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Georges Bank (5Z) Herring 1994 Update

by

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¹La présente série documente les bases scientifiques des évaluations des ressources halieutiques sur la côte atlantique du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

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Abstract

The results of the 1993 Canadian and United States fall surveys on Georges Bank indicated that the stock is well on its way to recovering. Abundance indices used to evaluate the relative stock status are among the highest observed in post-collapse years. Research samples collected on the bank during spawning season continue to be dominated by 3 and 4 year old herring, suggesting successful annual recruitment to the spawning stock. Furthermore, small (<10 mm) larvae have been observed in relatively large numbers on the northeastern portion of the bank for the past two years. Herring have not only reoccupied their historical spawning grounds, their numbers and distribution on the Canadian portion of the bank have increased to those observed in the late sixties/early seventies. Given the continued signs of recovery it is recommended that a commercial fishery, with a combined Canada/US catch of 20,000 t, could be developed on Georges Bank.

Résumé

Les résultats des relevés de recherche sur le stock de hareng du banc Georges réalisés en 1993 par le Canada et par les États-Unis révèlent que ce stock est nettement en voie de rétablissement. Les indices d'abondance servant à évaluer l'état relatif du stock sont parmi les plus élevés de ceux de la période qui a suivi l'effondrement des populations de hareng. Les échantillons prélevés sur le banc durant la saison de frai continuent d'être dominés par les harengs de trois et quatre ans, ce qui dénote un bon recrutement annuel dans le stock de reproducteurs. De plus, les petites larves (< 10 mm) se sont avérées relativement abondantes dans la partie nord-est du banc au cours des deux dernières années. Non seulement le hareng réoccupe-t-il ses frayères traditionnelles, son abondance et sa distribution sur la partie canadienne du banc atteignent à nouveau les niveaux observés à la fin des années soixante et au début des années soixante-dix. Compte tenu du maintien des signes de rétablissement du stock, une pêche commerciale, dont les prises combinées Canada-É.-U. seraient de 20 000 t, pourrait démarrer sur le banc Georges.

Introduction

Prior to its collapse in 1977, Georges Bank supported the largest herring fishery on the western Atlantic. During the late 1960's and early 1970's, reported commercial landings from the bank exceeded 200,000 mt annually. The fishery peaked in 1968 with reported landings in the 374,000 mt range (Fogarty et al. 1990), however it is suspected that actual landings may have been substantially higher. By 1977, reported landings had declined to less than 2,000 mt. The collapse of this stock has been attributed to over-fishing and poor recruitment. No directed herring fishery has operated on the bank since the collapse.

Between 1978 and 1985, virtually no adult or larval herring were detected on the bank by fall research surveys. The number of adult herring reported in US fall bottom trawl surveys during this period, ranged from 0 to 0.10 herring per standard tow (Melvin *et al.*, 1991). The first sign of a recovery occurred in 1984 when the Canadian R/V Alfred Needler collected more than 200 juvenile herring (mean length = 60.5 mm) in a mid-water trawl (IGYPT) on Georges Bank (Stephenson and Power, 1989). By 1986 significant evidence appeared in both Canadian and US research surveys to indicate the stock was on its road to recovery (Melvin *et al.*, 1992). The first observed spawning on historical grounds on the northeastern portion of the bank was reported in October of 1992 (Melvin and Fife, 1992). This was later substantiated by the US fall larval herring survey.

The recovery of Georges Bank herring stock has been monitored by annual fall adult/larval herring surveys since 1986. Each year the data have generally indicated an increasing relative level of abundance of herring on the bank. Recent reports from the US also indicate that Georges Bank has had several strong year-classes and that abundance may have recovered to a level which exceeds the mid-sixties (Anon. 1994). Details of the chronological reappearance of herring on the bank are discussed in Stephenson and Power, 1989 and Melvin *et al.* 1991.

As in previous years, the information available on stock status is presented in an annual update for review. This report represents the fourth in the series and incorporates the most recent data from the 1993 Canadian fall adult/larval herring and the US fall bottom trawl survey.

Data Sources

Data sources used to assess the recovery of Georges Bank herring include the US fall bottom trawl survey (1965-1993), which covered Massachusetts Bay, Nantucket Shoals and Georges Bank, and the Canadian fall Georges Bank larval/adult herring survey (1987-93). Unlike the US survey, which employed a random stratified design, the Canadian survey used opportunistic bottom trawl sets to collect adult herring samples. From 1987 to 1990, the larval

component of the Canadian survey covered only that portion of the bank which was likely to show signs of a recovery using standard plankton sampling protocol. In 1991, at CAFSAC's recommendation, the larval herring survey grid was expanded eastward to include the entire Canadian portion of the bank. Geographical coverage was extended westward to the Great South Channel (Figure 1) in 1992.

In 1993, the bottom trawl component of the Canadian survey was dropped in order to undertake an acoustic survey of the bank. Therefore, the fall geographical distribution data of herring represents only the US bottom trawl observations (DE 9306). The acoustic survey sampling rectangles and transects are presented in Figure 2 and the results in a separate section of this report. An IGYPT mid-water trawl was used to collect adult herring and to verify acoustic backscatter. The larvae component of the survey remained unchanged. During the 1993 fall adult/larval herring survey seventy-one larval stations and one mid-water trawl station were sampled.

Vessel changes have disrupted this survey since the Lady Hammond was released from charter. In 1992, the survey was conducted with two vessels instead of the traditional one; the "Parizeau" for larval work and the "E.E. Prince" for bottom trawl sets. While the larvae component (delayed 3 weeks) was extremely successful, the bottom trawl survey data were considered unreliable. Only 36 herring were collected in 31 sets. In 1993, the Alfred Needler served as the operational platform and only a few minor gear deployment problems were encountered. The multiple gear deployment capabilities of the Needler makes it ideal for the Georges Bank survey. It is hoped this vessel will be available for future surveys.

Adult Distribution

The location of adult herring observed during the acoustic survey are presented in Figure 2 and the distribution of sampling locations and catches of herring for 1993 from the US fall survey are shown in Figure 3.

In general, the distribution of herring on Georges Bank was consistent with past observations. Adult herring appeared concentrated in an arc between the 100-200 m isobath north of Cultivator shoals to the International Boundary along the northern fringe of Georges Bank and just west of the Great South Channel. Unfortunately, in 1993 the US survey provided only limited coverage of the 100-200 m contour along the northern fringe and the portion of the bank just east of the International Boundary where the majority of fish were observed in former Canadian surveys. It is therefore uncertain if the adult herring were present in this area. However, a month later the acoustic survey found several schools of herring in the area of uncertainty. A historical perspective of the combined Canada-US survey data for 1987-92 is presented in Fig. 4a-f.

Length Frequency

Length frequency data of herring collected during 1993 by the Canadian (acoustic) and US (bottom trawl) surveys, in 1 cm intervals, for Georges Bank, Nantucket Shoal and Massachusetts Bay are presented in Figure 5. In past years (1987-92), there were notable differences between the length frequency of herring caught during spawning time in Massachusetts Bay, Nantucket Shoals and Georges Bank. The largest modal lengths were consistently observed in Massachusetts Bay and the smallest on Georges Bank. However, in 1993 the length distribution for Massachusetts Bay and Georges Bank was found to be similar. The modal length of herring on Nantucket Shoals (27 cm) was approximately 2 cm larger than on either Georges Bank or in Massachusetts Bay. The presence of smaller (assumed younger) fish in Massachusetts Bay may indicate the recruitment to the spawning stock of a strong year-class in 1993.

The mean length of herring collected on Georges Bank in 1993 by both the Canadian and US fall surveys was the smallest since 1983 (Table 1) and significantly different from 1992. Herring collected in the US survey on Nantucket Shoals had the largest mean length (26.0 cm) followed by Massachusetts Bay at 25.5 cm and Georges Bank at 24.9 cm. The mean length of fish caught five weeks later on Georges Bank by the Canadian survey was 24.8 cm.

Age Distribution

Age data for Georges Bank herring are available only from the Canadian bottom trawl sets (1987-1992) and the acoustic mid-water trawl (1993) samples. Since 1987 the age distribution of herring has been dominated by 3 and 4 year old fish. This trend continued into 1993 where 59.1% and 30.4% of the fish collected were from the 1990 (age 3) and 1989 (age 4) year classes, respectively (Figure 6). The strong representation of 2-yr-old fish in 1991 was carried forward to 1992 as 3-yr-old herring, approximately 54% of the total catch, and 4 year olds in 1993. The absence of fish older than 6 was attributed to poor sampling (1 set). Both the 1986 and 1987 year-classes are well represented prior to 1993. Examination of the US length frequency distribution (Figure 5) also indicates the presence of herring greater than 30 cm which are likely to be the older age groups not collected by the Canadian survey. No data on the age distribution of the US survey samples are available to date.

The continued strong representation of young fish (4-yr-old and younger) in annual catches since 1986 and the general presence of older fish provides evidence of good annual recruitment to the spawning stock and supports the conclusion that there has been continued expansion of Georges Bank herring.

Spawning/Larval Distribution

The majority of herring collected on Georges Bank during the fall Canadian survey were mature (only 15% were identified as immature fish) and all adults were spent (Table 2). This implies that most, if not all, spawning of herring on Georges Bank was completed prior to the fall survey.

The observed larval distribution of the 1993 Canadian survey are presented in Fig. 7a-c and the results summarized in Table 3. Coverage included the expanded study area initiated in 1992 for the area west of the original grid where large concentration of larvae were thought to occur in previous years. The geographical distribution of larvae (all sizes) collected in 1993 was similar to 1992. However, the total number of larvae collected during the survey and the concentration was more than double that observed in 1992. This is the highest number of larvae/m² observed since the Canadian surveys began. For comparative purposes the distribution of larvae from 1987-92 are presented in Figure. 8a-f.

Examination of the distribution and abundance of larvae <10 mm (generally considered an indication of spawning areas) showed a marked change from all previous surveys. During the early years (1987-91) no small larvae were observed on the Canadian portion of the bank. In 1992 two aggregations of larvae were found just east of the International Boundary suggesting that herring had, for the first time since the collapse, reoccupied their historical spawning grounds on the northeastern portion of the bank (Melvin et al., 1993 and Melvin and Fife 1993). The US also reported large concentrations of small larvae in this area during their 1992 November larval herring survey. The major difference between 1992 and 1993 was the extensive distribution and increased concentration of young larvae over the entire eastern portion of the bank (Figure 7d).

The approximate time of hatching was again estimated by backcalculation from larval length at the time of capture, assuming a growth rate of 0.24 mm/d (Chenoweth et al. 1989). The 1993 hatching period ranged from early September to late November with a mean hatching date of October 20 (Table 3). This is the latest mean hatching date since the Canadian surveys began. With the exception of 1987 and 1992, the mean date of hatching occurred around the beginning of October.

Indices

Two indices were again used to evaluate the trends in abundance of the Georges Bank herring stock - one, the number of herring caught per standard bottom trawl tow (BTI) from US fall research surveys and two, the estimated number of larvae/m² in the Canadian fall larvae survey. An attempt was made to adjust the larval abundance index for spawning and cruise timing, however, given the reported annual variability in growth and early mortality rates for herring larvae, this approach was considered too sensitive to the input parameters.

The number of herring caught per bottom trawl tow from 1983-93 and the survey summaries are presented in Table 1. The Canadian data were discontinued in 1991 due to a vessel and gear change in 1992 and the absence of bottom trawling in 1993. Estimates of the stratified mean number of herring per tow for the US fall survey (ie. survey index) were made using STRAPUS. The index is relatively low for the period of the former fishery (1965-77) and declined even further between 1978 and 1984 (Figure 9). However, from 1985 to 1988 the index increased rapidly, declined slightly in 1989, and then increased to a peak in 1992. Although the 1993 index dropped to approximately 50% of the 1992 value it was still twice as large as any observed prior to 1990. A significant portion of this decline is believed attributable to the apparent lack of sampling stations in areas where herring were previously found.

The larval abundance index (number of larvae/m²) from 1987 to 1993 was estimated from the Canadian fall larval surveys for both stations contained within the original survey grid to maintain consistency and for all stations to include the expanded coverage initiated in 1991 (Figure 10). For a historical perspective (1971-86) the number of larvae/m² were extracted from the literature (Smith and Morse, 1990). Caution is however warranted in direct comparison of the current and historical indices. The latter covers a much broader area of the bank and corresponds to US surveys which occurred at approximately the same time period. Furthermore, it is likely that LAI's between 1987 and 1991 are underestimated given the presence of unspawned fish on the bank during the survey.

The 1993 larval abundance index for both the original survey area (1987-90) and the expanded coverage was double the 1992 index and the highest observed in post-crash years. Compared with historical levels the index is greater than 1971 and about 50% of 1973. The 1991 decline is believed to be a function of late spawning relative to survey timing as the US December survey identified a spawning period which occurred after the Canadian survey was completed.

The ability of the two indices currently being used to track the abundance of Georges Bank herring (ie. larval and bottom trawl) is uncertain. While the indices appear to track abundance in a relative sense, they are associated with large variances about the means which makes it difficult to determine the significance of annual changes. Alternate approaches such as acoustics should be investigated as a mechanism to estimate abundance and biomass.

Acoustics

In 1993, an acoustic survey was conducted on Georges Bank in areas most likely to contain spawning aggregations of herring. The actual rectangles and transects are shown in Figure 2. Unfortunately, due to the lack of a vessel for a dedicated survey it was piggy-backed on the fall larvae survey. The majority of herring had completed their spawning and it is therefore possible that they had left the bank prior to the survey.

The results of the acoustic backscatter and biomass estimates by rectangle and transect are presented in Tables 4 and 5. Herring were observed in boxes E,G,and H which were located along the northern fringe of the bank. The total estimated biomass was 26,555 t. This estimates is far below (an order of magnitude) the expected spawning stock biomass and is likely a function of the lateness of the survey. It is therefore recommended that future acoustic surveys be undertaken between mid-late October when most of the herring should be aggregated on the bank for spawning. This is consistent with the observed gonad stages (all spent) of the one sample collected in 1993.

Prognosis

The 1993 data indicate that the Georges Bank herring stock is well on its way to recovering, or has recovered, from the collapse in 1977. The 1993 US bottom trawl survey index, although down relative to the last three years, is far above earlier periods when catch levels were much higher (ie. 1960's and 70's). The Canadian larval abundance index was the highest observed in the time series. The age structure of herring collected continued to show a dominance of 3-yr-old fish in the catches, indicating successful recruitment over the past several years, although some concern was expressed about the absence of 7+ herring in the 1993 samples. Both newly hatched (ie. <10 mm) and older larvae in 1992 and 1993, displayed a much broader geographical distribution than in other post-crash years, including the northeastern portion of the bank. Finally, spawning on the Canadian side of the bank, which was first documented in 1992 by three independent surveys, was again observed in 1993 over a much broader geographical area.

It is therefore recommended that a commercial fishery could be developed on Georges Bank and that a combined Canada/US catch of 20,000 t would not exceed reference points commonly used for herring. The commencement of a commercial fishery would also provide additional scientific information which would improve estimates of stock status. However, given the truly transboundary nature of this stock, steps must begin immediately for: joint Can/US management, consideration be given to level of future effort of both the Canadian and US fleets, and for the development of a strategic harvest plan. For assessment purposes it is also imperative that area mis-reporting be minimized so catches and effort can be attributed to the appropriate stock. It would also be desirable if biological research objectives were incorporated into future fishery development plans.

Research Recommendations

- (1) Future acoustic surveys be undertaken between mid and late October when most of the herring would be expected to be on the bank for spawning.
- (2) An industry-based harvest plan be developed for the Georges Bank herring fishery.

- (3) Existing data be used to estimate natural mortality of this unharvested stock.
- (4) Historical assessments be examined to estimate current stock size.

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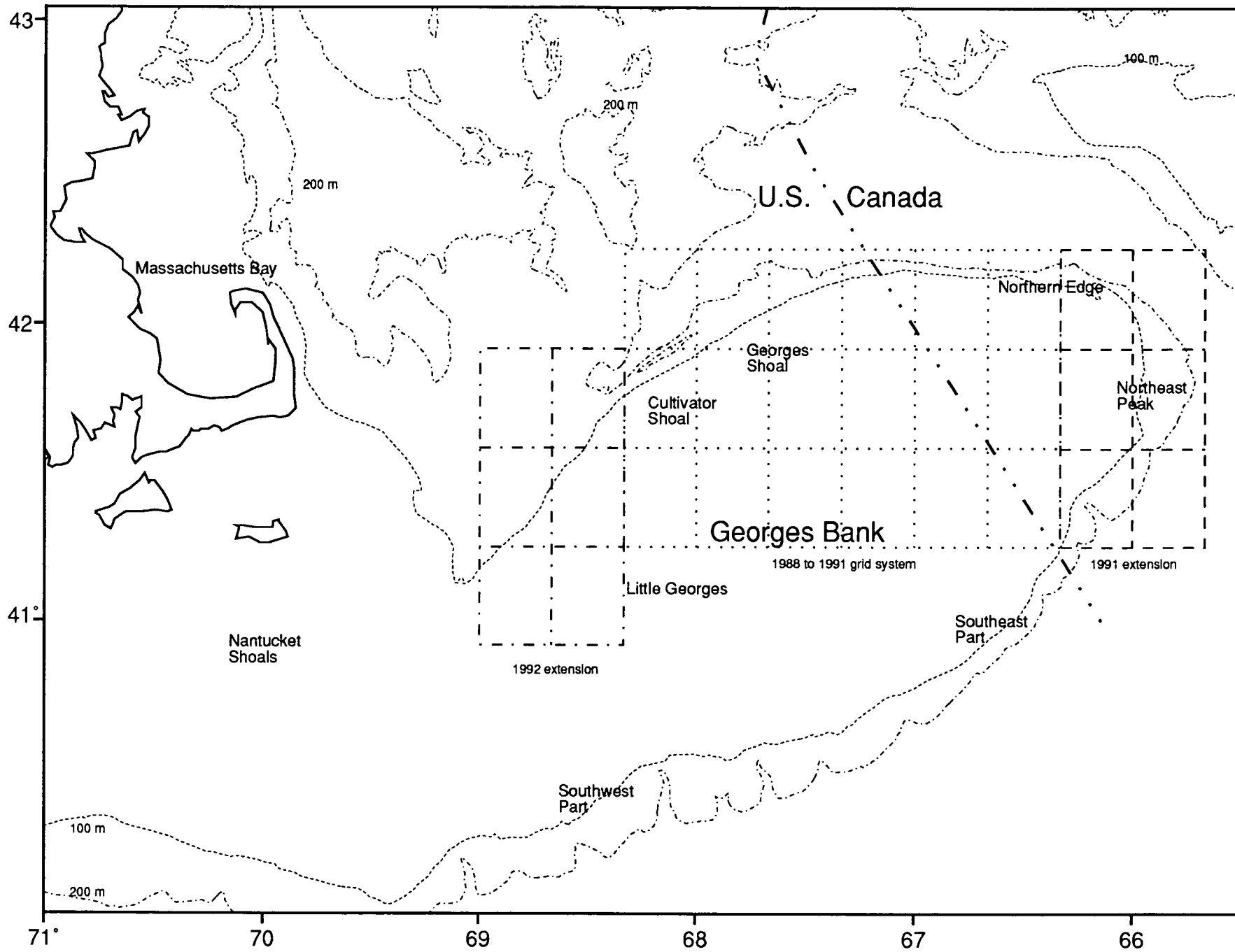


Figure 1. Herring survey area.

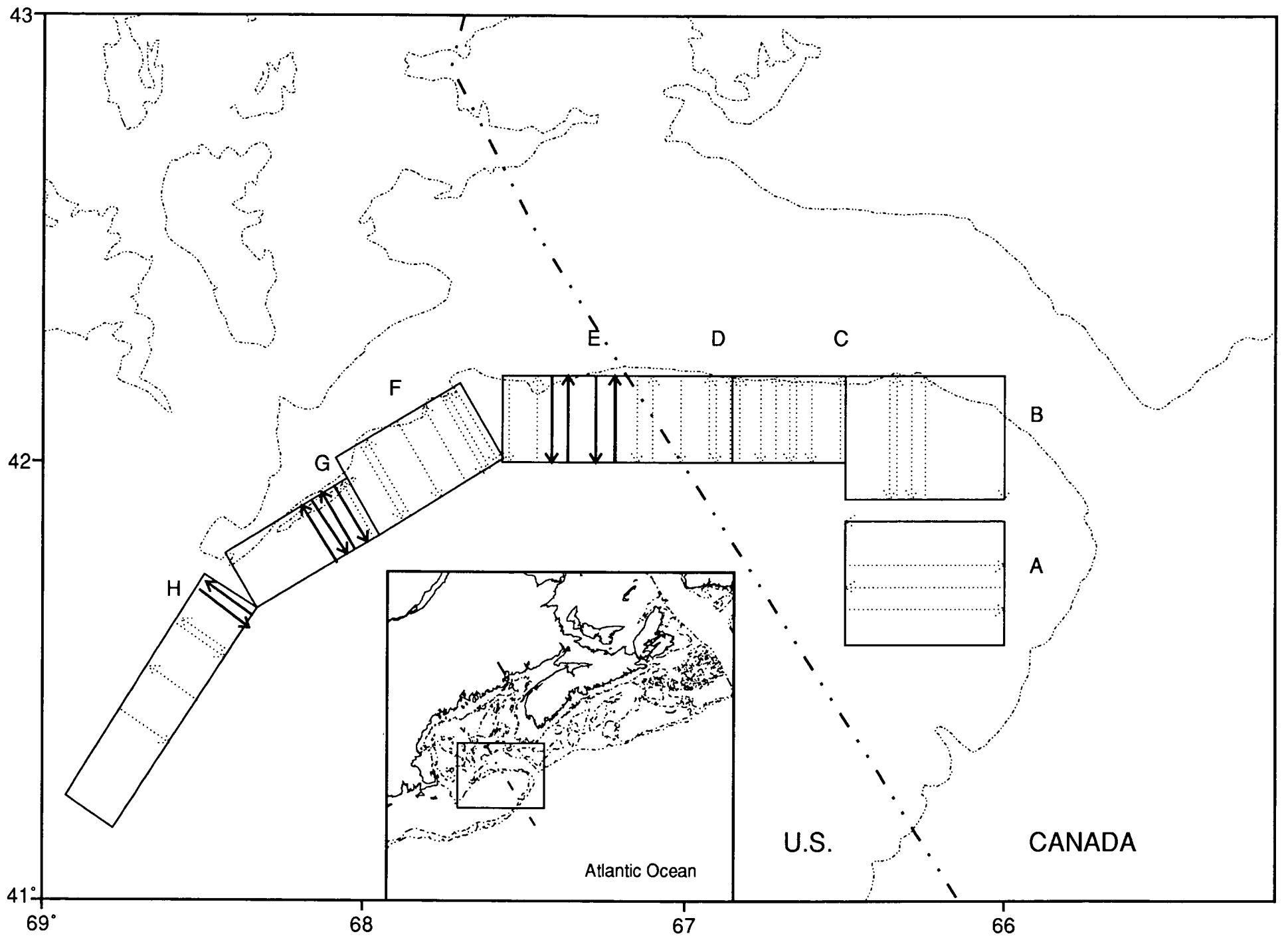


Figure 2. Acoustic survey transects. Solid arrows depict transects with biomass; dotted arrows describe uneventful transects.

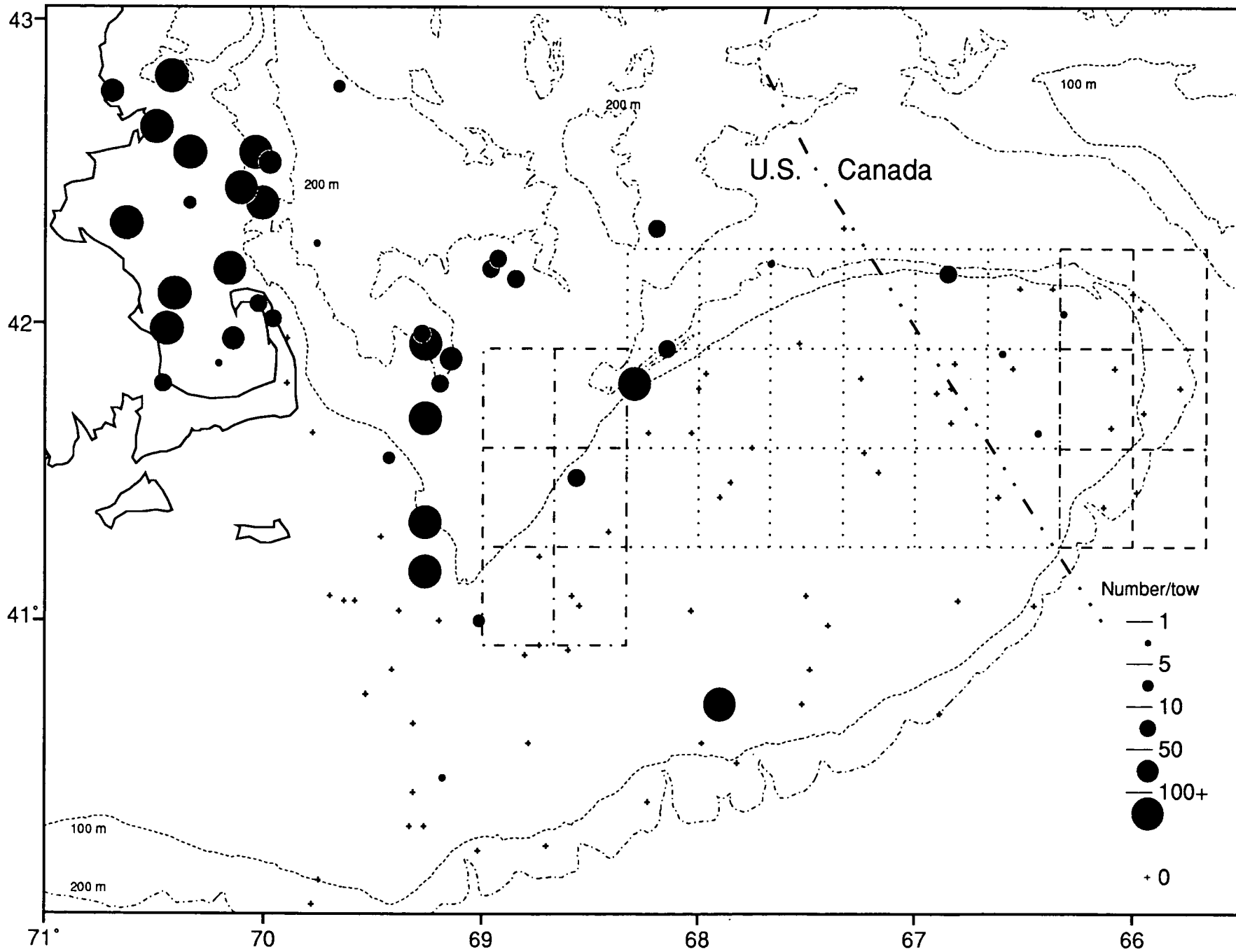


Figure 3. US 1993 adult herring sampling stations and catches. Numbers as per scale.

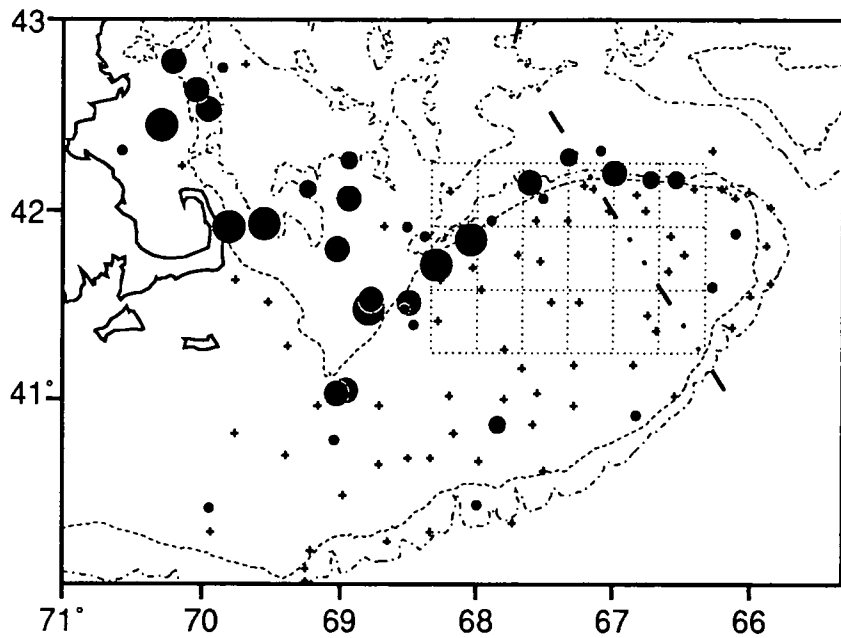


Figure 4a. US and Canadian 1987 surveys combined. Adult herring as per adjacent scale.

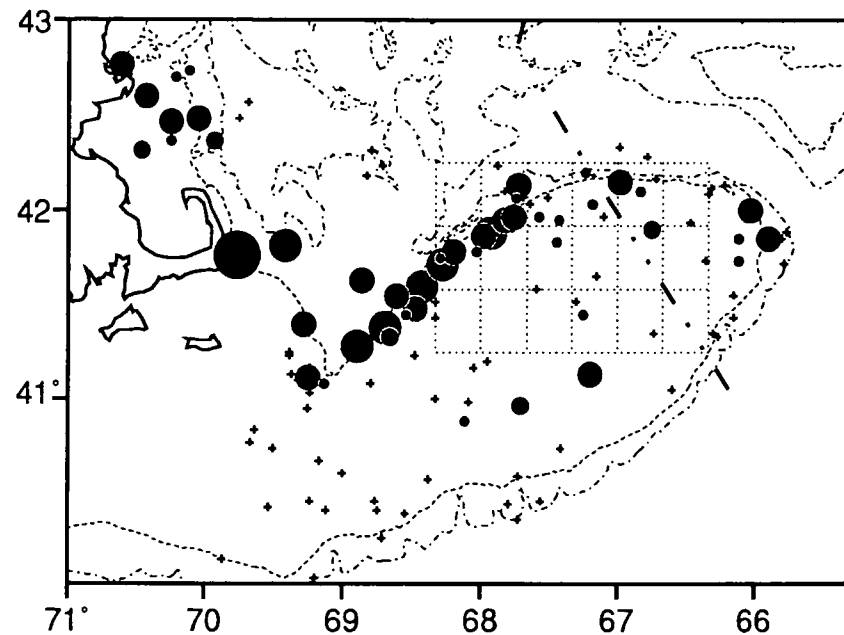


Figure 4b. US and Canadian 1988 surveys combined. Adult herring as per adjacent scale.

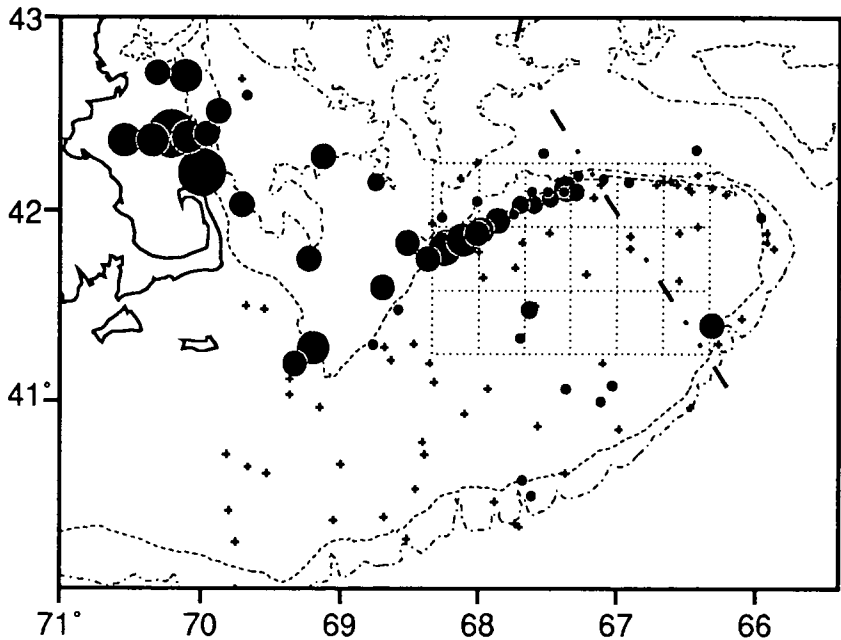
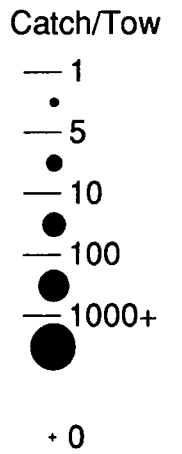


Figure 4c. US and Canadian 1989 surveys combined. Adult herring as per adjacent scale.

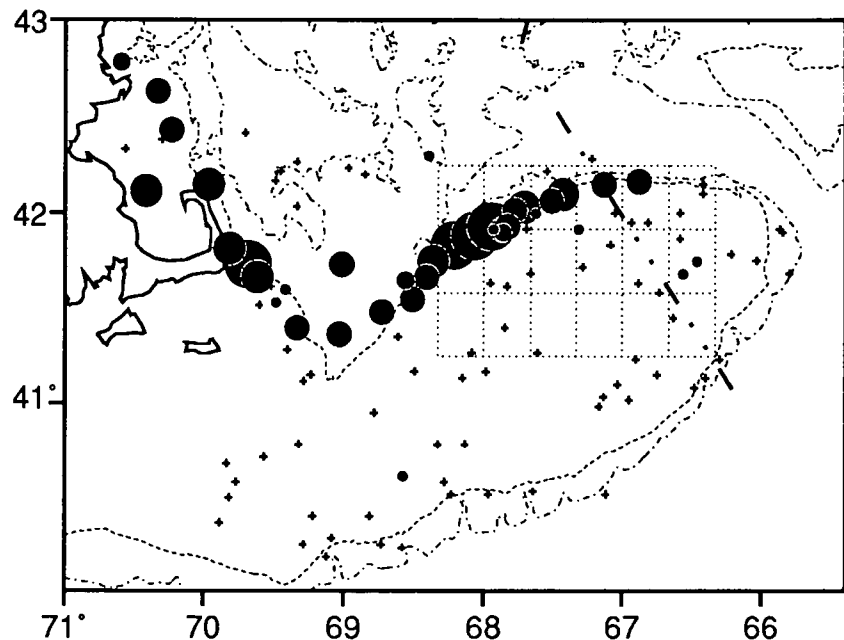


Figure 4d. US and Canadian 1990 surveys combined. Adult herring as per adjacent scale.

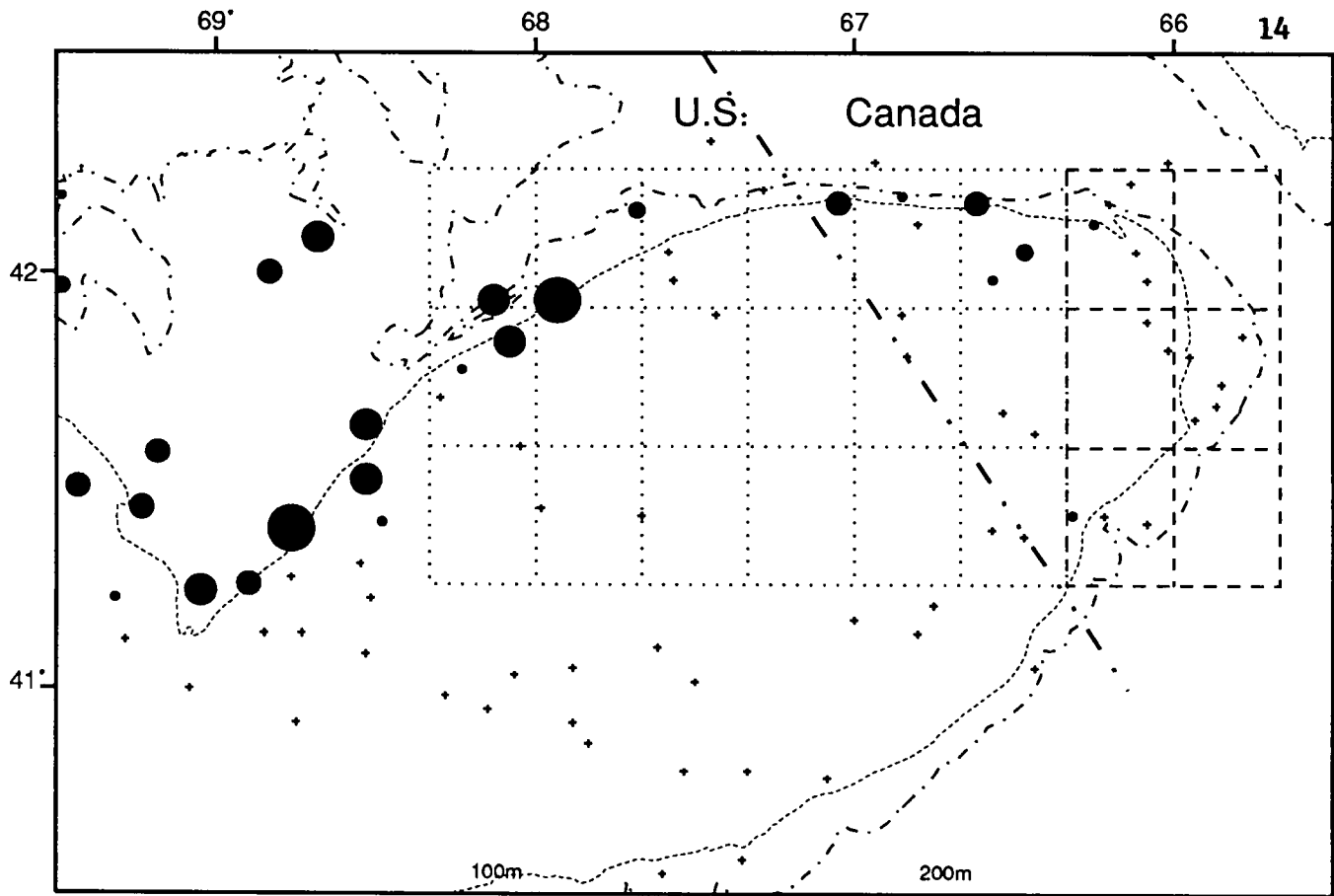


Figure 4e. US and Canadian 1991 Georges Bank survey. Adult herring as per scale

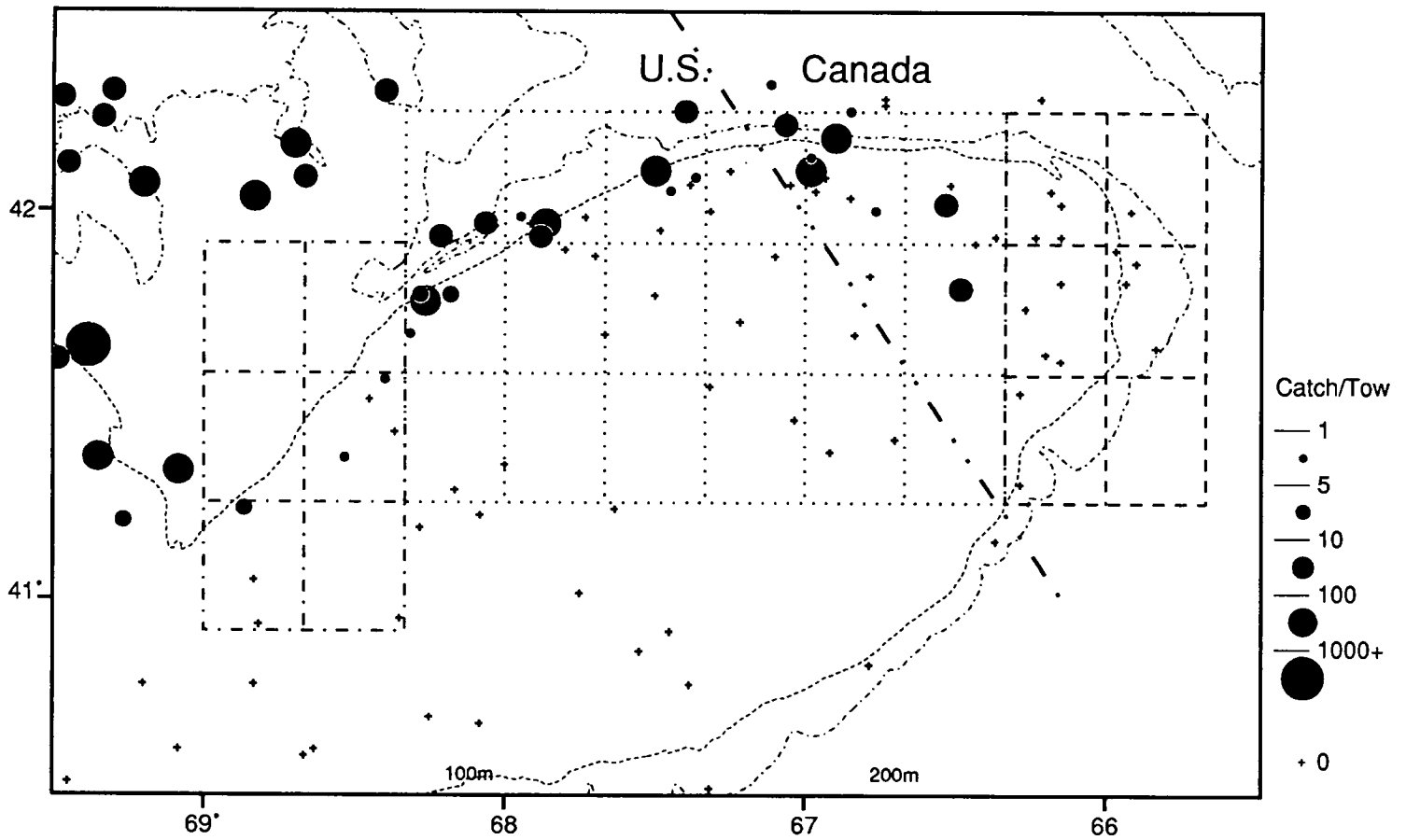


Figure 4f. US and Canadian 1992 Georges Bank survey. Adult herring as per scale

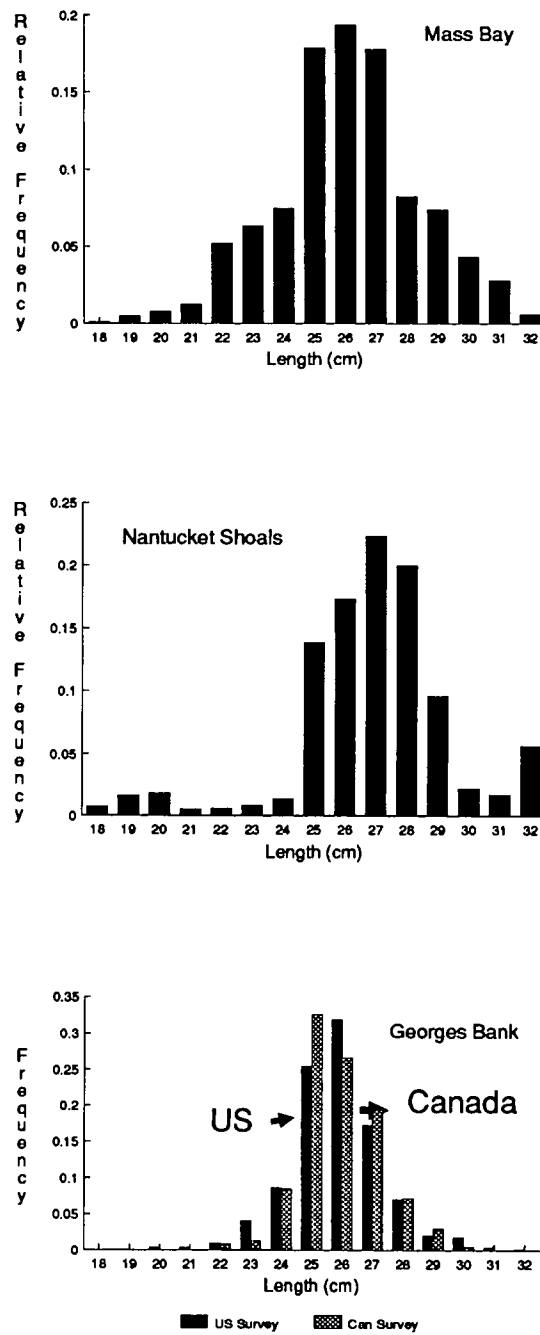


Figure 5. Length frequency of adult herring from Georges and adjacent areas in the fall of 1993.

Age Distribution
 Georges Bank Herring
 1987-1993

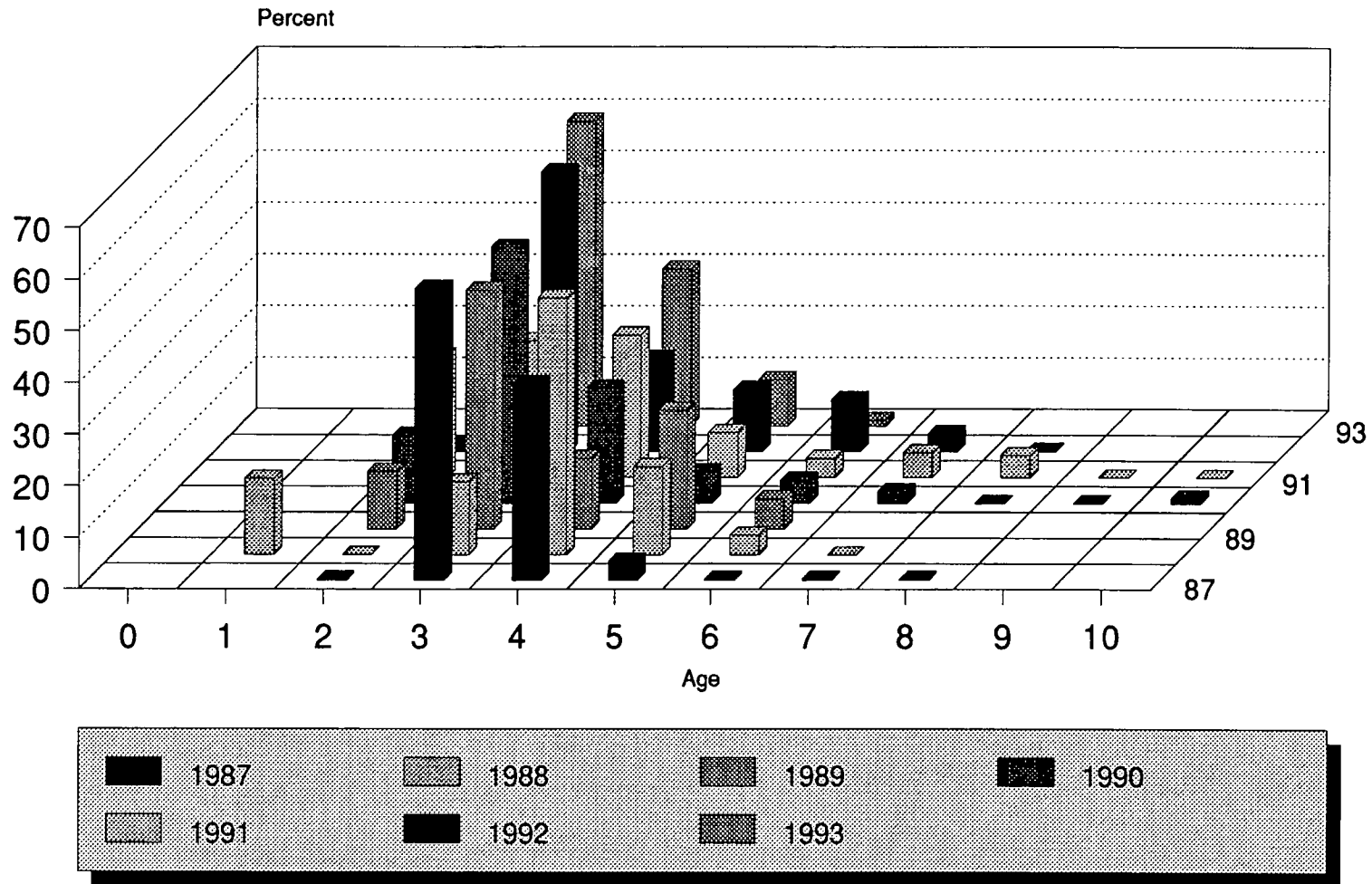


Figure 6. Age distribution of Georges Bank herring in 1993.

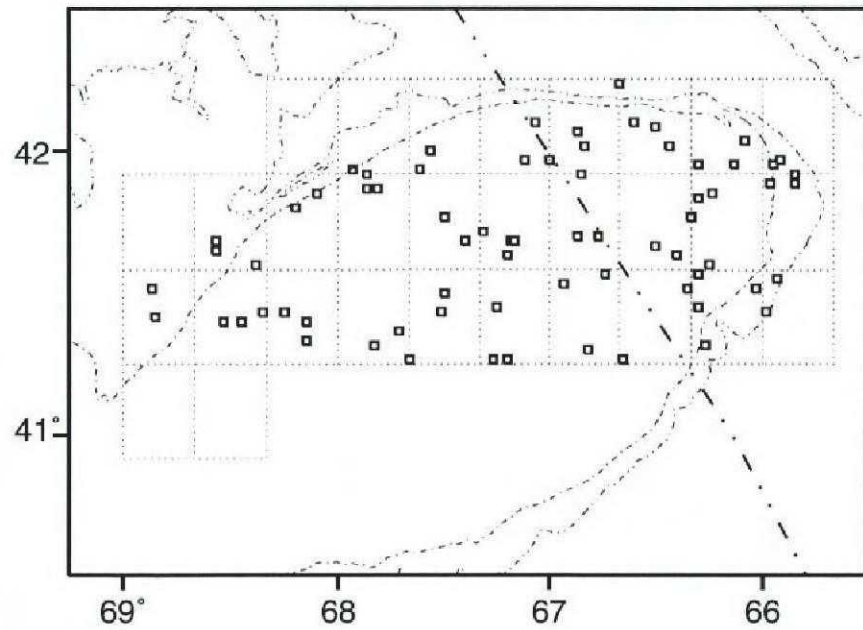


Figure 7a. 1993 Canadian larval survey (Nov 12 - 26). Sampling stations.

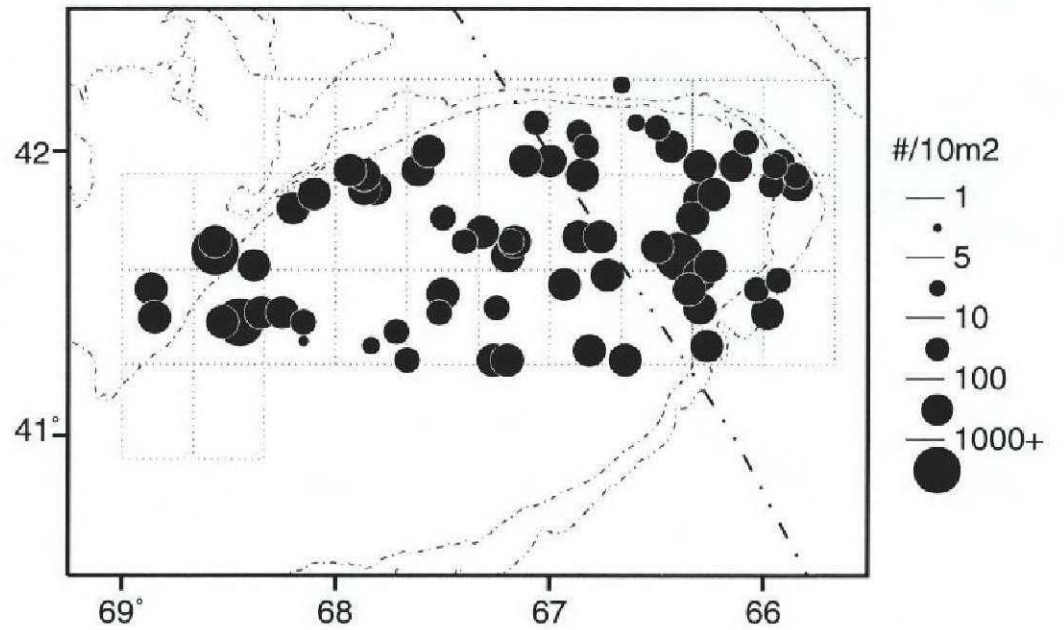


Figure 7b. 1993 Canadian larval survey (Nov 12 - 26). Larvae as per adjacent scale.

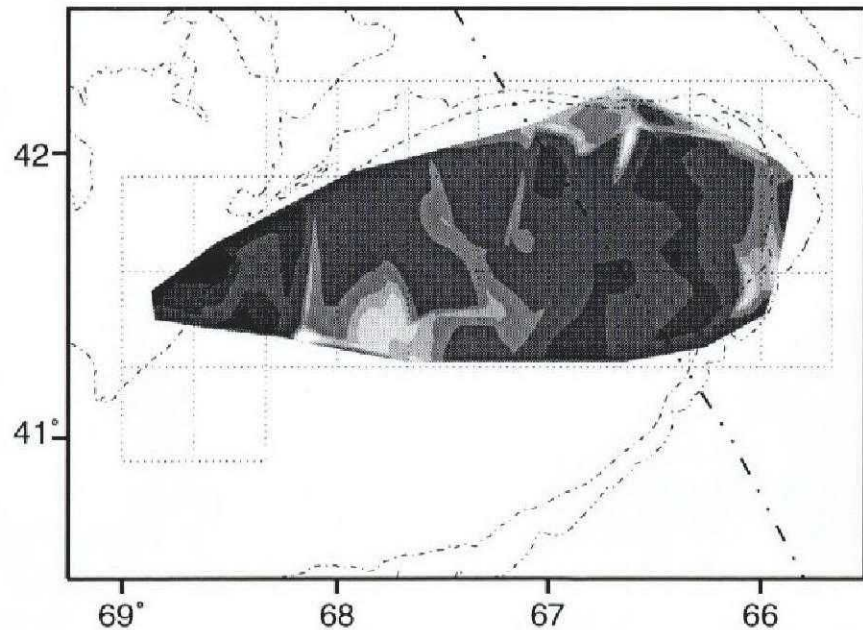


Figure 7c. 1993 Canadian larval survey (Nov 12 - 26). All larvae. Contours as per adjacent scale.

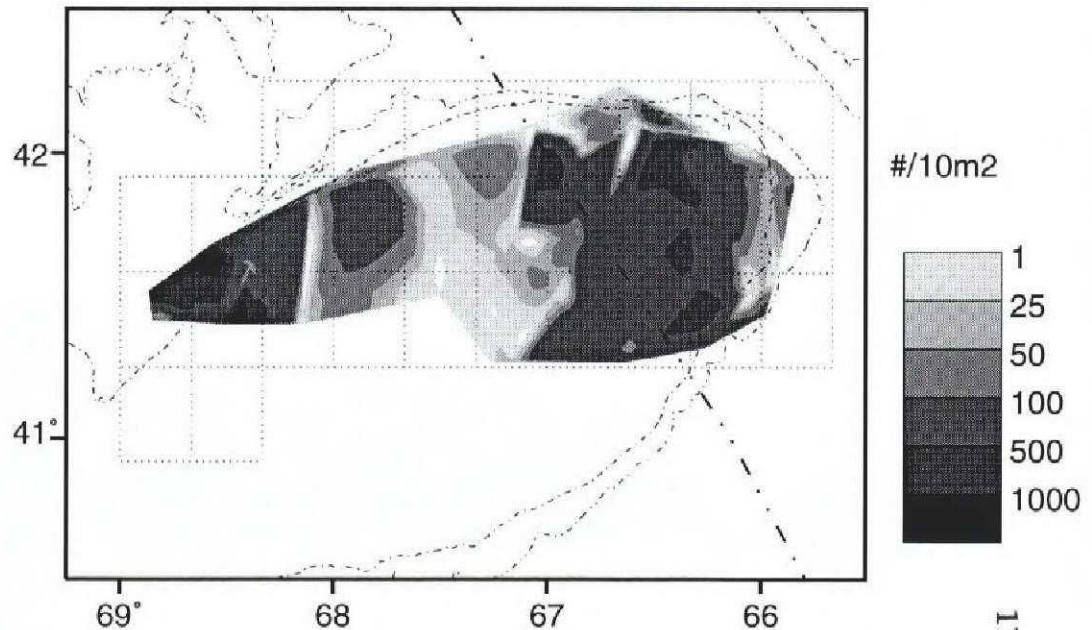


Figure 7d. 1993 Canadian larval survey (Nov 12 - 26). Larvae (<10mm). Contours as per adjacent scale.

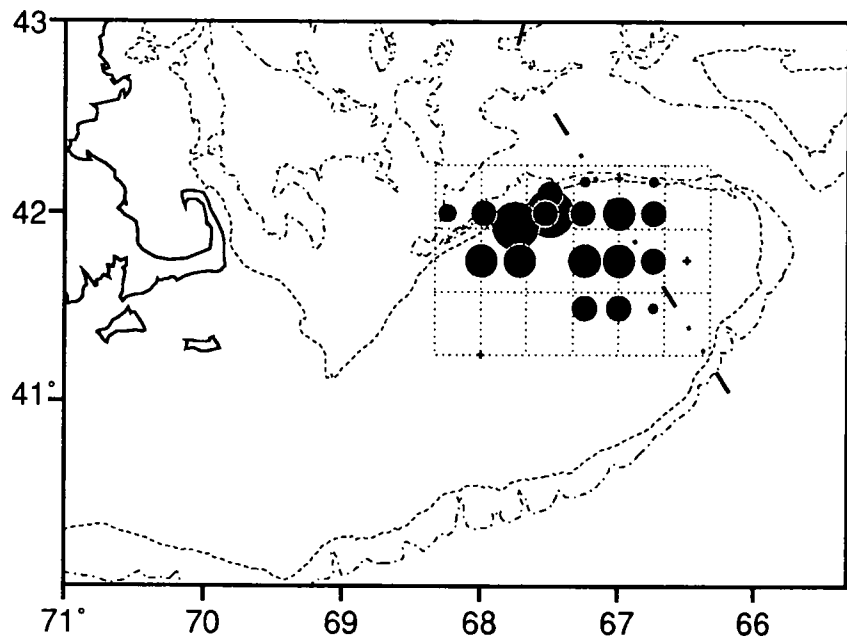


Figure 8a. Canadian 1987 larval survey.
Larval herring as per adjacent scale.

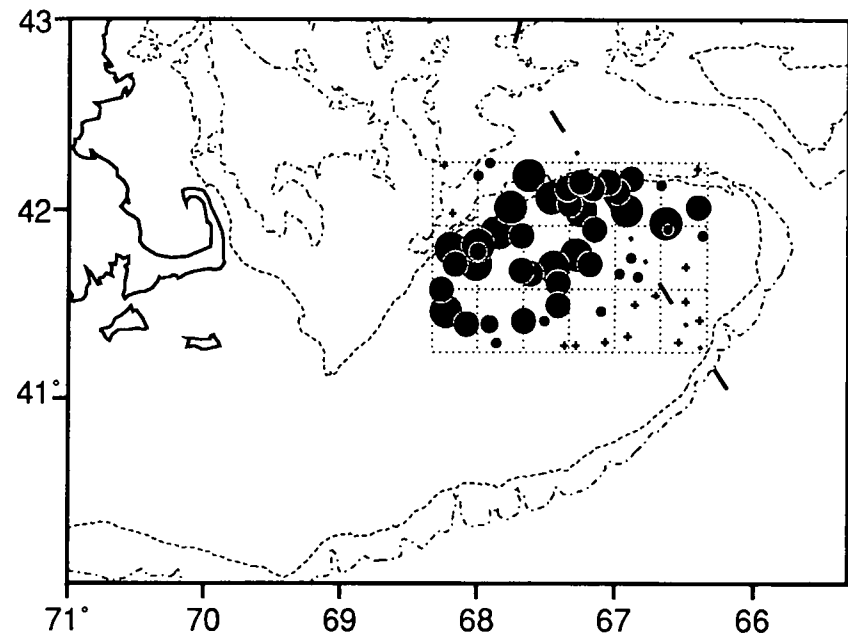


Figure 8b. Canadian 1988 larval survey.
Larval herring as per adjacent scale.

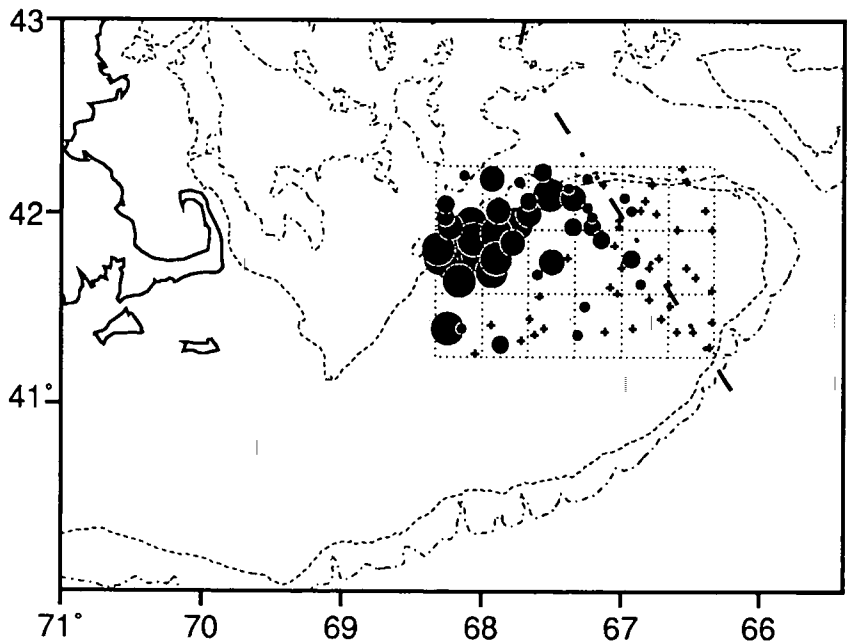
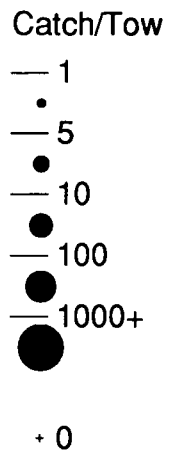


Figure 8c. Canadian 1989 larval survey.
Larval herring as per adjacent scale.

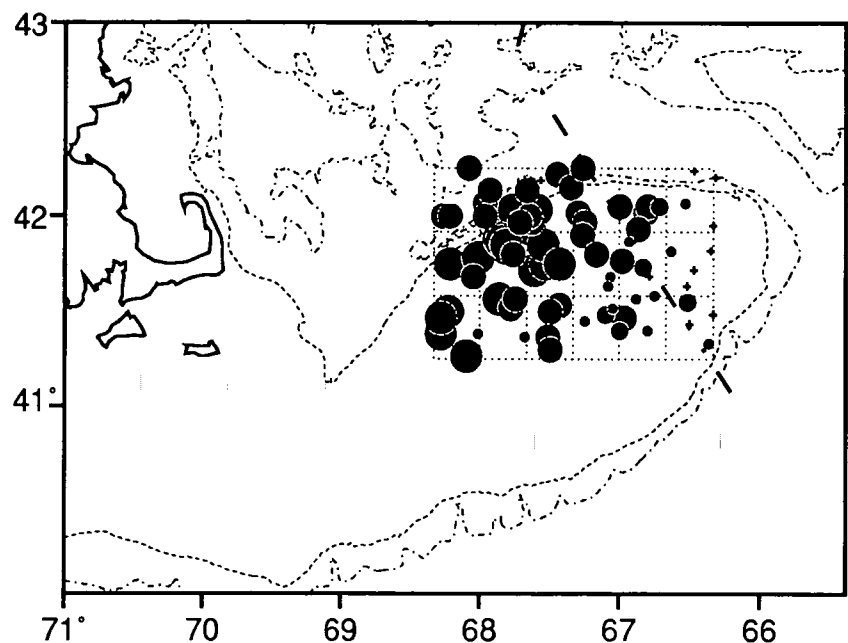


Figure 8d. Canadian 1990 larval survey.
Larval herring as per adjacent scale.

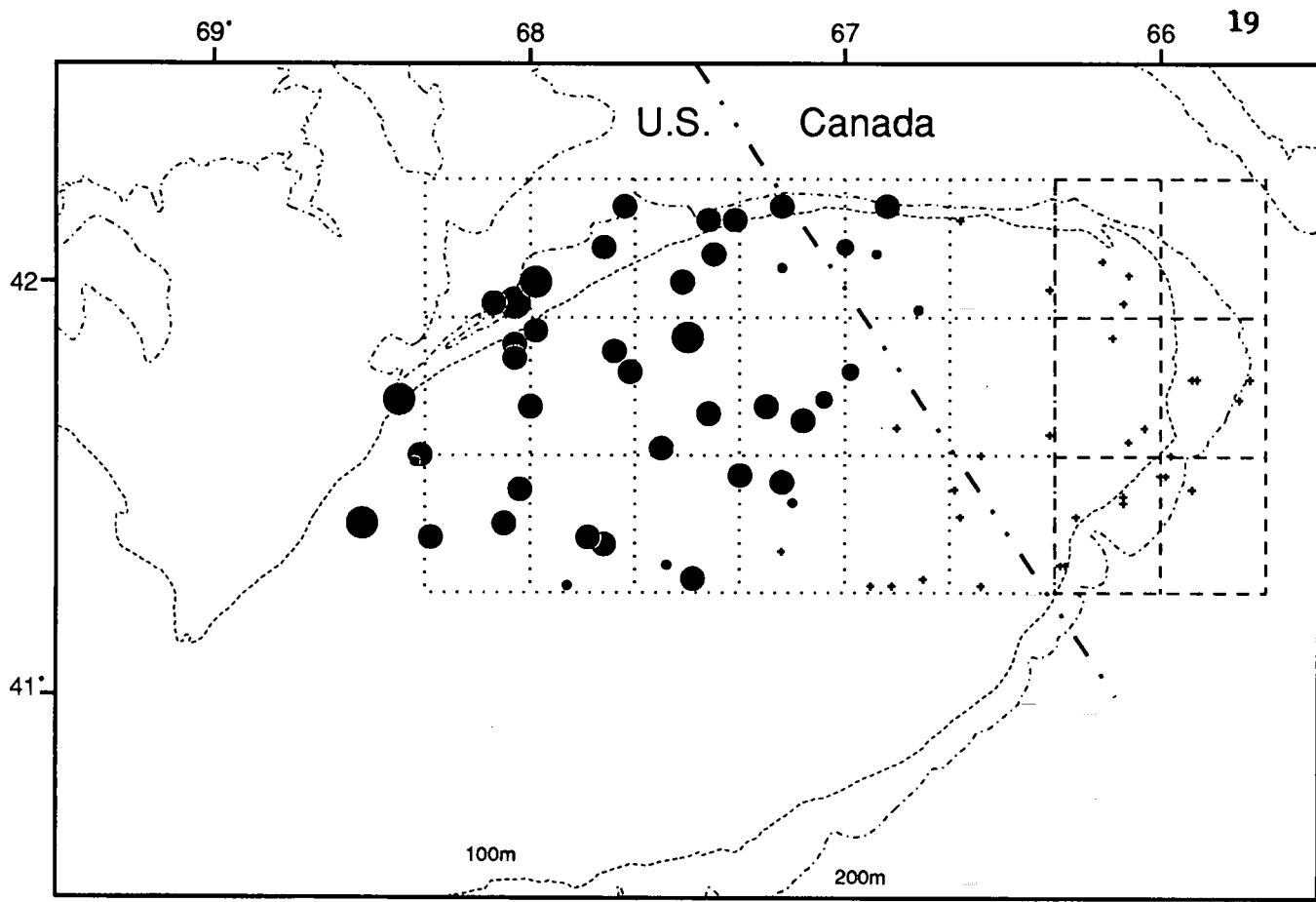


Figure 8e. Canadian 1991 larval survey. Larval herring as per scale

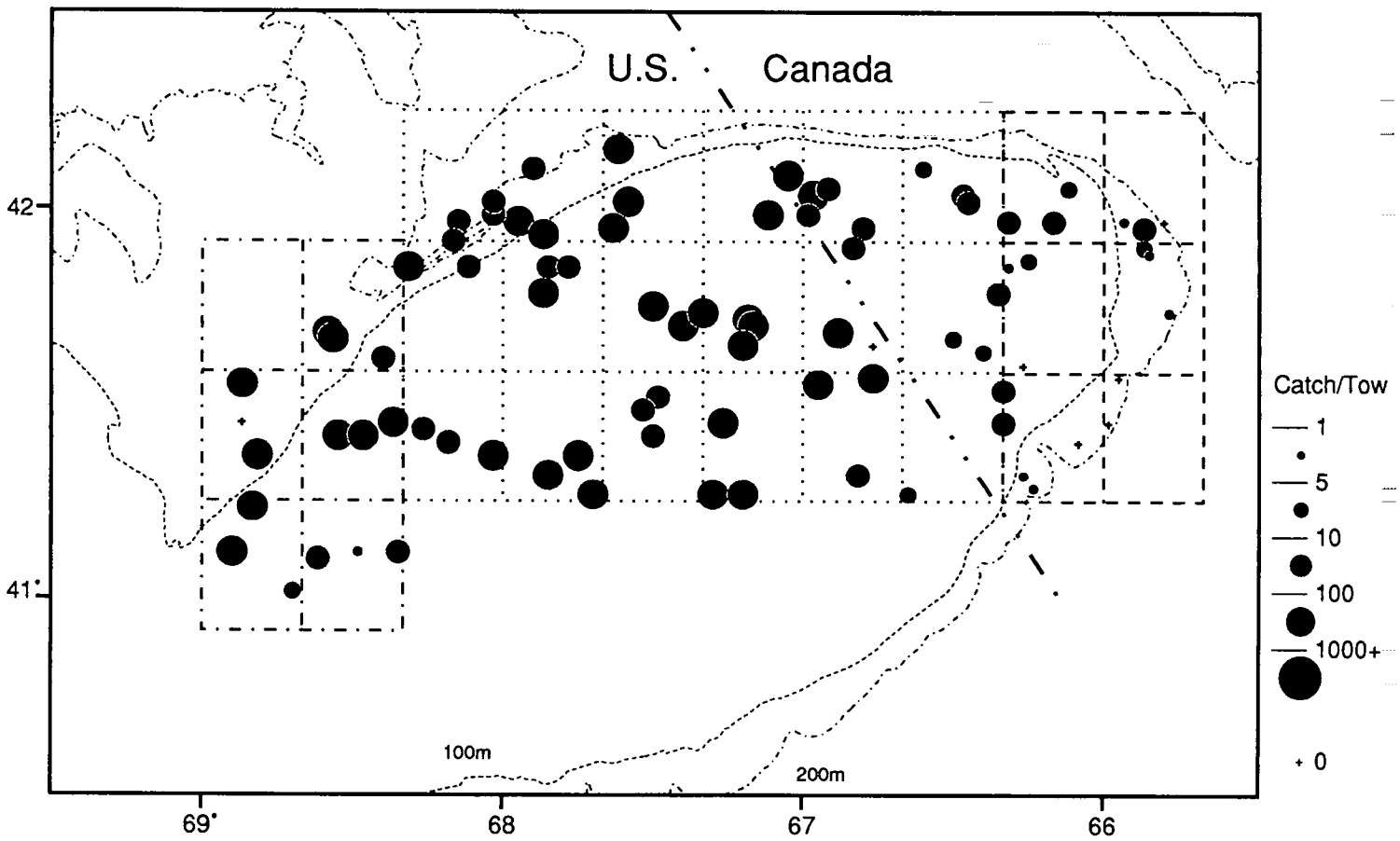


Figure 8f. Canadian 1992 larval survey. Larval herring as per scale

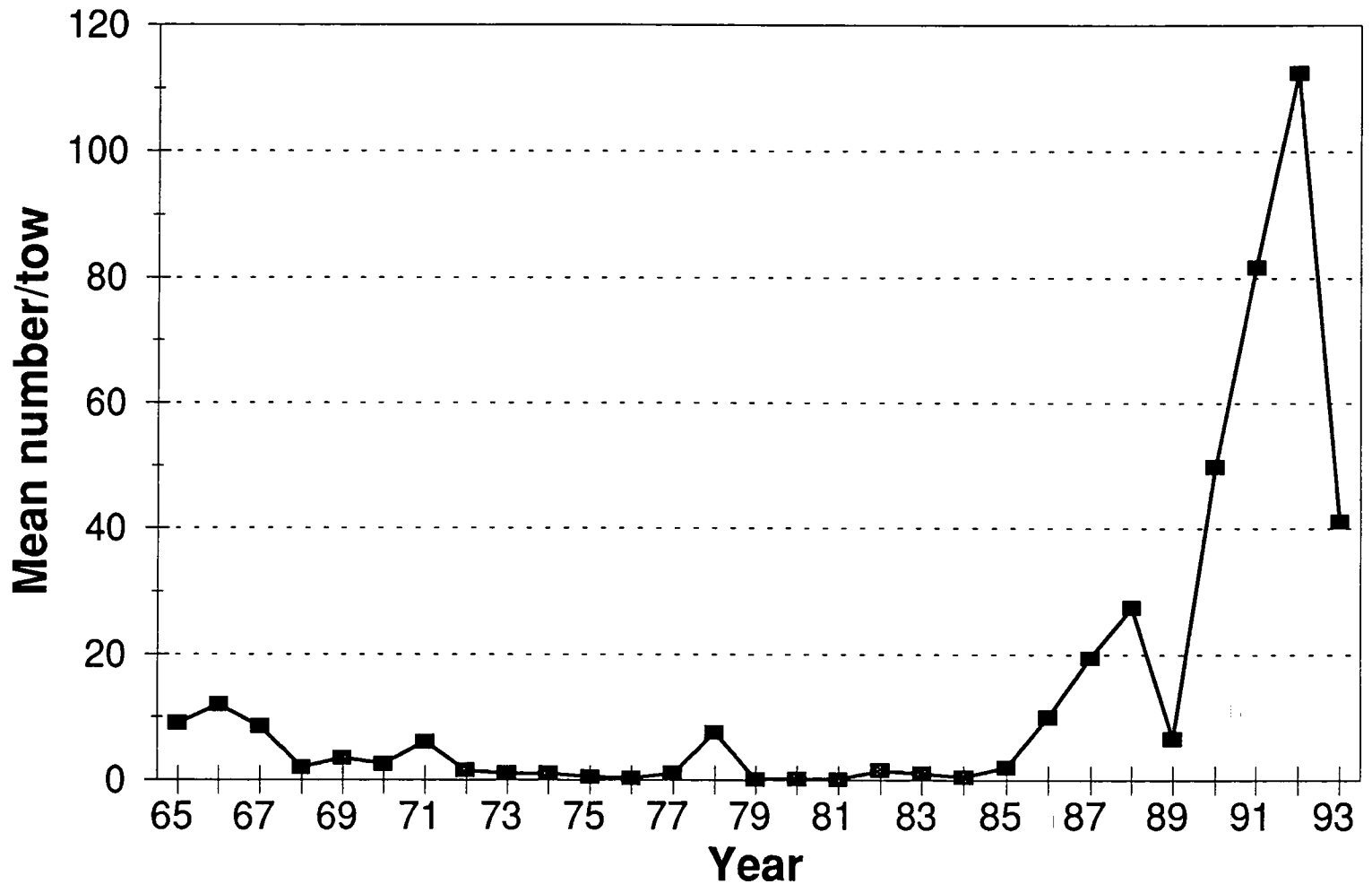


Figure 9. Summary of US Georges Bank fall bottom trawl survey index (1965-1993).

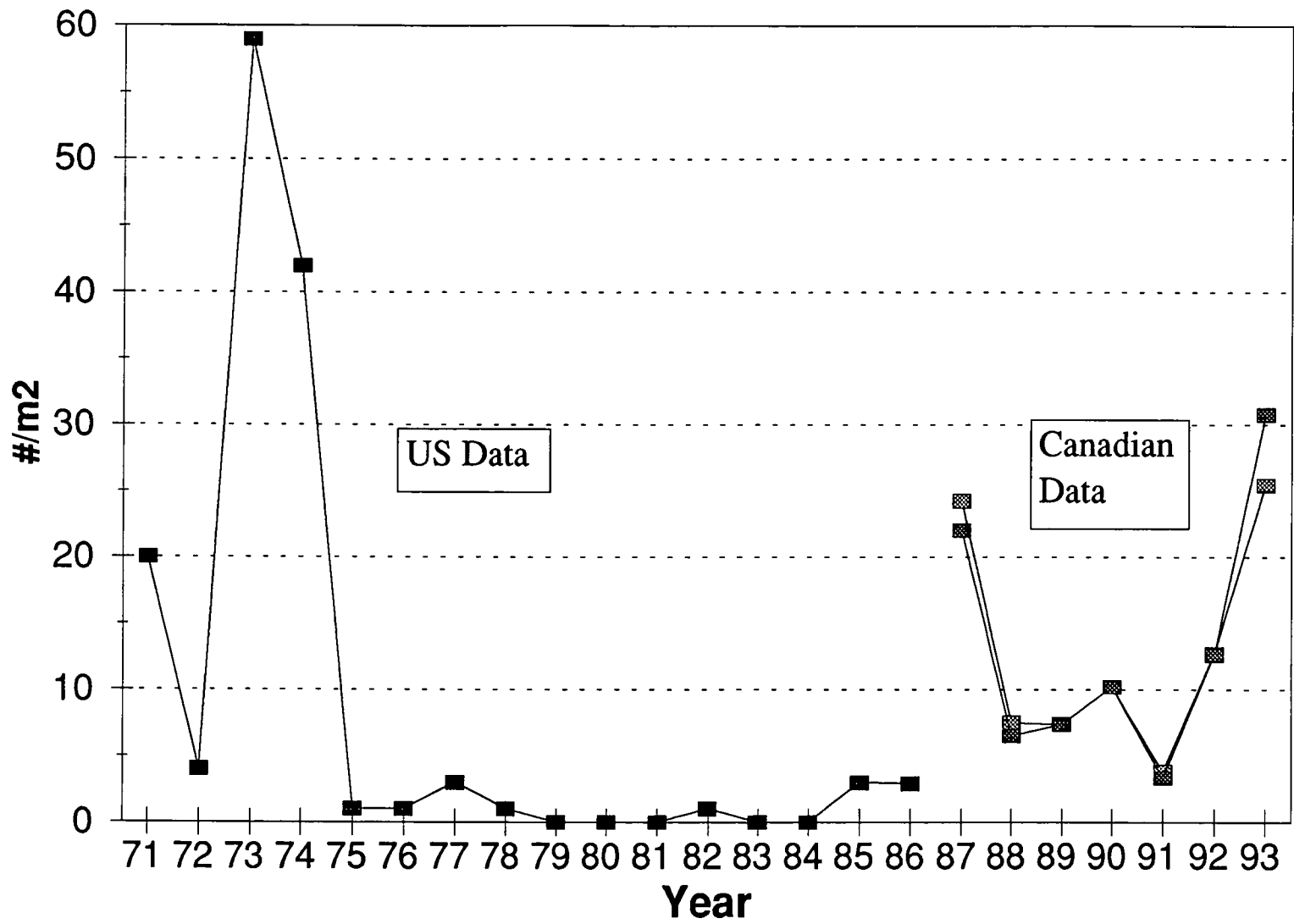


Figure 10. Summary of Canadian (1987-93) and US (1971-1986) larval abundance index. Note the Canadian data displays both the original survey grid and the expanded coverage index.

Table 1. Summary of Canada and US fall bottom trawl data combined for area 1 - Massachusetts Bay, Area 2 - Nantucket Shoals, and Area 3 - Georges Bank, by year. Note Canadian surveys started in 1986 and ended in 1991; for other years, the summary is based on US catches only.

Year	Area	Date start	Date finish	Total sets	Sets with herring	% with herring	No. herring	Catch all sets		Catch sets with herring		Length	
								x	SE	x	SE	x	SE
1983*	1	10-26	11-09	16	7	44	22	1.37	1.25	3.14	0.85	29.2	0.42
	2	10-12	11-09	33	5	15	18	0.55	1.80	3.60	0.98	33.3	0.30
	3	10-09	10-23	95	3	3	4	0.04	2.50	1.33	0.66	30.9	0.39
1984*	1	10-11	11-06	9	6	67	145	16.11	1.31	24.17	1.14	33.1	0.32
	2	10-05	11-17	21	4	19	22	1.05	1.98	5.50	1.28	31.7	0.40
	3	10-07	10-25	73	0	0	0	-	-	-	-	-	-
1985*	1	11-13	11-15	6	4	67	435	72.5	1.53	108.8	1.38	31.1	0.30
	2	10/18	11-07	28	4	14	16	0.57	1.65	4.0	0.68	31.5	0.24
	3	10-22	10-25	63	2	3	4	0.06	2.58	2.0	0.84	28.5	0.14
1986	1	10-27	11-05	8	3	37.5	9	1.13	1.20	3.00	0.58	32.8	0.32
	2	10-09	10-28	22	4	18	89	4.05	1.95	22.25	1.22	29.9	0.26
	3	10-09	10-21	103	23	22	241	2.06	3.31	9.21	1.15	27.71	0.23
1987	1	10-08	10-27	8	6	75	438	54.75	1.47	73.0	1.35	27.5	0.32
	2	10-02	10-29	24	10	42	832	34.66	1.77	83.2	1.39	28.9	0.33
	3	10-03	10-18	75	28	61	346	9.89	2.00	26.50	1.53	29.7	0.29
1988	1	10-26	10-27	11	9	82	85	7.73	1.06	9.44	0.96	38.7	0.28
	2	09-29	10-18	25	7	28	1650	66.00	1.94	235.71	1.38	29.2	0.30
	3	10-07	10-18	81	39	48	2127	22.48	1.78	46.69	1.44	27.3	0.41
1989	1	10-21	10-30	11	10	91	5182	471.09	1.26	518.2	1.22	31.20	0.29
	2	10-07	10-17	19	5	26	280	14.74	1.70	56.00	1.14	30.2	0.28
	3	10-08	10-25	88	46	52	881	10.22	1.90	19.56	1.59	27.9	0.36
1990	1	10-16	10-23	7	4	57	234	33.42	1.11	58.5	0.81	30.8	0.32
	2	09-27	10-16	35	9	26	3044	86.97	1.94	338.22	1.33	27.5	0.29
	3	10-06	10-11	83	27	33	2059	72.90	2.08	224.11	1.53	26.9	0.30
1991	1	10-17	10-24	6	4	67	29	4.83	1.15	7.25	0.96	32.2	0.29
	2	09-30	10-16	24	12	50	757	31.54	1.75	63.08	1.44	28.83	0.30
	3	09-30	11-12	77	17	22	14421	187.28	6.24	848.29	1.69	27.23	0.30
1992*	1	10-20	10-27	4	4	100	1934	483.50	1.82	483.5	1.82	29.49	0.27
	2	10-06	10-20	30	15	50	4590	153.00	3.71	306.0	2.64	29.09	0.31
	3	10-08	10-14	62	12	19	2548	41.10	5.12	134.10	2.86	27.53	0.32
1993*	1	10-20	10-20	18	18	100	3059	169.94	0.98	169.9	1.03	25.50	0.31
	2	09-27	10-14	34	15	44	3139	94.91	2.16	215.1	1.75	26.00	0.30
	3	09-28	10-10	58	10	17	671	11.57	2.21	67.1	1.38	24.88	0.24

*US data only.

Table 2. Summary of gonad development stage of herring collected on Georges Bank during November. The values 1-8 represent gonad stages of a modified Hjort Scale. Percent of sample is included in brackets.

Year	1	2	Gonad 3	4	Stages 5	6	7	8	Number samples
1986	-	10 (9.3)	1 (0.9)	-	6 (5.6)	30 (2.8)	2 1.9	59 (54.6)	108
1987	1.0 (.2)	181 (45.9)	-	-	10 (2.5)	24 (6.1)	14 (3.6)	164 (41.6)	394
1988	23 (7.7)	24 (8.8)	5 (1.7)	3 (1.0)	1 (0.3)	1 (0.3)	13 (4.3)	230 76.7	300
1989	-	24 (19.0)	4 (3.2)	-	1 0.8	3 2.4	33 (26.2)	61 (48.4)	126
1990	46 (8.8)	115 (22.0)	-	-	18 (3.4)	4 (.8)	120 (23.)	218 (41.8)	582
1991	14 (5.2)	48 (17.7)	-	-	19 (6.9)	20 (7.4)	33 (12.1)	137 (50.3)	272
1992	1 (2.8)	4 (11.1)	21 (58.3)	-	-	1 (2.8)	7 (19.4)	2 (5.5)	36
1993	-	33 (14.5)	1 (0.4)	-	-	-	28 (12.3)	166 (72.8)	228

Table 3. Summary of larval herring survey data (1987-93). The number in brackets under date of sampling are Julian days.

Cruise #	Date of sampling	Number Caught	# of Stations	#/m ²		Length				Estimated Hatching Day (Julian)			
				Mean	SE	(mm) mean	STD	(mm) min.	(mm) max.	Mean	STD	Min.	Max.
H181 (1987)	23 Oct - 10 Nov (296-314)	4898	40	22.02	1.24	9.38	1.94	5	19	291	7.71	253	312
H195 (1988)	28 Oct - 7 Nov (301-311)	4075	76	6.51	0.41	13.09	3.05	6	21	274	14.2	238	309
H207 (1989)	25 Oct - 5 Nov (298-309)	4386	90	7.37	0.53	12.41	1.78	7	21	277	7.34	238	301
H222 (1990)	31 Oct - 10 Nov (304-314)	5903	79	10.21	0.46	11.64	1.88	7	19	280	8.08	248	299
H235 (1991)	04 Nov - 12 Nov (307-315)	1508	76	3.32	0.31	13.41	3.73	5	20	275	15.44	247	311
P049 (1992)	24 Nov - 30 Nov (329-335)	7743	86	12.61	0.44	14.55	4.40	5	29	291	18.25	232	333
N195 (1993)	12 Nov - 26 Nov (316-330)	15718	71	30.78	0.70	12.84	2.24	5	26	293	16.30	221	329

Table 4. Backscatter and biomass for transects, Georges Bank herring, November 1993.

Survey	Transect number	Transect length (m)	Transect area (km ²)	Target strength (dB/kg)	Sa - Area scattering (sr ⁻¹)	Total scattering (m ² /sr)	Biomass density (kg/m ²)	Total biomass (t/transect)	Set number
A	6	41690	386.26	-34.5	0.000000	0	0.0000	0.000	
A	7	41690	386.26	-34.5	0.000000	0	0.0000	0.000	
A	8	41690	386.26	-34.5	0.000000	0	0.0000	0.000	
A	9	41690	386.26	-34.5	0.000000	0	0.0000	0.000	
B	1	41690	347.63	-34.5	0.000000	0	0.0000	0.000	
B	2	31500	262.66	-34.5	0.000000	0	0.0000	0.000	
B	3	31500	262.66	-34.5	0.000000	0	0.0000	0.000	
B	4	31500	262.66	-34.5	0.000000	0	0.0000	0.000	
B	5	31500	262.66	-34.5	0.000000	0	0.0000	0.000	
C	10	22240	94.20	-34.5	0.000000	0	0.0000	0.000	
C	11	22240	94.20	-34.5	0.000000	0	0.0000	0.000	
C	12	22240	94.20	-34.5	0.000000	0	0.0000	0.000	
C	13	22240	94.20	-34.5	0.000000	0	0.0000	0.000	
C	14	22240	94.20	-34.5	0.000000	0	0.0000	0.000	
C	15	22240	94.20	-34.5	0.000000	0	0.0000	0.000	
C	16	22240	94.20	-34.5	0.000000	0	0.0000	0.000	
D	17	22240	109.90	-34.5	0.000000	0	0.0000	0.000	
D	18	22240	109.90	-34.5	0.000000	0	0.0000	0.000	
D	19	22240	109.90	-34.5	0.000000	0	0.0000	0.000	
D	20	22240	109.90	-34.5	0.000000	0	0.0000	0.000	
D	21	22240	109.90	-34.5	0.000000	0	0.0000	0.000	
D	22	22240	109.90	-34.5	0.000000	0	0.0000	0.000	
E	23	22240	109.90	-34.5	0.000012	1319	0.0338	3716.723	
E	24	22240	109.90	-34.5	0.000001	110	0.0028	309.727	1
E	26	22240	109.90	-34.5	0.000007	769	0.0197	2168.088	
E	27	22240	109.90	-34.5	0.000008	879	0.0225	2477.815	
E	28	22240	109.90	-34.5	0.000000	0	0.0000	0.000	
E	29	22240	109.90	-34.5	0.000000	0	0.0000	0.000	
F	30	22240	117.74	-34.5	0.000000	0	0.0000	0.000	
F	31	22240	117.74	-34.5	0.000000	0	0.0000	0.000	
F	32	22240	117.74	-34.5	0.000000	0	0.0000	0.000	
F	33	22240	117.74	-34.5	0.000000	0	0.0000	0.000	
F	34	22240	117.74	-34.5	0.000000	0	0.0000	0.000	
F	35	22240	117.74	-34.5	0.000000	0	0.0000	0.000	
F	36	22240	117.74	-34.5	0.000000	0	0.0000	0.000	
G	46	16680	154.54	-34.5	0.000011	1700	0.0310	4791.088	
G	47	16680	154.54	-34.5	0.000002	309	0.0056	871.107	
G	48	16680	154.54	-34.5	0.000006	927	0.0169	2613.321	
G	49	16680	154.54	-34.5	0.000005	773	0.0141	2177.767	
H	37	14820	164.77	-34.5	0.000000	0	0.0000	0.000	
H	38	14820	164.77	-34.5	0.000000	0	0.0000	0.000	
H	39	14820	164.77	-34.5	0.000000	0	0.0000	0.000	
H	40	14820	164.77	-34.5	0.000000	0	0.0000	0.000	
H	44	14820	164.77	-34.5	0.000005	824	0.0141	2321.907	
H	45	14820	164.77	-34.5	0.000011	1812	0.0310	5108.196	

Table 5. Backscatter and biomass for Georges Bank November 1993 herring surveys.

Survey	Target strength (dB/kg)	Stratum area (km ²)	Area scattering (sr ⁻¹)	Total scattering (m ² /sr)		Biomass density (kg/m ²)	Total biomass (t/stratum)	
				Total	S.E.		Total	S.E.
A	0.0	1545.03	0.000000	0	0	0.0000	0	0
B	0.0	1398.28	0.000000	0	0	0.0000	0	0
C	0.0	659.37	0.000000	0	0	0.0000	0	0
D	0.0	659.37	0.000000	0	0	0.0000	0	0
E	-34.5	659.37	0.000000	3077	1358	0.0132	8672	3829
F	0.0	824.21	0.000000	0	0	0.0000	0	0
G	-34.5	618.16	0.000000	3709	1156	0.0169	10453	3259
H	-34.5	988.61	0.000000	2636	1835	0.0075	7430	5171
Total							26555	12259