# FIGURES

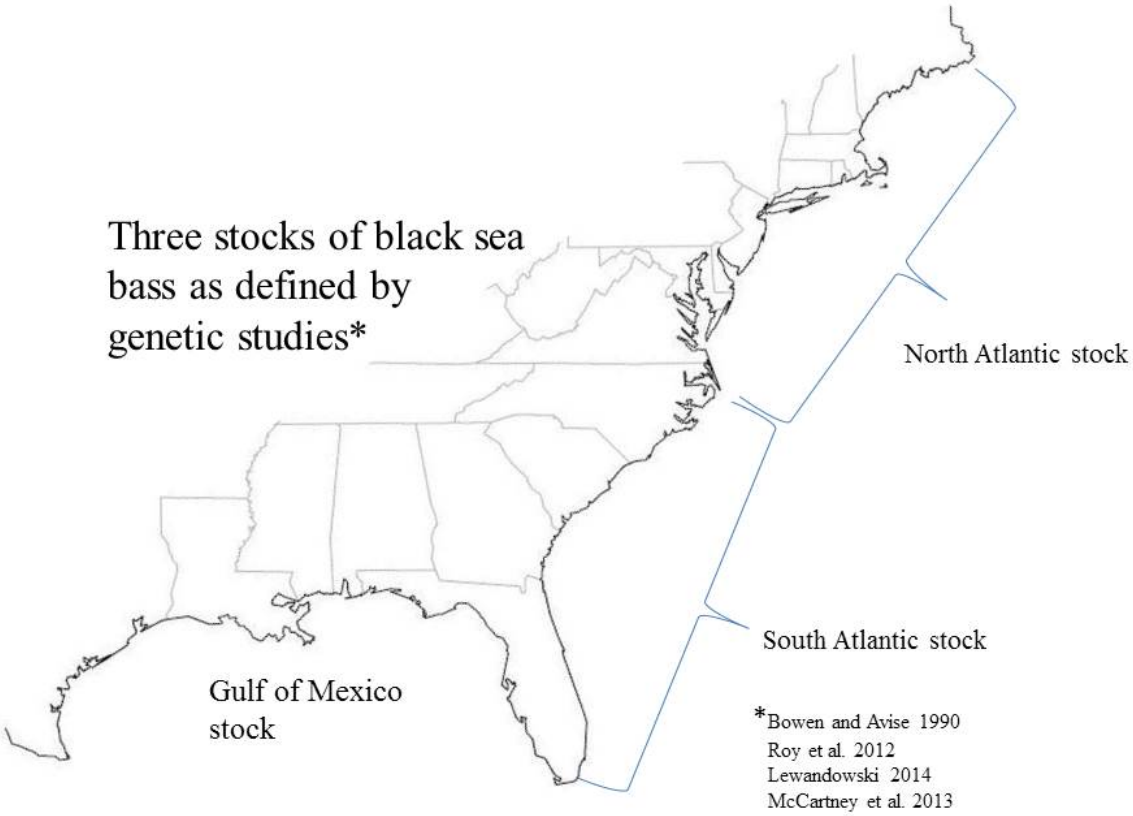


Figure A1. Map of geographic boundaries for three black sea bass stocks in United States.

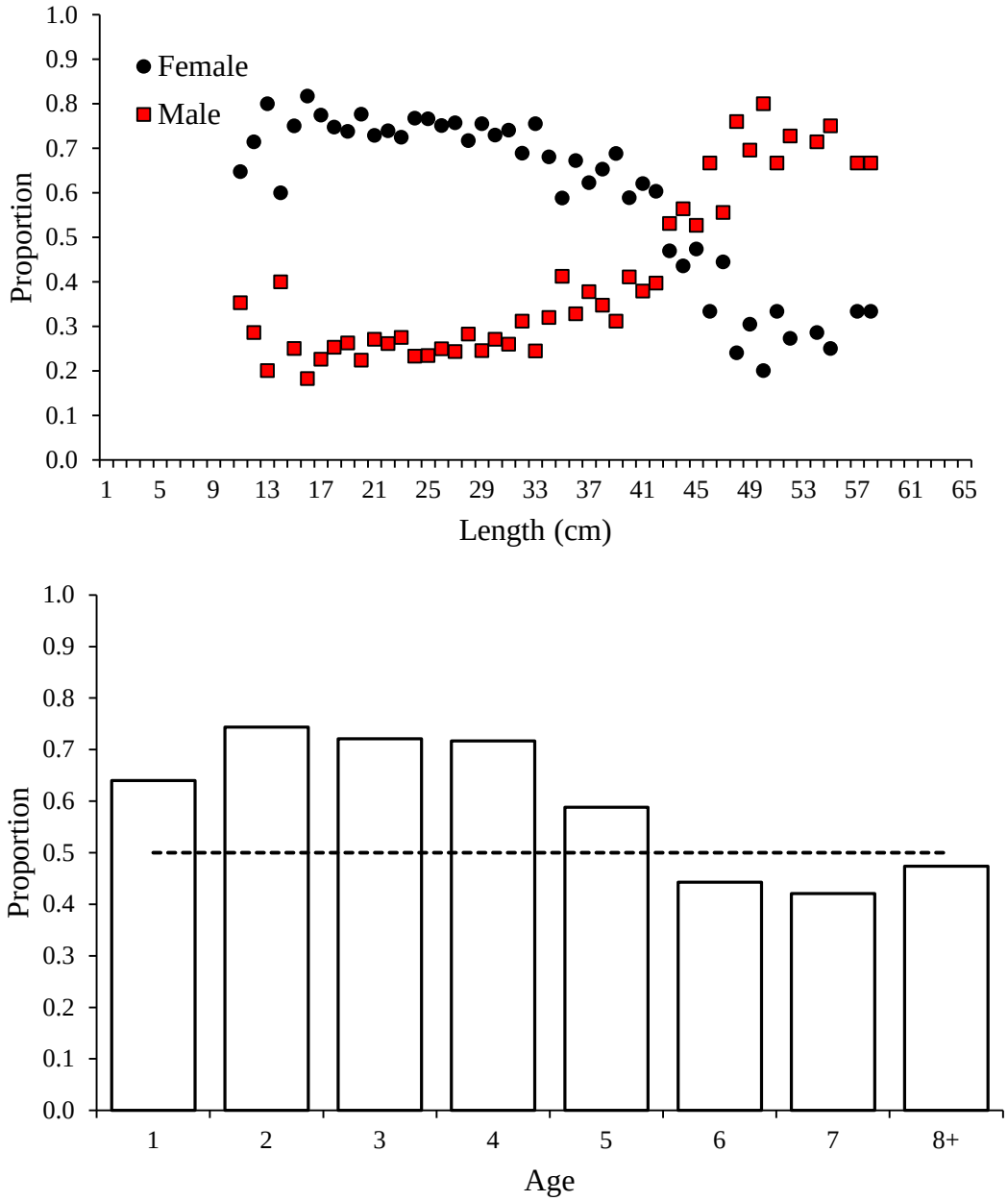


Figure A2. Black sea bass sex ratio at length and proportion female at age from NEFSC spring and winter surveys, 1984-2015.

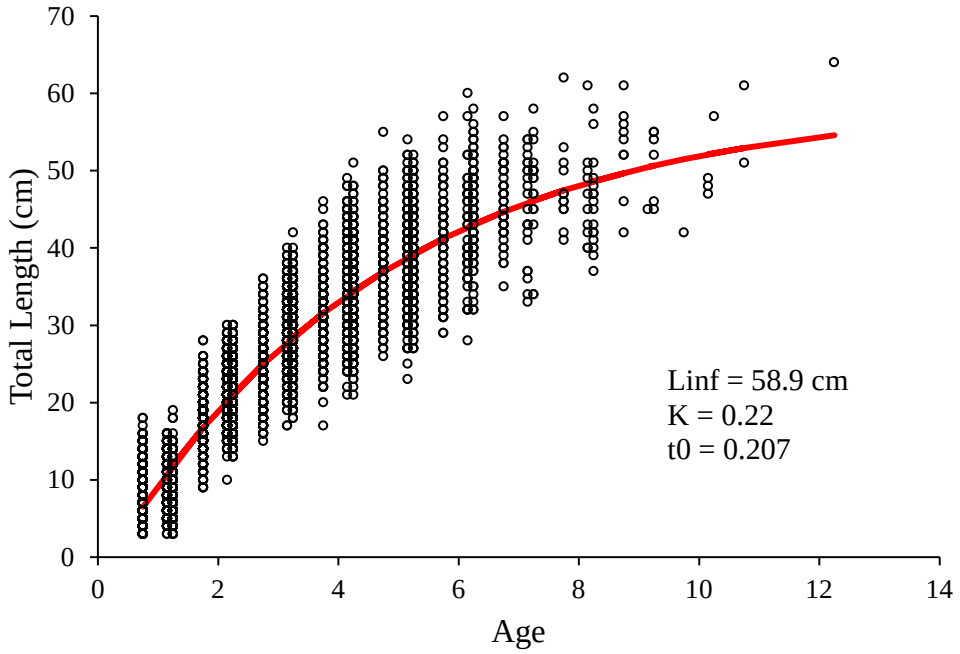


Figure A3. Black sea bass von Bertalanffy growth curve, all regions and sexes combined.

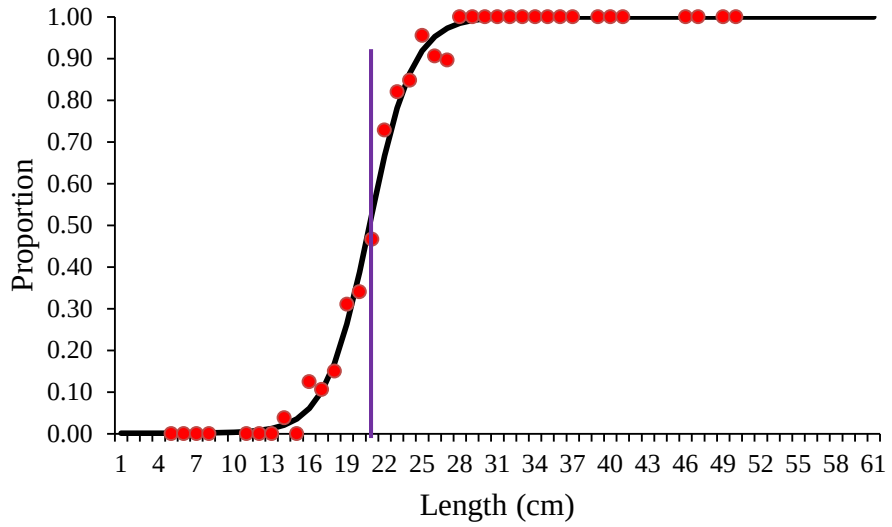


Figure A4. Black sea bass maturity at length from NEFSC spring and winter bottom trawl survey data, 1989-2015.

Figure A5. Black sea bass age at maturity from NEFSC spring and winter bottom trawl survey data, 1989-2015.

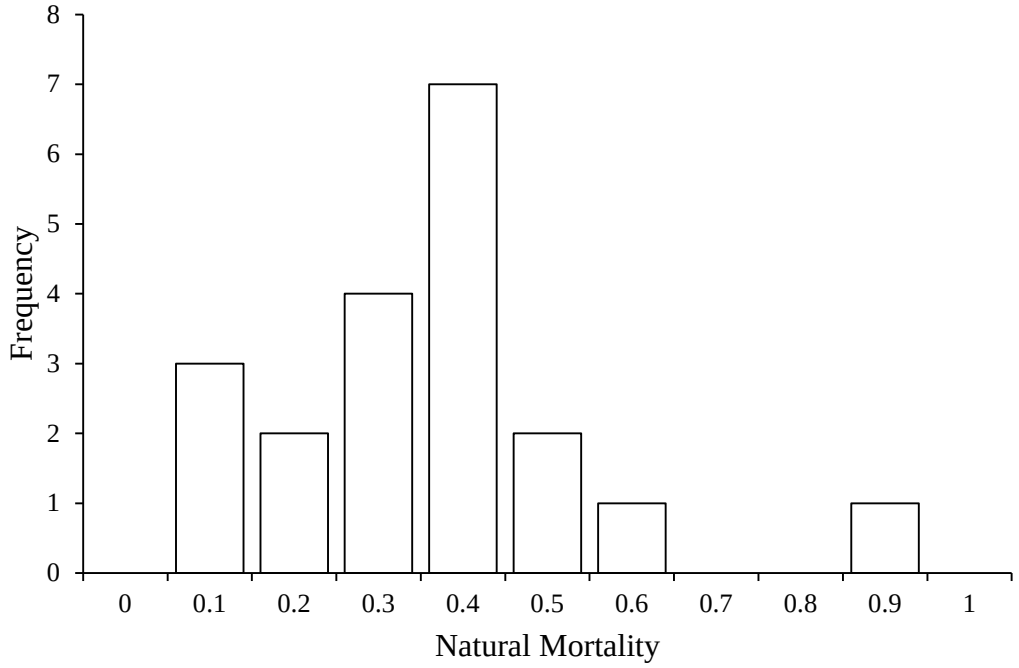


Figure A6. Frequency of natural mortality estimates from a variety of methods (see also Table A2).

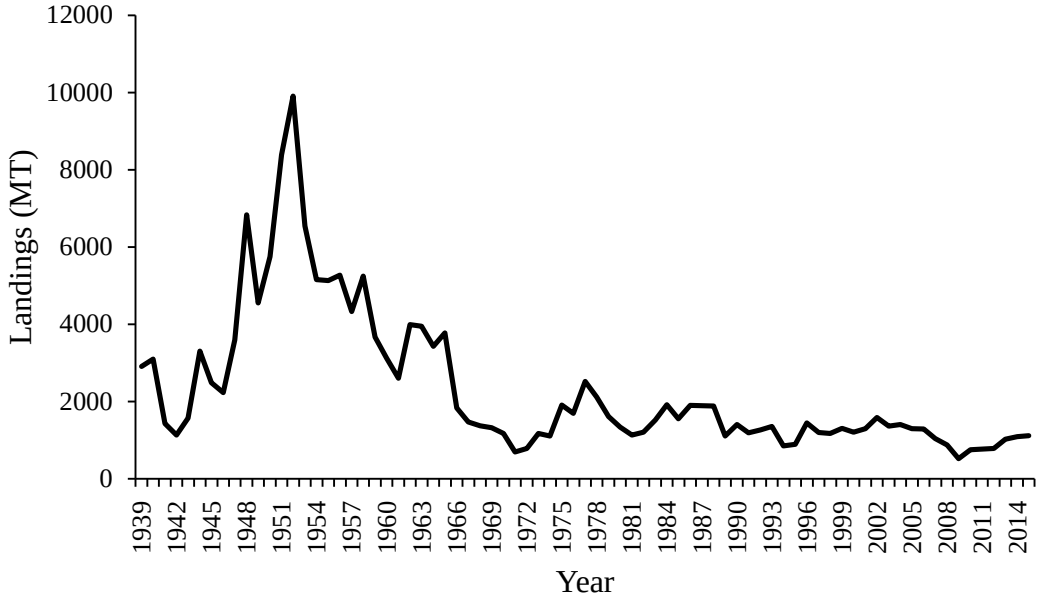


Figure A7 . Commercial landing time series for the North Atlantic stock of black sea bass.

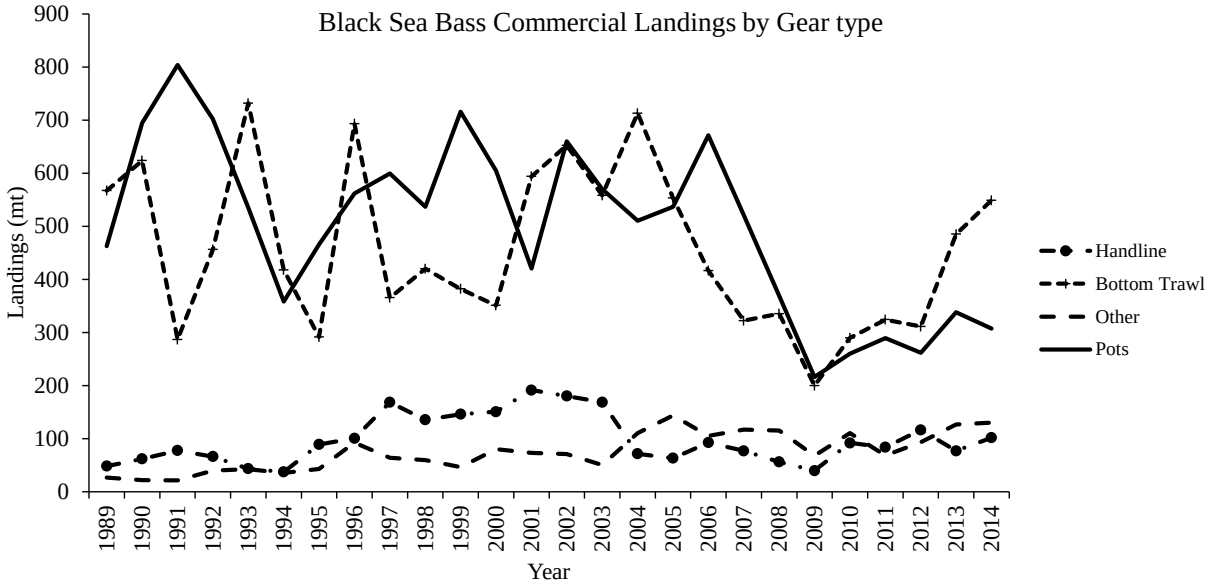


Figure A8. Black sea bass commercial landings by gear type, 1989-2015.

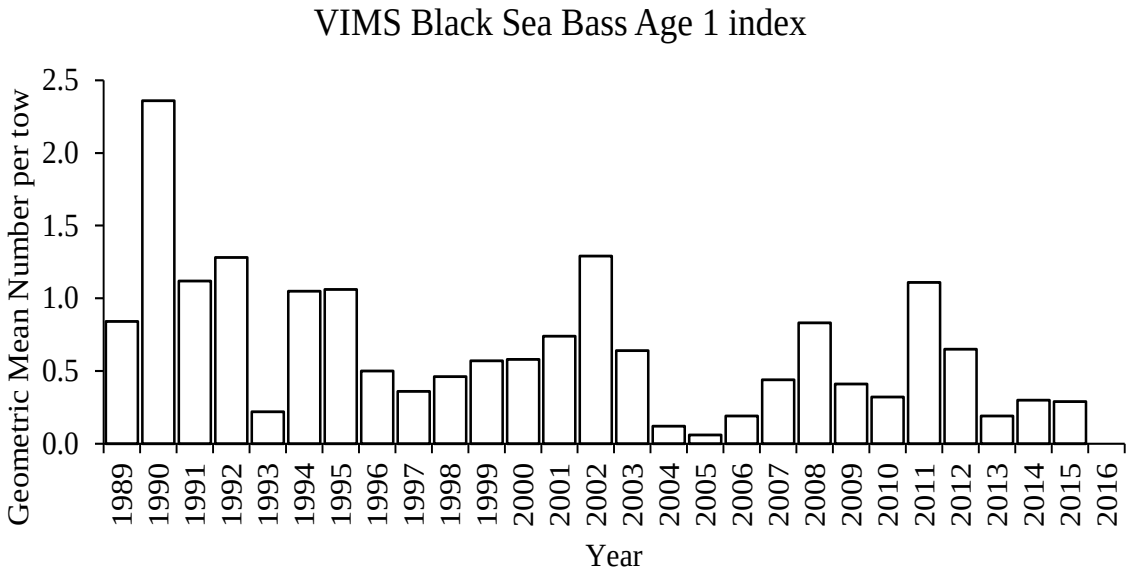


Figure A9 Black sea bass age one indices of abundance from VIMS spring trawl survey in Chesapeake Bay, 1989-2013.

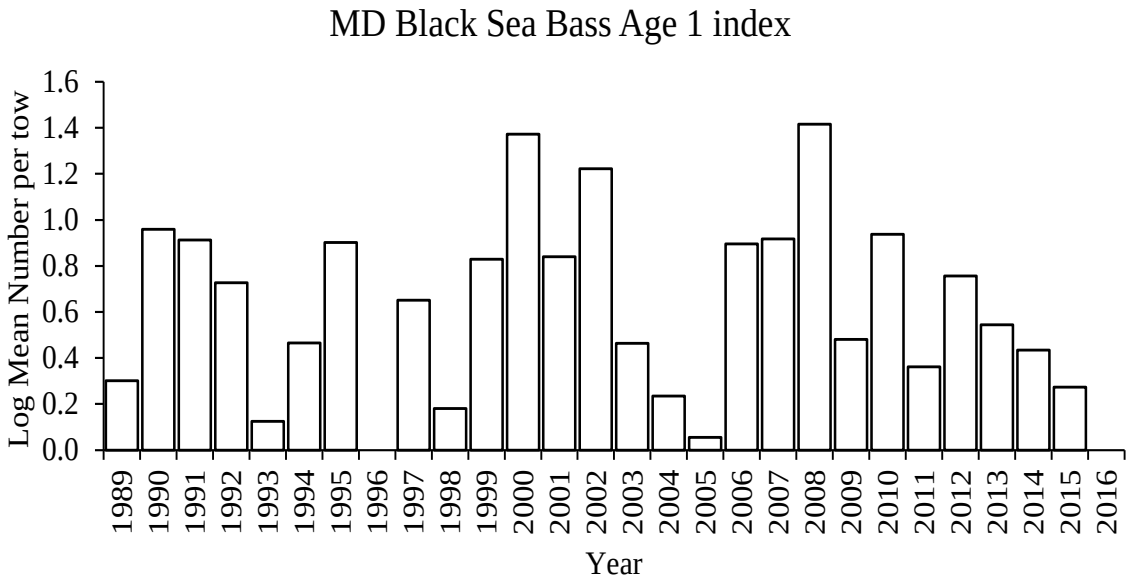


Figure A10. MD DNR trawl survey index of black sea bass age one indices of abundance in Maryland coastal bays, 1989-2015.

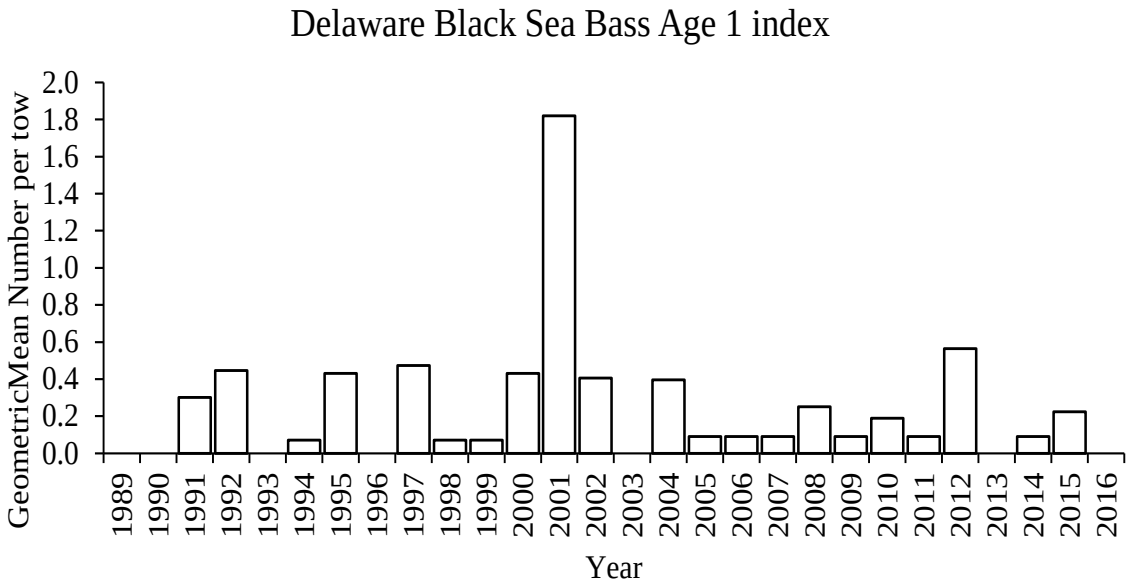


Figure A11. DE DFW trawl survey indices of black sea bass age one abundance in Delaware Bay, 1989-2015.

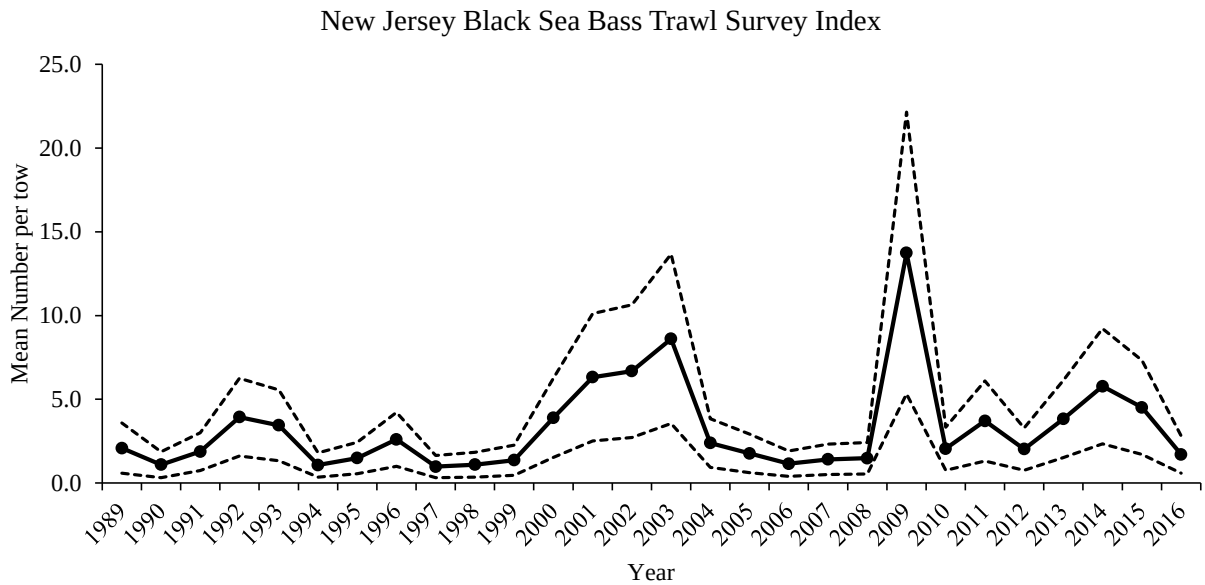


Figure A12. NJ DEM trawl survey indices (± 95% CI) of black sea bass abundance, age 1-8+ collected in coastal New Jersey, 1989-2016.

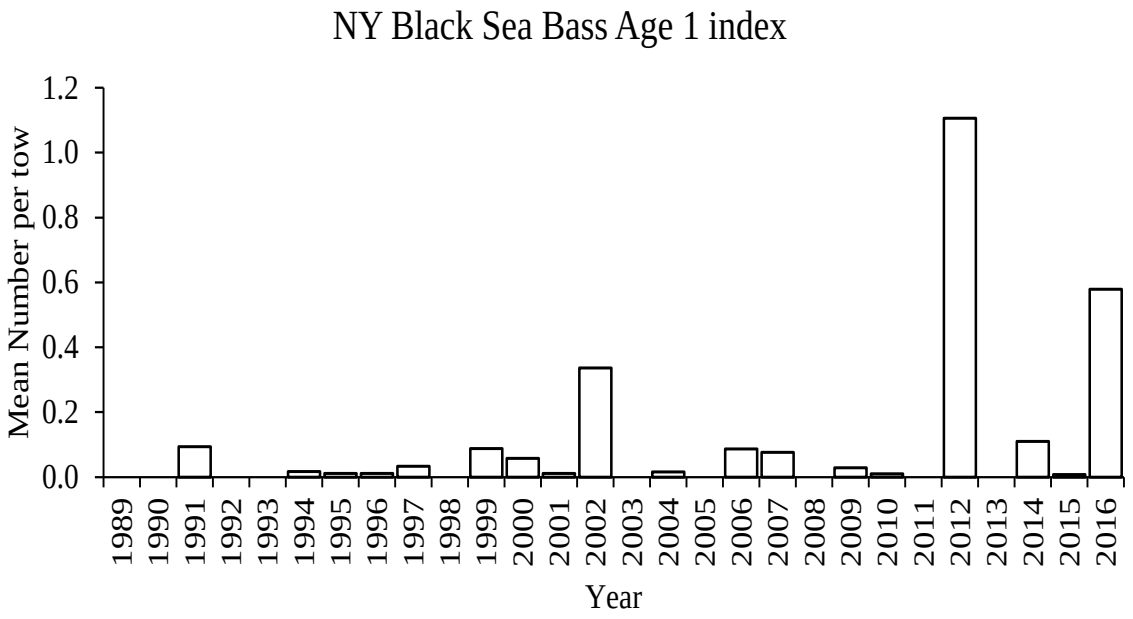


Figure A13. NY DEC spring trawl survey indices of black sea bass age one abundance collected in Peconic Bay, Long Island, 1989-2016.

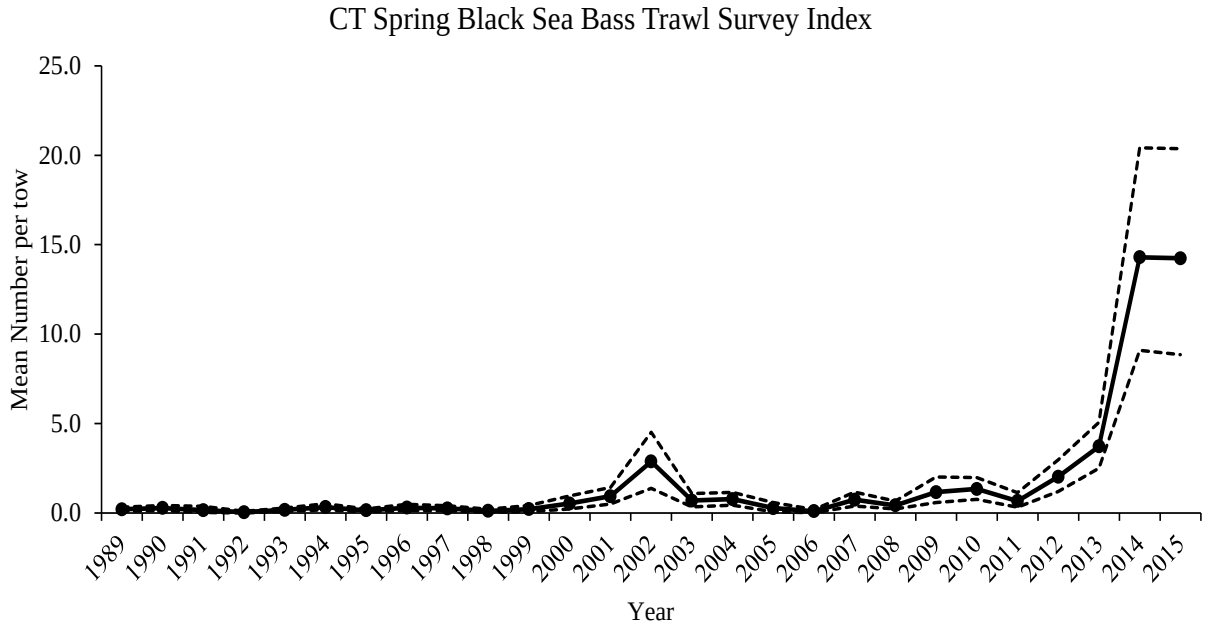


Figure A14. CT DEEP spring trawl survey indices (± 95% CI) of black sea bass, ages1-8+, collected in Long Island Sound, 1989-2015.

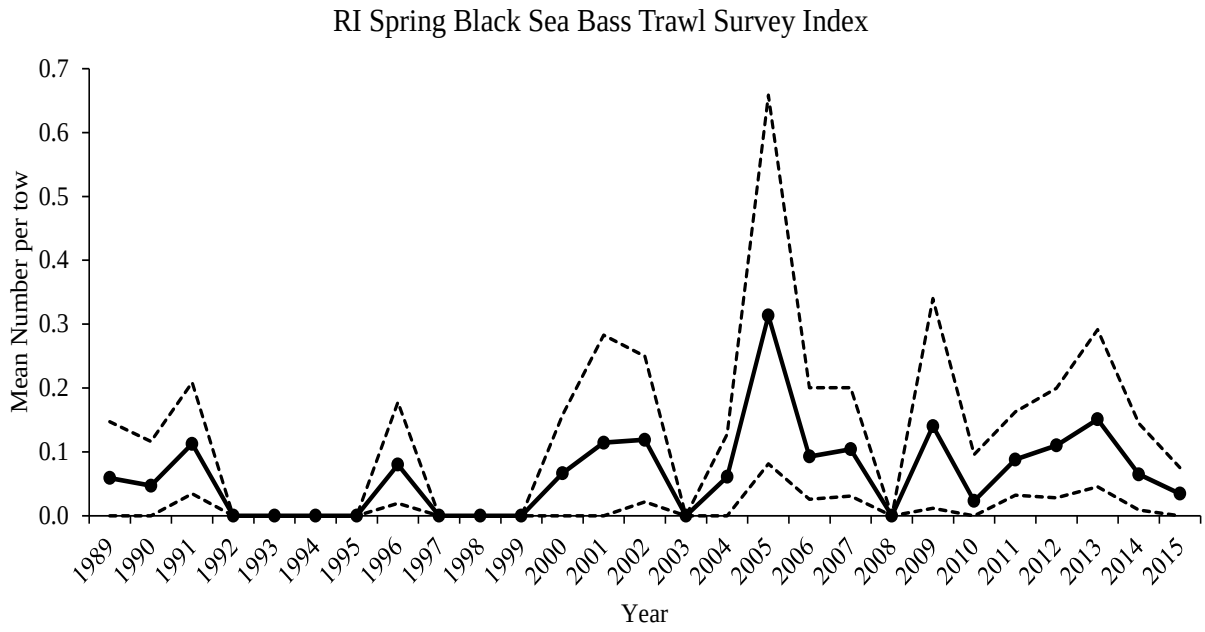


Figure A15. RI DEM spring trawl survey indices (± 95% CI) of black sea bass, ages1-8+, collected in Narragansett Bay, 1989-2015.

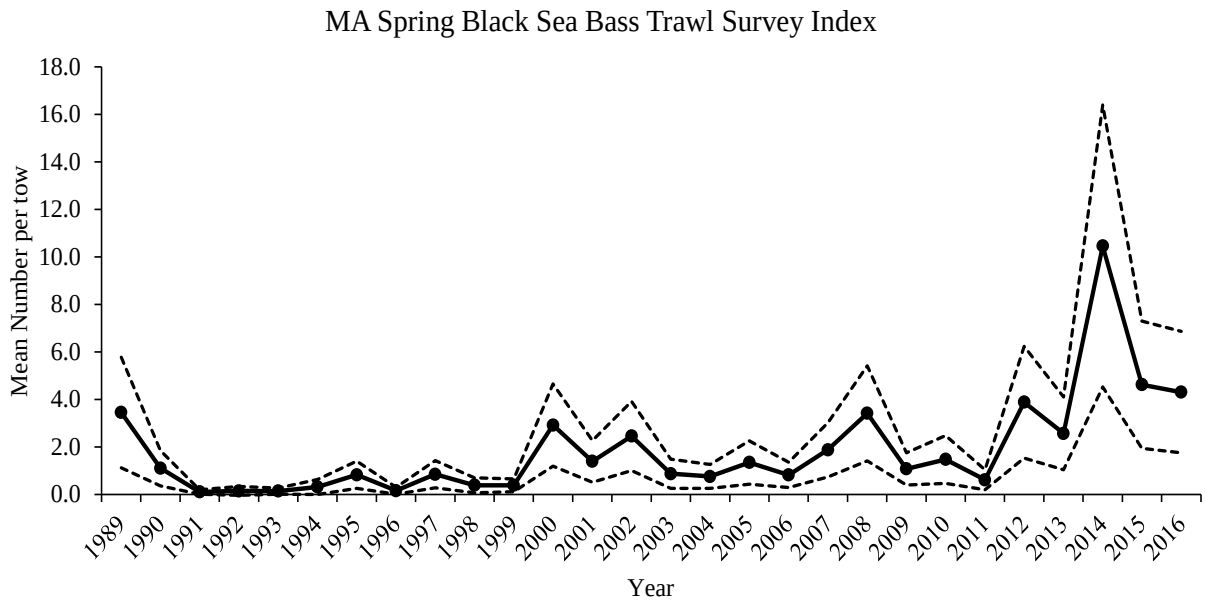


Figure A16. MA DMF spring trawl survey indices (± 95% CI) of black sea bass, ages1-8+, collected in south coastal Massachusetts, 1989-2015.

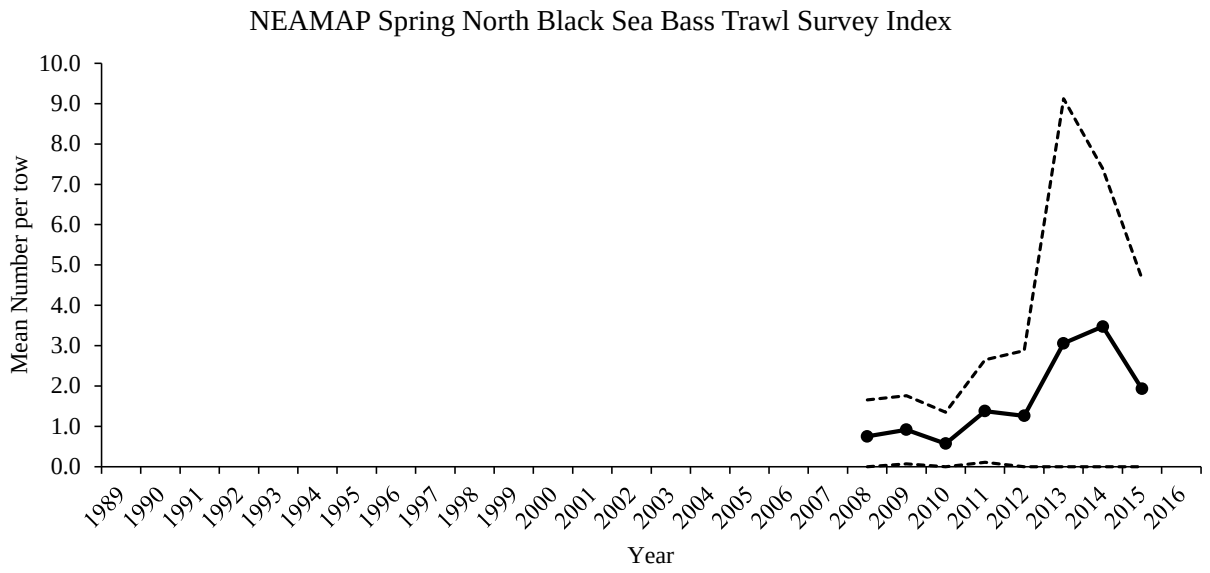


Figure A17. NEAMAP spring trawl survey indices (± 95% CI bounded by 0) of black sea bass abundance, ages 1-8+ collected in coastal strata north of Hudson Canyon, 2008-2015.

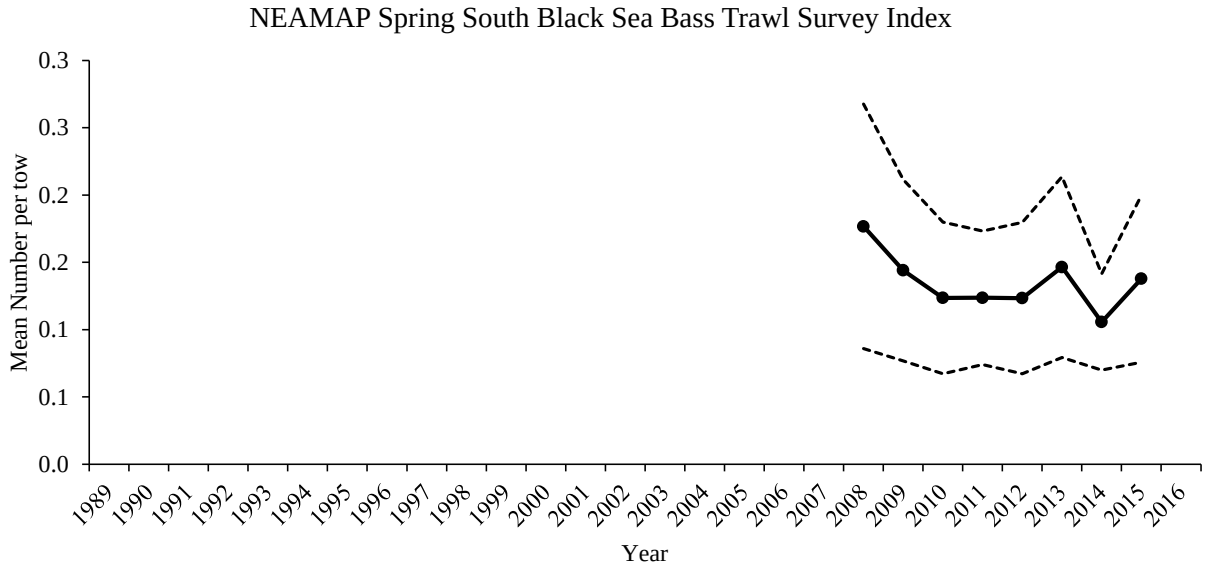


Figure A18. NEAMAP spring trawl survey indices (± 95% CI) of black sea bass abundance, ages 1-8+ collected in coastal strata south of Hudson Canyon, 2008-2015.

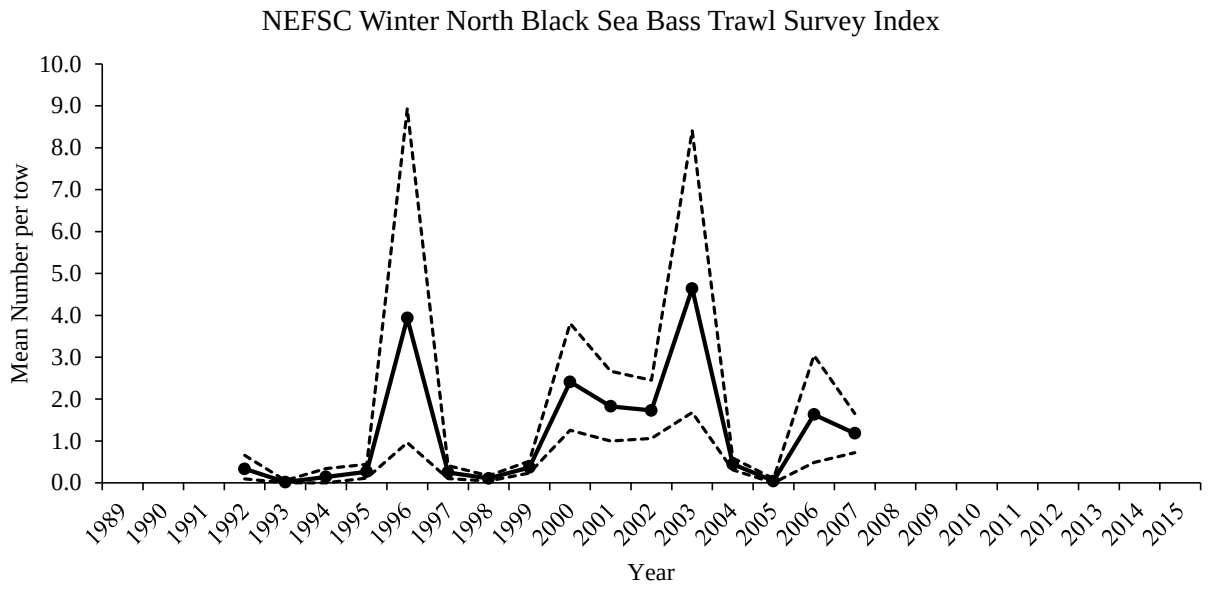


Figure A19. NEFSC winter trawl survey indices (± 95% CI) of black sea bass abundance, ages 1-8+ collected in offshore strata north of Hudson Canyon 1992-2007.

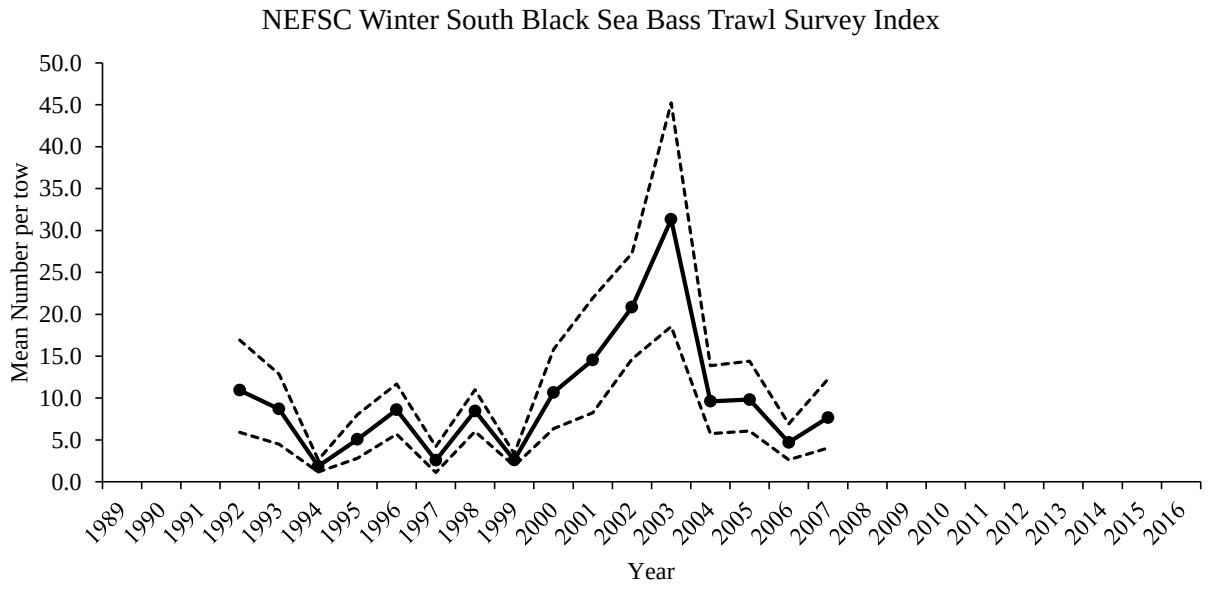


Figure A20. NEFSC winter trawl survey indices (± 95% CI) of black sea bass abundance, ages 1-8+ collected in offshore strata south of Hudson Canyon 1992-2007.

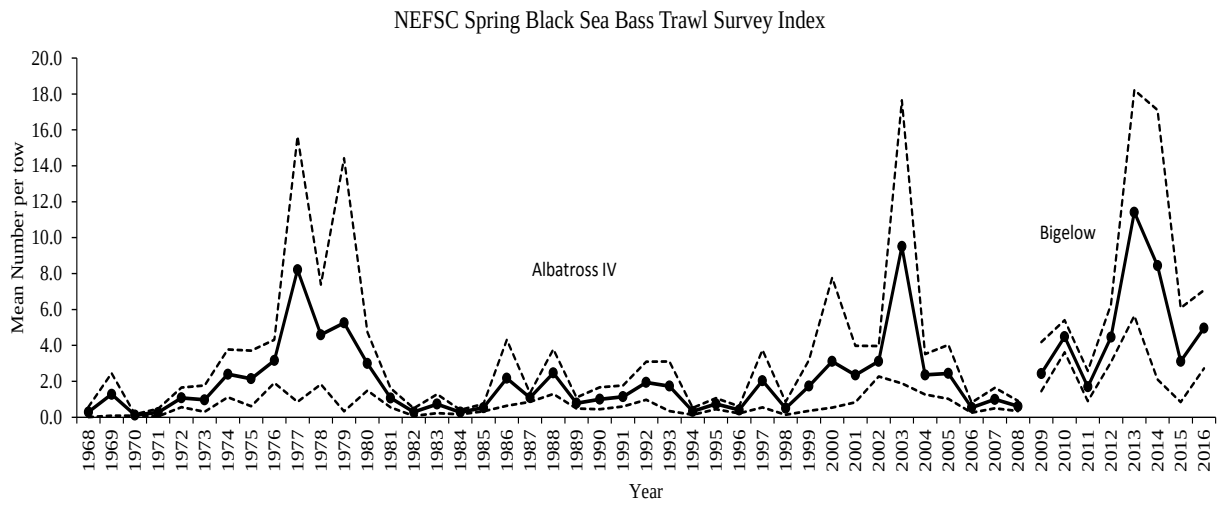


Figure A21. NEFSC spring trawl survey mean number per tow (± 95% CI), 1969-2016, from offshore strata. Bigelow indices are not calibrated to the Albatross series.

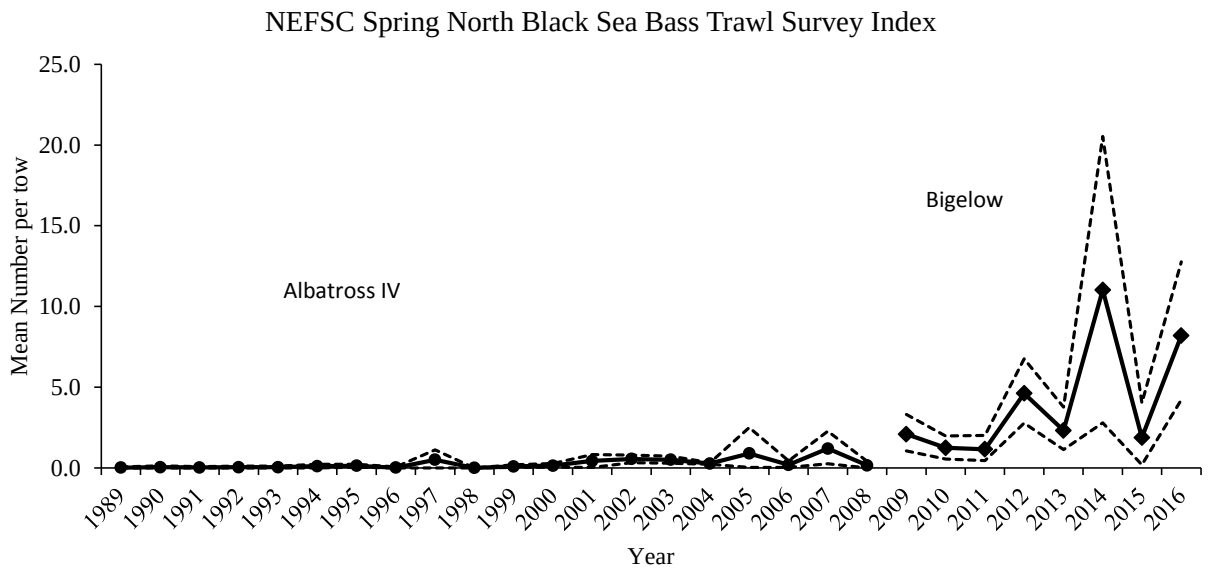


Figure A22. NEFSC spring trawl survey indices (± 95% CI) of black sea bass abundance, ages 1-8+ collected in offshore strata north of Hudson Canyon, 1989-2008 (*Albatross*) and 2009-2016 (*Bigelow*).

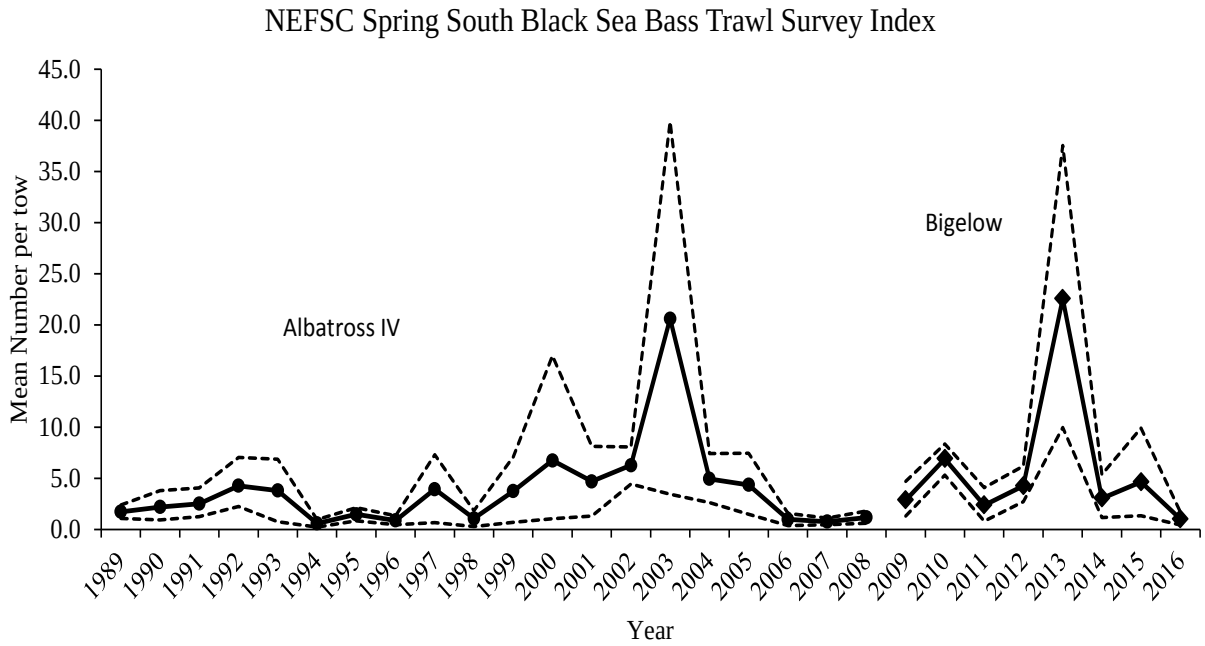


Figure A23. NEFSC spring trawl survey indices (± 95% CI) of black sea bass abundance, ages 1-8+ collected in offshore strata south of Hudson Canyon, 1989-2008 (*Albatross*) and 2009-2016 (*Bigelow*).

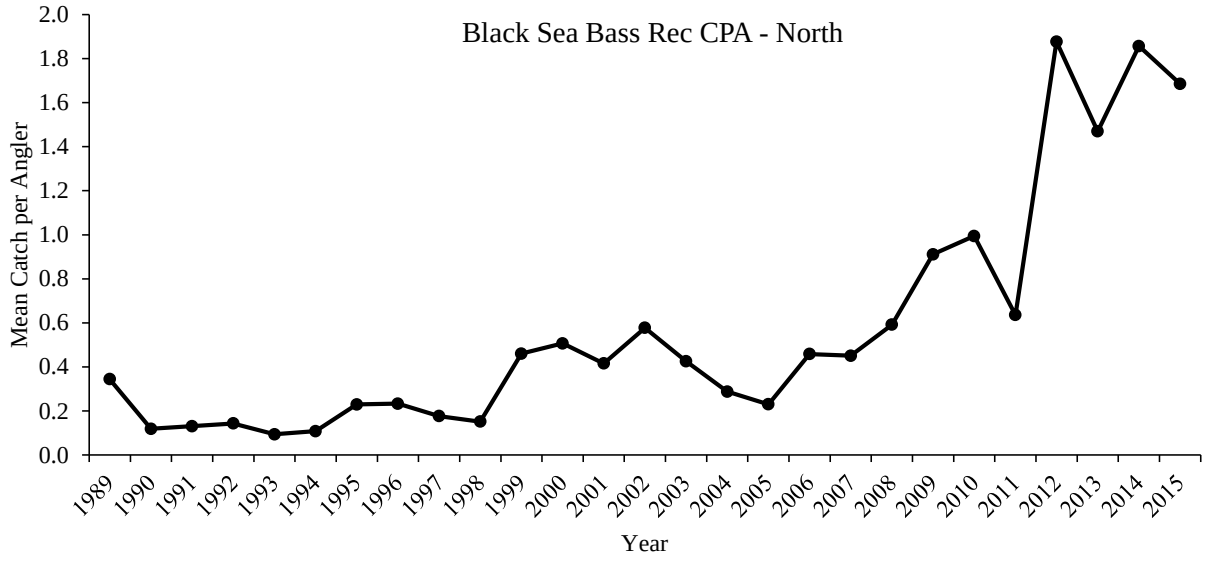


Figure A24. Recreational catch per angler for black sea bass caught from NY north, 1989-2015.

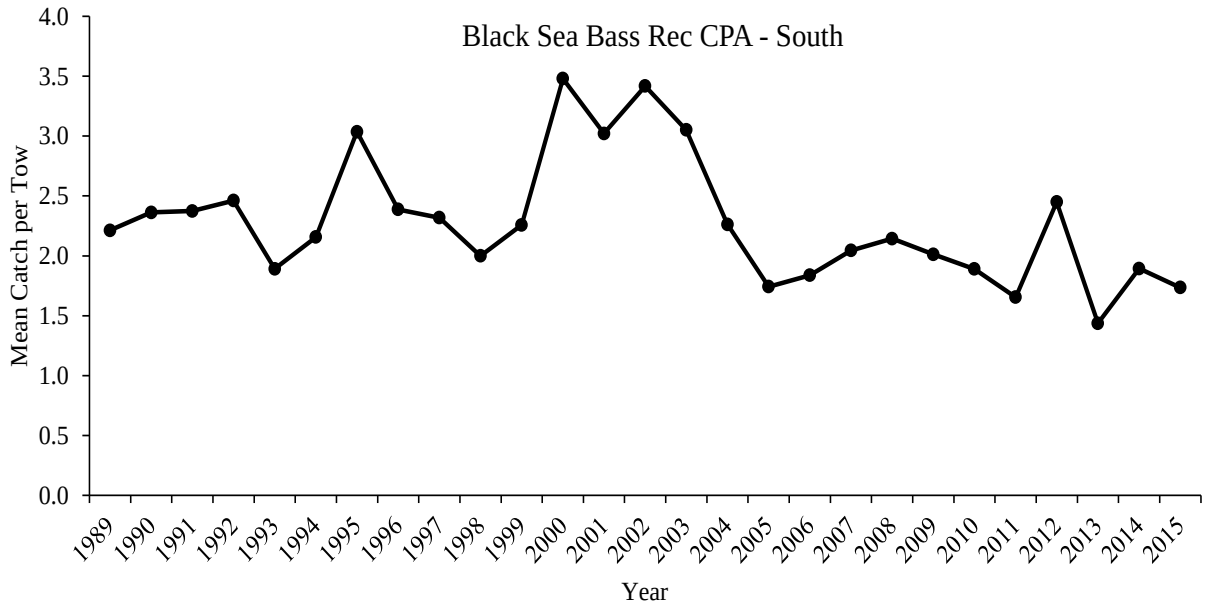


Figure A25. Recreational catch per angler for black sea bass caught from NJ south, 1989-2015.

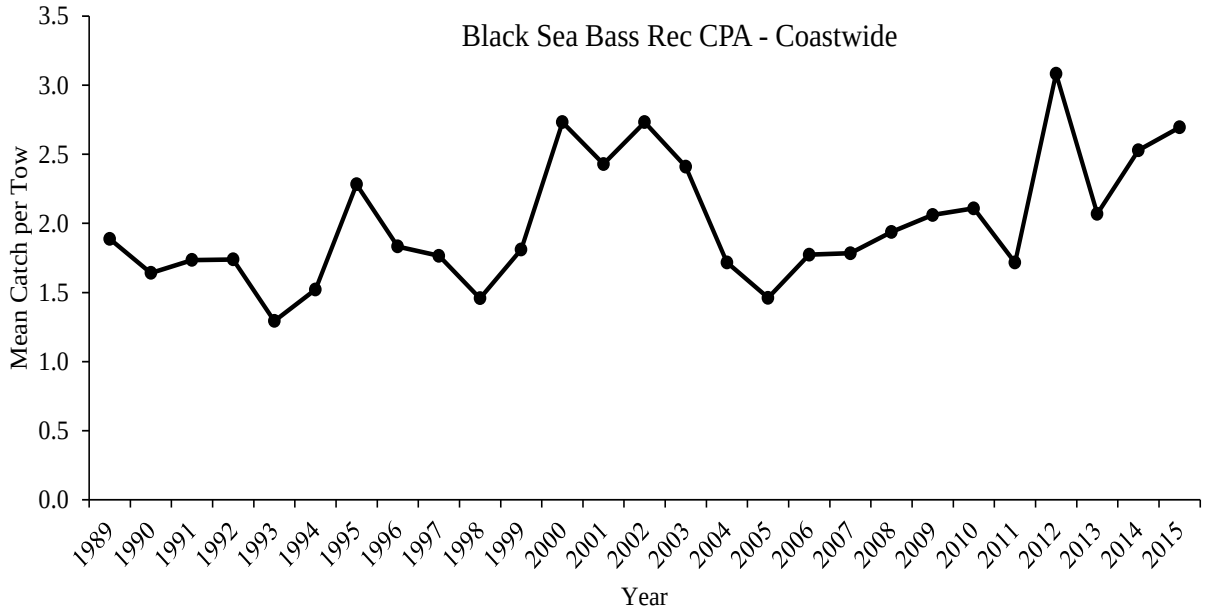


Figure A26. Recreational catch per angler for black sea bass caught from NC to ME, 1989-2015.

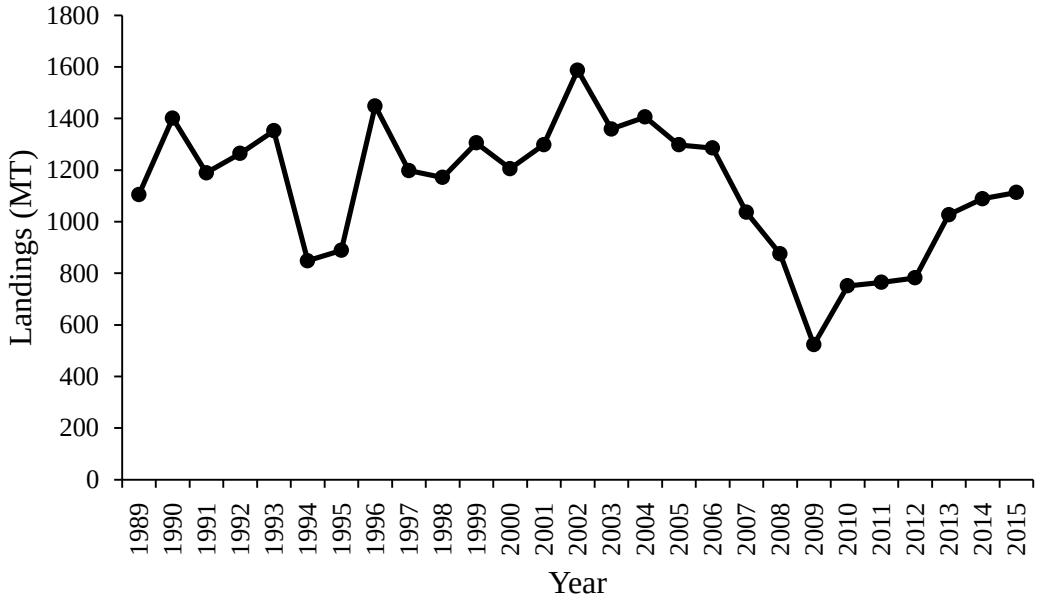


Figure A27. Commercial black sea bass Landings (mt), Maine-Cape Hatteras,NC, 1989-2015.

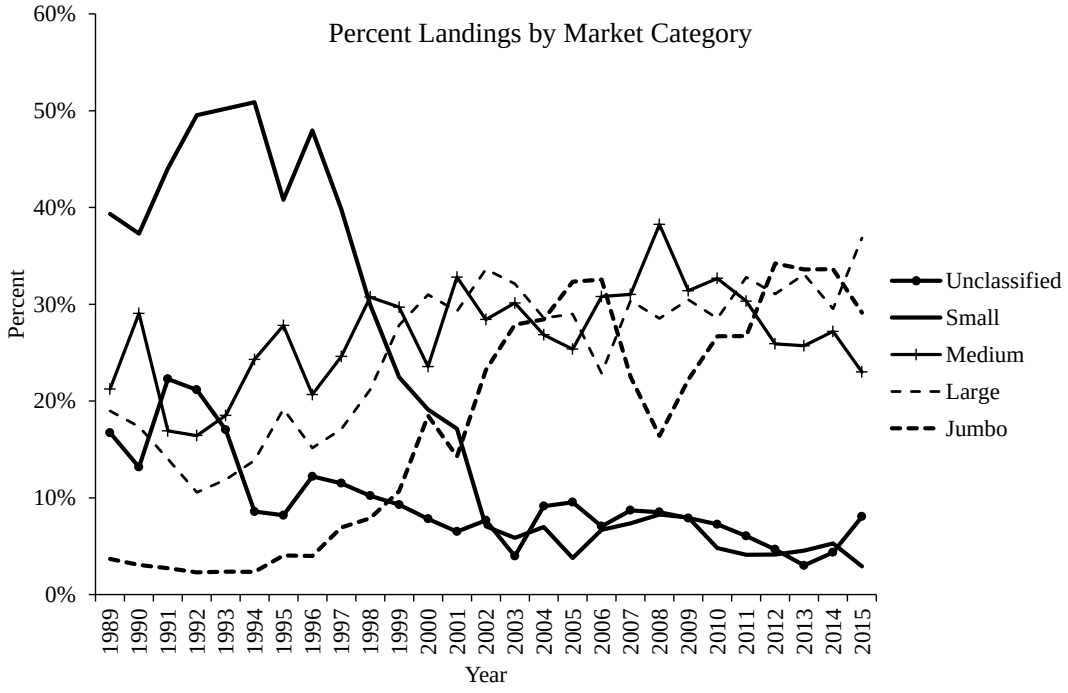


Figure A28. Percent of black sea bass commercial landings by market category, 1989-2015.

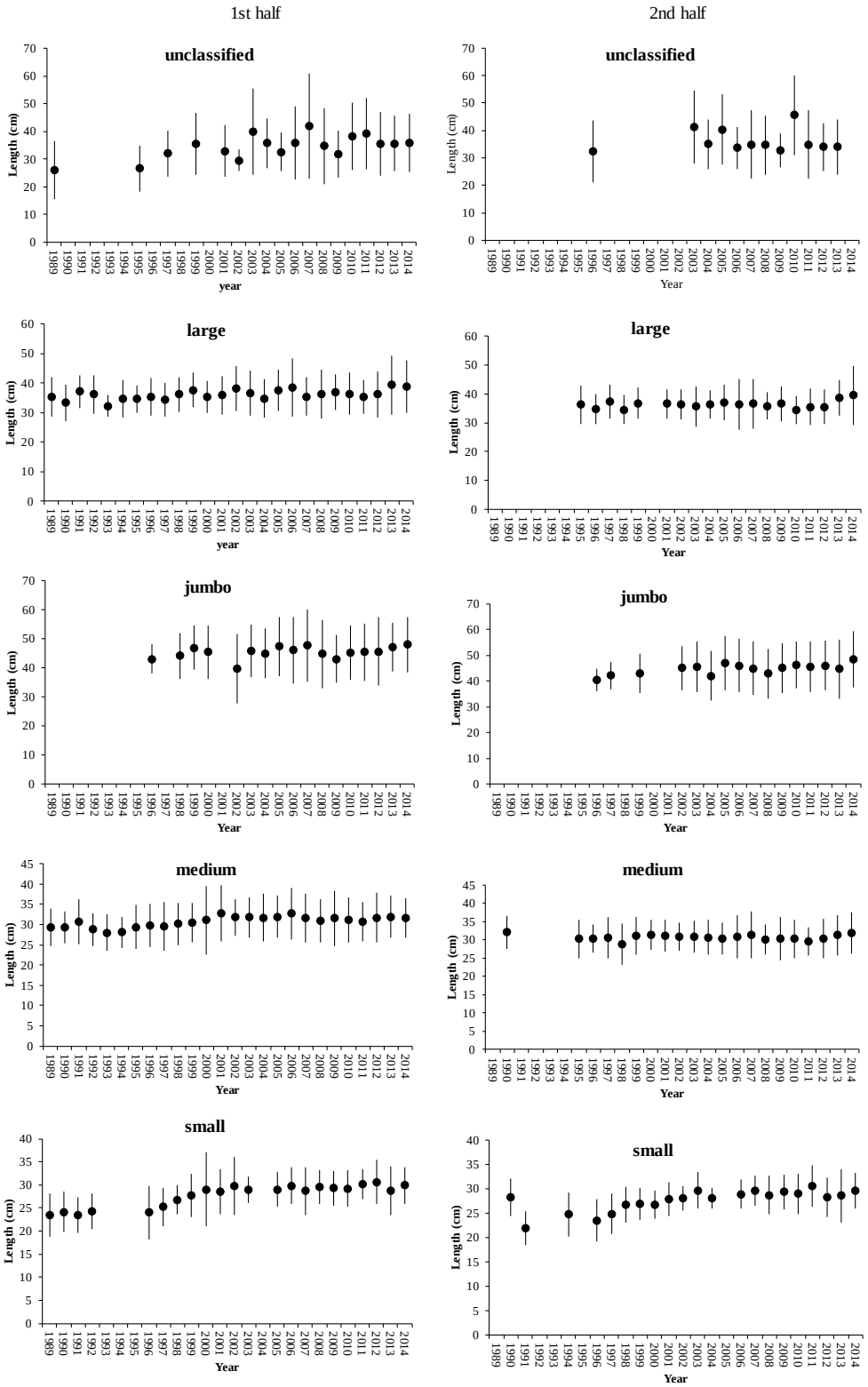


Figure A29. Mean length (cm ± 95% CI) of commercial landings black sea bass samples by market category, season and year.

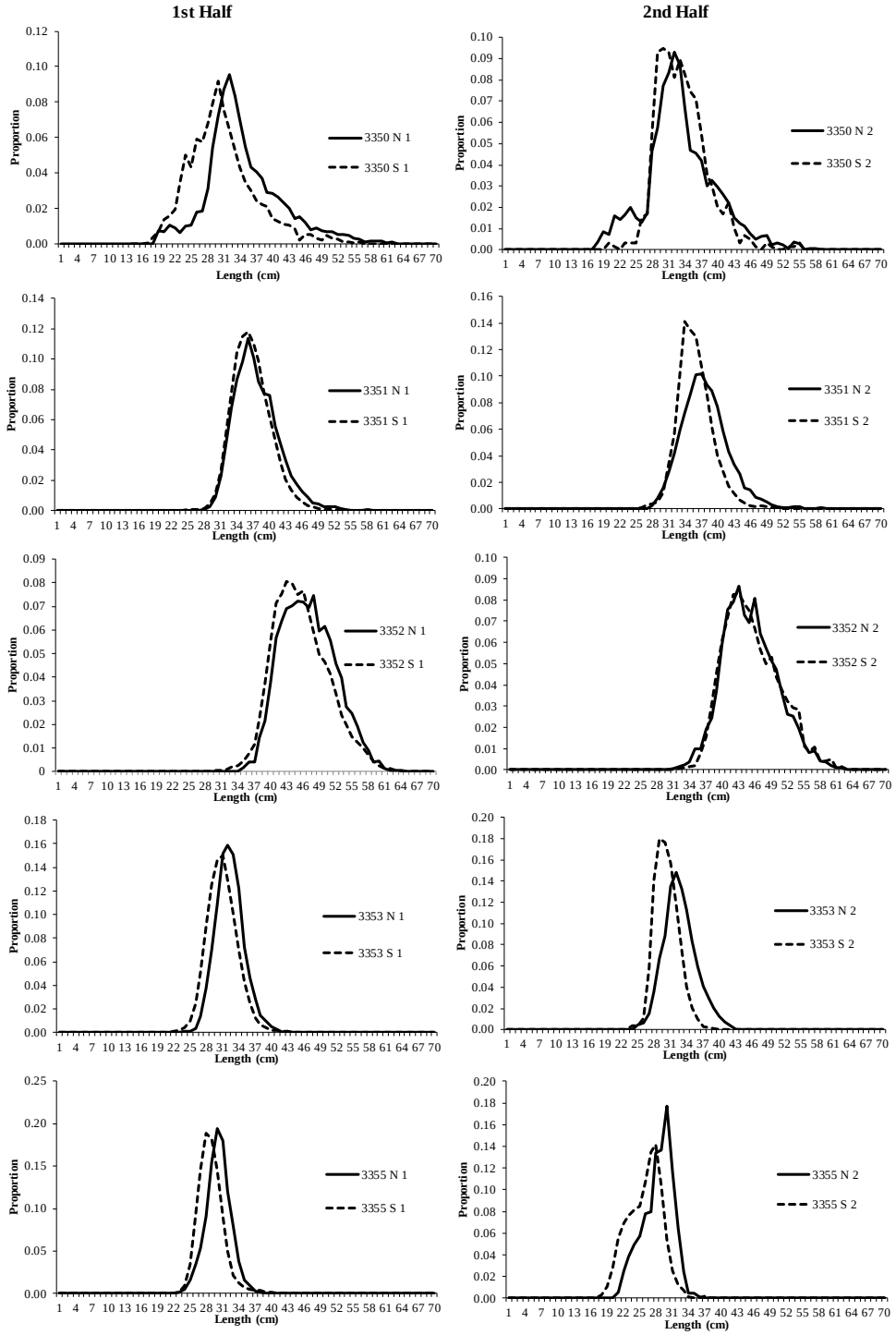


Figure A30. Comparison of black sea bass commercial landings length (cm) samples, by half year, collected north and south of Hudson Canyon. Length distributions in each panel represent the sum of samples in years common between areas.

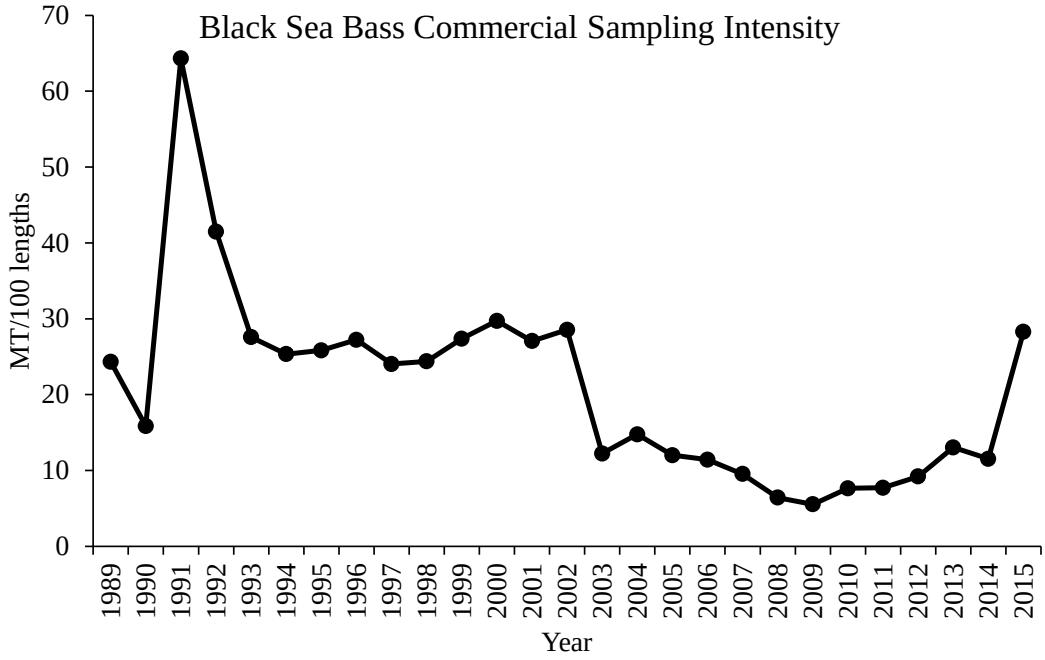


Figure A31. Annual sampling intensity for black sea bass sampled from the commercial fishery, 1989-2015. Intensity measured as the number of metric tons per length sampled. Larger values imply poorer sampling intensity.

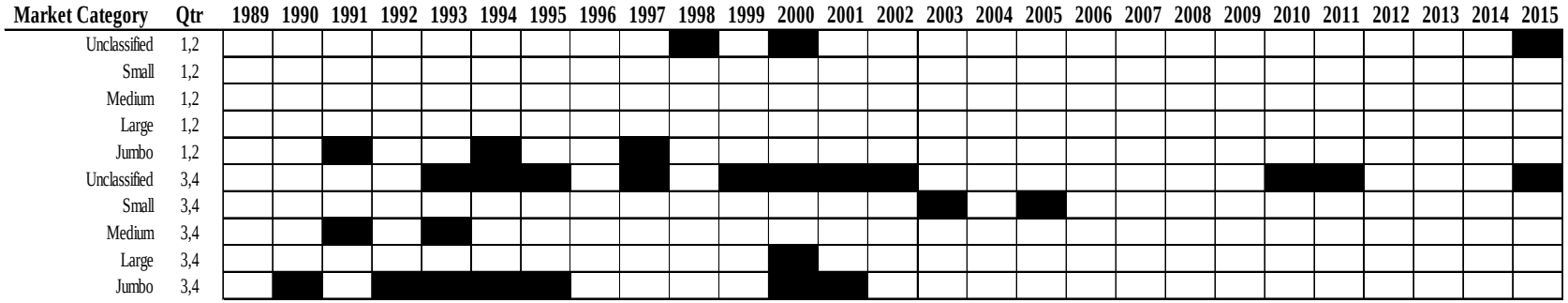


Figure A32. Black sea bass commercial length samples by market category and season (qtr 1,2 is Jan-Jun, qtr 3,4 is Jul-Dec) and year. Black squares in the matrix represent cells with no samples available and substitution required.

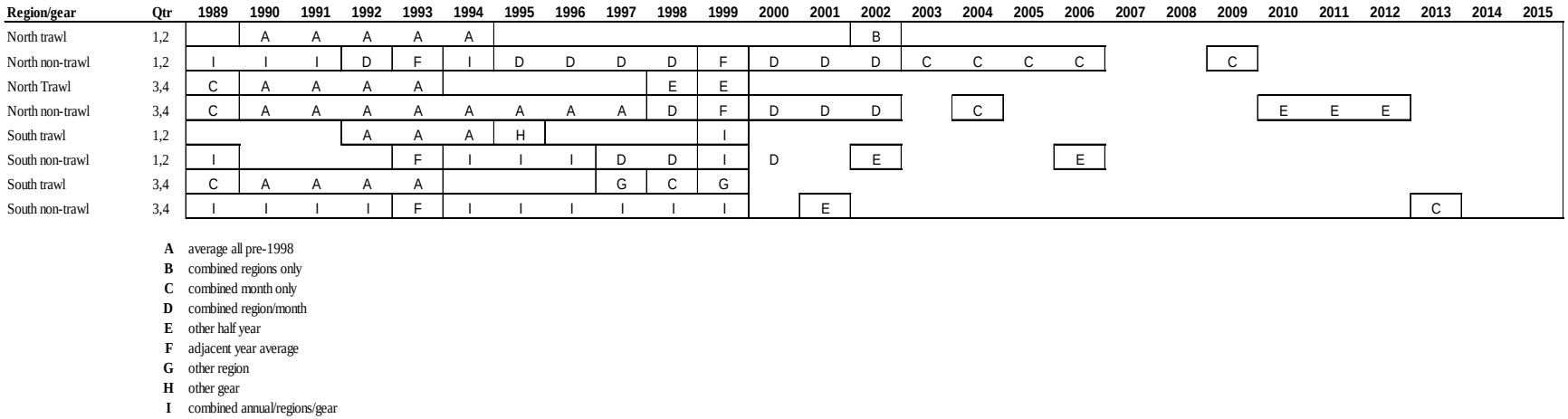


Figure A33. Sources of black sea bass commercial length sample by year, area and region. Cells without a letter indicate data available for that cell.

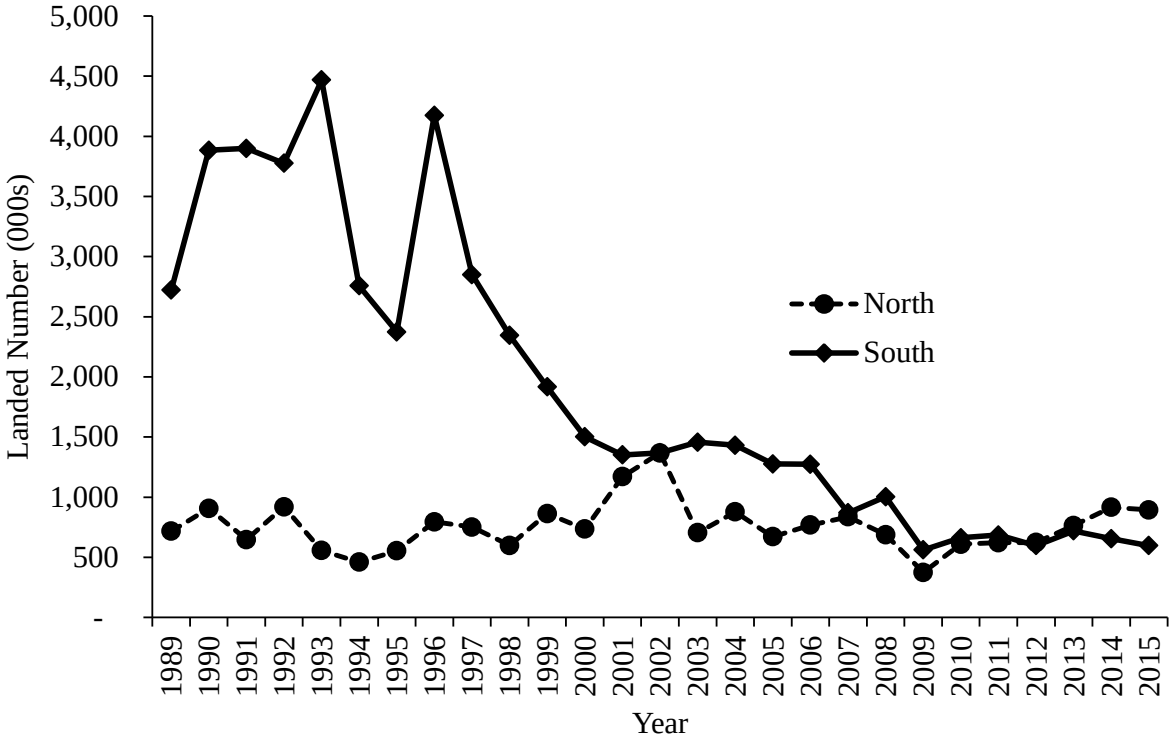


Figure A34. Black sea bass landings (number of fish in 000s) by area, 1989-2015.

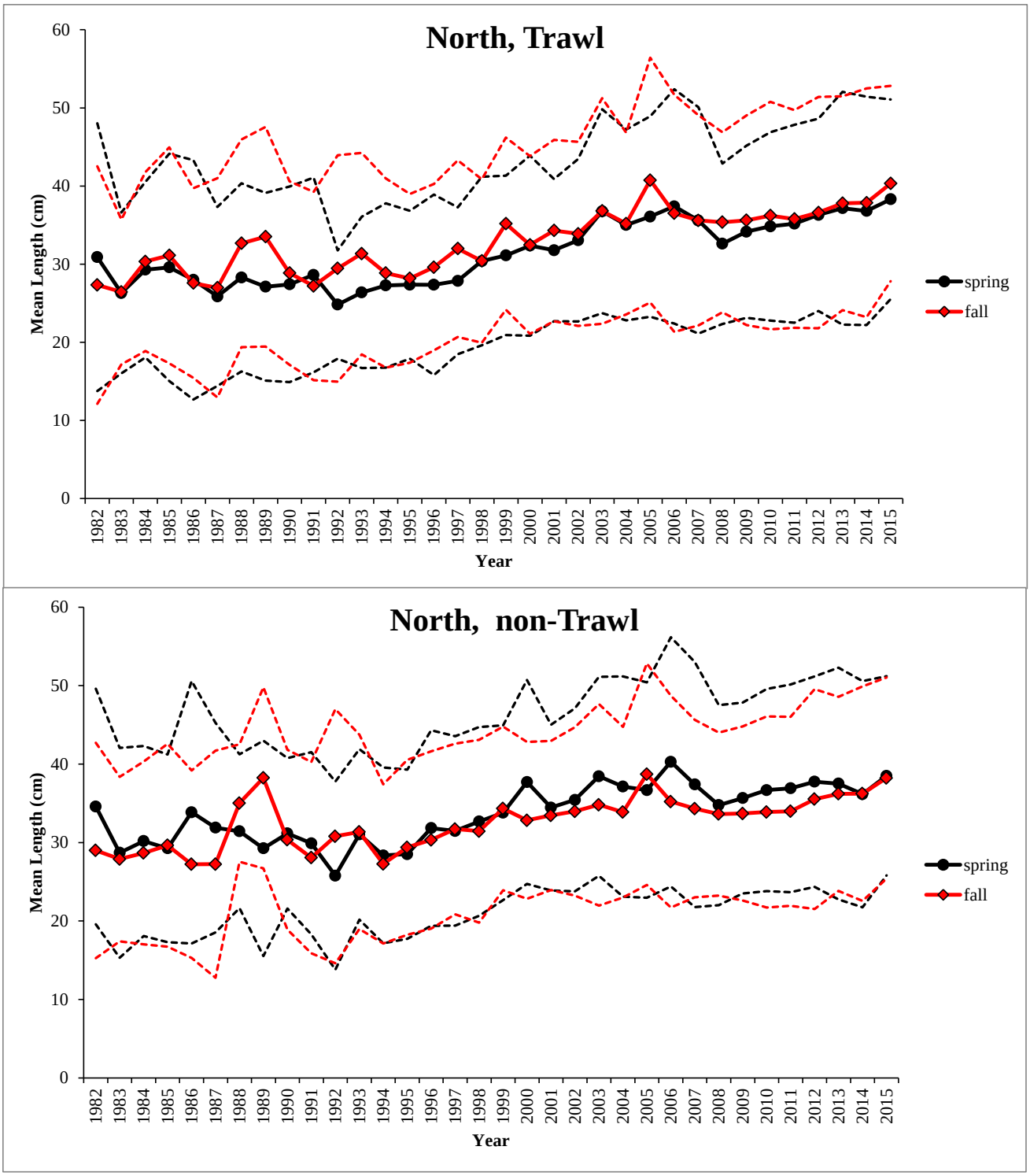


Figure A35. Annual mean length (cm ± 2 SD) from expanded black sea bass commercial landings length frequencies for northern region, by season and gear category, 1989-2015.

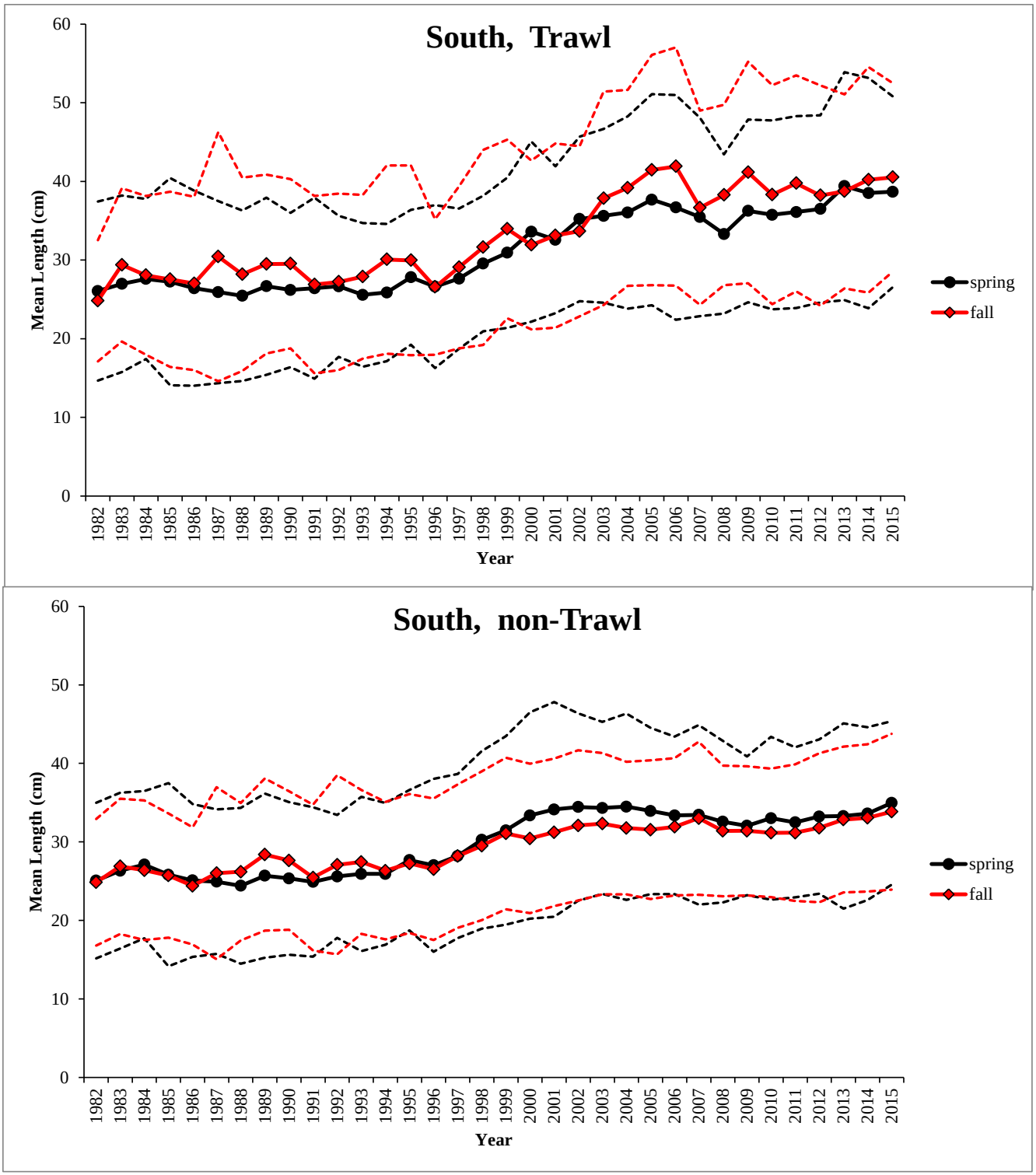


Figure A36. Annual mean length (cm ± 2 SD) from expanded commercial black sea bass landings length frequencies for South region, by season and gear category, 1989-2015.

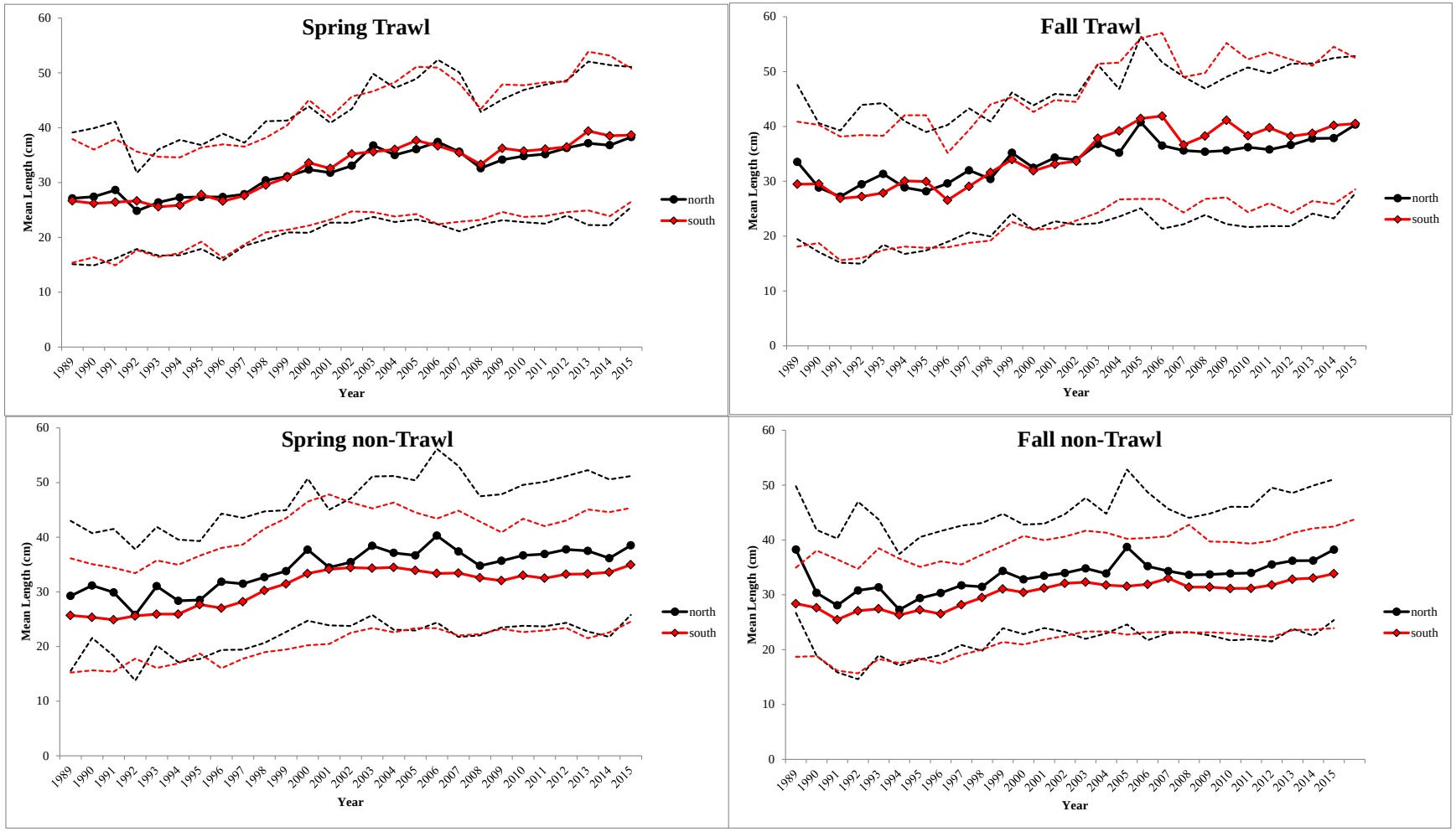


Figure A37. Annual mean black sea bass length (cm ± 2 SD) from expanded commercial landings length frequencies for region, by season and gear category, 1989-2015.

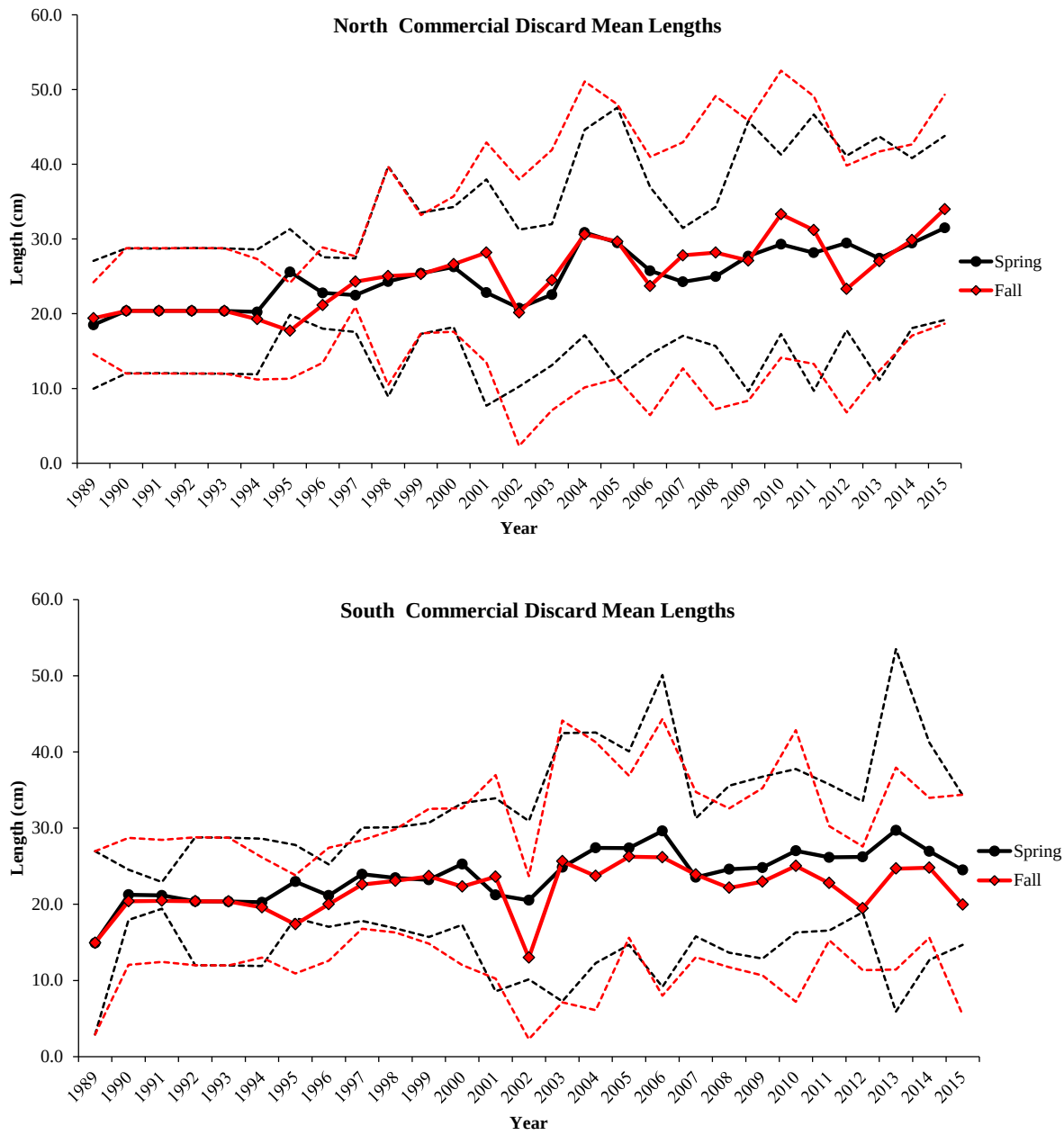


Figure A38. Annual mean black sea bass length (cm ± 2 SD) from expanded commercial discard length frequencies for region, by season 1989-2015.

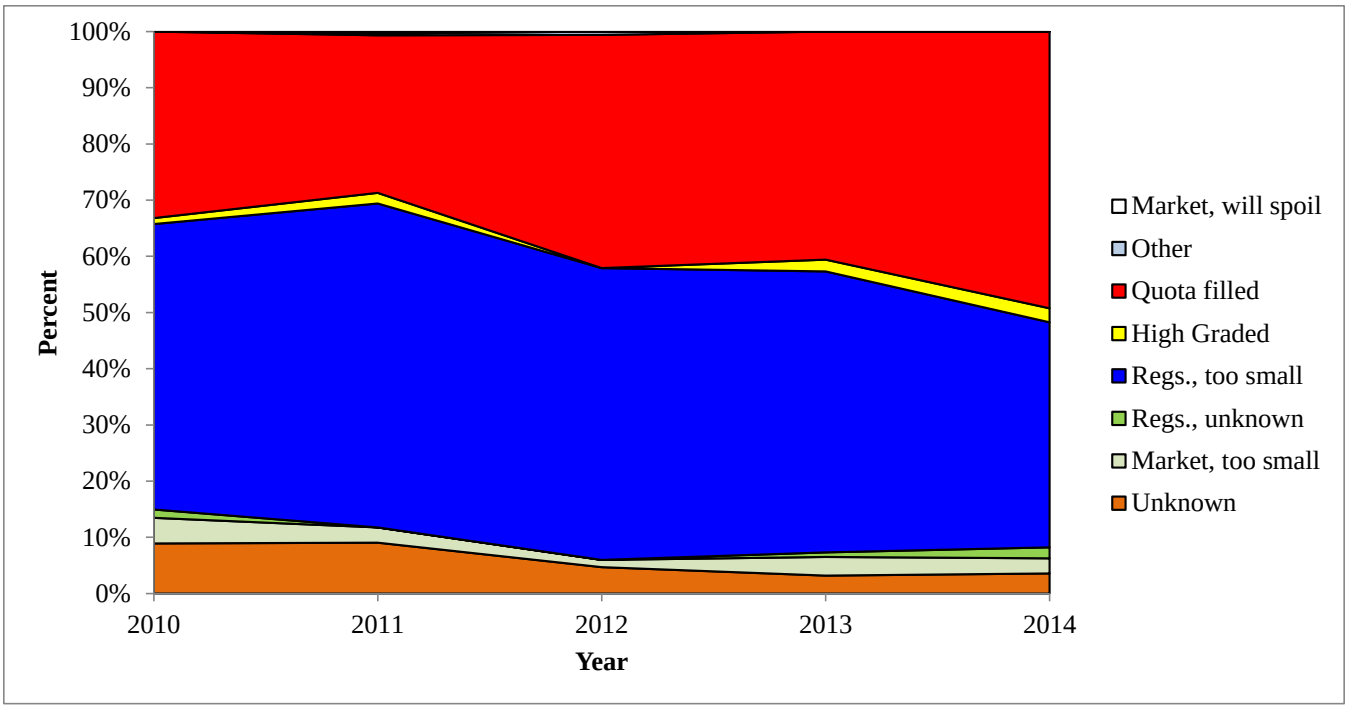


Figure A39. Reason for discarding black sea bass in commercial fisheries, 2010-2014.

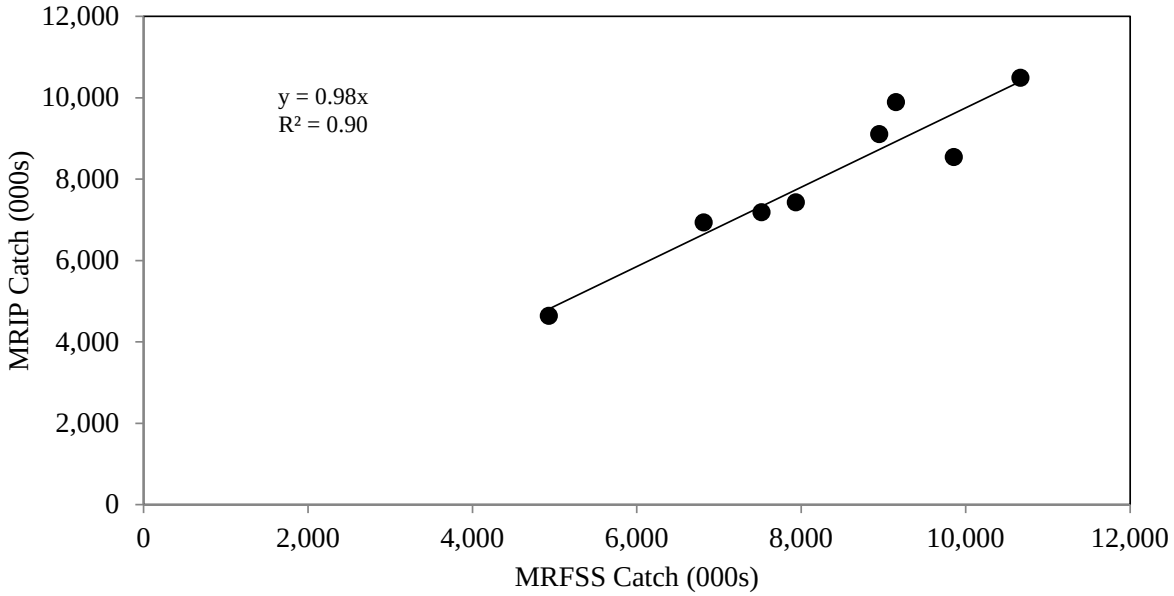


Figure A40. Relationship between black sea bass catch estimated by MRFSS survey vs MRIP survey, 2004-2011.

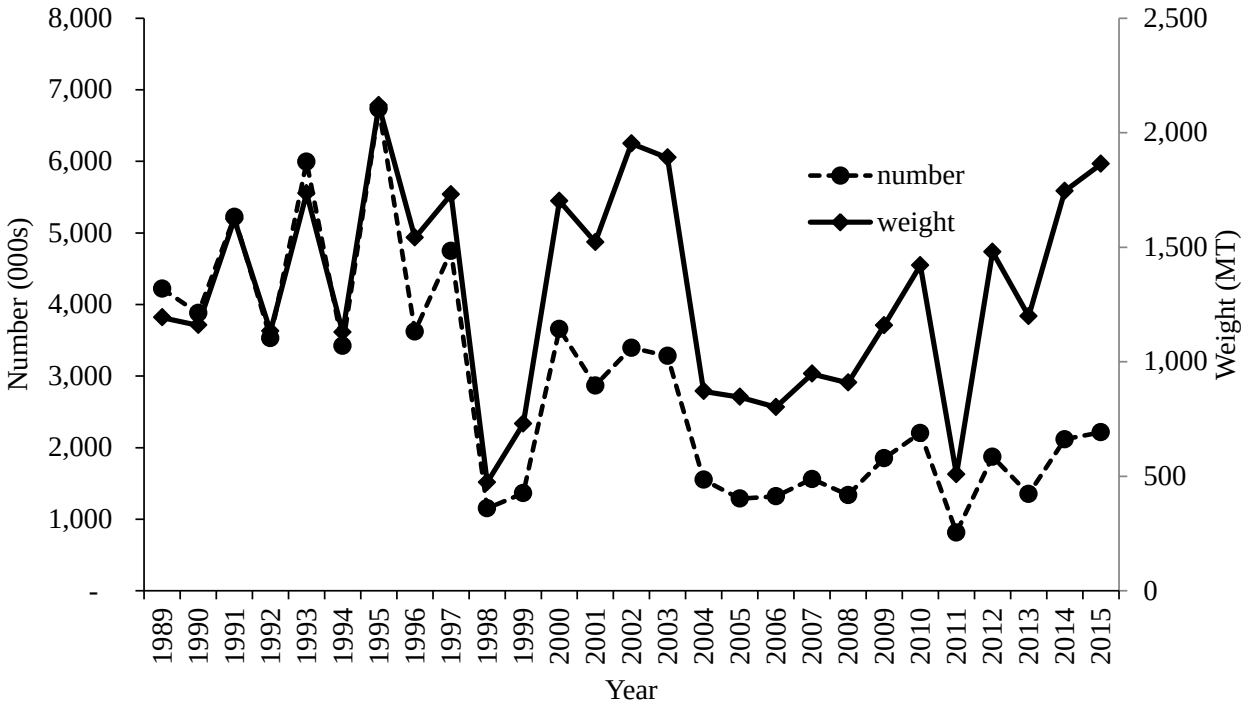


Figure A41. Black sea bass recreational landings (number) and weight (mt) coastwide, 1989-2015.

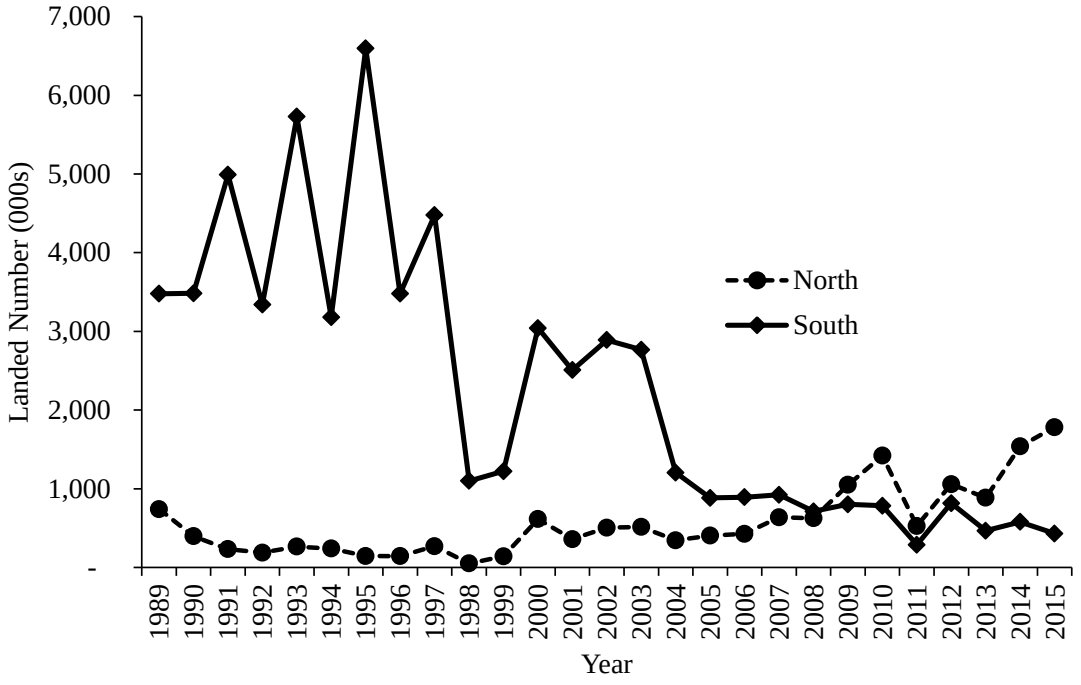


Figure A42. Black sea bass recreational landings (number) by year and region.

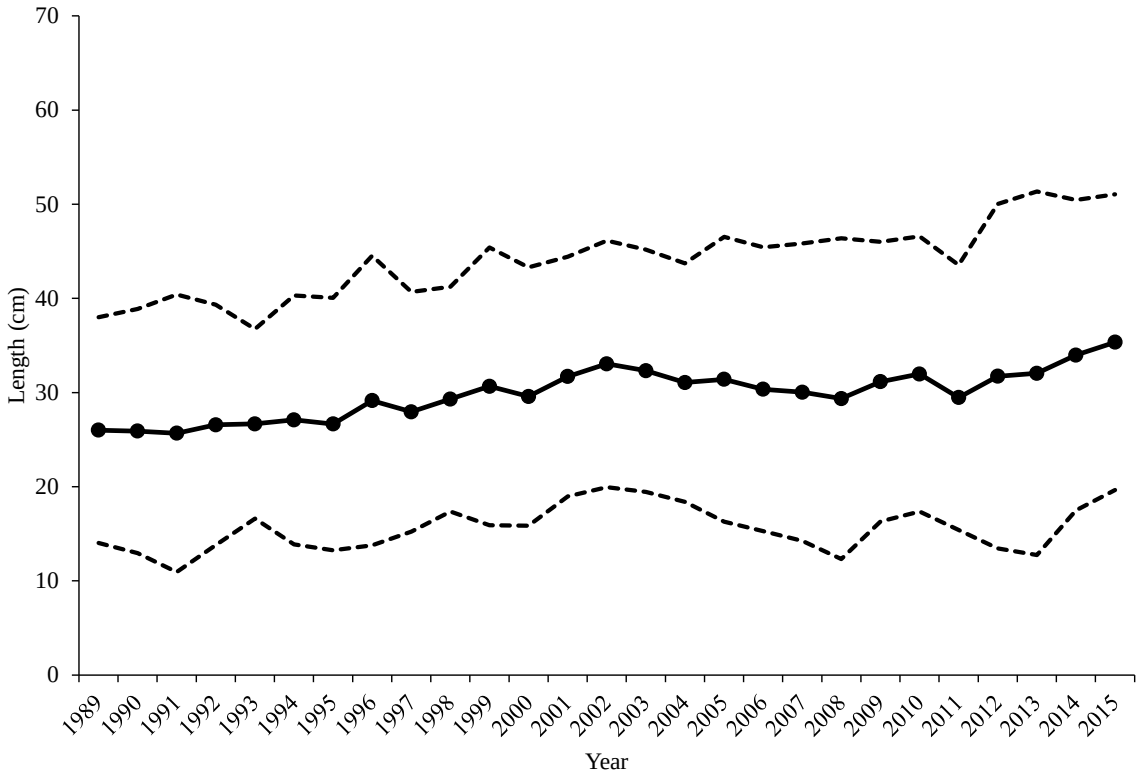


Figure A43. Mean length (± 2 SD) of black sea bass recreational landings, Maine to Cape Hatteras, NC, 1989-2015.

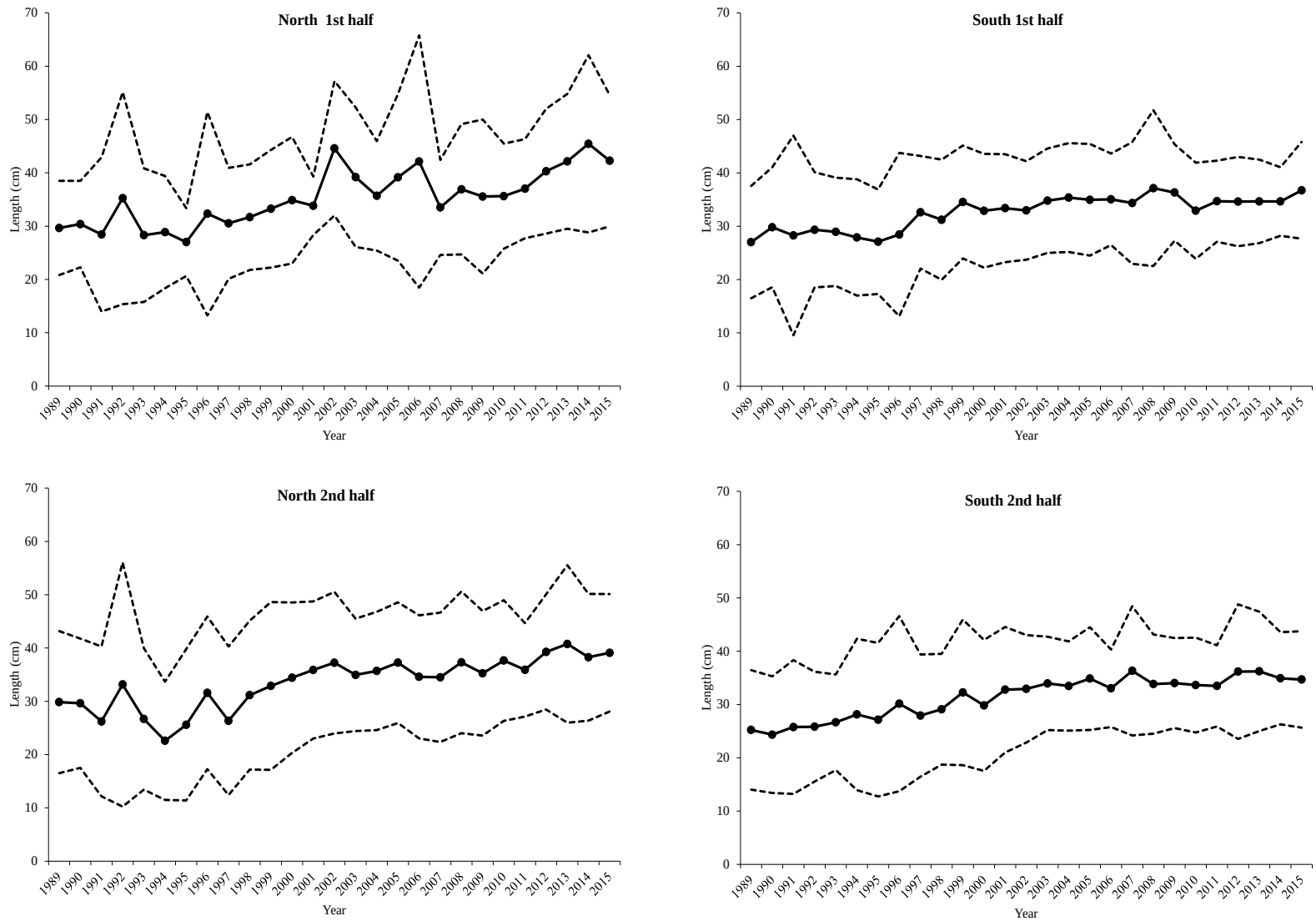


Figure A44. Mean length (cm ± 2 SD) of black sea bass recreational landings by region and season, 1989-2015.

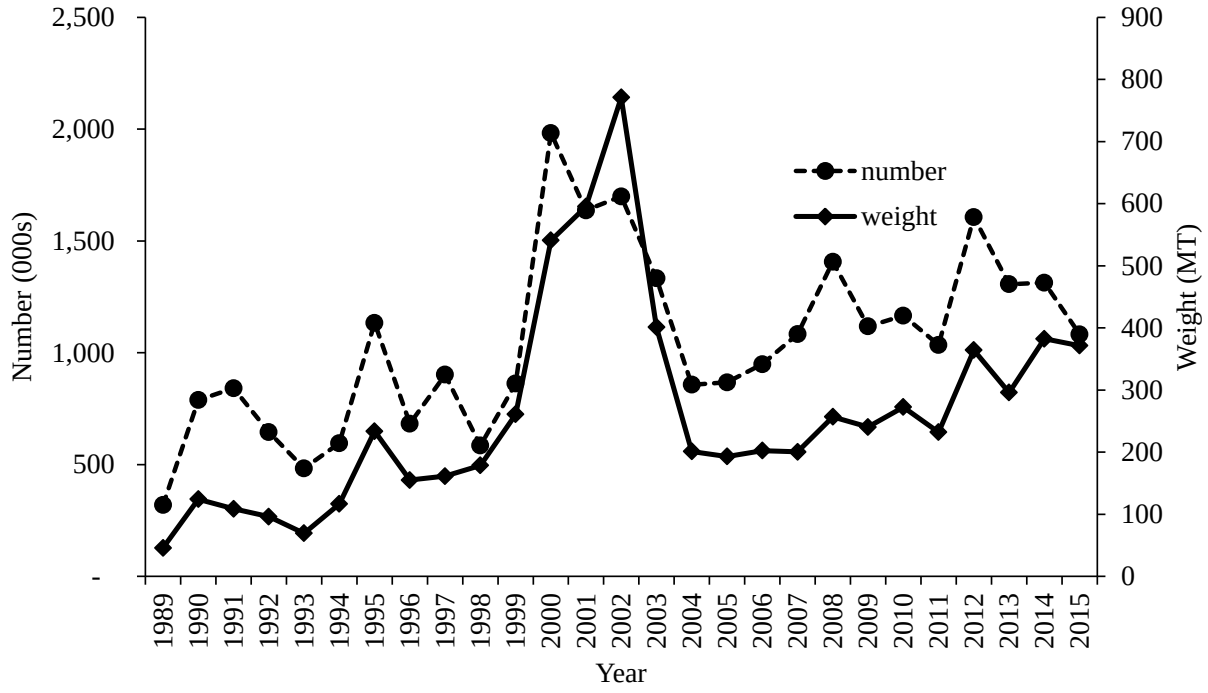


Figure A45. Black sea bass recreational discard mortalities (15% release mortality) by number and weight (mt) stock-wide, 1989-2015.

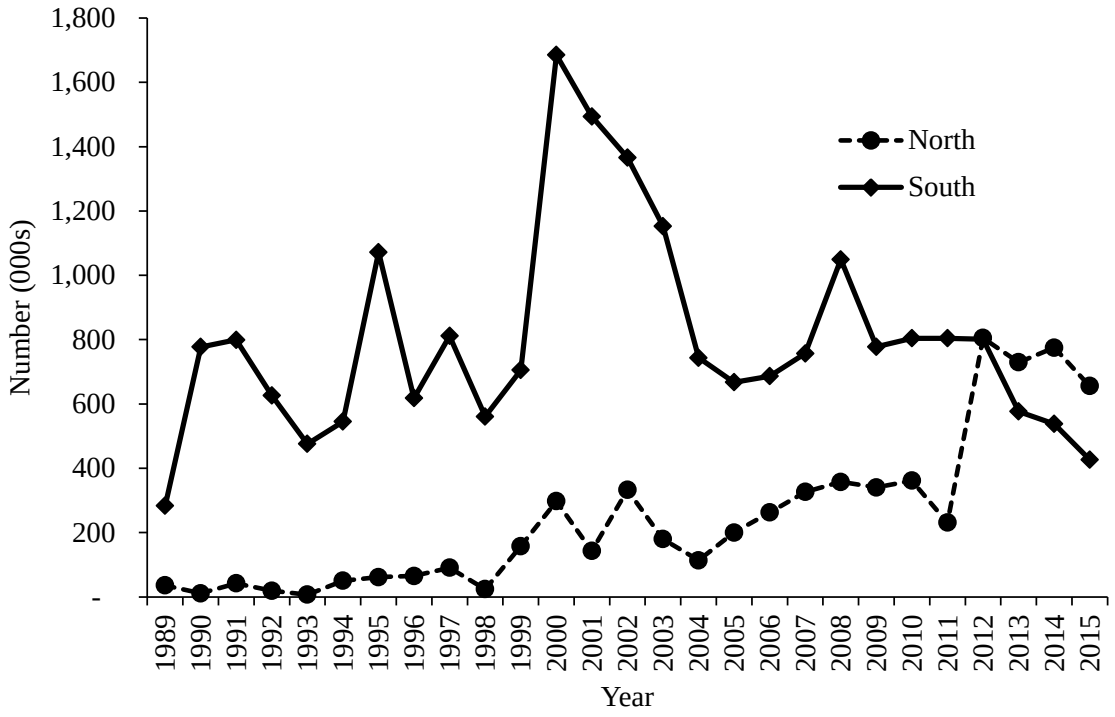


Figure A46. Black sea bass recreational discard mortalities (15% release mortality) by area, 1989-2015.

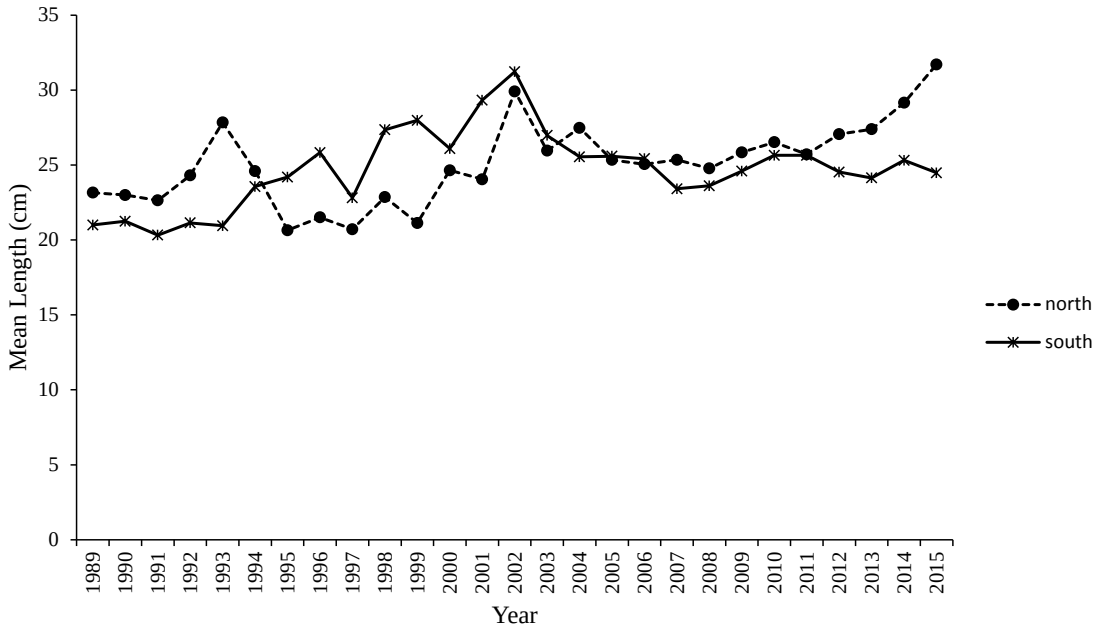


Figure A47. Mean length (cm) of black sea bass recreational discards by region.

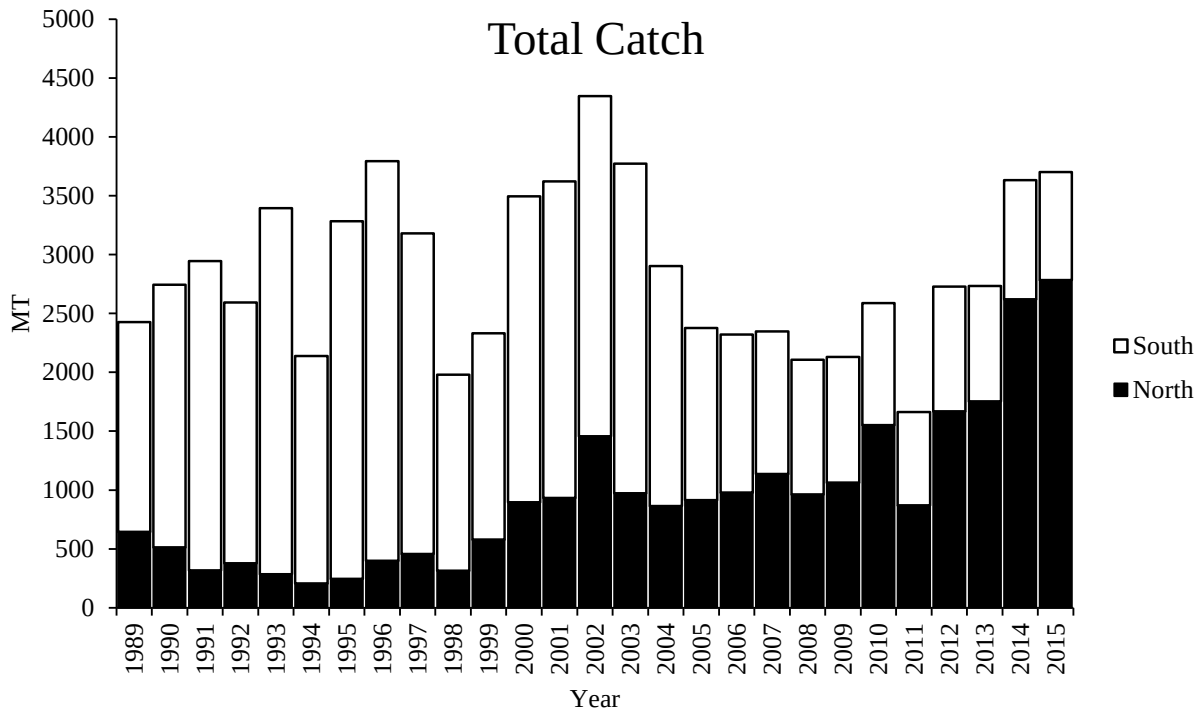


Figure A48. Total black sea bass catch (mt) by region, 1989-2015.

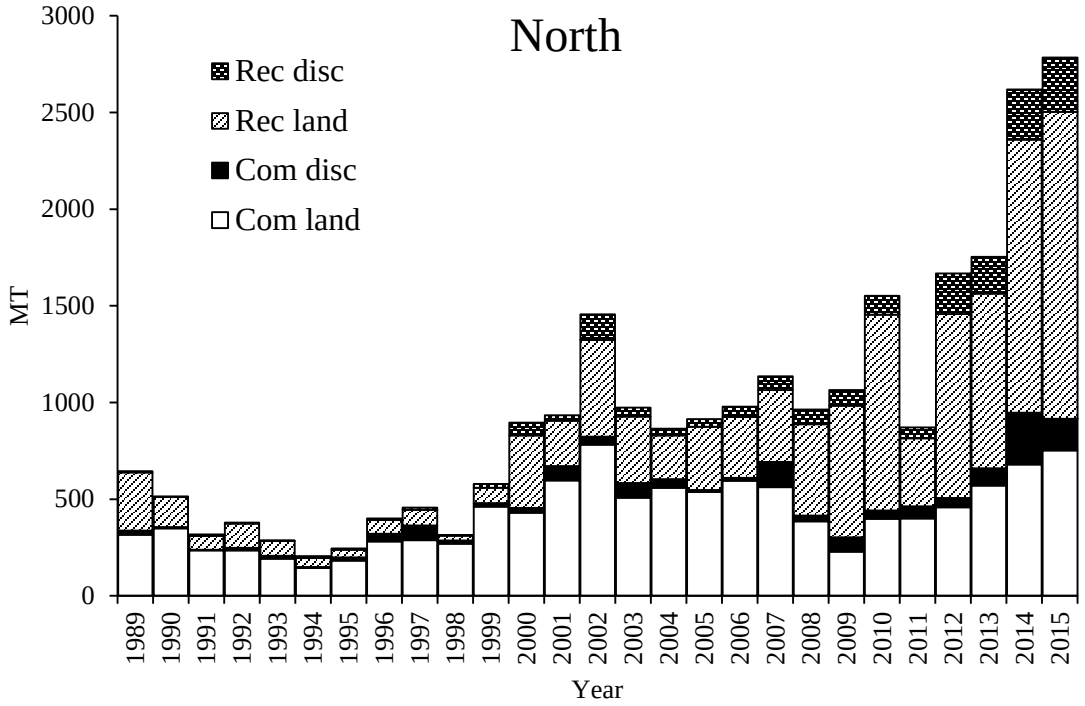


Figure A49. Total black sea bass catch (mt) by fishery and disposition for the northern region, 1989-2015.

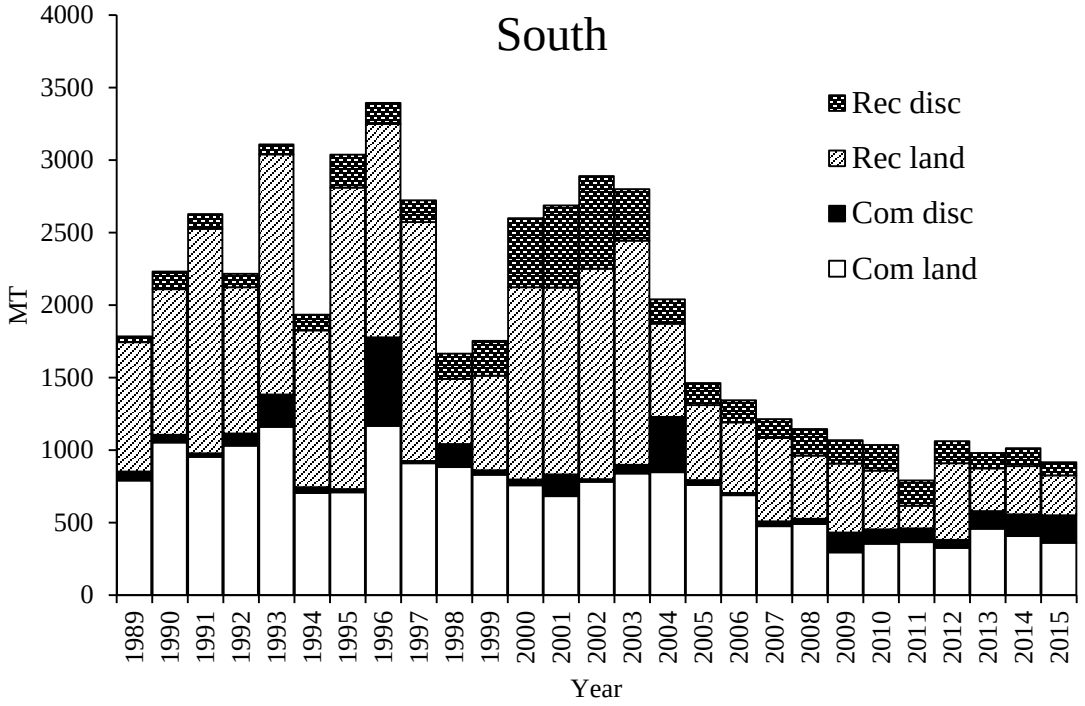


Figure A50. Total black sea bass catch (mt) by fishery and disposition for South region, 1989-2015.

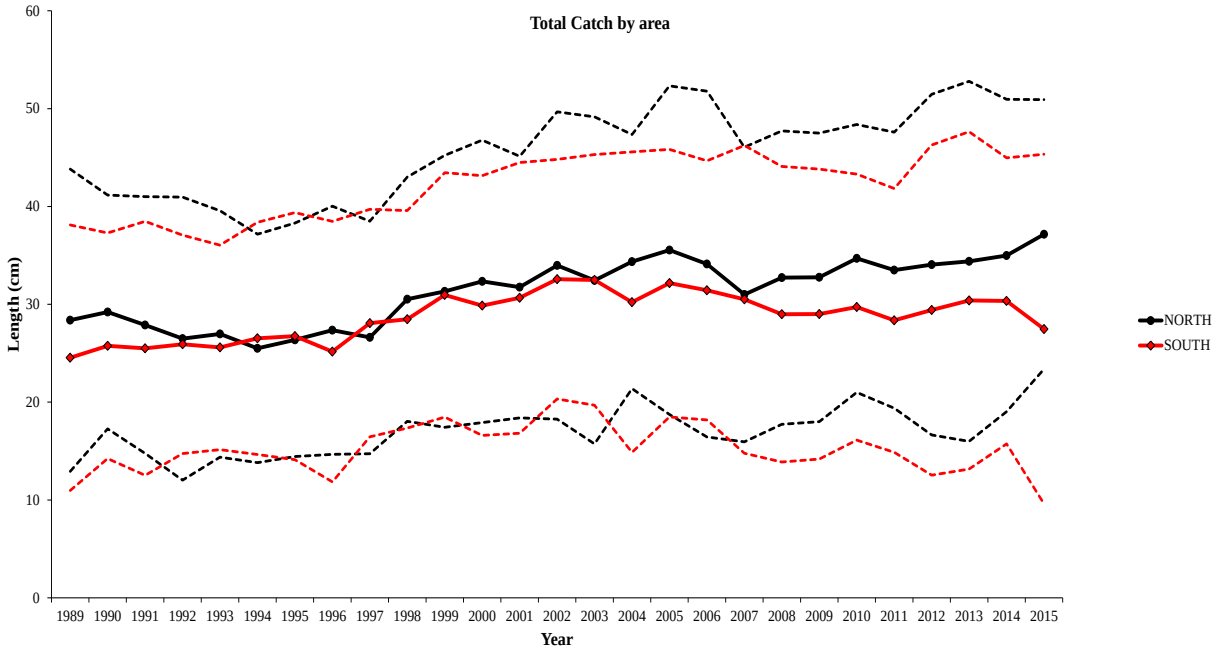


Figure A51. Mean length (± 2 SD) from black sea bass total expanded catch, by area, 1989-2015.

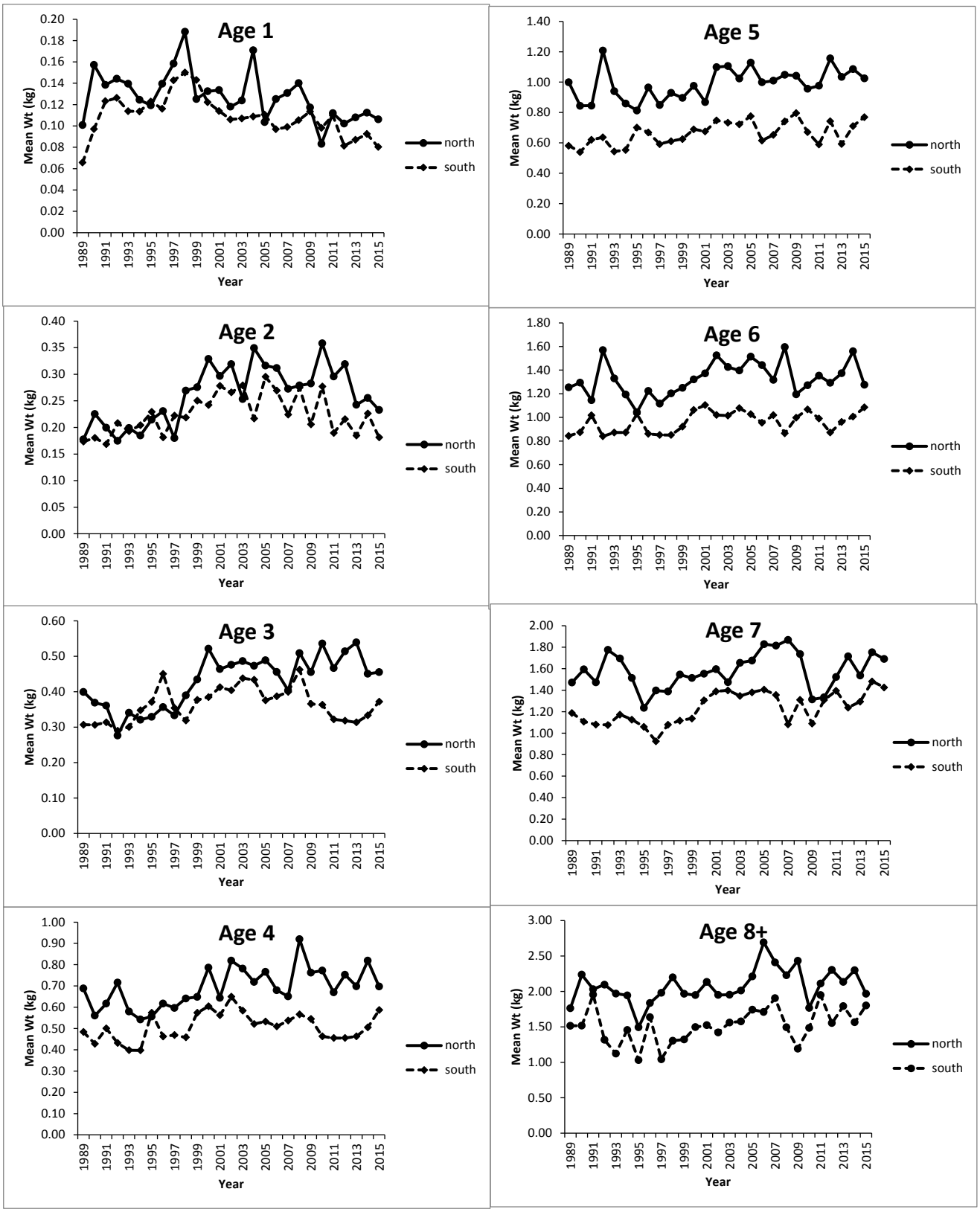


Figure A52. Mean weight at age (kg) for black sea bass by region, 1989-2015.

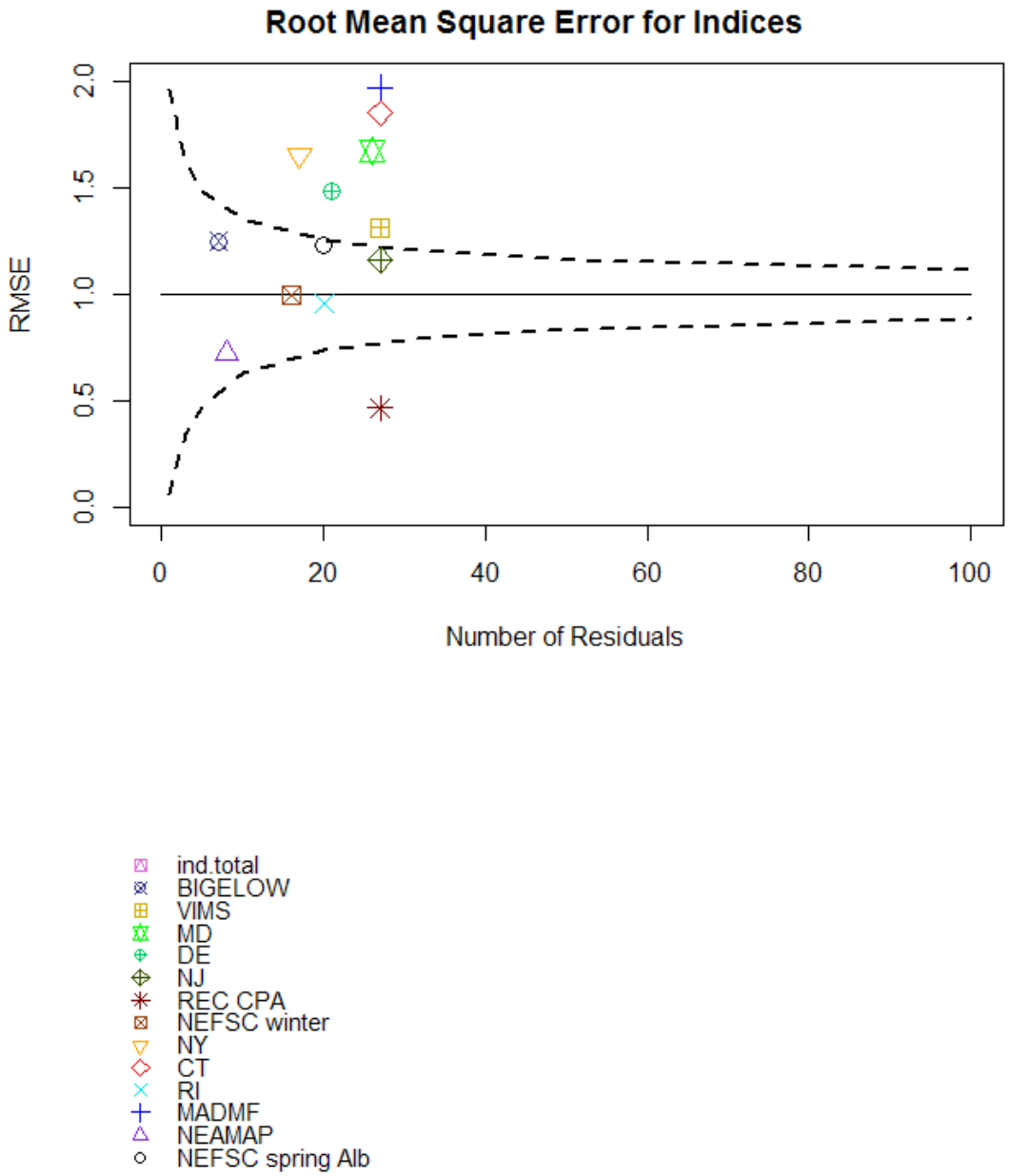


Figure A53. Final Root Mean Square Error (RMSE) values for black sea bass survey indices in final **Overall** single area model.

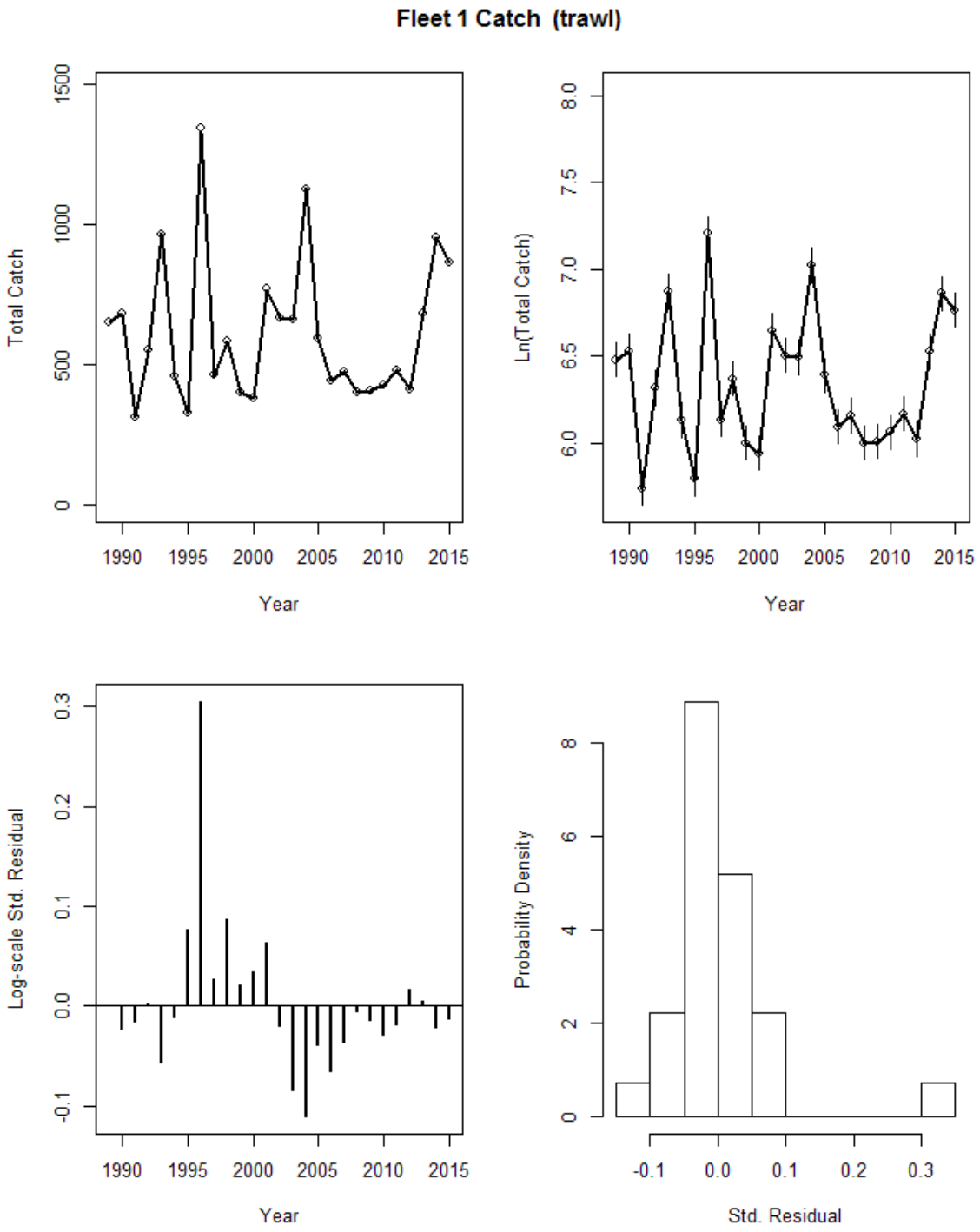


Figure A54. Fit diagnostics for the trawl catch in final black sea bass **Overall** single area model.

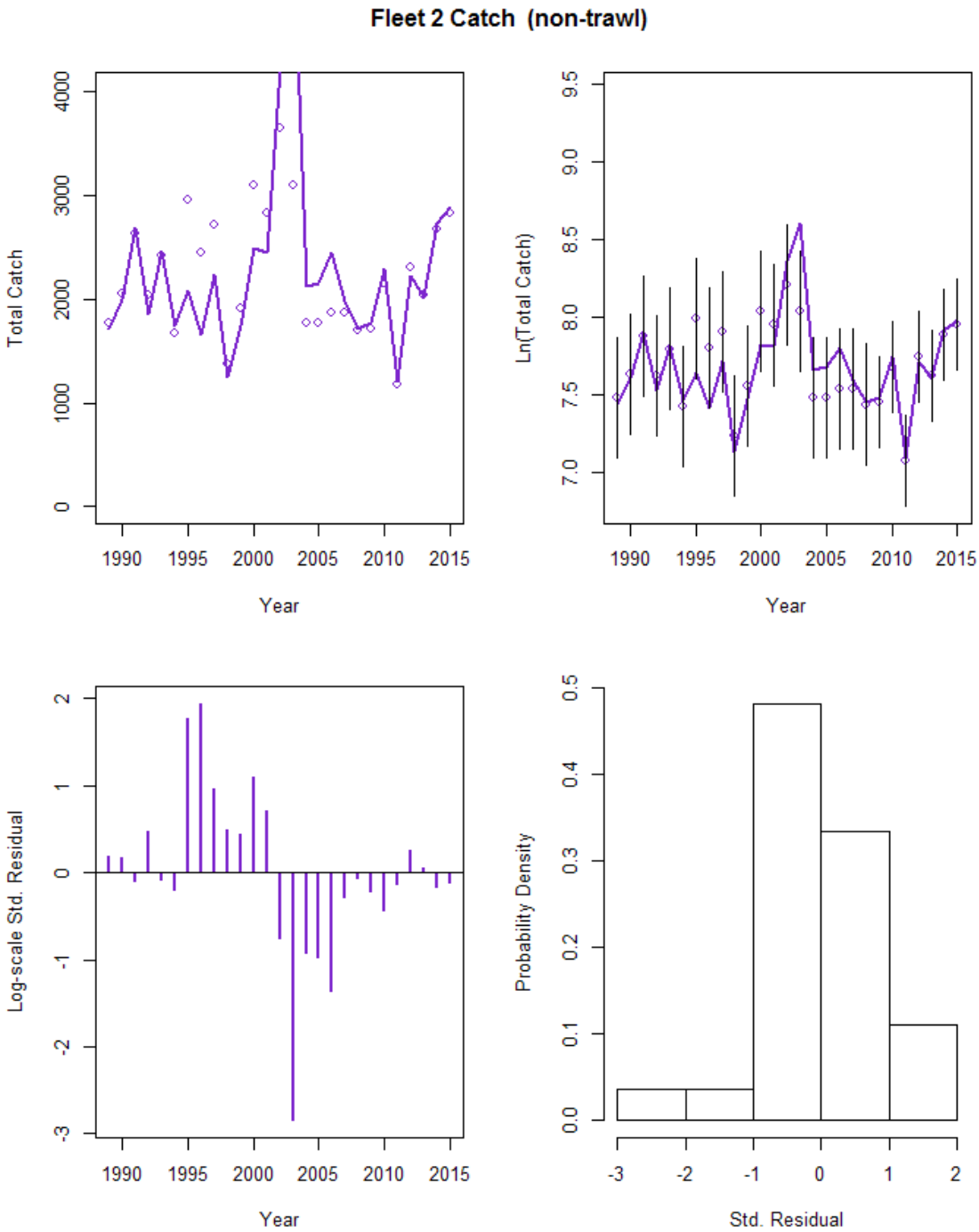


Figure A55. Fit diagnostics for the non- trawl catch in final black sea bass **Overall** single area model.

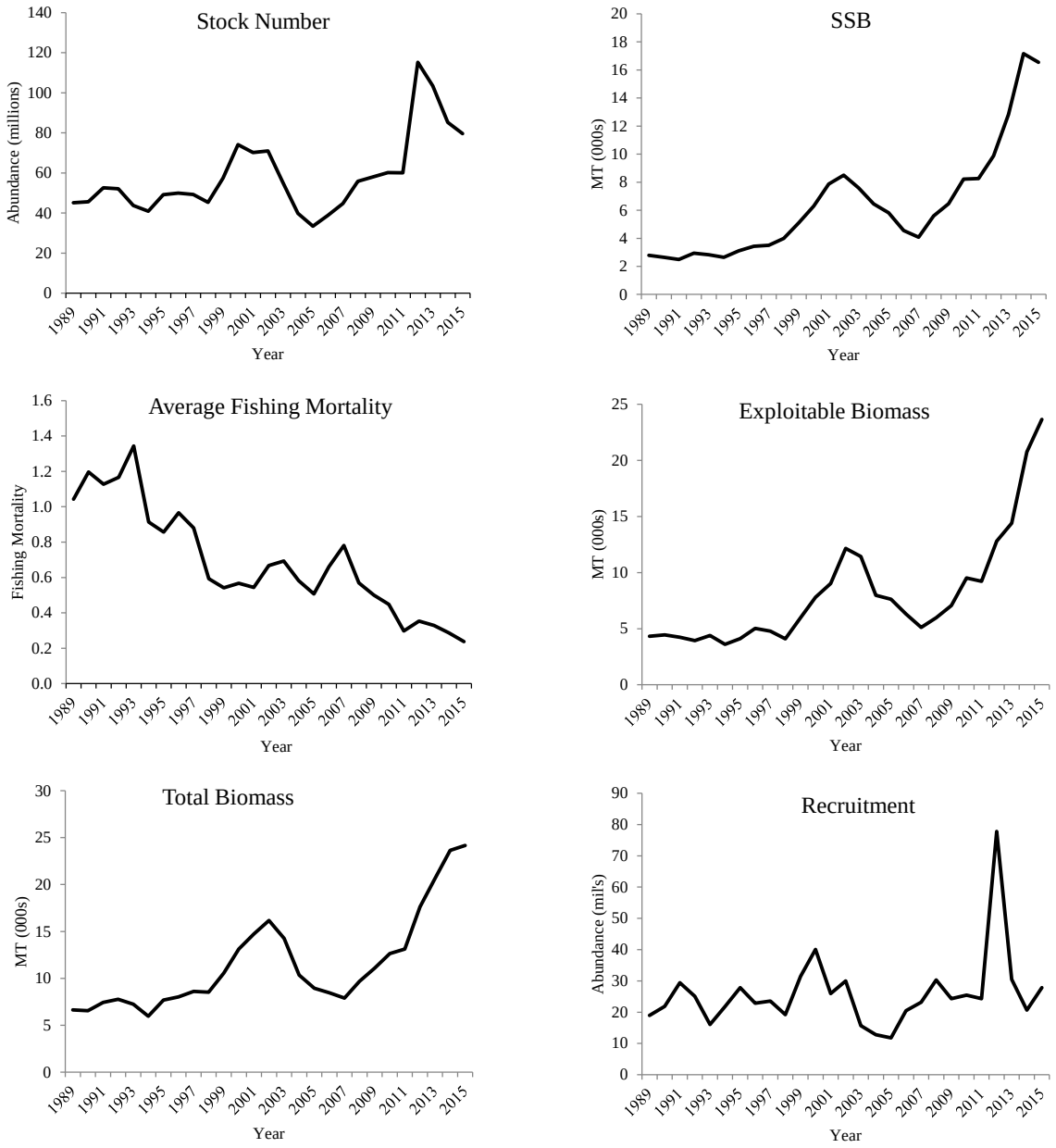


Figure A56. Results of stock number, fishing mortality, total biomass, spawning biomass, exploitable biomass and recruitment from the black sea bass **Overall** single area model.

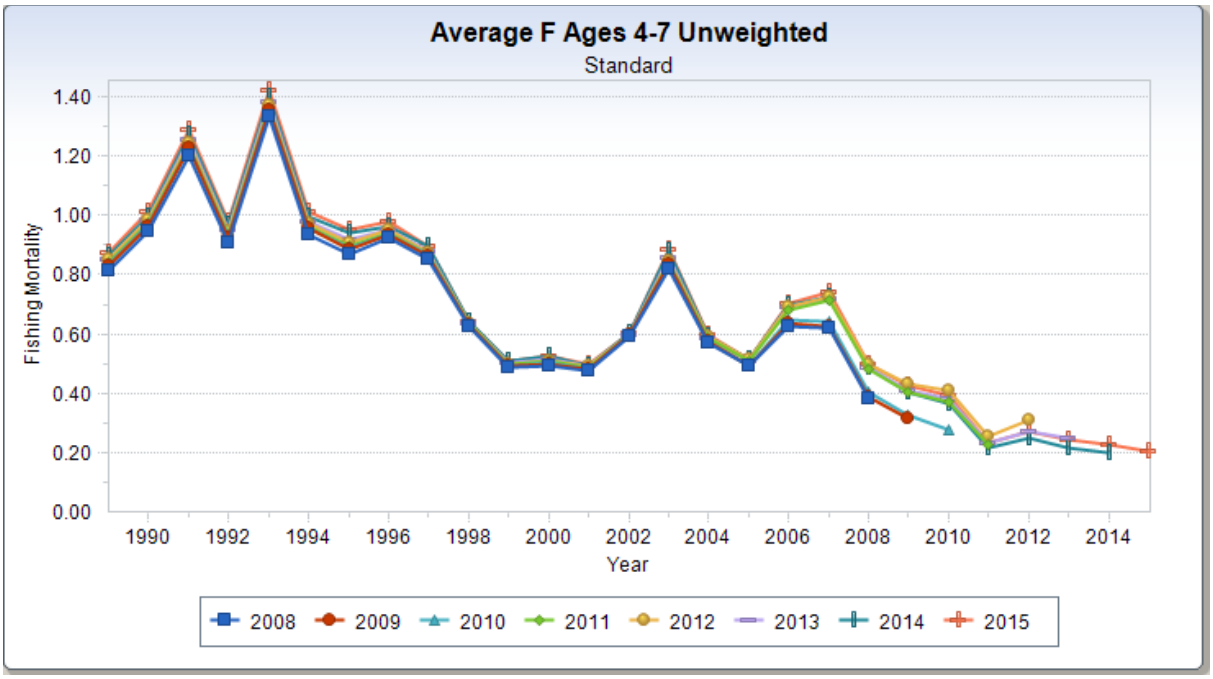


Figure A57. Retrospective pattern in average F estimates from black sea bass ASAP model for **Overall** single area model. Mohn's rho = -0.11

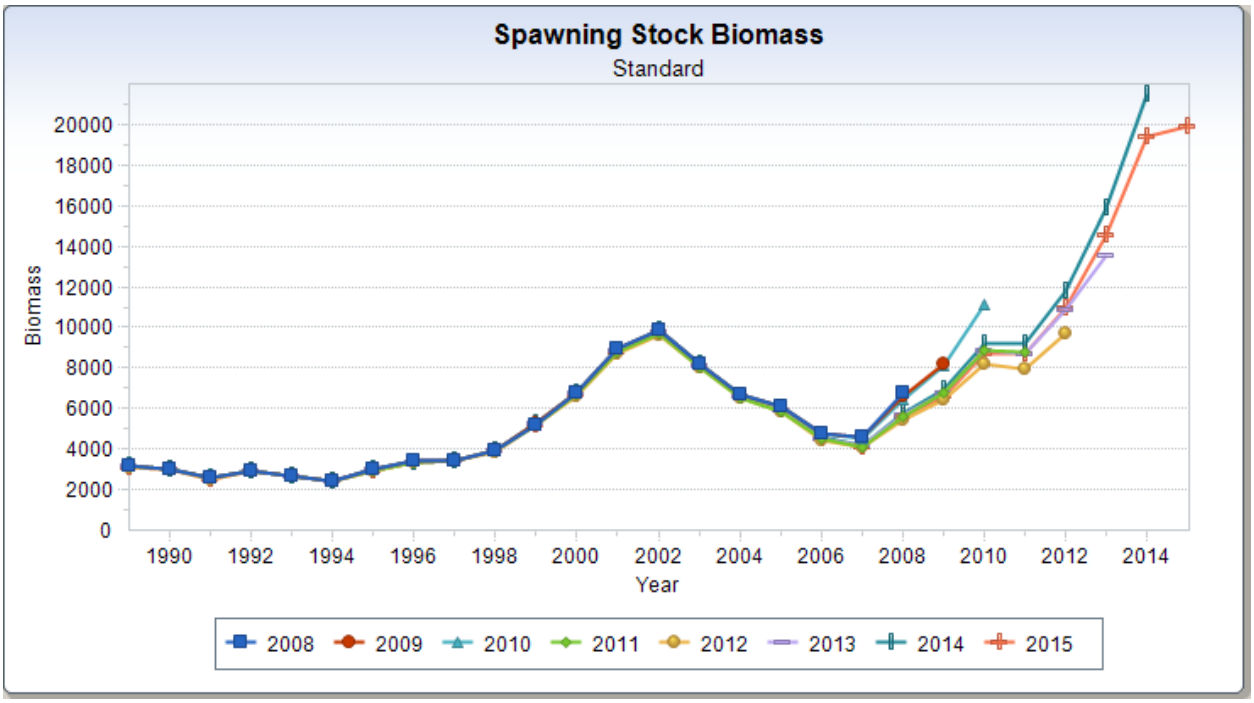


Figure A58. Retrospective pattern in spawning stock biomass (mt) estimates from black sea bass ASAP model for **Overall** single area model. Mohn's rho = 0.09

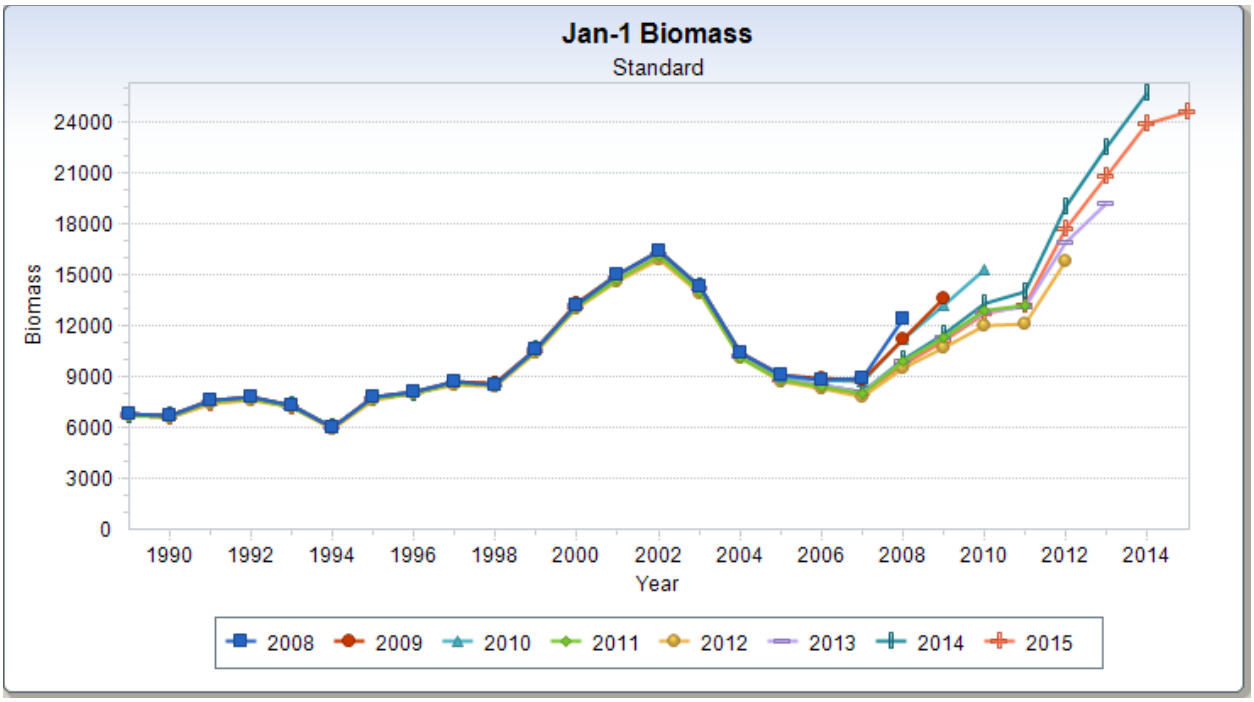


Figure A59. Retrospective pattern in total biomass (mt) estimates from black sea bass ASAP model for **Overall** single area model. Mohn's rho = 0.08

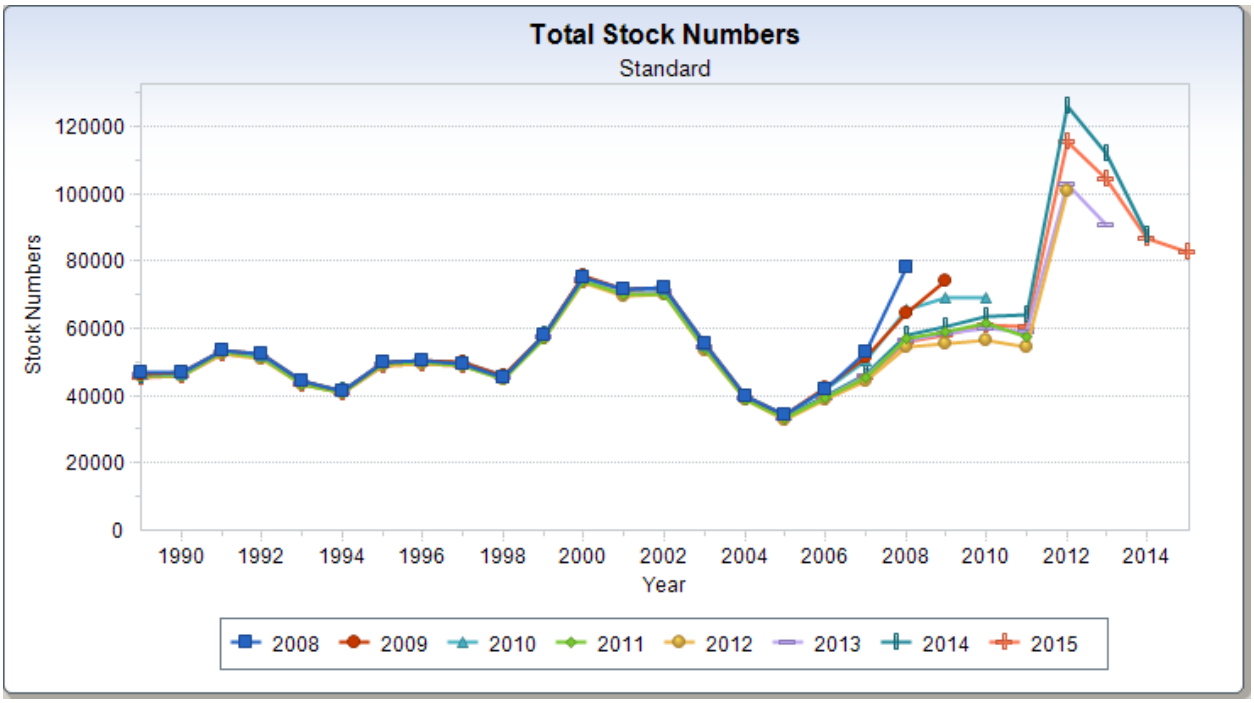


Figure A60. Retrospective pattern in total stock number estimates from black sea bass ASAP model for **Overall** single area model. Mohn's rho = 0.08

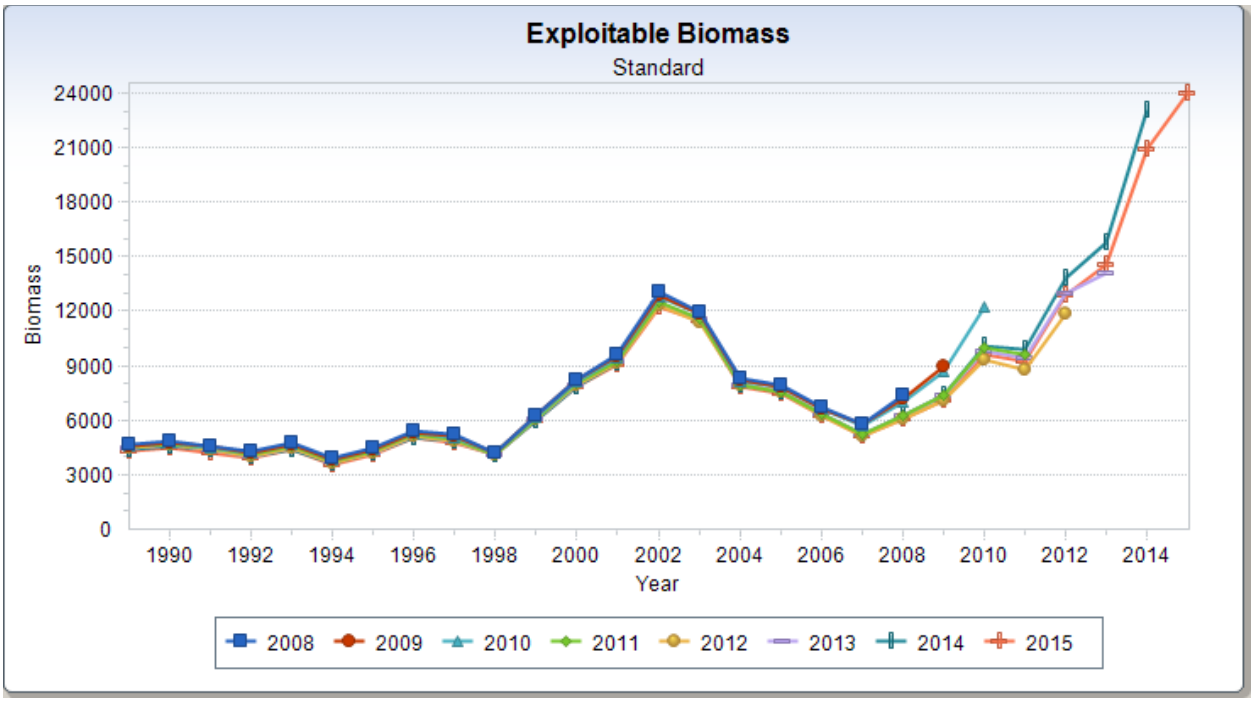


Figure A61. Retrospective pattern in exploitable biomass (mt) estimates from black sea bass ASAP model for **Overall** single area model. Mohn's rho = 0.11

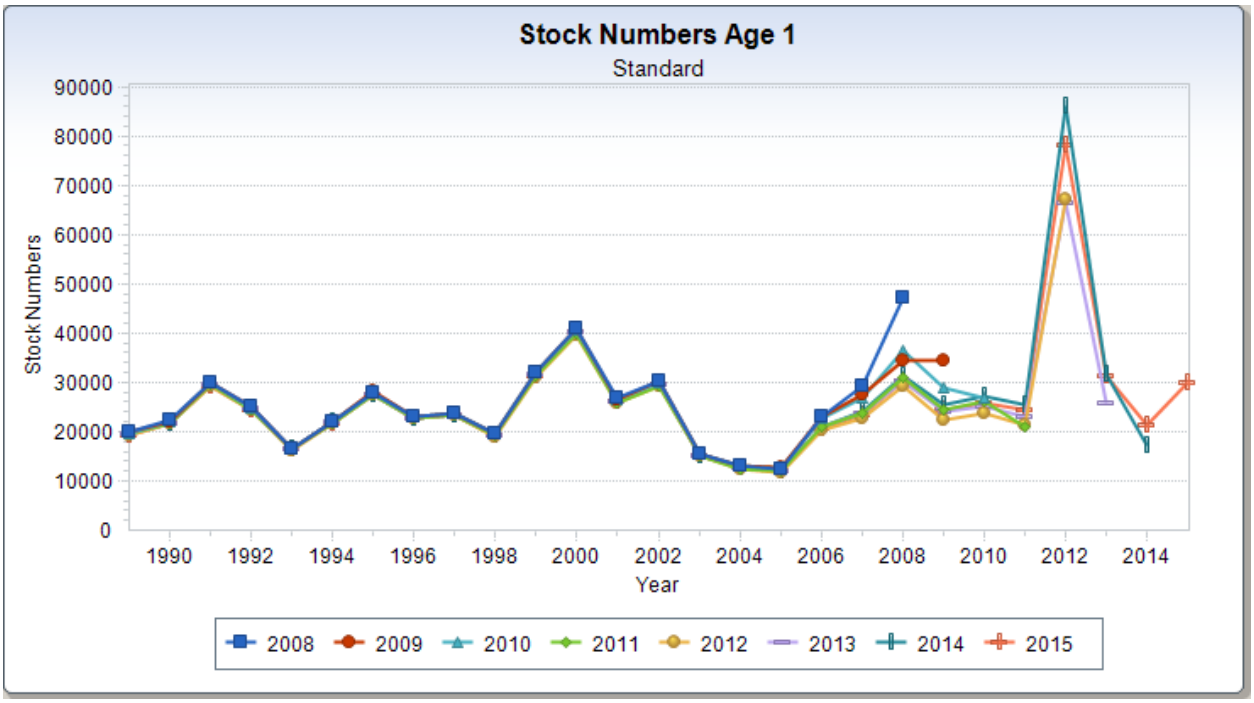


Figure A62. Retrospective pattern in age 1 stock number estimates from black sea bass ASAP model for **Overall** single area model. Mohn's rho = 0.06

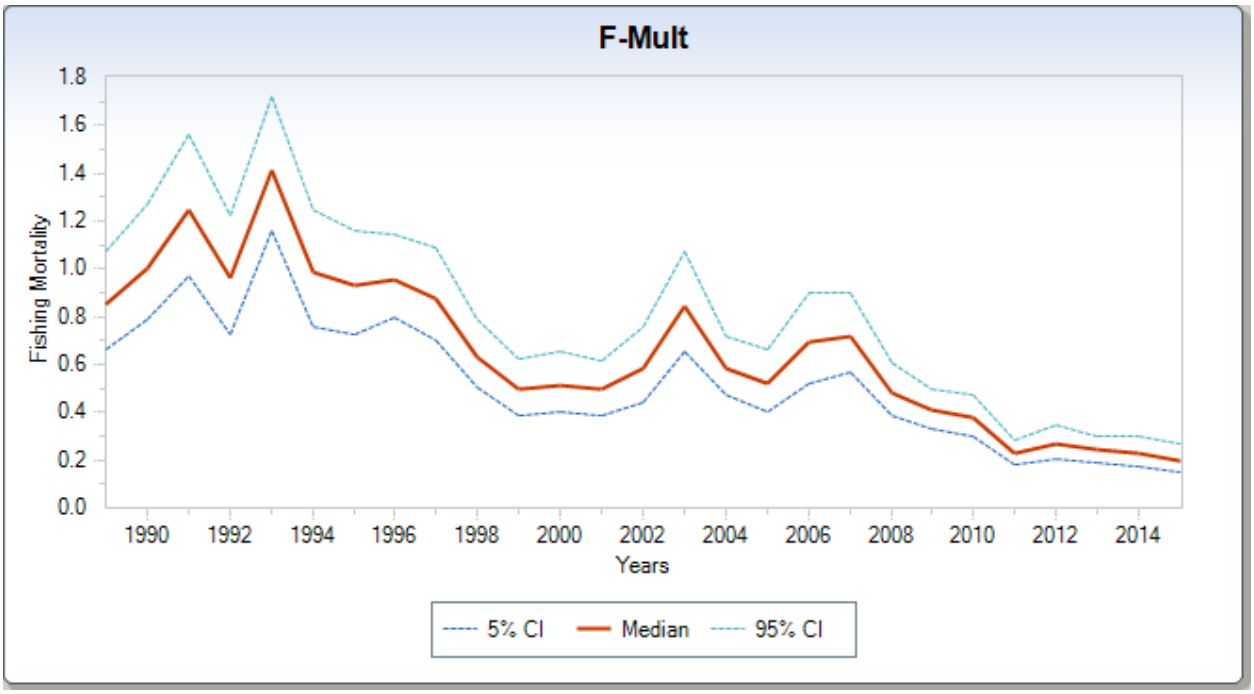


Figure A63. ASAP MCMC estimates of black sea bass F mult (± 90% CI) from **Overall** single area model.

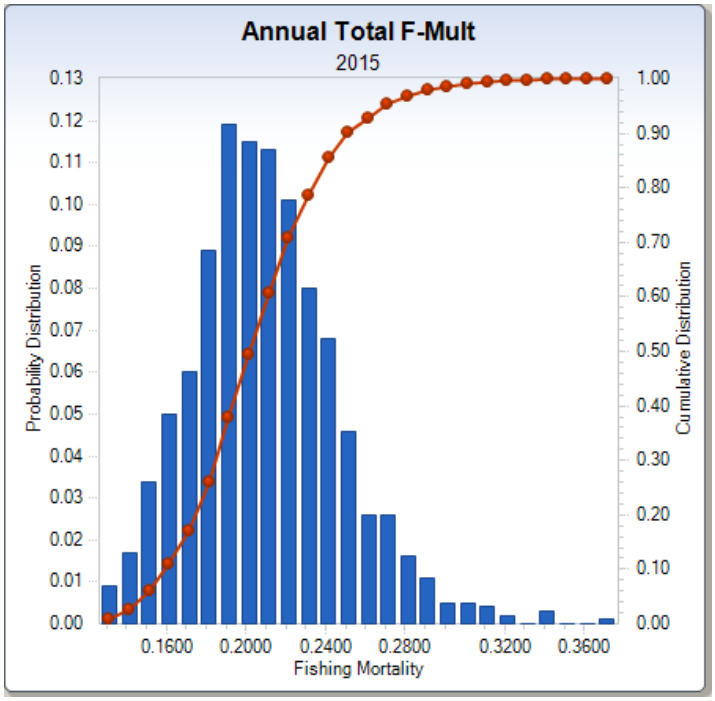


Figure A64. MCMC distribution of 2015 black sea bass Fmult estimates from **Overall** single area model.

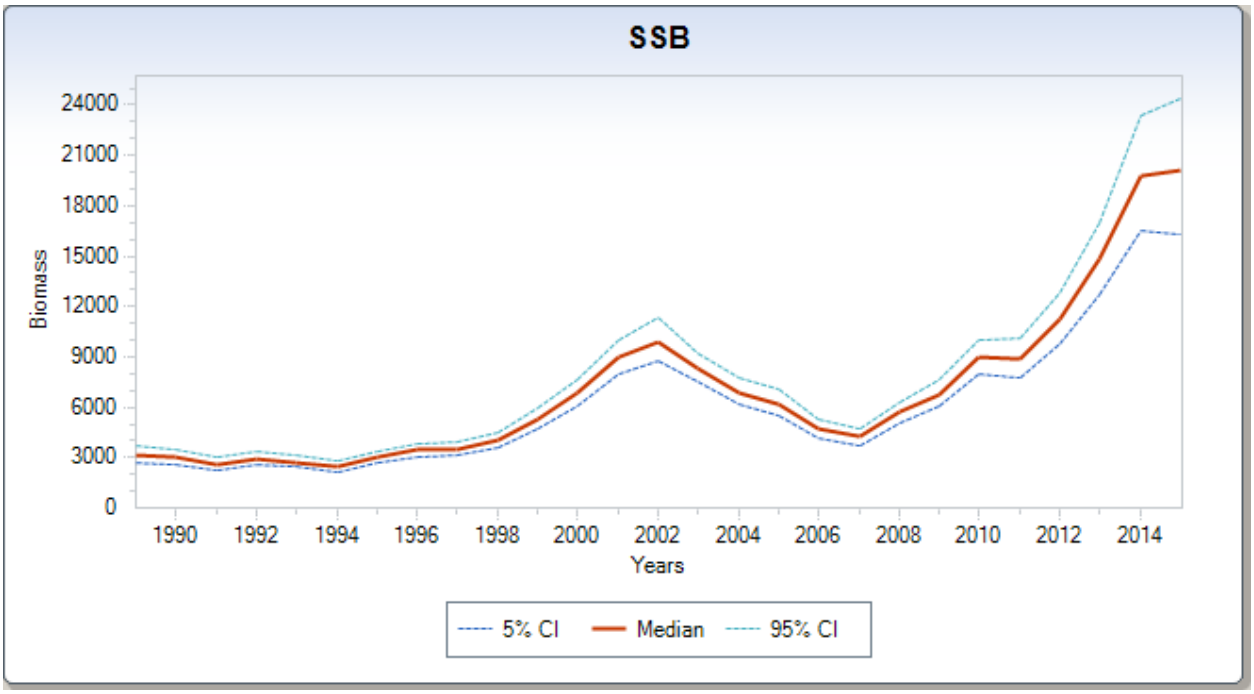


Figure A65. ASAP MCMC estimates of black sea bass spawning stock biomass (MT ± 90% CI) from **Overall** single area model.

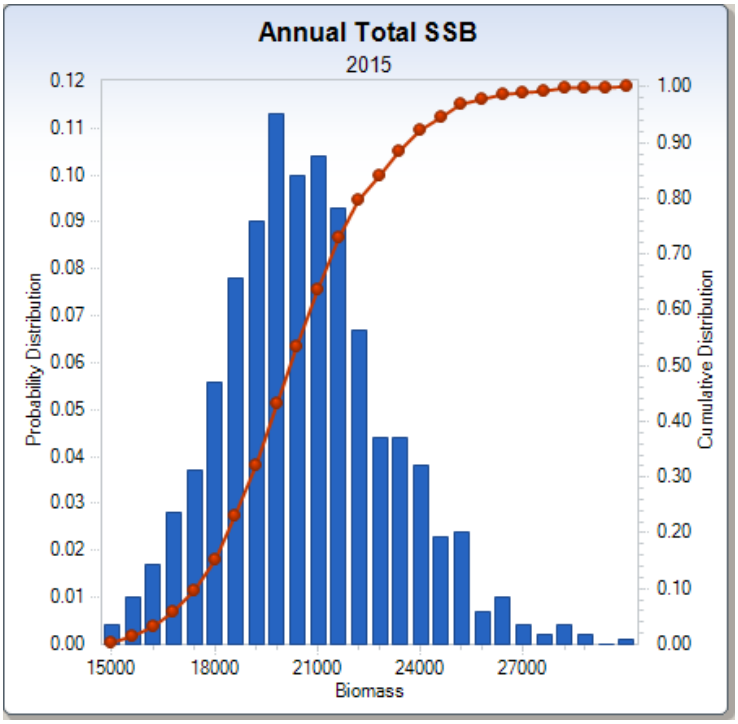


Figure A66. MCMC distribution of 2015 black sea bass spawning stock biomass (mt) estimates from **Overall** single area model.

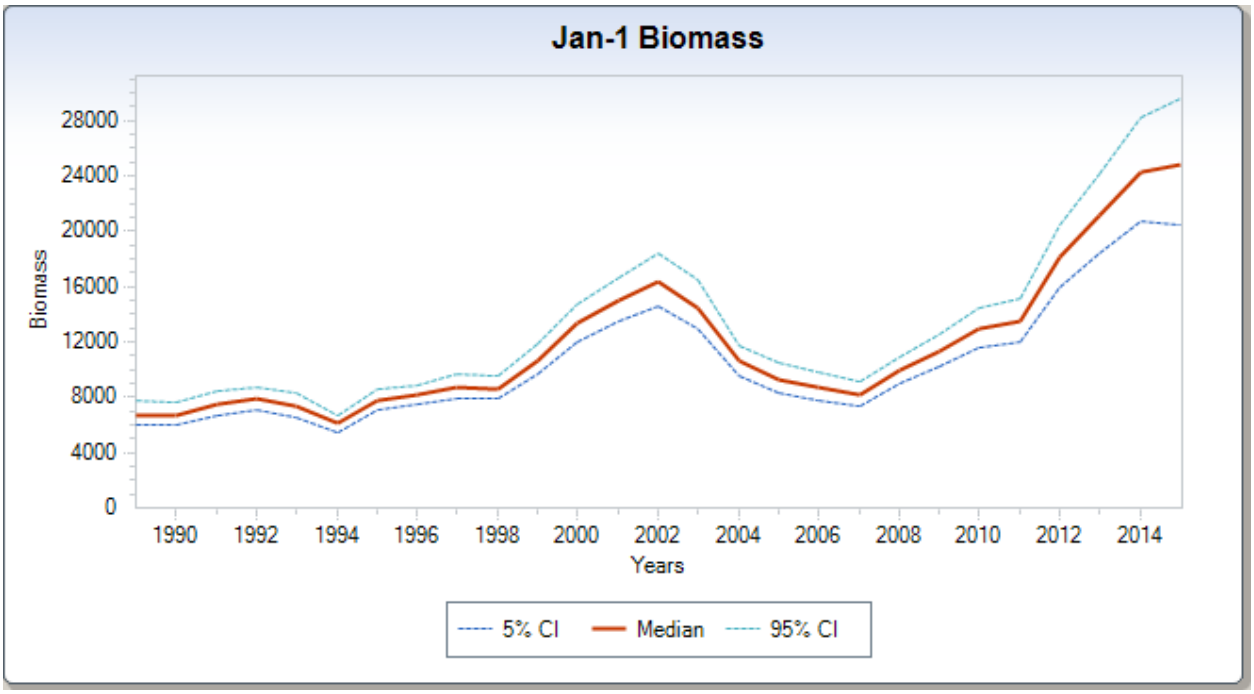


Figure A67. ASAP MCMC estimates of black sea bass total biomass (mt ± 90% CI) from **Overall** single area model.

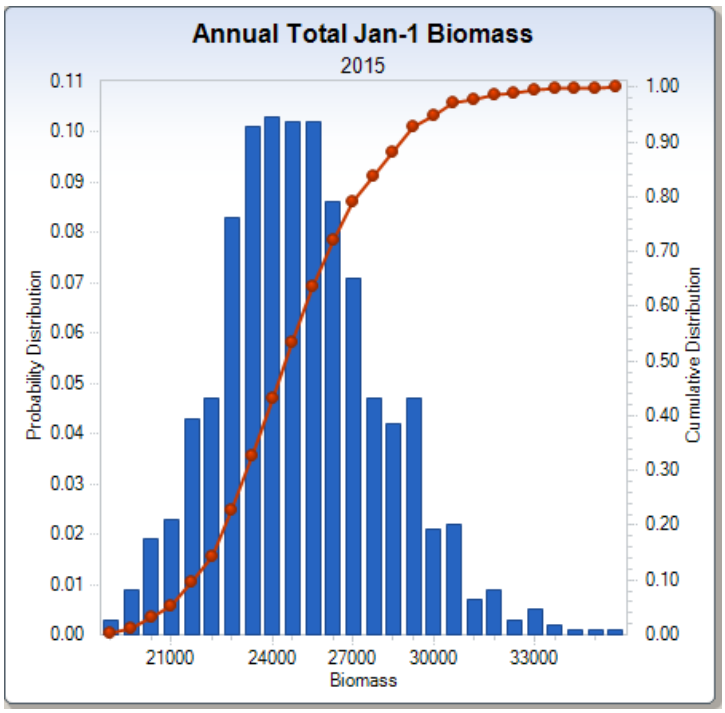


Figure A68. MCMC distribution of 2015 black sea bass total biomass (mt) estimates from **Overall** single area model.

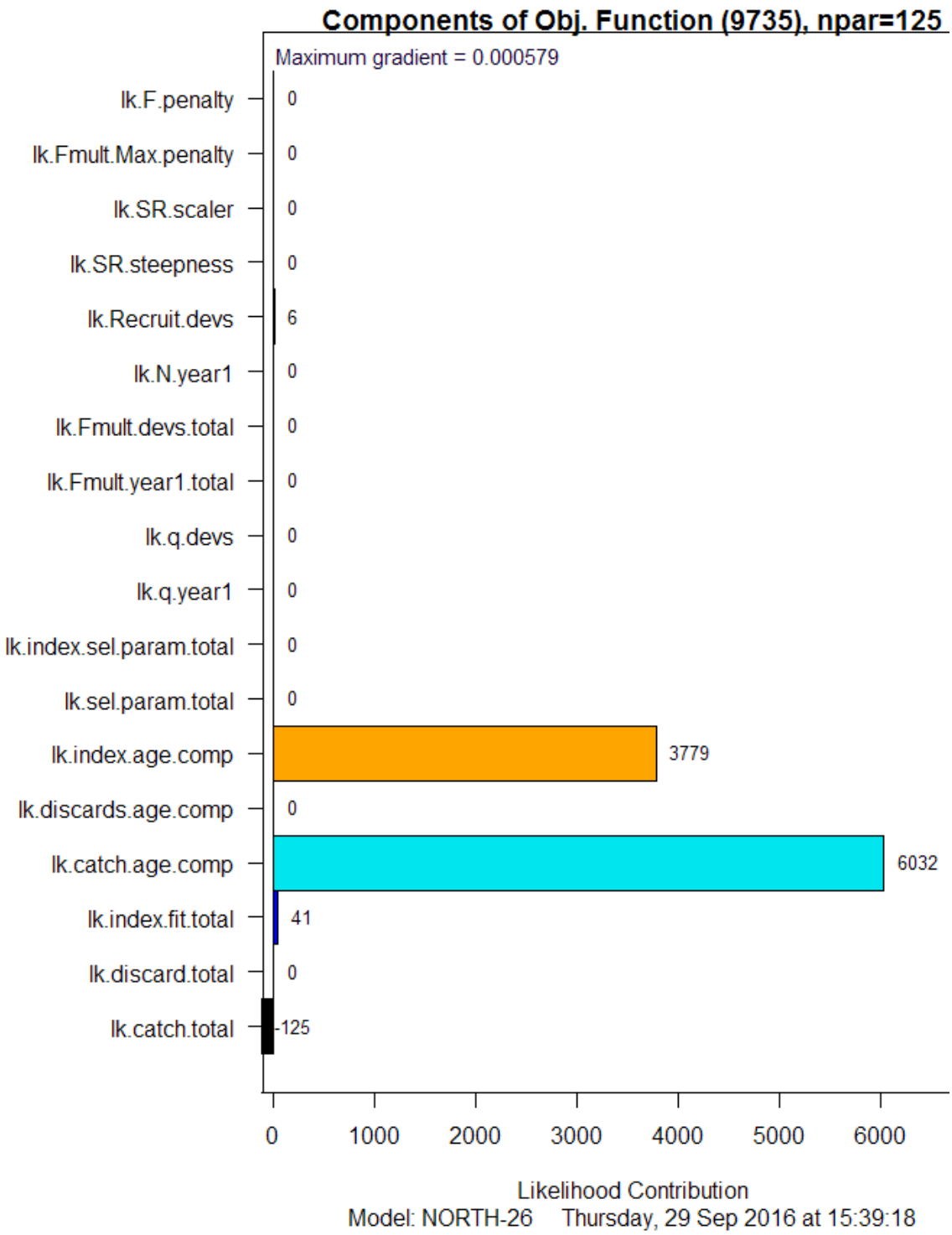


Figure A69. Distribution of objective function components contribution to total likelihood for black sea bass **North** area model.

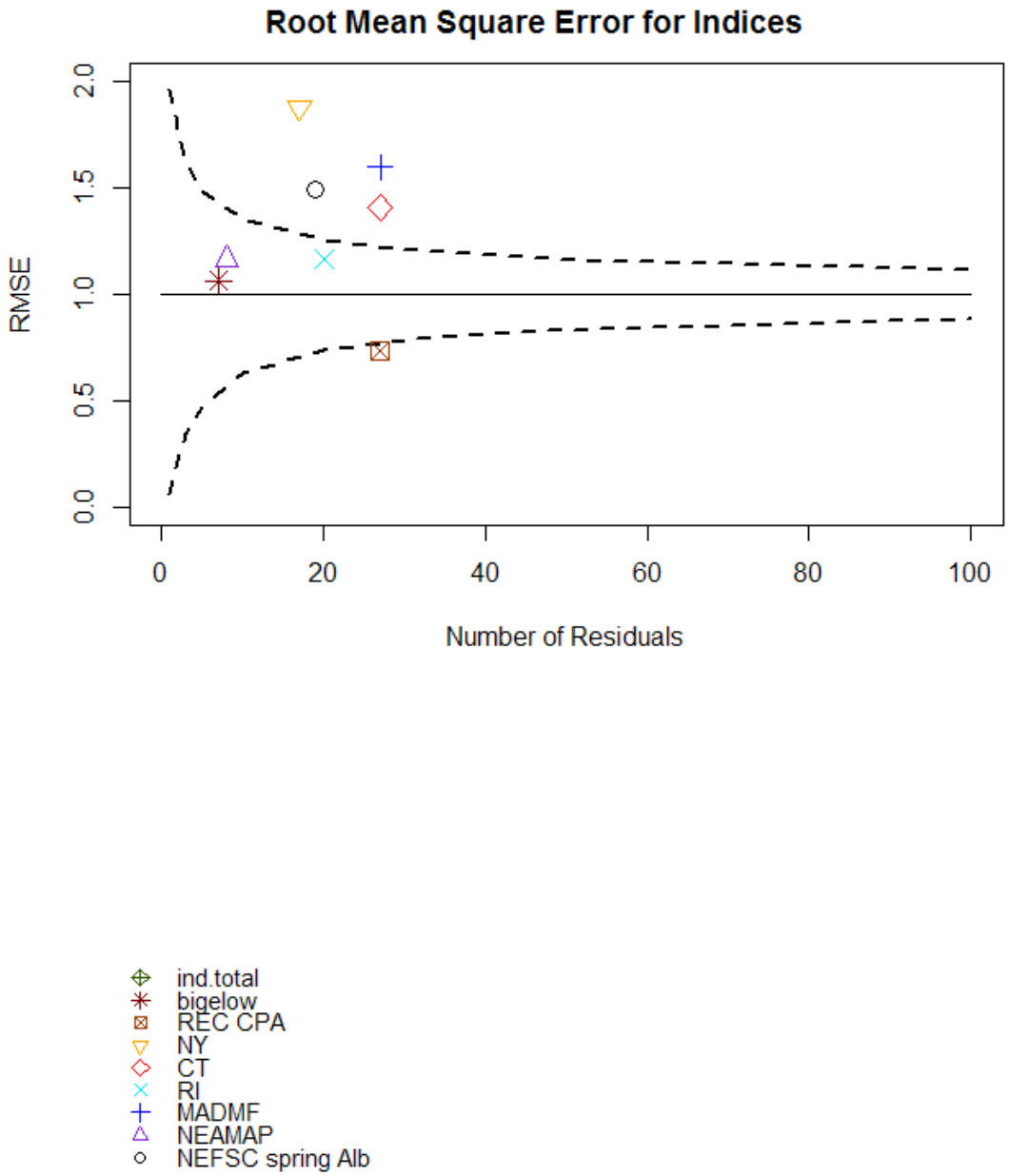


Figure A70. Final Root Mean Square Error (RMSE) values for survey indices in final black sea bass **North** area model.

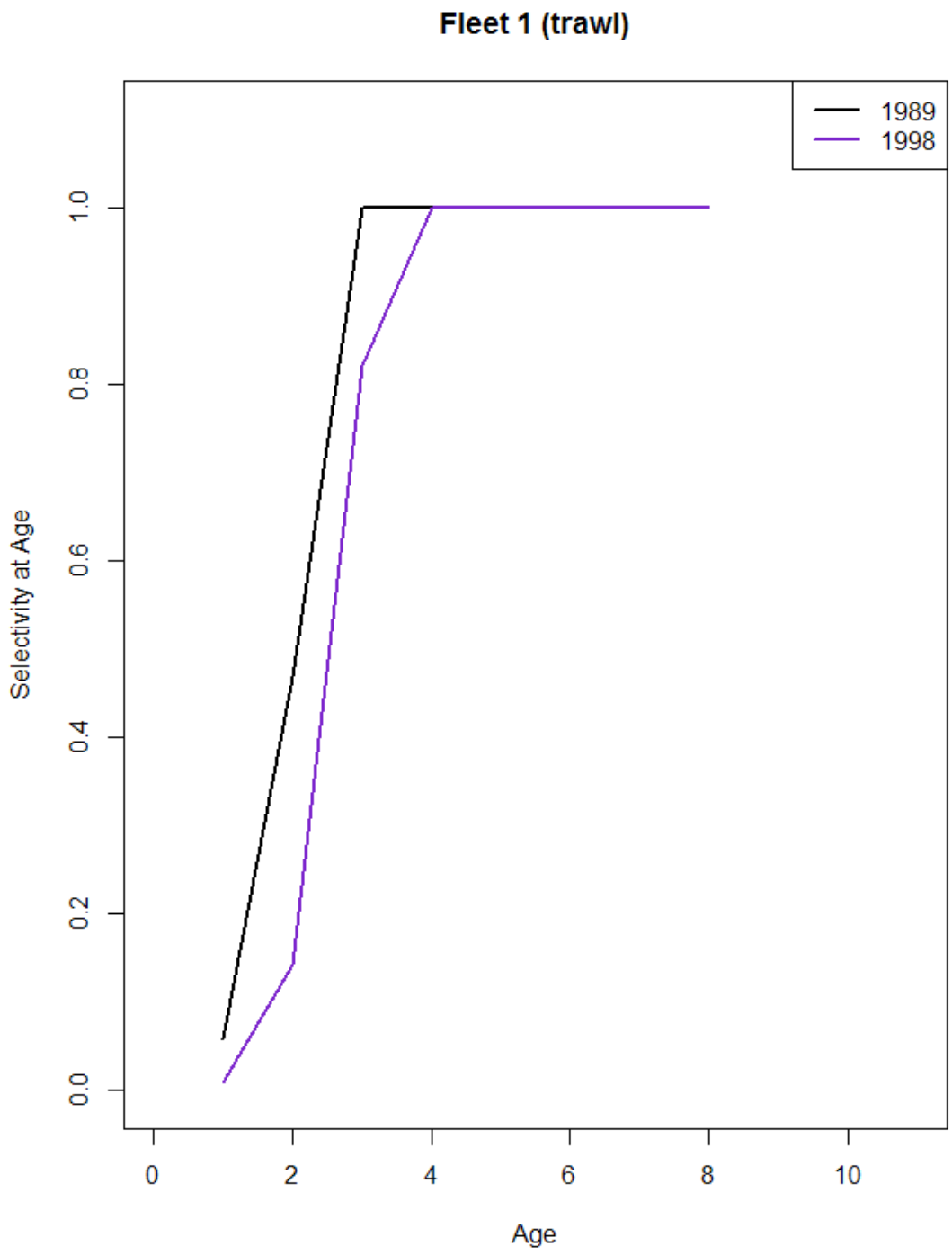


Figure A71. Selectivity at age from trawl fleet in final black sea bass **North** area model.

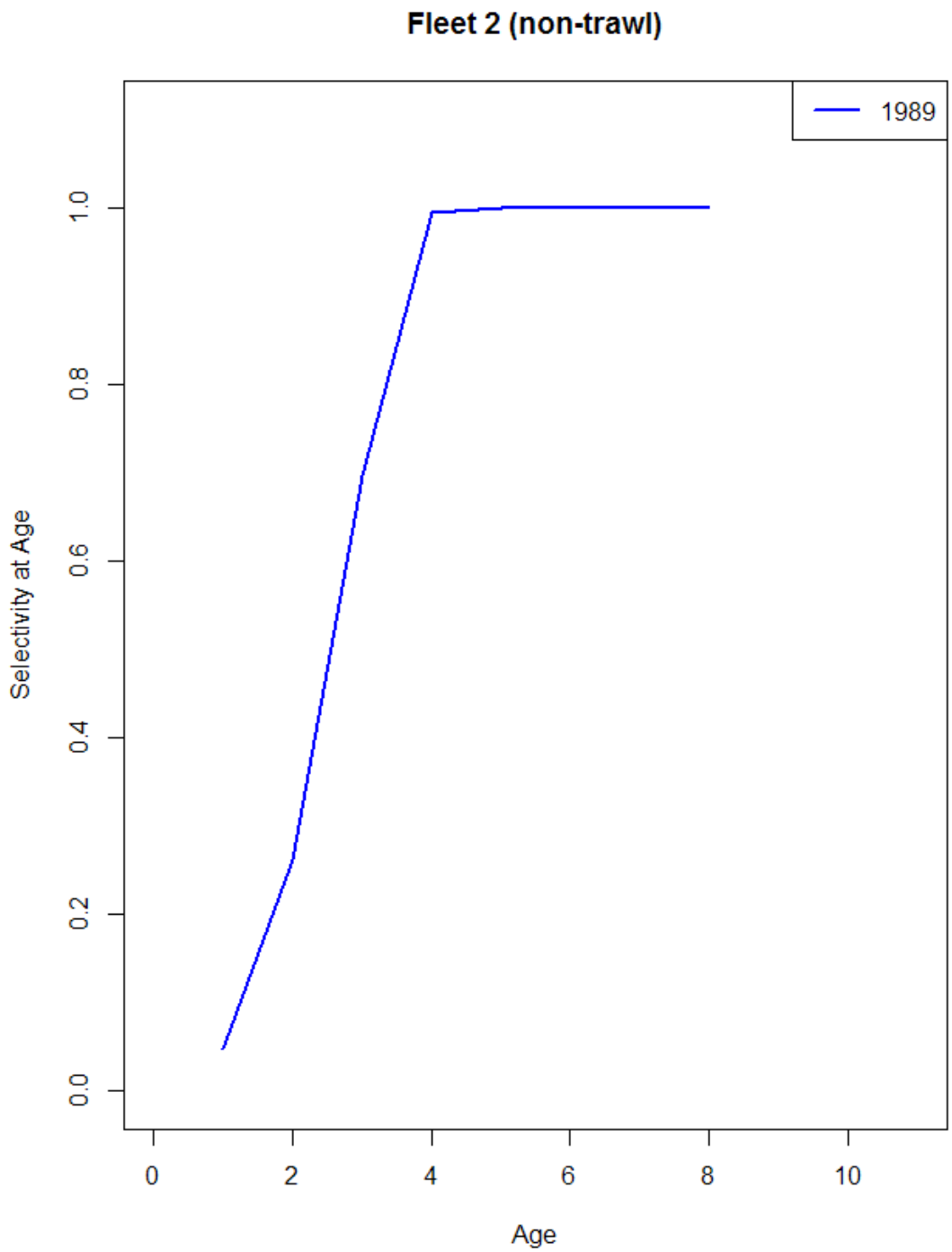


Figure A72. Selectivity at age from non-trawl fleet in final black sea bass **North** area model.

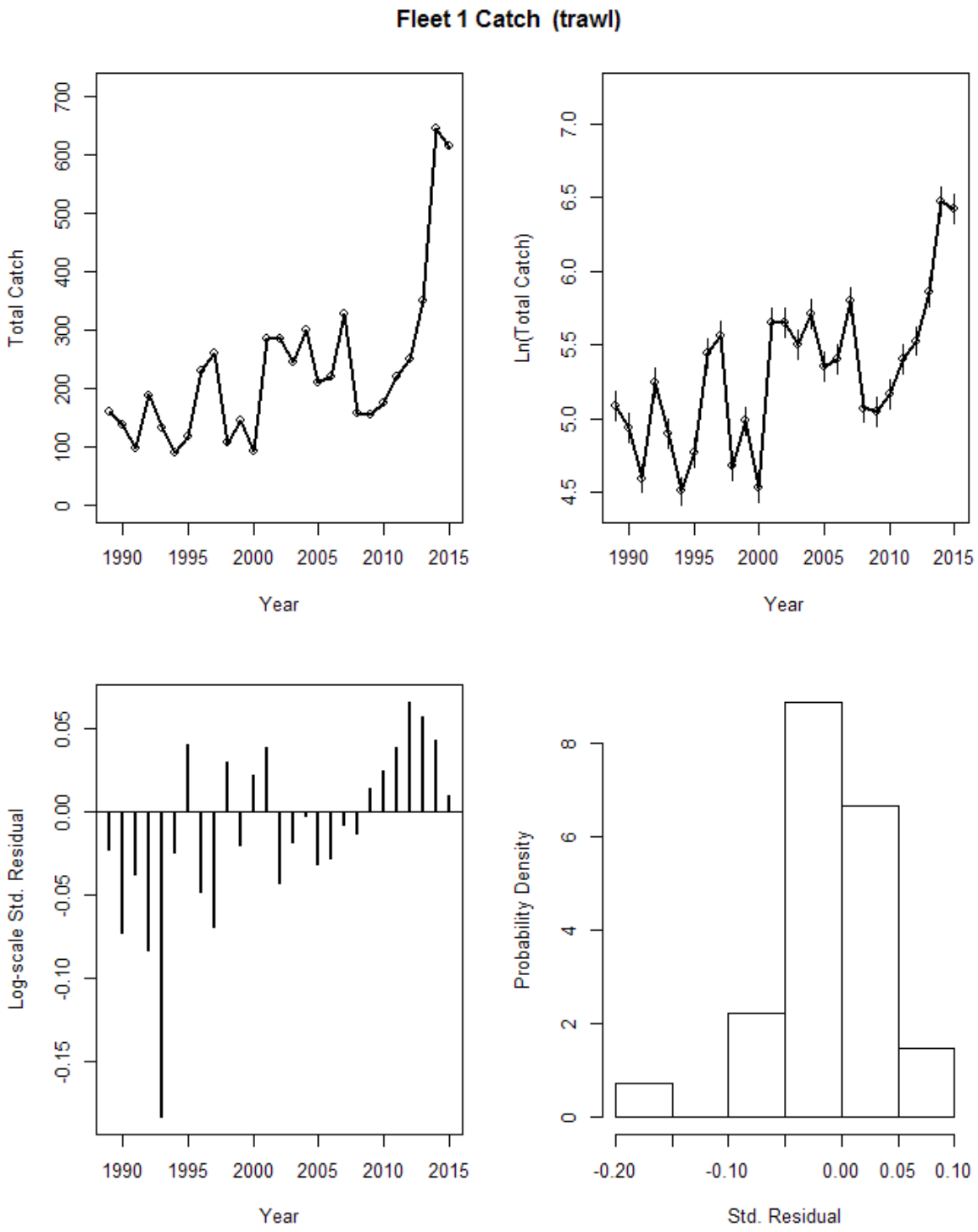


Figure A73. Fit diagnostics for the trawl catch in final black sea bass **North** area model.

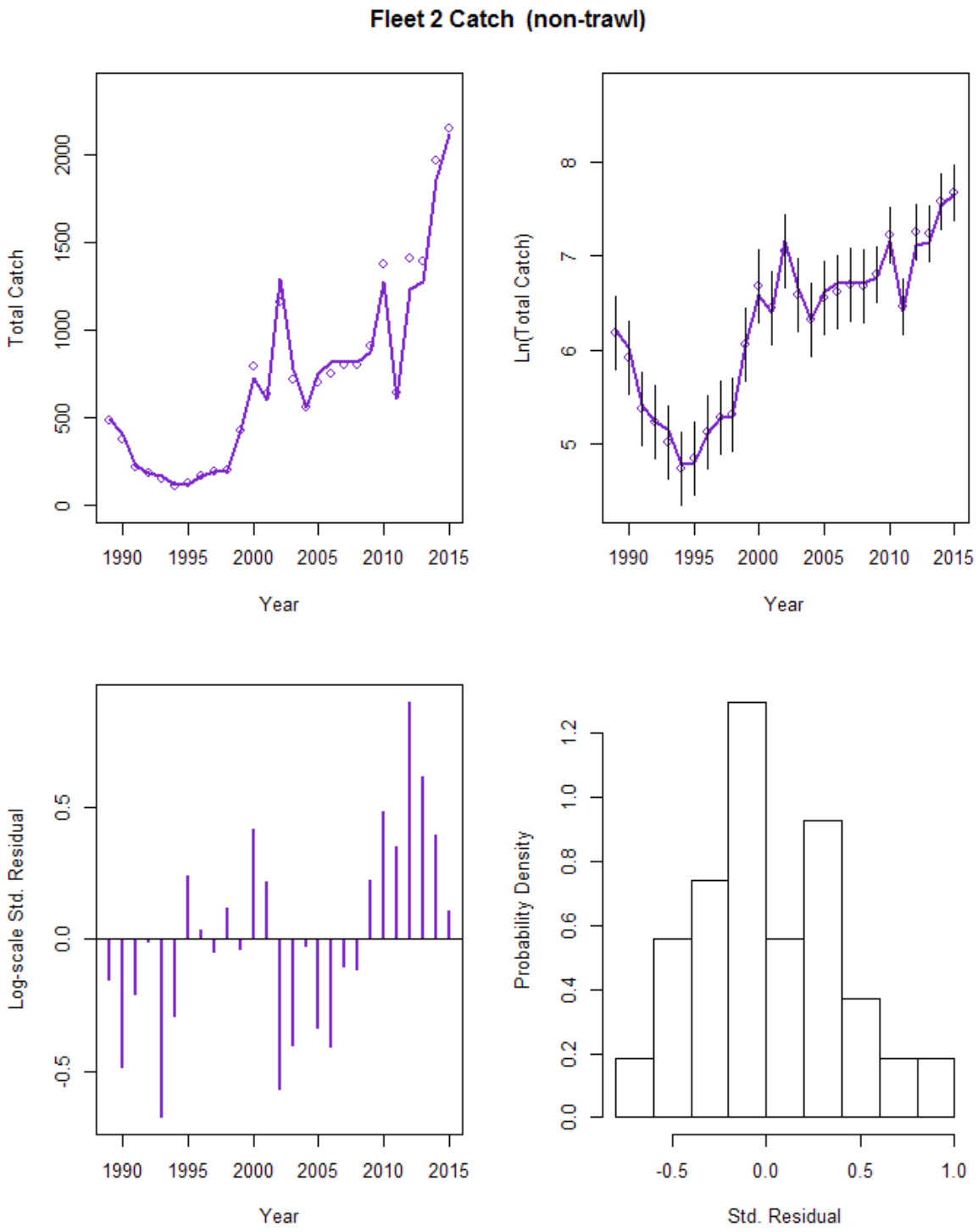


Figure A74. Fit diagnostics for the non-trawl catch in final black sea bass **North** area model.

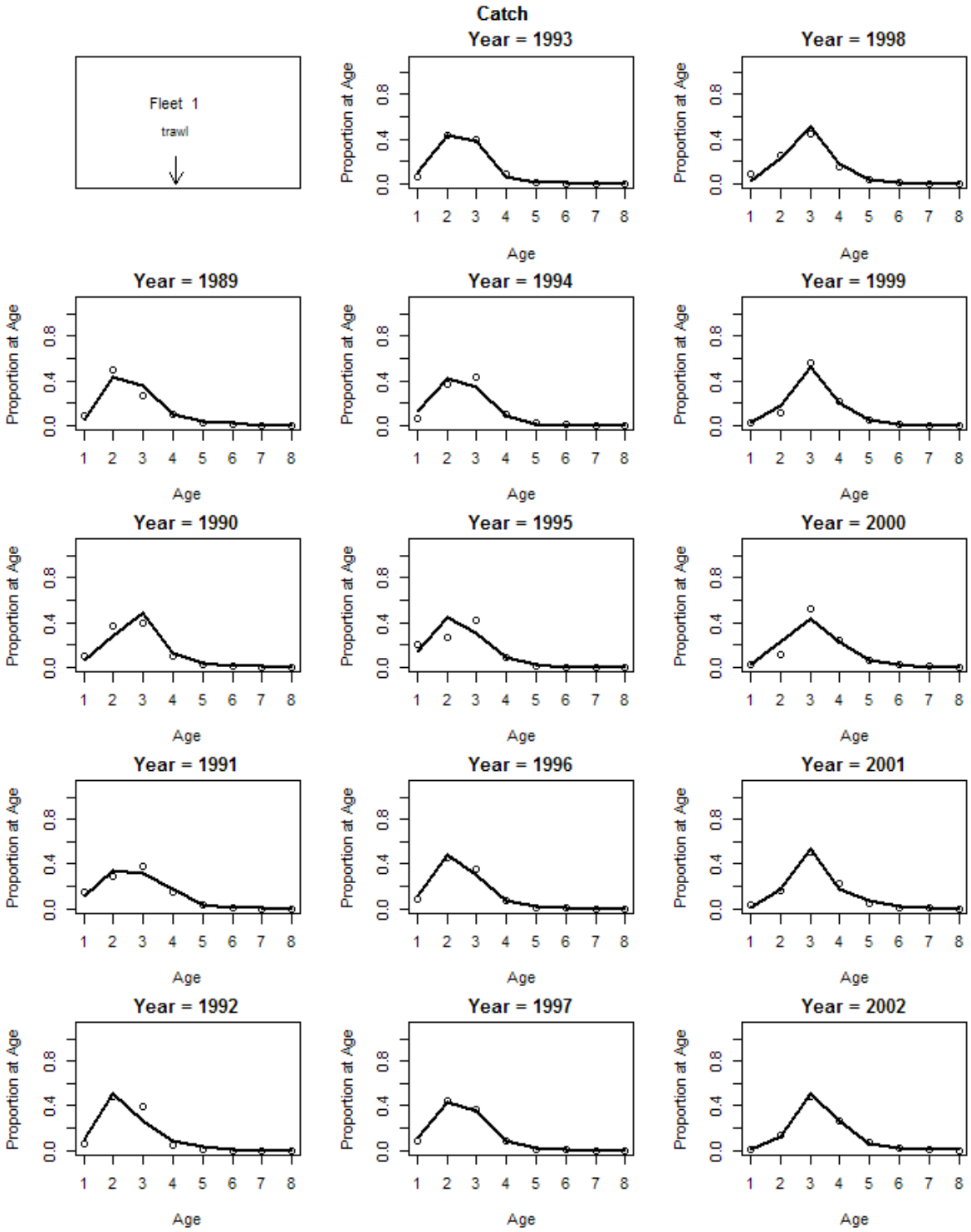


Figure A75. Fits to 1989-2002 trawl catch proportions at age in final black sea bass **North** area model.

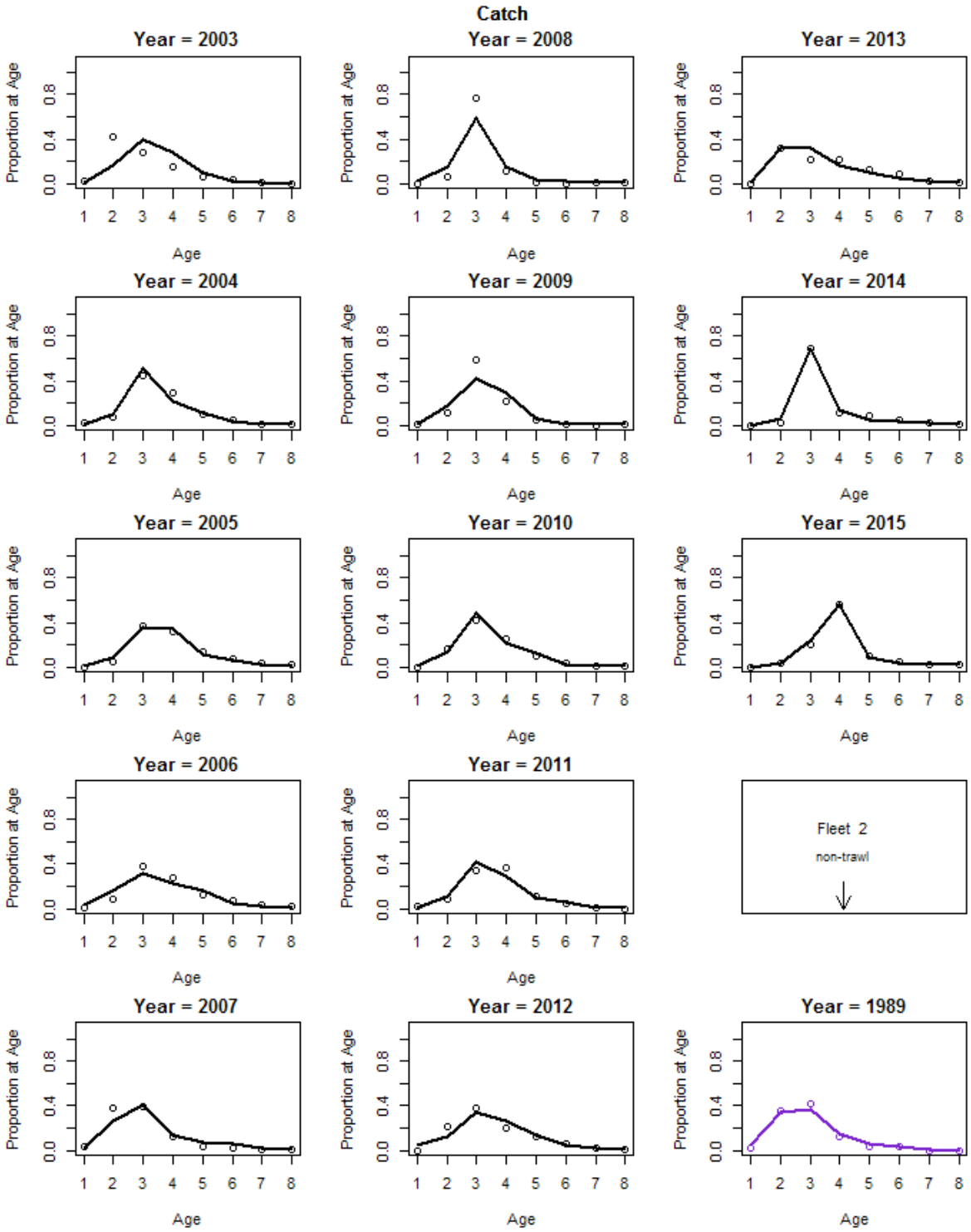


Figure A76. Fits to 2003-2015 trawl catch proportions at age and 1989 non-trawl catch proportion at age in final black sea bass **North** area model.

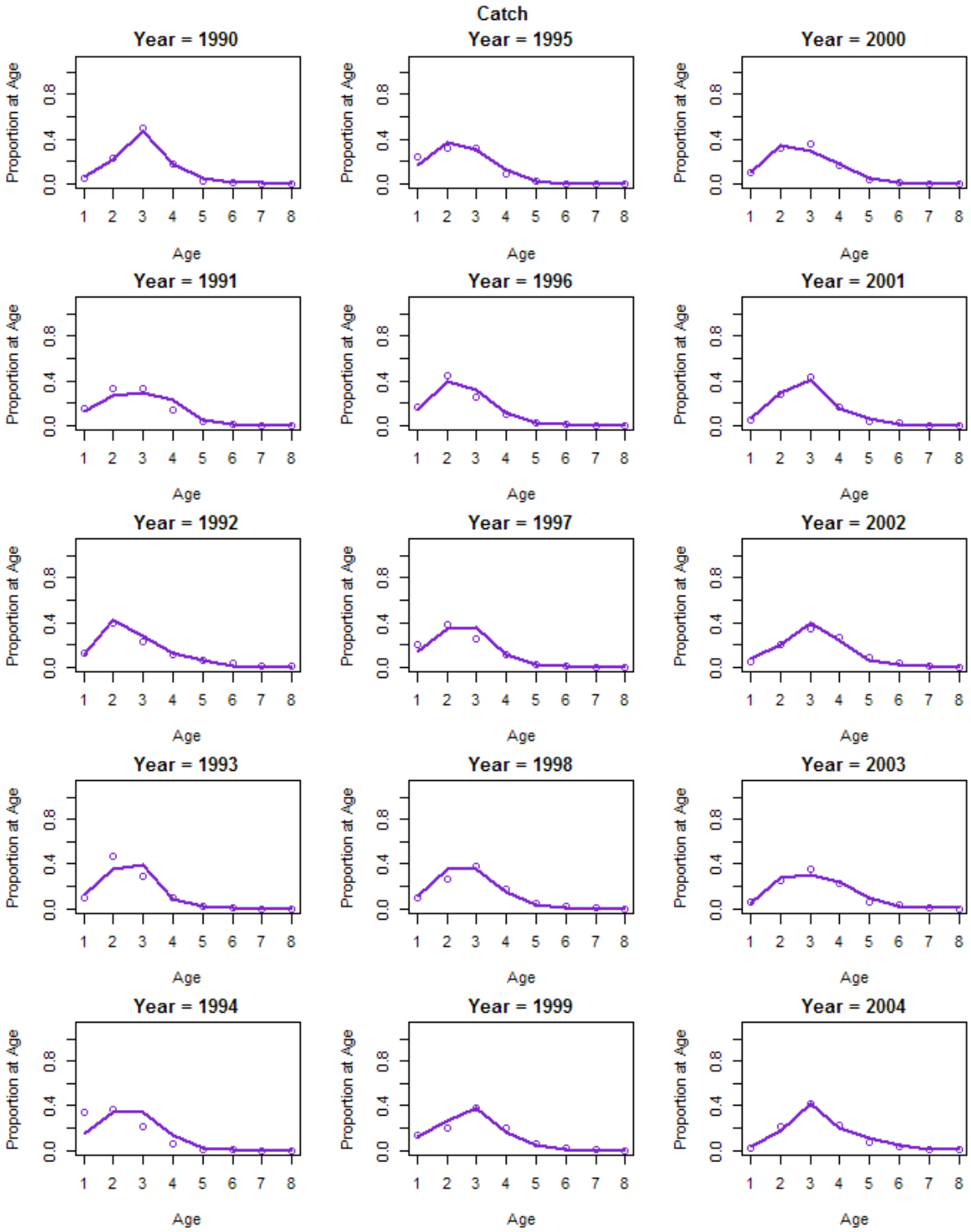


Figure A77. Fits to 1990-2004 non-trawl catch proportions at age in final black sea bass **North** area model.

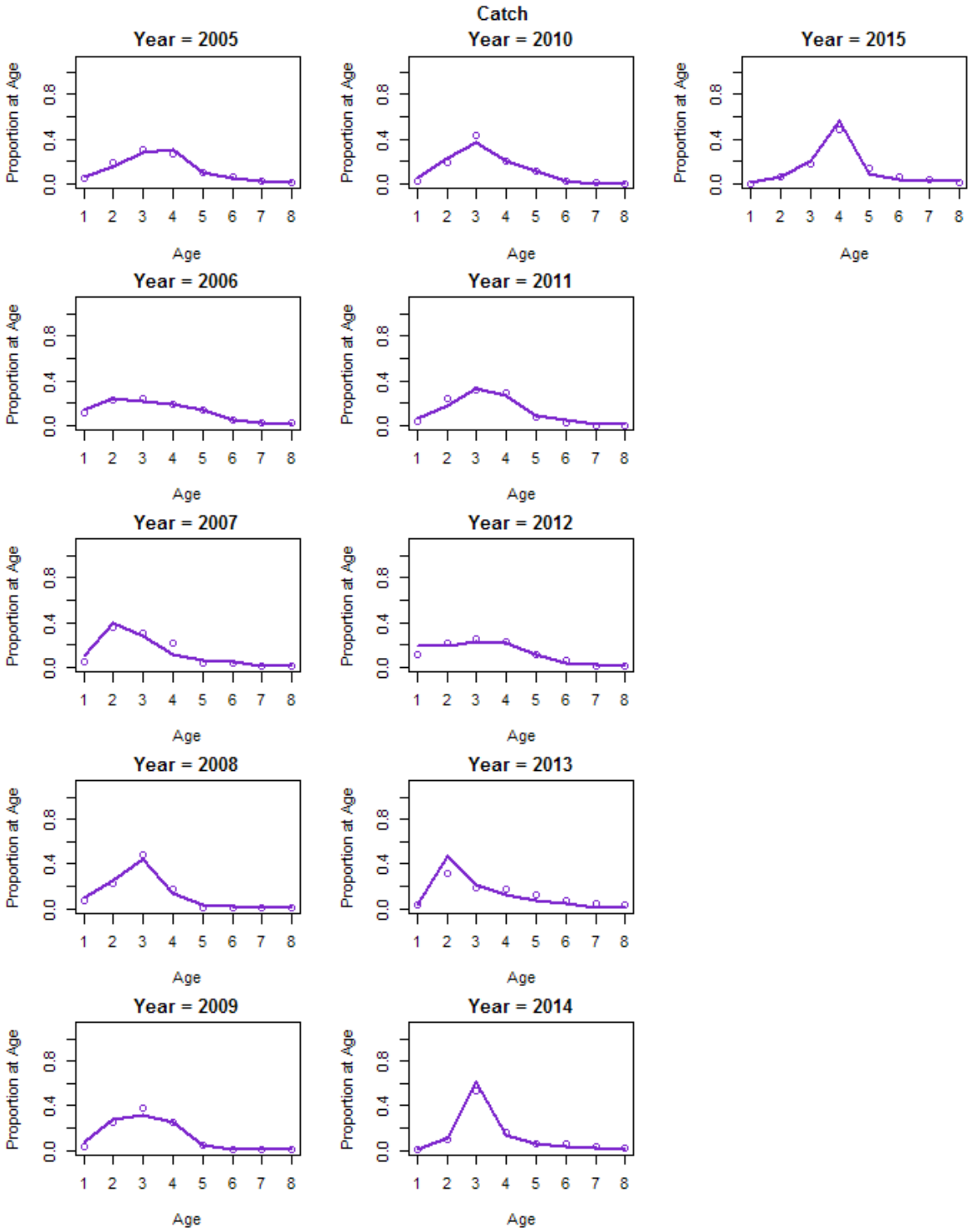


Figure A78. Fits to 2005-2015 non-trawl catch proportions at age in final black sea bass **North** area model.

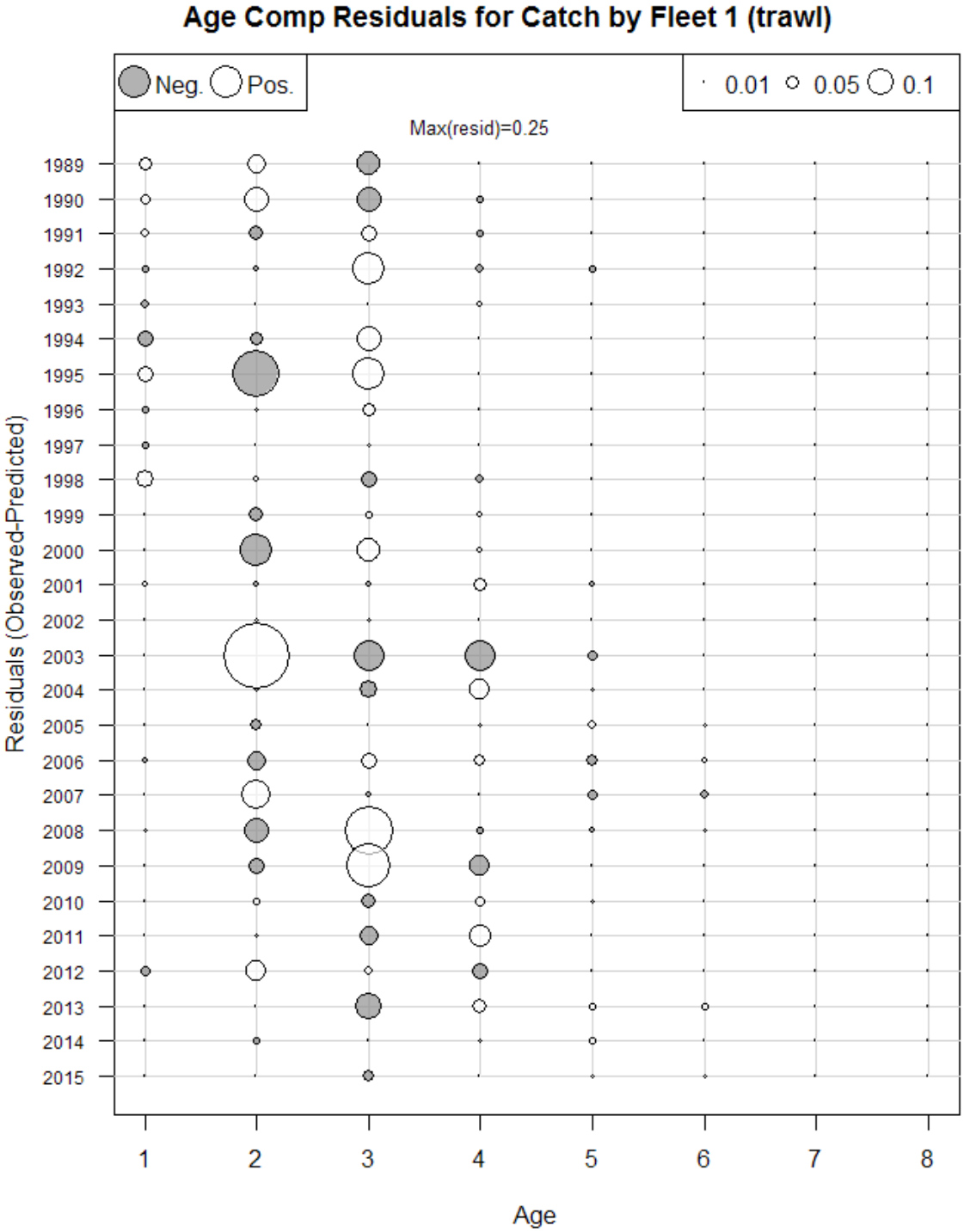


Figure A79. Trawl catch age composition residuals in final black sea bass **North** area model.

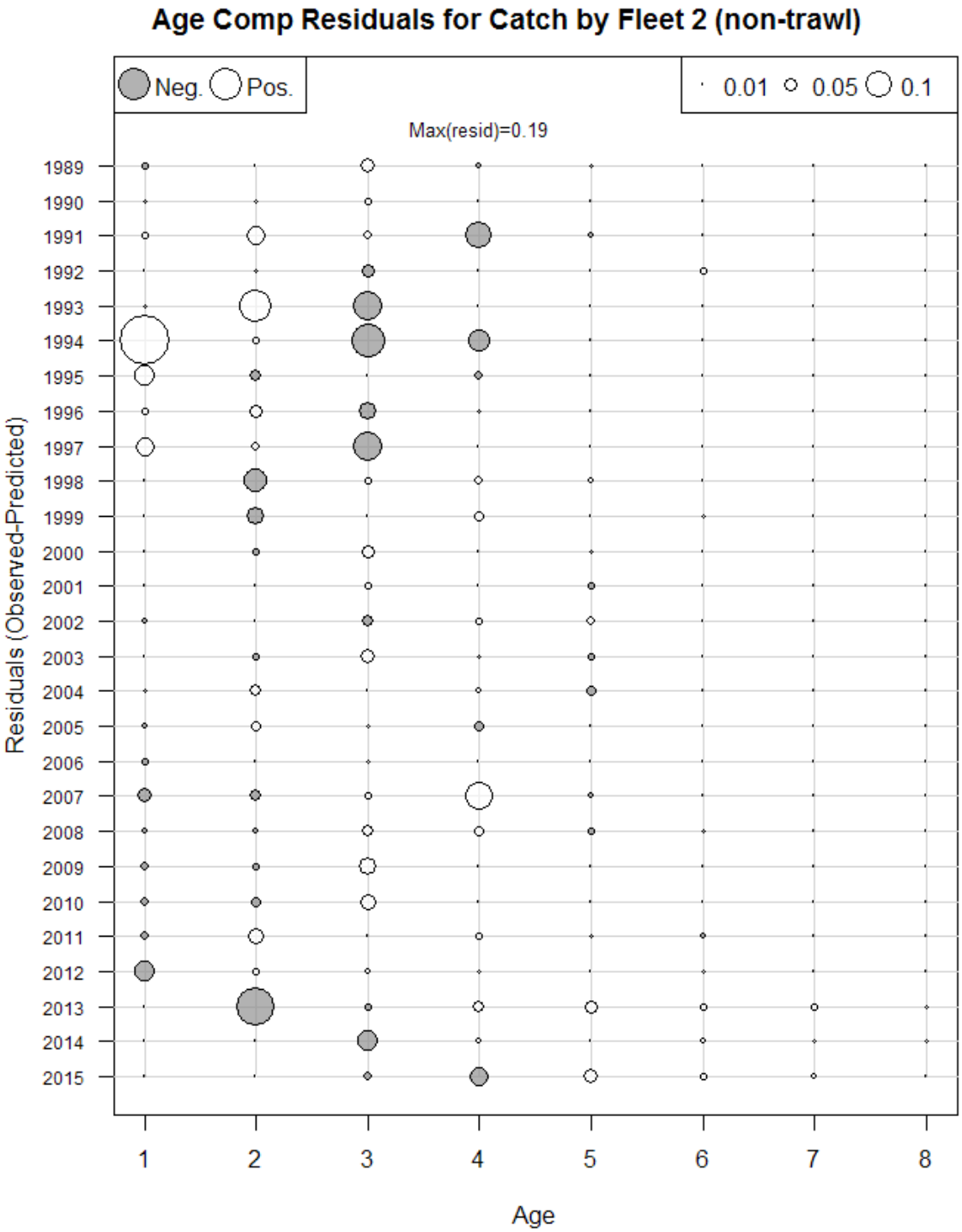


Figure A80. Non-trawl catch age composition residuals in final black sea bass **North** area model.

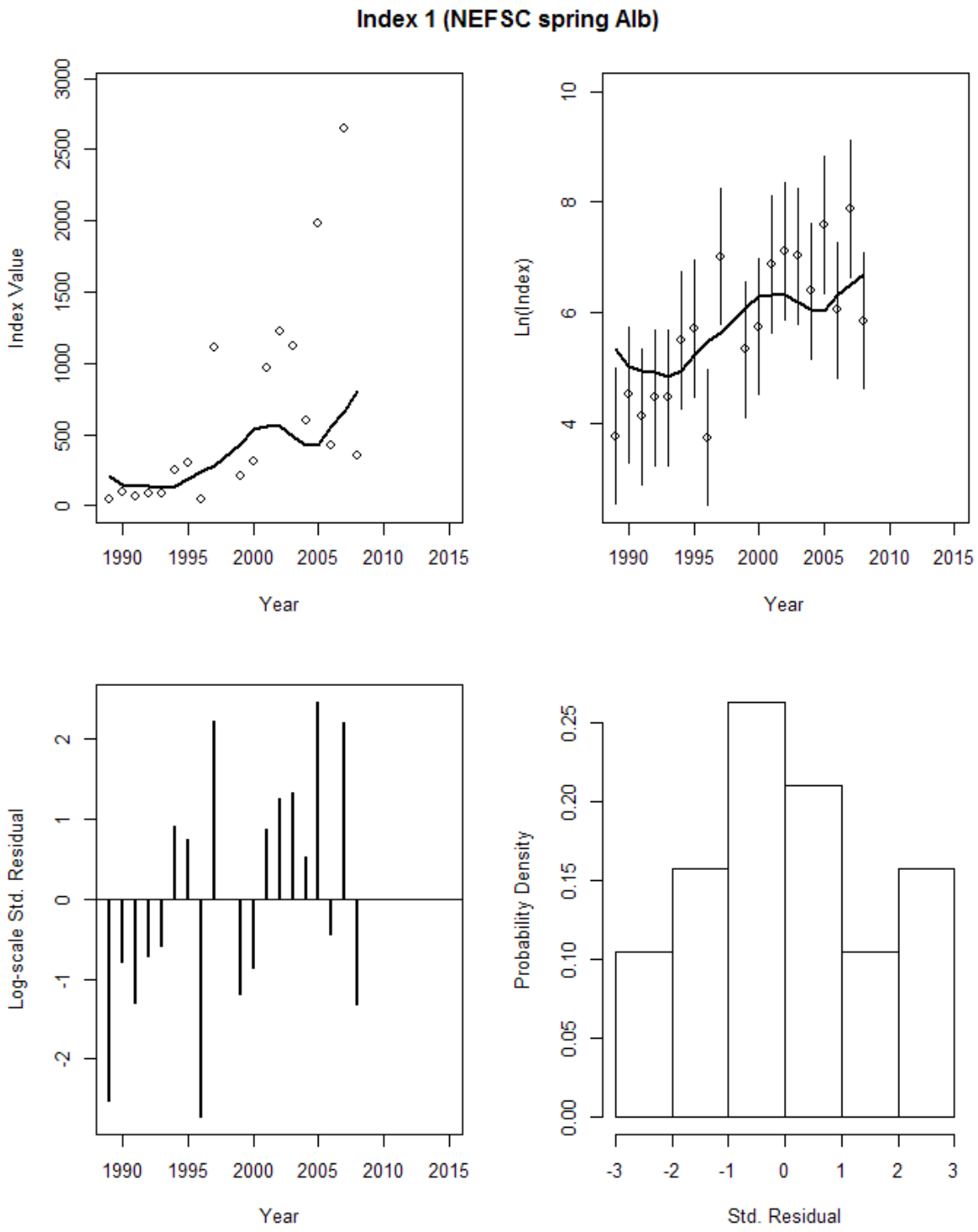


Figure A81. Fit diagnostics for the NEFSC spring trawl survey 1989-2008 (*Albatross*) in final black sea bass **North** area model.

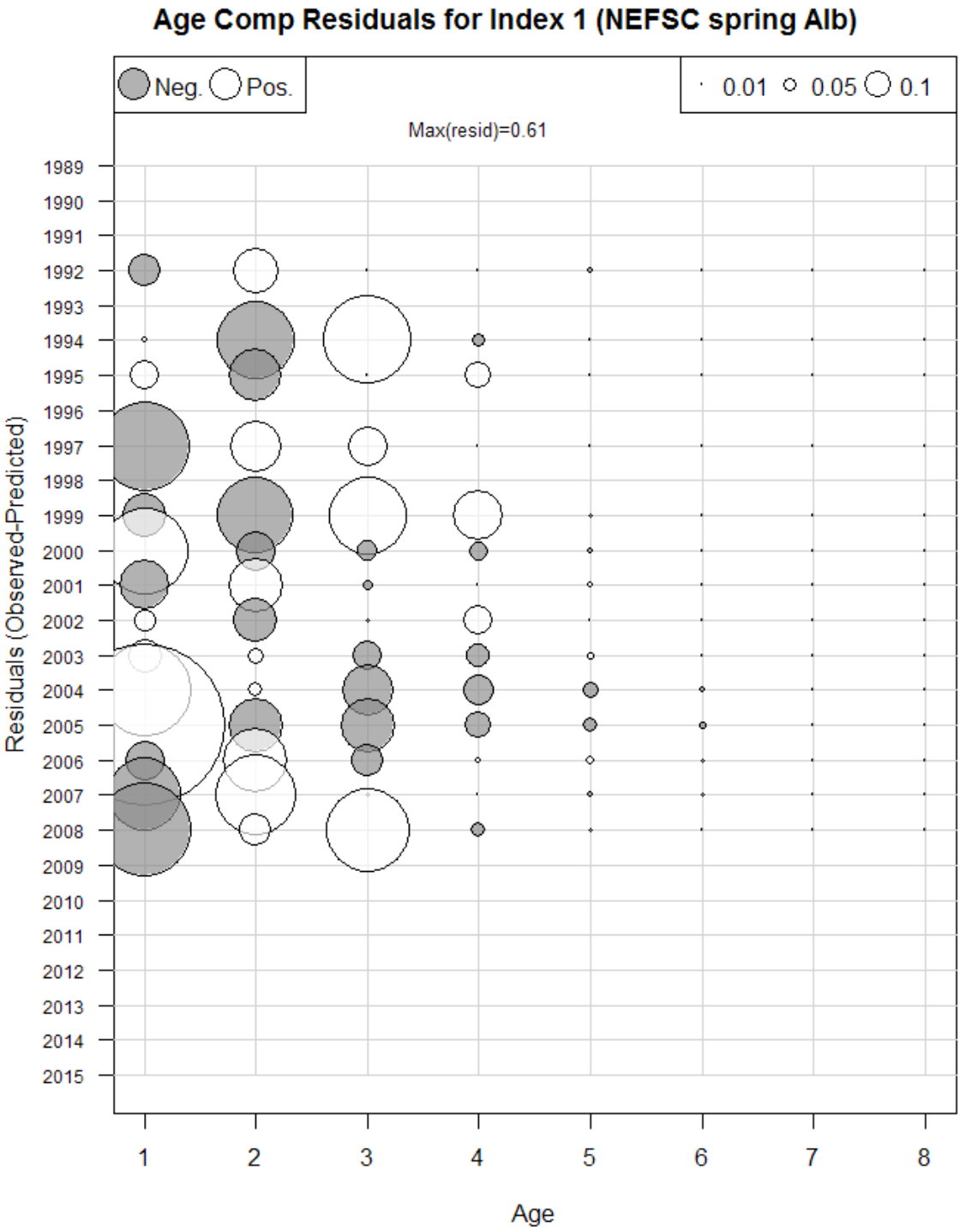


Figure A82. Age composition residuals for the NEFSC spring trawl survey 1989-2008 (*Albatross*) in final black sea bass **North** area model.

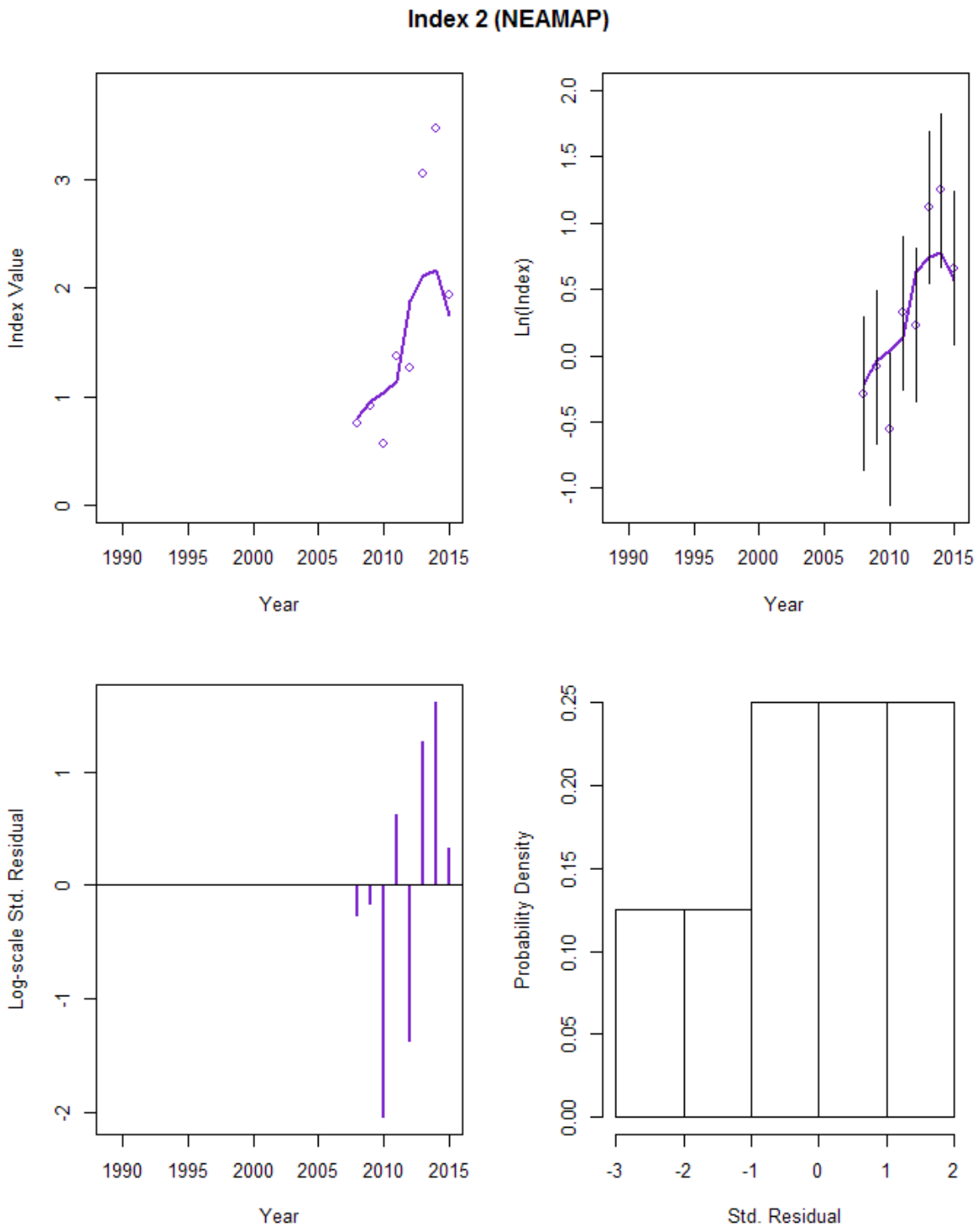


Figure A83. Fit diagnostics for the NEAMAP trawl survey in final black sea bass **North** area model.

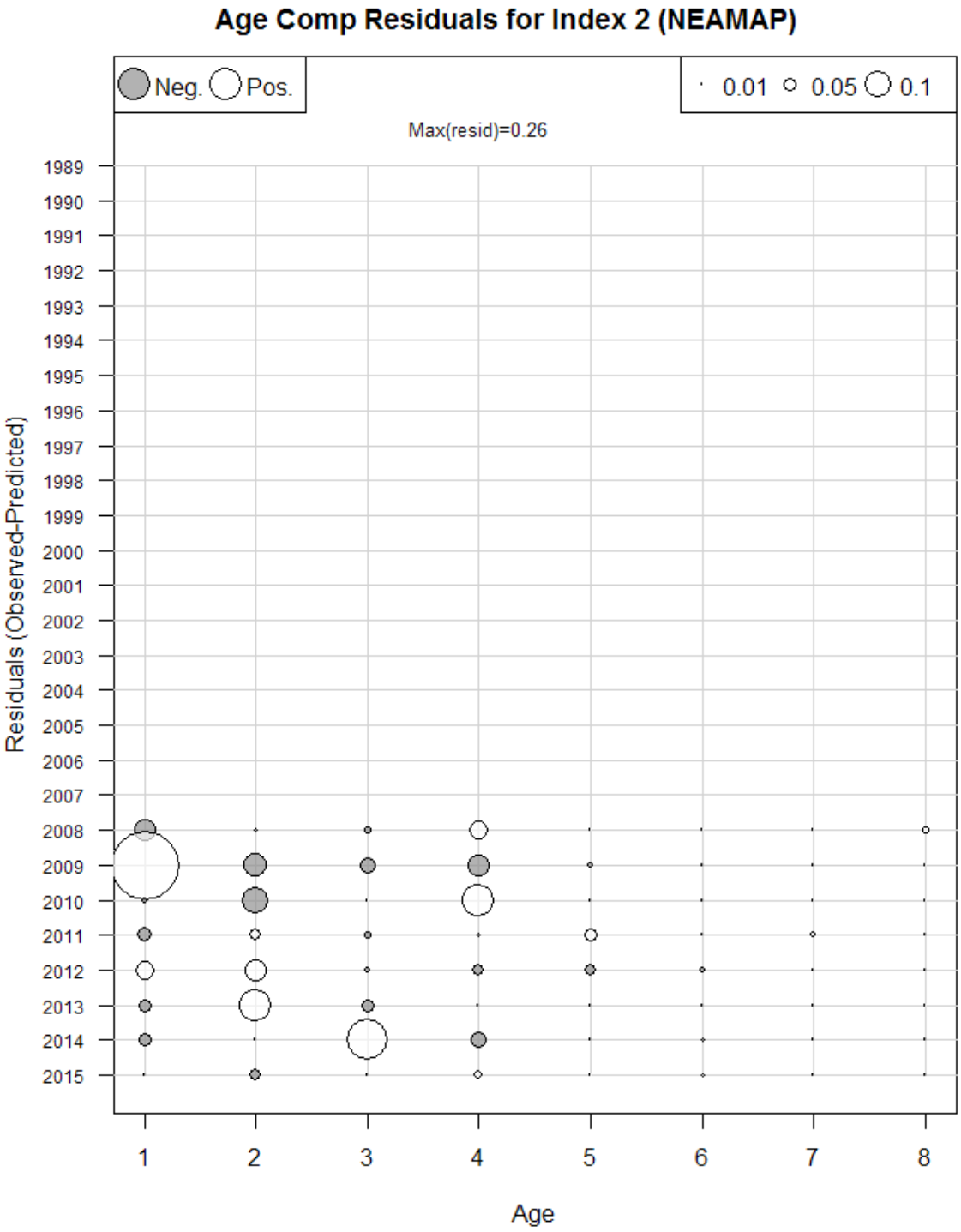


Figure A84. Age composition residuals for the NEAMAP trawl survey in final black sea bass **North** area model.

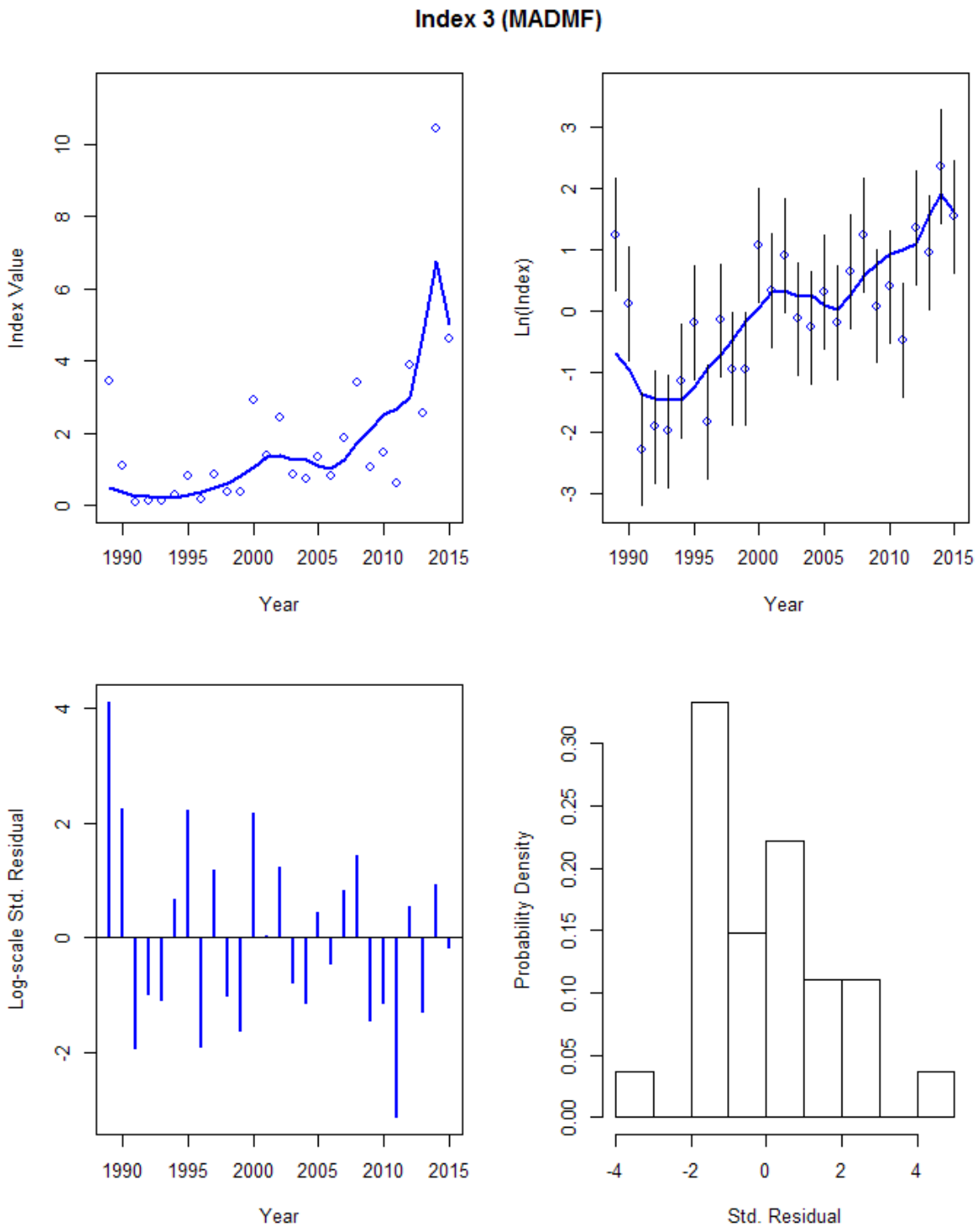


Figure A85. Fit diagnostics for the MADMF trawl survey in final black sea bass **North** area model.

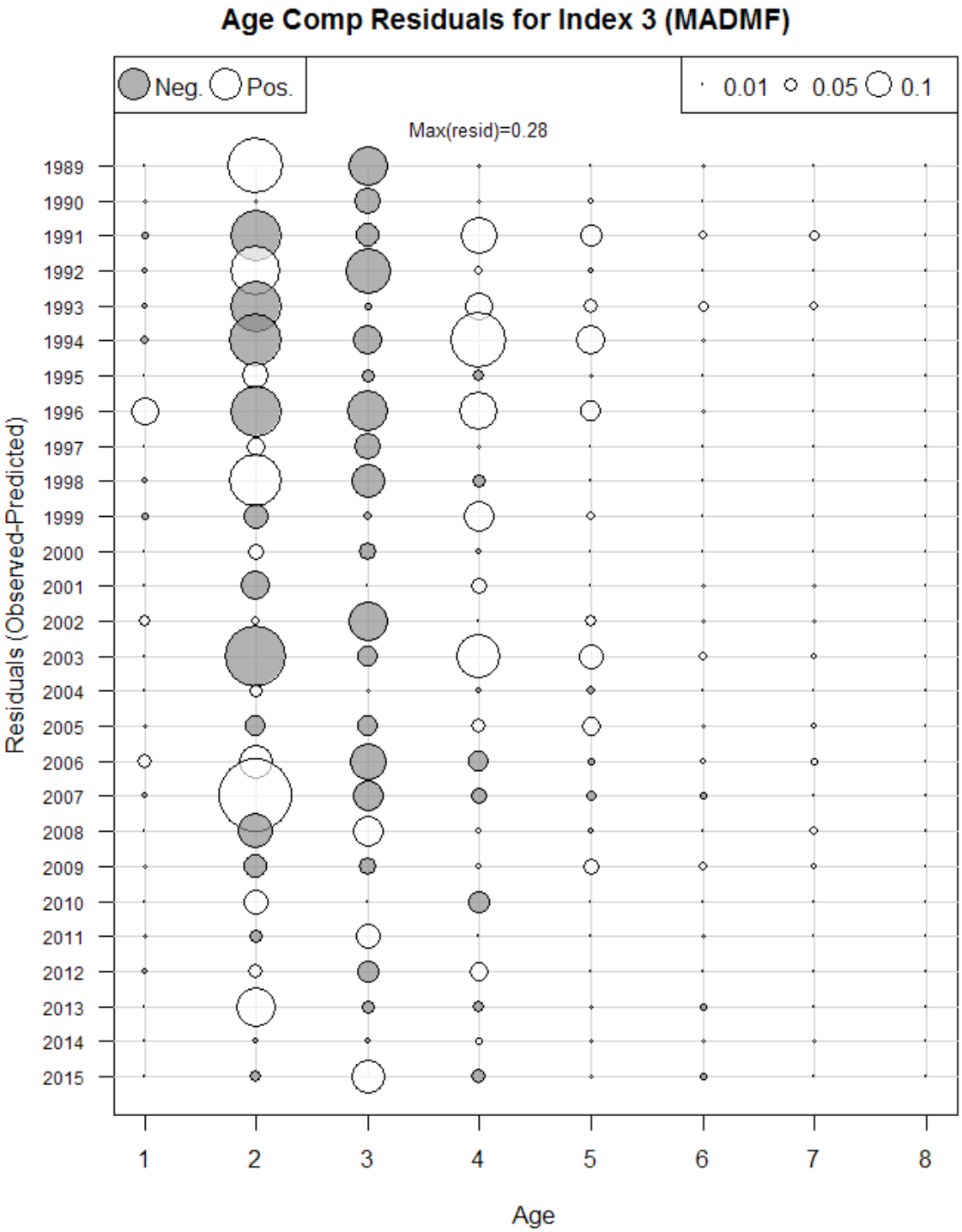


Figure A86. Age composition residuals for the MADMF trawl survey in final black sea bass **North** area model.

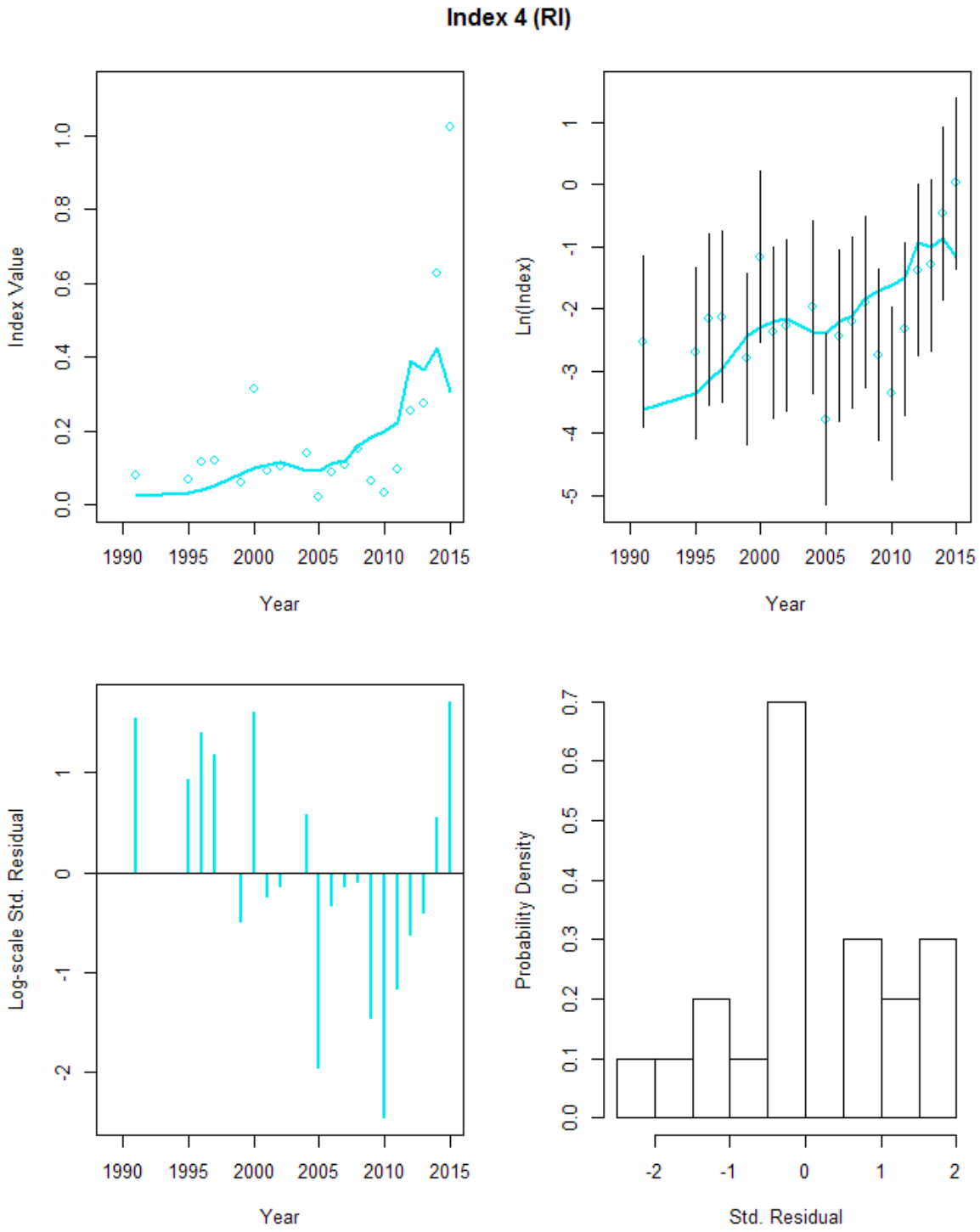


Figure A87. Fit diagnostics for the RI trawl survey in final black sea bass **North** area model.

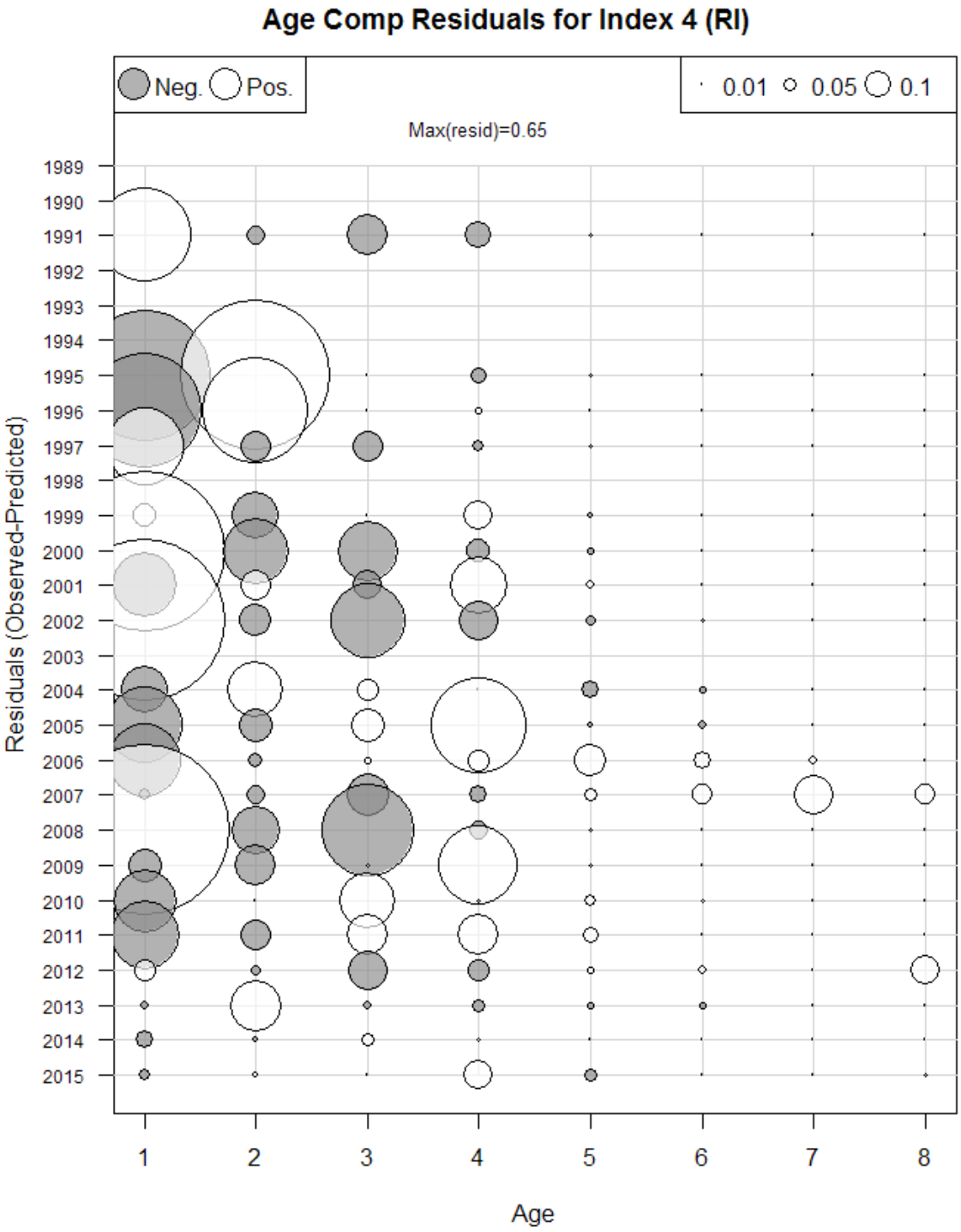


Figure A88. Age composition residuals for the RI trawl survey in final black sea bass **North** area model.

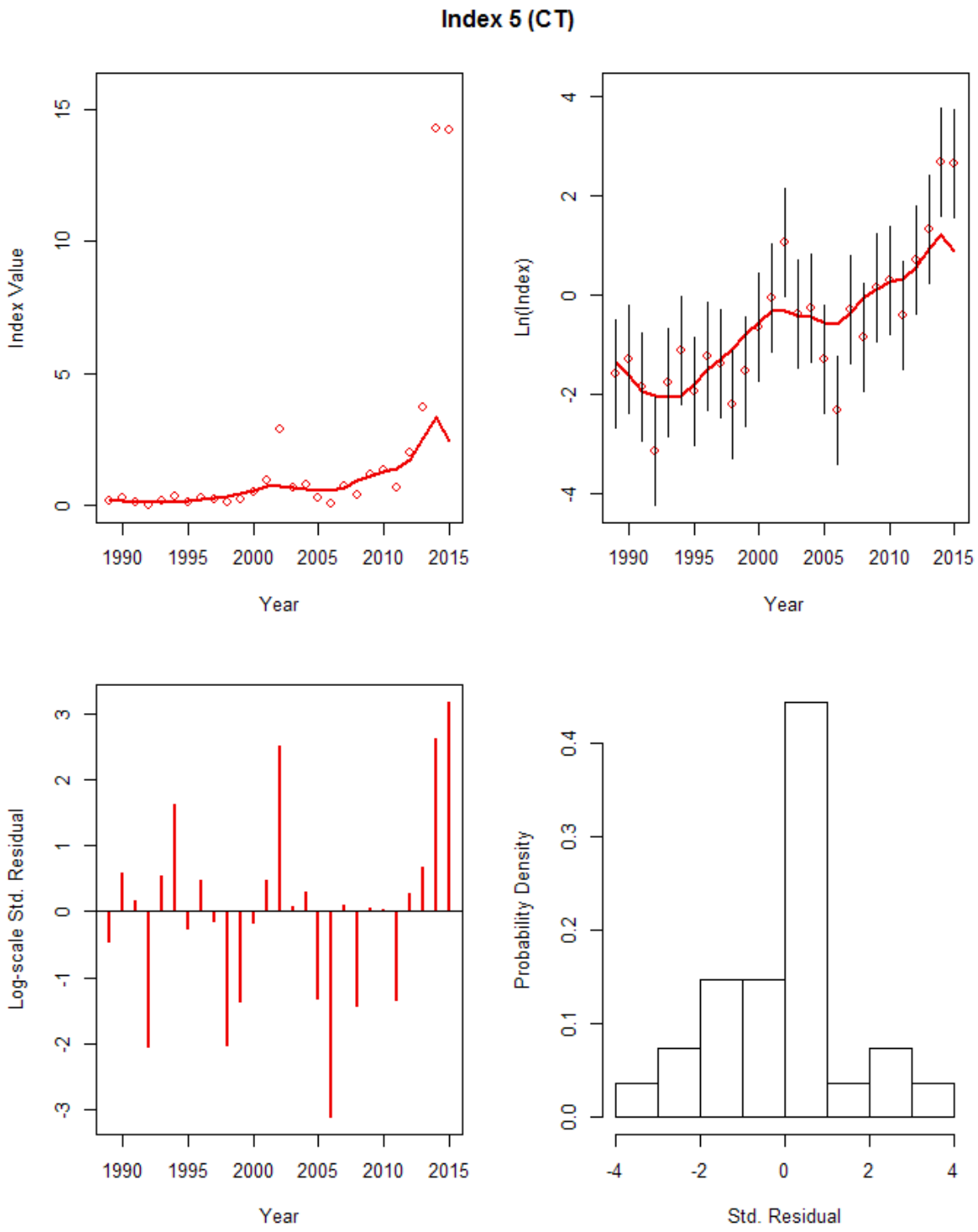


Figure A89. Fit diagnostics for the CT trawl survey in final black sea bass **North** area model.

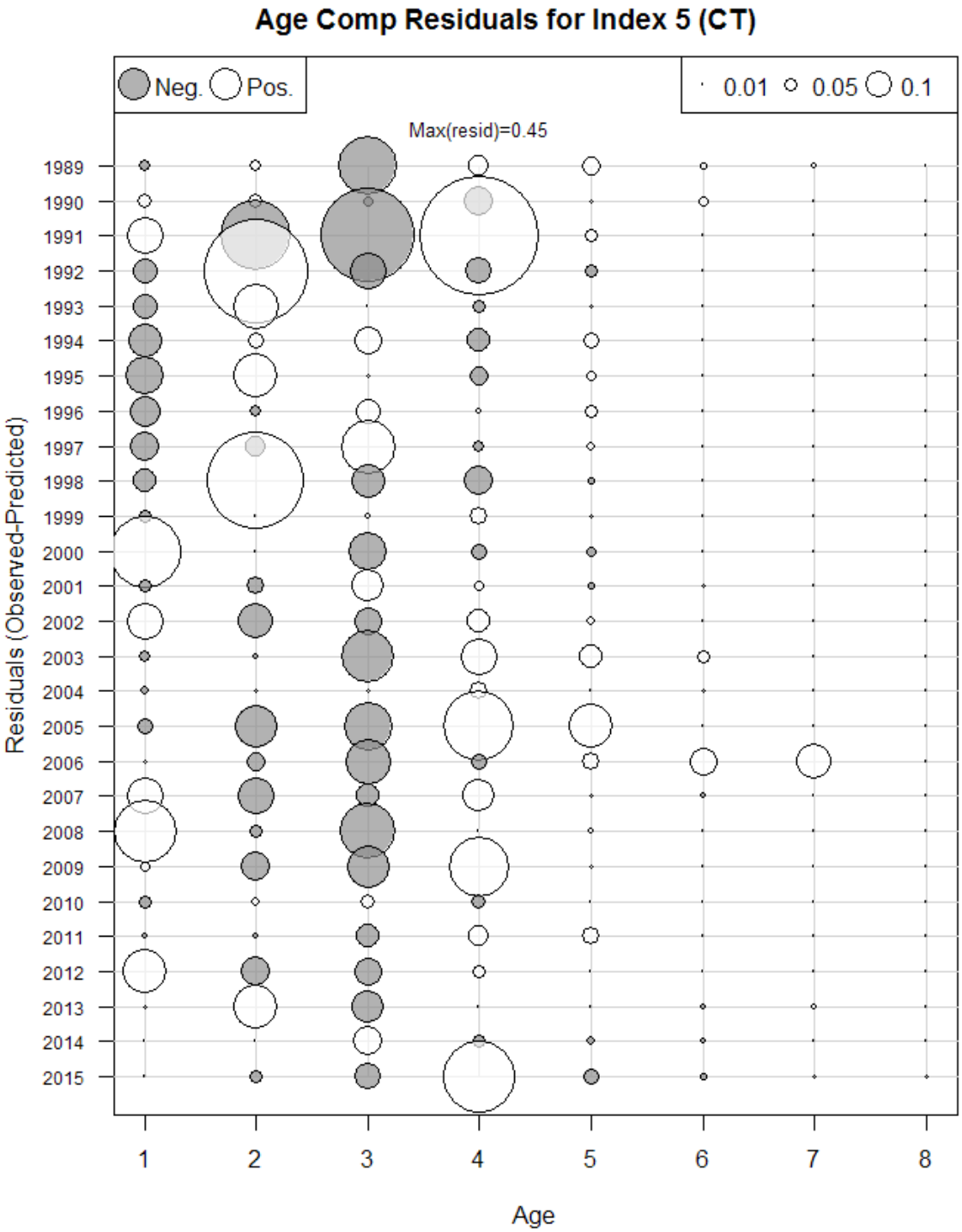


Figure A90. Age composition residuals for the CT trawl survey in final black sea bass **North** area model.

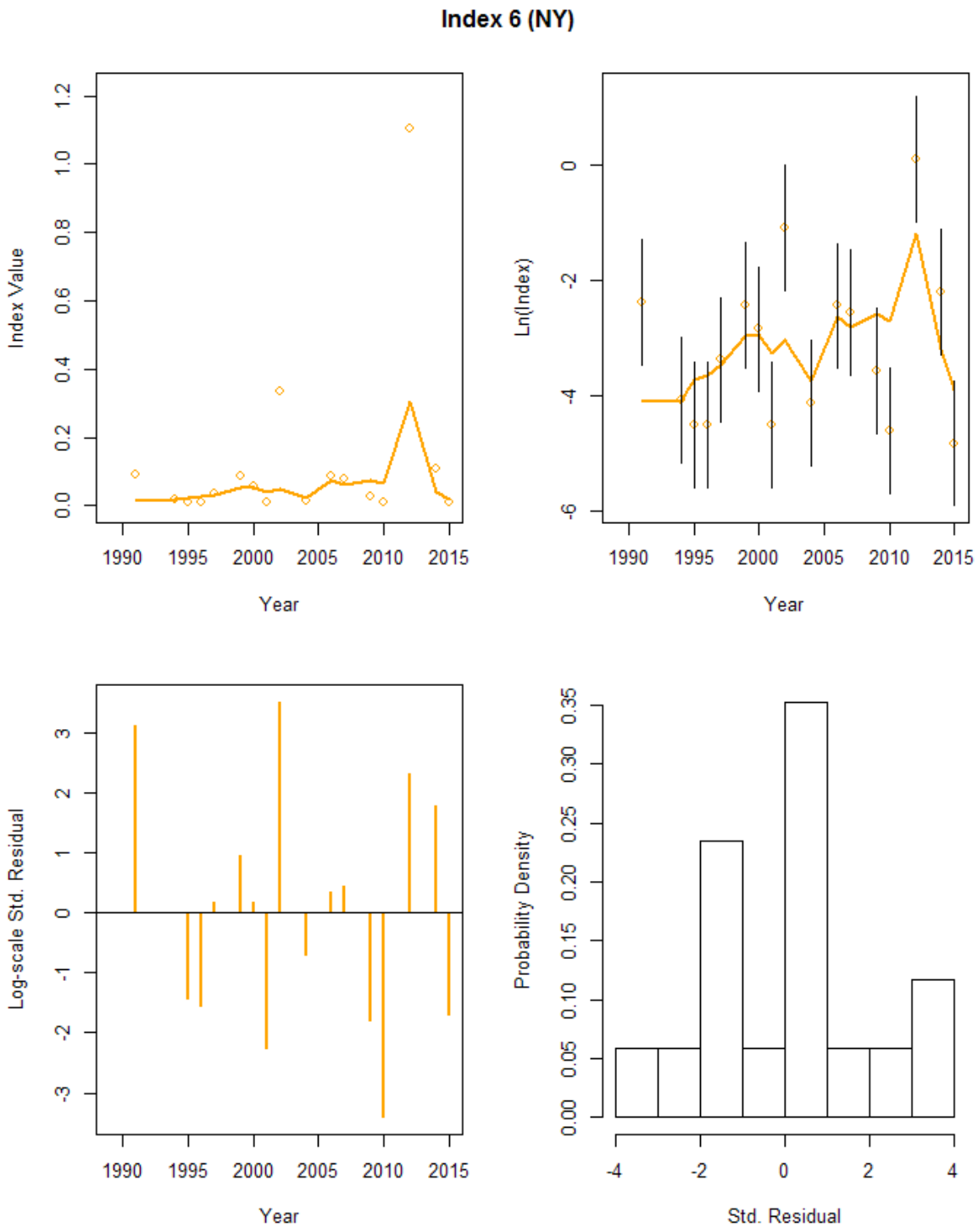


Figure A91. Fit diagnostics for the NY trawl survey in final black sea bass **North** area model.

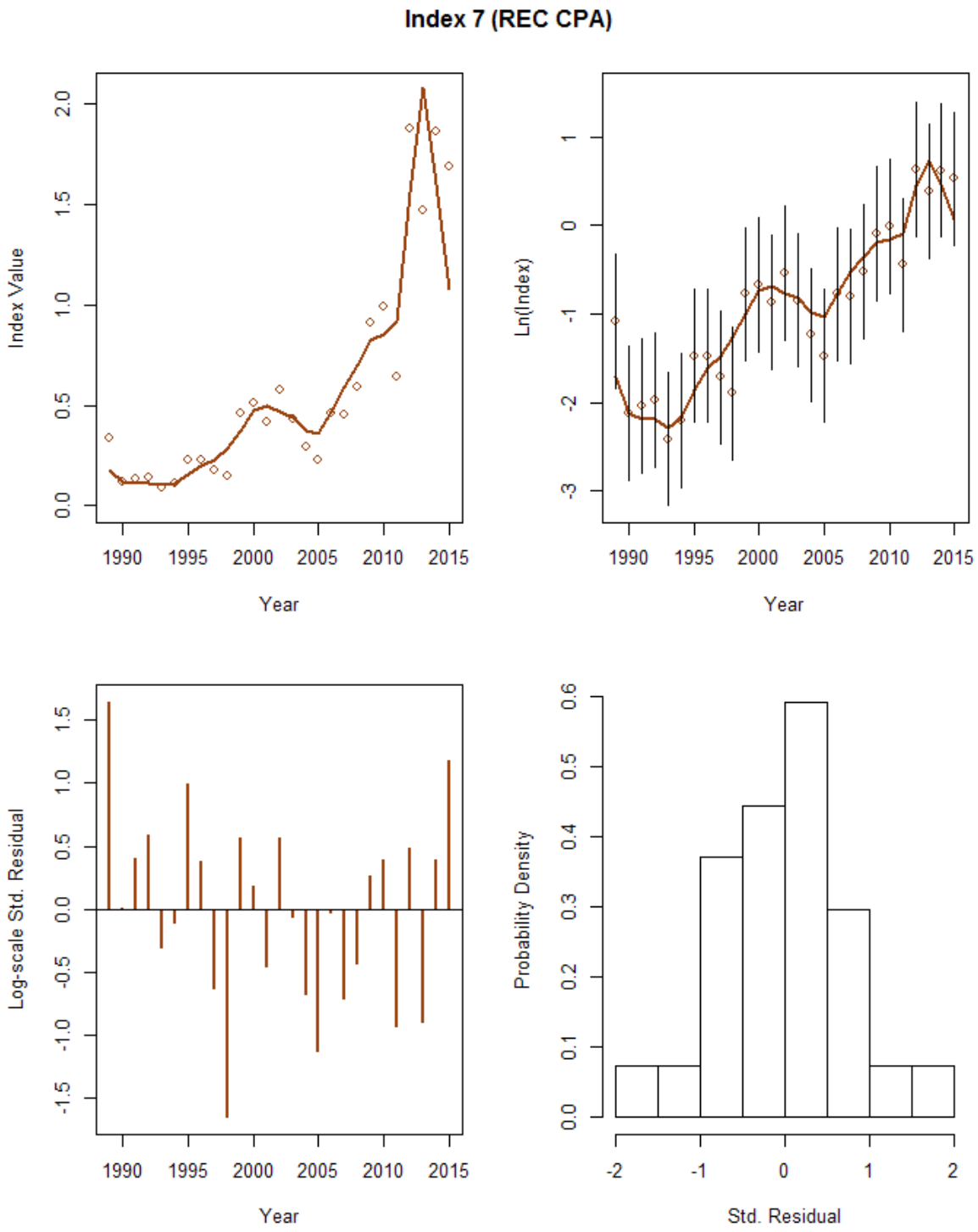


Figure A92. Fit diagnostics for the Rec CPA in final black sea bass **North** area model.

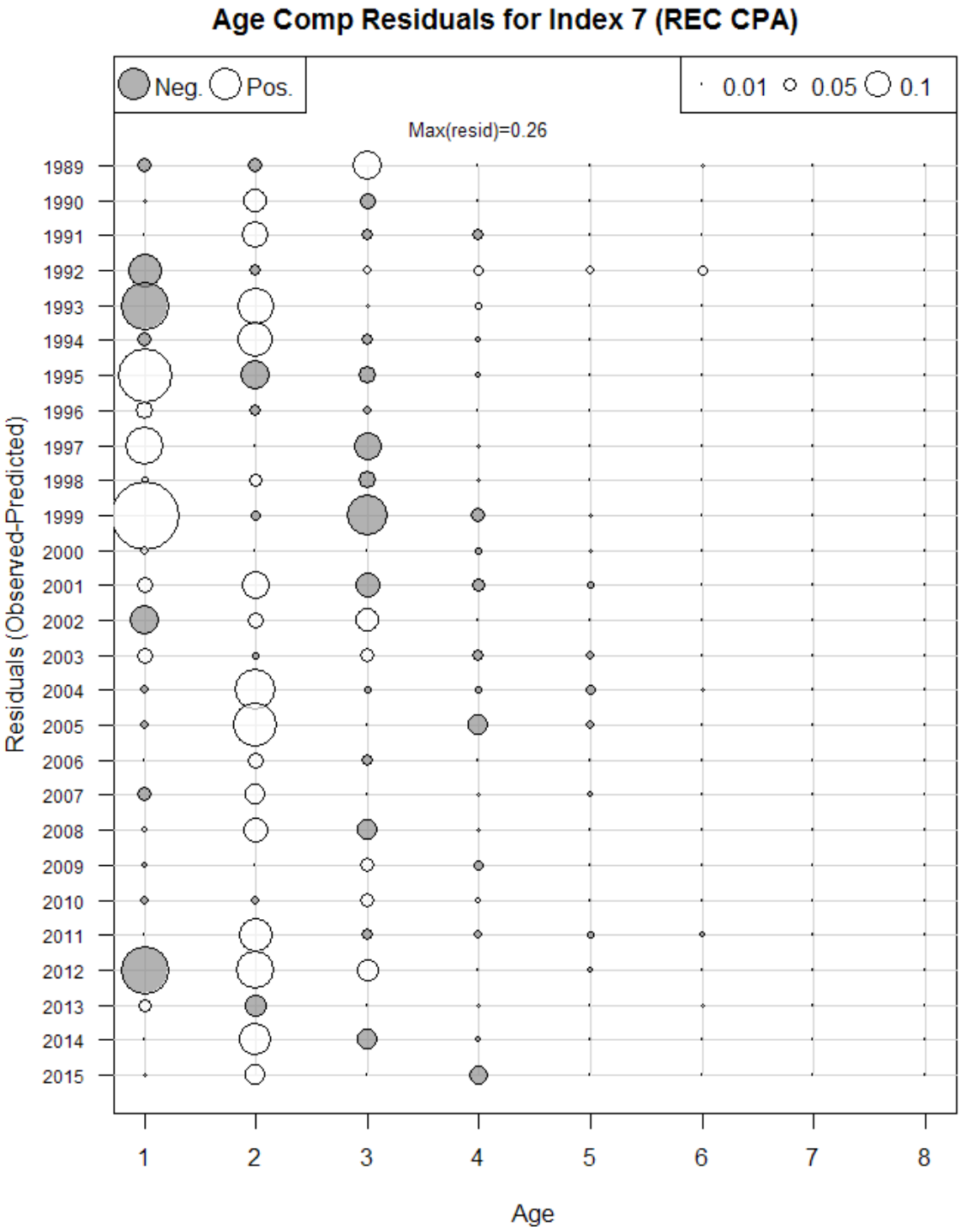


Figure A93. Age composition residuals for the Rec CPA in final black sea bass **North** area model.

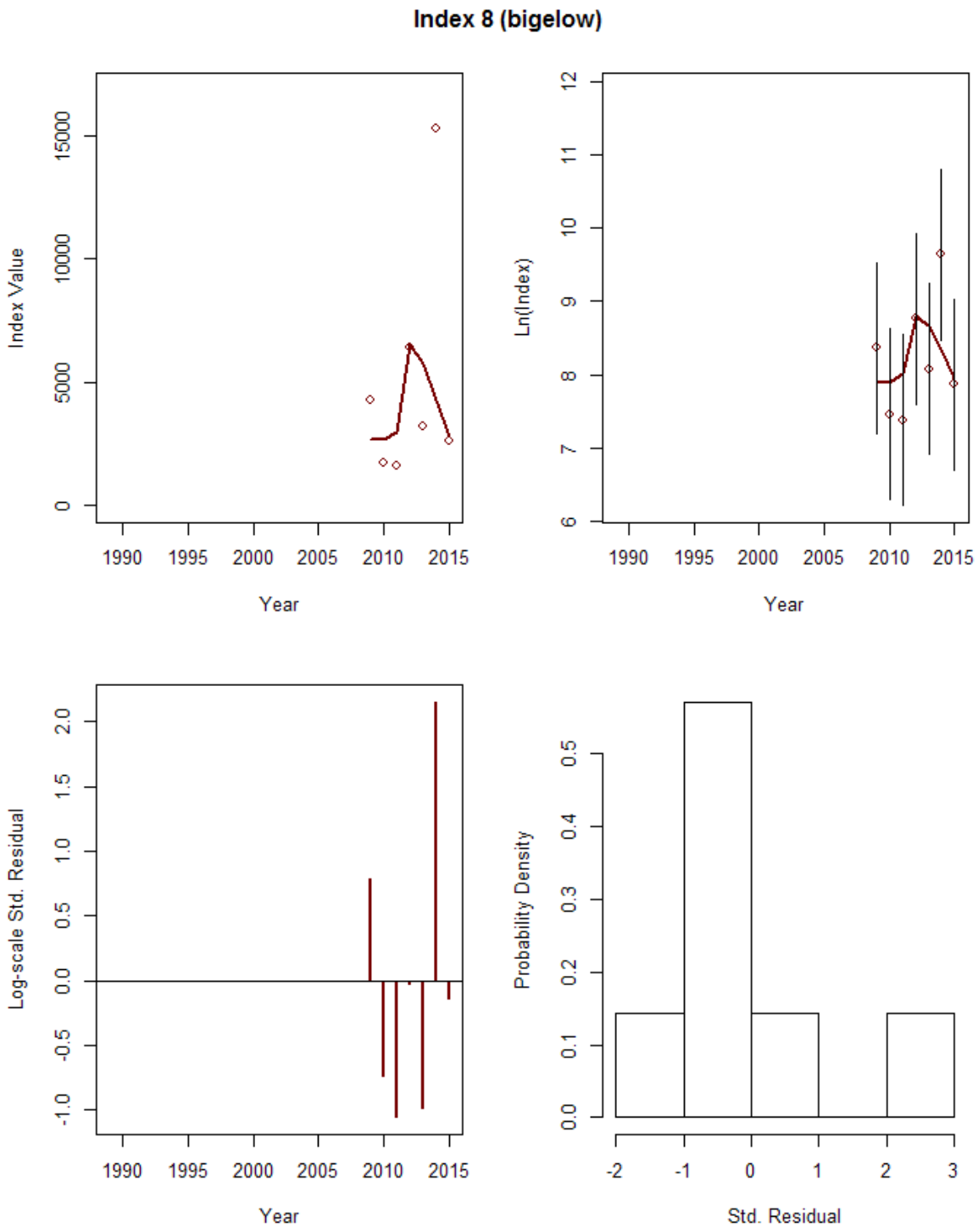


Figure A94. Fit diagnostics the NEFSC spring trawl survey, 2009-2015 (*Bigelow)* in final black sea bass **North** area model.

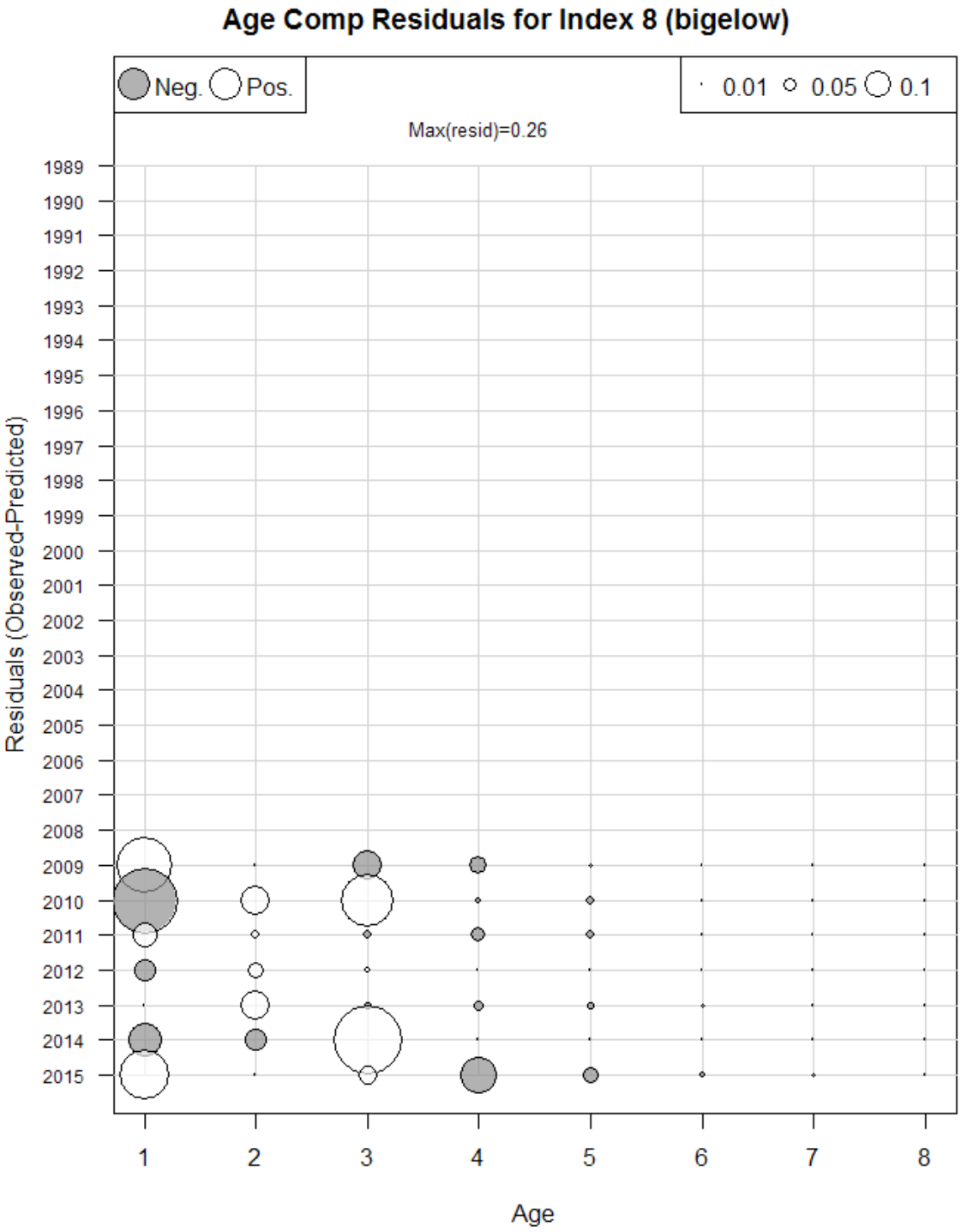


Figure A95. Age composition residuals for the NEFSC spring trawl survey, 2009-2015 (*Bigelow)* in final black sea bass **North** area model.

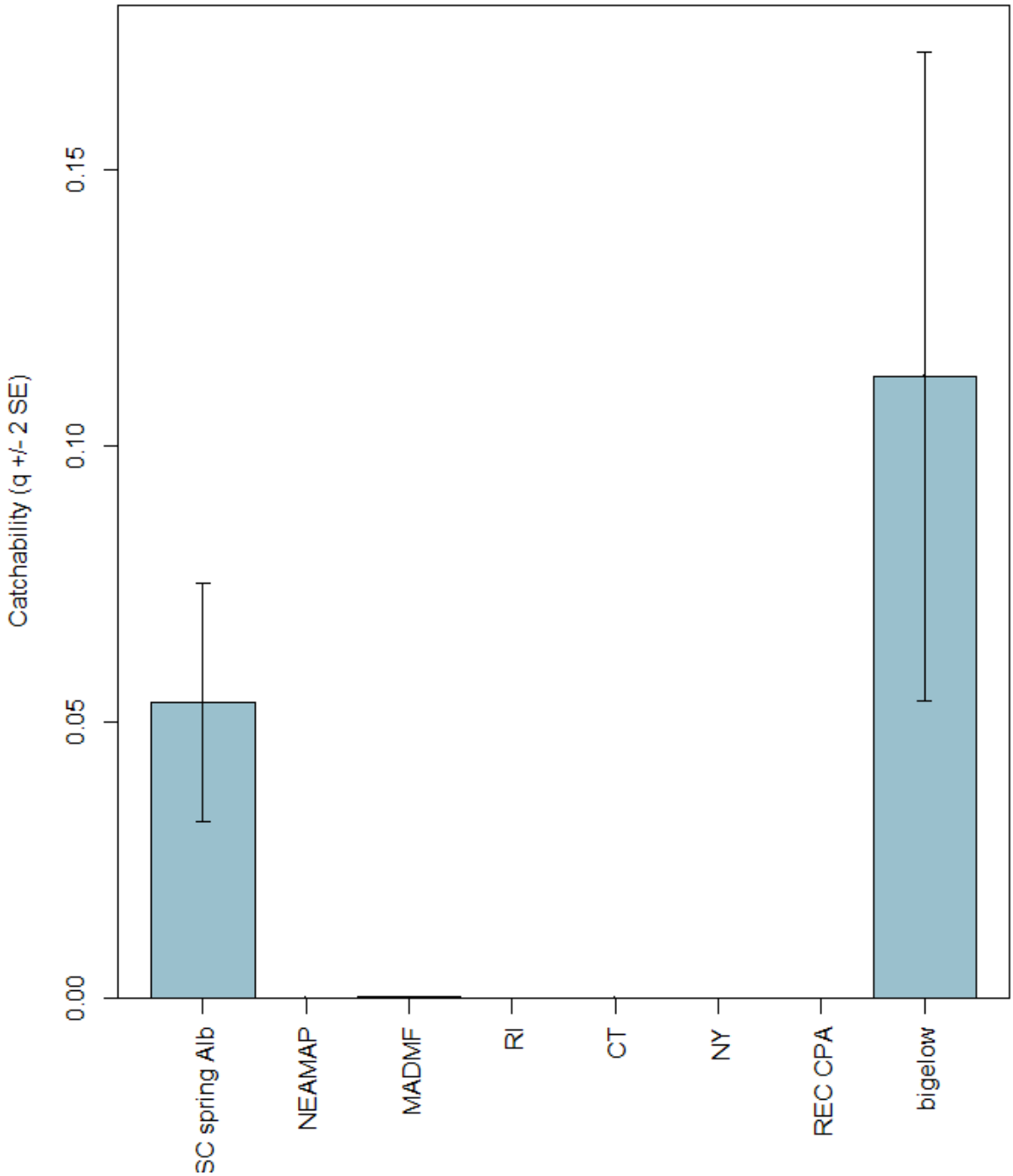

Figure A96. Index catchability estimates from final black sea bass **North** area model.

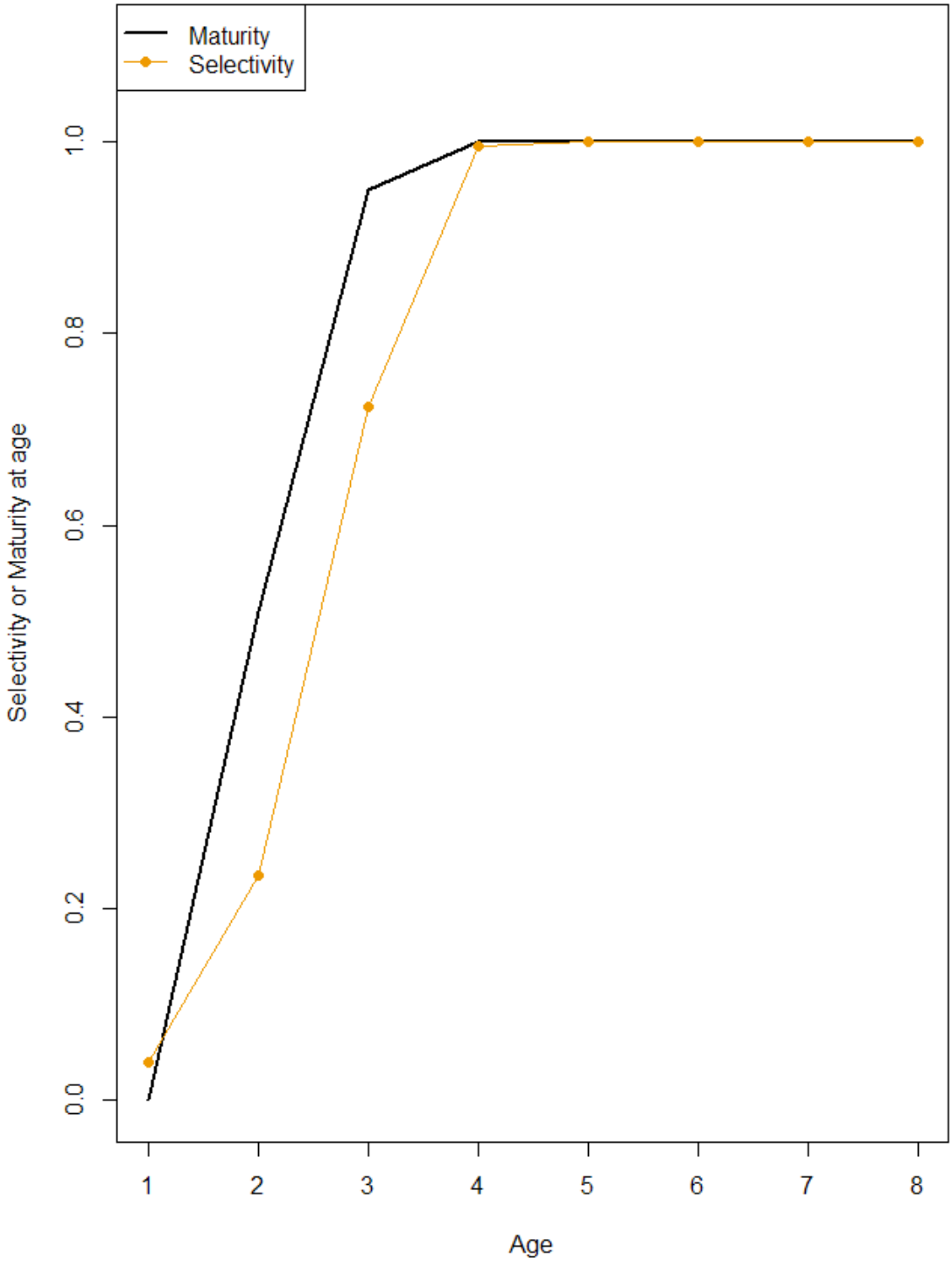


Figure A97. Comparison of age at maturity and average selectivity from final black sea bass **North** area model.

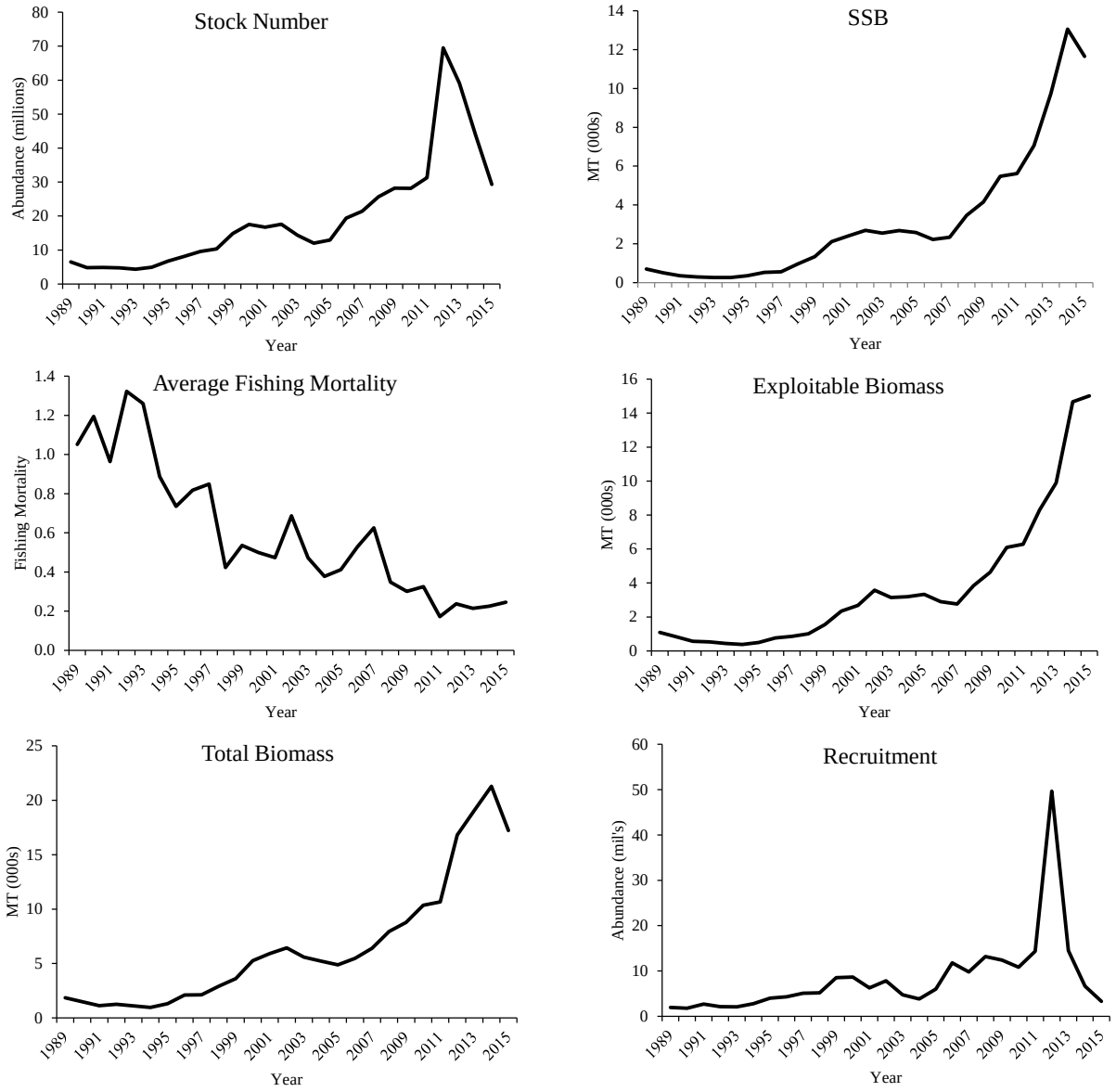


Figure A98. Results of stock number, fishing mortality, total biomass, spawning biomass, exploitable biomass and recruitment from the black sea bass **North** area model.

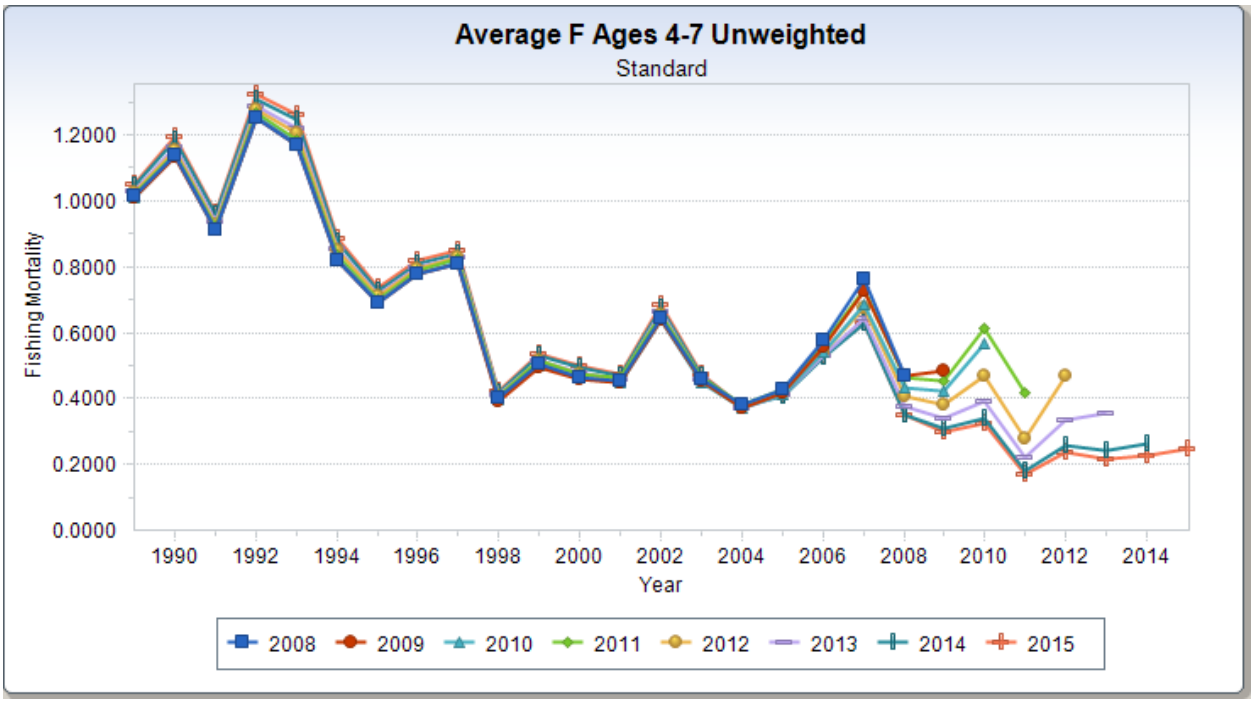


Figure A99. Retrospective pattern in average F estimates from black sea bass ASAP model for **North** area. Mohn's rho = 0.70.

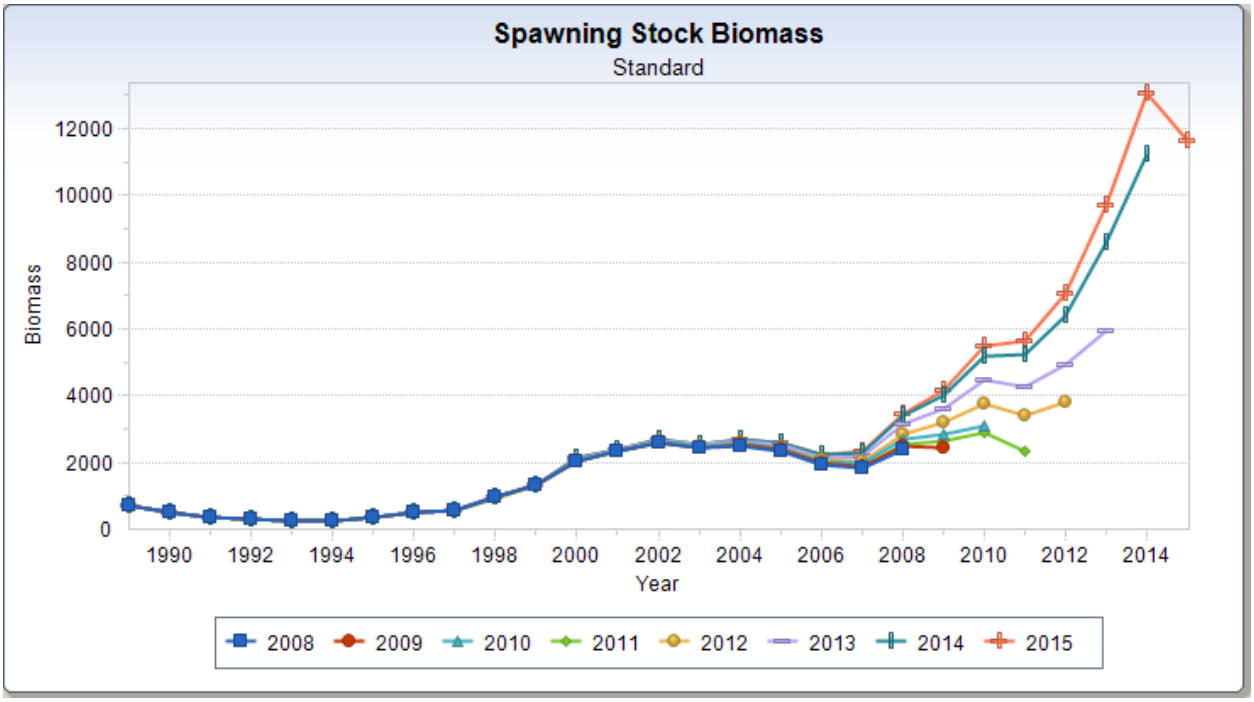


Figure A100. Retrospective pattern in spawning stock biomass (mt) estimates from black sea bass ASAP model for **North** area. Mohn's rho = -0.39

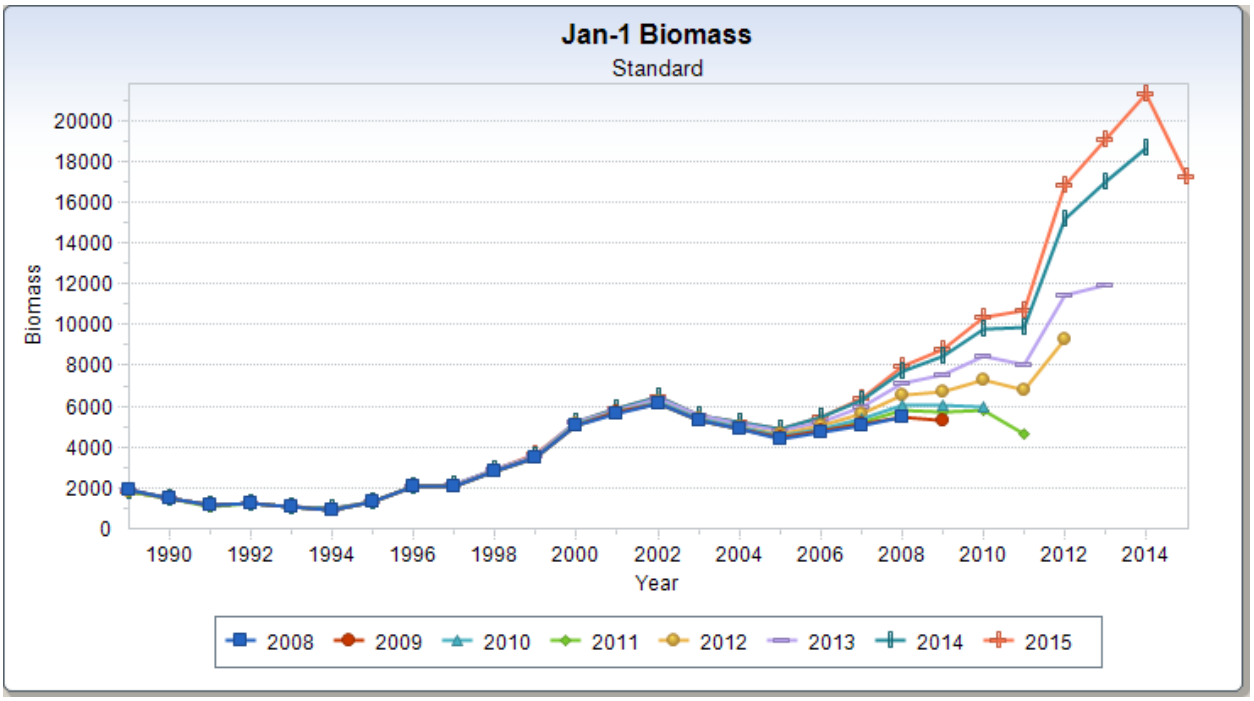


Figure A101. Retrospective pattern in January 1 biomass (mt) estimates from black sea bass ASAP model for **North** area. Mohn's rho = -0.38

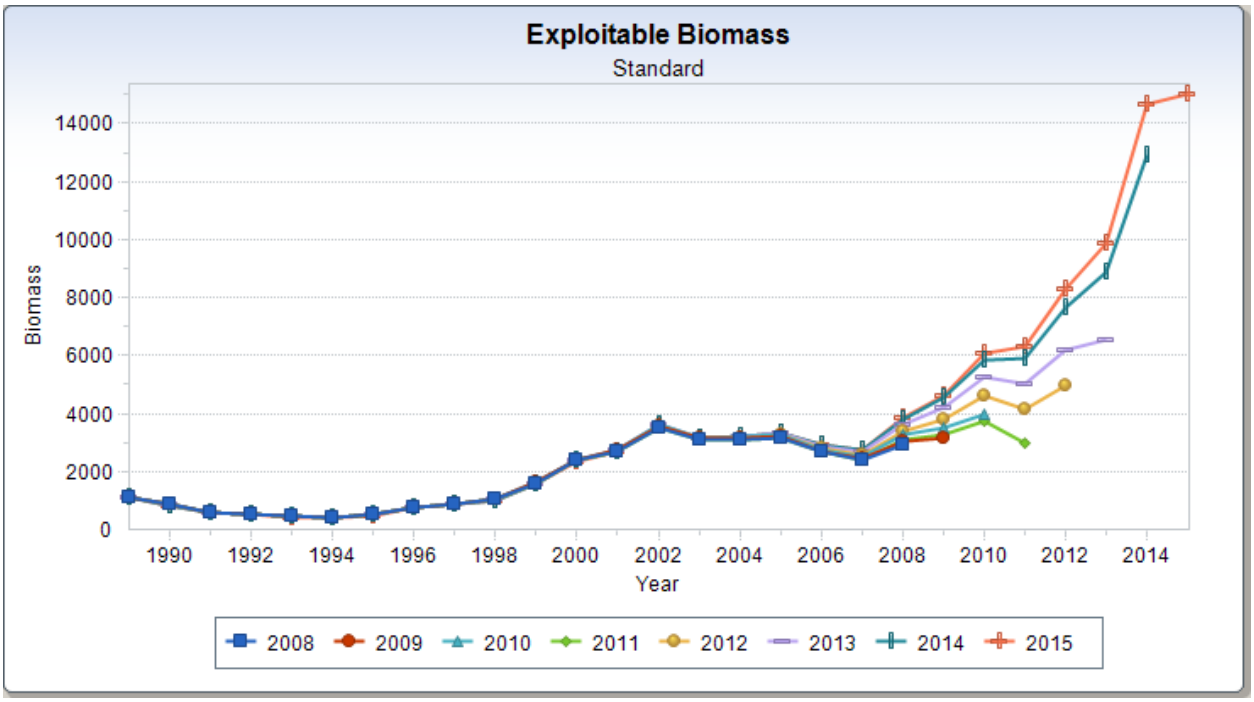


Figure A102. Retrospective pattern in exploitable biomass (mt) estimates from black sea bass ASAP model for **North** area. Mohn's rho = -0.33

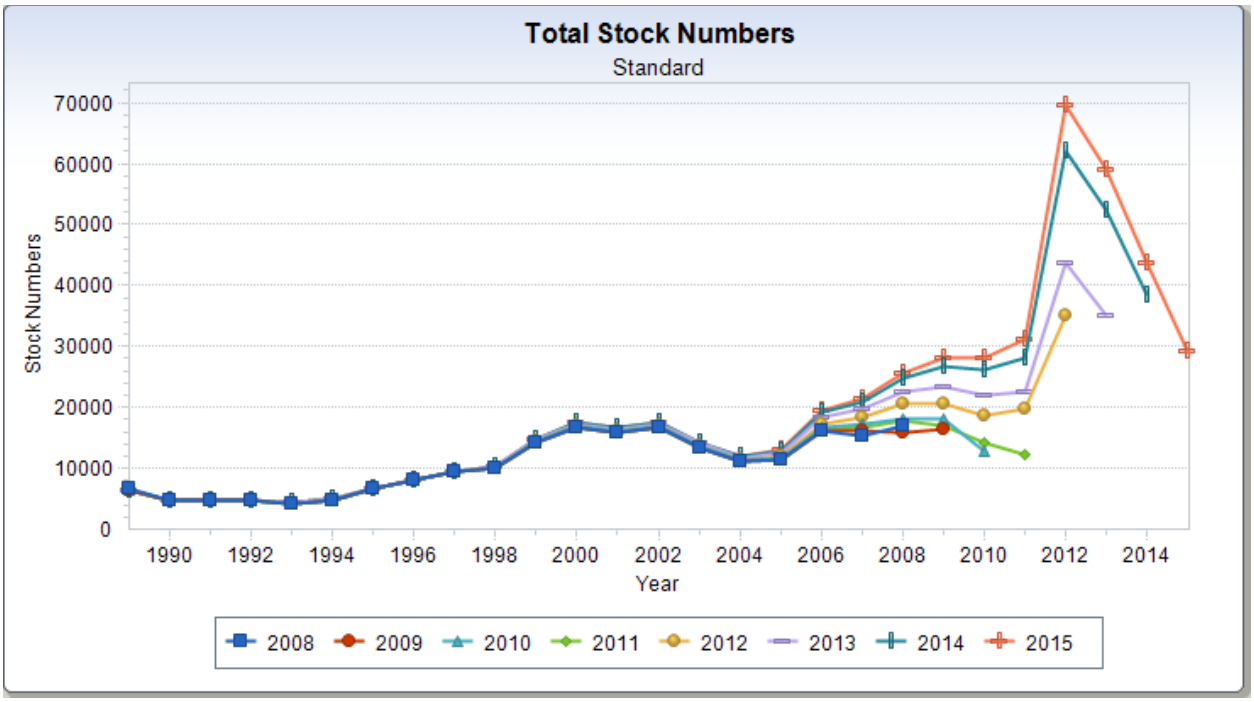


Figure A103. Retrospective pattern in total stock number estimates from black sea bass ASAP model for **North** area. Mohn's rho = -0.42

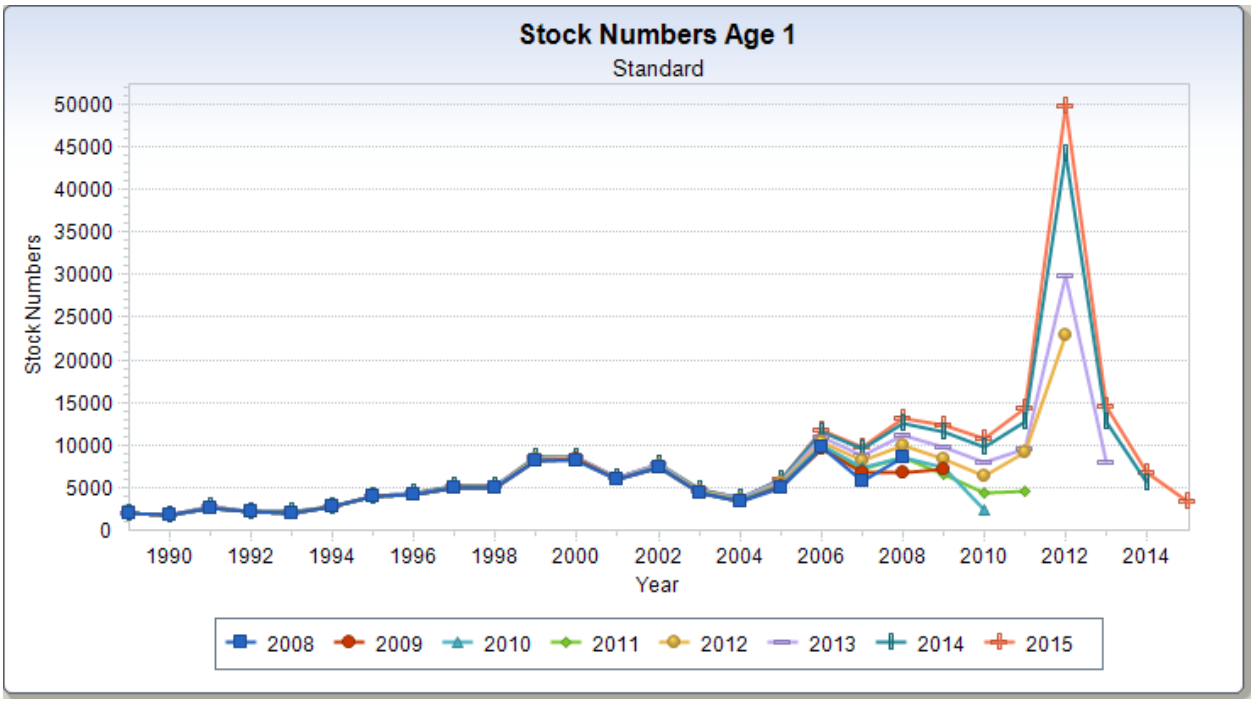


Figure A104. Retrospective pattern in age 1 (recruits) estimates from black sea bass ASAP model for **North** area. Mohn's rho = -0.48

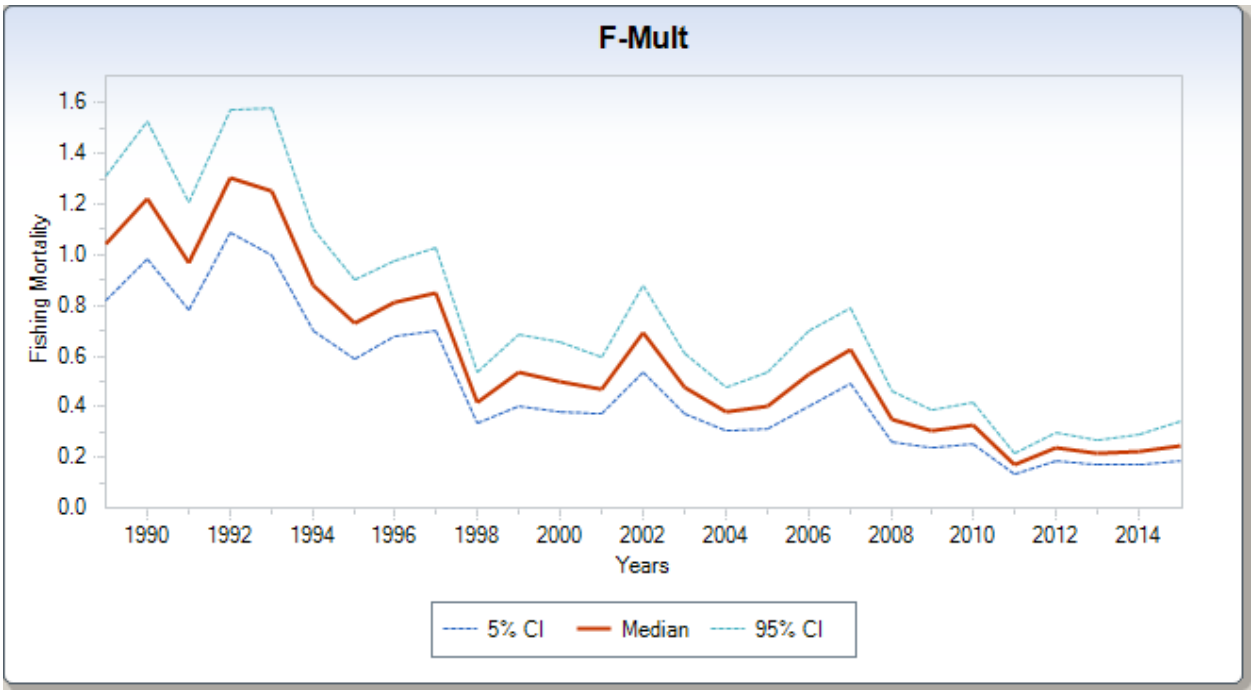


Figure A105. ASAP MCMC estimates of black sea bass Fmult (± 90% CI) from **North** area model.

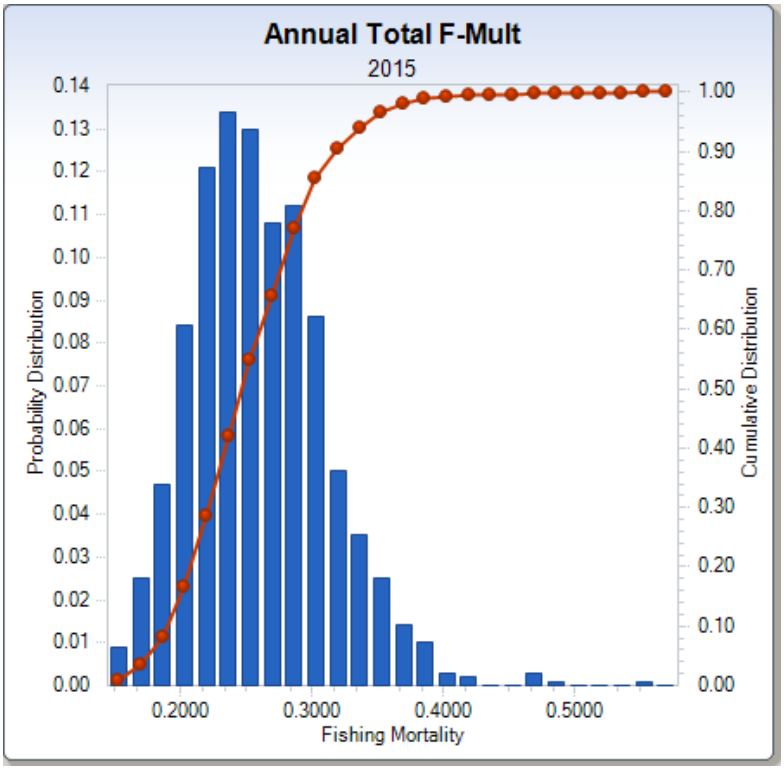


Figure A106. MCMC distribution of 2015 black sea bass F mult estimates from **North** area model.

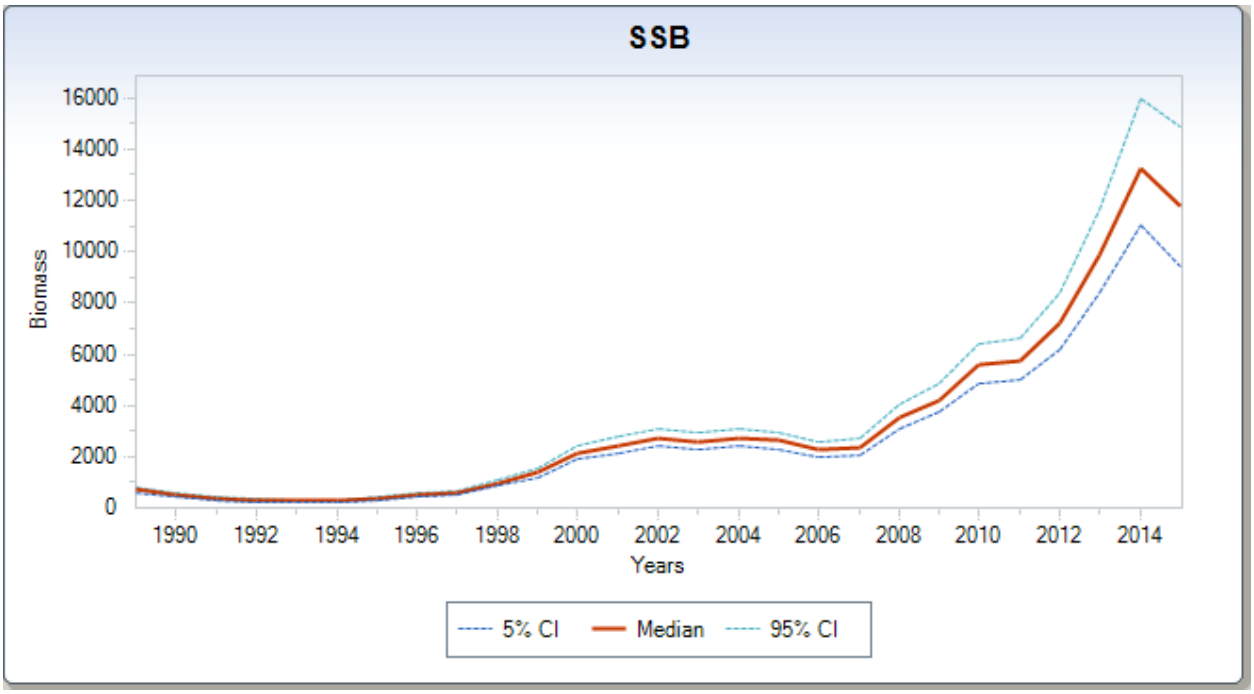


Figure A107. ASAP MCMC estimates of black sea bass spawning stock biomass (mt ± 90% CI) from **North** area model.

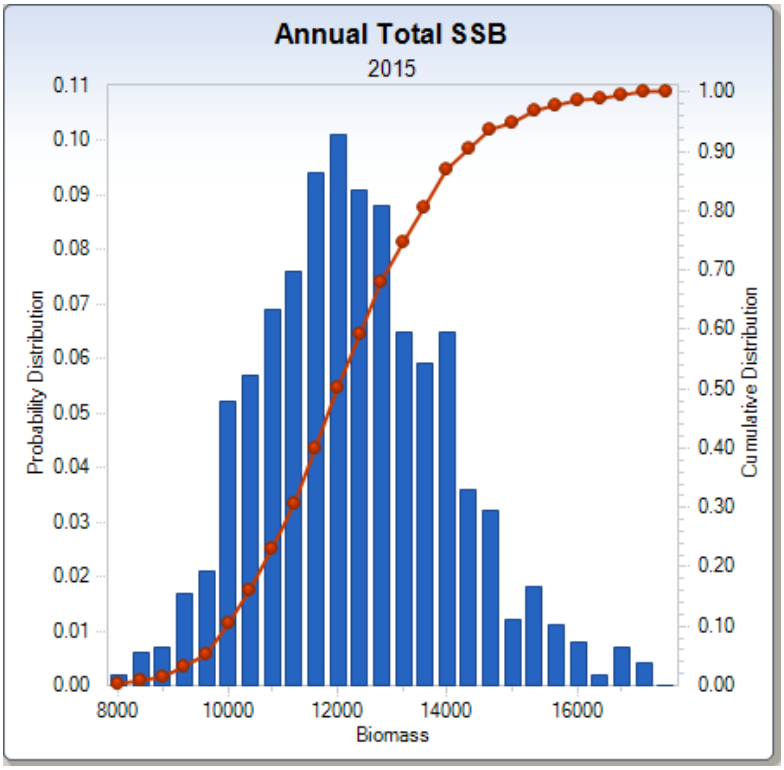


Figure A108. MCMC distribution of 2015 black sea bass spawning stock biomass (mt) estimates from **North** area model.

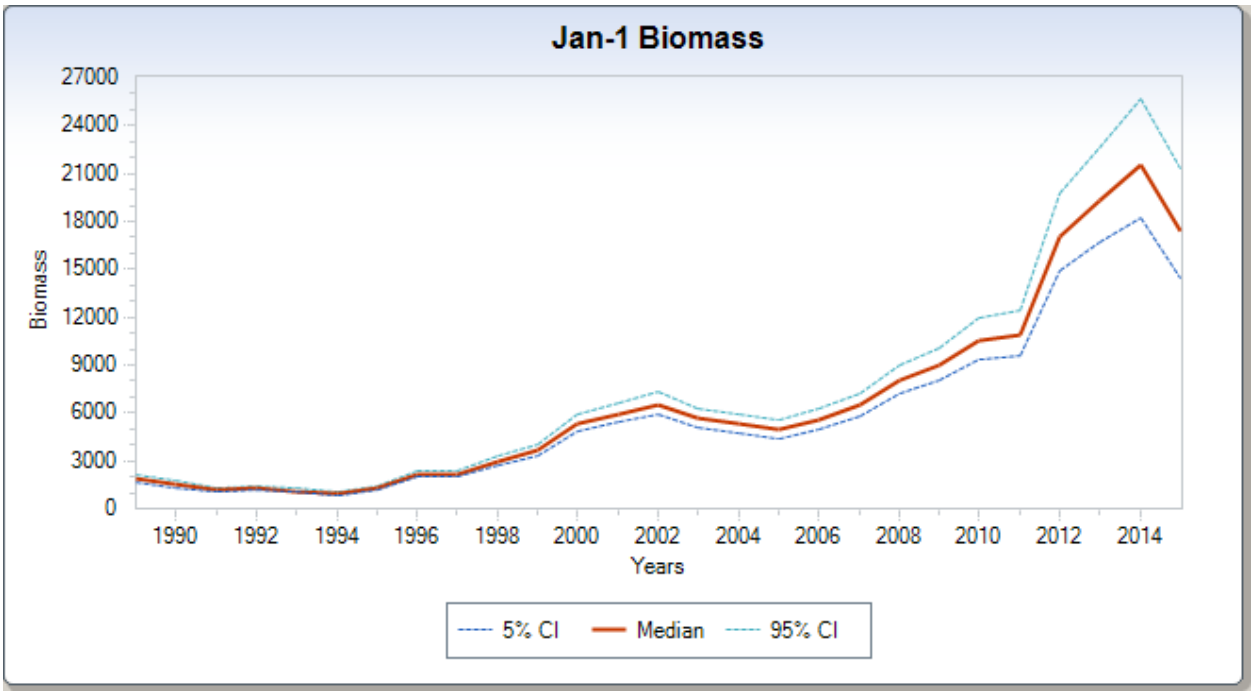


Figure A109. ASAP MCMC estimates of black sea bass Jan 1 biomass (mt ± 90% CI) from **North** area model.

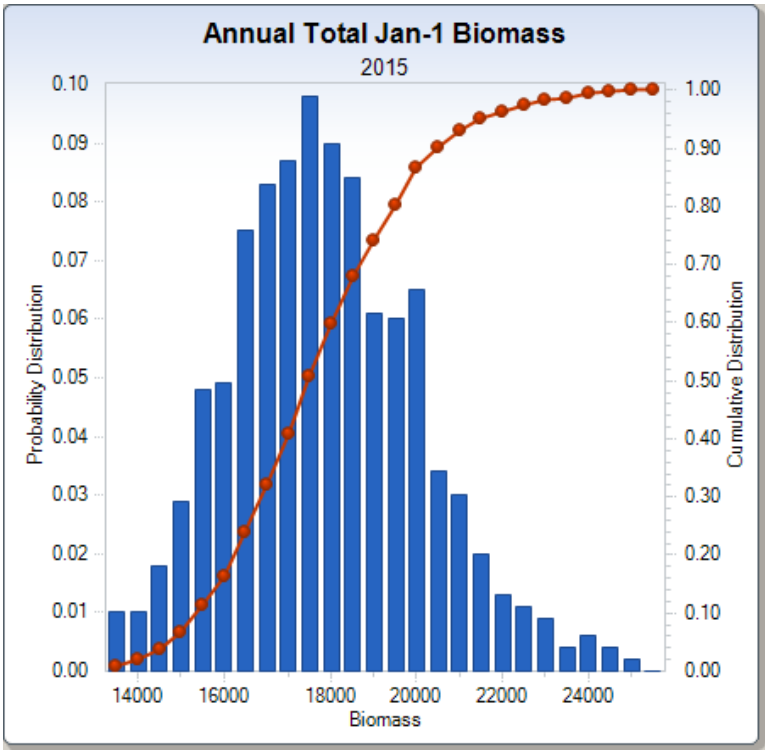


Figure A110. MCMC distribution of 2015 black sea bass total biomass (mt) estimates from **North** area model.

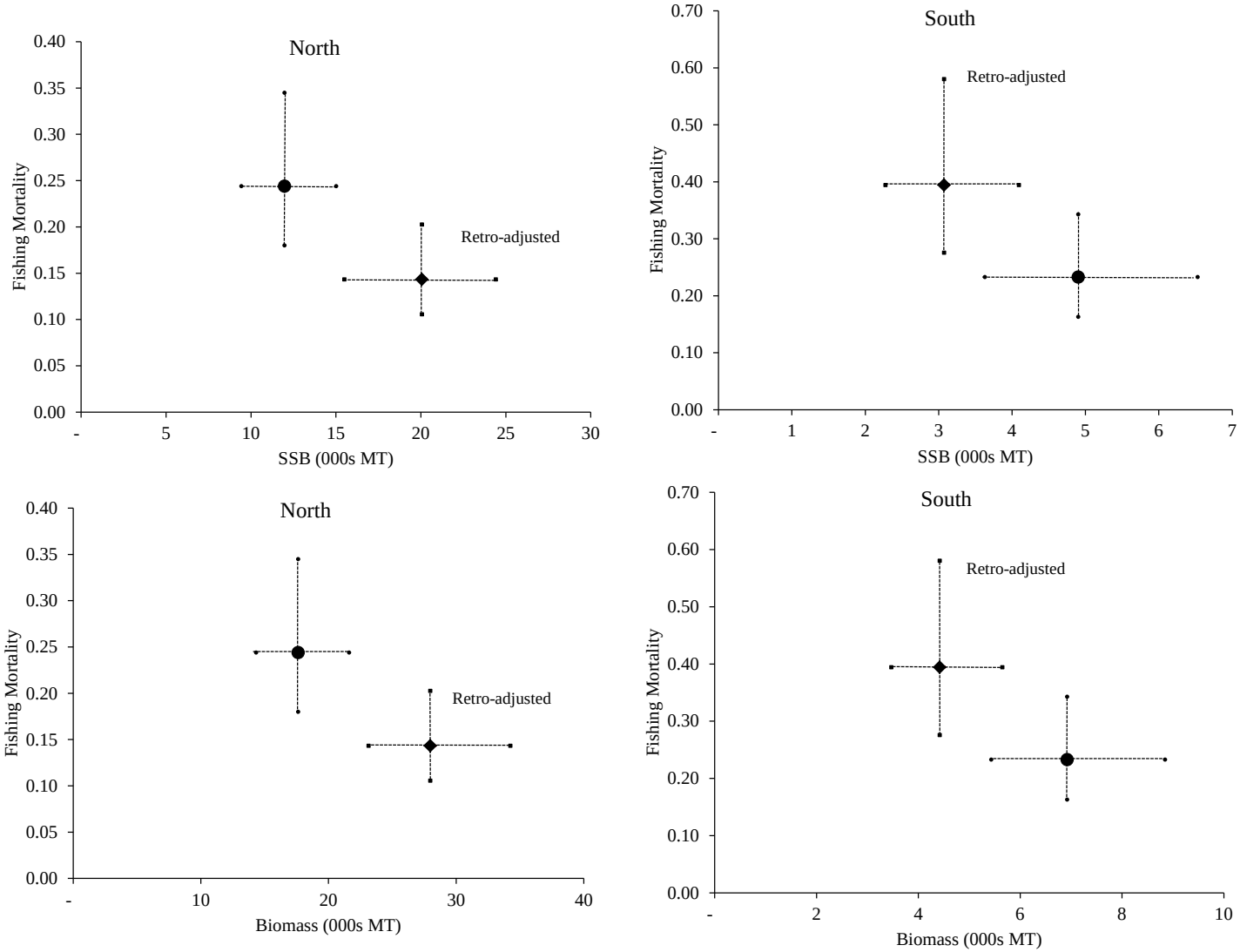


Figure A110a. Black sea bass median fishing mortality and SSB (000s mt) ± 90% CI and fishing morality and total biomass (000s mt) from base estimates and retro-adjusted values for North and South area.

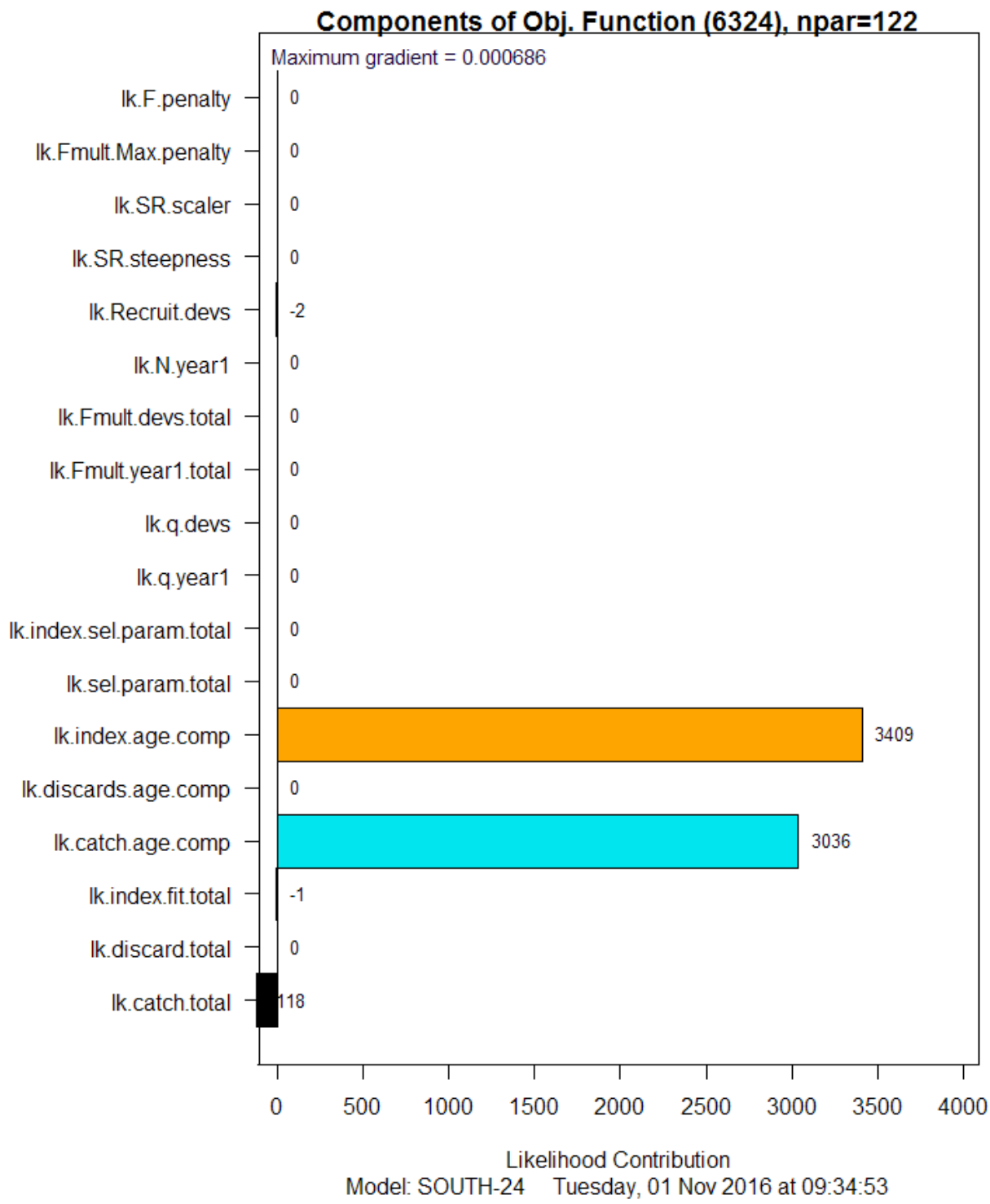


Figure A111. Distribution of objective function components contribution to total likelihood for black sea bass **South** area model.

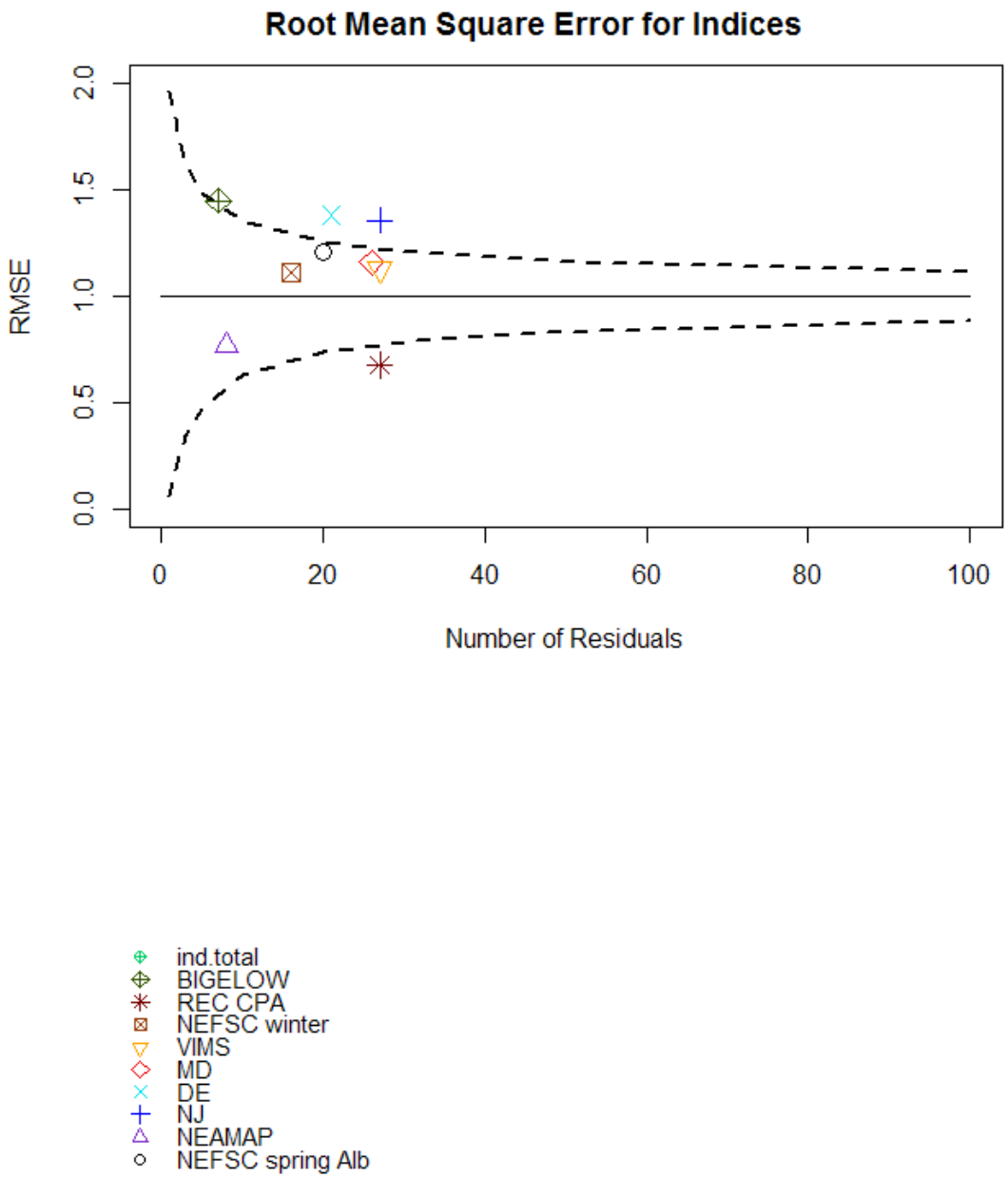


Figure A112. Final Root Mean Square Error (RMSE) values for survey indices in final black sea bass **South** area model.

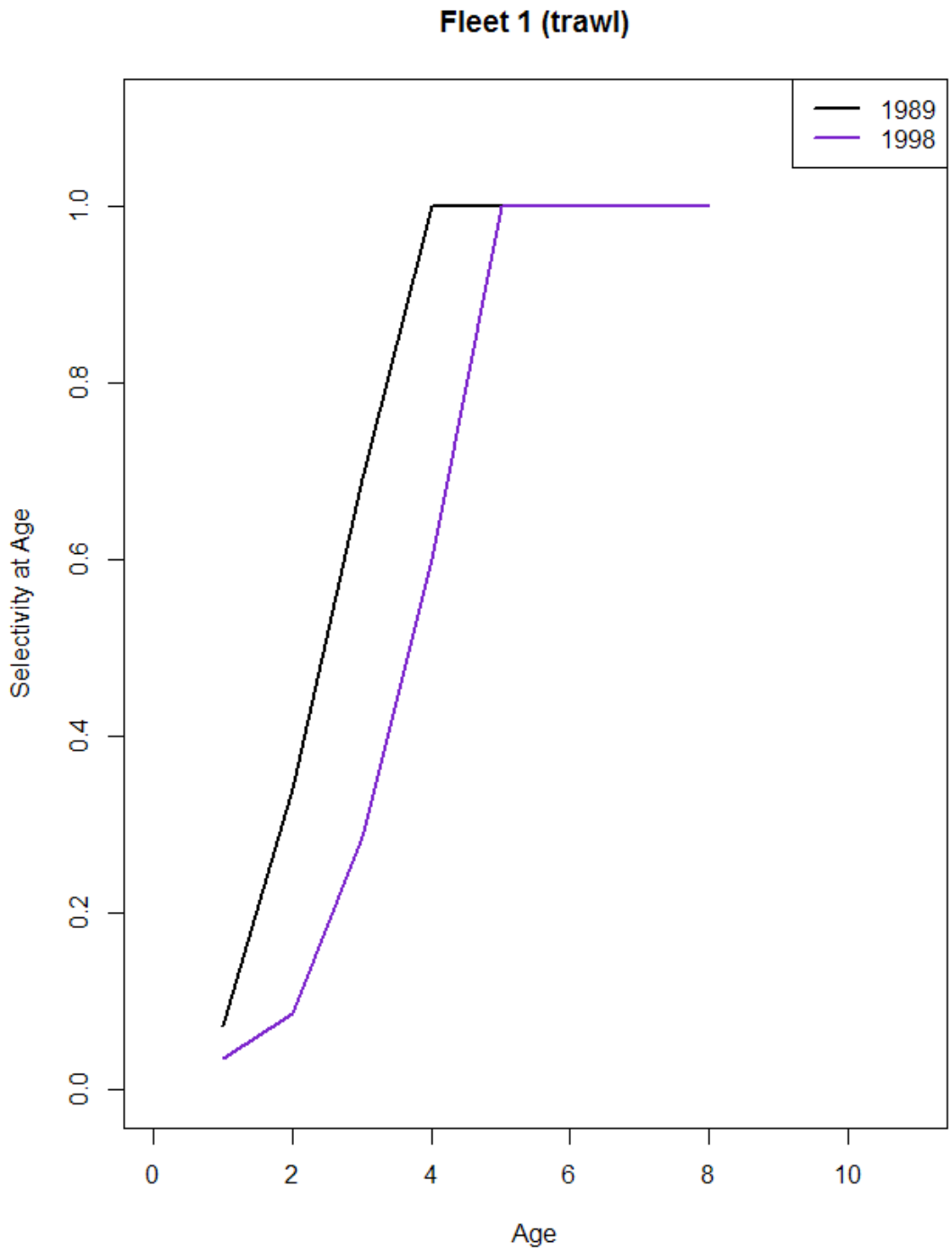


Figure A113. Selectivity at age from trawl fleet in final black sea bass **South** area model.

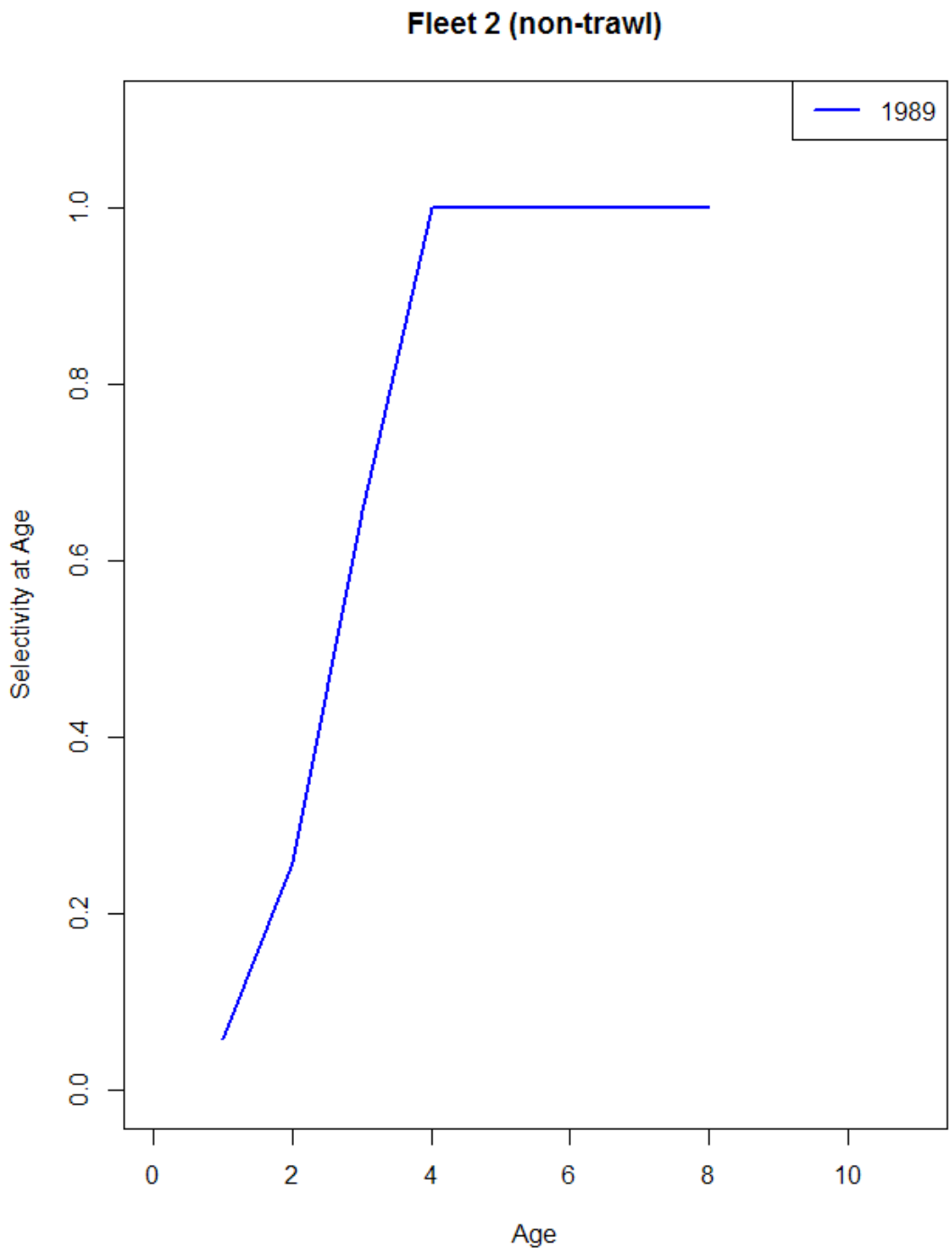


Figure A114. Selectivity at age from non-trawl fleet in final black sea bass **South** area model.

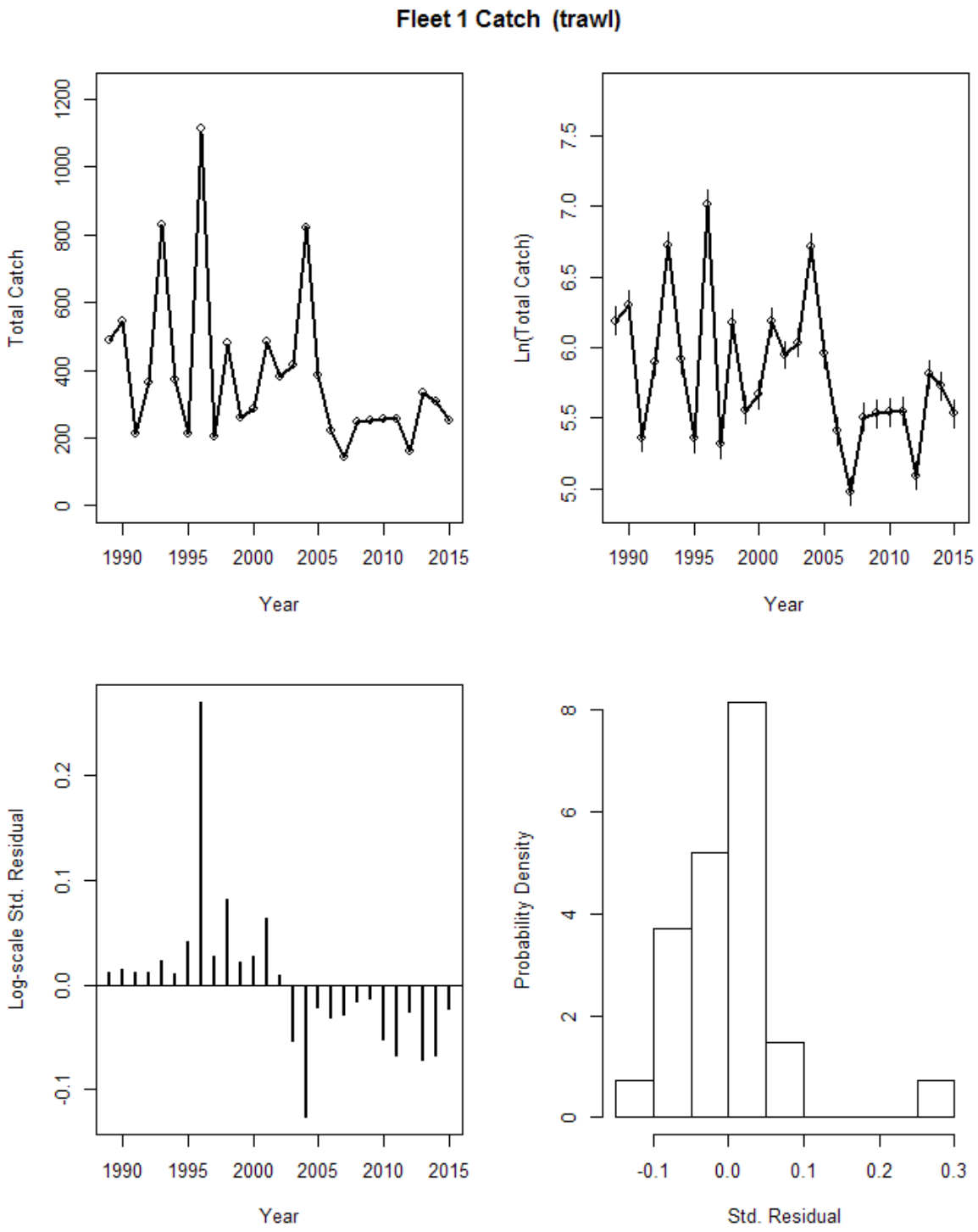


Figure A115. Fit diagnostics for the trawl catch in final black sea bass **South** area model.

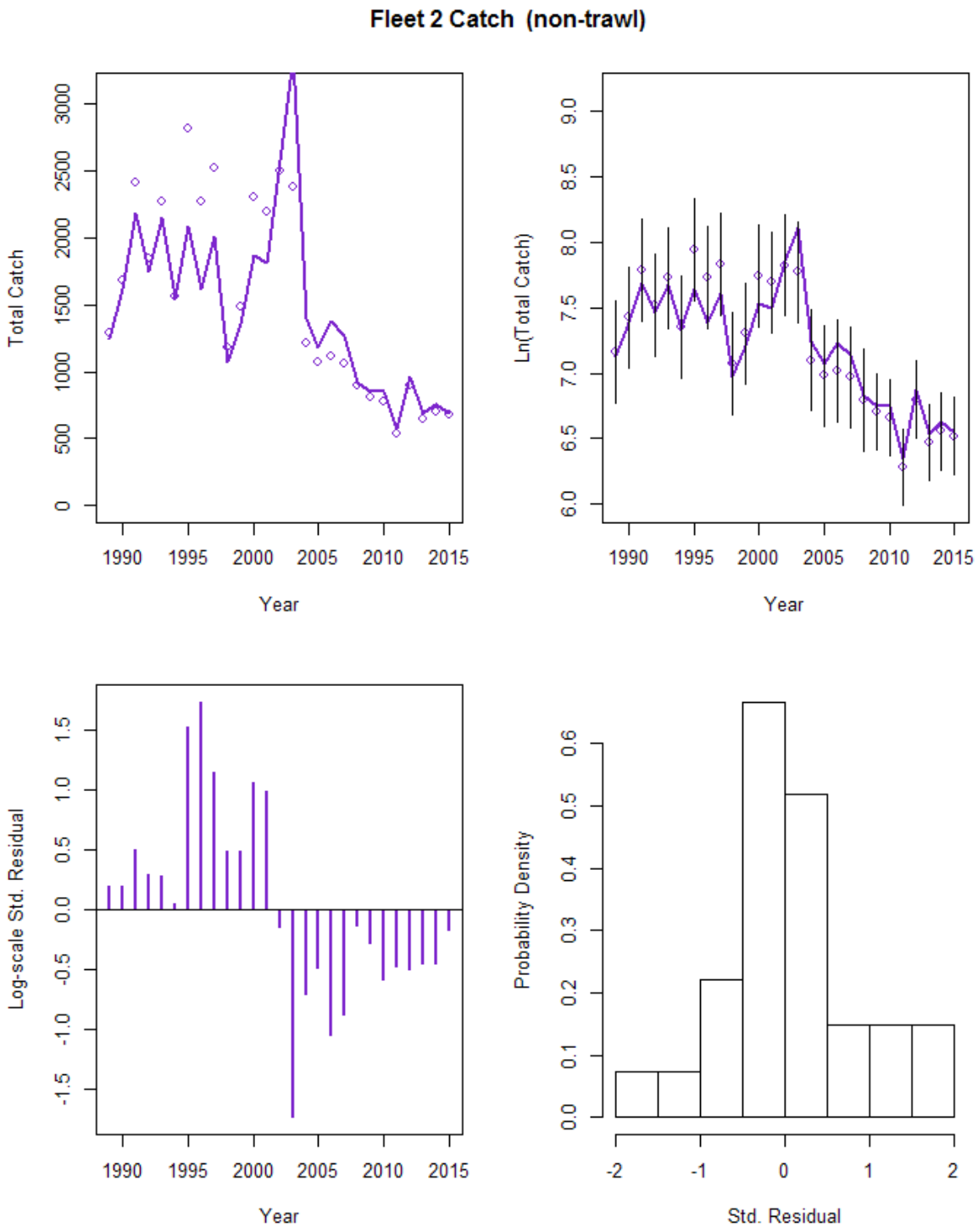


Figure A116. Fit diagnostics for the non-trawl catch in final black sea bass **South** area model.

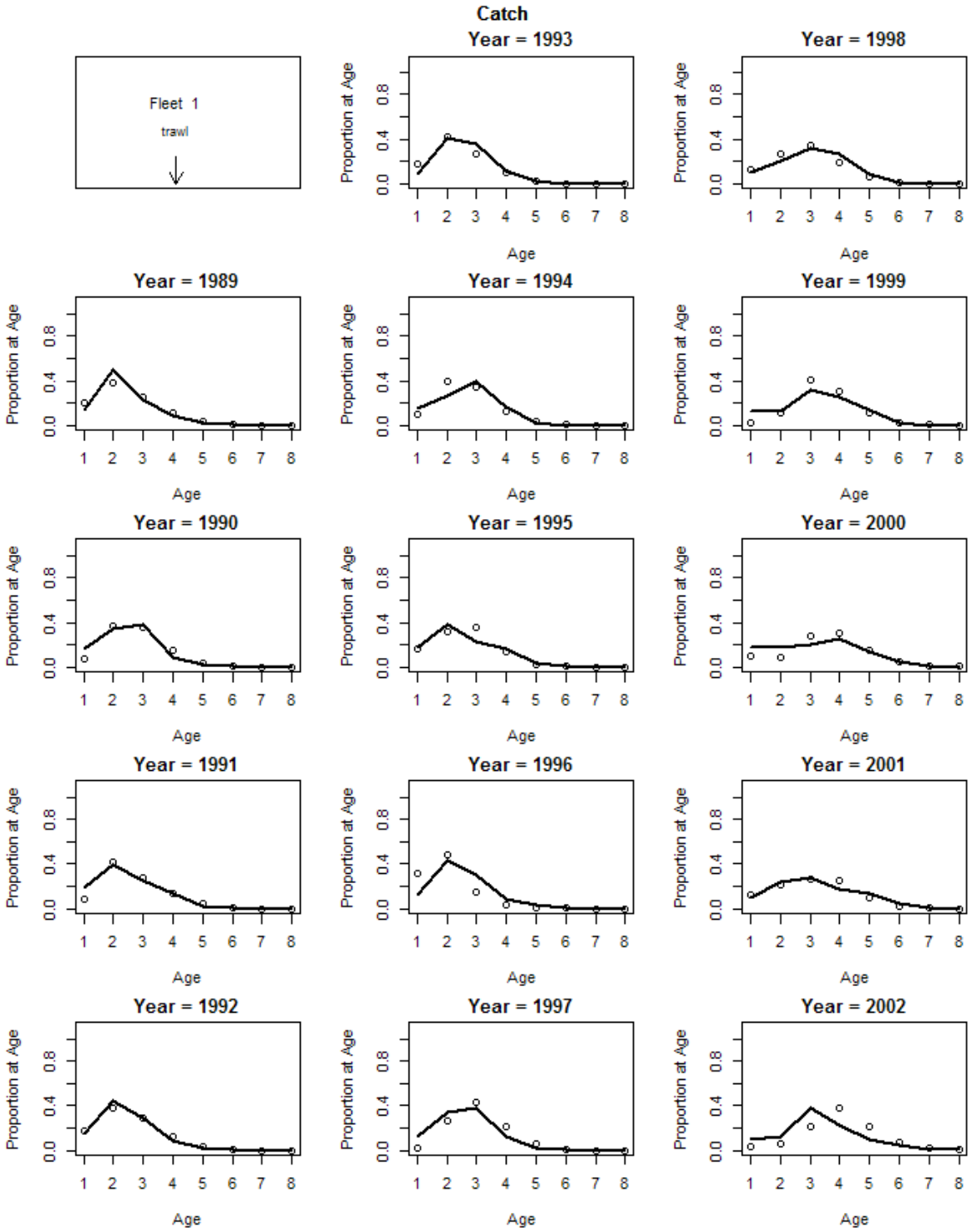


Figure A117. Fits to 1989-2002 trawl catch proportions at age in final black sea bass **South** area model.

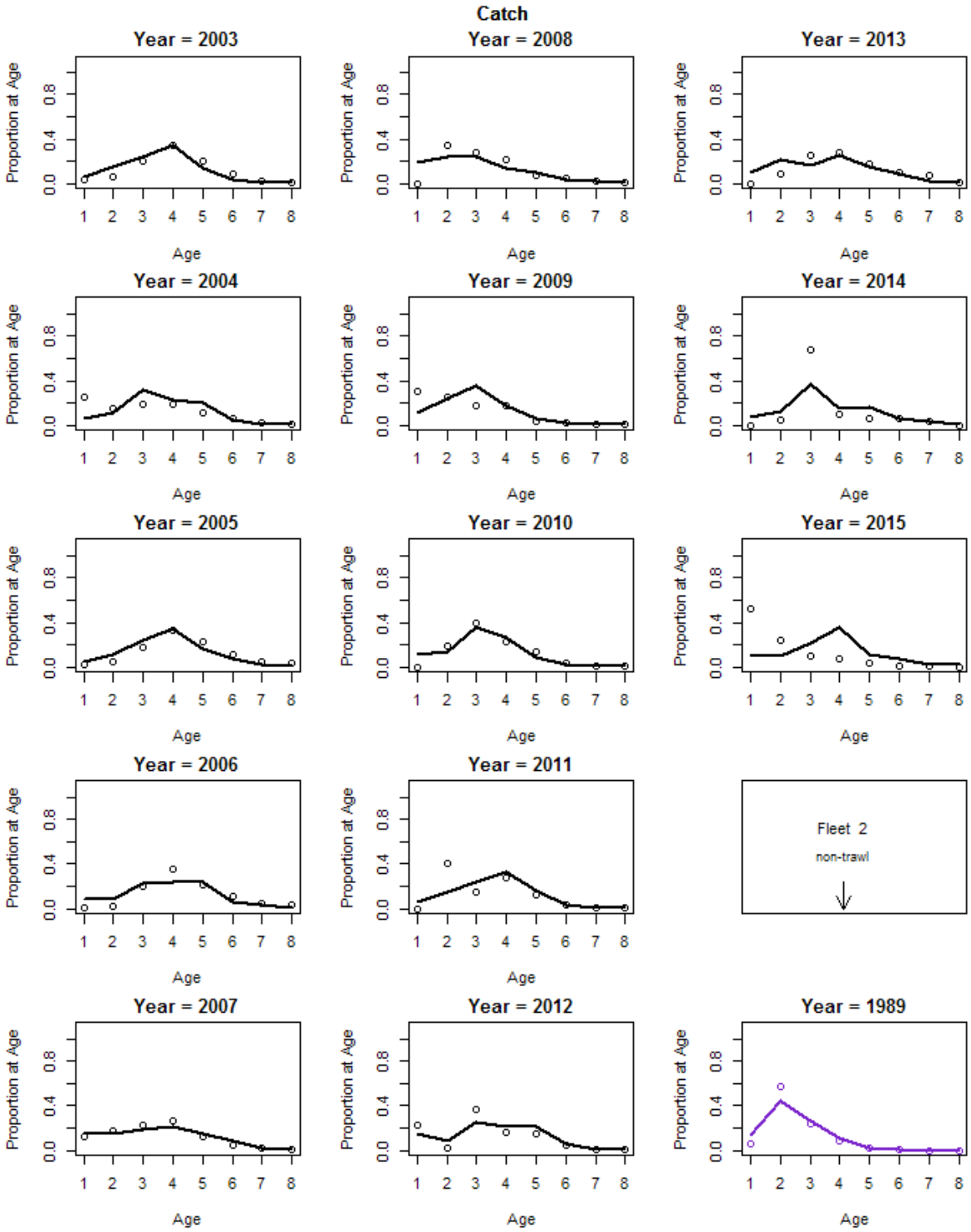


Figure A118. Fits to 2003-2015 trawl catch and 1989 non-trawl catch proportions at age in final black sea bass **South** area model.

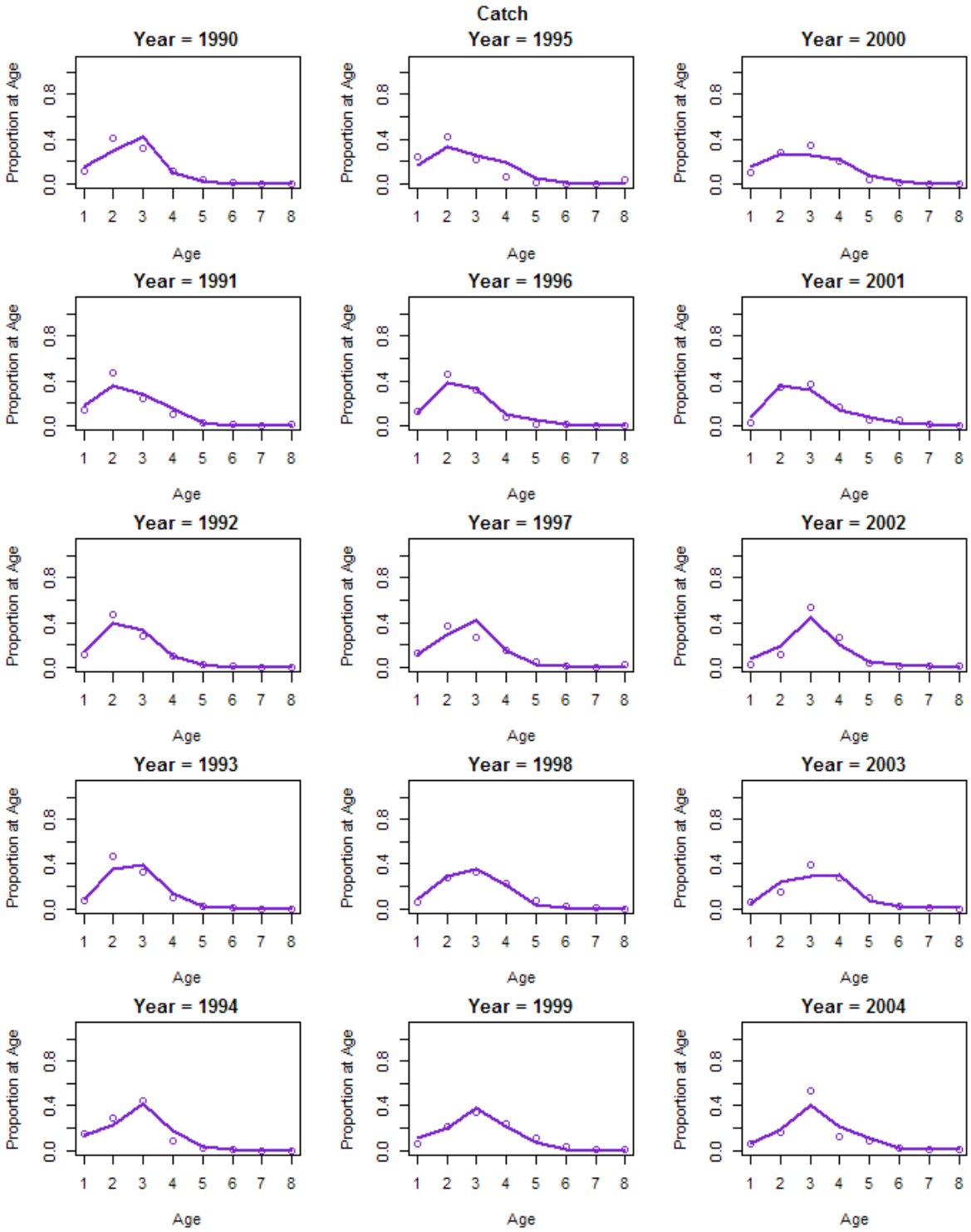


Figure A119. Fits to 1990-2004 trawl catch proportions at age in final black sea bass **South** area model.

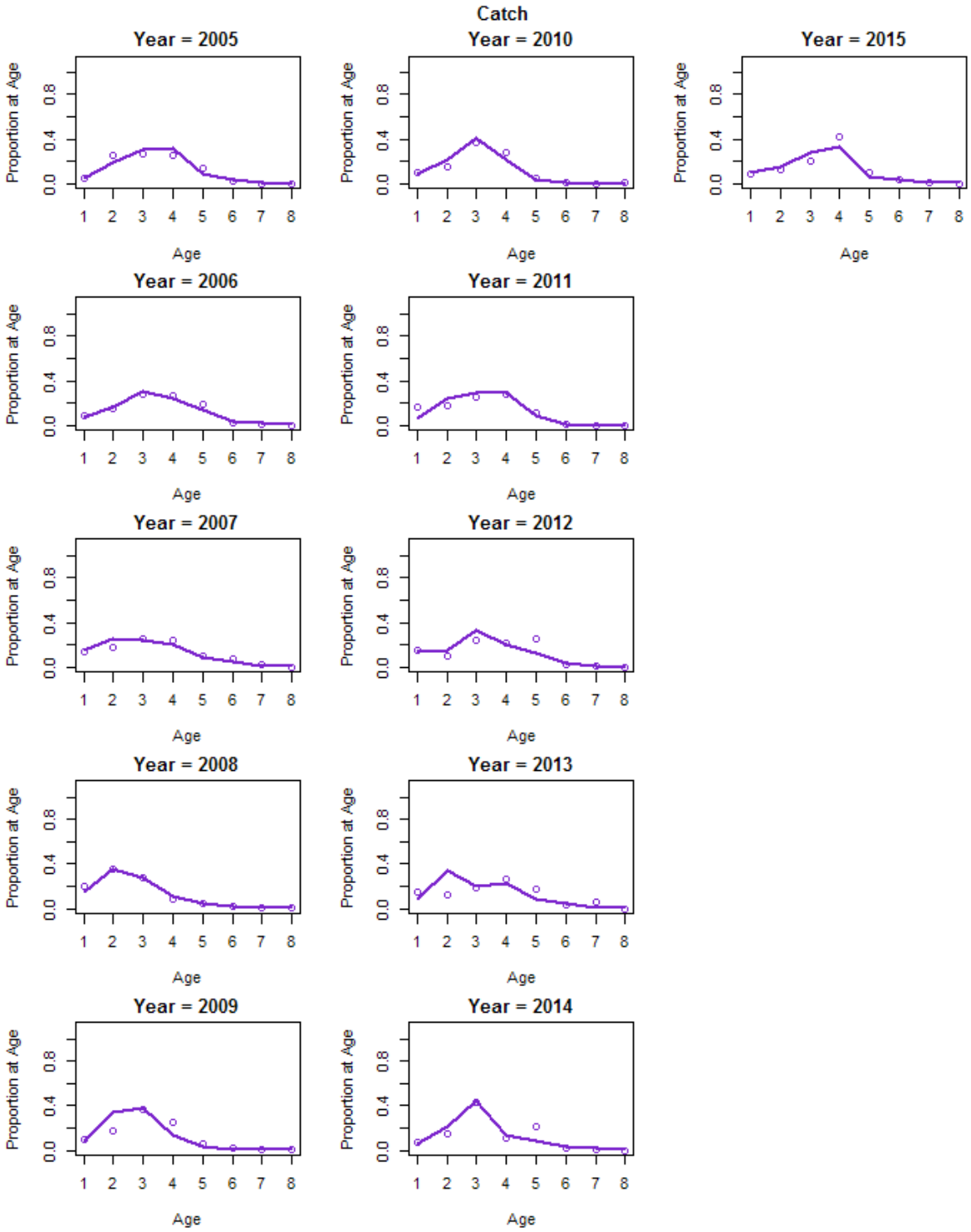


Figure A120. Fits to 2005-2015 trawl catch proportions at age in final black sea bass **South** area model.

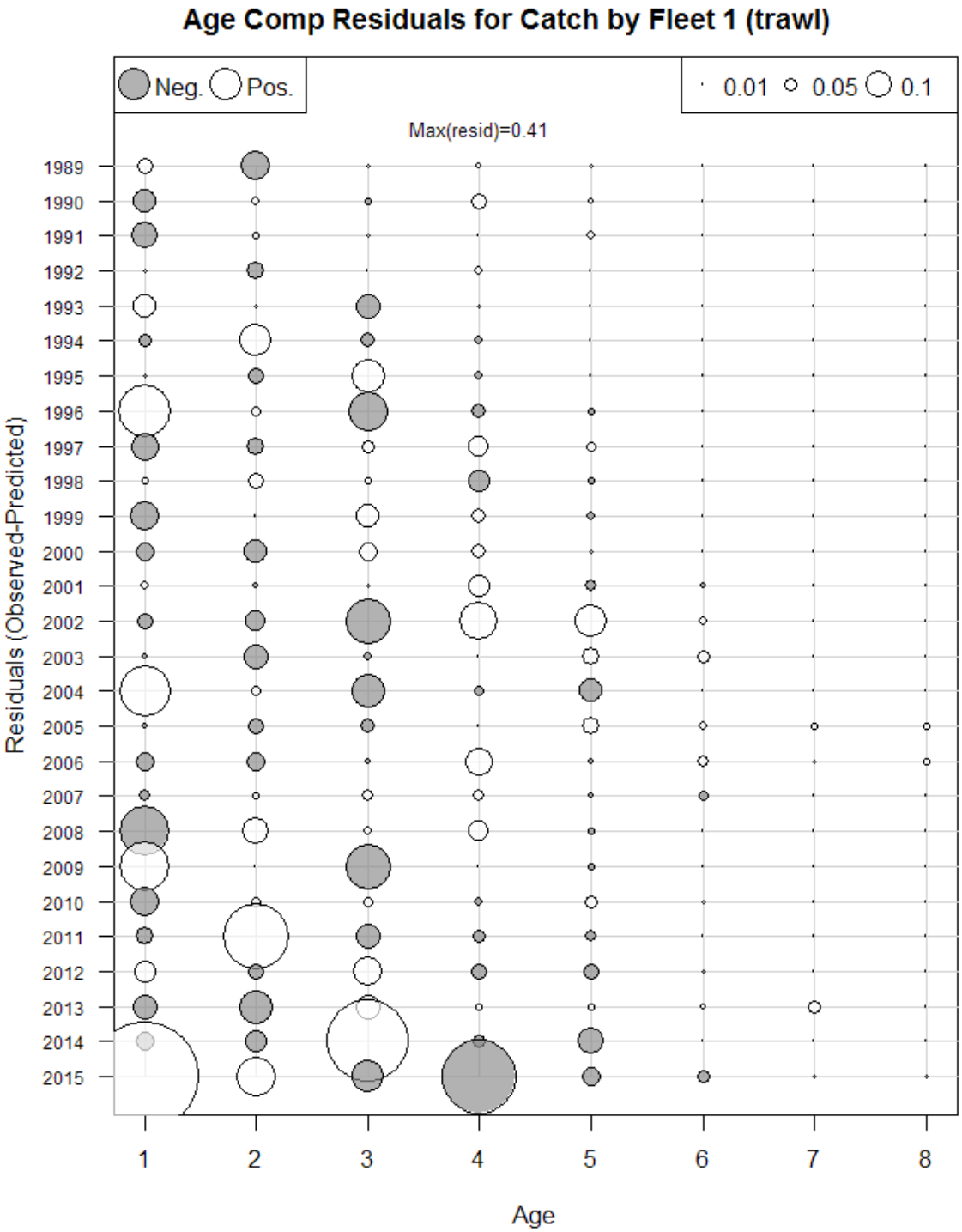


Figure A121. Age composition residuals of proportion at age from black sea bass trawl catch in final **South** area model.

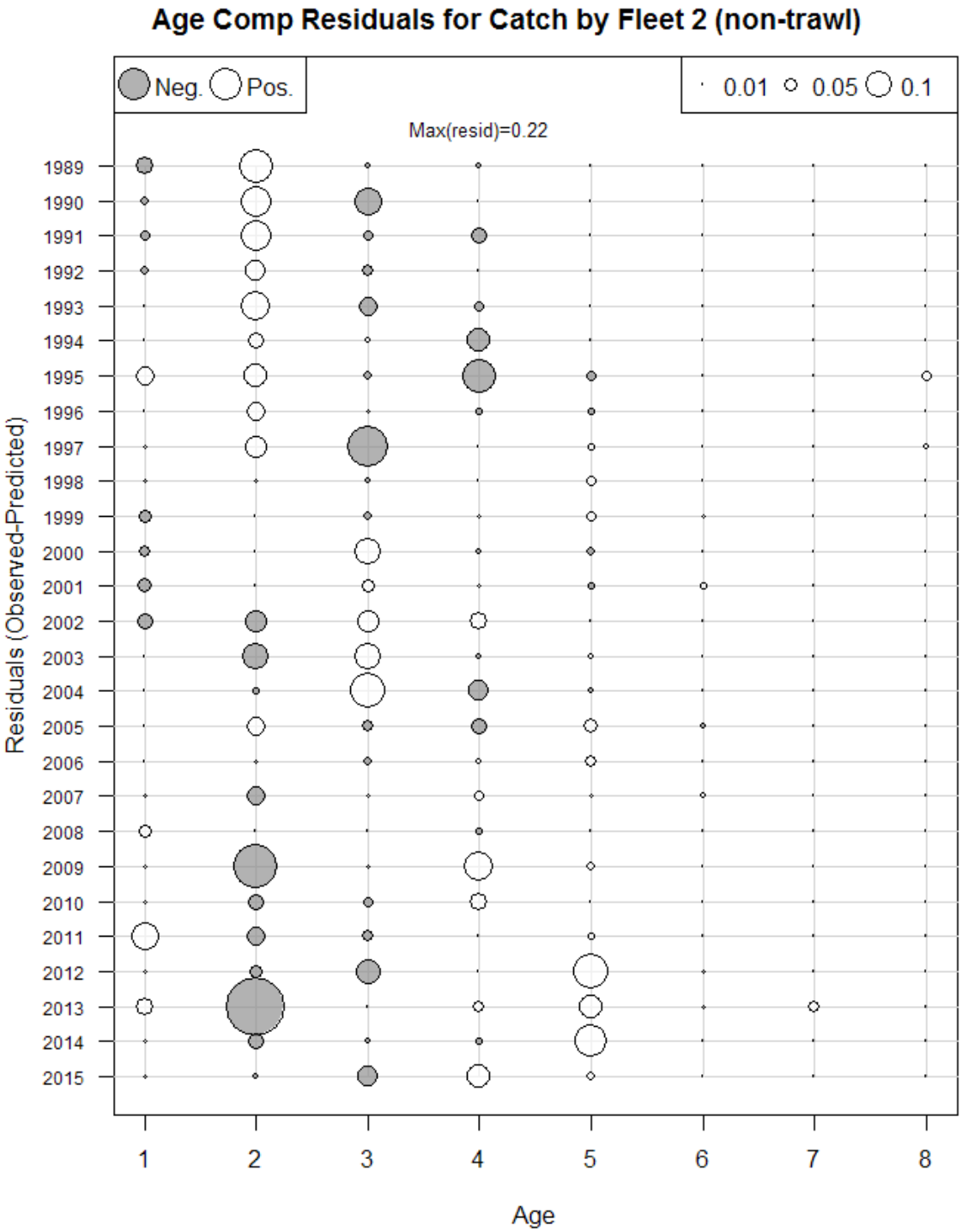


Figure A122. Age composition residuals of proportion at age from non-trawl black sea bass catch in final **South** area model.

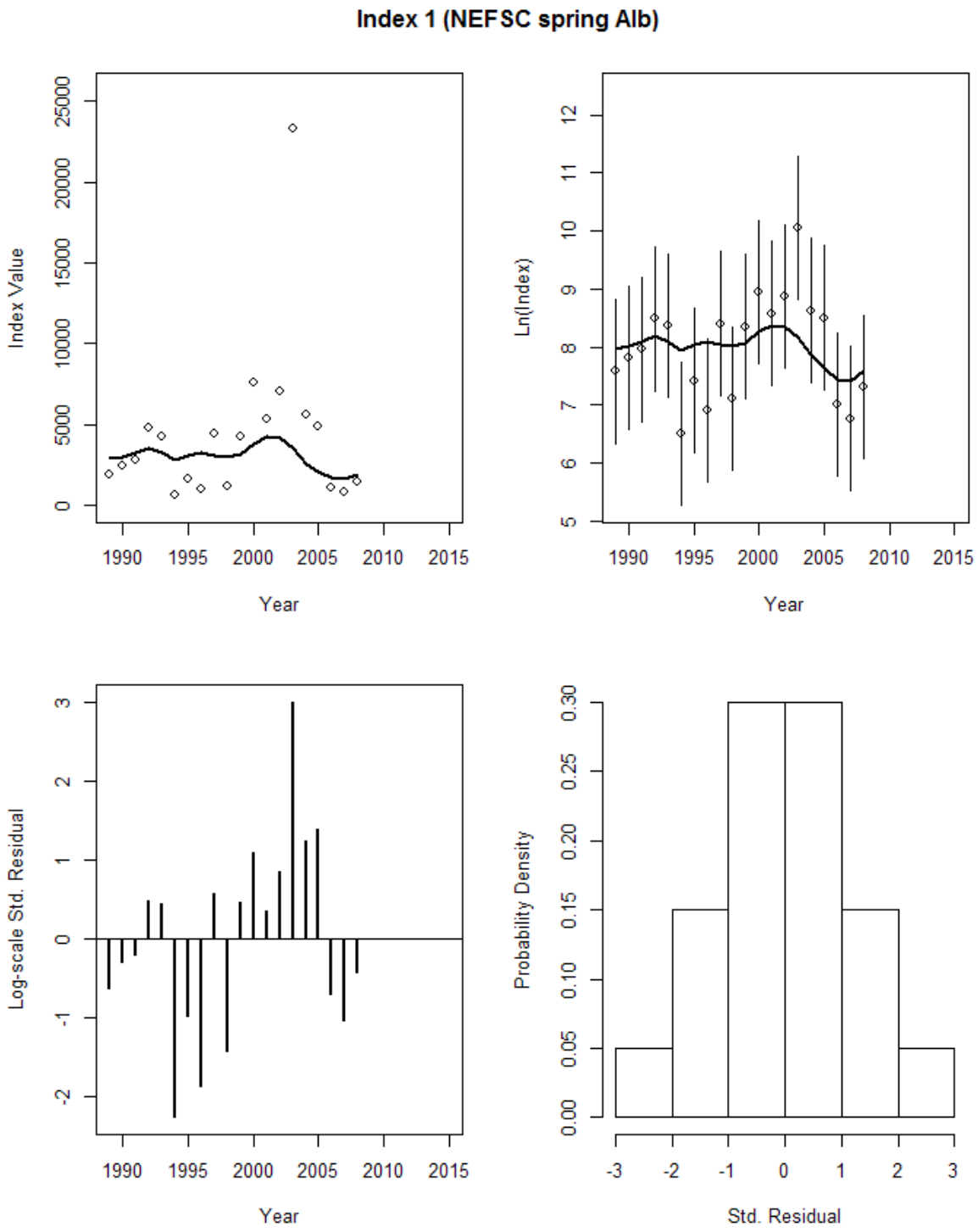


Figure A123. Fit diagnostics for NEFSC spring 1989-2008 (*Albatross*) trawl survey in final black sea bass **South** area model.

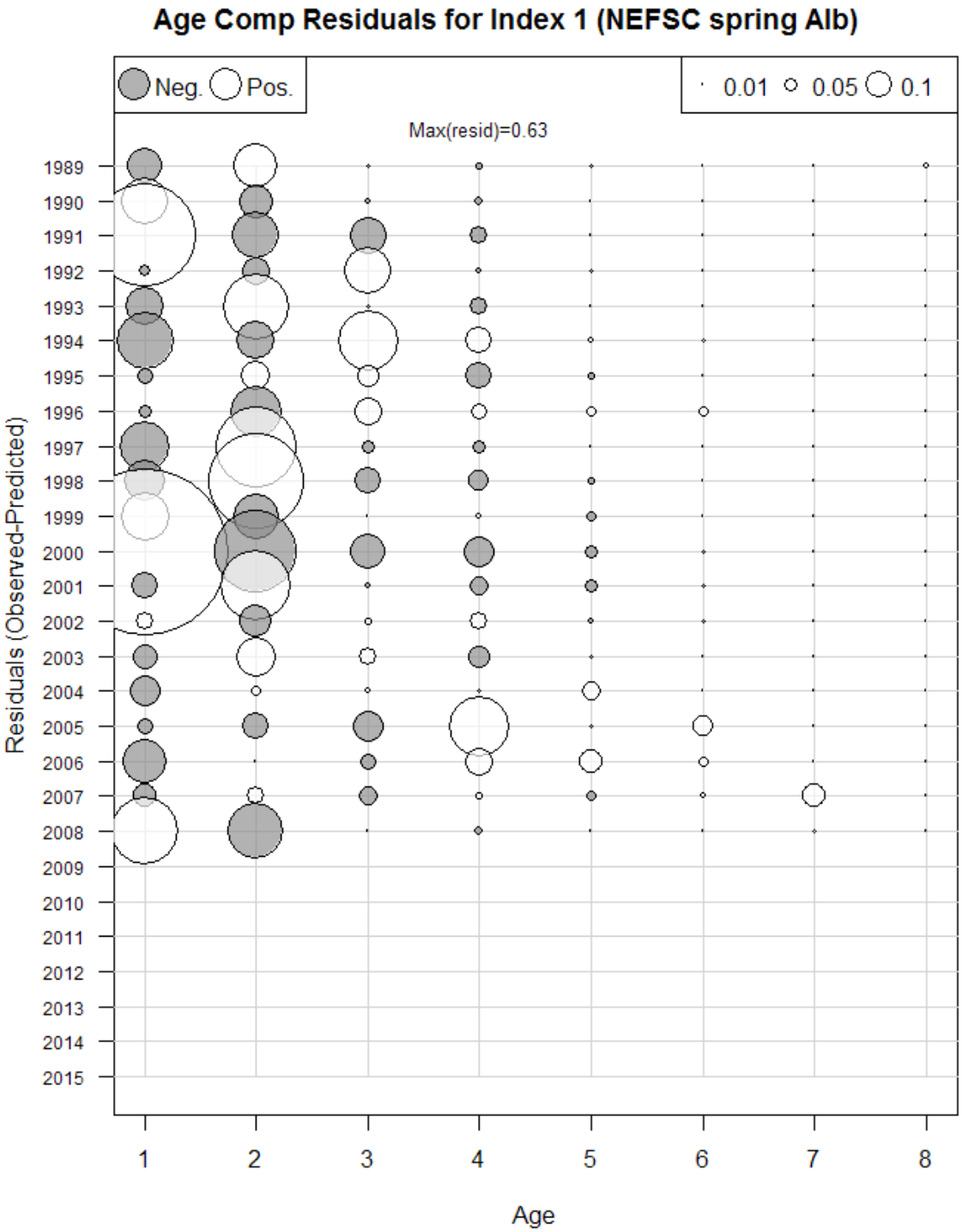


Figure A124. Age composition residuals for NEFSC spring 1989-2008 (*Albatross*) trawl survey in final black sea bass **South** area model.

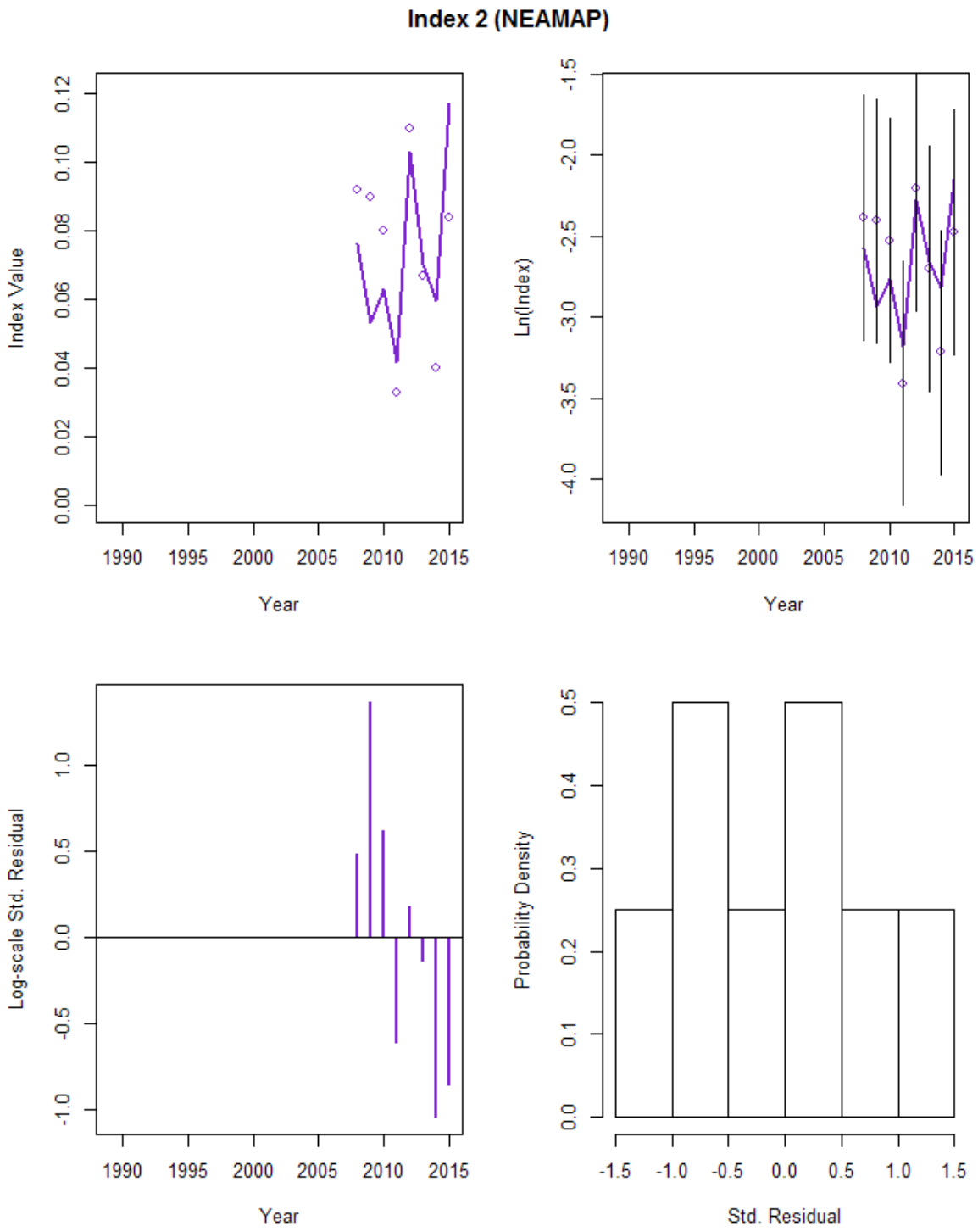


Figure A125. Fit diagnostics for NEAMAP trawl survey in final black sea bass **South** area model.

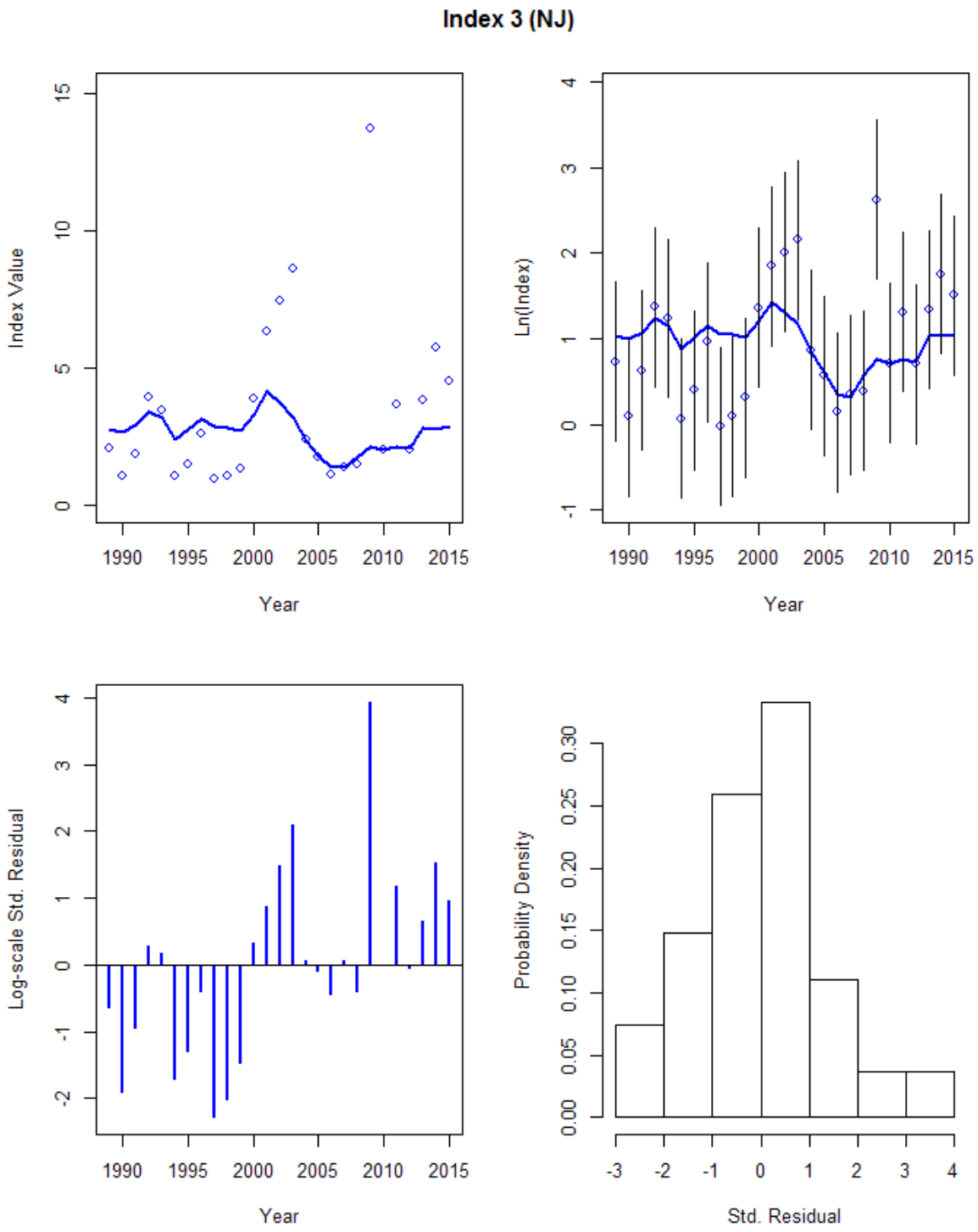


Figure A126. Age composition residuals for NEAMAP trawl survey in final black sea bass **South** area model.

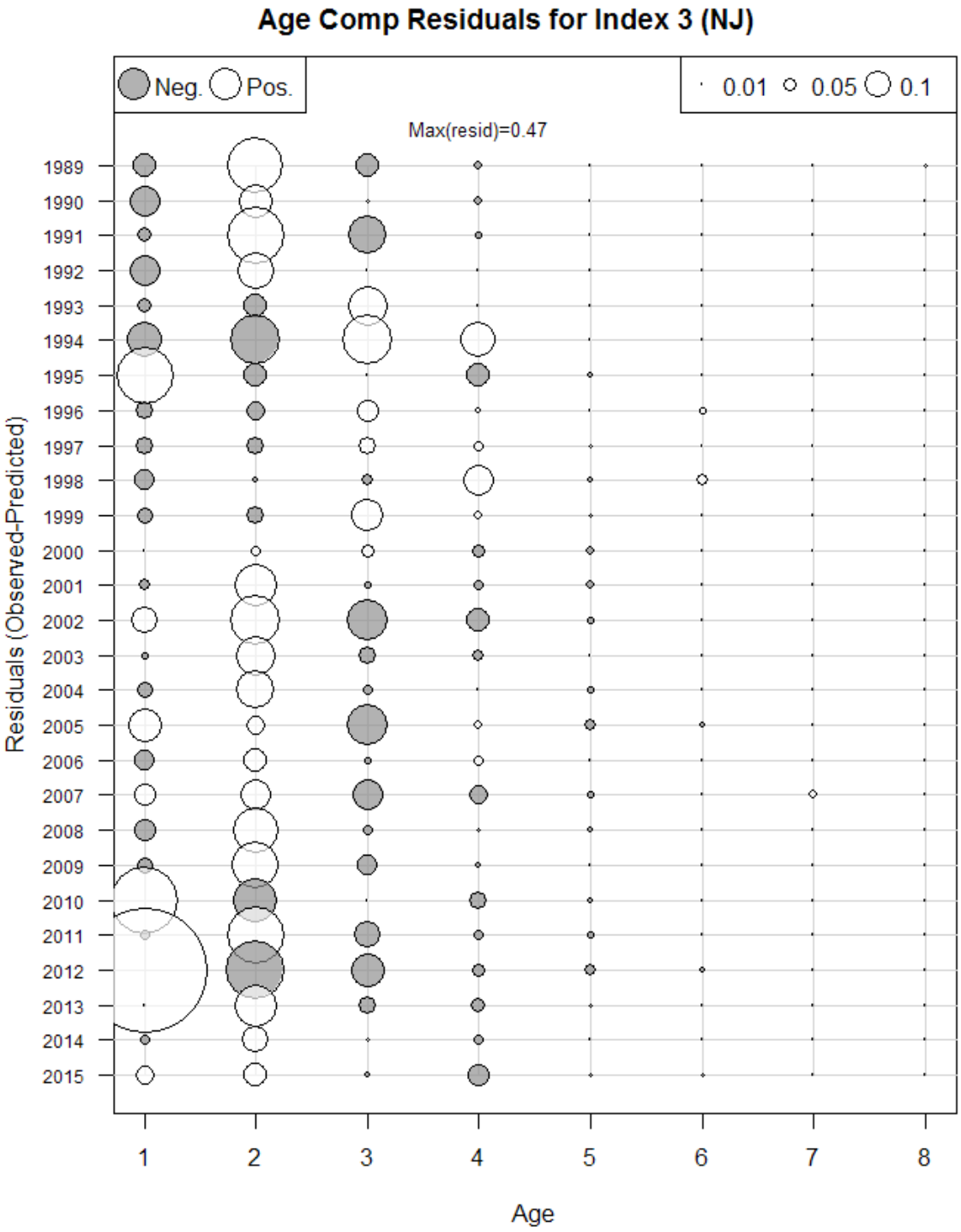


Figure A127. Fit diagnostics for NJ trawl survey in final black sea bass **South** area model.

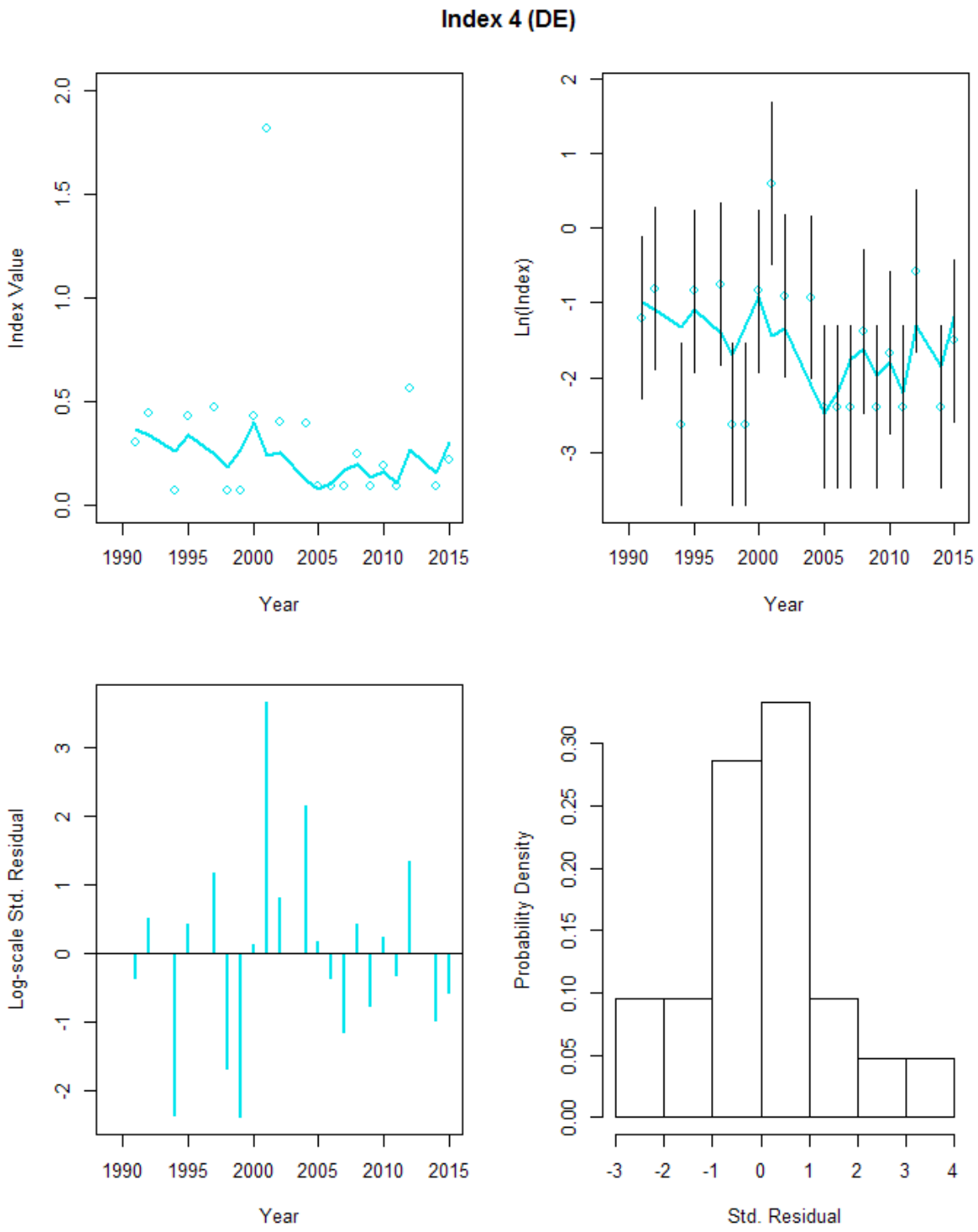


Figure A128. Fit diagnostics for DE trawl survey in final black sea bass **South** area model.

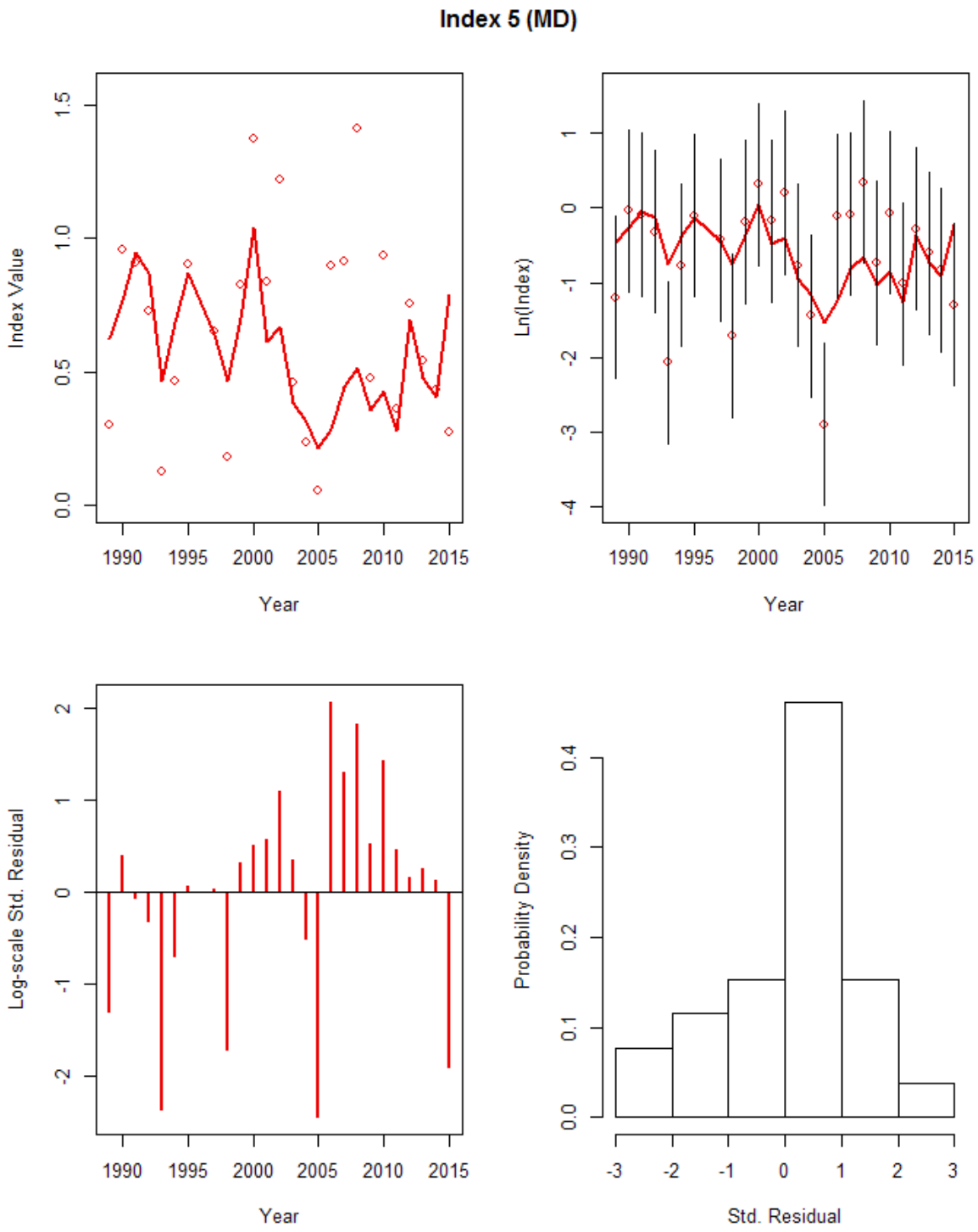


Figure A129. Fit diagnostics for MD trawl survey in final black sea bass **South** area model.

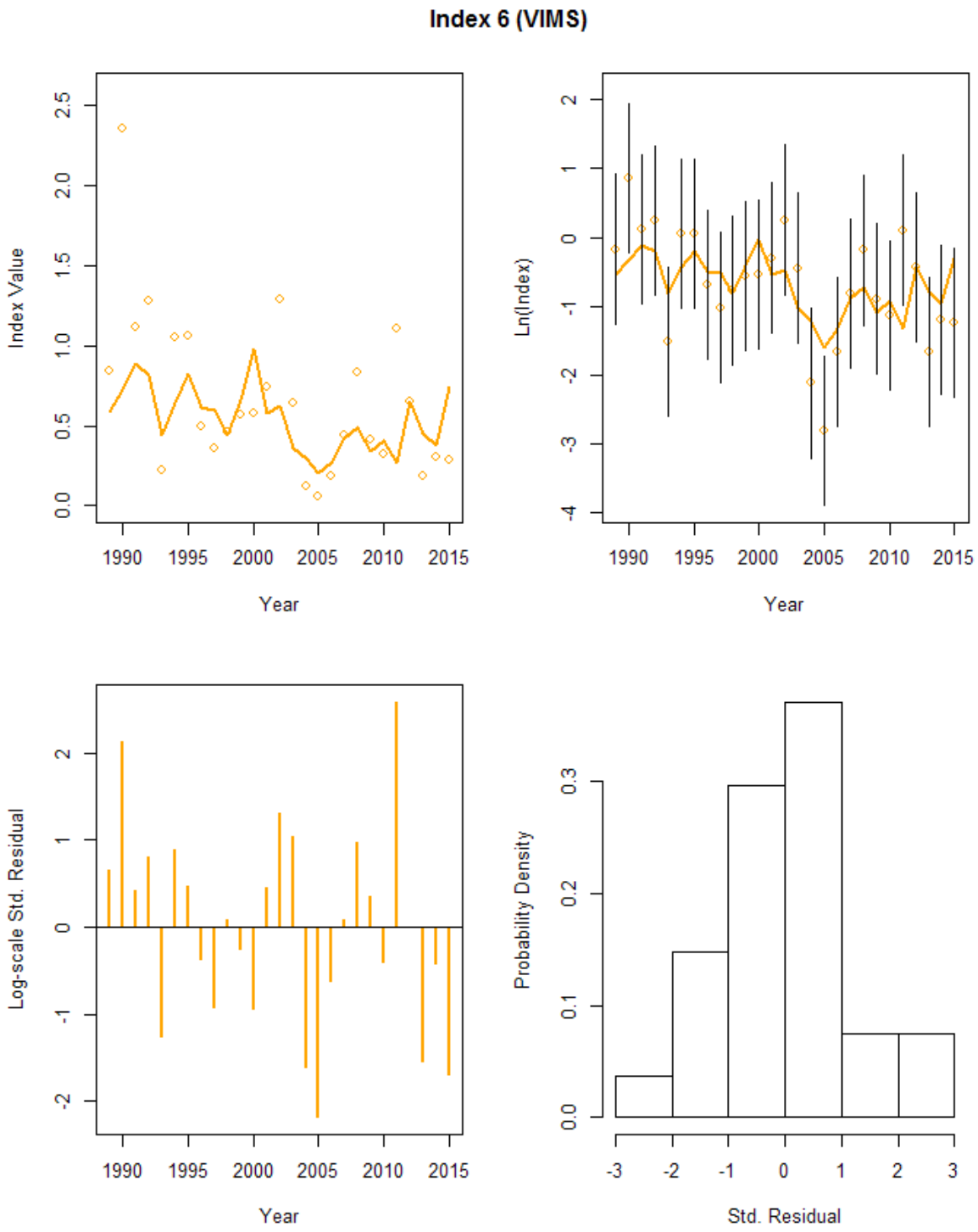


Figure A130. Fit diagnostics for VIMS trawl survey in final black sea bass **South** area model.

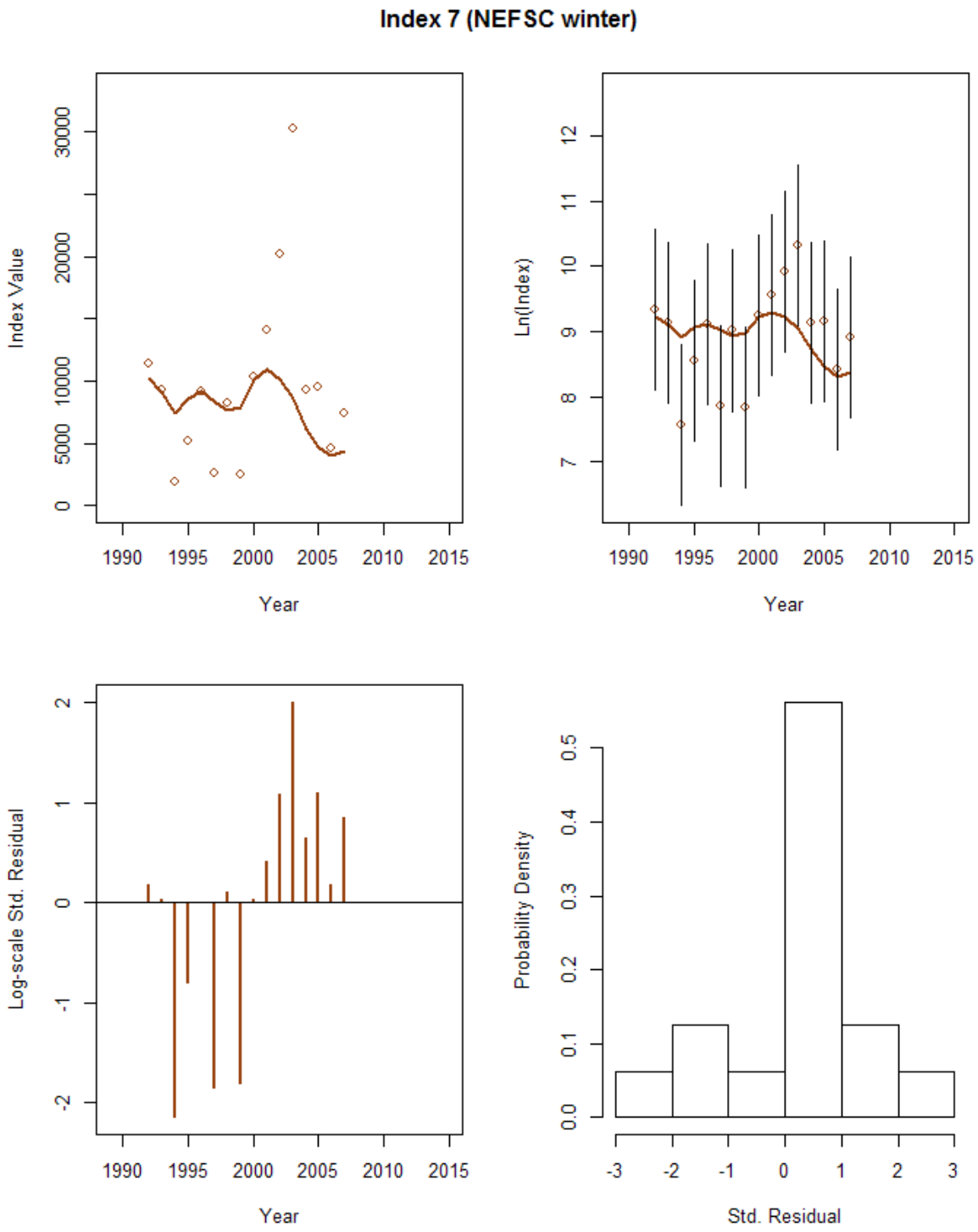


Figure A131. Fit diagnostics for NEFSC winter trawl survey in final black sea bass **South** area model.

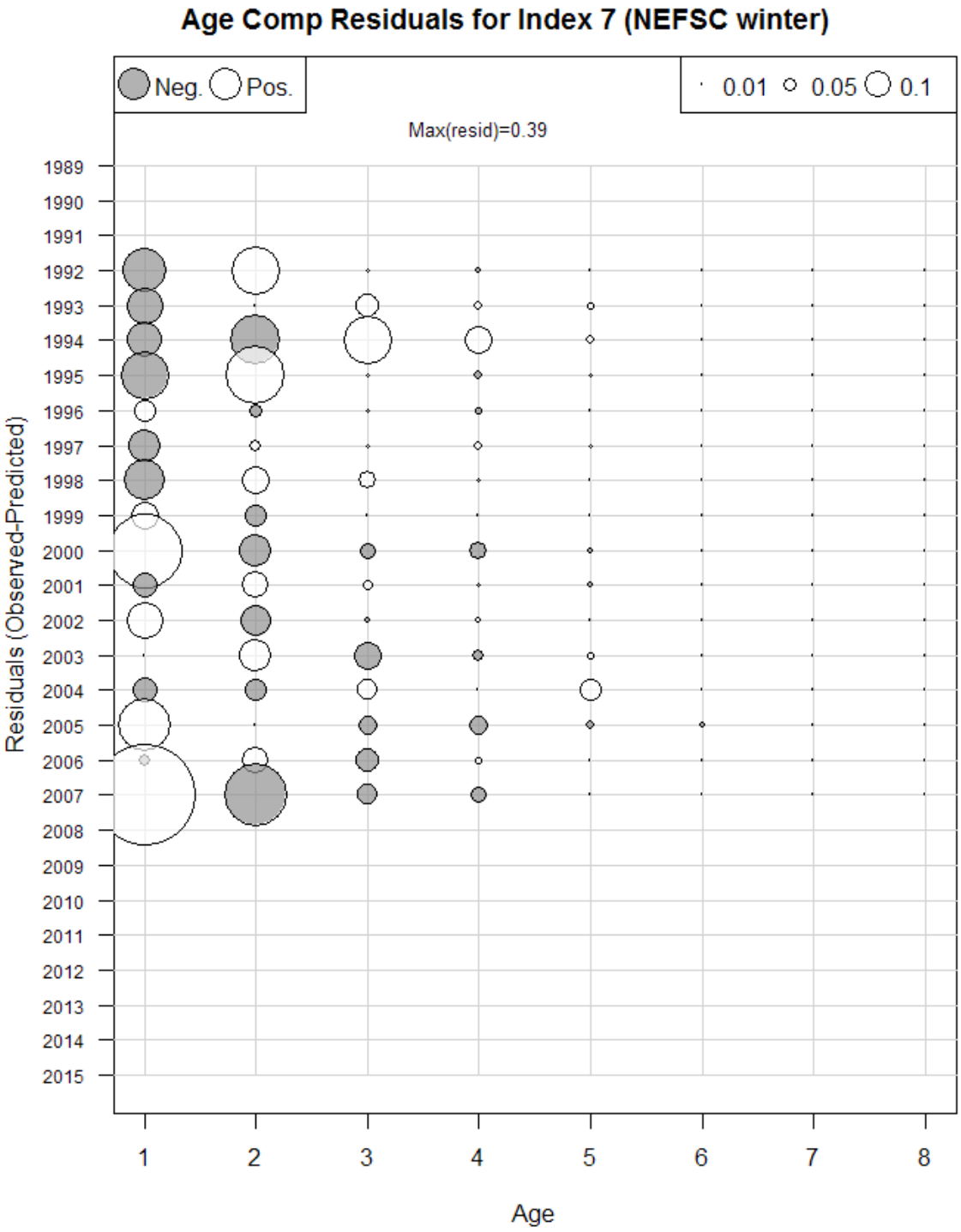


Figure A132. Age composition residuals for NEFSC winter trawl survey in final black sea bass **South** area model.

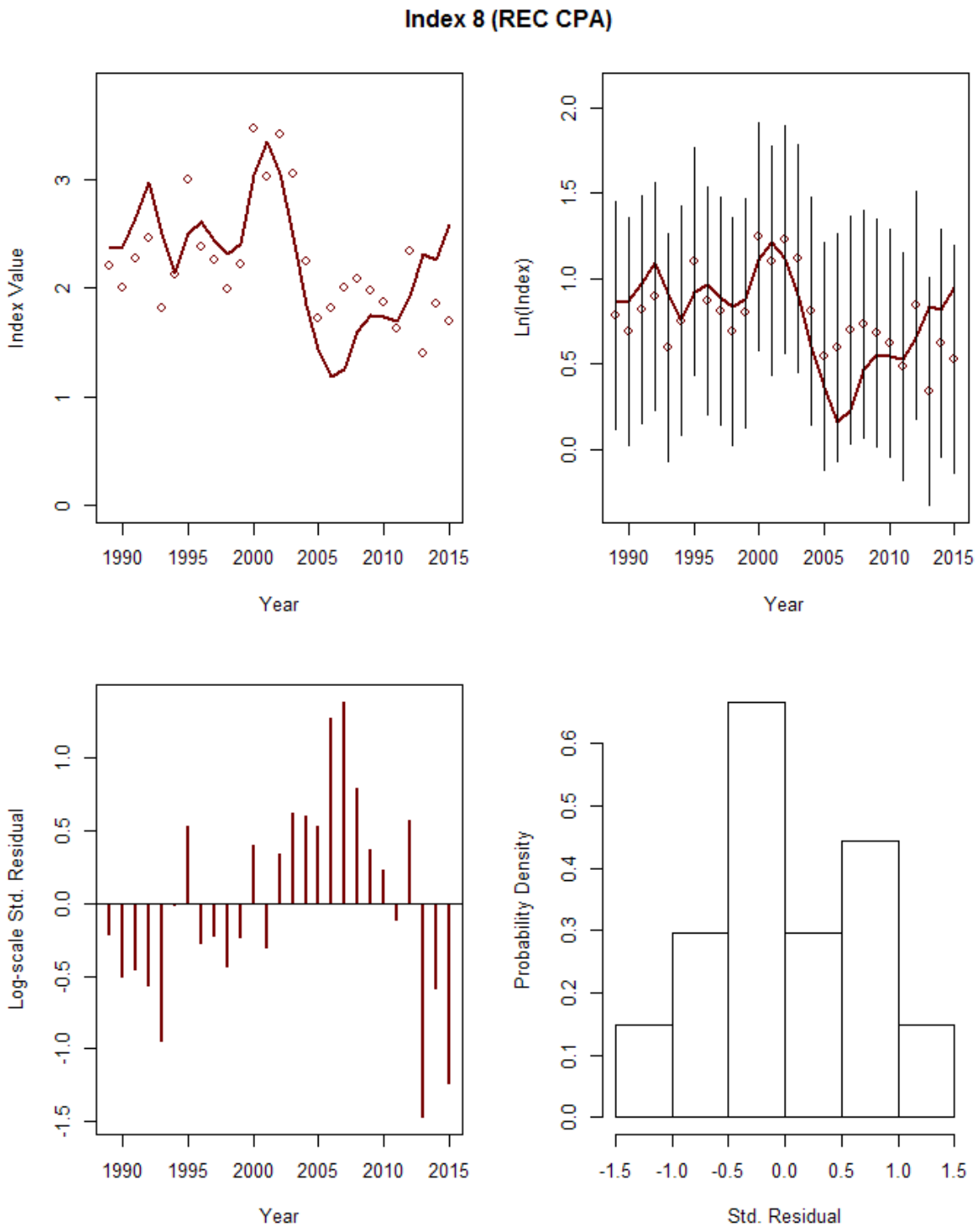


Figure A133. Fit diagnostics for Rec CPA in final black sea bass **South** area model.

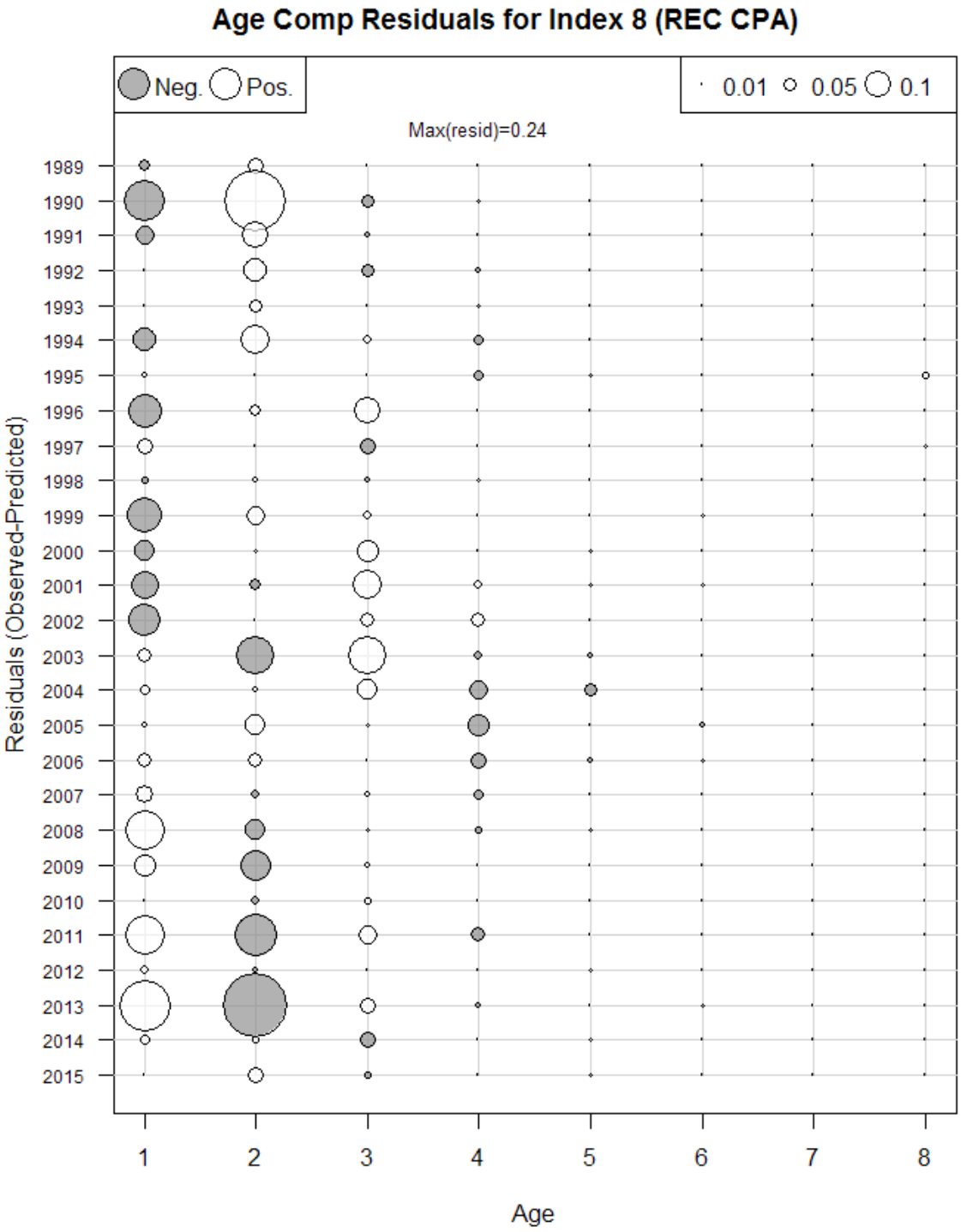


Figure A134. Age composition residuals for Rec CPA in final black sea bass **South** area model.

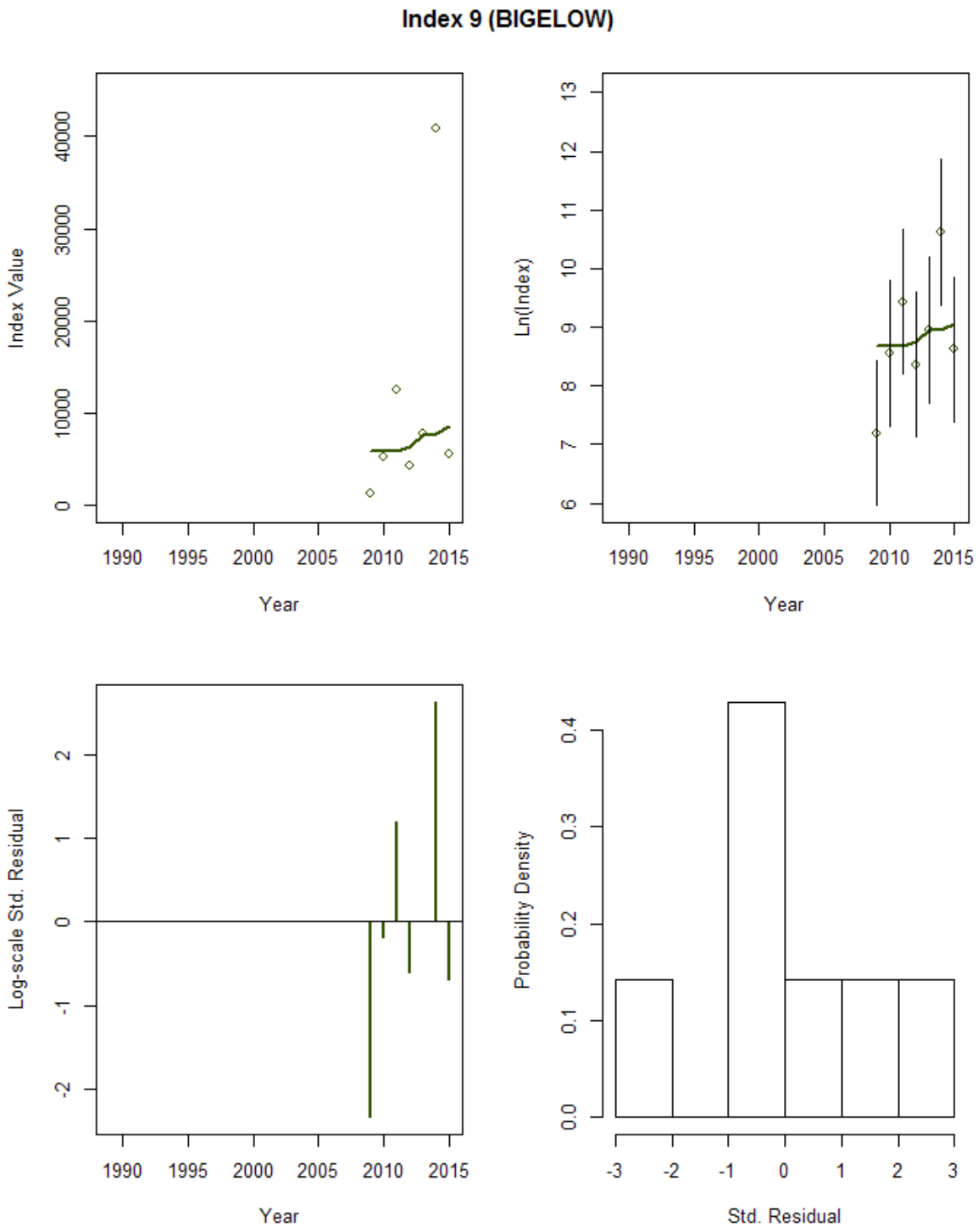


Figure A135. Fit diagnostics for NEFSC spring trawl survey (*Bigelow*) 2008-2015 in final black sea bass **South** area model.

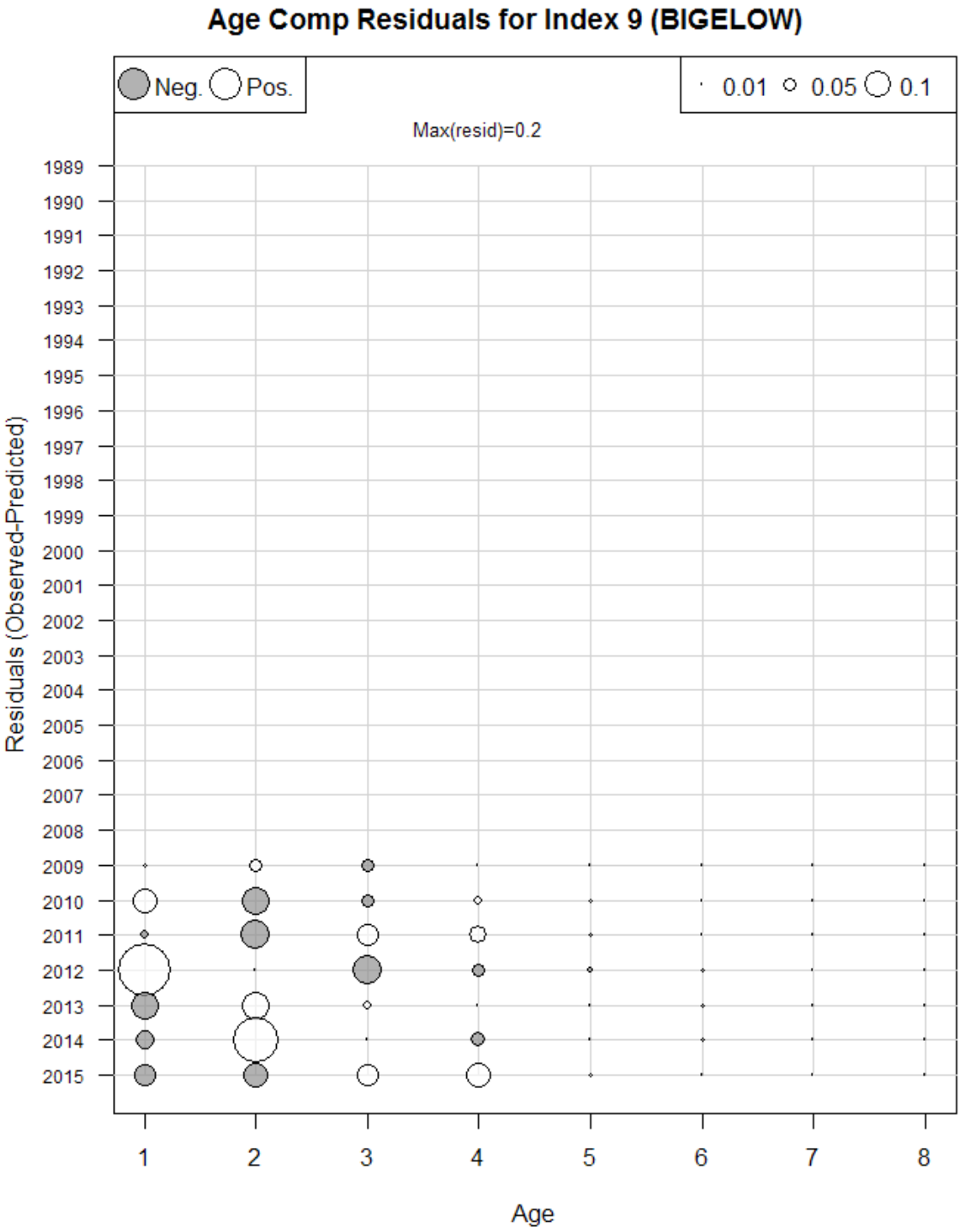


Figure A136. Age composition residuals for NEFSC spring trawl survey (*Bigelow*) 2008-2015 in final black sea bass **South** area model.

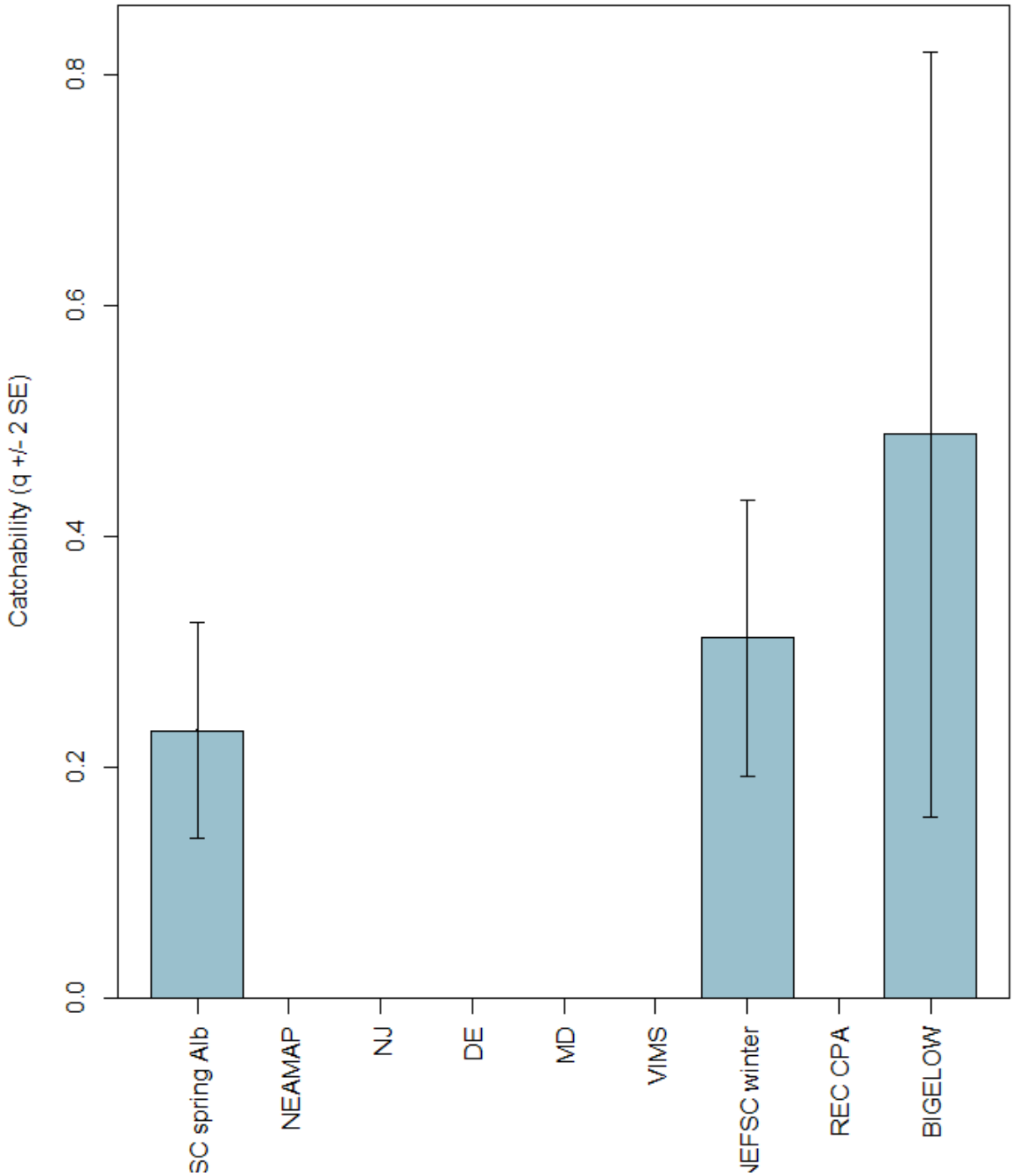

Figure A137. Index catchability estimates from final black sea bass **South** area model.

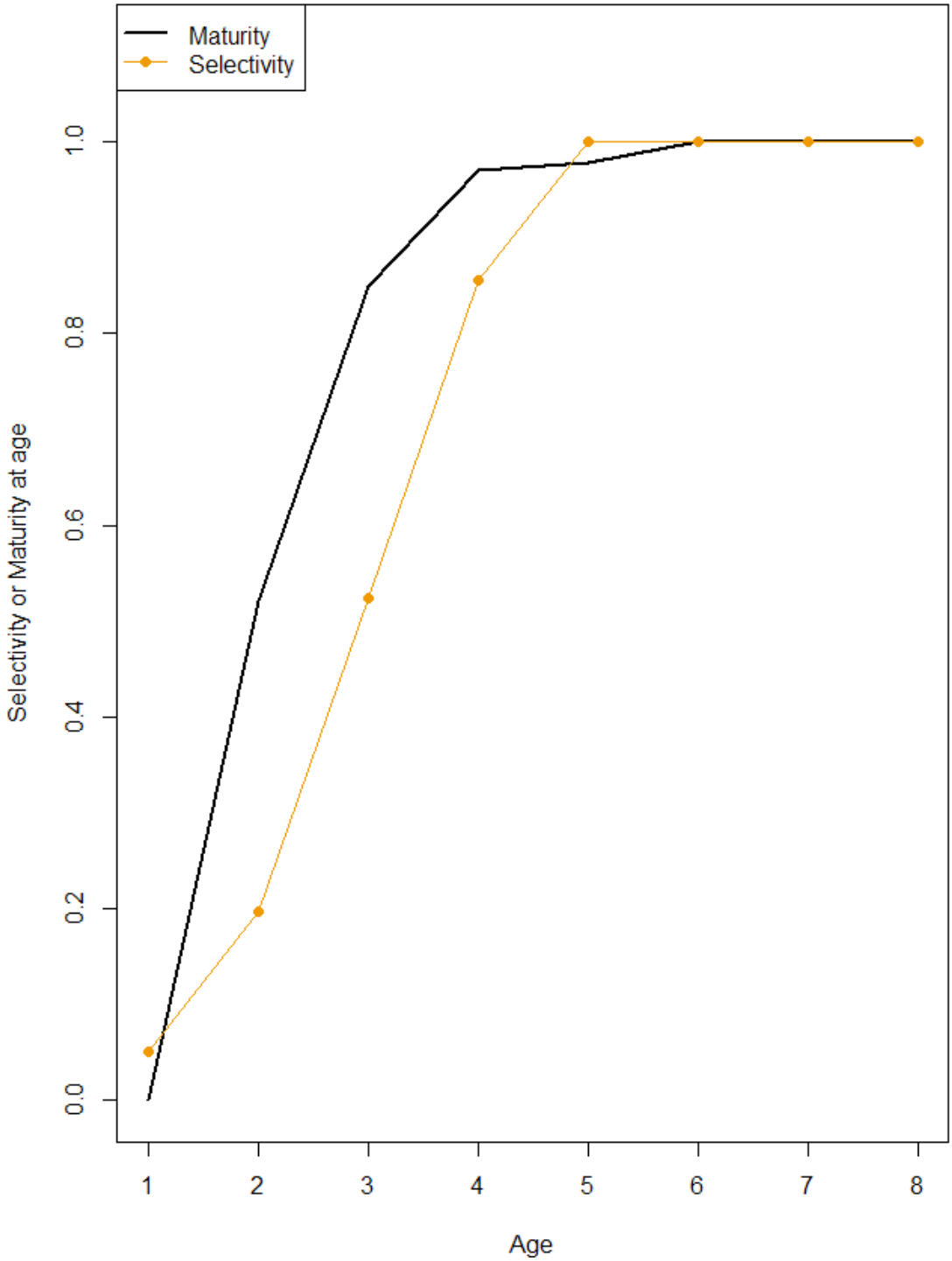

Figure A138. Comparison of maturity and average selectivity at age in final black sea bass **South** area model.

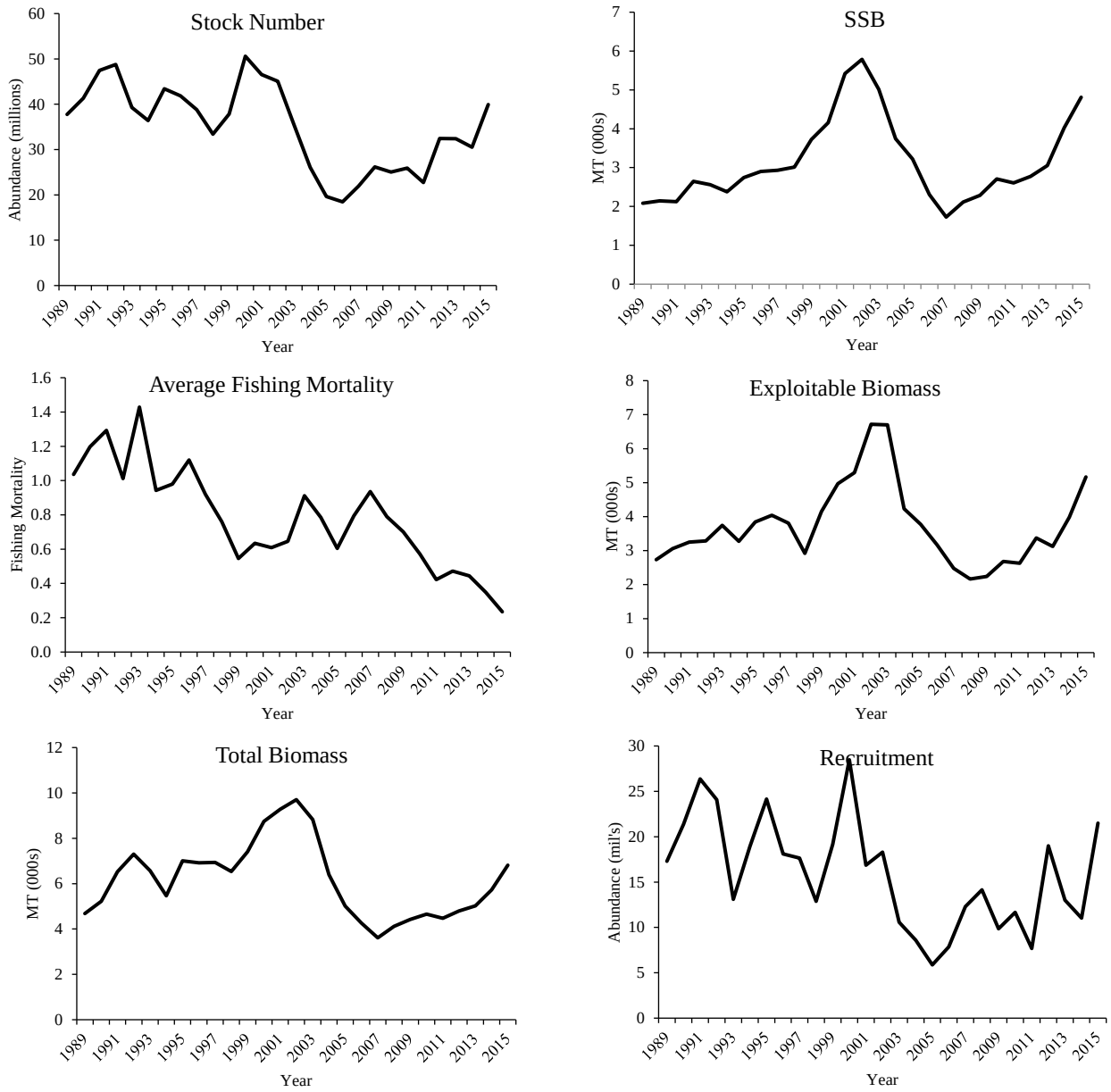


Figure A139. Results of stock number, fishing mortality, total biomass, spawning biomass, exploitable biomass and recruitment from the black sea bass **South** area model.

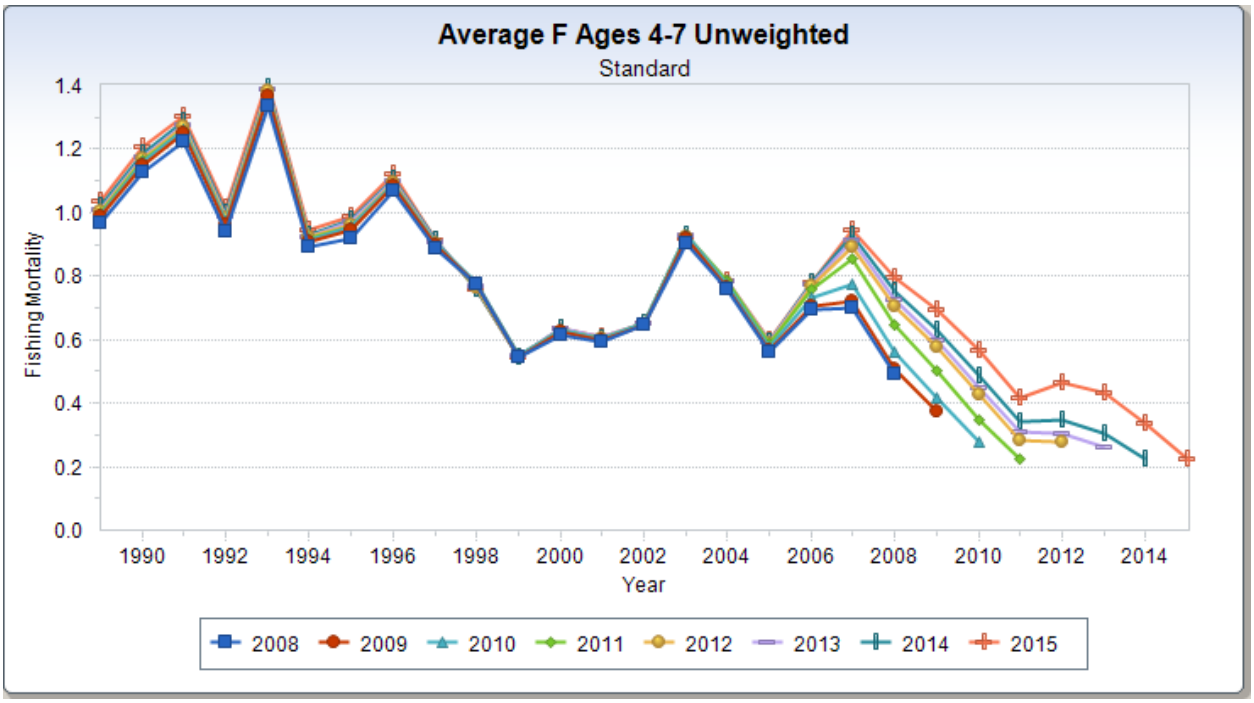


Figure A140. Retrospective pattern in average F estimates from black sea bass ASAP model for **South** area. Mohn's rho = -0.42

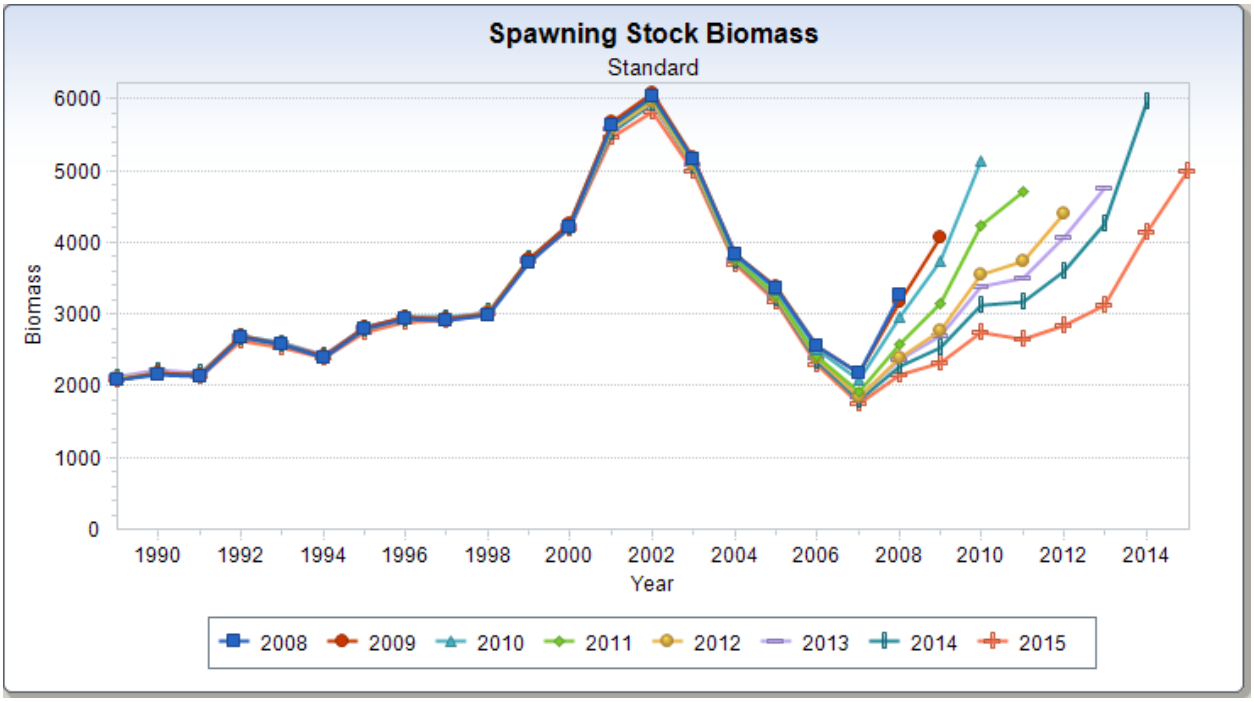


Figure A141. Retrospective pattern in spawning stock biomass (mt) estimates from black sea bass ASAP model for **South** area. Mohn's rho = 0.63

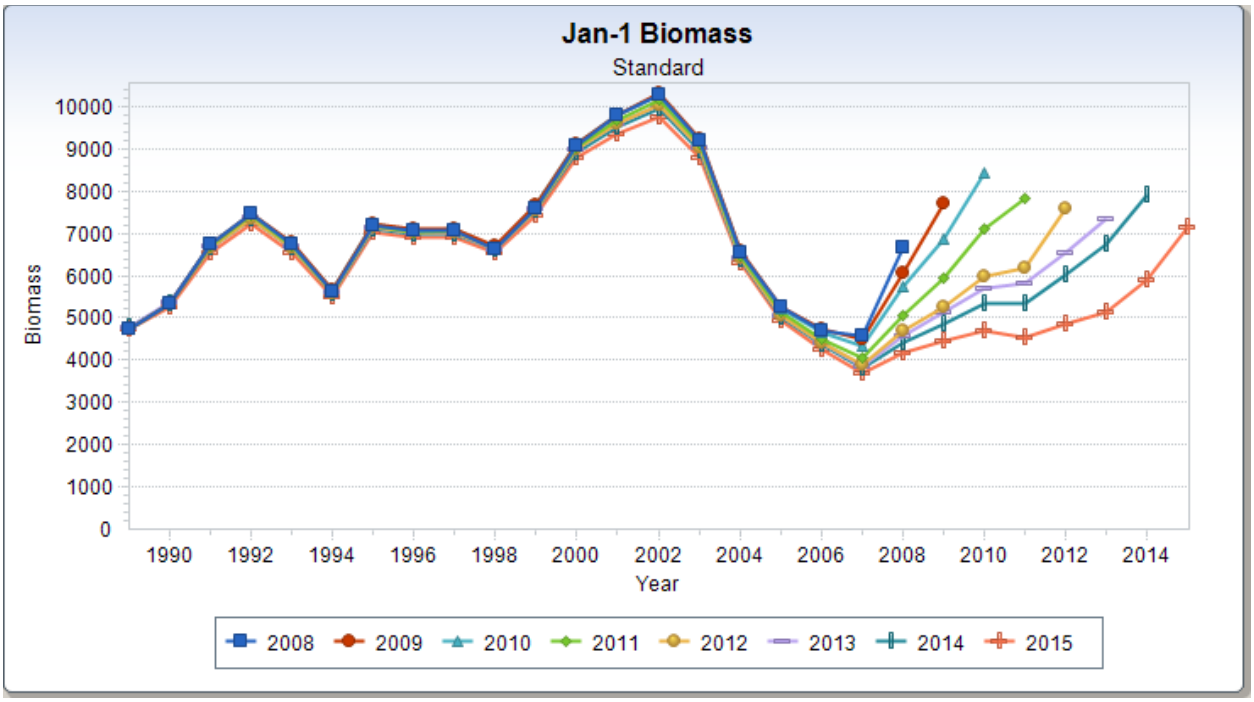


Figure A142. Retrospective pattern in total biomass (mt) estimates from black sea bass ASAP model for **South** area. Mohn's rho = 0.60

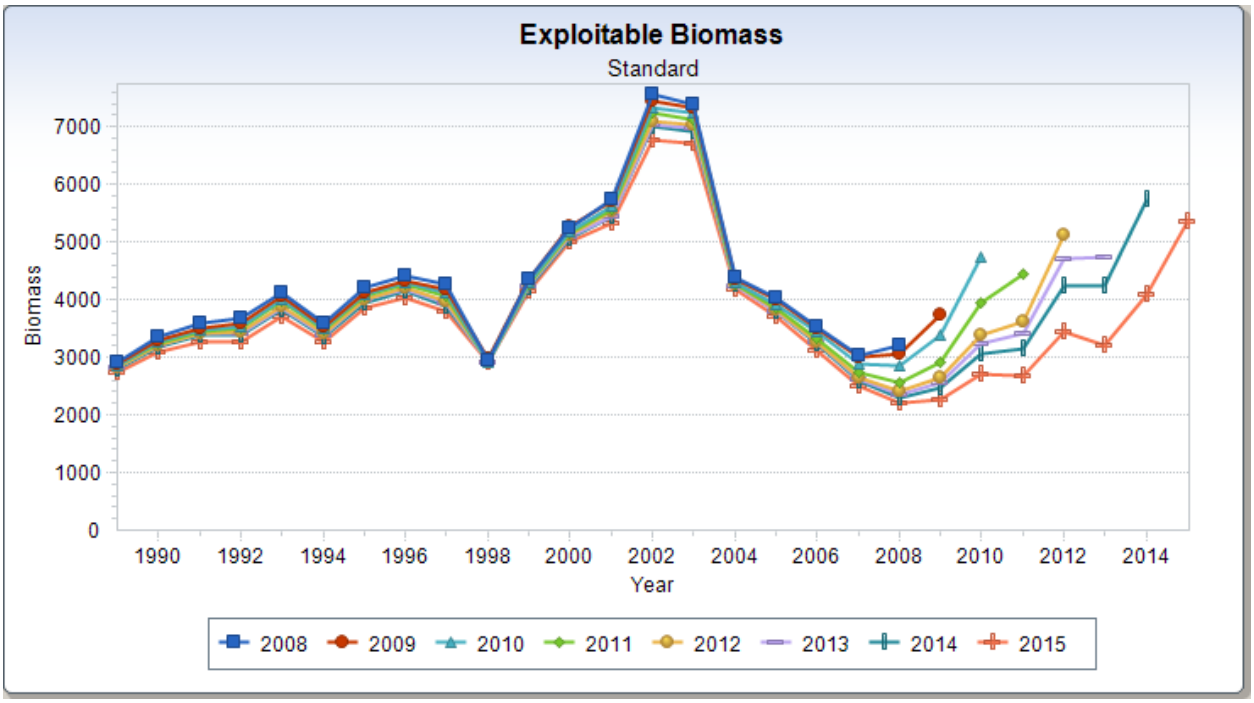


Figure A143. Retrospective pattern in exploitable biomass (mt) estimates from black sea bass ASAP model for **South** area. Mohn's rho = 0.55

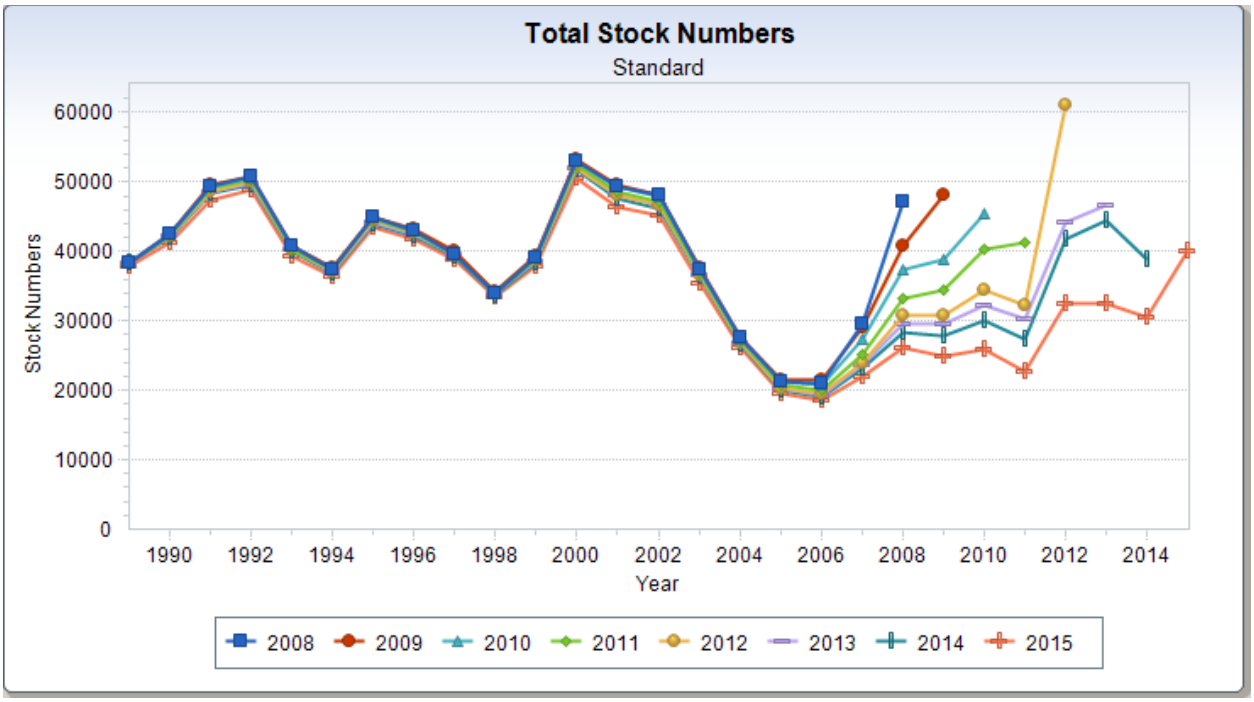


Figure A144. Retrospective pattern in total stock number estimates from black sea bass ASAP model for **South** area. Mohn's rho = 0.70

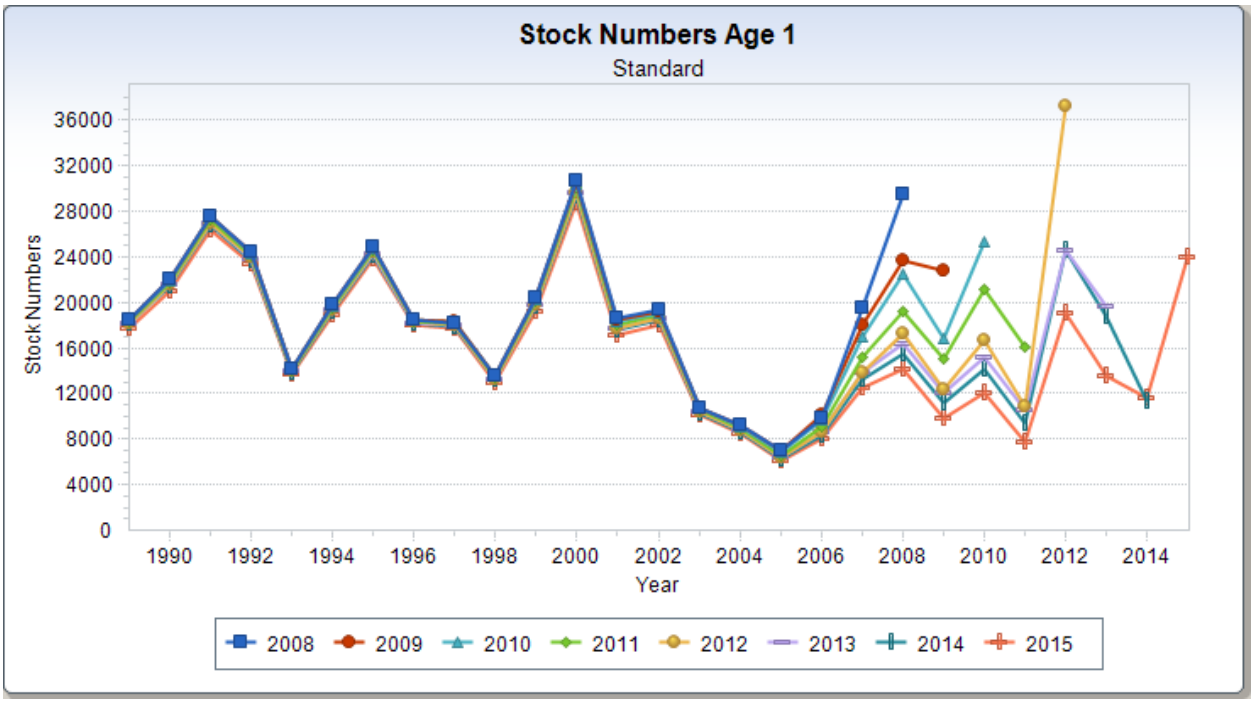


Figure A145 Retrospective pattern in age 1 abundance (recruits) estimates from black sea bass ASAP model for **South** area. Mohn's rho = 0.87

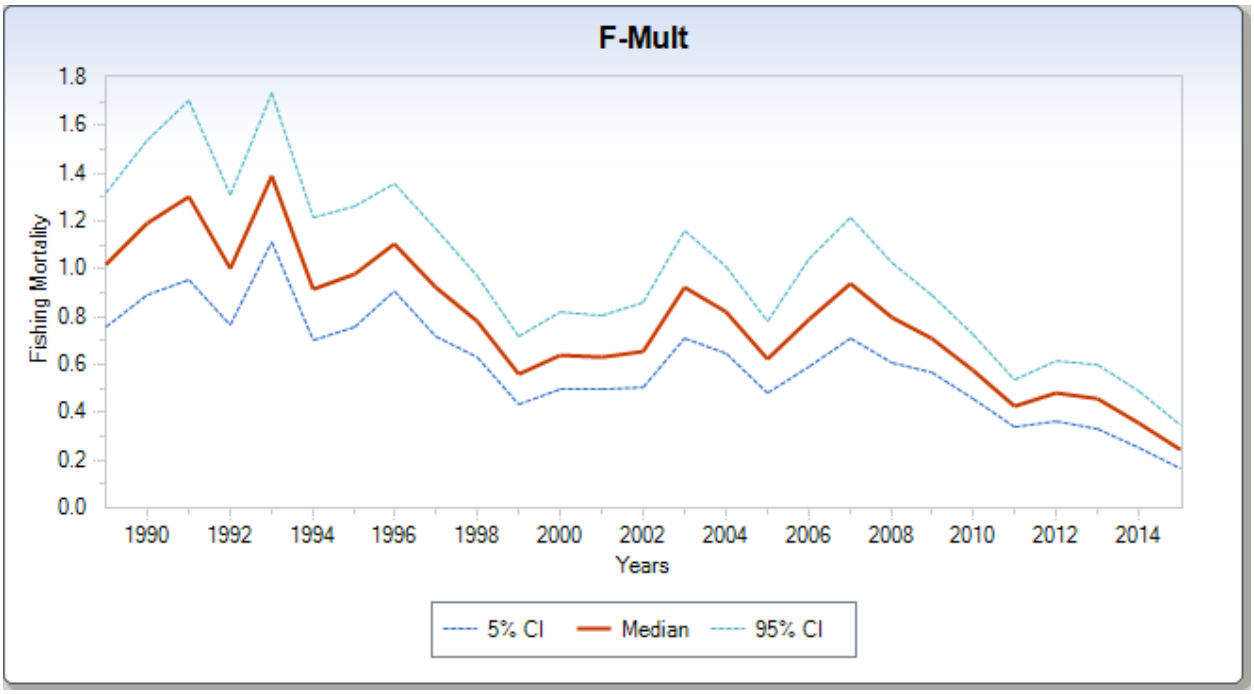


Figure A146. ASAP MCMC estimates of black sea bass F mult (± 90% CI) from **South** area model.

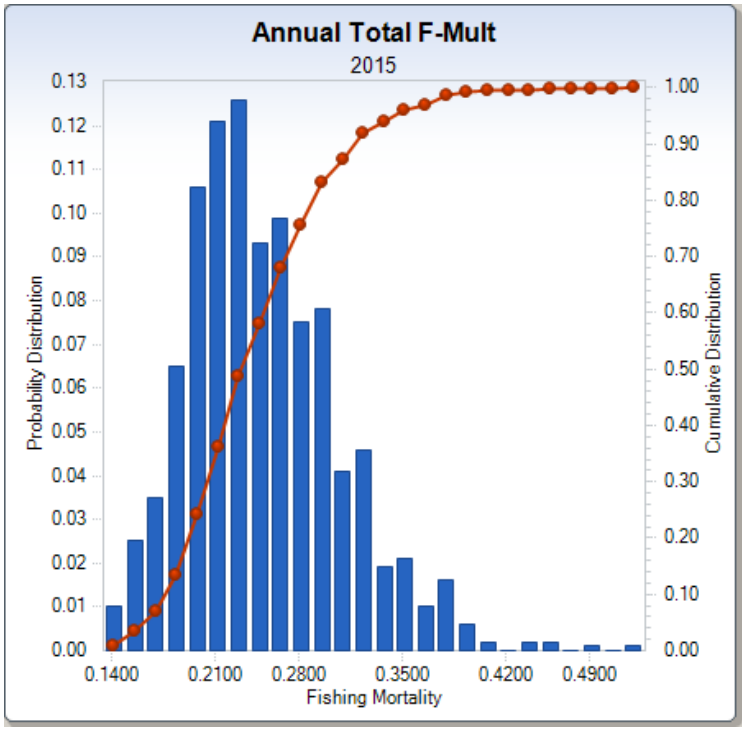


Figure A147. MCMC distribution of 2015 black sea bass F mult estimates from **South** area model.

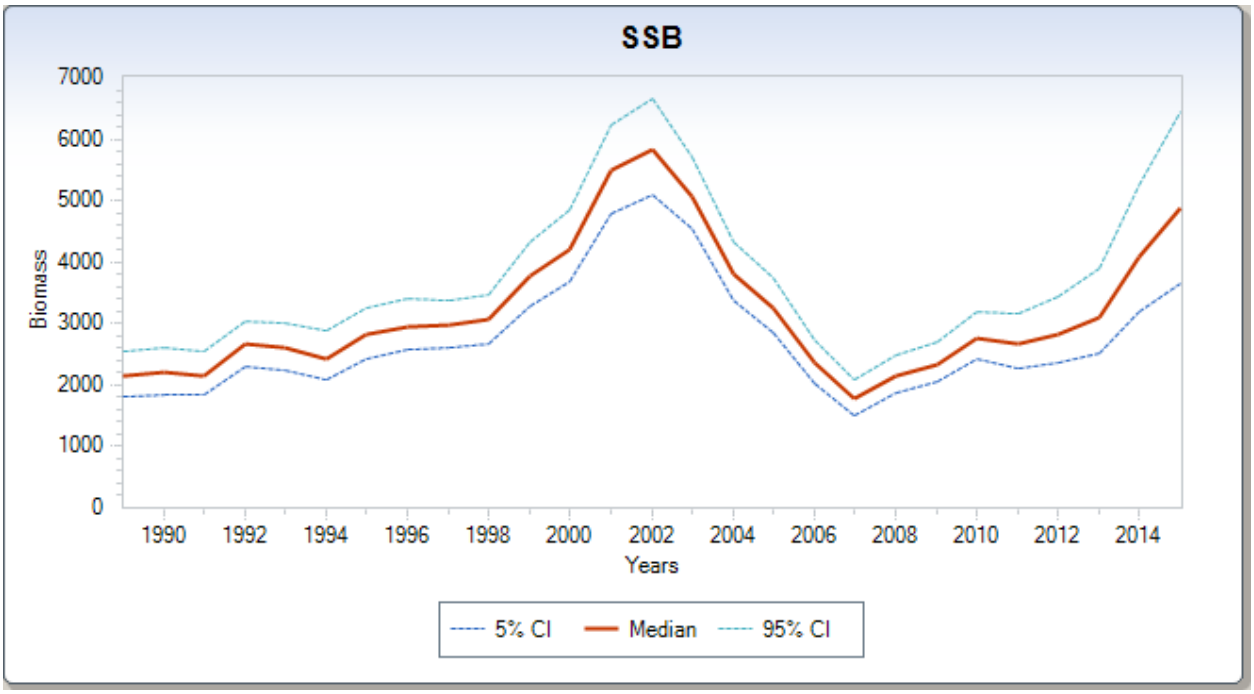


Figure A148. ASAP MCMC estimates of black sea bass spawning stock biomass (mt ± 90% CI) from **South** area model.

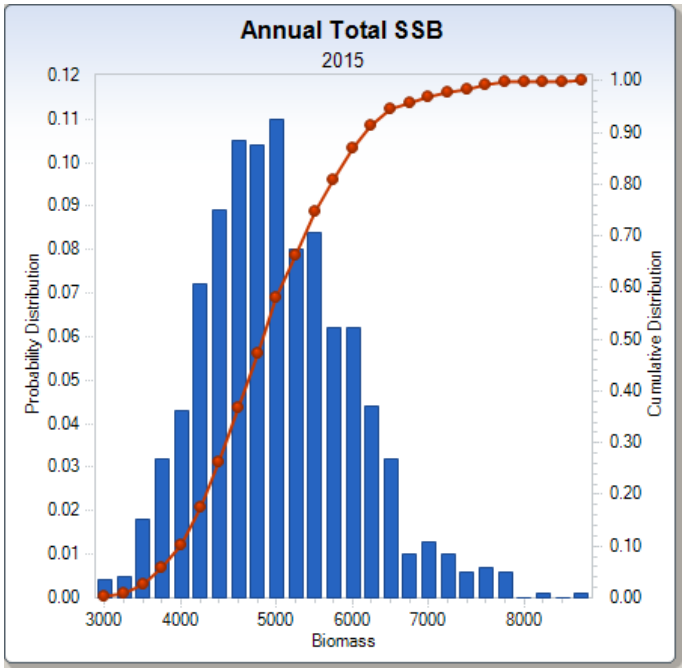


Figure A149. MCMC distribution of 2015 black sea bass spawning stock biomass (mt) estimates from **South** area model.

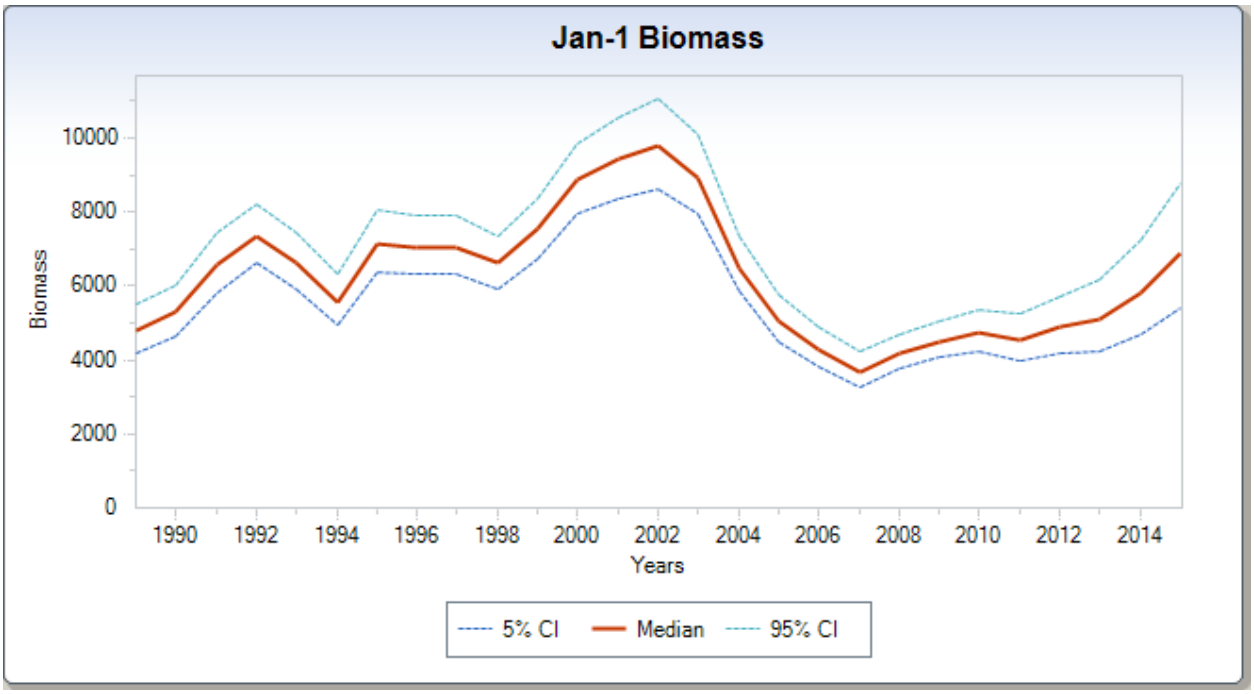


Figure A150. ASAP MCMC estimates of black sea bass total biomass (mt ± 90% CI) from **South** area model.

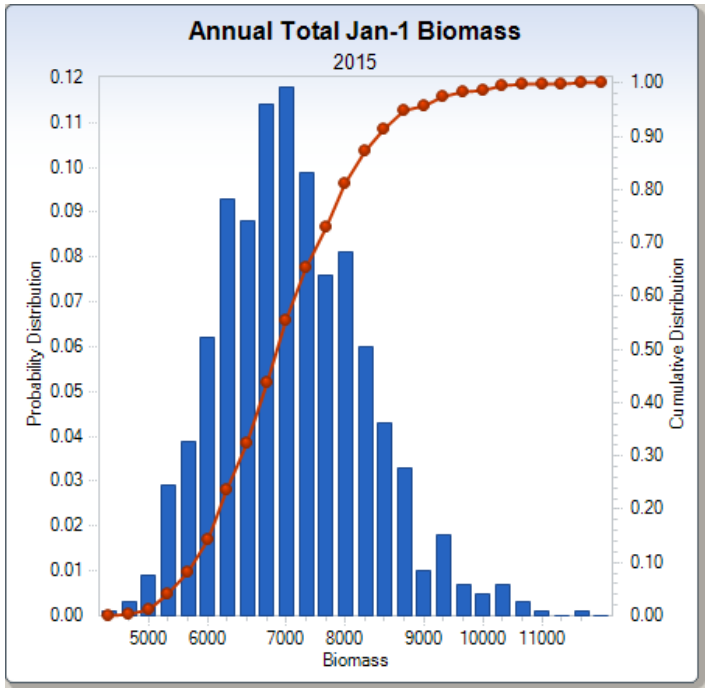


Figure A151. MCMC distribution of 2015 black sea bass total biomass (mt) estimates from **South** area model.

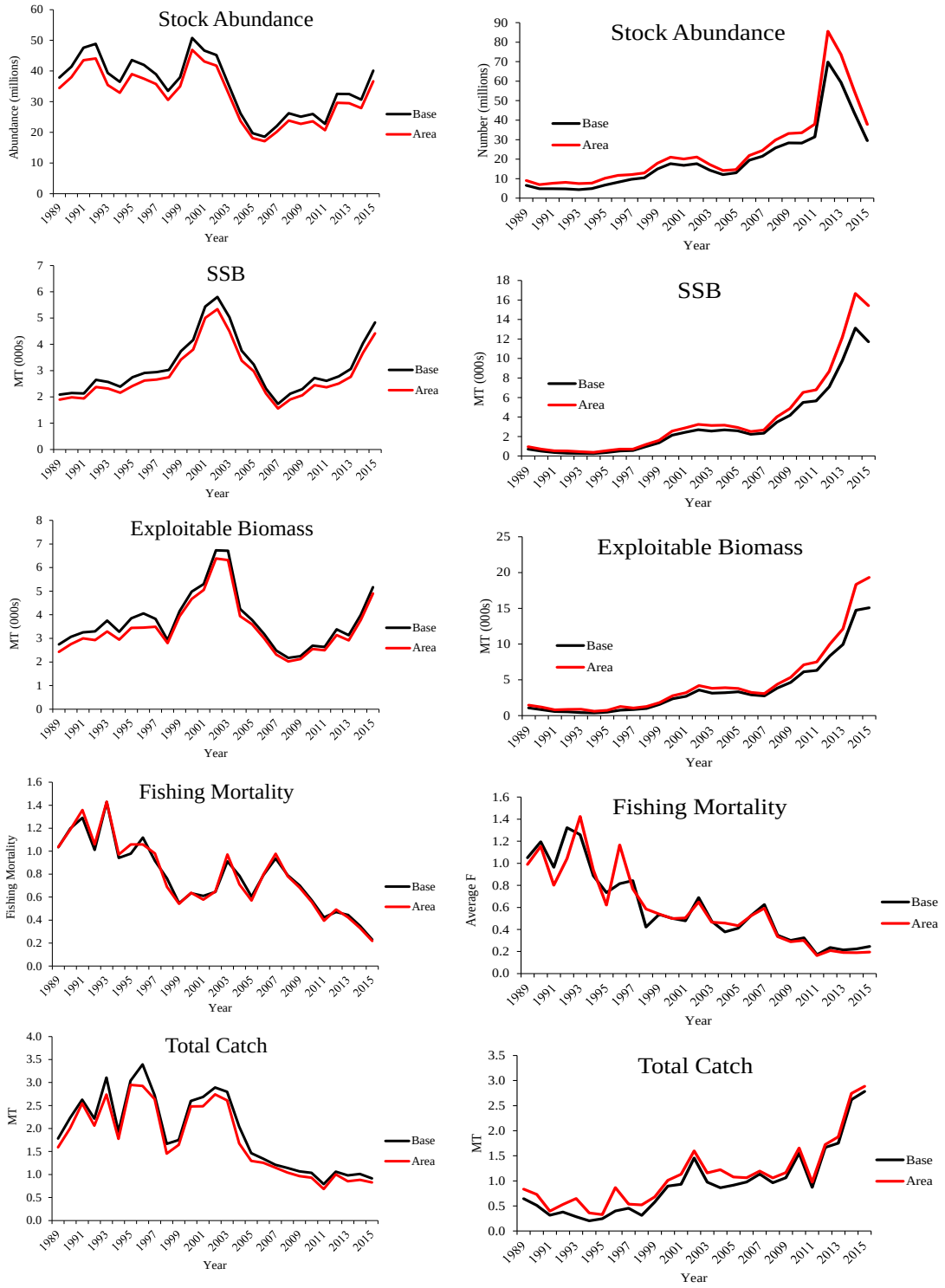


Figure A152. Comparison of black sea bass ASAP model results for base (Combined) area model and Area Exchange model, by region. Base model shown in black, area exchange model in red.

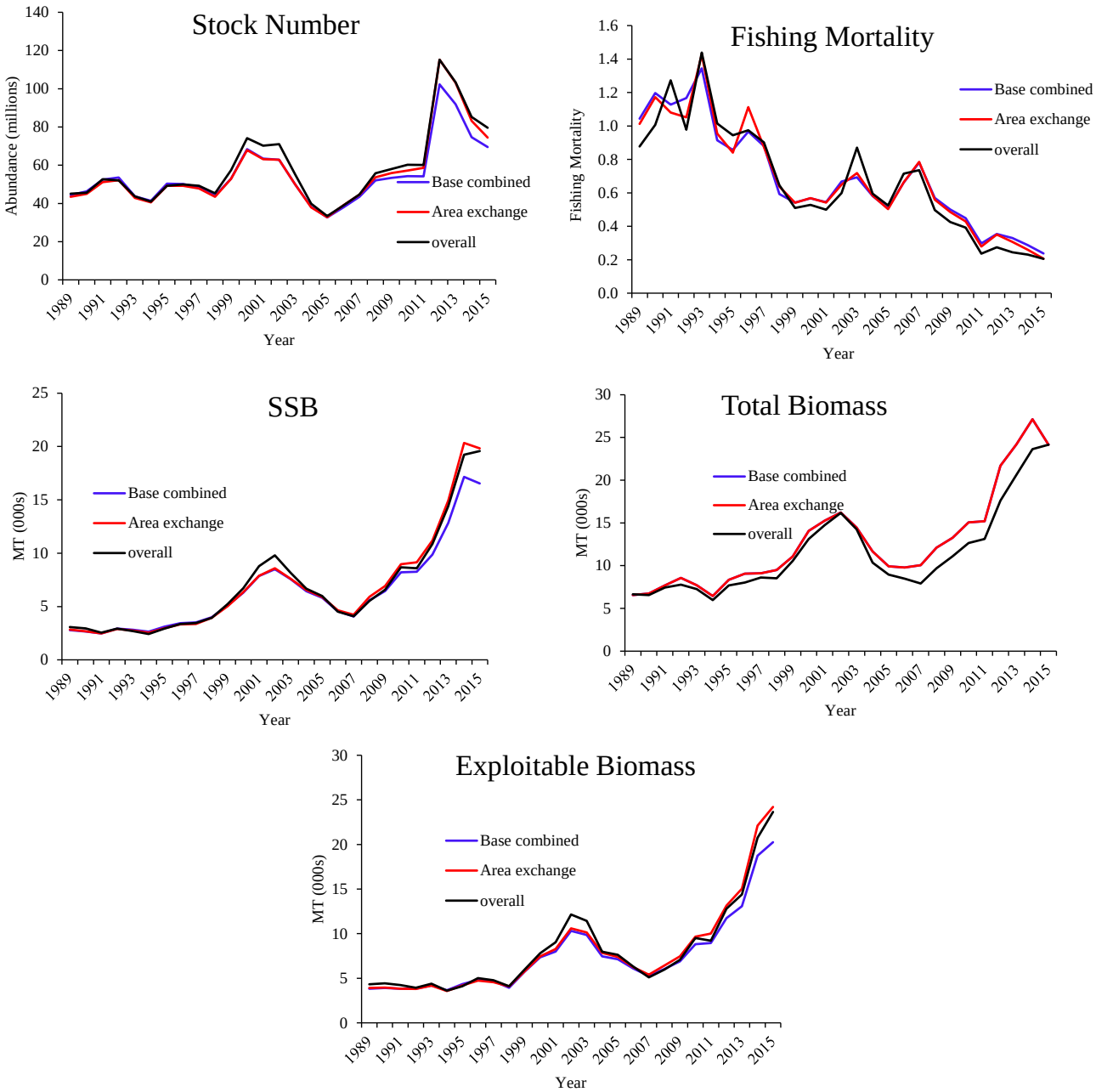


Figure A153. Comparison of black sea bass ASAP model results for Combined area model, Overall single area model and area exchange model. Base (Combined) model shown in blue, Area Exchange model in red and single Overall model in black.

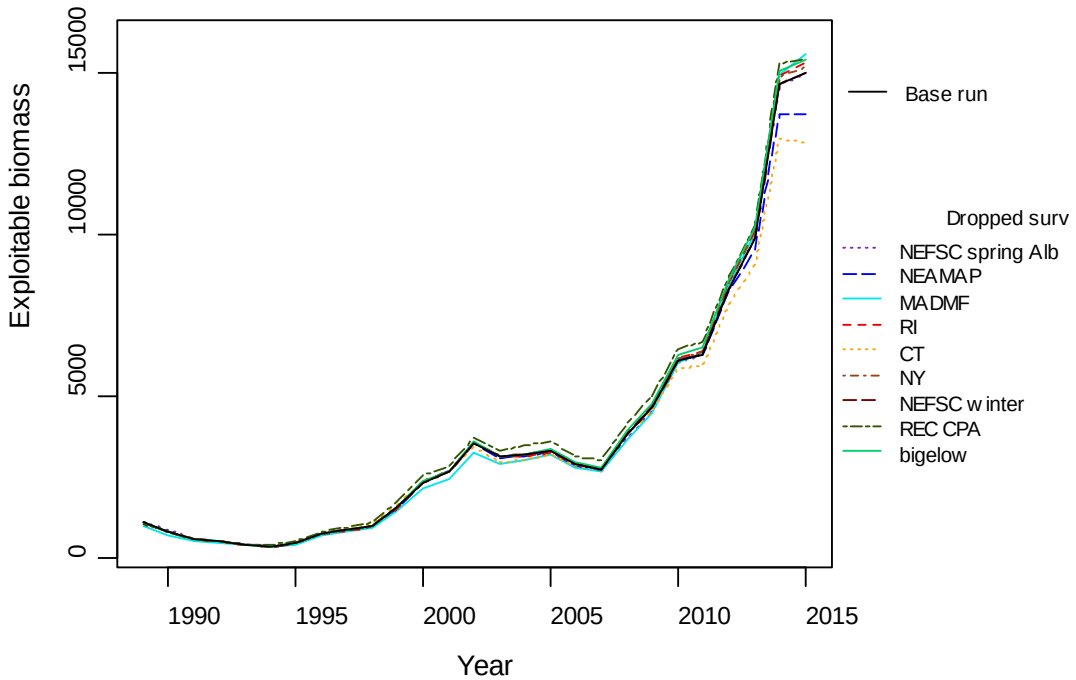


Figure A154. Exploitable biomass (mt) estimates from black sea bass ASAP **North** area model examining sensitivity to indices used in the model.

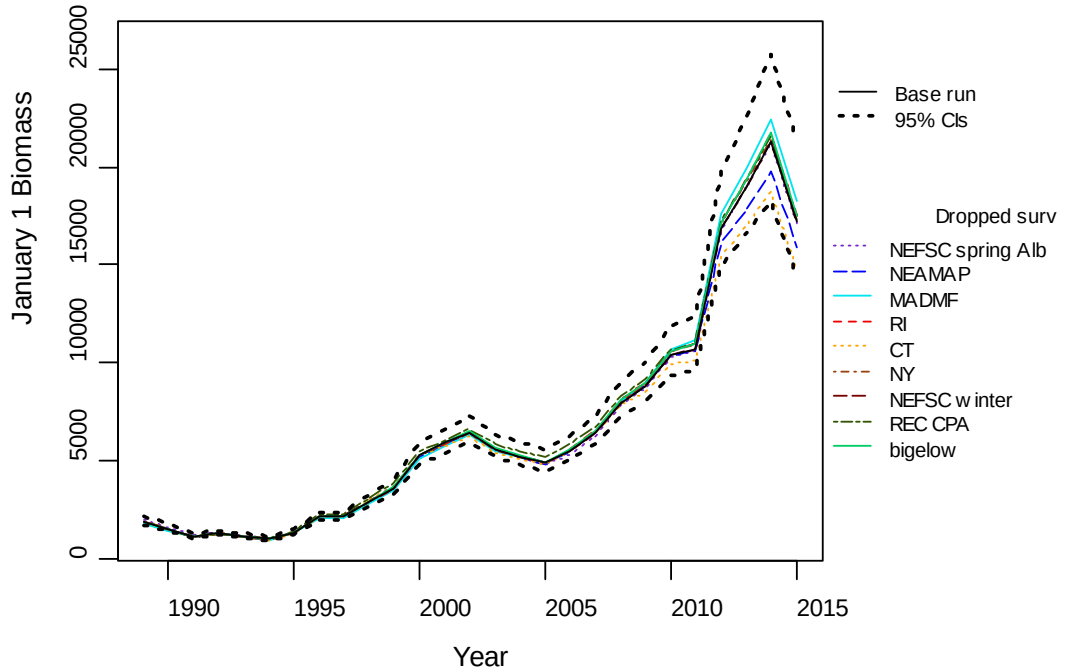


Figure A155. Total biomass (mt) estimates from black sea bass ASAP **North** area model examining sensitivity to indices used in the model.

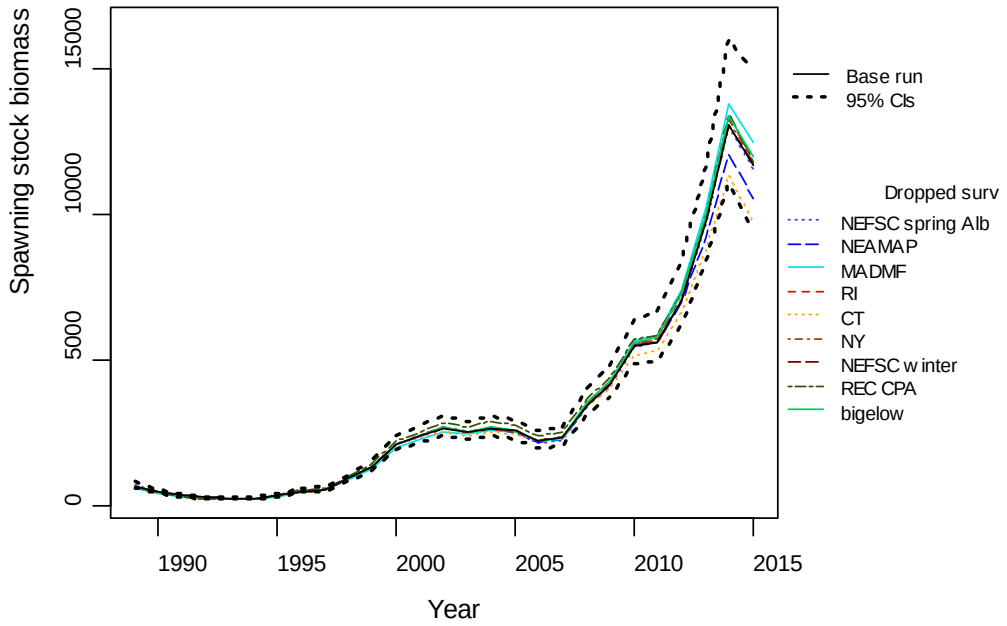


Figure A156. Spawning stock biomass (mt) estimates from black sea bass ASAP **North** area model examining sensitivity to indices used in the model.

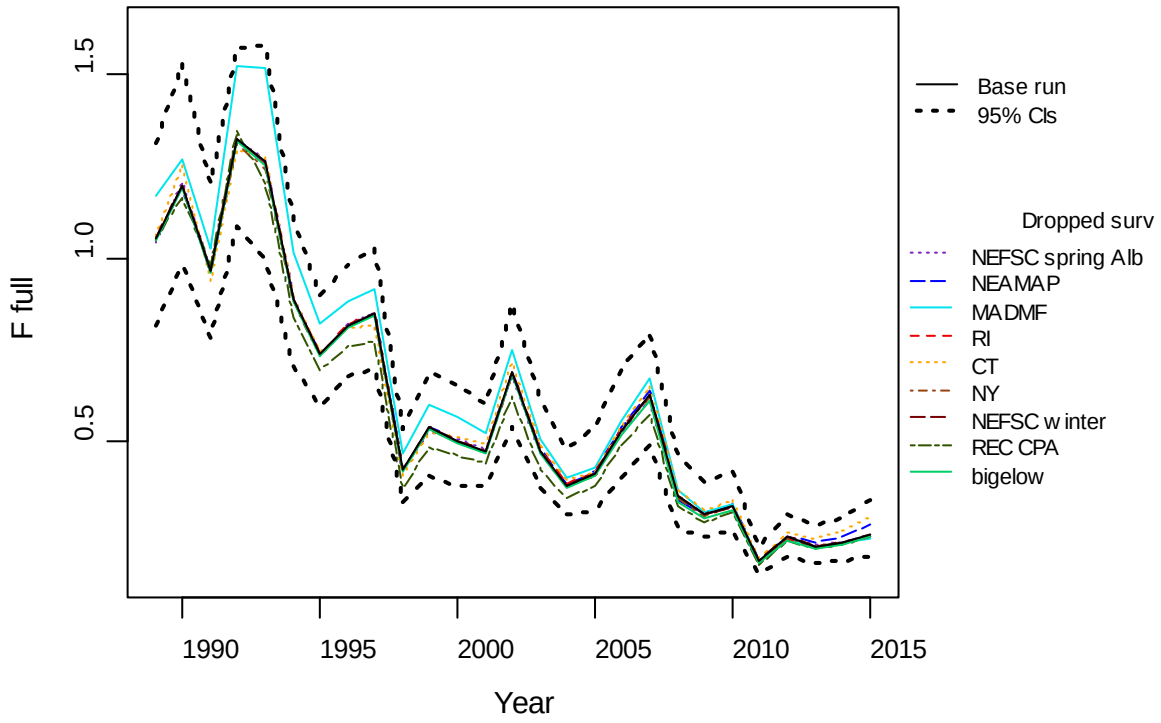


Figure A157. Fishing mortality estimates from black sea bass ASAP **North** area model examining sensitivity to indices used in the model.

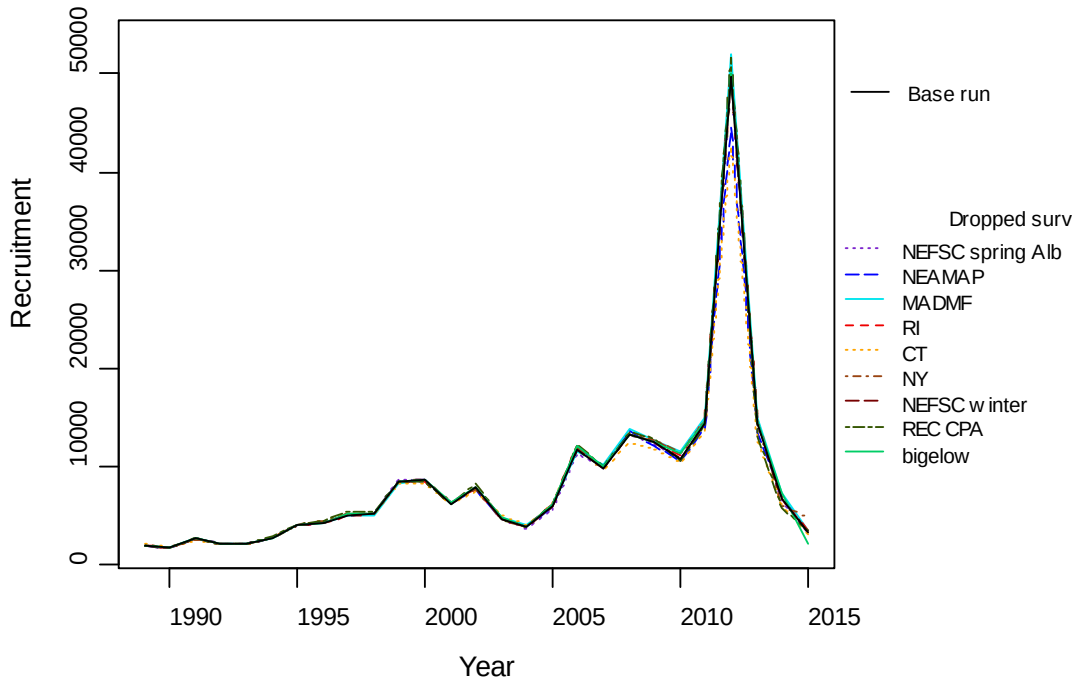


Figure A158. Recruitment (age 1) estimates from black sea bass ASAP **North** area model examining sensitivity to indices used in the model.

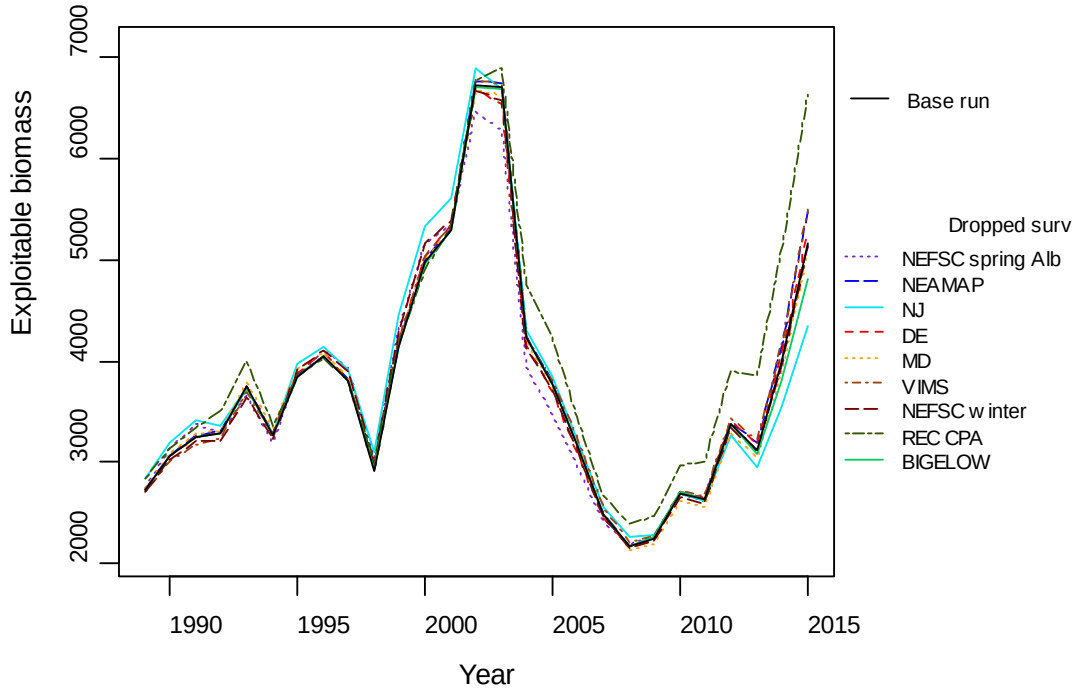


Figure A159. Exploitable biomass (mt) estimates from black sea bass ASAP **South** area model examining sensitivity to indices used in the model.

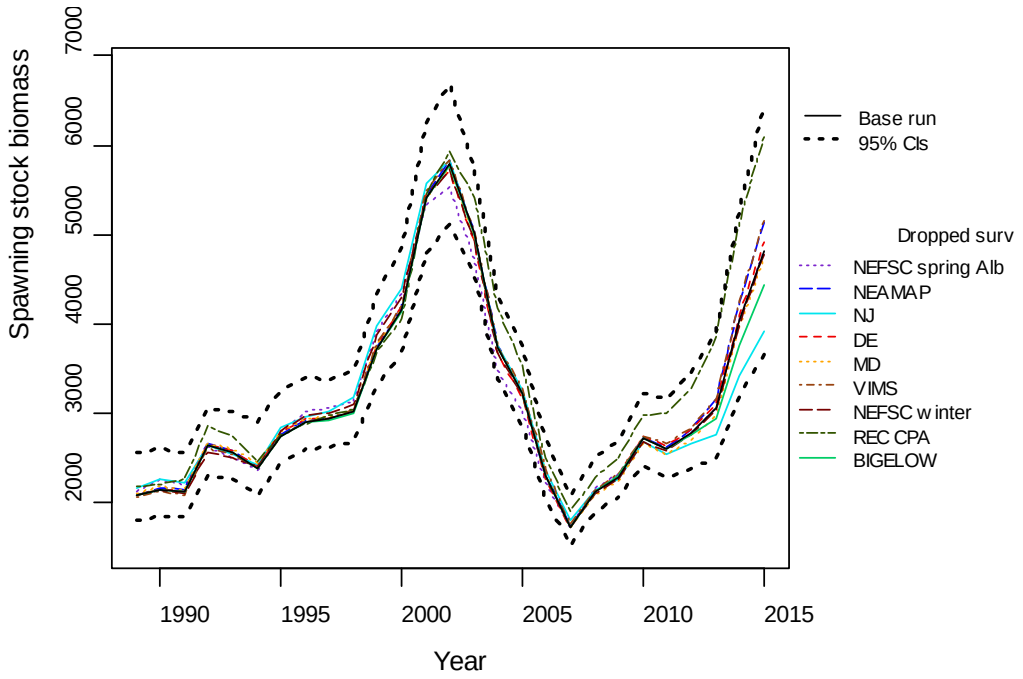


Figure A160. Spawning stock biomass (mt) estimates from black sea bass ASAP **South** area model examining sensitivity to indices used in the model.

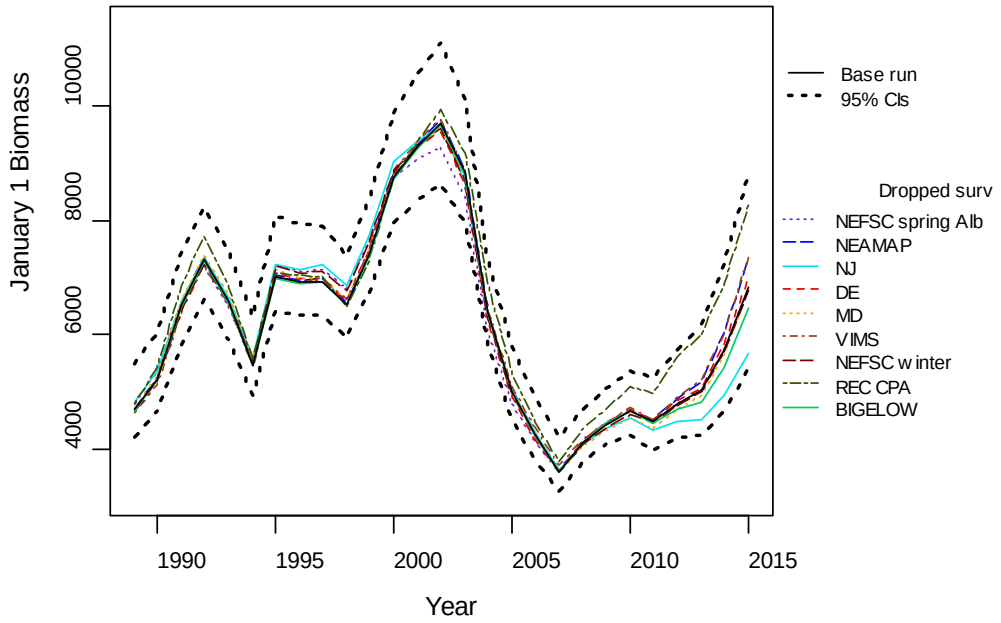


Figure A161. Total biomass (mt) estimates from black sea bass ASAP **South** area model examining sensitivity to indices used in the model.

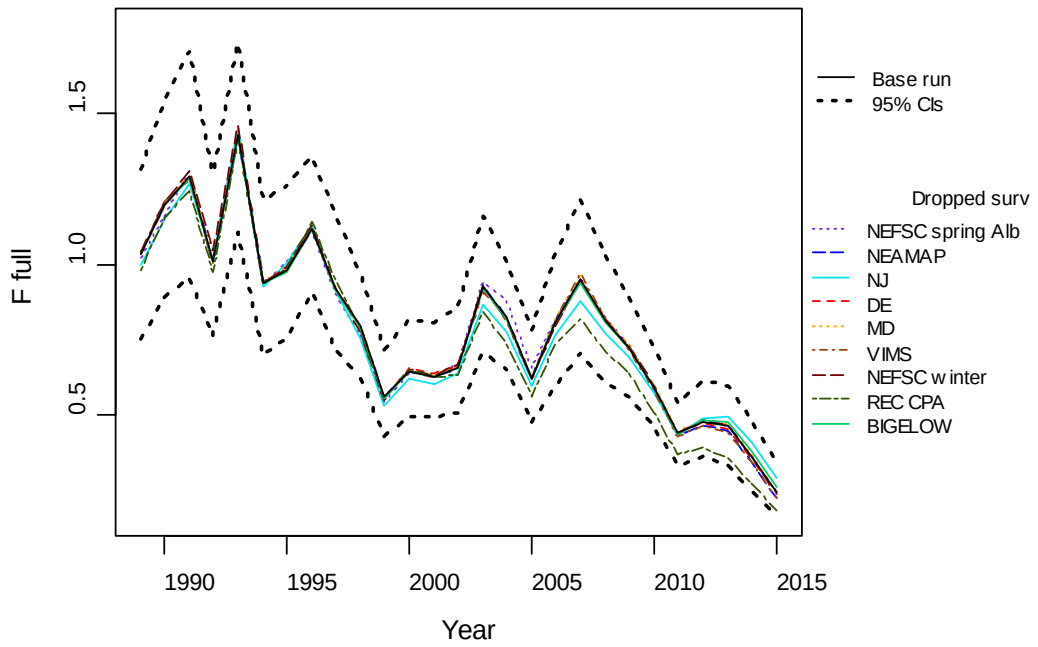


Figure A162. Fishing mortality estimates from black sea bass ASAP **South** area model examining sensitivity to indices used in the model.

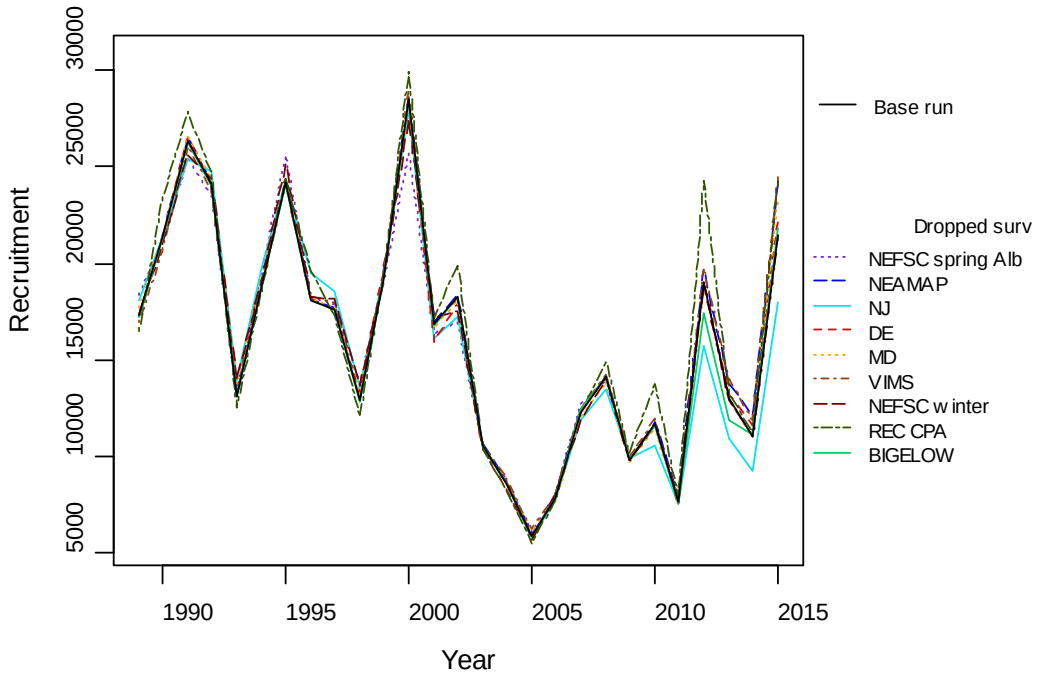


Figure A163. Recruitment (age 1) estimates from black sea bass ASAP **South** area model examining sensitivity to indices used in the model.

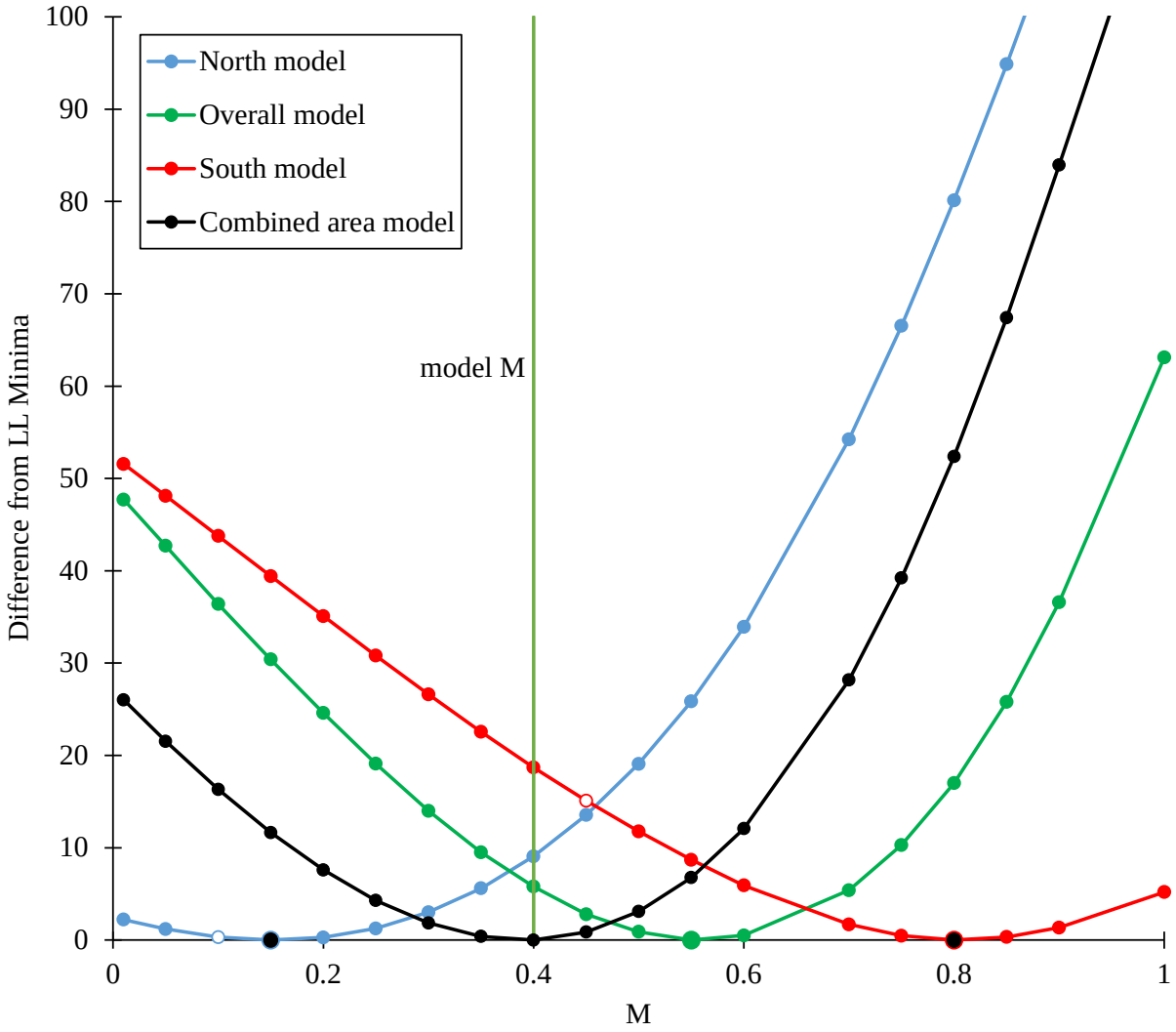


Figure A164. Likelihood profile of varying M estimates in regional black sea bass ASAP models.

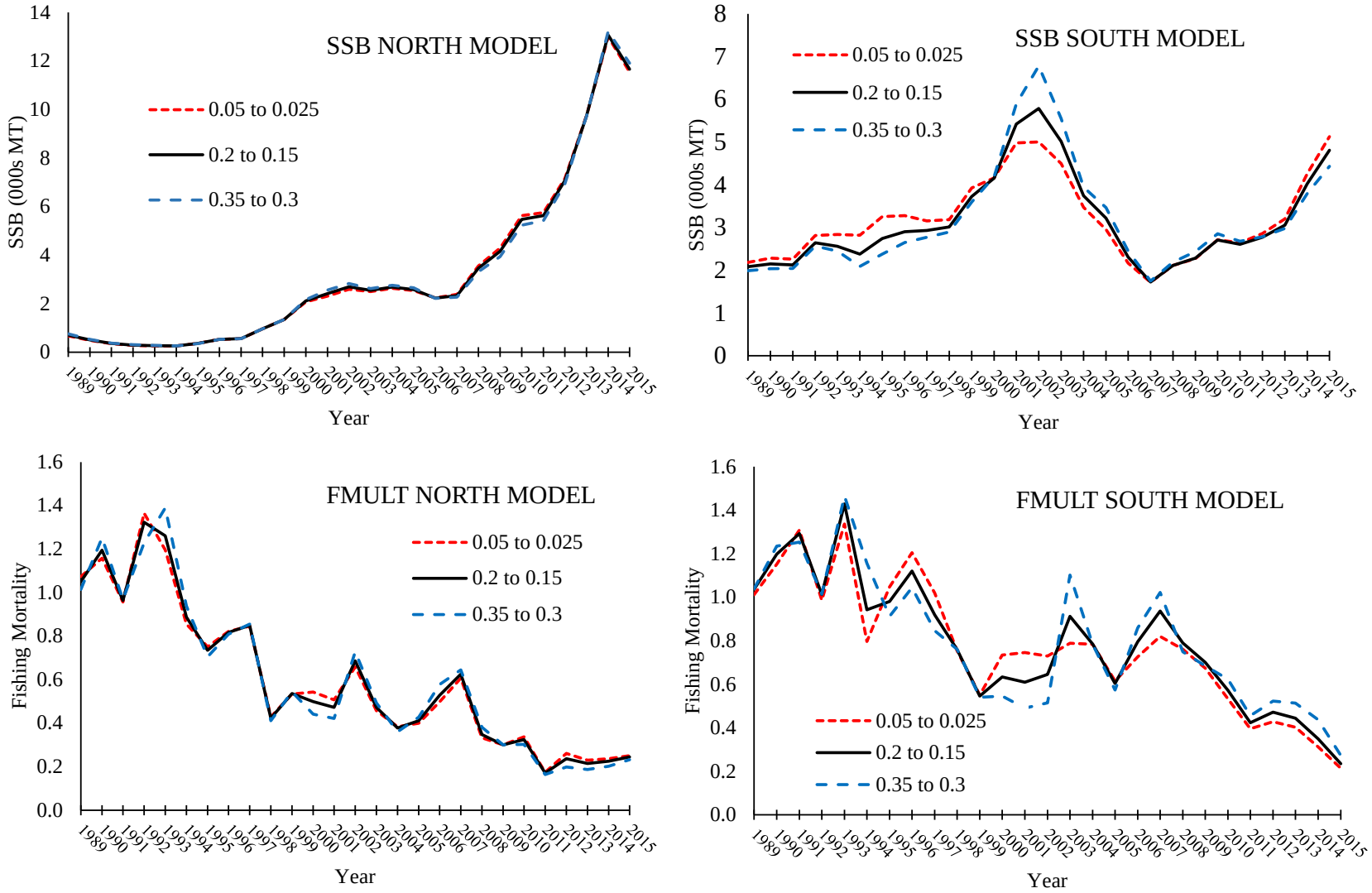


Figure A 165. Sensitivity of CV for non-trawl fleet on the resulting black sea bass spawning biomass and fishing mortality estimates.

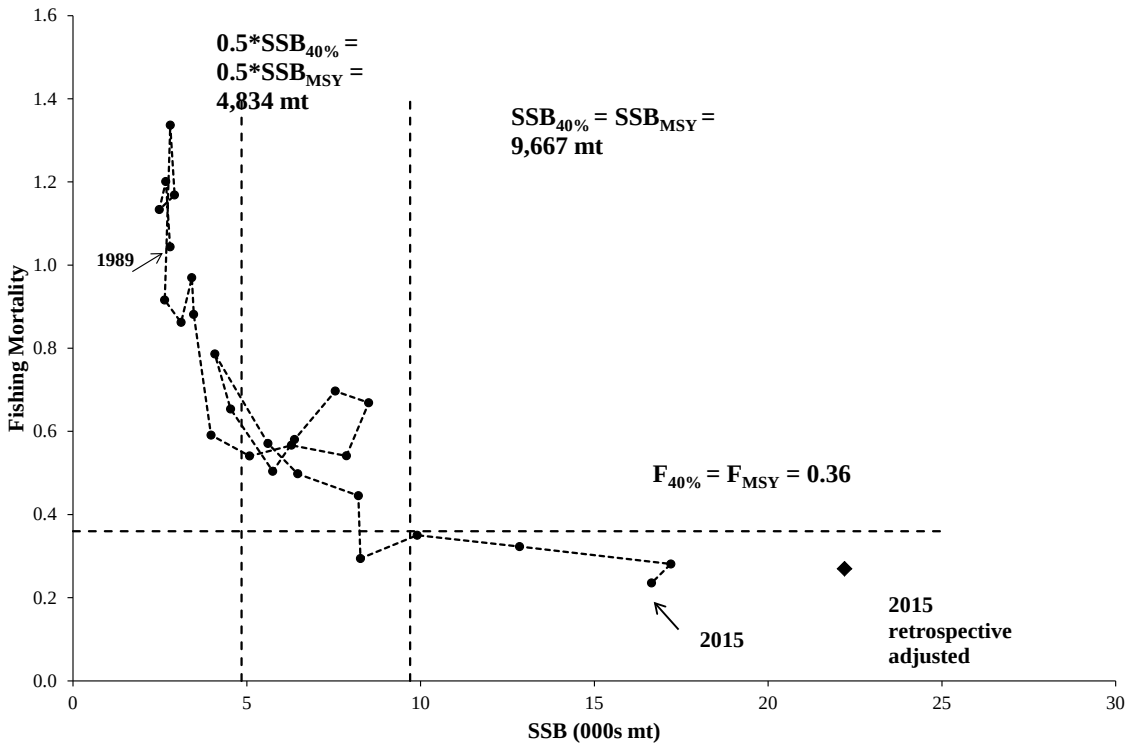


Figure A166. Time series trajectory of black sea bass SSB and F relative to biological reference points.

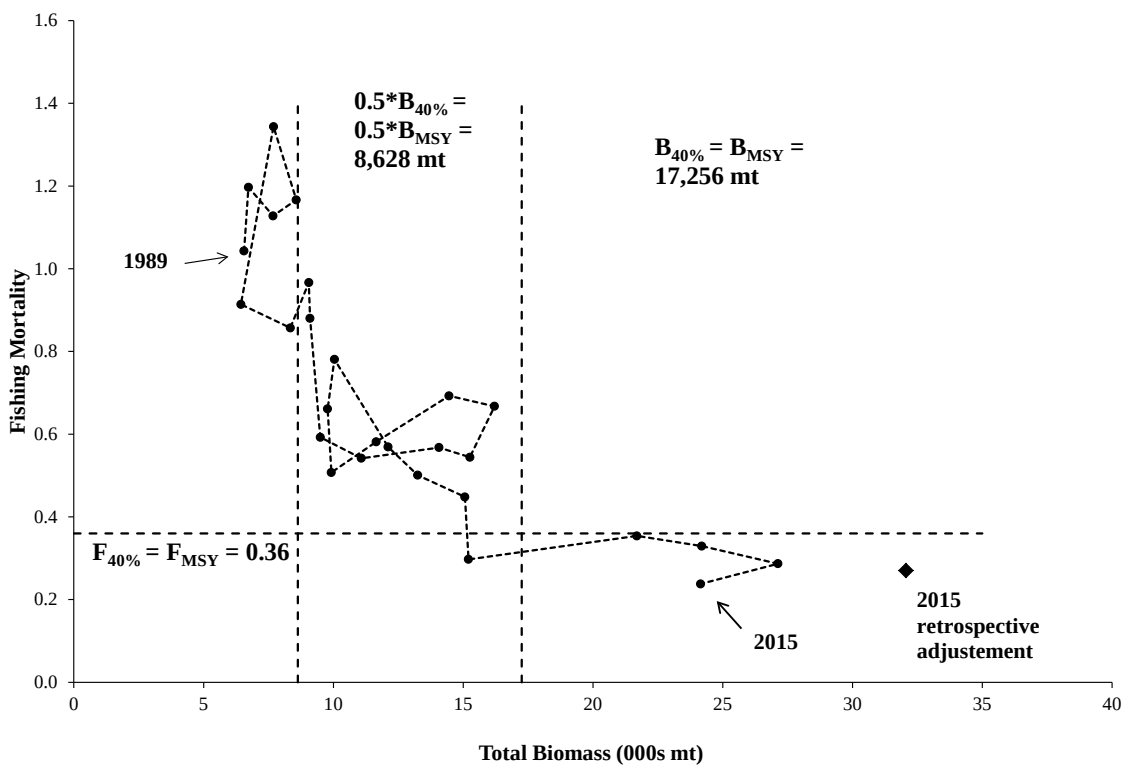


Figure A167. Time series trajectory of black sea bass total biomass and F relative to biological reference points.

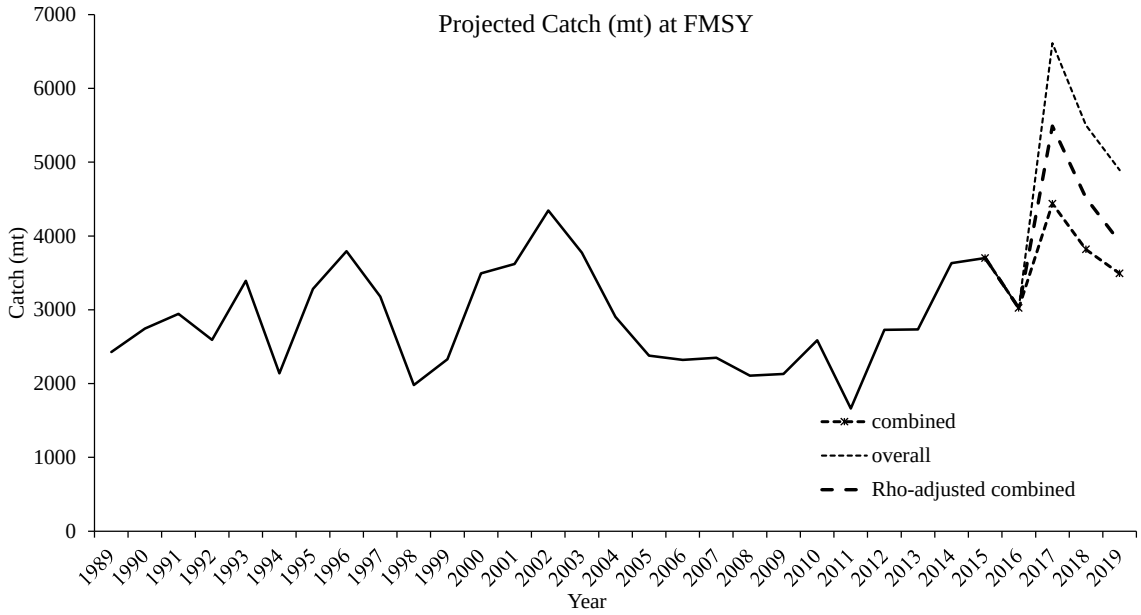


Figure A168. Time series of black sea bass total catch (mt) with 3 year projections at $F_{MSY}$. Projected catch based on the Overall single area model, the Combined area model and the Combined area model adjusted for retrospective patterns in each area.

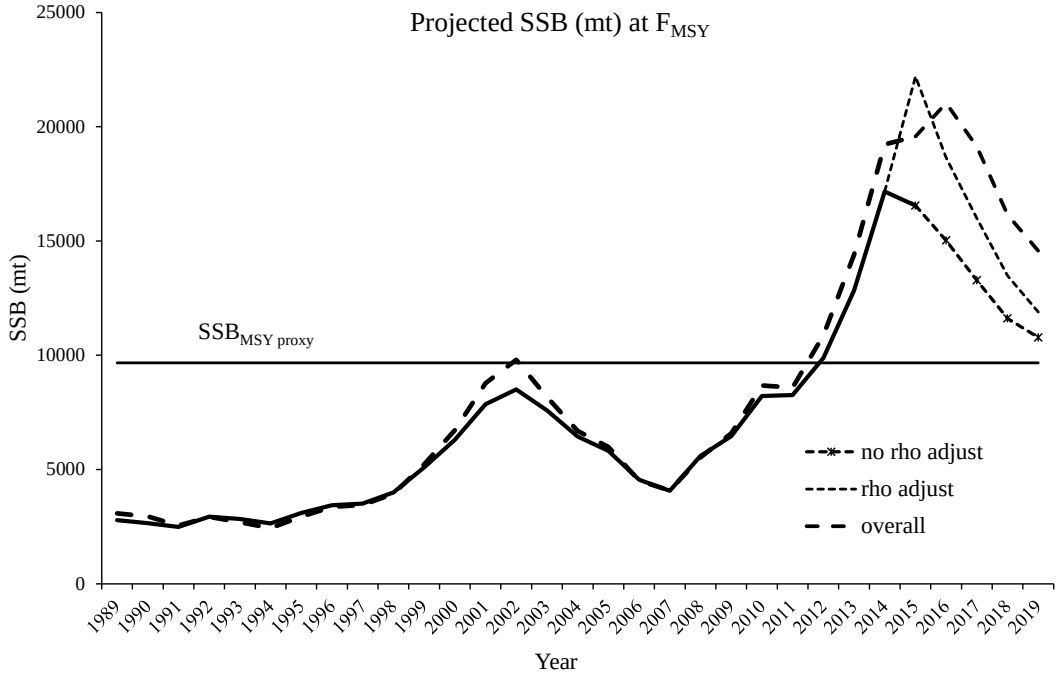


Figure A169. Time series of black sea bass SSB (mt) with 3 year projections at $F_{MSY}$. Projected SSB based on the Overall single area model, the Combined area model and the Combined area model adjusted for retrospective patterns in each area. $SSB_{MSYproxy}$ reference point shown.

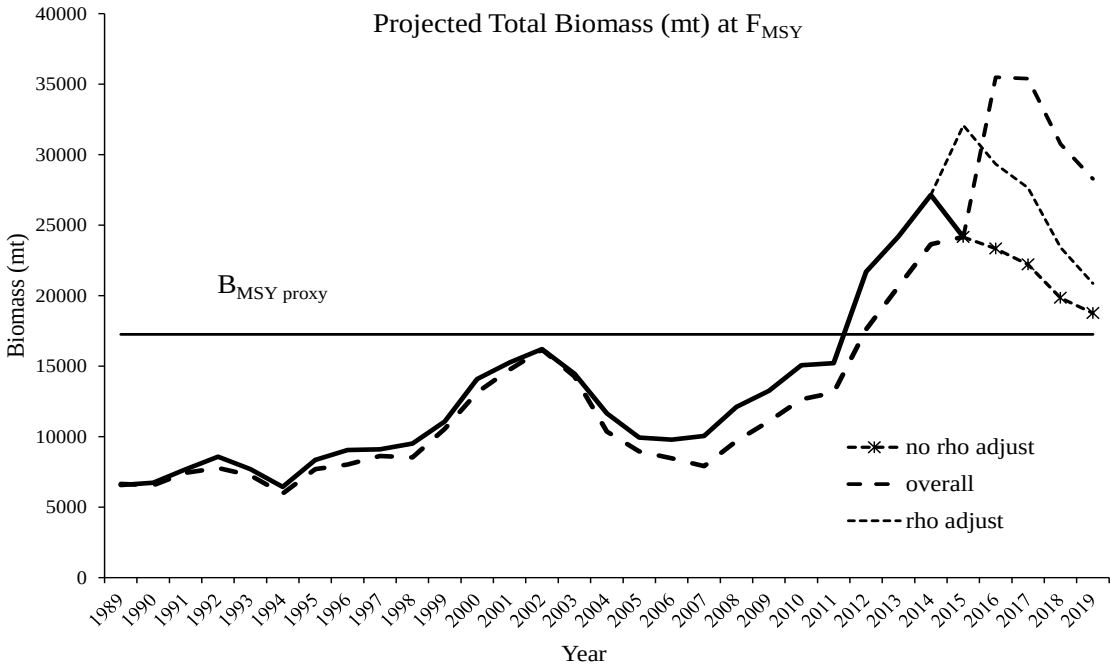


Figure A170. Time series of black sea bass Total Biomass (mt) with 3 year projections at $F_{MSY}$. Projected Biomass based on the Overall single area model, the Combined area model and the Combined area model adjusted for retrospective patterns in each area. $B_{MSYproxy}$ reference point shown.

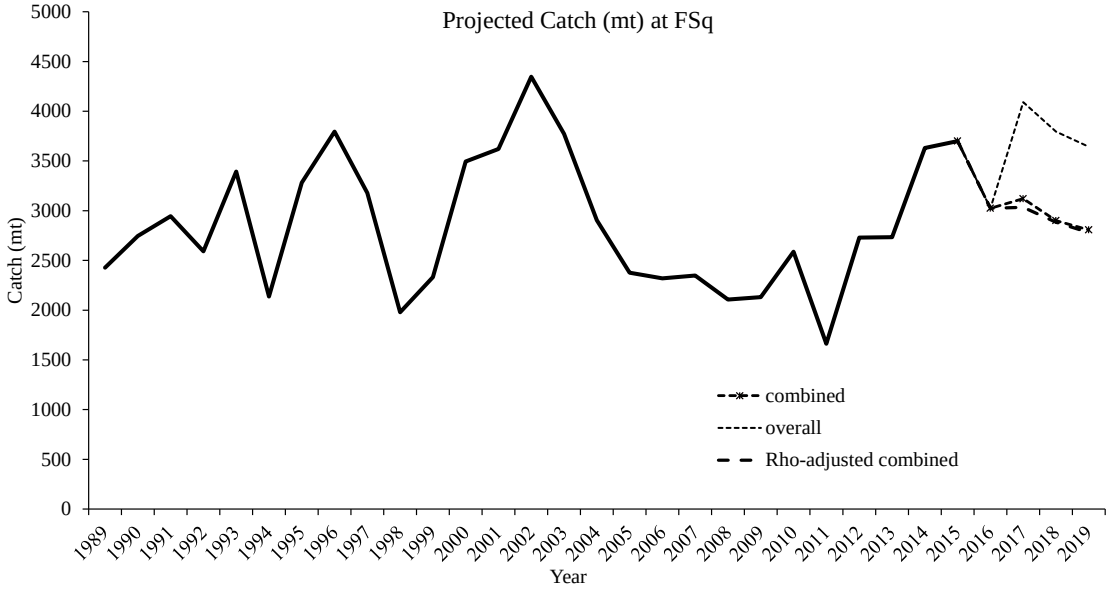


Figure A171. Time series of black sea bass total catch (mt) with 3 year projections at $F_{SQ}$. Projected catch based on the Overall single area model, the Combined area model and the Combined area model adjusted for retrospective patterns in each area.

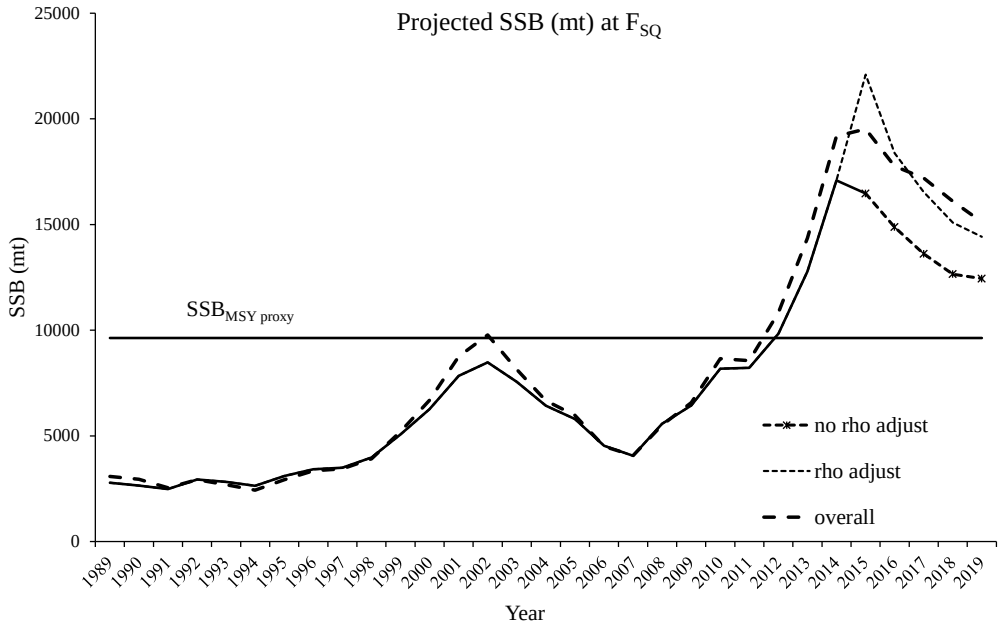


Figure A172. Time series of black sea bass SSB (mt) with 3 year projections at $F_{SQ}$. Projected SSB based on the Overall single area model, the Combined area model and the Combined area model adjusted for retrospective patterns in each area. $SSB_{MSYproxy}$ reference point shown.

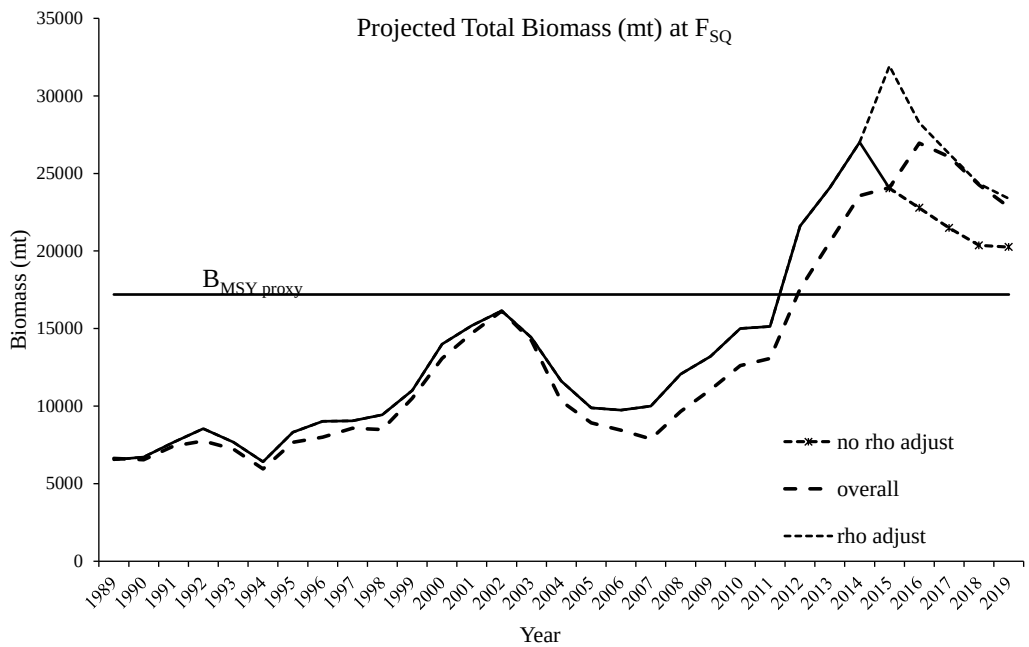


Figure A173. Time series of black sea bass Total Biomass (mt) with 3 year projections at $F_{SQ}$. Projected Biomass based on the Overall single area model, the Combined area model and the Combined area model adjusted for retrospective patterns in each area. $B_{MSYproxy}$ reference point shown.