

C. Red Hake - Figures

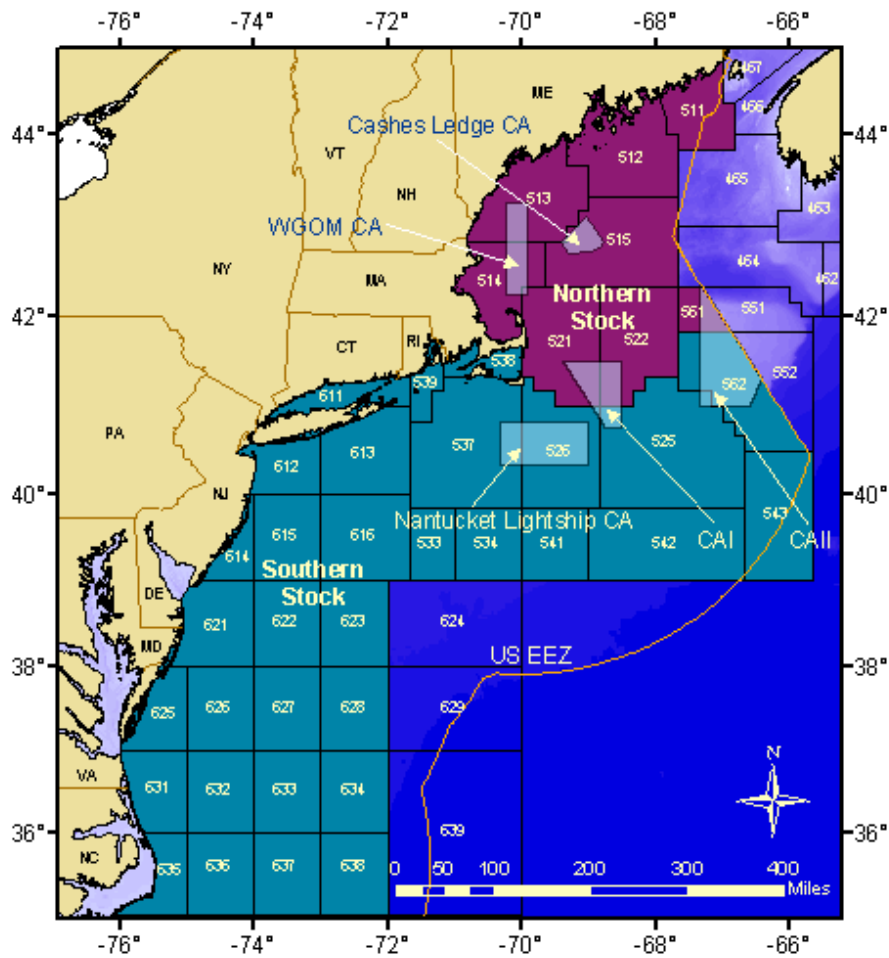


Figure C1. Statistical areas used to define the northern and southern red hake stocks.

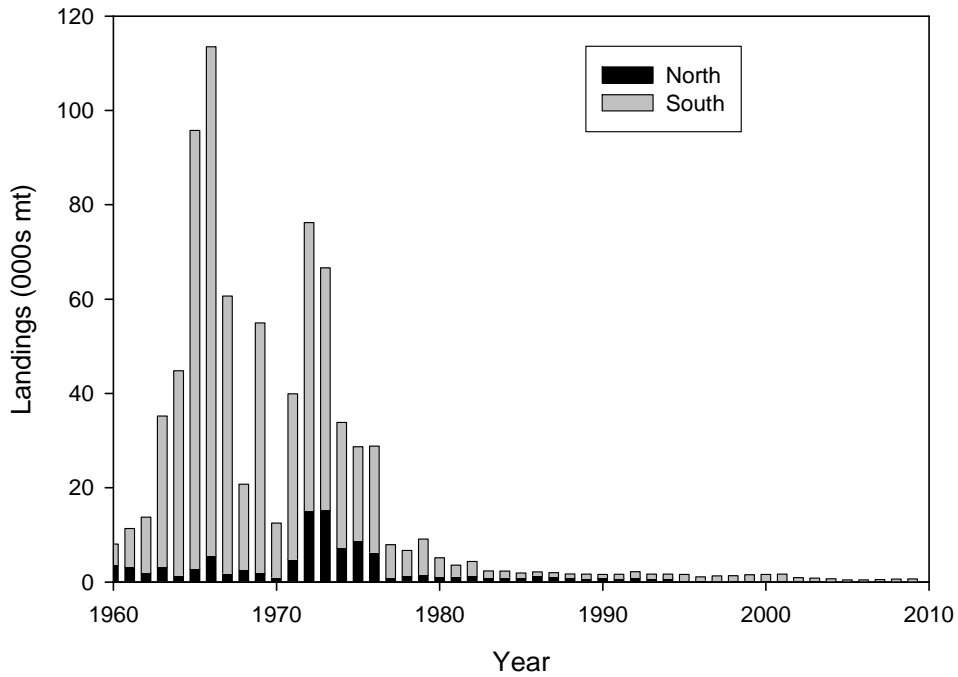


Figure C2. Nominal commercial landings (000s mt) by stock area for red hake, 1960-2009.

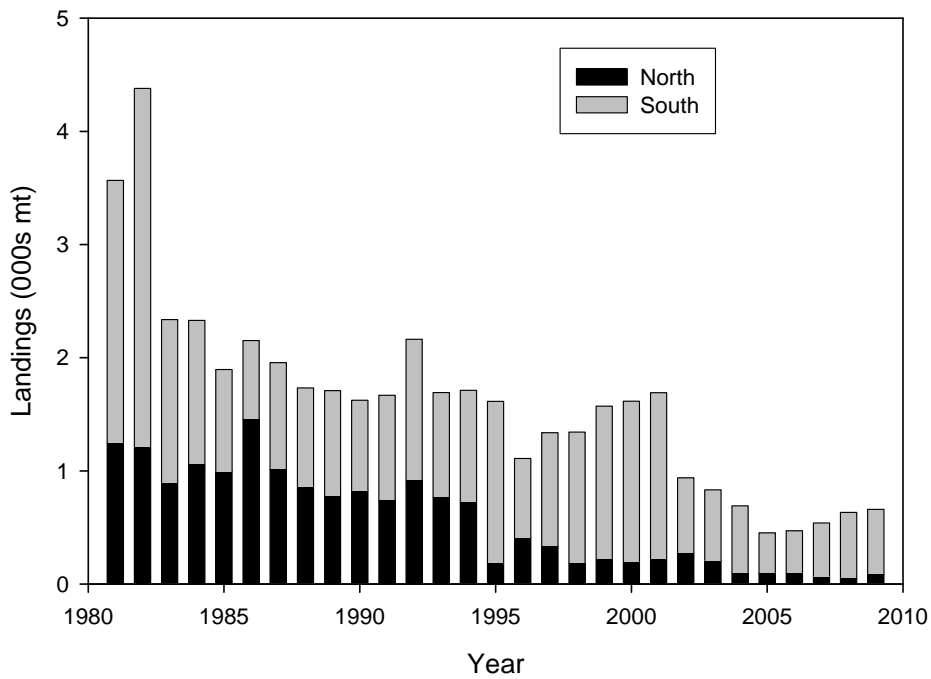


Figure C3. Nominal commercial landings (000s mt) by stock area for red hake, 1981-2009.

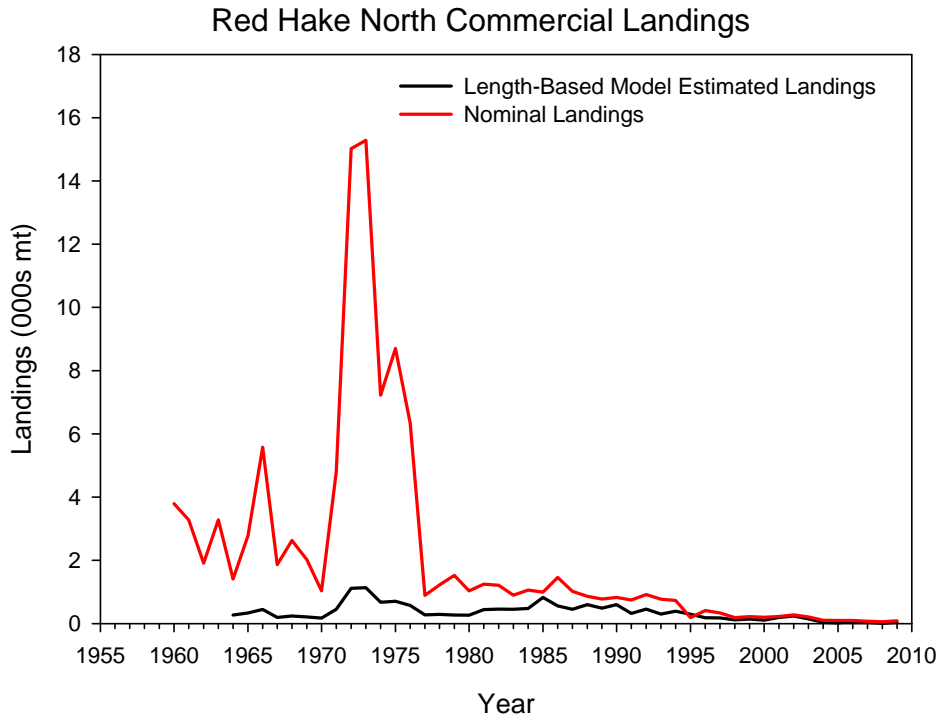


Figure C4. Comparison of nominal landings (000s mt) of red hake with length-based model estimated landings from the northern stock.

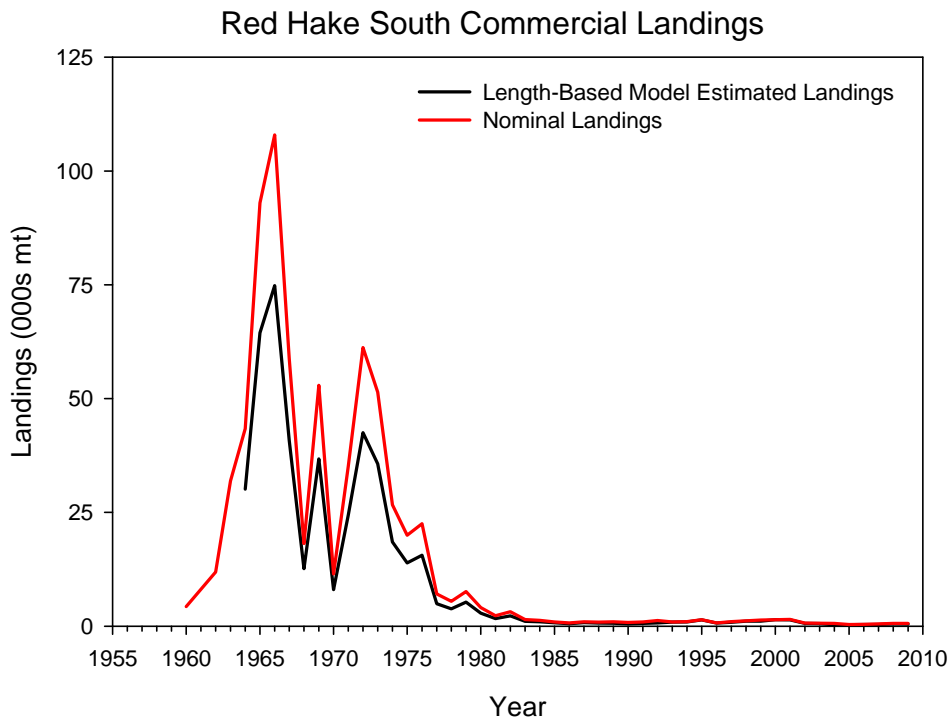
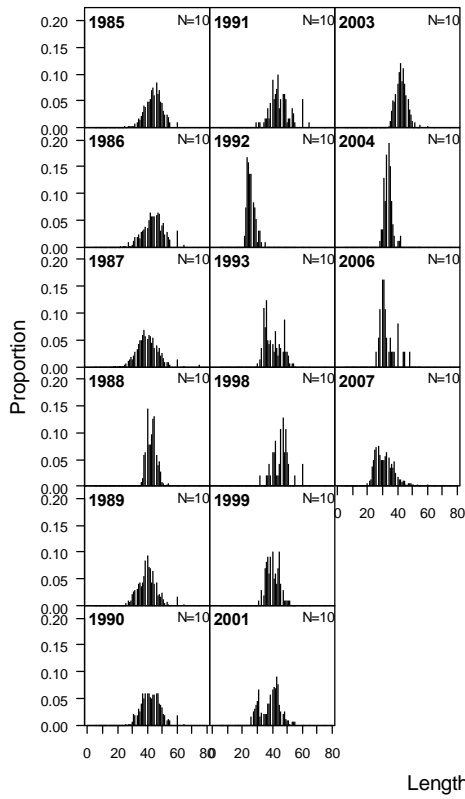


Figure C5. Comparison of nominal landings (000s mt) of red hake with length-based model estimated landings from the southern stock.

length comp data, sexes combined, whole catch, LANDINGS



length comp data, sexes combined, whole catch, LANDINGS (max=0.19)

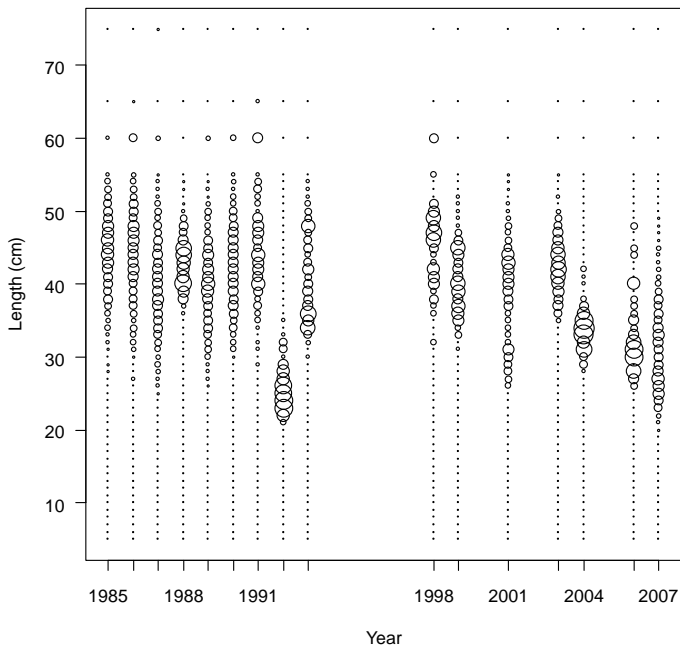


Figure C6. Length composition of nominal commercial landings from the northern stock.

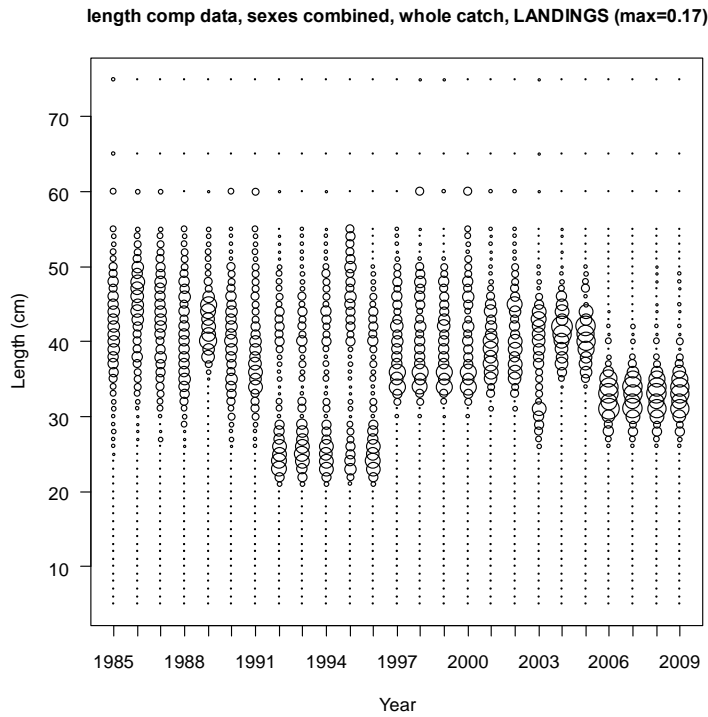
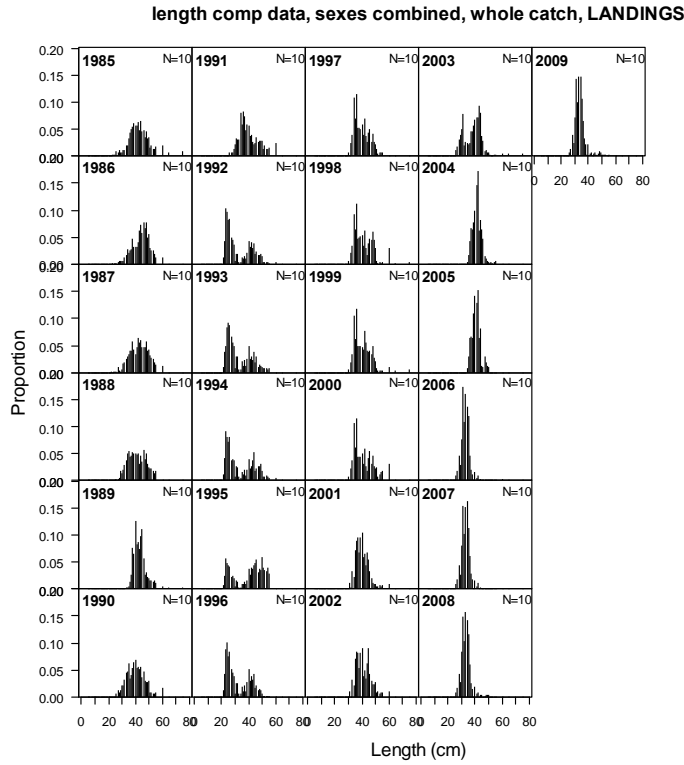


Figure C7. Length composition of length-based model estimated commercial landings from the northern stock.

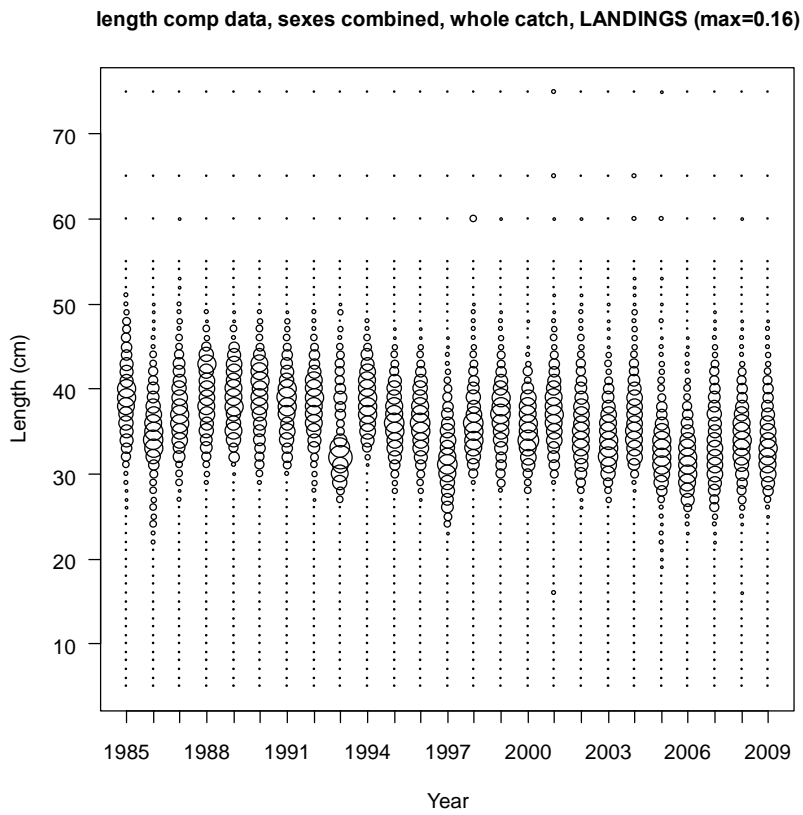
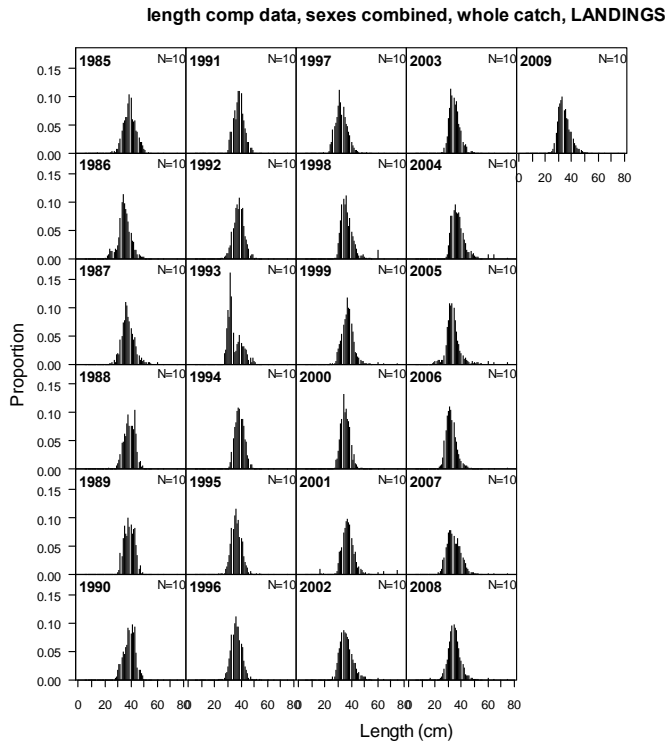
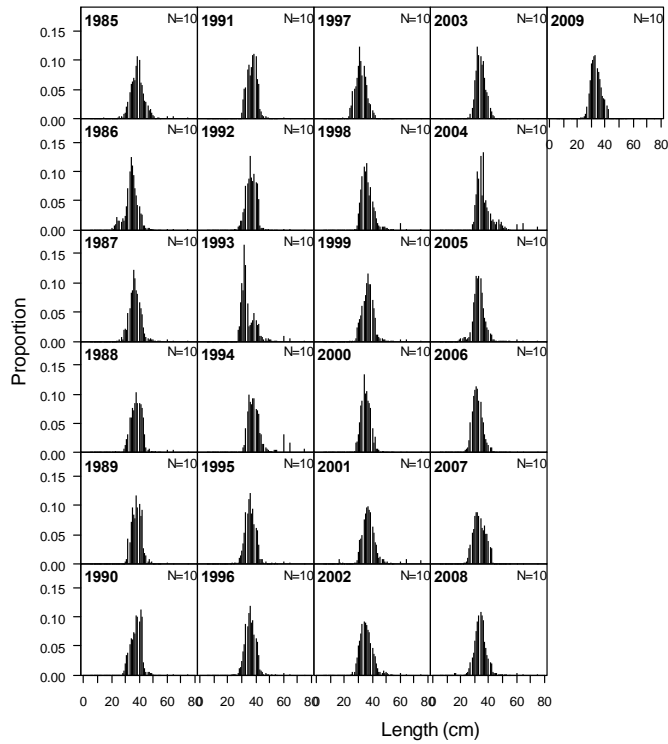


Figure C8. Length composition (proportion) of nominal commercial landings from the southern stock.

length comp data, sexes combined, whole catch, LANDINGS



length comp data, sexes combined, whole catch, LANDINGS (max=0.17)

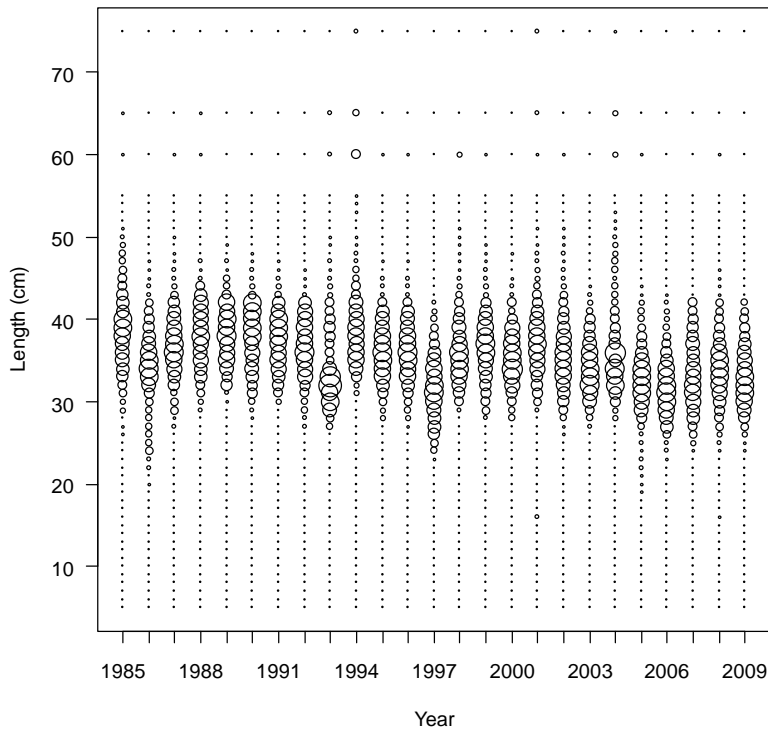


Figure C9. Length composition of length-based model estimated commercial landings from the northern stock.

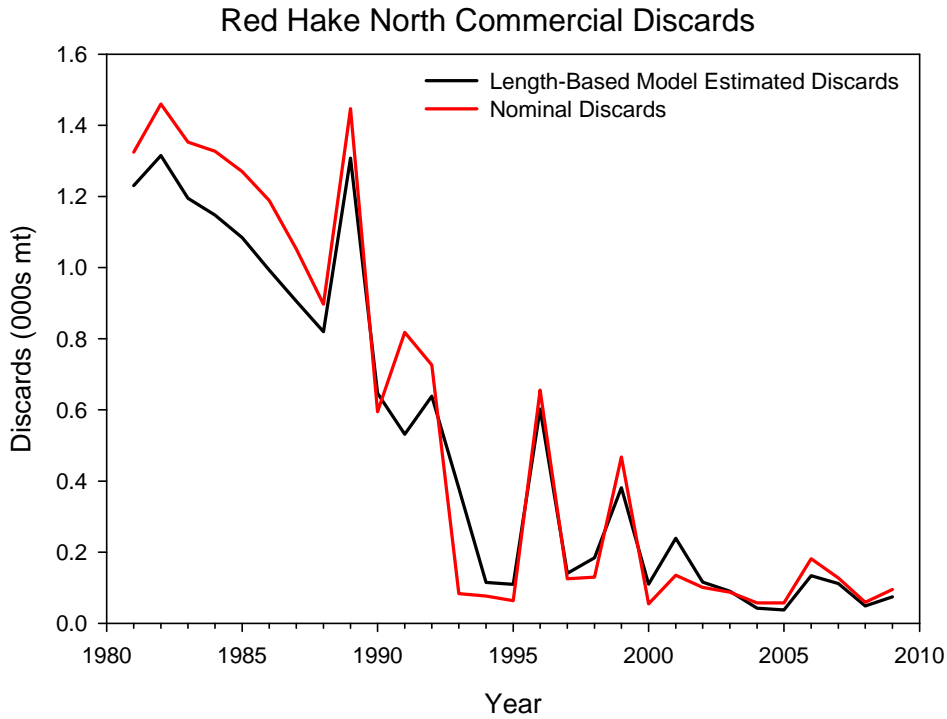


Figure C10. Comparison of nominal discards (000s mt) of red hake with length-based model estimated landings from the northern stock.

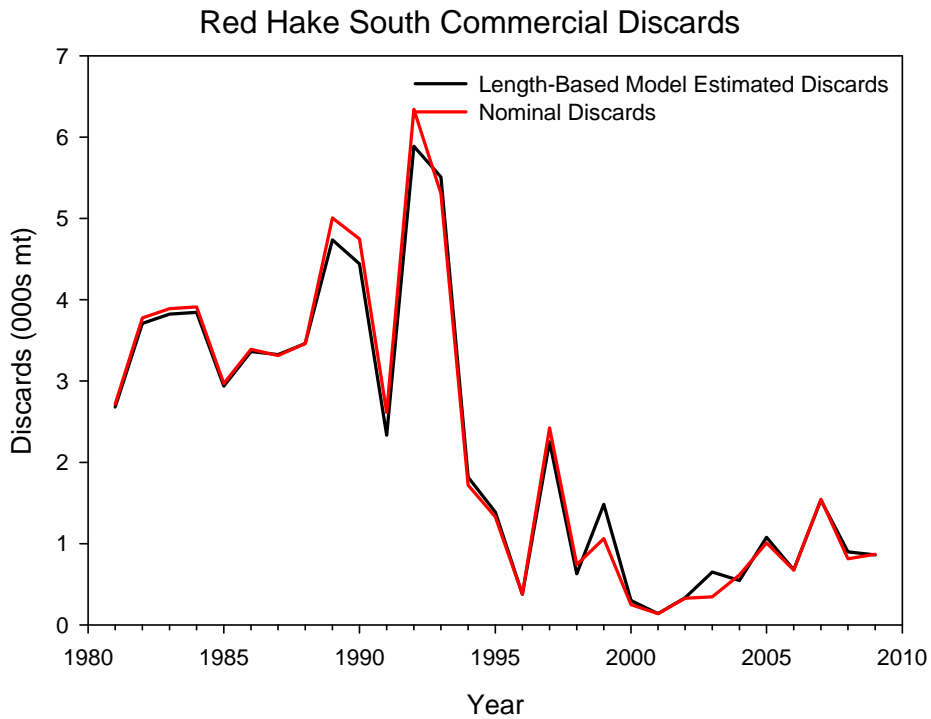
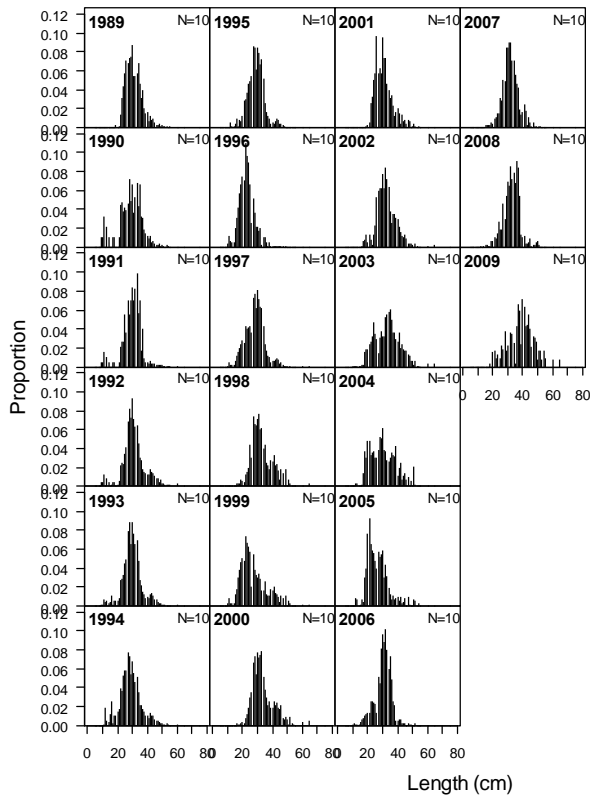


Figure C11. Comparison of nominal discards (000s mt) of red hake with length-based model estimated landings from the southern stock.

length comp data, sexes combined, whole catch, DISCARDS



length comp data, sexes combined, whole catch, DISCARDS (max=0.11)

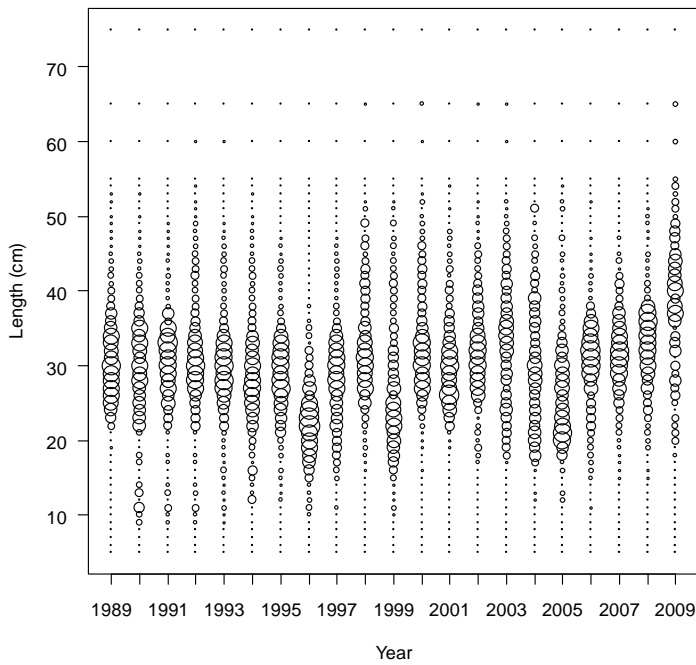


Figure C12. Length composition of nominal red hake commercial discards from the northern stock.

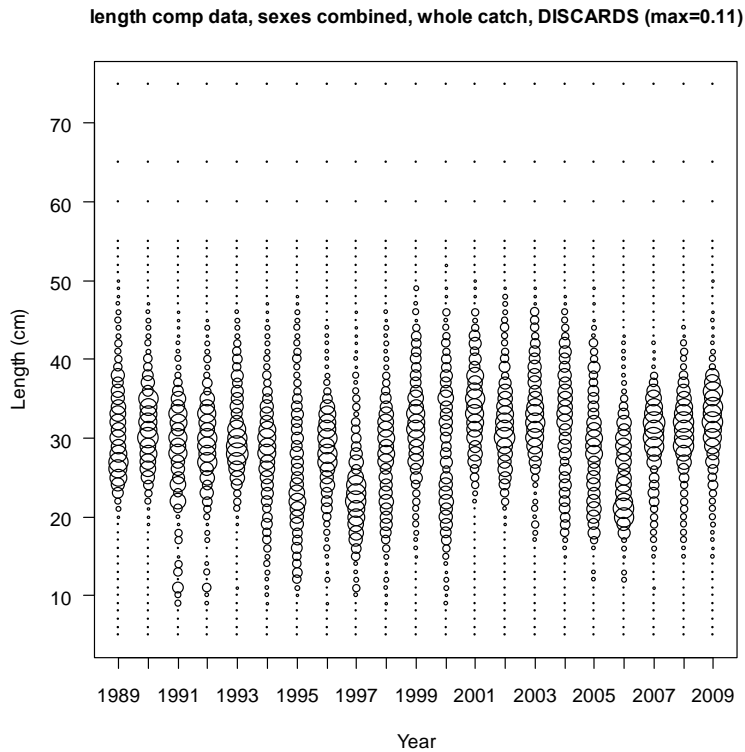
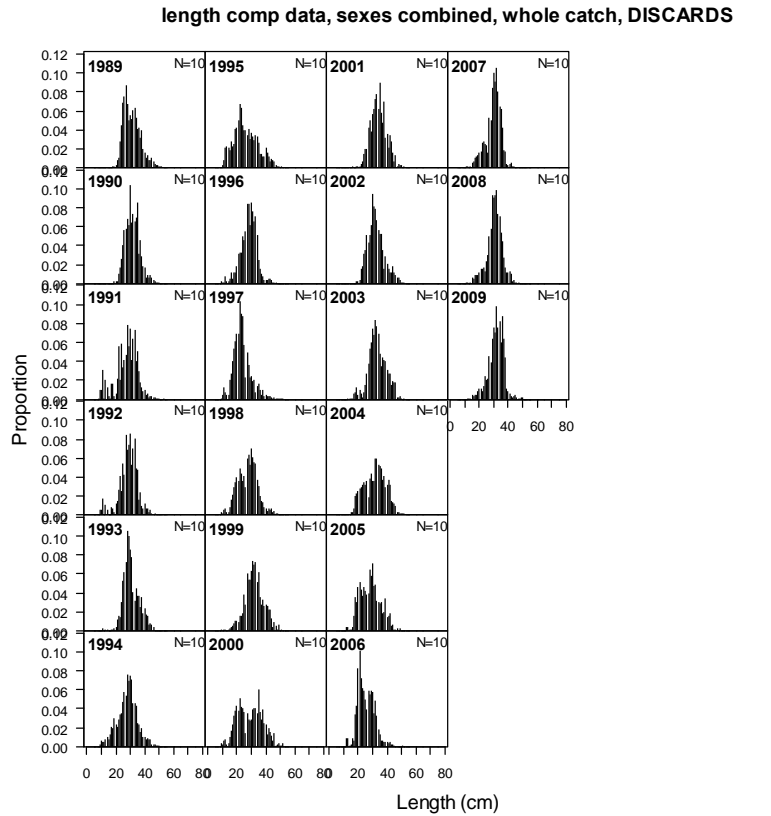


Figure C13. Length composition of length-based model estimated commercial discards from the northern stock.

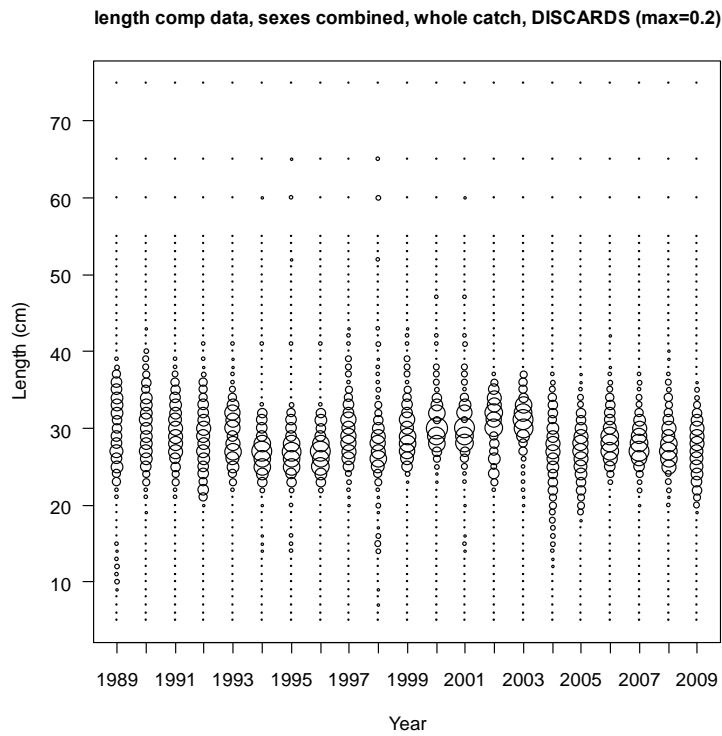
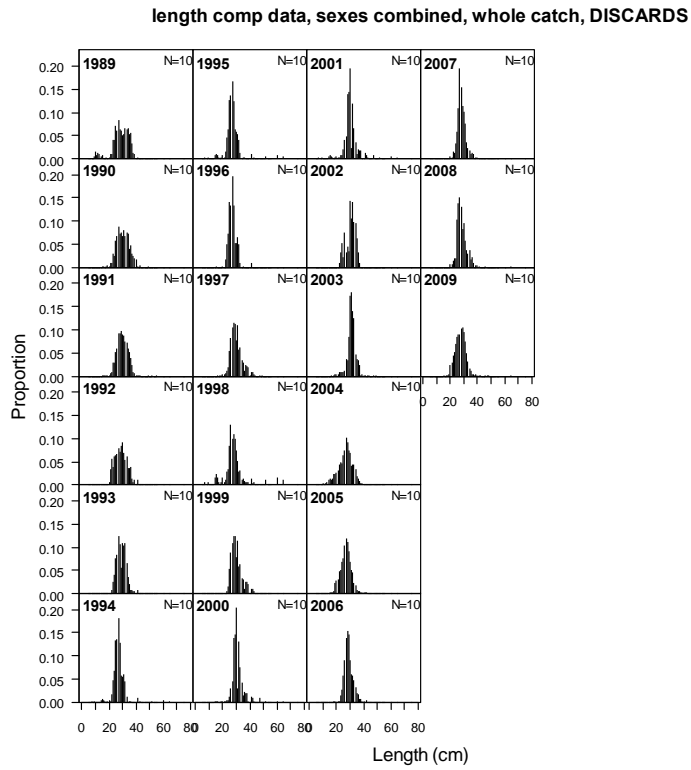


Figure C14. Length composition of nominal red hake commercial discards from the southern stock.

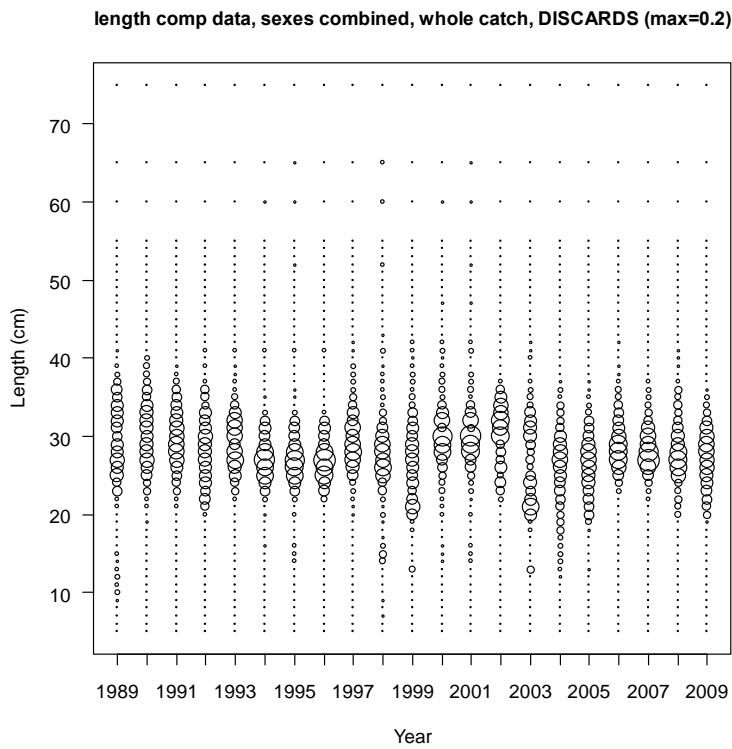
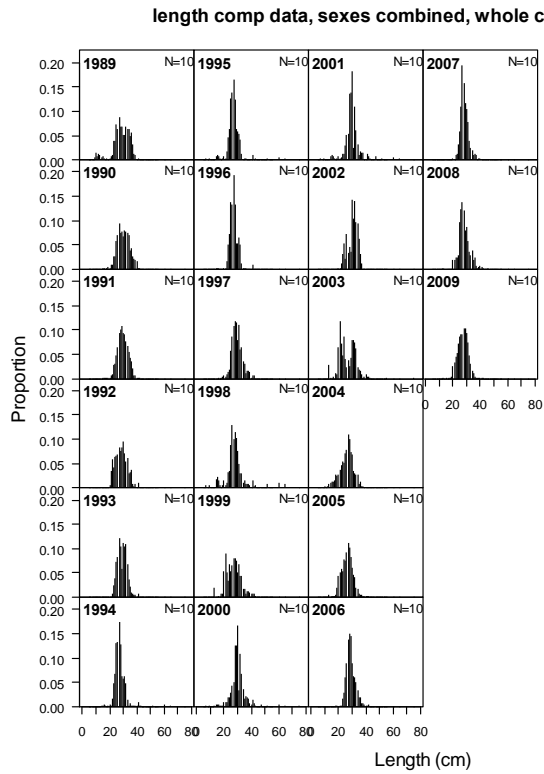


Figure C15. Length composition of length-based model estimated commercial discards from the southern stock.

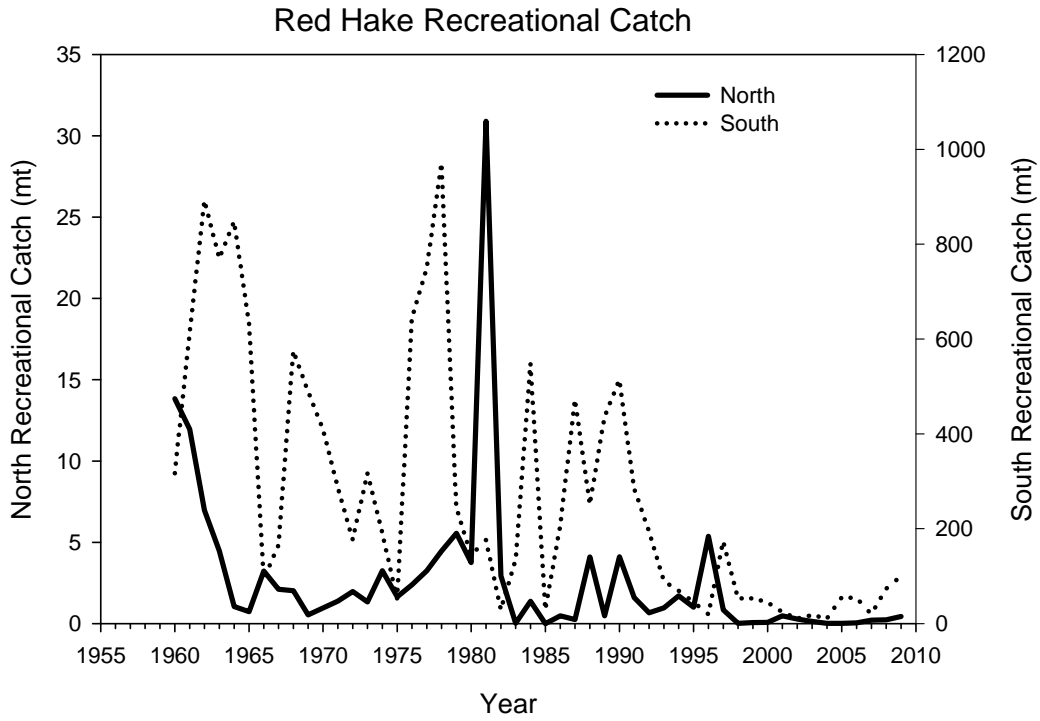


Figure C16. Recreational catch (mt) of red hake by stock. Note the southern stock is plotted against the right-hand axis.

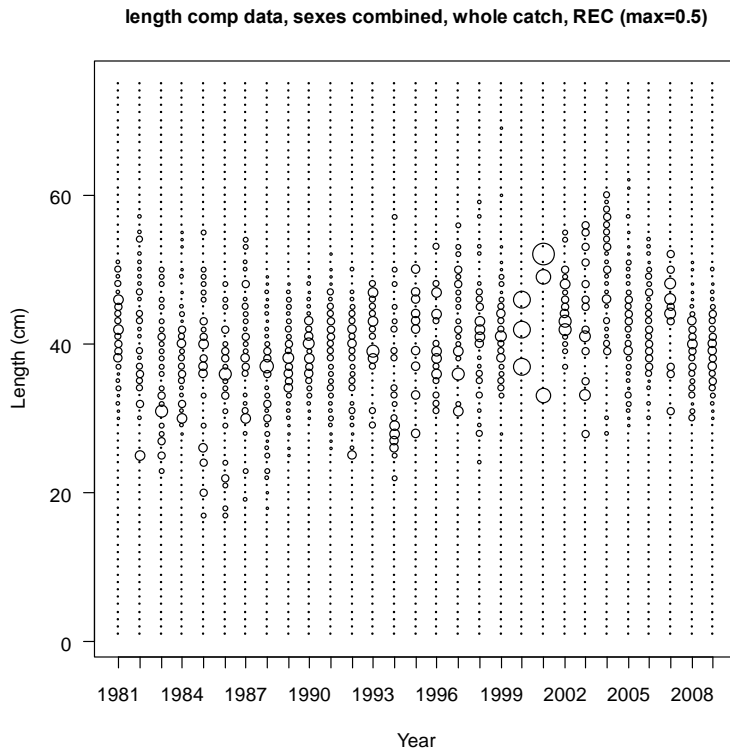
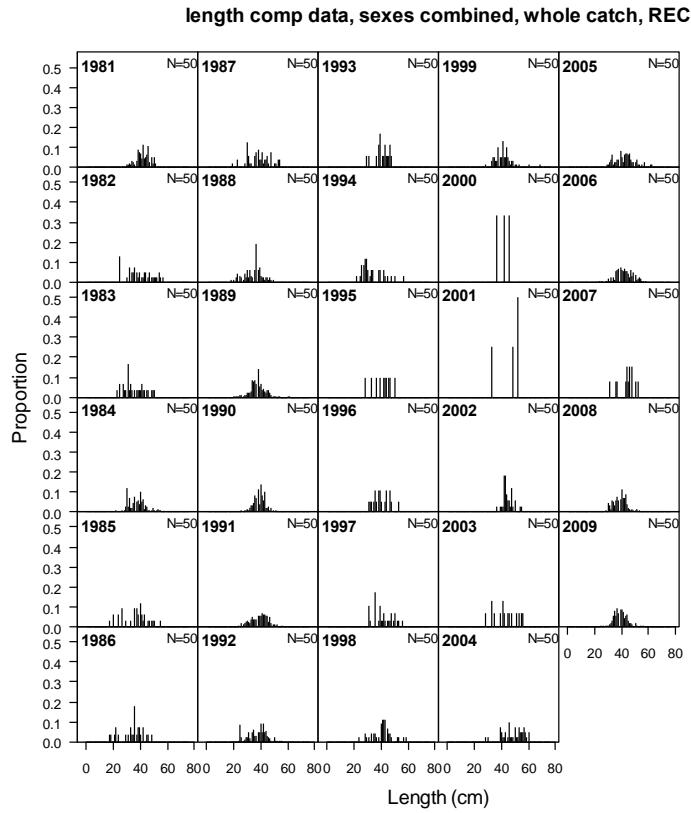


Figure C17. Length composition of recreational catch from the combined stock (mostly southern).

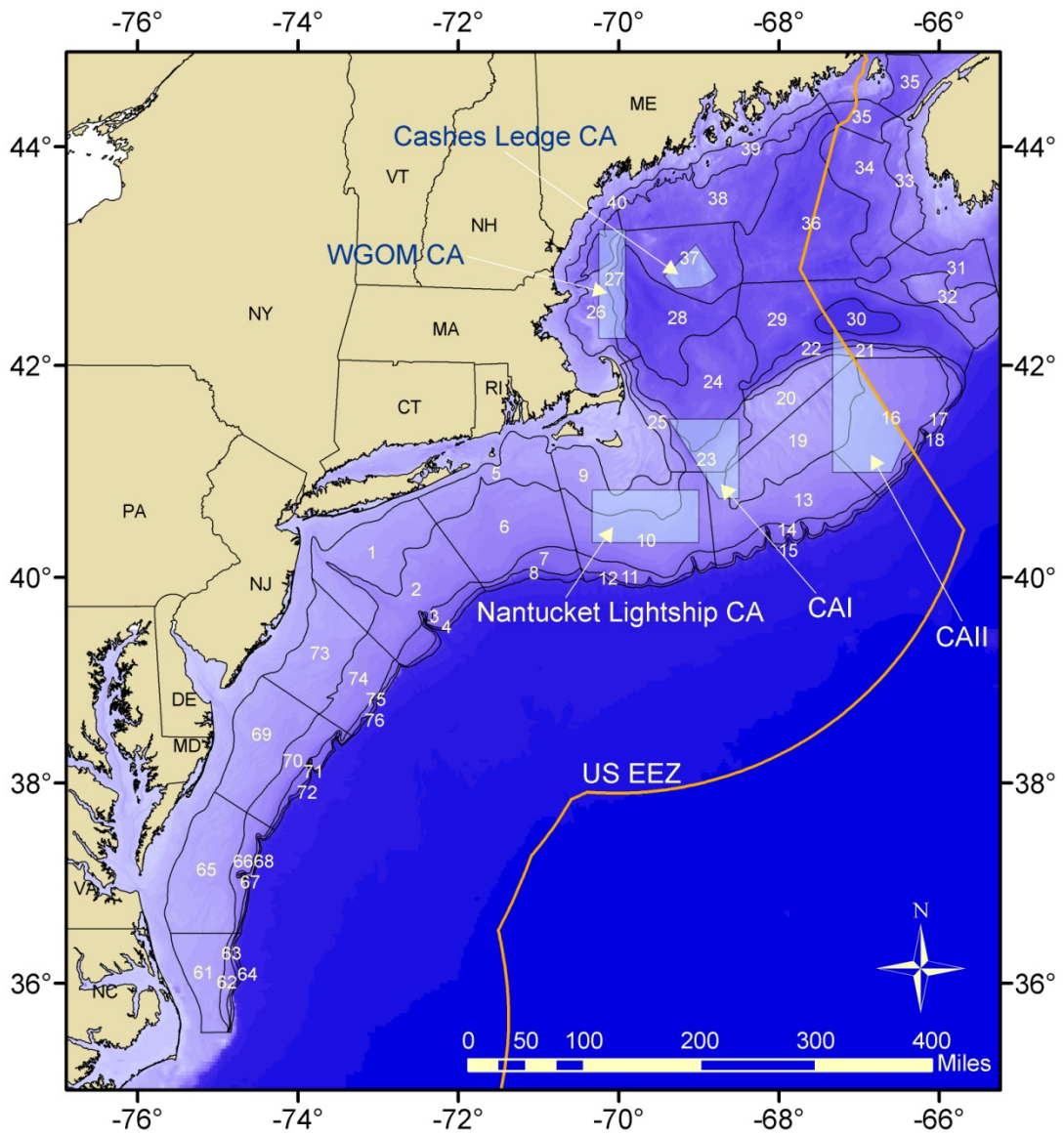


Figure C18. NEFSC survey strata.

Region	Stratum	Area(nm ²)
1. Buzzards Bay Vineyard Sd & coastal water south of Marthas Vineyard	11	102
	12	160
	13	88
	14	16
2. Nantucket Sound	15	190
	16	212
3. East of Cape Cod Race Point to Muskeget Island	17	85
	18	88
	19	39
	20	24
	21	40
4. Cape Cod Bay	25	47
	26	87
	27	94
	28	93
	29	103
	30	32
5. Massachusetts Bay north to N.H. border	31	41
	32	49
	33	78
	34	38
	35	174
	36	33

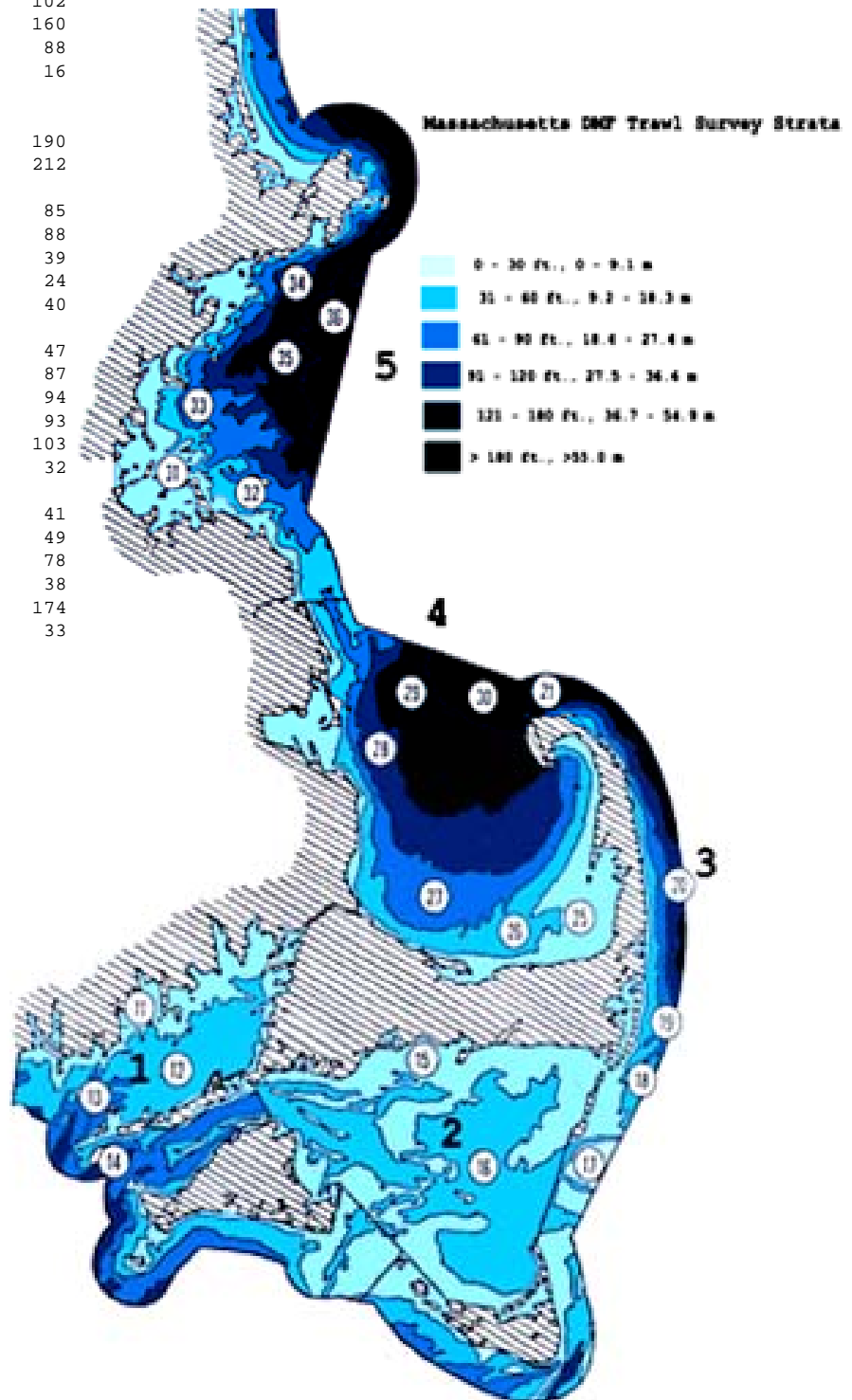


Figure C19. MADM survey strata.

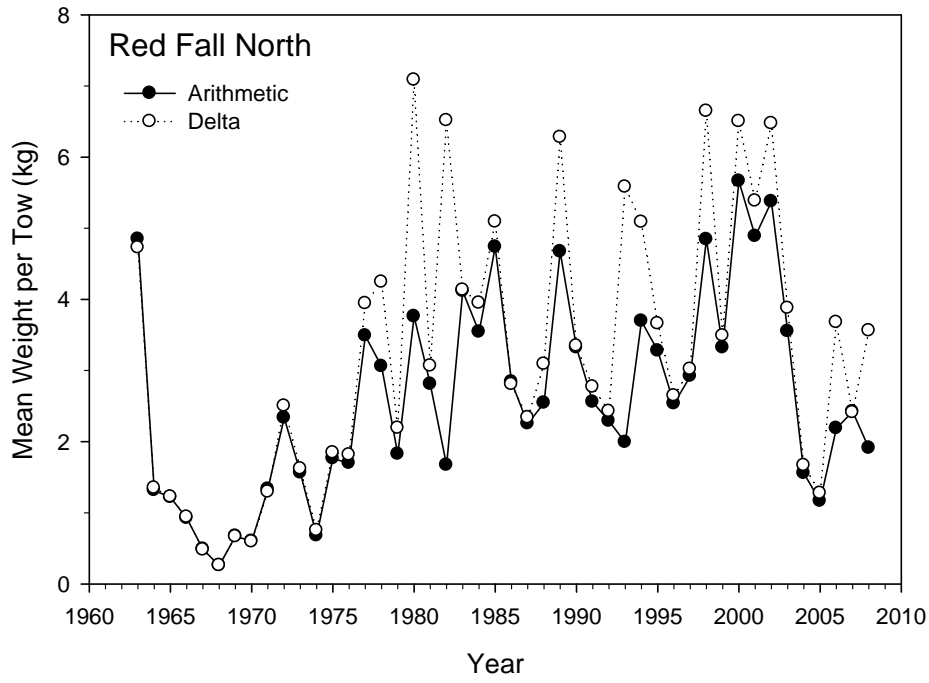


Figure C20. Comparison of the arithmetic and delta transformed mean weight per tow from the fall survey.

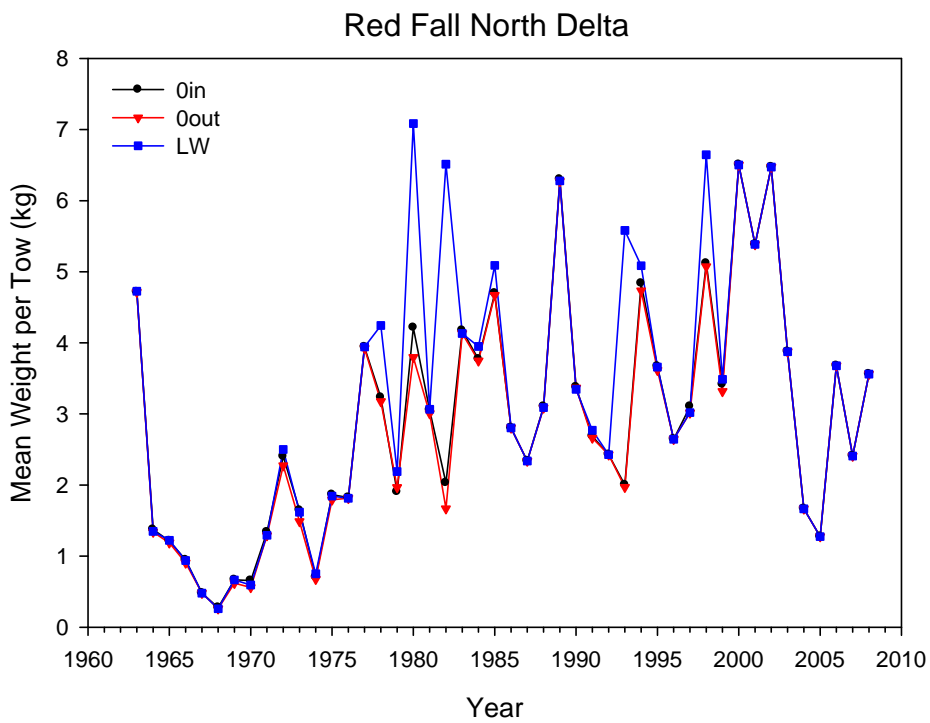
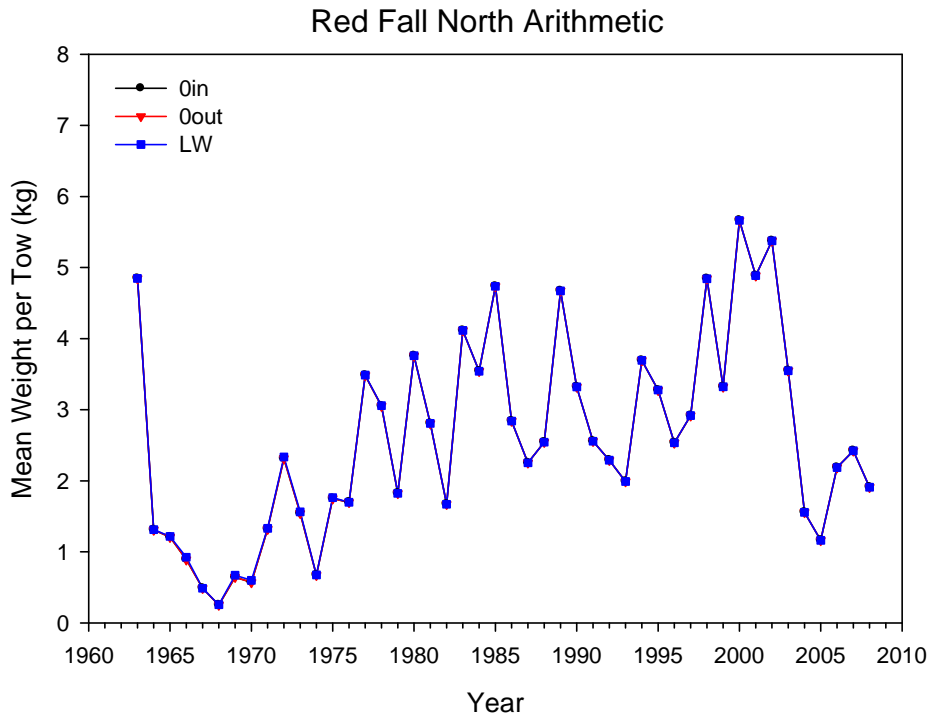


Figure C21. Comparison of the arithmetic and delta transformed mean weight per tow from the fall survey with three methods of handling missing weight data.

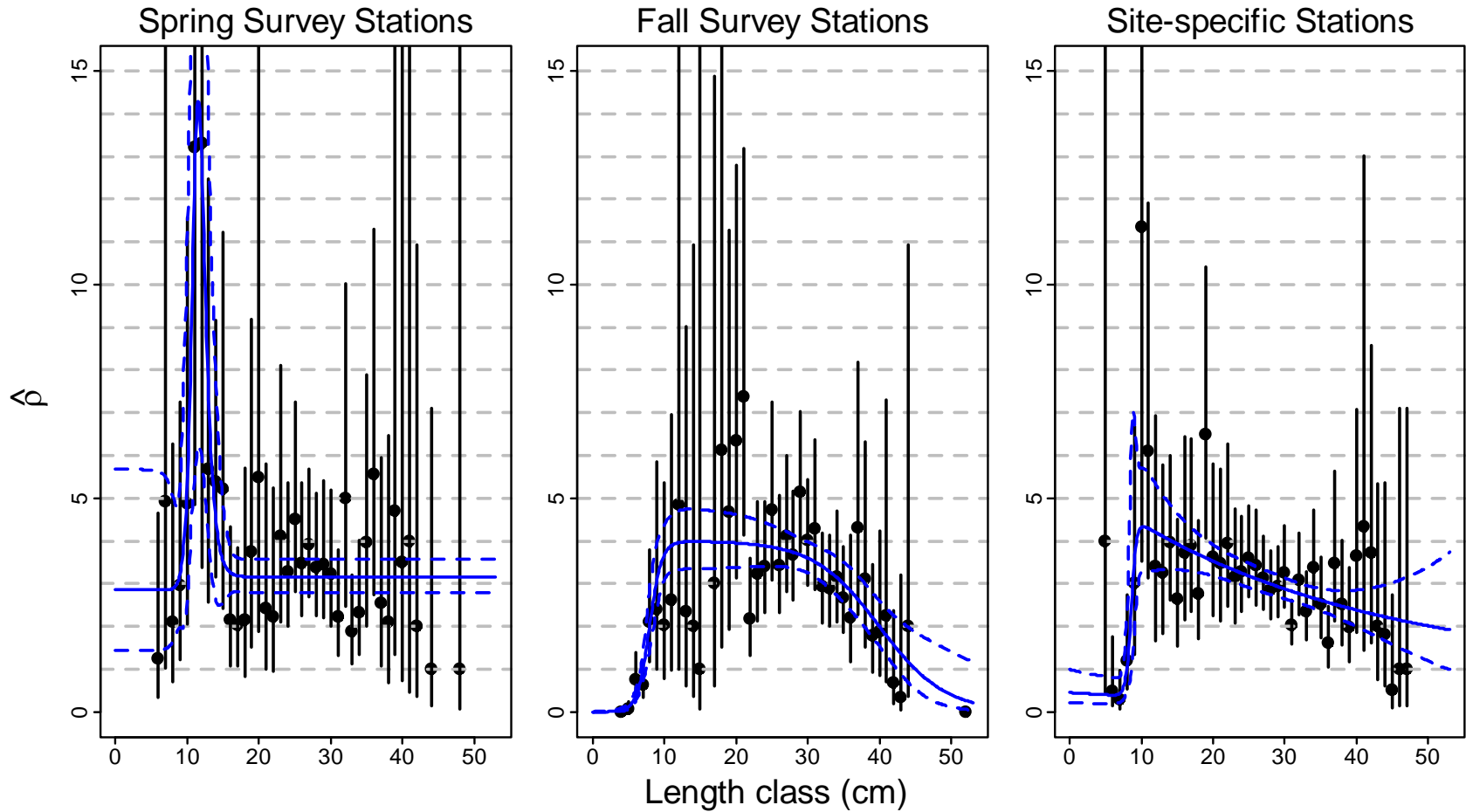


Figure C22. Beta-binomial based estimates of calibration factors and corresponding 95% confidence intervals by length class (1 cm bins) for **red hake**. The black points and vertical bars represent results where different calibration factors are estimated for each length class. The blue lines represent results from double-logistic models. For the fall, the double logistic model has with no minima (assumed equal to 0) for the ascending or descending logistic function.

Red Hake Distribution NEFSC Fall BTS 1963-2009

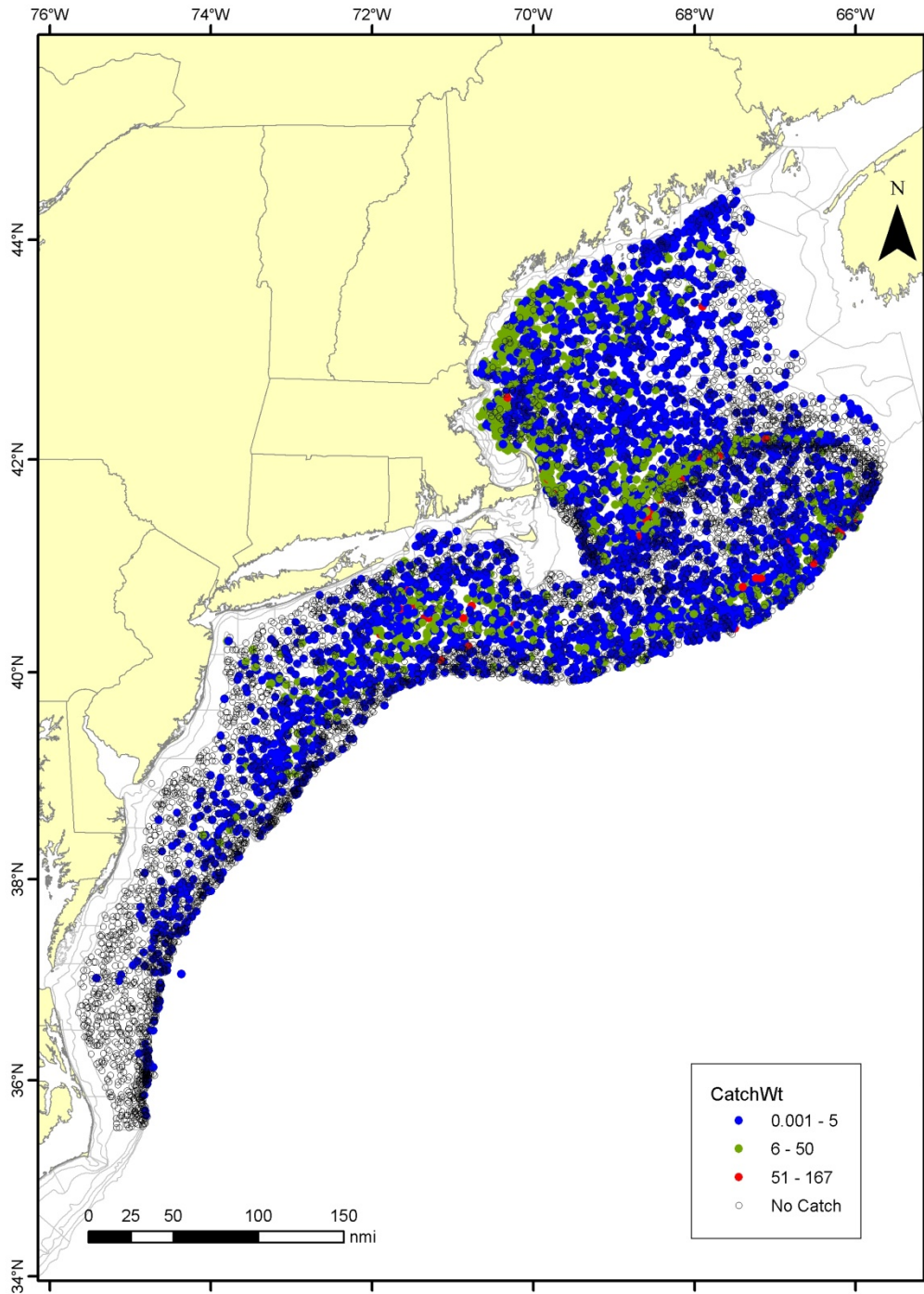


Figure C23. NEFSC distribution maps for red hake during the fall bottom trawl surveys, 1963-2009.

Red Hake Distribution NEFSC Spring BTS 1968-2010

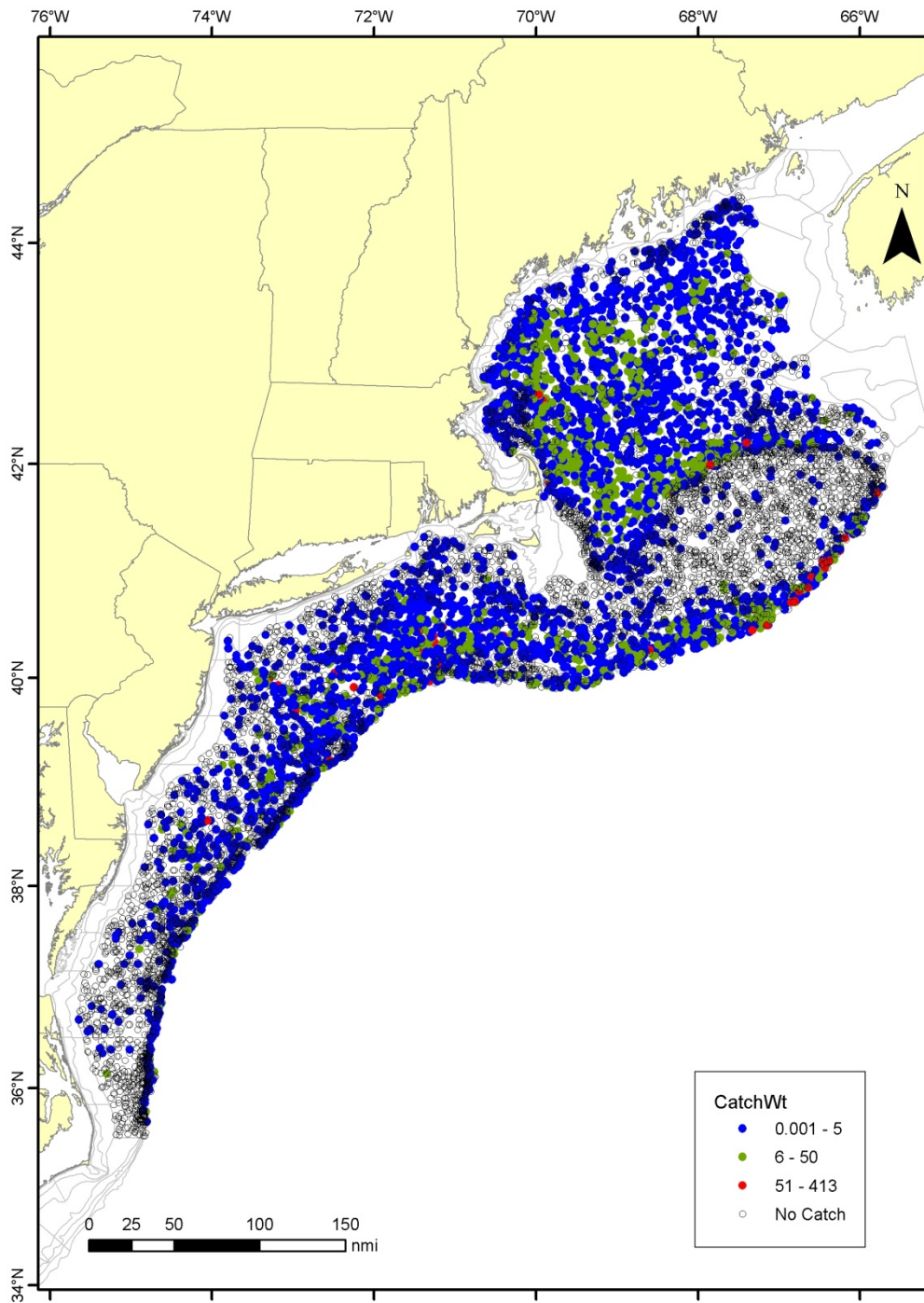


Figure C24. NEFSC distribution maps for red hake during the spring bottom trawl surveys, 1968-2010.

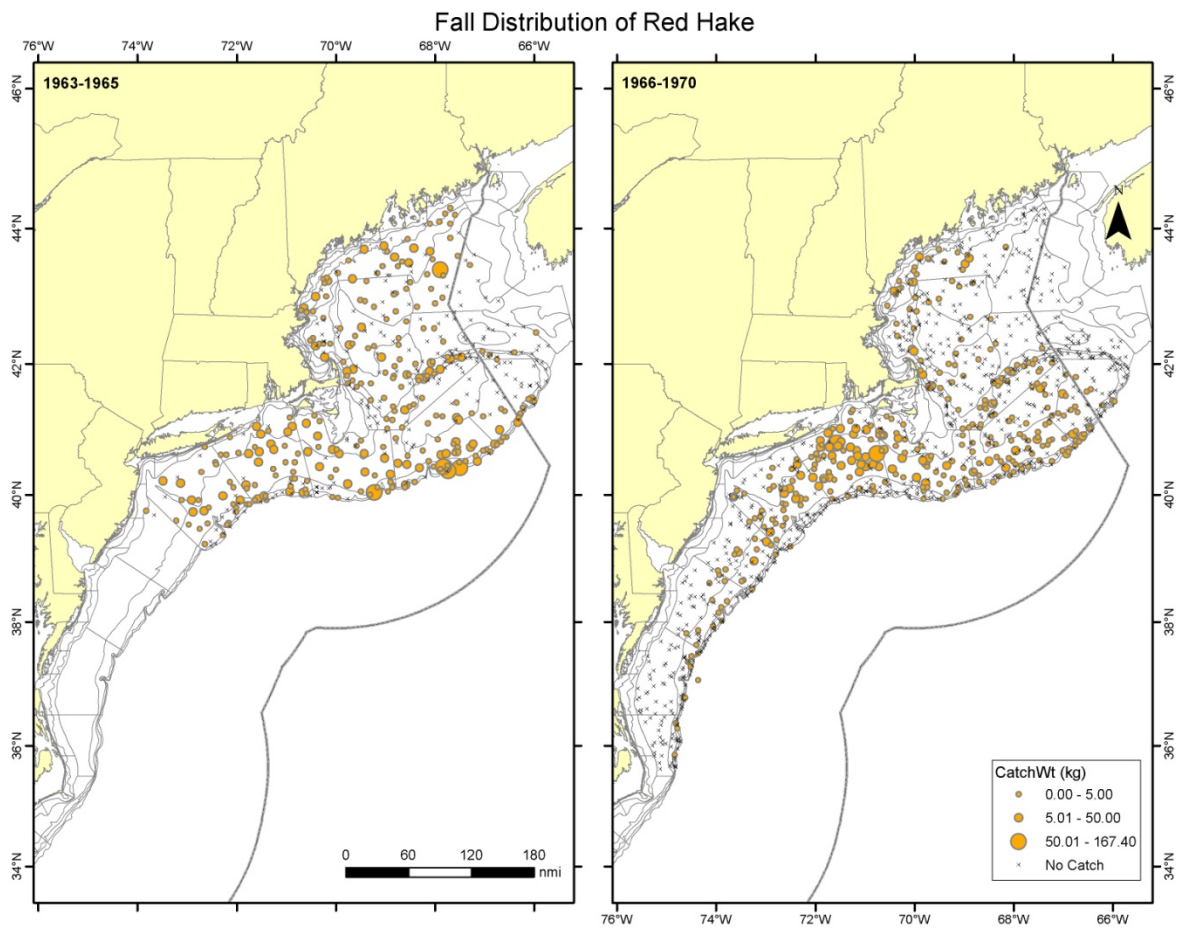


Figure C25. NEFSC distribution maps for red hake during the fall bottom trawl surveys, 1963-1970.

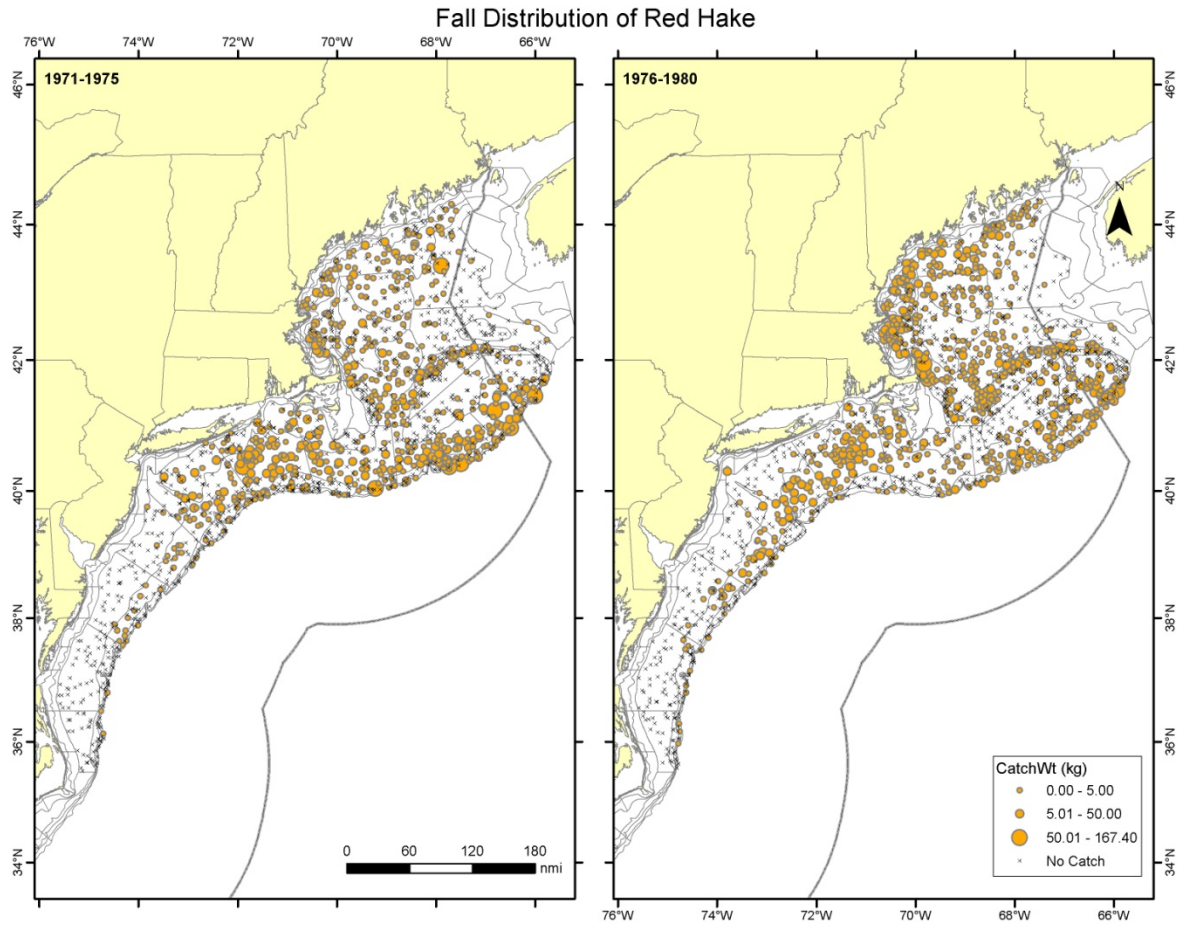


Figure C26. NEFSC distribution maps for red hake during the fall bottom trawl surveys, 1971-1980.

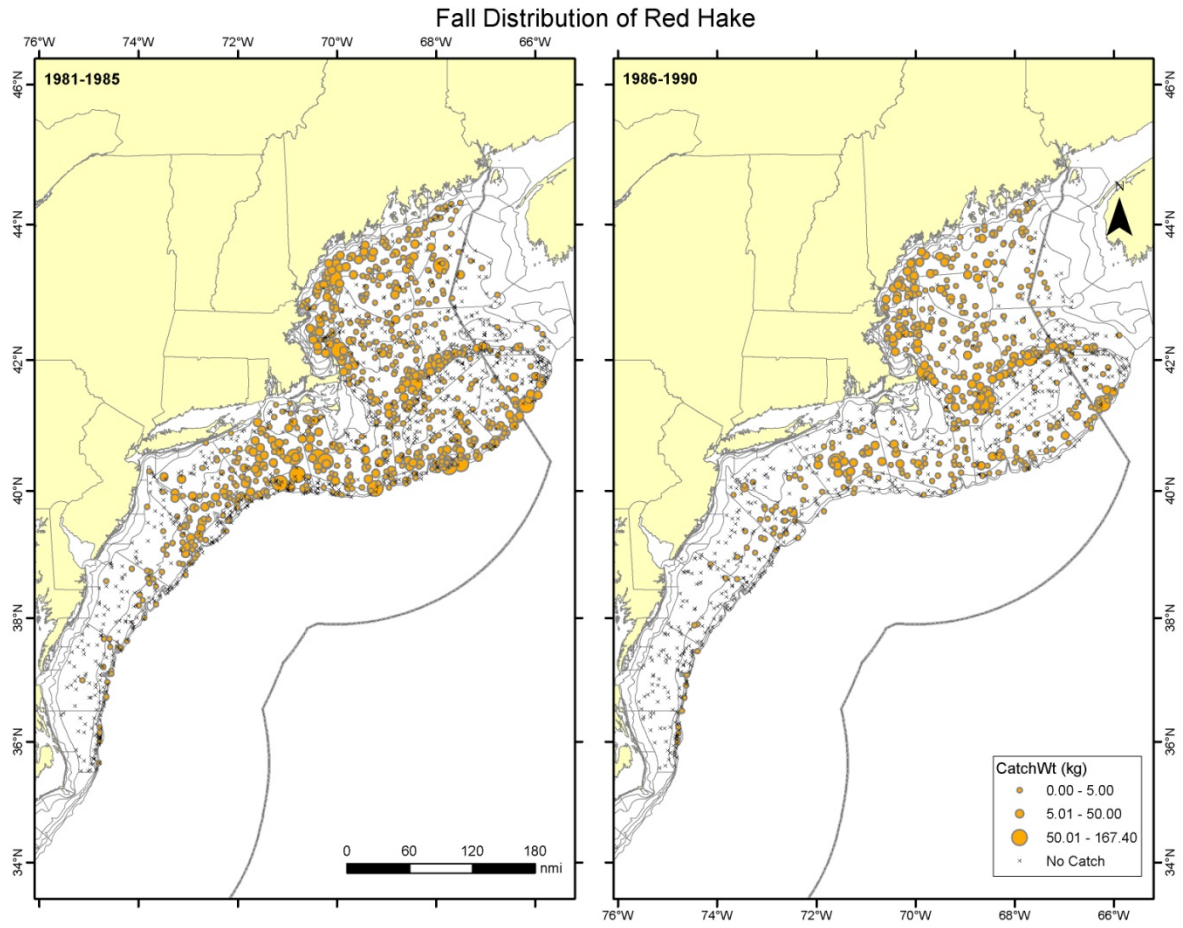


Figure C27. NEFSC distribution maps for red hake during the fall bottom trawl surveys, 1981-1990.

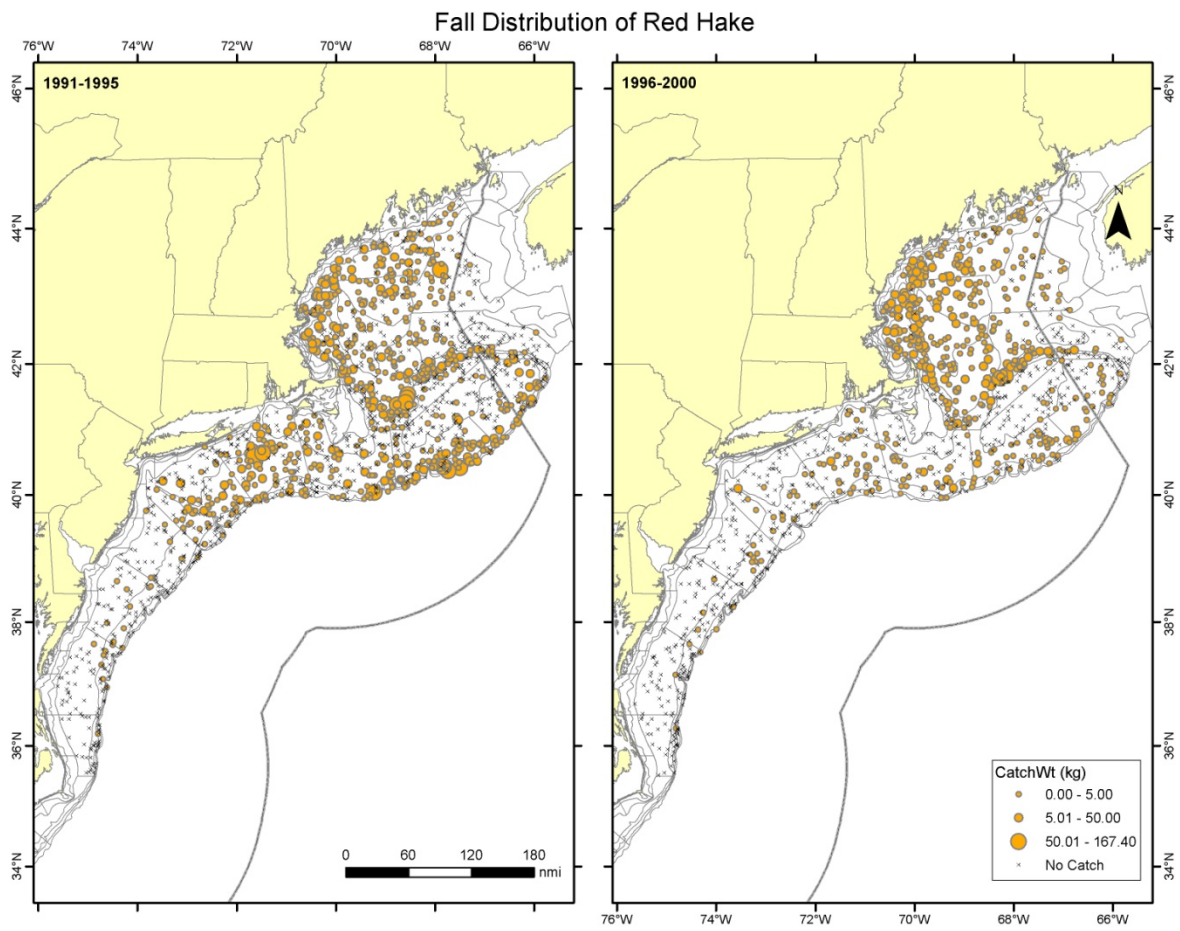


Figure C28. NEFSC distribution maps for red hake during the fall bottom trawl surveys, 1991-2000.

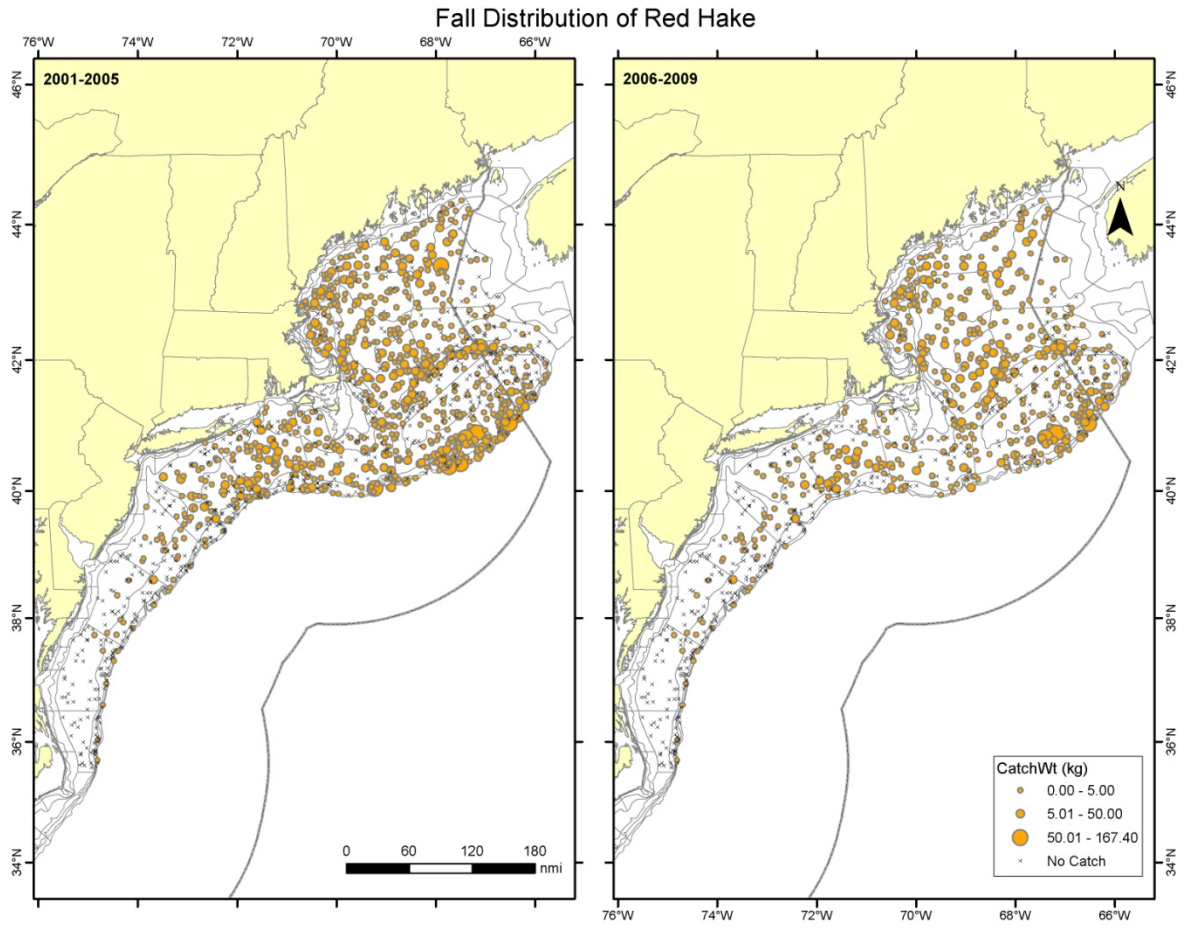


Figure C29. NEFSC distribution maps for red hake during the fall bottom trawl surveys, 2001-2009.

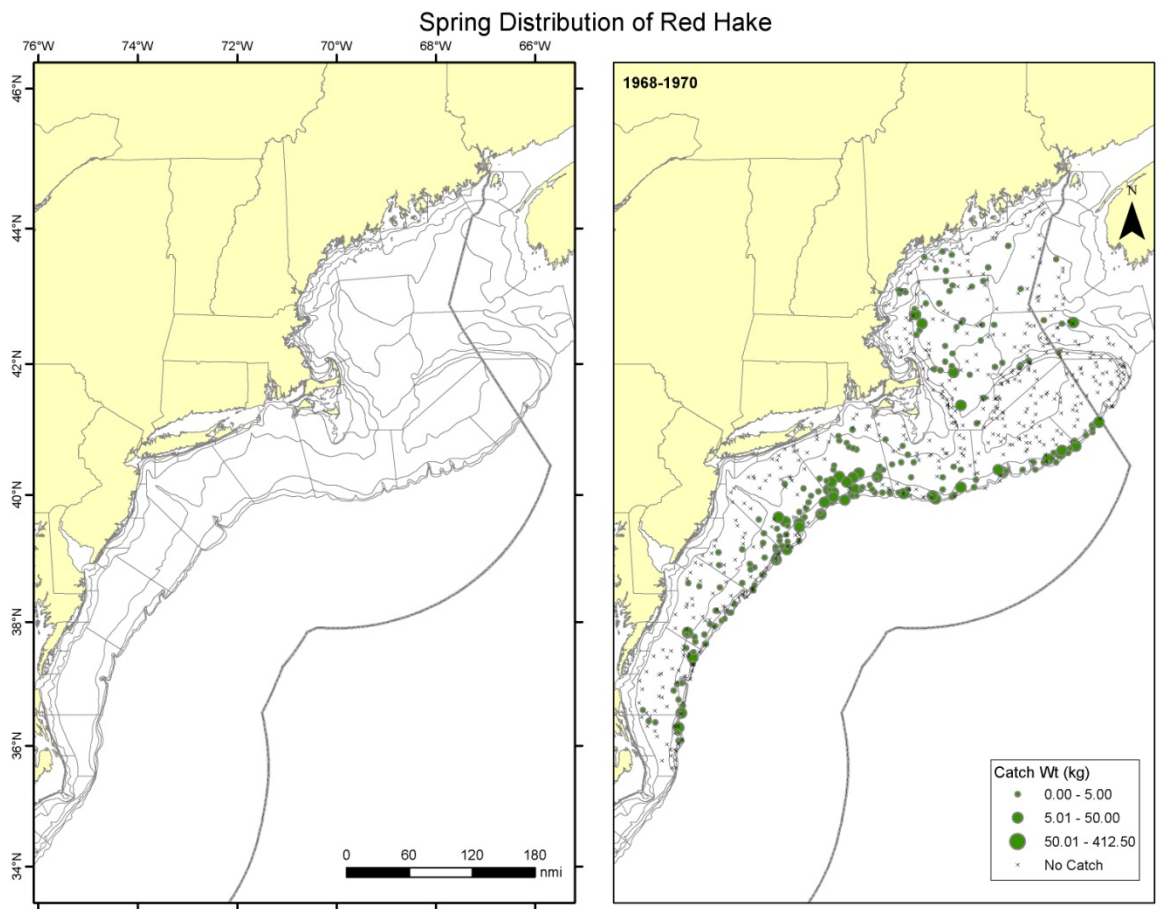


Figure C30. NEFSC distribution maps for red hake during the spring bottom trawl surveys, 1968-1970.

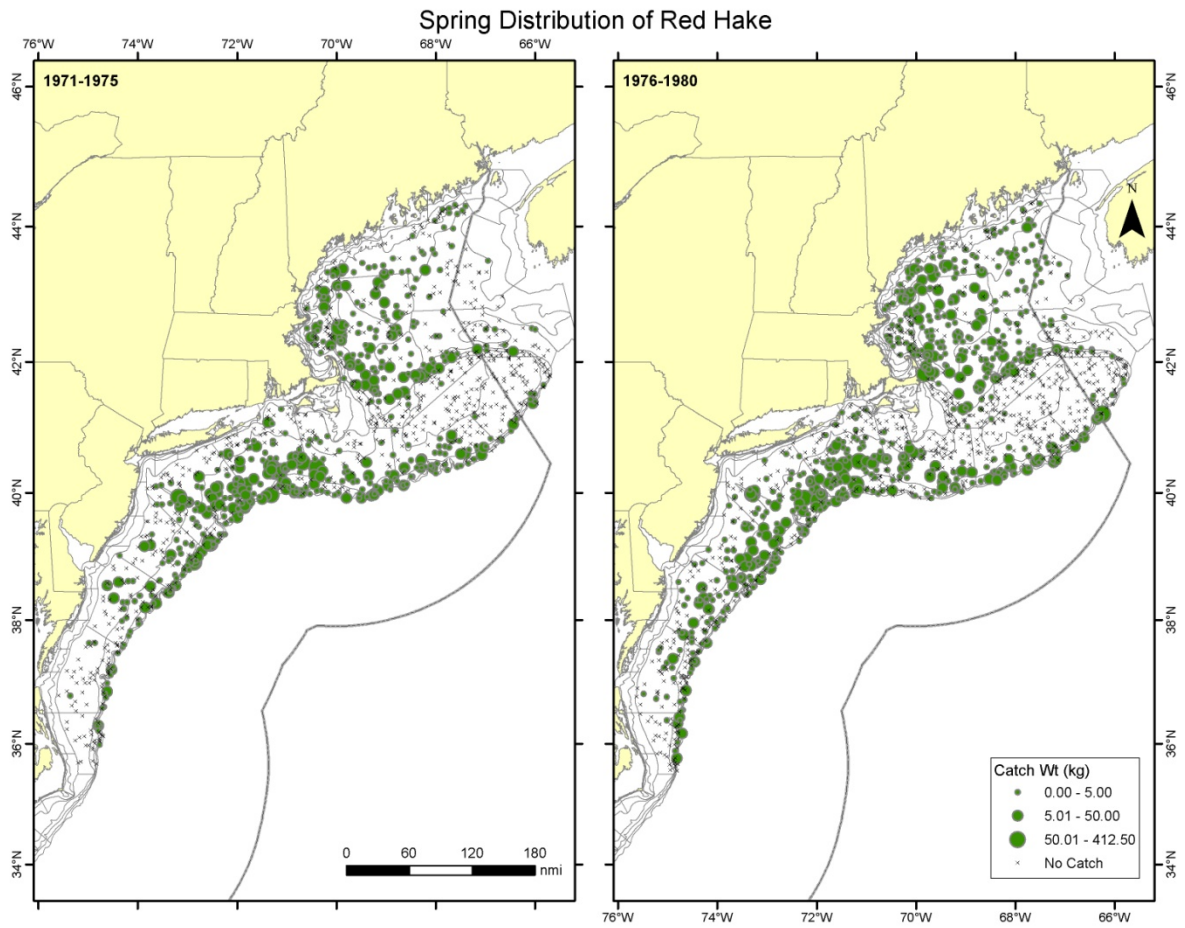


Figure C31. NEFSC distribution maps for red hake during the spring bottom trawl surveys, 1971-1980.

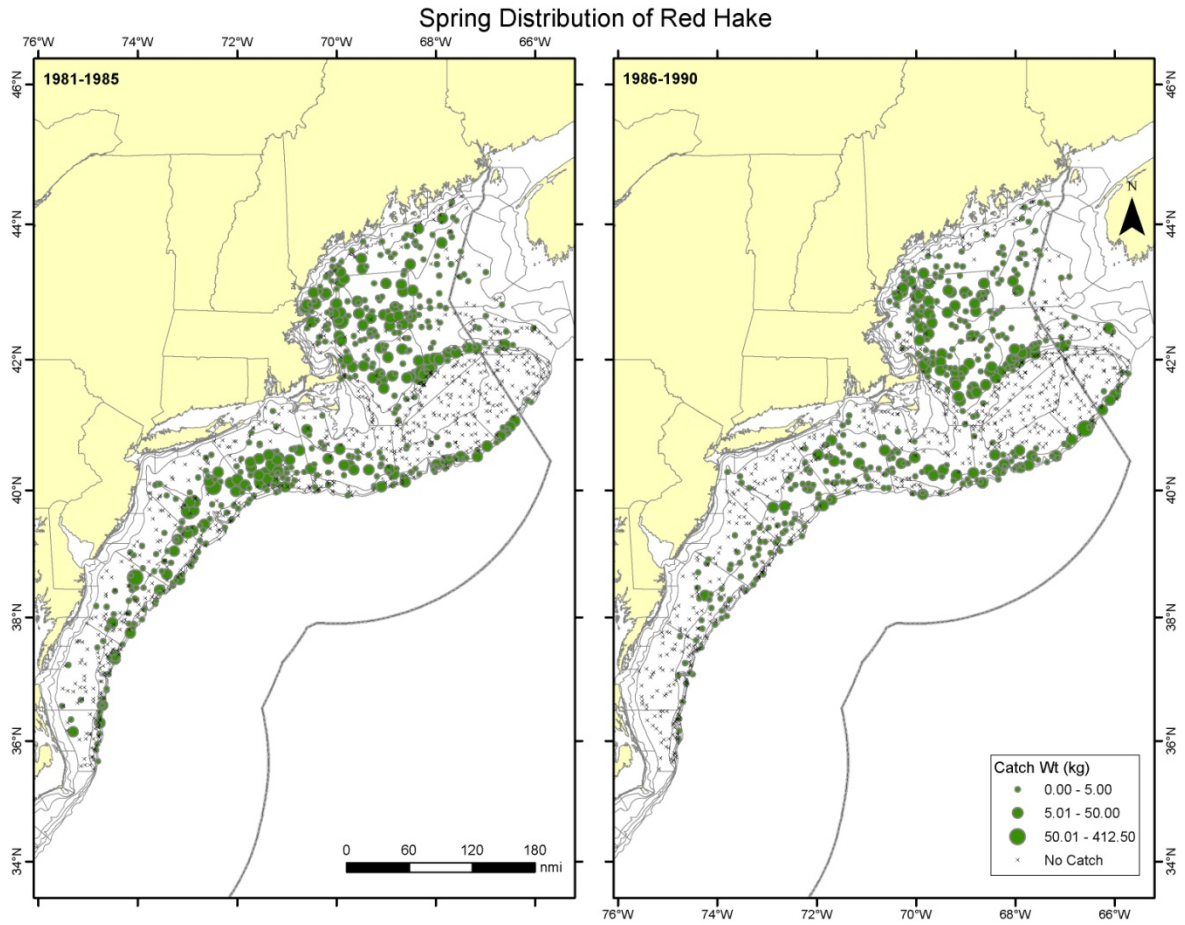


Figure C32. NEFSC distribution maps for red hake during the spring bottom trawl surveys, 1981-1990.

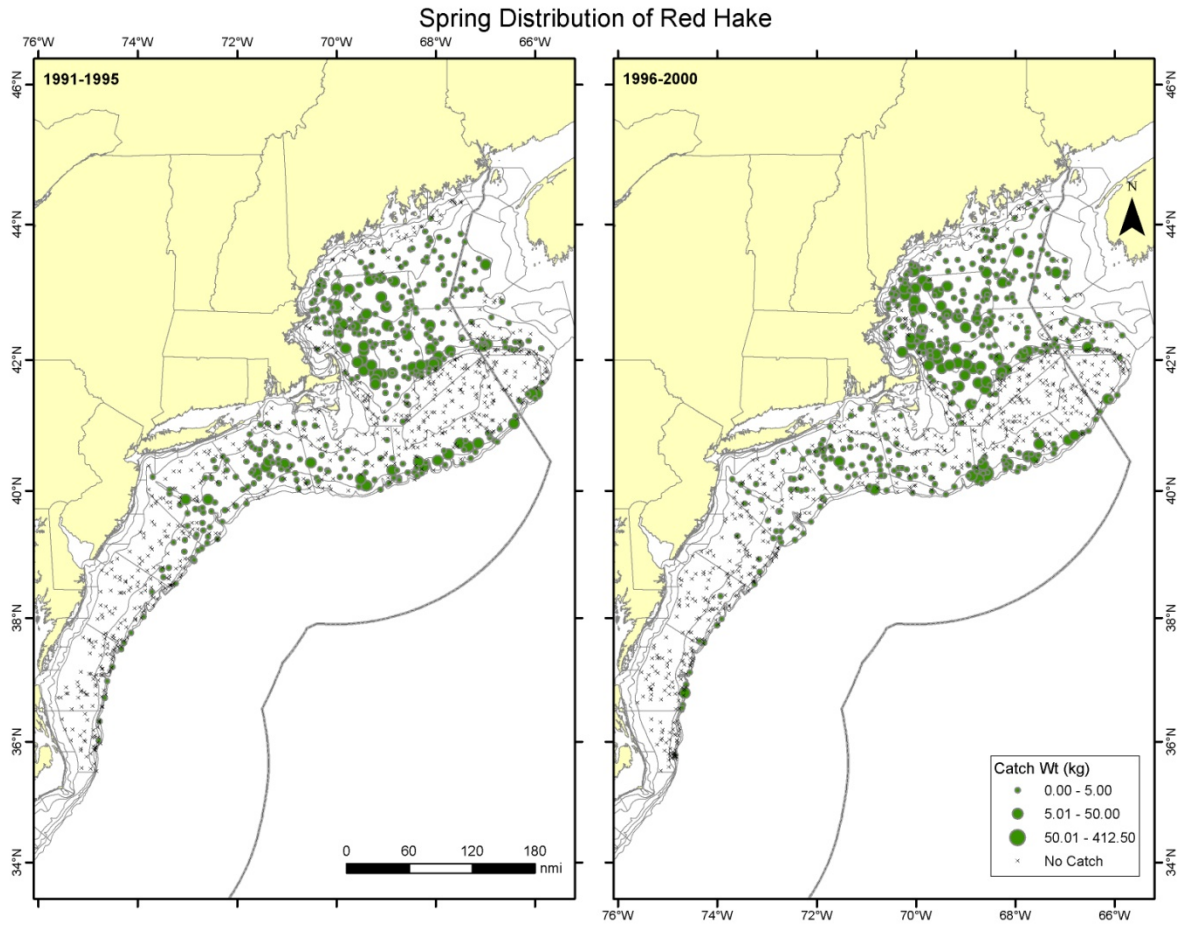


Figure C33. NEFSC distribution maps for red hake during the spring bottom trawl surveys, 1991-2000.

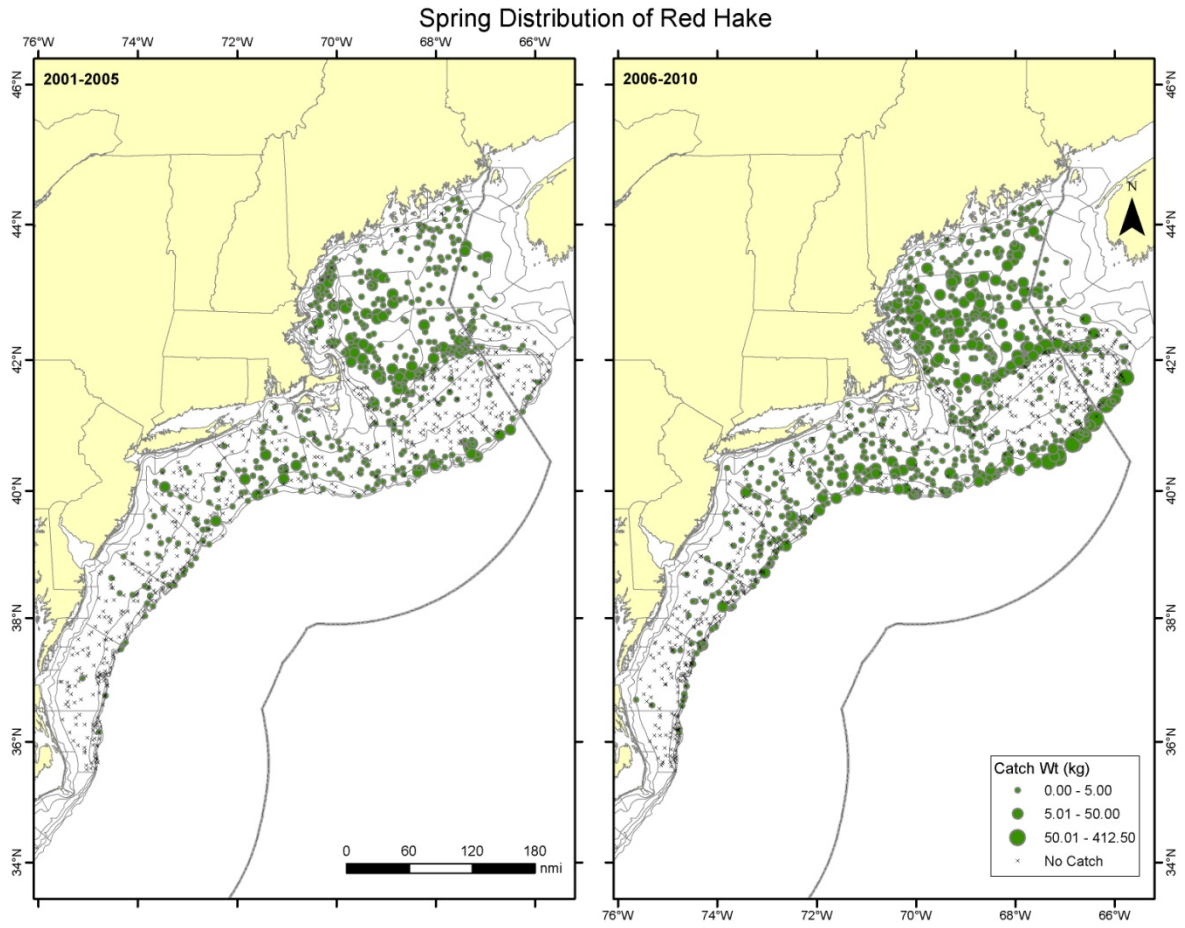


Figure C34. NEFSC distribution maps for red hake during the spring bottom trawl surveys, 2001-2010.

NORTH FALL

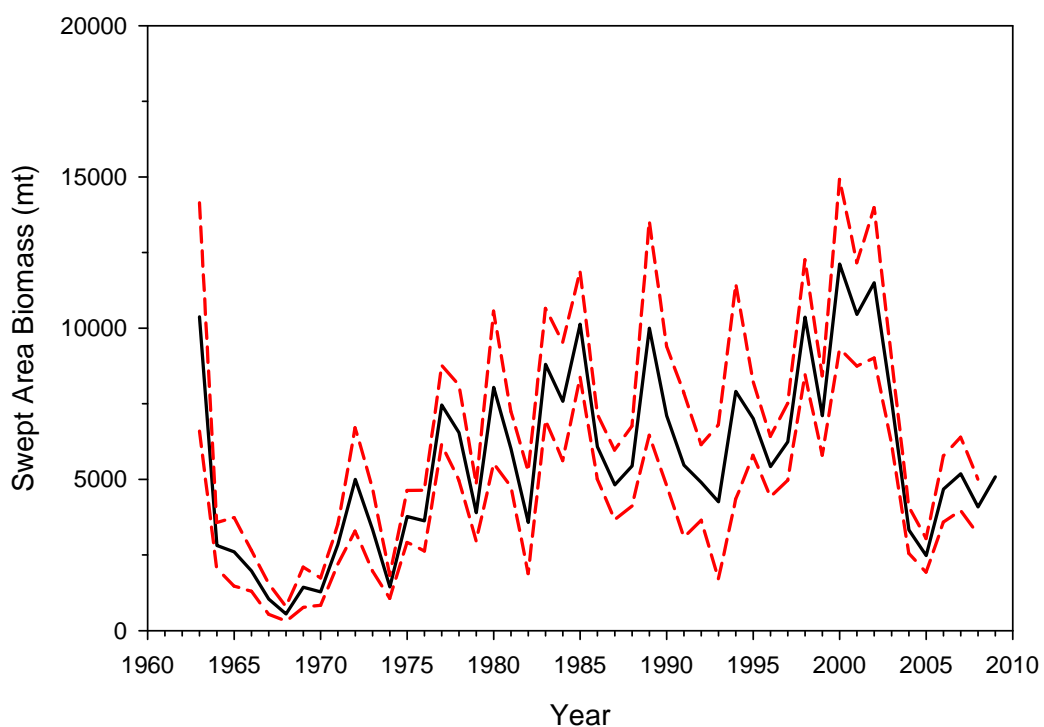
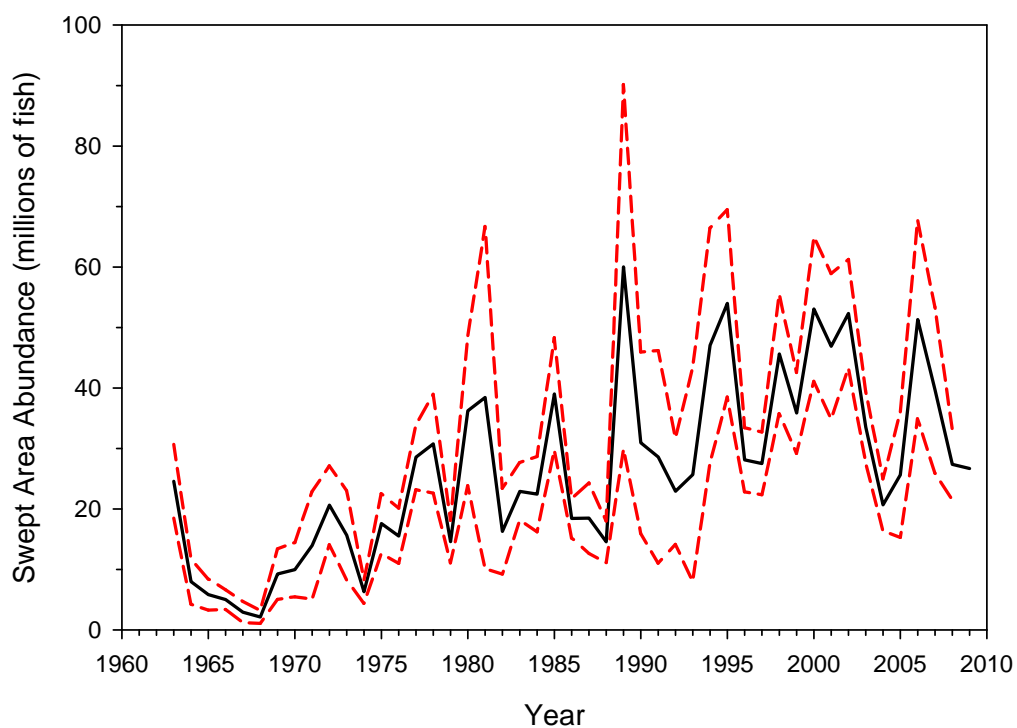


Figure C35. Swept area abundance (top) and biomass (bottom) with confidence intervals for the NEFSC fall survey in the northern management region. Estimates for 2009 were converted to Albatross units using the calibration factors at length in Table C34.

NORTH SPRING

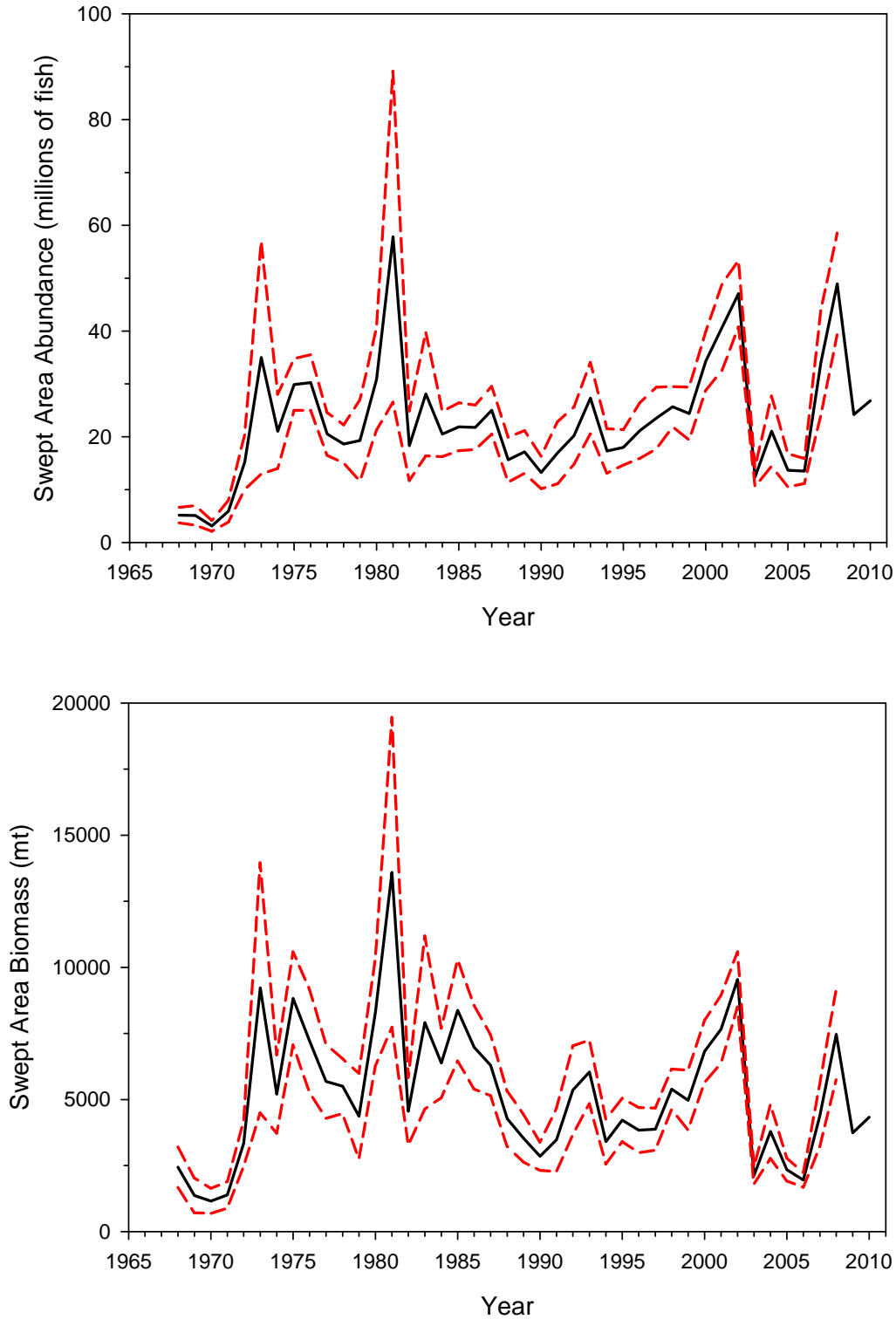


Figure C36. Swept area abundance (top) and biomass (bottom) with confidence intervals for the NEFSC spring survey in the northern management region. Estimates for 2009 and 2010 were converted to Albatross units using the calibration factors at length in Table C34.

SHRIMP NORTH

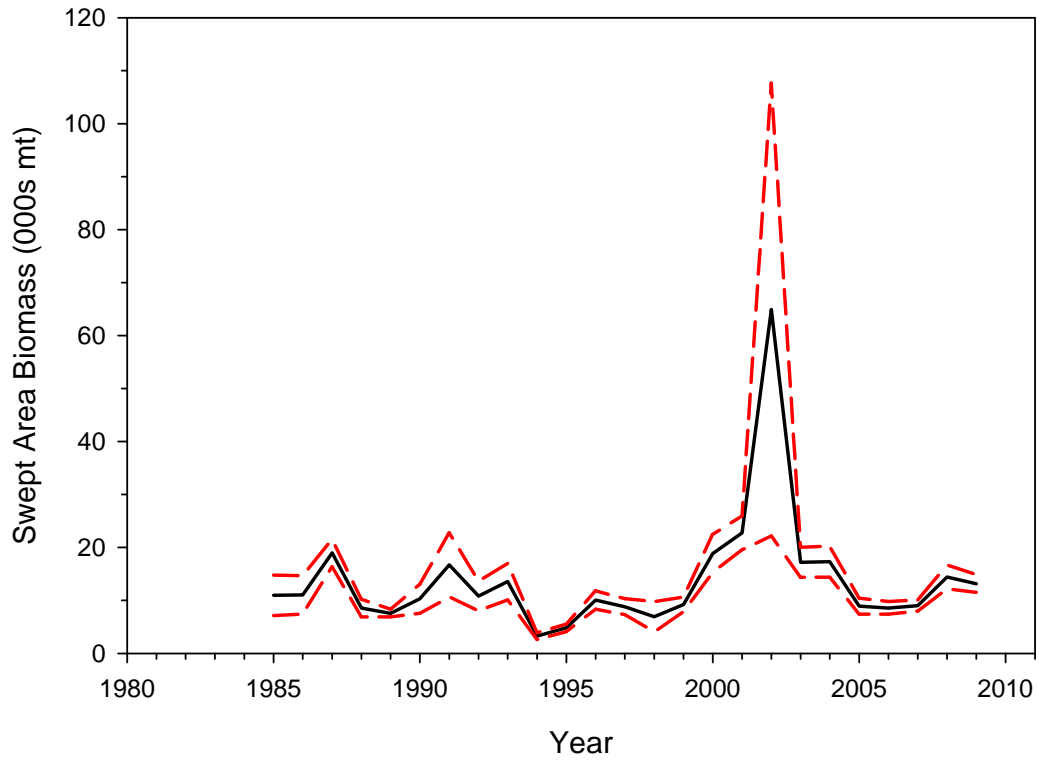
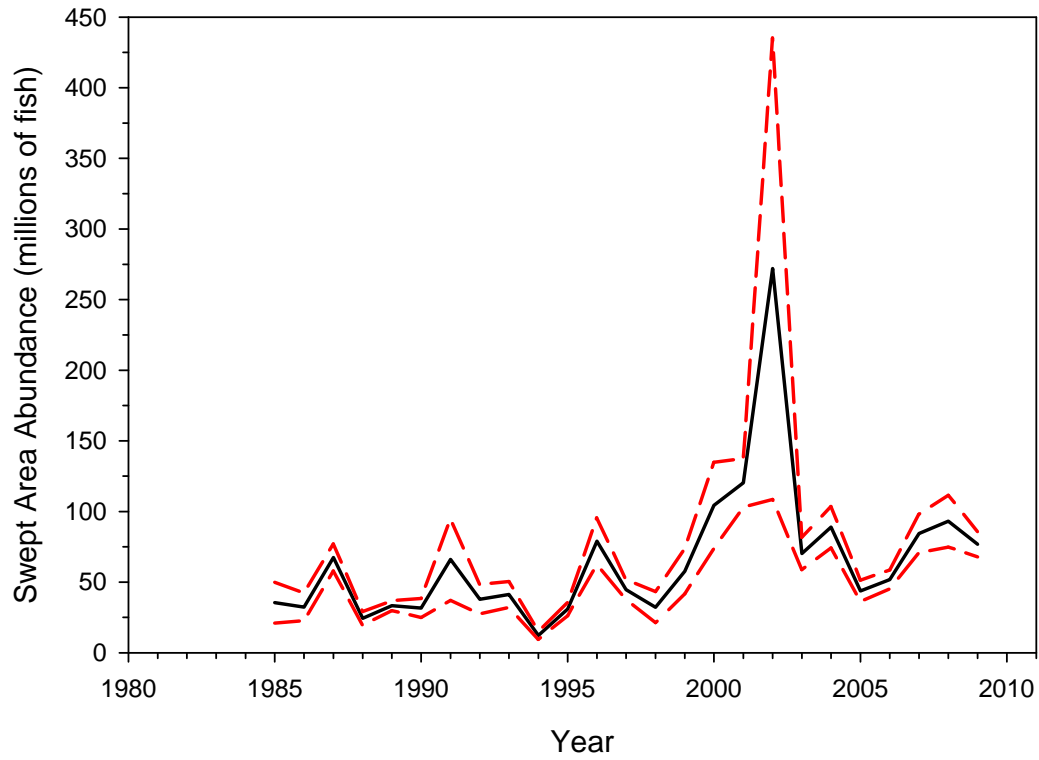


Figure C37. Swept area abundance (top) and biomass (bottom) with upper and lower confidence intervals for red hake from the NEFSC shrimp trawl surveys (strata 1-12).

MADMF NORTH FALL

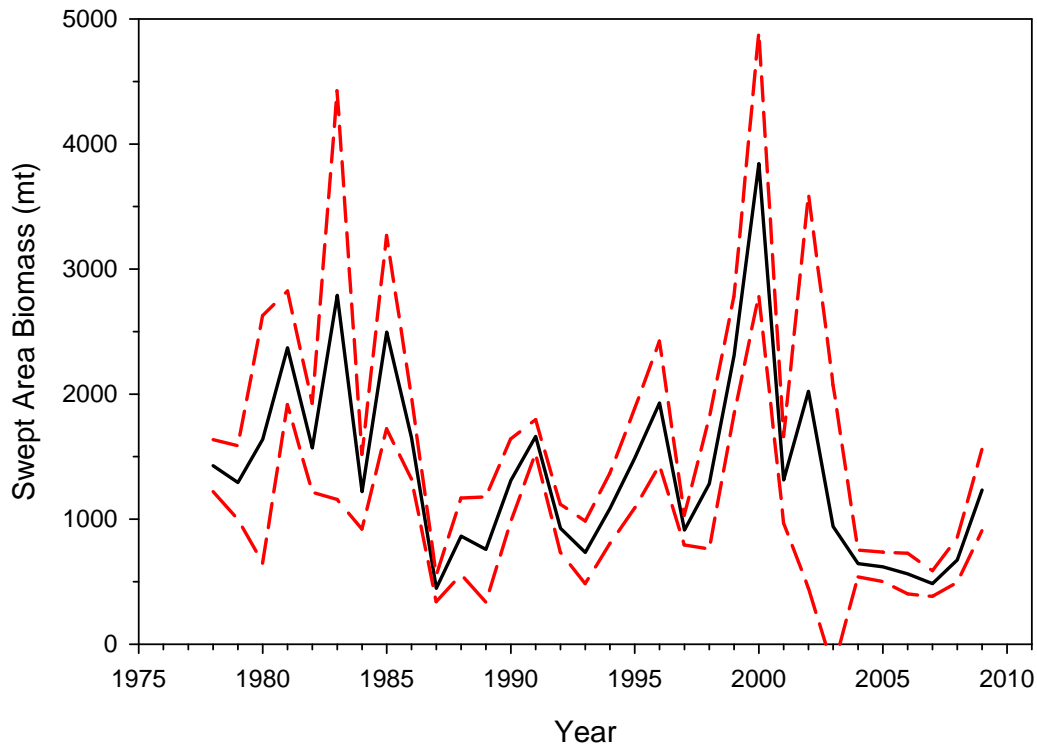
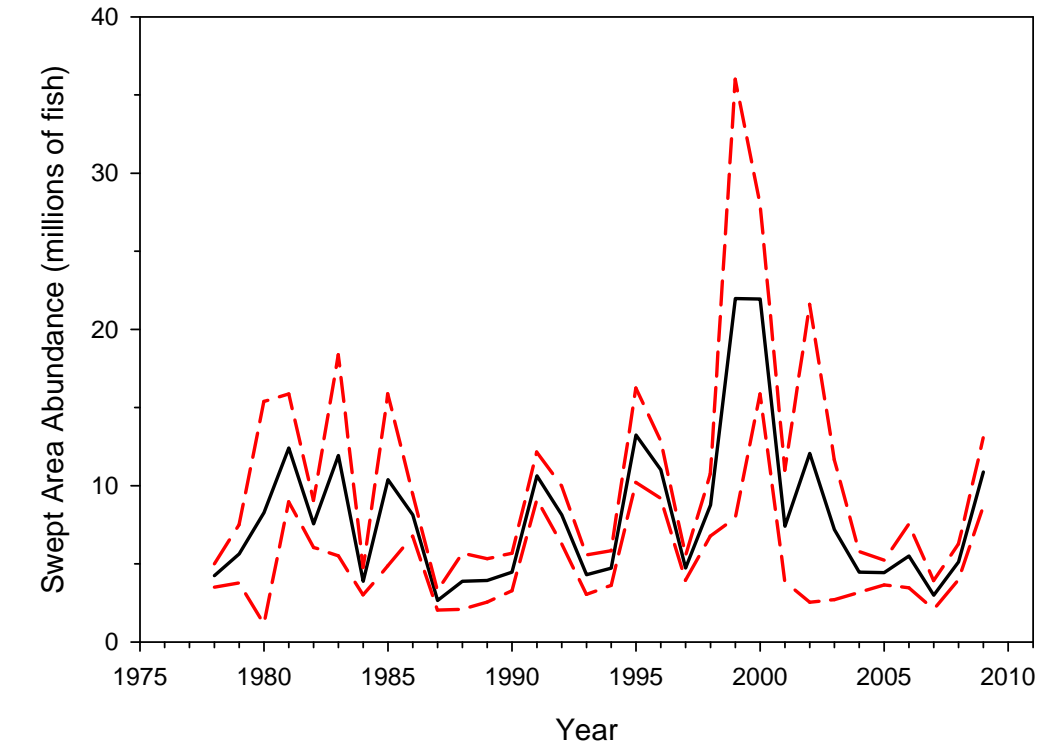


Figure C38. Swept area abundance (top) and biomass (bottom) with upper and lower confidence intervals for red hake from Massachusetts Division of Marine Fisheries fall north survey (strata 18-36).

MADMF NORTH SPRING

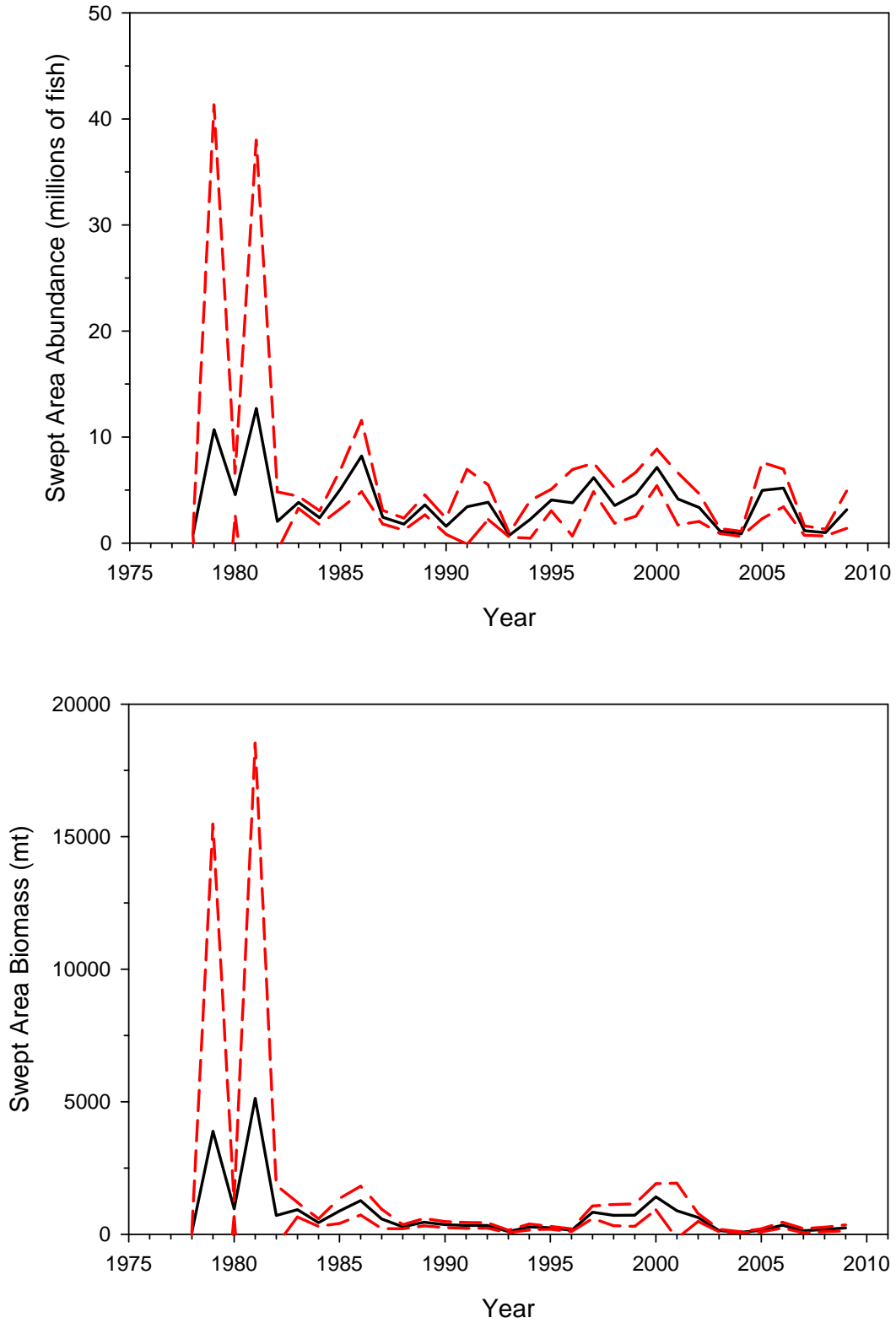


Figure C39. Swept area abundance (top) and biomass (bottom) with upper and lower confidence intervals for red hake from Massachusetts Division of Marine Fisheries spring north survey (strata 18-36).

NORTH FALL

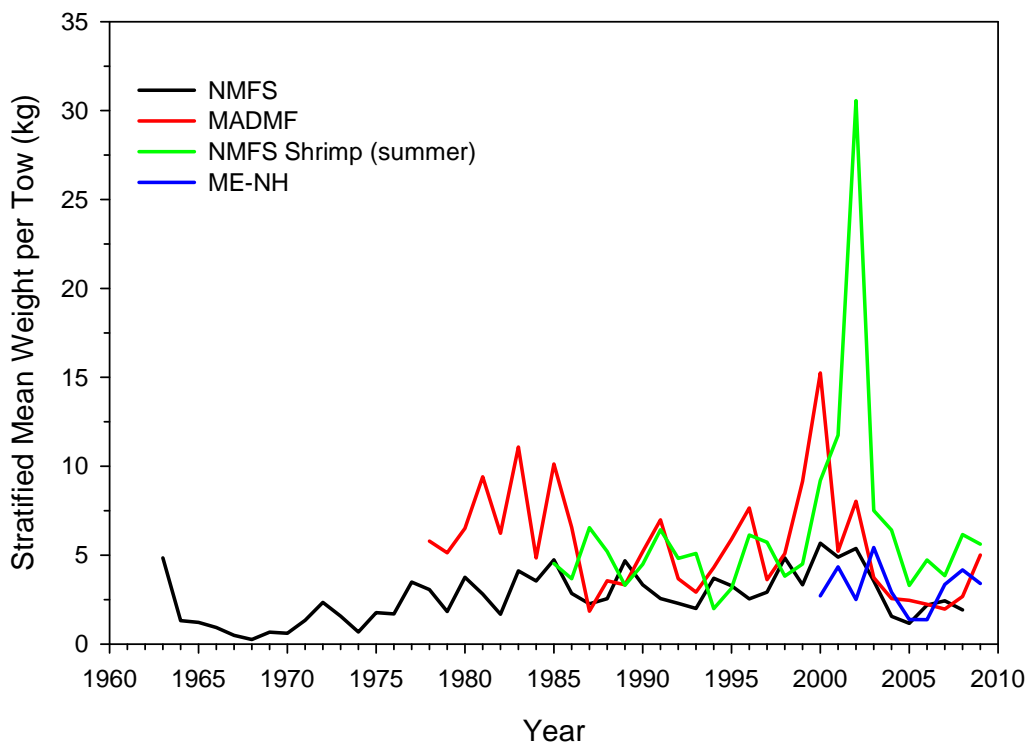
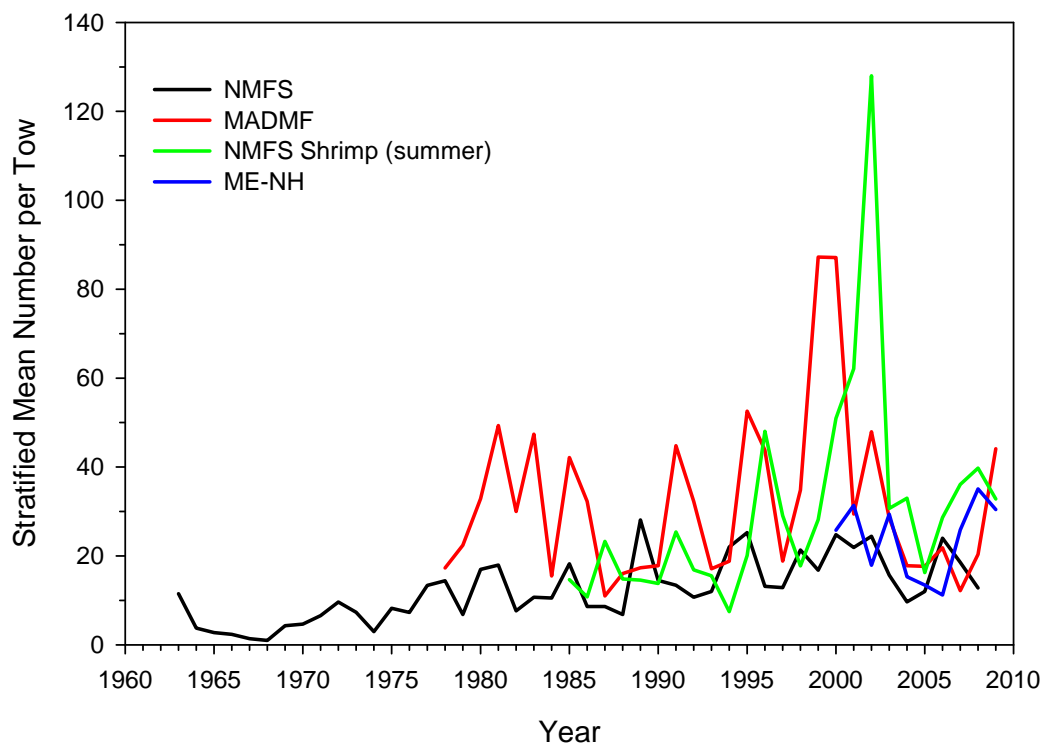


Figure C40. Stratified mean number and weight per tow (kg) for red hake from the all the fall north surveys: NEFSC, MADMF, shrimp and Maine-New Hampshire state surveys.

NORTH SPRING

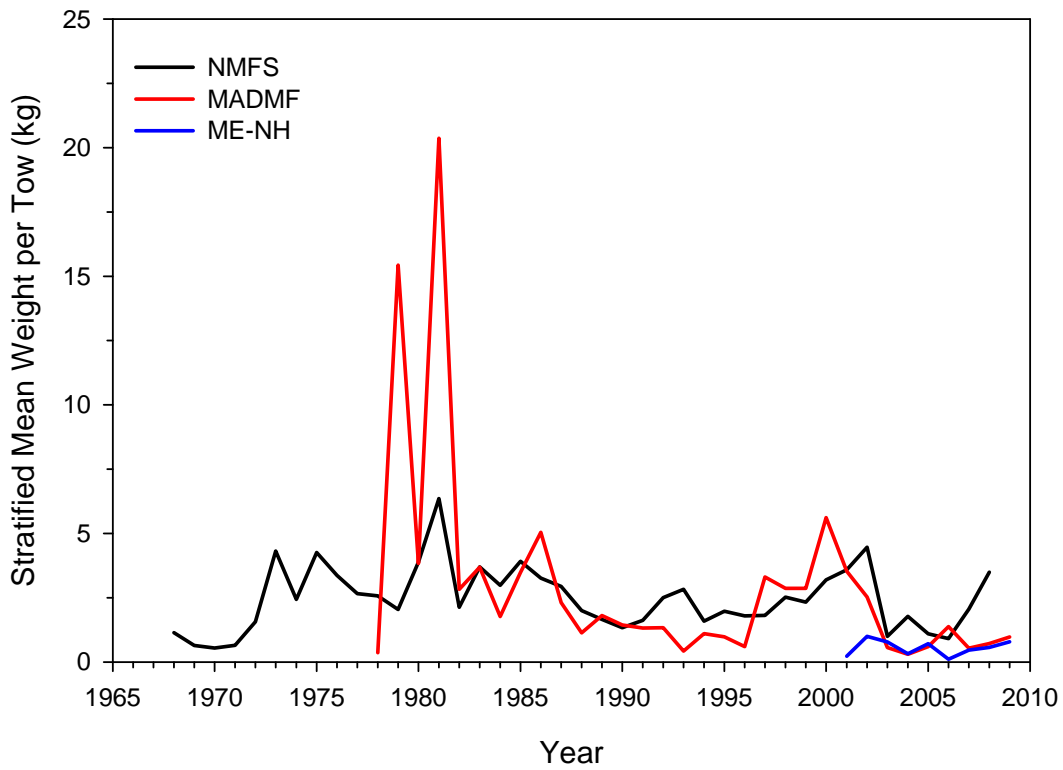
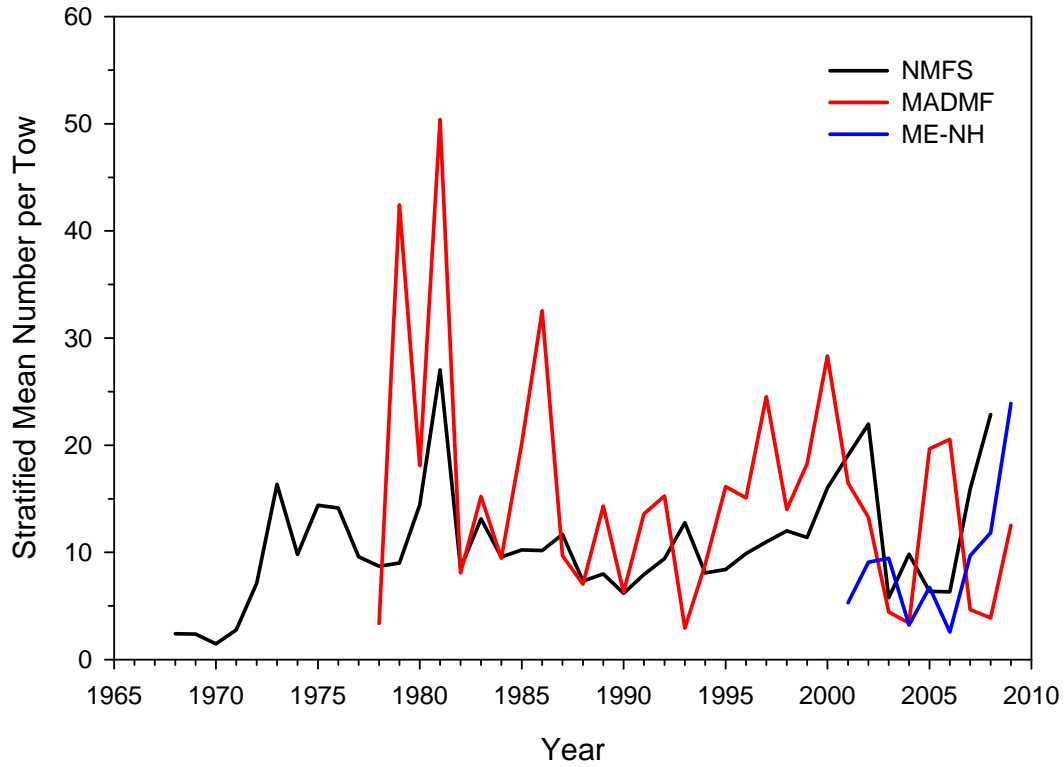


Figure C41. Stratified mean number and weight per tow (kg) for red hake from the all the spring north surveys: NEFSC, MADMF, and Maine-New Hampshire state surveys.

SOUTH FALL

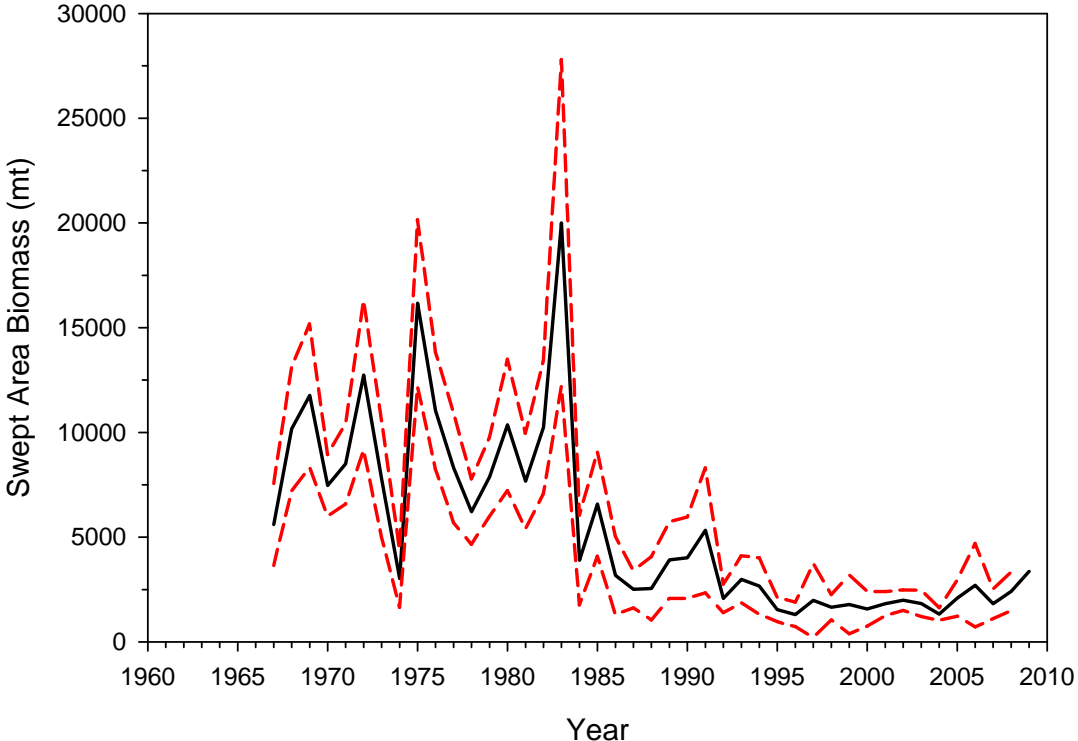
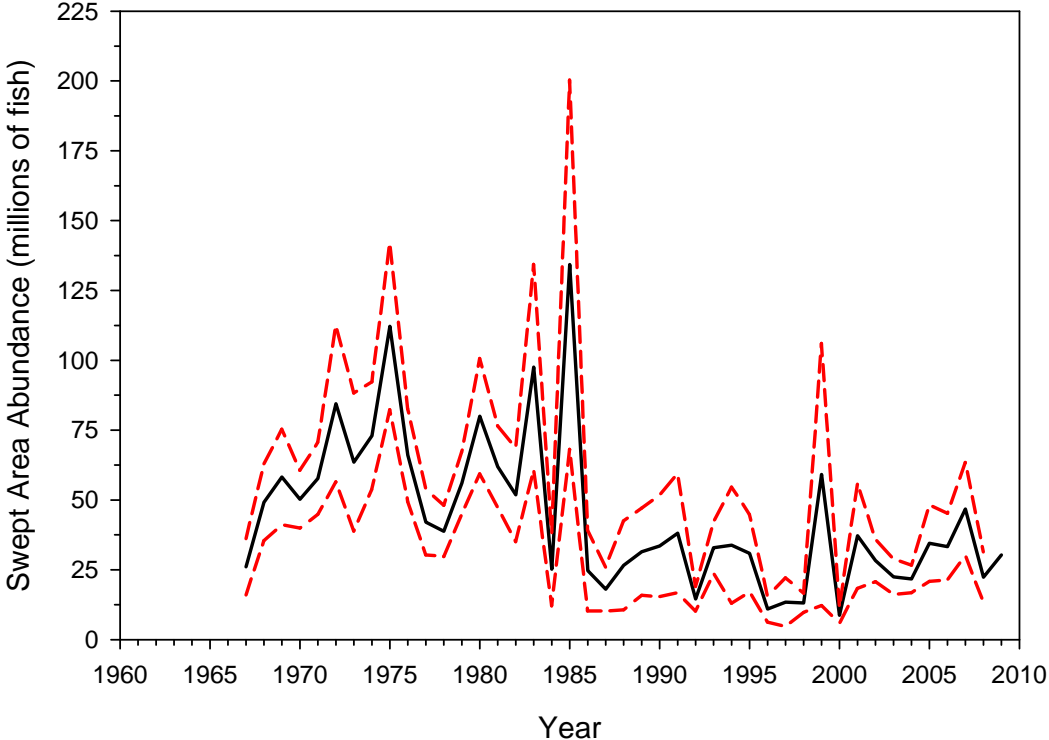


Figure C42. Swept area abundance (top) and biomass (bottom) with confidence intervals for the NEFSC fall survey in the southern management region. Estimates for 2009 were converted to Albatross units using the calibration factors at length in Table C34.

SOUTH SPRING

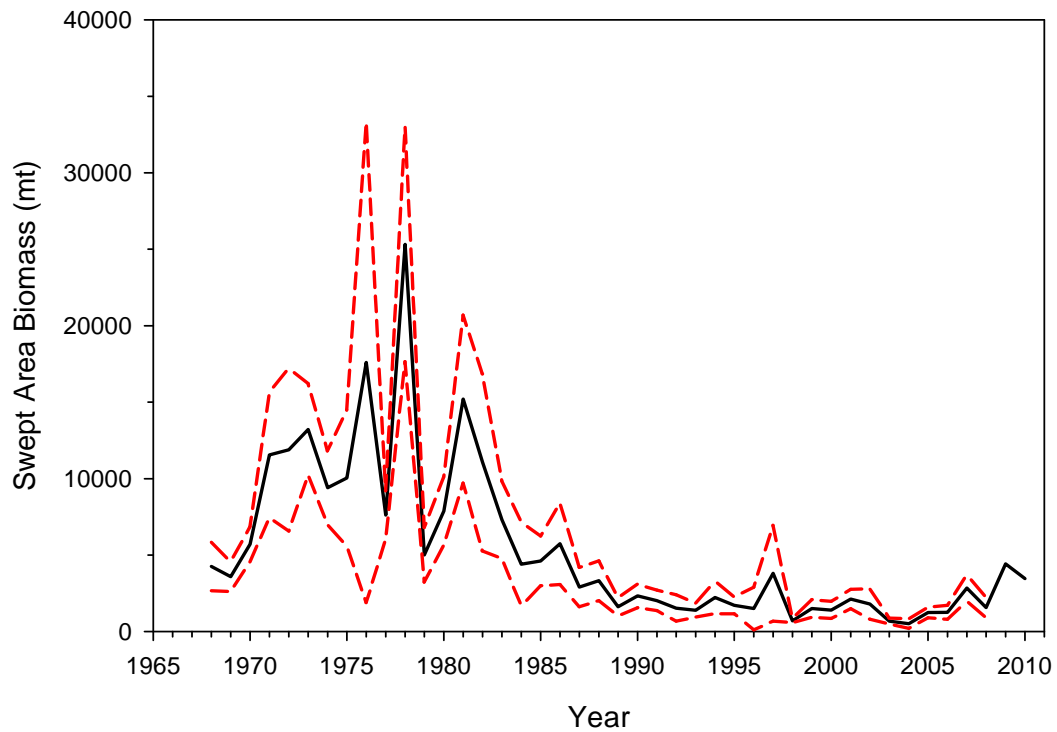
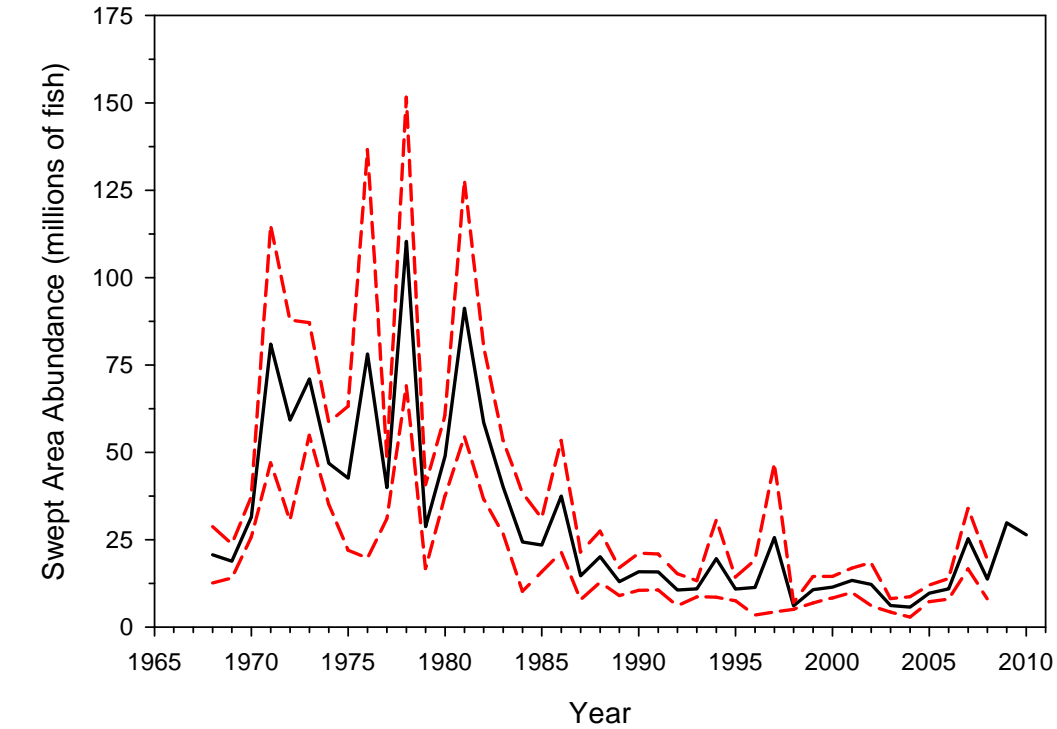


Figure C43. Swept area abundance (top) and biomass (bottom) with confidence intervals for the NEFSC spring survey in the southern management region. Estimates for 2009 and 2010 were converted to Albatross units using the calibration factors at length in Table C34.

RED WINTER SOUTH

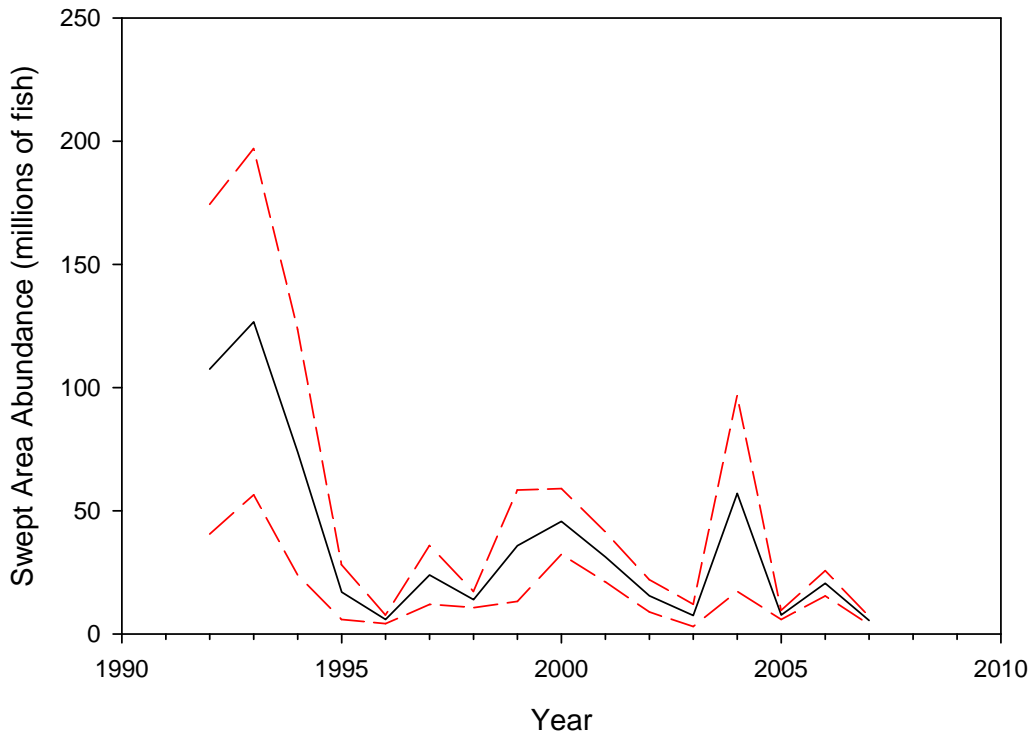


Figure C44. Swept area abundance and biomass and upper and lower confidence intervals for red hake from the NEFSC winter flatfish surveys in the southern management region (strata 1-3, 5-7, 9-11, 13-14, 61-63, 65-67, 69-71, 73-75).

SILVER FALL SOUTH MADMF

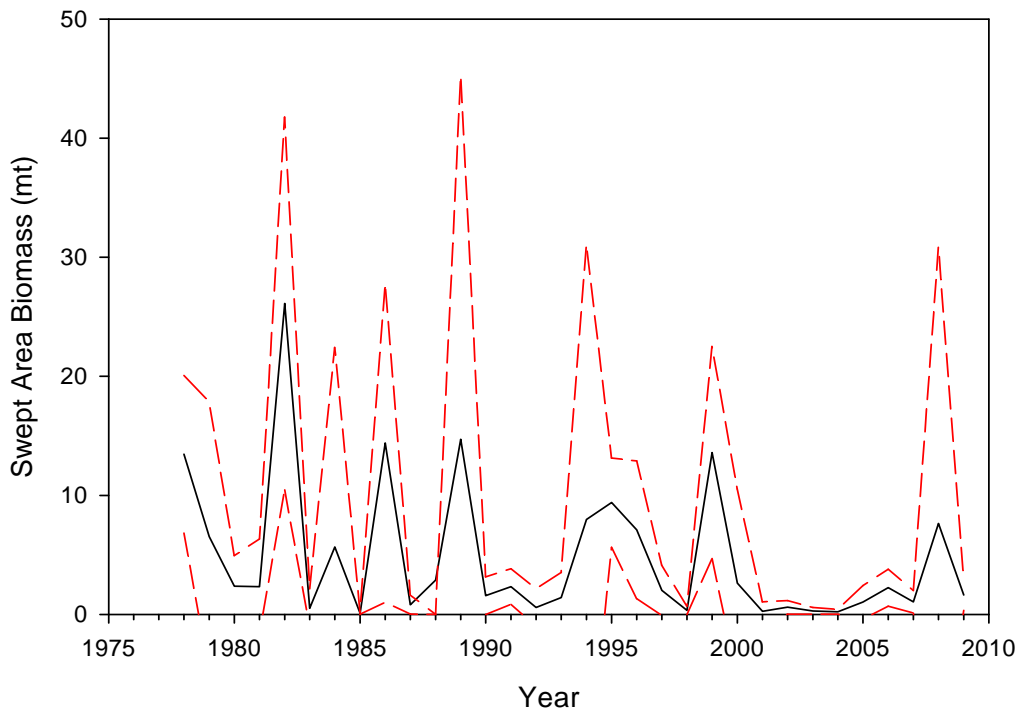
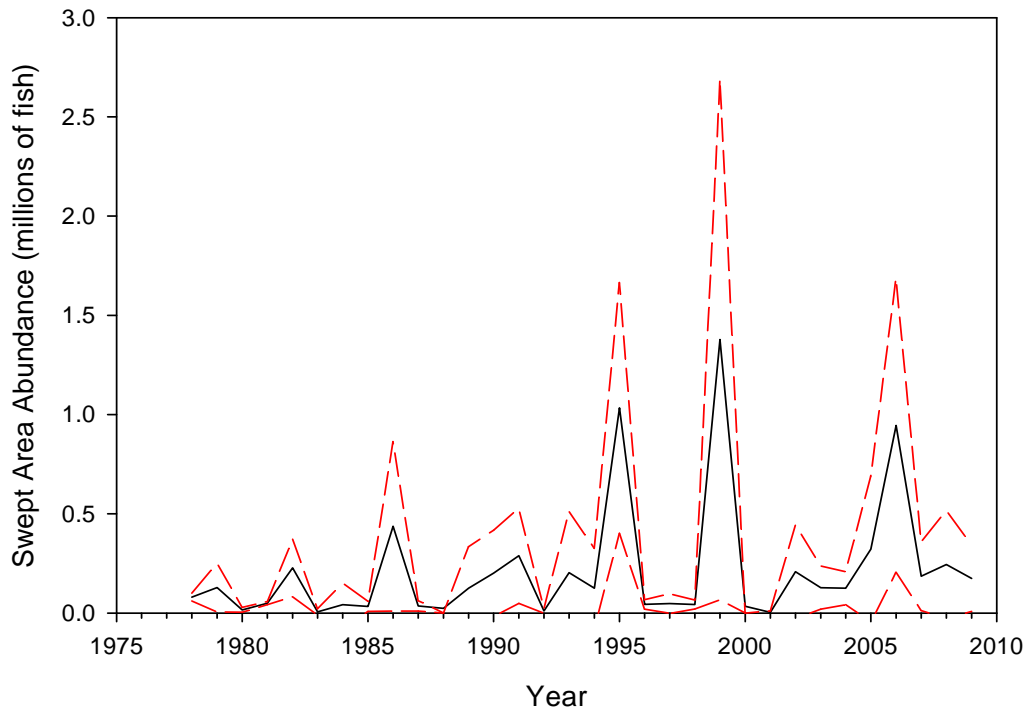


Figure C45. Swept area abundance (top) and biomass (bottom) with upper and lower confidence intervals for red hake from Massachusetts Division of Marine Fisheries fall south survey (strata 11-17).

SILVER SPRING SOUTH MADMF

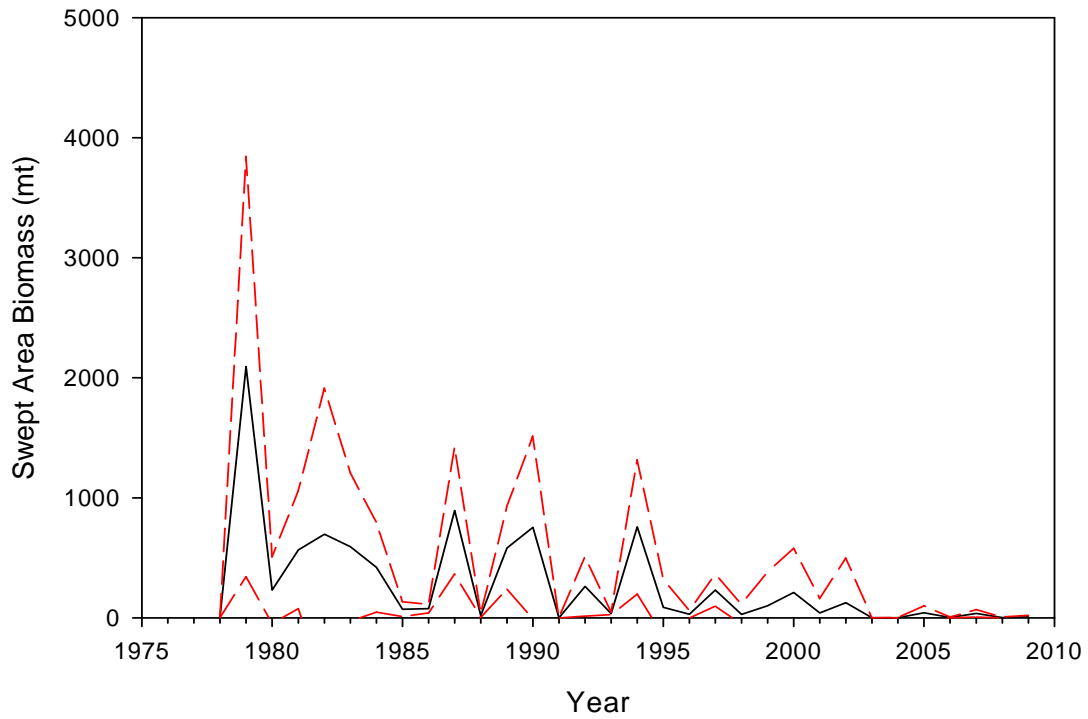
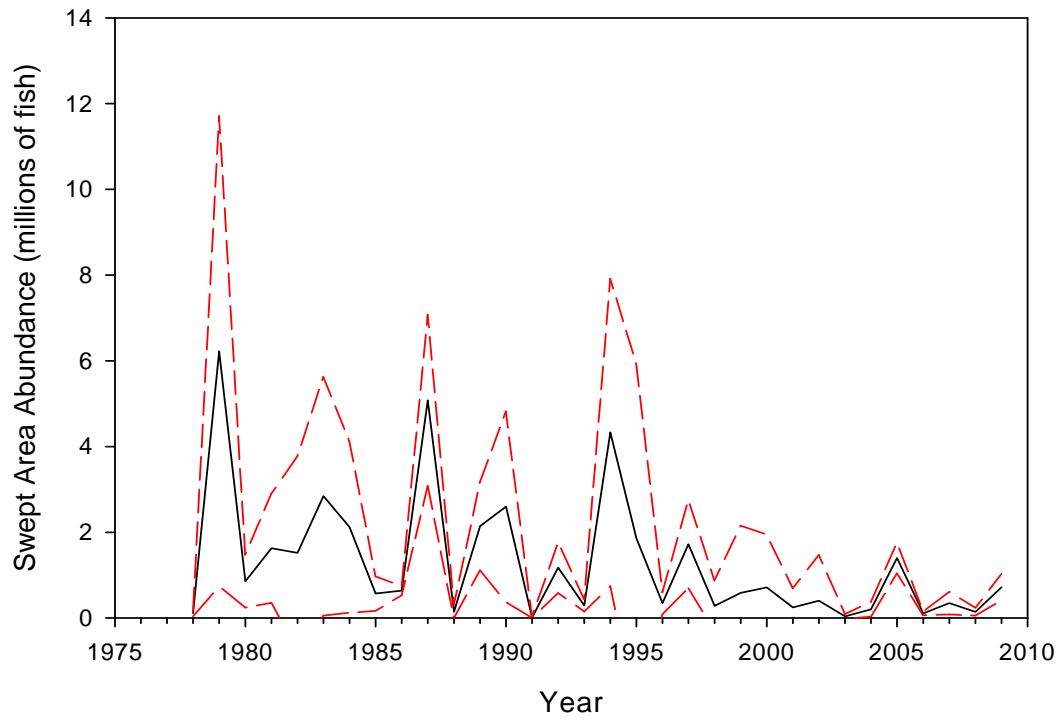


Figure C46. Swept area abundance (top) and biomass (bottom) with upper and lower confidence intervals for red hake from Massachusetts Division of Marine Fisheries spring south survey (strata 11-17).

SOUTH FALL

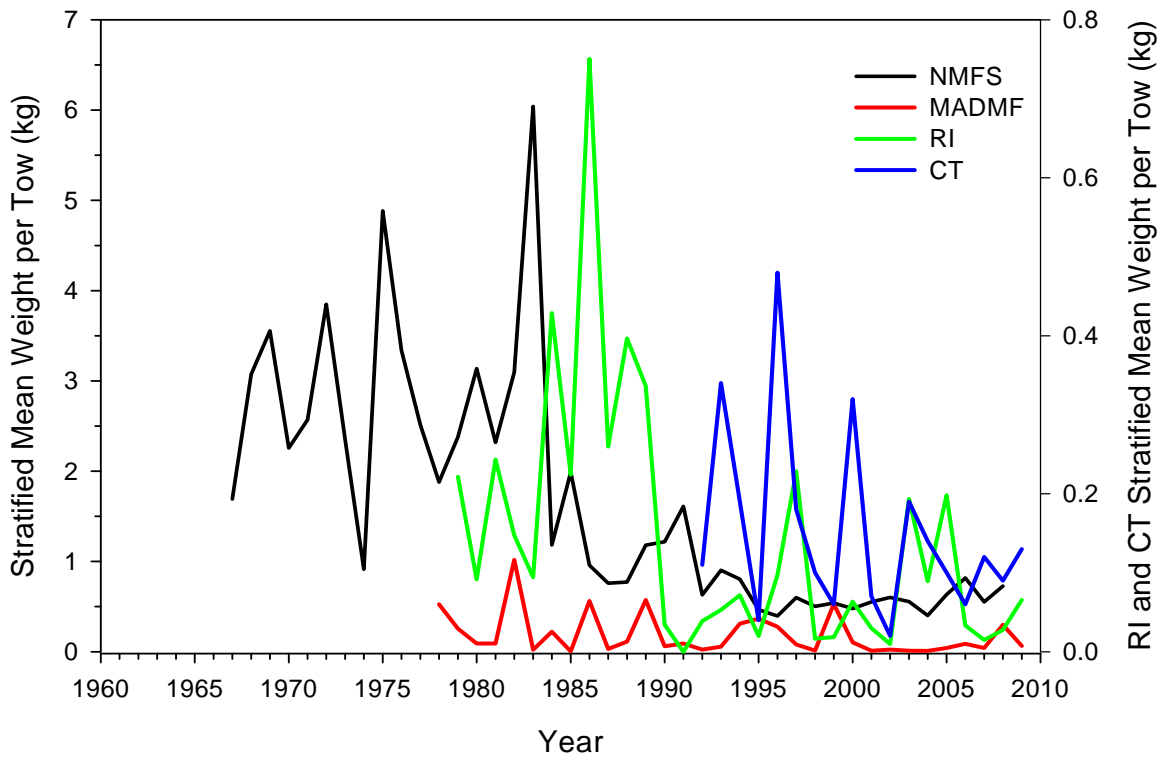
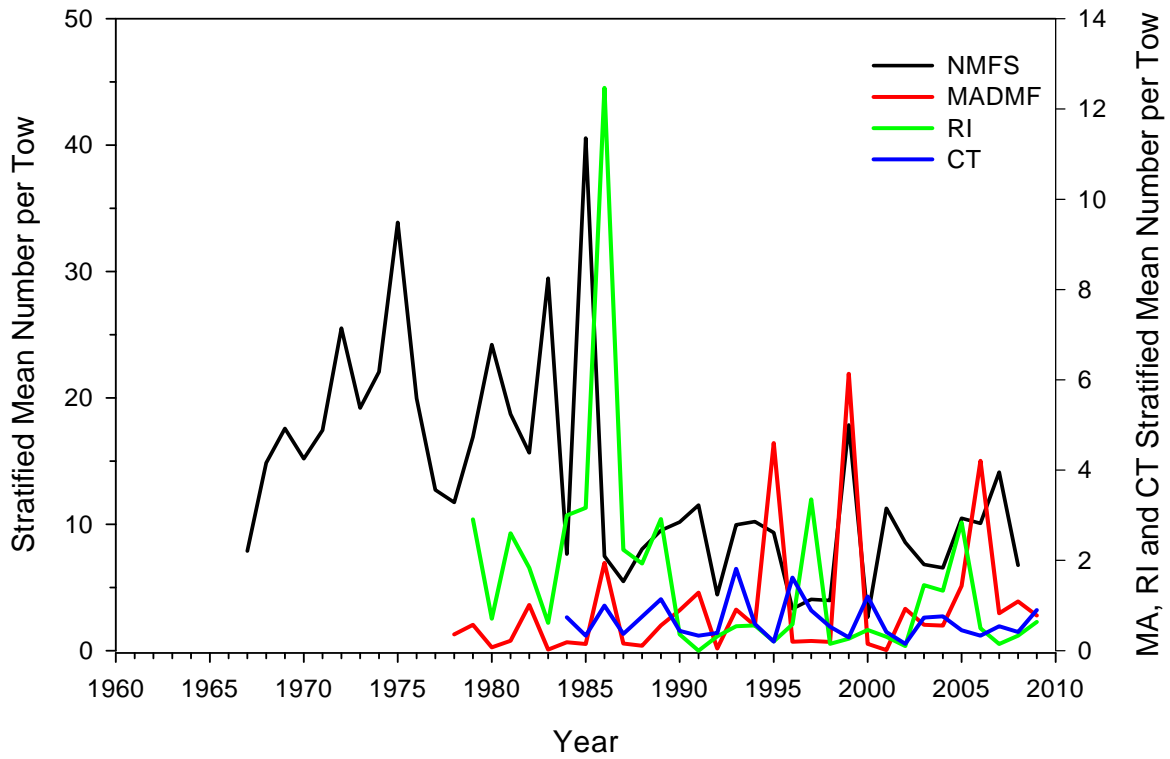


Figure C47. Stratified mean number and weight (kg) per tow for red hake from all the fall surveys in the southern management area: NEFSC, MADMF, RI and CT.

SOUTH SPRING/WINTER

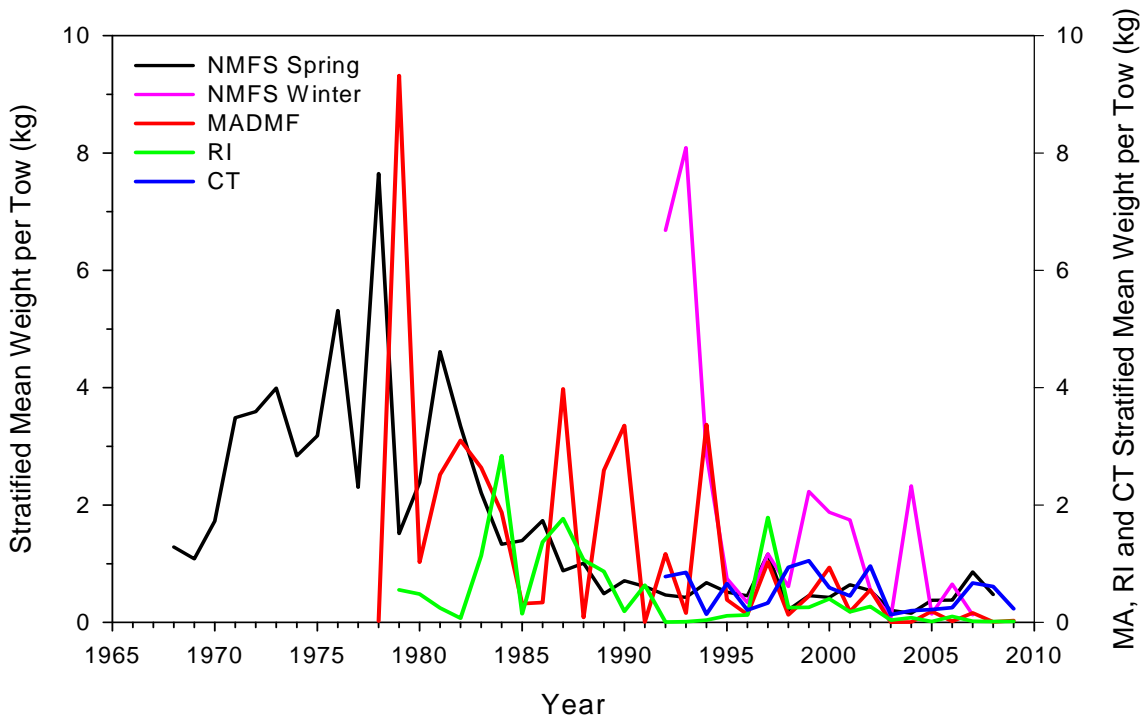
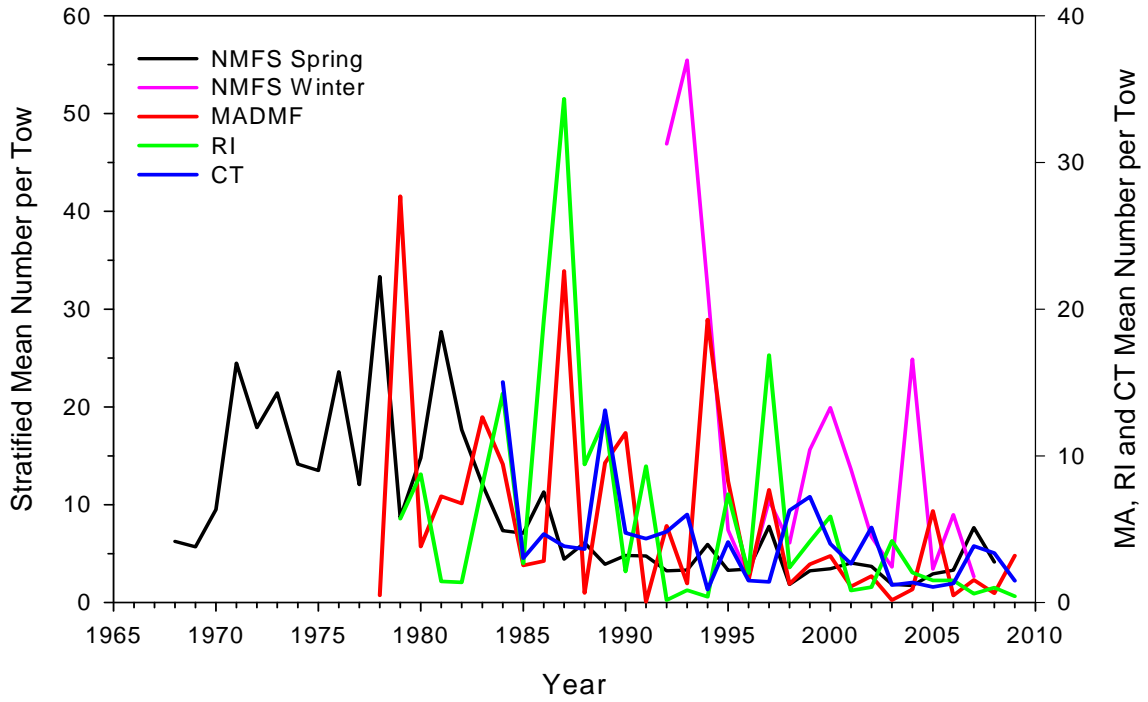


Figure C48. Stratified mean number and weight (kg) per tow for red hake from all the spring surveys in the southern management area: NEFSC, MADMF, RI and CT.

COMBINED FALL

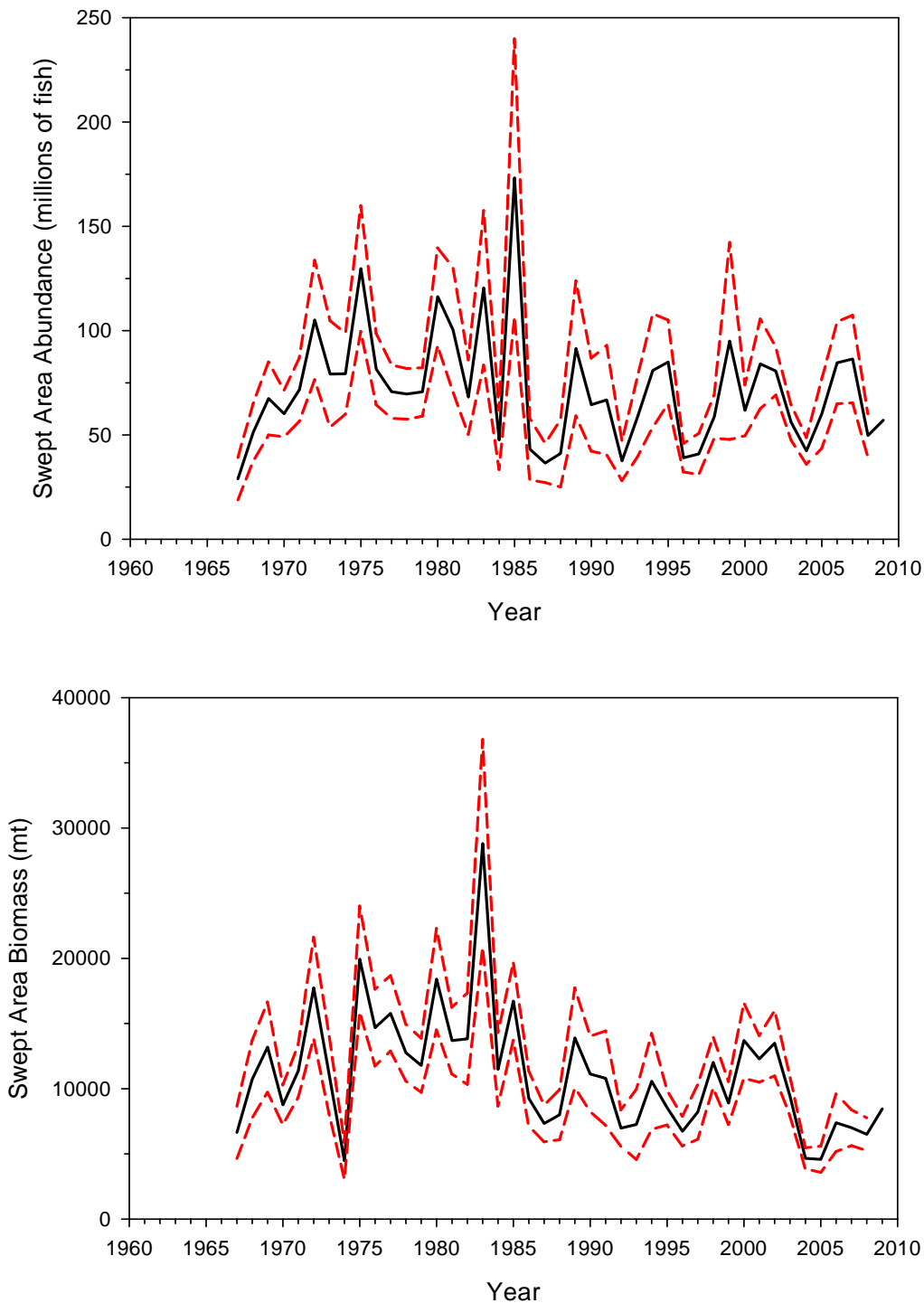


Figure C49. Swept area abundance (top) and biomass (bottom) with upper and lower confidence intervals for red hake from the NEFSC fall bottom trawl surveys in the northern and southern management regions combined (strata 1-30, 36-40, 61-76). Estimates for 2009 were converted to Albatross units using the calibration factors at length in Table C34.

COMBINED SPRING

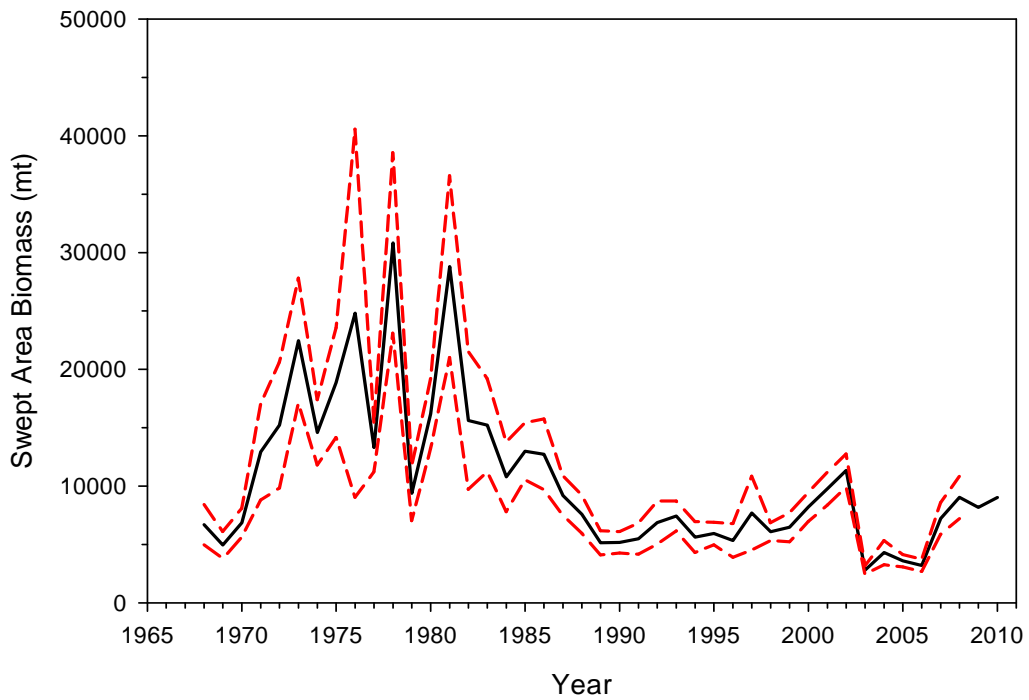
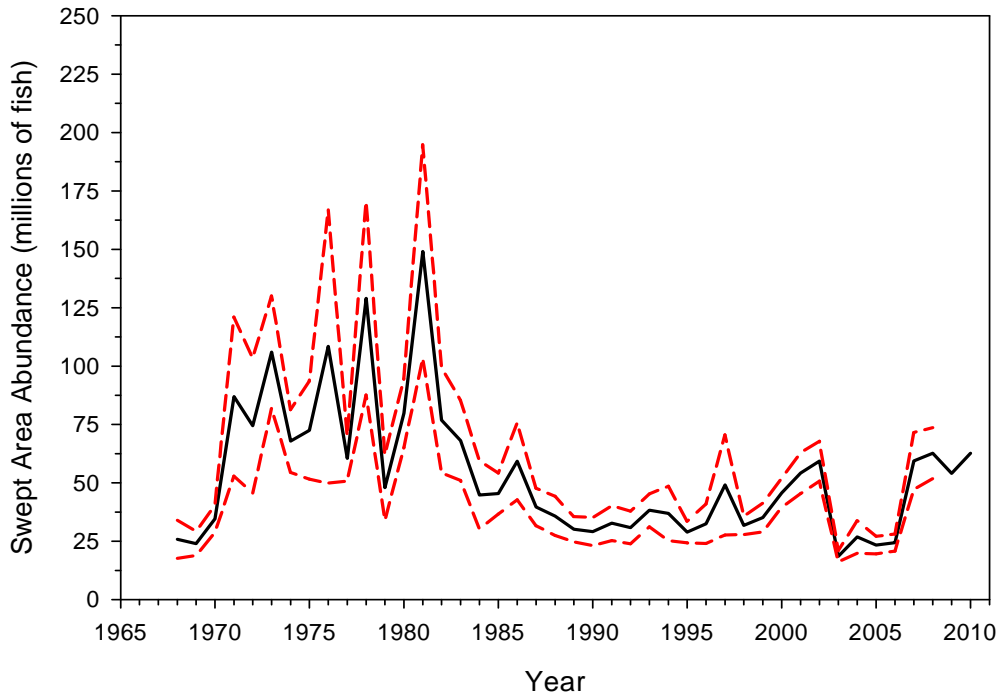


Figure C50. Swept area abundance (top) and biomass (bottom) with upper and lower confidence intervals for red hake from the NEFSC spring bottom trawl surveys in the northern and southern management regions combined (strata 1-30, 36-40, 61-76). Estimates for 2009 and 2010 were converted to Albatross units using the calibration factors at length in Table C34.

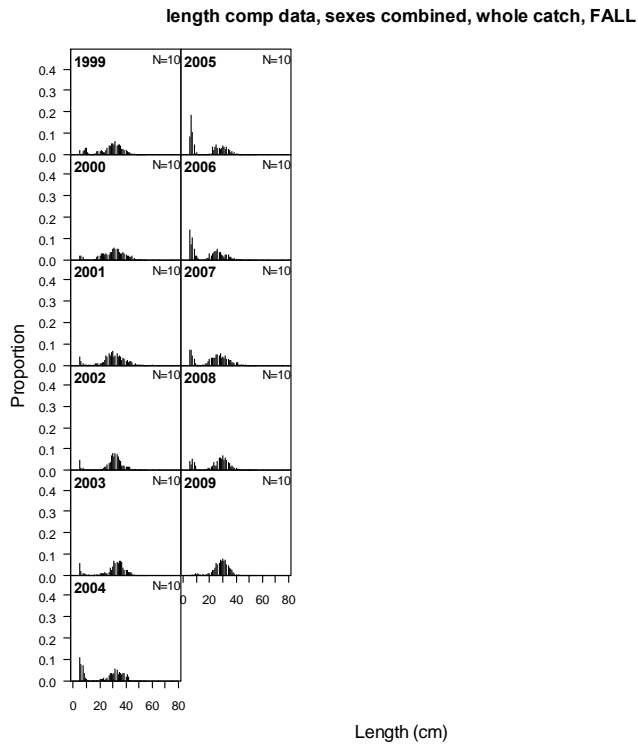
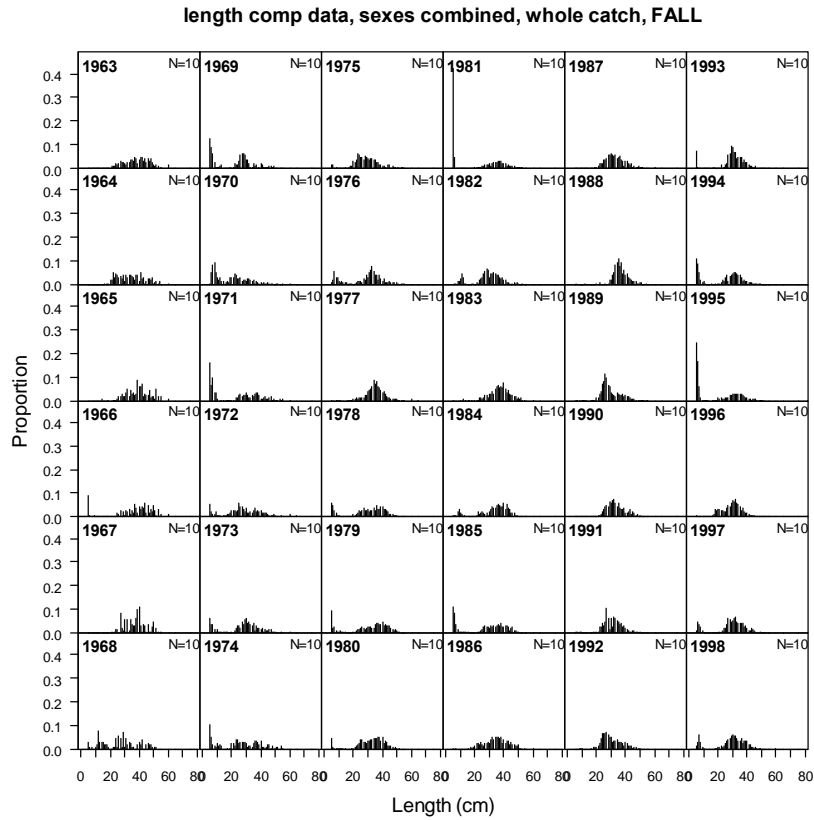


Figure C51. Length composition of red hake from the fall survey for the northern stock.

length comp data, sexes combined, whole catch, FALL (max=0.43)

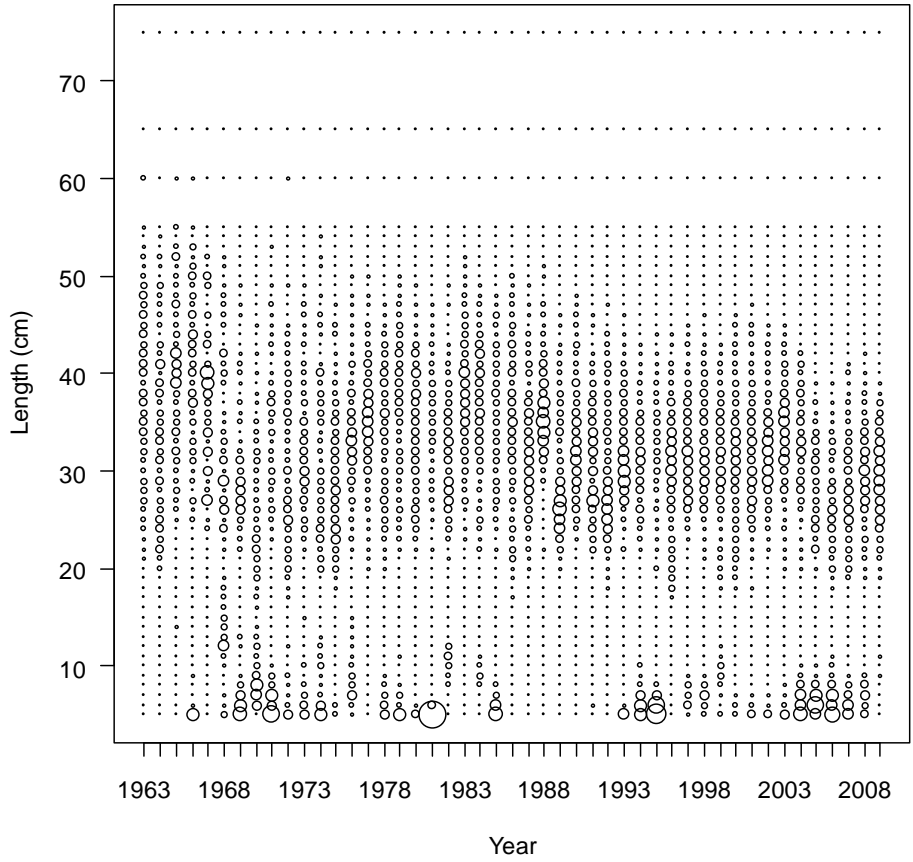


Figure C51 cont. Length composition of red hake from the fall survey for the northern stock.

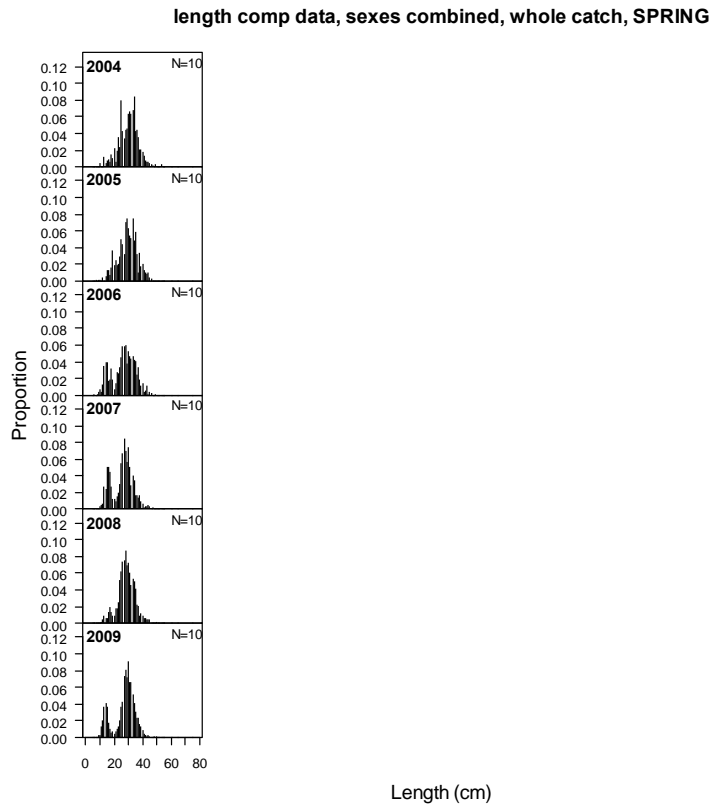
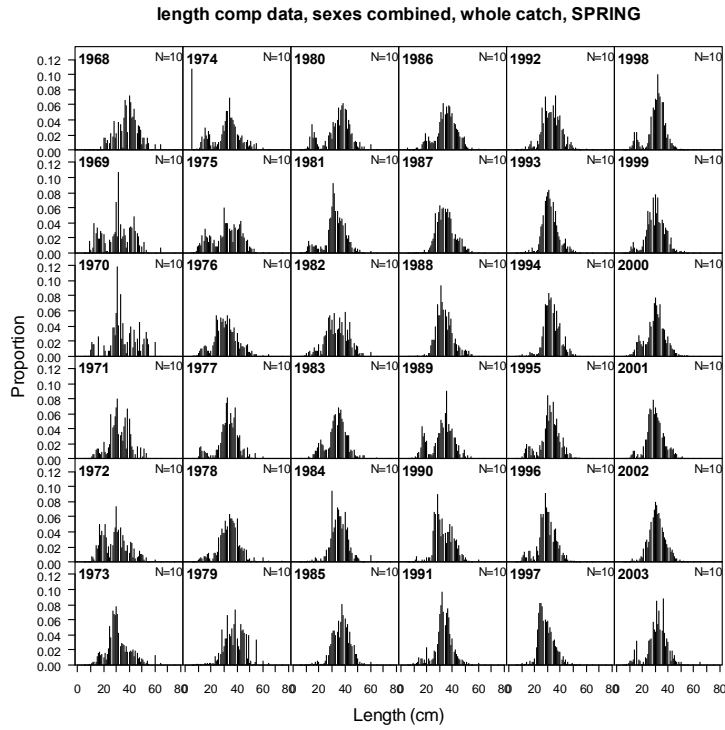


Figure C52. Length composition of red hake from the spring survey for the northern stock.

length comp data, sexes combined, whole catch, SPRING (max=0.12)

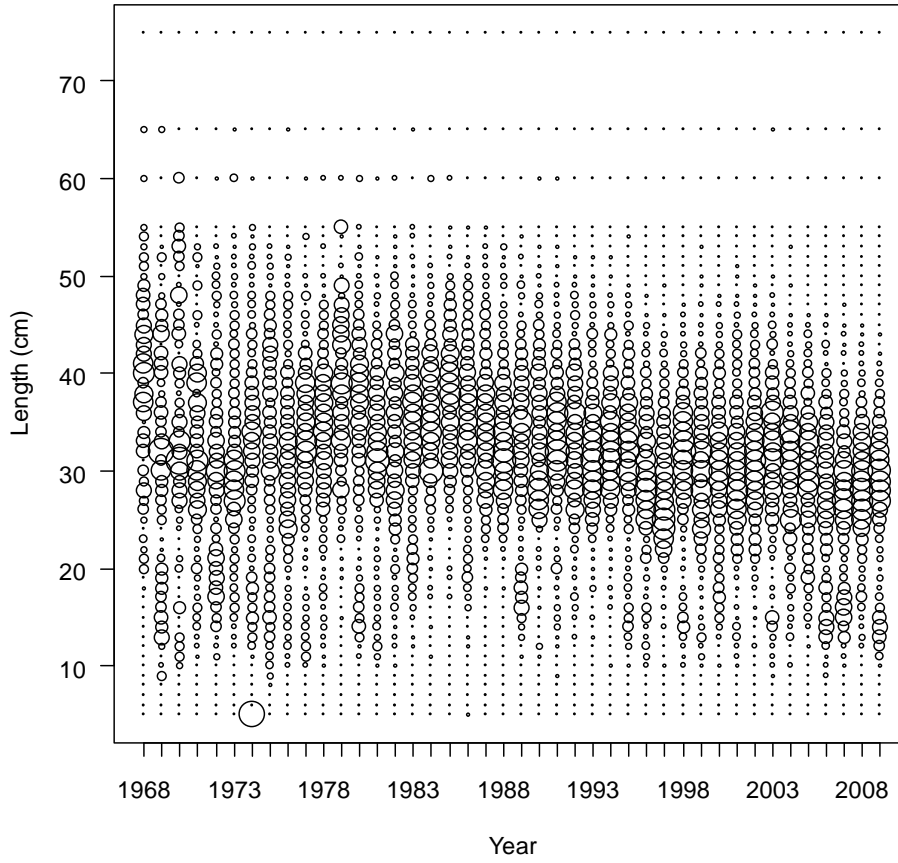


Figure C52 cont. Length composition of red hake from the spring survey for the northern stock.

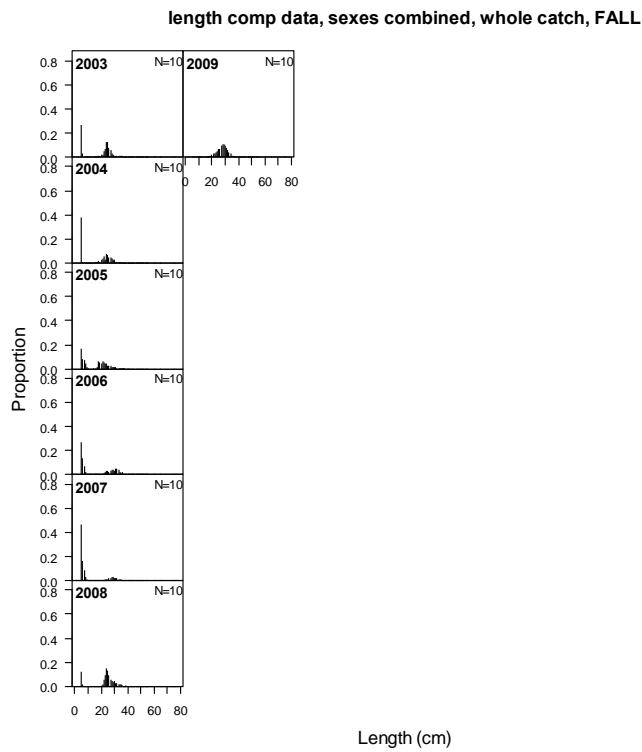
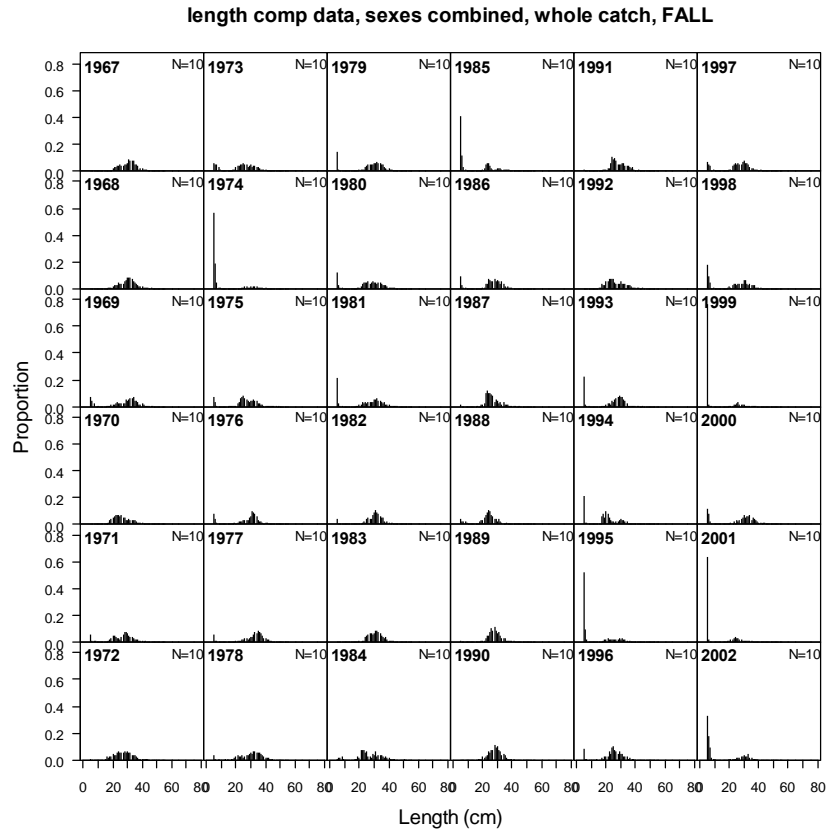


Figure C53. Length composition of red hake from the fall survey for the southern stock.

length comp data, sexes combined, whole catch, FALL (max=0.76)

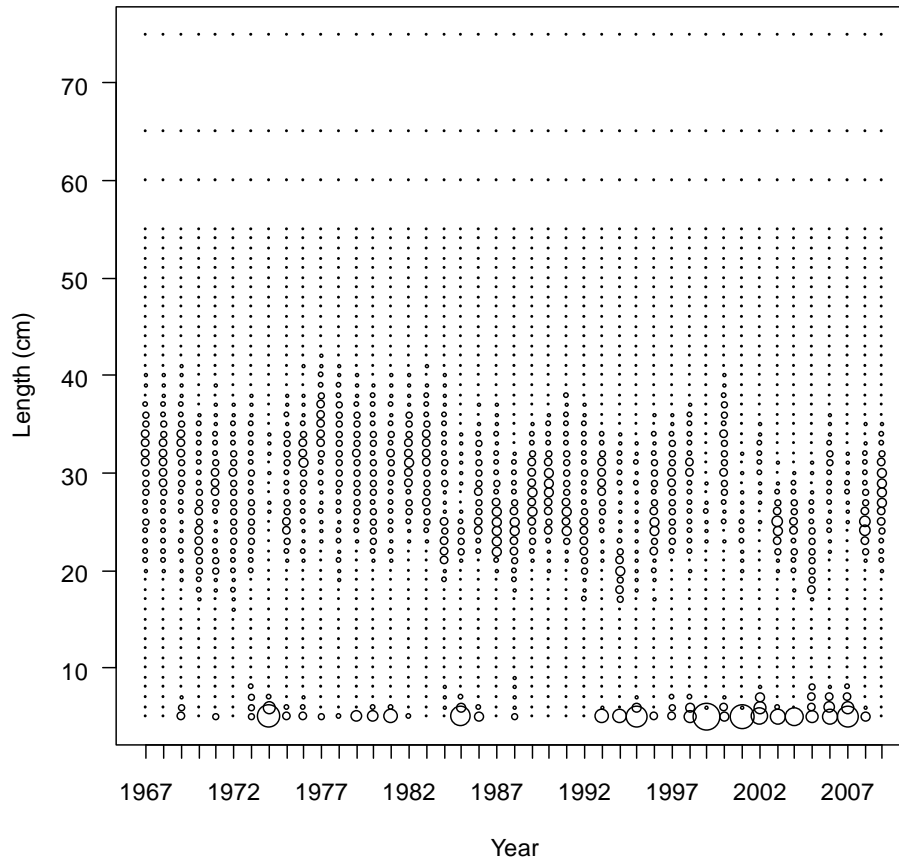


Figure C53 cont. Length composition of red hake from the fall survey for the southern stock.

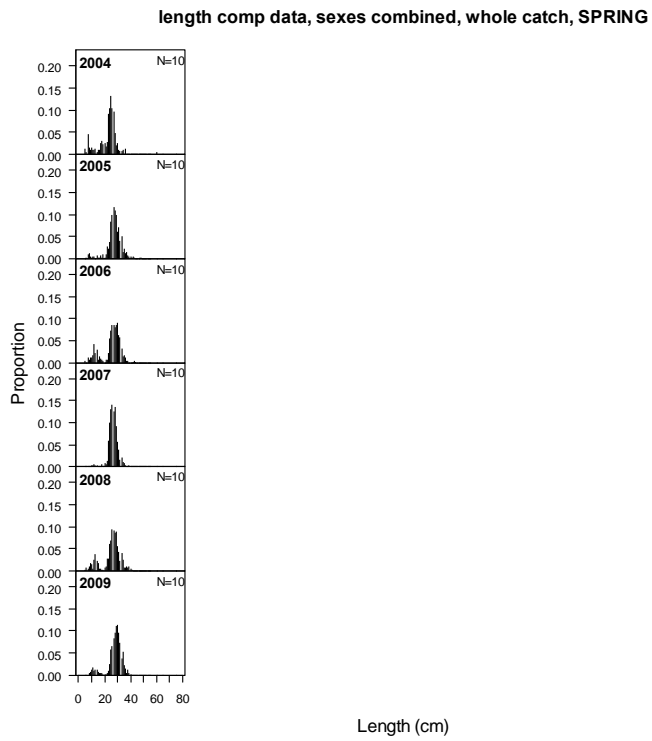
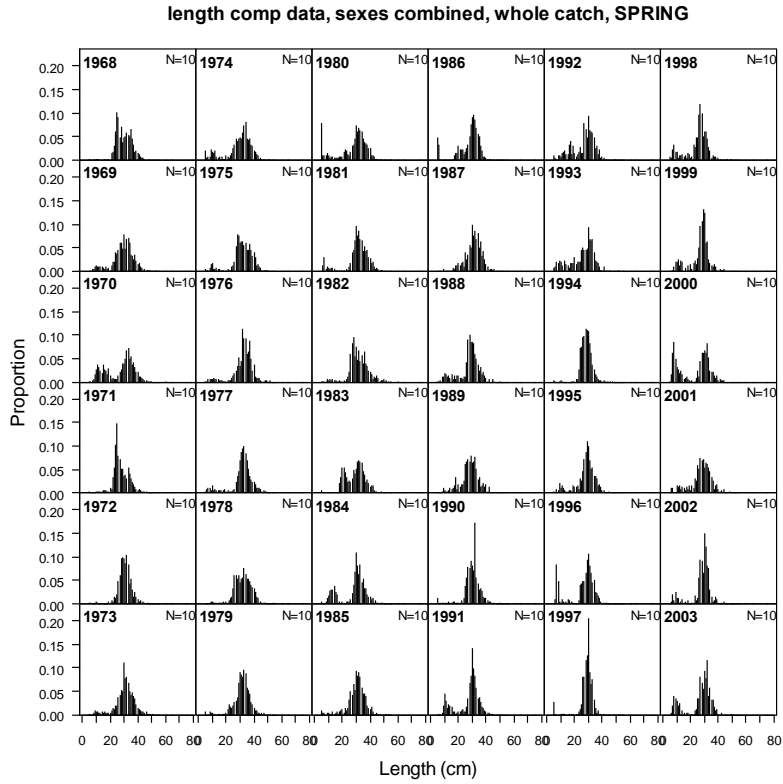


Figure C54. Length composition of red hake from the spring survey for the southern stock.

length comp data, sexes combined, whole catch, SPRING (max=0.2)

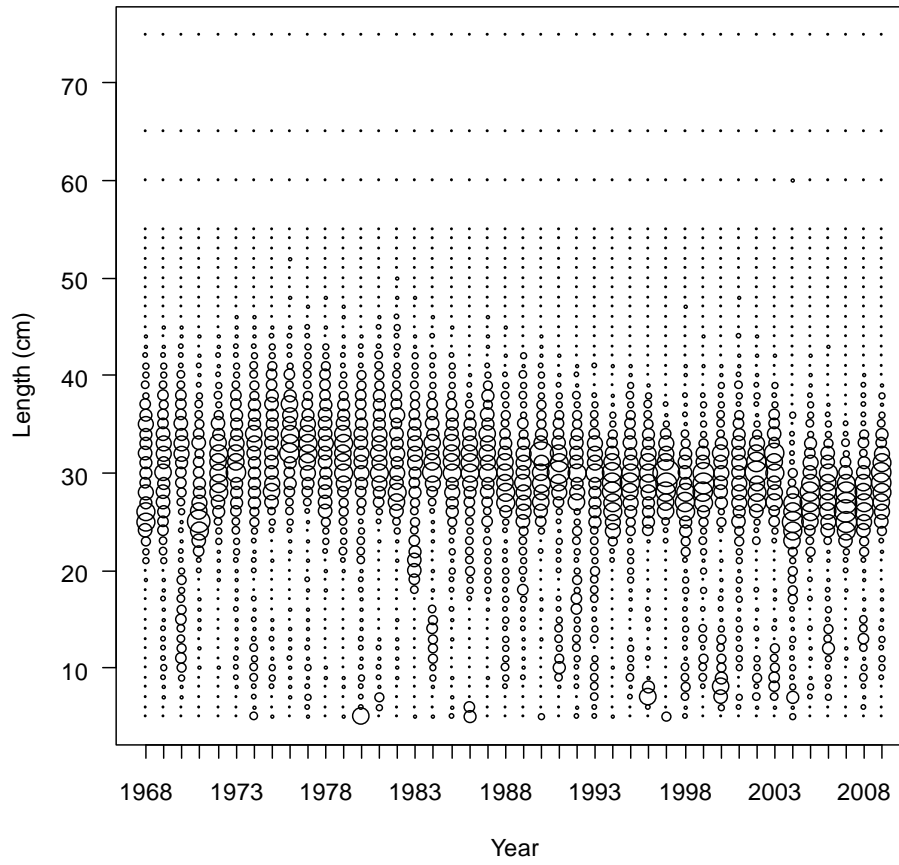


Figure C54 cont. Length composition of red hake from the spring survey for the southern stock.

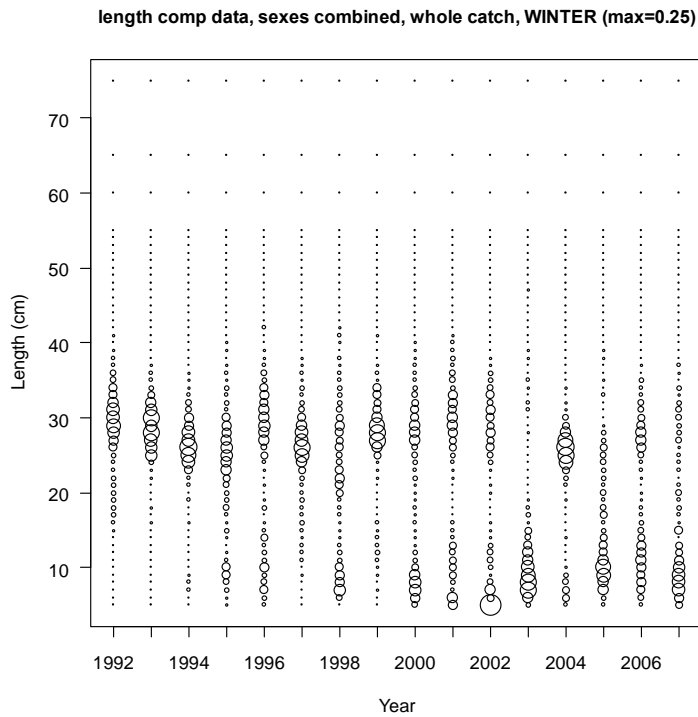
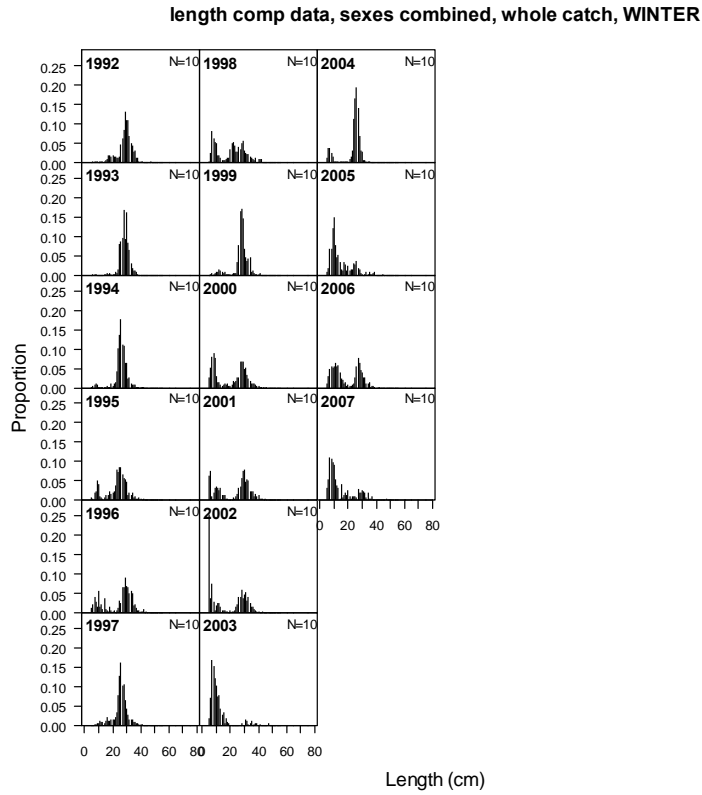


Figure C55. Length composition of red hake from the winter survey for the southern stock.

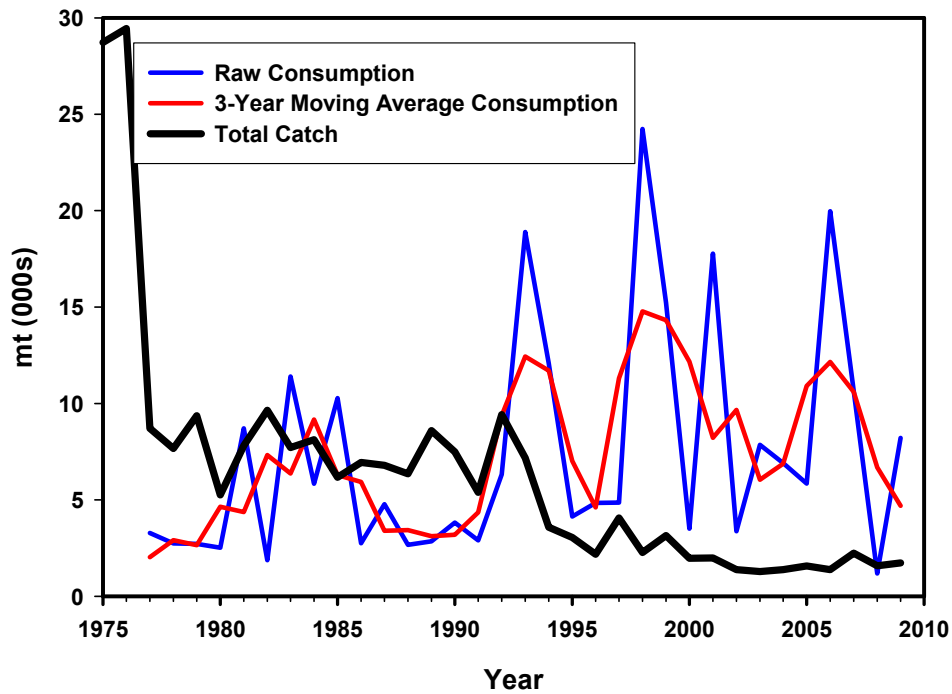


Figure C56. Minimal estimates of total red hake biomass removed by consumption by major fish predators compared to total catch.

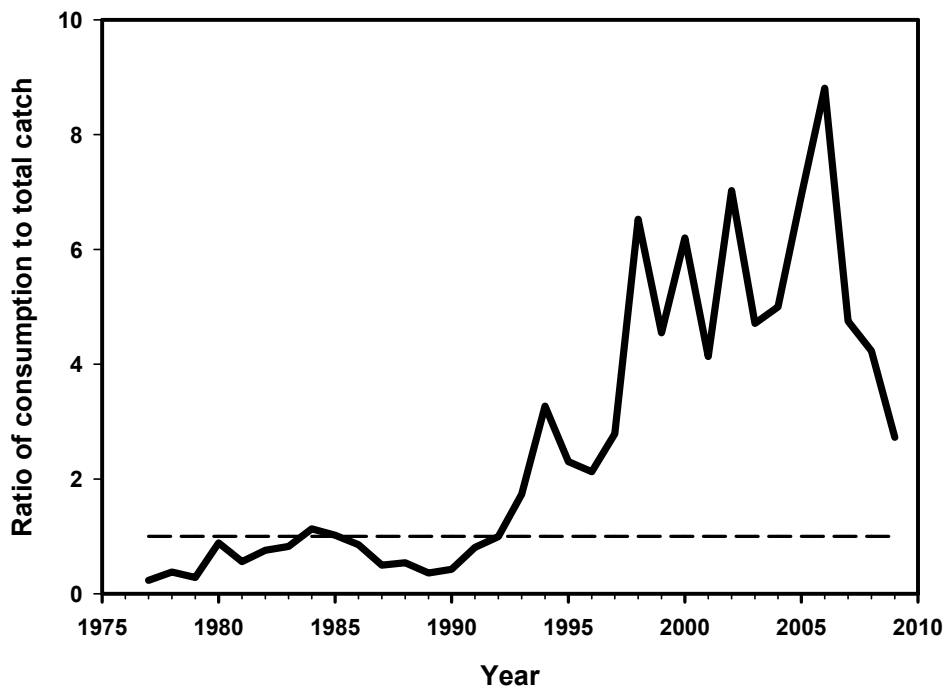
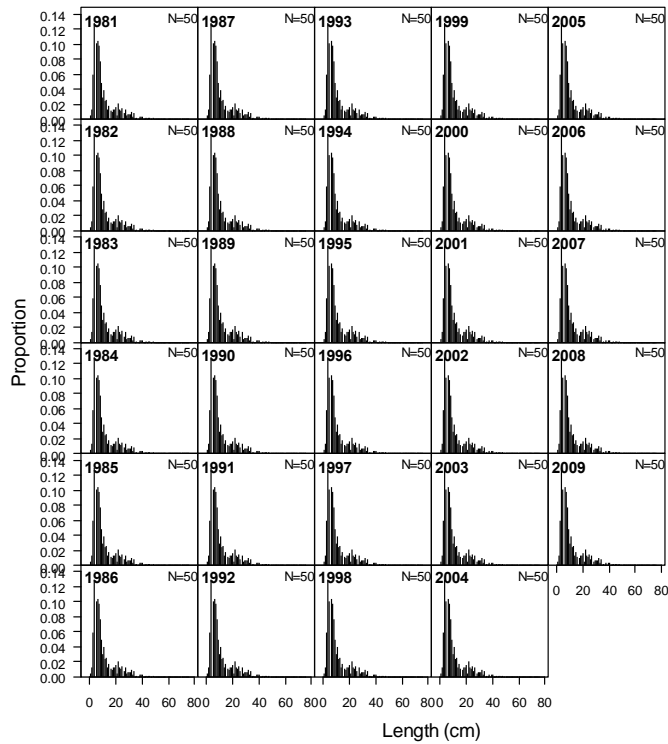


Figure C57. Ratio of consumption to total catch of red hake over the time series. The constant line represents a ratio of unity.

length comp data, sexes combined, whole catch, CONS



length comp data, sexes combined, whole catch, CONS (max=0.13)

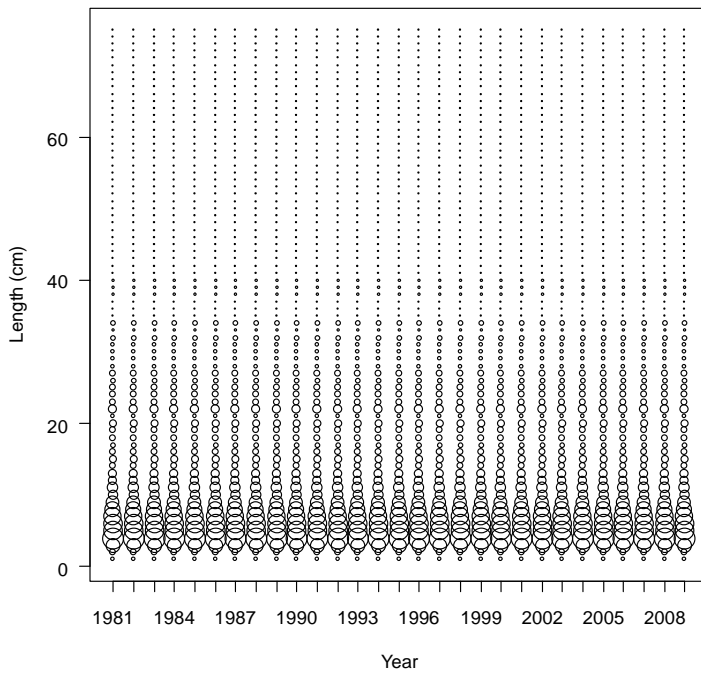
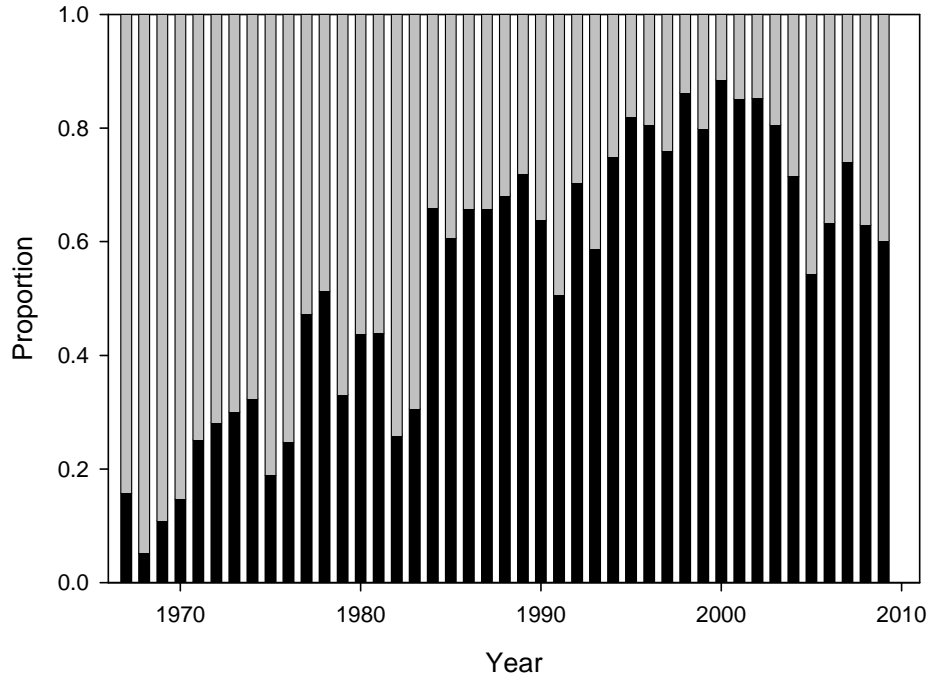


Figure C58. Length composition of red hake consumed by major predators from the NEFSC surveys for the northern and southern stocks combined.

Fall Survey



Spring Survey

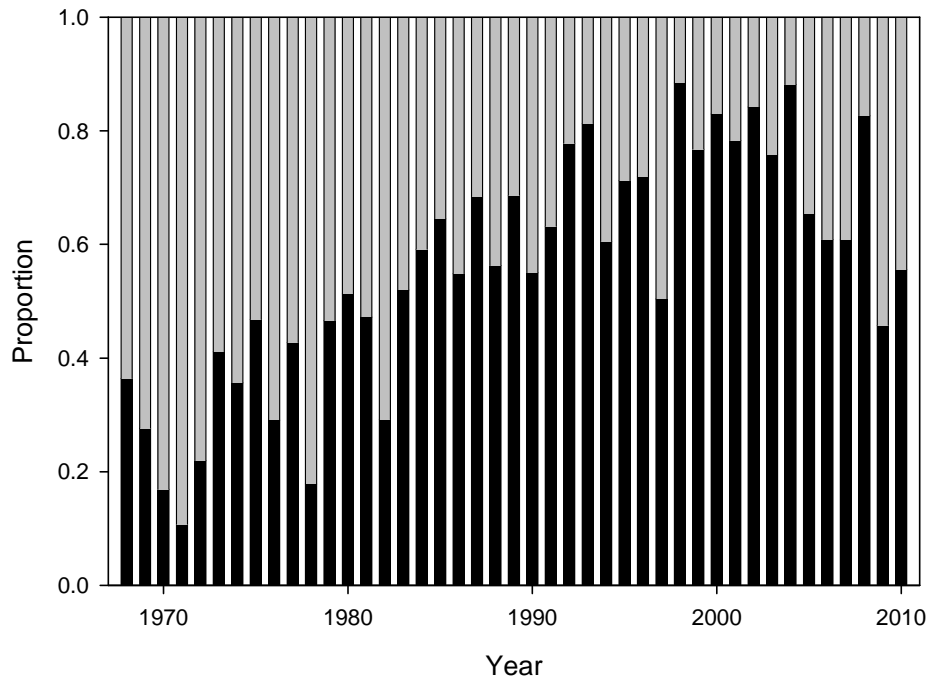


Figure C59. Proportion of swept area biomass found in the northern area (black) and the southern area (gray bars).

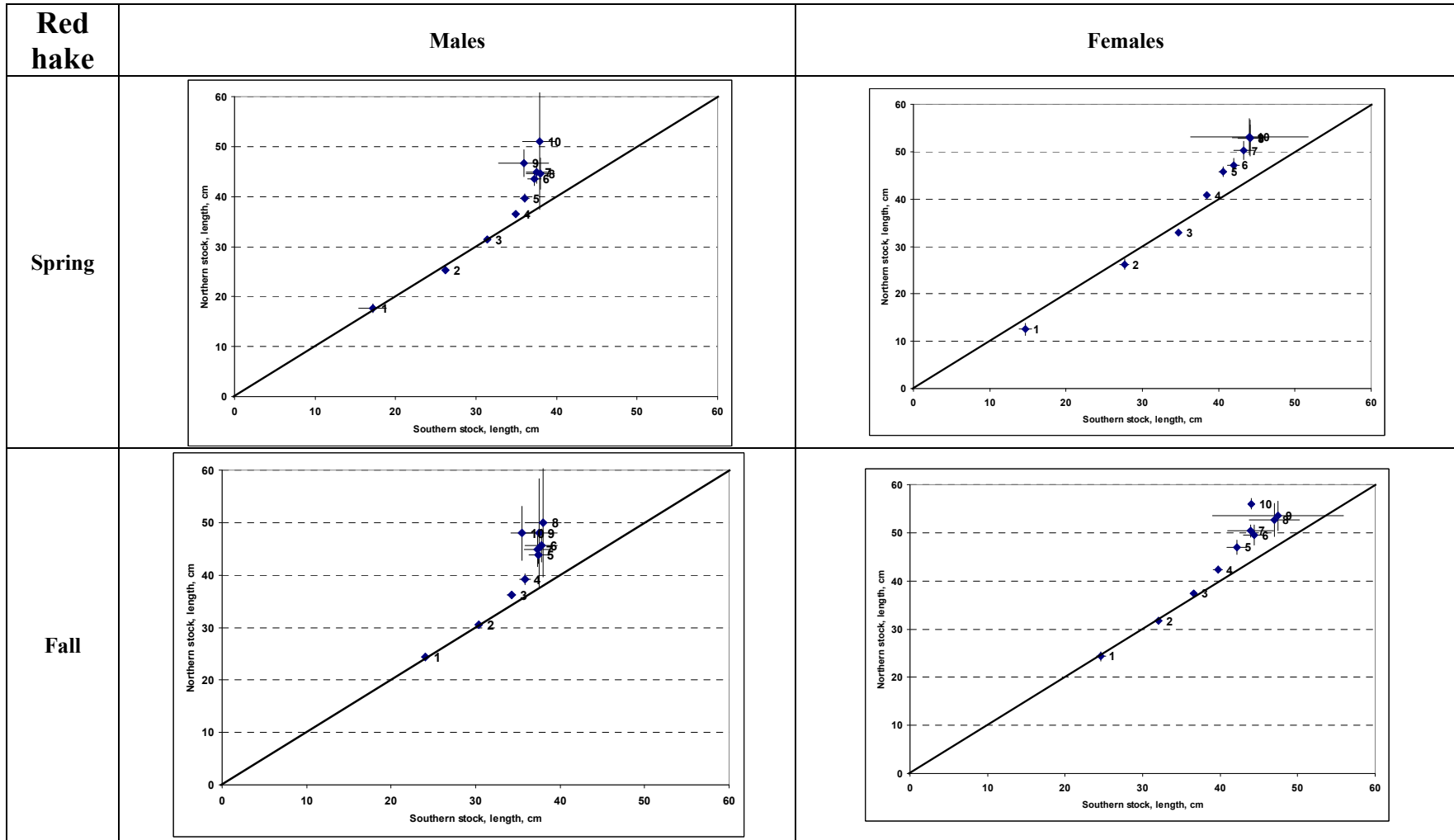


Figure C60a. Size (cm total length) at age comparison between red hake caught in strata 1-19, 61-76 (Southern stock) and strata 20-40 (Northern stock) for 1957-1974 cohorts.

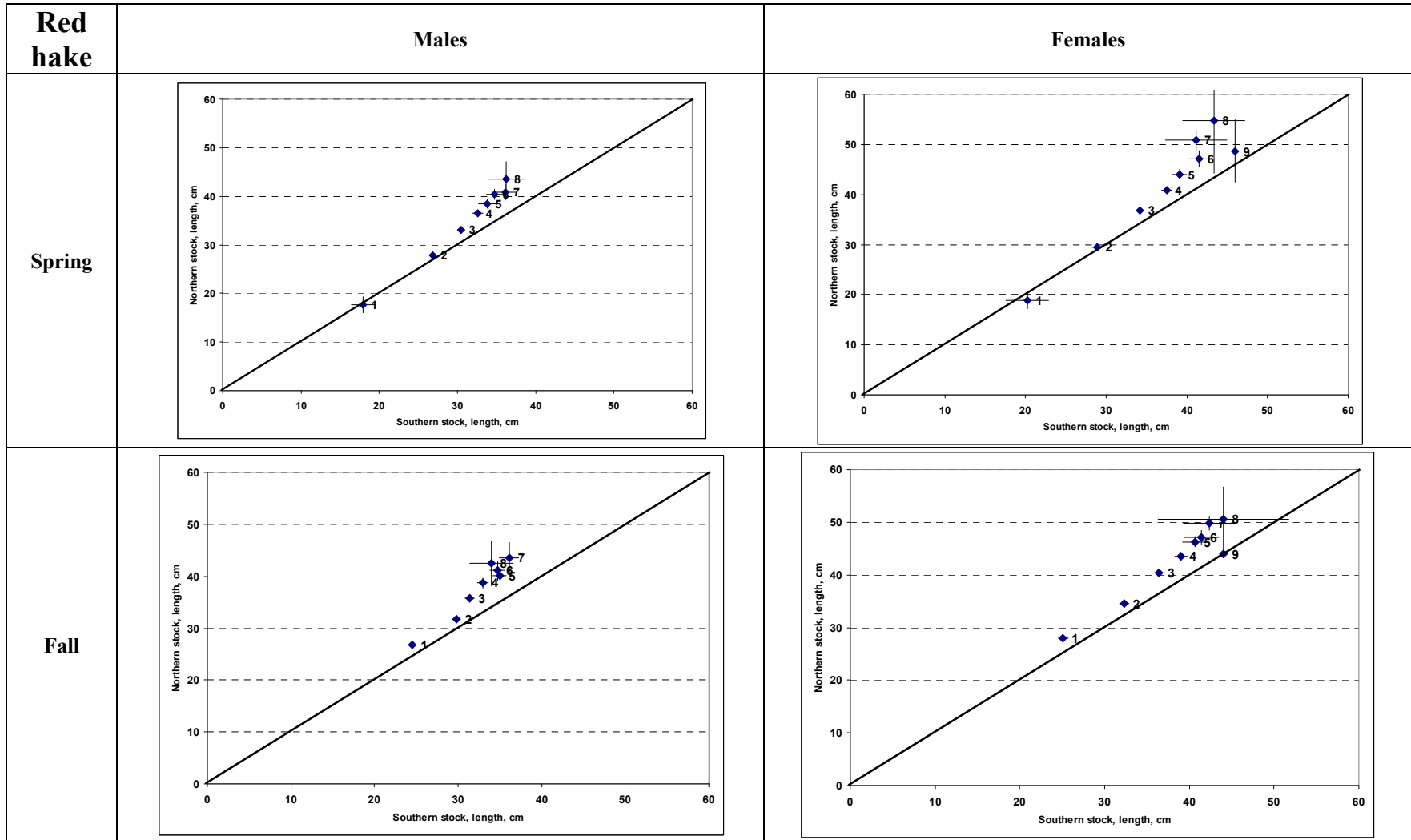


Figure C60b. Size (cm total length) at age comparison between red hake caught in strata 1-19, 61-76 (Southern stock) and strata 20-40 (Northern stock) for 1975-1985 cohorts.

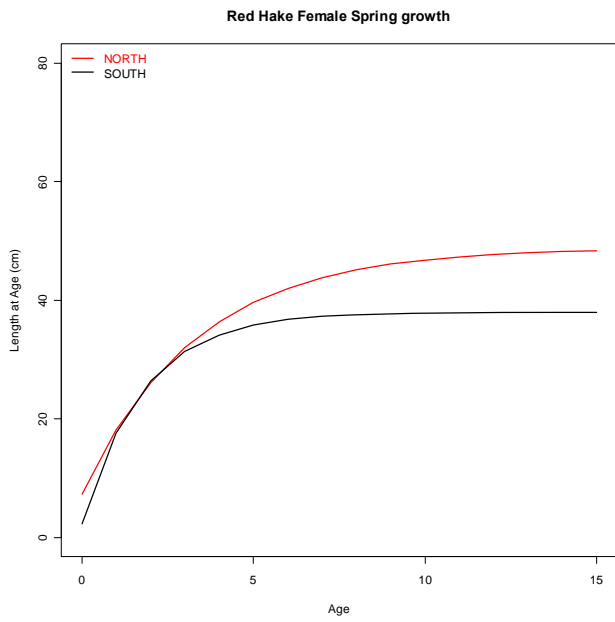
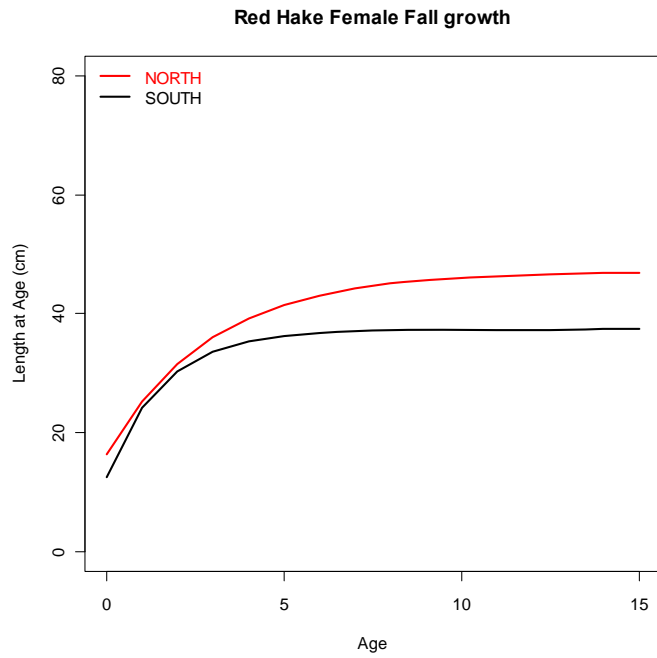


Figure C61a. Growth curves for female red hake by stock area.

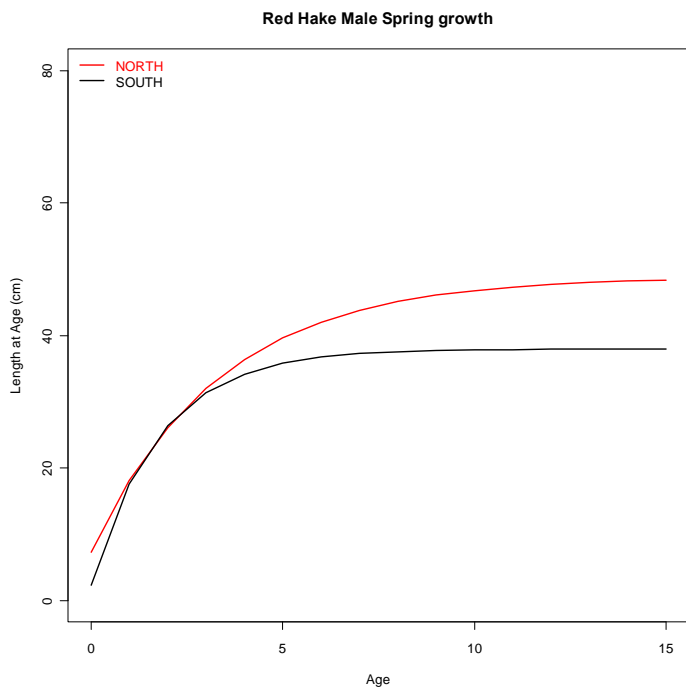
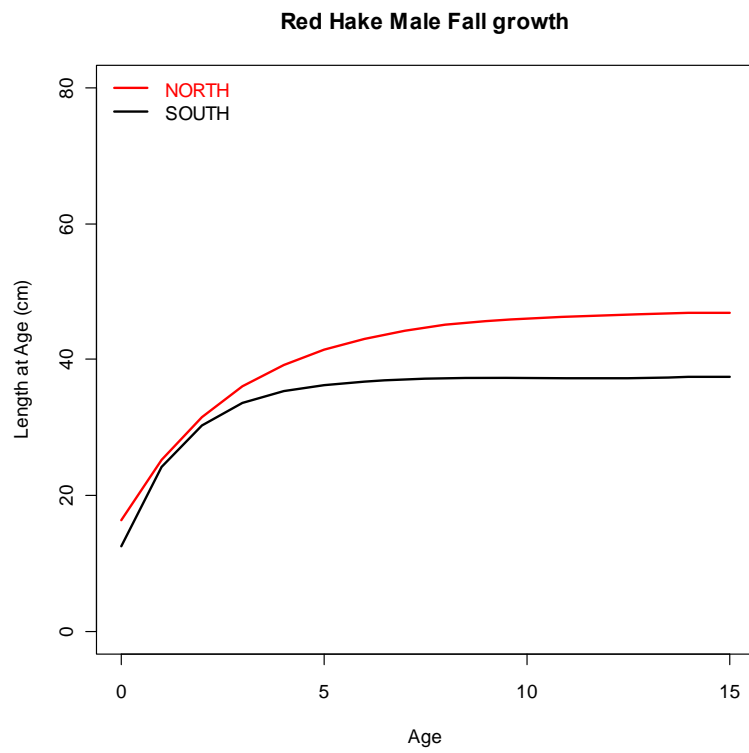


Figure C61a. Growth curves for male red hake by stock area.

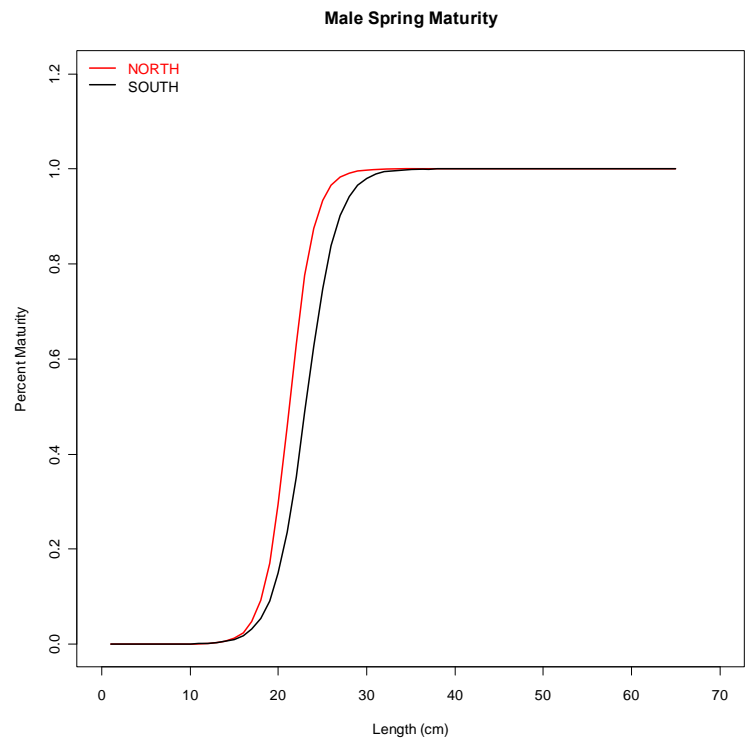
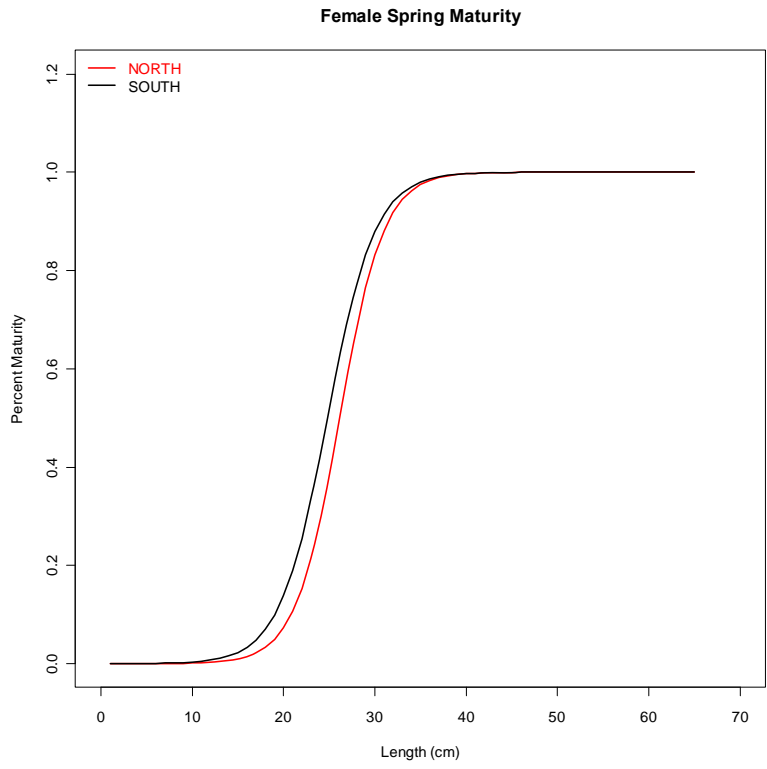


Figure C62. Maturity ogives for red hake by stock and sex.

Red north rawC2 NEFSC Fall Survey

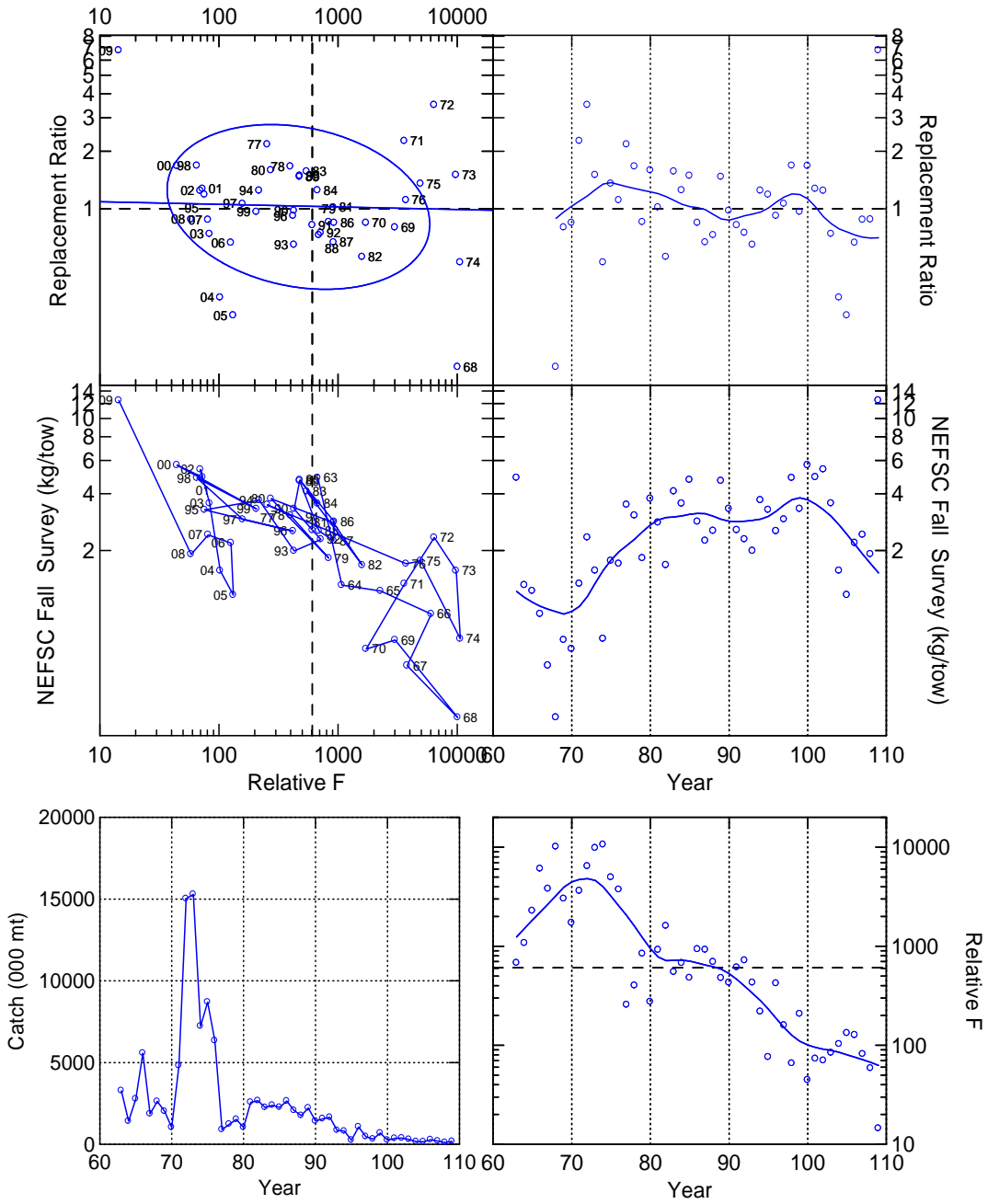


Figure C63. Six panel plot for northern red hake depicting trends in relative biomass, landings, relative fishing mortality and replacement ratios for the NEFSC fall survey index and landings based on catch method “raw C2”. Horizontal dashed lines (---) represent replacement ratios in the top two panels and the replacement F in the lower right panel. Smooth lines represent Lowess smooths (tension =0.3). The confidence ellipse in the top left panel has a nominal probability level of 0.68. The regression line in the top left panel is a robust regression using bisquare downweighting of residuals.

Red north rawC2 NEFSC Spring Survey

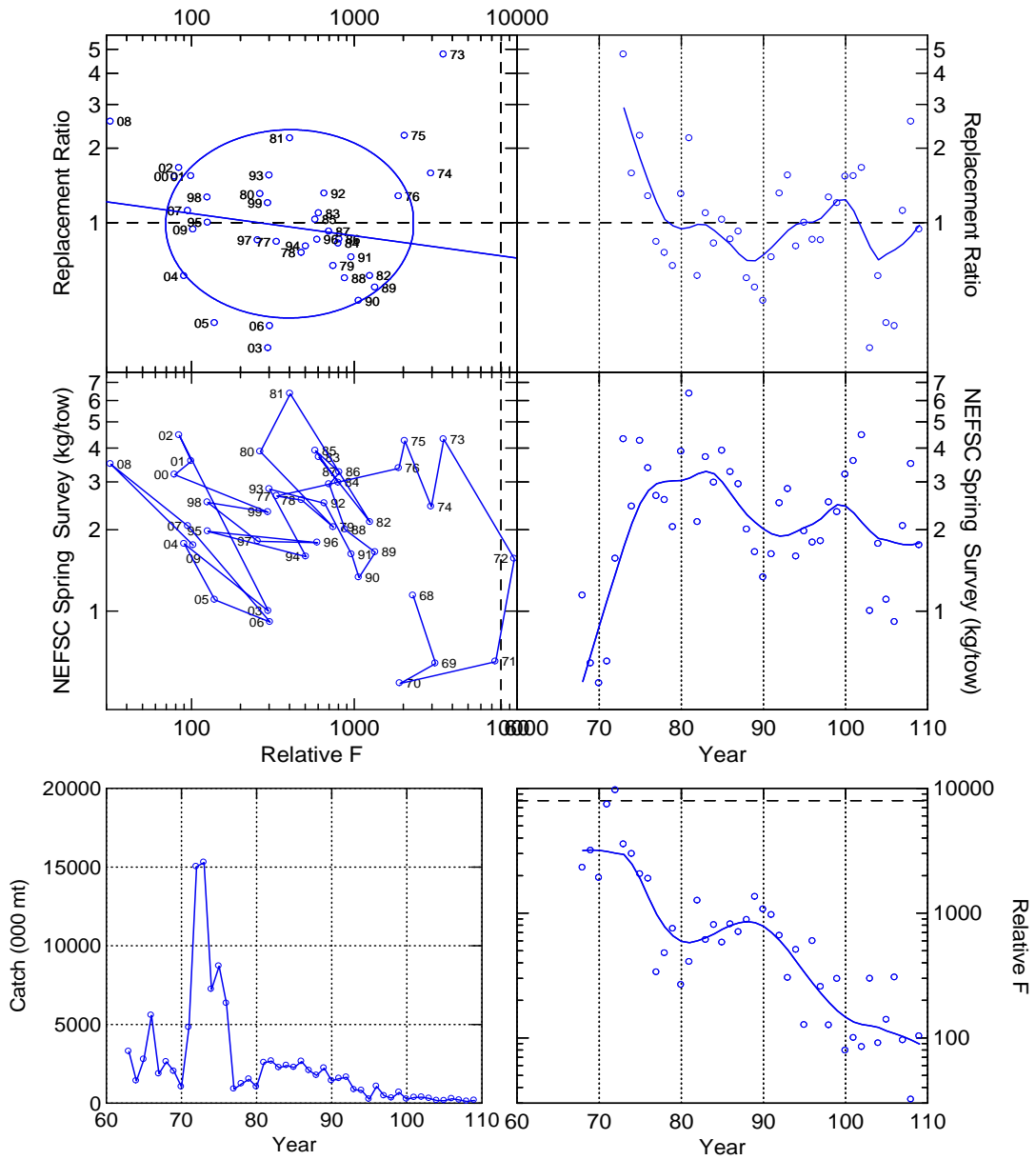


Figure C64. Six panel plot for northern red hake depicting trends in relative biomass, landings, relative fishing mortality and replacement ratios for the NEFSC spring survey index and landings based on catch method “raw C2”. Horizontal dashed lines (---) represent replacement ratios in the top two panels and the replacement F in the lower right panel. Smooth lines represent Lowess smooths (tension =0.3). The confidence ellipse in the top left panel has a nominal probability level of 0.68. The regression line in the top left panel is a robust regression using bisquare downweighting of residuals.

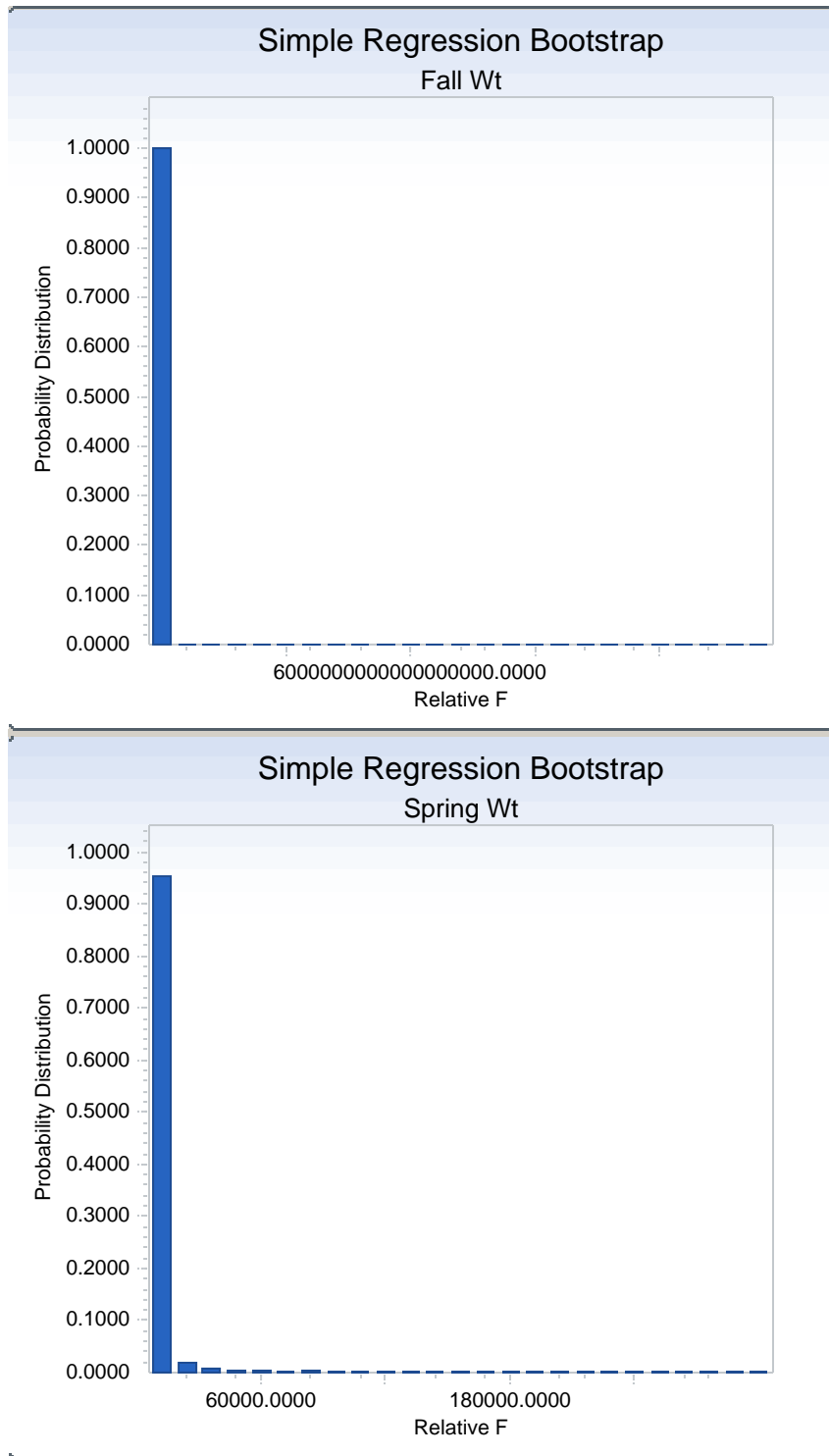


Figure C65. Randomization tests summary of sampling distribution of correlation coefficient between replacement ratio and relative F for fall (top) and spring (bottom) survey indices for northern red hake, using catch estimation method “raw C2”, 1963-2009.

Red south rawC2 NEFSC Fall Survey

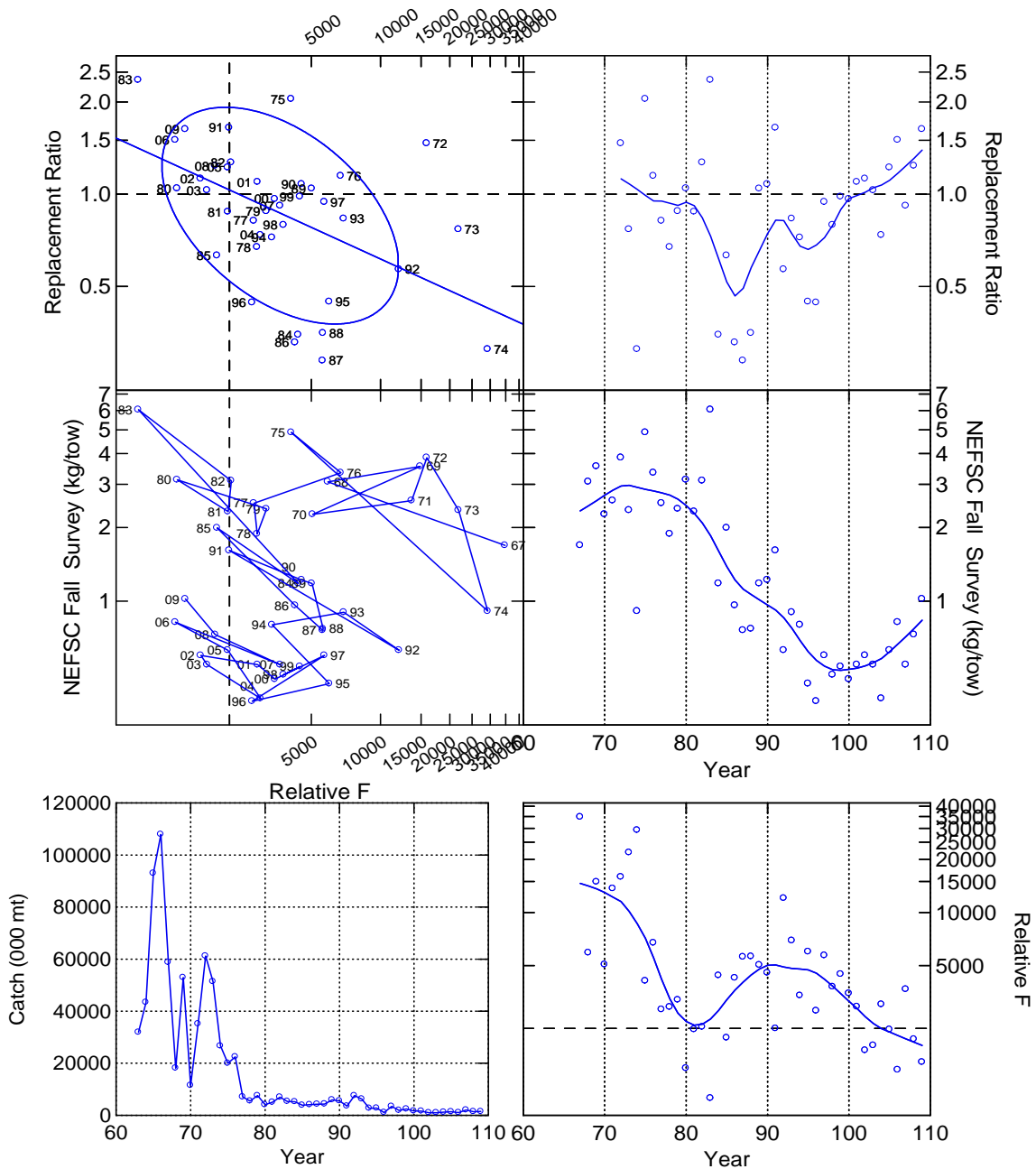


Figure C66. Six panel plot for southern red hake depicting trends in relative biomass, landings, relative fishing mortality and replacement ratios for the NEFSC fall survey index and landings based on catch method “raw C2”. Horizontal dashed lines (---) represent replacement ratios in the top two panels and the replacement F in the lower right panel. Smooth lines represent Lowess smooths (tension = 0.3). The confidence ellipse in the top left panel has a nominal probability level of 0.68. The regression line in the top left panel is a robust regression using bisquare downweighting of residuals.

Red south rawC2 NEFSC Spring Survey

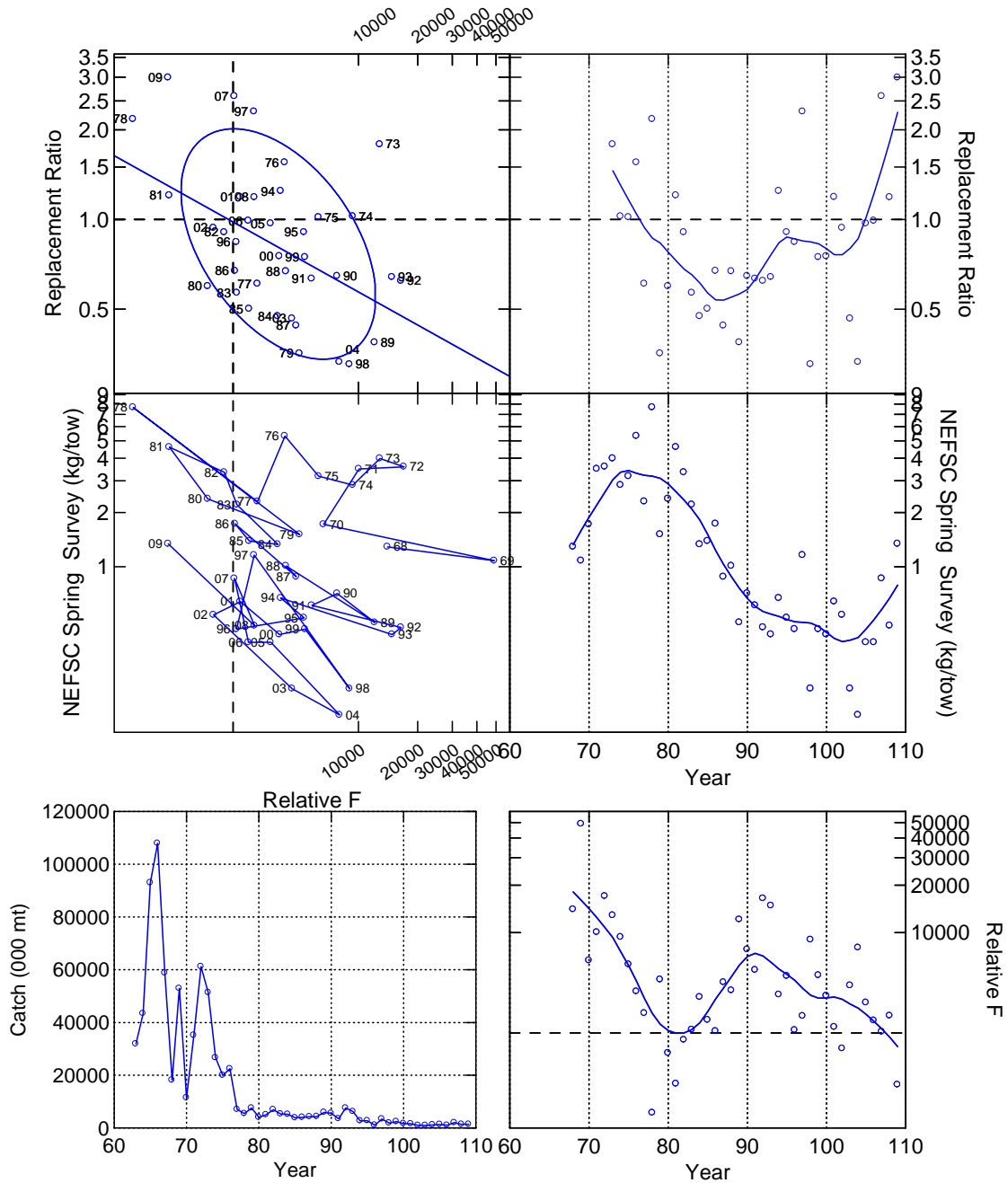


Figure C67. Six panel plot for southern red hake depicting trends in relative biomass, landings, relative fishing mortality and replacement ratios for the NEFSC spring survey index and landings based on catch method “raw C2”. Horizontal dashed lines (---) represent replacement ratios in the top two panels and the replacement F in the lower right panel. Smooth lines represent Lowess smooths (tension =0.3). The confidence ellipse in the top left panel has a nominal probability level of 0.68. The regression line in the top left panel is a robust regression using bisquare downweighting of residuals.

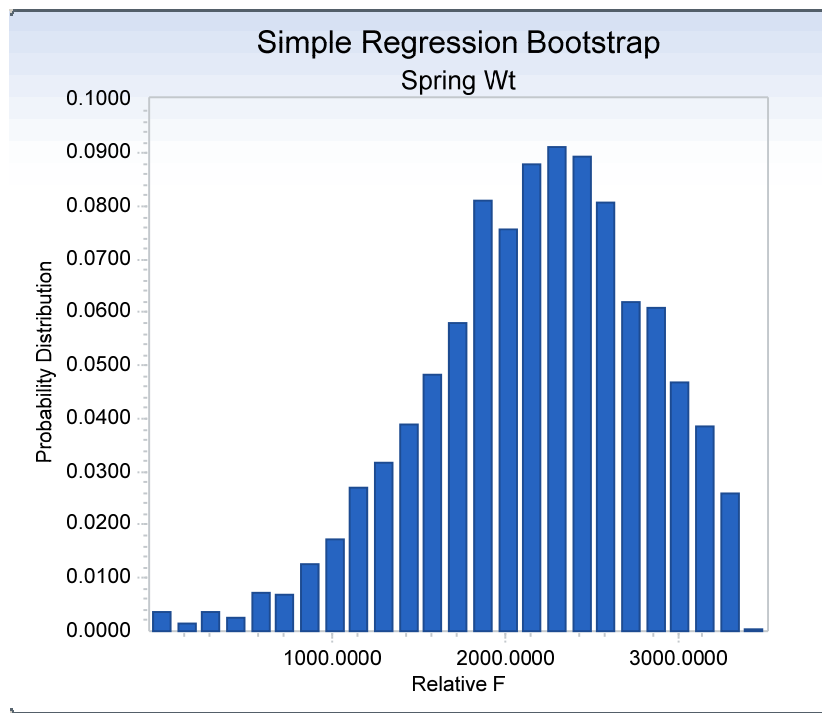
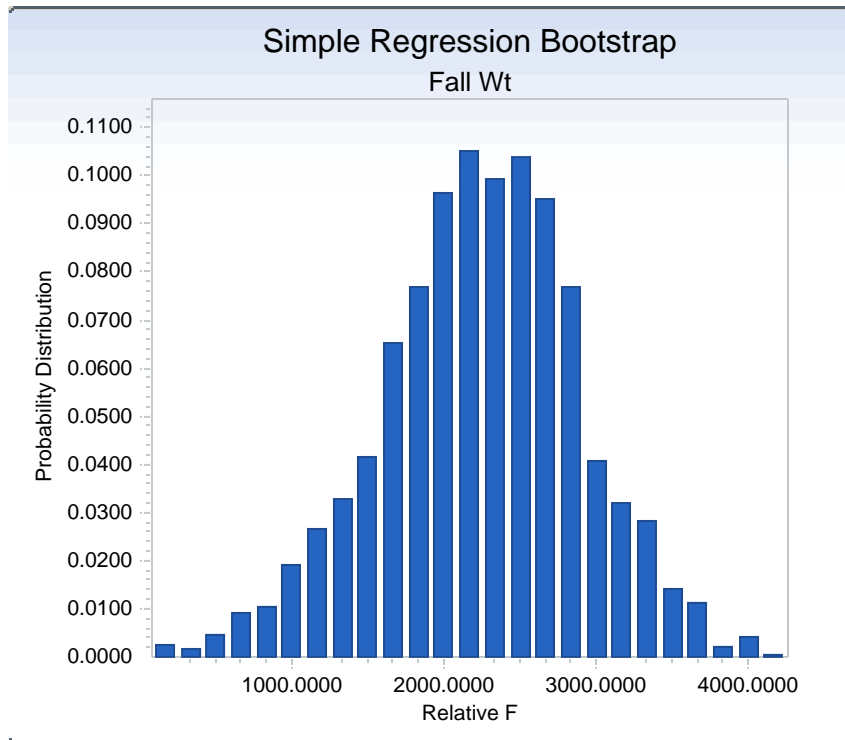
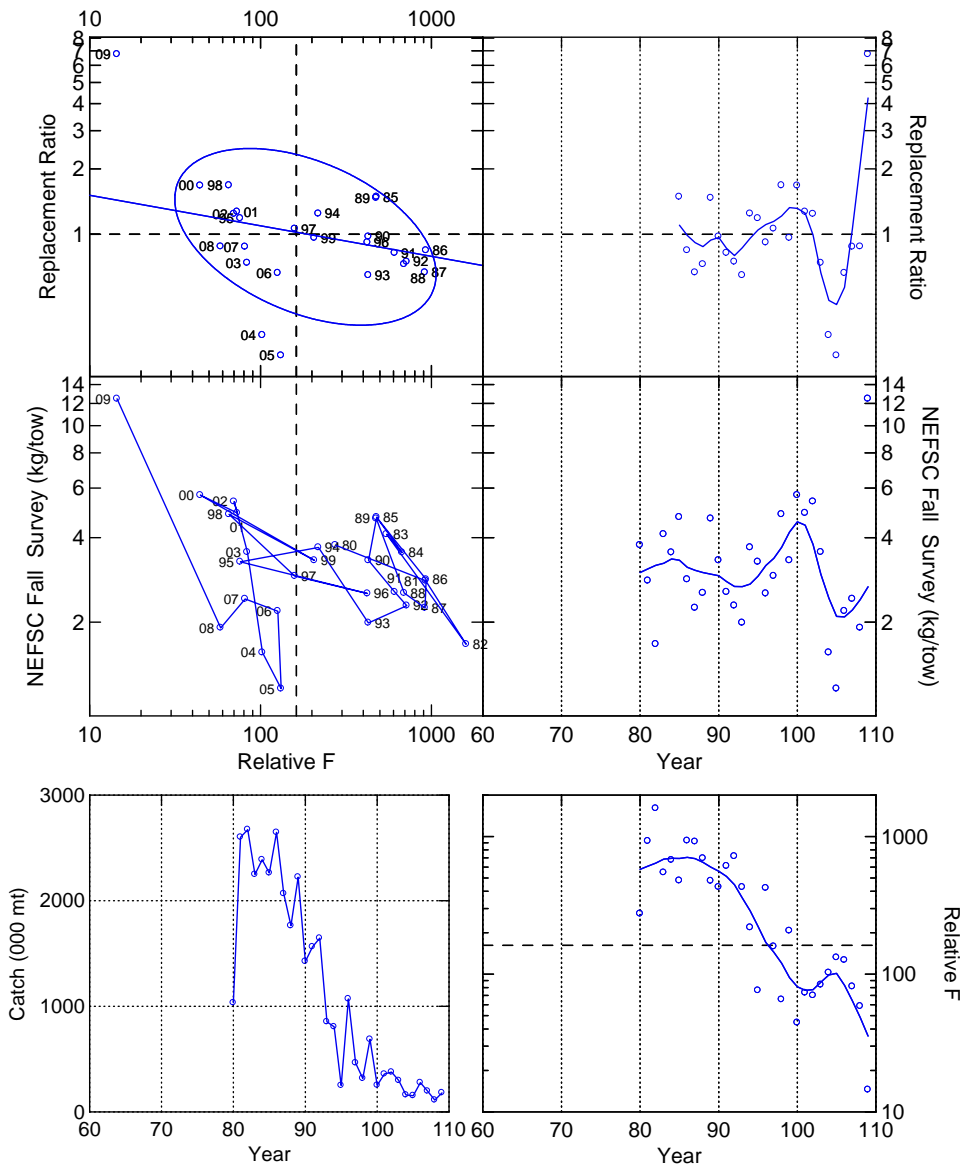


Figure C68. Randomization tests summary of sampling distribution of correlation coefficient between replacement ratio and relative F for fall (top) and spring (bottom) survey indices for southern red hake, using catch estimation method “raw C2”, 1963-2009.

Red north Catch3 NEFSC Fall Survey



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Figure C69. Six panel plot for northern red hake depicting trends in relative biomass, landings, relative fishing mortality and replacement ratios for the NEFSC fall survey index and landings based on catch method “Catch 3”, 1980-2009. Horizontal dashed lines (---) represent replacement ratios in the top two panels and the replacement F in the lower right panel. Smooth lines represent Lowess smooths (tension =0.3). The confidence ellipse in the top left panel has a nominal probability level of 0.68. The regression line in the top left panel is a robust regression using bisquare downweighting of residuals.

Red north catch3 NEFSC Spring Survey

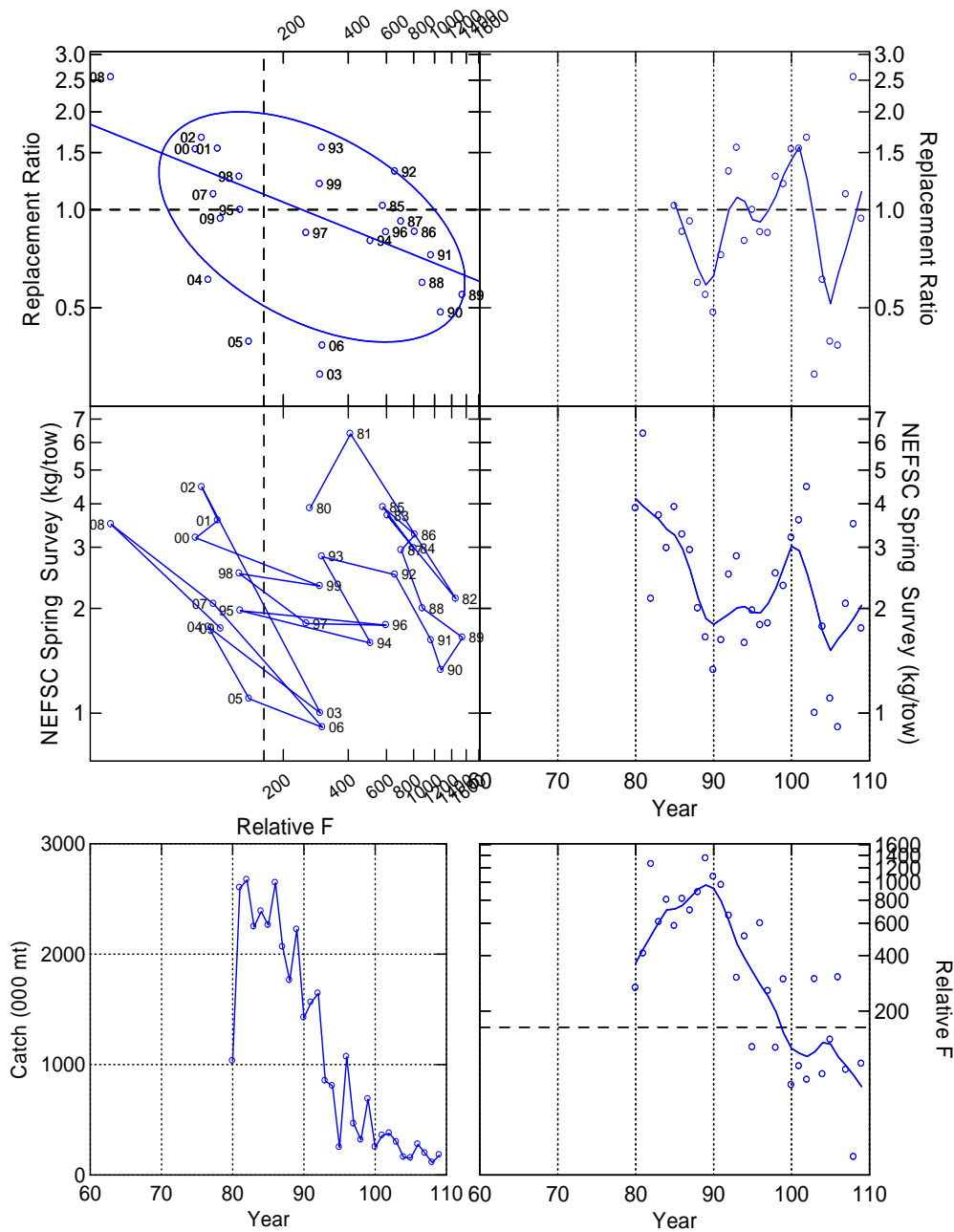


Figure C70. Six panel plot for northern red hake depicting trends in relative biomass, landings, relative fishing mortality and replacement ratios for the NEFSC spring survey index and landings based on catch method “Catch 3”, 1980-2009. Horizontal dashed lines (---) represent replacement ratios in the top two panels and the replacement F in the lower right panel. Smooth lines represent Lowess smooths (tension =0.3). The confidence ellipse in the top left panel has a nominal probability level of 0.68. The regression line in the top left panel is a robust regression using bisquare downweighting of residuals.

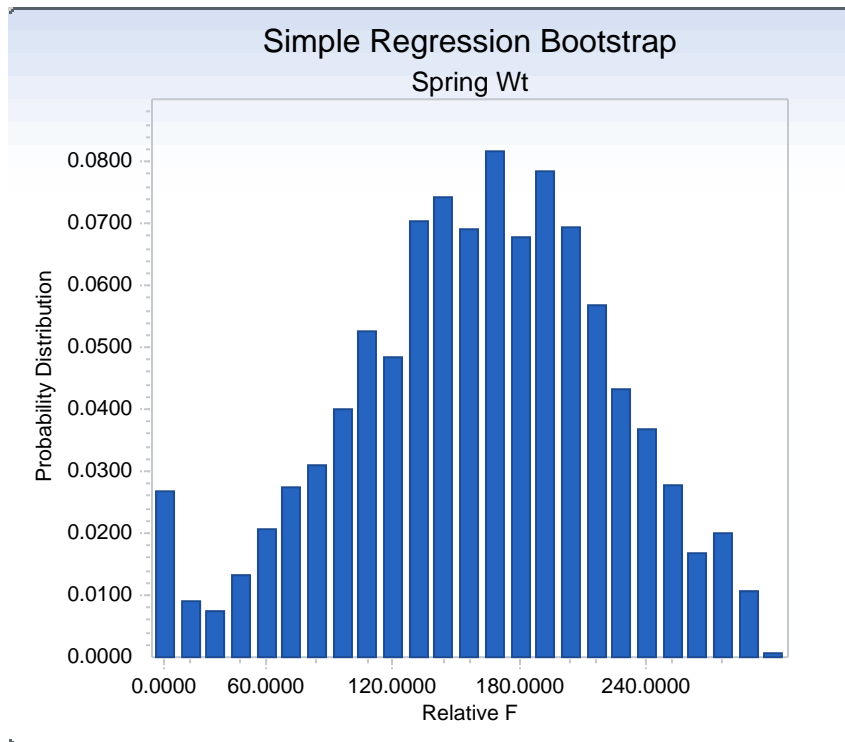
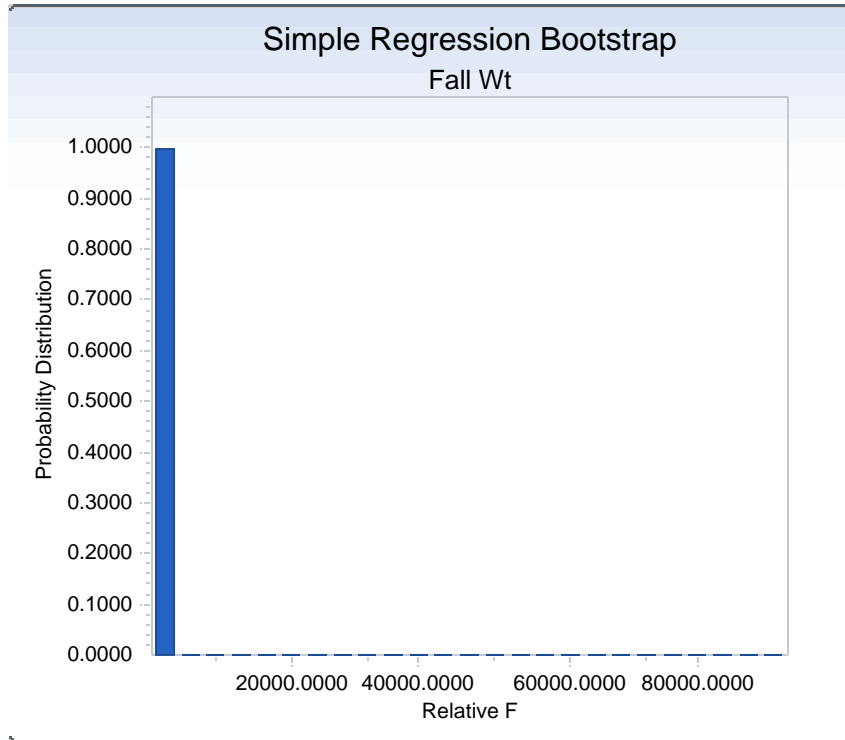


Figure C71. Randomization tests summary of sampling distribution of correlation coefficient between replacement ratio and relative F for fall (top) and spring (bottom) survey indices for northern red hake, using catch estimation method “Catch 3”, 1980-2009.

Red south Catch3 NEFSC Fall Survey

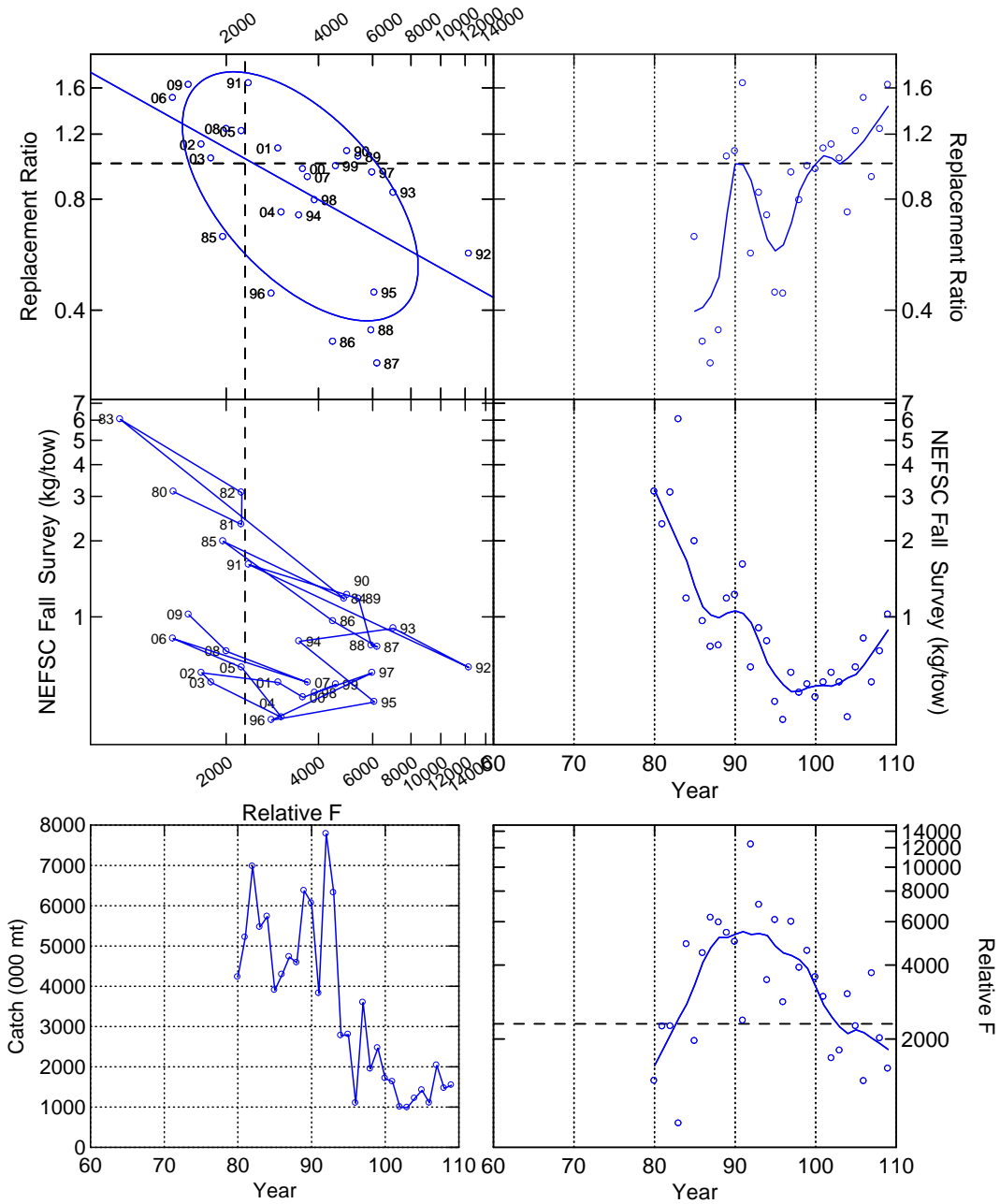


Figure C72. Six panel plot for southern red hake depicting trends in relative biomass, landings, relative fishing mortality and replacement ratios for the NEFSC fall survey index and landings based on catch method “Catch 3”, 1980-2009. Horizontal dashed lines (---) represent replacement ratios in the top two panels and the replacement F in the lower right panel. Smooth lines represent Lowess smooths (tension =0.3). The confidence ellipse in the top left panel has a nominal probability level of 0.68. The regression line in the top left panel is a robust regression using bisquare downweighting of residuals.

Red south catch3 NEFSC Spring Survey

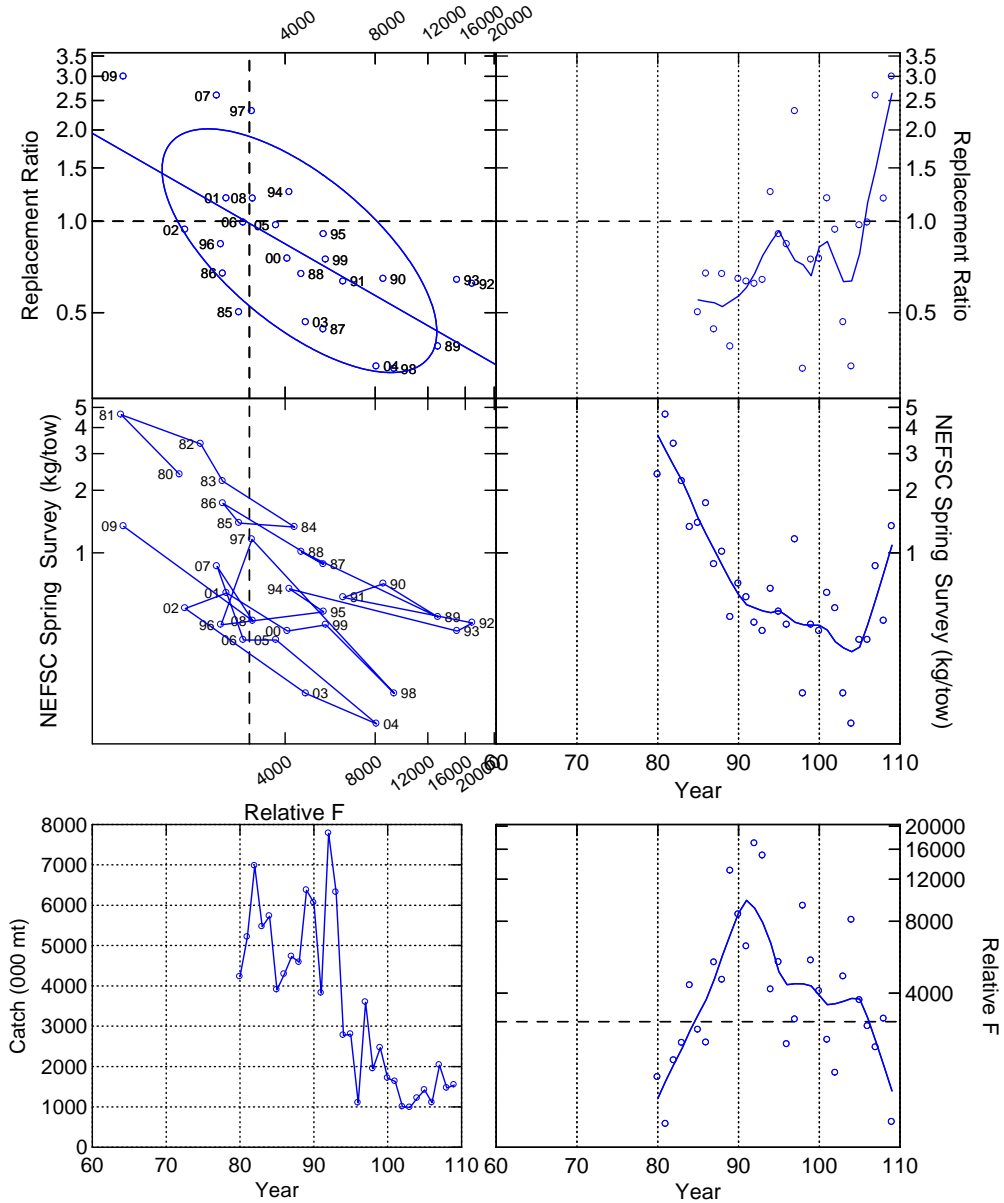


Figure C73. Six panel plot for southern red hake depicting trends in relative biomass, landings, relative fishing mortality and replacement ratios for the NEFSC spring survey index and landings based on catch method “Catch 3”, 1980-2009. Horizontal dashed lines (---) represent replacement ratios in the top two panels and the replacement F in the lower right panel. Smooth lines represent Lowess smooths (tension =0.3). The confidence ellipse in the top left panel has a nominal probability level of 0.68. The regression line in the top left panel is a robust regression using bisquare downweighting of residuals.

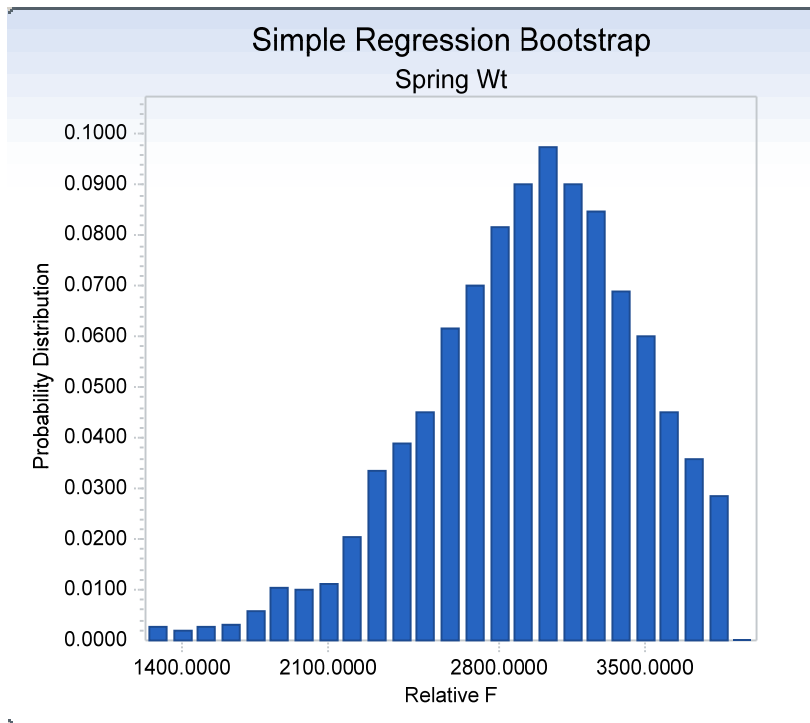
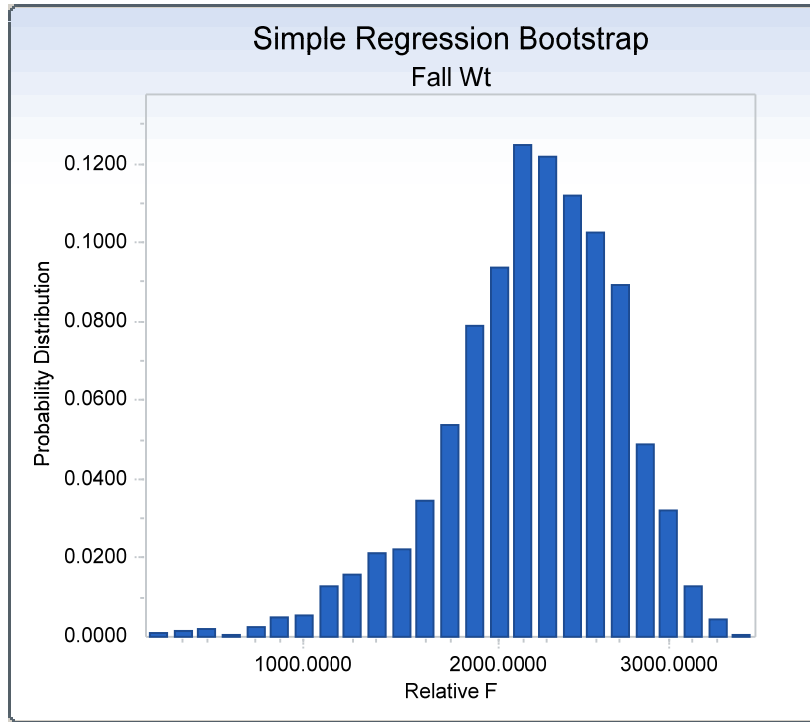


Figure C74. Randomization tests summary of sampling distribution of correlation coefficient between replacement ratio and relative F for fall (top) and spring (bottom) survey indices for southern red hake, using catch estimation method “Catch 3”, 1980-2009.

Pearson residuals, sexes combined, whole catch, FALL (max=4266.18)

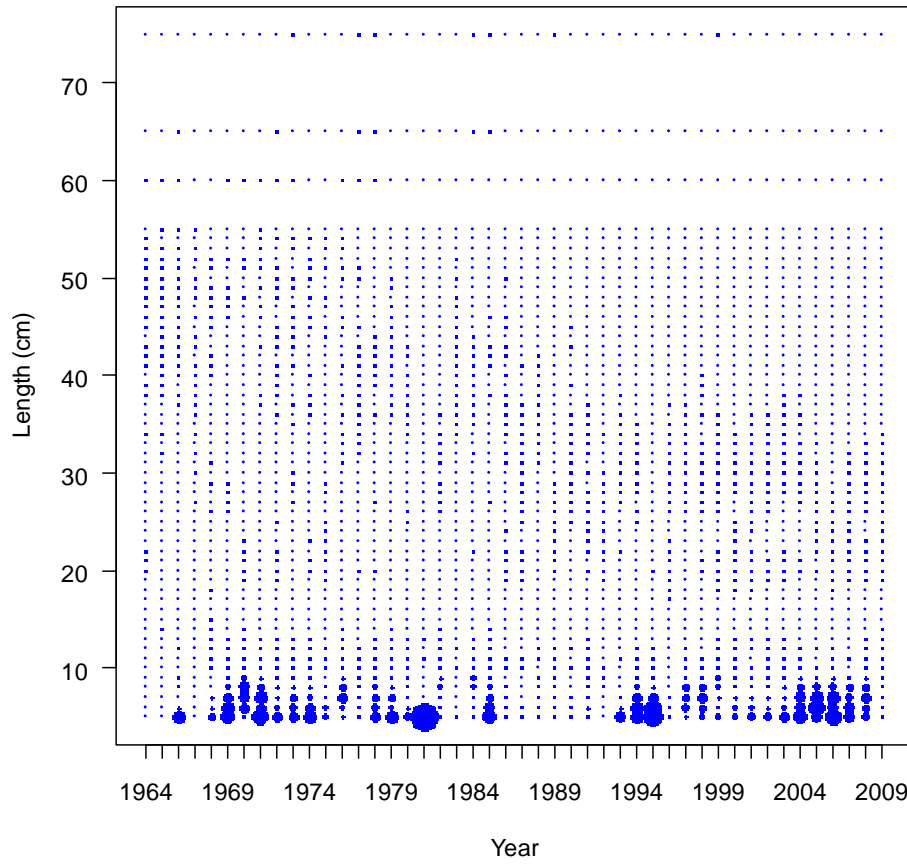


Figure C75. Residuals from SS3 run with the entire length composition for the fall survey.

length comps, sexes combined, whole catch, LANDINGS

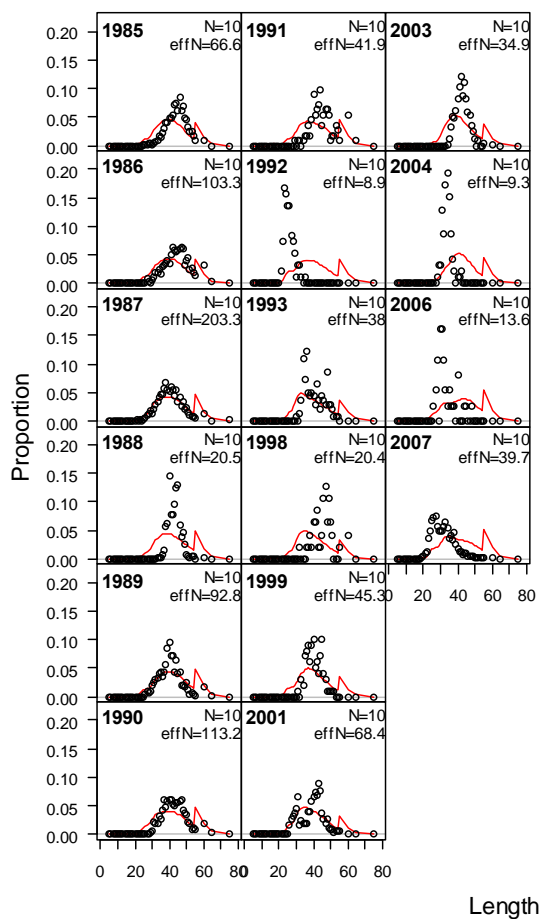


Figure C76. Fits to the length composition of the commercial landings with data pooled above 55 cm.

length comps, sexes combined, whole catch, LANDINGS

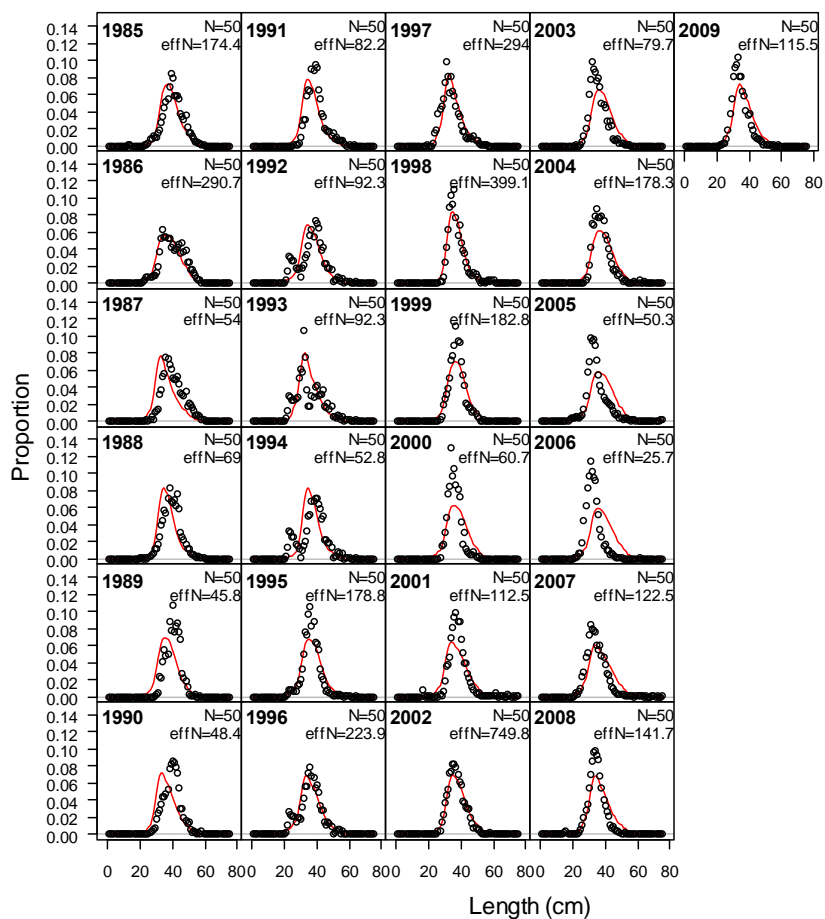


Figure C77. Fits to the length composition of the commercial landings data unpooled.

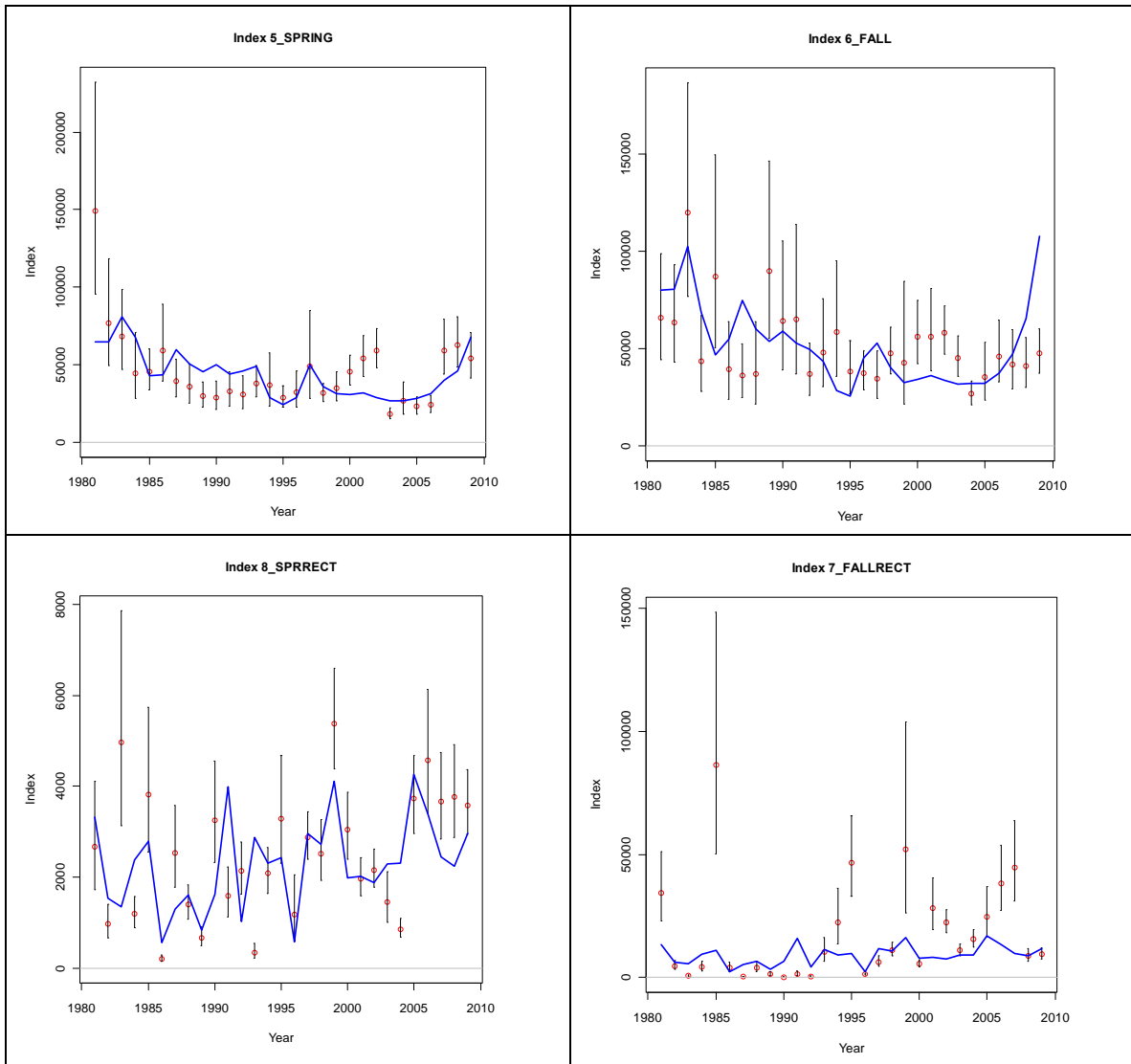


Figure C78. Fits to the survey indices from a final model run.

length comps, sexes combined, whole catch, CONS

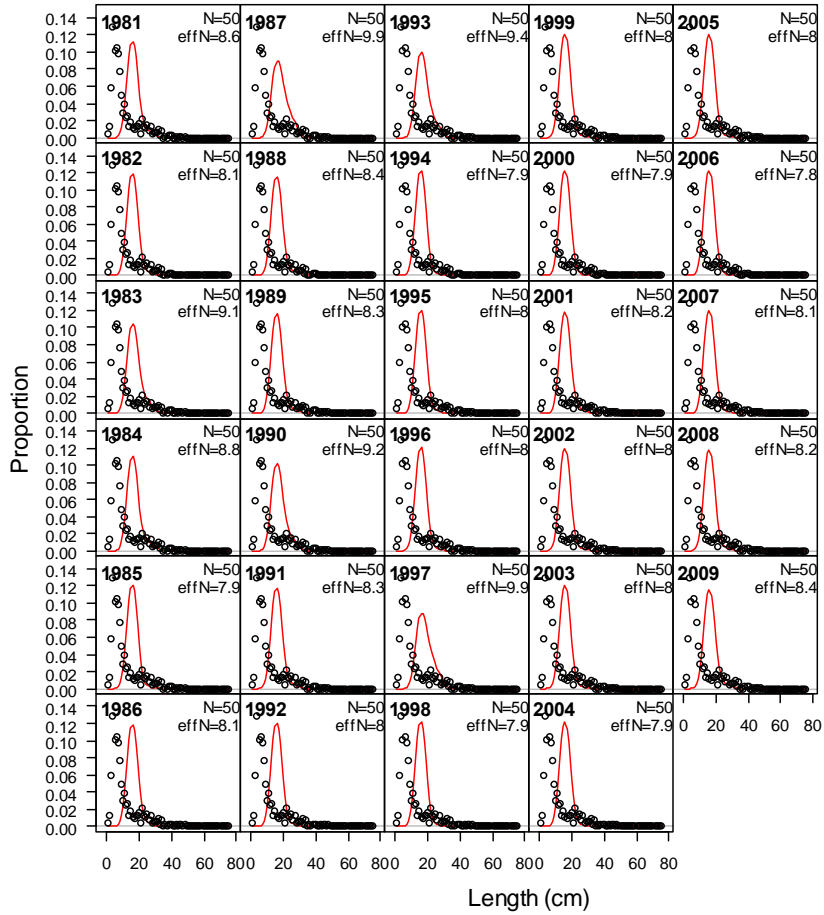


Figure C79. Fits to the length composition of the consumption.

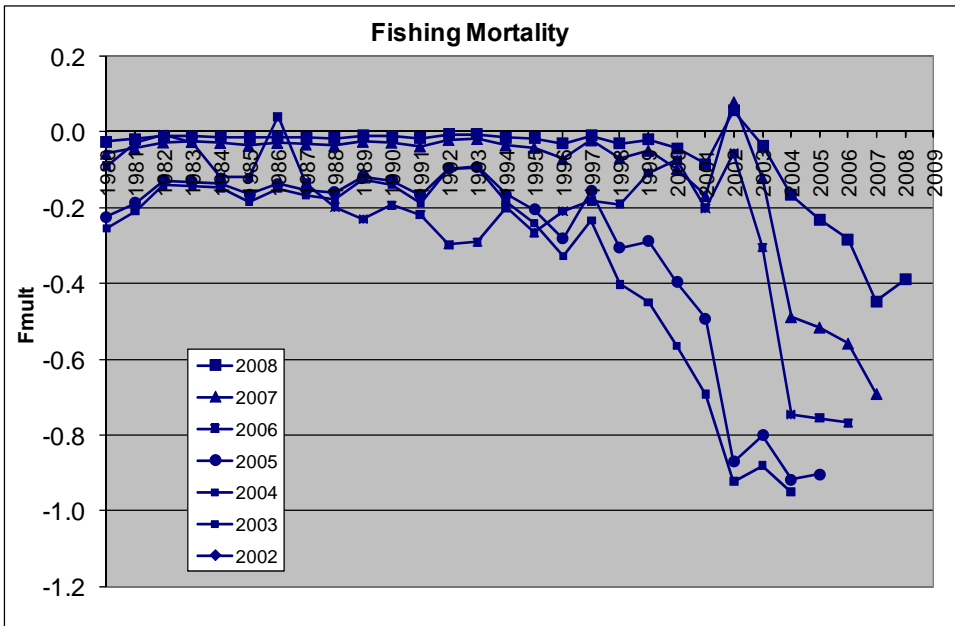
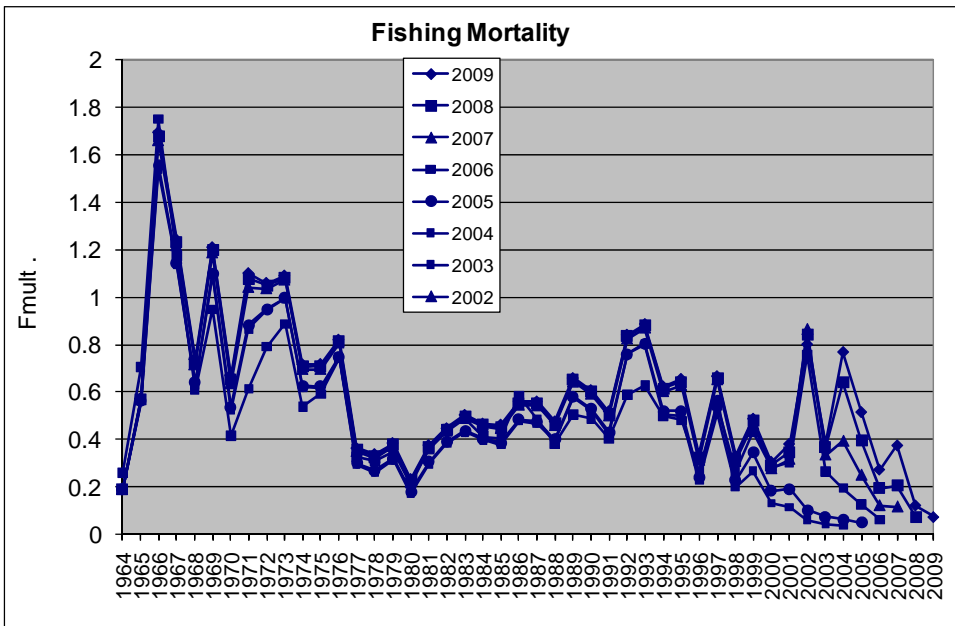


Figure C80a. Fishing mortality retrospective pattern of final SCALE model run.

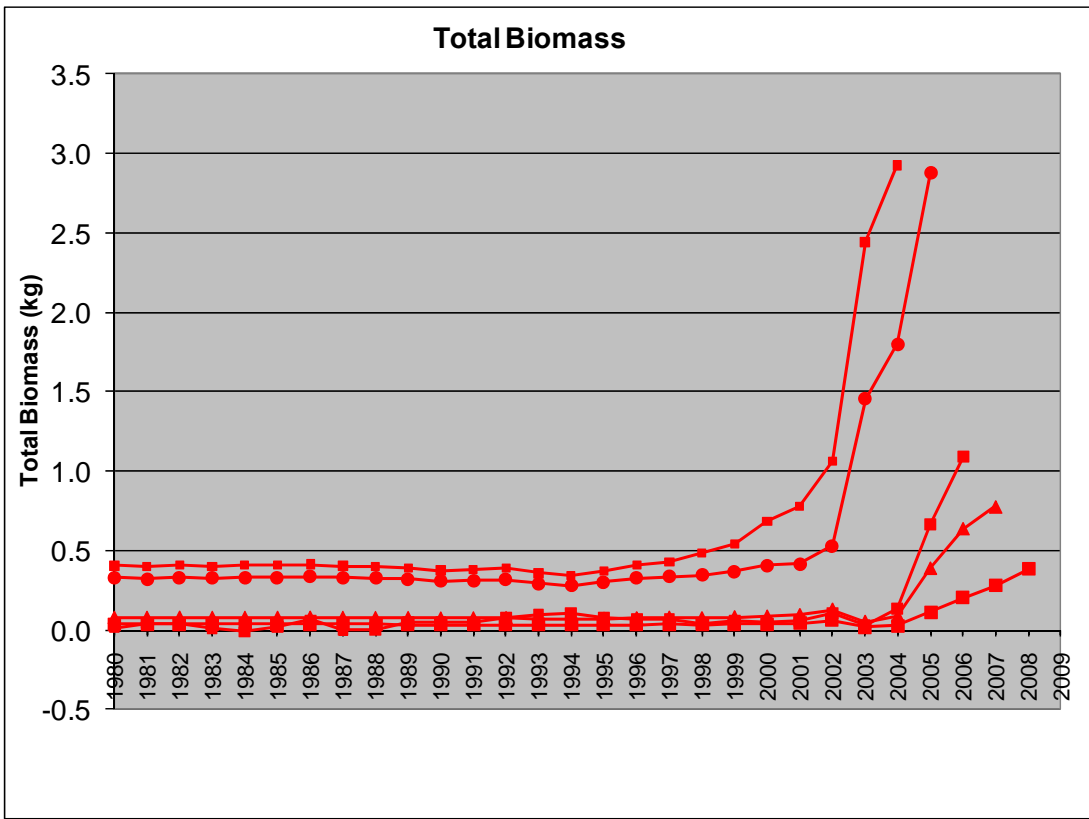
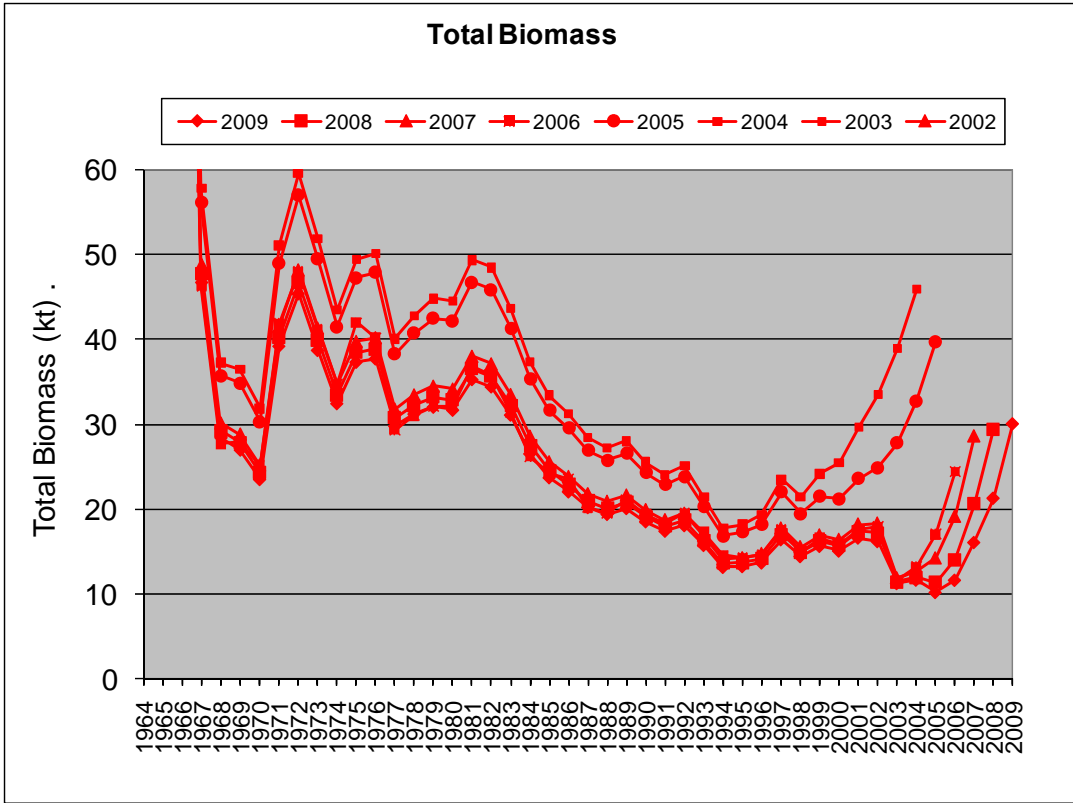


Figure C80b. Total biomass retrospective pattern of final SCALE model run.

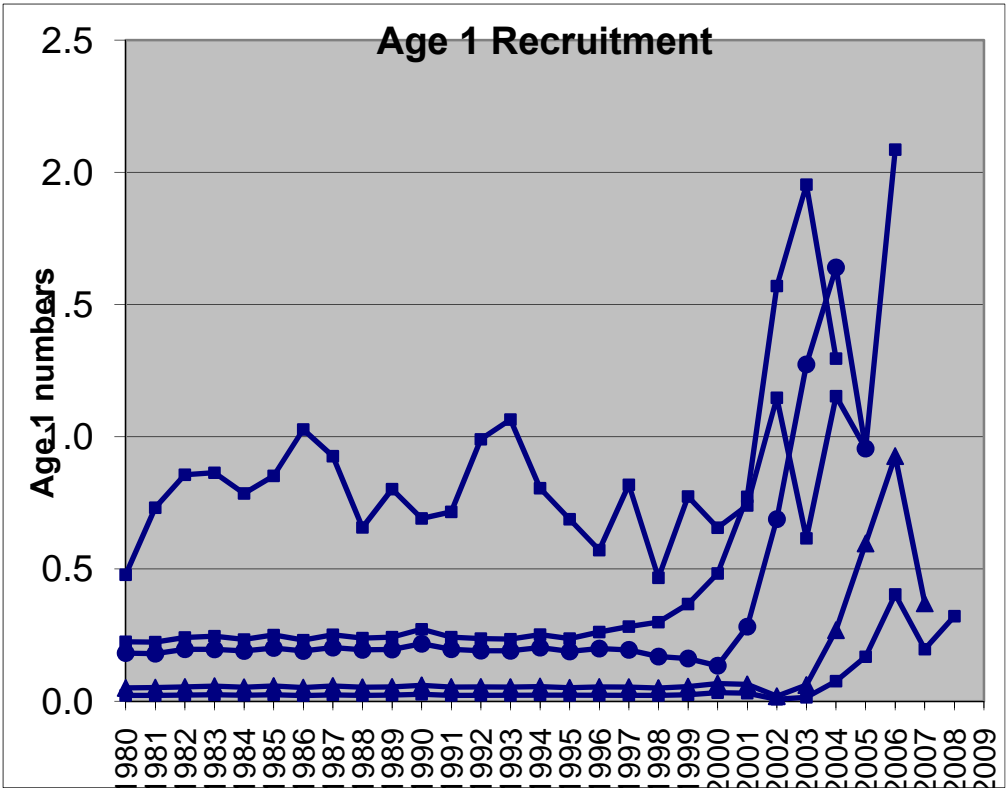
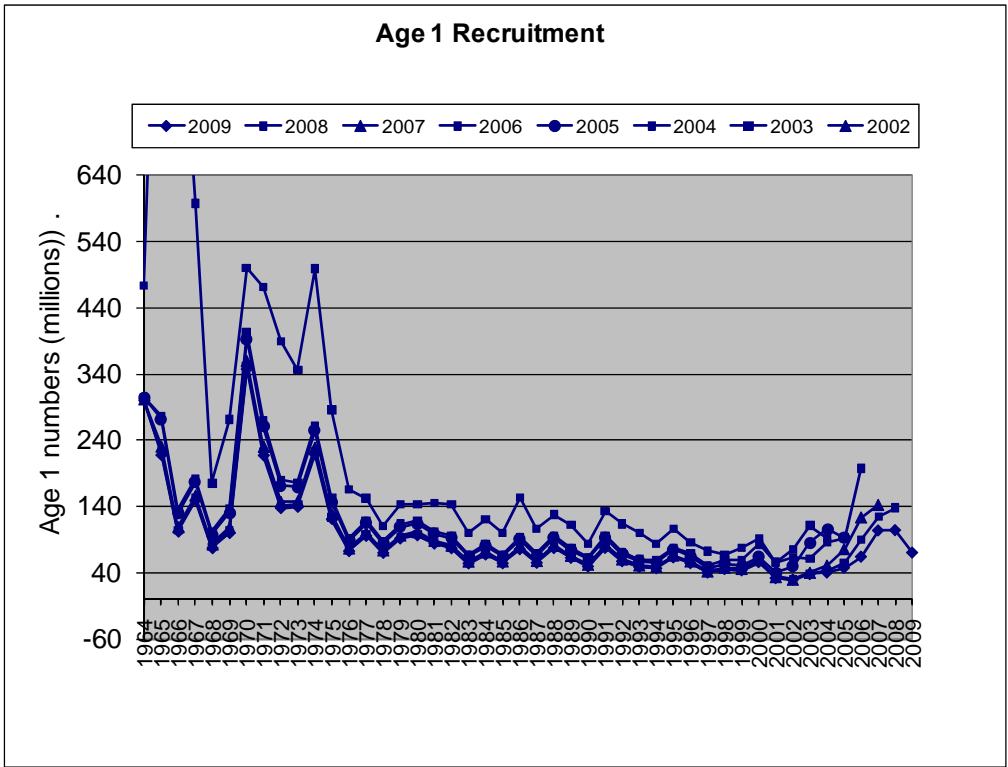


Figure C80c. Recruitment retrospective pattern of final SCALE model run.

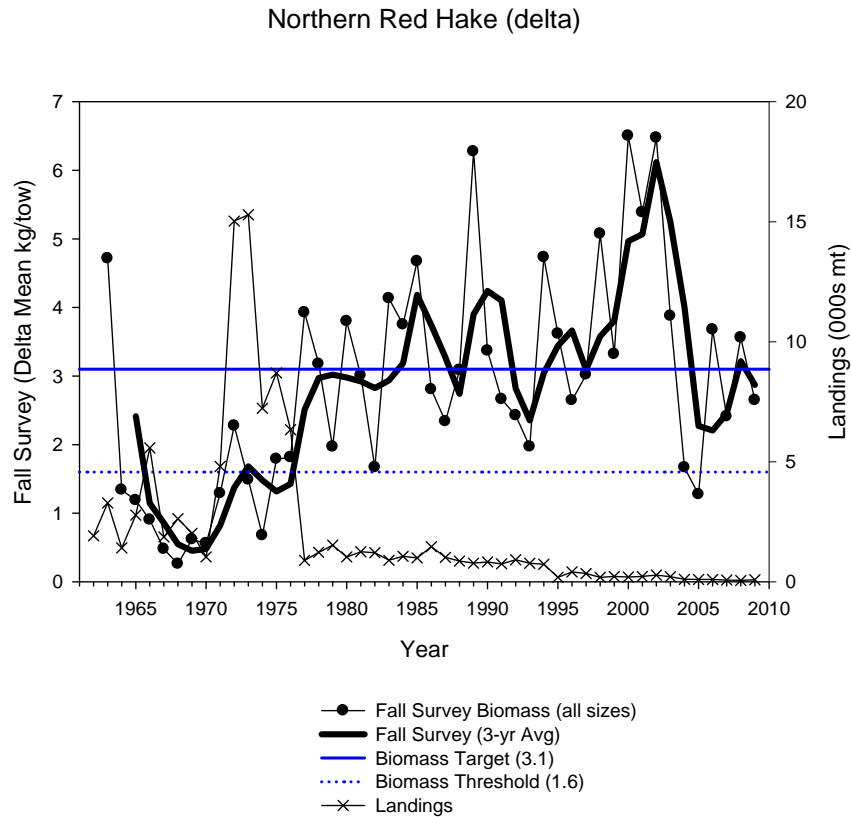


Figure C81. Fall survey biomass (delta transformation) and current BRPs (as opposed to “proposed” BRPs) for the northern stock of red hake.

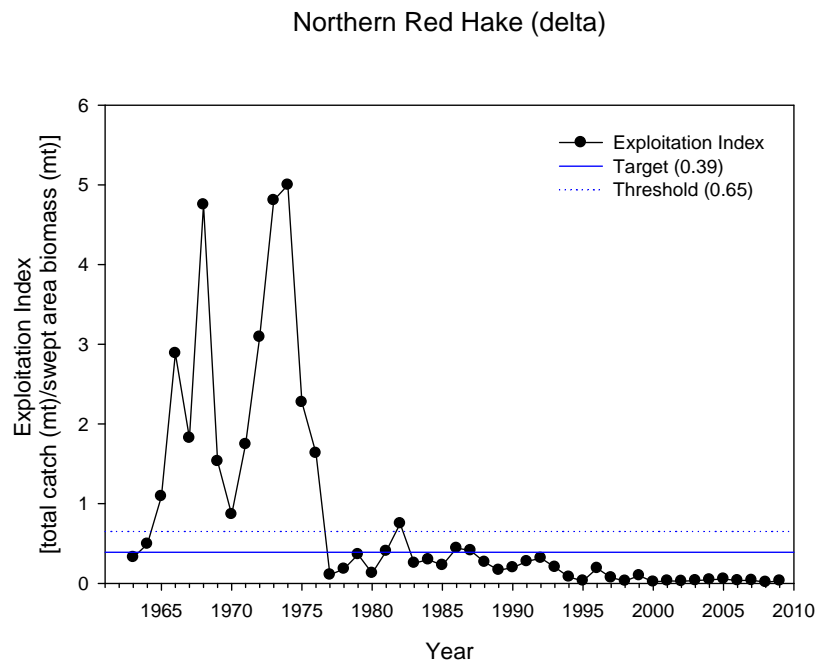


Figure C82. Exploitation Indices (delta transformation of fall survey) and current BRPs (as opposed to “proposed” BRPs) for the northern stock of red hake.

Southern Red Hake (delta)

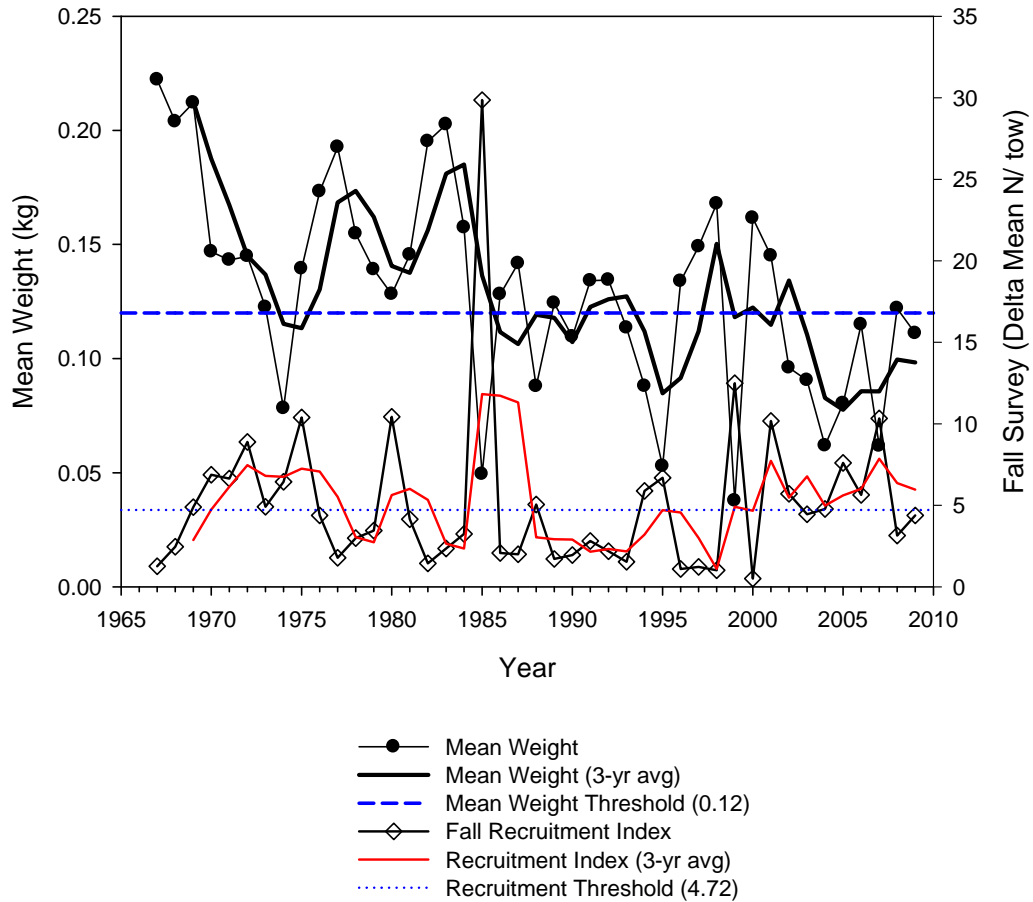


Figure C83. Mean individual weight (kg)/tow and recruitment index (Number of fish <25cm) from the NEFSC fall survey for the southern stock of red hake. Also shown are current BRP thresholds.

Northern Red Hake

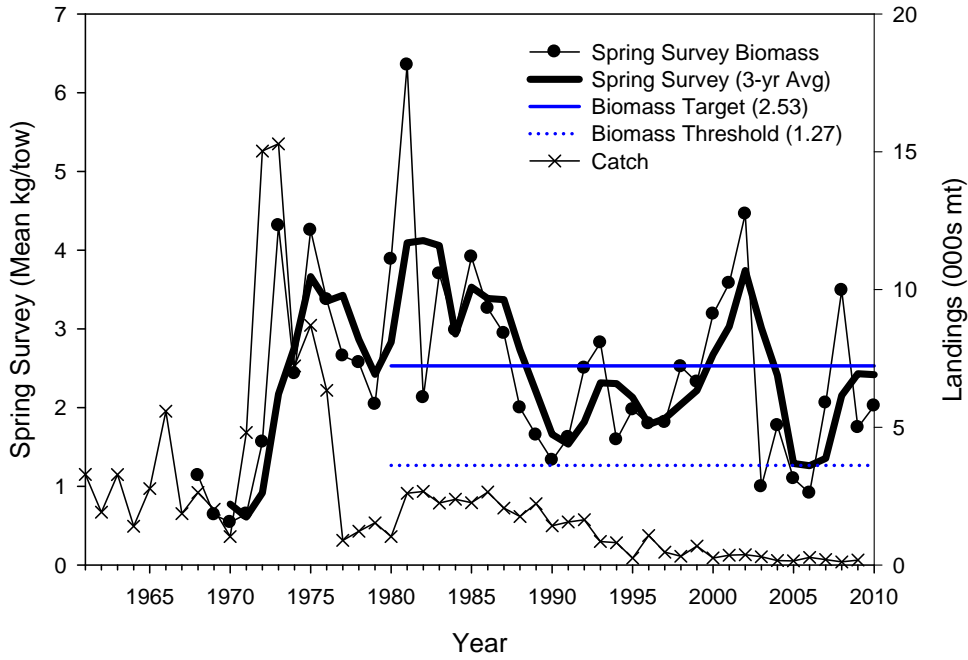


Figure C84. Spring survey biomass and newly proposed BRPs for the northern stock of red hake.

Northern Red Hake

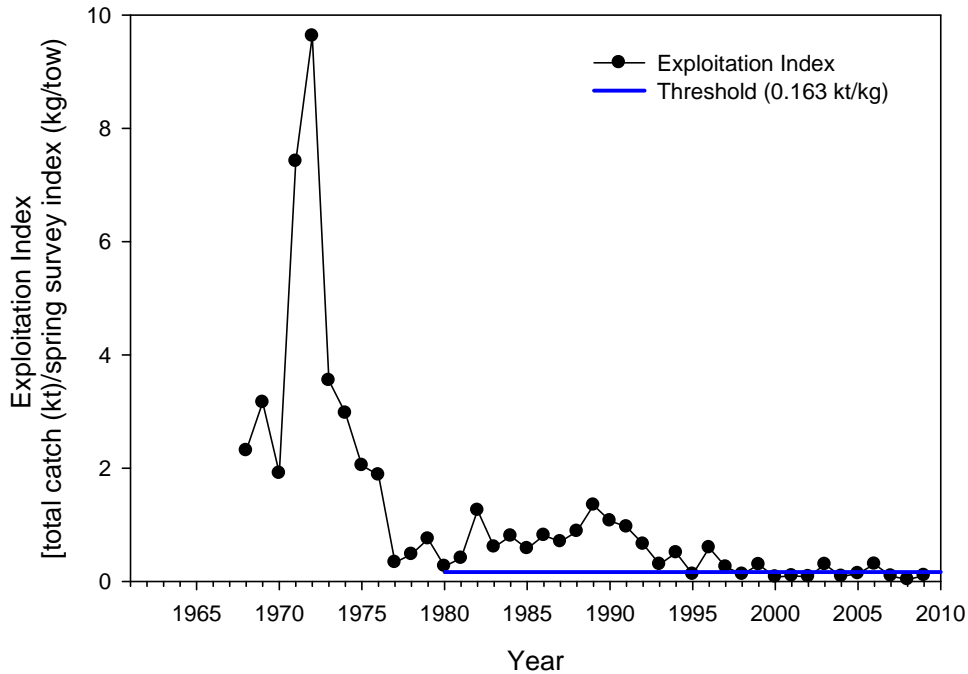


Figure C85. Exploitation indices (spring survey) and newly proposed overfishing threshold for the northern stock of red hake.

Southern Red Hake

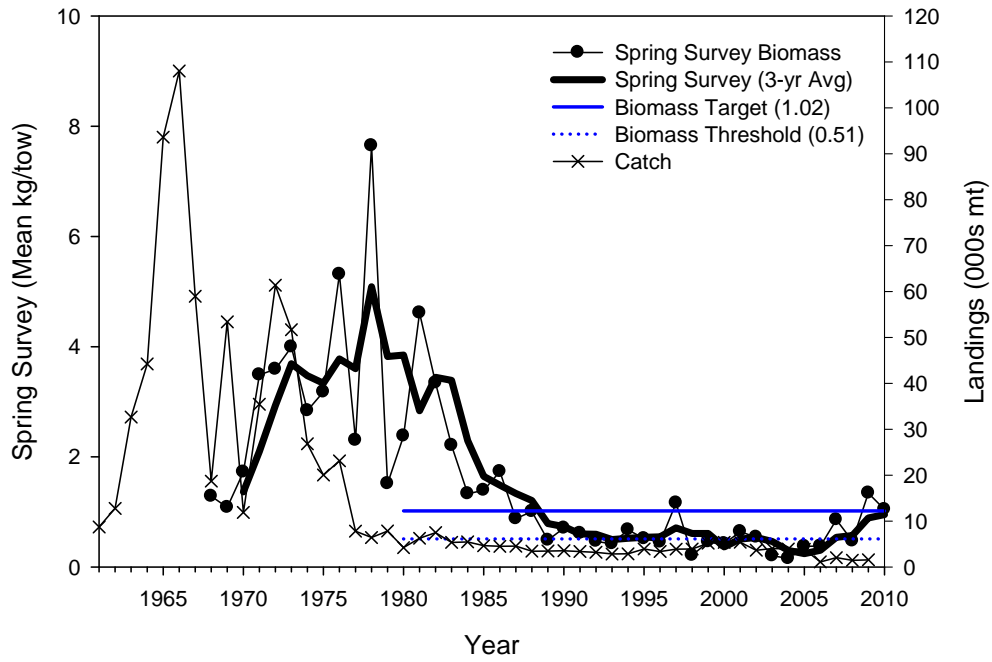
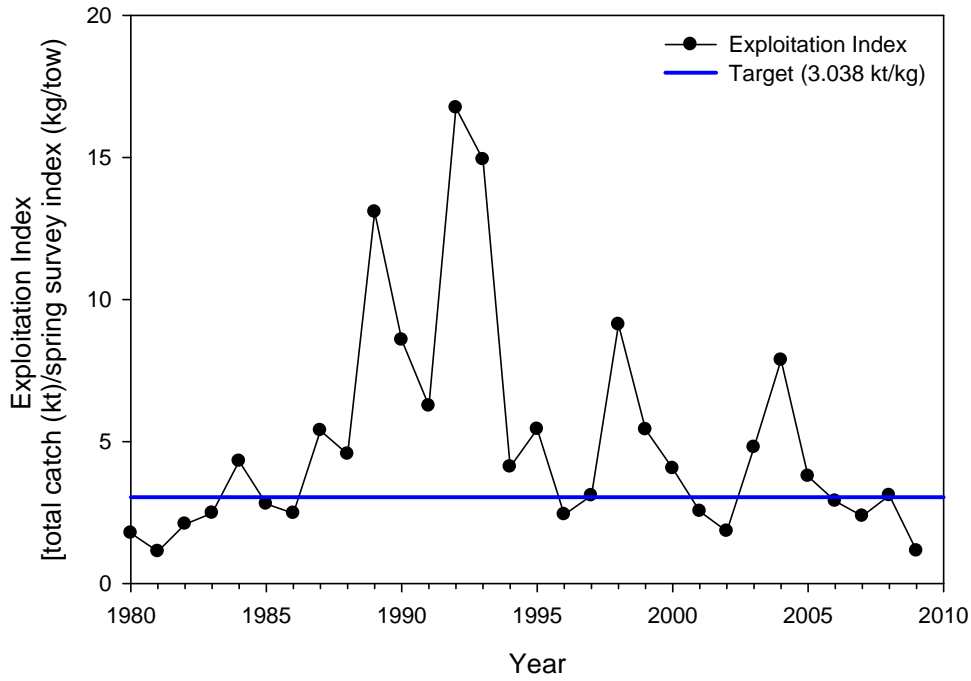


Figure C86. Spring survey biomass and newly proposed BRPs for the southern stock of red hake.

Southern Red Hake



Southern Red Hake

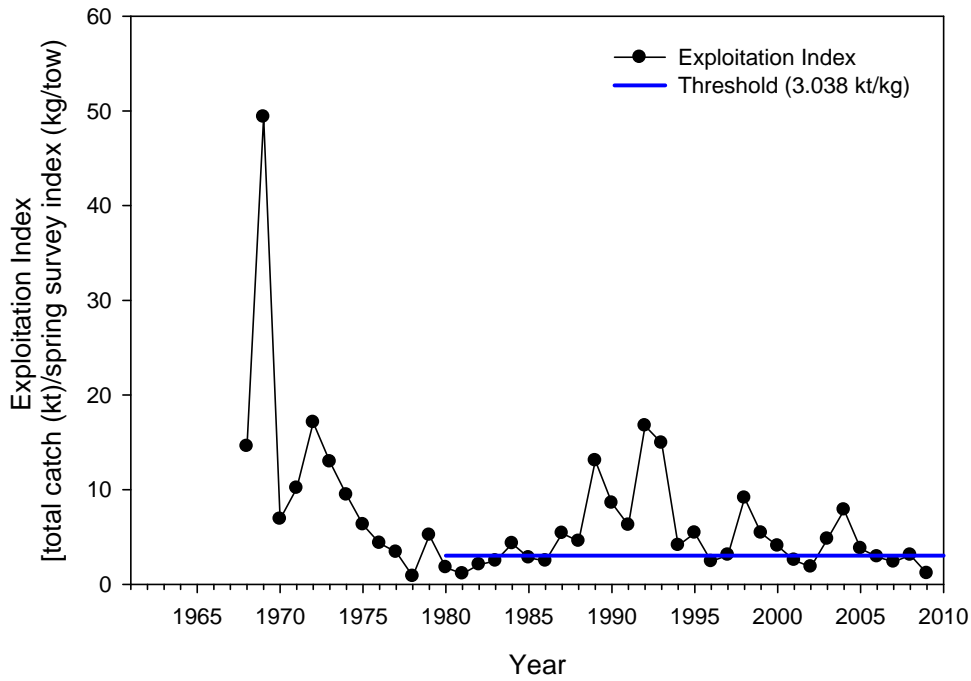


Figure C87. Exploitation indices (spring survey) and newly proposed overfishing threshold for the southern stock of red hake.