NOAA Technical Memorandum NMFS-NE-122

Essential Fish Habitat Source Document:

Fishery-Independent Surveys, Data Sources, and Methods

U. S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Region
Northeast Fisheries Science Center
Woods Hole, Massachusetts

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NOAA Technical Memorandum NMFS-NE-122

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Essential Fish Habitat Source Document:

Fishery-Independent Surveys, Data Sources, and Methods

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Editorial Notes on Issues 122-152
in the
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Editorial Production

For Issues 122-152, staff of the Northeast Fisheries Science Center's (NEFSC's) Ecosystems Processes Division have largely assumed the role of staff of the NEFSC's Editorial Office for technical and copy editing, type composition, and page layout. Other than the four covers (inside and outside, front and back) and first two preliminary pages, all preprinting editorial production has been performed by, and all credit for such production rightfully belongs to, the authors and acknowledgees of each issue, as well as those noted below in "Special Acknowledgments."

Special Acknowledgments

David B. Packer, Sara J. Griesbach, and Luca M. Cargnelli coordinated virtually all aspects of the preprinting editorial production, as well as performed virtually all technical and copy editing, type composition, and page layout, of Issues 122-152. Rande R. Cross, Claire L. Steimle, and Judy D. Berrien conducted the literature searching, citation checking, and bibliographic styling for Issues 122-152. Joseph J. Vitaliano produced all of the food habits figures in Issues 122-152.

Internet Availability

Issues 122-152 are being copublished, *i.e.*, both as paper copies and as web postings. All web postings are, or will soon be, available at: *www.nefsc.nmfs.gov/nefsc/habitat/efh*. Also, all web postings will be in "PDF" format.

Information Updating

By federal regulation, all information specific to Issues 122-152 must be updated at least every five years. All official updates will appear in the web postings. Paper copies will be reissued only when and if new information associated with Issues 122-152 is significant enough to warrant a reprinting of a given issue. All updated and/or reprinted issues will retain the original issue number, but bear a "Revised (Month Year)" label.

Species Names

The NMFS Northeast Region's policy on the use of species names in all technical communications is generally to follow the American Fisheries Society's lists of scientific and common names for fishes (*i.e.*, Robins *et al.* 1991[a]), mollusks (*i.e.*, Turgeon *et al.* 1998[b]), and decapod crustaceans (*i.e.*, Williams *et al.* 1989[c]), and to follow the Society for Marine Mammalogy's guidance on scientific and common names for marine mammals (*i.e.*, Rice 1998[d]). Exceptions to this policy occur when there are subsequent compelling revisions in the classifications of species, resulting in changes in the names of species (*e.g.*, Cooper and Chapleau 1998[e]).

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[a]Robins, C.R. (chair); Bailey, R.M.; Bond, C.E.; Brooker, J.R.; Lachner, E.A.; Lea, R.N.; Scott, W.B. 1991. Common and scientific names of fishes from the United States and Canada. 5th ed. *Amer. Fish. Soc. Spec. Publ.* 20; 183 p.

[b]Turgeon, D.D. (chair); Quinn, J.F., Jr.; Bogan, A.E.; Coan, E.V.; Hochberg, F.G.; Lyons, W.G.; Mikkelsen, P.M.; Neves, R.J.; Roper, C.F.E.; Rosenberg, G.; Roth, B.; Scheltema, A.; Thompson, F.G.; Vecchione, M.; Williams, J.D. 1998. Common and scientific names of aquatic invertebrates from the United States and Canada: mollusks. 2nd ed. *Amer. Fish. Soc. Spec. Publ.* 26; 526 p.

[c]Williams, A.B. (chair); Abele, L.G.; Felder, D.L.; Hobbs, H.H., Jr.; Manning, R.B.; McLaughlin, P.A.; Pérez Farfante, I. 1989. Common and scientific names of aquatic invertebrates from the United States and Canada: decapod crustaceans. *Amer. Fish. Soc. Spec. Publ.* 17; 77 p.

[d]Rice, D.W. 1998. Marine mammals of the world: systematics and distribution. *Soc. Mar. Mammal. Spec. Publ.* 4; 231 p.

[e]Cooper, J.A.; Chapleau, F. 1998. Monophyly and interrelationships of the family Pleuronectidae (Pleuronectiformes), with a revised classification. *Fish. Bull. (U.S.)* 96:686-726.

FOREWORD

One of the greatest long-term threats to the viability of commercial and recreational fisheries is the continuing loss of marine, estuarine, and other aquatic habitats.

Magnuson-Stevens Fishery Conservation and Management Act (October 11, 1996)

The long-term viability of living marine resources depends on protection of their habitat.

NMFS Strategic Plan for Fisheries Research (February 1998)

The Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), which was reauthorized and amended by the Sustainable Fisheries Act (1996), requires the eight regional fishery management councils to describe and identify essential fish habitat (EFH) in their respective regions, to specify actions to conserve and enhance that EFH, and to minimize the adverse effects of fishing on EFH. Congress defined EFH as "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity." The MSFCMA requires NMFS to assist the regional fishery management councils in the implementation of EFH in their respective fishery management plans.

NMFS has taken a broad view of habitat as the area used by fish throughout their life cycle. Fish use habitat for spawning, feeding, nursery, migration, and shelter, but most habitats provide only a subset of these functions. Fish may change habitats with changes in life history stage, seasonal and geographic distributions, abundance, and interactions with other species. The type of habitat, as well as its attributes and functions, are important for sustaining the production of managed species.

The Northeast Fisheries Science Center compiled the available information on the distribution, abundance, and habitat requirements for each of the species managed by the New England and Mid-Atlantic Fishery Management Councils. That information is presented in this series of 30 EFH species reports (plus one consolidated methods report). The EFH species reports comprise a survey of the important literature as well as original analyses of fishery-independent data sets from NMFS and several coastal states. The species reports are also the source for the current EFH designations by the New England and Mid-Atlantic Fishery Management Councils, and have understandably begun to be referred to as the "EFH source documents."

NMFS provided guidance to the regional fishery management councils for identifying and describing EFH of their managed species. Consistent with this guidance, the species reports present information on current and historic stock sizes, geographic range, and the period and location of major life history stages. The habitats of managed species are described by the physical, chemical, and biological components of the ecosystem where the species occur. Information on the habitat requirements is provided for each life history stage, and it includes, where available, habitat and environmental variables that control or limit distribution, abundance, growth, reproduction, mortality, and productivity.

Identifying and describing EFH are the first steps in the process of protecting, conserving, and enhancing essential habitats of the managed species. Ultimately, NMFS, the regional fishery management councils, fishing participants, Federal and state agencies, and other organizations will have to cooperate to achieve the habitat goals established by the MSFCMA.

A historical note: the EFH species reports effectively recommence a series of reports published by the NMFS Sandy Hook (New Jersey) Laboratory (now formally known as the James J. Howard Marine Sciences Laboratory) from 1977 to 1982. These reports, which were formally labeled as *Sandy Hook Laboratory Technical Series Reports*, but informally known as "Sandy Hook Bluebooks," summarized biological and fisheries data for 18 economically important species. The fact that the bluebooks continue to be used two decades after their publication persuaded us to make their successors – the 30 EFH source documents – available to the public through publication in the *NOAA Technical Memorandum NMFS-NE* series.

JAMES J. HOWARD MARINE SCIENCES LABORATORY
HIGHLANDS, NEW JERSEY
SEPTEMBER 1999

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NORTHEAST FISHERIES SCIENCE CENTER

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INTRODUCTION

This report describes the methods used to collect various data which have been utilized in the Northeast Fisheries Science Center Essential Fish Habitat (EFH) Source Documents to describe the life history and habitat characteristics of federally-managed species within the northeastern United States. These documents employ data which were collected in surveys by the Northeast Fisheries Science Center (NEFSC) and several New England and Middle Atlantic states, as well as other agencies. This report summarizes data collection methods for the food habits database, egg and larval surveys (presented north to south), and juvenile and adult surveys (NEFSC surveys, then other surveys north to south).

Geographic locations discussed in the EFH source documents are presented in Figures 1-4 (respectively, northeast U.S. and contiguous Canadian waters; larger scale of coastal New England and Georges Bank to Bay of Fundy; more northern Canadian waters; and South Atlantic Bight).

NEFSC FOOD HABITS DATABASE

Feeding ecology data are available from samples collected by the Food Web Dynamics Program during NEFSC Bottom Trawl Surveys from 1973-1990. This database contains over 123,000 stomach samples from 174 species of fish and squid. Diet summaries of species collected during the surveys were analyzed separately for the 1973-1980 and 1981-1990 time periods due to differences in stomach analyses and data processing.

During 1973-1980, stomach samples were preserved and processed in the laboratory. Prey weights were recorded to the nearest 0.01 g. During 1981-1990, stomach samples were processed at sea, and prey volumes were visually estimated to the nearest 0.1 cc. For prey without calcareous shells, there is an approximately 1:1 relationship between prey weight (mg) and volume (ml); for shelled prey, the weight:volume ratio exceeds unity (Steimle *et al*. 1994). The differences in prey identification and prey measurements make comparisons between 1973-1980 and 1981-1990 data difficult. Invertebrate prey were identified more accurately, and to lower taxonomic levels, in the laboratory-processed samples (1973-1980). In contrast, fish prey were more accurately identified to species, while most invertebrates were identified only to higher taxonomic levels, in the field-processed samples (1981-1990). Consequently, comparisons between the two periods are biased by differences in the level of identification.

EGG AND LARVAL SURVEYS

NEFSC MARMAP SURVEYS

The NEFSC Marine Resources Monitoring, Assessment and Prediction program (MARMAP) sampled fish eggs and larvae on monthly to bimonthly surveys from Cape Hatteras, NC, to Cape Sable, NS, from 1977 through 1987 (Sibunka and Silverman 1984, 1989). Sampling concentrated on the continental shelf, in depths ≥ 8 m, but stations as deep as 2,476 m were sampled. A total of 81 surveys were made. Dates and numbers of tows for each survey for which data are available are listed in Tables 1 and 2 for eggs and larvae, respectively. Less data are available for eggs than for larvae because egg samples from 1977 and two later cruises (cruises 1-11 and 51-52 in Table 2) were destroyed in a fire. Overall sampling effort (all surveys combined) for eggs and larvae is shown in Figure 5. Sampling effort by month (all years combined) is shown in Figures 6 and 7.

Sampling was conducted with 61 cm diameter "bongo" plankton samplers with 0.333 and 0.555 mm mesh nets; they were fished to a maximum depth of 200 m, or to within 5 m of the seabed. Towing wire was paid out at 50 m/min and retrieved at 20 m/min. Vessel speed was adjusted between 1 and 2 knots to maintain a 45^o angle in the tow wire. Digital flowmeters were used to determine volumes of water filtered. Catches were multiplied by a "haul factor" for conversion to densities per 10 m^2 of sea surface, where:

$$\text{Haul factor} = \frac{\text{maximum sampling depth}}{\text{(net mouth area)} \times \text{(flowmeter revolutions)} \times \text{(flowmeter calibration)}}$$

Depths were determined with an electronic meter block; a mechanical time depth recorder was also used beginning in 1982. Surface temperatures were measured with a stem thermometer in a bucket sample. Subsurface temperatures were measured with reversing thermometers on a string of Niskin water samplers set at specific water depths, and with expendable bathythermographs (XBTs). Beginning in 1987, hydrographic measurements were made using a Seabird conductivity, temperature, and depth (CTD) instrument.

SOUTH ATLANTIC BIGHT MARMAP

From 1973-1980, the South Carolina Marine Resources Research Institute conducted ichthyoplankton surveys throughout the South Atlantic Bight (SAB) (Powles and Stender 1976; Collins and Stender 1987). The studies were sponsored by the National Marine

Fisheries Service (NMFS) MARMAP Program Office. A total of 1,163 samples were taken from Cape Hatteras, NC to Cape Canaveral, FL, in depths ranging from 9-3,490 m. Locations of all collections are shown in Figure 8.

Two types of gear were used for neuston collections: a 1.0 x 0.5 m neuston net with 505 micron mesh, and a 2.0 x 1.0 m net with 947 micron mesh. Both nets were towed half-submerged. Samples were also taken with a bongo frame with 0.6 m diameter nets (333 and 505 micron mesh; only the latter samples were sorted for ichthyoplankton). All bongo tows were double oblique from 0 to ≤ 200 m depths. A total of 533 neuston tows and 500 bongo tows were taken over the duration of the study. Samples were preserved at sea and sorted in the laboratory under dissecting microscopes. No data were available for distribution/abundance of eggs. Larval abundance data were converted to numbers per 10 m^2 via the same calculations used for NEFSC MARMAP data.

JUVENILE AND ADULT SURVEYS

NEFSC BOTTOM TRAWL SURVEYS

Seasonal distributions of adult and juvenile fish were determined from the NEFSC bottom-trawl survey catch data. Surveys have been conducted in the fall since 1963 and in the spring since 1968; seasonal surveys have also been conducted in summer and winter on an intermittent basis (Table 3a-d). Temporal coverage of the surveys has changed through time; e.g., recent fall cruises have tended to occur earlier in the year (Figure 9). The general pattern of spring and fall surveys is typically south to north, beginning in central to southern portions of the Middle Atlantic Bight, followed by southern New England-Nantucket Shoals, Georges Bank, and finally the Gulf of Maine and Scotian Shelf. Trawl stations were selected in a stratified random design that provides unbiased estimates of fish availability to the trawl gear in relation to the distribution of species. Strata were defined based on water depth, latitude, and historical fishing patterns. Within each stratum, stations were assigned randomly for each survey; the number of stations allotted to a stratum was in proportion to its area. A minimum of two stations was assigned to small strata for the calculation of means and variances. Station allotments were approximately one station per 200 n mi^2.

The surveys were conducted in depths from 27 m to 366 m; however, greater depths were occasionally sampled in canyons along the continental shelf break. At each station, the total catch was sorted by species, and the catch of each species was weighed (to the nearest 0.1 kg) and measured (to the nearest cm); very large catches were subsampled. Geographic location, depth, and hydrographic data were also collected at each station. A complete description and evaluation of the bottom trawl survey program, including routine sampling protocols, can be found in Grosslein (1969), Azarovitz (1981), and Northeast Fisheries Science Center (1988). Geographic coverage of the NEFSC bottom-trawl surveys by season is shown in Figure 10.

Efforts have been made to maintain a standard trawl time series for over three decades. However, changes to the vessels, trawls, and trawl doors have been inevitable. To examine the effects of these changes to the survey, a series of gear comparison experiments was conducted; the data used in the EFH source documents reflects a standardization of these data.

Vessels

Three vessels have been used throughout the time series to conduct the surveys: the NOAA *R/V Albatross IV*, the *R/V Delaware II*, and the *R/V Atlantic Twin* (Table 3). The *Albatross IV* has been the primary vessel used in the survey with the *Delaware II* used during periods when the *Albatross IV* was unavailable. A series of vessel comparison cruises was conducted during 1981-1982 and 1986-1988 to evaluate the relative catchability of these vessels and to calculate fishing power (vessel conversion) coefficients (Table 4) (Byrne and Forrester 1991a).

During 1972-1975, the *R/V Atlantic Twin* was used to conduct inshore surveys primarily in the southern New England-Middle Atlantic area. There are no data available to examine the relative catchability of this vessel in comparison to the *Albatross IV*; therefore, the catch data from these surveys were not adjusted.

Trawls

Offshore surveys (depths greater than 27 m) conducted in the fall have used a #36 Yankee bottom trawl rigged with 41 cm rollers and a 1.25 cm (stretched mesh) cod end and towed at 1.8 m/s (= 6.5 km/h or approximately 3.7 kn) for 30 minutes at each station throughout the time series (see Table 3). The #36 Yankee trawl was also used during the 1968-1972 and 1982-1996 offshore spring surveys, but was replaced by a larger, high-opening #41 Yankee trawl during 1973-1981 in an effort to increase the fishing power for pelagic species.

Inshore surveys (depths less than 27 m) during 1972-1975 on the *R/V Atlantic Twin* were conducted with a modified 3/4 #36 Yankee trawl; all others used a standard #36 Yankee trawl. During 1976-1981, the #36 and #41 trawls were used inshore in the fall and spring, respectively. Surveys conducted in the summer used a #36 Yankee trawl throughout the series. A variety of trawls have been used during winter surveys including the #36 trawl (1964-1966, 1981), the #41 trawl (1972 and

1978), and a #36 trawl fitted with a chain sweep covered by rubber disks and 30 fathom ground cables designed to be more efficient in monitoring flounders (1992-1997).

An analysis of the differential catchability of the #36 and #41 Yankee trawls was conducted during gear comparison cruises in 1973-1975 and the calculation of trawl gear conversion coefficients for those nets (Table 4) was made by Sissenwine and Bowman (1978). No other trawl conversion factors are available.

Trawl Doors

During 1963-1984, the standard trawl doors used during the surveys were oval, wood/steel combination doors manufactured by the A.S. Bergens Mekaniske Versteder Co. (BMV) of Norway. These doors were used with both the #36 and #41 Yankee trawls with minimal modifications during this period. However, production of these doors ceased in 1983 and all-steel polyvalent doors manufactured by the Euronete Co. of Portugal were chosen to replace the BMV doors. In 1985, the polyvalent doors were placed in service as the standard survey door. An analysis of the differential catchability of the trawl doors was conducted using data collected from cruises in 1984, 1986-1987, and 1990-1991 and the calculation of trawl door conversion coefficients (Table 4) was made by Byrne and Forrester (1991b). To the extent possible, bottom trawl survey data were adjusted to reflect the following standard gear configuration:

vessel: *R/V Albatross IV*
trawl: #36 Yankee
trawl doors: Polyvalent.

Table 4 contains conversion coefficients for those species that had significantly different catch rates (in numbers) at the 0.05 level for each of the major gear changes in the survey. Catch data (in numbers) from each of the surveys were adjusted using these conversion factors on a station-by-station basis to provide a standardized set of data. Adjusted catches by species and survey were separated into juveniles and adults utilizing estimated lengths at 50% maturity (L_{50}) [O'Brien *et al.* (1993) for all species except the following: Marques da Silva (1993) (spiny dogfish); Almeida *et al.* (1995) (goosefish); and Hendrickson *et al.* (1996) (northern shortfin squid)]. The L_{50} values used were those calculated for females averaged over stock areas. The smallest adult lengths are the L_{50} values rounded to the nearest whole cm (Table 4). Total numbers-at-length data for each life stage were summed by station and plots of relative abundance by station generated for the spring and fall time series. Due to the variability in area covered and gears used during winter and summer surveys, distribution maps are presented as dot plots of presence/absence for each life stage.

NEFSC SEA SCALLOP SURVEYS

Sea scallop surveys by the NEFSC began in 1975 and have been conducted annually since 1977 (Table 5). Consistency of sampling dates and methods is greatest for the period 1982-1997, so this is the period for which data are presented. The surveys were designed to monitor the distribution, abundance, and recruitment patterns of the sea scallop resource in US offshore waters from Cape Hatteras, NC to Georges Bank (Figure 11). Sampling stations were selected using a stratified random design where strata were defined based on water depth and latitude. Within each stratum, stations were assigned randomly; the number of stations allotted to a stratum was proportional to its area. In selected strata in which commercial fishing activity or known concentrations of sea scallops were present, additional stations were randomly assigned prior to the survey to increase the precision of the abundance estimates for those strata.

The primary vessel used to conduct the survey throughout the series was the *R/V Albatross IV*; however, the *R/V Delaware II* (1978 only), *R/V Chapman* (1989 only), and *R/V Oregon II* (1989-1993) were also used during the series. Since 1979, the surveys have used a 2.44 m (8 ft) wide commercial sea scallop dredge with a 5.1 cm (2 in) ring bag and a 3.8 cm (1.5 in) mesh liner. The dredge was towed at 3.5 kn (~6.1 km/h) for 15 min at each station throughout the time series (Table 5).

The 1975 survey was conducted using transect sampling. Prior to 1979, a 3.05 m (10 ft) unlined dredge and different sampling strata were used. Data collected during these surveys have been standardized to the current gear configuration and stratification scheme [see Serchuk *et al.* (1982) for details]. In 1989, the sampling strata set was revised and strata with consistently low catch levels were eliminated (Wigley and Serchuk 1996). This resulted in slightly reduced spatial coverage, but increased precision in abundance estimates. Data from all prior surveys were post-stratified to conform to the current stratification scheme.

At each station, the total catch was sorted into biological and trash components. Live scallops collected at each station were counted and shell height measurements taken by 5 mm intervals. The bycatch of selected species was also enumerated and measured to the nearest centimeter and trash was measured by volume. Geographic location, depth, and hydrographic data were also collected at each station. A description of the survey program, including routine sampling protocols, can be found in Serchuk and Smolowitz (1980), Serchuk *et al.* (1979), Serchuk et al. (1982), and Wigley and Serchuk (1996). Total numbers-at-length data were summed by station and plots of sea scallop abundance by station were generated for the time series.

NEFSC ATLANTIC SURFCLAM/ OCEAN QUAHOG SURVEYS

The NEFSC conducted a total of 23 surveys during 1965-1997 to monitor and evaluate the distribution, abundance, and size composition of Atlantic surfclam and ocean quahog populations off the northeast coast between Cape Hatteras, NC and the Scotian Shelf. The survey was initially designed to monitor the surfclam population; however, as the ocean quahog industry grew, the survey was expanded to monitor that species as well. Prior to 1976, the surveys were conducted intermittently; annual surveys were conducted during 1976-1984, and at least every third year since 1986 (Table 6). Overall geographic coverage of all surveys combined is shown in Figure 12. During the earliest years of the survey, sampling stations were selected based on a grid-type design with stations spaced at approximate 10 nm intervals along latitude-longitude or LORAN lines. In 1978, the station selection method was modified to a stratified random design with strata defined primarily by depth and bottom type (the pre-1978 data have been post-stratified to conform to the stratified random design). Within each stratum, stations were assigned randomly; the number of stations allotted to a stratum was proportional to its area. In selected strata in which either commercial fishing activity or clam concentrations were known to occur, additional stations were randomly assigned prior to the survey to increase the precision of the abundance estimates in those strata.

The primary vessel used throughout the time series was the *R/V Delaware II*; however, the *R/V Albatross IV* (1966 and 1969) and *R/V Undaunted* (1965 only) were also used. Changes to the survey gear have included modifications to the dredge pump type, dredge width, and mesh size (Table 6). Since limited comparative gear testing occurred prior to some of the changes, and multiple changes were made sometimes simultaneously, it is difficult to calculate standardization coefficients from the survey data. The major change to the survey gear was the conversion from a 122 cm (48 in) width dredge with a surface supplied pump to a 152 cm (60 in) dredge with an electrohydraulic submersible pump in 1979 (Smolowitz and Nulk 1982). There are no data available to evaluate the effect of these changes to the gear. In addition to the pump and width changes, the mesh opening of the dredge changed from 1.91 cm to 5.08 cm over a period of three years (1978-1980). Limited data are available to evaluate effects of the changes in mesh on ocean quahog collections, but no data are available to evaluate effects of the changes on surfclam catch. No major changes have been made to the survey gear or methods since 1980, with the exception of a change in the vessel winch and the addition of a grate on the front of the dredge during the onboard wash of the catch (possibly increasing the retention of small clams) in 1997.

The dredge was towed at 1.5 knots (~2.6 km/h) for 5 min at each station throughout the time series (Table 6). At each station, the catch was sorted to species, and subsamples of surfclam and ocean quahog were measured to determine the size distribution of the catch. The total meat weight of the clams collected at each station was computed from length-weight equations (Murawski and Serchuk 1989; Northeast Fisheries Science Center 1998). Geographic location, depth, and hydrographic data were also collected at each station. A description of the survey program, including routine sampling protocols, can be found in Murawski (1981), Murawski and Serchuk (1989), Smolowitz and Nulk (1982), and Northeast Fisheries Science Center (1996).

During the 1997 survey, the performance of the survey gear was evaluated with bottom contact sensors, angle indicator (to determine when the dredge was fishing), pressure and depth sensors, GPS to determine ship speed and location, and video. The results indicated that the efficiency of the dredge gear was similar in 1997 to that in 1992 and different than in 1994. A complete description of this analysis is available in Northeast Fisheries Science Center (1998).

MASSACHUSETTS BOTTOM TRAWL SURVEYS

The Massachusetts Division of Marine Fisheries (MA-DMF) has conducted a series of standardized bottom trawl surveys in Massachusetts and adjacent coastal waters, including all of Buzzards Bay, Nantucket Sound and Cape Cod Bay, and the southwestern Gulf of Maine, during the spring and fall since 1978 (Table 7a, b). The surveys were designed to determine factors affecting the distribution and abundance of a broad suite of finfish and invertebrate species. The stations sampled are included in distribution/abundance figure in each source document. Trawl stations were selected using a stratified random design and sampling protocols were identical to those followed during NEFSC surveys. Sampling density was one station per 19 n. mi^2. At each station, the total catch was sorted by species, and the catch of each species weighed (to the nearest 0.1 kg) and measured (to the nearest cm). Geographic location, depth, and hydrographic data were also collected at each station. A complete description and evaluation of the bottom trawl survey program, including routine sampling protocols, can be found in Howe *et al.* (1997).

Two vessels have been used to conduct the surveys; the *R/V Francis Elizabeth* during 1978-1981, and the NOAA *R/V Gloria Michelle* from 1982 to the present. Vessel comparison experiments were not conducted to evaluate the relative catchability of these ships, so the data have not been standardized. The surveys used a 3/4 North Atlantic-type two seam (Whiting) trawl rigged with a 9-cm rubber disc chain sweep and 1.25 cm (stretched mesh) cod end towed at 2.5 kn (~4.4 km/h) for 20 min at each station throughout the time series (Table 7a, b). Stations were occupied during daylight hours only. Catch data (in numbers) were divided into juveniles and adults by species using the methods described for the NEFSC survey data.

RHODE ISLAND NARRAGANSETT BAY TRAWL SURVEYS

A monthly bottom trawl survey of 12 fixed stations in and just outside Narragansett Bay (Figure 13) by the Rhode Island Division of Fish and Wildlife began in January 1990 (Lynch 1998). A 13th station was added in 1992. The 12.8 m R/V *Thomas J. Wright* was used for sampling. Tows were made with a 3/4 scale high rise otter trawl with 11.9 m headrope, 16.5 m footrope, and mesh sizes (stretch) 10.2 cm below gore on wing, 11.4 cm at top of net above gore, 6.4 cm at top of belly, 5.1 cm at bottom of belly, 2.5 cm codend, and 0.95 cm codend liner. Trawl doors were wooden, 0.6 x 1.2 m, and located 14 m ahead of the wings. Tows were 20 min at 2.5 kn (~4.4 km/h). Catches were sorted by species. Numbers, lengths (nearest cm) and total weight were recorded for all species. Data presented are means of the three monthly tows per station per season for seven years of sampling (1990-1996). Depth and surface and bottom water temperature were recorded at all stations.

CONNECTICUT LONG ISLAND SOUND TRAWL SURVEYS

This survey by the Connecticut Department of Environmental Protection covered Long Island Sound waters in both CT and NY, from longitude 72^{o}03’ to 73^{o}39’, in depths of 5-46 m (Connecticut Department of Environmental Protection 1997). The data which are utilized in the source documents are from 1992 through 1997 sampling, and have been divided into spring and fall sampling periods. Typically, spring sampling consisted of 40 sites sampled monthly during April-June, and fall sampling was 40 sites/month in September and October. In 1992 there was no April sampling, and in 1993 and 1994 another 40 site cruise was added in November. Overall sampling effort for spring and fall sampling is shown in Figure 14.

The sampling design was stratified random. The study area was divided into 1.85 x 3.7 km (1 x 2 nautical mile) strata based on depth and bottom type. Sites were selected randomly from within each stratum, with the number of sites based on stratum size (minimum two sites per stratum). All samples were taken from the 15.2 m R/V *John Dempsey*. Sampling was done with a Wilcox 14 m high-rise otter trawl with 9.1 m headrope, 14.0 m footrope, 102 mm mesh trawl body and 51 mm mesh cod end. Trawl doors were steel "V" type, 1.2 m long x 0.8 m high, weighing 91 kg. Tows were 30 minutes at 3.5 kn (~6.1 km/h). Catches were sorted by species, all finfish and squid were counted, and total weight per species was determined with a model 8100 Doran scale. Subsamples (minimum 30 individuals) of squid and selected finfish species were measured to the centimeter (lengths rounded down). Measurements were made only on catches from selected tows (e.g., the first 3 tows of the day), and were not made on catches in all months of all years. Therefore, available length data from 1992-1997 was augmented with earlier data. Histograms showing seasonal length frequencies represent lengths typically encountered in spring and fall based on both a subset of 1992-1997 catches and on earlier data. Temperature and salinity were measured 1 m below the surface and 0.5 m above bottom, using a YSI model 33 S-C-T meter, before each tow.

NEFSC HUDSON-RARITAN TRAWL SURVEY

This survey used the same basic stratified random sampling design as the NEFSC bottom trawl survey. The lower Hudson-Raritan Estuary was divided into six non-channel and three channel strata, which in turn were divided into 217 blocks (Figure 15). Detailed stratum/block information is provided in Wilk *et al.* (1996); statistical descriptions of stratified random sampling design can be found in Grosslein (1969), Azarovitz (1981), and Northeast Fisheries Science Center (1988). The NOAA *R/V Gloria Michelle* was used for all sampling. Due to the vessel’s draft, only waters ≥ 3 m deep were sampled.

The data utilized in the source documents are based on monthly sampling from January 1992 through June 1997 (Figure 16), with the exception that no sampling was conducted in May or September. When possible, 40 blocks were sampled per month. The seasonal data are presented as averages of catches in spring (March-April), summer (June-August), fall (October-November), and winter (December-February) (Figure 16). Fish and large invertebrates were collected using an otter trawl with 8.5 m (28 ft) headrope, 10.4 m (34 ft) footrope, 102 mm (4 in) mesh trawl body, and 35 mm (1.375 in) mesh cod end liner. Trawl doors weighed 36.3 kg (80 lb). Tows were 10 min at ~3.7 km/hr (2 kn). Loran C coordinates and/or GPS positions, latitude, longitude, depth, and time were recorded at the beginning and end of each tow.

All specimens of each species caught were collectively weighed to the nearest 0.1 kg and individually measured to the nearest whole cm as follows. Fish from the snout to the end of the middle caudal ray (i.e., either fork or total length depending on species); bivalves across the widest point of the shell; and squid from the anterior margin to the posterior end of the dorsal mantle. Where large catches required subsampling, an expansion factor (weight of total catch/weight of subsample) was applied to the number and length frequency of the total catch. Catch data was separated into juveniles and adults using the same methods as described above for NEFSC survey data.

Hydrographic data were taken while drifting at each station using a Hydrolab Surveyor 3 Display Logger and H_2O Multiprobe fitted with sensors for depth, temperature, salinity and dissolved oxygen (the latter was not measured before 1993). The instrument was calibrated before each cruise. Bottom water observations were taken at the end of each trawl station.

SEAMAP-SA BOTTOM TRAWL SURVEYS

The Southeast Area Monitoring and Assessment Program-South Atlantic (SEAMAP-SA) is an NMFS-sponsored survey conducted by the South Carolina Department of Natural Resources, Marine Resources Division (SCMRD). Data were available from trawl surveys of coastal habitats between Cape Hatteras and Cape Canaveral beginning in 1986, but data presented in the source documents are for only 1990 through 1996, when sampling was most consistent (Webster *et al.* 1990; Beatty and Boylan 1997; SEAMAP-SA/SCMRD 1997). Collections were made at randomly selected sites in predefined strata. During 1990-1996 the survey included 24 strata, each of which was divided into an inshore (4.6-9.1 m depth) and offshore (9.1-18.2 m) stratum, for a total of 48 strata (Figure 4). The number of stations allotted to a stratum was in proportion to its area, although in 1990-1996 proportionally more samples were taken in the inshore than the offshore strata.

The 22.9 m R/V *Lady Lisa* was used for sampling. Trawls used were paired 22.9 m mongoose-type Falcon trawls, with 91.4 m three-lead bridles attached to pairs of 3.0 m x 1.0 m wooden chain doors. Headropes were 22.0 m and footropes 22.9 m. Trawl bodies were constructed of #15 twine and had 45 mm stretch mesh. Cod ends were #30 twine with 39 mm stretch mesh. A tickler chain was attached to each door. Tows were 20 minutes long. Fish collected were counted, measured to the nearest cm, and weighed by species to the nearest gram (except for very large catches, which were subsampled). Catch-per-tow was defined as the combined catch from both paired nets. Surface and bottom temperature, salinity and sampling depth were recorded at each station.

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Table 1. Dates and number of tows for each NEFSC MARMAP fish egg survey, 1978-1987.

Survey	*No. Tows*	*Start Date*	*End Date*		*Survey*	*No. Tows*	*Start Date*	*End Date*
12	155	10/06/78	11/11/78		46	160	09/14/83	11/09/83
13	72	11/16/78	11/29/78		47	149	11/16/83	12/19/83
14	102	02/25/79	03/14/79		48	159	01/10/84	02/08/84
15	102	04/01/79	05/07/79		49	151	03/02/84	04/25/84
16	170	05/06/79	05/29/79		50	177	05/09/84	06/02/84
17	123	06/17/79	07/13/79		53	106	07/10/84	07/30/84
18	145	08/11/79	09/02/79		54	119	07/25/84	08/30/84
19	158	10/04/79	10/28/79		55	158	09/17/84	11/03/84
20	102	11/15/79	12/20/79		56	144	11/01/84	12/05/84
21	170	02/20/80	04/04/80		57	125	01/08/85	02/06/85
22	175	04/16/80	05/12/80		58	120	02/27/85	04/12/85
23	148	05/23/80	06/29/80		59	130	04/02/85	04/22/85
24	153	07/16/80	08/09/80		60	134	05/09/85	05/30/85
25	174	09/26/80	10/29/80		61	150	07/17/85	08/29/85
26	137	11/19/80	12/21/80		62	173	08/30/85	09/22/85
27	151	02/18/81	03/24/81		63	140	09/10/85	11/15/85
28	99	03/19/81	04/08/81		64	179	11/07/85	12/12/85
29	143	03/19/81	05/12/81		65	173	01/10/86	02/12/86
30	143	05/21/81	06/17/81		66	145	03/04/86	04/27/86
31	78	06/27/81	07/19/81		67	161	05/08/86	06/06/86
32	94	08/04/81	09/02/81		68	105	06/17/86	07/17/86
33	169	09/17/81	11/08/81		69	116	07/29/86	08/29/86
34	88	11/18/81	12/21/81		70	155	08/27/86	09/24/86
35	145	02/14/82	03/23/82		71	147	09/14/86	11/06/86
36	166	03/11/82	05/08/82		72	159	11/05/86	12/11/86
37	132	05/18/82	06/11/82		73	132	01/07/87	02/08/87
38	123	07/13/82	08/07/82		74	152	03/24/87	04/28/87
39	149	09/15/82	11/09/82		75	91	04/13/87	04/22/87
40	152	11/17/82	12/20/82		76	193	05/07/87	06/07/87
41	148	01/18/83	03/01/83		77	129	05/31/87	06/30/87
42	139	03/09/83	05/01/83		78	155	07/07/87	08/10/87
43	170	05/26/83	06/21/83		79	179	08/19/87	09/20/87
44	116	07/27/83	08/30/83		80	144	09/11/87	10/30/87
45	62	08/16/83	09/04/83		81	124	11/04/87	12/10/87

Table 2. Dates and number of tows for each NEFSC MARMAP larval fish survey, 1977-1987.

Survey	***No. Tows***	***Start Date***	***End Date***		***Survey***	***No. Tows***	***Start Date***	***End Date***
1	183	02/13/77	04/08/77		41	153	01/18/83	03/01/83
2	189	03/04/77	04/22/77		42	139	03/09/83	05/01/83
3	189	04/14/77	05/13/77		43	176	05/26/83	06/21/83
4	205	05/18/77	06/22/77		44	117	07/27/83	08/30/83
5	160	07/30/77	08/30/77		45	62	08/16/83	09/04/83
6	142	10/18/77	11/09/77		46	165	09/14/83	11/09/83
7	90	11/13/77	12/13/77		47	151	11/16/83	12/19/83
8	166	02/16/78	03/17/78		48	160	01/10/84	02/08/84
9	172	04/18/78	05/23/78		49	156	03/02/84	04/25/84
10	148	06/24/78	07/16/78		50	178	05/09/84	06/02/84
11	152	08/12/78	09/04/78		51	41	06/17/84	06/24/84
12	155	10/06/78	11/11/78		52	68	07/04/84	07/18/84
13	74	11/16/78	11/29/78		53	107	07/10/84	07/30/84
14	102	02/25/79	03/14/79		54	119	07/25/84	08/30/84
15	106	04/01/79	05/07/79		55	158	09/17/84	11/03/84
16	170	05/06/79	05/29/79		56	144	11/01/84	12/05/84
17	123	06/17/79	07/13/79		57	125	01/08/85	02/06/85
18	146	08/11/79	09/02/79		58	120	02/27/85	04/12/85
19	160	10/04/79	10/28/79		59	130	04/02/85	04/22/85
20	103	11/15/79	12/20/79		60	134	05/09/85	05/30/85
21	171	02/20/80	04/04/80		61	150	07/17/85	08/29/85
22	175	04/16/80	05/12/80		62	173	08/30/85	09/22/85
23	148	05/23/80	06/29/80		63	140	09/10/85	11/15/85
24	153	07/16/80	08/09/80		64	179	11/07/85	12/12/85
25	174	09/26/80	10/29/80		65	173	01/10/86	02/12/86
26	137	11/19/80	12/21/80		66	145	03/04/86	04/27/86
27	152	02/18/81	03/24/81		67	161	05/08/86	06/06/86
28	99	03/19/81	04/08/81		68	105	06/17/86	07/17/86
29	144	03/19/81	05/12/81		69	116	07/29/86	08/29/86
30	145	05/21/81	06/17/81		70	155	08/27/86	09/24/86
31	78	06/27/81	07/19/81		71	147	09/14/86	11/06/86
32	96	08/04/81	09/02/81		72	159	11/05/86	12/11/86
33	169	09/17/81	11/08/81		73	133	01/07/87	02/08/87
34	88	11/18/81	12/21/81		74	151	03/24/87	04/28/87
35	145	02/14/82	03/23/82		75	90	04/13/87	04/22/87
36	166	03/11/82	05/08/82		76	193	05/07/87	06/07/87
37	132	05/18/82	06/11/82		77	129	05/31/87	06/30/87
38	124	07/13/82	08/07/82		78	155	07/07/87	08/10/87
39	151	09/15/82	11/09/82		79	179	08/19/87	09/20/87
40	152	11/17/82	12/20/82		80	144	09/11/87	10/30/87
					81	124	11/04/87	12/10/87

Table 3a. NMFS NEFSC bottom trawl surveys conducted during the spring, 1968-1997.

Year	***Vessel***	***Start Date***	***End Date***	***No. of Stations***	***Trawl Gear***	***Study Area***
1968	Albatross IV	4-Mar-68	8-Apr-68	251	36 Yankee	Scotian Shelf - Cape Hatteras
1969	Albatross IV	5-Mar-69	10 Apr 69	257	36 Yankee	Scotian Shelf - Cape Hatteras
1970	Albatross IV	13-Mar-70	30-Apr-70	279	36 Yankee	Scotian Shelf - Cape Hatteras
1971	Albatross IV	9-Mar-71	5-May-71	339	36 Yankee	Scotian Shelf - Cape Hatteras
1972	Albatross IV	8-Mar-72	28-Apr-72	303	36 Yankee	Gulf of Maine - Cape Hatteras
1973	Alb IV & AT	19-Mar-73	4-Jun-73	480	41 & 3/4 Yankee[1]	Scotian Shelf - Cape Hatteras
1974	Alb IV & AT	12-Mar-74	5-May-74	272	41 & 3/4 Yankee[1]	Scotian Shelf - So. Atlantic Bight
1975	Alb IV & AT	14-Mar-75	12-May-75	303	41 & 3/4 Yankee[1]	Scotian Shelf - Cape Hatteras
1976	Alb IV & De II	3-Mar-76	8-May-76	374	41 Yankee	Scotian Shelf - Cape Hatteras
1977	Alb IV & De II	19-Mar-77	20-May-77	351	41 Yankee	Scotian Shelf - Cape Hatteras
1978	Albatross IV	20-Mar-78	26-May-78	388	41 Yankee	Scotian Shelf - Cape Hatteras
1979	Alb IV & De II	20-Mar-79	12-May-79	470	41 Yankee	Scotian Shelf - Cape Hatteras
1980	Alb IV & De II	16-Mar-80	16-May-80	434	41 Yankee	Scotian Shelf - Cape Fear
1981	Delaware II	17-Mar-81	22-May-81	362	41 Yankee	Scotian Shelf - Cape Fear
1982	Delaware II	8-Mar-82	8-May-82	379	36 Yankee	Scotian Shelf - Cape Fear
1983	Albatross IV	7-Mar-83	6-May-83	375	36 Yankee	Gulf of Maine - Cape Fear
1984	Albatross IV	29-Feb-84	27-Apr-84	374	36 Yankee	Scotian Shelf - Cape Fear
1985	Albatross IV	25-Feb-85	13-Apr-85	362	36 Yankee	Gulf of Maine - Cape Fear
1986	Albatross IV	3-Mar-86	27-Apr-86	361	36 Yankee	Gulf of Maine - Cape Hatteras
1987	Alb IV & De II	23-Mar-87	5-May-87	334	36 Yankee	Gulf of Maine - Cape Hatteras
1988	Albatross IV	5-Mar-88	21-Apr-88	314	36 Yankee	Gulf of Maine - Cape Hatteras
1989	Delaware II	27-Feb-89	13-Apr-89	291	36 Yankee	Gulf of Maine - Cape Hatteras
1990	Delaware II	5-Mar-90	18-Apr-90	311	36 Yankee	Gulf of Maine - Cape Hatteras
1991	Delaware II	5-Mar-91	19-Apr-91	324	36 Yankee	Gulf of Maine - Cape Hatteras
1992	Albatross IV	2-Mar-92	16-Apr-92	307	36 Yankee	Gulf of Maine - Cape Hatteras
1993	Albatross IV	8-Mar-93	30-Apr-93	319	36 Yankee	Gulf of Maine - Cape Hatteras
1994	Delaware II	28-Feb-94	27-Apr-94	326	36 Yankee	Gulf of Maine - Cape Hatteras
1995	Albatross IV	7-Mar-95	27-Apr-95	325	36 Yankee	Gulf of Maine - Cape Hatteras
1996	Albatross IV	6-Mar-96	29-Apr-96	335	36 Yankee	Gulf of Maine - Cape Hatteras
1997	Albatross IV	3-Mar-97	23-Apr-97	327	36 Yankee	Gulf of Maine - Cape Hatteras

[1] #41 Yankee used by the Albatross IV; 3/4 Yankee used by the R/V Atlantic Twin.

Table 3b. NMFS NEFSC bottom trawl surveys conducted during the fall, 1963-1996.

Year	***Vessel***	***Start Date***	***End Date***	***No. of Stations***	***Trawl Gear***	***Study Area***
1963	Albatross IV	13-Nov-63	16-Dec-63	182	36 Yankee	Scotian Shelf - Hudson Canyon
1964	Albatross IV	22-Oct-64	25-Nov-64	183	36 Yankee	Scotian Shelf - Hudson Canyon
1965	Albatross IV	6-Oct-65	9-Nov-65	190	36 Yankee	Scotian Shelf - Hudson Canyon
1966	Albatross IV	12-Oct-66	13-Nov-66	189	36 Yankee	Scotian Shelf - Hudson Canyon
1967	Albatross IV	17-Oct-67	10-Dec-67	263	36 Yankee	Scotian Shelf - Cape Hatteras
1968	Albatross IV	10-Oct-68	26-Nov-68	266	36 Yankee	Scotian Shelf - Cape Hatteras
1969	Albatross IV	8-Oct-69	23-Nov-69	267	36 Yankee	Scotian Shelf - Cape Hatteras
1970	Alb IV & De II	3-Sep-70	21-Nov-70	295	36 Yankee	Scotian Shelf - Cape Hatteras
1971	Albatross IV	29-Sep-71	19-Nov-71	296	36 Yankee	Scotian Shelf - Cape Hatteras
1972	Alb & De & AT	28-Sep-72	5-Dec-72	455	36 & 3/4 Yankee[2]	Scotian Shelf - So. Atlantic Bight
1973	Alb & De & AT	26-Sep-73	20-Nov-73	417	36 & 3/4 Yankee[2]	Scotian Shelf - Cape Hatteras
1974	Alb IV & De II	23-Sep-74	10-Nov-74	371	36 Yankee	Scotian Shelf - Cape Hatteras
1975	Alb IV & De II	15-Oct-75	7-Nov-75	387	36 Yankee	Cape Cod - Cape Hatteras
1976	Albatross IV	28-Sep-76	23-Nov-76	340	36 Yankee	Scotian Shelf - Cape Hatteras
1977	Delaware II	26-Sep-77	15-Dec-77	402	36 Yankee	Scotian Shelf - Cape Hatteras
1978	Delaware II	6-Sep-78	22-Nov-78	533	36 Yankee	Scotian Shelf - Cape Hatteras
1979	Alb IV & De II	12-Sep-79	19-Nov-79	565	36 Yankee	Scotian Shelf - Cape Fear
1980	Delaware II	17-Sep-80	21-Nov-80	388	36 Yankee	Scotian Shelf - Cape Fear
1981	Alb IV & De II	15-Sep-81	13-Nov-81	376	36 Yankee	Scotian Shelf - Cape Fear
1982	Albatross IV	13-Sep-82	12-Nov-82	374	36 Yankee	Scotian Shelf - Cape Fear
1983	Albatross IV	12-Sep-83	10-Nov-83	366	36 Yankee	Scotian Shelf - Cape Fear
1984	Albatross IV	10-Sep-84	9-Nov-84	339	36 Yankee	Gulf of Maine - Cape Hatteras
1985	Alb IV & De II	9-Sep-85	16-Nov-85	340	36 Yankee	Scotian Shelf - Cape Hatteras
1986	Alb IV & De II	13-Sep-86	6-Nov-86	352	36 Yankee	Gulf of Maine - Cape Hatteras
1987	Albatross IV	10-Sep-87	6-Nov-87	316	36 Yankee	Gulf of Maine - Cape Hatteras
1988	Albatross IV	12-Sep-88	28-Oct-88	307	36 Yankee	Gulf of Maine - Cape Hatteras
1989	Delaware II	11-Sep-89	2-Nov-89	320	36 Yankee	Gulf of Maine - Cape Hatteras
1990	Delaware II	11-Sep-90	26-Oct-90	332	36 Yankee	Gulf of Maine - Cape Hatteras
1991	Delaware II	9-Sep-91	25-Oct-91	327	36 Yankee	Scotian Shelf - Cape Hatteras
1992	Albatross IV	8-Sep-92	28-Oct-92	324	36 Yankee	Gulf of Maine - Cape Hatteras
1993	Delaware II	7-Sep-93	27-Oct-93	325	36 Yankee	Gulf of Maine - Cape Hatteras
1994	Albatross IV	6-Sep-94	27-Oct-94	331	36 Yankee	Gulf of Maine - Cape Hatteras
1995	Albatross IV	5-Sep-95	27-Oct-95	326	36 Yankee	Gulf of Maine - Cape Hatteras
1996	Albatross IV	9-Sep-96	31-Oct-96	320	36 Yankee	Gulf of Maine - Cape Hatteras

[2] #36 Yankee used by the Albatross IV and Delaware II; 3/4 Yankee used by the R/V Atlantic Twin.

Table 3c. NMFS NEFSC bottom trawl surveys conducted during the summer 1963-1995.

Year	***Vessel***	***Start Date***	***End Date***	***No. of Stations***	***Trawl Gear***	***Study Area***
1963	Albatross IV	18-Jul-63	19-Aug-63	181	36 Yankee	Scotian Shelf - Hudson Canyon
1964	Albatross IV	27-Jul-64	22-Aug-64	176	36 Yankee	Scotian Shelf - Hudson Canyon
1965	Albatross IV	7-Jul-65	10-Aug-65	358	36 Yankee	Scotian Shelf - Hudson Canyon
1969	Albatross IV	14-Jul-69	16-Aug-69	257	36 Yankee	Scotian Shelf - Cape Hatteras
1977	Delaware II	27-Jul-77	31-Aug-77	291	36 Yankee	Gulf of Maine - Cape Hatteras
1978	Alb IV & De II	25-Jul-78	11-Aug-78	302	36 Yankee	Gulf of Maine - Cape Hatteras
1979	Alb IV & De II	25-Jul-79	31-Aug-79	272	36 Yankee	Gulf of Maine - Cape Fear
1980	Alb IV & De II	11-Jul-80	22-Aug-80	297	36 Yankee	Gulf of Maine - Cape Fear
1991	Delaware II	22-Jul-91	2-Aug-91	6	36 Yankee	Gulf of Maine
1993	Delaware II	20-Jul-93	6-Aug-93	70	36 Yankee	Gulf of Maine
1994	Albatross IV	26-Jul-94	5-Aug-94	28	36 Yankee	Gulf of Maine
1995	Albatross IV	14-Aug-95	25-Aug-95	38	36 Yankee	Gulf of Maine

Table 3d. NMFS NEFSC bottom trawl surveys conducted during the winter 1964-1997.

Year	***Vessel***	***Start Date***	***End Date***	***No. of Stations***	***Trawl Gear***	***Study Area***
1964	Albatross IV	16-Jan-64	15-Feb-64	194	36 Yankee	Scotian Shelf - Hudson Canyon
1965	Albatross IV	1-Feb-65	2-Mar-65	177	36 Yankee	Scotian Shelf - Hudson Canyon
1966	Albatross IV	18-Jan-66	23-Feb-66	187	36 Yankee	Scotian Shelf - Hudson Canyon
1972	Albatross IV	23-Feb-72	3-Mar-72	56	41 Yankee	northeast Georges Bank
1978	Albatross IV	18-Jan-78	27-Jan-78	174	41 Yankee	Nantucket Sound-Delaware Bay
1981	Delaware II	6-Jan-81	28-Jan-81	86	36 Yankee	southern New England – Mid-Atlantic Bight
1992	Delaware II	25-Feb-92	6-Mar-92	129	Mod. 36 Yankee[3]	Georges Bank - Cape Hatteras
1993	Albatross IV	3-Feb-93	27-Feb-93	122	Mod. 36 Yankee[3]	Georges Bank - Cape Hatteras
1994	Delaware II	31-Jan-94	23-Feb-94	92	Mod. 36 Yankee[3]	Georges Bank - Cape Hatteras
1995	Albatross IV	7-Feb-95	3-Mar-95	144	Mod. 36 Yankee[3]	Georges Bank - Cape Hatteras
1996	Albatross IV	5-Feb-96	29-Feb-96	129	Mod. 36 Yankee[3]	Gulf of Maine - Cape Hatteras
1997	Albatross IV	3-Feb-97	27-Feb-97	121	Mod. 36 Yankee[3]	Georges Bank - Cape Hatteras

[3] #36 Yankee trawl equipped with a rubber disk covered chain sweep and 30 fathom ground cables.

Table 4. Species-specific conversion factors, and lengths (L, in cm) at which both males and females are considered adults for EFH purposes, from NEFSC bottom trawl survey cruises conducted since 1963.

Common Name	***Scientific Name***	***Conversion Factors (numbers)***[1]			
		Trawls	**Doors**	**Vessels**	**L**
Atlantic cod	*Gadus morhua*	-	1.56	0.79	35
Haddock	*Melanogrammus aeglefinus*	-	1.49	0.82	32
Pollock	*Pollachius virens*	-	2.21	-	39
Redfish	*Sebastes* spp.	-	-	-	22
Goosefish	*Lophius americanus*	0.408	-	0.83	43
Ocean pout	*Macrozoarces americanus*	-	-	0.70	29
Silver hake	*Merluccius bilinearis*	0.424	-	-	23
Red hake	*Urophycis chuss*	-	1.31	-	26
White hake	*Urophycis tenuis*	-	-	-	35
Witch flounder	*Glyptocephalus cynoglossus*	-	-	-	30
American plaice	*Hippoglossoides platessoides*	-	-	0.82	27
Yellowtail flounder	*Limanda ferruginea*	0.568	1.22	0.85	26
Winter flounder	*Pseudopleuronectes americanus*	0.495	1.46	-	27
Windowpane	*Scophthalmus aquosus*	0.599	1.54	0.82	22
Sea scallop	*Placopecten magellanicus*	-	1.39	1.22	
Atlantic herring	*Clupea harengus*	-	-	0.59	25
Atlantic salmon	*Salmo salar*	-	-	-	
Bluefish	*Pomatomus saltatrix*	-	-	-	
Longfin inshore squid	*Loligo pealeii*	-	-	0.83	16
Northern shortfin squid	*Illex illecebrosus*	-	-	0.78	20
Atlantic mackerel	*Scomber scombrus*	-	-	-	26
Butterfish	*Peprilus triacanthus*	-	-	-	12
Summer flounder	*Paralichthys dentatus*	0.813	-	-	28
Scup	*Stenotomus chrysops*	-	-	-	15
Black sea bass	*Centropristis striata*	-	-	-	19
Spiny dogfish	*Squalus acanthias*	0.714	-	0.79	83[2]
Atlantic surfclam	*Spisula solidissima*	-	-	-	
Ocean quahog	*Arctica islandica*	-	-	-	4.9

[1]Conversion Factors to NEFSC Survey standard configuration:
Trawls: #41 Yankee to #36 Yankee **-** Spring 1973-1981 only
Doors: BMV to Polyvalent **-** Spring 1985 to present
Vessels: Delaware II to Albatross IV **-** Various, some during same survey

[2]Females are considered adults at 83 cm, males at 60 cm.

Table 5. NMFS NEFSC sea scallop surveys conducted during 1982-1997.

Year	***Season***	***Vessel***	***Start Date***	***End Date***	***No. of Stations***	***Study Area***
1982	Summer	Albatross IV	1-Jun-82	11-Jun-82	439	Mid Atlantic Bight - Cape Hatteras
1982	Summer	Albatross IV	12-Jul-82	6-Aug-82	205	Gulf of Maine - Mid Atlantic Bight
1983	Summer	Albatross IV	26-Jul-83	2-Sep-83	615	Georges Bank - Cape Hatteras
1984	Summer	Albatross IV	24-Jul-84	31-Aug-84	699	Georges Bank - Cape Hatteras
1985	Summer	Albatross IV	22-Jul-85	31-Aug-85	573	Georges Bank - Cape Hatteras
1986	Summer	Albatross IV	29-Jul-86	29-Aug-86	504	Georges Bank - Cape Hatteras
1987	Summer	Albatross IV	6-Jul-87	13-Aug-87	641	Georges Bank - Cape Hatteras
1988	Summer	Albatross IV	7-Jul-88	10-Aug-88	619	Georges Bank - Mid Atlantic Bight
1989	Summer	Alb/CH/OR	9-Jun-89	9-Aug-89	435	Georges Bank - Mid Atlantic Bight
1990	Summer	Oregon II	26-Jul-90	20-Aug-90	469	Georges Bank - Cape Hatteras
1991	Summer	Oregon II	28-Jul-91	21-Aug-91	437	Georges Bank - Cape Hatteras
1992	Summer	Oregon II	1-Aug-92	22-Aug-92	420	Georges Bank - Cape Hatteras
1993	Summer	Oregon II	31-Jul-93	25-Aug-93	446	Georges Bank - Cape Hatteras
1994	Summer	Albatross IV	22-Jun-94	18-Jul-94	482	Georges Bank - Cape Hatteras
1995	Summer	Albatross IV	19-Jun-95	30-Jun-95	247	Mid Atlantic Bight - Cape Hatteras
1995	Summer	Albatross IV	25-Jul-95	6-Aug-95	314	Long Island
1996	Summer	Albatross IV	29-Jul-96	26-Aug-96	453	Georges Bank - Cape Hatteras
1997	Summer	Albatross IV	21-Jul-97	17-Aug-97	496	Georges Bank - Cape Hatteras

Table 6. NMFS NEFSC Atlantic surfclam and ocean quahog surveys conducted during 1965-1997.

Year	***Season***	***Vessel***	***Start Date***	***End Date***	***Stations***	***Dredge Pump Type***	***Dredge Width (cm)***	***Size (cm)***	***Study Area***
1965	Spring	Undaunted	11-May-65	25-Jun-65	374	Surface	76	5.1	Montauk Pt. - Cape Hatteras
1965	Autumn	Undaunted	22-Oct-65	21-Nov-65	217	Surface	76	5.1	Montauk Pt. - Oregon Inlet
1966	Summer	Albatross IV	14-Aug-66	31-Aug-66	483	Surface	76	5.1	Montauk Pt. - False Cape
1969	Summer	Albatross IV	20-Jun-69	3-Jul-69	562	Surface	76	5.1	Gloucester - False Cape
1970	Summer	Delaware II	17-Jul-70	24-Aug-70	596	Surface	122	3.0	Nantucket Shoals - Delmarva
1974	Summer	Delaware II	5-Aug-74	10-Aug-74	141	Surface	76	5.1	New Jersey - Virginia
1976	Spring	Delaware II	6-Apr-76	13-May-76	217	Surface	122	3.0	Long Island - North Carolina
1977	Winter	Delaware II	26-Jan-77	17-Mar-76	280	Surface	122	3.0	Nantucket Shoals - Chesapeake Bay
1978	Winter	Delaware II	5-Jan-78	11-Feb-78	346	Surface	122	1.9	Gulf of Maine - Cape Hatteras
1978	Autumn	Delaware II	2-Dec-78	21-Dec-78	163	Surface	122	1.9	So. New England - Chesapeake Bay
1979	Winter	Delaware II	4-Jan-79	1-Feb-79	139	Submerse	152	2.5	Cape Cod - Cape Hatteras
1980	Winter	Delaware II	3-Jan-80	10-Feb-80	229	Submerse	152	5.1	So. New England - Mid Atlantic Bight
1980	Summer	Delaware II	15-Aug-80	12-Sep-80	199	Submerse	152	5.1	Scotian Shelf - Mid Atlantic Bight
1981	Summer	Delaware II	3-Aug-81	11-Sep-81	518	Submerse	152	5.1	Scotian Shelf - Chesapeake Bay
1982	Summer	Delaware II	22-Jul-82	3-Sep-82	394	Submerse	152	5.1	Georges Bank - Virginia
1983	Summer	Delaware II	15-Aug-83	28-Sep-83	396	Submerse	152	5.1	Scotian Shelf - Cape Hatteras
1984	Summer	Delaware II	9-Jul-84	1-Aug-84	448	Submerse	152	5.1	Georges Bank - Cape Hatteras
1986	Summer	Delaware II	17-Jun-86	18-Jul-86	334	Submerse	152	5.1	Georges Bank - Cape Hatteras
1989	Summer	Delaware II	26-Jun-89	21-Jul-89	361	Submerse	152	5.1	Georges Bank - Cape Hatteras
1992	Summer	Delaware II	8-Jun-92	13-Jul-92	484	Submerse	152	5.1	Gulf of Maine - Cape Hatteras
1994	Summer	Delaware II	18-Jul-94	24-Aug-94	538	Submerse	152	5.1	Georges Bank - Cape Hatteras
1997	Summer	Delaware II	8-Jun-97	14-Jul-97	472	Submerse	152	5.1	Georges Bank - Cape Hatteras

Table 7a. State of Massachusetts Division of Marine Fisheries bottom trawl surveys conducted during the spring, 1978-1997.

Year	***Vessel***	***Start Date***	***End Date***	***No. of Stations***	***Trawl Gear***	***Study Area***
1978	Francis Elizabeth	12-May-78	11-Jun-78	95	3/4 Whiting	Massachusetts State Waters
1979	Francis Elizabeth	30-Apr-79	27-May-79	100	3/4 Whiting	Massachusetts State Waters
1980	Francis Elizabeth	5-May-80	24-May-80	98	3/4 Whiting	Massachusetts State Waters
1981	Francis Elizabeth	6-May-81	21-May-81	97	3/4 Whiting	Massachusetts State Waters
1982	Gloria Michelle	4-May-82	21-May-82	95	3/4 Whiting	Massachusetts State Waters
1983	Gloria Michelle	9-May-83	25-May-83	96	3/4 Whiting	Massachusetts State Waters
1984	Gloria Michelle	7-May-84	22-May-84	99	3/4 Whiting	Massachusetts State Waters
1985	Gloria Michelle	6-May-85	22-May-85	94	3/4 Whiting	Massachusetts State Waters
1986	Gloria Michelle	4-May-86	17-May-86	96	3/4 Whiting	Massachusetts State Waters
1987	Gloria Michelle	4-May-87	19-May-87	97	3/4 Whiting	Massachusetts State Waters
1988	Gloria Michelle	9-May-88	25-May-88	92	3/4 Whiting	Massachusetts State Waters
1989	Gloria Michelle	8-May-89	24-May-89	97	3/4 Whiting	Massachusetts State Waters
1990	Gloria Michelle	7-May-90	23-May-90	95	3/4 Whiting	Massachusetts State Waters
1991	Gloria Michelle	7-May-91	22-May-91	98	3/4 Whiting	Massachusetts State Waters
1992	Gloria Michelle	5-May-92	20-May-92	92	3/4 Whiting	Massachusetts State Waters
1993	Gloria Michelle	5-May-93	19-May-93	88	3/4 Whiting	Massachusetts State Waters
1994	Gloria Michelle	10-May-94	25-May-94	88	3/4 Whiting	Massachusetts State Waters
1995	Gloria Michelle	9-May-95	24-May-95	98	3/4 Whiting	Massachusetts State Waters
1996	Gloria Michelle	7-May-96	22-May-96	101	3/4 Whiting	Massachusetts State Waters
1997	Gloria Michelle	6-May-97	21-May-97	98	3/4 Whiting	Massachusetts State Waters

Table 7b. State of Massachusetts Division of Marine Fisheries bottom trawl surveys conducted during the fall, 1978-1996.

Year	***Vessel***	***Start Date***	***End Date***	***No. of Stations***	***Trawl Gear***	***Study Area***
1978	Francis Elizabeth	5-Sep-78	2-Oct-78	95	3/4 Whiting	Massachusetts State Waters
1979	Francis Elizabeth	11-Sep-79	4-Oct-79	99	3/4 Whiting	Massachusetts State Waters
1980	Francis Elizabeth	8-Oct-80	29-Oct-80	97	3/4 Whiting	Massachusetts State Waters
1981	Francis Elizabeth	14-Oct-81	5-Nov-81	95	3/4 Whiting	Massachusetts State Waters
1982	Gloria Michelle	8-Sep-82	27-Sep-82	94	3/4 Whiting	Massachusetts State Waters
1983	Gloria Michelle	7-Sep-83	24-Sep-83	90	3/4 Whiting	Massachusetts State Waters
1984	Gloria Michelle	10-Sep-84	27-Sep-84	94	3/4 Whiting	Massachusetts State Waters
1985	Gloria Michelle	3-Sep-85	19-Sep-85	94	3/4 Whiting	Massachusetts State Waters
1986	Gloria Michelle	8-Sep-86	27-Sep-86	96	3/4 Whiting	Massachusetts State Waters
1987	Gloria Michelle	8-Sep-87	27-Sep-87	92	3/4 Whiting	Massachusetts State Waters
1988	Gloria Michelle	6-Sep-88	22-Sep-88	91	3/4 Whiting	Massachusetts State Waters
1989	Gloria Michelle	6-Sep-89	20-Sep-89	86	3/4 Whiting	Massachusetts State Waters
1990	Gloria Michelle	4-Sep-90	19-Sep-90	90	3/4 Whiting	Massachusetts State Waters
1991	Gloria Michelle	4-Sep-91	19-Sep-91	89	3/4 Whiting	Massachusetts State Waters
1992	Gloria Michelle	9-Sep-92	24-Sep-92	81	3/4 Whiting	Massachusetts State Waters
1993	Gloria Michelle	8-Sep-93	23-Sep-93	84	3/4 Whiting	Massachusetts State Waters
1994	Gloria Michelle	7-Sep-94	22-Sep-94	98	3/4 Whiting	Massachusetts State Waters
1995	Gloria Michelle	6-Sep-95	21-Sep-95	98	3/4 Whiting	Massachusetts State Waters
1996	Gloria Michelle	4-Sep-96	19-Sep-96	97	3/4 Whiting	Massachusetts State Waters

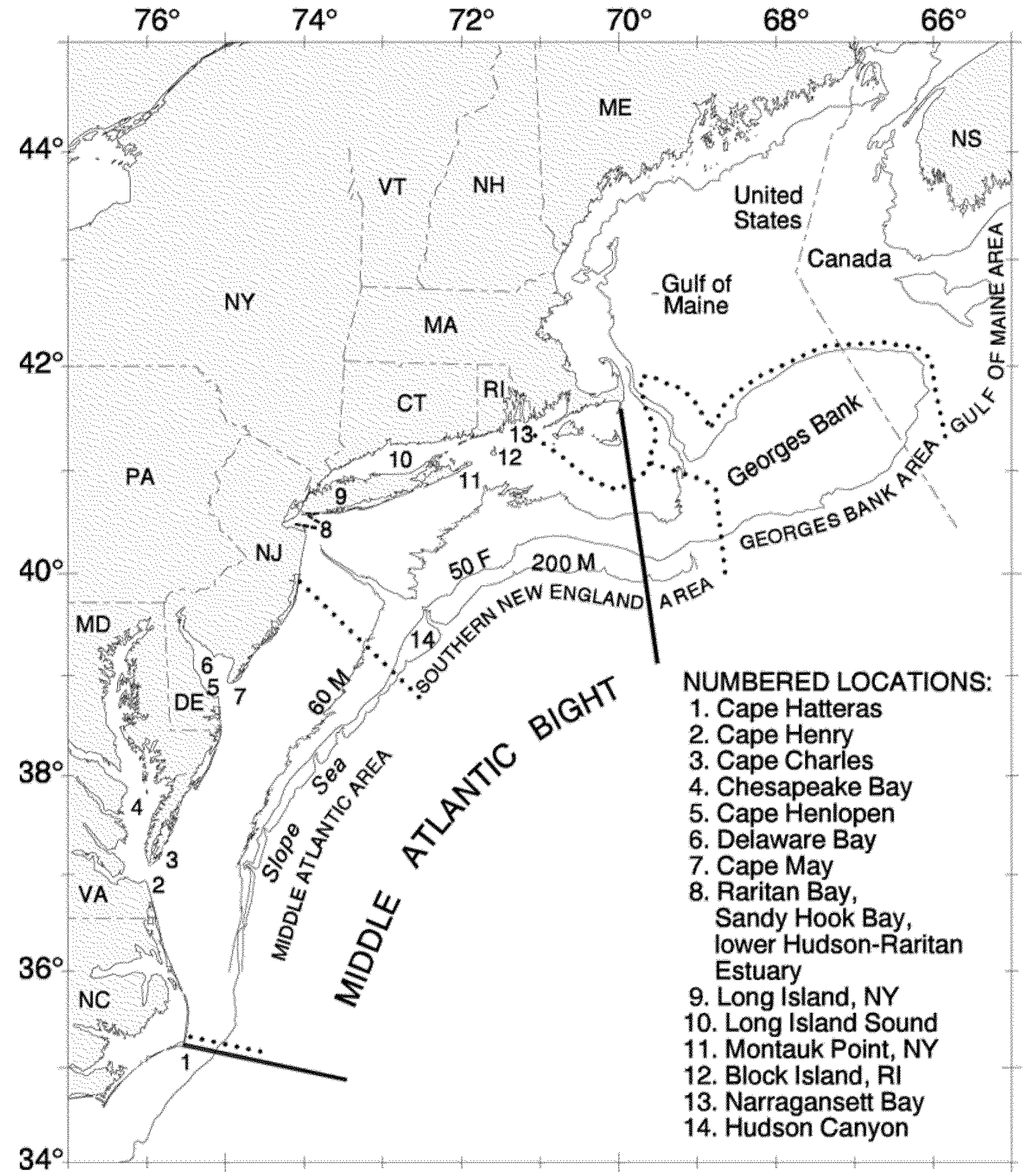


Figure 1. Geographic locations - northeast U.S. and contiguous Canadian waters.

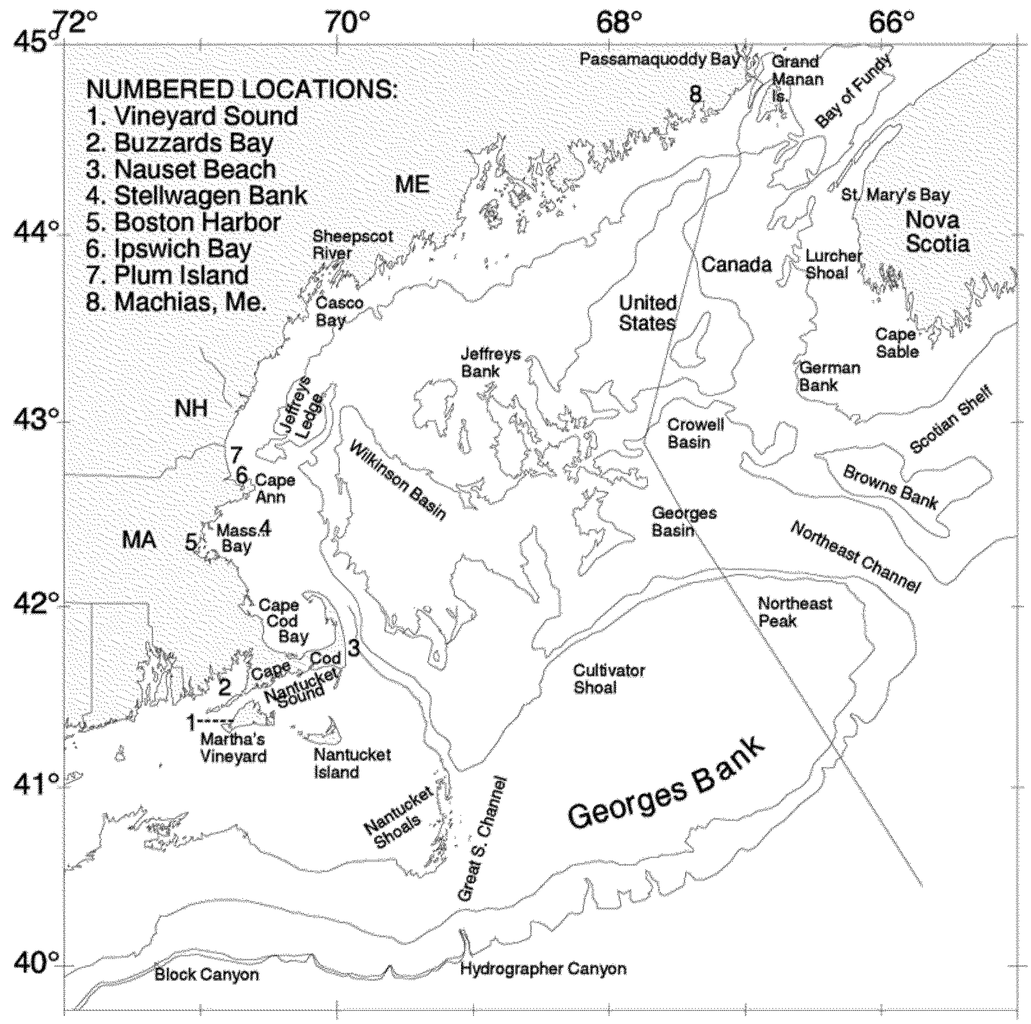


Figure 2. Geographic locations – coastal New England and Georges Bank to Bay of Fundy.

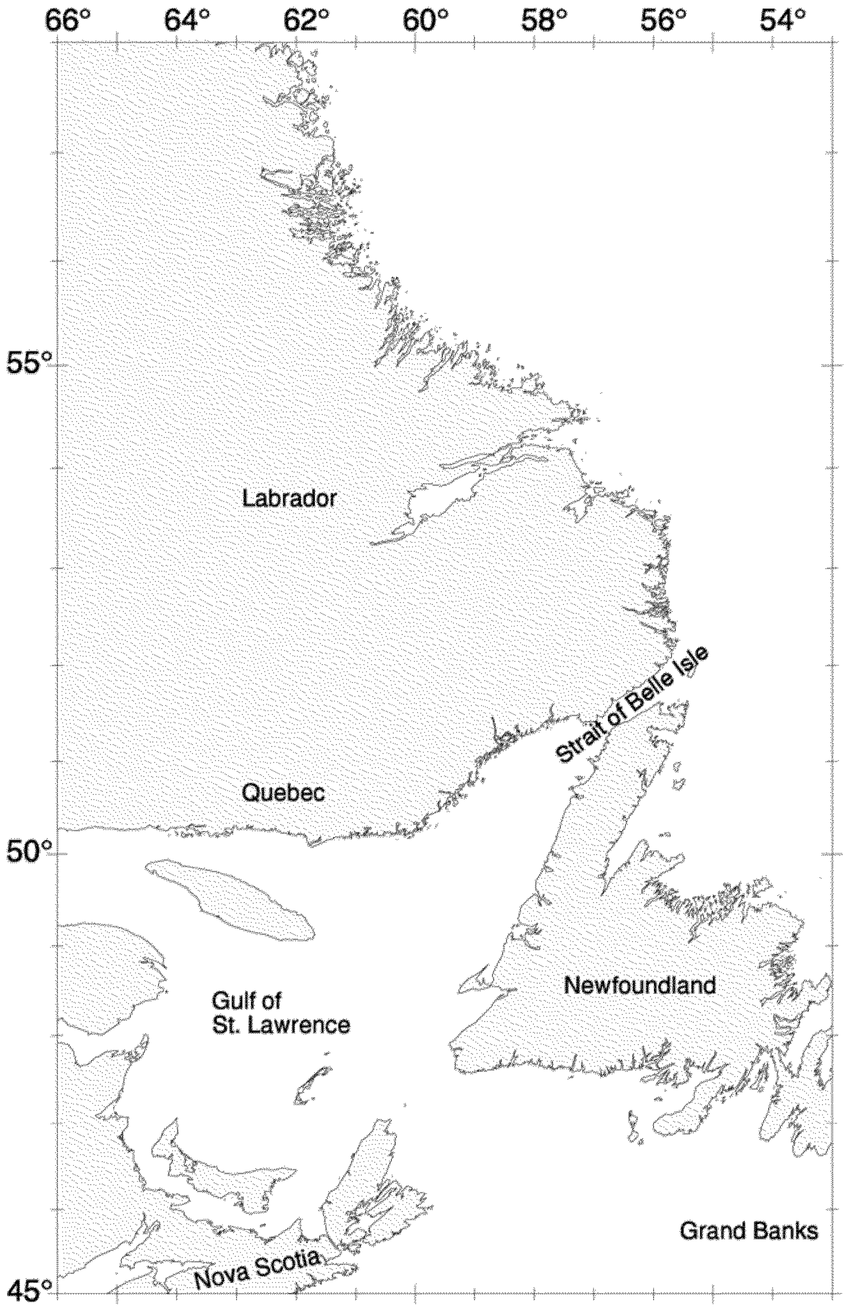


Figure 3. Geographic locations - Canadian waters from Nova Scotia north.

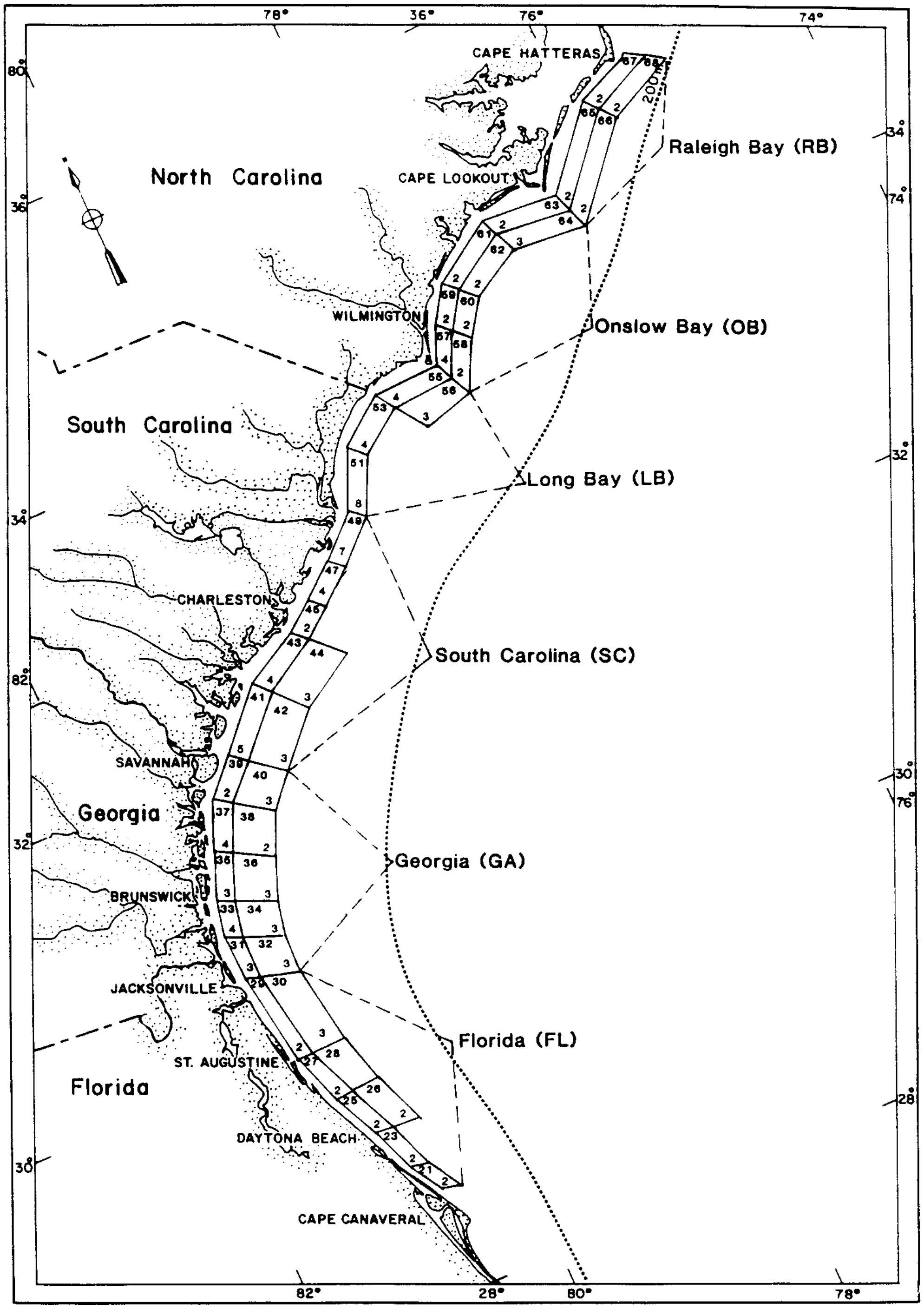


Figure 4. Geographic locations - South Atlantic Bight. Strata sampled in SEAMAP-SA shallow water trawl survey are also shown. Stratum number is shown in the upper left of each stratum, and the number of trawl sites within each stratum is shown in the lower right. Strata are not drawn to scale (from Webster *et al.* 1990).

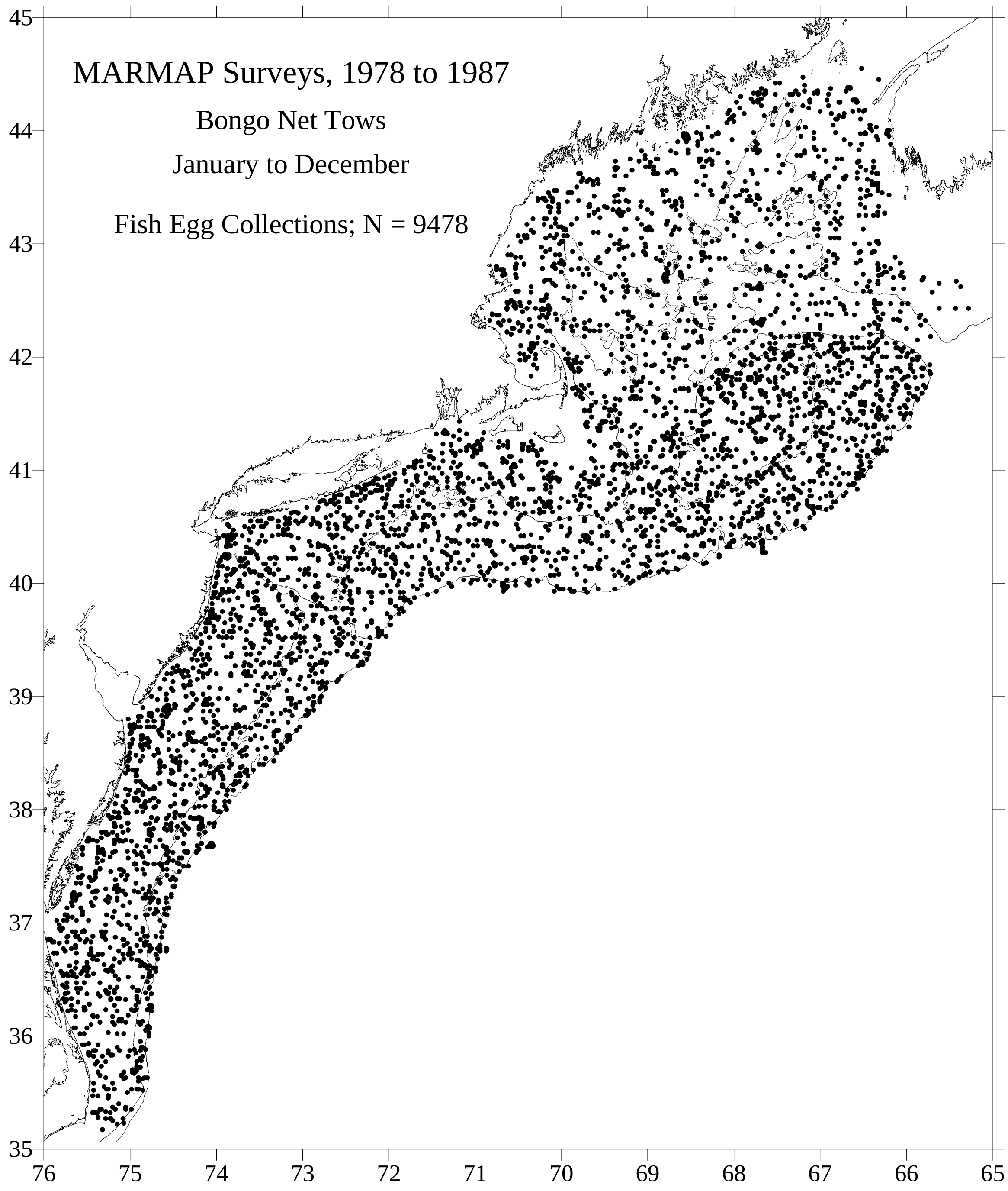
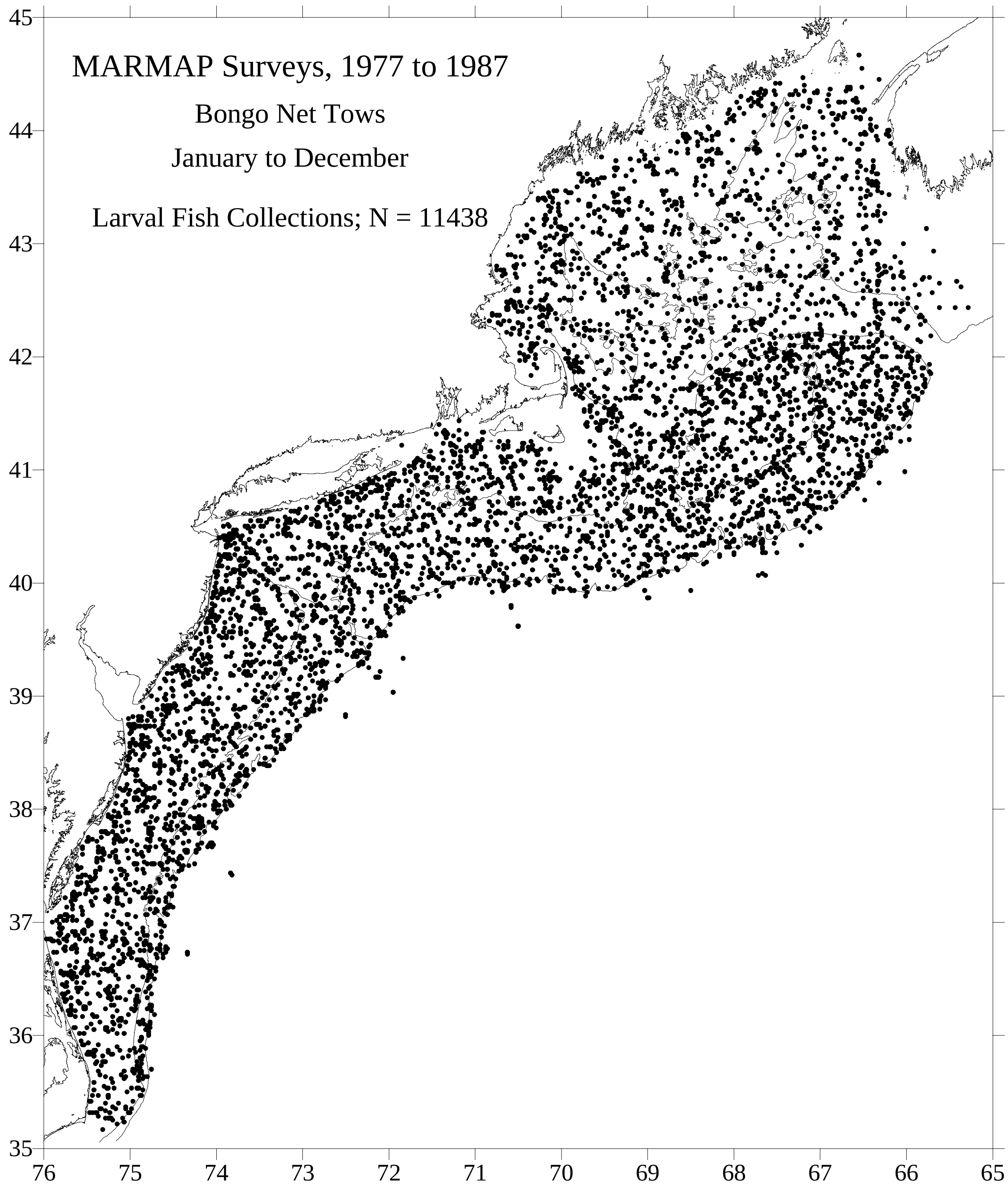


Figure 5. Distribution of all tows for ichthyoplankton eggs and larvae (all surveys combined) during NEFSC MARMAP surveys.



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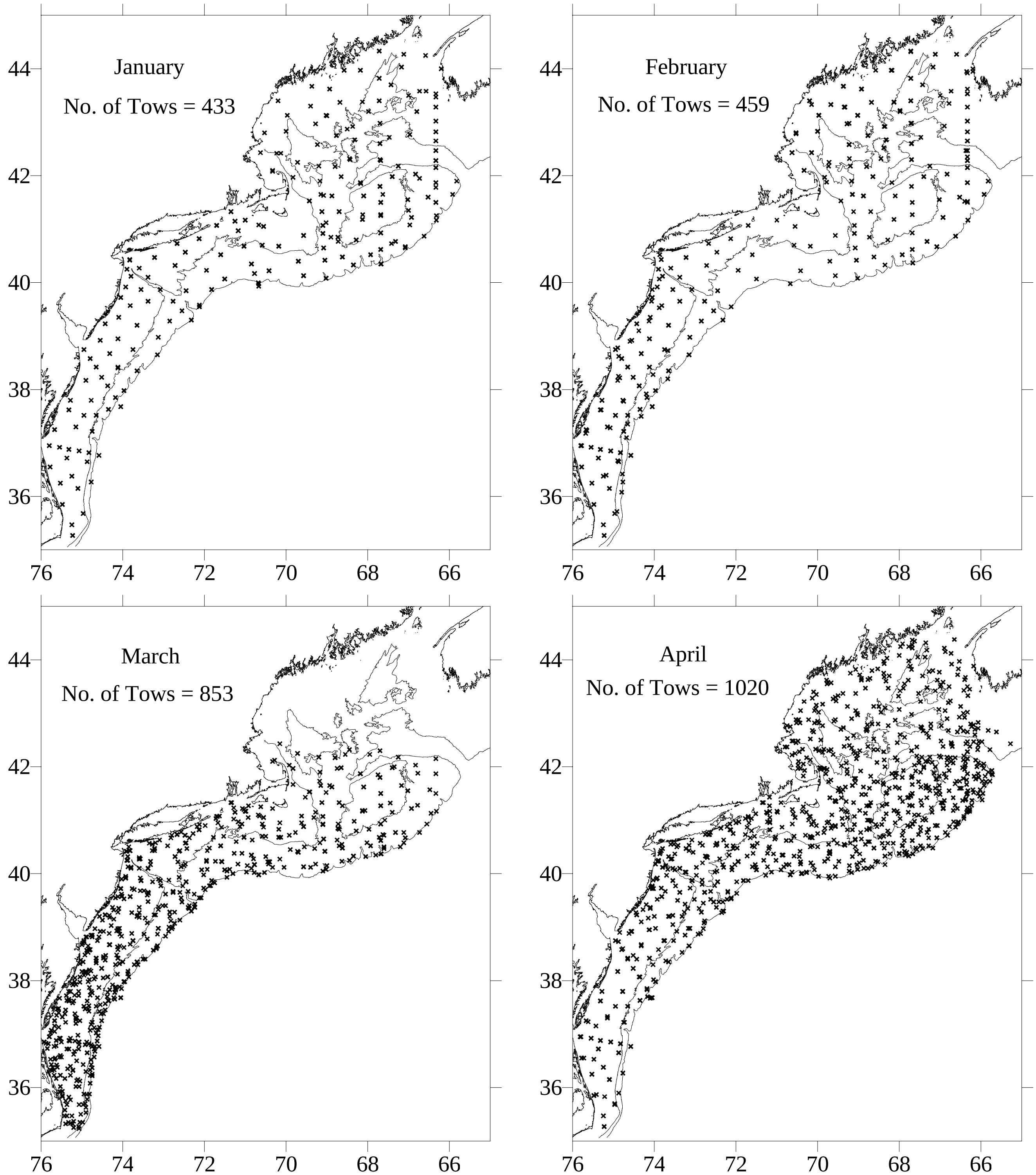
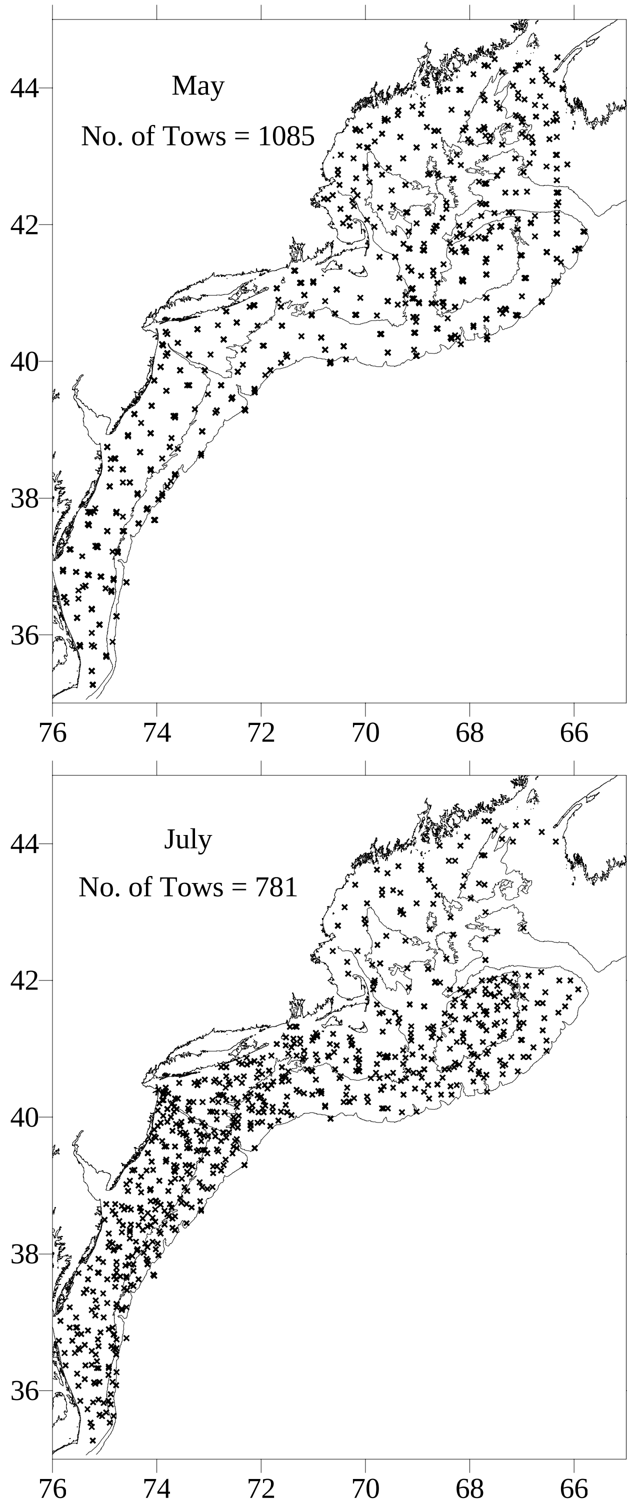


Figure 6. Distribution of all tows for ichthyoplankton eggs by month (all years combined) during NEFSC MARMAP surveys.



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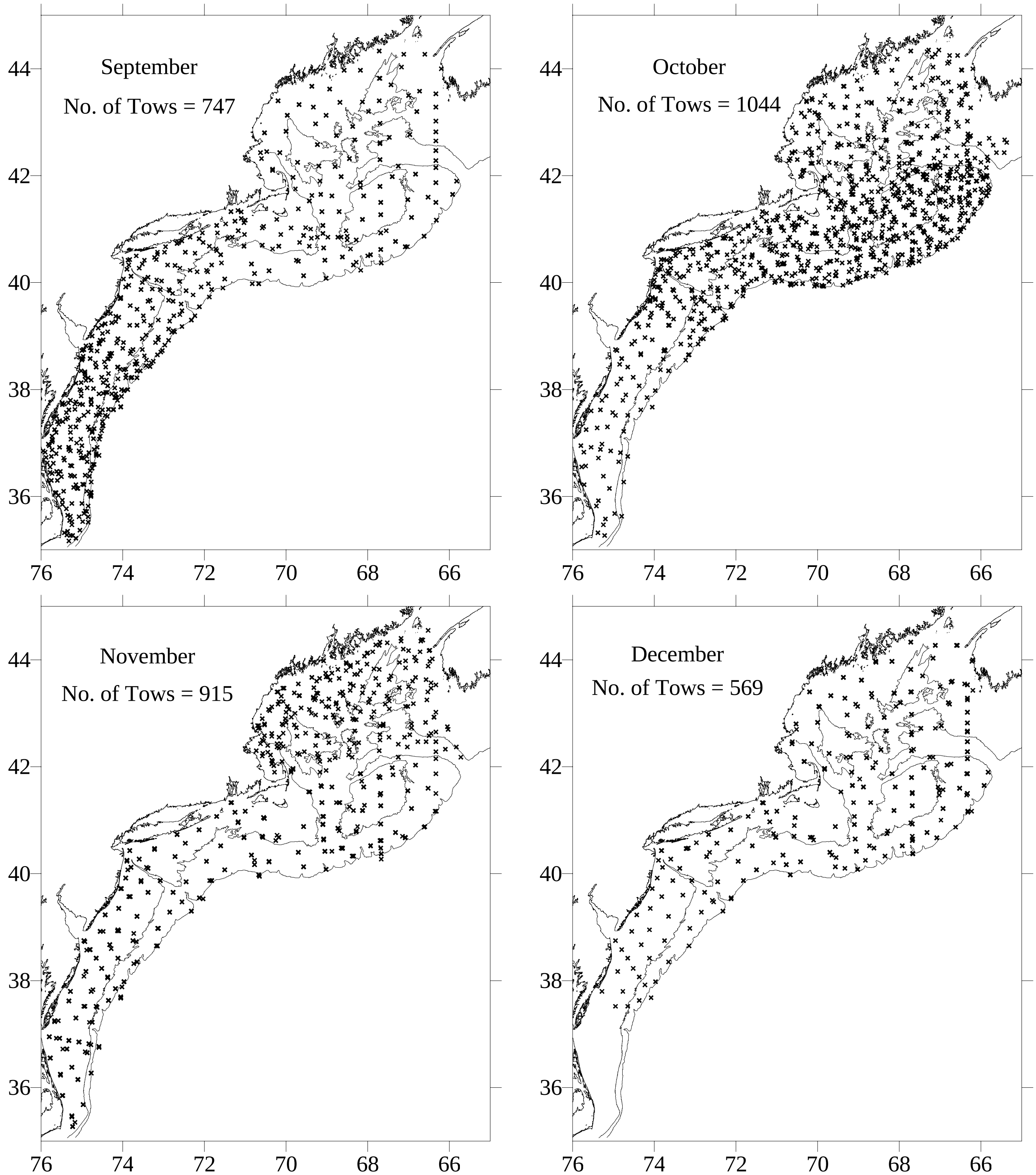

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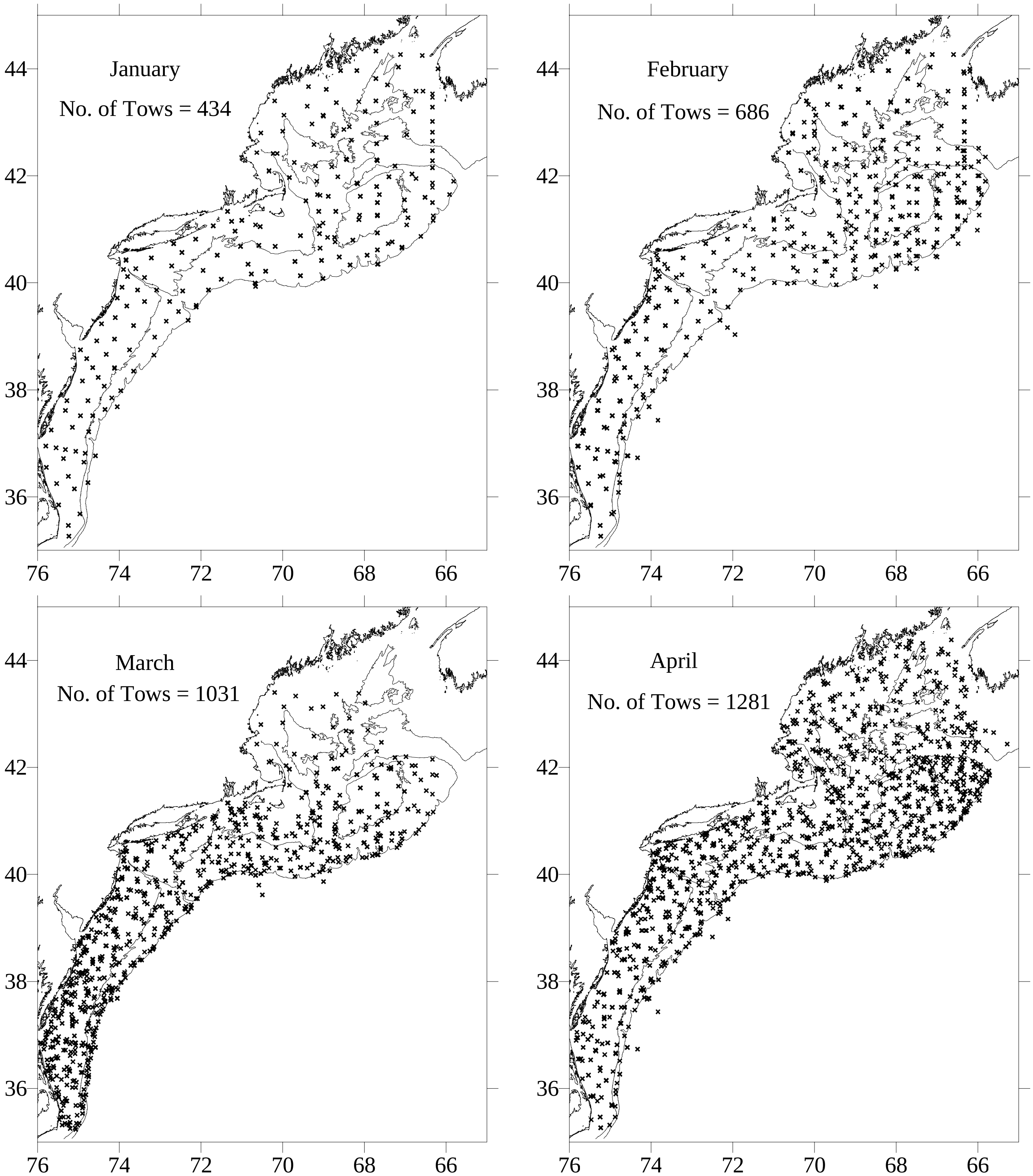


Figure 7. Distribution of all tows made by month for ichthyoplankton larvae during NEFSC MARMAP surveys (all years combined).

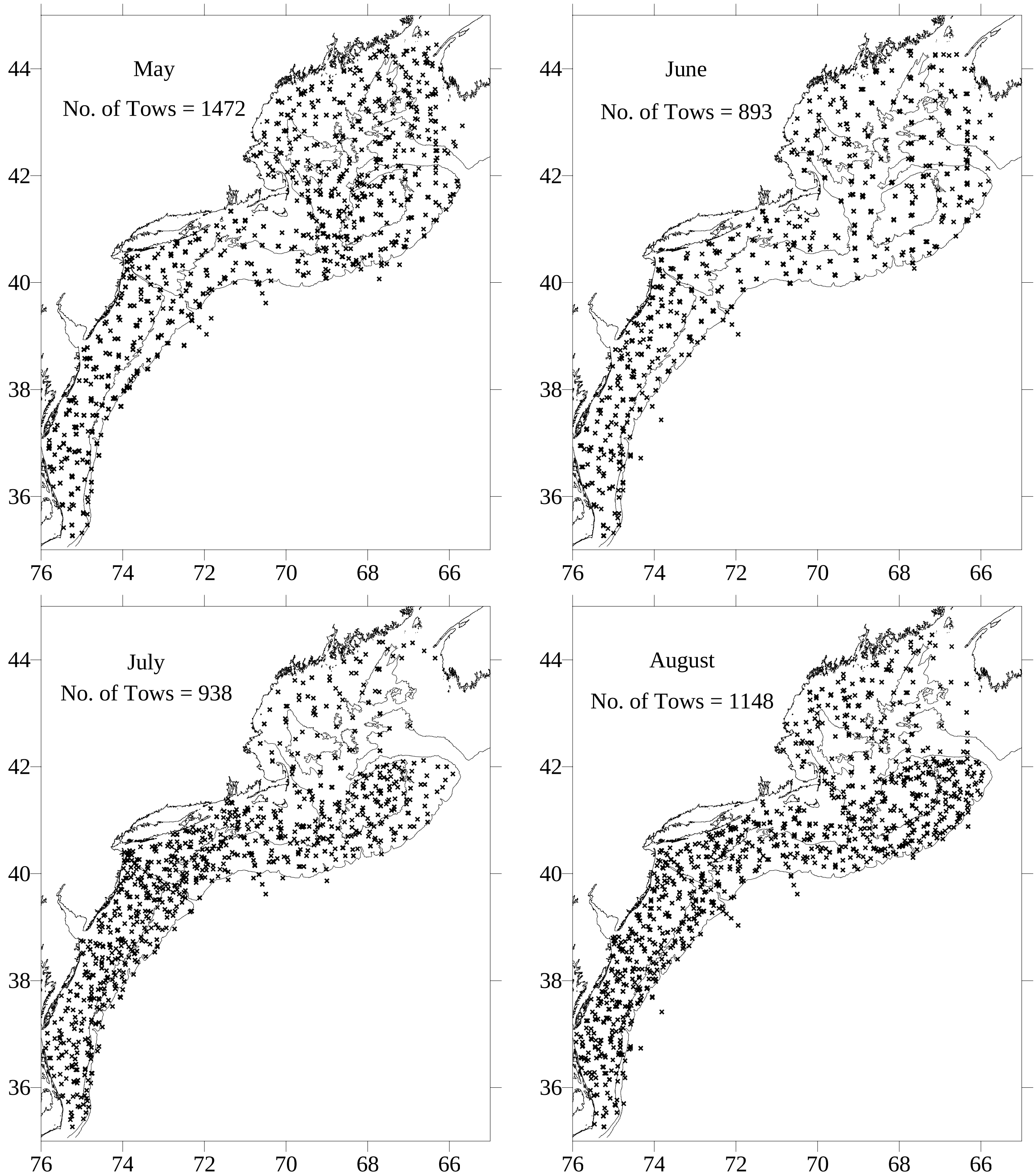


Figure 7. cont'd.

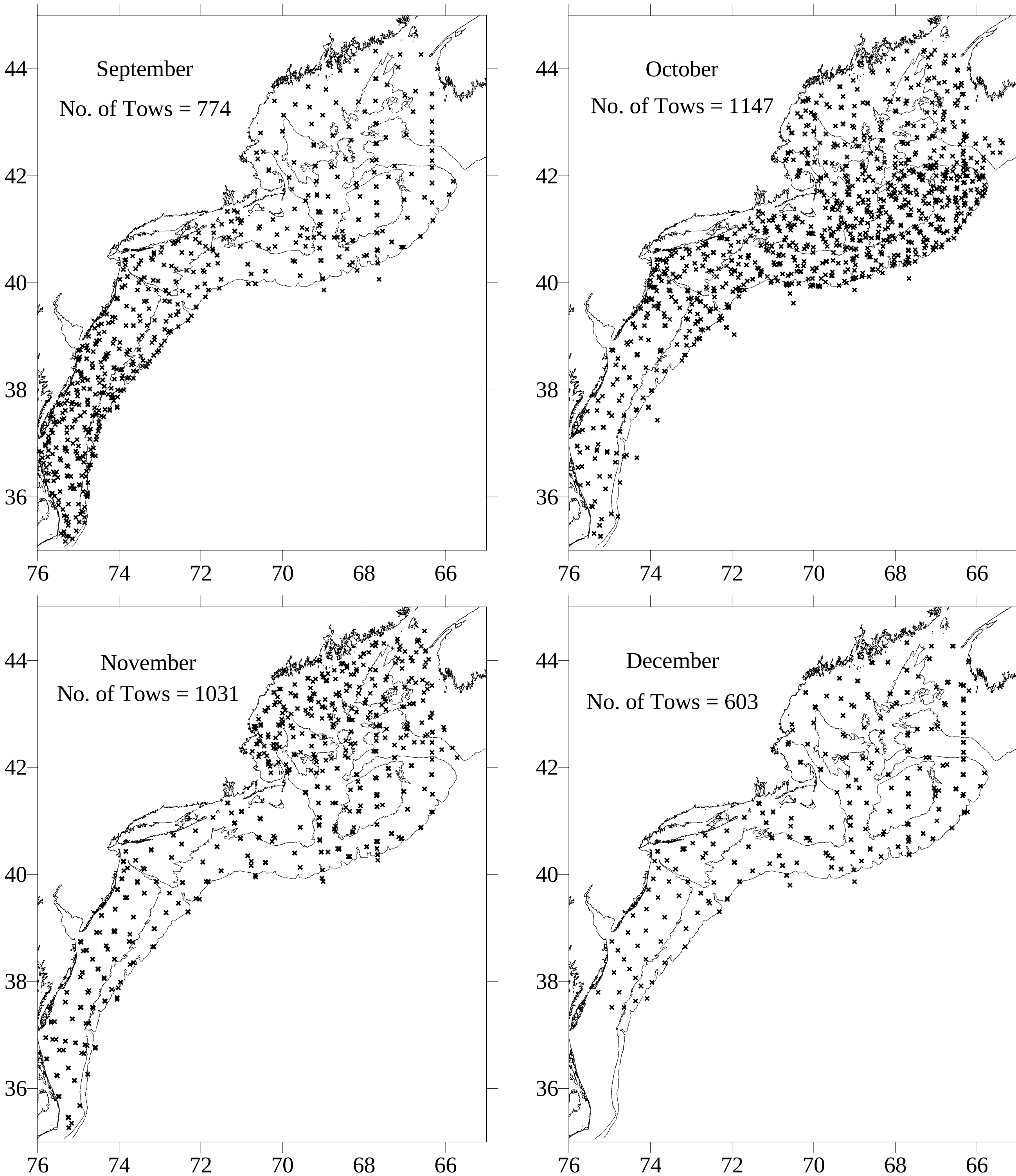


Figure 7. cont’d.

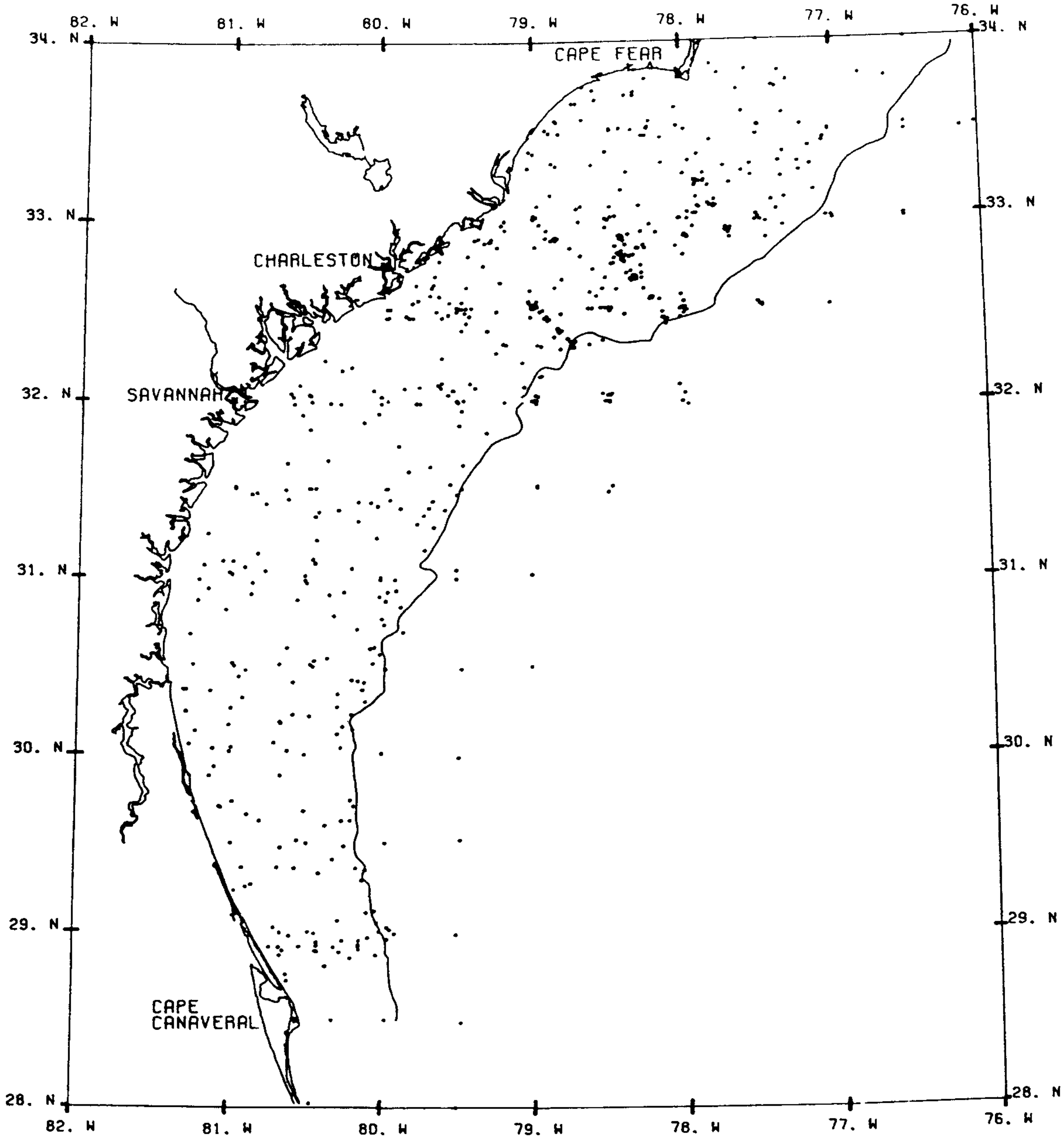


Figure 8. Distribution of all tows conducted during the South Atlantic Bight MARMAP surveys (from Collins and Stender 1987).

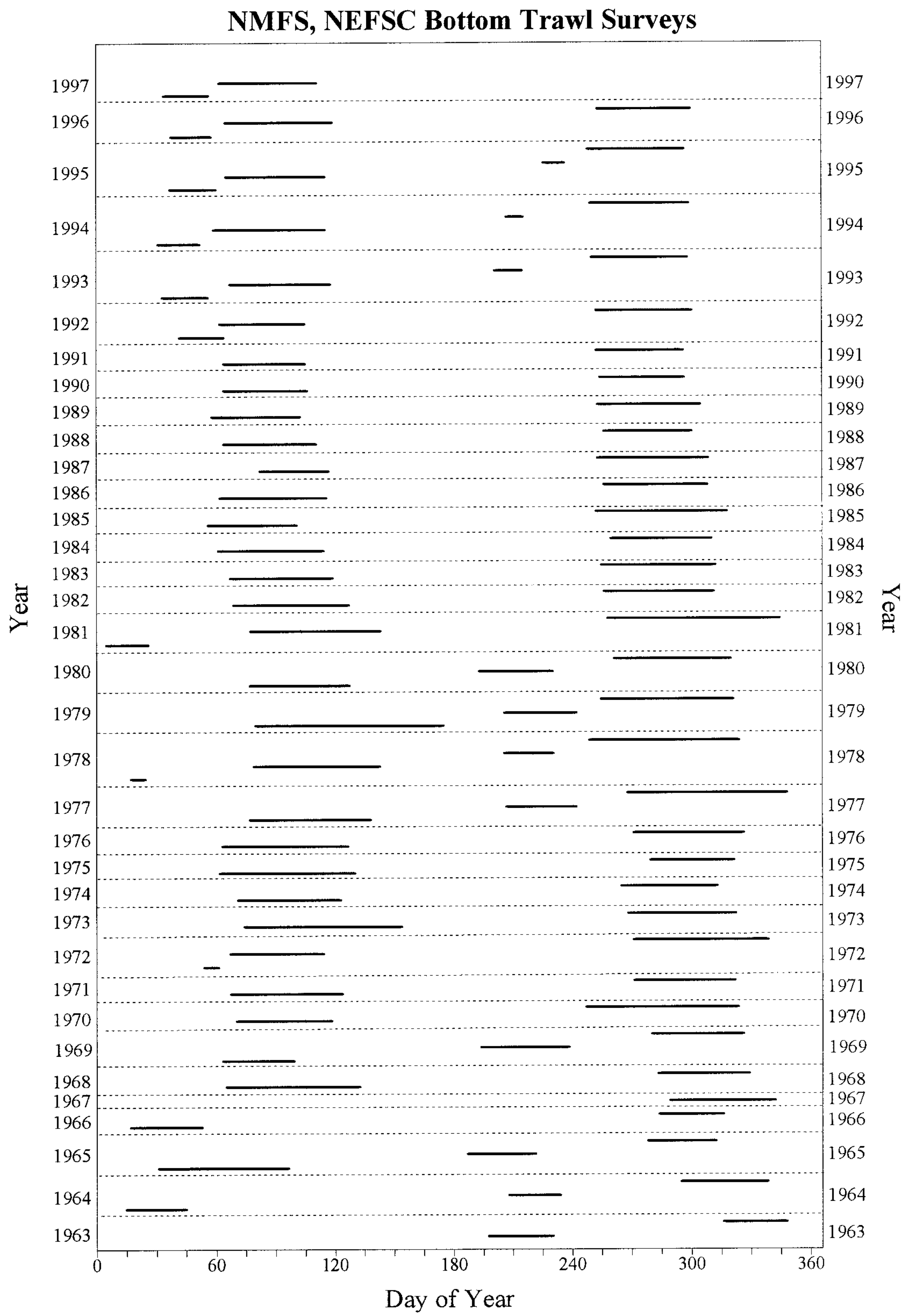


Figure 9. Temporal distribution of NEFSC bottom trawl surveys, 1963-1997.

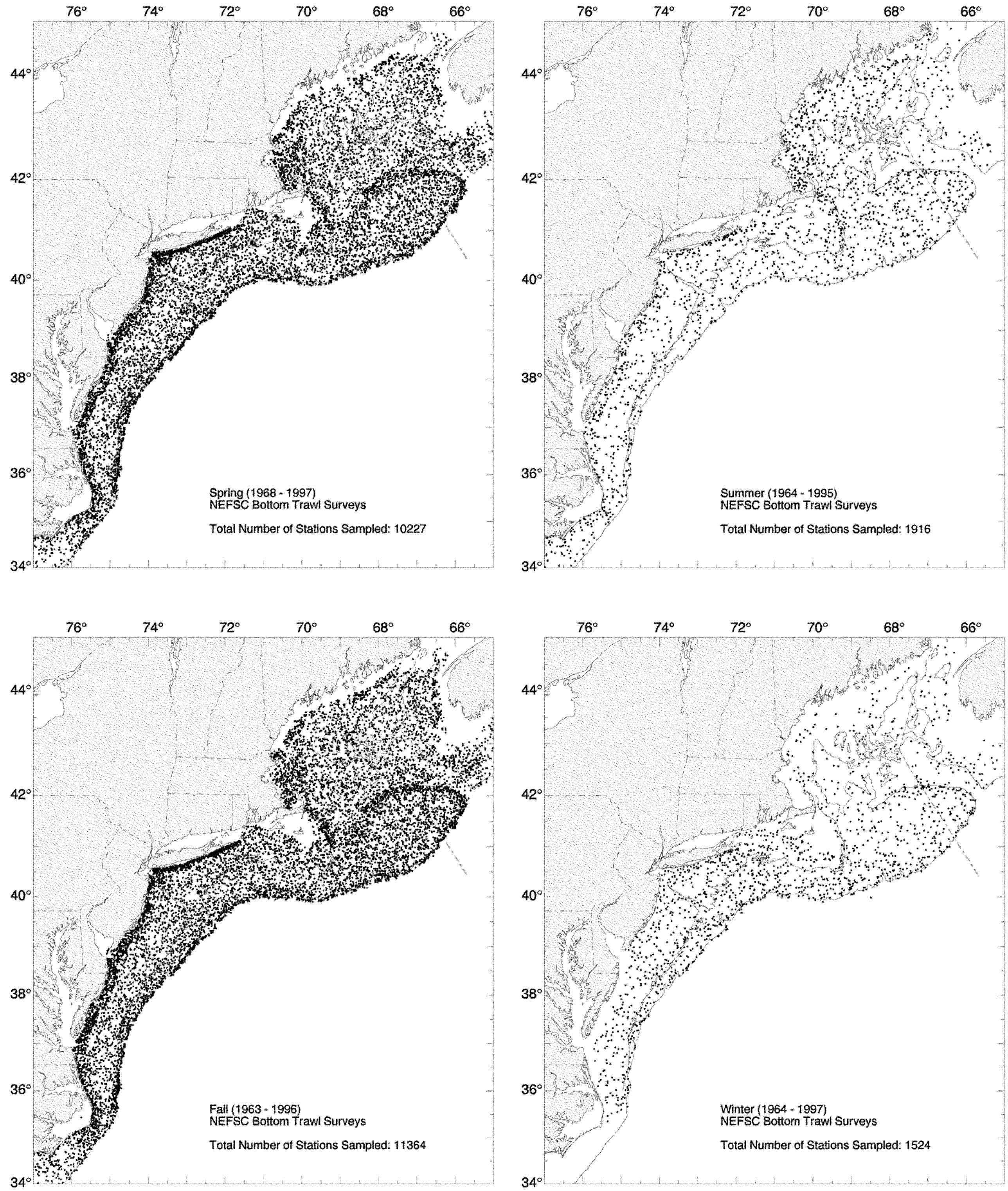


Figure 10. Distribution of NEFSC bottom trawl survey tows by season.

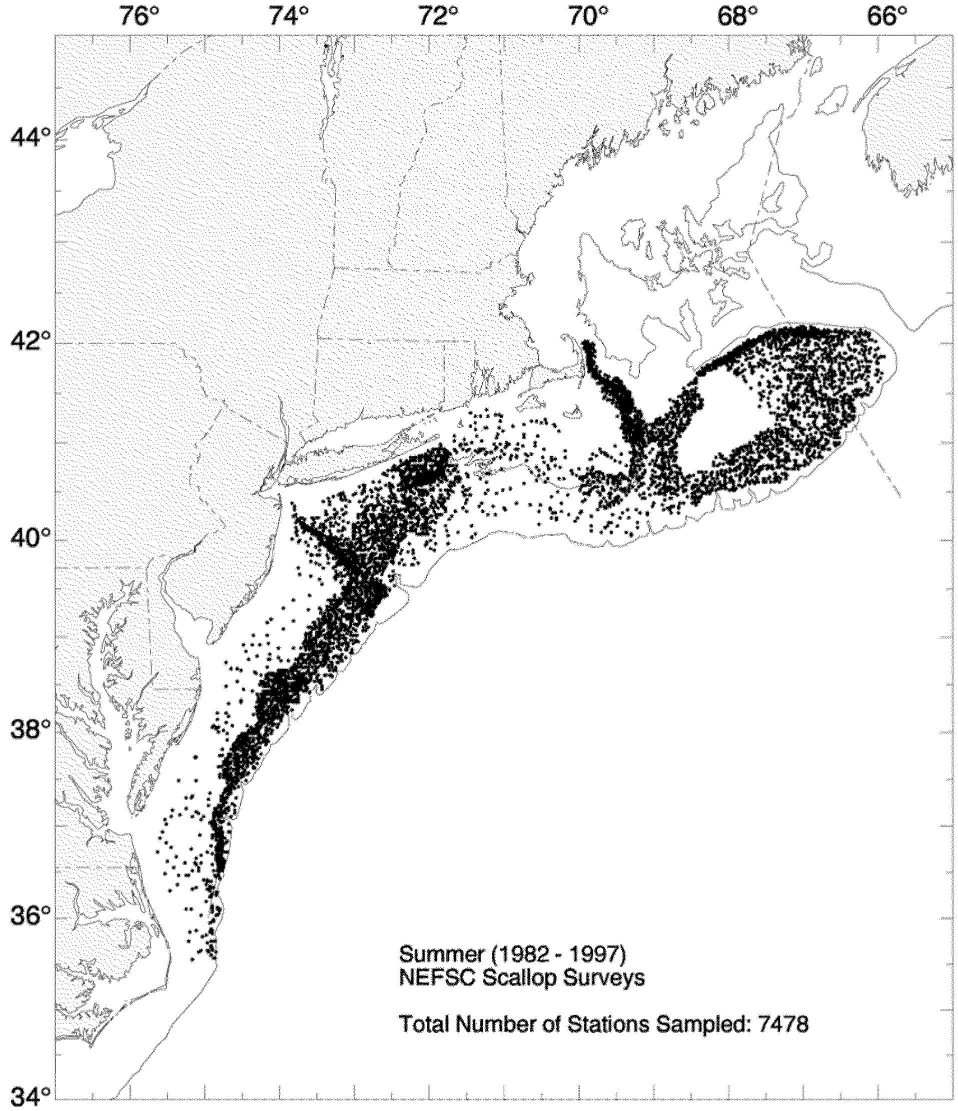


Figure 11. Distribution of all NEFSC sea scallop tows, summer 1982-1997.

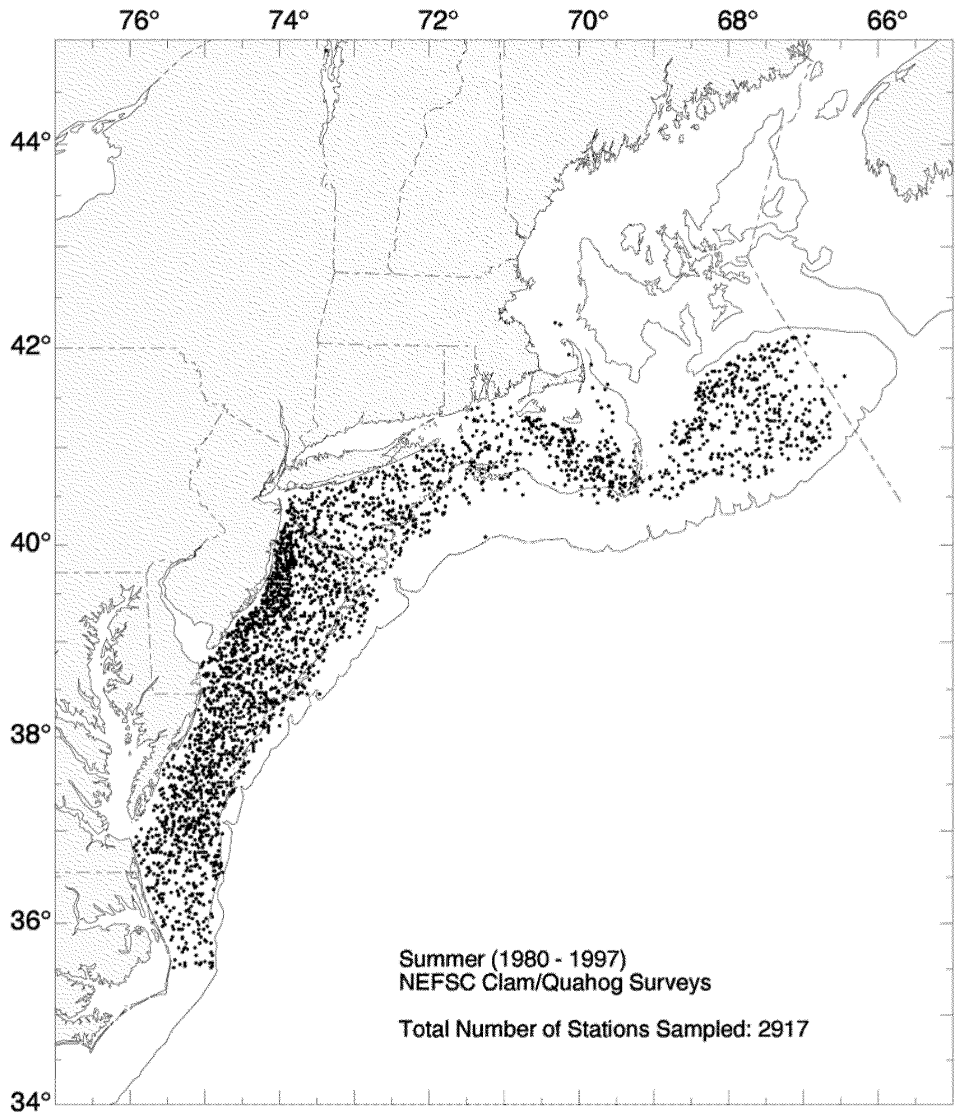


Figure 12. Distribution of all NEFSC Atlantic surfclam/ocean quahog tows, summer 1980-1997.

Rhode Island Division of Fish and Wildlife
Trawl Survey of Narragansett Bay 1990 - 1996

Standard Stations

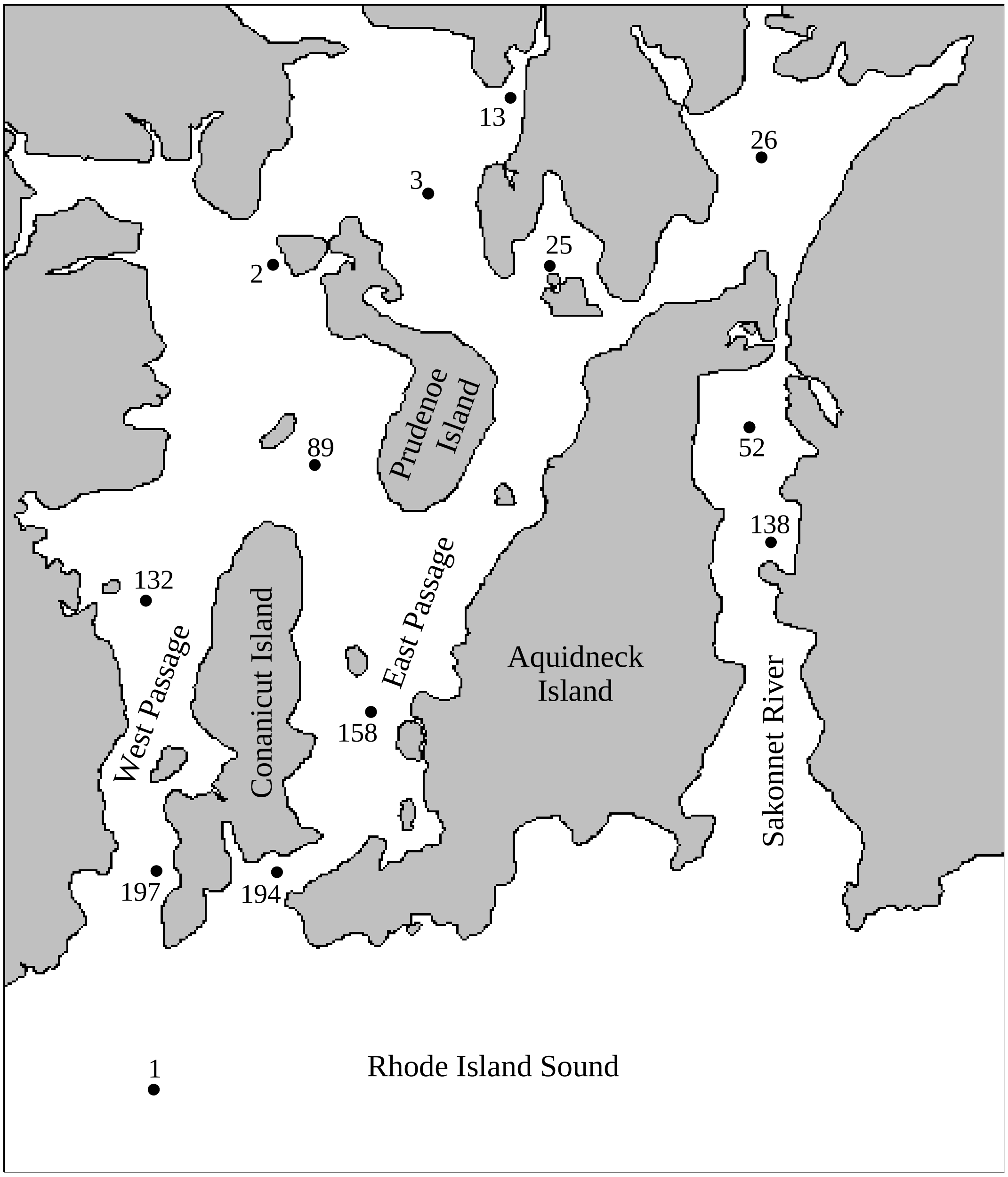
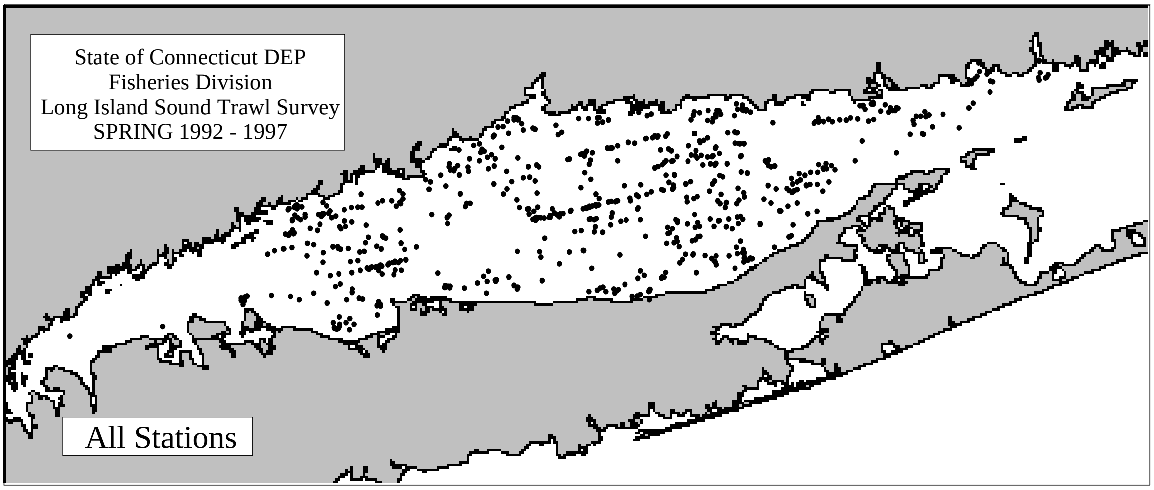


Figure 13. Stations sampled in Rhode Island's Narragansett Bay/Coastal trawl survey.



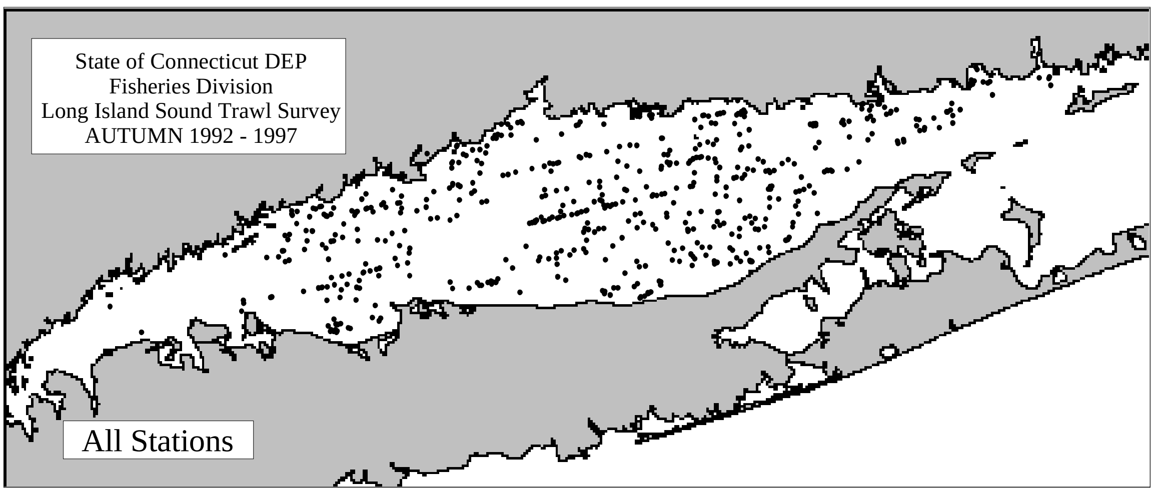
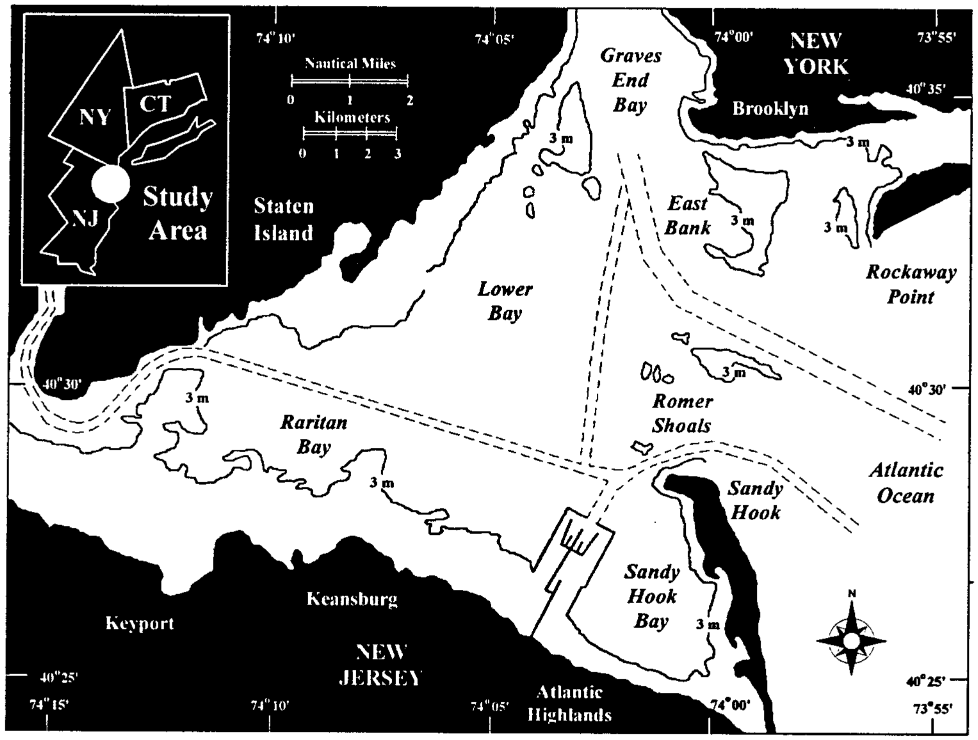


Figure 14. Distribution of all tows made during the Long Island Sound trawl survey in spring and autumn, 1992-1997.



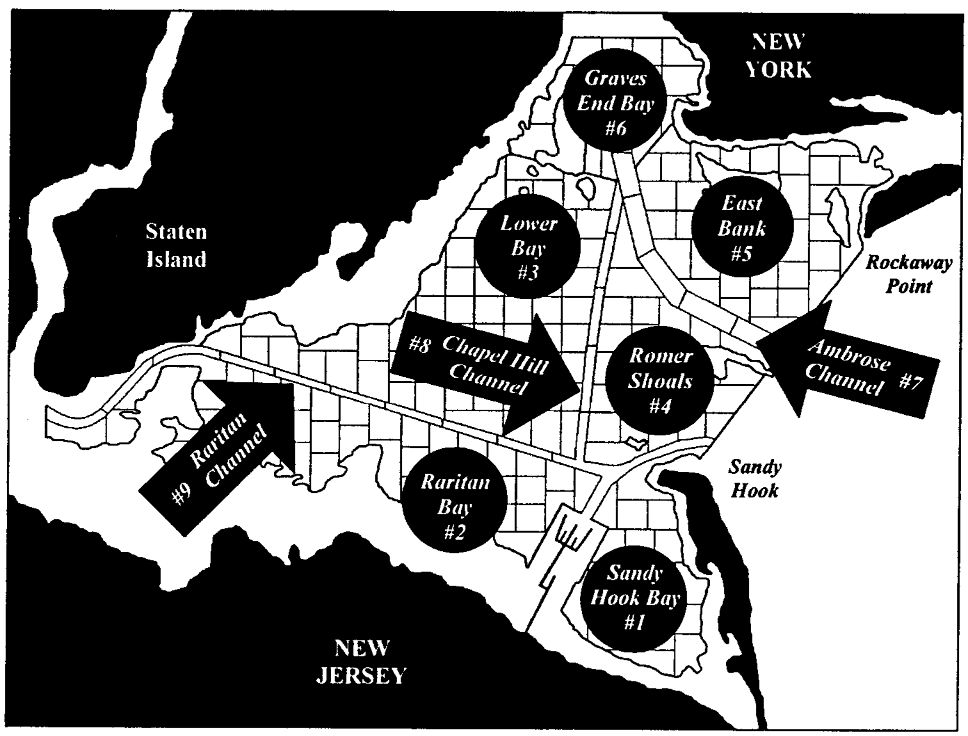


Figure 15. Lower Hudson-Raritan Estuary bottom trawl surveys. Upper map shows the survey area, and the lower map shows the area divided into 9 strata and 217 sampling blocks.

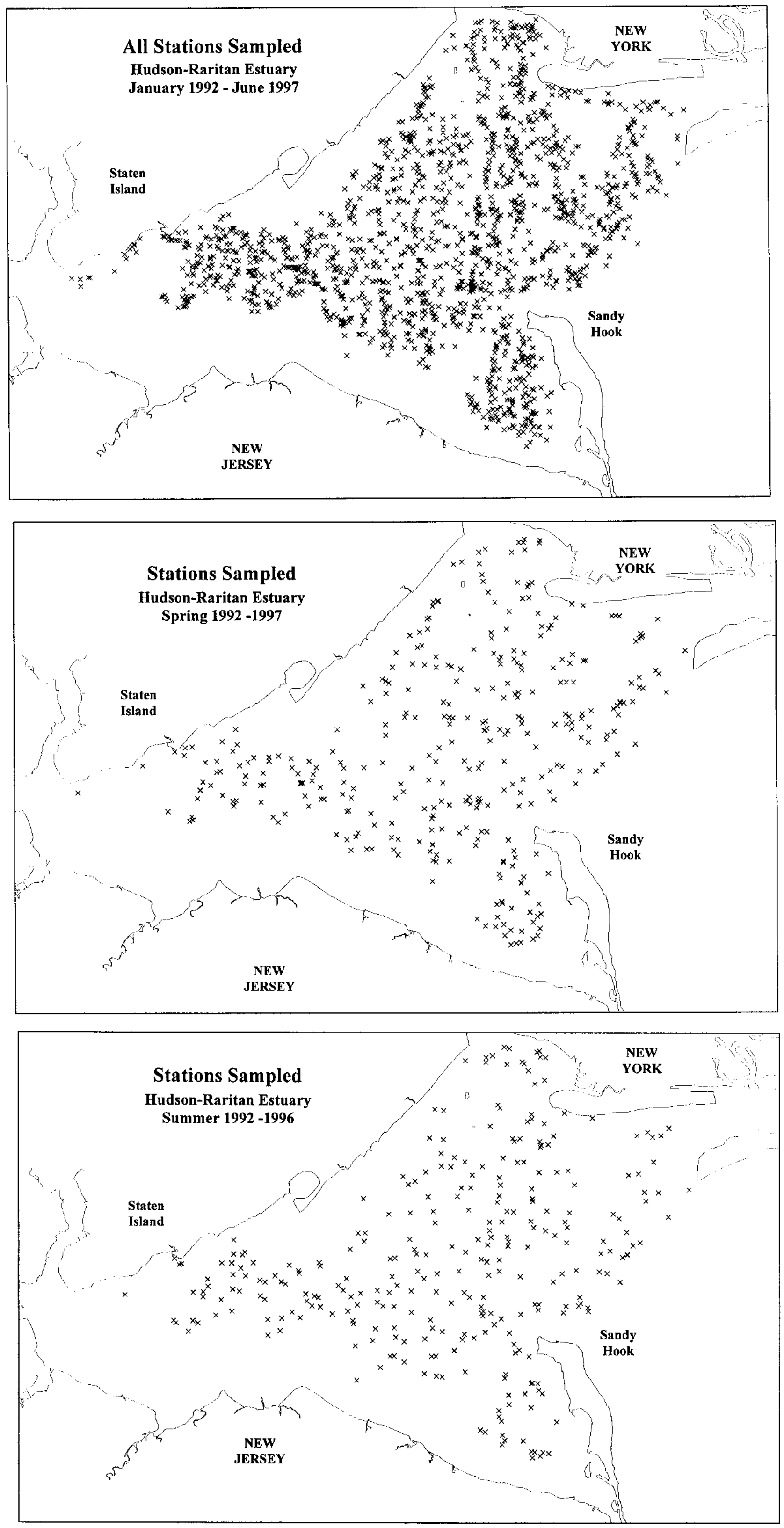
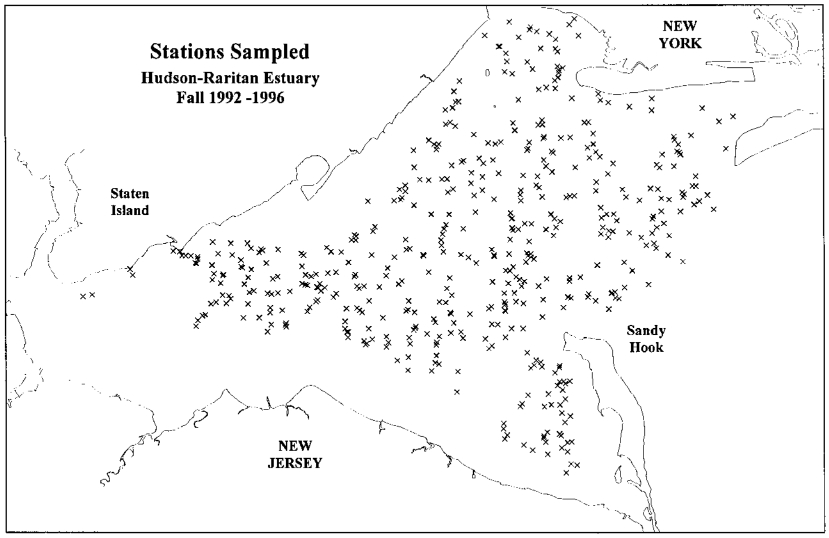


Figure 16. Distribution of Hudson-Raritan bottom trawl survey tows, January 1992 to June 1997.



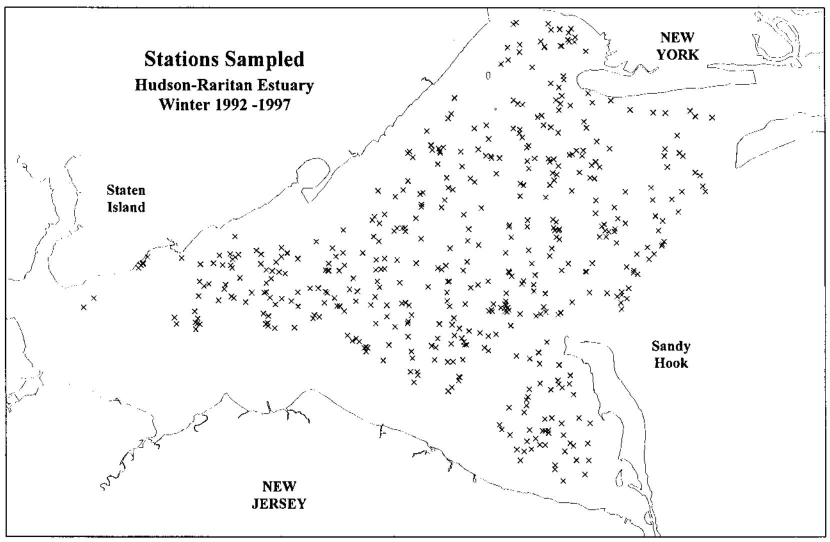


Figure 16. cont’d.

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