

**Temporal and Geographical Variations in
Abundance of Larval Sealworm,
Pseudoterranova (Phocanema) decipiens in
the Fillets of American Plaice
(*Hippoglossoides platessoides*) in Eastern
Canada: 1985-86 Surveys**

G. McClelland, R.K. Misra and D.J. Martell

Halifax Fisheries Research Laboratory
Fisheries Research Branch
Department of Fisheries and Oceans
Halifax, Nova Scotia, B3J 2S7

January, 1987

**Canadian Technical Report of
Fisheries and Aquatic Sciences
No. 1513**



Fisheries
and Oceans

Pêches
et Océans

Canada

Canadian Technical Report of Fisheries and Aquatic Sciences

Technical reports contain scientific and technical information that contributes to existing knowledge but which is not normally appropriate for primary literature. Technical reports are directed primarily toward a worldwide audience and have an international distribution. No restriction is placed on subject matter and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Technical reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1-456 in this series were issued as Technical Reports of the Fisheries Research Board of Canada. Numbers 457-714 were issued as Department of the Environment, Fisheries and Marine Service, Research and Development Directorate Technical Reports. Numbers 715-924 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Technical Reports. The current series name was changed with report number 925.

Technical reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport technique canadien des sciences halieutiques et aquatiques

Les rapports techniques contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais qui ne sont pas normalement appropriés pour la publication dans un journal scientifique. Les rapports techniques sont destinés essentiellement à un public international et ils sont distribués à cet échelon. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports techniques peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports techniques sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annuel des publications scientifiques et techniques du Ministère.

Les numéros 1 à 456 de cette série ont été publiés à titre de rapports techniques de l'Office des recherches sur les pêcheries du Canada. Les numéros 457 à 714 sont parus à titre de rapports techniques de la Direction générale de la recherche et du développement, Service des pêches et de la mer, ministère de l'Environnement. Les numéros 715 à 924 ont été publiés à titre de rapports techniques du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 925.

Les rapports techniques sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Canadian Technical Report of
Fisheries and Aquatic Sciences No. 1513

January, 1987

TEMPORAL AND GEOGRAPHICAL VARIATIONS IN ABUNDANCE
OF LARVAL SEALWORM, PSEUDOTERRANOVA (PHOCANEMA) DECIPIENS, IN THE
FILLET OF AMERICAN PLAICE (HIPPOGLOSSOIDES PLATESSOIDES) IN
EASTERN CANADA: 1985-86 SURVEYS

G. McClelland, R. K. Misra and D. J. Martell

Halifax Fisheries Research Laboratory
Fisheries Research Branch
Department of Fisheries and Oceans
Halifax, Nova Scotia
B3J 2S7

CONTENTS

LIST OF TABLES	v
LIST OF ILLUSTRATIONS	vii
ABSTRACT/RÉSUMÉ	ix
INTRODUCTION	1
MATERIAL AND METHODS	1
Collection and Examination of Samples	1
Statistical Analysis	1
RESULTS	1
Larval Sealworm (<u>P. decipiens</u>) in the Fillets of Plaice from Newfoundland Waters	1
Larval Sealworm (<u>P. decipiens</u>) in the Fillets of Plaice from the Gulf of St. Lawrence	2
Larval Sealworm (<u>P. decipiens</u>) in the Fillets of Plaice from Scotia-Fundy Fisheries	2
DISCUSSION	2
ACKNOWLEDGEMENTS	4
REFERENCES	4

LIST OF TABLES

TABLE 1.	Prevalence, abundance and density of sealworm larvae (<u>Pseudoterranova decipiens</u>) in the fillets of American plaice (<u>Hippoglossoides platessoides</u>), 31 cm-40 cm in length, from Newfoundland fisheries with contrasts of sealworm abundances in samples collected at corresponding locations during 1980-82, 1983-84 and 1985-86 surveys	5
TABLE 2.	Geographic variations in larval sealworm (<u>Pseudoterranova decipiens</u>) abundance in the fillets of American plaice (<u>Hippoglossoides platessoides</u>), 31cm - 40cm in length, in eastern Canada; contrasts of 1985 samples from Newfoundland waters	6
TABLE 3.	Prevalence, abundance and density of sealworm larvae (<u>Pseudoterranova decipiens</u>) in the fillets of Amercian plaice (<u>Hippoglassoides platessoides</u>), 31 cm-40 cm in length, from the Gulf of St. Lawrence with contrasts of sealworm abundance in samples collected from corresponding locations during 1980-82, 1983-84 and 1985-86 surveys	6
TABLE 4.	Geographic variations in larval sealworm (<u>Pseudoterranova decipiens</u>) abundance in the fillets of American plaice (<u>Hippoglossoides platessoides</u>), 31cm - 40cm in length, in eastern Canada; contrasts of 1985 samples from the Gulf of St. Lawrence	7
TABLE 5.	Prevalence, abundance and density of sealworm larvae (<u>Pseudoterranova decipiens</u>) in the fillets of American plaice (<u>Hippoglossoides platessoides</u>), 31 cm-40 cm in length, from Scotia-Fundy Fisheries with contrasts of sealworm abundances in samples collected from corresponding locations during 1980-82, 1983-84 and 1985-86 surveys	8
TABLE 6.	Geographic variations in larval sealworm (<u>Pseudoterranova decipiens</u>) abundance in the fillets of American plaice (<u>Hippoglossoides platessoides</u>), 31 cm-40 cm in length, in eastern Canada: contrasts of 1985-86 samples from the Breton and Scotian shelves, lower Bay of Fundy and Gulf of Maine	9

LIST OF ILLUSTRATIONS

FIG. 1.	NAFO divisions, subdivisions and unit areas	10
FIG. 2.	Sampling locations, April 1985 to January 1986	11
FIG. 3.	Frequency distributions of larval sealworm (<u>Pseudoterranova decipiens</u>) counts in the fillets of American plaice (<u>Hippoglossoides platessoides</u>), 31 cm-40 cm in length, from eastern Canada, 1985-86	12-13
FIG. 4	Geographical variations in abundance of larval sealworm (<u>Pseudoterranova decipiens</u>) in the fillets of American plaice (<u>Hippoglossoides platessoides</u>), 31 cm-40 cm in length, from eastern Canada, 1985-86.....	14
FIG. 5.	Geographical variations in abundance of larval sealworm (<u>Pseudoterranova decipiens</u>) in the fillets of American plaice (<u>Hippoglossoides platessoides</u>), 31 cm-40 cm in length, from eastern Canada, 1980-84.....	15

ABSTRACT

McClelland, G., R. K. Misra and D. J. Martell. 1986. Temporal and geographical variations in abundance of larval sealworm, Pseudoterranova (Phocanema) decipiens, in the fillets of American plaice (Hippoglossoides platessoides) in eastern Canada: 1985-86 surveys. Can Tech. Rep. Fish. Aquat. Sci. No. 1513. ix + 15p.

Larval sealworm (Pseudoterranova decipiens) infestations in the fillets of American plaice, 31 cm-40 cm in length, were surveyed at 34 locations in eastern Canada between April 1985 and January 1986. Temporal contrasts and worm-abundance/time trend analyses of the 1985-86 samples and samples collected at corresponding locations in earlier surveys (McClelland et al. 1983a and b; McClelland et al. 1985) indicated that sealworm was becoming increasingly numerous in plaice from southern Newfoundland, the northern and southern Gulf of St. Lawrence, and the Breton and Scotian shelves. The most significant increases were detected in plaice from west St. Pierre Bank (NAFO Unit Area 3PSd), St. Georges Bay, Newfoundland (4Rd), Anticosti Island (4Si), the Gaspé (4Tn) and Miramichi (4T1) areas, Louisbourg Hole (4VN), East Banquereau (4VSc), the Misaine Channel (4VSc), and Sable Island Bank (4W1).

Key words: Sealworm Pseudoterranova (Phocanema) decipiens, nematodes, larval parasitic anisakine, American plaice Hippoglossoides platessoides, eastern Canada, prevalence, abundance, density, variations, temporal, geographic.

RÉSUMÉ

McClelland, G., R. K. Misra and D. J. Martell. 1986. Temporal and geographical variations in abundance of larval sealworm, Pseudoterranova (Phocanema) decipiens, in the fillets of American plaice (Hippoglossoides platessoides) in eastern Canada: 1985-86 surveys. Can Tech. Rep. Fish. Aquat. Sci. No. 1513. ix + 15p.

On a étudié, entre avril 1985 et janvier 1986, des cas d'infestations, par les larves de vers du phoque (Pseudoterranova decipiens), de filets de plie canadienne, de 31 à 40 cm de longueur, à 34 endroits de l'Est canadien. Les analyses de contrastes temporelles et des tendances abondances/temps des vers dans des échantillons recueillis en 1985-1986 et des échantillons prélevés aux mêmes endroits lors d'études antérieures (McClelland et al. 1983a et b; McClelland et al. 1985) révèlent que le vers du phoque devient de plus en plus abondant chez la plie de la zone sud de Terre-Neuve, des zones nord et sud du Golfe Saint-Laurent et des plate-formes Scotian et Breton. On constate les augmentations les plus sensibles dans la plie de la zone ouest du Banc Saint-Pierre (3PSd), de la Baie Saint-Georges, Terre-Neuve (4Rd), de l'Île d'Anticosti (4Si), de la Gaspésie (4Tn), de la Miramichi (4T1), de la Fosse de Louisbourg (4VN), de Banquereau est (4VSc), du Chenal Misaine (4VSc) et du Banc de l'Île de Sable (4W1).

INTRODUCTION

In a previous study (McClelland et al. 1985) it was demonstrated that abundance and distribution of larval sealworm (Pseudoterranova decipiens) in eastern Canadian fisheries can be monitored efficiently by surveying infestations in the fillets of small (31-cm to 40-cm) American plaice (Hippoglossoides platessoides). The survey, completed between June 1983 and May 1984, documented worm abundances in plaice sampled at 55 locations ranging from Hamilton Inlet Bank (2Je) to George's Bank (5ZEj).

The sealworm monitoring program continued in 1985 with the collection of plaice samples from many of the locations previously surveyed. In the present study, sealworm infestations in those recent samples are compared with infestations found during the 1983-84 survey (McClelland et al. 1985) and earlier surveys (McClelland et al. 1983a and b).

MATERIALS AND METHODS

COLLECTION AND EXAMINATION OF SAMPLES

Samples of American plaice, 31 cm-40 cm in length, were collected during Department of Fisheries and Oceans (DFO) groundfish and shrimp surveys and from commercial draggers. The samples, frozen at sea or subsequent to landing, were allowed to thaw for 24 hours at room temperature. Each fish was then measured, weighed, sexed, and filleted and the fillets were inspected by systematic destruction of the flesh (Power 1961). All nematodes found in the fillets were identified by eye and counted.

STATISTICAL ANALYSES

Quantitative terms used in this report are defined as follows (Margolis et al. 1982).

Prevalence (P) = Number of fish infected ÷ number of fish examined (expressed as a percentage).

Abundance (A) = Total number of parasites in a sample of fish ÷ number of fish (infected and uninfected) in the sample = mean number of parasites per fish.

Density (D) in fillets = Total number of parasites found in the fillets of fish in a sample ÷ total weight of fillets in the sample = average number of parasites per unit fillet weight (per kg).

Temporal and geographical variations in sealworm abundance were analyzed in plaice sampled at 34 locations (Figs. 1 and 2) during present and earlier surveys (McClelland et al. 1983a and b; McClelland et al. 1985). The statistical methods employed herein were similar to those described in McClelland et al. (1985). Frequency distributions of sealworm counts, which were invariably skewed to the right (Fig. 3), were brought close to normality by a $\log_{10}(n+1)$ transformation (Platt

1975). Mean transformed worm counts for each sample were then weighted by the reciprocals of their estimated variances and contrasted by X^2 tests (Li 1964; Armitage 1971). As sample means of zero variance could not be weighted, infected samples were compared with worm-free samples (e.g., for samples from NAFO sub-divisions 3K, L, and N) by inference of t-tests which determined whether mean worm counts in the infected samples were significantly greater than zero. In cases where samples had been collected at a given location in each of three surveys, weighted mean worm counts were ranked in chronological order and the significance of a worm count/rank regression was tested (after Snedecor and Cochran 1980). Significance levels were set by Scheffe's a priori contrast method (Harris 1975) and the more conservative Bonferroni method, where $P \leq \frac{0.05}{K}$ for K contrasts

(Morrison 1976).

RESULTS

LARVAL SEALWORM (P. DECIPIENS) IN THE FILLETS OF PLAICE FROM NEWFOUNDLAND WATERS

Plaice samples collected from offshore Labrador (NAFO unit area 2Je) (See Fig. 1) the Northeastern Newfoundland offshore (3K), and the Grand Bank (NAFO sub-divisions 3L and N) in 1983 and 1985 were lightly infected or uninfected and there were no significant changes in parasite abundance (Table 1; Figs. 4 and 5). Anisakis simplex larvae were generally more numerous than sealworm larvae in the fillets of plaice from the above areas.

A 1985 sample from Whale Bank (30b) had fewer sealworms ($A=0.01$) than a 1984 sample ($A=0.09$) from the same location, but the majority of the worms (14) in the latter sample occurred in a single fish and the disparity in mean worm counts was not significant. Sealworm abundances in 1985 samples from Placentia Bay (3PSc) and east St. Pierre Bank (3PSf) were also lower than those found in the 1983-84 survey; Placentia Bay samples differed at the 5% Scheffe priori level, whereas east St. Pierre samples did not differ significantly. In the case of west St. Pierre Bank (3PSd), on the other hand, the infestation in the 1985 sample was much heavier ($P=49$; $A=1.36$) than that found in the 1983 sample ($P=19$; $A=0.37$), and the disparity was highly significant (1% Bonferroni significance). In 1985, sealworms were far more numerous (1% Bonferroni significance) in west St. Pierre than in east St. Pierre and Placentia Bay plaice (Table 2). Parasite abundance in the former was, however, similar to abundances detected in Gulf and Breton Shelf plaice.

LARVAL SEALWORM (*P. DECIPIENS*) IN THE
FILLETS OF PLAICE FROM THE GULF OF ST.
LAWRENCE

Comparisons of 1983 with 1985 samples from the Gulf of St. Lawrence reveal that sealworm abundances were significantly greater in 1985 samples at six of the seven locations surveyed (Table 3; Figs. 4 and 5). Although the disparities between 1983 and 1985 samples from the North Shore (4Syz) and the southern Gulf offshore (4Tfk) were not great (5% Scheffe priori significance), increased worm abundances in 1985 samples from St. George's Bay, Newfoundland (4Rd), west Anticosti Island (4Si), and Gaspé (4Tn) were highly significant (1% Bonferroni significance). Also of great significance (1% Bonferroni) was the trend of increasing worm abundance in plaice collected from the Miramichi area (4Tl) during 1980-81, 1983-84, and 1985 surveys; however, there was no significant change in sealworm abundance in Chéticamp (4Tg) plaice from 1980 to 1985.

In the 1985 survey of the Gulf, the lightest sealworm infections ($P=29$, $A=0.36$) occurred in North Shore (4Syz) plaice, which had significantly fewer worms (1% Bonferroni significance) than plaice from Anticosti Island ($P=47$; $A=1.27$) (Table 4). The heaviest infections were detected in plaice from the Miramichi area; Miramichi plaice had greater (1% Bonferroni significance) numbers of sealworm ($P=69$; $A=1.60$) than Chéticamp plaice ($P=44$; $A=0.88$).

LARVAL SEALWORM (*P. DECIPIENS*) IN THE
FILLETS OF PLAICE FROM SCOTIA-FUNDY
FISHERIES

Although plaice samples collected off Ingonish, Nova Scotia (4VN) in November 1980 and 1985 did not differ in respect to sealworm abundance, there was a trend (5% Bonferroni significance) of increasing worm abundance in plaice sampled in the Louisbourg Hole area (4VN) in 1981, 1983, and 1985 (Table 5; Figs. 4 and 5). Similar trends were also apparent for worm abundances in 1982, 1983, and 1985 samples from Misaine Bank (4VSb), (1% Scheffe priori significance), and east Banquereau (4VSc) (1% Bonferroni significance) but contrasts of 1983 and 1985 samples from Artimon Bank, central Banquereau, and the western extremity of Banquereau (4VSc) were not significant.

Sealworms were more numerous (1% Scheffe priori significance) in 1985 plaice samples from Canso (4Ws) and Middle (4We) banks than in 1983 samples from these respective locations and the trend of increasing worm abundance in 1982, 1983 and 1985 samples from Sable Island Bank (4Wl) was highly significant (1% Bonferroi significance). On the other hand, 1983 and 1985 plaice samples from the Canso Hole (4Wde) and 1982 and 1986 samples from the southern edge of Western Bank (4Wj) did not differ in respect to sealworm abundance. Both samples from the edge of Western Bank

had significantly fewer sealworms ($A=2.14-2.58$) than a sample taken from the centre of Western Bank (4Wh) ($A=6.58$) in the 1983 survey.

Although sealworm were clearly most numerous in the 1985 plaice sample from Chebucto Head (4Xm), the worm-abundance/time trend from 1982 to 1985 was not particularly strong (5% Scheffe priori significance). In the Browns-LaHave area (4Xno), sealworms were more abundant in a 1985 sample ($A=0.97$) than in a 1983 sample ($A=0.64$), but the difference was not significant. Recent (1985) samples from the Jordan Basin (4Xq) and Lower Bay of Fundy (4Xrs, 5Yb) had fewer sealworms than earlier (1983-84) samples at the corresponding locations, but again the differences were not significant.

Contrasts of 1985 samples indicate that sealworm were uniformly abundant ($A=1.10-1.99$) in plaice from the Breton Shelf (4VN) and eastern portion of the Scotian Shelf (4VS), including Canso Bank and Canso Hole (4Wde) (Table 6). Significantly greater numbers of worms (1% Bonferroni significance), however, occurred in plaice from the Misaine Channel (4VSc) ($A=2.81$), the western extremity of Banquereau (4VSc) ($A=4.20$), Middle Bank (4We) ($A=5.88$), and Sable Island Bank (4Wl) ($A=12.07$). Plaice from the Browns-LaHave area (4Xno) had the fewest sealworm among Scotia-Fundy samples. Worm abundance in the Browns-LaHave sample ($A=0.97$) was significantly lower (1% Bonferroni significance) than it was in samples from adjacent areas such as the edge of Western Bank (4Wj) ($A=2.58$), Chebucto Head (4Xm) ($A=2.43$) and Jordan Basin (4Xg) ($A=2.60$). Jordan Basin plaice had fewer worms (5% Scheffe priori significance), in turn, than plaice from the Lower Bay of Fundy (4Xrs, 5Yb) ($A=3.59$).

DISCUSSION

In the present study, weighted methods (Li 1964; Armitage 1971) for comparing mean worm counts and analyzing worm-count/time trends were chosen over ANOVA procedures employed in earlier studies (McClelland et al. 1983a and b; McClelland et al. 1985). With heteroclasticity such as was prevalent in these samples, use of unweighted methods leads to inefficient estimators (Neter et al. 1985), and confidence intervals and F-tests are not valid (Draper and Smith 1981).

As samples were not collected at precisely the same locations from survey to survey, temporal contrasts and time trend analyses herein are prone to the influence of geographical variation in sealworm abundance. In some of the more obvious cases, this problem has been corrected by redefining sampling locations. For example, the disparity in sealworm abundance indicated in the contrast of 1982 and 1983 samples from Western Bank (McClelland et al. 1985) was probably related more to geographic variation than

to increasing abundance of the parasite; the 1982 sample was taken on the southern edge of the bank and the more heavily infected 1983 sample on the central portion, 50 km to the north. Worm abundance in the 1985-86 sample from the southern edge of Western Bank was not significantly greater than that found in the 1982 sample, and the southern edge of Western Bank is now considered to be a sampling area separate and distinct from the central portion of the bank. A similar distinction is made herein for the extremity of Banquereau lying west of 59°30' longitude and north of Sable Island. Analysis of 1983 and 1985 samples revealed that plaice from this latter area have significantly more sealworm than plaice from areas of Banquereau lying north and northeast of "The Gully."

Contrasts and time-trend analyses in the present study seem to indicate that sealworm abundances are increasing in American plaice from southern Newfoundland (3PS), the Gulf of St. Lawrence (4R-4S-4T), the Breton Shelf (4VN), and the Scotia Shelf (4VS-4W-4X). Significant increases in worm abundance (Scheffe priori significance) were detected in plaice from six of seven locations surveyed in the Gulf and from eight of fifteen locations on the Breton and Scotia shelves. Increased worm abundances in west St. Pierre Bank (3PSd), St. George's Bay (4Rd), Anticosti Island (4Si), and Gaspé (4Tn) plaice, and positive worm-abundance/time trends in Miramichi (4Tl), Louisbourg Hole (4VN), east Banquereau (4VSc), Misaine Channel (4VSc), and Sable Island Bank (4Wl) plaice were highly significant.

Although declines in sealworm abundance were noted at several locations, the only decrease of significance (5% Scheffe priori) was that detected in Placentia Bay (3PSc) samples. In most cases, apparent decreases in mean worm count, e.g., in Whale Bank (3Ob), east St. Pierre (3PSf), Ingonish (4VN), Banquereau (4VS), Jordan Basin (4Xq) and lower Fundy (4Xrs-5Yb) plaice, were attributable to infestations in the more recent samples being less over-dispersed, i.e., having fewer heavily infected fish (Crofton 1971). With the log transformation and weighted mean approach employed in the present analyses, however, the influences of a few (often just one or two) extraordinarily high worm counts were minimized, and contrasts of 1985 and earlier samples from the latter locations were not significant.

A review of the history of larval sealworm infestations in eastern Canadian groundfish (Scott and Martin 1957; Templeman et al. 1957; McClelland et al. 1983a and b; McClelland et al. 1985; Wells et al. 1985) reveals that although the abundance of the parasite has increased dramatically in groundfish from the Breton and Scotia shelves in recent years, infestations in Gulf of St. Lawrence and Newfoundland fisheries have remained relatively stable. Hence, increased

sealworm abundances detected in Breton and Scotia Shelf plaice in the present study were not unexpected, whereas those evident in Gulf and west St. Pierre plaice were somewhat surprising.

In a previous report (McClelland et al. 1985), it was speculated that sealworm infestations in Gulf and Newfoundland groundfish may be mitigated by the influence of another anisakine species, Contracaecum osculatum. Abundant in groundfish and harp seal (Phoca groenlandicus) in Gulf of St. Lawrence and Newfoundland waters, but uncommon in Scotia-Fundy fisheries, C. osculatum seems to compete with and displace other anisakine species in the gastrointestinal tract of seals (Berland 1963). Indeed, studies currently in progress indicate that Gulf gray seals, which are heavily infected with C. osculatum, have considerably fewer P. decipiens than gray seals from the Scotia Shelf. It follows that growing seal populations would have less impact on the abundance of sealworm in the Gulf of St. Lawrence or other areas where C. osculatum prevails. Yet, increases in worm abundance apparent in our 1985 samples from west St. Pierre and several locations in the Gulf were of unprecedented magnitude and infestations in plaice from these latter areas now rival those found in Breton and Scotia Shelf plaice.

There seems to be a clear relationship between the growth of the gray seal herds and the increasing abundance of larval sealworm in groundfish in the Scotia-Fundy Region (McClelland et al. 1985). Although it is also tempting to attribute recent increases in sealworm abundance apparent in our Gulf and west St. Pierre plaice samples to the expanding eastern Canadian gray seal population, the evidence is far from conclusive. Sealworm infestations in Chéticamp (4Tg) plaice, for example, have not varied significantly since 1980 in spite of the proximity of large gray seal breeding colonies in the George's Bay/Northumberland Strait area. The heavily infected plaice sample from west St. Pierre Bank in the present study was taken near the slope of the Laurentian Channel, more than 80 km from the nearest harbour and gray seal colonies on Ile Miquelon (Mansfield and Beck 1977). An inshore sample from the Burin Peninsula, on the other hand, was lightly infected although gray and harbour seals are known to frequent the immediate area. Ambiguous or contradictory findings such as the above can perhaps be clarified by more intensive sampling of Gulf and southern Newfoundland plaice in the future.

ACKNOWLEDGEMENTS

We thank Caroline Ervine for performing statistical tests in this report, and Chris Hunter and Gerry Black (Fisheries Research Branch, Halifax) for assisting in the preparation of graphics. We are also grateful to Gerry Hare (Marine Fish Division, Gulf Region) and Claude

Bishop (Marine Fish Division, Newfoundland Region) who arranged for the collection of samples from their respective regions. Gratitude is also extended to Dr. L. Margolis of the Pacific Biological Station, Nanaimo, B.C., Dr. J.S. Scott of the St. Andrews Biological Station, St. Andrews, N.B., and Ken Smith of the Fisheries Research Branch, Halifax, N.S. for reviewing this manuscript.

REFERENCES

- Armitage, P. 1971. Statistical methods in medical research. Blackwell Scientific Publications, Oxford. xv + 504 p.
- Berland, B. 1963. Phocascaris cystophorae sp. nov. (Nematoda) from the hooded seal with an emendation of the genus. Arbok Univ., Bergen (17).
- Crofton, H. D. 1971. A quantitative approach to parasitism. Parasitology 62:179-193.
- Draper, H., and H. Smith. 1981. Applied regression analyses. John Wiley and Sons Inc., Toronto. xiv + 709 p.
- Harris, R.J. 1975. A primer of multivariate statistics. Academic Press, New York. xiv + 332 p.
- Li, J.C.R. 1964. Statistical inference. Vol. I. Edwards Bros. Inc., Ann Arbor, Michigan, USA. 658 p.
- Mansfield, A.W., and B. Beck. 1977. The gray seal in eastern Canada. Environment Canada, Fish. Mar. Serv. Tech. Rep. 704.
- Margolis, L., G.W. Esch, J.C. Holmes, A.M. Kuris and G.A. Schad. 1982. The use of ecological terms in parasitology (Report of an ad hoc committee of the American Society of Parasitologists.) J. Parasitol. 68:131-133.
- McClelland, G., R.K. Misra and D.J. Marcogliese. 1983a. Variations in abundance of larval anisakines, sealworm (Phocanema decipiens) and related species in cod and flatfish from the southern Gulf of St. Lawrence (4T) and the Breton Shelf (4Vn). Can. Tech. Rep. Fish. Aquat. Sci. No. 1201. ix + 51 p.
- McClelland, G., R.K. Misra and D.J. Marcogliese. 1983b. Variations in abundance of larval anisakines, sealworm (Phocanema decipiens) and related species, in Scotian Shelf (4V_s and 4W) cod and flatfish. Can. Tech. Rep. Fish. Aquat. Sci. No. 1202. ix + 27 p.
- McClelland, G., R. K. Misra and D. J. Martell. 1985. Variations in abundance of larval anisakines, sealworm (Pseudoterranova decipiens) and related species, in eastern Canadian cod and flatfish. Can. Tech. Rep. Fish. Aquat. Sci. No. 1392. xi + 57p.
- Morrison, D.F. 1976. Multivariate statistical methods. McGraw-Hill Book Co. 415 p.
- Neter, J., W. Wasserman and M. H. Kutner. 1985. Applied linear statistical models. Richard D. Irwin Inc., Homewood, Illinois. xx + 1127 p.
- Platt, N.E. 1975. Infestation of cod (Gadus morhua L.) with larvae of codworm (Terranova decipiens) and herring worm, Anisakis sp. (Nematoda: Ascaridata) in North Atlantic and Arctic waters. J. Appl. Ecol. 12:437-450.
- Power, H.E. 1961. Slicing of fillets as an aid in detection and removal of codworms from Atlantic cod fillets. J. Fish. Res. Board Canada 18:137-140.
- Scott, D.M., and W.R. Martin. 1957. Variation in the incidence of larval nematodes in Atlantic cod fillets along the southern Canadian mainland. J. Fish. Res. Board Canada 14:975-996.
- Snedecor, G.W., and W.G. Cochran. 1980. Statistical methods. Iowa State University Press, Ames, Iowa. xvi + 507 p.
- Templeman, W., H.J. Squires and A.M. Fleming. 1957. Nematodes in the fillets of cod and other fishes in Newfoundland and neighbouring areas. J. Fish. Res. Board Canada 14:831-897.
- Wells, R., J.H.C. Pippy, and C.H. Bishop. 1985. Nematodes in cod collected from NAFO Divisions 2J, 3K, 3L and 3PS in autumn, 1983. CAFSAC Res. Doc. 85/79.

TABLE 1. Prevalence, abundance and density of sealworm larvae (*Pseudoterranova decipiens*) in the fillets of American plaice (*Hippoglossoides platessoides*), 31 cm-40 cm in length, from Newfoundland Fisheries with contrasts of sealworm abundances in samples collected at corresponding locations during 1980-82, 1983-84 and 1985-86 surveys.

Host			<i>P. decipiens</i>			Contrasts ^a				
Map reference ^b and location	Time	n	Prevalence	Abundance	Density (no./kg)	χ^2	t	p	Bonferroni significance ^c	Scheffe prior significance ^d
1 Hamilton Inlet Bank (2Je)	Jul/Nov 83 Oct 85	319 182	4 3	0.04 0.03	0.36 0.30	0.5086		0.5173	ns	ns
2 Northeast Newfoundland Offshore (3Kbef)	Dec 83 Nov 85	232 279	0 <1	0 <0.01	0 0.08		1.4168	0.1536	ns	ns
3 Northern Grand Bank (3Ld)	Jul/Oct 83 May 85	277 85	<1 0	<0.01 0	0.08 0		1.4168	0.1536	ns	ns
4 Nose of Grand Bank (3Lt, 3Nb)	Nov 83 May 85	159 120	0 0	0 0	0 0					
5 Southern Grand Bank (3Nac)	Dec 83 May 85	187 195	0 2	0 0.02	0 0.18		1.7410	0.0794	ns	ns
6 Tail of Grand Bank (3Ne)	Nov 83 Apr 85	190 182	0 0	0 0	0 0					
7 Whale Bank (3Ob)	May 84 Apr 85	193 192	2 1	0.09 0.01	0.83 0.11	1.1916		0.2746	ns	ns
8 Placentia Bay (3PSc)	Jul 83 Oct 85	207 197	25 12	0.34 0.28	3.23 2.40	4.4822		0.0323	ns	*
9 East St. Pierre Bank (3PSf)	Apr 84 Nov 85	77 126	10 14	0.30 0.19	3.03 1.84	0.0197		0.8835	ns	
10 West St. Pierre Bank (3PSd)	Sep 83 Nov 85	83 138	19 49	0.37 1.36	4.65 12.94	23.9044		0.0000	**	**

a. Means of transformed $[\log(n+1)]$ worm counts weighted by reciprocals of their estimated variances and compared by χ^2 tests; t-tests employed where worm-free samples involved.

b. See Fig. 1.

c. $P < 0.05/34$ (*) and $P < 0.01/34$ (**).

d. $P < 0.05$ (*) and $P < 0.01$ (**).

TABLE 2. Geographic variations in larval sealworm (*Pseudoterranova decipiens*) abundance in the fillets of American plaice (*Hippoglossoides platessoides*), 31 cm-40 cm in length in eastern Canada; contrasts of 1985 samples from Newfoundland waters.

Contrasts ^a		χ^2	P	Bonferroni significance
Whale Bank (30b)	vs Placentia (3PSc) and East St. Pierre (3PSf)	33.0006	0.0000	**b
Placentia (3PSc) and East St. Pierre (3PSf)	vs West St. Pierre (3PSd)	49.8098	0.0000	**b
West St. Pierre (3PSd)	vs St. Georges Bay, Nfld (4Rd)	0.7278	0.6019	ns ^c
West St. Pierre (3PSd)	vs 4VN	7.0679	0.0077	ns ^b

a. Means of transformed $[\log(n+1)]$ worm counts weighted by reciprocals of their estimated variances and compared by χ^2 tests; where mean transformed worm counts for samples from discrete geographical areas did not differ, the samples were pooled and subjected to a second set of contrasts.

b. $P < 0.05/28$ (*) and $P < 0.01/28$ (**)

c. $P < 0.05/63$ (*) and $P < 0.01/63$ (**)

TABLE 3. Prevalence, abundance and density of sealworm larvae (*Pseudoterranova decipiens*) in the fillets of American plaice (*Hippoglossoides platessoides*), 31 cm-40 cm in length, from the Gulf of St. Lawrence, with contrasts of sealworm abundances in samples collected from corresponding locations during 1980-82, 1983-84 and 1985-86 surveys.

Host		<i>P. decipiens</i>				Contrasts ^a			
Map reference ^b and location	Time	n	Prevalence	Abundance	Density (no./kg)	χ^2	p	Bonferroni significance ^c	Scheffe Priori significance ^d
11 St. George's Bay, Nfld. (4Rd)	Oct 83	212	22	0.49	4.07	29.6283	0.0000	**	**
	Sep 85	88	56	1.38	11.34				
12 North Shore, Quebec (4Syz)	Oct 83	154	15	0.25	2.59	3.7519	0.0498	NS	*
	Oct 85	97	29	0.36	4.87				
13 West Anticosti Island (4Si)	Oct 83	217	17	0.21	2.70	34.8930	0.0000	**	**
	Oct 85	106	47	1.27	17.64				
14 Edge of Laurentian Channel (4Tfk)	Jun 83	150	25	0.48	4.32	5.5095	0.180	NS	*
	Sep 85	56	46	0.84	10.62				
15 Gaspé (4Tn)	Aug 83	150	17	0.18	2.70	64.7693	0.0000	**	**
	Sep 85	152	53	0.99	9.97				
16 Miramichi area (4T1)	Nov 80/					108.7653	0.0000	**	**
	Jun 81	707	28	0.41	4.42				
	Jun 83	328	38	0.63	6.41				
	Sep 85	163	69	1.60	23.05				
17 Chéticamp (4Tg)	Nov 80	42	45	1.00	11.09	0.0097	0.9182	ns	ns
	Jul/Nov 83	385	51	1.16	12.64				
	Sep 85	165	44	0.88	11.13				

a. Means of transformed $[\log(n+1)]$ worm counts weighted by reciprocals of their estimated variances and compared by χ^2 tests.

b. See Fig. 1.

c. $P < 0.05/34$ (*) and $P < 0.01/34$ (**).

d. $P < 0.05$ (*) and $P < 0.01$ (**).

TABLE 4. Geographic variations in larval sealworm (*Pseudoterranova decipiens*) abundance in the fillets of American plaice (*Hippoglossoides platessoides*), 31 cm-40 cm in length, in eastern Canada; contrasts of 1985 samples from the Gulf of St. Lawrence.

Contrasts ^a		χ^2	P	Bonferroni significance
St. Georges Bay (4Rd)	vs Anticosti Island (4Si)	0.9902	0.6795	ns ^b
St. Georges Bay (4Rd)	vs Laurentian Channel (4Tfk) and Gaspé (4Tn)	2.8842	0.0854	ns ^c
St. Georges Bay (4Rd)	vs Chéticamp (4Tg)	5.4276	0.0189	ns ^c
Anticosti Island (4Si)	vs Quebec North Shore (4Syz)	17.7136	0.0001	** ^c
Anticosti Island (4Si)	vs Laurentian Channel (4Tfk) and Gaspé (4Tn)	0.2755	0.6063	ns ^c
Laurentian Channel (4Tfk) and Gaspé (4Tn)	vs Miramichi area (4Tl)	18.0481	0.0000	** ^c
Laurentian Channel (4Tfk) and Gaspé (4Tn)	vs Chéticamp (4Tg)	0.9711	0.6745	ns ^c
Chéticamp (4Tg)	vs Miramichi area (4Tl)	23.7832	0.0000	** ^c
Chéticamp (4Tg)	vs 4VN	26.7849	0.0000	** ^c

a. Means of transformed $[\log(n+1)]$ worm counts weighted by reciprocals of their estimated variances and compared by χ^2 tests; where mean transformed worm counts for samples from discrete geographical areas did not differ, the samples were pooled and subjected to a second set of contrasts.

b. $P < 0.05/63$ (*) and $P < 0.01/63$ (**).

c. $P < 0.05/28$ (*) and $P < 0.01/28$ (**).

TABLE 5. Prevalence, abundance and density of sealworm larvae (*Pseudoterranova decipiens*) in the fillets of American plaice (*Hippoglossoides platessoides*), 31 cm-40 cm in length from Scotia-Fundy fisheries, with contrasts of sealworm abundances in samples collected from corresponding locations during 1980-82, 1983-84 and 1985-86 surveys.

Map reference ^b and location	Host	Time	<i>P. decipiens</i>			Contrasts ^a			
			Prevalence	Abundance	Density (no./kg)	χ^2	P	Bonferroni significance ^c	Scheffe priori significance ^d
18 Ingonish N.S. (4VN)		Nov 80	130	55	1.91	0.0005	0.9805	ns	ns
		Nov 85	190	62	1.65				
19 Louisbourg Hole (4VN)		Mar 81	55	40	1.00	11.3670	0.0009	*	**
		Jul/Oct/Nov/83	164	65	1.58				
		Apr/Jul/Oct/Nov 85	123	70	1.82				
					22.11				
20 Misaine Bank (4VSb)		Feb 82	93	35	0.65	8.7936	0.0032	ns	**
		Oct 83	76	41	0.68				
		Jul/nov 85	135	53	1.10				
21 Artimon Bank (4VSc)		Oct 83	48	69	2.13	0.0005	0.9805	ns	ns
		Nov 85	99	75	1.99				
22 East Banquereau (4VSc) ^e		May 82	59	31	0.46	28.4332	0.0000	**	**
		Jul/Oct 83	258	63	1.84				
		Jul/Oct 85	159	62	1.61				
23 Central Banquereau (4VSc) ^f		Jul/Oct 83	120	71	2.21	1.4774	0.2223	ns	ns
		Jul/Oct 85	703	71	1.71				
24 West Banquereau (4VSc) ^g		Jul 83	44	91	5.11	0.8166	0.6305	ns	ns
		May 85	150	91	4.20				
25 Misaine Channel (4VSc)		Mar 82	67	54	1.48	15.6585	0.0001	**	**
		Jul/Oct 83	141	57	1.52				
		Oct 85	147	82	2.81				
26 Canso Bank (4Wd)		Jul/Oct 83	83	52	0.95	7.3929	0.0065	ns	**
		Jul 85	49	73	1.92				
27 Canso Hole (4Wde)		Nov 83	154	77	2.08	2.1020	0.1429	ns	ns
		Apr/Oct 85	64	70	1.59				
28 Middle Bank (4We)		Jul/Oct 83	71	89	3.92	9.9375	0.0018	ns	**
		May/Oct 85	57	96	5.88				
29 Sable Island Bank (4Wl)		Jul 82	78	87	3.21	125.1186	0.0000	**	**
		Jul/Oct 83	132	95	5.17				
		May/Oct 85	143	98	12.07				
30 Edge of Western Bank (4Wj)		Sep 82	69	72	2.14	0.1173	0.7318	ns	ns
		Jul 85/Jan 86	83	73	2.58				
31 Chebucto Head (4Xm)		Mar 82	62	56	1.66	5.6187	0.0169	ns	*
		Jan 84	187	53	1.20				
		Nov 85	211	71	2.43				
32 Browns-LaHave (4Xno)		Jul/Oct 83	114	43	0.64	3.6511	0.0530	ns	ns
		Jun 85	104	54	0.97				
33 Jordan Basin (4Xq)		Mar 84	57	84	3.28	1.2292	0.2668	ns	ns
		Jun/Jul 85	169	78	2.60				
34 Lower Fundy (4Xrs,5Yb)		Jul 83/				2.3231	0.1231	ns	ns
		Mar 84/	28	89	5.82				
		Jun/Jul 85	100	88	3.59				

a. Means of transformed [$\log(n+1)$] worm counts weighted by reciprocals of their estimated variances and compared by χ^2 tests.

b. See Fig. 1.

c. $P < 0.05/34$ (*) and $P < 0.01/34$ (**).

d. $P < 0.05$ (*) and $P < 0.01$ (**).

e. East of 58° longitude.

f. 58° to $59^\circ 30'$ longitude.

g. Extremity of bank, west of $59^\circ 30'$ longitude.

TABLE 6. Geographic variations in larval sealworm (*Pseudoterranova decipiens*) abundance in the fillets of American plaice (*Hippoglossoides platessoides*), 31 cm-40 cm in length in eastern Canada; contrasts of 1985-86 samples from the Breton and Scotian shelves, lower Bay of Fundy and Gulf of Maine.

Contrasts ^a		χ^2	P	Bonferroni significance
4Vn	vs Misaine, Artimon, east and central Banquereau (4VSbc)	0.0467	0.8237	ns ^b
Misaine, Artimon, east and central Banquereau (4VSbc)	vs Misaine Channel and west Banquereau (4VSc)	86.9670	0.0000	**b
Misaine, Artimon, east and central Banquereau (4VSbc)	vs Canso Bank and Canso Hole (4VSc)	0.2659	0.6125	ns ^b
Misaine Channel and west Banquereau (4VSc)	vs Canso Bank and Canso Hole (4Wd)	30.0176	0.0000	**b
Misaine Channel and west Banquereau (4VSc)	vs Middle Bank (4We)	32.3757	0.0000	**b
Misaine Channel and west Banquereau (4VSc)	vs Sable Island Bank (4Wl)	27.9561	0.0000	**b
Middle Bank (4We)	vs Sable Island Bank (4Wl)	28.9405	0.0000	**c
Sable Island Bank (4Wl)	vs Edge of Western Bank (4Wj)	70.1350	0.0000	**c
Edge of Western Bank (4Wj)	vs Chebucto Head (4Xm)	0.0757	0.7799	ns ^c
Edge of Western Bank ((4Wj)	vs Browns-LaHave (4Xno)	16.2930	0.0001	**c
Chebucto Head (4Xm)	vs Browns-LaHave (4Xno)	24.2898	0.0000	**c
Browns-LaHave ((4Xno)	vs Jordan Basin (4Xq)	39.8930	0.0000	**c
Jordan Basin (4Xq)	vs Lower Fundy (4Xrs)	6.0153	0.0136	ns ^c

a. Means of transformed $[\log(n+1)]$ worm counts weighted by reciprocals of their estimated variances and compared by χ^2 tests; where mean transformed worm counts for sample from discrete geographical areas did not differ, the samples were pooled and subjected to a second set of contrasts.

b. $P < 0.05/28$ (*) and $P < 0.01/28$ (**).

c. $P < 0.05/63$ (*) and $P < 0.01/63$ (**).

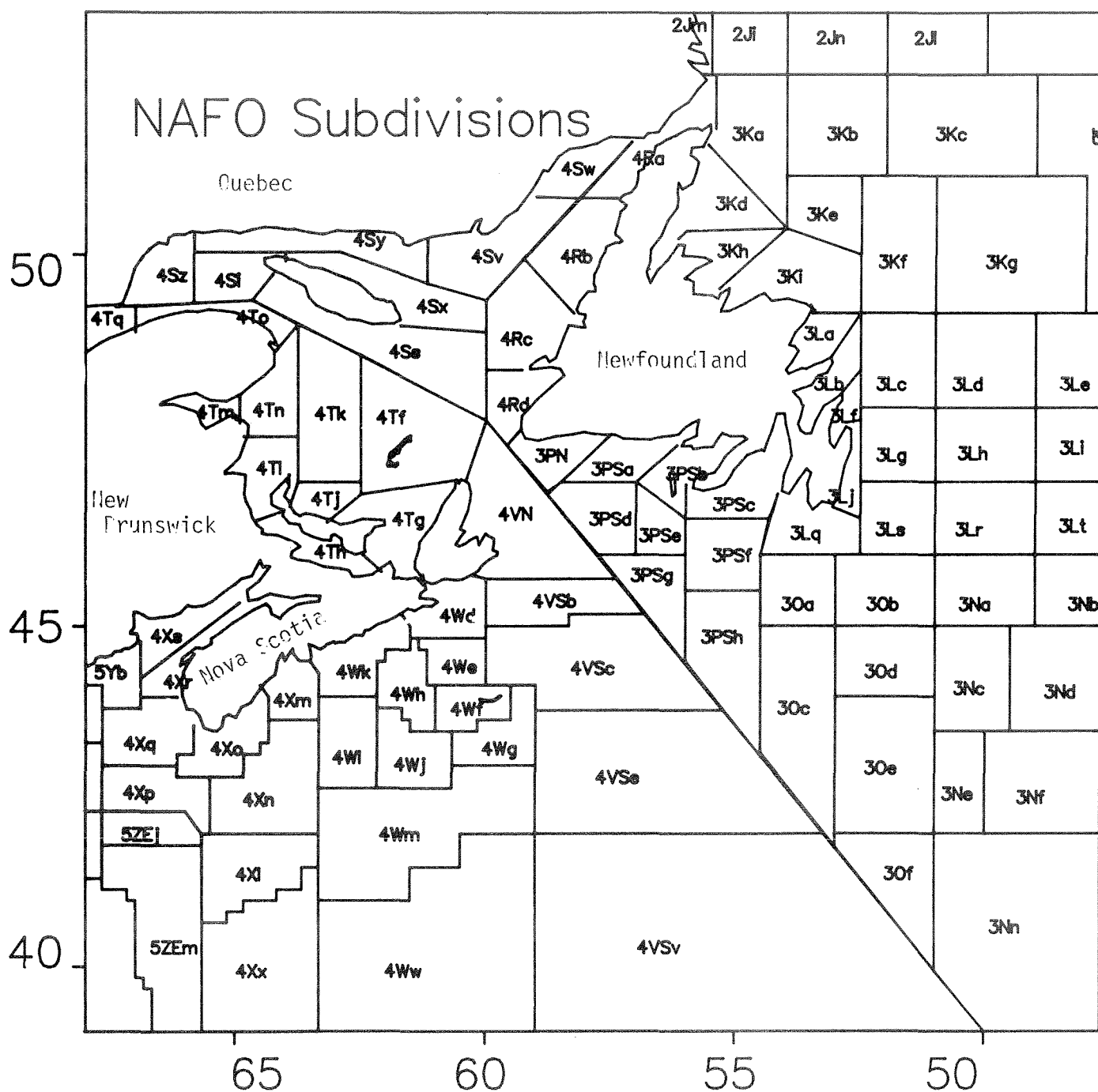


FIG. 1. NAFO divisions, subdivisions and unit areas for eastern Canada (Jones 1978). (Updates and corrections by G. Black, Fisheries Analyst, Resource Mapping and Graphic Illustration.)

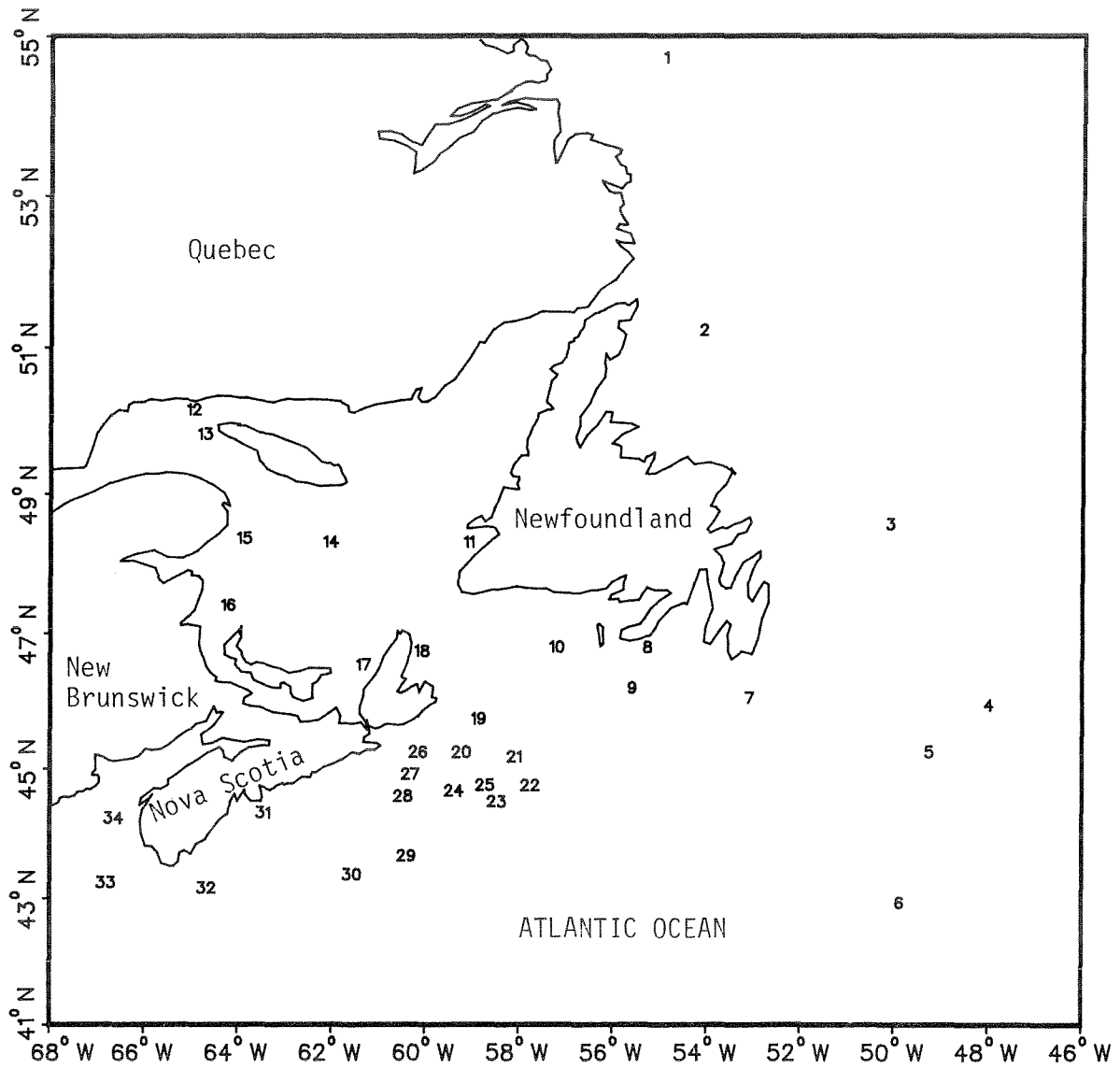


FIG. 2. Sampling locations, April 1985 to January 1986.

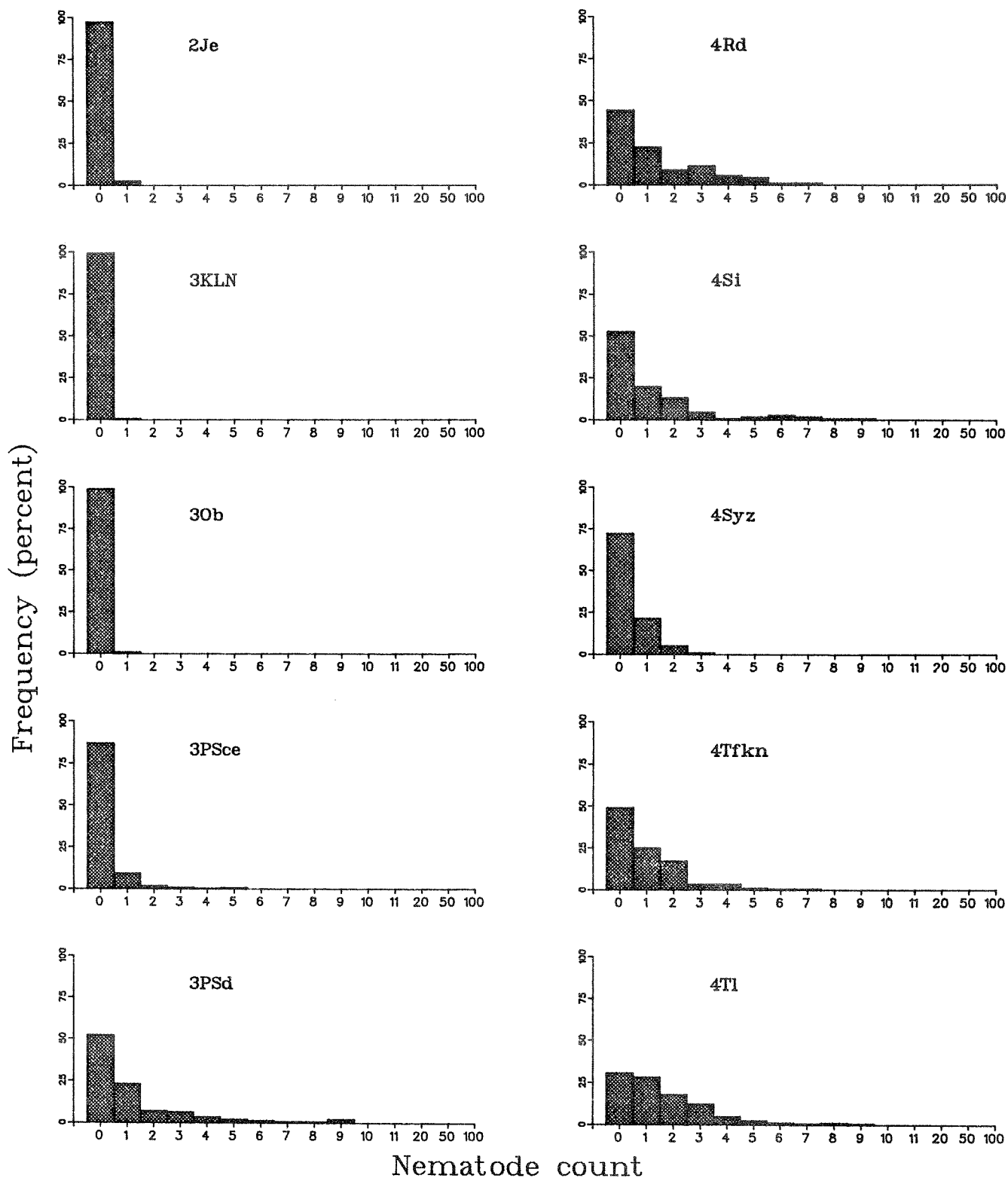


FIG. 3. Frequency distributions of larval sealworm (*Pseudoterranova decipiens*) counts in the fillets of American plaice (*Hippoglossoides platessoides*), 31 cm-40 cm in length, from eastern Canada, 1985-86.

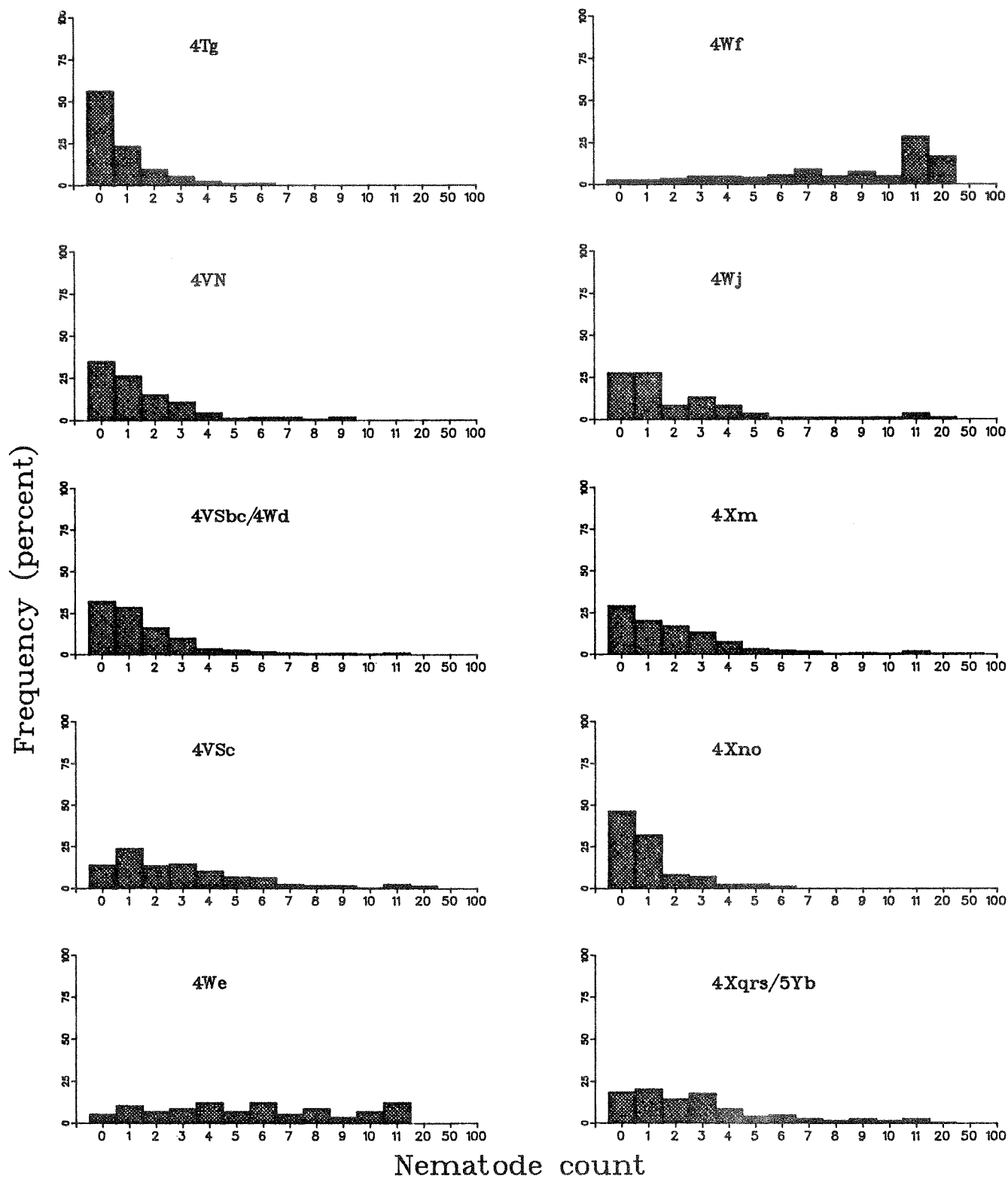


FIG. 3. (continued)

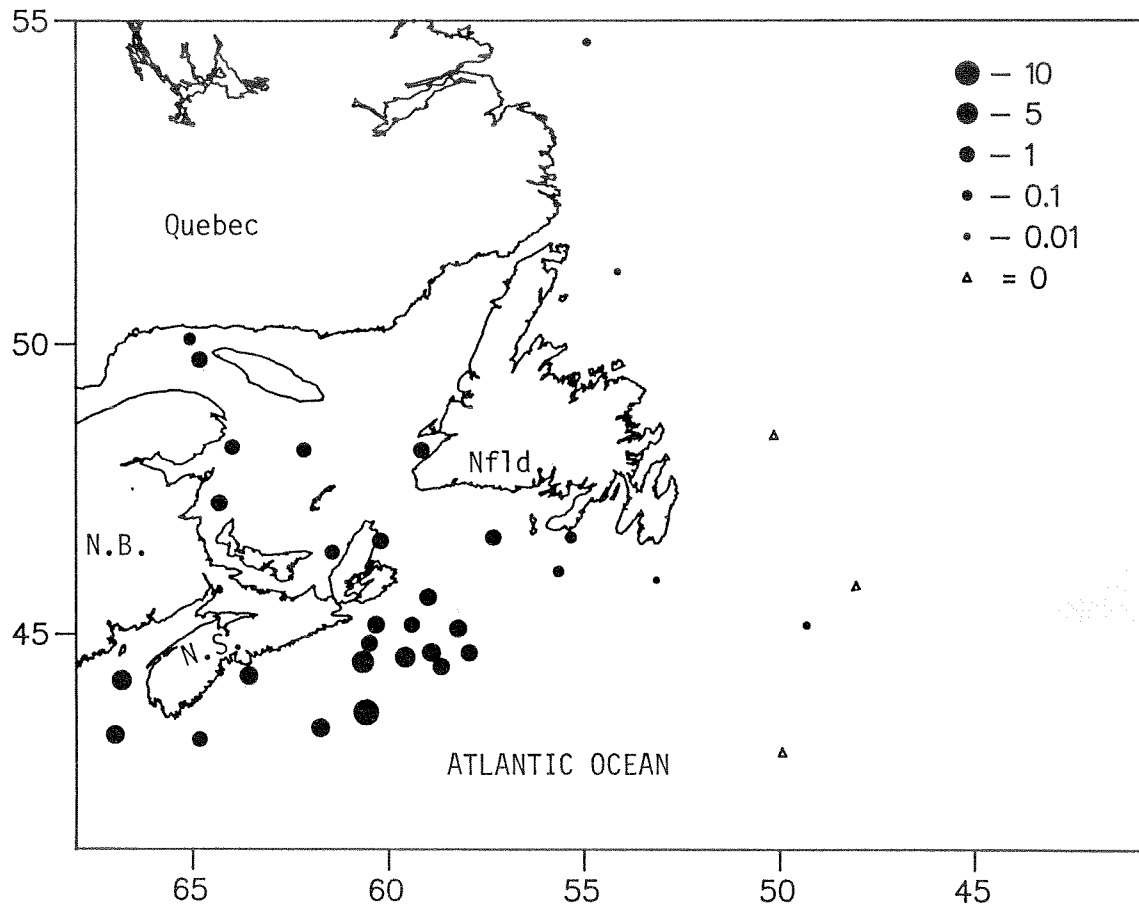


FIG. 4. Geographical variations in abundance of larval sealworm (*Pseudoterranova decipiens*) in the fillets of American plaice (*Hippoglossoides platessoides*), 31 cm-40 cm in length, from eastern Canada, 1985-86. (Diameters of symbols scaled according to nematode abundance.)

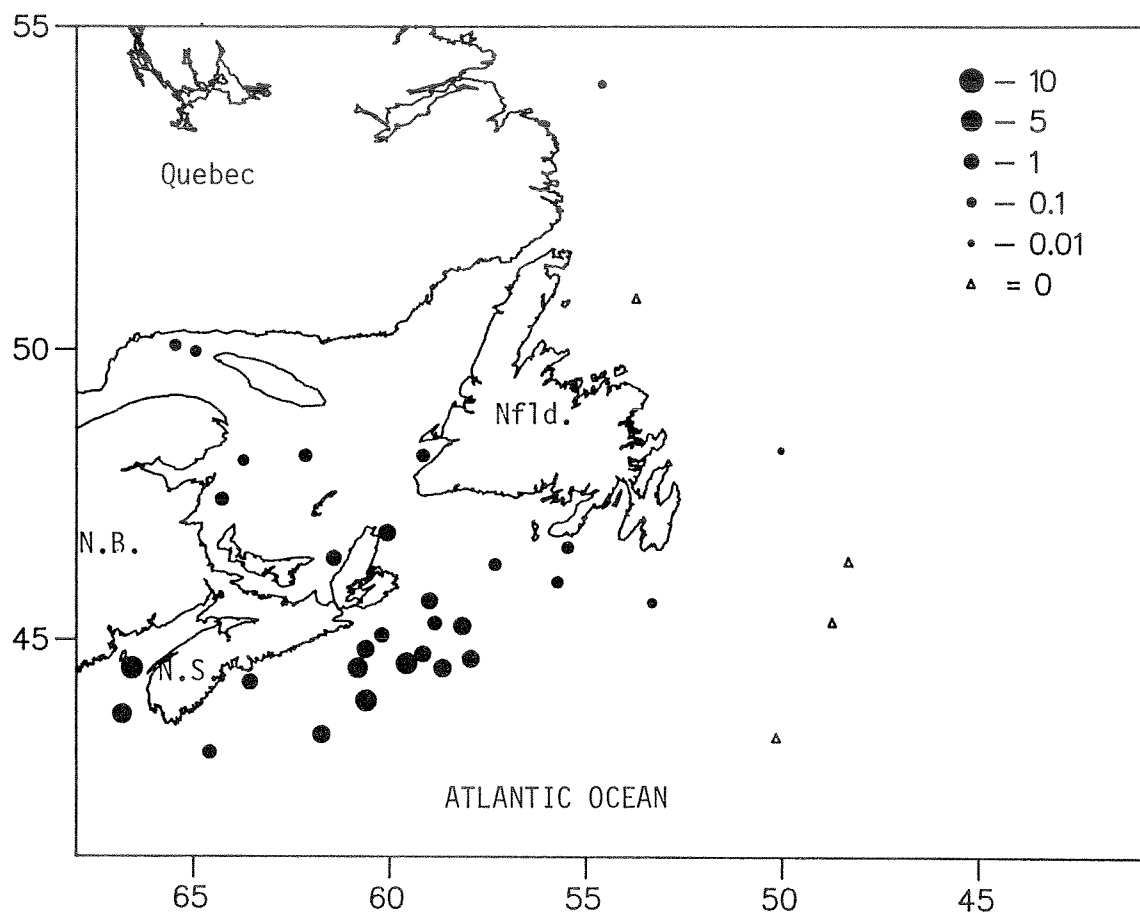


FIG. 5. Geographical variations in abundance of larval sealworm (*Pseudoterranova decipiens*) in the fillets of American plaice (*Hippoglossoides platessoides*), 31 cm-40 cm in length, from eastern Canada, 1980-84. (Diameters of symbols scaled according to nematode abundance.)