Figures

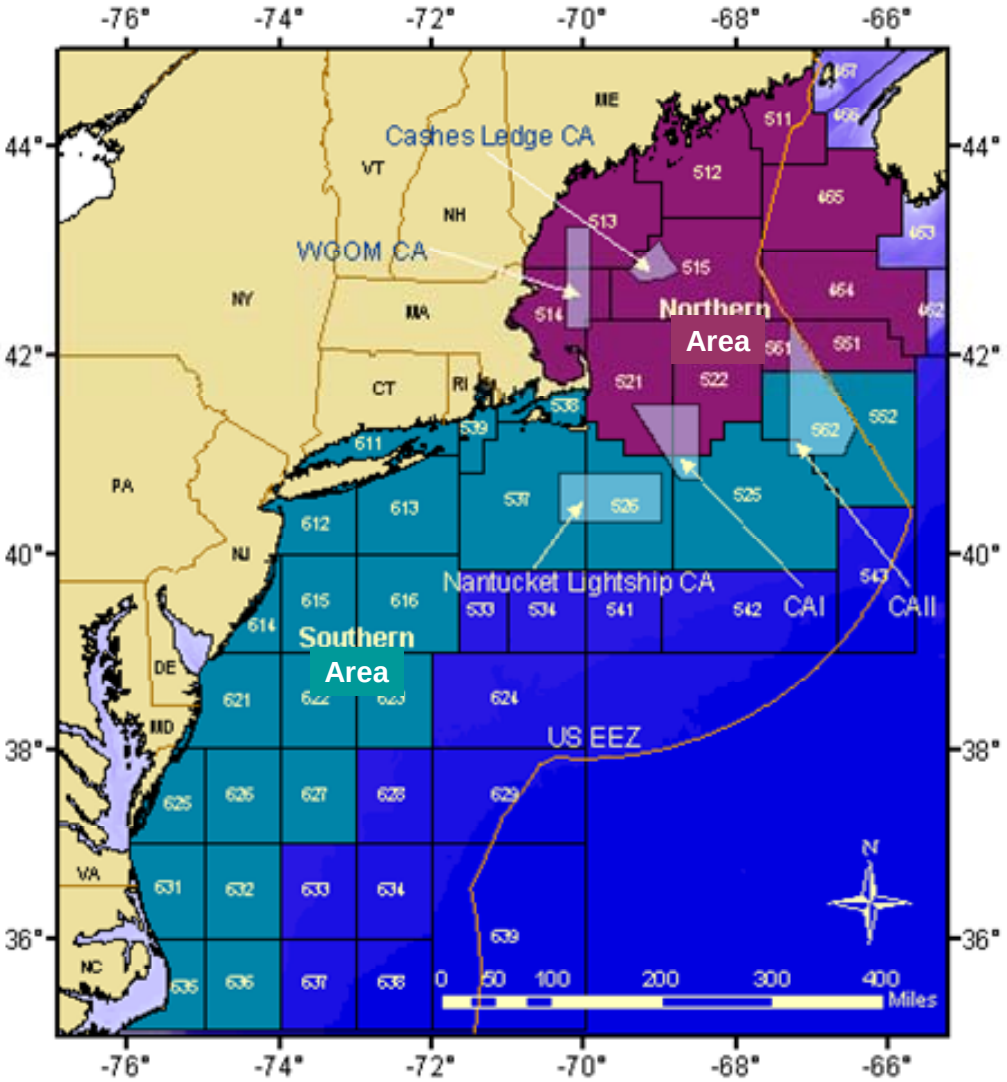


Figure A1. Statistical areas used to define the northern and southern monkfish management areas (from Richards 2006).

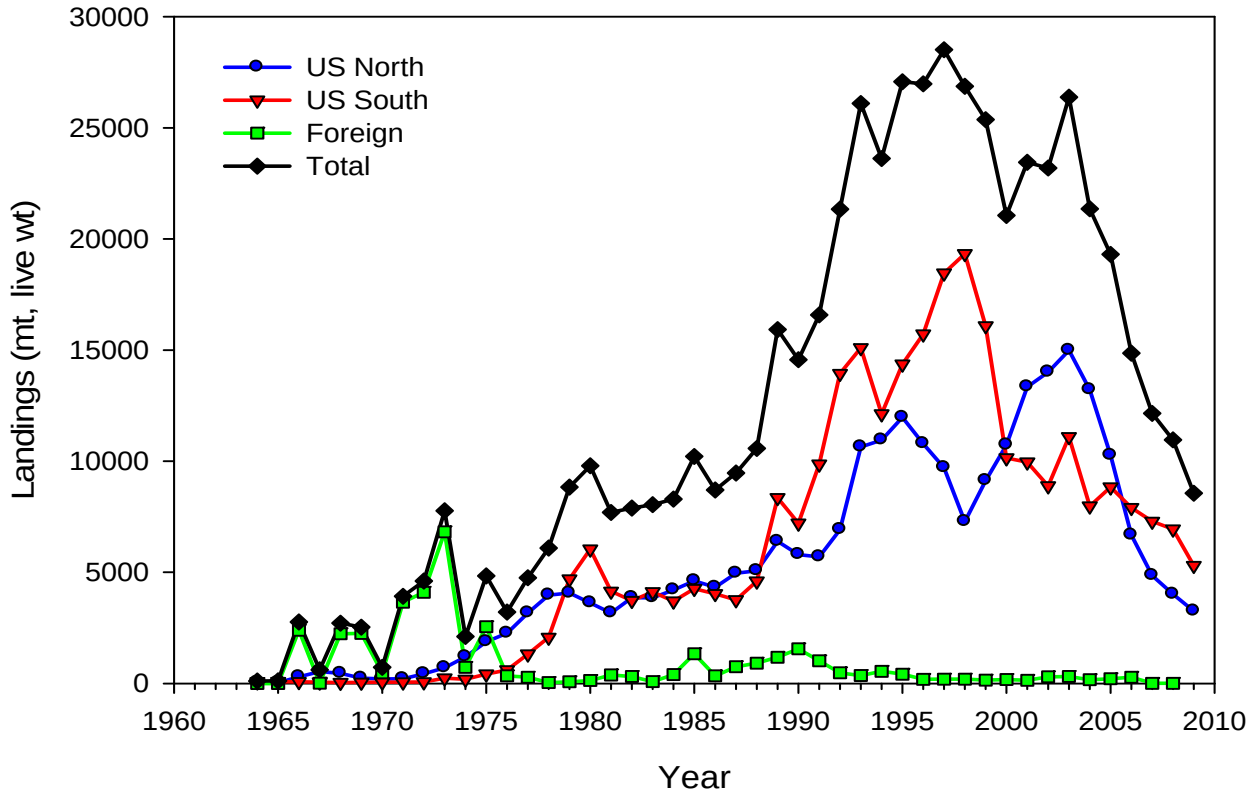


Figure A2. Monkfish landings, by management area and total, 1964-2009.

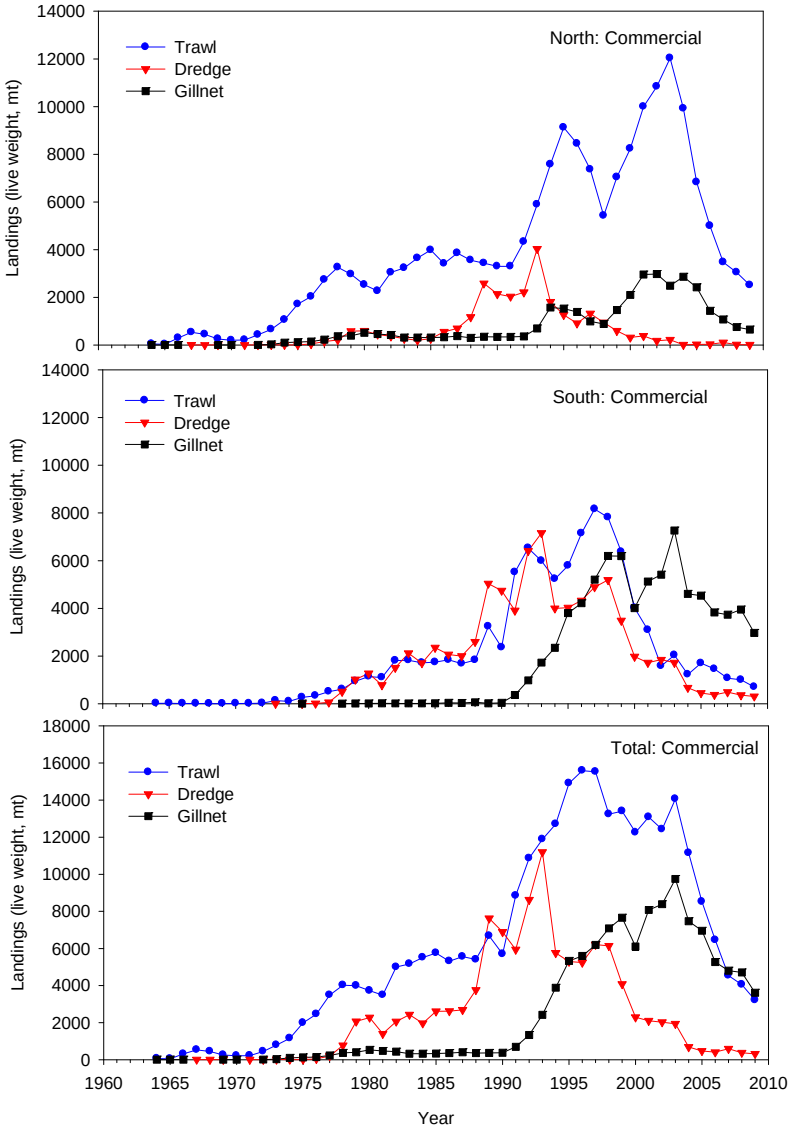


Figure A3. Commercial landings for monkfish by gear type and area.

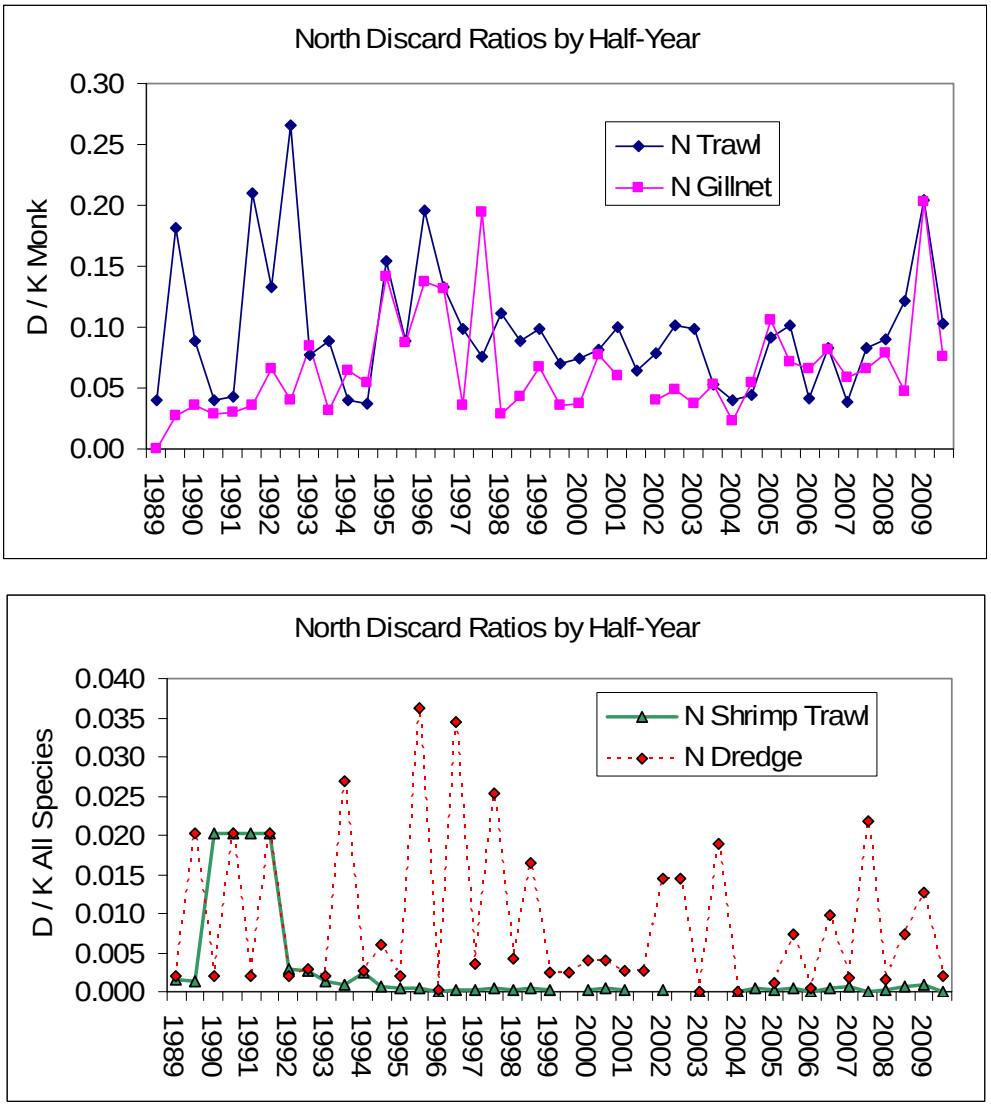


Figure A4. Discard ratios (mt monkfish discarded/mt all species landed) of goosefish by gear and half year using the SBRM methodology in the northern area. Gillnet 2001 half=2 and dredge 2004 half=2 are not shown to preserve scale.

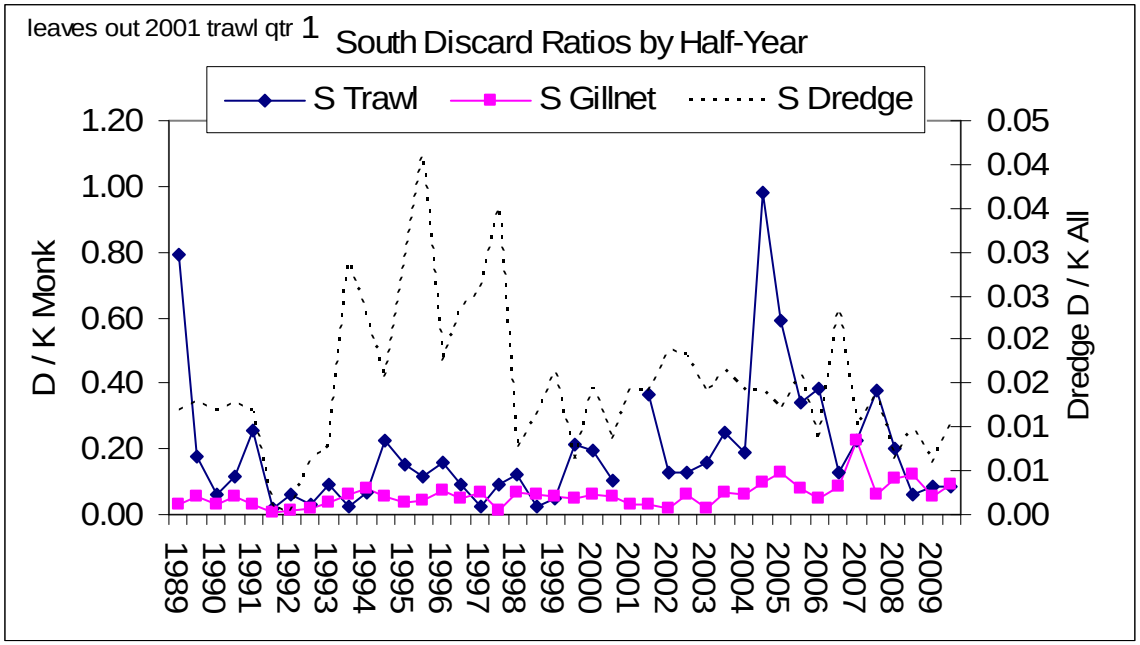


Figure A5. Discard ratios (mt monkfish discarded/mt all species landed) of goosefish by gear and half year using the SBRM methodology in the southern area. Trawl 2001 half=1 not shown to preserve scale.

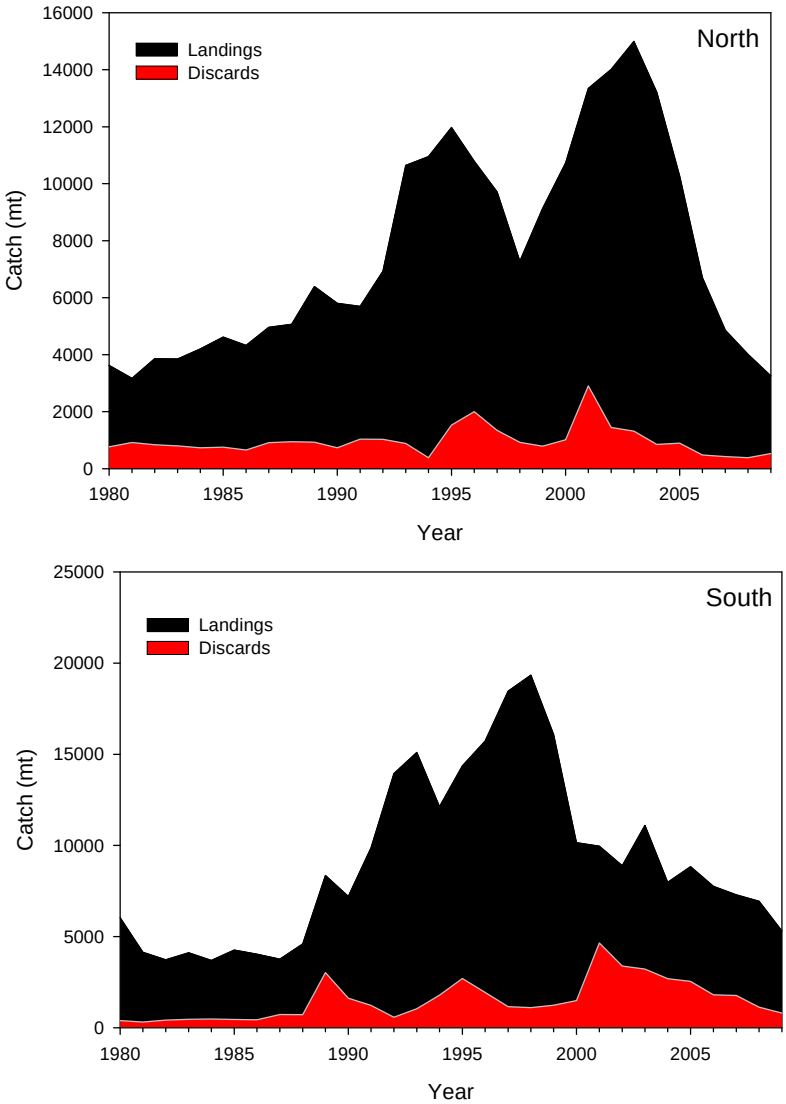


Figure A6. Annual catch of monkfish by management area.

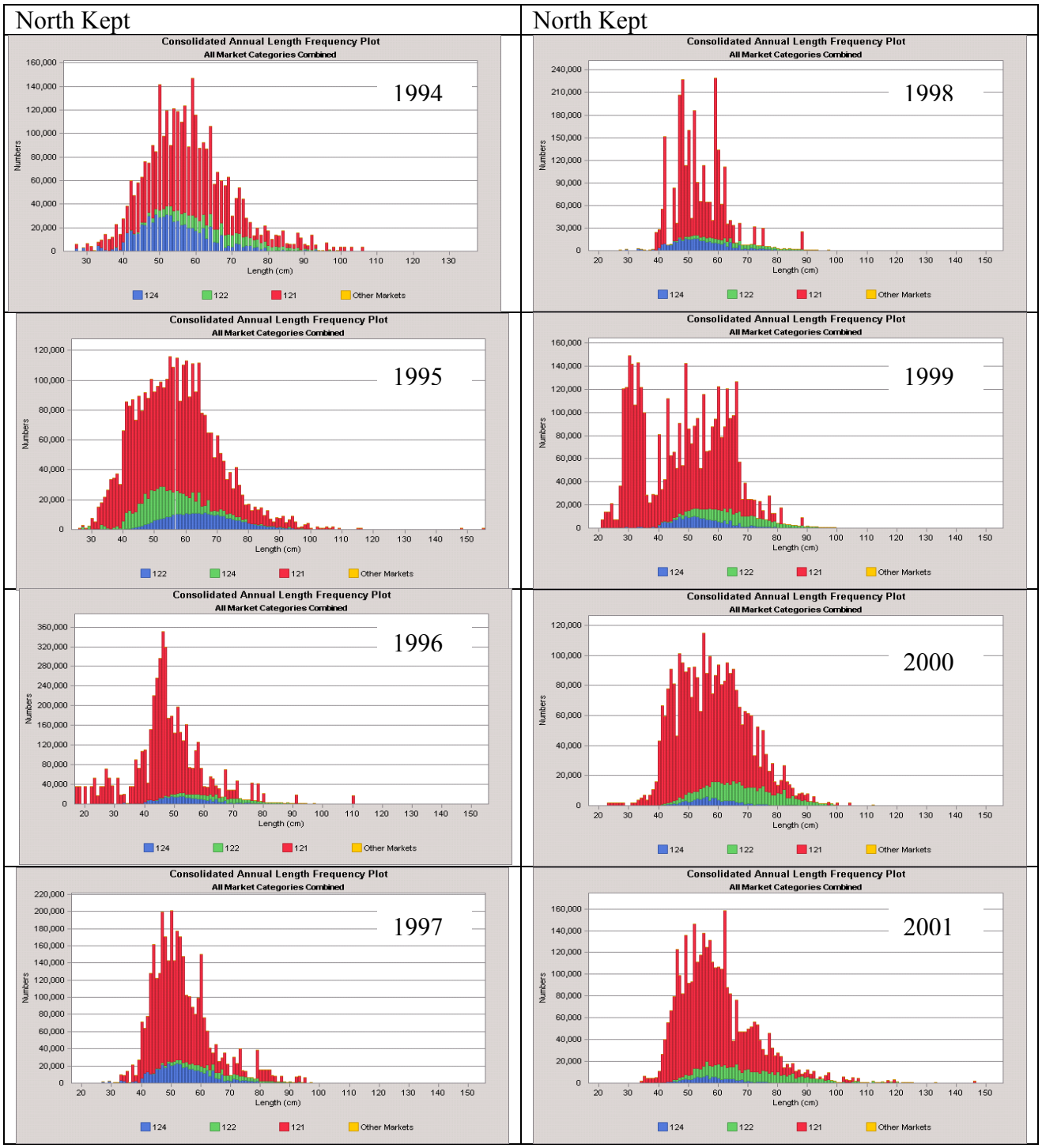


Figure A7. Northern management area, landings at length by gear type, estimated using data from fishery observers. Red=trawls, green=gillnets, blue=dredges, gold=other.

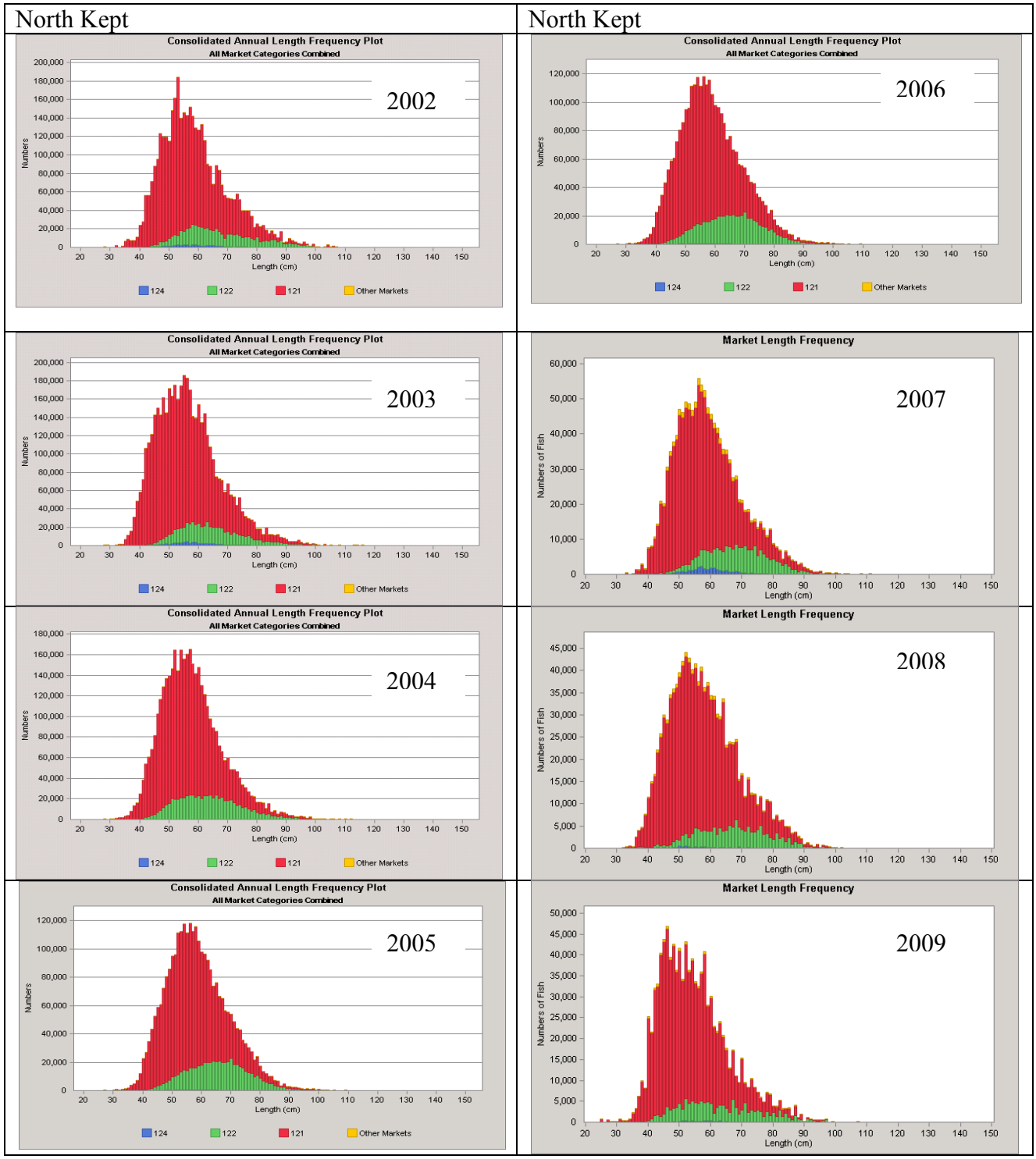


Figure A7, continued. Northern management area, landings at length by gear type, estimated using data from fishery observers. Red=trawls, green=gillnets, blue=dredges, gold=other.

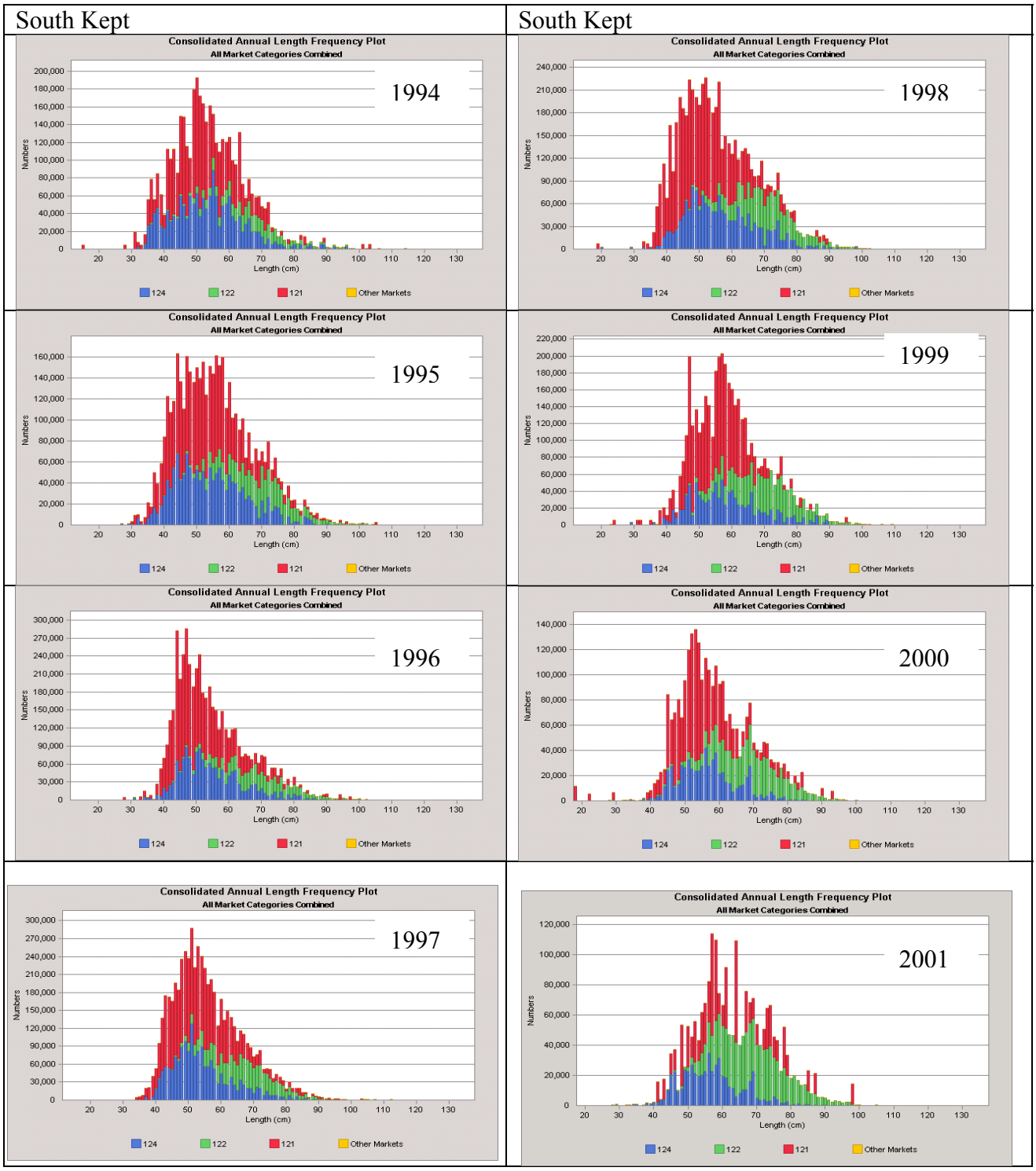


Figure A8. Southern management area, landings at length by gear type, estimated using data from fishery observers. Red=trawls, green=gillnets, blue=dredges, gold=other.

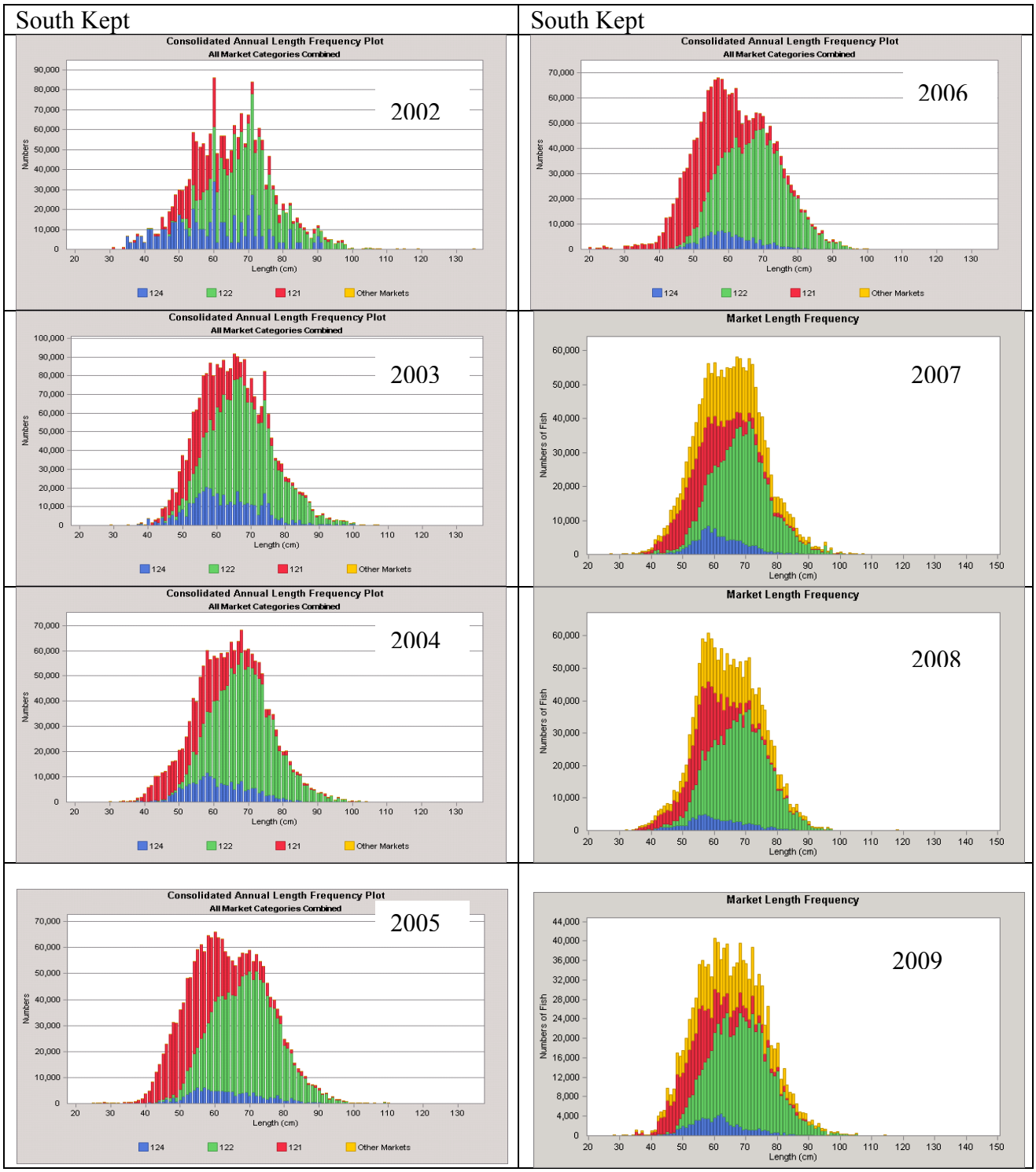


Figure A8, continued. Southern management area, landings at length by gear type, estimated using data from fishery observers. Red=trawls, green=gillnets, blue=dredges, gold=other.

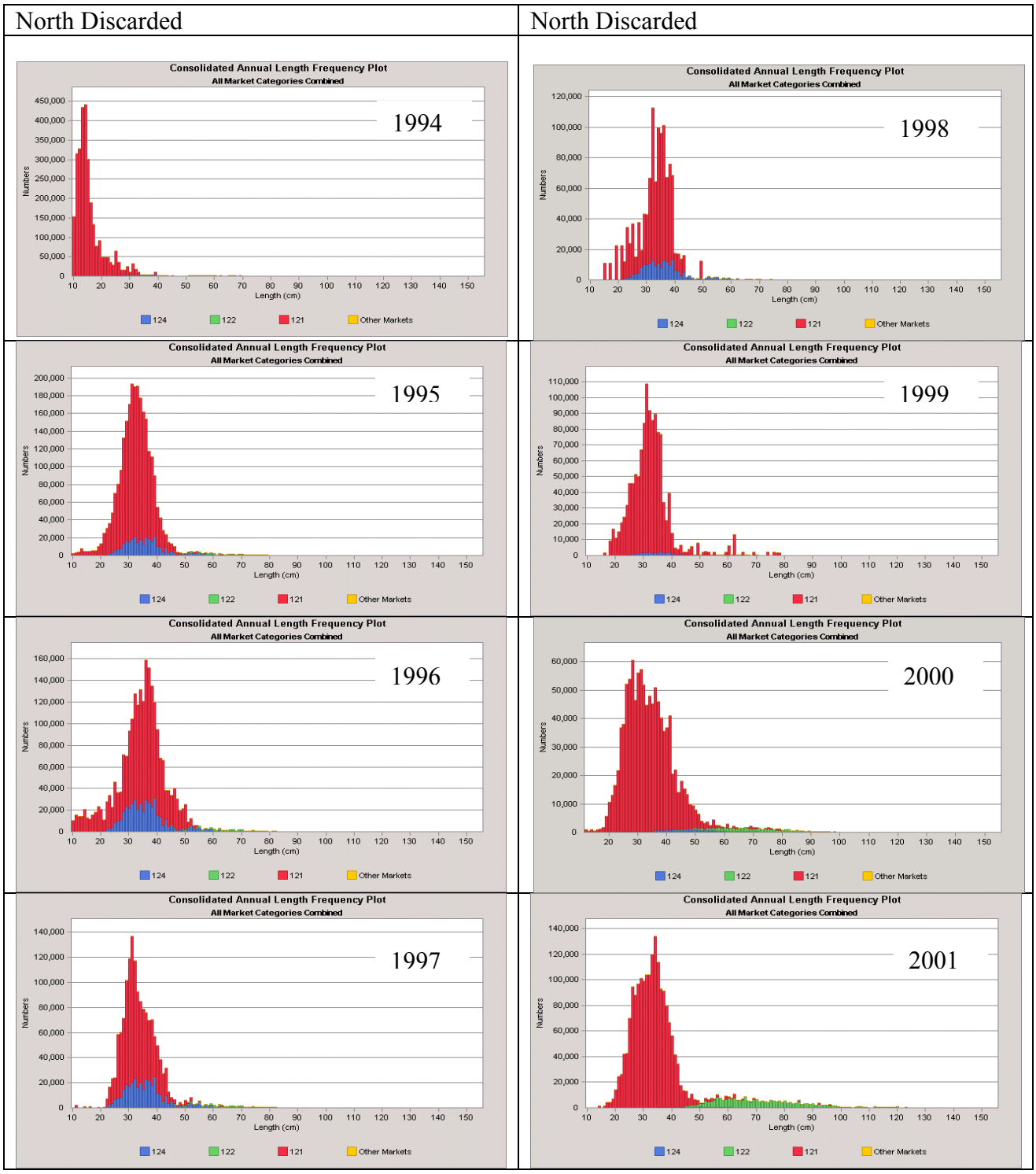


Figure A9. Northern management area, discards at length by gear type, estimated using data from fishery observers. Red=trawls, green=gillnets, blue=dredges, gold=other.

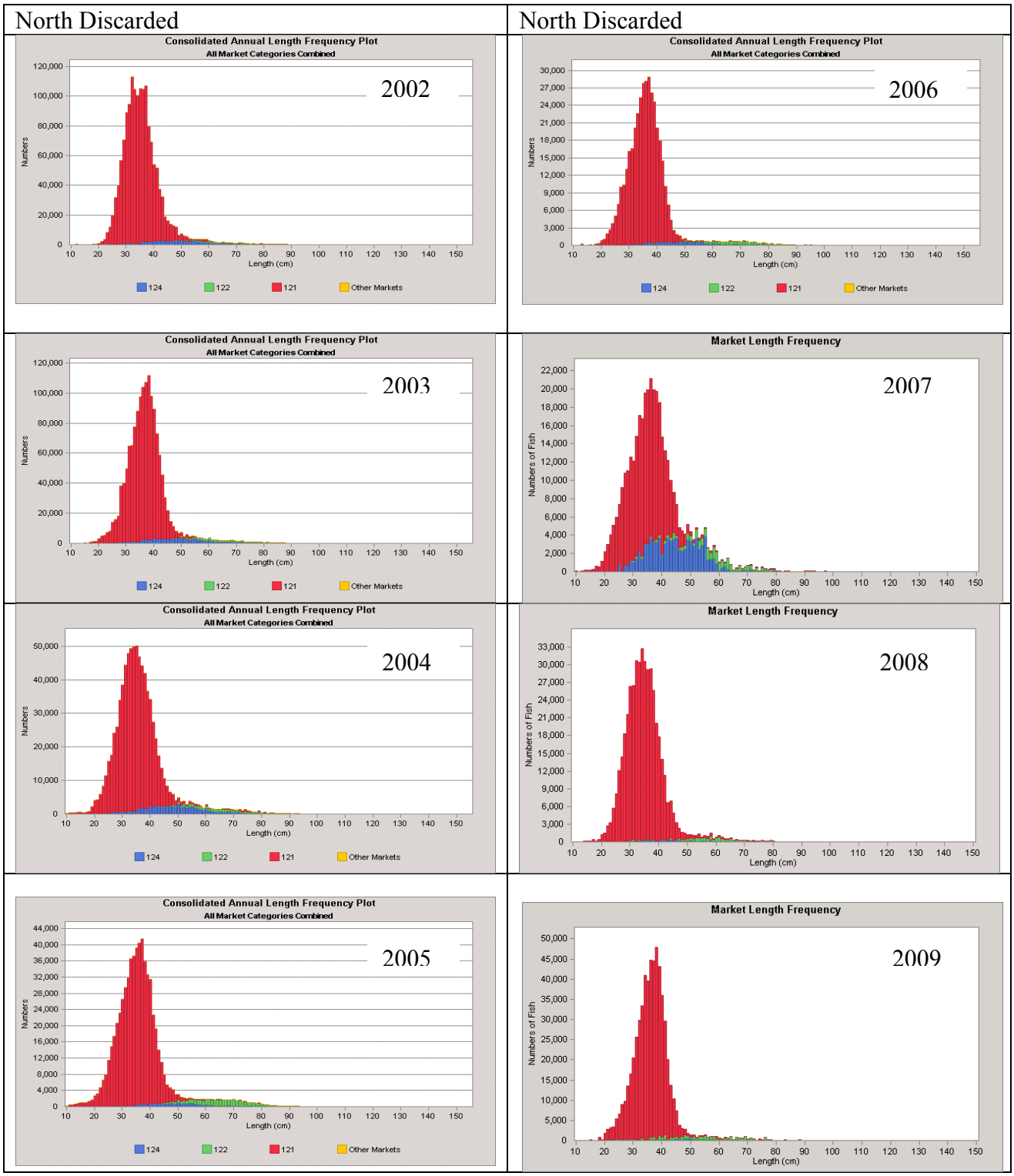


Figure A9, continued. Northern management area, discards at length by gear type, estimated using data from fishery observers. Red=trawls, green=gillnets, blue=dredges, gold=other.

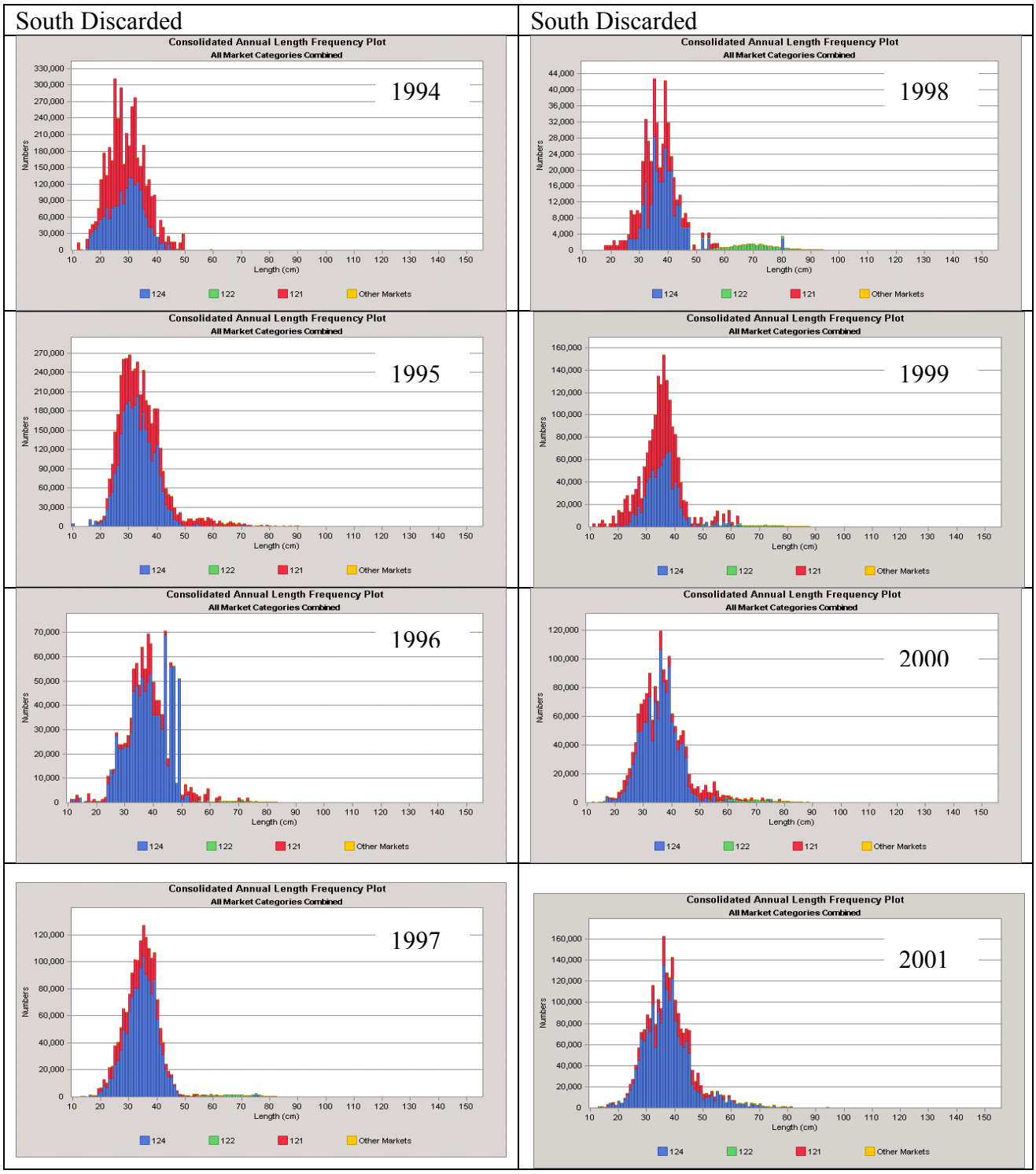


Figure A10. Southern management area, discards at length by gear type, estimated using data from fishery observers. Red=trawls, green=gillnets, blue=dredges, gold=other.

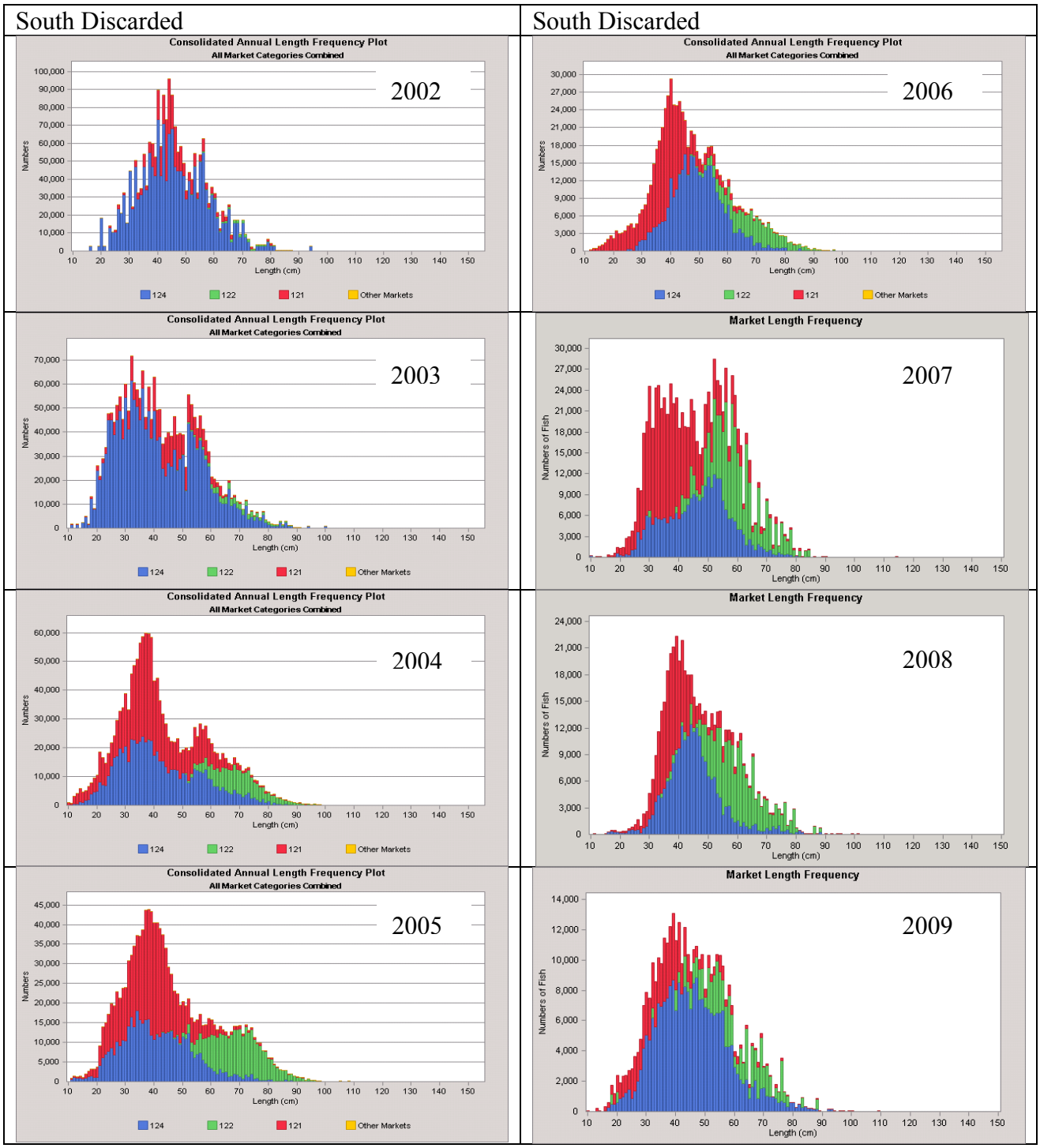


Figure A10, continued. Southern management area, discards at length by gear type, estimated using data from fishery observers. Red=trawls, green=gillnets, blue=dredges, gold=other.

NORTH

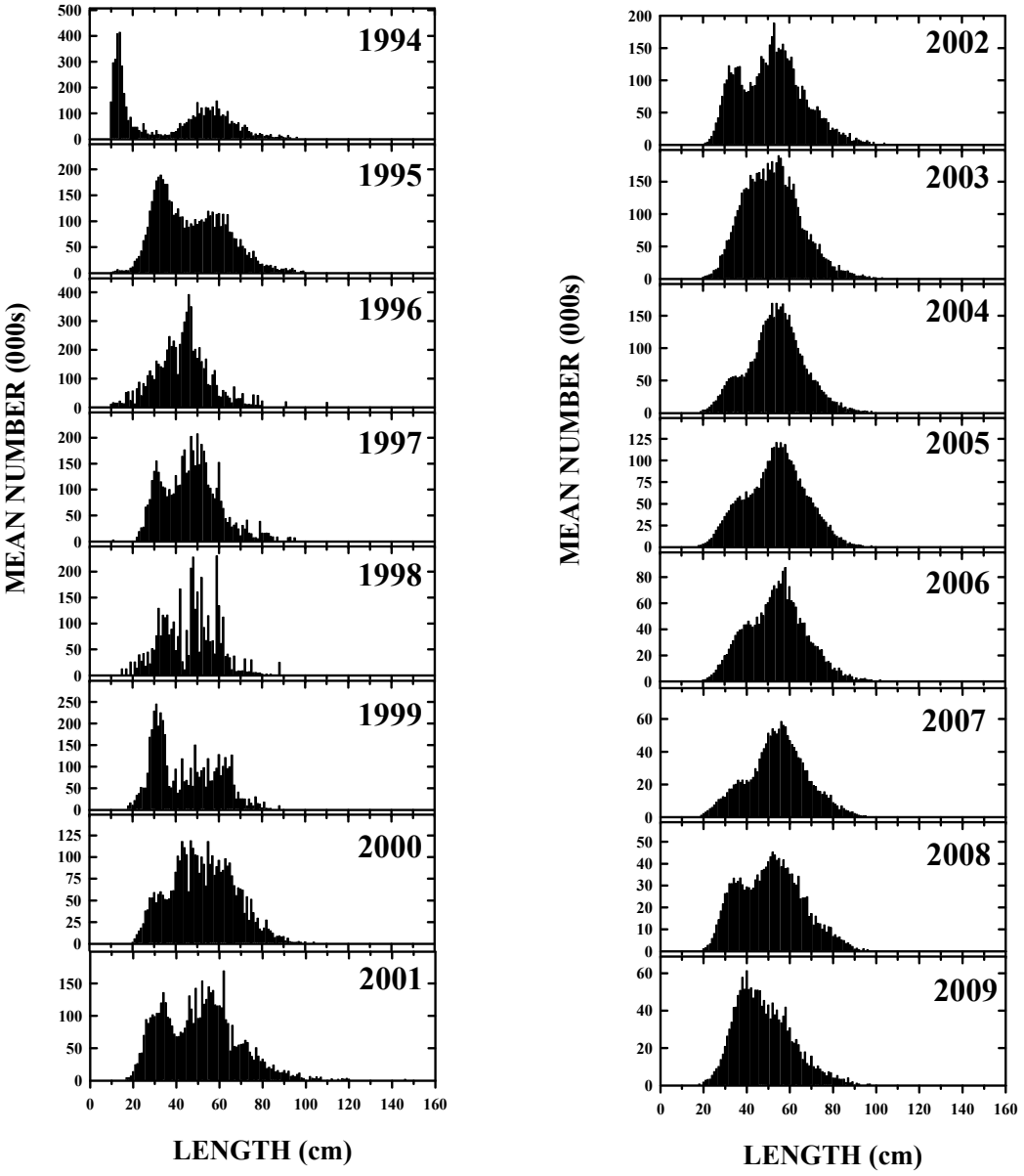


Figure A11. Length composition of commercial catch estimated from observed length samples in the northern management region.

SOUTH

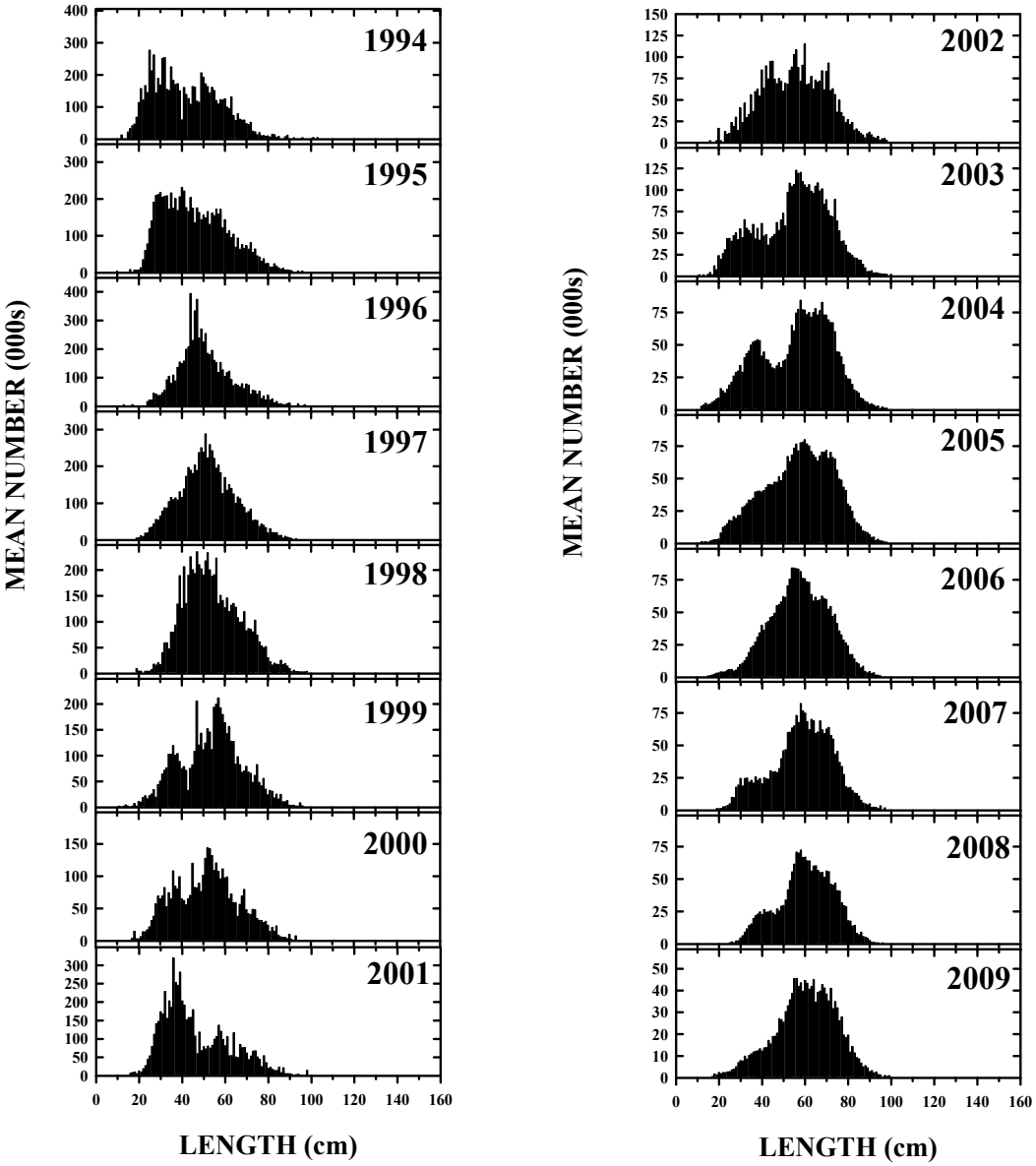


Figure A12. Length composition of commercial catch (discard estimates) estimated from observed length samples in the southern management region.

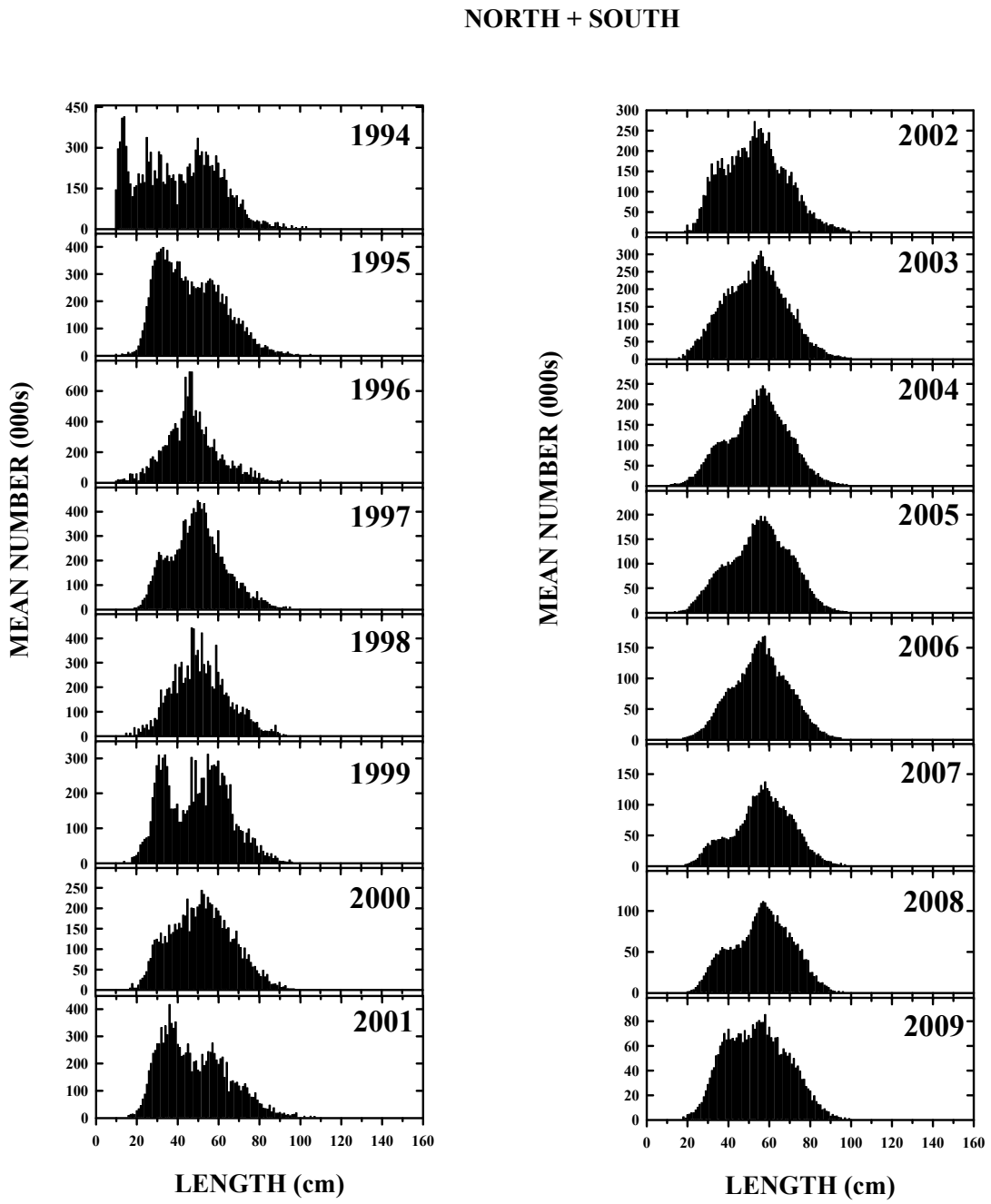


Figure A13. Length composition of commercial catch (discard estimates) estimated from observed length samples in the northern and southern management regions combined.

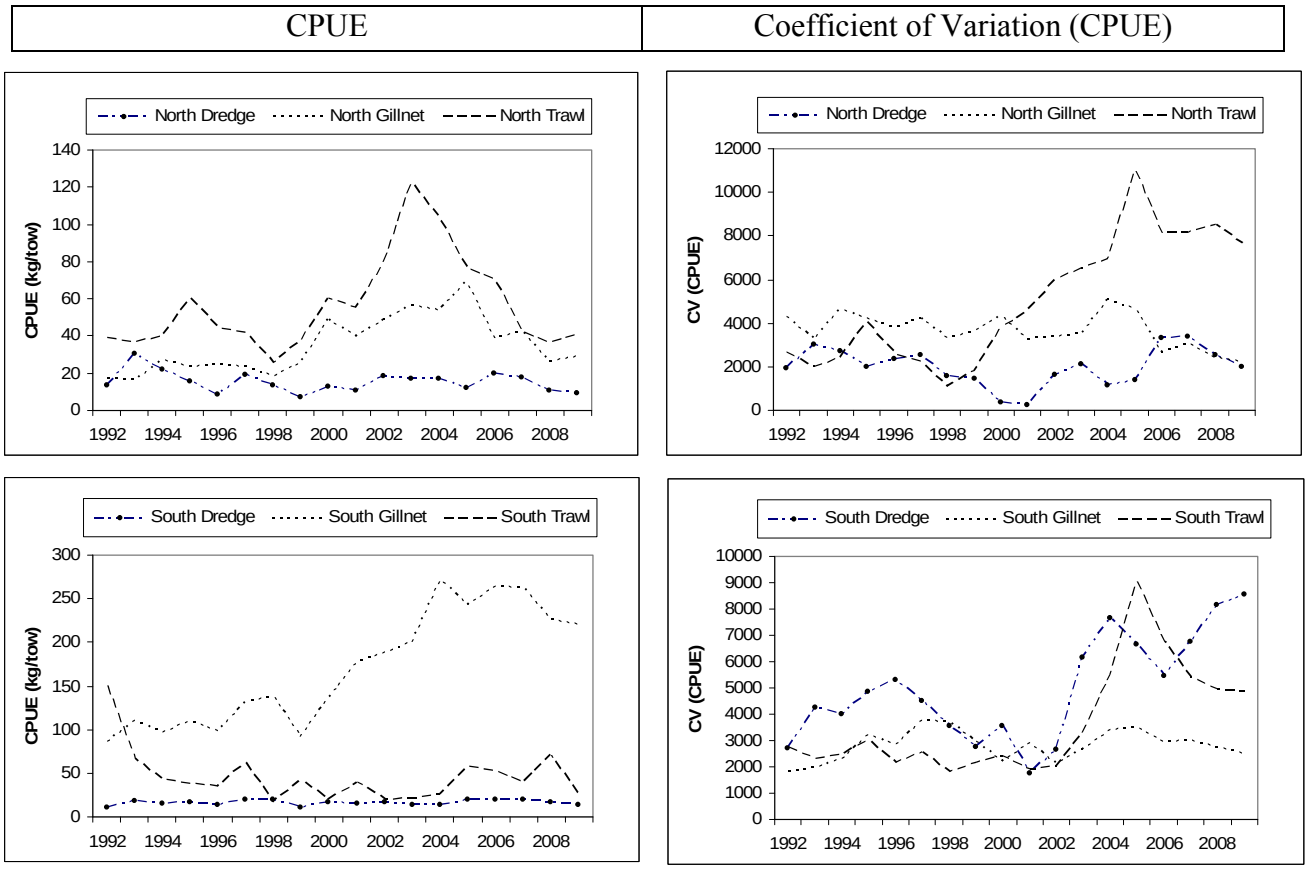


Figure A14. Catch rates of monkfish in the northern and southern management areas from observed tows that caught monkfish by gear-type. Left column, CPUE; right column, coefficient of variation of CPUE estimate.

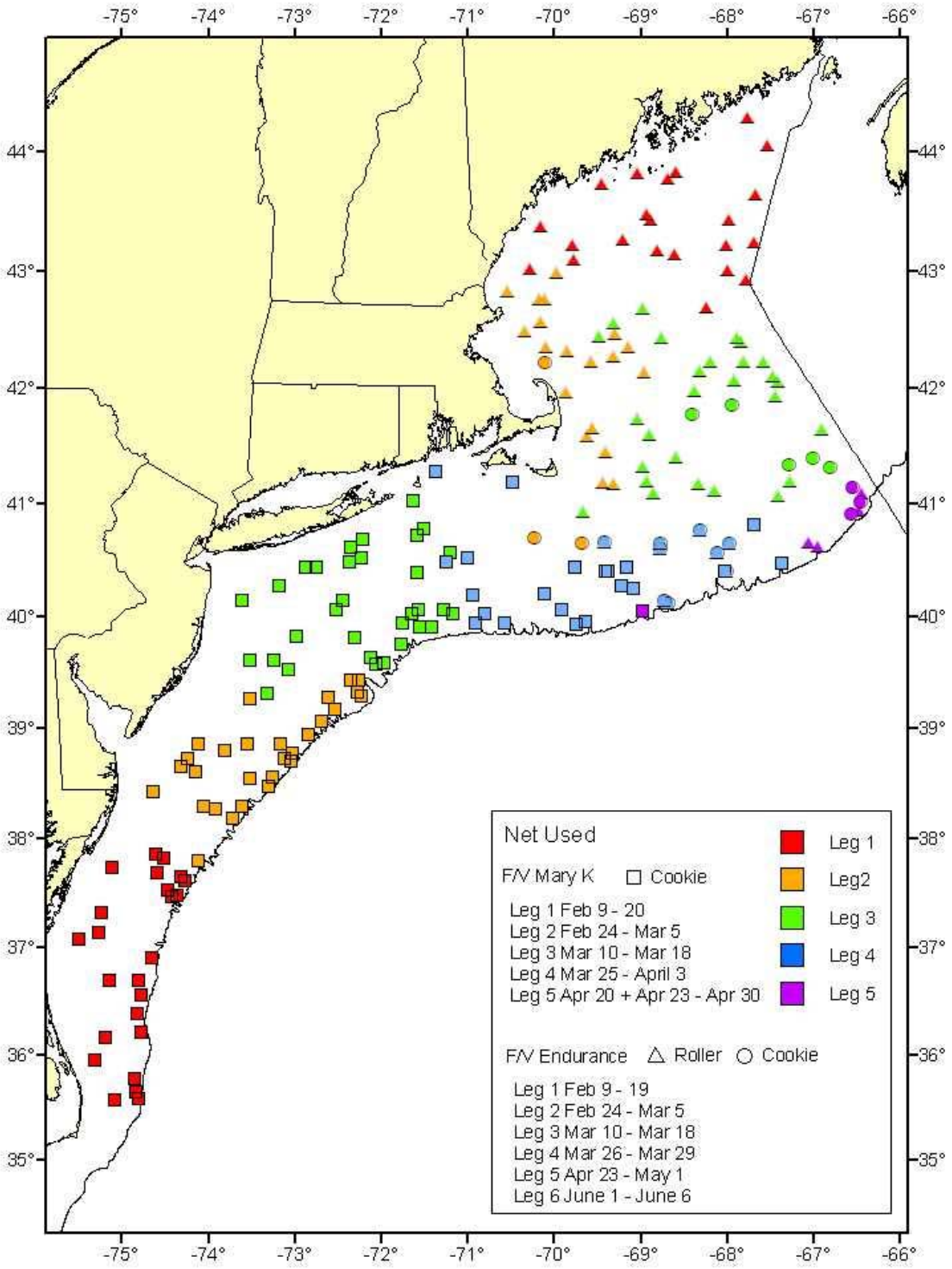


Figure A15. Location of successful survey stations sampled during 2009 cooperative monkfish survey, coded by net type and time of sampling (leg).

2008-2009
408 x 20 cm Fishing circle Trawl with 7"cookie sweep.
Design spread at end of bottom wing web 36 meters for a wing end angle of 24°.
Headrope 49 meters. Sweep 56 meters.
Ground gear 82 feet. End of ground gear to back straps' door attachments 36 feet.
Sensor to back straps' door attachments 6 feet.

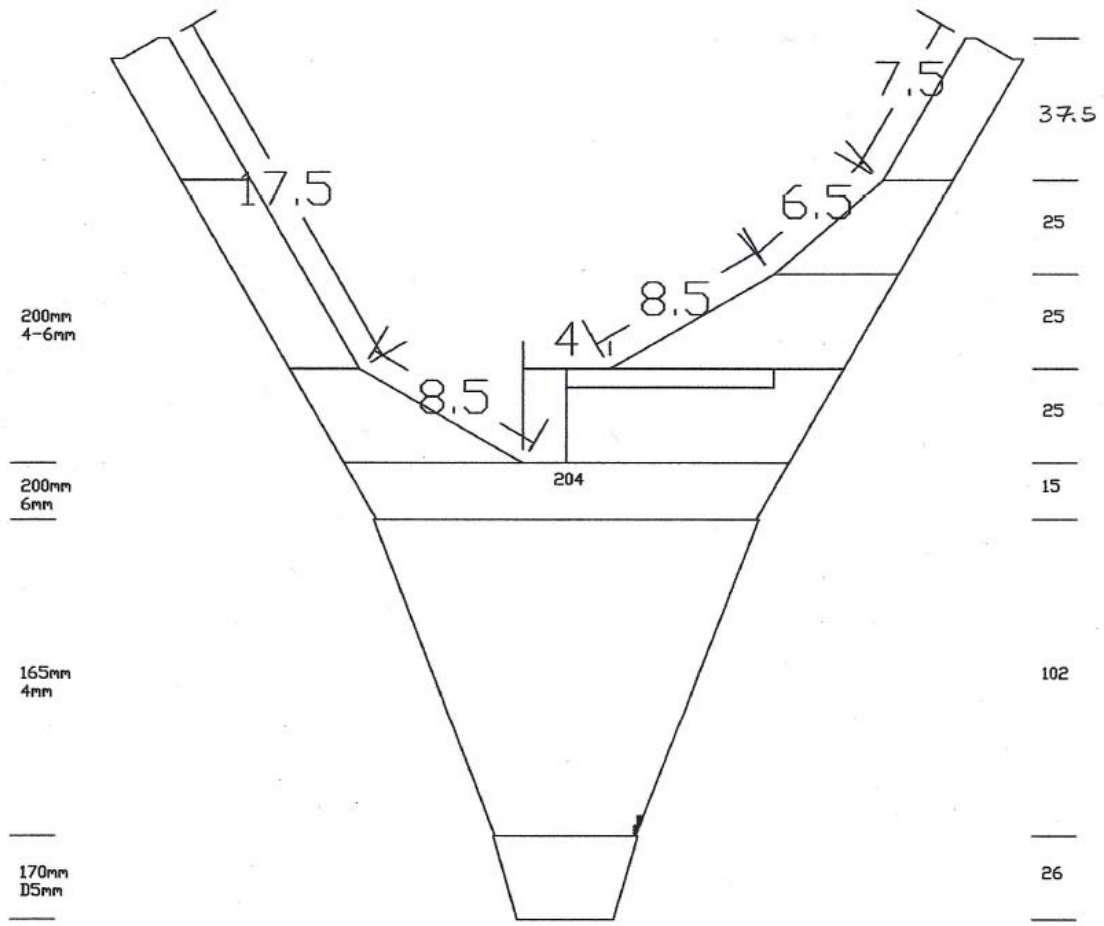


Figure A16. Plan for flat net used on F/V Endurance during 2009 cooperative survey.

F/V ENDURANCE
2008-2009
508 x 20 cm Fishing circle Trawl with rock hopper sweep.
Design spread 45.6 meters for a wing end angle of 23°.
Headrope 79 meters.
Sweep 86 meters (10.4 meters w/o web).
Center section 40 meters w/ 14" discs. Wing sections 22.7 meters w/ 12" discs. 30cm chain.
Ground gear 60 feet. End of ground gear to back straps' door attachment 36 feet.
Sensor to back straps' door attachment 6 feet.

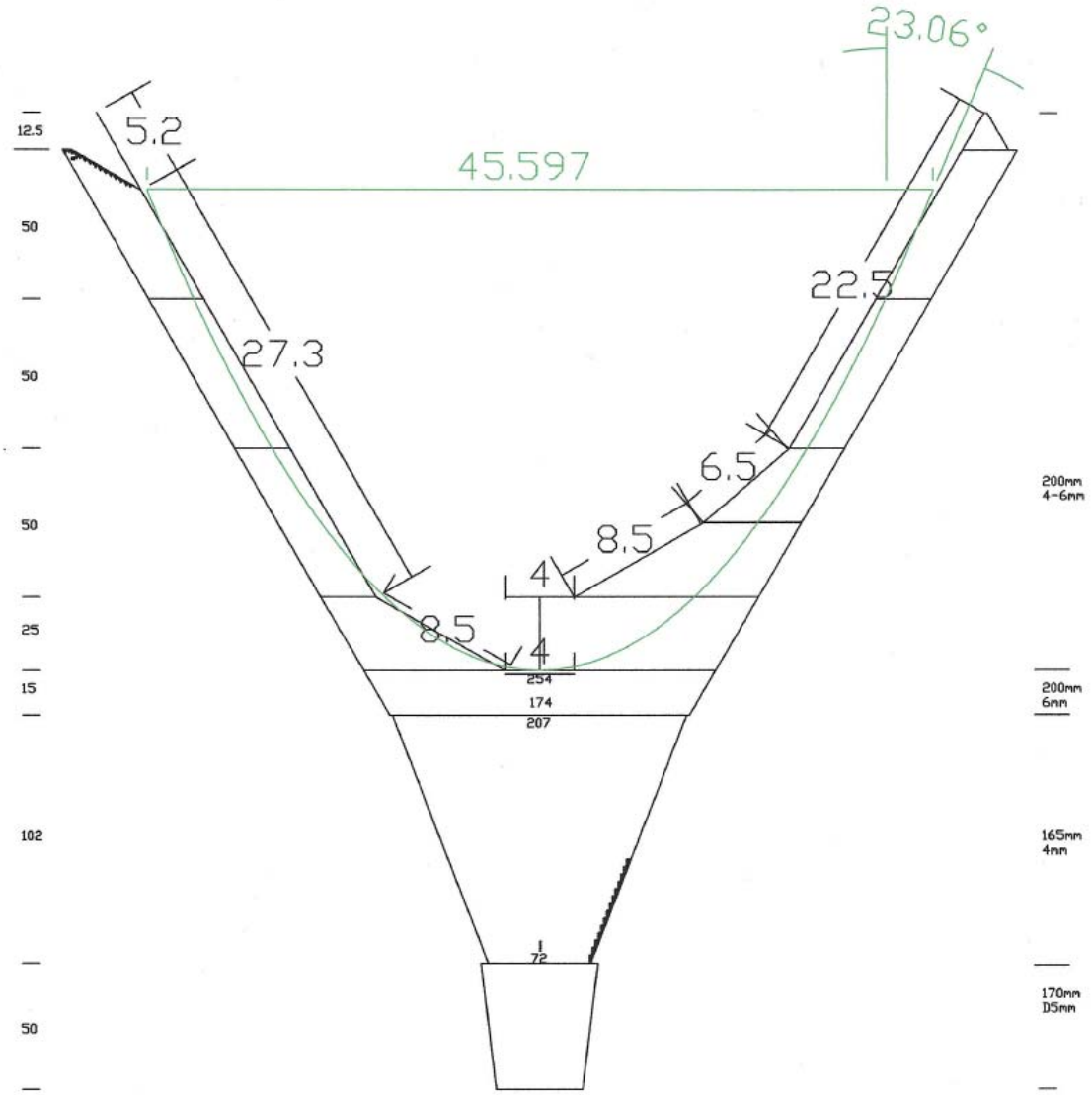


Figure A17. Plan for rockhopper net used on F/V Endurance during 2009 cooperative survey.

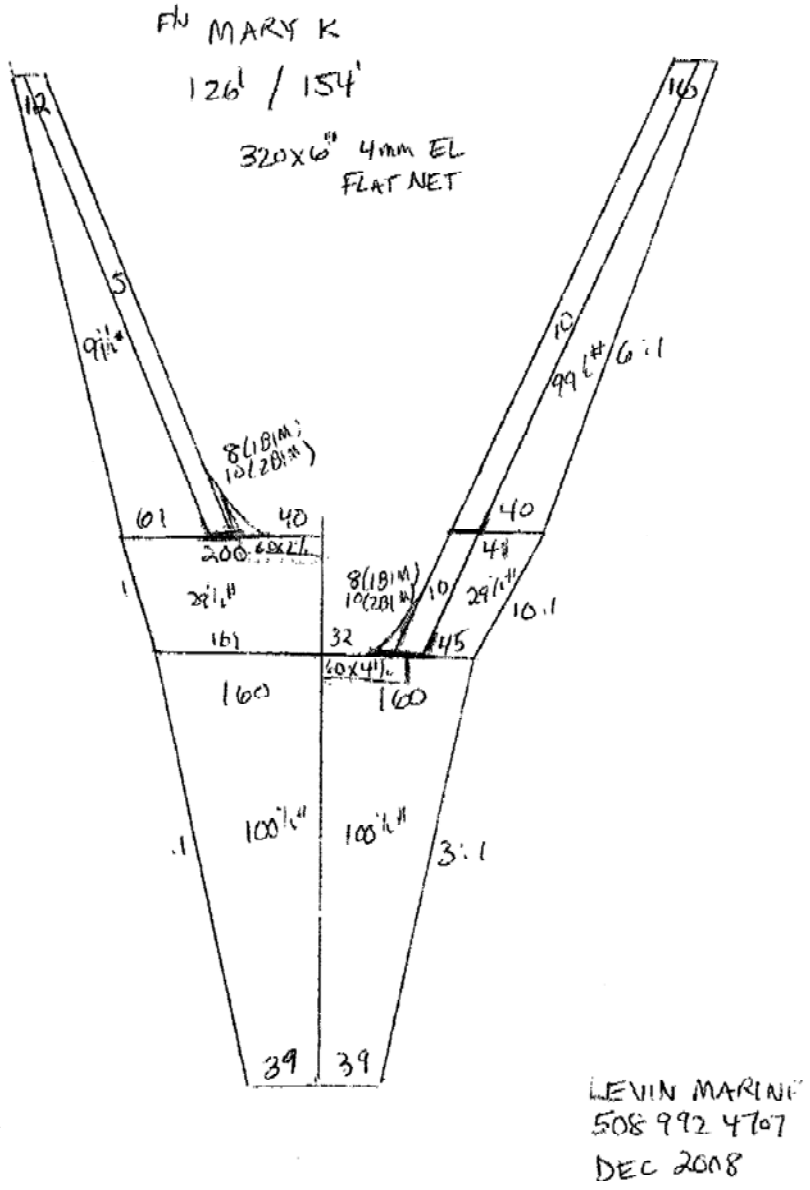
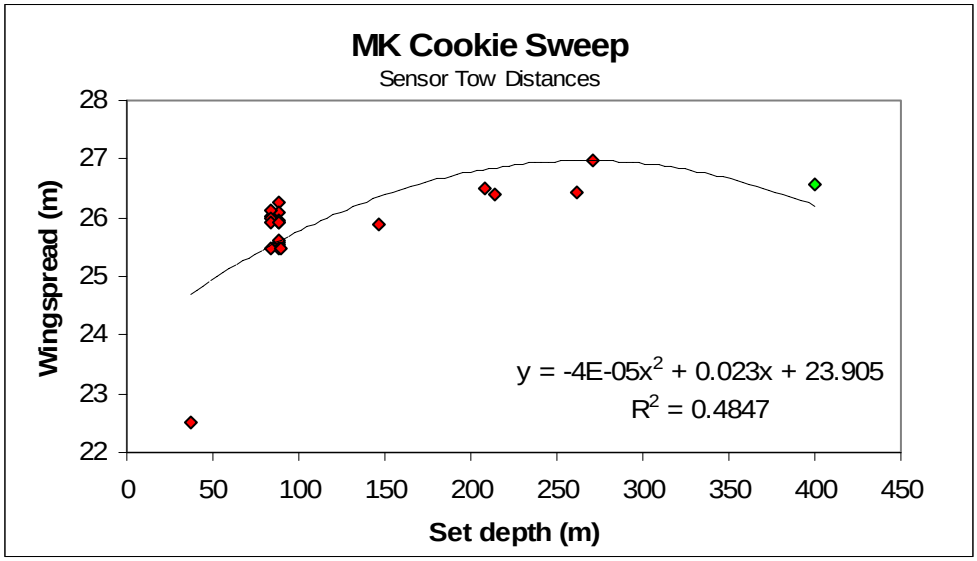


Figure A18. Plan for net used on F/V Mary K during 2009 cooperative survey.



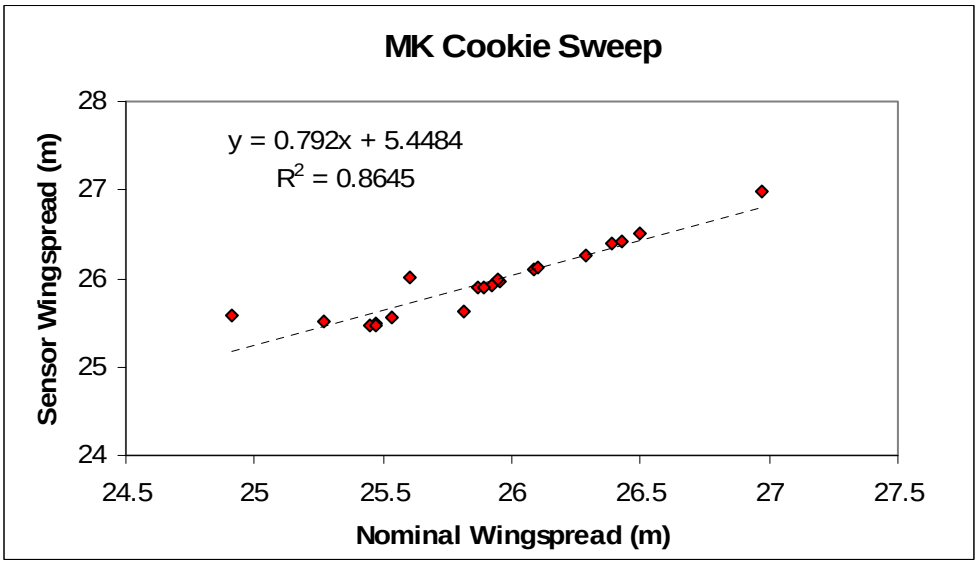
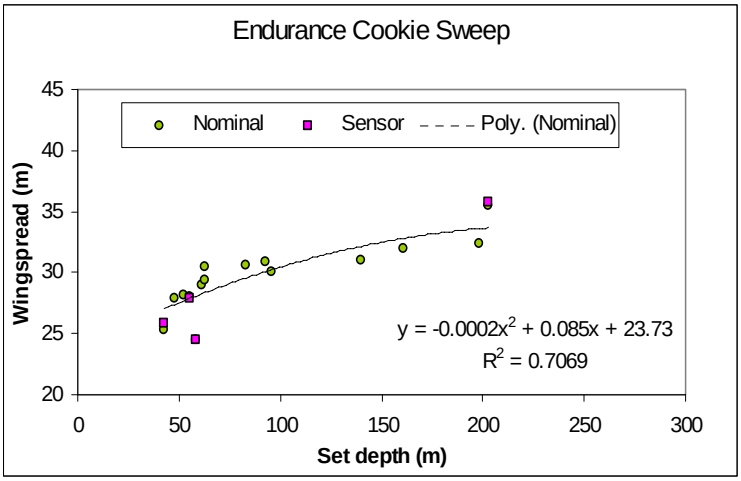
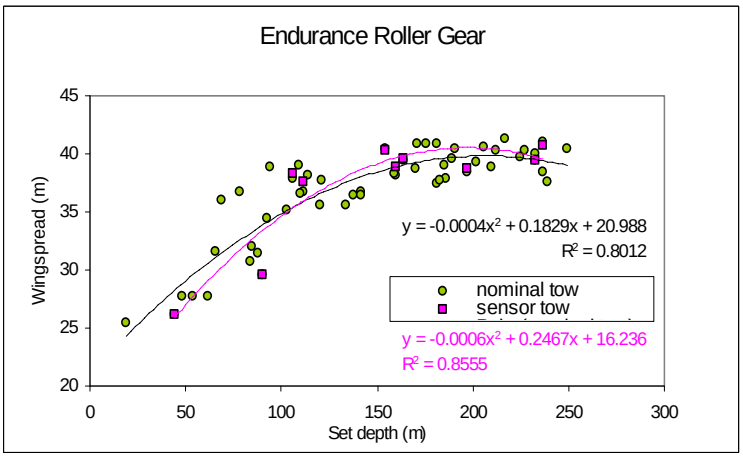


Figure A19. (A) Relationship between depth and wingspread for the cookie sweep net used on the Mary K, 2009 cooperative survey. Data are from mensuration tows and depletion experiments with good quality bottom contact and wingspread measurements, trimmed to sensor tow length before averaging for each tow. Point at 400 m is average wingspread for tows > 200 m set depth, not an observed value; maximum depth with observed wingspread was 271 m. Point at 37 m is based on only 6 wingspread readings. (B) relationship between average wingspread during nominal tow vs. sensor tow duration.





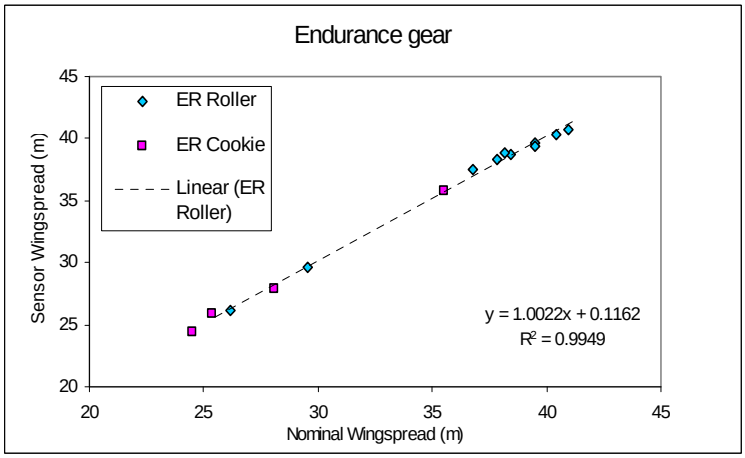
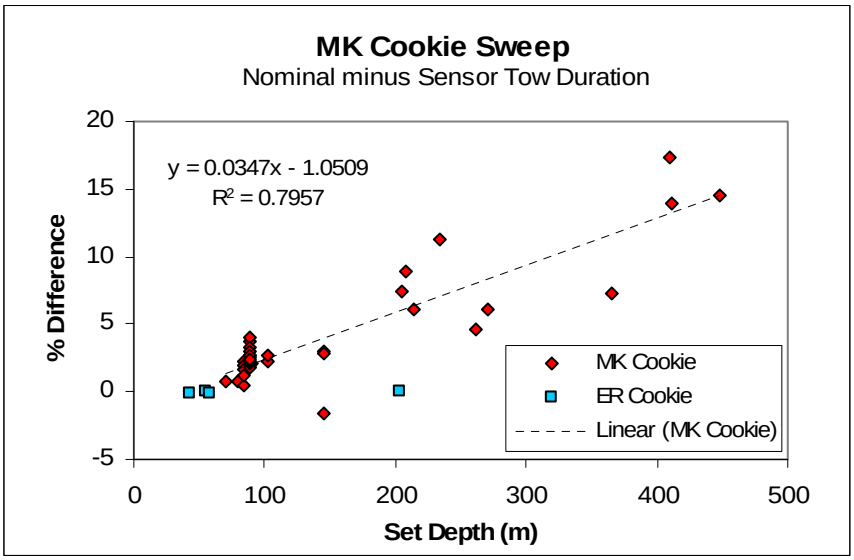


Figure A20. Wingspread-depth relationship for Endurance (A) cookie sweep net, (B) roller gear net, and (C) relationship between average wingspread during nominal tow vs. sensor tow duration.



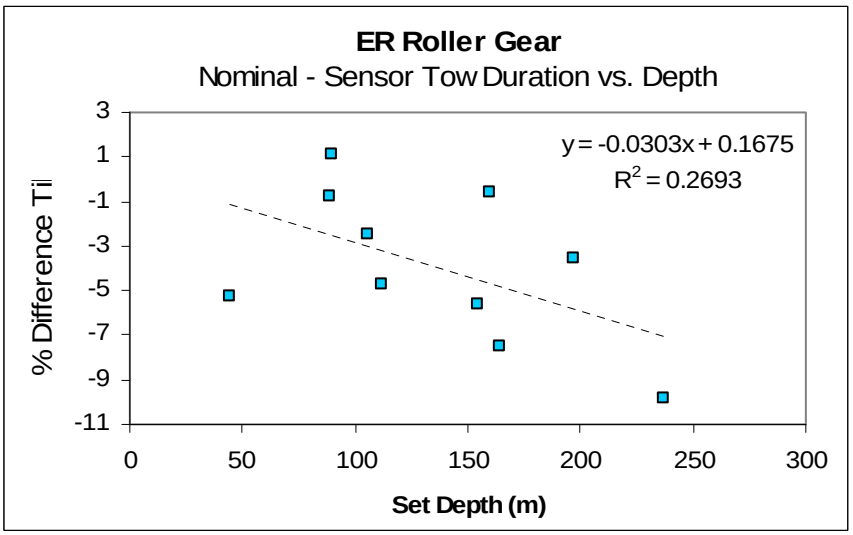


Figure A21. Relative difference between tow duration estimated from sensor data (tows with good bottom contact readings) and nominal tow duration for each net. (A) Endurance and Mary K cookie sweeps, (B) Endurance roller sweep.

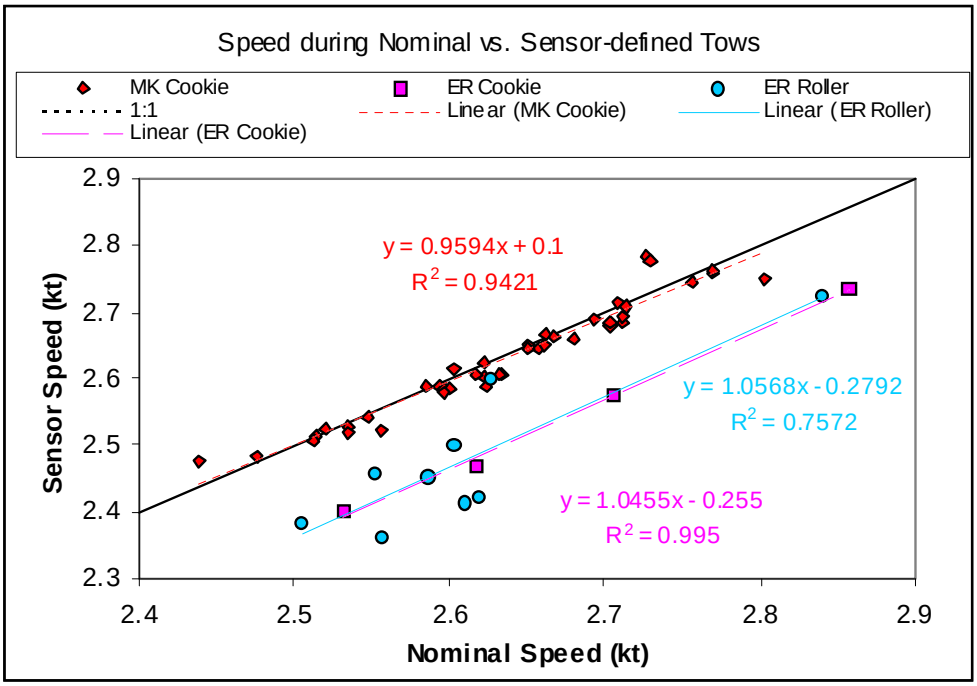


Figure A22. Adjustments to nominal average speed for tows with no bottom contact sensor data to define sensor tow length (and average sensor tow speed).

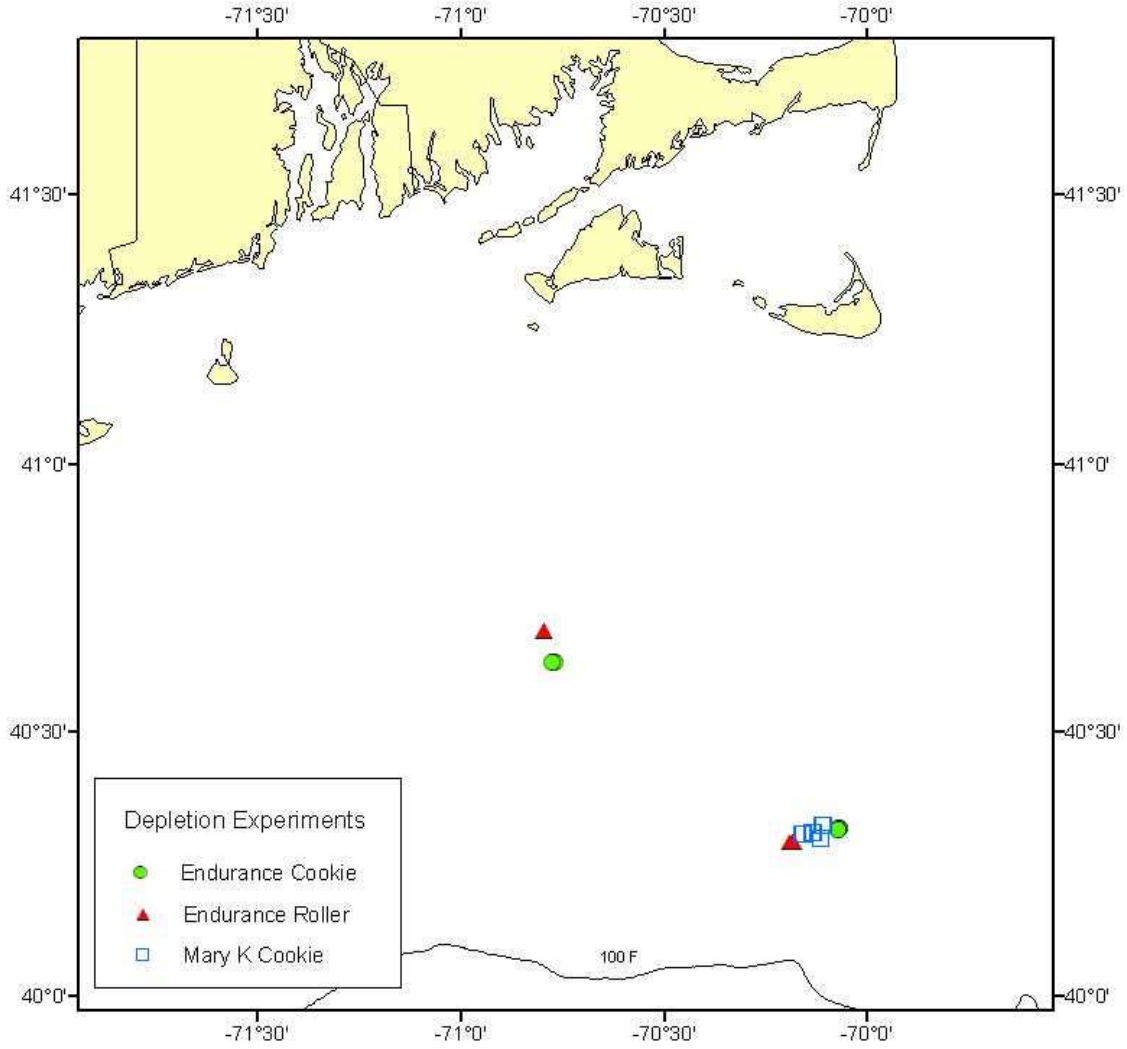


Figure A23. Location of depletion experiments for the 3 net types used in the 2009 cooperative monkfish survey.

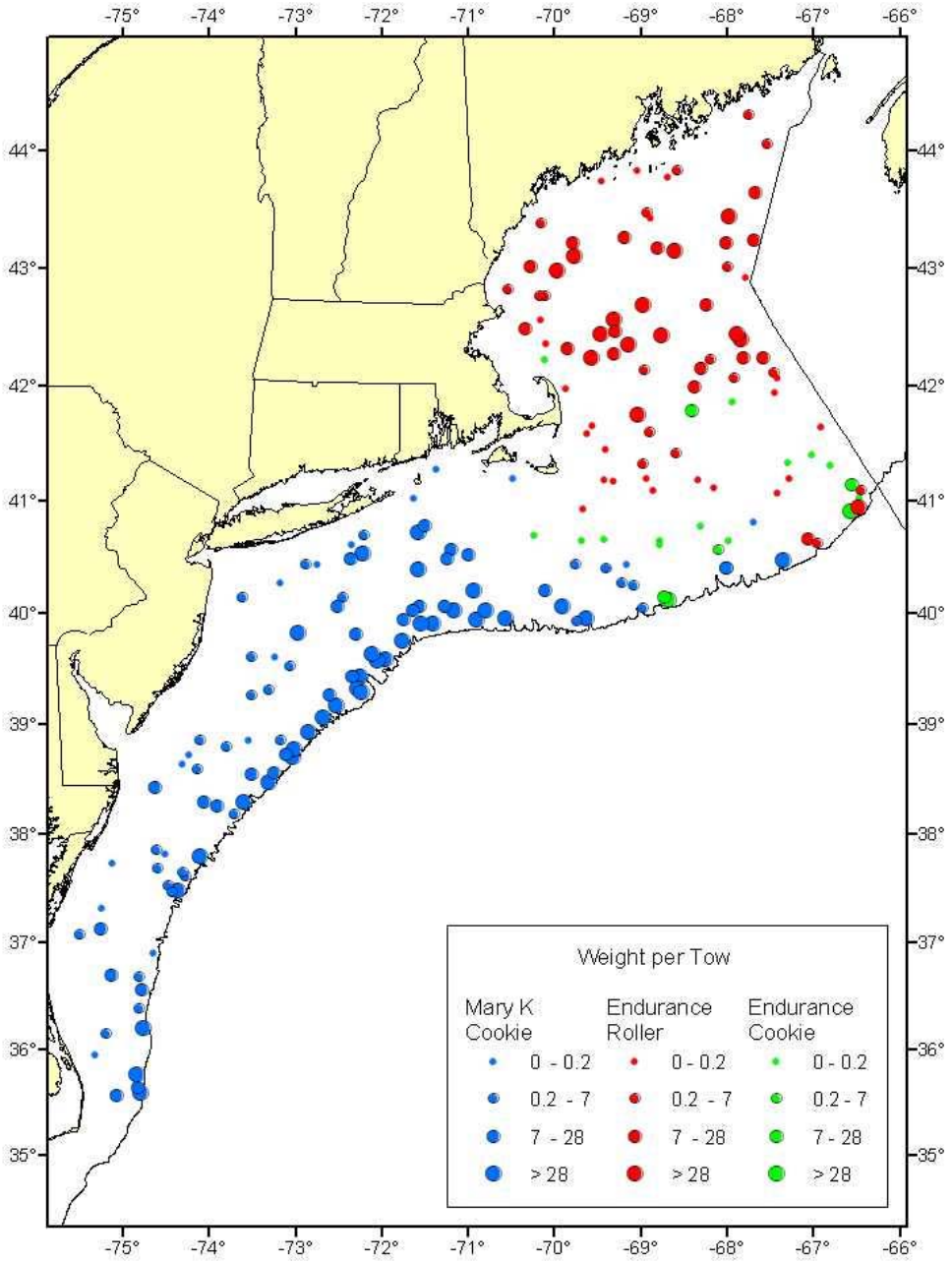


Figure A24. Nominal catch per tow (kg) coded by net type.

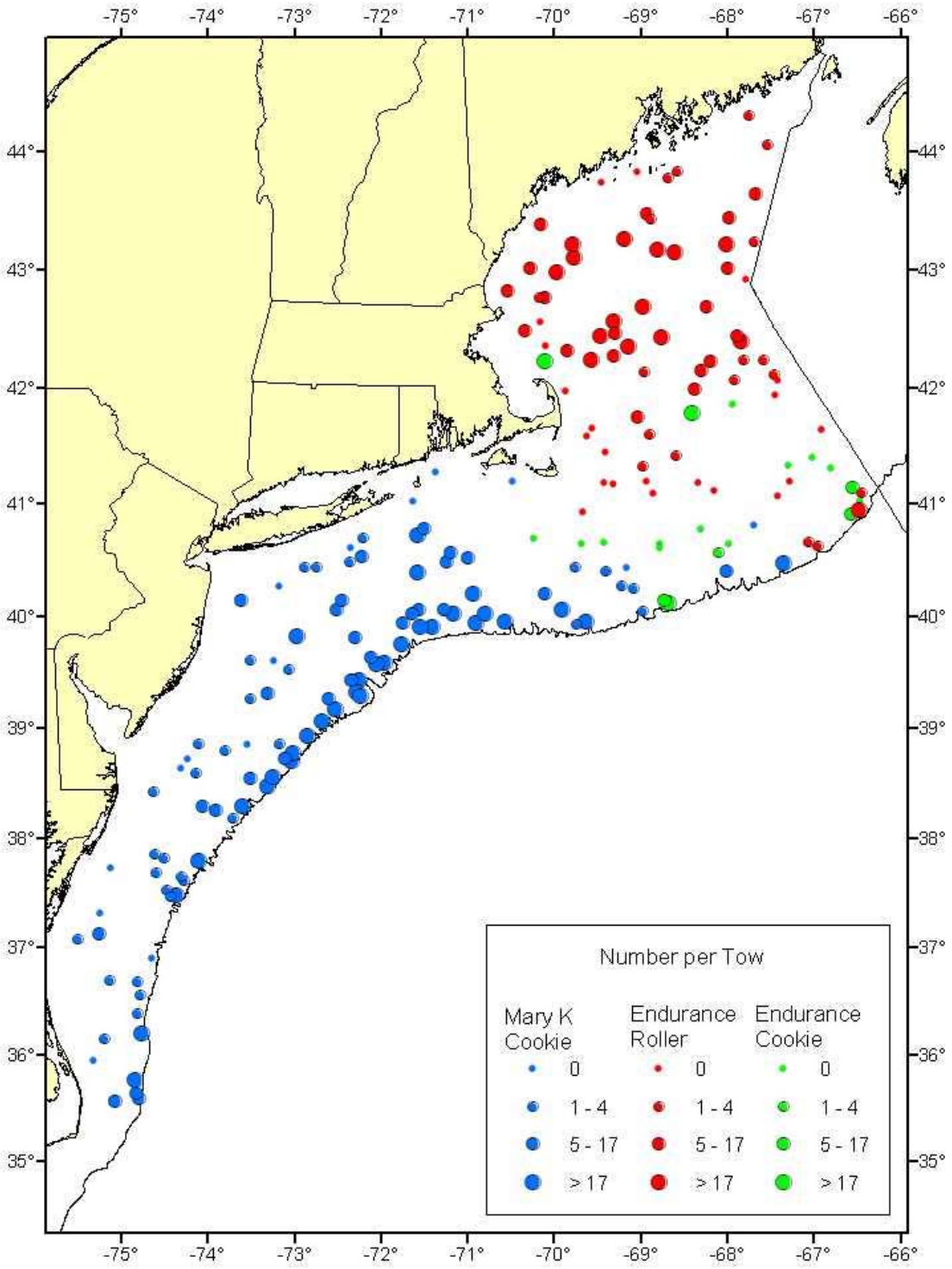


Figure A25. Nominal catch per tow (numbers) coded by net type.

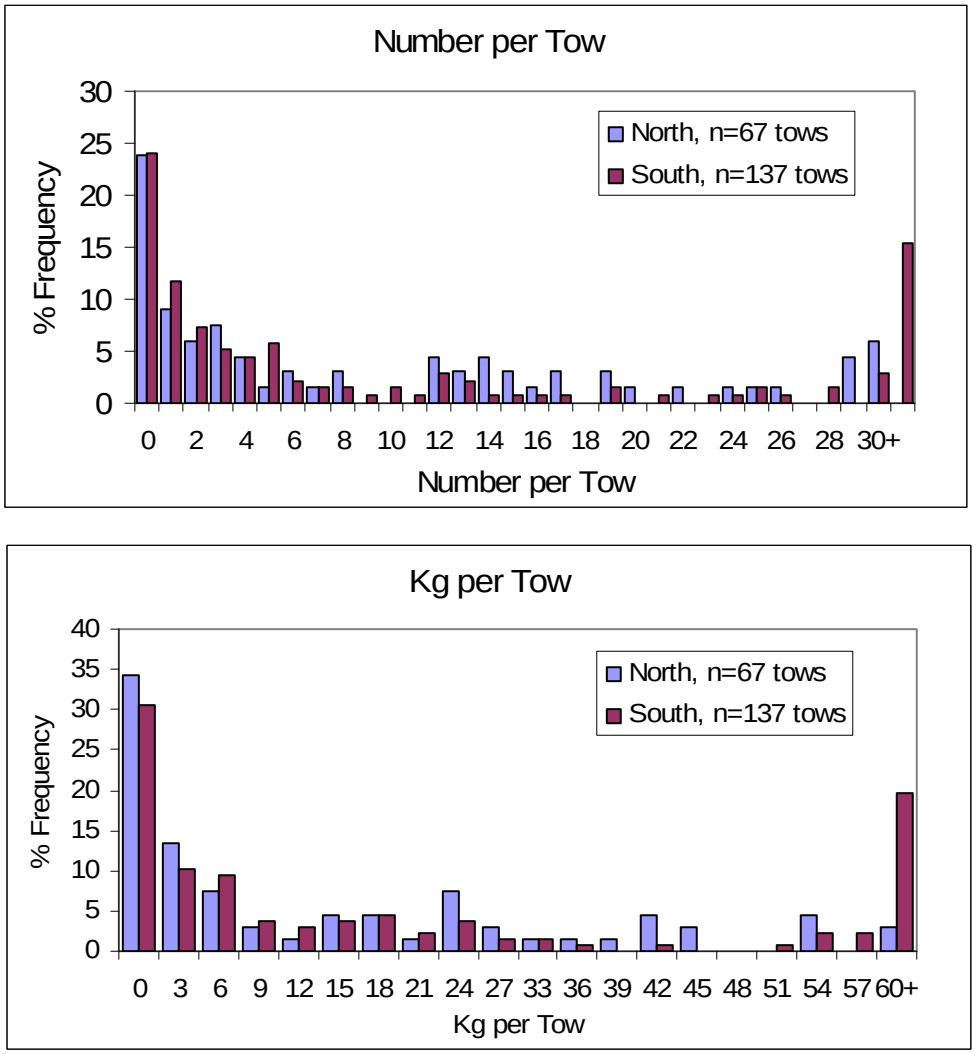


Figure A26. Relative frequency of catch per tow (number, kg), good survey tows.

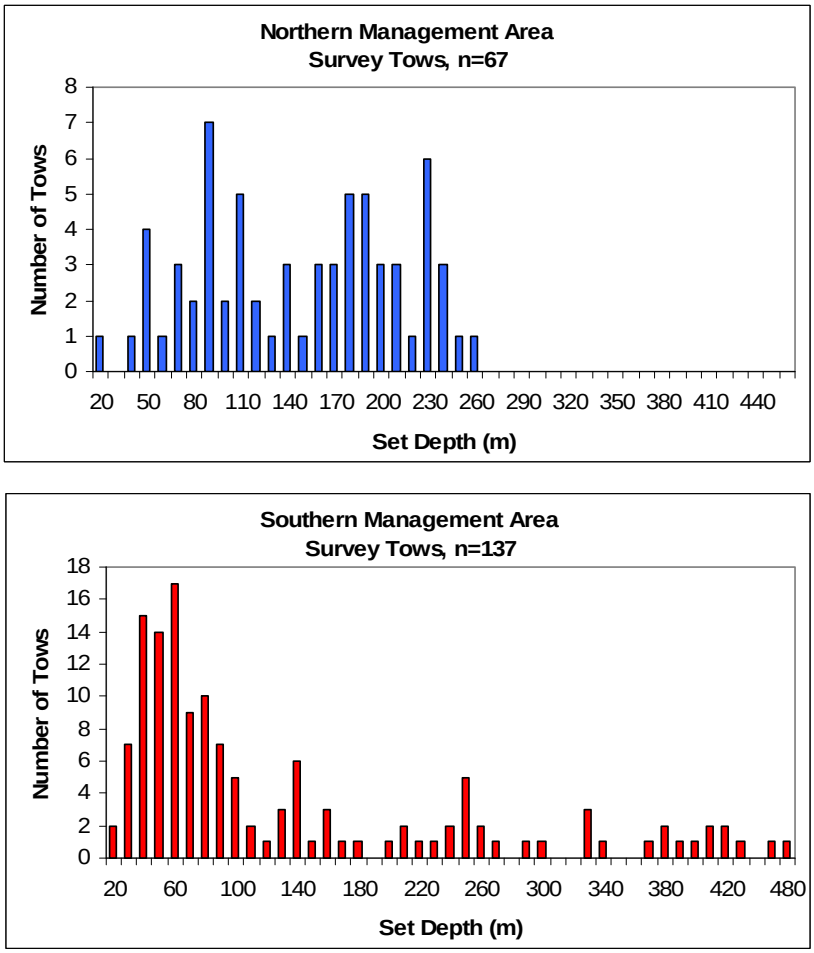
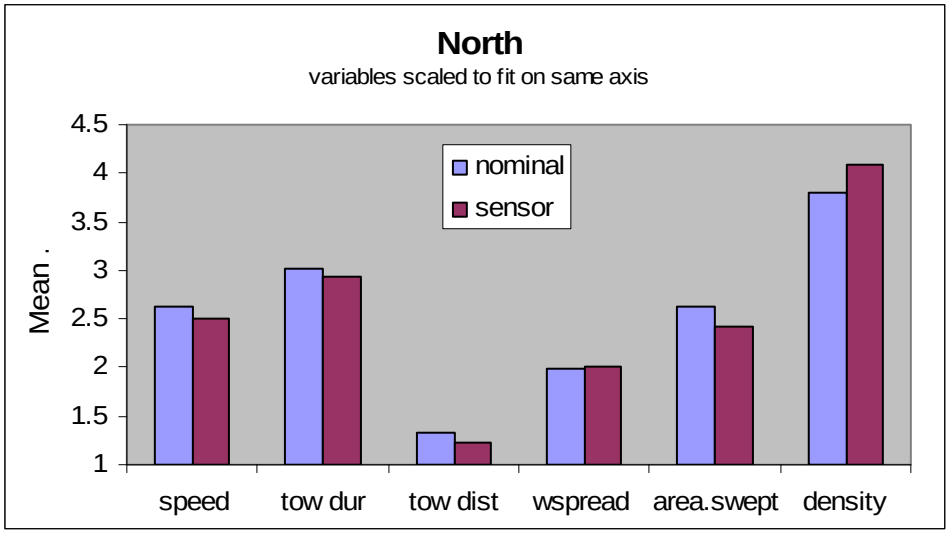


Figure A27. Depth distribution (binned by 10 m) of good survey tows from 2009 cooperative monkfish survey.



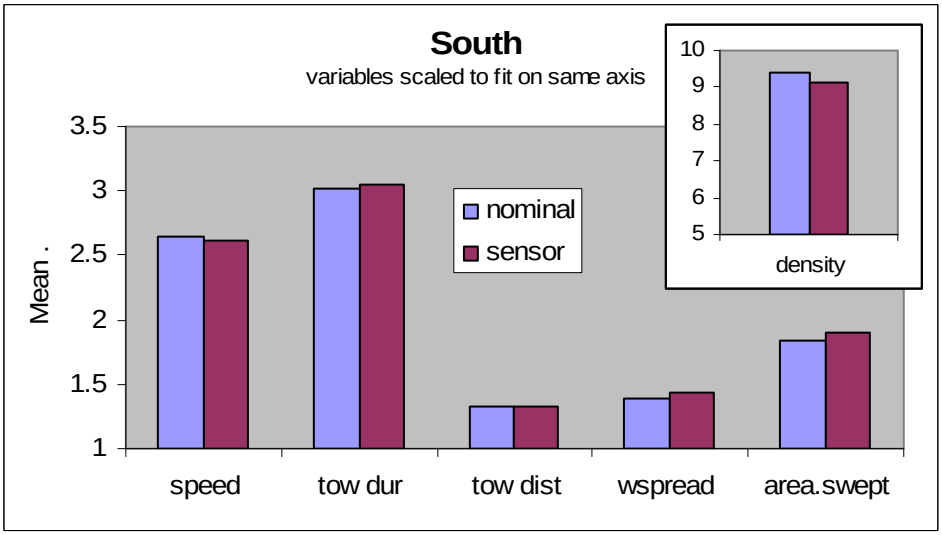
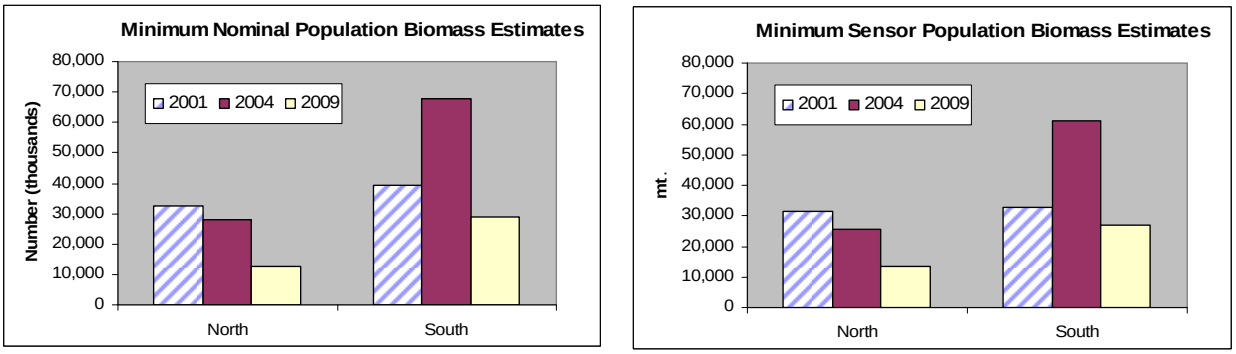
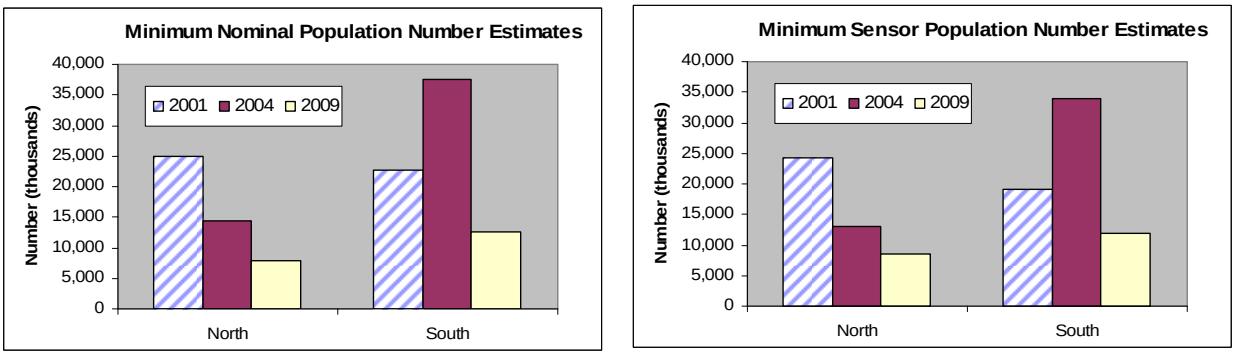


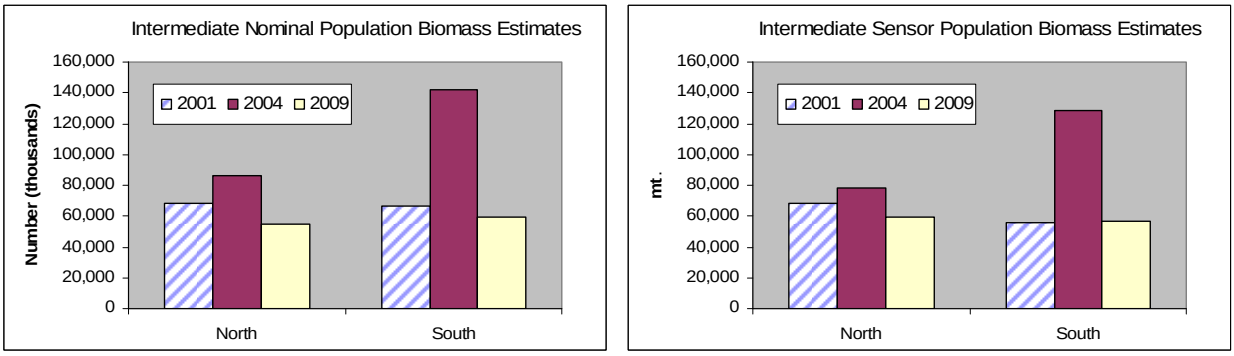
Figure A28. Effects of adjustments to derive sensor-based estimates, averaged over management area. Variables have been scaled to fit on the same x-axis. Density is number per nautical mile.

A.





B.



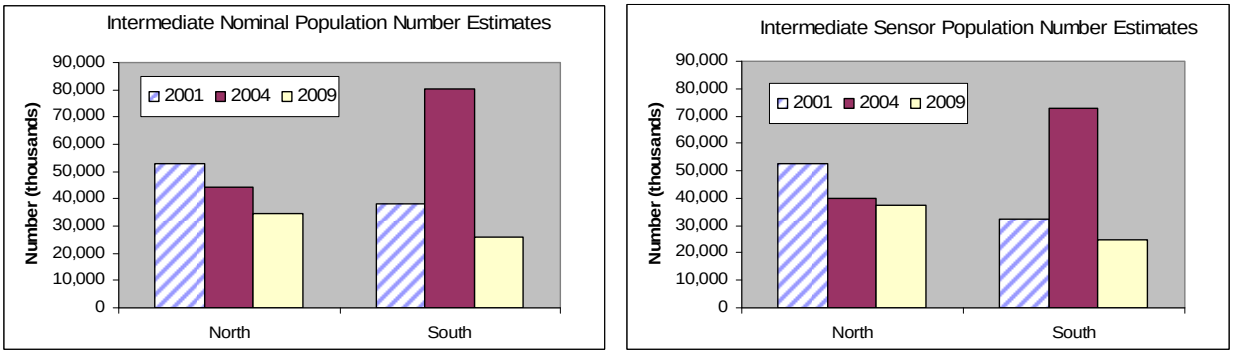


Figure A29. A. Minimum estimates (assuming 100% net efficiency) of population size and biomass based on nominal and sensor-defined tows from 2001, 2004 and 2009 cooperative surveys. B. Estimates assuming intermediate net efficiencies.

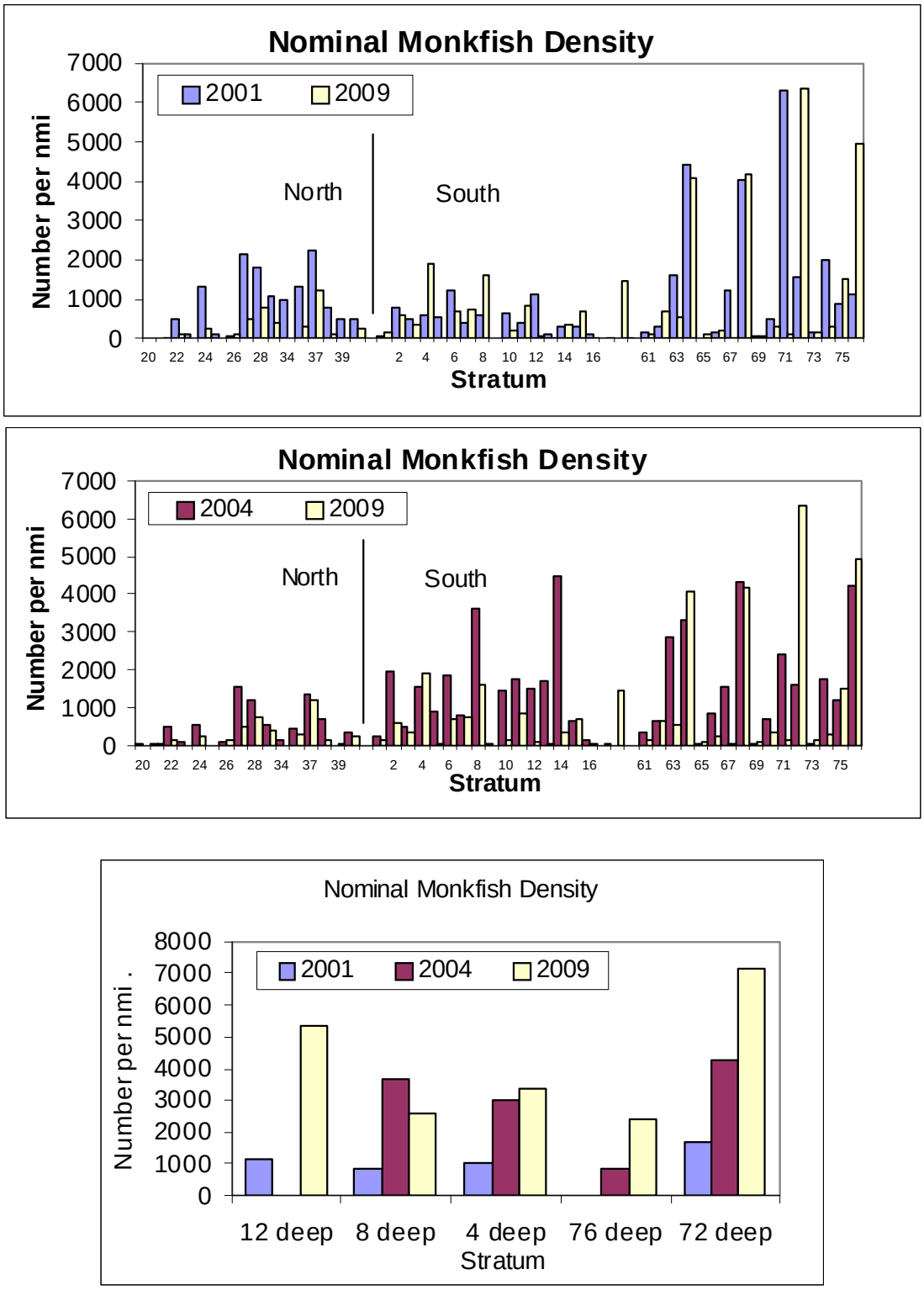


Figure A30. Monkfish density (nominal number per nmi swept) by stratum, 2001, 2004, and 2009 cooperative surveys. Bottom panel shows deep strata.

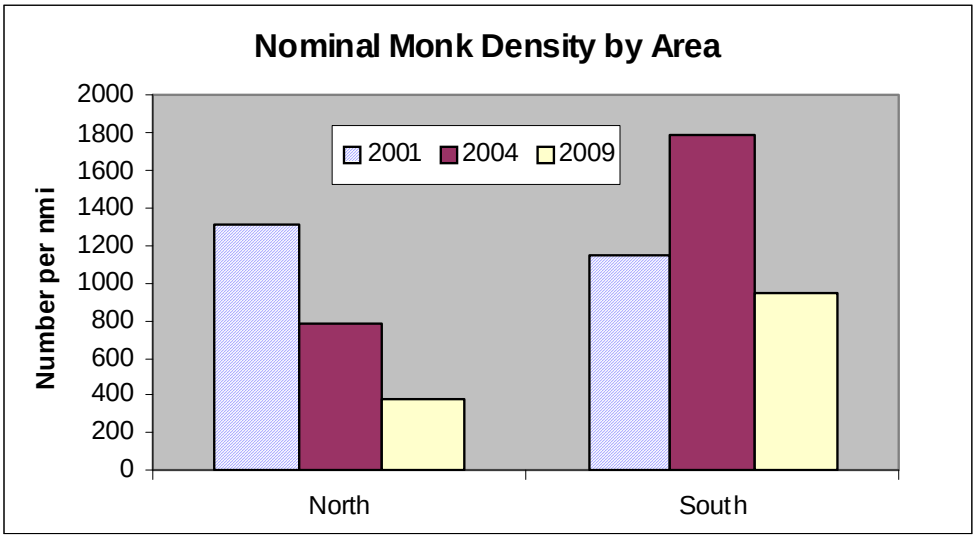
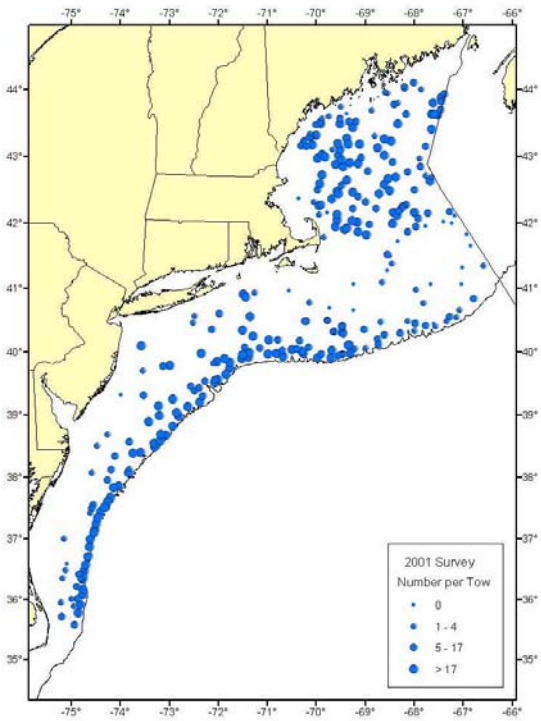
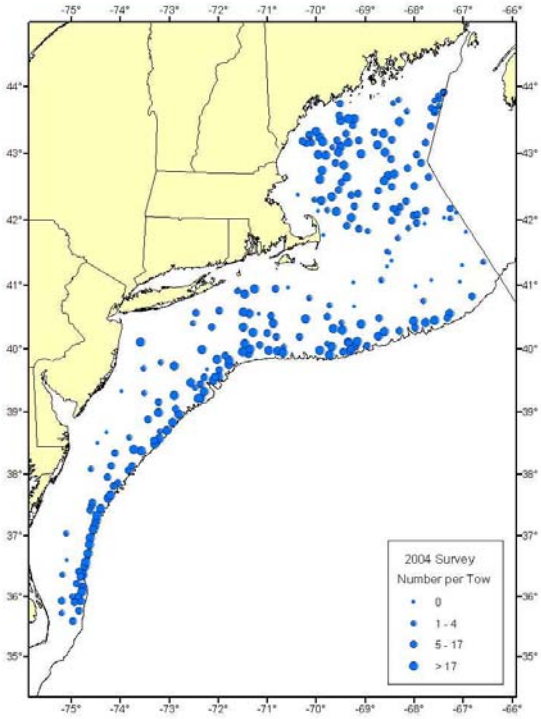


Figure A31. Nominal monkfish density by management region, 2001, 2004, 2009.


2001 Survey
Number per Tow
0
1 - 4
5 - 17
> 17


2004 Survey
Number per Tow
0
1 - 4
5 - 17
> 17

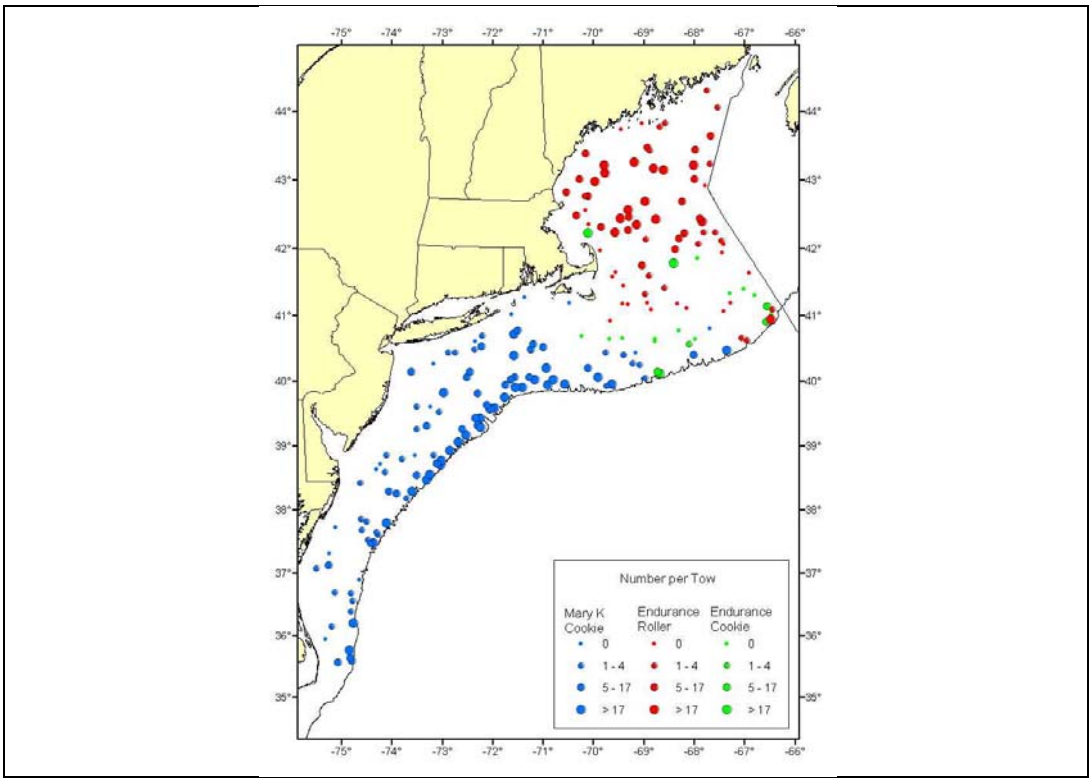


Figure A32. Distribution of catch rates (number per tow) in 2001, 2004 and 2009 cooperative surveys.

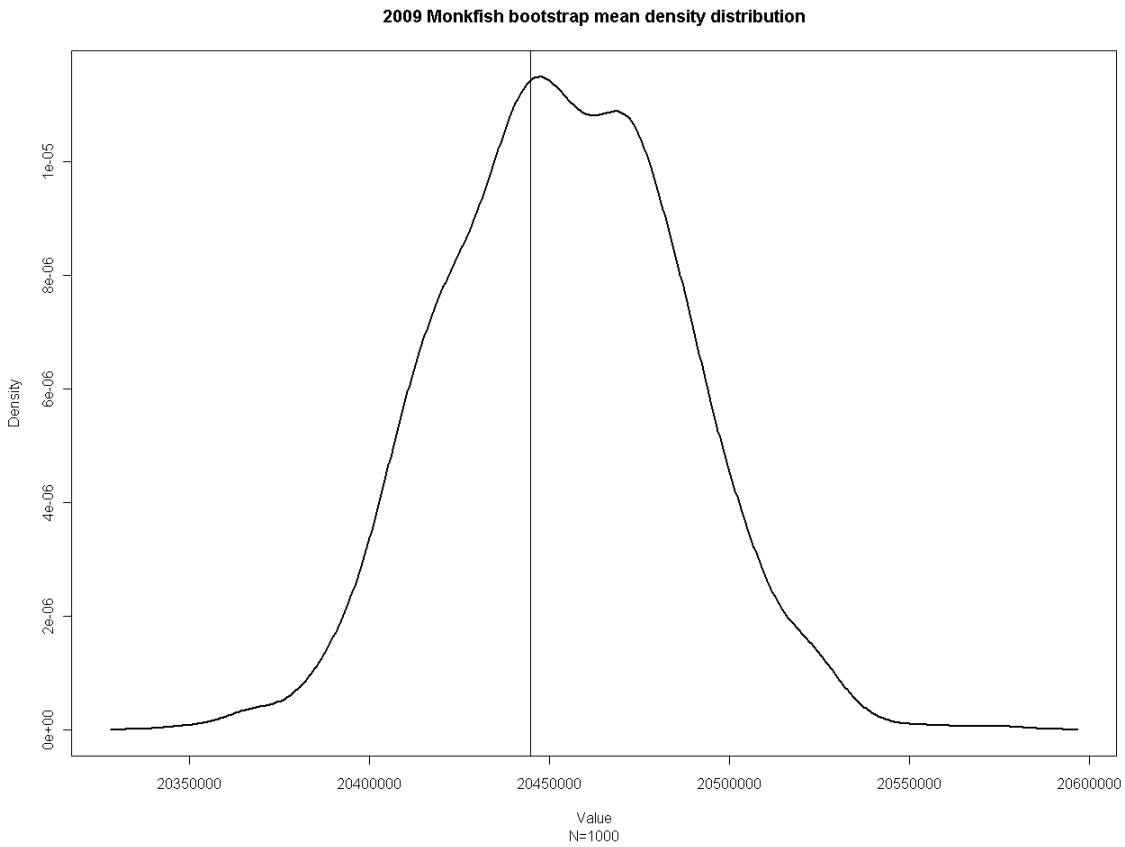
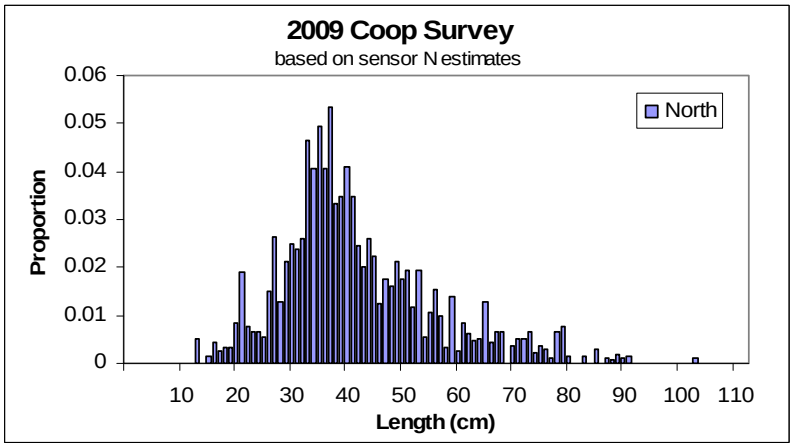
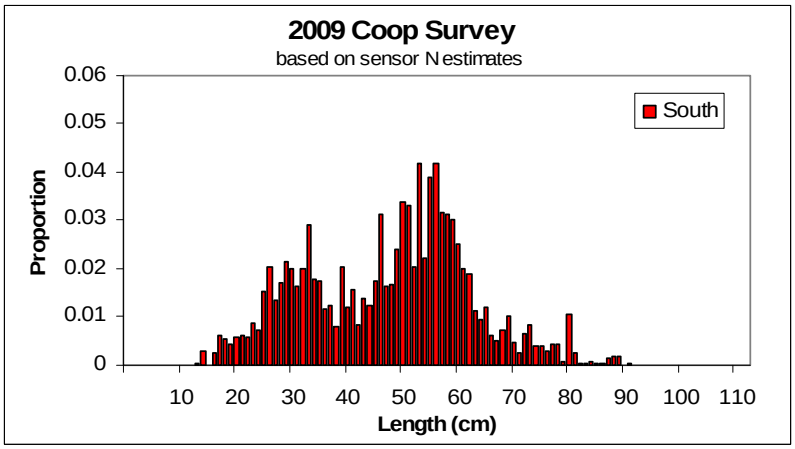
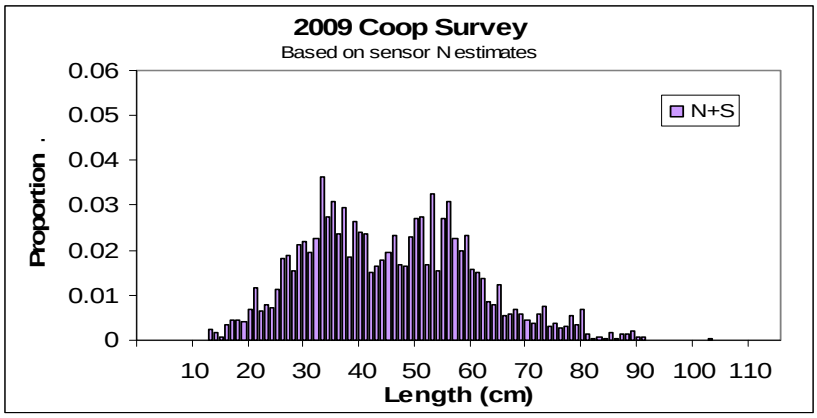


Figure A33. Results of bootstrapping analysis of monkfish catches in 2009 cooperative survey for the entire survey region based on 1,000 realizations.







Mean= 20,444,757
S.E. = 32,204.99
CV= 0.157522%

Figure A34. Proportion at length from the 2009 cooperative survey for northern, southern and combined management regions. Estimates were derived by applying proportion at length in each stratum to minimum sensor-based population numbers in that stratum, summing to numbers at length in each area and calculating the overall proportion at length.

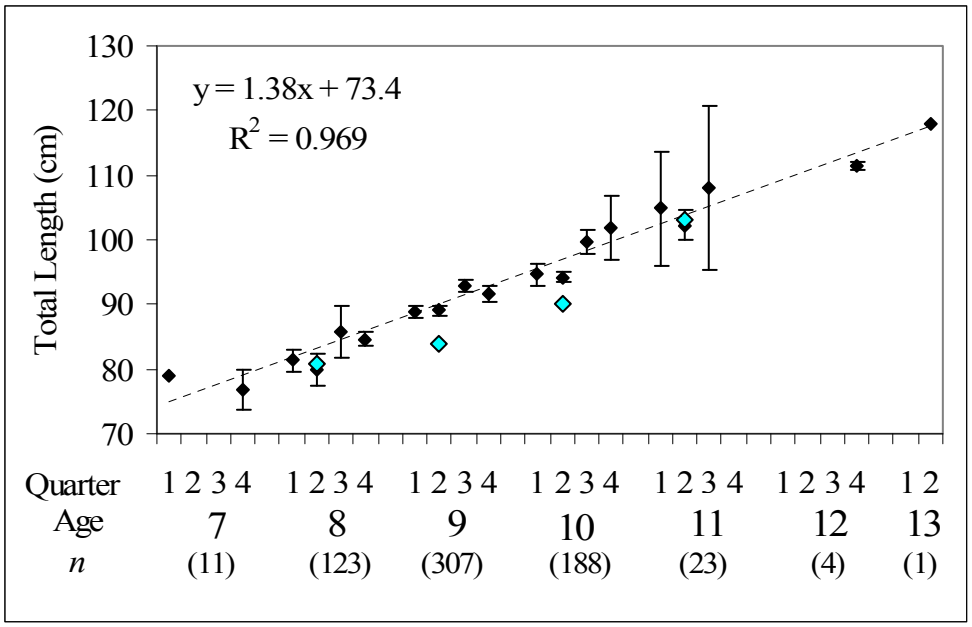


Figure A35. Mean length at age for samples from 2009 cooperative survey that were ≥ 80 cm (cyan diamonds) compared to mean length at age from NEFSC surveys and previous cooperative surveys (from Johnson et al. 2008). N for cooperative survey samples: age 8 = 4; age 9 = 17; age 10 = 3; age 11= 1.

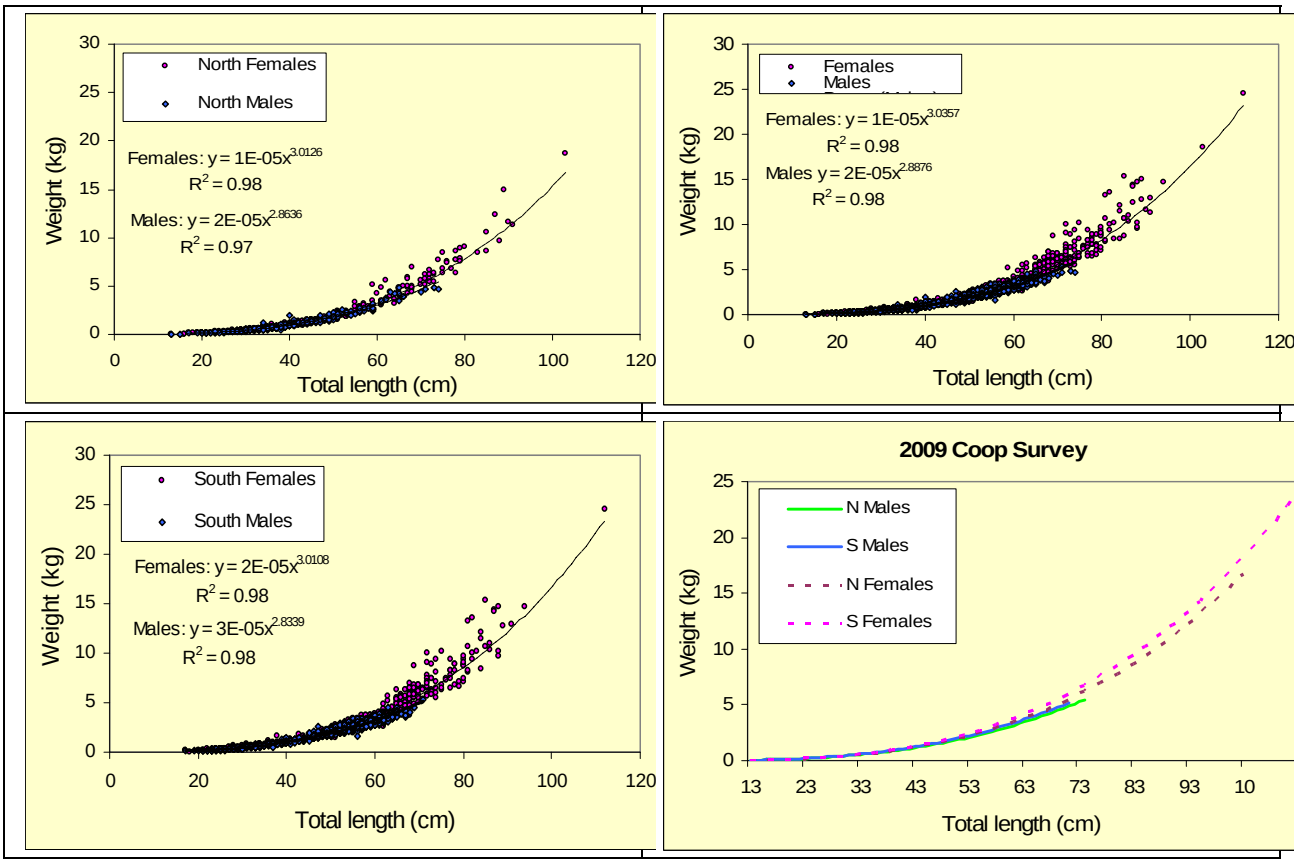


Figure A36. Length-weight relationships for male and female monkfish from northern and southern management areas, 2009 cooperative survey data.

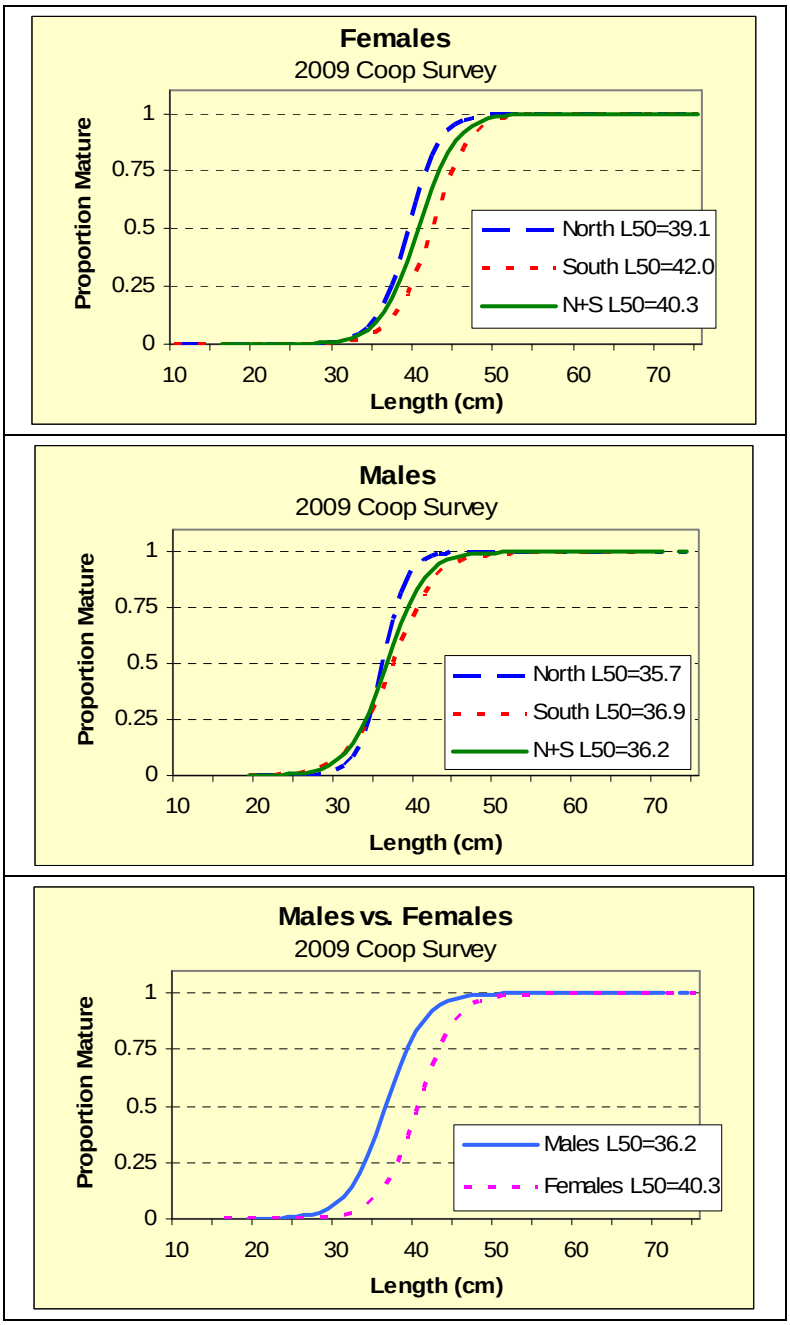


Figure A37. Maturity ogives for male and female monkfish from northern and southern management areas, 2009 cooperative survey data.

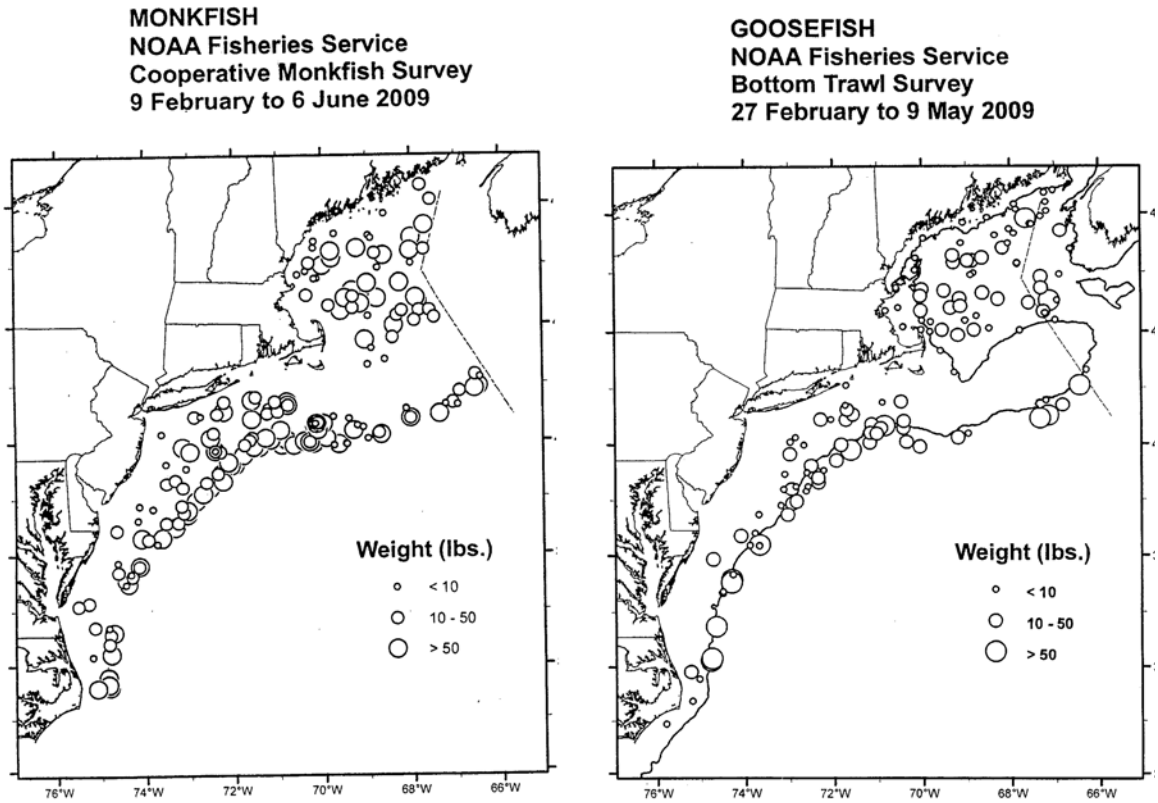


Figure A38. Catch rates (kg per tow) in 2009 cooperative monkfish survey and NEFSC 2009 spring survey.

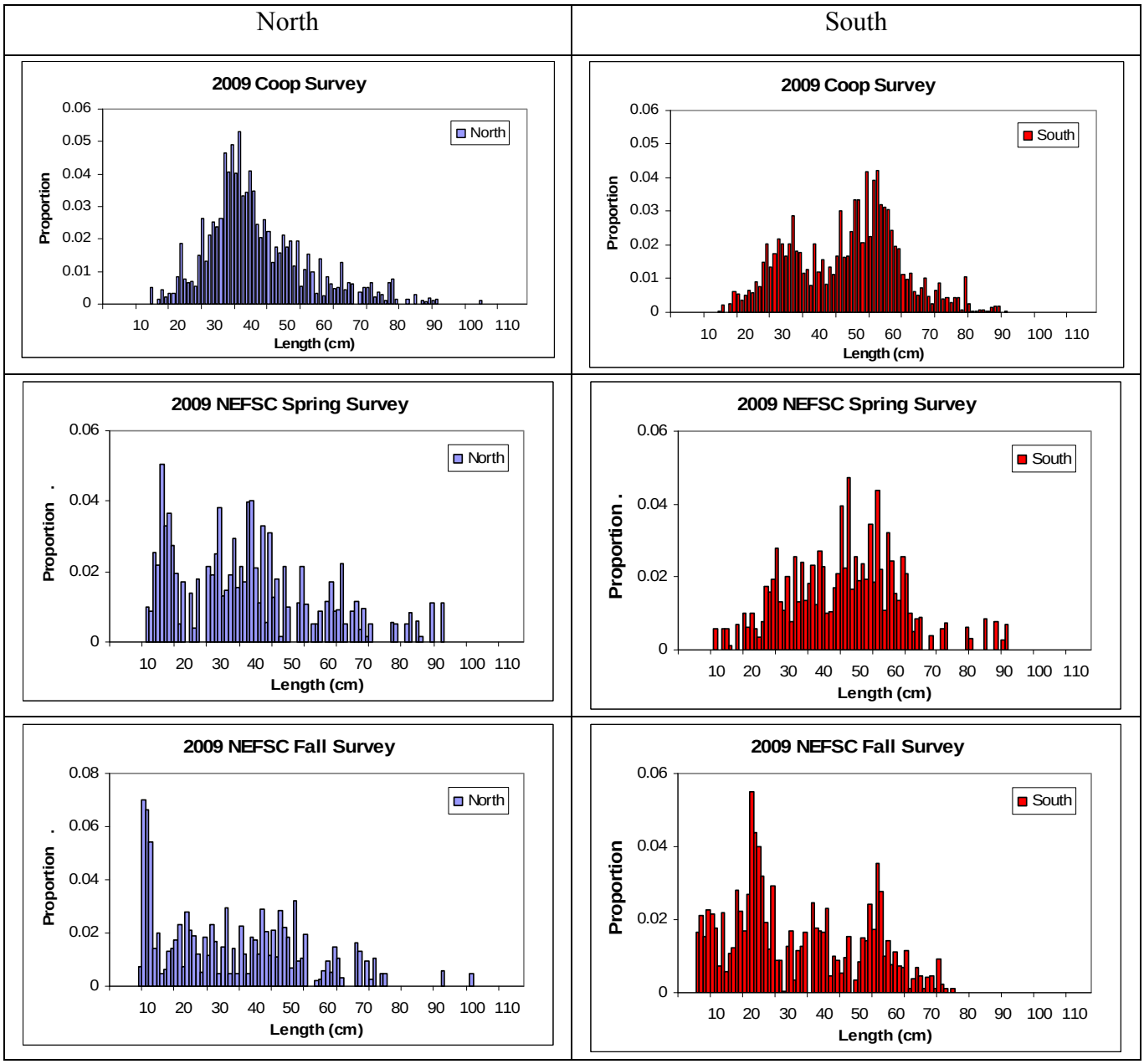


Figure A39. Proportion at length in NFMA and SFMA from the 2009 cooperative survey (top row), NEFSC 2009 spring survey (middle row) and NEFSC 2009 autumn survey (bottom row).

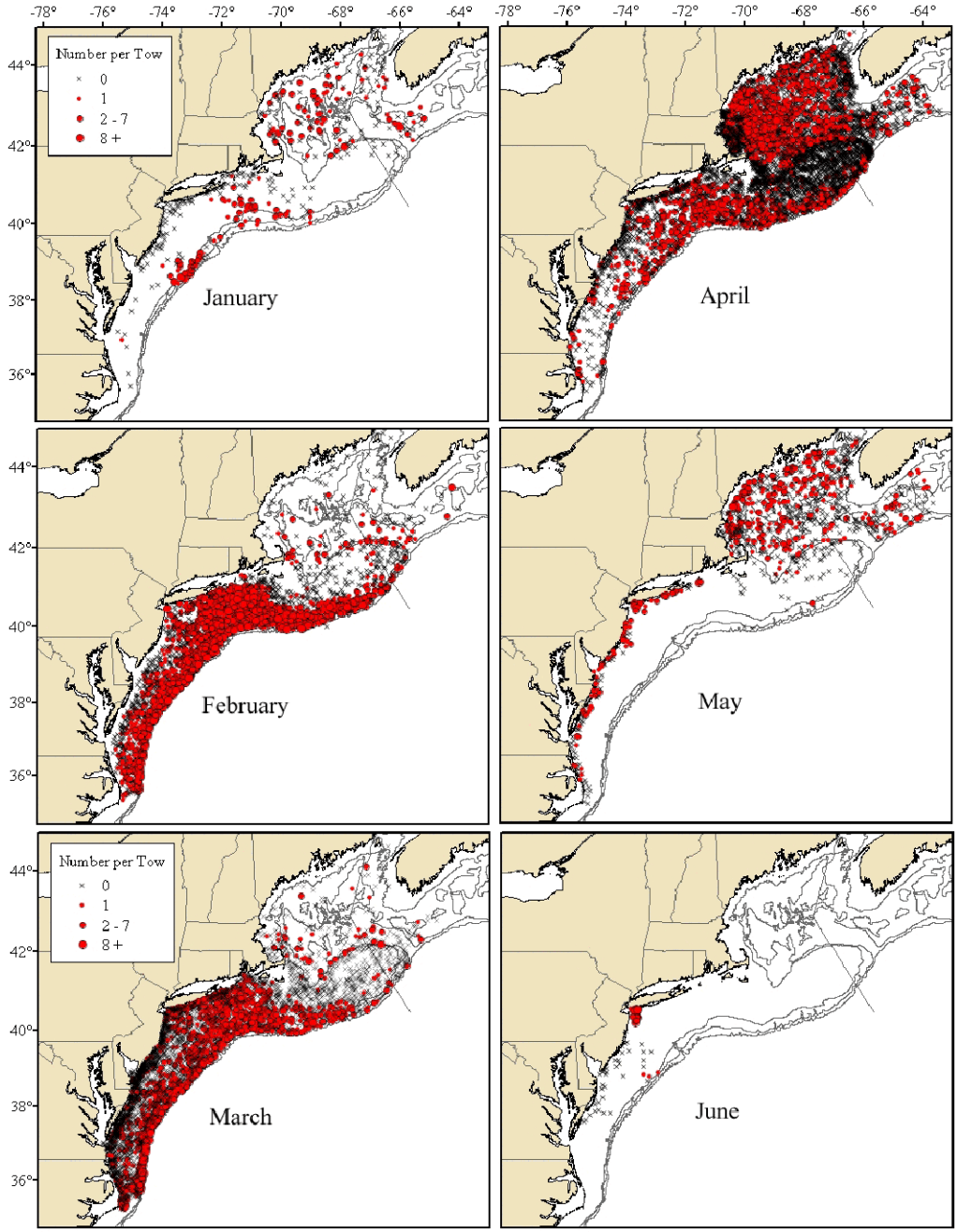


Figure A40. Monthly distribution plots for monkfish, January-December.

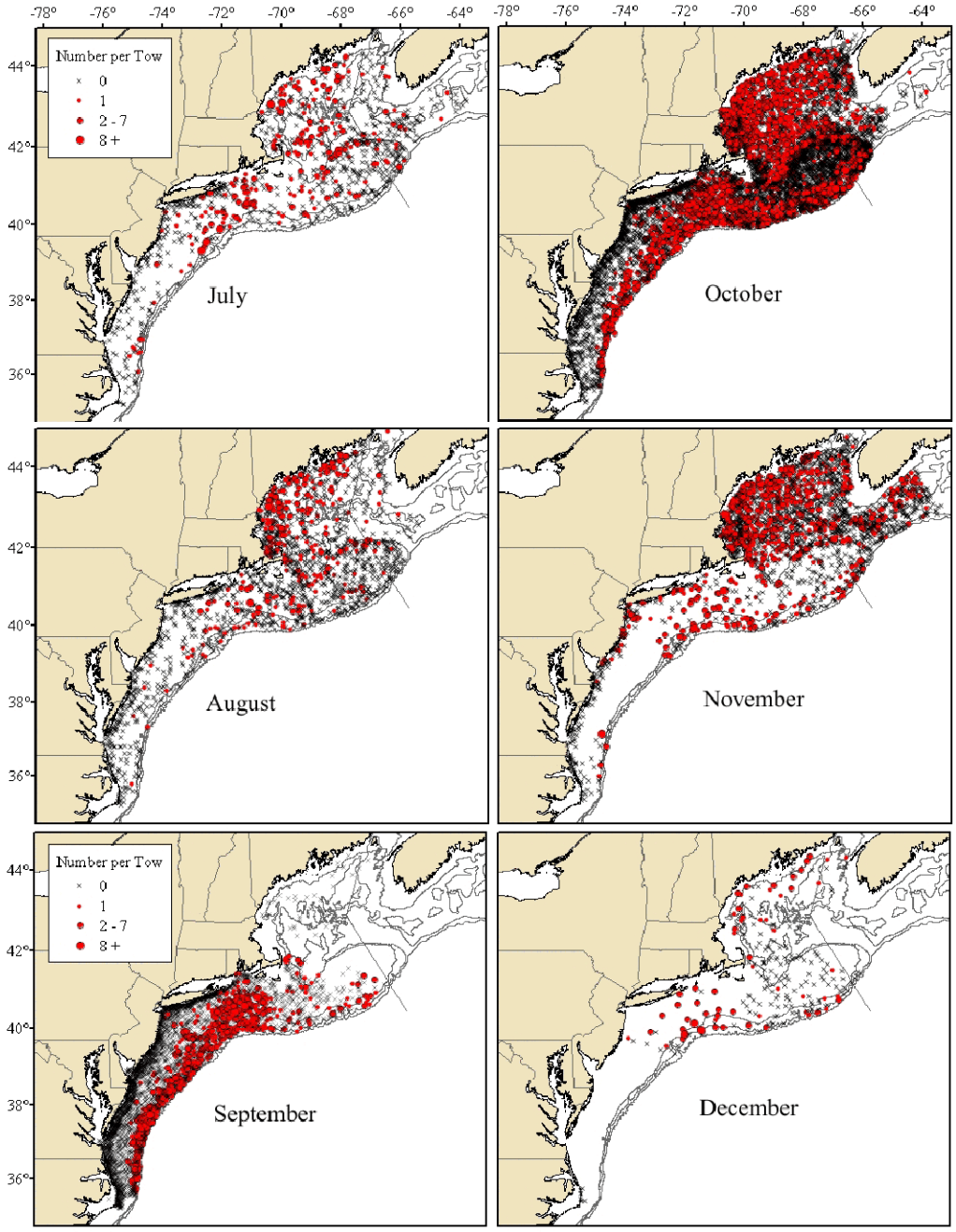


Figure A40, cont'd.

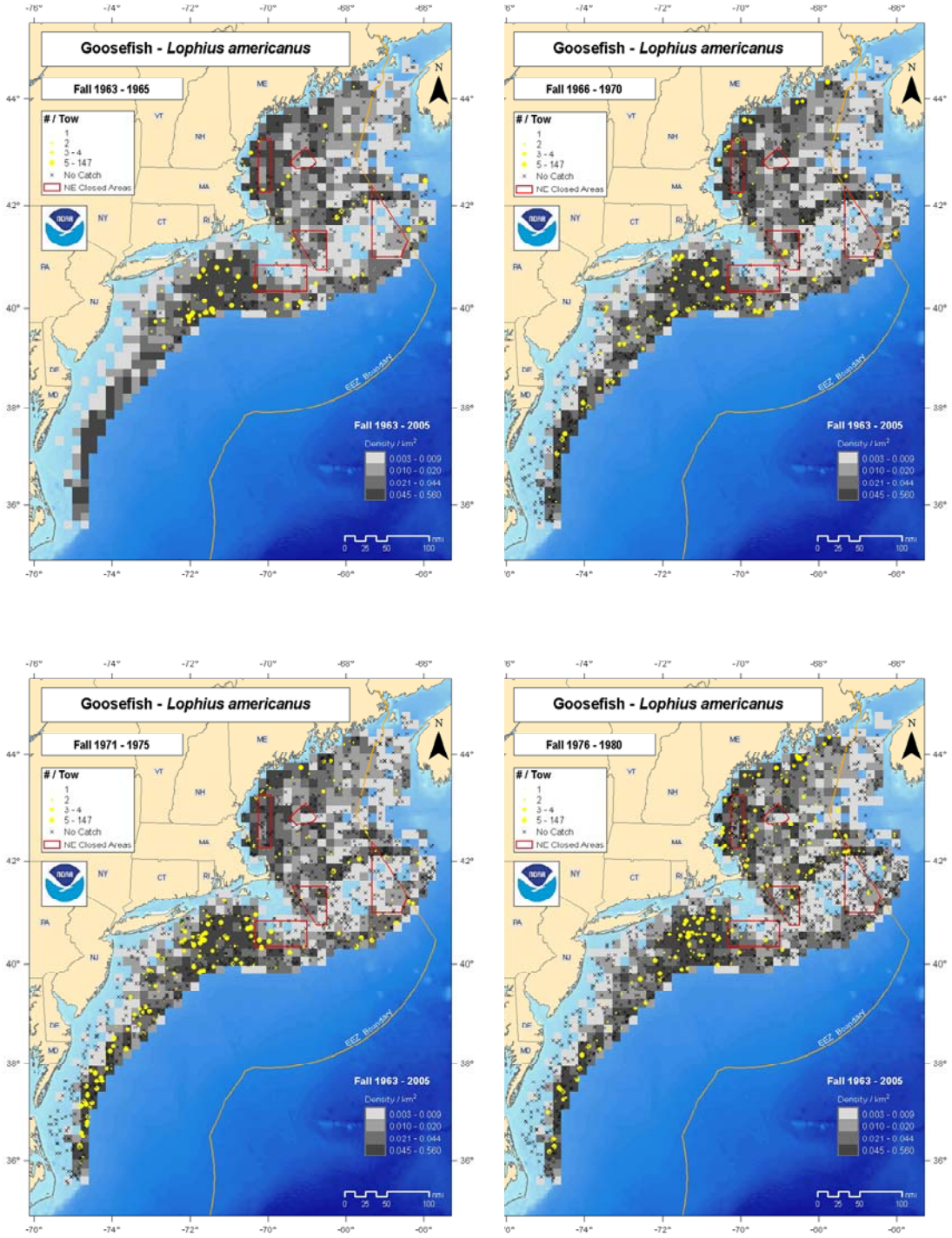


Figure A41. Distribution of monkfish from the NEFSC fall survey, 1963-2005 (from www.nefsc.noaa.gov/sos).

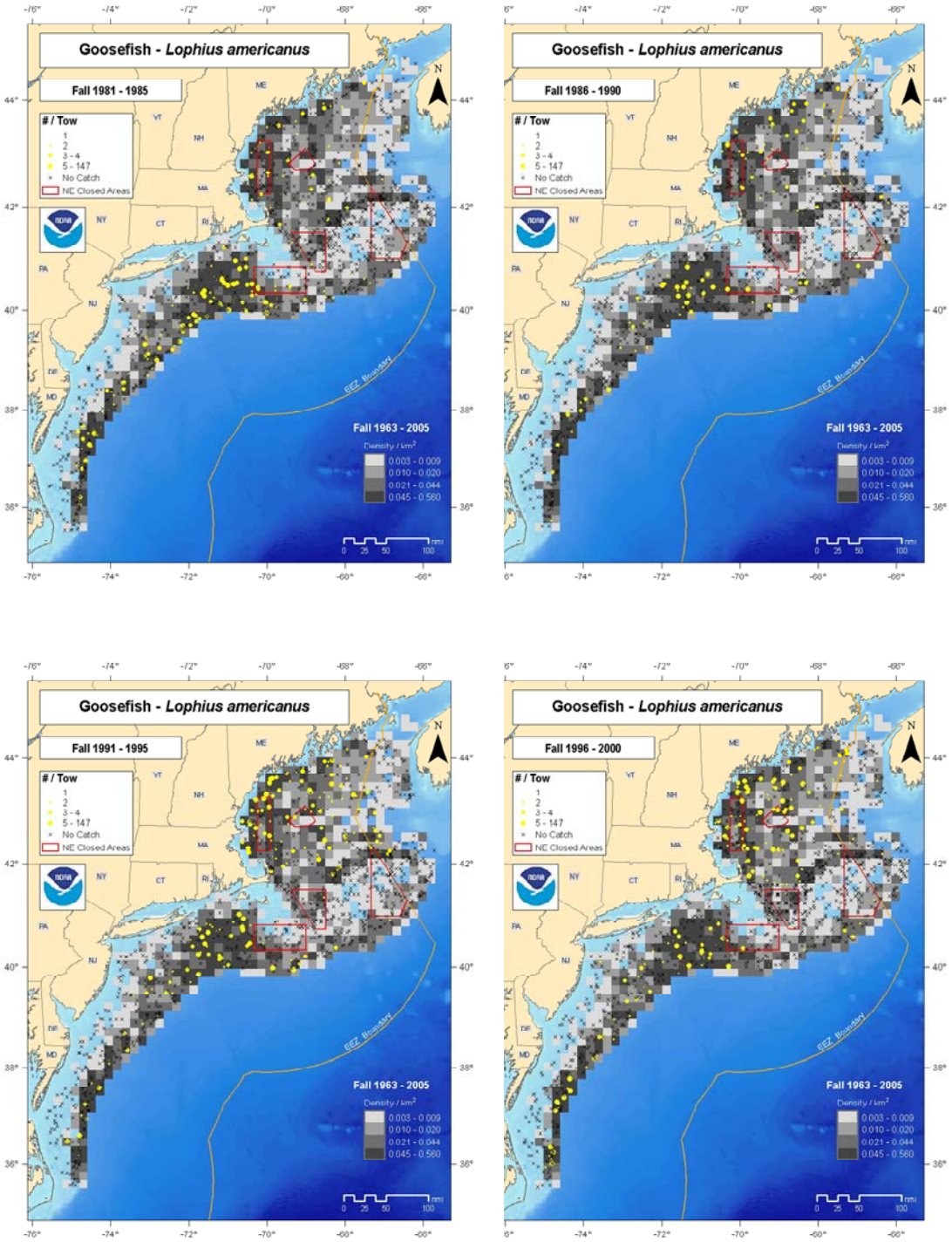


Figure A41. continued

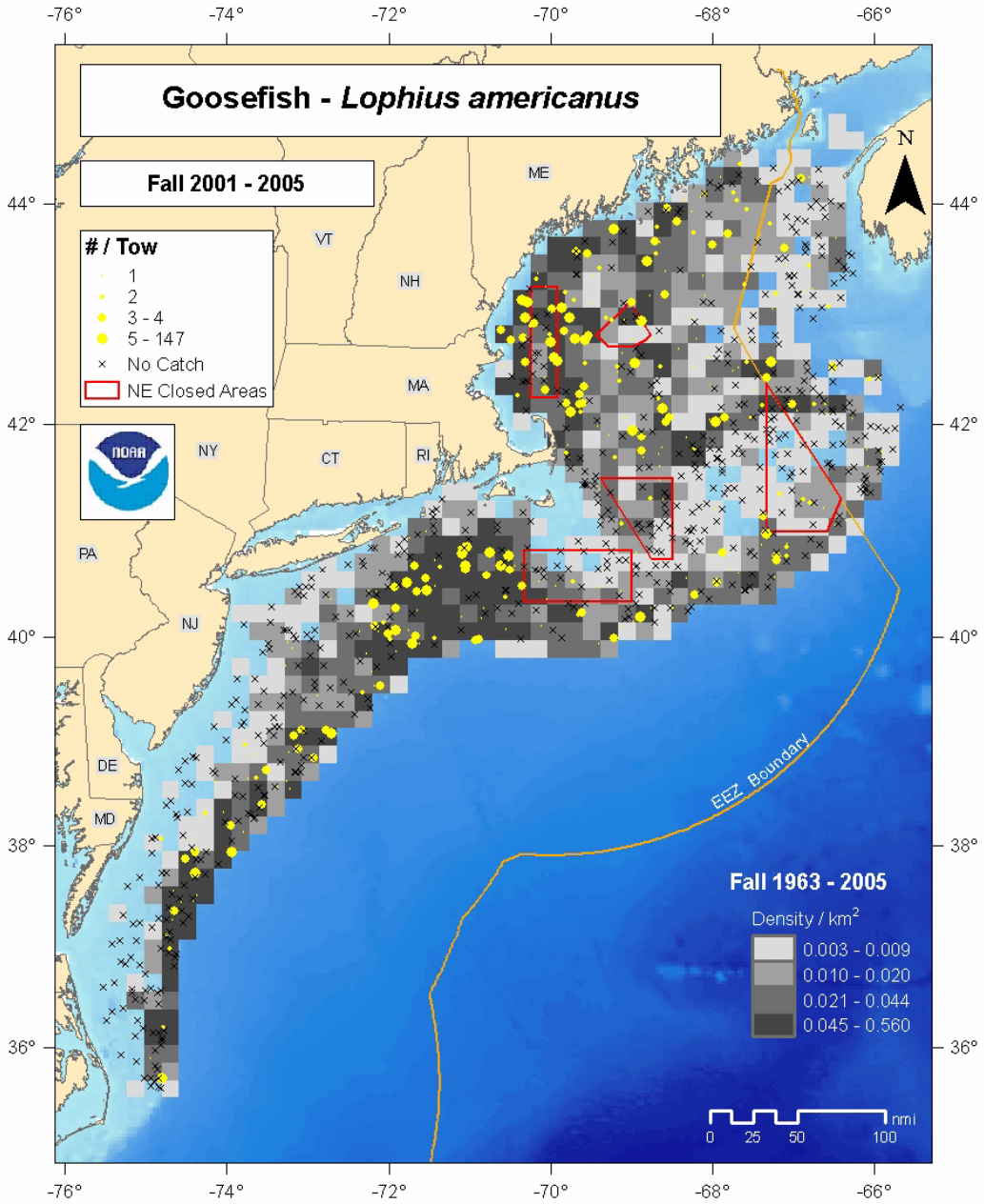


Figure A41. continued

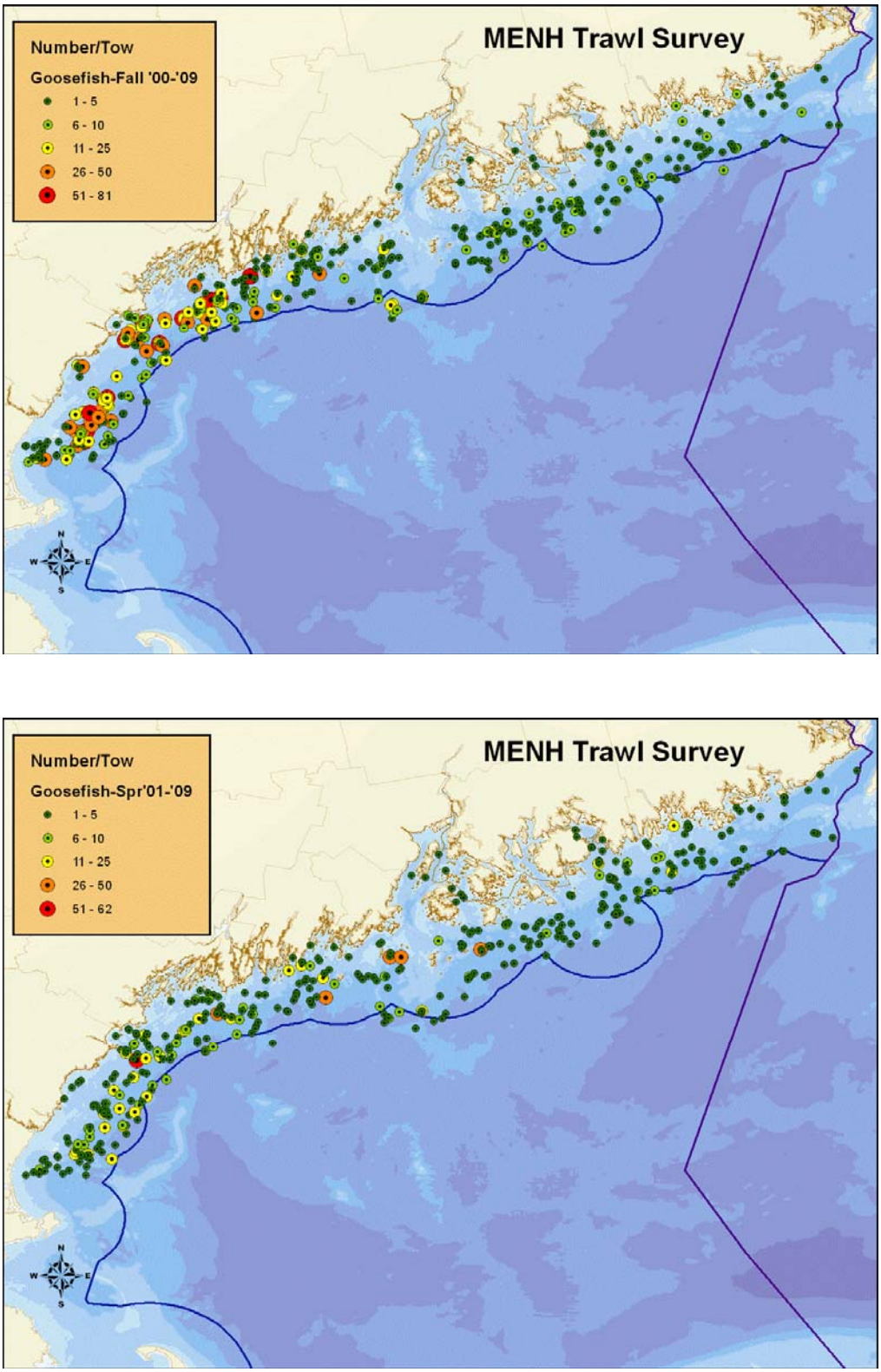


Figure A42. Geographic distribution of catches in fall (top panel) and spring (bottom panel) ME-NH inshore trawl surveys. Outer limit of survey (bold dark blue line) is 200 m.

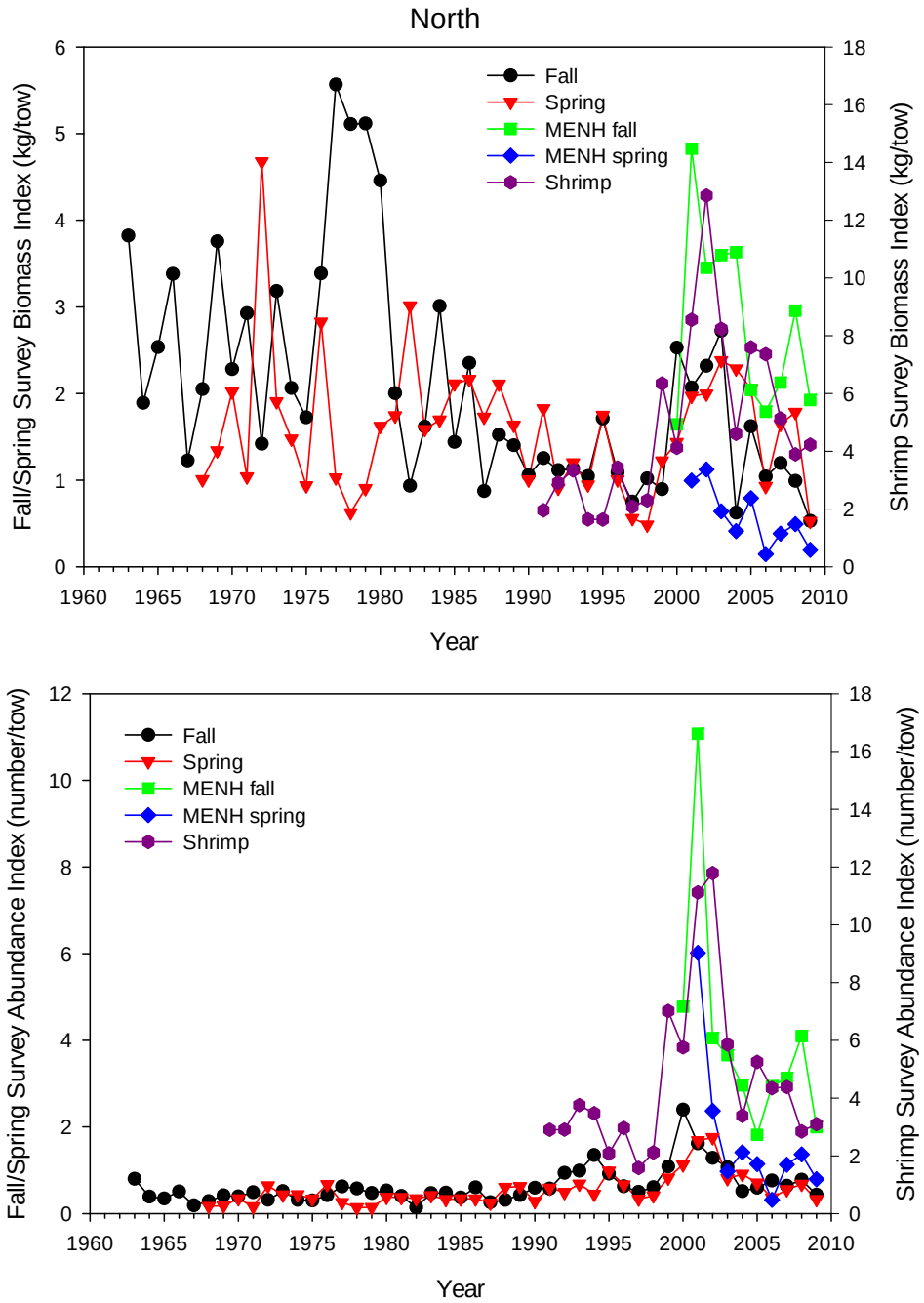


Figure A43. NEFSC spring and autumn surveys of monkfish biomass and abundance in the northern management region.

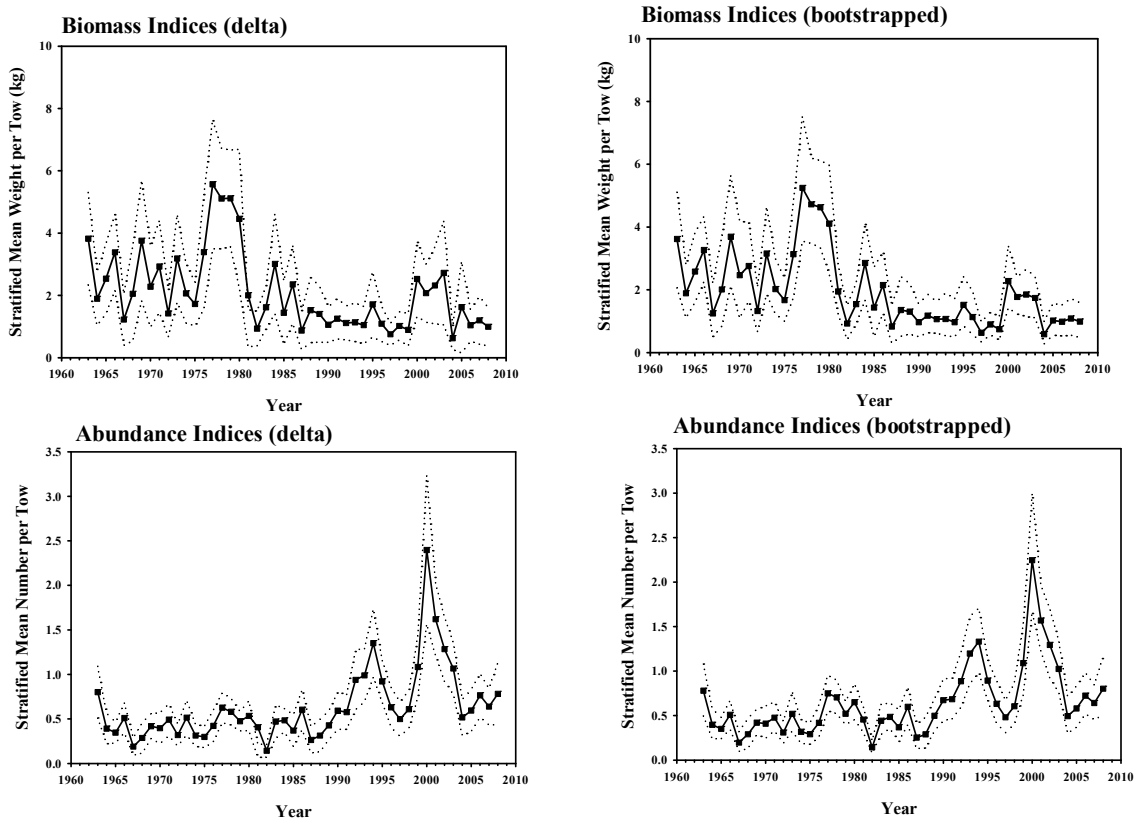


Figure A44. Delta distribution (parametric) and bootstrapped (arithmetic) biomass and abundance indices from the NEFSC autumn bottom trawl survey for the northern management region from 1963-2008. Data prior to 1971 have been revised following an audit of historical data. The 95% confidence limits are shown by the dashed line.

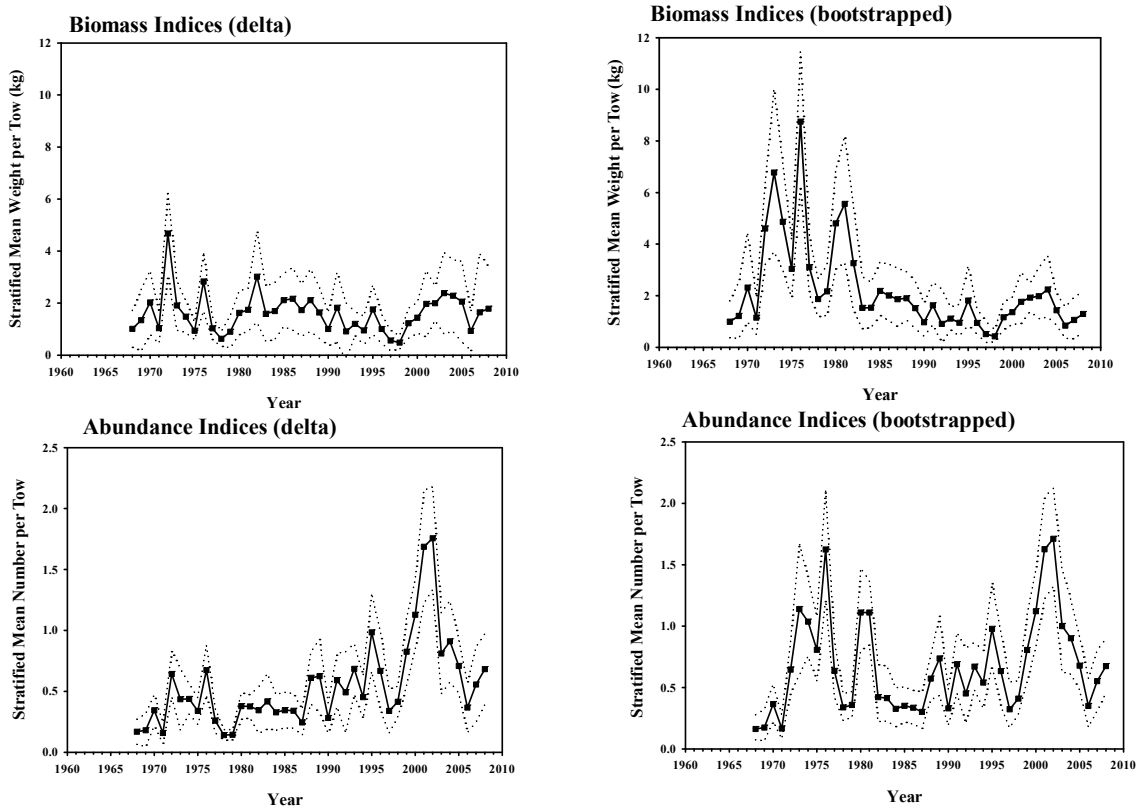


Figure A45. Delta distribution (parametric) and bootstrapped (arithmetic) biomass and abundance indices from the NEFSC spring bottom trawl survey for the northern management region from 1968-2008. Data prior to 1971 have been revised following an audit of historical data. The 95% confidence limits are shown by the dashed line.

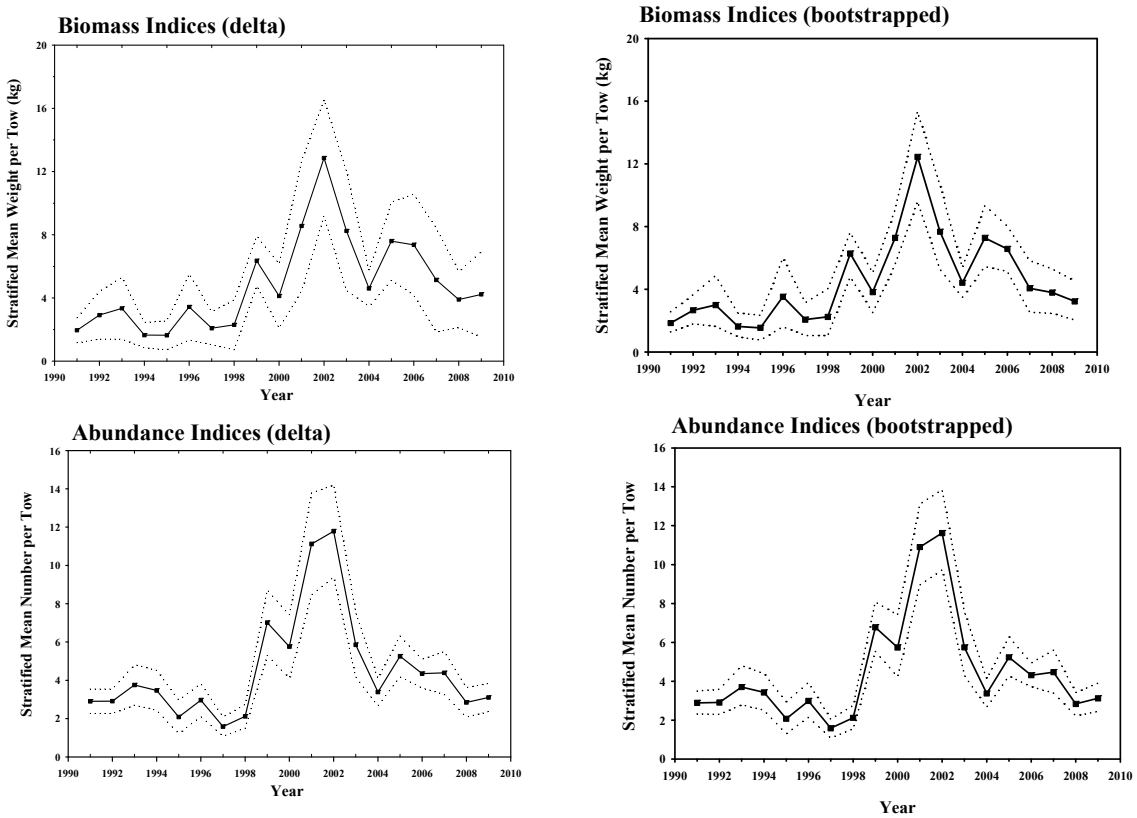
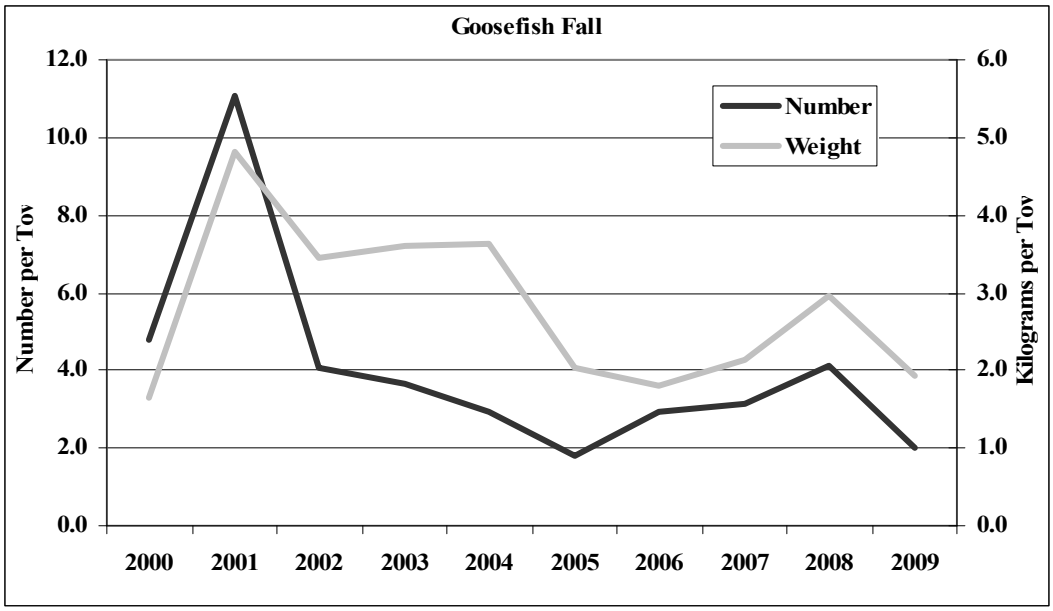


Figure A46. Delta distribution (parametric) and bootstrapped (arithmetic) biomass and abundance indices from the NEFSC shrimp survey for the northern management region from 1991-2009. Data prior to 1971 have been revised following an audit of historical data. The 95% confidence limits are shown by the dashed line.



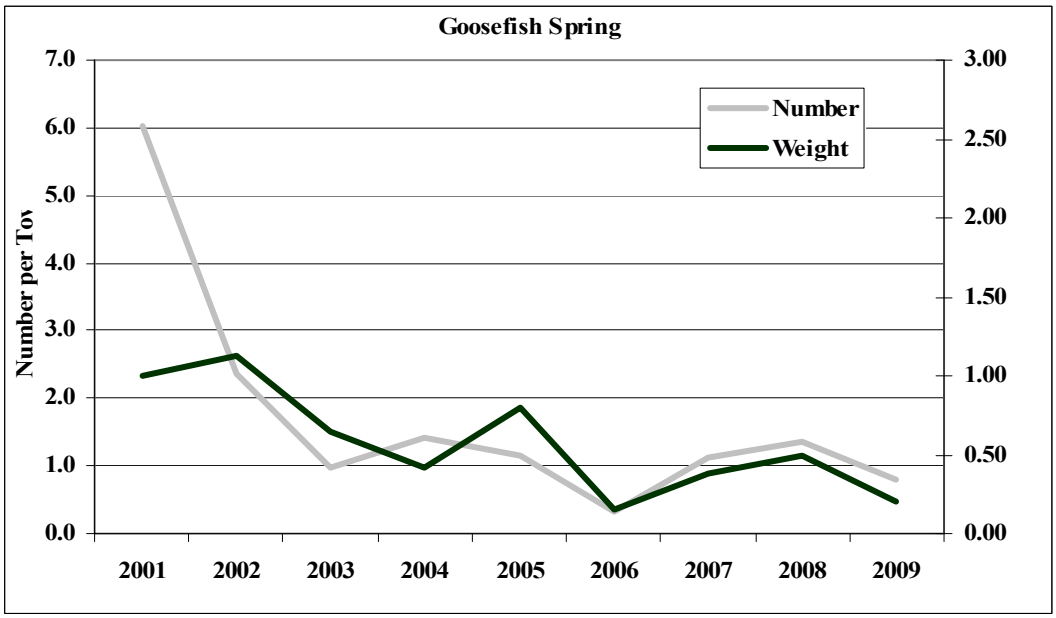


Figure A47. Survey indices from ME-NH inshore trawl surveys, NFMA.

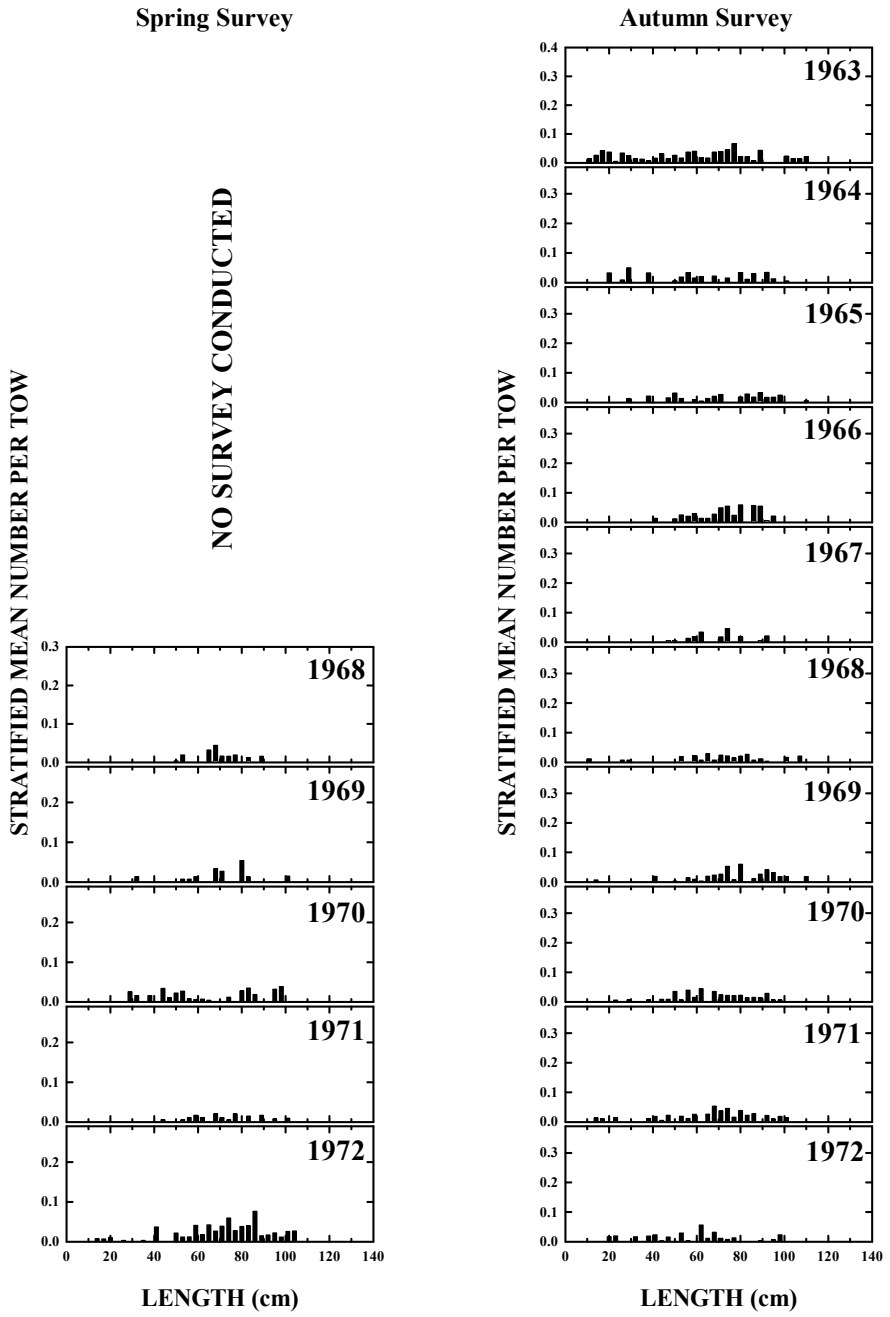


Figure A48. Goosefish length composition from the NEFSC spring and autumn bottom trawl surveys in the northern management region,

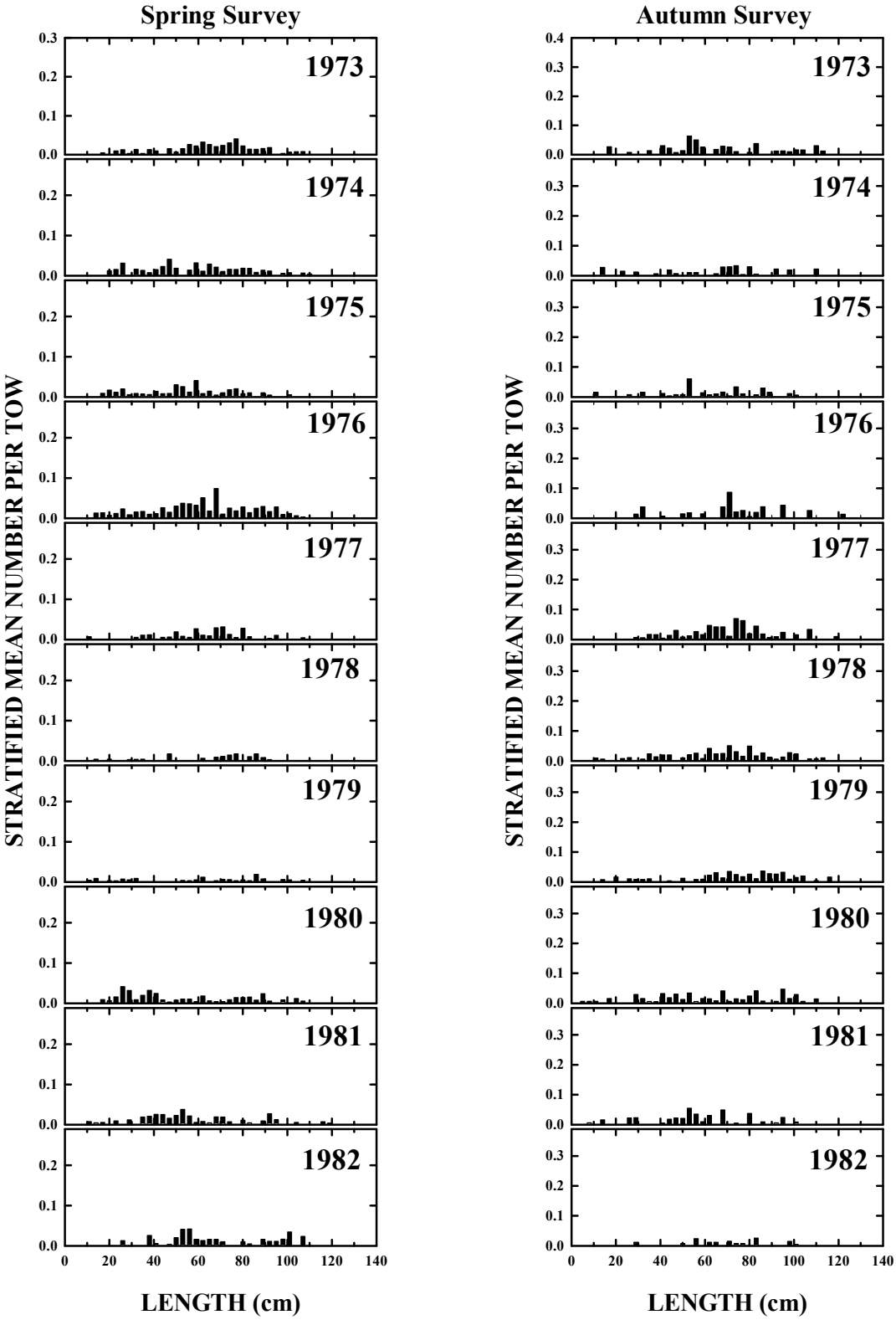


Figure A48, continued

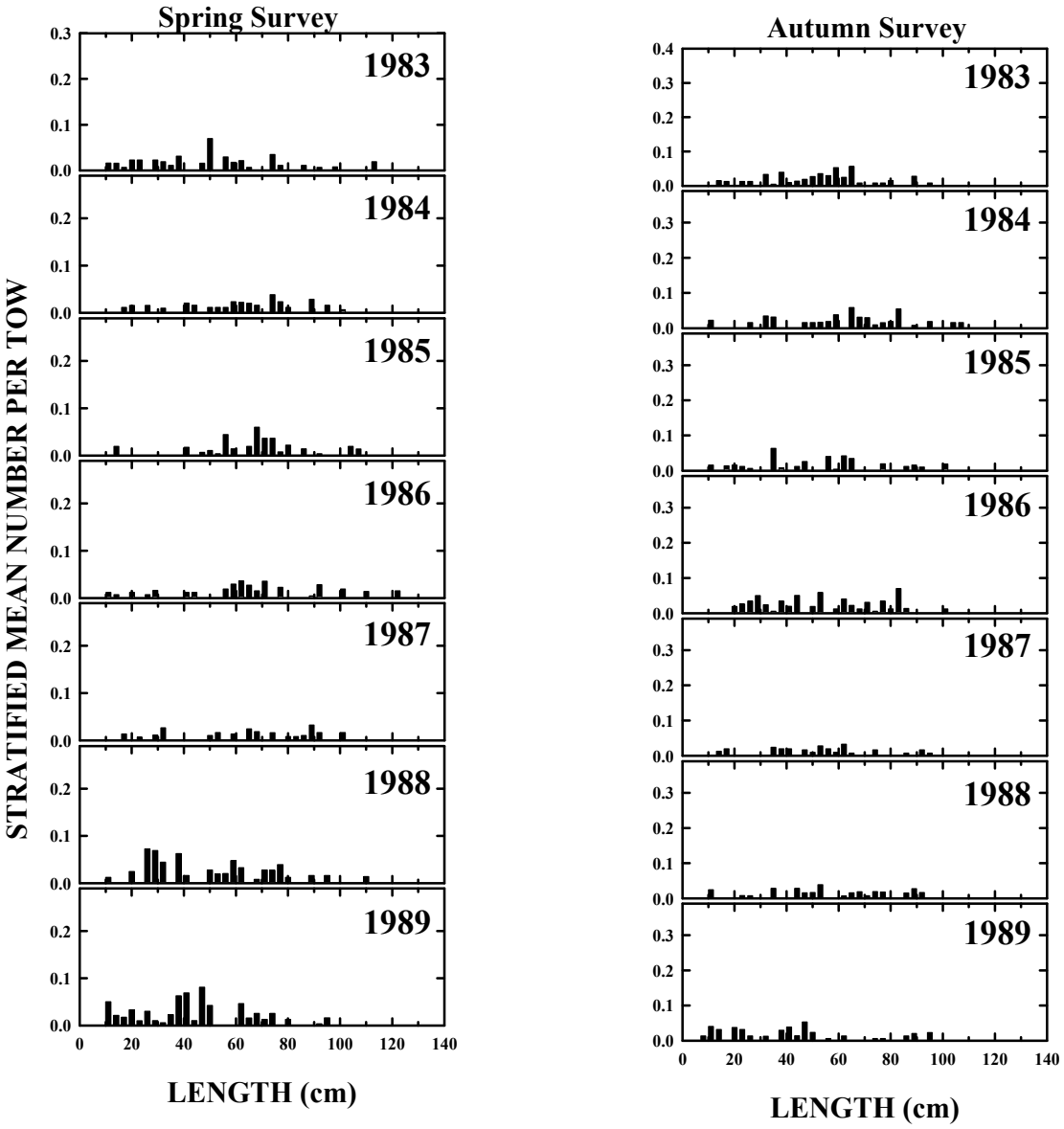


Figure A48, continued.

NOTE: Y-AXIS SCALE CHANGES ON THIS PAGE

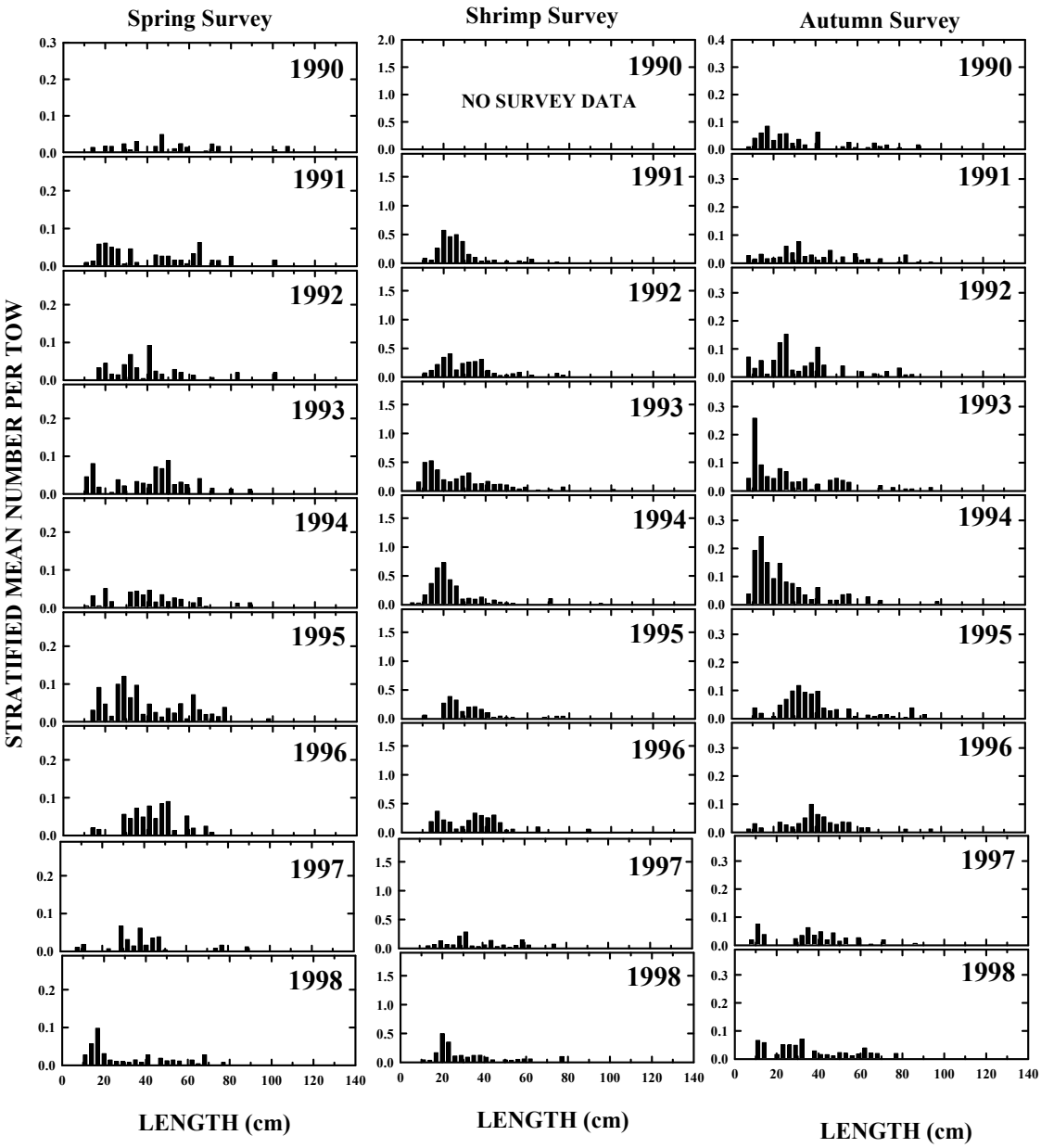


Figure A48, continued

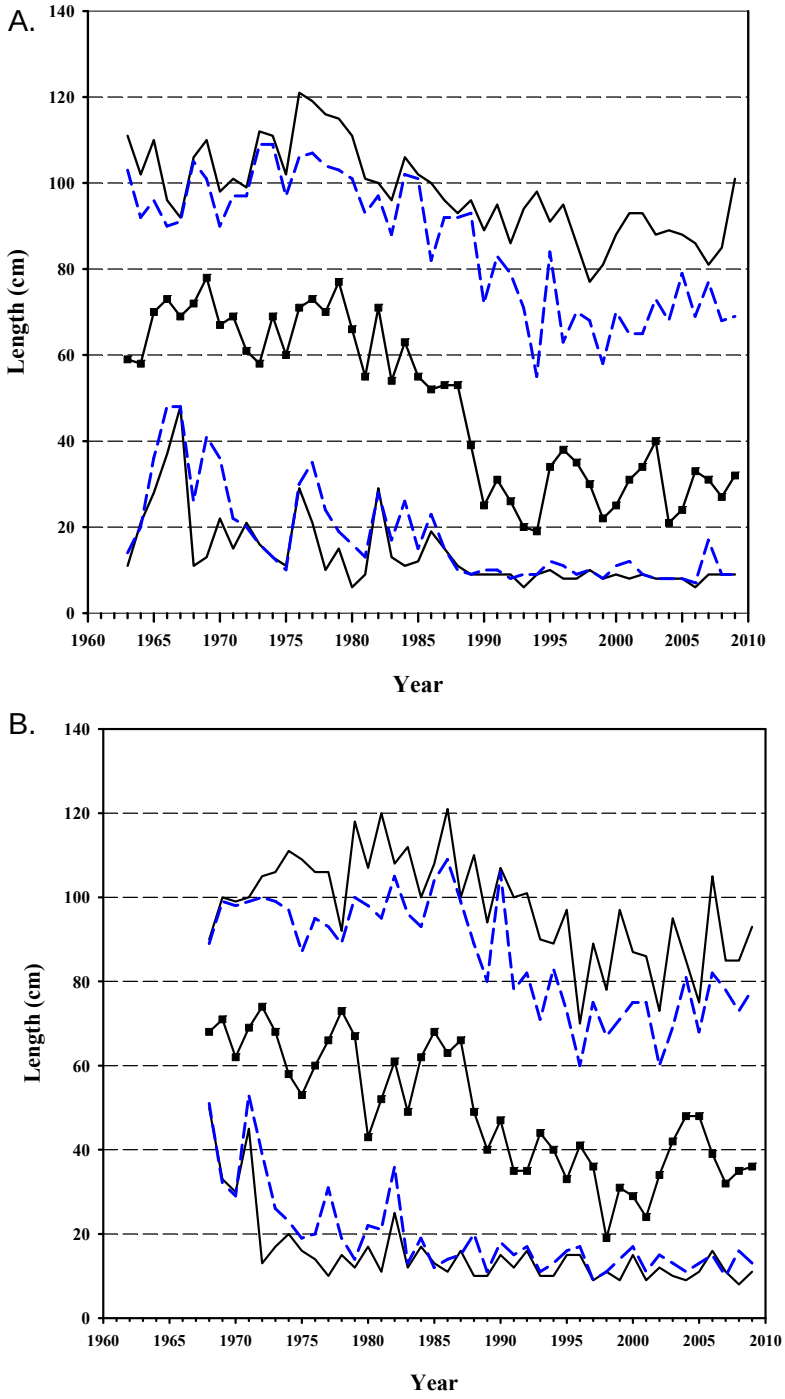


Figure A49. Minimum, median, and, maximum lengths for the northern management region from (A) NEFSC autumn surveys and (B) NEFSC spring surveys

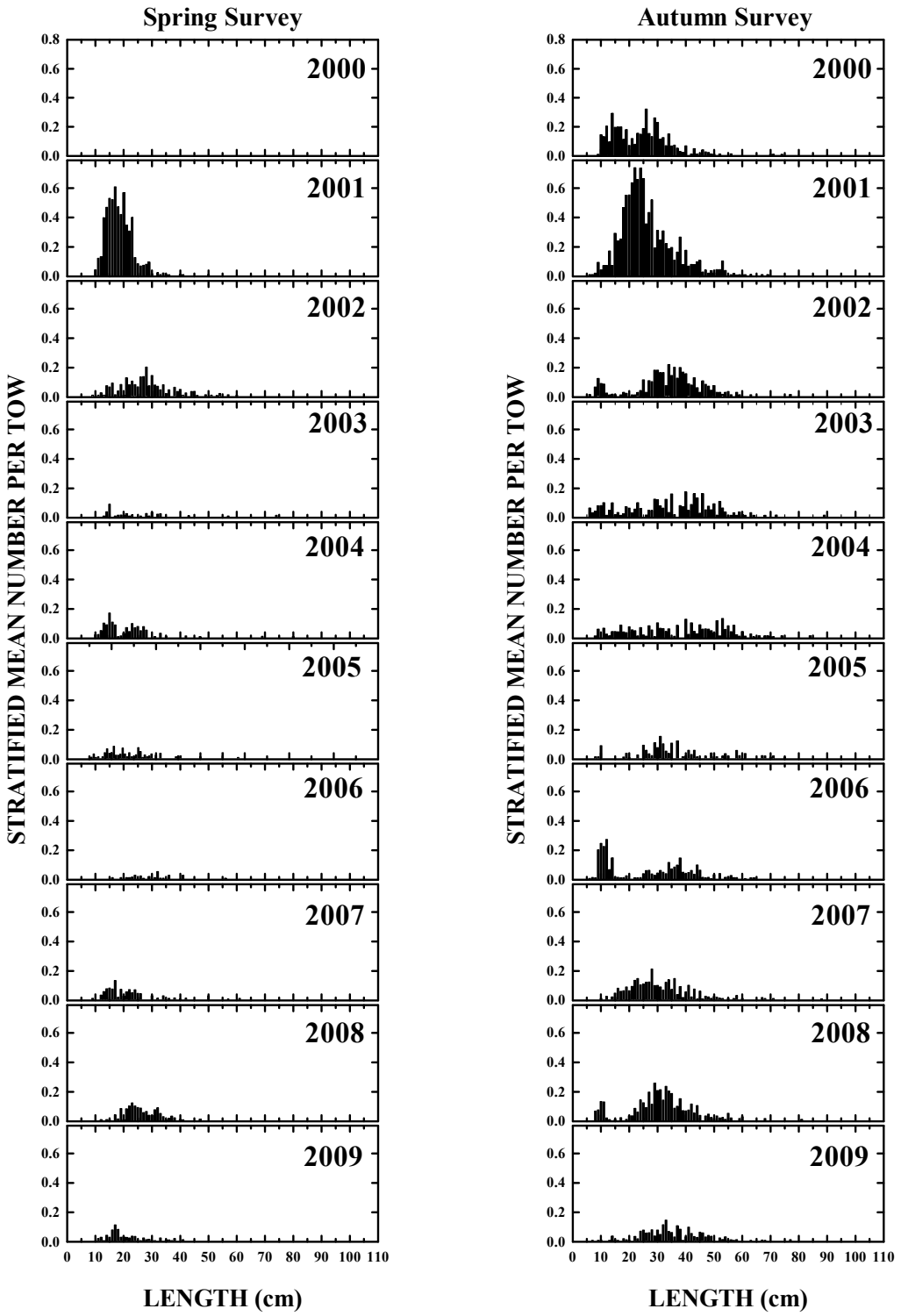
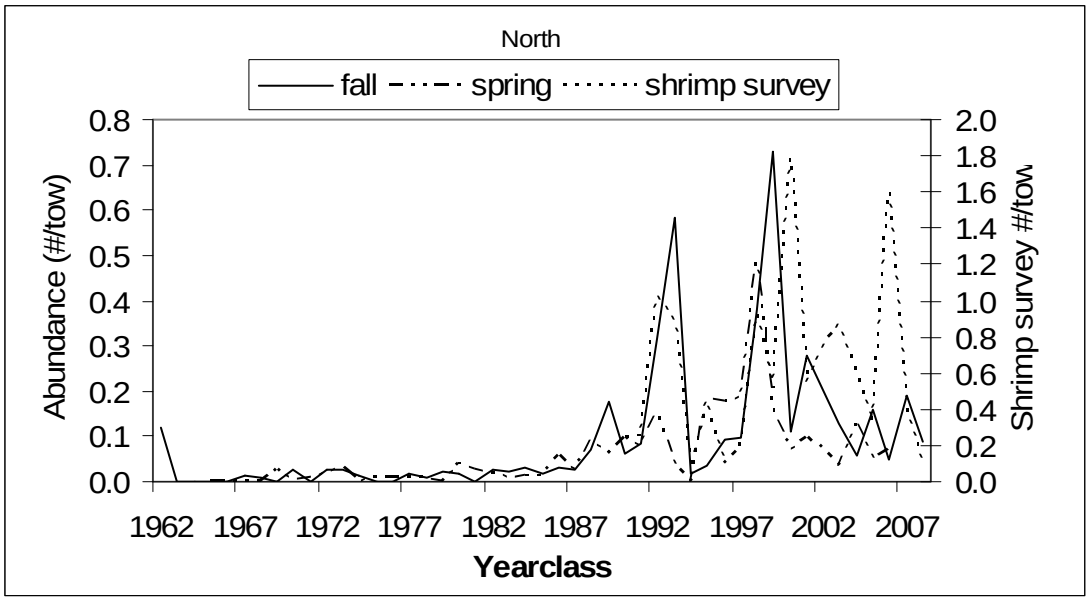


Figure A50. ME-NH inshore survey length frequency plots, 2000-2009.



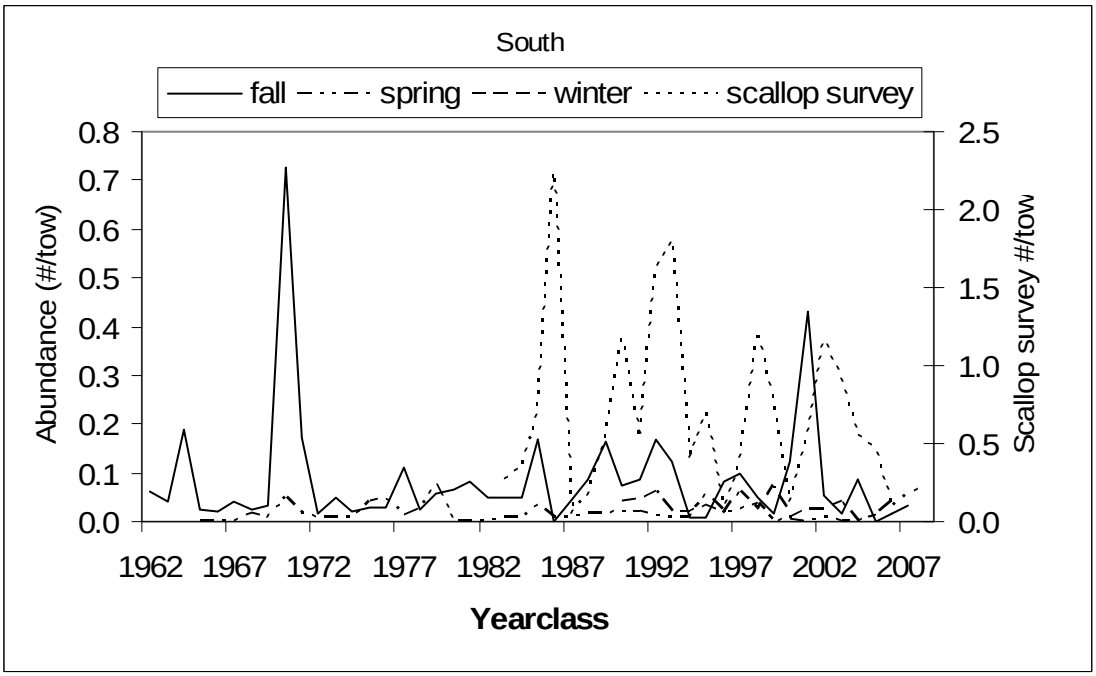


Figure A51. Abundance indices for approximate age 1 (shrimp, scallop and autumn surveys) and age 2 (winter and spring surveys) by yearclass. 2009 FSV Bigelow indices were corrected using calibration coefficient for numbers.

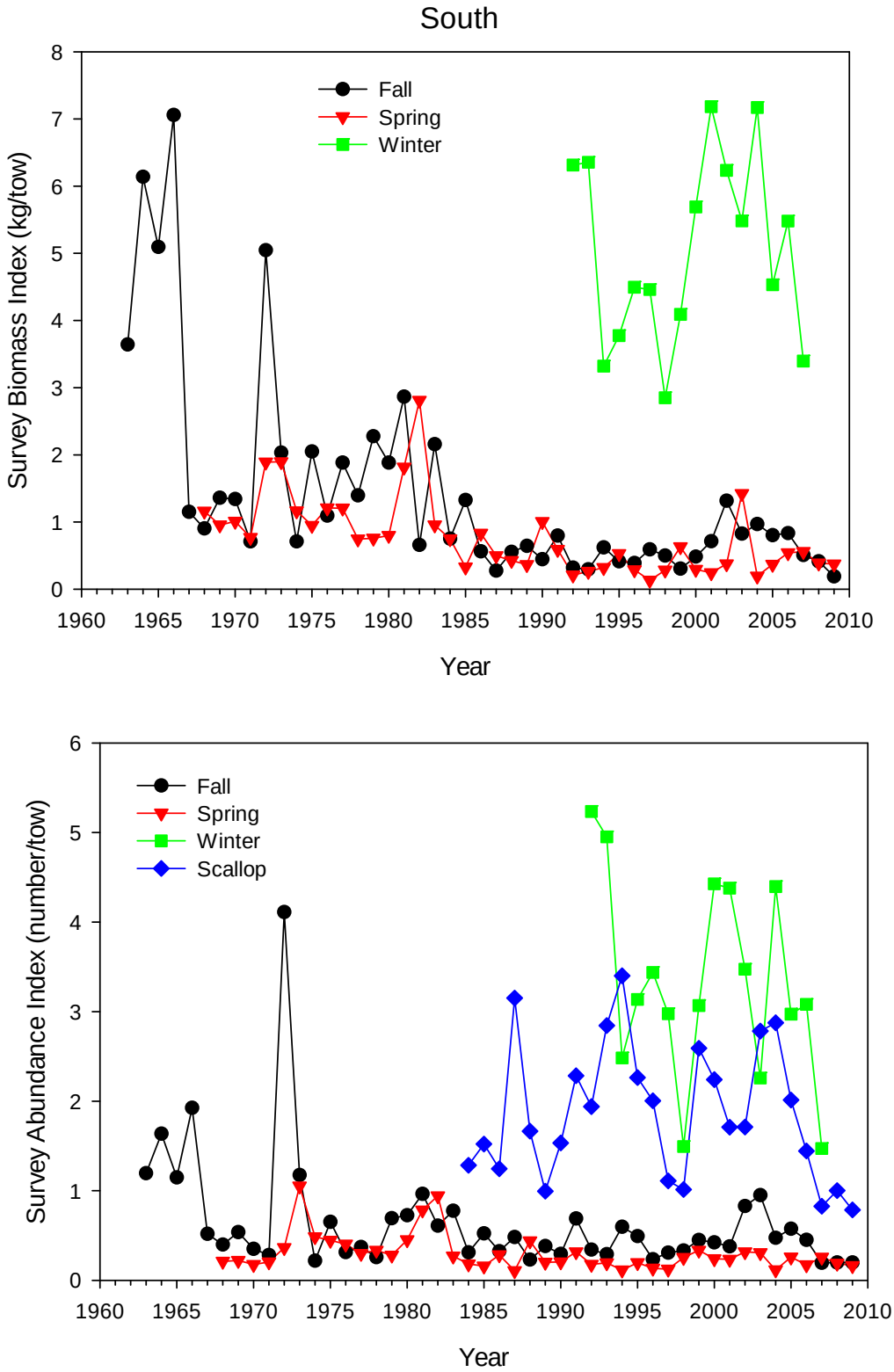


Figure A52. NEFSC spring and autumn surveys of monkfish biomass and abundance in the southern management region.

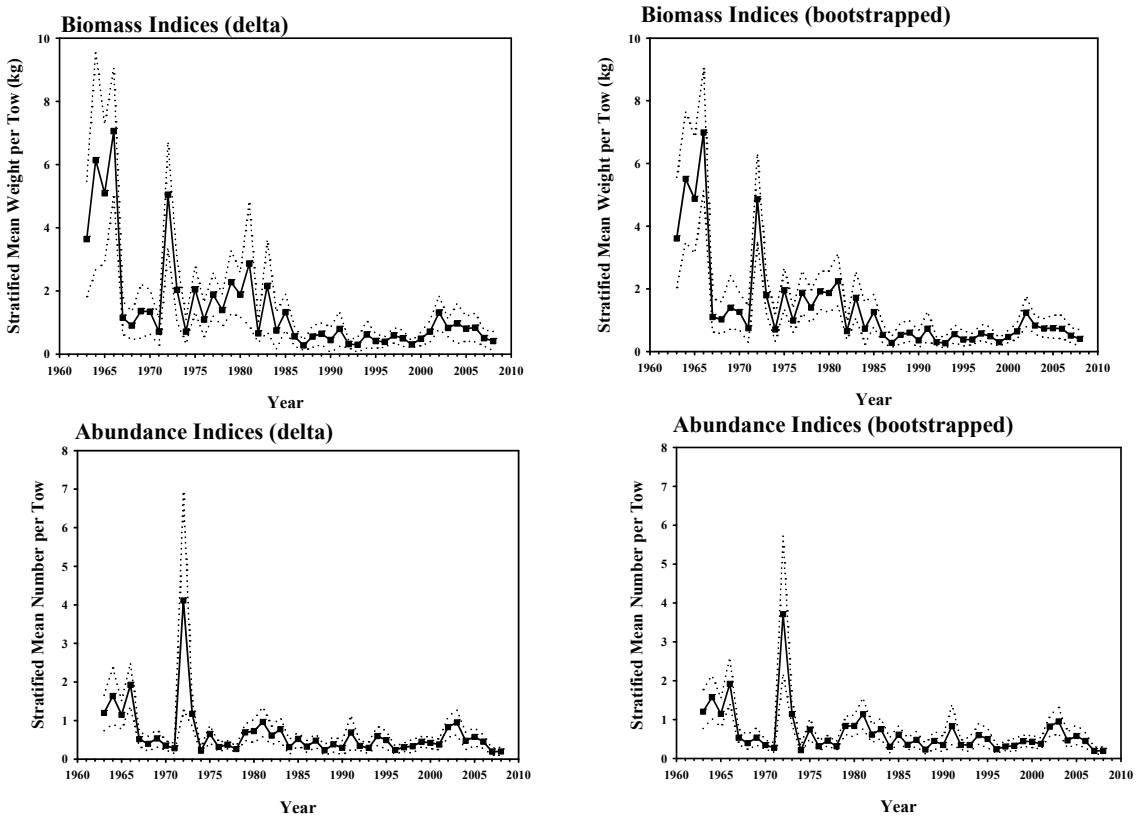


Figure A53. Delta distribution (parametric) and bootstrapped (arithmetic) biomass and abundance indices from the NEFSC autumn bottom trawl survey for the southern management region from 1963-2008. Data prior to 1971 have been revised following an audit of historical data. The 95% confidence limits are shown by the dashed line.

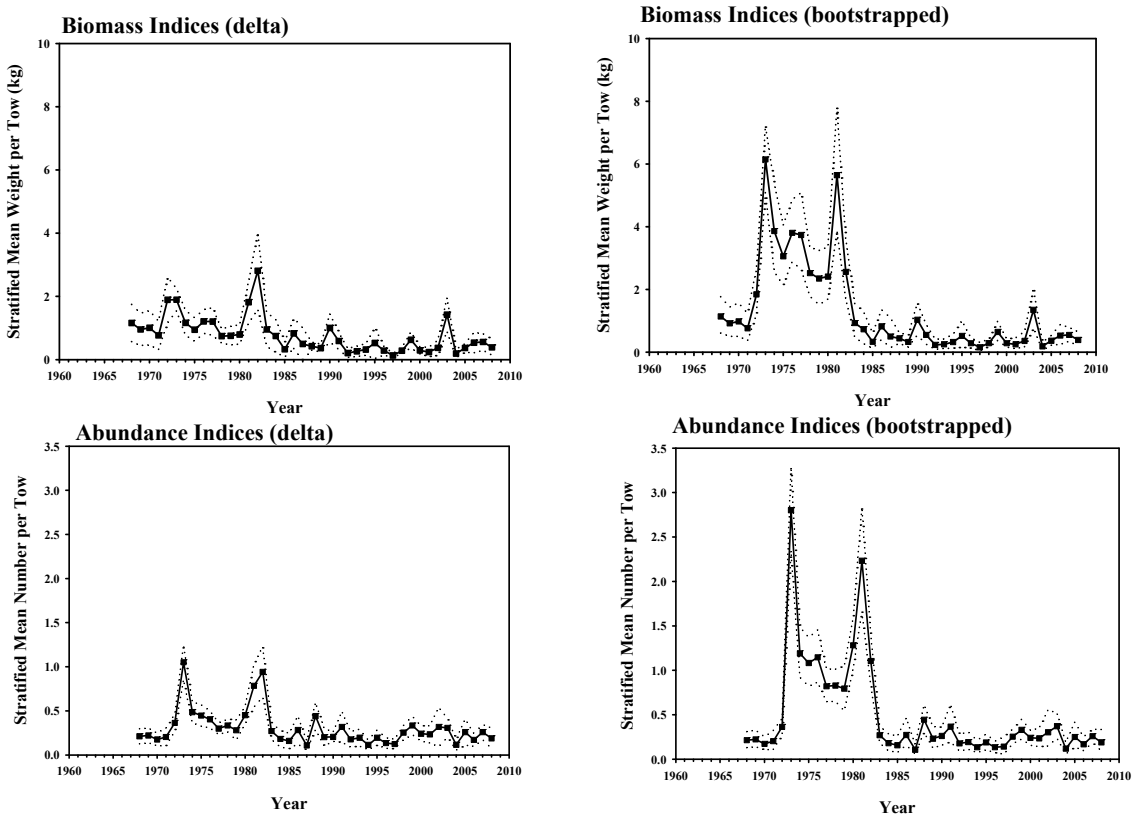


Figure A54. Delta distribution (parametric) and bootstrapped (arithmetic) biomass and abundance indices from the NEFSC spring bottom trawl survey for the southern management region from 1968-2008. Data prior to 1971 have been revised following an audit of historical data. The 95% confidence limits are shown by the dashed line.

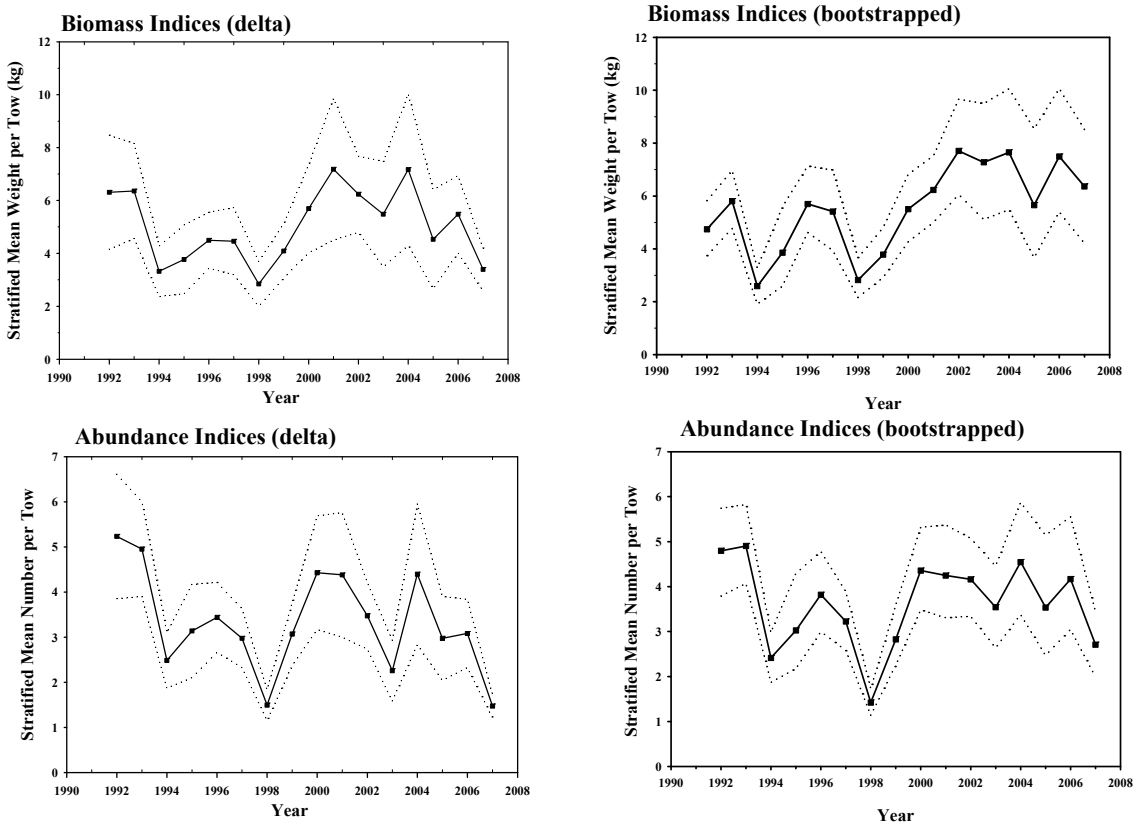


Figure A55. Delta distribution (parametric) and bootstrapped (arithmetic) biomass and abundance indices from the NEFSC winter survey for the southern management region from 1992-2007. Data prior to 1971 have been revised following an audit of historical data. The 95% confidence limits are shown by the dashed line.

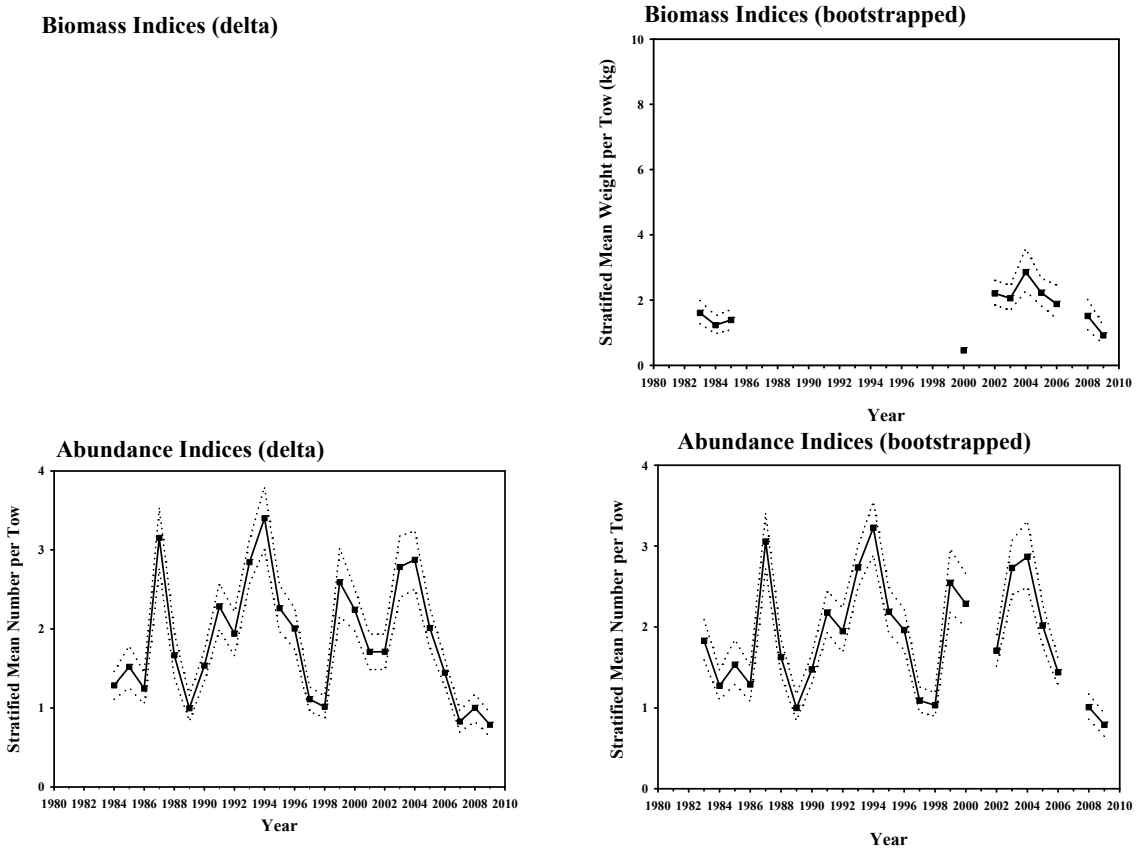


Figure A56. Delta distribution (parametric) and bootstrapped (arithmetic) biomass and abundance indices from the NEFSC scallop survey for the southern management region from 1983-2009. Data prior to 1971 have been revised following an audit of historical data. The 95% confidence limits are shown by the dashed line.

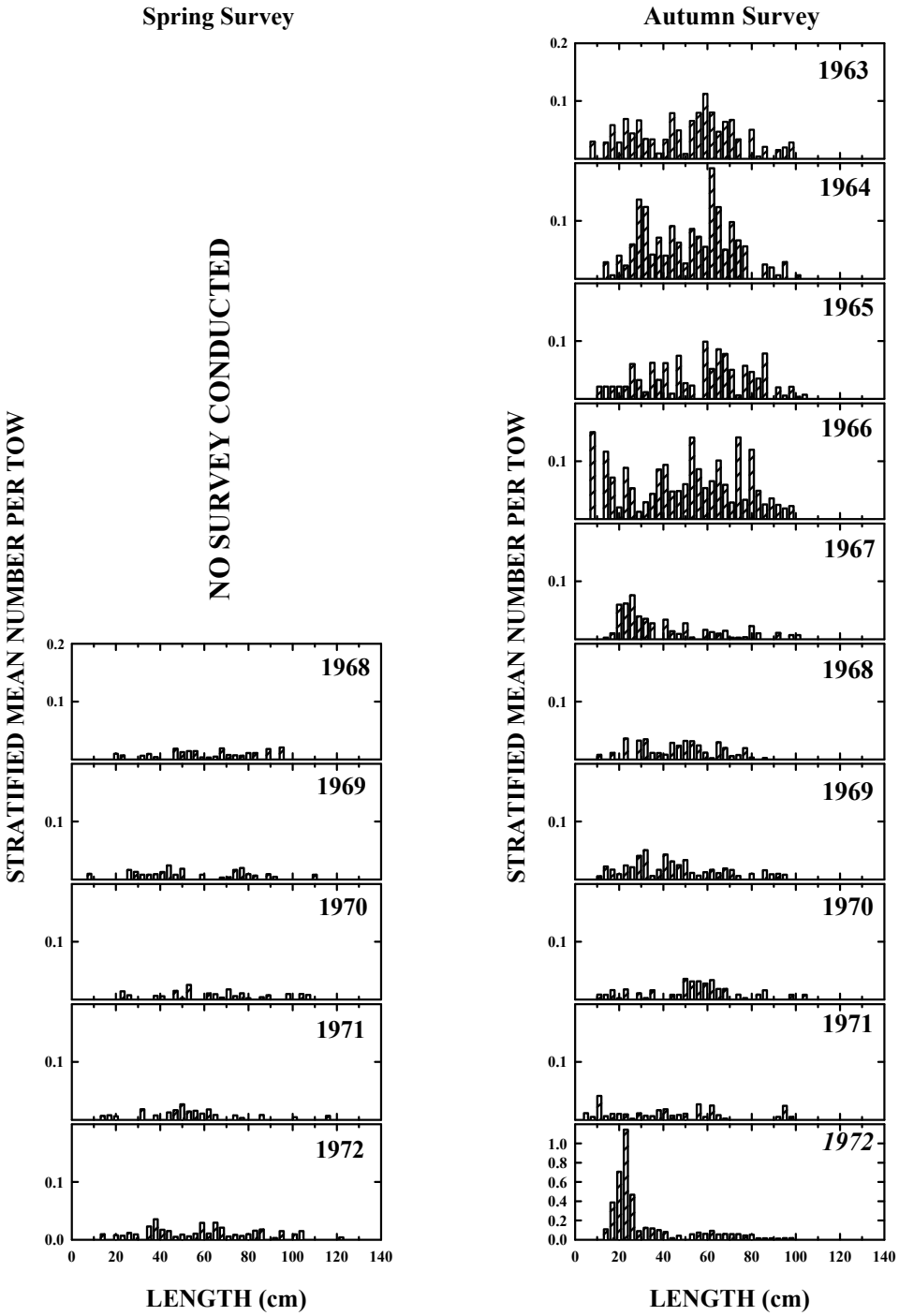


Figure A57, continued

Figure A57. Goosefish length composition from the NEFSC spring bottom trawl (March-April), winter flatfish (February), summer scallop (July-August), and autumn (September-October) bottom trawl surveys in the southern management region, 1963-2009. Note: 1963-1966 sampled reduced strata set

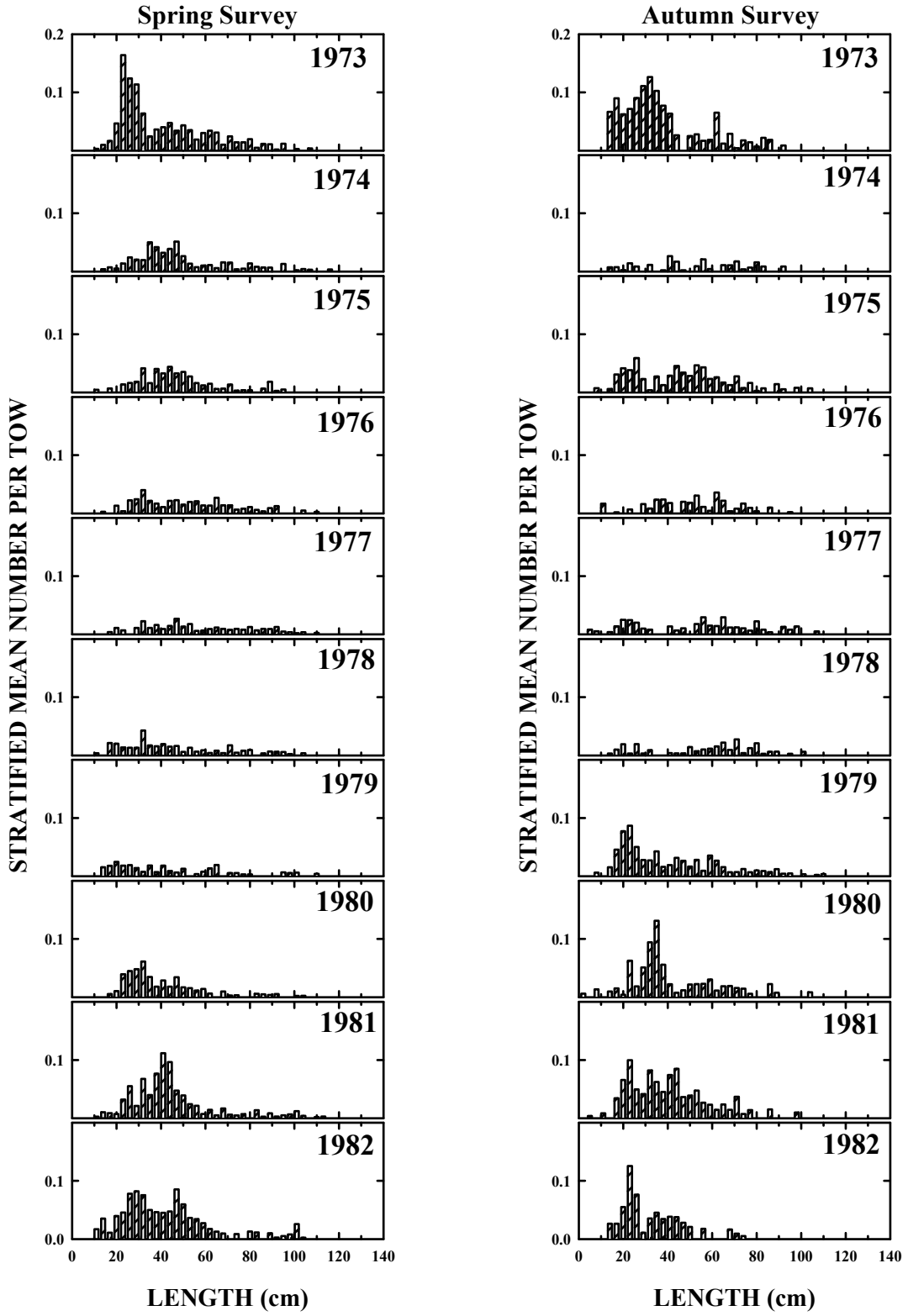


Figure A57, continued

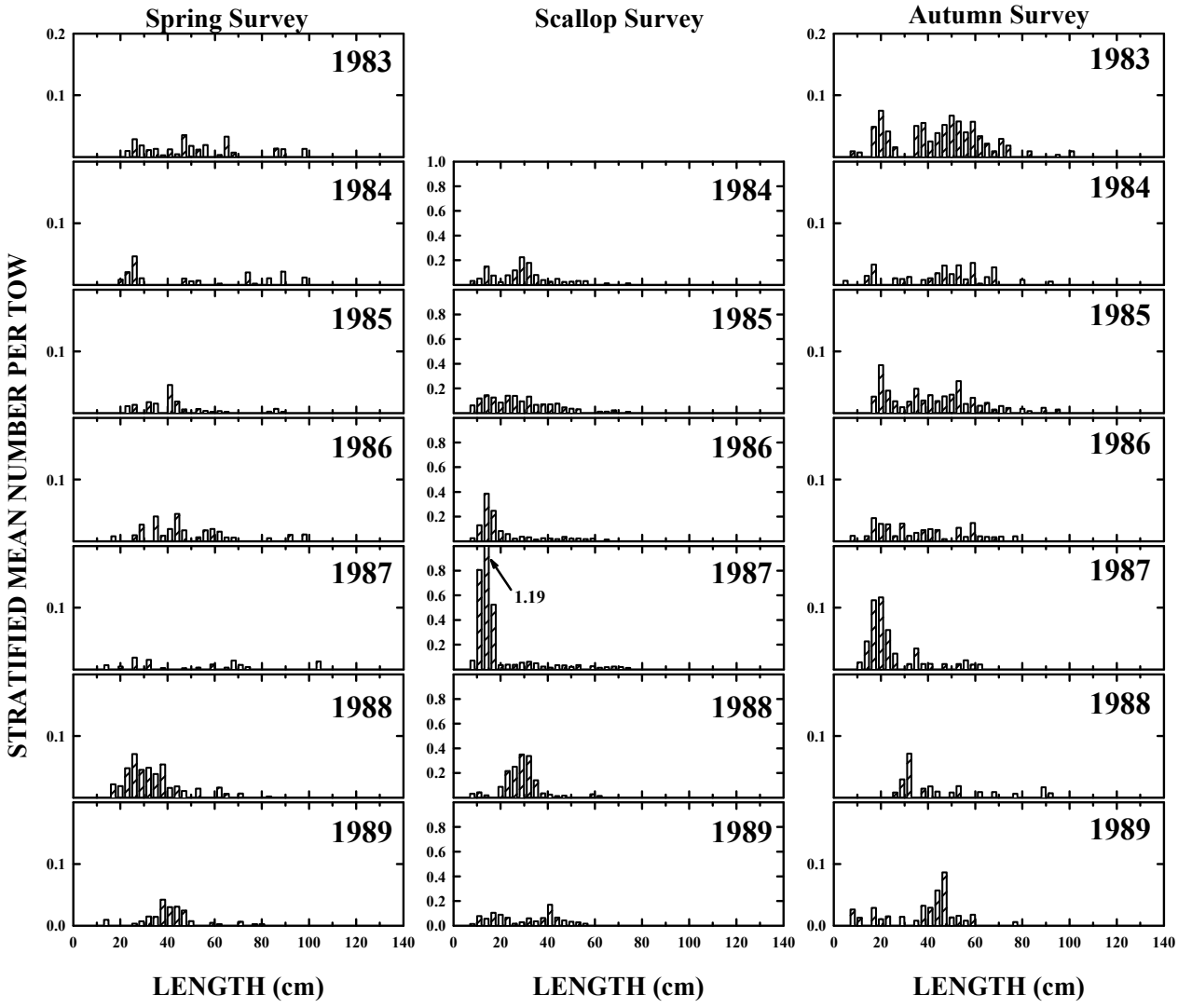


Figure A57, continued

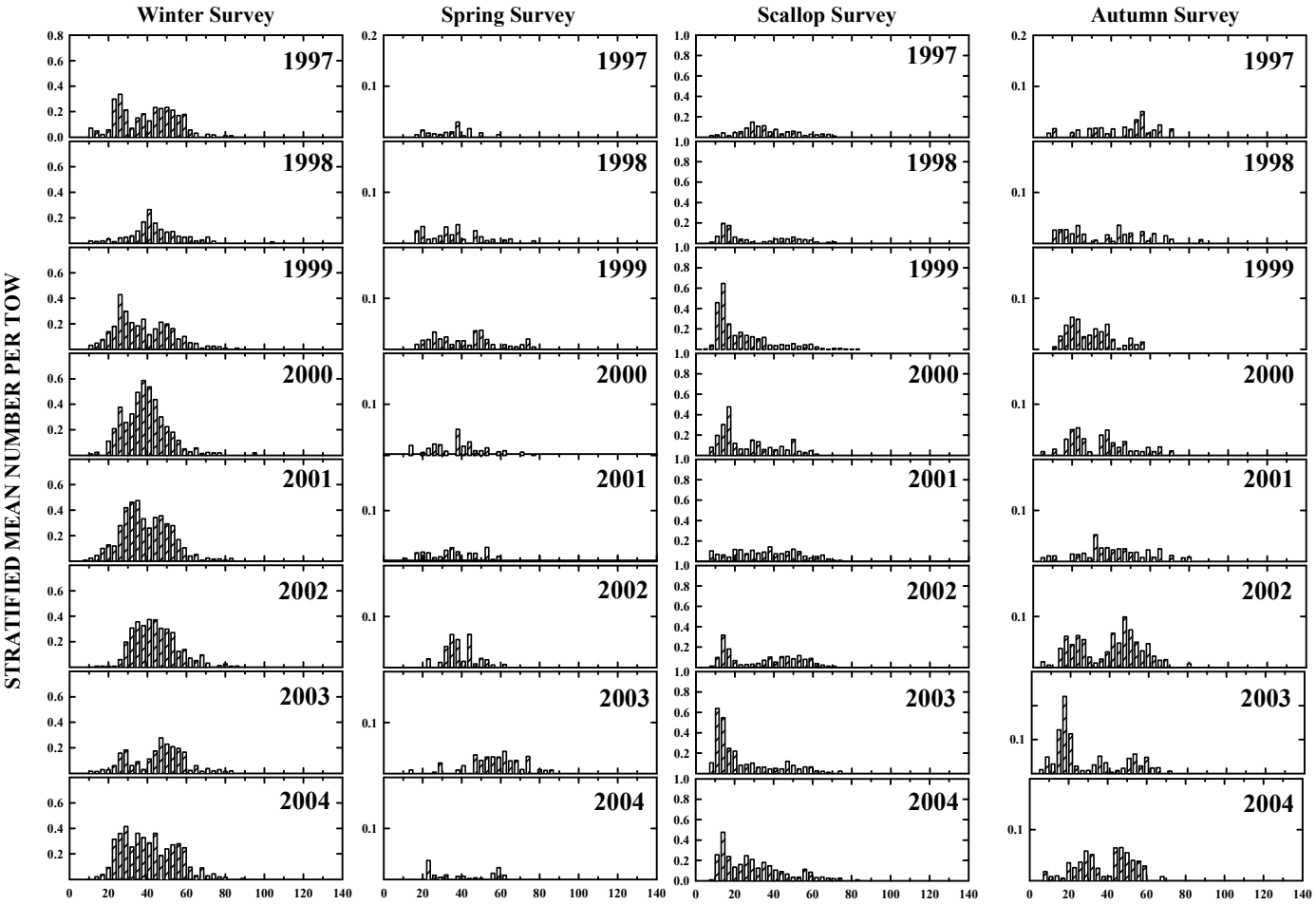


Figure A57, continued

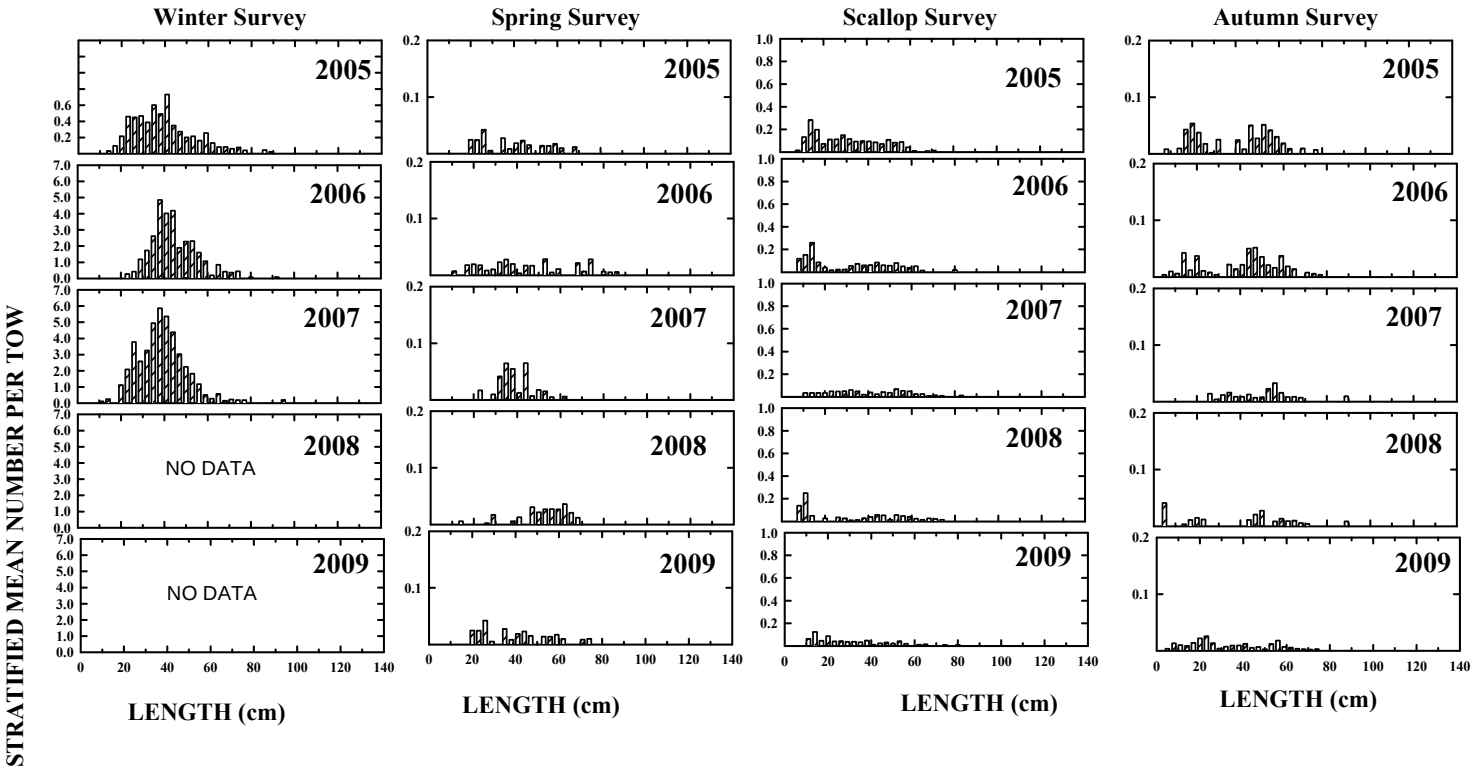
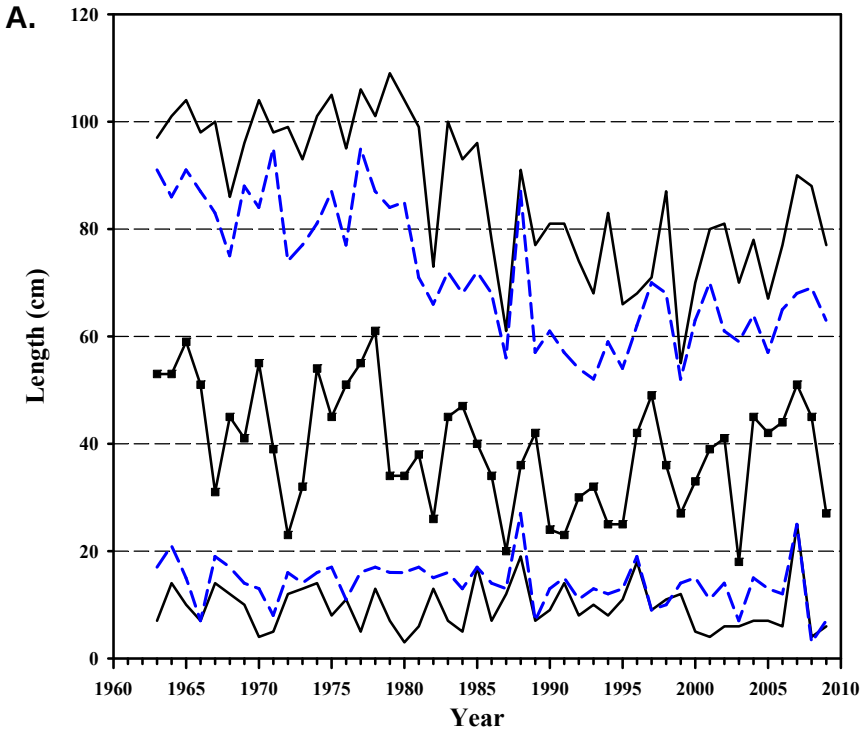


Figure A57, continued



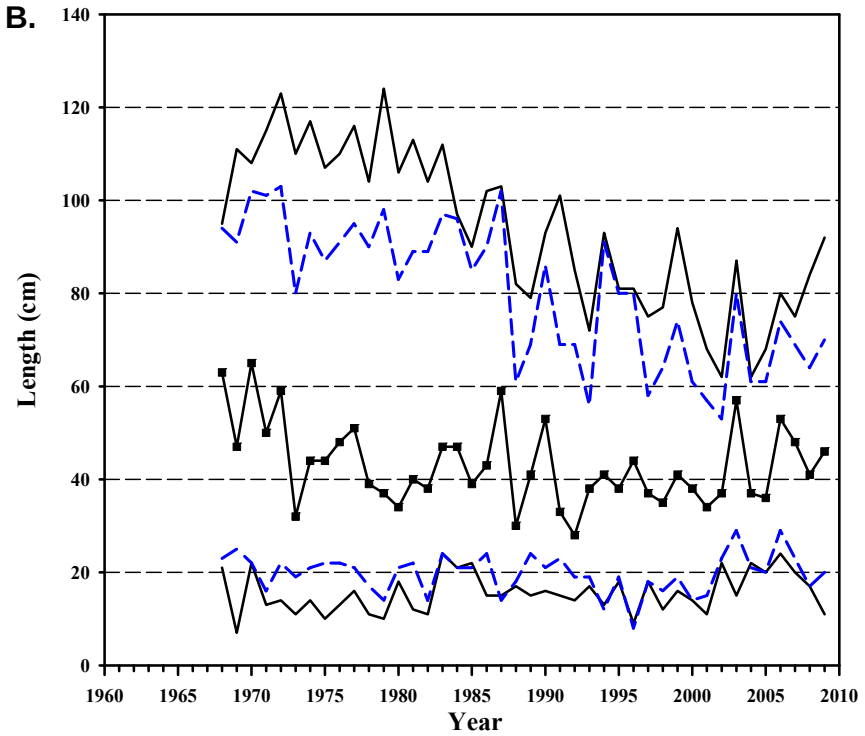


Figure A58. Minimum, median, and, maximum lengths for the southern management region from (A) NEFSC autumn surveys and (B) NEFSC spring surveys.

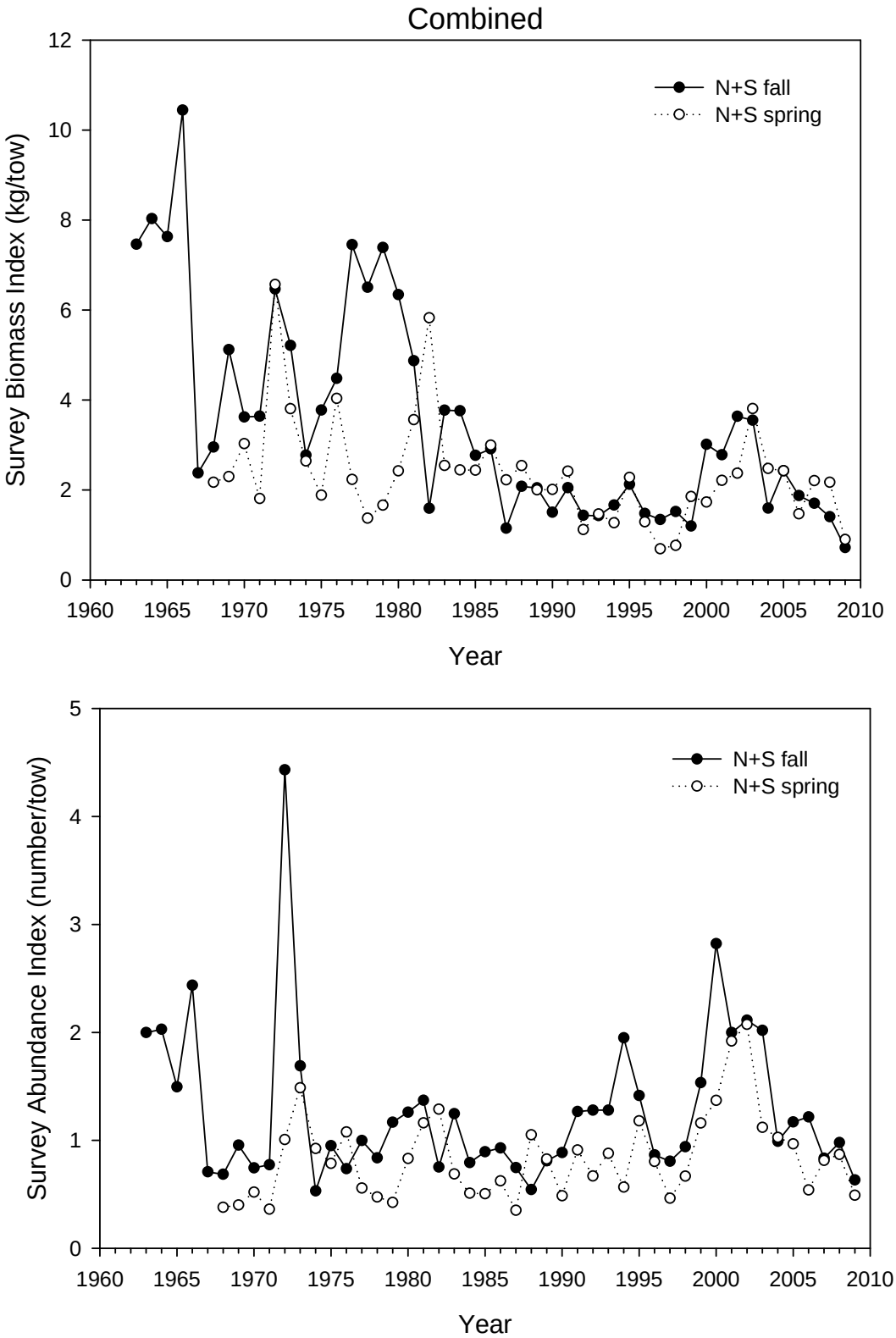


Figure A59. NEFSC spring and autumn surveys of monkfish biomass and abundance in both the northern and southern management regions

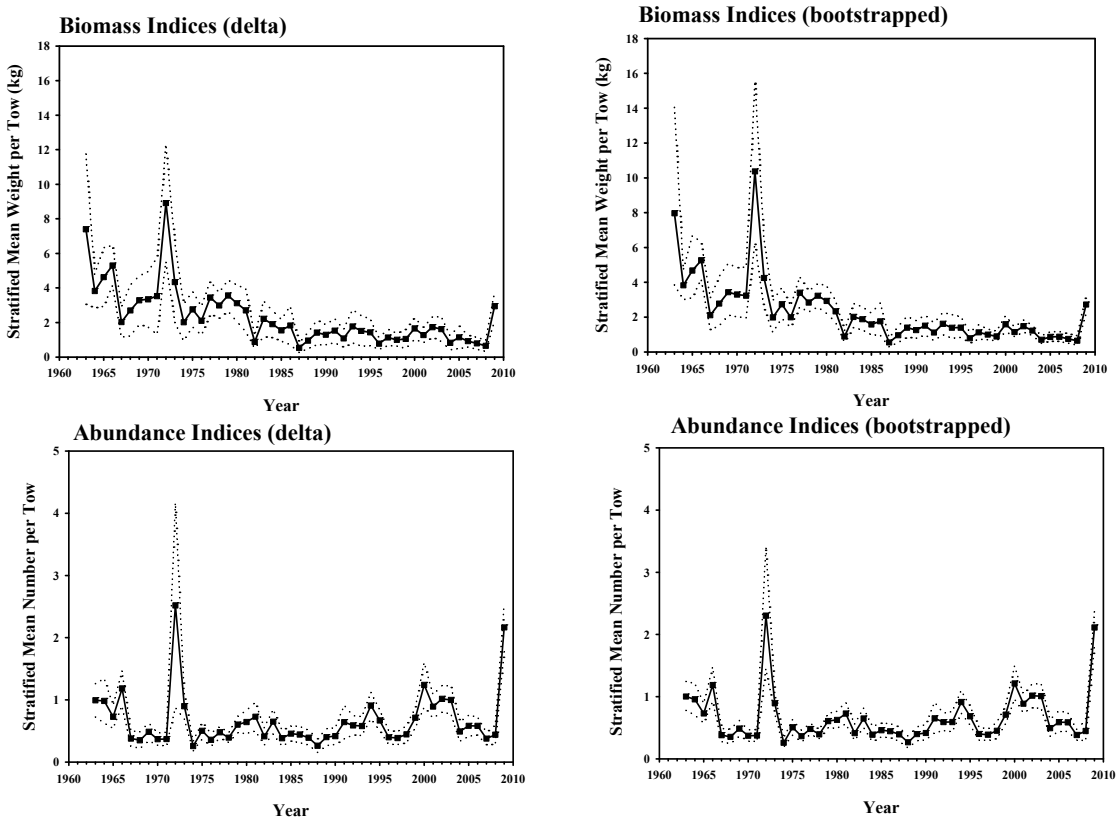


Figure A60. Delta distribution (parametric) and bootstrapped (arithmetic) biomass and abundance indices from the NEFSC autumn bottom trawl survey for combined management regions from 1963-2009. Data prior to 1971 have been revised following an audit of historical data. The 95% confidence limits are shown by the dashed line.

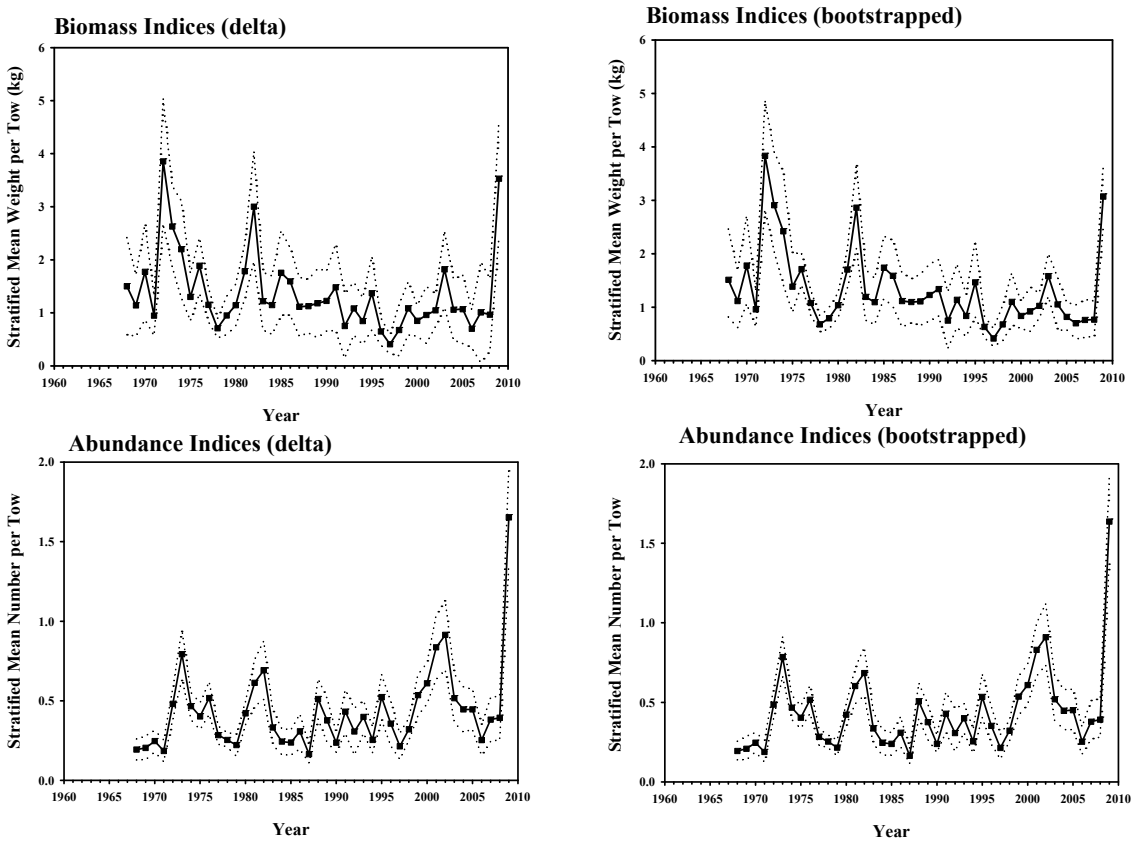


Figure A61. Delta distribution (parametric) and bootstrapped (arithmetic) biomass and abundance indices from the NEFSC spring bottom trawl survey for management regions combined from 1963-2009. Data prior to 1971 have been revised following an audit of historical data. The 95% confidence limits are shown by the dashed line.

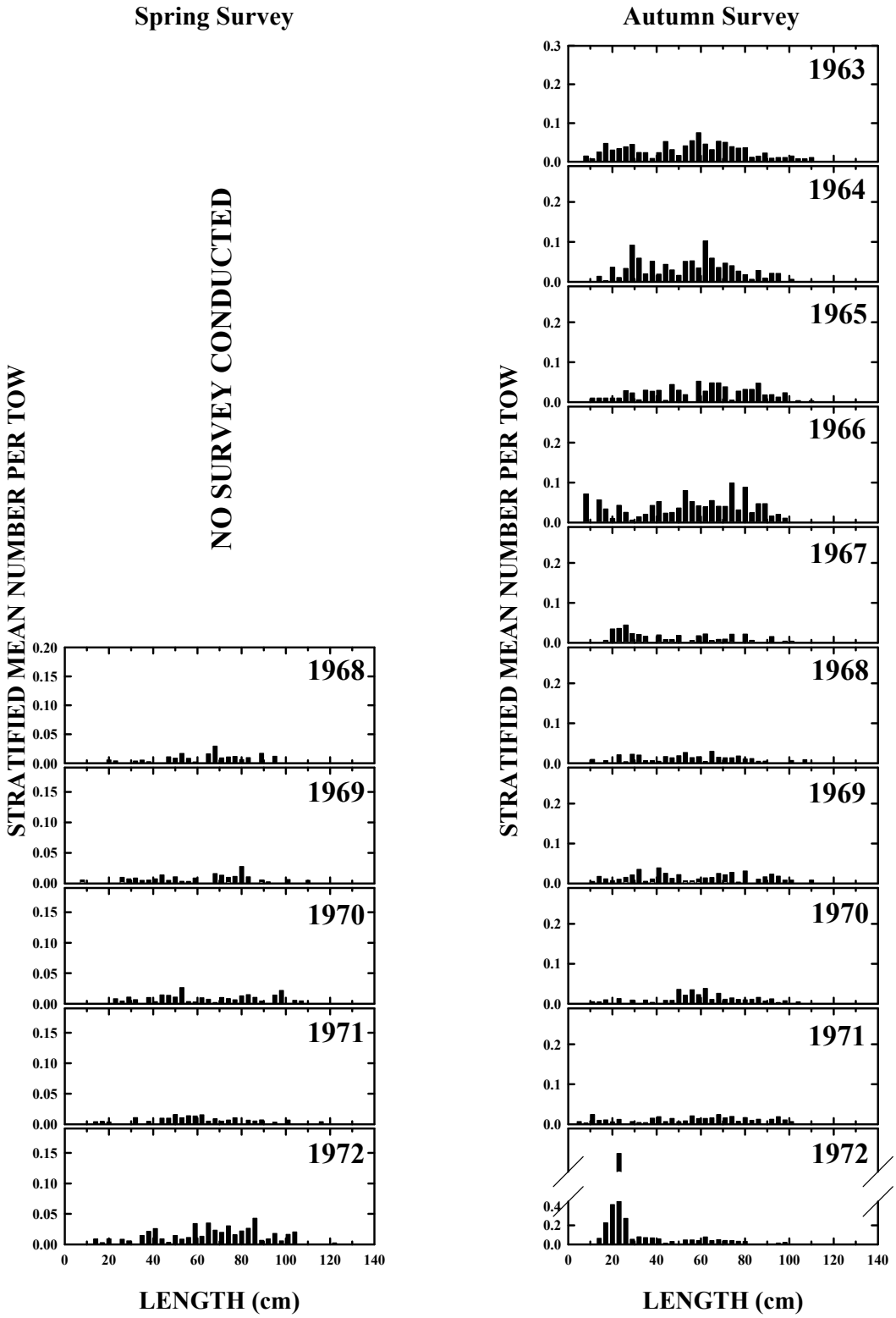


Figure A62. Goosefish length composition from the NEFSC spring and autumn bottom trawl surveys in both management regions combined, 1963-2009.

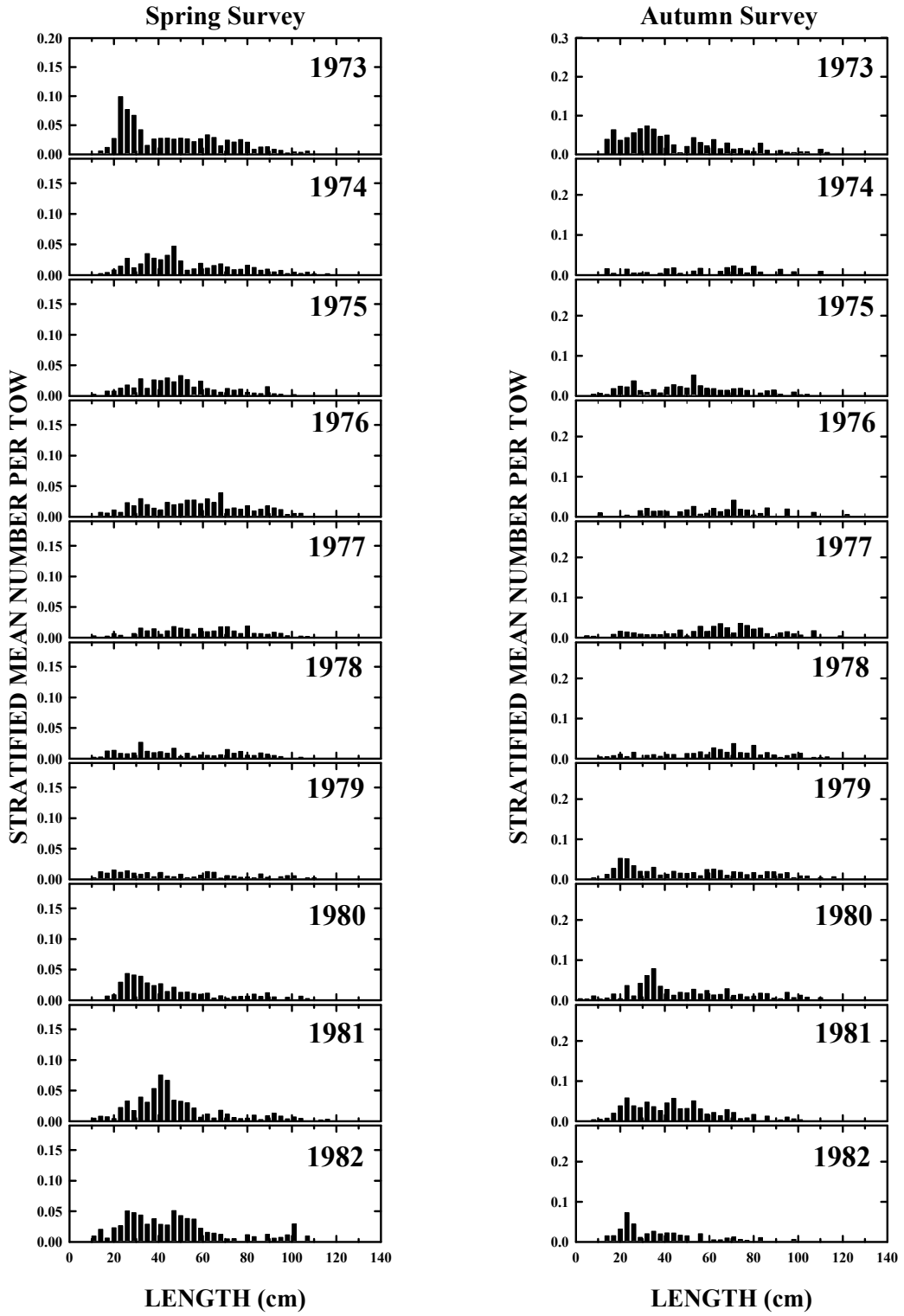


Figure A62, continued

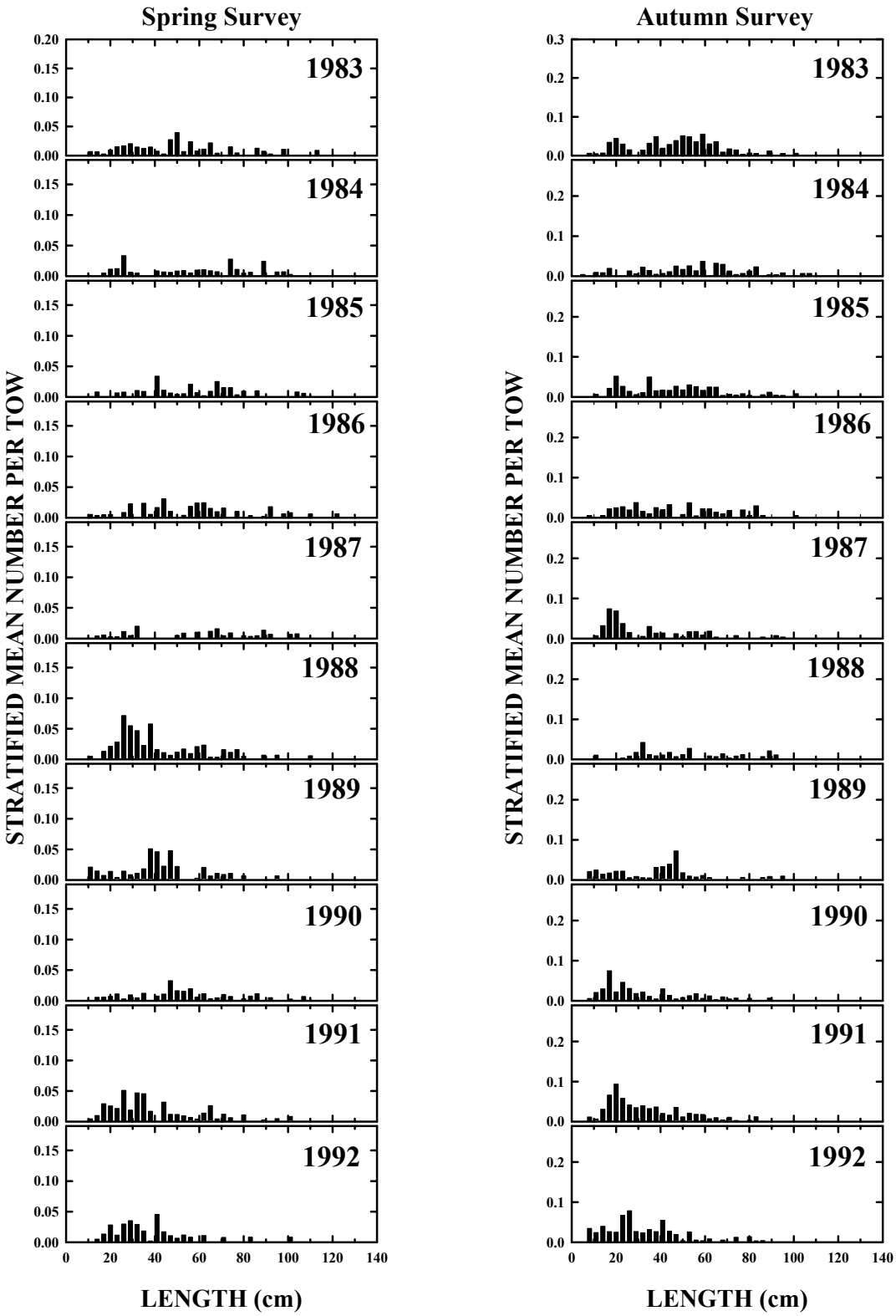


Figure A62, continued

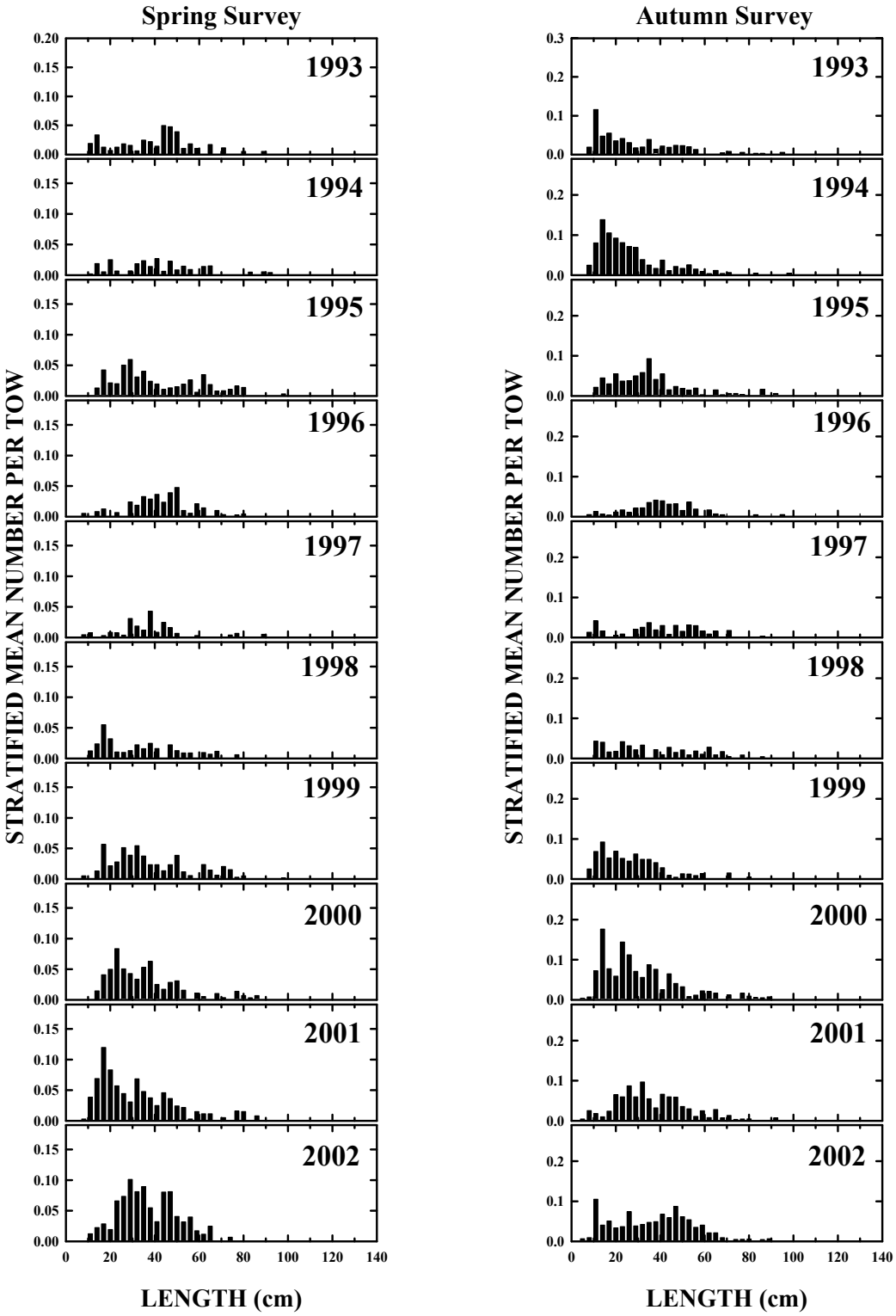


Figure A62, continued

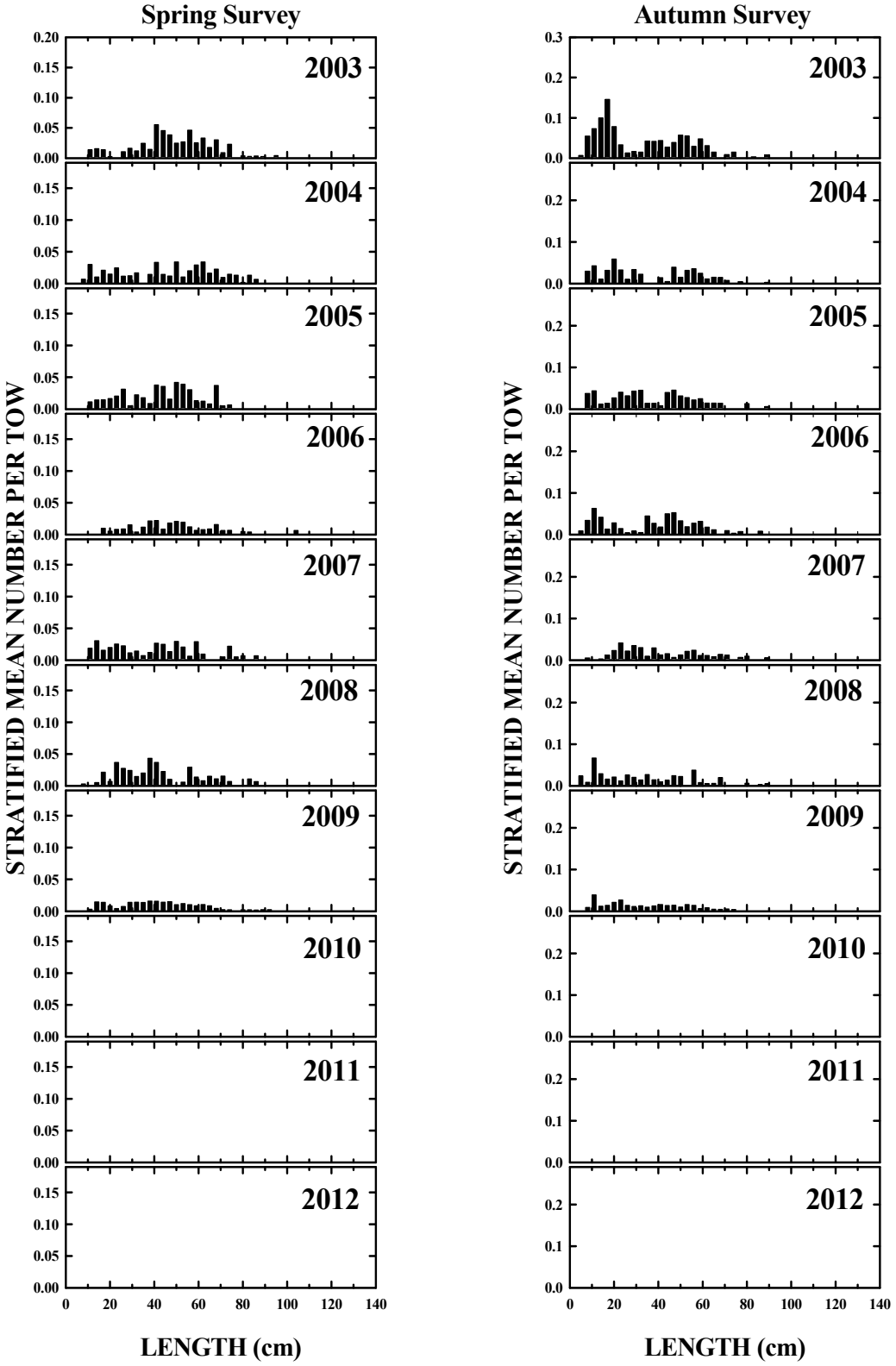


Figure A62, continued

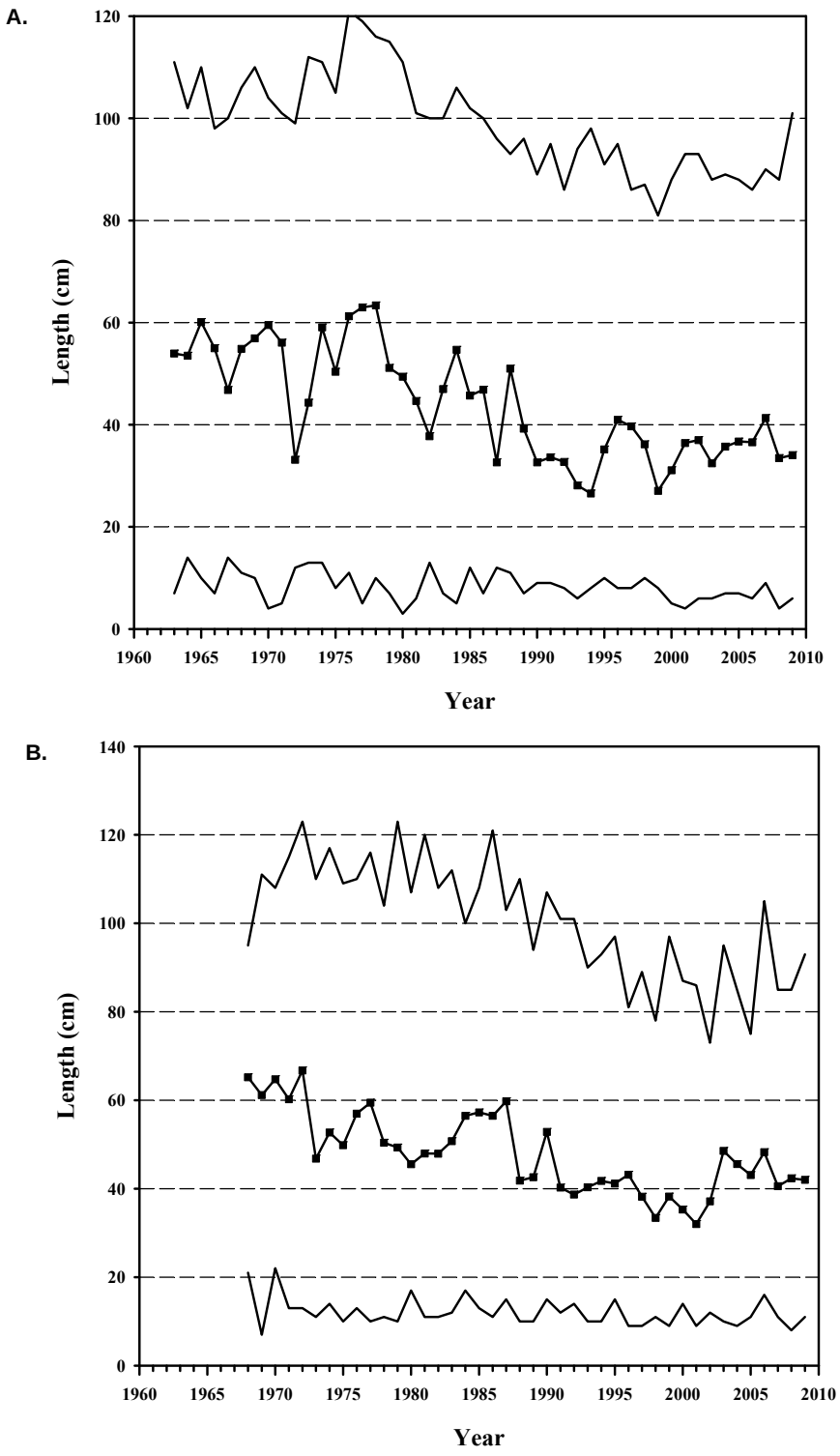


Figure A63. Minimum, median, and, maximum lengths for the northern and southern management regions combined from (A) NEFSC autumn surveys and (B) NEFSC spring surveys.

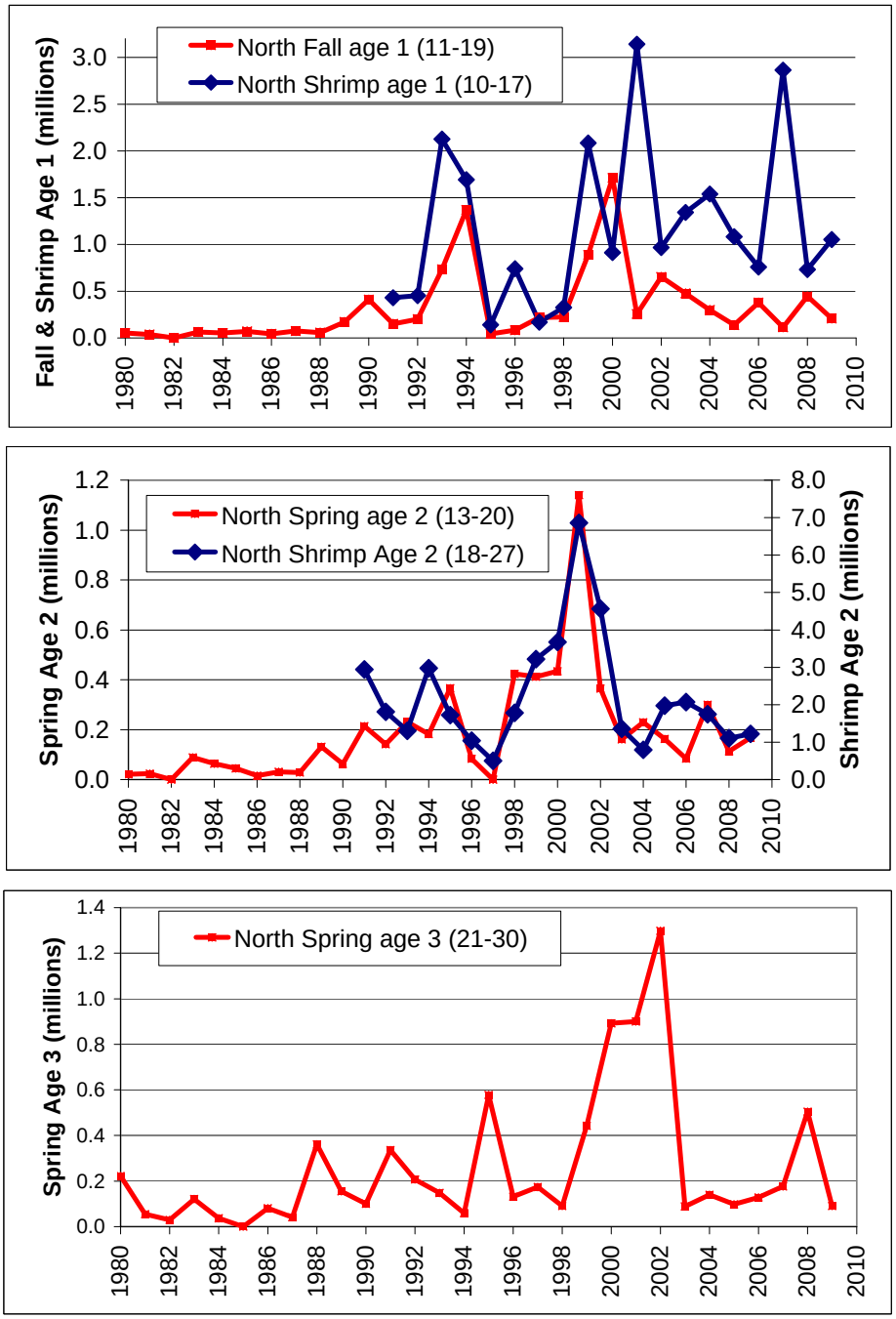


Figure A64. Northern management area monkfish recruitment indices at age. Centimeter intervals used to estimate recruitment ages are given in parenthesis.

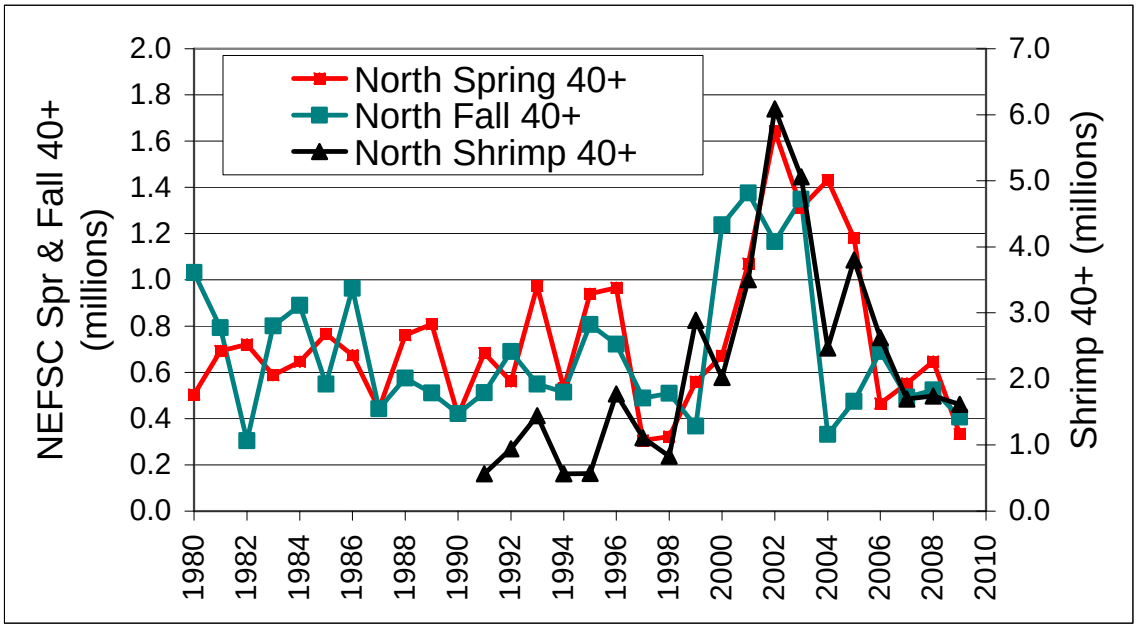


Figure A65. Adult 40+ cm abundance indices for the northern management area.

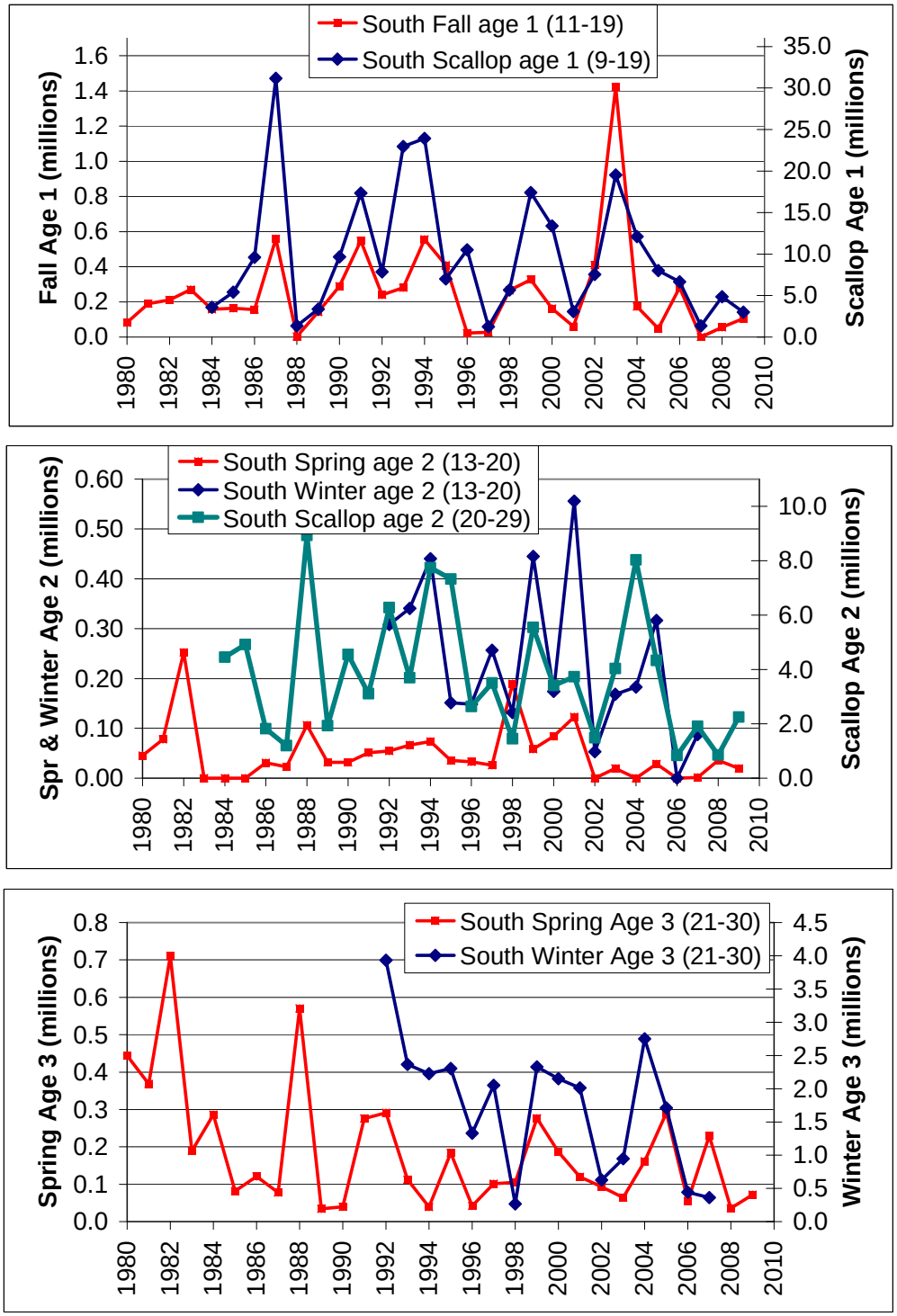


Figure A66. Southern management area monkfish recruitment indices at age. Centimeter interval used to estimate recruitment ages are given in parenthesis.

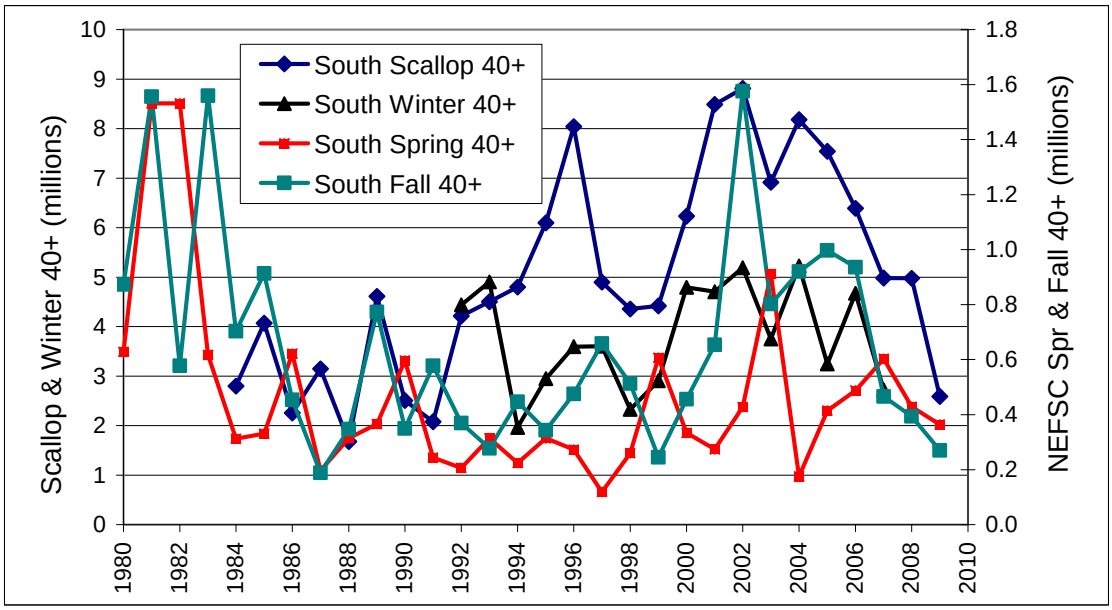


Figure A67. Adult 40+ cm abundance indices for the southern management area.

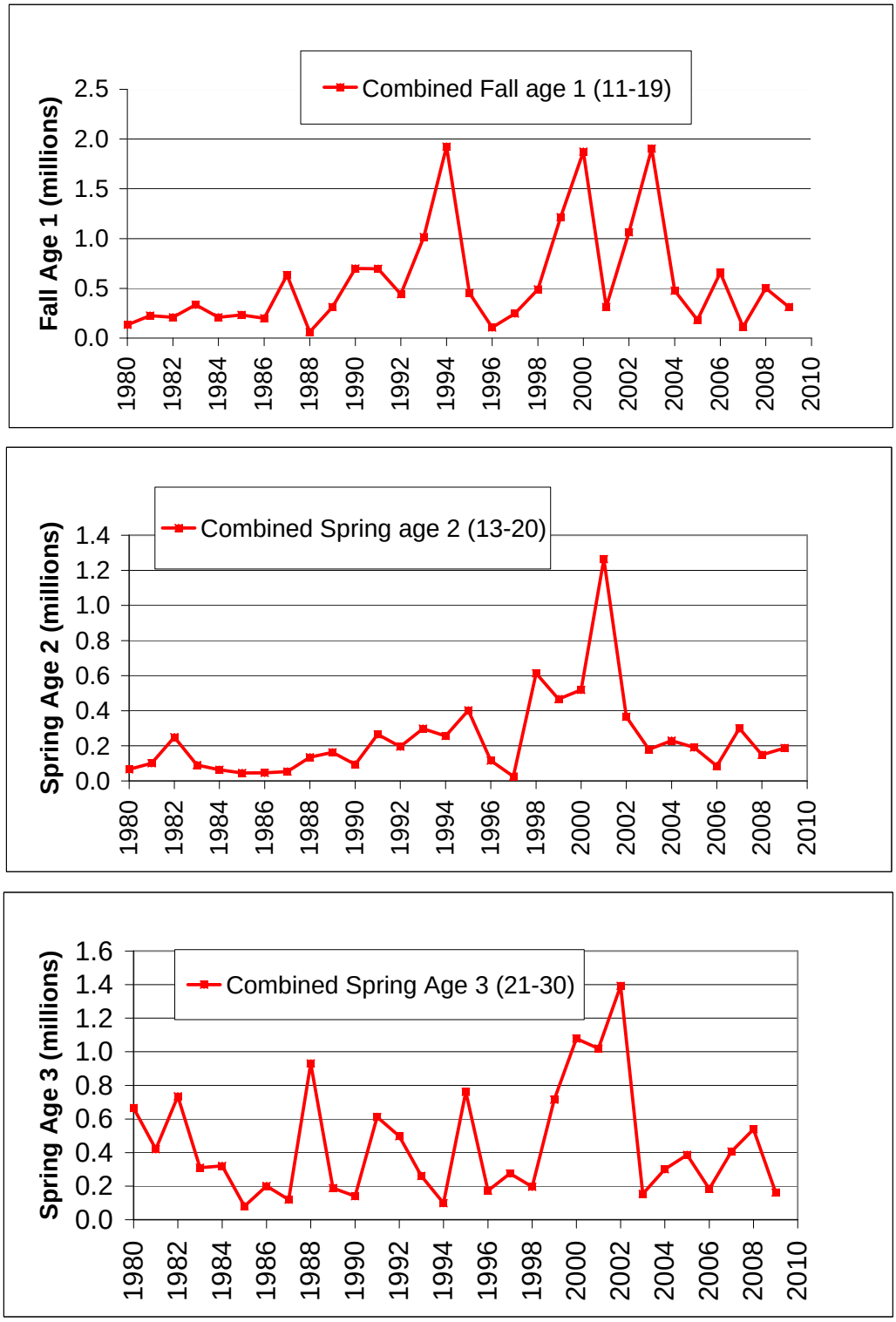


Figure A68. Combined management areas monkfish recruitment indices at age for the NEFSC surveys. Centimeter intervals used to estimate recruitment ages are given in parentheses.

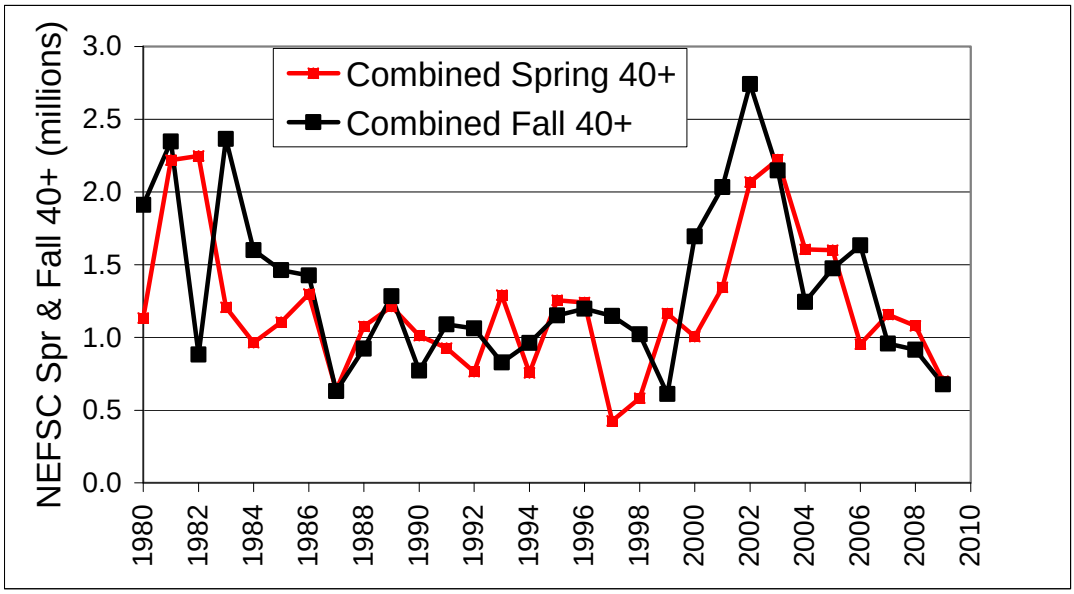


Figure A69. Adult 40+ cm abundance indices for the combined management areas for the NEFSC bottom trawl surveys

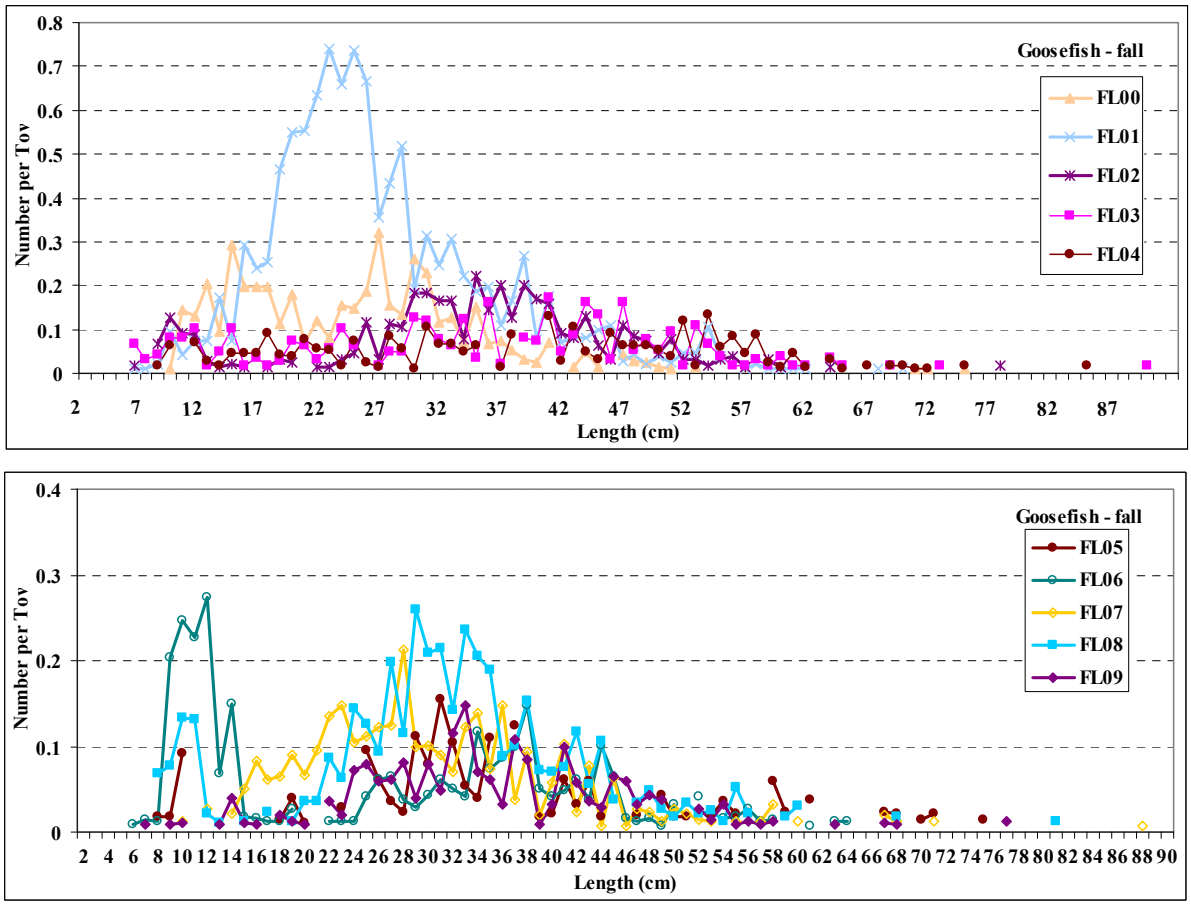


Figure A70. Length frequency distributions from the fall ME/NH bottom trawl survey from 2000 to 2009.

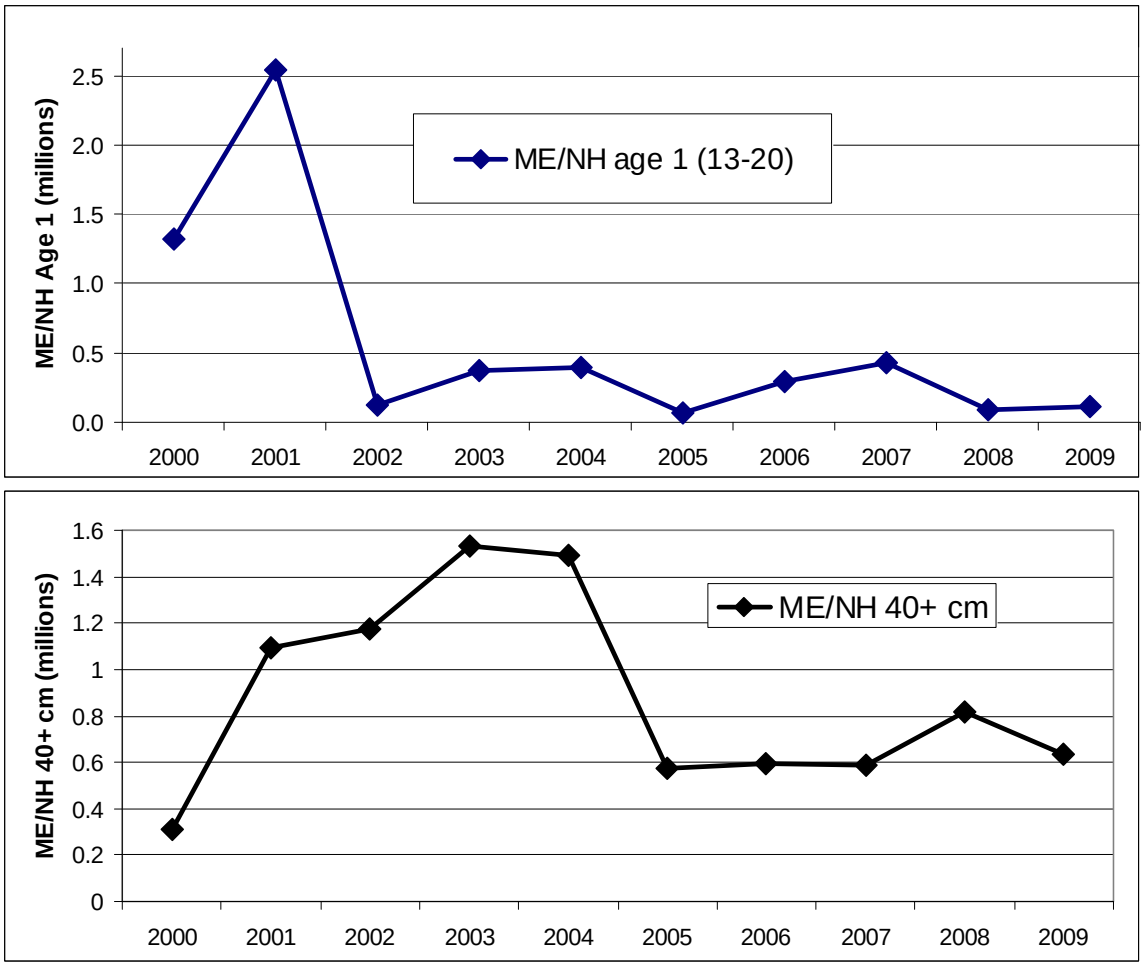


Figure A71. Age 1 (13 to 20cm) and 40+ cm indices from the fall ME/NH bottom trawl survey from 2000 to 2009.

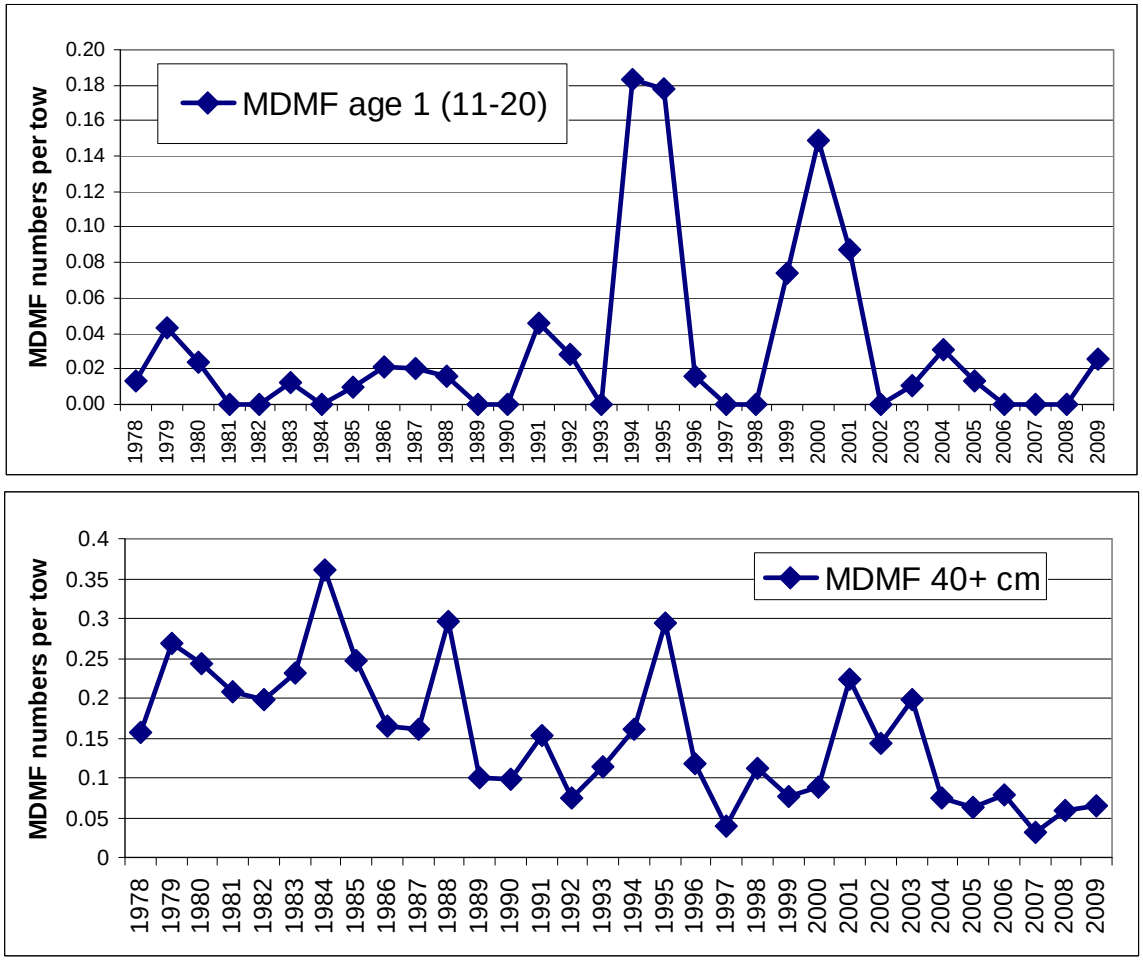
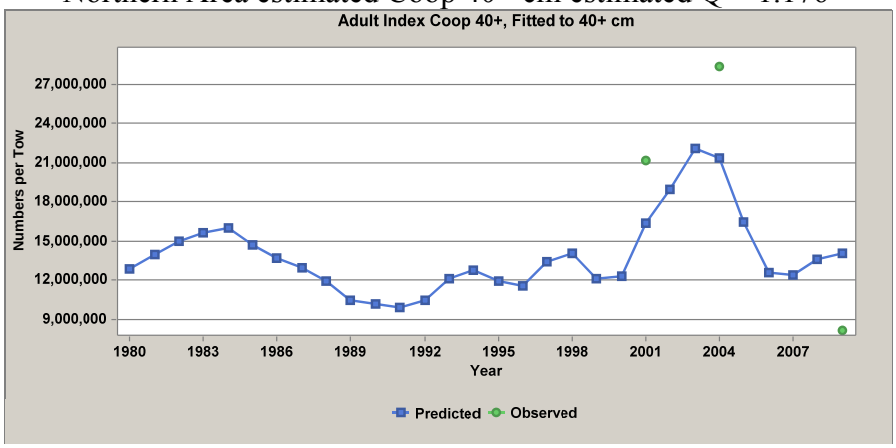
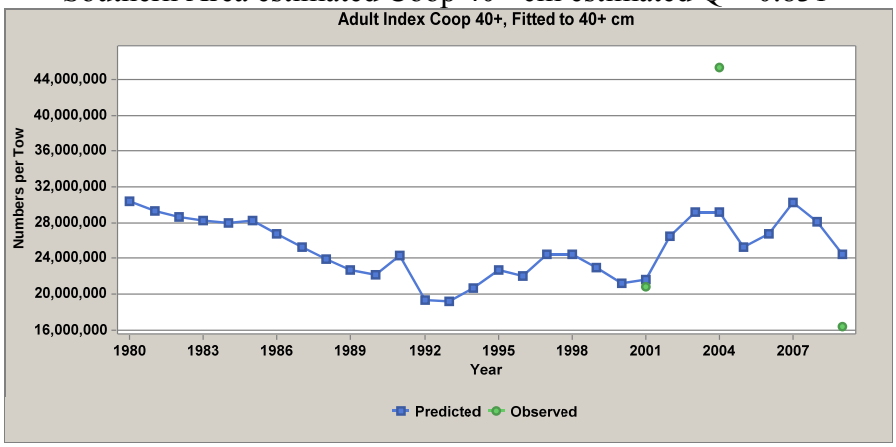


Figure A72. Age 1 (11 to 20cm) and 40+ cm indices from the fall MDMF bottom trawl survey from 1978 to 2009. Many of the years in the age 1 index did not catch any monkfish and relatively low numbers of 40+ cm monkfish are caught per tow.

Northern Area estimated Coop 40+ cm estimated Q = 1.176



Southern Area estimated Coop 40+ cm estimated Q = 0.831



Combined Area estimated Coop 40+ cm estimated Q = 0.679

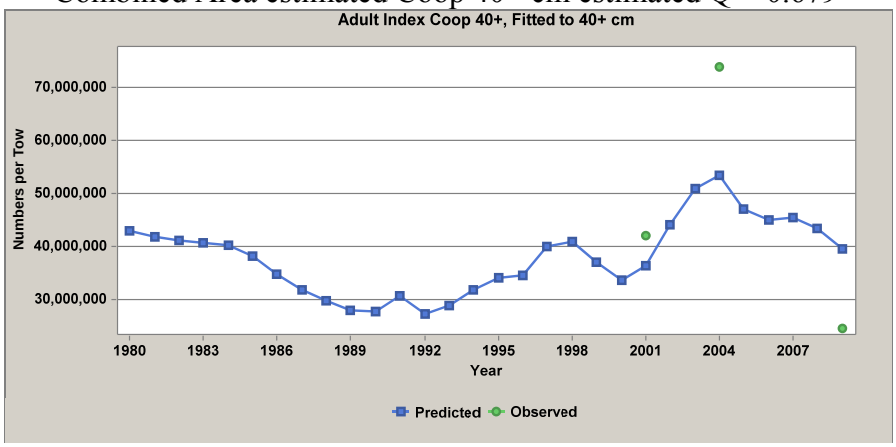


Figure A73. Estimated q's and fits for the north, south, and combined management area diagnostic runs which incorporated the absolute cooperative 40+ numbers.

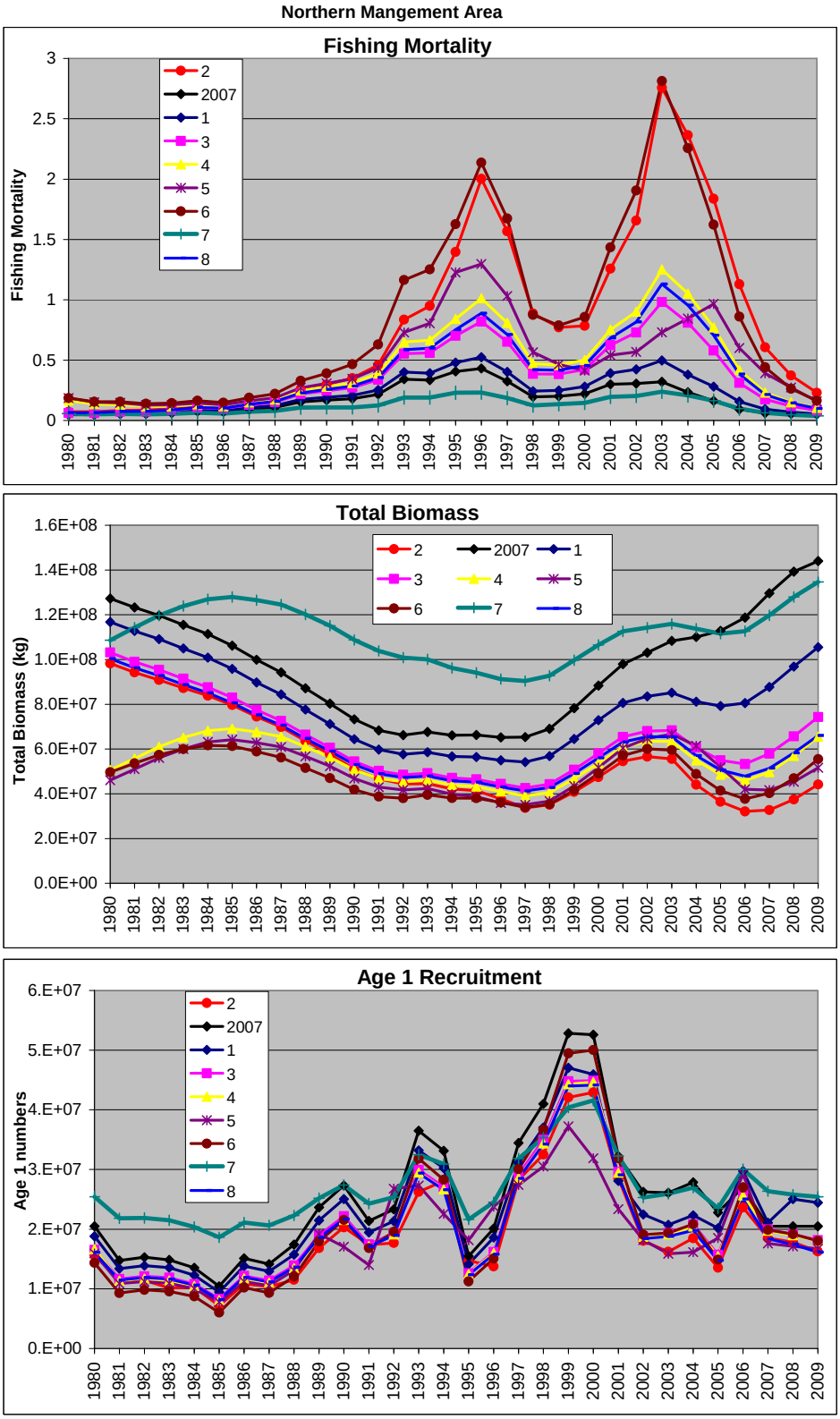


Figure A74. Northern management area monkfish SCALE sensitivity runs (table A3).

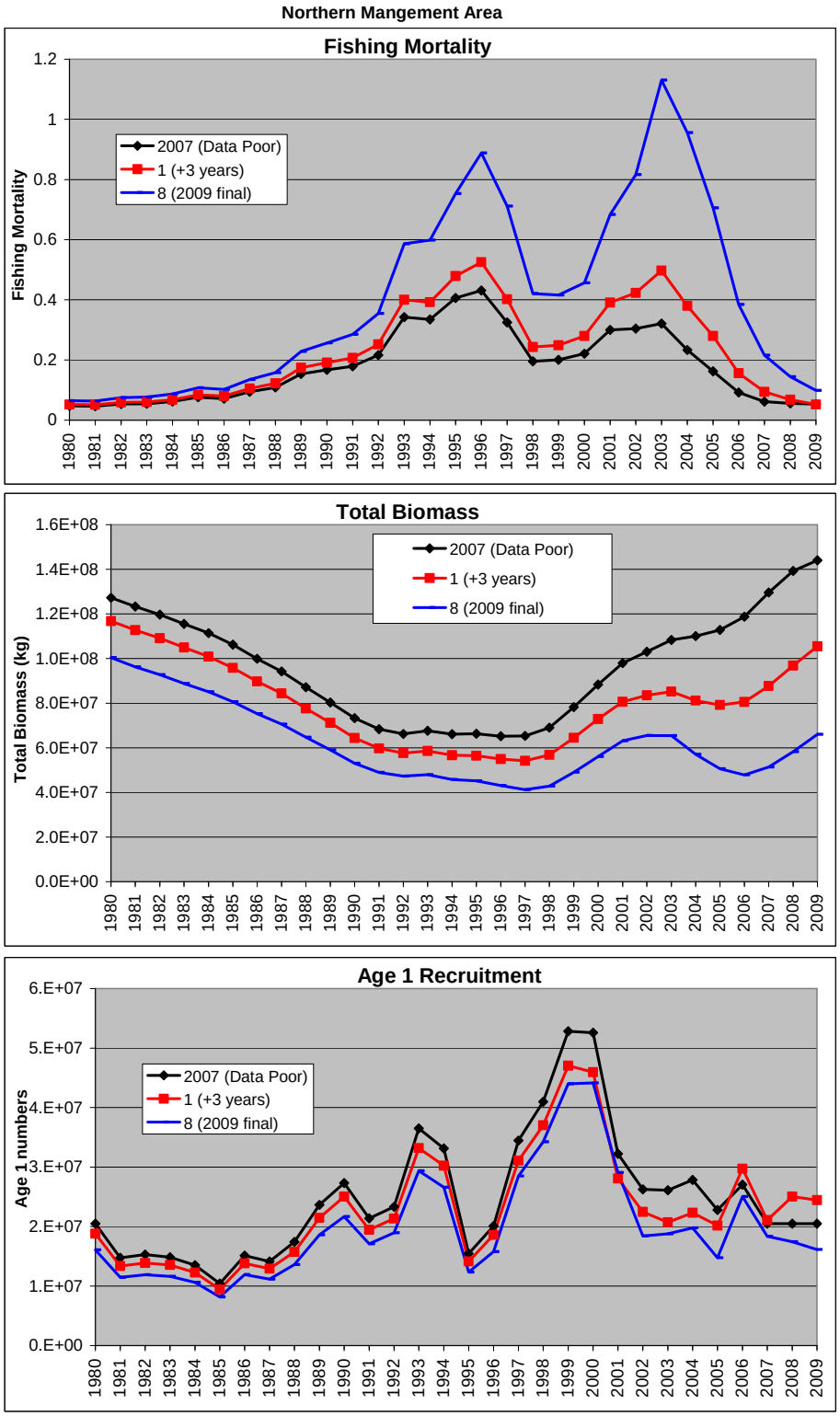


Figure A75. Comparison of northern management area final runs from the 2007 and this assessment. Run 1 (2007 run with updated 2007-2009 data) is also shown.

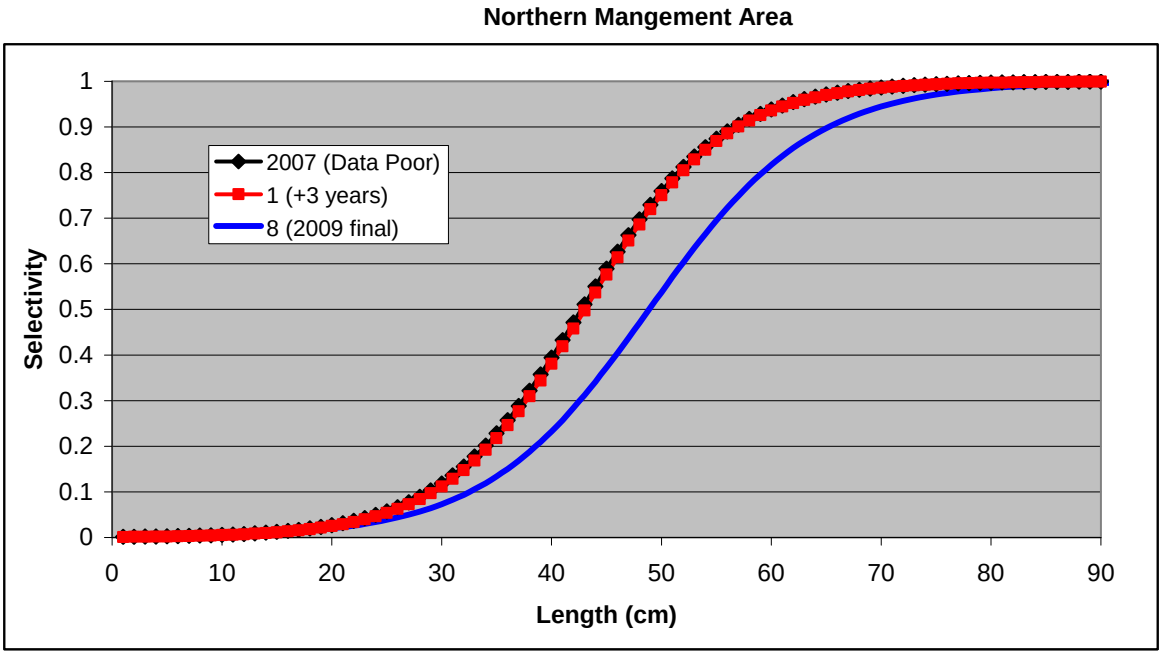


Figure A76. Comparison of northern management area estimated selectivity for the final runs from the 2007 and this assessment. Run 1 (2007 run with updated 2007-2009 data) is also shown.

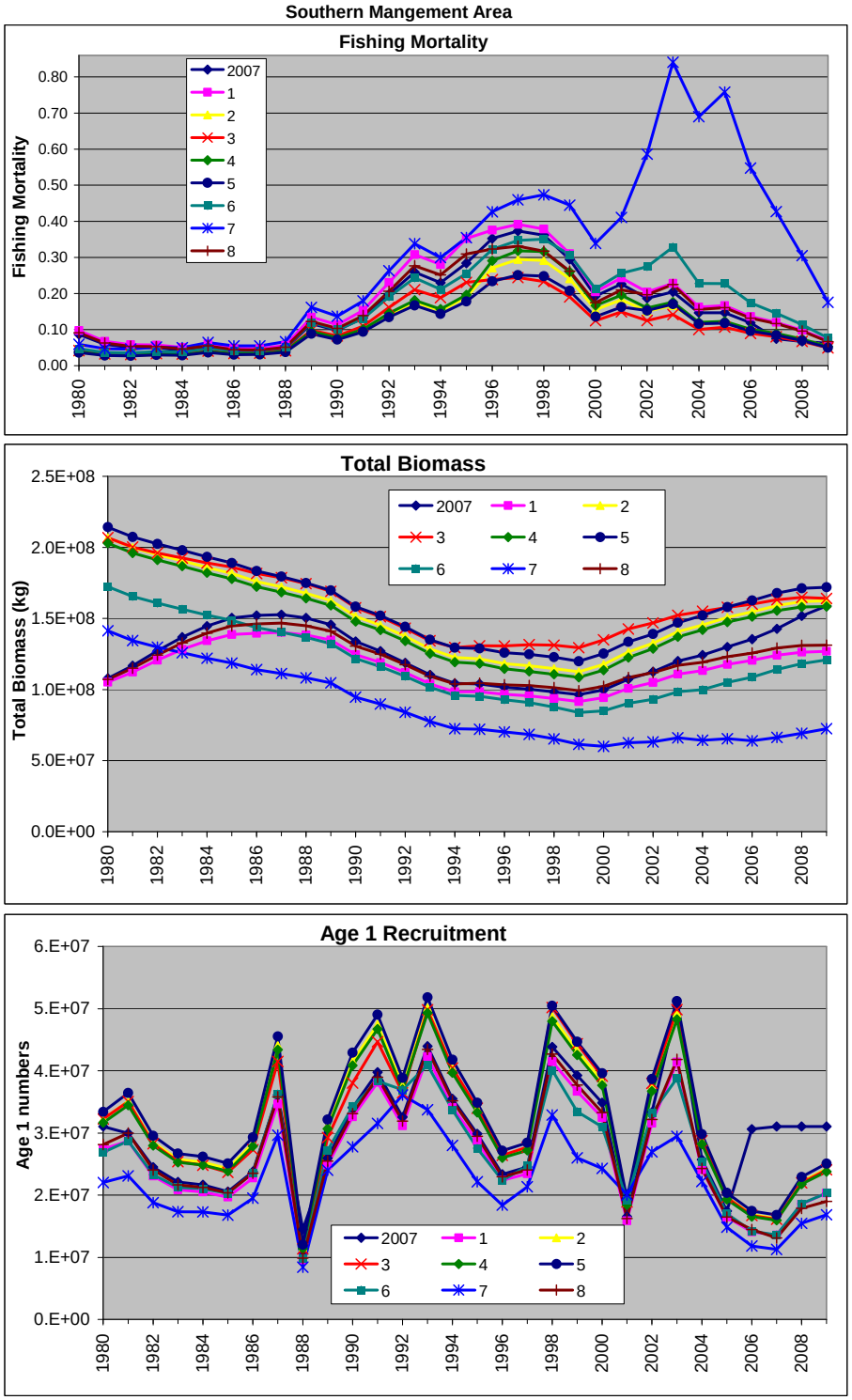


Figure A77. Southern management area monkfish SCALE sensitivity runs.

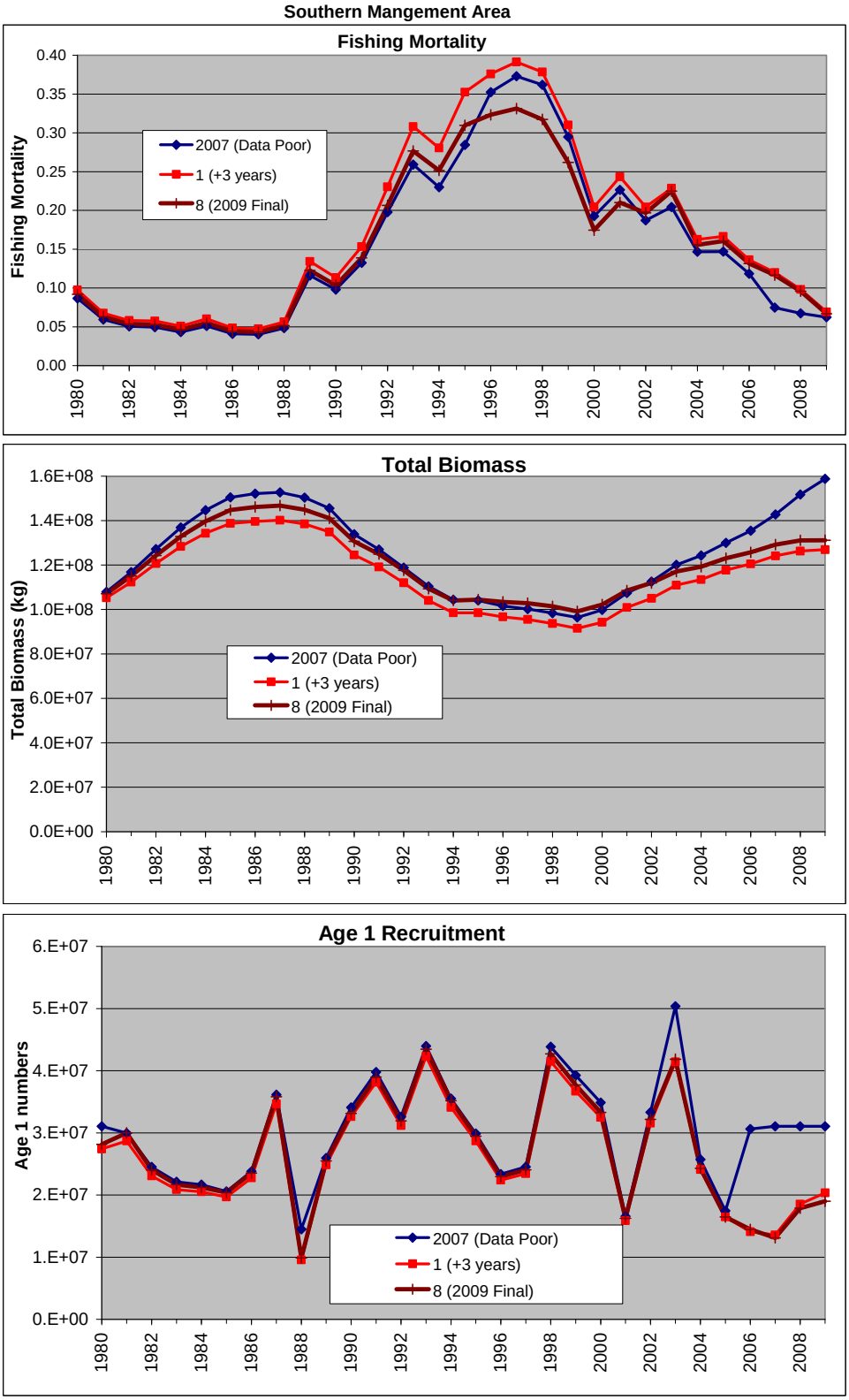


Figure A78. Comparison of southern management area final runs from the 2007 and this assessment. Run 1 (2007 run with updated 2007-2009 data) is also shown.

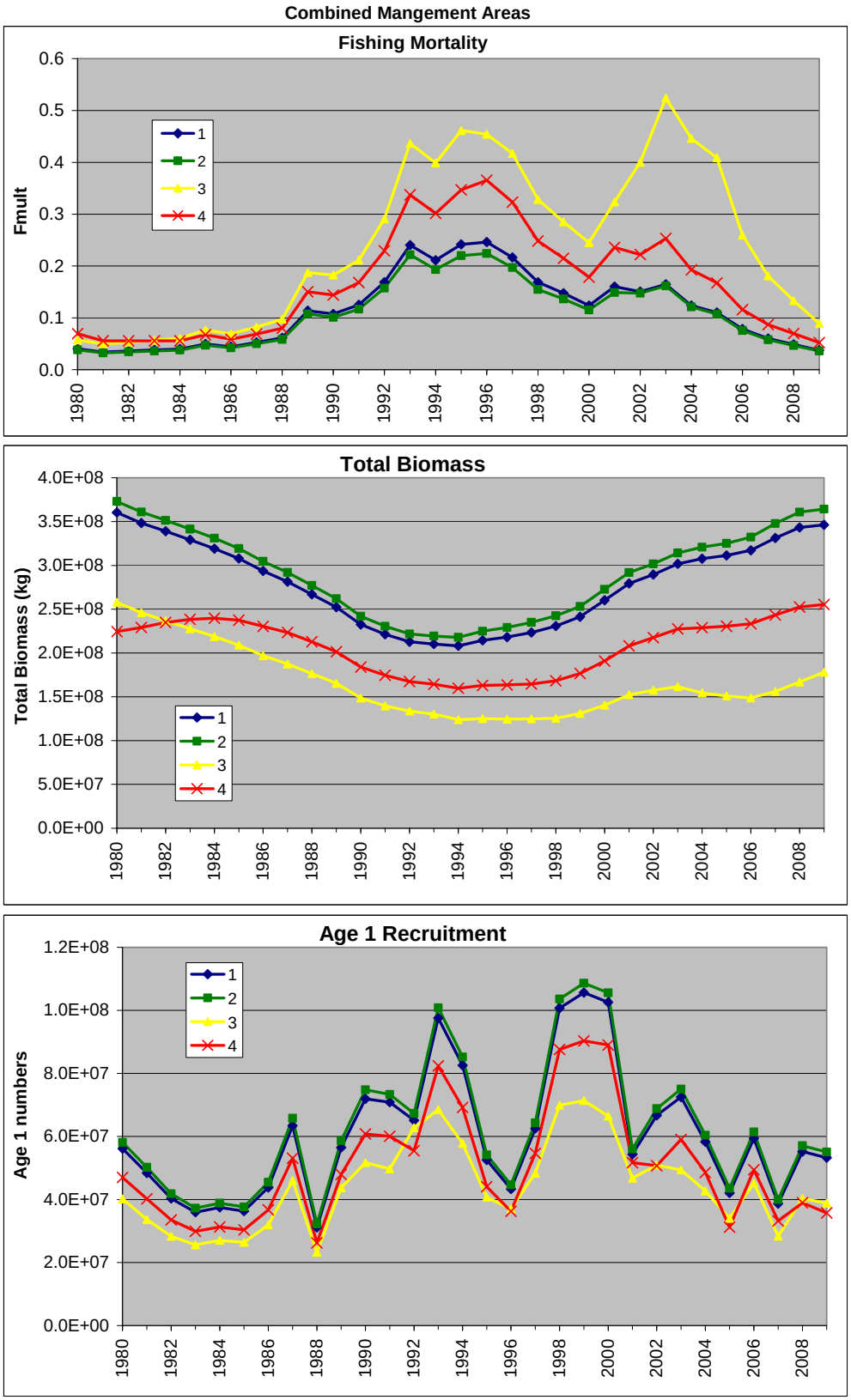
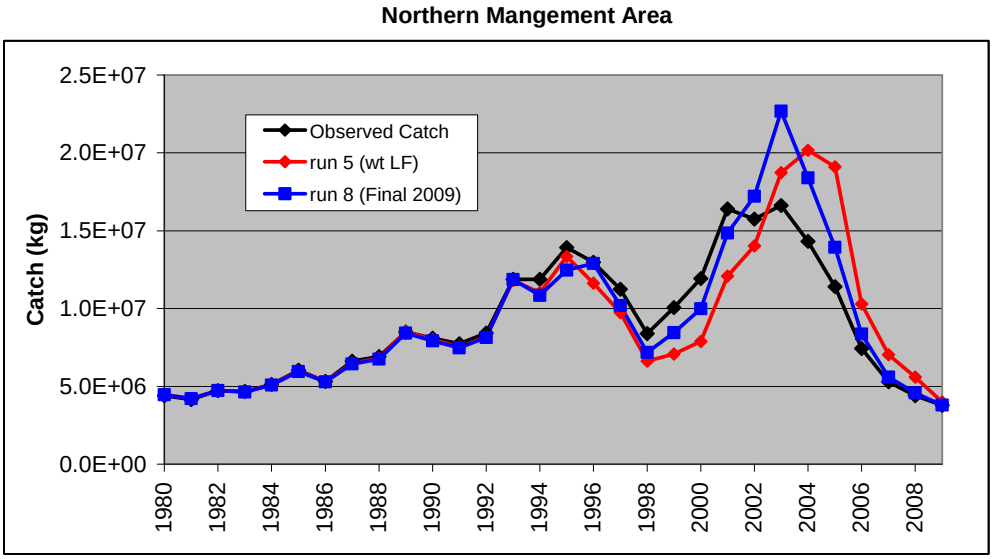


Figure A79. Combined management area monkfish SCALE sensitivity runs.



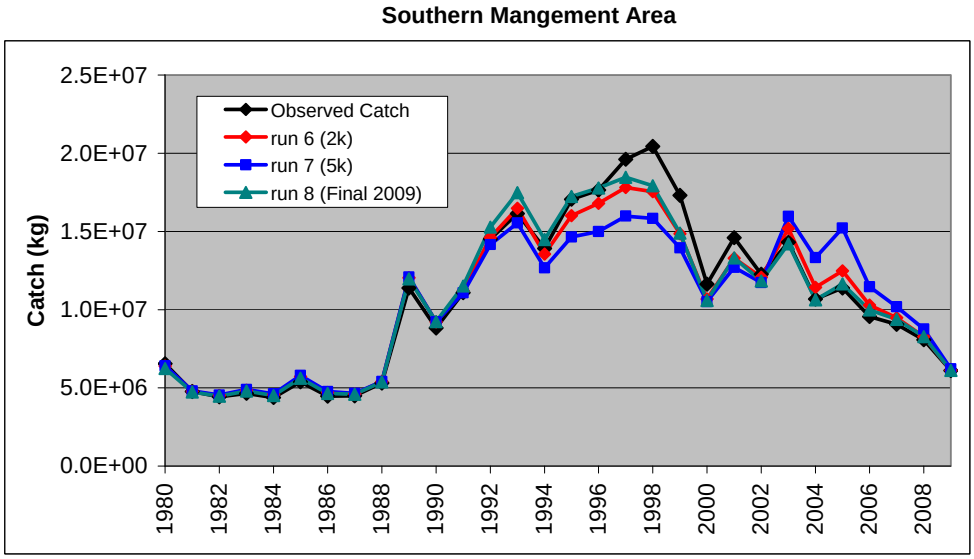


Figure A80. Comparison of northern and southern fits to the catch between the final and sensitivity runs which increased the weighting on fitting the length frequency data.

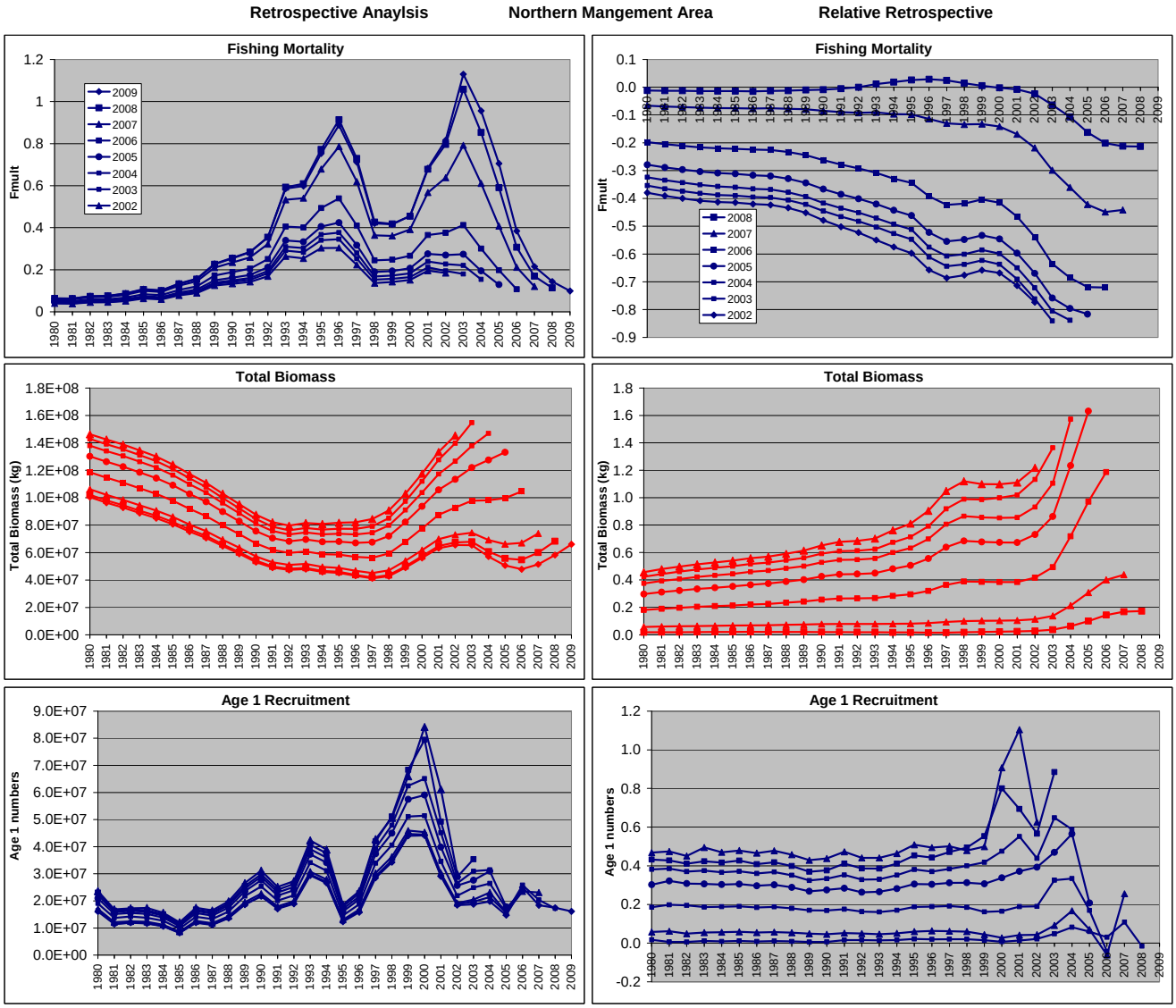


Figure A81. Northern management area retrospective plot for F, total biomass and age 1 recruitment (left). Retrospective relative trends to the terminal year run are on the right.

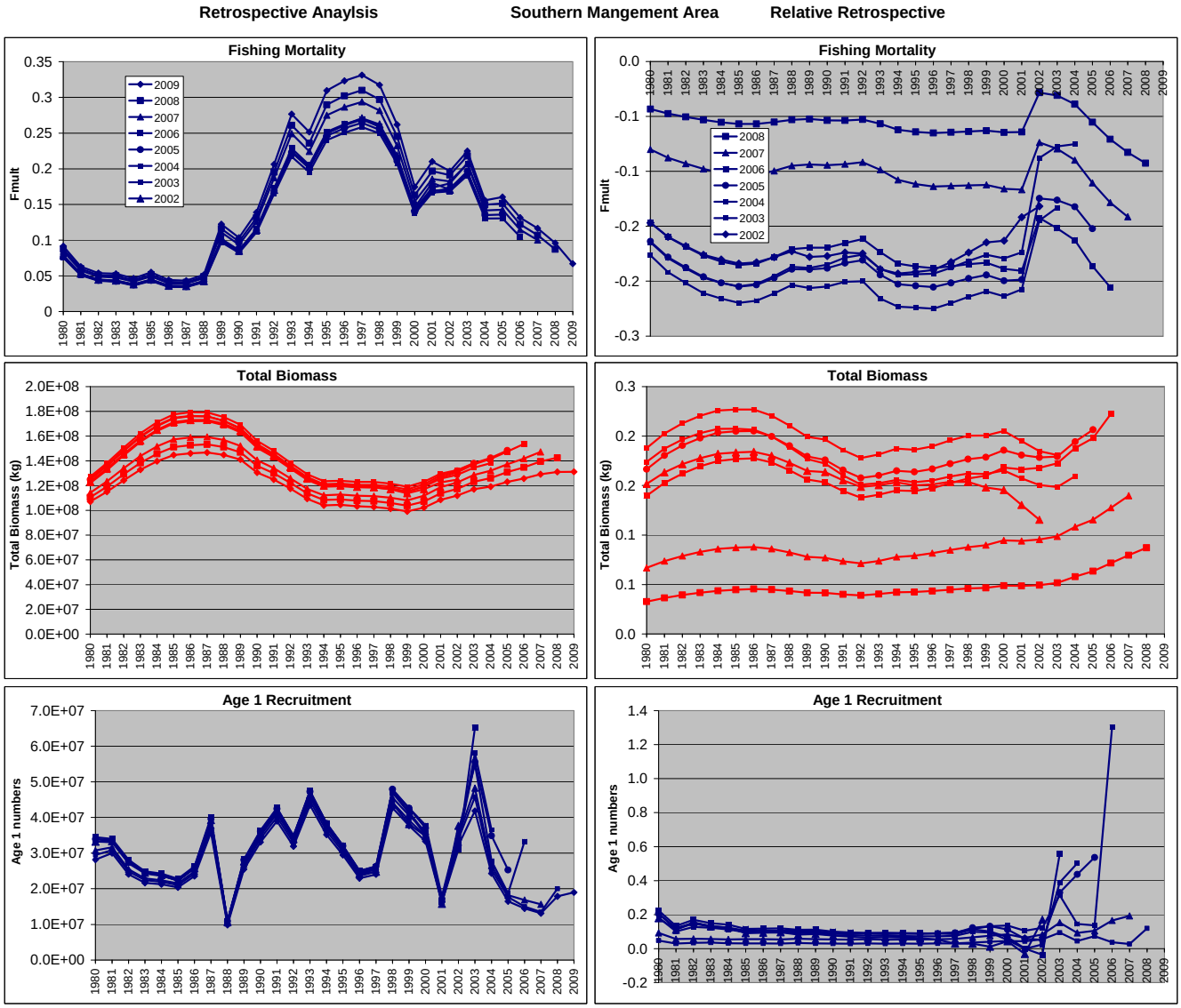


Figure A82. Southern management area retrospective plot for F, total biomass and age 1 recruitment (left). Retrospective relative trends to the terminal year run are on the right.

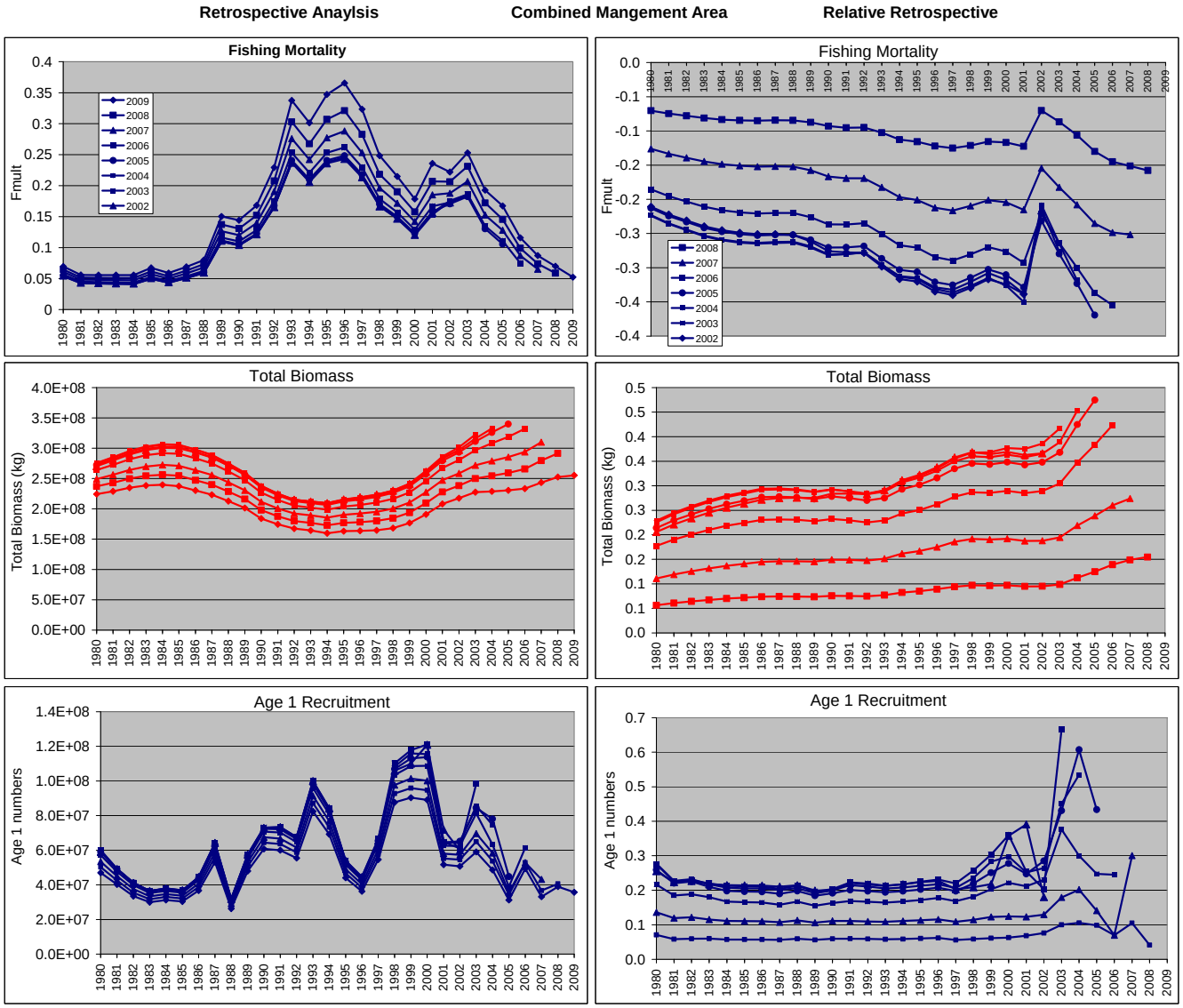


Figure A83. Combined management area retrospective plot for F, total biomass and age 1 recruitment (left). Retrospective relative trends to the terminal year run are on the right.

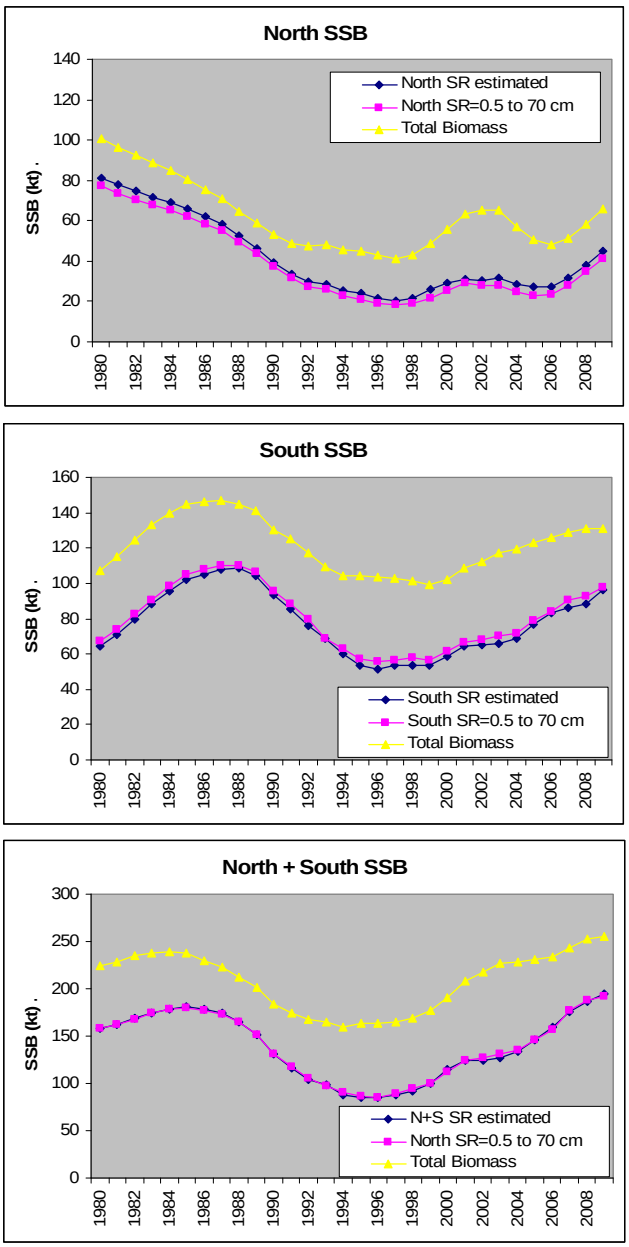


Figure A84. Trends in spawning biomass estimated from SCALE output of numbers at length and applying relationships for maturity at length, weight at length and fraction female at length. Fraction female was estimated from observed ratios at length in survey data (blue diamonds) and assuming 50% female up to 70 cm and 100% female $\geq$ 70 cm (pink squares).

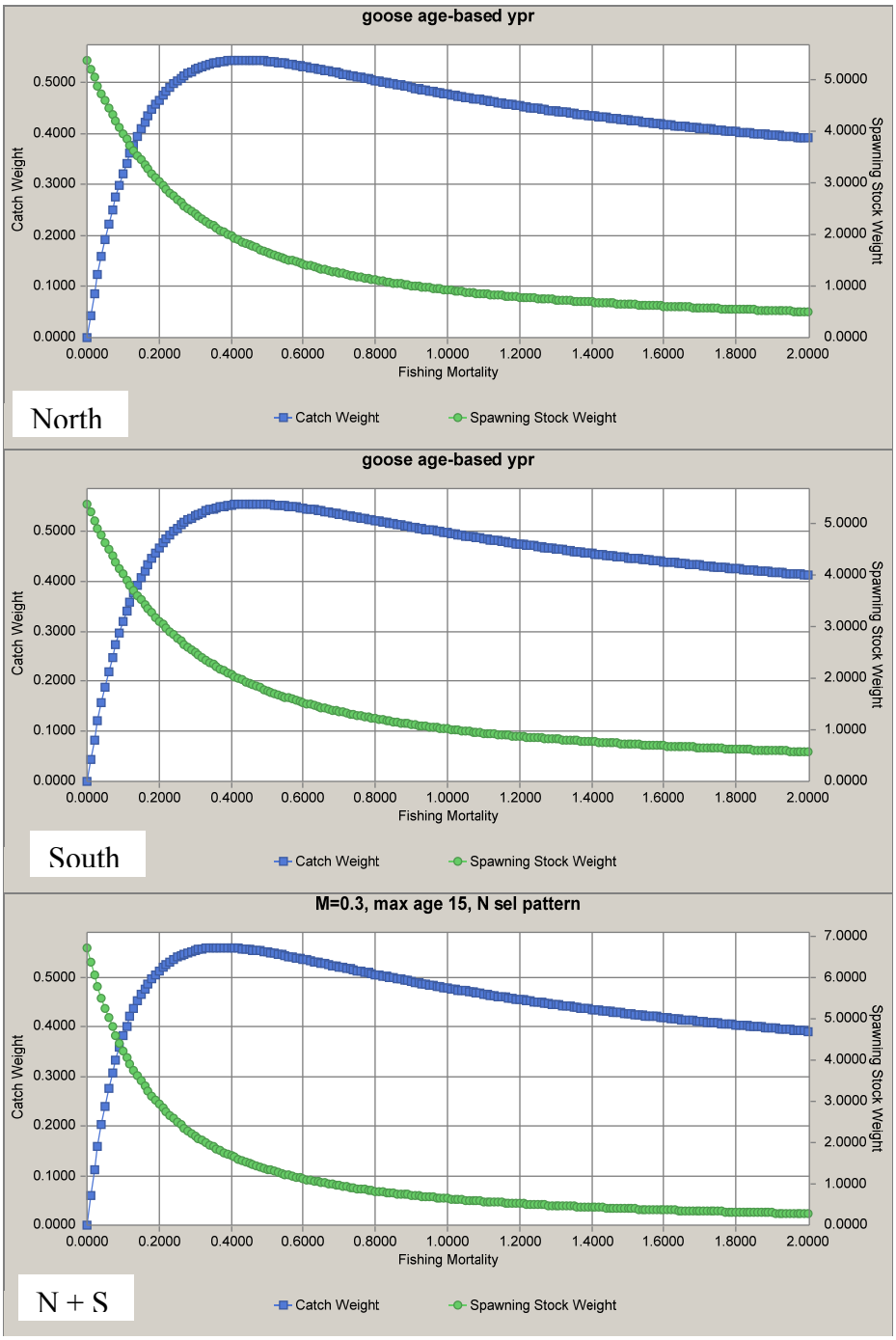


Figure A85. Yield per recruit and spawning stock biomass per recruit curves using selectivity from 2010 SCALE model.

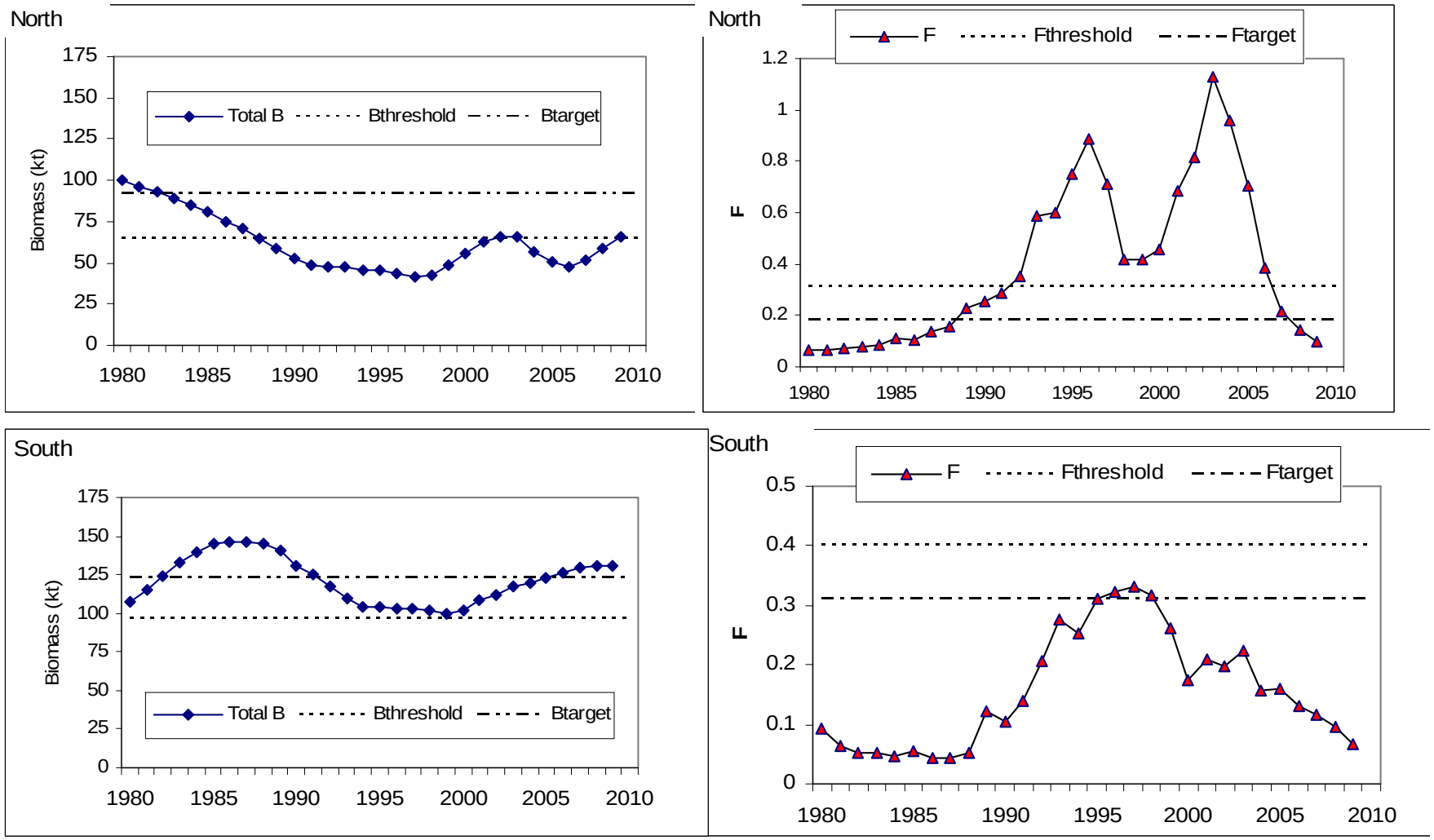


Figure A86. Trends in total biomass and fishing mortality rate (F), from the assessment model (SCALE), relative to the existing (2007) biological reference points for monkfish northern and southern management areas.

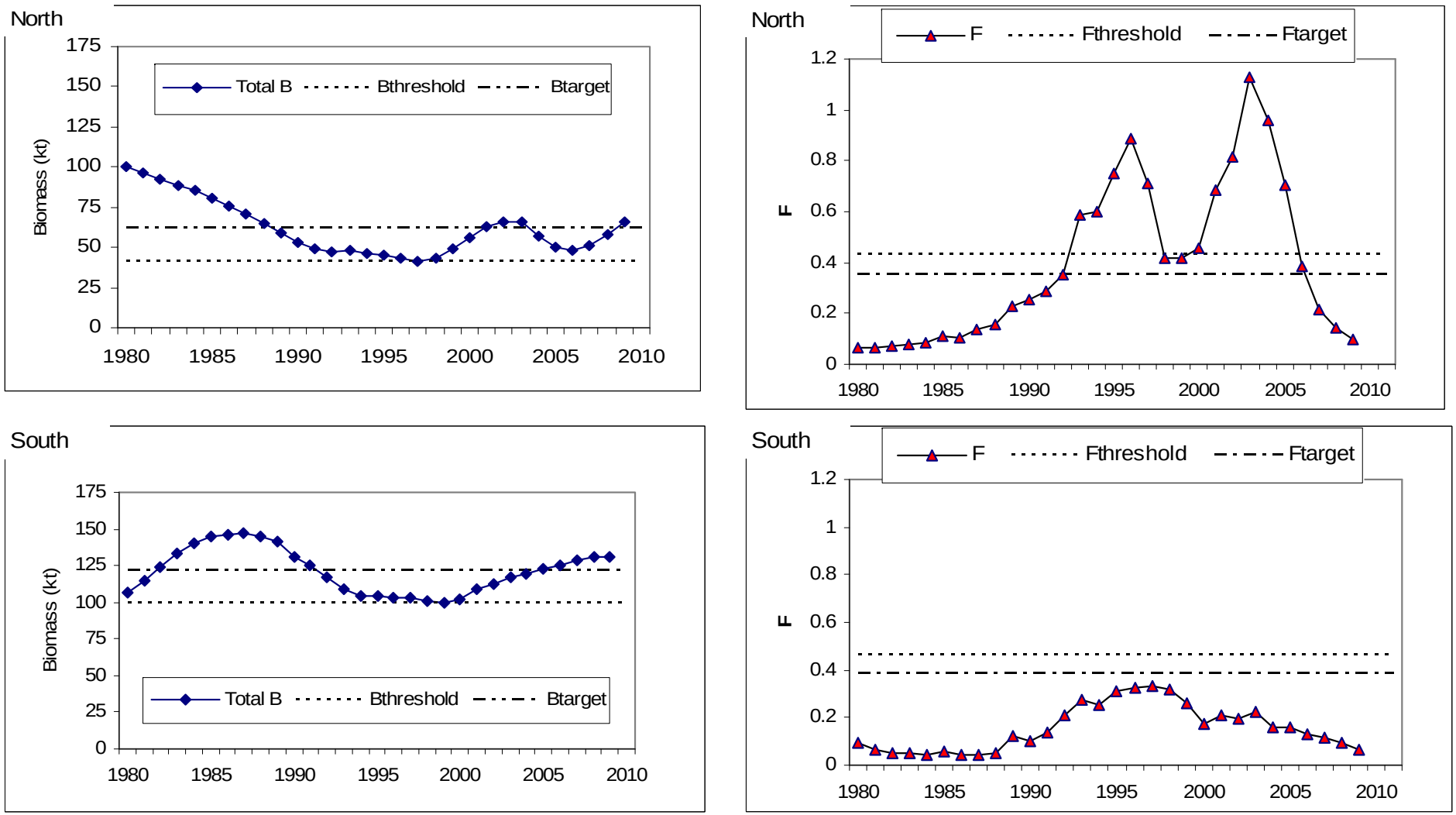


Figure A87. Trends in total biomass and fishing mortality rate (F) from the assessment model (SCALE) relative to updated biological reference points using existing definitions (Bloss, Fmax) for monkfish for northern and southern areas.

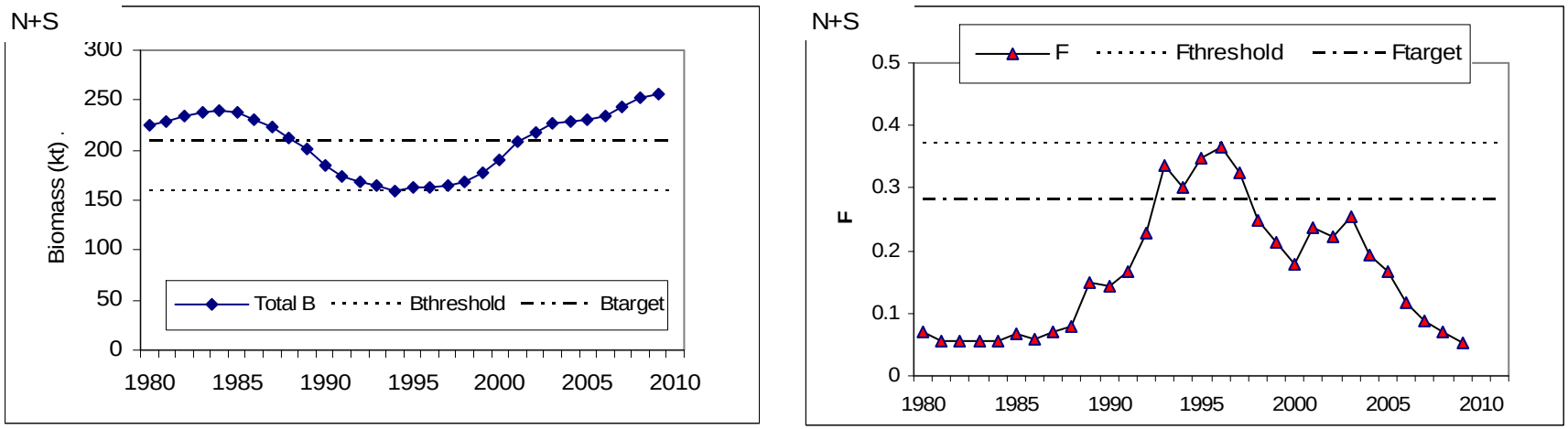


Figure A88. Trends in total biomass and fishing mortality rate (F) from the assessment model (SCALE) relative to updated biological reference points using existing definitions (Bloss, Fmax) for monkfish for combined areas.

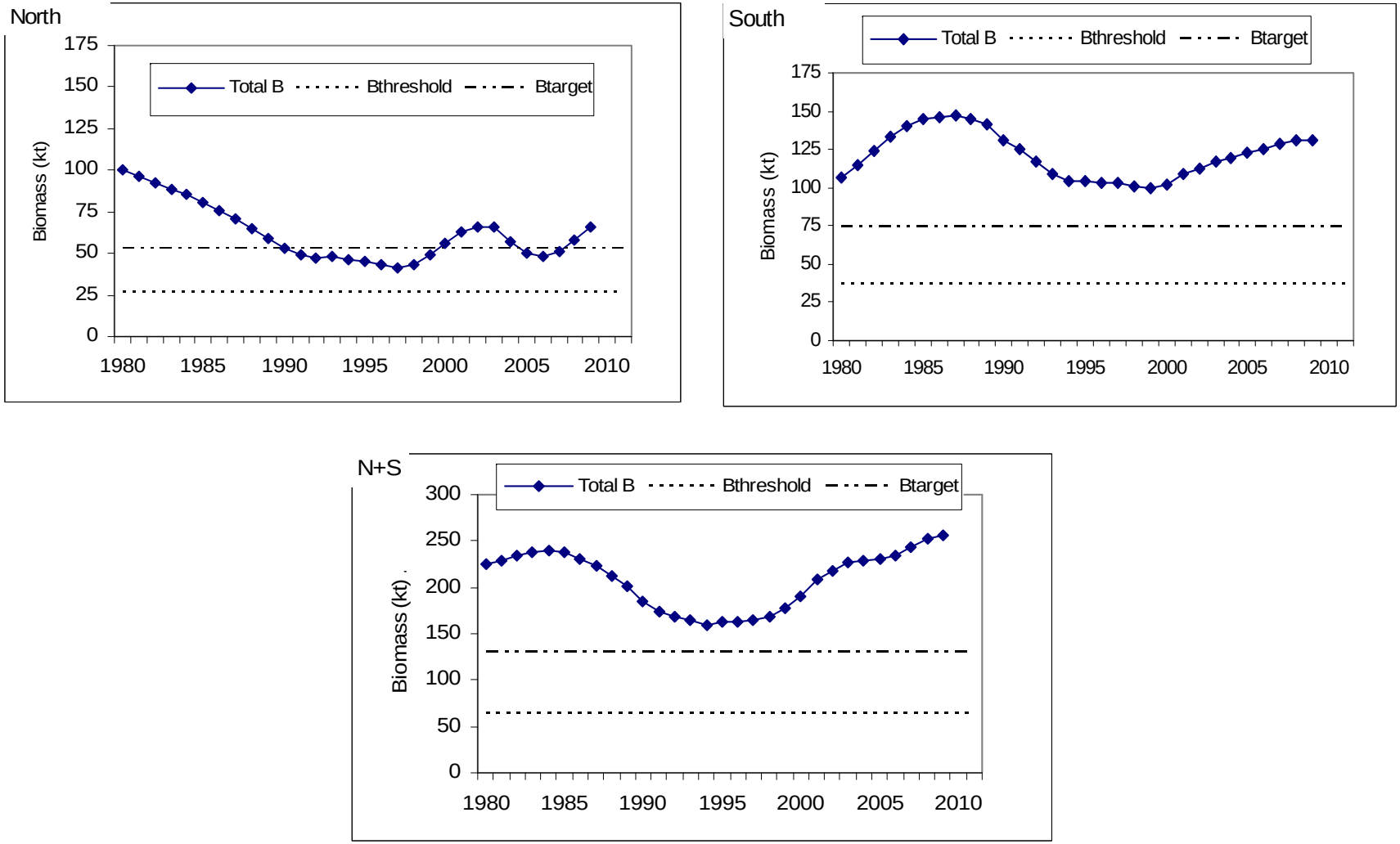


Figure A89. Trends in total biomass from the assessment model (SCALE), relative to the Bmax biological reference points for monkfish for northern, southern and combined management areas.

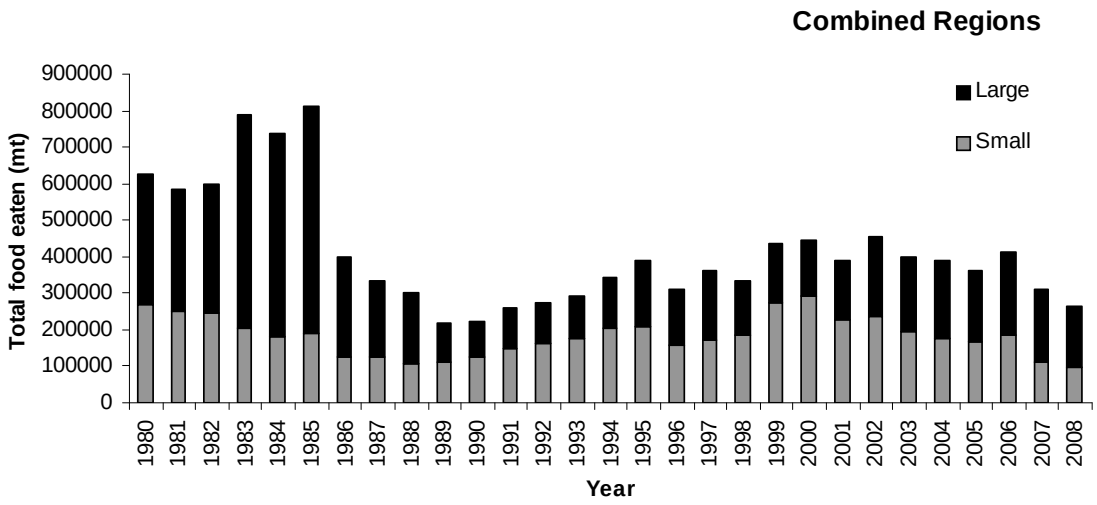


Figure A90. Total amount of food consumed by goosefish.