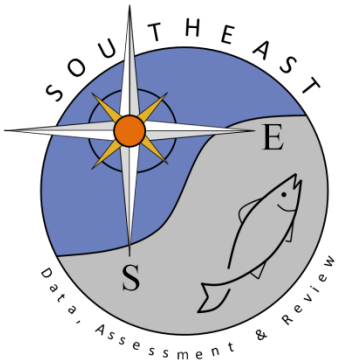
Biomass. Abundance and distribution of smooth dogfish (Mustelus canis) from the Northeast Fisheries Science Center and Massachusetts Department of Marine Fisheries trawl surveys

Katherine A, Sosebee, Jeremy King, Michele Traver, and Larry Alade

SEDAR39-DW-24

19 May 2014
Updated: 24 June 2014



Please cite this document as:

Sosebee, K.A.. , J.King, M. Traver, and L. Alade 2014. Biomass. Abundance and distribution of smooth dogfish (Mustelus canis) from the Northeast Fisheries Science Center and Massachusetts Department of Marine Fisheries trawl surveys. SEDAR39-DW-24. SEDAR, North Charleston, SC. 33 pp.

Biomass, abundance and distribution of smooth dogfish (*Mustelus canis*) from the Northeast Fisheries Science Center and Massachusetts Department of Marine Fisheries trawl surveys.

Katherine A, Sosebee[1], Jeremy King[2], Michele Traver[1], and Larry Alade[1].

[1]National Marine Fisheries Serv., Woods Hole Lab., 166 Water St., Woods Hole, MA 02543

[2]Massachusetts Division of Marine Fisheries, 1213 Purchase Street, New Bedford, MA 02740

Abstract

Temporal and spatial patterns in biomass and abundance of smooth dogfish during 1967-2013 were determined using data from annual spring, autumn and winter research vessel bottom trawl surveys conducted by the Northeast Fisheries Science Center (NEFSC) and the Massachusetts Department of Marine Fisheries (MADMF). Indices of abundance and biomass were calculated for the NEFSC spring and fall surveys from both north and south of Cape Hatteras. Time series of relative abundance and biomass were calculated for the NEFSC winter survey as well as the MADMF spring and fall surveys. Maps of the spring and fall surveys were created depicting abundance distributions, within five-year periods, for all dogfish and for the entire time series by sex for the winter survey and the MADMF surveys.

Introduction

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 (Figure 1, Figure 2, and Figure 3). 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 3.5 -3.8 knots. Sampling also occurs south of Cape Hatteras (Figure 3) but the entire area was only surveyed in one year (1972 fall) and partially in 1974 spring. A subset of about five strata is sampled in most years (Johnston and Sosebee 2014).

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. Four vessels have conducted the survey (RV *Albatross IV*, RV *Delaware II*, RV *Atlantic Twin and* FSV *Henry B. Bigelow*). 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 not been calculated for smooth dogfish (NEFSC 1991; Sissenwine and Bowman 1978). The *Atlantic Twin* surveyed the inshore areas from autumn 1972 to spring 1975, as well as the areas south of Cape Hatteras, but no conversion factors have been calculated for this vessel. In 2009, the *Albatross IV* was replaced with the *Henry B. Bigelow* and the #36 Yankee net was replaced with a 4-seam, 3-bridle box net with rock-hopper sweep. Conversion factors for this gear/vessel change have been derived for smooth dogfish and are 1.161 for numbers and 1.082 for weight (Miller 2010).

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.

Methods

Since 1989, smooth dogfish have been identified to sex on both the NEFSC and MADMF surveys. When a tow is completed, the catch is separated into species and dogfish are then separated by sex and each sex is treated as a separate species. If there are a large number of dogfish, subsamples are taken, by sex, usually around 100 individuals per sex. The rest of the dogfish are counted and discarded by sex. The fish in the subsample are weighed and measured for length. To expand the subsample to the entire catch at length:

(NsampF+NdiscF)/NsampF*NlengthF

(NsampM+NdiscM)/NsampM*NlengthM

The same ratio is also used to derive total weight of the catch.

Example: 1000 F discarded, 100 females sampled, subsample weight 200kg

500 M discarded, 80 males sampled, subsample weight 100 kg

(100+1000)/100 = 11.0

For each length, the number of females and the weight of females are multiplied by 11.

Weight = 11*200 = 2200kg

(80 +500)/ 80 = 7.25

For each length, the number of males and the weight of males are multiplied by 7.25

Weight = 7.25*100 = 725kg.

To derive the stratified mean number/weight/tow (Cochran 1977), the mean (weight/number) of the tows within each stratum is calculated. Each mean is then multiplied by the area of the stratum and these are summed together. The final estimate is derived by dividing the summed value by the total area of the entire set. This can be done for sexes combined or separate sexes, which can then be added together. The number/tow at length is calculated the same way, and these values add to the total number/tow

These indices of relative biomass and abundance were calculated for four strata sets for the spring and autumn surveys. Three of these are for north of Cape Hatteras and are similar so only one is proposed as an index of relative abundance. The fourth index was calculated using a

subset of the strata that are sampled south of Cape Hatteras. Indices were also calculated for the winter survey and the Massachusetts DMF spring and fall surveys. Distribution maps of abundance were developed for all dogfish for five-year periods and for the time series for the winter and Massachusetts DMF spring and fall surveys.

Results/Discussion

Smooth dogfish are distributed mainly right around Cape Hatteras in the spring and in inshore areas along the Mid-Atlantic into Southern New England in the fall (Figure 4). In the fall, there are also some smooth dogfish out onto the western part of Georges Bank. In the 2000s, some smooth dogfish extend into the middle of Georges Bank (Figure 4g-4h).

The fall survey indices for all three strata sets show an increase in the mid-1970s, followed by a decline to low values in the early 1990s (Figure 5-upper panels). The indices then increased through 2003 and have since slowly declined. The CVs for these indices are lowest for the entire strata set and highest for the indices including only offshore strata (Figure 5-bottom panels). Since the reduced inshore set has a very similar CV to the all inshore set, this should be considered to be the most useful index (Table 1).

The spring survey series is much more variable than the fall (Figure 6-upper panels, Table 2). It appears that the timing of smooth dogfish moving north in the spring can affect the index. If they are north of Cape Hatteras, a large number of dogfish can be caught by the spring survey. A slight movement both north/south and deep/shallow can have a large impact on the survey indices.

For the survey time series south of Cape Hatteras (five strata), there were a total of 4 tows that caught smooth dogfish in the fall survey. The spring survey may be more useful, but this time series has the same issue as the spring survey north of Cape Hatteras in that it is highly variable and subject to large spikes in biomass and abundance (Figure 7 – upper panels, Table 3). During the two surveys in which coverage extended further south, smooth dogfish were caught down to about the middle of South Carolina in the fall and northern South Carolina in the spring (Figure 8). The spring survey did not sample in offshore waters, so there may have been smooth dogfish present in the area in the spring that were not captured by this survey.

The NEFSC winter survey distribution is similar to that of the spring survey, with both male and female dogfish found in offshore strata just north of Cape Hatteras (Figure 9). However, they are also found in offshore strata up to just off New Jersey. Since March generally has the lowest bottom temperatures, this may be due to the dogfish not having reached the southernmost distribution in February. The indices for this survey are variable and show no trend (Figure 10, Table 4).

The MADMF surveys catch dogfish south of Cape Cod sporadically in the spring and mostly south of Cape Cod with some caught in Cape Cod Bay in the fall (Figure 11). The fall survey shows that the lowest abundance and biomass were in the 1990s (Figure 12), similar to the NEFSC fall survey. The spring survey is more variable, since the arrival of smooth dogfish into the area may not coincide with the survey every year (Figure 12).

Length compositions from the NEFSC spring and fall survey north of Cape Hatteras with the reduced inshore strata set show most fish caught are between 80 and 100 cm (Figure 13). The spring survey lengths are much sparser than the fall until the 1990s and 2000s.

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Table 1. Indices of abundance and biomass (sexes combined) for smooth dogfish from the NEFSC spring survey (strata 01010-01250, 01610-01760, 03020, 03050, 03080, 03110, 03140, 03170, 03200, 03230, 03260, 03290, 03320, 03350, 03380, 03410, 03440-03550).

Year	Num	CV	WT	CV	No Tows	No Pos Tows	Mn Temp	Mn Depth	Day
1973	0.164	18.7	0.431	16.0	289	48	7.2	72.9	105
1974	12.956	0.5	40.958	0.6	212	19	8.3	75.2	96
1975	0.029	100.0	0.043	100.0	185	1	7.0	78.2	88
1976	0.430	80.3	0.964	92.1	224	8	7.5	73.2	81
1977	0.242	55.1	0.361	49.1	222	6	6.2	74.9	99
1978	0.188	42.5	0.452	44.5	227	11	5.4	71.4	98
1979	0.040	39.7	0.055	52.0	292	6	6.3	70.8	103
1980	0.021	76.4	0.009	83.1	275	4	6.9	73.2	101
1981	0.009	100.0	0.042	100.0	206	1	6.2	72.0	104
1982	0.217	85.7	0.301	92.2	218	6	5.2	76.7	96
1983	0.000		0.000						
1984	0.105	79.4	0.112	70.4	217	7	6.5	73.8	81
1985	0.141	69.2	0.187	59.8	210	5	5.9	74.2	76
1986	0.240	57.1	0.466	54.5	221	8	6.6	74.4	86
1987	0.013	70.8	0.018	69.4	216	3	6.3	76.4	99
1988	0.066	69.0	0.074	50.3	197	4	6.3	74.1	80
1989	0.766	81.3	1.774	83.8	194	4	3.8	73.2	74
1990	0.112	30.4	0.299	33.2	196	4	6.2	72.4	80
1991	0.238	28.0	0.593	27.1	199	11	7.6	76.8	81
1992	0.068	42.8	0.148	42.1	191	6	6.3	71.1	80
1993	0.284	43.2	0.636	45.3	195	6	5.5	70.6	88
1994	0.005	54.3	0.003	56.1	197	2	6.2	73.3	82
1995	0.073	31.4	0.157	24.0	193	5	7.4	74.9	89
1996	0.409	22.8	1.111	25.0	215	12	5.9	74.6	92
1997	0.644	22.4	2.414	20.9	196	8	7.3	71.1	80
1998	0.529	4.0	1.233	5.7	202	9	6.3	73.3	78
1999	0.341	55.3	0.830	60.9	198	9	7.5	73.3	84
2000	2.548	26.1	6.559	29.0	199	8	7.6	69.3	92
2001	0.391	52.8	0.937	49.1	199	9	6.6	76.2	84
2002	1.873	23.5	4.319	21.5	196	19	8.2	74.8	85
2003	10.718	52.0	22.134	51.8	191	8	5.5	71.3	85
2004	0.286	69.7	0.744	70.9	199	3	5.1	74.9	83
2005	0.917	51.5	2.704	62.6	197	7	5.7	73.5	83
2006	0.161	24.3	0.280	30.5	200	12	7.4	73.6	81
2007	1.893	45.7	4.510	49.4	225	12	6.4	73.7	84
2008	0.602	37.0	1.541	35.8	204	11	6.1	72.0	89
2009	0.732	36.6	2.849	38.0	268	14	6.5	74.2	85
2010	0.043	18.5	0.062	26.2	269	14	6.4	73.2	81
2011	0.228	37.3	0.587	38.4	255	14	6.5	75.9	82
2012	2.920	18.9	10.775	24.5	249	31	9.0	73.5	84
2013	3.517	38.4	10.171	40.6	270	36	7.3	73.7	91

Table 2. Indices of abundance and biomass (sexes combined) for smooth dogfish from the NEFSC fall survey (strata 01010-01250, 01610-01760, 03020, 03050, 03080, 03110, 03140, 03170, 03200, 03230, 03260, 03290, 03320, 03350, 03380, 03410, 03440-03550).

Year	Num	CV	WT	CV	No Tows	No Pos Tows	Mn Temp	Mn Depth	Day
1972	0.467	27.7	1.131	32.4	231	25	12.9	73.2	292
1973	1.216	17.9	3.344	18.1	237	54	13.3	73.2	284
1974	0.773	21.1	2.163	22.3	227	49	13.3	74.9	278
1975	1.939	23.3	6.311	29.5	224	53	12.4	74.1	293
1976	2.004	32.4	6.048	33.1	220	39	13.1	73.3	289
1977	1.709	24.5	4.782	29.4	253	32	12.6	72.8	289
1978	0.798	31.4	2.348	29.1	323	30	11.1	72.5	281
1979	1.385	35.9	8.257	44.0	319	40	12.3	71.4	289
1980	0.561	15.5	2.053	20.8	232	18	12.2	71.8	286
1981	0.441	32.0	1.878	39.3	212	22	11.9	74.4	283
1982	0.629	44.7	2.719	55.3	211	24	12.2	71.4	281
1983	0.317	40.1	1.281	37.9	213	25	12.2	73.8	278
1984	0.939	26.1	3.264	29.0	210	24	12.1	74.6	275
1985	1.026	13.8	3.610	15.6	207	41	12.3	74.9	284
1986	0.406	36.7	1.411	36.8	209	21	12.5	74.5	277
1987	0.544	48.7	2.473	60.7	198	22	10.6	73.3	271
1988	0.466	39.6	1.643	39.4	196	21	10.3	73.2	273
1989	0.438	24.0	1.222	24.1	195	32	10.3	72.9	272
1990	0.734	26.8	2.621	35.4	206	32	na	74.0	270
1991	0.219	30.9	0.851	30.6	197	23	12.6	70.3	268
1992	0.420	26.2	1.541	28.4	195	27	12.2	69.3	272
1993	0.329	17.6	1.073	19.4	196	24	11.7	75.4	266
1994	0.416	22.6	1.353	23.1	203	29	13.1	73.4	270
1995	0.572	25.7	1.820	28.9	196	31	14.4	72.8	265
1996	0.706	28.5	1.962	32.9	198	32	11.5	73.5	269
1997	0.498	26.8	1.320	27.2	200	26	13.0	73.2	270
1998	1.120	21.2	3.680	21.4	199	34	11.7	71.6	279
1999	2.052	22.8	6.166	24.9	198	33	14.7	71.4	281
2000	0.528	21.6	1.358	25.0	198	30	13.6	70.9	265
2001	1.808	40.3	4.920	38.0	196	40	12.3	70.8	264
2002	0.951	16.1	2.408	19.2	198	46	13.3	74.9	267
2003	2.085	24.2	6.320	40.7	197	53	12.7	73.8	270
2004	1.713	17.3	4.940	21.0	200	57	12.0	72.2	271
2005	1.125	20.2	3.318	20.7	196	40	11.8	71.9	272
2006	1.582	19.9	4.883	26.1	217	62	13.7	72.9	265
2007	1.266	26.0	4.004	31.4	210	41	11.3	73.6	273
2008	0.897	20.5	2.749	26.1	209	40	na	72.0	269
2009	1.262	23.3	4.230	27.9	257	51	13.8	75.7	278
2010	0.640	24.6	1.945	25.7	267	47	13.1	75.3	276
2011	0.794	17.9	2.195	22.0	254	48	13.2	74.9	272
2012	0.780	33.7	2.072	40.8	260	52	13.6	74.7	271
2013	0.564	36.5	1.652	41.1	262	36	12.2	73.0	273

Table 3. Indices of abundance and biomass (sexes combined) for smooth dogfish from the NEFSC spring survey south of Cape Hatteras (Strata 05510-07520, 08500-08520).

Year	Num	CV	WT	CV	No Tows	No Pos Tows	Mn Temp	Mn Depth	Day
1974	1.320	0.0	4.003	0.0	2	1	16.4	18.4	107
1975	No survey								
1976	No survey								
1977	No survey								
1978	No survey								
1979	3.704	48.9	12.665	52.2	11	4	15.2	51.0	84
1980	1.138	41.2	3.511	31.5	10	5	16.6	52.8	82
1981	3.694	37.9	10.190	32.6	11	4	15.3	55.7	82
1982	0.195	73.8	0.137	73.8	11	2	17.3	58.4	72
1983	4.105	65.0	16.851	67.1	12	3	12.1	56.1	72
1984	0.867	55.6	3.435	53.2	12	3	16.4	51.9	65
1985	0.312	52.5	1.000	49.6	11	3	10.0	55.5	61
1986	0.323	63.4	0.645	85.3	10	3	11.4	61.3	68
1987	5.056	97.5	20.131	97.9	11	2	18.1	57.0	85
1991	0.041	100.0	0.318	100.0	12	1	18.4	53.7	69
1993	8.819	98.8	28.362	99.2	7	1	15.1	54.6	72
1994	3.015	14.5	10.763	14.3	11	5	17.9	56.5	64
1995	No survey								
1996	No survey								
1997	No survey								
1995	6.618	95.7	23.709	93.5	12	3	14.0	53.8	69
1996	No survey								
1997	No survey								
1998	2.302	57.7	8.010	58.1	12	4	11.3	55.1	66
1999	1.089	42.7	2.325	49.3	12	6	17.1	54.2	67
2000	5.519	46.9	7.679	33.3	12	4	16.2	58.3	80
2001	No survey								
2002	No survey								
2003	1.765	55.2	4.576	49.8	11	5	17.4	53.6	68
2004	103.639	73.9	276.404	69.4	12	5	15.7	52.3	66
2005	13.263	39.1	44.373	39.7	12	6	14.5	55.6	65
2006	0.296	72.3	0.989	64.9	12	2	17.2	60.8	71
2007	No survey								
2008	1.408	77.9	7.597	84.0	12	4	10.4	57.2	83
2009	50.561	45.6	141.909	46.0	11	6	14.2	52.6	66
2010	6.414	38.6	28.311	43.3	13	7	12.8	60.0	64
2011	11.074	44.7	40.188	42.3	11	4	15.6	63.2	66
2012	No survey								
2013	48.825	65.8	166.544	68.6	11	5	15.0	59.1	77

Table 4. Indices of abundance and biomass (sexes combined) for smooth dogfish from the NEFSC winter survey (strata 01010-01120, 01610-01760).

Year	Num	CV	WT	CV	No Tows	No Pos Tows	Mn Temp	Mn Depth	Day
1992	1.852	11.9	5.209	7.5	92	6	6.9	60.9	51
1993	0.099	57.5	0.175	55.5	97	2	6.6	59.8	44
1994	8.127	0.0	34.630	0.0	68	3	7.0	62.2	39
1995	3.172	26.4	9.792	28.5	96	6	7.5	65.3	46
1996	1.126	47.0	3.931	57.0	108	7	6.4	64.5	45
1997	3.087	87.7	10.398	82.6	100	2	7.8	65.7	43
1998	0.543	55.3	1.318	64.2	107	8	6.8	65.8	46
1999	0.761	46.4	2.617	47.1	109	12	8.9	63.8	39
2000	1.665	43.1	4.058	43.1	117	22	7.7	62.4	49
2001	5.898	36.4	17.285	46.6	143	15	7.3	67.7	38
2002	3.967	19.9	10.315	23.7	141	31	9.0	66.6	48
2003	10.678	34.2	23.980	37.9	99	22	6.1	66.0	48
2004	0.687	34.6	1.272	50.1	126	17	5.7	68.2	47
2005	0.196	22.0	0.278	31.4	97	14	6.2	66.1	44
2006	1.829	22.9	3.606	30.8	124	21	8.9	67.1	47
2007	2.900	24.9	9.093	24.2	132	25	8.0	67.6	48

Table 5. Indices of abundance and biomass (sexes combined) for smooth dogfish from the MA DMF spring survey (strata 09110-09210).

Year	Num	CV	WT	CV	No Tows	No Pos Tows	Mn Temp	Mn Depth	Day
1978	0.816	39.5	2.345	38.7	54	12	11.9	13.2	147
1979	0.951	40.5	3.822	45.7	49	10	12.2	13.1	135
1980	2.057	52.0	5.691	50.4	51	16	11.5	13.3	140
1981	0.544	25.6	2.212	27.0	53	16	10.3	13.6	137
1982	0.418	41.6	1.864	46.9	49	9	10.4	11.9	136
1983	0.361	42.6	1.212	46.5	51	7	11.1	13.9	140
1984	0.397	34.8	1.303	35.1	52	11	11.0	14.4	138
1985	0.870	47.8	2.764	55.1	50	15	11.2	14.1	137
1986	0.662	50.9	2.159	49.5	54	10	9.9	14.1	135
1987	0.040	51.2	0.139	41.8	49	2	10.5	14.5	133
1988	0.335	33.9	1.182	33.3	47	9	10.3	14.2	142
1989	0.106	42.3	0.365	44.1	46	4	8.7	13.7	138
1990	0.951	35.3	1.979	32.3	51	12	10.4	14.2	139
1991	0.539	44.3	1.599	42.8	49	9	12.5	13.4	138
1992	0.118	55.1	0.474	54.6	49	4	9.7	13.7	135
1993	0.031	75.0	0.090	76.9	50	2	11.1	14.3	135
1994	0.442	63.0	2.510	72.5	51	8	9.7	14.0	140
1995	0.060	73.3	0.203	72.6	52	2	10.1	14.2	140
1996	0.041	100.0	0.126	100.0	54	1	10.7	14.2	139
1997	0.020	100.0	0.105	100.0	53	1	10.1	14.2	134
1998	0.021	100.0	0.085	100.0	50	1	13.0	14.1	142
1999	0.358	27.1	1.061	27.2	50	11	11.8	14.0	141
2000	2.740	70.6	13.848	82.6	51	11	11.7	14.6	138
2001	0.038	66.7	0.134	66.7	52	2	11.3	14.1	138
2002	0.485	22.5	1.907	22.8	52	17	11.3	14.1	138
2003	0.000		0.000						
2004	0.090	54.8	0.216	56.8	52	3	11.4	14.2	136
2005	0.221	37.6	0.640	38.4	51	7	9.6	15.1	143
2006	0.175	42.0	0.527	41.5	54	7	10.9	14.3	139
2007	0.086	59.1	0.244	62.3	52	3	11.2	14.1	141
2008	0.592	25.1	1.671	25.9	54	7	10.5	14.7	138
2009	0.236	37.3	0.861	42.4	54	7	11.5	13.9	136
2010	0.135	45.8	0.436	45.1	54	5	11.3	13.9	134
2011	0.038	70.7	0.174	75.9	54	2	10.6	13.9	135
2012	0.698	26.3	2.073	24.9	54	13	13.3	14.2	138
2013	0.158	48.9	0.529	57.6	52	4	12.4	13.7	138

Table 6. Indices of abundance and biomass (sexes combined) for smooth dogfish from the MA DMF fall survey (strata 09110-09210).

Year	Num	CV	WT	CV	No Tows	No Pos Tows	Mn Temp	Mn Depth	Day
1978	4.784	29.2	3.159	22.8	91	34	13.0	21.1	261
1979	6.680	35.3	3.427	26.4	98	29	13.0	21.0	265
1980	5.814	29.4	4.201	20.0	97	31	14.7	21.2	262
1981	2.383	18.9	1.904	18.0	95	43	15.6	21.2	268
1982	3.035	31.7	1.456	26.5	93	21	13.7	21.4	260
1983	6.194	46.1	4.036	26.2	85	22	13.6	21.2	258
1984	8.234	37.2	4.540	33.3	92	30	13.8	21.8	262
1985	11.320	22.4	5.582	19.2	88	32	15.6	22.1	253
1986	9.422	39.9	5.928	31.6	90	30	14.0	22.1	258
1987	4.124	48.2	2.280	40.0	88	22	12.3	22.5	260
1988	0.967	41.6	1.063	31.5	75	16	12.5	22.0	259
1989	0.535	21.0	0.898	21.5	68	16	13.9	21.8	255
1990	2.691	24.7	3.310	26.8	87	21	15.9	21.8	254
1991	3.369	25.8	2.701	20.9	86	21	16.1	21.7	255
1992	0.773	35.2	1.458	40.3	77	11	13.7	22.0	261
1993	0.769	20.6	1.566	19.7	81	20	13.7	22.3	258
1994	0.776	27.1	1.072	39.1	97	23	15.9	22.2	257
1995	1.943	47.9	1.569	28.7	95	21	10.4	22.0	256
1996	2.180	23.4	3.379	27.3	95	25	15.2	22.4	255
1997	2.012	20.6	2.323	20.1	90	19	15.3	21.6	259
1998	0.752	24.3	1.656	28.3	86	20	13.5	22.2	261
1999	0.876	23.9	1.874	29.2	91	22	15.2	22.3	258
2000	0.927	19.6	1.208	20.1	93	20	15.9	21.9	257
2001	0.622	25.2	1.577	27.8	96	19	14.2	22.4	255
2002	2.225	24.5	5.762	28.0	89	21	16.4	22.0	254
2003	1.524	21.5	3.613	22.6	93	32	14.4	22.3	253
2004	1.323	27.0	3.095	26.8	84	20	13.0	22.3	265
2005	4.170	23.4	12.956	24.1	92	31	14.5	23.1	256
2006	0.529	24.9	1.332	28.1	96	18	15.2	22.2	259
2007	1.377	21.6	4.362	20.6	101	32	14.4	22.1	254
2008	3.567	40.1	12.864	42.5	98	26	15.8	22.2	255
2009	1.768	37.0	4.083	35.0	96	20	15.9	21.8	259
2010	2.018	31.7	7.435	32.8	90	17	15.1	21.5	258
2011	0.797	24.3	2.168	28.6	93	24	15.6	21.8	257
2012	2.668	25.0	2.406	22.8	92	19	15.2	21.3	257
2013	5.207	29.6	3.473	26.4	98	29	14.9	21.7	254

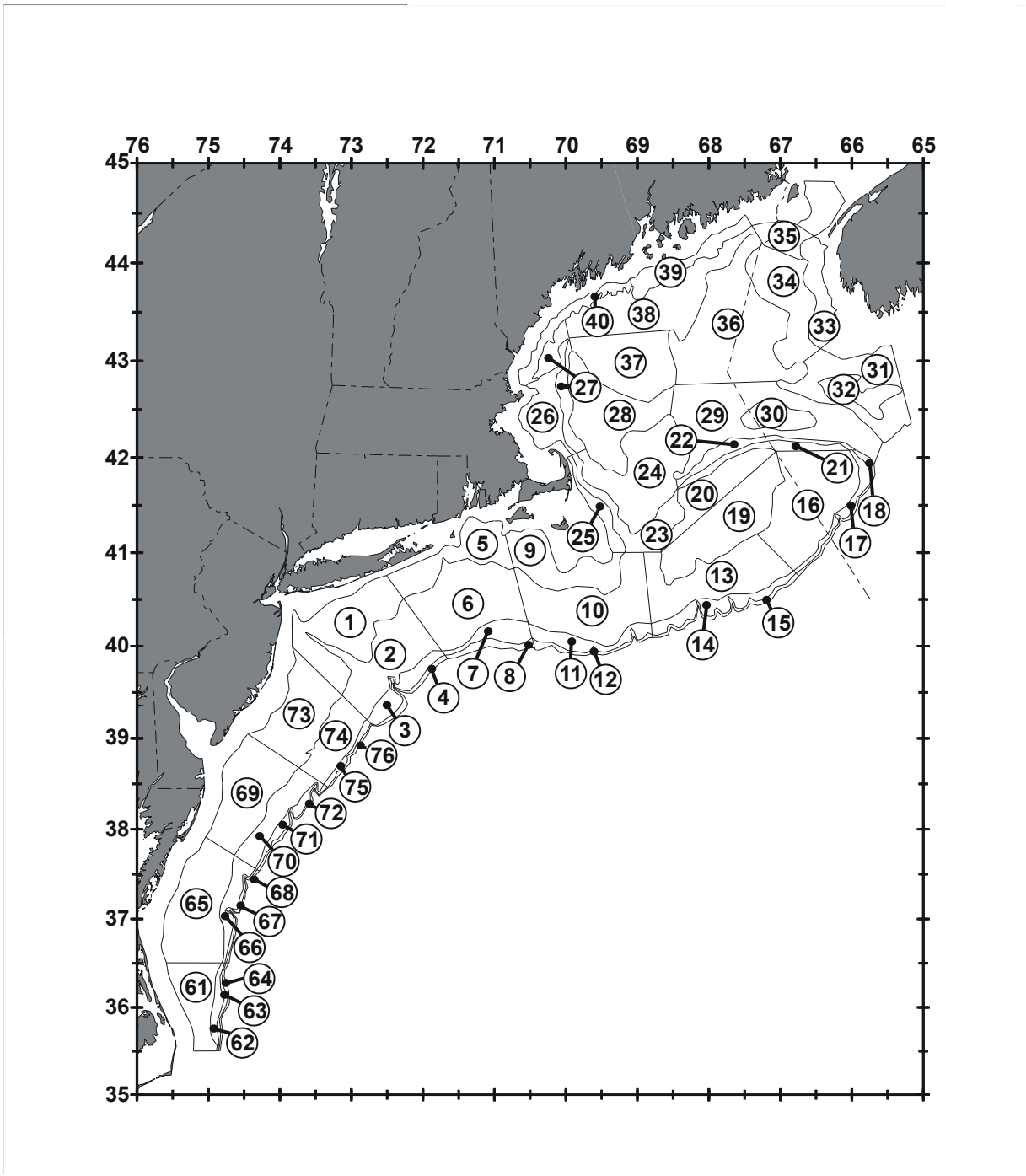


Figure 1. Map of offshore strata (01 code) for the autumn, spring and winter surveys.

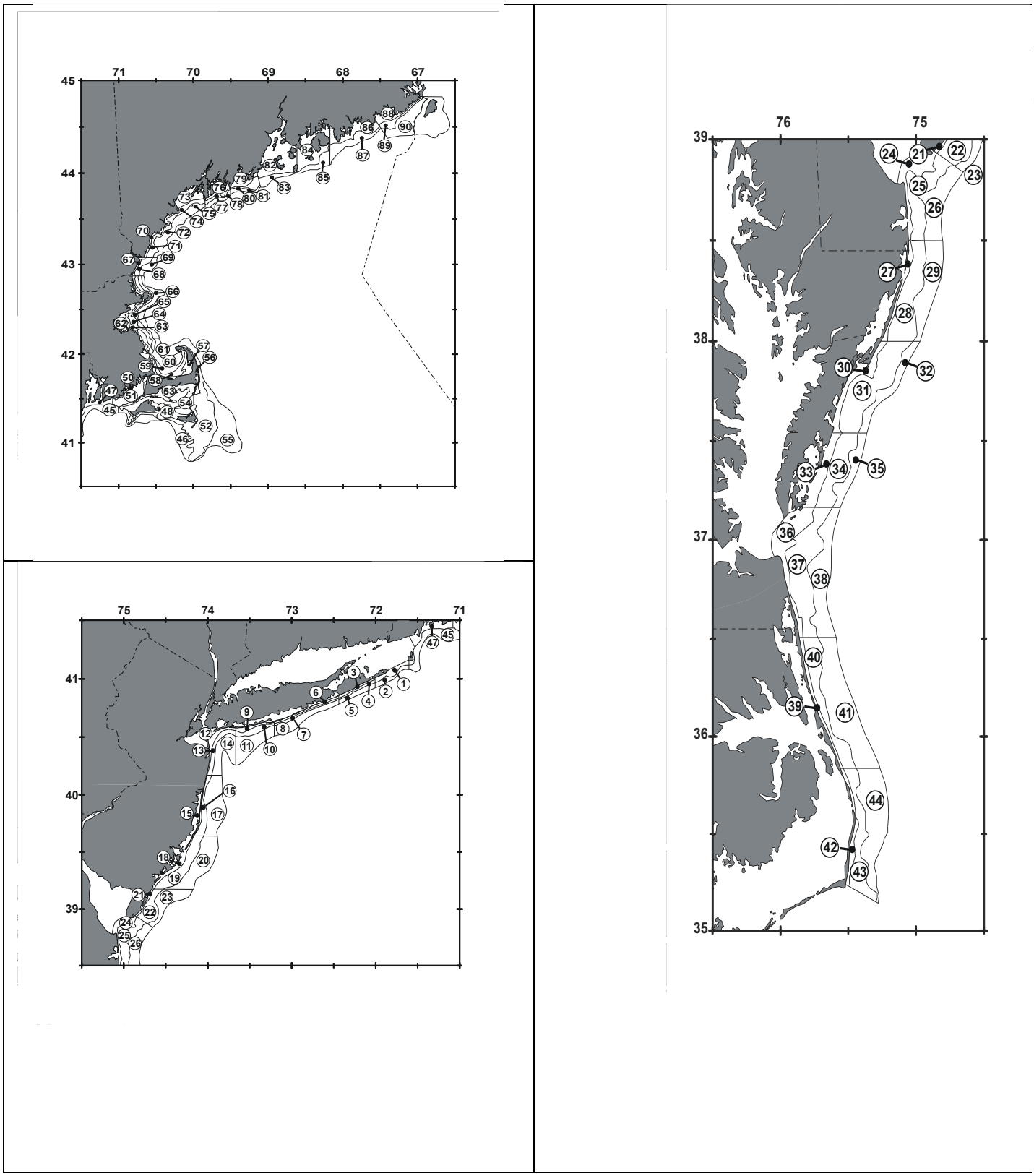


Figure 2. Map of offshore strata (03 code) for the autumn, spring and winter surveys.

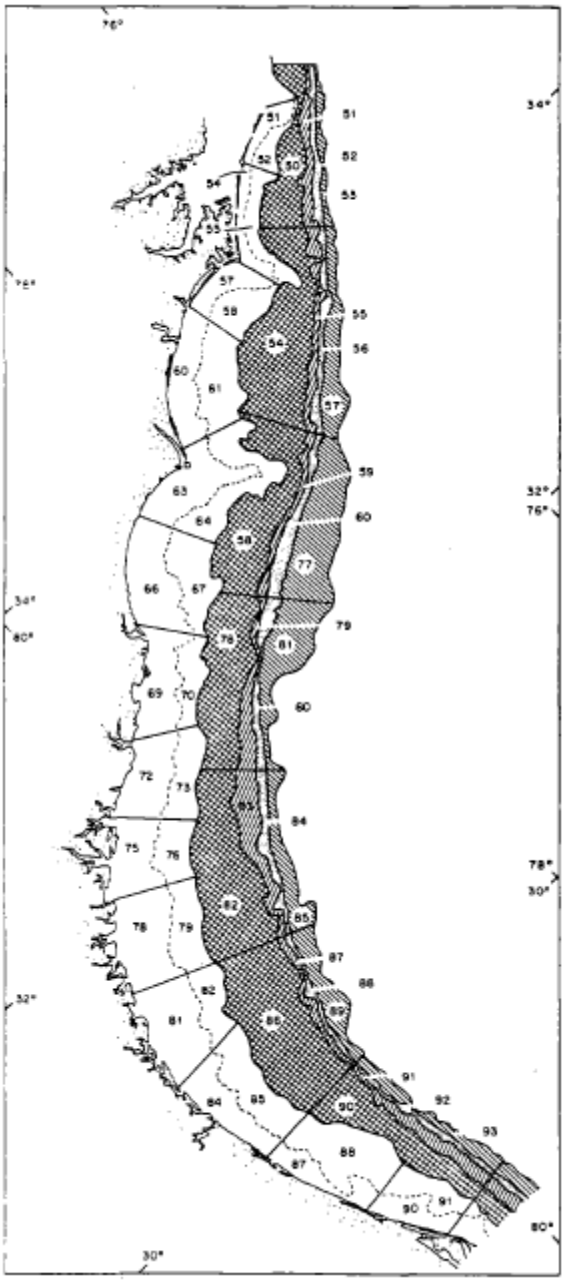
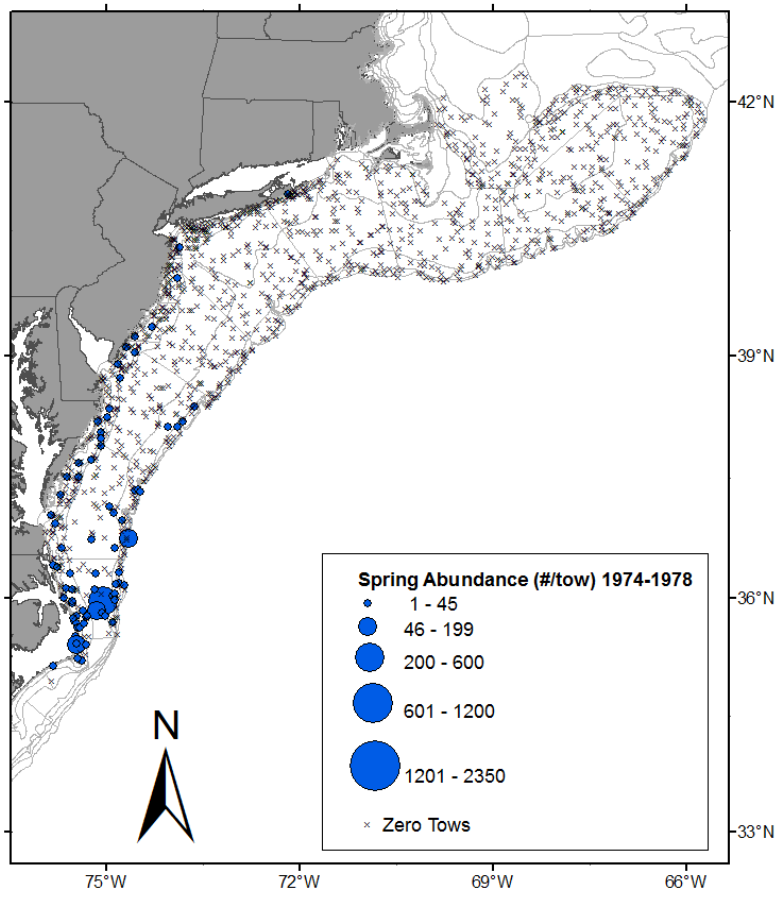
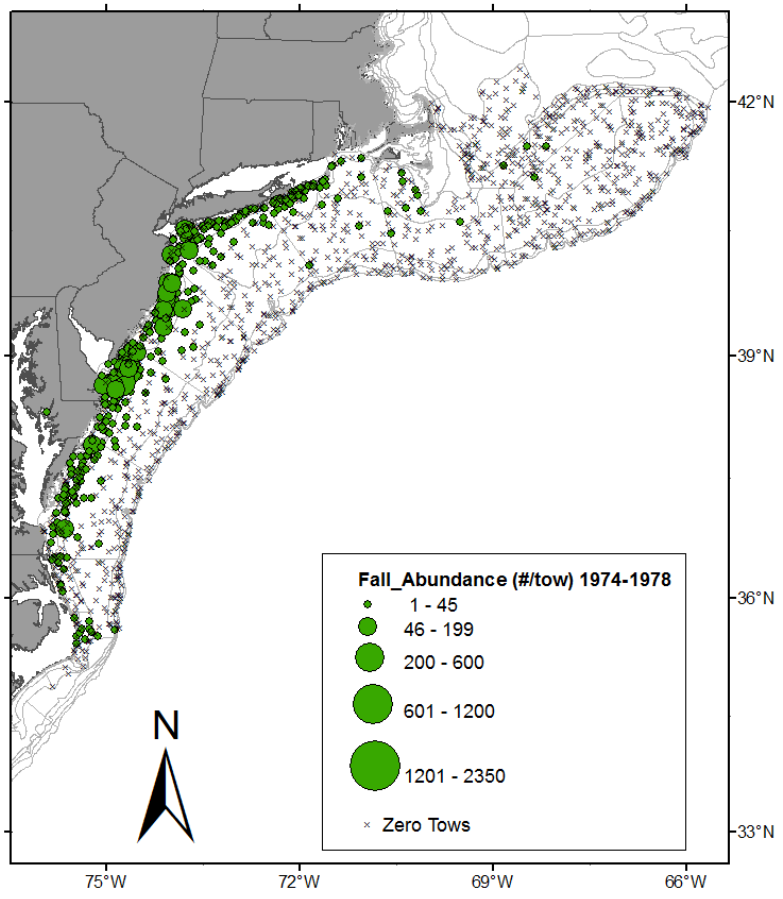


Figure 3. Strata sampled on NEFC inshore (07 code) and offshore (08 code) bottom trawl surveys between Cape Hatteras, North Carolina and Cape Canaveral, Florida.

Smooth dogfish (Mustelus canis) NEFSC Spring BTS Abundance
(1974-1978)



Smooth dogfish (Mustelus canis) NEFSC Spring BTS Abundance
(1974-1978)



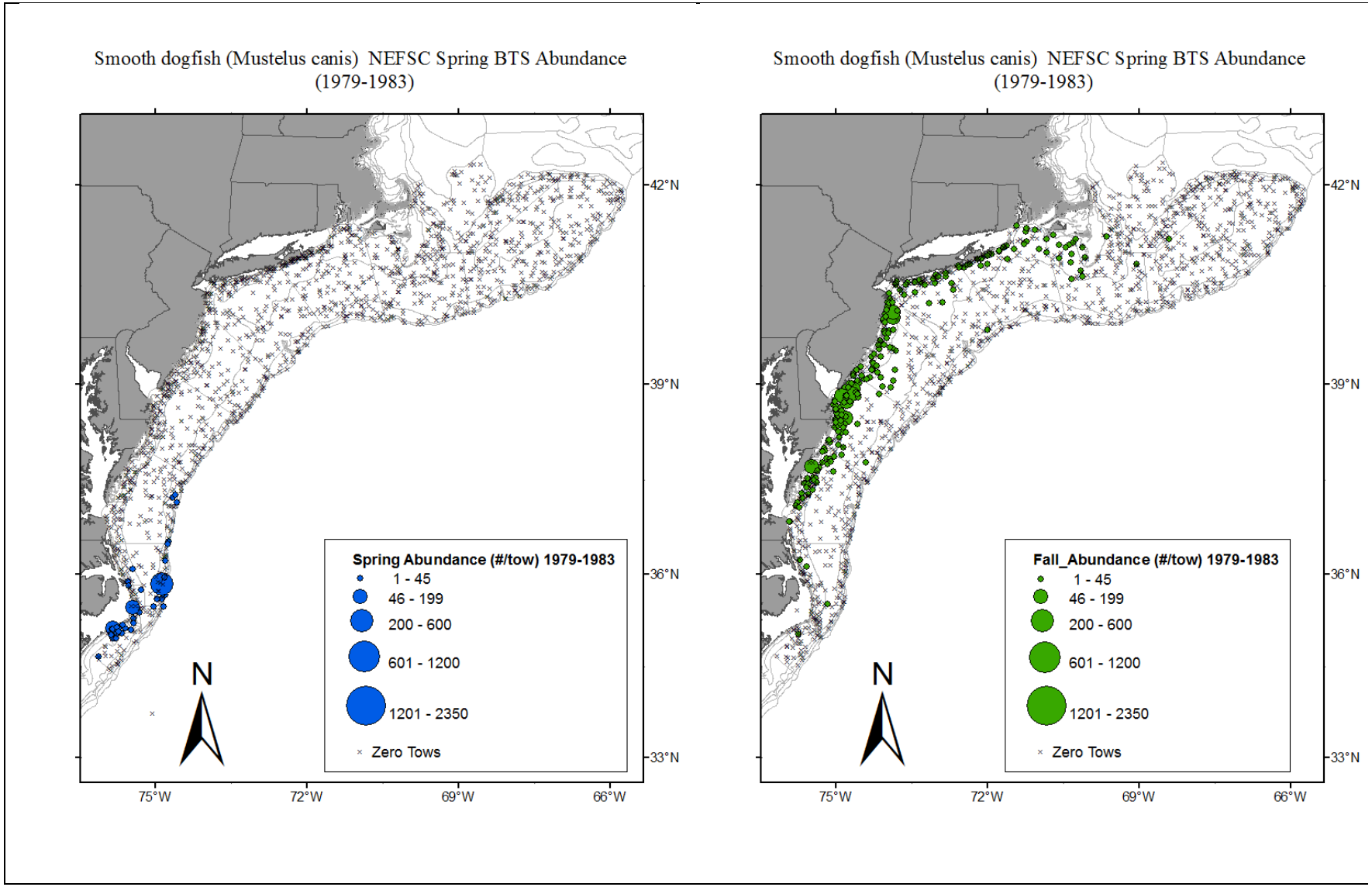


Figure 4b. Distribution of smooth dogfish in the spring and autumn surveys from 1979-1983.

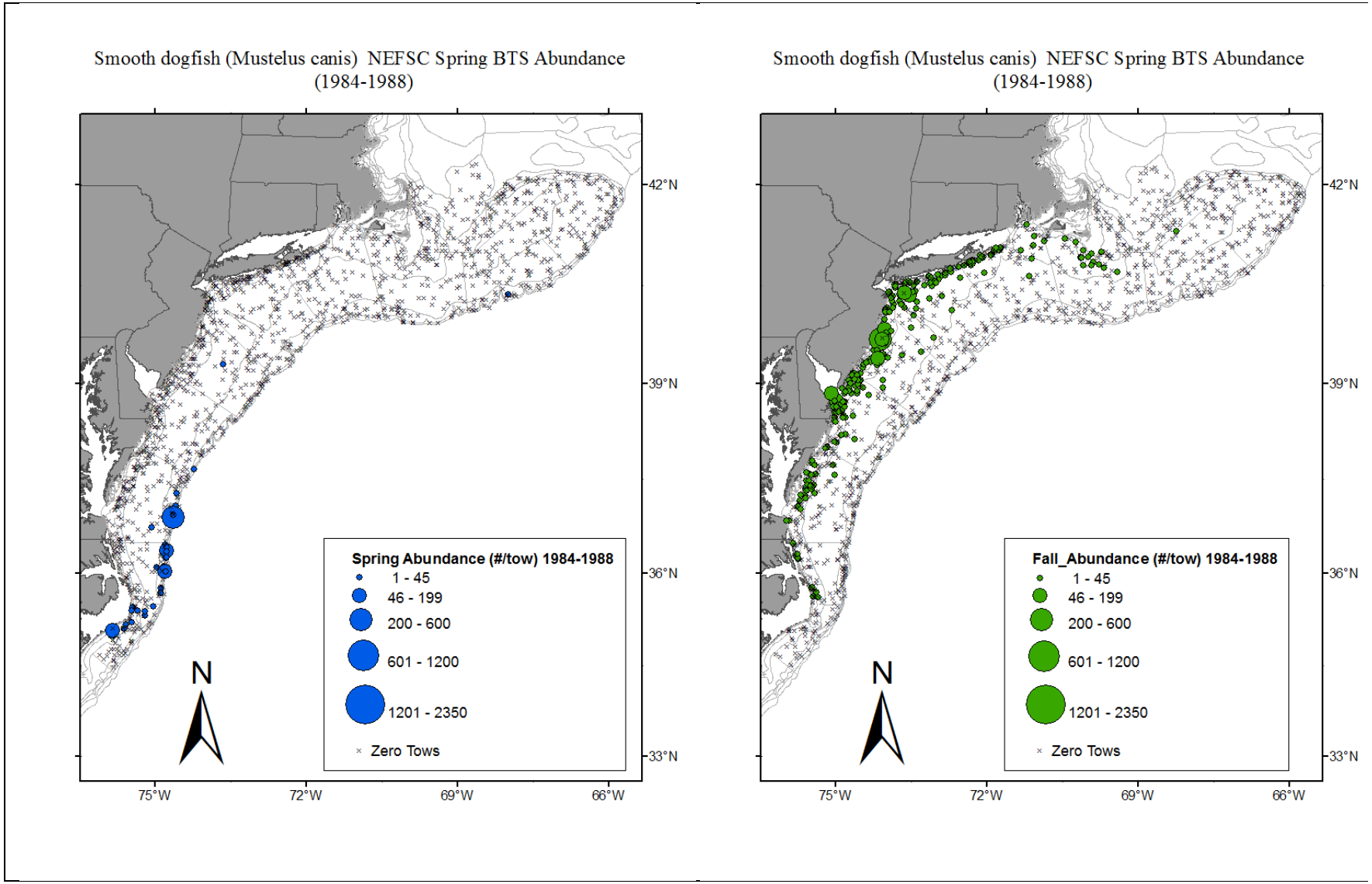


Figure 4c. Distribution of smooth dogfish in the spring and autumn surveys from 1984-1988.

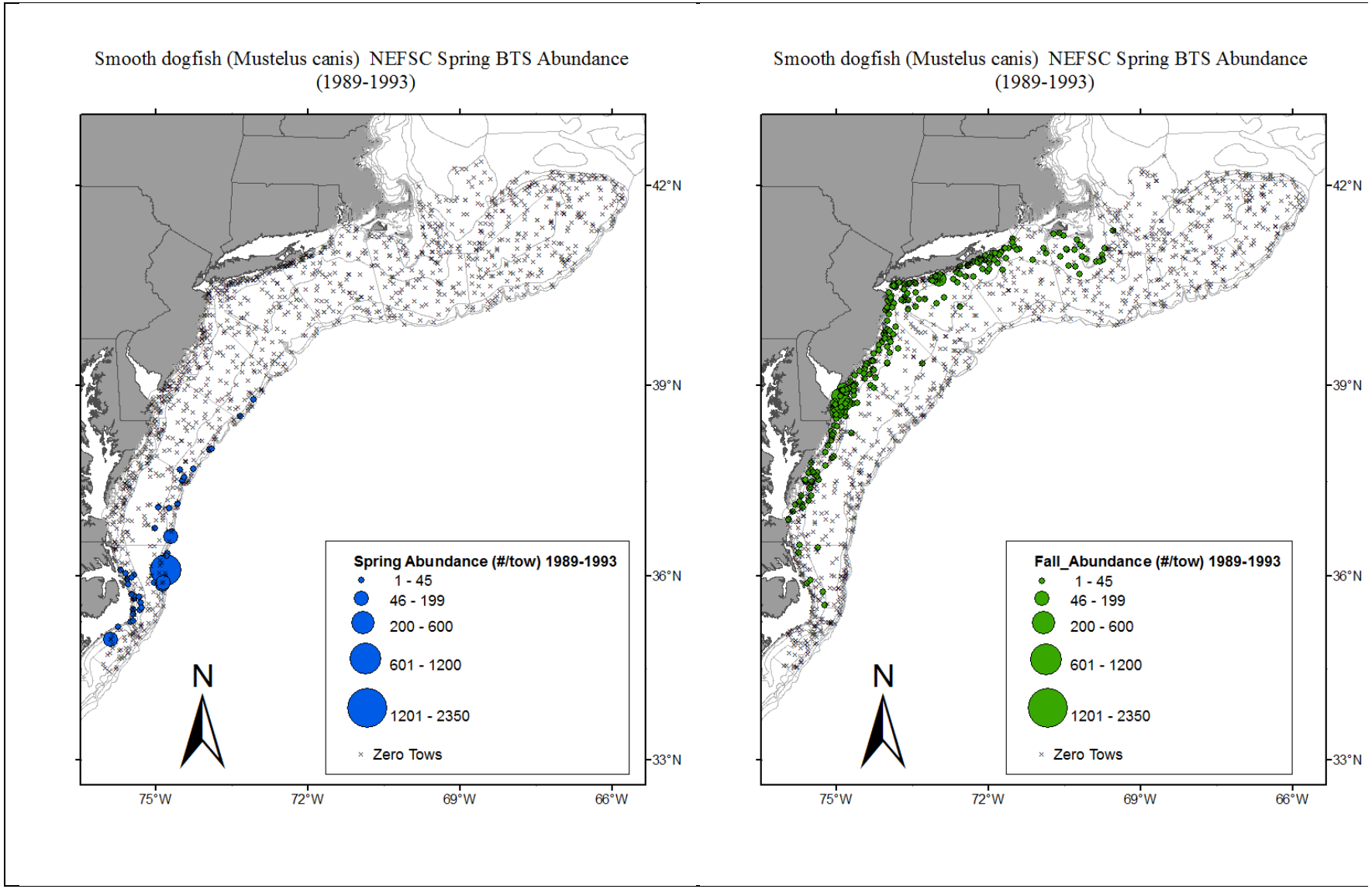


Figure 4d. Distribution of smooth dogfish in the spring and autumn surveys from 1989-1993.

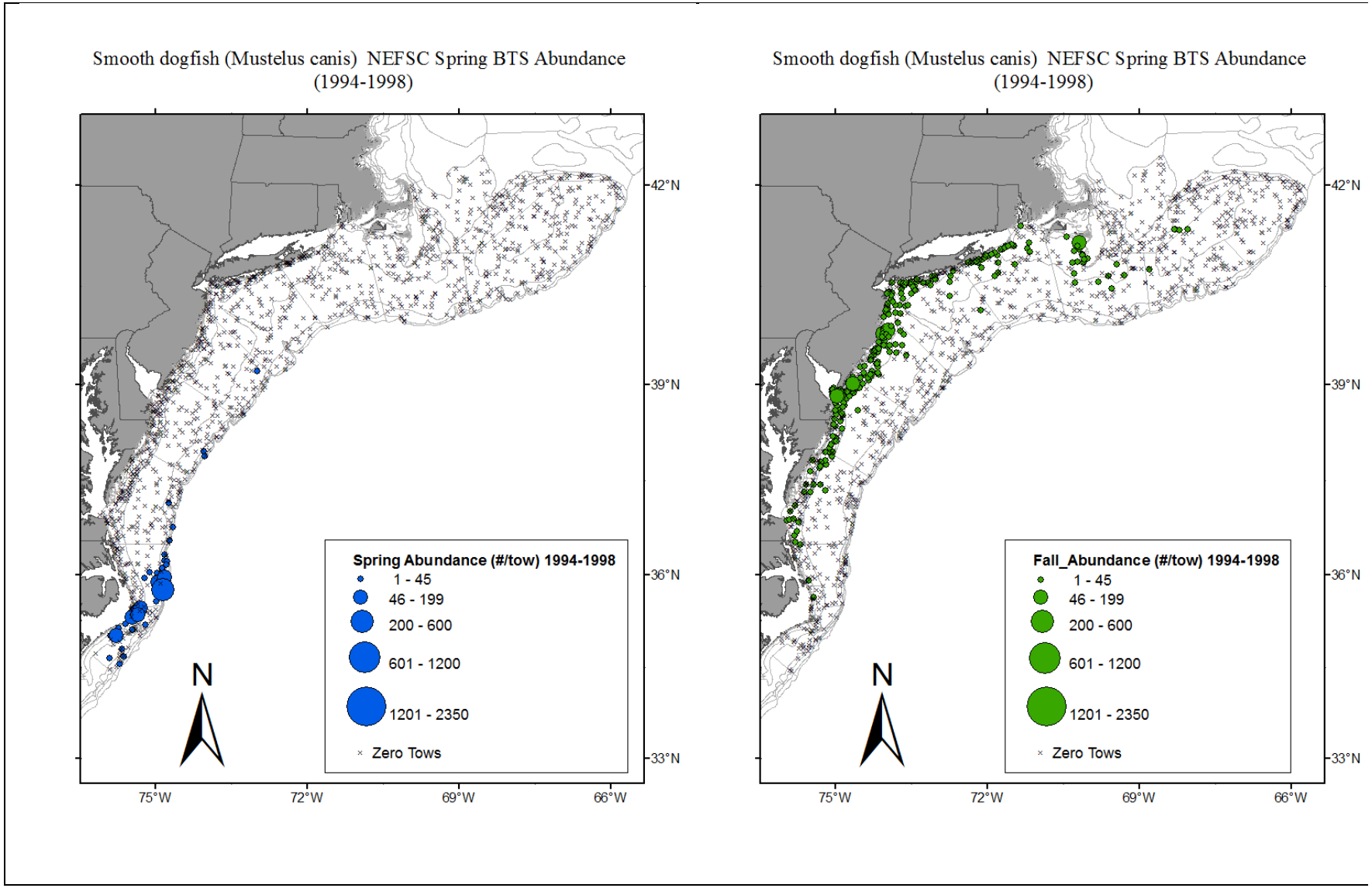


Figure 4e. Distribution of smooth dogfish in the spring and autumn surveys from 1994-1998.

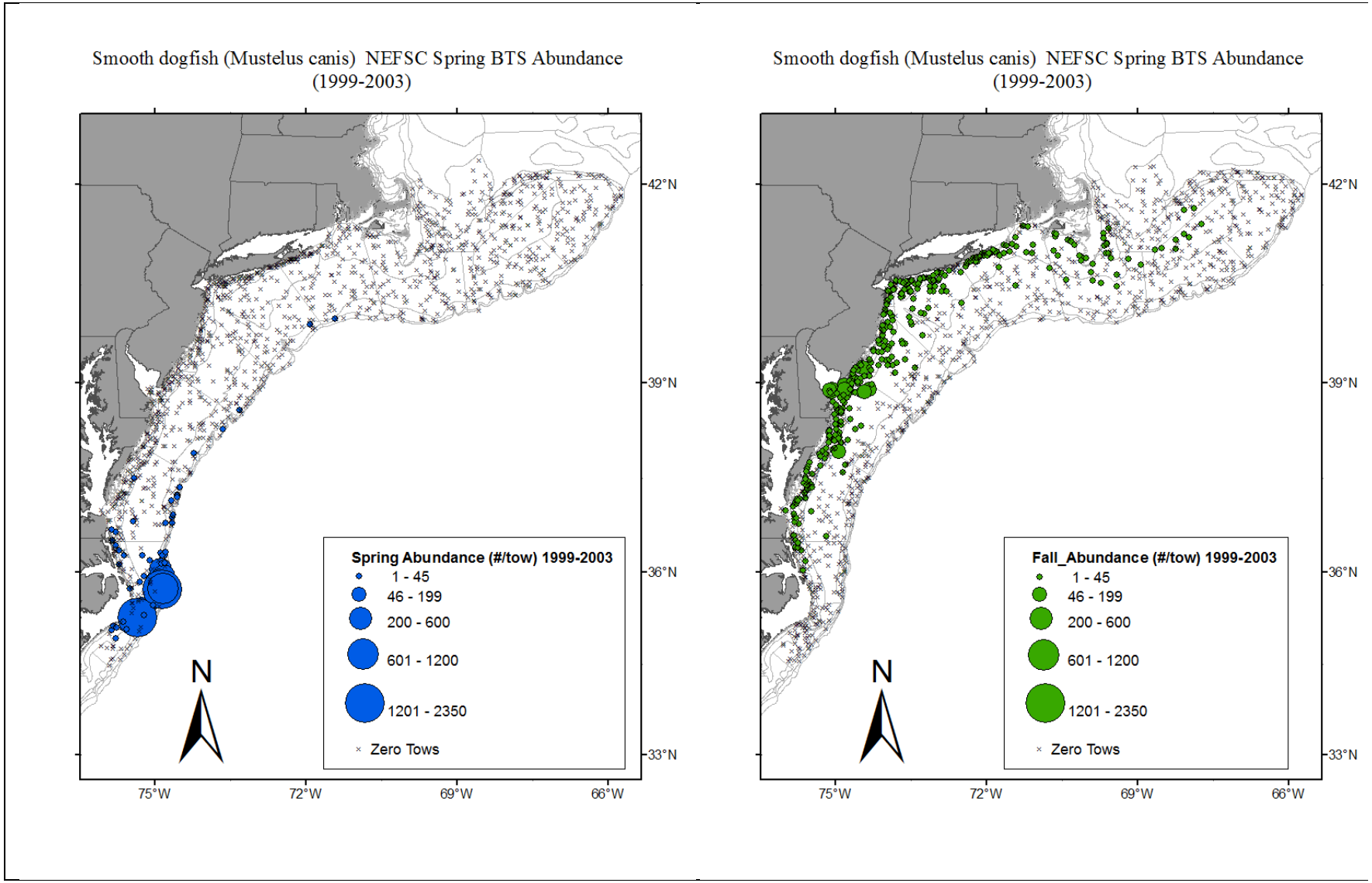


Figure 4f. Distribution of smooth dogfish in the spring and autumn surveys from 1999-2003.

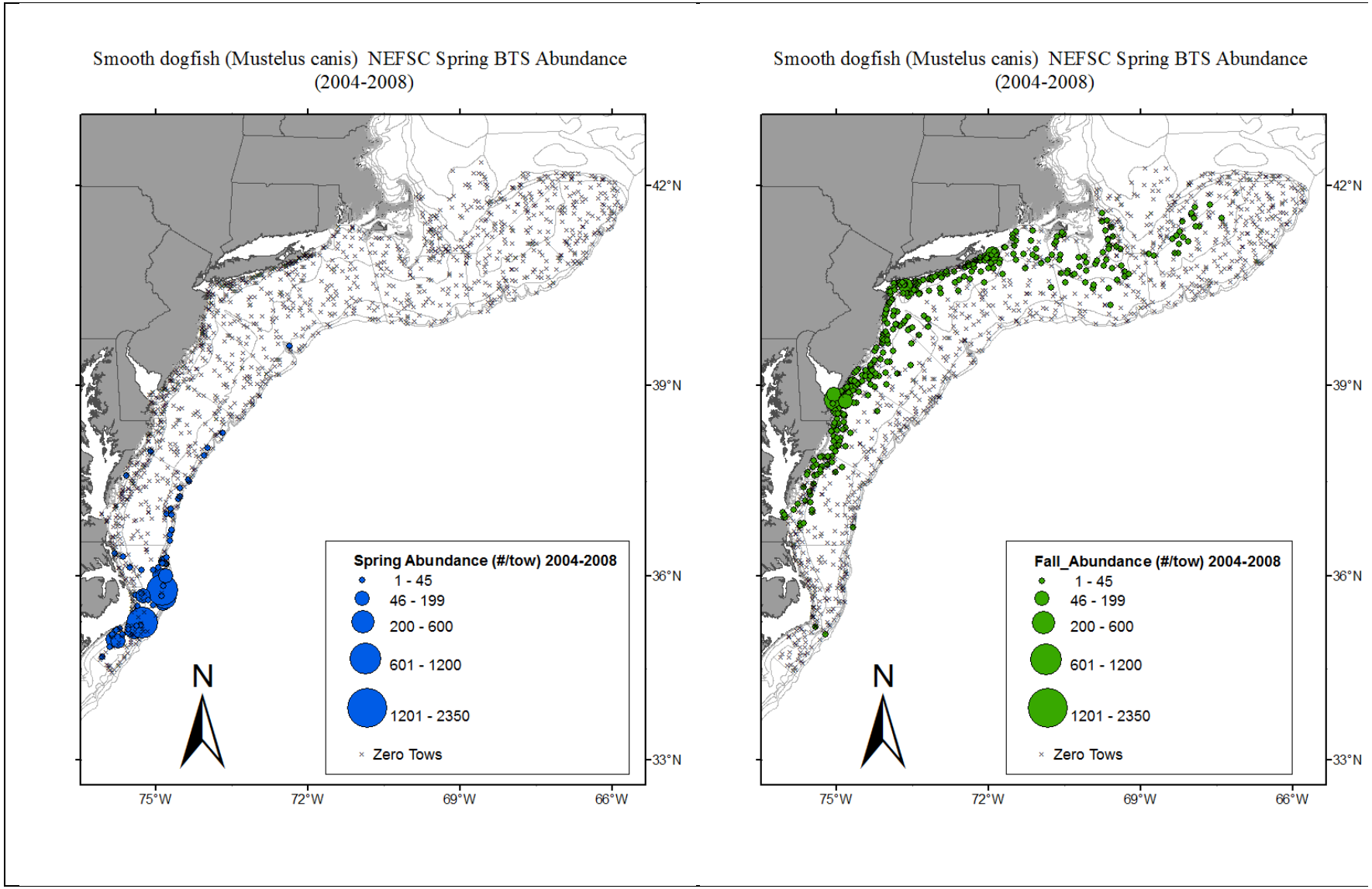


Figure 4g. Distribution of smooth dogfish in the spring and autumn surveys from 2004-2008.

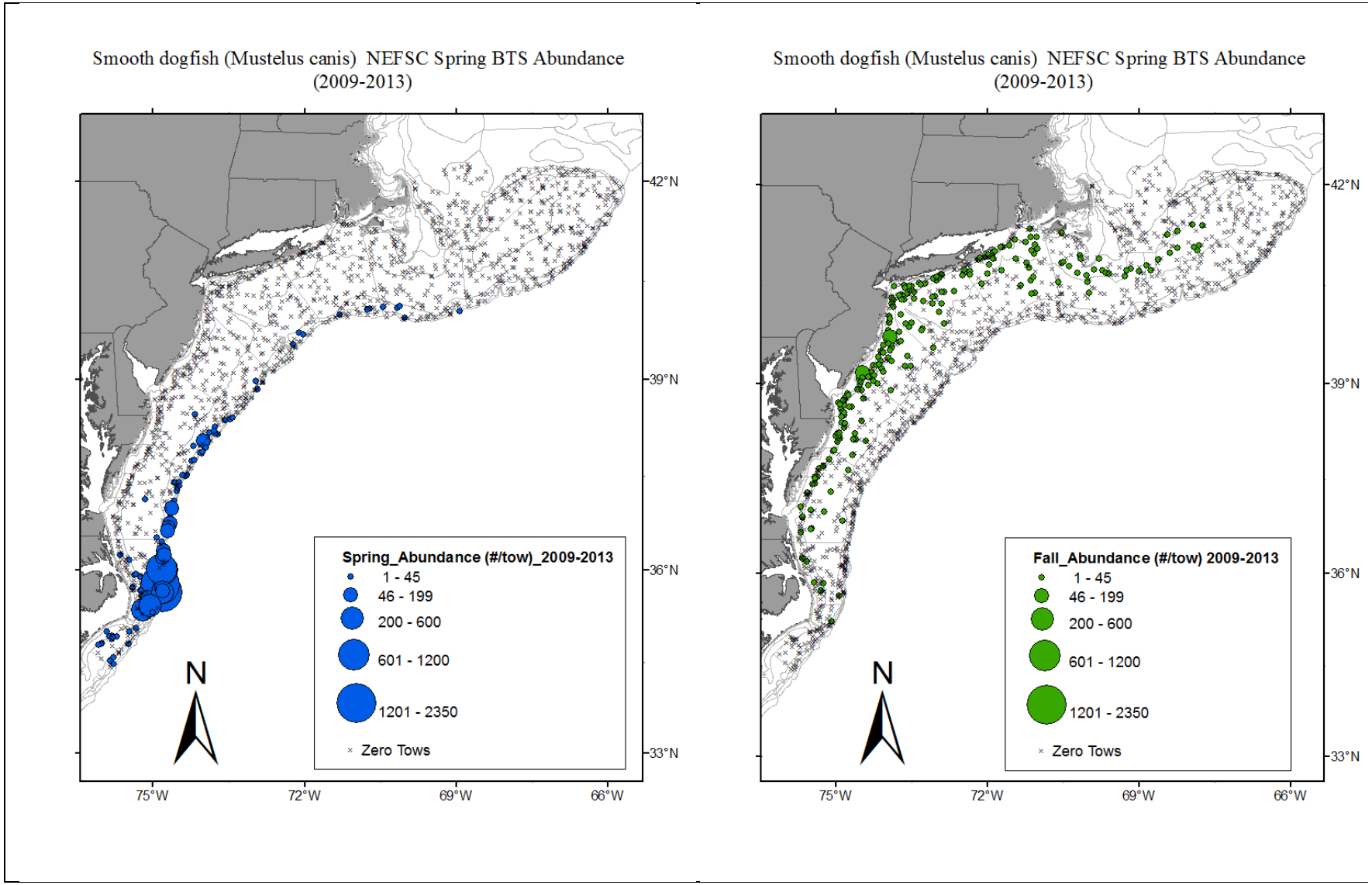


Figure 4h. Distribution of smooth dogfish in the spring and autumn surveys from 2009-2013.

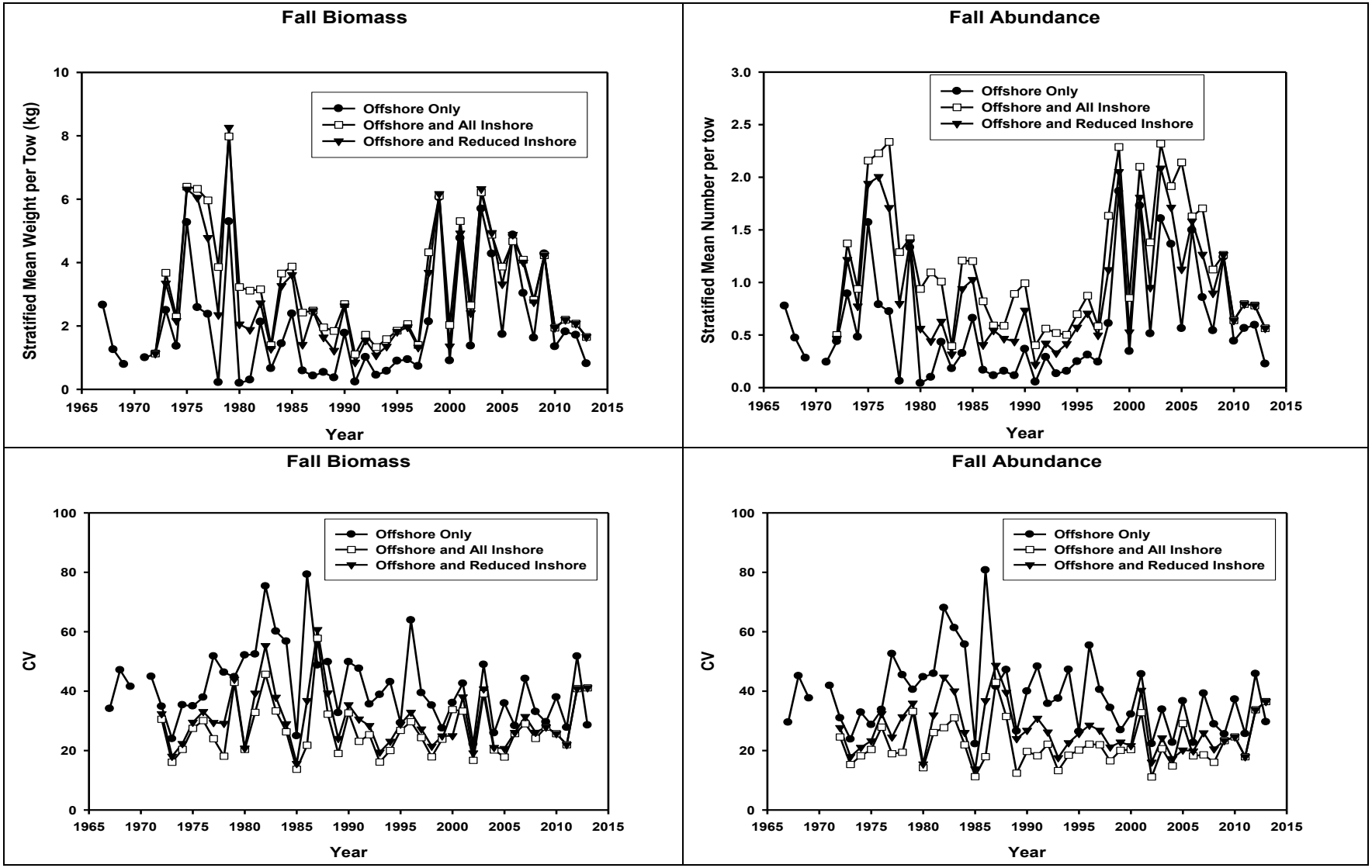


Figure 5. NEFSC fall survey indices (top panels) and cvs (bottom panels) for smooth dogfish from three strata sets (circles-01010-01250, 01610-01760;squares-01010-01250,01610-01760, 03010-03550; triangles-01010-01250, 01610-01760, 03020, 03050, 03080, 03110, 03140, 03170, 03200, 03230, 03260, 03290, 03320, 03350, 03380, 03410, 03440-03550).

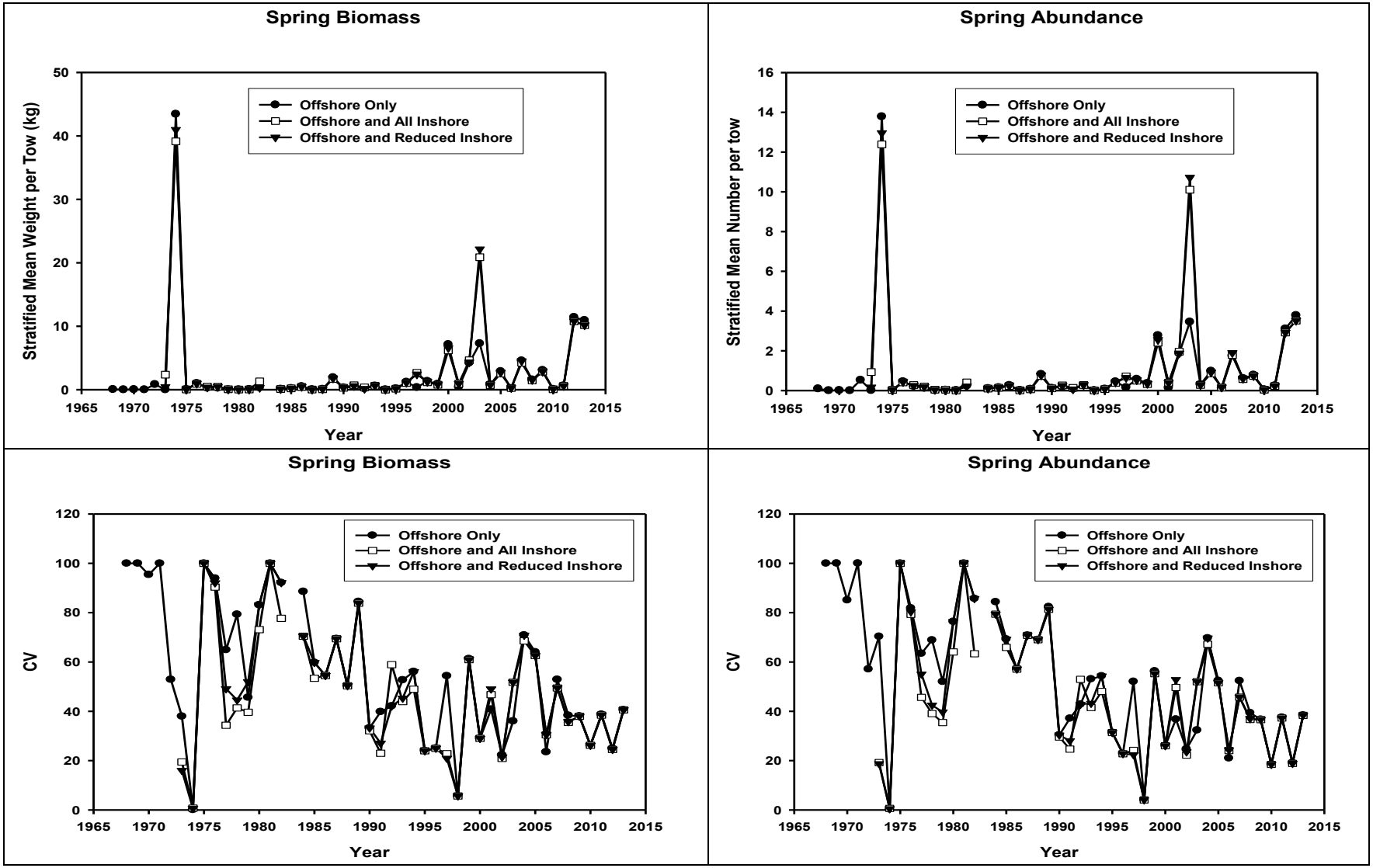


Figure 6. NEFSC spring survey indices (top panels) and cvs (bottom panels) for smooth dogfish from three strata sets (circles-01010-01250, 01610-01760;squares-01010-01250,01610-01760, 03010-03550; triangles-01010-01250, 01610-01760, 03020, 03050, 03080, 03110, 03140, 03170, 03200, 03230, 03260, 03290, 03320, 03350, 03380, 03410, 03440-03550).

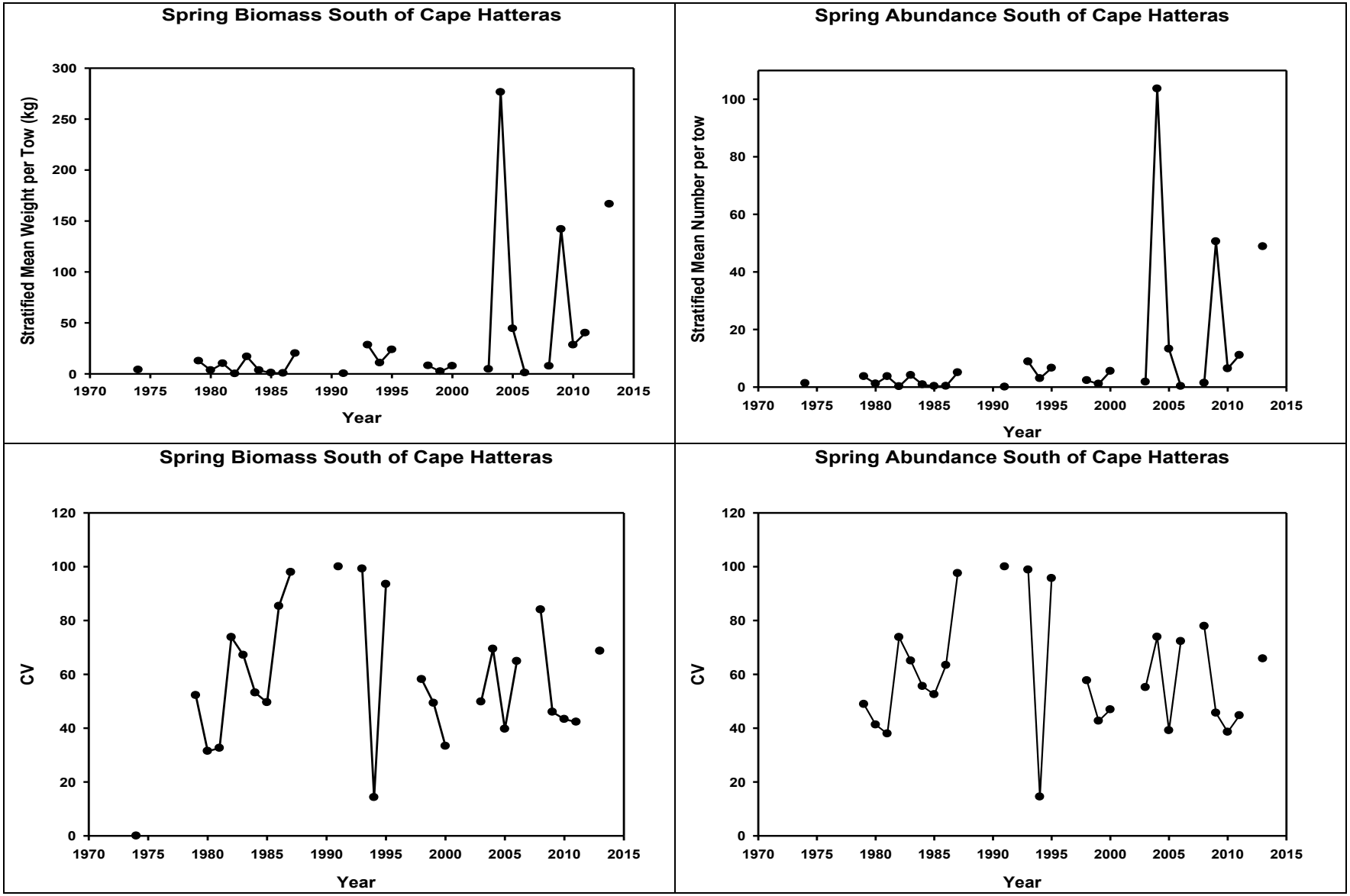


Figure 7. NEFSC spring survey indices (top panels) and cvs (bottom panels) for smooth dogfish from south of Cape Hatteras (07510-07520, 08500-08520).

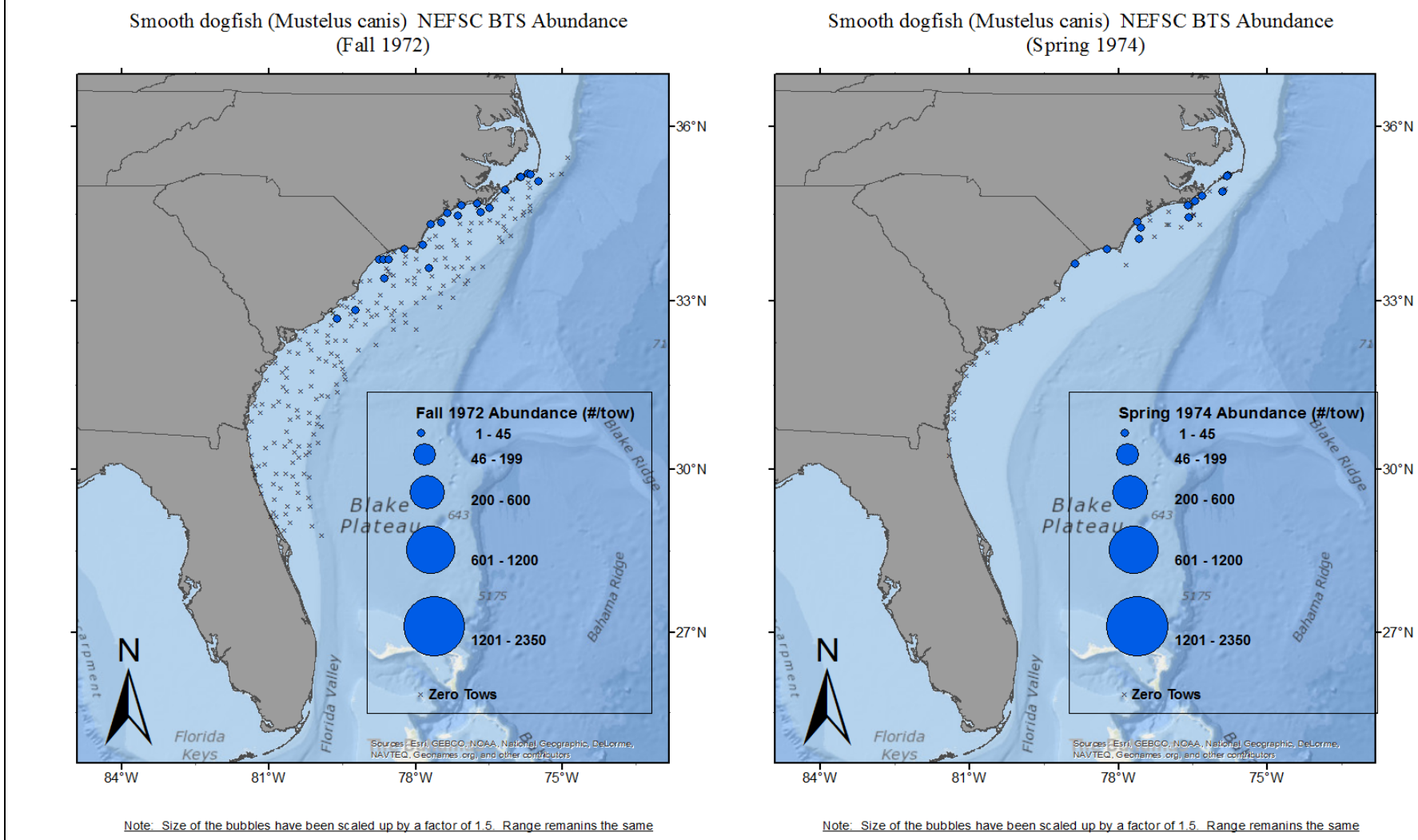


Figure 8. Distribution of smooth dogfish in the two NEFSC surveys which extended to Florida.

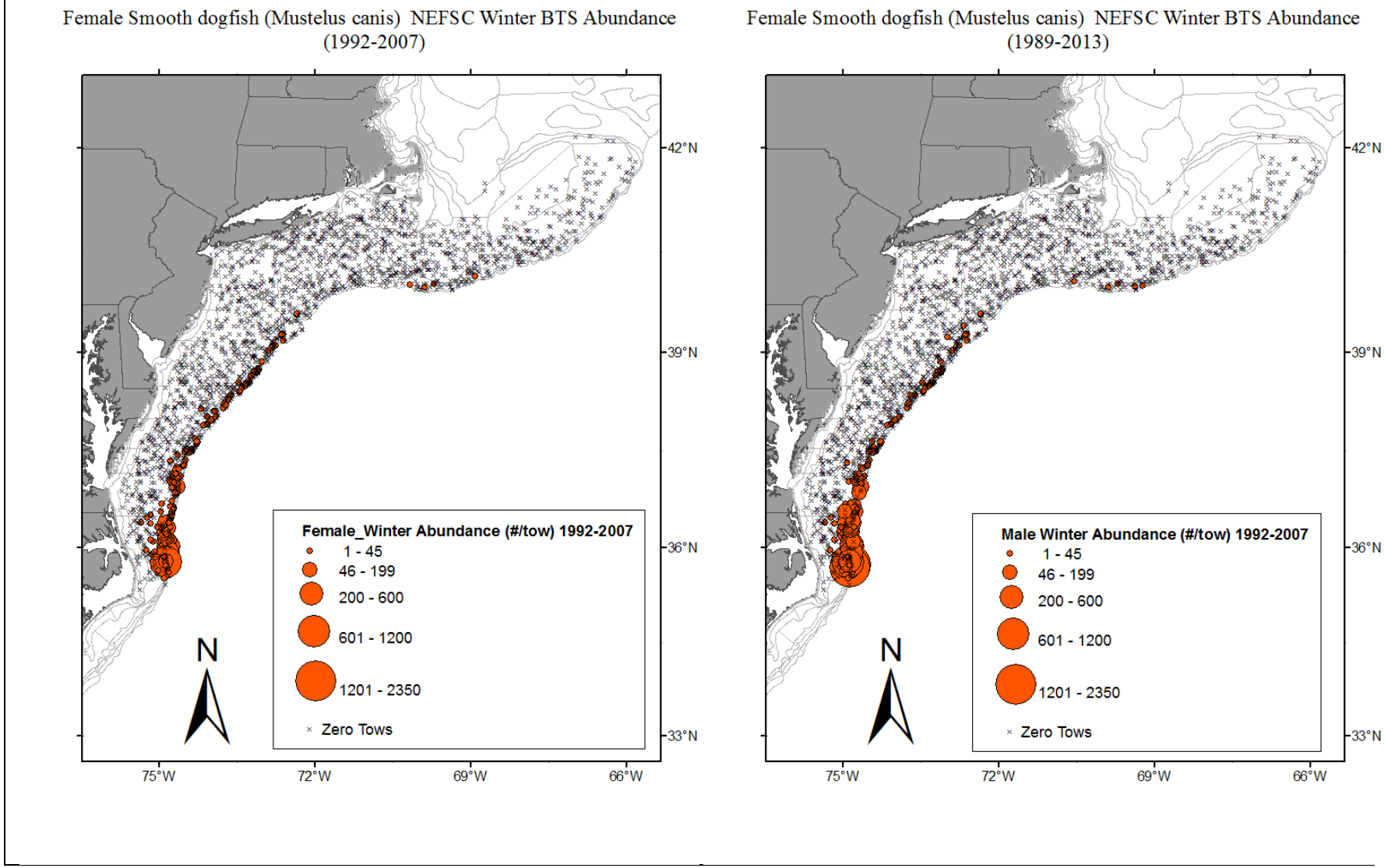


Figure 9. Distribution of smooth dogfish in NEFSC winter surveys from 1992-2007 by sex.

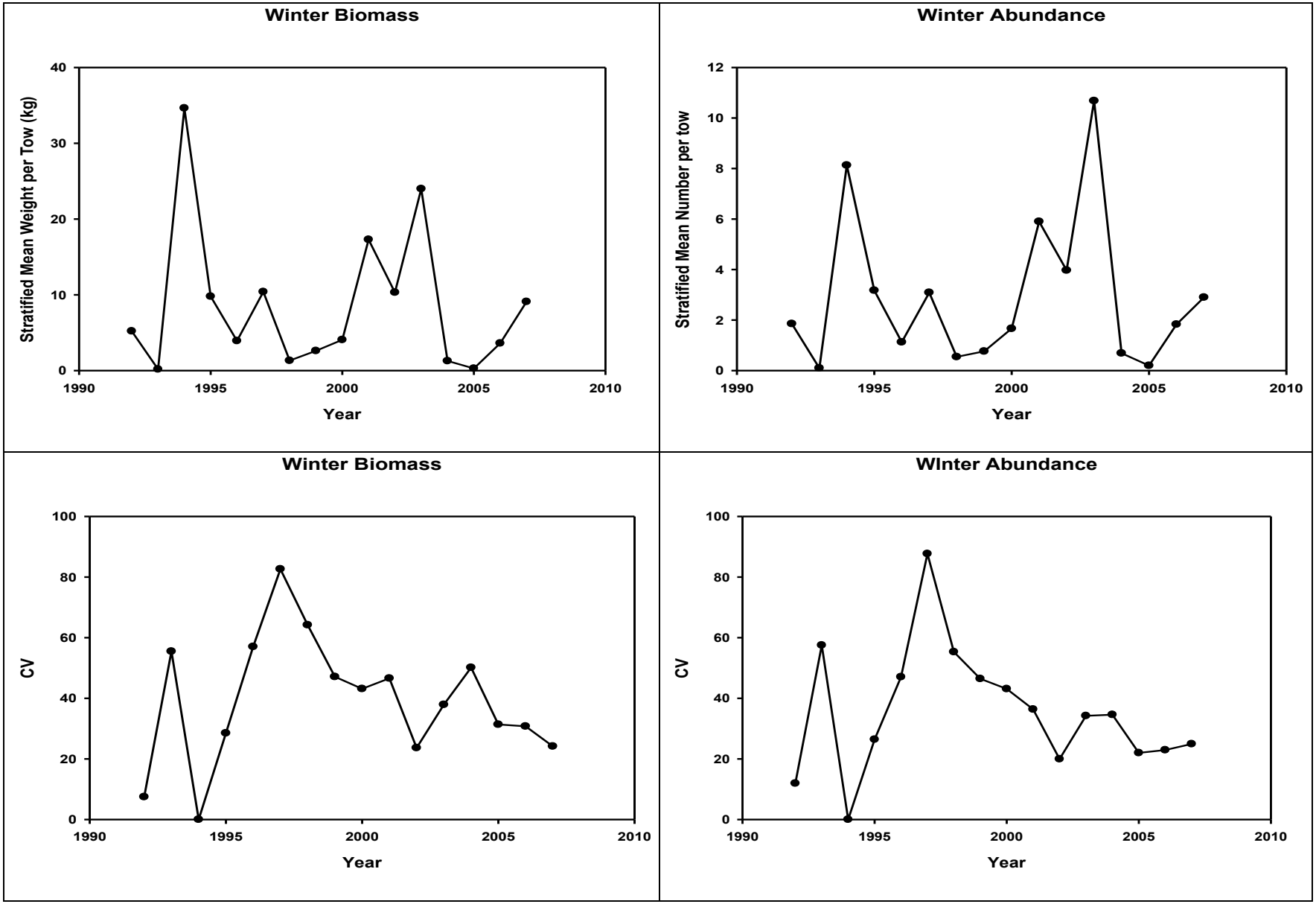


Figure 10. NEFSC winter survey indices (top panels) and cvs (bottom panels) for smooth dogfish.

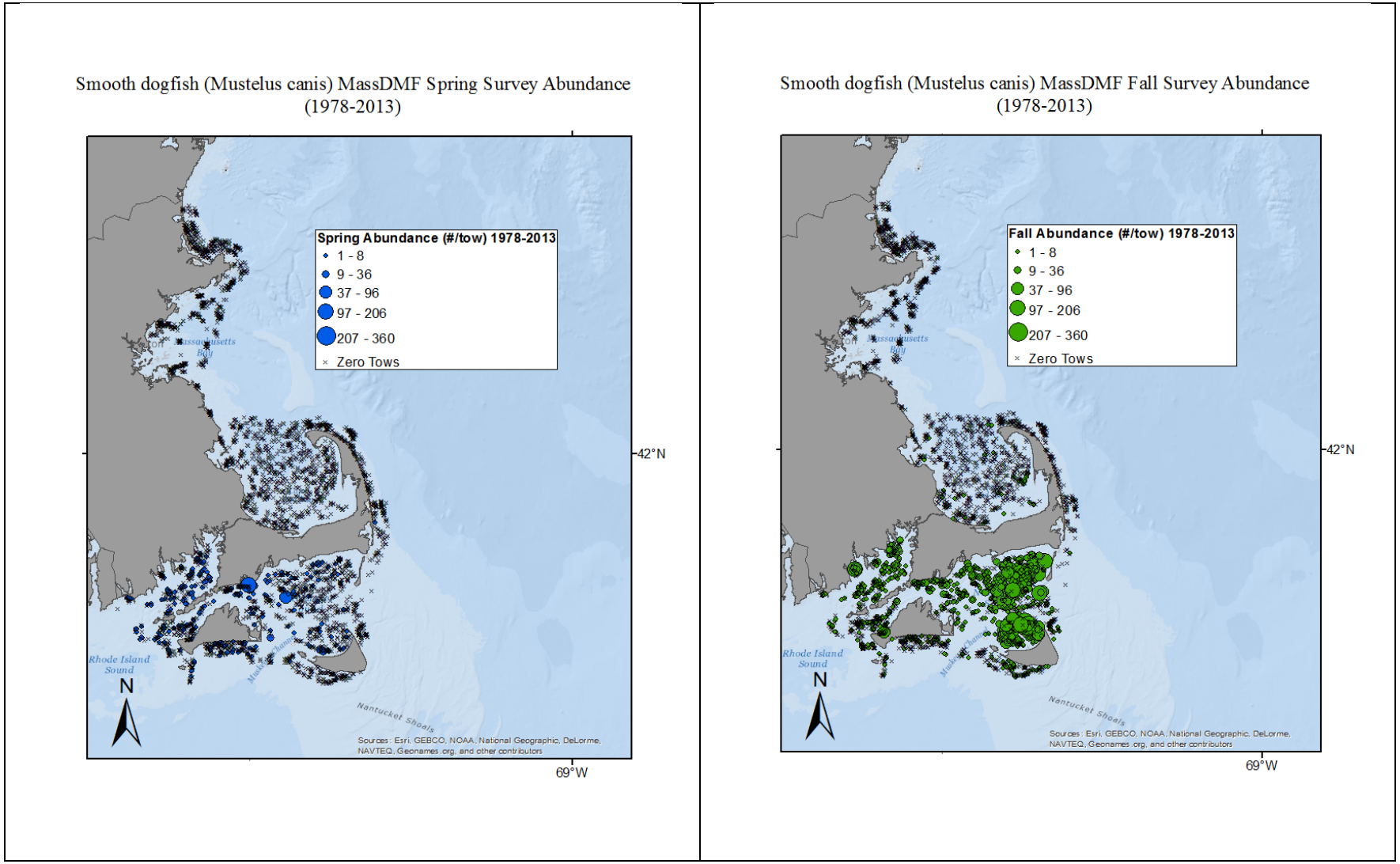


Figure 11. Distribution of smooth dogfish in Mass DMF spring and fall surveys from 1978-2013.

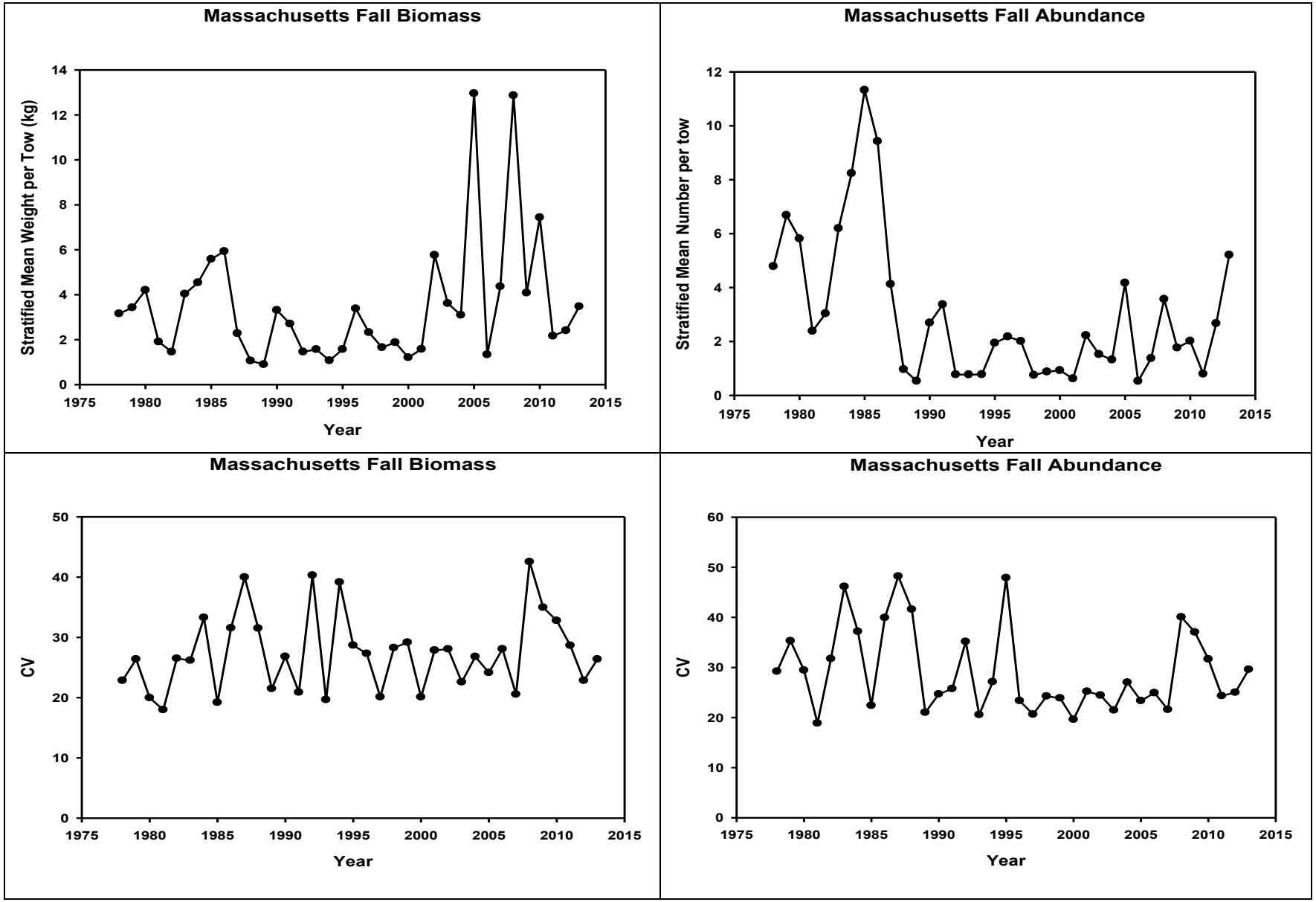


Figure 12. Massachusetts DMF fall survey indices (top panels) and cvs (bottom panels) for smooth dogfish.

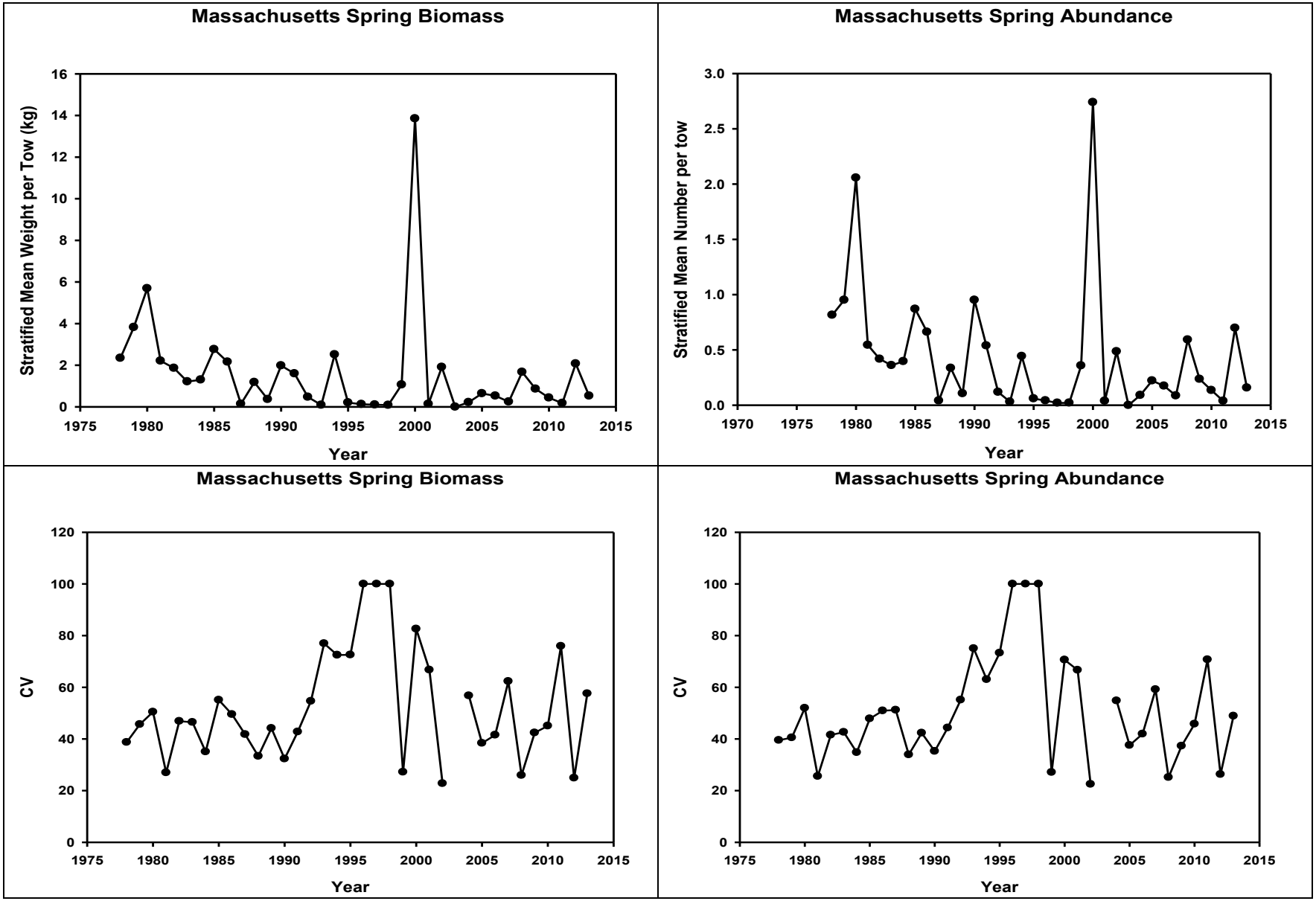


Figure 13. Massachusetts DMF spring survey indices (top panels) and cvs (bottom panels) for smooth dogfish.

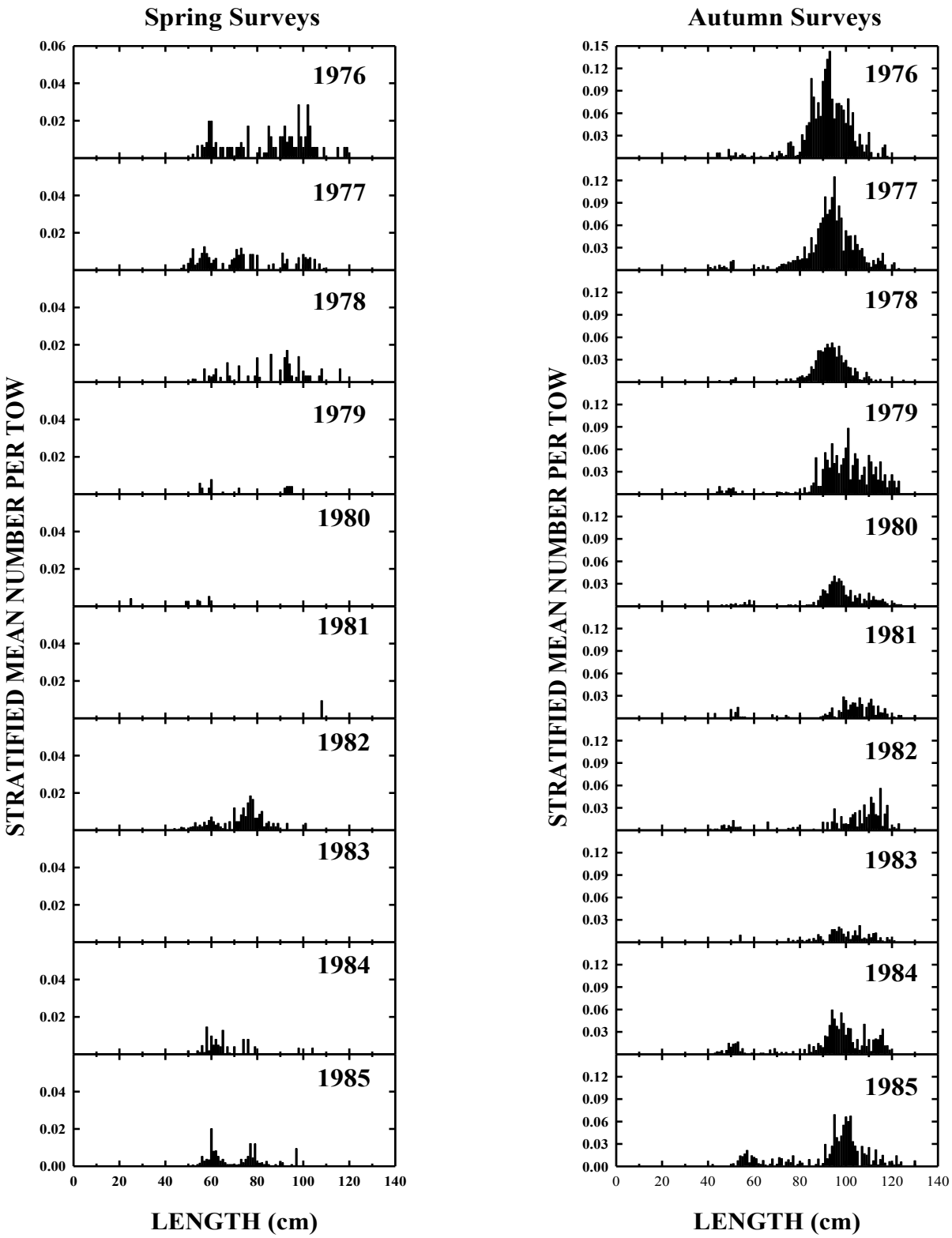


Figure 14a. Length frequency of smooth dogfish from the NEFSC spring and autumn surveys, 1976-1985. Note the difference in scale between the spring and autumn surveys.

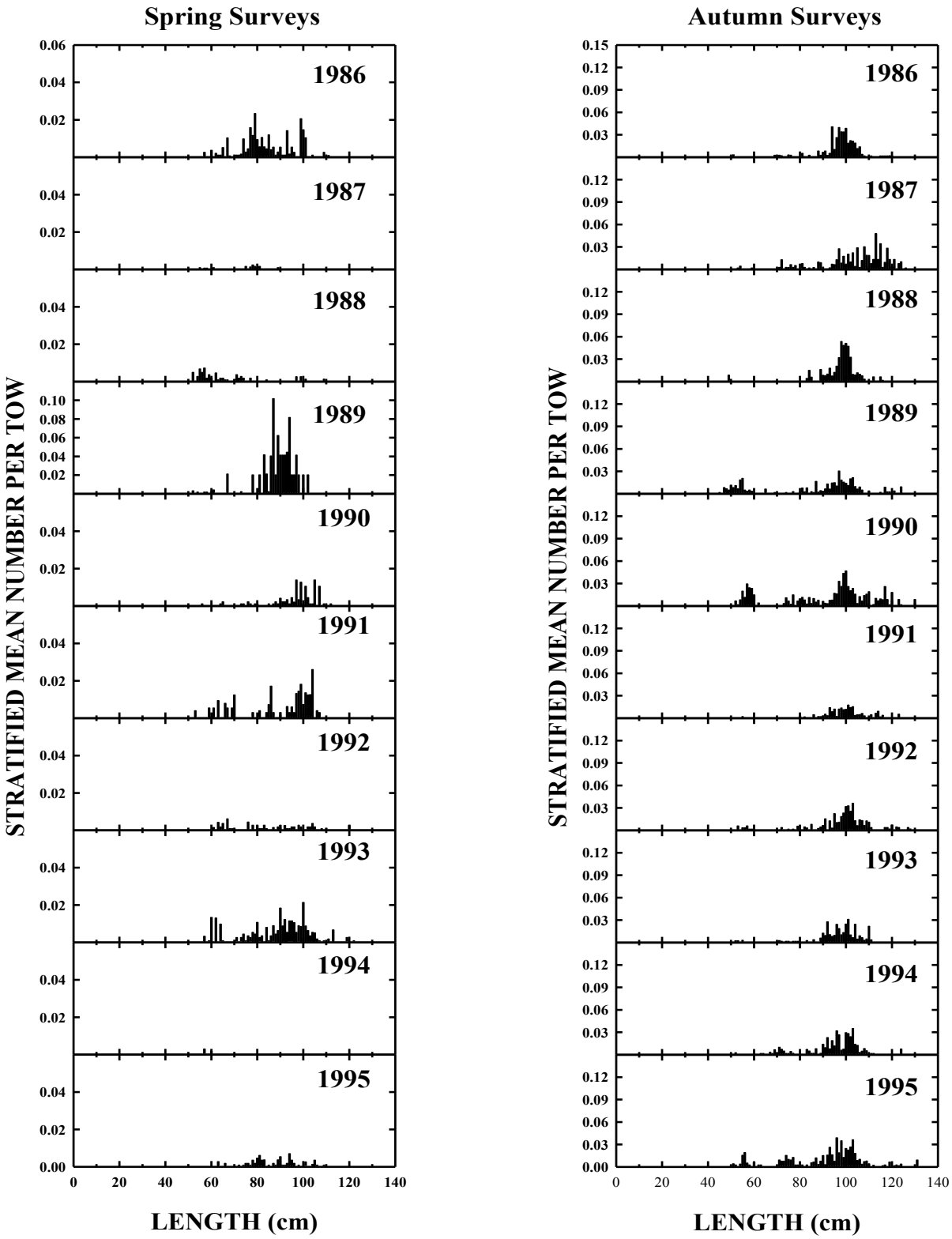


Figure 14b. Length frequency of smooth dogfish from the NEFSC spring and autumn surveys, 1986-1995. Note the difference in scale between the spring and autumn surveys and the change in spring survey scale in 1989.

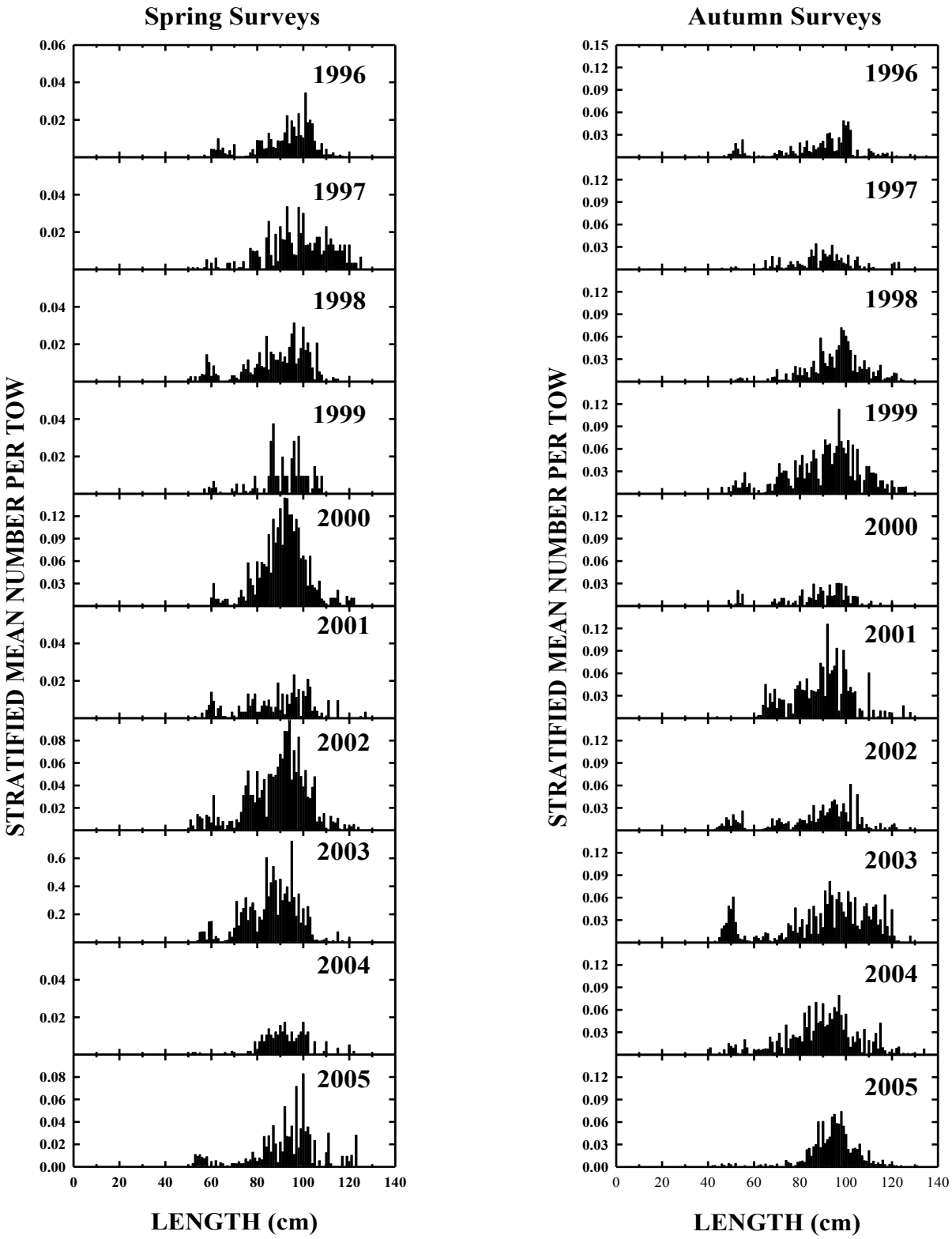


Figure 14c. Length frequency of smooth dogfish from the NEFSC spring and autumn surveys, 1996-2005. Note the difference in scale between the spring and autumn surveys and the change in spring survey scale in 2000, 2002, 2003, and 2005.

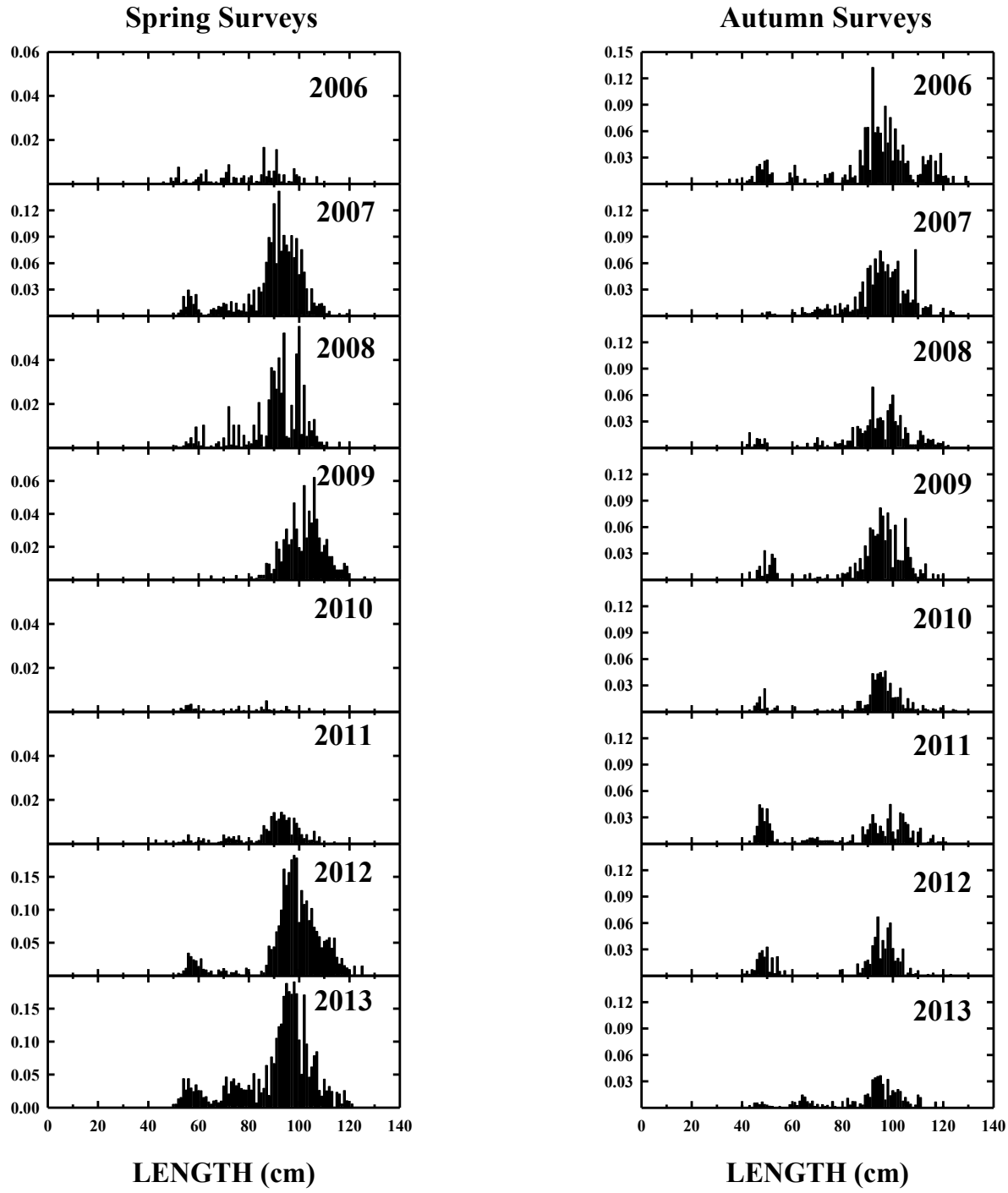


Figure 14d. Length frequency of smooth dogfish from the NEFSC spring and autumn surveys, 2006-2013. Note the difference in scale between the spring and autumn surveys and the change in spring survey scale in 2007, 2009, 2012, and 2013.