DOGFISH FIGURES

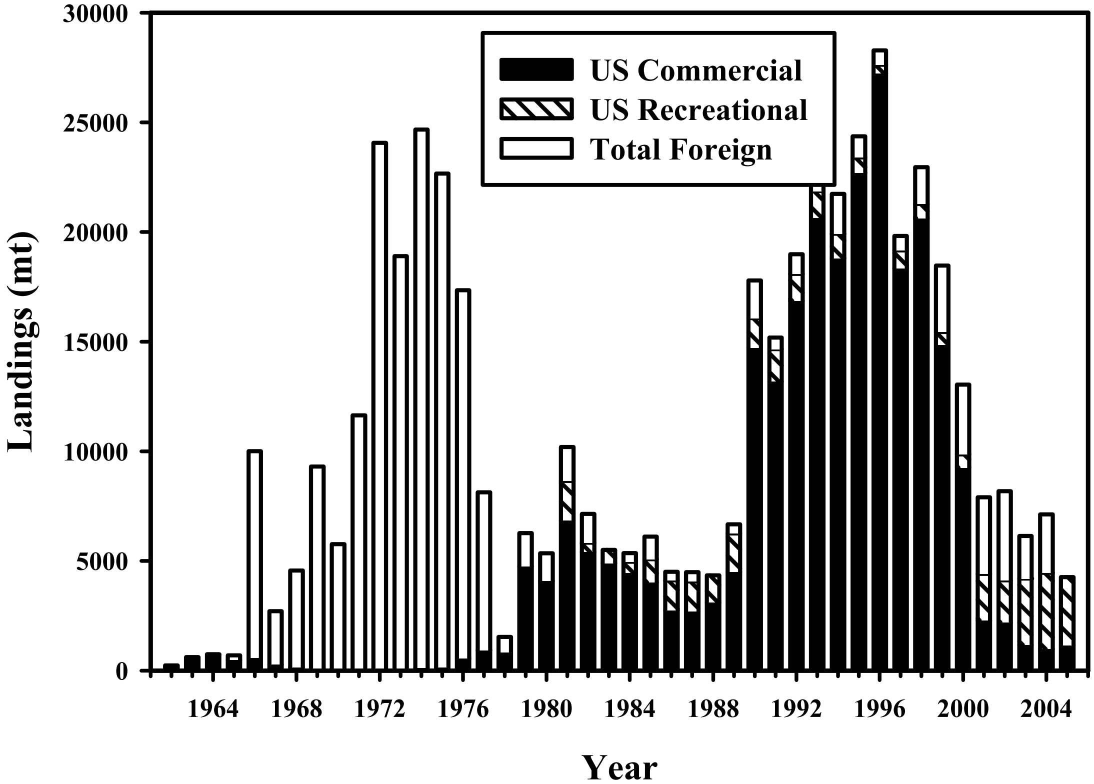


Figure B4.1. Commercial landings (metric tons) and total recreational catch, 1962-2005.

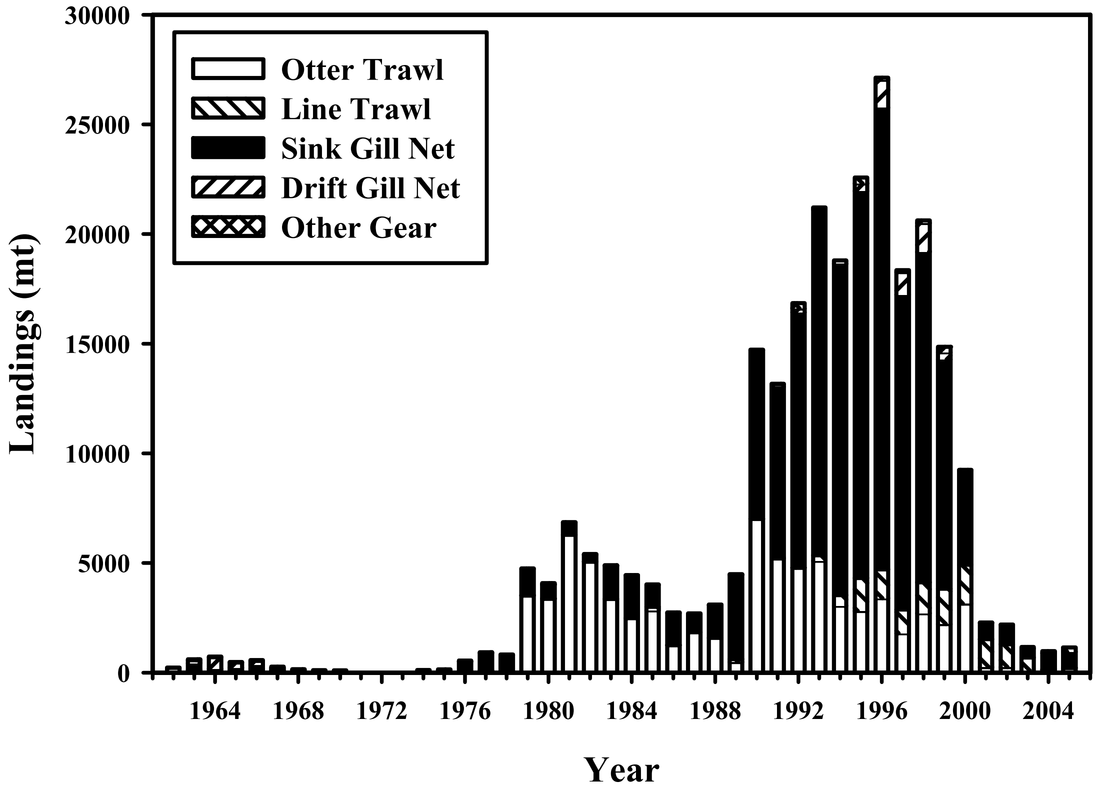


Figure B4.2. U.S. landings (metric tons) of spiny dogfish from NAFO subareas 2-6 by gear type, 1962-2005.

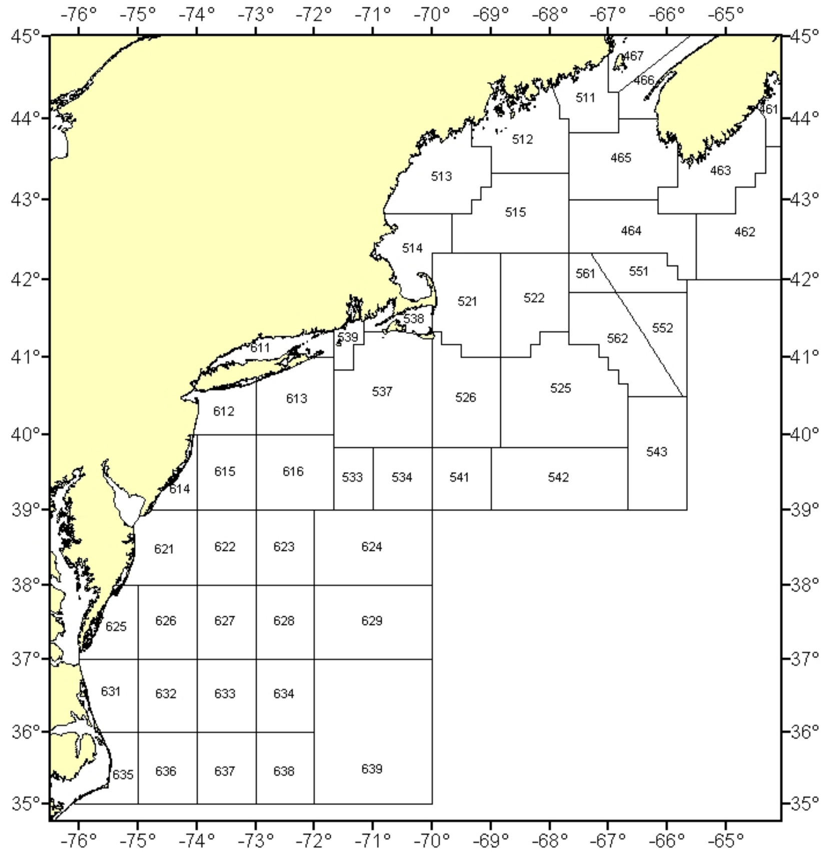


Fig. B4.3. Statistical areas for Canada and USA.

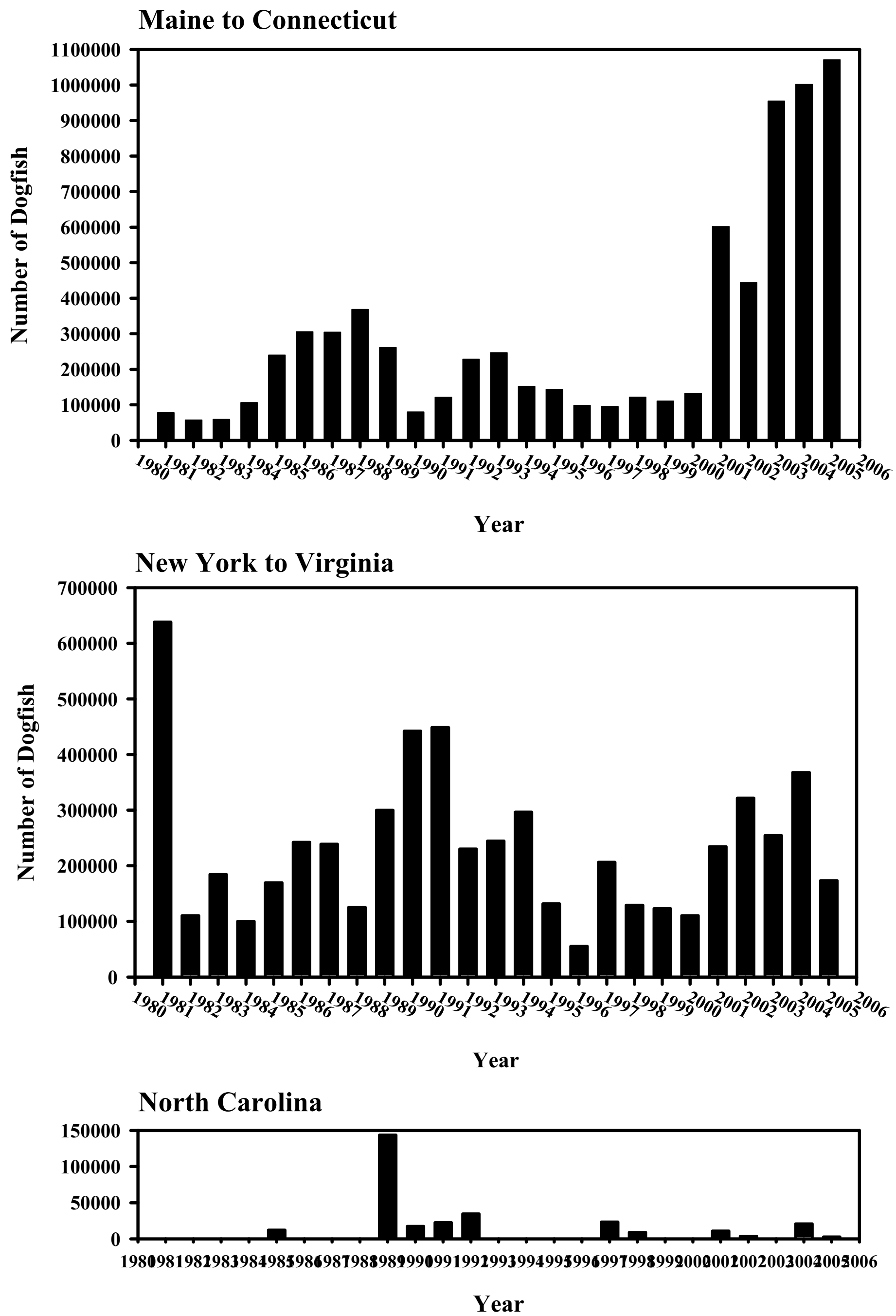


Figure B4.4. Estimated total recreational catch of spiny dogfish (numbers of fish) by geographical area, 1981-2005.

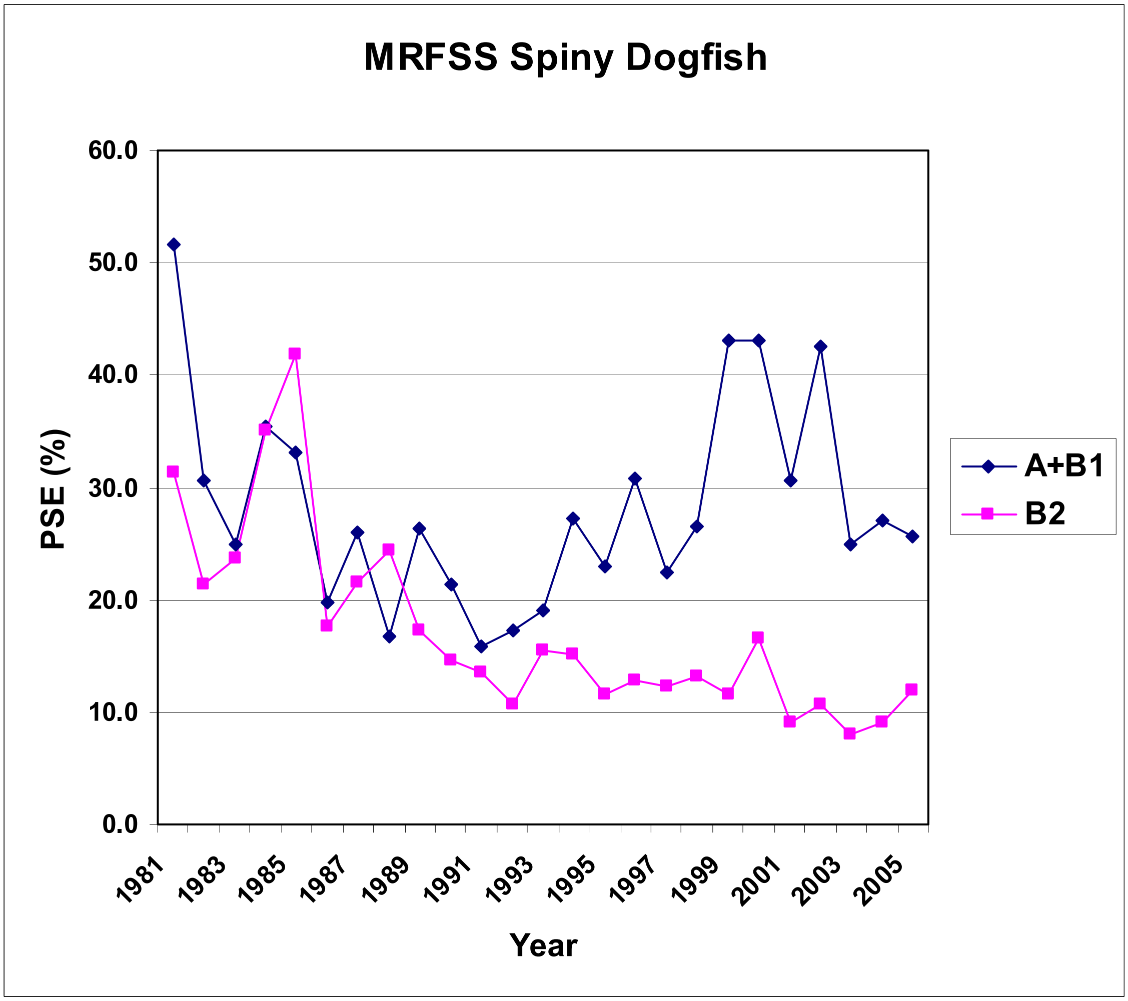


Fig. B4. 5. Estimate proportional standard errors (PSE) for spiny dogfish landings (A+B1) and discards (B2), 1981-2005, in Marine Recreational Fisheries Statistical Survey for Northeast US.

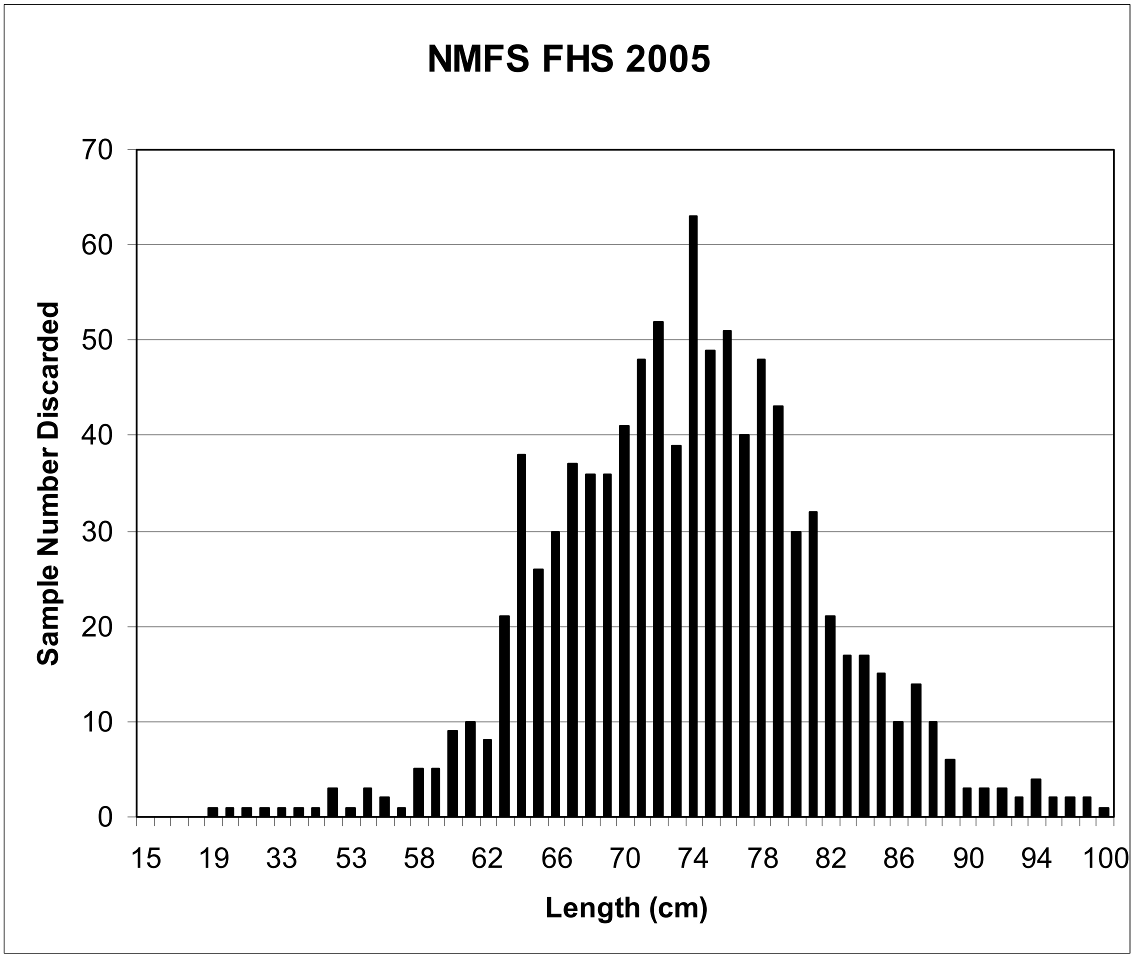
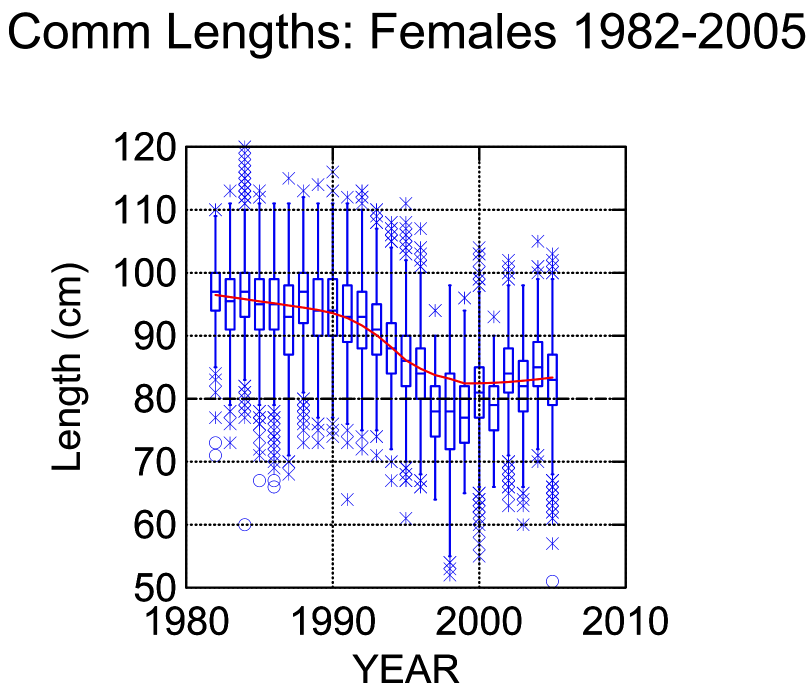


Fig. B4.6 Length frequency distribution of discarded spiny dogfish measured (n=946) during 2005 survey of recreational charter boat vessels.



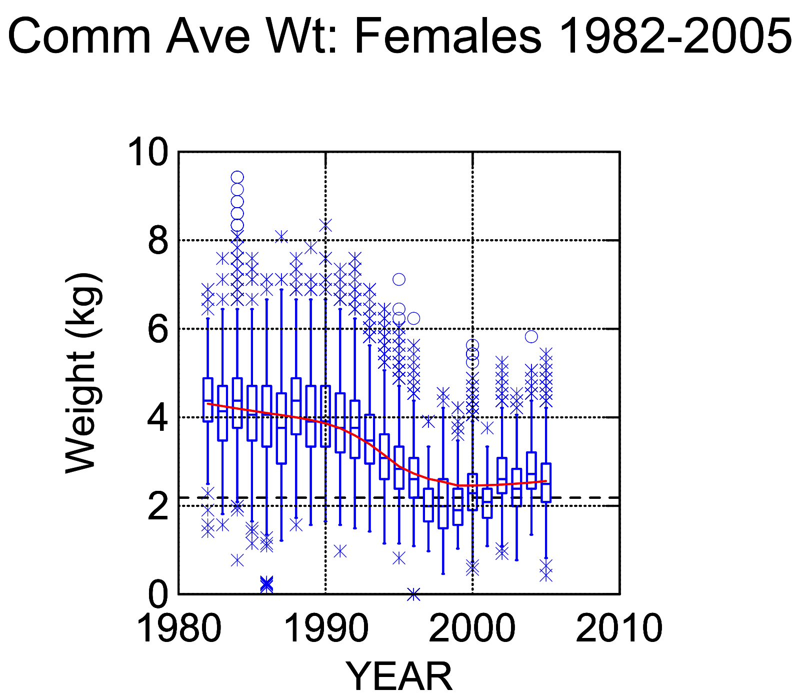


Fig. B4.7 Box plots of length (cm) and weight (kg) frequencies of female dogfish in commercial fishery samples.

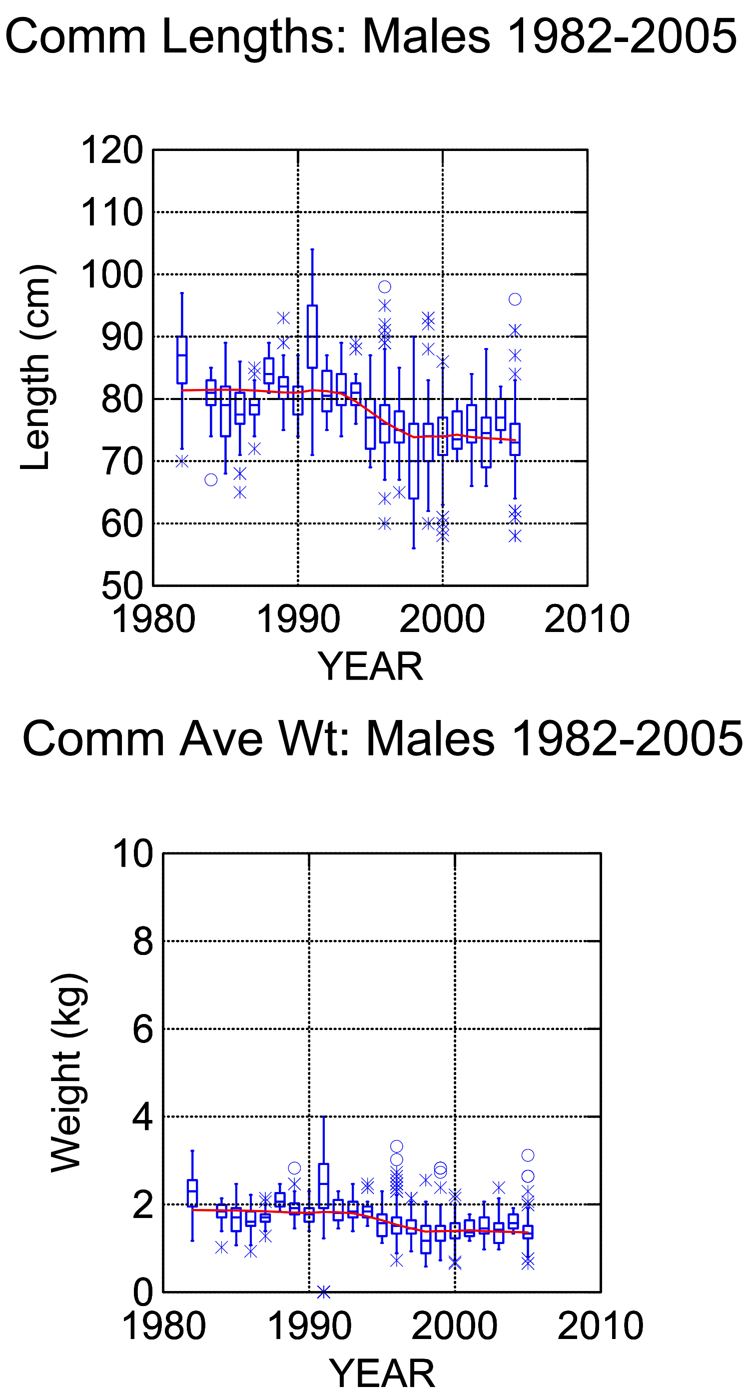
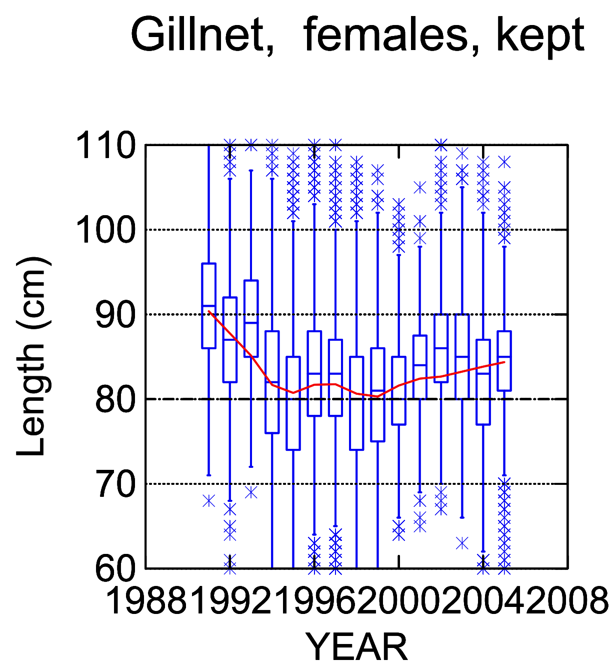


Fig. B4.8 Box plots of length (cm) and weight (kg) frequencies of male dogfish in commercial fishery samples.



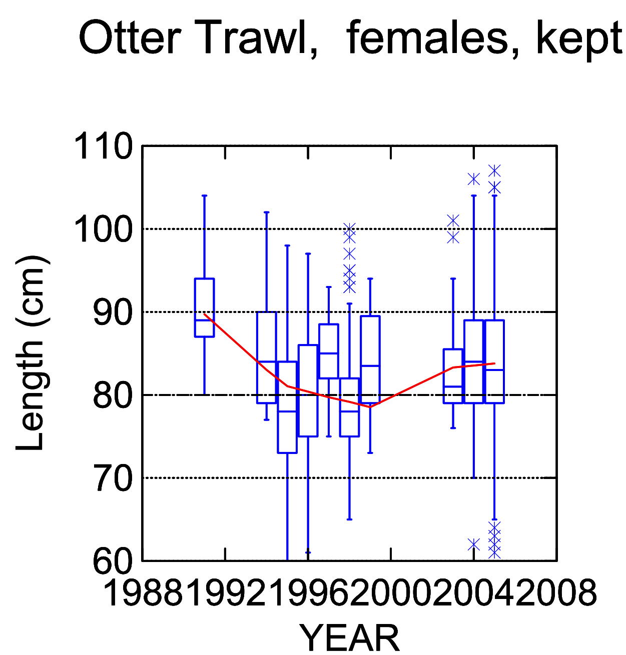


Fig.B4.9 Comparison of trends in size distribution of kept of female spiny dogfish by at-sea observers in gill nets (top) and otter trawl gear (bottom), 1989-2005. Lines represent lowess smoothes (tension=0.5) of composite annual size frequencies. Boxes represent medians and interquartile range of lengths.

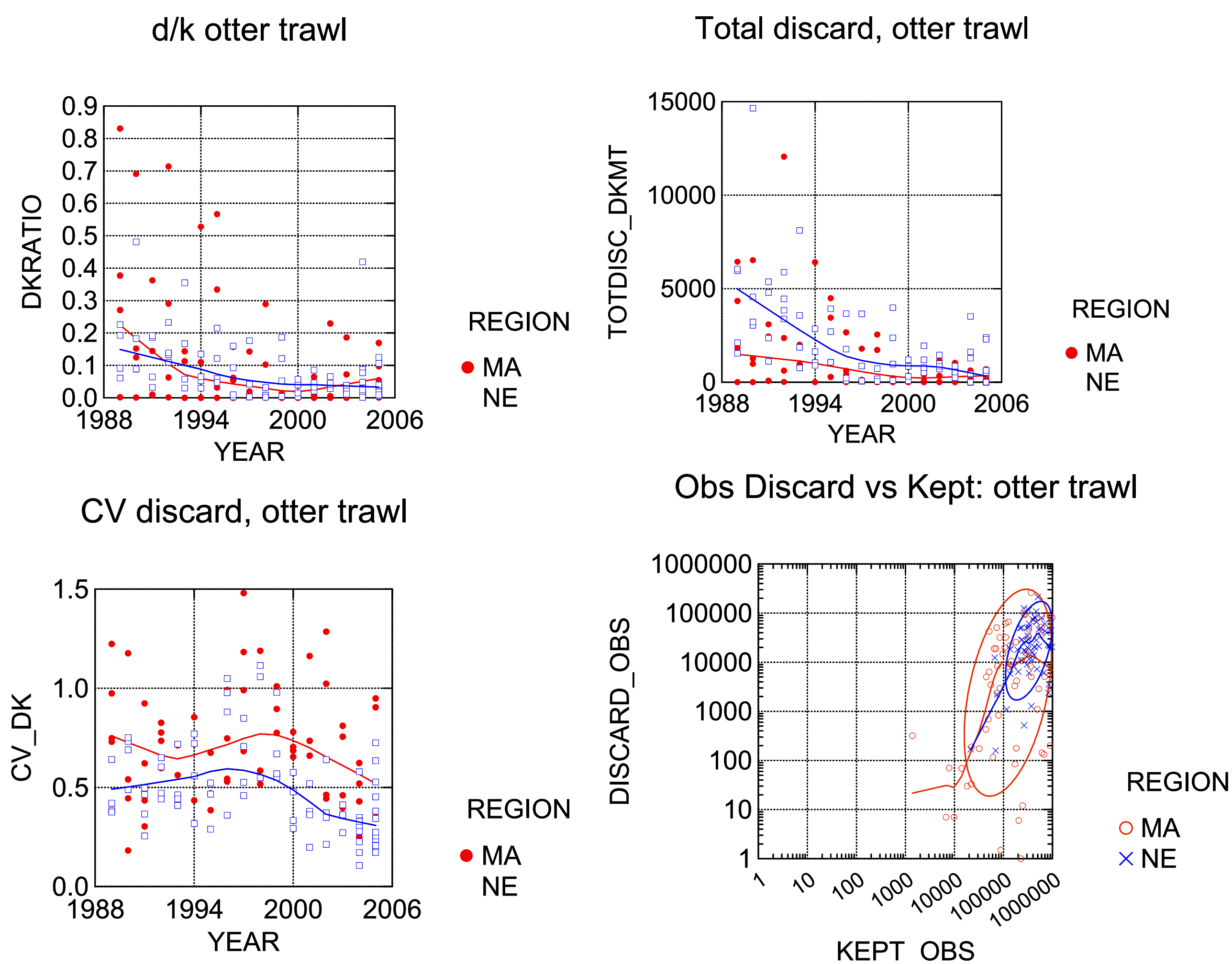


Fig. B4.10 Quarterly estimates of d/k ratios, total discards, coefficients of variation for spiny dogfish discards in otter trawl fisheries in the Mid Atlantic and New England, 1989-2005. The lower right panel depicts the association between dogfish discards discards and total weight of all kept species.

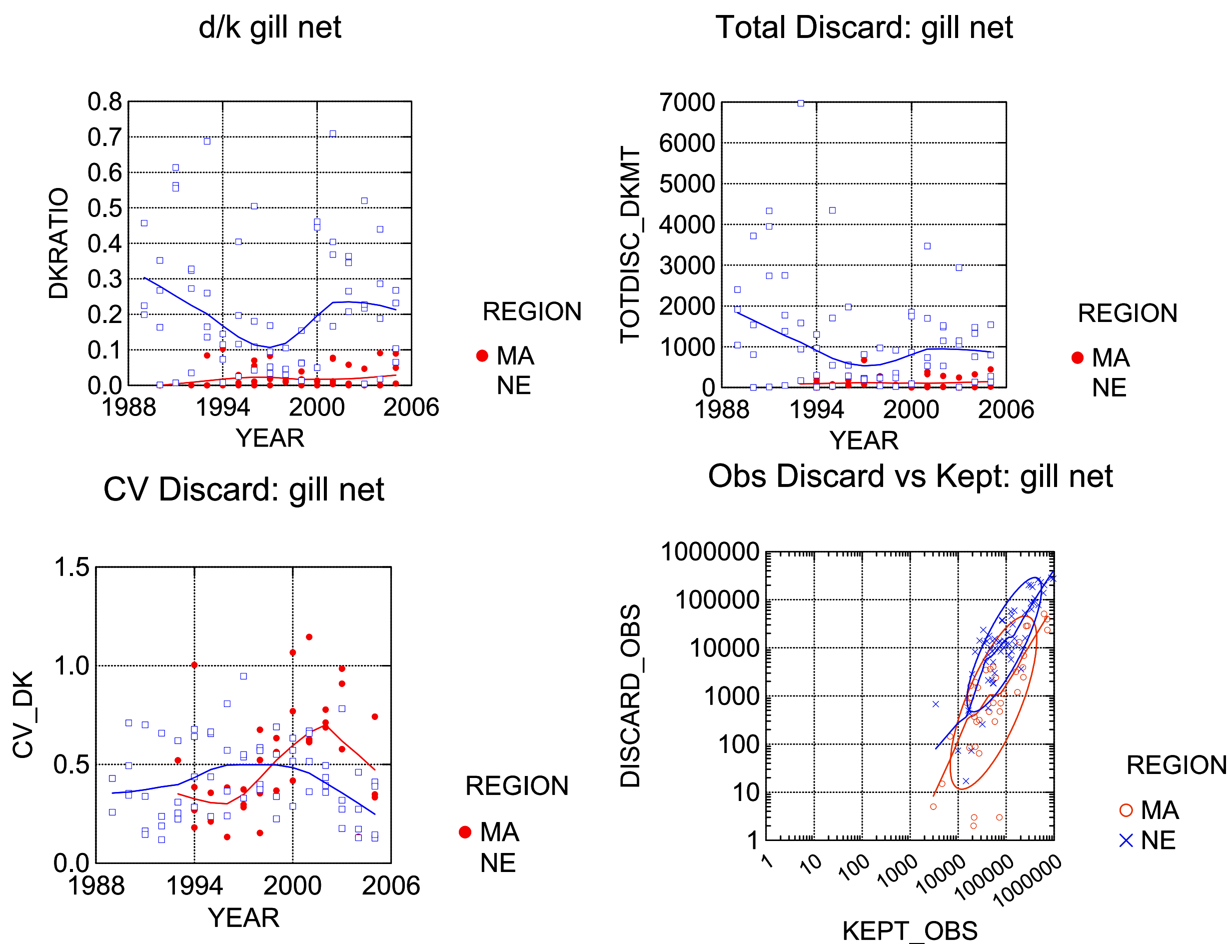


Fig. B4.11 Quarterly estimates of d/k ratios, total discards, coefficients of variation for spiny dogfish discards in gill net fisheries in the Mid Atlantic and New England, 1989-2005. The lower right panel depicts the association between dogfish discards discards and total weight of all kept species.

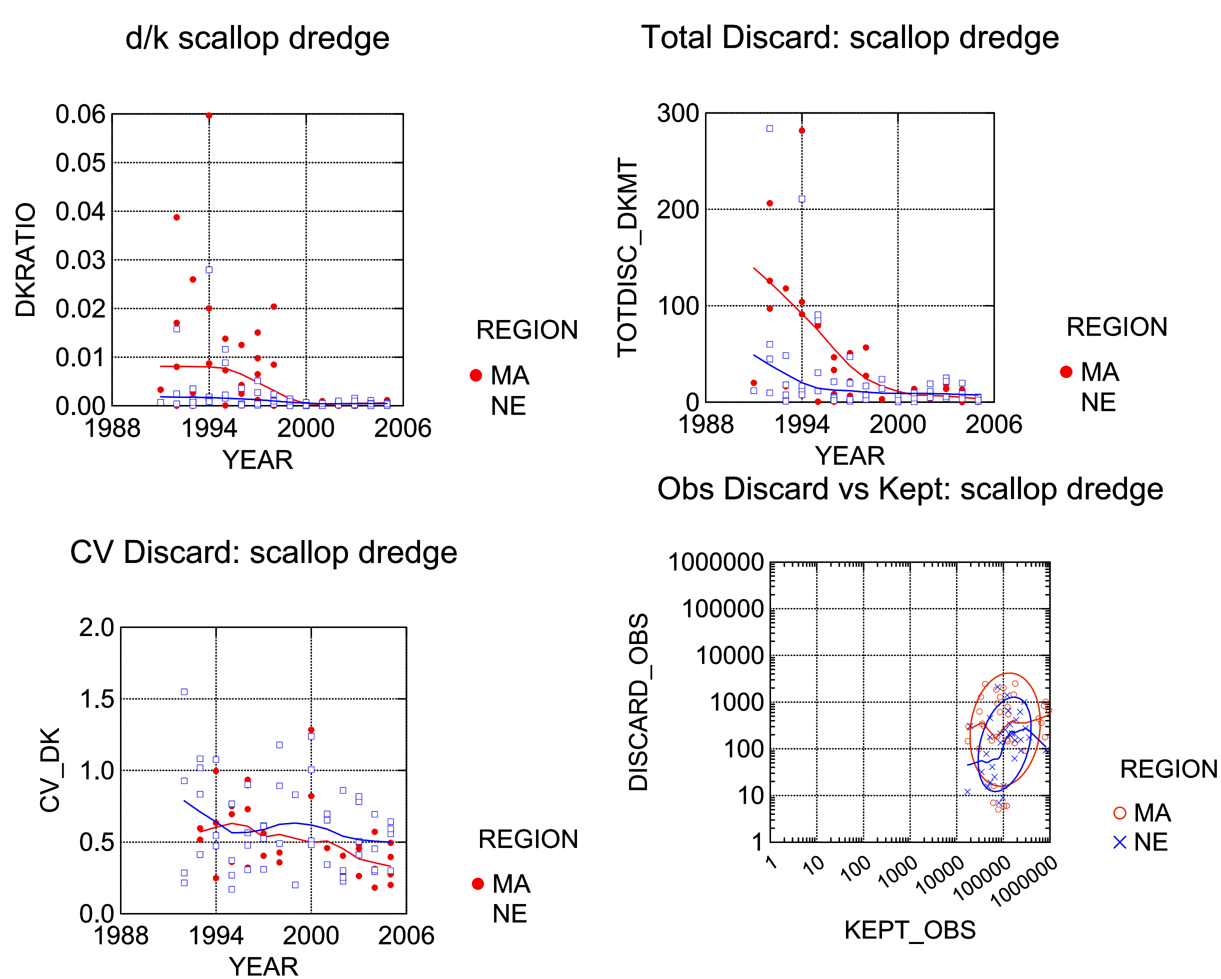
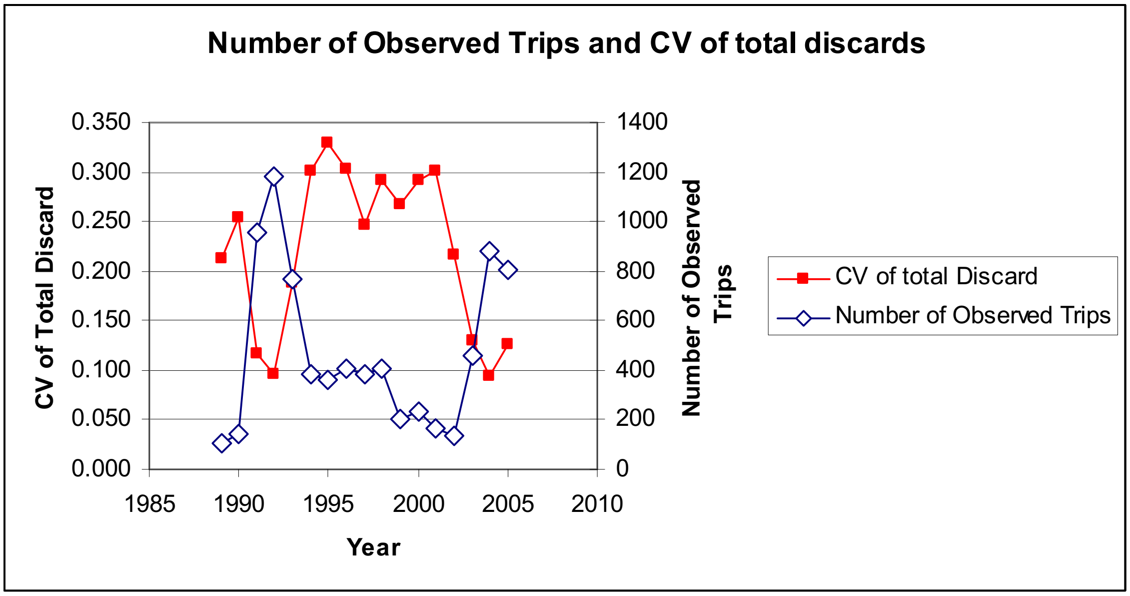


Fig. B4.12 Quarterly estimates of d/k ratios, total discards, coefficients of variation for spiny dogfish discards in scallop dredge fisheries in the Mid Atlantic and New England, 1989-2005. The lower right panel depicts the association between dogfish discards discards and total weight of all kept species.



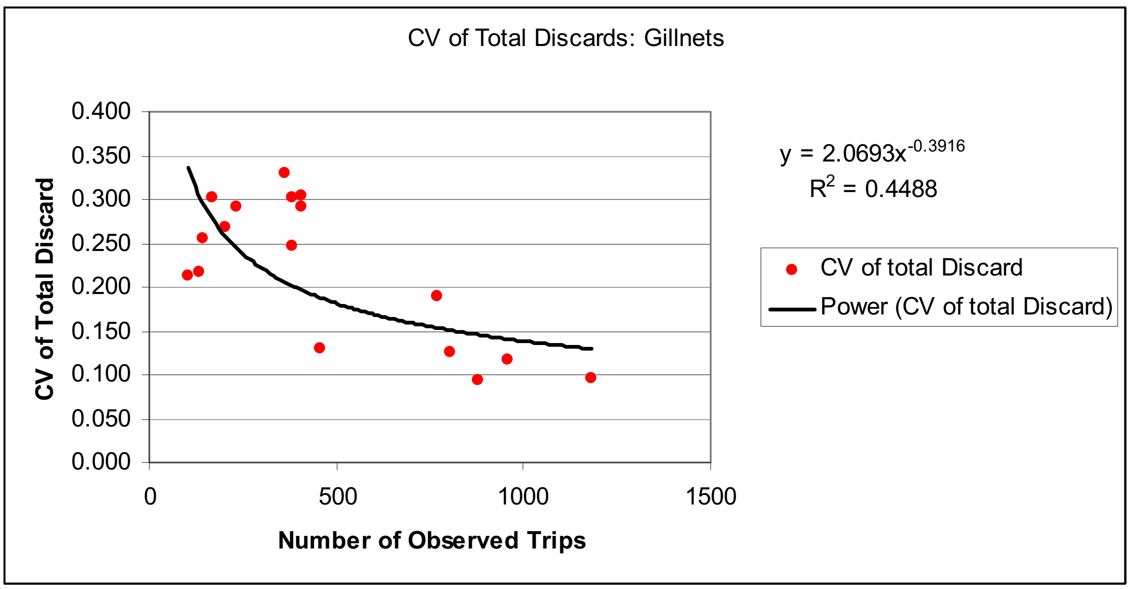
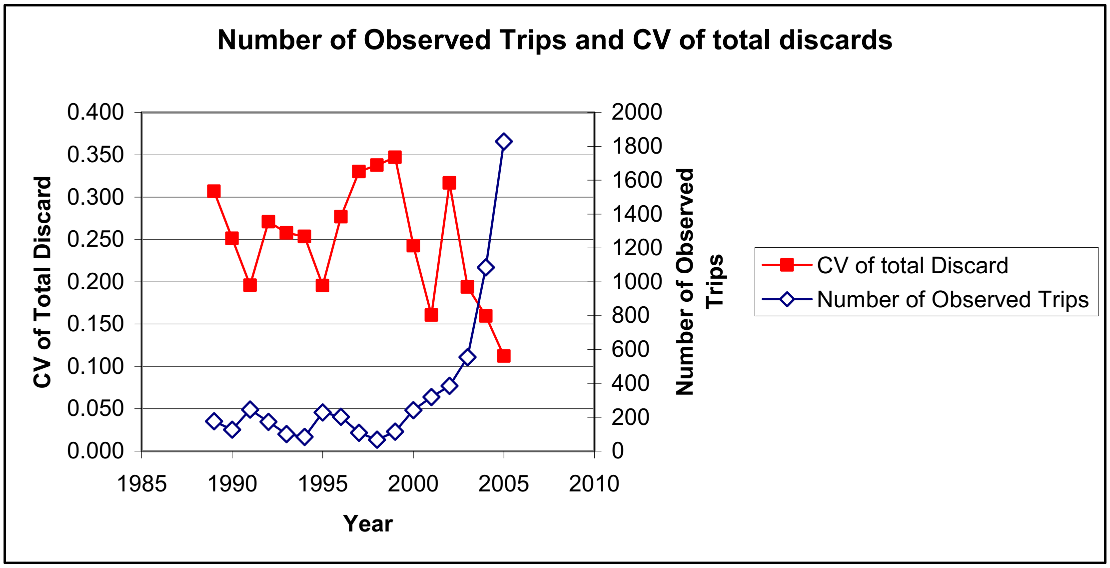


Fig. B4.13. Trends in relative precision of discard estimates for spiny dogfish discards in gill net fisheries (top) and the the effects of increased trips on coefficient of variation (bottom).



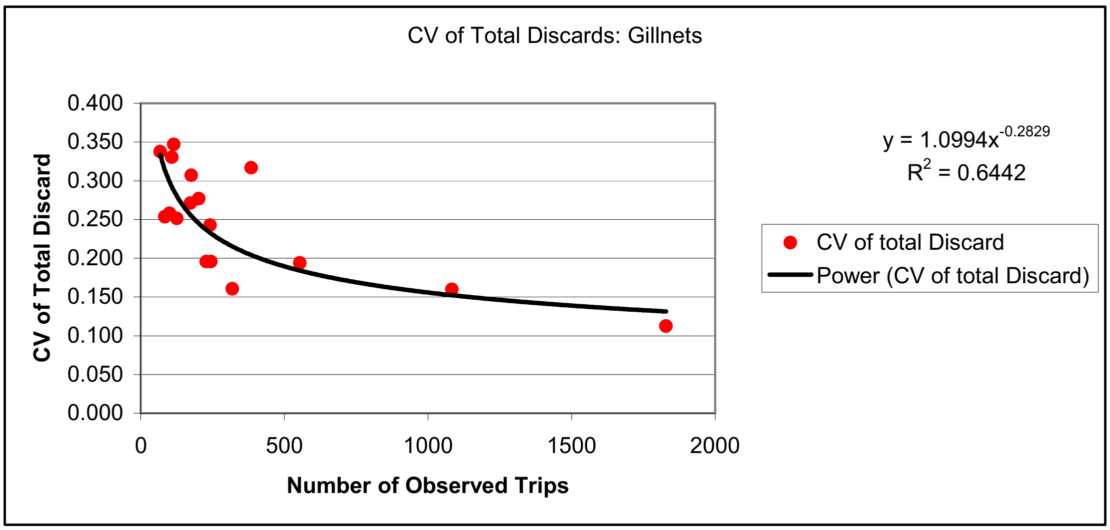
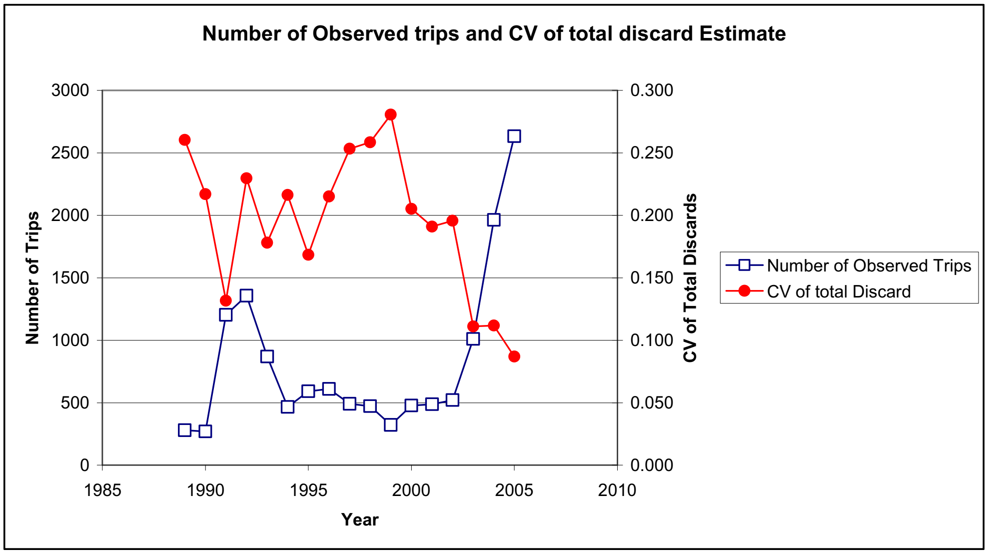


Fig. B4.14. Trends in relative precision of discard estimates for spiny dogfish discards in otter trawl fisheries (top) and the the effects of increased trips on coefficient of variation (bottom).



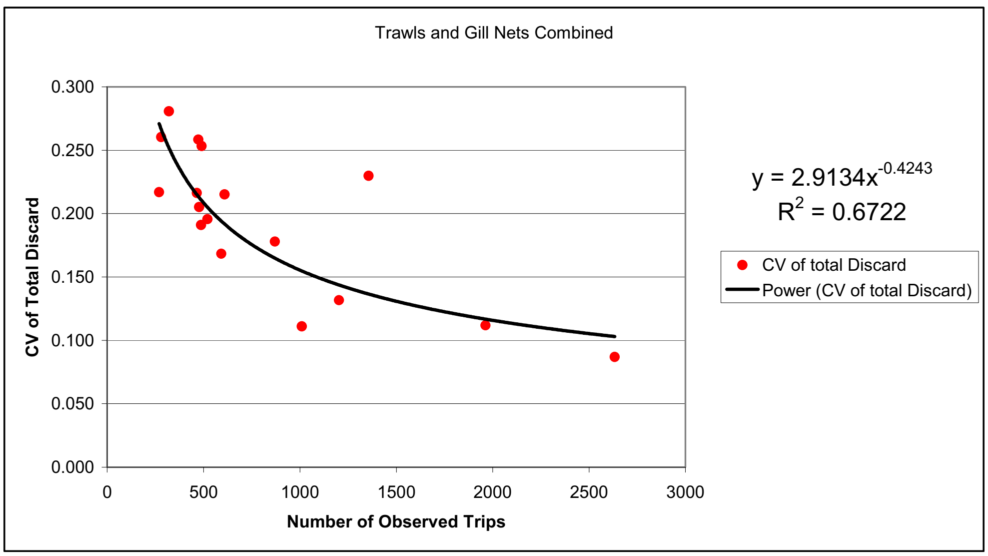


Fig. B4.15. Trends in relative precision of discard estimates for spiny dogfish discards in trawl and gill net fisheries combined (top) and the the effects of increased trips on coefficient of variation (bottom).

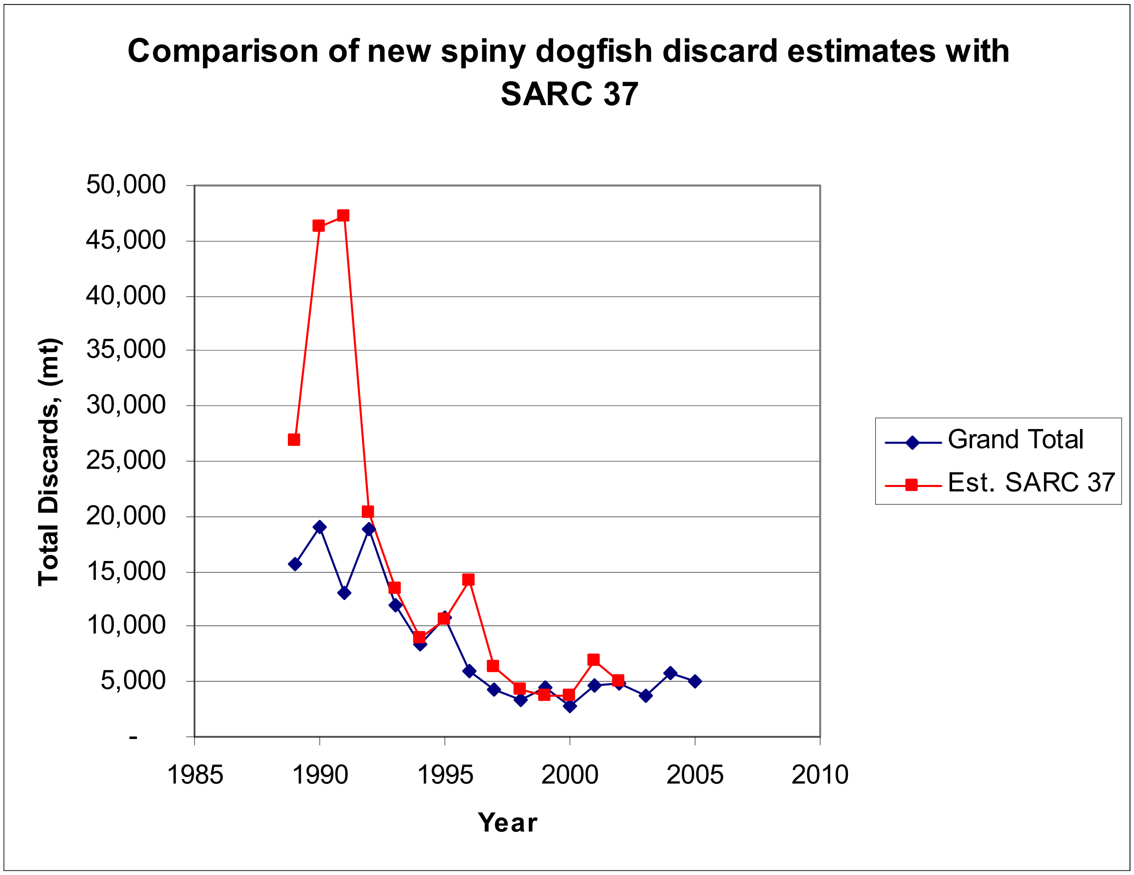
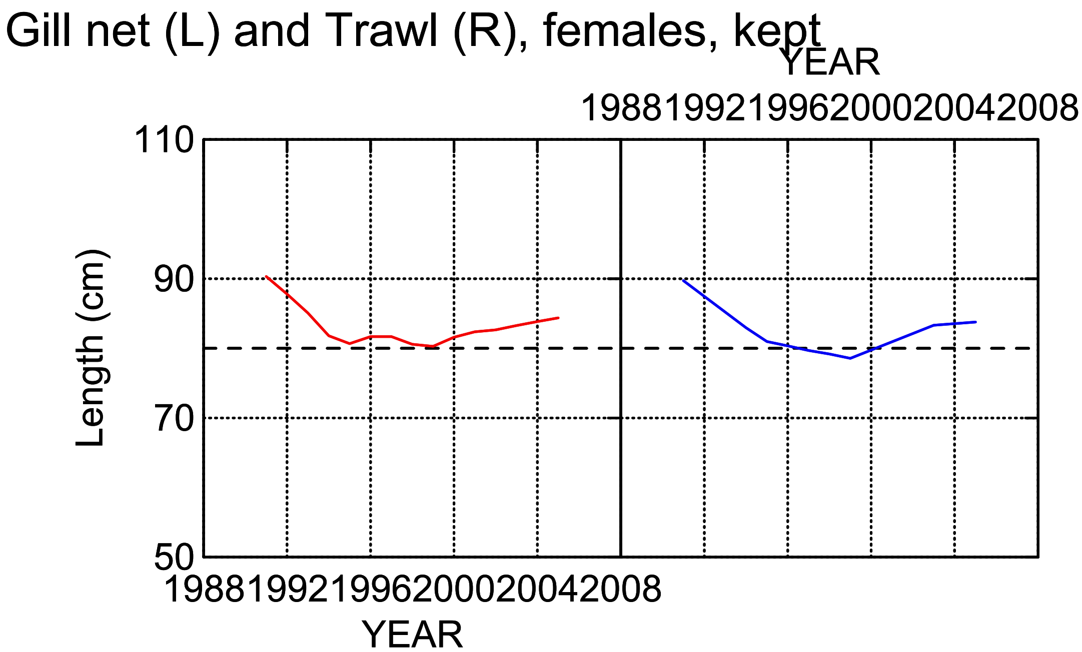


Fig. B4.16. Comparison of total discard estimates for spiny dogfish using the methodology developed in this report with estimates derived for SARC 37 in 2003.



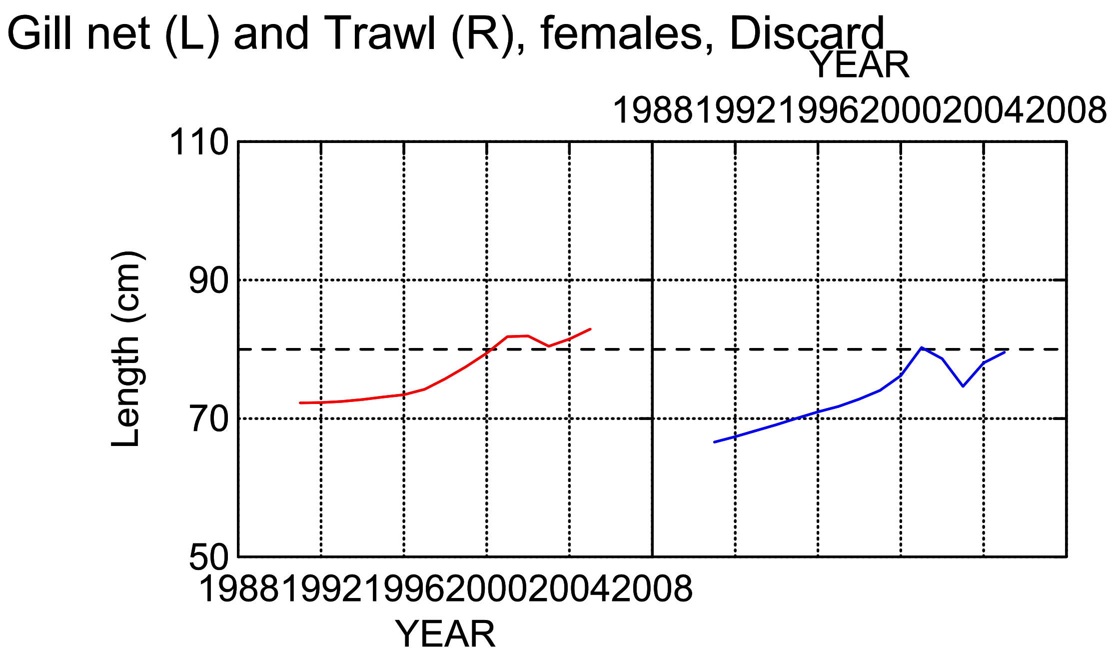
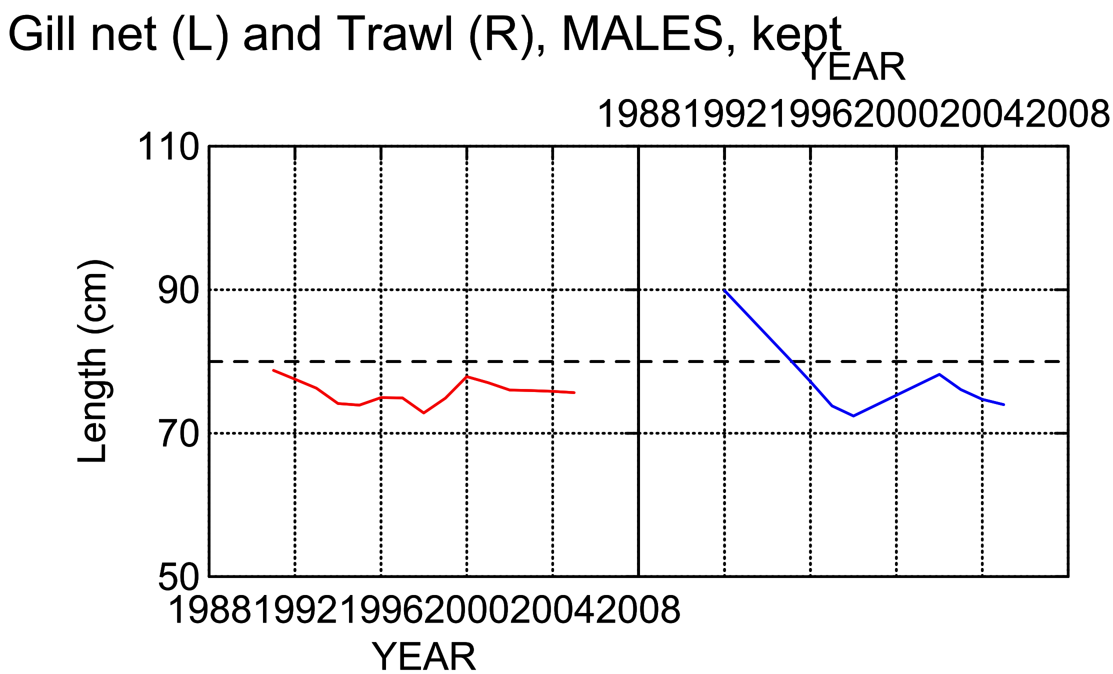


Fig.B4.17 Comparison of trends in discard and kept of female spiny dogfish by at-sea observers in gill nets (left) and otter trawl gear, 1989-2005. Lines represent lowess smoothes of composite annual size frequencies.



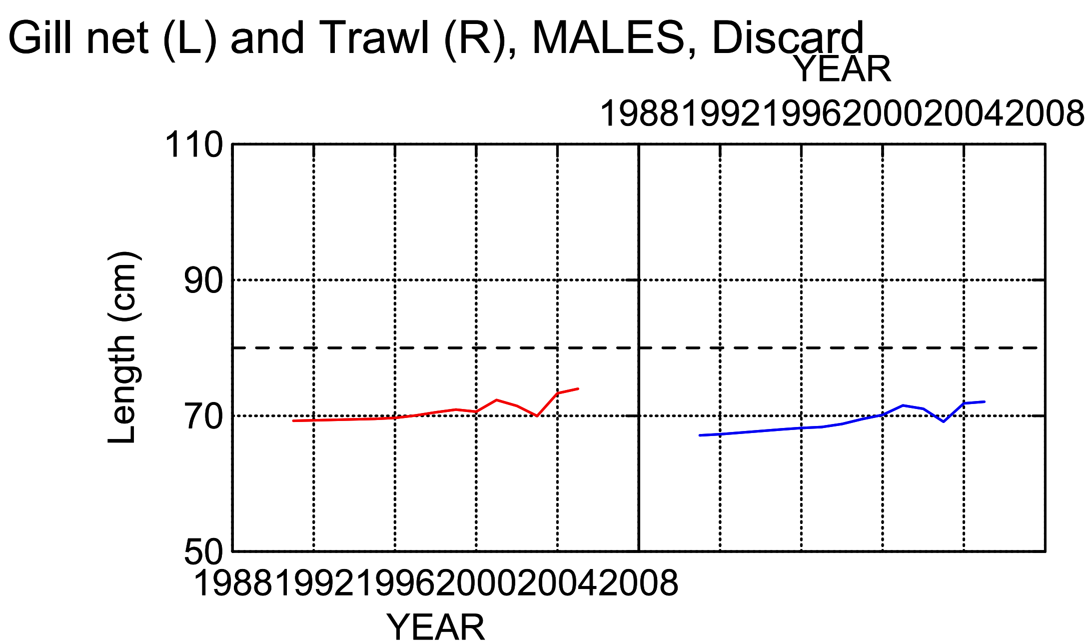


Fig. B4.18. Comparison of trends in discard and kept of MALE spiny dogfish by at-sea observers in gill nets (left) and otter trawl gear, 1989-2005. Lines represent lowess smoothes of composite annual size frequencies.

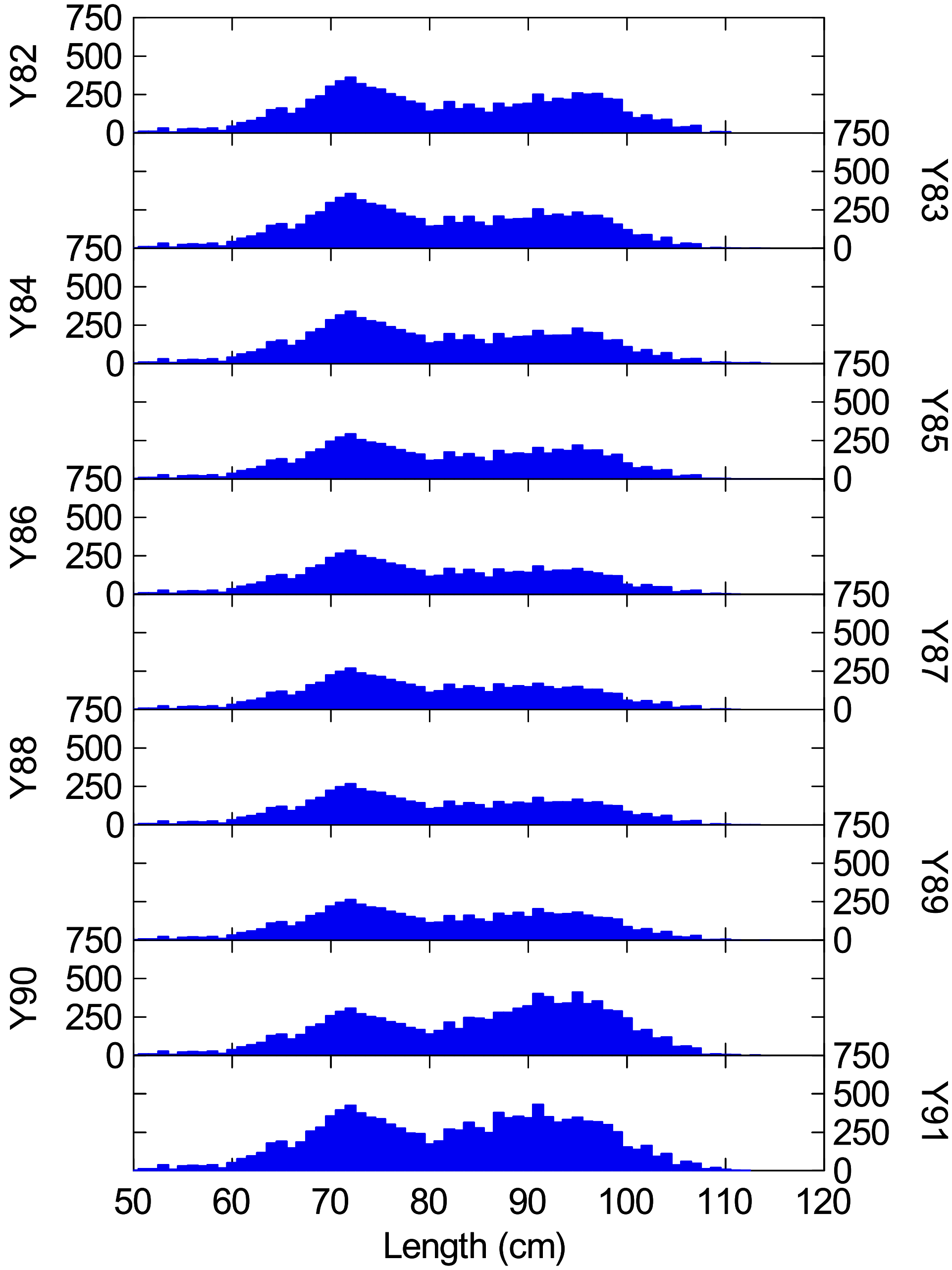


Fig. B4.19. Size frequency distribution of female spiny dogfish landed or assumed to be dead discard in gill net, otter trawl, and recreational fisheries, 1982-1991.

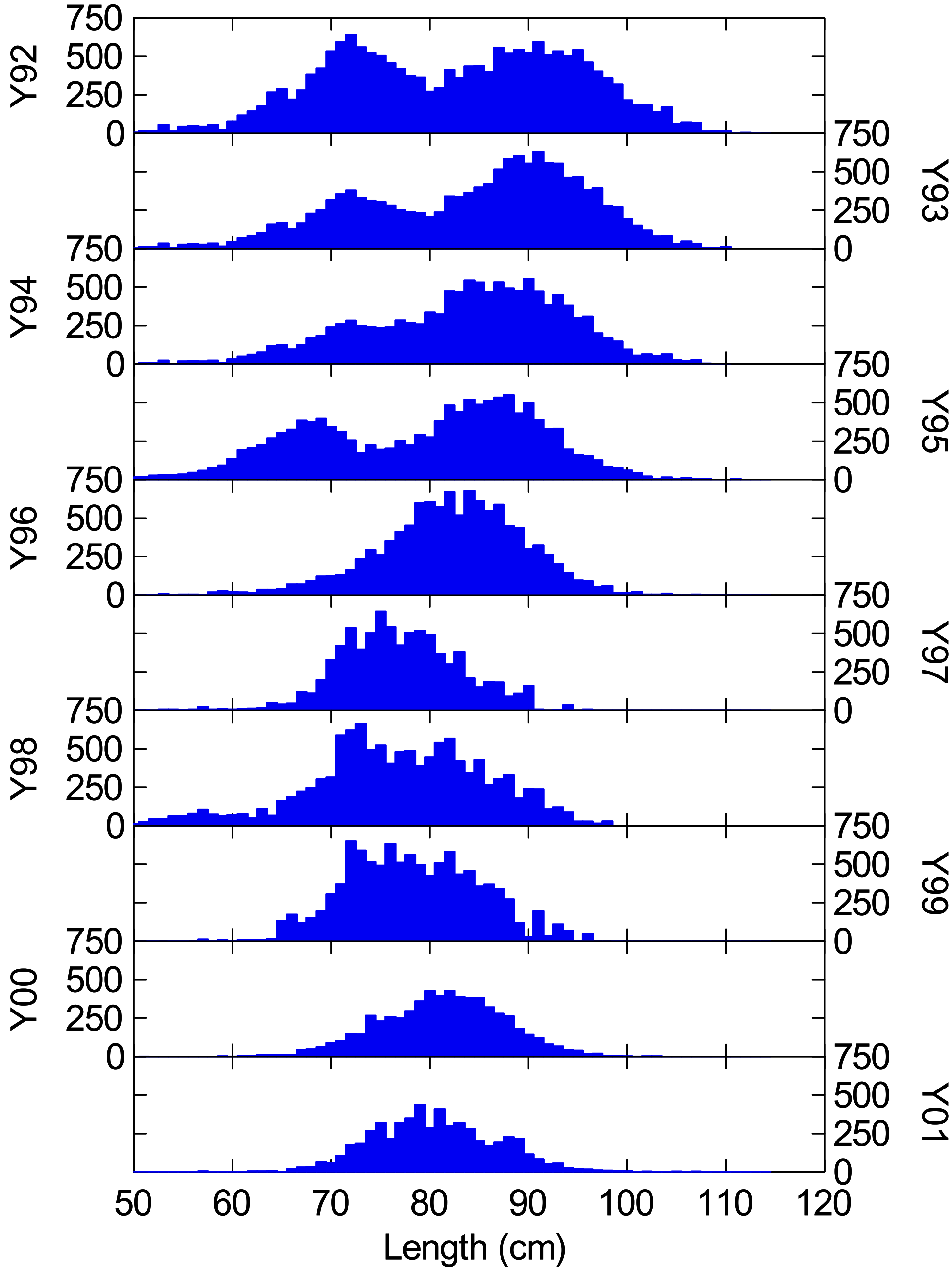


Fig. B4.20. Size frequency distribution of female spiny dogfish landed or assumed to be dead discard in gill net, otter trawl, and recreational fisheries, 1992-2001.

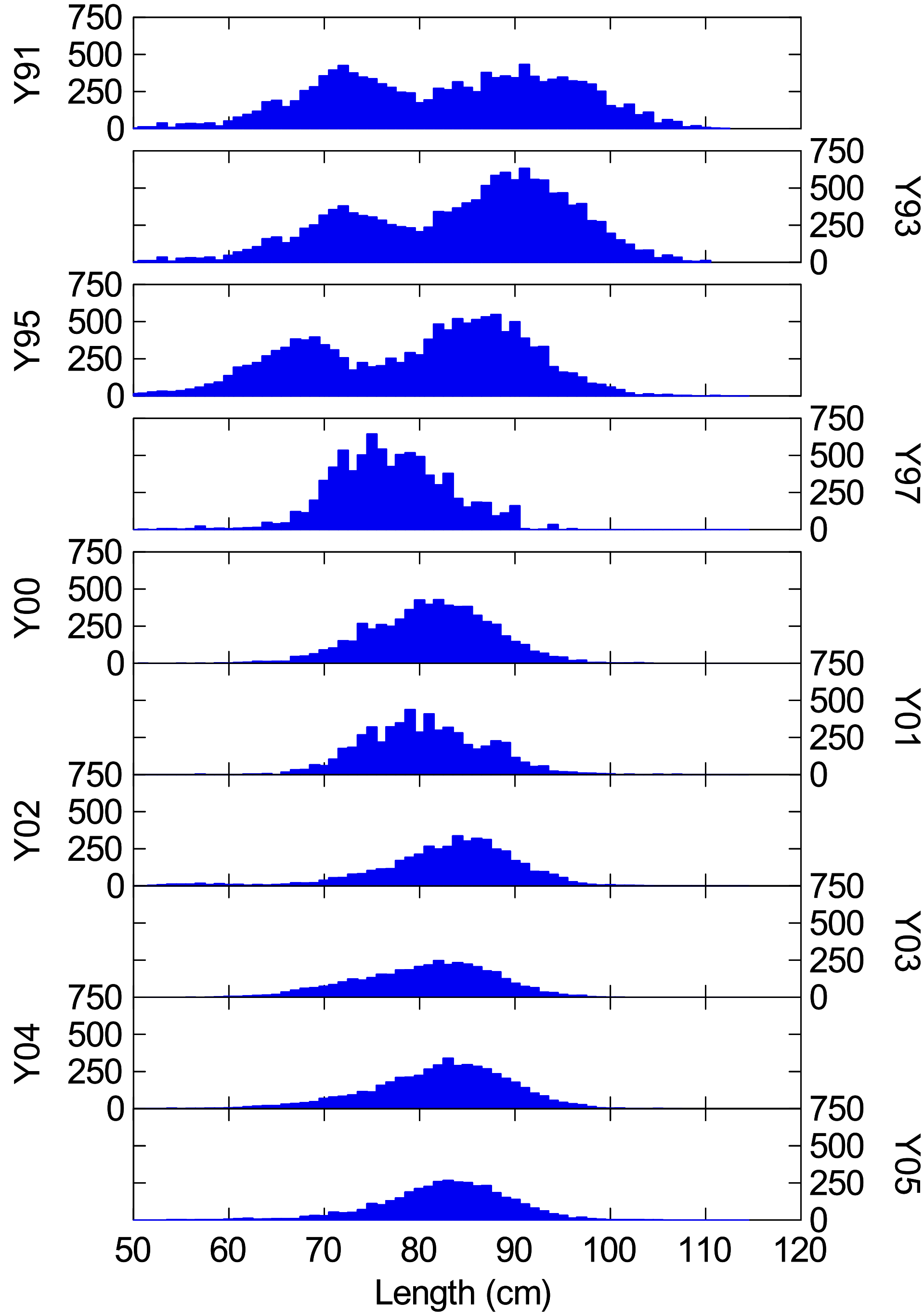


Fig. B4.21. Size frequency distribution of female spiny dogfish landed or assumed to be dead discard in gill net, otter trawl, and recreational fisheries, 1991, 1993, 1995, 1997, 2000-2005.

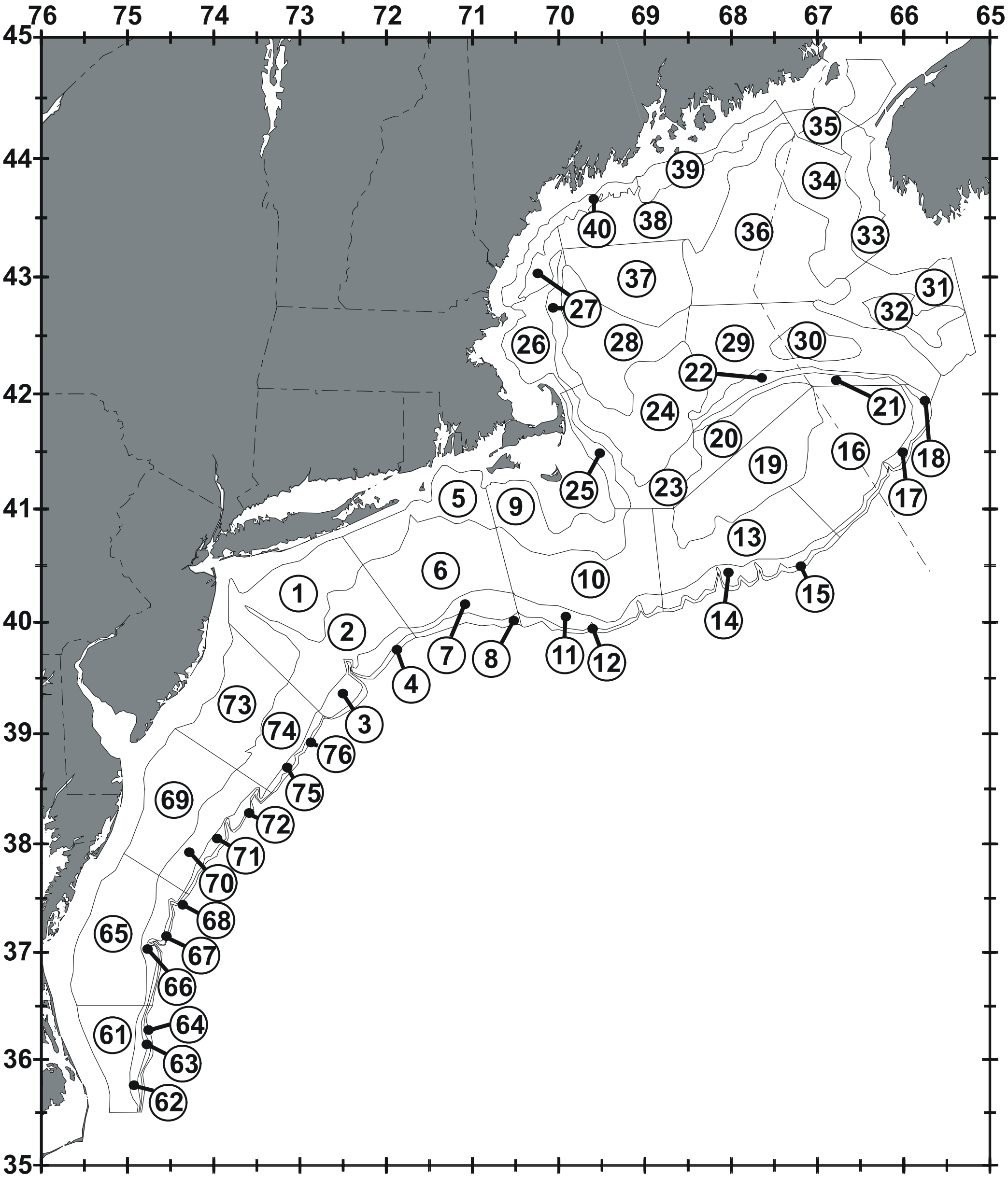


Fig. B5.1. Offshore Sampling strata for NMFS research trawl finfish surveys.

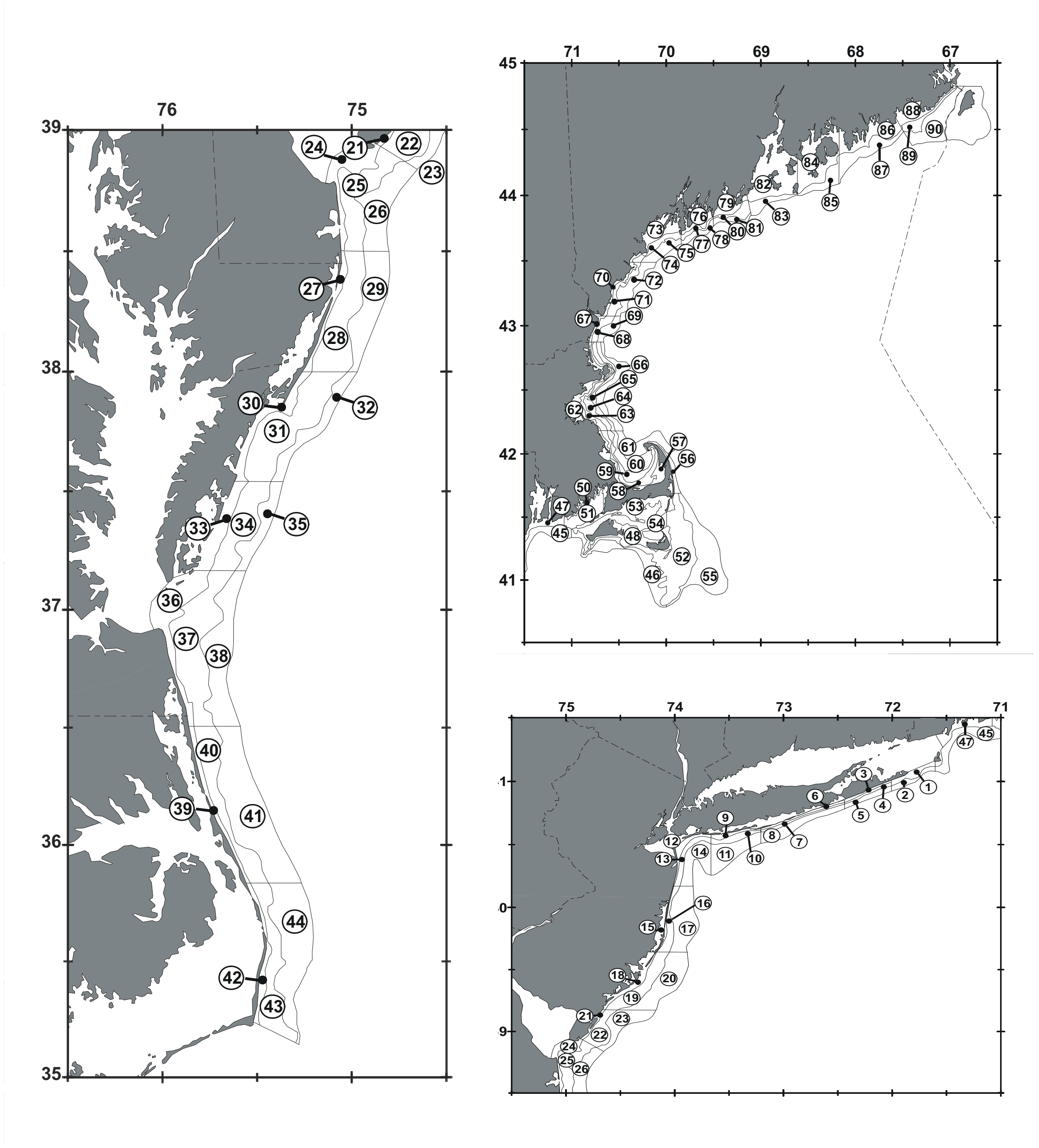


Fig. B5.2. Inshore strata used in NEFSC R/V trawl surveys.

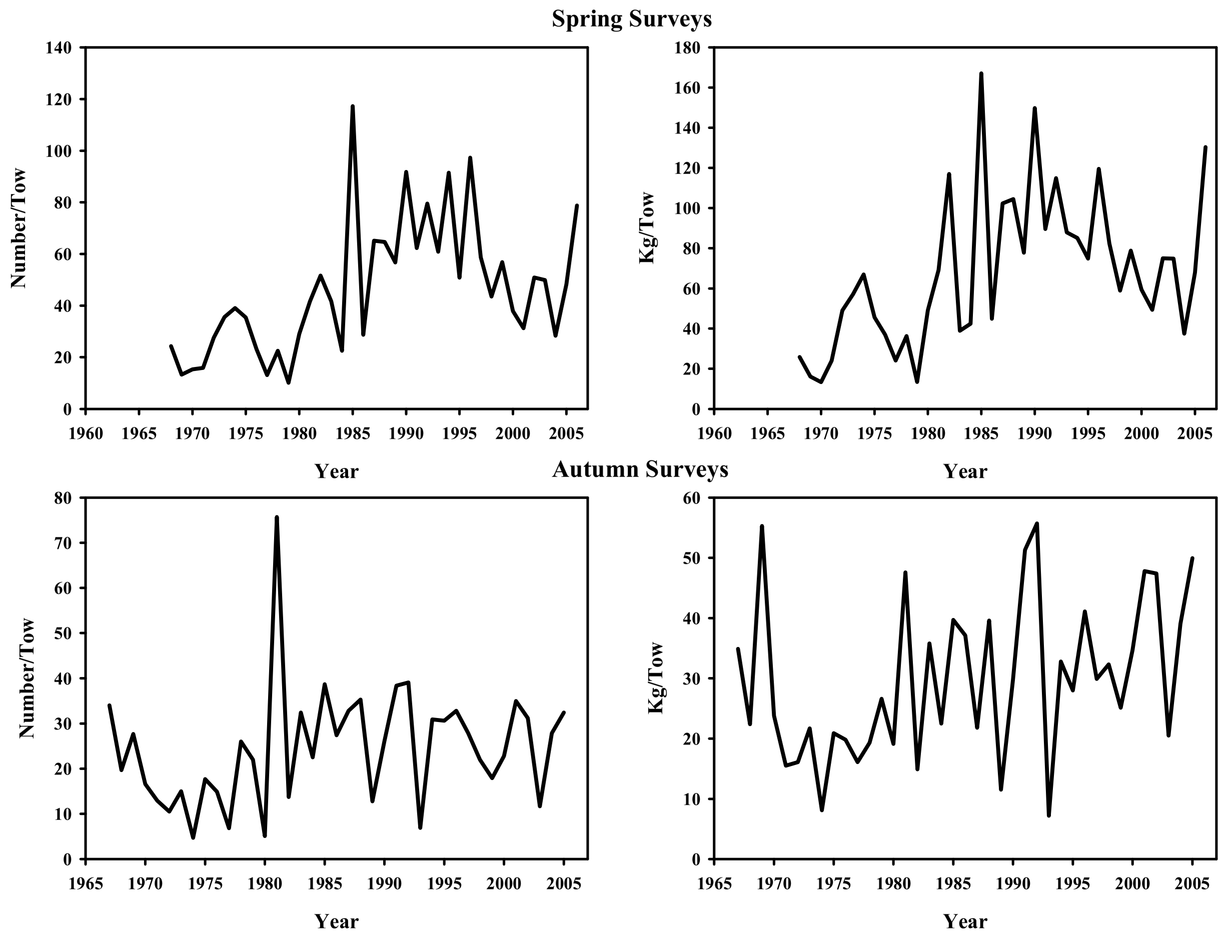


Figure B5.3 Abundance (stratified mean catch per tow in numbers) and biomass (stratified mean catch per tow in kilograms) indices of spiny dogfish from the NEFSC spring survey, 1968-2006, and autumn survey, 1967-2005 (Offshore strata 1-30, 33-40, 61-76).

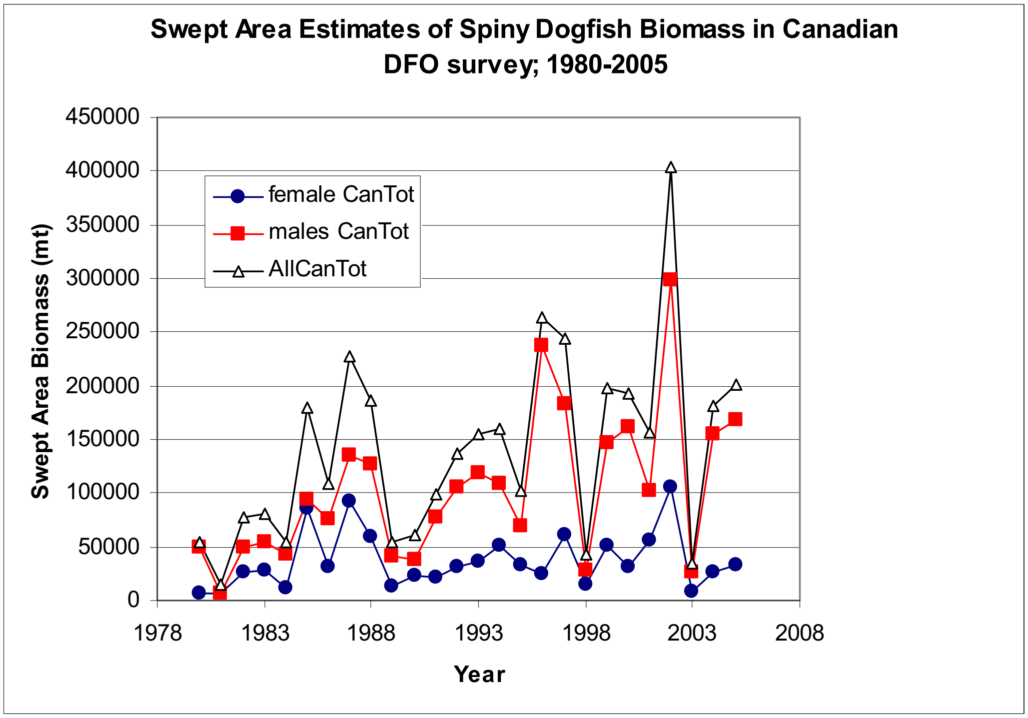
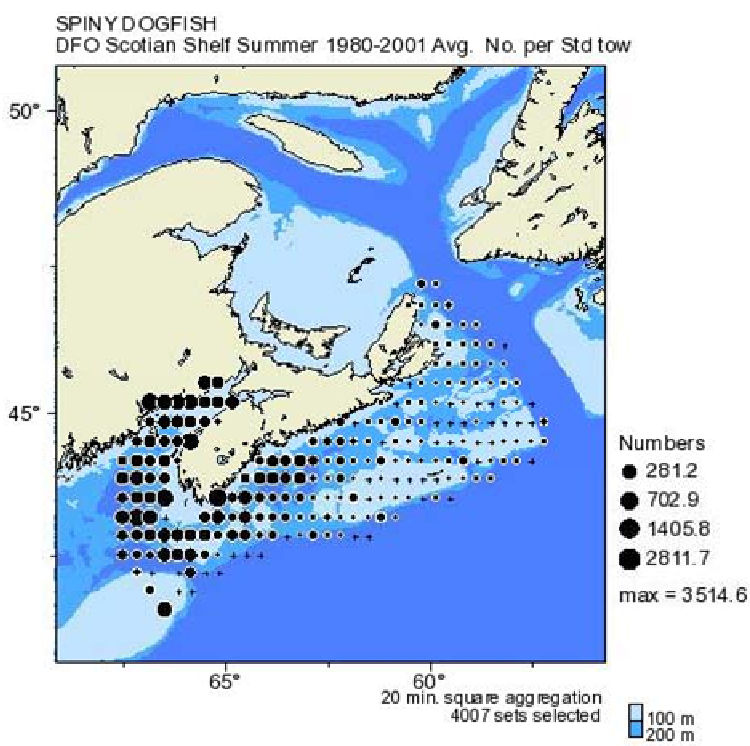


Fig B5.4 Summary of DFO Canadian R/V trawl survey swept area survey estimates (mt), 1980-2005 for males, females and total. Map data express average densities per standard tow, binned at a 20 minute square aggregation. Survey estimates provide courtesy of Bette Hatt and Stratis Gavaris, DFO.



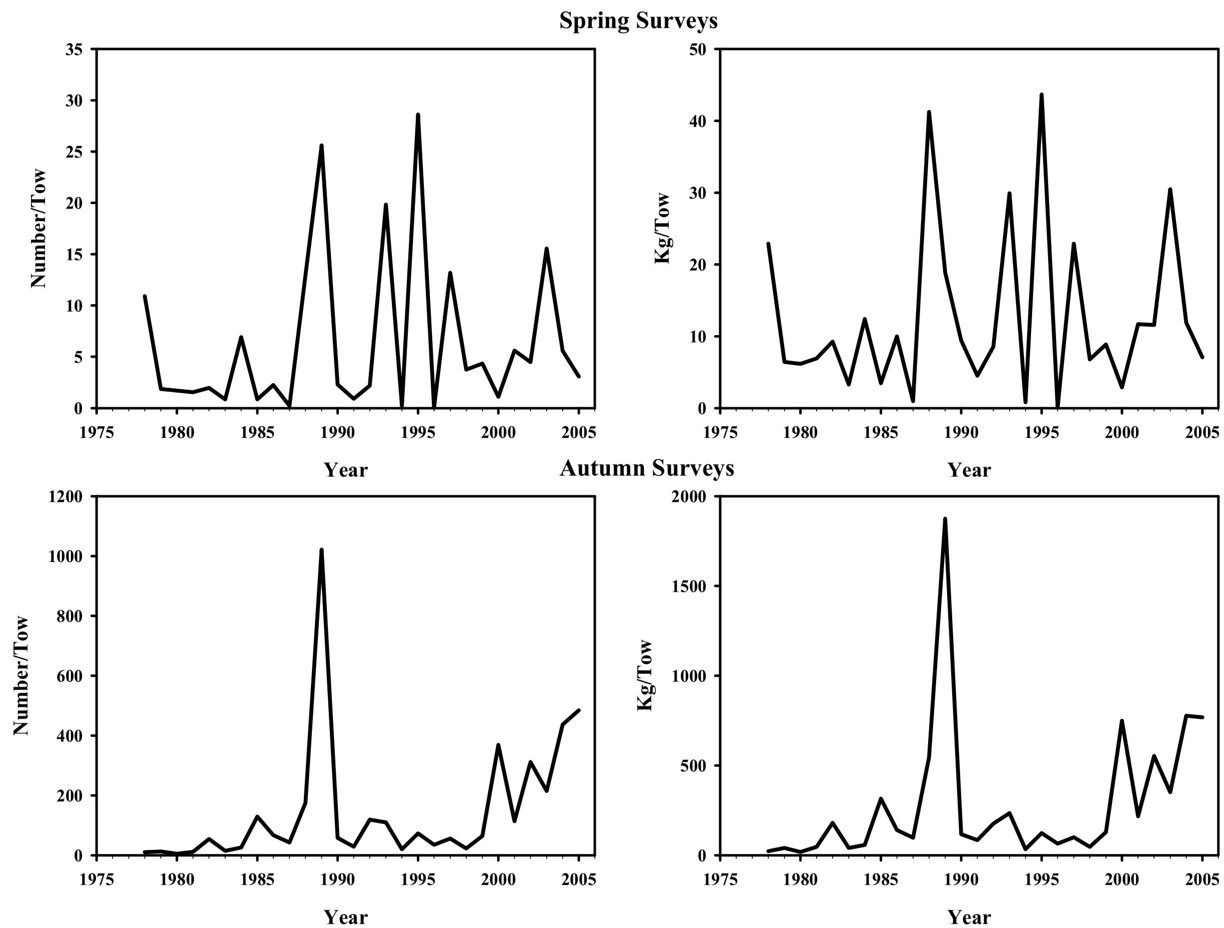


Figure B5.5. Abundance (stratified mean catch per tow in numbers) and biomass (stratified mean catch per tow in kilograms) indices of spiny dogfish from the Massachusetts spring and autumn surveys, 1978-2005.

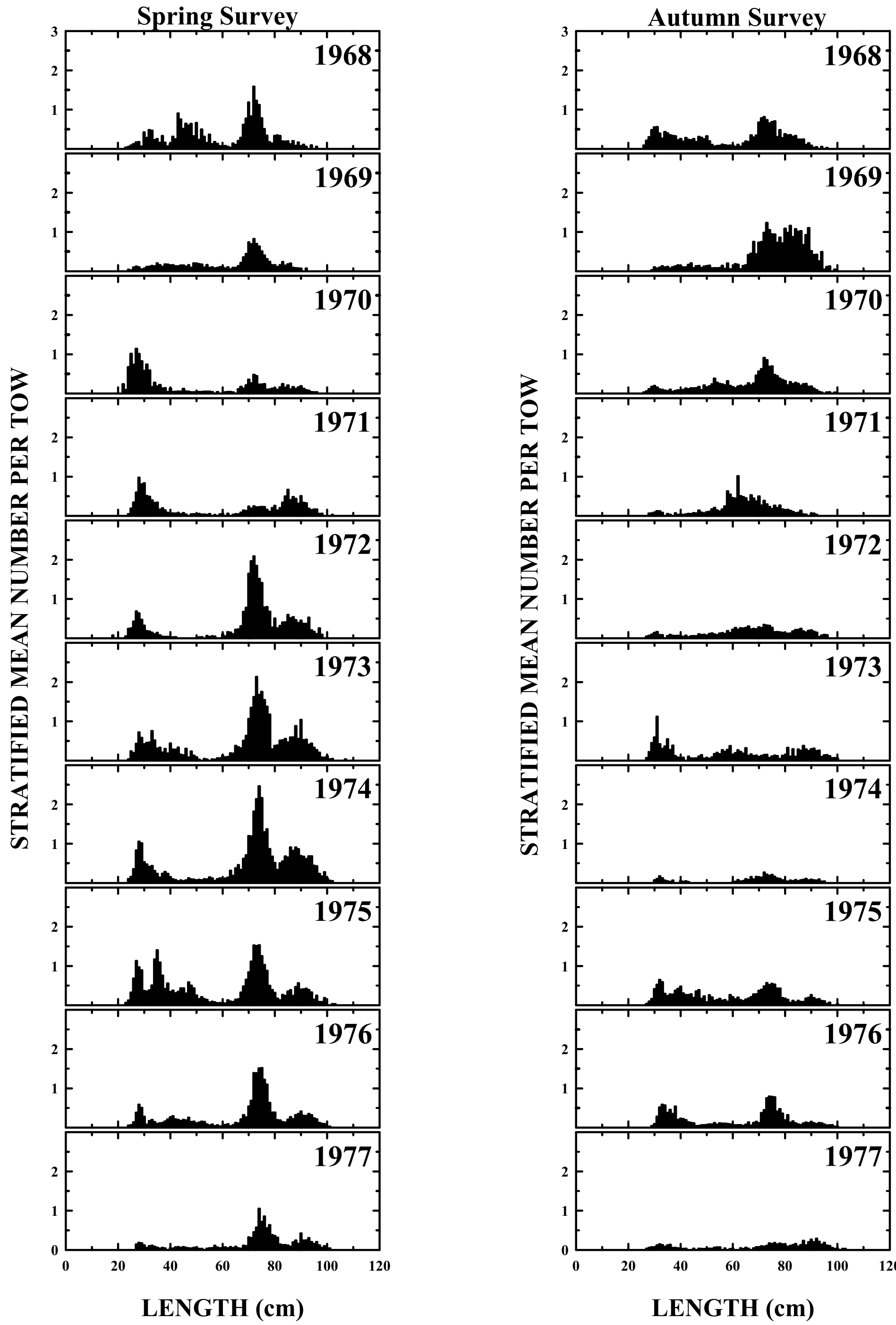


Figure B5.6a. Length composition of spiny dogfish from the NEFSC spring and autumn bottom trawl surveys, 1968-1977 (Offshore strata 1-30, 33-40, 61-76).

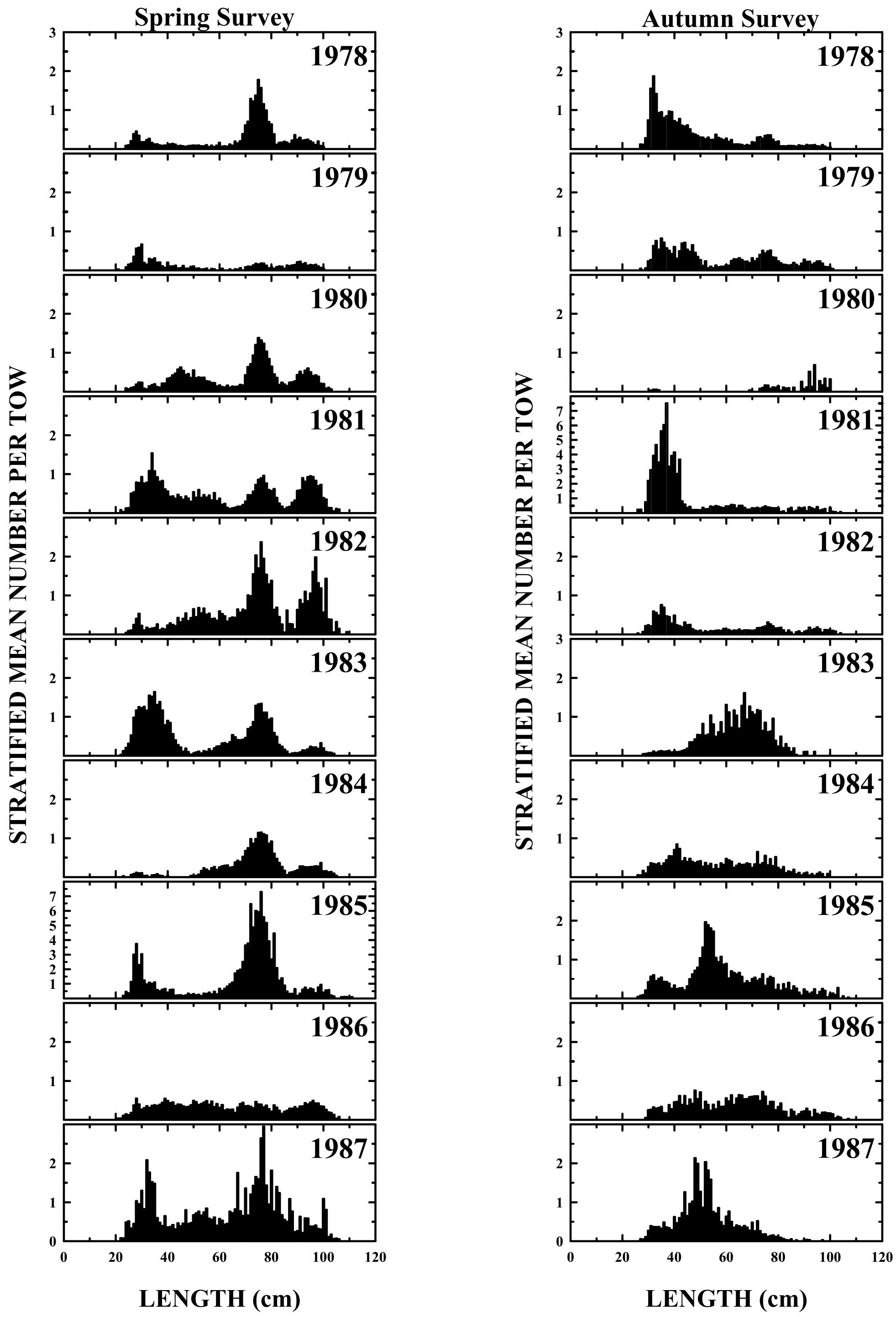


Fig. B5.6b. Length composition of spiny dogfish from the NEFSC spring and autumn bottom trawl surveys, 1978-1987 (Offshore strata 1-30, 33-40, 61-76). Note the scale for spring 1985 and autumn 1981 are higher.

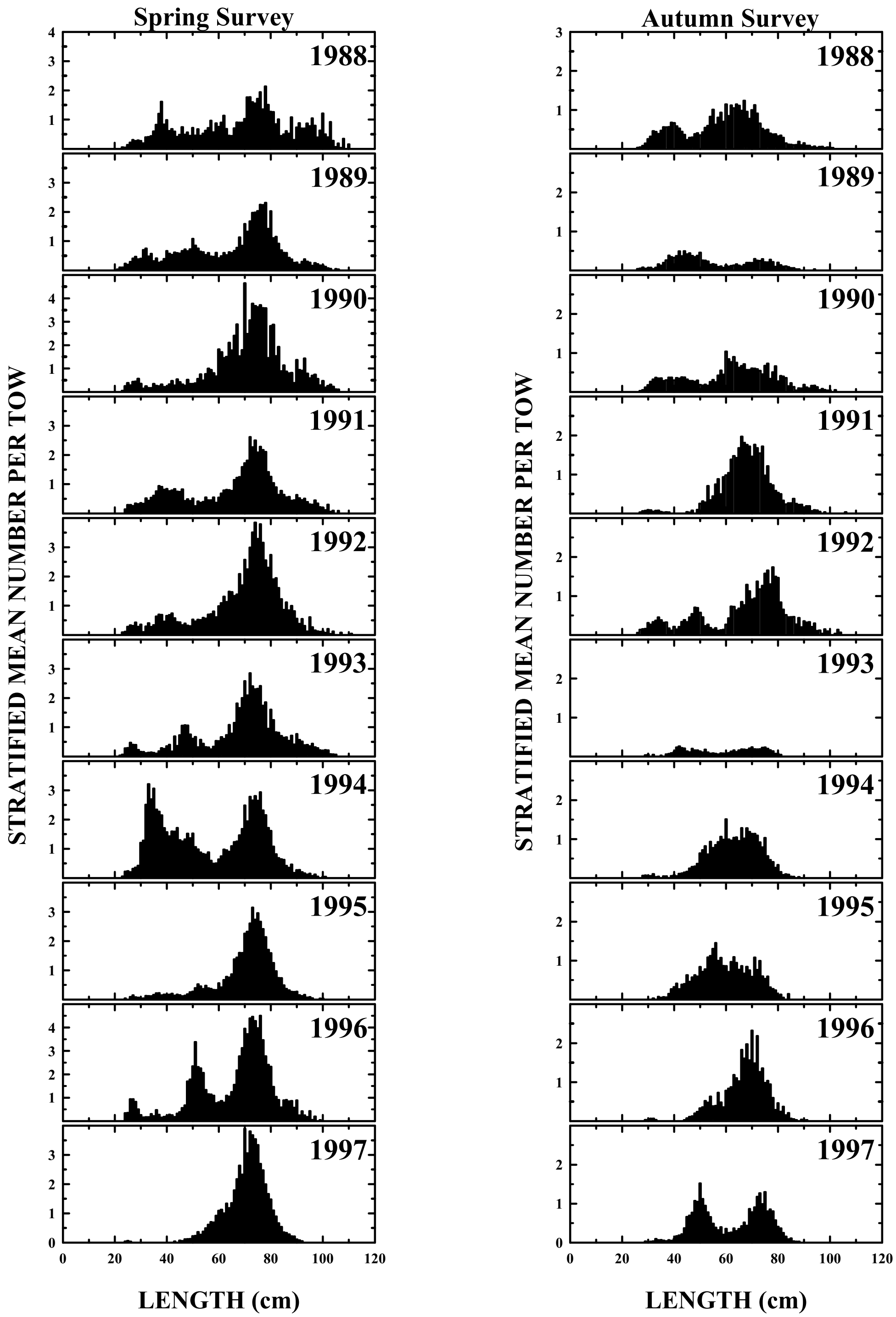


Fig. B5.6c. Length composition of spiny dogfish from the NEFSC spring and autumn bottom trawl surveys, 1988-1997 (Offshore strata 1-30, 33-40, 61-76). Note the scale for spring and autumn differ and spring 1990 and 1996 are also higher.

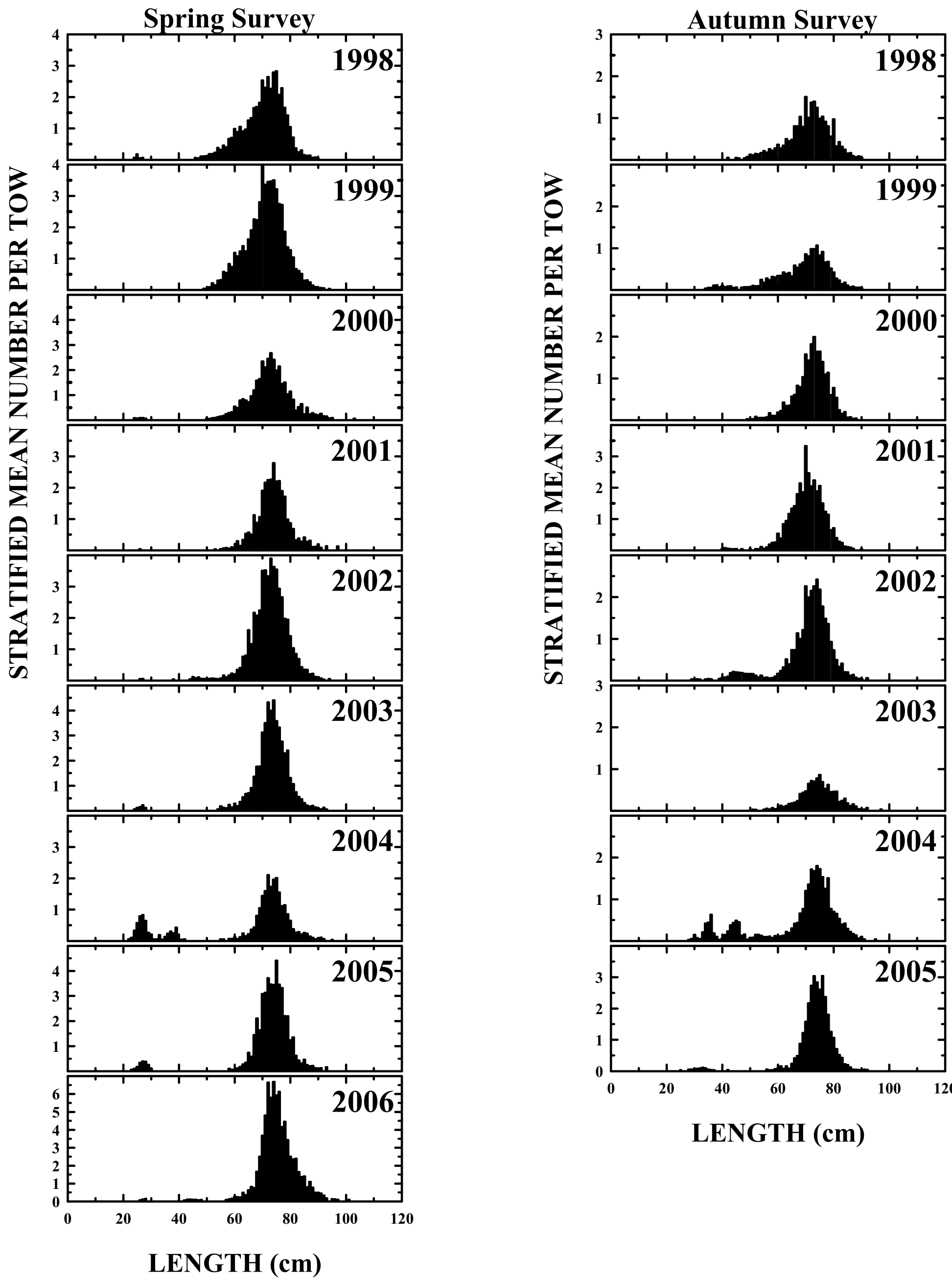


Fig. B5.6d. Length composition of spiny dogfish from the NEFSC spring and autumn bottom trawl surveys, 1998-2006 (Offshore strata 1-30, 33-40, 61-76). Note the scale for spring and autumn differ and spring 2002, 2005, and 2006 and autumn 2001 and 2005 are also different.

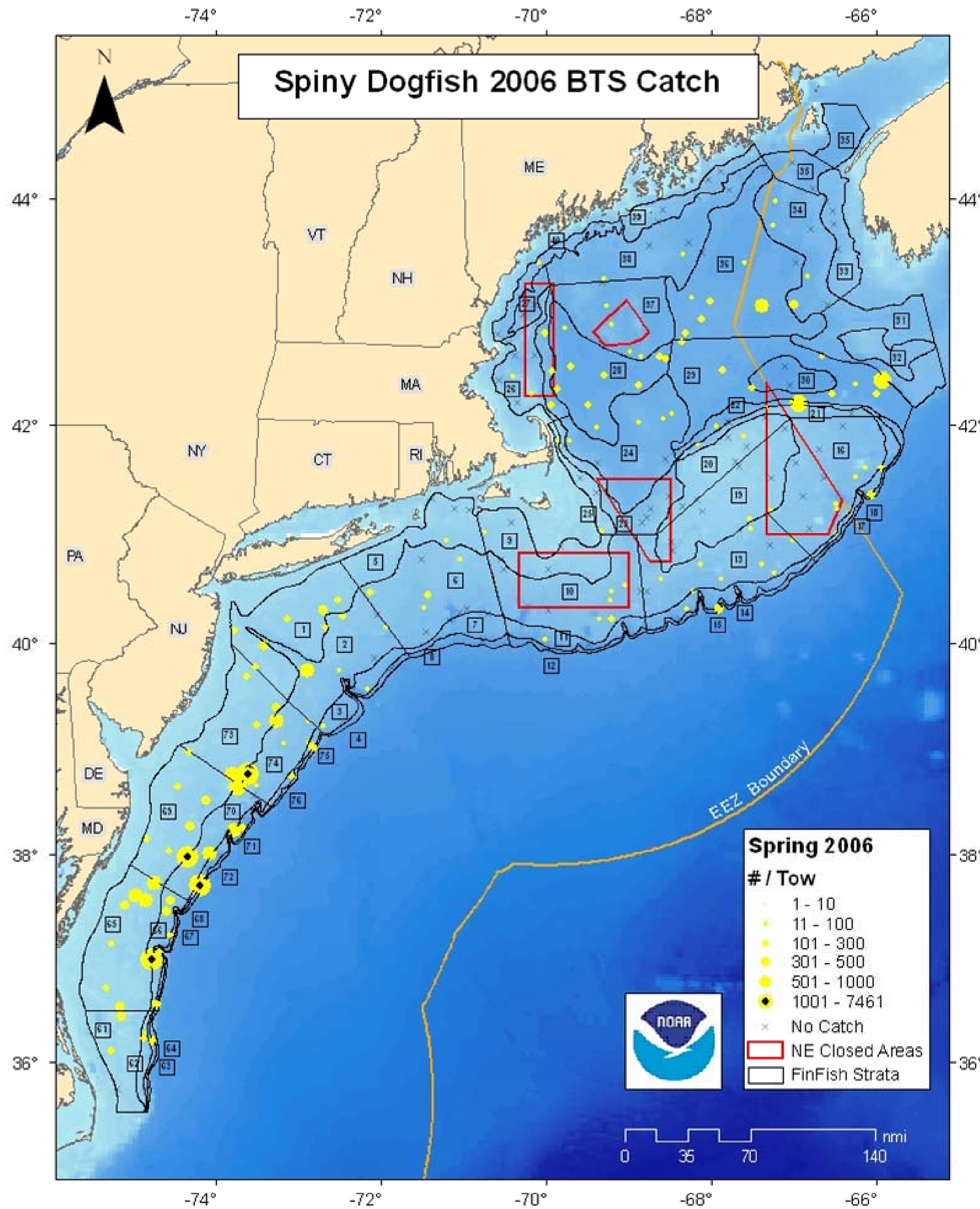


Figure B5.6e. Catch per tow of spiny dogfish, 2006 NEFSC Spring survey.

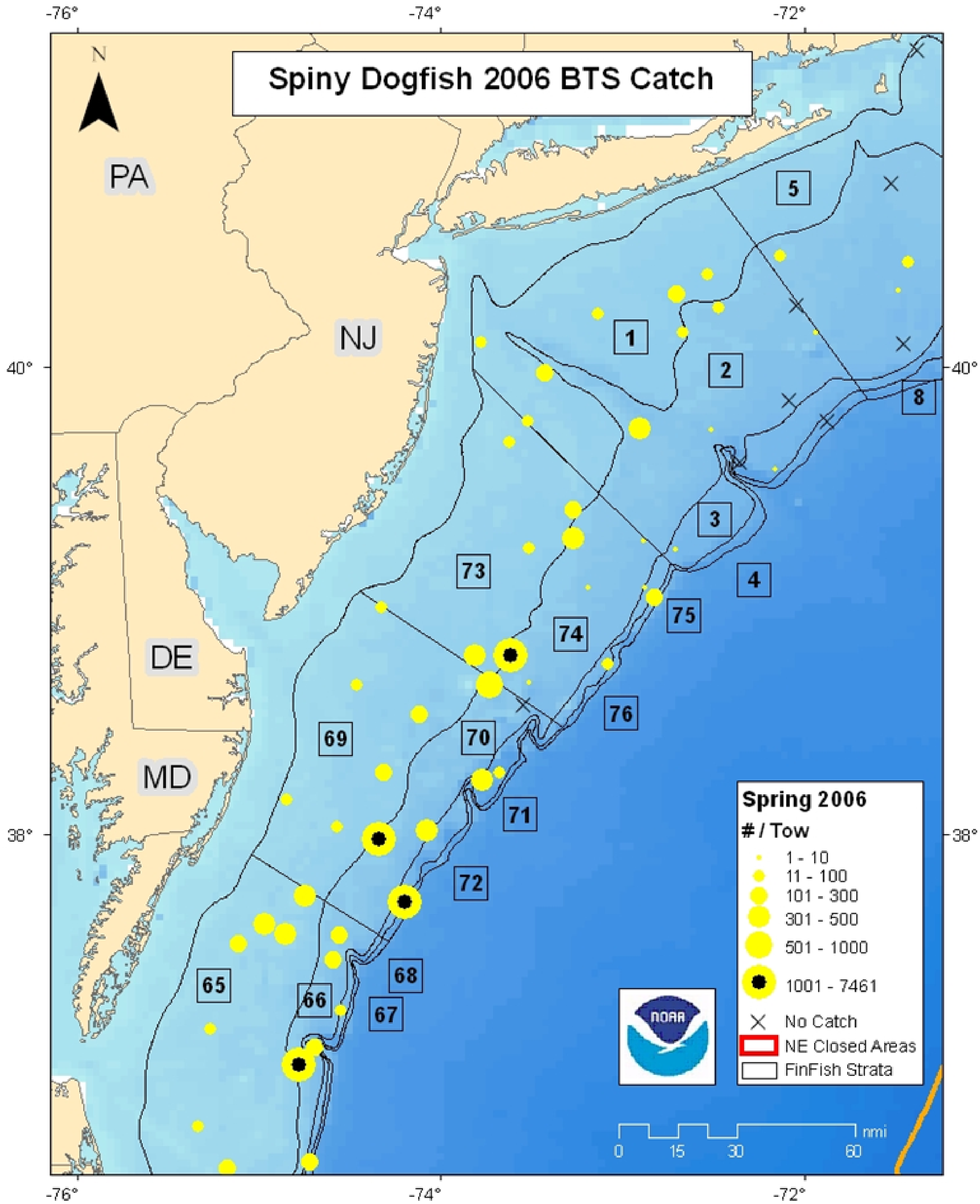


Figure B5.6f. Catch per tow of spiny dogfish, 2006 NEFSC Spring survey.

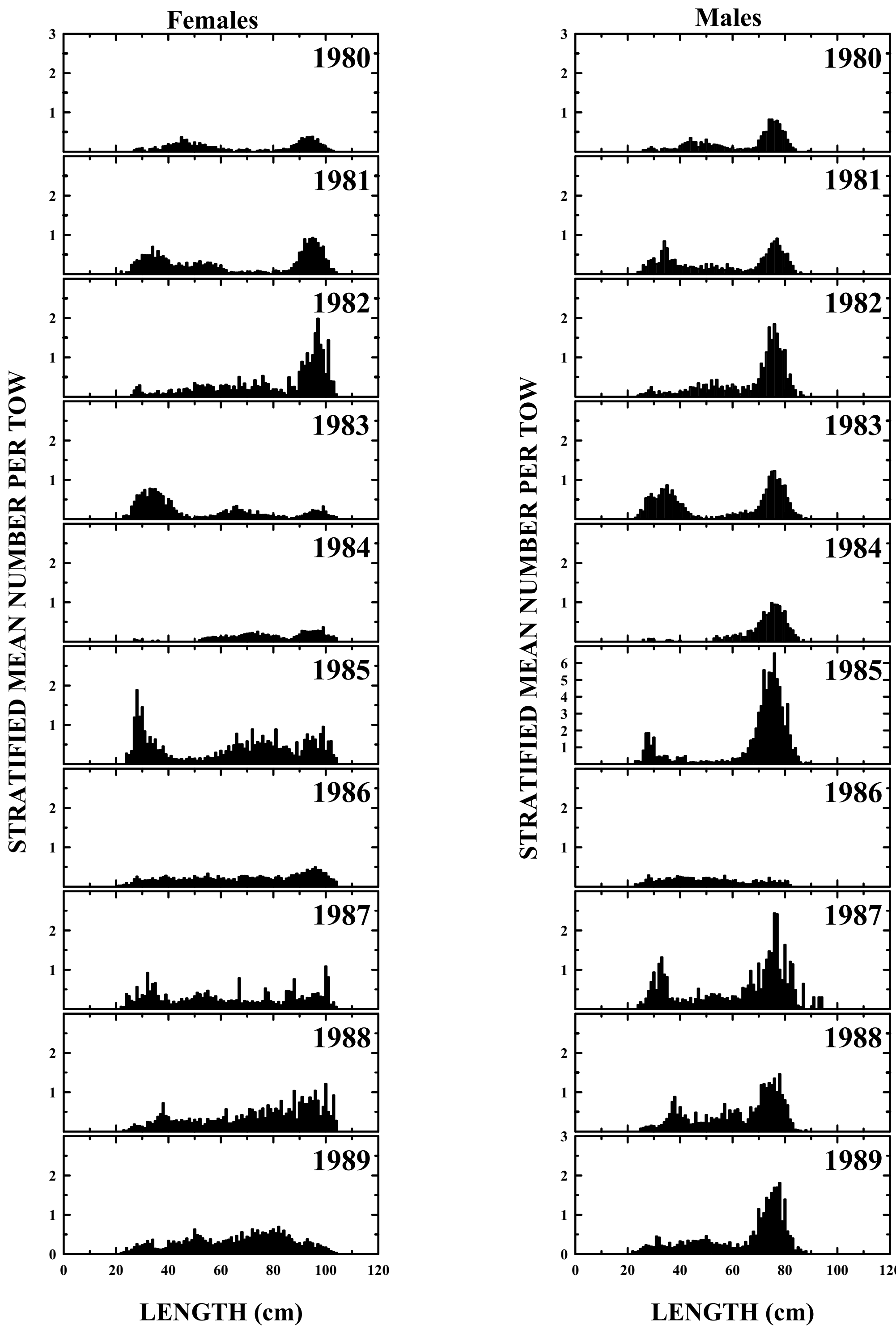


Fig. B5.7a.. Length composition of male and female spiny dogfish from the NEFSC spring bottom trawl surveys, 1980-1989 (Offshore Strata 1-30, 33-40, 61-76). Note the scale for males in 1985 is larger.

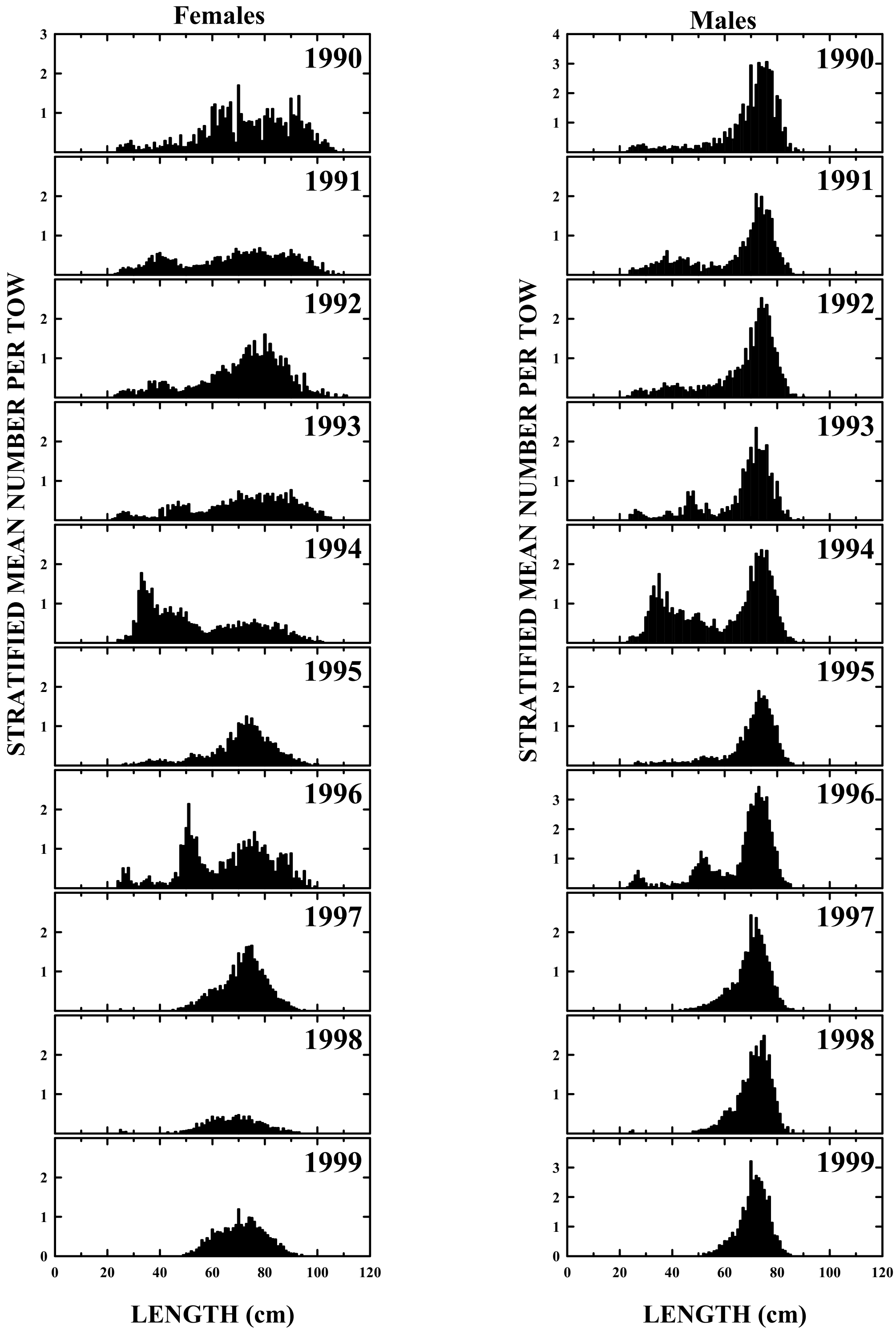


Fig. B5.7b. Length composition of male and female spiny dogfish from the NEFSC spring bottom trawl surveys, 1990-1999 (Offshore Strata 1-30, 33-40, 61-76). Note the scales for males in 1990, 1996, and 1999 are different.

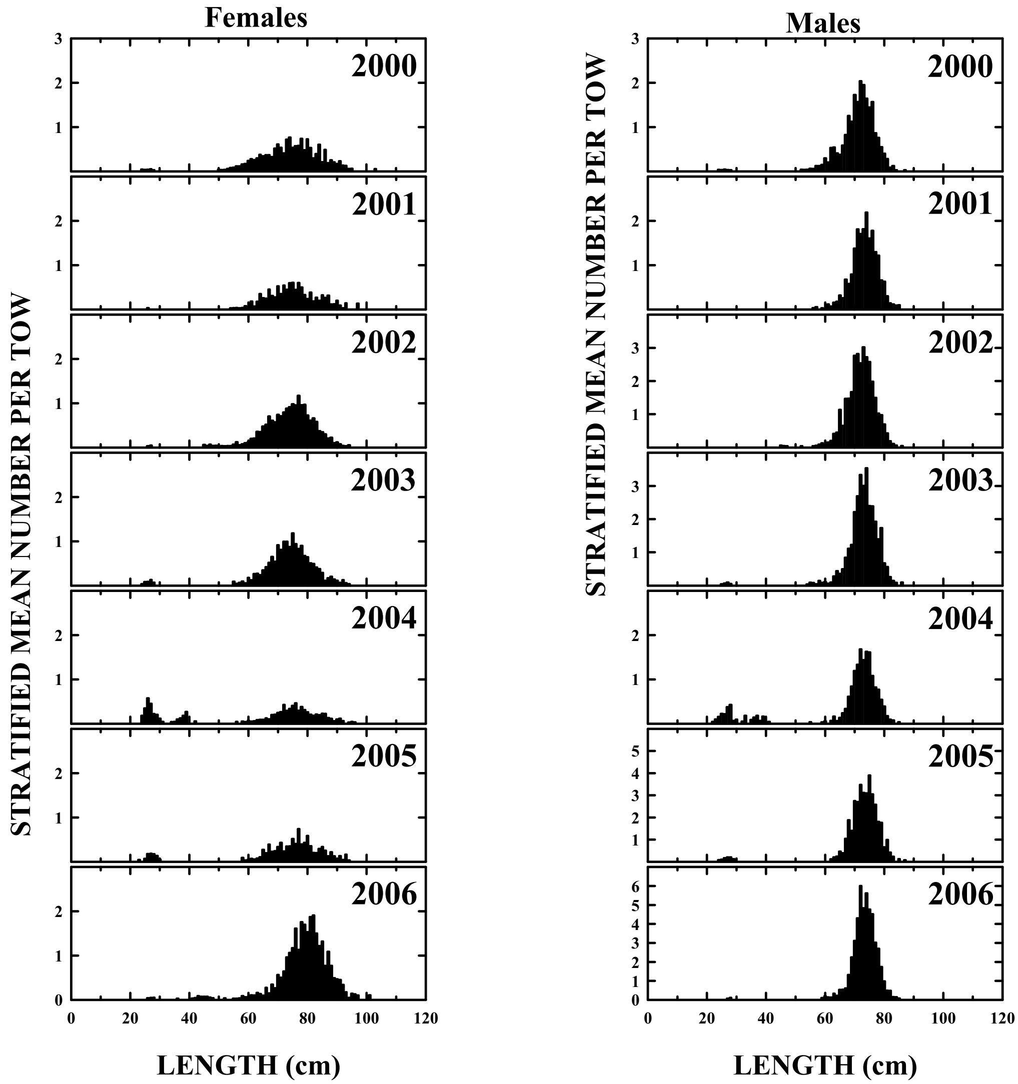


Fig. B5.7c. Length composition of male and female spiny dogfish from the NEFSC spring bottom trawl surveys, 2000-2006 (Offshore Strata 1-30, 33-40, 61-76). Note the scales for males in 2002, 2003, 2005, and 2006 are different.

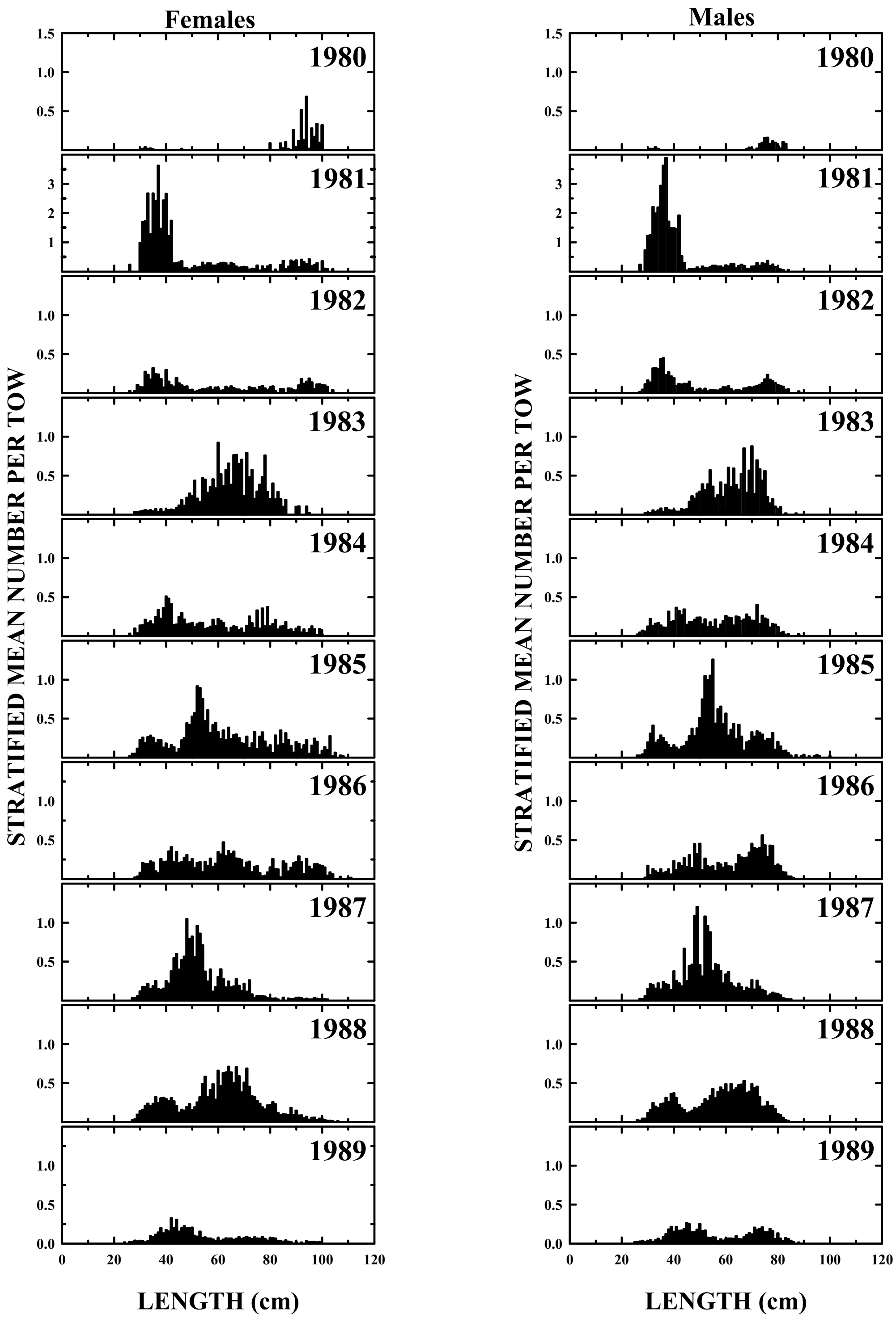


Fig. B5.8a. Length composition of male and female spiny dogfish from the NEFSC autumn bottom trawl surveys, 1980-1989 (Offshore Strata 1-30, 33-40, 61-76). Note the scales in 1981 are larger.

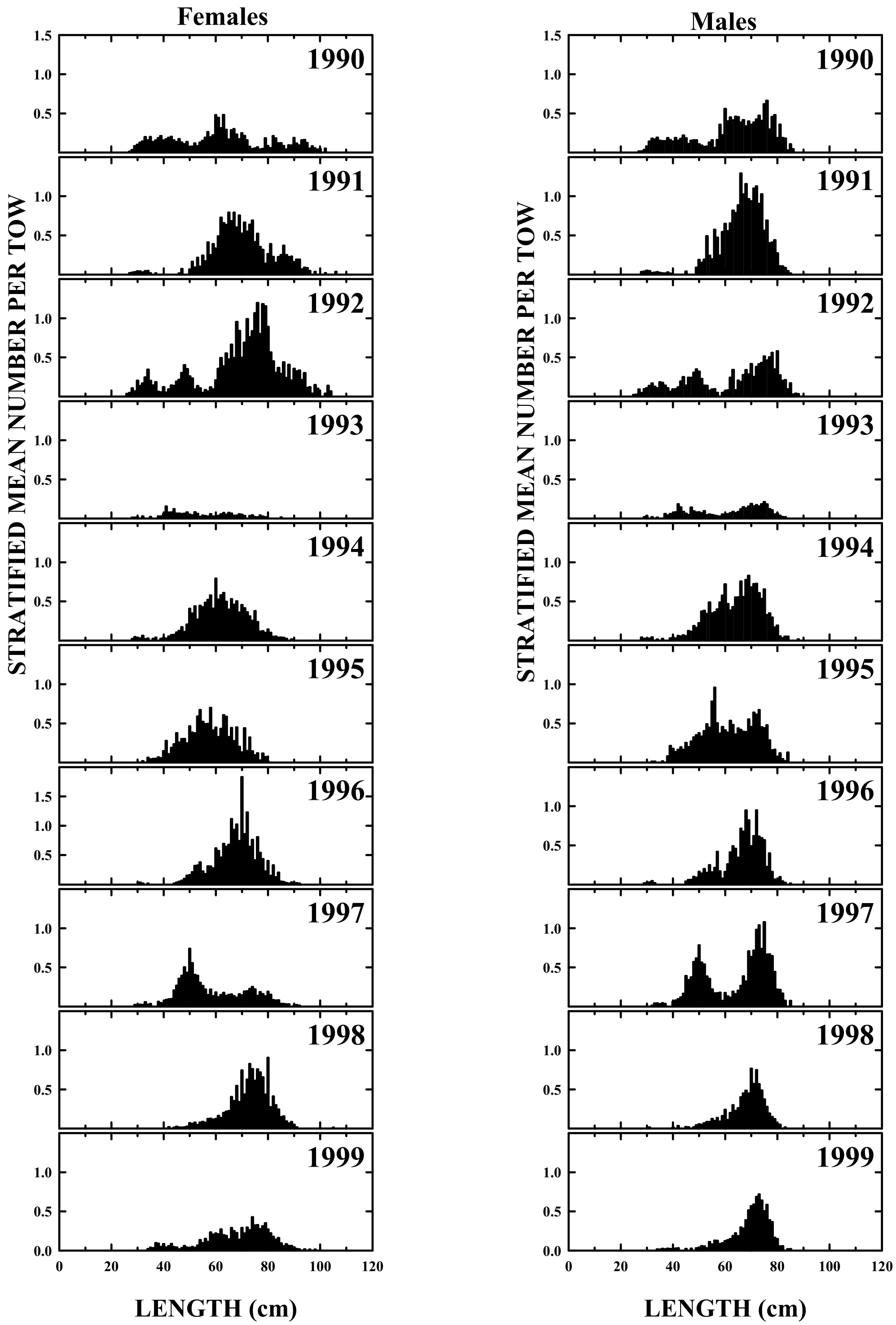


Fig. B5.8b. Length composition of male and female spiny dogfish from the NEFSC autumn bottom trawl surveys, 1990-1999 (Offshore Strata 1-30, 33-40, 61-76). Note the scale for females in 1996 is larger.

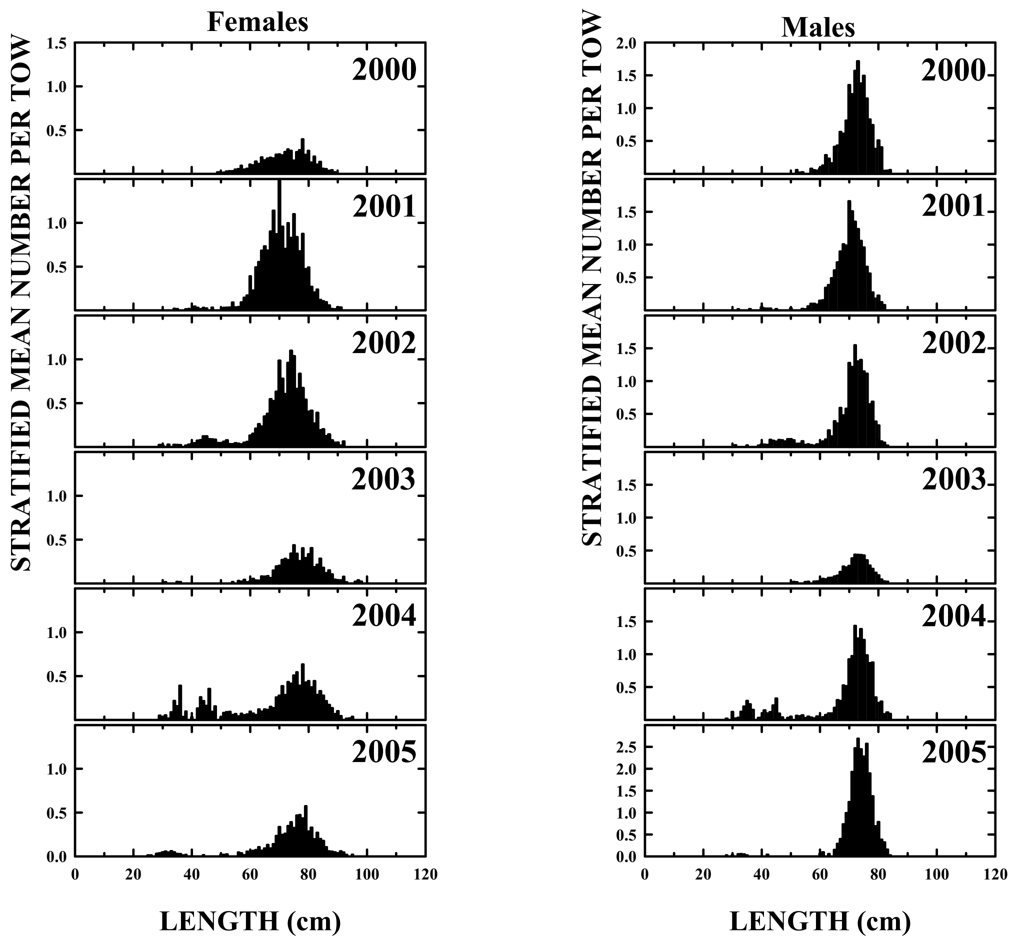


Fig. B5.8c. Length composition of male and female spiny dogfish from the NEFSC spring bottom trawl surveys, 2000-2005 (Offshore Strata 1-30, 33-40, 61-76). Note the scale for males in 2000-2004 is different from previous figures and the scale for males in 2005 is larger.

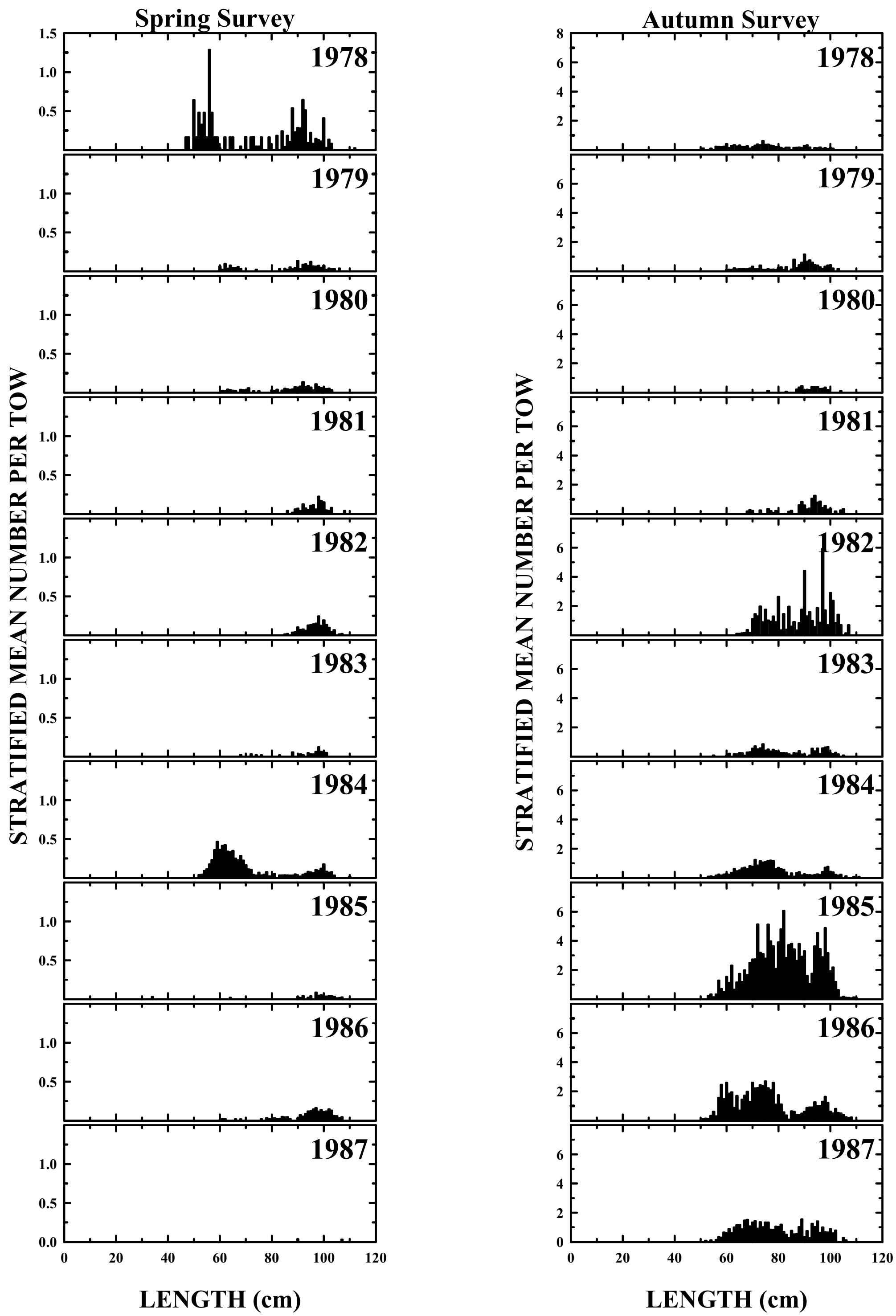


Fig. B5.9a. Length composition of spiny dogfish from the Massachusetts spring and autumn bottom trawl surveys, 1978-1987 Note the scales for Spring and autumn differ.

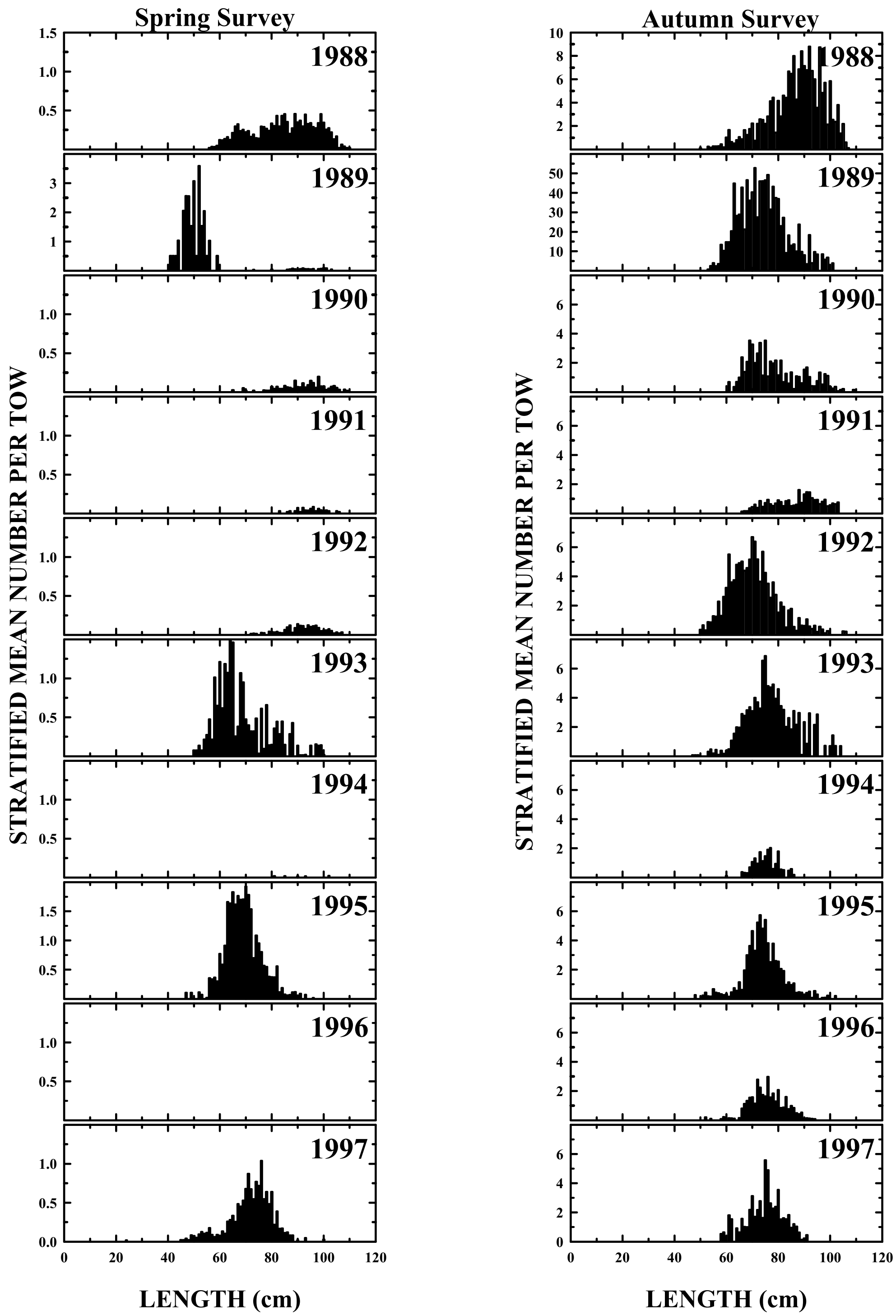


Fig. B5.9b. Length composition of spiny dogfish from the Massachusetts spring and autumn bottom trawl surveys, 1988-1997 Note the scales for spring and autumn differ and spring (1989,1995) and autumn (1988,1989) are also different.

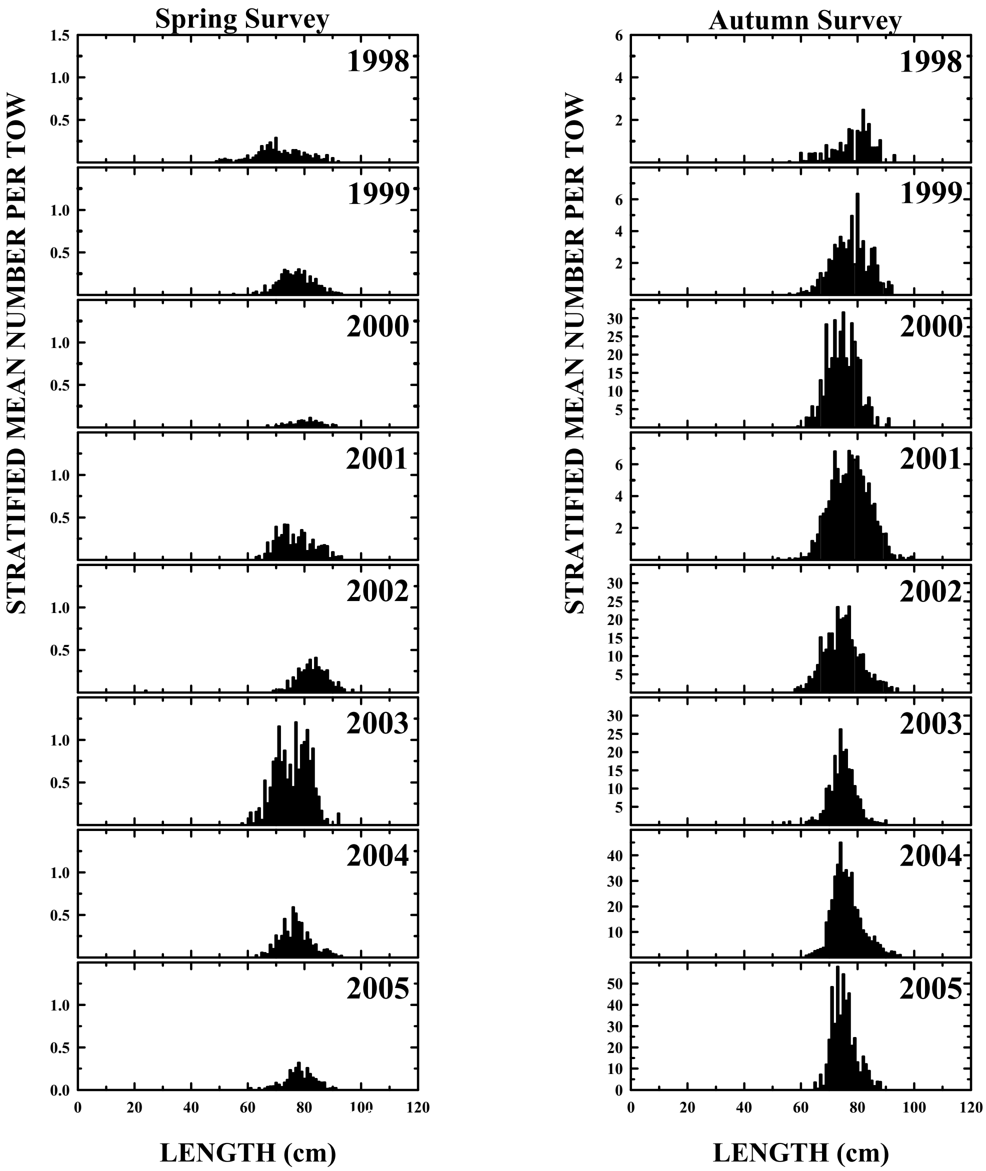
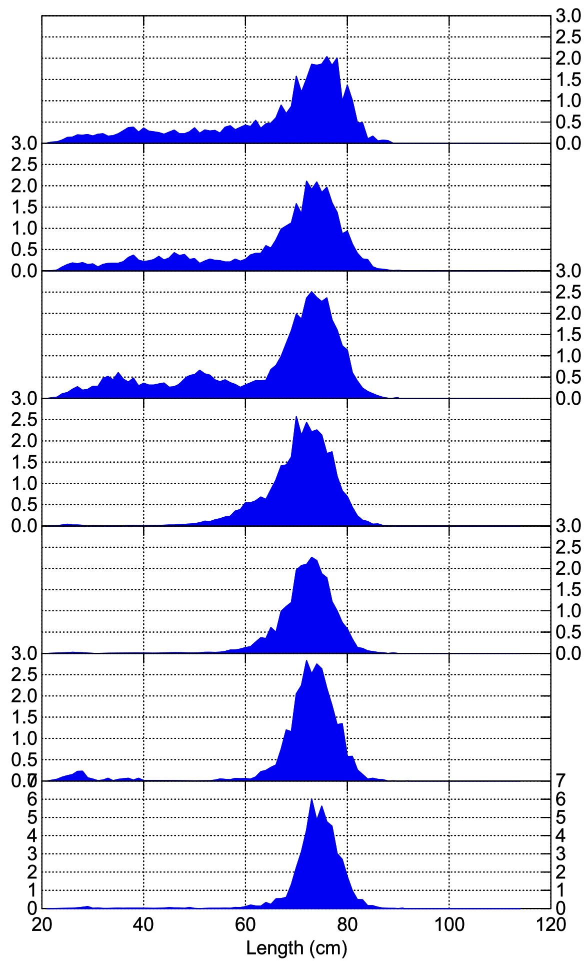


Fig. B5.9c. Length composition of spiny dogfish from the Massachusetts spring and autumn bottom trawl surveys, 1998-2005. Note the scales for spring and autumn differ and note the scale change in autumn 2000 and 2002-2005.



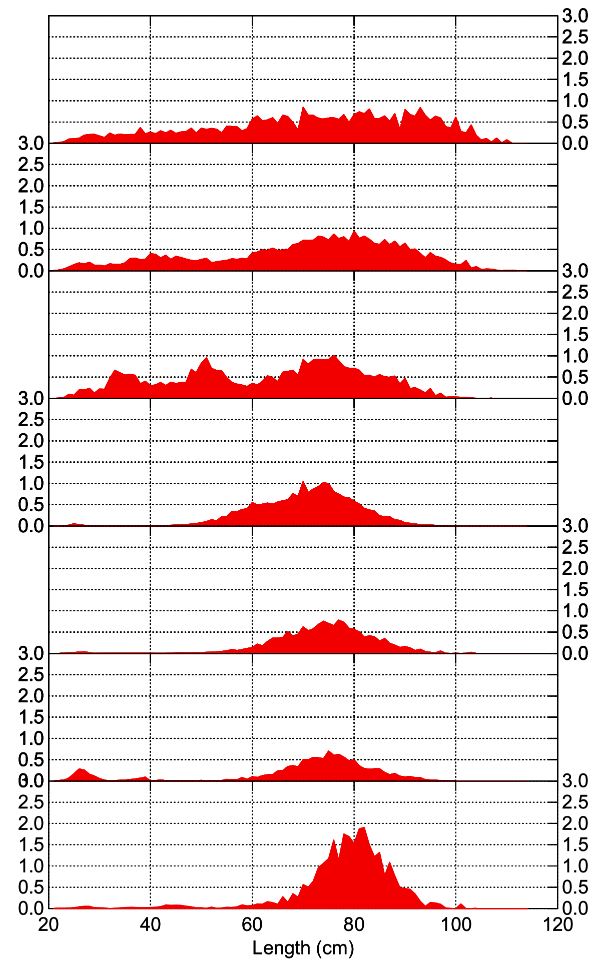


Fig. B5.10 Number of spiny dogfish per tow by 1 cm length class for male (left) and females (right) in NEFSC spring survey by 3-yr period 1988-2005 and for 2006 separately. Note the scale change for males in 2006.

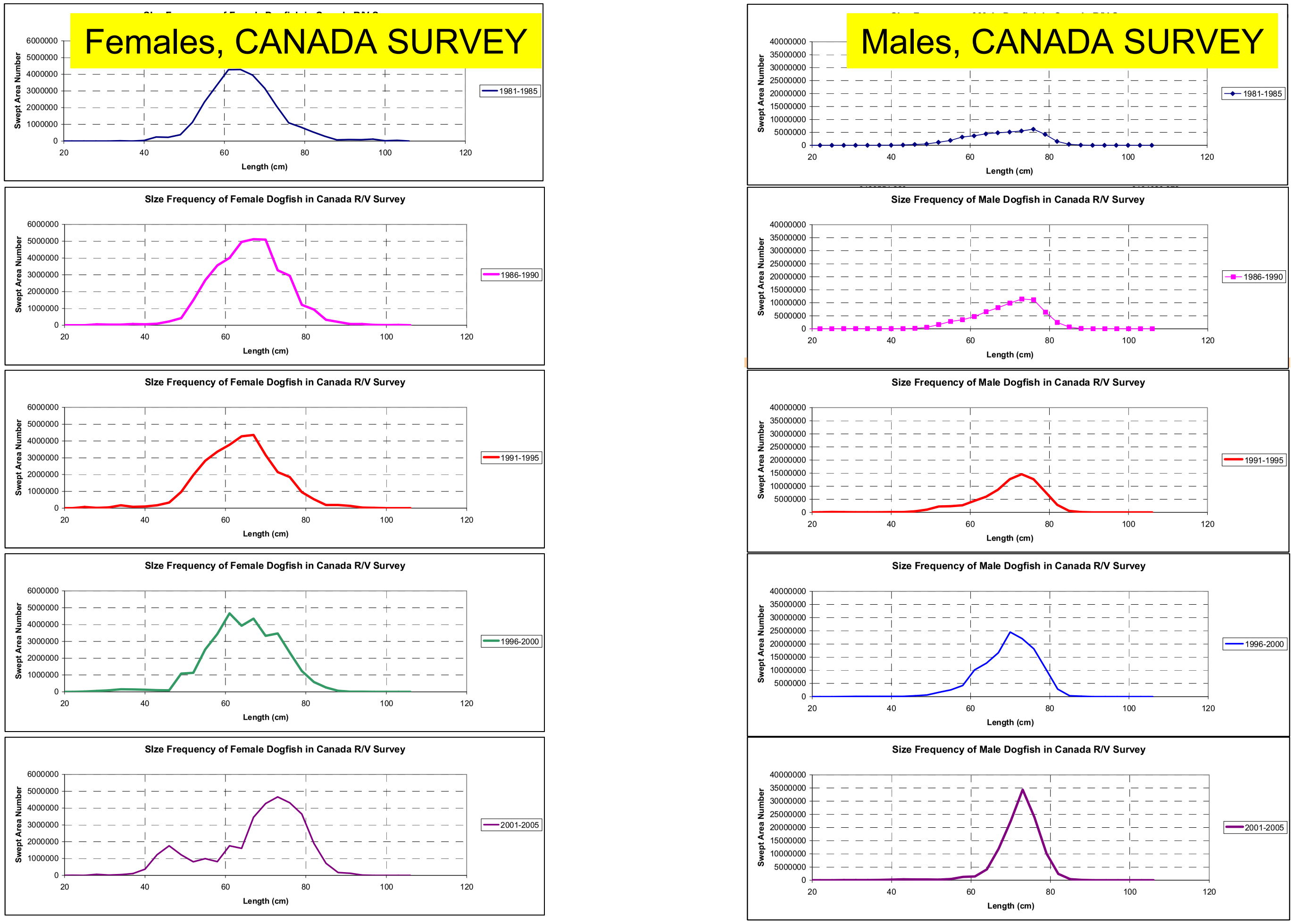


Fig. B5.11 Number of spiny dogfish per tow by 3 cm length class for female (left) and males (right) in DFO summer survey by 5-yr period, 1981-2005.

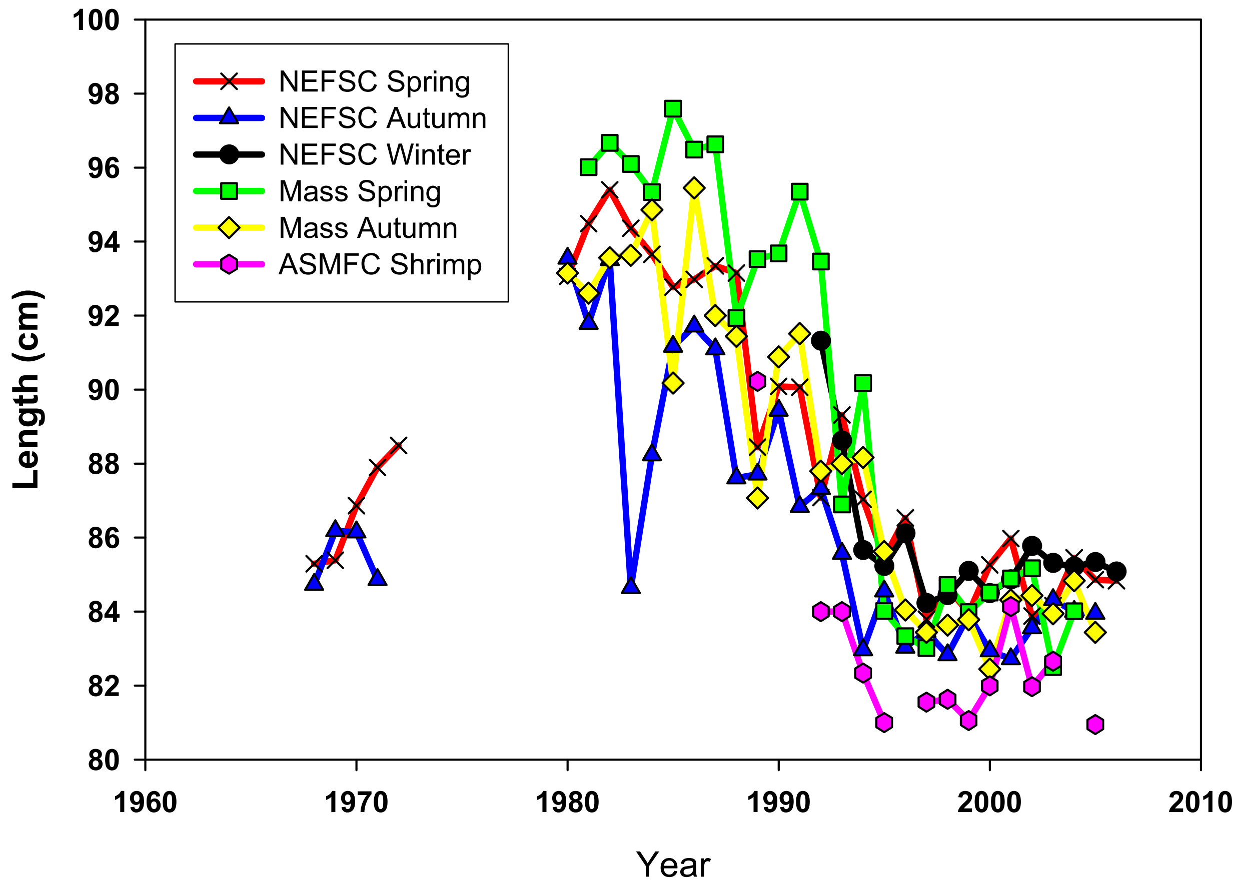


Figure B5.11a. Mean length (cm) of mature spiny dogfish females from NEFSC, Massachusetts and ASMFS shrimp surveys.

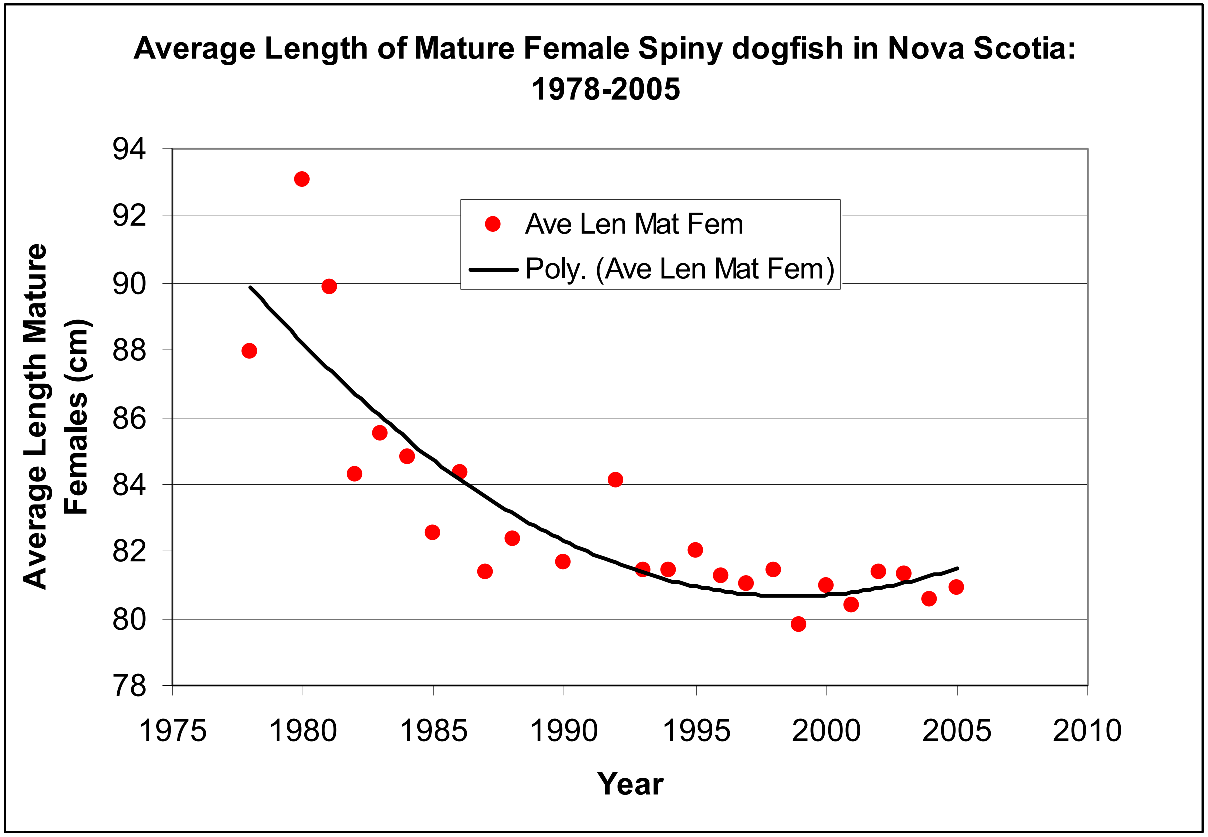


Figure B5.11b. Mean length (cm) of mature spiny dogfish females in DFO Summer R/V trawl survey in NAFO areas 4VWX.

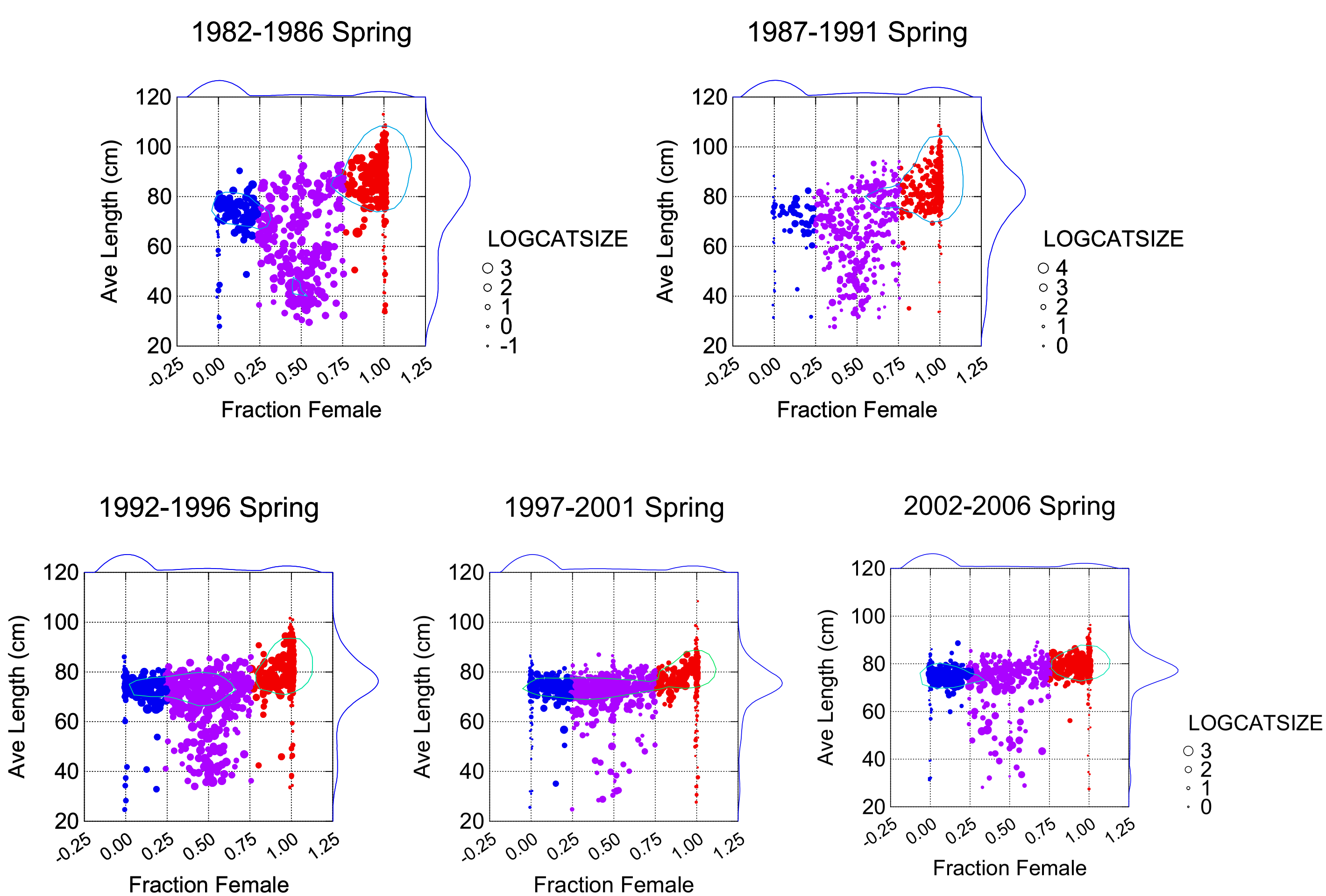


Fig B5.12. Trend in average size and sex ratio of dogfish caught in NEFSC spring trawl survey, 1982-2006. Dots represent individual tows and are scaled relative to total catch weight. Nonparametric kernels are used to describe the marginal and joint densities. Inshore and offshore strata are combined.

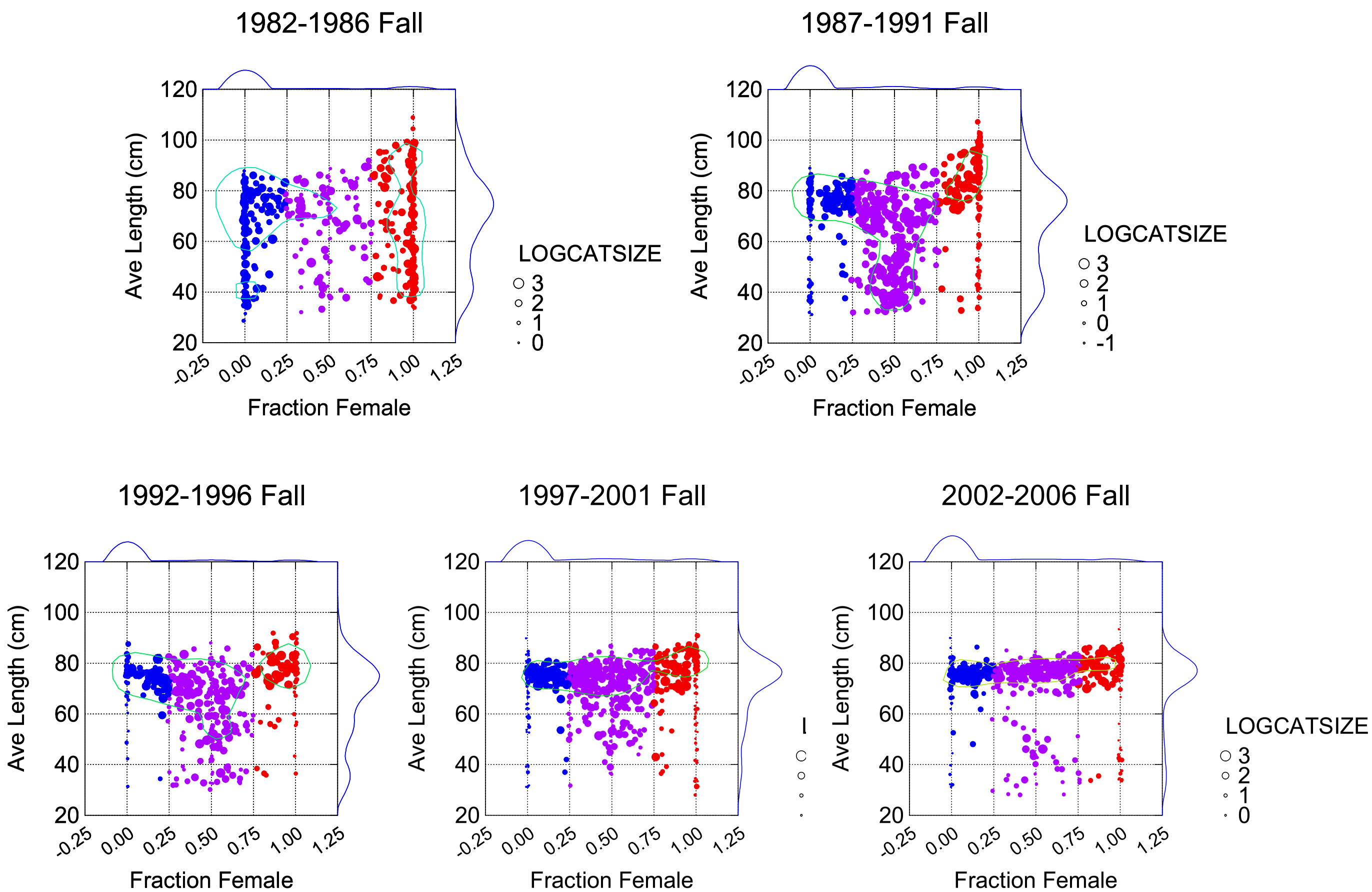


Fig B5.13 Trend in average size and sex ratio of dogfish caught in NEFSC fall trawl survey, 1982-2005. Dots represent individual tows and are scaled relative to total catch weight. Nonparametric kernels are used to describe the marginal and joint densities. Inshore and offshore strata are combined.

Mature Male to Female Ratio, Spring Survey, 1980-2006

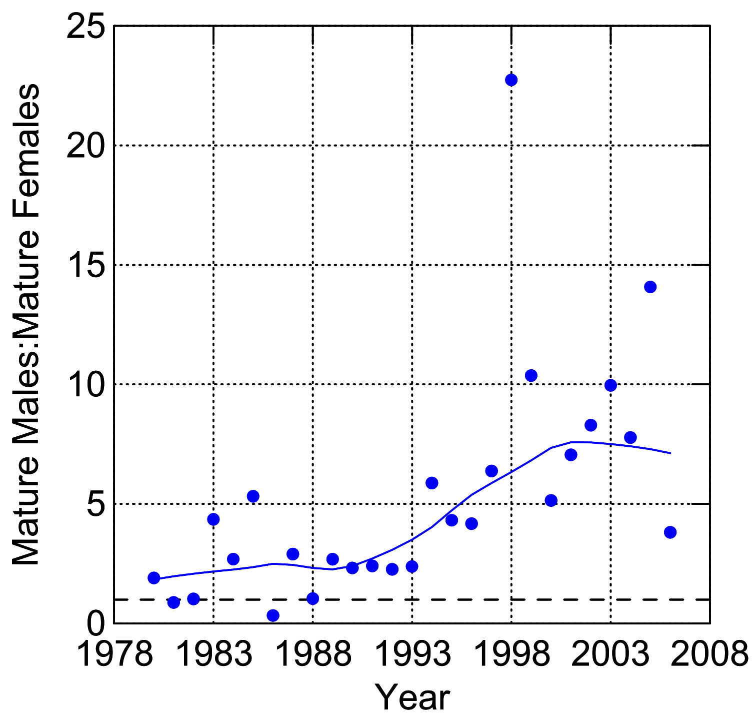
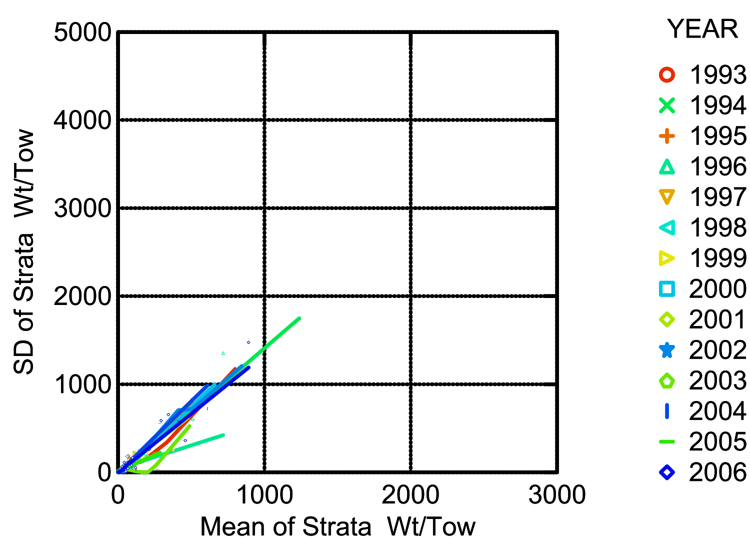


Fig. B5.13a Ratio of numbers per tow of mature males (>60cm) to mature females (>80 cm) spiny dogfish in NEFSC spring trawl survey, 1980-2006. Line represents Lowess smooth with tension =0.5.

SD vs Means by strata, Spring Survey: 1993-2006



SD vs Means by strata, Spring Survey: 1980-1992

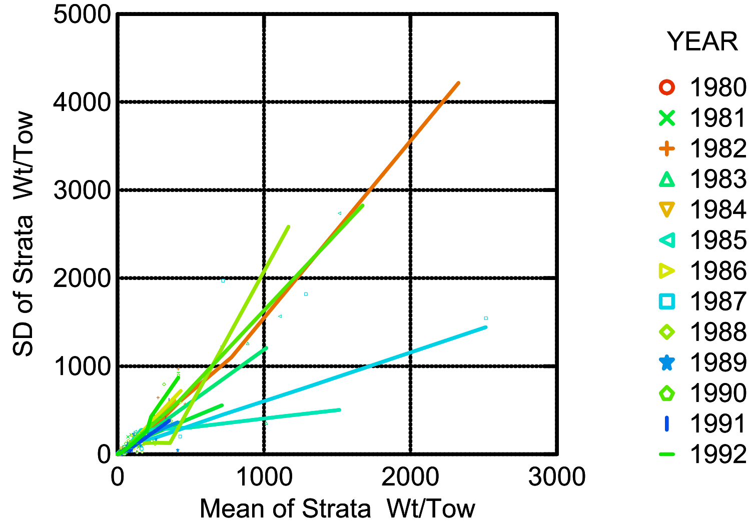
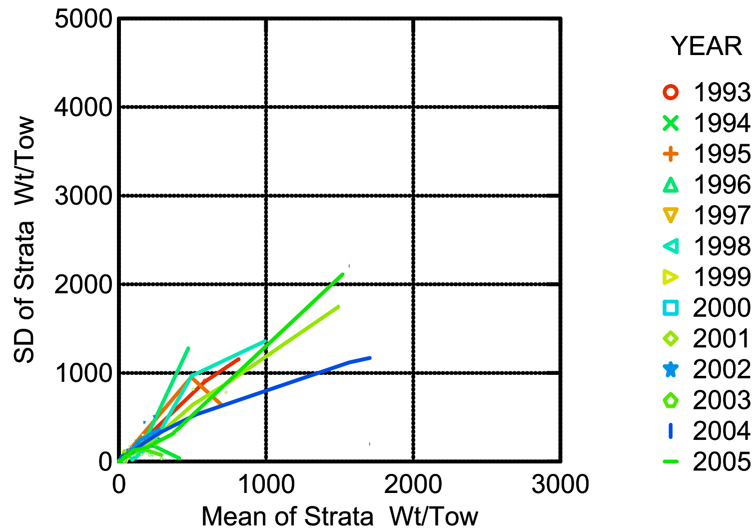


Fig. B5.14 Comparison of SD of strata vs Mean of strata for female spiny dogfish in NMFS Spring survey, 1993 to 2005 (top) and 1980 to 1992 (bottom). Lines represent lowess smooth with tension = 0.50.

SD vs Means by strata, Fall Survey: 1993-2006



SD vs Means by strata, Fall Survey: 1980-1992

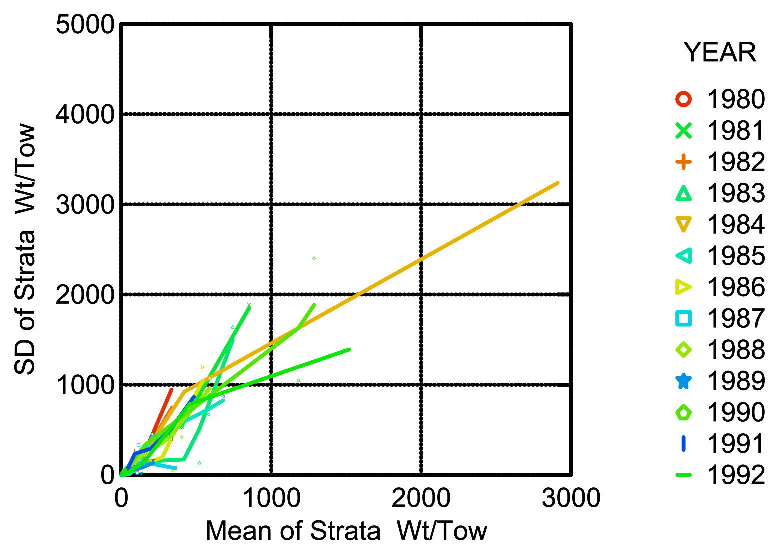
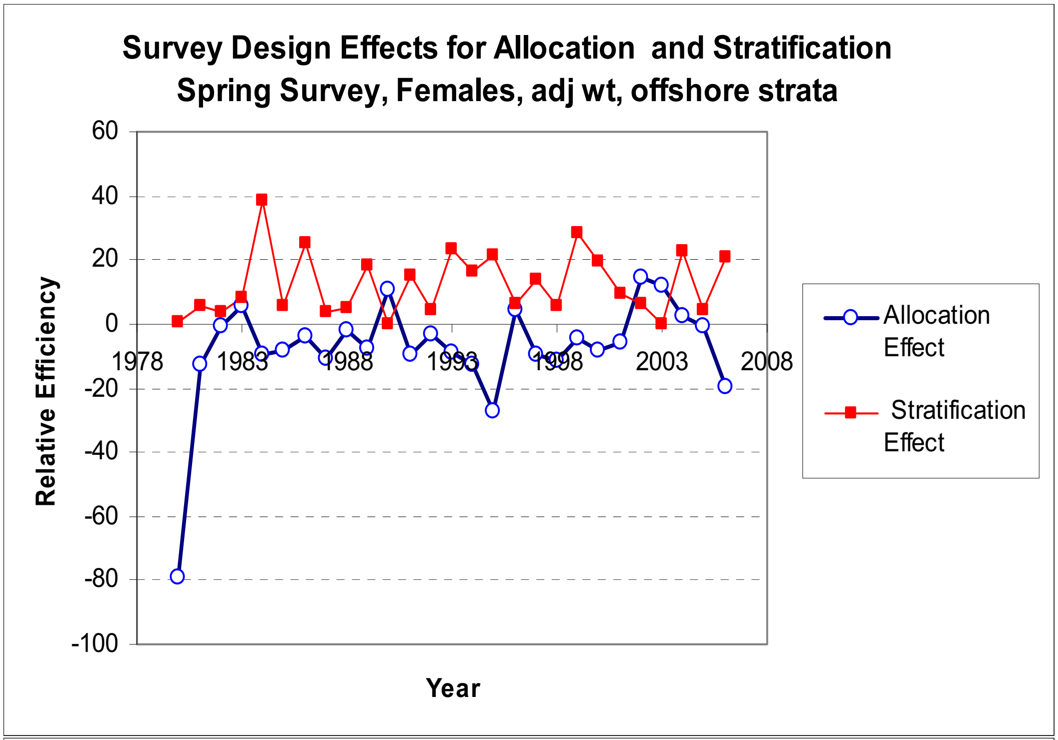


Fig. B5.15. Comparison of SD of strata vs Mean of strata for female spiny dogfish in NMFS Fall survey, 1993 to 2005 (top) and 1980 to 1992 (bottom). Lines represent lowess smooth with tension = 0.50.



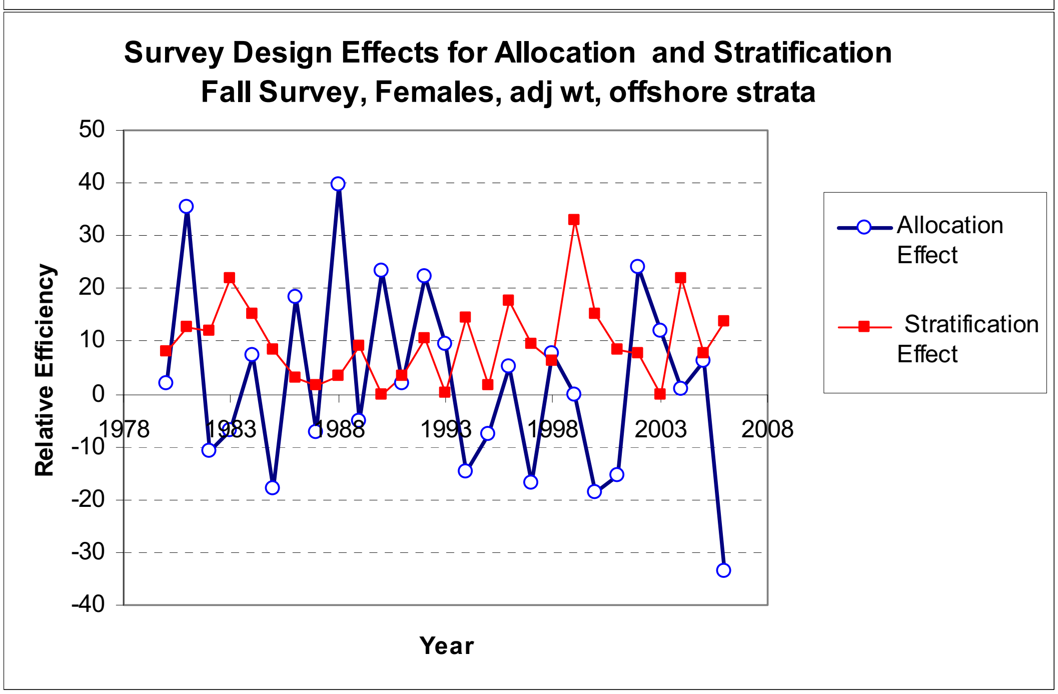
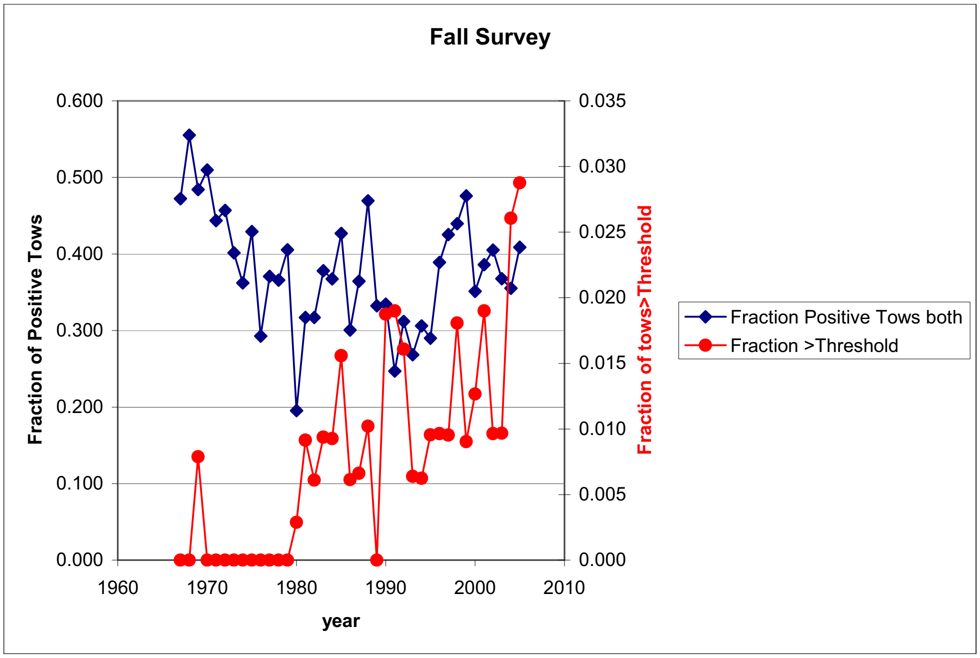


Fig. B5.16. Evaluation of survey design efficiency for NEFSC spring and fall R/V surveys for female spiny dogfish, 1980-2006. Design efficiency is the sum of two effects: stratification and allocation. A design efficiency of zero is equivalent to a simple random sample.



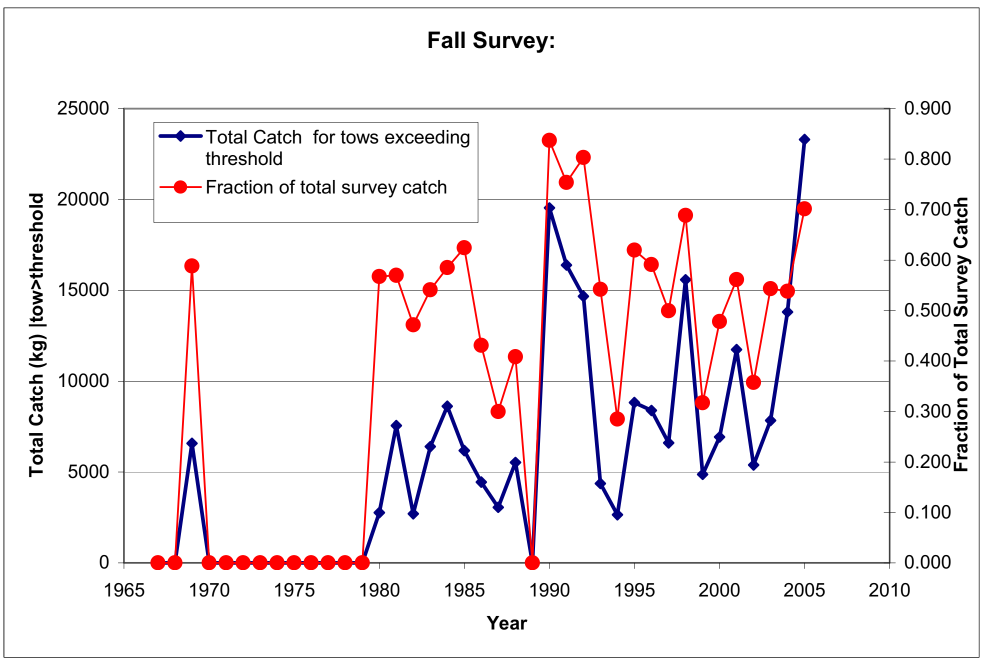
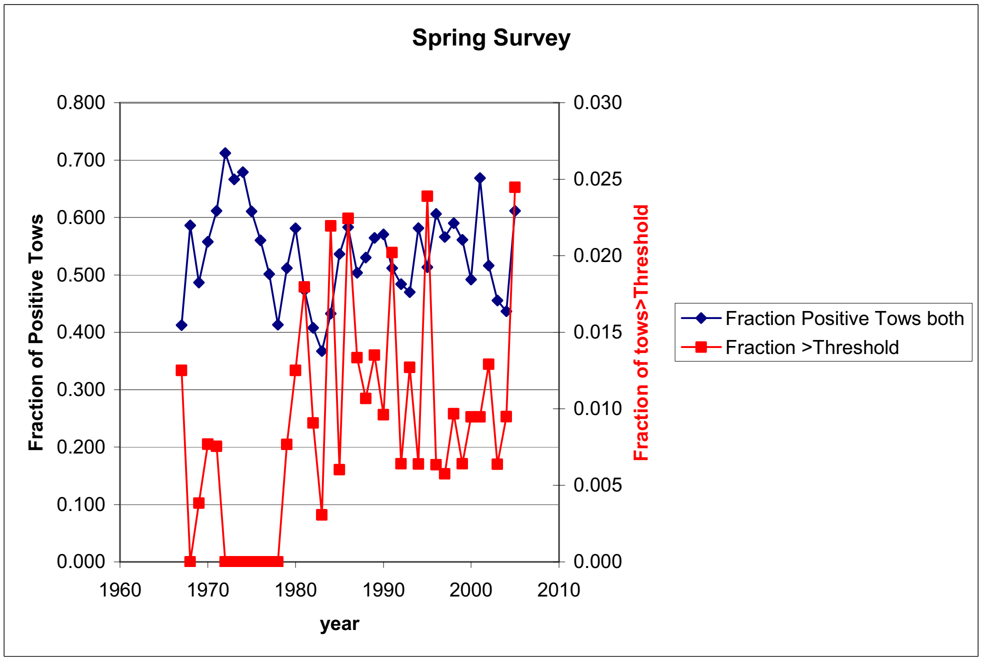


Fig. B5.17. Trends in fraction of positive tows and tows exceeding 1000 kg/tow for female spiny dogfish in fall survey (top) through 2005. Bottom panel depicts total catch taken in large tows and their fraction of total catch in the NMFS survey 1967-2005. Dogfish sex information prior to 1980 is incomplete.



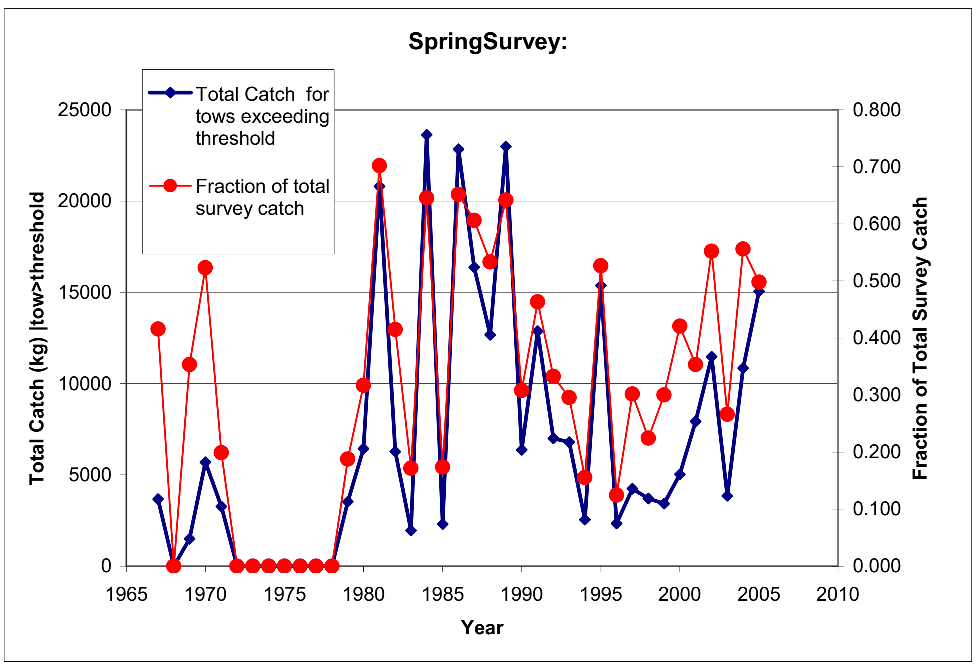


Fig. B5.18. Trends in fraction of positive tows and tows exceeding 1000 kg/tow for female spiny dogfish in spring survey (top) through 2005. Bottom panel depicts total catch taken in large tows and their fraction of total catch in the NMFS survey 1967-2005. Dogfish sex information prior to 1980 is incomplete.

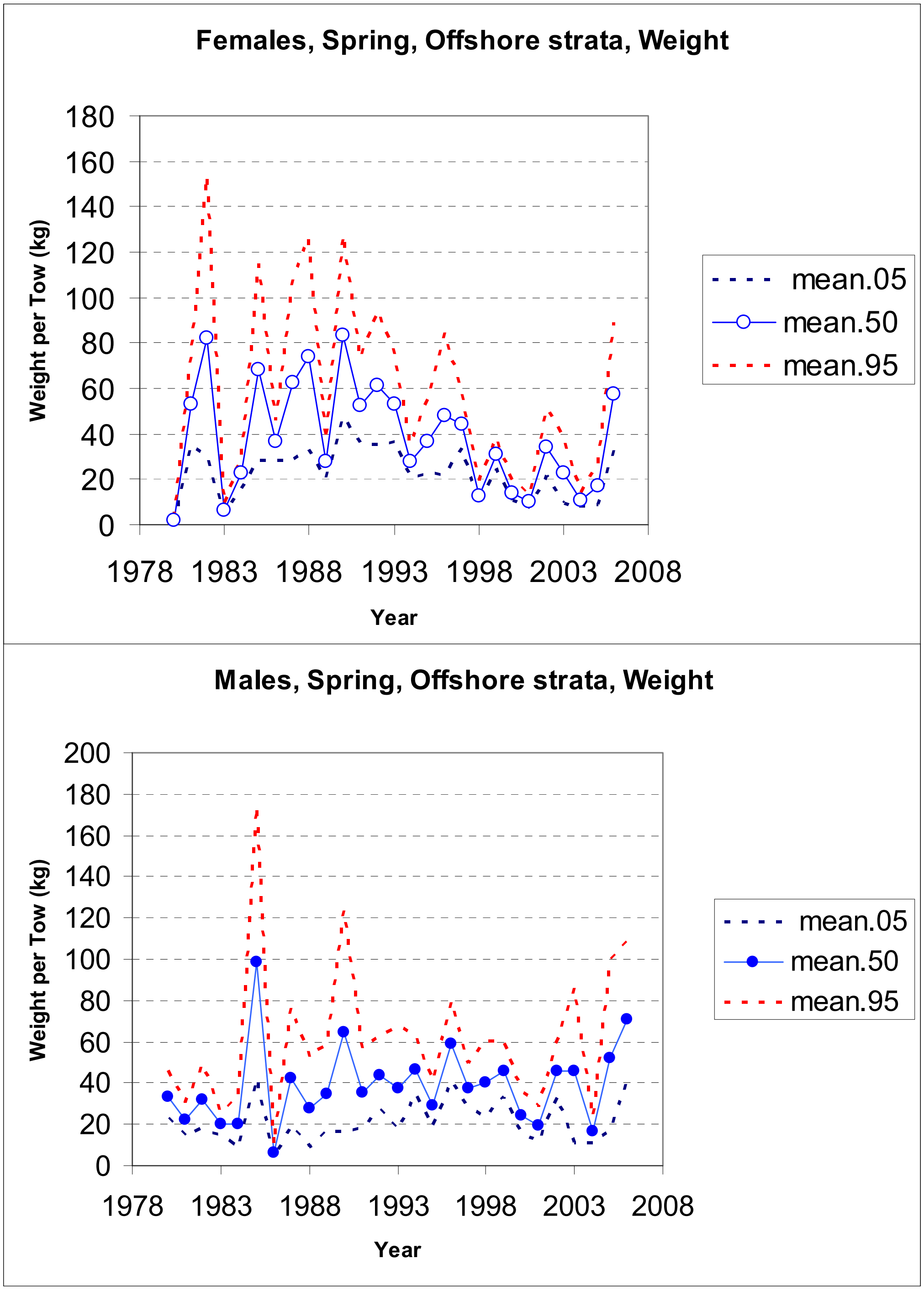


Fig. B5.19. Bootstrap sampling distributions of mean weight per tow for female and male spiny dogfish taken in the spring survey for offshore strata. Confidence intervals are based on the percentile method and represent 90% of the realized values. Number of bootstrap realizations per year =2000.

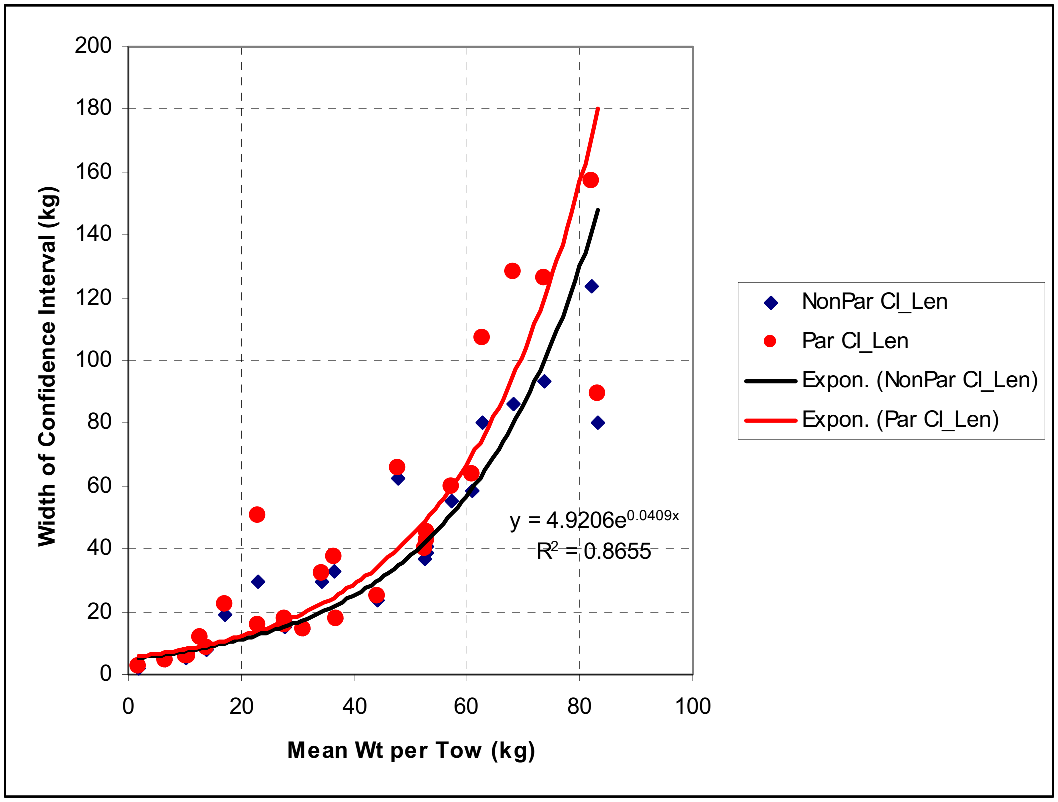


Fig. B5.20 Comparison of parametric and bootstrap 90% confidence interval widths of female weight per tow for spring survey, 1980-2006.

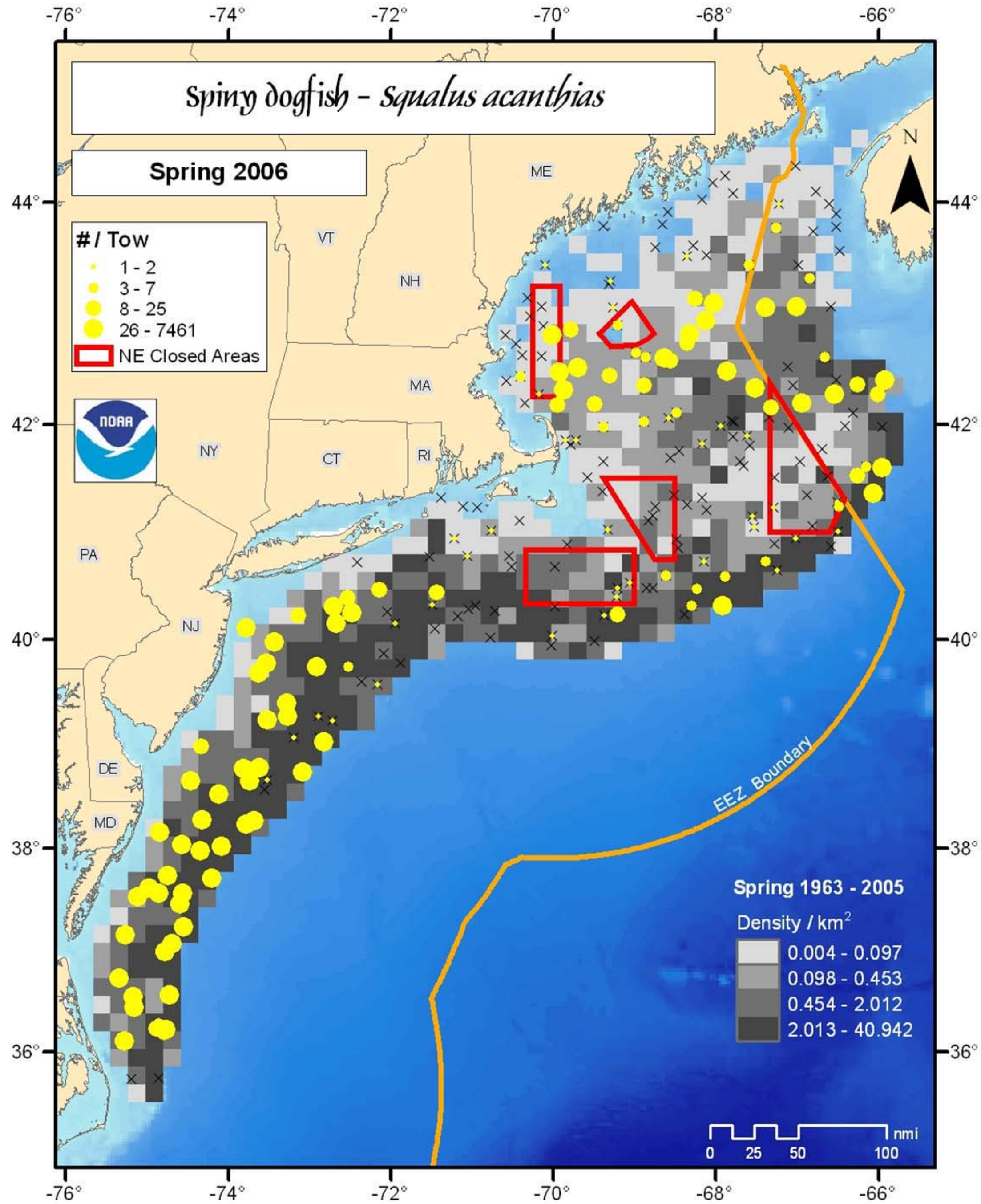


Fig. B5.20.1. Distribution of spiny dogfish in 2006 NEFSC spring research trawl survey. Yellow dots represent number per tow. Shaded 10 minute squares represent relative habitat utilization in March-April, 1963-2005

Spring Survey: comparison of 2006 vs 1993-2005

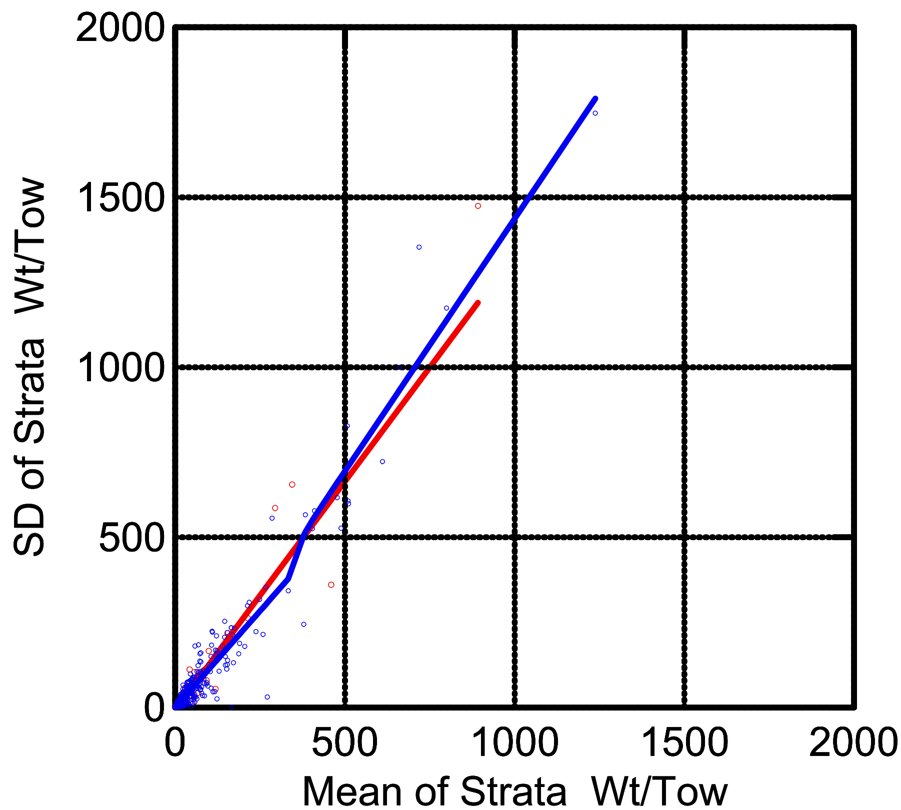
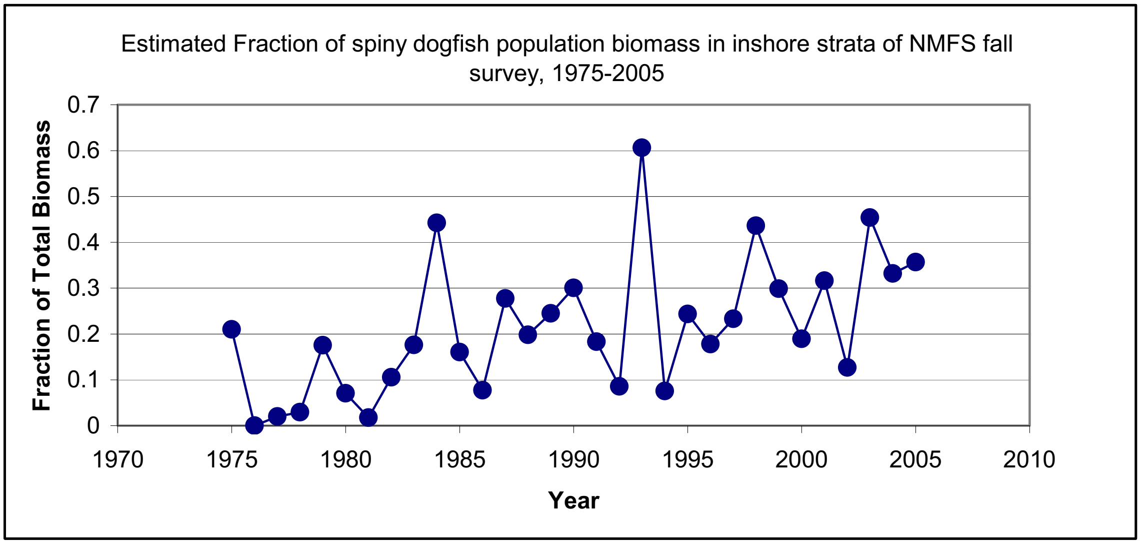


Fig. B5.20.2. Comparison of SD of strata vs Mean of strata for female spiny dogfish spring in NMFS spring survey, 2006 with 1993 to 2005 pooled. Lines represent lowess smooth with tension = 0.50.



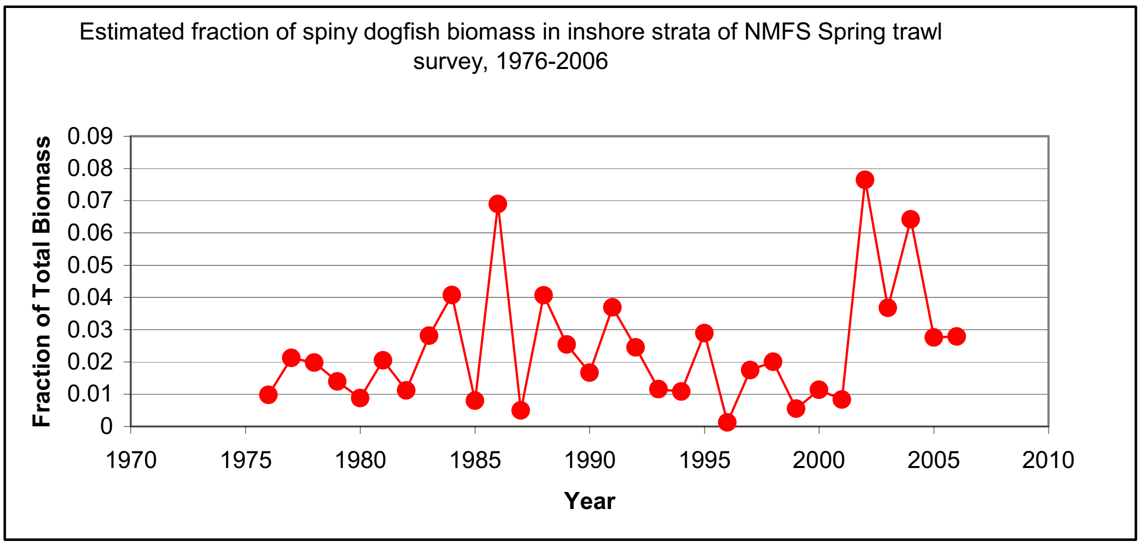


Fig. B5.21. Fraction of total spiny dogfish swept-area estimates of population biomass in inshore strata in NMFS fall (top panel) and spring (bottom) bottom trawl survey.

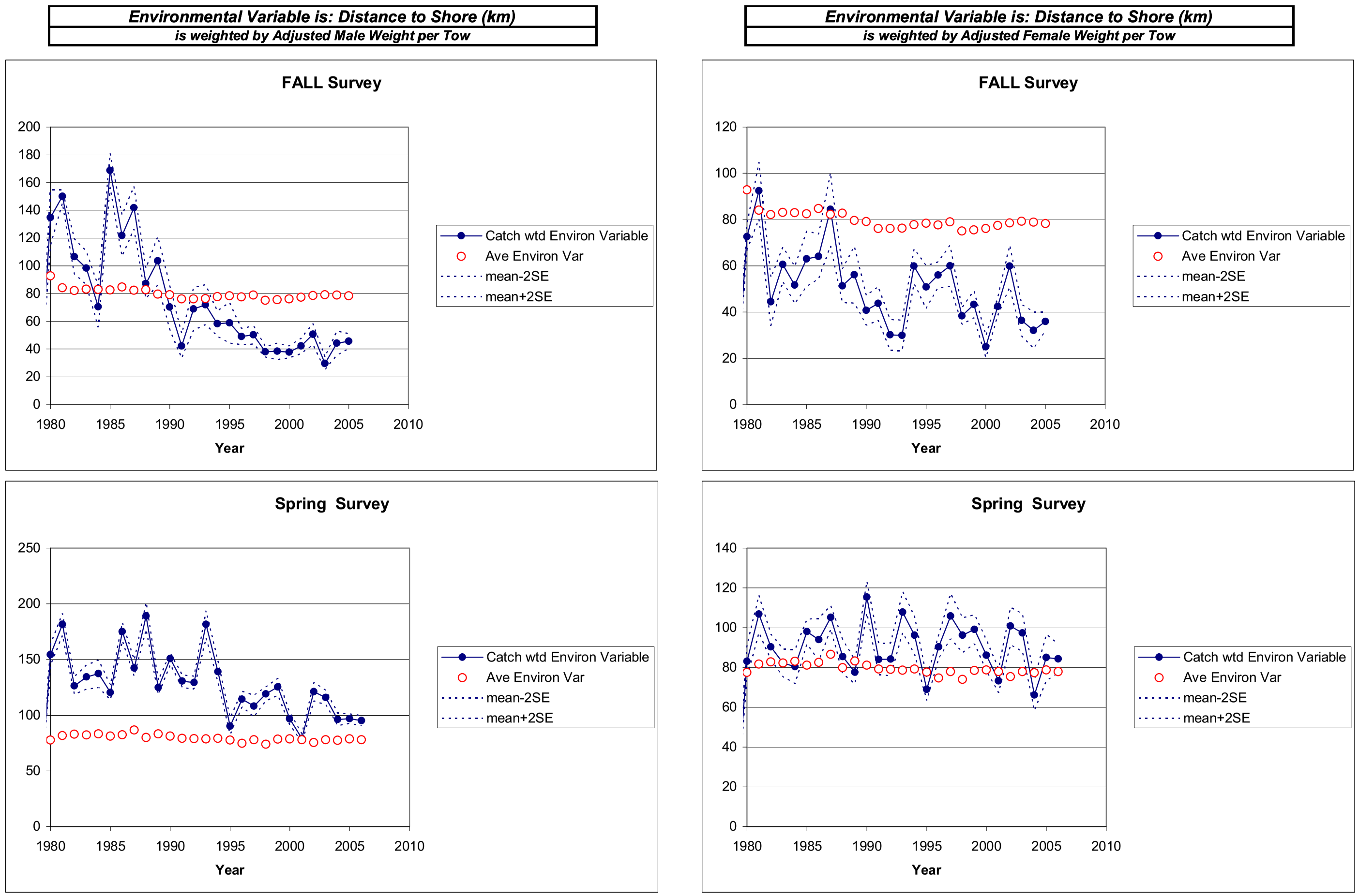


Fig. B5.22 Comparison of average distance from shore (km) for samples taken in NMFS fall (open dots) and spring surveys with distances weighted by male (left) and female (right) spiny dogfish adjusted weight per tow (kg) (closed dots). Adjustments account for effect of gear and vessel changes. Distance to shore represent closest distance from sample station to shore.

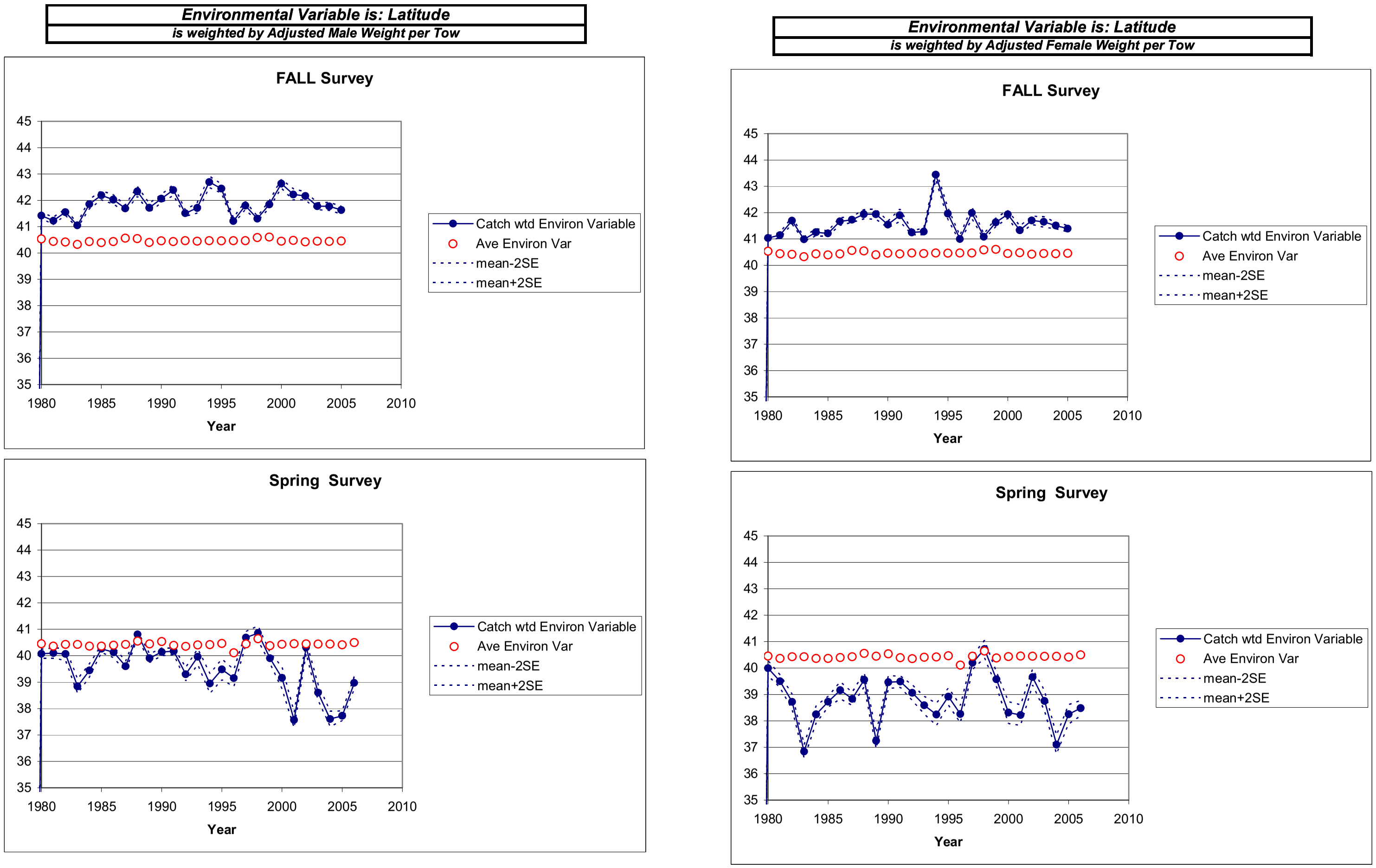


Fig. B5.23 Comparison of average latitude (degrees) for samples taken in NMFS fall (open dots) and spring surveys with latitudes weighted by male (left) and female (right) spiny dogfish adjusted weight per tow (kg) (closed dots). Adjustments account for effect of gear and vessel changes.

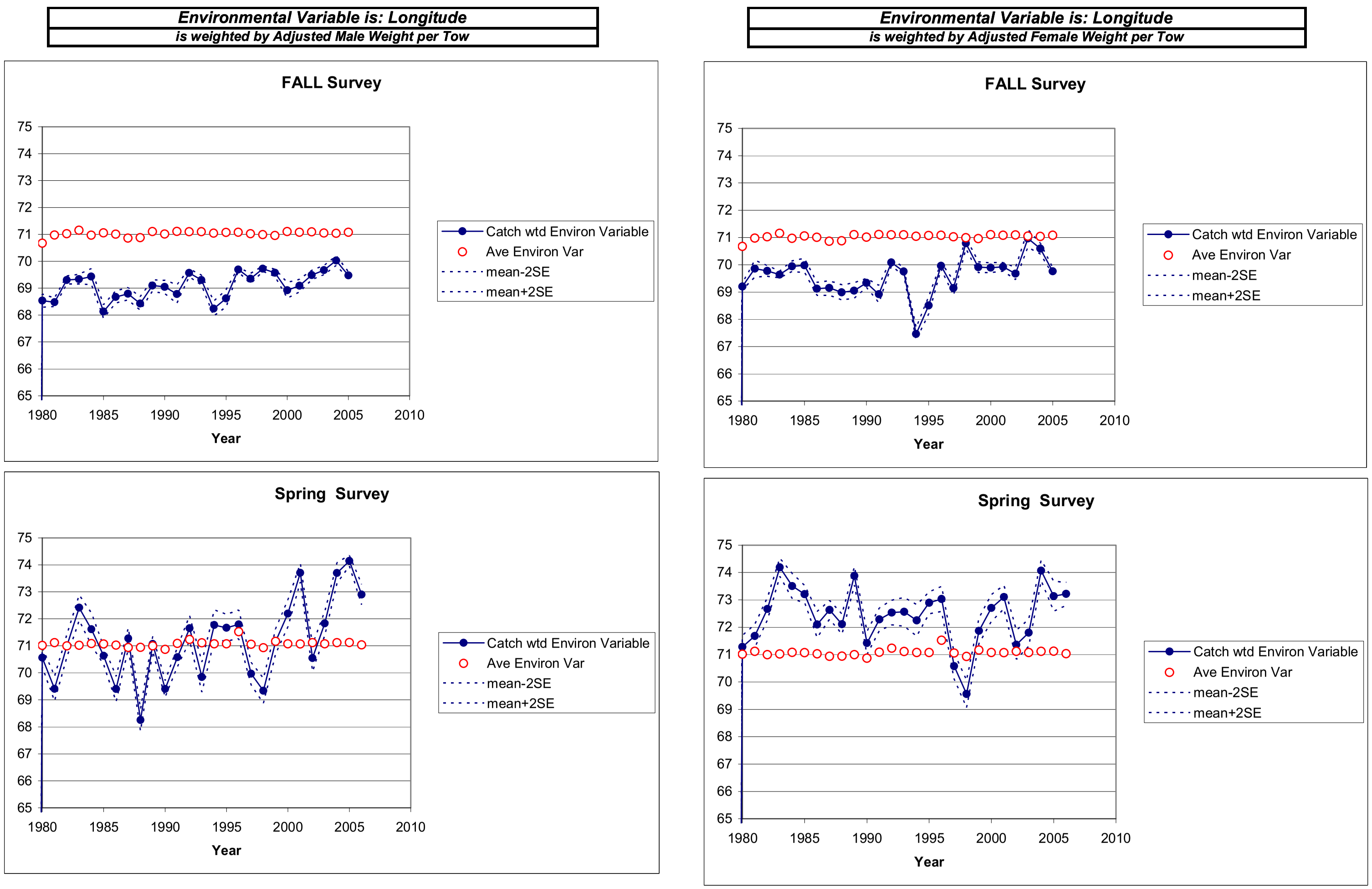


Fig. B5.24 Comparison of average longitude (degrees) for samples taken in NMFS fall (open dots) and spring surveys with longitudes weighted by male (left) and female(right) spiny dogfish adjusted weight per tow (kg) (closed dots). Adjustments account for effect of gear and vessel changes.

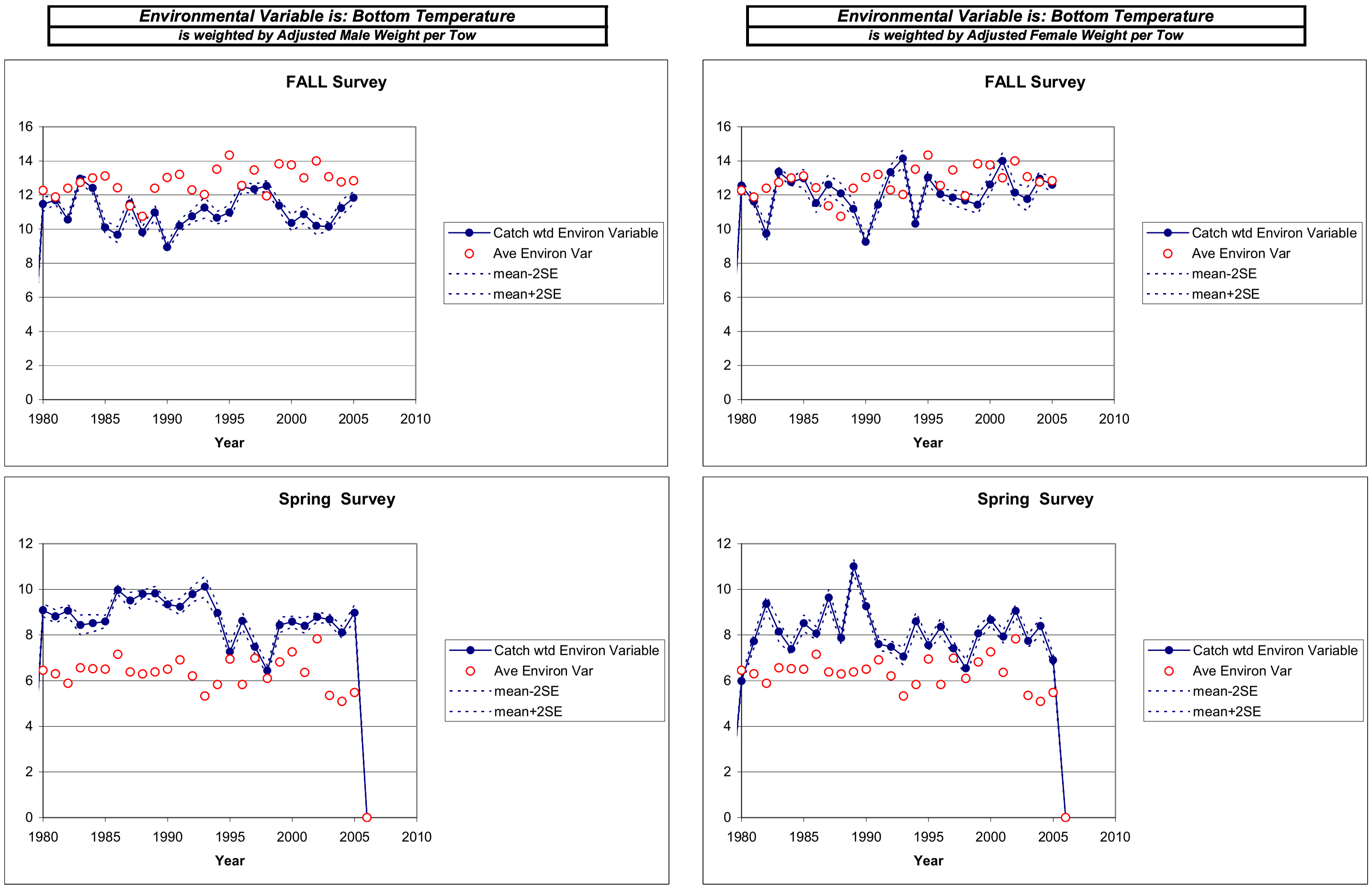


Fig. B5.25 Comparison of average bottom temperature (degrees C) for samples taken in NMFS fall (open dots) and spring surveys with temperatures weighted by male (left) and female (right) spiny dogfish adjusted weight per tow (kg) (closed dots). Adjustments account for effect of gear and vessel changes.

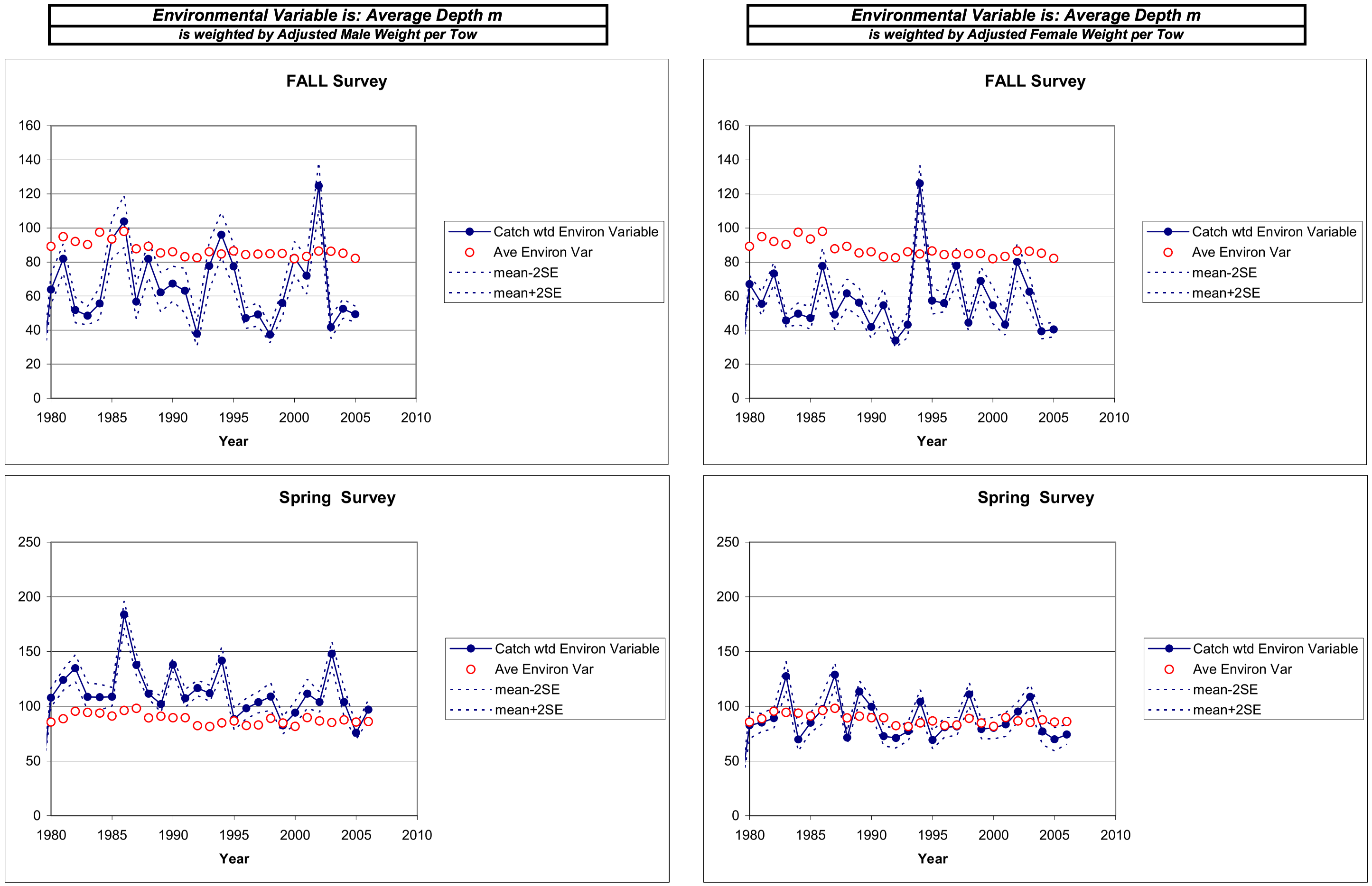


Fig. B5.26 Comparison of average depth (m) for samples taken in NMFS fall (open dots) and spring surveys with depths weighted by male(left) and female(right) spiny dogfish adjusted weight per tow (kg) (closed dots). Adjustments account for effect of gear and vessel changes.

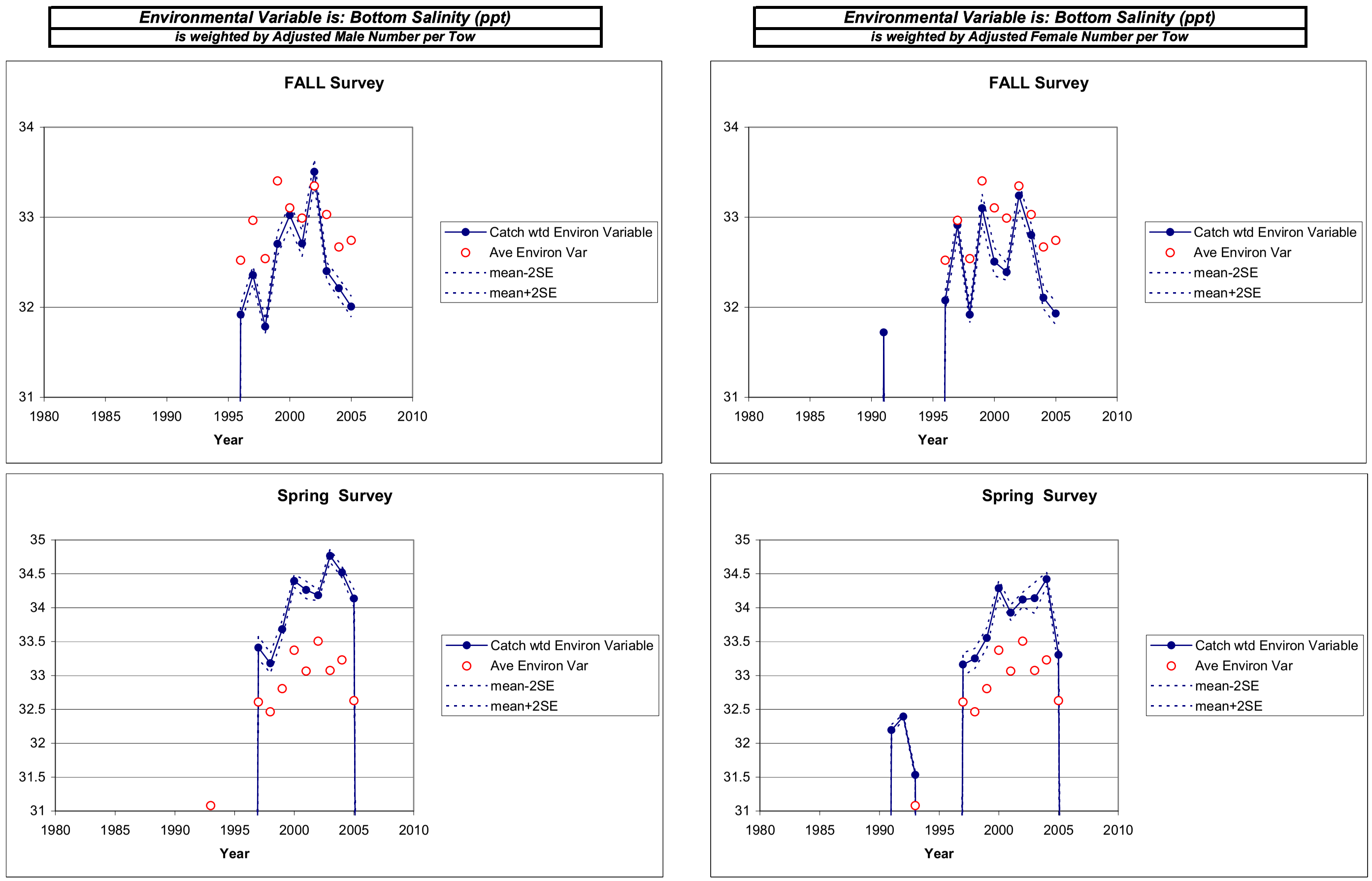
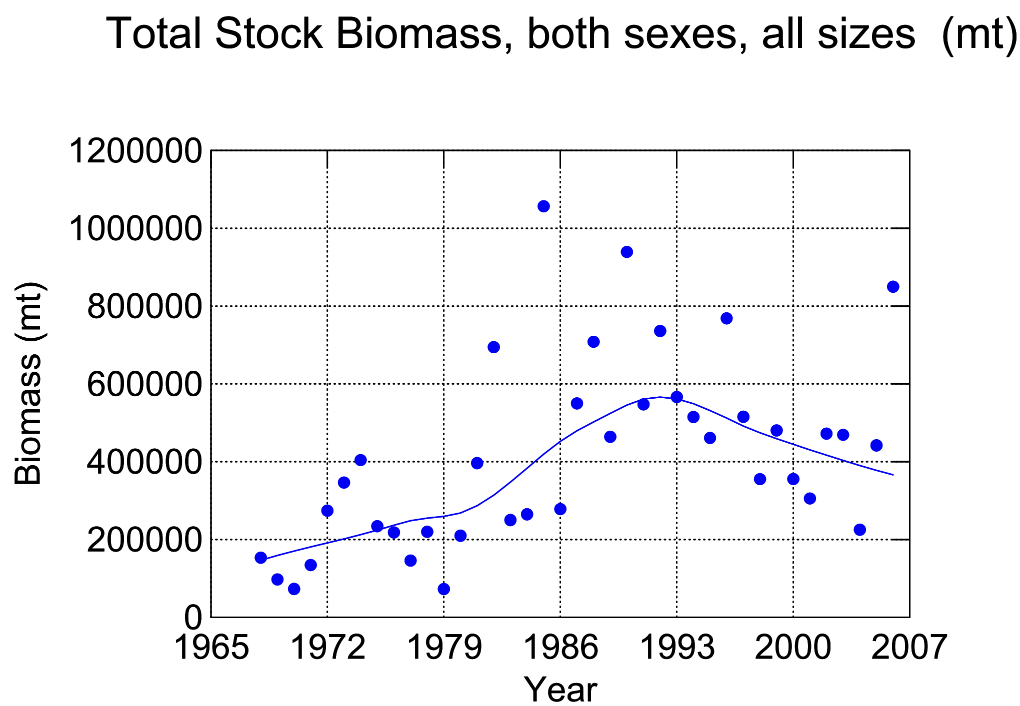


Fig. B5.27 Comparison of average salinity (ppt) for samples taken in NMFS fall (open dots) and spring surveys with salinities weighted by male (left) and female (right) spiny dogfish adjusted weight per tow (kg) (closed dots). Adjustments account for effect of gear and vessel changes. Bottom salinities are not available for all stations.



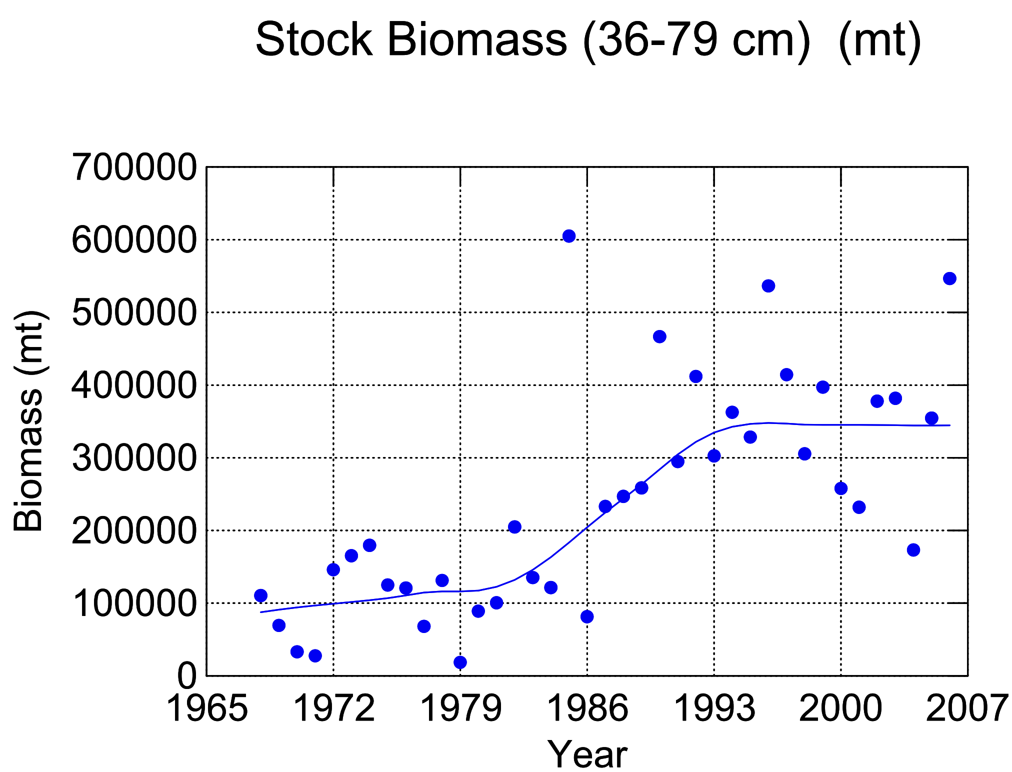


Fig. B6.1 Swept area estimate of total dogfish biomass (000 mt) (top) and biomass of individuals between 36 and 79 cm in spring R/V trawl survey, 1968-2006. Lines represents Lowess smooth with tension factor = 0.5.

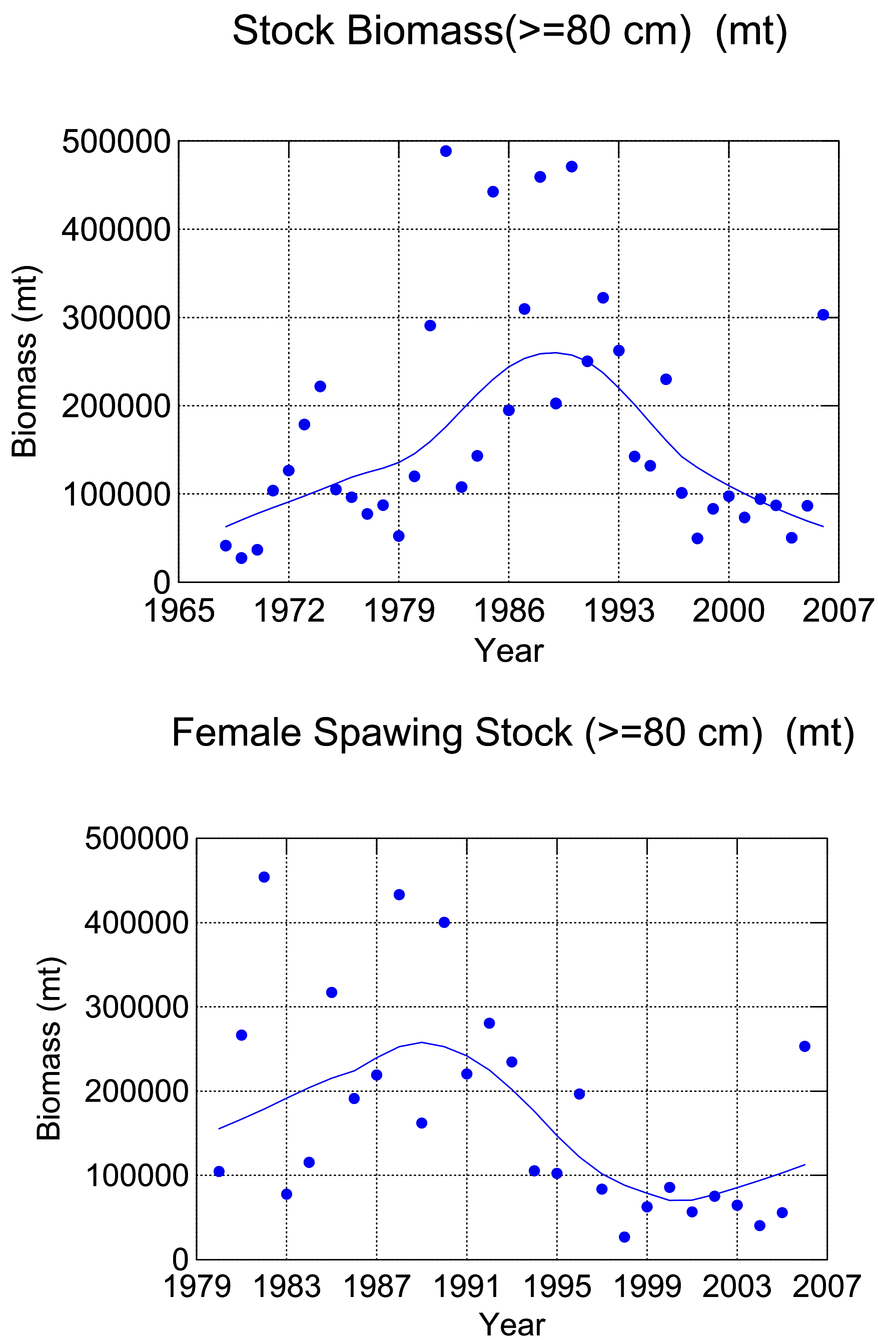
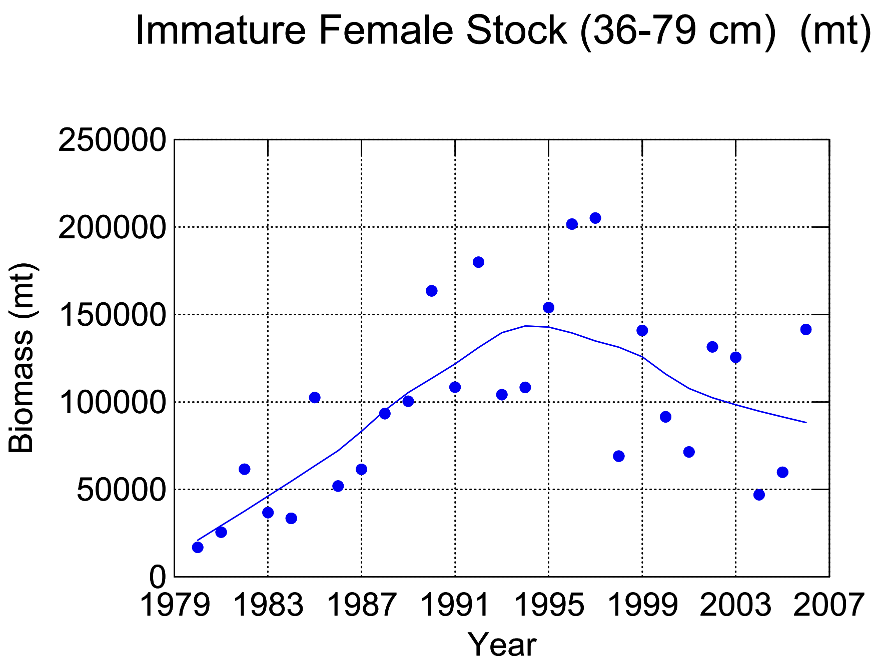


Fig. B6.2 Swept area estimate of dogfish biomass (000 mt) greater than 80 cm, 1968-2006 (top) and for mature females only (bottom), 1980-2006 in spring R/V trawl survey. Line represents Lowess smooth with tension factor = 0.5. Spiny dogfish sex in R/V survey unavailable prior to 1980.



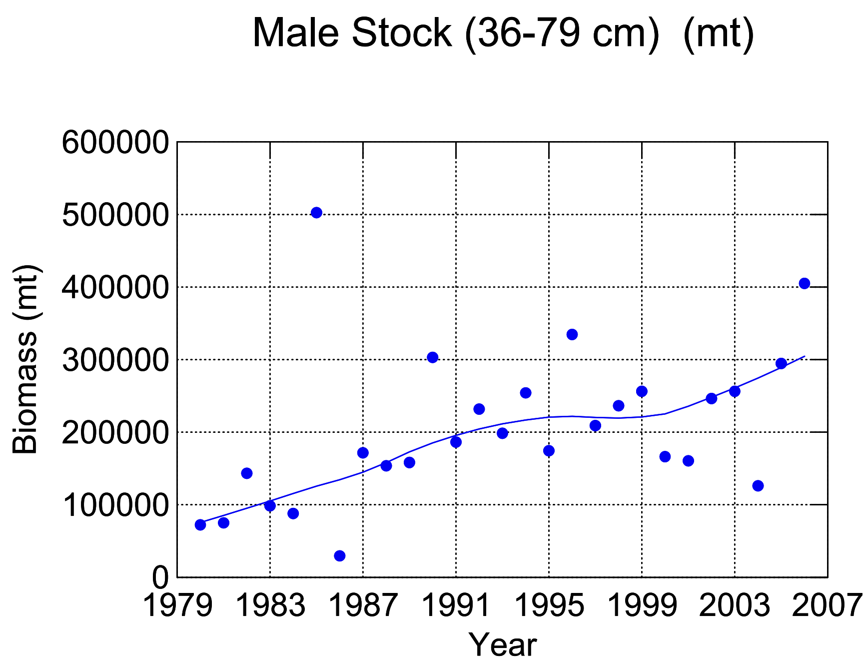


Fig. B6.3 Swept area estimate of female (top) and male (bottom) spiny dogfish biomass (000 mt) 36-79, 1980-2006 in spring R/V trawl survey. Line represents Lowess smooth with tension factor = 0.5. Spiny dogfish sex in R/V survey unavailable prior to 1980.

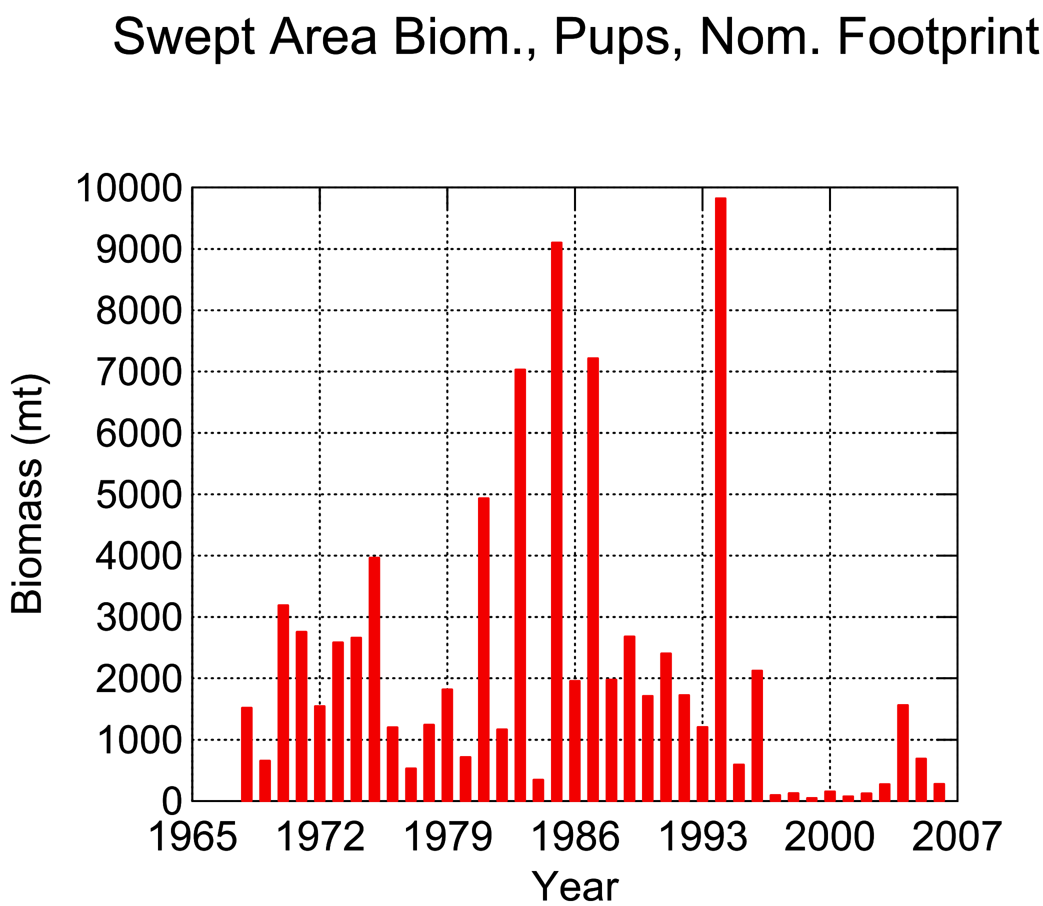


Fig. B6.4 Swept area estimate of dogfish biomass recruits in spring R/V trawl survey, 1968-2006. Recruits defined as individuals less than 36 cm.

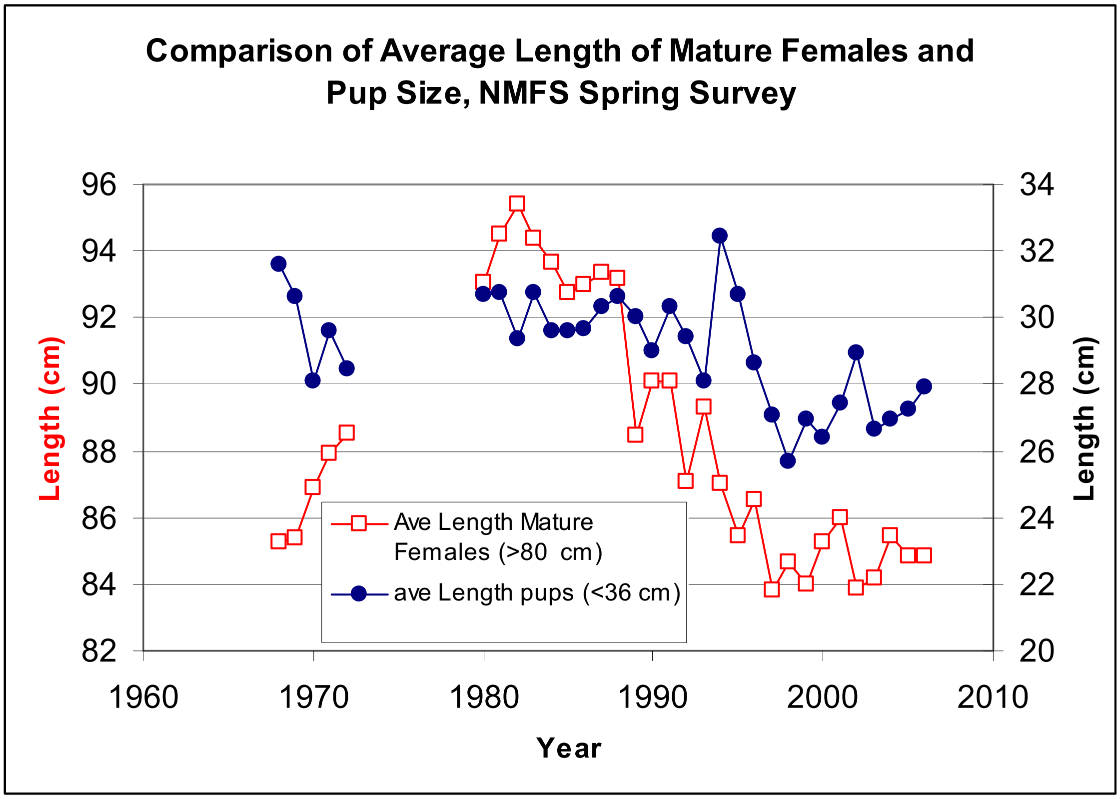


Fig. B6.5 Comparison of average length of mature female spiny dogfish caught in NMFS spring survey and female juvenile dogfish caught in the same year.

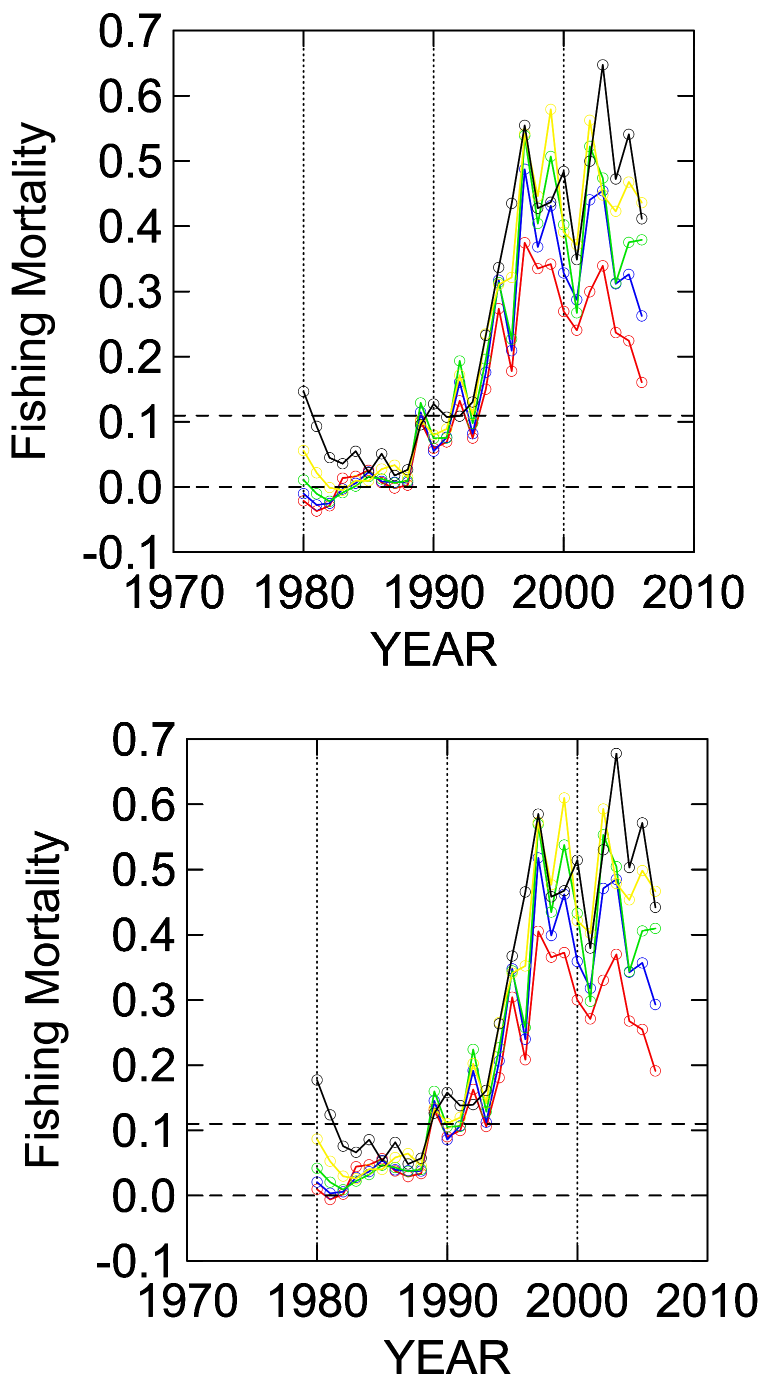


Fig. B7.1. Estimates of F based on Beverton-Holt model for two assumed levels of M and 5 assumed levels of size at entry into the fishery. Estimates are based on a 3-yr moving average of size composition of the NEFSC spring survey, 1980-2006

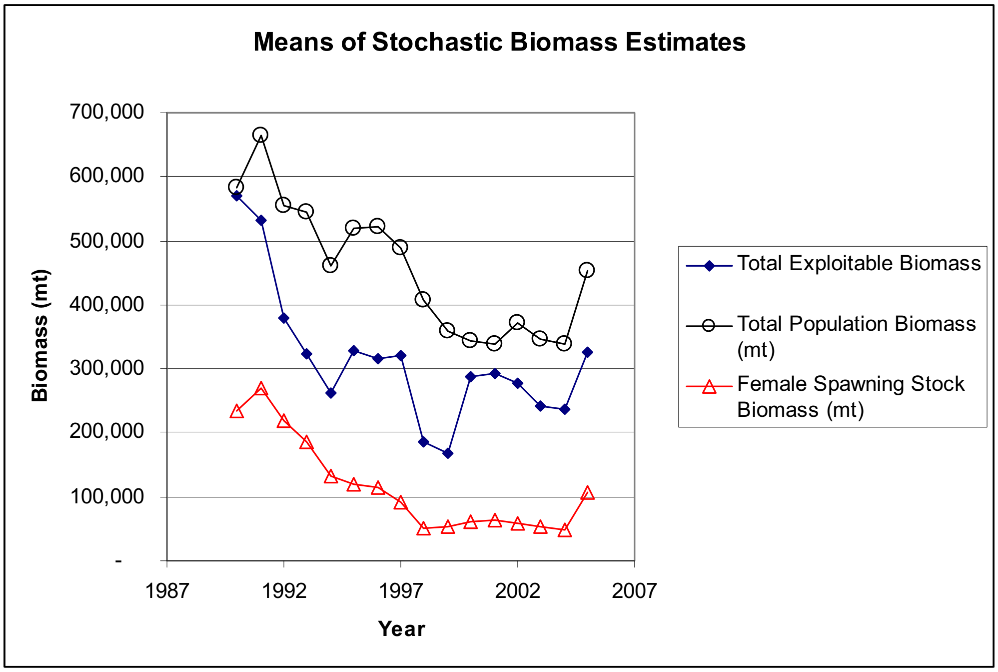


Fig. 7.2. Mean estimates of total, exploitable and mature female biomass from stochastic model. Assumes minimum trawl footprint = 0.01 nm^2.

Mean estimates of biomass from stochastic model. Assumes minimum trawl footprint = 0.01 nm^2. SSB target is 200,000 mt.

Year	Total Exploitable Biomass	Exploitable Female Biomass (mt)	Exploitable Male Biomass (mt)	Total Population Biomass (mt)	Female Spawning Stock Biomass (mt)	Fraction > SSB target
1990	570,113	339,405	230,208	582,274	234,229	0.706344
1991	532,641	278,419	253,722	664,850	269,624	0.840524
1992	379,501	169,227	209,773	553,731	220,002	0.658844
1993	322,345	93,716	228,128	544,415	186,132	0.347196
1994	261,387	55,102	205,785	460,932	133,264	0.000284
1995	329,048	77,600	250,948	519,920	120,664	0.00324
1996	316,075	81,413	234,162	520,782	114,091	0.000788
1997	319,828	69,005	250,323	489,233	91,458	0
1998	185,468	77,142	107,825	406,287	51,821	0
1999	167,483	66,023	100,960	358,185	52,562	0
2000	286,458	96,233	189,725	343,602	61,552	0
2001	291,695	107,026	184,169	337,686	64,844	0
2002	278,283	63,794	213,989	371,200	58,376	0
2003	241,697	39,745	201,452	347,176	53,625	0
2004	237,536	17,432	219,604	338,170	47,719	0
2005	327,077	54,587	271,991	453,881	106,180	0

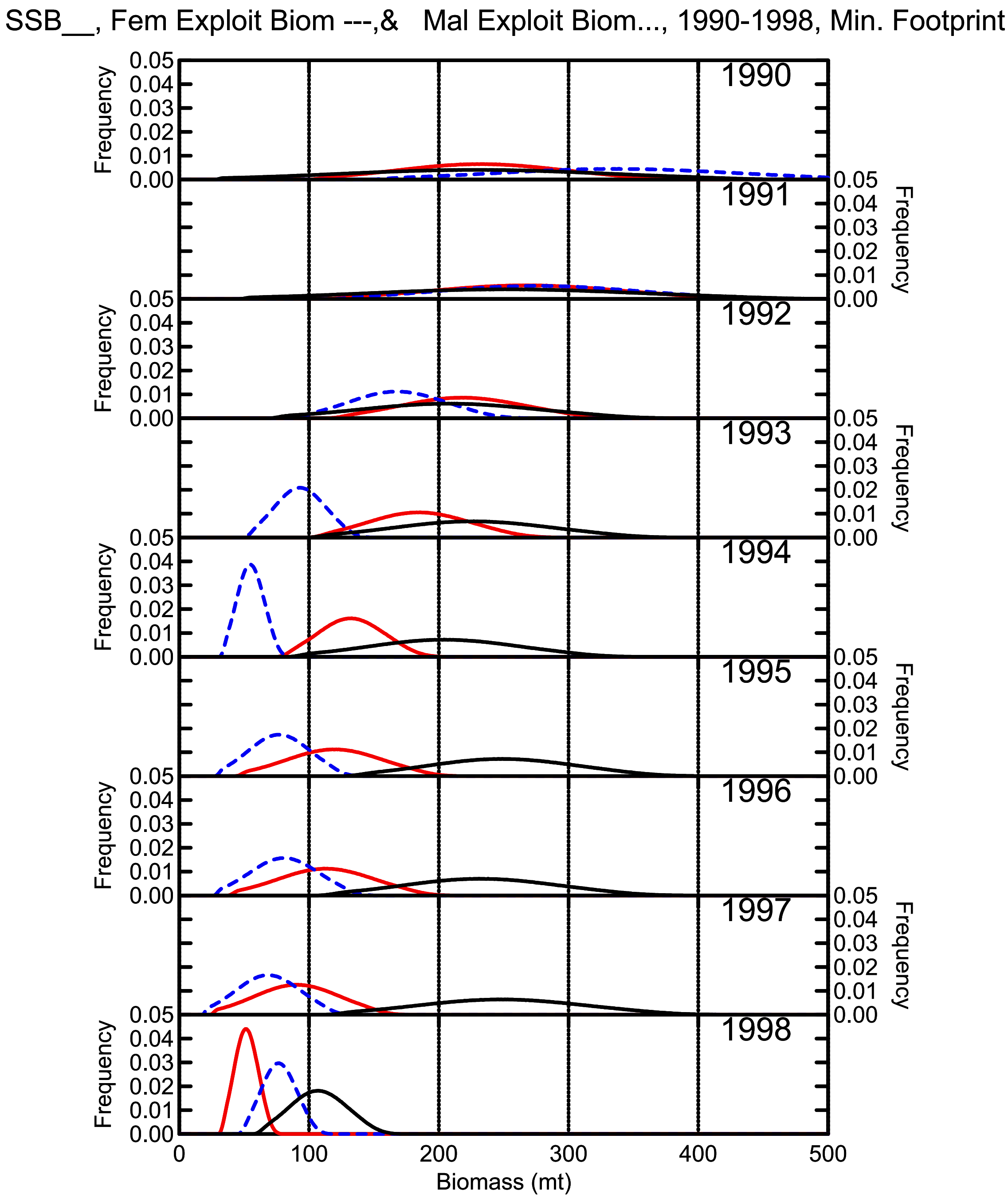


Fig. B7.3a. Sampling distribution of population biomass for mature females (red), exploited female (dashed), and exploited male biomass (black), 1990-1998. Years represent midpoint of 3-yr average; i.e., 1998 is average for 1997-1999. Sampling distribution represents joint effect of sampling variability and variations in average footprint of trawl (min estimate of footprint, assumes no herding effect of doors).

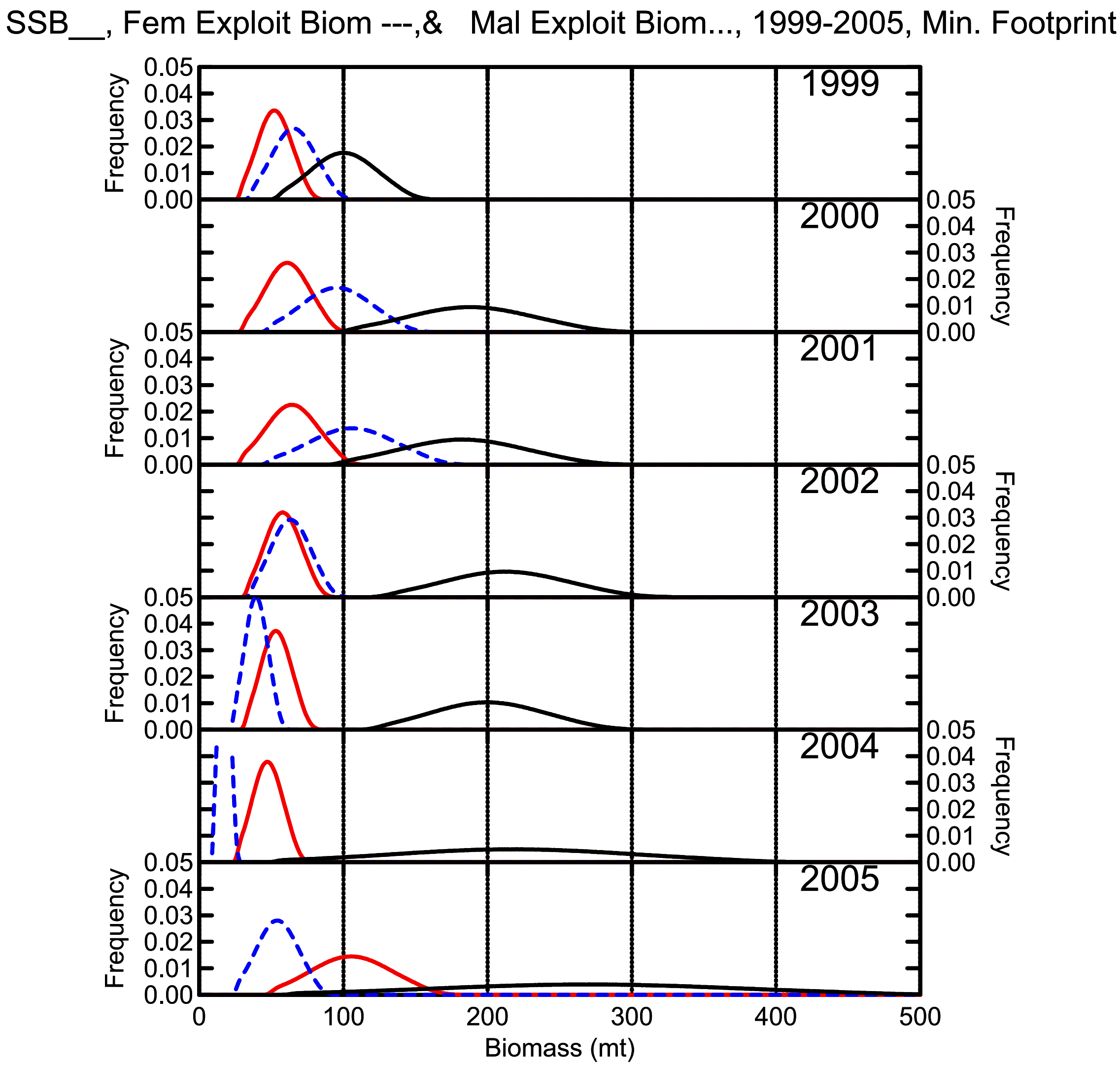


Fig. B7.3b. Sampling distribution of population biomass for mature females (red), exploited female (dashed), and exploited male biomass (black), 1990-1998. Years represent midpoint of 3-yr average; i.e., 2005 is average for 2004-2006. Sampling distribution represents joint effect of sampling variability and variations in average footprint of trawl (min estimate of footprint, assumes no herding effect of doors).

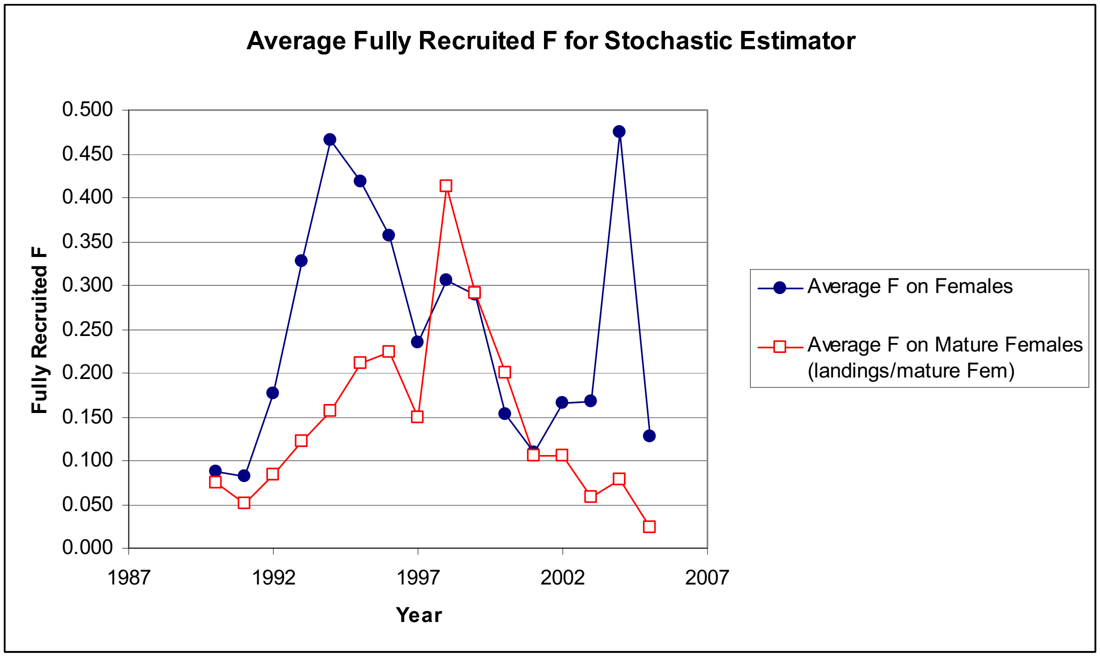


Fig. 7.4 Average fully recruited F derived from stochastic F estimator. Average F on mature females represents ratio of female landings to mature (>80 cm) spiny dogfish.

Year	Average F on Females	Average F on Mature Females (landings/mature Fem)
1990	0.088	0.074
1991	0.082	0.050
1992	0.177	0.083
1993	0.327	0.121
1994	0.465	0.156
1995	0.418	0.211
1996	0.355	0.223
1997	0.234	0.149
1998	0.306	0.413
1999	0.289	0.292
2000	0.152	0.201
2001	0.109	0.106
2002	0.165	0.105
2003	0.168	0.058
2004	0.474	0.078
2005	0.128	0.024

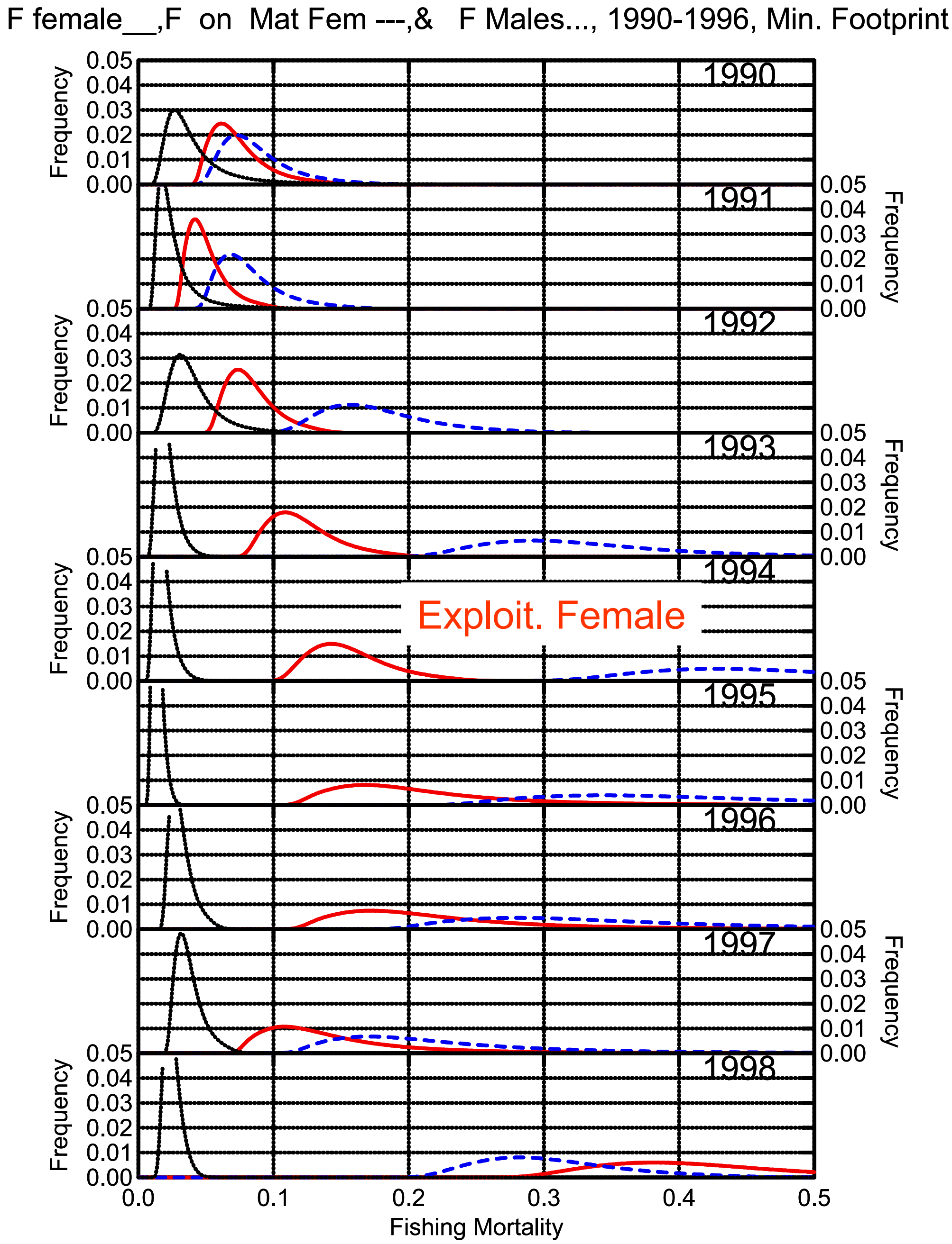


Fig.B 7.5a. Sampling distribution of F on fully recruited sizes for mature females (blue dashed), exploited female (solid red), and exploited male biomass (black dashed), 1990-1998. Years represent midpoint of 3-yr average; i.e., 1998 is average for 1997-1999. Sampling distribution represents joint effect of sampling variability and variations in average footprint of trawl (min estimate of footprint, assumes no herding effect of doors), variation in discards in trawl, gill net and recreational fisheries, and annual changes in selectivity patterns.

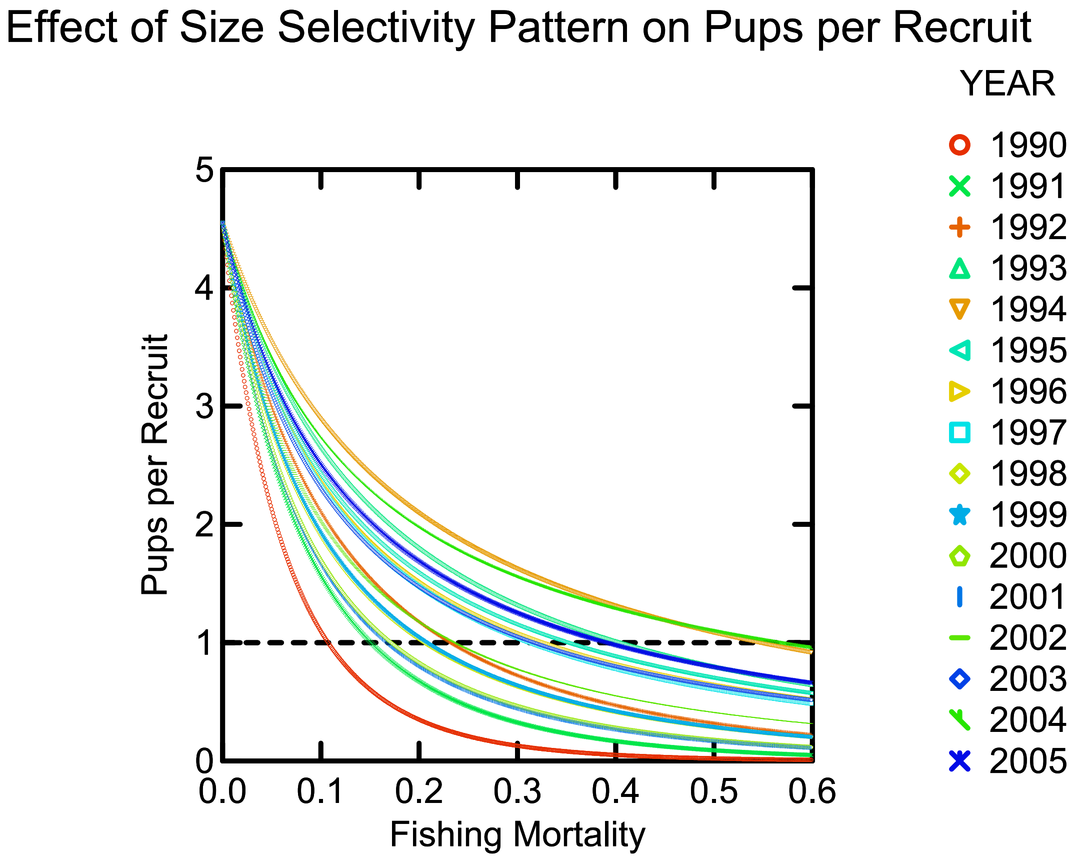


Fig. B7.6 Effect of size selectivity of fishery and F on the expected pups per recruit. Abscissa represents F on fully-recruited length classes. Selectivity changes vary across years due to changes in commercial landings patterns and varying degrees of discard mortality. Selectivity patterns are described in Appendix xx

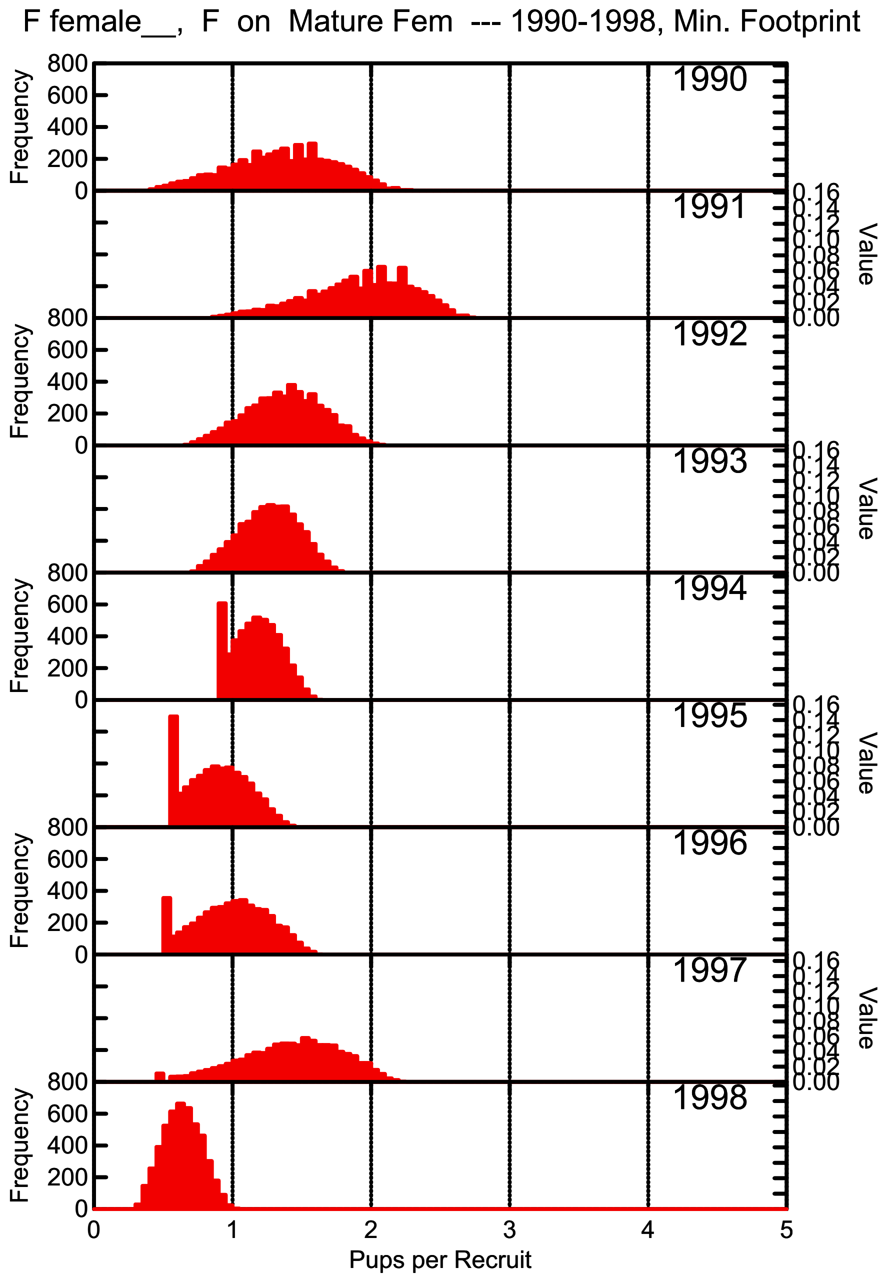


Fig. B7.7a Predicted sampling distribution for pups per recruit given variations in size selectivity and fishing mortality, 1990-1998. Pups per recruit represents integral measure of the force of mortality on longterm reproductive potential. Year represents a 3-yr average centered on the year label, i.e., 1998 is average for 1997-1999. PPR values above one suggest that the force of mortality is low enough to allow population growth. Histograms represents effect of landings plus discards on entire population of female spiny dogfish.

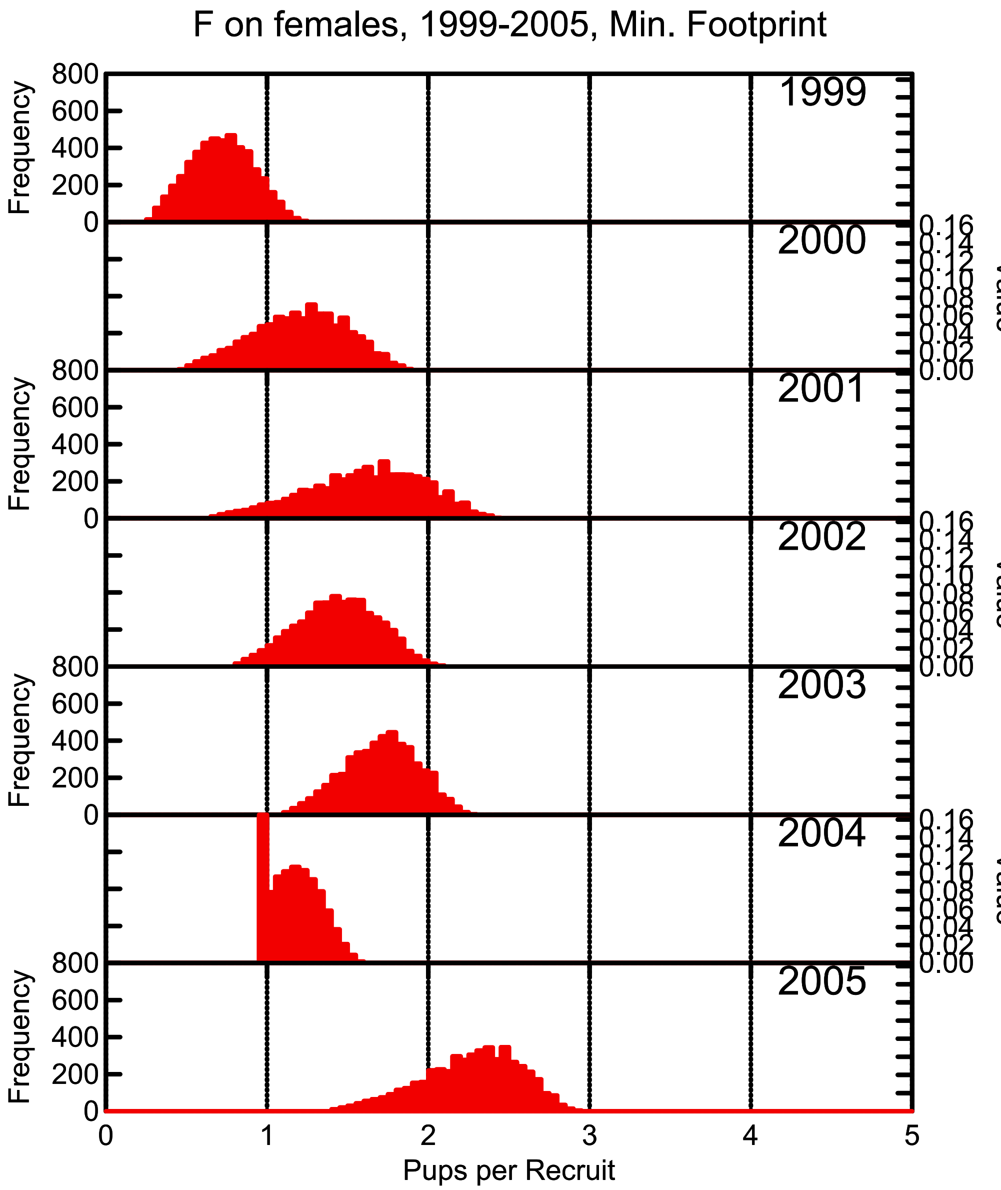
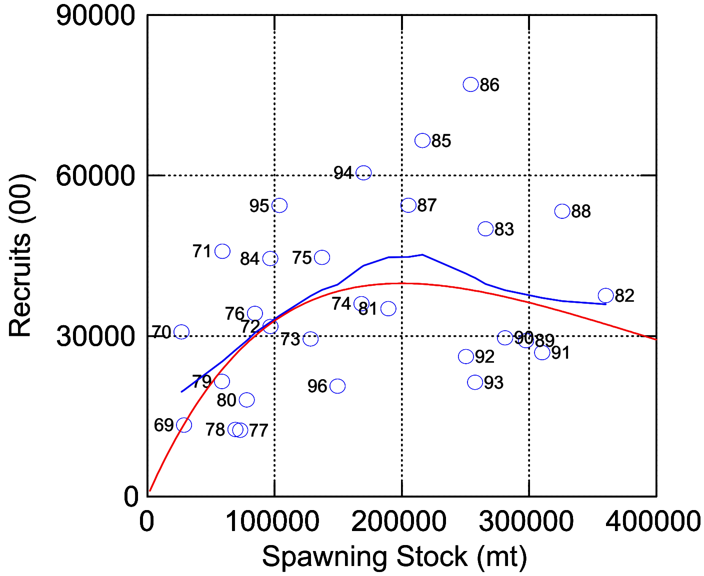


Fig. B7.7b Predicted sampling distribution for pups per recruit given variations in size selectivity and fishing mortality, 1999-2005. Pups per recruit represents integral measure of the force of mortality on longterm reproductive potential. Year represents a 3-yr average centered on the year label, i.e., 1998 is average for 1997-1999. PPR values above one suggest that the force of mortality is low enough to allow population growth. Histograms represents effect of landings plus discards on entire population of female spiny dogfish.

1968-1996 data



1968-2006 data

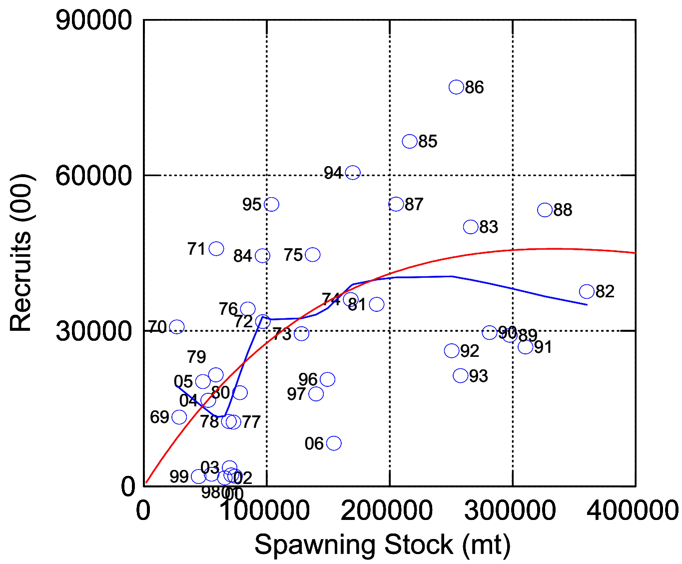


Fig. B8.1 Comparison of parametric and non-parametric stock-recruitment model fits for spiny dogfish captured in NMFS spring survey for 1968-1996 (top) and 1968-2006 (bottom). Nonparametric model fits base on lowess smoothes with tension=0.6. Estimated SSBmax, 1968-1996 of 215 k mt, corresponds to average catch of 33.2 kg mature females/tow. Estimated SSBmax for the 1968-2006 period increases to 304 k mt or 46.8 k mt.

1968-2006 data

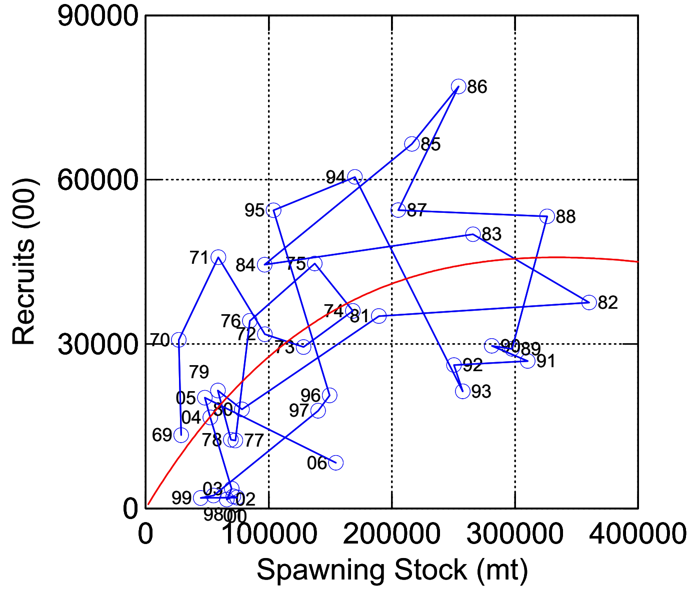


Fig. B8.2 Temporal pattern of .spawning stock and recruits for 1968-2006. Swept area estimates of abundance based on NMFS spring survey.

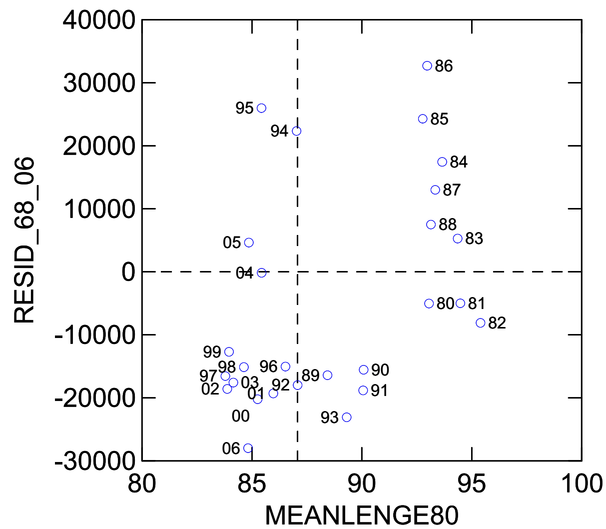


Fig. B8.3 Model residuals from Ricker model vs mean length of mature female spiny dogfish. Odds ratio test statistic suggests that odds of recruitment less than model prediction is of 4.5 times greater when females are below median size of 87 cm.

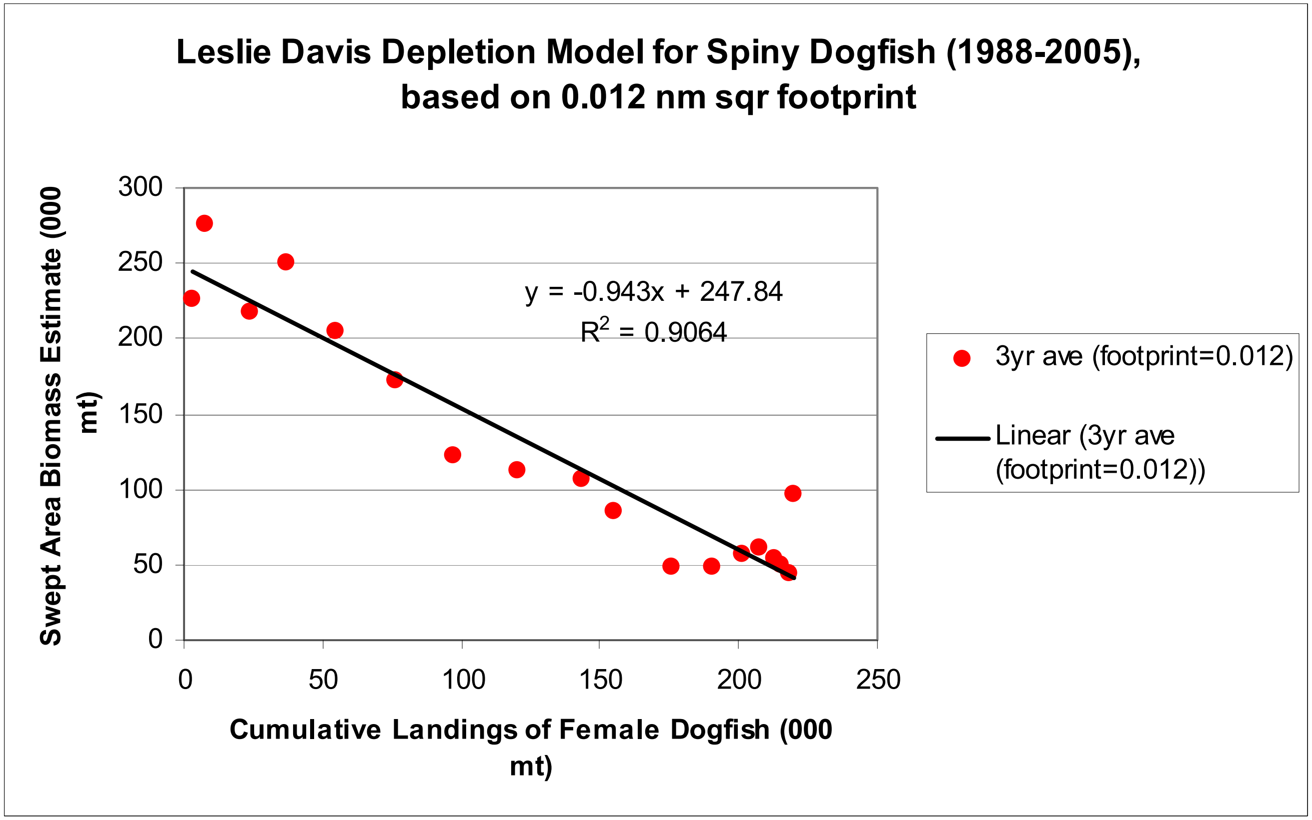


Fig. B9.1 Summary of Leslie Davis depletion model for female spiny dogfish, assuming a closed population.

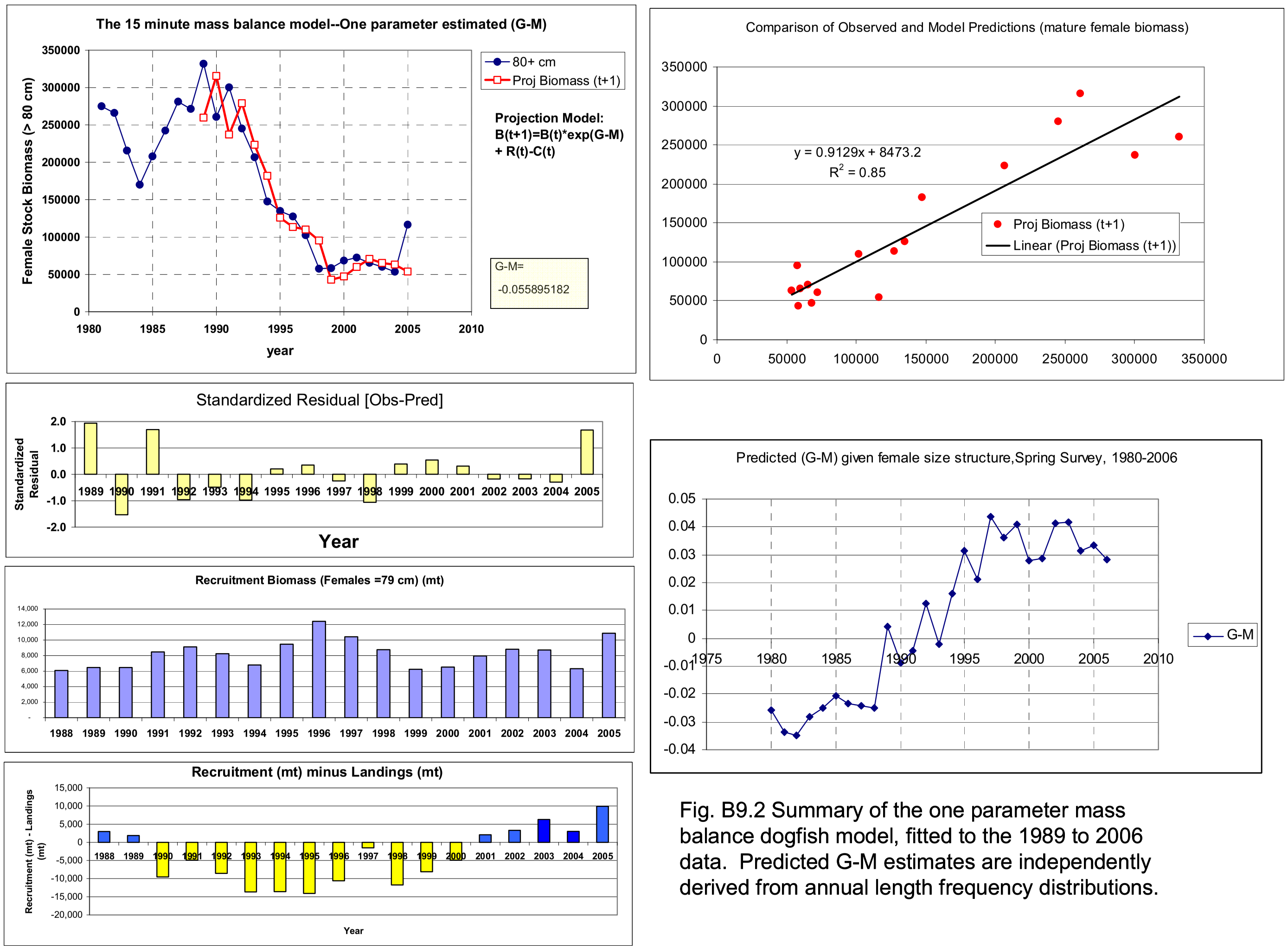


Fig. B9.2 Summary of the one parameter mass balance dogfish model, fitted to the 1989 to 2006 data. Predicted G-M estimates are independently derived from annual length frequency distributions.

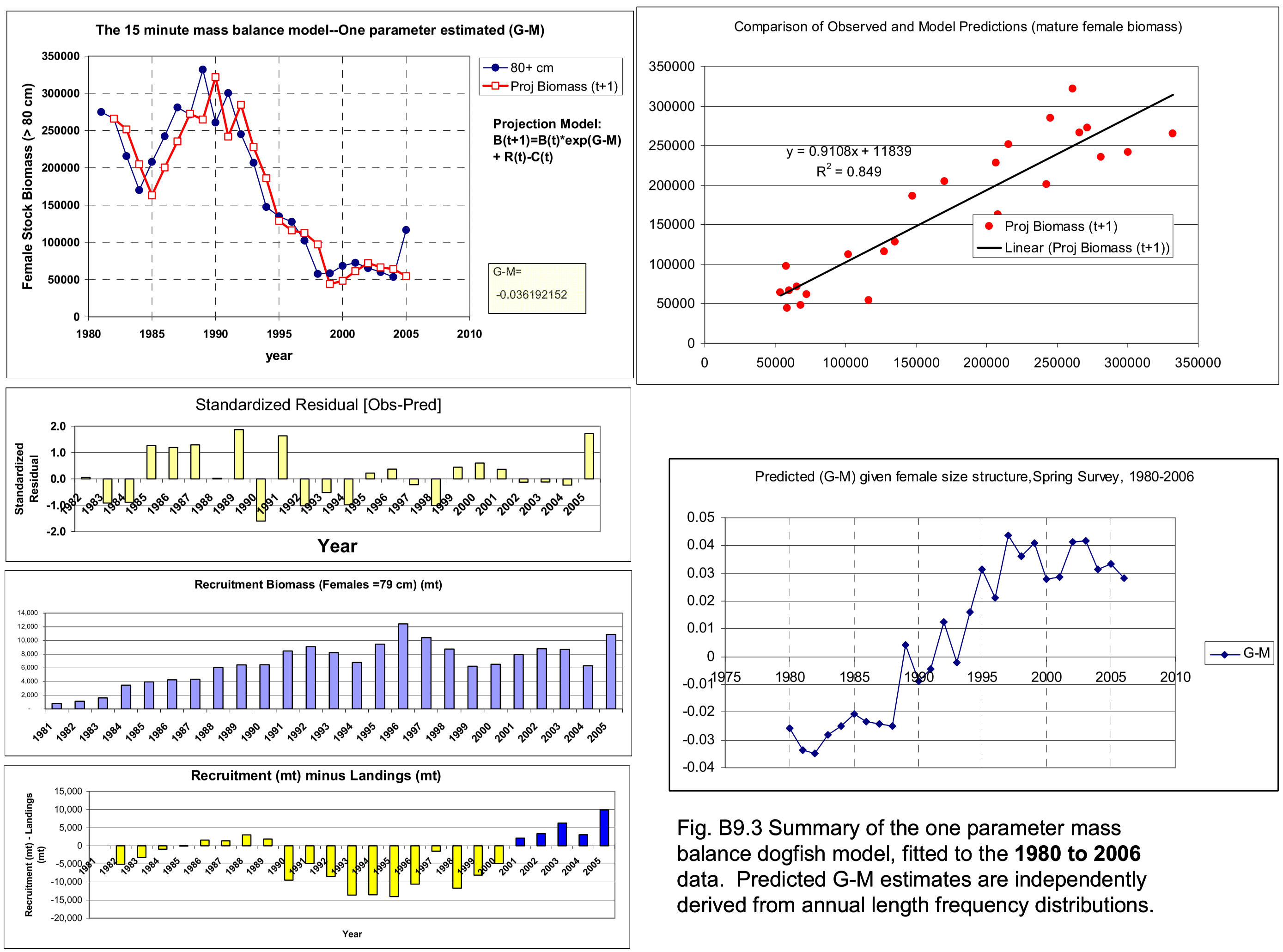


Fig. B9.3 Summary of the one parameter mass balance dogfish model, fitted to the **1980 to 2006** data. Predicted G-M estimates are independently derived from annual length frequency distributions.

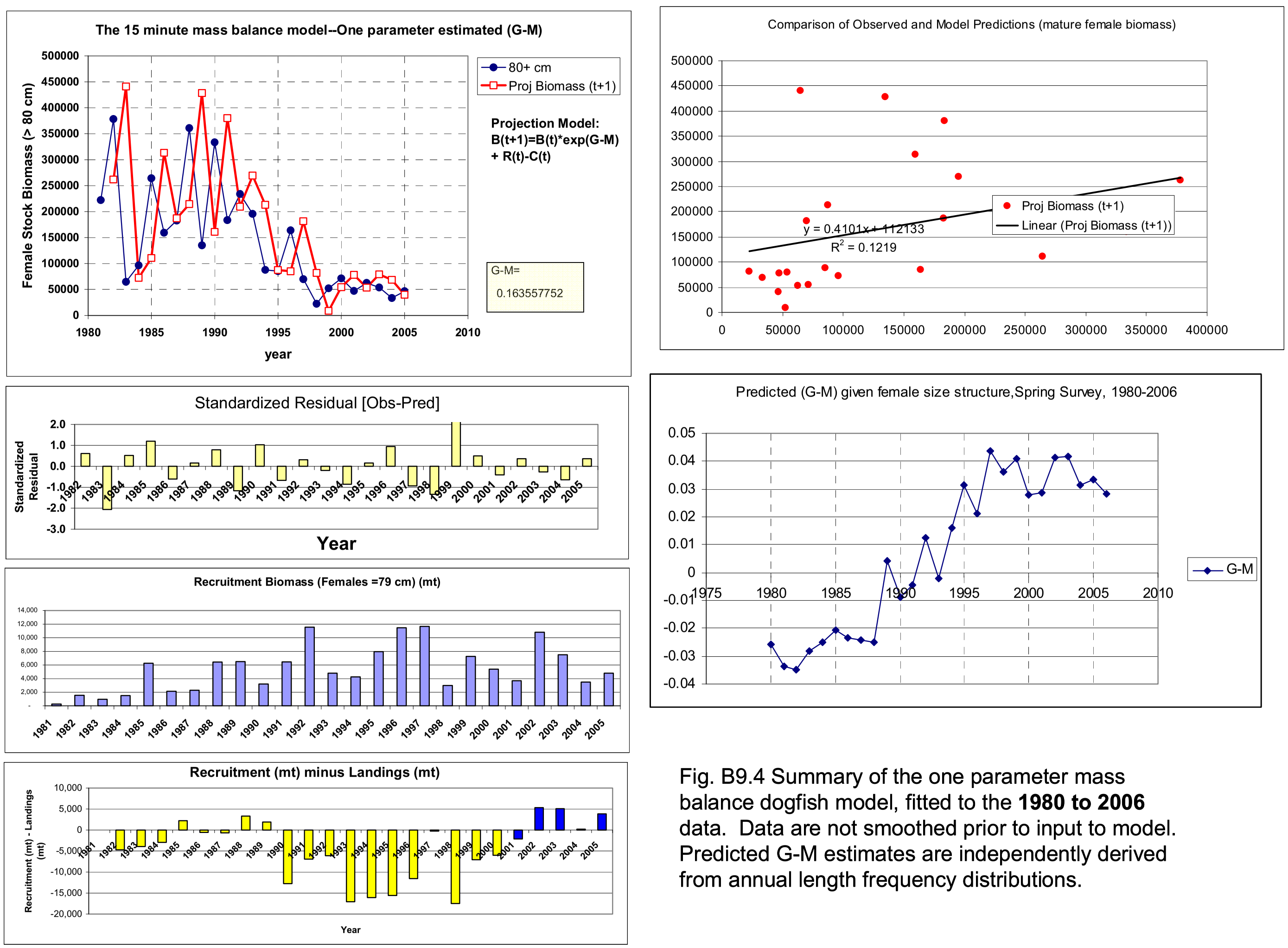


Fig. B9.4 Summary of the one parameter mass balance dogfish model, fitted to the **1980 to 2006** data. Data are not smoothed prior to input to model. Predicted G-M estimates are independently derived from annual length frequency distributions.

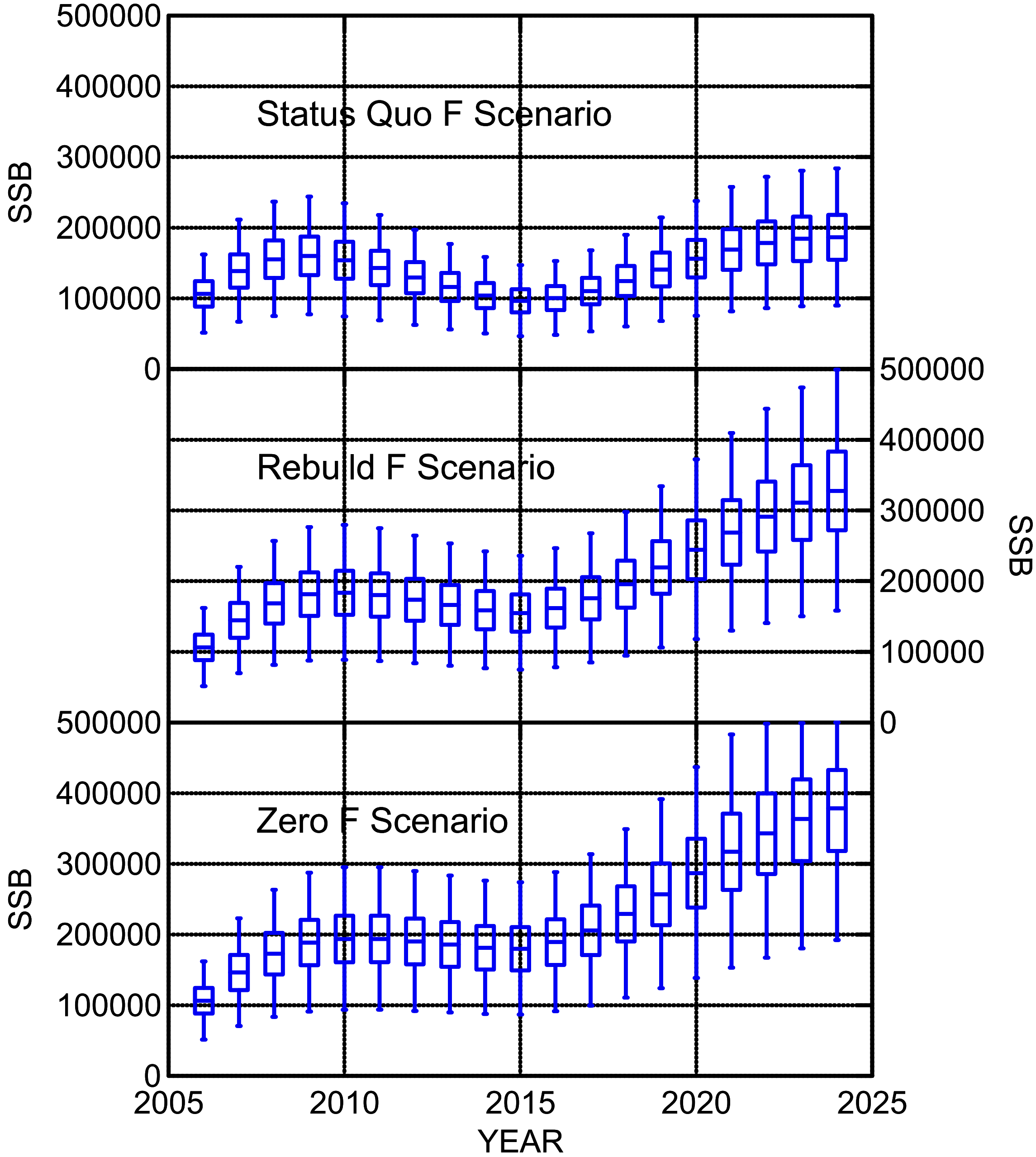


Figure B10.1. Spiny dogfish spawning stock biomass (mt) projections, 2006-2024, for three scenarios: Status quo (full F=0.128), Rebuild F(=0.03), and Zero F. Boxes represent interquartile ranges.