Figures

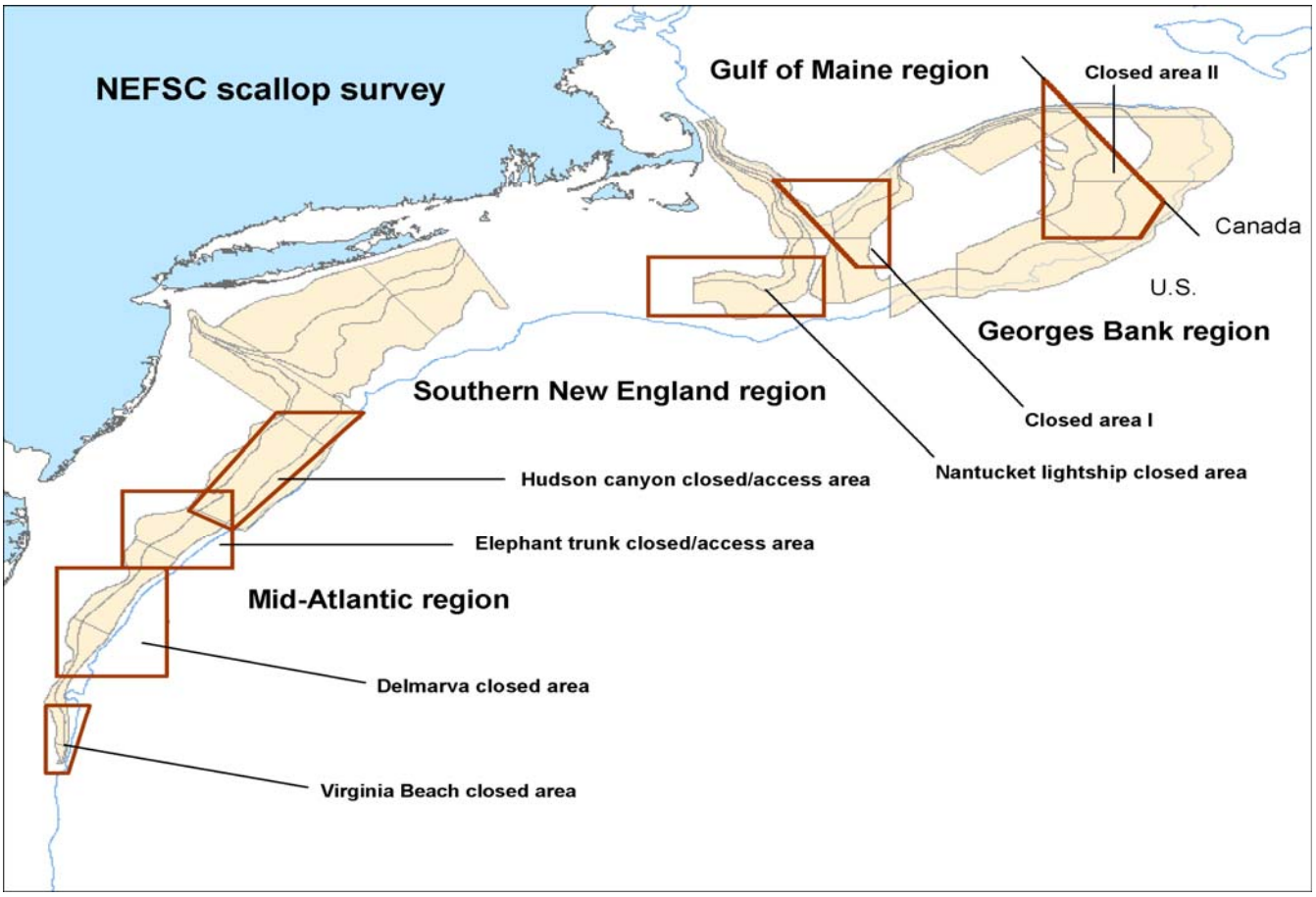
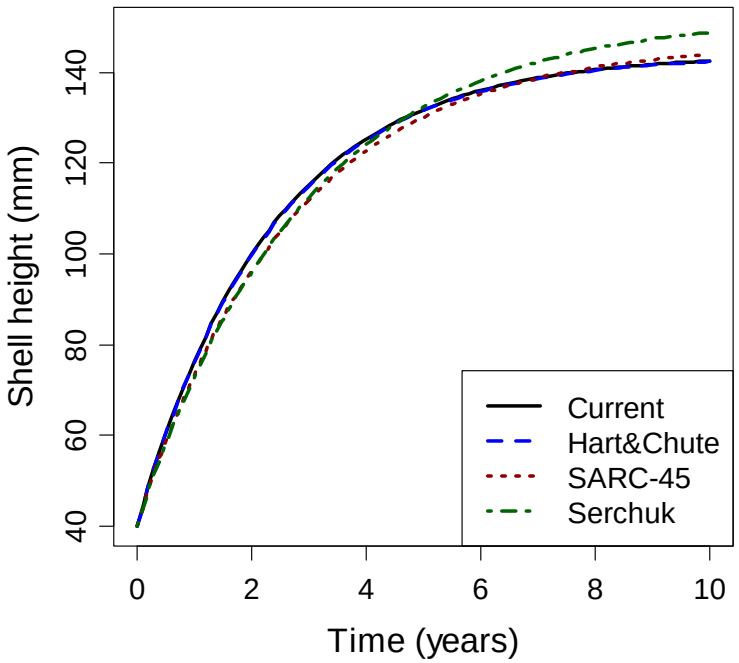


Figure B-1. Map of NEFSC sea scallop survey areas (yellow, with stratum boundaries shown) and the closed or rotational access areas (bounded by dark red lines).

(a)



(b)

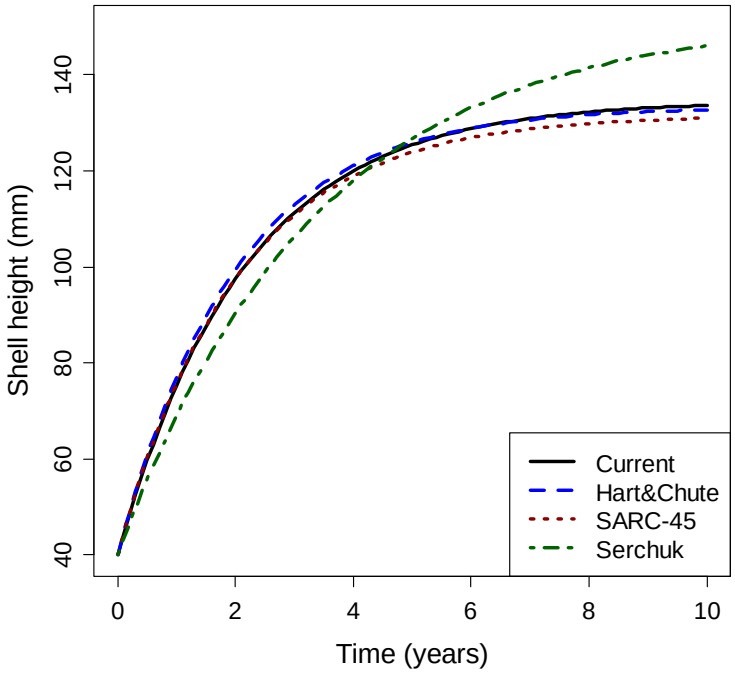
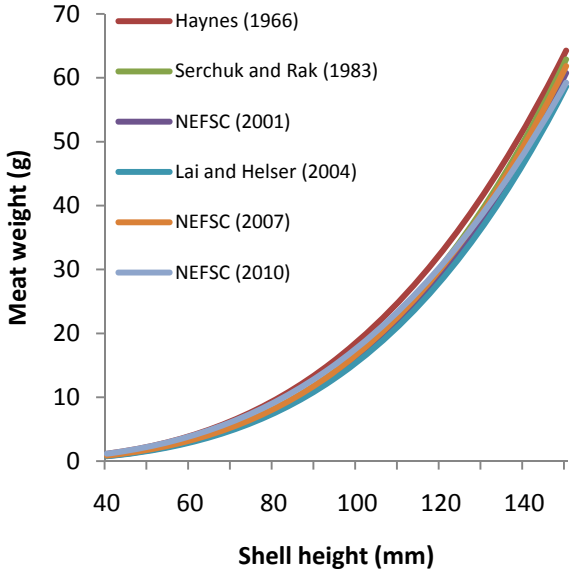


Figure B-2. Comparison of growth curves for a scallop with starting shell height of 40 mm in (a) Georges Bank and (b) Mid-Atlantic.

(a)



(b)

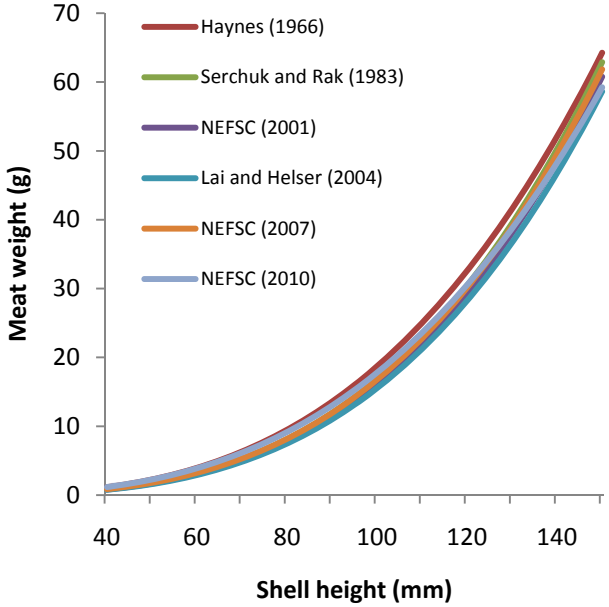
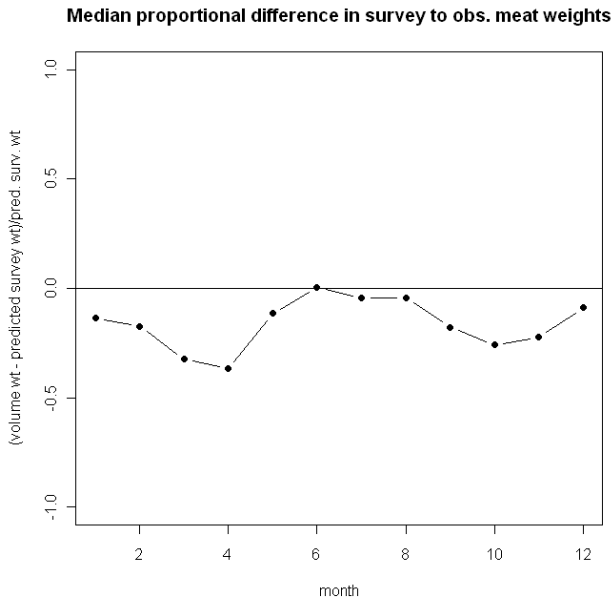


Figure B-3. Comparison of new shell height/meat weight relationships (calculated ignoring depth effects) for (a) Georges Bank and (b) Mid-Atlantic with other shell height/meat weight curves.

(a)



(b)

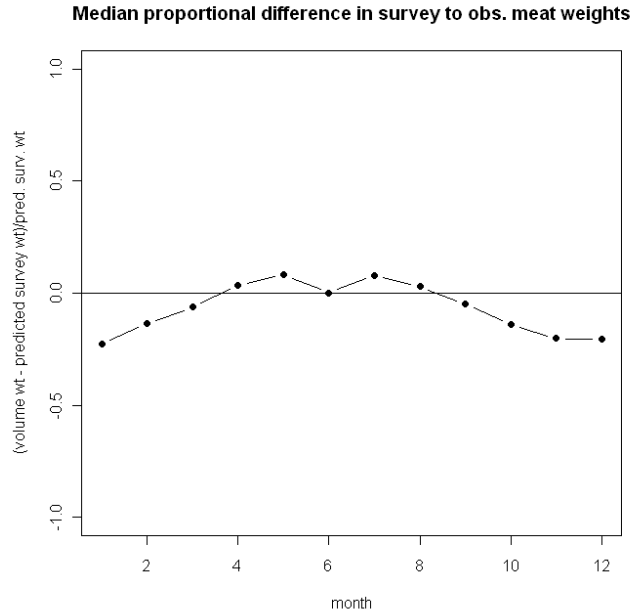


Figure B-4. Seasonal anomalies in shell height/meat weight relationships relative to that estimated from R/V data for (a) Georges Bank and (b) Mid-Atlantic Bight.

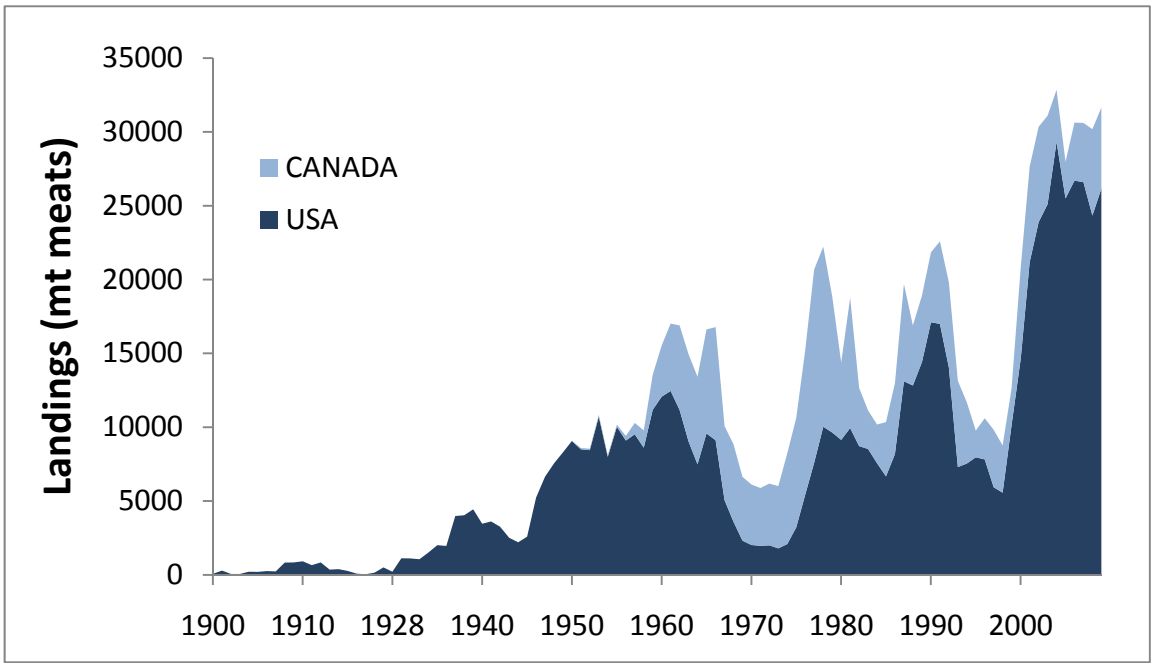


Figure B-5. Long-term sea scallop landings in NAFO areas 5 and 6 (U.S. and Canadian Georges Bank).

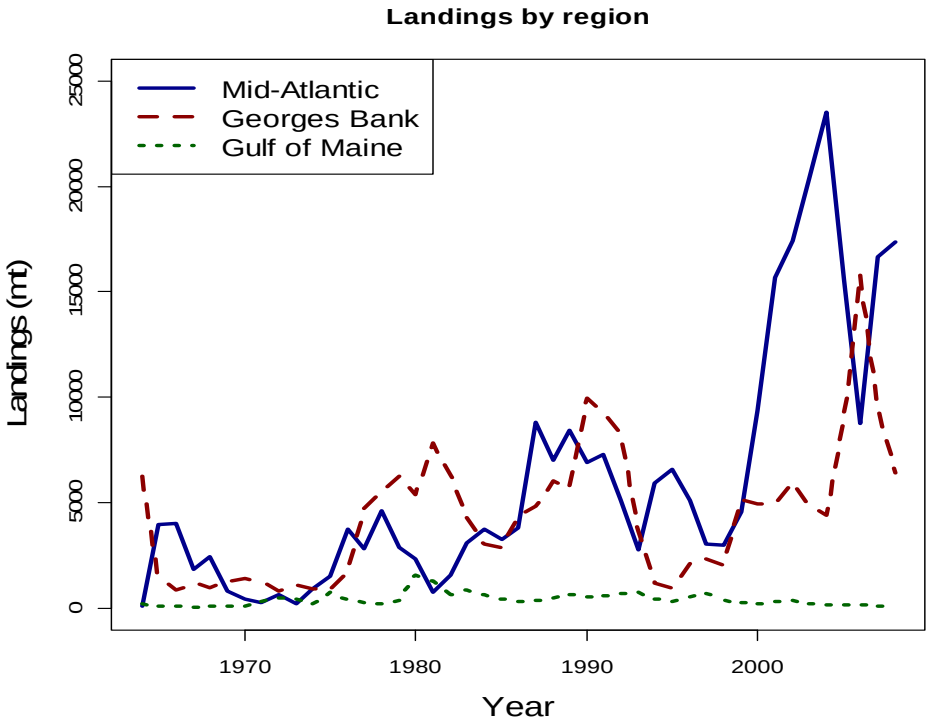
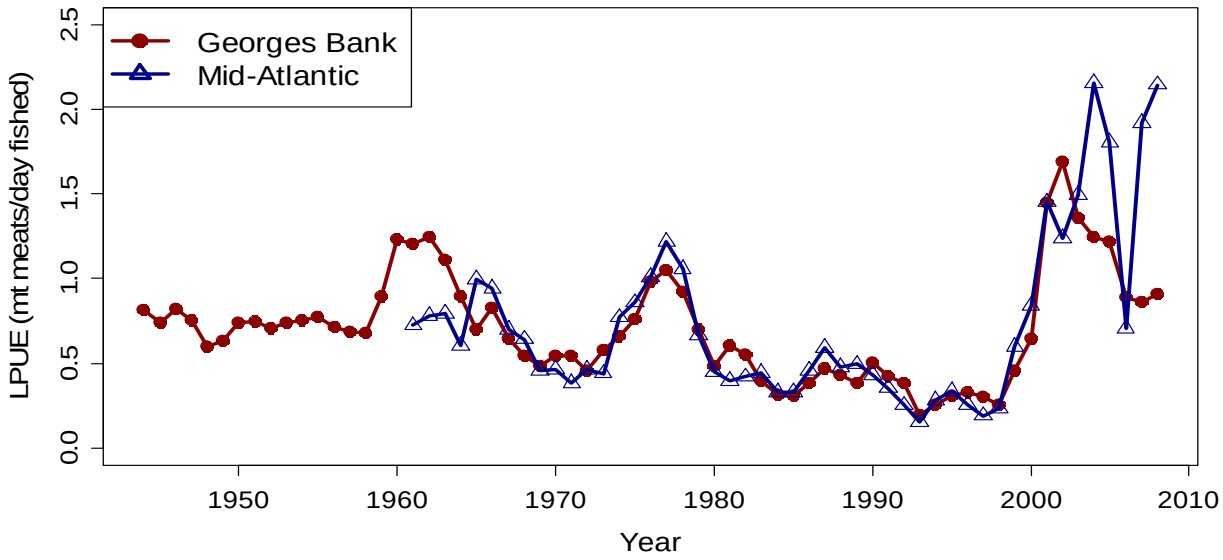


Figure B-6. U.S. sea scallop landings (mt meats) by region.

(a)



(b)

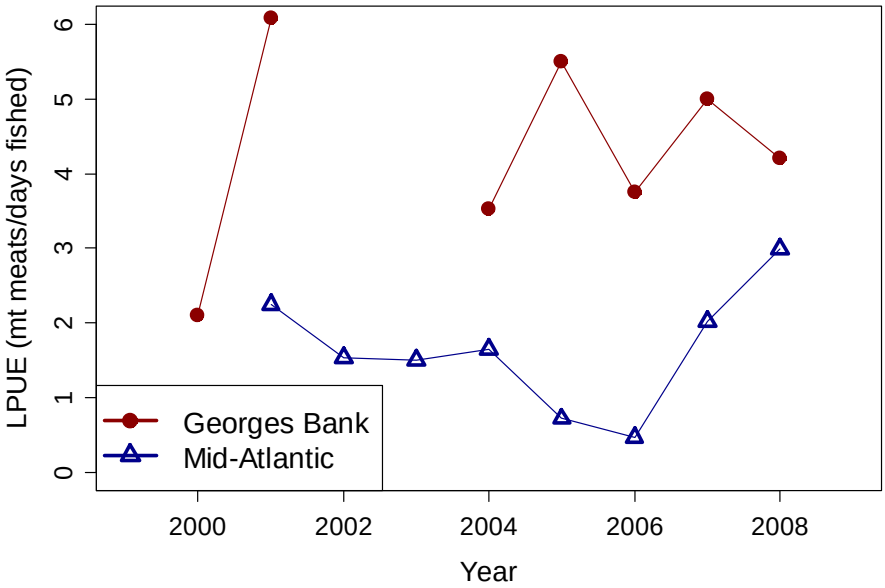
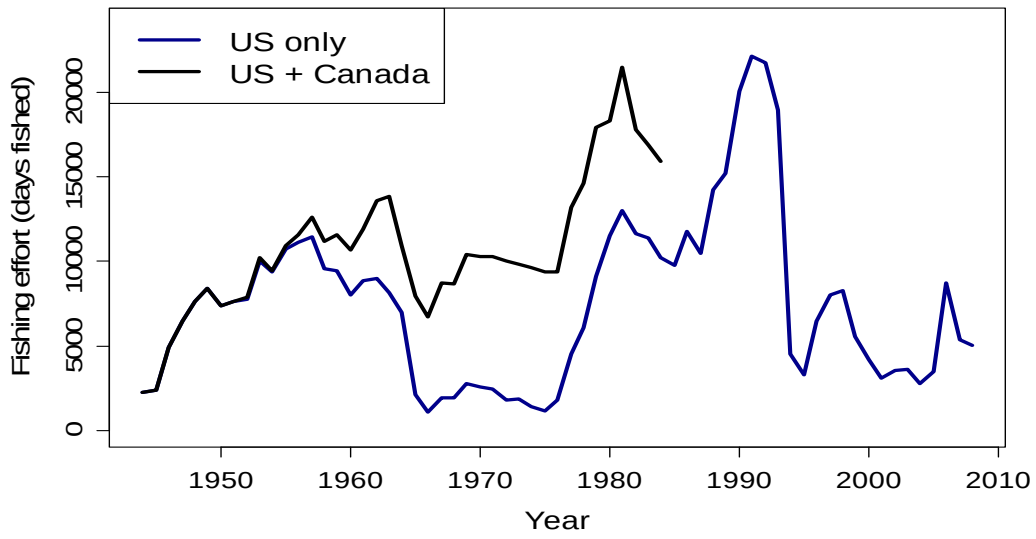


Figure B-7. Landings per day fished in (a) “open” areas, and (b) special access areas.

(a)



(b)

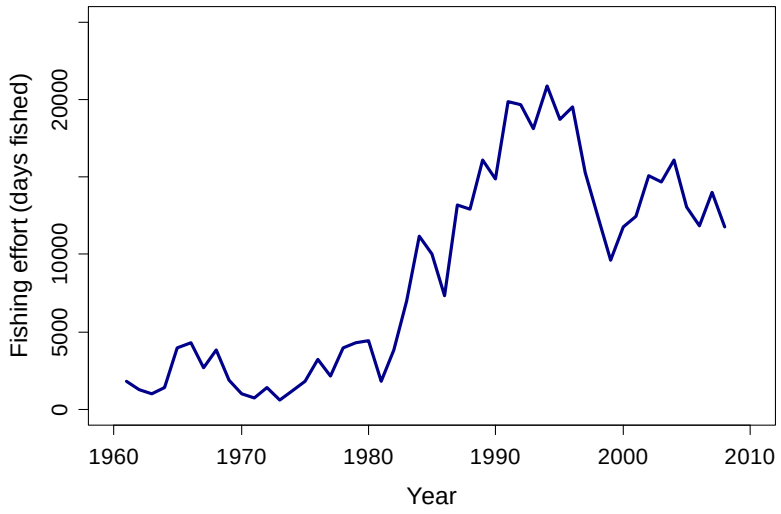


Figure B-8. Days fished in the sea scallop fishery in (a) Georges Bank and (b) Mid-Atlantic

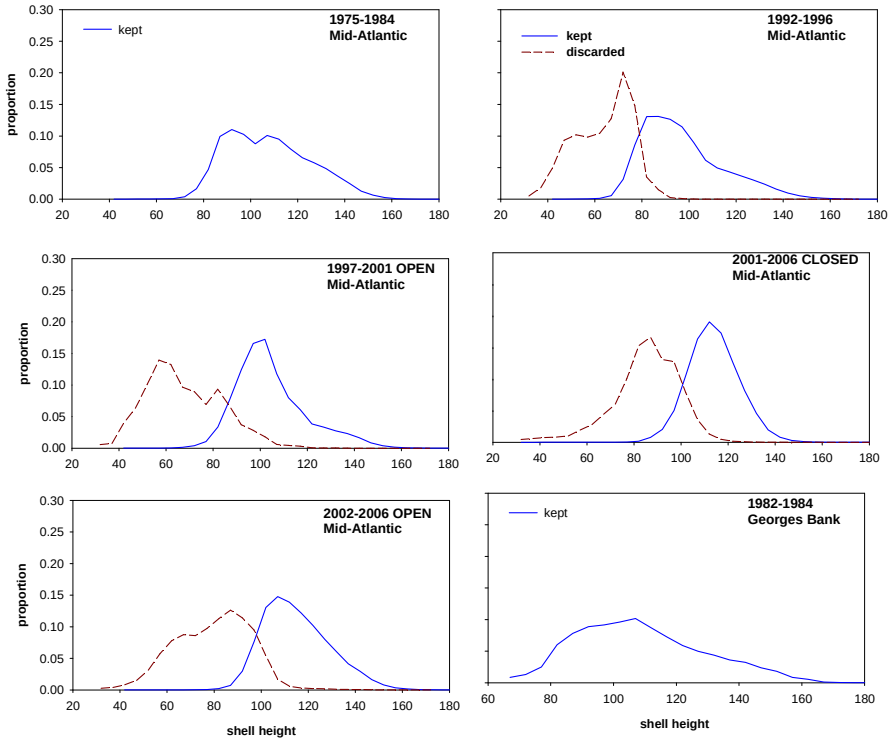


Figure B-9. Shell heights of commercial kept (solid line) and discarded (dashed line) sea scallops, from port sampling (1975-1984) and sea sampling (1992-2009).

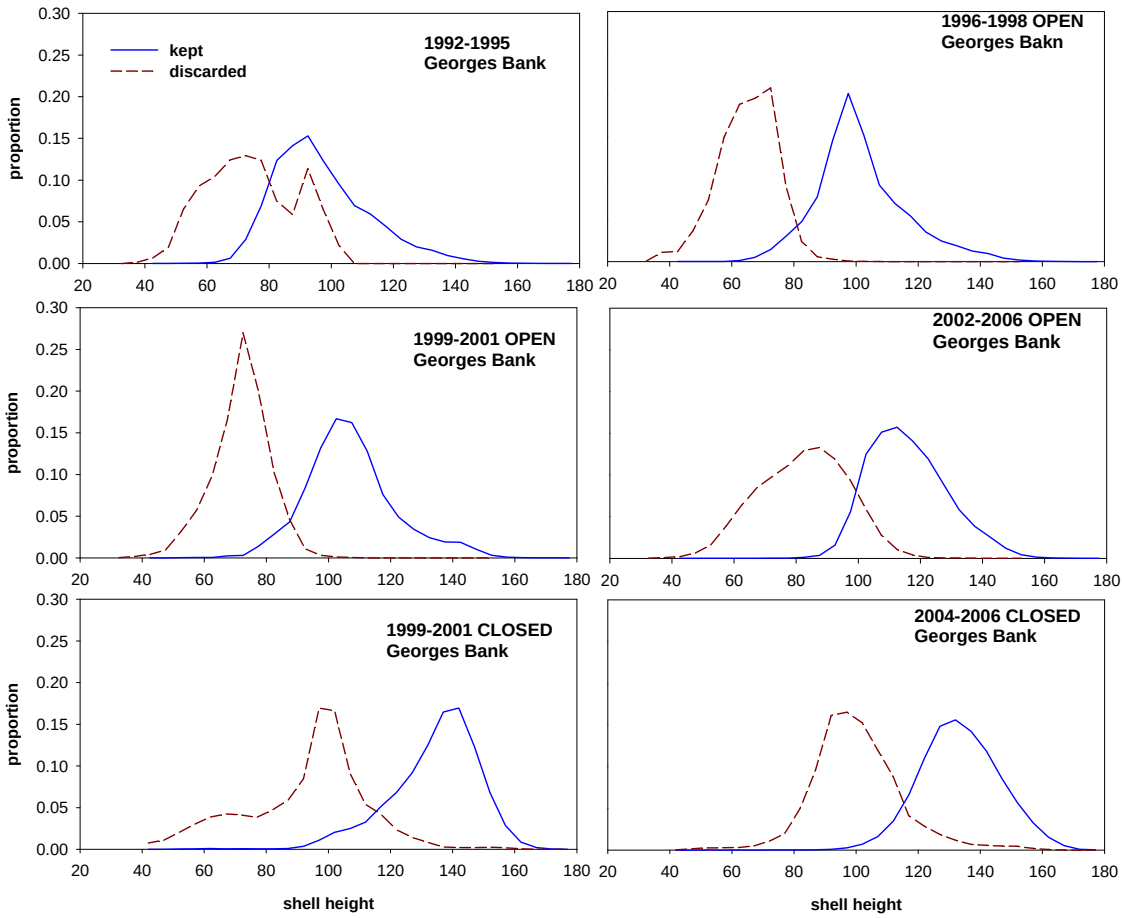


Figure B-9 continued

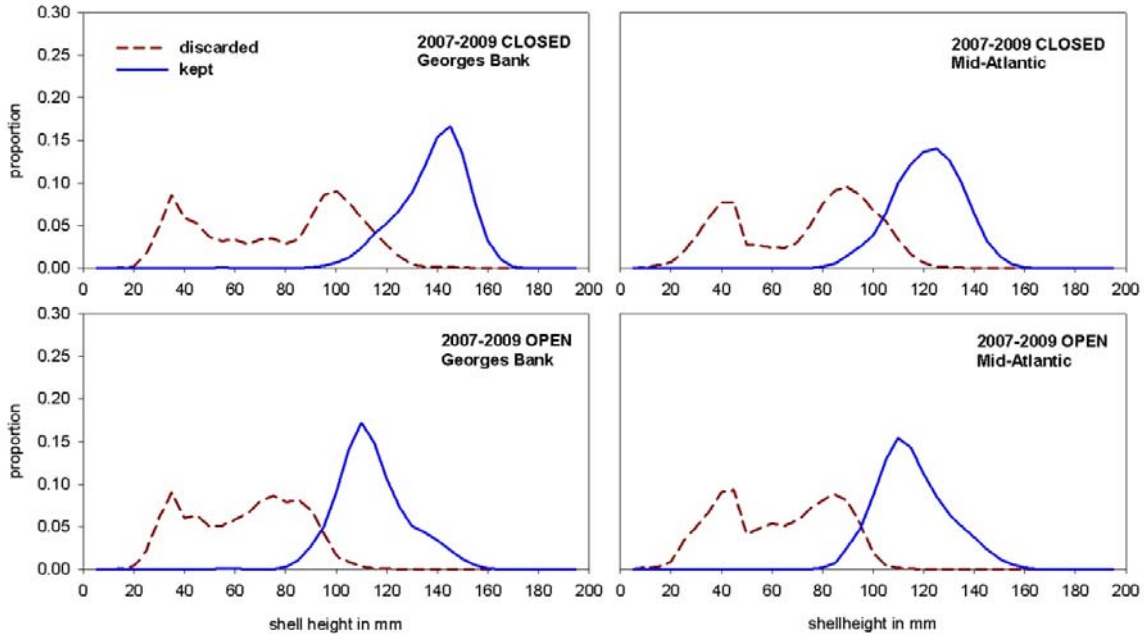


Figure B-9 continued

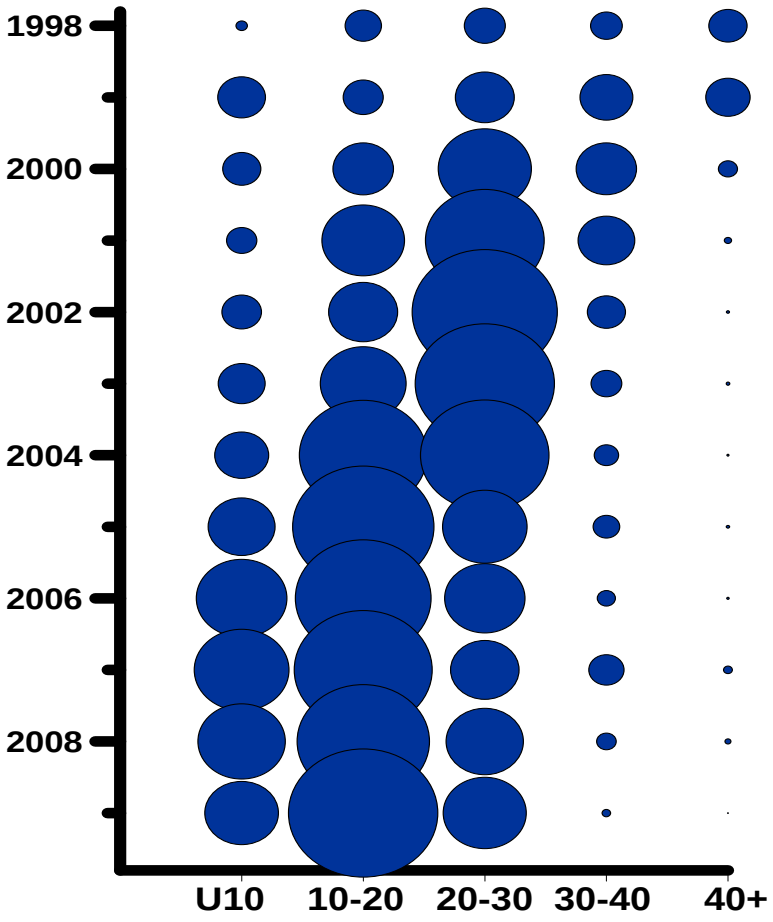


Figure B-10. Commercial landings by meat count category (number of meats per pound, U10 = less than 10 meats per pound).

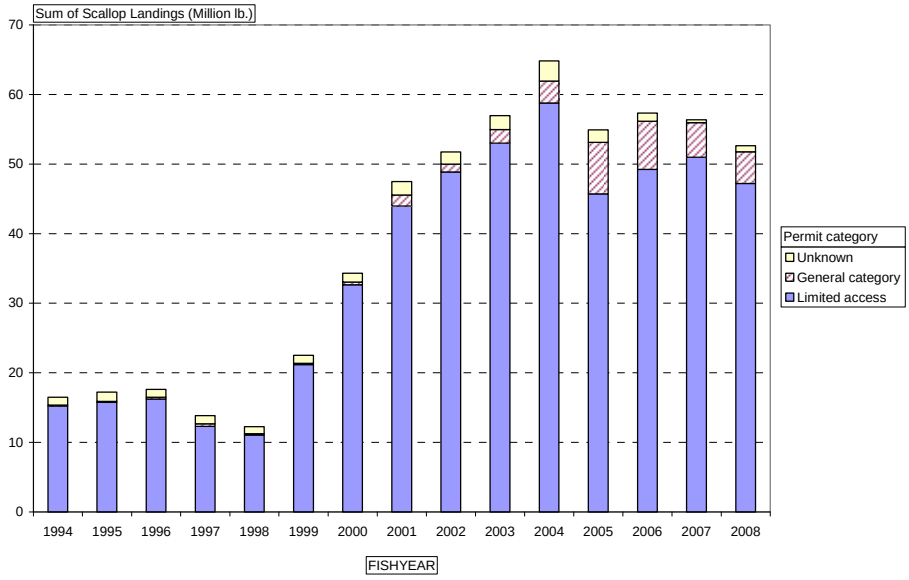


Figure B-11. Landings by permit category and fishing year (fishing year starts March 1).

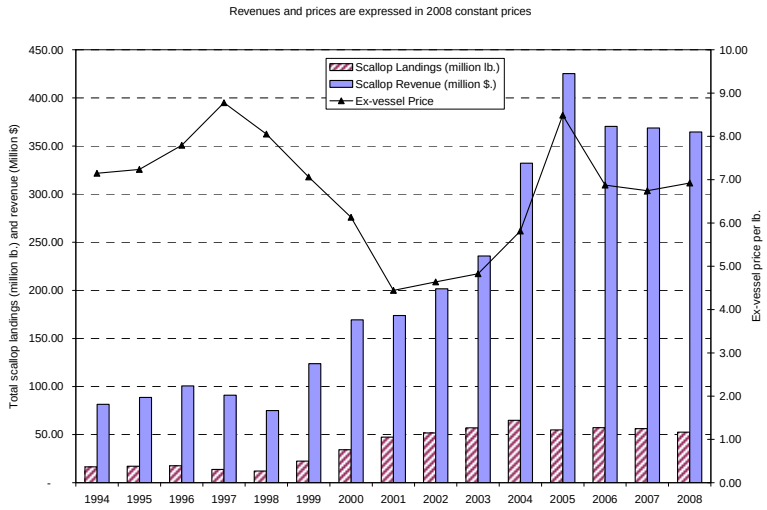


Figure B-12. Trends in scallop landings, revenue and ex-vessel prices by fishing year.

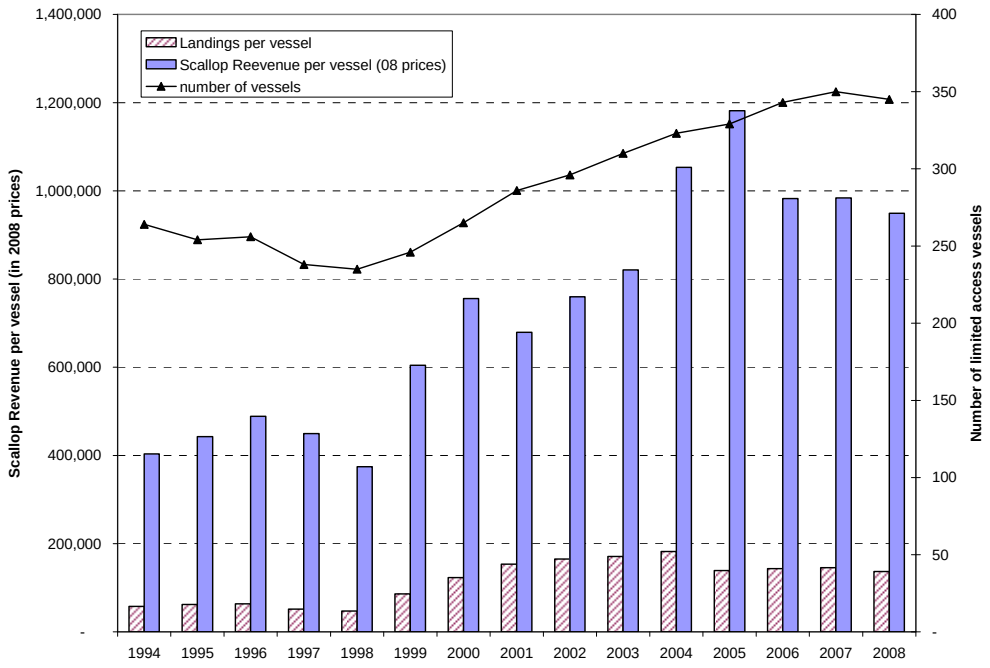


Figure B-13. Trends in average scallop landings and revenue per full time vessel and number of active limited access vessels.

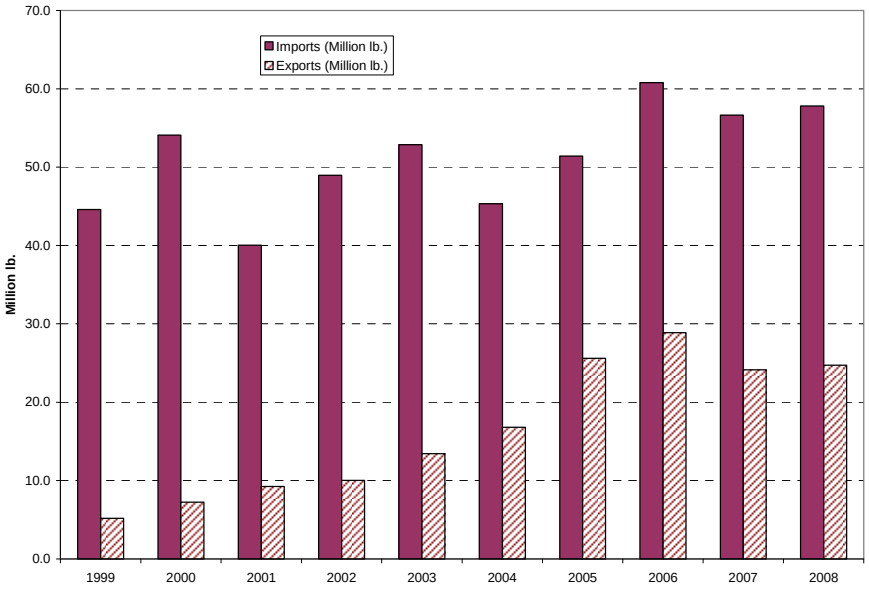
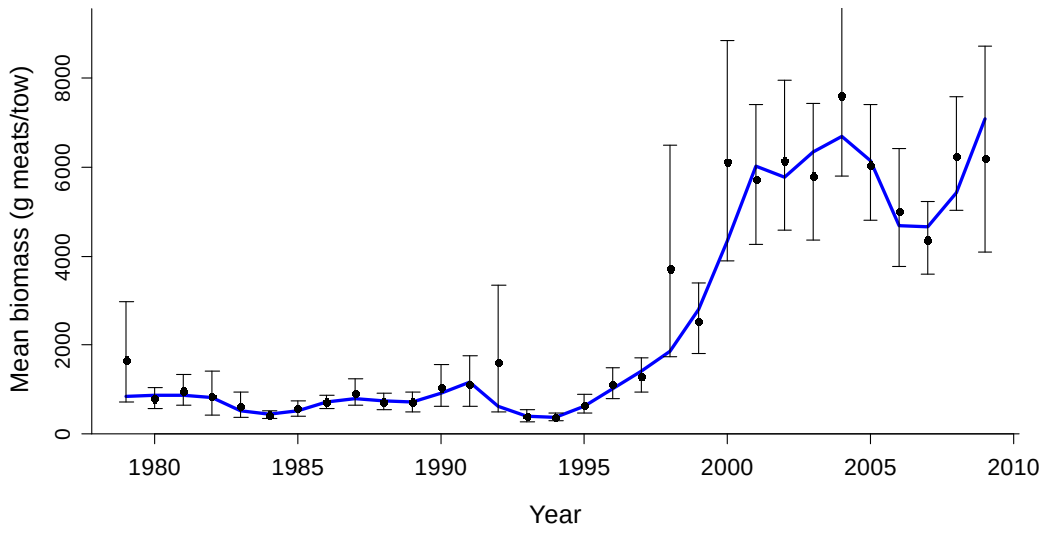


Figure B-14. Scallop exports and imports (includes other scallop species).

(a)



(b)

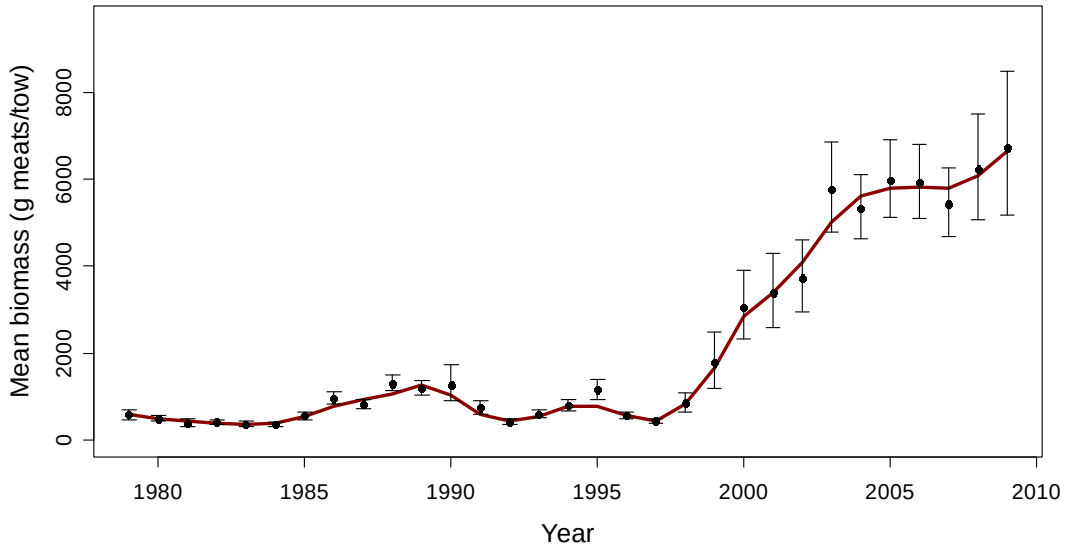
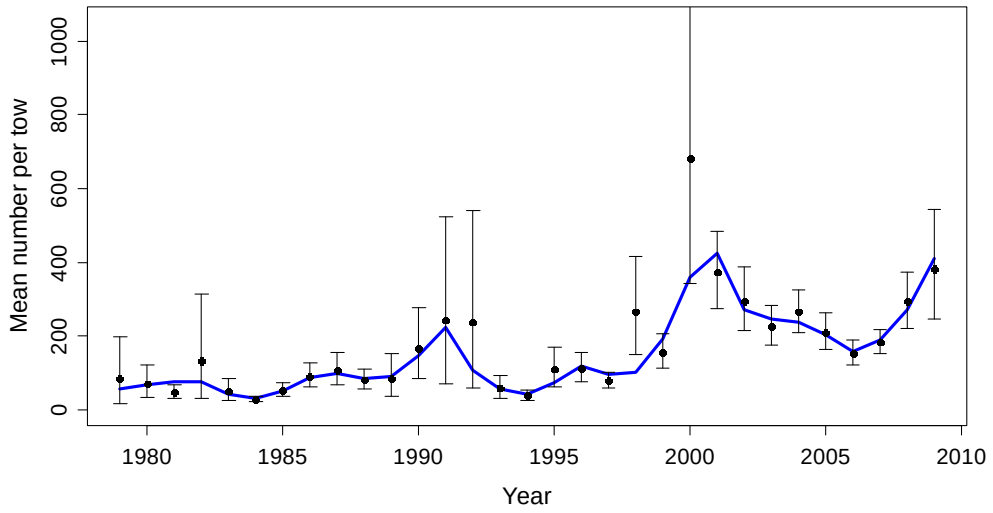


Figure B-15. NEFSC lined dredge sea scallop survey biomass indices in (a) Georges Bank and (b) Mid-Atlantic. 95% confidence intervals and inverse variance weighted lowess smoothers (lines, span = 0.25) are also shown.

(a)



(b)

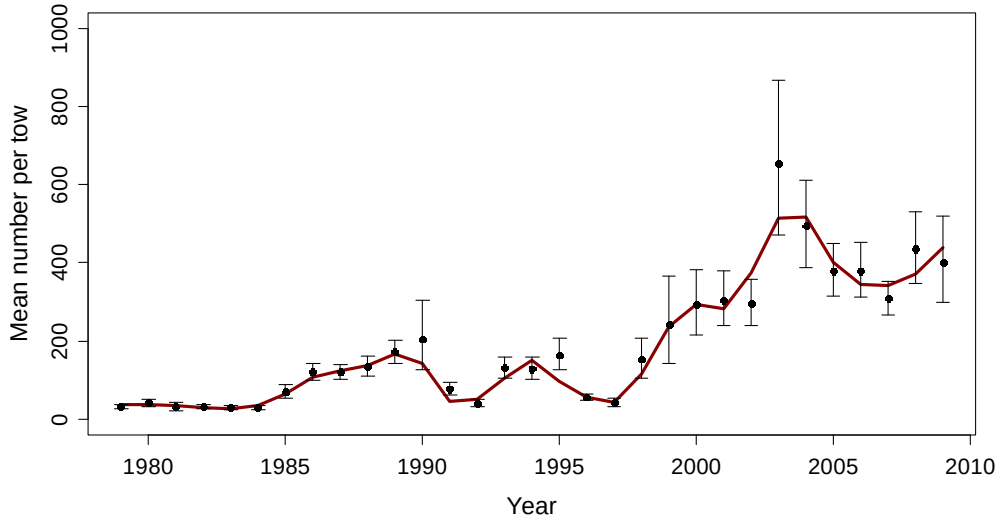
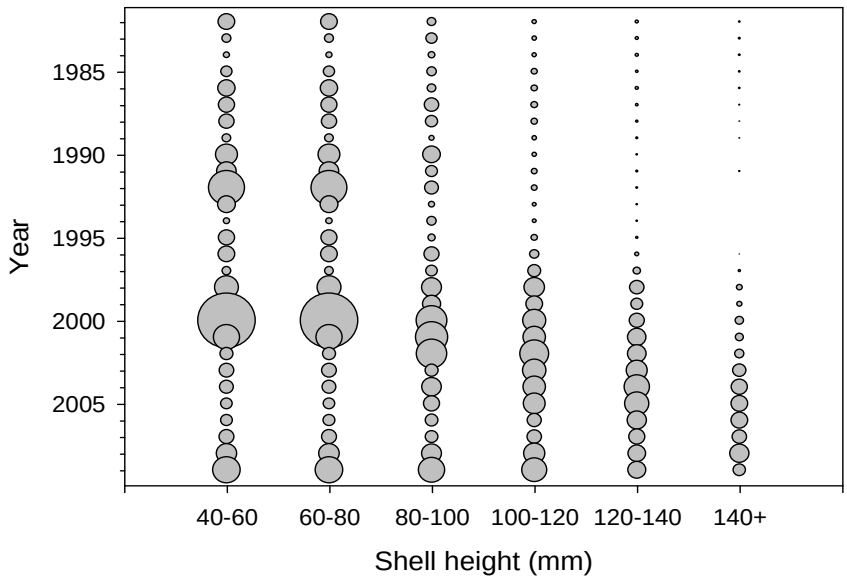


Figure B-16. NEFSC lined dredge sea scallop survey abundance indices in (a) Georges Bank and (b) Mid-Atlantic. 95% confidence intervals and inverse variance weighted lowess smoothers (lines, span = 0.25) are also shown.

(a)



(b)

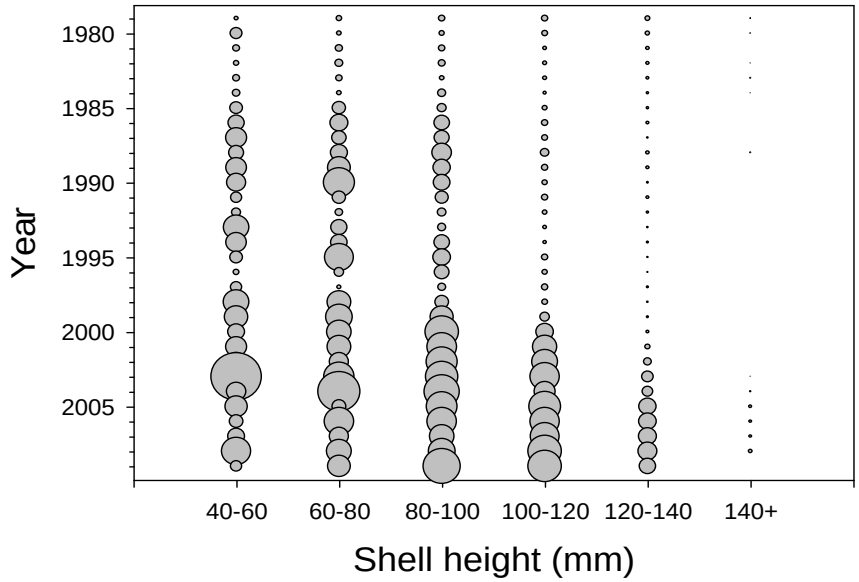


Figure B-17. Numbers of scallops by shell height group for (a) Georges Bank and (b) Mid-Atlantic, based on the NEFSC lined dredge survey.

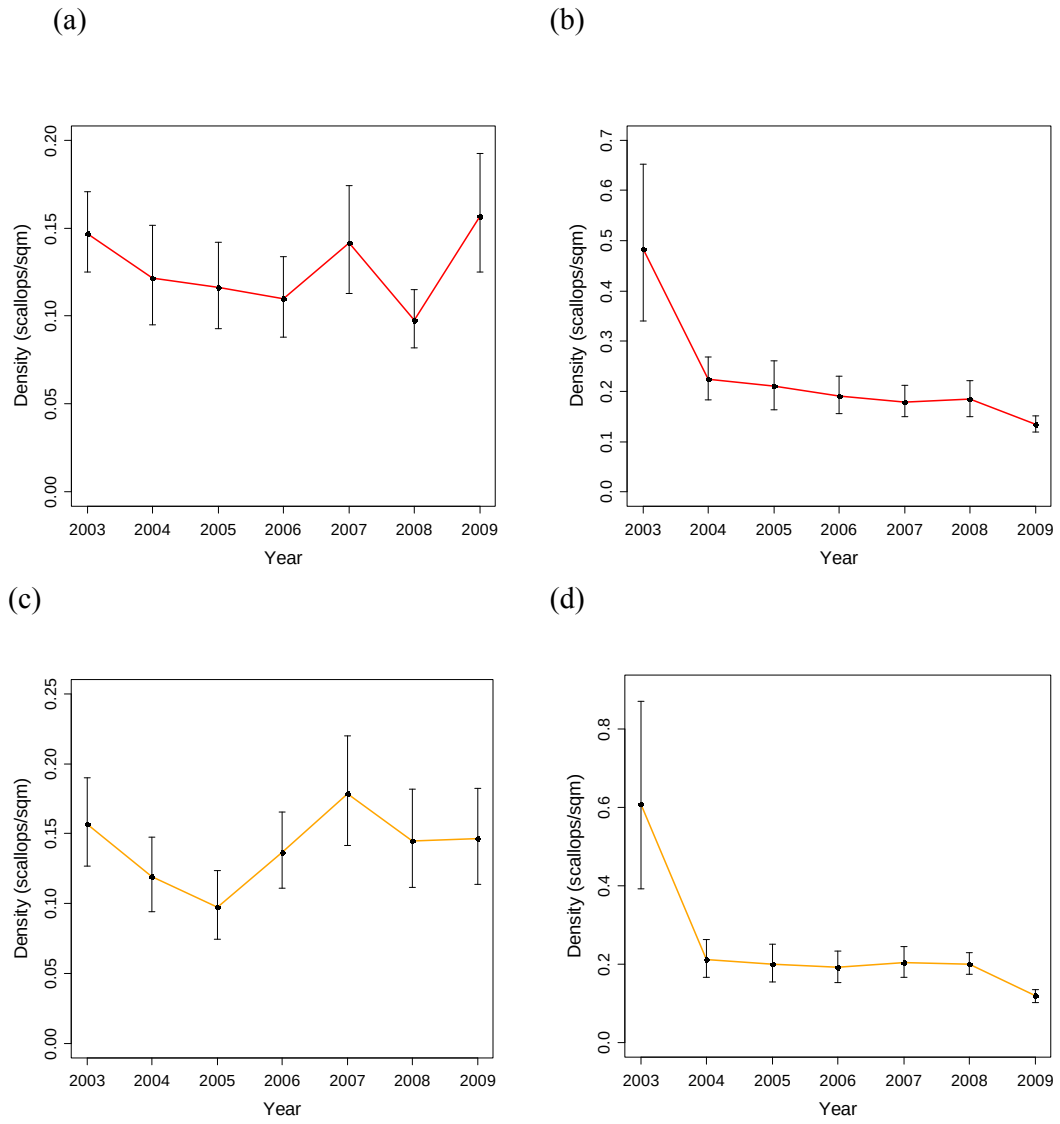
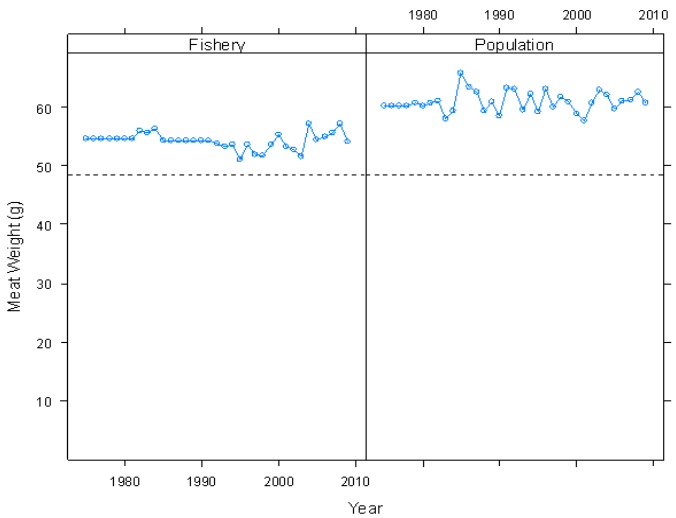


Figure B-18. Sea scallop density estimates from (a-b) the large video camera, and (c-d) the small video camera, in (a) and (c) Georges Bank and (b) and (d) the Mid-Atlantic. 95% confidence intervals are also shown.

(a)



(b)

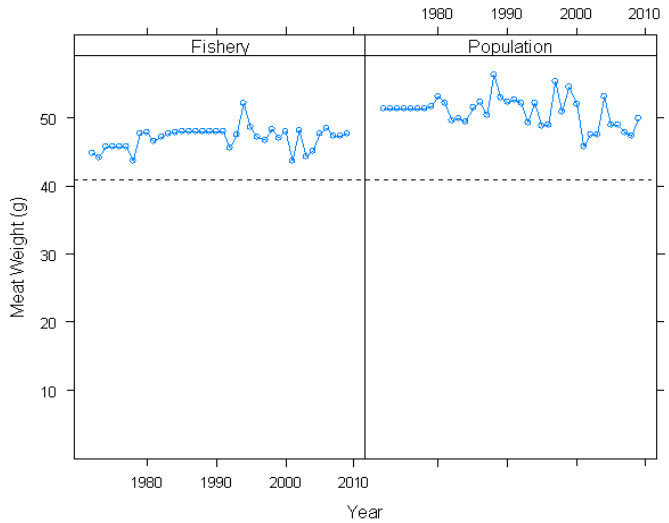


Figure B-19. Plus group meat weights for the population and the fishery in (a) Georges Bank and (b) Mid-Atlantic. Plus groups represent >140 mm SH in Geroges Bank and >130mm SH in the Mid-Atlantic.

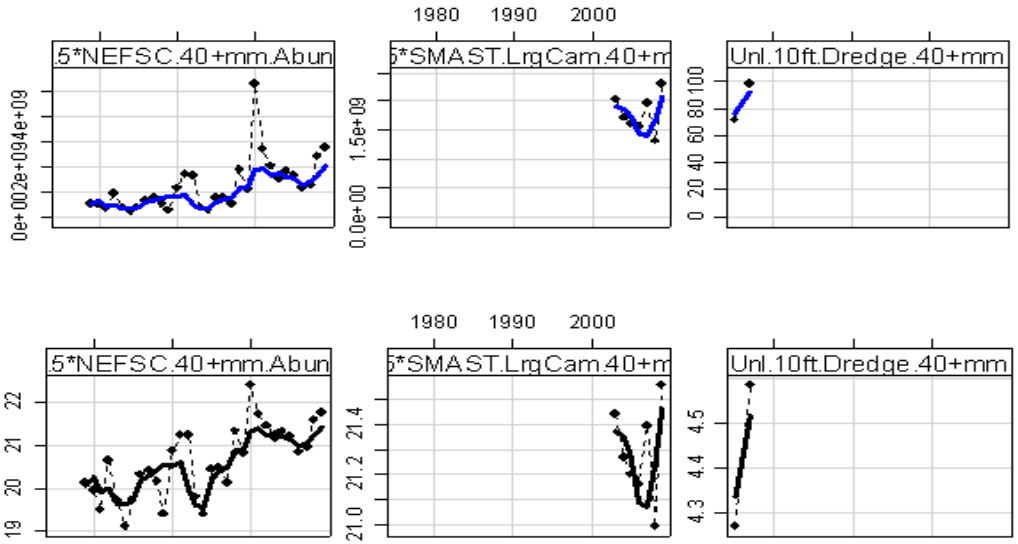


Figure B-20. Comparison between survey trend data (solid circles) and corresponding model estimates (lines) for the NEFSC lined dredge survey, the SMAST large camera survey and the NEFSC unlined dredge survey. Results are shown on a linear scale (top) and a log scale (bottom).

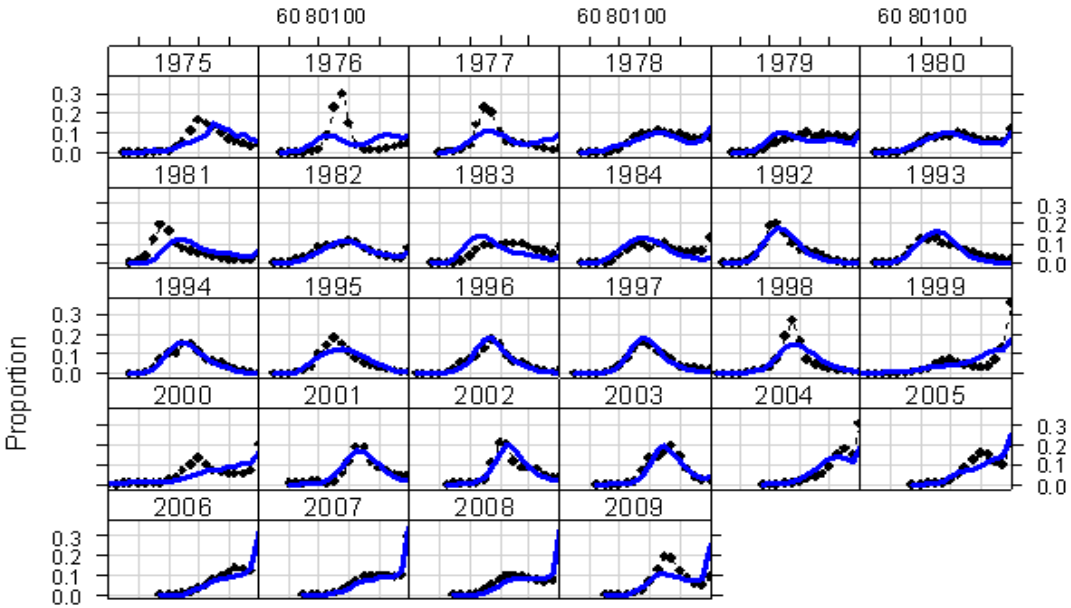


Figure B-21. Comparison of fishery shell height proportions (solid circles) and model estimated fishery shell height proportions (lines) for Georges Bank.

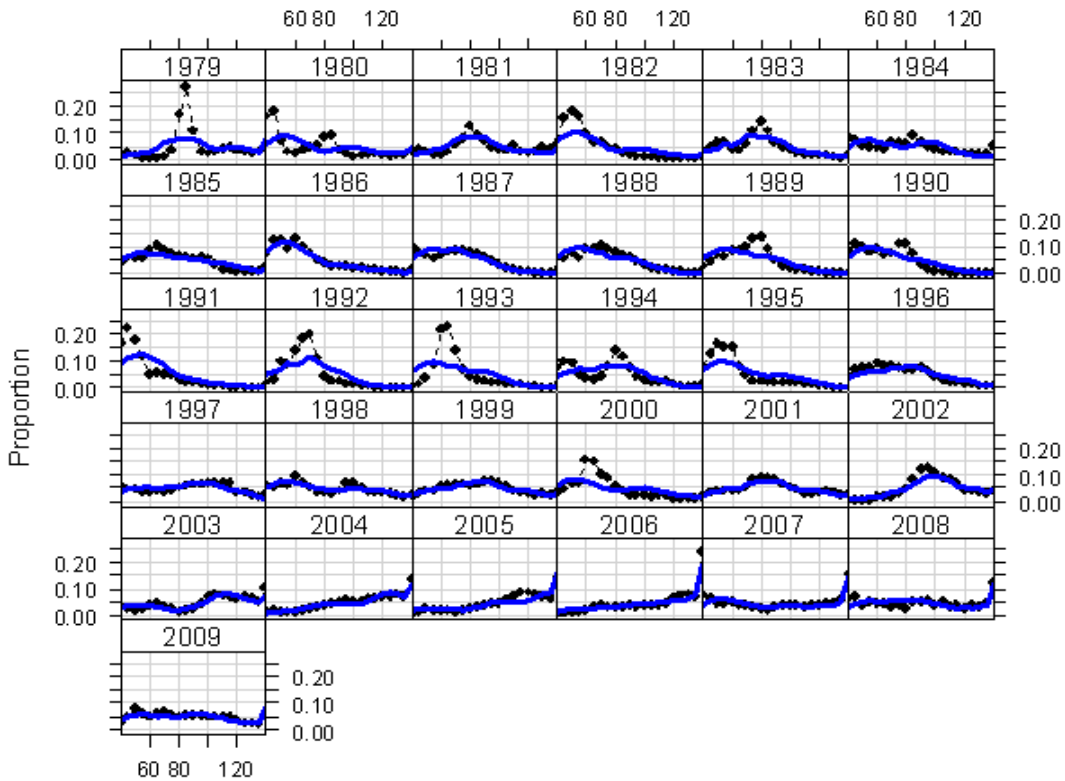
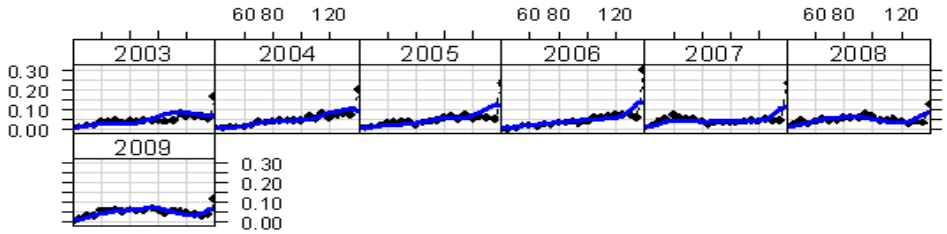


Figure B-22. NEFSC lined dredge survey shell height proportions (solid circles) and model estimated shell height proportions (line) for Georges Bank.

(a)



(b)

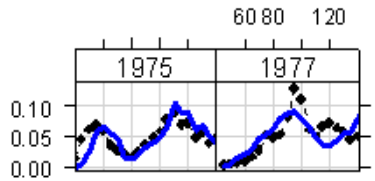


Figure B-23. Shell height proportions for (a) the SMAST large camera survey and (b) the NEFSC unlined dredge survey together with model predicted proportions (lines).

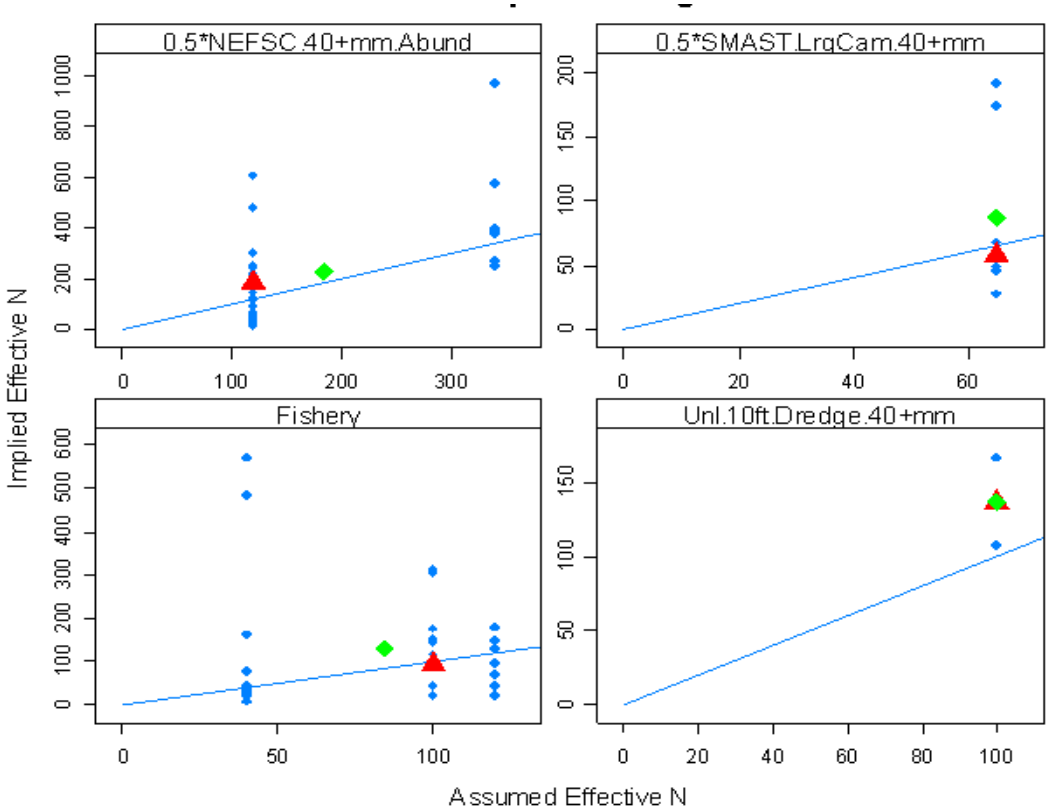


Figure B-24. Assumed and model implied effective sample sizes for the three surveys (NEFSC unlined dredge, SMAST large camera, NEFSC unlined dredge) and the fishery shell height compositions for Georges Bank.

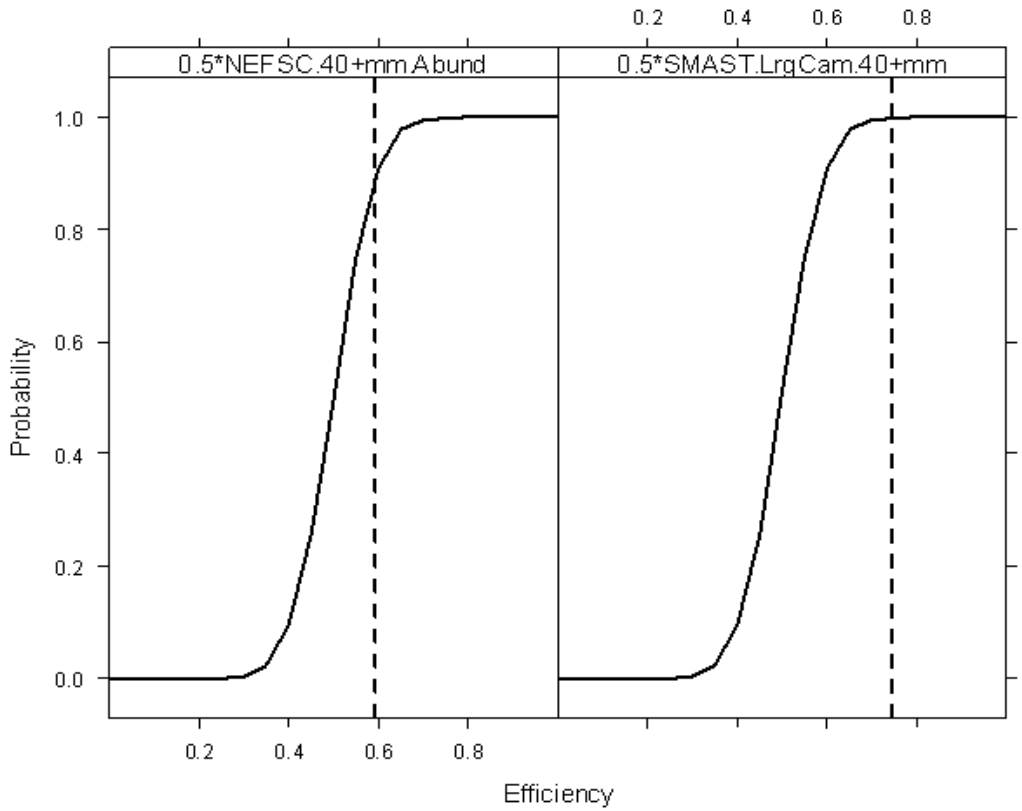
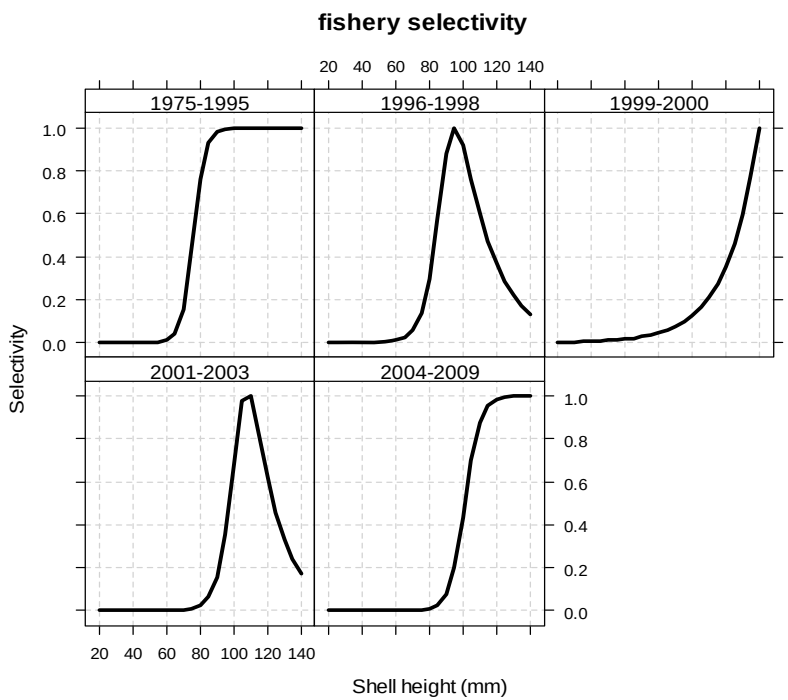


Figure B-25. Prior cumulative distributions for efficiency of the lined dredge survey (left) and large camera video survey (right) for Georges Bank. The dashed lines are the mean posterior estimate for survey efficiency.

(a)



(b)

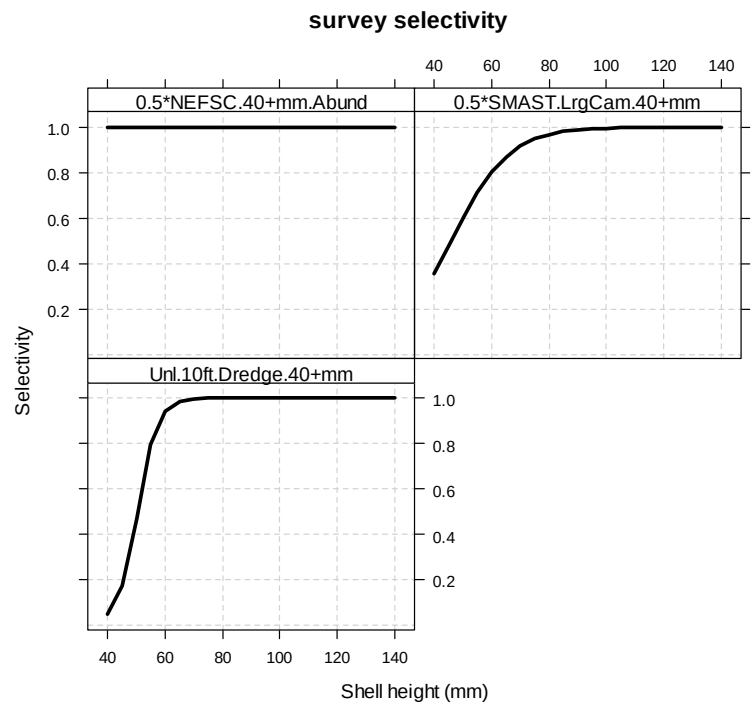


Figure B-26. (a) Estimated fishery selectivities and (b) assumed survey selectivities (lined dredge top right, large camera top left, unlined dredge bottom left) for Georges Bank.

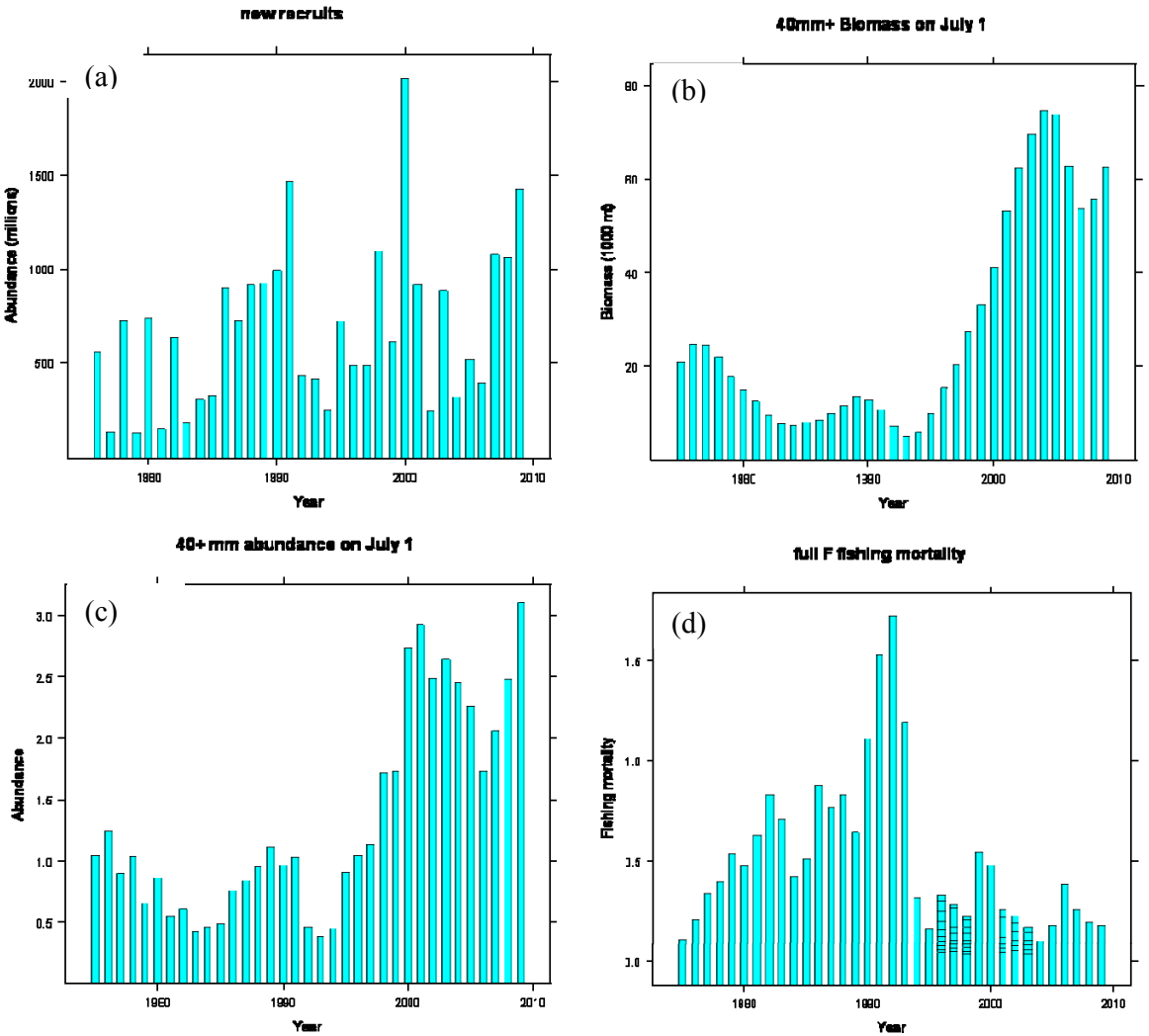


Figure B-27. CASA model estimated (a) recruitment, (b) July 1 biomass, (c) July 1 abundance and (d) fully recruited fishing mortality for Georges Bank.

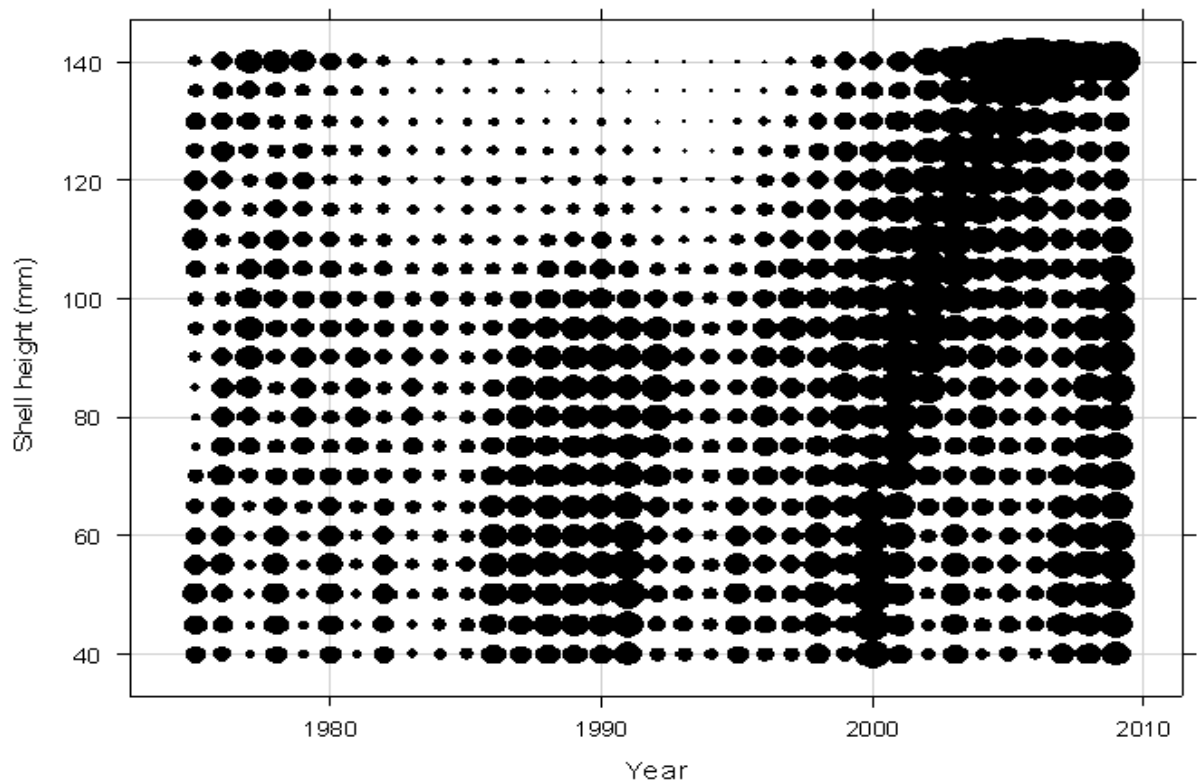


Figure B-28. Model estimated abundances at shell height for Georges Bank. Disk areas are proportional to abundance.

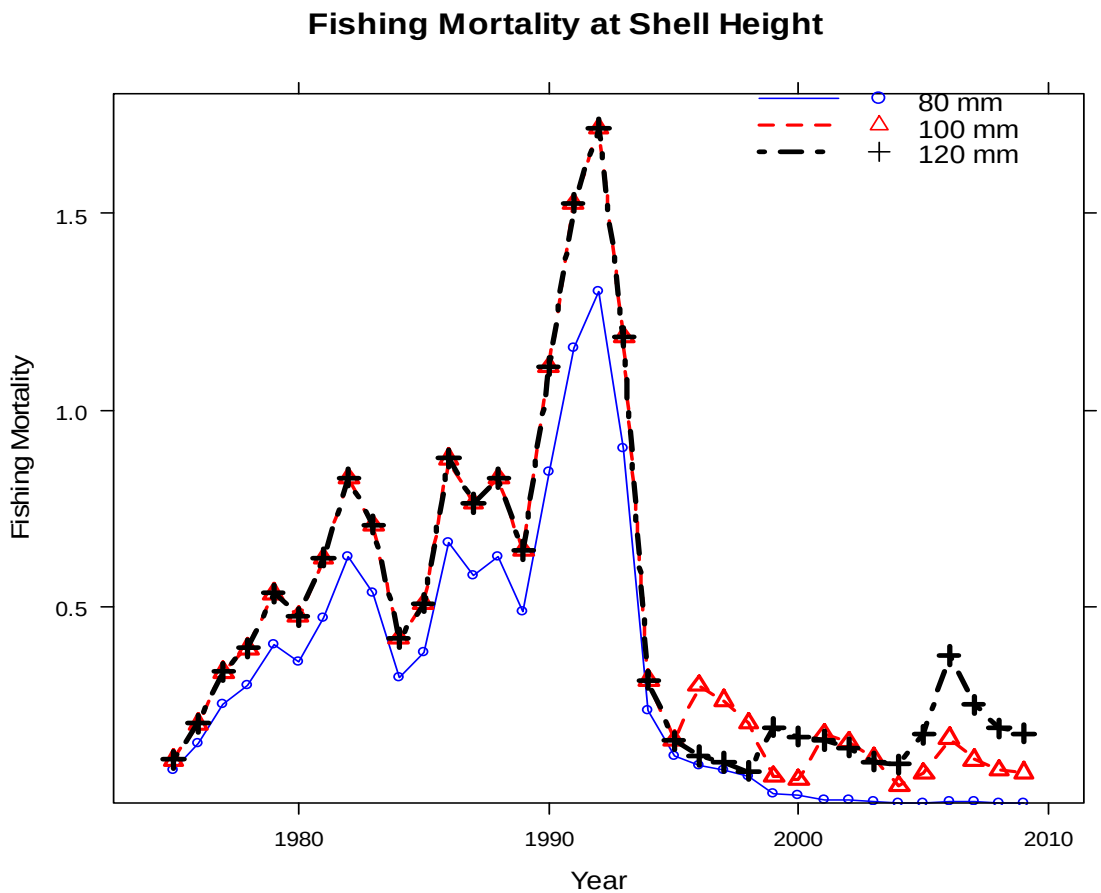


Figure B-29. CASA model estimated fishing mortality at 80 mm (blue line with circles), 100 mm (red dashed line with triangles) and 120 mm SH (black dot-dashed line with pluses) for Georges Bank.

(a) (b)

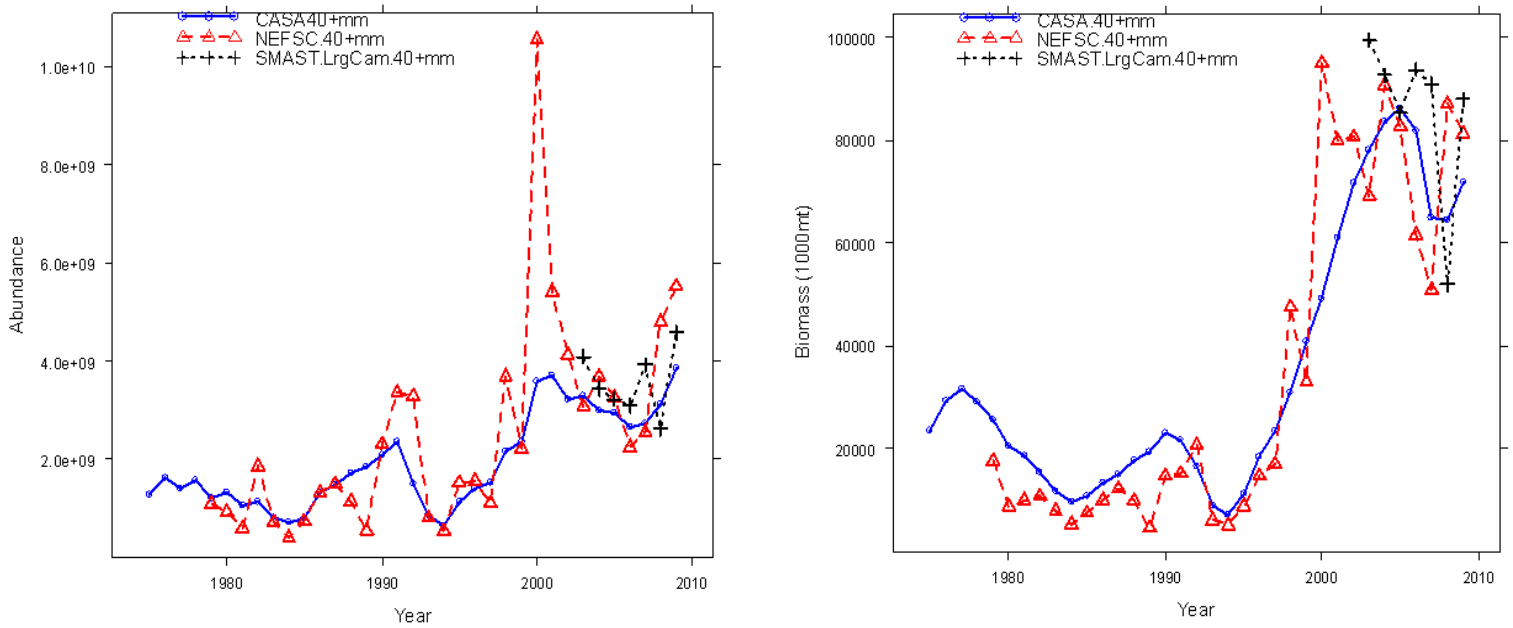


Figure B-30. Comparison of CASA model estimated (a) abundance and (b) biomass with estimates from the lined dredge survey (dashed red line with triangles) and large camera survey (dotted line with pluses) for Georges Bank. The dredge survey was expanded assuming an efficiency of 0.41.

(a) (b)

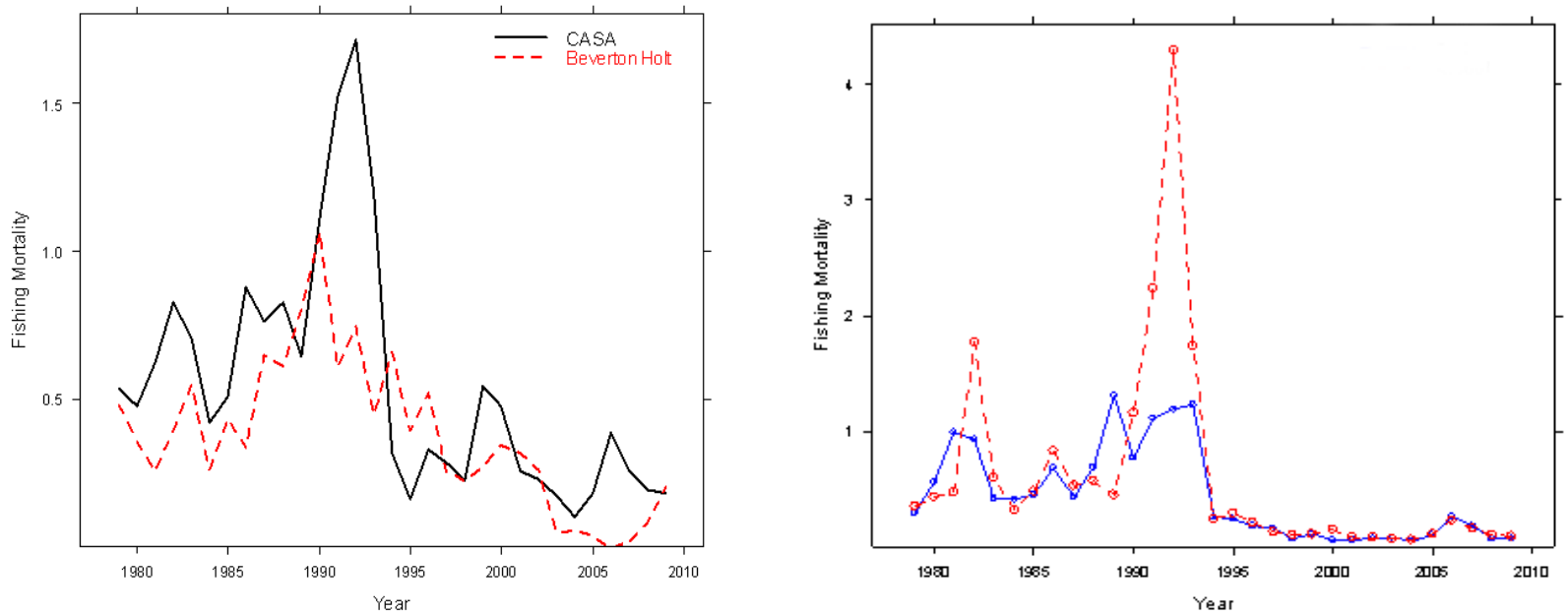


Figure B-31. (a) Comparison of fully recruited CASA fishing mortality with those calculated from the Beverton-Holt equilibrium estimator (Lc=100mm) for Georges Bank. (b) Comparison of an exploitation index (number landed/population abundance > 80mm) based on the fishery and lined dredge survey data (red dotted line), and CASA model (blue solid line) for Georges Bank.

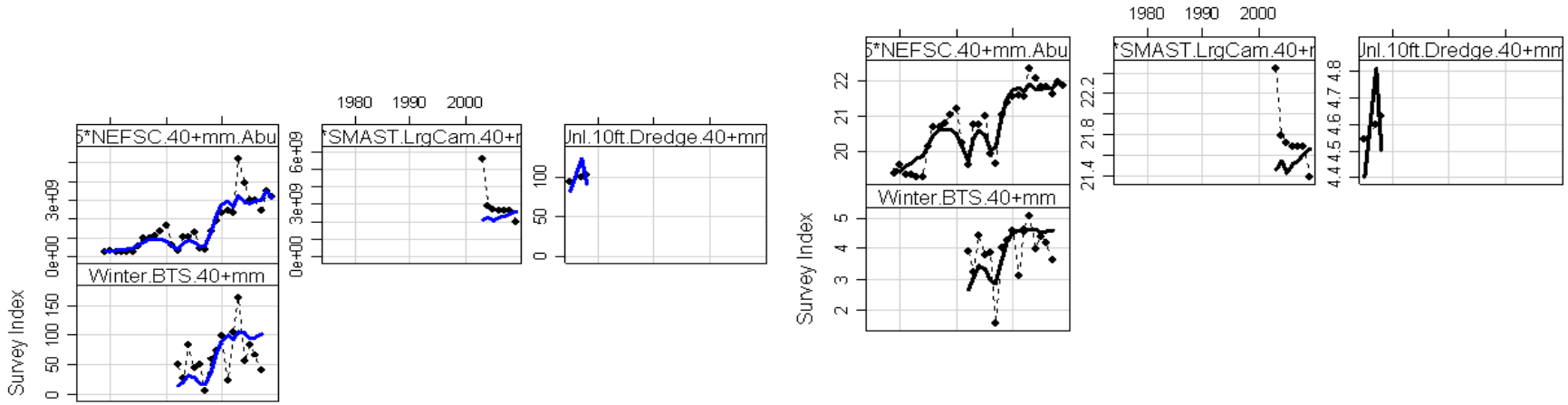


Figure B-32. Comparison between survey trend data (solid circles) and corresponding model estimates (lines) for the NEFSC lined dredge survey, the SMAST large camera survey, the NEFSC unlined dredge and winter trawl surveys for the Mid-Atlantic. Results are shown on a linear scale (left) and a log scale (right).

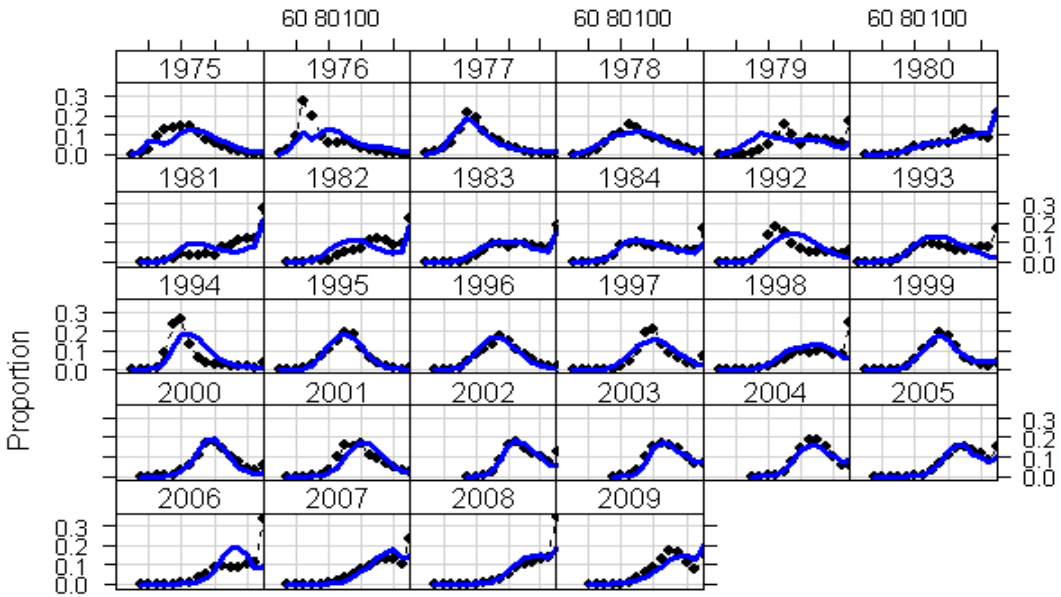


Figure B-33. Comparison of fishery shell height proportions (solid circles) and model estimated fishery shell height proportions (lines) for the Mid-Atlantic.

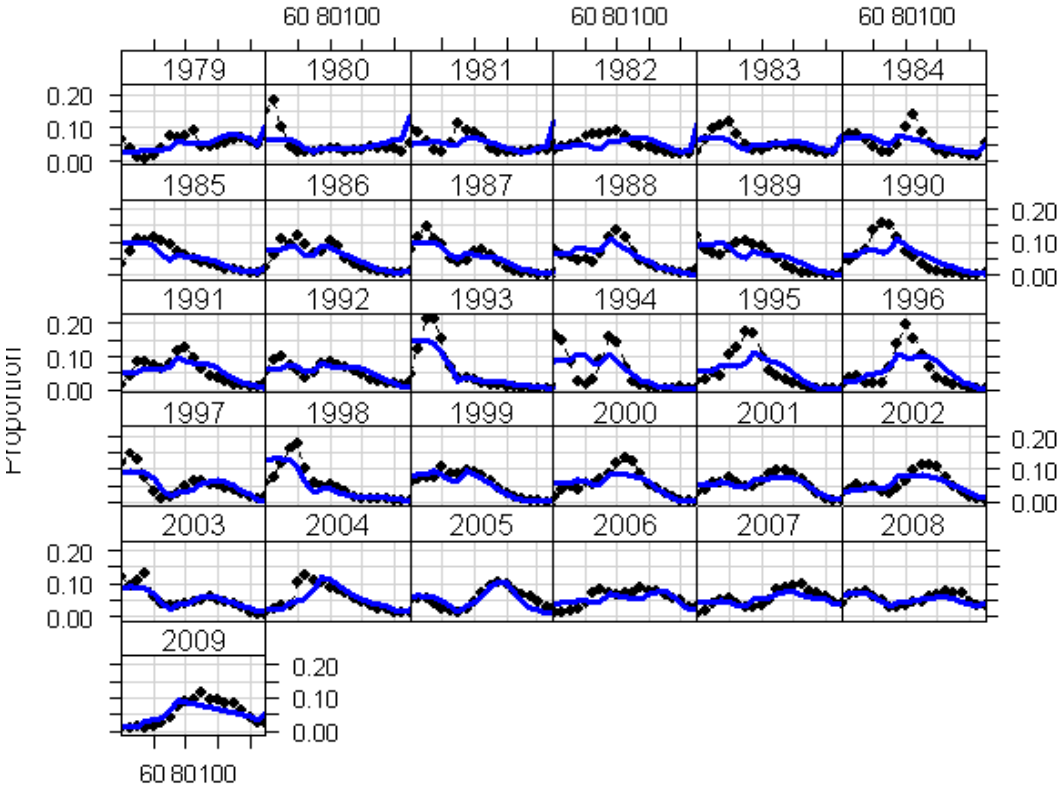
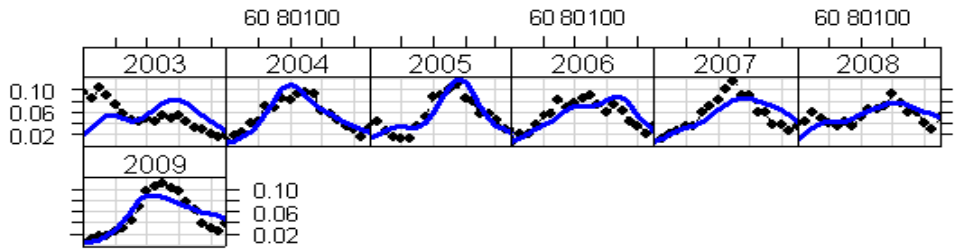
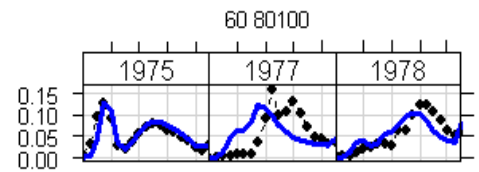


Figure B-34. NEFSC lined dredge survey shell height proportions (solid circles) and model estimated shell height proportions (line) for the Mid-Atlantic.

(a)



(b)



(c)

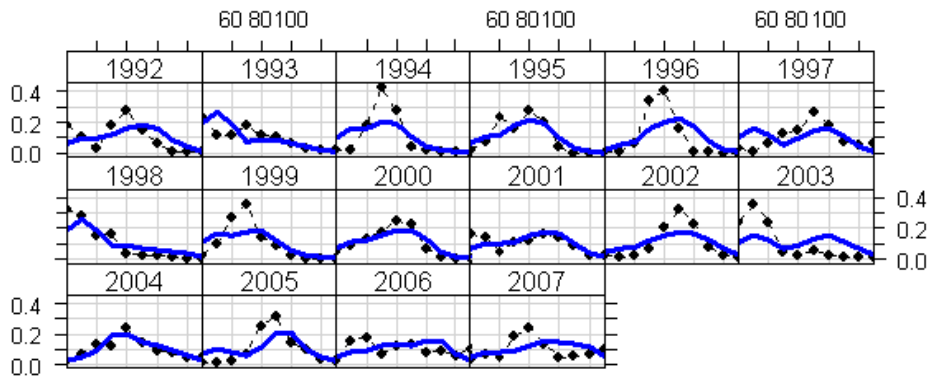


Figure B-35. Shell height proportions for (a) the SMAST large camera survey (b) the NEFSC unlined dredge survey and (c) the NEFSC winter trawl survey together with model predicted proportions (lines) in the Mid-Atlantic.

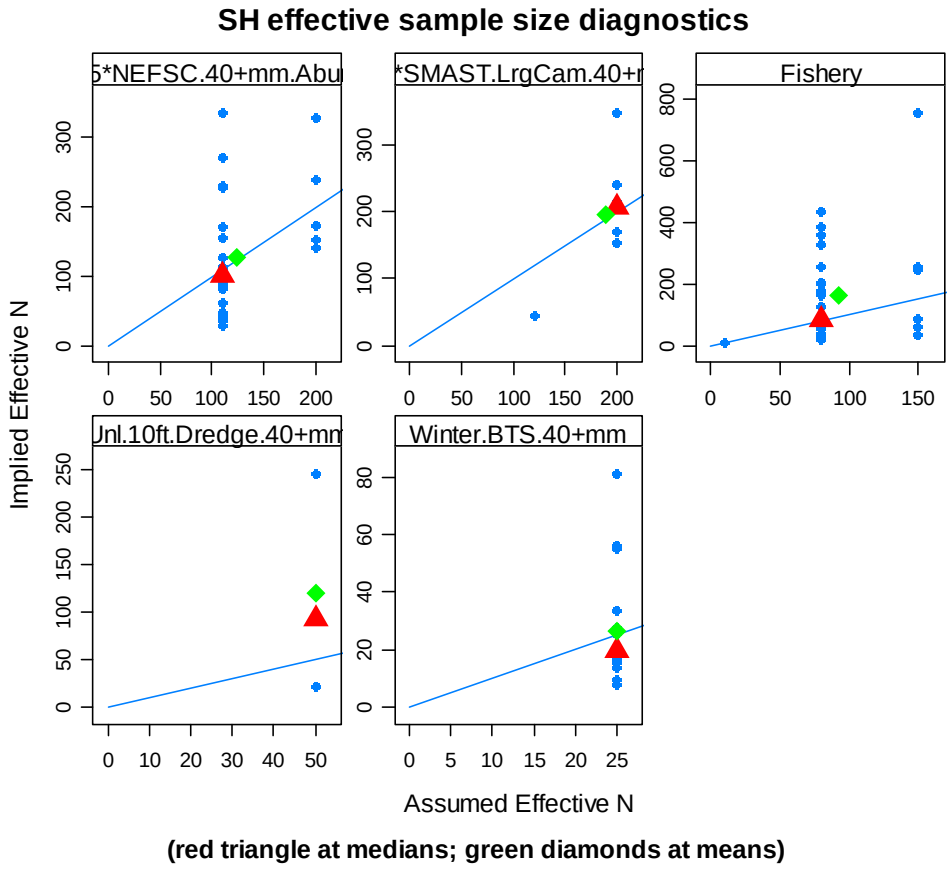


Figure B-36. Assumed and model implied effective sample sizes for the four surveys (NEFSC unlined dredge, SMAST large camera, NEFSC unlined dredge, winter bottom trawl) and the fishery shell height compositions for the Mid-Atlantic.

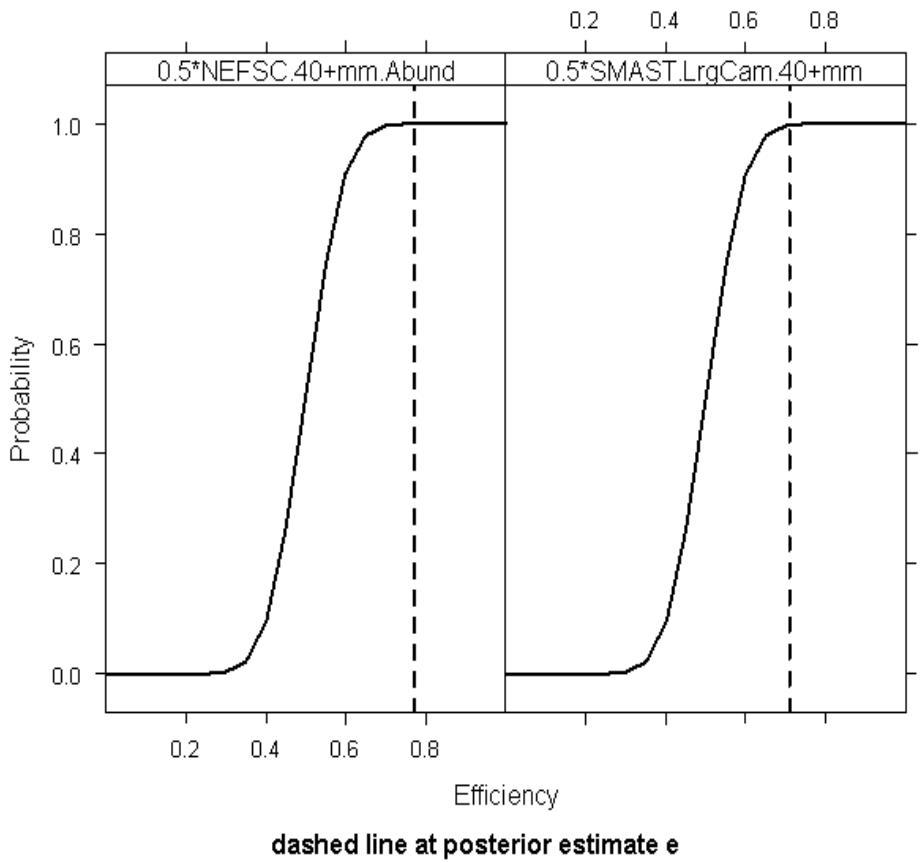
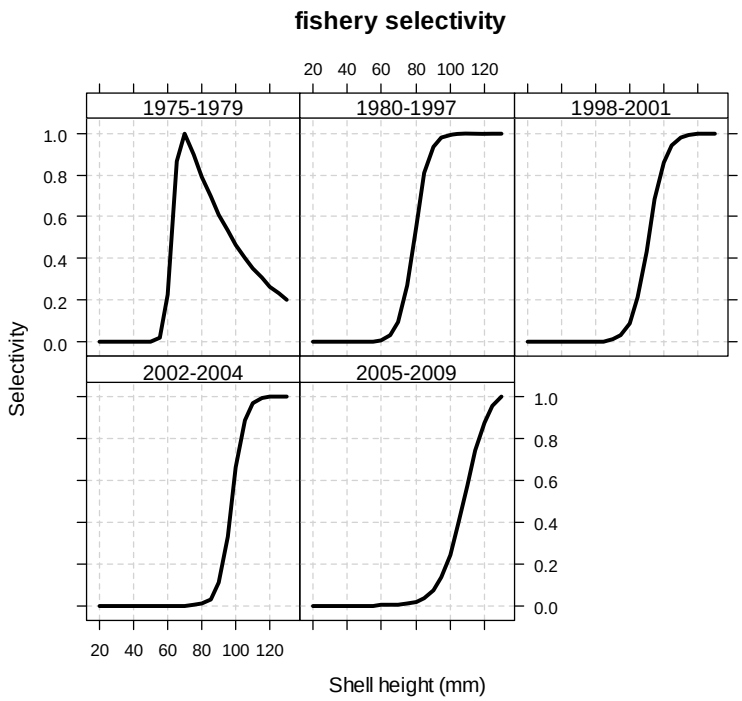


Figure B-37. Prior cumulative distributions for efficiency of the lined dredge survey (left) and large camera video survey (right) for the Mid-Atlantic. The dashed lines are the mean posterior estimate for survey efficiency.

(a)



(b)

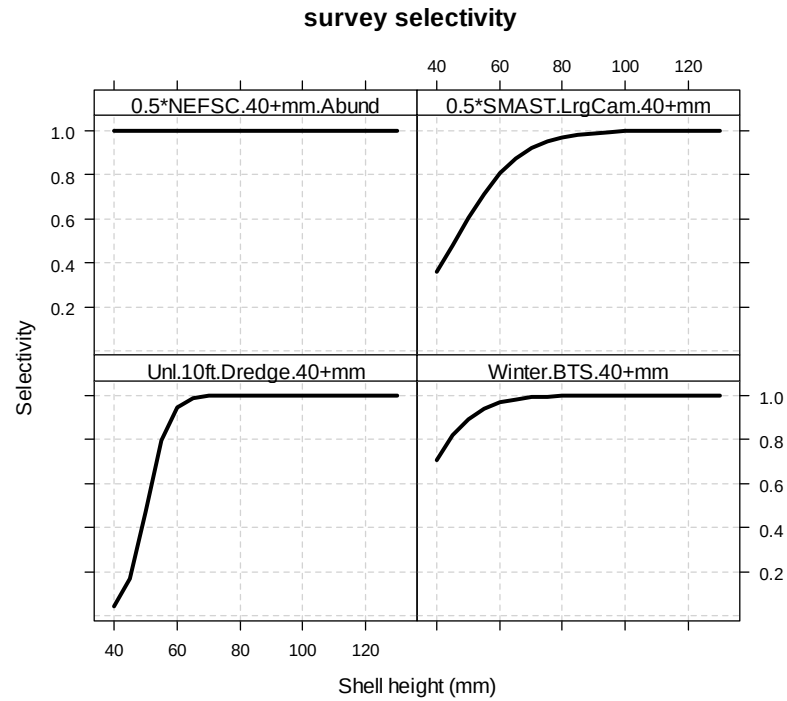


Figure B-38. (a) Estimated fishery selectivities and (b) survey selectivities (lined dredge top left, large camera top right, unlined dredge bottom left, winter trawl bottom right) for the Mid-Atlantic. The trawl survey selectivity was estimated; the other survey selectivities were fixed.

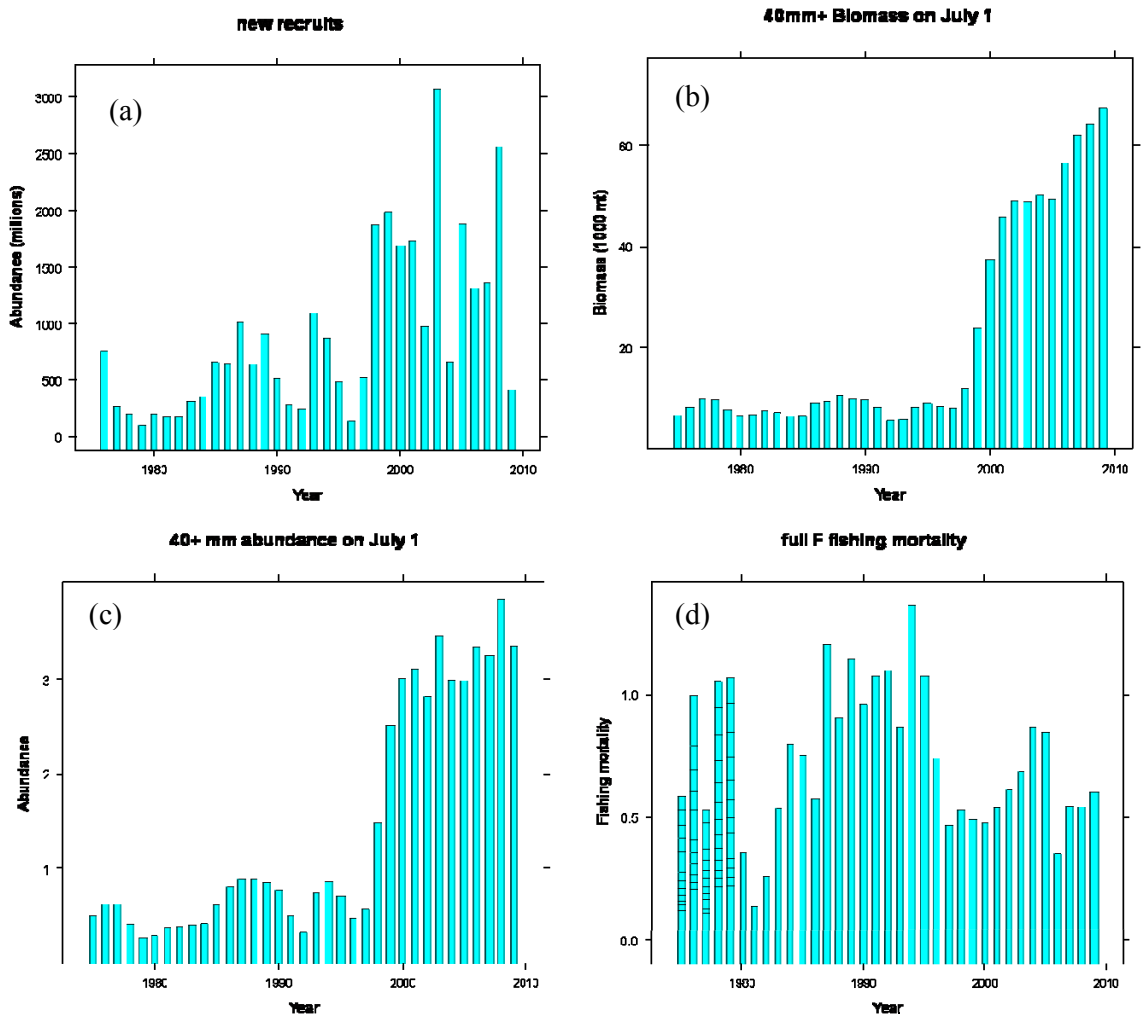


Figure B-39. CASA model estimated (a) recruitment, (b) July 1 biomass, (c) July 1 abundance and (d) fully recruited fishing mortality for the Mid-Atlantic.

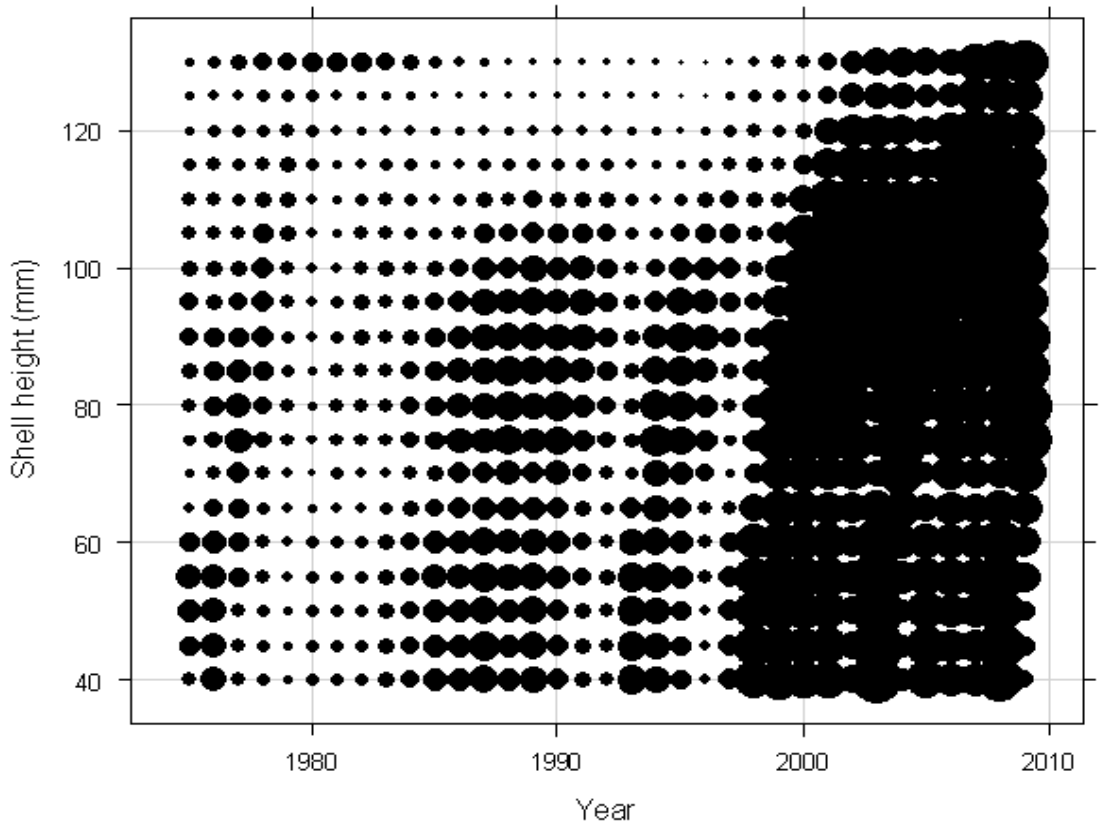


Figure B-40. Model estimated abundances at shell height for the Mid-Atlantic. Disk areas are proportional to abundance.

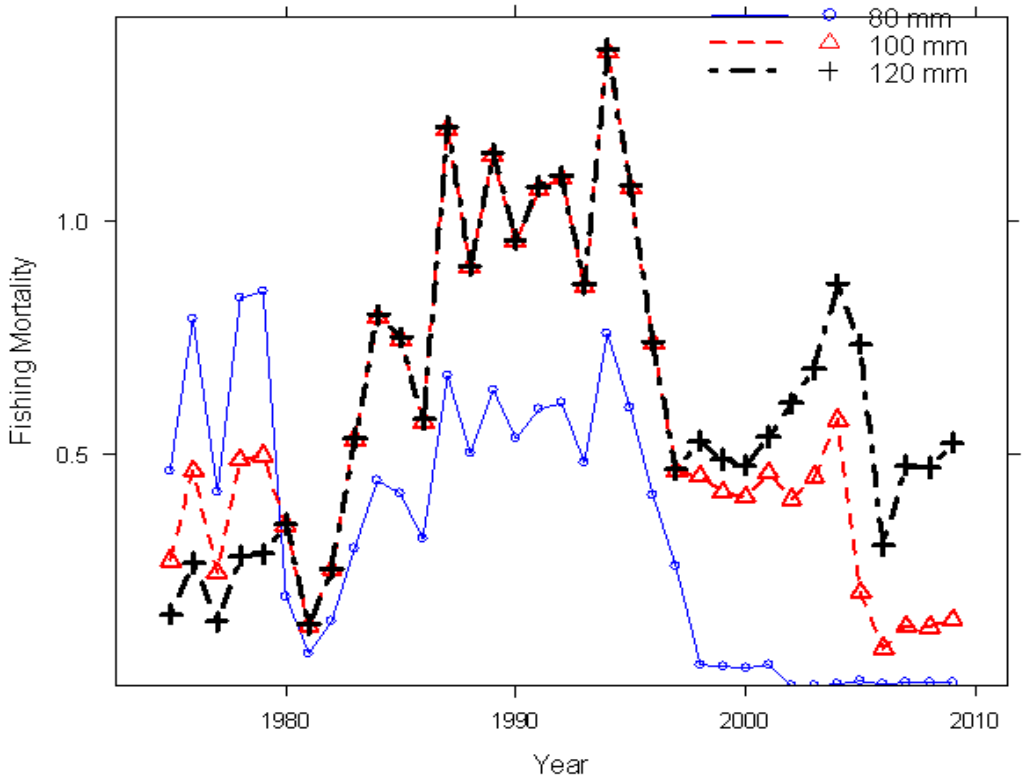


Figure B-41. CASA model estimated fishing mortality at 80 mm (blue line with circles), 100 mm (red dashed line with triangles) and 120 mm SH (black dot-dashed line with pluses) for the Mid-Atlantic.

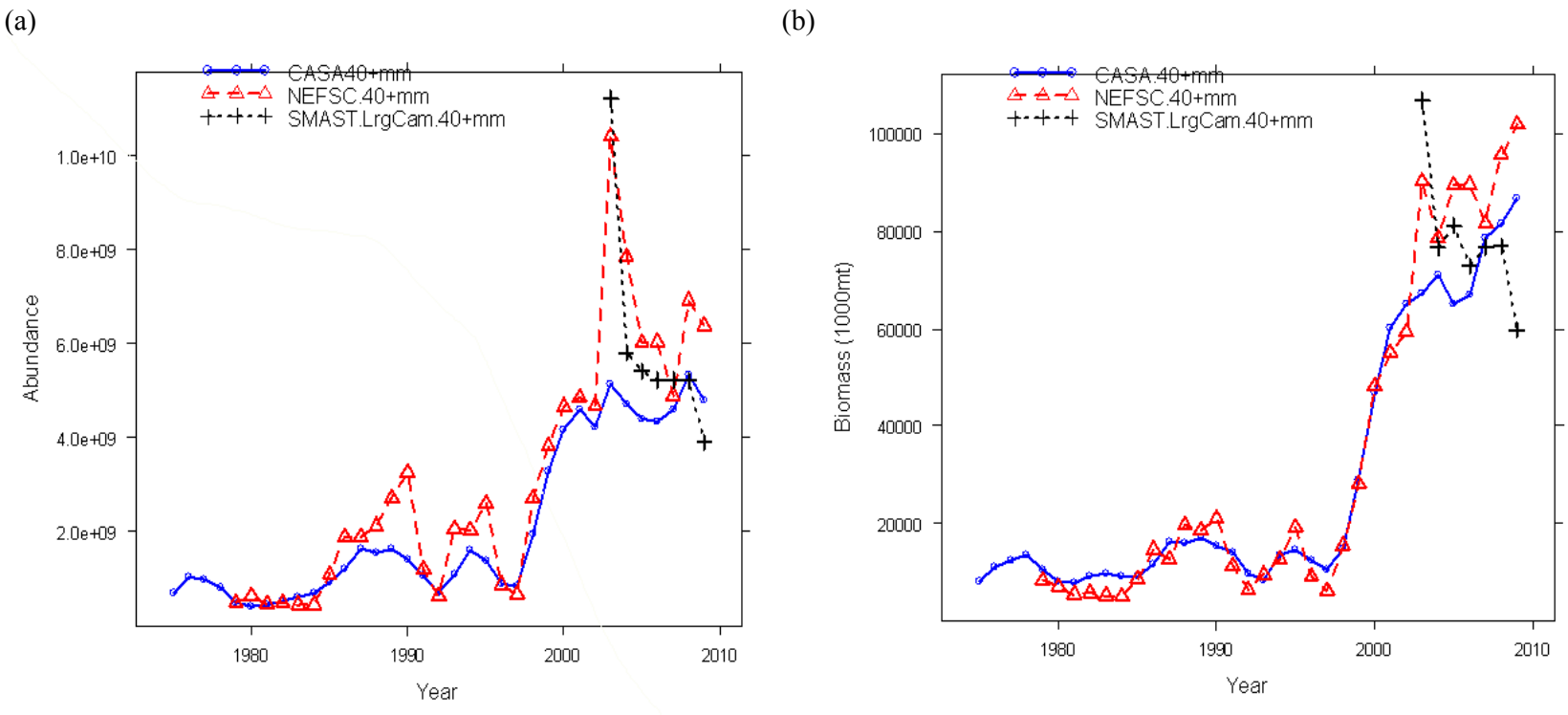
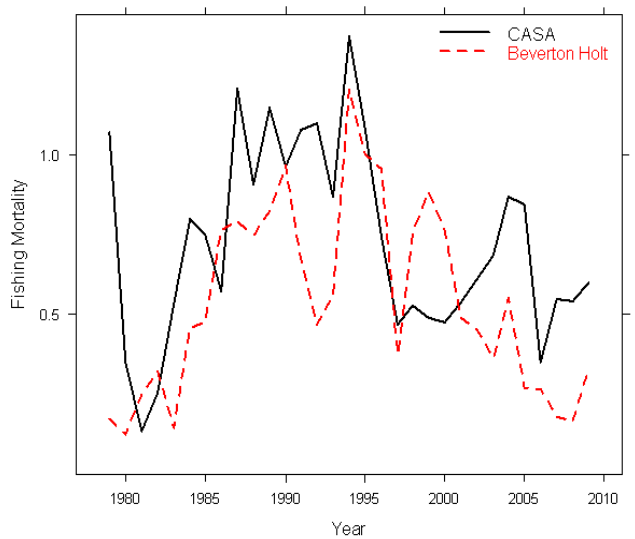


Figure B-42. Comparison of CASA model estimated (a) abundance and (b) biomass with estimates from the lined dredge survey (dashed red line with triangles) and large camera survey (dotted line with pluses) for the Mid-Atlantic. The dredge survey was expanded assuming an efficiency of 0.44.

(a)



(b)

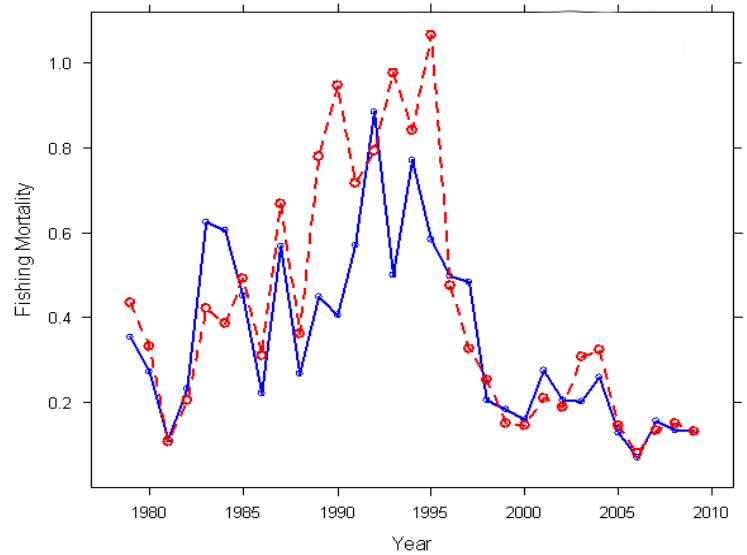


Figure B-43. (a) Comparison of fully recruited CASA fishing mortality with those calculated from the Beverton-Holt equilibrium estimator (Lc=100mm) for the Mid-Atlantic. (b) Comparison of an exploitation index (number landed/population abundance > 80mm) based on the fishery and lined dredge survey data (red dashed line), and CASA model (blue solid line) for the Mid-Atlantic.

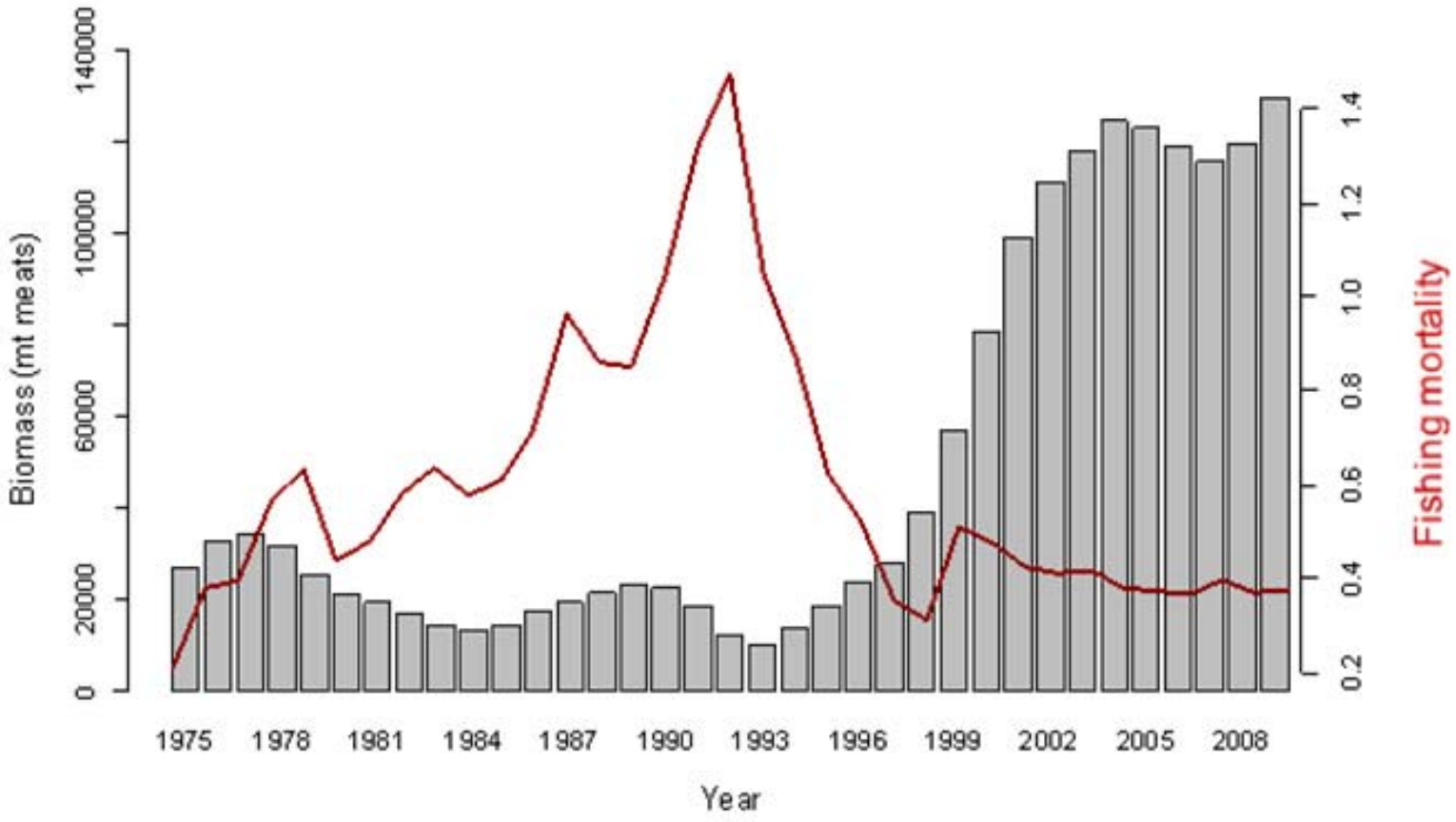


Figure B-44. Whole-stock CASA model estimates of biomass (bars) and fully recruited fishing mortality (line).

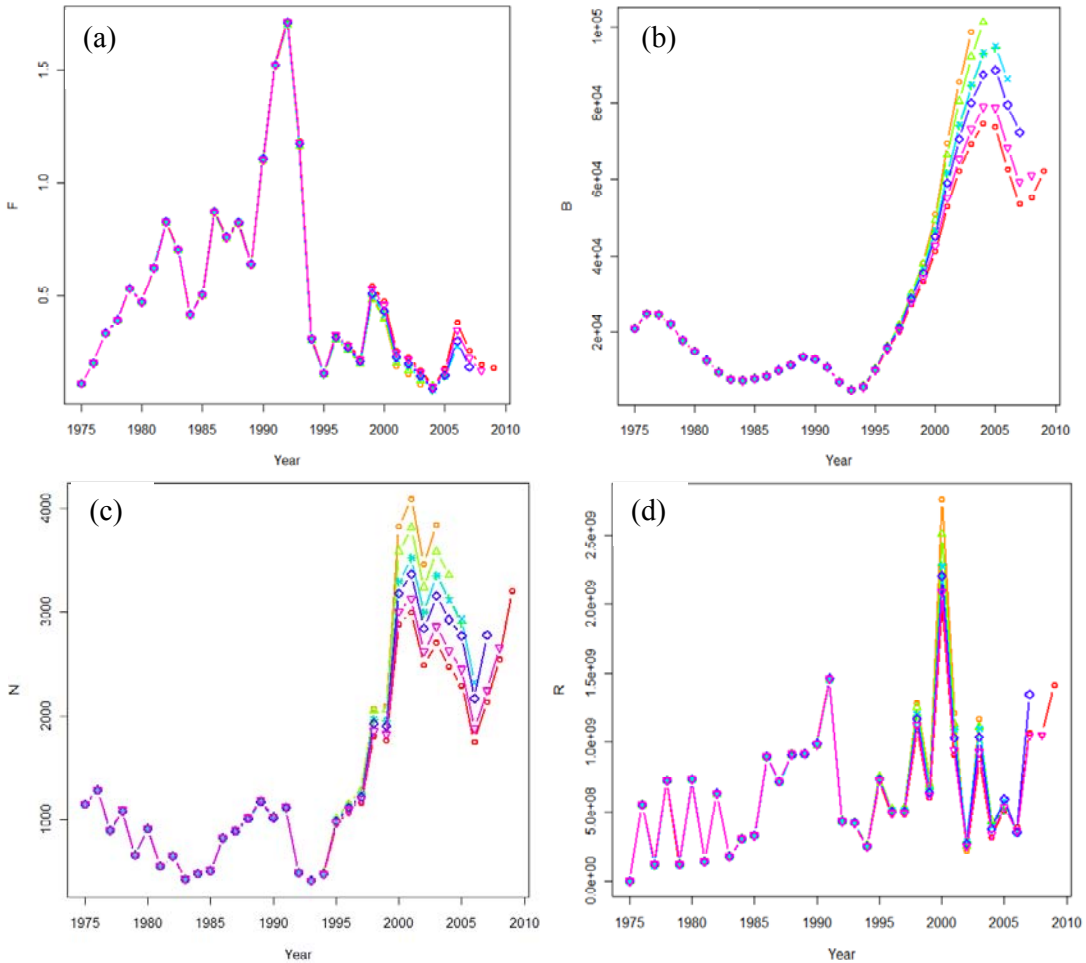


Figure B-45. Plots of retrospective analysis of the Georges Bank CASA model: (a) fishing mortality, (b) biomass, (c) abundance, and (d) recruitment. The CASA model was run with terminal year 2004 (orange), 2005 (green), 2006 (cyan), 2007 (blue), 2008 (magenta) and 2009 (red).

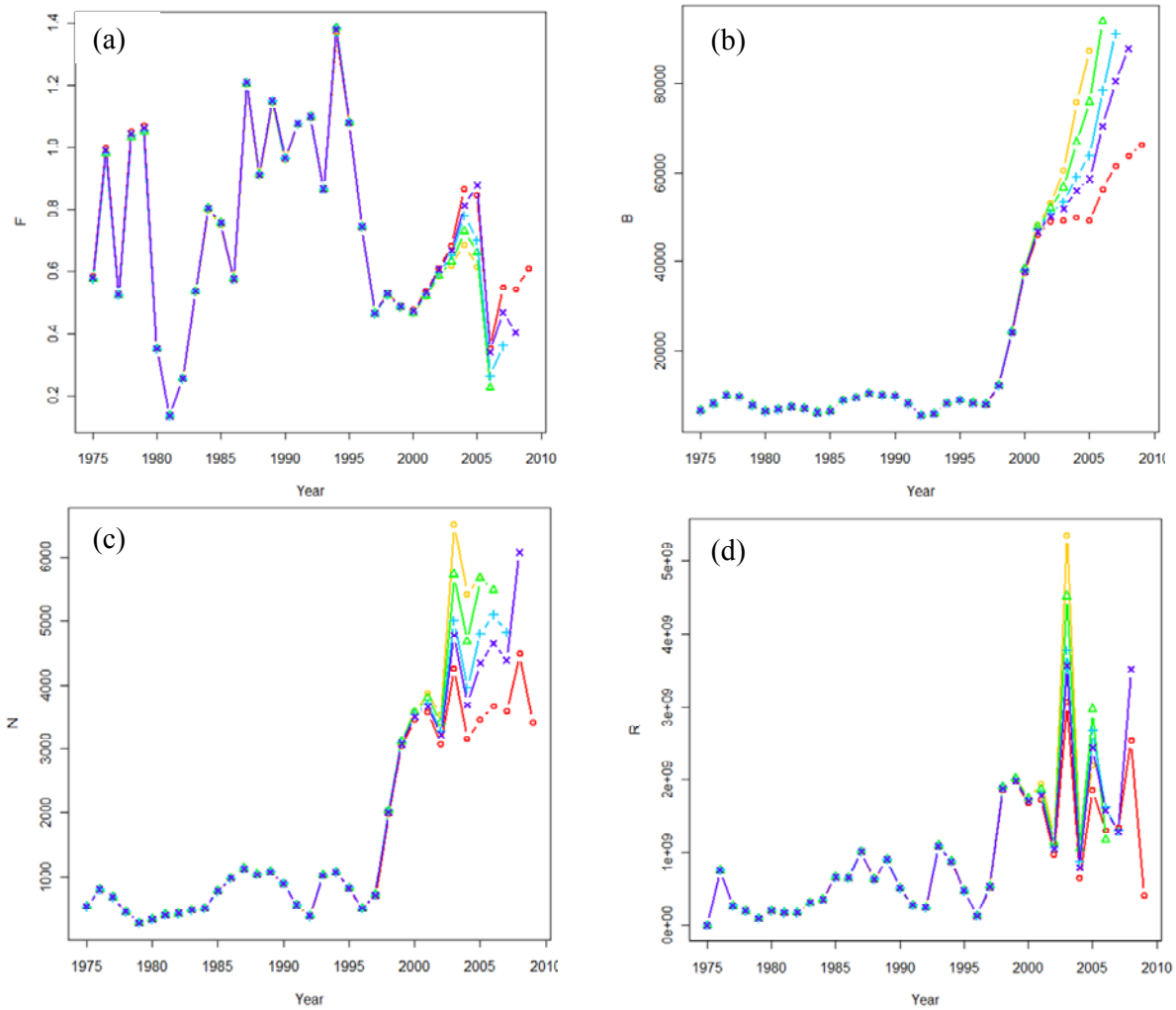


Figure B-46. Plots of retrospective analysis of the Mid-Atlantic CASA model: (a) fishing mortality, (b) biomass, (c) abundance, and (d) recruitment. The CASA model was run with terminal years 2004 (orange), 2005 (green), 2006 (cyan), 2007 (blue), 2008 (purple) and 2009 (red).

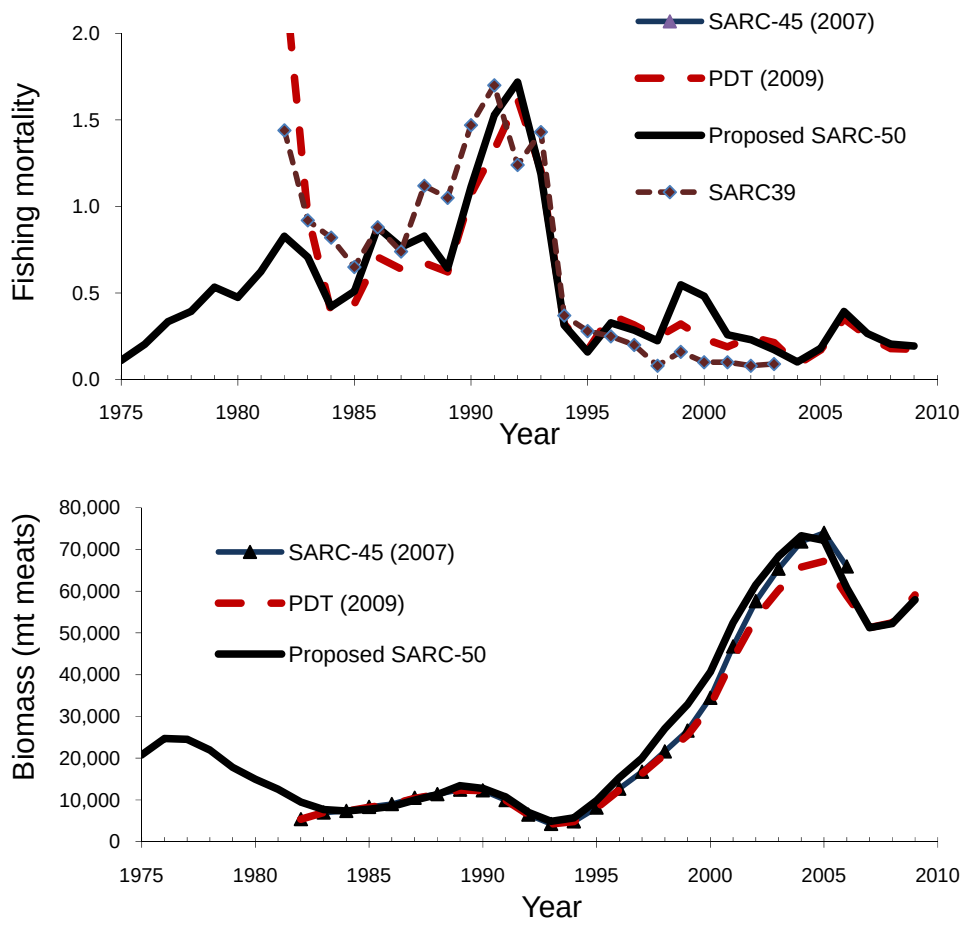


Figure B-47. Comparison of current estimates (black line) of fully recruited fishing mortality (above) and July 1 biomass (below) on Georges Bank with that of previous assessments (SARC-39/NEFSC 2004 short dashed line (fishing mortality only), SARC-45/NEFSC 2007, blue line with triangles, update assessment by the scallop PDT in 2009 (NEFMC 2010), long red dashed line).

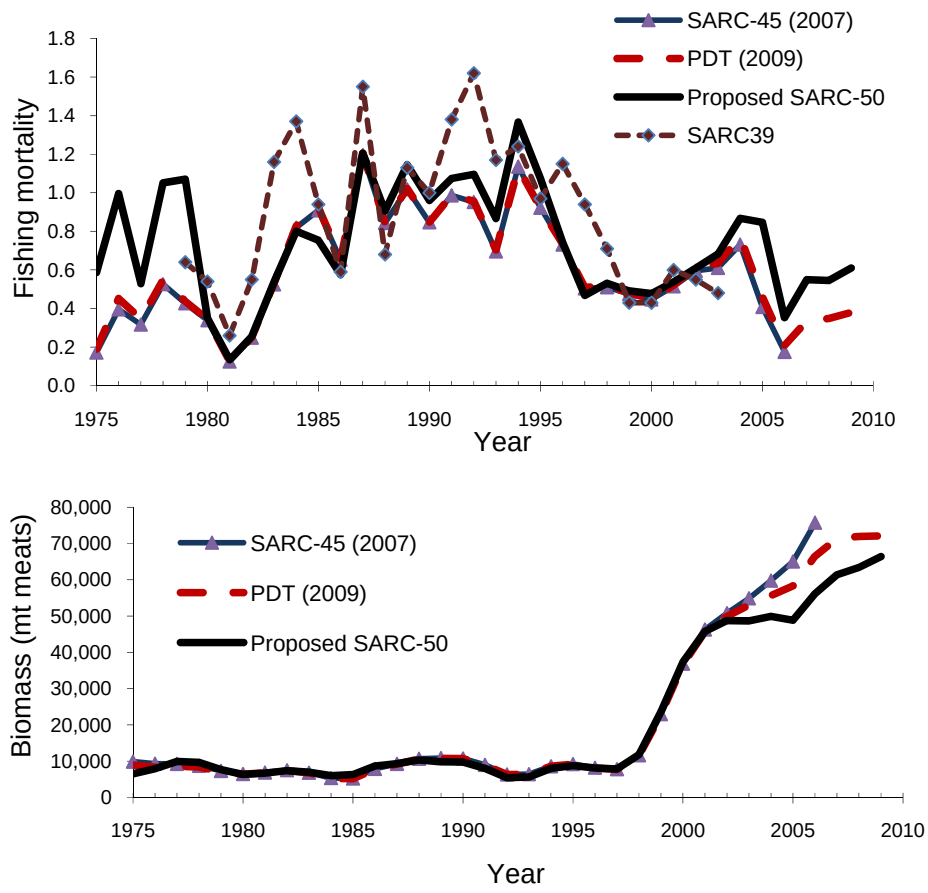


Figure B-48. Comparison of current estimates (black line) of fishing mortality (above) and biomass (below) in the Mid-Atlantic with that of previous assessments (SARC-39/NEFSC 2004 short dashed line (fishing mortality only), SARC-45/NEFSC 2007, blue line with triangles, update assessment by the scallop PDT in 2009 (NEFMC 2010), long red dashed line).

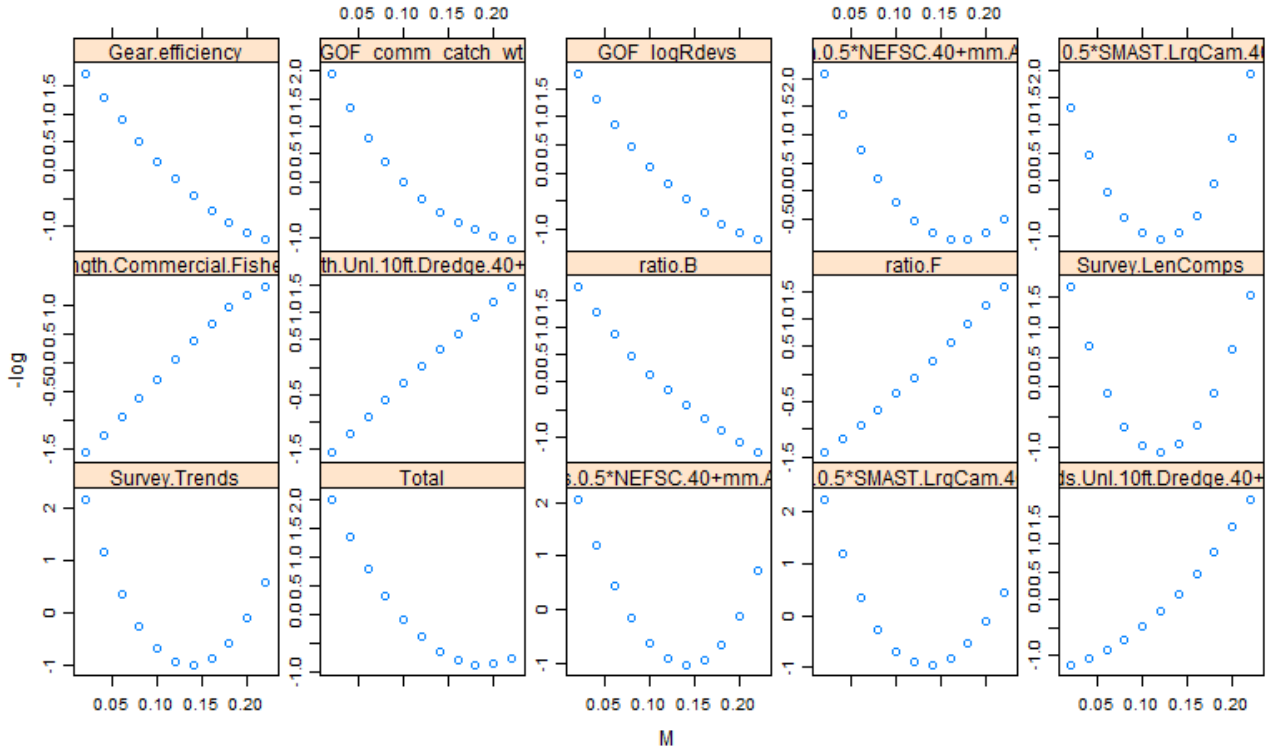


Figure B-49 Likelihood profile for (a) natural mortality and (b) large camera efficiency (q) on Georges Bank.

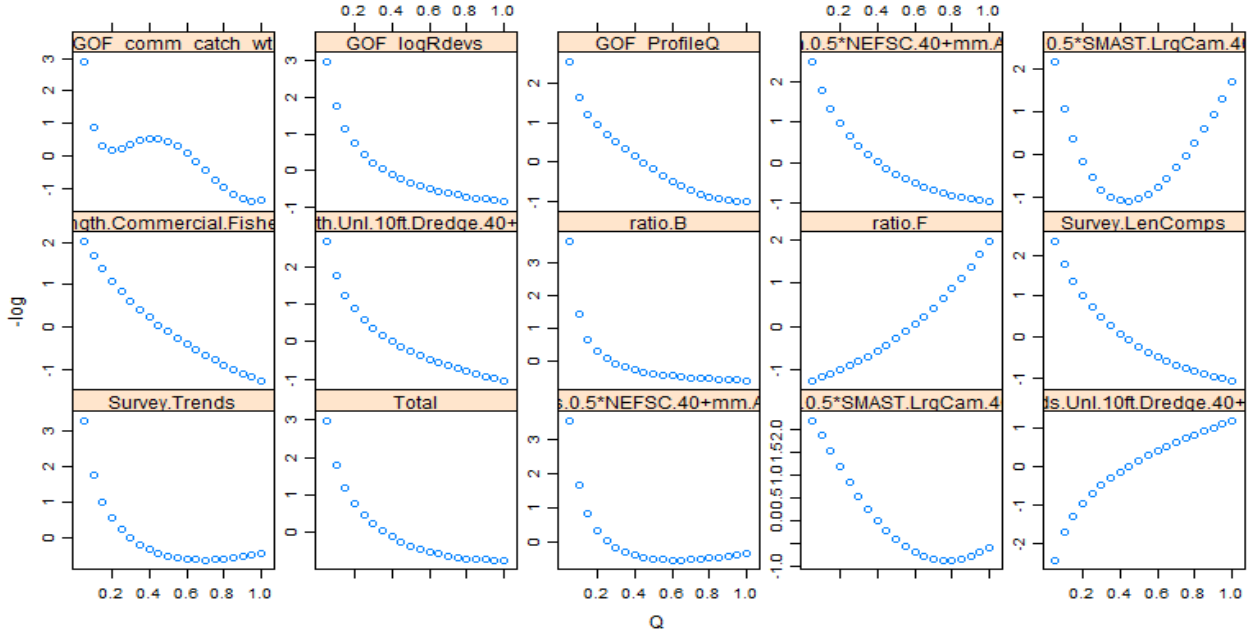

GOF_comm_catch_wt
GOF_logRdevs
GOF_ProfileQ
0.5*NEFSC.40+mm.A
0.5*SMAST.LrgCam.4
ngth.Commercial.Fishe
th.Unl.10ft.Dredge.40+
ratio.B
ratio.F
Survey.LenComps
Survey.Trends
Total
s.0.5*NEFSC.40+mm.A
0.5*SMAST.LrgCam.4
ds.Unl.10ft.Dredge.40+
-log
Q

Figure B-49(b)

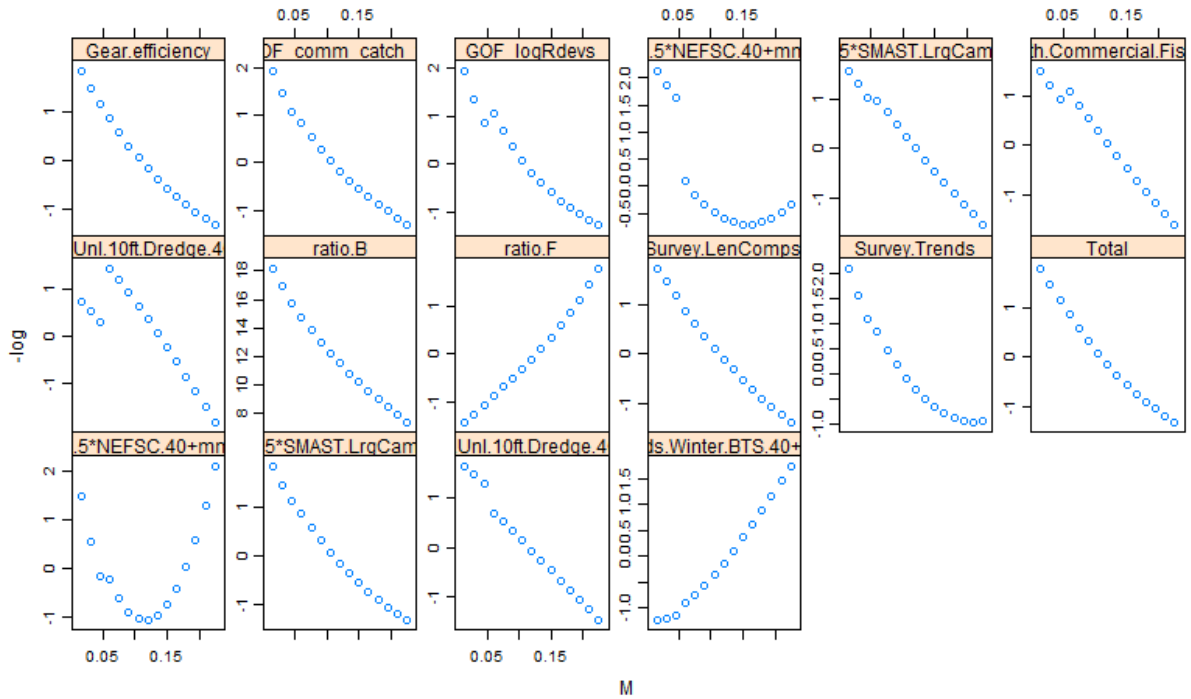


Figure B-50. Likelihood profiles for (a) natural mortality and (b) large camera survey *q* for the Mid-Atlantic.

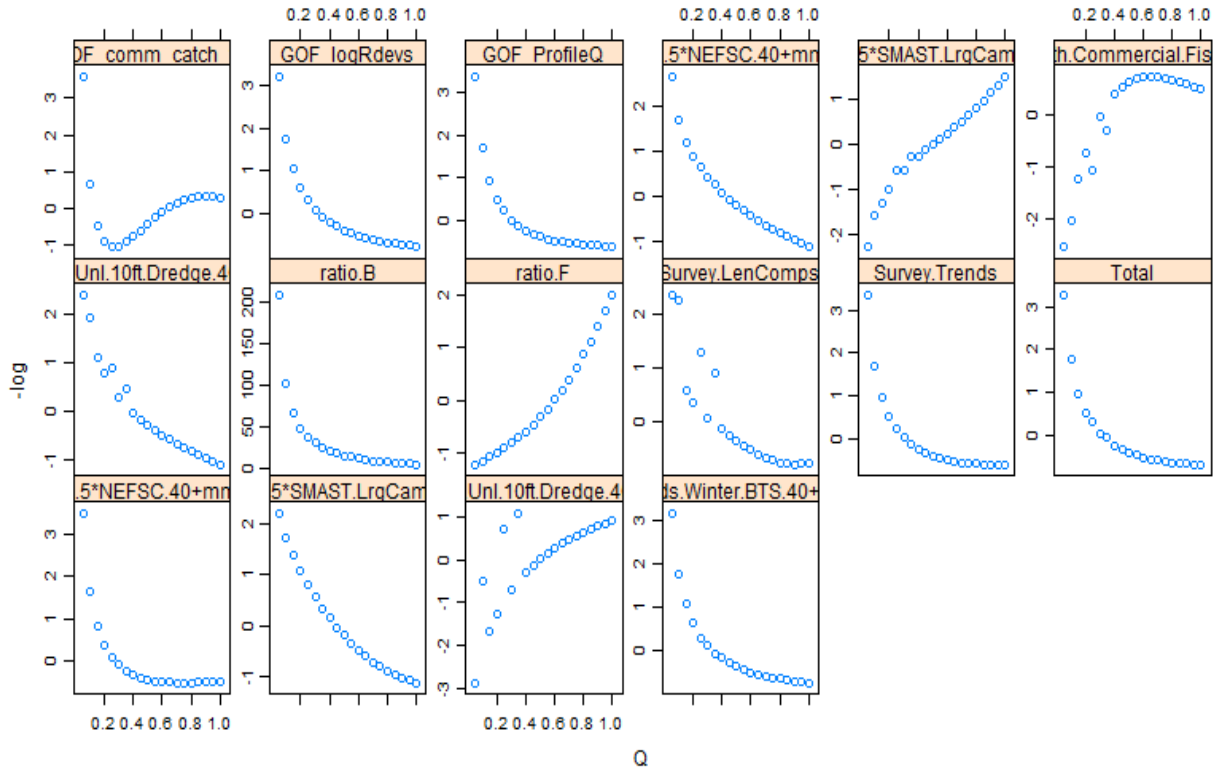

DF_comm_catch
GOF_logRdevs
GOF_ProfileQ
.5*NEFSC.40+mn
5*SMAST.LrgCam
h.Commercial.Fis
Unl.10ft.Dredge.4
ratio.B
ratio.F
Survey.LenComps
Survey.Trends
Total
.5*NEFSC.40+mn
5*SMAST.LrgCam
Unl.10ft.Dredge.4
ds.Winter.BTS.40+
-log
Q

Figure B-50 (b)

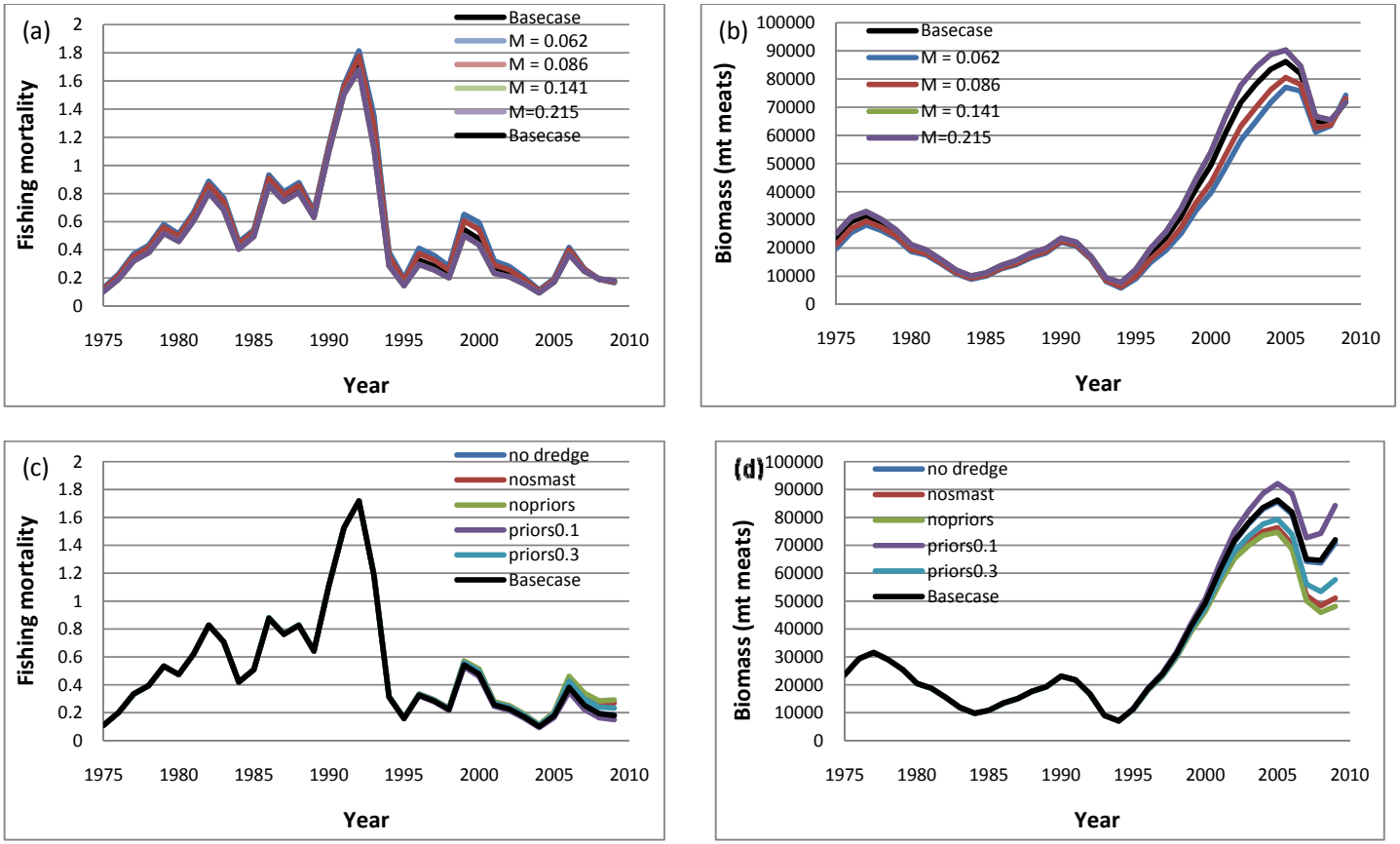


Figure B-51. Sensitivity analysis to the assumed value of (a-b) natural mortality and (c-d) priors on estimated values of fully recruited fishing mortality (a) and (c), and biomass (b) and (d) on Georges Bank. The values of natural mortality represent the assumed value (0.12, basecase) and the 5th, 25th, 75th and 95th percentile of the distribution of *M* used in the stochastic reference point model (Section 7). The assumptions on the priors are dredge and large camera cv = 0.15 (basecase), no dredge prior, no camera prior, no priors, cv = 0.1 for both priors and cv = 0.3 for both priors.

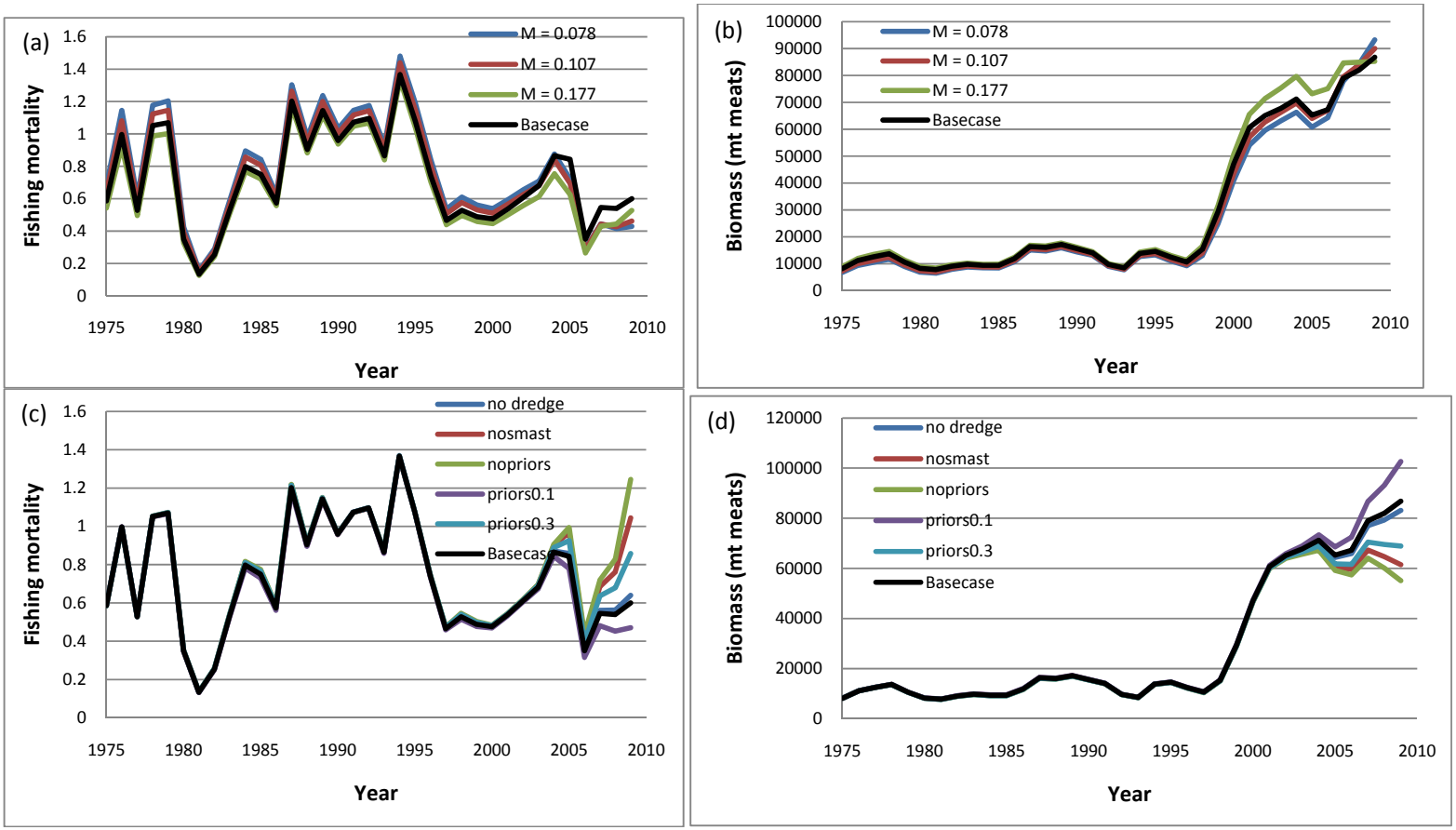


Figure B-52. Sensitivity analysis to the assumed value of (a-b) natural mortality and (c-d) large camera efficiency on estimated values of fully recruited fishing mortality (a) and (c), and biomass (b) and (d) on Georges Bank. The values of natural mortality represent the assumed value (0.12, basecase) and the 5th, 25th and 75th of the distribution of *M* used in the stochastic reference point model (Section 7; the model did not converge for the 95th percentile of M). The assumptions on the priors are dredge and large camera cv = 0.15 (basecase), no dredge prior, no camera prior, no priors, cv = 0.1 for both priors and cv = 0.3 for both priors.

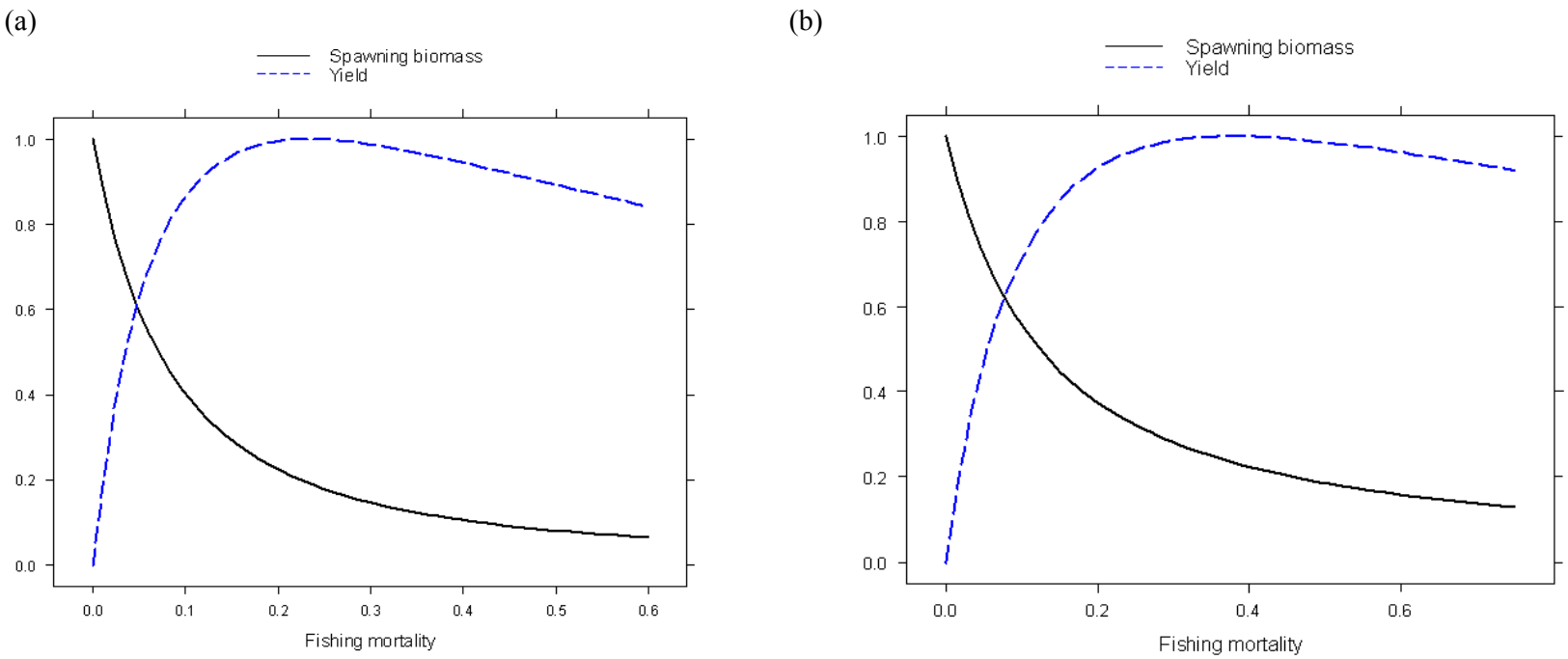
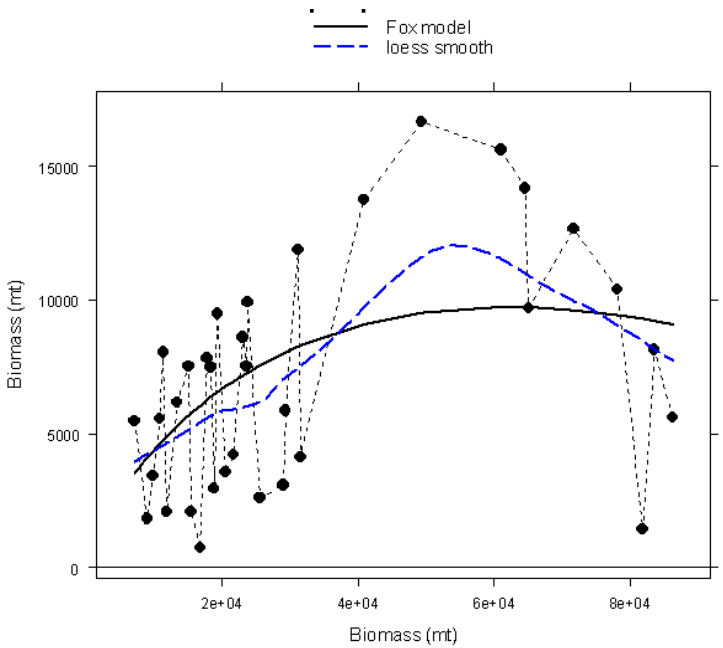


Figure B-53. Yield per recruit (blue dashed line) and spawning biomass per recruit (black solid line) for (a) Georges Bank and (b) Mid-Atlantic from the CASA model.

(a)



(b)

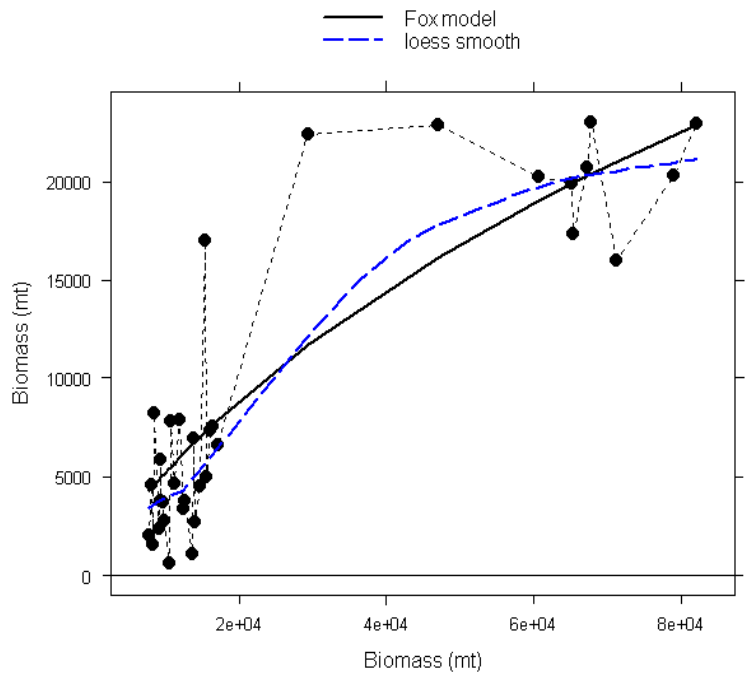


Figure B-54. Annual surplus production (solid circles) vs. biomass for (a) Georges Bank and (b) Mid-Atlantic. Fits to the Fox surplus production model (solid lines) and a lowess smoother are also shown.

(a) (b)

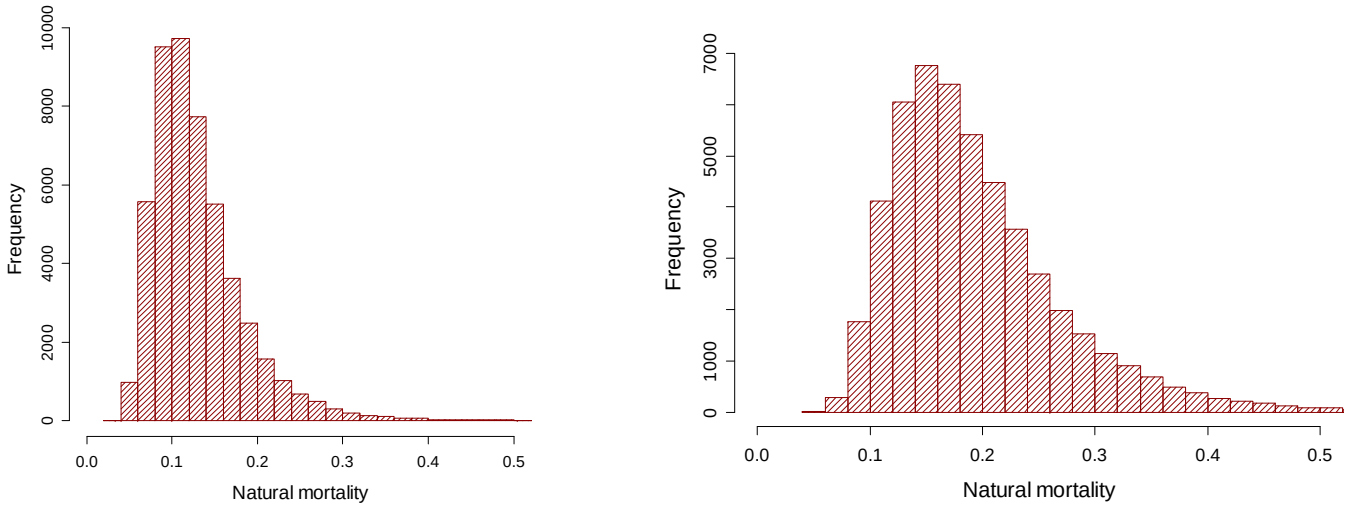
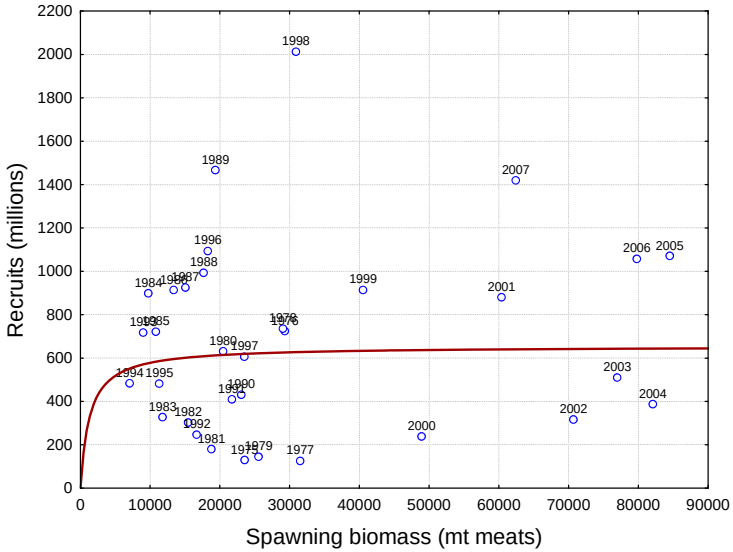


Figure B-55. Histograms of the assumed distributions of natural mortality in (a) Georges Bank and (b) the Mid-Atlantic.

(a)



(b)

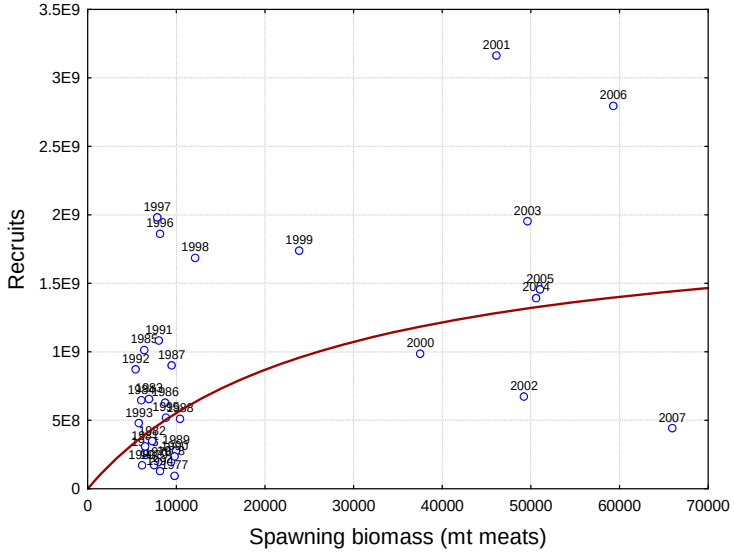


Figure B-56. Plots of stock-recruit relationships together with fits to Beverton-Holt stock-recruit curves for (a) Georges Bank and (b) Mid-Atlantic.

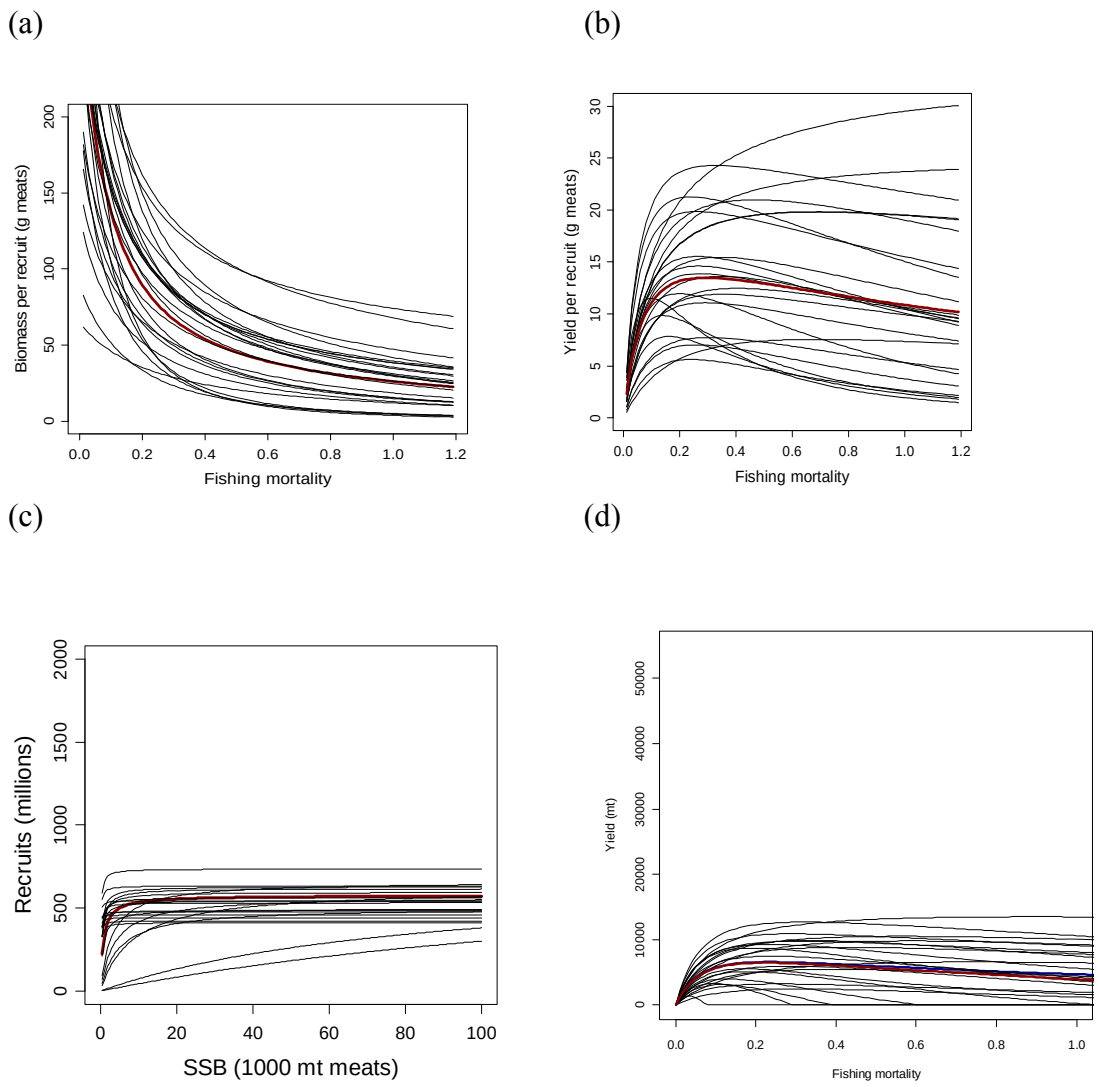


Figure B-57. Plots of (a) yield per recruit, (b) biomass per recruit, (c) stock-recruit and (d) yield from the SYM model for Georges Bank. The heavy red line is the mean of 50000 simulations, the blue line the median (yield only). 25 example plots from individual simulations are also shown.

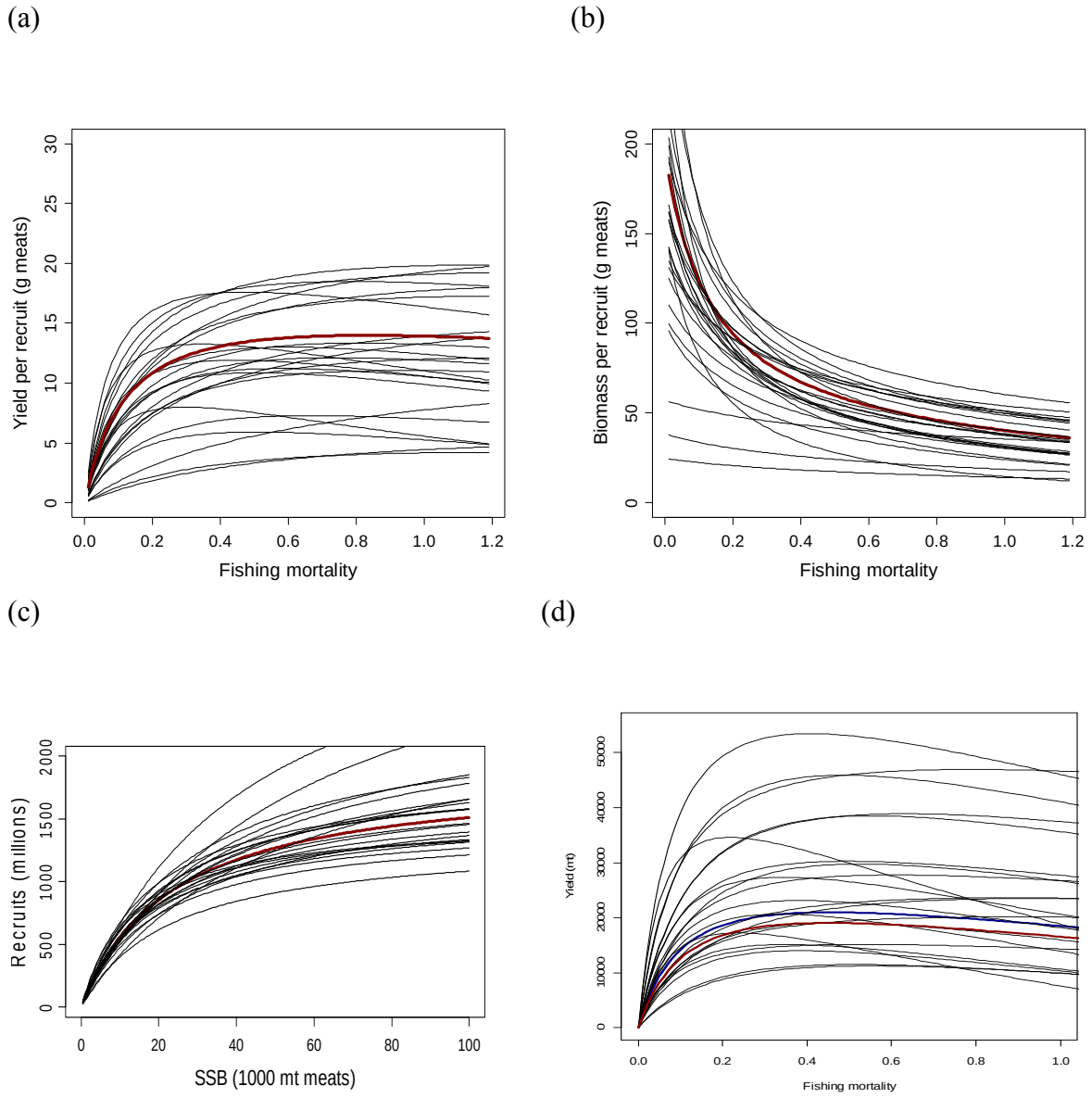
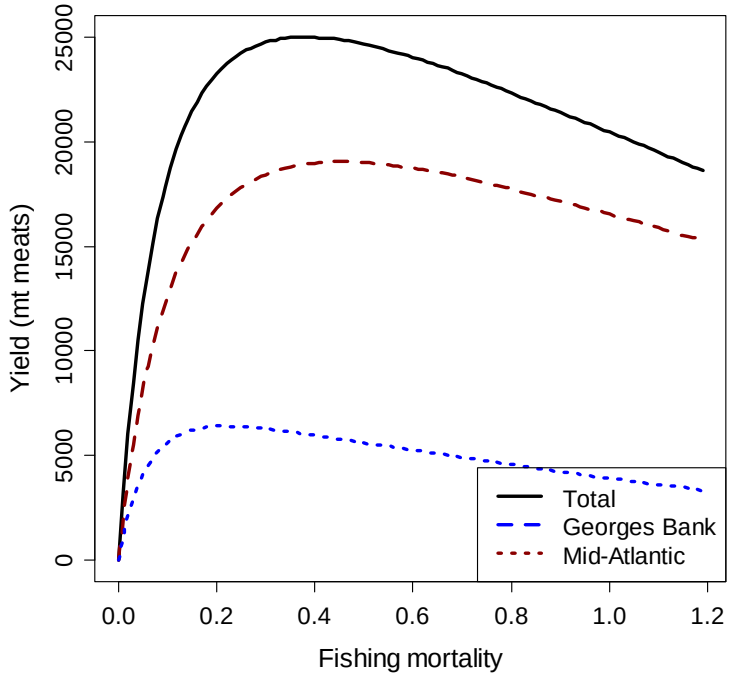
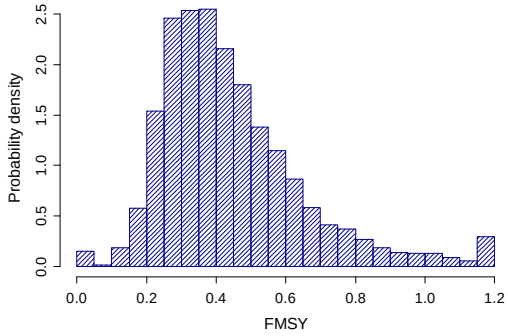


Figure B-58. Plots of (a) yield per recruit, (b) biomass per recruit, (c) stock-recruit and (d) yield from the SYM model for the Mid-Atlantic. The heavy red line is the mean of 50000 simulations, the blue line the median (yield only). 25 example plots from individual simulations are also shown.

(a)



(b)



(c)

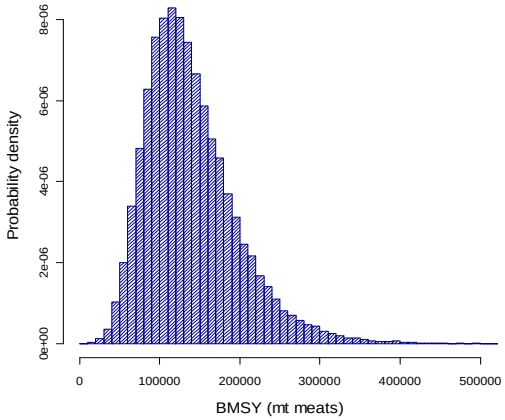


Figure B-59. (a) Median yield curves for Georges Bank, Mid-Atlantic, and overall yield. (b) Probability densities for whole-stock F_{MSY} and (c) probability densities for whole-stock B_{MSY} obtained from the SYM model.

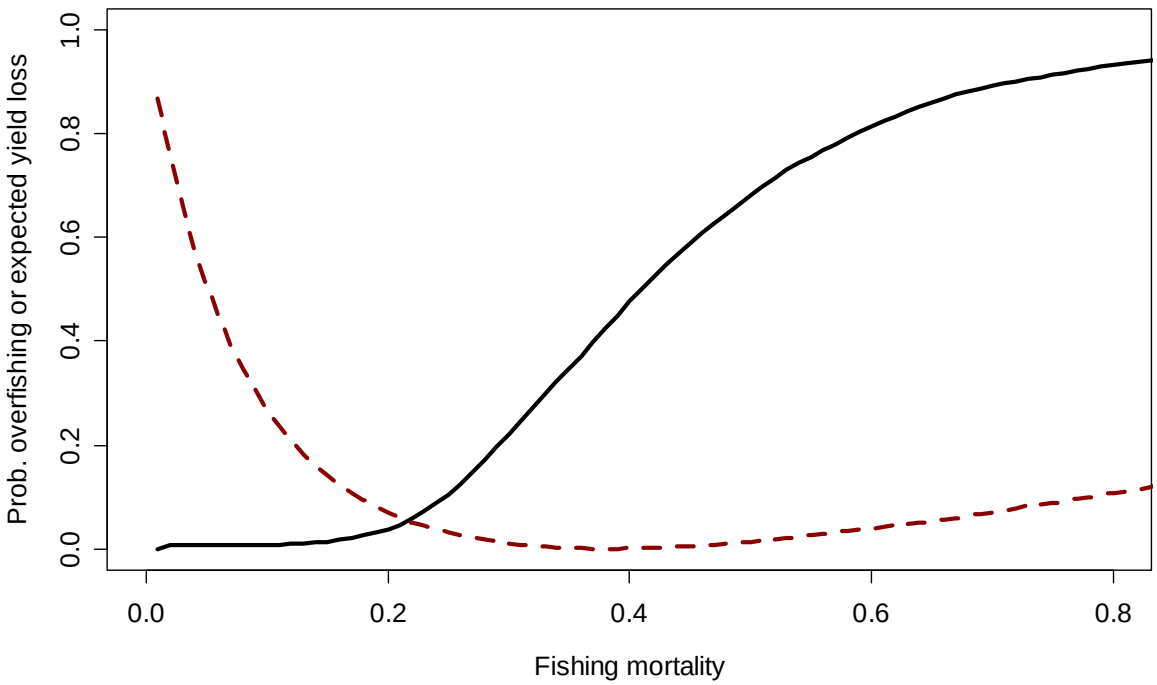


Figure B-60. The probability of overfishing as a function of realized fishing mortality (black solid line) and the loss of expected yield relative to that obtained at F_{MSY}.

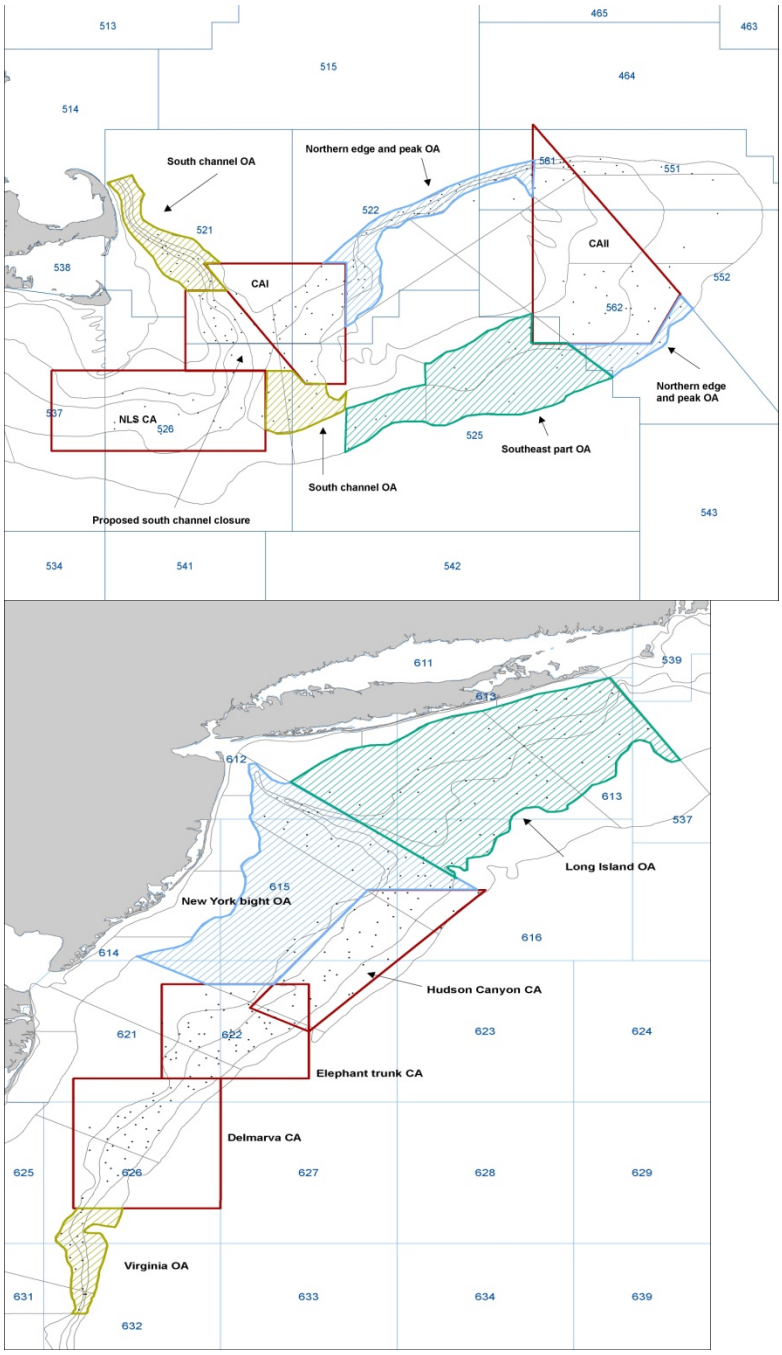


Figure B-61. Map of the 16 SAMS model areas. Each of the three Georges Bank closed areas are split into access and essential fish habitat areas, consistent with current management. Shellfish survey strata, NAFO statistical areas (rectangles), and 2009 NEFSC survey stations (dots) are also shown

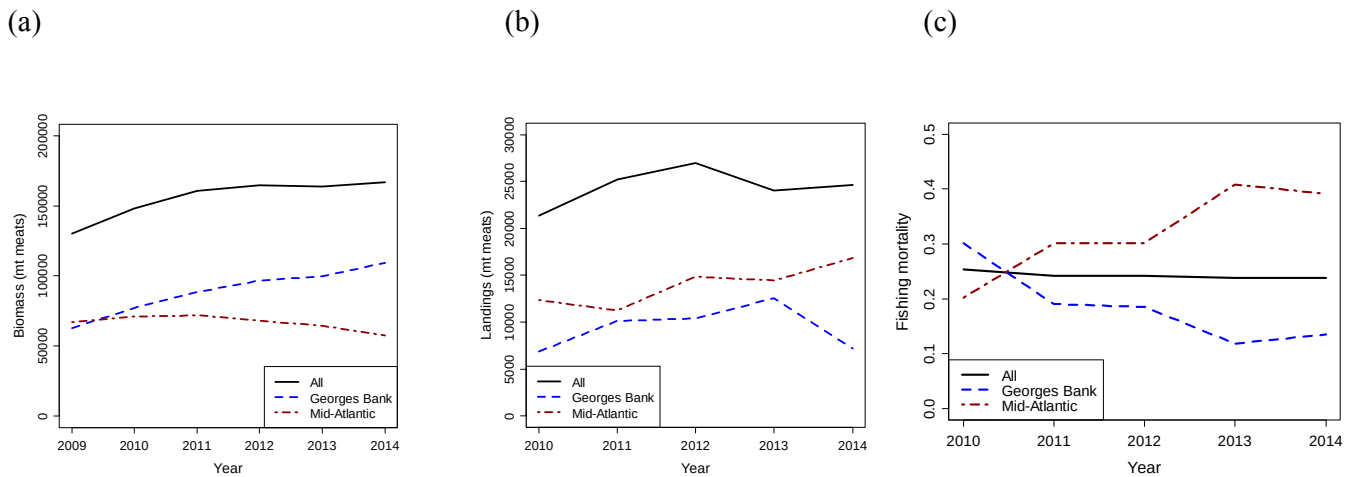


Figure B-62. Mean projected (a) biomass, (b) landings and (c) fishing mortality for Georges Bank (blue dashed line), Mid-Atlantic (red dot-dashed line) and overall (solid black line).

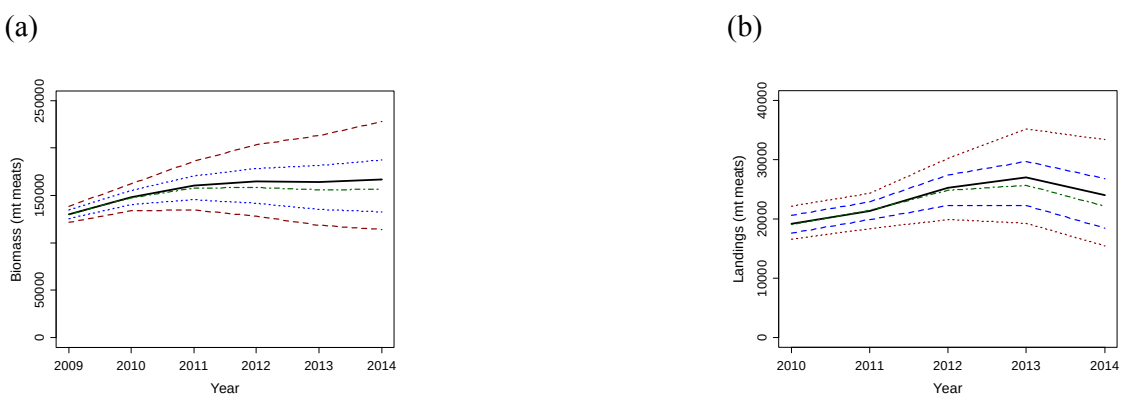


Figure B-63. The mean (black solid line), 10th and 90th percentiles (red dashed lines), 25th and 75th percentiles (dotted blue lines) and median (green dashed-dotted line) of projected overall (a) biomass and (b) landings.