Northeast Fisheries Science Center Reference Document 06-05

A Historical Perspective on the Abundance and Biomass of Northeast Demersal Complex Stocks from NMFS and Massachusetts Inshore Bottom Trawl Surveys, 1963-2002

by

Katherine A. Sosebee and Steven X. Cadrin

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ABSTRACT

Temporal and spatial patterns in biomass and abundance of 16 species of groundfish and four groups of groundfish species during 1963-2002 were determined using data from annual spring and autumn research vessel bottom trawl surveys conducted by the Northeast Fisheries Science Center (NEFSC) and the Massachusetts Department of Marine Fisheries (MADMF). Maps were created depicting abundance distributions, within five-year periods, for each species and species group. General temporal trends in abundance and biomass were modeled with regression analysis. The results indicate varying degrees of spatial change in distribution, and a general decline in overall groundfish abundance through 2002.

INTRODUCTION

The northeast demersal groundfish complex was defined by the Northern Demersal Subcommittee of the Northeast Regional Stock Assessment Workshop as a group of sixteen species inhabiting the northeast United States continental shelf (NEFSC 1996). The group comprises: (a) ten species regulated under the Northeast Multispecies Fishery Management Plan: Atlantic cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), pollock (*Pollachius virens*), Acadian redfish *(Sebastes fasciatus*), white hake (*Urophycis tenuis*), yellowtail flounder (*Limanda ferruginea*), American plaice (*Hippoglossoides platessoides*), witch flounder (*Glyptocephalus cynoglossus*), winter flounder (*Pseudopleuronectes americanus*), and windowpane flounder (*Scophthalmus aquosus*; NEFMC 1993); (b) three species exploited by small mesh fisheries: silver hake (*Merluccius bilinearis*), red hake (*Urophycis chuss*), and ocean pout (*Macrozoarces americanus)*; and (c) three additional species often caught by the northeast demersal fishery: Atlantic wolffish (*Anarhichas lupus*), goosefish, (*Lophius americanus*) and cusk (*Brosme brosme*). In 1995, a request was made by the Steering Committee of the Stock Assessment Workshop for the 21st Stock Assessment Review Committee to investigate the distribution of these species (NEFSC 1996). Several analytical techniques including Generalized Additive Models (O'Brien 1997), habitat preference (Helser and Brodziak 1996), and Lorenz Curve (Wigley 1996) methods were used at this time to examine the changes in distribution for some of the species. This report provides a retrospective analysis of indices of abundance and biomass through 2002 for 25 individual stocks and 12 aggregate groups from Northeast Fisheries Science Center (NEFSC) and Massachusetts Division of Marine Fisheries (MADMF) research vessel bottom trawl surveys but is not intended to replace individual stock assessments. A simple examination of temporal and spatial trends in the distribution of species comprising the complex is also presented.

METHODS

Stock Indices and Distribution

NEFSC offshore research vessel bottom trawl surveys have been conducted annually in the autumn since 1963 (offshore strata 61-76 started in 1967), and in the spring since 1968 (Azarovitz 1981). Inshore stations (< 27 m; 15 fm) from Southern New England to Cape Hatteras were added to the surveys beginning in autumn 1972, and then added in the Gulf of Maine beginning in spring 1979. Sampling is based on a stratified random design using area and depth zones (Figures 1, 2, 3 and 4). Between 300 and 600 stations are sampled in each survey, with the number of stations allocated to each stratum in proportion to stratum area. Standard tows are 30 minutes in duration, at a towing speed of approximately 3.8 knots.

Several gear changes have occurred since the start of the NEFSC surveys (NEFSC 1991). In 1985, “Portuguese polyvalent” doors replaced the “BMV” oval doors used since 1963. Three vessels have conducted the survey (*Albatross IV*, *Delaware II* and *Atlantic Twin*). The standard sampling gear used in the surveys has been the “#36 Yankee” trawl , except during the spring from 1973 through 1981 when a “#41 Yankee” trawl was used. Conversion factors for these gear changes have been calculated for some species (NEFSC 1991; Sissenwine and Bowman 1978). The *Atlantic Twin* surveyed the inshore areas from autumn 1972 to spring 1975, but no conversion factors have been calculated for this vessel.

Massachusetts inshore spring and autumn bottom trawl surveys, conducted by the Massachusetts Division of Marine Fisheries, were initiated in 1978 (Howe 1989). Sampling is based on a stratified random design using five geographic regions and six depth strata (Figure 5). In each seasonal survey, approximately 100 sampling stations are allocated and assigned in proportion to the stratum area. Standard tows are 20 minutes in duration at a speed of 2.5 knots. The sampling gear is a 3/4 North Atlantic type two seam ('whiting') otter trawl. Two vessels have conducted the survey (*Francis Elizabeth*, 1978-1981; *Gloria Michelle*, 1982-Present) but no conversion factors are available.

For each stock, indices of relative biomass (stratified mean weight per tow) and abundance (stratified mean number per tow) were calculated for each of the surveys (Cochran 1977). Strata sets, transformations, and gear conversions used for each stock are listed in Table 1. Distribution maps of abundance were developed for each species for five-year periods. The depth contours on each map represent 60 m (33 fathoms), 90 m (50 fm), 180 m (100 fm) and 900 m (500 fm). The 60 m contour was not digitized east and north of Cape Cod and is not plotted in this region.

Aggregate Indices and Distribution

Abundance and biomass indices were calculated for four aggregate groups of species: principal groundfish (Atlantic cod, haddock, pollock, Acadian redfish, and white hake), principal flounders (yellowtail flounder, American plaice, witch flounder, winter flounder, and windowpane flounder), small-mesh groundfish (silver hake, red hake, and ocean pout), and other groundfish (Atlantic wolffish, goosefish, and cusk). The indices were calculated for three areas: Gulf of Maine (Offshore Strata 26-30,36-40), Georges Bank (Offshore Strata 13-25), and Southern New England (Offshore Strata 1-12) for both seasons of the NEFSC survey. Indices were also calculated for these groups for the entire Massachusetts survey area for both seasons. Distribution maps (in five-year blocks) were generated for each species group using data from both the NEFSC and the Massachusetts trawl surveys.

Trend Analyses

General temporal trends in survey indices of abundance and biomass were modeled with regression analysis. The rate of change in a stock was assumed to be an exponential process:

$$N_t = N_{t-1}\, e^{r} \qquad (1)$$

where abundance (N) at time t is a function of abundance in the previous year and the exponential rate of change (*r*). The parameter *r* is a composite rate incorporating recruitment, somatic growth (for biomass), natural mortality and fishing mortality (and perhaps emigration and immigration). When *r* equals zero, the stock size remains constant, because mortality and growth (including recruitment) are in balance. When *r* is negative the stock declines (mortality exceeds growth and recruitment) and when *r* is positive the stock increases (growth and recruitment exceed mortality). The same process can be assumed for an index of abundance (n):

$$n_t = n_{t-1}\, e^{r} \qquad (2)$$

A value of *r* was estimated for each survey time series (autumn NEFSC; spring NEFSC; autumn Massachusetts; spring Massachusetts) with simple loglinear regression:

$$n_t = n_o\, e^{rt + \varepsilon} \qquad (3)$$

or

$$Ln(n_t) = Ln(n_o) + rt + \varepsilon \qquad (4)$$

where an abundance index observation is a loglinear function of the predicted index level at the start of the series (n_o), the exponential rate of change over t years, and a lognormally distributed observation error (ε). As this simple model assumes that *r* is constant over the survey time series, episodes of recruitment and mortality are integrated over the time series.

RESULTS AND DISCUSSION

Stock Indices and Distribution

Spring and autumn NEFSC survey abundance and biomass indices from 1963-2002 are presented in Appendix A (Figures A1-A10). Abundance and biomass indices from the spring and autumn Massachusetts surveys, 1978-2002, are presented in Appendix B (Figures B1-B6). Species distributions in the NEFSC surveys are presented in Appendix C (Figures C1-21), and distributions in MADMF surveys are presented in Appendix D (Figures D1-D20). Station locations in these NEFSC and MADMF surveys are depicted in the first set of figures of Appendices C and D.

Indices of biomass and abundance for **Gulf of Maine cod** in the NEFSC spring and autumn surveys declined from the early 1980s to the early 1990s after a ten-year period of fluctuating catches (Figure A1; Mayo 1998; Mayo *et al.* 2002b). NEFSC survey indices of Gulf of Maine cod in 1997 remained at or near record-low levels but increased through 2002. The very large 2002 autumn survey index was due primarily to one large tow (Mayo and Terceiro, 2005). The distribution map of cod in the Gulf of Maine shows high catches in inshore waters (around and inshore of the 50 fathom contour), particularly since 1979 when the survey first began to sample these habitats (Figure C2). The most recent survey time block (1998-2002) shows the highest concentrations of Gulf of Maine cod are found in inshore waters while low catches occur in the deeper waters of the central Gulf of Maine (Figure C2d). Biomass indices of cod from the MADMF spring survey declined throughout the entire time series despite large survey catches in 1989 and 1990 (Figure B1). The large indices recorded in the spring of 1999 through 2001 surveys were due mainly to the 1998 year class (Mayo and Terceiro 2005). The majority of Gulf of Maine cod sampled by the inshore survey were caught in Massachusetts Bay at stations greater than 15 m (8 fm) deep (Figure D2).

Georges Bank cod indices of abundance and biomass in the NEFSC spring and autumn surveys declined steadily from the 1970s to the 1990s after an initial increase in the late 1960s (Figure A1; O'Brien 1998; O'Brien and Munroe 2001). Abundance and biomass indices of Georges Bank cod from NEFSC surveys in spring 2002 and autumn 2001 remained at or near record-low levels. The large 2002 survey values were caused primarily by a few large tows (Mayo and Terceiro 2005). The decline in abundance can also be seen in the distribution of cod on Georges Bank (Figure C2) both in the autumn and in the spring. By the autumn period from 1993-1997, cod were not present in the central portion of the northern edge and in Southern New England, and the remaining were concentrated on the Northeast Peak and in the Great South Channel. This pattern remained in place for the 1998-2002 time period as well. Cod are distributed in shallower waters on Georges Bank in the spring than in the autumn. Cod are found in the deeper waters of the northern edge of Georges Bank in the autumn.

Abundance and biomass indices for **Gulf of Maine haddock** from the NEFSC autumn and spring surveys followed similar trends, with a sharp decline in the 1960s followed by a smaller peak in the late 1970s (NEFC 1986; NEFSC 2001a; Figure A1). A steady decrease then occurred, and both abundance and biomass fluctuated at extremely low levels from the mid-1980s to near historic lows in 1997. Increases in both biomass and abundance indices occurred from 1997-2002 in the spring and through 2000 in the autumn (Mayo and Terceiro 2005). The decline and subsequent increase in haddock abundance in the Gulf of Maine can also be seen in the distribution plots based on NEFSC surveys, particularly between the 90 m (50 fm) and 180 m (100 fm) depth contours (Figure C3). All MADMF indices of haddock abundance and biomass decreased through 1997 and then increased, similar to the NEFSC survey indices (Figure B1). MADMF inshore autumn catch rates of Gulf of Maine haddock have been used to indicate year class strength because the survey is able to detect differences in cohort strength (NEFC 1986). Although haddock were caught in very low numbers from 1983 to 1997, the 1998 year class was apparently detected (NEFSC 2001a).

Georges Bank haddock indices of abundance and biomass declined rapidly from very high levels supported by large year classes from the early to mid-1960s, increased in the 1970s following recruitment of large year classes, but remained low through the mid-1990s (Figure A1; Brown and Munroe 2000). Indices increased slightly through 1997 but remained well below historic levels. The increase in the value of the spring index in 1996 was due to a single large tow in an area that had been closed to fishing since December 1994. Further increases in the survey indices occurred through 2002 as the above average 1998 year class recruited to the survey and was protected by the closed areas (Mayo and Terceiro 2005). Haddock appeared to have concentrated on the Northeast peak and in the Great South Channel from the early 1980s through 2002 (Figure C3).

The NEFSC **pollock** biomass and abundance indices declined steadily following a peak in the mid-1970s (Figure A2; Mayo and Terceiro 2005) and remained among the lowest values detected through 1997. The spring survey indices remained low but highly variable through 2002 while the autumn survey indices increased steadily. Pollock were found in greatest numbers in Massachusetts Bay, the edges of Georges Bank, the Great South Channel and the Scotian Shelf (Figure C4). Pollock were generally found in the shallows of Georges Bank in slightly higher numbers in the spring than in the autumn (Figure C4). The decline in abundance indices over the time series can be seen in the increased proportion of tows with zero pollock catch, mostly in the Gulf of Maine. Pollock have been sampled in all but two MADMF autumn surveys (Figure B1). The majority of pollock caught by the MADMF survey were in Massachusetts Bay in the spring (Figure D4).

The NEFSC biomass and abundance indices for **Acadian redfish** declined steadily from 1963 through 1982 (Figure A2; Mayo 1993; Mayo *et al.* 2002a). From 1982 through 1995 there was a slight increasing trend. In 1996, the availability of redfish to the survey gear in the autumn appeared to have changed abruptly and the abundance indices increased to a new maximum value. The 1997 spring survey was dominated by one very large tow (the largest in the time series). The increase in survey abundance and biomass indices continued through 2002 and appears to have been caused by an increased survival of year classes produced in the 1980s (Mayo and Terceiro 2005). These changes are evident also in the distribution maps for both the spring and the autumn (Figure C5). MADMF redfish indices have fluctuated without trend (Figure B1), but appear to detect relatively abundant year classes. The inshore survey may not adequately sample redfish for stock assessment purposes because they were not present in ten spring surveys and seven autumn surveys. The Massachusetts survey catches some redfish in deep waters of Massachusetts Bay (Figure D5).

Spring and autumn indices of biomass and abundance for **white hake** in the NEFSC survey increased in the 1960s and fluctuated without trend throughout the 1970s (Figure A2; NEFSC 1995; Sosebee *et al.* 1998; NEFSC 1998; NEFSC 2001b). The indices then fluctuated without trend at a slightly lower level than in the 1970s during the remainder of the time series. Since the early 1990s, the indices declined and were at or near record low levels in 1997. The survey indices increased slightly through 2002 due to a large 1998 year class (Mayo and Terceiro 2005). White hake are caught in shallower waters in the autumn, when juveniles are found in inshore areas (Figure C6). In the spring, white hake are located in deeper waters of the

Gulf of Maine and off the southern slope of Georges Bank (Figure C6). All MADMF white hake abundance and biomass indices decreased during the time series (Figure B2). Most white hake caught by the Massachusetts survey were in Cape Cod and Massachusetts Bays in the autumn (Figure D6).

Georges Bank yellowtail flounder indices of biomass and abundance exhibited a steady decline from the beginning of the time series (Figure A3; Cadrin 1997; Cadrin *et al.* 2000) in the NEFSC survey. Biomass and abundance indices increased temporarily in 1980 and 1981, fluctuated in the late 1980s and early 1990s, and increased rapidly through 2001-2002 (Mayo and Terceiro 2005). The decrease in abundance is shown in the distribution maps for both seasons (Figure C7), and the increased survey catches in recent years are primarily from the eastern portion of Georges Bank (Figure C7d).

Southern New England – Mid-Atlantic yellowtail flounder NEFSC survey indices fluctuated without trend throughout the 1960s but declined precipitously in the early 1970s (Cadrin 2003; Figure A3). An increase occurred in the late 1970s and early 1980s, but the indices again decreased and remained relatively low for the rest of the time period, except for a small increase due to the 1987 year class. Yellowtail flounder became concentrated around the 60 m (33 fm) contour in southern New England as abundance declined (Figure C7). Spring MADMF abundance indices declined (Figure B2) although SNE yellowtail flounder are rarely caught by the MADMF survey (Figure D7), and were absent in several years.

NEFSC abundance and biomass indices of **Cape Cod – Gulf of Maine yellowtail flounder** (Cadrin and King 2003) fluctuated at low levels throughout the 1980s and 1990s (Figure A3). The spring survey indices increased through 2000 while the autumn survey indices remained variable. MADMF spring biomass and abundance indices of Cape Cod yellowtail decreased from 1978 through 1986, but remained relatively constant between 1987 and 2002 (Figure B2). Yellowtail flounder in the Cape Cod group are generally caught at stations greater than 30 m (17 fm) deep by the MADMF inshore survey (Figure D7).

American plaice NEFSC survey indices of abundance and biomass declined from the 1960s through the early 1970s (Figure A3; O'Brien *et al.* 1992; O'Brien and Esteves 2001). A period of high relative abundance followed until the early 1980s when abundance again began to decline. This decline continued throughout the 1980s, reaching a low in 1987. Since that time there has been a generally increasing trend in both indices (Mayo and Terceiro 2005). Concentrations of American plaice can be found around the 90 m (50 fm) contour in the NEFSC surveys (Figure C8). Spring MADMF inshore indices fluctuated without trend throughout the time-series (Figure B2). Autumn MADMF indices increased from 1987 through 1991 then slightly decreased (Figure B2). American plaice are most frequently caught by the MADMF survey at stations greater than 60m (33 fm) deep (Figure D8).

Witch flounder indices of biomass and abundance have been variable, exhibiting an overall declining trend throughout most of the NEFSC survey time series (Figure A4; NEFSC 1994; Wigley and Mayo 1994; Wigley *et al.* 1999; Wigley *et al.* 2003) and reaching a record low in the late 1980s. Both abundance and biomass indices remained low until very recently, with increased abundance in the last five years. Witch flounder are found primarily at depths exceeding 90 m (50 fm) in the NEFSC surveys (Figure C9). All MADMF biomass and abundance indices decreased (Figure B3). Most witch flounder sampled by the inshore survey in the Gulf of Maine are caught in Massachusetts Bay at stations greater than 40 m (22 fm) deep (Figure D9).

Gulf of Maine winter flounder biomass and abundance indices decreased in both the spring and autumn NEFSC surveys from 1981 to the early 1990s (Figure A4; NEFSC 2003). While these indices have since fluctuated, an overall decrease in biomass is evident until the last few years (Mayo and Terceiro 2005). The majority of winter flounder caught in the NEFSC survey are found in waters less than 90 m (50 fm; Figure C10). MADMF spring biomass decreased through the mid-1980s and gradually increased through 2000 (Figure B3). Winter flounder catches in the Gulf of Maine are distributed throughout the range covered by the MADMF inshore survey (Figure D10).

Georges Bank winter flounder abundance and biomass indices from the NEFSC survey fluctuated without trend until the late 1970s when biomass began to steadily decline while abundance continued to fluctuate in response to apparent variability in recruitment (Figure A4; Brown *et al.* 2000; NEFSC 2002a). Both indices reached record lows in 1991 but had increased through 2002 (Mayo and Terceiro 2005). Winter flounder occur on the shallowest parts of Georges Bank (Figure C10).

Southern New England-Mid-Atlantic winter flounder biomass and abundance indices decreased in the 1960s to a low in the early 1970s in the NEFSC survey (Figure A4; Shepherd *et al.* 1996; NEFSC 1999; NEFSC 2003). A short period of increase in the survey indices followed until 1980 when there was a rapid decline in both indices. Since that time, indices fluctuated without trend through 1996 at or near record-low levels, increasing in 1997. The autumn survey continued to increase through 2002 (Mayo and Terceiro 2005). Most winter flounder in the southern New England and Mid-Atlantic area are caught in waters less than 60 m (33 fm) deep (Figure C10). MADMF inshore spring indices of abundance and biomass declined throughout the 1980s, increasing after 1991 (Figure B3; NEFSC 1999). Most winter flounder in this area are caught at stations greater than 20 m (11 fm) deep in MADMF surveys (Figure D10).

Gulf of Maine – Georges Bank windowpane flounder indices of biomass and abundance from the NEFSC surveys increased during the early part of the time series to the early 1970s (Figure A5; NEFSC 1993; NEFSC 1998; NEFSC 2002b). Subsequently, all indices fluctuated without trend until the mid-1980s, when a steady decline began to occur. In the mid-to-late 1990s, an increase in the survey indices occurred (Mayo and Terceiro 2005). The majority of windowpane flounder in this stock unit occur on Georges Bank proper with some fish also caught in shallower portions of the Gulf of Maine (Figure C11). There appears to be a seasonal shift in distribution, with fish found in deeper waters off the southern flank of Georges Bank in the spring and on top of the Bank in the autumn.

Southern New England – Mid-Atlantic windowpane flounder indices of abundance and biomass from the NEFSC survey decreased through the mid-1990s, then remained relatively low through 1997 with a slight increase through 2000 (Figure A5; NEFSC 1993; NEFSC 1998; Mayo and Terceiro 2005). Indices through 2002 were among the lowest on record. This decline in abundance in the NEFSC survey is shown in the distribution maps for this stock by both fewer fish caught per tow and fewer tows with any windowpane flounder (Figure C11). Most windowpane are now caught in inshore areas less than 60 m (33 fm).

The MADMF indices of biomass and abundance for windowpane flounder for the entire Massachusetts survey area decreased steadily between 1982 and 1991, increased through 1997, and again declined through 2002 (Figure B3). The majority of windowpane flounder sampled by the inshore survey are caught in the spring, at stations less than 30 m (17 fm) deep (Figure D11).

Gulf of Maine – Northern Georges Bank silver hake indices of biomass and abundance declined sharply in the early 1960s, but then generally increased since the late 1960s (Figure A6; NEFSC 2006). This increase in abundance can be seen in the relative accumulation of data points in the Gulf of Maine over time (Figure C12).

Southern Georges Bank – Mid-Atlantic silver hake indices decreased in the early part of the time series then fluctuated without trend. (Figure A6; NEFSC 2006). The decline in abundance can be seen in the distribution maps for the southern New England area in particular (Figure C12).

MADMF inshore biomass and abundance indices for silver hake have fluctuated without trend (Figure B4). Most silver hake sampled by the Massachusetts survey are caught at stations greater than 20 m (11 fm) deep in spring and throughout the Gulf of Maine in autumn (Figure D12).

The trend in the **Gulf of Maine – Northern Georges Bank red hake** survey indices resembles that of the northern stock of silver hake indices (Figure A6; Sosebee 2005). Most red hake are caught between 60 m (33 fm) and 180 m (100 fm) in the NEFSC survey (Figure C13).

Southern Georges Bank – Mid-Atlantic red hake indices also followed a pattern similar to the southern stock of silver hake (Figure A6; Sosebee 2005). Following a decline in abundance and biomass indices in the 1960s, the 1970s represented a period of relative stability as both biomass and abundance indices fluctuated without trend. In the mid-1980s, a slight decline occurred and the indices are now fluctuating without trend at a lower level. This lower level of abundance is also shown in the distribution maps for the late 1980s and 1990s in the reduction of both numbers of fish and number of positive tows (Figure C13).

MADMF spring indices of biomass and abundance for red hake decreased (Figure B4). The majority of red hake sampled by the inshore survey are caught at stations greater than 20 m (11 fm) deep in spring and greater than 30 m (17 fm) deep in autumn (Figure D13).

Spring NEFSC biomass and abundance indices of **ocean pout** declined in the early part of the time-series until the mid-1970s, when a sharp increase occurred (Figure A7; NEFC 1990; NEFSC 1998; NEFSC 2002b). In the mid-1980s, however, a decline began that continued through 1997, with stable catches following through 2002 (Mayo and Terceiro 2005). The seasonal difference in the catchability of ocean pout is evident in the distribution maps (Figure C14). The decline in abundance is also evident as ocean pout have concentrated around the 60 m (33 fm) depth contour, particularly in autumn. MADMF abundance indices from spring surveys also decreased from the early 1980s through 1997 (Figure B4). Most ocean pout in the Massachusetts survey are caught in the spring, predominantly in Cape Cod and Massachusetts Bays, at depths greater than 30 m (17 fm; Figure D14).

Atlantic wolffish NEFSC abundance and biomass indices fluctuated without trend until the 1980s, when they decreased precipitously and remained at or near record-low levels through 2002 (Figure A7; NEFSC 1998). Wolffish appeared to be concentrated between the 90 m (50 fm) and 180 m (100 fm) depth contours in the NEFSC surveys (Figure C15). MADMF spring biomass and abundance indices are more variable but indicate the same sharp decline (Figure B5). There have been 6 spring surveys and 17 autumn surveys which have not caught any wolffish. In the latest 5-year time block, only one wolffish was caught in the spring, and no wolffish were caught in the autumn. The Massachusetts survey caught wolffish primarily in the spring in deep waters of Massachusetts Bay (Figure D15).

NEFSC **goosefish** abundance indices fluctuated without trend throughout most of the time series while there has been an overall decline in biomass indices (Figure A7, NEFSC 1992; NEFSC 2002a). In the autumn survey, biomass has remained low while abundance has increased, signifying a decline in the mean weight of the stock. Changes in distribution have occurred over the time series with declines notably occurring in the Southern New England area in waters between 90 m (50 fm) and 180 m (100 fm) (Figure C16). The recent increases in abundance are due primarily to increased recruitment in the Gulf of Maine region. All MADMF biomass and abundance indices decreased, except for autumn abundance, which increased (Figure B5). Goosefish are caught in almost all Massachusetts survey strata in spring, and most are caught at stations greater than 30 m (17 fm) deep in autumn (Figure D16).

NEFSC indices of biomass and abundance for **cusk** fluctuated greatly, but these indices have steadily declined since 1985, and all indices remained at or near record-low levels through 2002 (Figure A7; NEFSC 1998). Cusk have been primarily distributed in deeper water in the central portion of the Gulf of Maine (Figure C17). The steady decline is also evident in the distribution maps, with very few fish caught in 1993-1997 and 1998-2002. Only one cusk was caught in the 25-year MADMF inshore survey.

Aggregate Indices

Gulf of Maine

Principal groundfish biomass and abundance indices from the NEFSC surveys declined steadily over the time series in both spring and autumn (Figure A8). These indices were dominated mostly by haddock and redfish at the start of the time series; by pollock, cod and white hake during the 1970s; and by white hake followed by redfish in the later part of the time series. As a result of the shift in species composition from cod and haddock to white hake, and, to a lesser extent, redfish during the 1980s, the aggregate biomass index for this group had stabilized at a record-low level and the aggregate abundance index increased slightly through 1995. The increases in both survey indices from 1996-2002 were due primarily to the influx of redfish and the large tow of cod in the 2002 autumn survey. The change in abundance is reflected in the distribution maps with lower catches in the Gulf of Maine in 1993-1997, followed by increase in 1998-2002 (Figure C18).

The Gulf of Maine **principal flounder** indices of abundance and biomass (Figure A8), dominated by American plaice and witch flounder, decreased in the early 1960s and increased in the 1970s. All indices declined sharply in the early 1980s, and the biomass indices remained relatively low through 2002. The abundance indices, however, fluctuated widely from 1985 through 2002, particularly in the autumn, in response to apparent variability in recruitment. The deviation between the trend in biomass and abundance indices implies a reduction in mean weight of this group in recent years. The early reduction in abundance is evident in the distribution maps and there has been a shift in distribution from the central Gulf of Maine to the inshore areas of the Gulf of Maine (Figure C19).

Autumn and spring biomass and abundance indices for **small-mesh groundfish** show a pattern similar to that of silver and red hake, because they are dominated by those two species (Figure A8). All indices fluctuated considerably since 1980, but indicate a general increase in both abundance and biomass for this group through 2002, which is reflected by the increase in the abundance of fish in the central Gulf of Maine (Figure C20).

The spring indices of biomass and abundance for **other groundfish** in the Gulf of Maine show an increase in the early part of the time series to a high level in the mid-1970s (Figure A8).

In the early 1980s, a sharp decrease occurred in both biomass and abundance indices. The spring biomass index has since continued to decline, while the abundance index has remained constant. The autumn indices fluctuated without trend for most of the time series (Figure A8) until the mid-1980s, when a decline in biomass and an increase in abundance occurred. This group of species is dominated by goosefish but also reflects the declines noted earlier for wolffish and cusk beginning in the mid-1980s.

Georges Bank

Principal groundfish indices of biomass and abundance show similar patterns in both seasons (Figure A9). This group was dominated by cod and haddock through the survey period. Both spring and autumn indices reveal a consistent pattern of increased abundance and biomass during the 1970s, followed by sharp declines in both indices to historic low levels during the mid-1980s. An increase and subsequent decline in biomass in the autumn survey during the late 1980s reflects recruitment of several low to moderate year classes of cod and haddock on Georges Bank during the 1980s. Abundance and biomass indices were at or near record-low levels in the mid-1990s, but increased slightly through 1997. Survey indices for this group increased through 2002, particularly in the autumn survey due to the increases in haddock abundance and biomass. In the early part of the time series, principal groundfish were found all over Georges Bank (Figure C18). As the abundance declined in the late 1980s and early 1990s, catches occurred mostly on the Northeast Peak and in the Great South Channel.

The **principal flounder** indices for Georges Bank have fluctuated considerably over the survey period, but revealed consistent declines in abundance and biomass (Figure A9). This group was dominated by yellowtail flounder and winter flounder. Much of the variability in the abundance index was due to fluctuations in winter flounder recruitment, but both species experienced consistent declines in both indices since the late 1970s or early 1980s. Both indices were at or near historic lows with respect to the autumn series through the early 1990s. The subsequent increases reflected higher catches of yellowtail flounder on the southeast part of Georges Bank (Figure C7) and increases in winter flounder abundance. The decline in abundance through 1993-1997 is evident in the distribution maps (Figure C19) as well as the subsequent increase through 2002.

Small-mesh groundfish indices of biomass and abundance fluctuated considerably without any distinct trends throughout both spring and autumn series (Figure A9). These indices reflect trends in both stocks of silver hake and red hake throughout Georges Bank. As a result, the aggregate indices do not depict consistent trends for either of the stocks.

Abundance and biomass indices for **other groundfish** for both seasons on Georges Bank display similar patterns (Figure A9). This group is dominated by goosefish in this region and the aggregate indices reflect the recent decline in mean weight of the stock. Both surveys indicate that biomass for this group through 2002 was at or near record-low levels.

Southern New England

The spring indices of **principal groundfish** off Southern New England are highly variable, but indicate a general decline in abundance and biomass over the time series (Figure A10). The autumn survey also fluctuated with more consistent declines during the 1960s and 1970s (Figure A10). However, the trend in abundance was affected by the one large index in 1987, caused by three very large tows of small haddock. Most of the principal groundfish are at the end of their geographic range and, therefore, occur more sporadically in survey catches in this region (Figure C18).

The indices for **principal flounders** off Southern New England are dominated by yellowtail flounder and reflect the trend for this species. Abundance and biomass declined sharply in the early 1970s, increased during the late 1970s and early 1980s due to improved recruitment, but subsequently declined to historic lows in the 1990s (Figure A10). The slight increase in 1994 (autumn) and 1995 (spring) is due to winter flounder and windowpane flounder indices. The indices in both surveys remained near historic lows through 2002. The distribution maps for this group show the decline in abundance over time from the early 1960s through 1998-2002 (Figure C19).

Spring and autumn indices for **small-mesh groundfish** are highly variable (Figures A10), reflecting trends in the southern stocks of red and silver hake. The sharp but consistent decline in spring abundance and biomass reflects overall trends for all three species in this group and is reflected in the distribution maps (Figure C20).

Biomass and abundance indices from spring surveys for **other groundfish** suggest a sharp decline since the 1970s in both seasons (Figure A10). The large increase in both indices in 1981 is due to a large increase in goosefish biomass and abundance. Abundance and biomass for this group off Southern New England remained among the lowest on record through 1997, with some increase through 2002. The lack of fish in Southern New England can be seen in the distribution maps (Figure C21).

Massachusetts Inshore Survey

Biomass and abundance indices of principal groundfish (cod, haddock, and white hake), flatfish (yellowtail flounder, American plaice, witch flounder, winter flounder, and windowpane flounder), small-mesh groundfish (silver hake, red hake, and ocean pout), and other groundfish (wolffish and goosefish) were derived for the entire Massachusetts inshore strata set (Figure B6). MADMF spring biomass indices of each species group declined through 1997, and the autumn index of other groundfish declined. The MADMF principal groundfish index reflects the MADMF cod index (Figure B1), because the catch is dominated by catches of cod. This is reflected in the increase observed in the last five years in both spring and autumn. The maps display a seasonal difference in distribution and the changes in abundance over time (Figure D17). The principal flounder autumn survey index declined in the early part of the time series, increased through the early 1990s, and was stable for the rest of the time period. The maps show a relatively stable abundance north of Cape Cod but a decline in abundance south of Cape Cod, driven by winter flounder (Figure D18). Small-mesh groundfish inshore indices are influenced by all three species in the group, show a decline in abundance in the spring, and fluctuate without trend in the fall. The maps show no trends by season or time (Figure D19). The other groundfish indices are almost identical to goosefish and the maps are also similar (Figure D20).

Trend Analyses

The total number of time series was 160 (abundance and biomass indices for 25 stocks from 2 to 4 surveys). At the 95% confidence level, 68 regressions were not significant, 81 estimates of r were significantly negative, and 11 r estimates were significantly positive (5%, or eight regressions should be falsely significant by chance, Table 2). Estimates of r had common signs within stocks, except American plaice, and values of *r* were generally similar within stocks.

All NEFSC indices of abundance and biomass significantly decreased for Georges Bank cod, southern New England – Mid Atlantic yellowtail flounder, southern New England – Mid Atlantic winter flounder, southern windowpane, southern red hake, and cusk. Most MADMF indices were also negative for these stocks, but some were insignificant. All indices of goosefish biomass significantly decreased. The most rapid decrease was exhibited by southern New England yellowtail NEFSC abundance indices, which declined by nearly 10% per year ($e^{-0.105} = 0.90$).

Gulf of Maine cod, both haddock stocks, pollock, white hake, Georges bank yellowtail, plaice, witch, Georges Bank winter flounder, southern silver hake, ocean pout, and wolffish had significant decreases, but regressions for some survey indices were insignificant. NEFSC spring indices of American plaice abundance and biomass significantly decreased, but the MADMF autumn biomass index significantly increased.

Regressions of all redfish and Gulf of Maine winter flounder indices were insignificant. Significant increases were also found for northern windowpane (three of four indices), northern silver hake (three of four indices), and northern red hake (all four indices).

CONCLUSIONS

These results indicate that most northeast groundfish stocks significantly decreased over the last four decades. Based on model assumptions, it appears that total mortality rates had exceeded population growth rates for these stocks.

Of the twenty-five stocks examined, only three stocks showed an increase in abundance and biomass in the NEFSC surveys over the time-series. Two stocks mostly fluctuated without trend. However, twenty (80%) of the stocks declined throughout most of the time-series. This was a cause for concern, since some of these stocks were considered to be "under-utilized" (NEFSC 1993). The status of some of these stocks has changed since 2002, although most still remain at low abundance and biomass even after some increases (Mayo and Terceiro 2005).

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Table 1. Strata sets used for the NEFSC and the Massachusetts Inshore surveys. Conversion factors and transformations are also listed if any were applied to the NEFSC data (V = Vessel, D = Door, G = Gear).

Stock	NEFSC Strata Set	Conversion	Transform	Massachusetts Strata Set
GM Cod	Offshore 26-30, 36-40	D,V		25-36
GB Cod	Offshore 13-25	D,V		-
GM Haddock	Offshore 26-28, 36-40	D,V		25-36
GB Haddock	Offshore 13-25, 29-30	D,V		-
Pollock	Offshore 13-30, 33-34,36-40	-	Log	11-36
Redfish	Offshore 24, 26-30, 36-40	-		11-36
White Hake	Offshore 21-30, 33-40	-		11-36
GB Yellowtail Flounder	Offshore 13-21	D,V,G		-
SNE-MA Yellowtail Flounder	Offshore 1-2,5-6, 9-10, 69, 73-74 Spring Only	D,V,G		11-16
CC Yellowtail Flounder	Offshore 25-27, 39-40 Inshore 56-66 (Fall no offshore 27)	D,V,G		17-36
American Plaice	Offshore 13-30, 36-40	D		25-36
Witch Flounder	Offshore 22-30, 36-40	-		25-36
GM Winter Flounder	Offshore 26-27, 38-39 Inshore 58-61, 65-66	D		25-36
GB Winter Flounder	Offshore 13-22	D		-
SNE-MA Winter Flounder	Offshore 1-12, 25, 69-76 Inshore 1-29, 45-56	D		11-21
GM-GB Windowpane Flounder	Offshore 13-29, 37-40	-		11-36
SNE-MA Windowpane Flounder	Offshore 1-12, 61-76	-		-
GM-NGB Silver Hake	Offshore 20-30, 36-40	-	Delta	11-36
SGB-MA Silver Hake	Offshore 1-19, 61-76	-	Delta	-
GM-NGB Red Hake	Offshore 20-30, 36-40	-	Delta	11-36
SGB-MA Red Hake	Offshore 1-19, 61-76	-	Delta	-
Ocean Pout	Offshore 1-26, 73-76	-		11-36
Wolffish	Offshore 21-40	-		11-36
Goosefish	Offshore 1-30, 34-40, 61-76	-	Delta	11-36
Cusk	Offshore 21-40	-		-

Table 2. Instantaneous rates of change from exponential regressions of survey indices over time.

Stock	NEFSC spring abundance	NEFSC autumn abundance	MADMF spring abundance	MADMF autumn abundance	NEFSC spring biomass	NEFSC autumn biomass	MADMF spring biomass	MADMF autumn biomass
GB cod	-0.040	-0.038	---	---	-0.048	-0.051	---	---
GOM cod	ns	-0.029	ns	ns	-0.032	-0.047	ns	ns
GB haddock	ns	-0.033	---	---	ns	-0.050	---	---
GOM haddock	ns	-0.057	ns	ns	-0.034	-0.070	ns	ns
pollock	ns	ns	-0.042	ns	-0.044	-0.038	-0.010	ns
redfish	ns	ns	ns	ns	ns	ns	ns	ns
white hake	ns	ns	-0.037	-0.048	-0.037	ns	-0.013	-0.020
GB yellowtail	ns	-0.045	---	---	ns	-0.044	---	---
SNE-MA yellowtail	-0.104	-0.105	-0.013	ns	-0.095	-0.103	-0.005	ns
CC-GOM yellowtail	ns	ns	ns	ns	ns	ns	ns	ns
American plaice	ns	ns	-0.028	ns	-0.022	ns	ns	0.025
witch flounder	-0.022	ns	-0.052	ns	-0.069	-0.048	-0.051	-0.026
GB winter flounder	ns	ns	---	---	-0.029	-0.020	---	---
GOM winter flounder	ns	ns	ns	ns	ns	ns	ns	ns
SNE-MA winter flounder	-0.023	-0.023	-0.038	ns	-0.029	-0.022	-0.053	ns
northern windowpane	ns	0.025	---	---	0.034	0.023	---	---
southern windowpane	-0.044	-0.049	---	---	-0.037	-0.046	---	---
northern silver hake	0.053	0.051	---	---	ns	0.028	---	---
southern silver hake	-0.028	ns	---	---	-0.042	-0.023	---	---
northern red hake	0.046	0.063	---	---	0.032	0.054	---	---
southern red hake	-0.044	-0.028	---	---	-0.058	-0.051	---	---
ocean pout	-0.019	ns	-0.080	-0.085	ns	ns	-0.072	-0.034
wolffish	-0.056	-0.031	-0.005	-0.001	-0.085	ns	-0.017	-0.003
goosefish	ns	ns	ns	ns	-0.050	-0.039	-0.031	-0.023
cusk	-0.056	-0.036	---	---	-0.079	-0.061	---	---

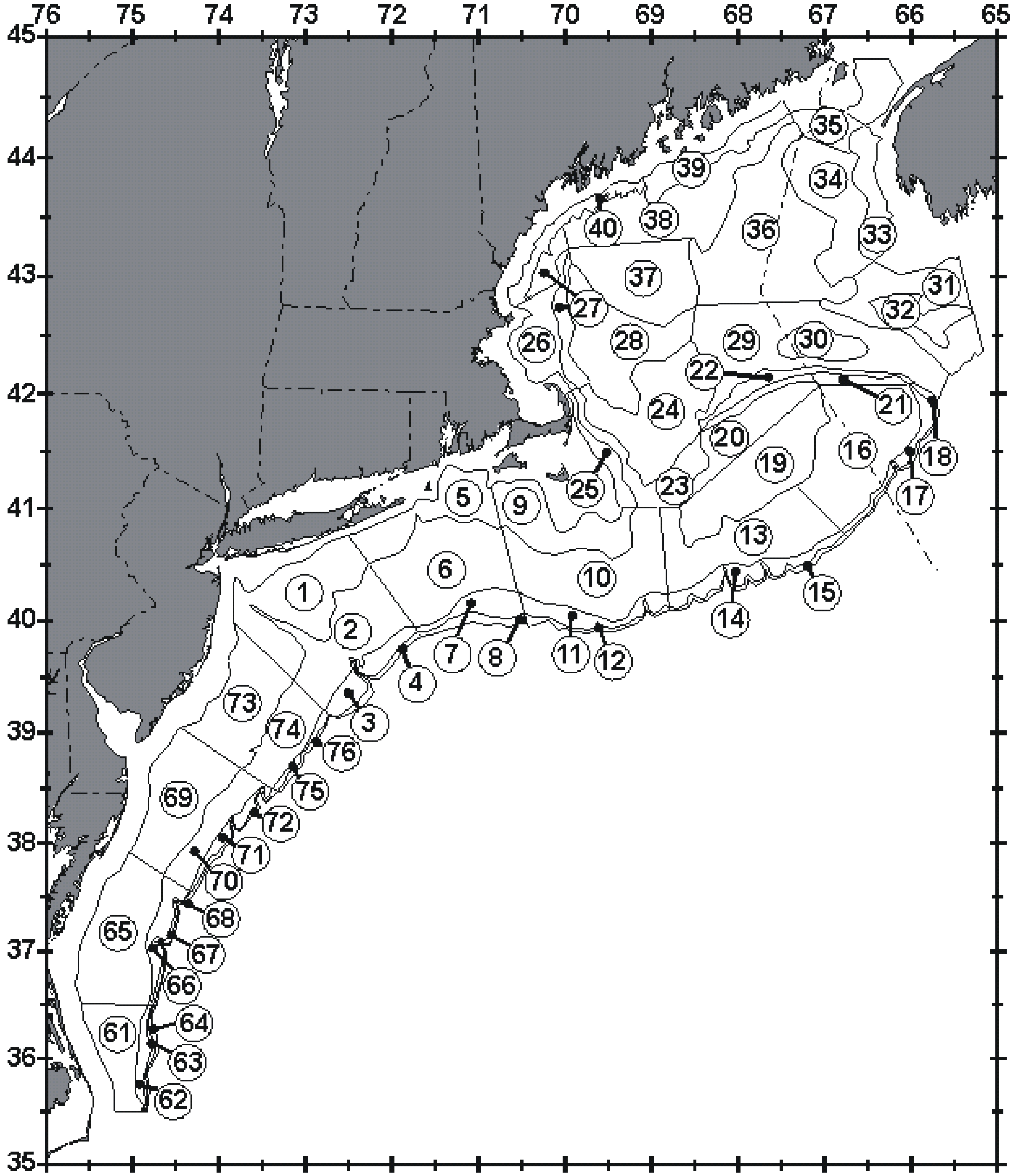

Figure 1. Strata sampled on NEFSC offshore bottom trawl surveys. Depths range from 27 to > 200 meters.

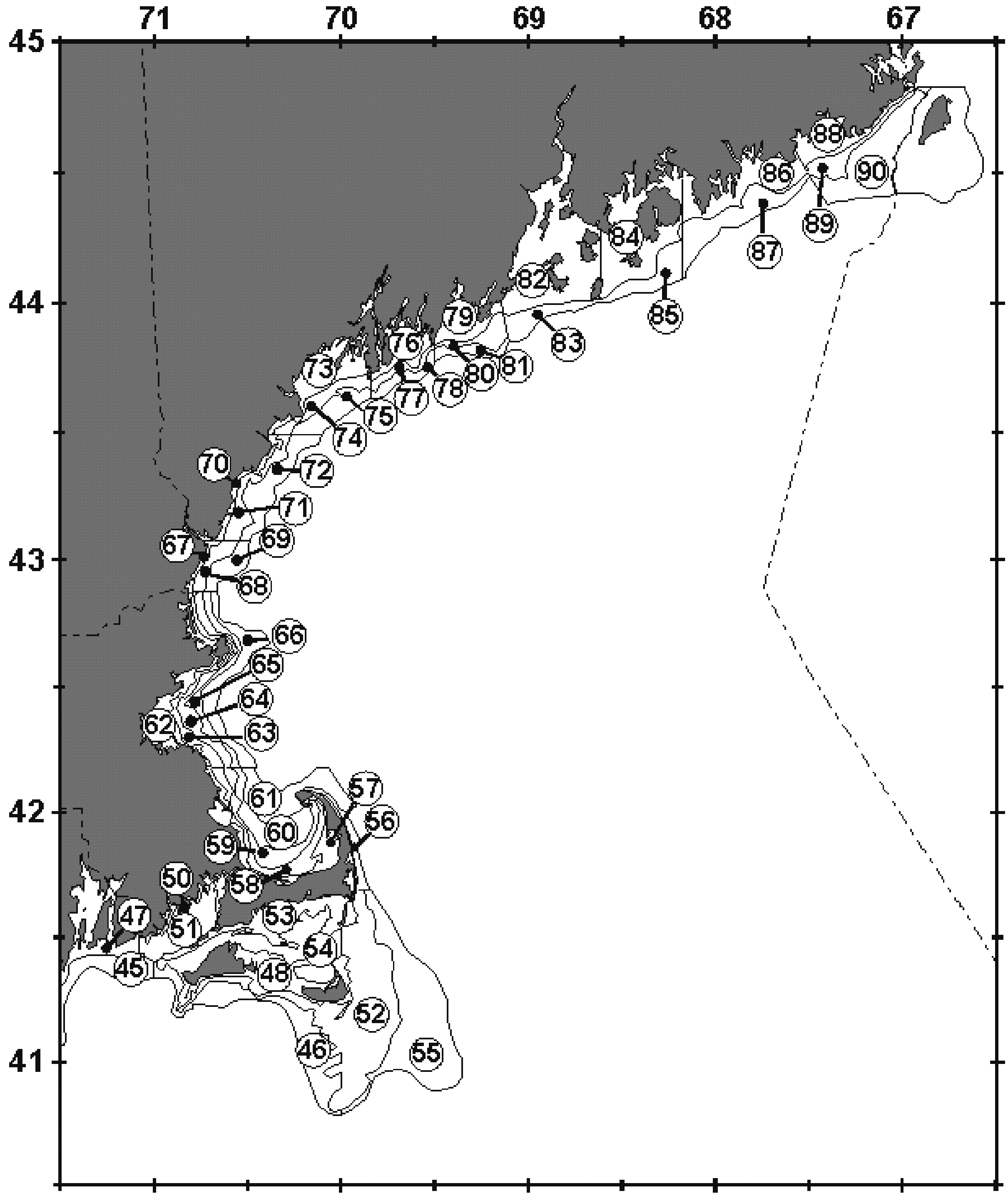

Figure 2. Strata sampled on NEFSC inshore bottom trawl surveys from Eastport, ME to Buzzards Bay, MA. Depths range from 0-54 meters.

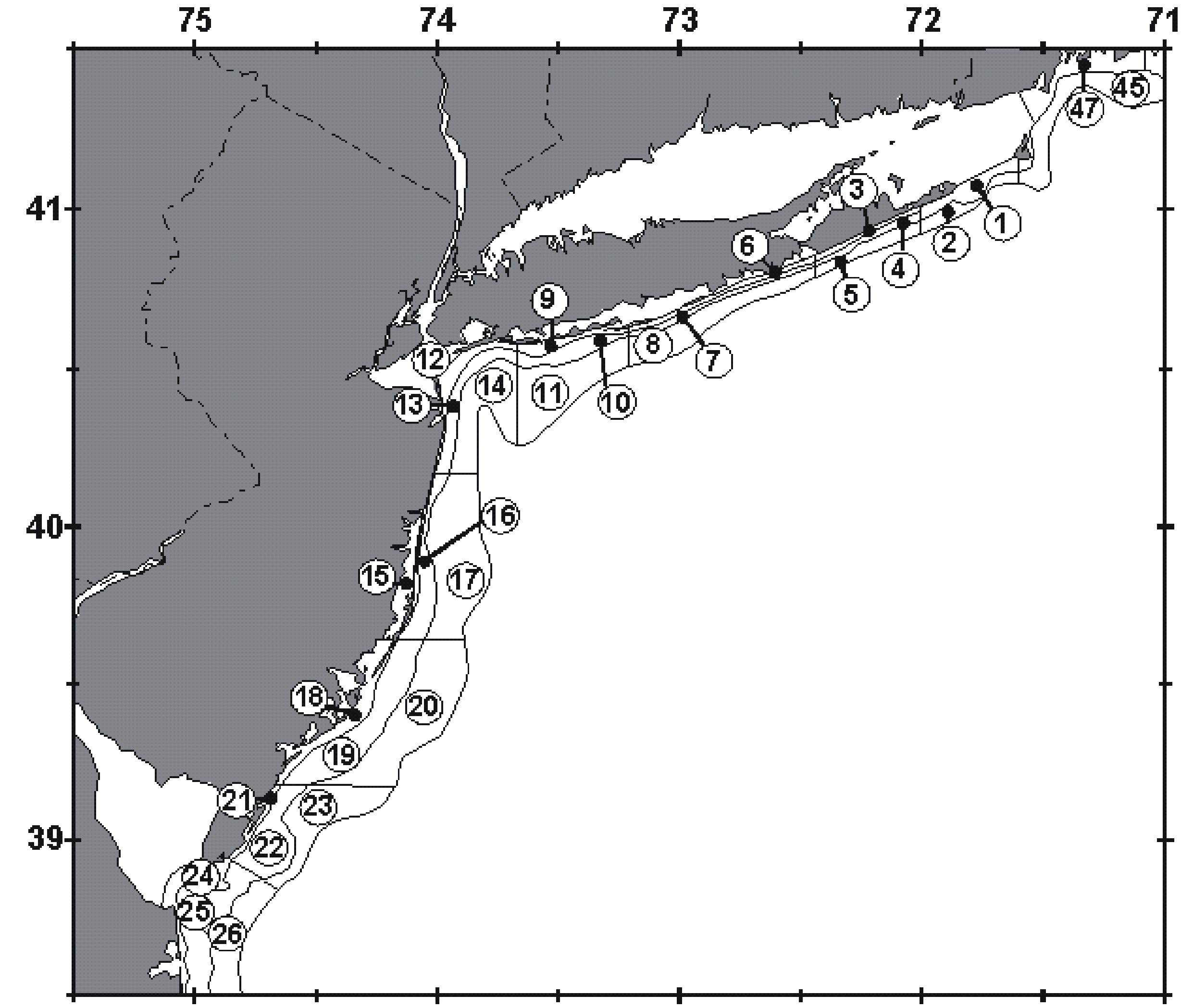

Figure 3. Strata sampled on NEFSC inshore bottom trawl surveys from Buzzards Bay, MA to Delaware Bay, DE. Depths range from 0-27 meters.

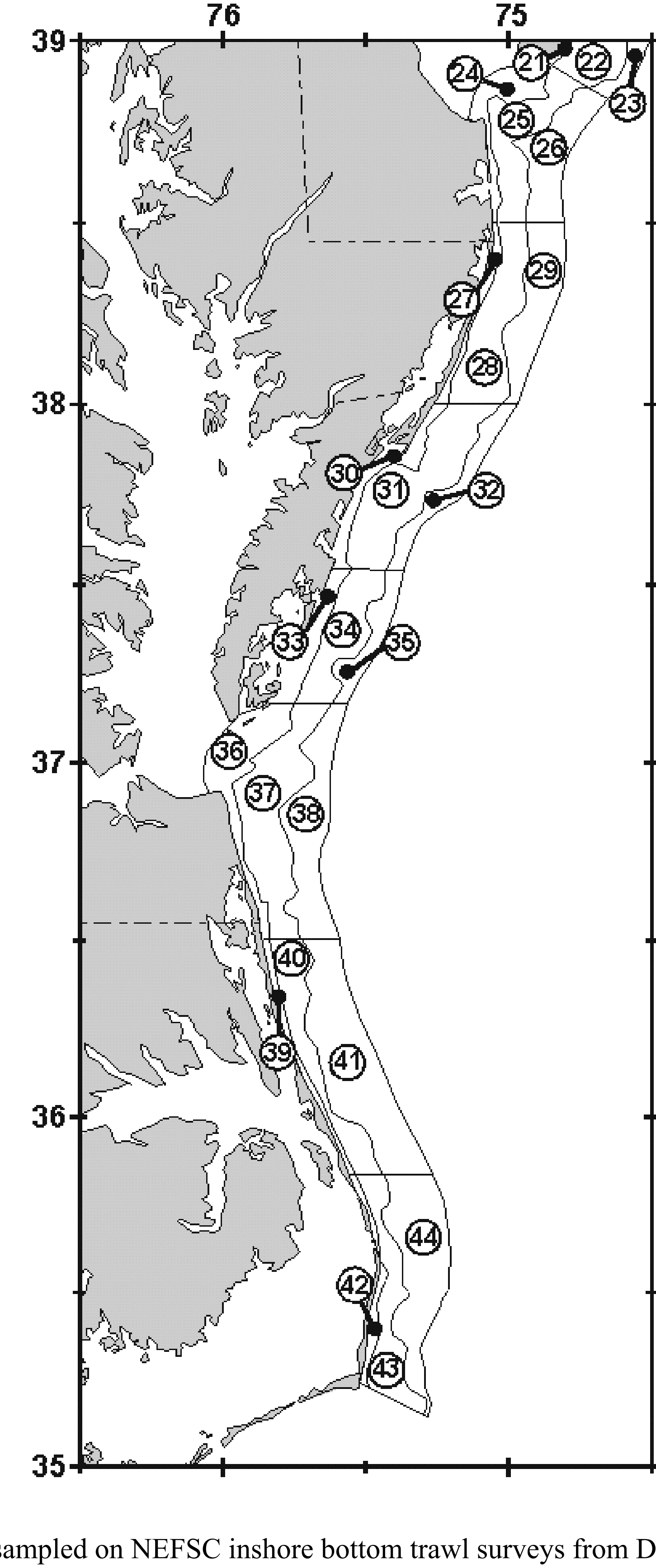

Figure 4. Strata sampled on NEFSC inshore bottom trawl surveys from Delaware Bay, DE to Cape Hatteras, NC. Depths range from 0-27 meters.

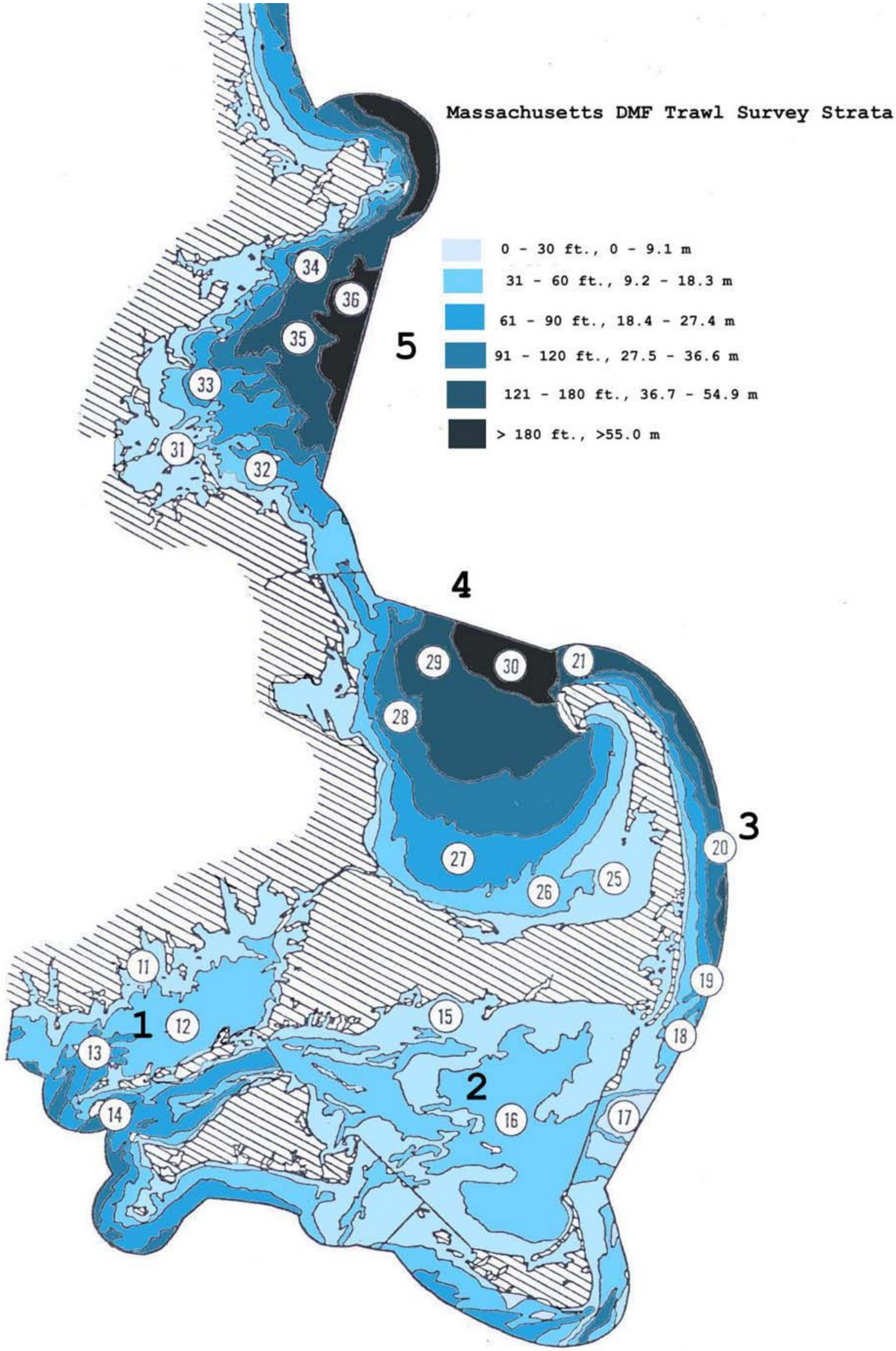

Figure 5. Strata sampled on Massachusetts DMF inshore bottom trawl surveys.

APPENDIX A.

Abundance and biomass indices from NEFSC spring and autumn bottom trawl surveys

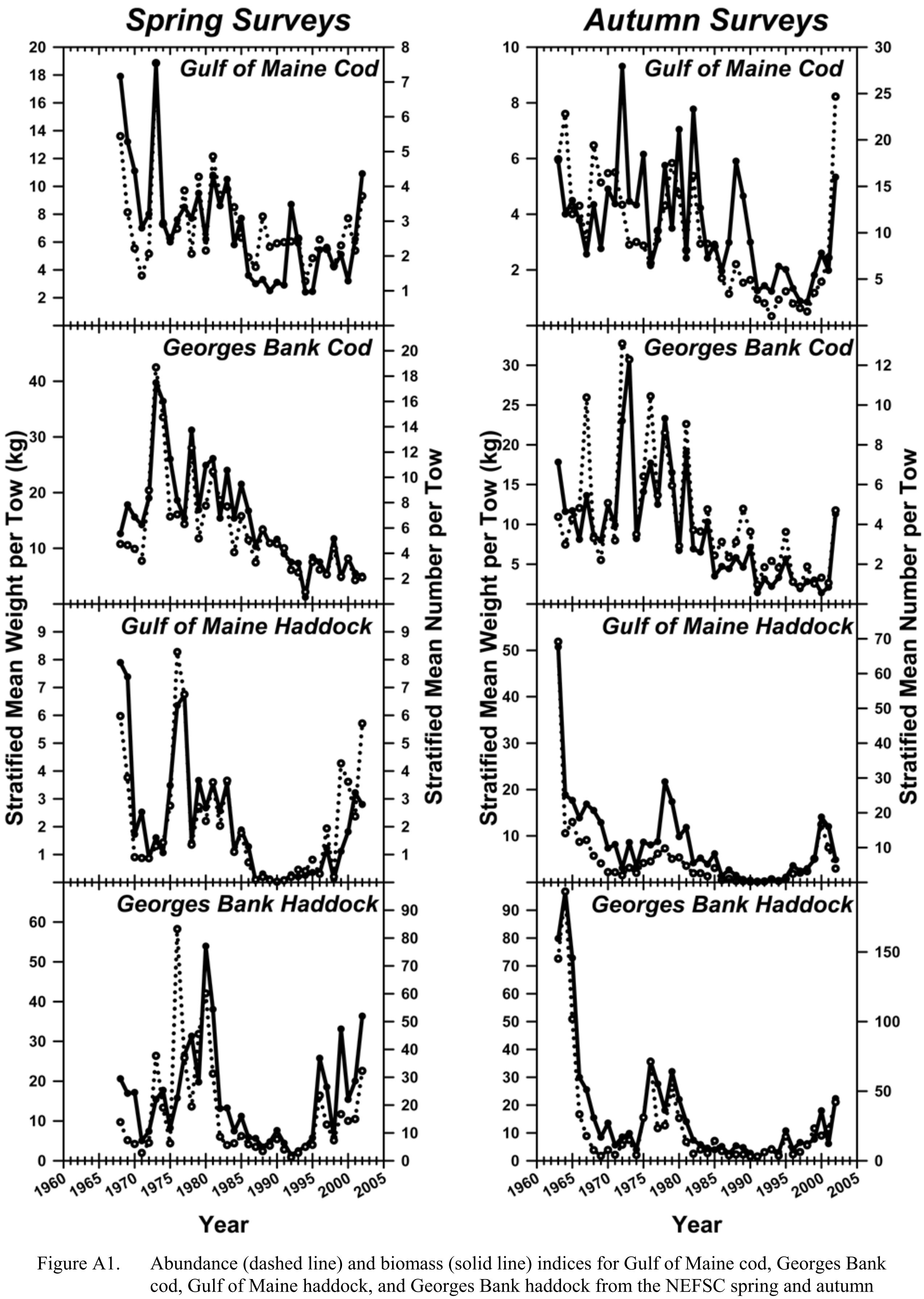

Figure A1. Abundance (dashed line) and biomass (solid line) indices for Gulf of Maine cod, Georges Bank cod, Gulf of Maine haddock, and Georges Bank haddock from the NEFSC spring and autumn surveys, 1963-2002.

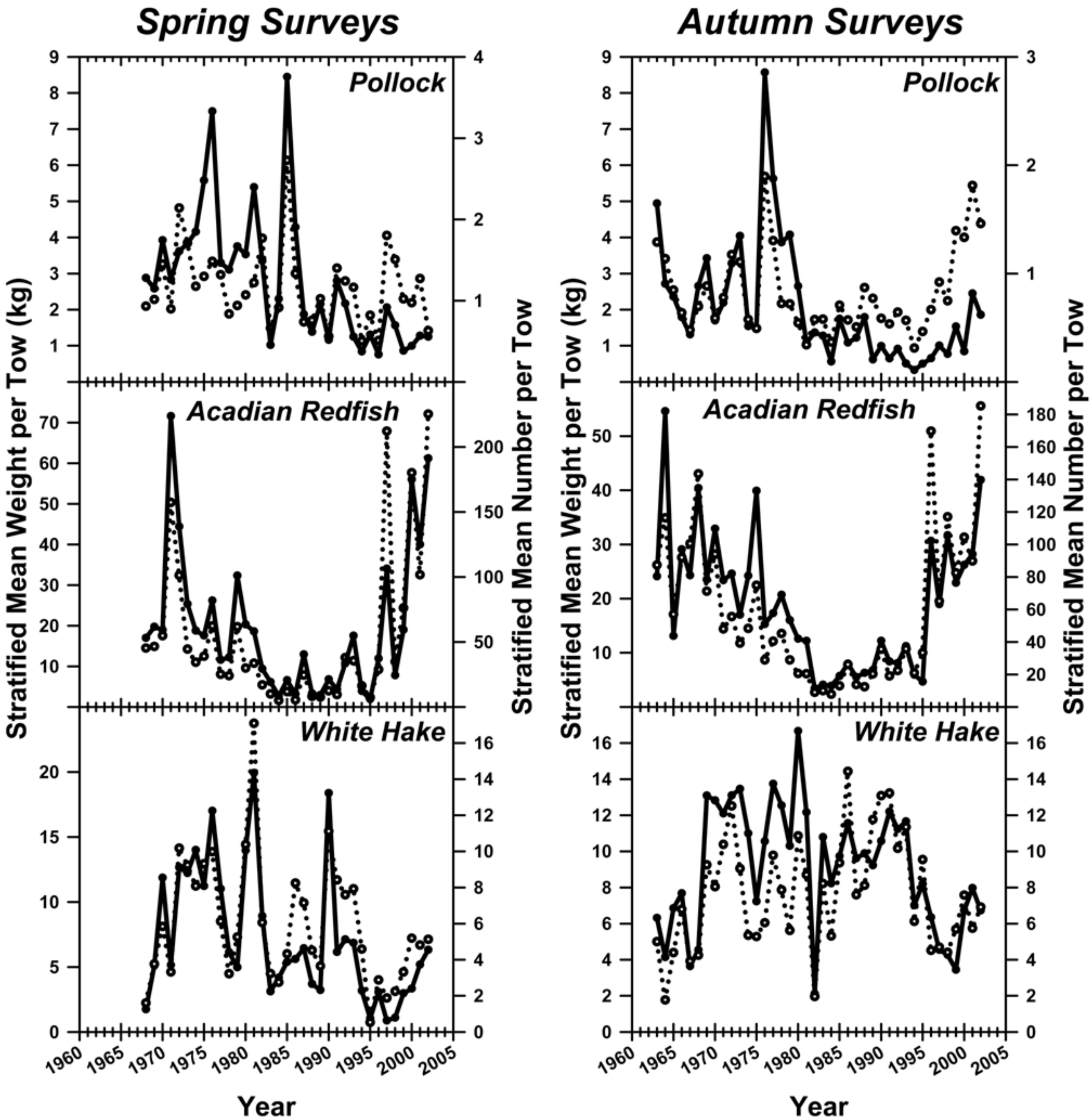

Figure A2. Abundance (dashed line) and biomass (solid line) indices for pollock, Acadian redfish and white hake from the NEFSC spring and autumn surveys, 1963-2002.

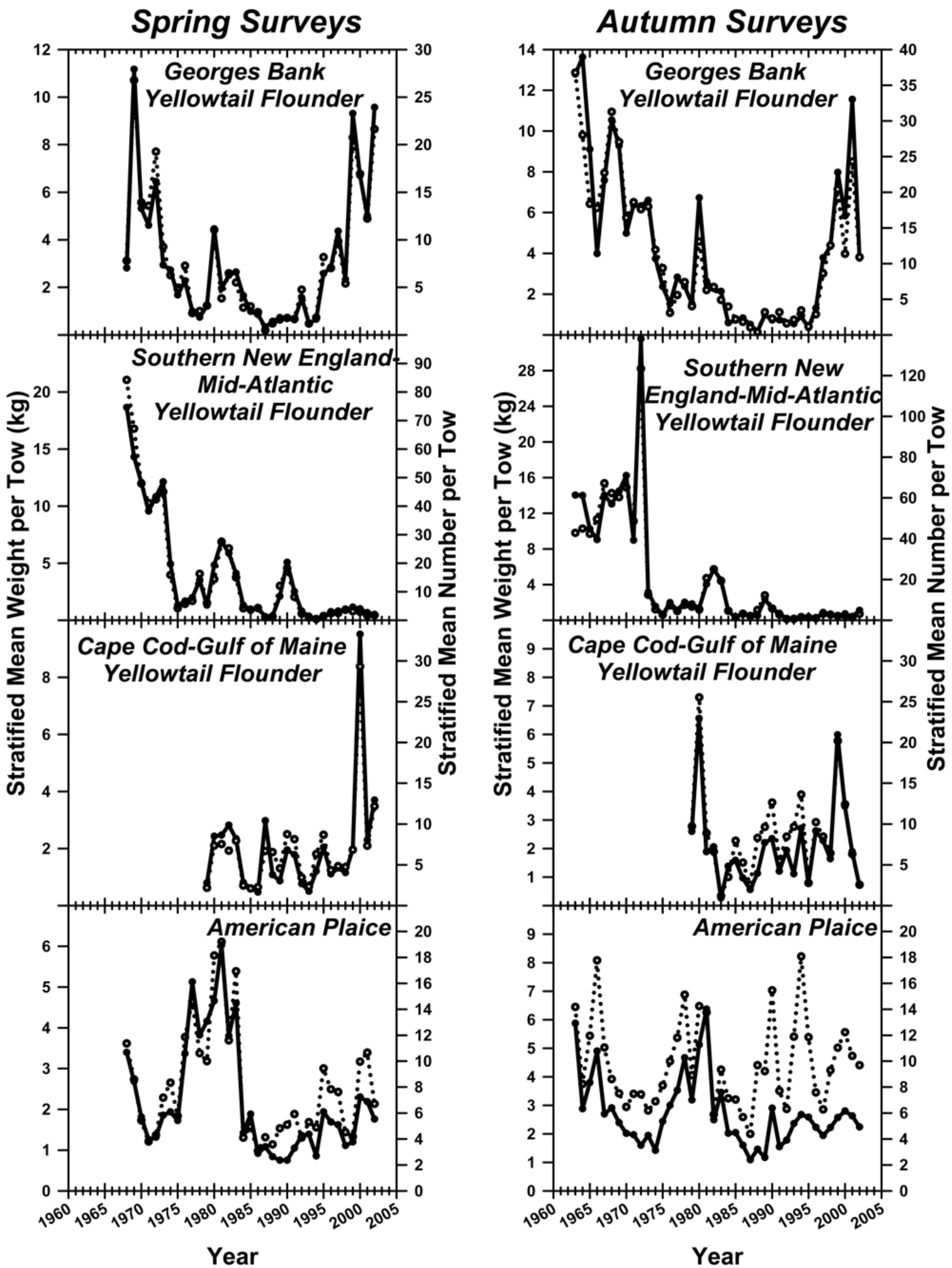

Figure A3. Abundance (dashed line) and biomass (solid line) indices for Georges Bank yellowtail flounder, Southern New England-Mid-Atlantic yellowtail flounder, Cape Cod-Gulf of Maine yellowtail flounder, and American plaice from the NEFSC spring and autumn surveys, 1963-2002.

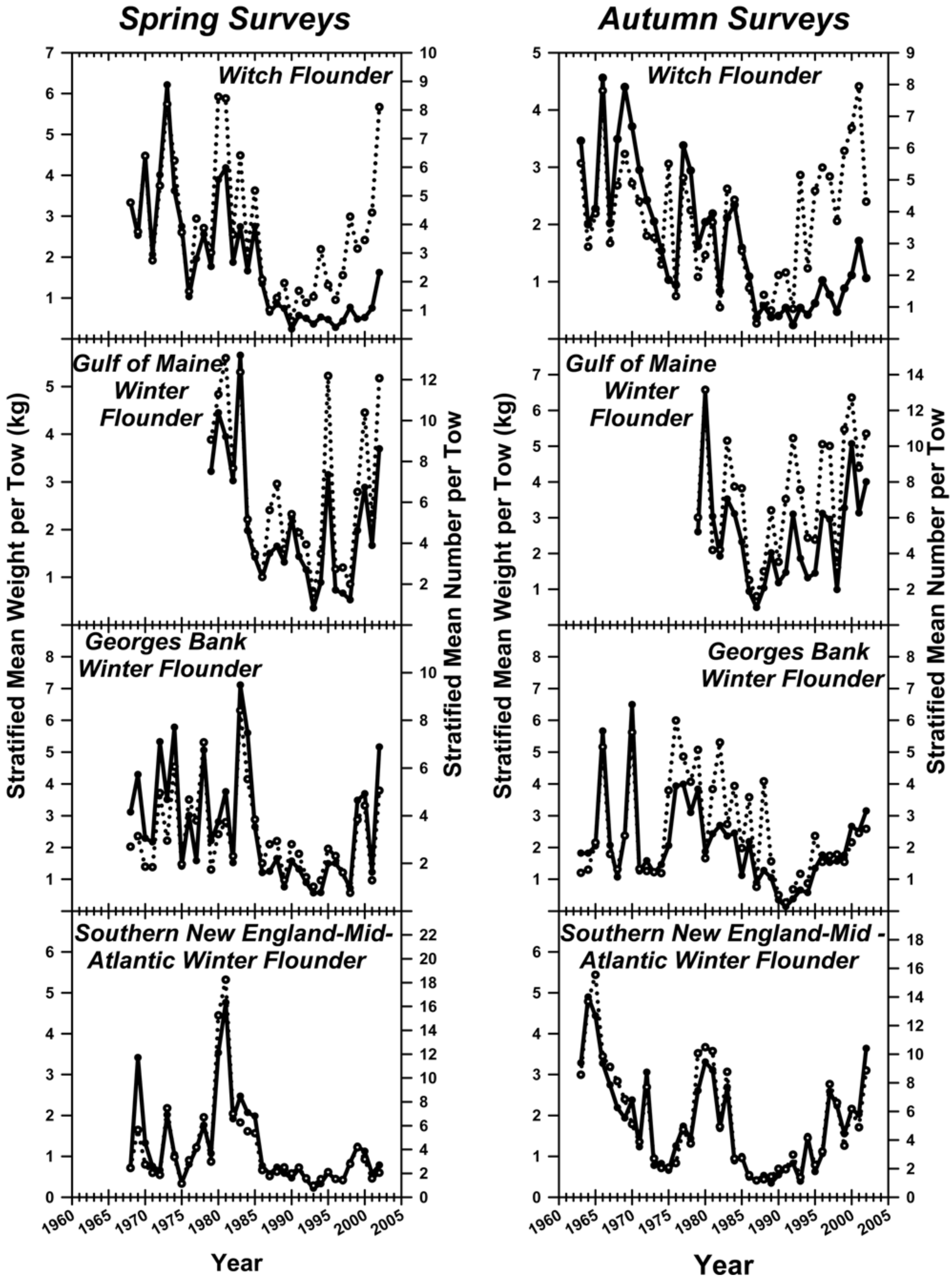

Figure A4. Abundance (dashed line) and biomass (solid line) indices for witch flounder, Gulf of Maine winter flounder, Georges Bank winter flounder, and Southern New England-Mid-Atlantic winter flounder from the NEFSC spring and autumn surveys, 1963-2002.

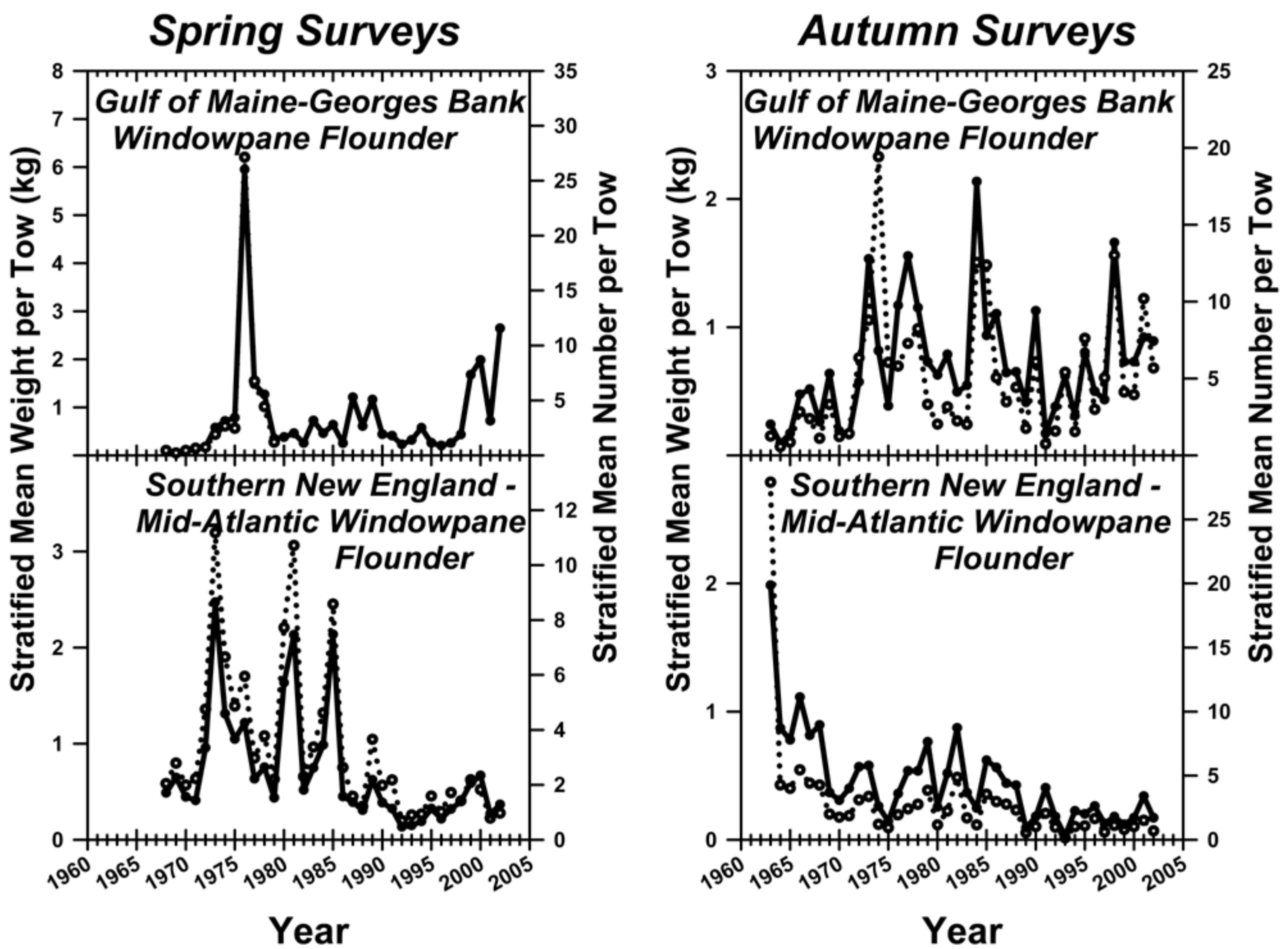

Figure A5. Abundance (dashed line) and biomass (solid line) indices for Gulf of Maine-Georges Bank windowpane flounder and Southern New England-Mid-Atlantic windowpane flounder from the NEFSC spring and autumn surveys, 1963-2002.

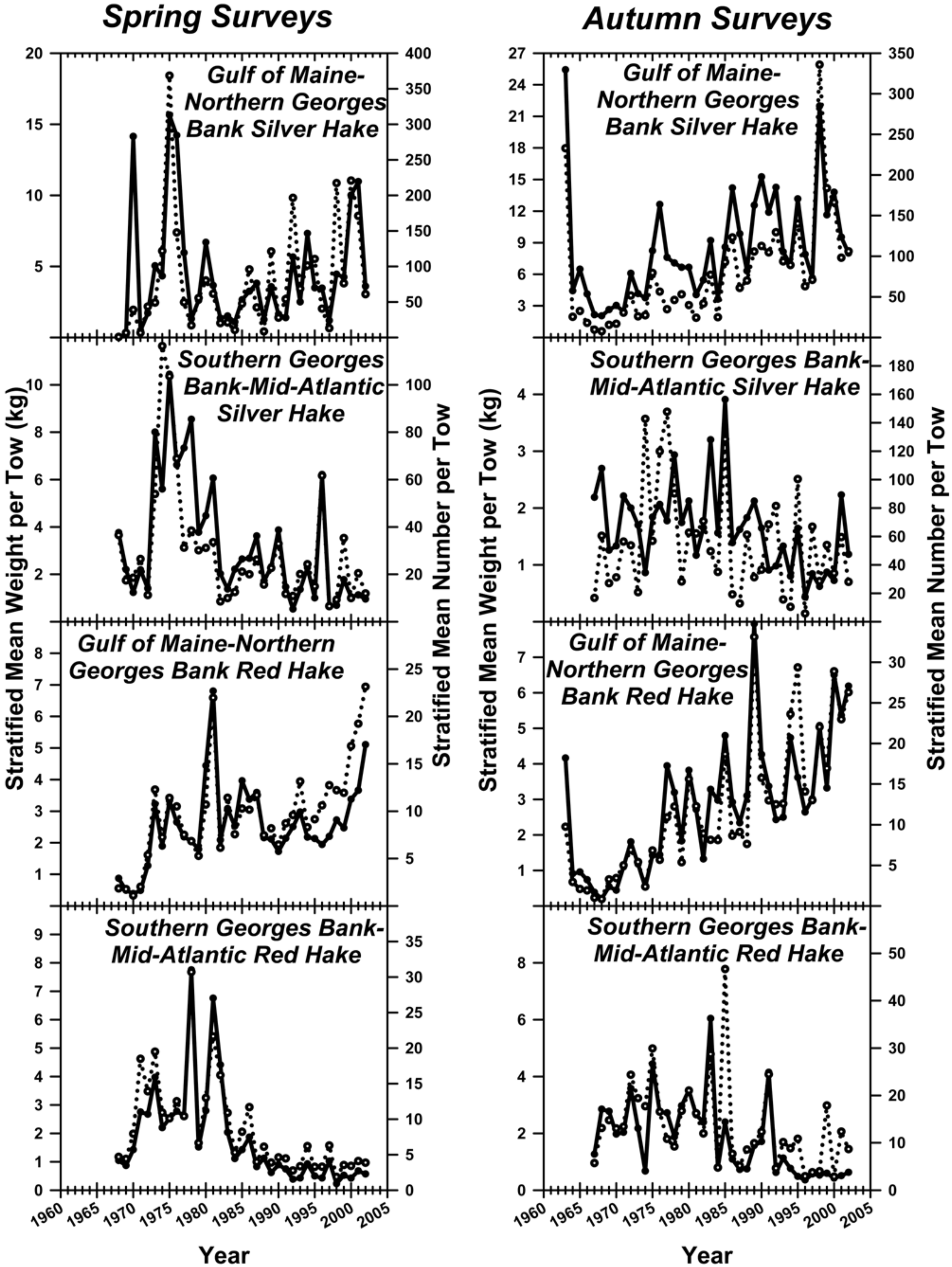

Figure A6. Abundance (dashed line) and biomass (solid line) indices for Gulf of Maine- Northern Georges Bank silver hake, Southern Georges Bank-Mid-Atlantic silver hake, Gulf of Maine-Northern Georges Bank red hake, and Southern Georges Bank-Mid-Atlantic red hake from the NEFSC spring and autumn surveys, 1963-2002.

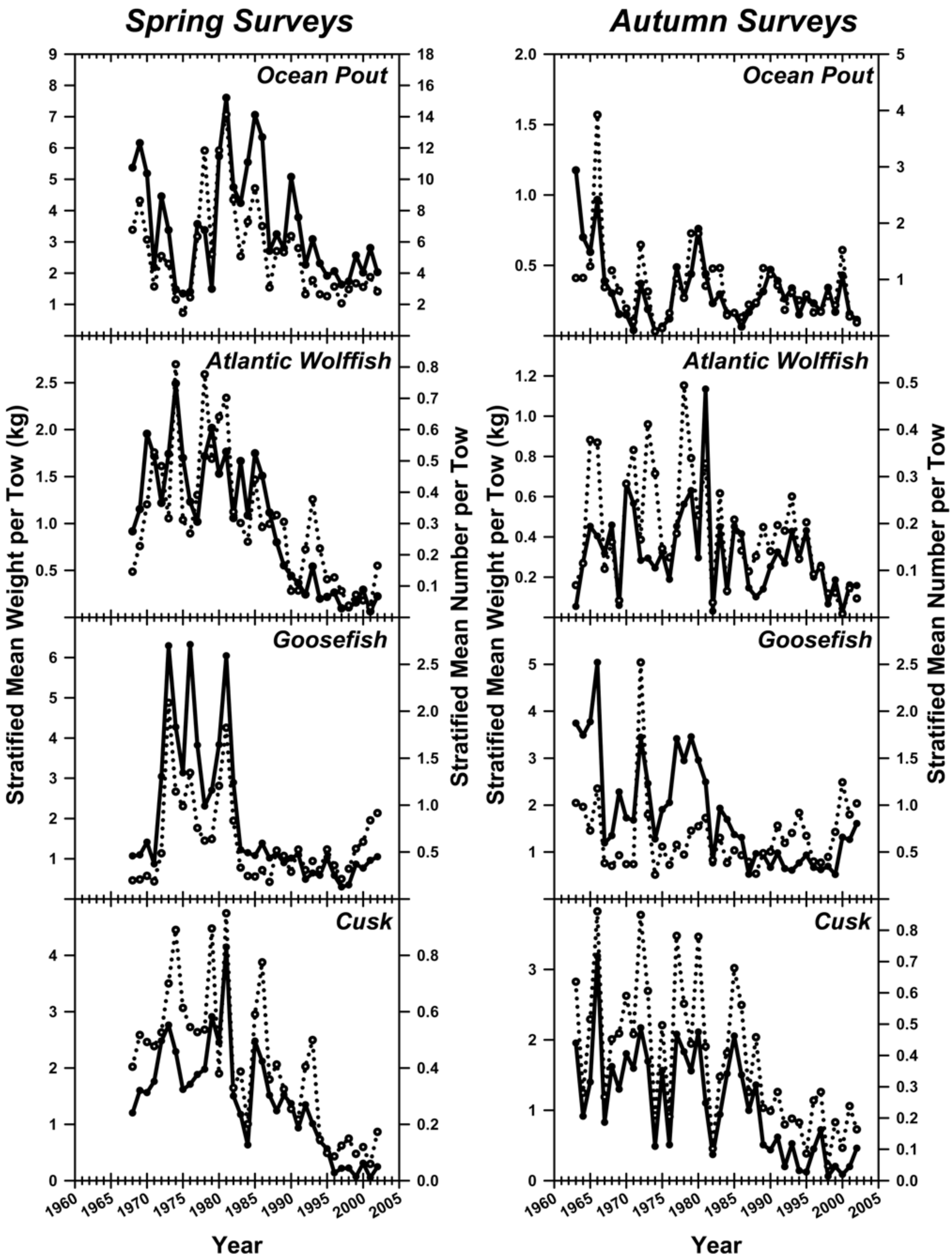

Figure A7. Abundance (dashed line) and biomass (solid line) indices for ocean pout, Atlantic wolffish, goosefish, and cusk from the NEFSC spring and autumn surveys, 1963-2002.

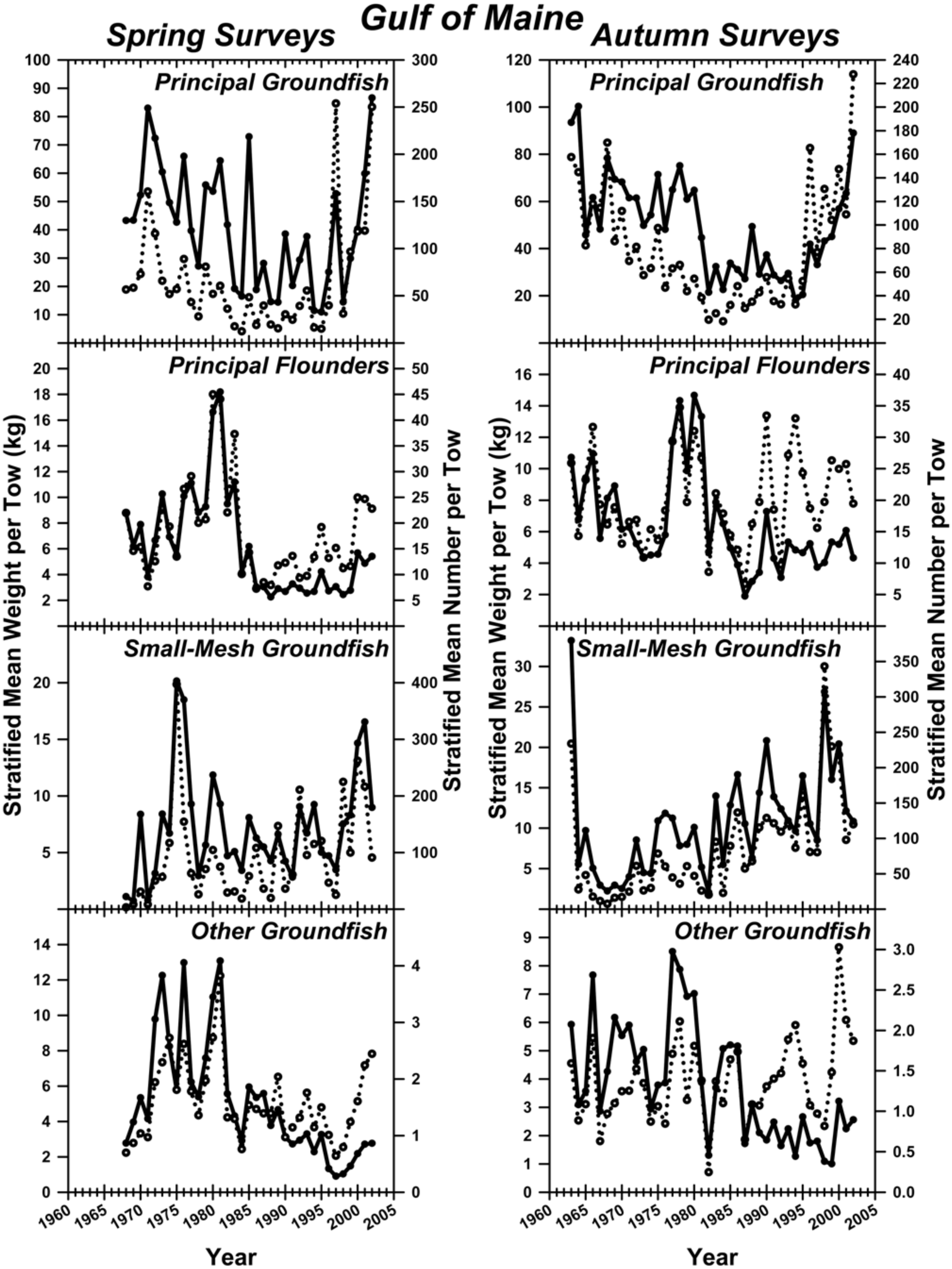

Figure A8. Abundance (dashed line) and biomass (solid line) indices for principal groundfish (Atlantic cod, haddock, pollock, Acadian redfish, and white hake), principal flounders (yellowtail flounder, American plaice, witch flounder, winter flounder, and windowpane flounder), small-mesh groundfish (silver hake, red hake, and ocean pout) and other groundfish (Atlantic wolffish, goosefish, and cusk) from the NEFSC spring and autumn surveys in the Gulf of Maine, 1963-2002.

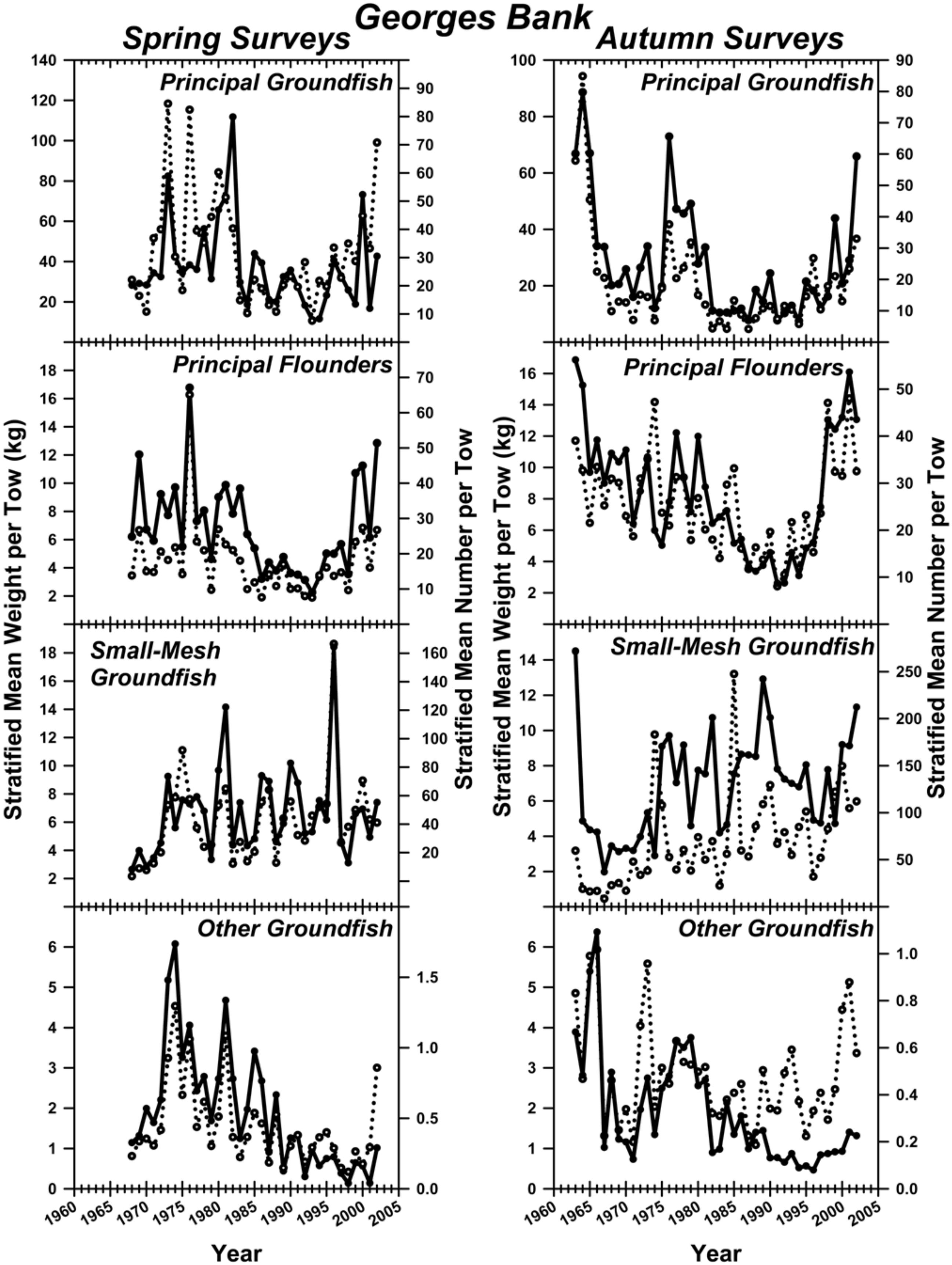

Figure A9. Abundance (dashed line) and biomass (solid line) indices for principal groundfish (Atlantic cod, haddock, pollock, Acadian redfish, and white hake), principal flounders (yellowtail flounder, American plaice, witch flounder, winter flounder, and windowpane flounder), small-mesh groundfish (silver hake, red hake, and ocean pout) and other groundfish (Atlantic wolffish, goosefish, and cusk) from the NEFSC spring and autumn surveys on Georges Bank, 1963-2002.

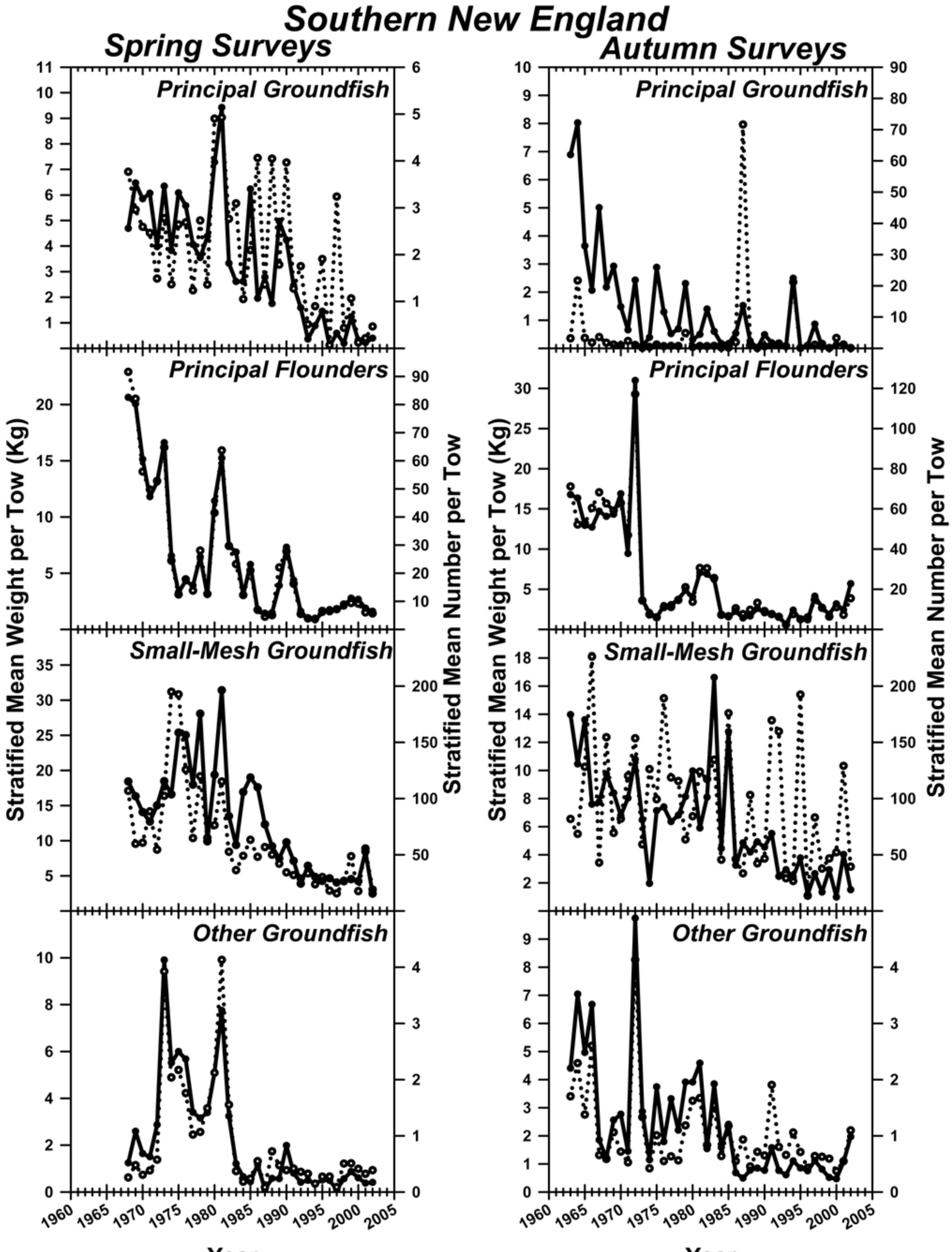

Figure A10. Abundance (dashed line) and biomass (solid line) indices for principal groundfish (Atlantic cod, haddock, pollock, Acadian redfish, and white hake), principal flounders (yellowtail flounder, American plaice, witch flounder, winter flounder, and windowpane flounder), small-mesh groundfish (silver hake, red hake, and ocean pout) and other groundfish (Atlantic wolffish, goosefish, and cusk) from the NEFSC spring and autumn surveys in Southern New England, 1963-2002.

APPENDIX B.

Abundance and biomass indices from Massachusetts inshore spring and autumn bottom trawl surveys.

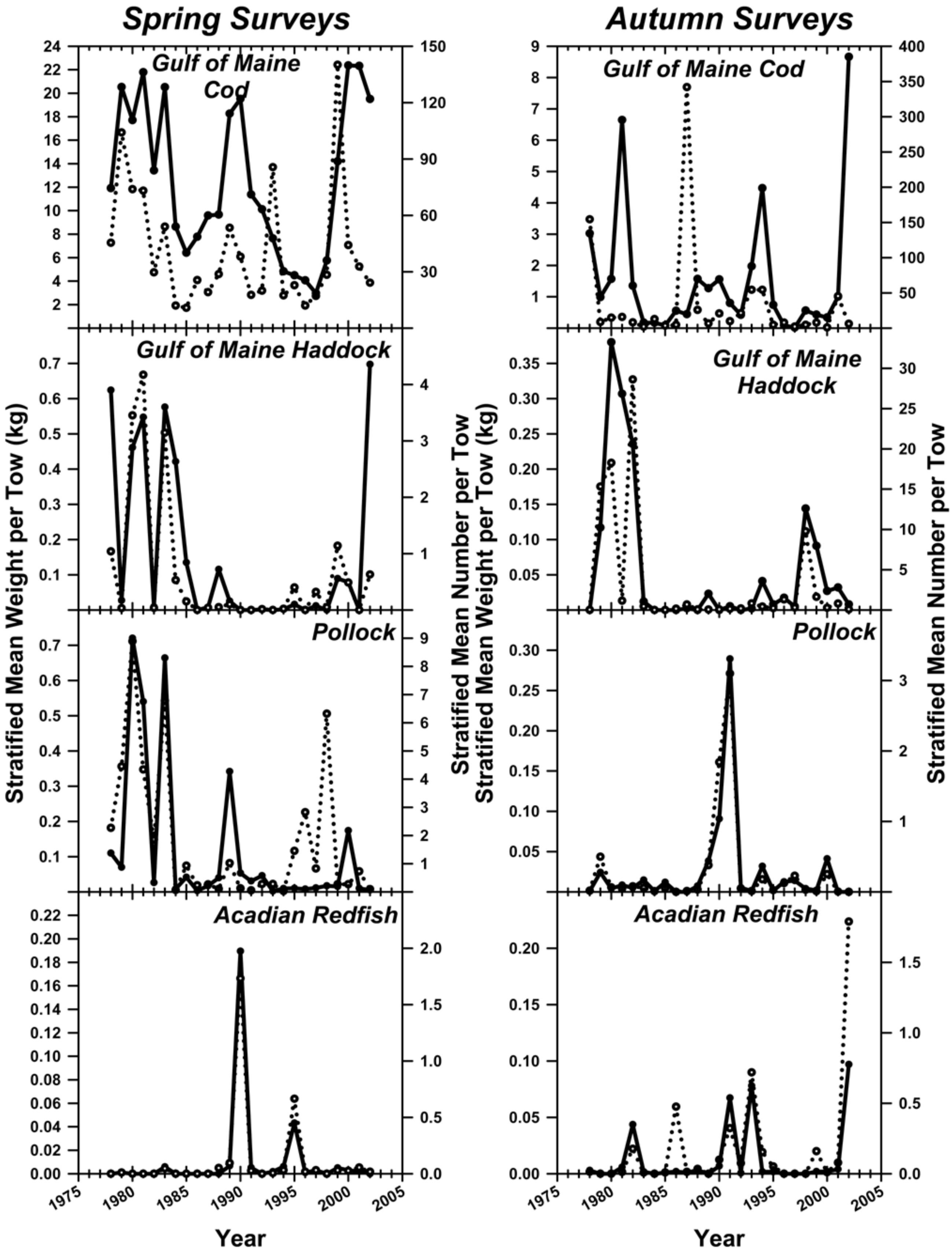

Figure B1. Abundance (dashed line) and biomass (solid line) indices for Gulf of Maine cod, Gulf of Maine haddock, pollock and Acadian redfish from the Massachusetts inshore spring and autumn surveys, 1978-2002.

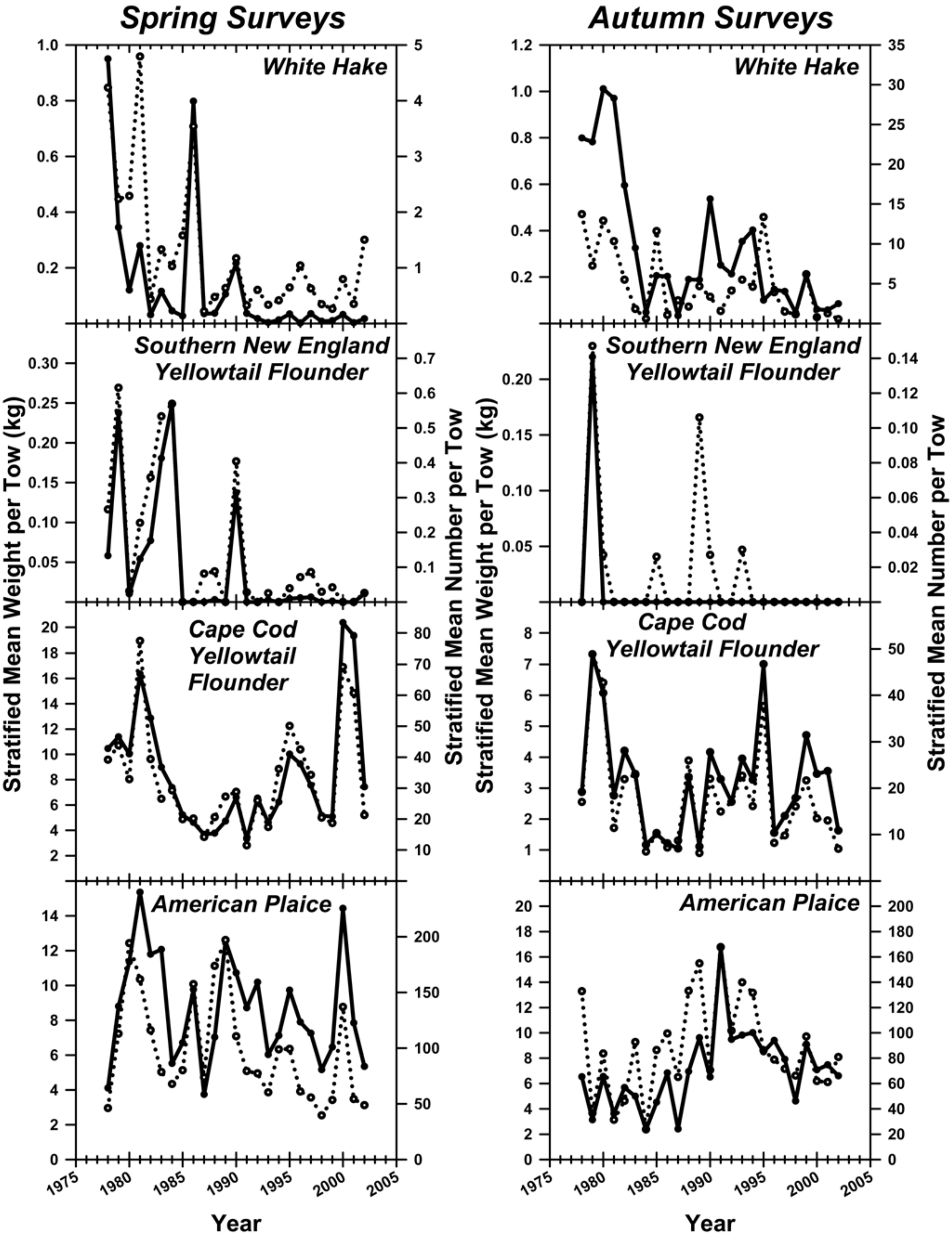

Figure B2. Abundance (dashed line) and biomass (solid line) indices for white hake, Southern New England yellowtail flounder, Cape Cod yellowtail flounder and American plaice from the Massachusetts inshore spring and autumn surveys, 1978-2002.

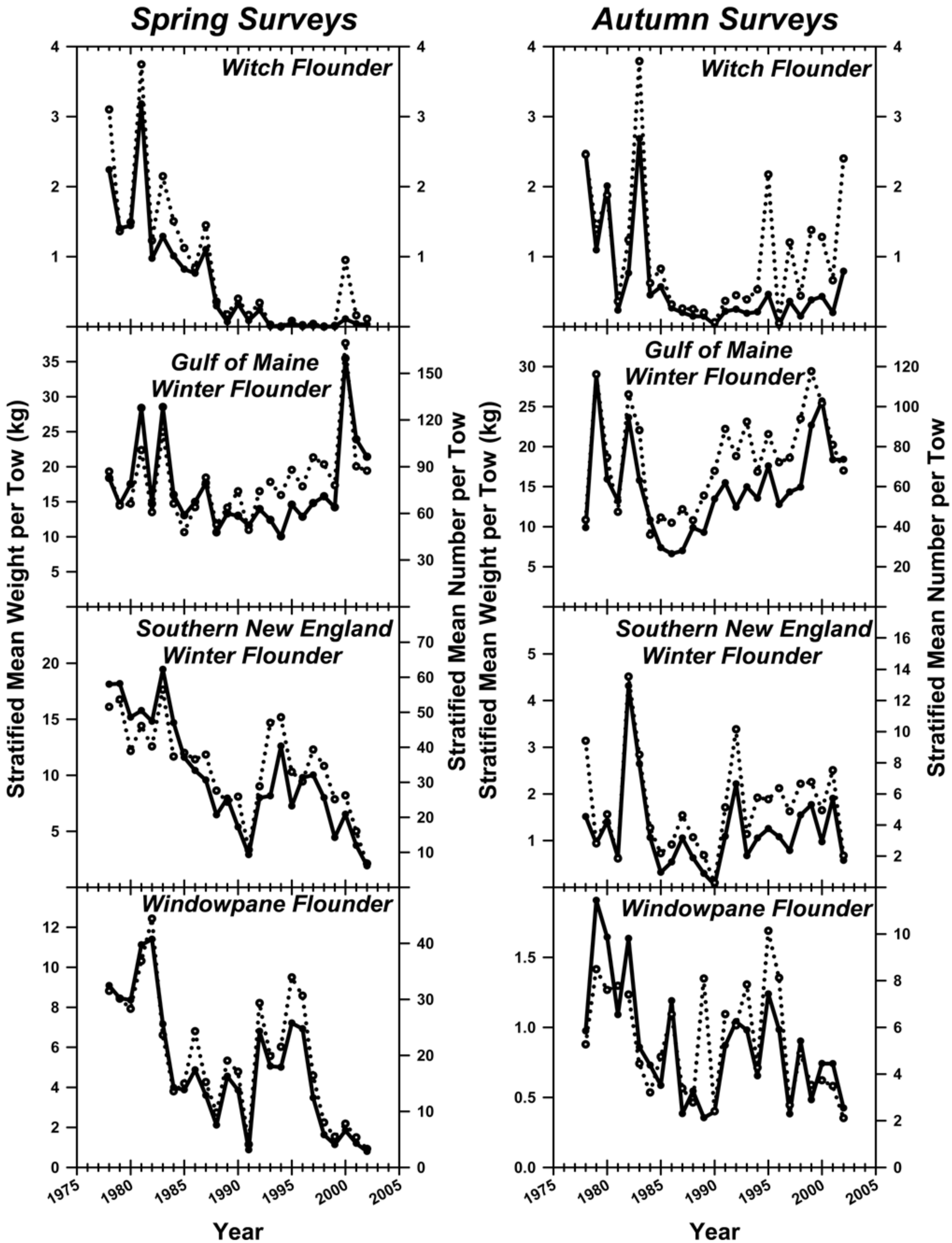

Figure B3. Abundance (dashed line) and biomass (solid line) indices for witch flounder, Gulf of Maine winter flounder, Southern New England-Mid-Atlantic winter flounder and windowpane flounder from the Massachusetts inshore spring and autumn surveys, 1978-2002.

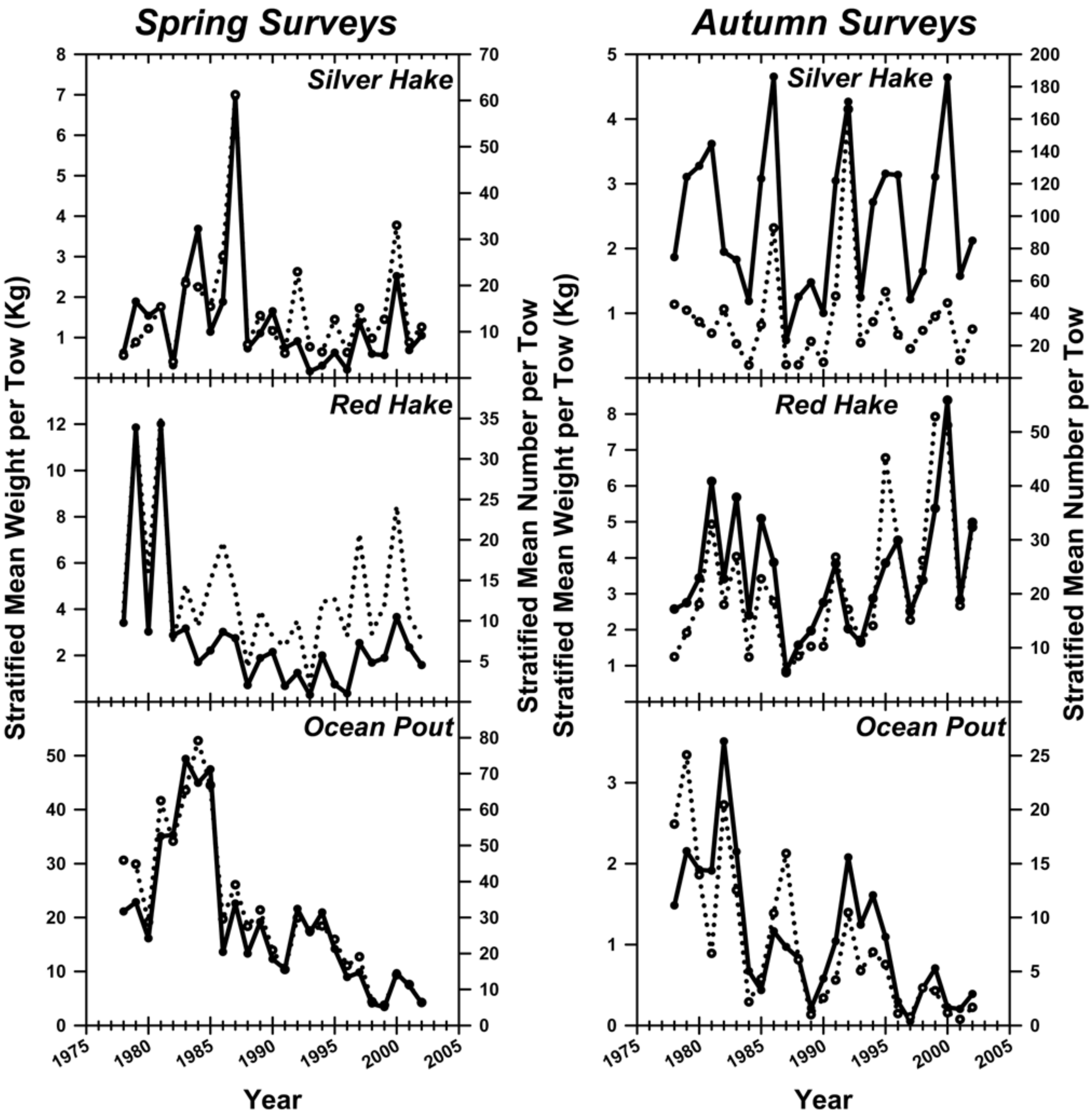

Figure B4. Abundance (dashed line) and biomass (solid line) indices for silver hake, red hake, and ocean pout from the Massachusetts inshore spring and autumn surveys, 1978-2002.

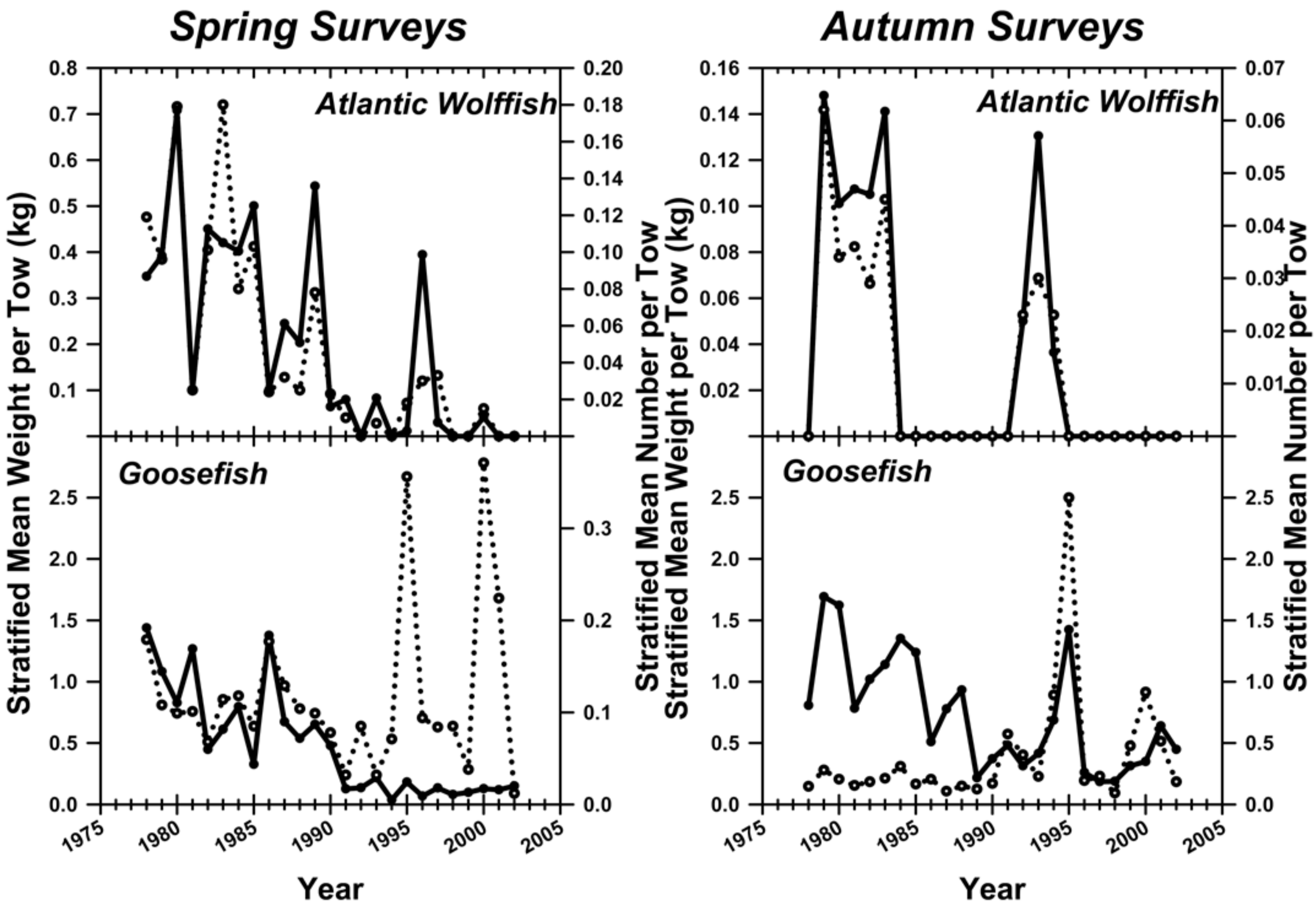

Figure B5. Abundance (dashed line) and biomass (solid line) indices for Atlantic wolffish and goosefish from the Massachusetts inshore spring and autumn surveys, 1978-2002.

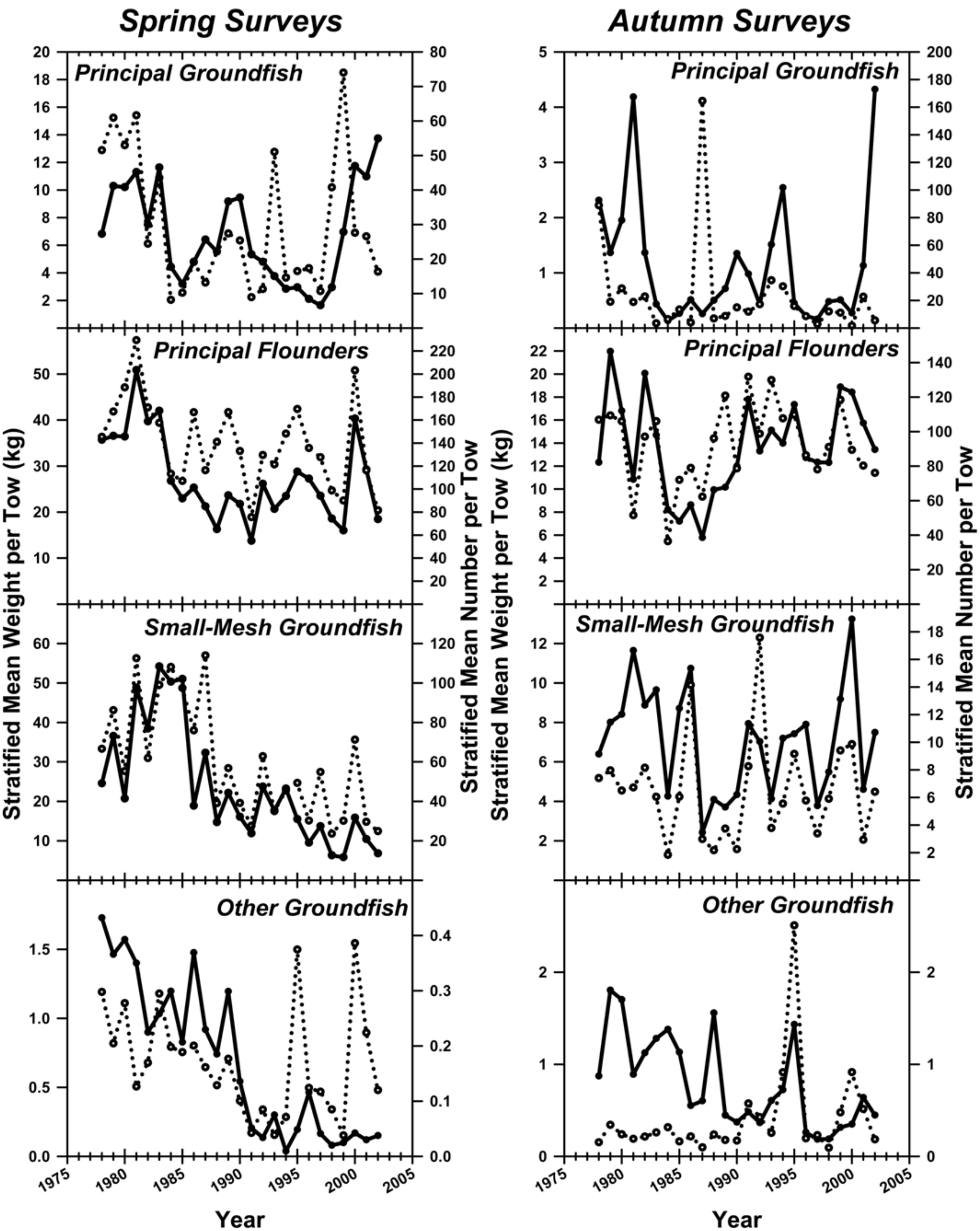

Figure B6. Abundance (dashed line) and biomass (solid line) indices for principal groundfish (Atlantic cod, haddock, pollock, Acadian redfish, and white hake), principal flounders (yellowtail flounder, American plaice, witch flounder, winter flounder, and windowpane flounder), small-mesh groundfish (silver hake, red hake, and ocean pout) and other groundfish (Atlantic wolffish and goosefish) from the Massachusetts inshore spring and autumn surveys, 1978-2002.

APPENDIX C.

Distribution maps from NEFSC spring and autumn bottom trawl surveys.

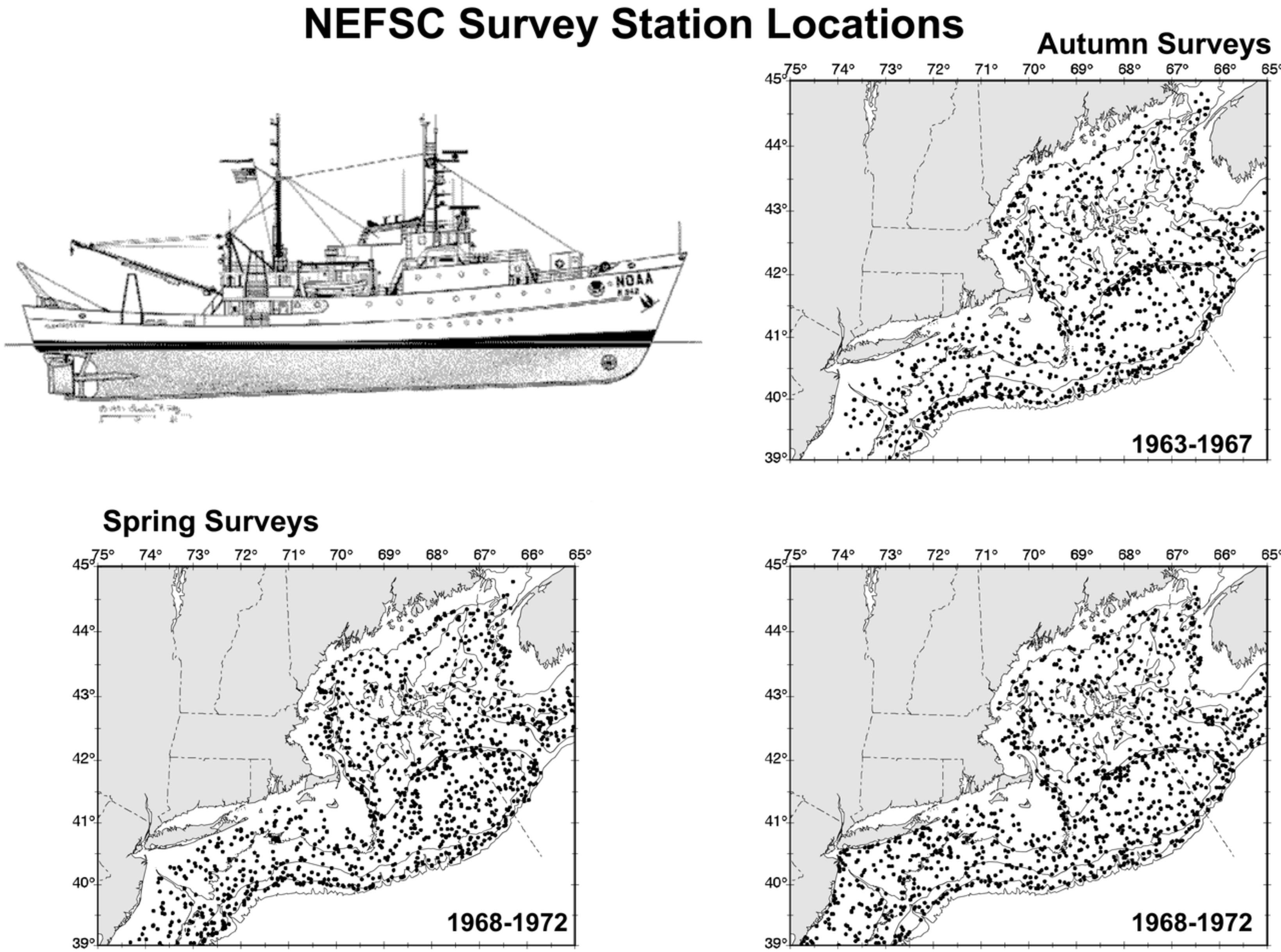

Figure C1a. Distribution of survey station locations in the NEFSC spring and autumn bottom trawl surveys from 1963-1972.

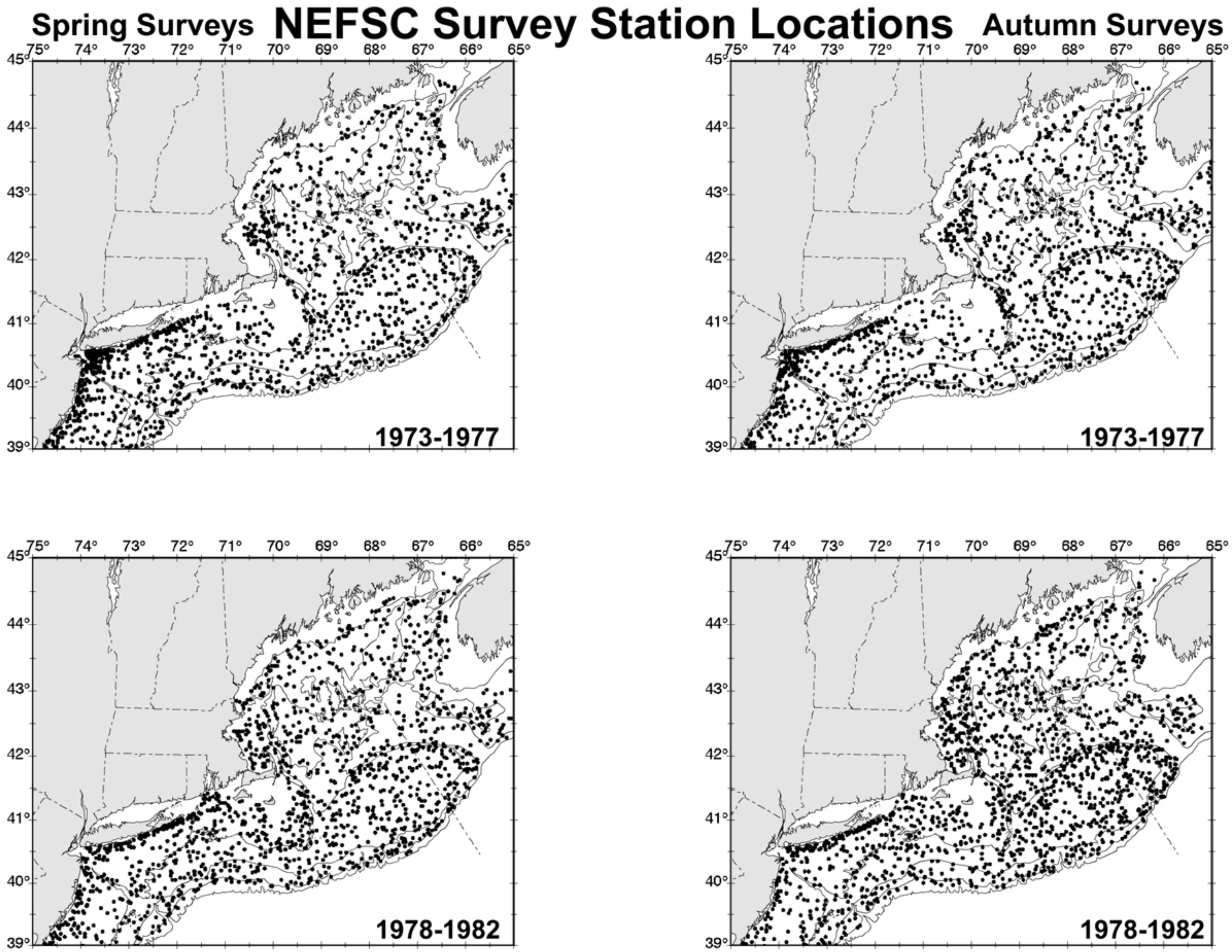

Figure C1b. Distribution of survey station locations in the NEFSC spring and autumn bottom trawl surveys from 1973-1982.

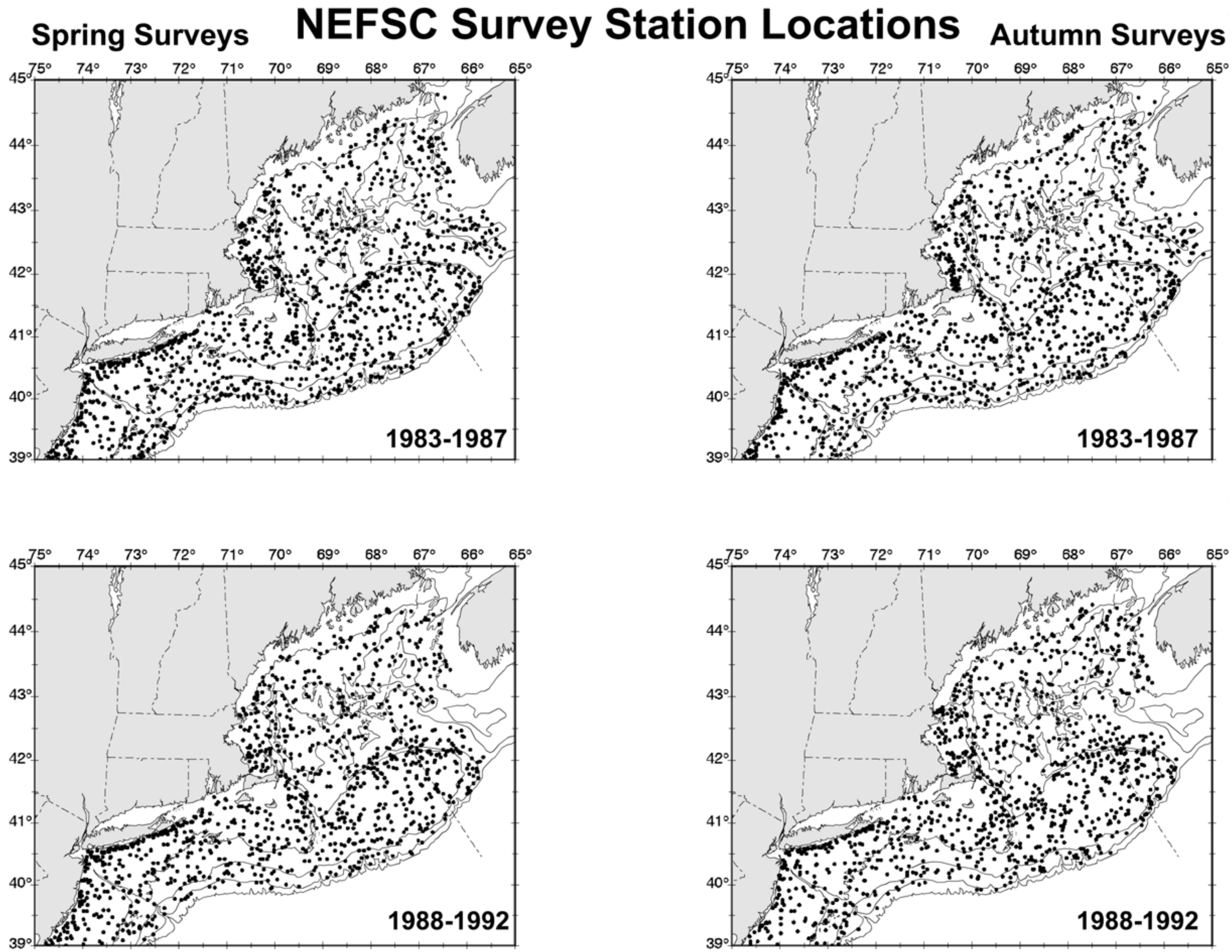

Figure C1c. Distribution of survey station locations in the NEFSC spring and autumn bottom trawl surveys from 1983-1992.

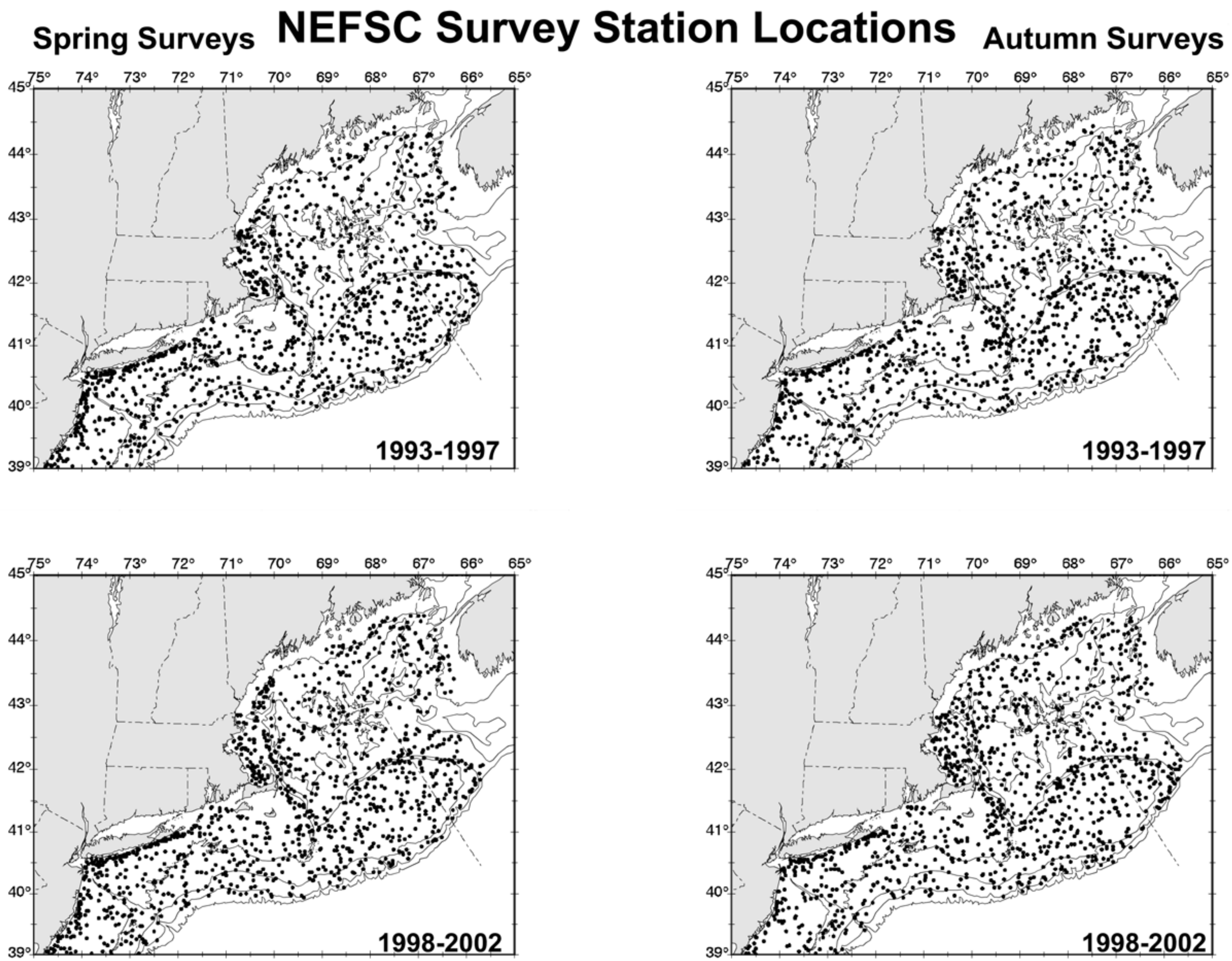

Figure C1d. Distribution of survey station locations in the NEFSC spring and autumn bottom trawl surveys from 1993-2002.

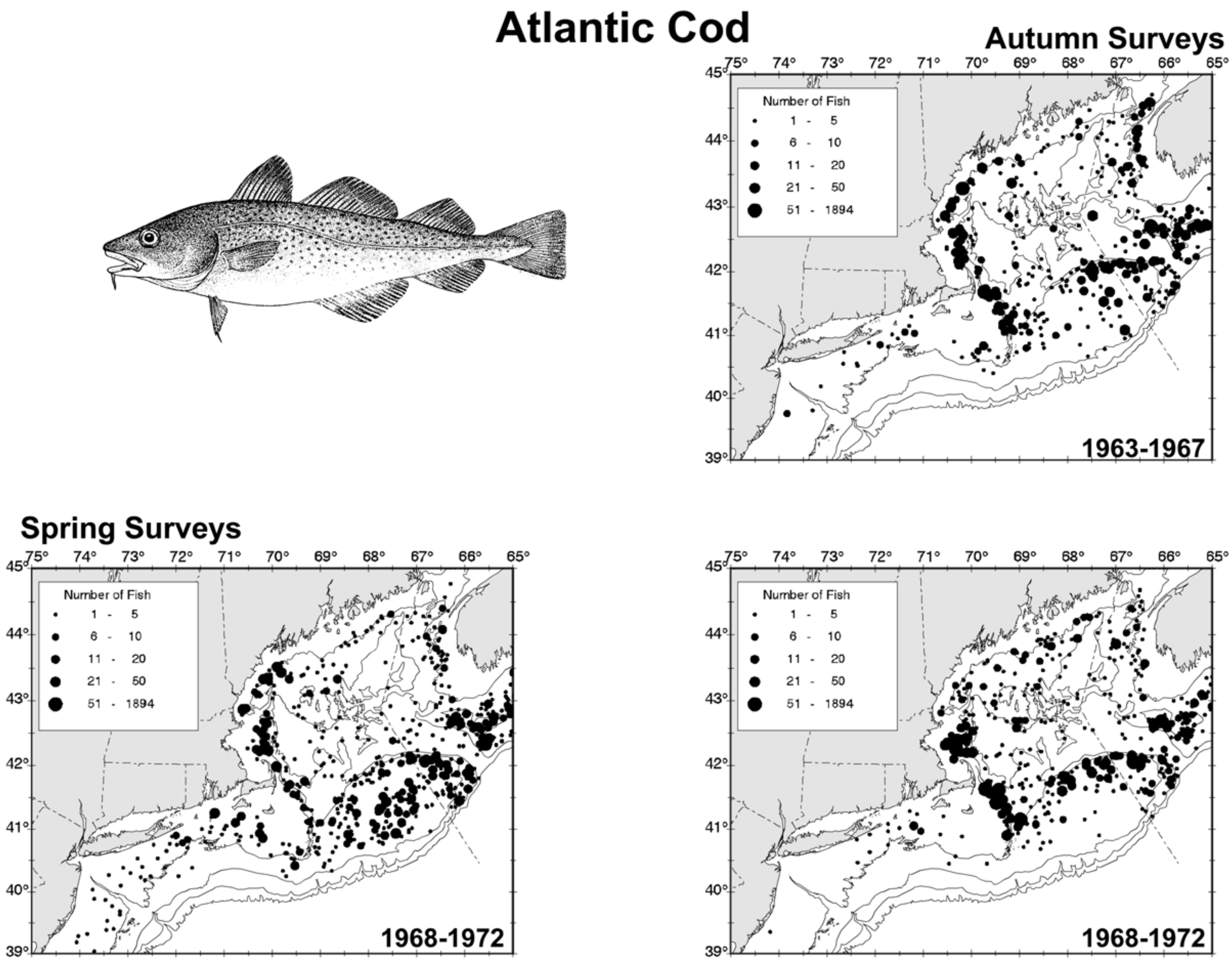

Figure C2a. Distribution of Atlantic cod in the NEFSC spring and autumn bottom trawl surveys from 1963-1972.

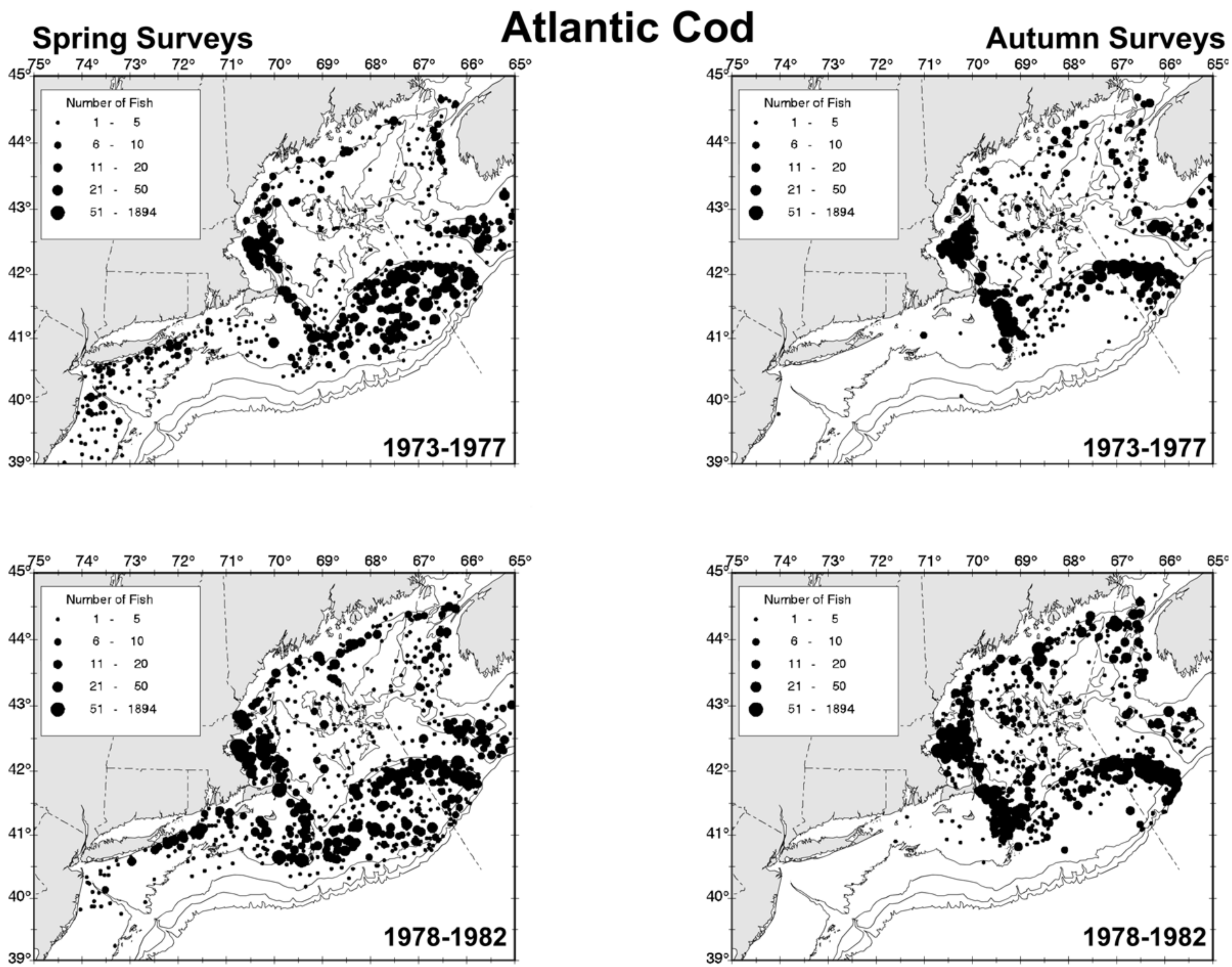

Figure C2b. Distribution of Atlantic cod in the NEFSC spring and autumn bottom trawl surveys from 1973-1982.

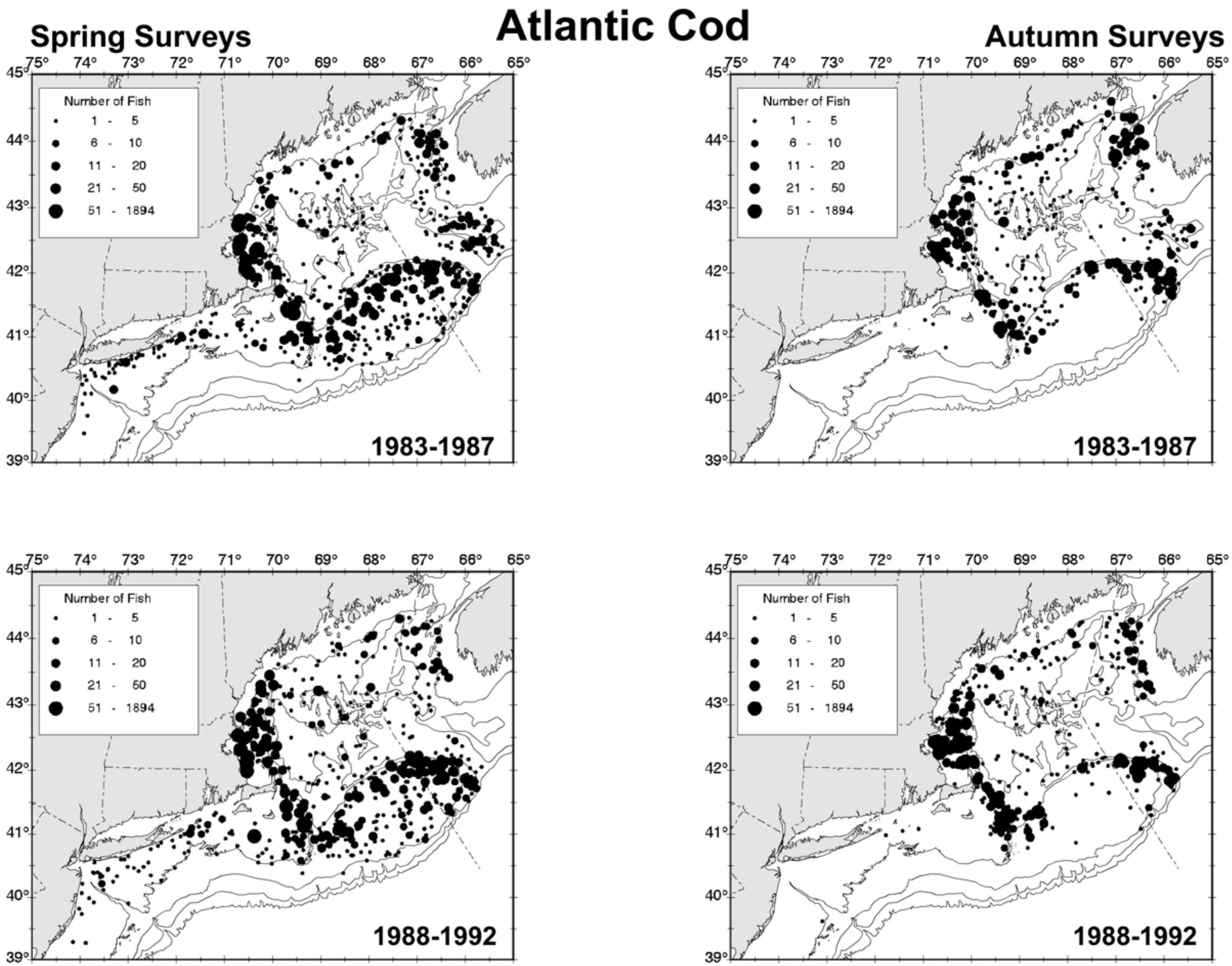

Figure C2c. Distribution of Atlantic cod in the NEFSC spring and autumn bottom trawl surveys from 1983-1992.

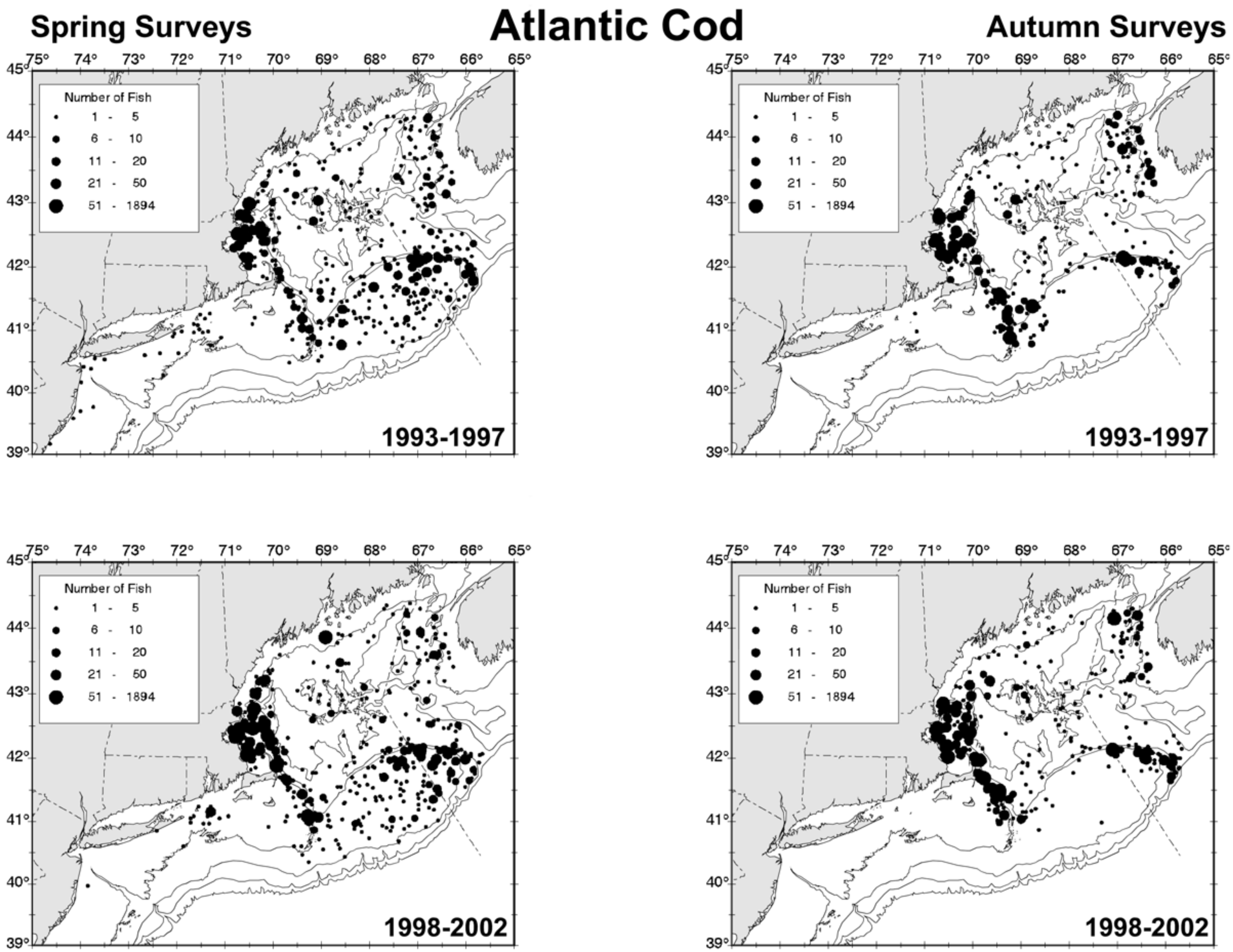

Figure C2d. Distribution of Atlantic cod in the NEFSC spring and autumn bottom trawl surveys from 1993-2002.

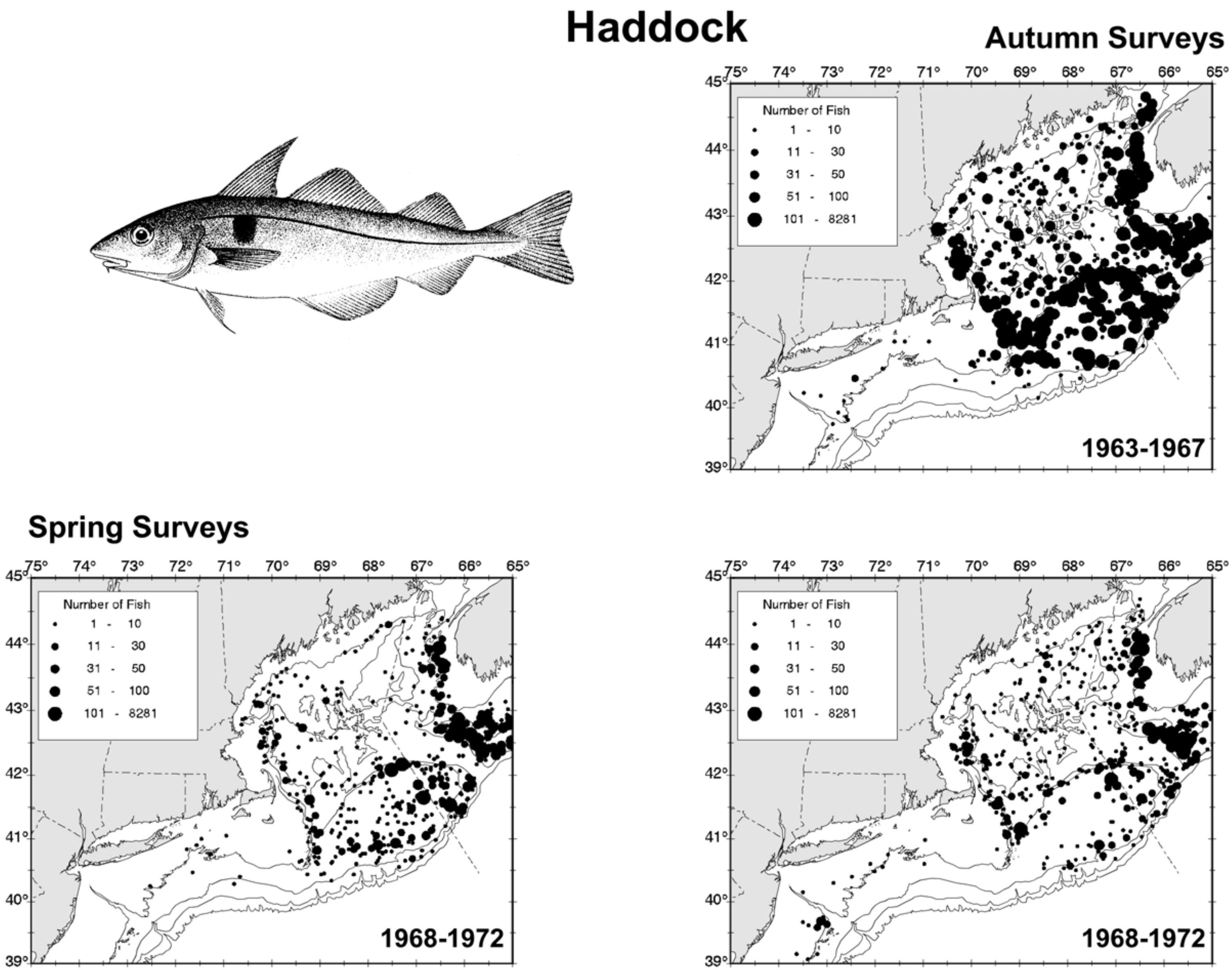

Figure C3a. Distribution of haddock in the NEFSC spring and autumn bottom trawl surveys from 1963-1972.

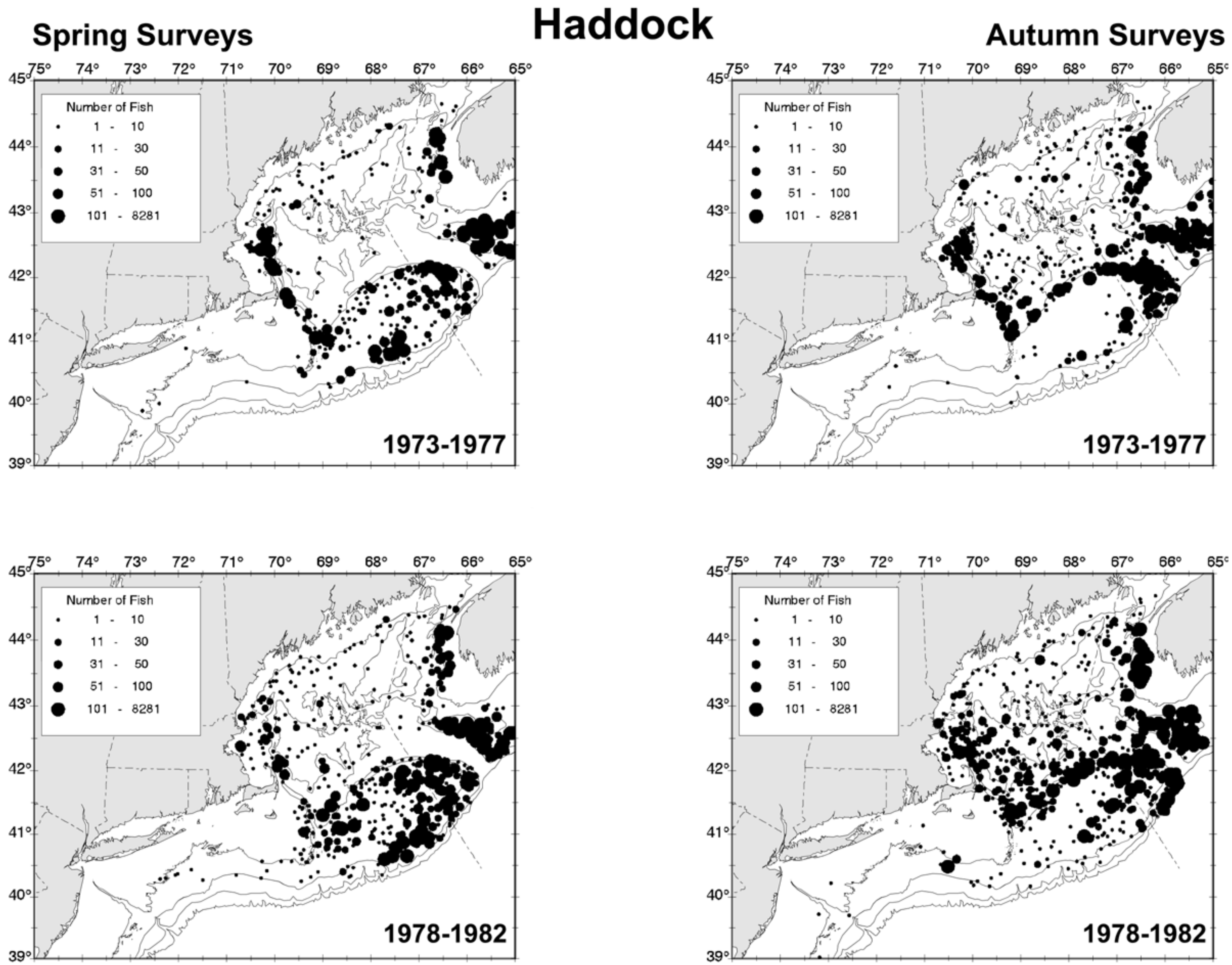

Figure C3b. Distribution of haddock in the NEFSC spring and autumn bottom trawl surveys from 1973-1982.

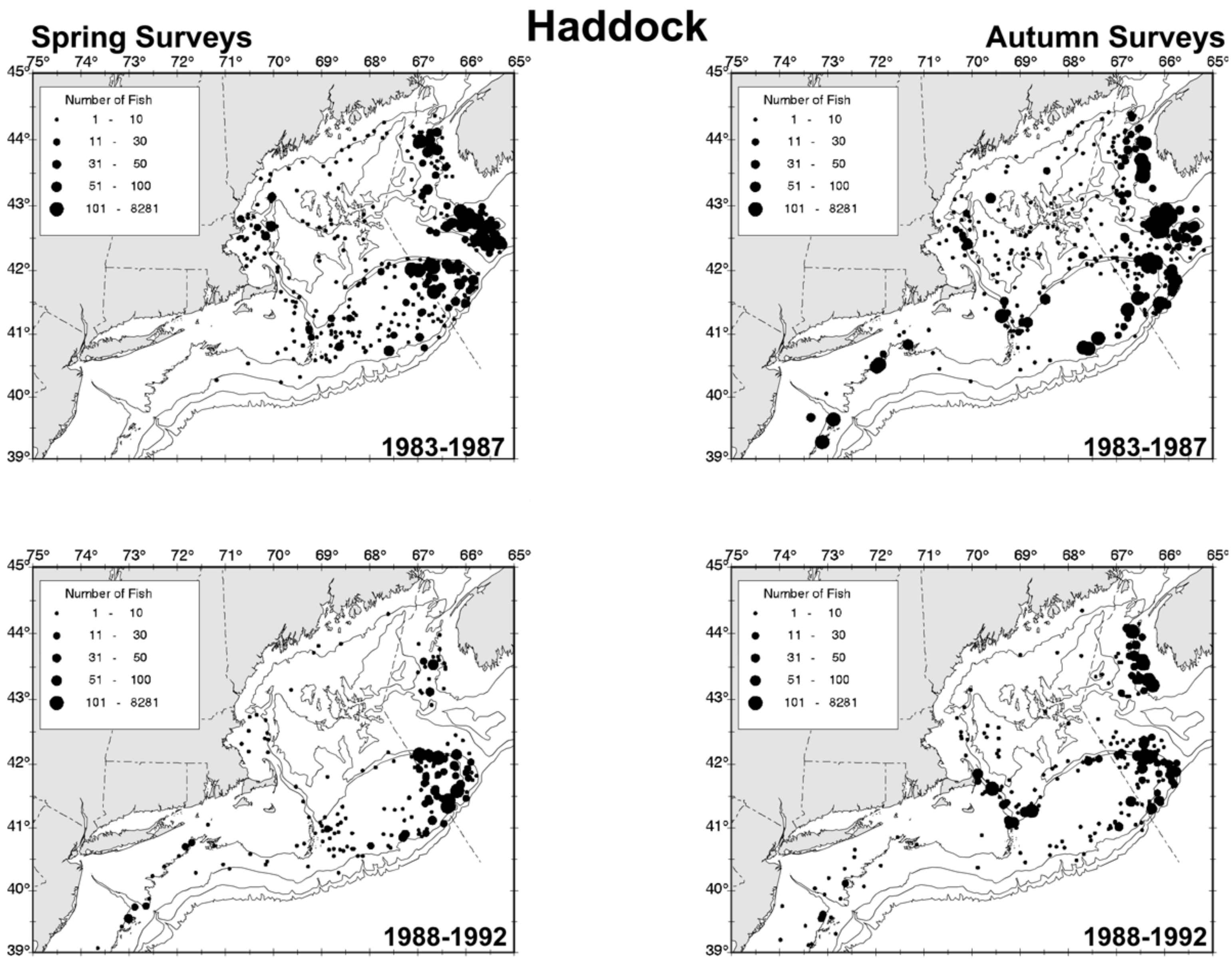

Figure C3c. Distribution of haddock in the NEFSC spring and autumn bottom trawl surveys from 1983-1992.

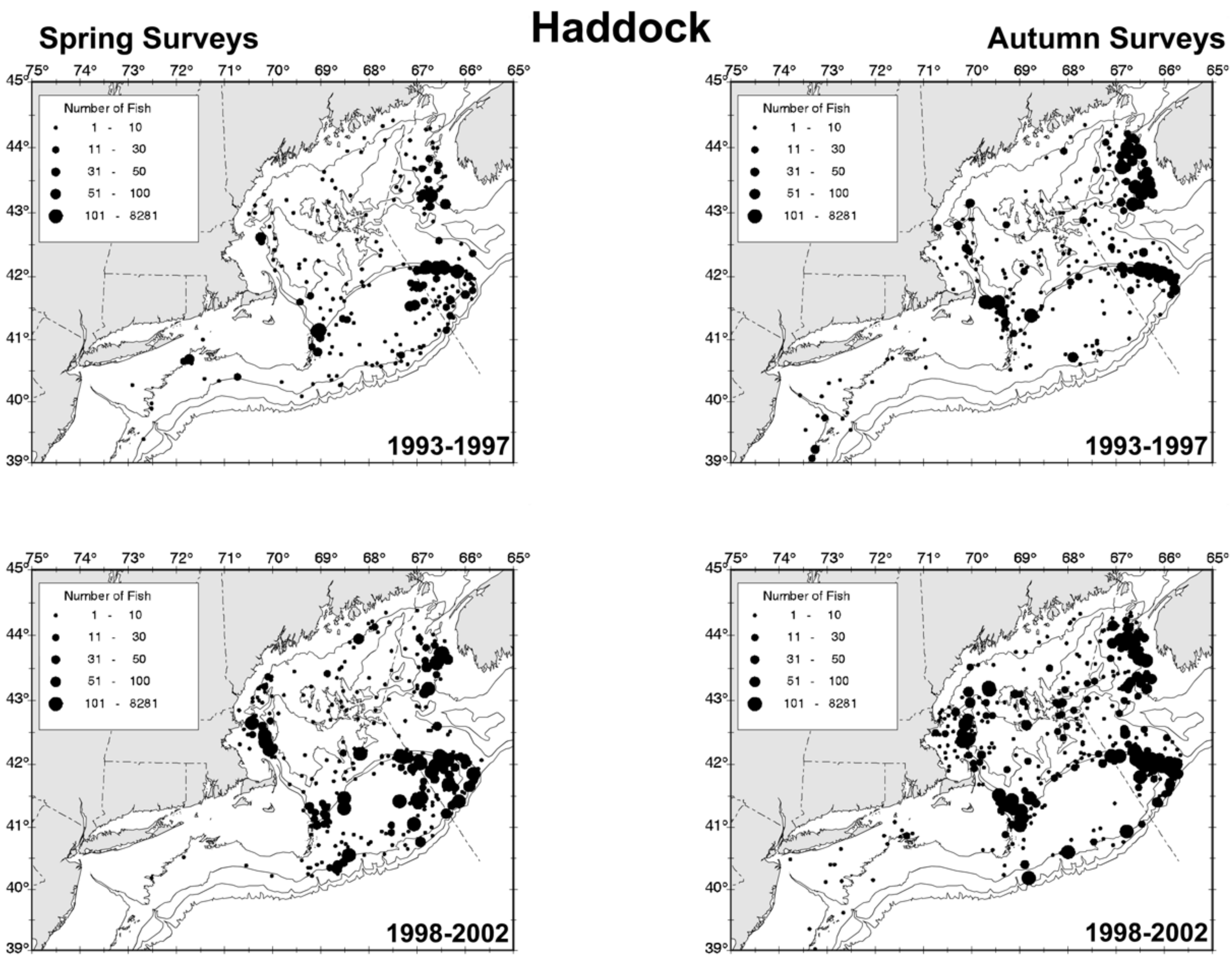

Figure C3d. Distribution of haddock in the NEFSC spring and autumn bottom trawl surveys from 1993-2002.

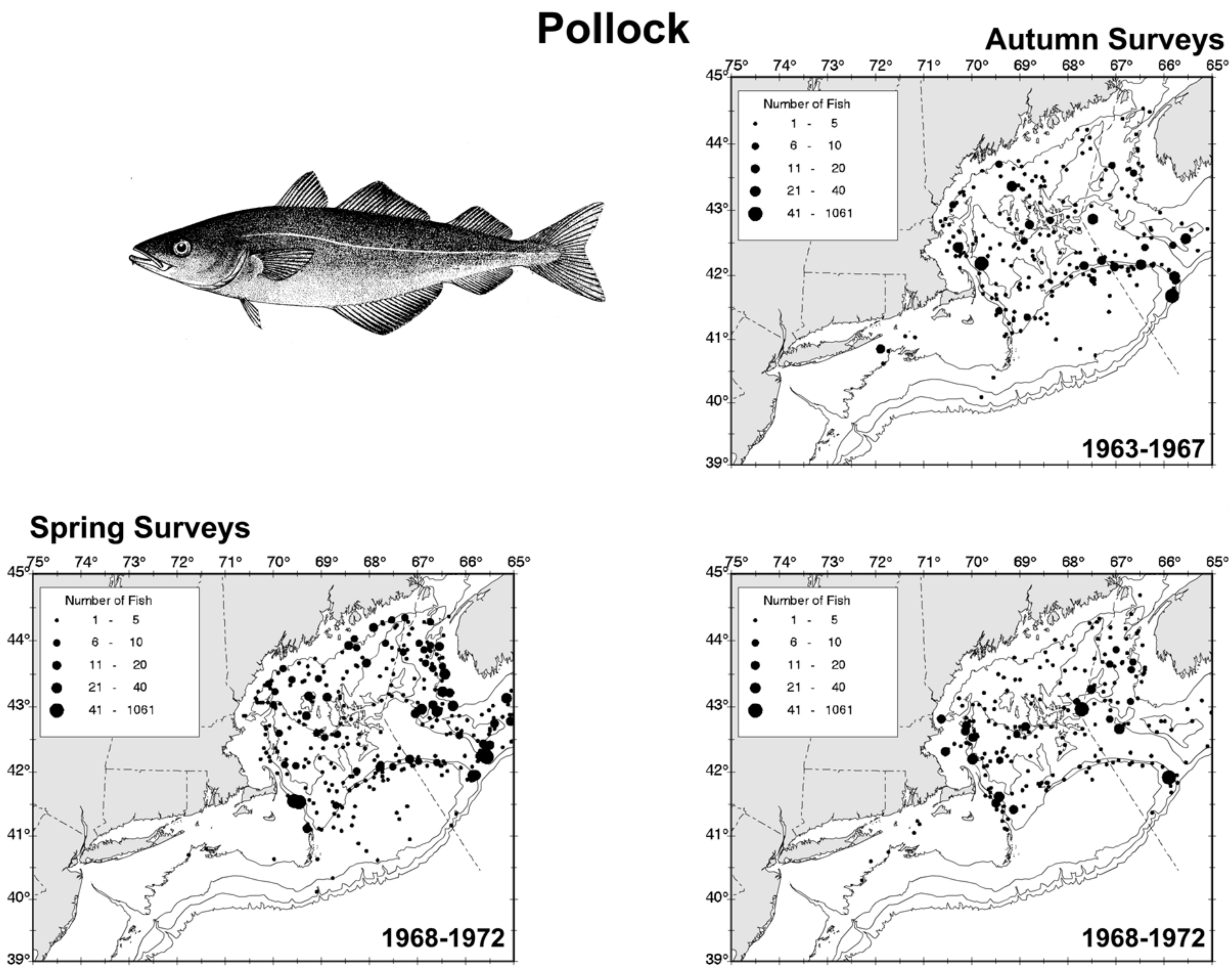

Figure C4a. Distribution of pollock in the NEFSC spring and autumn bottom trawl surveys from 1963-1972.

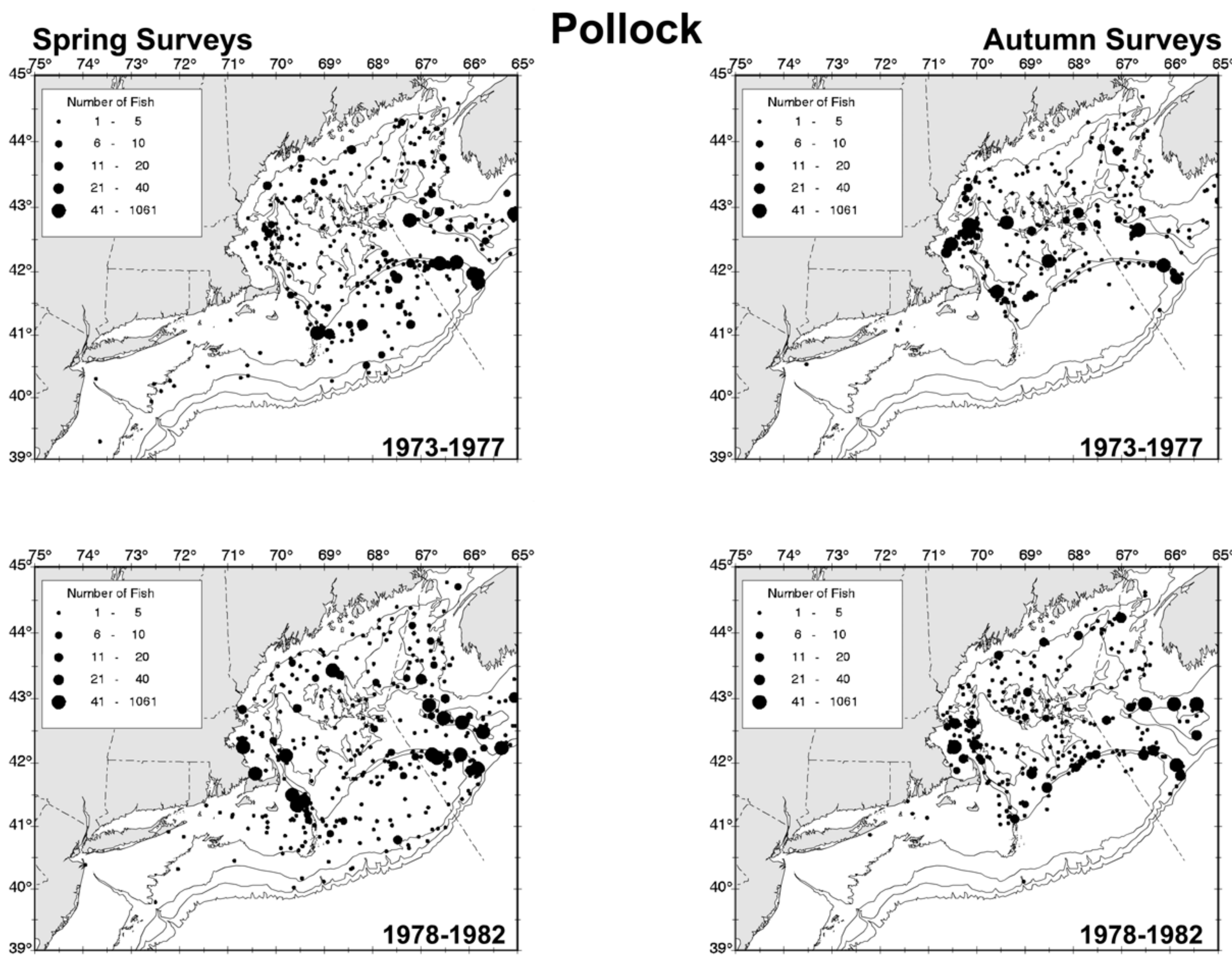

Figure C4b. Distribution of pollock in the NEFSC spring and autumn bottom trawl surveys from 1973-1982.

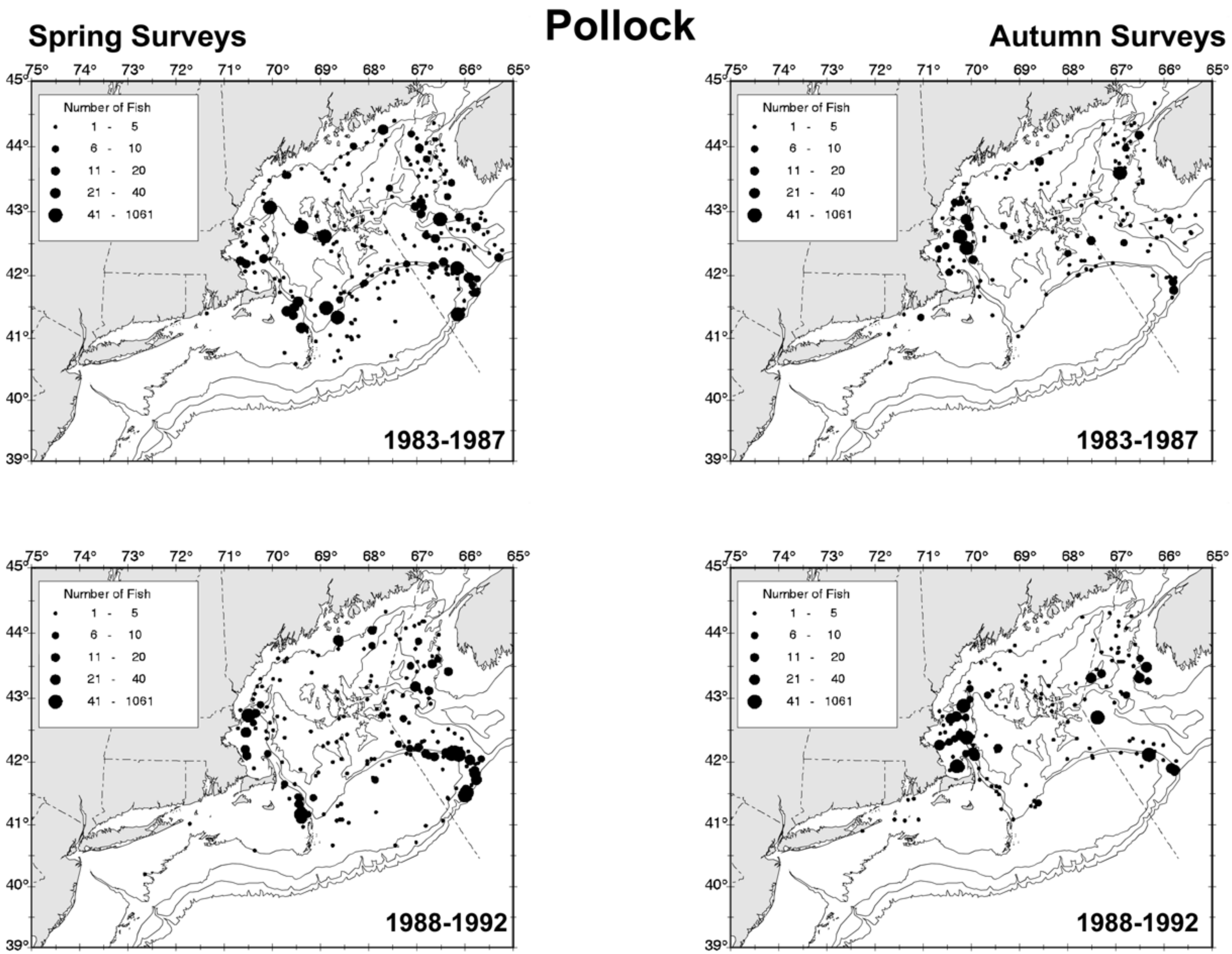

Figure C4c. Distribution of pollock in the NEFSC spring and autumn bottom trawl surveys from 1983-1992.

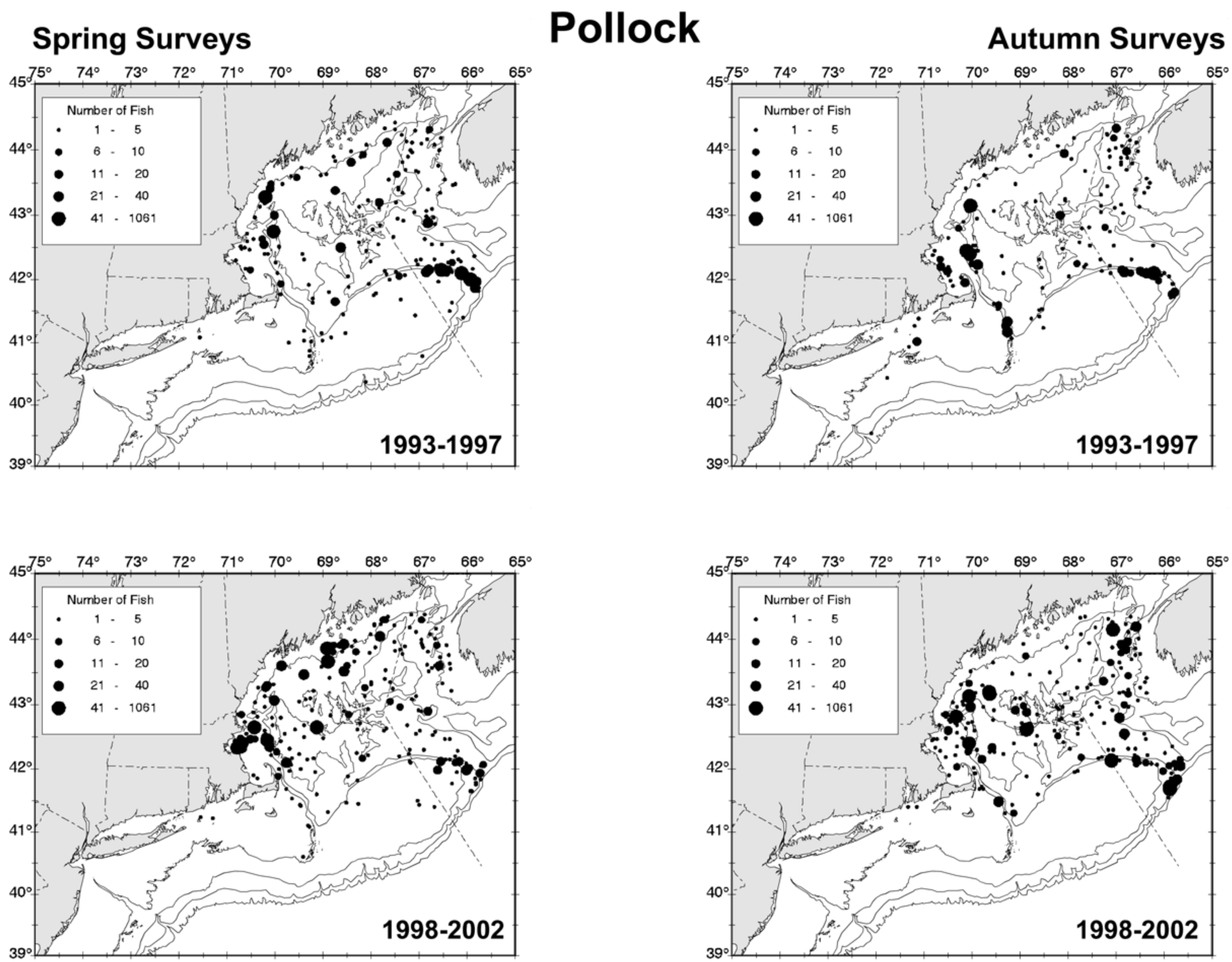

Figure C4d. Distribution of pollock in the NEFSC spring and autumn bottom trawl surveys from 1993-2002.

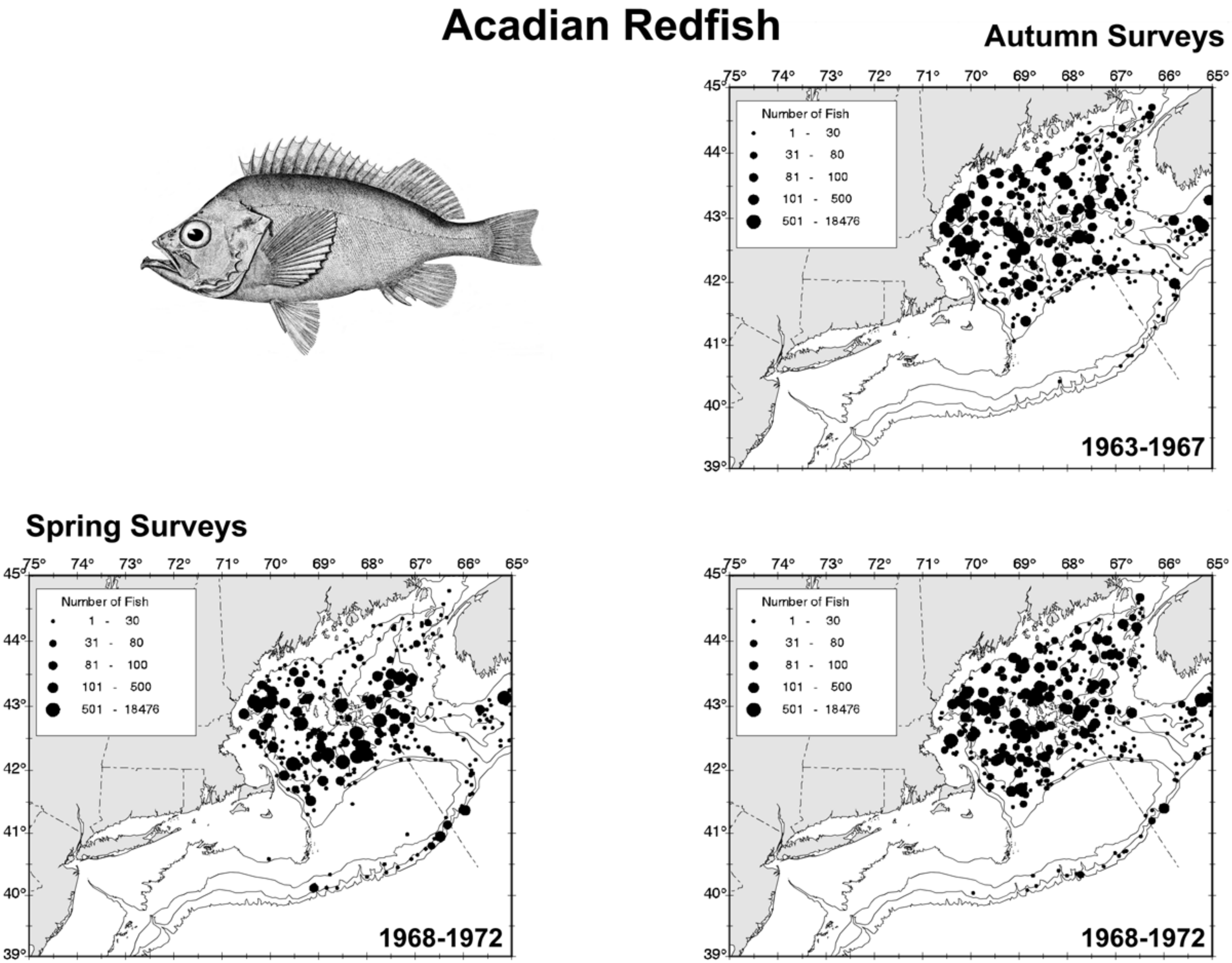

Figure C5a. Distribution of Acadian redfish in the NEFSC spring and autumn bottom trawl surveys from 1963-1972.

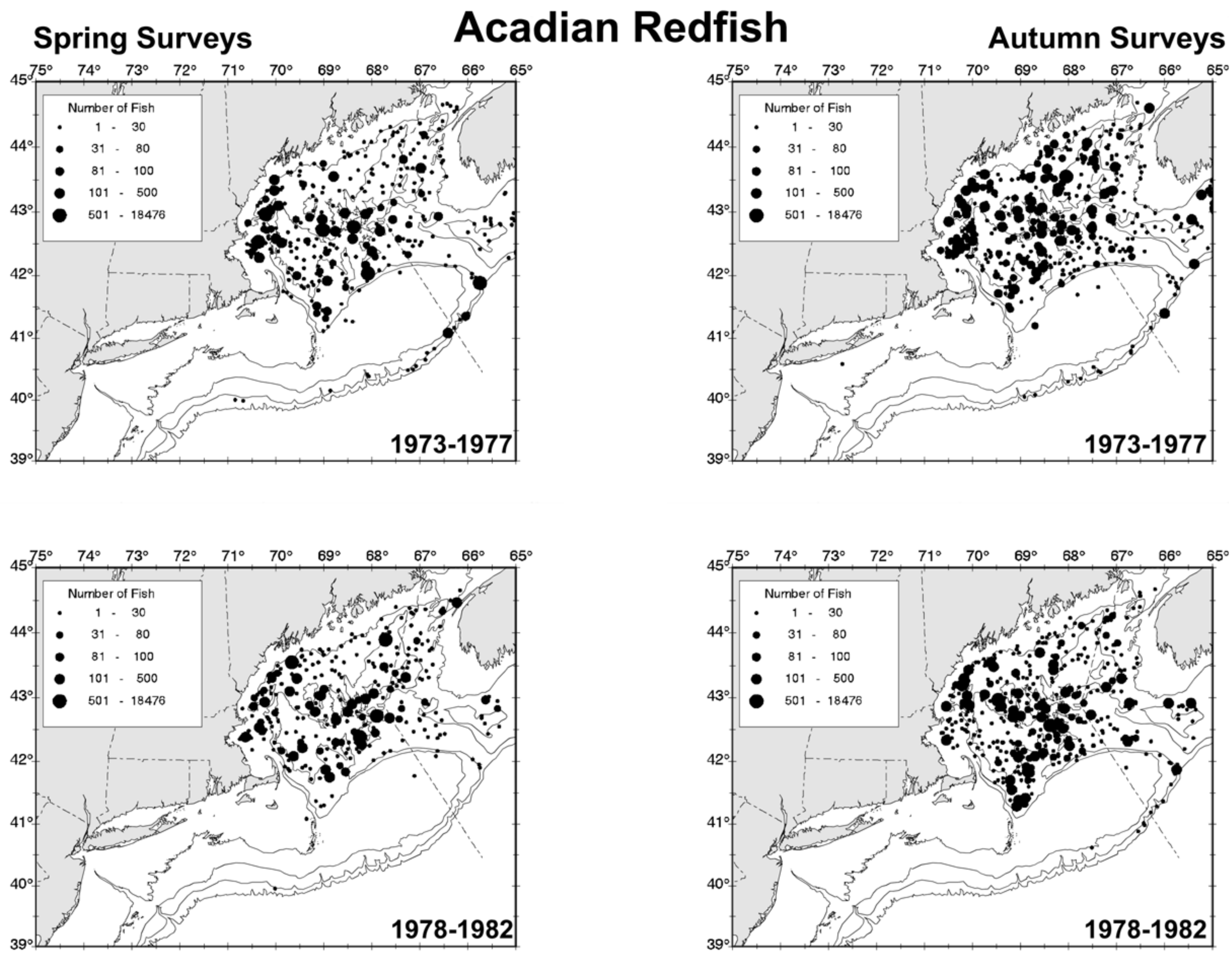

Figure C5b. Distribution of Acadian redfish in the NEFSC spring and autumn bottom trawl surveys from 1973-1982.

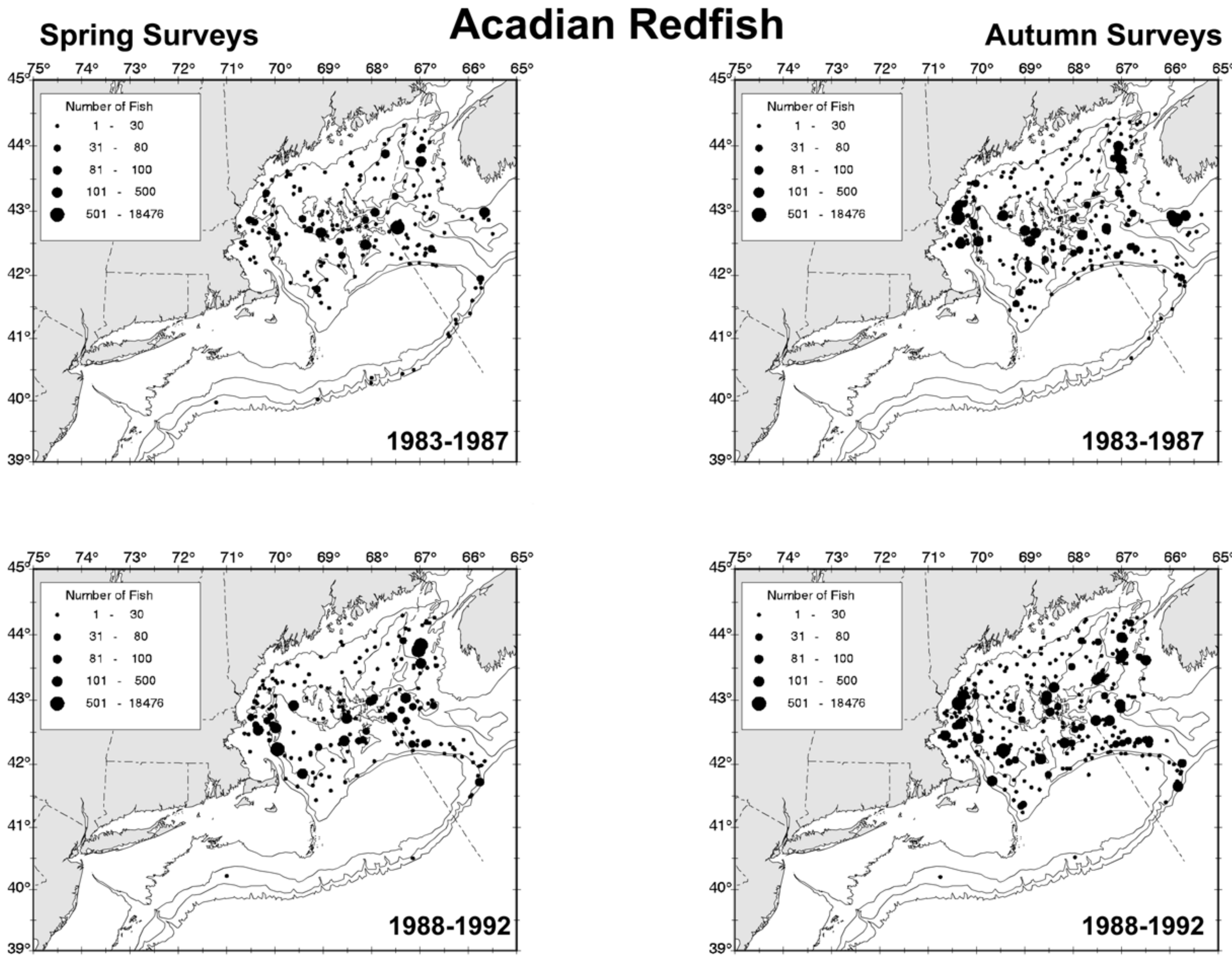

Figure C5c. Distribution of Acadian redfish in the NEFSC spring and autumn bottom trawl surveys from 1983-1992.

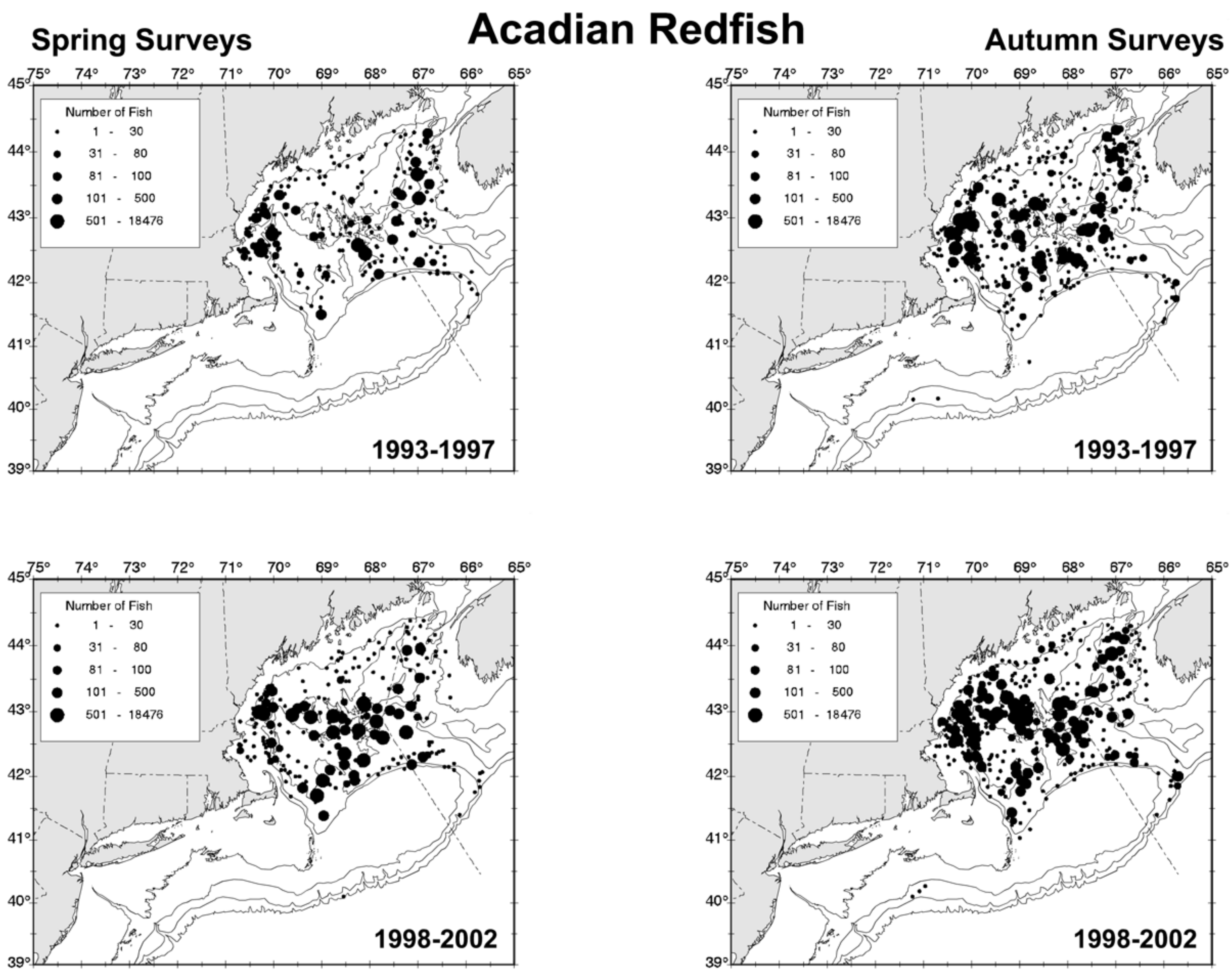

Figure C5d. Distribution of Acadian redfish in the NEFSC spring and autumn bottom trawl surveys from 1993-2002.

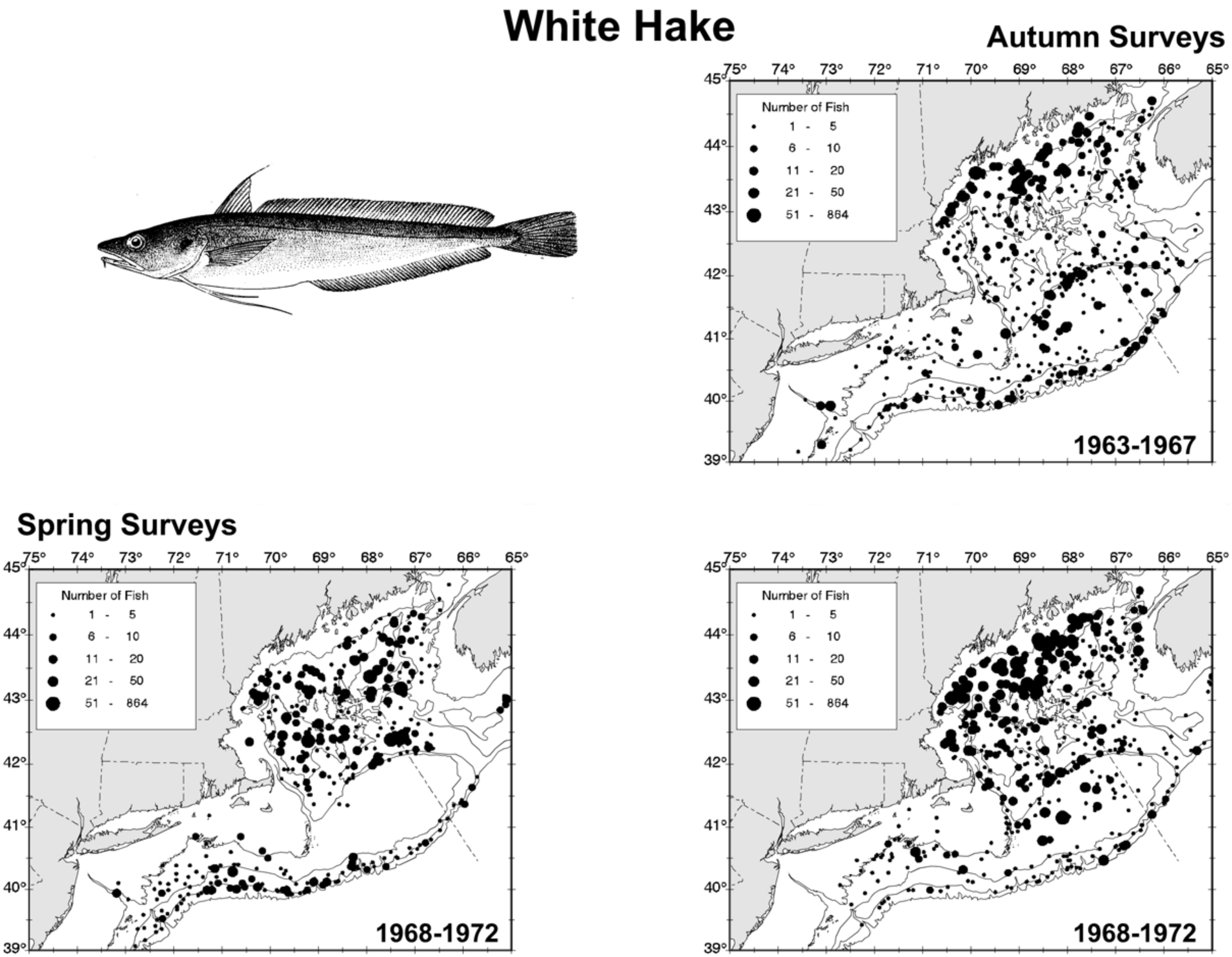

Figure C6a. Distribution of white hake in the NEFSC spring and autumn bottom trawl surveys from 1963-1972.

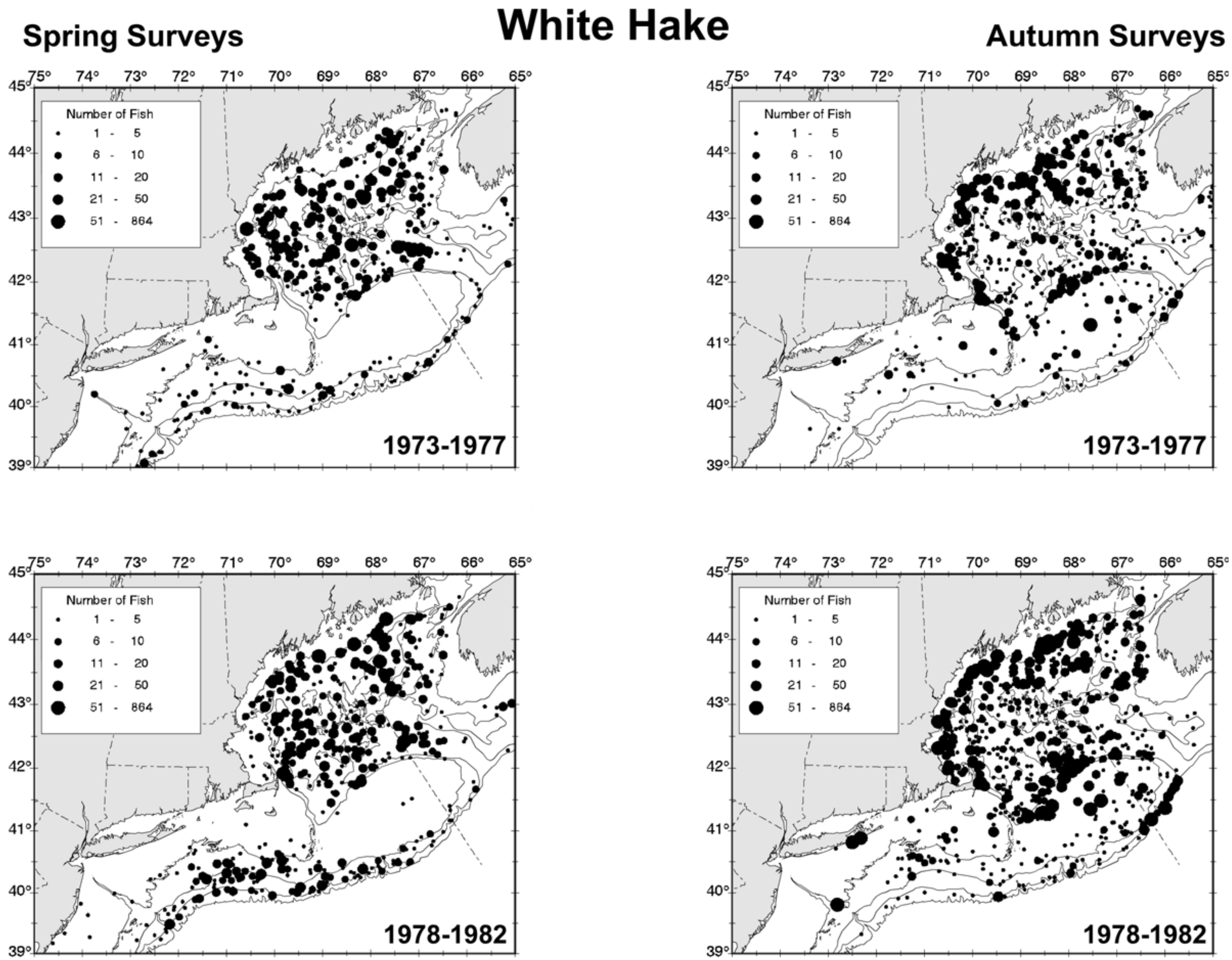

Figure C6b. Distribution of white hake in the NEFSC spring and autumn bottom trawl surveys from 1973-1982.

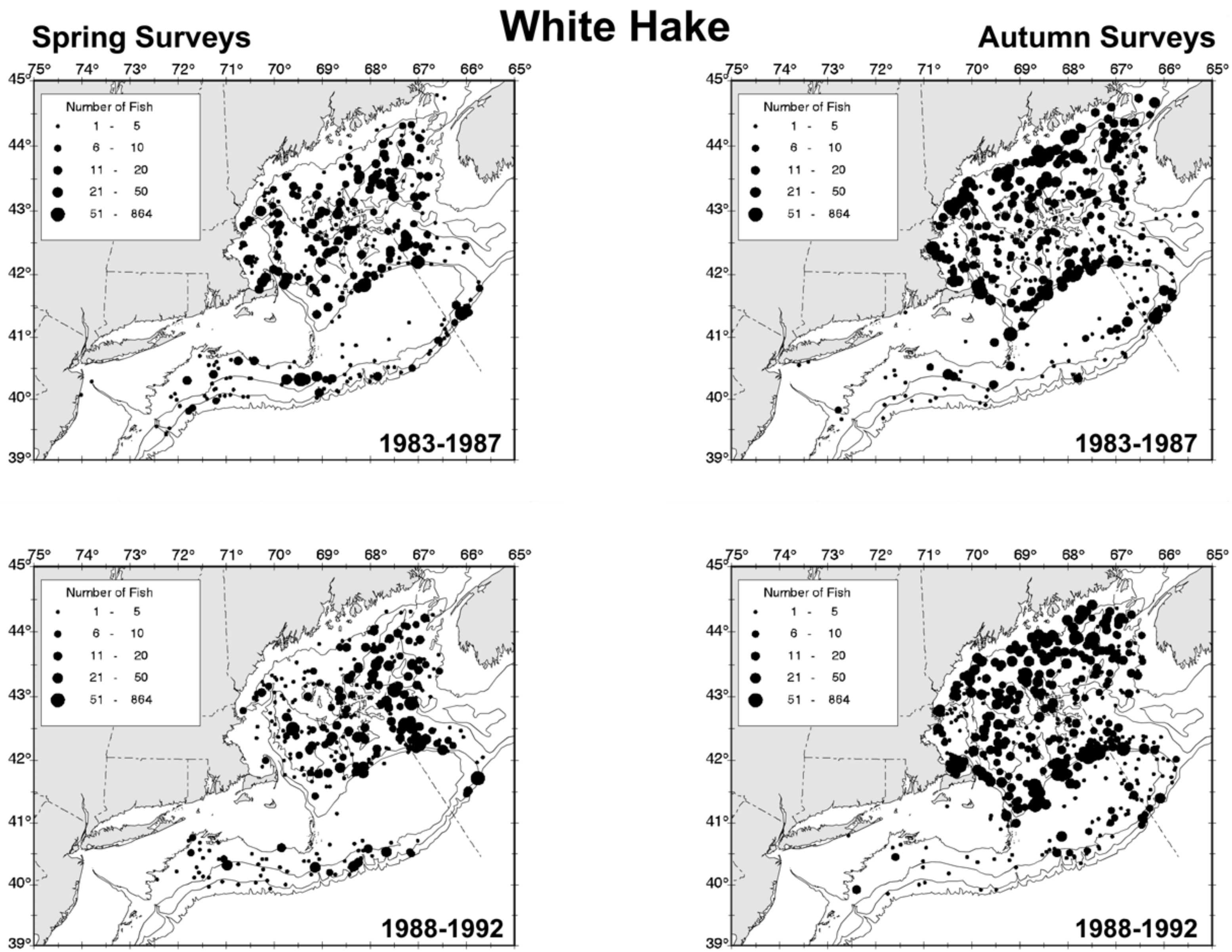

Figure C6c. Distribution of white hake in the NEFSC spring and autumn bottom trawl surveys from 1983-1992.

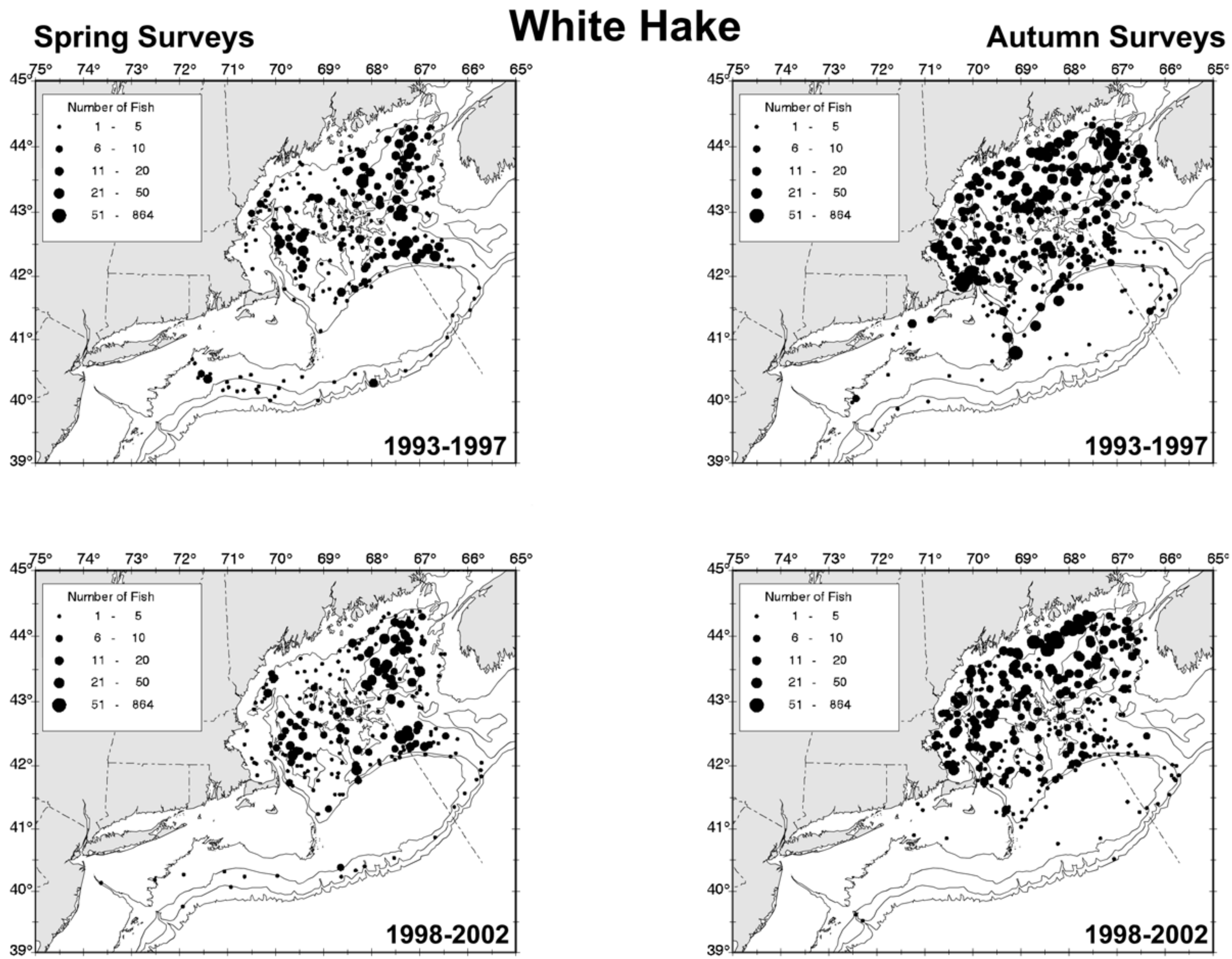

Figure C6d. Distribution of white hake in the NEFSC spring and autumn bottom trawl surveys from 1993-2002.

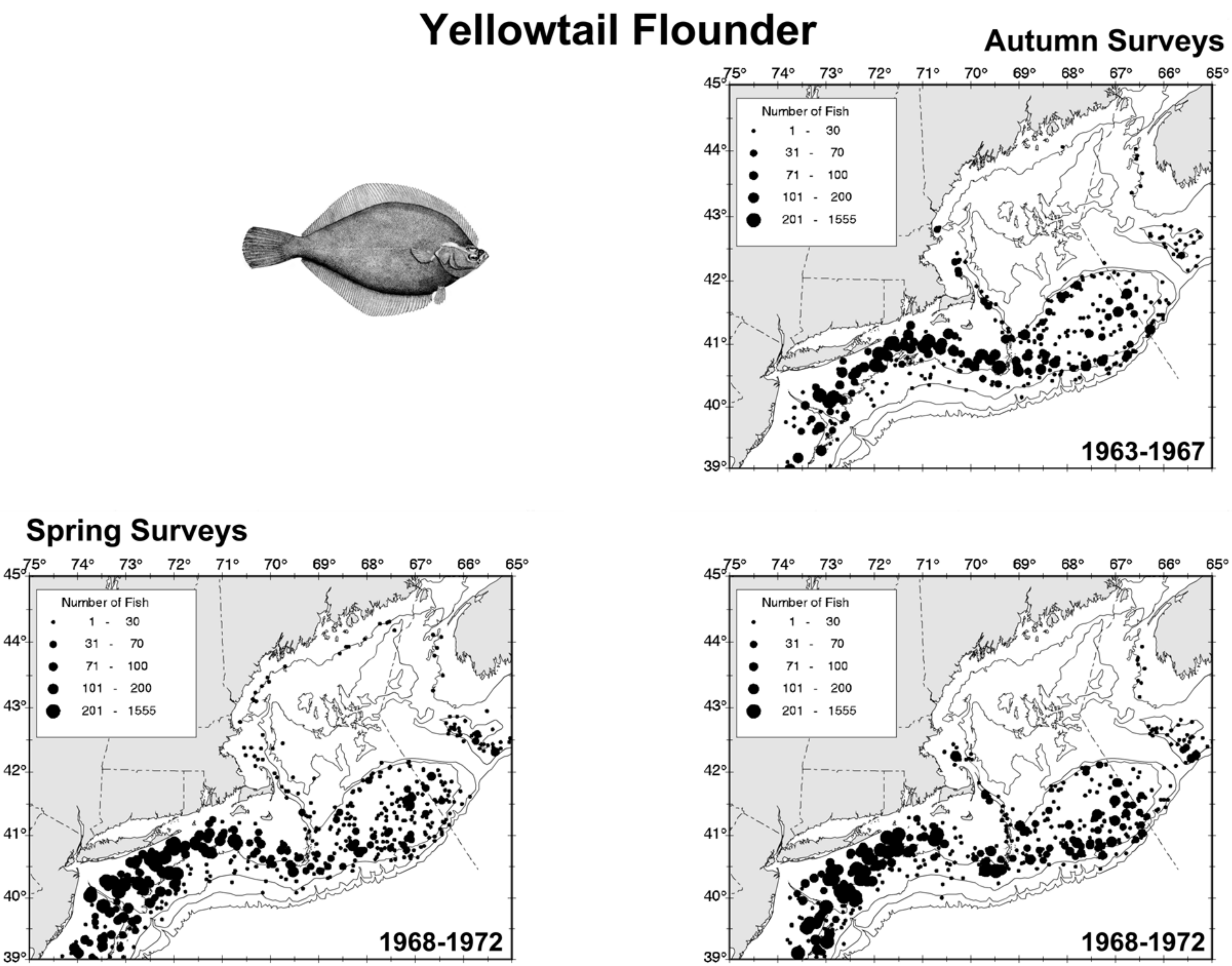

Figure C7a. Distribution of yellowtail flounder in the NEFSC spring and autumn bottom trawl surveys from 1963-1972.

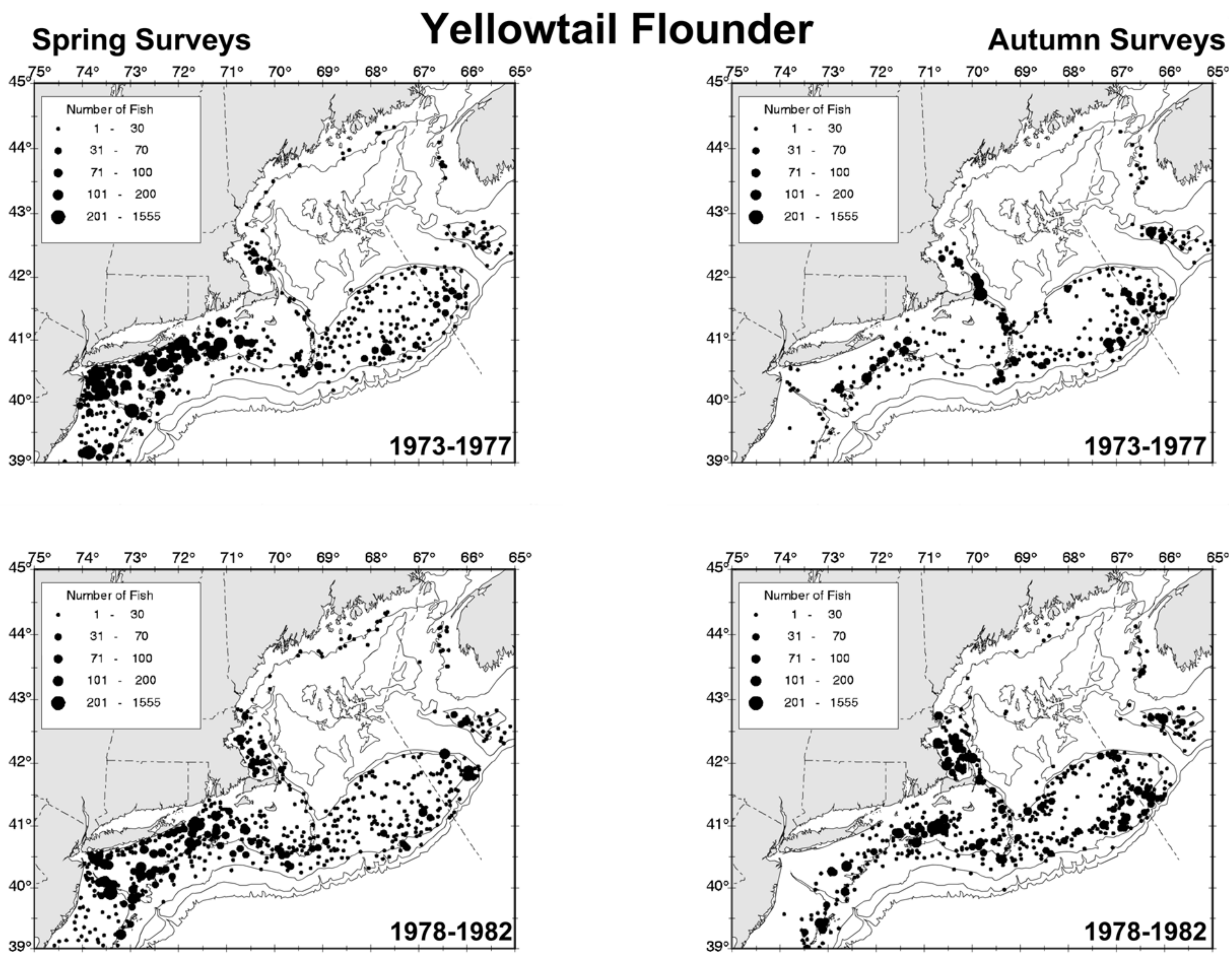

Figure C7b. Distribution of yellowtail flounder in the NEFSC spring and autumn bottom trawl surveys from 1973-1982.

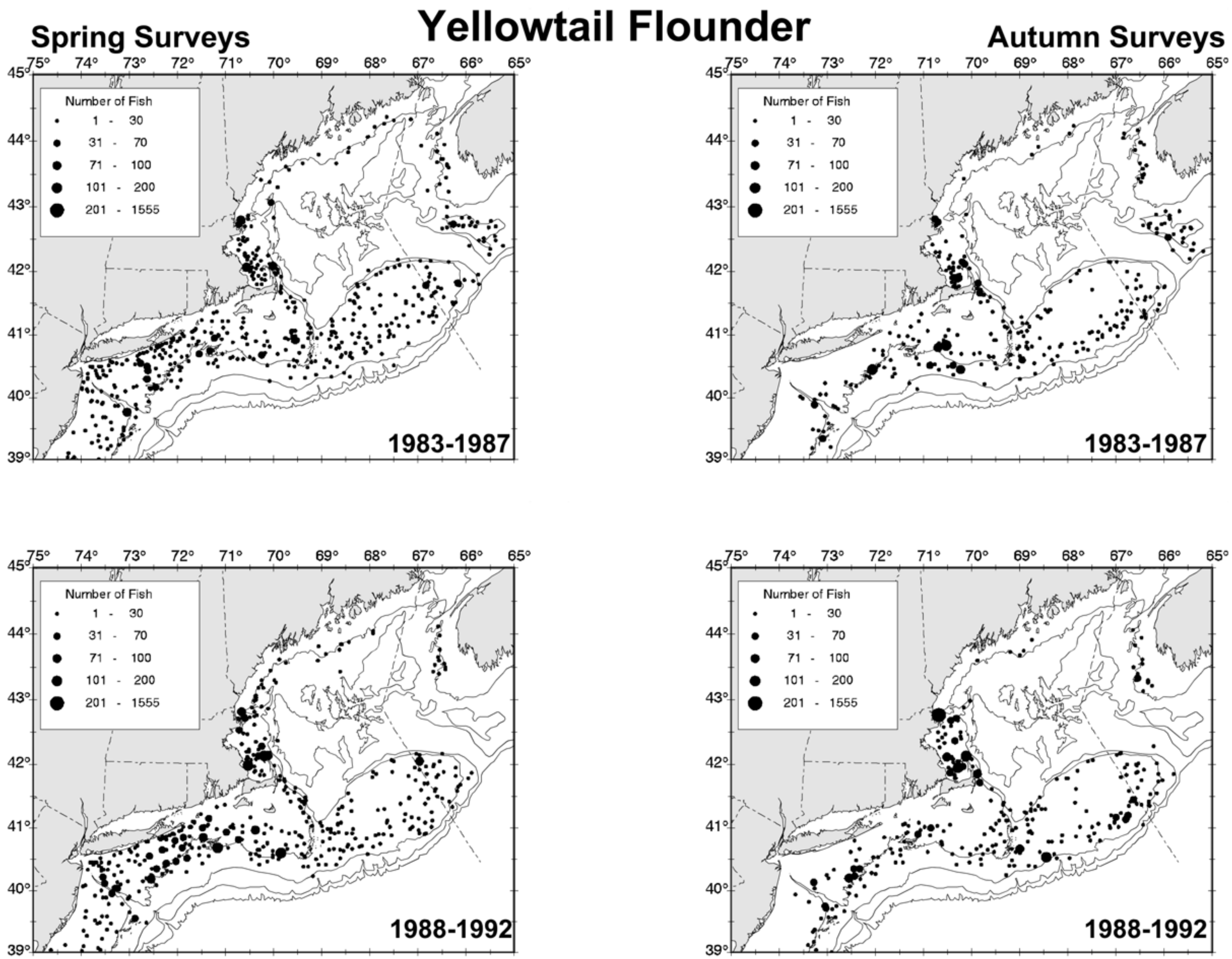

Figure C7c. Distribution of yellowtail flounder in the NEFSC spring and autumn bottom trawl surveys from 1983-1992.

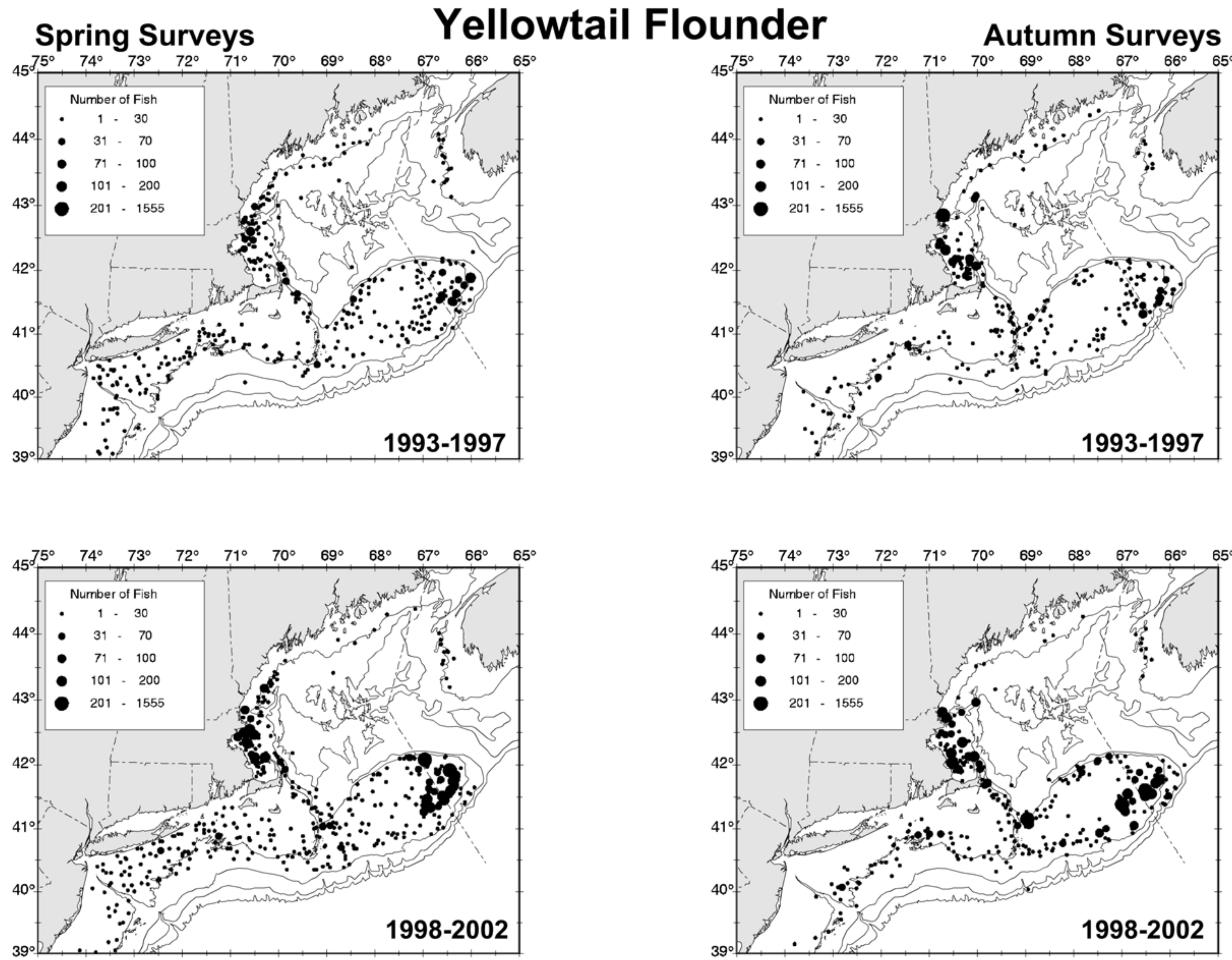

Figure C7d. Distribution of yellowtail flounder in the NEFSC spring and autumn bottom trawl surveys from 1993-2002.

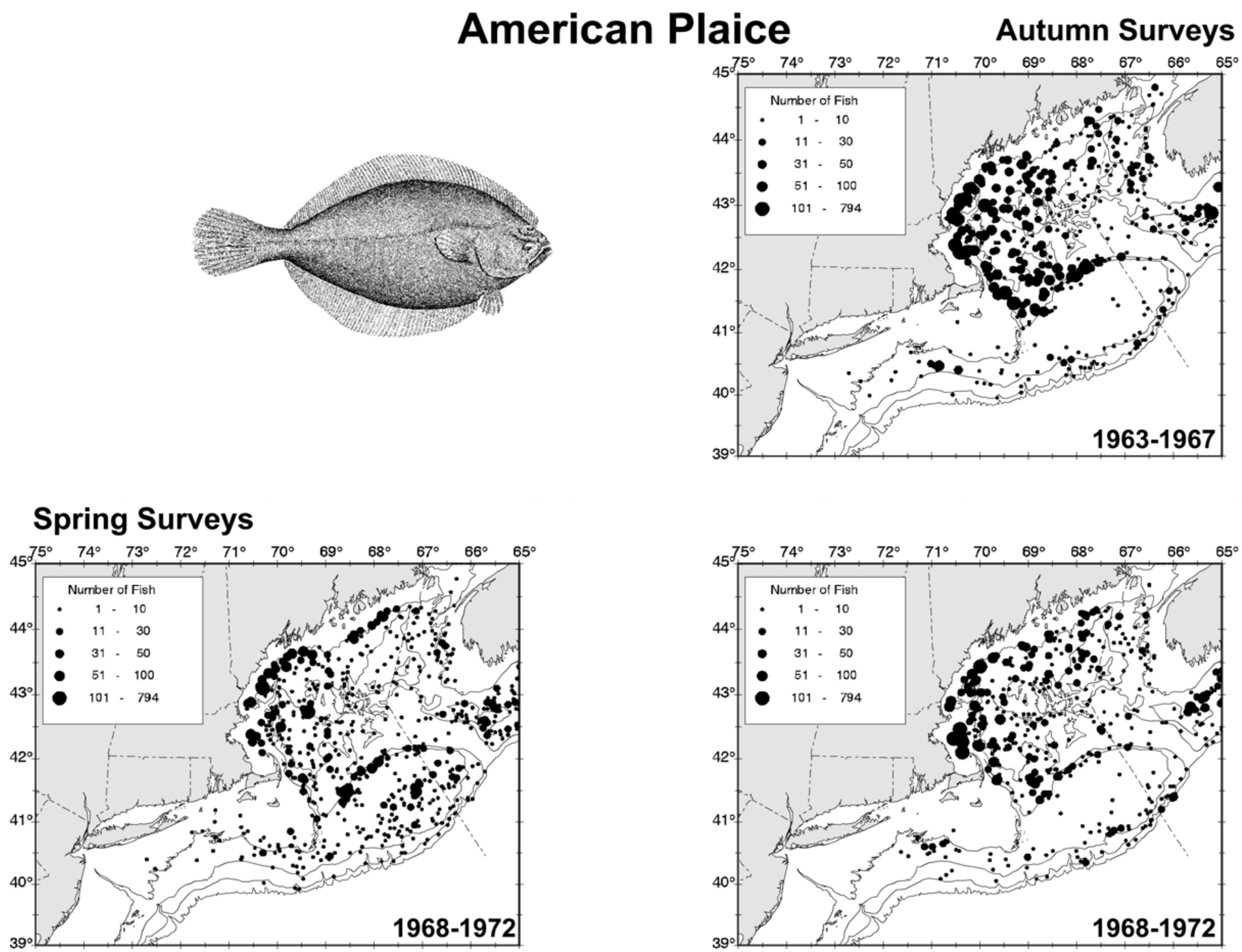

Figure C8a. Distribution of American plaice in the NEFSC spring and autumn bottom trawl surveys from 1963-1972.

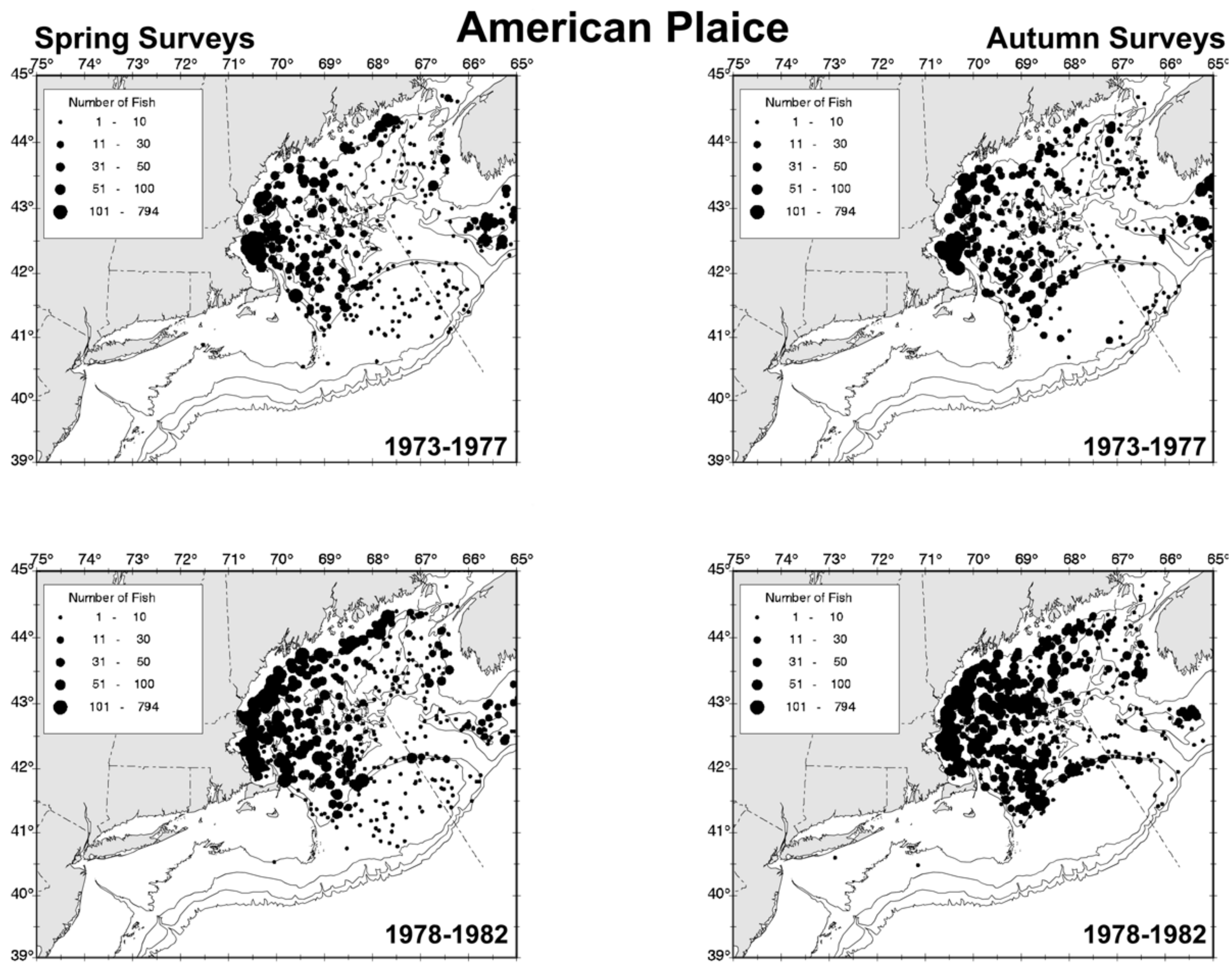

Figure C8b. Distribution of American plaice in the NEFSC spring and autumn bottom trawl surveys from 1973-1982.

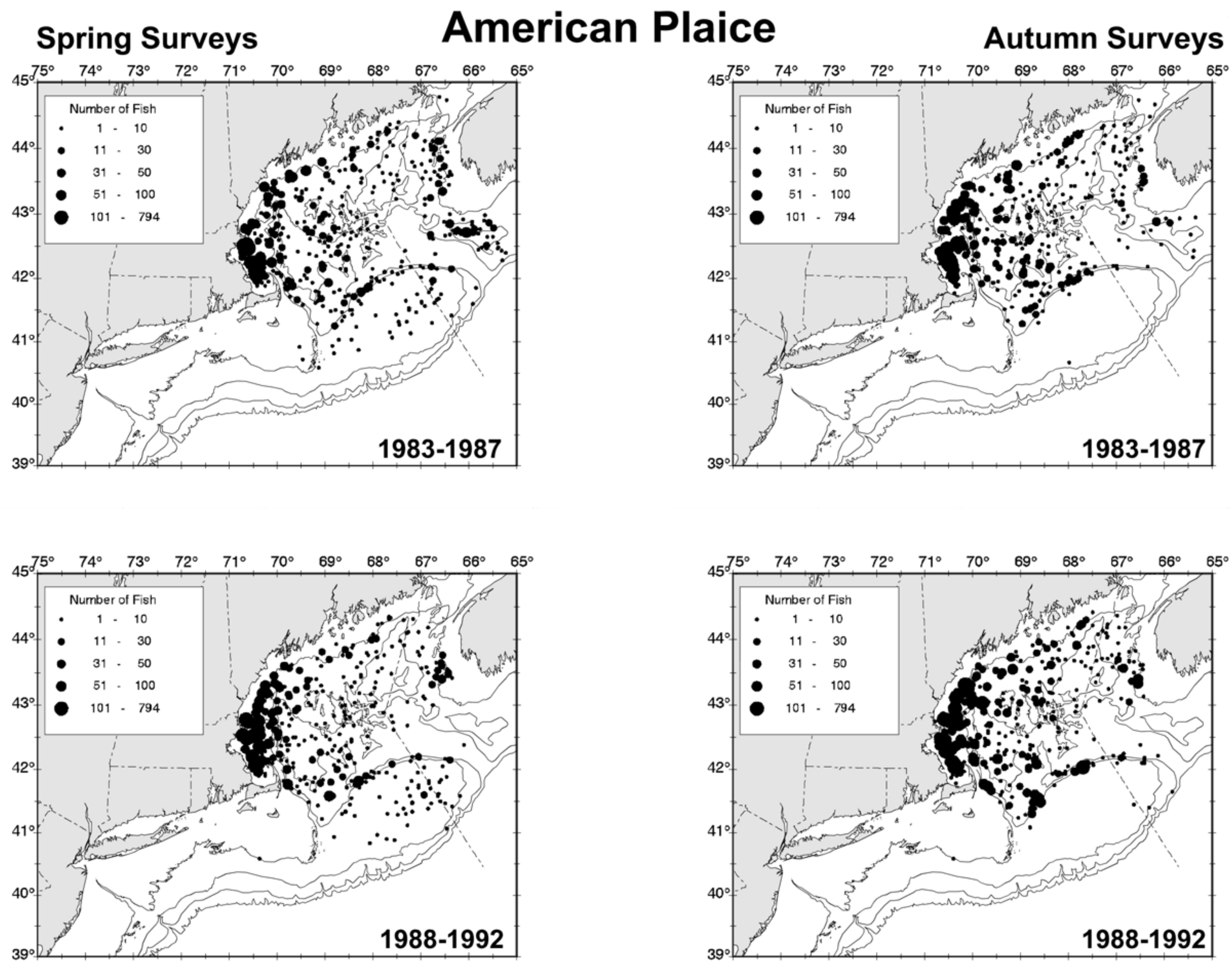

Figure C8c. Distribution of American plaice in the NEFSC spring and autumn bottom trawl surveys from 1983-1992.

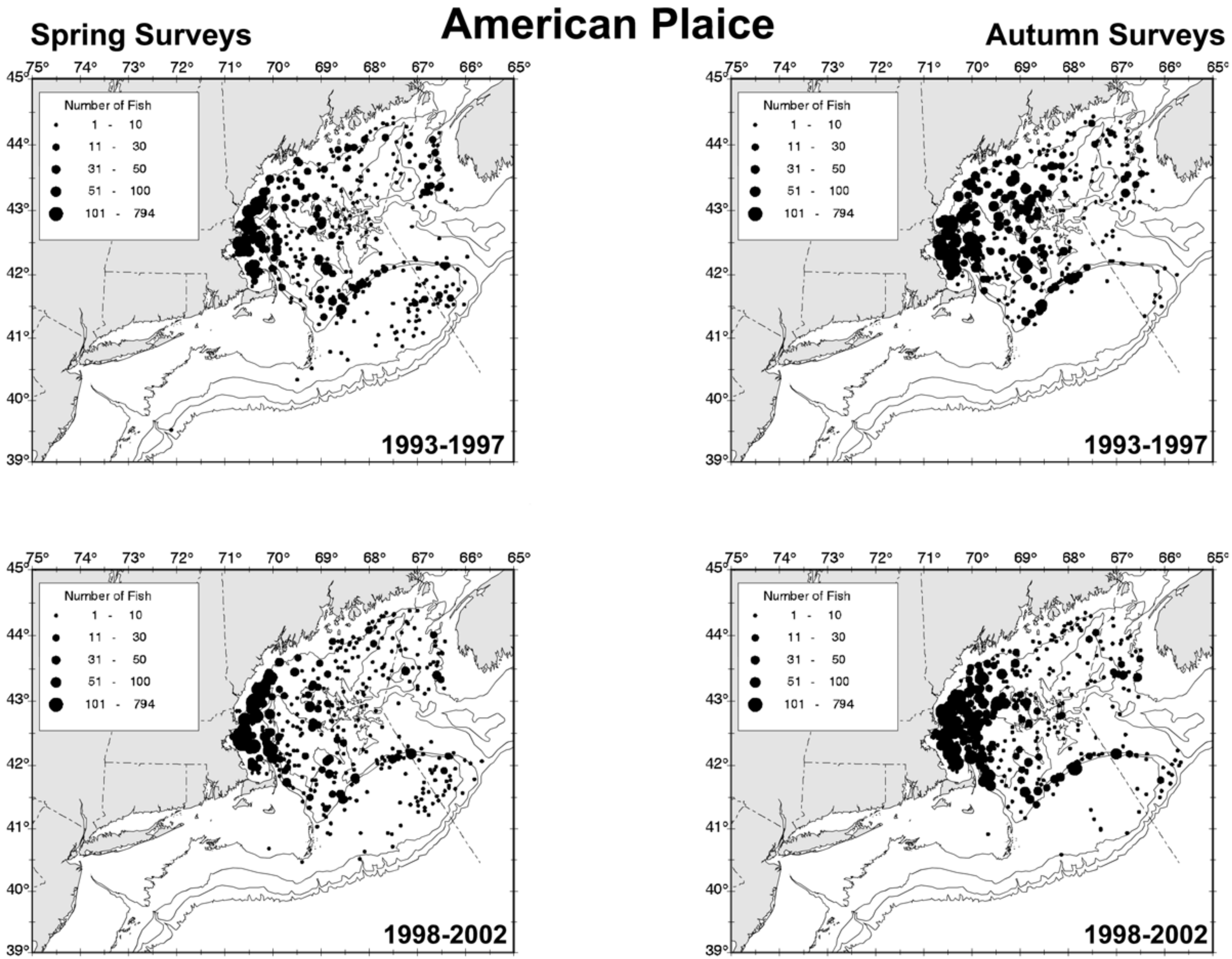

Figure C8d. Distribution of American plaice in the NEFSC spring and autumn bottom trawl surveys from 1993-2002.

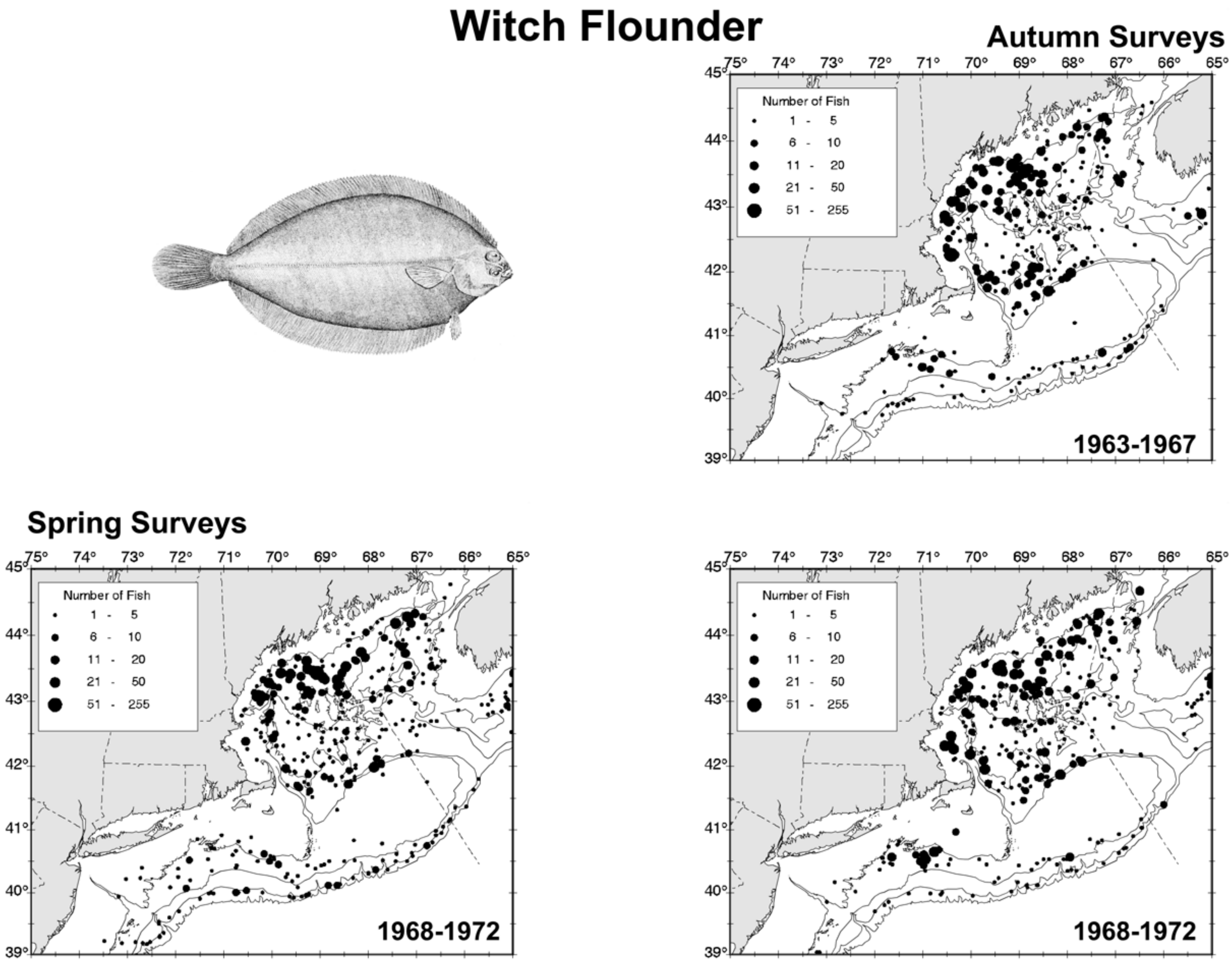

Figure C9a. Distribution of witch flounder in the NEFSC spring and autumn bottom trawl surveys from 1963-1972.

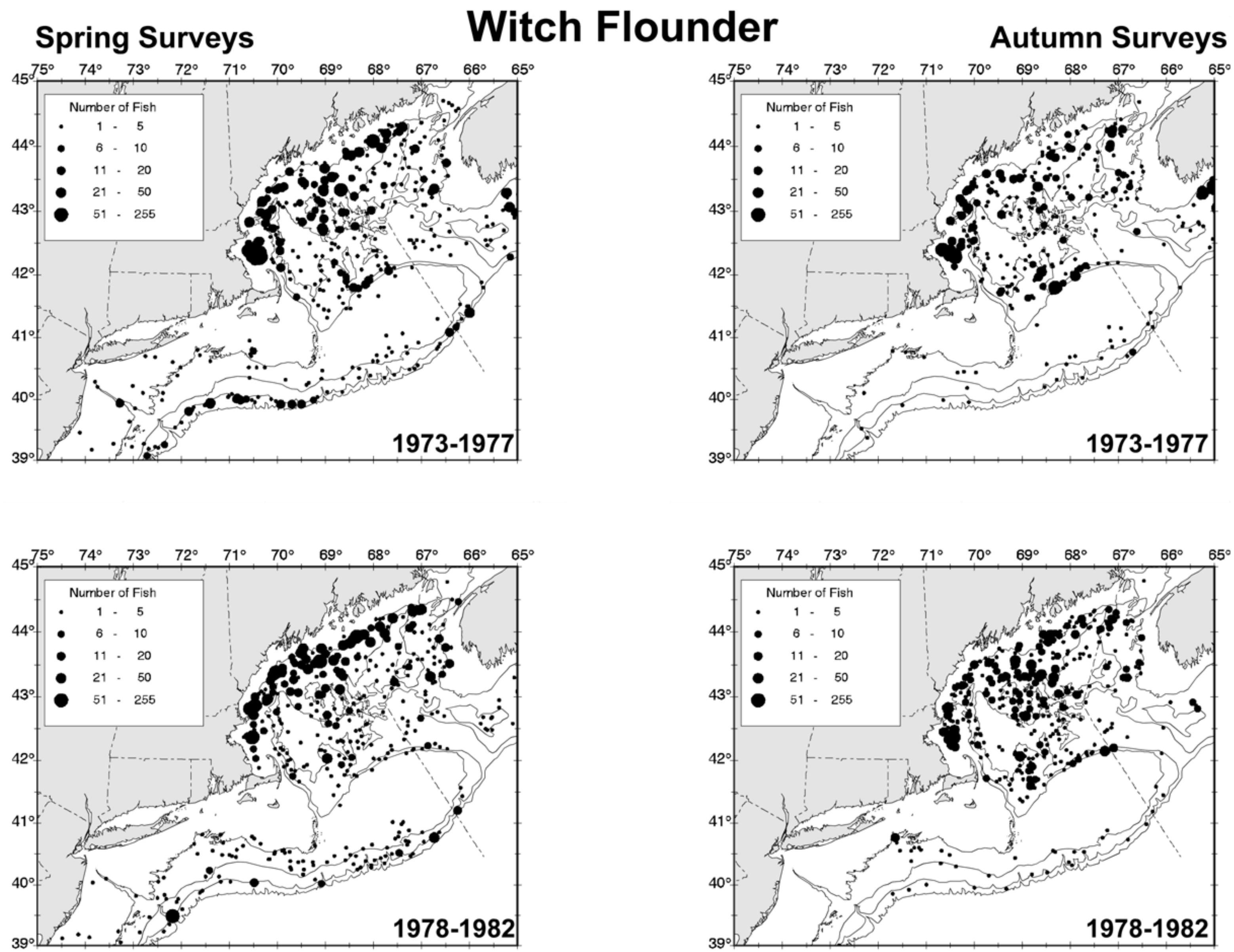

Figure C9b. Distribution of witch flounder in the NEFSC spring and autumn bottom trawl surveys from 1973-1982.

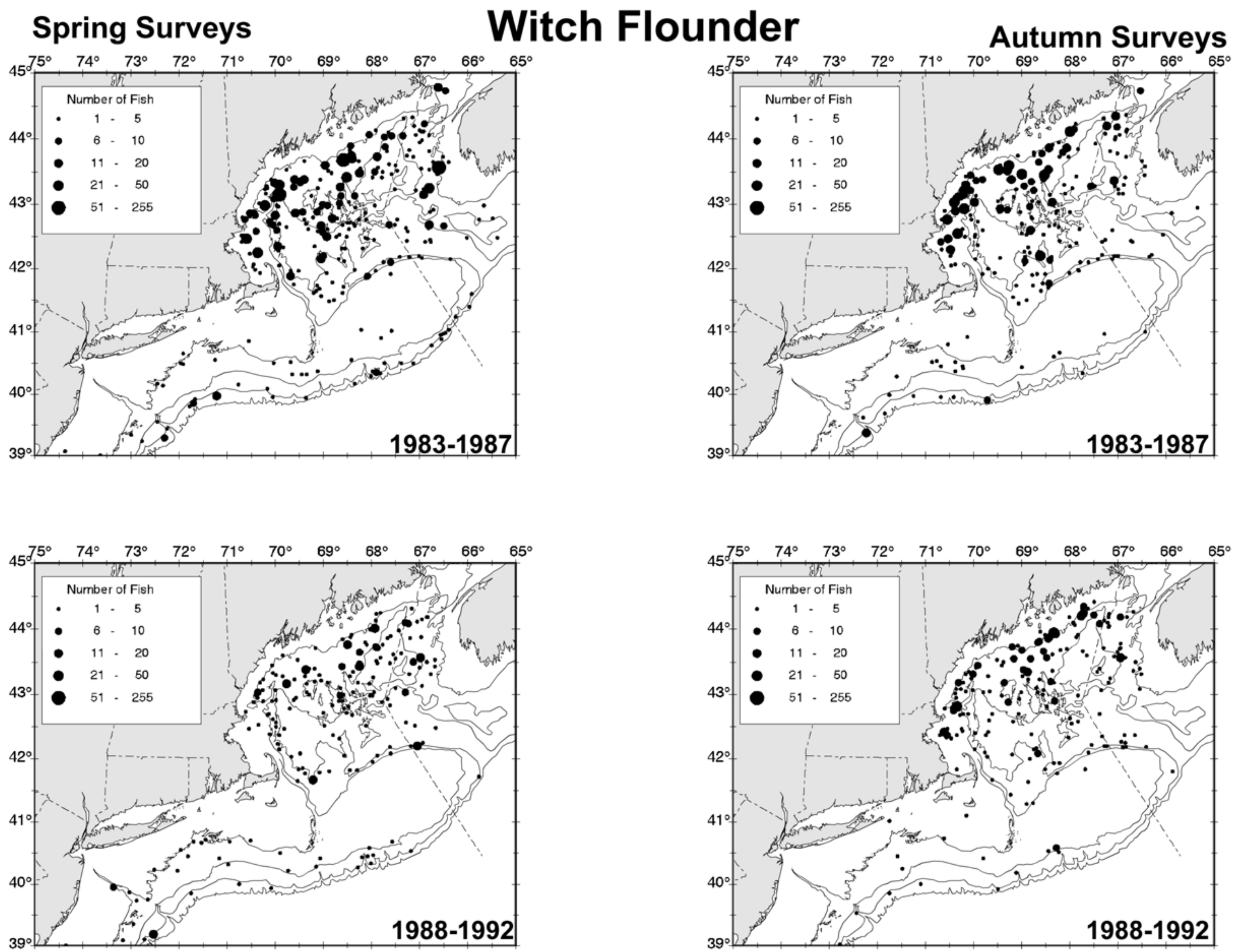

Figure C9c. Distribution of witch flounder in the NEFSC spring and autumn bottom trawl surveys from 1983-1992.

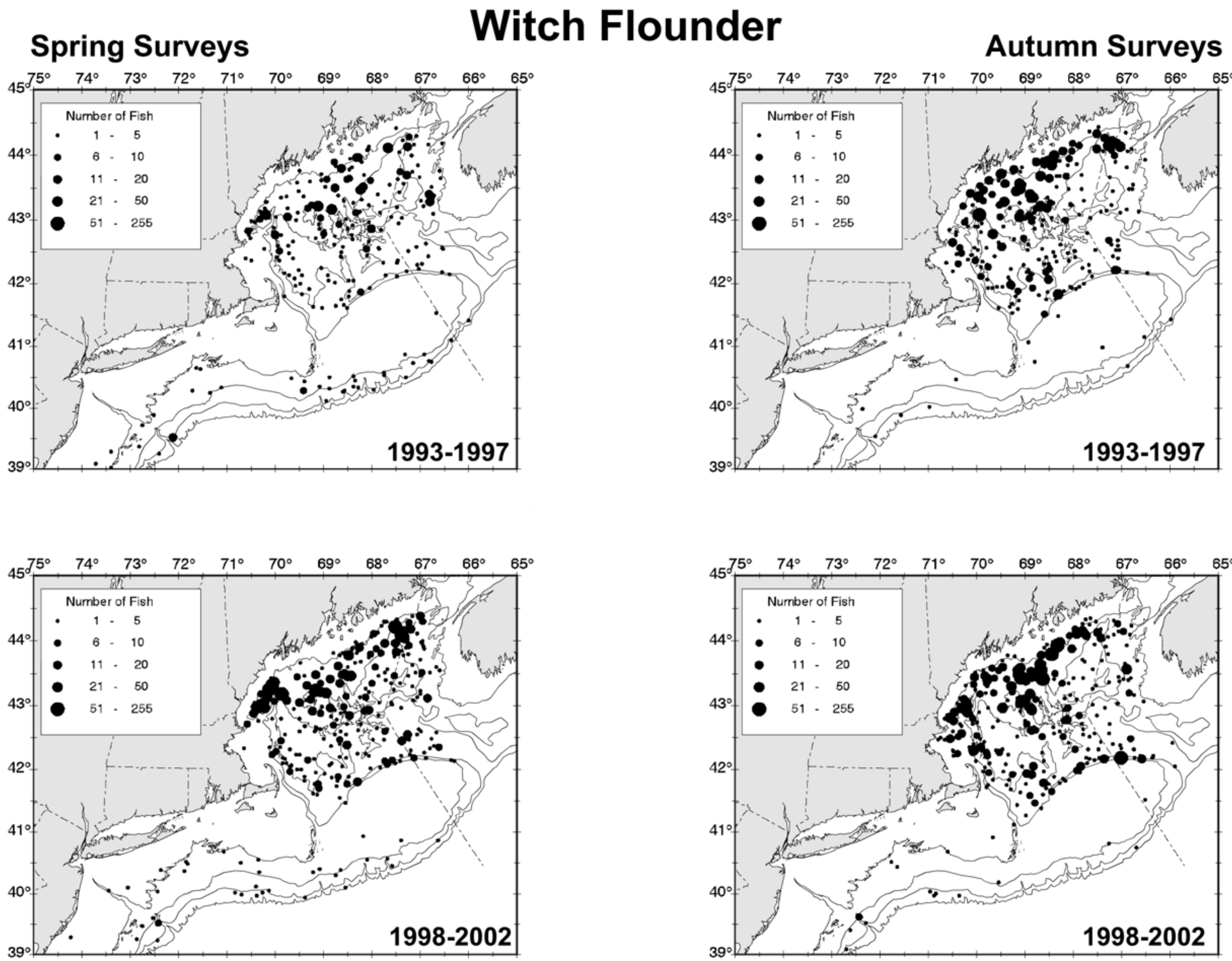

Figure C9d. Distribution of witch flounder in the NEFSC spring and autumn bottom trawl surveys from 1993-2002.

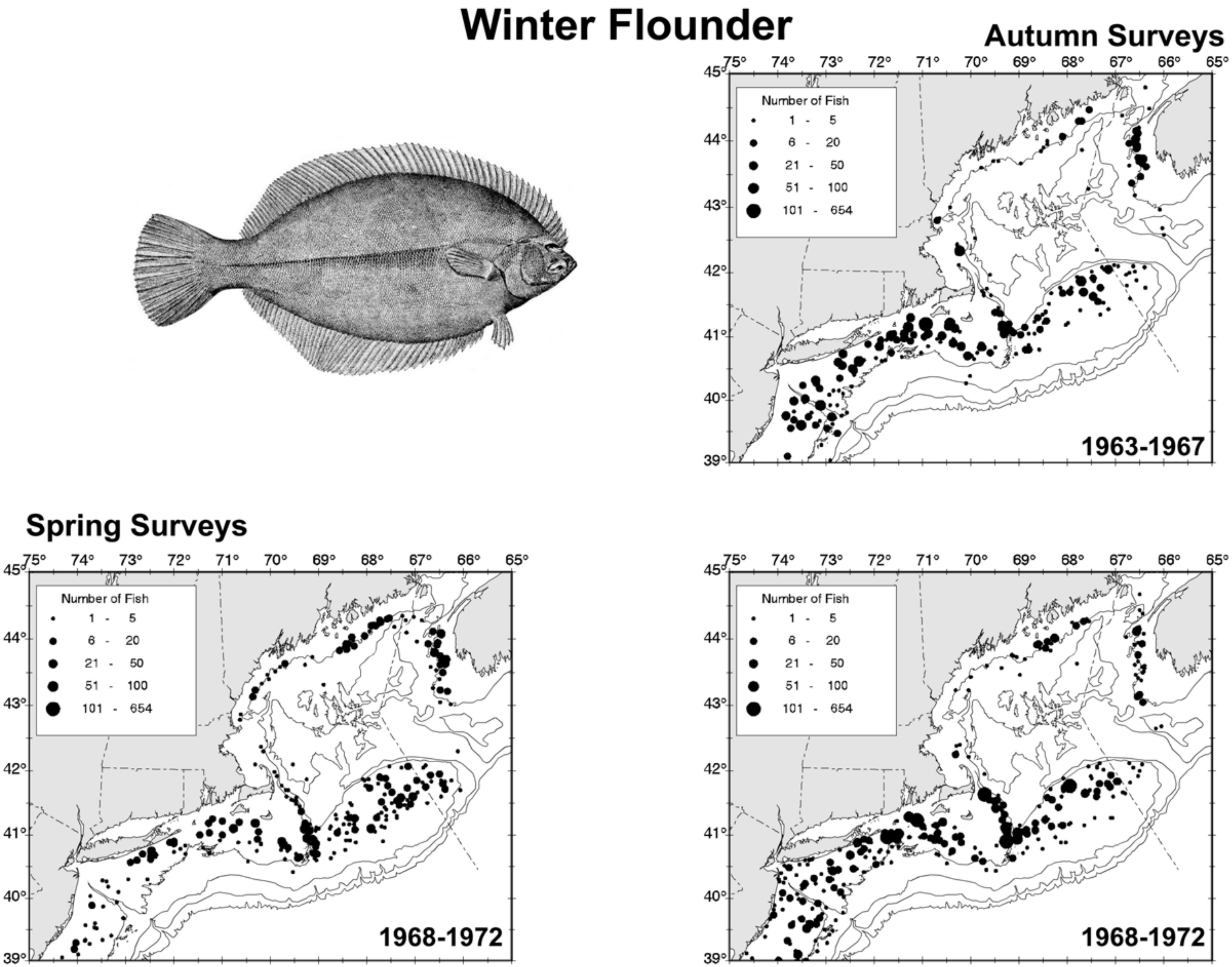

Figure C10a. Distribution of winter flounder in the NEFSC spring and autumn bottom trawl surveys from 1963-1972.

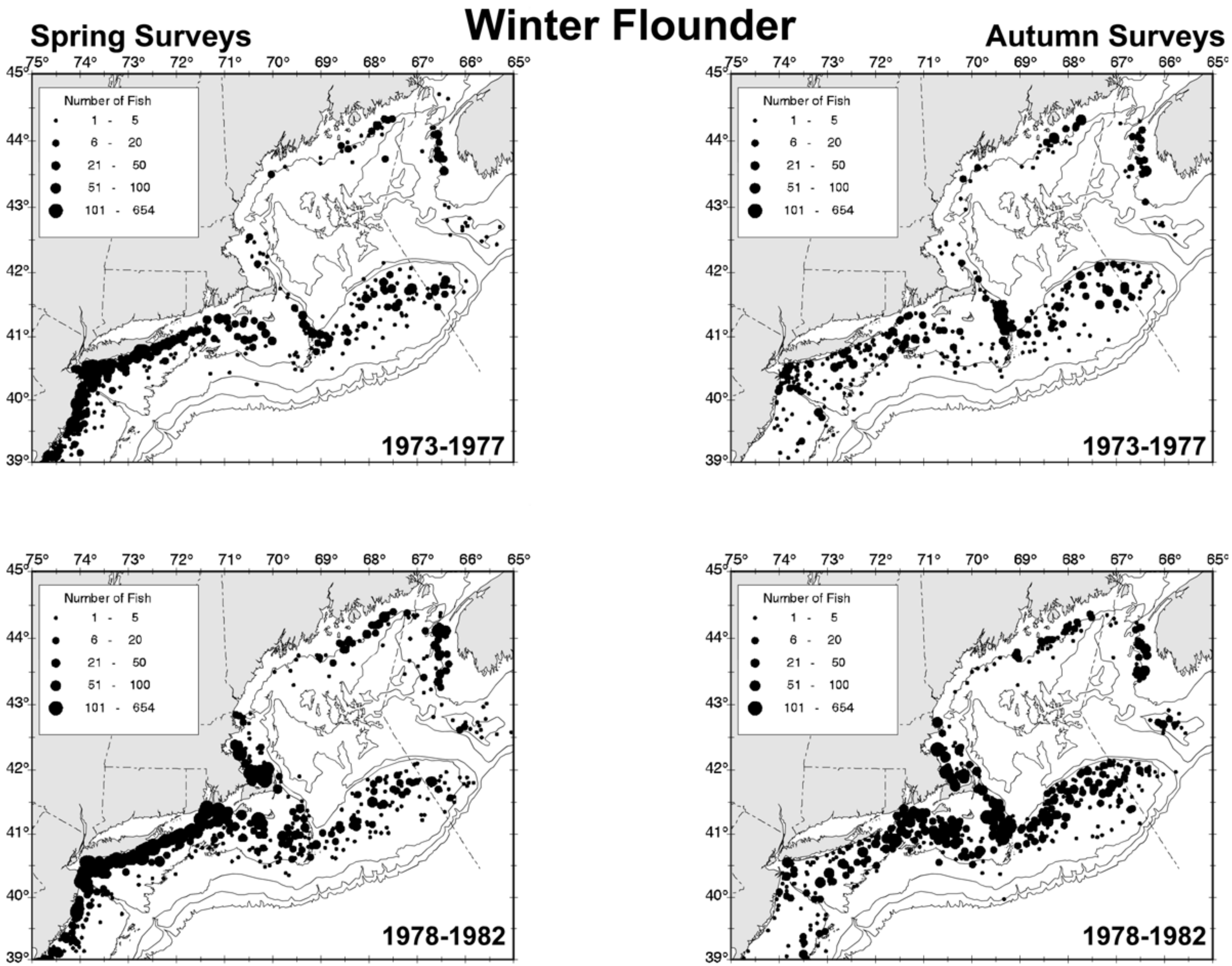

Figure C10b. Distribution of winter flounder in the NEFSC spring and autumn bottom trawl surveys from 1973-1982.

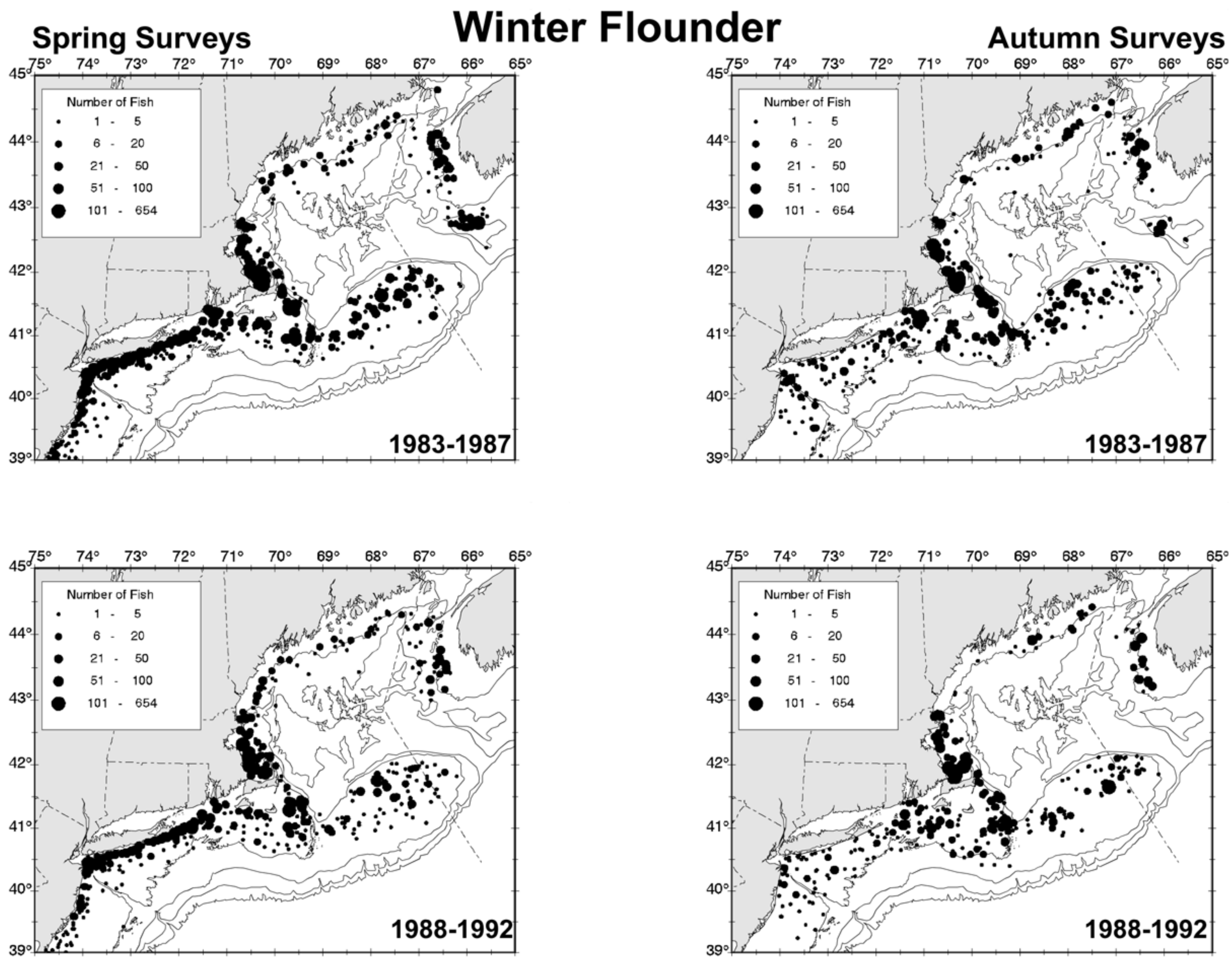

Figure C10c. Distribution of winter flounder in the NEFSC spring and autumn bottom trawl surveys from 1983-1992.

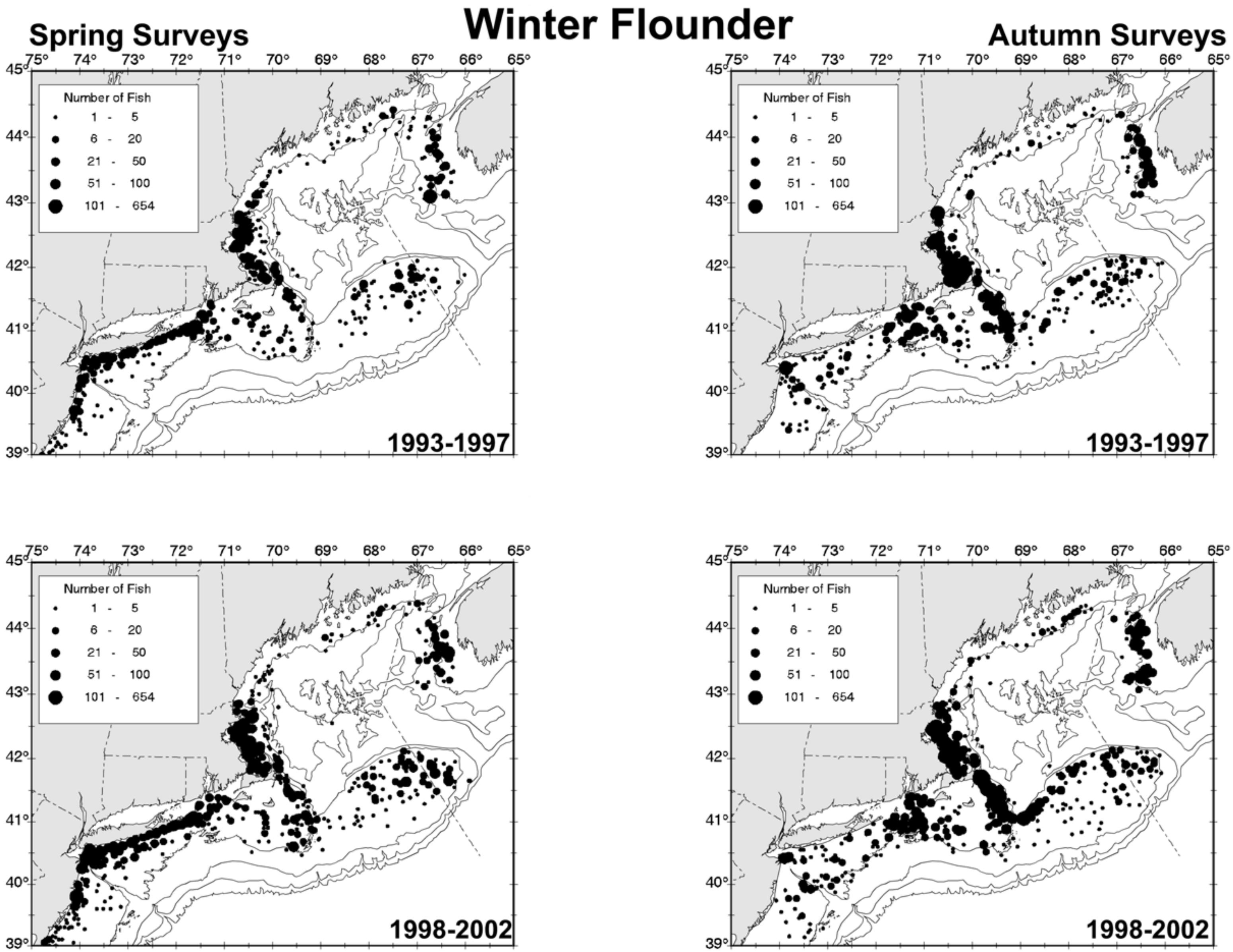

Figure C10d. Distribution of winter flounder in the NEFSC spring and autumn bottom trawl surveys from 1993-2002.

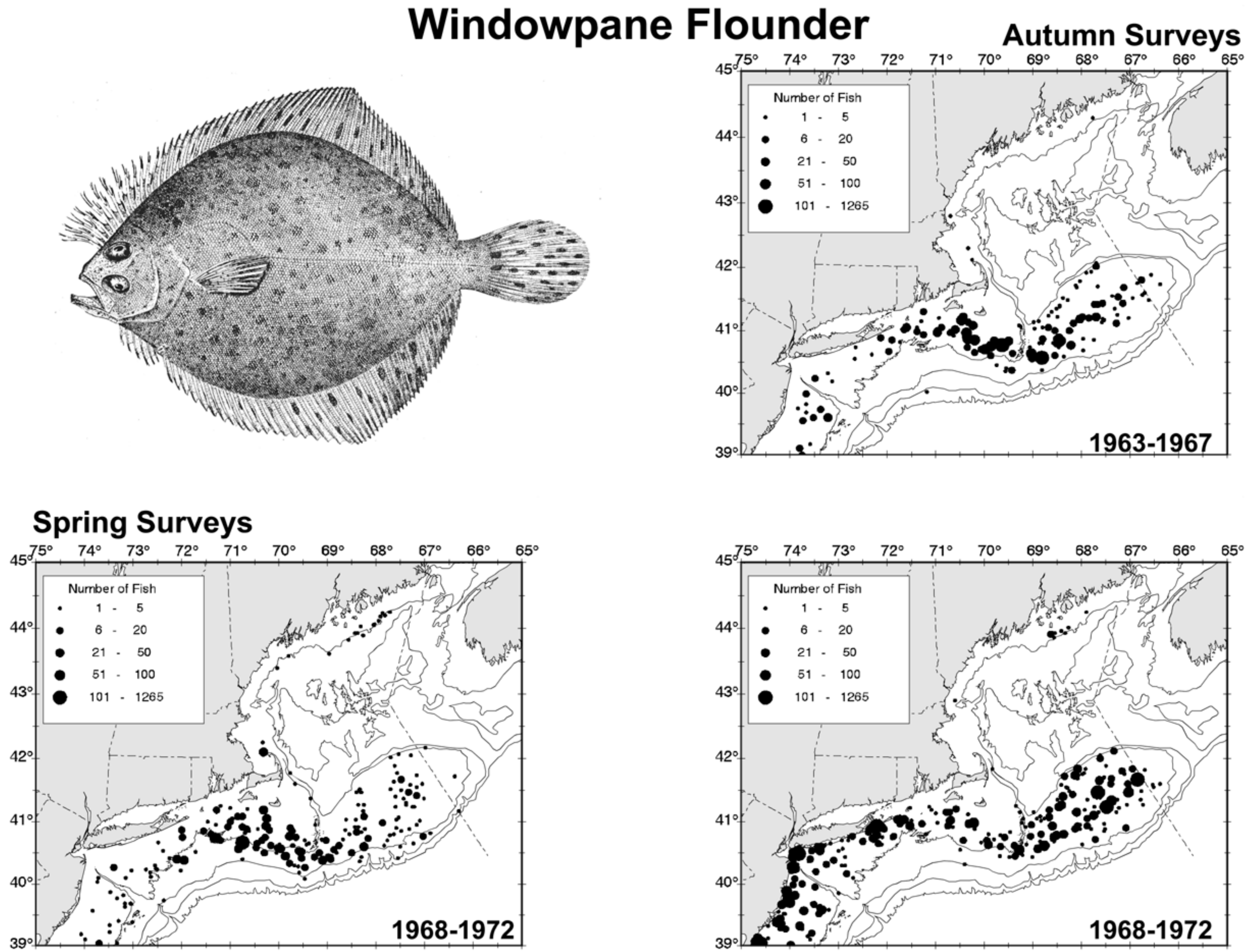

Figure C11a. Distribution of windowpane flounder in the NEFSC spring and autumn bottom trawl surveys from 1963-1972.

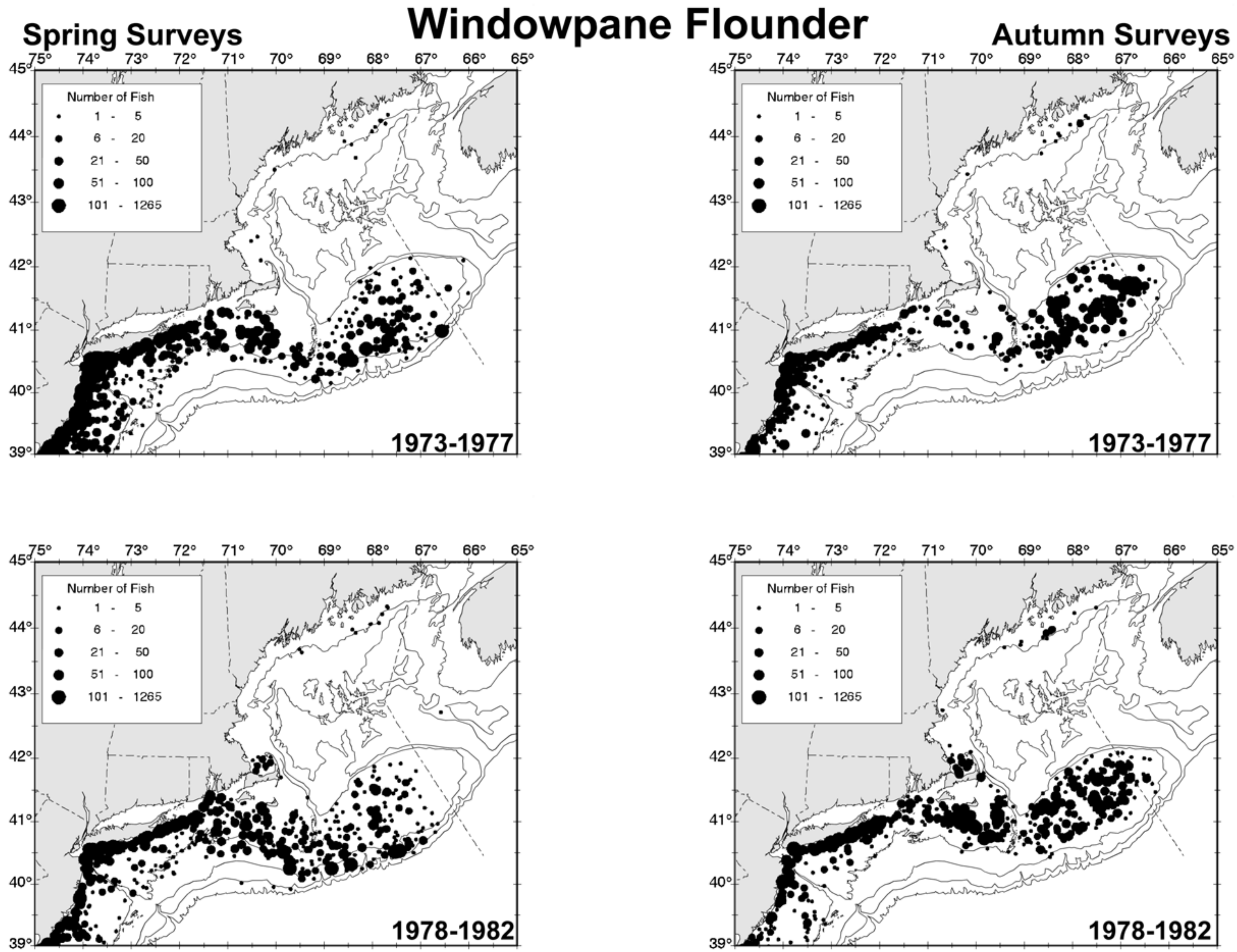

Figure C11b. Distribution of windowpane flounder in the NEFSC spring and autumn bottom trawl surveys from 1973-1982.

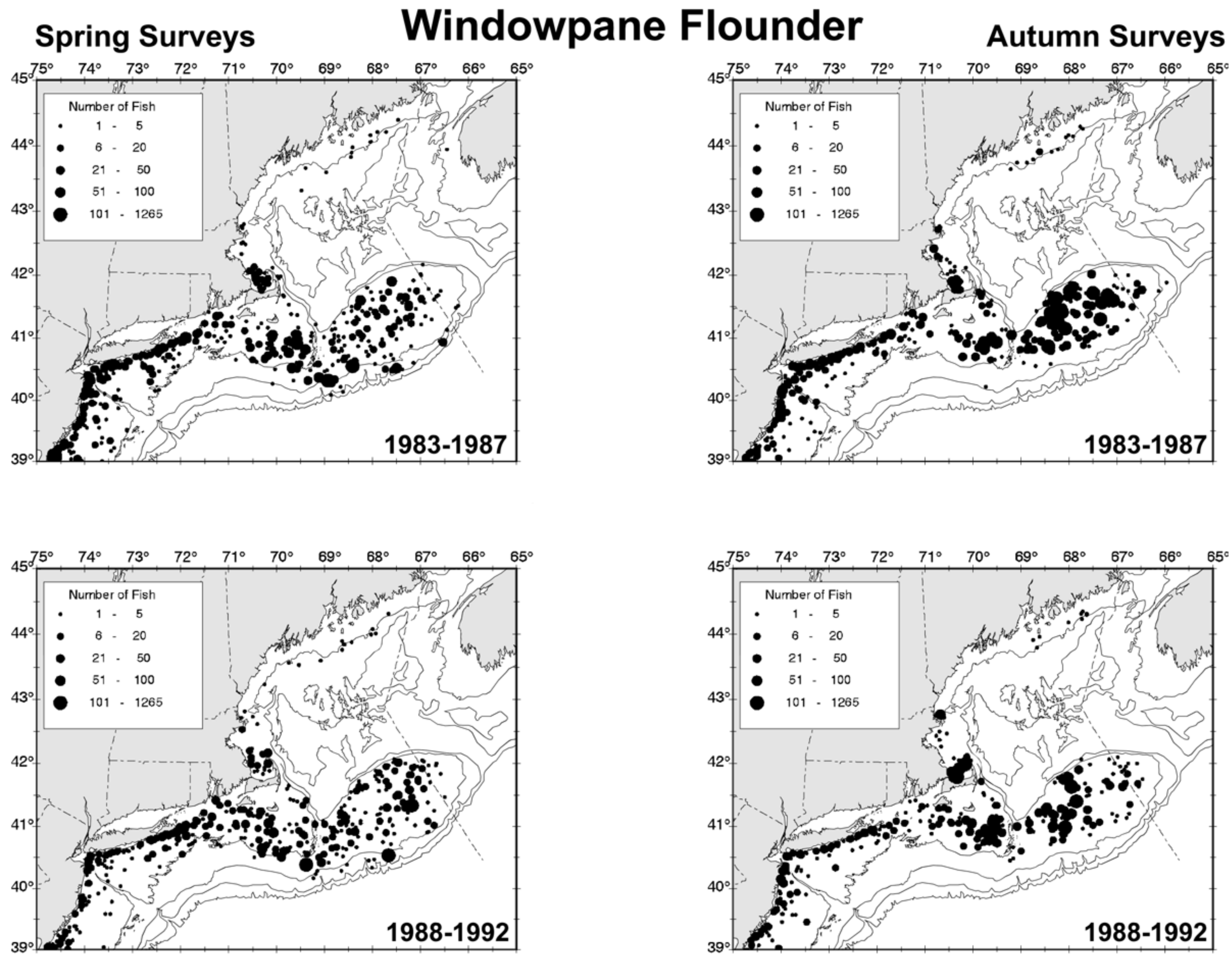

Figure C11c. Distribution of windowpane flounder in the NEFSC spring and autumn bottom trawl surveys from 1983-1992.

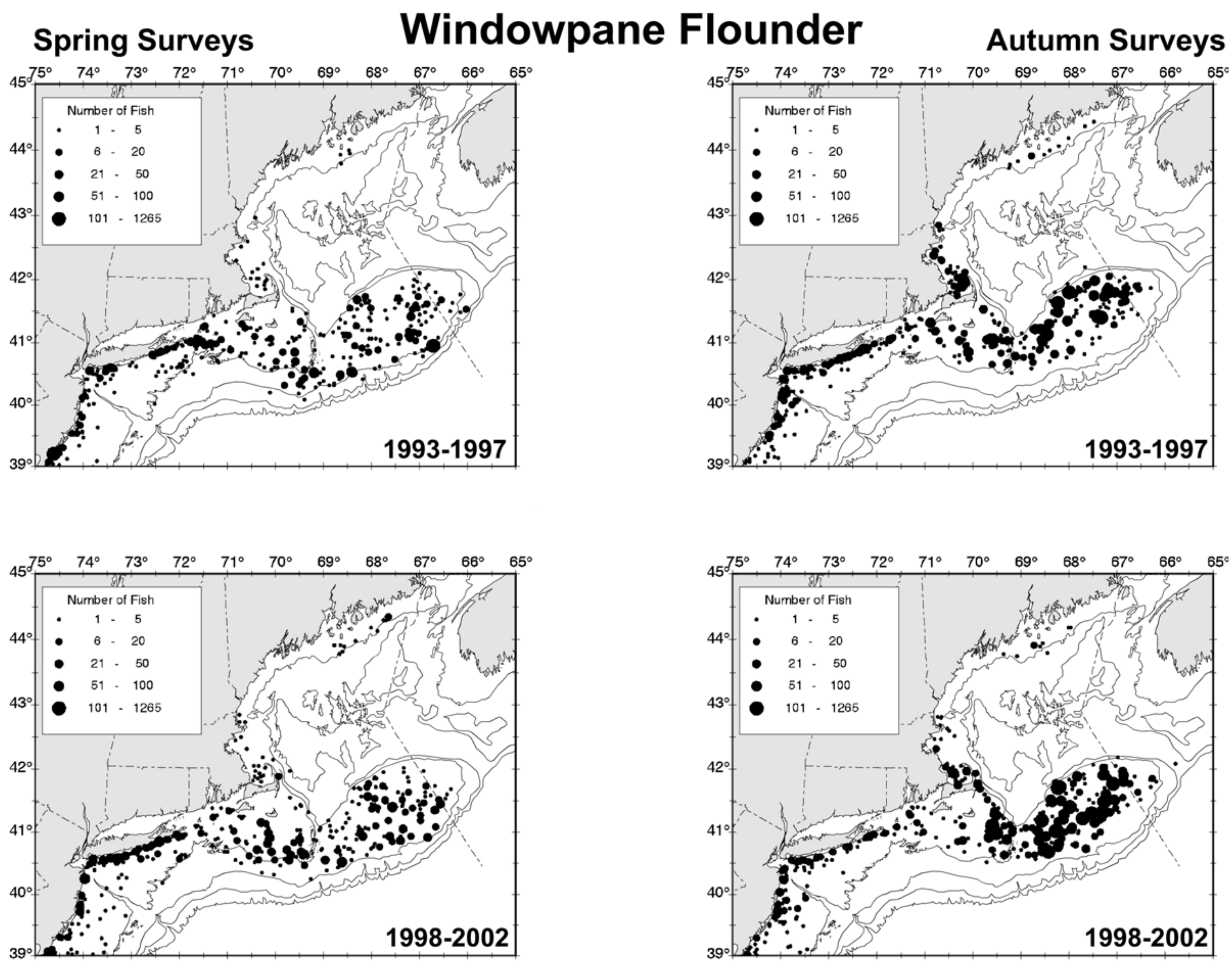

Figure C11d. Distribution of windowpane flounder in the NEFSC spring and autumn bottom trawl surveys from 1993-2002.

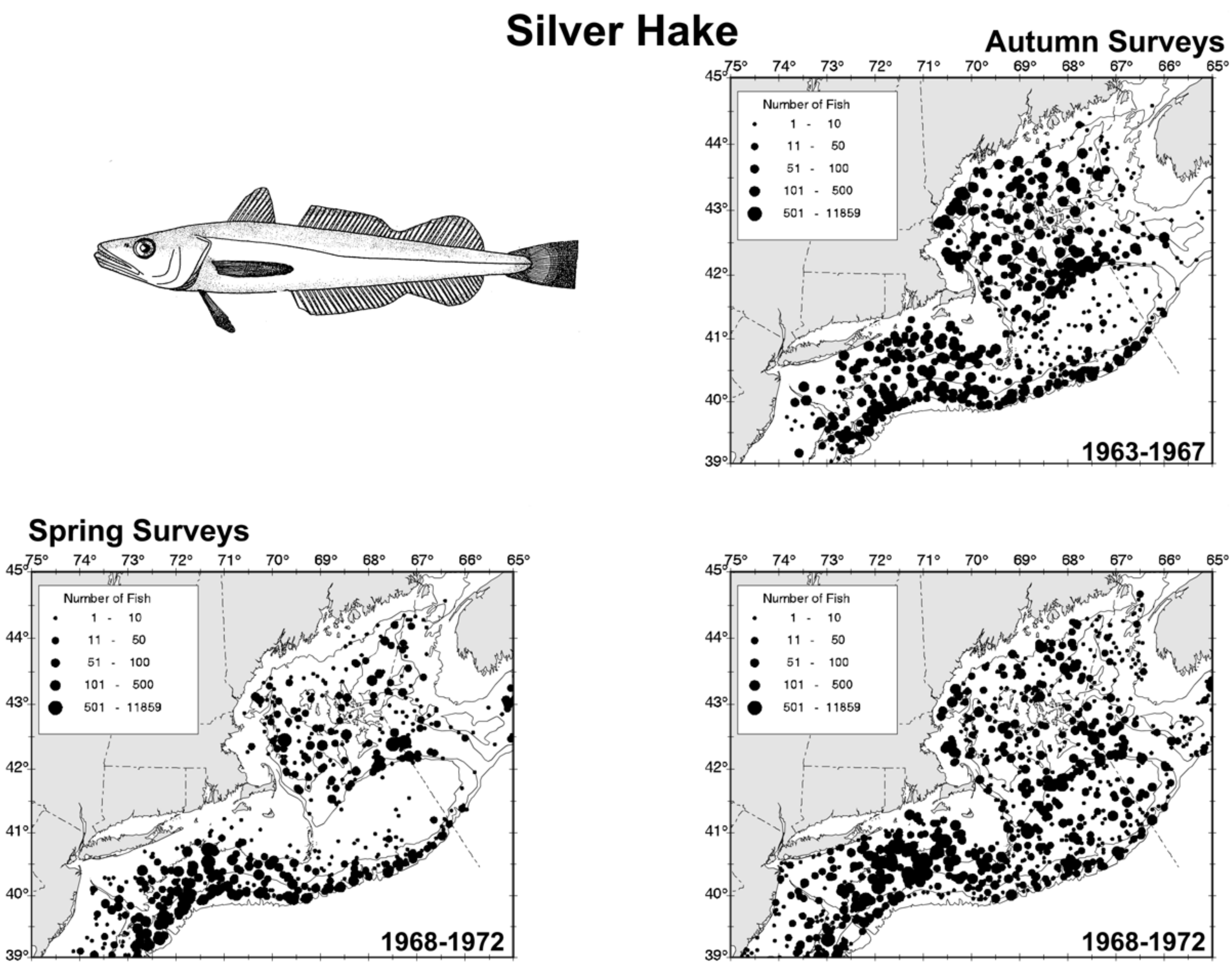

Figure C12a. Distribution of silver hake in the NEFSC spring and autumn bottom trawl surveys from 1963-1972.

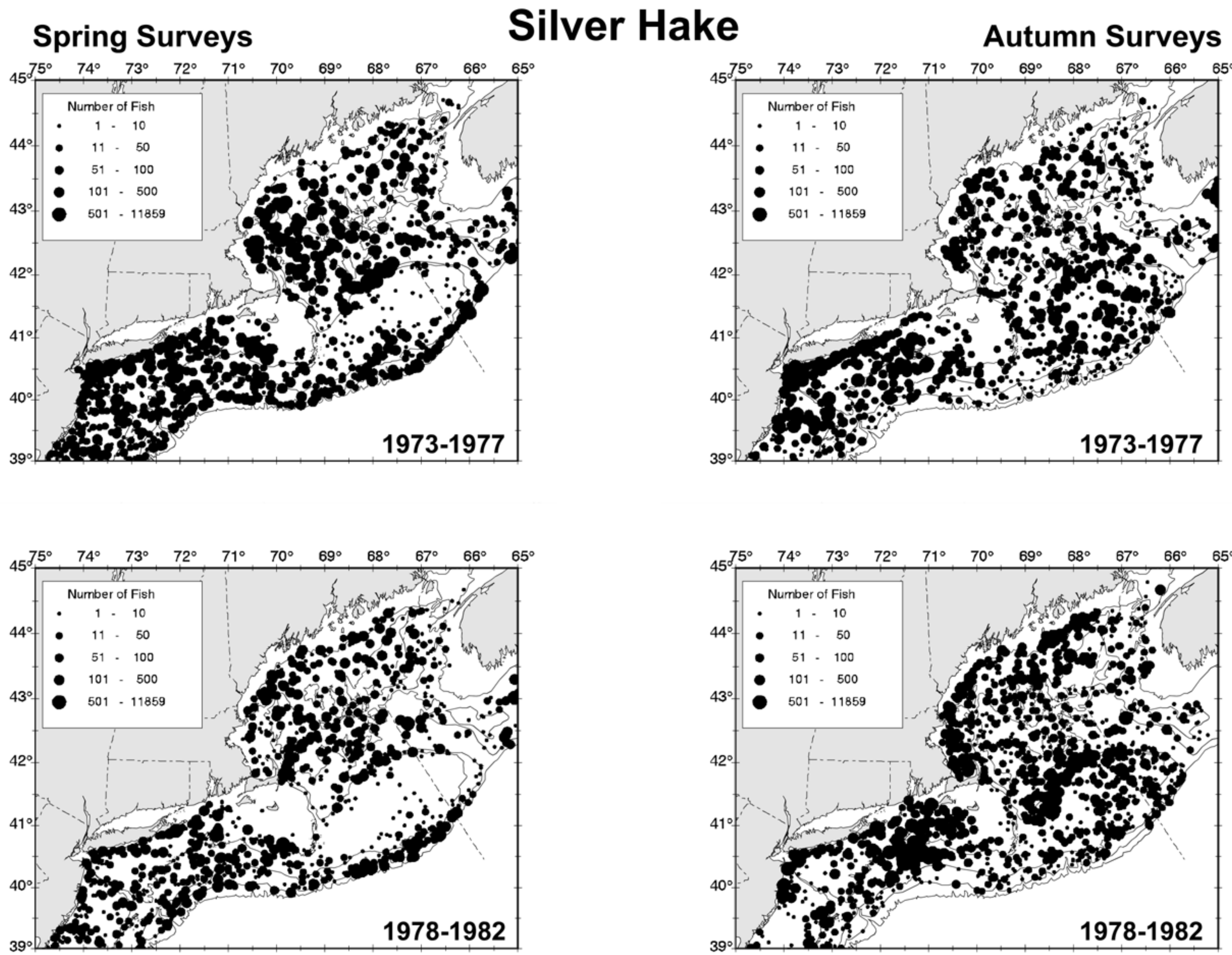

Figure C12b. Distribution of silver hake in the NEFSC spring and autumn bottom trawl surveys from 1973-1982.

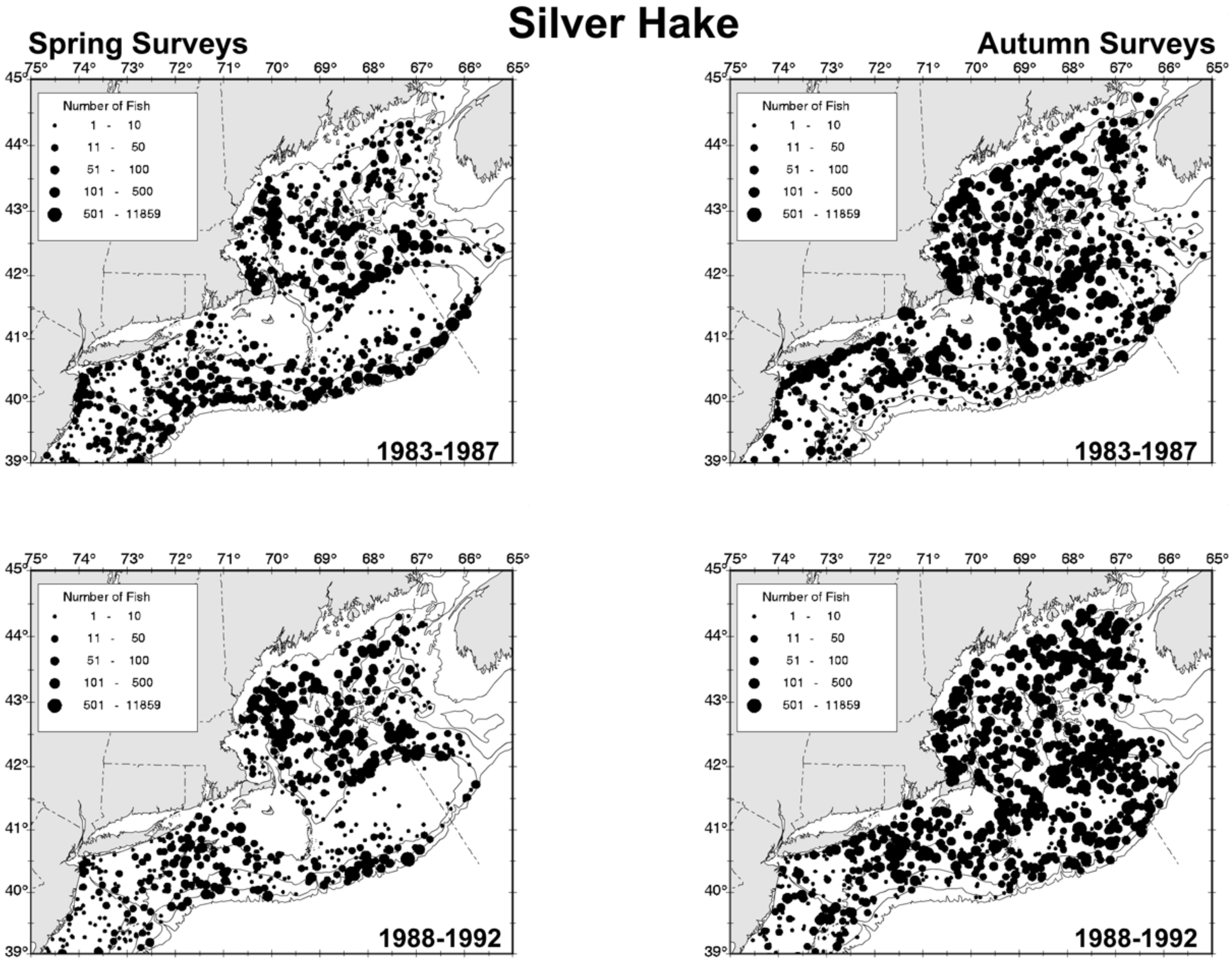

Figure C12c. Distribution of silver hake in the NEFSC spring and autumn bottom trawl surveys from 1983-1992.

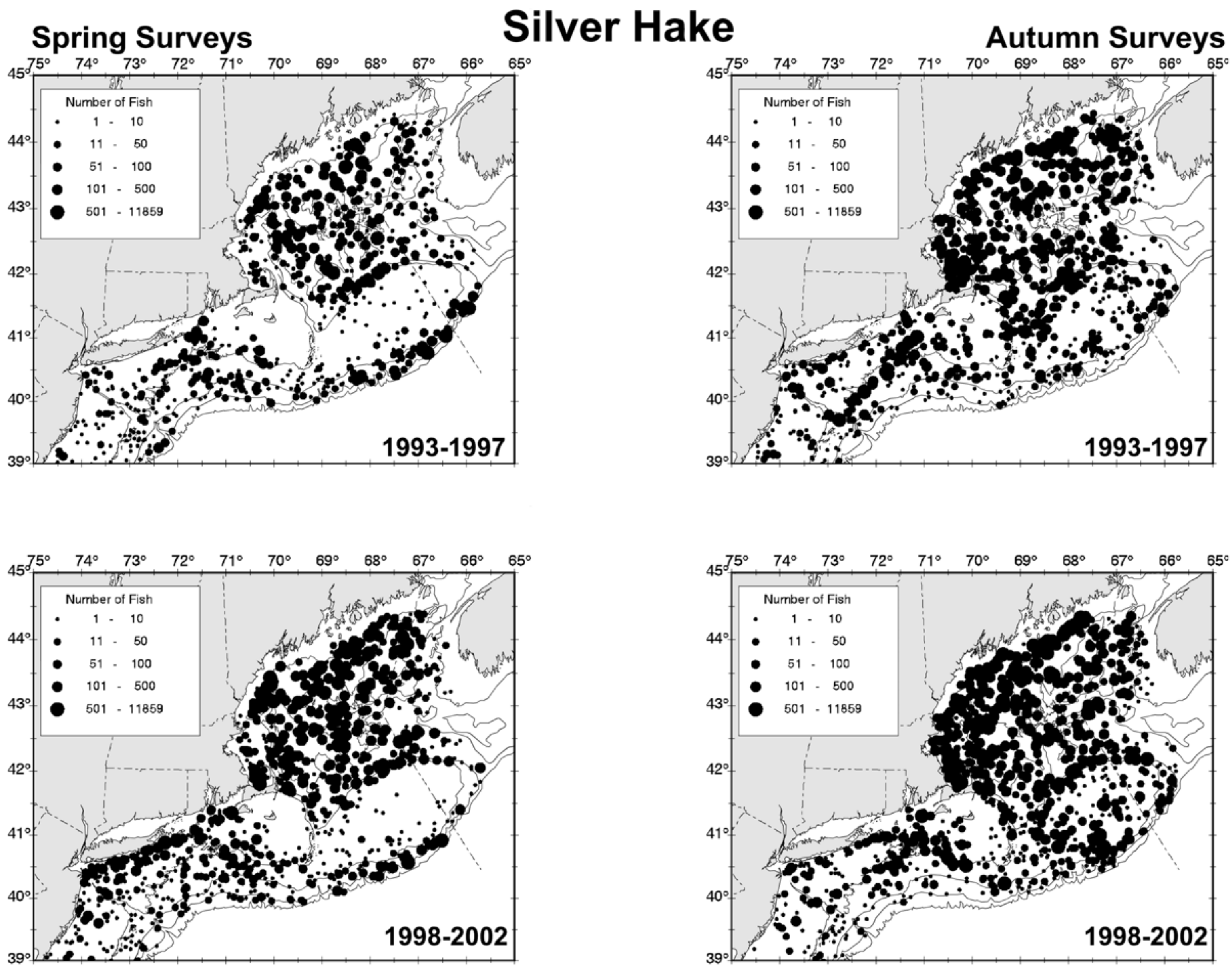

Figure C12d. Distribution of silver hake in the NEFSC spring and autumn bottom trawl surveys from 1993-2002.

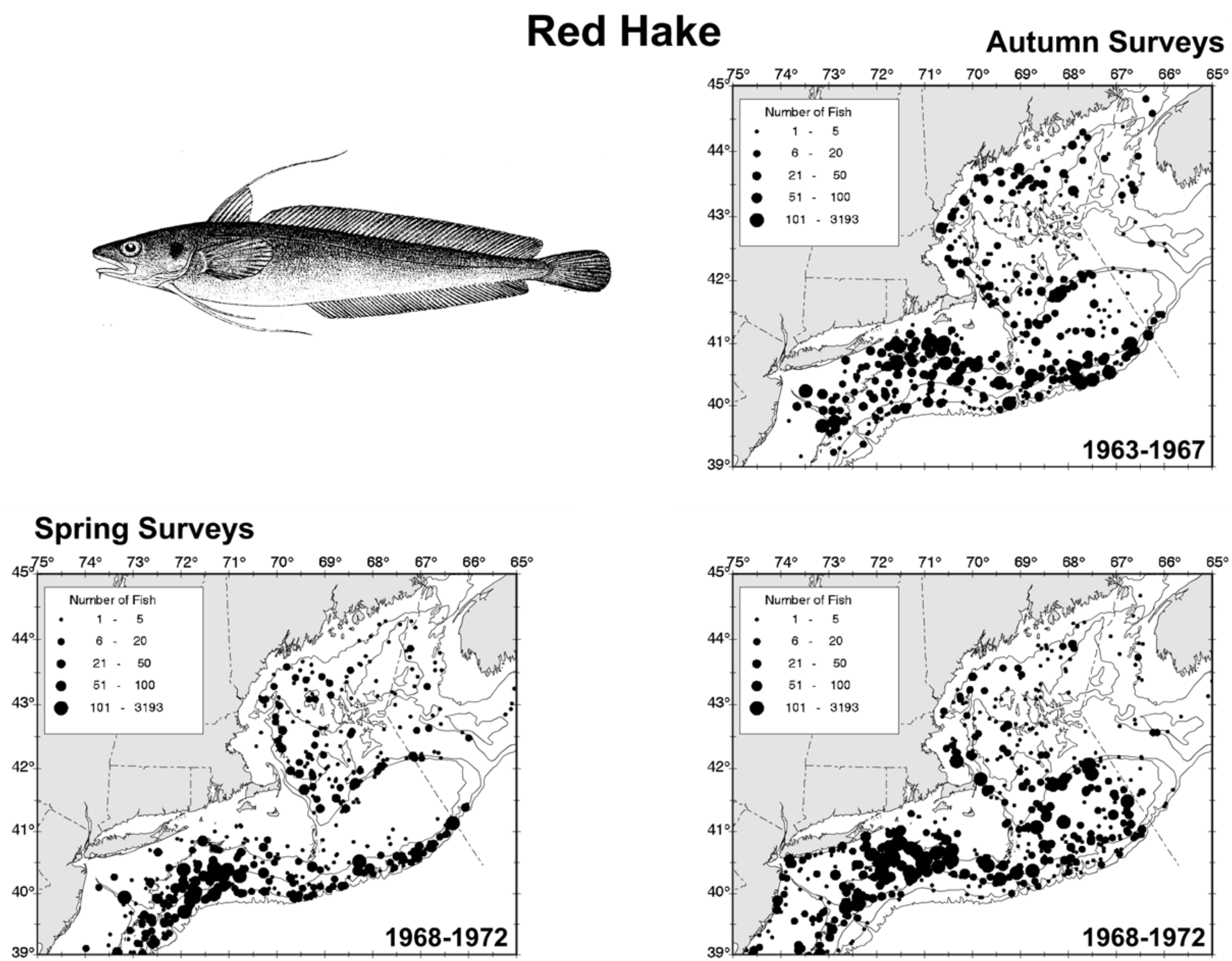

Figure C13a. Distribution of red hake in the NEFSC spring and autumn bottom trawl surveys from 1963-1972.

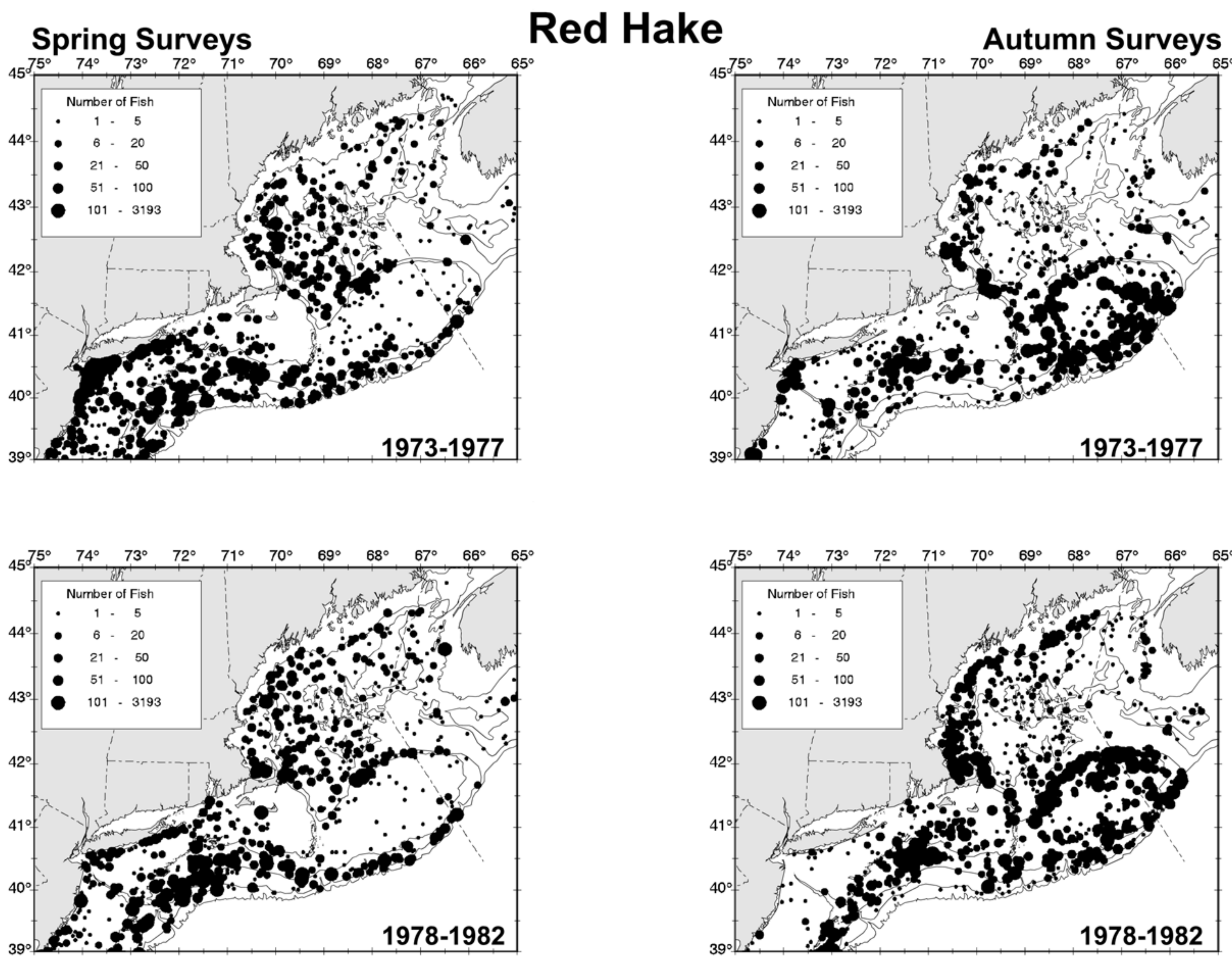

Figure C13b. Distribution of red hake in the NEFSC spring and autumn bottom trawl surveys from 1973-1982.

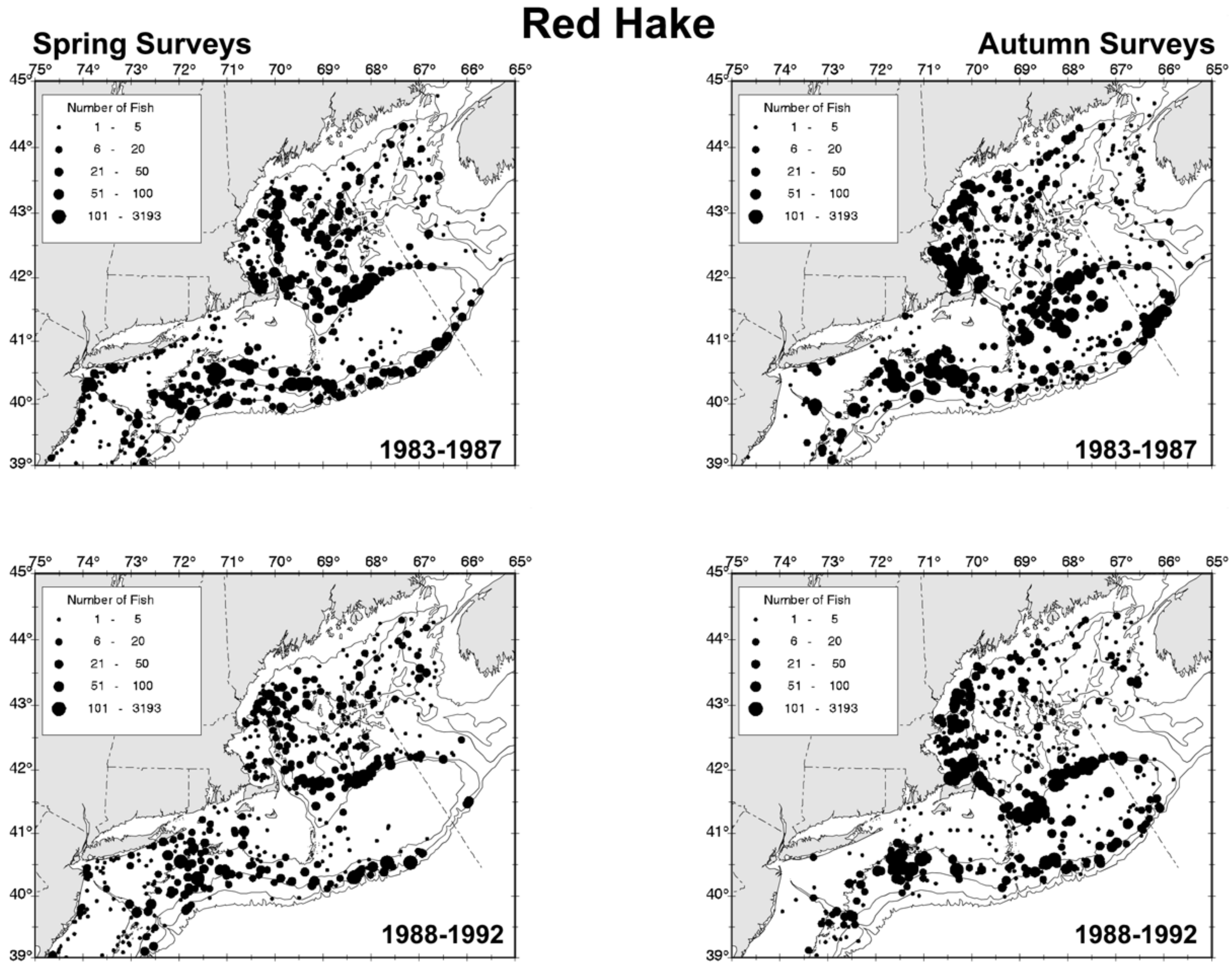

Figure C13c. Distribution of red hake in the NEFSC spring and autumn bottom trawl surveys from 1983-1992.

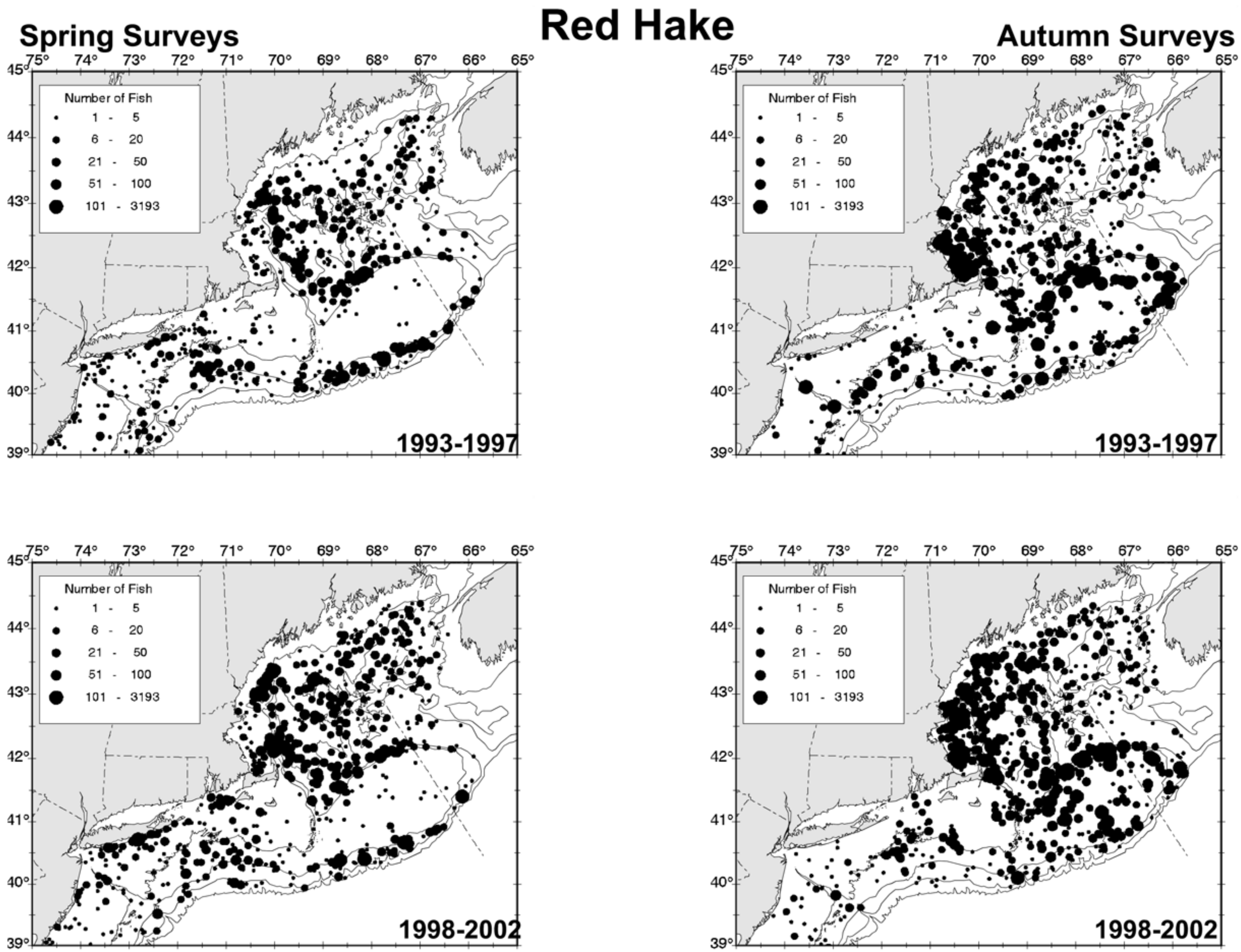

Figure C13d. Distribution of red hake in the NEFSC spring and autumn bottom trawl surveys from 1993-2002.

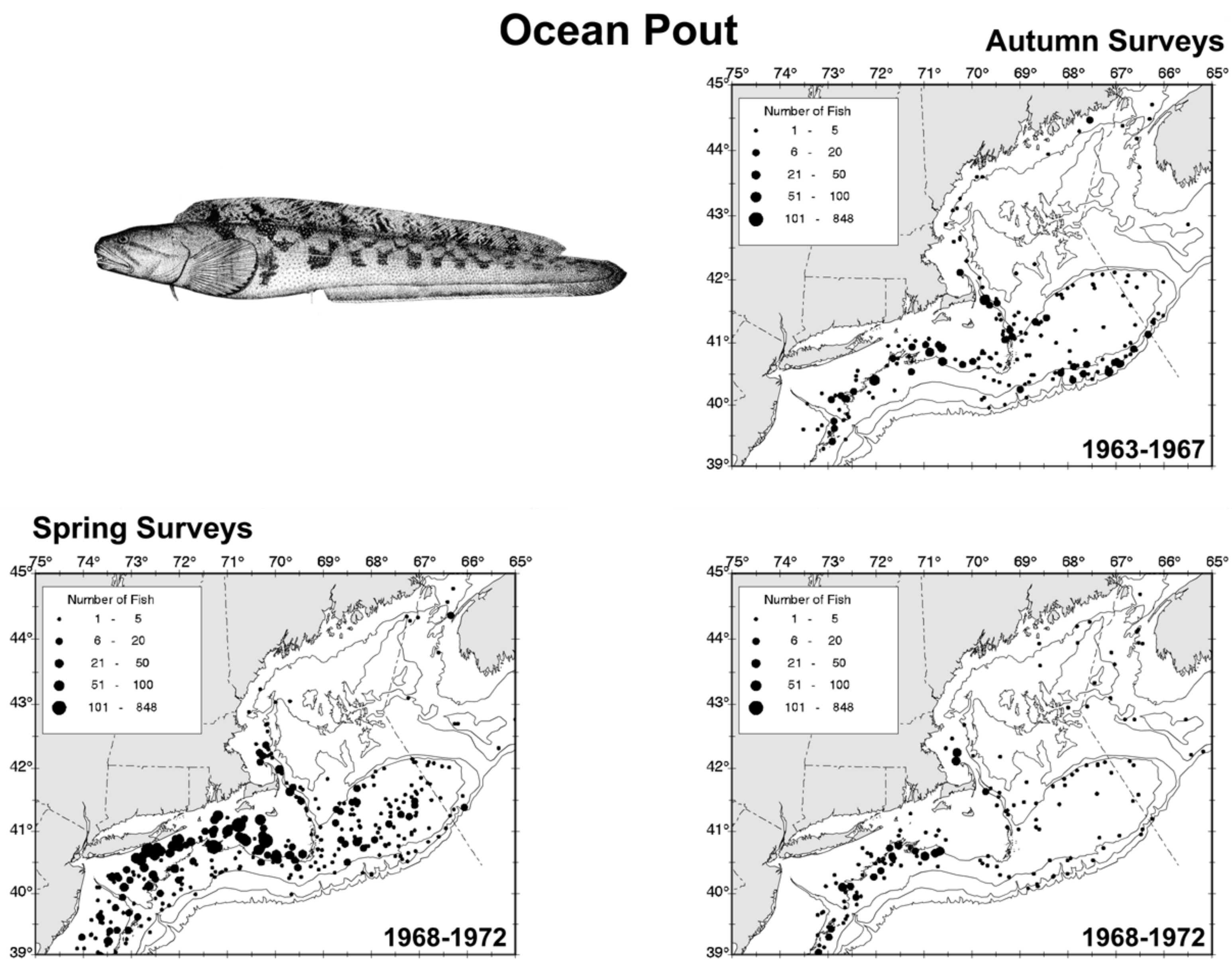

Figure C14a. Distribution of ocean pout in the NEFSC spring and autumn bottom trawl surveys from 1963-1972.

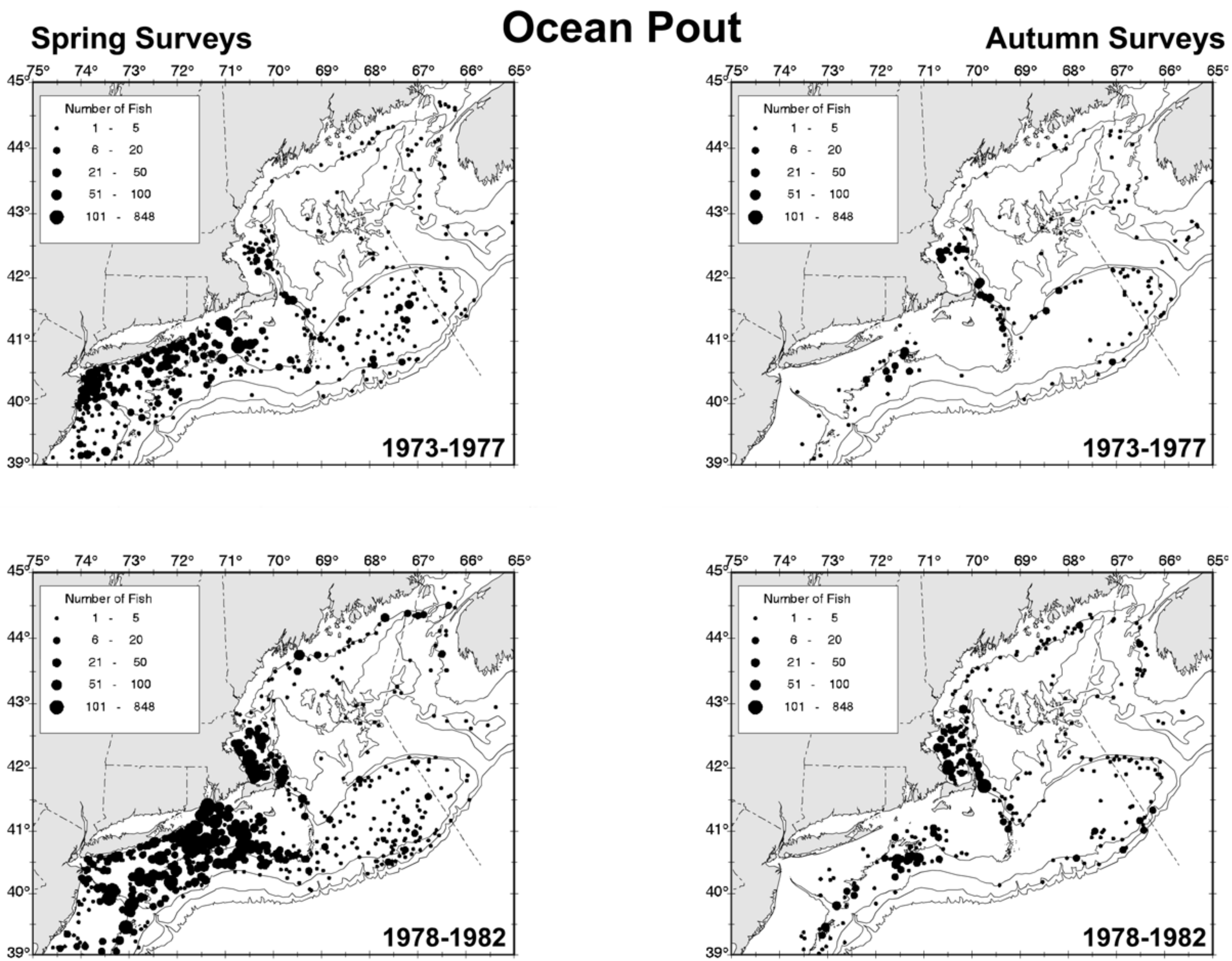

Figure C14b. Distribution of ocean pout in the NEFSC spring and autumn bottom trawl surveys from 1973-1982.

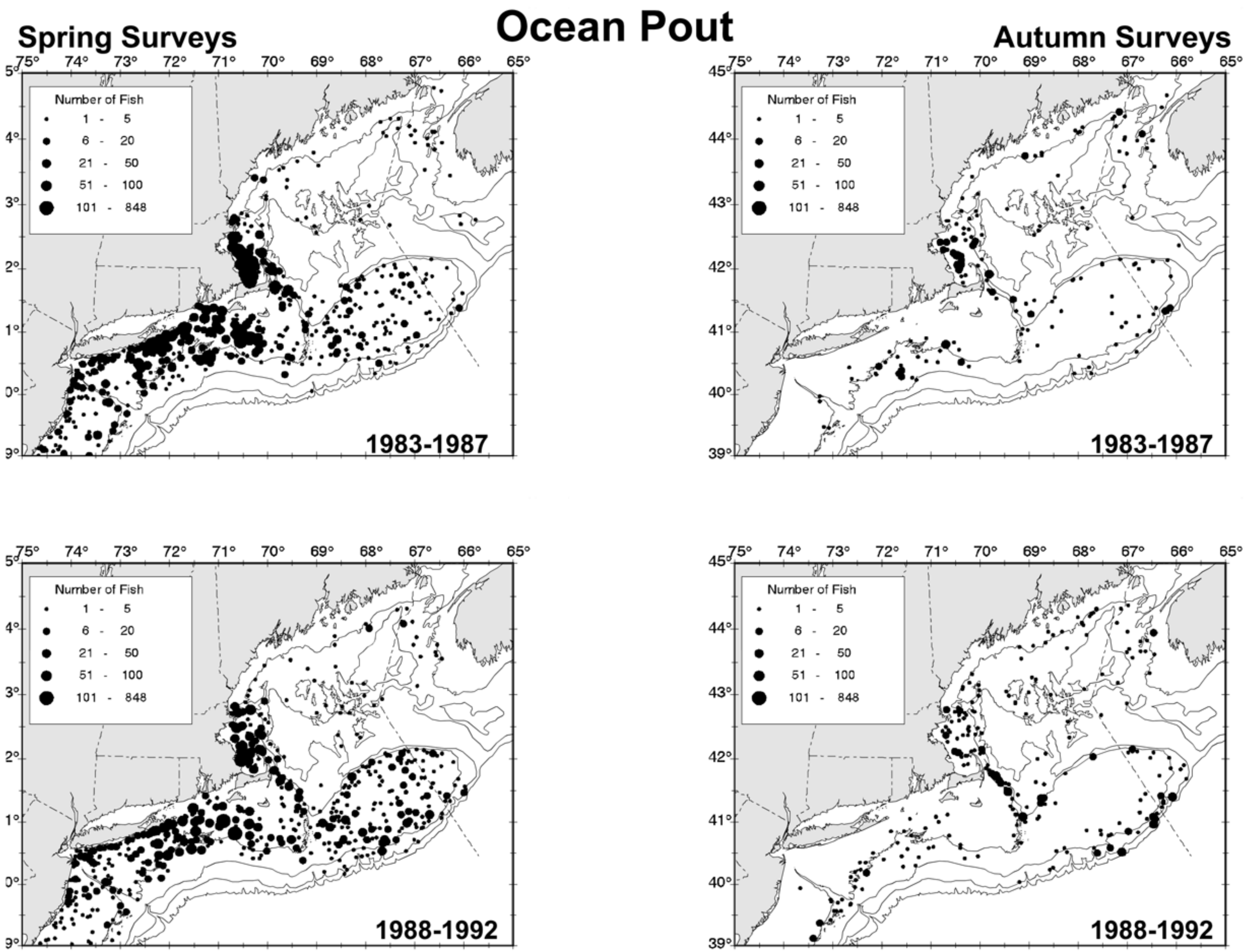

Figure C14c. Distribution of ocean pout in the NEFSC spring and autumn bottom trawl surveys from 1983-1992.

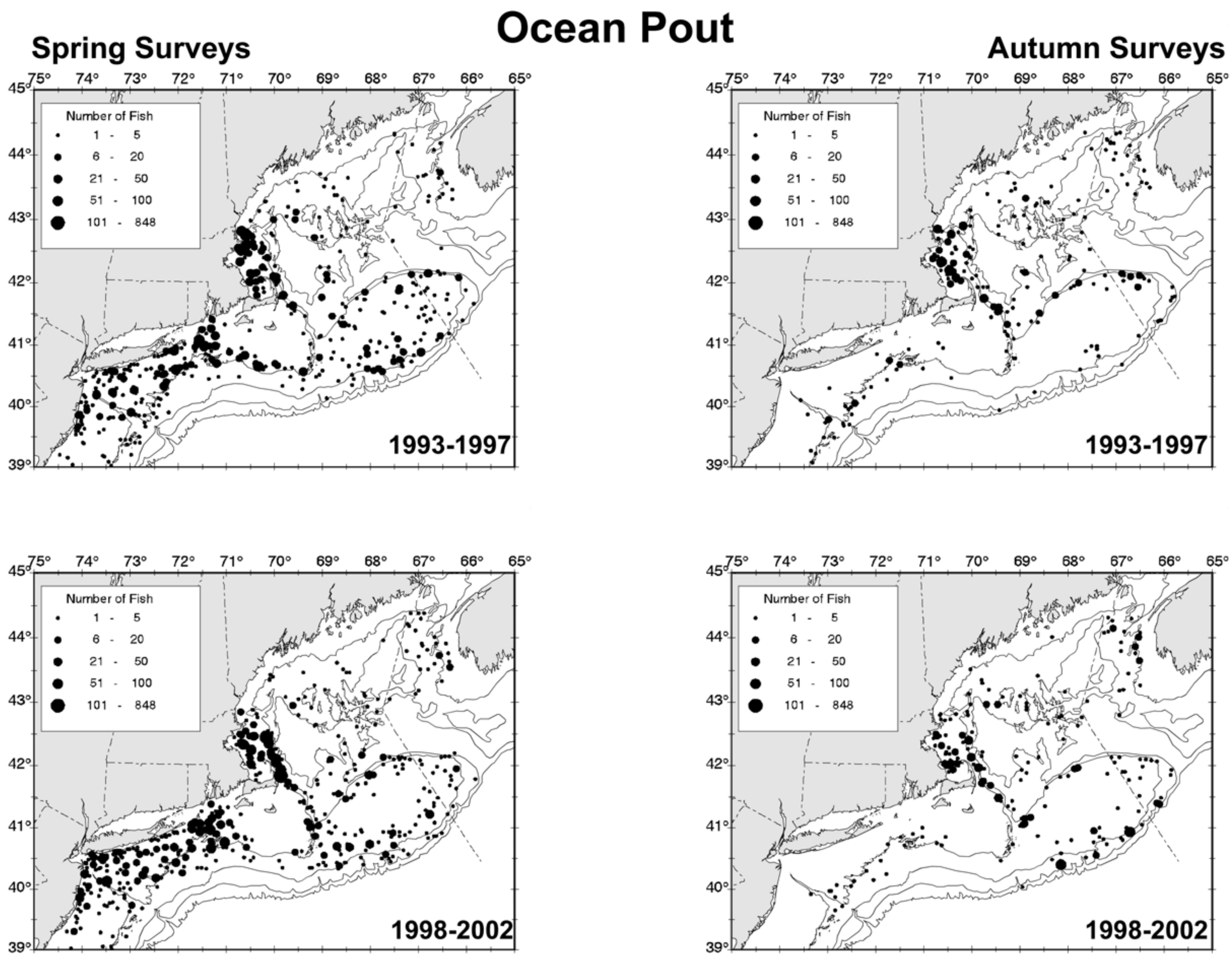

Figure C14d. Distribution of ocean pout in the NEFSC spring and autumn bottom trawl surveys from 1993-2002.

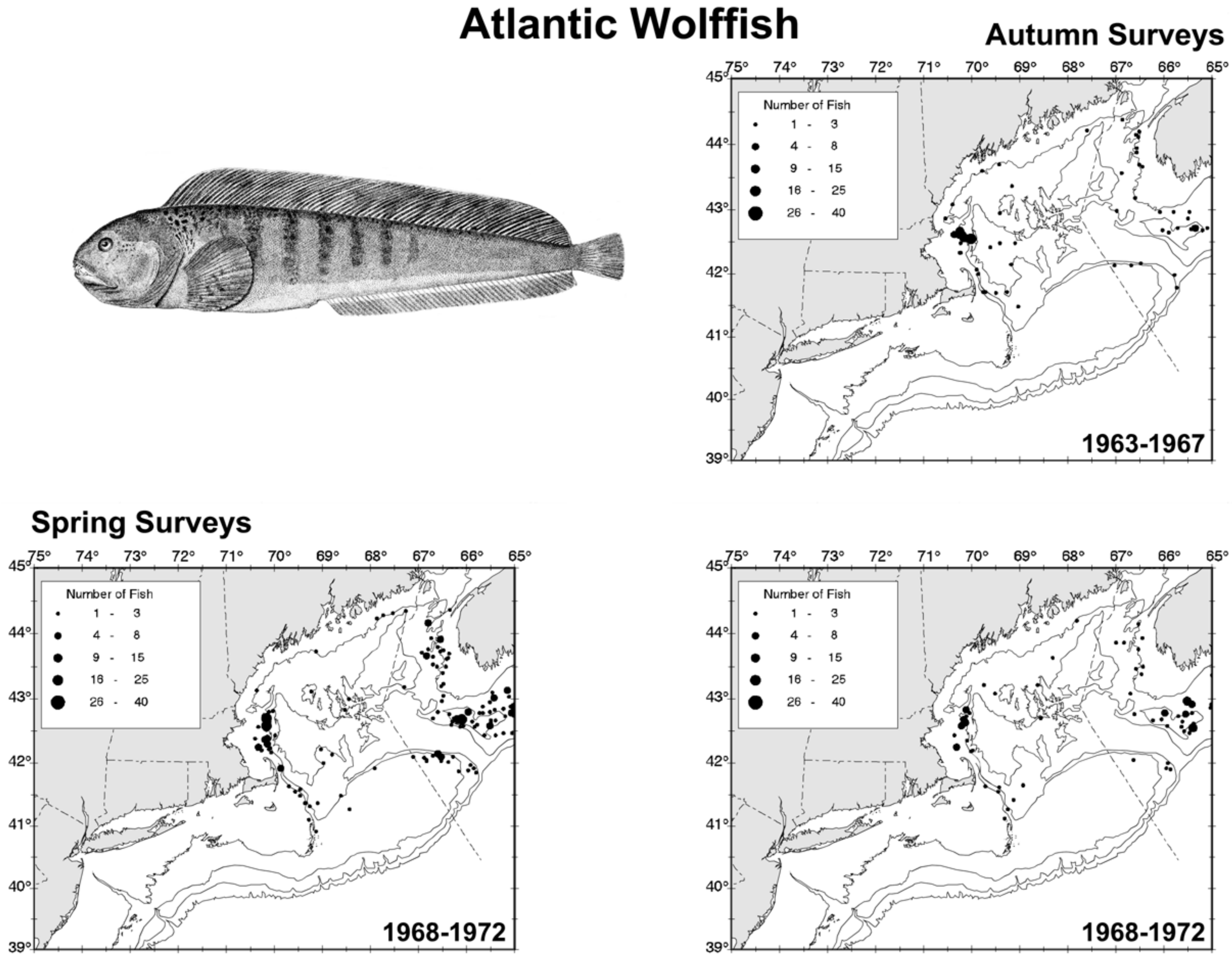

Figure C15a. Distribution of Atlantic wolffish in the NEFSC spring and autumn bottom trawl surveys from 1963-1972.

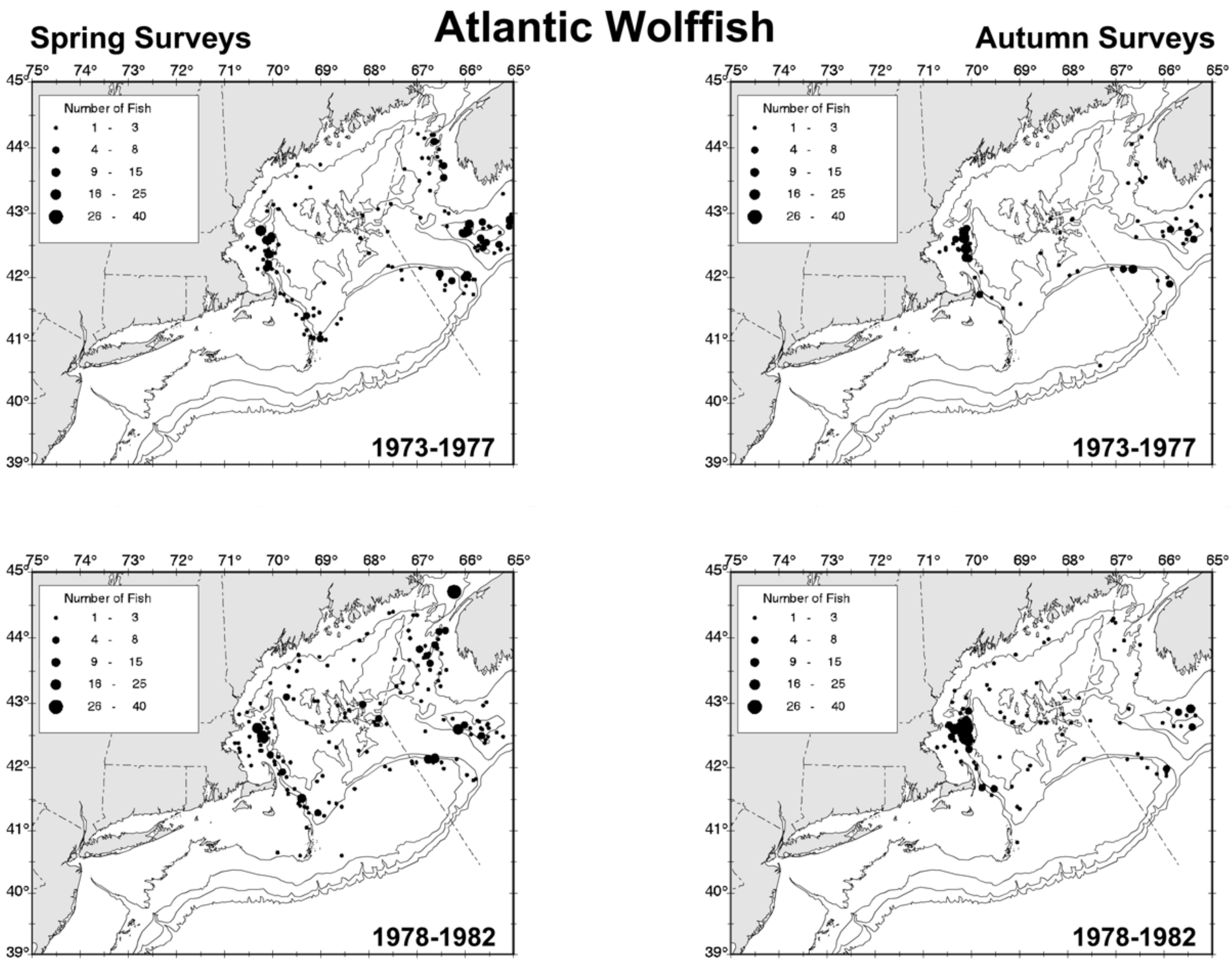

Figure C15b. Distribution of Atlantic wolffish in the NEFSC spring and autumn bottom trawl surveys from 1973-1982.

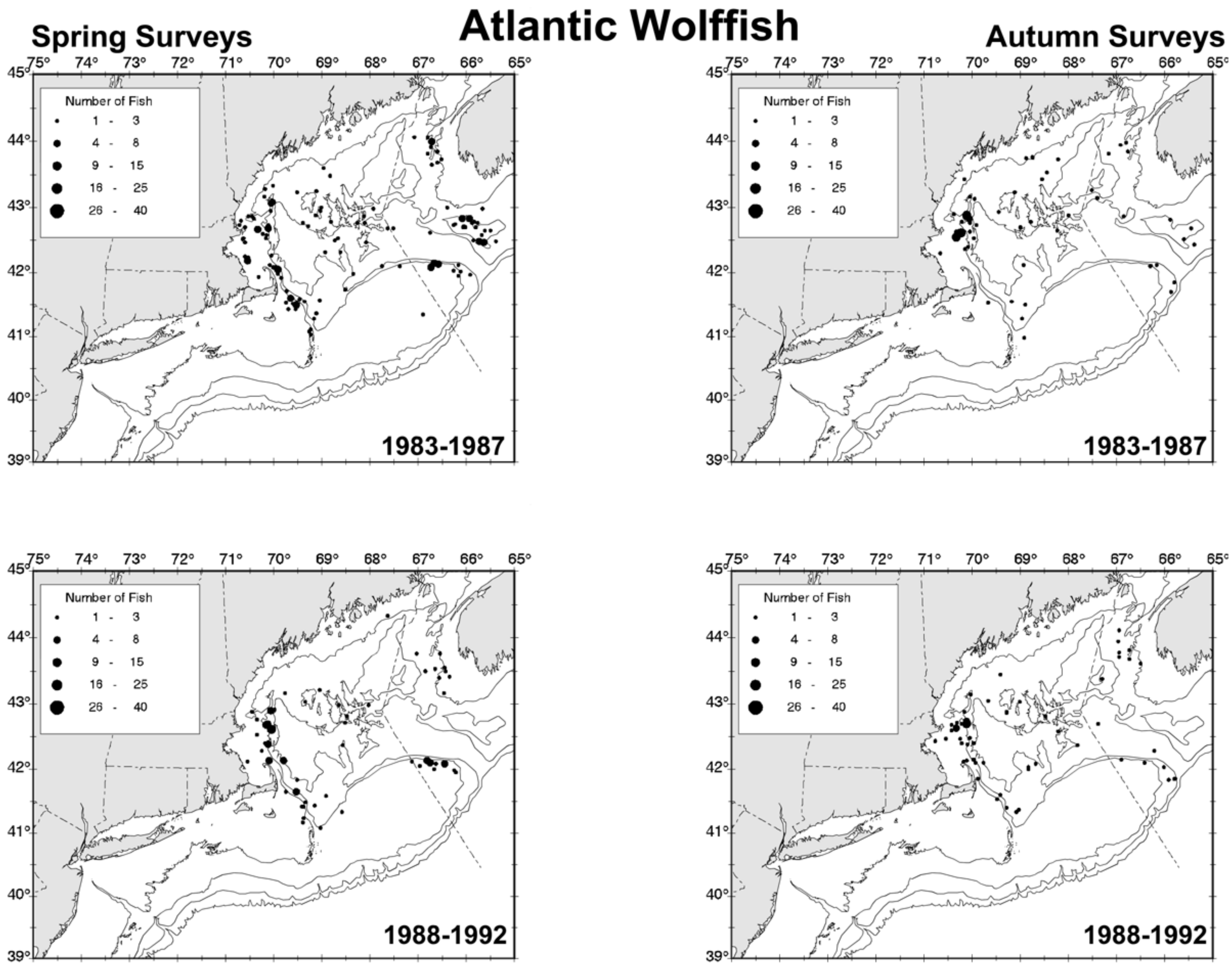

Figure C15c. Distribution of Atlantic wolffish in the NEFSC spring and autumn bottom trawl surveys from 1983-1992.

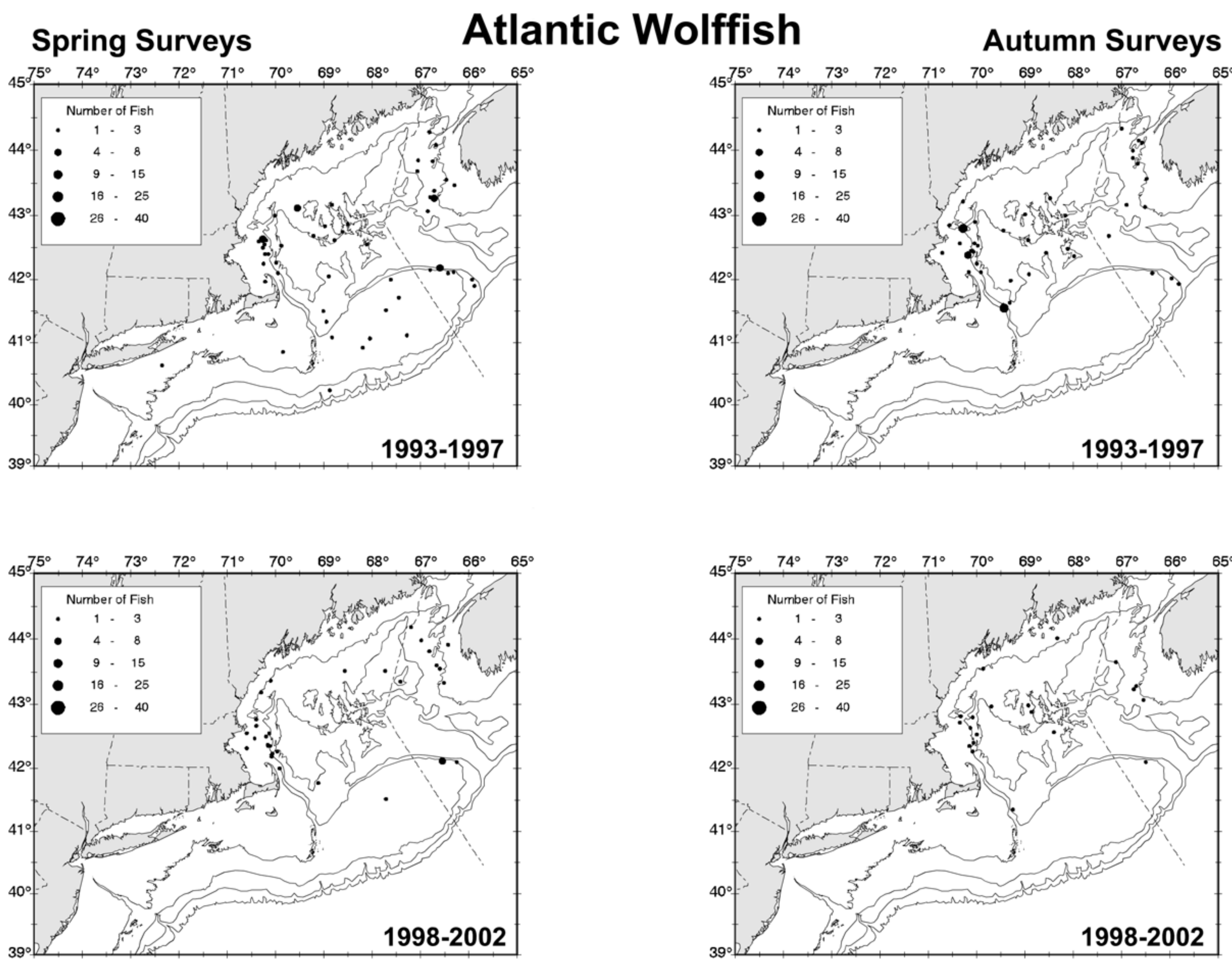

Figure C15d. Distribution of Atlantic wolffish in the NEFSC spring and autumn bottom trawl surveys from 1993-2002.

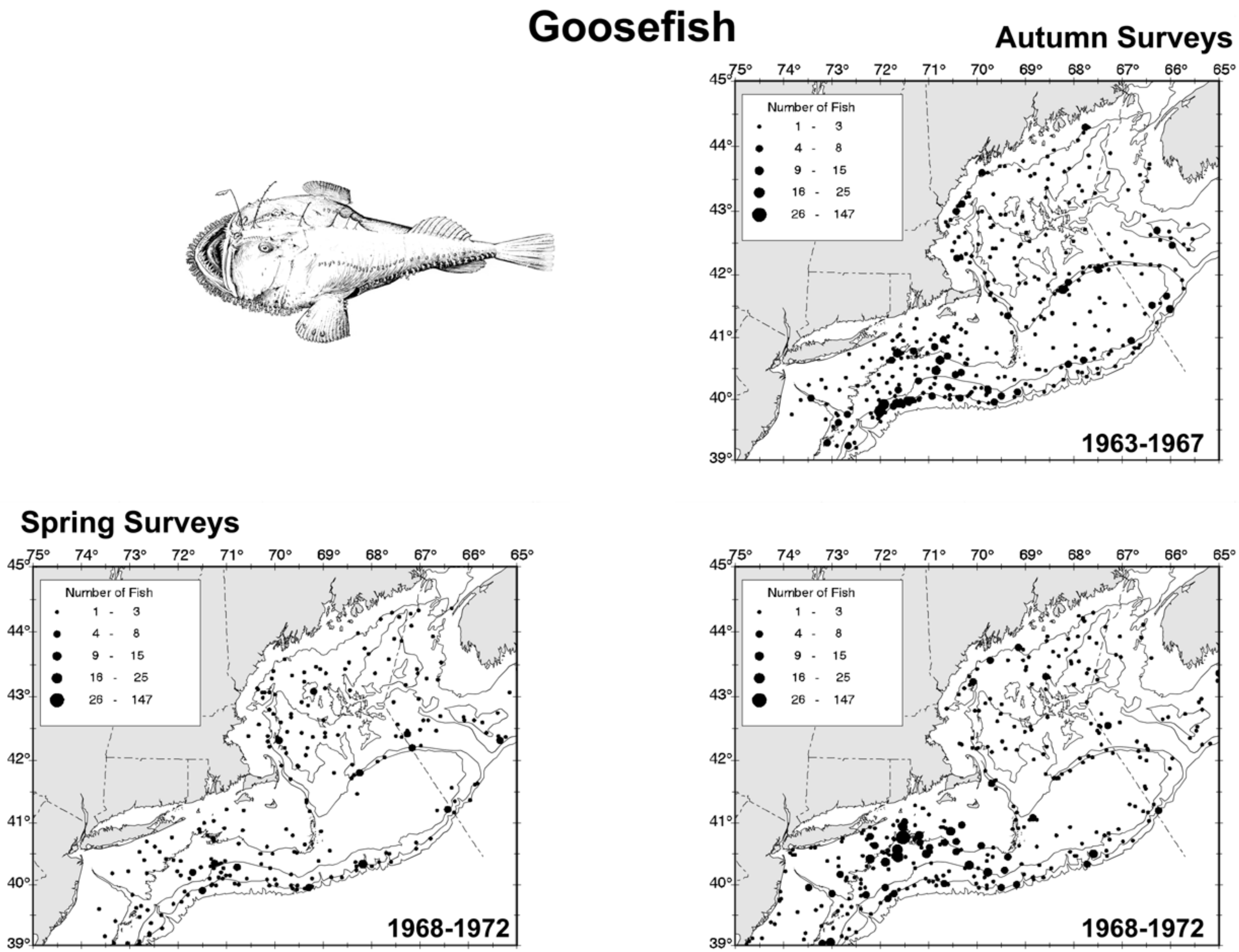

Figure C16a. Distribution of goosefish in the NEFSC spring and autumn bottom trawl surveys from 1963-1972.

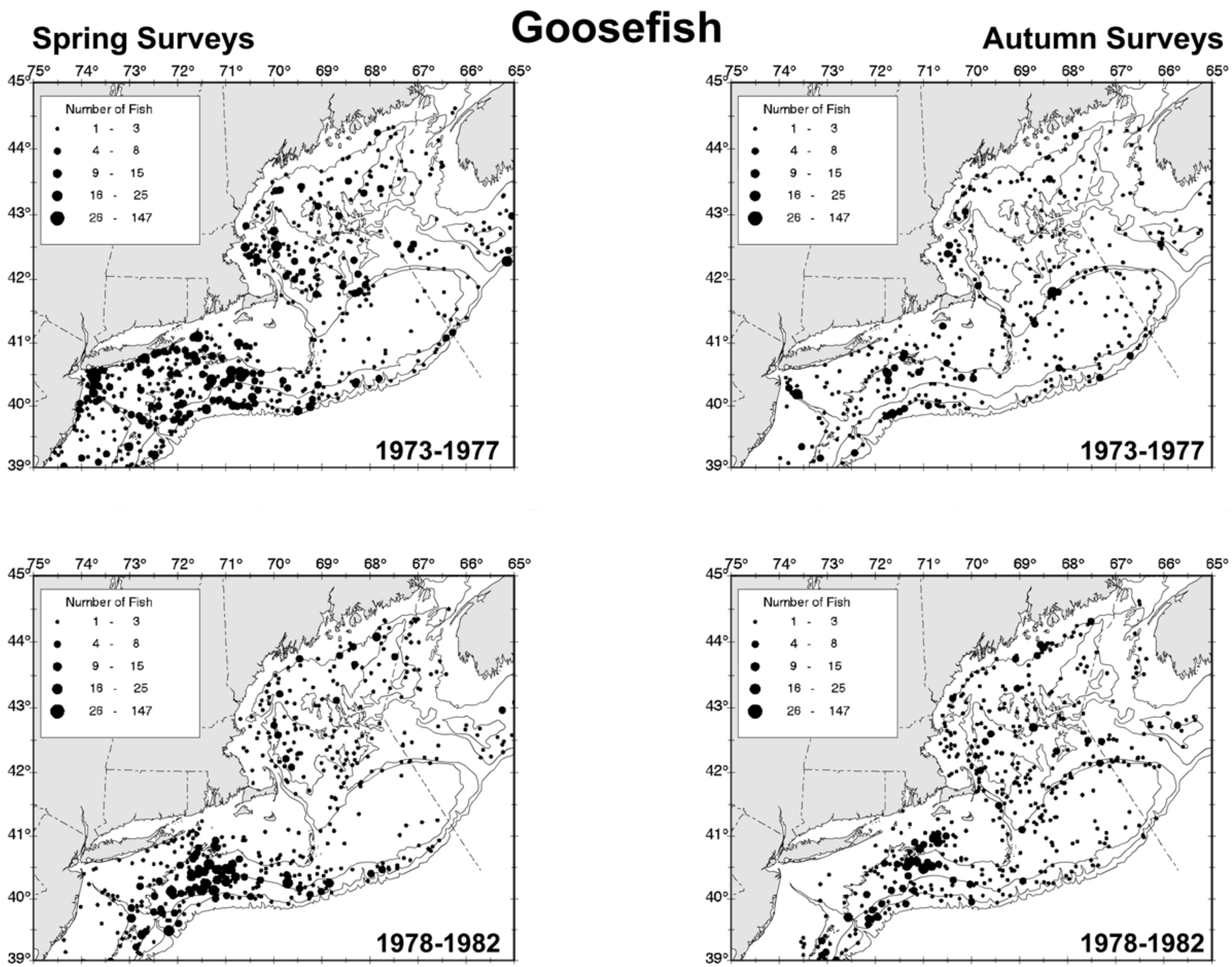

Figure C16b. Distribution of goosefish in the NEFSC spring and autumn bottom trawl surveys from 1973-1982.

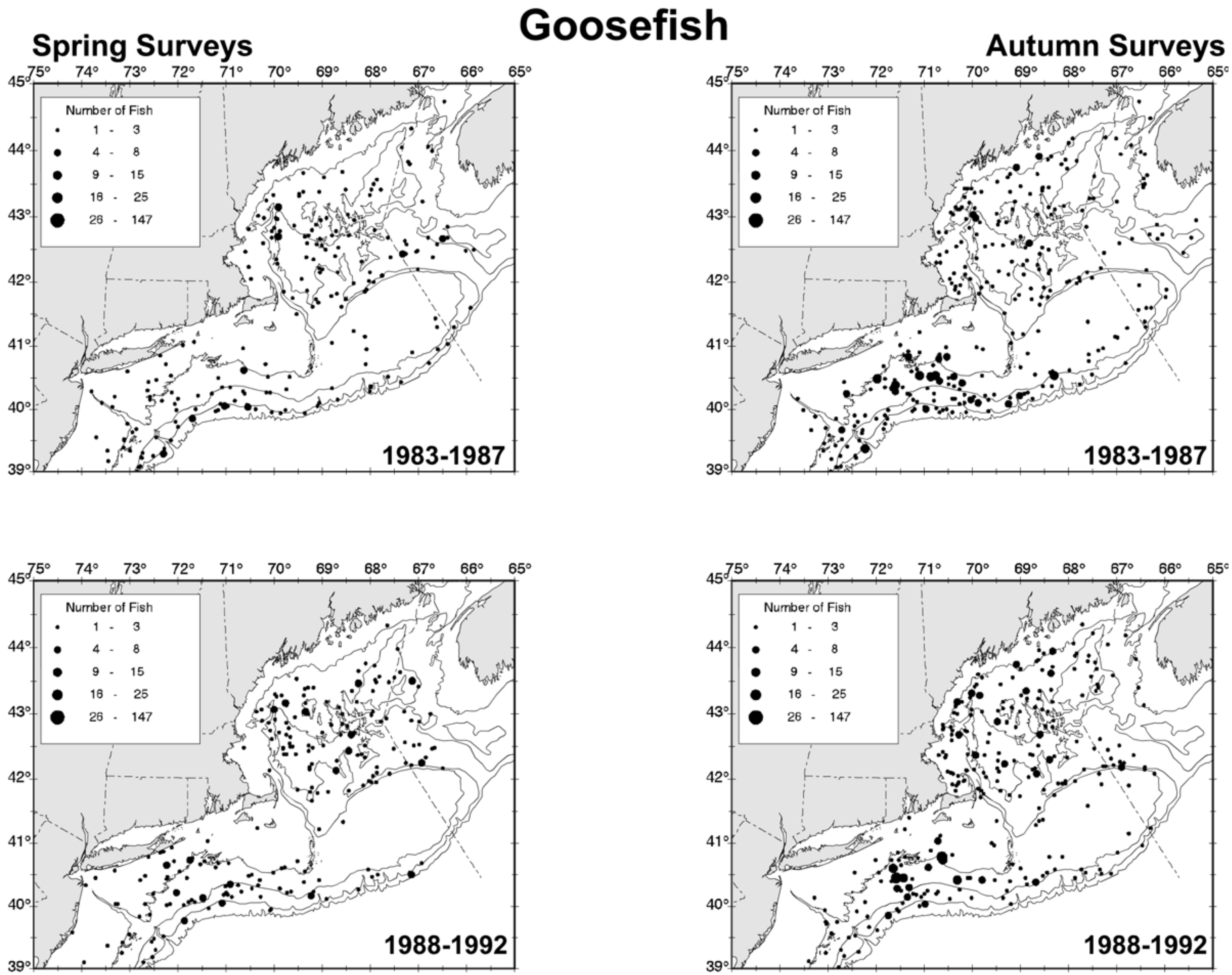

Figure C16c. Distribution of goosefish in the NEFSC spring and autumn bottom trawl surveys from 1983-1992.

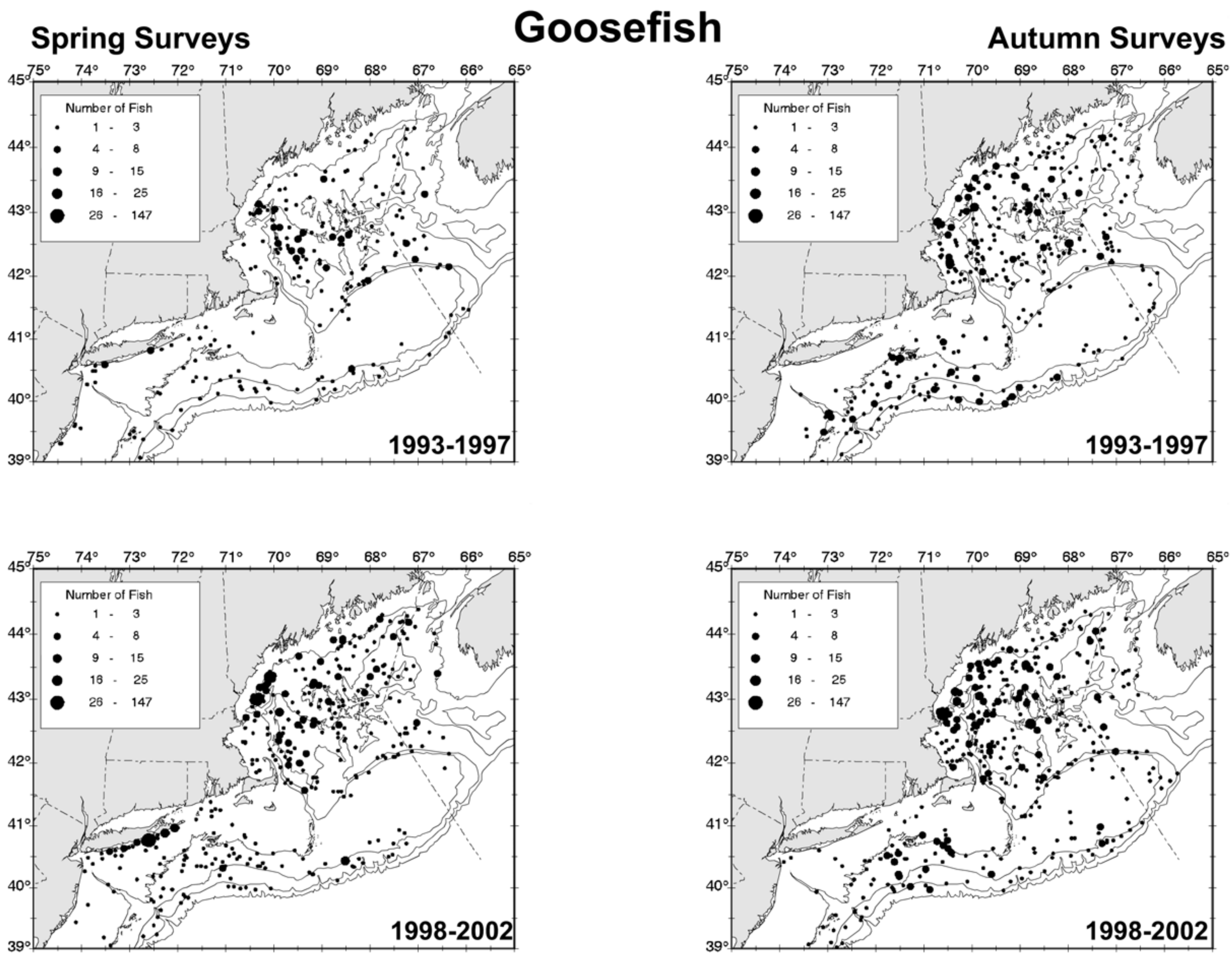

Figure C16d. Distribution of goosefish in the NEFSC spring and autumn bottom trawl surveys from 1993-2002.

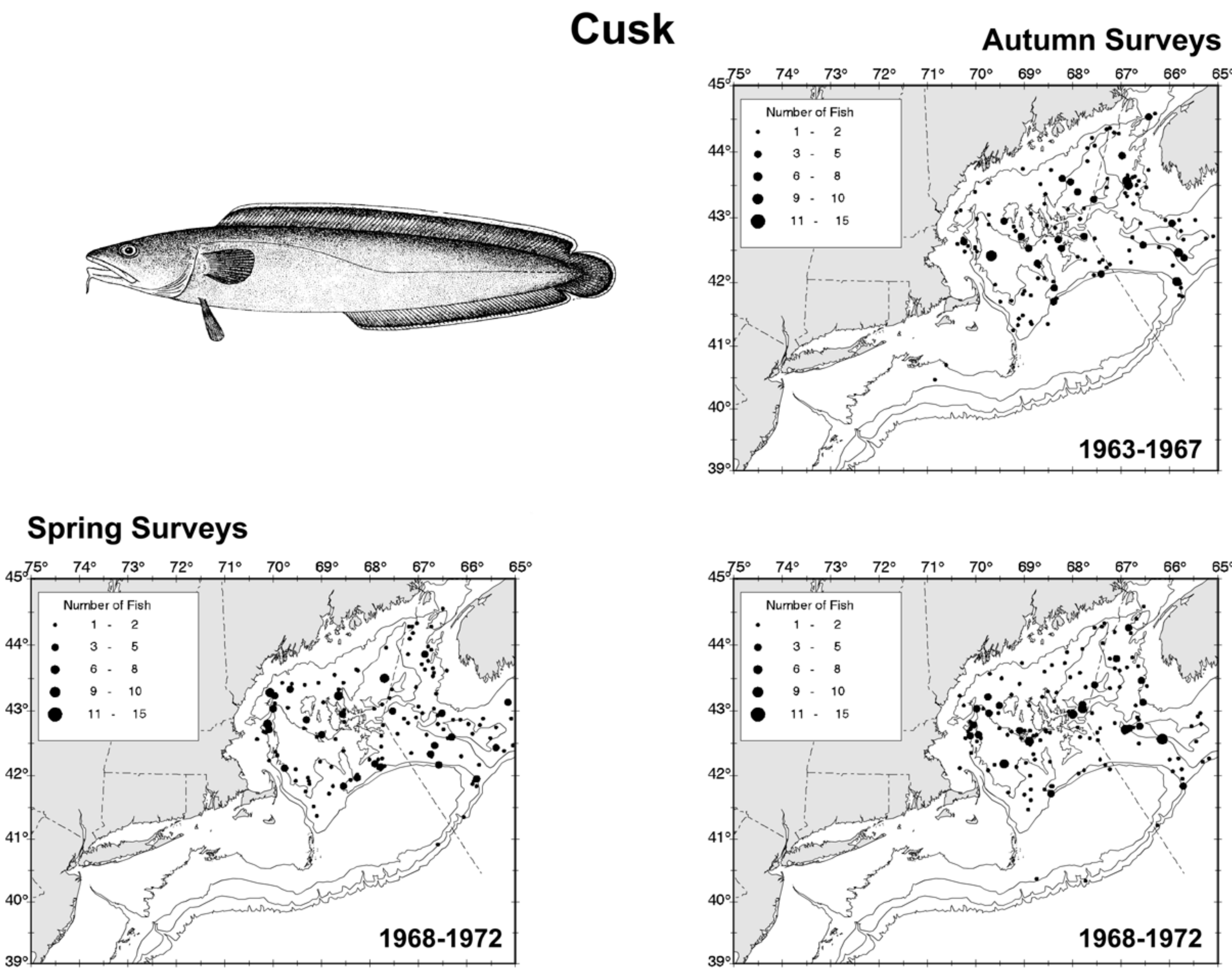

Figure C17a. Distribution of cusk in the NEFSC spring and autumn bottom trawl surveys from 1963-1972.

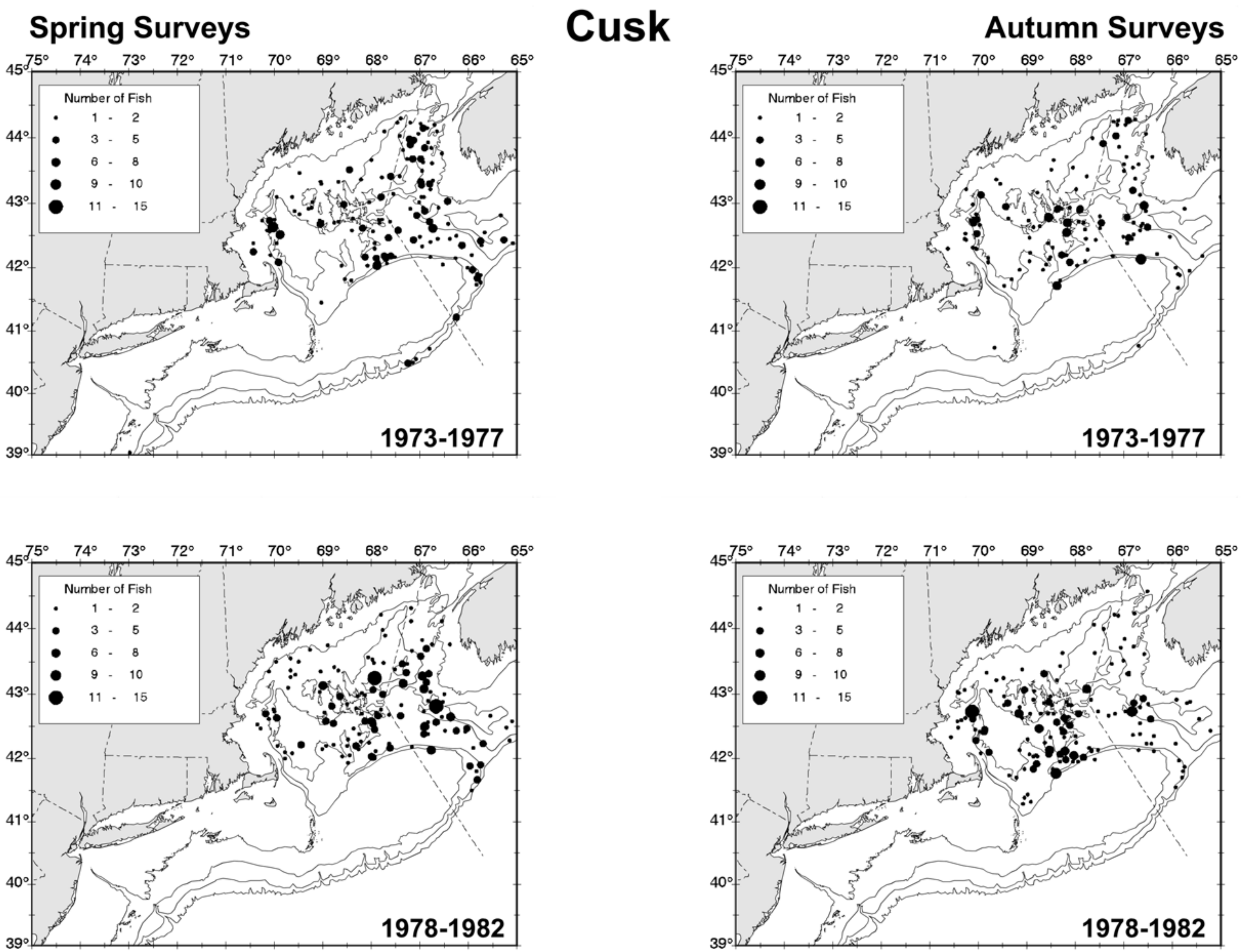

Figure C17b. Distribution of cusk in the NEFSC spring and autumn bottom trawl surveys from 1973-1982.

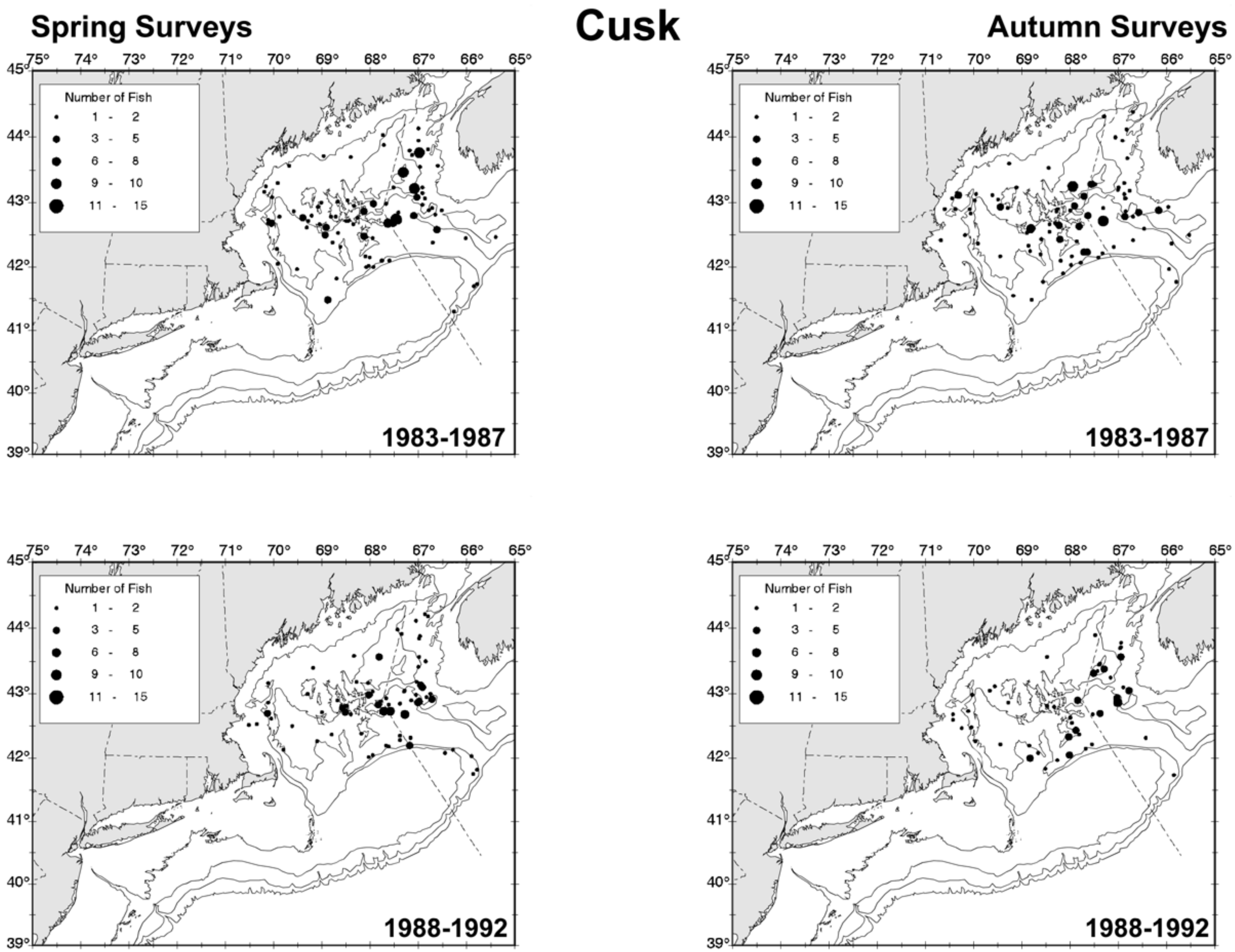

Figure C17c. Distribution of cusk in the NEFSC spring and autumn bottom trawl surveys from 1983-1992.

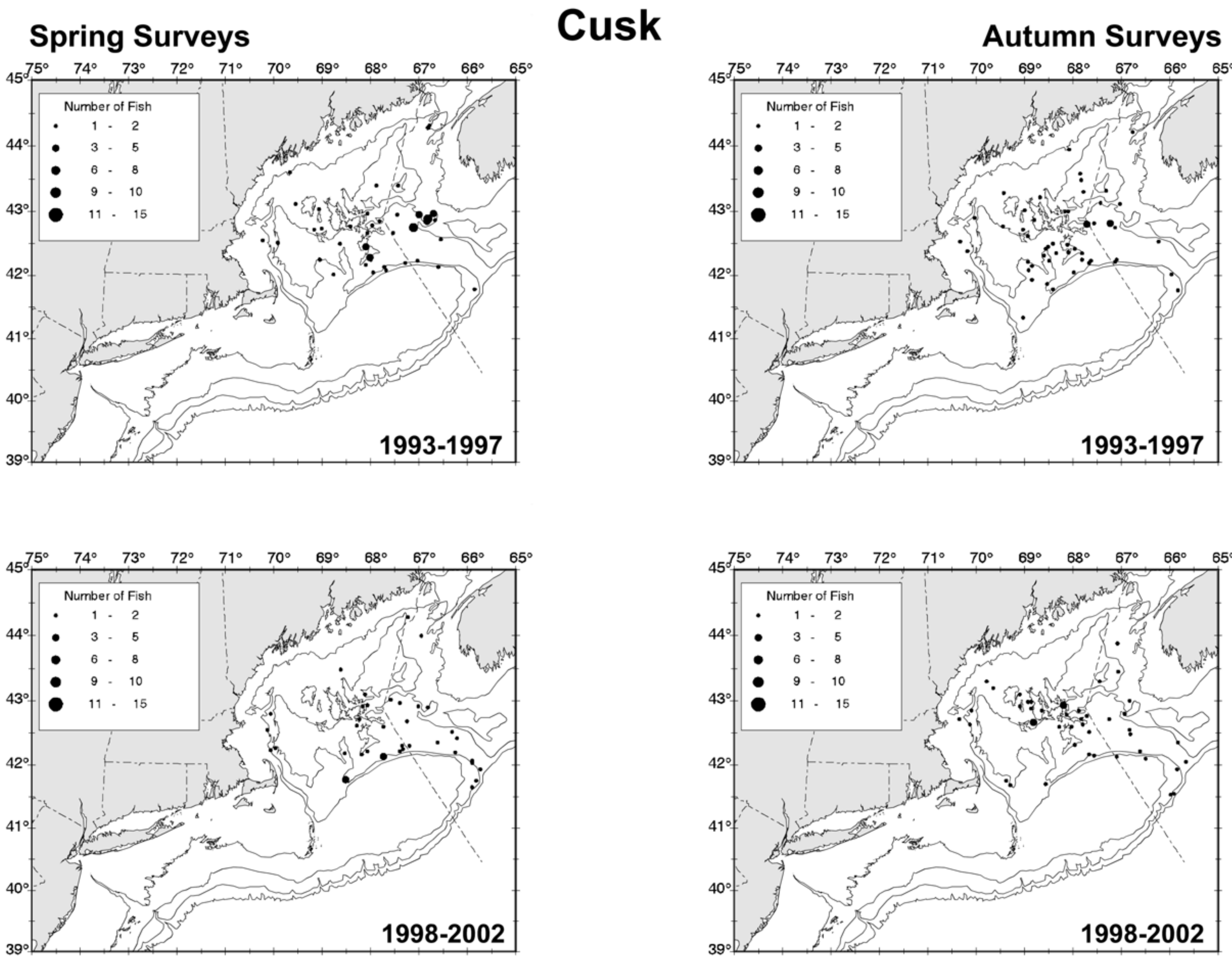

Figure C17d. Distribution of cusk in the NEFSC spring and autumn bottom trawl surveys from 1993-2002.

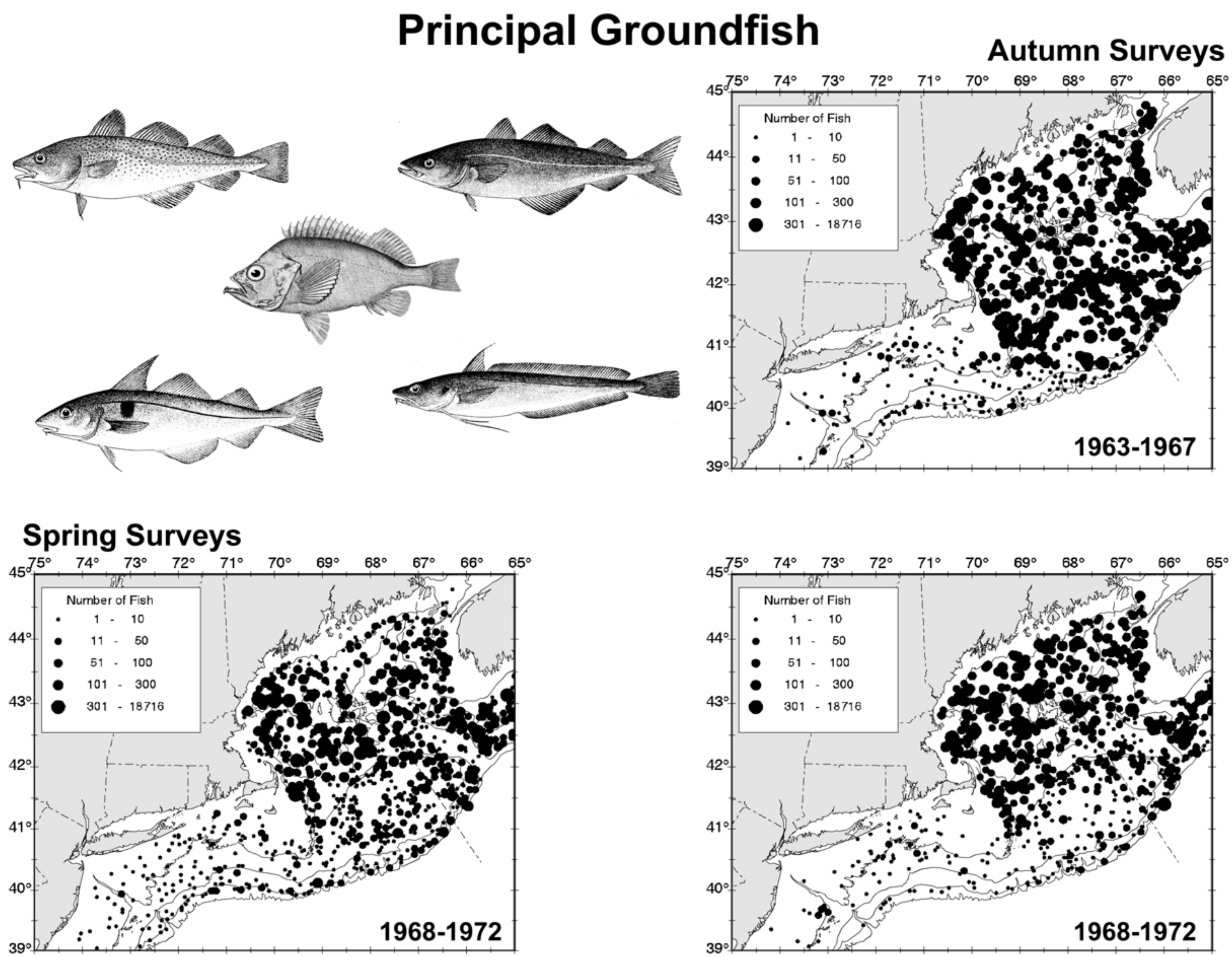

Figure C18a. Distribution of principal groundfish (Atlantic cod, haddock, pollock, Acadian redfish, and white hake) in the NEFSC spring and autumn bottom trawl surveys from 1963-1972.

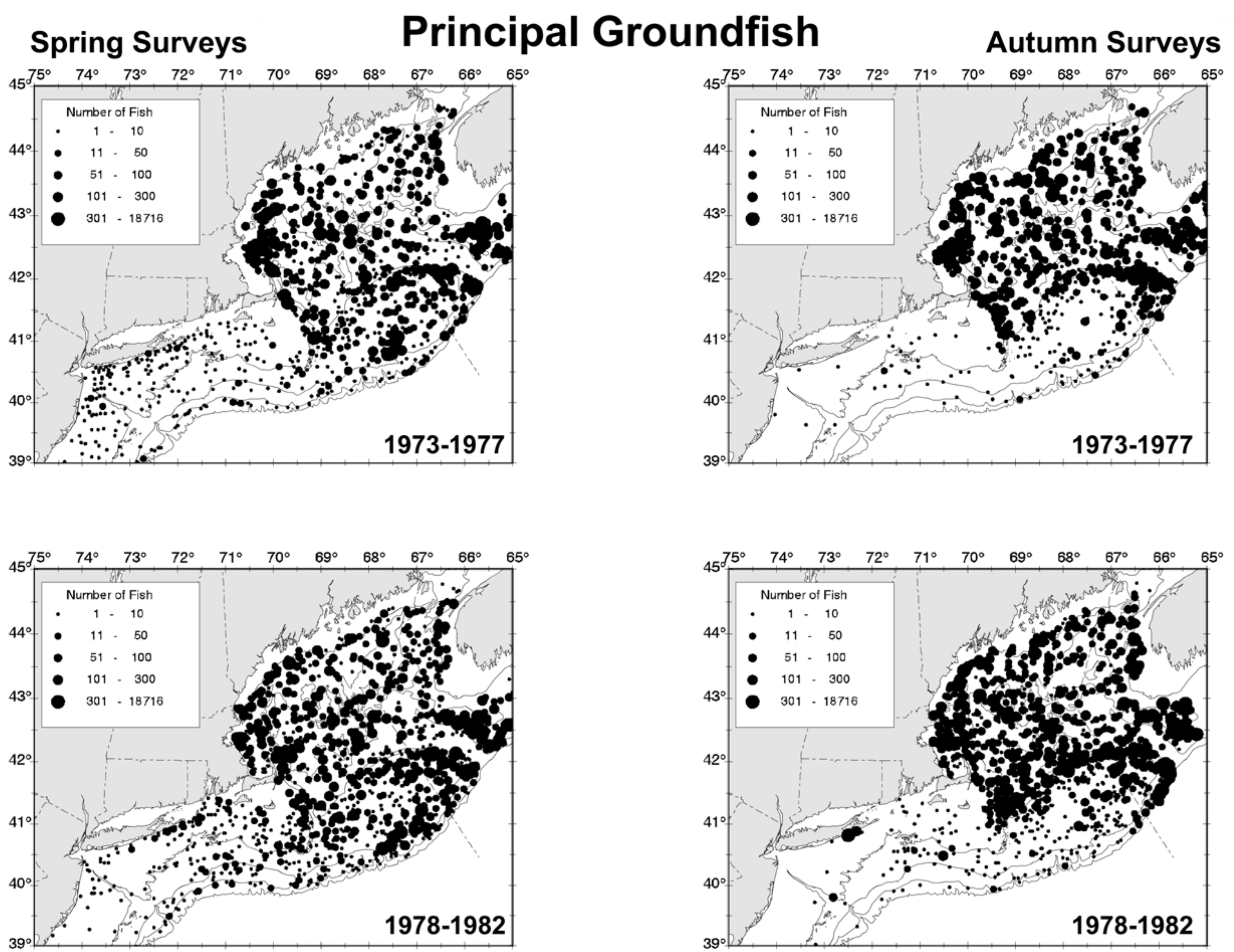

Figure C18b. Distribution of principal groundfish (Atlantic cod, haddock, pollock, Acadian redfish, and white hake) in the NEFSC spring and autumn bottom trawl surveys from 1973-1982.

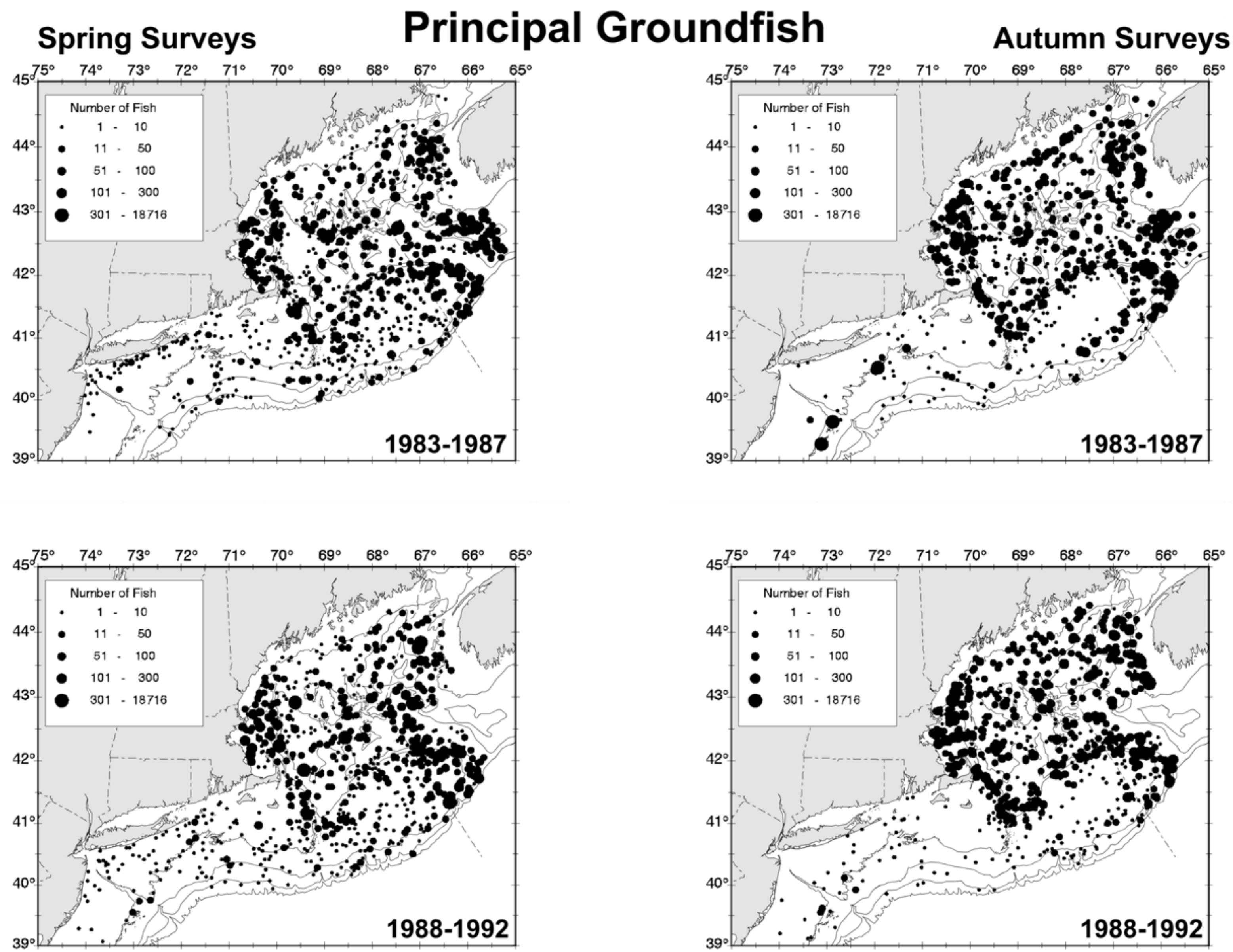

Figure C18c. Distribution of principal groundfish (Atlantic cod, haddock, pollock, Acadian redfish, and white hake) in the NEFSC spring and autumn bottom trawl surveys from 1983-1992.

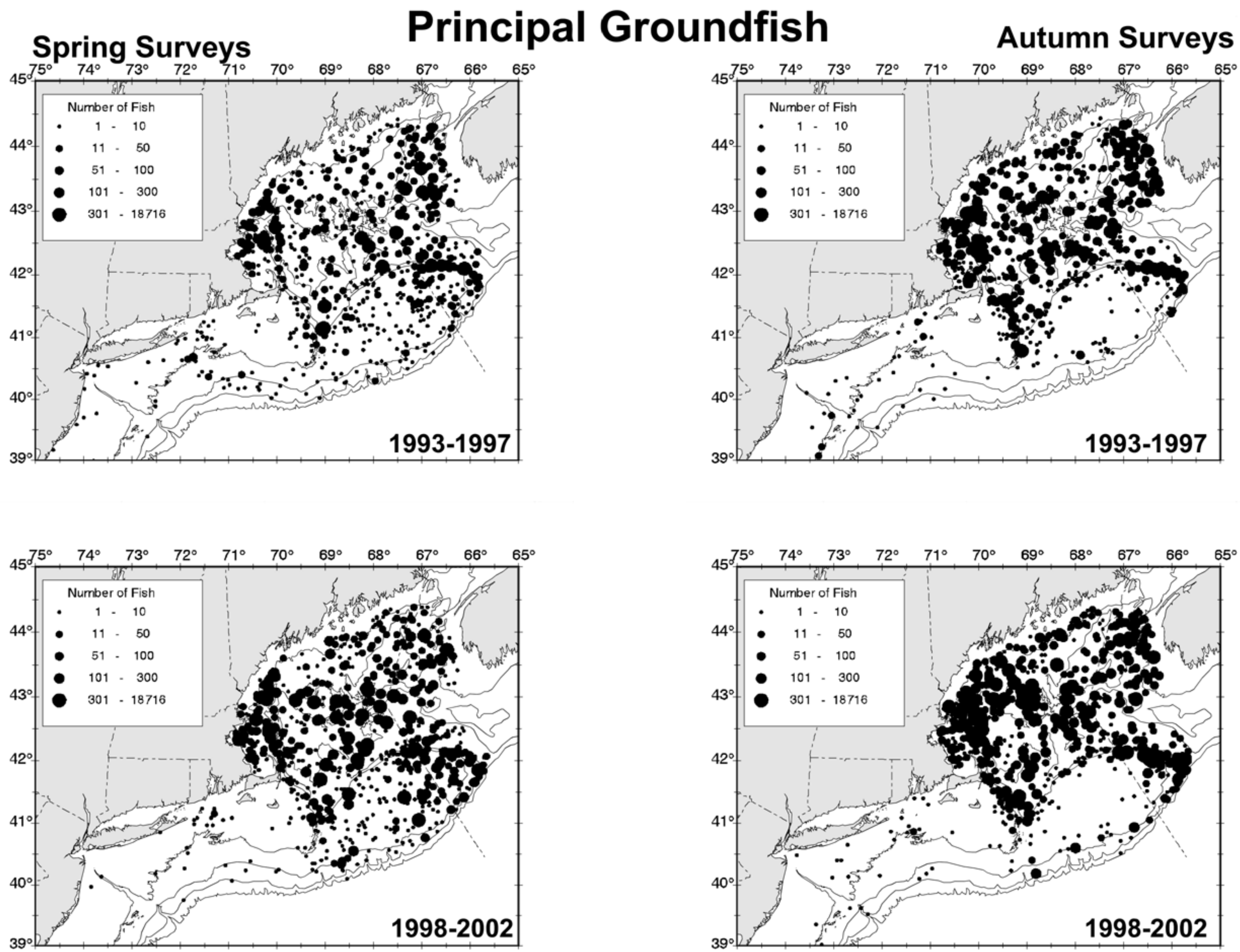

Figure C18d. Distribution of principal groundfish (Atlantic cod, haddock, pollock, Acadian redfish, and white hake) in the NEFSC spring and autumn bottom trawl surveys from 1993-2002.

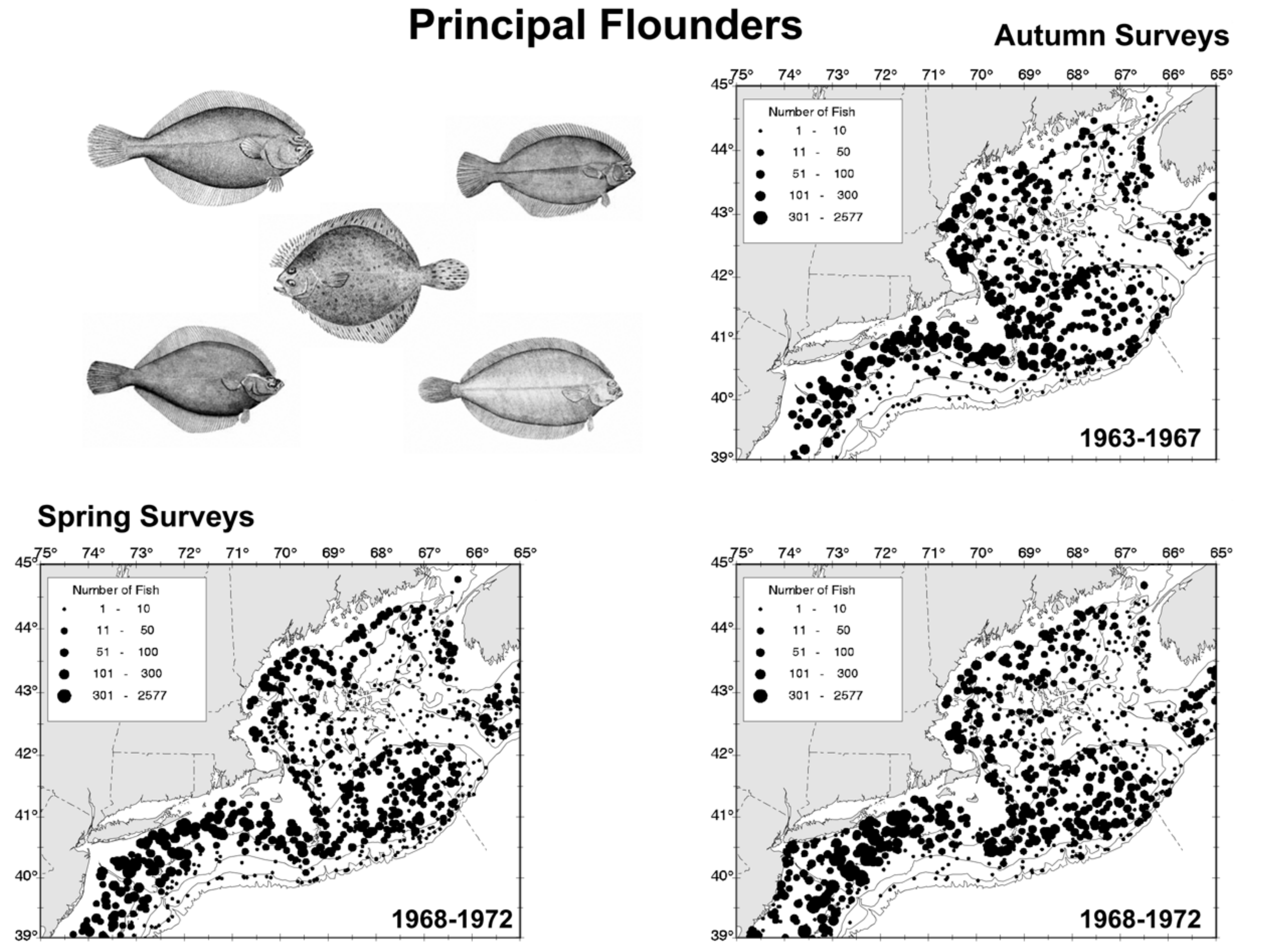

Figure C19a. Distribution of principal flounders (yellowtail flounder, American plaice, witch flounder, winter flounder, and windowpane flounder) in the NEFSC spring and autumn bottom trawl surveys from 1963-1972.

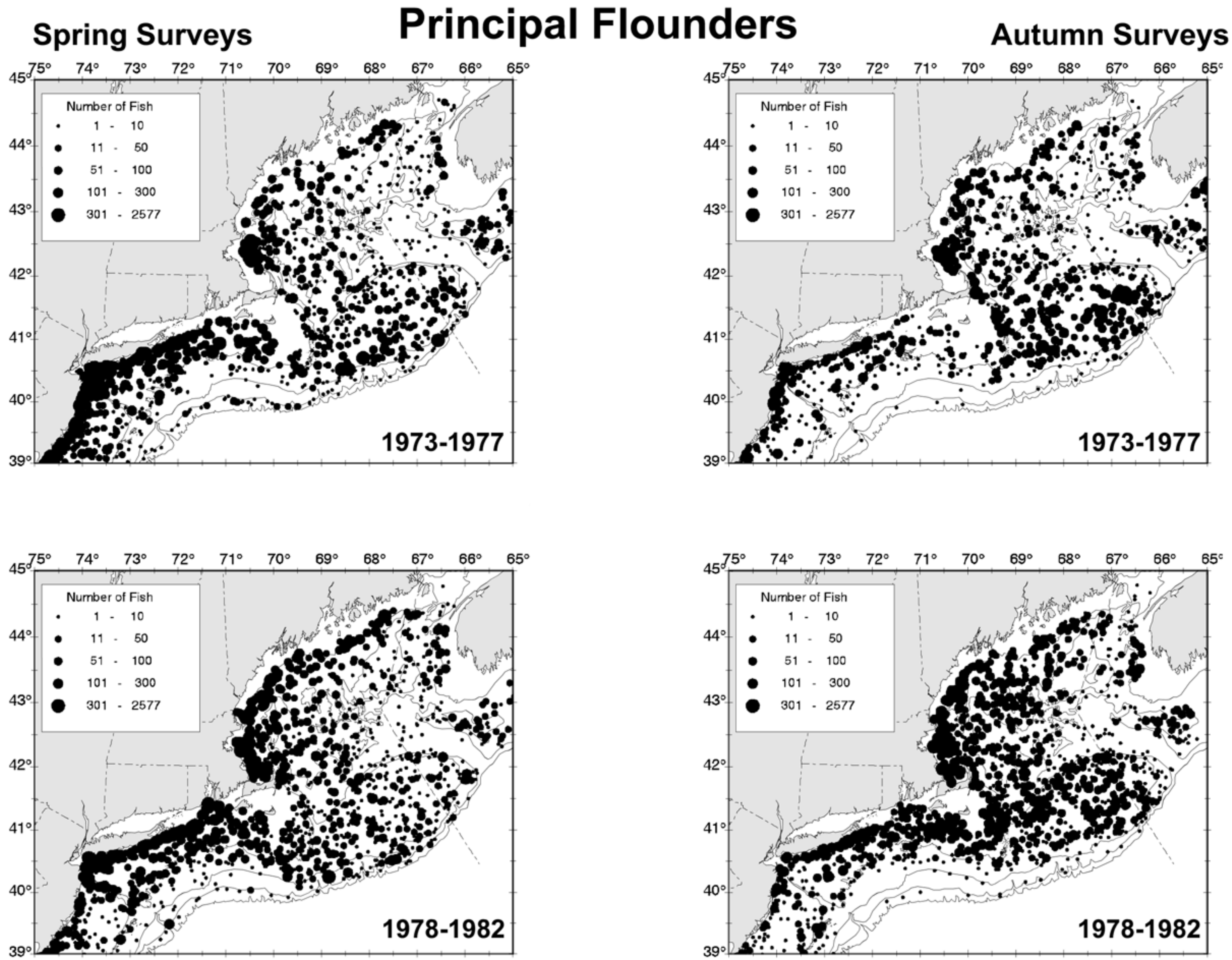

Figure C19b. Distribution of principal flounders (yellowtail flounder, American plaice, witch flounder, winter flounder, and windowpane flounder) in the NEFSC spring and autumn bottom trawl surveys from 1973-1982.

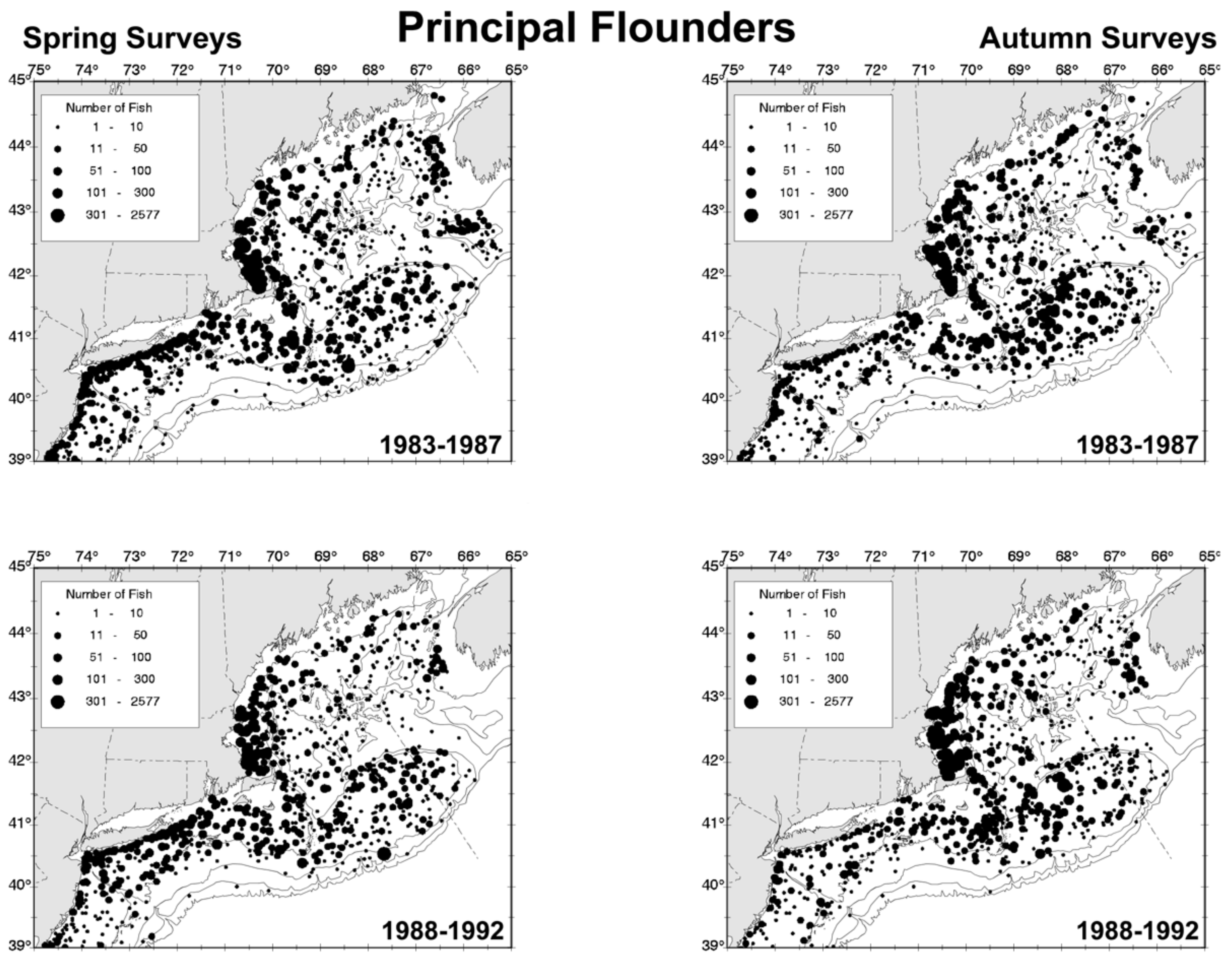

Figure C19c. Distribution of principal flounders (yellowtail flounder, American plaice, witch flounder, winter flounder, and windowpane flounder) in the NEFSC spring and autumn bottom trawl surveys from 1983-1992.

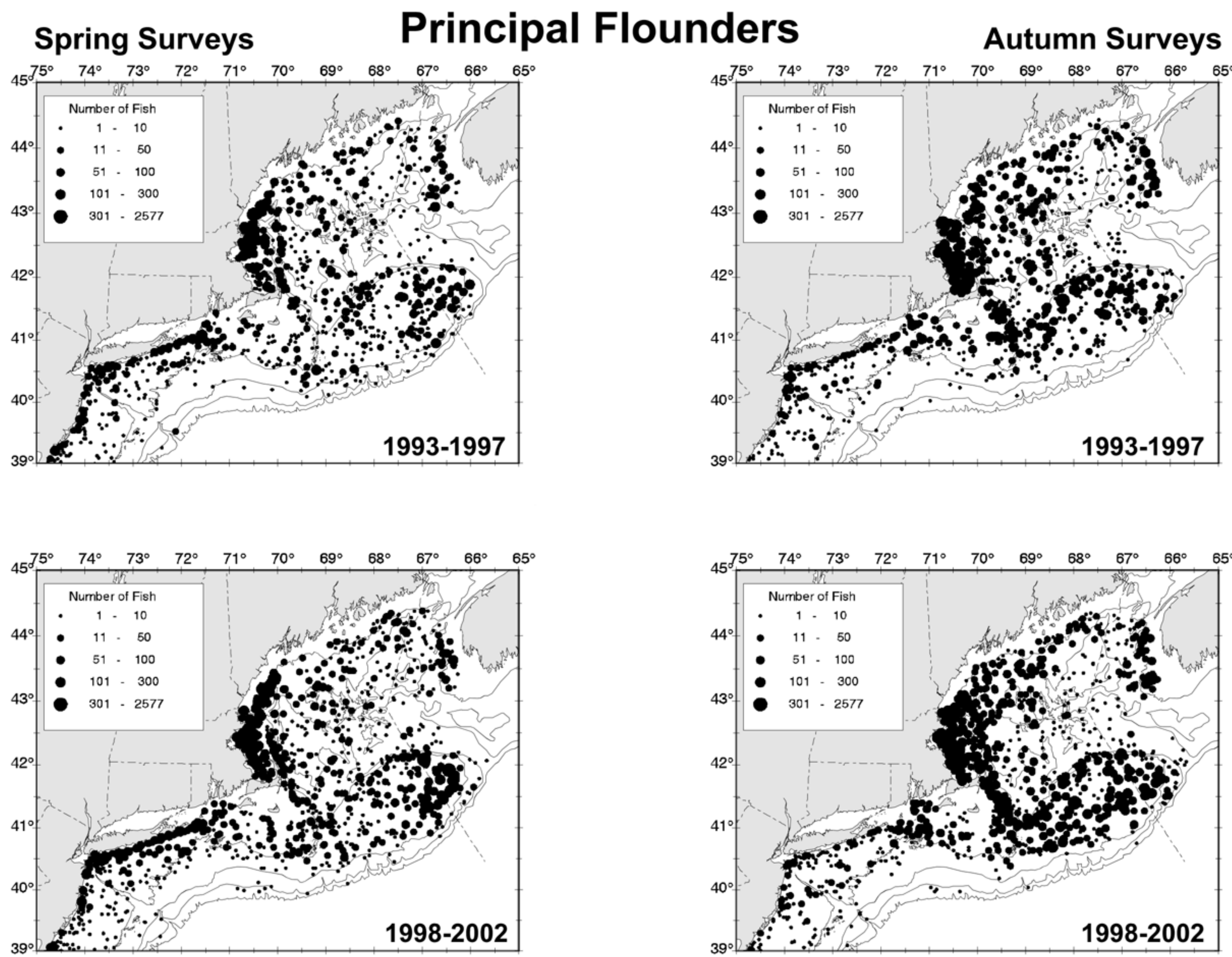

Figure C19d. Distribution of principal flounders (yellowtail flounder, American plaice, witch flounder, winter flounder, and windowpane flounder) in the NEFSC spring and autumn bottom trawl surveys from 1993-2002.

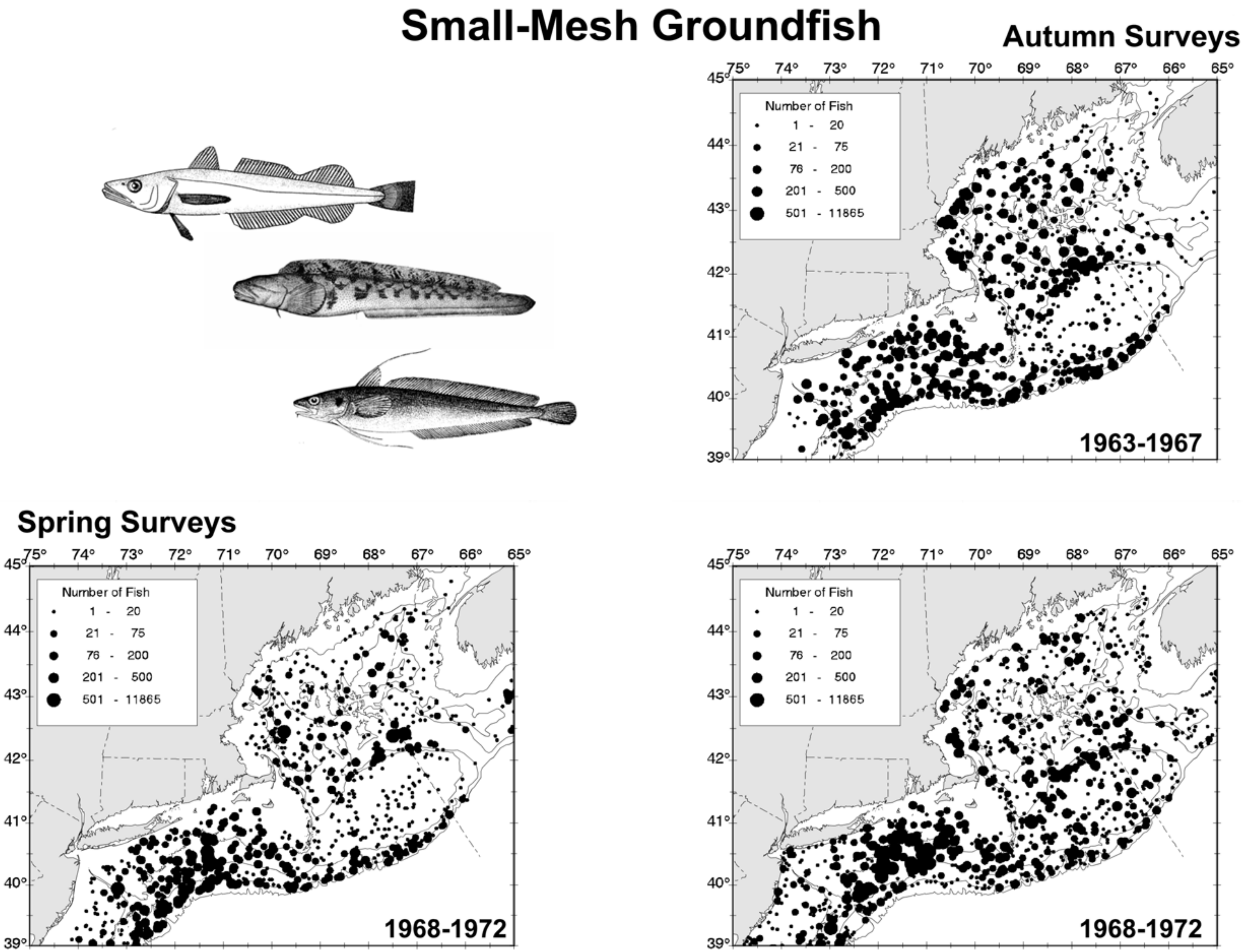

Figure C20a. Distribution of small-mesh groundfish (silver hake, red hake, and ocean pout) in the NEFSC spring and autumn bottom trawl surveys from 1963-1972.

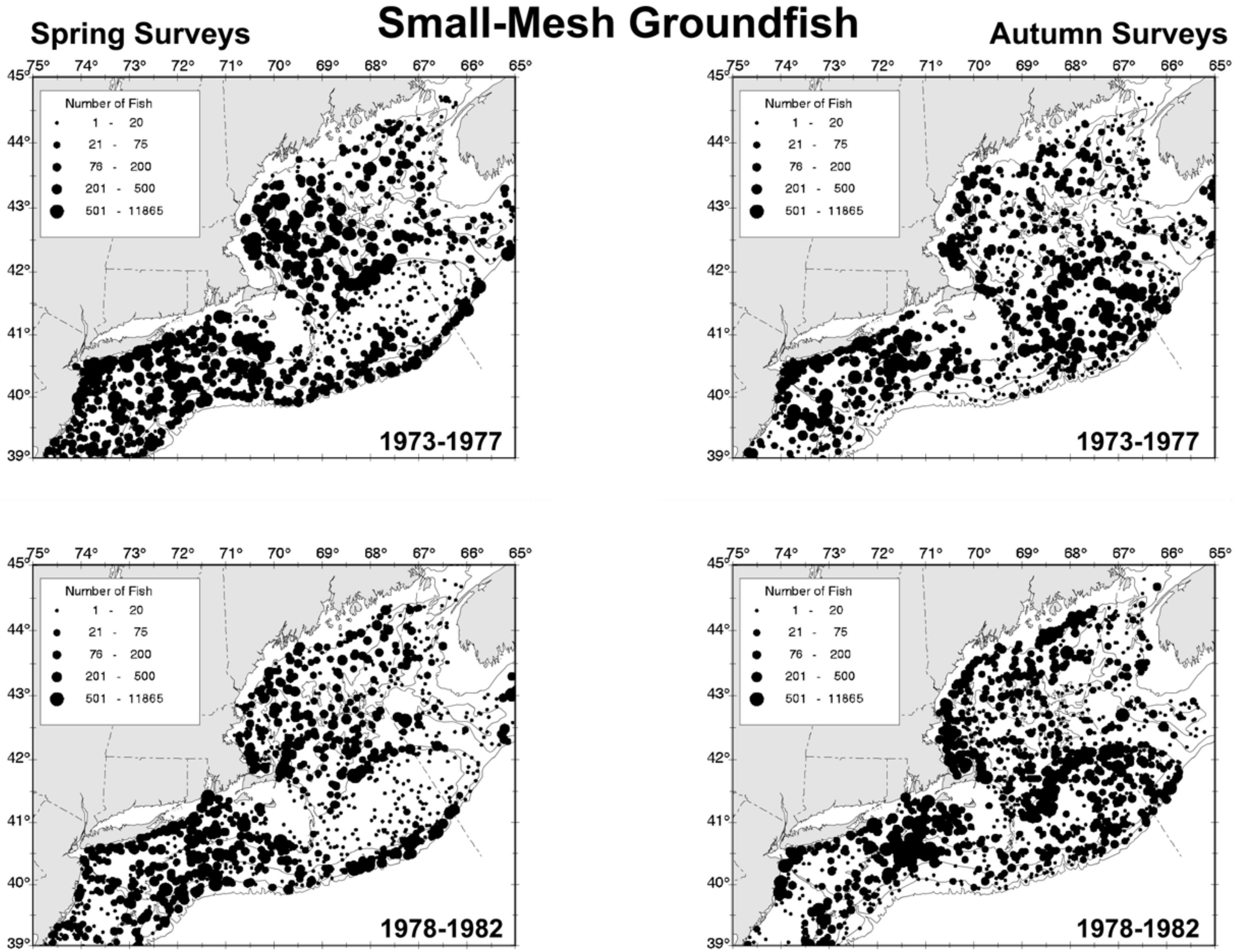

Figure C20b. Distribution of small-mesh groundfish (silver hake, red hake, and ocean pout) in the NEFSC spring and autumn bottom trawl surveys from 1973-1982.

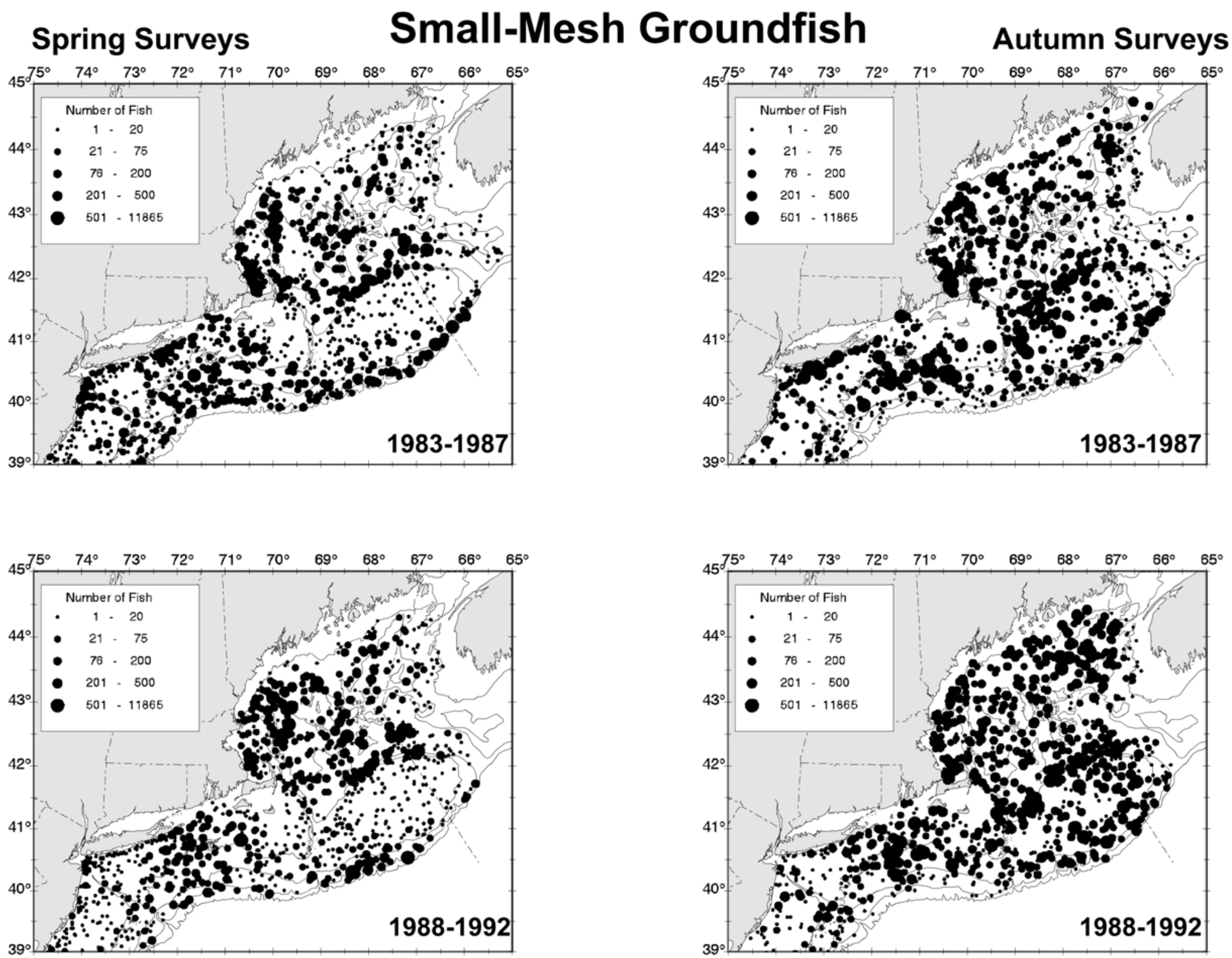

Figure C20c. Distribution of small-mesh groundfish (silver hake, red hake, and ocean pout) in the NEFSC spring and autumn bottom trawl surveys from 1983-1992.

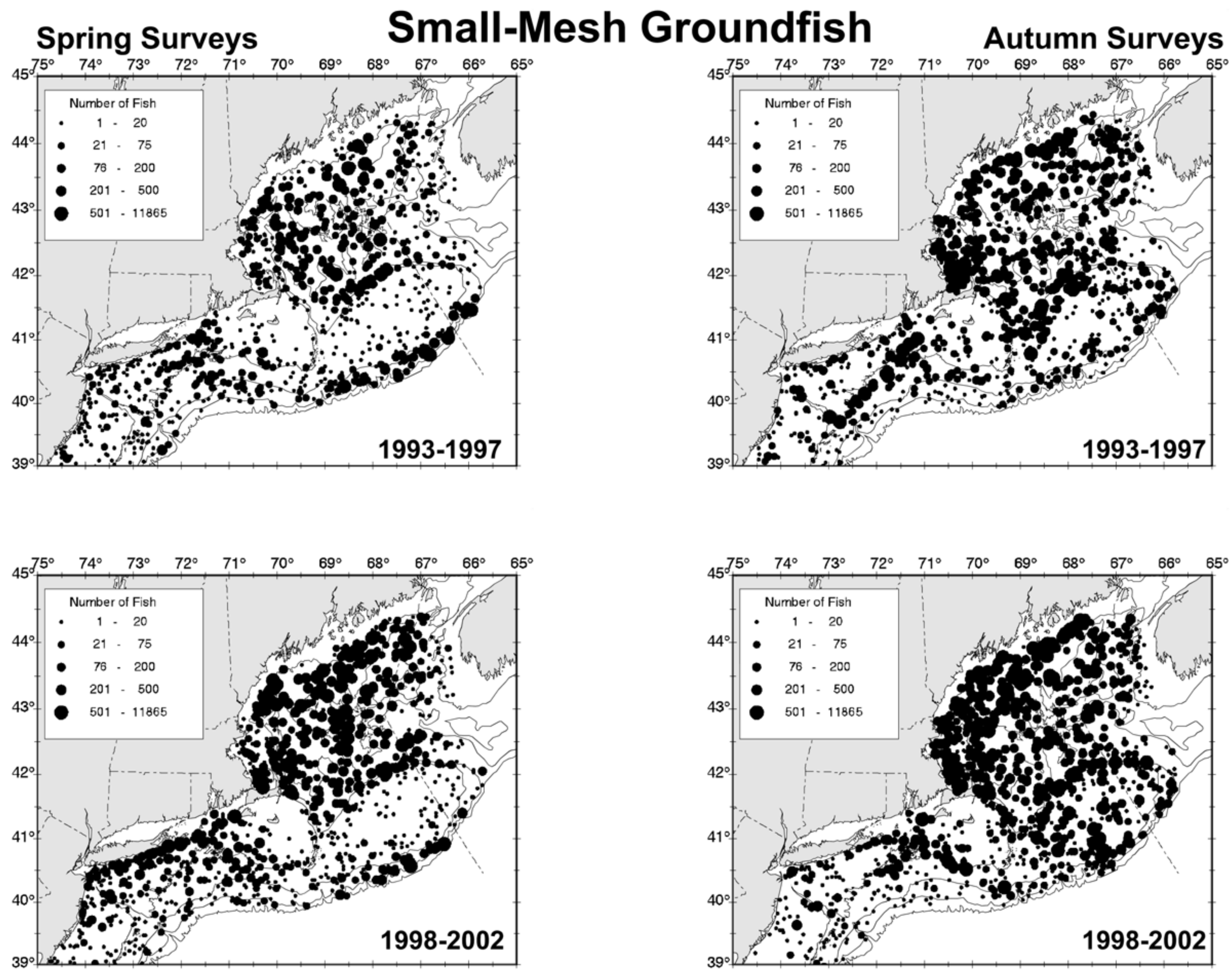

Figure C20d. Distribution of small-mesh groundfish (silver hake, red hake, and ocean pout) in the NEFSC spring and autumn bottom trawl surveys from 1993-2002.

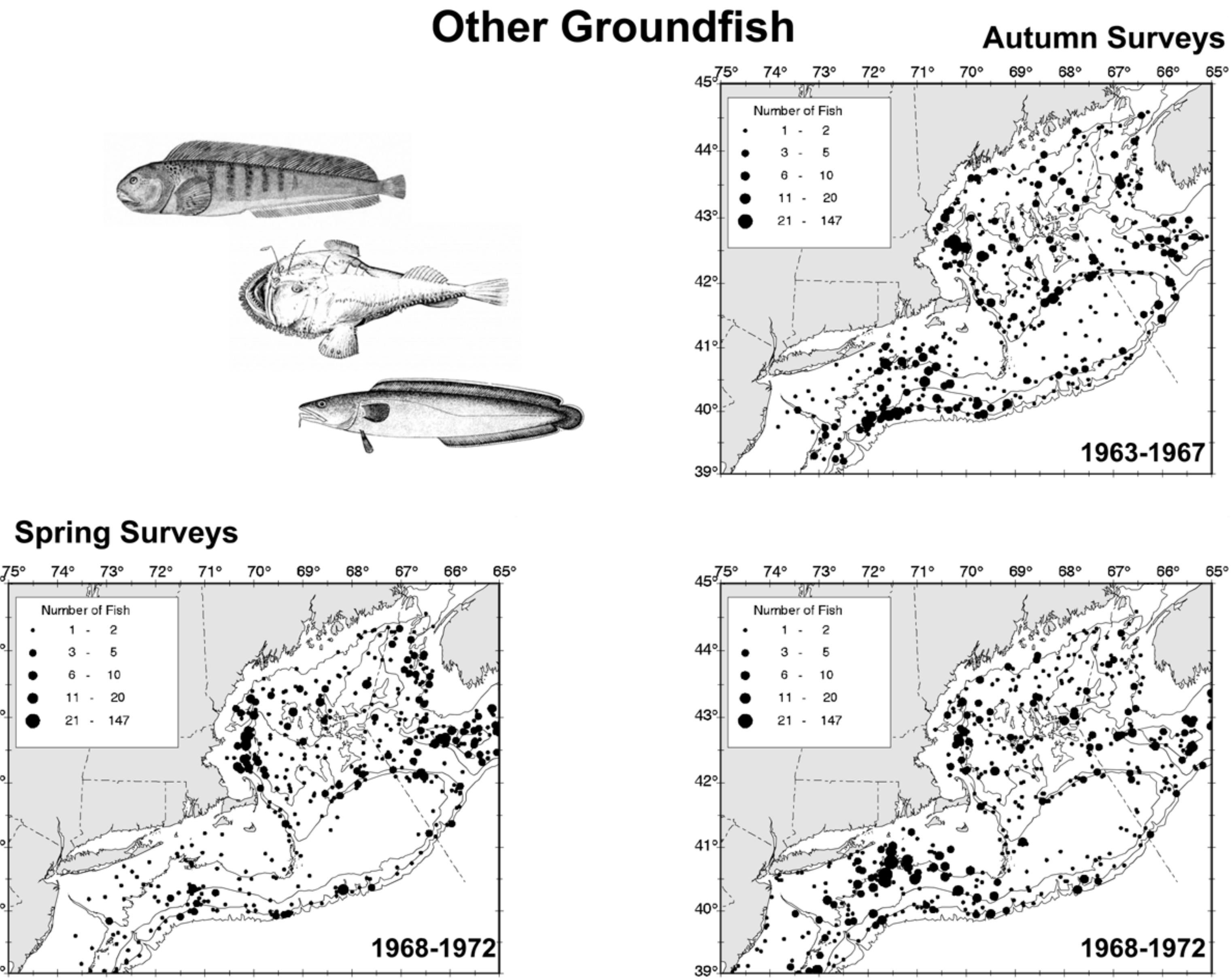

Figure C21a. Distribution of other groundfish (Atlantic wolffish, goosefish, and cusk) in the NEFSC spring and autumn bottom trawl surveys from 1963-1972.

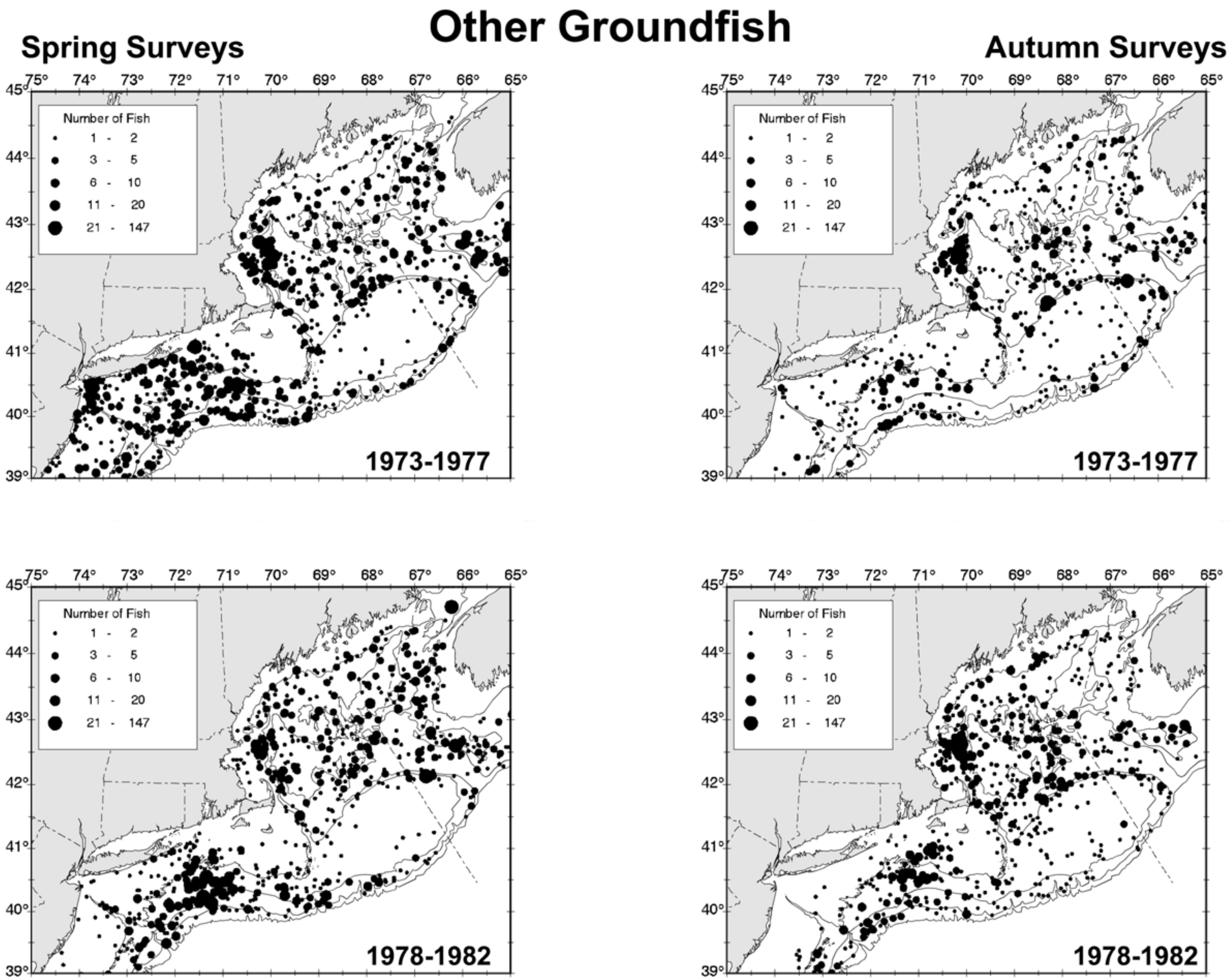

Figure C21b. Distribution of other groundfish (Atlantic wolffish, goosefish, and cusk) in the NEFSC spring and autumn bottom trawl surveys from 1973-1982.

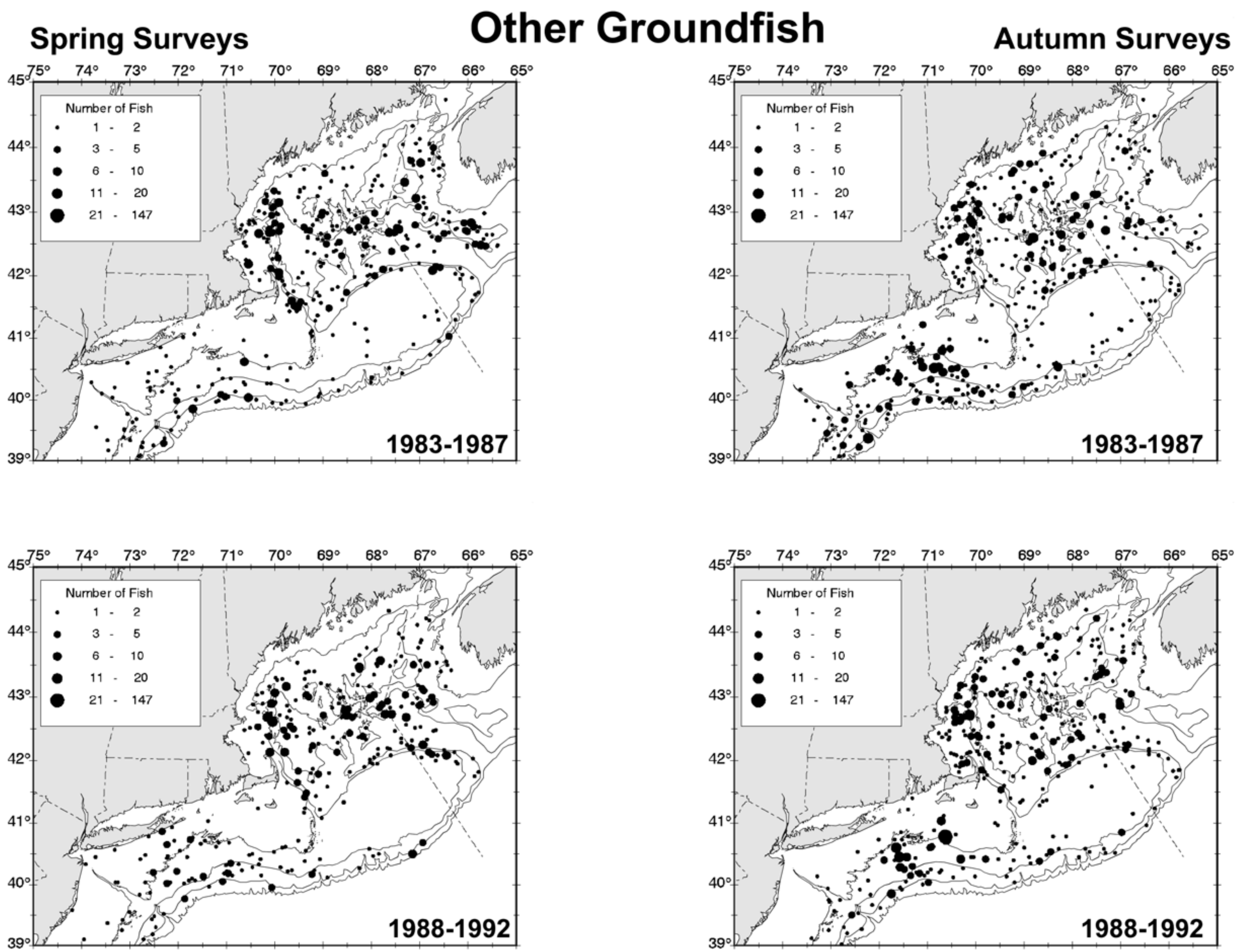

Figure C21c. Distribution of other groundfish (Atlantic wolffish, goosefish, and cusk) in the NEFSC spring and autumn bottom trawl surveys from 1983-1992.

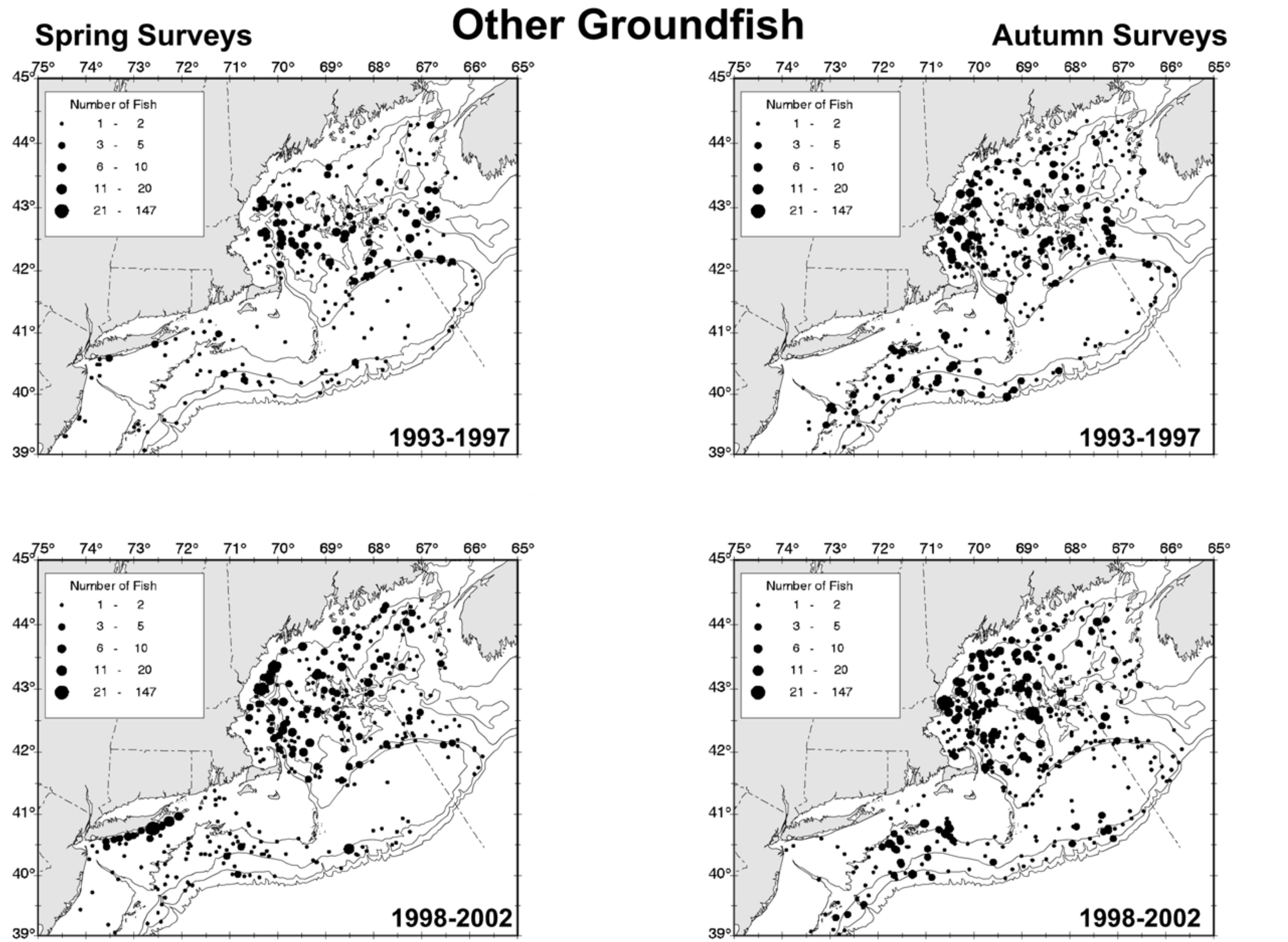

Figure C21d. Distribution of other groundfish (Atlantic wolffish, goosefish, and cusk) in the NEFSC spring and autumn bottom trawl surveys from 1993-2002.

APPENDIX D.

Distribution maps from Massachusetts inshore spring and autumn bottom trawl surveys.

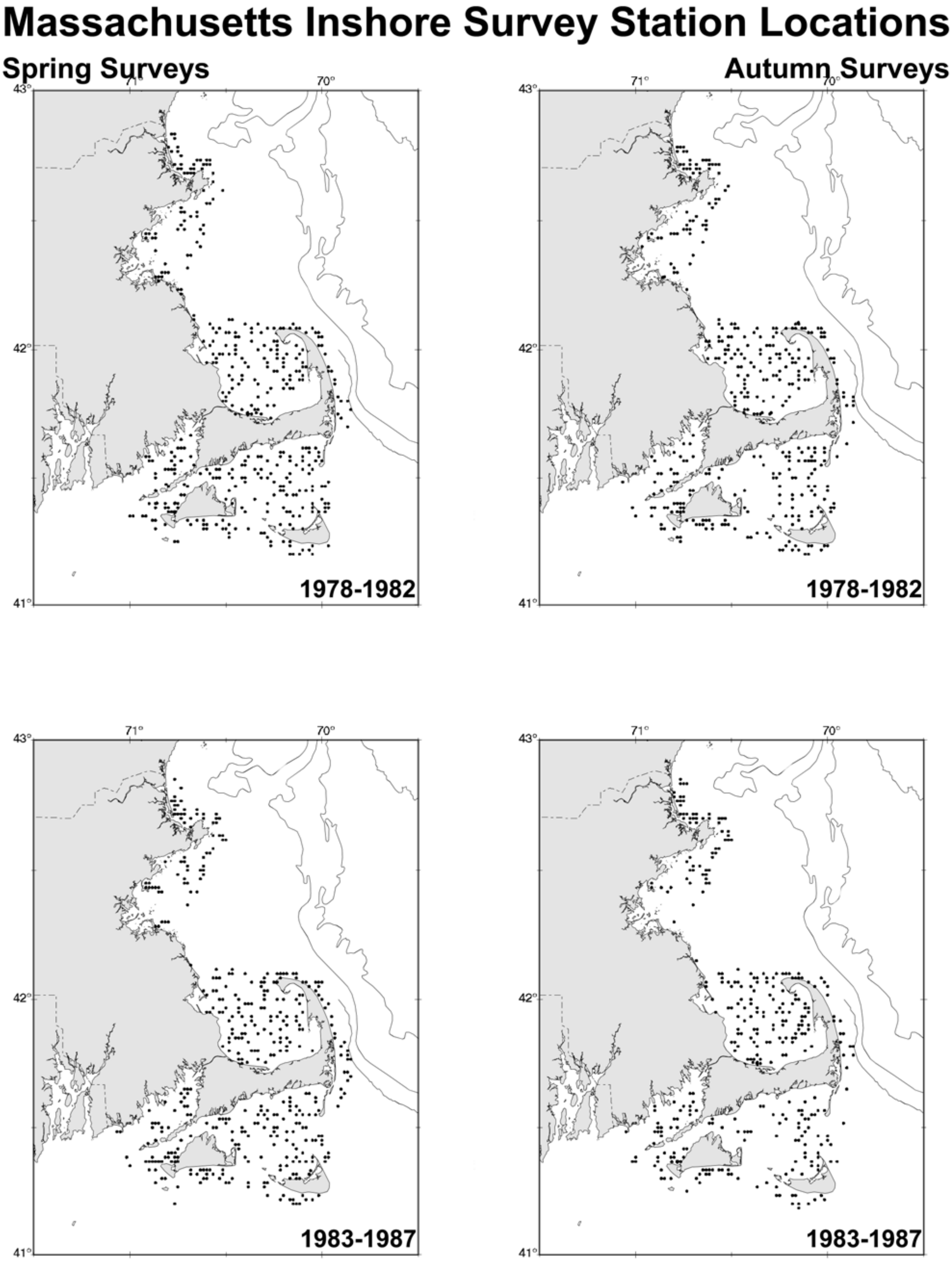

Figure D1a. Distribution of survey station locations in the Massachusetts inshore spring and autumn bottom trawl surveys from 1978-1987.

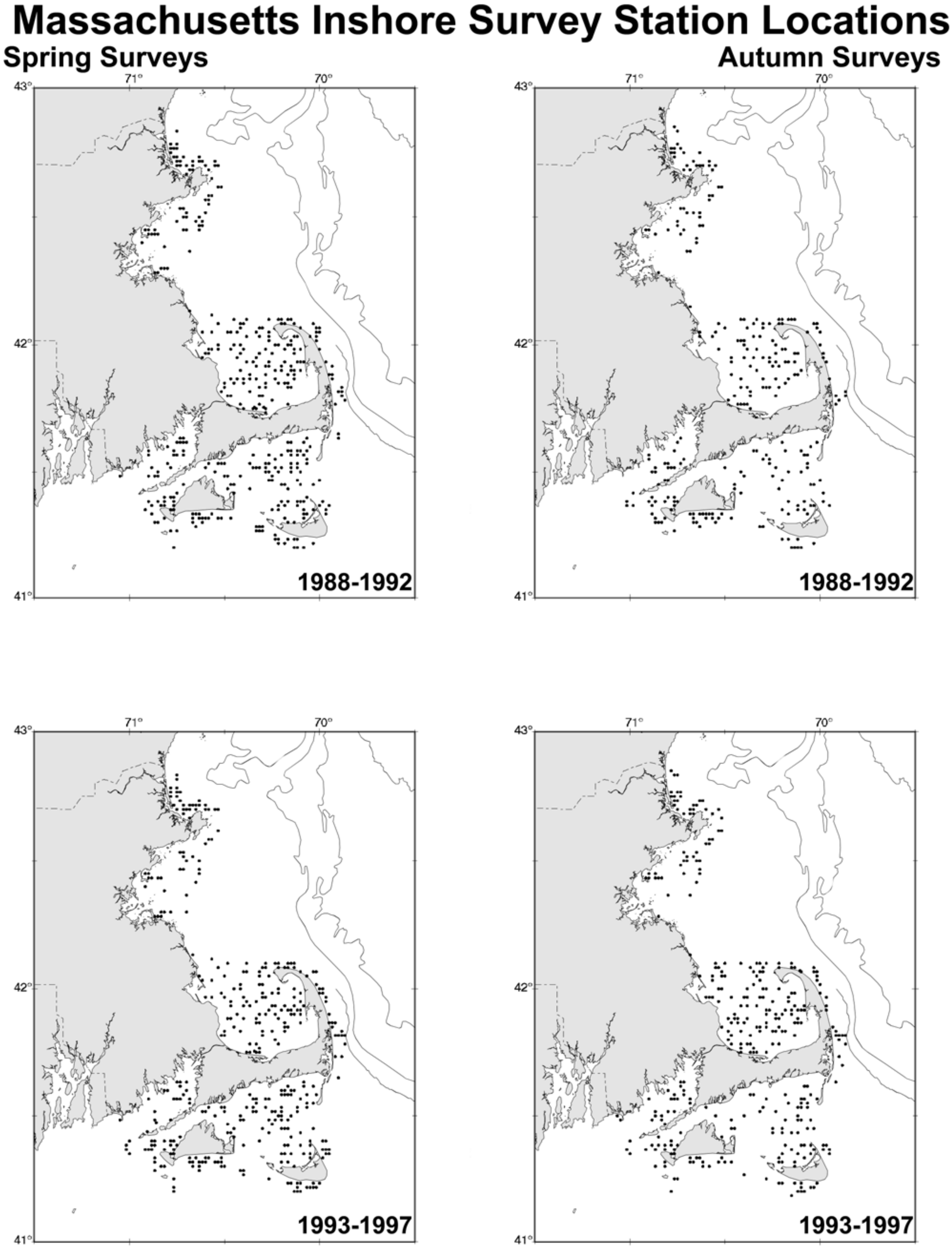

Figure D1b. Distribution of survey station locations in the Massachusetts inshore spring and autumn bottom trawl surveys from 1988-1997.

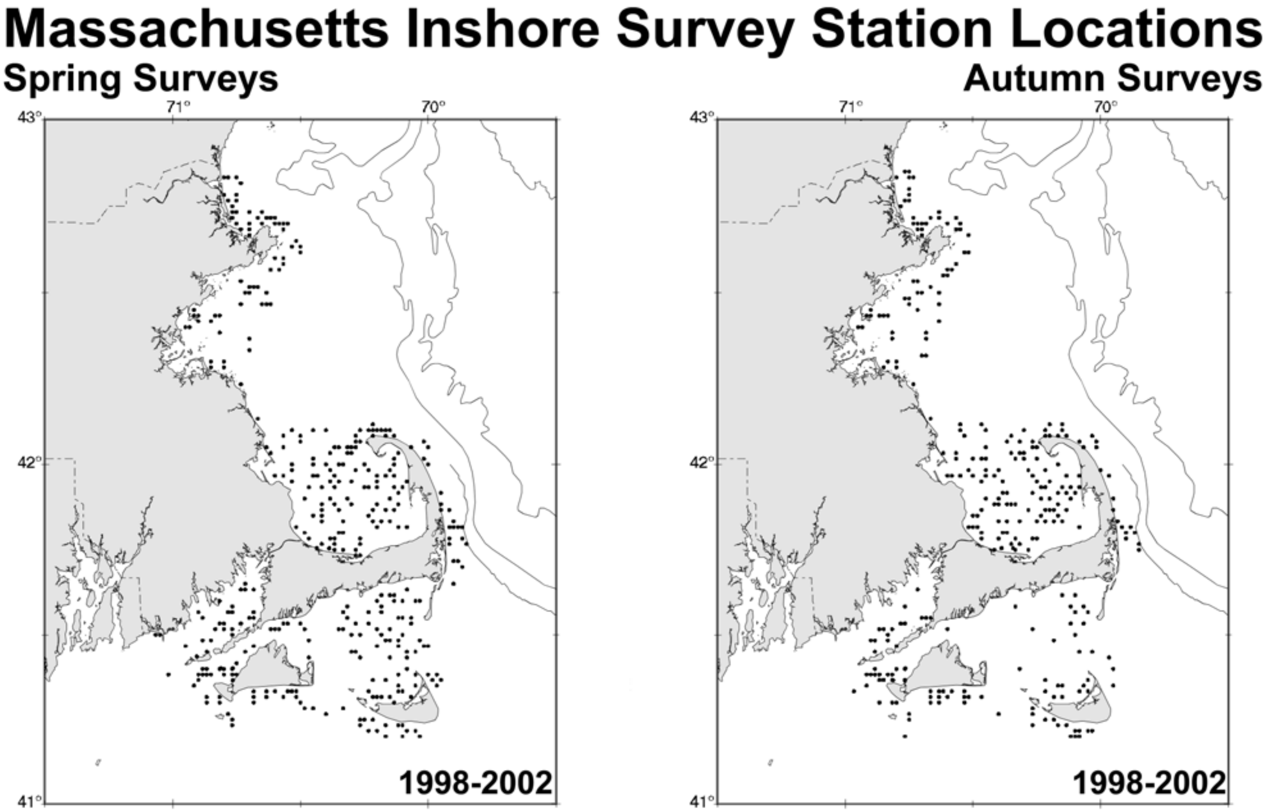

Figure D1c. Distribution of survey station locations in the Massachusetts inshore spring and autumn bottom trawl surveys from 1998-2002.

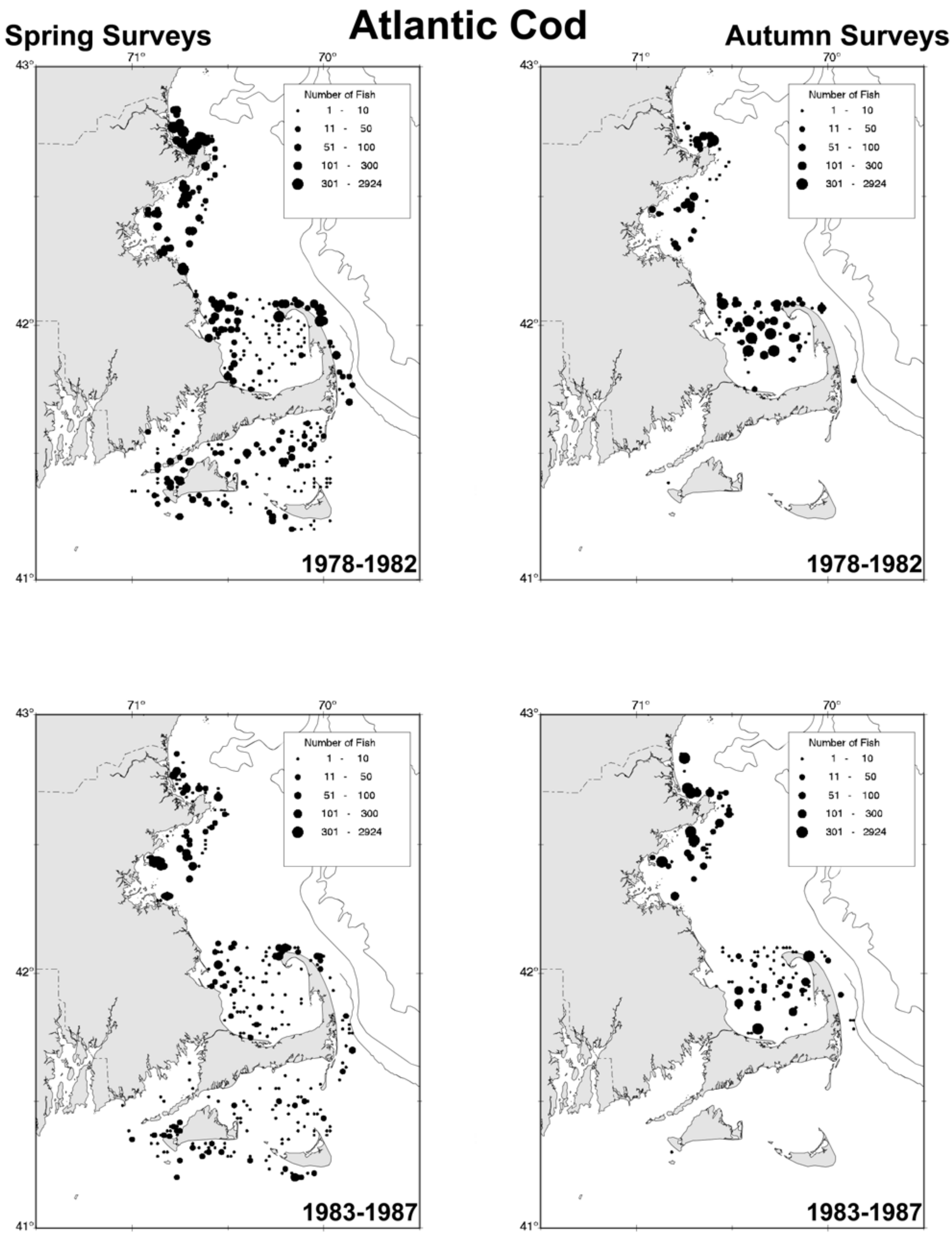

Figure D2a. Distribution of Atlantic cod in the Massachusetts inshore spring and autumn bottom trawl surveys from 1978-1987.

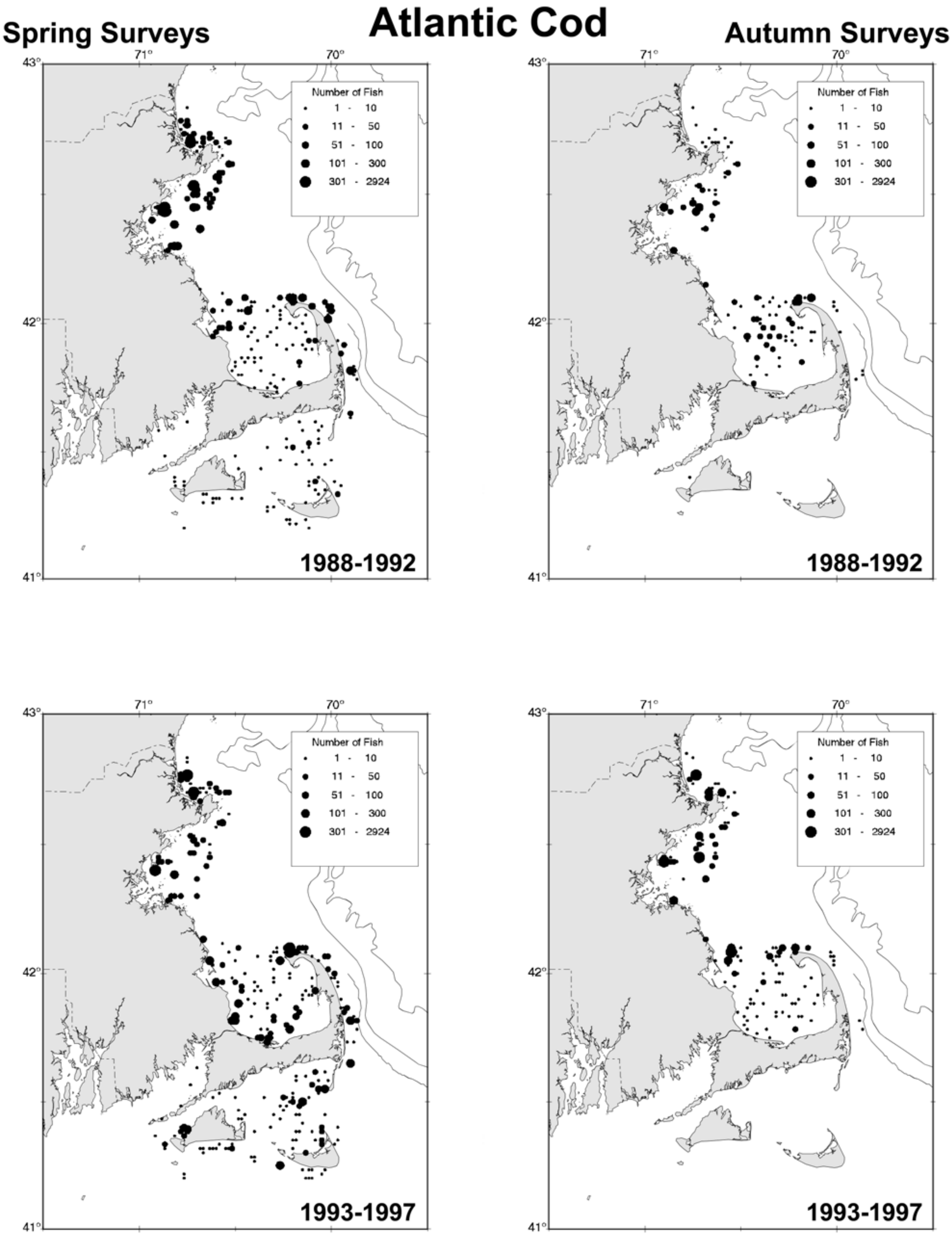

Figure D2b. Distribution of Atlantic cod in the Massachusetts inshore spring and autumn bottom trawl surveys from 1988-1997.

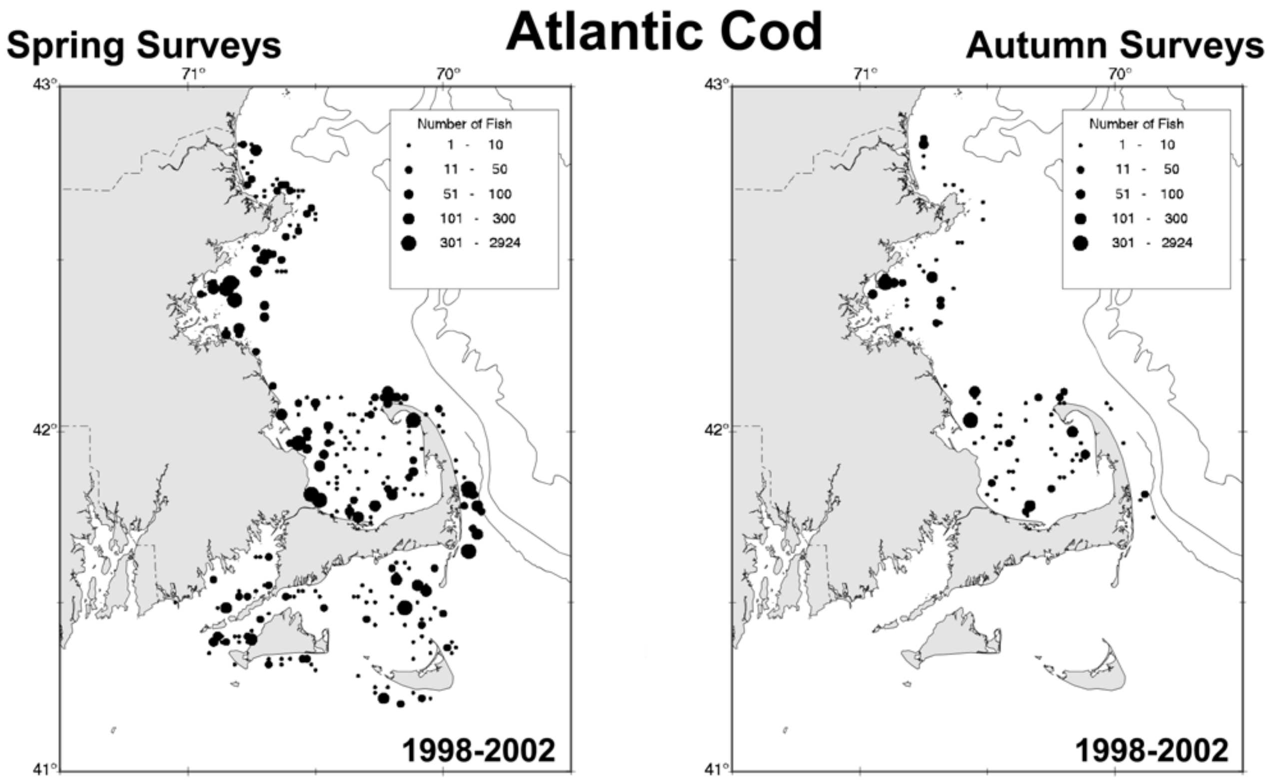

Figure D2c. Distribution of Atlantic cod in the Massachusetts inshore spring and autumn bottom trawl surveys from 1998-2002.

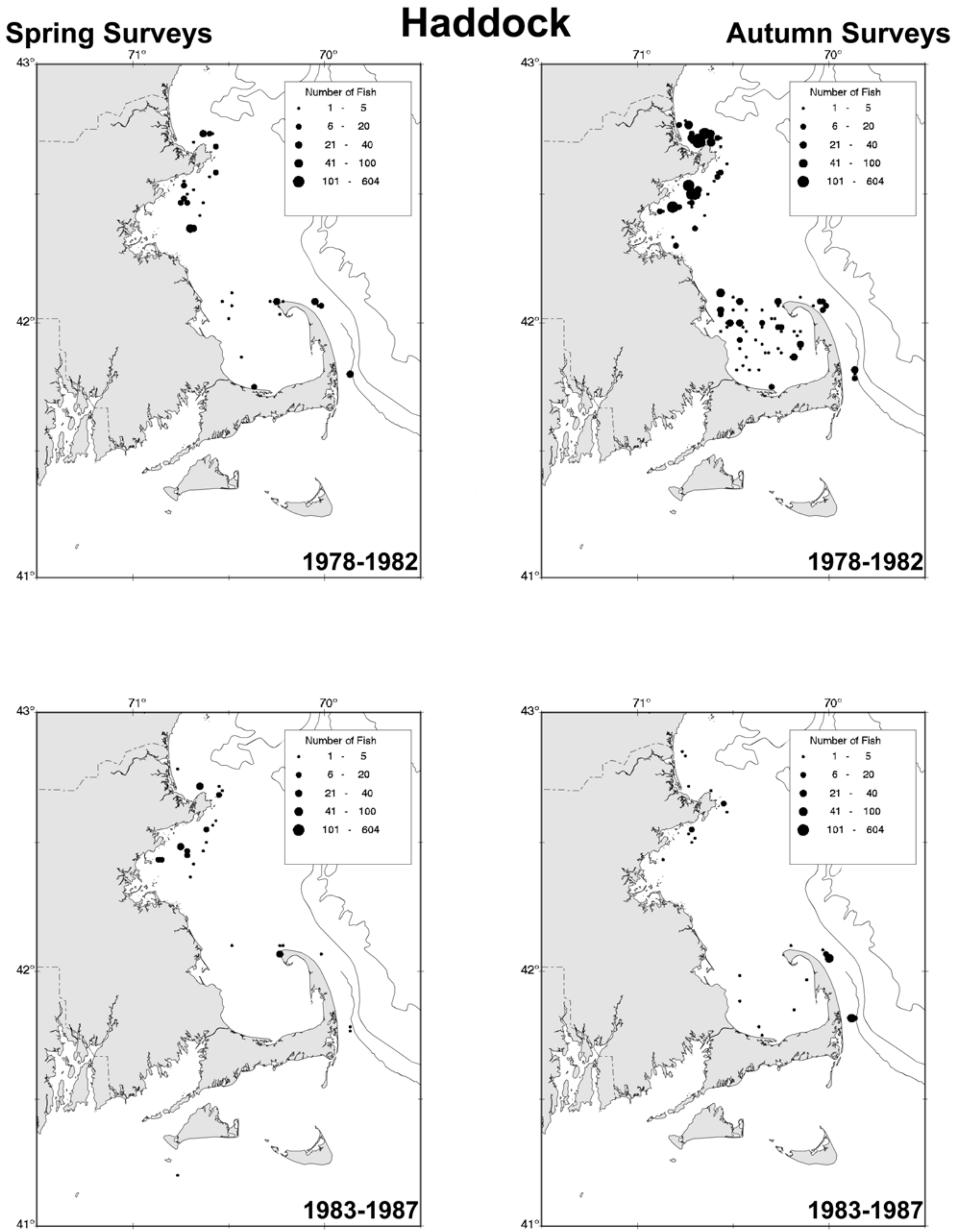

Figure D3a. Distribution of haddock in the Massachusetts inshore spring and autumn bottom trawl surveys from 1978-1987.

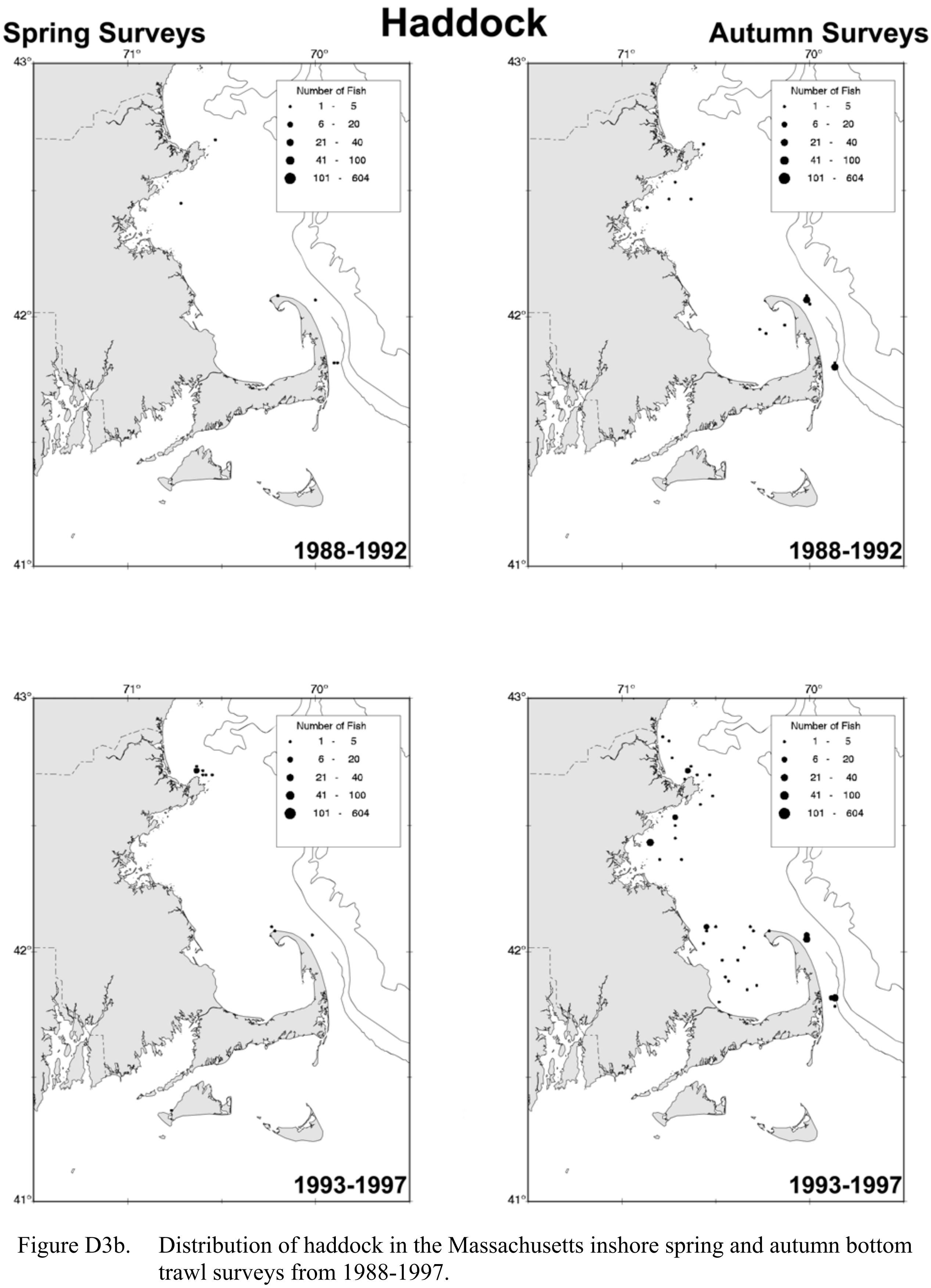

Figure D3b. Distribution of haddock in the Massachusetts inshore spring and autumn bottom trawl surveys from 1988-1997.

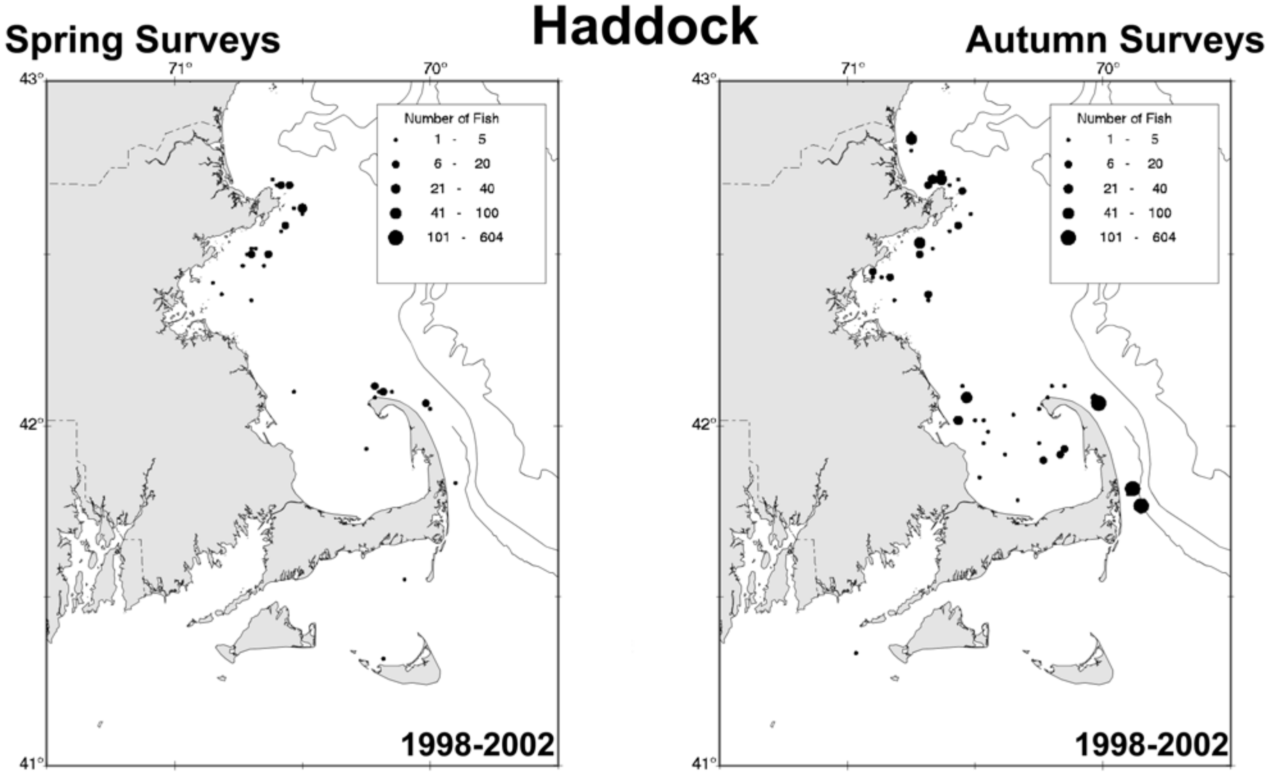

Figure D3c. Distribution of haddock in the Massachusetts inshore spring and autumn bottom trawl surveys from 1998-2002.

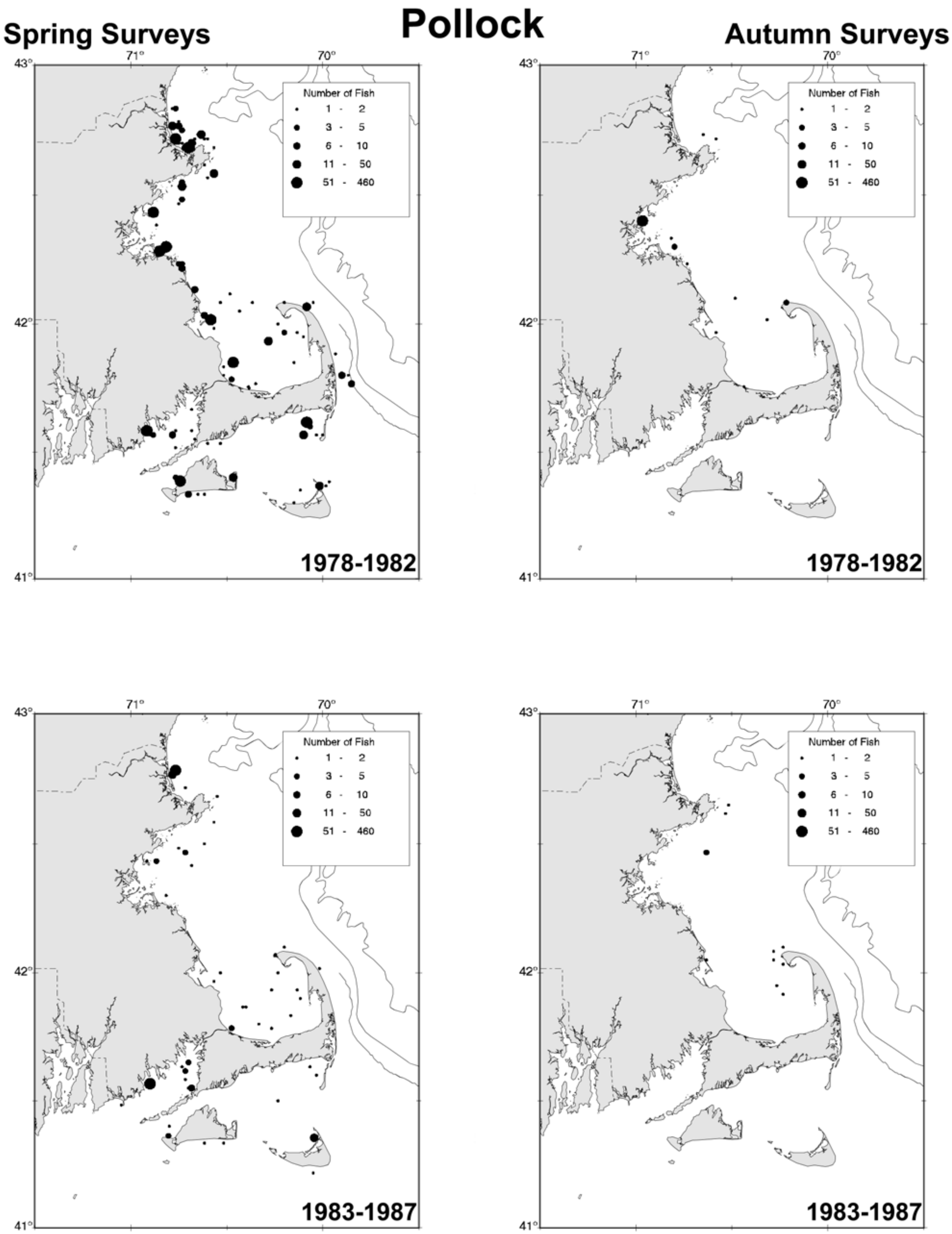

Figure D4a. Distribution of pollock in the Massachusetts inshore spring and autumn bottom trawl surveys from 1978-1987.

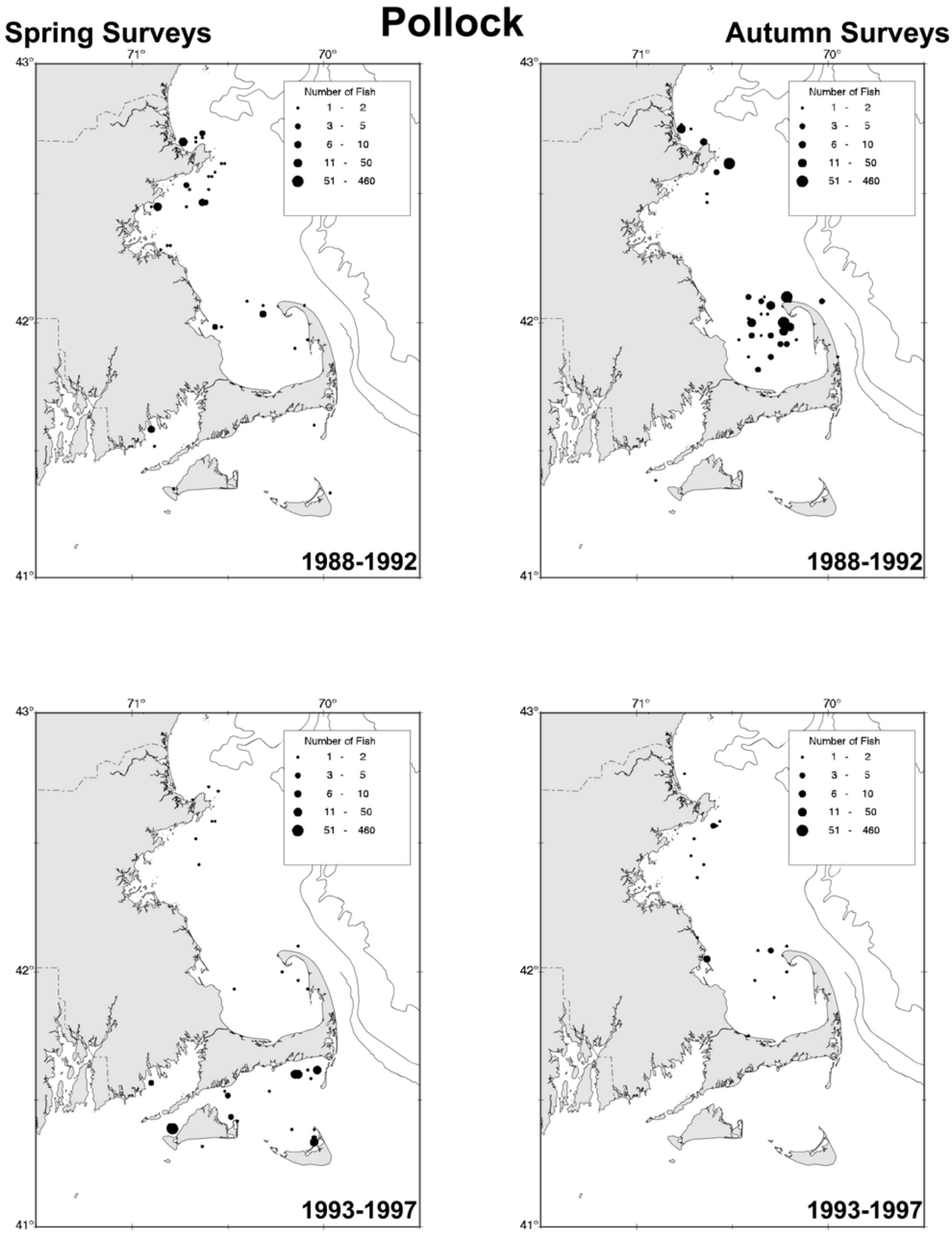

Figure D4b. Distribution of pollock in the Massachusetts inshore spring and autumn bottom trawl surveys from 1988-1997.

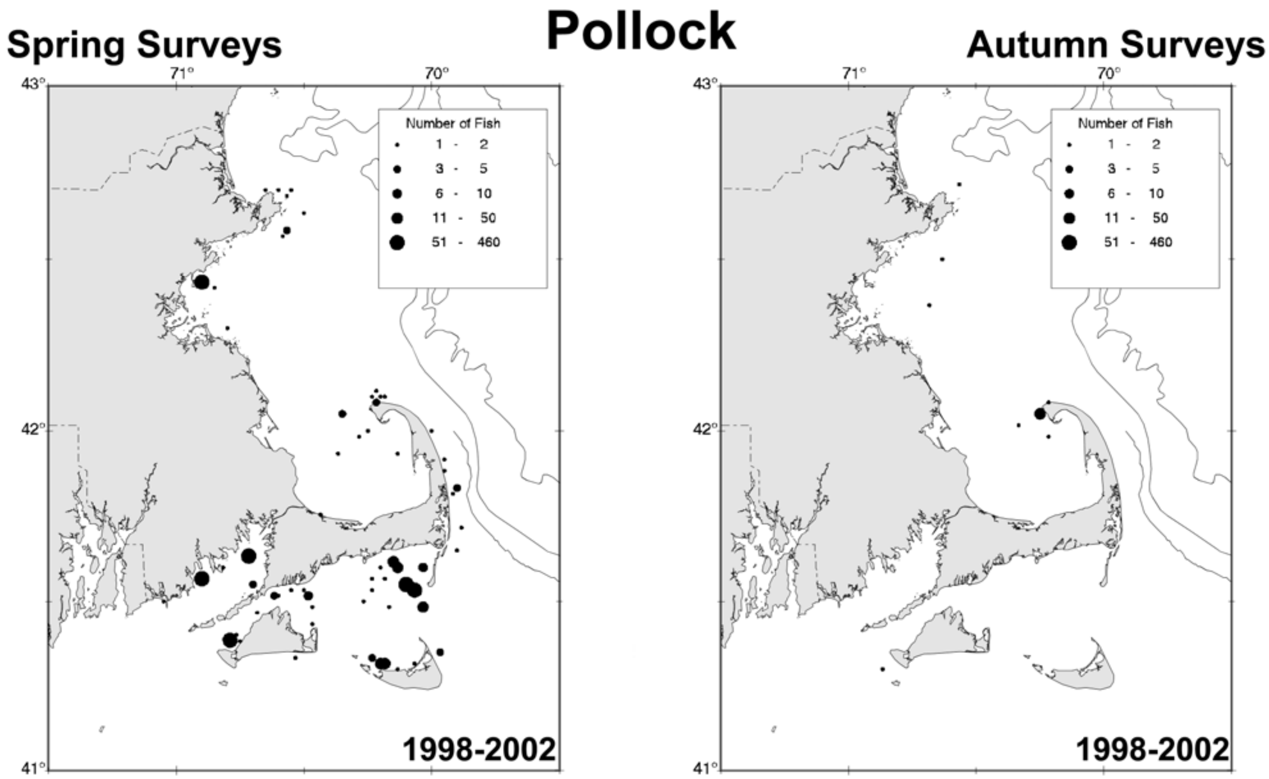

Figure D4c. Distribution of pollock in the Massachusetts inshore spring and autumn bottom trawl surveys from 1998-2002.

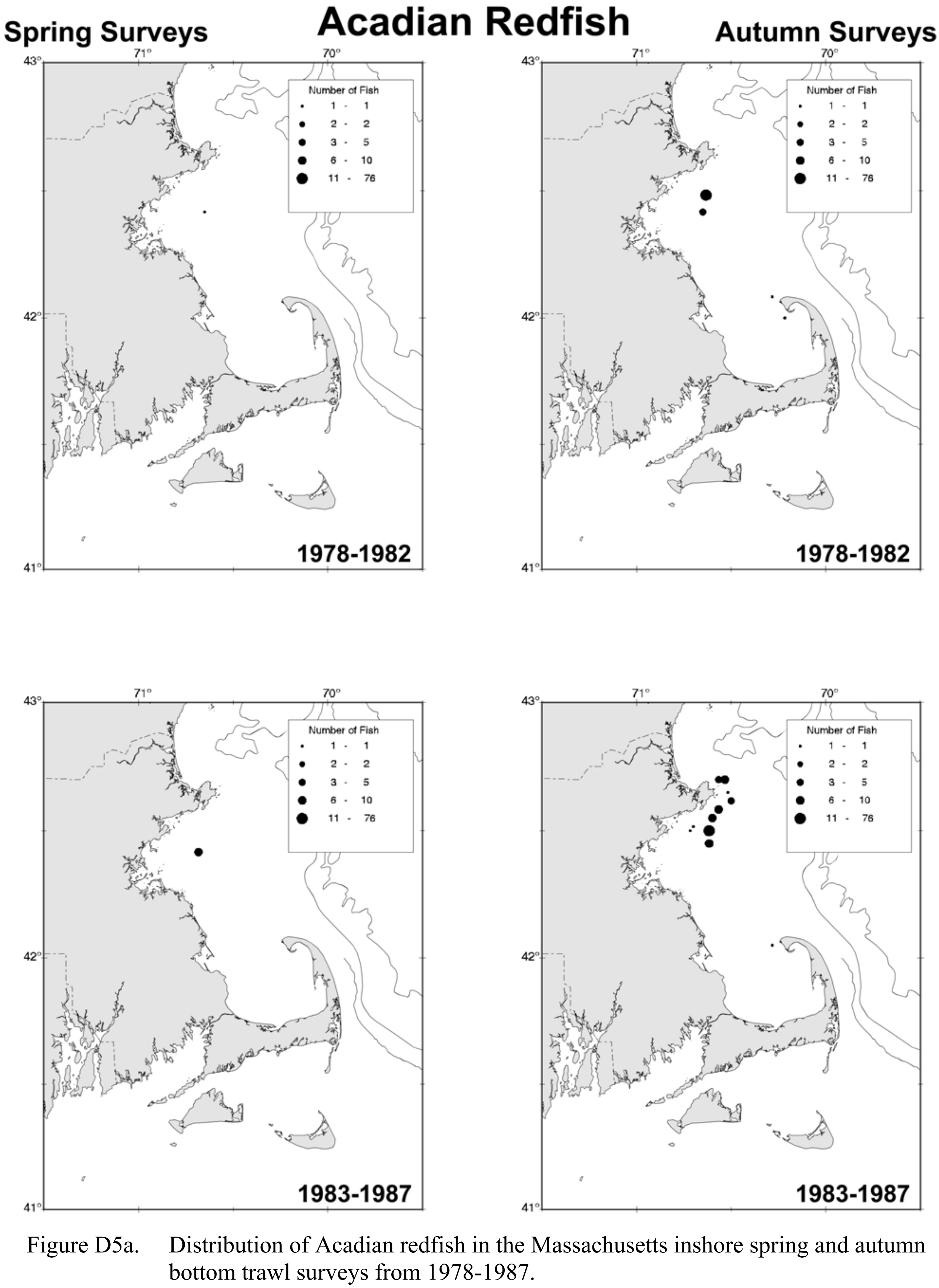

Figure D5a. Distribution of Acadian redfish in the Massachusetts inshore spring and autumn bottom trawl surveys from 1978-1987.

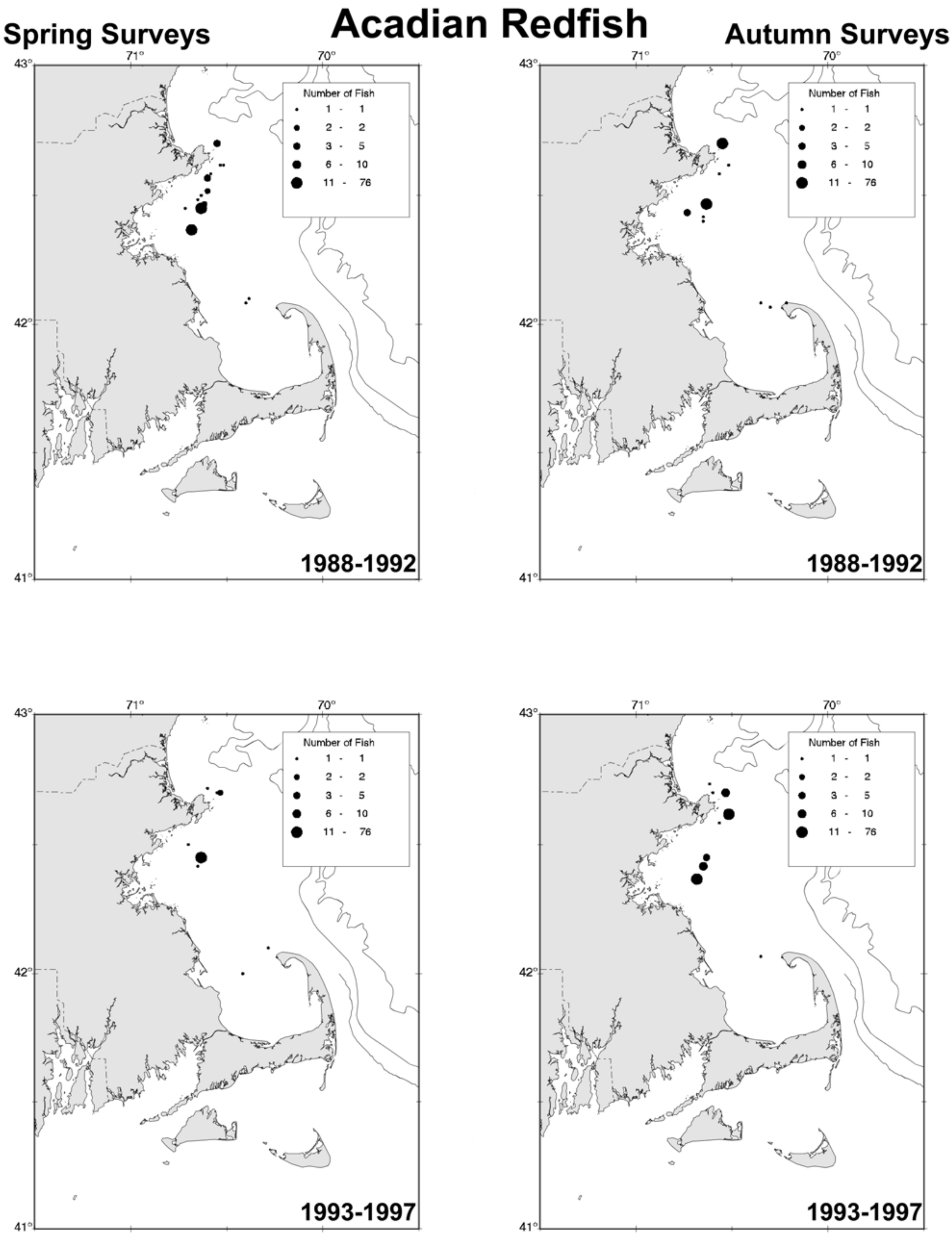

Figure D5b. Distribution of Acadian redfish in the Massachusetts inshore spring and autumn bottom trawl surveys from 1988-1997.

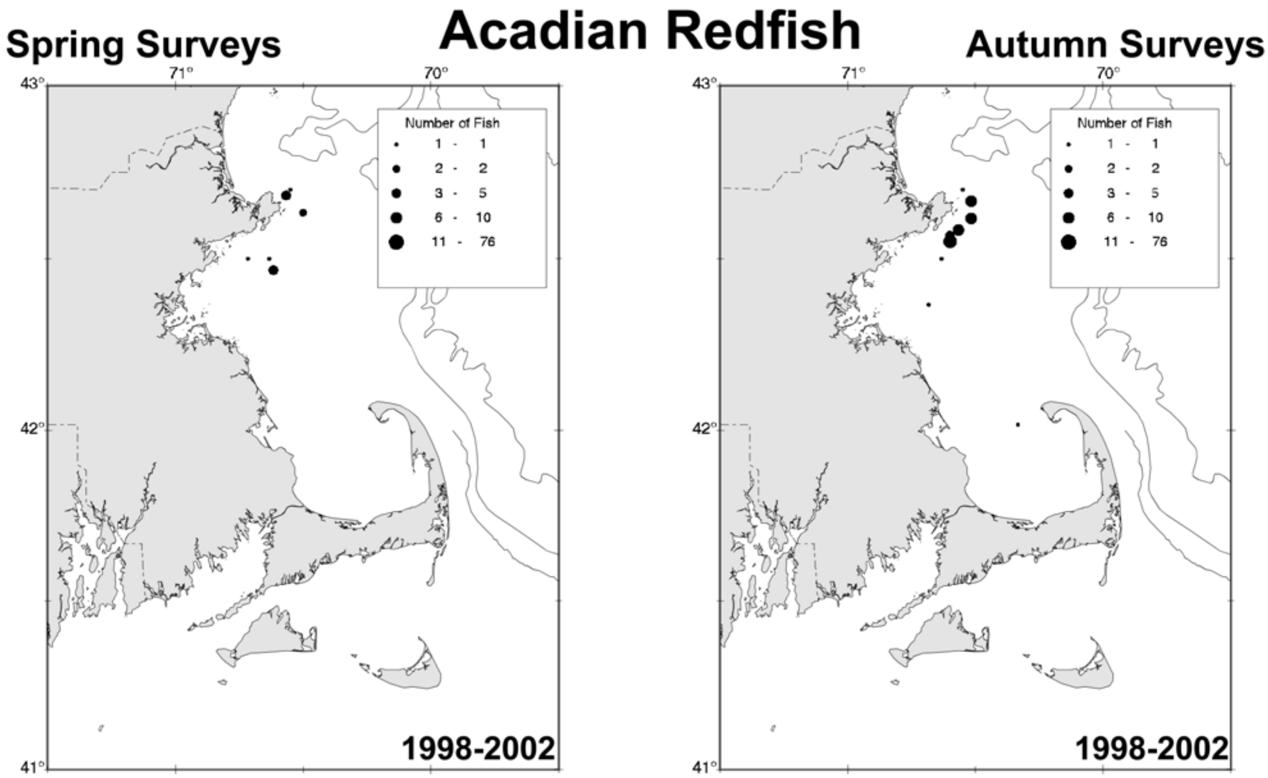

Figure D5c. Distribution of Acadian redfish in the Massachusetts inshore spring and autumn bottom trawl surveys from 1998-2002.

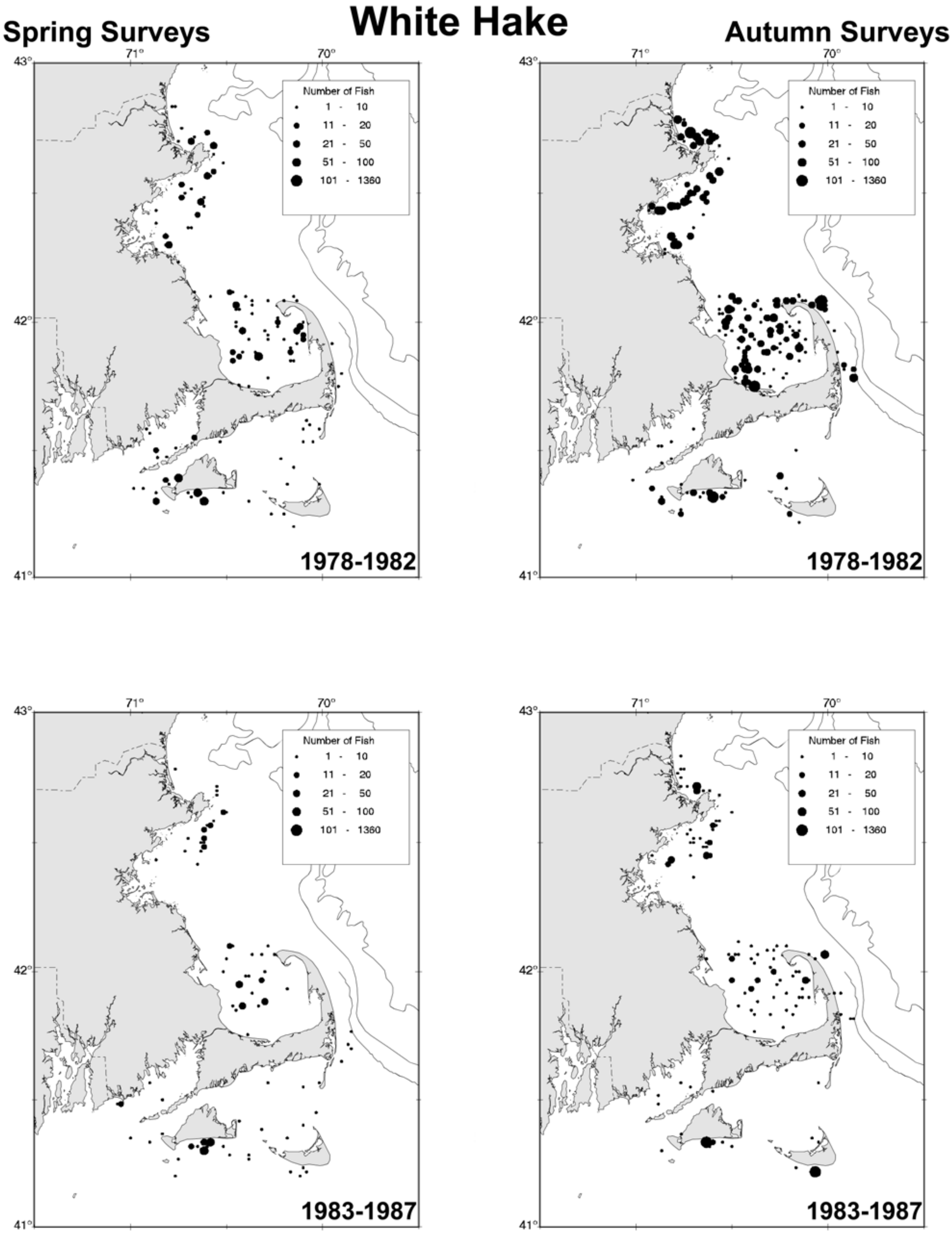

Figure D6a. Distribution of white hake in the Massachusetts inshore spring and autumn bottom trawl surveys from 1978-1987.

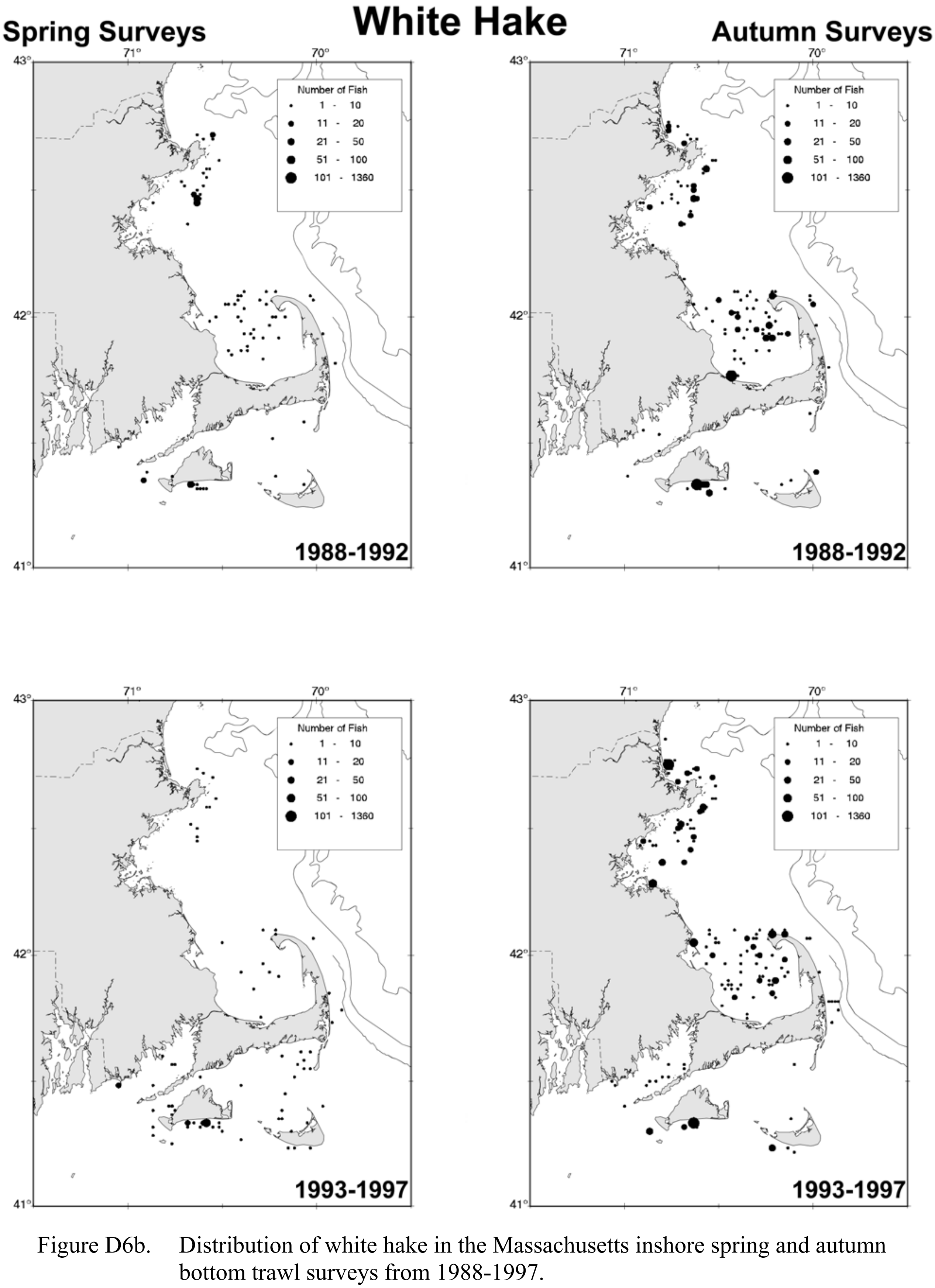

Figure D6b. Distribution of white hake in the Massachusetts inshore spring and autumn bottom trawl surveys from 1988-1997.

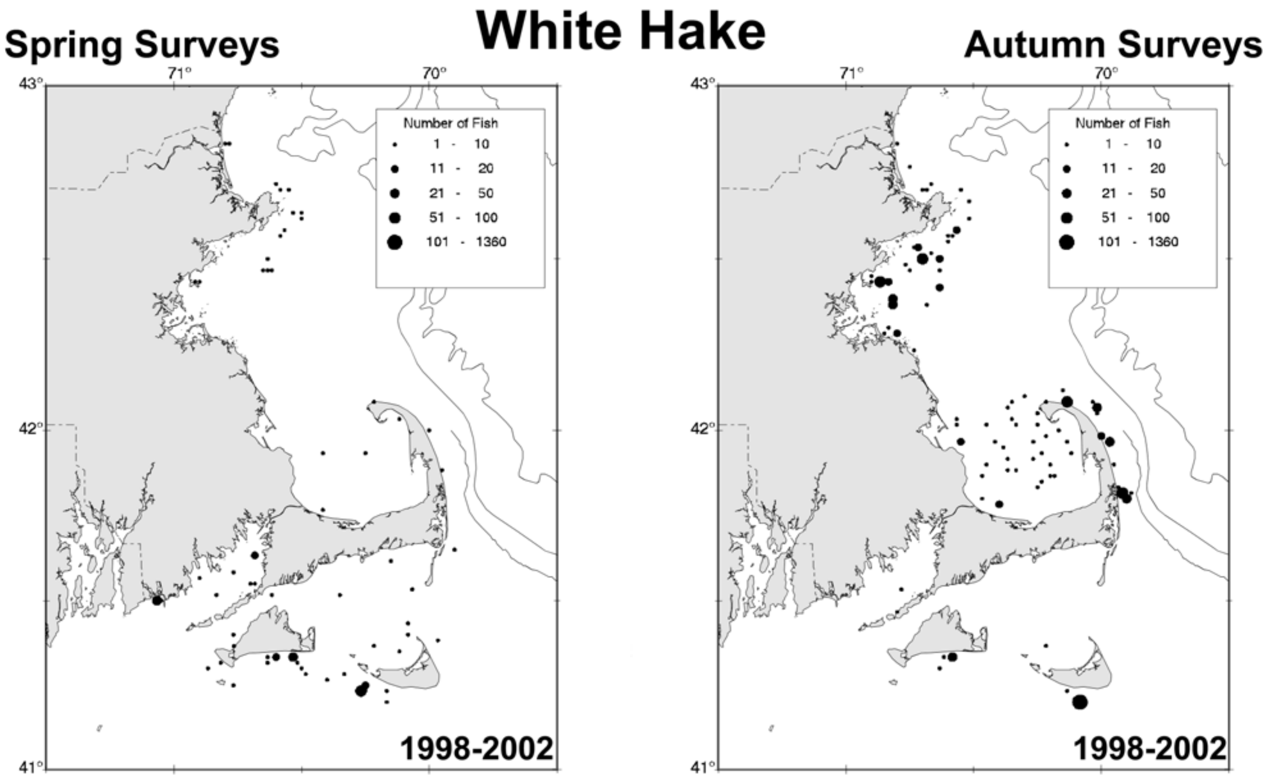

Figure D6c. Distribution of white hake in the Massachusetts inshore spring and autumn bottom trawl surveys from 1998-2002.

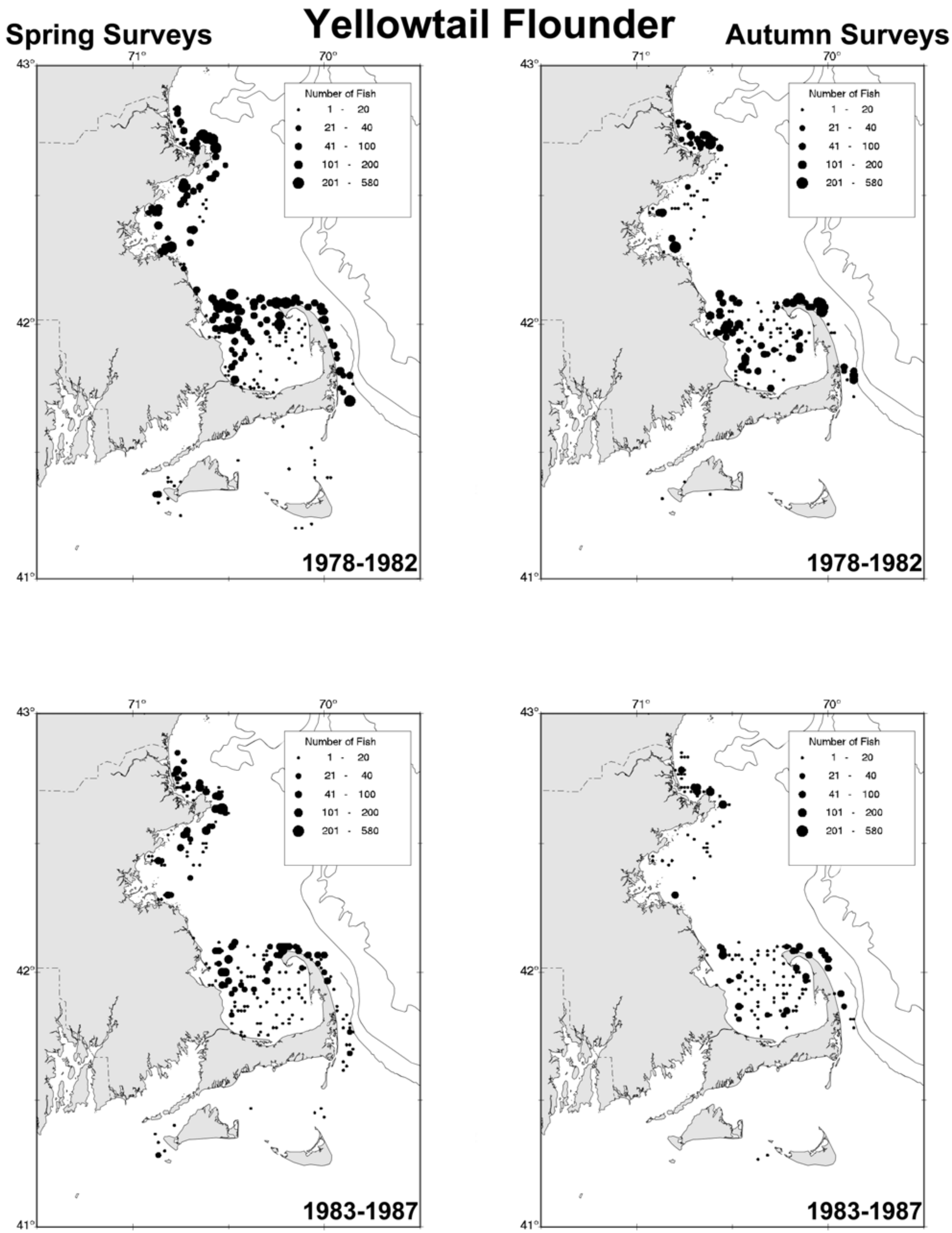

Figure D7a. Distribution of yellowtail flounder in the Massachusetts inshore spring and autumn bottom trawl surveys from 1978-1987.

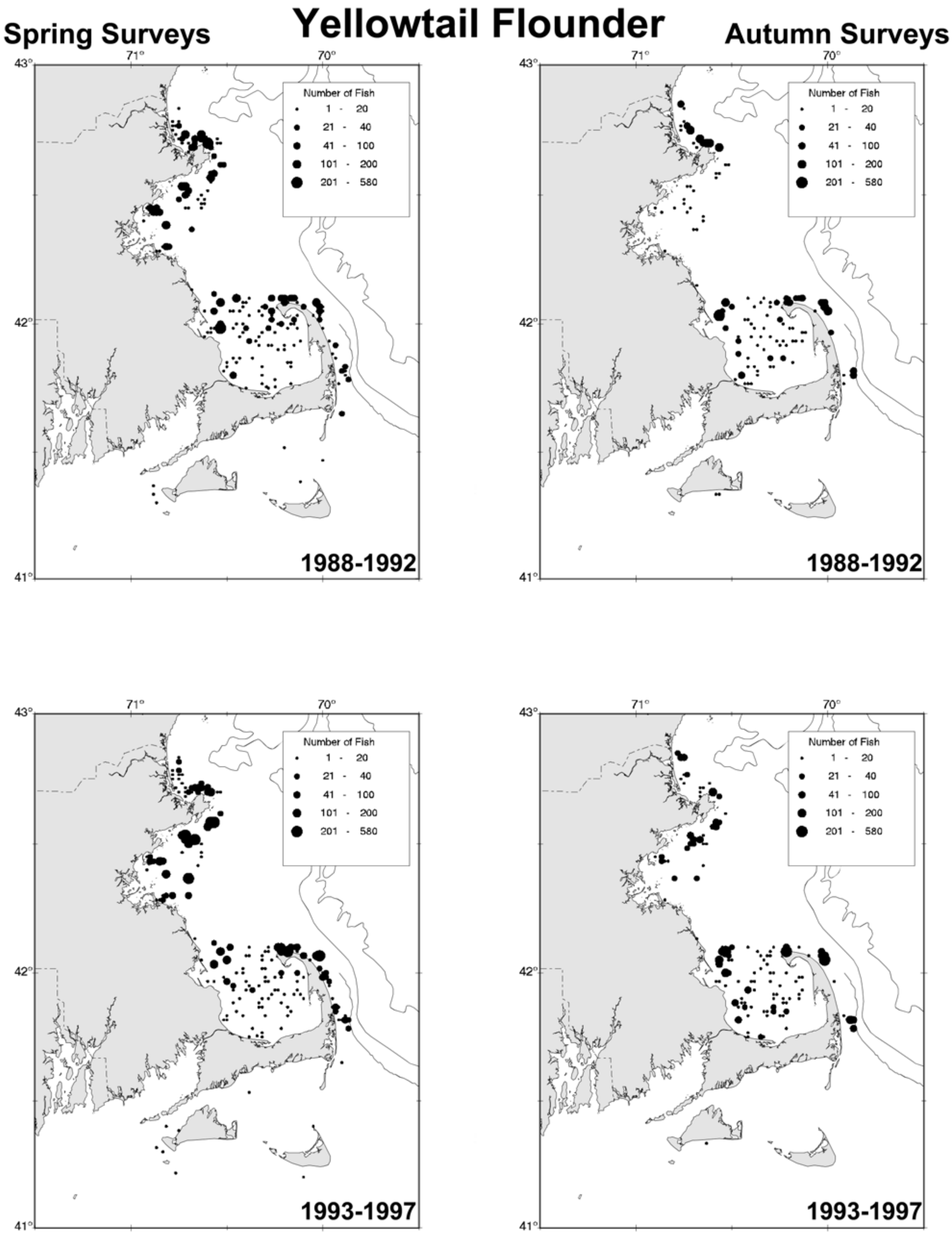

Figure D7b. Distribution of yellowtail flounder in the Massachusetts inshore spring and autumn bottom trawl surveys from 1988-1997.

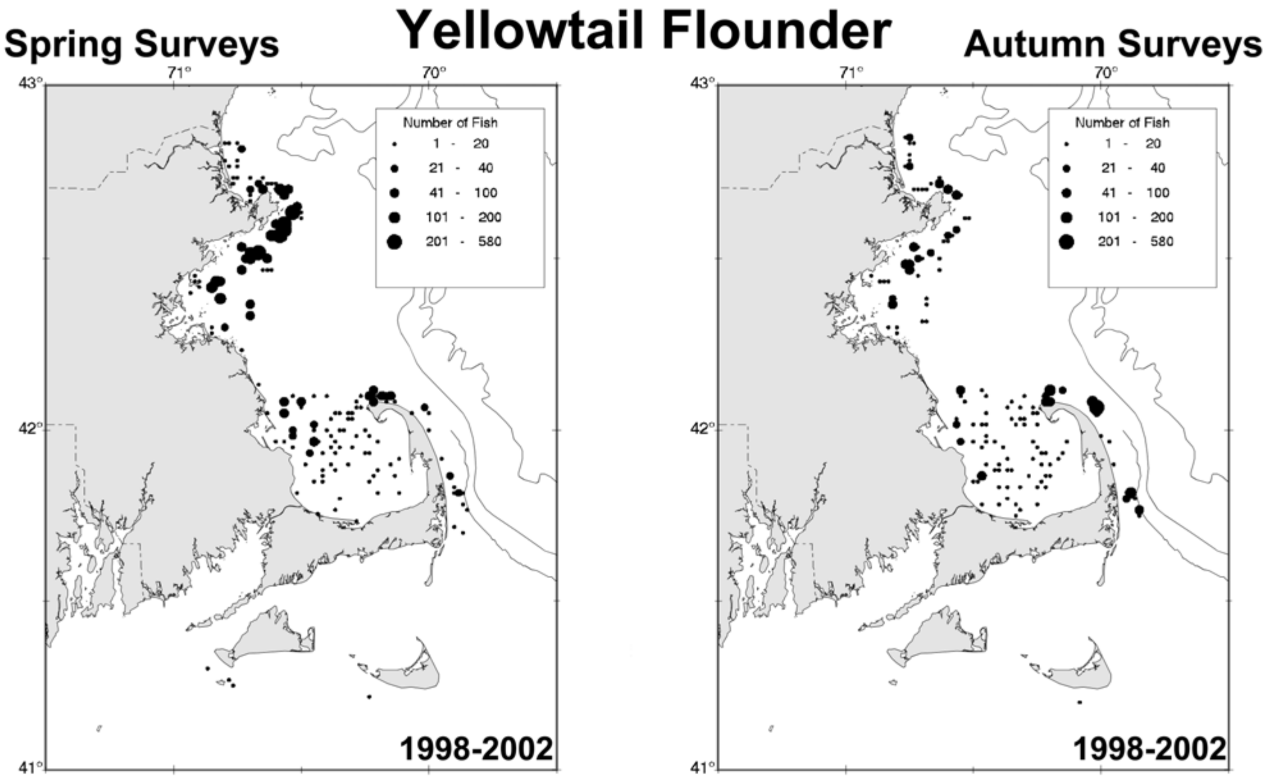

Figure D7c. Distribution of yellowtail flounder in the Massachusetts inshore spring and autumn bottom trawl surveys from 1998-2002.

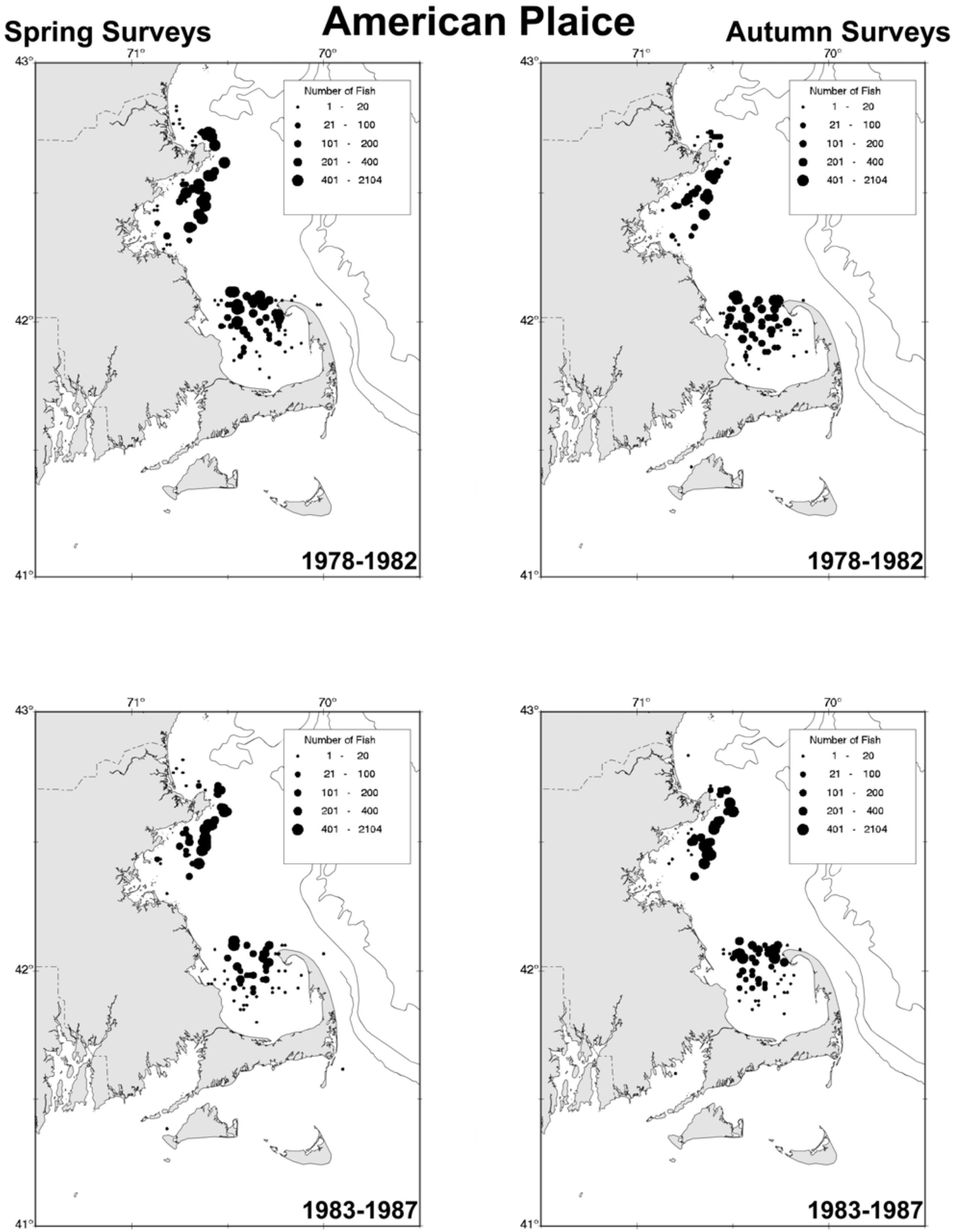

Figure D8a. Distribution of American plaice in the Massachusetts inshore spring and autumn bottom trawl surveys from 1978-1987.

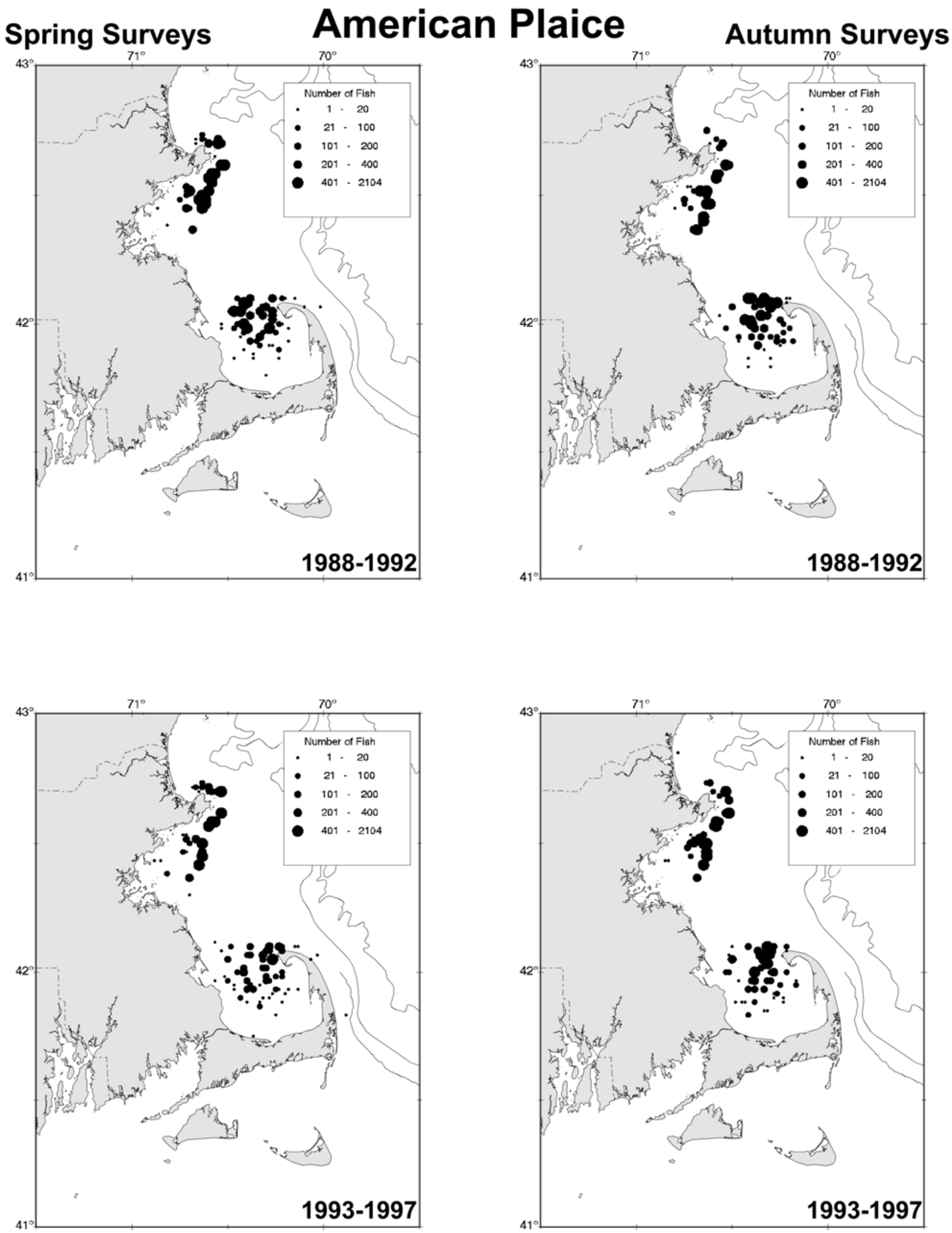

Figure D8b. Distribution of American plaice in the Massachusetts inshore spring and autumn bottom trawl surveys from 1988-1997.

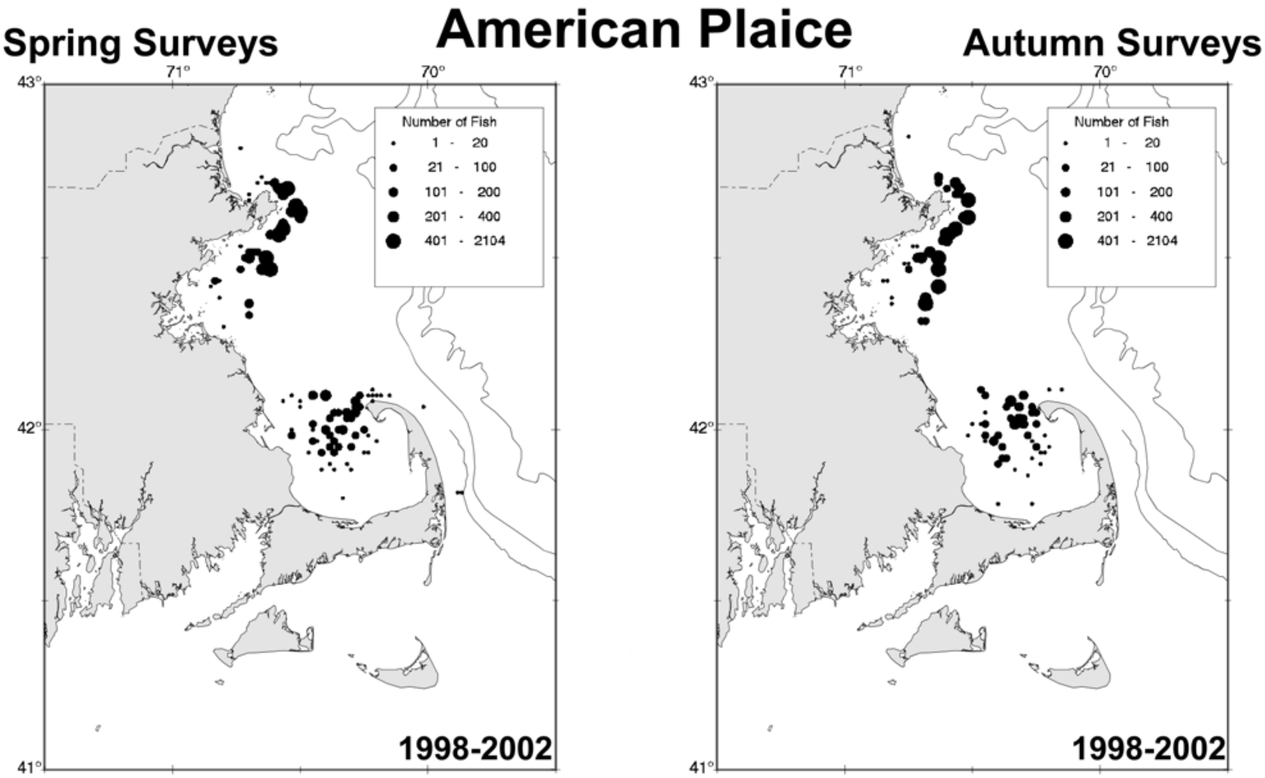

Figure D8c. Distribution of American plaice in the Massachusetts inshore spring and autumn bottom trawl surveys from 1998-2002.

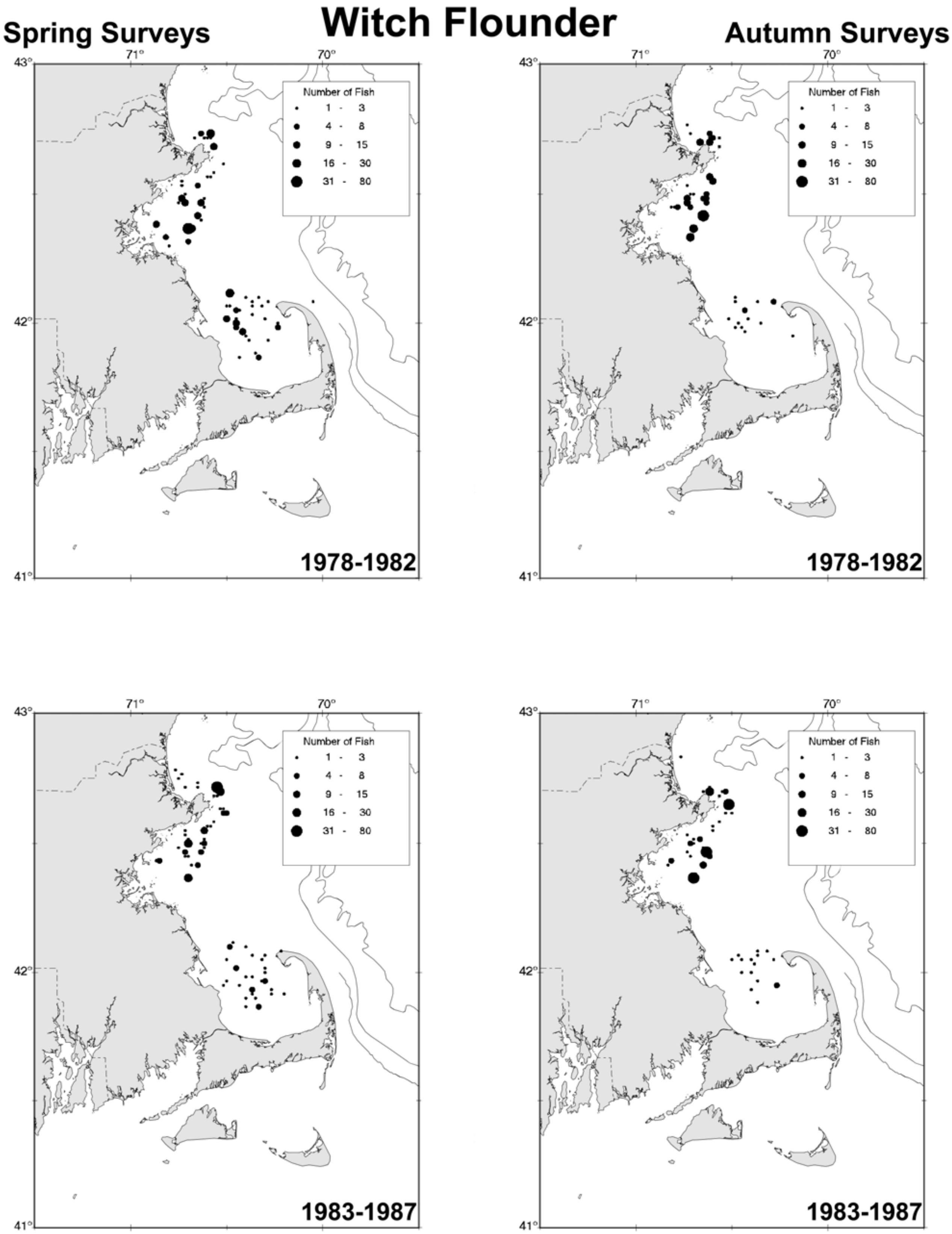

Figure D9a. Distribution of witch flounder in the Massachusetts inshore spring and autumn bottom trawl surveys from 1978-1987.

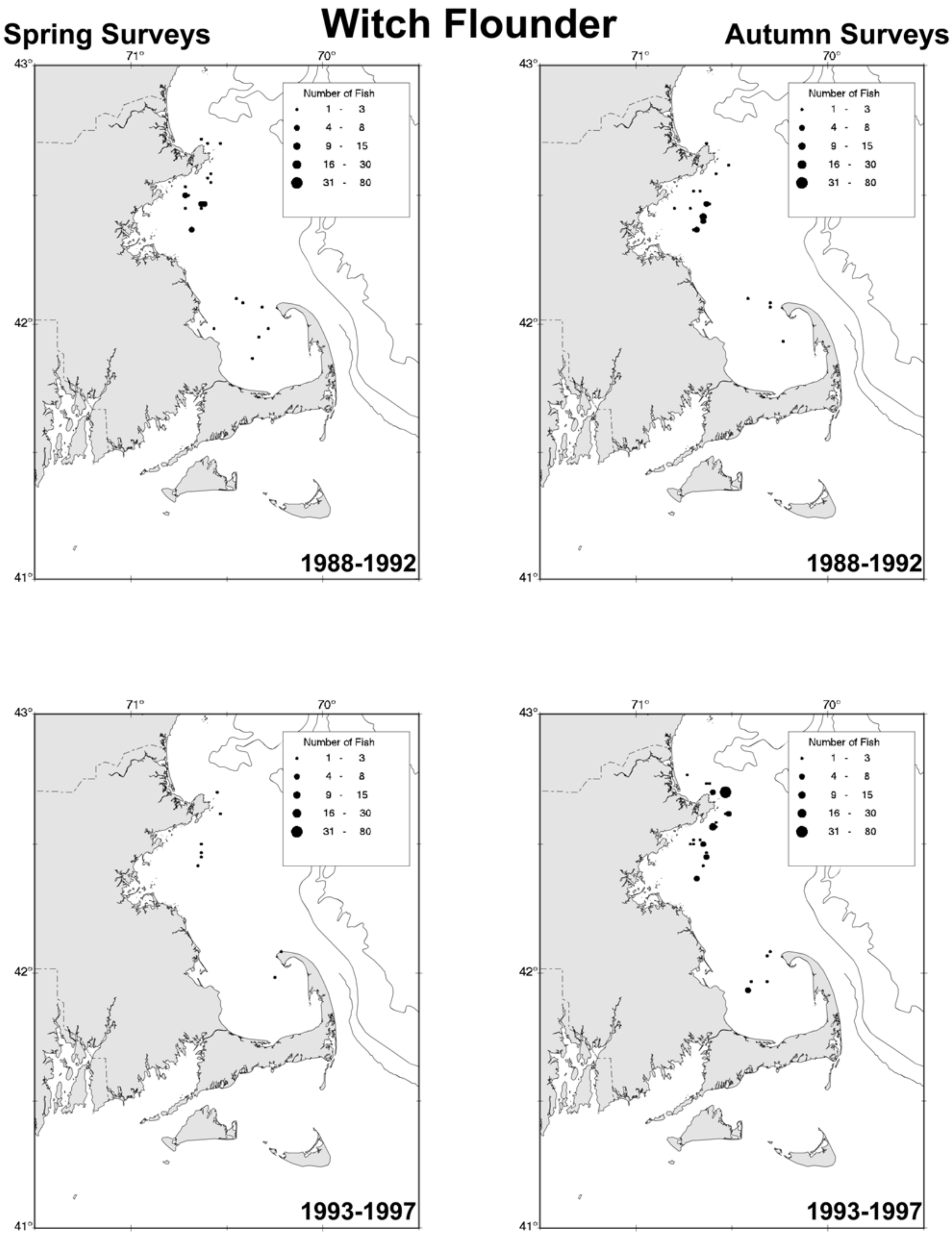

Figure D9b. Distribution of witch flounder in the Massachusetts inshore spring and autumn bottom trawl surveys from 1988-1997.

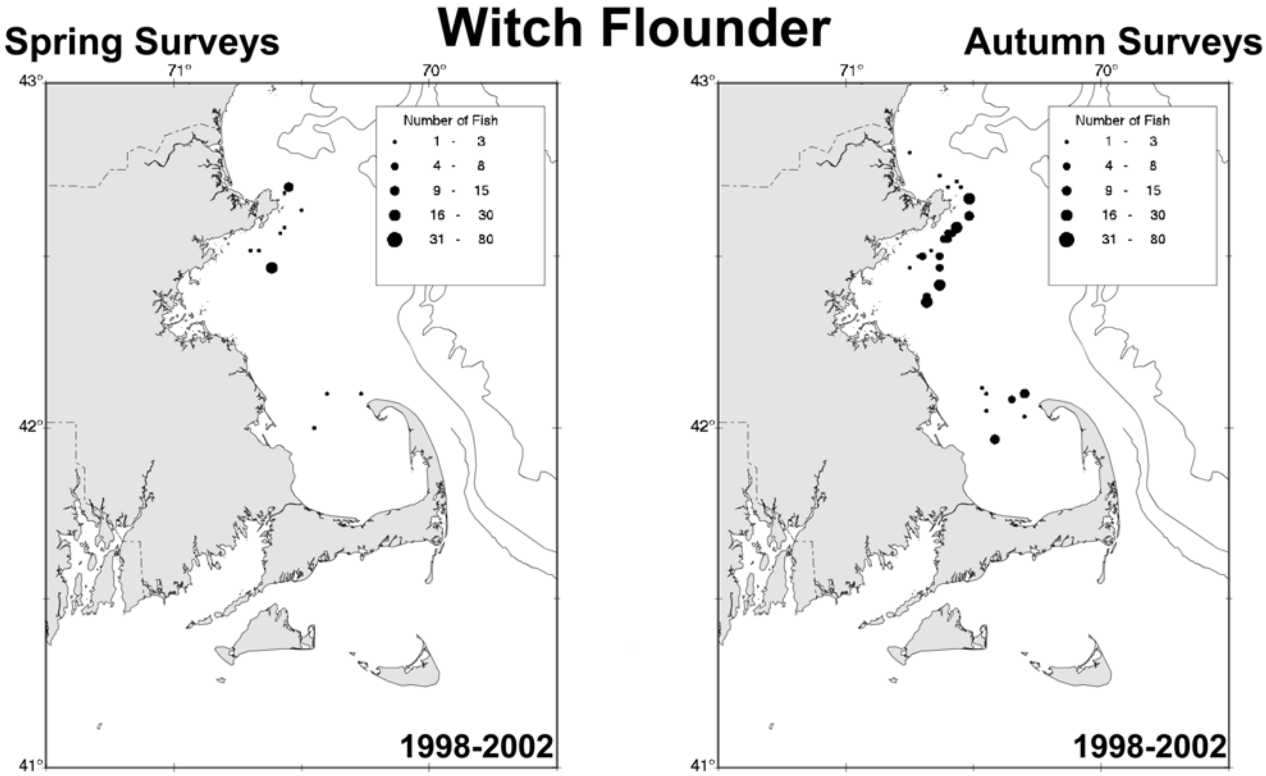

Figure D9c. Distribution of witch flounder in the Massachusetts inshore spring and autumn bottom trawl surveys from 1998-2002.

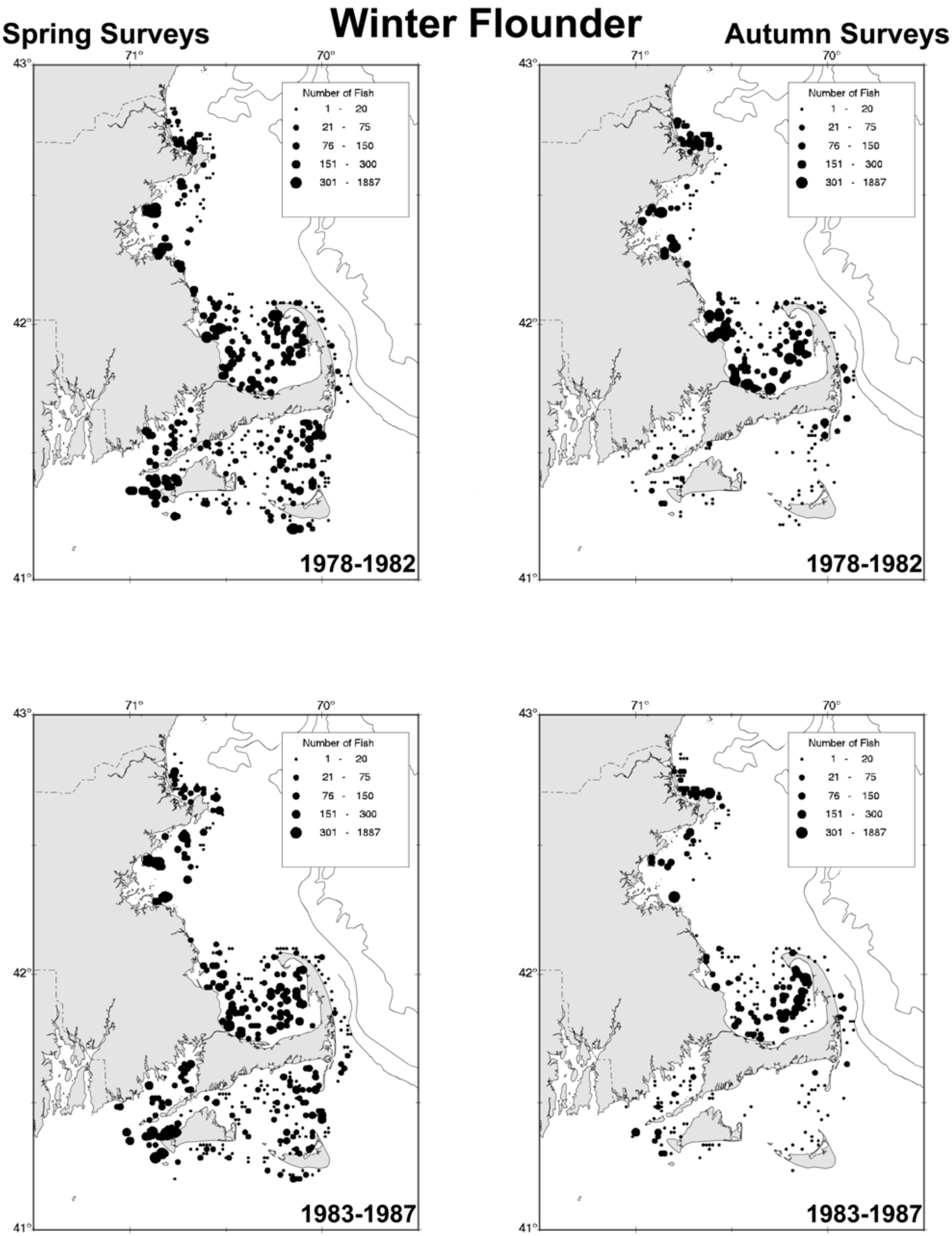

Figure D10a. Distribution of winter flounder in the Massachusetts inshore spring and autumn bottom trawl surveys from 1978-1987.

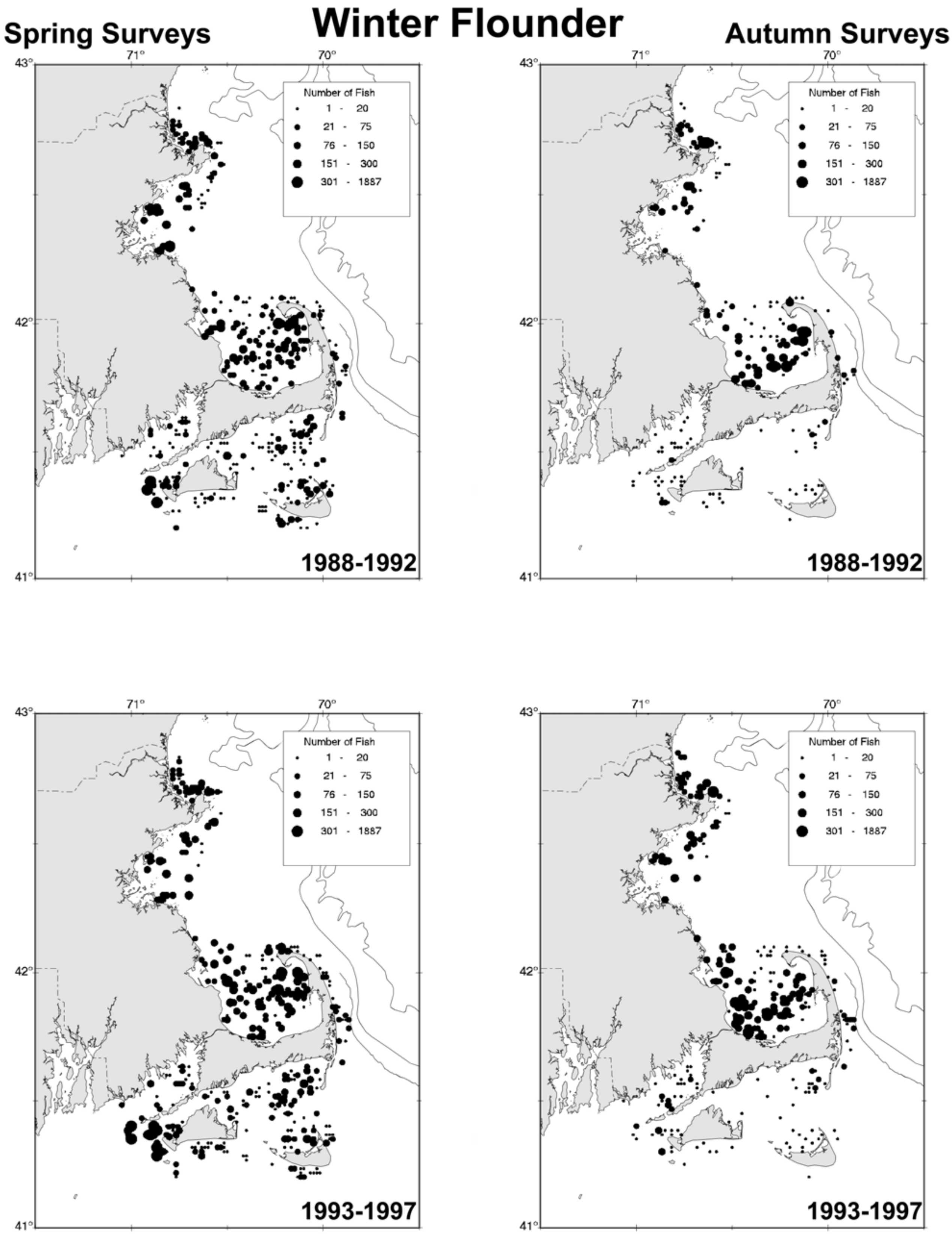

Figure D10b. Distribution of winter flounder in the Massachusetts inshore spring and autumn bottom trawl surveys from 1988-1997.

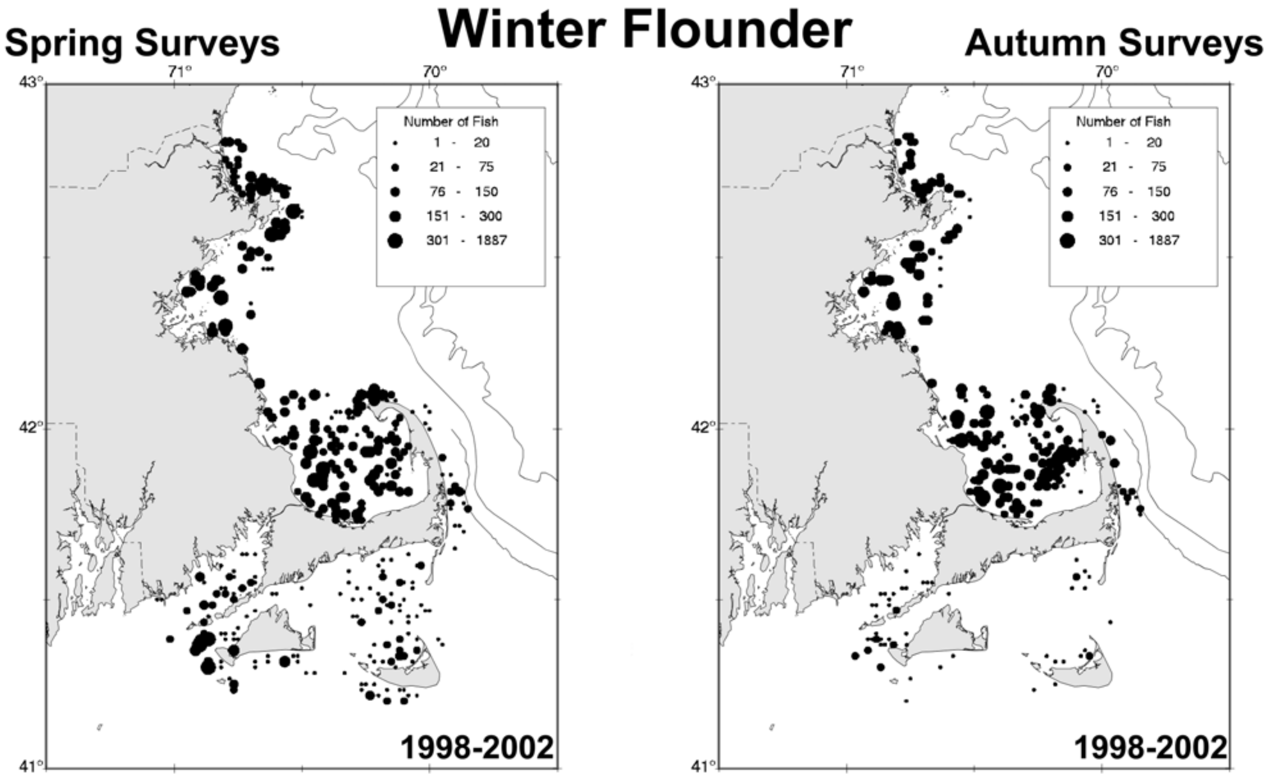

Figure D10c. Distribution of winter flounder in the Massachusetts inshore spring and autumn bottom trawl surveys from 1998-2002.

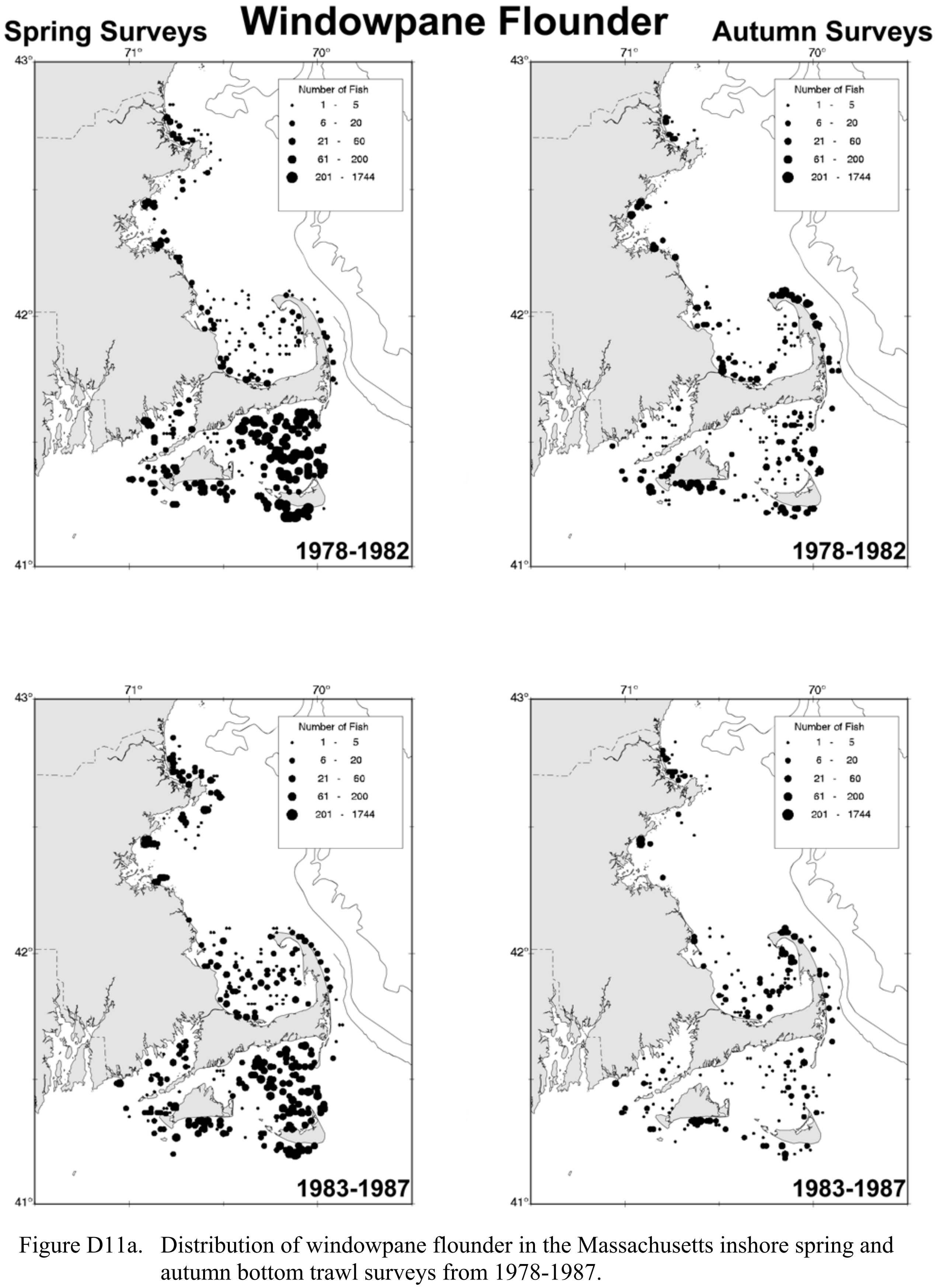

Figure D11a. Distribution of windowpane flounder in the Massachusetts inshore spring and autumn bottom trawl surveys from 1978-1987.

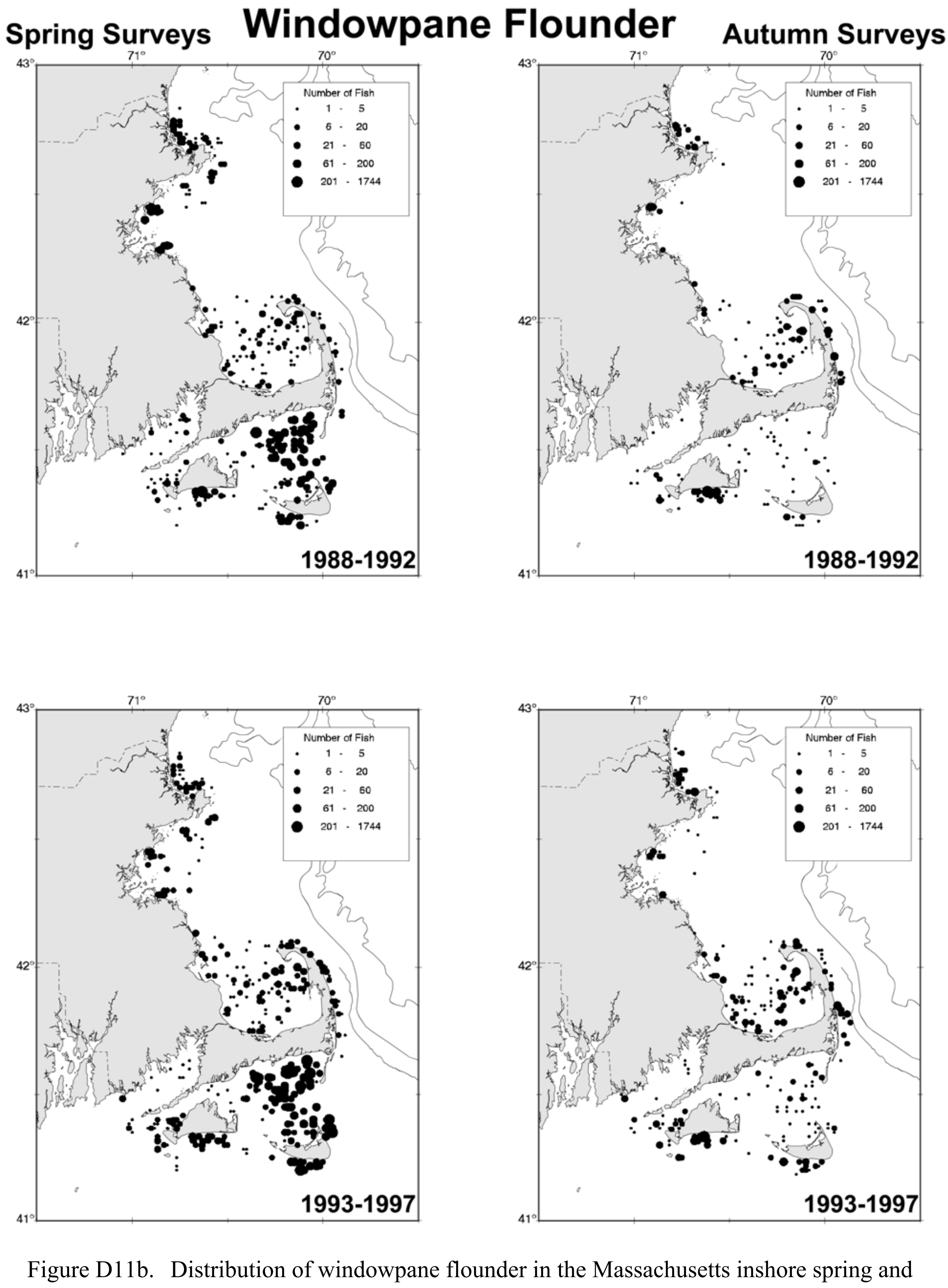

Figure D11b. Distribution of windowpane flounder in the Massachusetts inshore spring and autumn bottom trawl surveys from 1988-1997.

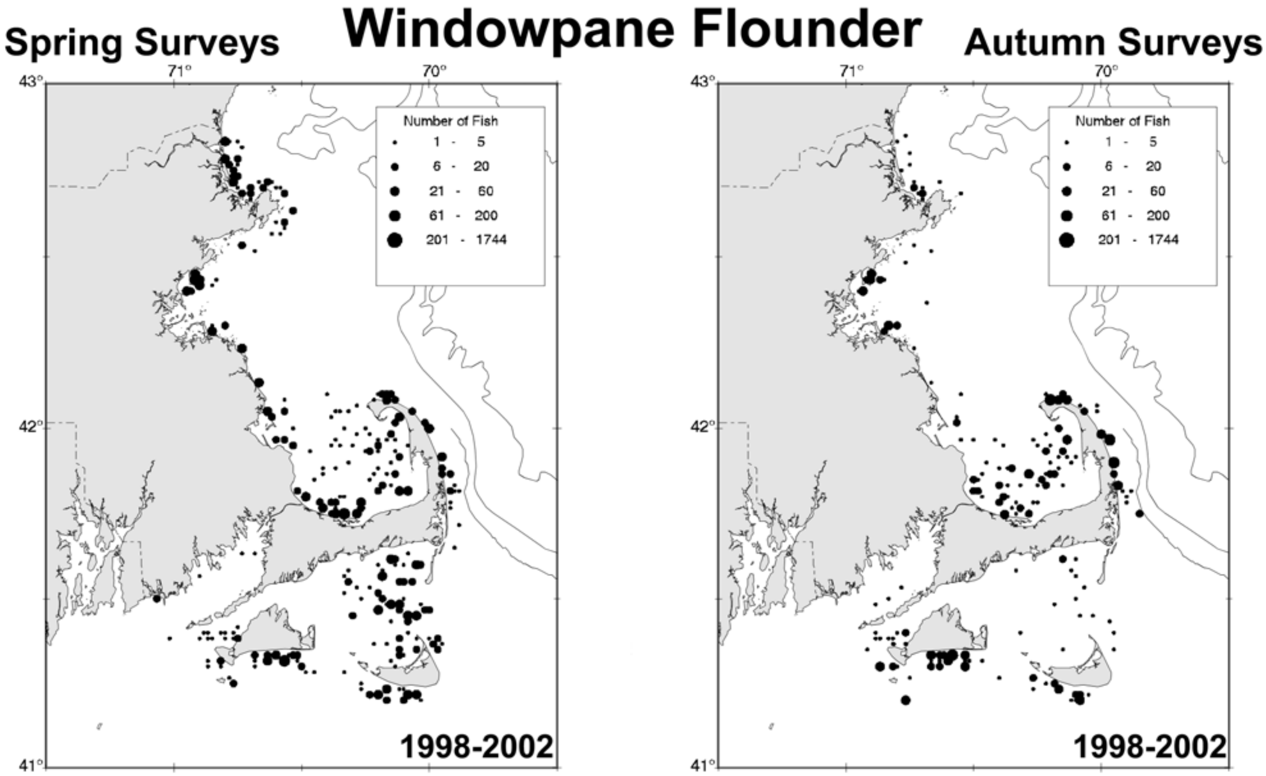

Figure D11c. Distribution of windowpane flounder in the Massachusetts inshore spring and autumn bottom trawl surveys from 1998-2002.

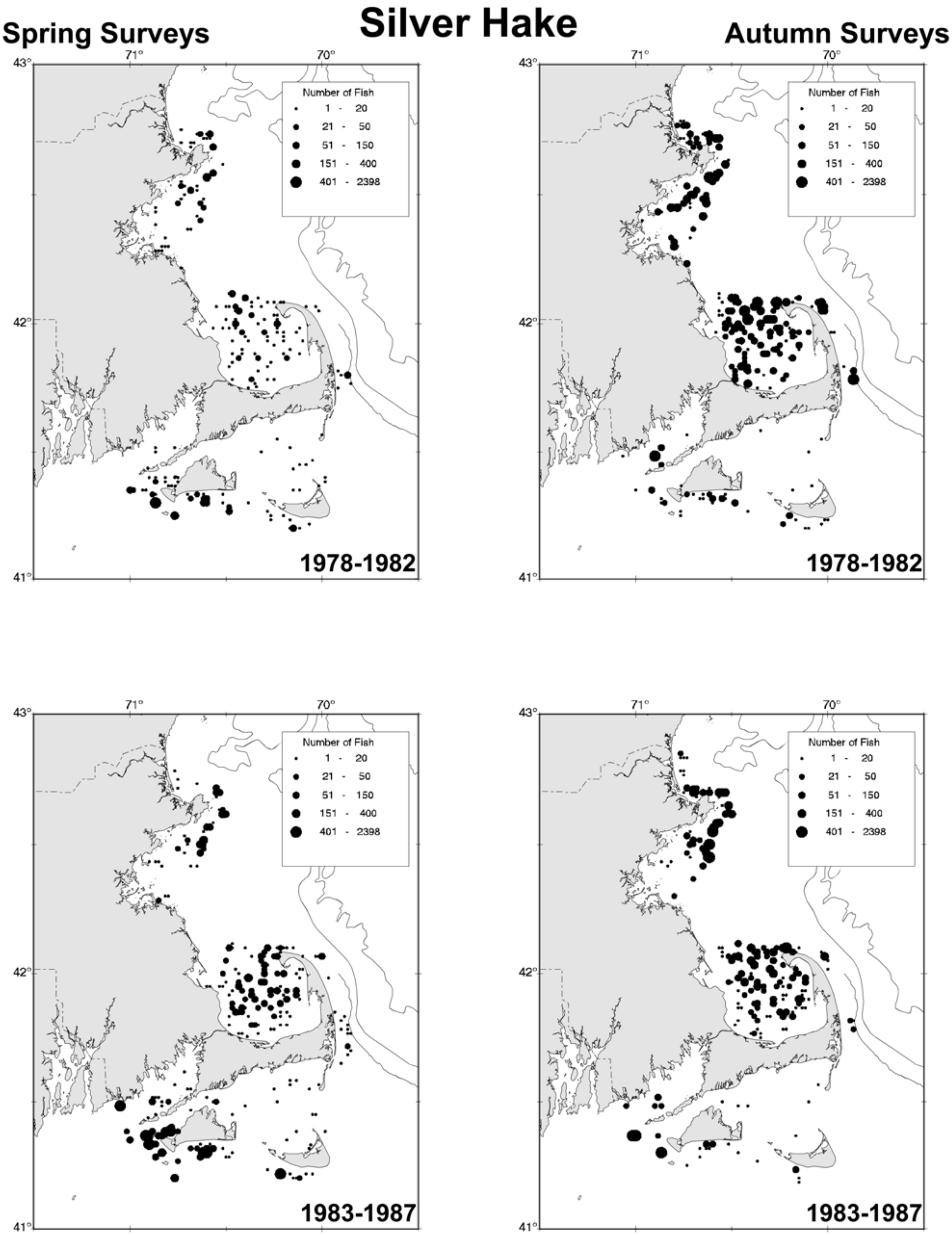

Figure D12a. Distribution of silver hake in the Massachusetts inshore spring and autumn bottom trawl surveys from 1978-1987.

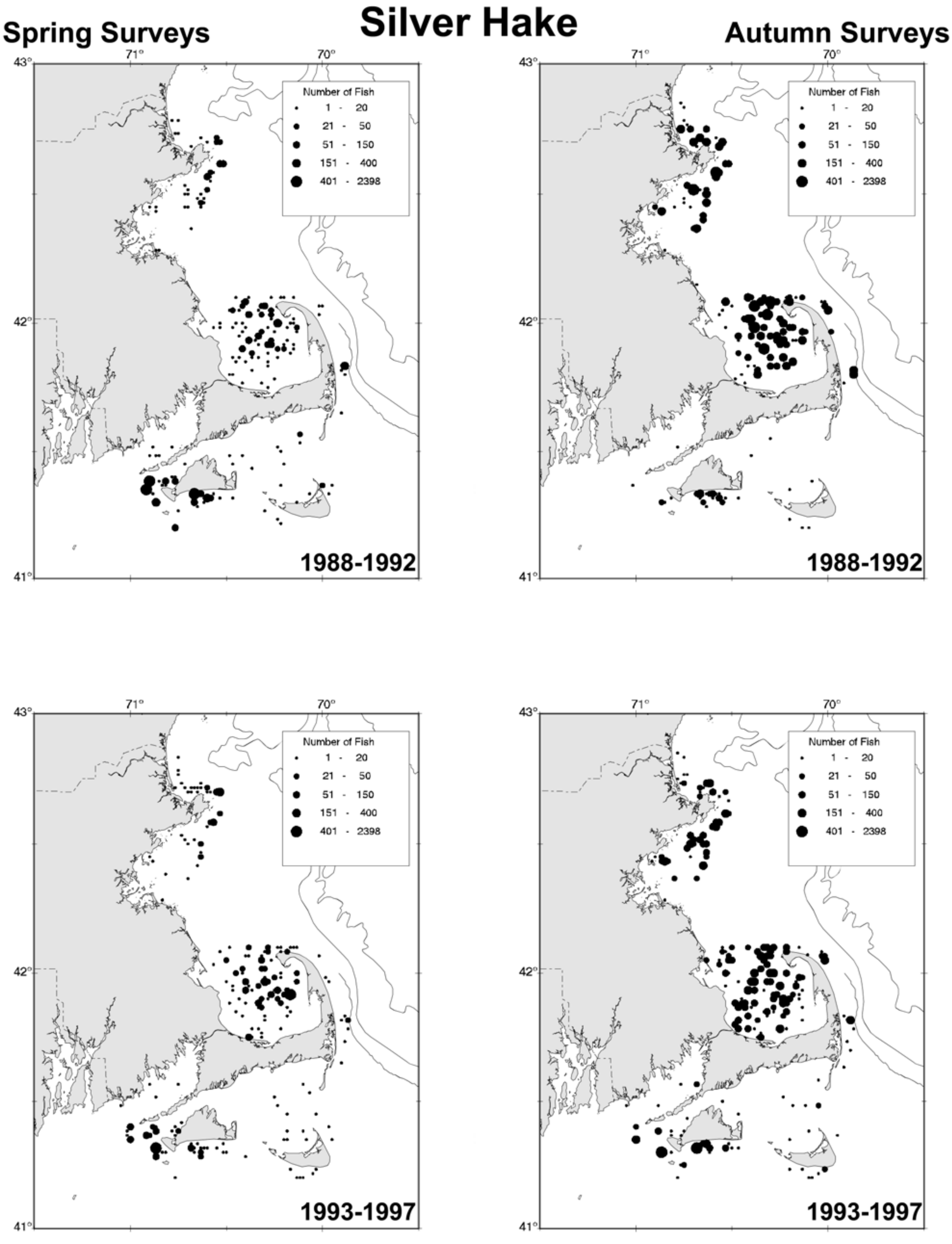

Figure D12b. Distribution of silver hake in the Massachusetts inshore spring and autumn bottom trawl surveys from 1988-1997.

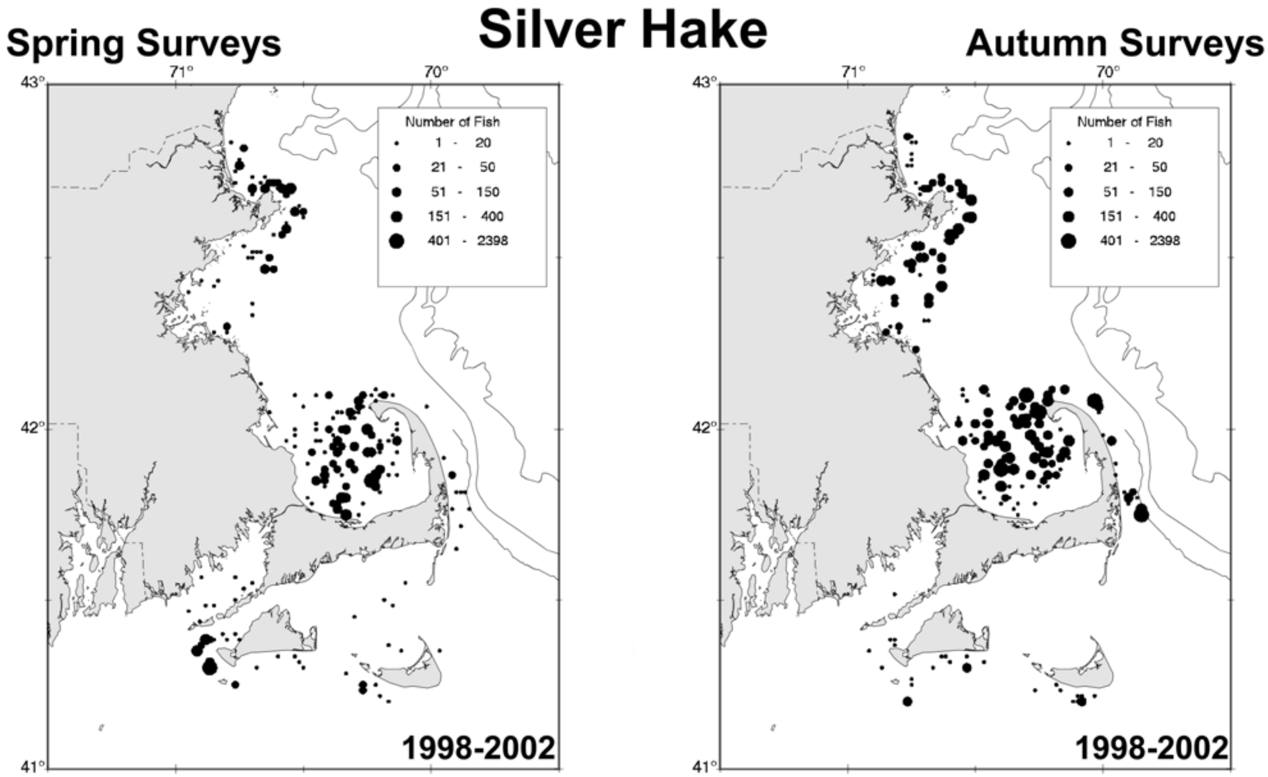

Figure D12c. Distribution of silver hake in the Massachusetts inshore spring and autumn bottom trawl surveys from 1998-2002.

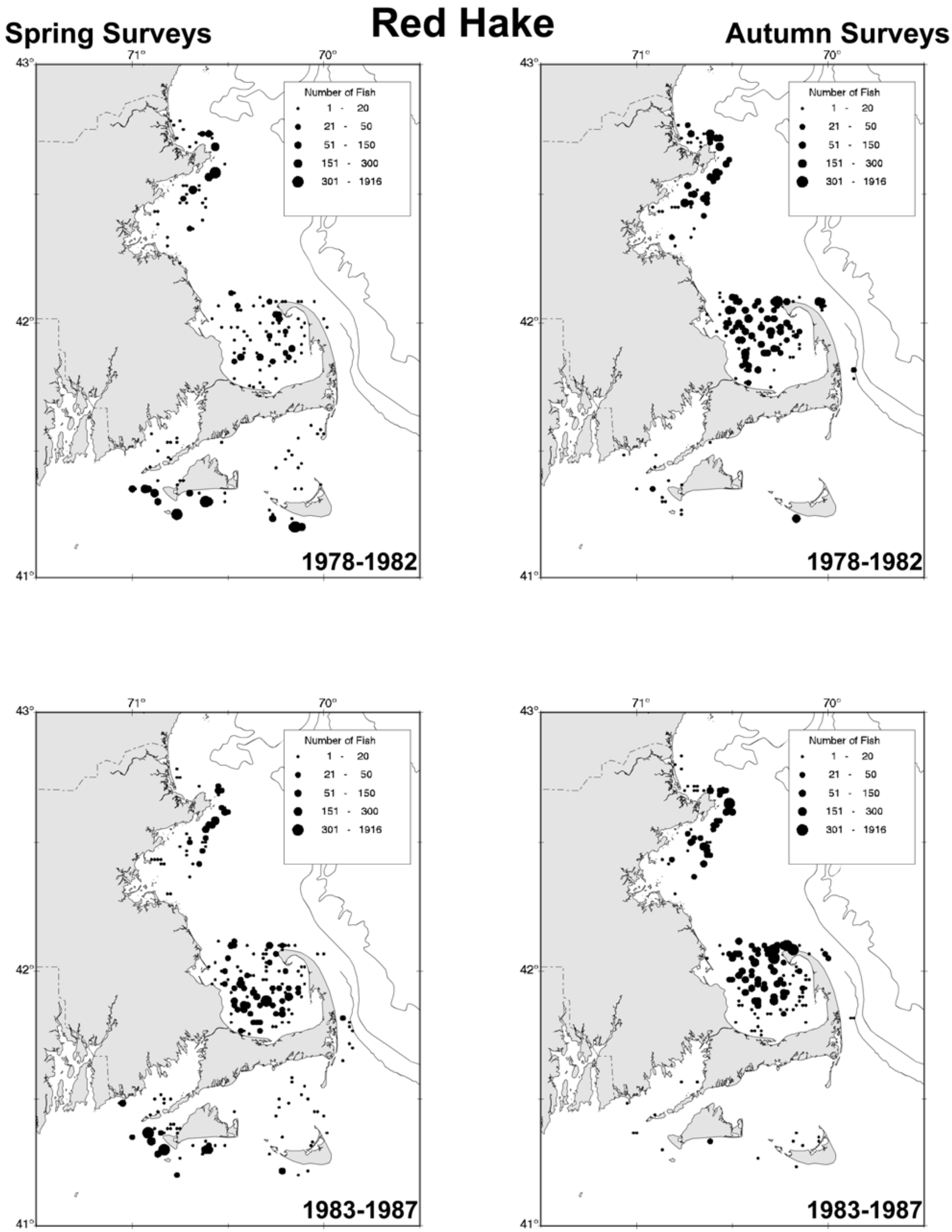

Figure D13a. Distribution of red hake in the Massachusetts inshore spring and autumn bottom trawl surveys from 1978-1987.

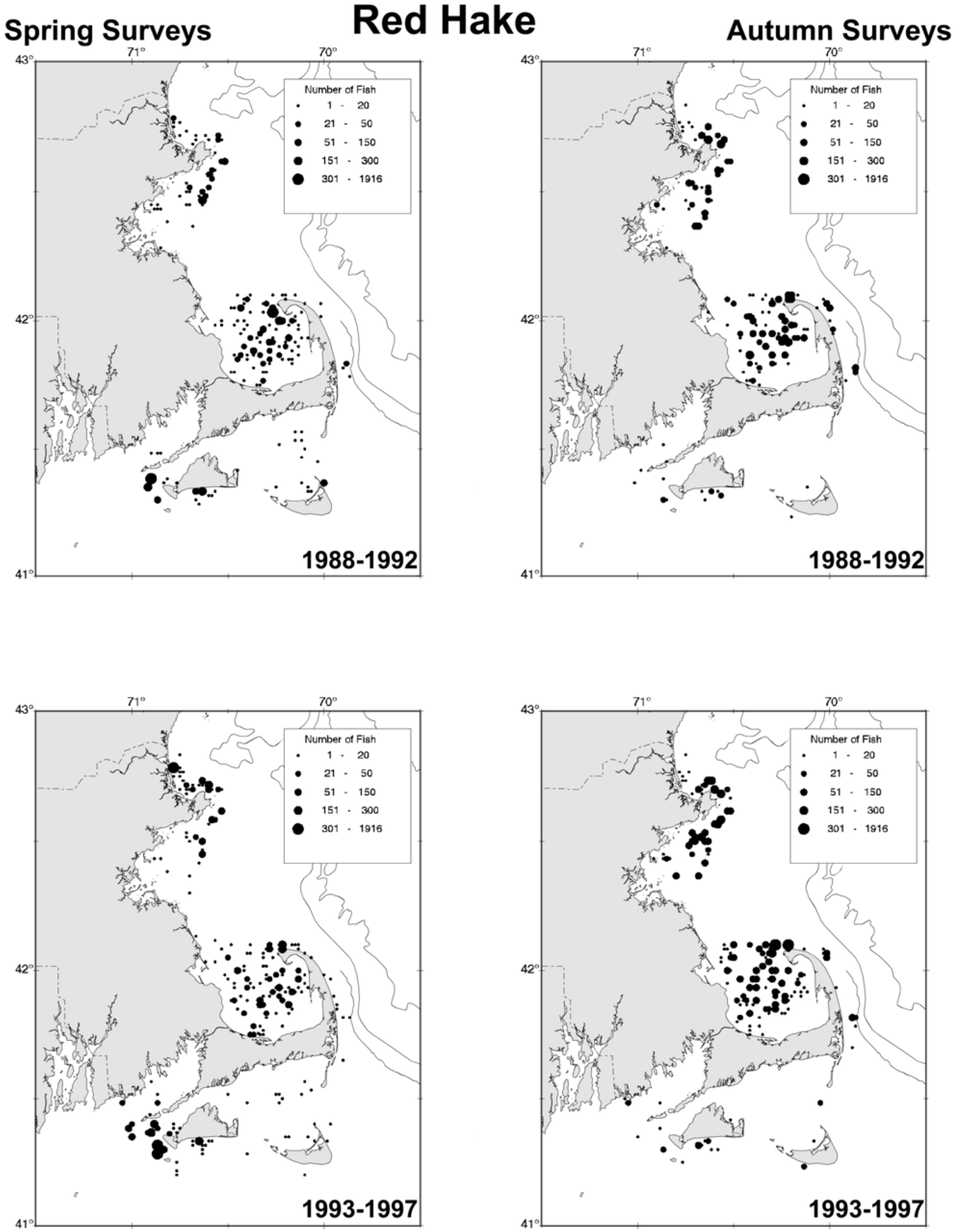

Figure D13b. Distribution of red hake in the Massachusetts inshore spring and autumn bottom trawl surveys from 1988-1997.

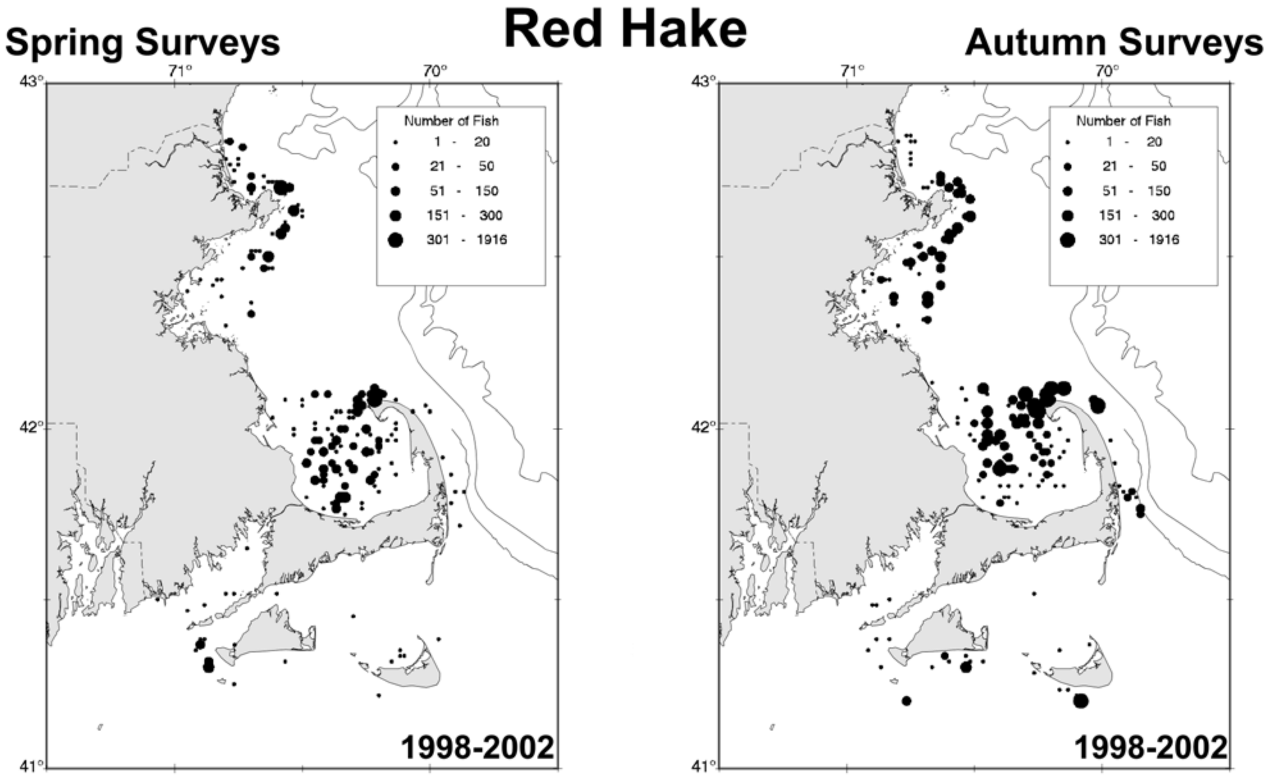

Figure D13c. Distribution of red hake in the Massachusetts inshore spring and autumn bottom trawl surveys from 1998-2002.

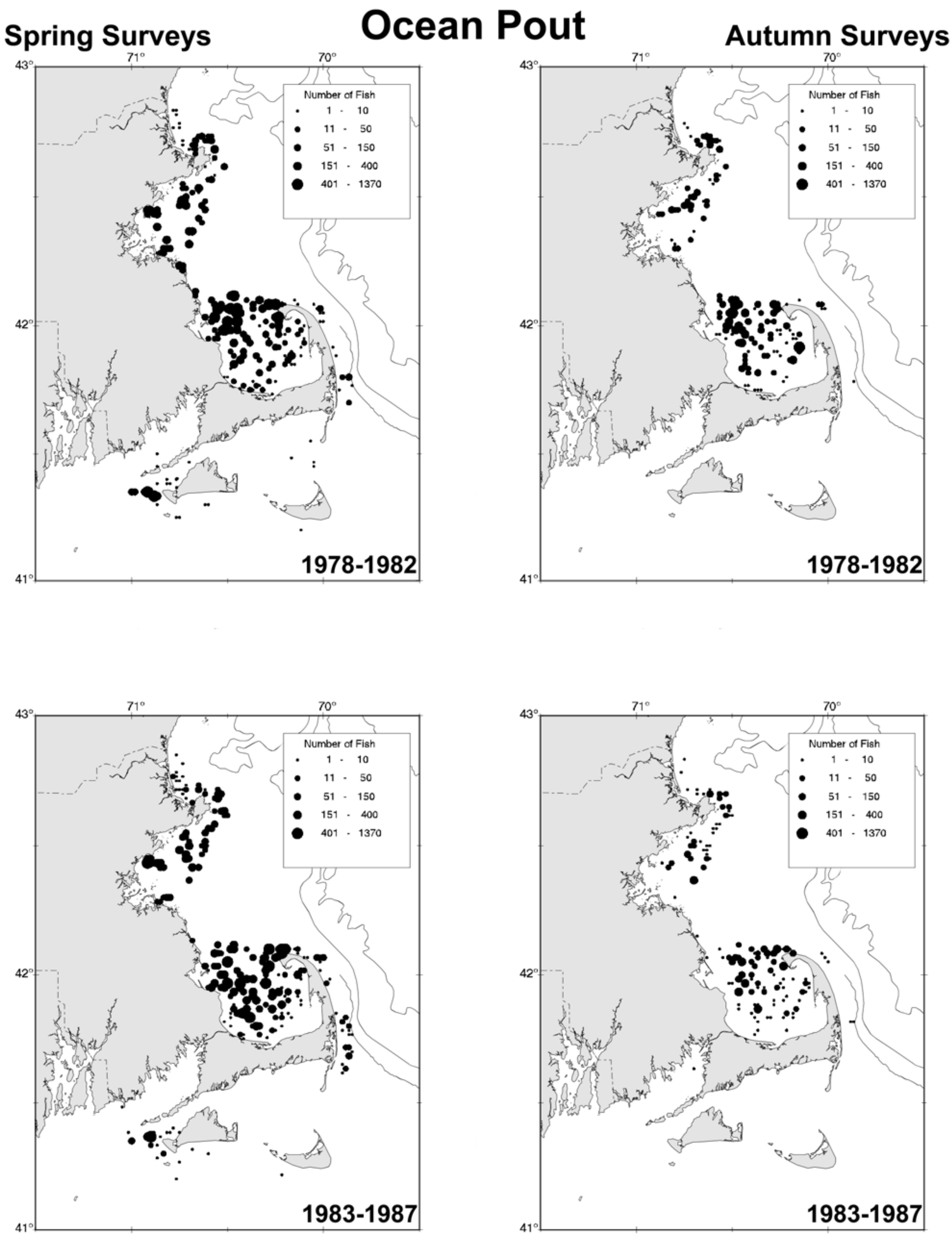

Figure D14a. Distribution of ocean pout in the Massachusetts inshore spring and autumn bottom trawl surveys from 1978-1987.

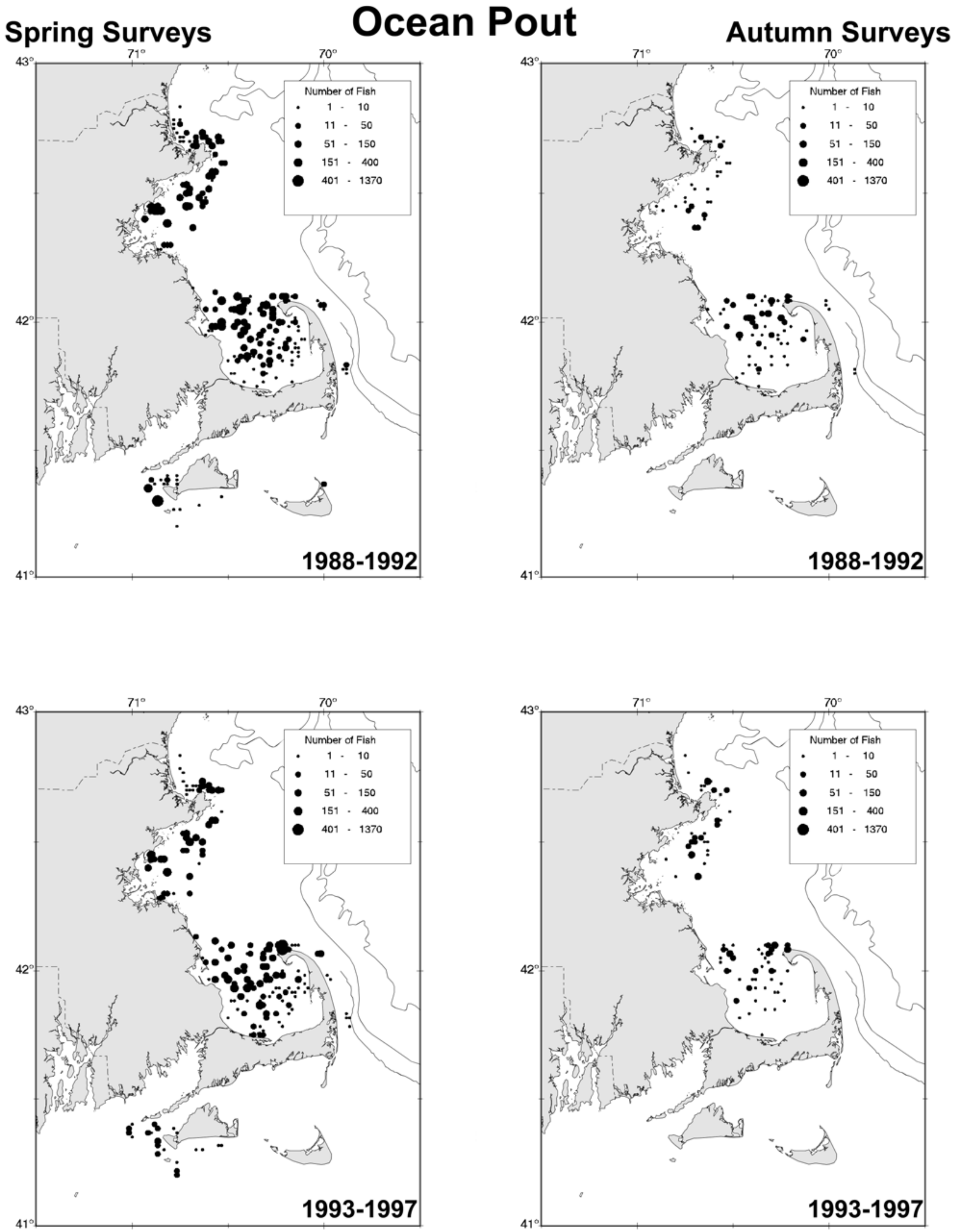

Figure D14b. Distribution of ocean pout in the Massachusetts inshore spring and autumn bottom trawl surveys from 1988-1997.

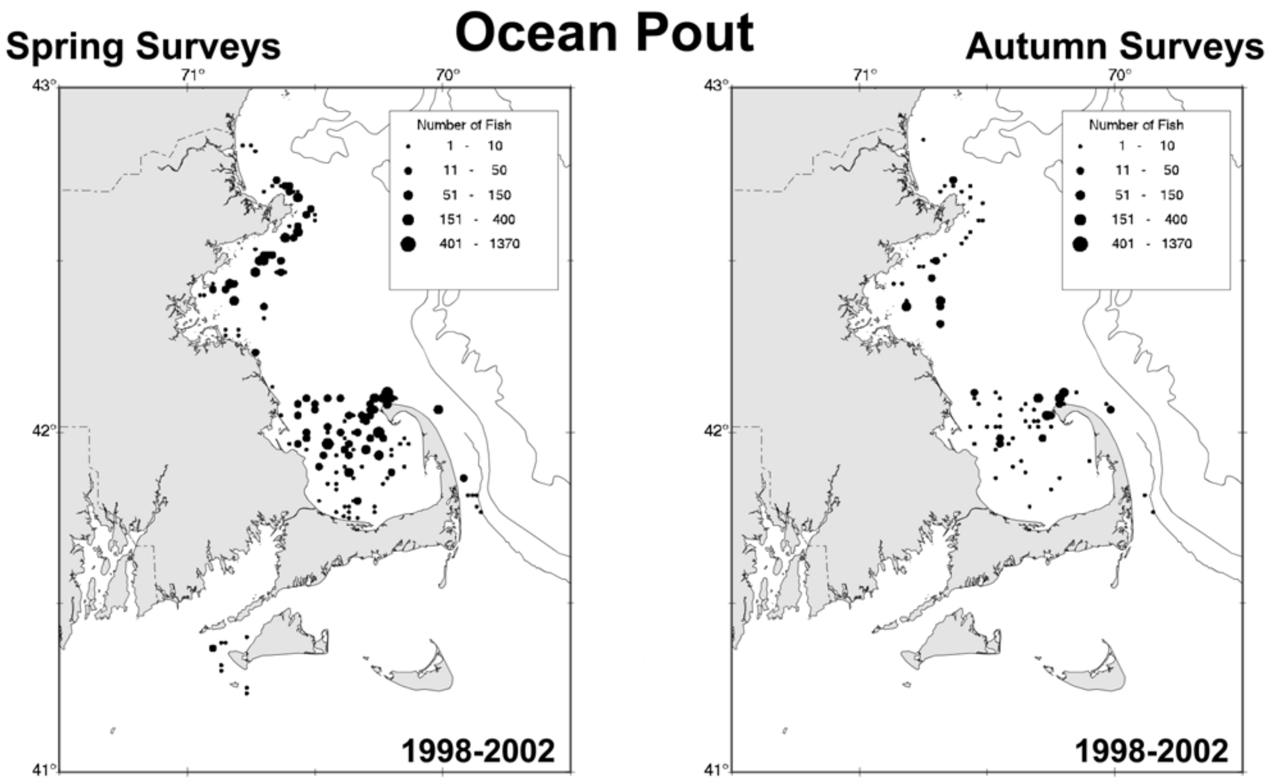

Figure D14c. Distribution of ocean pout in the Massachusetts inshore spring and autumn bottom trawl surveys from 1998-2002.

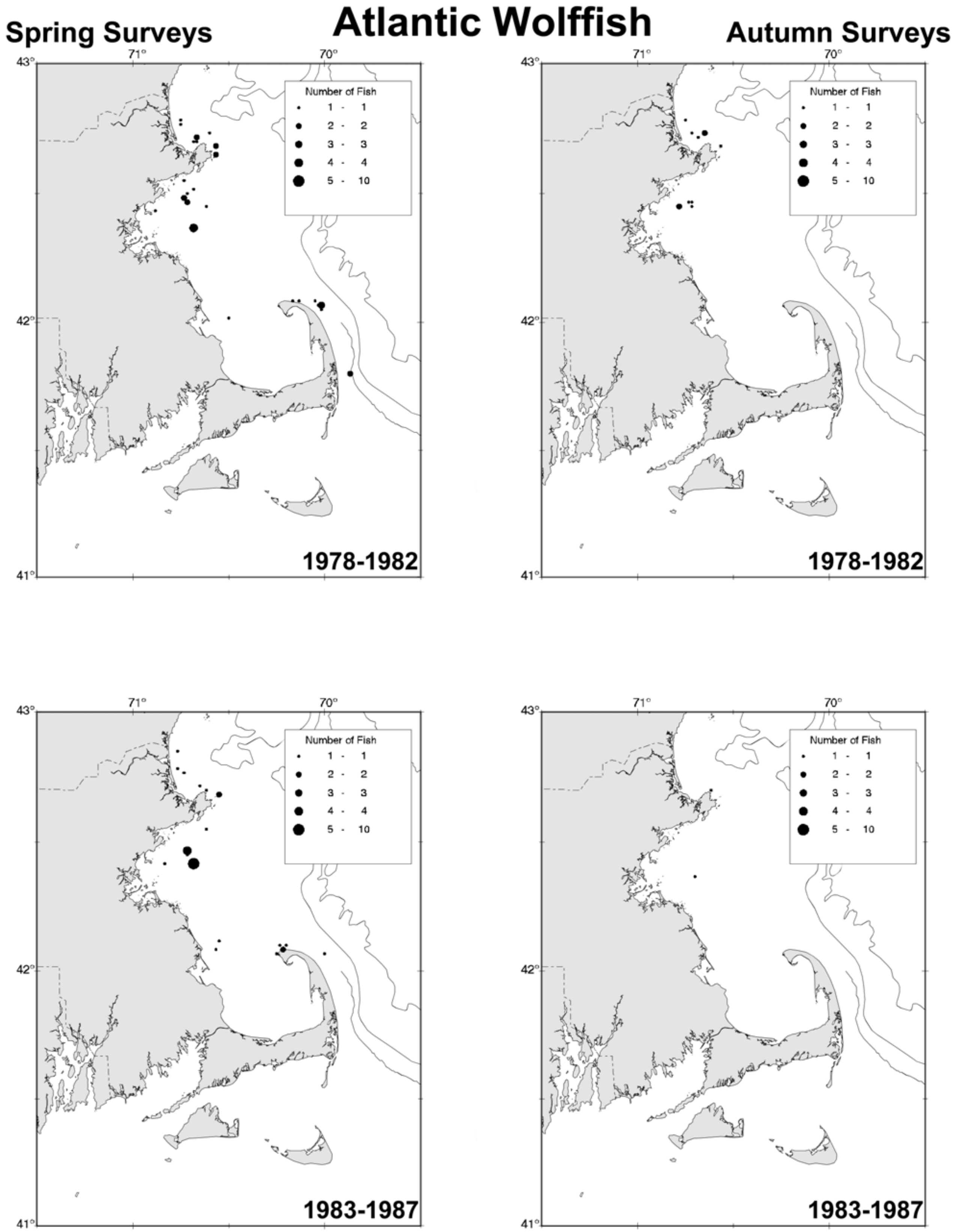

Figure D15a. Distribution of Atlantic wolffish in the Massachusetts inshore spring and autumn bottom trawl surveys from 1978-1987.

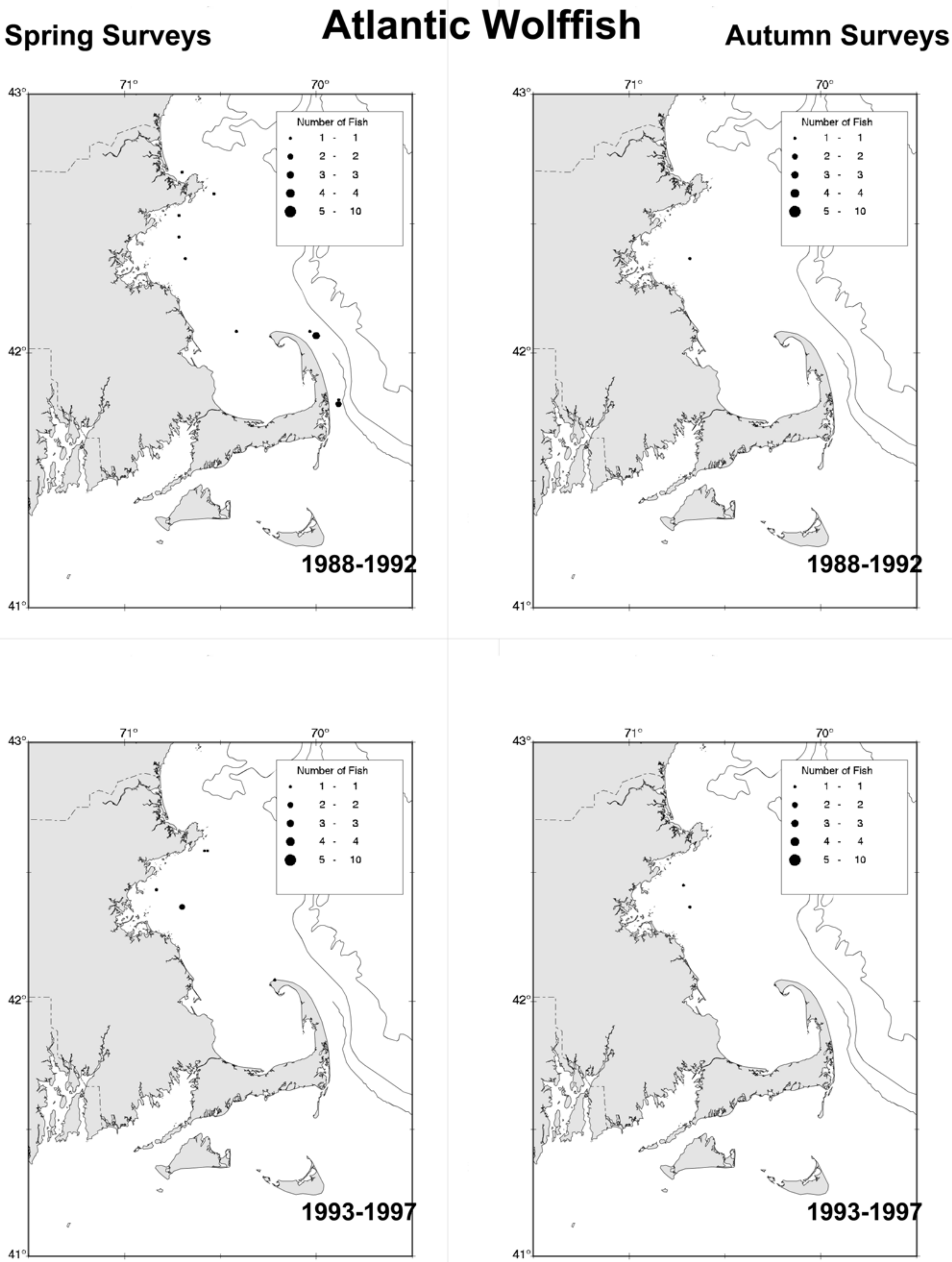

Figure D15b. Distribution of Atlantic wolffish in the Massachusetts inshore spring and autumn bottom trawl surveys from 1988-1997.

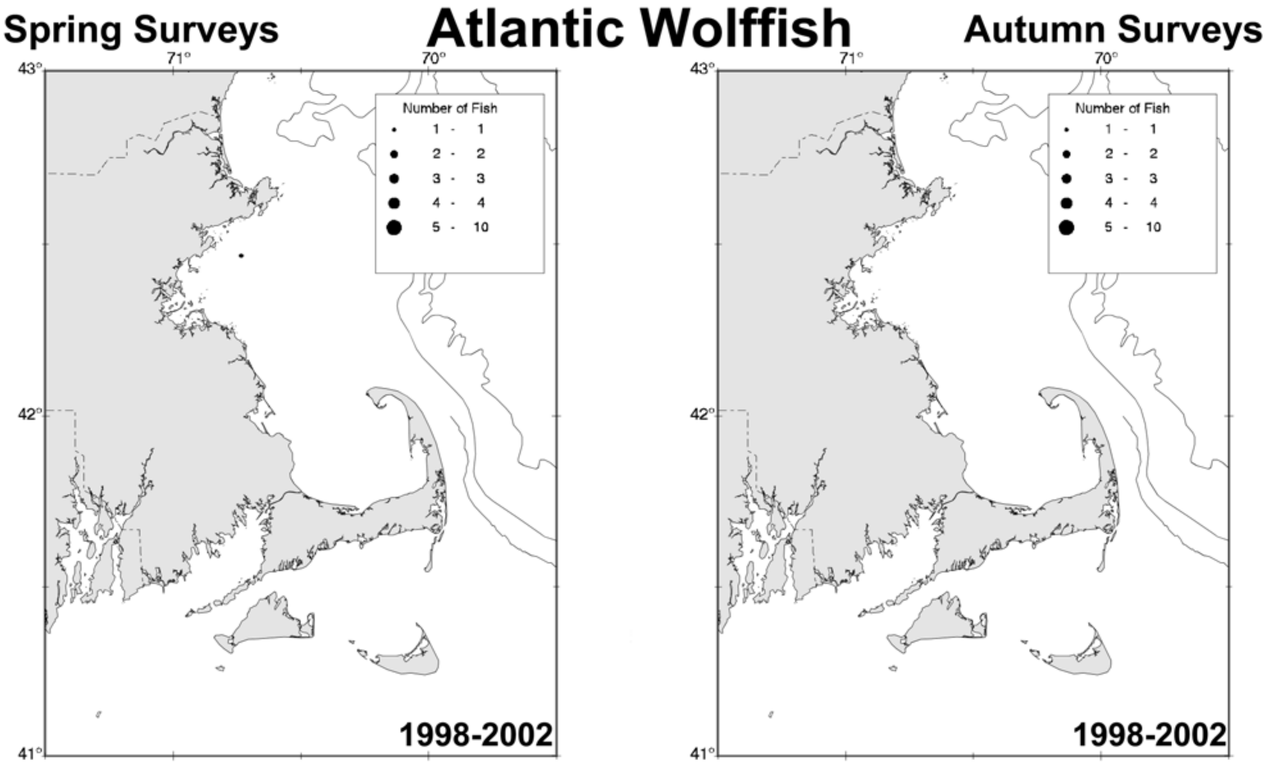

Figure D15c. Distribution of Atlantic wolffish in the Massachusetts inshore spring and autumn bottom trawl surveys from 1998-2002.

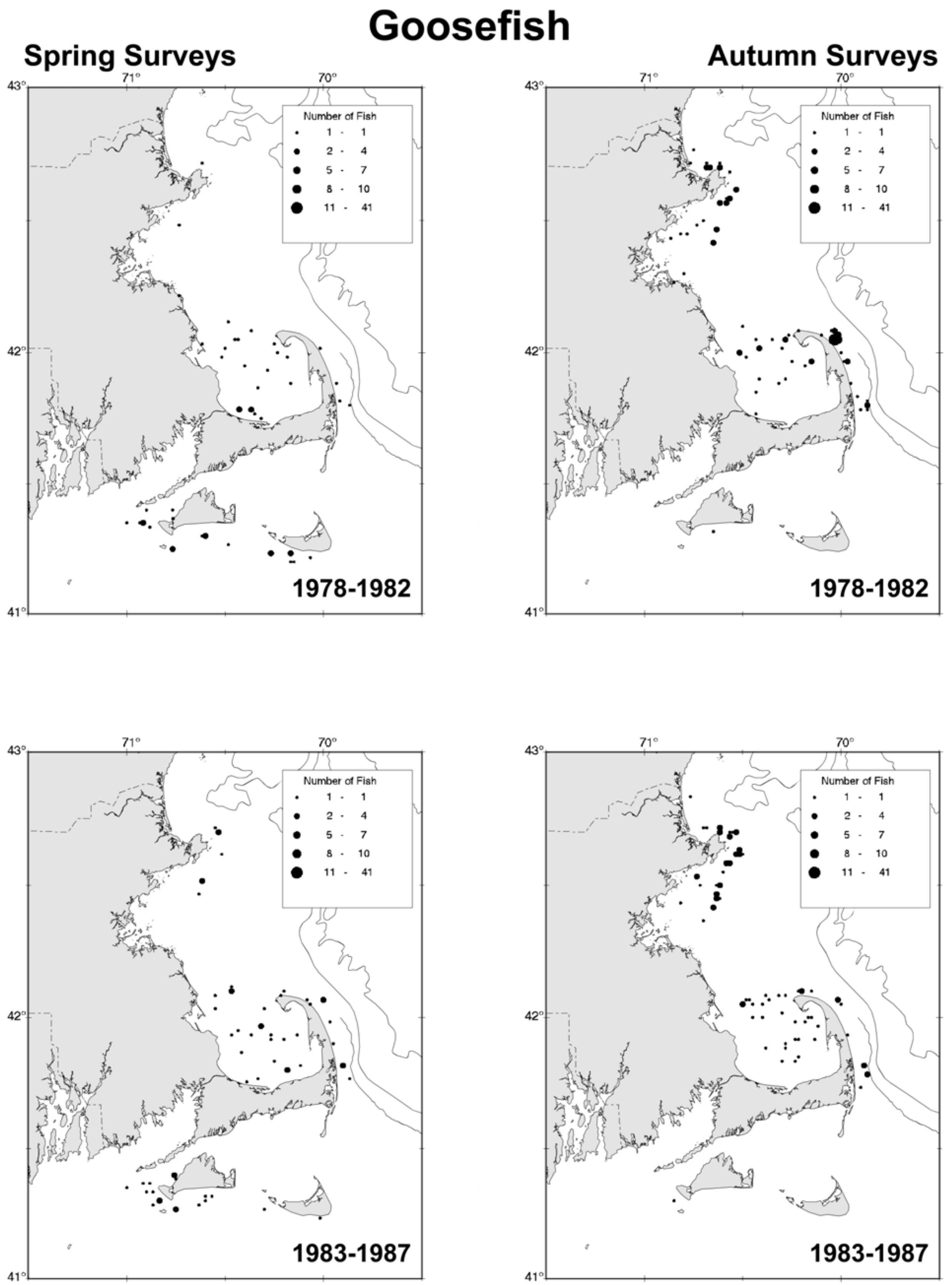

Figure D16a. Distribution of goosefish in the Massachusetts inshore spring and autumn bottom trawl surveys from 1978-1987.

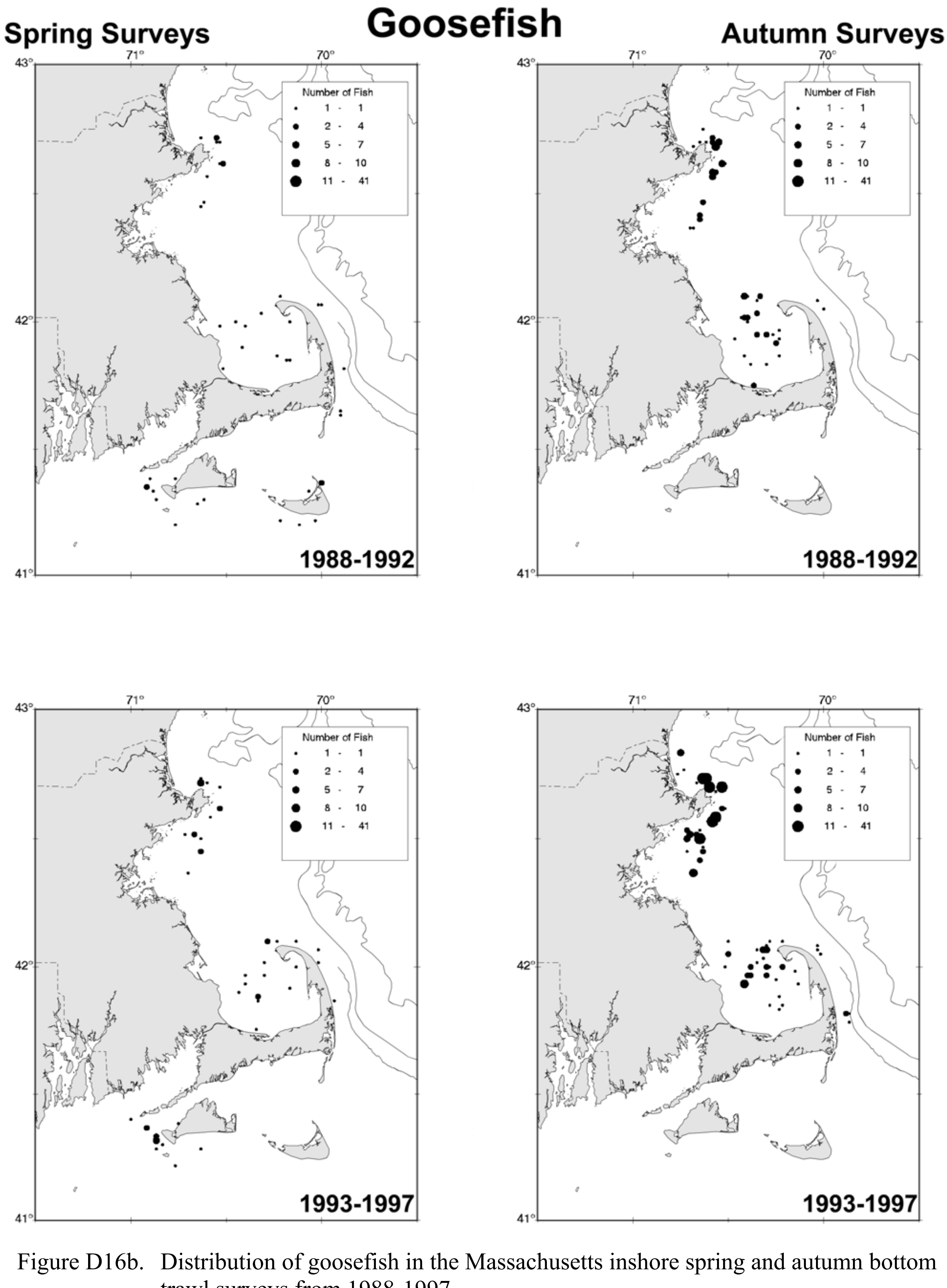

Figure D16b. Distribution of goosefish in the Massachusetts inshore spring and autumn bottom trawl surveys from 1988-1997.

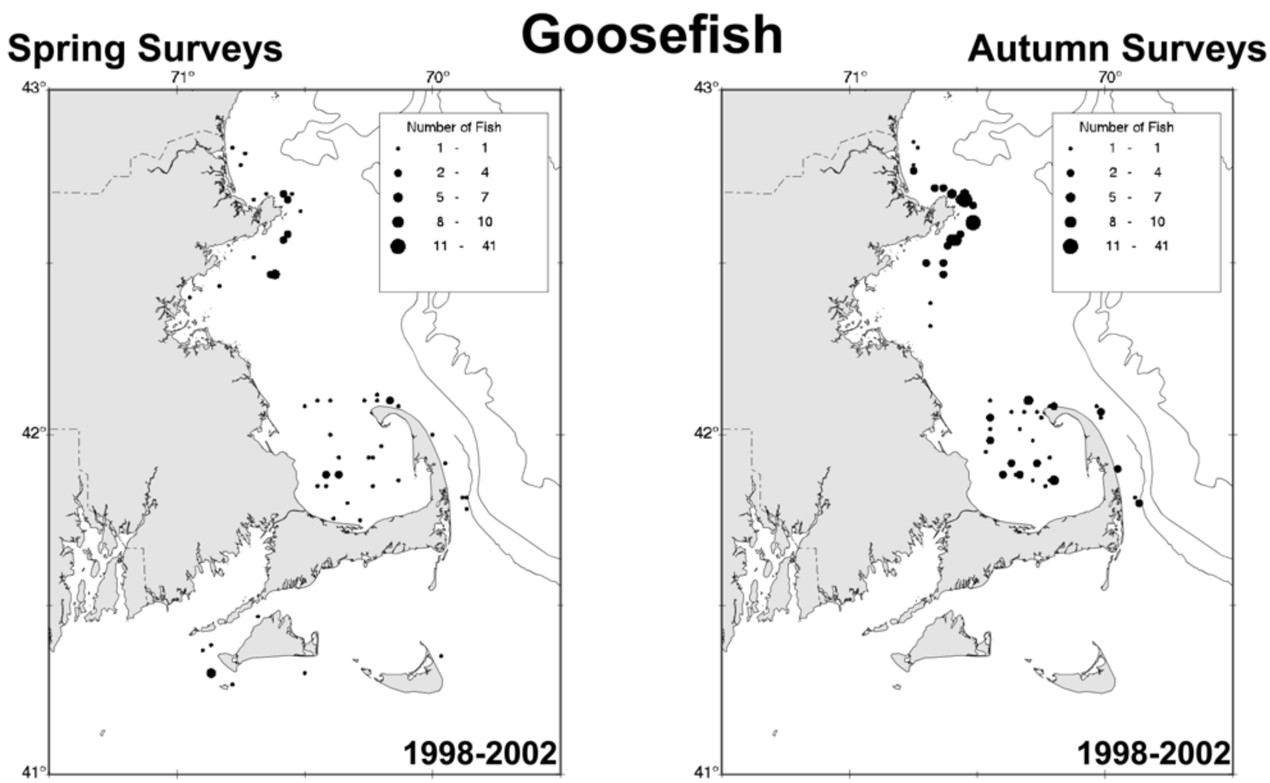

Figure D16c. Distribution of goosefish in the Massachusetts inshore spring and autumn bottom trawl surveys from 1998-2002.

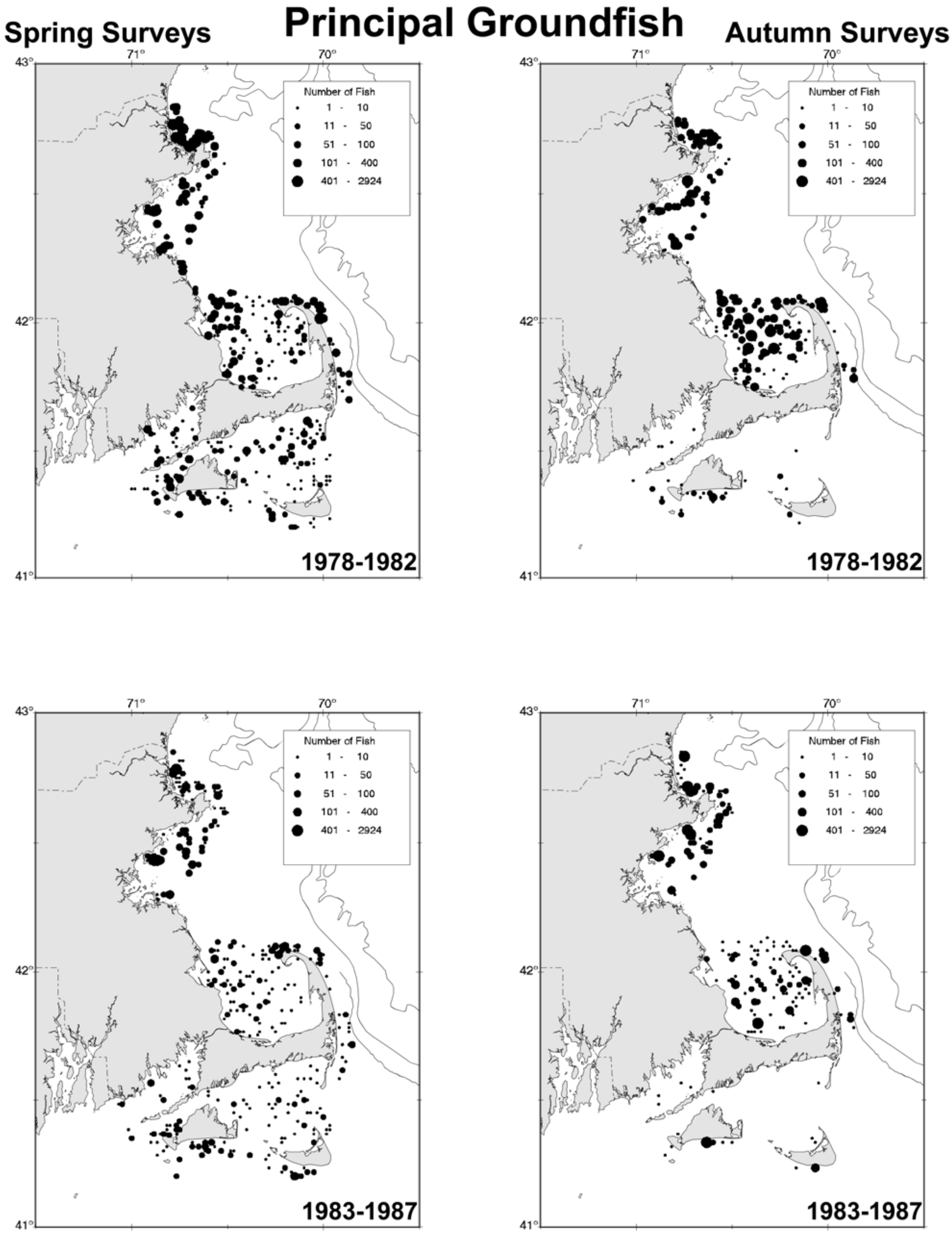

Figure D17a. Distribution of principal groundfish (Atlantic cod, haddock, pollock, Acadian redfish, and white hake) in the Massachusetts inshore spring and autumn bottom trawl surveys from 1978-1987.

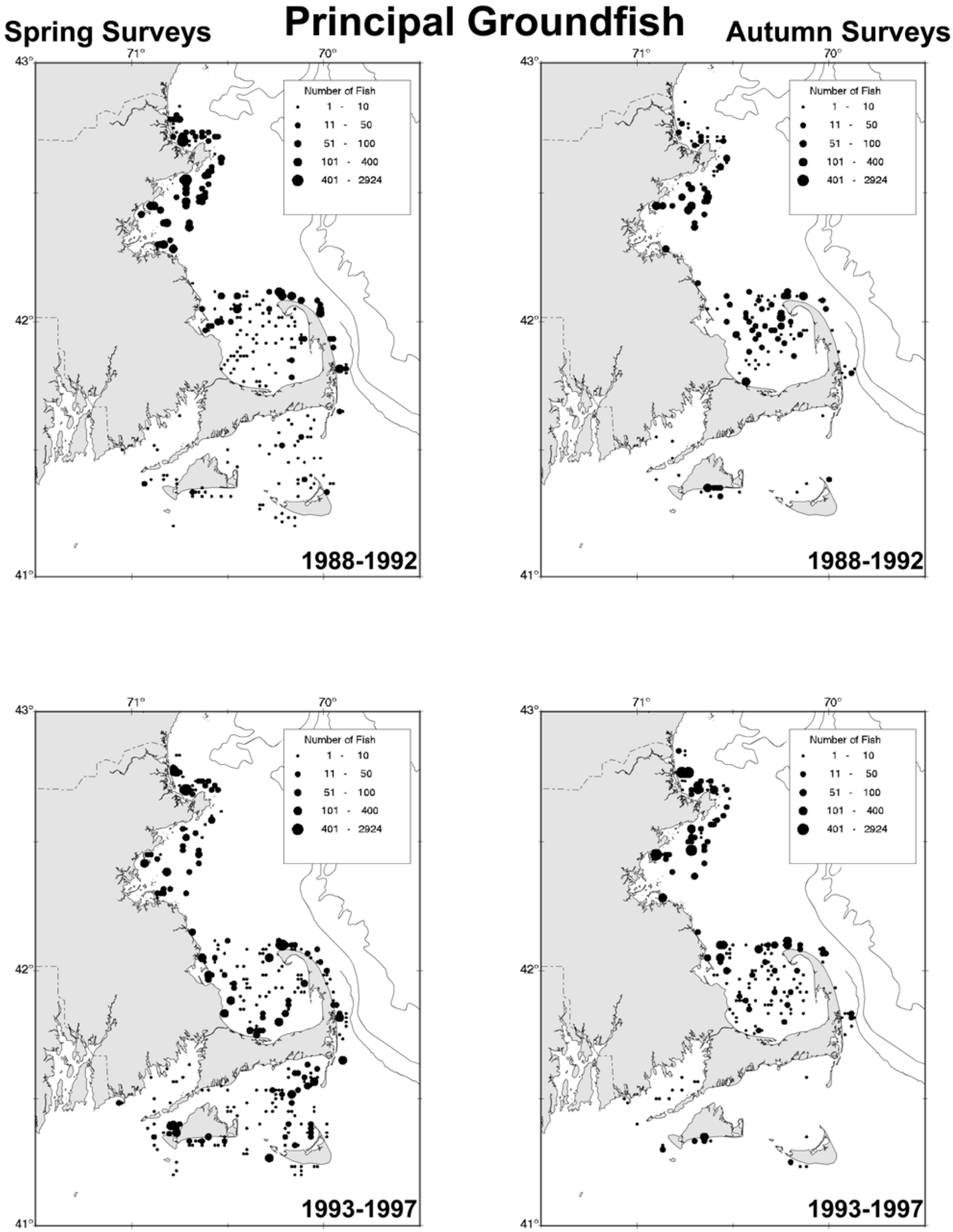

Figure D17b. Distribution of principal groundfish (Atlantic cod, haddock, pollock, Acadian redfish, and white hake) in the Massachusetts inshore spring and autumn bottom trawl surveys from 1988-1997.

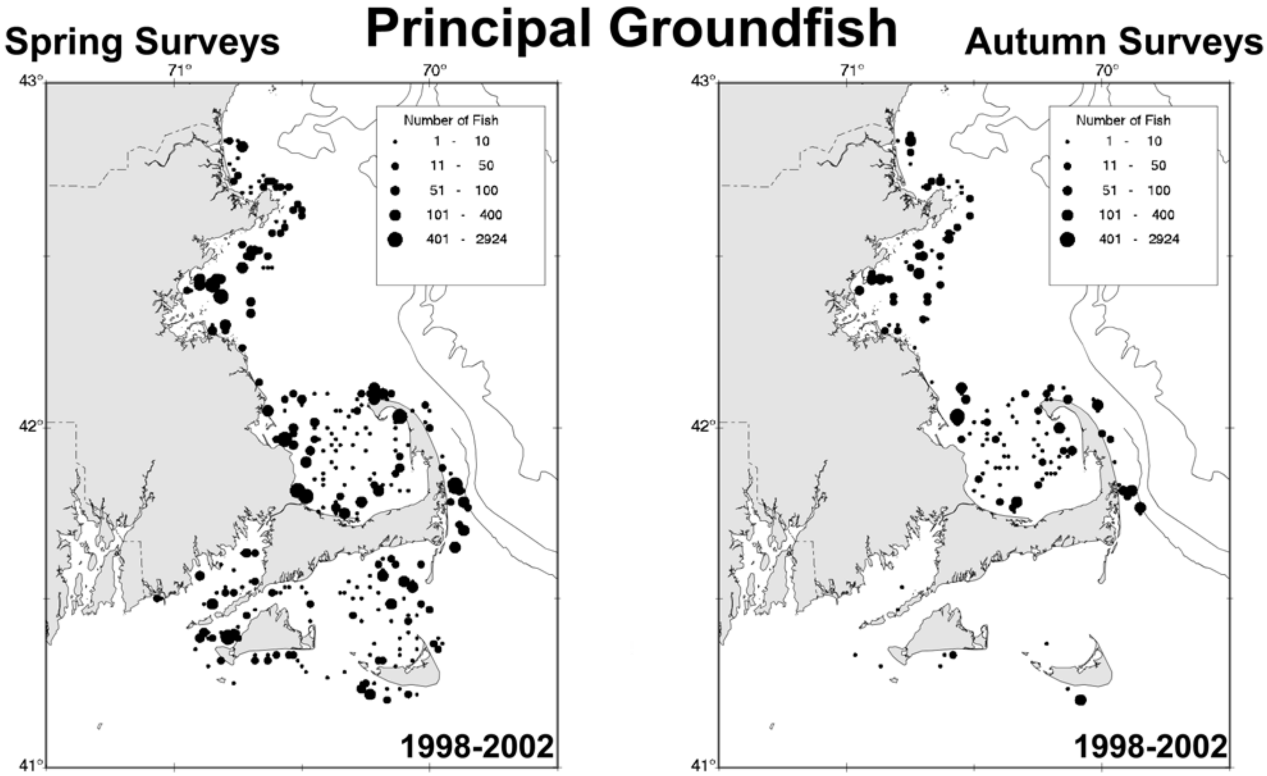

Figure D17c. Distribution of principal groundfish (Atlantic cod, haddock, pollock, Acadian redfish, and white hake) in the Massachusetts inshore spring and autumn bottom trawl surveys from 1998-2002.

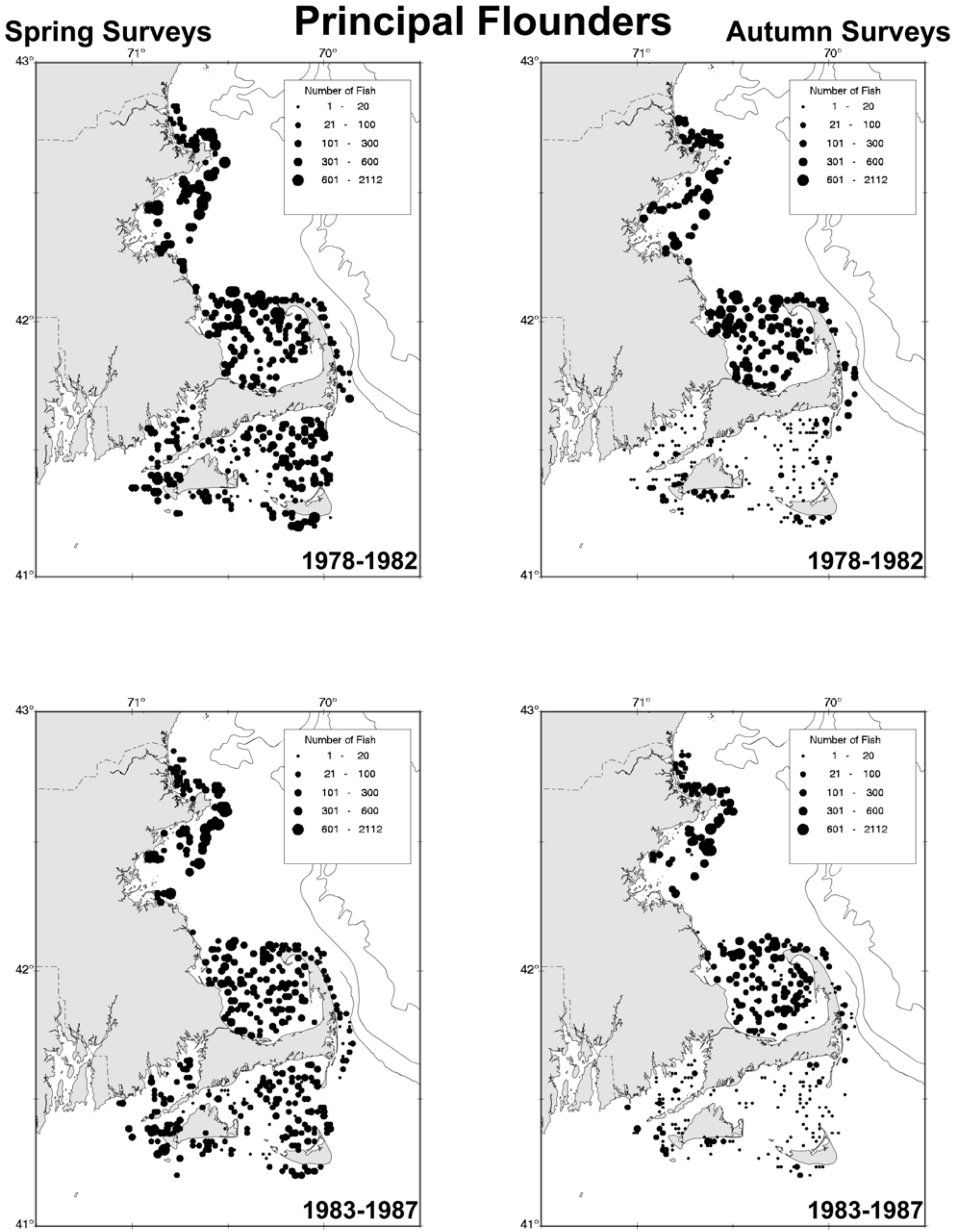

Figure D18a. Distribution of principal flounders (yellowtail flounder, American plaice, witch flounder, winter flounder, and windowpane flounder) in the Massachusetts inshore spring and autumn bottom trawl surveys from 1978-1987.

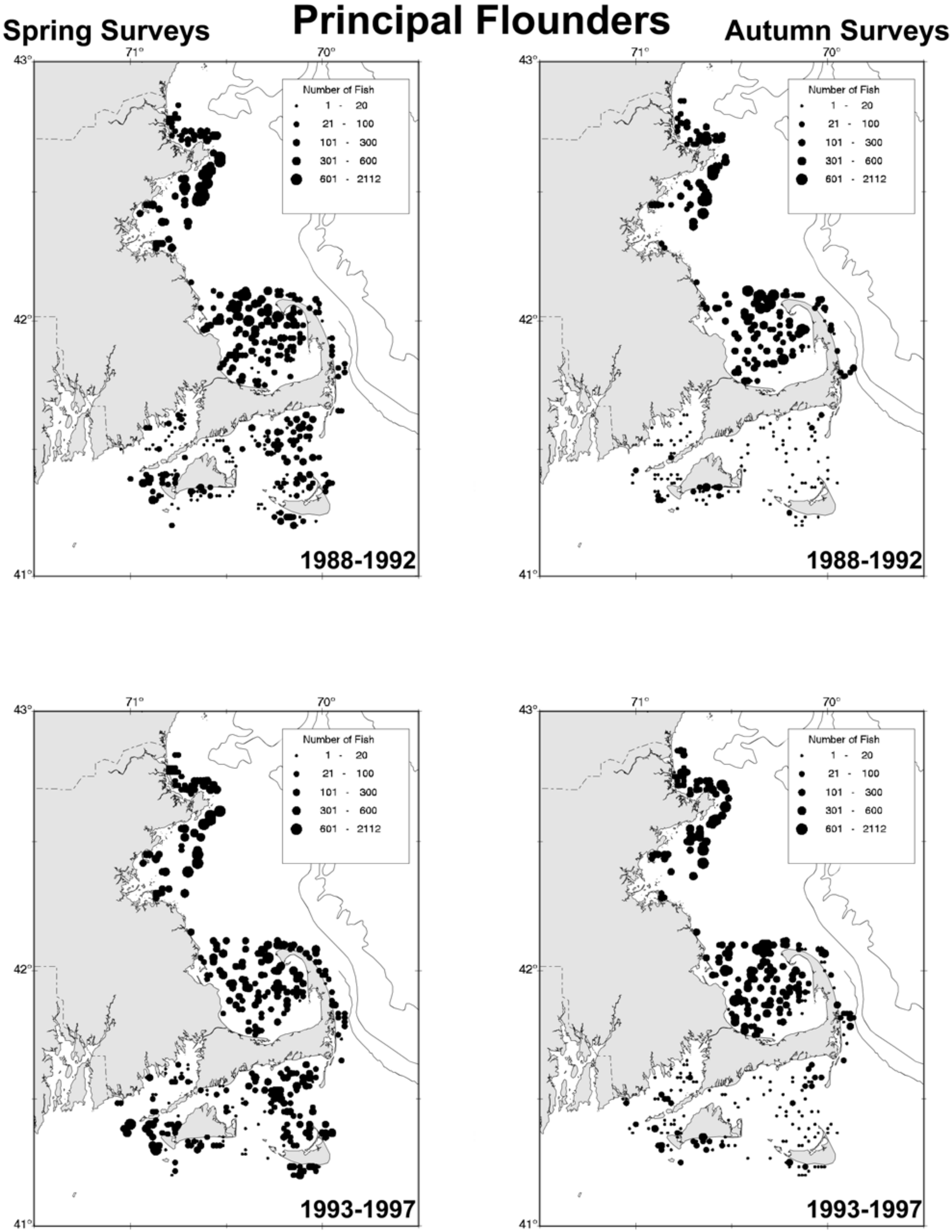

Figure D18b. Distribution of principal flounders (yellowtail flounder, American plaice, witch flounder, winter flounder, and windowpane flounder) in the Massachusetts inshore spring and autumn bottom trawl surveys from 1988-1997.

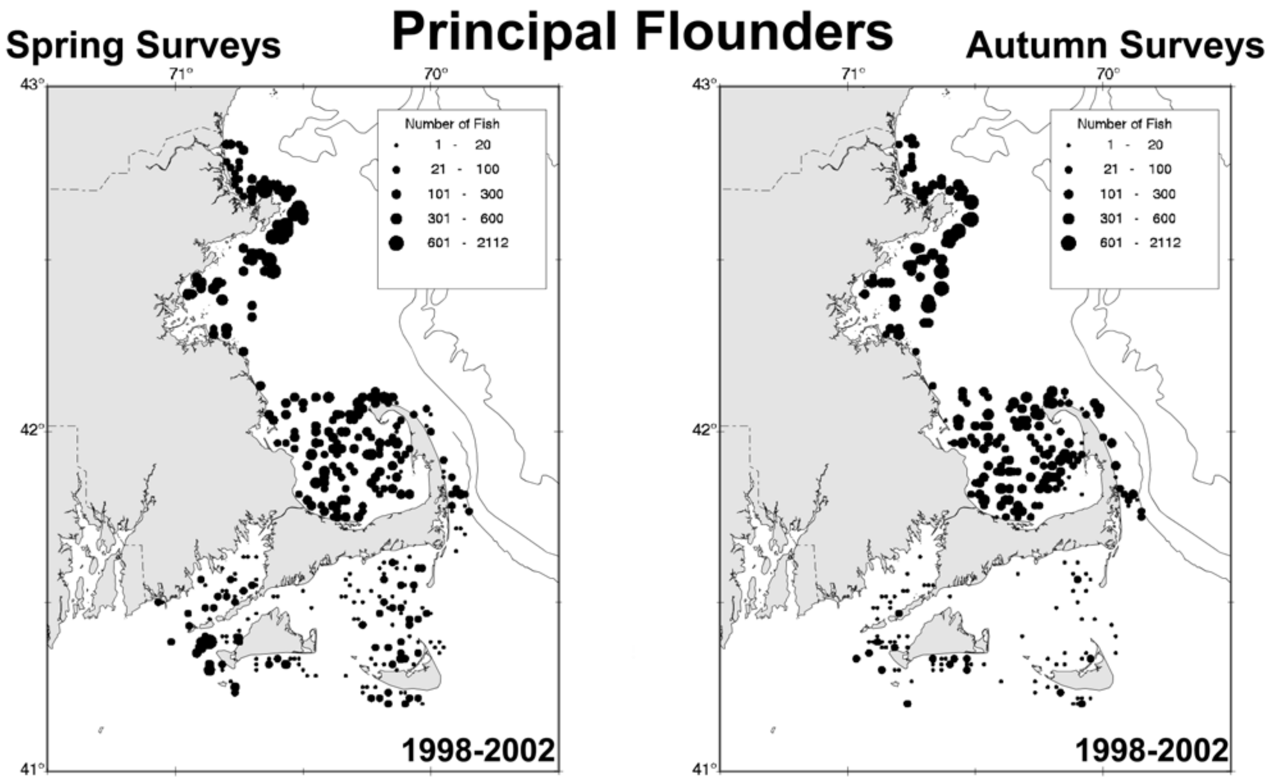

Figure D18c. Distribution of principal flounders (yellowtail flounder, American plaice, witch flounder, winter flounder, and windowpane flounder) in the Massachusetts inshore spring and autumn bottom trawl surveys from 1998-2002.

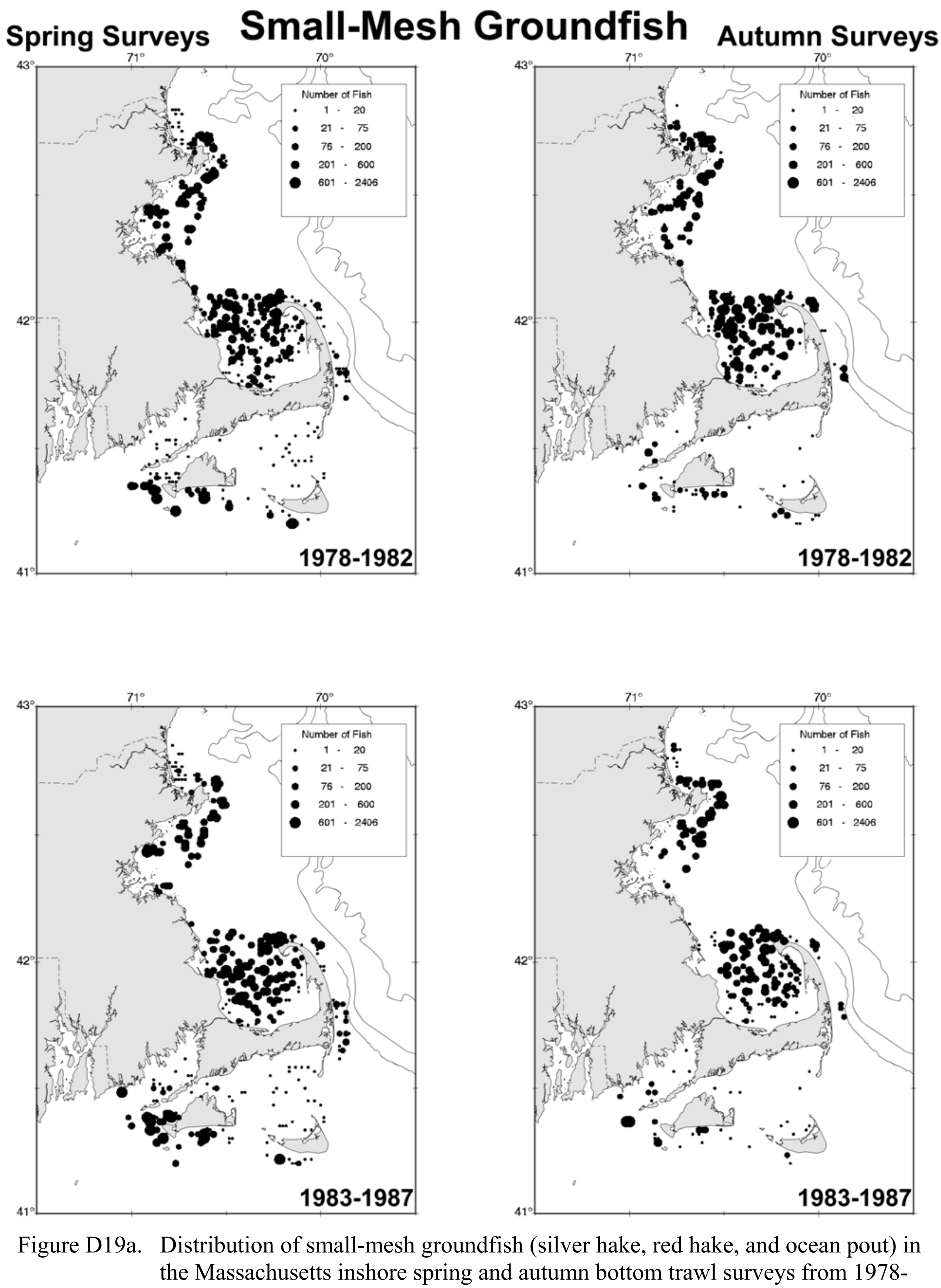

Figure D19a. Distribution of small-mesh groundfish (silver hake, red hake, and ocean pout) in the Massachusetts inshore spring and autumn bottom trawl surveys from 1978-1987.

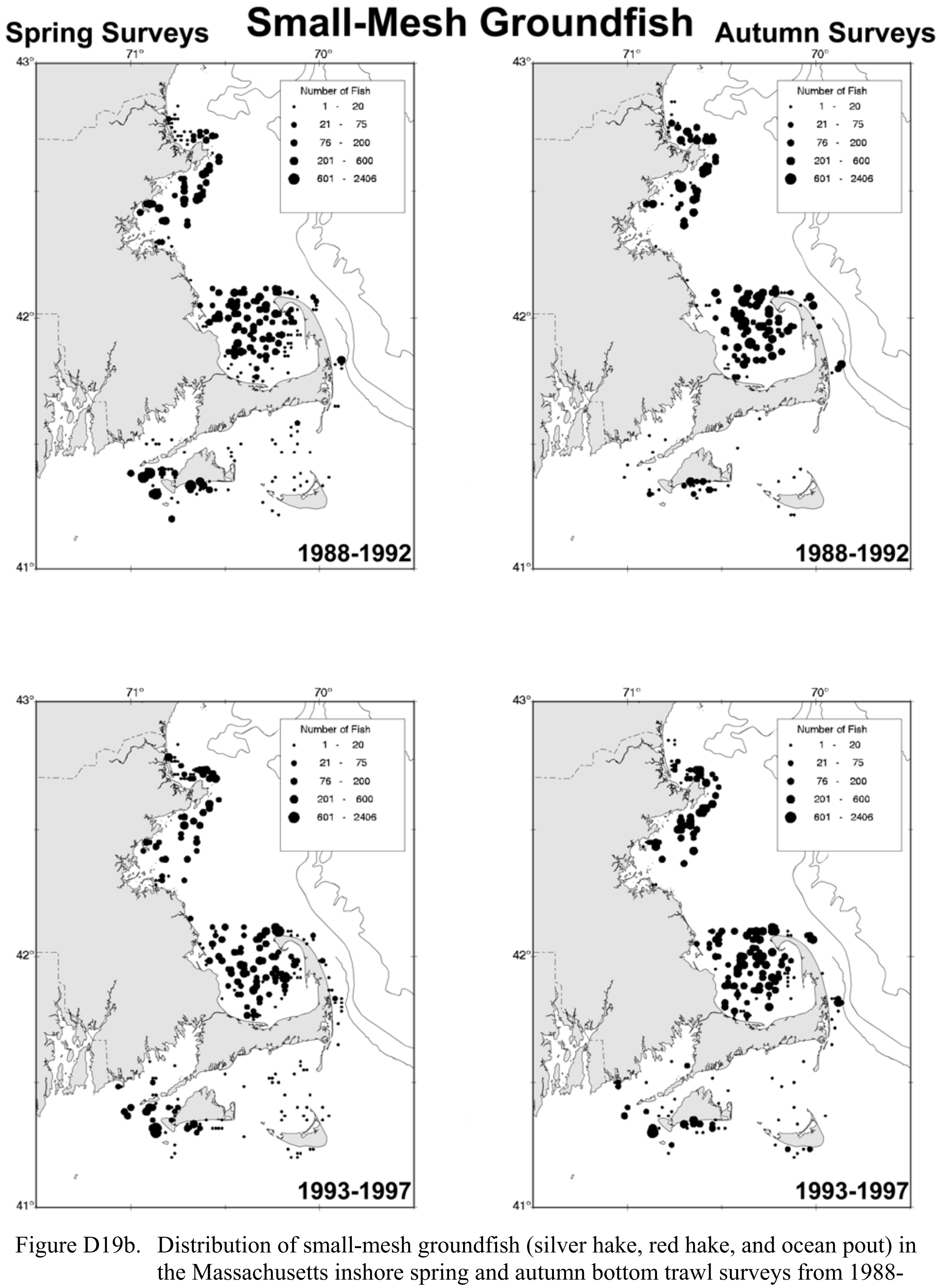

Figure D19b. Distribution of small-mesh groundfish (silver hake, red hake, and ocean pout) in the Massachusetts inshore spring and autumn bottom trawl surveys from 1988-1997.

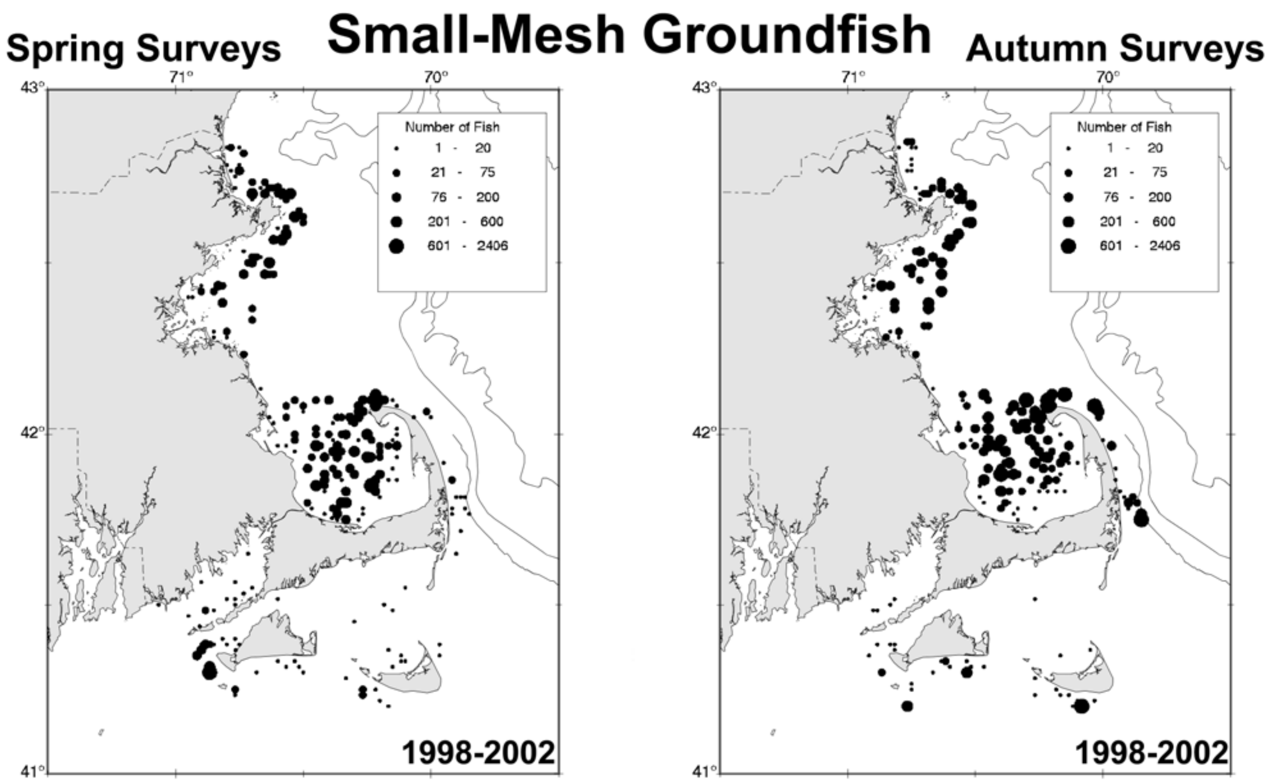

Figure D19c. Distribution of small-mesh groundfish (silver hake, red hake, and ocean pout) in the Massachusetts inshore spring and autumn bottom trawl surveys from 1998-2002.

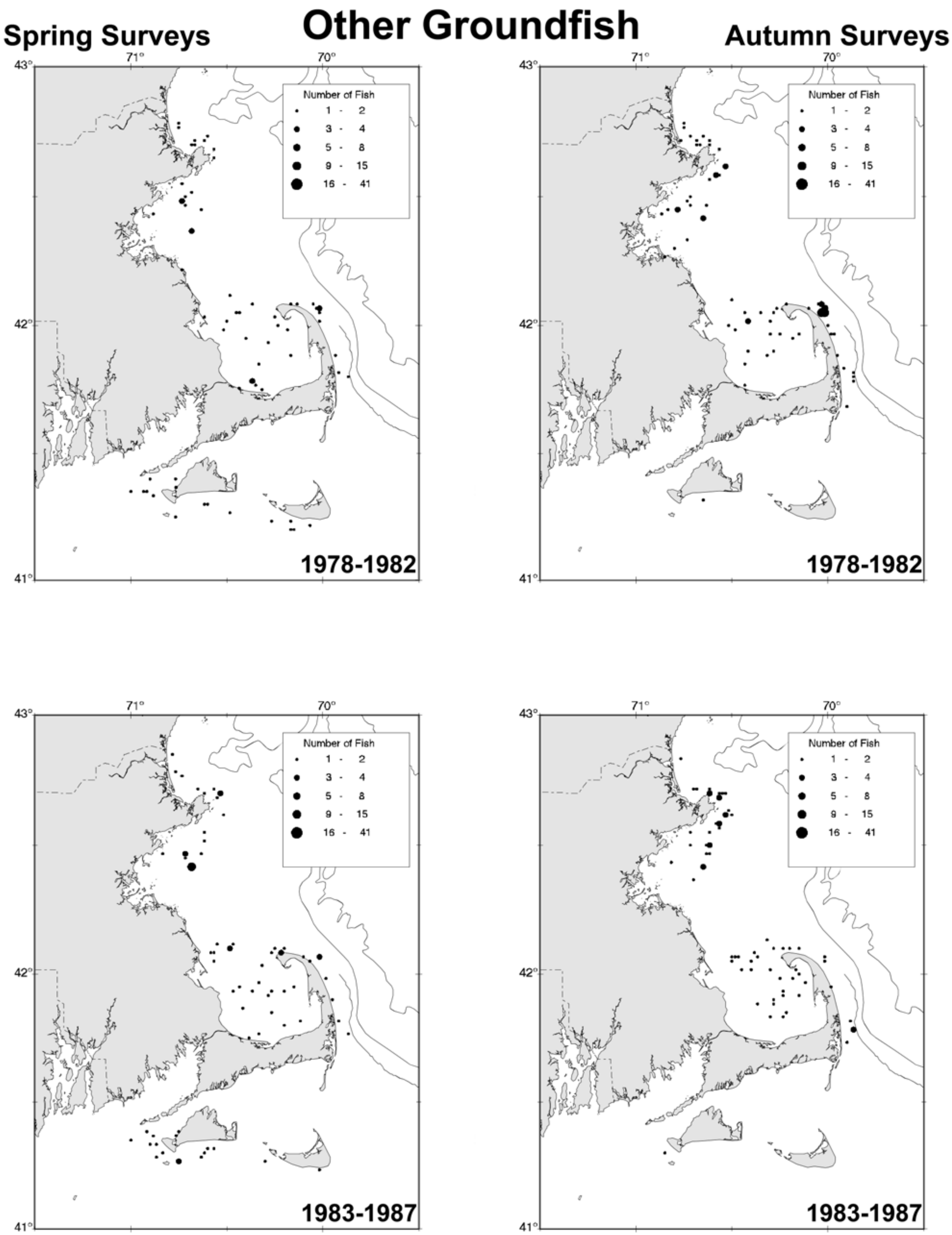

Figure D20a. Distribution of other groundfish (Atlantic wolffish and goosefish) in the Massachusetts inshore spring and autumn bottom trawl surveys from 1978-1987.

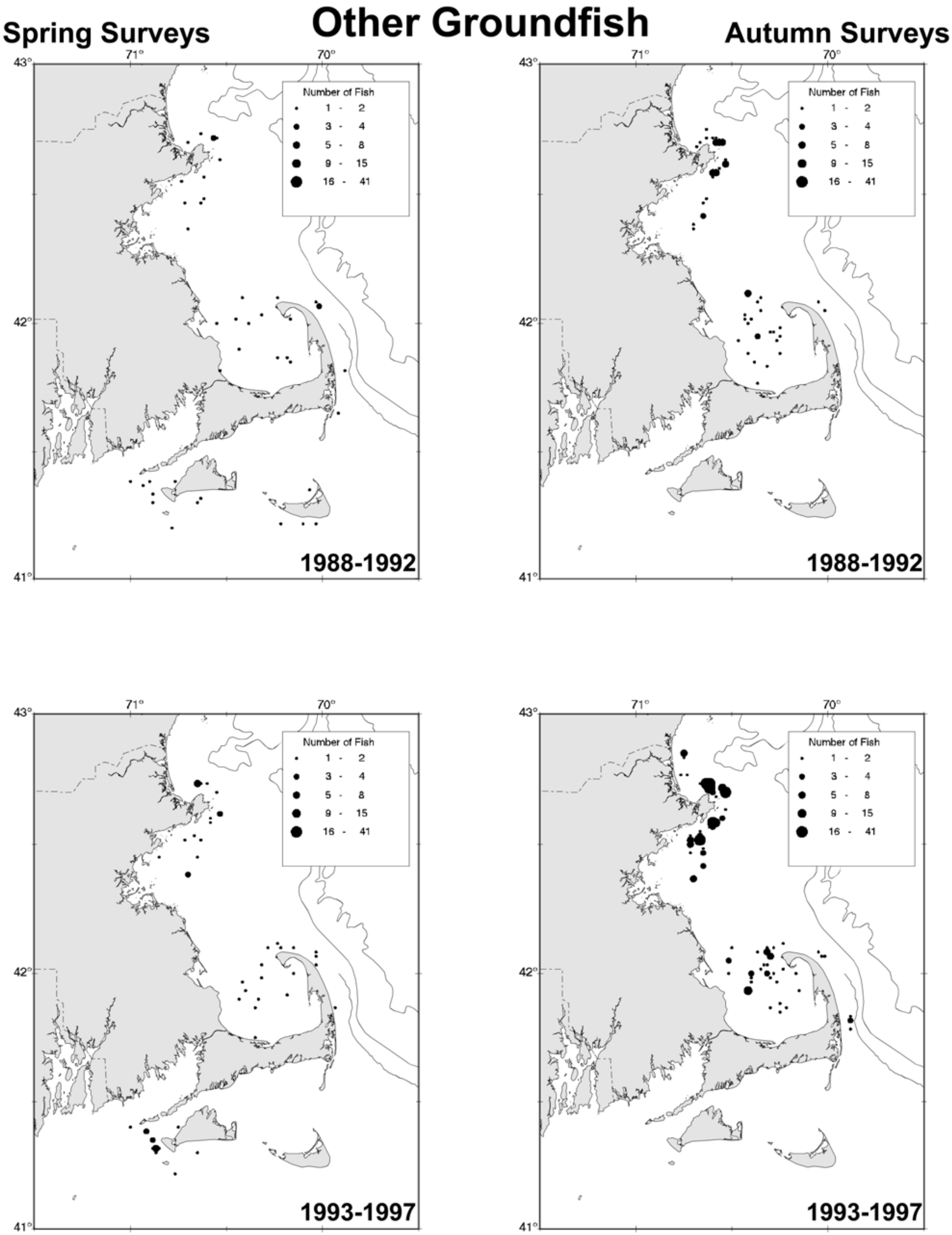

Figure D20b. Distribution of other groundfish (Atlantic wolffish and goosefish) in the Massachusetts inshore spring and autumn bottom trawl surveys from 1988-1997.

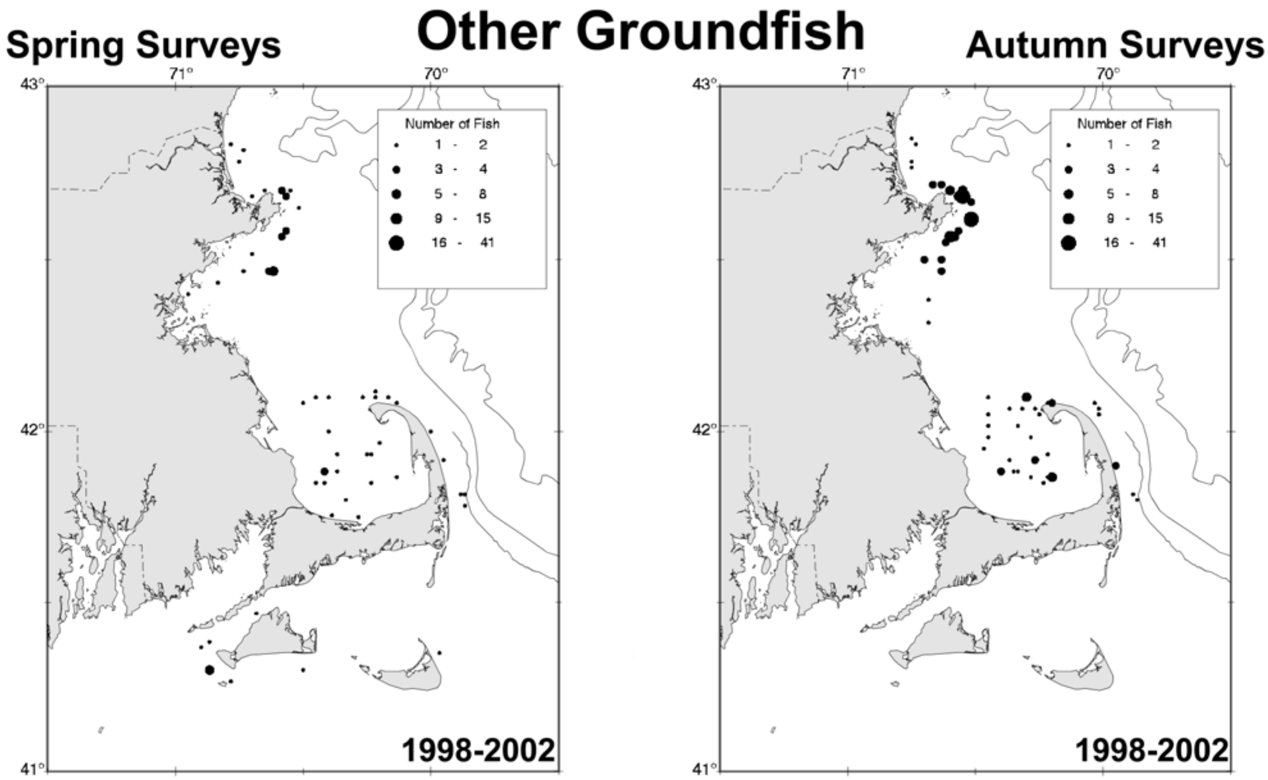

Figure D20c. Distribution of other groundfish (Atlantic wolffish and goosefish) in the Massachusetts inshore spring and autumn bottom trawl surveys from 1998-2002.

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