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The 1996 Review of Georges Bank (5Z) Herring Stock

by

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Abstract

Analysis of the 1995 Canadian and United States fall survey data on Georges Bank indicates that the stock has recovered to historical levels of the mid-seventies. Abundance indices used to evaluate the relative stock status are among the highest observed in post-collapse years and are comparable or exceed those of the early 70's. Research samples collected on the bank during spawning season were again dominated by 3 and 4 year old herring, suggesting successful recruitment to the spawning stock. The 1995 samples also contained a large number of two year old herring indicating the possibility of strong recruitment for 1996. Furthermore, small (<10 mm) larvae have been observed in relatively large numbers on the northeastern portion of the bank for the past three years. Herring have not only reoccupied their historical spawning grounds, but their numbers and distribution on the Canadian portion of the bank have increased to historical levels. Previous spawning stock biomass estimates, when the larval abundance index (#/10m2 of 4-7mm larvae) was at current levels, ranged from 100,000-200,000 mt. It is therefore considered that a commercial fishery could be developed on Georges Bank and that a combined Canada/US catch of 20,000 mt would not exceed reference points commonly used for herring.

Résumé

L'analyse des données recueillies pendant le relevé mené à l'automne 1995 par le Canada et les États-Unis sur le banc Georges indique que le stock de hareng a retrouvé son niveau du milieu des années 70. Les indices d'abondance qui ont servi à évaluer l'état relatif du stock sont parmi les plus élevés qu'on ait observé depuis l'effondrement, et sont comparables ou supérieurs à ceux du début des années 70. Les échantillons prélevés à des fins scientifiques sur le banc pendant la saison de fraye étaient encore dominés par les harengs de trois et quatre ans, ce qui semble indiquer un bon recrutement au stock reproducteur. Les échantillons de 1995 contenaient aussi un grand nombre de harengs de deux ans, ce qui permet de penser que le recrutement a été fort en 1996. De plus, on observe depuis trois ans de petites larves (< 10 mm) en assez grandes quantités dans la partie nord-est du banc. Non seulement le hareng a réoccupé l'ensemble de son aire de fraye d'autrefois, mais ses effectifs et sa répartition sur la portion canadienne du banc sont remontés à leur ancien niveau. Selon des estimations antérieures, alors que l'indice d'abondance des larves (n^{bre} de larves de 4-7 mm/10 m^2) était au même niveau que maintenant, la biomasse du stock reproducteur se situait entre 100 000 et 200 000 tm. Nous jugeons donc qu'il serait possible de développer une pêche commerciale du hareng sur le banc Georges, et qu'un volume de prises combiné Canada/États-Unis de 20 000 tm ne dépasserait pas les points de référence communément retenus pour le hareng.

Historical Overview

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 (Figure 1). The fishery peaked in 1968 with reported landings in the 374,000 mt range (NEFSC, 1993), however, actual landings are suspected to have been substantially higher. By 1977 reported landings had declined to less than 2,000 mt. The collapse has been attributed to over-fishing and poor recruitment. Although no directed herring fishery operated on the bank between 1977 and 1993, incidental catches during this period ranged from 2,000 to 11 mt.

Between 1978 and 1984 virtually no adult or larval herring were detected on the bank by USA fall research surveys. The number of adult herring reported in US fall bottom trawl surveys fell to less than 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 (age 1+) herring in a mid-water trawl (IGYPT) on Georges Bank (Stephenson and Power, 1989). However, it wasn't until 1986 that significant evidence appeared in both Canadian and US research surveys to indicate the stock was recovering. Canadian bottom trawl by-catches in the fall of 1986 were dominated by three year olds from the 1983 year-class. The first observed spawning on historical grounds on the northeastern portion of the bank was reported in October of 1992 (Melvin and Fife, 1993). This was later substantiated by the US fall larval survey (W. Smith, Pers. Com., NMFS - Sandy Hook Lab, New Jersey,1993).

Canada has monitered the recovery of the Georges Bank herring stock through annual fall adult/larval surveys since 1987 (Figure 2). Each year the data has generally indicated an increasing relative level of abundance of herring on the bank. Recent reports from US larval studies also show 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.

Description of the Fishery

The commercial fishery on Georges Bank began in 1961 when the former USSR landed 68,000 mt of herring. Between 1961 and 1965 the USSR dominated the herring fishery with annual catches ranging from 38,000 to 151,000 mt. The fishery expanded rapidly from 1967 when Poland and the German Democratic Republic entered the fishery. Over the next 9 years, vessels from 12 countries harvested herring from the bank, including Canada and the US which by reported landings were minor players (Anthony and Waring, 1980). Annual catches by country are presented in Table 1 for the period 1961 to 1977 when the fishery collapsed. No directed fishery for herring occurred on the bank between 1978 and 1993.

Fishing gear varied by country and year. Drift gillnets dominated the early period from 1961-1963. This was followed by side and stern trawlers between 1963 and 1972, mid-water trawlers from 1971 to 1977 and purse seiners from 1969 to 1975. Fishing activity occurred throughout the year, but the majority of catches were reported from May to October when large numbers of herring were on the bank for summer feeding or spawning (September/October).

Given the positive signs of recovery an experimental fishery with a combined Canada/United States catch of 5,000 mt was recommended by Canada for Georges Bank in 1993 and in 1994. The first directed fishery for herring on the bank since the stock's collapse occurred in August of 1993 when four Canadian vessels made a single excursion to the bank. Although no fish were caught, the lack of catch was not attributed to the absence of fish, but to their distribution within the water column. Most herring were observed too deep to capture with a purse seine. Effort increased in 1994 when a total of 14 trips were made to the bank by Scotia Fundy seiners (11 in June and 3 in July) with a total Canadian 5Z herring catch of 228 t. The majority of successful sets were made on the northern edge just east of the International Boundary (Figure 3). The USA catch, which occurred in the vicinity of the Great South Channel, was estimated at 350 mt for 1994.

In 1995 the recommended combined Canada/US catch was increased to 20,000 mt in recognition of strong and continued signs of an expanding stock. Several short exploratory excursions were made to the bank by Canadian vessels, however, no landings were reported. As in previous years the fish were reported too deep to capture by purse seine.

Industry Consultations

Several formal and informal consultations with industry took place in 1995. These included presentations at two Scotia-Fundy Herring Advisory Committee (SFHAC) meetings, annual industry meetings, ad hoc fishing excursions, Canada/US industry meetings and the pre-assessment input data review. Fishermen again expressed concern that the herring remained too close to bottom for capture by purse seine. There were no reports of low fat content from either the commercial fleet or the research surveys. Other fishery sectors again reported a large number of herring on the northeastern portion of Georges Bank during the spring and early fall of 1995.

Assessment Approaches

Major differences exist between Canada and the United States in their assessment of Georges Bank herring stock status. Canada has adopted the historical approach of assessing the stock as single spawning unit which includes only the bank proper (i.e. 69° eastward). As such, the information and data discussed within this report relate solely to Georges Bank. The US on the other hand includes Georges Bank herring as one component of their coastal zone complex which is comprised of several spawning components from NAFO subdivision 5Y and 5Z.

Historically the US assessed two separate stocks within the coastal complex; Georges Bank/Nantucket Shoals and the Gulf of Maine. However, because the Gulf of Maine stock VPA was calibrated with their spring bottom trawl data, known to contain a mixture of herring from both components, a new approach was adopted in 1991. The two stock approach was abandoned and replaced for assessment purposes with the single coastal zone complex which included New Brunswick weirs, coastal US waters north and south of Cape Cod, Nantucket Shoals, and Georges Bank. While the US still recognizes individual stocks within the complex, the biomass estimates and harvest strategies provided in their stock status reports refer to the overall complex. Harvest allocations are based on three sea herring management units, Area 1- Coastal Maine to the southern tip of Cape Cod, Area 2 - south of Cape Cod and west of the Great South Channel , and Area 3 - Georges Bank (Figure 4).

Given the current healthy state of the complex IWP (Internal Waters Program) allocations are derived primarily from market and socio-economic demands, not scientific data. Partitioning of the harvest levels for each management area is based on a percentage split (Report of NEFMC, 1995). The following text table describes the 1994/95 fishing season allocation of 340,000 mt.

Management Area	Percentage	Total Amount	Initial Amount	Reserve
Area 1	30%	102,000	32,000	70,000
Area 2	40%	136,000	36,000	100,000
Area 3	30%	102,000	20,000	82,000
Total	100%	340,000	88,000	252,000

Annual allocations are based on target F's (F=0.29 for the Preliminary Fishery Management Plan - June, 1995) to estimate an MSY which is further adjusted downward to reflect estimates of precision. In this case the MSY was reduced to 60% of the calculated value. The initial amounts are then established based on area requirements and the remainder placed in reserve unless a State requests additional allocation. It is estimated that if all ASMFC (Atlantic States Marine Fisheries Commission) members agree, a revision to the initial allocation can be processed in two weeks.

Future allocations will depend upon the target F-levels adopted for the stock complex. In the recent (February, 1996) US Advisory Report on Stock Status of Atlantic herring three F's were simulated; status quo F=0.025, $F_{0.1}$ = 0.20, and $F_{20\%}$ = 0.34 for 1996. Estimated landings and SSB's for each scenario were 120,000 / 4,200,000 mt ; 800,000 / 3,400,000 mt ; and 1,200,000 / 2,800,000 mt, respectively (NEFSC, 1996).

Research Survey Data

Available Data

The major data sources used to assess the recovery of Georges Bank herring include the US fall bottom trawl survey (1965-95), which covers Massachusetts Bay, Nantucket Shoals and Georges Bank, and the Canadian fall Georges Bank larval/adult herring survey (1987-95). Additional data are collected from the commercial fleet whenever possible. Sampling design and gear type differ between the two research surveys. The US survey uses a random stratified design with a 36

Yankee trawl employed for data collection, compared to the Canadian approach of opportunistic (i.e. sets made at random and when herring were observed on the ship's sounder) bottom trawl (Western IIa) sets to collect adult herring samples during larval surveys. The US survey strata are presented in Figure 5.

The larval component of the Canadian fall adult/larval survey, which uses standard ichthyoplankton sampling protocol, was originally established to cover an area of the bank most likely to show signs of a recovery (Melvin et al., 1993). In 1991, at CAFSAC's request, the larval survey grid was expanded eastward to include the entire Canadian portion of the bank. The survey area was again expanded in 1992 westward to the Great South Channel to cover an area where further spawning was suspected (Figure 2).

Several changes in gear type and vessels have occurred throughout the Canadian survey period. From 1987 to 1991 both larval and adult collections were made with standard sampling gear using the "Lady Hammond". In 1992 the "Lady Hammond" was removed from its long term charter and two vessels were required to sample Georges Bank; the "Parizeau" for the larval component and the "E.E. Prince" for bottom trawling. The bottom trawl component of the fall survey was dropped in 1993 to undertake an acoustic survey of the bank, but the larval component of the survey remained unchanged. An IGYPT mid-water trawl was used to sample adult herring and to verify acoustic backscatter. Gear and vessel changes resulted in poor adult sampling in 1992 and in 1993. The pre-1992 survey approach was re-established in 1994 and continued in 1995 using the "Alfred Needler". Eighty-seven larval stations and 17 bottom trawl stations were occupied in 1995 (Figure 6).

Bottom Trawl Surveys

In the absence of a commercial catch-at-age specific to Georges Bank, which precludes an analytical assessment, stock status must be evaluated based on general biological characteristics and indices of abundance obtained from research surveys. The following compares the information from current US fall bottom trawl surveys with those of the past, including the period when VPA estimates of SSB were available.

Bottom Trawl Abundance Indices

In the past peak spawning on Georges Bank has generally occurred during the months of September and October. As such, the US fall bottom trawl survey which covers the period from 1963 to present represents the longest time series of a fishery independent index of abundance upon which to assess the stock. Furthermore, because of the surveys timing (i.e. spawning time) and area of coverage, it should reflect abundance trends. For comparative purposes the bottom trawl survey data (catch/tow for number and weight) are presented in three forms; one covering the entire time series using the historical VPA tuning strata (Figure 7a), the entire time series including all Georges Bank strata (Figure 7b) and the early period 1963-80 where trends are difficult to discern (Figure 7c). Biomass estimates for the period 1963-77 are presented in Figure 7d. The historical VPA tuning strata which includes Georges Bank plus a small portion of

Nantucket Shoals are 13, 16 and 21 to 24. Southern slope strata were excluded from the analysis as herring are not usually observed in this area.

Examination of the full time series (Figure 7a and b) shows major differences in the catch/tow, for both weight and number, between the pre-crash (1963-77) and the recovery period (1986-95). The recovery period is marked by extremely high catches compared to the pre-crash era. Although there is no direct evidence that catchability has changed, it is obvious that something significant has occurred with respect to the availability of herring to the sampling gear or to herring abundance. The only reported gear change occurred in 1983 when the trawl doors were modified. Vessel changes were accounted for by standardizing catches to the Albatross. The stratified mean catch per tow in most recent years is also dominated by 1 or 2 extremely high catches, yet even the removal of these sets from the analysis can not account for the difference. Similar difference can also be found in the spring bottom trawl index which is used to tune the Gulf of Maine Coastal Zone Herring Complex VPA.

Such large discrepancies make comparison of past and present situations unreliable. However, the indices do appear to be representative of the two periods if considered separately. Comparison of the bottom trawl index (number and weight/tow), although noisy, generally tracks the stock's decline from the late sixties to the mid-seventies (Figures 7 c and d). With the exception of 1978, few herring were observed on the bank between 1973 and 1986 by research surveys (Figure 7a and b). From 1986 to 1988 the recent index increased rapidly, declined in 1989 and then increased until 1992 (Figure 7a and b). The 1993 index dropped substantially from the 1992 value. A significant portion of this decline is believed attributable to the apparent lack of sampling stations on the northern edge in the vicinity of the International Boundary where herring commonly occur. The index increased substantially in 1995. Differences in the number per tow compared with the weight per tow reflect the presence of a large number of small fish in the catches for any given year.

Adult Distribution

Review of the published literature and research survey data shows that herring are present on Georges Bank throughout the year, yet their abundance appears to vary with season. Commercial catches for the period 1967-77 show the majority of landings occur in summer and early fall (65%). Maximum catches (27.5%) occurred in September (Anthony and Waring, 1980). By November catches diminish to less than 5% of the annual total, a trend which continues throughout the winter months. From April to June catches gradually increase. A similar pattern is also found in the reports of commercial fishing activity during this period.

Zinkevich (1967) describes the distribution of herring from Georges Bank observed by Soviet fishing and scouting vessels which fished this stock year round (Figure 8). During the winter (November to March) Georges Bank herring were scattered from their southern extreme to the northeastern tip, with the bulk of the fish in February and March being observed south of Cape Cod (offshore waters of Long Island, in the Hudson Canyon and further south). In Spring the herring moved from over-wintering areas to the southern part of Georges Bank where their numbers increased as summer approached. Herring remained on the bank for feeding and

spawning until late October/early November when they dispersed and slowly moved south to over-wintering areas.

Information specific to herring distribution during the spawning period is presented for the US fall bottom trawl survey from 1966 to present. The results of these surveys are presented in a series of figures covering the entire period (Figure 9-38). Briefly summarized, herring during the peak period of the commercial fishery, were found throughout most of the bank, in Massachusetts Bay and to a lesser extent around Nantucket Shoals at spawning time. Major concentrations were generally consistent with known spawning areas. However, about 1973 the occurrence, as reflected by the number and percent sets with herring, began to diminish. This trend continued, excluding 1978, until 1979 and 1980 when not a single herring was collected in 227 and 135 sets respectively. From 1981 to 1985 a few sets on Georges Bank contained herring, even in years when no fish were observed in Massachusetts Bay or on Nantucket Shoals. The number of sets with herring began to increase in 1986 and has continued to increase, with some inter-year variability, to present day (Table 2).

The 1995 distribution of adult herring on Georges Bank was consistent with both recent and historical observations. As in previous years adult herring appear to be concentrated in an arc between the 100-200 m isobath north of Cultivator Shoals to the Northern Edge along the northern fringe of Georges Bank and just west of the Great South Channel. Large sample sizes were also observed on Nantucket Shoals and in Massachusetts Bay. The main difference between 1995 and recent (1986-94) observations was the occurrence of adults in the central region, just west of the International Boundary, and in the area south of Georges Shoals (Figure 38); a distribution which is similar to the mid-sixties. A large number of small herring larvae (<10mm) were also found in the same areas during the 1995 Canadian fall survey; an indication that spawning occurred nearby. Comparison of the 1993, 1994 and 1995 sampling stations illustrates the critical nature of location selection. In 1993 the US survey did not provide good coverage of the 100-200 m isobath on the northern fringe nor the portion of the bank just east of the International Boundary where the majority of herring were observed in past 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 this area. Better coverage in 1994 showed a continuation of this trend in the occurrence of herring along the northern fringe.

In recent years whenever sampling stations were located along the northern fringe during the fall survey herring were observed. The Canadian fall herring surveys, although approximately 1 month later than the US and opportunistic, support this observation. Each fall since the survey began samples have been collected along the northern fringe for length frequency, age structure and maturity information. The Canadian catches are presented in Figures 39-46. Note that no bottom trawl sets were undertaken in 1993.

Length Frequency

Length frequency distribution of Georges Bank herring collected by the US fall bottom trawl survey (1986-95) are presented in Figure 47 and by the Canadian fall herring survey (1986-95) in Figure 48. The difference in size breakdown, 1 cm intervals for the US and 0.5 cm intervals for

the Canadian originates from measuring procedures at sea. As well, US lengths were converted from fork length to total length. The Canadian length range was restricted to fish 20 cm or larger to examine mature or maturing herring at the time of sampling.

Comparison of the length frequency distributions from Canadian fall research samples (1987-95) indicates a transition from a broad distribution to one which reflects the dominance of younger recruits (Figure 48). In the early years of the recovery (1987-89) length frequencies covered almost the entire spectrum of possible lengths, with poor representation of sizes which approximate recruitable year-classes. Around 1990 this trend began to change when herring 25-27 cm started to dominate catches. The trend continued to 1993. In 1994 the mode shifted upward by approximately 1-2cm, suggesting that slightly older fish (4+) were dominating the stock. The mode was even higher in 1995 supporting the presence of 1 or 2 strong year-classes (1989/1990). However, new recruits (24-26 cm) were also well represented in 1995.

It is also possible to follow modal trends in length from year to year in both the Canadian and US data (Figures 47 and 48) especially from 1992-95, although because of the 0.5cm interval the Canadian modes are more distinct.

Examination of the US length frequencies illustrate similar patterns, unfortunately because of the length interval restriction slight shifts in modes are observed. The US also consistently catches larger fish in any given year throughout the series. While several possible explanations exist, it is likely that the larger herring were not available to the sampling gear in the area of the Canadian survey. Figures 29b to 38b show for the period 1986 to 1995 that the distribution of herring >30 (fork length) is generally outside the Canadian sampling area. It is also worth noting that even during the 1960's fish greater than 30 cm were rare (Zinkevich, 1967).

The mean length of herring collected on Georges Bank in 1995 by both the Canadian and US fall surveys were slightly smaller than in 1994 and similar to those observed between 1988 and 1992. The largest mean length of herring collected by the US survey occurred on Massachusetts Bay (27.4 cm) followed by Georges Bank at 26.2 cm and Nantucket Shoals at 25.9 cm (Table 2). Mean lengths of fish collected by the US survey on Georges Bank, which was conducted about four weeks earlier, and the Canadian survey, were almost identical at 26.2 and 26.3, respectively. Comparison of the 1995 Canada/US length frequency distributions show very similar patterns, except the strong influence of 13-16 cm herring and the presence of 33-36 cm fish in the US samples (Figure 49).

Age Distribution

Age data for Georges Bank herring are available for the Canadian bottom trawl sets (1987-92, 1994-95), the Canadian acoustic mid-water trawl (1993) samples, and the US fall bottom trawl survey (1986-94). The relative frequency of age by year for both datasets are presented in Figure 50 and display some major differences. The distributions are similar for only 1991 and 1992 in the eight years of available data. Ages for the US seem to be offset by 1 year (+) compared with the Canadian data. The Canadian data also indicates a broader age range than the US even though the

latter consistently reports larger herring in their samples. Comparative otolith reading is recommended to ascertain if the discrepancies are reader specific.

Canadian research samples have been dominated since the surveys began by 3 and 4 year old fish (Figure 50). This trend continued in 1995 where herring 4 years old dominated the catches (39.4%). However, unlike 1994, 2 and 3 year olds (1992 and 1993 year-classes) were well represented (32%) in 1995 as well as a continued strong (24%) presence of the 1990 year-class (age 5). Fish over age 7 were noticeably absent from catches in 1995. Regardless , the continued strong representation of young fish (4 yr old and younger) in annual catches since 1987 provides evidence of good annual recruitment to the spawning stock and continues to support the expansion of this stock.

A catch at age matrix was generated from both datasets using the length frequency data, aged fish and assuming 1000 mt catch as input for the Canadian data and STRAPUS age/length key for the US fall survey. These results are presented in Tables 3 and 4, respectively. Cohorts are difficult to follow beyond age 5 in both datasets.

Larval Survey

Larval Abundance Index

Larval abundance indices are available for both the Canadian (1987-1995) and the US (1971-1994) fall surveys. The main difference between the two indices is that the US are estimated on a composite of 3-4 surveys for each year, whereas the Canadian index is based on a single annual survey. There are also differences in units and size of larvae used to estimate the annual index. In the most recent US stock assessment, the larval abundance index (LAI) for Georges Bank is based on the number of larvae between 4 and 7mm expressed as the number per $10m^2$. The Canadian index represents the mean number of larvae per m^2 . For comparison the Canadian index has been re-calculated to US units.

The Canadian larval abundance index (number of larvae/m^2) is sub-divided into two groups, one for stations contained only within the original survey grid (i.e. to maintain consistency) and, two all stations, which includes the expanded coverage initiated in 1991 (Figure 51). The 1995 larval abundance index for both the original survey area (1987-90) and the expanded coverage decreased from the all time high observed in 1994. However, the LAI in both cases is the second highest reported since the Canadian surveys began and continues the general upward trend. The 1995 index is also the third highest value in the entire time series and above average for the early seventies if reported values for total larvae from US data are examined (Figure 52).

To investigate how these values compare with historical levels (1971-90) the number of larvae/m^2 were extracted from the literature (Smith and Morse, 1990) for the cruises which occurred at approximately the same time (late October/early November, 1971-86) and the Canada/US larval comparison study (Melvin and Fife, 1992). In addition, because the 1995 US stock status report contained a LAI for Georges Bank based on the number of larvae per $10m^2$ the Canadian index was recalculated to provide a similar view. Figure 52 compares the total number of larvae/m^2 for

both the Canadian and US data and displays some major discrepancies in the period of overlap (1987-90). A similar pattern of inconsistencies is also observed when the #/10m^2 of 4-7 mm larvae are examined (Figure 53). Between 1987 and 1991 the two indices do not appear at all comparable, yet from 1992 to 1994 both show a consistent upward pattern.

The question of comparability between Canadian and US larval survey results has arisen on several occasions. During years when the surveys were conducted at approximately the same time, the total number of larvae observed are almost identical (Figure 52, 1988 and 1990). However, when only a few weeks separate the surveys major differences can occur. For example, in 1987 and 1989 approximately two weeks separated the surveys and marked differences were observed. It is therefore postulated, and supported by the available data, that survey timing plays a critical roles in the observed LAI.

For the Canadian index (Figure 51) inconsistencies in the general increasing level of abundance, such as the 1991 decline, are also believed to be a function of late spawning relative to survey timing. In 1991 the US December survey identified a spawning period which occurred after the Canadian survey was completed (Smith, Personal Communication). It is also likely that larval abundance indices (LAI's) between 1987 and 1991 are underestimated given the presence of unspawned fish on the bank during the survey (Table 5). This is also observed when Canadian and US data are compared for only the small larvae(Figure 53). Between 1988 and 1991 the indices show no semblance of similarity, yet when the Canadian survey was moved from early November to late November the indices began to parallel each other. The US values are always higher than the Canadian due to the composite effect of 3 or four surveys. It is obvious that the Canadian survey missed an unknown portion of larval production in the early years. This is also supported by the observed larval length frequency distributions.

Larval Length Frequency

During the early stages of the recovery on Georges Bank the larval length frequency distribution was generally unimodal (1987-90) and dominated by smaller larvae (Figure 54). In 1991 a second mode appeared and the distribution expanded to many larvae greater than 20mm. This trend continued through to 1994. A trimodal distribution was observed in both 1992 and 1995 when the latest larval survey to date occurred. Furthermore, based on the small size of collected larvae in 1995 (Figure 54), some were just hatching, it is possible that even with the later survey some production was missed. Consequently, in most of the early years the Canadian larval abundance index is an underestimate of abundance as some unknown portion of the stock had not yet spawned. The gonad development stages of mature fish collected on the bank also supports this explanation. For 1991, the lowest Canadian index observed in recent times, approximately 16% of the mature herring were unspent (Table 5). In 1995, 82% of the herring were spent at the time of sampling.

Spawning/Larval Distribution

The geographical distribution of larvae (all sizes) collected in 1995 was similar to observations made from 1992-94, and covered most of the bank, including a large part of the Canadian portion of the bank. The total number of larvae collected during the survey was also in the same range as in 1994 when the number almost tripled the 1993 observation (Table 6) . Major differences between 1994 and 1995 include the maximum number of larvae yet observed in a single set (6500) and the reporting of larvae less than 5 mm in length. Canadian larval survey sampling locations and distribution maps are presented in Figures 55-63 for 1987-95.

Examination of the distribution and abundance of larvae <10 mm (generally considered an indication of spawning areas) for 1993, 1994 and 1995 showed a marked change from most of the earlier 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, re-occupied their historical spawning grounds on the eastern portion of the bank. Spawning, as indicated by the presence of small larvae, covered a large area on the Canadian side of the bank in 1993, 1994 and 1995. Another difference observed in 1994 was the apparent reduction of young larvae in the vicinity of Little Georges and Cultivator Shoals where most spawning occurred during the early stages of the recovery. This trend continued into 1995 with an almost complete absence of small larvae in the area where spawning was first detected during the early stages of the recovery. It now appears that the majority of spawning is occurring further eastward in the historical areas. Both 1994 and 1995 also show a large concentration of large and small herring larvae near the southern extreme of the Canadian survey grid, which would suggest spawning may be occurring south the current coverage. In fact, in 1995 the largest concentration of larvae in a single set was taken in this area.

Prognosis

The 1995 data support last years conclusion that the Georges Bank herring stock has recovered from the collapse in 1977 to levels observed in the early seventies. While the US bottom trawl survey index does not provide a mechanism for direct comparison of pre-and post crash biomass levels, the fact that it has substantially increased since the first signs of a recovery were observed (1986) and that it continues to increase suggests the stock is expanding. The index doubled from 1993 to 1994 and the 1995 index represents the highest level observed to-date with respect to numbers. Furthermore, it is far above all years when catch levels were much higher (i.e. 1960's and 70's). The strong representation of small fish in research samples is also encouraging and may indicate good recruitment in the next 1-2 years.

The 1995 Canadian larval abundance index although down slightly from 1994 , is still the second highest observed in the time series (1987-95). Comparison with the US #/10m2 of larvae 4-7mm indicates that levels are as high as recent times and higher than the first few years of the survey. When compared with the total number of reported larvae, the 1995 Canadian index is the third highest, and just slightly lower than the 1973 US index. The age structure of research samples continued to show a dominance of young fish (4-yr-old) in the catches, indicating successful

recruitment over the past several years. Two and three year old herring were also well represented in the 1995 samples. Both newly hatched (i.e. <10 mm) and older larvae in 1993, 1994 and 1995, displayed a much broader geographical distribution than in other post-crash years, extending to the northeastern portion of the bank. Spawning on the Canadian side of the bank, as shown by the presence of larvae (<10 mm), was first documented in 1992 by four independent sources (Canada and US fall surveys, a seiner survey and the presence of eggs in groundfish stomachs). Spawning in 1995 was slightly contracted from the 1993 and 1994 observations but still covered most of the historical spawning areas, including a large portion of the eastern bank.

Other factors which might be considered related to stock size include, the mean length and percent of fish mature at age 3, both of which have shown a substantial decline (26.7 Vs 24.7 cm and 89% vs 50%, respectively) since the early stages of the recovery (1987). These characters may reflect a density-dependent relationship with stock abundance/biomass.

In the absence of an analytical assessment the evaluation of stock status must rely heavily on comparison with past observations. Unfortunately, with the exception of the larval abundance index (#/m^2 of 4-7mm larvae), which does not extend back to the peak biomass estimates of the late sixties, no comparison is possible with the available data. We do however know from the indicators available that the Georges Bank herring stock has likely recovered to levels observed in the early seventies. It is also known that catches exceeding 100,000 mt during this period, combined with poor recruitment, led to a rapid collapse of the stock. The 3+ biomass during this period was estimated to be in the range of 100,000-200,000 mt. It is therefore recommended that this range be adopted as the best estimate of SSB and that a combined Canada/US catch of 20,000 mt for this stock would not exceed reference points commonly used for herring.

The fishing industry can play a key role in our better understanding of the stock's recovery and status. As the fishery develops it is critical that information be obtained regarding seasonal distribution of fish and that herring samples be collected to determine the size and age structure of the stock. Distributing fishing effort throughout the season, with some coverage during the spawning season (i.e. October), will be extremely informative assuming accurate logs are kept.

Caution is however warranted for this transboundary stock in that no direct estimate of biomass is available. While the development of a commercial fishery in the long term will provide additional scientific information to improve estimates of stock status, in the short term, uncertainties should err on the side of conservation. In addition, it is recommended that a Joint Canada/United States Working Group be established to discuss and to address differences in assessment approaches with the goal of developing a long term strategy for the management of this transboundary stock.

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Table 1. Georges Bank / Gulf of Maine commercial herring landings by country in metric tonnes.

Year	USA	Canada	FRG	GDR	USSR	Poland	Japan	Bulgaria	France	Iceland	Norway	Romania	Cuba	Others	Total
1961	105				67550										67655
1962	101				151864	277									152242
1963	322				97646										97968
1964	489				130914	35									131438
1965	1191				38262	1447						1982			42882
1966	4308			1133	120113	14473						2677			142704
1967	1211	1306	28171	22159	126759	36677	40					1420			218743
1968	758	13674	71086	67719	143097	75080	171			292		1656		65	373598
1969	3678	945	61990	44624	138673	45021	586	812		12786	1224	337		85	310758
1970	2011	7	82498	28063	61579	70691	1412	348				685			247294
1971	3822	12863	54744	18447	81258	88325	2466	4551				898			267374
1972	2782	53	27703	40016	48072	49392	1161	2355	500			2156			174190
1973	4627	5083	31501	53326	52340	49275	1722	1380	2784			297			202335
1974	3370	217	23690	31530	41541	39312	4242	1773	3617			2018			149510
1975	4582	0	22957	30901	40945	38392	1878	421	3304			1544	10	1162	146096
1976	744		8806	7891	12996	10517	868	105	1166			115	296	3	43507
1977	361	2			1492	119		1					152		2127
Total	34462	34150	413146	345809	1355101	519033	14546	11746	11371	13078	1224	15785	458	1315	2770421

Source: Anthony & Waring, 1980

Table 2. Summary of the US fall bottom trawl survey for Massachusetts Bay (Area 1), Nantucket Shoals (Area 2) and Georges Bank (Area 3) by year.

Year	Area	Start Date	Date Finish	Total Sets	Sets with Herring	% with Herring	No. Herring	Length Mean	Length SE
1983	1	10-26	11-09	16	7	43.75	22	29.2	0.42
	2	10-12	11-09	33	5	15.15	18	33.3	0.30
	3	10-09	10-23	95	3	3.16	4	30.9	0.39
1984	1	10-11	11-06	9	6	66.67	145	33.1	0.32
	2	10-05	11-17	21	4	19.05	22	31.7	0.40
	3	10-07	10-25	73	0	0.00	0	-	-
1985	1	10-13	11-15	6	4	66.67	435	31.1	0.30
	2	10-18	11-07	26	4	15.38	16	31.5	0.24
	3	10-22	10-25	63	2	3.17	4	28.5	0.14
1986	1	10-27	11-05	8	3	37.50	9	32.8	0.32
	2	10-09	10-28	22	4	18.18	89	29.9	0.26
	3	10-09	10-21	103	23	22.33	241	27.3	0.23
1987	1	10-08	10-27	8	6	75.00	438	27.5	0.32
	2	10-02	10-29	24	10	41.67	832	28.9	0.33
	3	10-03	10-18	75	28	37.33	346	29.7	0.29
1988	1	10-26	10-27	11	9	81.82	85	38.7	0.28
	2	09-29	10-18	25	7	28.00	1650	29.2	0.30
	3	10-07	10-18	81	39	48.15	2127	27.3	0.41
1989	1	10-21	10-30	11	10	90.91	5182	31.2	0.29
	2	10-07	10-17	19	5	26.32	280	30.2	0.28
	3	10-08	10-25	88	46	52.27	881	27.9	0.36
1990	1	10-16	10-23	7	4	57.14	234	30.8	0.32
	2	09-27	10-16	35	9	25.71	3044	27.5	0.29
	3	10-06	10-11	83	27	32.53	2059	26.9	0.30
1991	1	10-17	10-24	6	4	66.67	29	32.2	0.29
	2	09-30	10-16	24	12	50.00	757	28.8	0.30
	3	09-30	10-12	77	17	22.08	14421	27.2	0.30
1992	1	10-20	10-27	4	4	100.00	1934	29.5	0.27
	2	10-06	10-20	30	15	50.00	4590	29.1	0.31
	3	10-08	10-14	62	12	19.35	2548	27.5	0.32
1993	1	10-20	10-20	18	18	100.00	3059	25.5	0.31
	2	09-27	10-14	34	15	44.12	3139	26.0	0.30
	3	09-28	10-10	58	10	17.24	671	24.9	0.24
1994	1	10-13	10-27	15	12	80.00	304	28.9	0.55
	2	10-04	10-27	39	10	25.64	1000	29.2	0.34
	3	10-04	10-27	85	16	18.82	1379	27.9	0.44
1995	1	10-16	10-19	17	13	76.00	1012	27.4	0.43
	2	09-25	10-03	25	15	60.00	3241	25.9	0.68
	3	10-02	10-26	83	24	29	713	26.2	0.57

Table 3. Research Catch-at -age in numbers for Georges Bank research samples based on 1,000 t and the 1994 commercial fishery of 228 t.

Year	Number Aged	Age 1	2	3	4	5	6	7	8	9	10	TOTAL
1986	108	0	0	65043	4703	2677	0	0	0			72350
1988	381	0	11481	32355	22892	2157	278	278	278			69580
1988	300	9372	445	9796	30689	11159	2450	160	304			64375
1989	126	4877	7574	31408	9255	15591	4013	295	137			73150
1990	521	0	10584	39633	17904	4905	3636	1845	382	121	808	79818
1991	272	0	19340	21693	22576	7098	3047	3932	3527	293	265	81772
1992	36	0	6360	38052	18553	8499	5753	5148				82365
1993	228	0	349	48661	25100	7430	906					82446
1994	351	0	2722	2627	35610	21863	6379	3005	647	414		73268
1995	165	0	15120	11450	32280	19420	2760	1280				82310
Commercial Fishery 1994		0	0	62	2193	5359	2301	2531	91	0	0	12537

Table 4. Georges Bank numbers at age (000's) for abundance estimates from the fall bottom trawl surveys.

Year	Number Aged	Age 1	2	3	4	5	6	7	8	9	10	Total
1987	42	0	353	6029	7850	895	0	0	0	0	0	15127
1988	152	388	1385	8238	9159	2680	0	52	0	0	0	21902
1989	82	222	2422	3348	1505	777	422	59	0	0	0	8755
1990	31	0	0	778	3521	481	219	0	0	0	0	4999
1991	169	0	0	244065	94681	16448	3817	0	0	0	0	359011
1992	276	0	4402	35081	14771	5045	1128	227	0	0	0	60654
1993	43	0	0	2401	8515	3006	409	0	0	0	0	14331
1994	76	652	3278	7746	3810	3510	987	58	0	0	0	20041

Table 5. Summary of maturity stages of adult herring taken during Canadian fall surveys on Georges Bank (1986 - 1995).

Year	Gonad stages 1	2	3	4	5	6	7	8	Number samples
1986	-	10 (9.3)	1 (0.9)	-	6	30	2	59	108
1987	1 (0.2)	181 (45.9)	-	-	10 (2.5)	24 96.1)	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 (0.8)	120 (23.0)	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
1994	3 (1.0)	25 (8.0)	4 (1.3)	-	3 (1.0)	3 (1.0)	26 (8.3)	250 (79.6)	315
1995	5 (3.0)	20 (11.0)	- -	-	5 (3.0)	2 (1.0)	34 (18.0)	119 (64.0)	185

Table 6. Dates, catch of larval herring, mean number of larvae per tow and mean total length from Canadian fall larval surveys on Georges Bank.

	catch					Length (mm)			
Year	Dates	# caught	# of sets	mean	SE	mean	STD	min	max
1987	23 Oct - 10 Nov	4898	40	22.02	1.24	9.38	1.94	5	19
1988	28 Oct - 7 Nov	4075	76	6.51	0.41	13.09	3.05	6	21
1989	25 Oct - 05 Nov	4386	90	7.37	0.53	12.41	1.78	7	21
1990	31 Oct - 10 Nov	5903	79	10.21	0.46	11.64	1.88	7	19
1991	04 Nov - 12 Nov	1508	76	3.32	0.31	13.41	3.73	5	20
1992	24 Nov - 30 Nov	7743	86	12.61	0.44	14.55	4.40	5	29
1993	12 Nov - 26 Nov	15718	71	30.78	0.70	12.84	2.24	5	26
1994	16 Nov - 29 Nov	43106	81	52.90	0.96	11.34	1.60	5	28
1995	16 Nov - 30 Nov	41286	85	47.30	1.01	14.10	3.80	3	27

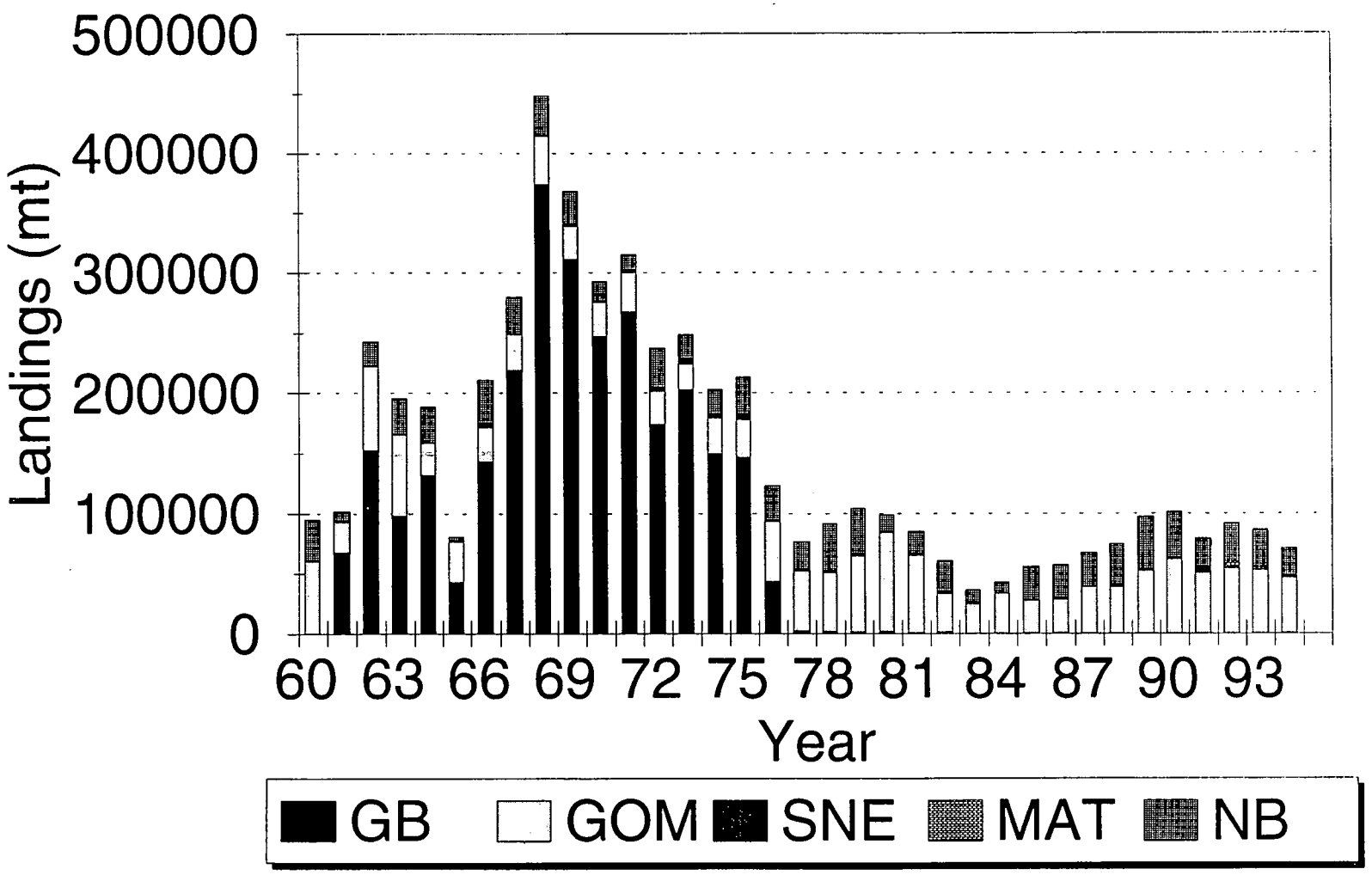

Figure 1. Atlantic herring landings (mt) for Georges Bank, Gulf of Maine, Southern New England, Mid-Atlantic, and the NB weir fishery. Source: (US 21st SAW).

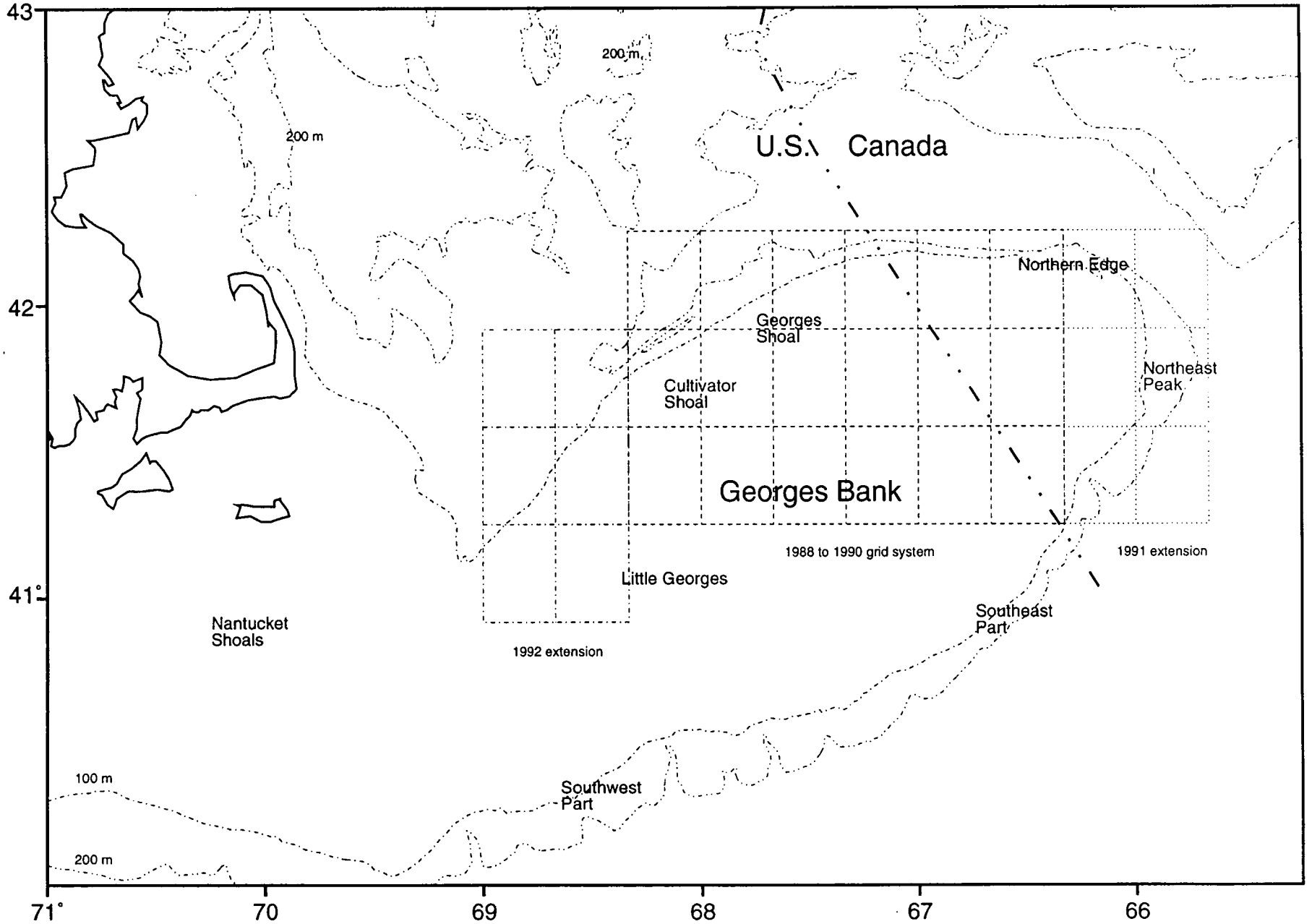

Figure 2. Georges Bank herring survey area including the original sampling grid (1988-1991) and the extensions in 1991 and 1992.

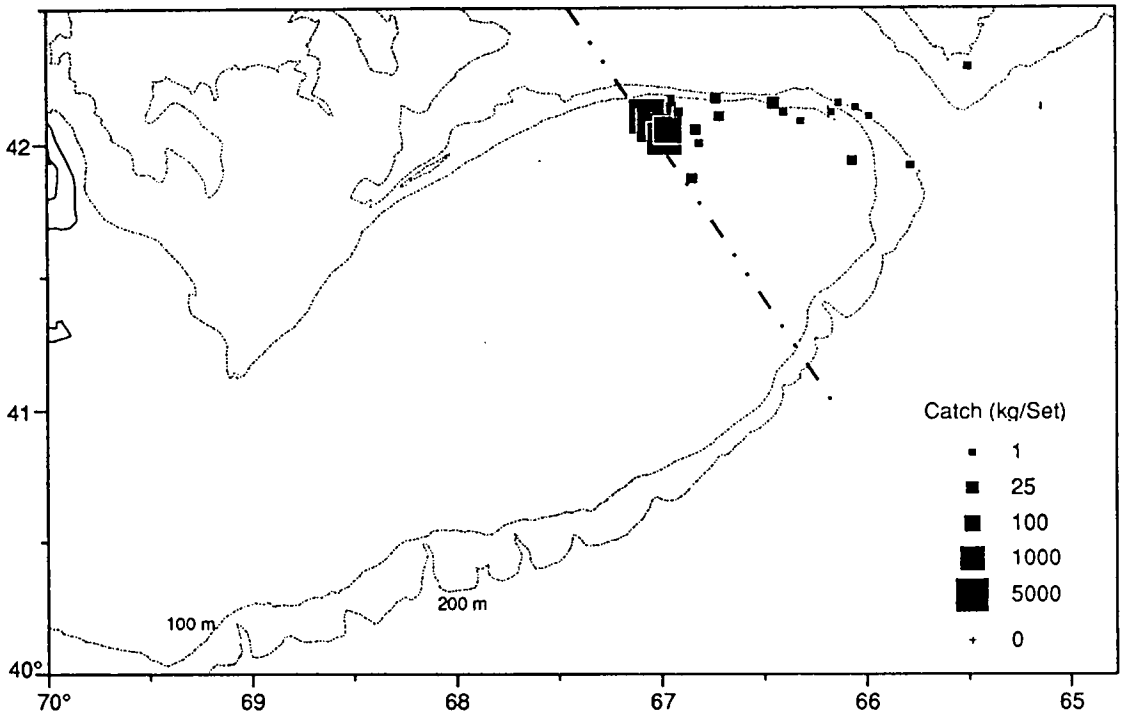

Figure 3. The 1994 reported landings (directed and by-catch) of herring on Georges Bank from IOP database. Note: Catches in excess of 5000 kg represent seiner reports.

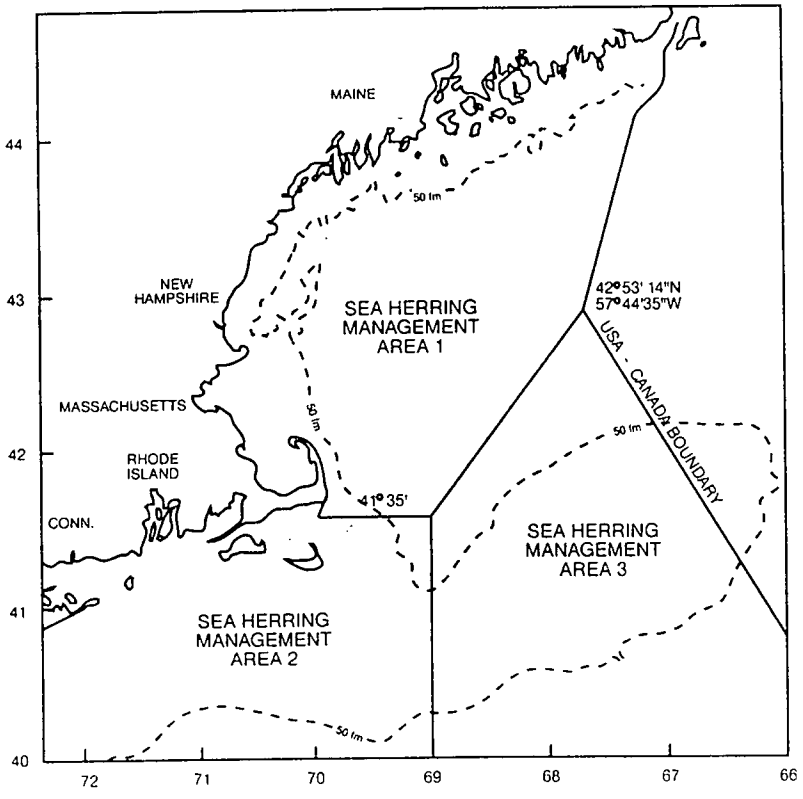

Figure 4. Chart of western Gulf of Maine showing the 3 herring management areas that make up the USA coastal zone complex from which biomass estimates are derived. The 50 fathom depth contour is also shown.

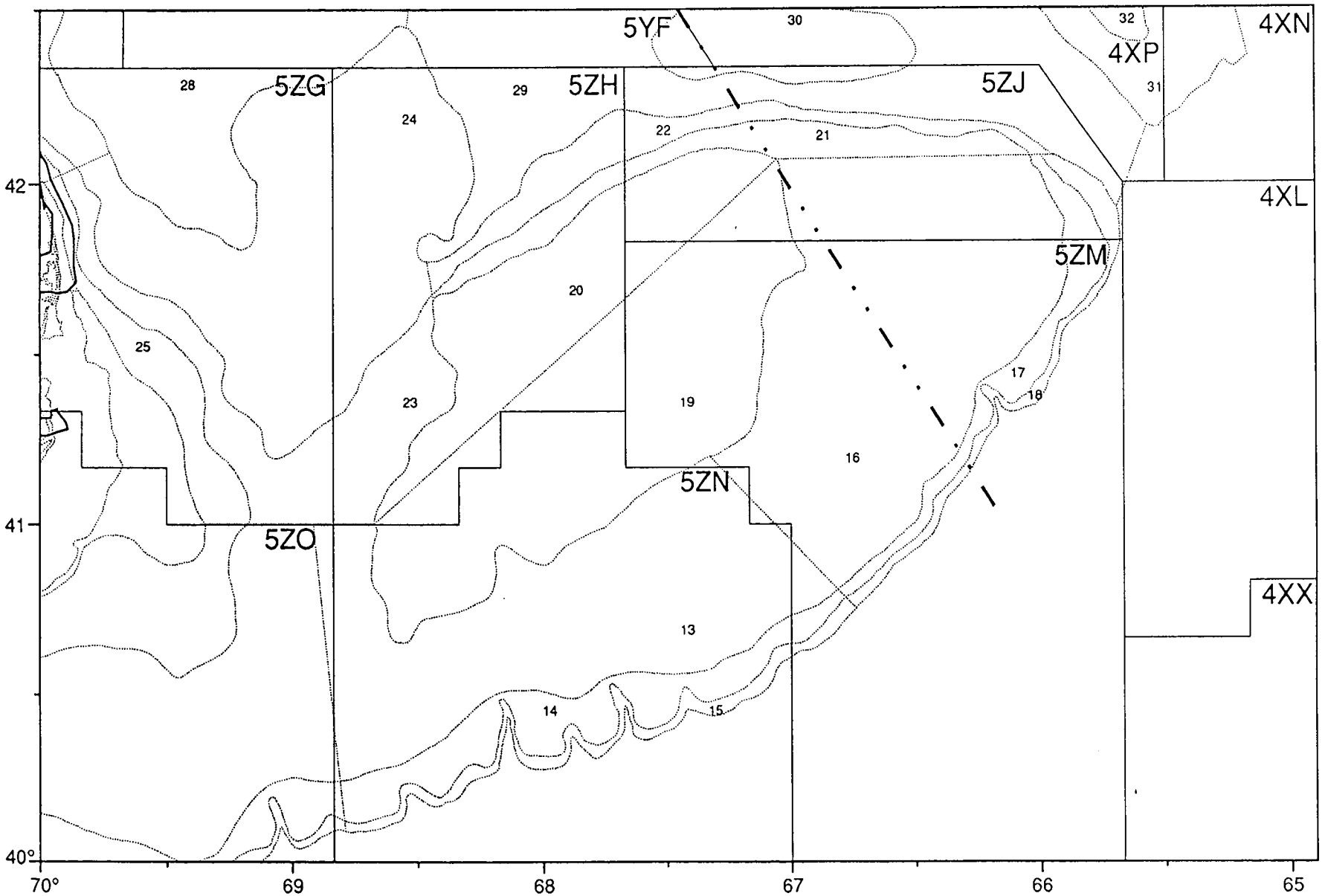

Figure 5. US survey strata (numbers)and NAFO subdivisions (letters) for the Georges Bank area.

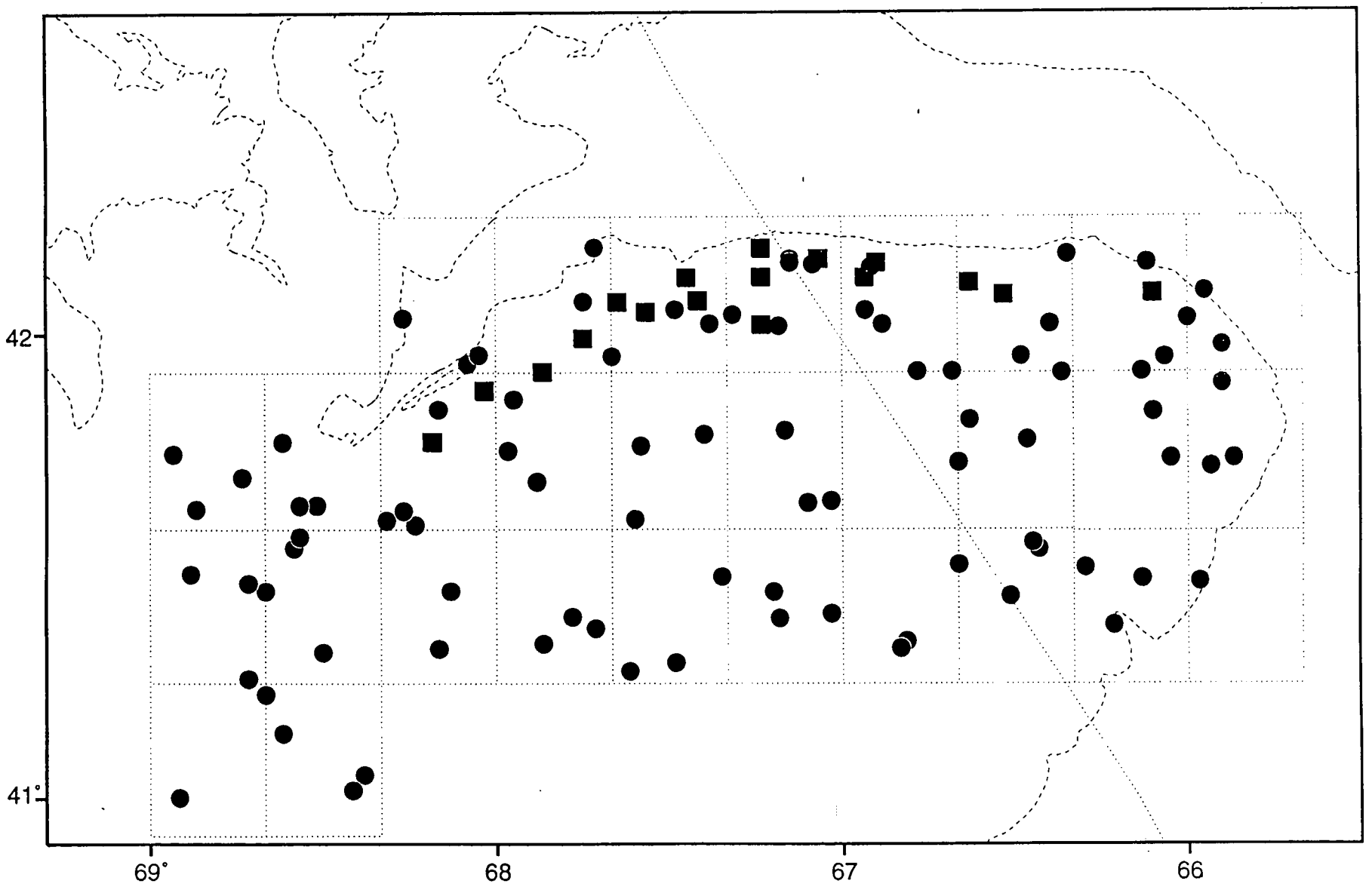

Figure 6. The 1995 bongo (circle) and bottom trawl (square) sampling stations for Georges Bank herring survey - N233.

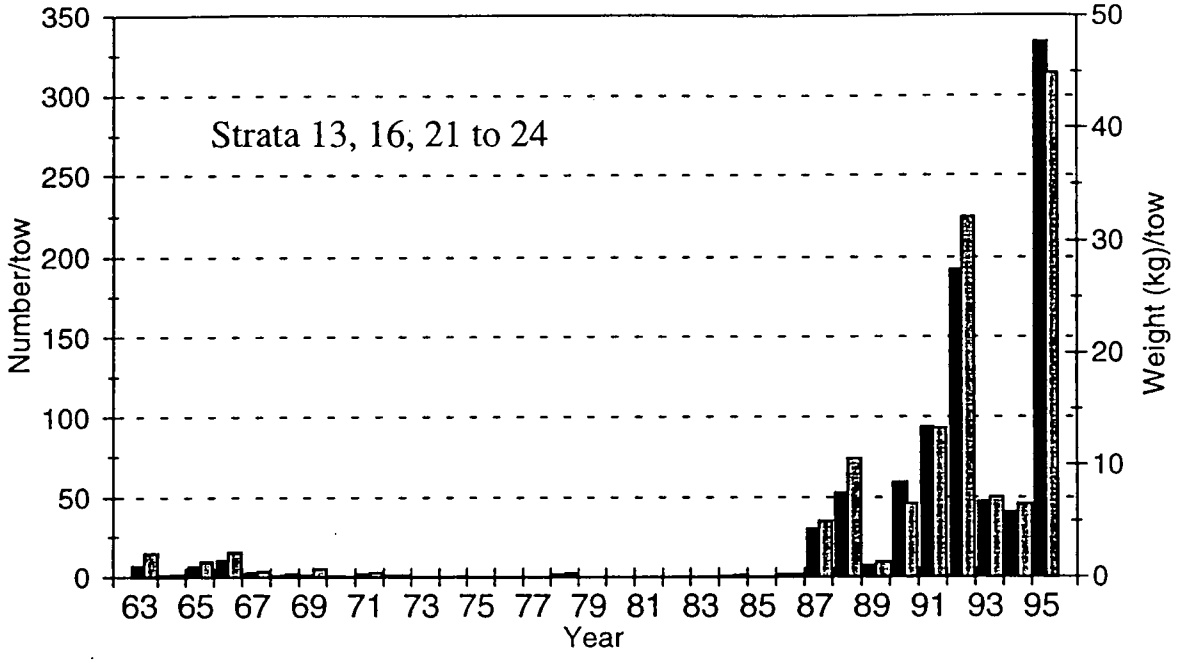

Figure 7a. US fall bottom trawl straified mean catch per tow (numbers - solid and weight - hatched) for the stratum used in the historical VPA.

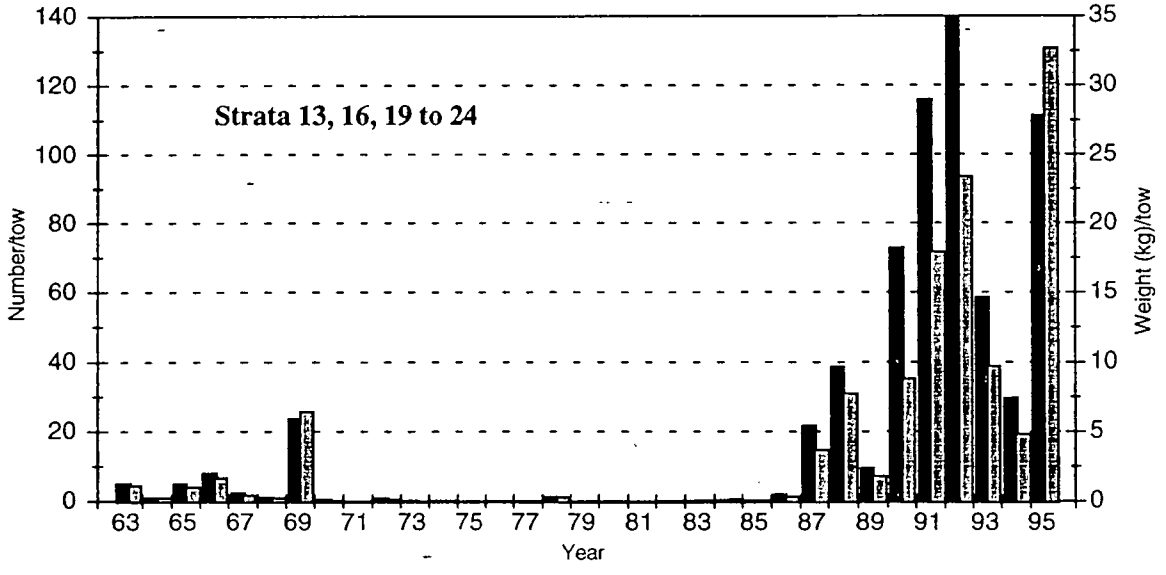

Figure 7b. US fall bottom trawl straified mean catch per tow (numbers - solid and weight - hatched) for the all Georges Bank strata. See Figure for strata locations.

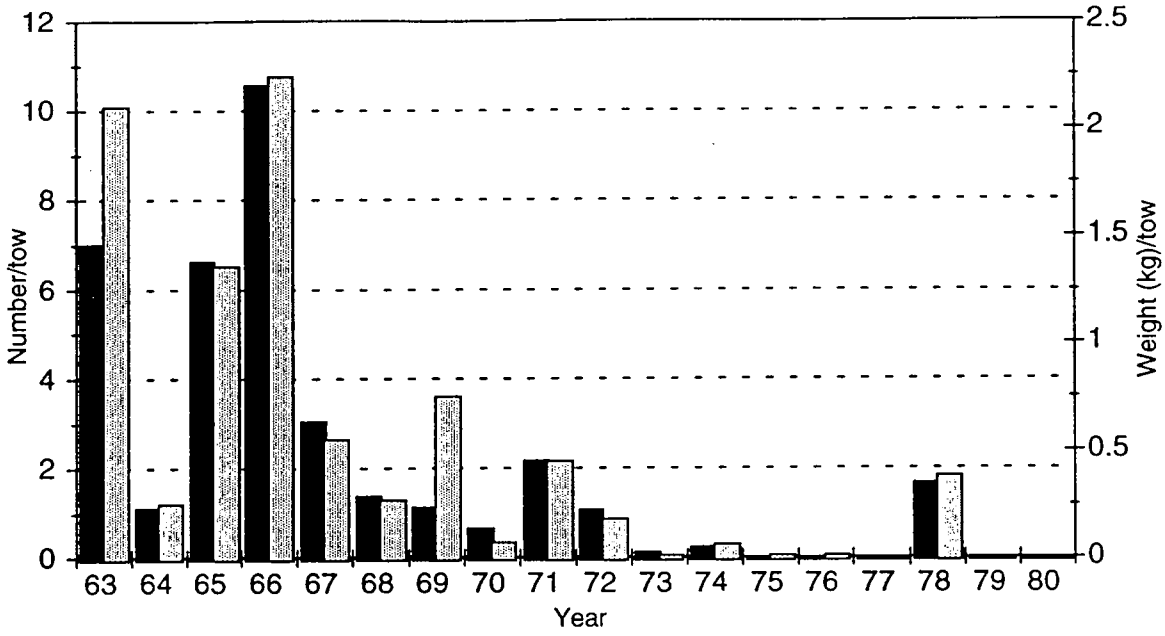

Figure 7c. US fall bottom trawl, 1963-80, stratified mean catch per tow (Numbers -solid and Weight -dotted) for the historical assessment strata (13, 16, 21 to 24).

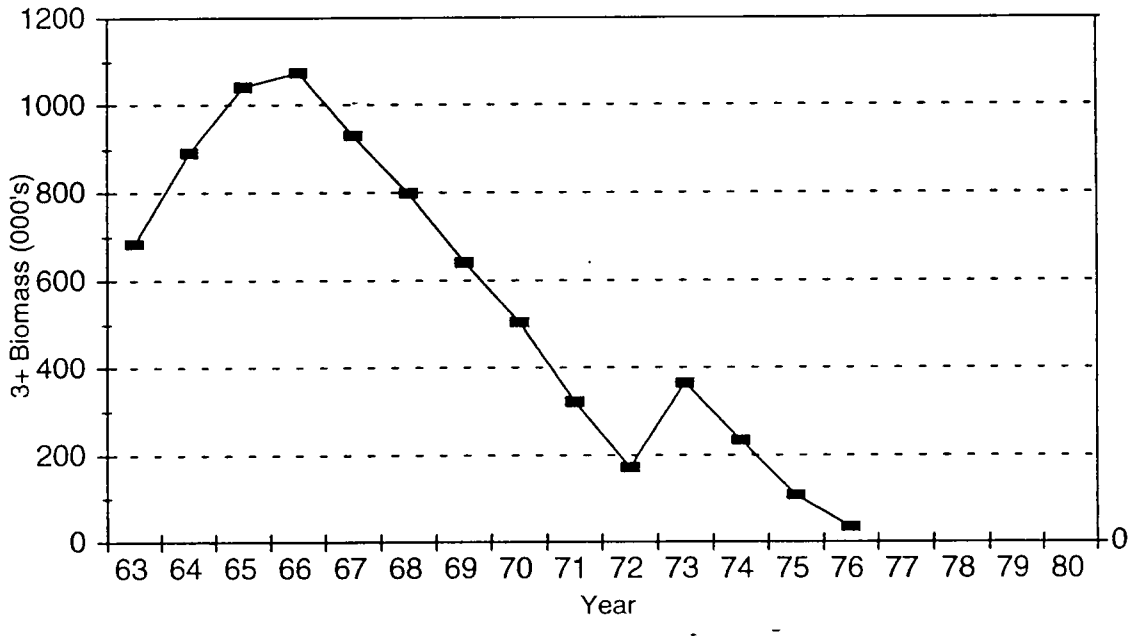

Figure 7d. Georges Bank 3+ biomass as reported by Anthony and Waring , 1990.

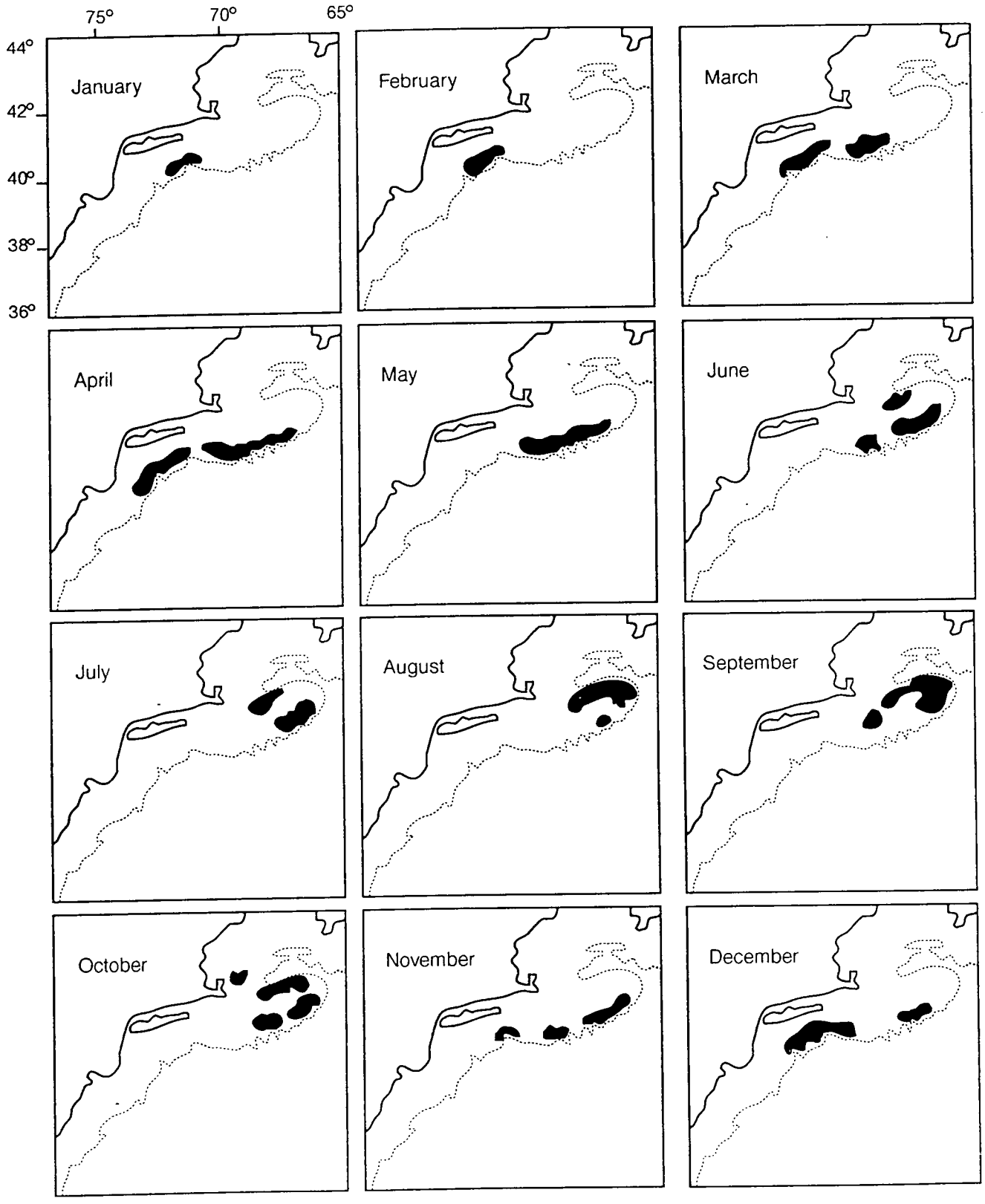

Figure 8. Monthly distribution of herring observed by the USSR fleet in 1965.
Source: Zinkevich (1967)

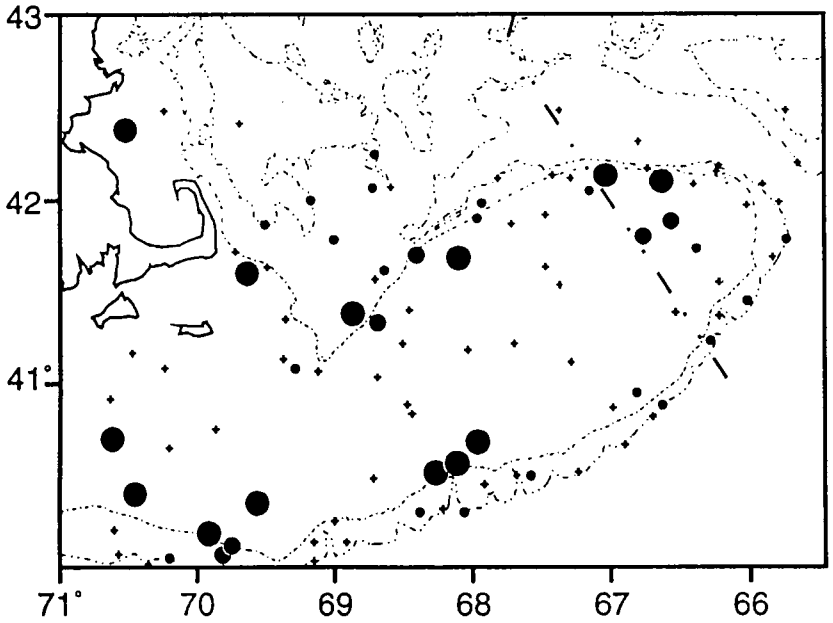

Figure 9. US 1966 survey. Oct 12 - Nov 10
Adult herring as per adjacent scale.

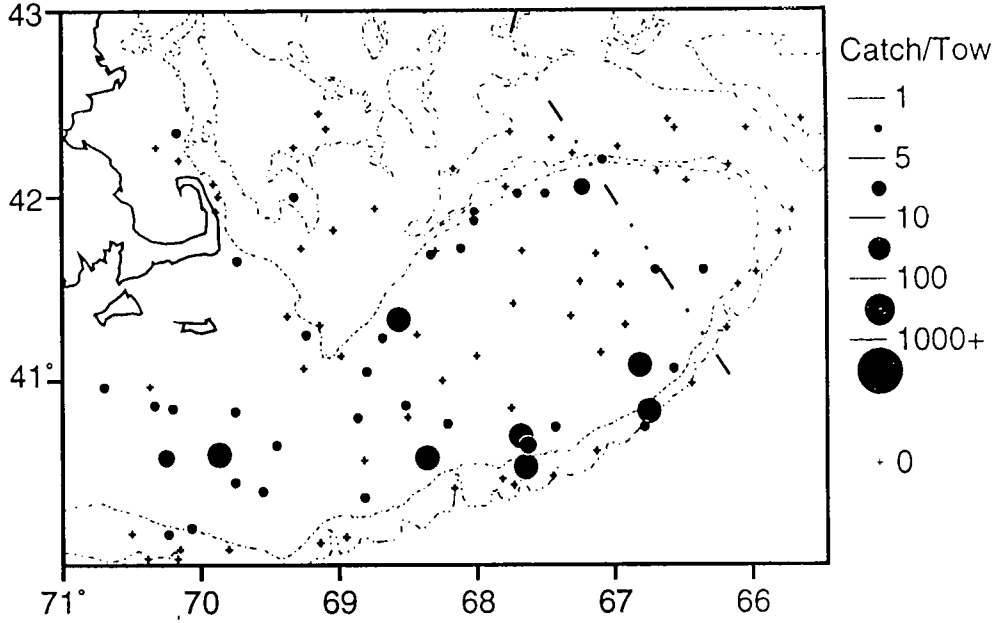

Figure 10. US 1967 survey. Oct 17 - Dec 9
Adult herring as per adjacent scale.

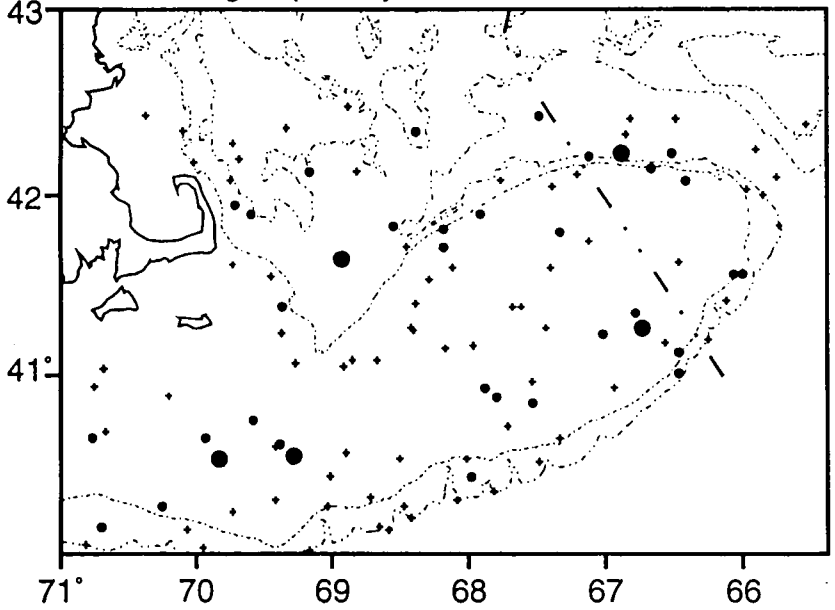

Figure 11. US 1968 survey. Oct 10 - Nov 22
Adult herring as per adjacent scale.

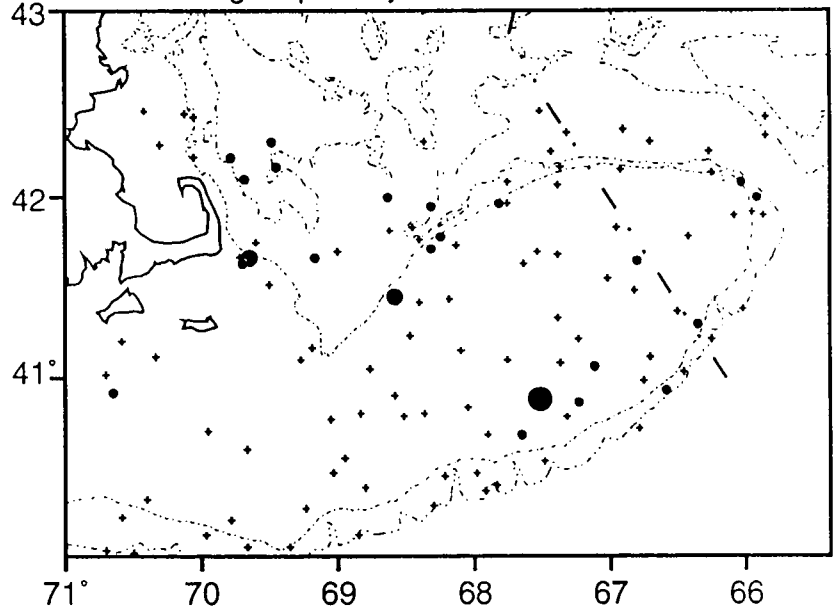

Figure 12. US 1969 survey. Oct 9 - Nov 23
Adult herring as per adjacent scale.

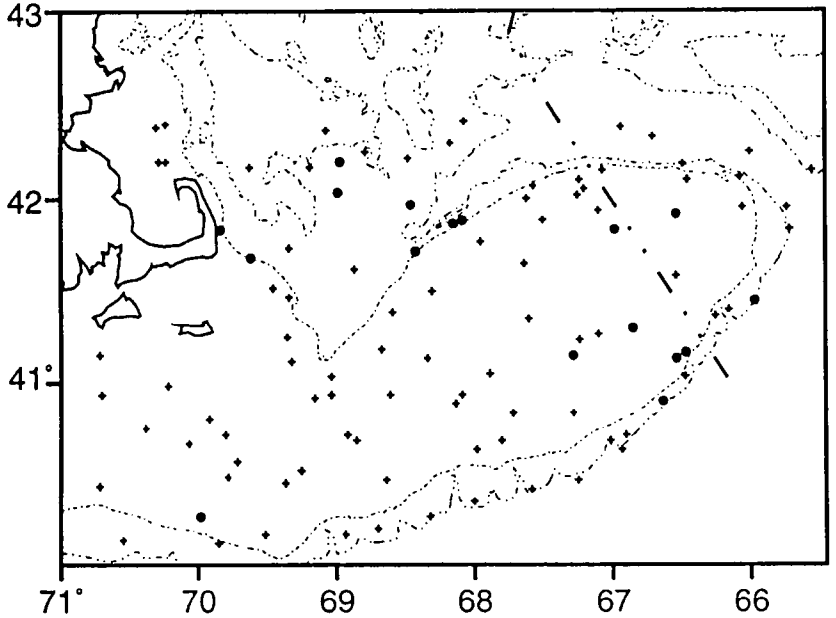

Figure 13. US 1970 survey. Oct 16 - Nov 20
Adult herring as per adjacent scale.

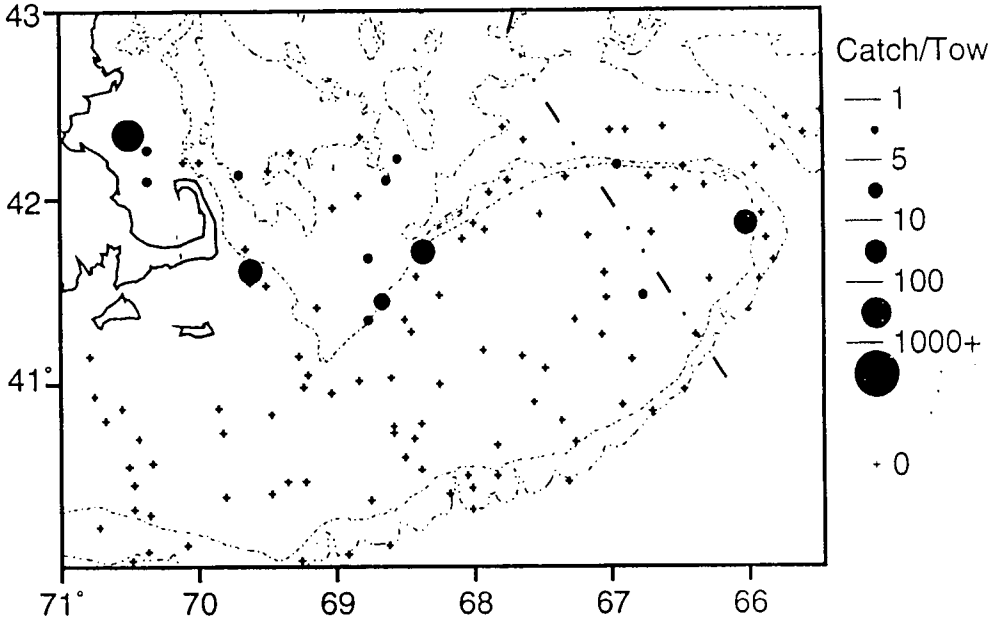

Figure 14. US 1971 survey. Sept 29 - Nov 19
Adult herring as per adjacent scale.

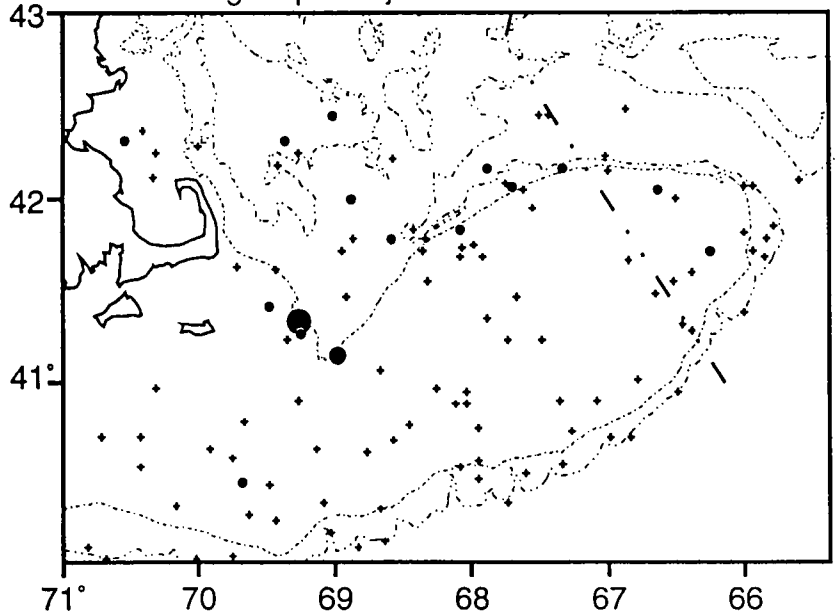

Figure 15. US 1972 survey. Sept 29 - Nov 19
Adult herring as per adjacent scale.

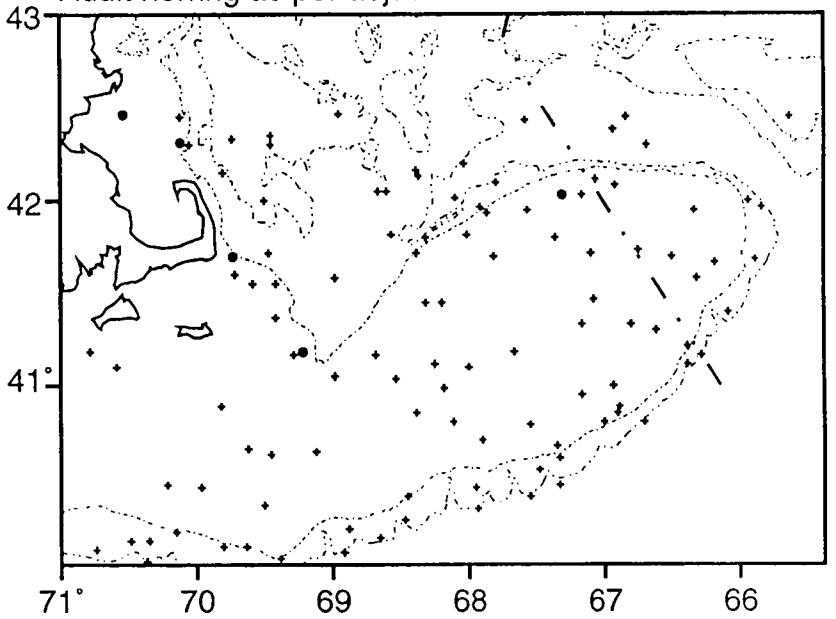

Figure 16. US 1973 survey. Oct 6 - Nov 19
Adult herring as per adjacent scale.

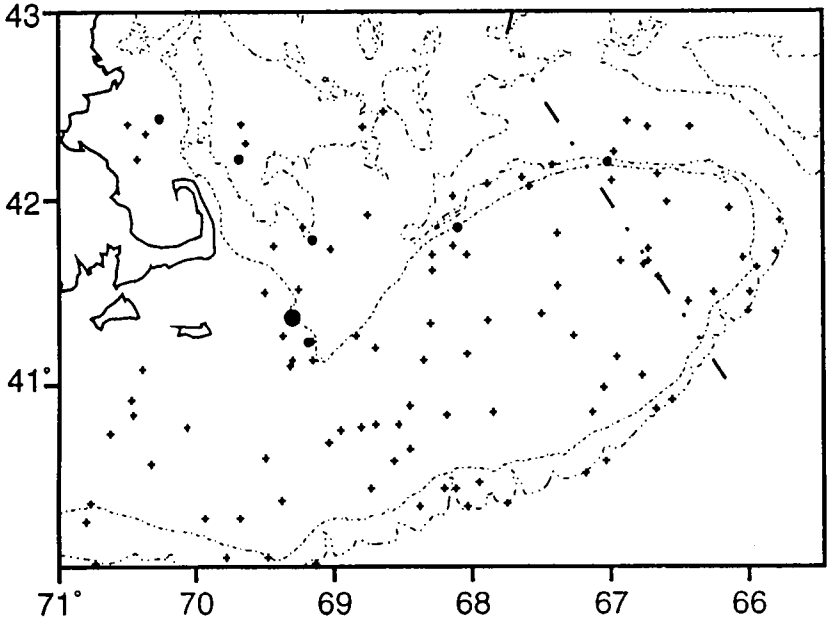

Figure 17. US 1974 survey. Sept 23 - Nov 1
Adult herring as per adjacent scale.

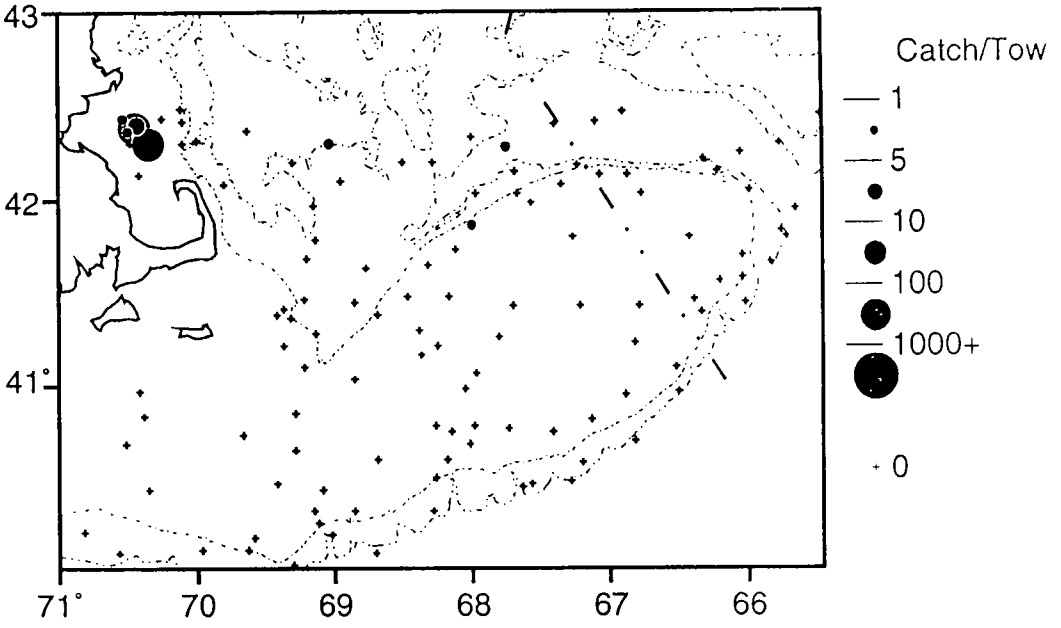

Figure 18. US 1975 survey. Oct 7 - Nov 9
Adult herring as per adjacent scale.

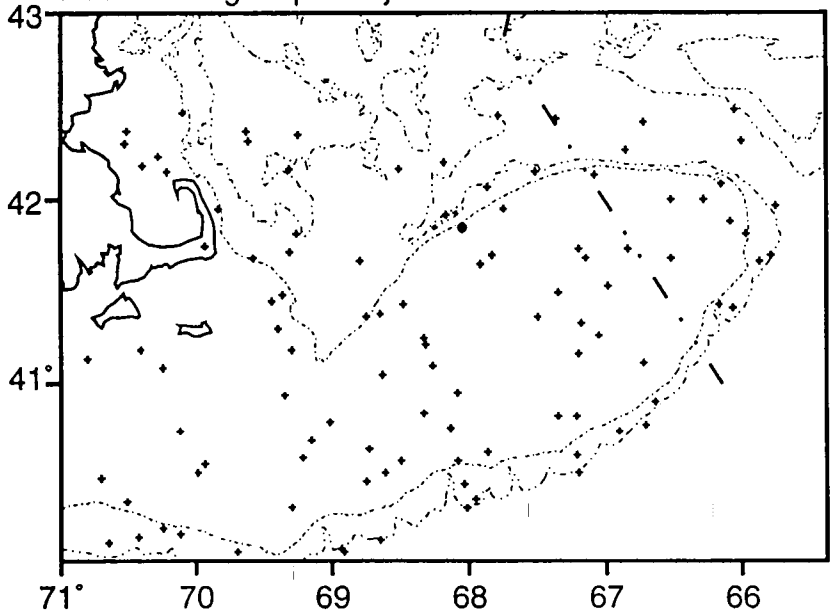

Figure 19. US 1976 survey. Sept 29 - Nov 22
Adult herring as per adjacent scale.

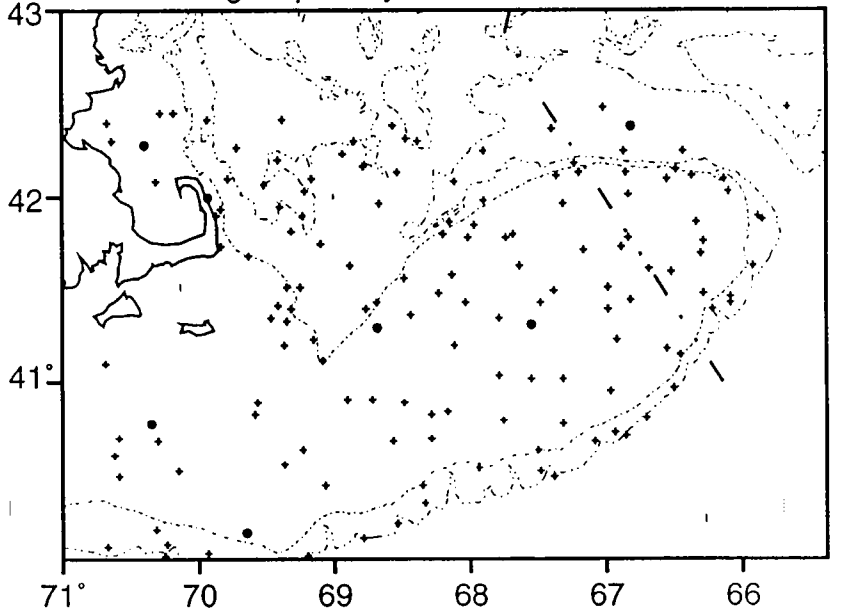

Figure 20. US 1977 survey. Oct 16 - Dec 15
Adult herring as per adjacent scale.

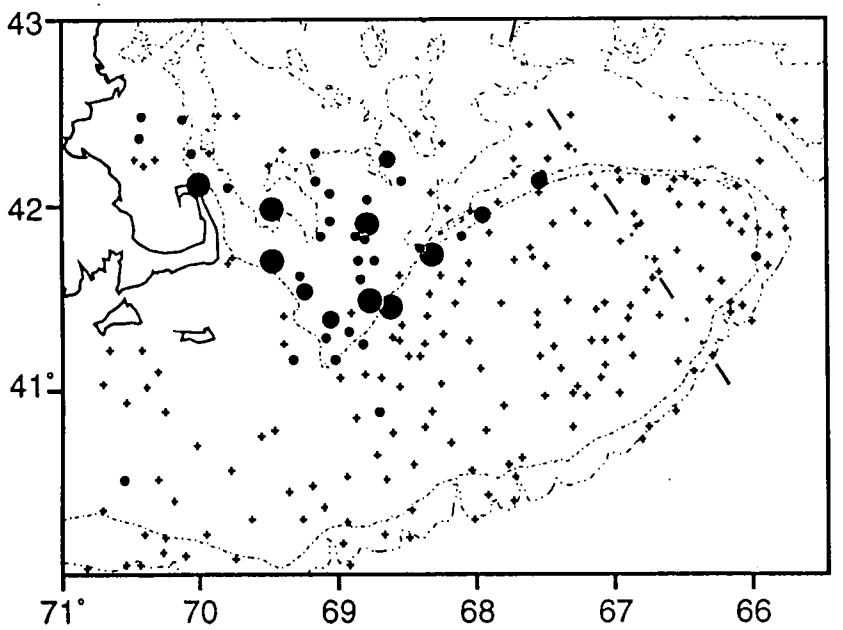

Figure 21. US 1978 survey. Sept 26 - Nov 20
Adult herring as per adjacent scale.

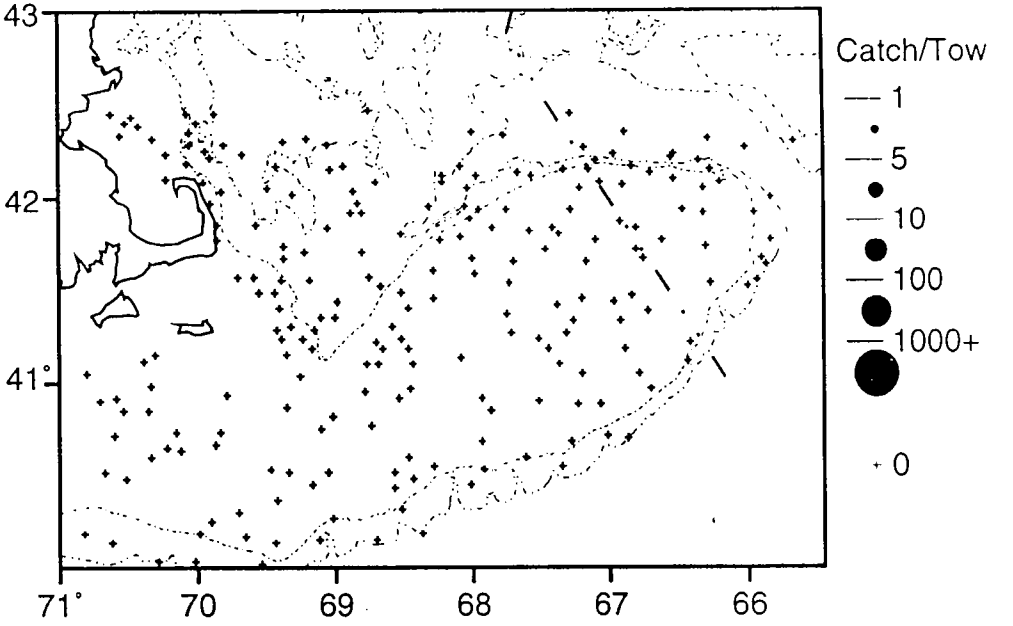

Figure 22. US 1979 survey. Oct 12 - Nov 18
Adult herring as per adjacent scale.

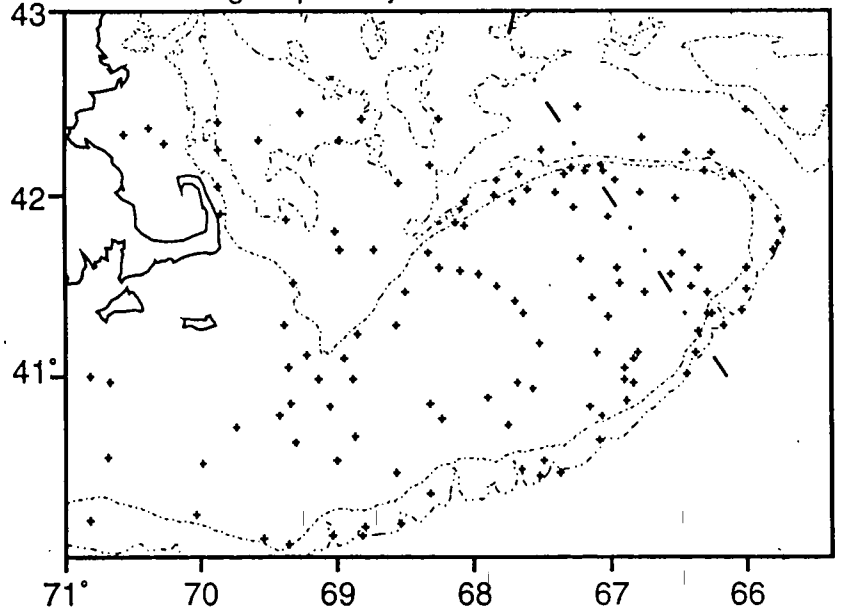

Figure 23. US 1980 survey. Oct 7 - Nov 14
Adult herring as per adjacent scale.

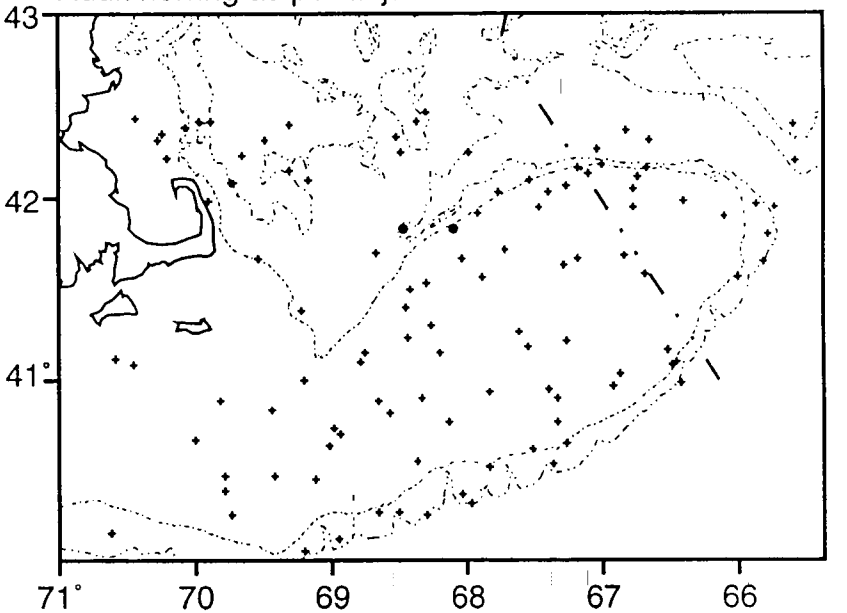

Figure 24. US 1981 survey. Oct 6 - Nov 7
Adult herring as per adjacent scale.

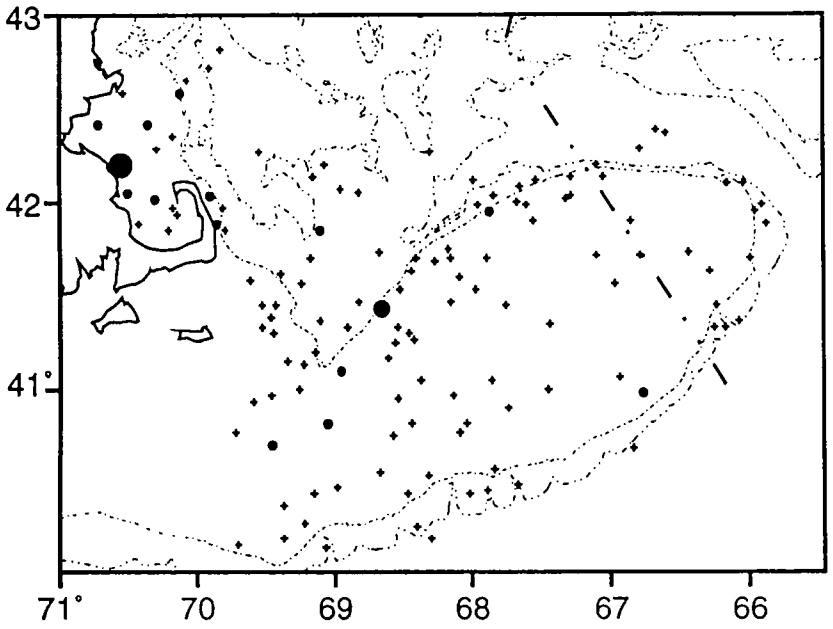

Figure 25. US 1982 survey. Oct 12 - Nov 11
Adult herring as per adjacent scale.

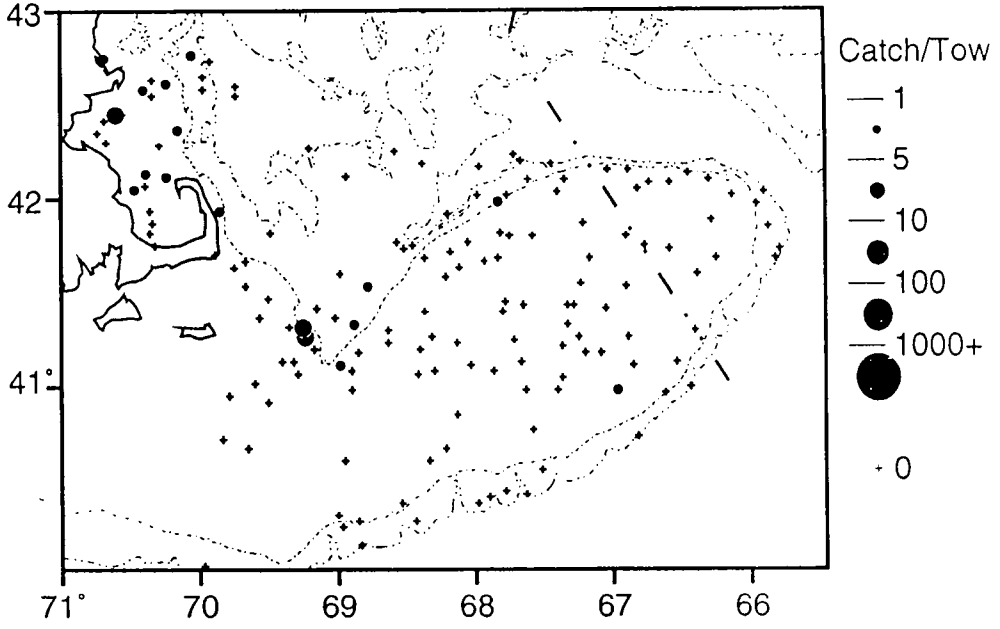

Figure 26.US 1983 survey. Oct 8 - Nov 9
Adult herring as per adjacent scale.

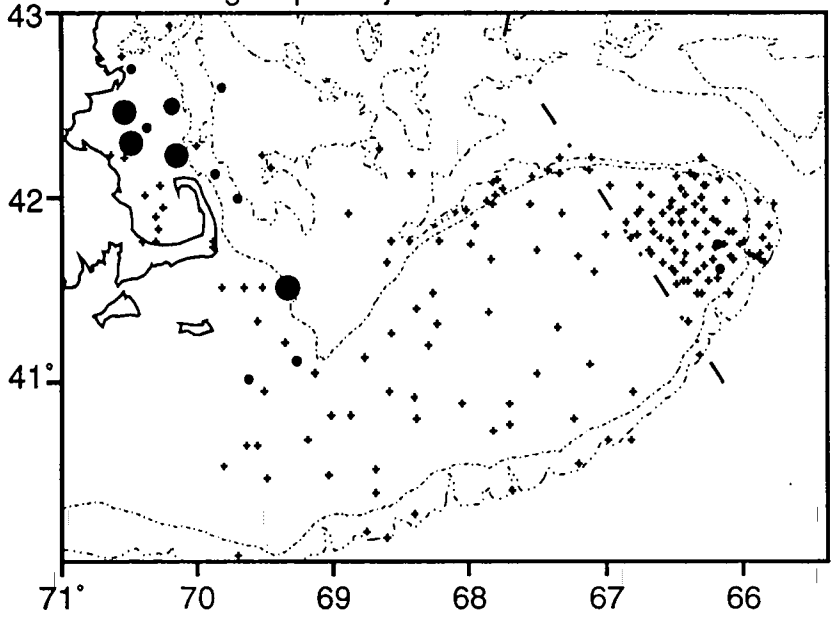

Figure 27. US 1984 survey. Sept 11 - Nov 6
Adult herring as per adjacent scale.

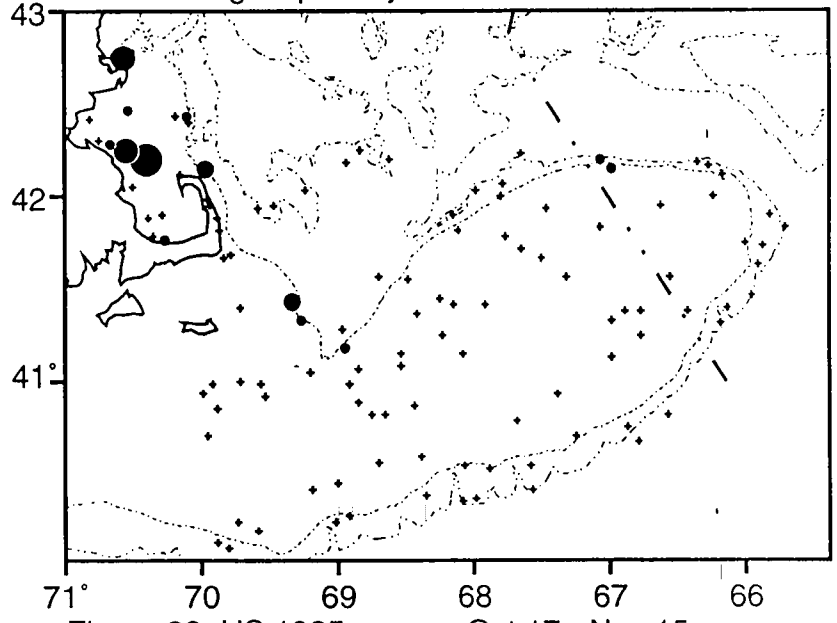

Figure 28. US 1985 survey. Oct 17 - Nov 15
Adult herring as per adjacent scale.

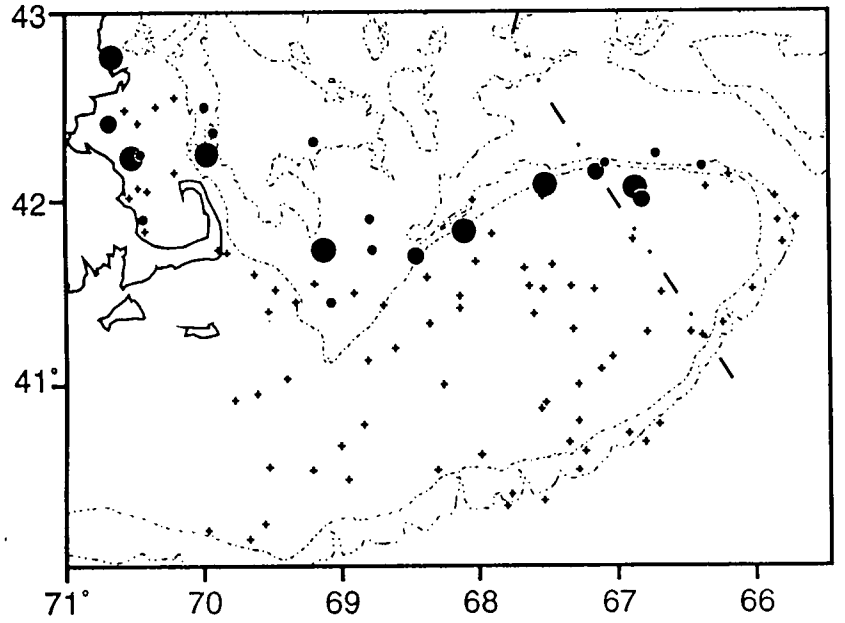

Figure 29a. US 1986 survey. Oct 7 - Nov 5
Adult herring as per adjacent scale.

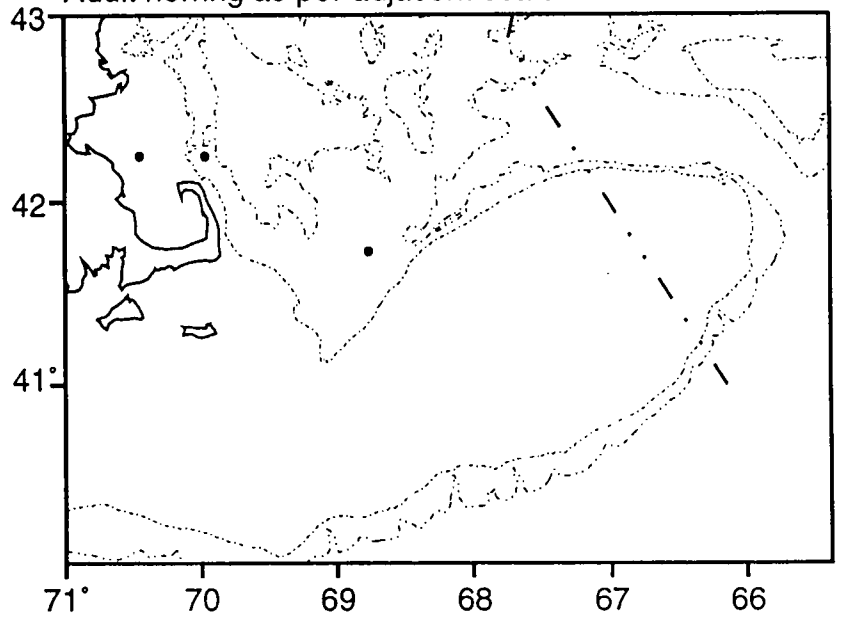

Figure 29b. US 1986 survey. Oct 7 - Nov 5
Large herring (>30cm total length) as per adjacent scale.

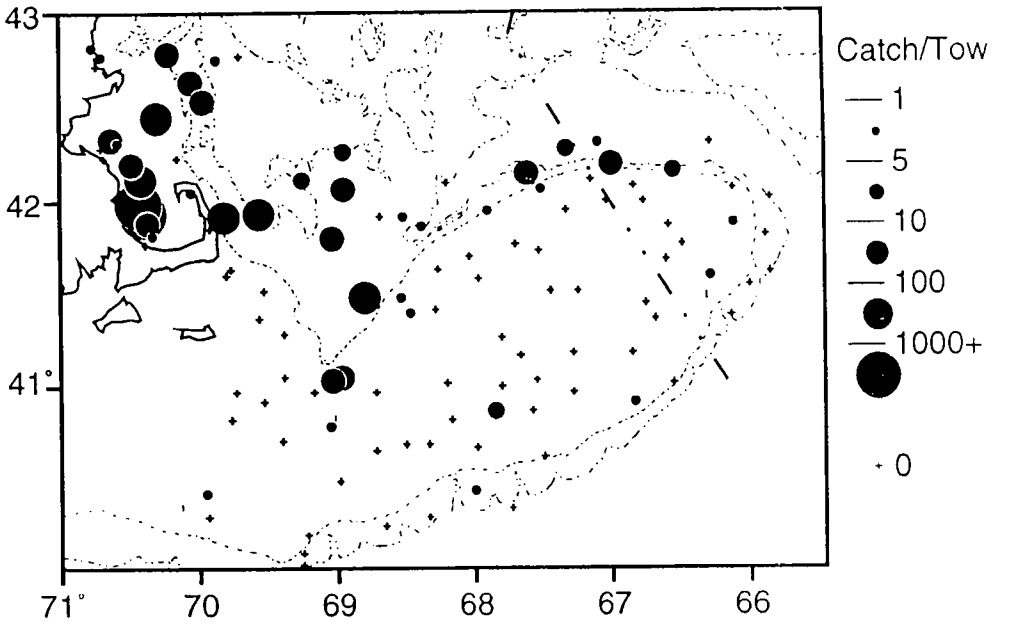

Figure 30a. US 1987 survey. Oct 2 - Nov 5
Adult herring as per adjacent scale.

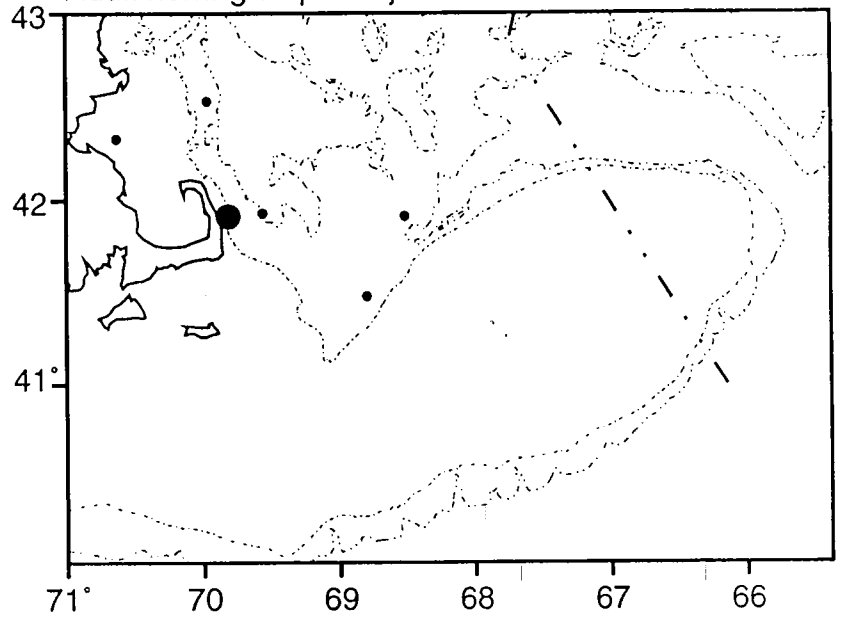

Figure 30b. US 1987 survey. Oct 2 - Nov 5
Large herring (>30cm total length) as per adjacent scale.

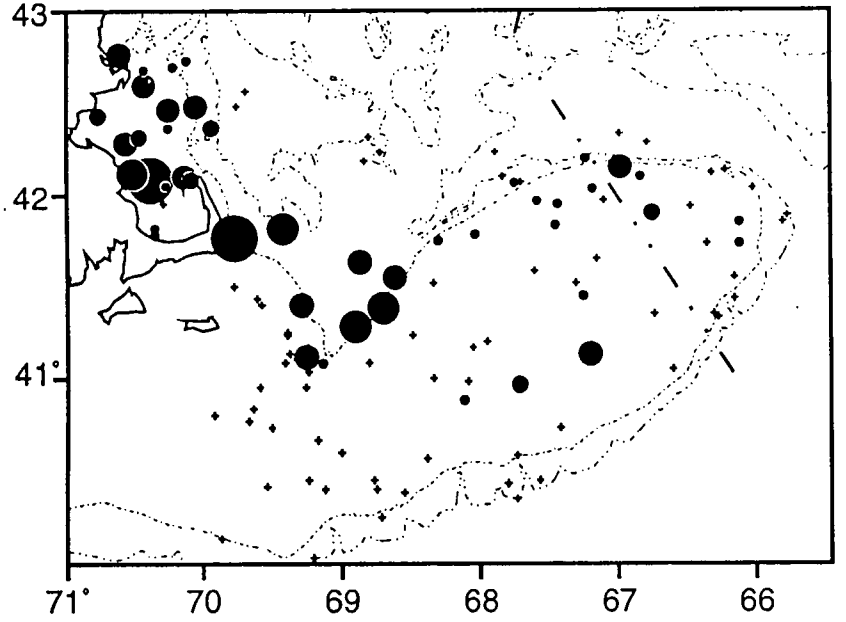

Figure 31a. US 1988 survey. Sept 29 - Oct 27
Adult herring as per adjacent scale.

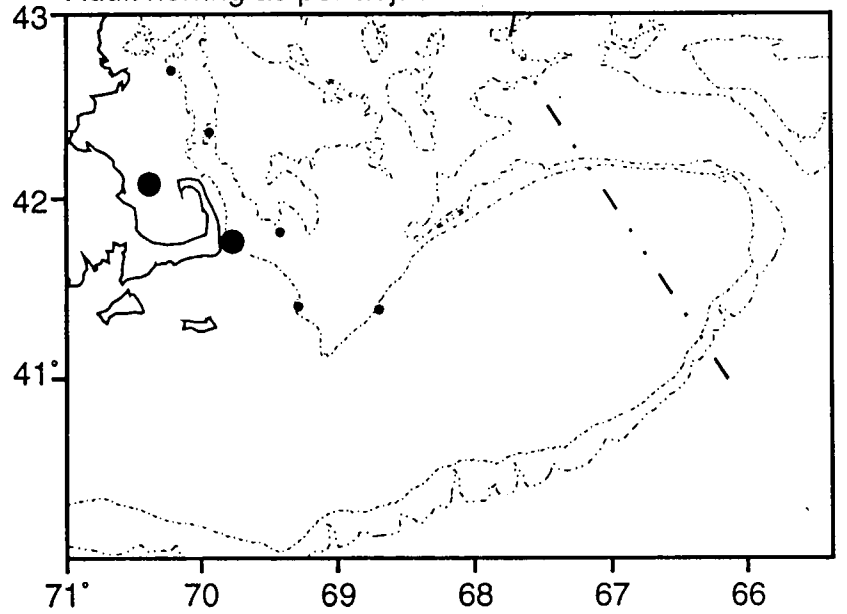

Figure 31b. US 1988 survey. Sept 29 - Oct 27
Large herring (>30cm total length) as per adjacent scale.

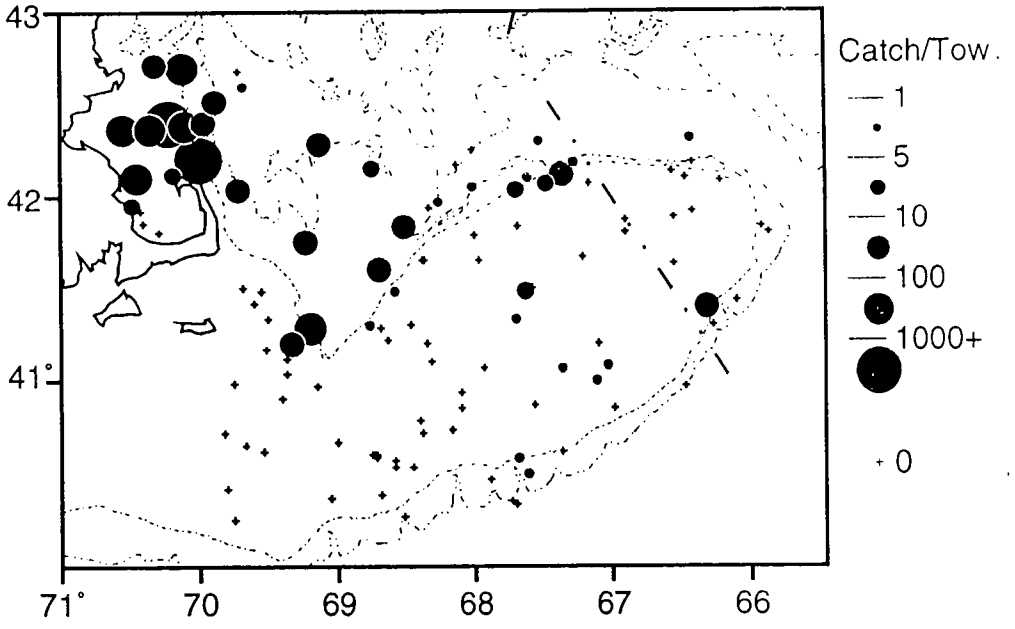

Figure 32a. US 1989 survey. Oct 6 - 31
Adult herring as per adjacent scale.

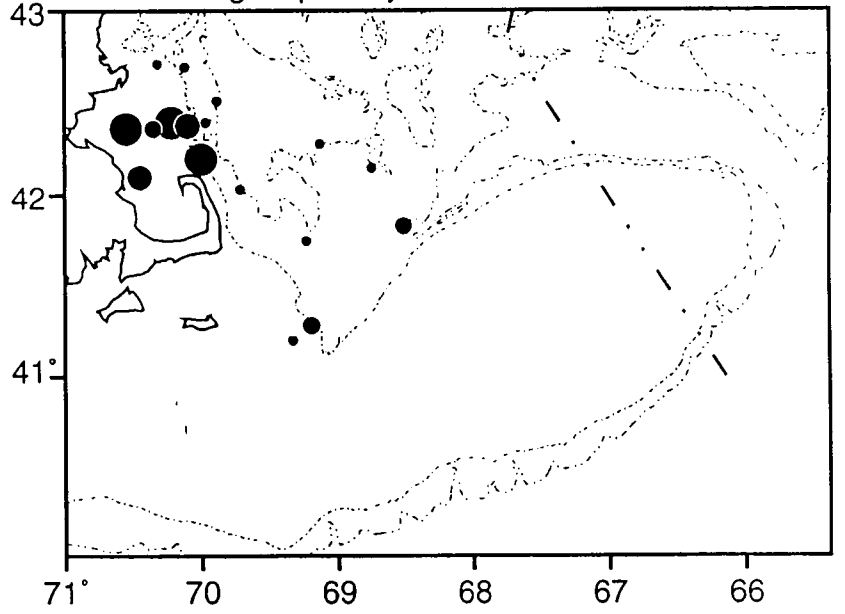

Figure 32b. US 1989 survey. Oct 6 - 31
Large herring (>30cm total length) as per adjacent scale.

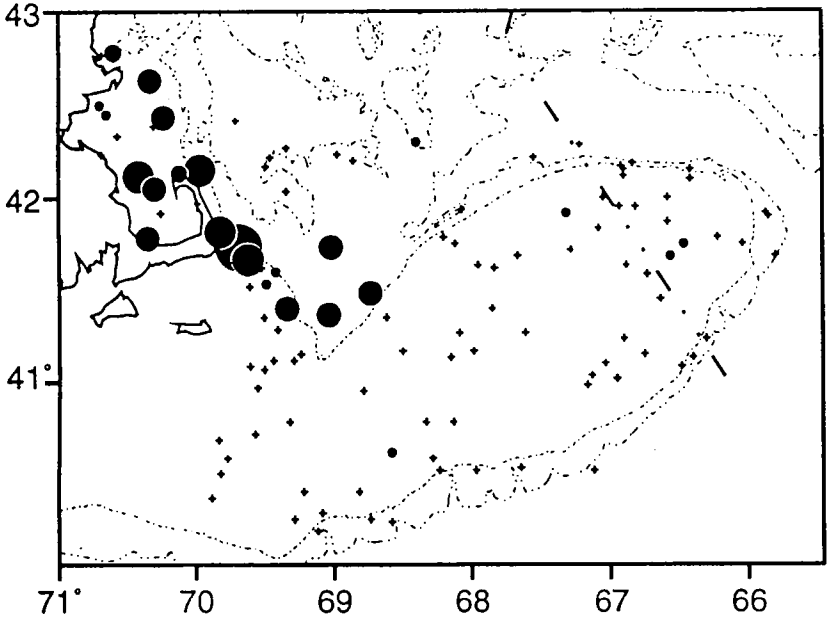

Figure 33a. US 1990 survey. Sept 27 - Oct 24
Adult herring as per adjacent scale.

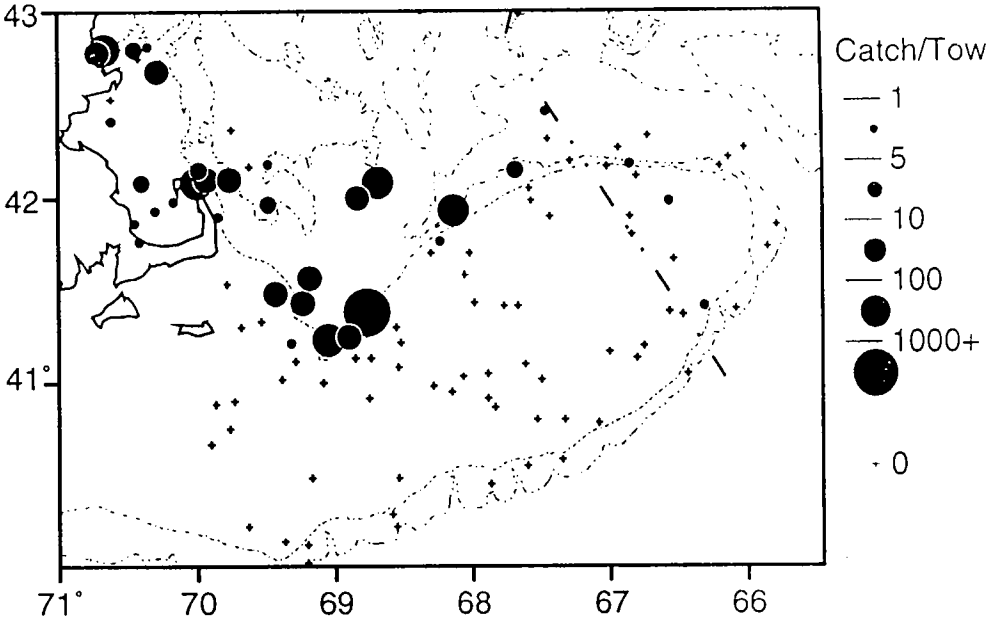

Figure 34a. US 1991 survey. Sept 30 - Oct 24
Adult herring as per adjacent scale.

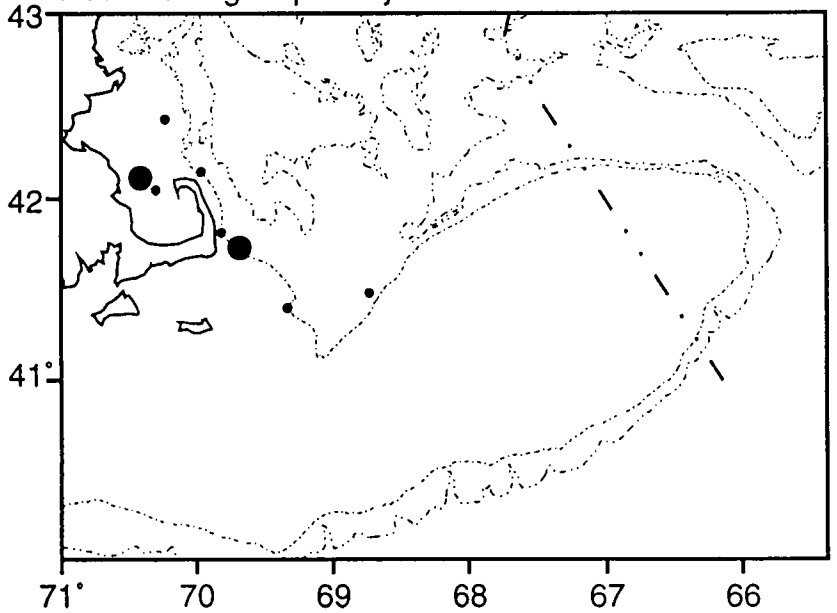

Figure 33b. US 1990 survey. Sept 27 - Oct 24
Large herring (>30cm total length) as per adjacent scale.

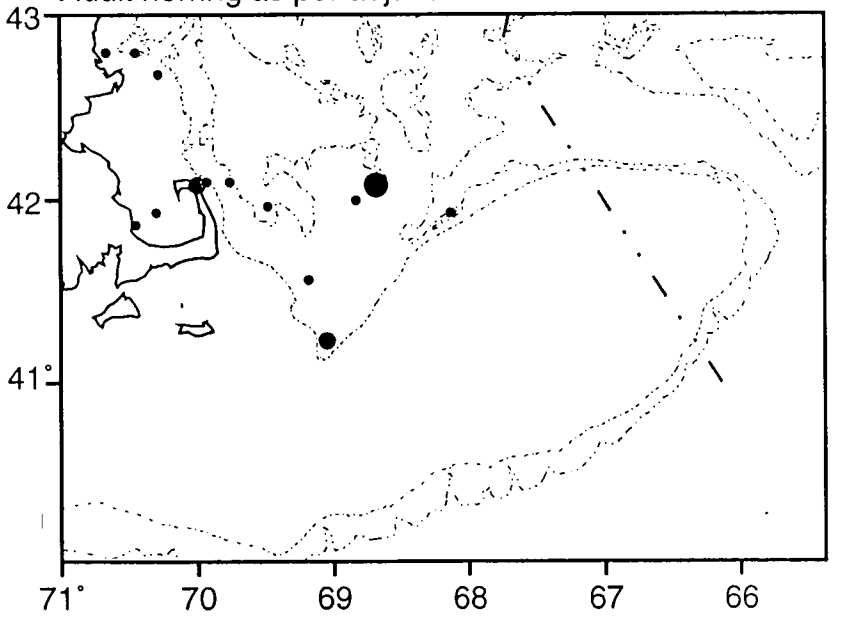

Figure 34b. US 1991 survey. Sept 30 - Oct 24
Large herring (>30cm total length) as per adjacent scale.

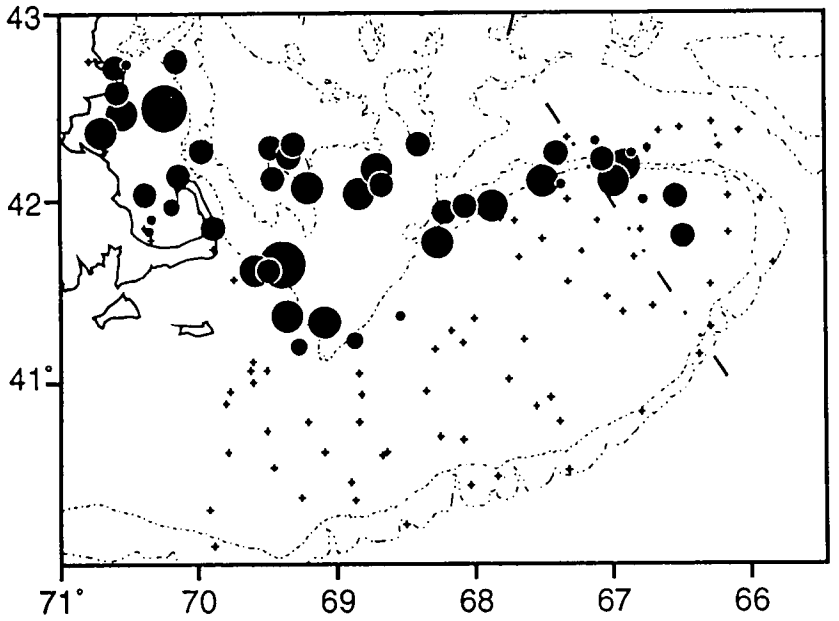

Figure 35a. US 1992 survey. Oct 6 - 27
Adult herring as per adjacent scale.

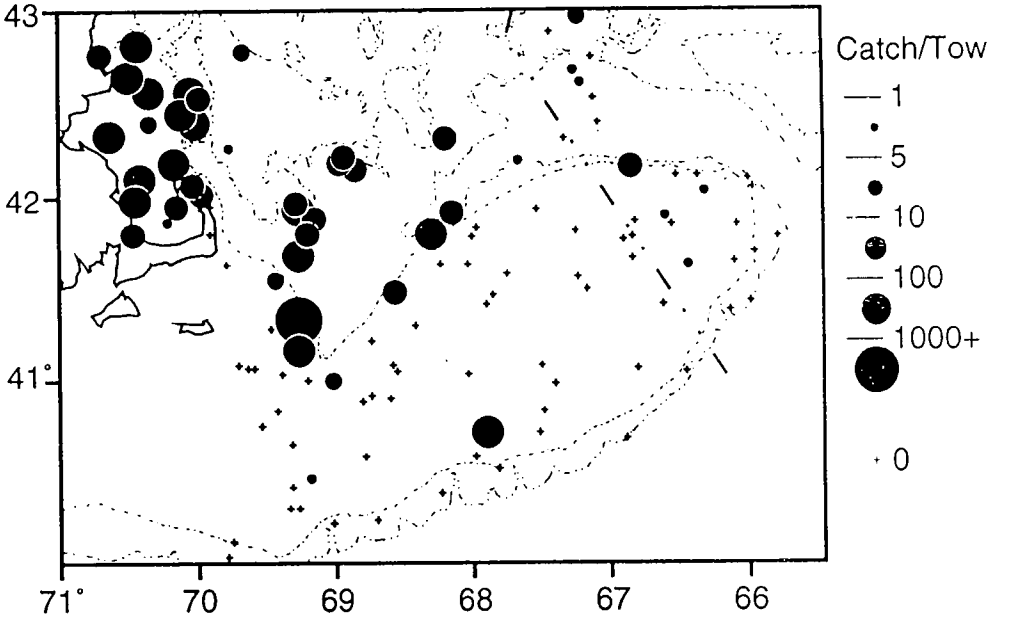

Figure 36a. US 1993 survey. Sept 27 - Oct 20
Adult herring as per adjacent scale.

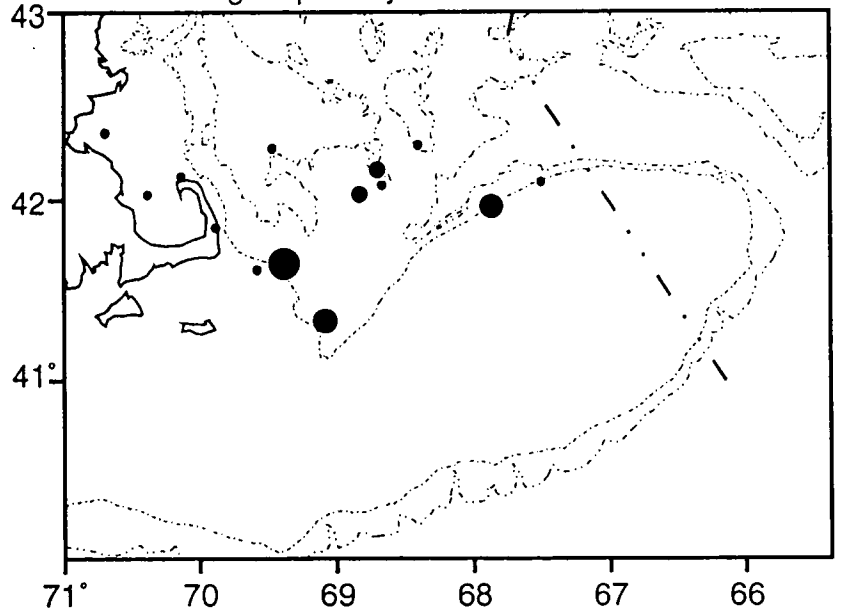

Figure 35b. US 1992 survey. Oct 6 - 27
Large herring (>30cm total length) as per adjacent scale.

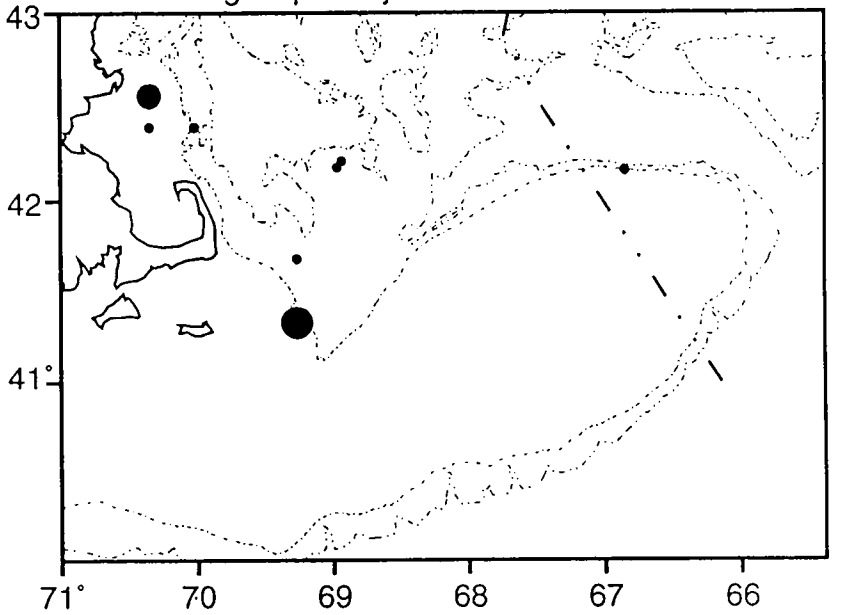

Figure 36b. US 1993 survey. Sept 27 - Oct 20
Large herring (>30cm total length) as per adjacent scale.

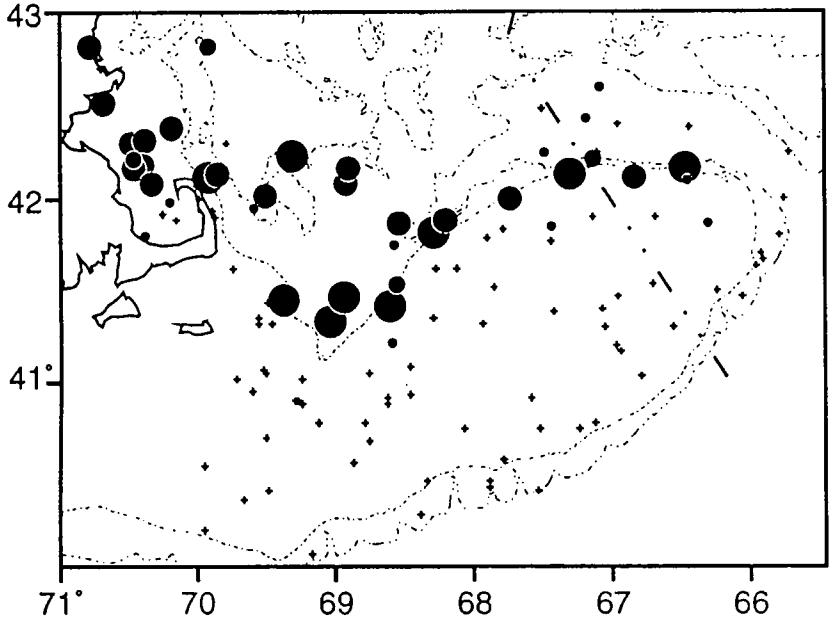

Figure 37a. US 1994 survey. Oct 4 - 27
Adult herring as per adjacent scale.

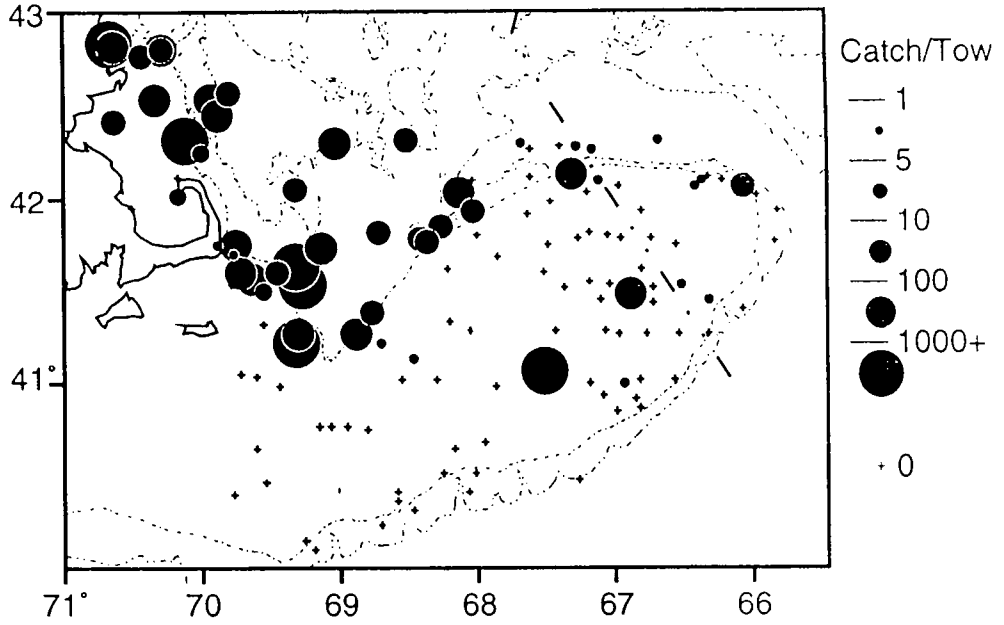

Figure 38a. US 1995 survey. Sept 25 - Oct 26
Adult herring as per adjacent scale.

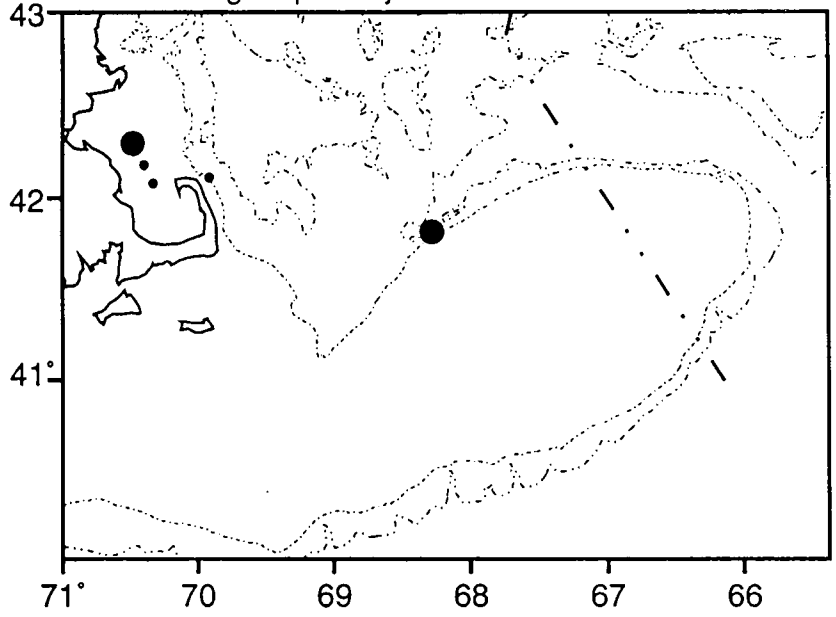

Figure 37b. US 1994 survey. Oct 4 - 27
Large herring (>30cm total length) as per adjacent scale.

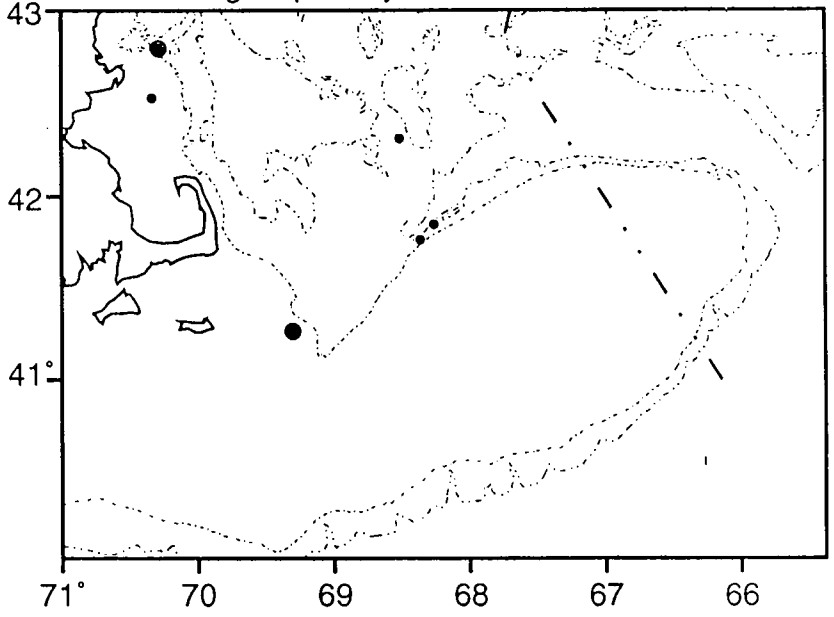

Figure 38b. US 1995 survey. Sept 25 - Oct 26
Large herring (>30cm total length) as per adjacent scale.

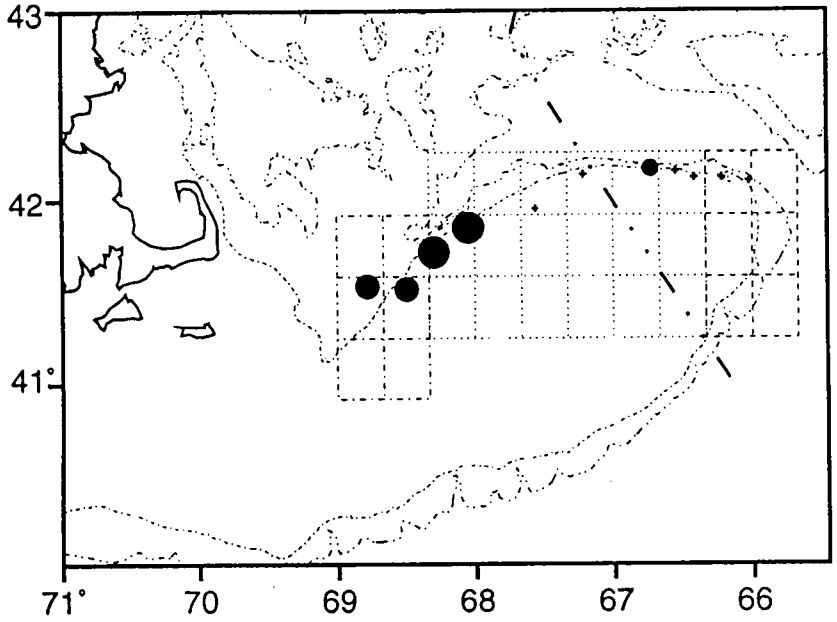

Figure 39. Georges Bank Cdn 1987 survey herring catch. Adult herring number as per adjacent scale.

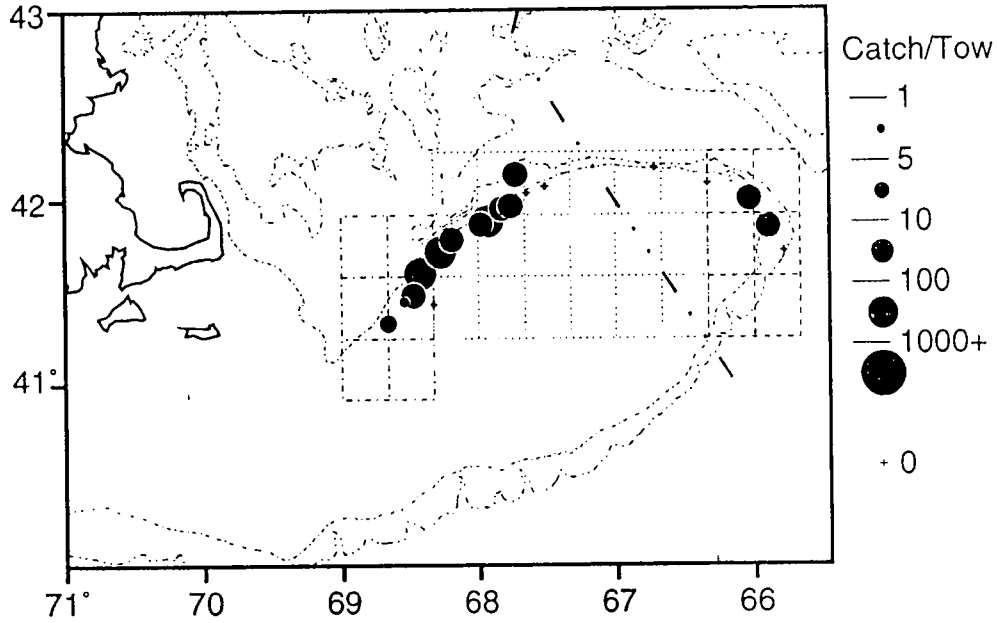

Figure 40. Georges Bank Cdn 1988 survey herring catch. Adult herring number as per adjacent scale.

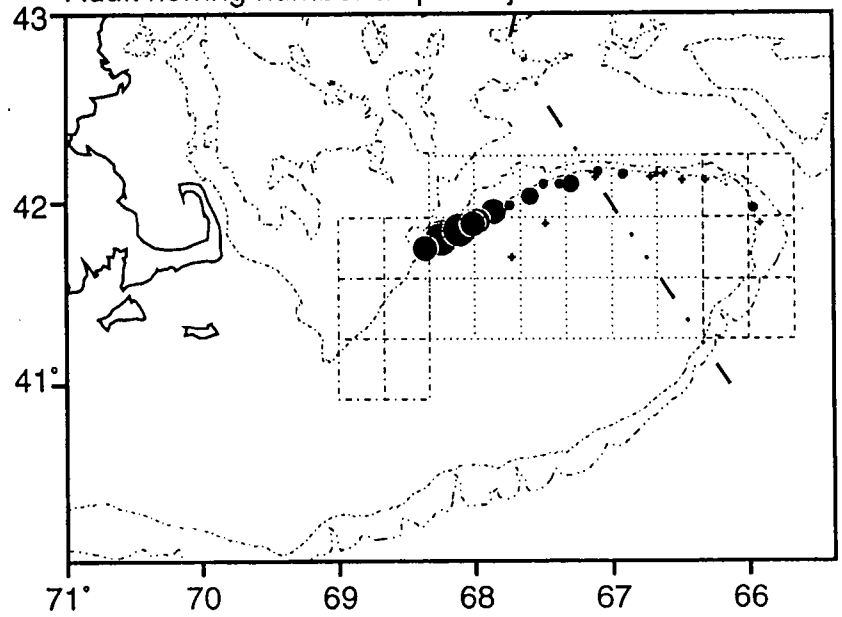

Figure 41. Georges Bank Cdn 1989 survey herring catch. Adult herring number as per adjacent scale.

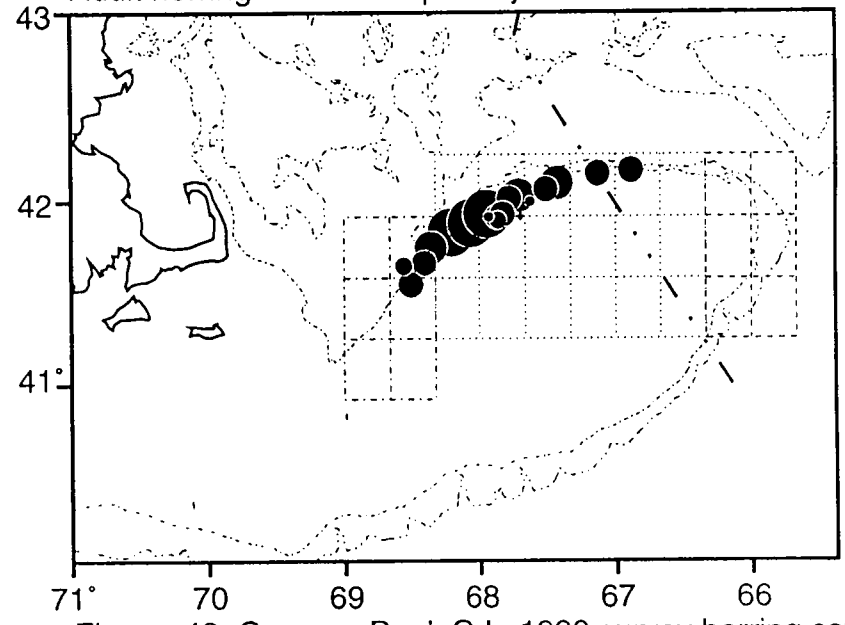

Figure 42. Georges Bank Cdn 1990 survey herring catch. Adult herring number as per adjacent scale.

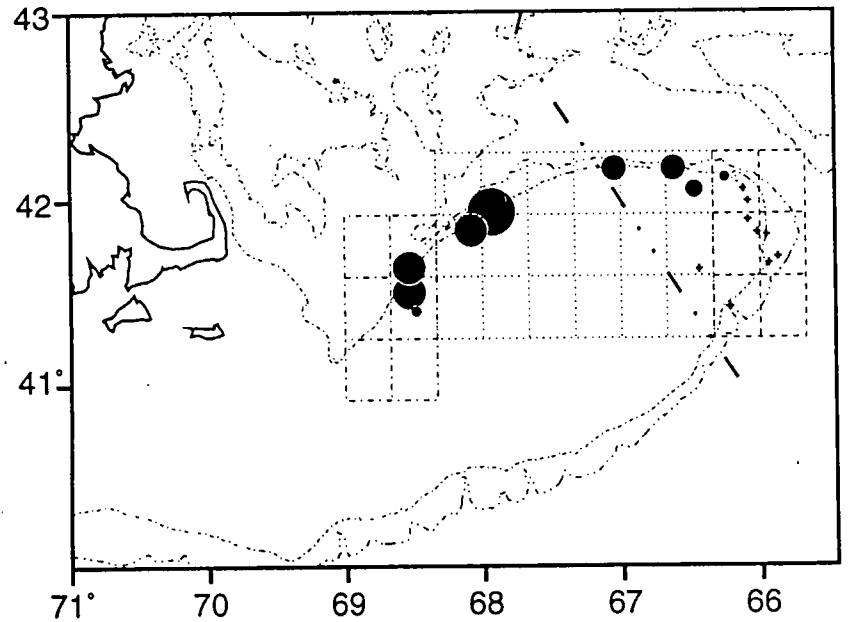

Figure 43. Georges Bank Cdn 1991 survey herring catch. Adult herring number as per adjacent scale.

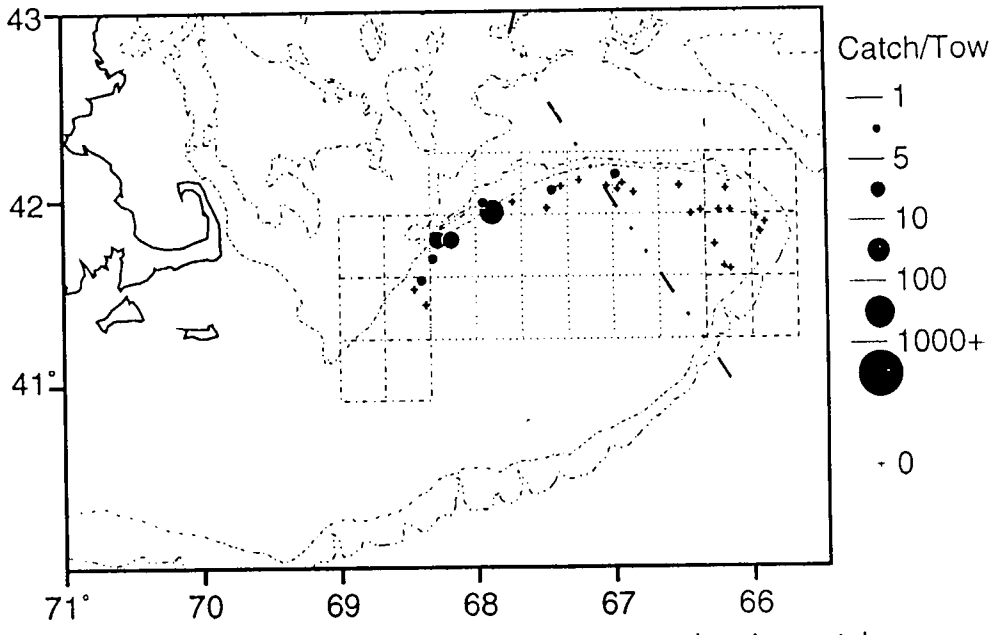

Figure 44. Georges Bank Cdn 1992 survey herring catch. Adult herring number as per adjacent scale.

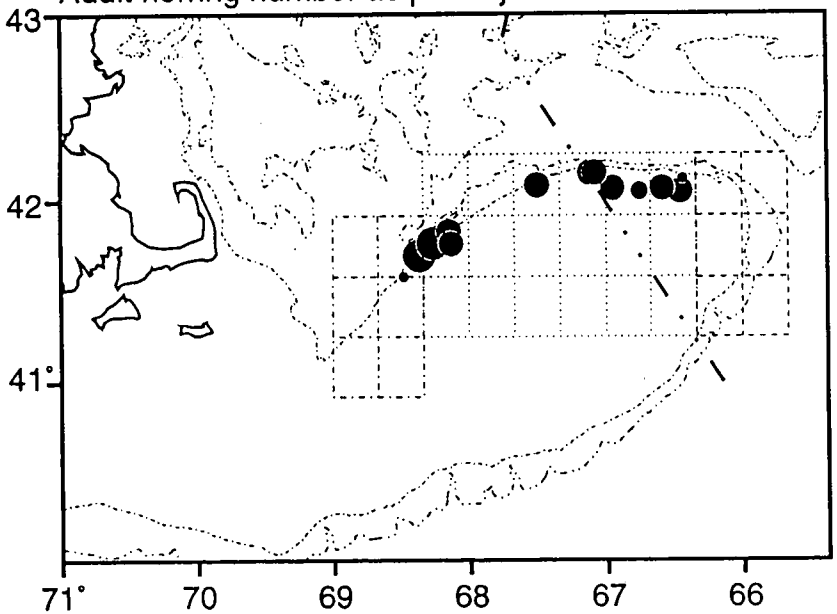

Figure 45. Georges Bank Cdn 1994 survey herring catch. Adult herring number as per adjacent scale.

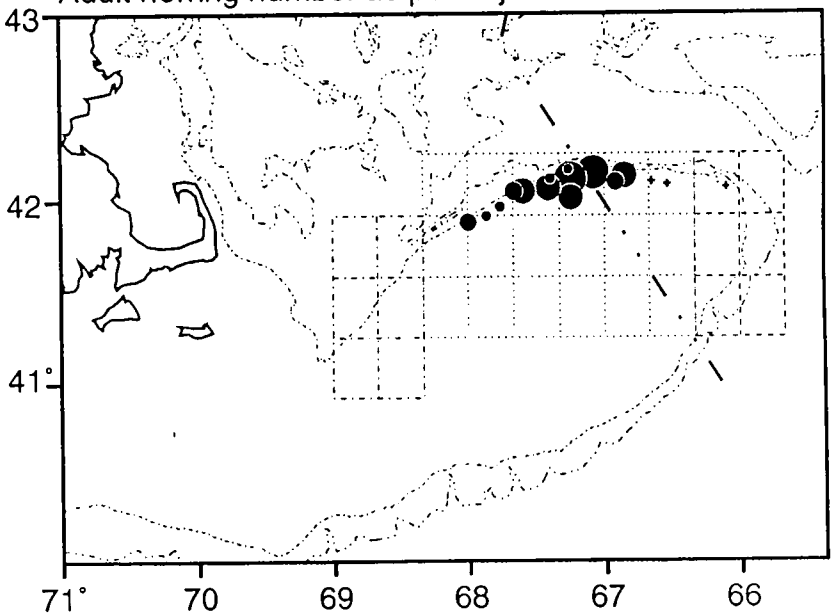

Figure 46. Georges Bank Cdn 1995 survey herring catch. Adult herring number as per adjacent scale.

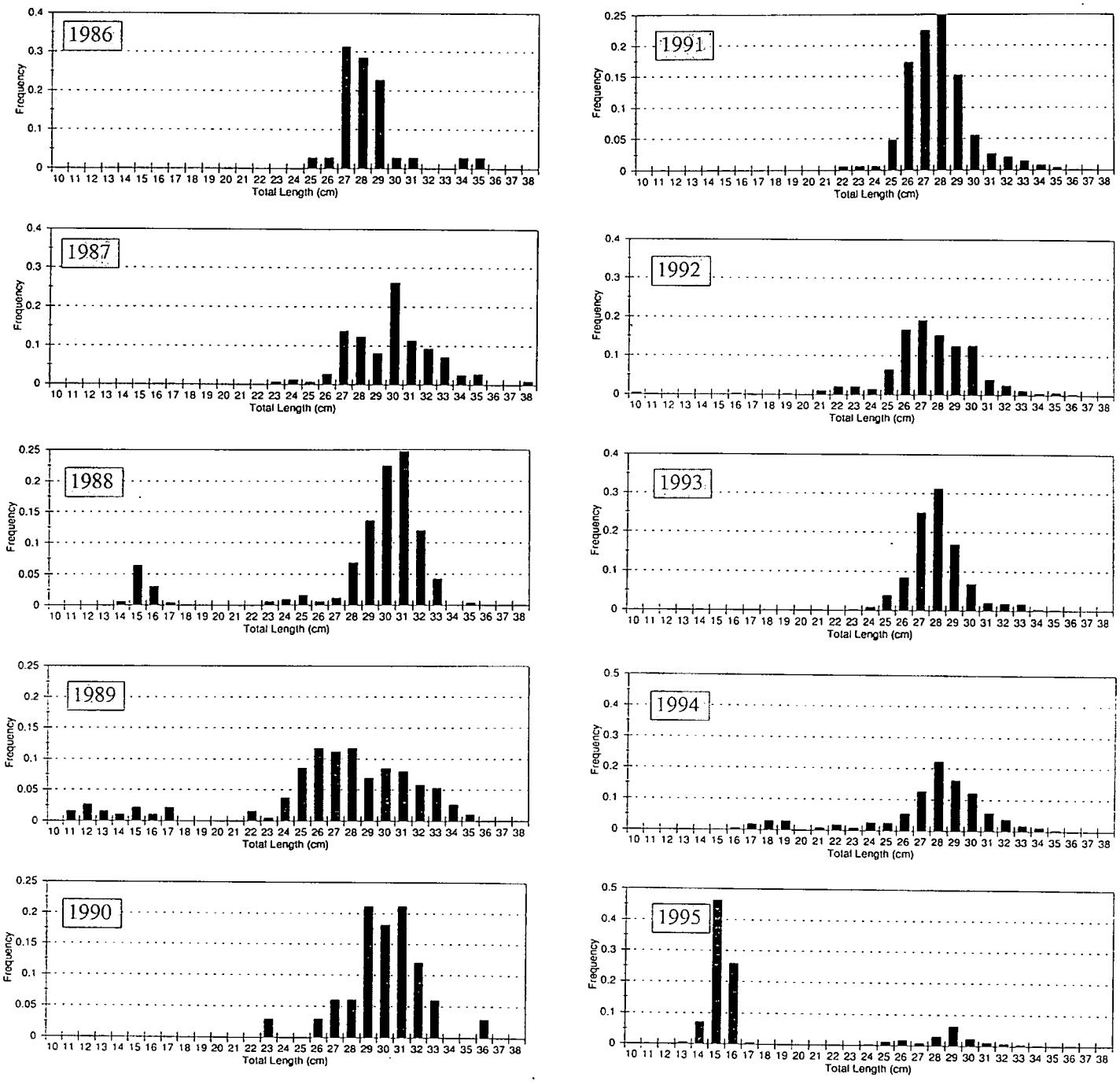

Figure 47. Length frequency distribution for US bottom trawl samples (1986 - 1995).

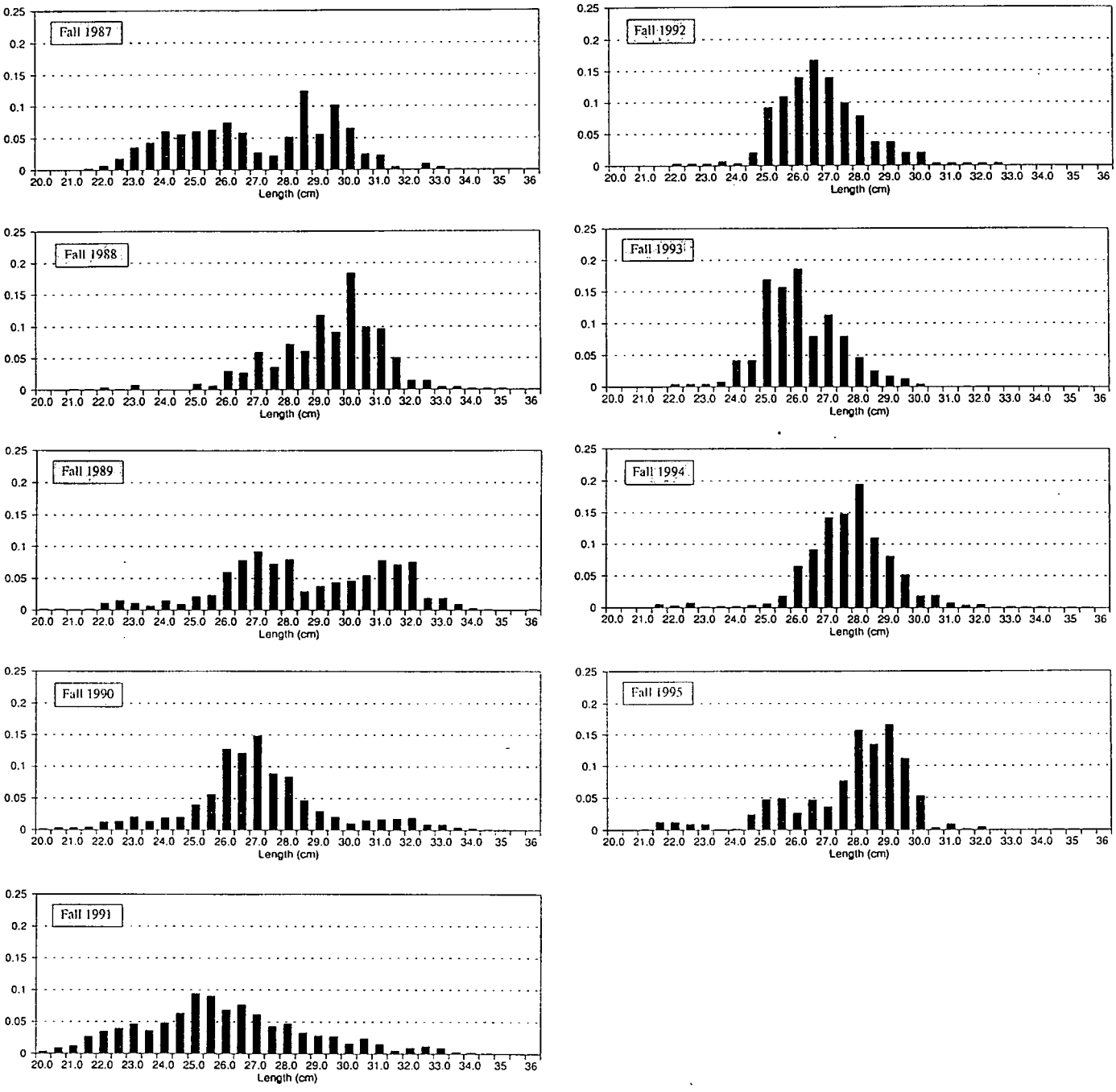

Figure 48. Length frequency distribution for Canadian fall survey samples (1987 - 1995).

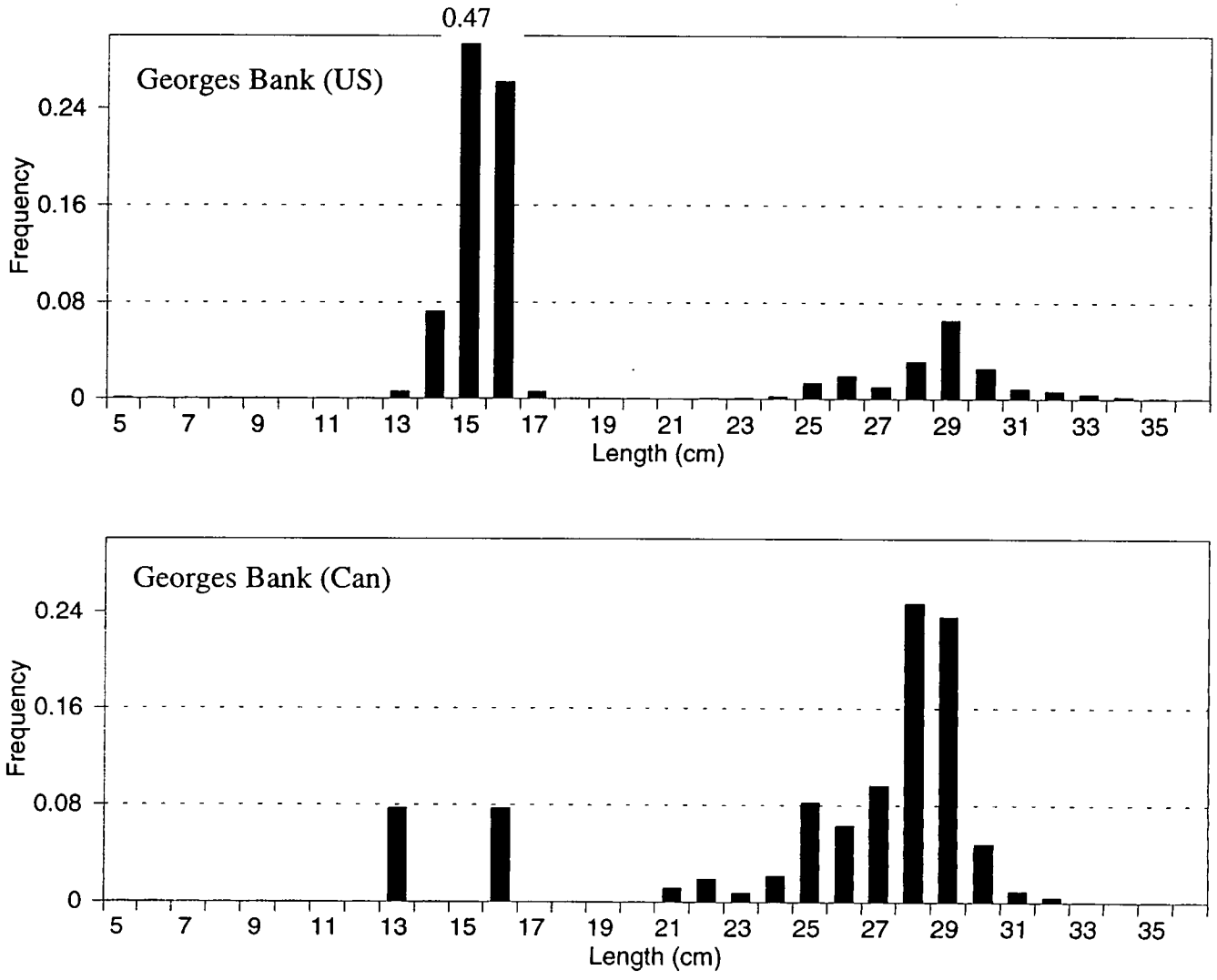

Figure 49. Comparison of the Canadian and US 1995 herring length frequency distributions from the fall research survey.

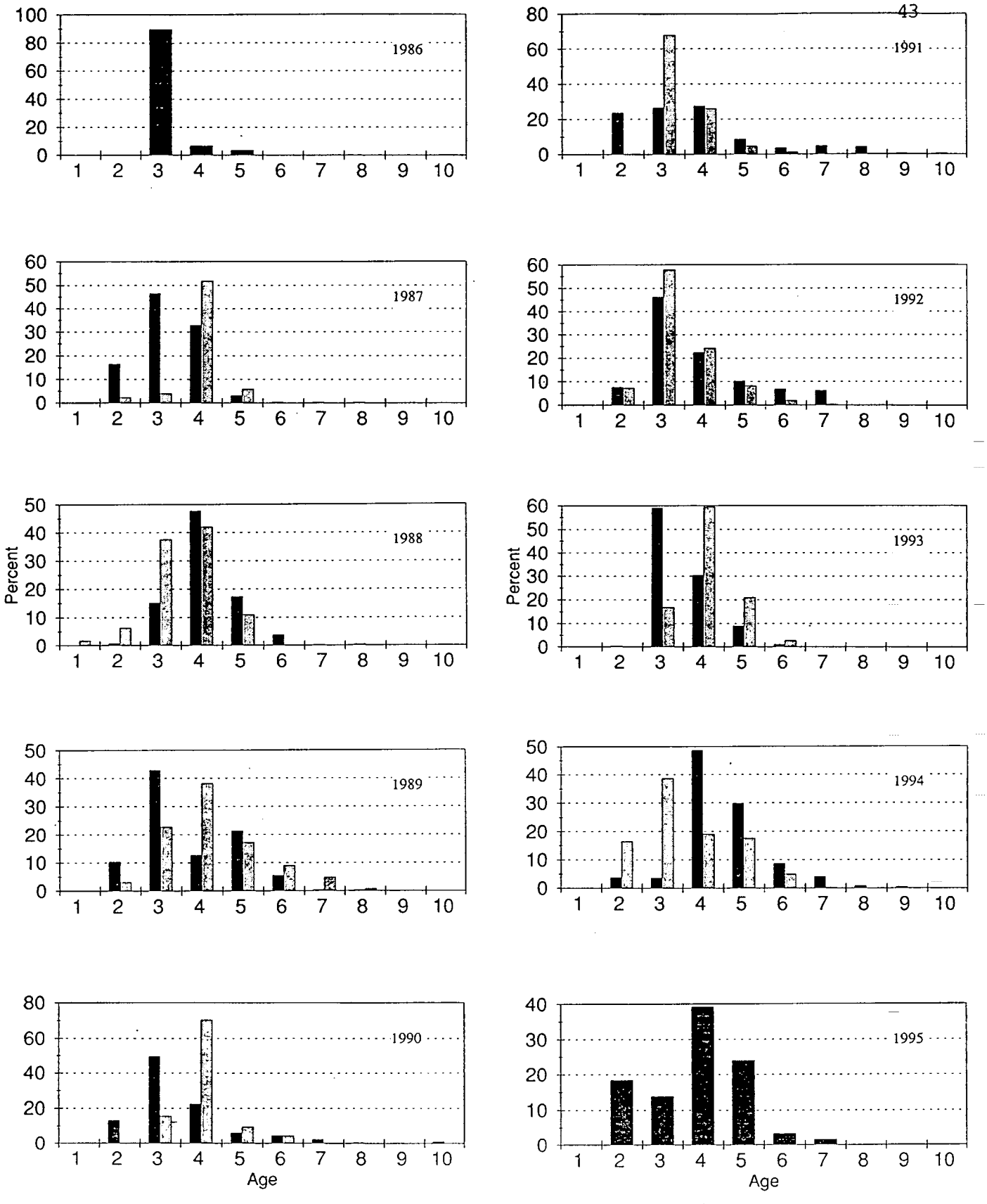

Figure 50. Canadian (dark) and US (light) age distribution for Georges Bank (1986-1995).

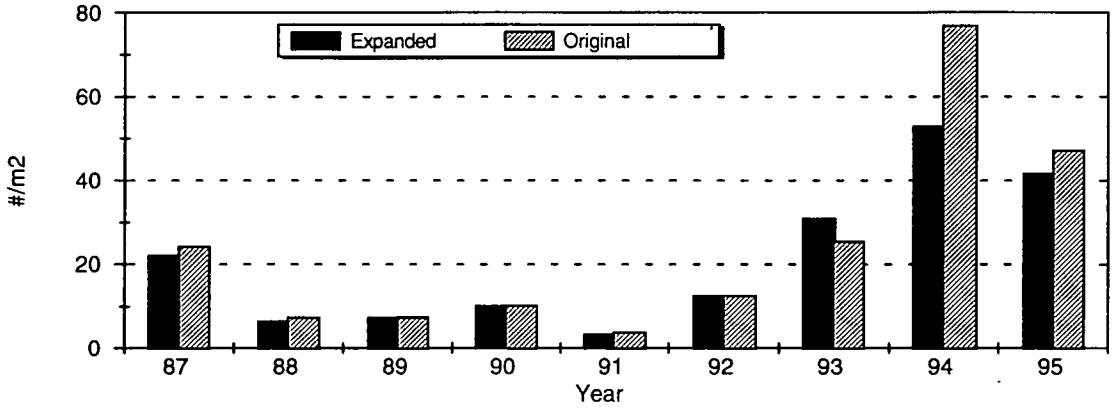

Figure 51. Summary of the Canadian larval abundance index (mean #/m^2) for the original and expanded survey area from 1987 to 1995.

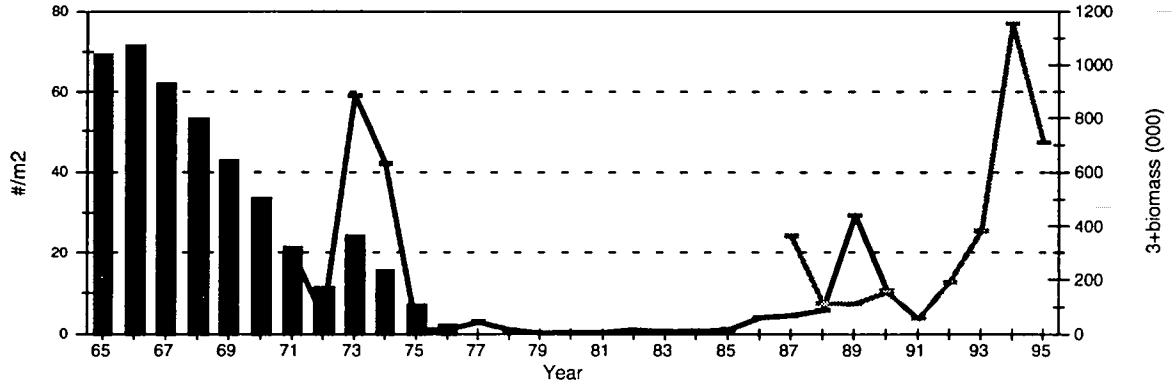

Figure 52. Georges Bank larval abundance index (mean #/m^2) from US (1971-1990) and Canadian (1987-1995) fall research surveys and the historical VPA biomass estimates. US data from Smith and Morse ,1992.

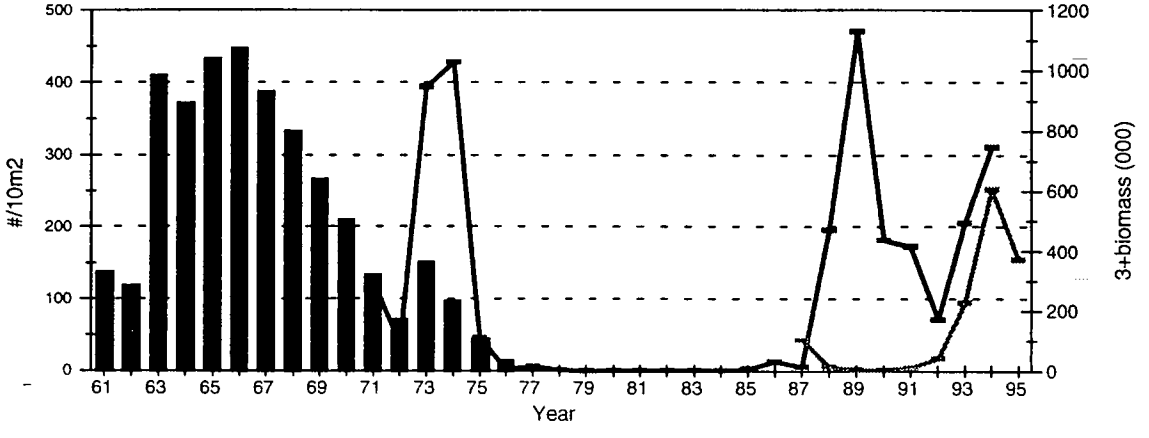

Figure 53. Georges Bank larval abundance index (#/$10m^2$ of 4-7mm larvae) from the US (1971-1994) and the Canadian (1987-1995) fall research surveys.

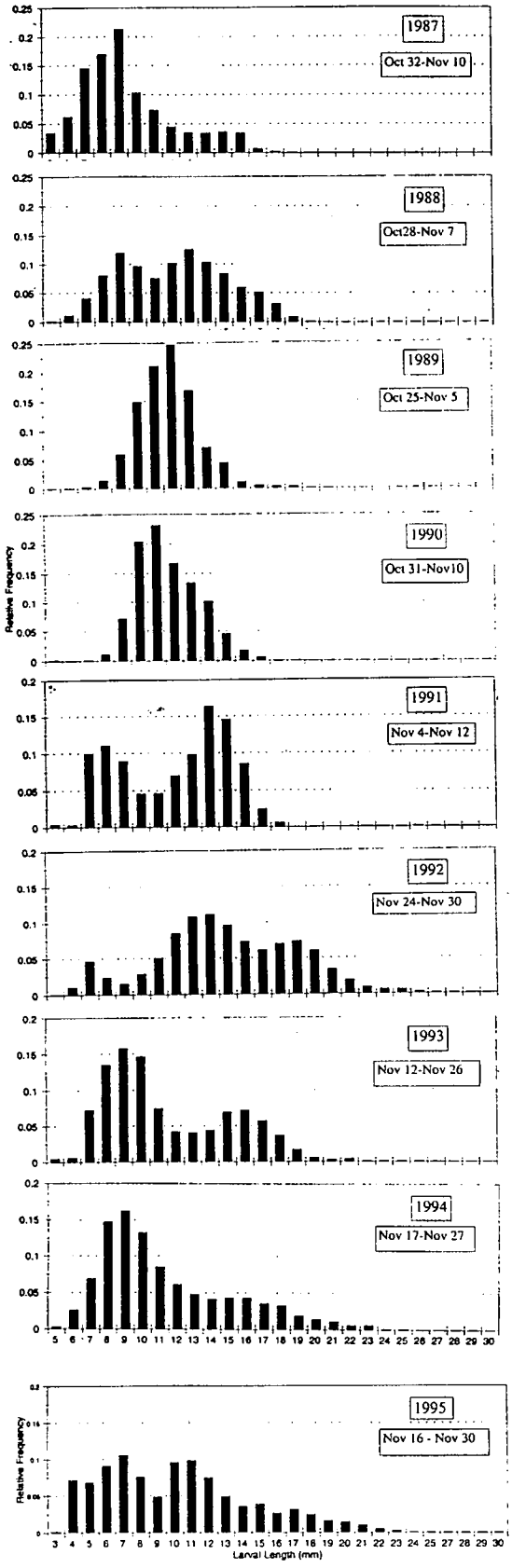

Figure 54. Canadian larval length frequencies for 1987-1995. Note the larval length scale is different in 1995 to accomodate the yolk sac larvae sampled.

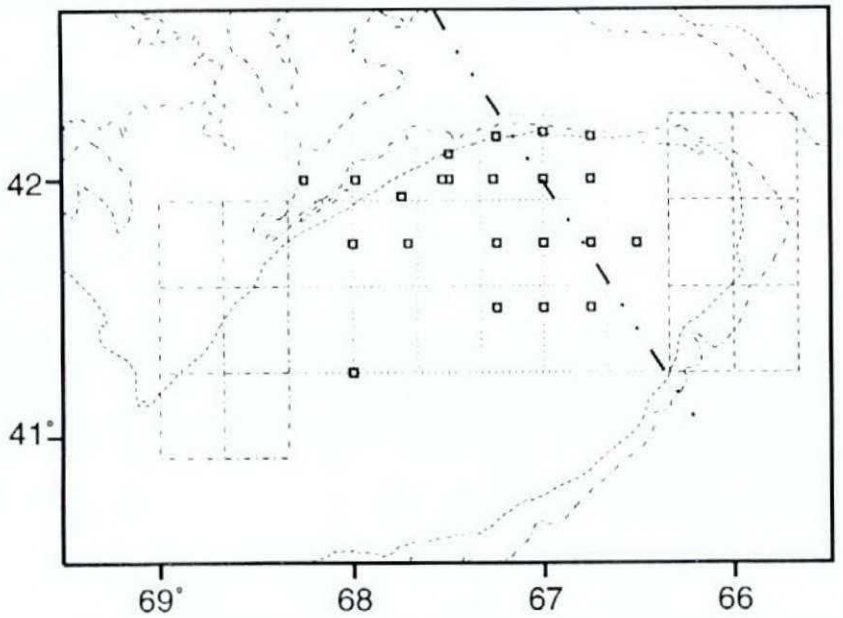

Figure 55a. 1987 Canadian larval survey (Oct 4 - 17). Sampling stations.

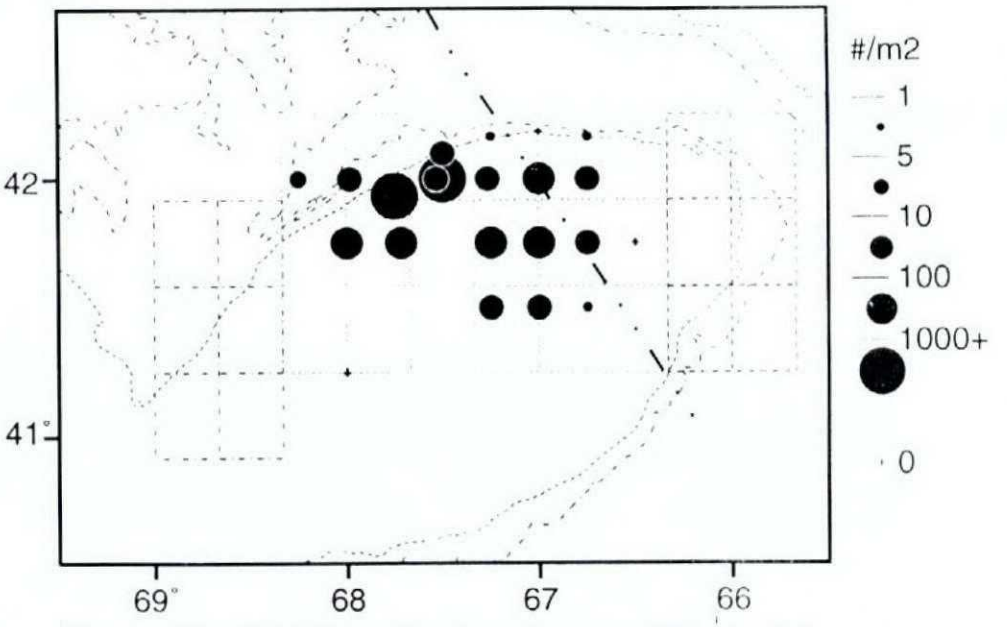

Figure 55b. 1987 Canadian larval survey (Oct 4 - 17). Larvae as per adjacent scale.

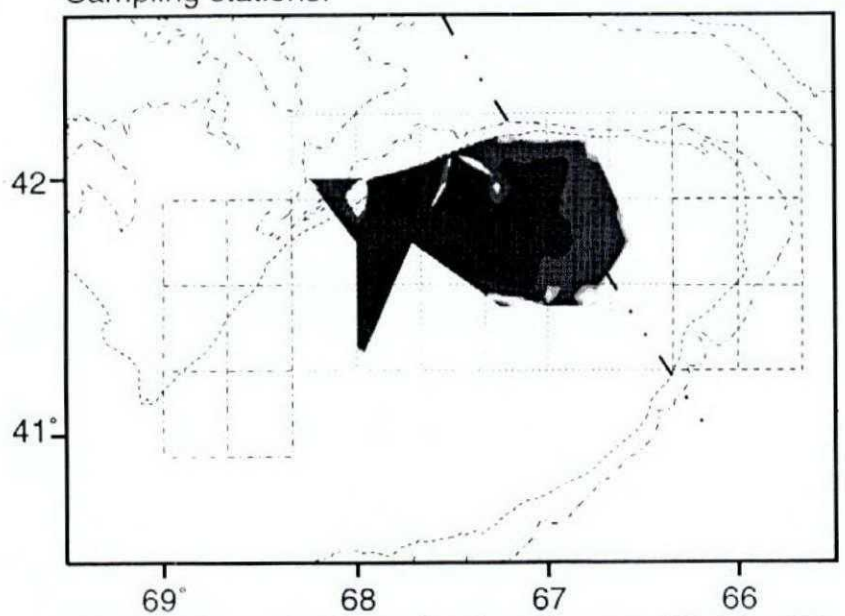

Figure 55c. 1987 Canadian larval survey (Oct 4 - 17). All larvae. Contours as per adjacent scale.

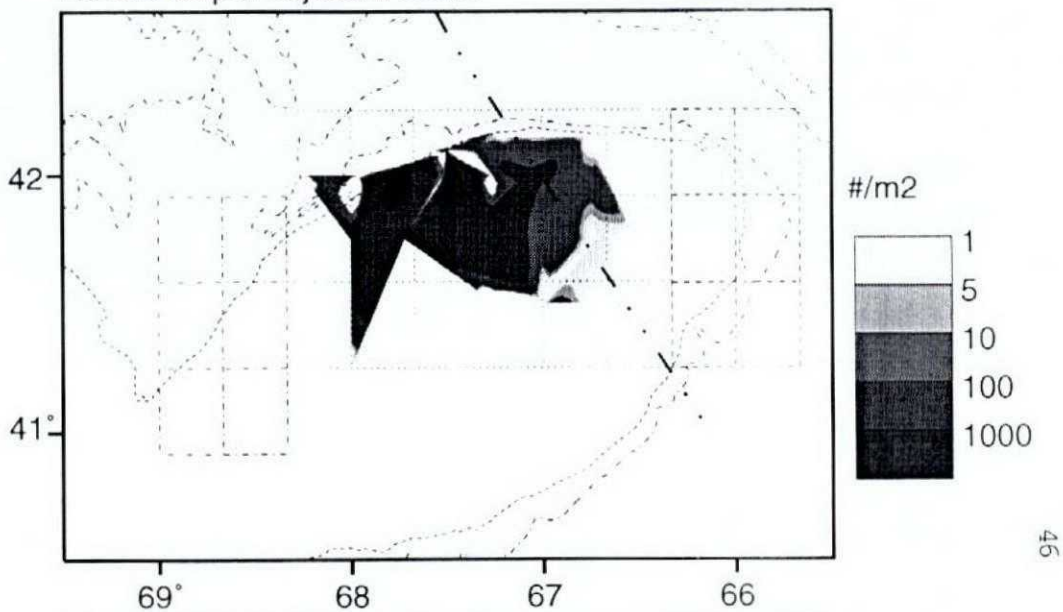

Figure 55d. 1987 Canadian larval survey (Oct 4 - 17). Larvae (<10mm). Contours as per adjacent scale.

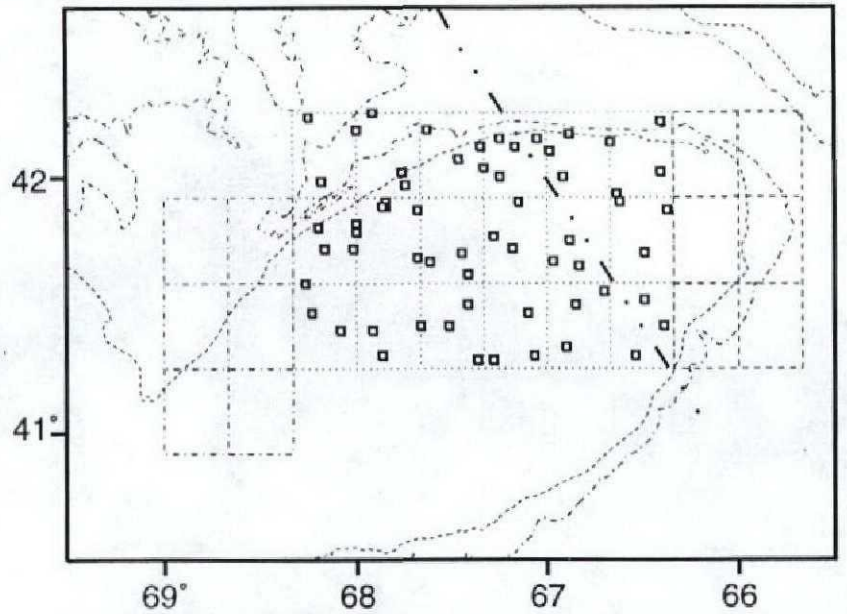

Figure 56a. 1988 Canadian larval survey (Oct 29 - Nov 9). Sampling stations.

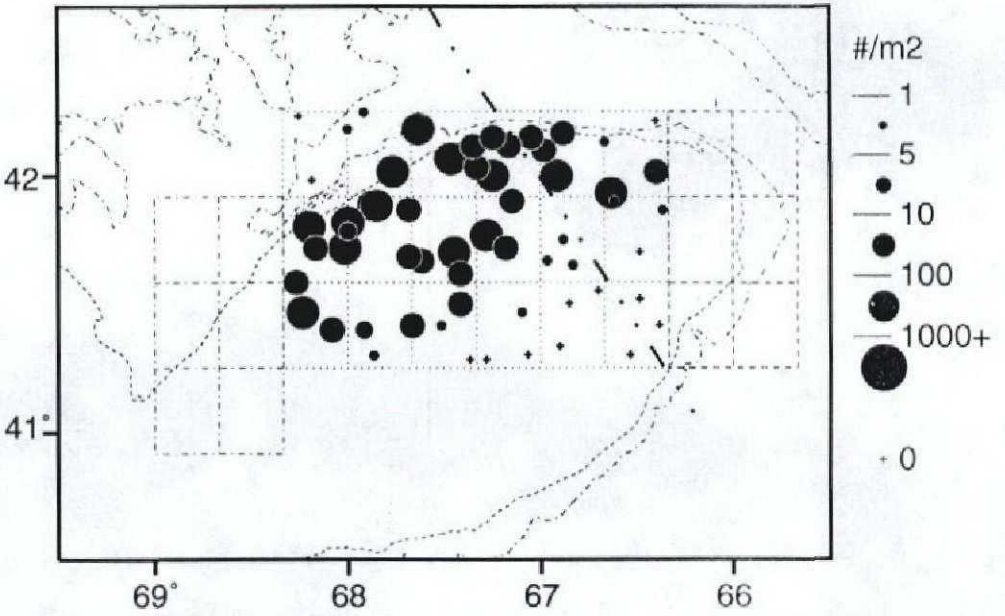

Figure 56b. 1988 Canadian larval survey (Oct 29 - Nov 9). Larvae as per adjacent scale.

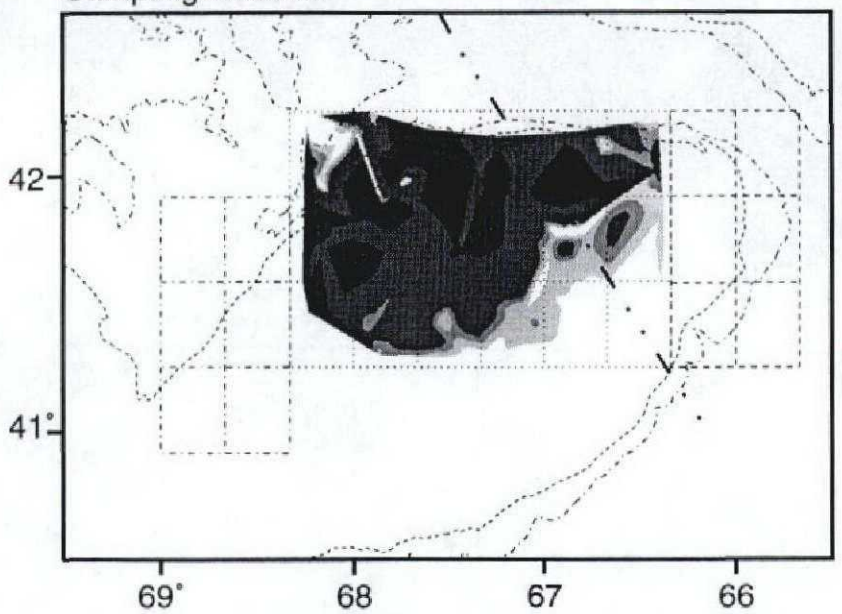

Figure 56c. 1988 Canadian larval survey (Oct 29 - Nov 9). All larvae. Contours as per adjacent scale.

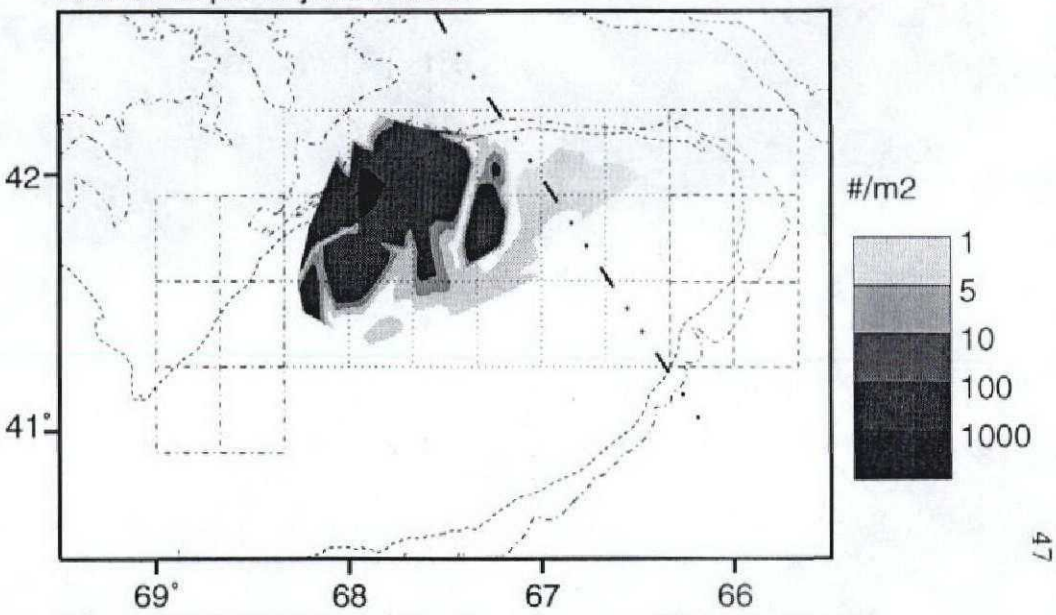

Figure 56d. 1988 Canadian larval survey (Oct 29 - Nov 9). Larvae (<10mm). Contours as per adjacent scale.

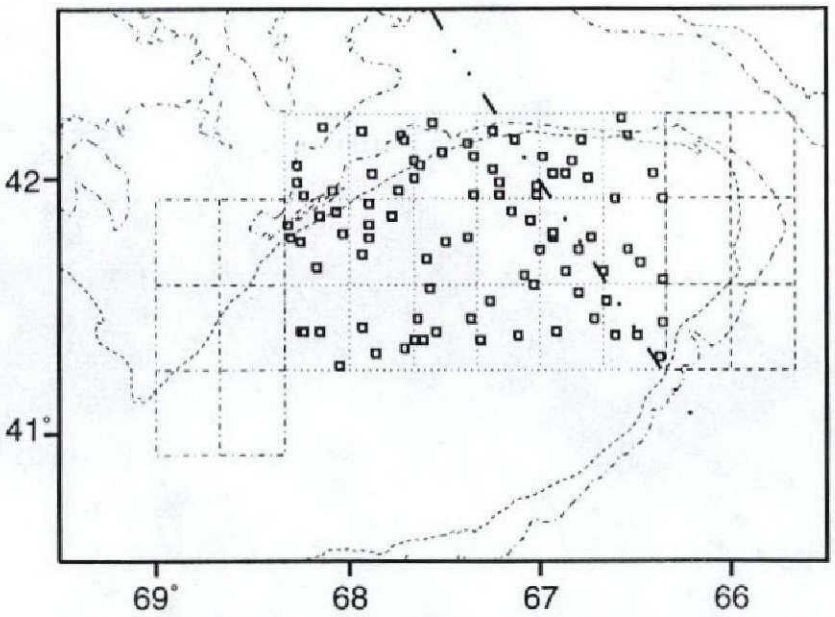

Figure 57a. 1989 Canadian larval survey (Oct 27 - Nov 6). Sampling stations.

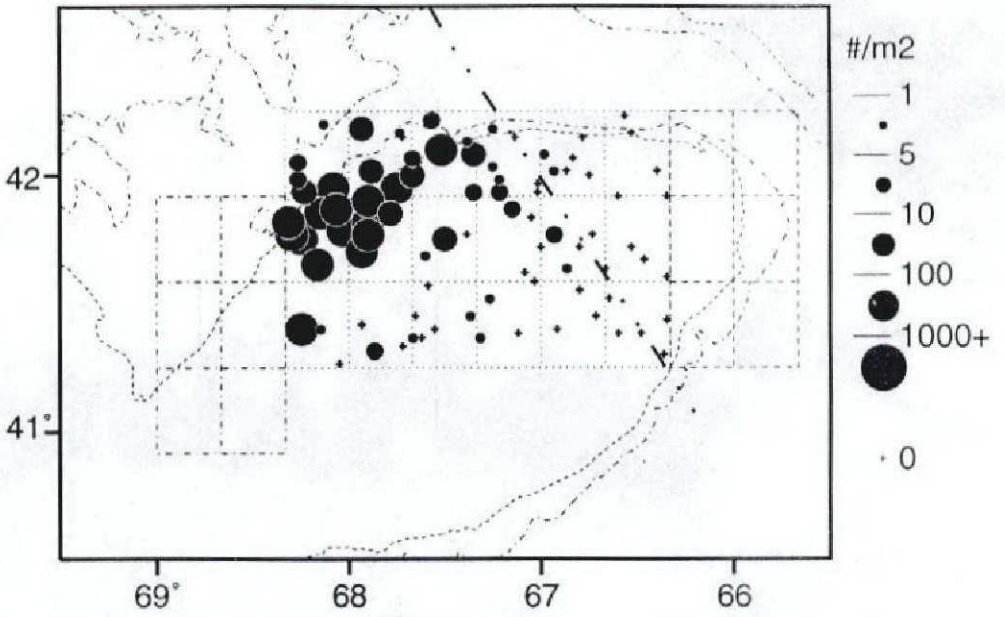

Figure 57b. 1989 Canadian larval survey (Oct 27 - Nov 6). Larvae as per adjacent scale.

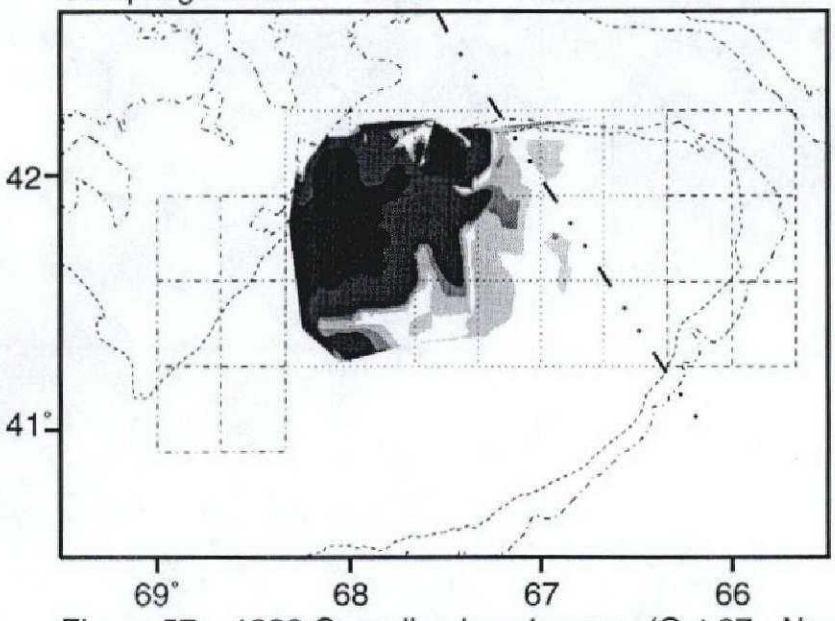

Figure 57c. 1989 Canadian larval survey (Oct 27 - Nov 6). All larvae. Contours as per adjacent scale.

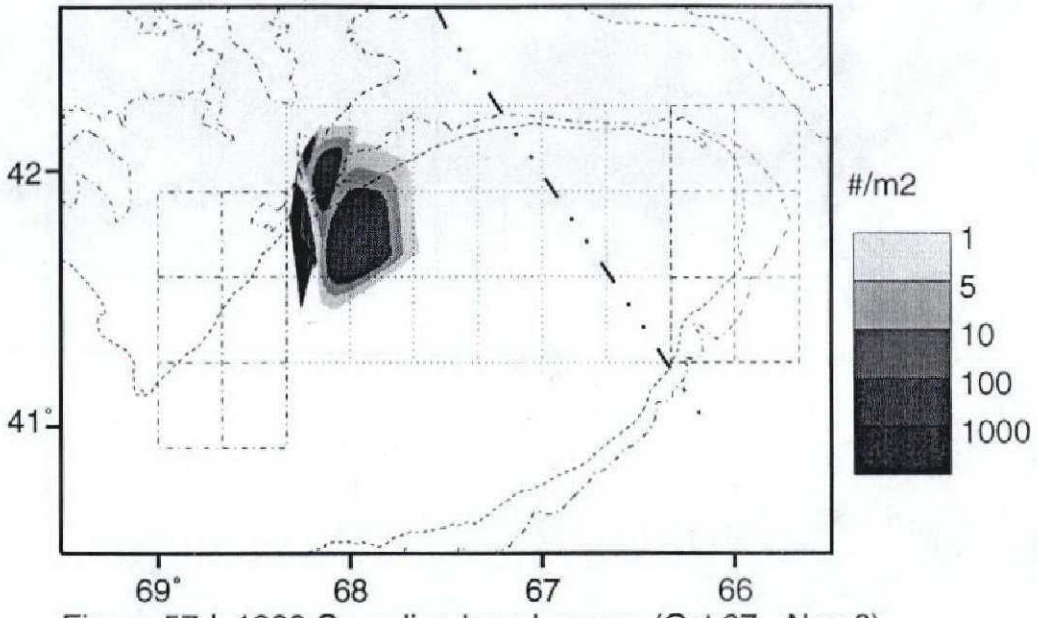

Figure 57d. 1989 Canadian larval survey (Oct 27 - Nov 6). Larvae (<10mm). Contours as per adjacent scale.

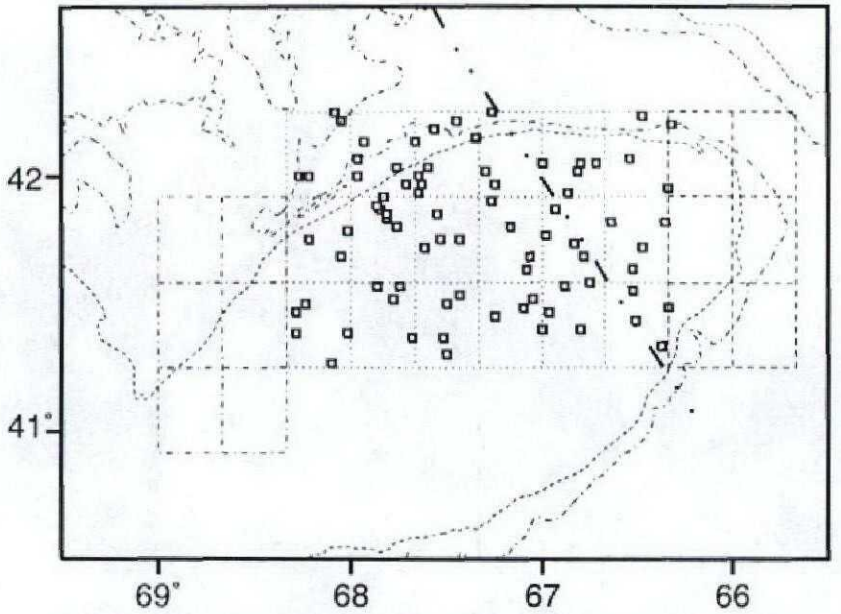

Figure 58a. 1990 Canadian larval survey (Nov 1 - 5). Sampling stations.

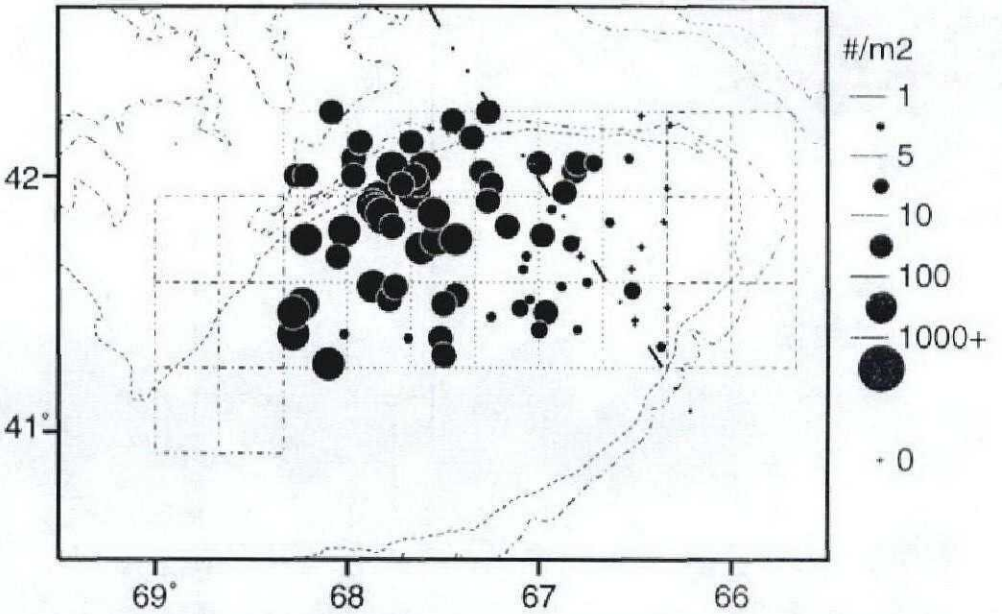

Figure 58a. 1990 Canadian larval survey (Nov 1 - 5). Larvae as per adjacent scale.

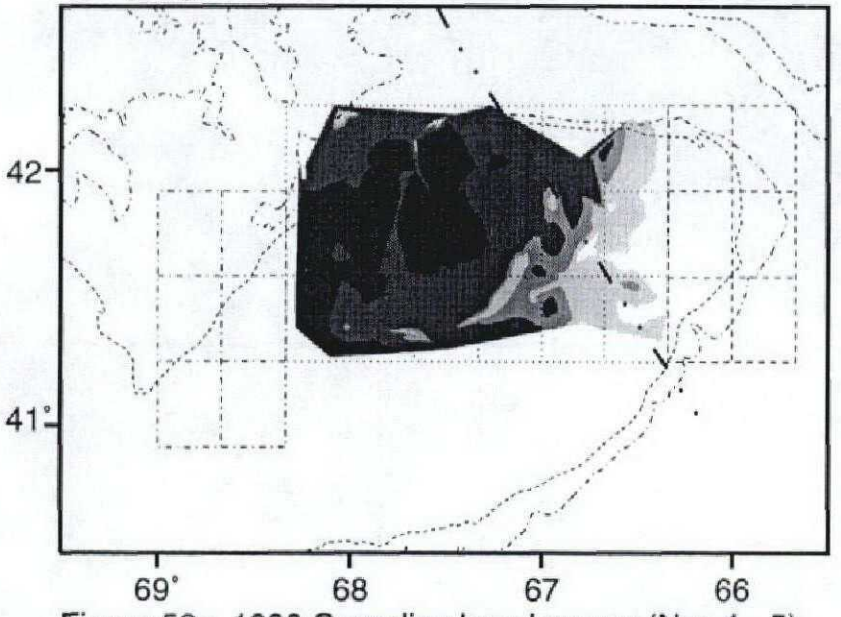

Figure 58c. 1990 Canadian larval survey (Nov 1 - 5). All larvae. Contours as per adjacent scale.

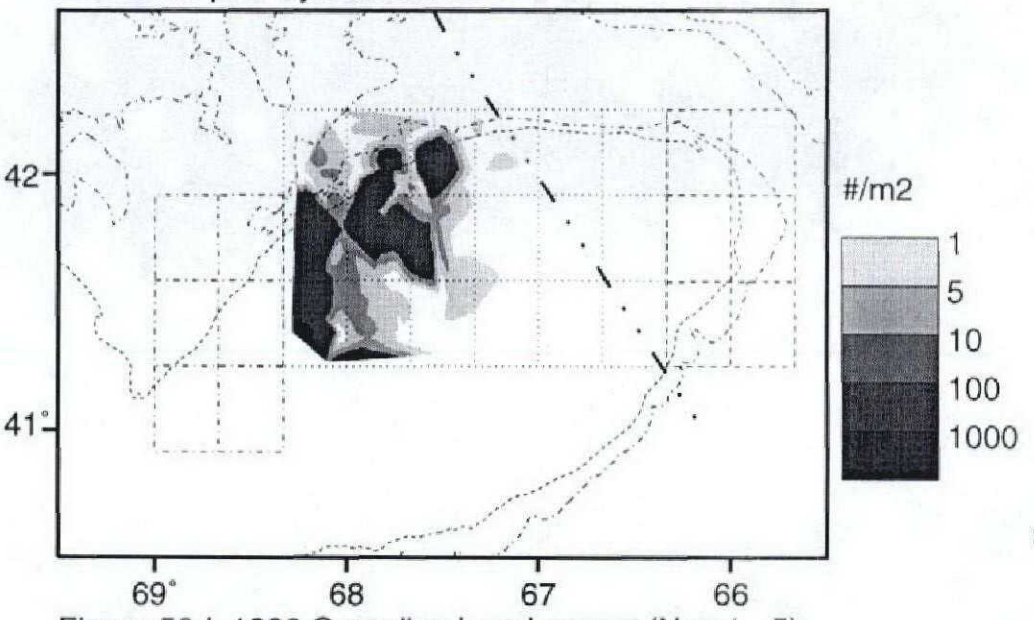

Figure 58d. 1990 Canadian larval survey (Nov 1 - 5). Larvae (<10mm). Contours as per adjacent scale.

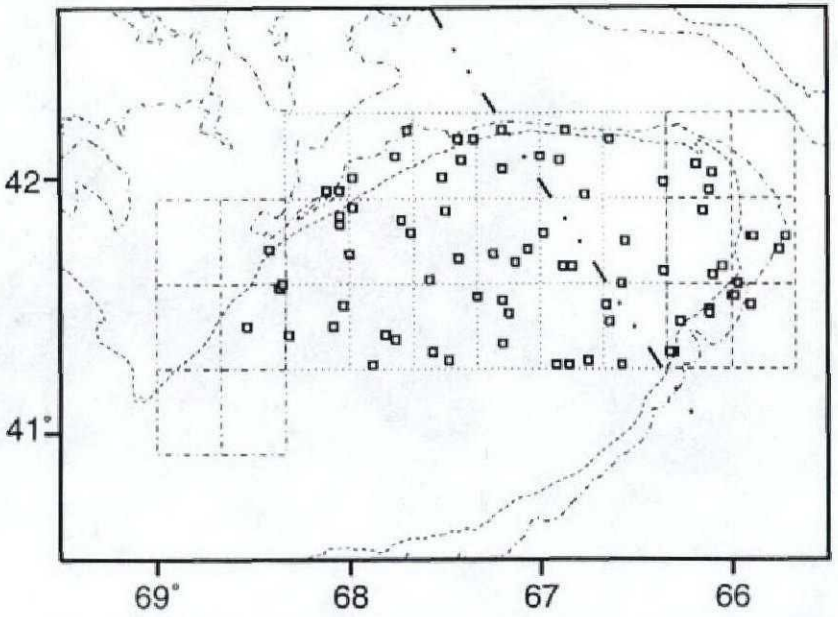

Figure 59a. 1991 Canadian larval survey (Nov 4 - 15). Sampling stations.

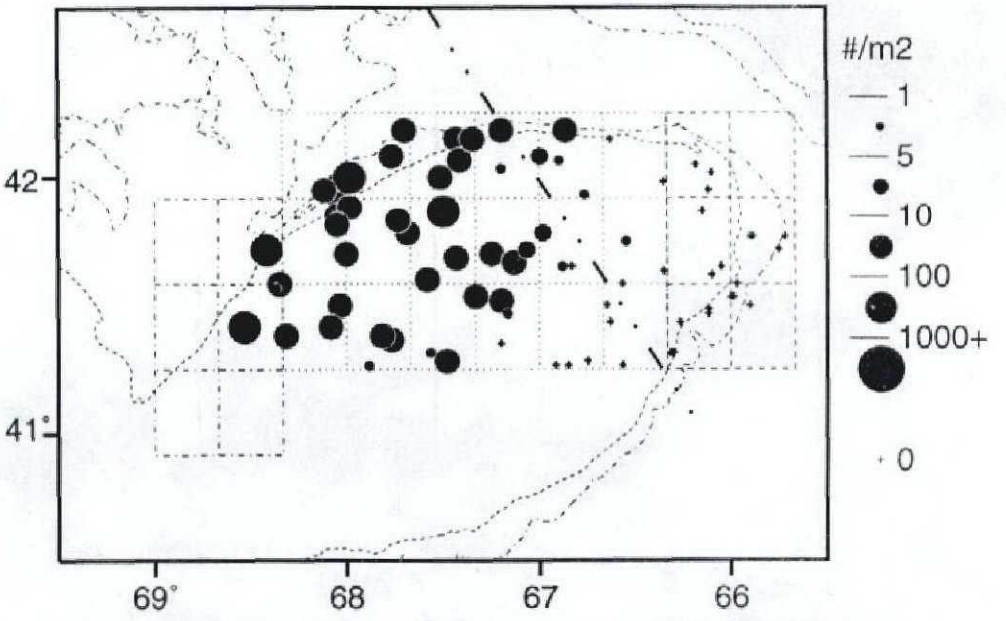

Figure 59b. 1991 Canadian larval survey (Nov 4 - 15). Larvae as per adjacent scale.

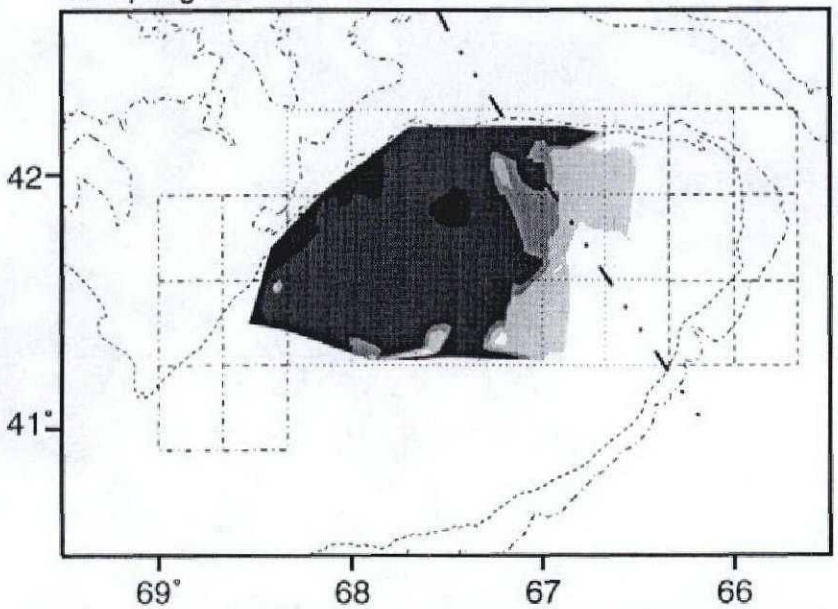

Figure 59c. 1991 Canadian larval survey (Nov 4 - 15). All larvae. Contours as per adjacent scale.

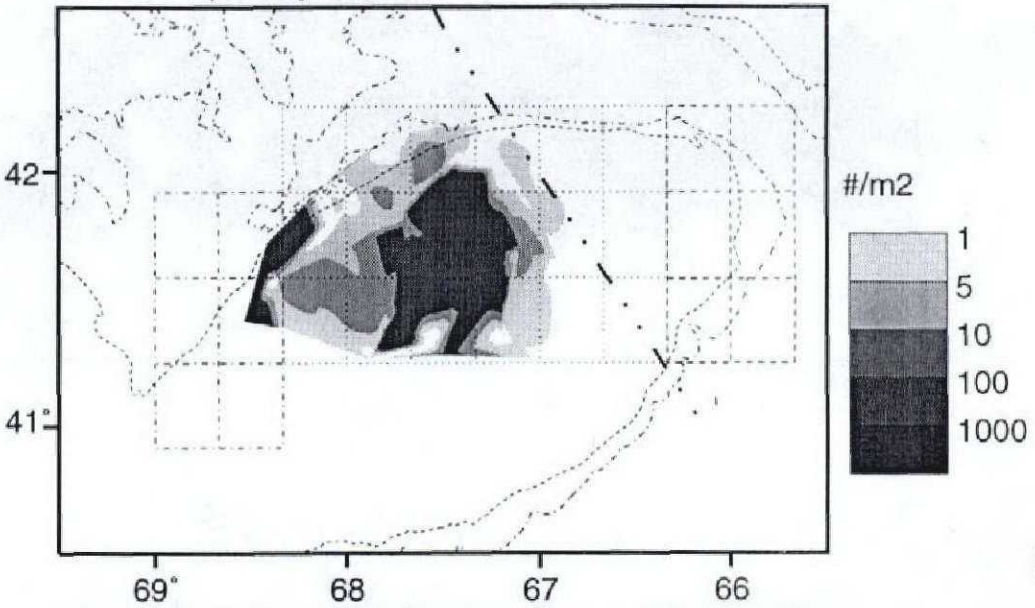

Figure 59d. 1991 Canadian larval survey (Nov 4 - 15). Larvae (<10mm). Contours as per adjacent scale.

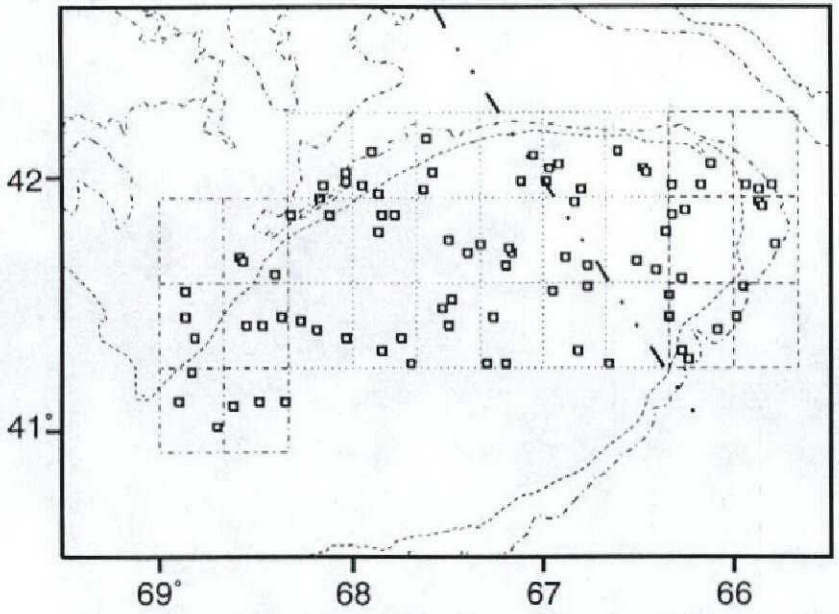

Figure 60a. 1992 Canadian larval survey (Nov 18 - 25). Sampling stations.

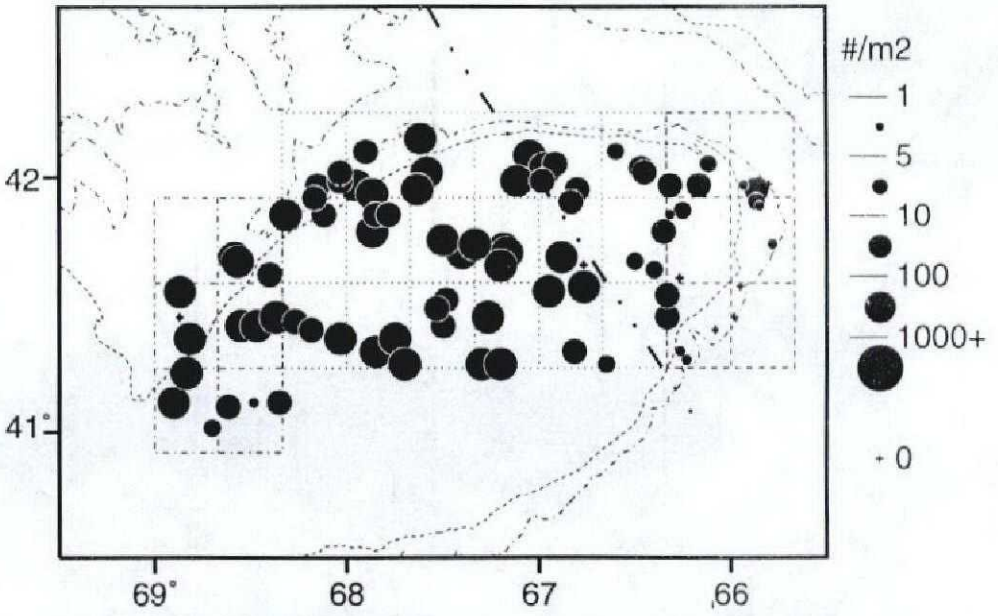

Figure 60b. 1992 Canadian larval survey (Nov 18 - 25). Larvae as per adjacent scale.

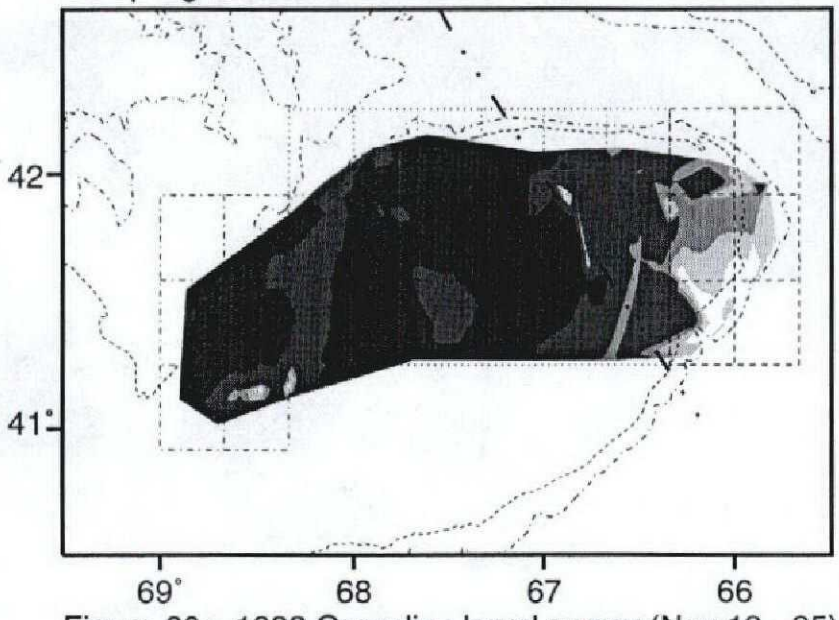

Figure 60c. 1992 Canadian larval survey (Nov 18 - 25). All larvae. Contours as per adjacent scale.

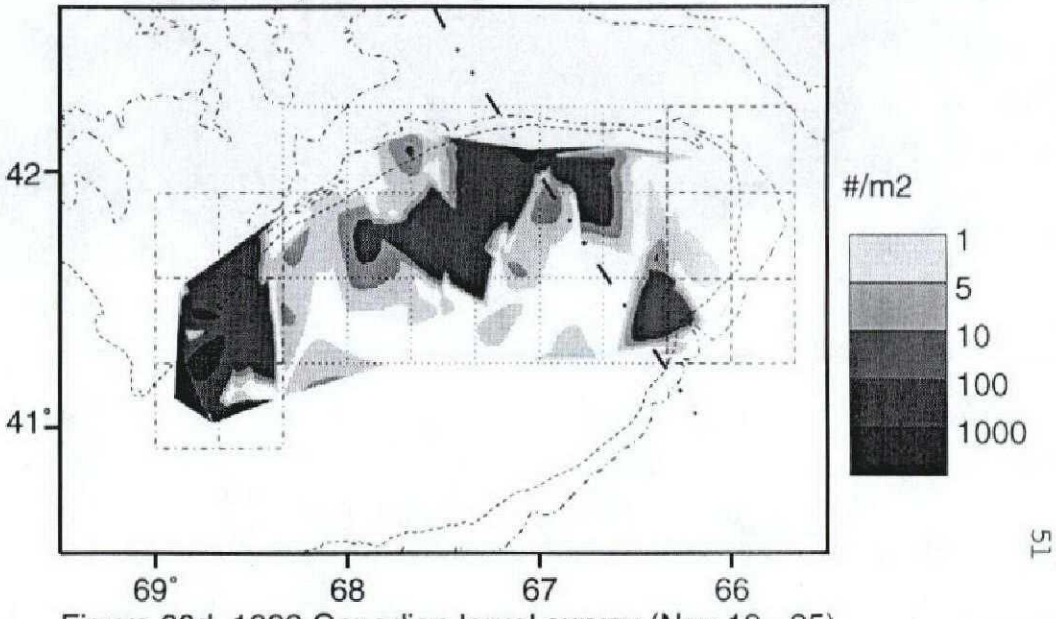

Figure 60d. 1992 Canadian larval survey (Nov 18 - 25). Larvae (<10mm). Contours as per adjacent scale.

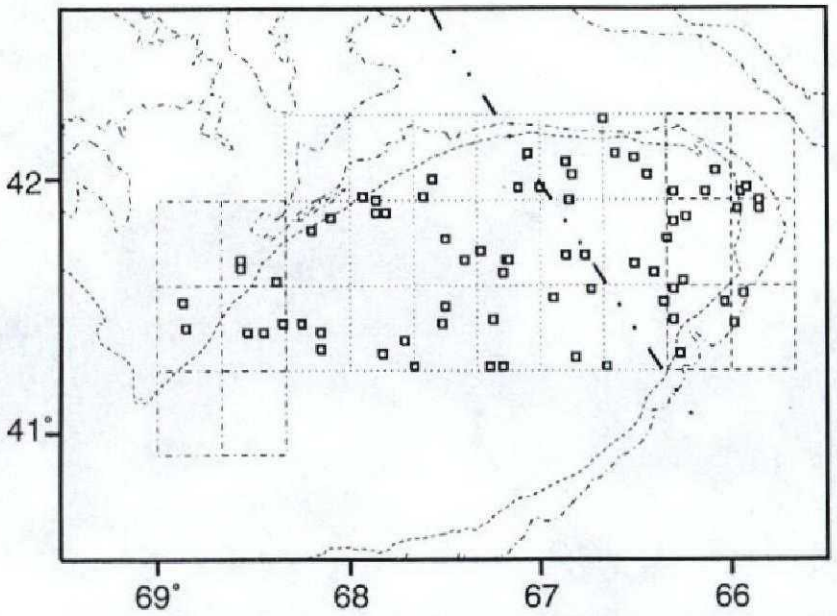

Figure 61a. 1993 Canadian larval survey (Nov 12 - 26). Sampling stations.

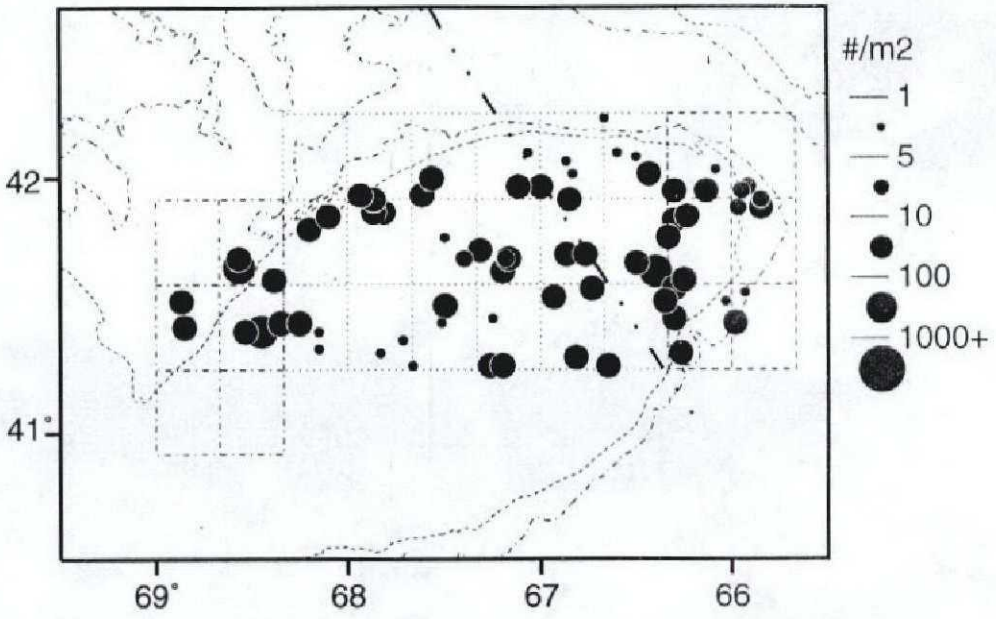

Figure 61b. 1994 Canadian larval survey (Nov 12 - 26). Larvae as per adjacent scale.

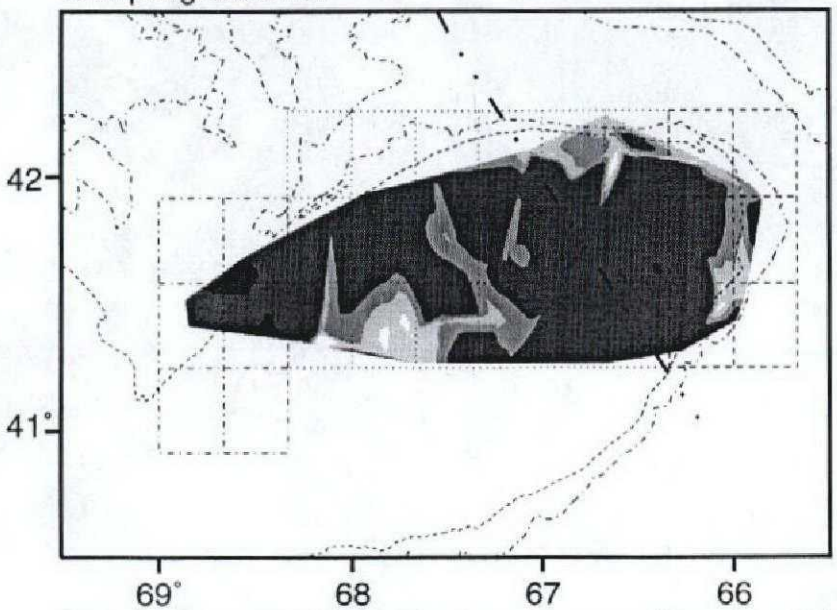

Figure 61c. 1993 Canadian larval survey (Nov 12 - 26). All larvae. Contours as per adjacent scale.

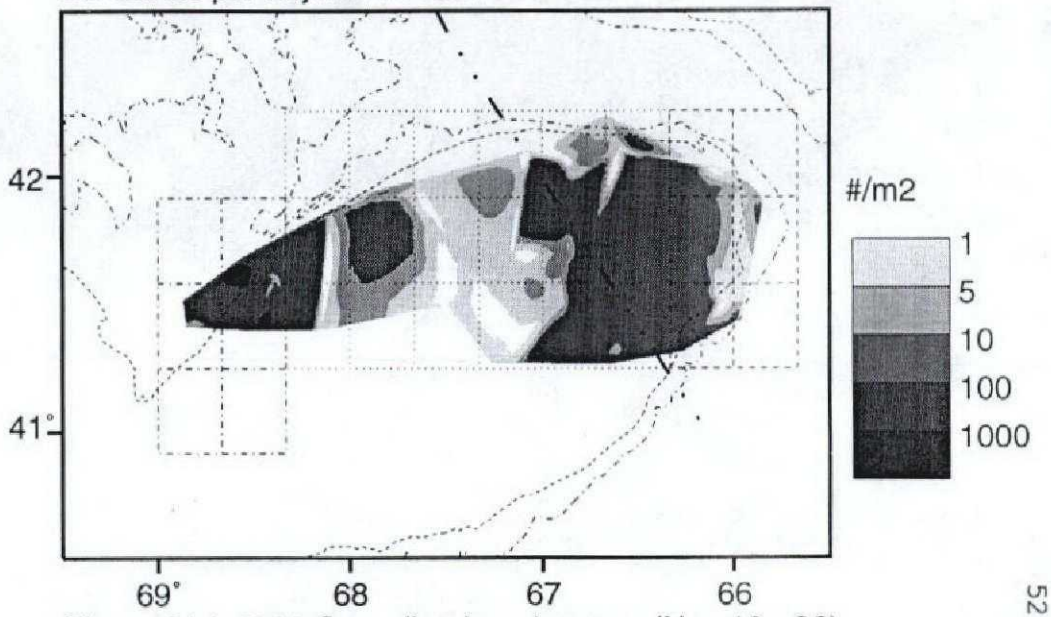

Figure 61d. 1993 Canadian larval survey (Nov 12 - 26). Larvae (<10mm). Contours as per adjacent scale.

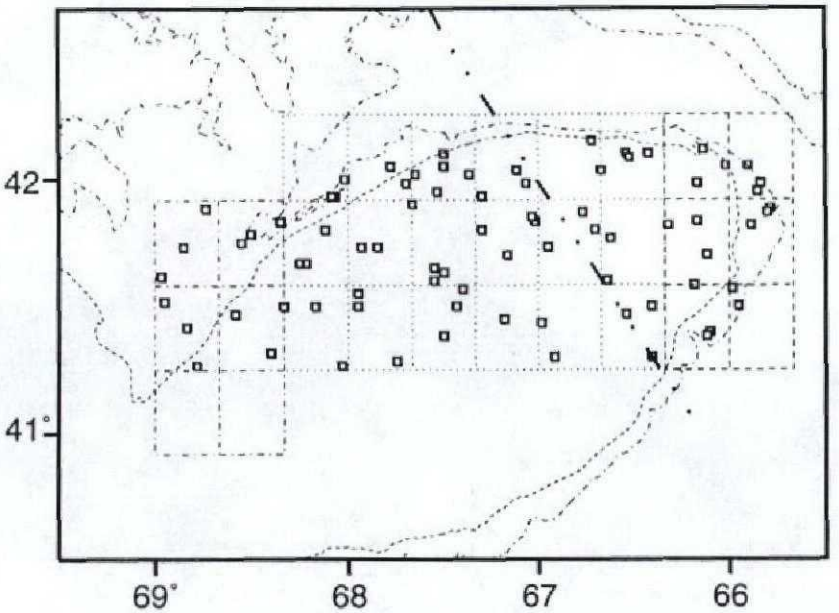

Figure 62a. 1994 Canadian larval survey (Nov 16 - 29). Sampling stations.

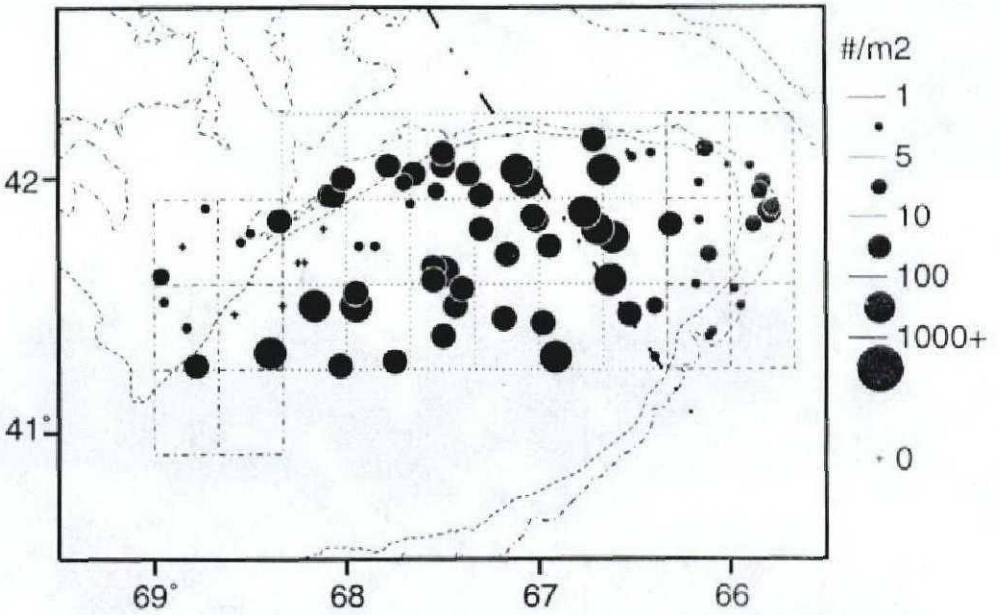

Figure 62b. 1994 Canadian larval survey (Nov 16 - 29). Larvae as per adjacent scale.

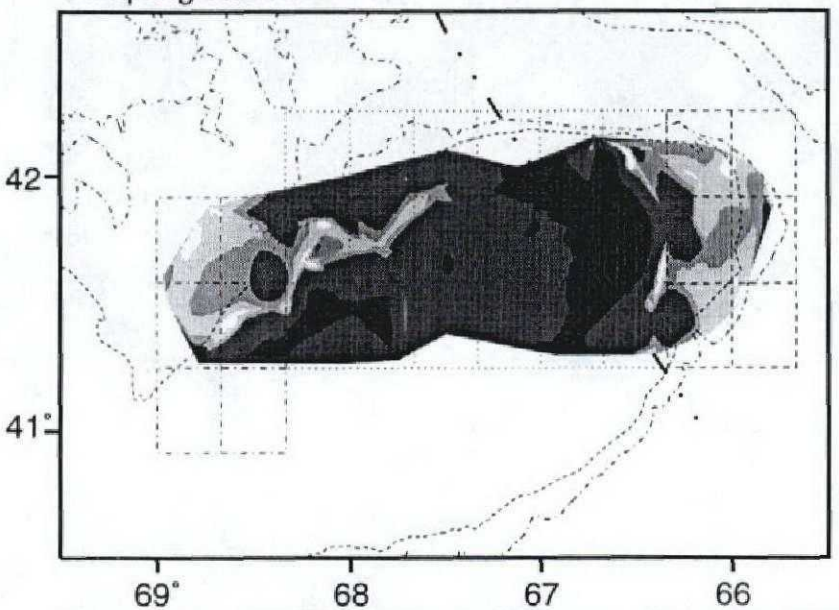

Figure 62c. 1994 Canadian larval survey (Nov 16 - 29). All larvae. Contours as per adjacent scale.

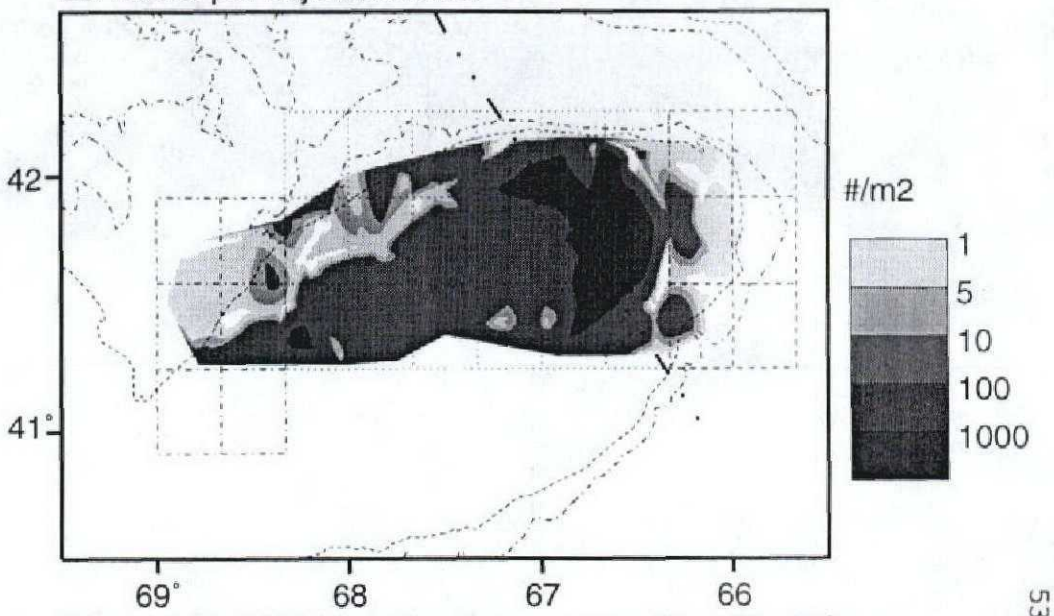

Figure 62d. 1994 Canadian larval survey (Nov 16 - 29). Larvae (<10mm). Contours as per adjacent scale.

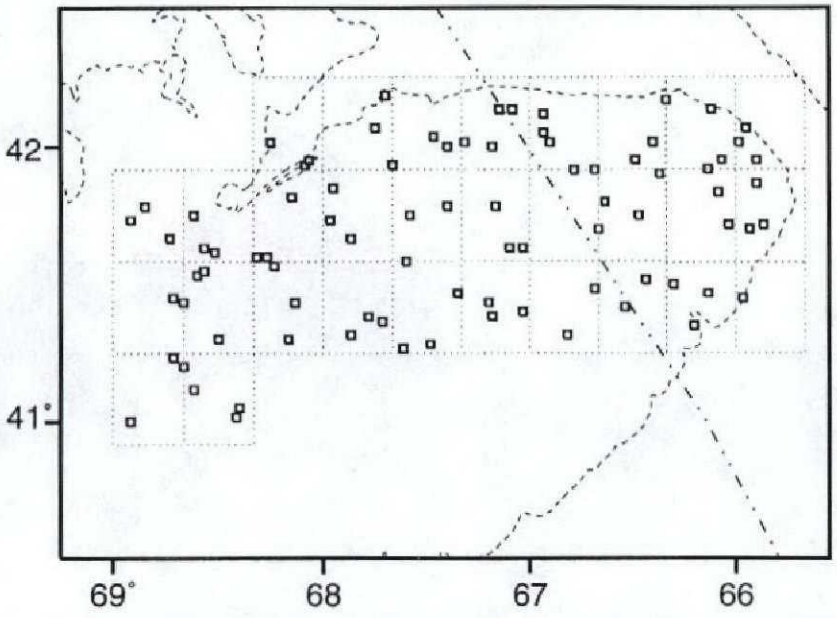

Figure 63a. 1995 Canadian larval survey (Nov 16 - 30). Sampling stations.

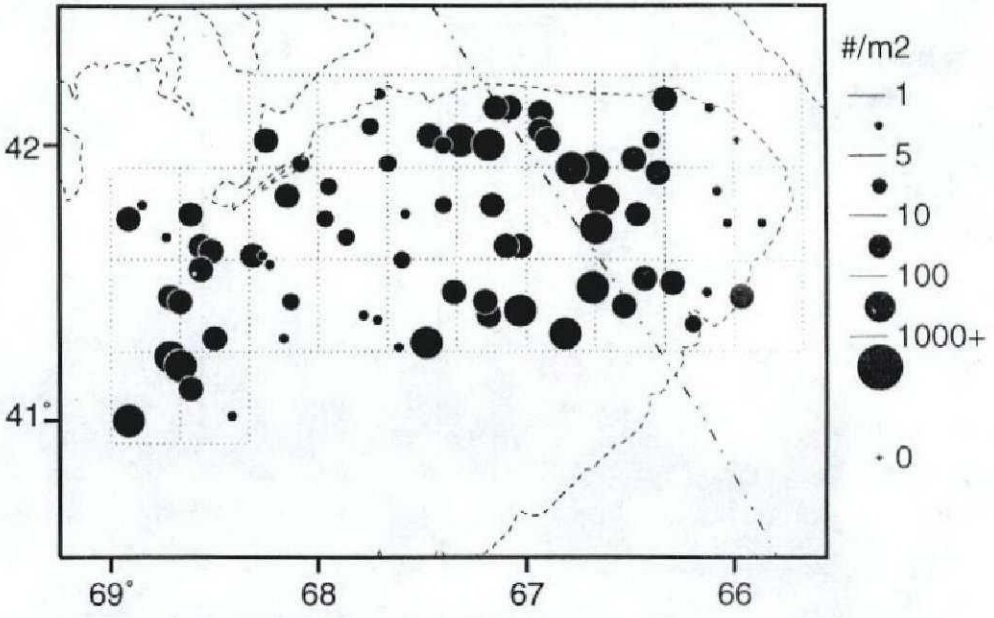

Figure 63b. 1995 Canadian larval survey (Nov 16 - 30). Larvae as per adjacent scale.

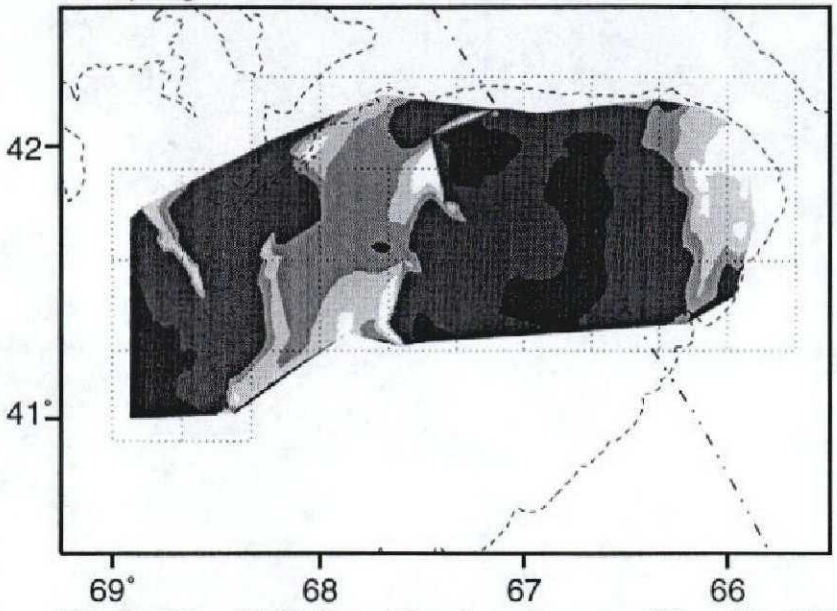

Figure 63c. 1995 Canadian larval survey (Nov 16 - 30). All larvae. Contours as per adjacent scale.

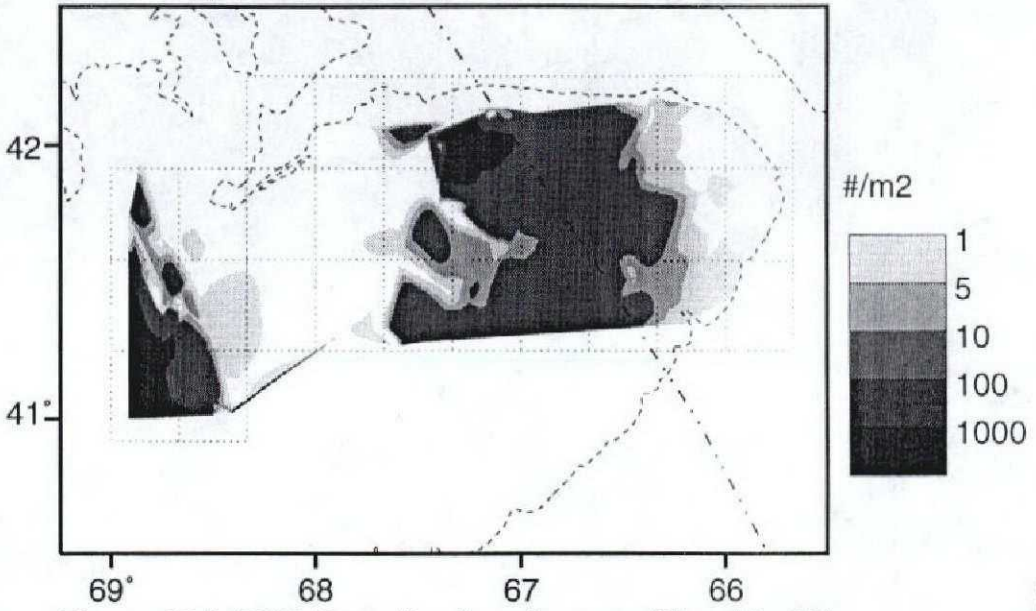

Figure 63d. 1995 Canadian larval survey (Nov 16 - 30). Larvae (<10mm). Contours as per adjacent scale.