Comparison of Canadian and United States larval herring surveys on Georges Bank: 1987-91

by

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Abstract

Canadian and United States larval herring survey observations between 1987 and 1991 on Georges Bank are compared. Geographical and length frequency distributions of larval herring were found to be similar when the cruises occurred at approximately the same time. However, large variations in both larval concentration and distribution were observed for cruises separated by only a short period of time. Between 1987 and 1990, Canadian November surveys tracked what appeared to be a single protracted spawning wave. A second, possibly equally as large, spawning was observed in the US December surveys from 1988-90. The importance of cruise timing and the number of annual surveys is discussed.

Résumé

On compare les résultats des campagnes d'évaluation des larves de hareng réalisées par le Canada et par les États-Unis de 1987 à 1991 sur le banc Georges. On a constaté que la distribution de la fréquence géographique et de la fréquence des longueurs des larves de hareng était comparable lorsque les campagnes d'évaluation avaient lieu à peu près en même temps. Toutefois, de vastes écarts dans la concentration et la distribution des larves ont été observés lors de campagnes réalisées à court intervalle. Entre 1987 et 1990, les campagnes d'évaluation effectuées par le Canada en novembre ont permis d'établir l'existence de ce qui semble être une seule vague étalée de reproduction. Une seconde période de frai, qui pourrait être aussi longue, a été observée par les Américains, lors de des campagnes d'évaluation de décembre réalisées entre 1988 et 1990. On discute ici de l'importance du nombre de campagnes d'évaluation annuelles et de la période à laquelle elles ont lieu.

Introduction

Larval surveys for Atlantic herring (*Clupea harengus*) have been conducted on Georges Bank and in the Gulf of Maine by the United States National Marine Fisheries Service (US) and by other countries since the 1950's. In 1971, the International Commission for the Northwest Atlantic Fisheries (ICNAF) initiated a cooperative research program to measure annual variation, dispersal, mortality and growth of early life stages of herring in the Georges Bank-Gulf of Maine region (Colton and Byron 1976; Lough et al. 1985; Grosslein 1987). This program was terminated in 1976 and followed by the NEFC's (Northeast Fisheries Centre) fisheries ecosystem study known as MARMAP (Marine Resources Monitoring Assessment and Prediction) which operated until 1987. Since 1988 the NEFC larval surveys have concentrated on the investigation of competitive interactions of Atlantic herring, Atlantic mackerel (*Scomber scombrus*) and sand lance (*Ammodytes* spp.) populations (Smith and Morse 1990). Area of coverage of these surveys includes the entire Bank.

Annual Canadian larval herring surveys on Georges Bank are relatively new by comparison. In 1987 the first in the current time series of fall larval herring surveys was started in order to track what earlier opportunistic cruises had indicated as the early stages of recovery of this once thought lost herring stock (Stephenson et al. 1987). The geographical extent of survey coverage was reduced in 1988 to concentrate on the area of the Bank which was most likely to show signs of a recovery (Stephenson and Power 1989; Melvin et al. 1991). The survey area established in 1988 (Fig. 1) was sampled annually until 1990 at three to four randomly selected stations in each of the 18 grids. In 1991 the study area was expanded by six grids, to cover the entire northeastern portion of the Bank (Fig. 8).

While Canada has conducted only one annual survey on Georges Bank during the latter part of October and early November, the US has undertaken a minimum of four surveys each year since 1988 covering, in most years, the period of October through January. The geographical area of coverage includes not only Georges Bank, but Nantucket Shoals and Massacheutts Bay as well. This report summarizes the results of both the Canadian and US surveys from 1987-91 in the Canadian survey area only. A detailed comparison is also made for surveys that were found to have operated concurrently. No data are available for the fall 1991 US cruises. The authors would like to express their sincere thanks to their US counterparts for making the US data available.

Methods

Slight differences exist in the sampling protocol employed by Canadian and US research surveys. The US surveys covered in this report use the MARMAP oblique procedure where the gear is deployed at a rate of 50 m/min to a maximum depth of 200m

or to within 5 m of the bottom. Retrieval rate is 20 m/min with no minimum time required for towing. A similar deployment and retrieval rate is used on Canadian surveys, except there is a minimum tow time. For a haulback time of less than 10 min the gear is returned to within 5 m of bottom in a saw-tooth manner until the minimum time is exceeded. Both Canadian and US surveys use 61-cm bongo frames equipped with flow meters and one each of a 0.333-mm and a 0.505-mm mesh plankton net. The gear is towed at approximately 3.5 knots, although the US vessel speed is sometimes adjusted to maintain a constant 45° warp angle. Larval samples are preserved in 5% buffered formaldehyde.

Comparative Bongo Tows

In November of 1988 the Canadian research vessel "Lady Hammond" and the US research vessel "Delaware II" undertook a series of comparative bongo tows just west of the Canadian survey area. Six bongo tows were made at latitude 41°15' and longitude 68°40' with the vessels approximately 1/4 of a mile (500 m) apart. Standard methods of deployment and retrieval were employed for the comparison. A large difference was noted in speed between the two vessels, 3.5 knots (1.9 m/s) for the "Lady Hammond" vs 1.5 knots (0.8 m/s) for the "Delaware II" (Cruise Report - H195 Lady Hammond 1988).

Although differences were observed between the sampling operations a relatively strong relationship was found when the catches (#/10 m^2) were regressed against each other. Figure 2 displays this relationship for the five valid sets. One US sample was discarded because the gear hit bottom. Canadian catches were usually larger than US catches. This is consistent with the 1988 findings for the entire survey area (Table 1 - DL8812 and LH195). The range of larval number/10 m^2 is, however, rather narrow and much lower than the levels being observed in tows in recent years.

Canada\US Surveys

From February 1987 to January 1990 (latest available data) the US undertook 20 larval fish surveys within the Canadian herring study area on Georges Bank compared to Canada's four (Table 1). Although the US cruises were scattered throughout the year they tended to be concentrated in the fall and early winter. For 1988 (LH 8819), the US substituted Canadian survey data from H195 to compensate for areas missed. In 1990 the Canadian and US surveys overlapped in their sampling time making direct comparison possible.

The larval information collected by each of the cruises is summarized in Table 1 from 1986-91. The 1986 data are included to illustrate the relatively low densities of herring larvae observed prior to 1988 by US surveys. Figure 3 depicts the larval densities observed by Canadian and US surveys between 1987 and 1991 for cruises which were conducted at approximately the same time of year (Oct. to Dec.). In 1987 the US October survey (AL8707) collected no larvae in the Canadian study area in 12

tows. Published larval densities for 1971-73 are included for comparison (Smith and Morse 1990).

Apparent from these data is the critical nature of cruise timing. In 1990 when the surveys were conducted at approximately the same time, larval abundance was about equal. However, dramatic differences can be found when cruises are separated by only a short period of time. In October 1987 no larvae were detected by the US survey (AL8707) in the study area (larvae were detected in the Great South Channel area), yet 3 wk later the Canadian survey (H181) found the second highest mean larval density in this time series. The largest number of larvae collected by a US survey (DL8710) in 1987 occurred during the early part of December (Table 1). The maximum number of larvae per 10 m^2 during the period covered by this report was observed in mid-November of 1989 (DL8907).

Distribution

The distribution of larvae from 1987-91 within the study area on Georges Bank for Canadian and US cruises which occurred in late October/early November are shown in Fig. 4-8. Both the relative number/10 m^2 for each sampling station and the estimated contours from ACON Version 5.02 (DFO plotting software) are presented for comparison. With the exception of 1987 the surveys depict similar distribution patterns. Observed discrepancy for the most part can be attributed to differences in timing or sampling coverage. Figure 4 clearly demonstrates the variation which can occur in a relatively short period of time. In 1987 the observed Canadian distribution (Nov. 2-9) was similar to that found in other years whereas the US survey (Oct. 4-17) found no larvae at 12 stations within the survey area.

As documented in the 1991 update, larval herring collected by both countries are concentrated west of the International Boundary in the vicinity of Georges and Cultivator Shoals (Melvin et al. 1991). This pattern is persistent throughout the study period (Fig. 4-8). There has, however, been a general expansion in the distribution of larval herring eastward since 1987 with the widest range of occurrence in the 1990 Canadian survey. The 1991 data does not indicate a continuation of this expansion. In spite of an enlarged survey area in 1991, the observed larval distribution in 1991 was similar to that of 1990.

To investigate the location of spawning areas on the Bank, distributions of newly hatched larvae (i.e. less than 10 mm) from each of the October/November research cruises were examined. Figures 9-13 display the results of this exercise. Assuming the occurrence of newly hatched larvae is an indication of spawning area, then the major concentration of spawning herring would be in the vicinity of Georges and Cultivator Shoals. Again, for 1990, when Canadian and US cruises were conducted at the same time the pattern is almost identical. The distribution in 1987

and 1989 serve to demonstrate the differences that can be encountered for cruises which are separated by only a few weeks. The 1987 US cruise appears to have occurred prior to hatching while the 1989 Canadian survey seems to have just caught the commencement of hatching. Newly hatched larvae were observed east of the International Boundary from 1987 to 1989. No such observation was made by the 1991 Canadian survey.

Larval Length Frequency

The relative length-frequency distributions of larval herring collected within the study area by all fall/winter (i.e. October through January) Canadian and US research cruises are presented in Fig. 14-17. It is evident from these figures that, although quite variable, hatching, assuming a hatch size of 5-7 mm, begins around the middle of October and peaks about two weeks later depending upon the year. These are the larval fish which show up in the November surveys at lengths of 5-15 mm. In 1987 the US October cruise (AL8707) did not detect a single herring larva, and the length frequency observed by the Canadian survey in early November was consistent with what would be expected from a mid-October survey. The 1990 cruise seems to have caught the beginning of hatching with length frequencies ranging from 6-12 mm.

Comparison of the length frequencies for Canadian and US cruises which operated at the same time indicates that they are tracking the same group of fish. The range of larval length and the shape of the size-frequency distributions for November are similar from 1989-90. Slight shifts in the modes by 1-2 mm are assumed to related to differences in the sampling times. No US larval survey was undertaken in November of 1987. In 1988, due to survey problems, the US used data from Canadian sampling stations that were collected by a Canadian cruise.

Spawning

The availability of seasonal (October through January) data for larval length from US counterparts has shed some new light on the timing and location of spawning. The 1987 length distribution (Fig. 14, November/December) depicts what was thought to occur within the study area. A single length mode resulted from a single protracted spawning period that peaked over a relatively short period of time (1-2 wk), and moved to the right as the fish grew. No evidence to the contrary appeared in the annual Canadian research survey until 1991 (Fig. 18). However, it is obvious from the December US data (1988-90) that a second wave of spawning, perhaps equally as large as the first, must occur on the Bank. Herring larvae which were 8-12 mm at the beginning of November would be expected to be 18-22 mm a month later. This latter length group is well represented in the length frequencies (Fig. 15-18).

Assuming a hatching time of 15-20 days (Baxter 1974) at 12°C, the approximate temperature found on Georges Bank at the time of the November survey, and another 15-25 days to grow to 8-12 mm (Blaxter 1962), then the larvae observed in November resulted from spawning in early October while those collected in the December US surveys originated from spawning in early November. This also implies that larval herring observed in December are the progeny of the unspawned and recently spent adult fish collected during the November Canadian surveys, thereby explaining the large percent of gonad stage 6 (spawning) and 7 (just spent) fish in samples (Table 3, Melvin et al. 1992) whose offspring are unlikely to have hatched at the time of the Canadian survey.

Summary

The results of this comparsion serve to illustrate the similarities of larval herring concentrations and the distribution of two independent observations within the Canadian study area. For years when surveys were conducted at approximately the same time (early November), similar results were found. The difference which occurred when surveys were separated by only a few weeks demonstrates the possible range of variation and the critical nature of cruise timing. The larval density (#/10 m^2) observed by the US October survey in 1987 is a prime example of how misleading the findings can be if spawning is delayed by even a short period of time. The Canadian 1987 survey produced the second highest estimate of larvae density to date.

The usefulness of a single annual larval survey as an index of abundance, given a variable spawning season, is also compromised by the results of this study. It is therefore recommended that future indices incorporate a mortality function to account for the high daily (5-10%) mortality (Lough et al. 1985; Chenoweth et al. 1989) which occurs during this early phase of the life cycle.

More importantly, however, with respect to the recovery/status of this stock, is the discovery of what appears to be a second wave of spawning that went undetected by the single Canadian annual survey until 1991 because of possible changing spawning times. The implication of this finding is that although the Canadian larval surveys have shown strong signs of recovery over the past 5 yr, only an unknown portion of the recovery is presently being evaluated. If larval densities are any indication of spawning stock biomass then the portion of undetected larvae may be as large as the portion currently being tracked by the Canadian fall survey.

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Table 1. Summary of Canadian and US herring larval surveys in the Canadian study area on Georges Bank from 1986-91.

Year	Cruise #	Dates	Number of stations	Percent with herring larvae	Number per 10 m^2	Standard error
1986	DL8601	Jan 30-Feb 5	13	15.4	0.85	0.58
1986	AL8602	Apr 12-16	11	0.0	-	-
1986	AL8605	Oct 20-22	13	30.8	8.82	5.05
1986	DL8607	Sept 15-16	13	0.0	-	-
1986	DL8610	Nov 24-Dec 7	13	46.2	40.13	20.22
1987	DL8701	Feb 4-8	13	18.8	3.92	2.94
1987	AL8701	Apr 22-26	12	0.0	-	-
1987	AL8707	Oct 4-17	12	0.0	-	-
1987	DL8710	Dec 2-10	13	38.4	45.02	41.90
1987	H181	Nov 2-9	19	86.3	200.95	93.10
1988	AL8802	Mar 28-31	10	20.0	2.15	1.87
1988	AL8809	Oct 10-19	11	36.4	11.57	6.22
1988	LH8819	Oct 29-Nov 7	45	73.8	58.72	13.65
1988	DL8812	Nov 8-10	4	100.0	75.74	39.52
1988	AL8811	Dec 5-9	43	72.9	161.80	40.90
1988	LH195	Oct 29-Nov 9	61	73.8	66.41	13.37
1989	DL8901	Jan 15-19	43	30.2	7.98	2.89
1989	DL8906	Oct 12-25	15	6.7	0.35	0.35
1989	DL8907	Nov 11-16	40	92.5	293.90	61.19
1989	DL8909	Dec 7-14	39	74.4	188.84	65.71
1989	LH207	Oct 27-Nov 6	90	51.1	54.75	17.38
1990	DL9001	Jan 9-12	41	58.5	13.87	4.69
1990	DL9003	Feb 28-Mar 1	14	28.6	23.16	5.96
1990	DL9004	Mar 30-Apr 10	10	60.0	17.05	5.67
1990	DL9011	Oct 6-17	18	16.7	67.73	64.49
1990	DL9012	Nov 4-7	41	78.9	107.81	30.26
1990	DL9014	Dec 6-9	38	84.2	99.07	27.48
1990	LH222	Nov 1-5	79	87.3	98.81	18.89
1991	DL9101	Jan 8-15	31	74.2	52.67	19.27
1991	LH235	Nov 4-15	53	77.4	41.12	10.72

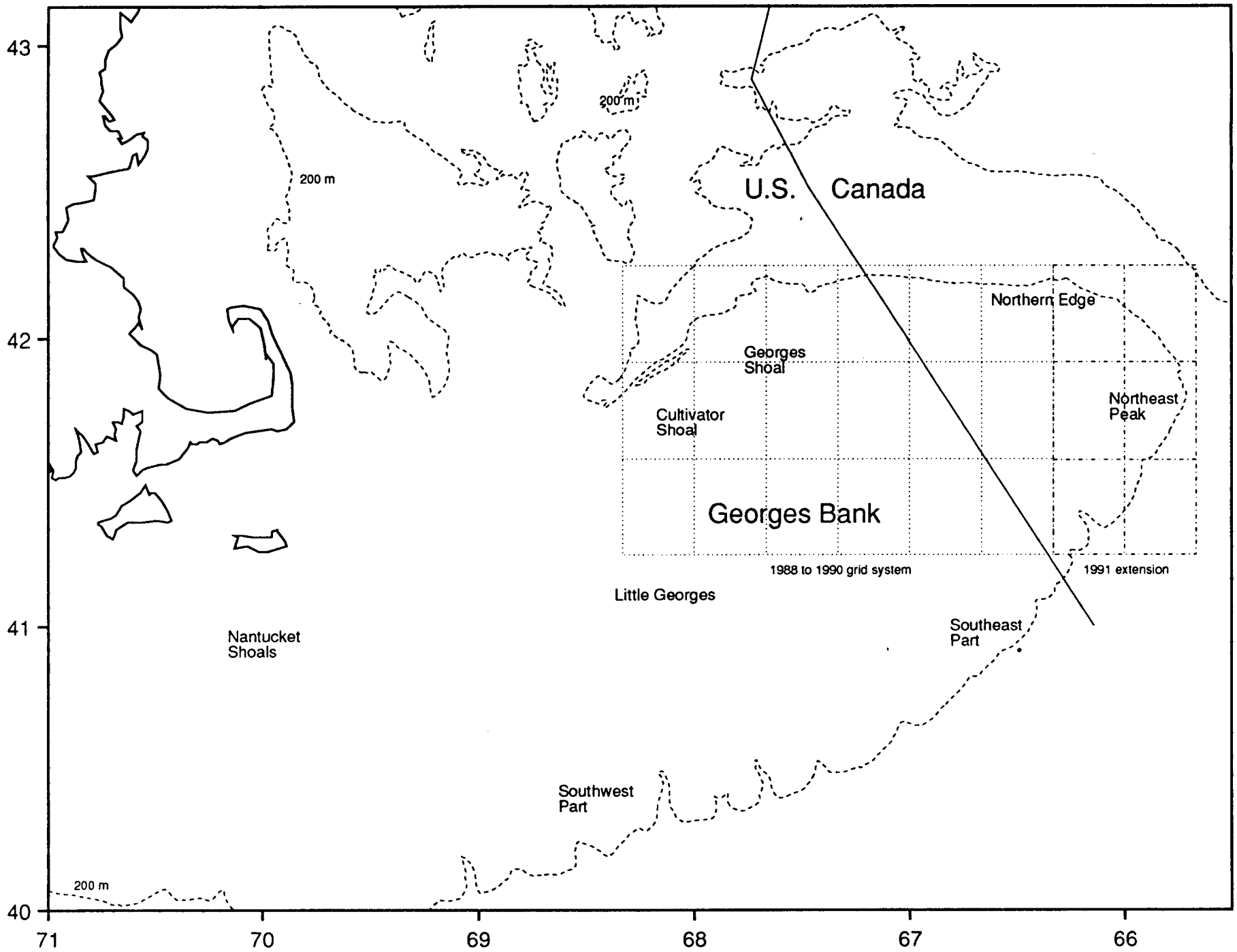
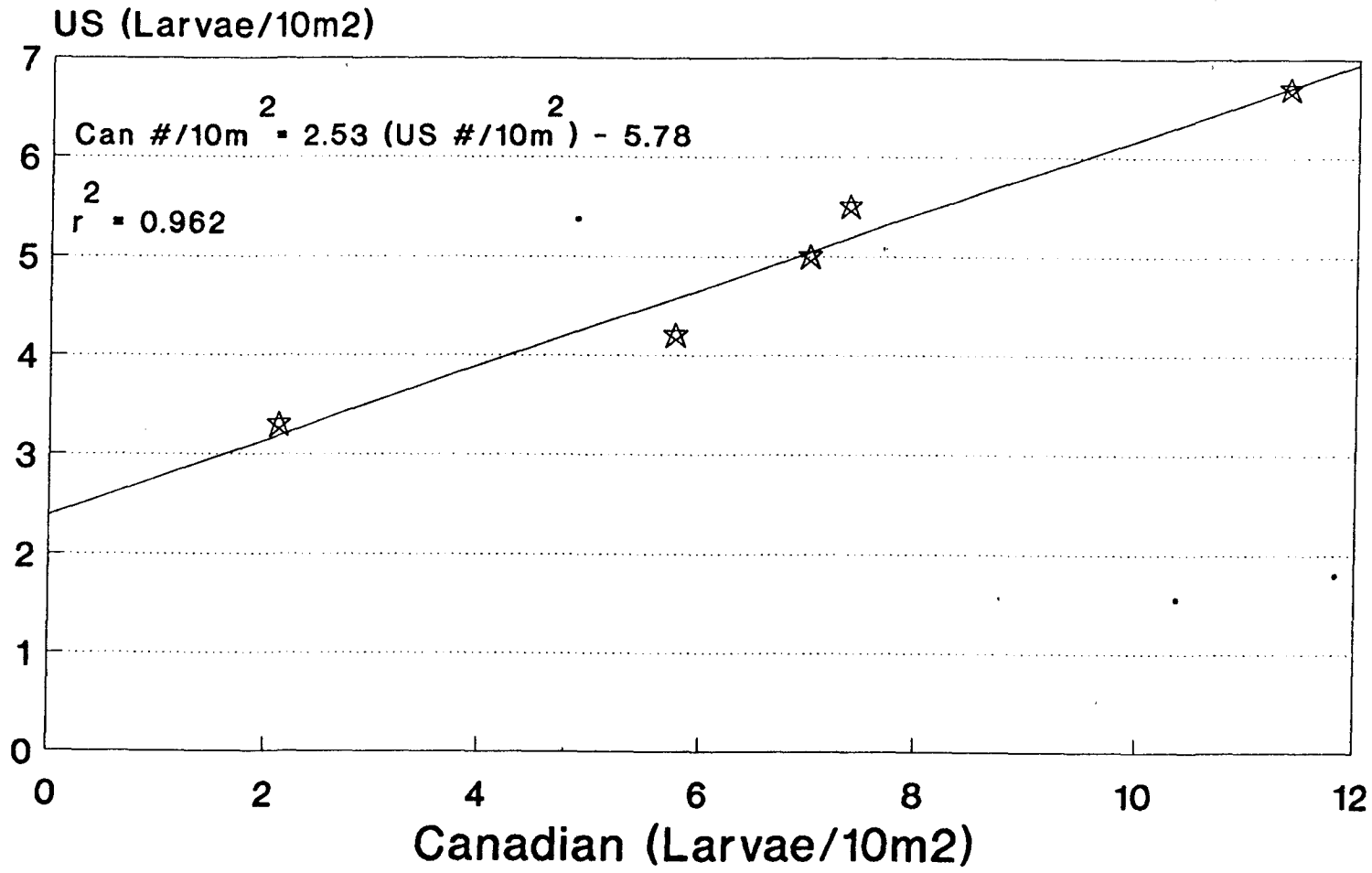


Figure 1. Location of larval grid system used by Canadian Surveys.



1988

Figure 2 Comparative tows. Delaware II vs Lady Hammond

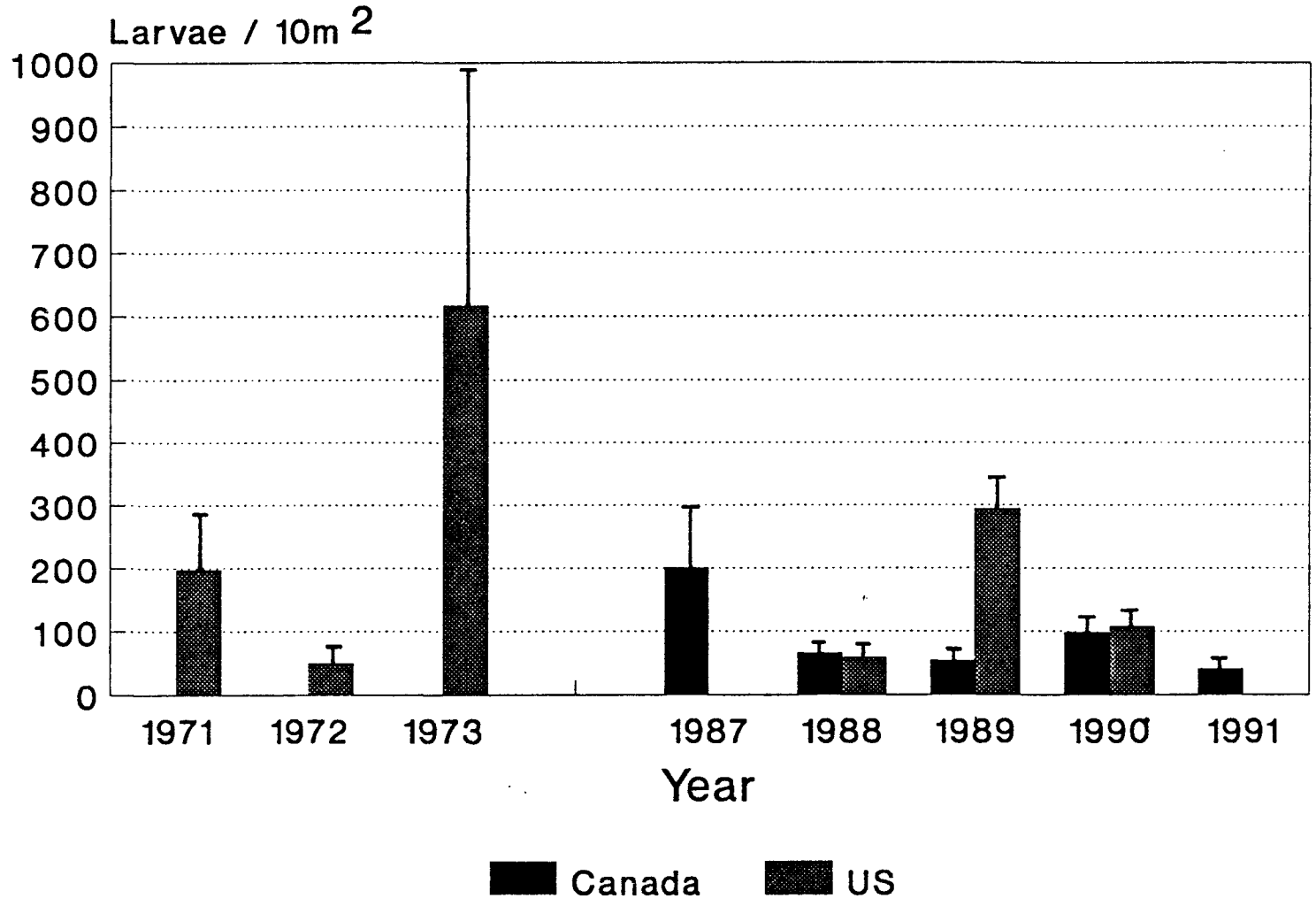


Figure 3. Canada - US larval surveys. 1987 - 1991.

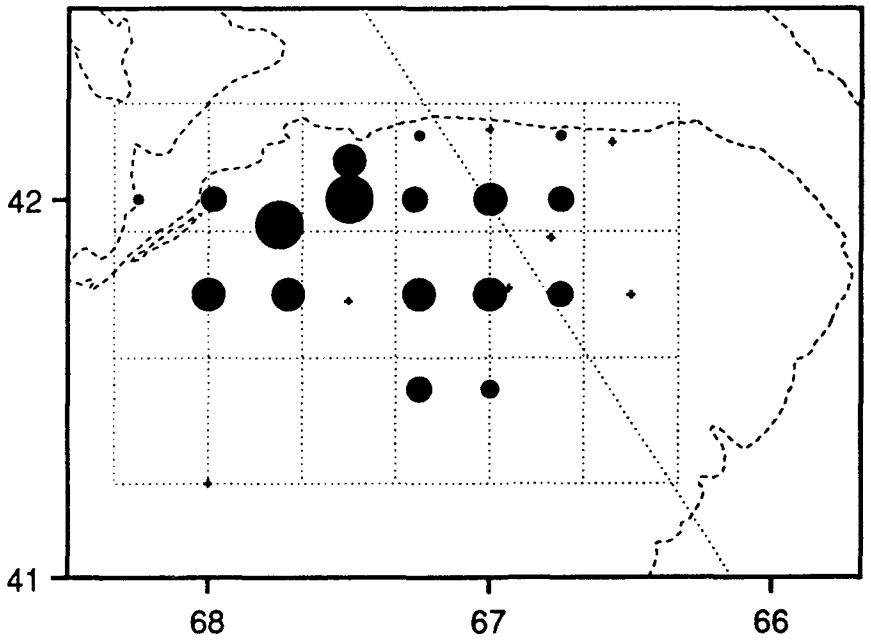


Figure 4a. Canadian Georges Bank larval survey - 1987.
Dates: (Nov 2 - Nov 9). Larvae as per adjacent scale.

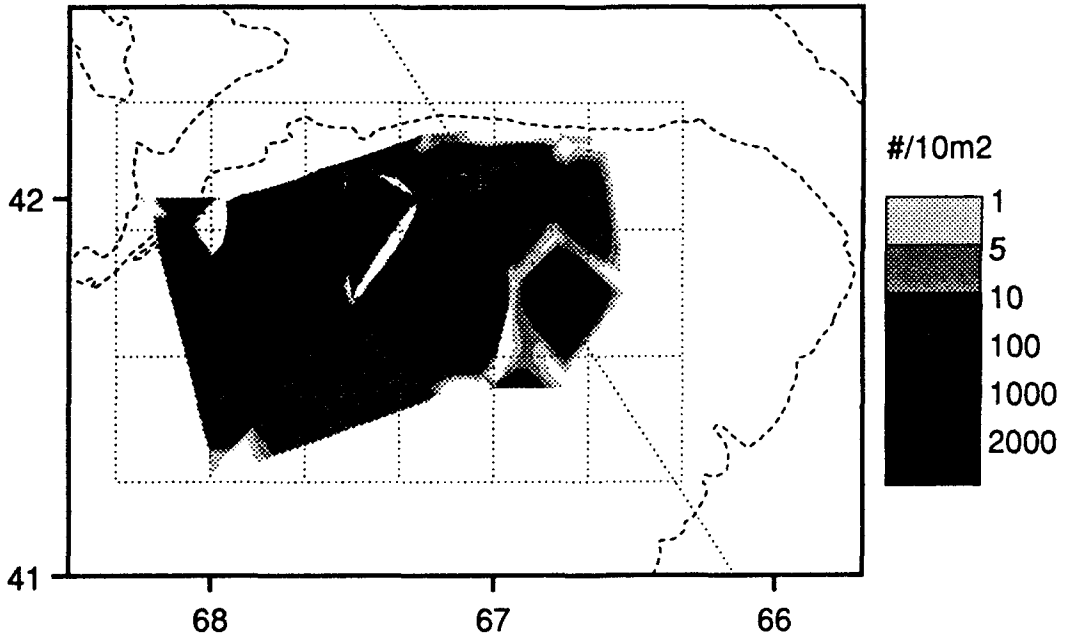


Figure 4b. Canadian Georges Bank Larval survey - 1987.
Contours as per adjacent scale.

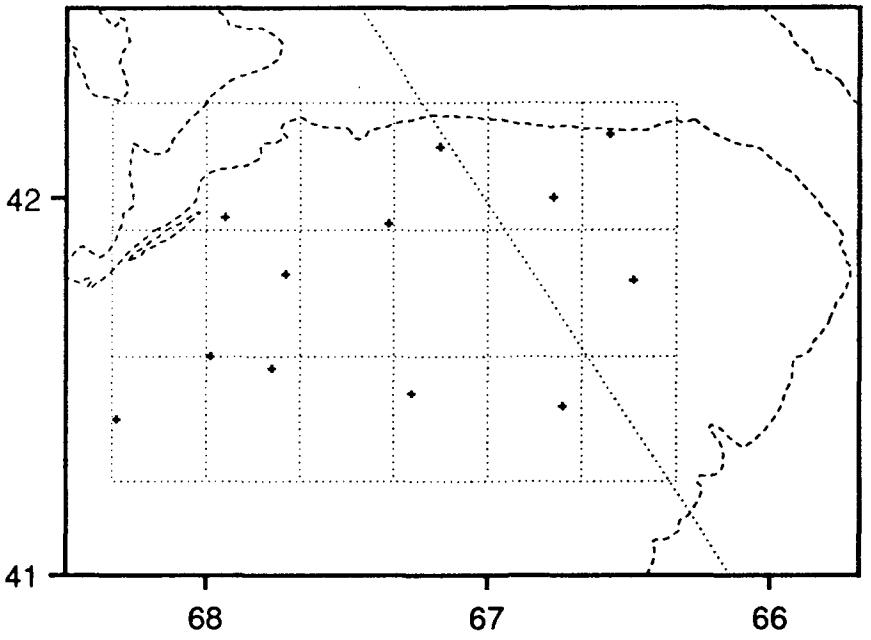


Figure 4c. US Georges Bank larval survey 1987.
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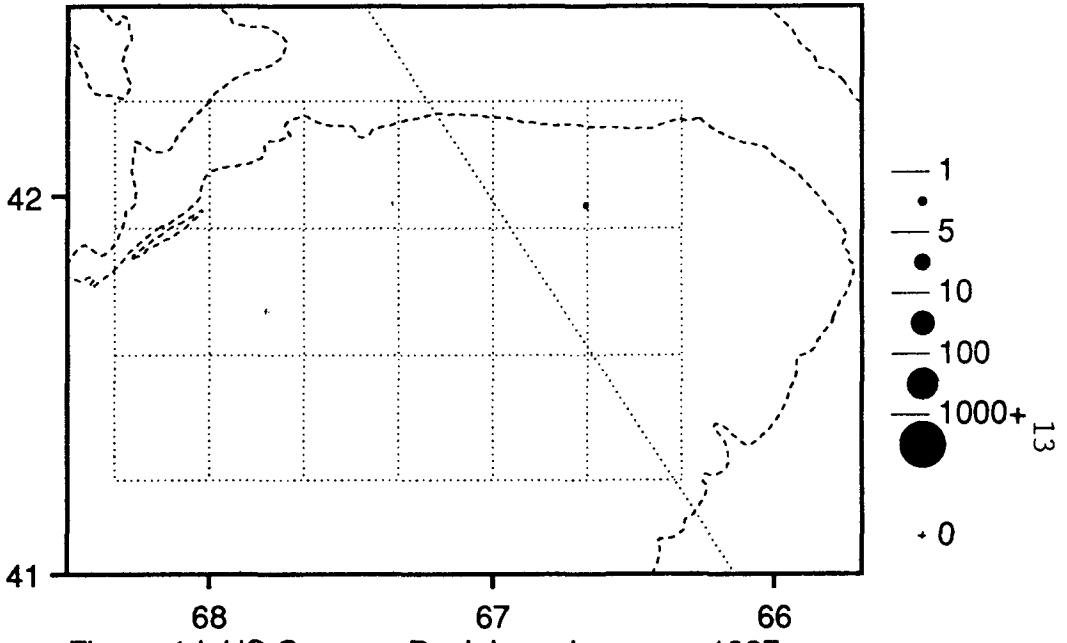

Figure 4d. US Georges Bank Larval survey - 1987.
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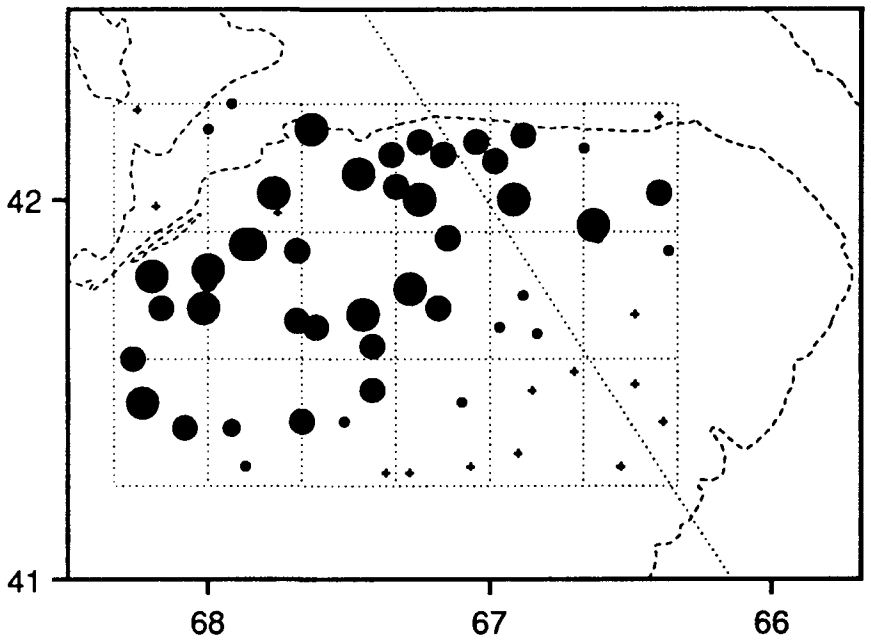

Figure 5a. Canadian Georges Bank larval survey - 1988. Dates: (Oct 29 - Nov 9). Larvae as per adjacent scale.

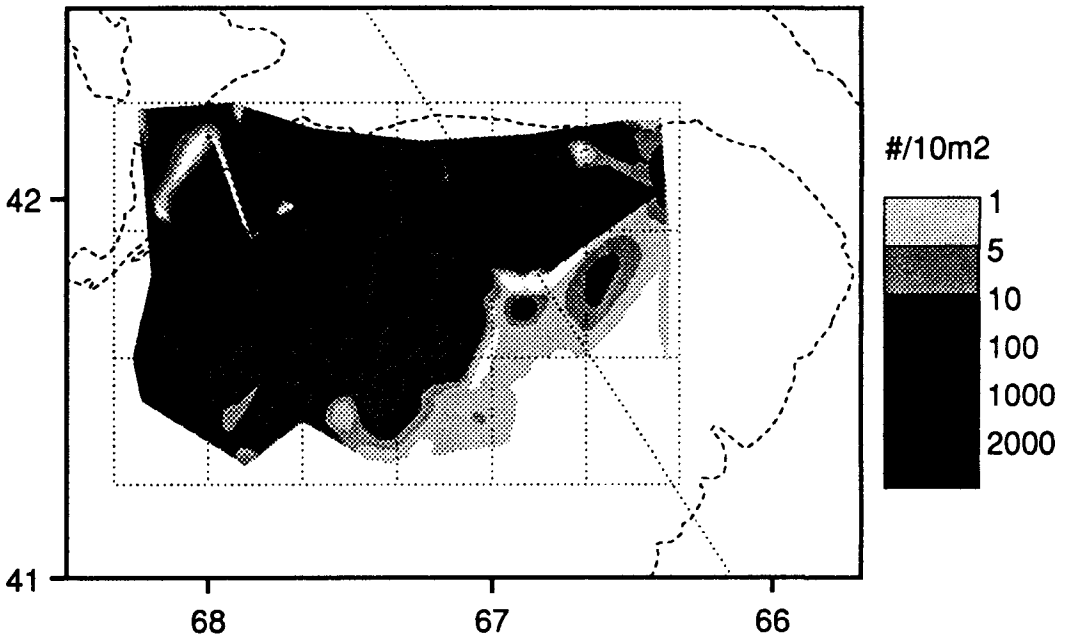

Figure 5b. Canadian Georges Bank larval survey - 1988. Contours as per adjacent scale.

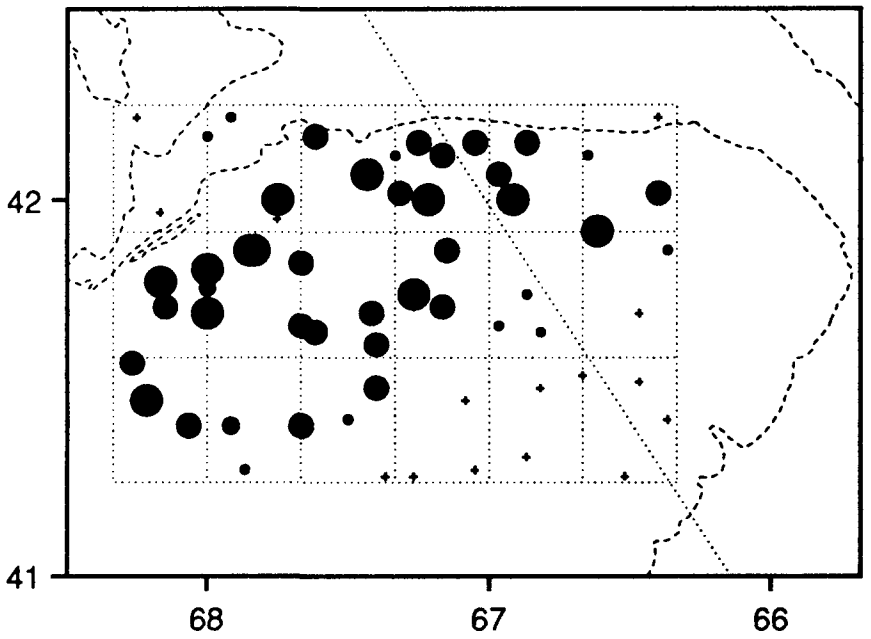

Figure 5c. US Georges Bank larval survey 1988. Dates: (Oct 29 - Nov 7). Larvae as per adjacent scale.

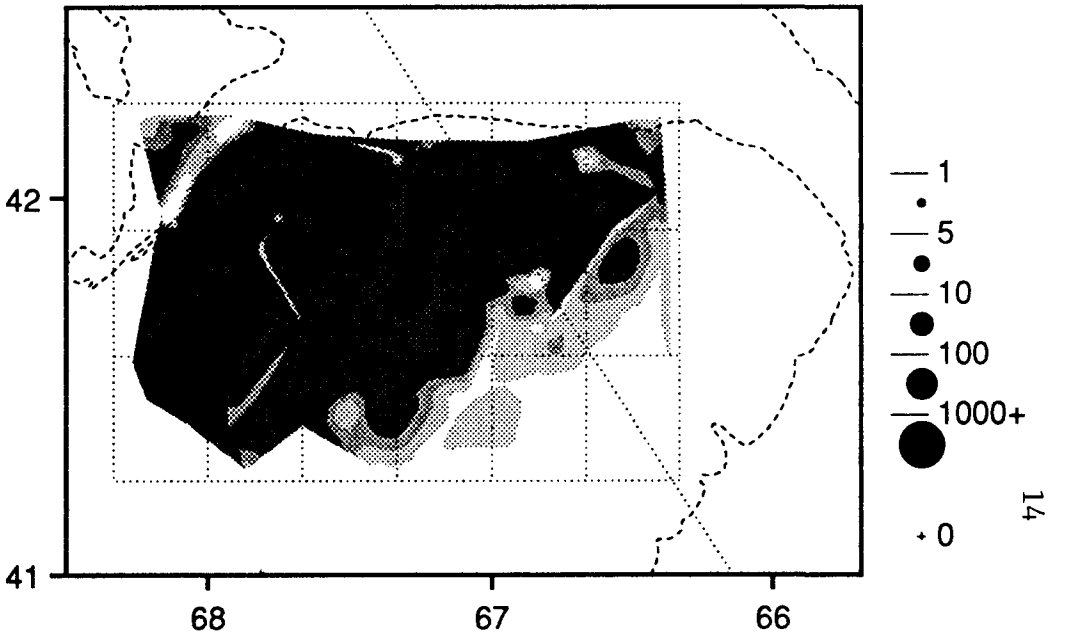

Figure 5d. US Georges Bank larval survey - 1988. Contours as per adjacent scale.

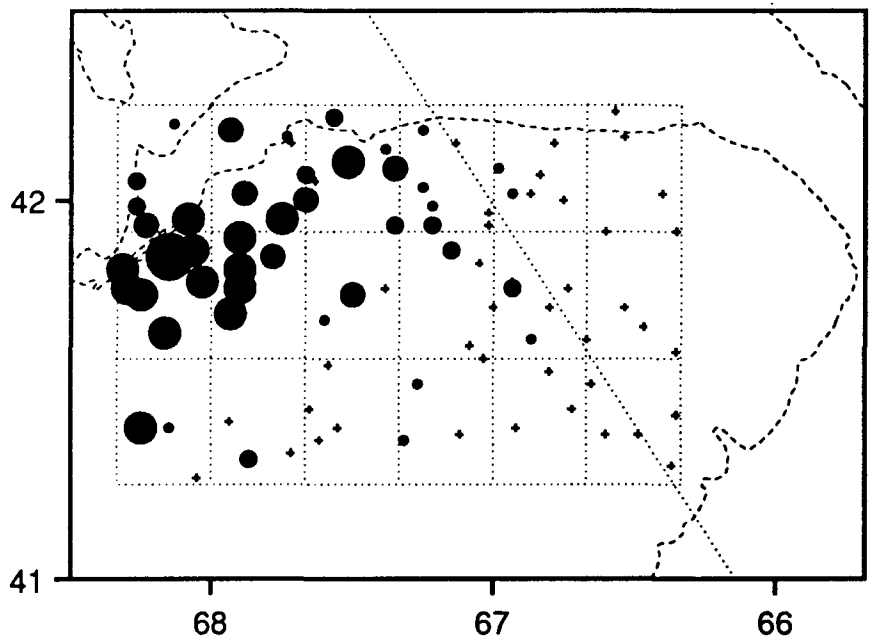

Figure 6a. Canadian Georges Bank larval survey - 1989. Dates: (Oct 27 - Nov 6). Larvae as per adjacent scale.

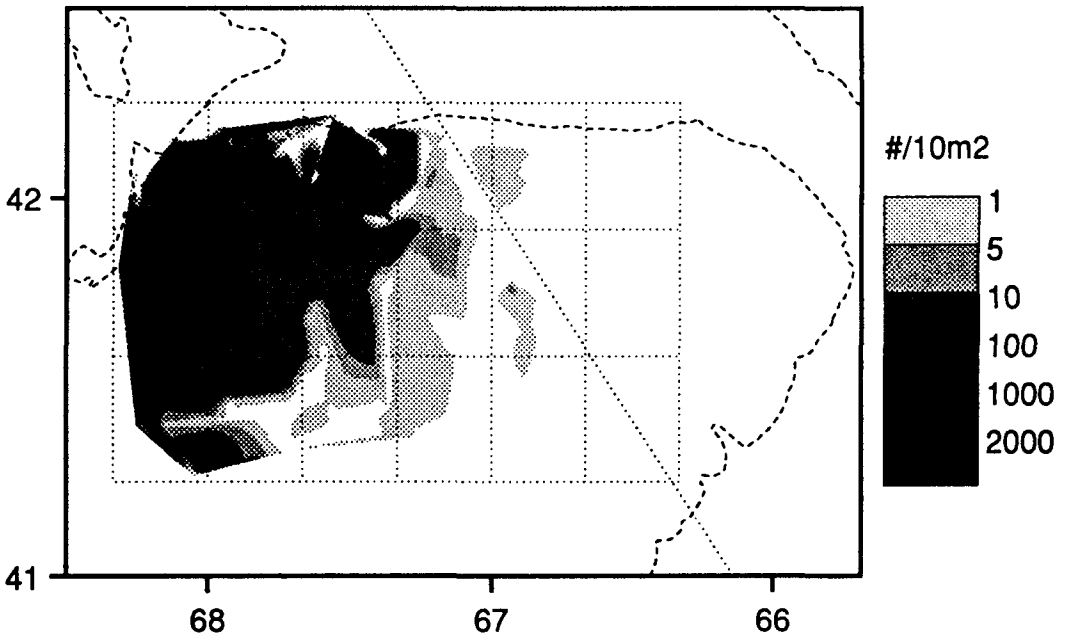

Figure 6b. Canadian Georges Bank larval survey - 1989. Contours as per adjacent scale.

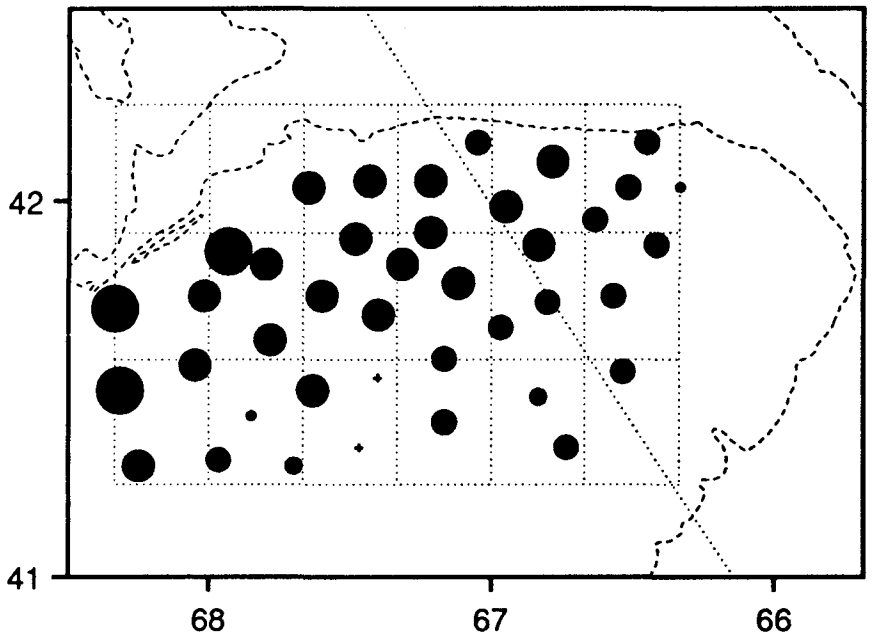

Figure 6c. US Georges Bank larval survey 1989. Dates: (Nov 11 - Nov 16). Larvae as per adjacent scale.

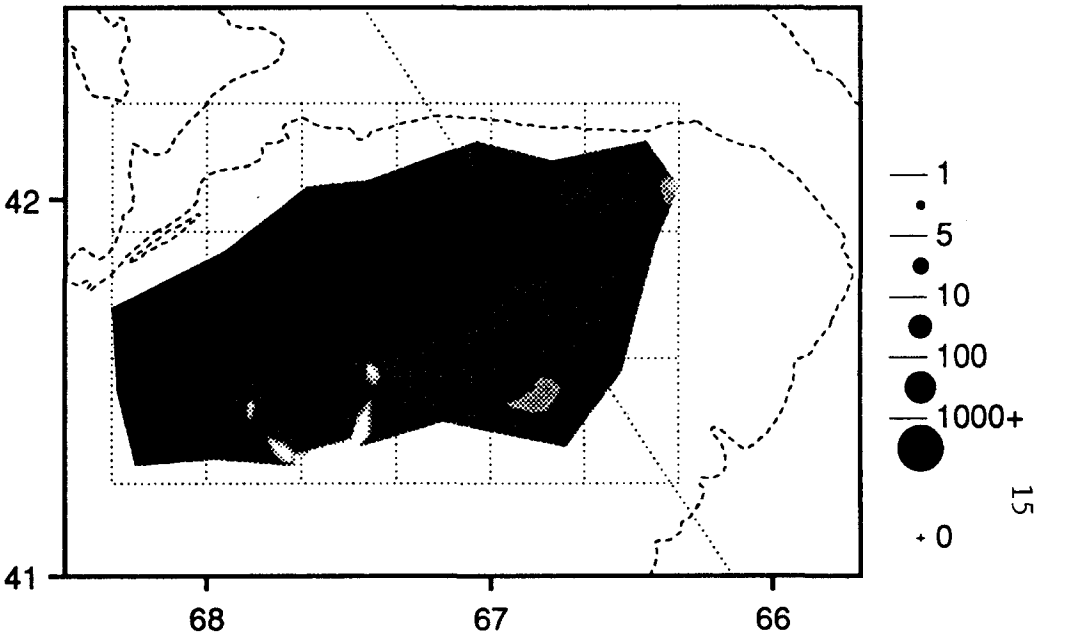

Figure 6d. US Georges Bank larval survey - 1989. Contours as per adjacent scale.

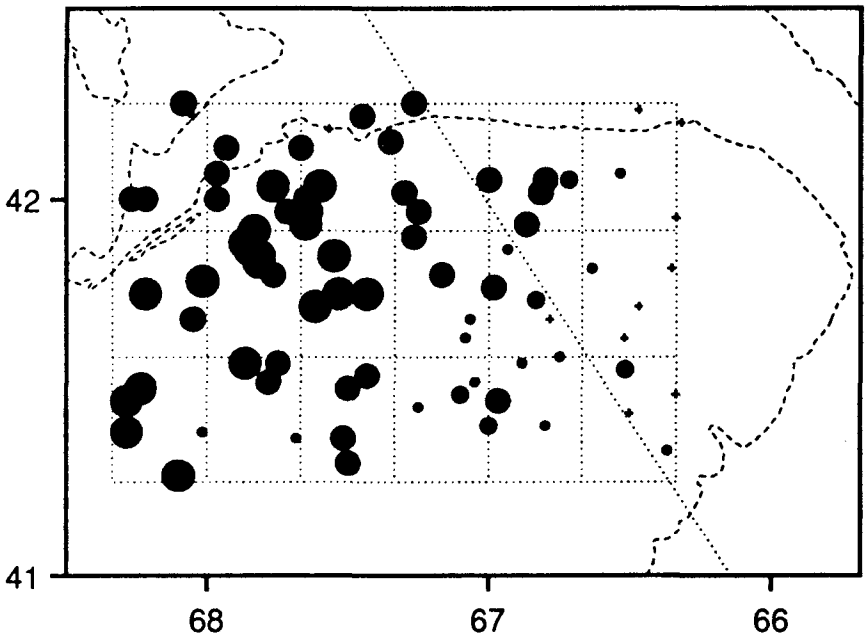

Figure 7a. Canadian Georges Bank larval survey - 1990. Dates: (Nov 1 - Nov 5). Larvae as per adjacent scale.

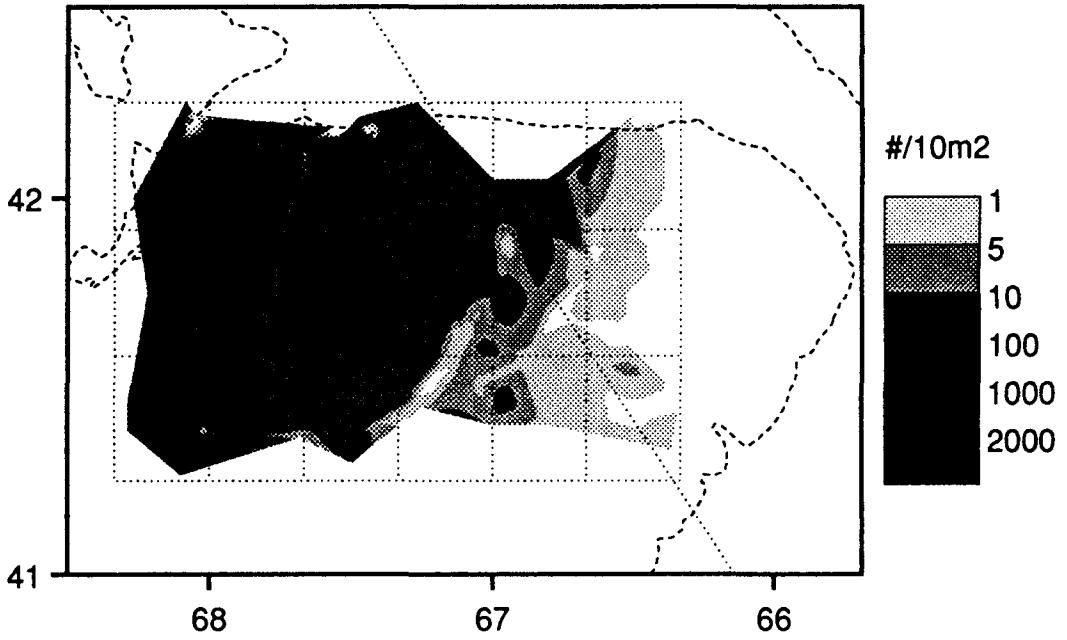

Figure 7b. Canadian Georges Bank larval survey - 1990. Contours as per adjacent scale.

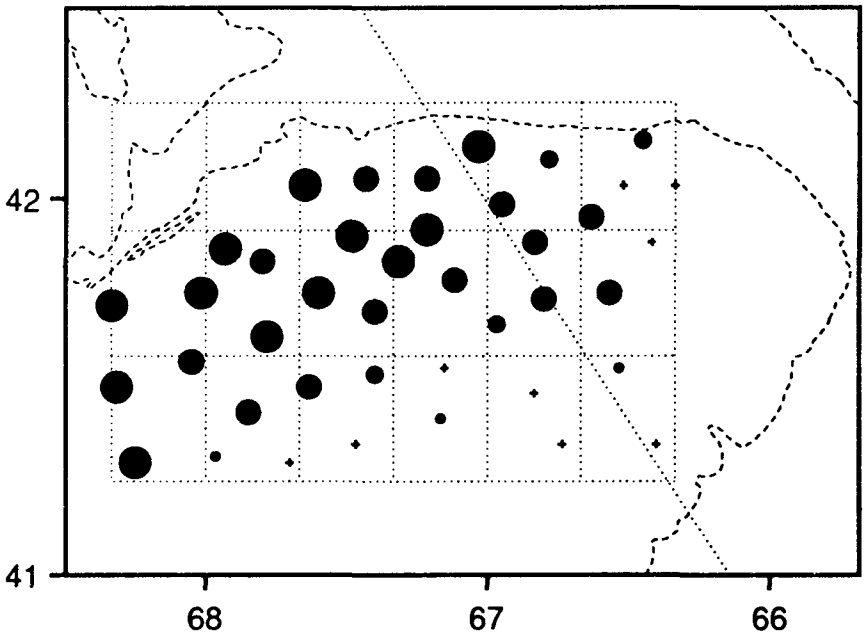

Figure 7c. US Georges Bank larval survey 1990. Dates: (Nov 4 - Nov 7). Larvae as per adjacent scale.

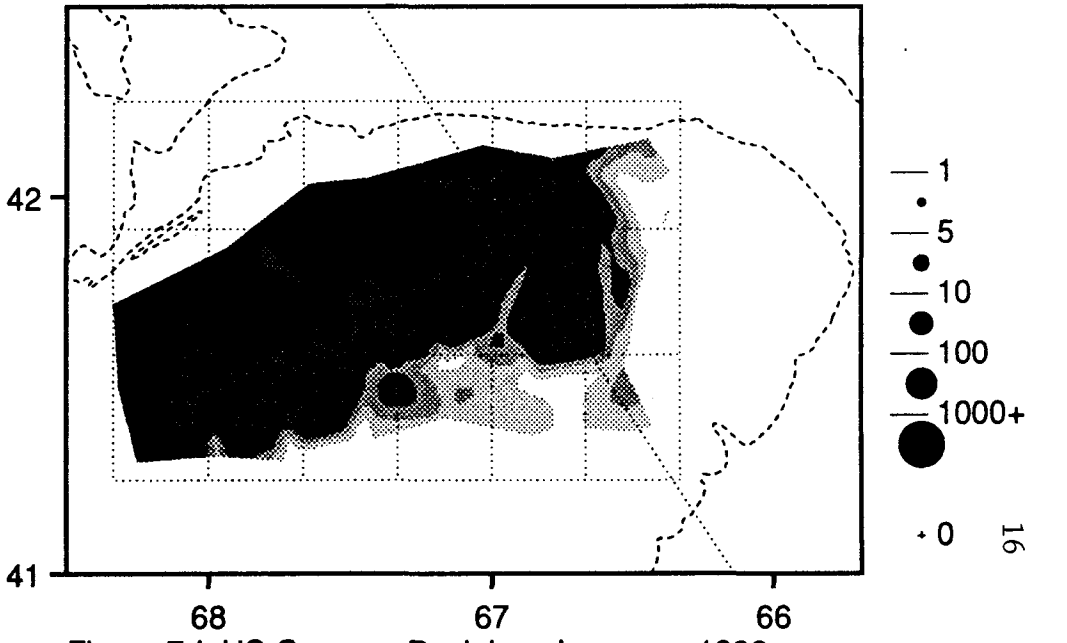

Figure 7d. US Georges Bank larval survey - 1990. Contours as per adjacent scale.

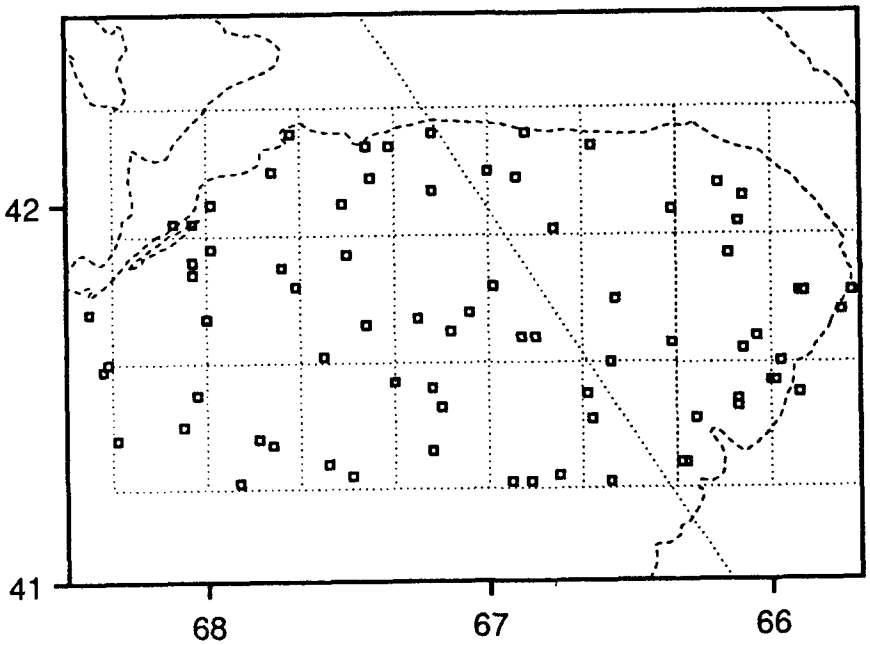

Figure 8a. 1991 Canadian larval survey (Nov 4 - 15). Sampling stations.

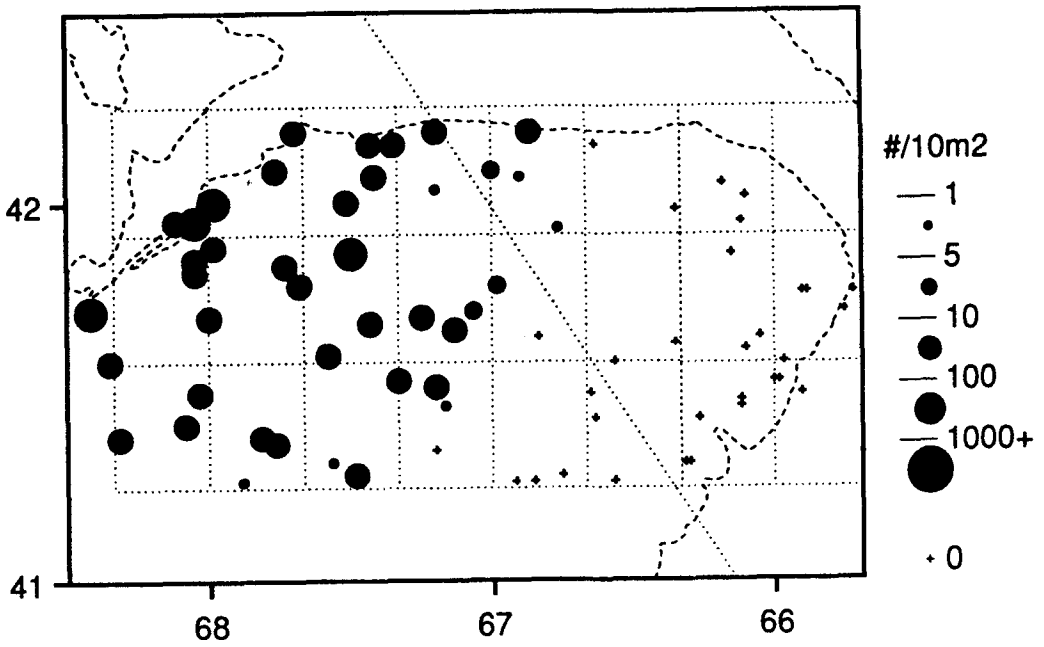

Figure 8b. 1991 Canadian larval survey (Nov 4 - 15). Larvae as per adjacent scale.

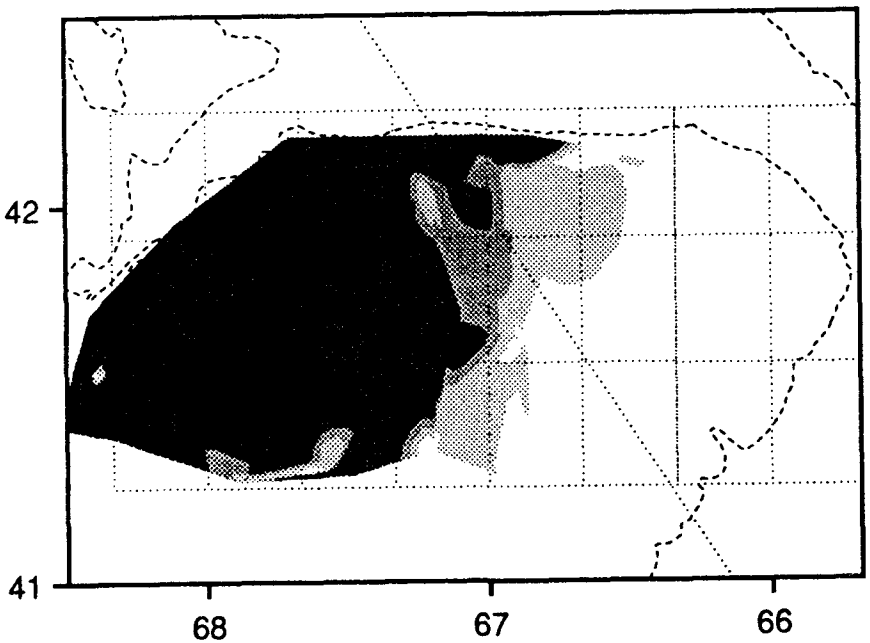

Figure 8c. 1991 Canadian larval survey (Nov 4 - 15). All larvae. Contours as per adjacent scale.

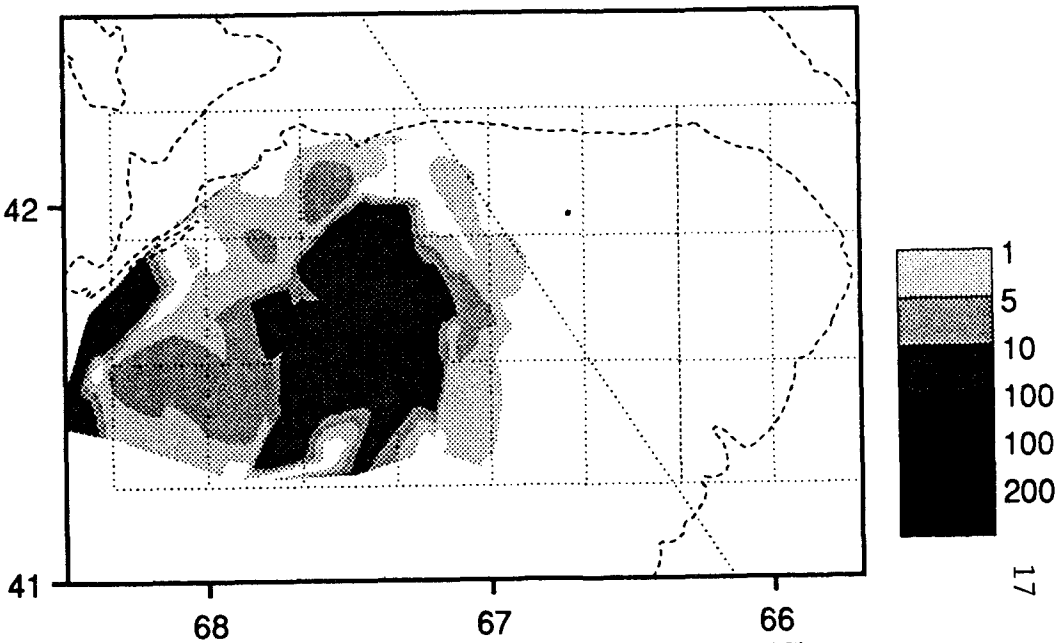

Figure 8d. 1991 Canadian larval survey (Nov 4 - 15). Larvae (<10mm). Contours as per adjacent scale.

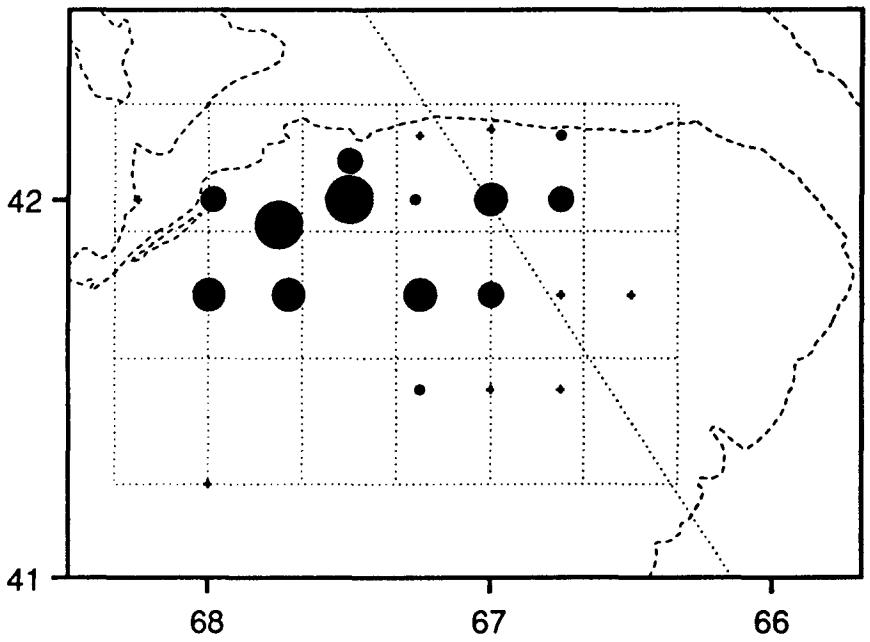

Figure 9a. Canadian Georges Bank larval survey - 1987. Larvae (<10mm) as per adjacent scale. Dates: (Oct 4 - 17).

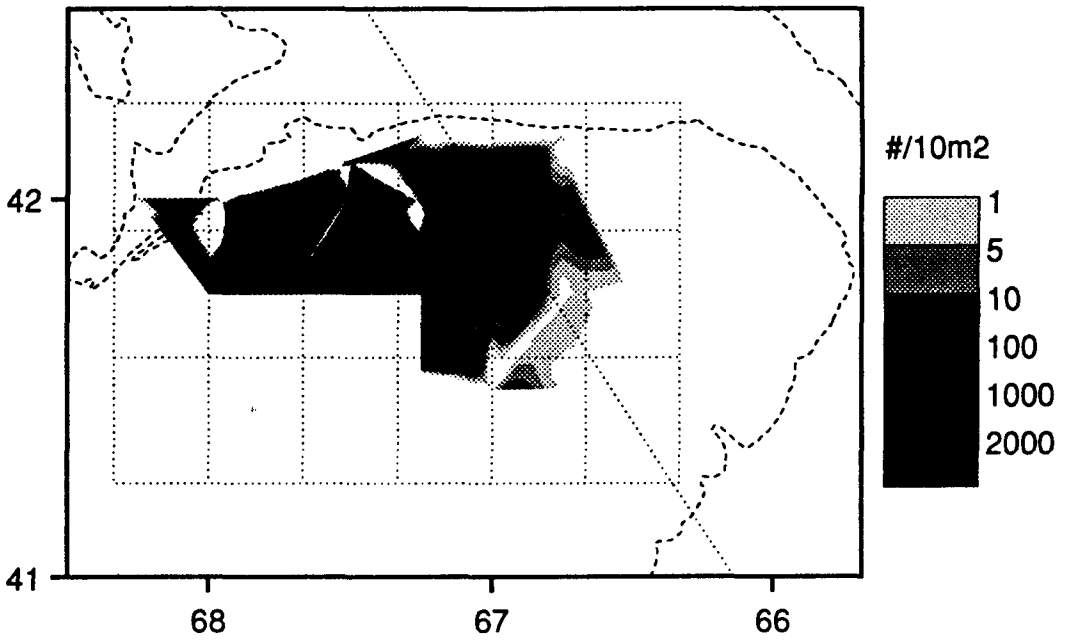

Figure 9b. Canadian Georges Bank larval survey - 1987. Larvae (<10mm). Contours as per adjacent scale.

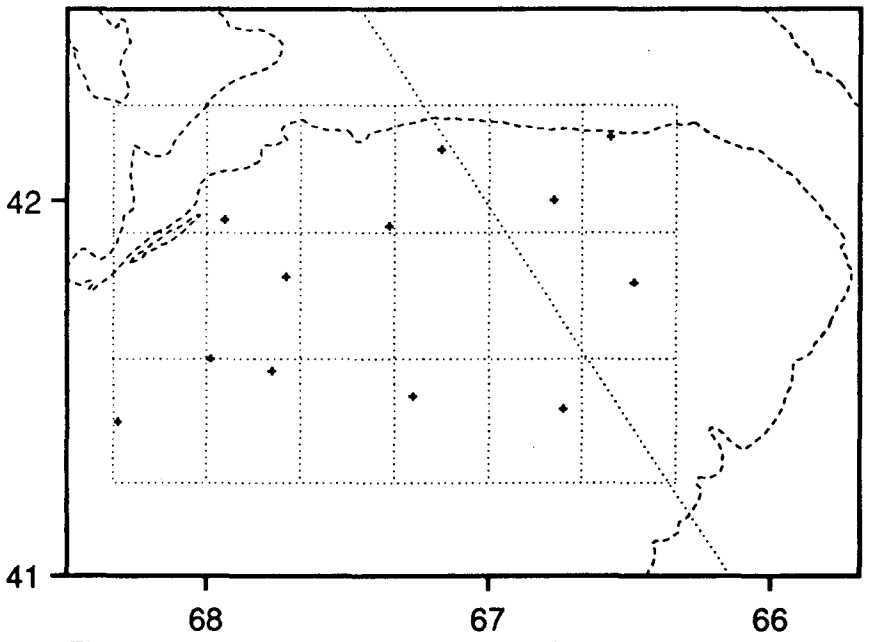

Figure 9c. US Georges Bank larval survey 1987. Larvae (<10mm) as per adjacent scale. Dates: (Oct 4 - 17).

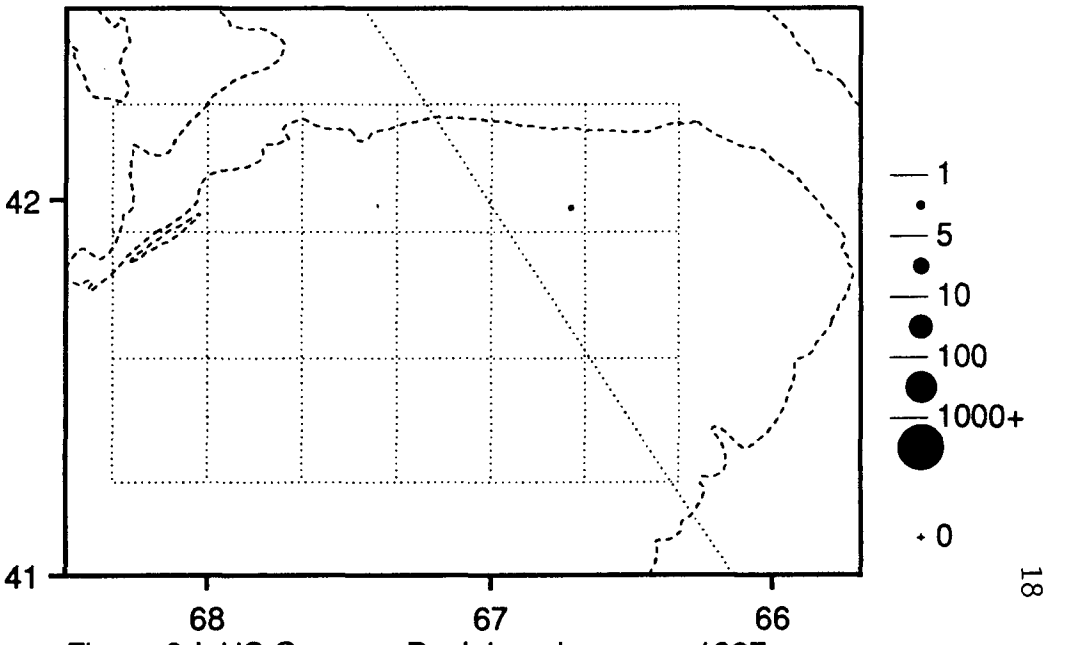

Figure 9d. US Georges Bank larval survey - 1987. Larvae (<10mm). Contours as per adjacent scale.

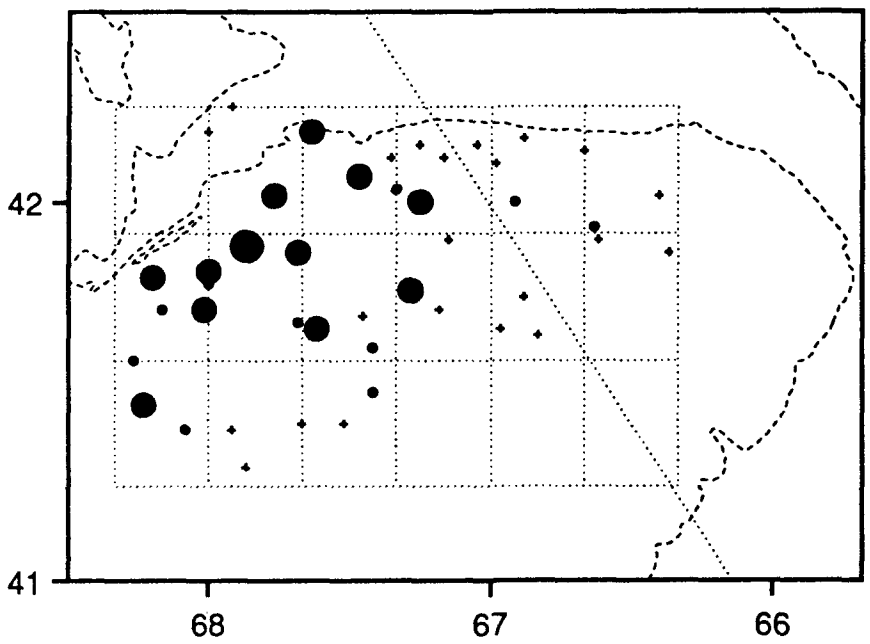

Figure 10a. Canadian Georges Bank larval survey - 1988. Larvae (<10mm) as per adjacent scale. Dates: (Oct 29 - Nov 9).

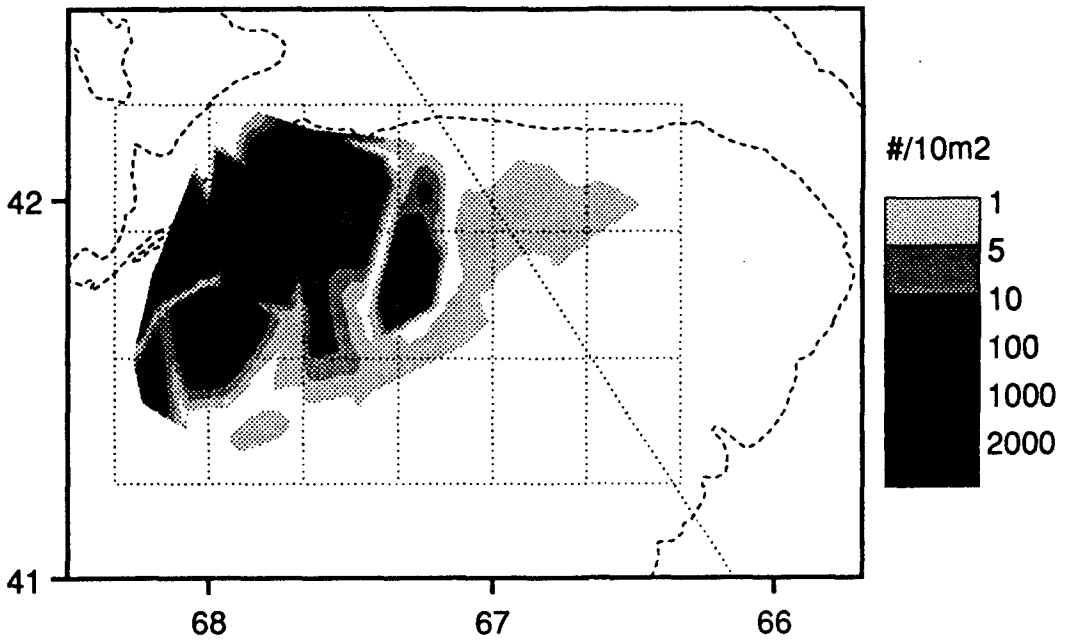

Figure 10b. Canadian Georges Bank larval survey - 1988. Larvae (<10mm). Contours as per adjacent scale.

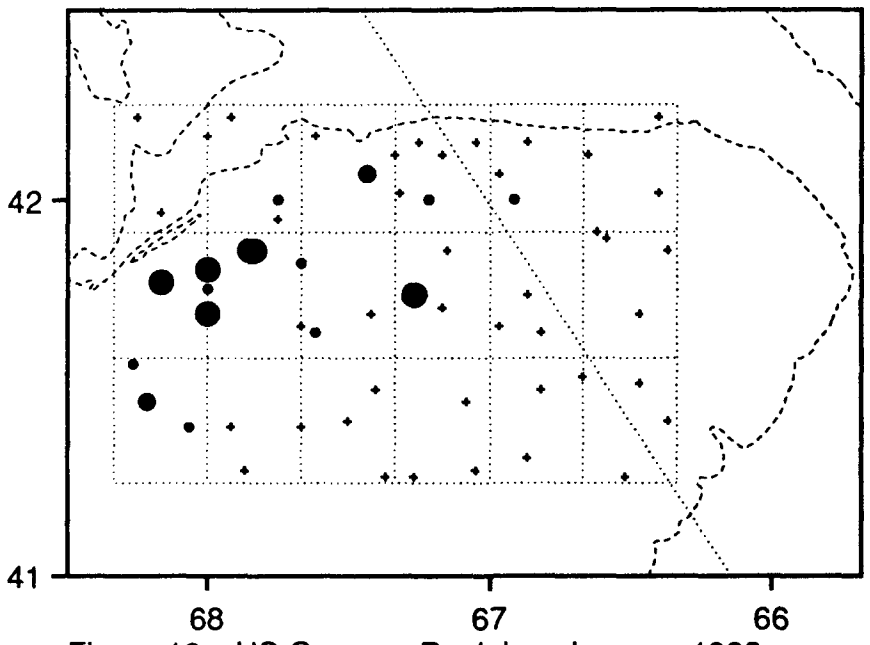

Figure 10c. US Georges Bank larval survey 1988. Larvae (<10mm) as per adjacent scale. Dates: (Oct 29 - Nov 7).

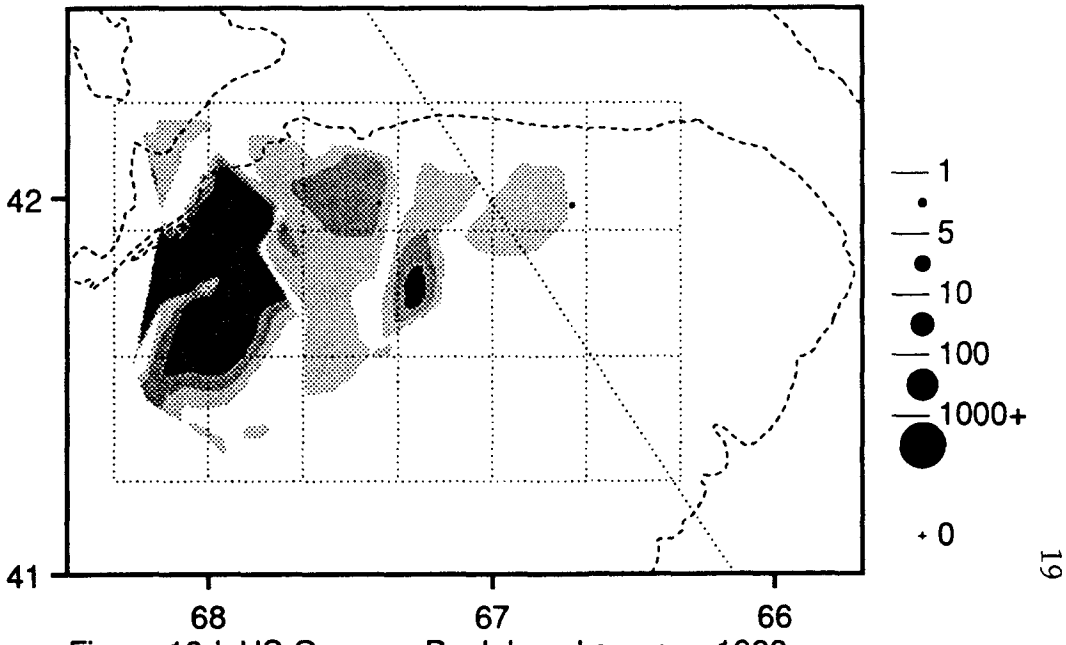

Figure 10d. US Georges Bank larval survey - 1988. Larvae (<10mm). Contours as per adjacent scale.

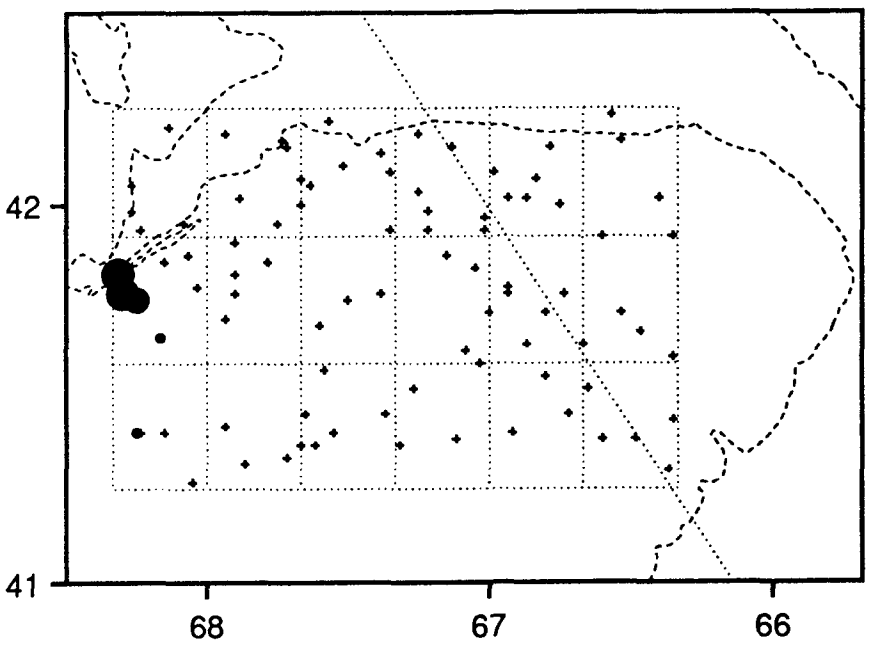

Figure 11a. Canadian Georges Bank larval survey - 1989. Larvae (<10mm) as per adjacent scale. Dates: (Oct 27 - Nov 6).

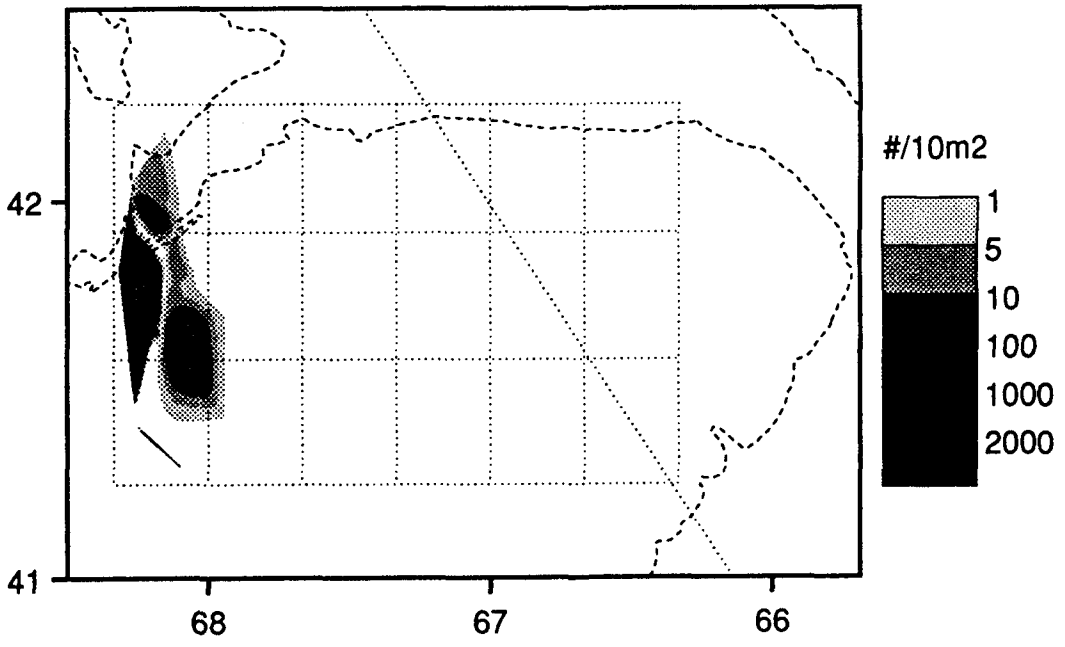

Figure 11b. Canadian Georges Bank larval survey - 1989. Larvae (<10mm). Contours as per adjacent scale.

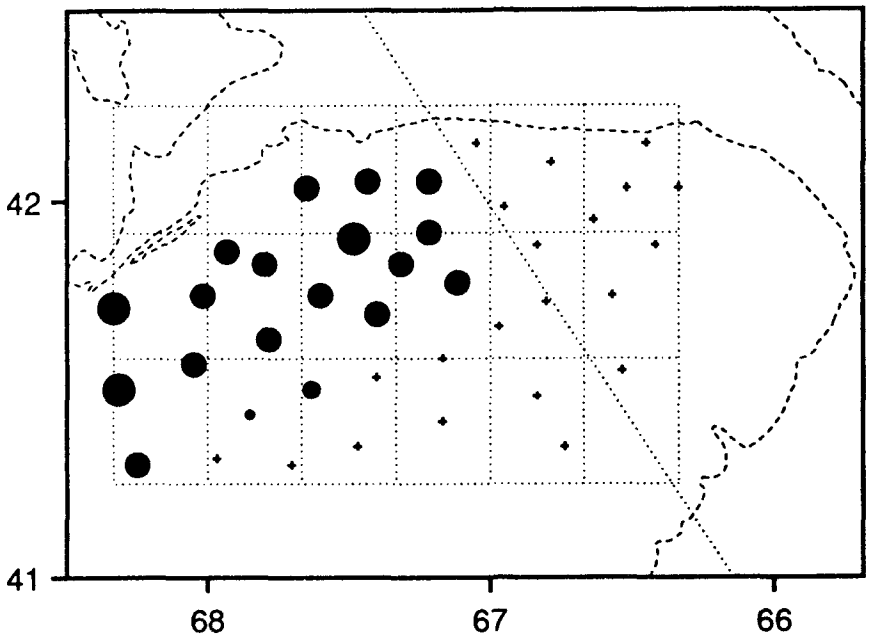

Figure 11c. US Georges Bank larval survey 1989. Larvae (<10mm) as per adjacent scale. Dates: (Nov 11 - 16).

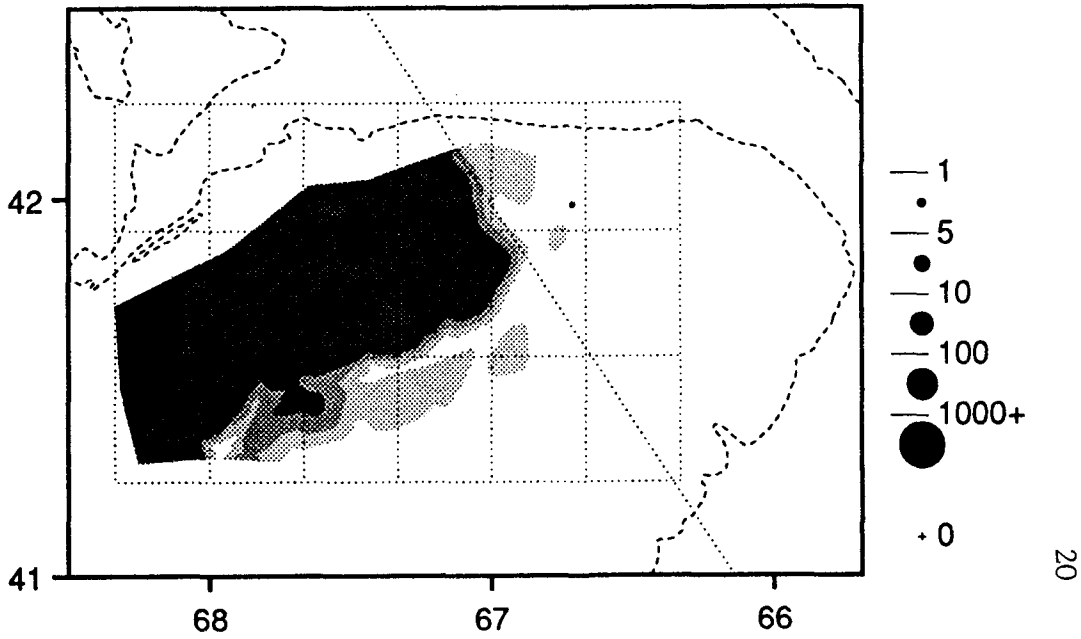

Figure 11d. US Georges Bank larval survey - 1989. Larvae (<10mm). Contours as per adjacent scale.

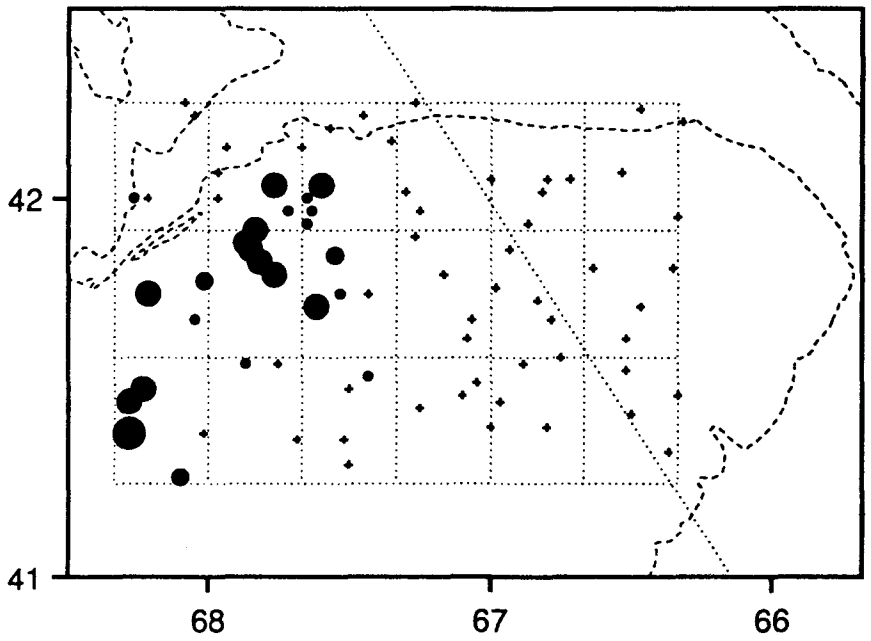

Figure 12a. Canadian Georges Bank larval survey 1990. Larvae (<10mm) as per adjacent scale. Dates: (Nov 1- 5).

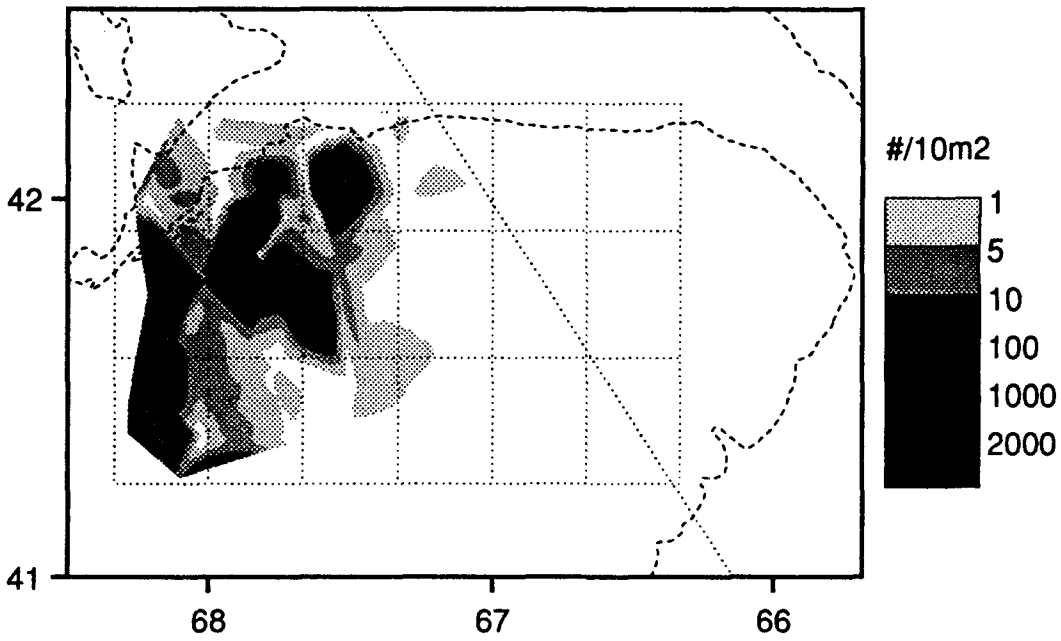

Figure 12b. Canadian Georges Bank larval survey - 1990. Larvae (<10mm). Contours as per adjacent scale.

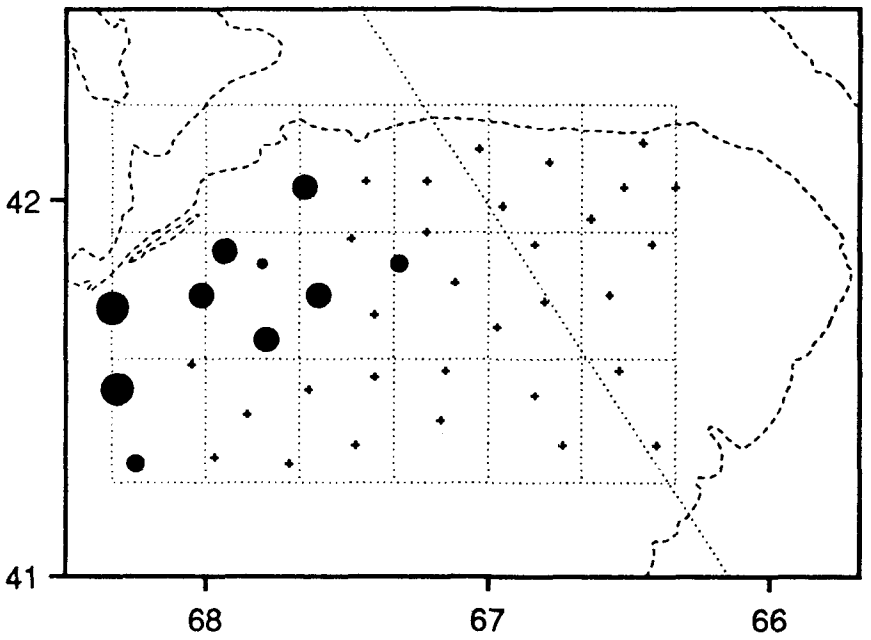

Figure 12c. US Georges Bank larval survey 1990. Larvae (<10mm) as per adjacent scale. Dates: (Nov 4 - 7).

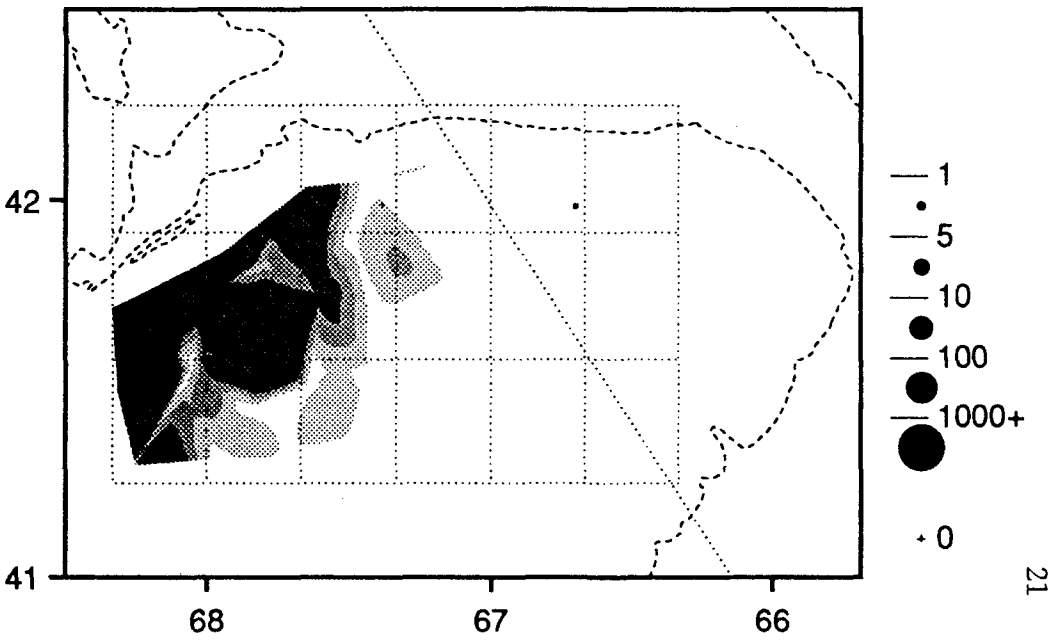

Figure 12d. US Georges Bank larval survey - 1990. Larvae (<10mm). Contours as per adjacent scale.

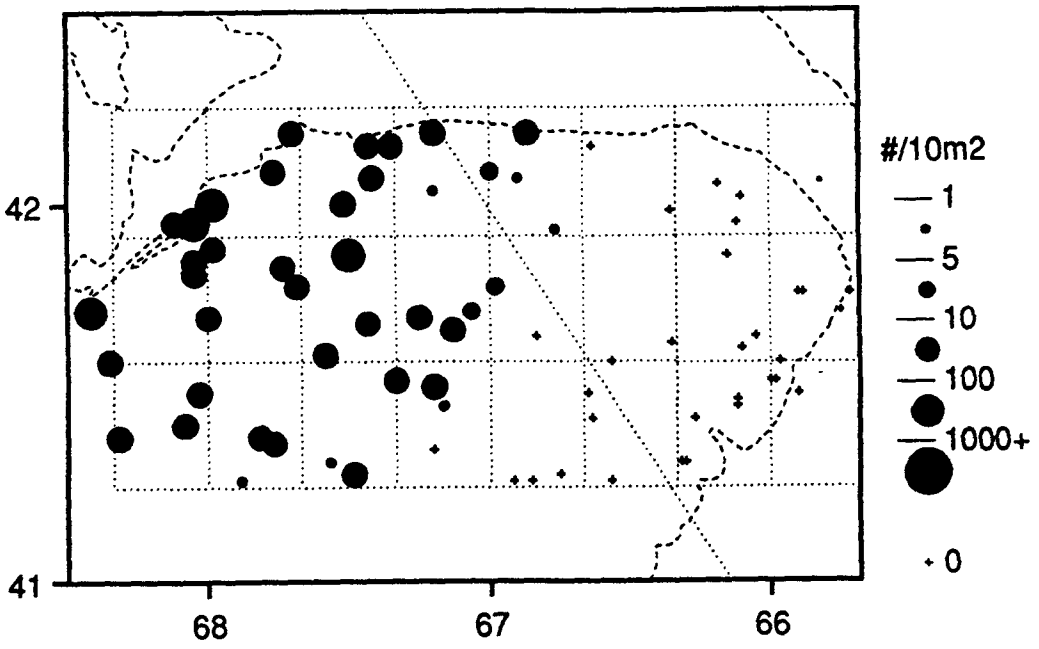

Figure 13a. 1991 Canadian Larval survey (Nov 4 - 15). Larvae as per adjacent scale.

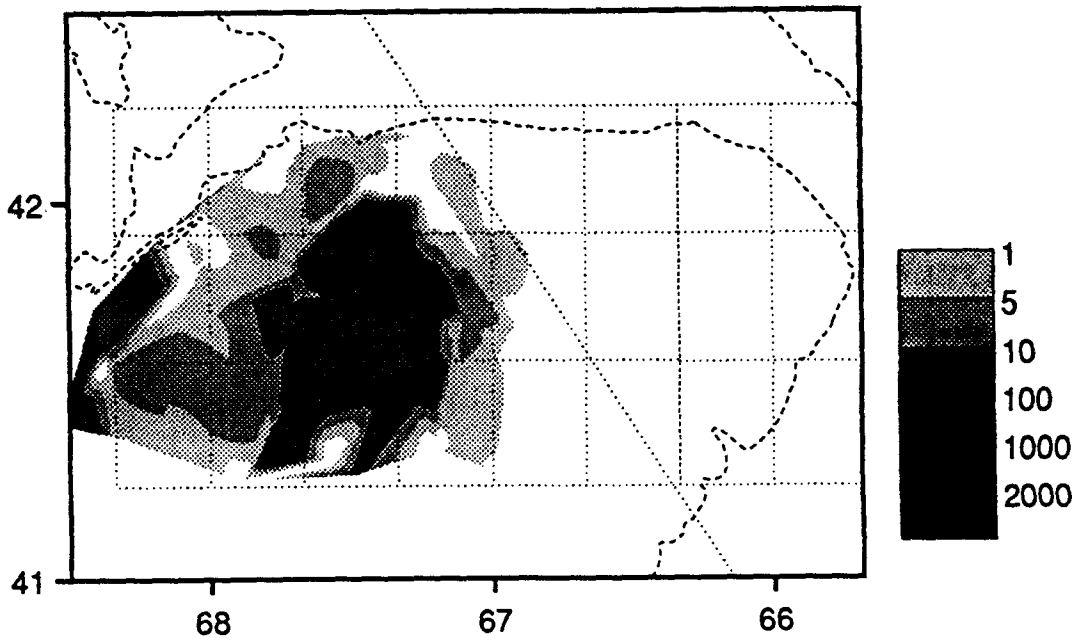

Figure 13b. 1991 Canadian Larval survey (Nov 4 - 15). Larvae (<10mm). Contours as per adjacent scale.

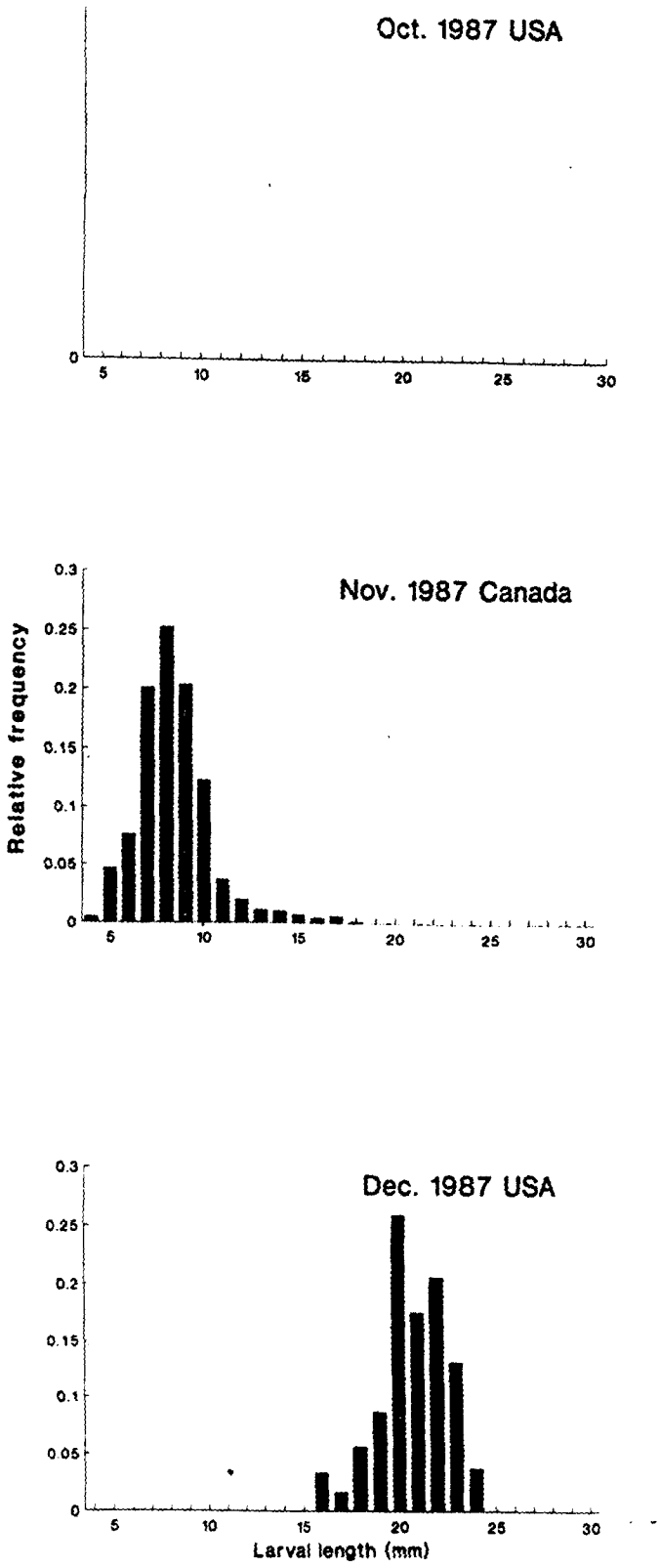

Figure 14 Georges Bank larval length frequency

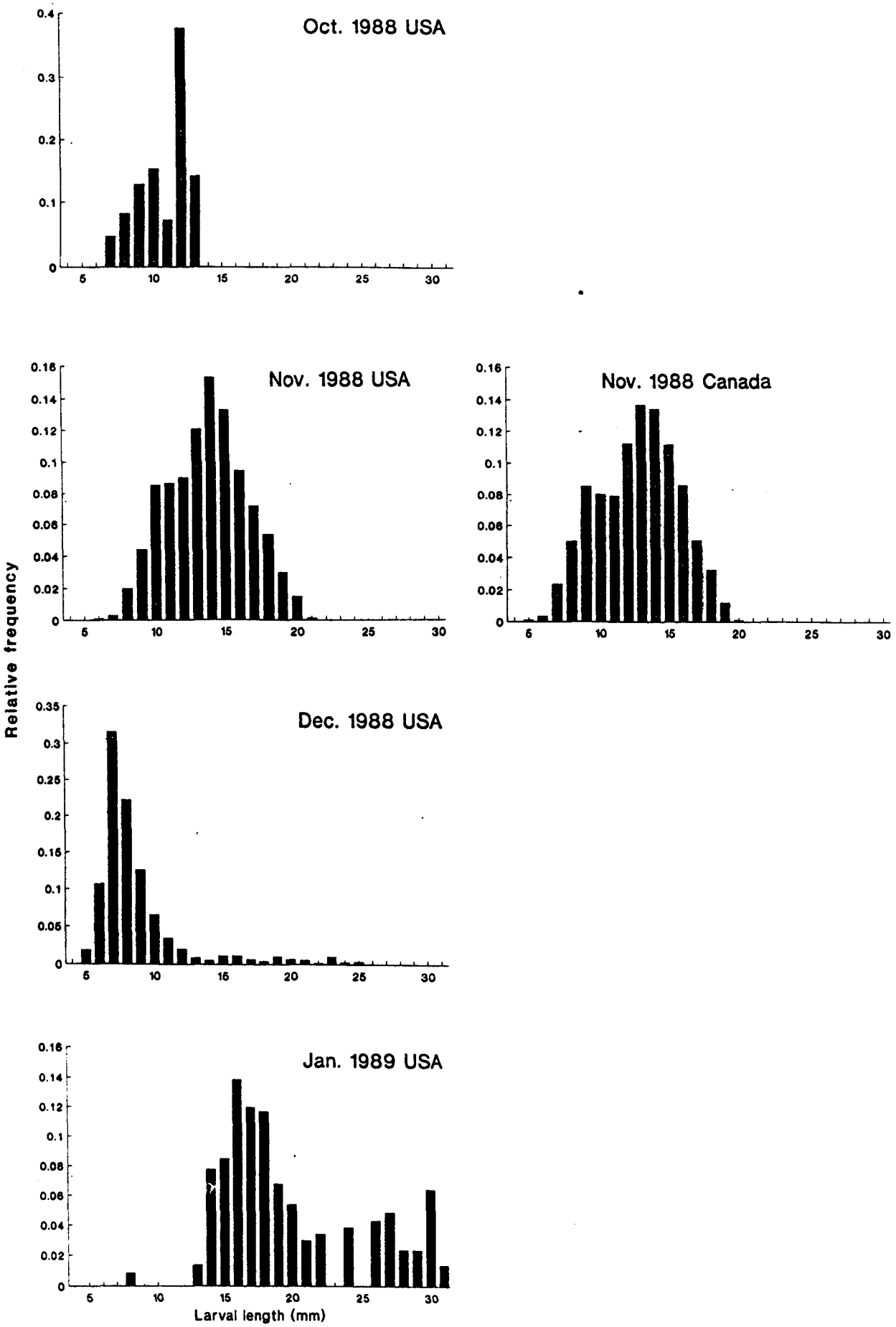

Figure 15 Georges Bank larval length frequency

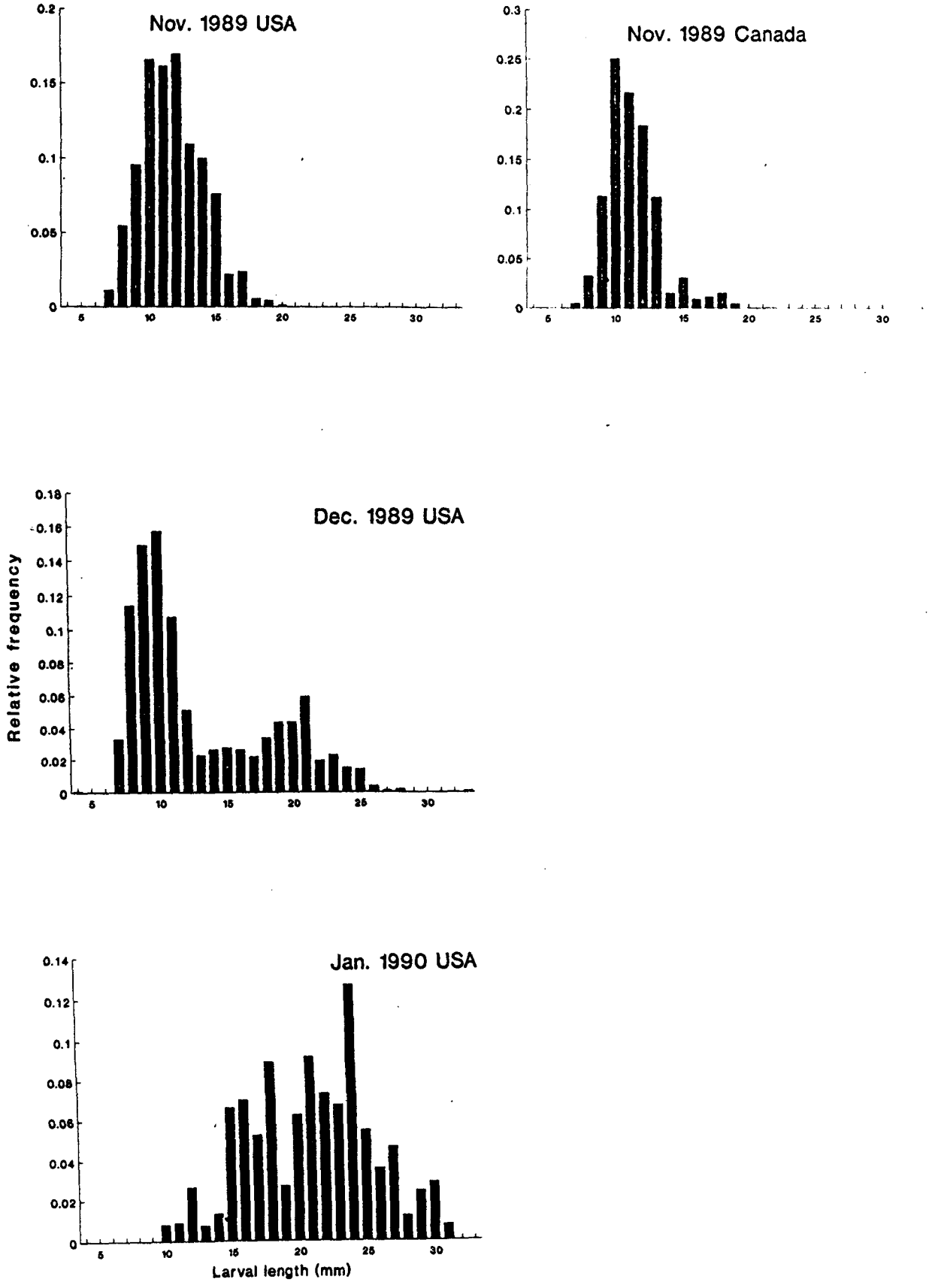

Figure 16 Georges Bank larval length frequency

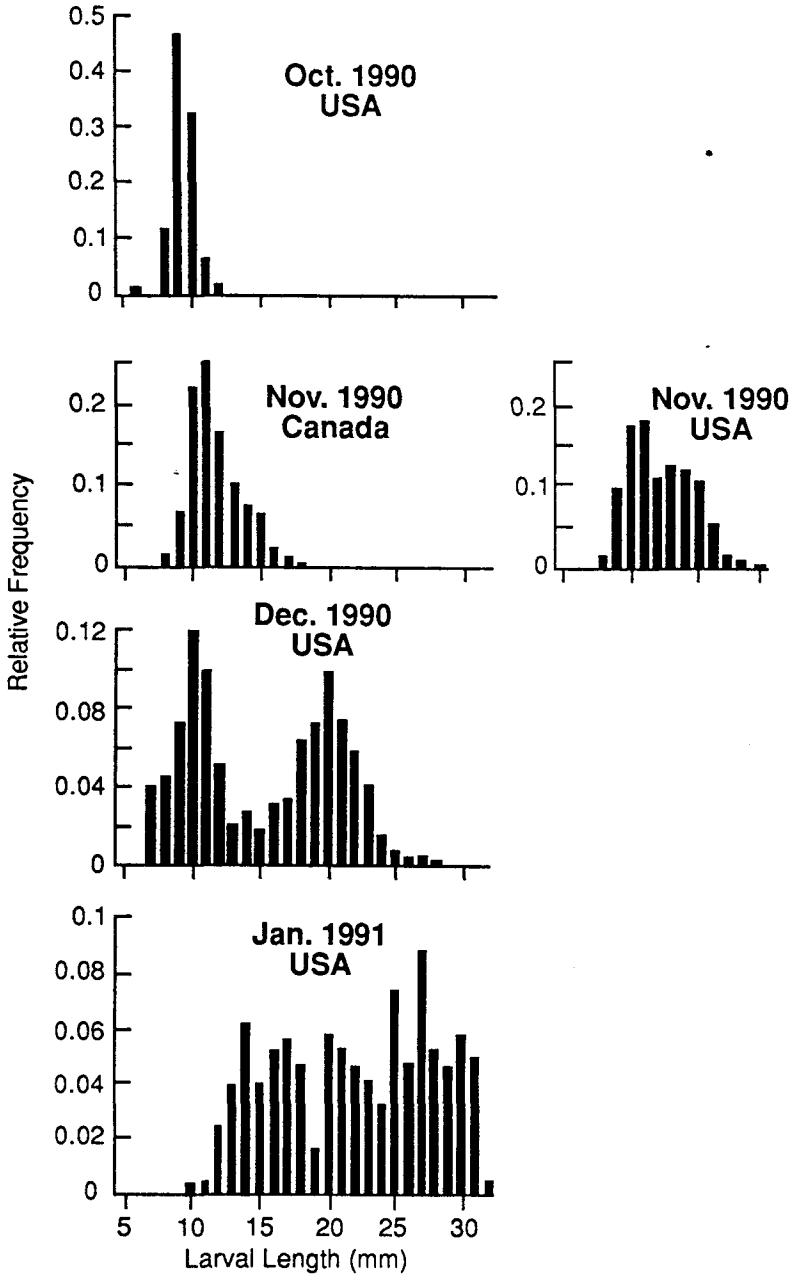

Figure 17 Georges Bank larval length frequency

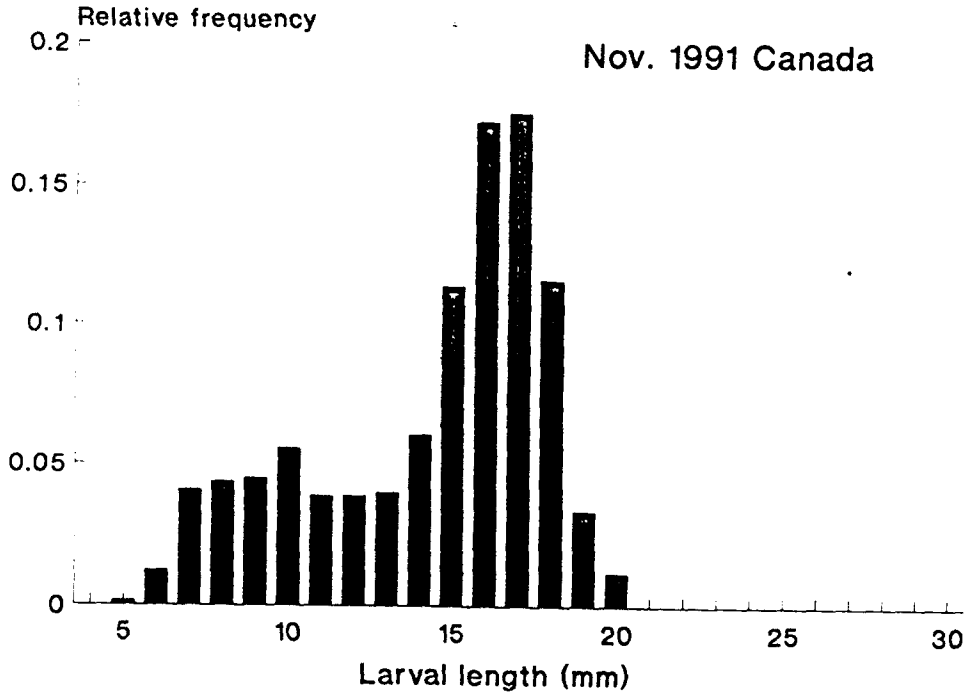

Figure 18 Georges Bank larval length frequency