, and a myxozoan. This indicated that separate sub-stocks of cod might exist within the all-encompassing Labrador - East Newfoundland cod stock complex. The present study was carried out in 1986 and 1987 with the same methodology but a larger scope. Sampling at St. Lewis was repeated in 1986 and 1987, sampling at Makkovik was repeated in 1986, three offshore sites parallel to these areas were sampled in February of 1986, and a sample was taken from the more northerly location of Nain (NAFO division 2H) in September of 1987. The results did not concur with the previous work. Prevalence and abundance levels of parasites examined were found to vary significantly with respect to both time and location. No consistently significant patterns were observed for any of the biological parameters examined. Based upon this result it was concluded that Atlantic cod which occur in NAFO divisions 2H and 2J cannot be distinguished in this way.

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1.0 INTRODUCTION

1.1 Background

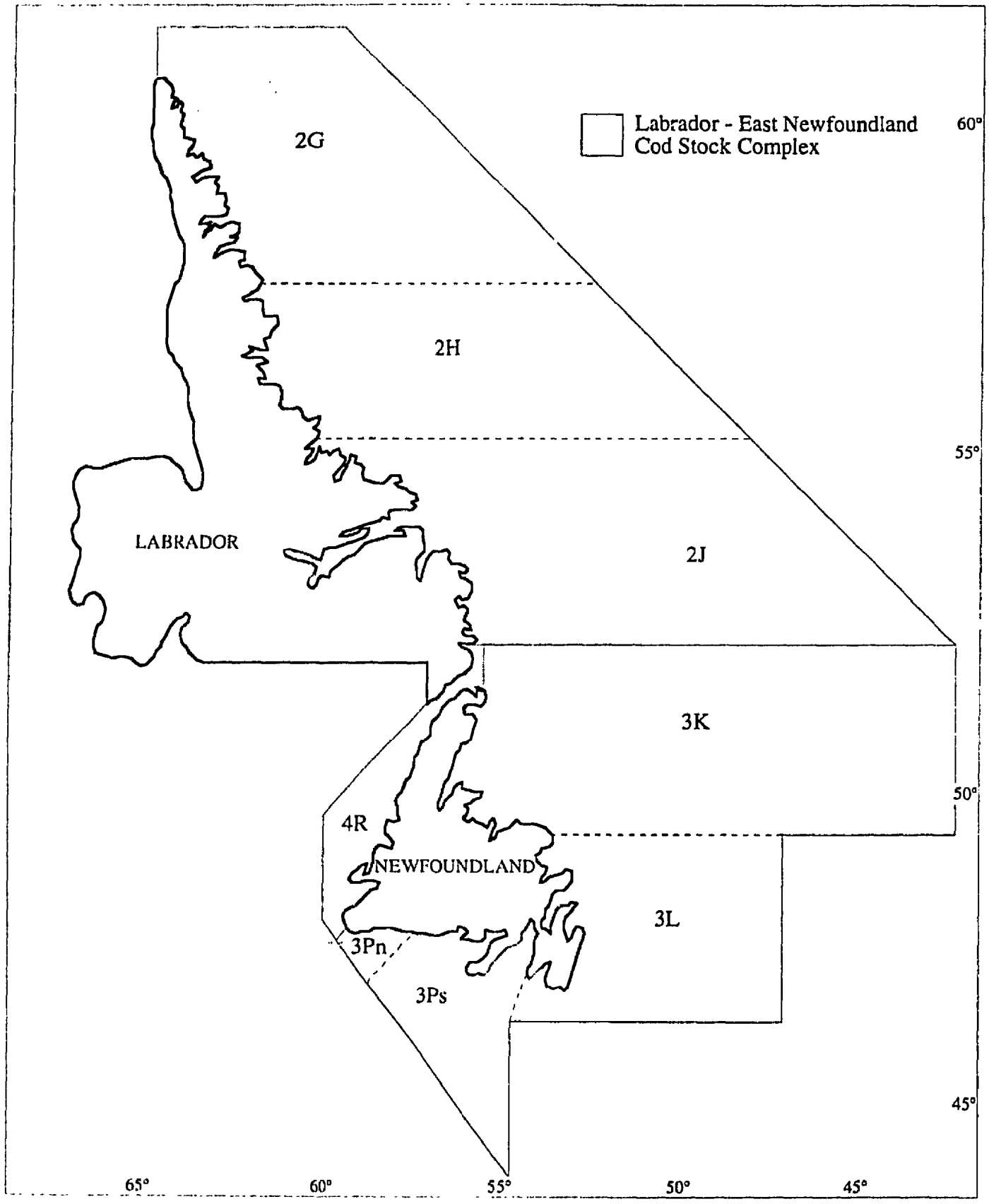
Atlantic cod *Gadus morhua* (Linnaeus 1758) has always been the most important commercial species in the Newfoundland and Labrador fishery (Pinhorn 1969). Knowledge of fish stocks is an important factor in fisheries science since it enables researchers to calculate the maximum sustainable yield of a particular stock and determine how fishing effort should be distributed over an entire stock complex without causing catastrophic results to the population. In this paper, " population" refers to the cod occupying any defined area at a particular time. The word "stock" is used to denote more unity in the group with regard to its greater degree of intermingling within itself and considerably less mixing with other groups, or withdrawal to its own territory during some part of the year, either for spawning or feeding (Templeman 1962).

Stock discrimination in cod off Newfoundland and Labrador encompassing North Atlantic Fisheries Organization (NAFO) divisions 2G - 2H - 2J - 3K - 3L (Figure 1), has been studied using a number of different methods, including: (1) tagging and recapture (Templeman 1953, 1962, 1974, 1979; Templeman and Fleming 1962; Lear 1982, 1984a, 1984b, 1986); (2) biochemical systematics (Jamieson 1975, Cross and Payne 1978, Mork et al. 1985, Smith et al. 1989, Carr and Marshall 1991a, 1991b, Dahle 1991); (3) otolith shape analysis (Campana and Casselman 1993); (4) meristics (Postolaky 1962, Stanek 1968, Templeman 1981, Lear 1982, Lear and Wells 1984); (5) growth rates (Templeman 1953, Fleming 1960, Postolaky 1962, May et al. 1965, Aikenhead et al. 1982); (6) size

and age at sexual maturity (Templeman 1960, Fleming 1960); (7) spawning times and locations (Templeman 1962, 1964, 1965, 1979, 1981; Serebryakov 1967, Noskov and Zakharov 1964, Bogdanov et al. 1965, Dias 1965, 1967, 1968, 1971, 1972; Chrzan 1968, Monteiro and Dias 1964); and (8) parasites as biological tags (Templeman 1953; Templeman et al. 1957, 1976; Templeman and Fleming 1963, Postolaky 1962; Khan et al. 1980a, 1980b, 1982; Wells et al. 1985; Lee 1986, Bishop et al. 1988).

Templeman (1953, 1962, 1974, 1979, 1981), Templeman et al. (1957, 1960, 1963) and Lear (1982, 1984a, 1984b, 1986) deduced from tagging experiments, morphometric studies, and parasite data that there is a Labrador - East Newfoundland cod stock complex inhabiting NAFO divisions 2J-3K-3L (Figure 1) This area occupies the coastal and continental shelf areas east of Newfoundland and Labrador and extends to the northern tip of the Grand Banks east of the Avalon Peninsula. Most cod stock discrimination studies in Newfoundland and Labrador have concentrated on areas south of 2J with relatively little work performed in the northern regions (NAFO divisions 2G - 2H - 2J). Since the implementation of total allowable catches in 1973, the cod populations off southern Labrador and eastern Newfoundland, NAFO divisions 2J-3K-3L, have been managed as a single stock complex (ICNAF, 1974). The cod of northern Labrador (NAFO divisions 2G, 2H, and the northern portion of 2J) are also part of the Labrador - East Newfoundland cod stock complex but are usually considered separately for management purposes due to the deleterious effects of past overfishing in this area (Pinhorn 1976).

Figure 1. Dimensions of the Labrador - East Newfoundland cod stock complex (adapted from Templeman 1962 and Pinhorn 1976).



1.2 Parasites as Natural Tags for Marine Fish

Over the past century, parasites have been employed in numerous animal studies as 'indicators', 'tags', or 'markers' of various aspects of host biology. The first documented use of parasites with respect to understanding the movements and/or population dynamics of marine fishes was the 1939 study by Dogiel and Dykhovski which distinguished between two groups of acipenserids in the Caspian Sea using the monogeneans *Diclybothrium circularis* and *Nitzschia sturionis* . Research on parasites as natural tags for aquatic hosts is rapidly increasing. Williams et al. (1992) documents nine relevant papers from the 1950's, more than 30 for the 1960's, more than 50 from the 1970's, and over 140 from the 1980's. Mackenzie (1992) also notes that from 1980 to the present, most studies have been conducted upon fish species of commercial importance.

Parasites as biological tags can be more appropriate in certain fish population studies than artificial tags. This is especially true in studies of delicate or deepwater species which can experience high mortality rates due to handling stress or pressure differences encountered upon being trawled up from deep water. Herrington et al. (1939) used parasites as tags for redfish (*Sebastes sp.*) due to high mortalities experienced when the fish were brought up from deep water for artificial tagging and returned to the sea. Parasite tags have also been employed to study crustaceans such as *Homarus americanus* (Bratley and Campbell 1986), which may shed artificial tags during the moulting process. Specialized artificial tagging experiments tend to be conducted independently over a long period of time and usually at a significant cost, whereas fish for parasitological examination can be obtained from routine sampling programmes. Concerns have also been raised as to the possibility of abnormal behaviour in artificially tagged fish due to irritation or infection; the use of parasites as tags

can eliminate this problem.

A number of generally accepted guidelines have arisen over time with respect to the use of parasites as biological indicators of host populations. The following list is taken from Williams et al. (1992) and has been condensed from Kabata (1963), Sindermann (1961, 1983), MacKenzie (1983, 1987), Lester (1990), and Möser (1991).

1. The parasite should have significantly different levels of infection in the subject host in different parts of the study area (i. e. differences in prevalence and /or mean abundance of infection between samples).

2. The life cycle of the parasite should preferably involve only a single host. This, however, does not eliminate the use of parasites with complex life cycles which usually require more work and a wider study (Williams et al. 1992). In fact, many parasites with multiple hosts have proved to be good biological indicators.

3. The parasite should have a life span, or remain in an identifiable form in the subject host, sufficiently long to cover the time scale of the investigation.

4. The prevalence of a tag parasite should remain relatively stable from season to season and from year to year. Seasonal variations, however, can be used to determine seasonal migrations of the subject host

5. The environmental conditions throughout the area studied should preferably be

constant within the physiological range of the parasite intended as a tag. This implies that a good knowledge of the ranges of tolerance of a proposed tag parasite and its hosts is important.

6. The parasite should be easily detected and identified, preferably by gross examination. If a parasite is easily confused with other species, the time taken to confirm the identity of each specimen may become a limiting factor.

7. Examination of the host for a tag parasite should involve the minimum of dissection. A high degree of site specificity is an advantage.

8. The tag parasite should have no marked pathological effects on the subject host. A highly pathogenic parasite may cause selective mortalities or behavioral changes in infected fish which will reduce its value as a tag.

A natural tag which can satisfy all of these attributes is rarely encountered, and as such, compromises are usually made when choosing a parasite for study. Departure from the ideal situation may be overcome by using several different parasites simultaneously and employing appropriate multivariate statistical procedures, both in sampling design and in data analysis (Sindermann 1983).

1.3 Previous Parasitic Studies on Cod

Parasites have been employed as biological tags in the past to discriminate the cod stocks of Newfoundland and Labrador. Templeman et al.(1957) made inferences regarding stock divisions and migrations of cod off eastern Canada using the nematodes *Pseudoterranova decipiens* and *Anisakis sp.* The incidence of the parasitic copepod *Lernaeocera branchialis* was found to be indicative of the extent and the degree of inshore-offshore migration of cod and also served to delineate the cod of the Flemish Cap as a separate offshore stock (Templeman 1963, Templeman et al. 1976). Khan et al. (1980) observed that the infection of eastern Newfoundland cod with the protozoan *Trypanosoma murmanensis* (which is transmitted by the cold water leech *Johanssonia arctica)* was useful in discriminating between cold-water and warm-water cod stocks. Cod taken on coastal Labrador and northern Newfoundland had a high prevalence of trypanosome infection (94%) while the more easterly bays had intermediate levels (13-16%), and the lowest prevalences (4%) were encountered at four inshore localities within the Gulf of St. Lawrence. Sherman and Wise (1961) used the prevalence of the parasitic copepod *Lernaeocera branchialis* to indicate a discrete cod population off southern New England which was free of infestation. An increasing gradient of prevalences extending northward permitted the identification of three more discrete cod subgroups consisting of the northern Gulf of Maine, the southern Gulf of Maine, and the Georges Bank respectively. Platt (1976) used infestation rates of the larvae of the codworm *Pseudoterranova decipiens* as a biological indicator of the degree of mixing of Greenland and Iceland cod stocks. The codworm larvae was found to be virtually absent from cod at Greenland and abundant in cod from Iceland. A reduction in the characteristic level of infection encountered on the Icelandic spawning grounds led to the conclusion there was intermingling of the two stocks. These findings were later

confirmed by studies of egg and larval drift and artificial tagging work (Boje 1987). Khan et al. (1986) conducted a general survey of myxozoan parasites of marine fishes of the Newfoundland and Labrador region. This work concluded that the myxozoan parasite *Myxidium gadi* (Georgevitch 1916) is potentially a useful indicator in identifying discrete populations of cod or their general geographical areas. Cod from the Flemish Cap (NAFO division 3M), which rarely intermingle with other stocks (Templeman 1974), harboured a higher prevalence of *M. gadi* than cod from the Grand Banks (NAFO divisions 3L, 3N, and 3O). A preliminary investigation of the parasitic fauna of cod from east Greenland by Boje (1987) identified 4 species of trematodes, 9 species of nematodes, and 1 species of acanthocephalan. Of these parasites the trematode *Hemiurus levinseni* and the nematode *Hysterothylacium aduncum* were found to have marked differences in prevalences and intensities between the investigated localities. *Hemiurus levinsini* had a higher prevalence in inshore waters (89%) than offshore waters (< 4%), whereas *Hysterothylacium aduncum* had higher prevalence and abundance rates in the offshore waters off east Greenland than anywhere else. Both parasites have a good potential as biological tags.

1.4 Study Rationale

As was mentioned previously Templeman (1953, 1962, 1974, 1979, 1981), Templeman et al. (1957, 1960, 1963) and Lear (1982, 1984a, 1984b, 1986) concluded that there is a Labrador - East Newfoundland cod stock complex inhabiting NAFO divisions 2J-3K-3L. This stock complex occupies the coastal and continental shelf areas east of Newfoundland and Labrador and extends to the northern tip of the Grand Banks east of the Avalon Peninsula. Cod tagging performed by Templeman and Fleming (1962) at Nutak in northern Labrador (NAFO division 2H) resulted in low levels of recapture outside of the

original tagging area. Only one fish was recaptured south of the tagging area in southern Labrador, while none were retrieved south of the Labrador coast. May (1961) observed a three centimeter difference in growth rate for each size class between cod of the NAFO divisions 2G and 2H and the more southern division 2J, indicating an increase in the growth of cod from north to south. Additional tagging studies by Templeman (1974) and Postolaky (1966) led the authors to hypothesize that cod from the more northern range of the Labrador-East Newfoundland stock complex may be composed of several interrelated components. A northern component would occupy NAFO divisions 2H and 2G, a central component would inhabit NAFO division 2J and the northern portion of NAFO division 3K, and a southern component would occupy NAFO division 3L and the southern portion of NAFO division 3K. Templeman (1962) also made the point that sufficient differences (via artificial tagging, commercial catch records, and parasites as biological tags) would be found in future to indicate a number of north-south, and inshore-offshore sub-stock components.

Templeman (1962) stated that the onshore movement of feeding cod occurs earlier in southern Labrador (about the first week in July) than it does in the more northerly areas (about the first week in August). Therefore, samples taken inshore during August would be representative of a population during a relatively stable period with respect to migration or emigration. With this in mind, a study was initiated in 1985 in an attempt to confirm or refute the hypothesis that interrelated components exist within the Labrador-East Newfoundland stock complex (Lee 1986).

Cod were sampled in August 1985 at Makkovik (northern portion of NAFO division 2J)

and at St. Lewis (southern portion of NAFO division 2J). A number of biological parameters were compared between sample areas; these included length-weight-age relationships, diet, and parasitic fauna (Lee 1986). The results were encouraging with respect to stock separation. Makkovik fish were significantly different ($P< 0.05$) from St. Lewis fish in terms of the prevalence and intensities of the intestinal parasites acanthocephalans (*Echinorhynchus gadi*) and nematodes. The myxozoan *Myxidium gadi* located within the gall bladder, was also significantly different ($P< 0.05$) between both locations. Trematodes in the intestine of the digestive tract had a low frequency of occurrence in fish from both areas and there was no recognizable pattern between locations. *Anisakis sp.* infestation on the digestive caeca was variable between and within sites, and as such was not particularly useful for stock discrimination. Length-age-weight relationships provided little insight, although k-factors (condition factors) were significantly different between the two sites. Based upon conclusions from previous studies conducted in a similar fashion (e.g. Kabata 1967; Margolis 1963; Templeman 1962, 1963; Templeman et al. 1957; Templeman and Squires 1960; Platt 1976; Khan et al. 1980; Pippy 1980; Khan et al. 1982; Mackenzie and Mehl 1984; Lester et al. 1988; Wood et al. 1989), I concluded that there was adequate preliminary evidence for the existence of separate stocks of cod at Makkovik and St. Lewis, Labrador.

This previous conclusion was based upon ' a snapshot in time' in that all sampling was performed in a single month and year (August 1985) from both locations. Thus, while providing an insight into the possibility of separate stocks within the Labrador-East Newfoundland cod stock complex, the results also give rise to a number of new questions. Of major concern is whether the prevalence and abundance of the parasitic infections from

the various locations sampled remain consistent from year to year. The preliminary results also pose the question of how cod from the more northerly NAFO division 2H fit into the overall picture i.e. are they separate from their southern counterparts in NAFO division 2J or are they a part of the Makkovik stock identified in 1985? There is also the offshore environment to consider. Templeman (1962) states that there is a seasonal migration of cod inshore in the summer months for feeding and offshore in the winter months for spawning. This migration is believed to follow a generally parallel route between summer and winter locations. Based on this information one would expect to encounter similarities between cod sampled at both onshore and parallel offshore locations during the same year.

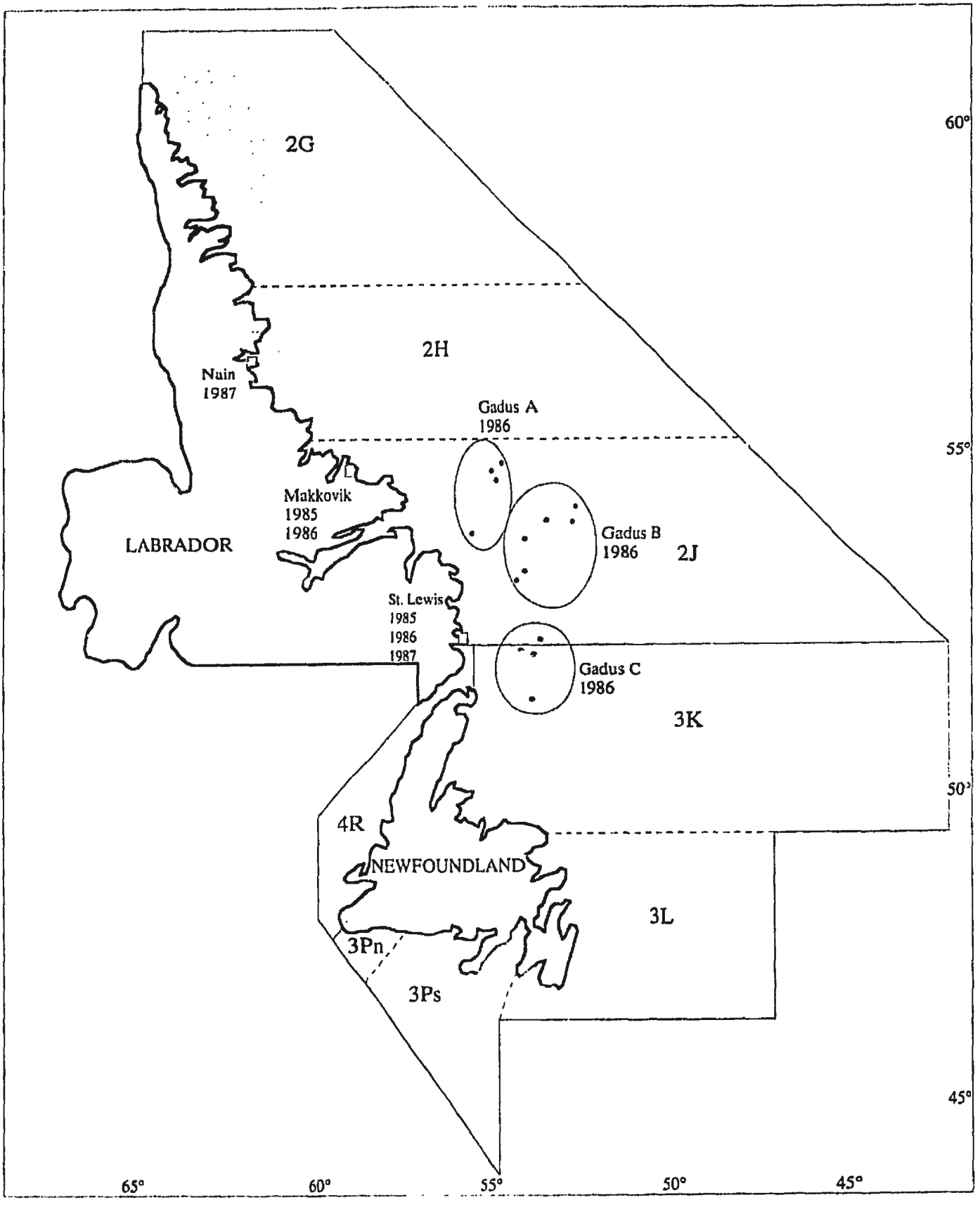
My study was initiated to address these questions. Makkovik (NAFO division 2J) was sampled in 1986, St. Lewis (NAFO division 2J) was sampled in 1986 and 1987, Nain (NAFO division 2H) was sampled in 1987, and offshore sampling was performed during 1986 at a number of stations parallel to the inshore communities of Makkovik and St. Lewis. As in Lee (1986), length-weight-age relationships, diet, and parasitic fauna were examined and compared for all sampling locations and years. With this expanded sampling strategy, it was felt that a more complete picture of the stock components which were previously identified could be elucidated.

2.0 MATERIALS AND METHODS

This study examined the diet, parasitic fauna, and length-weight-age relationships of Atlantic cod *Gadus morhua* over a three year period (1985, 1986, 1987) from samples collected at both inshore and offshore locations in the Labrador area (NAFO divisions 2H, 2J, and 3K). Cod from inshore locations were obtained by handline, codtrap, and gill nets from depths ranging from 30 to 100 meters. Offshore cod were obtained during the annual (1986) groundfish survey on board the 74 m Department of Fisheries and Oceans (DFO) research vessel Gadus Atlantica. Cod were sampled using an Engel-145 otter trawl with a 29 mm mesh liner inserted into the codend. Offshore sampling locations were chosen on the basis of a random stratified sampling strategy determined by DFO prior to departure. The sampling strategy employed at all locations was to obtain ten cod in each of five 10 cm length classes (31-40 cm, 41-50 cm, 51-60 cm, 61-70 cm, and 71-80 cm), however cod from other size classes were also taken on an opportunistic basis

In 1985, 46 cod were collected in the first week of August at Makkovik (NAFO division 2J) and 49 cod were collected in the third week of August at St. Lewis (NAFO division 2J). In 1986, 34 cod were collected in the first week of August at Makkovik and 41 cod were collected in the third week of August at St. Lewis. Offshore collections in 1986 (November 1-27) consisted of 31 cod from the northern portion of NAFO division 2J (Gadus Group A), 66 cod from the middle portion of NAFO division 2J (Gadus Group B) and 52 cod from an area straddling the demarcation between NAFO divisions 2J and 3K (Gadus Group C). In 1987, 42 cod were collected in [illegible]ugust at St. Lewis and 40 cod were collected in the second week of September at Nain (NAFO division 2H) (Figure 2).

Figure 2. Map indicating sampling locations and times.



The following parameters were recorded in the field: the length of each fish from the tip of the snout to the end of the tail (± 1 cm) using a two meter steel measuring tape, whole weight (± 0.05 kg) using hand held 15 kg scales (no weights were obtained for the offshore samples of Gadus A-B-C as the motion of the vessel prevented accurate readings), the presence and number of *Lernaeocera branchialis* on the gills, and sex of each fish. The digestive tract, from esophagus to anus, was removed, labelled, and frozen immediately. Gall bladders were removed, preserved in 70% alcohol, and separated on the basis 31-50 cm and 51-90+ cm length classes respectively. Otoliths were removed and placed into individual coin envelopes. Cod collected in 1985 were aged by microscopic examination of otoliths. Cod collected in 1986 and 1987 were aged using Department of Fisheries and Oceans age - length keys for the appropriate years and locations (Baird et al. 1986 *2J*, Bishop and Baird 1987 *2H*).

In the laboratory, the digestive tracts were thawed and the stomachs were examined independently from the digestive caeca and intestines. Stomach contents were divided into nine taxonomic categories, and organisms were identified to the species level where possible. Stomachs were slit open with a scalpel and the wet weights (after towel drying) of the individual food items were recorded (± 0.01g) using a Mettler PC4400 electronic balance. In the subsequent analyses, both the percent biomass of the total and the percent frequency of occurrence of each food item was calculated for all sampling times and locations. Occurrence was calculated as the number of stomachs with a given food taxon expressed as a percentage of the number of stomachs which contained identifiable food. Percent biomass was calculated by dividing the total amount of a given taxon found in all

stomachs by the total biomass of all stomachs combined and multiplying by 100. Simultaneous presentation of percent biomass and percent frequency of occurrence data provides a better indication of the overall feeding habits of the fish than either one independently (deGraff et al. 1979).

The digestive caeca of samples taken in 1985 were examined for the presence of the coelozoic nematode *Anisakis sp.*. Samples taken in subsequent years were not examined for *Anisakis sp.* as it was shown in the initial study they were not useful in terms of stock separation due to the variability in infection rates. Next, the contents of the digestive caeca and intestines were emptied into a # 60 (250 um) sieve and washed with running water. After discarding debris, the parasites which remained were identified and enumerated using a Nikon dissecting microscope (40x magnification) into: Nematoda, Trematoda, and Acanthocephala according to the descriptions of Meyer and Olsen (1983). The parasites were subsequently preserved in 70% alcohol.

Bile was removed from the gall bladders using syringes which were then allowed to stand upright for two days to facilitate the settling of contents. Two drops from each syringe were placed upon a microscope slide, covered with a cover slip and examined with a Zeiss compound microscope (10x ocular, 40x objective) for the presence of the Myxozoan *Myxidium gadi.* A mean number from four field counts was recorded. Identification of the myxozoan was performed by Dr. R. A. Khan.

Parasite prevalences were calculated as the number of cod infected divided by the number examined, and expressed as a percentage. Parasite abundance was calculated as the total

number of individuals of a particular parasite species in the overall sample divided by the number of cod sampled (Margolis et al. 1982).

A data screen was performed to assess the normality of all the data. This was followed by a Chi-square test ($P < 0.05$) which indicated that sex-related differences were not significant for the parameters examined. Logarithmic transformations of length, weight, and age data were performed to remove inherent variability. Regressions were performed upon all combinations of length-weight-age data for all sampling locations and times, these were followed by post-hoc tests comparing line elevations (Scheffe's F test, $P = 0.05$) if the initial analysis proved to be significant.

Summary statistics (numbers, standard deviations, standard errors, ranges, and coefficients of variation) were calculated for all parasites for all locations and times sampled. Logarithmic transformations were performed on all parasite data to remove inherent variability. A one-way ANOVA (Analysis of Variance) was performed for all possible combinations of groups with respect to both abundance and prevalence. These were followed by post-hoc tests where appropriate, using Scheffe's F test ($P = 0.05$) for abundance comparisons and Fisher's exact two-sample test ($P = 0.05$) for prevalence comparisons. All groups were further subdivided into eight 10 centimeter length classes which were analyzed using one-way ANOVA, followed by post-hoc tests (Scheffe's F test, $P = 0.05$). Statistical analyses were performed and graphics generated upon a Macintosh Classic II microcomputer using Abacus Concepts, Statview and SuperAnova statistical analysis packages (Haycock 1992, Gagnon 1989).

3.0 RESULTS

3.1 Length-Weight-Age Relationships

Comparative analysis of length-weight-age data was conducted using regression plots of logarithmic data transformations to remove any of the inherent variability that the data might contain. This was then followed by a test of significance based upon line elevations (Scheffe's F test, P = 0.05) to determine if distinct groups existed. Samples from Gadus A-B-C, 1986 are excluded from weight comparisons because no weight data were collected from the offshore samples.

3.1.1 Temporal Variation

Initially, locations sampled repetitively over a number of years were examined with respect to continuity over time. Regression plots and significance comparisons (comparing line elevations) are presented for log length vs log weight (Figure 3), log length vs log age (Figure 4), and log weight vs log age (Figure 5). Regression plots of log length vs log weight are presented as opposed to log weight vs log length (which provide a measure of condition of the fish) because only a simple regression analysis was desired. The regression plots for Nain 1987 (sampled only one year) are presented to provide a complete graphical representation of the data. Offshore samples were omitted from this section as they were sampled only during the 1986 season.

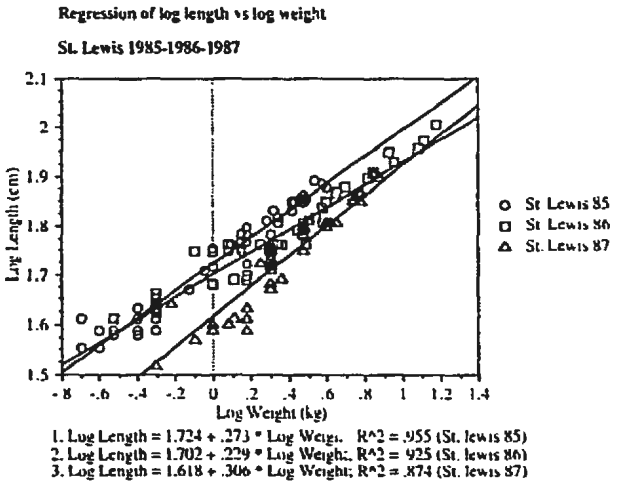
Examination of log length vs log weight by year regressions (Figure 3) reveals that cod from St. Lewis 1985 (R^2 = 0.955), 1986 (R^2 = 0.925), and 1987 (R^2 = 0.874) were significantly (P = 0.05) different from each other. However, small cod of the same weight

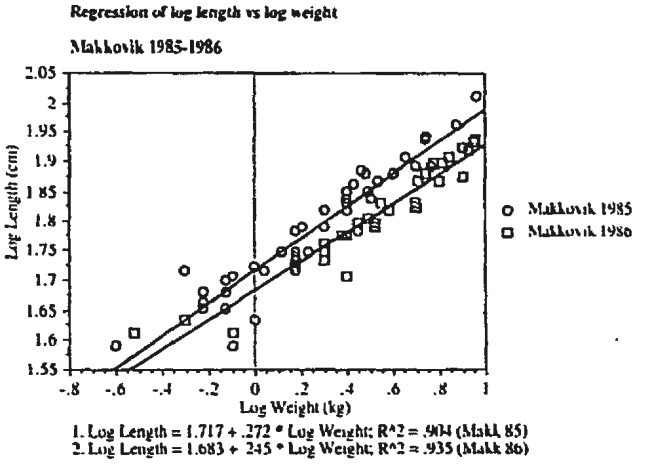
from St. Lewis 1985 and 1986, and large cod of the same weight from St. Lewis 1986 and 1987 were indistinguishable from each other in terms of length. Cod from Makkovik 1985 ($R^2 = 0.904$) were significantly ($P = 0.05$) greater in length than cod of the same weight from Makkovik 1986 ($R^2 = 0.935$).

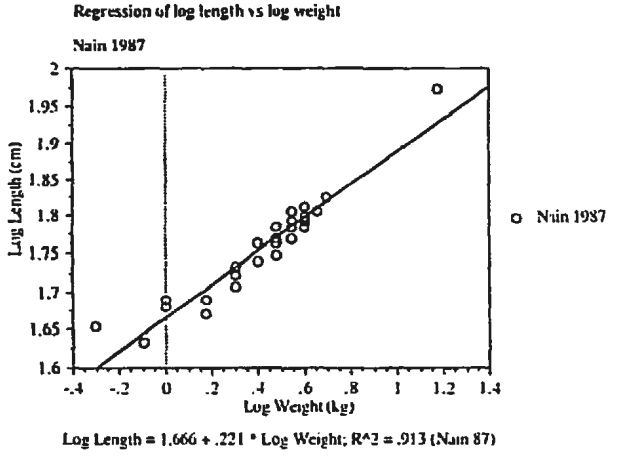
Examination of log length vs log age by year regressions (Figure 4) reveals that although cod from St. Lewis 1985 ($R^2 = 0.877$), 1986 ($R^2 = 0.973$), and 1987 ($R^2 = 0.965$) are considered significantly ($P = 0.05$) different from each other, young cod from all locations were similar in length. The older cod from St. Lewis 1986 were greater in length than the older cod from either St. Lewis 1985 or 1987. Cod from Makkovik 1985 ($R^2 = 0.793$) were significantly greater in length than cod of the same age from Makkovik 1986 ($R^2 = 0.977$).

Examination of log weight vs log age by year regressions (Figure 5) reveals that cod from St. Lewis 1985 ($R^2 = 0.823$) and 1986 ($R^2 = 0.903$) were not significantly ($P = 0.05$) different from each other but were both significantly different ($P = 0.05$) from 1987 ($R^2 = 0.852$). Regression lines for both older and younger fish are similar except for the younger cod from St. Lewis 1987 which were heavier than younger cod from either 1985 or 1986. Fish from Makkovik 1986 ($R^2 = 0.891$) were significantly ($P = 0.05$) heavier overall than fish of the same age from 1985 ($R^2 = 0.708$). However, young fish from both years were similar in weight.

Figure 3. Regression plots of log length vs log weight of Atlantic cod by year, for St. Lewis, Makkovik and Nain.







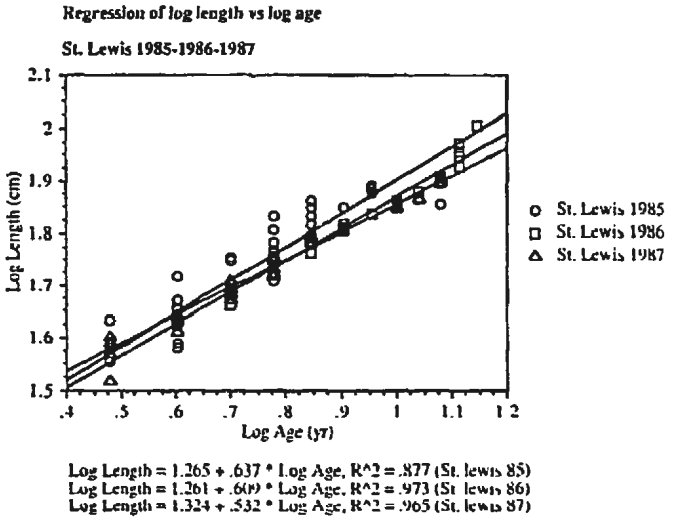
Scheffe's F test comparisons, P = 0.05

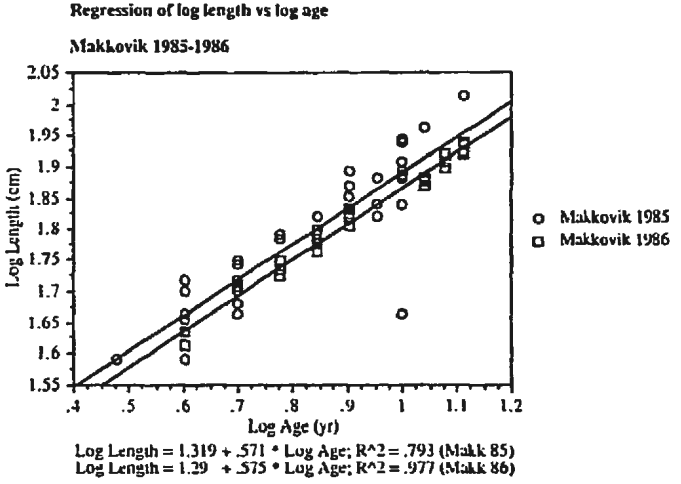
	N = 49 St. Lewis 85	N = 41 St. Lewis 86	N = 42 St. Lewis 87
St. Lewis 85		*	*
St. Lewis 86	*		*
St. Lewis 87	*	*	

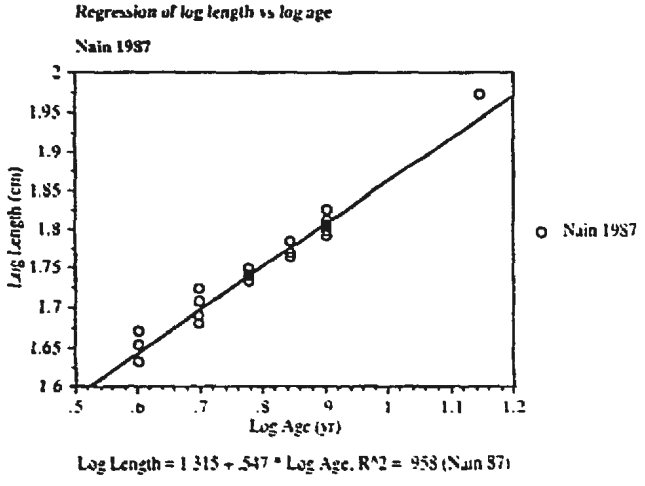
	N = 46 Makkovik 85	N = 34 Makkovik 86
Makkovik 85		*
Makkovik 86	*	

* = significant
NS = not significant

Figure 4. Regression plots of log length vs log age of Atlantic cod by year, for St. Lewis, Makkovik, and Nain.







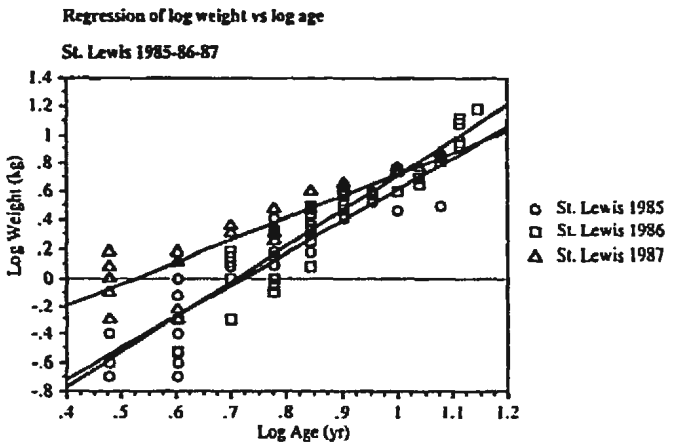
Scheffe's F test comparisons, $P = 0.05$

	N = 49 St. Lewis 85	N = 41 St. Lewis 86	N = 42 St. Lewis 87
St. Lewis 85		*	*
St. Lewis 86	*		*
St. Lewis 87	*	*	

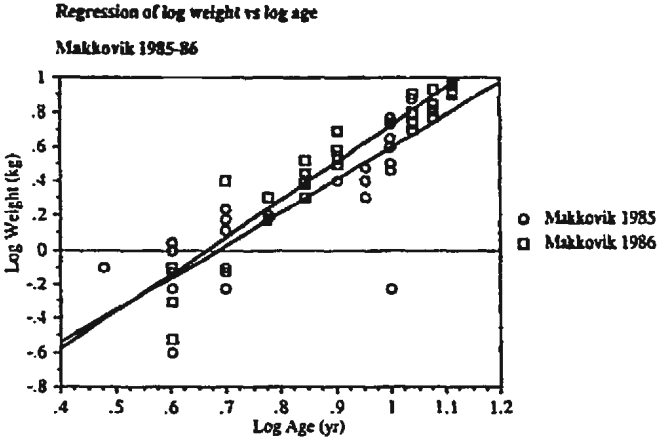
	N = 46 Makkovik 85	N = 34 Makkovik 86
Makkovik 85		*
Makkovik 86	*	

* = significant
NS = not significant

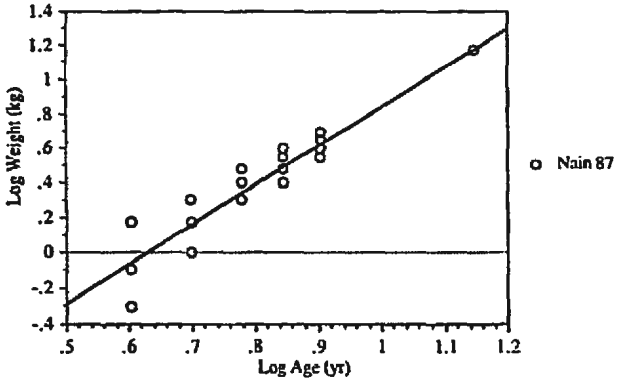
Figure 5. Regression plots of log weight vs log age of Atlantic cod by year class for St. Lewis, Makkovik, and Nain.



1. Log Weight = -1.609 + 2.227 * Log Age; R^2 = .823 (St. lewis 85)
2. Log Weight = -1.758 + 2.469 * Log Age; R^2 = .903 (St. lewis 86)
3. Log Weight = - .802 + 1.527 * Log Age; R^2 = .852 (St. lewis 87)



1. Log Weight = -1.291 + 1.886 * Log Age; R^2 = .708 (Makk 85)
2. Log Weight = -1.442 + 2.164 * Log Age; R^2 = .891 (Makk 86)



Log Weight = -1.413 + 2.259 * Log Age; R^2 = .878 (Nain 87)

Scheffe's F test comparisons, P = 0.05

	St. Lewis 85	St. Lewis 86	St. Lewis 87
St. Lewis 85		NS	*
St. Lewis 86	NS		*
St. Lewis 87	*	*	

	Makkovik 85	Makkovik 86
Makkovik 85		*
Makkovik 86	*	

* = significant
NS = not significant

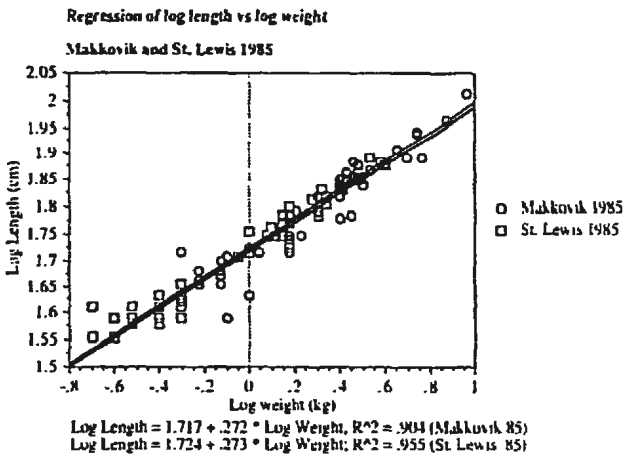
3.1.2 Spatial Variation

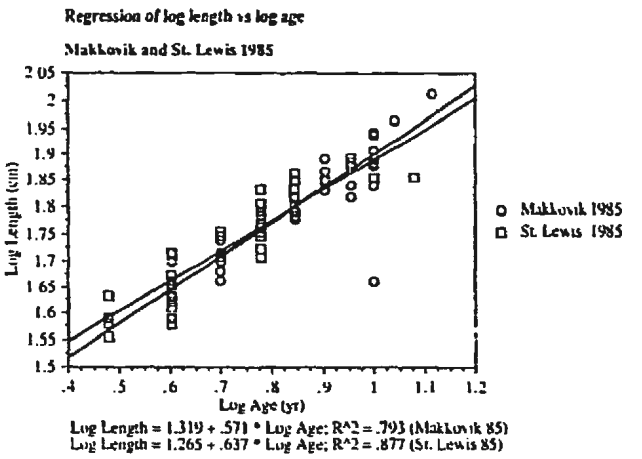
Separate locations which were sampled within the same year were examined with respect to site specific differences. Regression plots and significance comparisons are presented for log length vs log weight, log length vs log age, and log weight vs log age relationships comparing Makkovik 1985 and St. Lewis 1985 (Figure 6); St. Lewis 1986, Makkovik 1986, and Gadus A-B-C 1986 (Figure 7); and finally, St. Lewis 1987 and Nain 1987 (Figure 8).

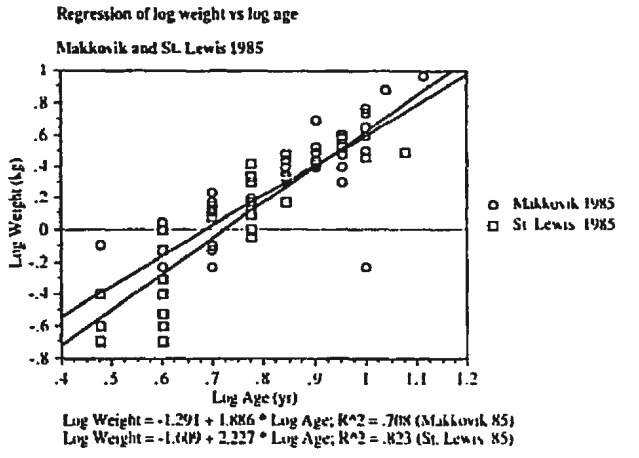
Cod from St. Lewis 1985 and Makkovik 1985 are compared by regression analysis in Figure 6. The two groups were not significantly (P = 0.05) different in terms of log length vs log weight comparisons. The log length vs log age comparison shows the two groups were significantly different (P = 0.05). Young cod from Makkovik (R^2 = 0.793) were greater in length than young cod from St. Lewis (R^2 = 0.877), while older cod from St. Lewis were greater in length than older cod from Makkovik. The log weight vs log age comparison reveals a significant difference (P = 0.05) between the two groups. Young cod from Makkovik (R^2 = 0.708) were heavier than young cod from St. Lewis (R^2 = 0.823), while older St. Lewis cod were heavier than older cod from Makkovik.

Cod from St.Lewis 1986, Makkovik 1986, and Gadus A-B-C 1986 (no weight data were collected for Gadus samples) are compared by regression analysis in Figure 7. The log length vs log weight comparison shows that small cod from St. Lewis (R^2 = 0.925) were significantly (P = 0.05) greater in length than small cod from Makkovik (R^2 = 0.935). The regression of log length vs log age indicates the only groups not significantly different (P =

Figure 6. Regression plots of log length vs log weight, log length vs log age, and log weight vs log age comparing Makkovik and St. Lewis (1985).







Scheffe's F test comparisons, P = 0.05

log length vs log weight

	N = 46 Makkovik 85	N = 49 St Lewis 85
Makkovik 85		NS
St Lewis 85	NS	

log length vs log age

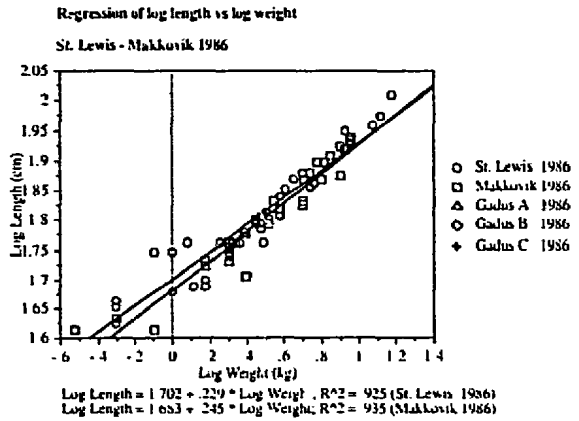
	N = 46 Makkovik 85	N = 49 St Lewis 85
Makkovik 85		*
St. Lewis 85	*	

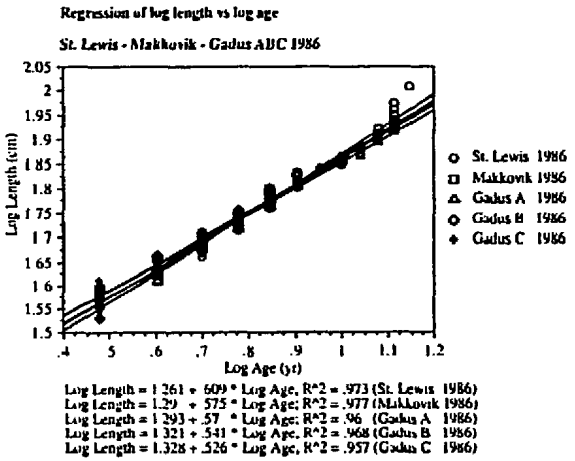
log weight vs log age

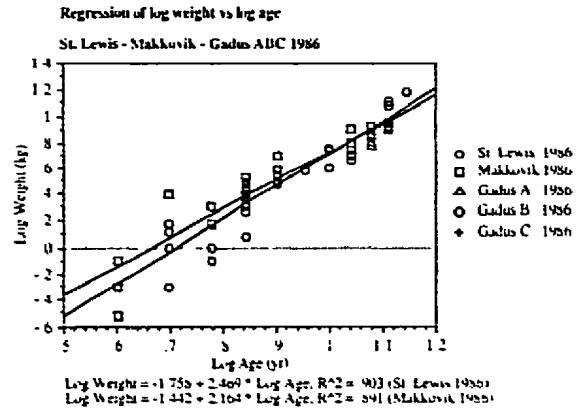
	N = 46 Makkovik 85	N = 49 St Lewis 85
Makkovik 85		*
St Lewis 85	*	

* = significant
NS = not significant

Figure 7. Regression plots of log length vs log weight, log length vs log age, and log weight vs log age comparing St. Lewis, Makkovik, and Gadus ABC*, (1986).







Schelle's F test comparisons, P = 0.05

log length vs log weight

	N = 41 St. Lewis 86	N = 34 Makkovik 86
St. Lewis 86		*
Makkovik 86	*	

log length vs log age

	N = 41 St. Lewis 86	N = 34 Makkovik 86	N = 33 Gadus A 86	N = 68 Gadus B 86	N = 52 Gadus C 86
St. Lewis 86		*	*	*	*
Makkovik 86	*		*	*	*
Gadus A 86	*	*		NS	*
Gadus B 86	*	*	NS		*
Gadus C 86	*	*	*	*	

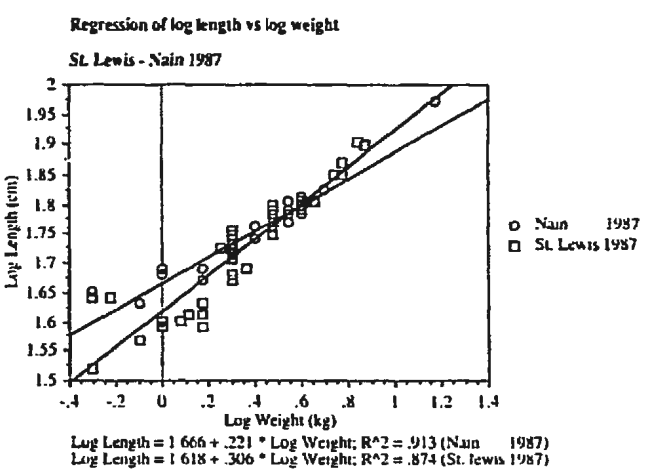
log weight vs log age

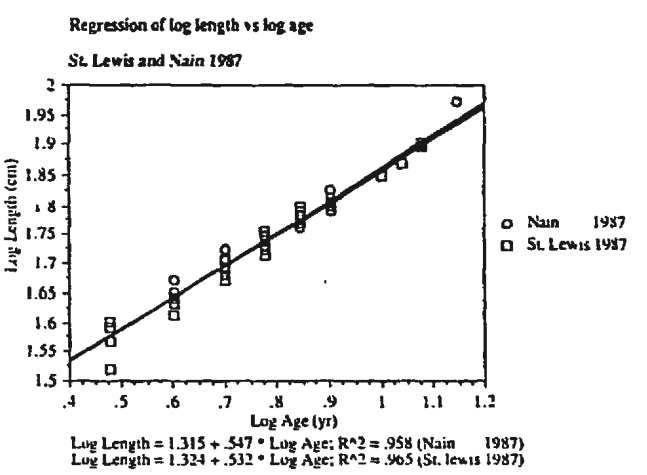
	N = 41 St. Lewis 86	N = 34 Makkovik 86
St. Lewis 86		*
Makkovik 86	*	

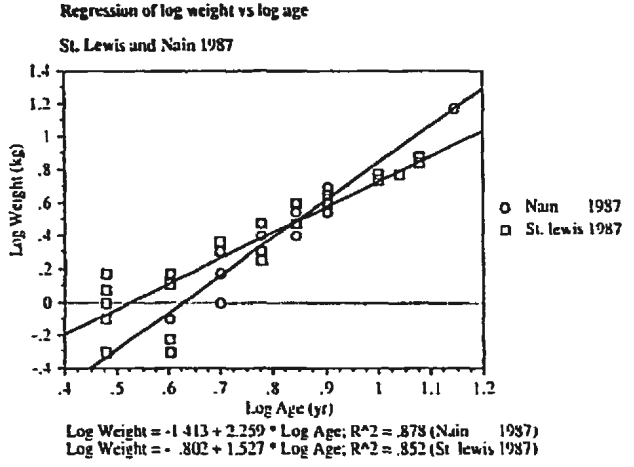
* = significant
NS = not significant

* Note that no weight data were collected for Gadus samples.

Figure 8. Regression plots of log length vs log weight, log length vs log age, and log weight vs log age comparing St. Lewis and Nain (1987).







Scheffe's F test comparisons, P = 0.05

log length vs log weight

	N = 42 St. Lewis 87	N = 40 Nain 87
St. Lewis 87		*
Nain 87	*	

log length vs log age

	N = 42 St. Lewis 87	N = 40 Nain 87
St. Lewis 87		NS
Nain 87	NS	

log weight vs log age

	N = 42 St. Lewis 87	N = 40 Nain 87
St. Lewis 87		*
Nain 87	*	

* = significant
NS = not significant

0.05) were Gadus A ($R^2 = 0.96$) and Gadus B ($R^2 = 0.968$), due to the convergence of the regression lines it is difficult to speculate upon the relationships of the other groups. The regression of log weight vs log age reveals young cod from Makkovik ($R^2 = 0.891$) were significantly heavier than young cod from St. Lewis.

Cod from St. Lewis 1987 and Nain 1987 are compared by regression analysis in Figure 8. The regression of log length vs log weight reveals a significant ($P = 0.05$) difference between the two groups. The less heavy cod from St. Lewis ($R^2 = 0.874$) were longer than cod of the same weight from Nain ($R^2 = 0.913$), while the heavier cod from Nain were greater in length than those from St. Lewis. No significant difference was found between the two groups in terms of the log length vs log age comparison. The log weight vs log age comparison revealed a significant ($P = 0.05$) difference. Young cod from St. Lewis ($R^2 = 0.852$) were heavier than young cod from Nain ($R^2 = 0.878$), and the older cod from Nain were heavier than the older cod from St. Lewis.

3.2 Diet

Analysis of stomach contents by percent frequency of occurrence does not indicate the nutritional importance of a specific food item. Analysis by percent biomass, while providing an indication of nutritional importance allows large but rare prey items (eg *Anarhichas sp.*) to mask the importance of small but abundant prey items (e.g. Hyperiidea). Therefore, to obtain a clear understanding of cod feeding habits for the various locations and times sampled, both methods have been used simultaneously on the data (Table 1, Figure 9). From Table 1 and Figure 9 the eight dominant prey taxa were selected and ranked in order of importance (R = 1-8) for both percent frequency of occurrence and percent biomass for all locations and sampling seasons (Table 2).

Table 2 reveals that for the Makkovik 1985 sample the dominant prey category (R = 1) in terms of percent frequency of occurrence was *Pandalus sp.* (0.49 %), while the dominant prey category (R = 1) in terms of percent biomass was *Anarhichas sp.* (64 %). These were followed (R = 2) by *Mallotus villosus* and unidentified fish, with a percent frequency of occurrence of .29 %, and *Mallotus villosus* with a percent biomass of 15.87 %. Next in order of importance (R = 3) were Majidae with a percent frequency of occurrence of 0.13 % and a percent biomass of 7.53 %. Next in order of importance (R = 4) were *Anarhichas sp.* with a percent frequency of occurrence of 0.07 %, and *Pandalus sp.* with a percent biomass of 7.25 %. Lastly, with an R value of 5, were unidentified fish with a percent biomass of 1.24 %. The prey categories of Gammeridea, Hyperiidea, and *Eualus sp.* were not encountered in the Makkovik 1985 group.

Table 2 reveals that for St. Lewis 1985 the dominant prey category (R = 1) in terms of

Table 1. Percent occurrence (% occ) and percent biomass (% bio) of prey taxa found in stomachs of Atlantic cod from all locations and sampling seasons.

Prey Category	Group 1 Makk 1985		Group 2 St. Lew 1985		Group 3 Nain 1987		Group 4 St. Lew 1986		Group 5 St. Lew 1987		Group 6 Makk 1986		Group 7 Gadus A 86		Group 8 Gadus B 86		Group 9 Gadus C 86	
	% occ	% bio	% occ	% bio	% occ	% bio	% occ	% bio	% occ	% bio	% occ	% bio	% occ	% bio	% occ	% bio	% occ	% bio
Cnidaria																		
Anthozoa	*	*	*	*	2.50	0.03	*	*	*	*	3.00	0.78	*	*	*	*	*	*
Annelida																		
Polychaeta																		
Arenicola Sp.	*	*	0.02	0.31	0.00	0.00	*	*	*	*	*	*	*	*	4.60	0.18	*	*
Mollusca																		
Gastropoda	0.02	0.01	*	*	*	*	*	*	2.40	0.25	*	*	*	*	1.50	0.57	*	*
Nudibranchia	*	*	*	*	2.50	0.36	*	*	*	*	*	*	*	*	*	*	*	*
Cephalopoda	*	*	*	*	*	*	*	*	*	*	11.80	3.72	*	*	*	*	*	*
Bivalvia	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Pectinidae																		
Placopecten magellanicus	*	*	*	*	*	*	*	*	*	*	3.00	0.02	*	*	*	*	*	*
Crustacea																		
Amphipoda																		
Gammeridea	*	*	*	*	22.50	2.16	12.20	0.01	14.30	1.55	8.80	0.12	6.50	0.25	18.50	1.74	*	*
Hyperiidea	*	*	*	*	27.50	2.03	19.50	0.09	23.80	0.43	*	*	29.00	13.92	61.50	31.82	60.80	12.53
Caprellidea	*	*	*	*	*	*	*	*	*	*	*	*	3.20	0.05	*	*	*	*
Mysidacea	0.09	0.12	*	*	5.00	0.07	*	*	*	*	*	*	*	*	*	*	*	*
Euphausiacea	0.02	1.47	*	*	20.00	0.79	*	*	*	*	*	*	*	*	6.20	1.15	*	*
Natantia																		
Pandalidae																		
Pandalus sp.	0.49	7.25	40.00	12.60	*	*	*	*	*	*	11.80	14.32	*	*	7.70	4.69	35.30	24.24
Hippolytidae																		
Eualus sp.	*	*	*	*	10.00	0.73	17.10	1.13	2.40	0.05	35.30	9.30	38.70	32.89	13.80	6.56	2.00	0.22
Lebbeus sp.	*	*	*	*	*	*	*	*	*	*	*	*	*	*	3.10	0.80	9.80	2.38
Spirontocaris sp.	*	*	*	*	*	*	*	*	7.10	6.17	14.70	9.30	*	*	*	*	*	*
Reptantia																		
Majidae	0.13	7.53	0.14	8.50	*	*	19.50	4.83	7.10	0.93	17.70	9.31	*	*	4.60	19.60	2.00	13.72
Lithodidae	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

Table 1. continued

Prey Category	Group 1 Makk 1985		Group 2 St. Lew 1985		Group 3 Nain 1987		Group 4 St. Lew 1986		Group 5 St. Lew 1987		Group 6 Makk 1986		Group 7 Gadus A 86		Group 8 Gadus B 86		Group 9 Gadus C 86	
	% occ	% bio	% occ	% bio	% occ	% bio	% occ	% bio	% occ	% bio	% occ	% bio	% occ	% bio	% occ	% bio	% occ	% bio
Echinodermata																		
Holothuroidea	0.02	0.27	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Ophiuroidea	0.04	0.13	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Chordata																		
Osmeridae																		
Mallotus villosus	0.29	15.87	0.10	70.83	*	*	48.80	81.82	14.30	32.19	26.50	32.94	12.90	14.82	15.40	28.60	47.10	45.27
Gadidae																		
Gadus morhua	*	*	*	*	*	*	*	*	2.40	56.87	*	*	*	*	*	*	*	*
Cottidae																		
Myoxocephalus scorpius	*	*	*	*	10.00	17.03	*	*	*	*	*	*	*	*	1.50	0.09	*	*
Cyclopteridae																		
Cyclopterus sp.	*	*	*	*	*	*	*	*	*	*	3.00	1.01	*	*	*	*	*	*
Pleuronectidae																		
Reinhardtius hippoglossoides	*	*	*	*	*	*	*	*	*	*	*	*	9.70	35.96	4.60	2.52	*	*
Anarhichadidae																		
Anarhichas sp.	0.07	64.00	0.06	4.48	5.00	0.97	7.30	9.67	*	*	8.80	18.18	*	*	3.10	0.34	*	*
Ammodytidae																		
Ammodytes sp.	*	*	*	*	2.50	59.23	*	*	*	*	*	*	*	*	*	*	*	*
Scorpaenidae																		
Sebastes sp.	*	*	*	*	35.00	12.22	*	*	*	*	*	*	*	*	*	*	*	*
Unidentified Fish	0	1.24	0.12	0.78	10.00	4.35	22.00	0.70	9.50	1.00	14.70	0.71	6.50	1.79	1.50	0.01	19.60	1.63
Stones	0.24	2.35	0.16	2.51	2.50	0.04	29.30	1.75	*	*	8.80	0.28	3.20	0.32	3.10	1.33	*	*
Plant Material	*	*	*	*	*	*	*	*	2.40	0.57	*	*	*	*	*	*	*	*

Figure 9. Percent frequency of occurrence and percent biomass of prey taxa found in stomachs of Atlantic cod from all locations and sampling seasons.

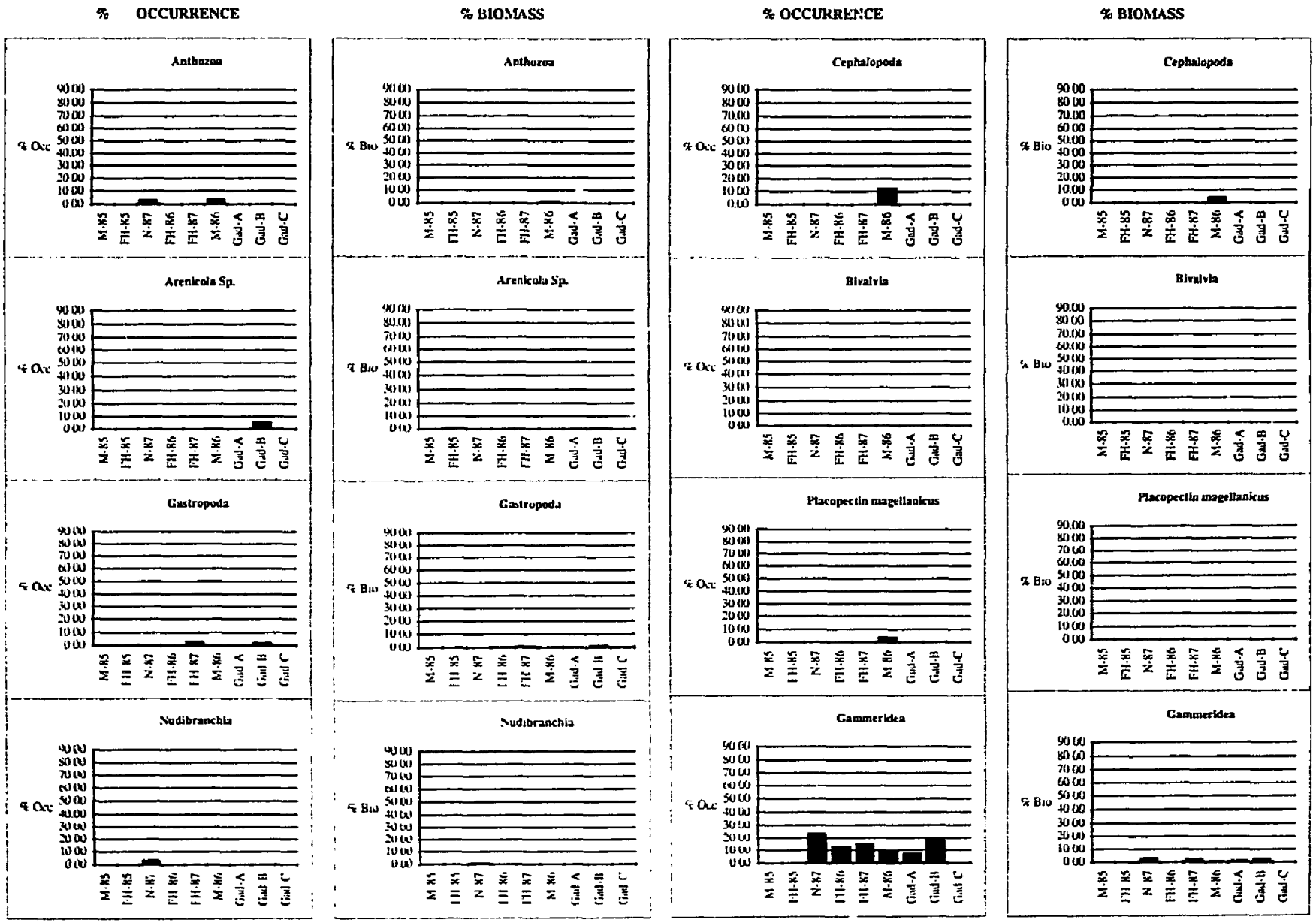


Figure 9. continued

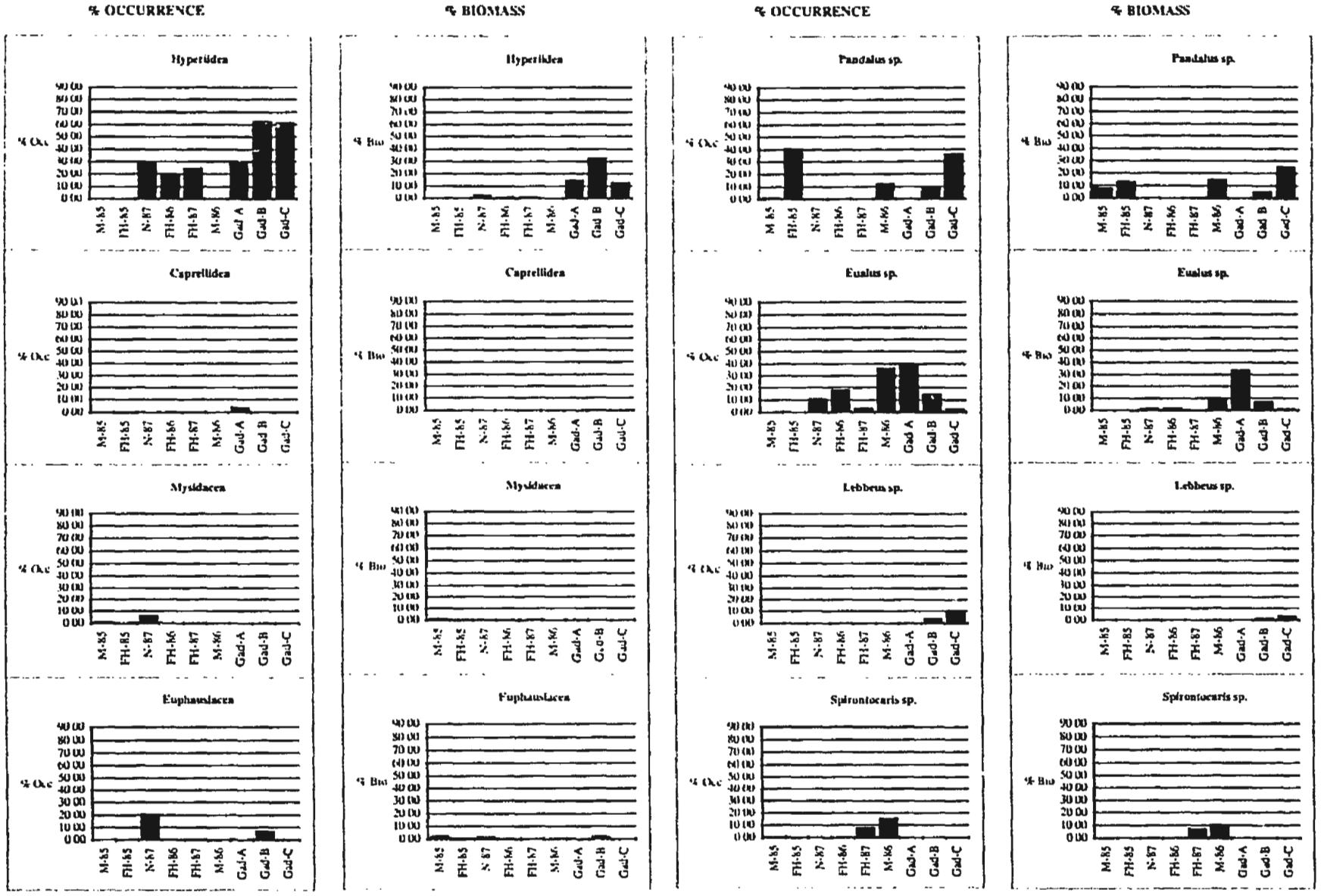


Figure 9. continued

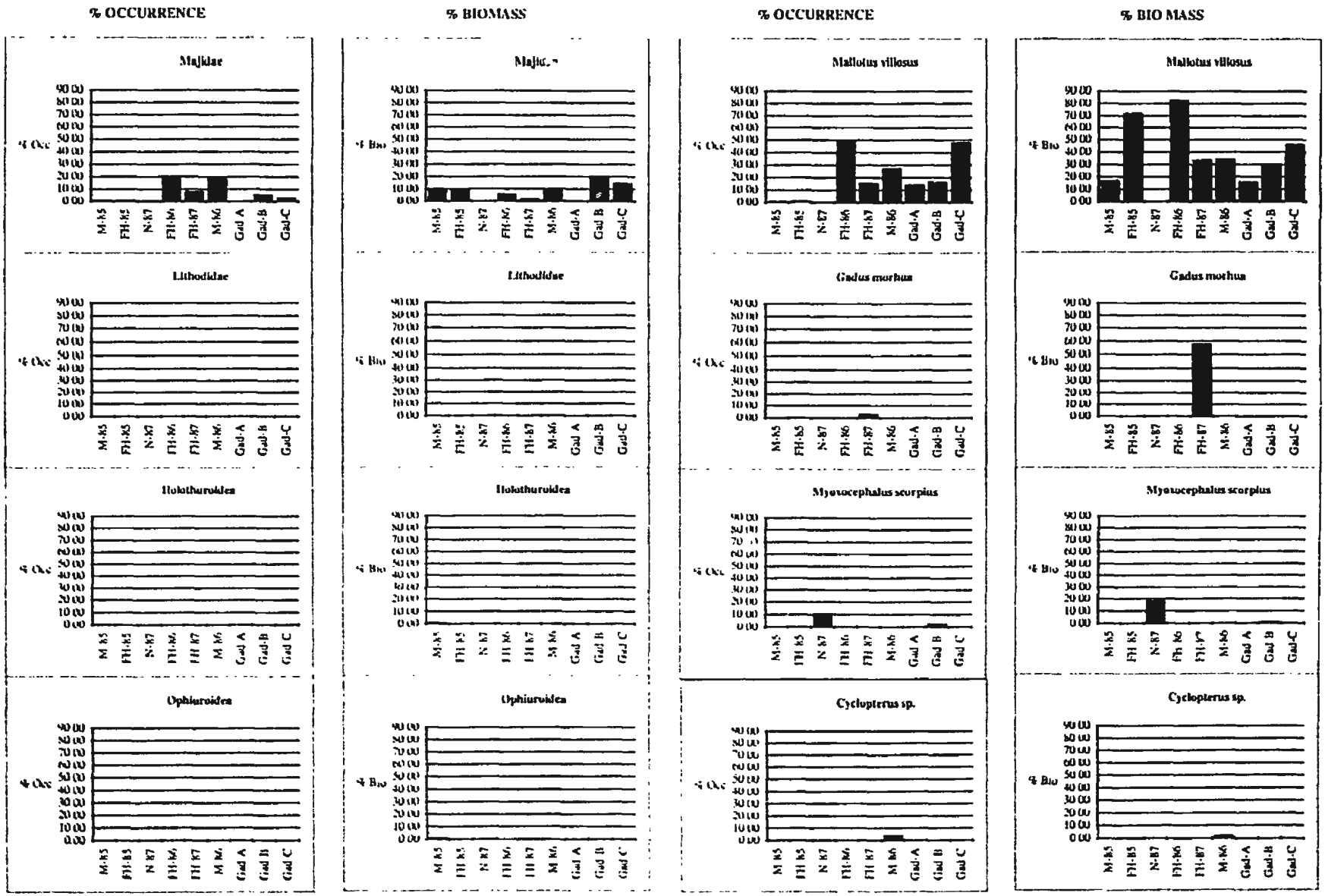


Figure 9. continued

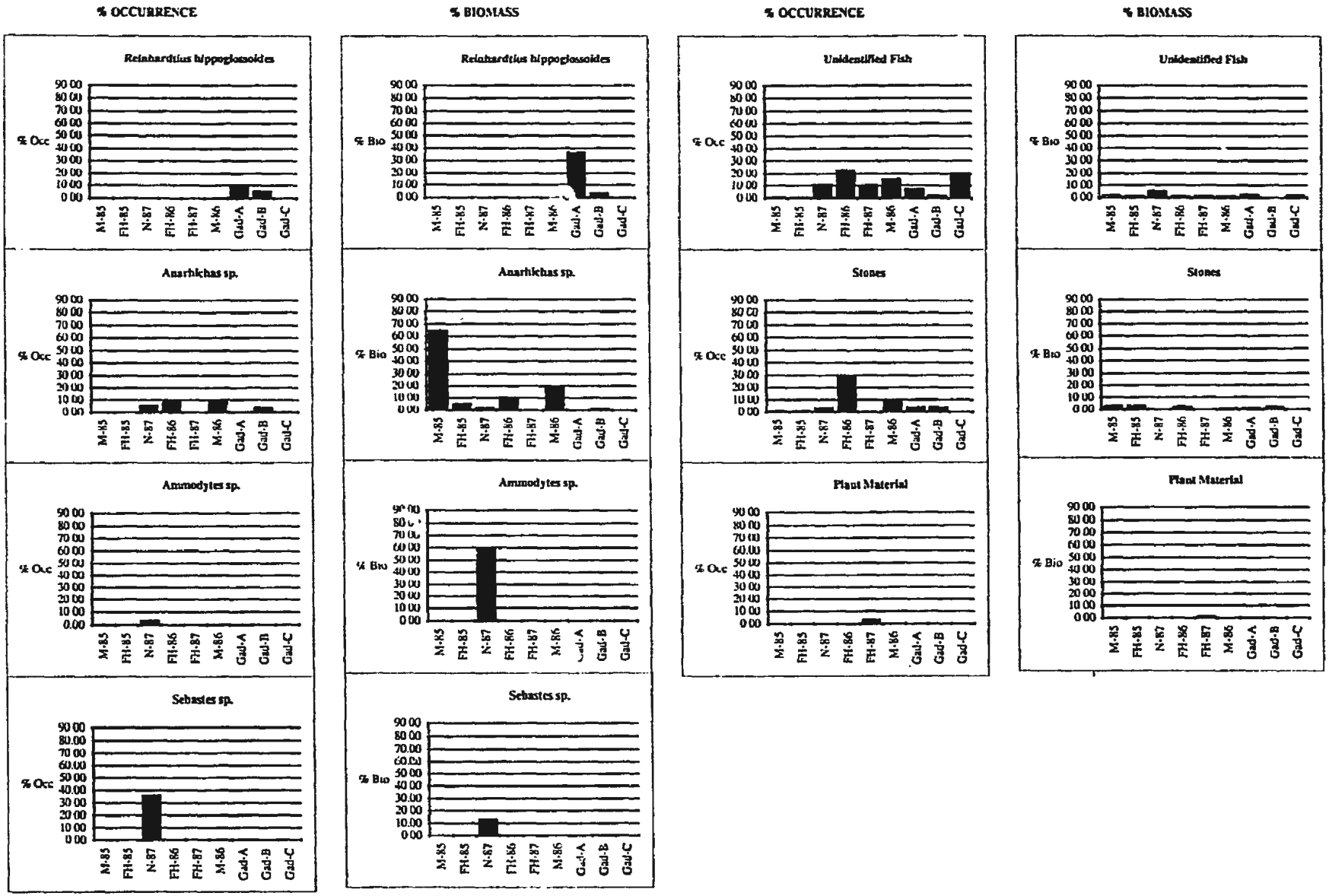


Table 2. Percent fequency of occurrence (% occ), percent biomass (% bio), and rankings of importance (R) for the eight dominant prey taxa found in stomachs of Atlantic cod from all locations and sampling seasons.

Prey Category	Group 1 Makkovik 1985				Group 2 St. Lewis 1985				Group 3 Nain 1987				Group 4 St. Lewis 1986				Group 5 St. Lewis 1987				Group 6 Makkovik 1986				Group 7 Gadus A 86				Group 8 Gadus B 86				Group 9 Gadus C 86			
	R	% occ	R	% bio	R	% occ	R	% bio	R	% occ	R	% bio	R	% occ	R	% bio	R	% occ	R	% bio	R	% occ	R	% bio	R	% occ	R	% bio	R	% occ	R	% bio	R	% occ	R	% bio
Gammeridea		*		*		*		*	2	22.50	2	2.16	5	12.20	7	0.01	2	14.30	2	1.55	6	8.80	7	0.12	4	6.50	5	0.25	2	18.50	6	1.74		*		*
Hyperiidea		*		*		*		*	1	27.50	3	2.03	3	19.50	6	0.09	1	23.80	5	0.43		*		*	2	29.00	3	13.92	1	61.50	1	31.82	1	60.80	4	12.53
Pandalus sp.	1	0.49	4	7.25	1	40.00	2	12.60		*		*		*		*		*		*	5	11.80	3	14.32		*		*	5	7.70	5	4.69	3	35.30	2	24.24
Eualus sp.		*		*		*		*	3	10.00	5	0.73	4	17.10	4	1.13	5	2.40	6	0.05	1	35.30	5	9.30	1	38.70	1	32.89	4	13.80	4	6.56	5	2.00	6	0.22
Majidae	3	0.13	3	7.53	2	0.14	3	8.50		*		*	3	19.50	3	4.83	4	7.10	4	0.93	3	17.70	4	9.31		*		*	6	4.60	3	19.60	5	2.00	3	13.72
Mallotus villosus	2	0.29	2	15.87	4	0.10	1	70.83		*		*	1	48.80	1	81.82	2	14.30	1	32.19	2	26.50	1	32.94	3	12.90	2	14.82	3	15.40	2	28.60	2	47.10	1	45.27
Anarhichas sp.	4	0.07	1	64.00	5	0.06	4	4.48	4	5.00	4	0.97	6	7.30	2	9.67		*		*	6	8.80	2	18.18		*		*	7	3.10	7	0.34		*		*
Unidentified Fish	2	0.29	5	1.24	3	0.12	5	0.78	3	10.00	1	4.35	2	22.00	5	0.70	3	9.50	3	1.00	4	14.70	6	0.71	4	6.50	4	1.79	8	1.50	8	0.01	4	19.60	5	1.63

percent frequency of occurrence was *Pandalus sp.* (40 %), while the dominant prey category in terms of percent biomass was *Mallotus villosus* (70.83 %). Following these (R = 2) were Majidae with a percent frequency of occurrence of 0.14 % and *Pandalus sp.* with a percent biomass of 12.6 %. Next in order of importance (R = 3) were Unidentified fish with a percent frequency of occurrence of 0.12 % and Majidae with a percent biomass of 8.5 %. Next in order of importance (R = 4) were *Mallotus villosus* with a percent frequency of occurrence of 0.10 % and *Anarhichas sp.* with a percent biomass of 4.48 %. Lastly, were *Anarhichas sp.* (R = 5) with a percent frequency of occurrence 0.06 % and unidentified fish with a percent biomass of 0.78 %. The prey categories of Gammeridea, Hyperiidea, and *Eualus sp.* were not encountered in the St. Lewis 1985 group.

Table 2 reveals that for Nain 1987 the dominant prey category (R = 1) in terms of percent frequency of occurrence was Hyperiidea (27.5 %), while the dominant prey category in terms of percent biomass was unidentified fish (4.35 %). Next in order of importance (R = 2) were Gammeridea with a percent frequency of occurrence of 22.5 % and a percent biomass of 2.16 %. Following these were (R = 3) *Eualus sp.* and unidentified fish which both had a percent frequency of occurrence of 10 %, and Hyperiidea with a percent biomass of 2.03 %. Next in order of importance (R = 4) were *Anarhichas sp.* with a percent frequency of occurrence of 5 % and a percent biomass of 0.97 %. Lastly were *Eualus sp.* (R = 5) with a percent biomass of 0.73 %. The prey categories of *Pandalus sp.*, Majidae, and *Mallotus villosus* were not encountered in the Nain 1987 group.

Table 2 reveals that for St. Lewis 1986 the dominant prey category (R = 1) in terms of both percent frequency of occurrence and percent biomass was *Mallotus villosus* with values of

48.8 % and 81.82 % respectively. Next in order of importance (R = 2) were unidentified fish with a percent frequency of occurrence of 22 % and *Anarhichas sp.* with a percent biomass of 9.67 %. Following these (R = 3) were Hyperiidea and Majidae which both had a percent frequency of occurrence of 19.5 %, and again Majidae, with a percent biomass of 4.83 %. Following these (R = 4) were *Eualus sp.* which had values of 17.1 % and 1.13 % for percent frequency of occurrence and percent biomass respectively. Next in order of importance (R = 5) were Gammeridea with a percent frequency of occurrence of 12.2 % and unidentified fish with a percent biomass of 0.7 %. Following these (R = 6) were *Anarhichas sp.* with a percent frequency of occurrence of 7.3 % and Hyperiidea with a percent biomass of 0.09 %. Last in order of importance (R = 7) were Gammeridea with a percent biomass of 0.01 %. The prey category *Pandalus sp.* was not encountered in the St. Lewis 1986 group.

Table 2 reveals that for St. Lewis 1987 the dominant prey category (R = 1) with respect to percent frequency of occurrence was Hyperiidea (23.8 %), while the dominant prey category in terms of percent biomass was *Mallotus villosus* (32.19 %). Next in order of importance (R = 2) were Gammeridea and *Mallotus villosus* which both had values of 14.3 % for percent frequency of occurrence, and Gammeridea again, which had a value of 1.55 % for percent biomass. Following these (R =3) were unidentified fish which had values of 9.5 % and 1 % for both percent frequency of occurrence and percent biomass respectively. Next (R = 4) were Majidae which had values of 7.1 % and 0.93 % for both percent frequency of occurrence and percent biomass respectively. Following these (R = 5) were *Eualus sp.* with a percent frequency of occurrence of 2.4 % and Hyperiidea with a percent biomass of 0.43 %. Last in order of importance (R = 6) were *Eualus sp.* with a percent

biomass of 0.05 %. The prey categories of *Pandalus sp.* and *Anarhichas sp.* were not encountered in the St. Lewis 1987 group.

Table 2 reveals that for Makkovik 1986 the dominant prey category (R = 1) in terms of percent frequency of occurrence was *Eualus sp.* (35.3 %), while the dominant prey category in terms of percent biomass was *Mallotus villosus* (32.94 %). Next in order of importance (R = 2) were *Mallotus villosus* with a percent frequency of occurrence of 26.5 % and *Anarhichas sp.* with a percent biomass of 18.18 %. Following these (R = 3) were Majidae with a percent frequency of occurrence of 17.7 % and *Pandalus sp.* with a percent biomass of 14.32 %. Next (R = 4) were unidentified fish with a percent frequency of occurrence of 14.7 % and Majidae with a percent biomass of 9.31 %. After Majidae were *Pandalus sp.* (R = 5) with a percent frequency of occurrence of 11.8 % and *Eualus sp.* with a percent biomass of 9.3 %. Next in order of importance (R = 6) were Gammeridea and *Anarhichas sp.* which both had a percent frequency of occurrence of 8.8 %, and unidentified fish with a percent biomass of 0.71 %. Last in order of importance (R = 7) were Gammeridea with a percent biomass of 0.12 %. The prey category of Hyperiidea was not encountered in the Makkovik 1986 group.

Table 2 reveals that for Gadus A 1986 the dominant prey category (R = 1) was *Eualus sp.* in terms of both percent frequency of occurrence (38.7 %) and percent biomass (32.89 %). Next (R = 2) were Hyperiidea with a percent frequency of occurrence of 29 % and *Mallotus villosus* with a percent biomass of 14.82 %. After these (R = 3) were *Mallotus villosus* with a percent frequency of occurrence of 12.9 % and Hyperiidea with a percent biomass of 13.92 %. After Hyperiidea were Gammeridea (R = 4) and unidentified fish

which both had a percent frequency of occurrence of 6.5 % and unidentified fish again, with a percent biomass of 1.79 %. Last in importance (R = 5) were Gammeridea with a percent biomass 0.25 %. The prey categories of *Pandalus sp.* and *Anarhichas sp.* were not encountered in the Gadus A 1986 group.

Table 2 reveals that for Gadus B 1986 the dominant prey category (R = 1) was Hyperiidea in terms of both percent frequency of occurrence (61.5 %) and percent biomass (31.82 %). Next in order of importance (R = 2) were Gammeridea with a percent frequency of occurrence of 18.5 % and *Mallotus villosus* with a percent biomass of 28.6 %. Following these (R = 3) were *Mallotus villosus* with a percent frequency of occurrence of 15.4 % and Majidae with a percent biomass of 19.6 %. After Majidae was *Eualus sp.* (R = 4) which had a percent frequency of occurrence of 13.8 % and a percent biomass of 6.56 %. Next in order of importance (R = 5) was *Pandalus sp.* which had a percent frequency of occurrence of 7.7 % and a percent biomass of 4.69 %. Following *Pandalus sp.* were Majidae (R = 6) with a percent frequency of occurrence of 4.6 % and Gammeridea with a percent biomass of 1.74 %. Next (R = 7) was *Anarhichas sp.* which had a percent frequency of occurrence of 3.1 % and a percent biomass of 0.34 %. Last in order of importance (R = 8) was unidentified fish which had a percent frequency of occurrence of 1.5 % and a percent biomass of 0.01 %.

Table 2 reveals that for Gadus C 1986 the main prey categories (R = 1) were Hyperiidea in terms of percent frequency of occurrence (60.8 %) and *Mallotus villosus* in terms of percent biomass (45.27 %). Next (R = 2) were *Mallotus villosus* with a percent frequency of occurrence of 47.1 % and *Pandalus sp.* with a percent biomass of 24.24 %. Following

these (R = 3) were *Pandalus sp.* with a percent frequency of occurrence of 35.3 % and Majidae with a percent biomass of 13.72 %. After Majidae were unidentified fish (R = 4) with a percent frequency of occurrence of 19.6 % and Hyperiidea with a percent biomass of 12.53 %. Next in order of importance (R = 5) were *Eualus sp.* and Majidae which both had a percent frequency of occurrence of 2 % and unidentified fish with a percent biomass of 1.63 %. Last (R = 6) was *Eualus sp.* with a percent biomass of 0.22 %. The prey categories of Gammeridea and *Anarhichas sp.* were not encountered in the Gadus C 1986 group.

3.3 Parasitic Fauna

3.3.1 Summary of Statistical Comparisons

Summary statistics (numbers, abundance, prevalence, standard deviations, standard errors, ranges, and coefficients of variation) are presented for nematodes (Table 3), trematodes (Table 4), acanthocephalans (Table 5), and myxozoans (Table 6). Abundance levels (number of parasites per fish) of nematodes, trematodes, acanthocephalans, and myxozoans are presented for all locations and sampling seasons in Figure 10. Prevalence levels (percent of fish infected by the parasite) of nematodes, trematodes, acanthocephalans, and myxozoans are presented for all locations and sampling seasons in Figure 11. Comparisons (Scheffe's f test, P = 0.05) of abundance for both spatial and temporal differences respectively are presented for nematodes (Figures 12 and 13), trematodes (Figures 14 and 15), acanthocephalans (Figures 16 and 17), and myxozoans (Figures 18 and 19). Comparisons (Fisher's exact test, P = 0.05) of prevalence for both spatial and temporal differences respectively are presented for nematodes (Figures 20 and

Table 3. Abundance, prevalence, and summary statistics for nematodes present within the digestive tract of Atlantic cod from all locations.

Statistic	Group 1 Makk 1985	Group 2 St. Lewis 1985	Group 3 Nain 1987	Group 4 St. Lewis 1986	Group 5 St. Lewis 1987	Group 6 Makk. 1986	Group 7 Gadus A 1986	Group 8 Gadus B 1986	Group 9 Gadus C 1986
Number (N)	46	49	40	41	42	34	33	66	52
Abundance	15.8	9.6	7.2	8.0	4.6	4.5	2.9	1.6	1.6
Prevalence (%)	97.9	100	86.4	90.4	72.7	84.2	66.7	54.5	65.4
Stand. dev.	± 15.4	± 10.5	± 8.1	± 8	± 7.1	± 5	± 4.5	± 2.3	± 1.8
Stand. error	2.3	1.5	1.3	1.3	1.1	0.9	0.8	0.3	0.2
Range	0 - 81	0 - 49	0 - 39	0 - 30	0 - 30	0 - 20	0 - 20	0 - 13	0 - 8
Coeff. of Var.	1.0	1.1	1.1	1.0	1.5	1.1	1.6	1.4	1.1

Table 4. Abundance, prevalence, and summary statistics for trematodes present within the digestive tract of Atlantic cod from all locations and sampling seasons.

Statistic	Group 1 Makk 1985	Group 2 St. Lewis 1985	Group 3 Nain 1987	Group 4 St. Lewis 1986	Group 5 St. Lewis 1987	Group 6 Makk. 1986	Group 7 Gadus A 1986	Group 8 Gadus B 1986	Group 9 Gadus C 1986
Number (N)	46	49	40	41	42	34	31	66	52
Abundance	3.5	1.3	0.5	0.2	0.0	0.0	0.0	0.2	0.0
Prevalence (%)	22.9	12.0	4.5	4.8	0.0	0.0	0.0	3.0	1.9
Stand. dev.	±8.5	±4.9	±2.2	±1.6	±0	±0	±0	±0.2	±0
Stand. error	1.3	0.7	0.3	0.2	0.0	0.0	0.0	0.0	0.0
Range	0 - 40	0 - 40	0 - 24	0 - 10	0	0 - 10	0 - 0	0 - 2	0 - 0
Coeff. of Var.	2.4	3.8	4.4	6.4	_	0.0	0.0	0.1	0.0

Table 5. Abundance, prevalence, and summary statistics for acanthocephalans present within the digestive tract of Atlantic cod from all locations.

Statistic	*Group 1* Makk 1985	*Group 2* St. Lewis 1985	*Group 3* Nain 1987	*Group 4* St. Lewis 1986	*Group 5* St. Lewis 1987	*Group 6* Makk. 1986	*Group 7* Gadus A 1986	*Group 8* Gadus B 1986	*Group 9* Gadus C 1986
Number (N)	46	49	40	41	42	34	31	66	52
Abundance	17.1	6.3	9.9	9.6	7.5	8.1	10.7	10.3	5.1
Prevalence (%)	95.8	82	93.2	90.4	88.6	94.7	96.9	98.5	94.2
Stand. dev.	± 19.8	± 10.3	± 12.7	± 12.1	± 12.2	± 8.2	± 10.5	± 9.9	± 5.1
Stand. error	2.9	1.5	2.0	1.9	1.9	1.4	1.9	1.2	0.7
Range	0 - 75	0 - 48	0 - 69	0 - 48	0 - 66	0 - 39	0 - 42	0 - 38	0 - 23
Coeff. of Var.	1.2	1.6	1.3	1.3	1.6	1.0	1.0	1.0	1.0

Table 6. Abundance, prevalence, and summary statistics for Myxozoans present within the gall bladders of Atlantic cod from all locations.

Statistic	Group 1 Makk 1985	Group 2 St. Lewis 1985	Group 3 Nain 1987	Group 4 St. Lewis 1986	Group 5 St. Lewis 1987	Group 6 Makk. 1986	Group 7 Gadus A 1986	Group 8 Gadus B 1986	Group 9 * Gadus C 1986
Number (N)	42	39	37	32	38	20	31	53	
Abundance	8.5	2.6	4.3	2.1	1.9	3.3	2.3	2.5	
Prevalence (%)	54.3	16.7	43.6	54.8	20	47.6	27.6	21.8	
Stand. dev.	± 17.6	± 9.4	± 10	± 4.3	± 5.3	± 8.5	± 5.5	± 7.0	
Stand. error	2.7	1.5	1.7	0.8	0.9	1.9	1	1	
Range	0 - 60	0 - 50	0 - 51	0 - 18	0 - 25	0 - 38	0 - 24	0 - 35	
Coeff. of Var.	2.1	3.7	2.3	2.1	2.8	2.6	2.4	2.8	

* Please note that no myxozoans were collected from Gadus C 1986.

Figure 10. Abundance (# parasites/fish) of nematodes, trematodes, acanthocephalans, and myxozoans present within Atlantic cod from all locations.

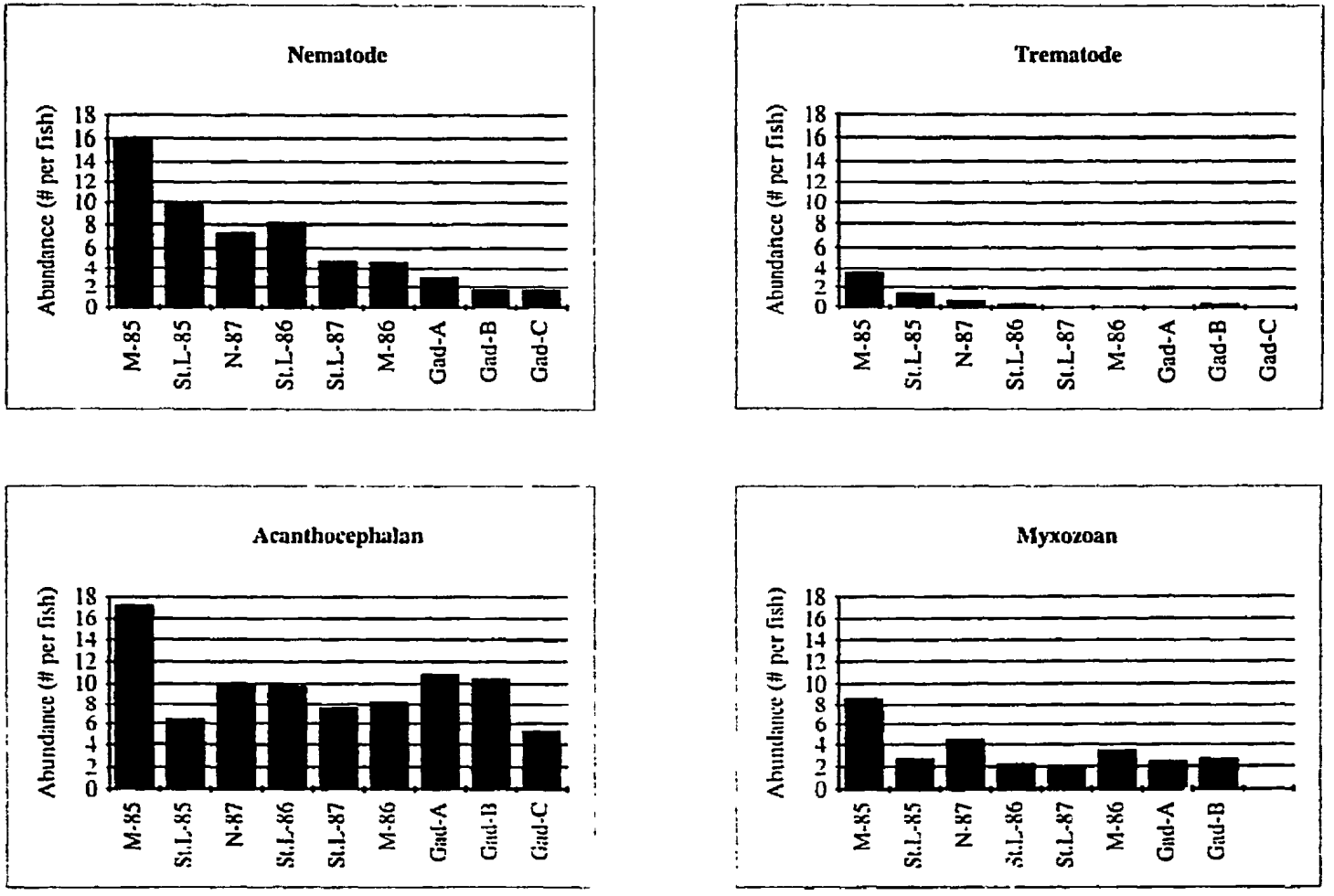


Figure 11. Prevalence of nematodes, trematodes, acanthocephalans, and myxozoans present within Atlantic cod from all locations.

21), trematodes (Figures 22 and 23), acanthocephalans (Figures 24 and 25), and myxozoans (Figures 26 and 27).

Parasite (nematode, trematode, acanthocephalan, and myxozoan) abundance levels are further divided into ten centimeter length classes for each location and sampling season; Makkovik 1985 (Figure 28), St. Lewis 1985 (Figure 29), St. Lewis 1987 (Figure 30), Nain 1987 (Figure 31), St. Lewis 1986 (Figure 32), Makkovik 1986 (Figure 33), Gadus A 1986 (Figure 34), Gadus B 1986 (Figure 35), and Gadus C 1986 (Figure 36). Statistical comparisons (Scheffe's F test, P = 0.05) between all length classes and groups sampled are presented in Table 7.

3.3.2 Parasite Abundance Comparisons

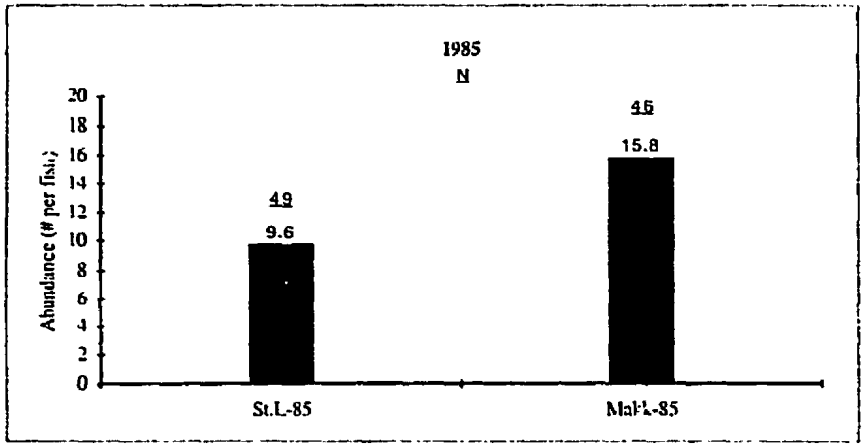
Spatial comparisons of nematode abundance (Figure 12) reveal that cod from St. Lewis 1986 were significantly different (Scheffe's F test, P = 0.05) than cod from Gadus C 1986. No other groups were found to be significantly different from each other. Spatial comparisons (Scheffe's f test, P = 0.05) of trematode (Figure 14), acanthocephalan (Figure 16), and myxozoan (Figure 18) abundances reveal that no groups were significantly different from each other. Temporal comparisons (Scheffe's f test, P = 0.05) of nematode (Figure 13), trematode (Figure 15), acanthocephalan (Figure 17), and myxozoan (Figure 19) abundances reveal that no groups were significantly different from each other.

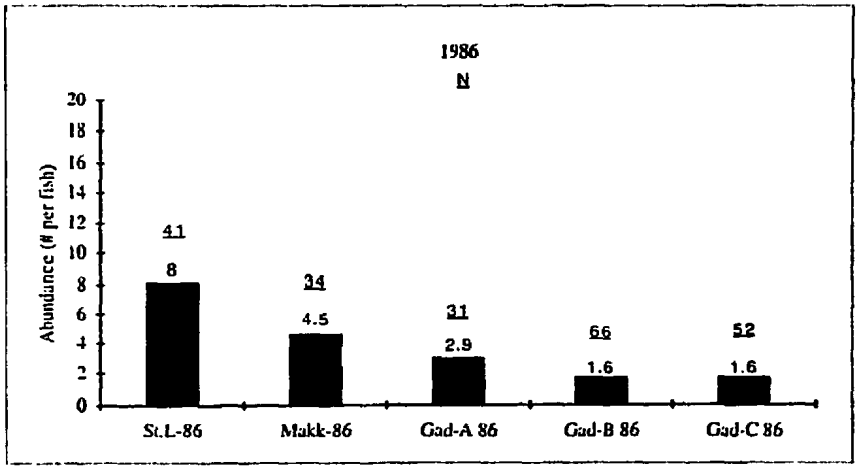
3.3.3 Parasite Prevalence Comparisons

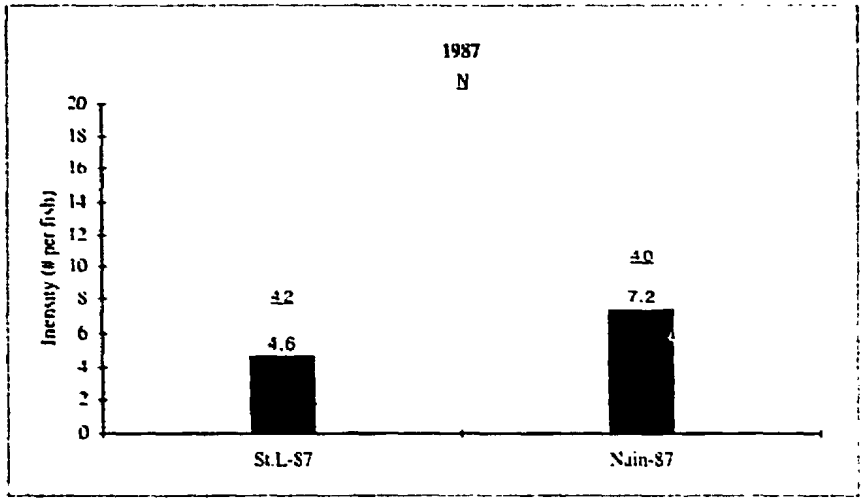
Spatial comparisons of nematode prevalence (Figure 20) reveal that cod from St. Lewis 1986 were significantly different (Fisher's exact test, P = 0.05) than cod from Gadus A

1986, Gadus B 1986, and Gadus C 1986. Cod from Makkovik 1986 were found to be significantly different (P = 0.05) than cod from Gadus B 1986. Temporal comparisons of nematode prevalence (Figure 21) reveal that cod from St. Lewis 1985 were significantly different (P = 0.05) than cod from St. Lewis 1987. Cod from Makkovik 1985 were significantly different (P = 0.05) than cod from Makkovik 1986. Spatial comparisons of trematode prevalence (Figure 22) reveal that no groups were significantly different (P = 0.05) from each other. Temporal comparisons of trematode prevalence (Figure 23) reveal that cod from St. Lewis 1985 were significantly different (P = 0.05) than cod from St. Lewis 1987. Cod from Makkovik 1985 were significantly different (P = 0.05) than cod from Makkovik 1986. Spatial comparisons of acanthocephalan prevalence (Figure 24) reveal that cod from St. Lewis 1985 were significantly different (P = 0.05) than cod from Makkovik 1985. Cod from St. Lewis 1986 were significantly different (P = 0.05) than cod from Gadus B 1986. Temporal comparisons of acanthocephalan prevalence (Figure 25) reveal that no groups were significantly different from each other. Spatial comparisons of myxozoan prevalence (Figure 26) reveal that cod from St. Lewis 1985 were significantly different (P = 0.05) than cod from Makkovik 1985. Cod from St. Lewis 1986 were significantly different (P = 0.05) than cod from Gadus B 1986. Temporal comparisons of myxozoan prevalence (Figure 27) reveal that cod from St. Lewis 1985 were significantly different (Scheffe's F test, P = 0.05) than cod from St. Lewis 1986. Cod from St Lewis 1986 were significantly different (P = 0.05) than cod from St. Lewis 1987.

Figure 12. Nematode Abundance comparisons (Scheffe's F test, P = 0.05) by location for the years 1985, 1986, and 1987.







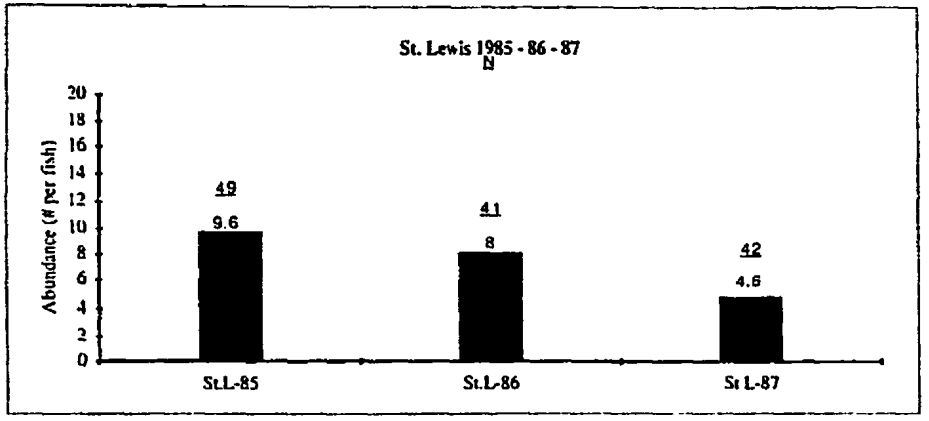
	Makkovik 85	St. Lewis 85
Makkovik 85		NS
St. Lewis 85	NS	

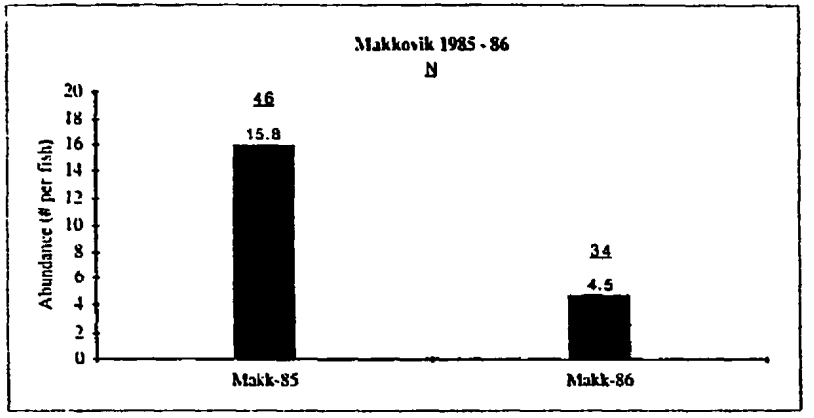
	St. Lewis 86	Makkovik 86	Gadus A 86	Gadus B 86	Gadus C 86
St. Lewis 86		NS	NS	NS	*
Makkovik 86	NS		NS	NS	NS
Gadus A 86	NS	NS		NS	NS
Gadus B 86	NS	NS	NS		NS
Gads C 86	*	NS	NS	NS	

	St. Lewis 87	Nain 87
St. Lewis 87		NS
Nain 87	NS	

* = significantly different, P = 0.05
NS = not significant

Figure 13. Nematode abundance comparisons (Scheffe's F test, P = 0.05) by year for St. Lewis and Makkovik.



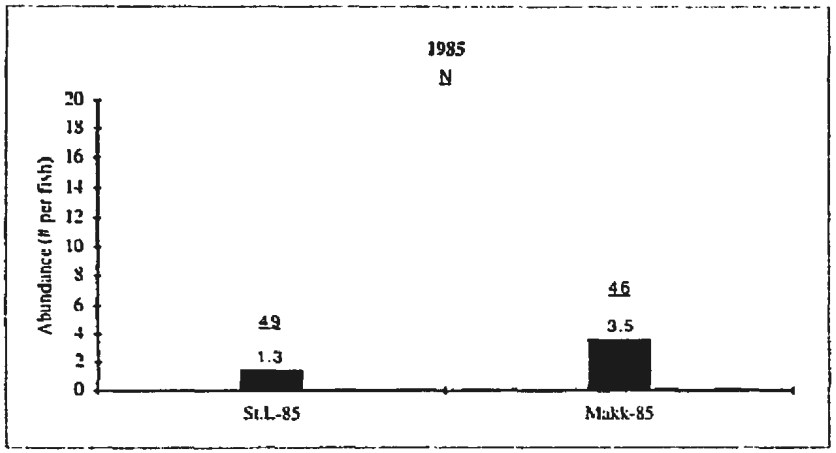


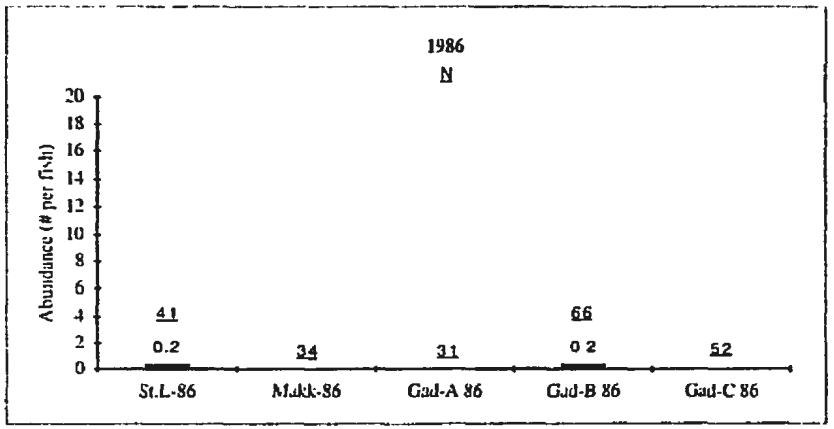
	St. Lewis 85	St. Lewis 86	St. Lewis 87
St. Lewis 85		NS	NS
St. Lewis 86	NS		NS
St. Lewis 87	NS	NS	

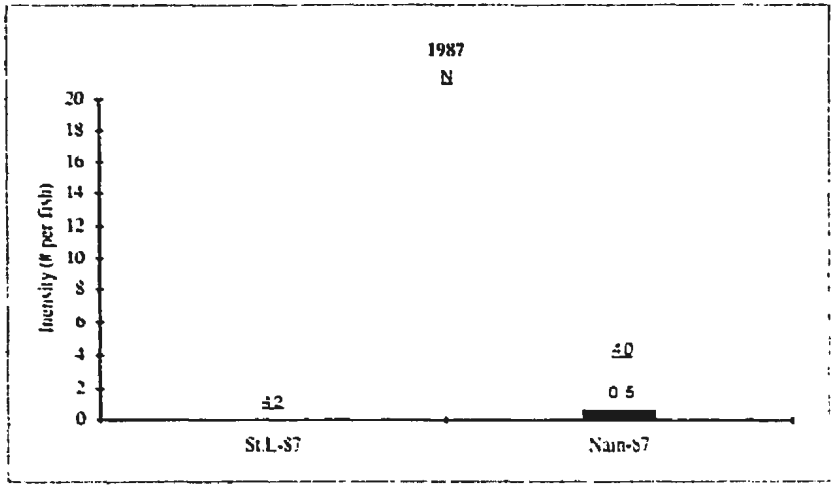
	Makkovik 85	Makkovik 86
Makkovik 85		*
Makkovik 86	*	

* = significantly different, P = 0.05
NS = not significant

Figure 14. Trematode abundance comparisons (Scheffe's F test, P = 0.05) by location for the years 1985, 1986, and 1987.







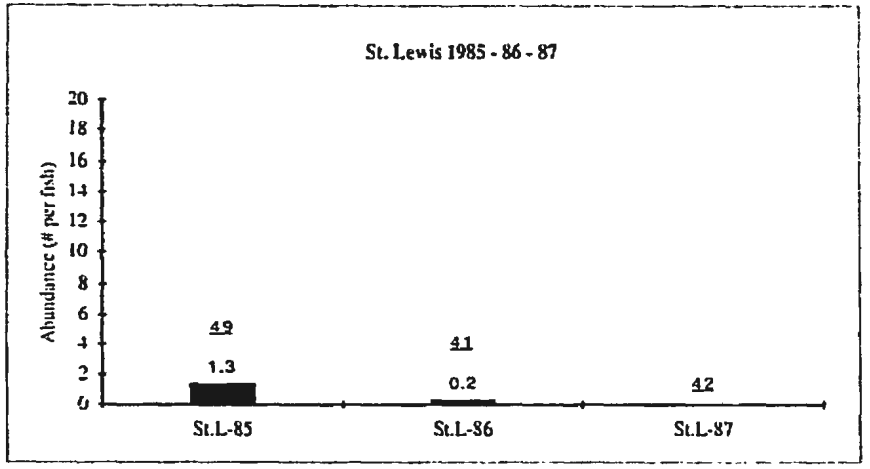
	Makkovik 85	St. Lewis 85
Makkovik 85		NS
St. Lewis 85	NS	

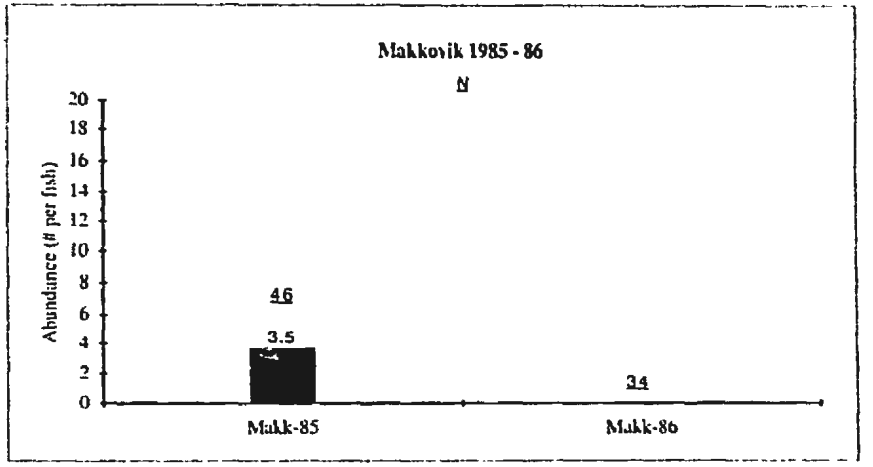
	St. Lewis 86	Makkovik 86	Gadus A 86	Gadus B 86	Gadus C 86
St. Lewis 86		NS	NS	NS	NS
Makkovik 86	NS		NS	NS	NS
Gadus A 86	NS	NS		NS	NS
Gadus B 86	NS	NS	NS		NS
Gads C 86	NS	NS	NS	NS	

	St. Lewis 87	Nain 87
St. Lewis 87		NS
Nain 87	NS	

* = significantly different, P = 0.05
NS = not significant

Figure 15. Trematode abundance comparisons (Scheffe's F test, P = 0.05) by year for St. Lewis and Makkovik.



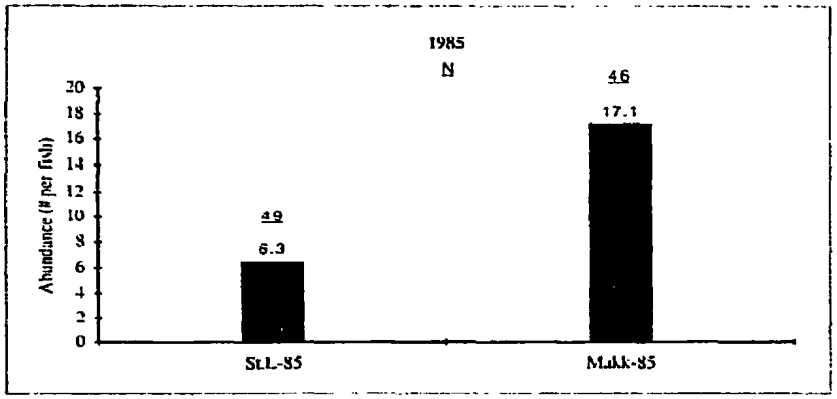


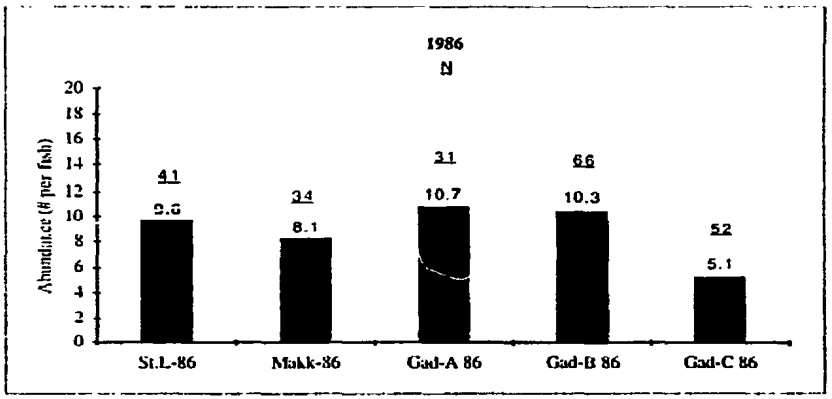
	St. Lewis 85	St. Lewis 86	St. Lewis 87
St. Lewis 85		NS	NS
St. Lewis 86	NS		NS
St. Lewis 87	NS	NS	

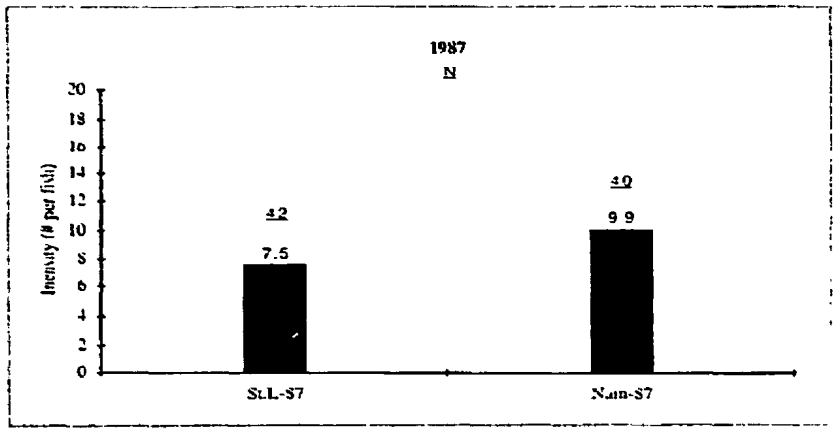
	Makkovik 85	Makkovik 86
Makkovik 85		NS
Makkovik 86	NS	

* = significantly different, P = 0.05
NS = not significant

Figure 16. Acathocephalan abundance comparisons (Scheffe's F test, P = 0.05) by location for the years 1985, 1986, and 1987.







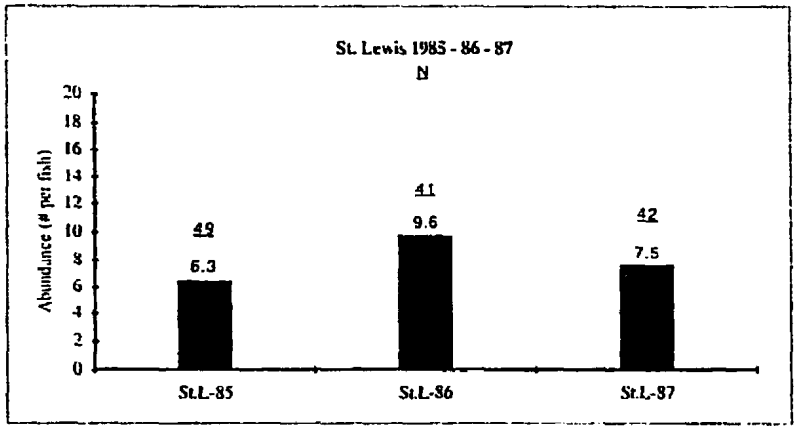
	Makkovik 85	St. Lewis 85
Makkovik 85		NS
St. Lewis 85	NS	

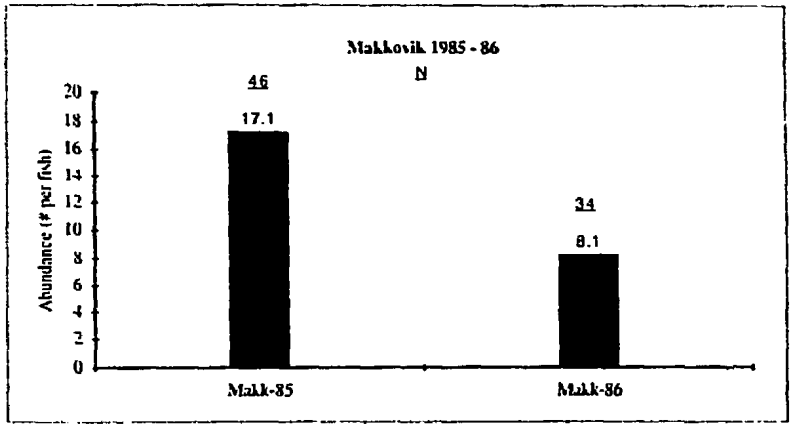
	St. Lewis 86	Makkovik 86	Gadus A 86	Gadus B 86	Gadus C 86
St. Lewis 86		NS	NS	NS	NS
Makkovik 86	NS		NS	NS	NS
Gadus A 86	NS	NS		NS	NS
Gadus B 86	NS	NS	NS		NS
Gads C 86	NS	NS	NS	NS	

	St. Lewis 87	Nain 87
St. Lewis 87		NS
Nain 87	NS	

* = significantly different, P = 0.05
NS = not significant

Figure 17. Acanthocephalan abundance comparisons (Scheffe's F test, P = 0.05) by year for St. Lewis and Makkovik.



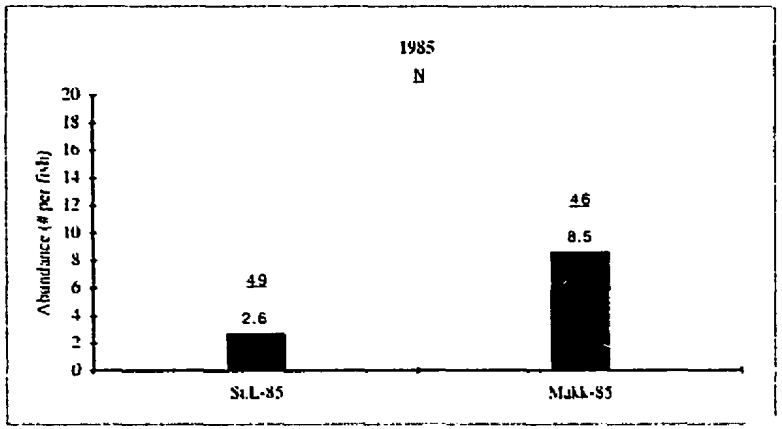


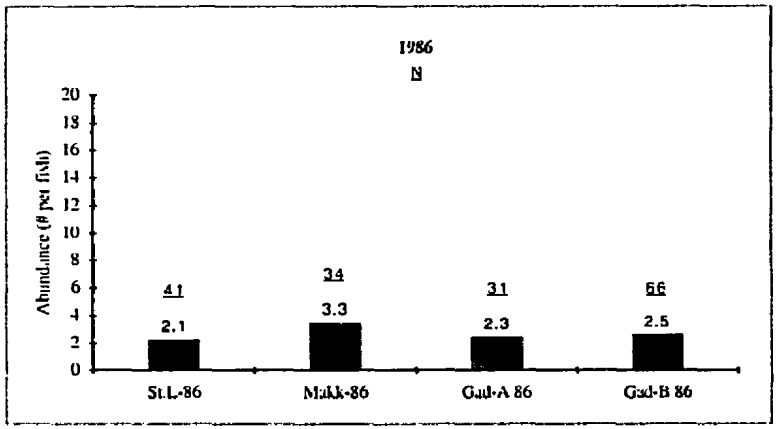
	St. Lewis 85	St. Lewis 86	St. Lewis 87
St. Lewis 85		NS	NS
St. Lewis 86	NS		NS
St. Lewis 87	NS	NS	

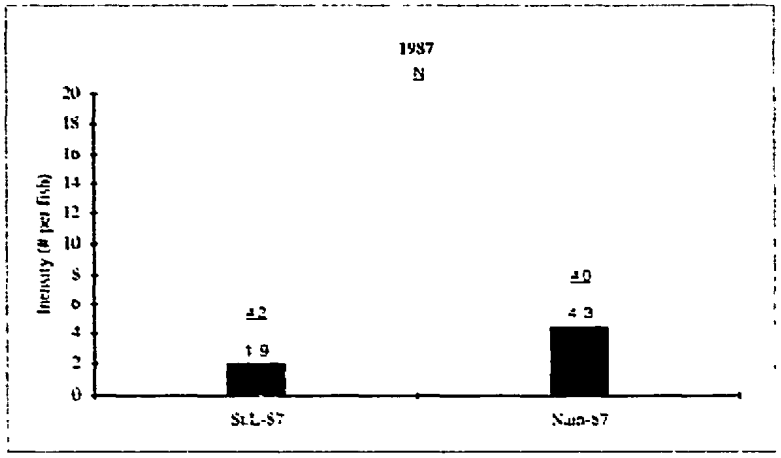
	Makkovik 85	Makkovik 86
Makkovik 85		NS
Makkovik 86	NS	

* = significantly different, P = 0.05
NS = not significant

Figure 18. Myxozoan abundance comparisons (Scheffe's F test, P = 0.05) by location for the years 1985, 1986, and 1987.







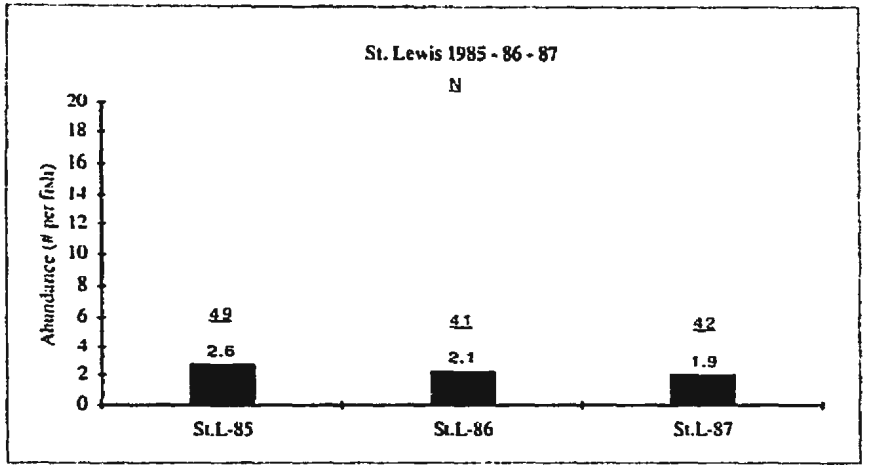
	Makkovik 85	St. Lewis 85
Makkovik 85		NS
St. Lewis 85	NS	

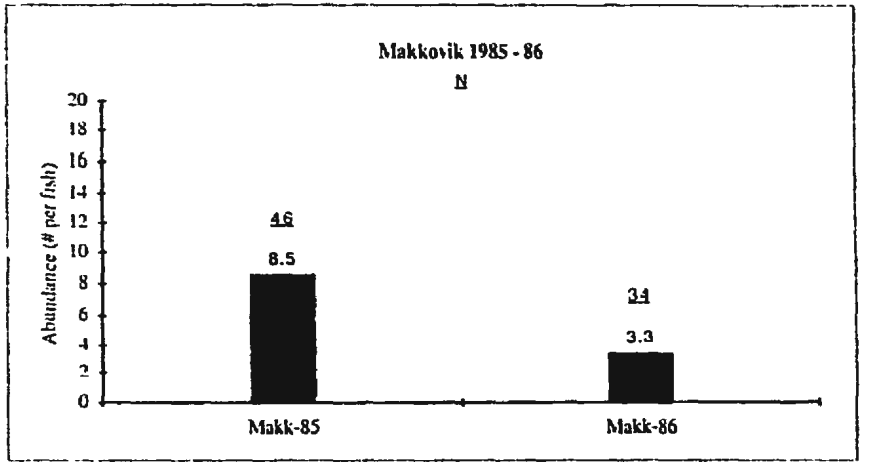
	St. Lewis 86	Makkovik 86	Gadus A 86	Gadus B 86	Gadus C 86
St. Lewis 86		NS	NS	NS	NS
Makkovik 86	NS		NS	NS	NS
Gadus A 86	NS	NS		NS	NS
Gadus B 86	NS	NS	NS		NS
Gadus C 86	NS	NS	NS	NS	

	St. Lewis 87	Nain 87
St. Lewis 87		NS
Nain 87	NS	

* = significantly different. P = 0.05
NS = not significant

Figure 19. Myxozoan abundance comparisons (Scheffe's F test, P = 0.05) by year for St. Lewis and Makkovik.



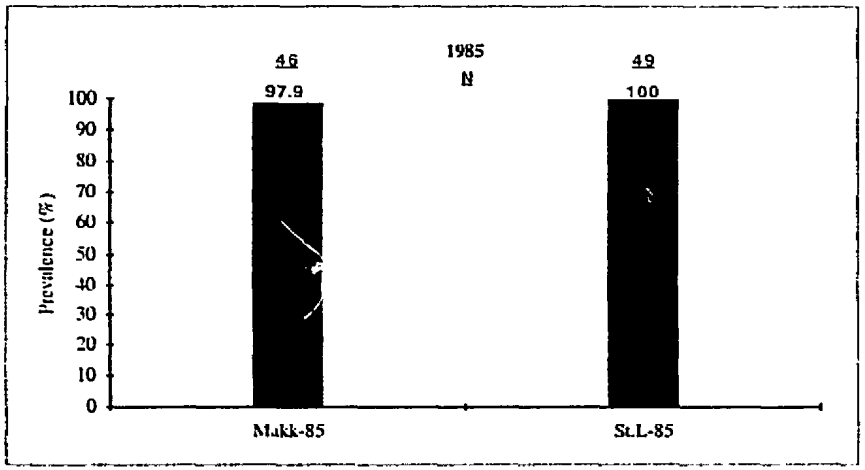


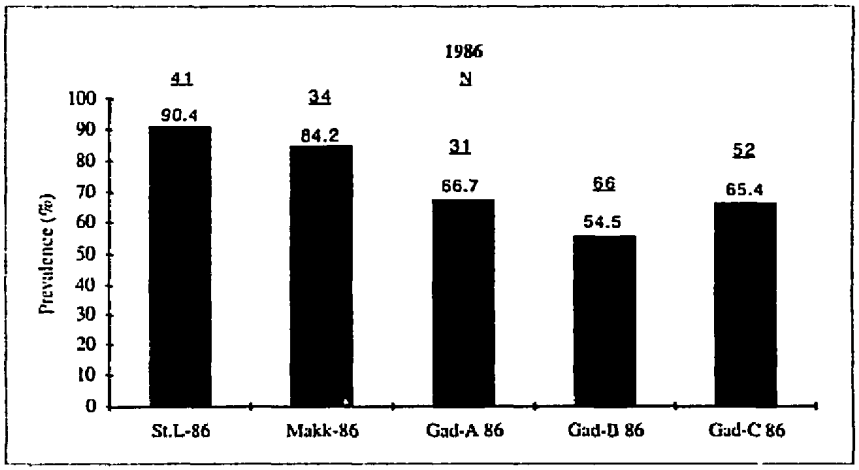
	St. Lewis 85	St. Lewis 86	St. Lewis 87
St. Lewis 85		NS	NS
St. Lewis 86	NS		NS
St. Lewis 87	NS	NS	

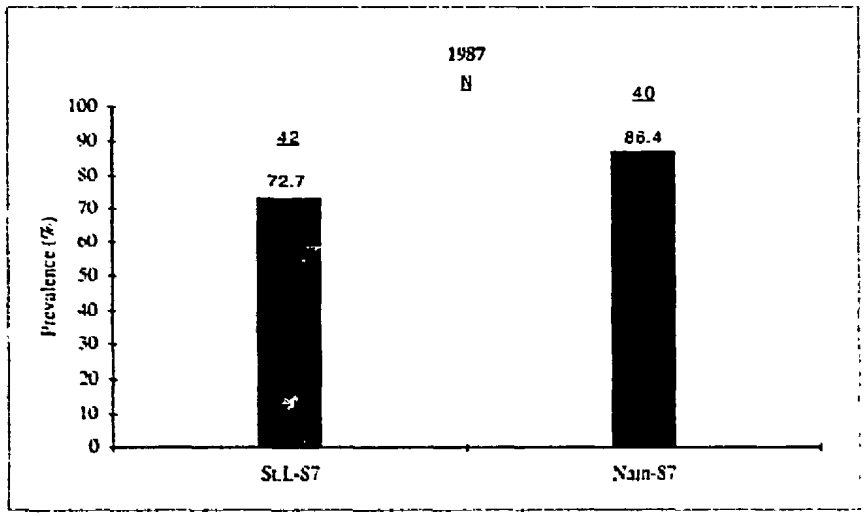
	Makkovik 85	Makkovik 86
Makkovik 85		NS
Makkovik 86	NS	

* = significantly different, P = 0.05
NS = not significant

Figure 20. Nematode prevalence comparisons (Fisher's exact test, P = 0.05) by location for the years 1985, 1986, and 1987.







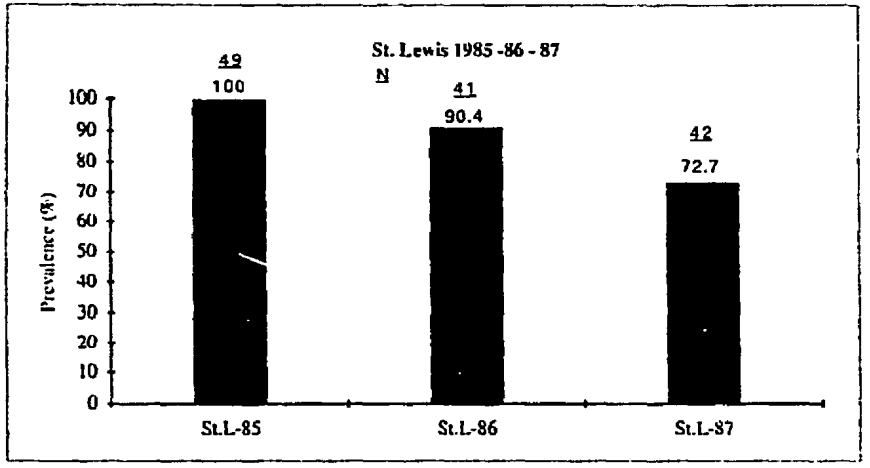
	Makkovik 85	St. Lewis 85
Makkovik 85		NS
St. Lewis 85	NS	

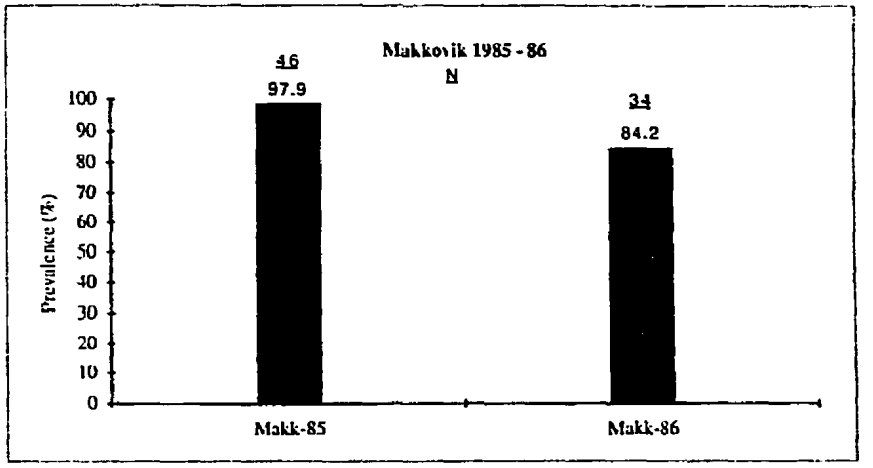
	St. Lewis 86	Makkovik 86	Gadus A 86	Gadus B 86	Gadus C 86
St. Lewis 86		NS	*	*	*
Makkovik 86	NS		NS	*	NS
Gadus A 86	*	NS		NS	NS
Gadus B 86	*	*	NS		NS
Gadus C 86	*	NS	NS	NS	

	St. Lewis 87	Nain 87
St. Lewis 87		NS
Nain 87	NS	

* = significantly different, P = 0.05
NS = not significant

Figure 21. Nematode prevalence comparisons (Fisher's exact test, P = 0.05) by year for St. Lewis and Makkovik.



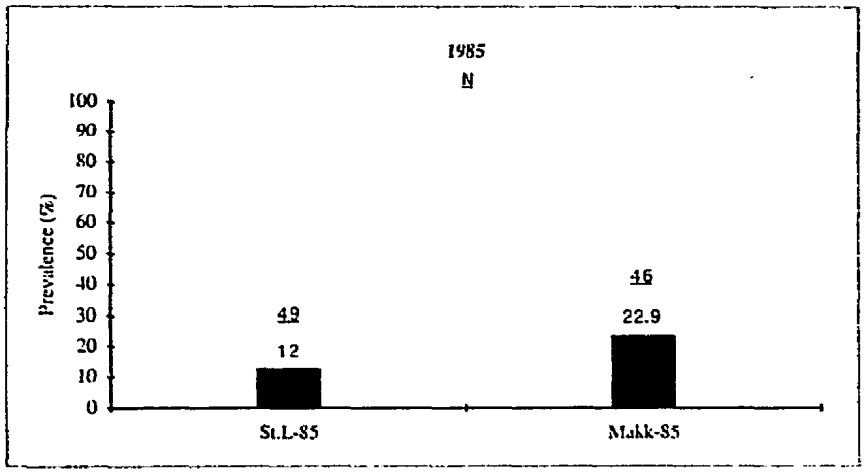


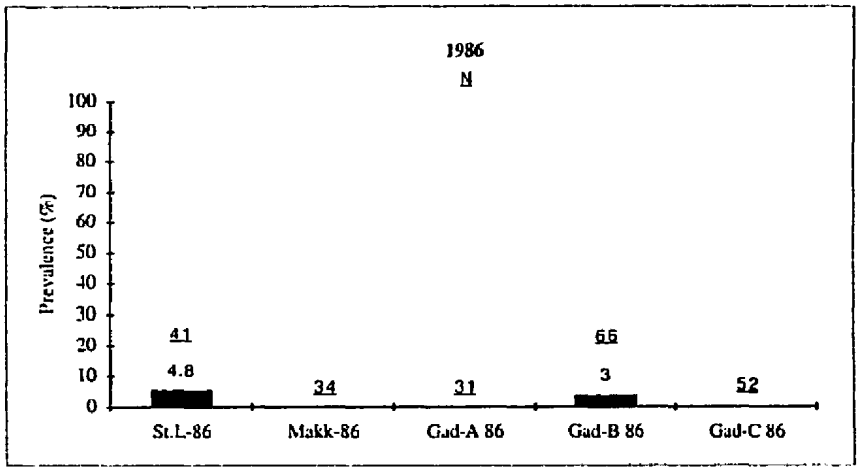
	St. Lewis 85	St. Lewis 86	St. Lewis 87
St. Lewis 85		NS	*
St. Lewis 86	NS		NS
St. Lewis 87	*	NS	

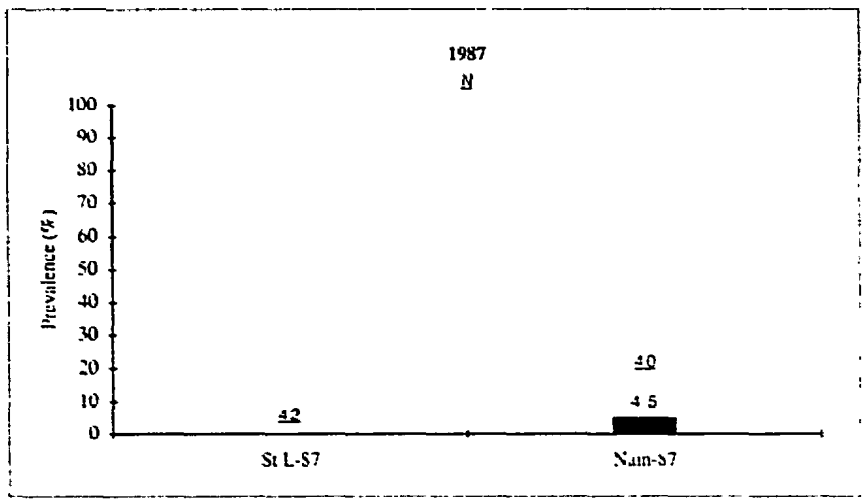
	Makkovik 85	Makkovik 86
Makkovik 85		*
Makkovik 86	*	

* = significantly different, P = 0.05
NS = not significant

Figure 22. Trematode prevalence comparisons (Fisher's exact test, P = 0.05) by location for the years 1985, 1986, and 1987.







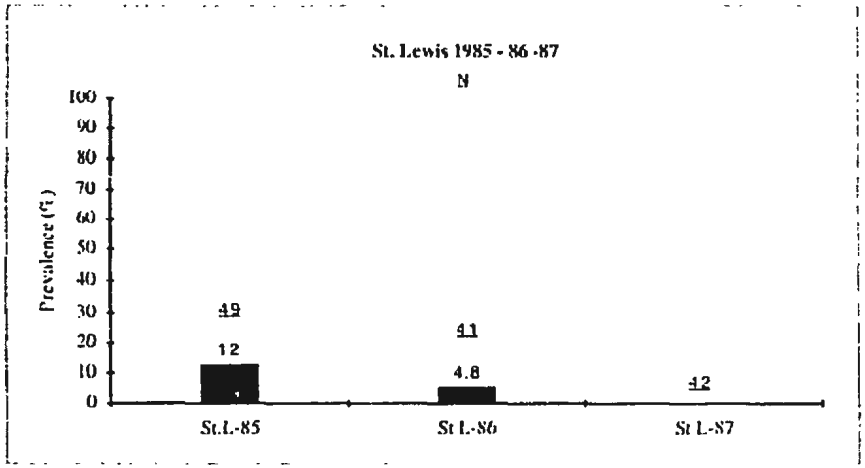
	Makkovik 85	St. Lewis 85
Makkovik 85		NS
St. Lewis 85	NS	

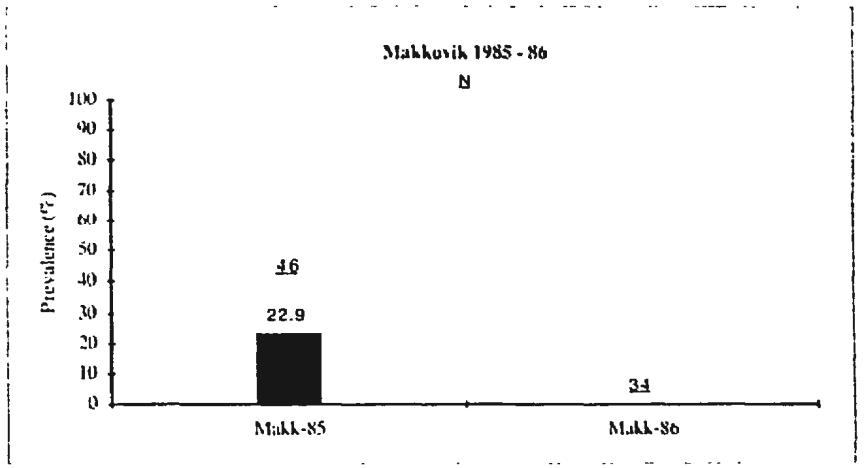
	St. Lewis 86	Makkovik 86	Gadus A 86	Gadus B 86	Gadus C 86
St. Lewis 86		NS	NS	NS	NS
Makkovik 86	NS		NS	NS	NS
Gadus A 86	NS	NS		NS	NS
Gadus B 86	NS	NS	NS		NS
Gads C 86	NS	NS	NS	NS	

	St. Lewis 87	Nain 87
St. Lewis 87		NS
Nain 87	NS	

* = significantly different, P = 0.05
NS = not significant

Figure 23. Trematode prevalence comparisons (Fisher's exact test, P = 0.05) by year for St. Lewis and Makkovik.



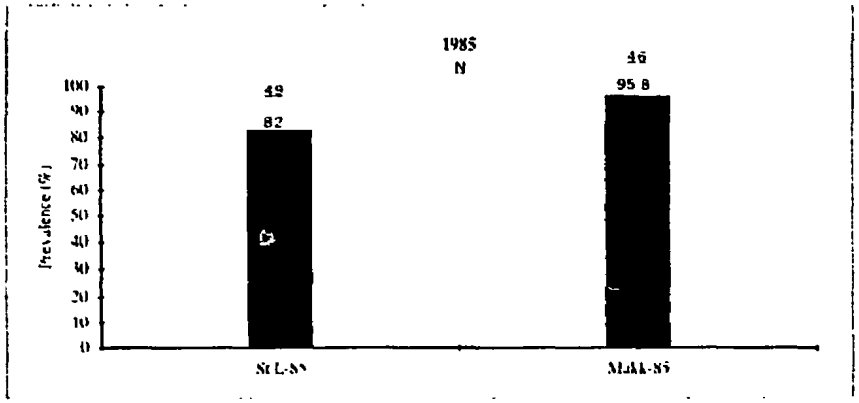


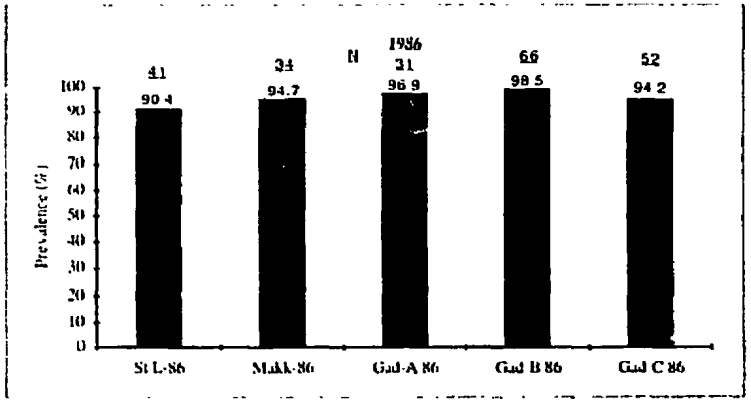
	St. Lewis 85	St. Lewis 86	St. Lewis 87
St. Lewis 85		NS	*
St. Lewis 86	NS		
St. Lewis 87	*	NS	NS

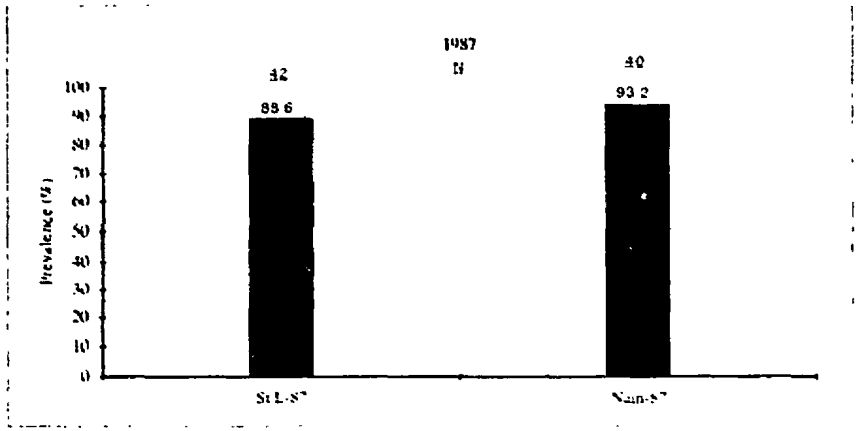
	Makkovik 85	Makkovik 86
Makkovik 85		*
Makkovik 86	*	

* = significantly different, P = 0.05
NS = not significant

Figure 24. Acanthocephalan prevalence comparisons (Fisher's exact test, P = 0.05) by location for the years 1985, 1986, and 1987.







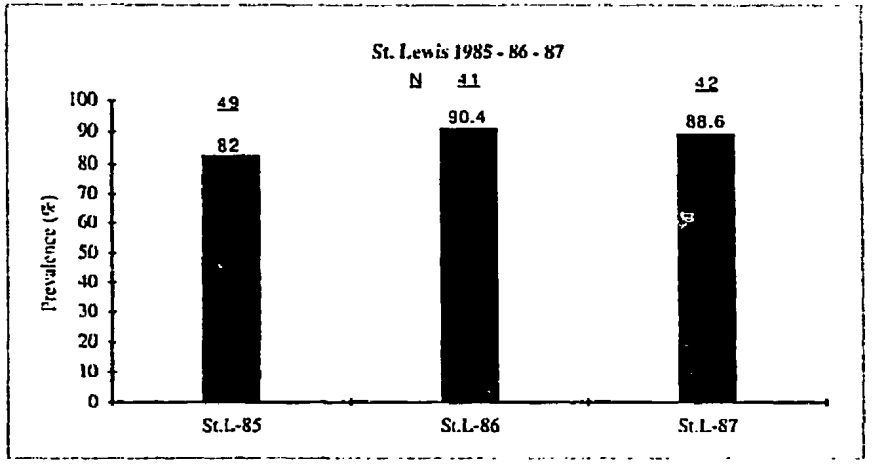
	Makkovik 85	St Lewis 85
Makkovik 85		*
St Lewis 85	*	

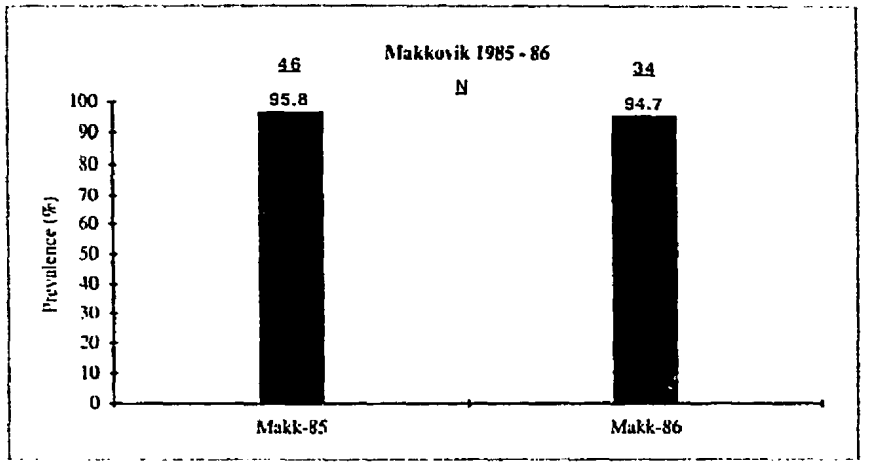
	St Lewis 86	Makkovik 86	Gadus A 86	Gadus B 86	Gadus C 86
St Lewis 86		NS	NS	*	NS
Makkovik 86	NS		NS	NS	NS
Gadus A 86	NS	NS		NS	NS
Gadus B 86	*	NS	NS		NS
Gadus C 86	NS	NS	NS	NS	

	St Lewis 87	Nan 87
St Lewis 87		NS
Nan 87	NS	

* = significantly different, P = 0.05
NS = not significant

Figure 25. Acanthocephalan prevalence comparisons (Fisher's exact test, P = 0.05) by year for St. Lewis and Makkovik.



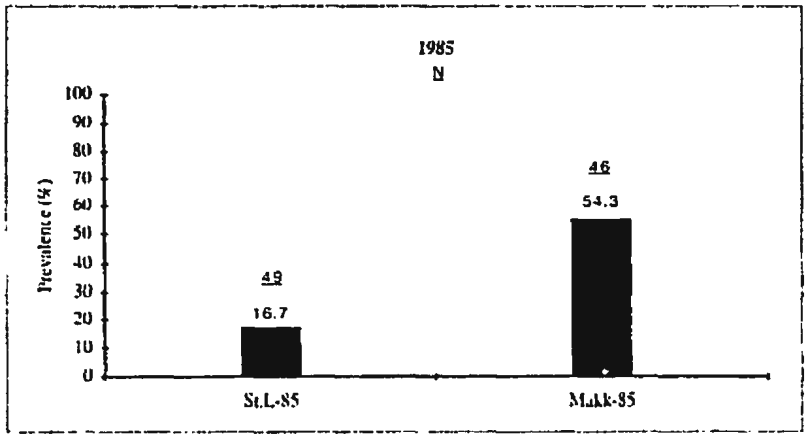


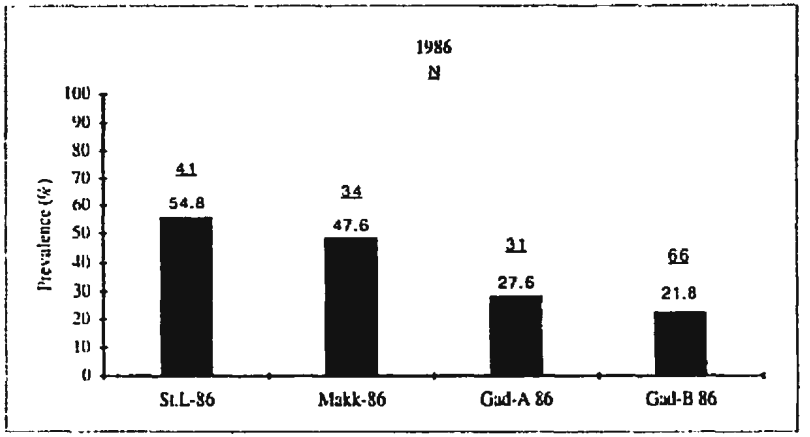
	St. Lewis 85	St. Lewis 86	St. Lewis 87
St. Lewis 85		NS	NS
St. Lewis 86	NS		NS
St. Lewis 87	NS	NS	

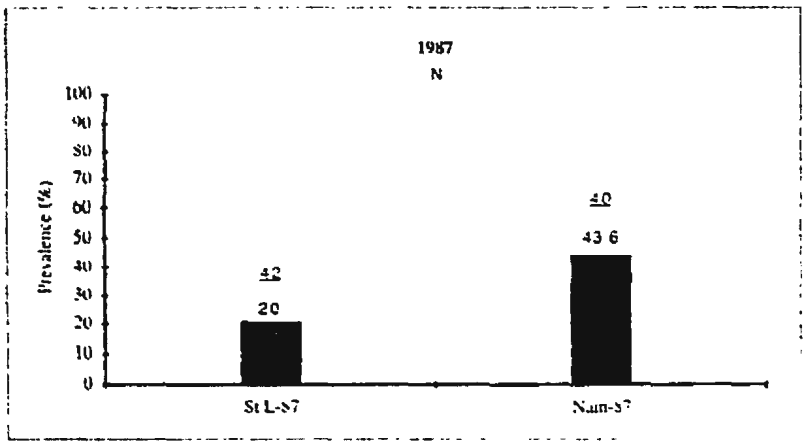
	Makkovik 85	Makkovik 86
Makkovik 85		NS
Makkovik 86	NS	

* = significantly different, P = 0.05
NS = not significant

Figure 26. Myxozoan prevalence comparisons (Fisher's exact test, P = 0.05) by location for the years 1985, 1986, and 1987.







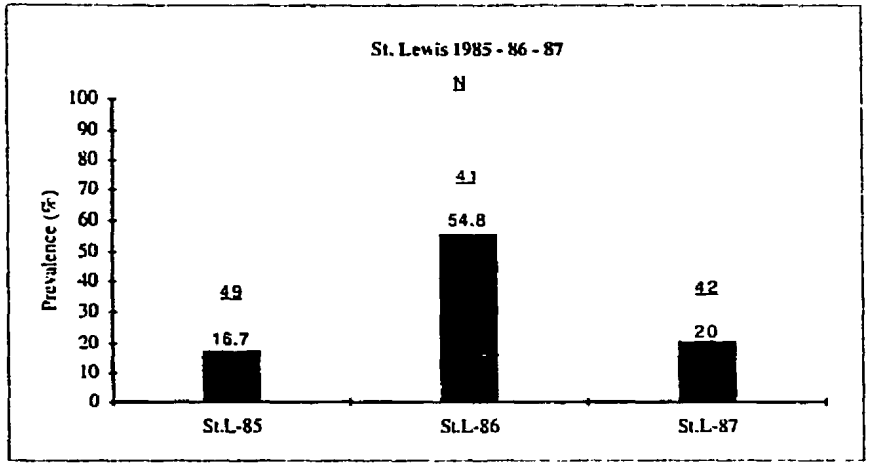
	Makkovik 85	St. Lewis 85
Makkovik 85		*
St. Lewis 85	*	

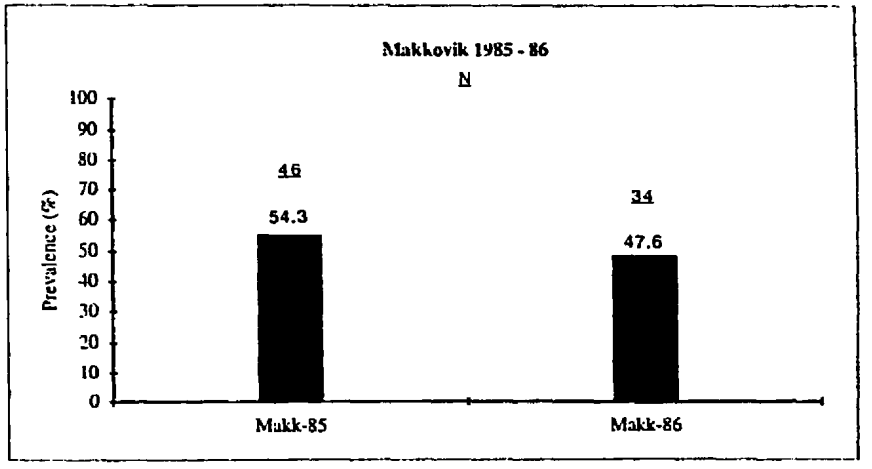
	St. Lewis 86	Makkovik 86	Gadus A 86	Gadus B 86	Gadus C 86
St. Lewis 86		NS	NS	*	No Sample
Makkovik 86	NS		NS	NS	No Sample
Gadus A 86	NS	NS		NS	No Sample
Gadus B 86	*	NS	NS		No Sample
Gadus C 86	No Sample	No Sample	No Sample	No Sample	

	St. Lewis 87	Nain 87
St. Lewis 87		NS
Nain 87	NS	

* = significantly different, P = 0.05
NS = not significant

Figure 27. Myxozoan prevalence comparisons (Fisher's exact test, P = 0.05) by year for St. Lewis and Makkovik.



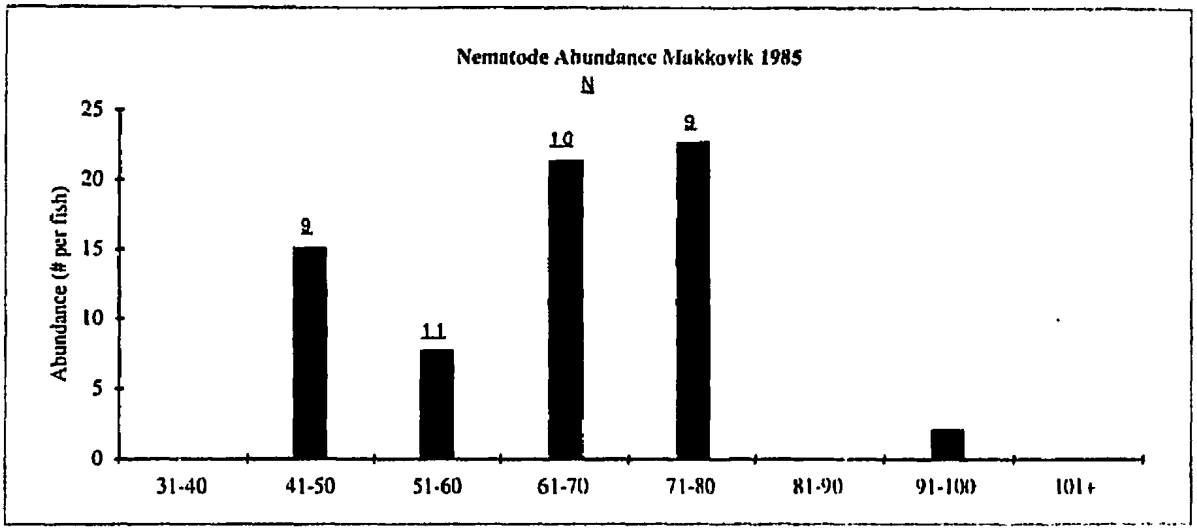


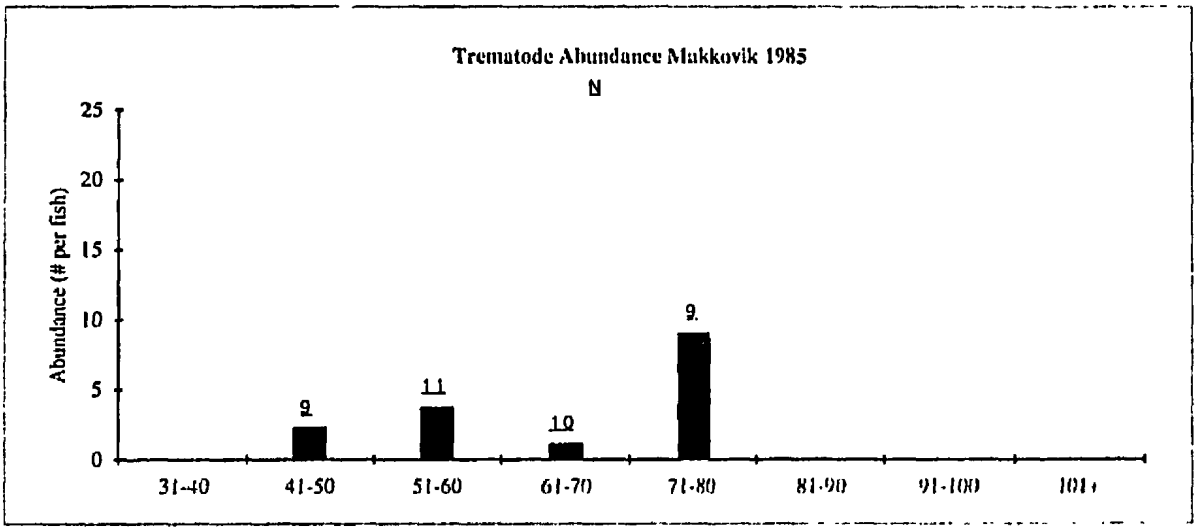
	St. Lewis 85	St. Lewis 86	St. Lewis 87
St. Lewis 85		*	NS
St. Lewis 86	*		*
St. Lewis 87	NS	*	

	Makkovik 85	Makkovik 86
Makkovik 85		NS
Makkovik 86	NS	

* = significantly different, P = 0.05
NS = not significant

Figure 28. Nematode, trematode, and acanthocephalan abundance by length class for Makkovik 1985.





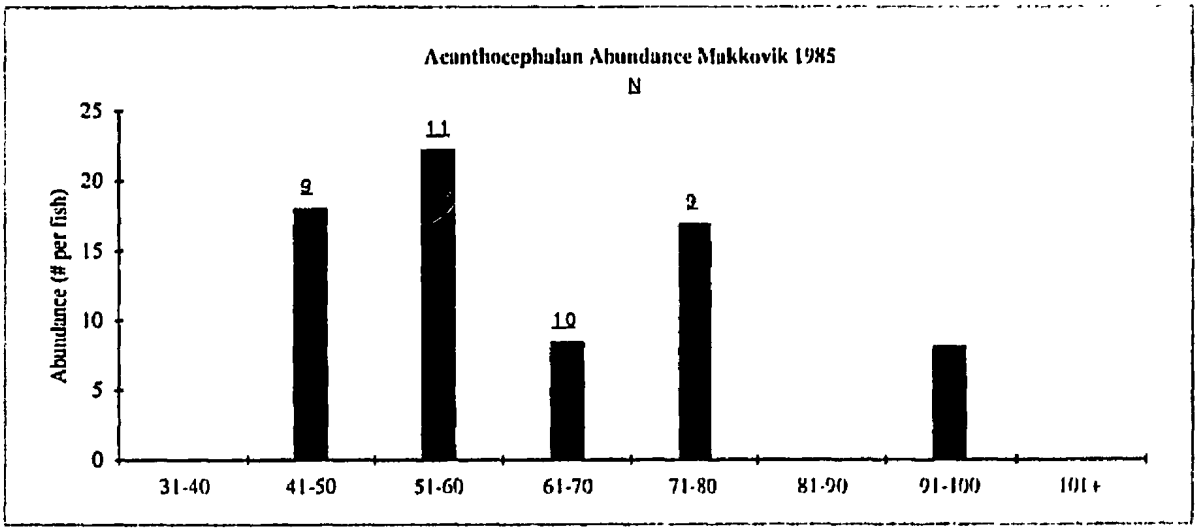


Figure 29. Nematode, trematode, and acanthocephalan abundance by length class for St. Lewis 1985.

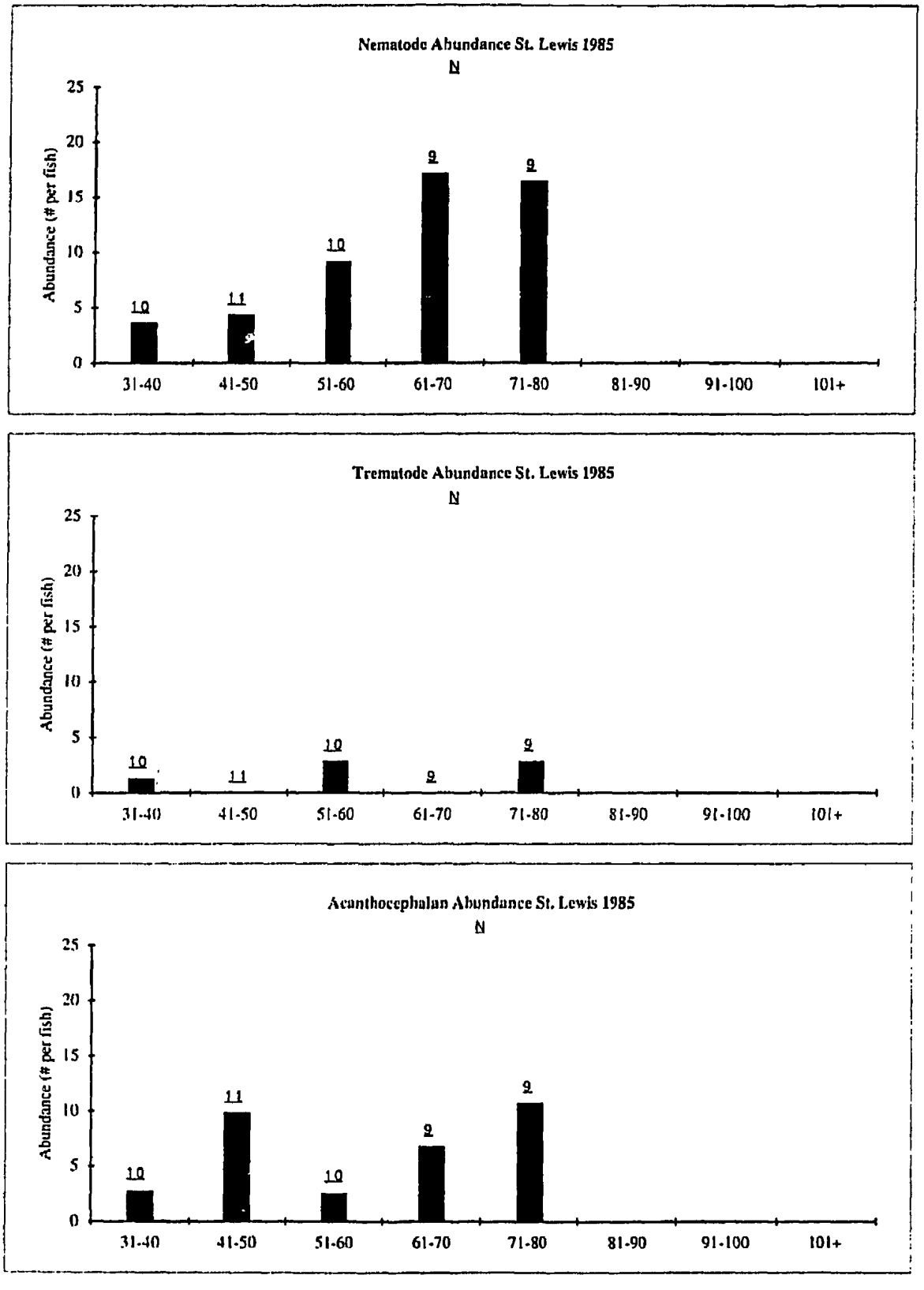


Figure 30. Nematode, trematode, acanthocephalan, and myxozoan abundance by length class for St. Lewis 1987.

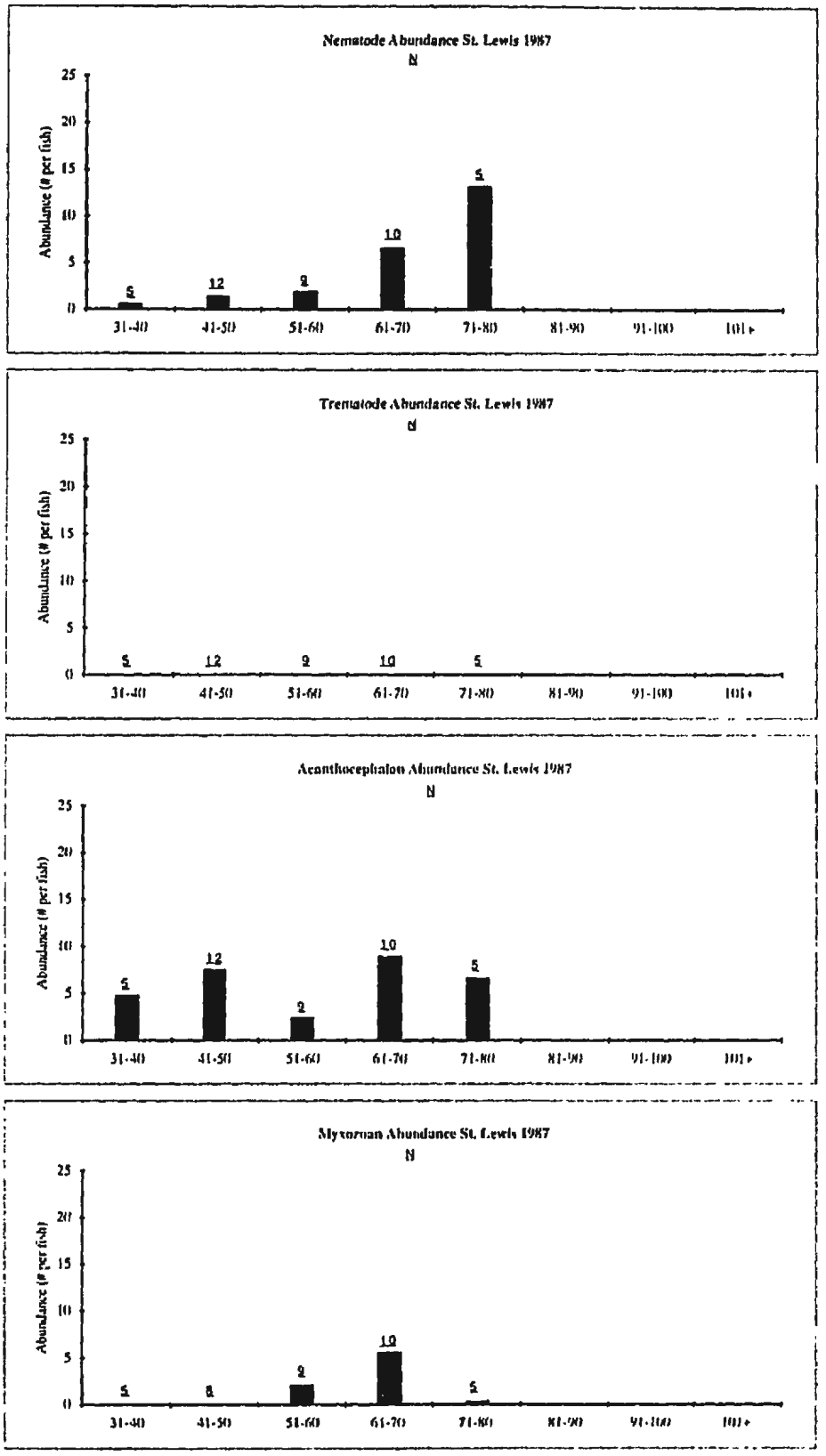


Figure 31. Nematode, trematode, acanthocephalan, and myxozoan abundance by length class for Nain 1987.

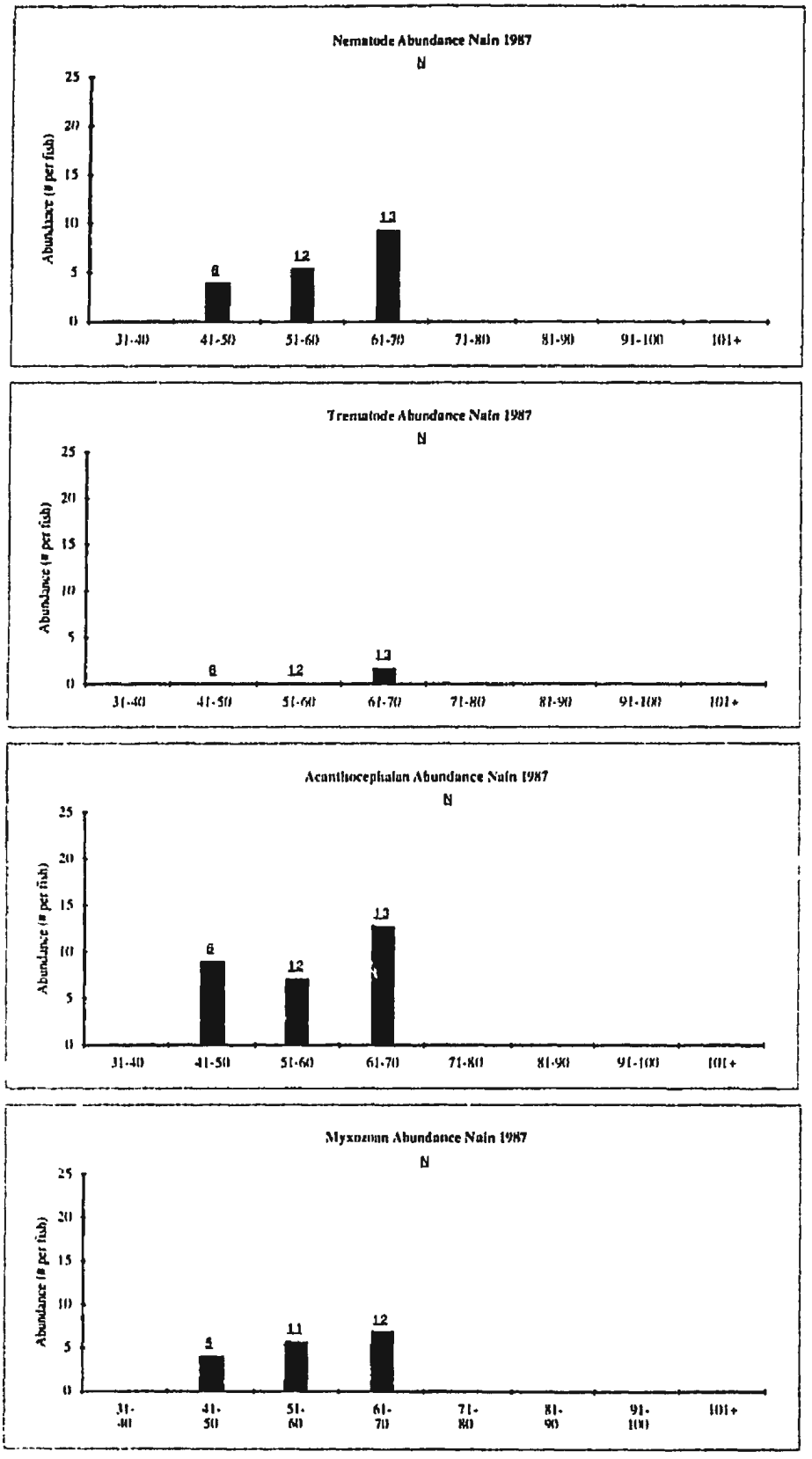


Figure 32. Nematode, trematode, acanthocephalan, and myxozoan abundance by length class for St. Lewis 1986.

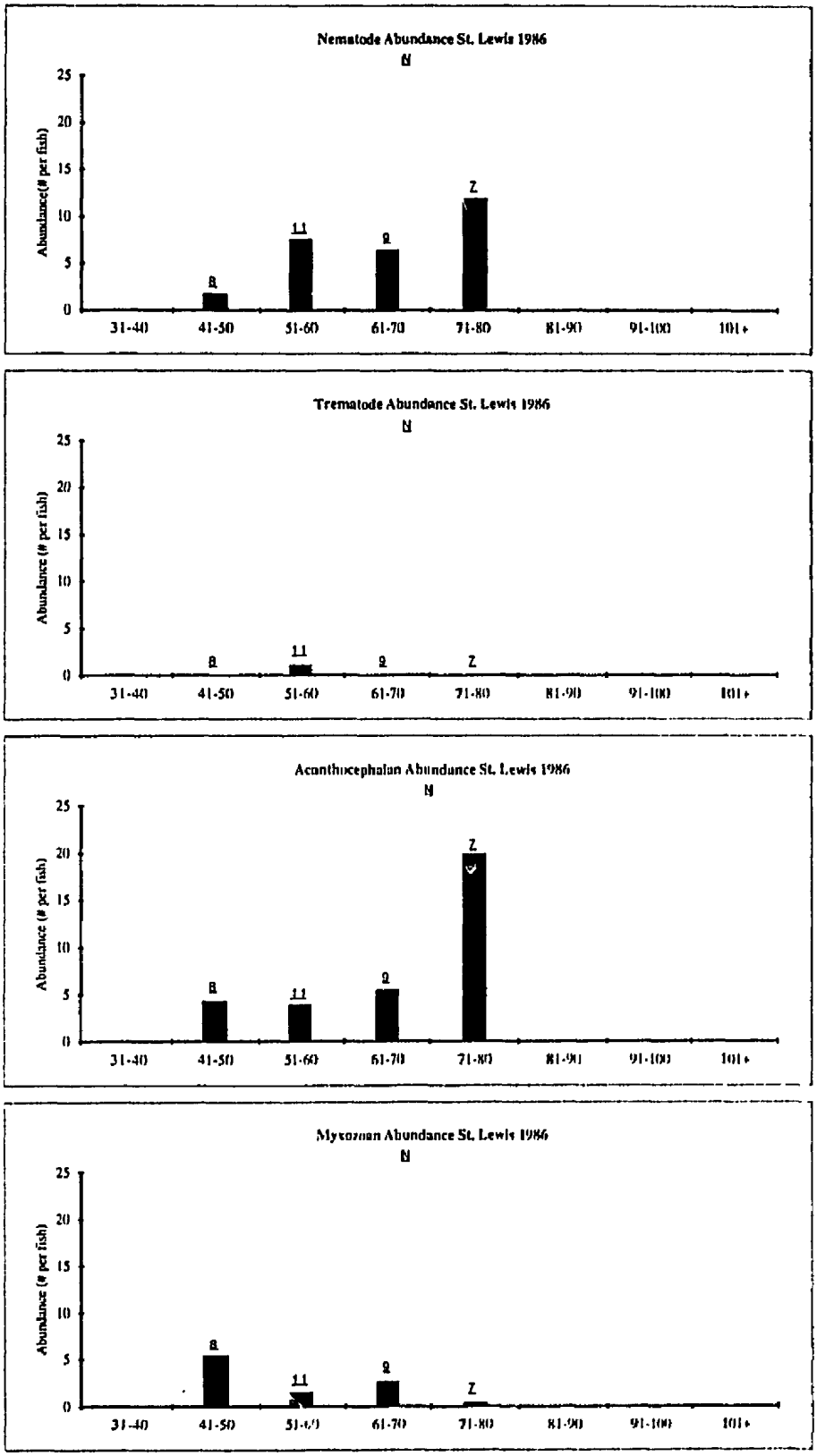


Figure 33. Nematode, trematode, acanthocephalan, and myxozoan abundance by length class for Makkovik 1986.

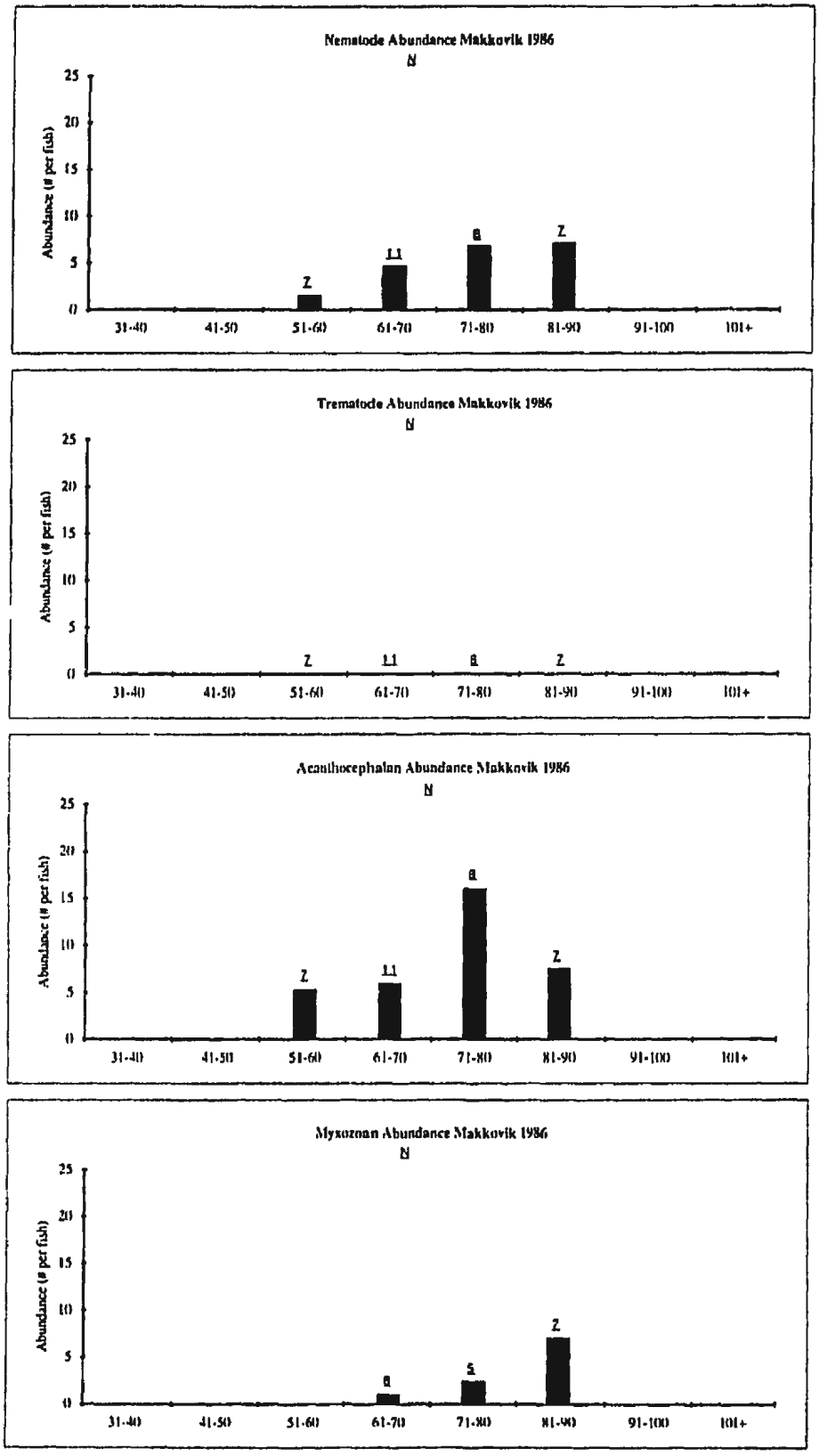


Figure 34. Nematode, trematode, acanthocephalan, and myxozoan abundance for Gadus A 1986.

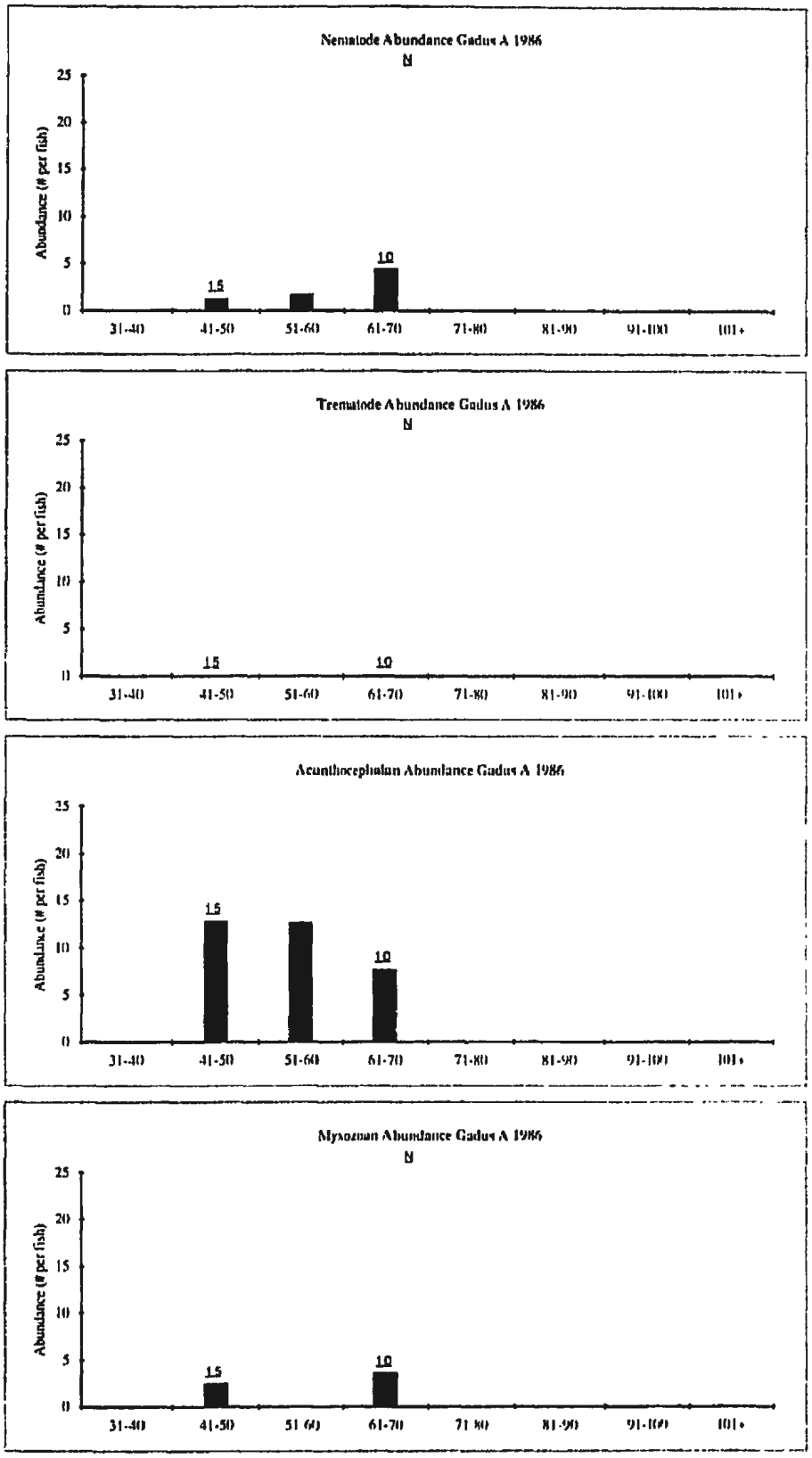


Figure 35. Nematode, trematode, acanthocephalan, and myxozoan abundance for Gadus B 1986.

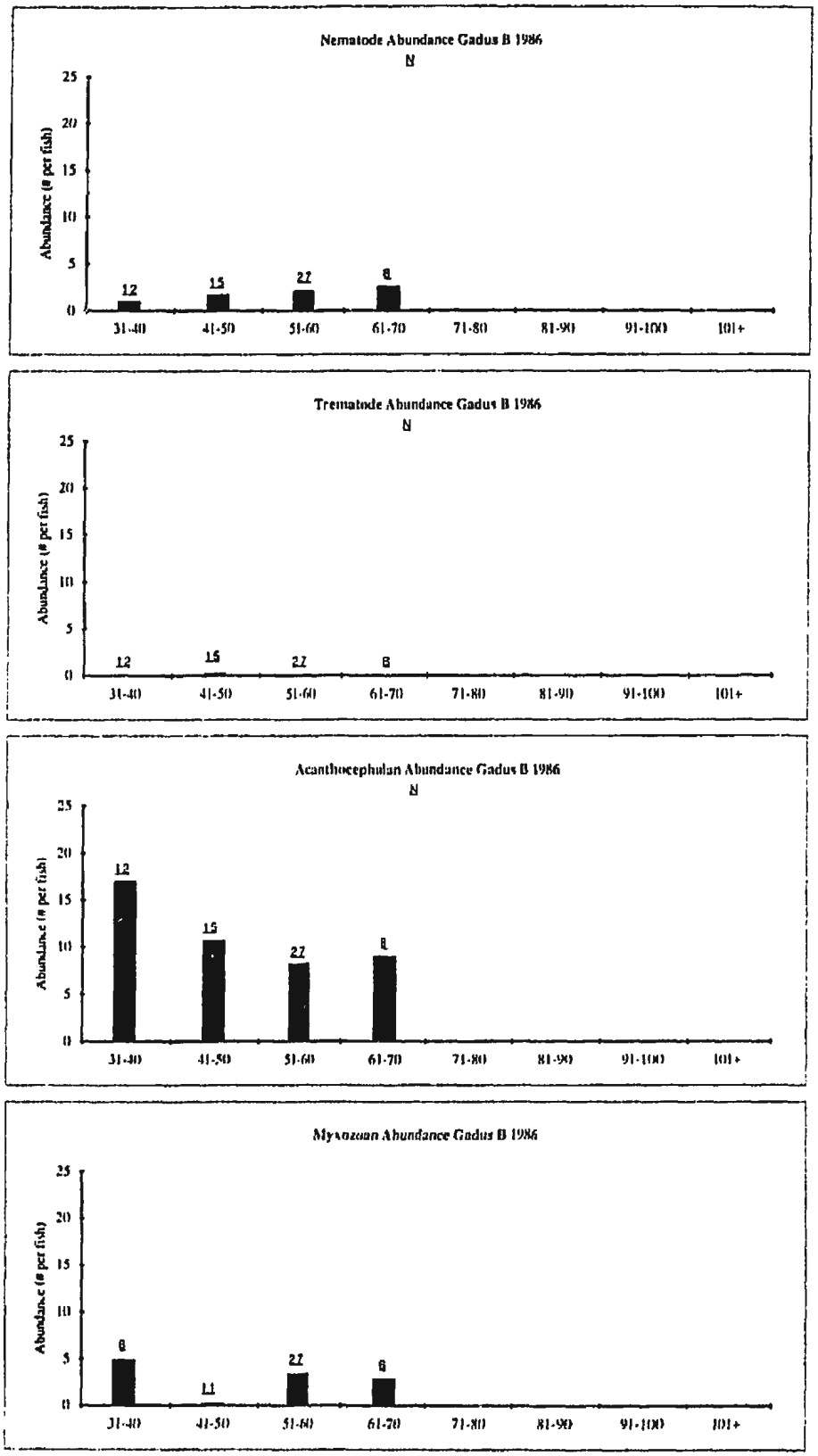


Figure 36. Nematode, trematode, and acanthocephalan abundance for Gadus C 1986 .

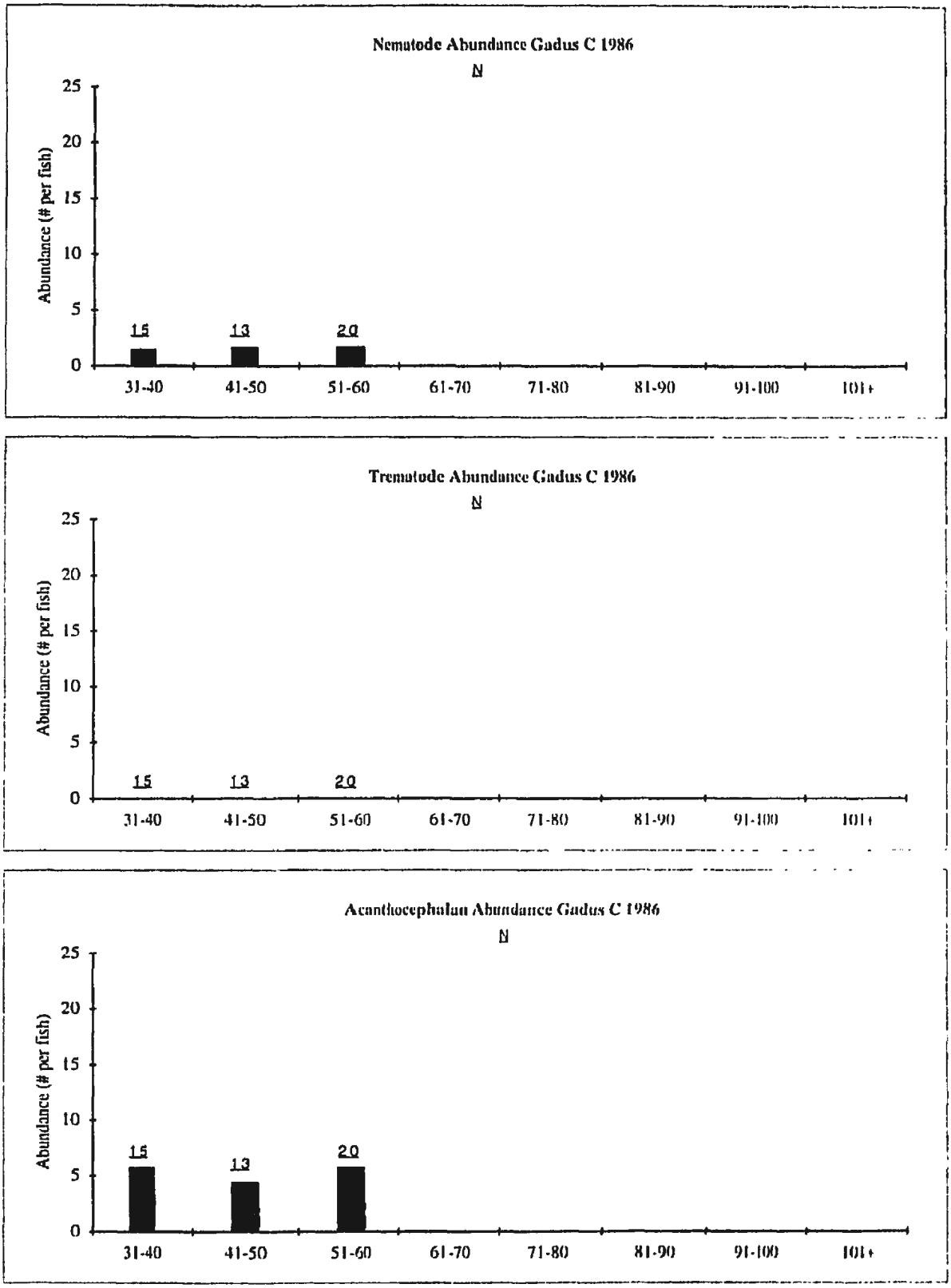


Table 7. Significance tables for Scheffe's F test (P = 0.05) parasite abundance comparisons between length classes of all locations and years sampled.

31- 40 cm

Nematode - No Significant Differences
Trematode - No Significant Differences
Acanthocephalan - No Significant Differences
Myxozoan - No Significant Differences

41 - 50 cm

Nematode - * significant (see below)
Trematode - No Significant Differences
Acanthocephalan - No Significant Differences
Myxozoan - No Significant Differences

Nematode

	St. Lewis 85	Nain 87	St. Lewis 86	St. Lewis 87	Makkovik 86	Gadus A 86	Gadus B 86	Gadus C 86
Makkovik 85	*		*	*		*	*	*

51- 60 cm

Nematode - * significant (see below)
Trematode - No Significant Differences
Acanthocephalan - * significant (see below)
Myxozoan - No Significant Differences

Table 7. continued

Nematode

	Makkovik 85	Nain 87	St. Lewis 86	St. Lewis 87	Makkovik 86	Gadus A 86	Gadus B 86	Gadus C 86
St. Lewis 85							*	*

Acanthocephalan

	St. Lewis 85	Nain 87	St. Lewis 86	St. Lewis 87	Makkovik 86	Gadus A 86	Gadus B 86	Gadus C 86
Makkovik 85	*		*	*			*	*

61-70 cm

Nematode - No Significant Differences
Trematode - No Significant Differences
Acanthocephalan - No Significant Differences
Myxozoan - No Significant Differences

71-80 cm

Nematode - No Significant Differences
Trematode - No Significant Differences
Acanthocephalan - No Significant Differences
Myxozoan - No Significant Differences

81-90 cm

insufficient sample numbers for statistical comparisons

Table 7. continued

91-100 cm

insufficient sample numbers for statistical comparisons

101+ cm

insufficient sample numbers for statistical comparisons

3.3.4 Parasite Abundance Comparisons by Length Class

Parasite abundance levels by length class are presented for all locations and sampling seasons (Figures 28 - 36). Statistical comparison tables (Scheffe's F test, P = 0.05) comparing abundance levels for all locations and sampling seasons are presented in Table 7. For the length class 31-40 cm no significant differences (P = 0.05) were found with respect to parasite abundances between locations and/or sampling seasons. For the length class 41 - 50 cm no significant differences (P = 0.05) were found for parasite abundance with respect to trematodes, acanthocephalans, and myxozoans. In terms of nematodes, cod of the 41 - 50 cm length class from Makkovik 1985 were significantly different (P = 0.05) than cod from St. Lewis 1985, St. Lewis 1986, St. Lewis 1987, Gadus A 1986, Gadus B 1986, and Gadus C 1986. For the length class 51 - 60 cm no significant differences (P = 0.05) were found for parasite abundance with respect to trematodes or acanthocephalans. In terms of nematodes, cod of the 51 - 60 cm length class from St. Lewis 1985 were significantly different (P = 0.05) than cod from Gadus B 1986 and Gadus C 1986. In terms of acanthocephalans, cod of the 51 - 60 cm length class from Makkovik 1985 were significantly different than cod from St. Lewis 1985, St. Lewis 1986, St. Lewis 1987, Gadus B 1986, and Gadus C 1986. For the length classes 61 - 70 cm and 71 - 80 cm no significant differences (P = 0.05) were found with respect to parasite abundances between locations and/or sampling seasons. Insufficient sample numbers from the length classes 81 - 90 cm, 91 - 100 cm, and 101+ cm prevented statistical comparisons.

4.0 DISCUSSION

4.1 Length - Weight - Age Relationships

It has been reported in the past, that cod within the Labrador - East Newfoundland cod stock complex exhibit a gradation with respect to growth. Specifically, size and age at maturity tend to decline from north to south, while average length and weight at age tends to increase from north to south i.e. fish grow more rapidly in the southern regions (Templeman 1953, Fleming 1960, Postoloky 1962, May et al. 1965, May 1966, Aikenhead et al. 1982). Fleming (1960) reported a general increase in length and weight of cod with decreasing latitude in the eastern part of the Newfoundland and Labrador area, proceeding from Labrador to the southwestern portion of the Grand Bank. At about age six there is an increase in length at age for cod from inshore Labrador (2G - 2J) at 48.8 cm, to 51.0 cm inshore on the northeast coast of Newfoundland (3K), to 54.8 cm inshore on the southeast coast of Newfoundland (3L), and 57.8 cm offshore on the northeast Grand Bank. Postolaky (1962) showed that both male and female cod of 2J were on the average slightly smaller than those of 3K. May et al. (1965) attributed these variations to the varying influence of the Labrador current in terms of increasing surface temperatures and decreasing volume of cold water (less than 0° C) from north to south.

The results from my study do not always support this established spatial pattern. Small cod from St. Lewis 1985 and 1986 were longer and heavier than small cod from the more northerly Makkovik. But the reverse is true for the larger fish, with larger cod from Makkovik being longer and heavier than those from the more southerly St. Lewis. A similar situation is encountered in comparing cod collected from Nain and St. Lewis in

1987. The small cod from St. Lewis were longer and heavier than those from the more northerly Nain, while the large cod from Nain are longer and heavier than those from the more southerly St. Lewis. These discrepancies were not related to any trends in prey consumption between the various sampling locations. The differences may be related to the slower growth of older fish which results in an overlap of growth rates between the larger size classes. This bias may have been enhanced due to the fact that age - length keys were used to determine ages of individual fish. It is believed that sample sizes may have been insufficient to truly delineate any overall trends with respect to spatial growth rates. This reasoning is supported by the temporal variability that exists within the dataset as well. Length - weight - age relationships for both St. Lewis and Makkovik, which were sampled over a number of years, were not consistent over time. Cod from St. Lewis 1985 were larger than cod sampled at St. Lewis in 1986 and 1987. Cod from Makkovik 1985 were larger than cod sampled from Makkovik in 1986. These results might indicate differences in prey availability and/or consumption between the various sampling years, but the diet data does not support this. In fact, the major prey items (*Mallotus villosus* and shrimp) encountered were fairly similar in terms of both percent occurrence and percent biomass between all locations and years sampled. Again, the lack of consistency is likely related to sample size, in that the numbers of cod examined were not sufficient to eliminate the inherent variability present in fish growth rate studies.

Thus, it was concluded that length - weight - age relationships were not particularly useful in the present study in terms of attempting to identify separate stocks within the Labrador - East Newfoundland cod stock complex. This was due to the fact that the data indicated a high degree of variability with respect to both spatial and temporal growth rate patterns.

This approach may be better suited to a study utilizing larger sample sizes, or a study which encompasses a larger geographic region in terms of north - south separation.

4.2 Diet

Labrador cod feed on a variety of pelagic, hyperbenthic and benthic organisms (Thompson 1943, Popova 1962, Sidorenko 1962, Turuk 1968, 1973; Stanek 1973, deGraaf et al. 1980, Chaput 1981, Buchanan et al. 1982, Lilly 1984, Lilly et al. 1984), but the importance of various groups of food items can vary markedly between different locations and years or seasons.

For all locations and years sampled capelin (*Mallotus villosus*) tended to be the predominant prey item in terms of percent biomass, with rankings of importance (R) values of 1 or 2 for all groups. Percent frequency of occurrence data tended to be more variable but again, capelin was the most important prey item with rankings of importance values ranging from 1 to 4. The only location sampled which had no incidence of capelin in the diet was Nain 1987. This may be due to the fact that cod sampled at Nain were taken approximately 15 miles offshore among a small group of islands where capelin might not have been present. The predominance of capelin as the major food source of cod has been previously reported. Lilly (1984) and Lilly et al. (1984) examined 8,800 and 1,500 Atlantic cod stomachs respectively from offshore sites within NAFO divisions 2J - 3K - 3L and concluded that capelin was the major prey. Buchanan et al. (1982) examined 370 fish from the Pack's Harbour and Domino regions of the Labrador coast (NAFO division 2J) and concluded that capelin was the dominant prey item, accounting for 64.1 % of the total percent biomass and 42.4 % of the total percent frequency of occurrence.

After capelin, shrimp were the next most important prey item encountered in cod stomachs for most groups. A number of species of shrimp were identified but the predominant taxa in terms of percent frequency of occurrence and percent biomass were *Pandalus sp.* and *Eualus sp.*. These were followed in terms of important prey taxa by Majidae (crabs), both hyperiid and gammerid amphipods, and *Anarhichas sp.*. Unidentified fish were also encountered in cod stomachs from all sampling locations and times. Lilly (1984) and Lilly et al. (1984) report shrimp (primarily *Pandalus borealis*) as the next important prey taxa after capelin, and also note the occurrence of amphipods within most samples. Buchanan et al. (1982) observed crabs (*Chionoecetes opilio* in particular) to be next in importance to capelin, and the crabs in turn were followed by sixteen species of shrimp.

Brawn (1969) reported that cod put forward particular predator strategies which serve to maximize the intake of food per unit effort. The feeding behaviour of captive Atlantic cod was based upon sight, thus food falling through the water column was consumed in preference to food on the bottom. This would account for the relatively high frequencies of pelagic vertebrates (capelin) and invertebrates (shrimp and amphipods) encountered in cod stomachs from the present study. Sidorenko (1962) originally suggested that the relatively large amounts of benthic prey items encountered in cod stomachs were 'emergency and/or substitute food' consumed only when preferred prey (e.g. capelin) were lacking. However, Templeman (1965) reported that cod stomachs from a Hamilton Bank sample which contained 98 % capelin also consisted of 1.5 % spider crabs. The St. Lewis 1986 sample from the present study had a percent frequency of occurrence of 48.8 % capelin and a percent biomass of 81.82 % capelin while still containing substantial amounts of Majidae

(19.5 % percent frequency of occurrence and 4.83 % percent biomass). This would suggest that benthic animals are a normal component of the diet of Labrador cod even in the presence of available fish prey.

Templeman (1965) states ' The habit of cod with full stomachs settling near the bottom periodically to digest their food is certain to be a factor in the establishment of bottom feeding.' Observations of bottom feeding cod conducted by Brawn (1969) noted that buried food is captured by turning and pushing stones with the snout and by sucking gravel into the mouth. This can then account for the common presence of stones and plant material within cod stomachs containing large amounts of pelagic food items. It is interesting that cod from St. Lewis 1986 in the present study had the highest percent frequency of occurrence of capelin (48.8 %) of all groups I examined and also had the highest percent frequency of occurrence of stones (29.30 %). Turuk (1973) reported stones occurring in 6.7 % to 46.7 % of cod stomachs sampled from the northeastern slope of the Grand Banks. Buchanan et al. (1982) reports stones and algae in 9 % of cod stomachs from the Packs Harbour and Domino regions of the Labrador coast. Stones are also fairly common in the present study, in ranges of 0 % to 29.3 % frequency of occurrence. Plant material was encountered in only one group (St. Lewis 1987), at a level of 2.4 % frequency of occurrence.

Analysis of diet data can identify interesting trends in prey consumption and provide some insight into general biological differences between locations and sampling seasons. It can also be used to link parasite abundance or prevalence levels with percent frequency of occurrence levels of their intermediate hosts encountered as prey items. However, as the

analysis revealed, the importance of various groups of prey taxa can vary markedly with respect to spatial and temporal differences. Consequently, analysis of diet data is not particularly useful in attempting to identify separate stocks within the Labrador - East Newfoundland cod stock complex.

4.3 Parasitic Fauna

4.3.1 Nematodes

All nematodes were isolated from the intestines of Atlantic cod, which indicated that they were acquired as a result of feeding. Fagerholm (1982) states that copepods are the most common intermediate host for nematodes, but that different fish and invertebrates such as chaetognaths, polychaetes or crustaceans, may function as intermediate hosts or transport hosts. Due to the fact that capelin, shrimp and amphipods were the dominant prey taxa from most locations and years, it is not surprising that nematodes exhibited high prevalence and abundance levels with little variability among groups. Prevalence levels of nematodes in all groups examined ranged from 54.5 % to 100 %, while abundance levels ranged from 1.6 to 15.8 parasites per fish. Cod from St. Lewis 1986 (90.4 %) had a significantly higher prevalence of nematodes than cod from the offshore sampling sites of Gadus A 1986 (66.7 %), Gadus B 1986 (54.5 %), and Gadus C 1986 (64.5 %). Cod from St. Lewis 1986 also had a significantly higher abundance of nematodes (8 per fish) than cod from Gadus C 1986 (1.6 per fish). Templeman (1962) states that there is a seasonal migration of cod inshore in the summer months for feeding and offshore in the summer months for spawning. Hence, one would expect similarities in nematode abundance between St. Lewis and the parallel offshore Gadus sampling sites due to their similar diets. The diet analysis revealed cod from both the inshore and offshore sites to be similar in

terms of prey taxa consumed. Perhaps an explanation for the discrepancy lies in the diet of the dominant prey item consumed, which was capelin. Possibly capelin inhabiting inshore waters are feeding on prey (e.g. amphipods) which harbour more nematodes than their offshore counterparts. Crustaceans which serve as the intermediate hosts of nematodes may also be more common in the inshore areas, and thus can directly increase prevalence and abundance levels of the parasites within cod.

Prevalence and abundance levels of nematodes also varied significantly over time for locations which were sampled over a number of years. Prevalence levels in cod obtained from St. Lewis in 1985 were significantly higher than those for cod sampled from St. Lewis in 1987 (100 % and 72.7 % respectively). Prevalence levels in cod sampled from Makkovik in 1985 were significantly higher than those for cod sampled from Makkovik in 1986 (97.9 % and 84.2 % respectively). Abundance levels in cod from Makkovik in 1985 were significantly higher than those for cod sampled from Makkovik in 1986 (15.8 and 4.5 respectively). These differences are not readily explained by diet as there was little variation in prey consumed between years.

There are a number of trends which can be observed with respect to nematode prevalence and abundance. Offshore samples tend to have lower nematode levels than do inshore samples. This might be related to the offshore - inshore seasonal migrations of cod and the differences in the diet of their prey species or differences in the availability of prey which serve as the intermediate hosts. There is also a consistent trend of decreasing nematode levels over time from 1985 to 1986 to 1987. This could possibly be related to a general decrease in the overall health of the ecosystem. In the early to mid 1980's there were

indications within the scientific literature that conditions (e.g. water temperatures and species abundances) off coastal Labrador were changing. The effects of this change are now obvious from the decline of numerous commercial and non-commercial stocks which have been documented (Minet et al. 1980, Harris 1990, Atkinson 1993). These changes might also have been reflected in nematode levels.

Analysis of nematode abundances with respect to 10 centimeter length classes did not reveal any overall trends or patterns either within or between groups examined. Abundance levels did not increase with fish size, thus it would appear that all size classes of fish have an equal opportunity to acquire the prey items which harbour the parasite. As amphipods and capelin are small enough to be ingested by the entire size range of adult cod (Lilly 1984) it can be assumed that maximum gape size and thus fish length would have little effect on parasite levels. The fact that nematode abundances from the two length classes of Makkovik 1985 (41 - 50 cm) and St. Lewis 1985 (51 - 60 cm) were found to be significantly higher than some of the equivalent length classes from other locations is most likely due to a sampling anomaly.

Nematodes have been identified as worth-while biological tags by a number of researchers. Boje (1987) found that the nematode *Hysterothylacium aduncum* exhibited a high prevalence and abundance in the offshore waters of East Greenland. Hemmingsen et al. (1991) noted that *Phocascaris sp.* showed highly significant differences in prevalence between the open Barents Sea and inshore fjord locations. However, in both these studies sample sizes tended to be relatively small (as low as ten fish per site) and were only taken from a single year. Initial work by Lee (1986) in the present study area indicated that

nematode numbers were significantly different between Makkovik and St. Lewis in 1985. However, two additional years of sampling (present study) revealed that these initial differences did not remain consistent. Thus, although initial sampling of a nematode species may appear to be promising in terms of stock separation it must be repeated over a number of years to be considered valid.

Although a number of interesting trends arose from the analysis of nematode abundances and prevalences, there were no statistically significant consistent patterns. Because of this it was concluded that nematodes were not a particularly useful parasite within the terms of this study for use in attempting to identify separate stocks of cod within the Labrador - East Newfoundland cod stock complex. It can be argued more differences could be elucidated if the parasites were identified and analyzed at a species level. However, with abundance levels attaining a maximum of 15.8 parasites per fish per site, and with as many as nine separate nematode species identified within Atlantic cod (Boje 1987), large sample sizes would be required to provide valid numbers for statistical analysis. The identification and enumeration of the parasites would also be a very time consuming task.

4.3.2 Trematodes

Trematodes were isolated from the intestines of Atlantic cod, and as such, infestation levels are assumed to be directly related to diet. Koie (1984) states that the first intermediate host of trematodes is probably a gastropod, with a broad range of second intermediate hosts such as chaetognaths and pelagic copepods. Cod can also be infected with trematodes by consuming other final fish hosts (Koie 1984). The usually short life spans of less than one year for adult trematodes in the intestines of cod tends to limit their usefulness as biological

tags (Mackenzie, 1983).

In the present study trematodes were consistently low in both prevalence and abundance for all locations and sampling seasons. The sampling methodology of freezing the digestive tracts might have had a role to play in these low values, as Schmidt (1988) noted that trematodes have a tendency to degenerate in frozen samples. No significant differences in prevalence or abundance were found between locations sampled within the same year. No significant differences were observed in abundance and prevalence comparisons of ten centimeter length classes between all sampling locations and years. No significant differences were found in abundance for locations sampled repetitively over a number of years. Cod from St. Lewis 1985 had a significantly higher prevalence (12 %) than did cod from St. Lewis 1987 (0 %), and cod from Makkovik 1985 had a significantly higher prevalence (22.9 %) than did cod from Makkovik 1986 (0 %). These differences could not be related to any divergent patterns of prey consumption between years and might be due to the inherent variability within the trematode dataset which had an average coefficient of variation value of 1.9.

Other adult digeneans have been put forward as possible biological tags for cod. Hemmingsen et al. (1991) identified *Hemiurus leininseni* as a valid biological tag candidate because of highly significant variations in prevalence between fjord locations (high) and the open sea (low). Koie (1990) identified the mollusc *Lunatia pallida* which tends to be located more frequently in fjords than the open sea as the trematode's intermediate host. This leads to the hypothesis that trematodes might be potentially useful indicators of cod stocks that are somewhat isolated in areas which are predisposed to infection due to the

abundance of a primary host. Koie (1983) and Mackenzie (1987) suggest that this high degree of specificity with respect to a primary host can be an advantage in using a digenean parasite as a biological tag. The geographical distribution of the primary host determines the area within which a secondary host can become infected, which in turn more or less determines the area of infection of a primary fish host. In the case of Newfoundland this might have potential for the identification of so called 'bay or localized stocks' which are groups of cod which tend to spend the initial years of, or their entire life histories within a particular coastal locality i.e. they do not take part in annual migrations.

Because no statistically significant consistent patterns emerged with respect to prevalences or abundances of trematodes in the sampling area, trematodes were not a particularly useful parasite to identify separate stocks of cod within the Labrador - East Newfoundland cod stock. This is not to imply that the parasite could not be used in other biological tag applications, but its presence would appear limited to the presence of a relatively restricted primary or secondary host species within the diet of cod. If such an area was identified it is felt that the prevalence and abundance patterns of trematodes could emerge as a useful tool.

4.3.3 Acanthocephalans

An adult acanthocephalan *Echinorhynchus gadi* was isolated from the intestines of Atlantic cod, and thus its distribution can be related directly to diet. The most common intermediate hosts of acanthocephalans are amphipods and copepods (Yamaguti 1963, Möller and Anders 1986). As amphipods were very widespread in the diet of cod throughout the study area it is logical that prevalences and abundances of acanthocephalans would be uniformly high for all locations and sampling seasons. Prevalence levels from all sampling

groups ranged from 82 to 98.5 % while abundance levels ranged from 5.1 to 17.1 parasites per fish. It is this characteristic 'universality' of infection which prevents the acanthocephalans from making a good biological tag. There is also evidence within the literature that adult acanthocephalans can transfer from one definitive host to the other via predation (Chubb 1964). This feature of their biology makes for a great deal of uncertainty as to the origin of infections. This is particularly true in the case of cod which are known via numerous diet analyses to be cannibalistic and to feed upon other gadidae (Lilly 1980, present study).

No significant differences in prevalence or abundance levels were found for locations repetitively sampled over a number of years. No significant differences in abundance levels were found between any of the locations sampled within a single year. Cod from St. Lewis 1985 (82 %) had significantly lower prevalence than did cod from Makkovik 1985 (95.8 %), and cod from St. Lewis 1986 (90.4 %) had significantly lower prevalence than did cod from Gadus B 1986 (98.5 %). In terms of comparisons between groups based upon a ten centimeter size class breakdown, the only significant difference noted was that cod of the 51 - 60 cm size class from Makkovik 1985 had a significantly higher abundance than a number of other groups. These differences did not appear related to any identifiable trends in the diet of cod from these locations. There did not appear to be a recognizable trend, as groups which were found to be significantly different in terms of prevalence in 1985 (St. Lewis and Makkovik) were not significantly different from each other in 1986. With respect to the size class related differences, amphipods and copepods are small enough to be ingested by the entire size range of adult cod (Lilly 1984), and thus maximum gape size and the corresponding length classes would be assumed to have little effect upon

acanthocephalan levels.

Despite their tendency to exhibit widespread patterns of infection, a number of successful biological tag studies have been performed using acanthocephalans. Mitenev and Zubchenko (1975) found that *E. gadi* was a good indicator of marine feeding and consequently was a useful tool in determining the sea - migratory habits of whitefish, *Coregonus clupeaformis*, and Arctic char, *Salvelinus alpinus*, in the Baltic Sea. Shotter (1973) indicated that the prevalence and abundance levels of *E. gadi* in the North Sea were considerably higher in samples of juvenile whiting *Micromesistius poutassou* taken in inshore waters than in those taken offshore. Hemmingsen et al. 1991 found that *E. gadi* had a higher prevalence in offshore locations of cod within the Barents Sea than in inshore locations, but felt that the relatively short lifespan within the alimentary tract of less than a year might limit its use as a tag for tracing seasonal migrations. This relates partly to the inherent problems in the present study. Because cod encounter the intermediate hosts (amphipods, copepods) at both extremities of their inshore - offshore migration patterns, the time for voiding the parasite is minimal. Thus, cod sampled from both inshore and offshore localities will tend to exhibit the same prevalences and abundances of *E. gadi* infection. Since prey taxa identified in the diet of all inshore locations were similar, it can also be assumed that infection levels of *E. gadi* would be similar throughout the range of this study (Nain to St. Lewis). The lack of significant differences between inshore locations suggests this is the case. Thus, diet information for a species of fish intended for a biological tag study using *E. gadi* is important. If the intermediate host or hosts of *E. gadi* are known to be present within the entire range of the fish, then it is likely the parasite distribution will be similar to that found in this study, that is, the distribution will be

universal to the point that statistically significant differences will not exist between areas sampled.

Although acanthocephalans were by far the most widespread and numerous both in terms of prevalence and abundance in the present study, these characteristics decrease its ability to act as a biological tag. There were no statistically significant consistent patterns or trends with respect to the acanthocephalan *Echinorhynchus gadi* within the study area. Because of this acanthocephalans were not particularly useful parasites for attempting to separate stocks of cod within the Labrador - East Newfoundland cod stock complex.

4.3.4 Myxozoans

The protozoan parasite, *Mxyidium gadi* was isolated from the gall bladders of cod. Infections of fish gall bladders with myxozoan protozoans are considered to be of long duration, probably persisting for the entire lifespan of the host (Kabata 1963). For this reason it is incorrect to make inferences about myxozoan distributions with respect to diet. Myxozoan parasites are acquired by cod via the direct ingestion of spores present within the water column and on the ocean floor; these in turn enter the gall bladder via the bile duct and commence to reproduce (Kabata 1967). However, Markiw and Wolf (1983) have shown that on occasion a turbificid worm may function as an intermediate host. Because of their sporogonic life cycle, the distributions of myxozoans are most likely related to the presence or absence of hostile environmental conditions (to the spores) between study areas. Multiple infections by more than one myxozoan species, although known to occur, are considered rare to the point that competitive inhibition between species has been

postulated (Kabata 1967).

No significant differences were found between myxozoan abundance either between different locations sampled within the same year or between locations which were repetitively sampled over a number of years i.e. abundance levels of myxozoans were consistent between both locations and sampling seasons. No significant differences were observed with respect to abundance based on comparisons of 10 centimeter size classes i.e. abundance did not appear to be related to fish size. In terms of different geographical locations sampled within the same year, levels of prevalence were significantly higher in Makkovik 1985 (54.3%) than in St. Lewis 1985 (16.7%), and were also significantly higher in St. Lewis 1986 (54.8 %) than in Gadus C 1986 (21.8%). In terms of repetitive sampling of the same location over a number of years, prevalence levels were significantly higher at St. Lewis in 1986 (54.8%) than in either 1985 (16.7 %) or 1987 (20%). None of the parameters examined in the present study provided any insight into these differences. The most plausible explanation probably lies in the inherent variability that exists within the myxozoan data, which had an average coefficient of variation value of 2.3. A larger sample size may provide a more interpretive dataset.

Myxozoan parasites have been used successfully as biological tags in the past. Kabata (1967), on examination of 7,527 whiting, *Merlangius merlangus*, from the North Sea, concluded that the differences in infection levels of the myxozoan parasites *Ceratomyxa arcuata* and *Myxidium sphaericum* between a northern and southern component were sufficient to conclude the existence of separate stocks. Burn (1980) found the myxozoan urinary bladder parasite *Myxobilatus sp.* to be common in juvenile smooth flounders from

a lower estuarine sampling site but absent from an upper estuarine sampling site within the same New Hampshire estuary. Hemmingsen et al. (1991) felt that based on their preliminary work upon cod parasites within the Barents Sea and coastal zones of Norway, the protozoans *Myxidium sp.* have the greatest potential for use as a biological tag. However, the authors also caution that improper identification of individual species can lead to erroneous results.

Thus, due to their single-host life cycle, longevity within the gall bladder of cod, and previous successful use as a biological tag, it would seem logical that myxozoans could serve as a potential biological tag in the study area. The results from the initial sampling of St. Lewis and Makkovik in 1985 were encouraging, as significant differences in infection levels of *M. Gadi* were evident (Lee 1986). However, subsequent sampling over the next two years showed that the original results were not repetitive. There were no statistically significant, consistent patterns or trends with respect to myxozoans within the study area. Because of this, myxozoans were not particularly useful to separate stocks of cod from within the Labrador - East Newfoundland stock complex.

5.0 SUMMARY

Comparisons of nematodes, trematodes, an acanthocephalan, and a myxozoan, length-weight-age-relationships, and diet were not successful in delineating separate stocks of cod within the Labrador - East Newfoundland cod stock complex. These results lead to speculation that cod within the area considered (NAFO divisions 2H and 2J) may constitute one homogeneous population i.e. there would appear to be a fair degree of mixing and

intermingling of fish throughout the geographical range of the study. This does not imply that differences might not exist within the area studied, but that the methodology employed was unsuccessful in finding any at the present time. Perhaps, a more comprehensive approach is needed, in terms of increased sample sizes, the identification of individual parasite species, or a wider geographical area. The necessity of repetitive sampling over a number of years was clearly demonstrated by a marked lack of consistency for most of the parameters observed over time. The initial sampling season (1985) yielded some encouraging results in that fish from St. Lewis and Makkovik were deemed 'separate' based upon significantly different levels of an acanthocephalan, nematodes and a myxozoan. However, further sampling in the present study, which was performed in an identical manner, showed that these patterns could be variable over time.

The value of a parasitic biological tag approach to stock studies is enhanced by the simultaneous application of other methods such as length-weight-age relationships, diet studies, artificial tags, and biochemical systematics. In other words, biological tag studies should not be performed in a 'vacuum' because the results obtained are usually related to the different phases of the life history of a host and/or parasite.

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