Figures

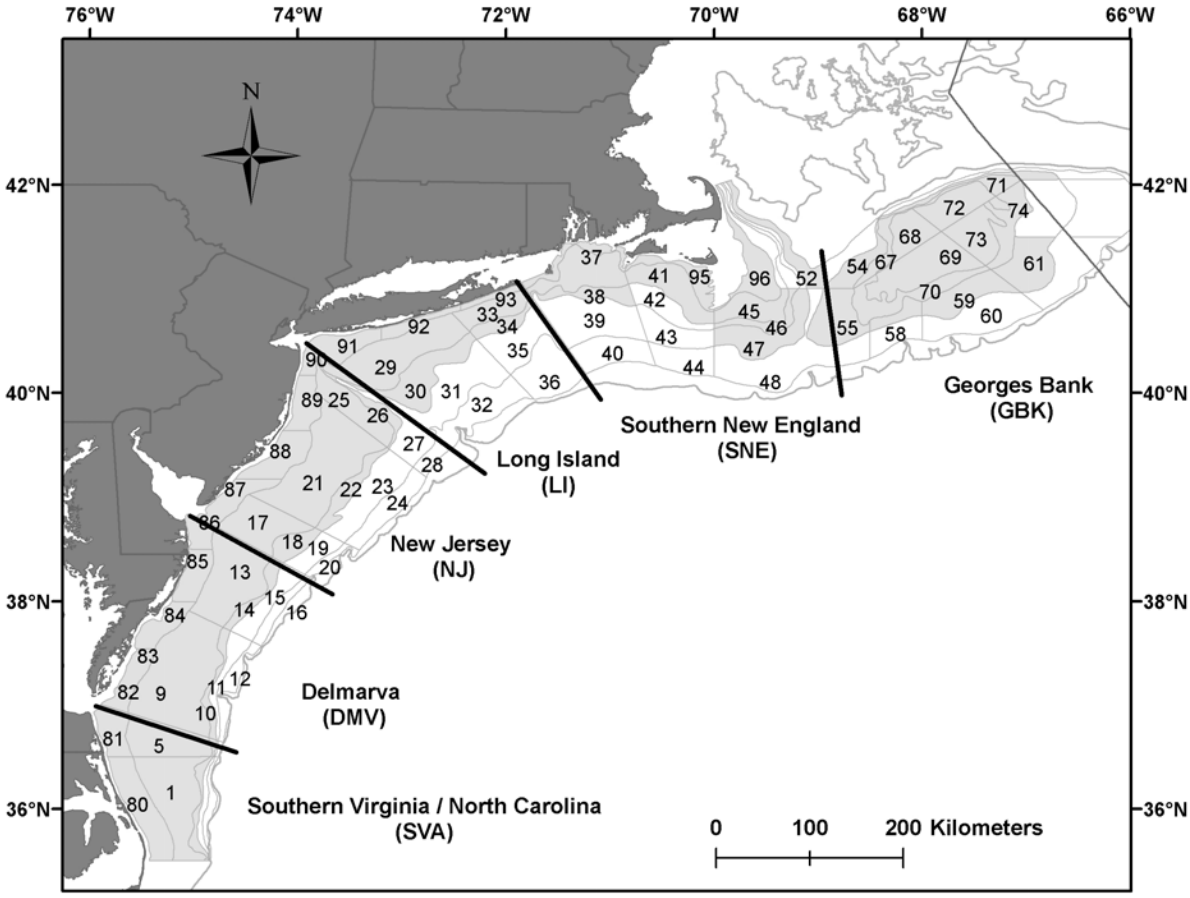

Figure A1. Surfclam stock assessment regions and NEFSC shellfish survey strata. The shaded strata are where surfclams are found.

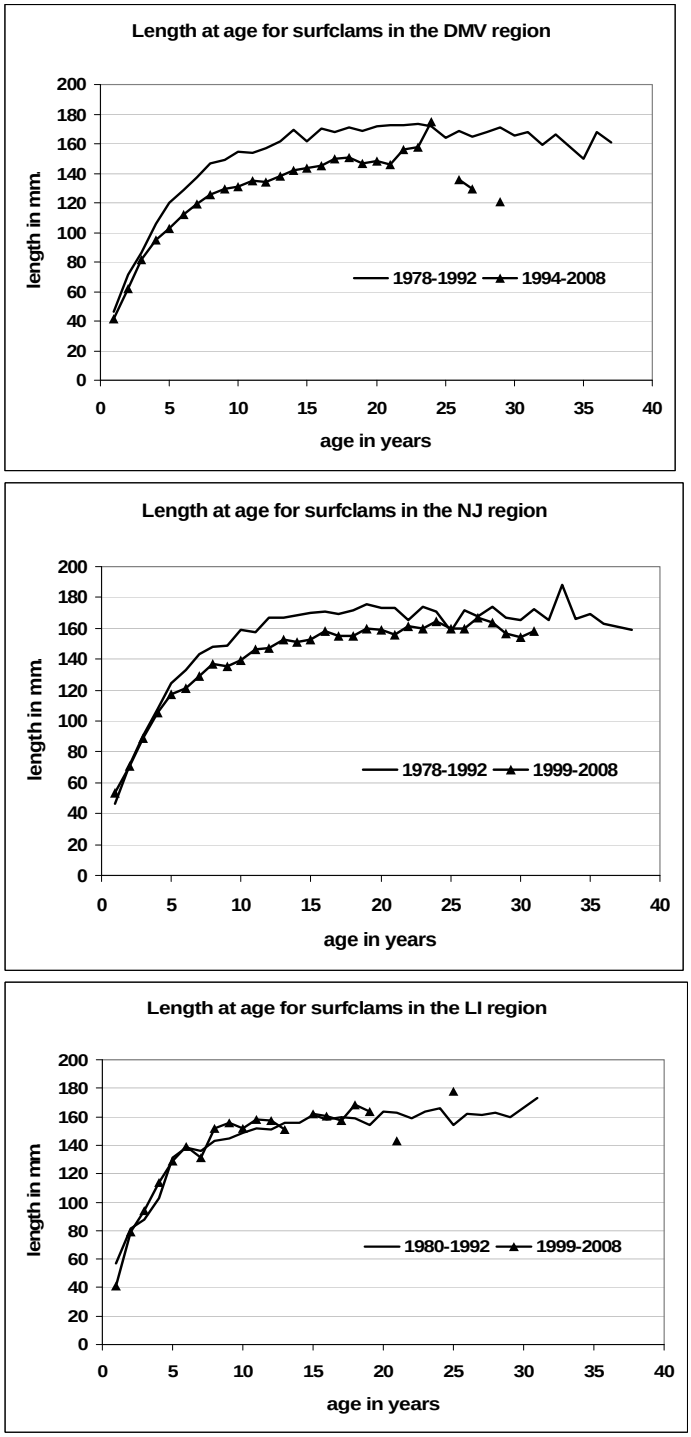

Figure A2. Length at age for surfclams in the DMV, NJ and LI regions, based on NEFSC clam survey data.

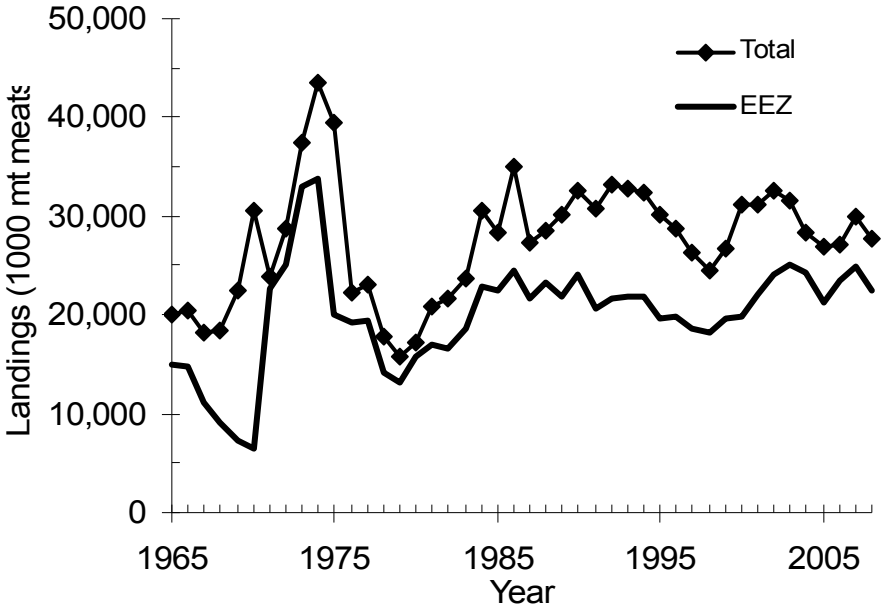

Figure A3. Surfclam landings (total and EEZ) during 1965-2008. Landings from fishing state waters (primarily NJ and NY) account for the difference between total and EEZ landings.

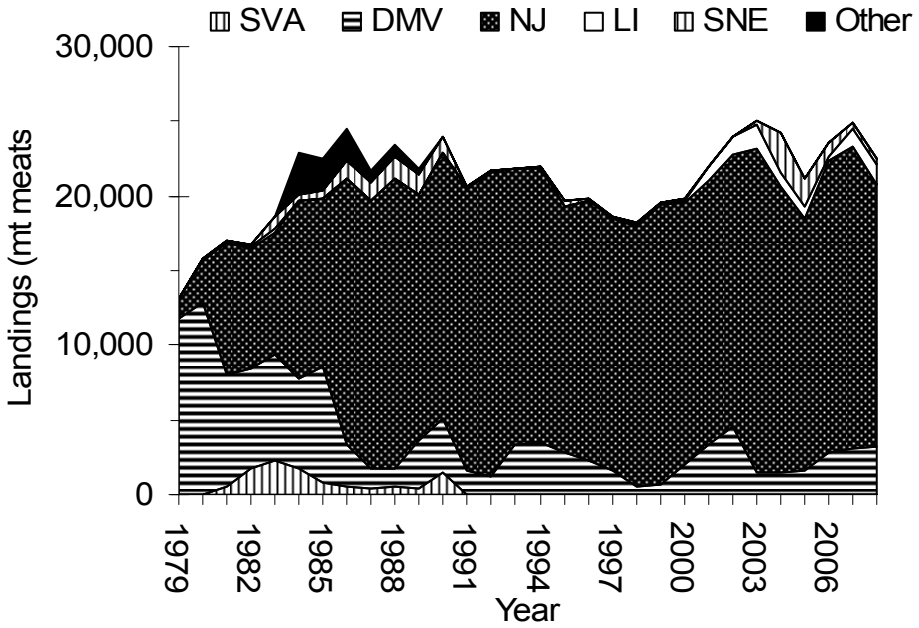

Figure A4. Surfclam landings from the US EEZ during 1979-2008, by stock assessment region.

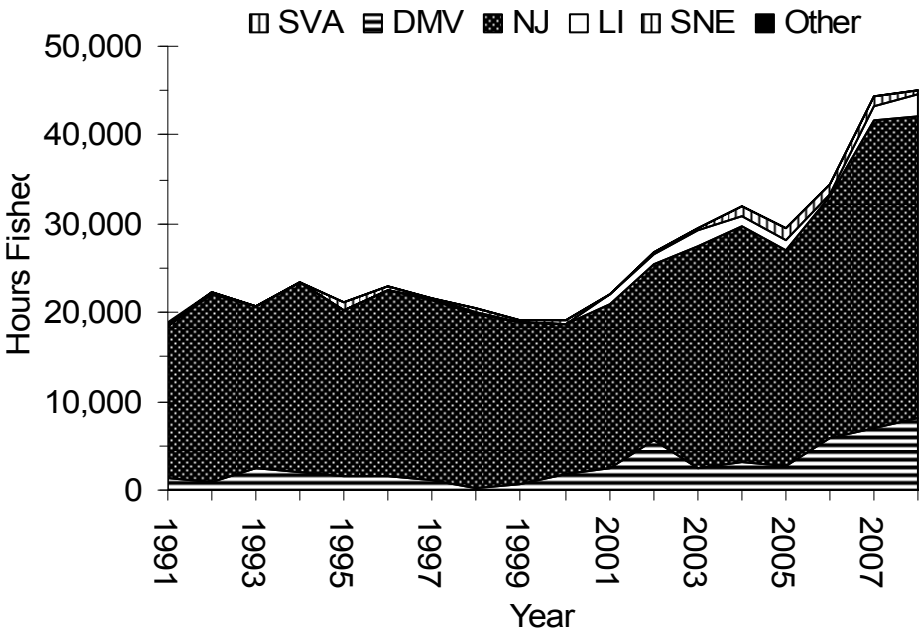

Figure A5. Total fishing effort (hours fished during all trips by all vessels) for surfclams during 1991-2008 in the US EEZ, by stock assessment region.

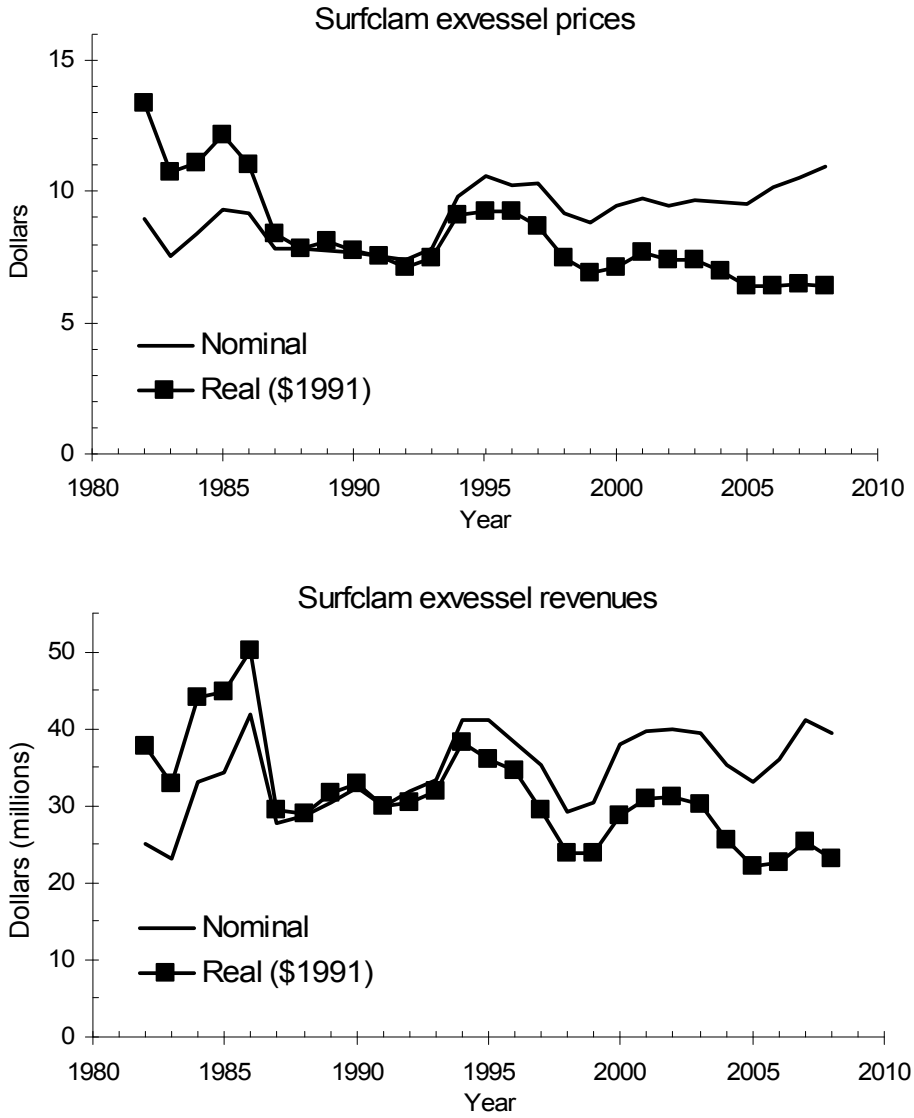

Figure A6. Real and nominal exvessel prices and revenues for surfclams based on dealer data. Average price was computed as total revenues (state waters and EEZ) divided by total landed meat weight during each year, rather than as annual averages of prices for individual trips, to reduce effects of small deliveries at relatively high prices. The consumer price index (CPI) used to convert nominal dollars to 1991 equivalent dollars is for unprocessed and packaged fish, which includes shellfish and finfish (Eric Thunberg, NEFSC, pers. comm.)

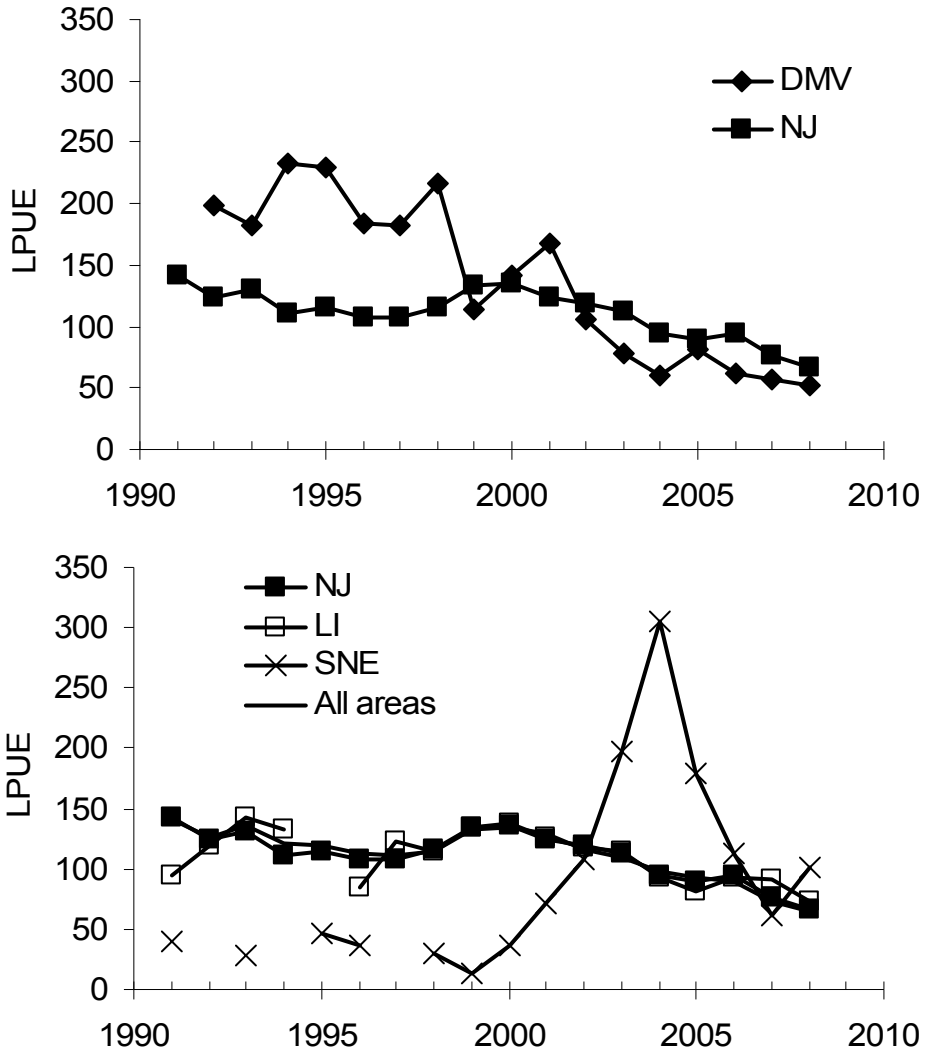

Figure A7. Nominal landings per unit effort (LPUE in bushels landed per hour fished) for surfclams, by region. NJ is shown in both panels to facilitate comparison of northern and southern regions. LPUE is total landings in bushels divided by total fishing effort.

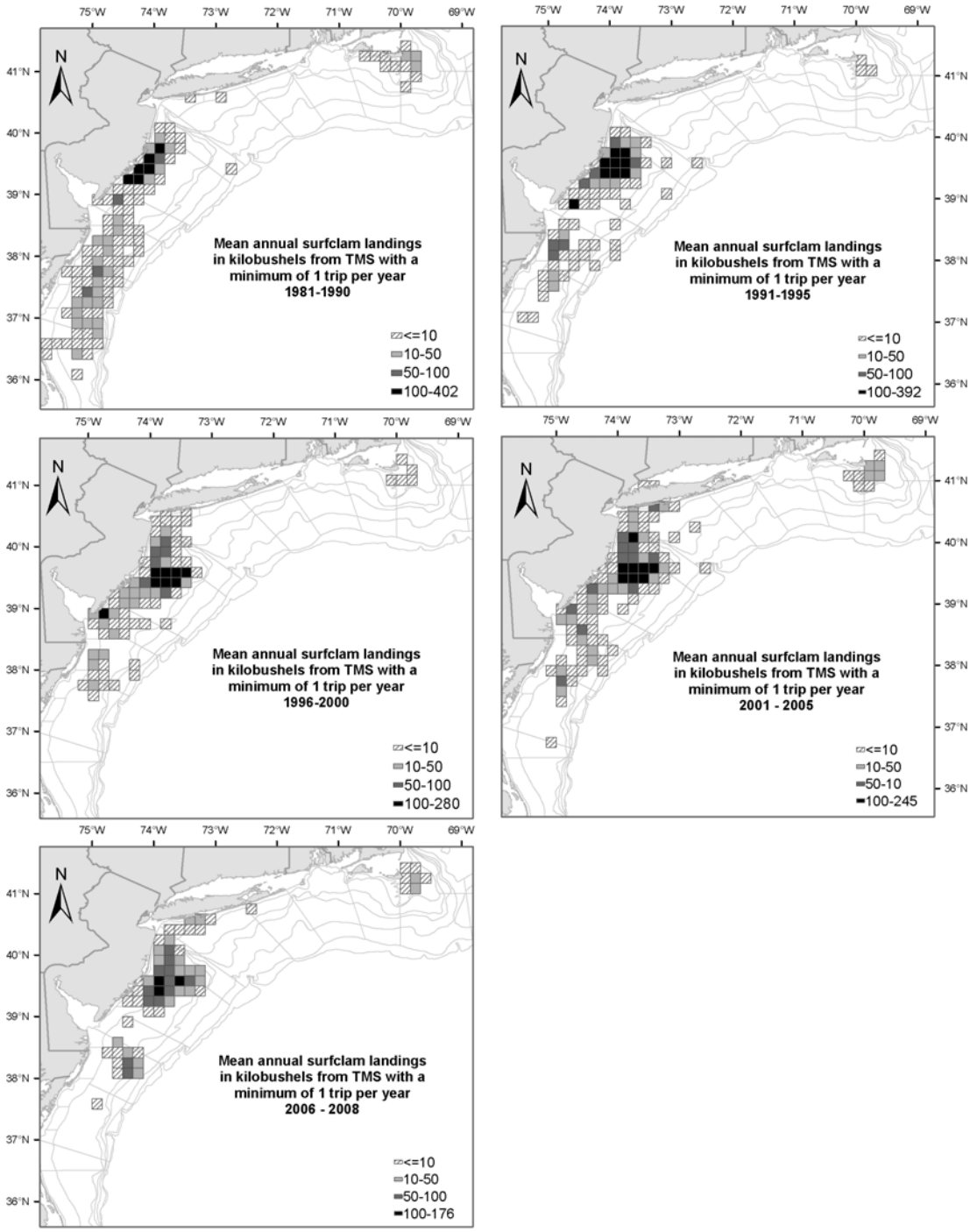

Figure A8. Spatial patterns in surfclam landings (1000 bu) in the US EEZ from logbooks. Spatial blocks are ten minute squares (TMS) shaded to reflect average landings per year.

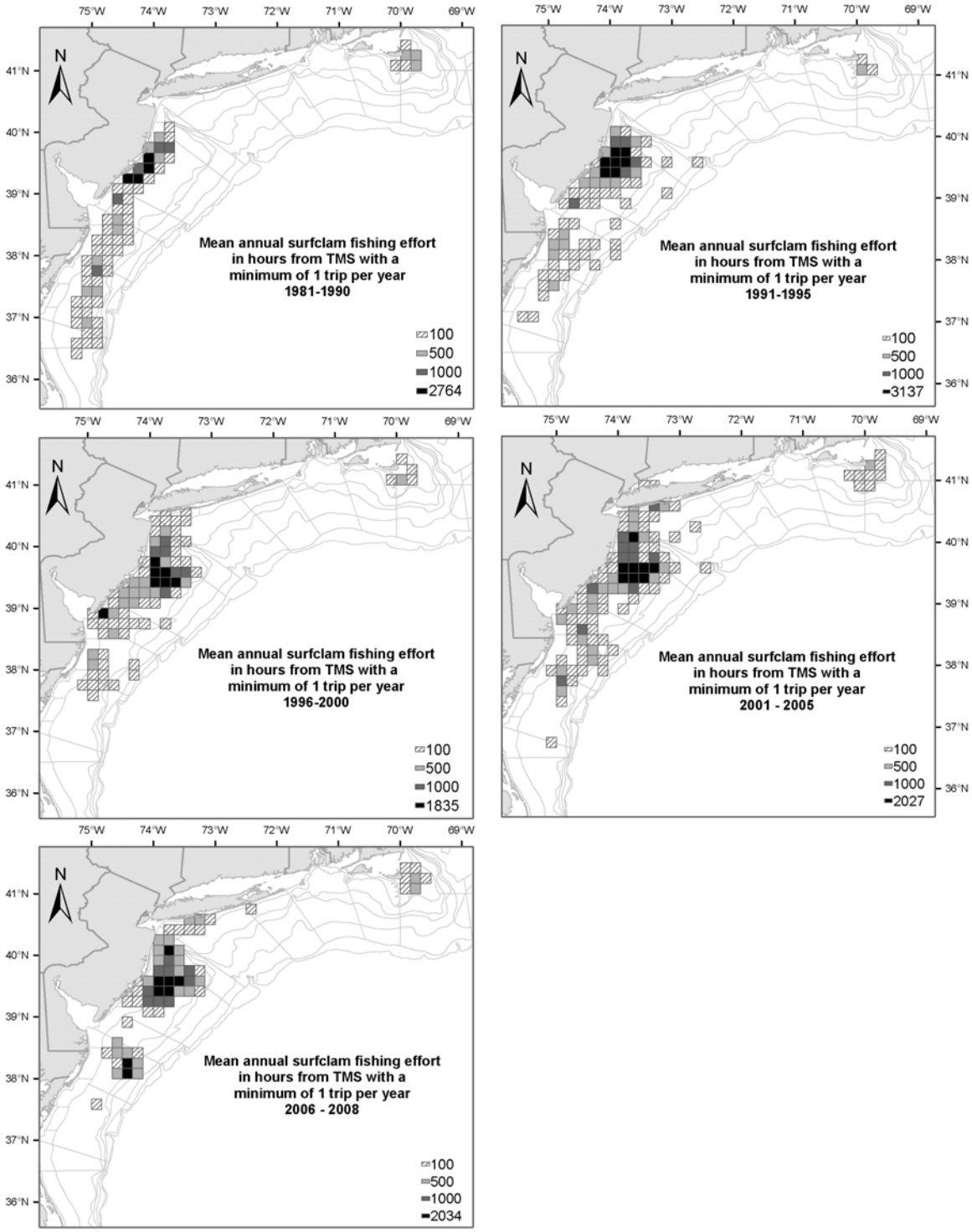

Figure A9. Spatial patterns in fishing effort (hours fished) in the US EEZ from logbooks. Spatial blocks are ten minute squares (TMS) shaded to reflect average fishing effort per year.

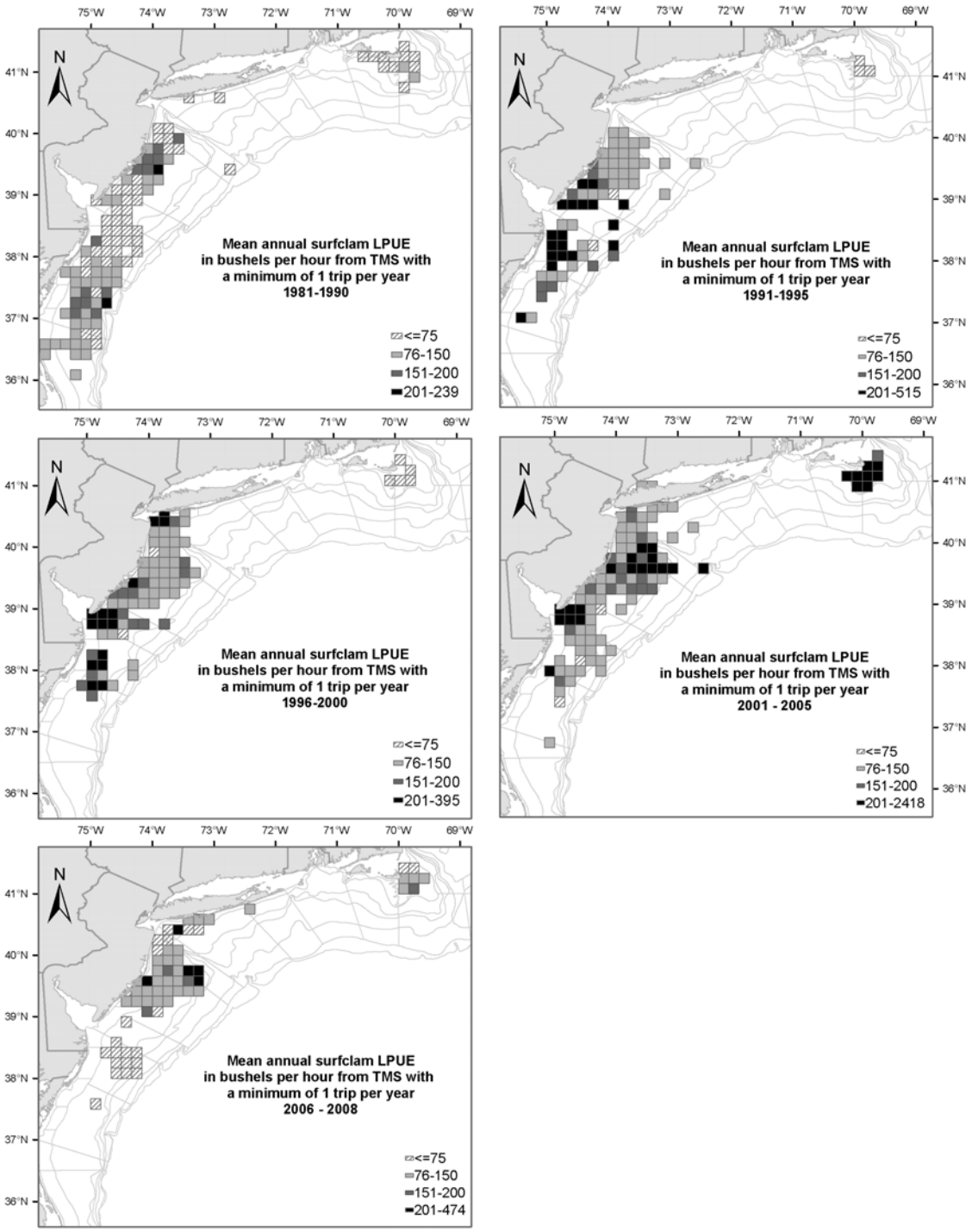

Figure A10. Spatial patterns in surfclam landings per unit fishing effort (LPUE, bushels landed per hour fished) in the US EEZ from logbooks. Spatial blocks are ten minute squares (TMS) shaded to reflect average LPUE per year.

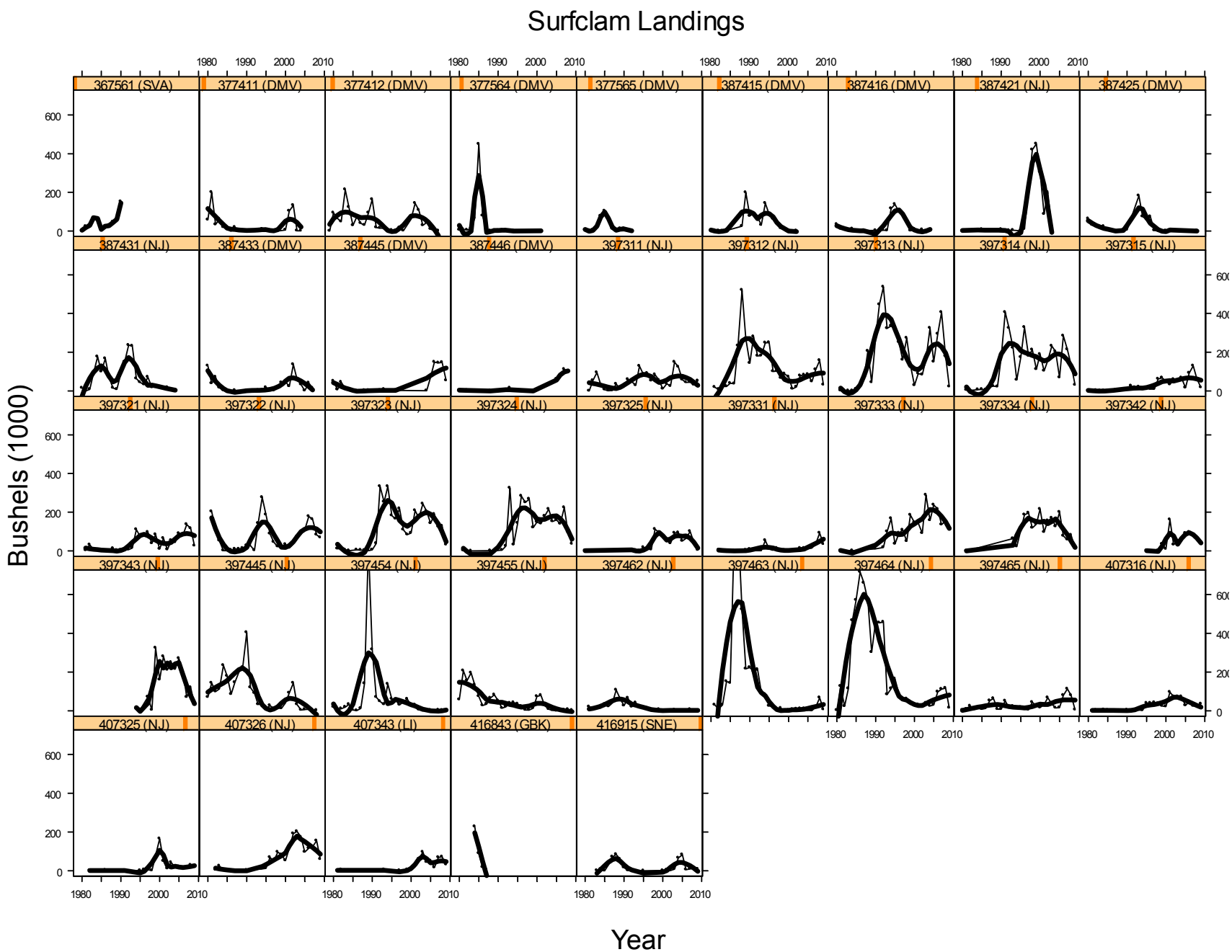

Figure A11. Annual surfclam landings (kilobushels per year) for important ten-minute squares during 1980-2008 based on logbook data. The smooth dark line is a spline intended to show trends.

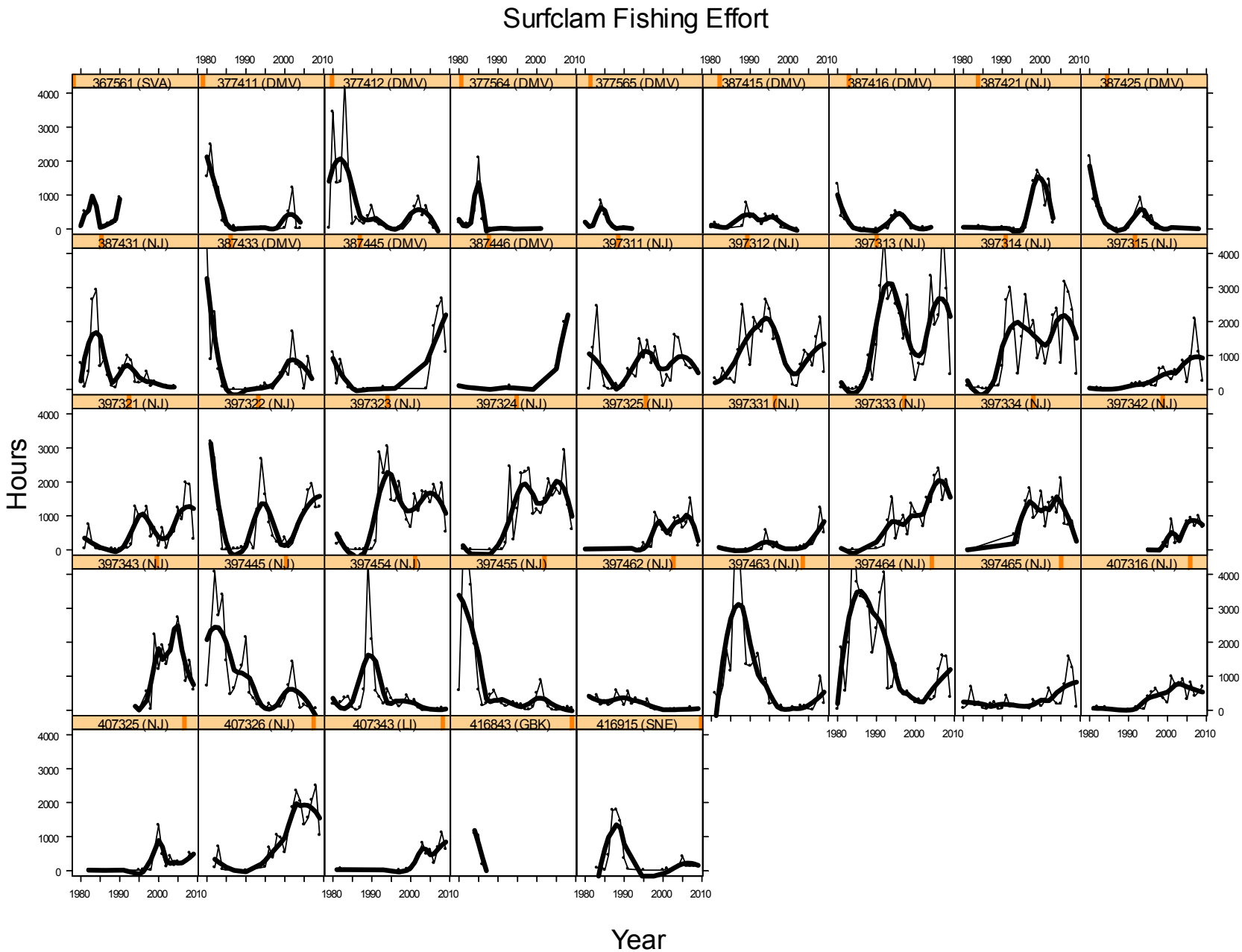

Figure A12. Annual surfclam fishing effort (hours per year) for important ten-minute squares during 1980-2008 based on logbook data. The smooth dark line is a spline intended to show trends.

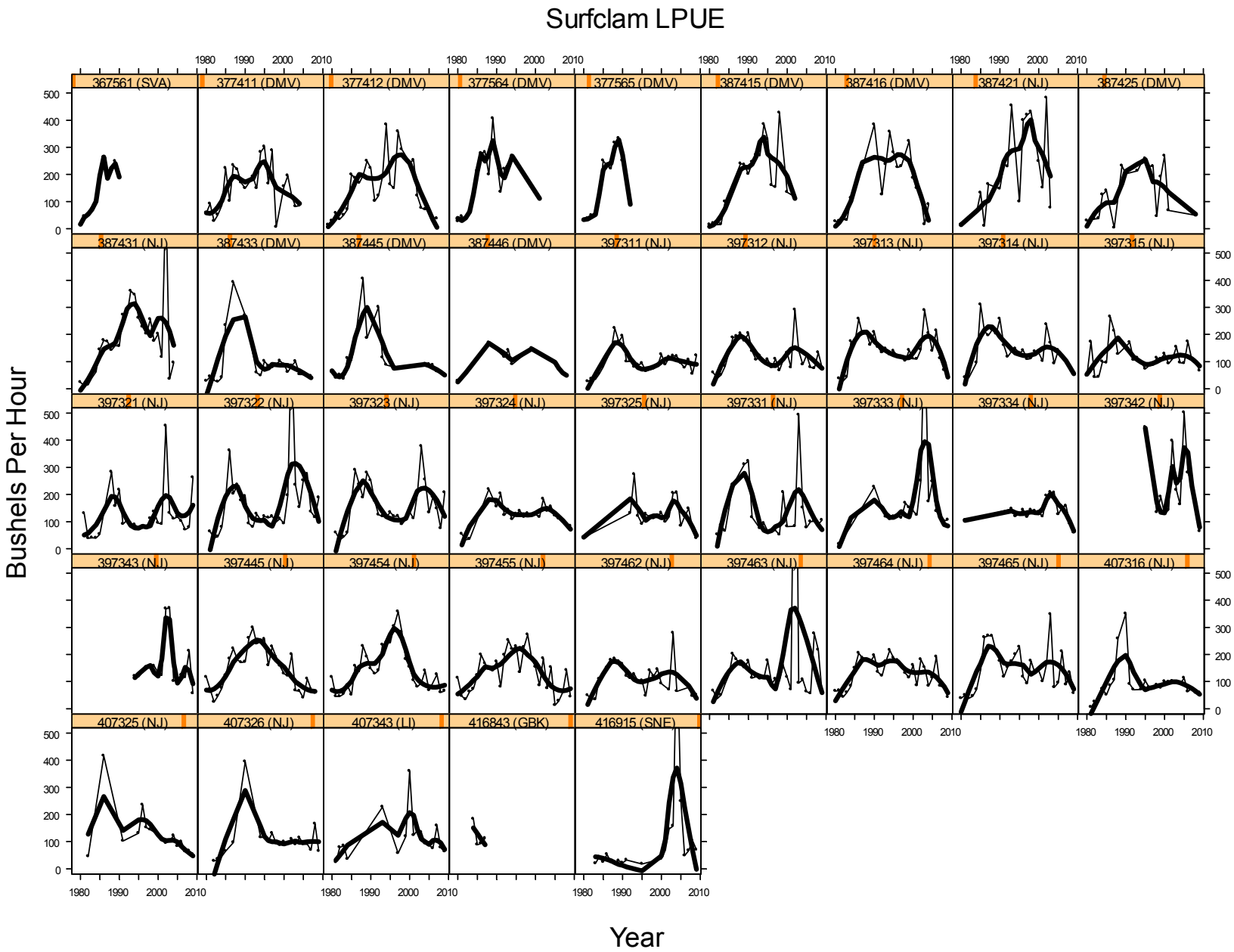

Figure A13. Annual surfclam LPUE (bushels per hour fished) for important ten-minute squares during 1980-2008 based on logbook data. The smooth dark line is a spline intended to show trends.

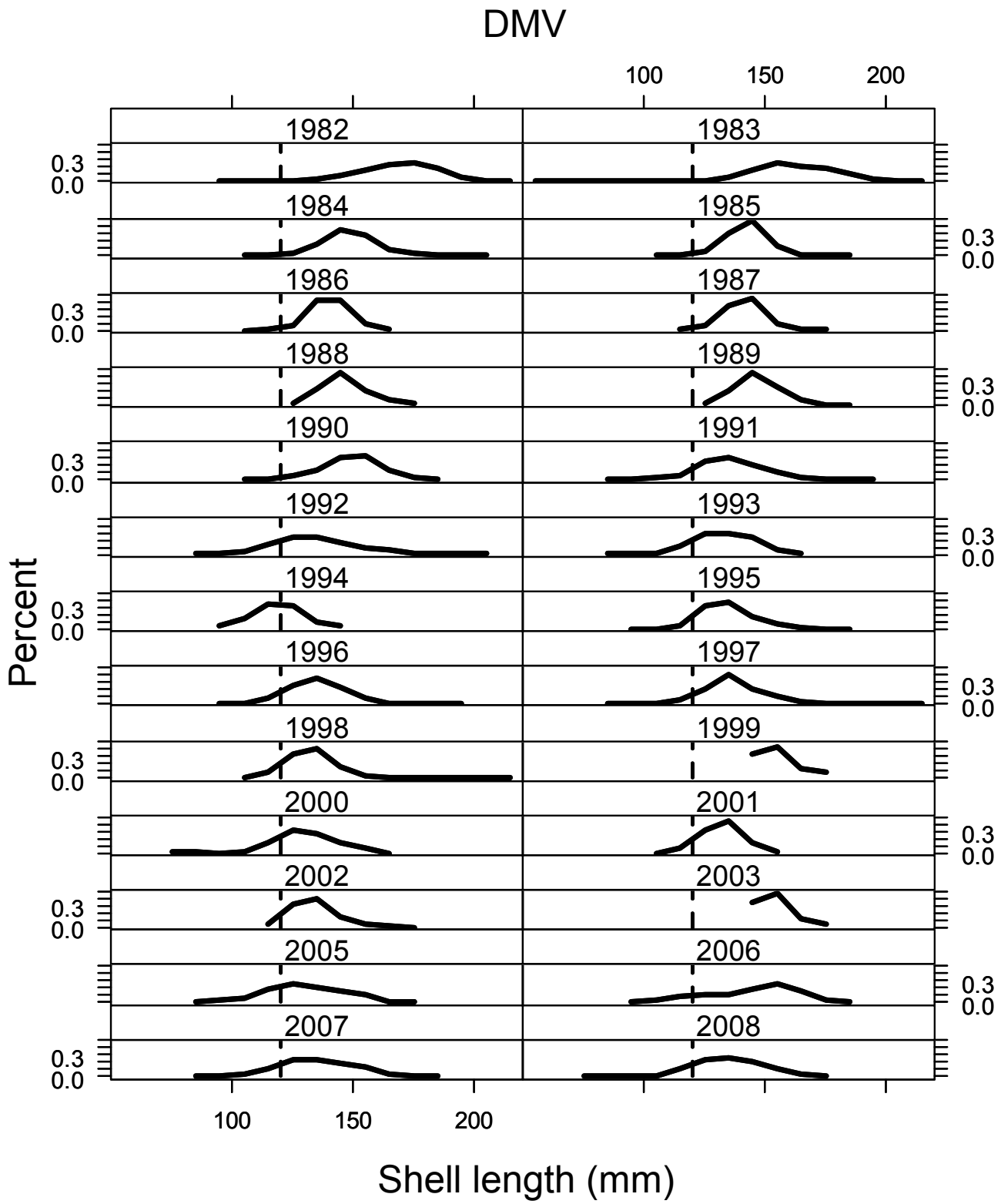

Figure A14. Port sample length composition data for surfclams from the DMV region.

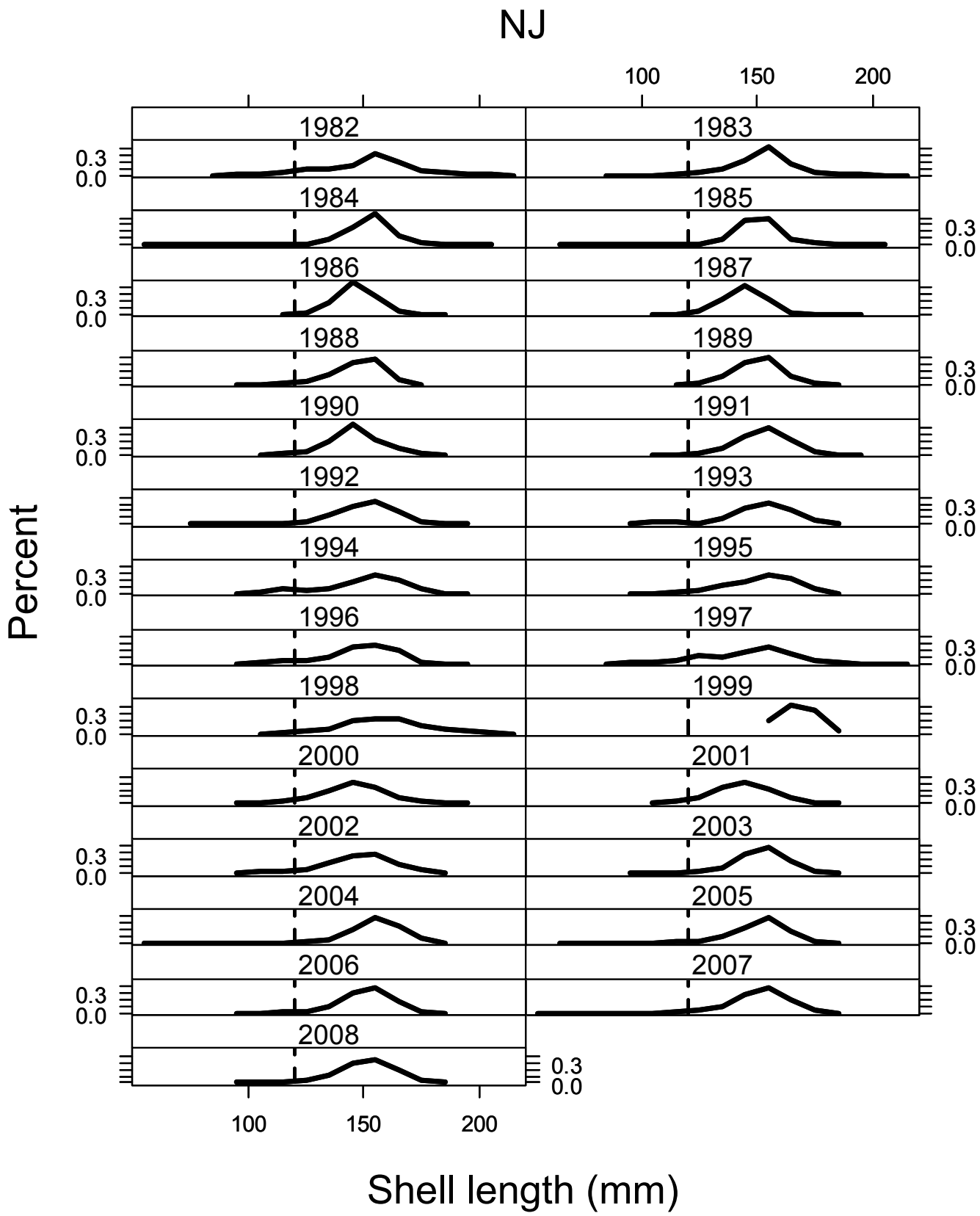

Figure A15. Length Port sample length composition data for surfclams from the NJ region.

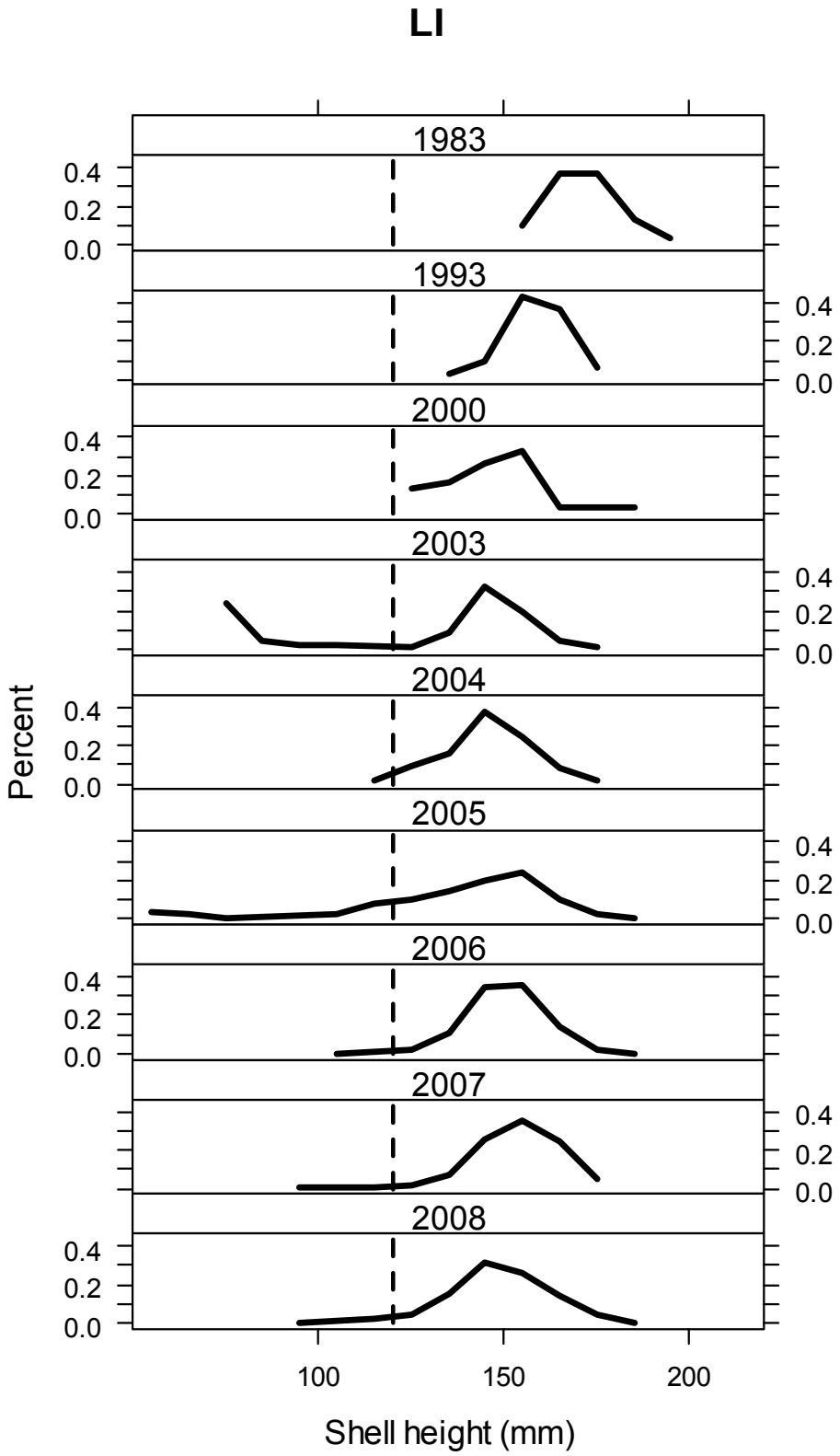

Figure A16. Port sample length composition data for surfclams from the LI region. Data from 1983 and 1993 may be because the number of trips sampled is unknown.

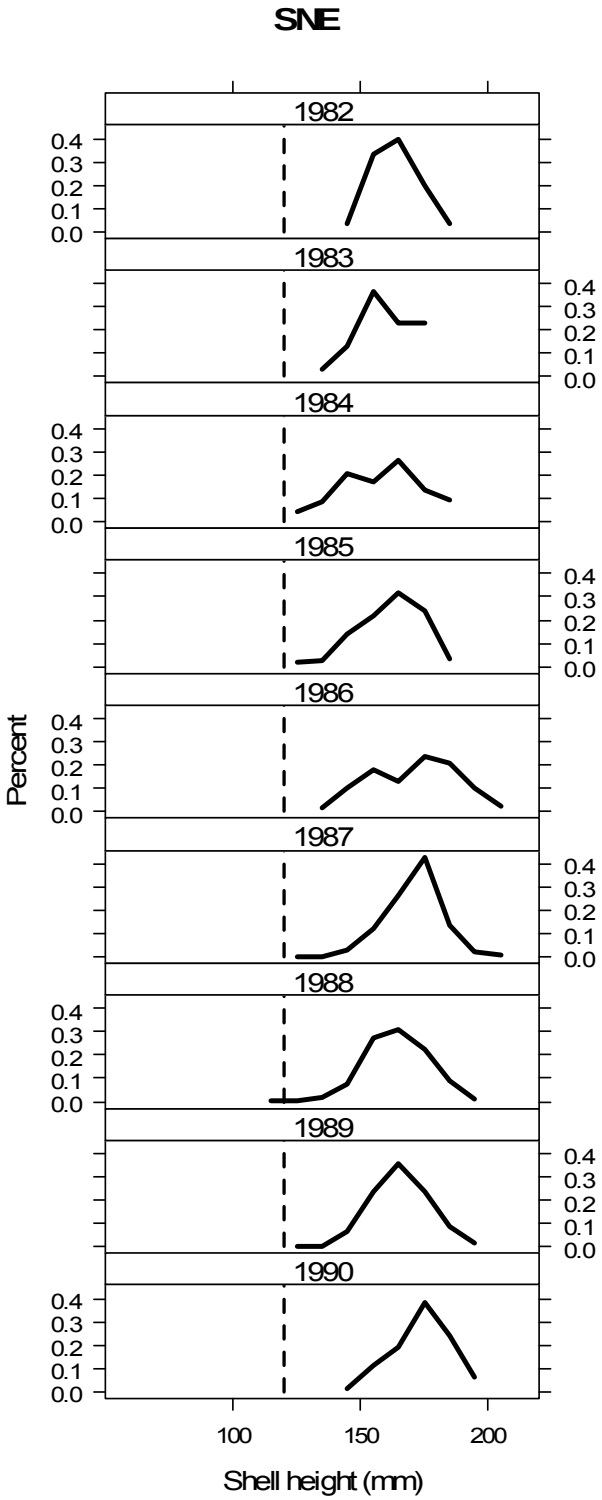

Figure A17. Port sample length composition data for surfclams from the SNE region.

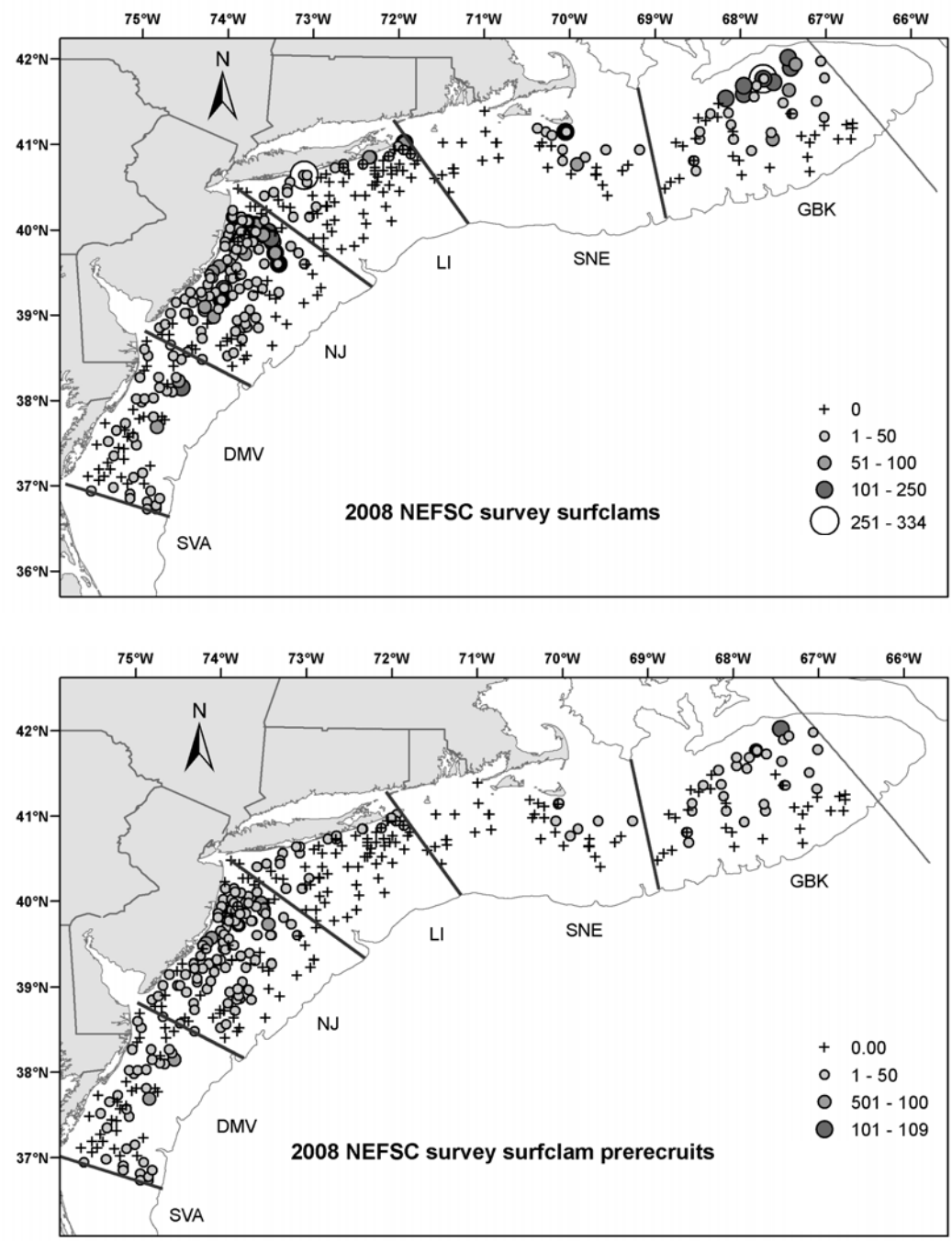

Figure A18. 2008 NEFSC survey catches per tow of all surfclams at top and surfclam prerecruits (less than 120mm SL) at bottom.

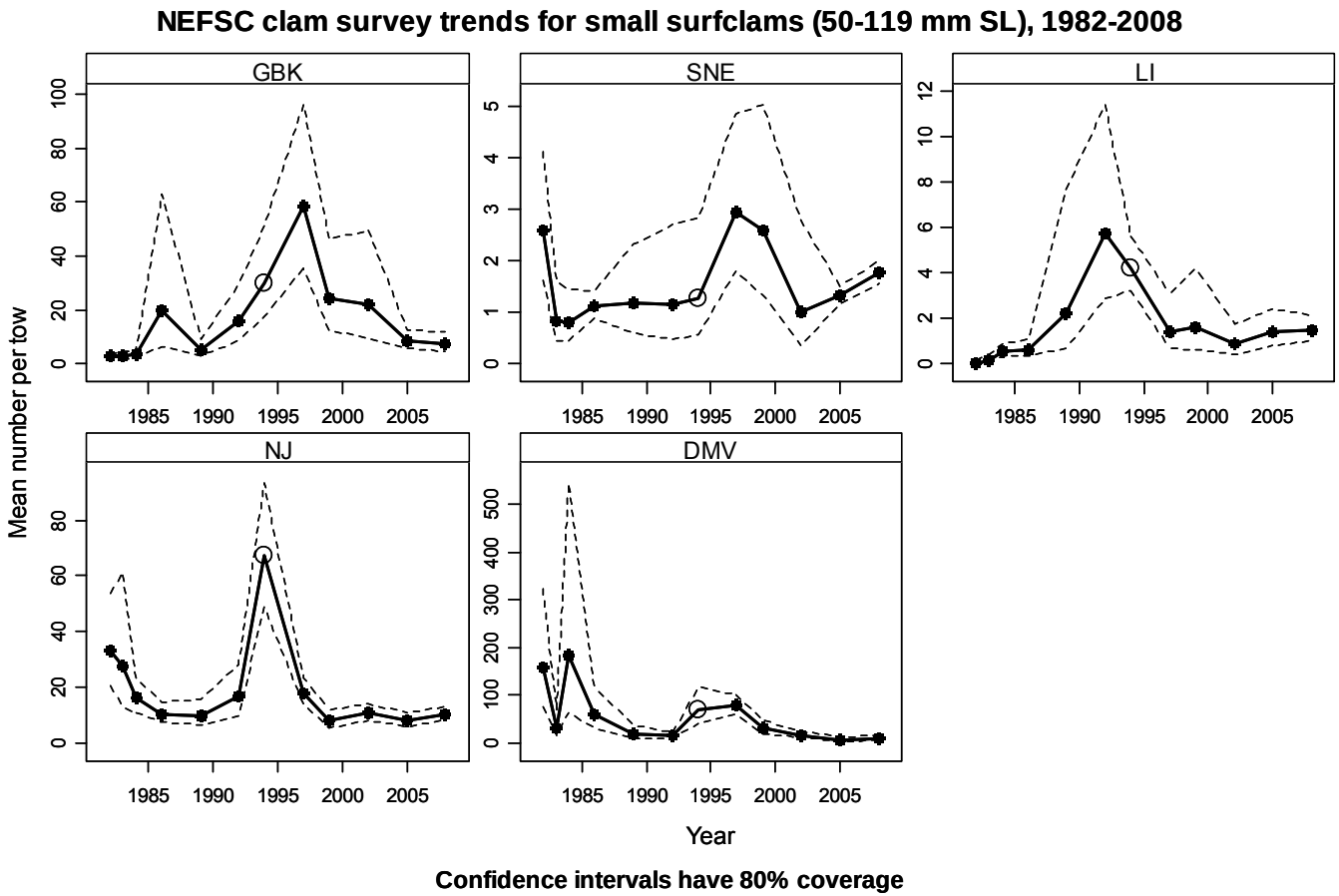

Figure A19. Trends in mean number of small (50-119 mm SL) surfclams in the NEFSC clam survey during 1982-2008 by region with approximate 80% confidence intervals (data not adjusted for survey dredge selectivity). Data for 1994 (open circle) may not be comparable to other years because of a problem with pump voltage that increased capture efficiency in some regions. These data are shown without confidence intervals and excluding 1994 in the next figure.

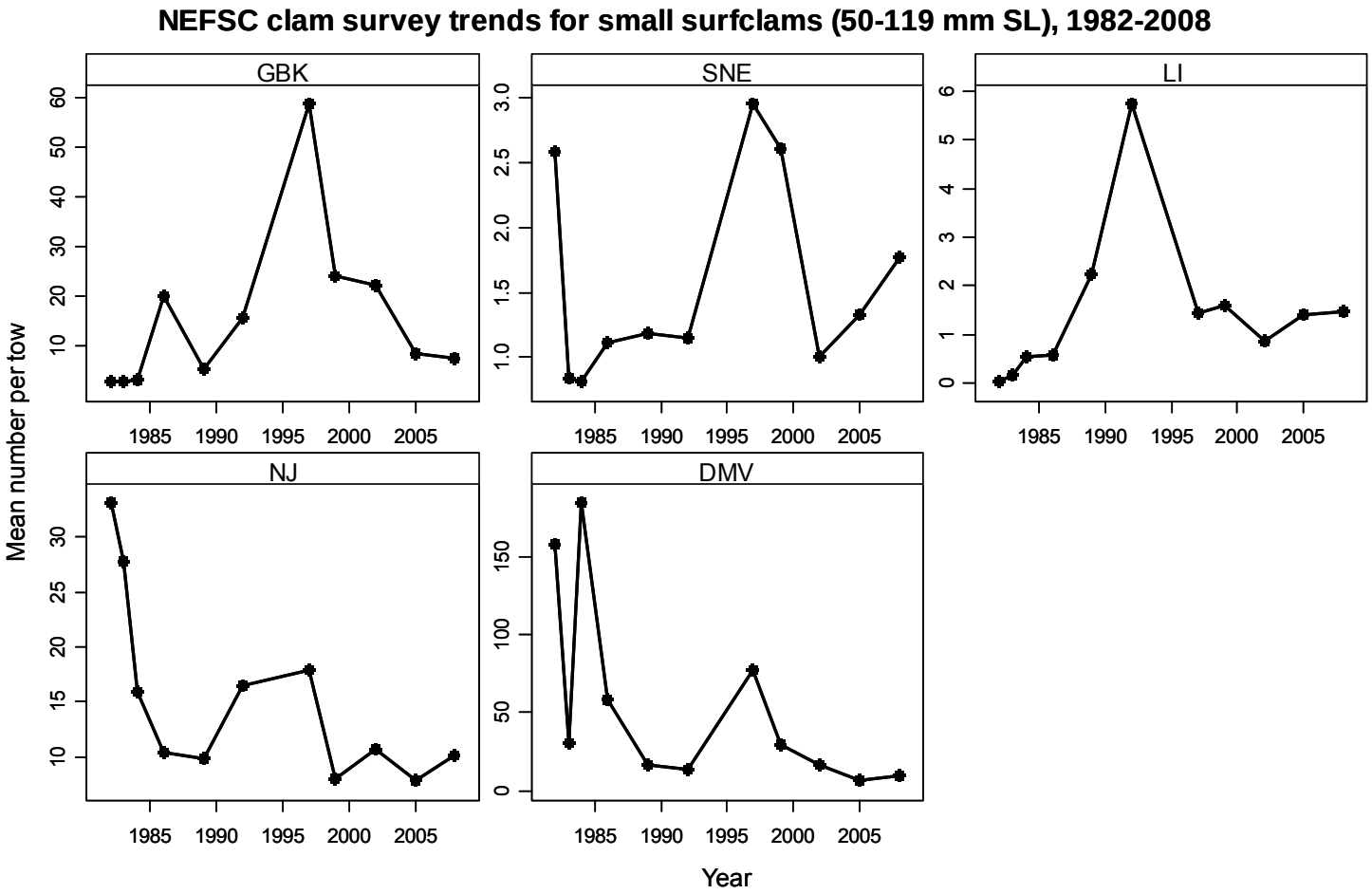

Figure A20. Trends in mean number of small (50-119 mm SL) surfclams in the NEFSC clam survey during 1982-2008 by region, excluding 1994 and without confidence intervals to facilitate comparison of trends in recruitment.

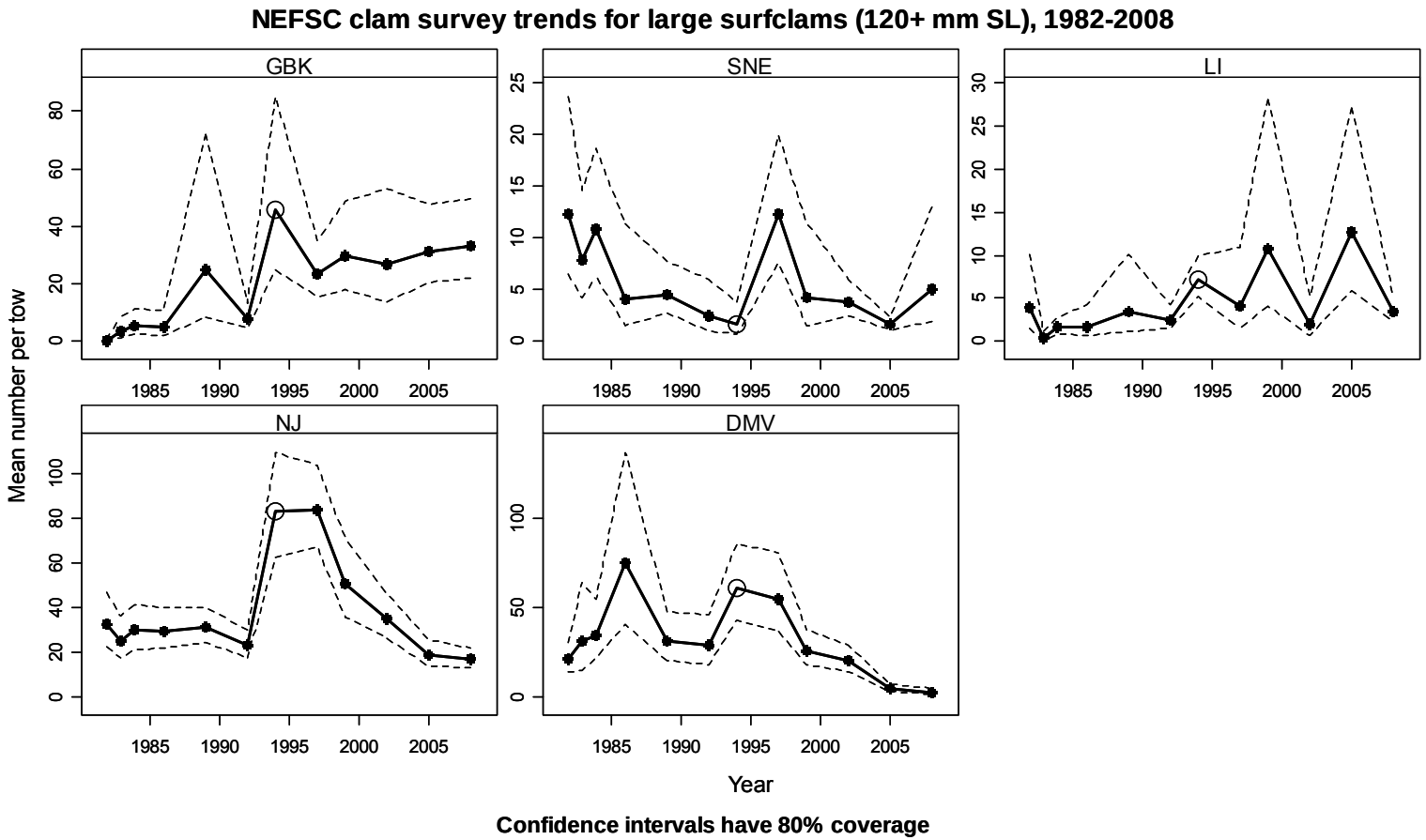

Figure A21. Trends in mean number of large (120+ mm SL) surfclams in the NEFSC clam survey during 1982-2008 by region, with approximate 80% confidence intervals (data not adjusted for survey dredge selectivity). Data for 1994 (open circle) may not be comparable to other years because of a problem with pump voltage that increased capture efficiency in some regions. These data are shown without confidence intervals and excluding 1994 in the next figure.

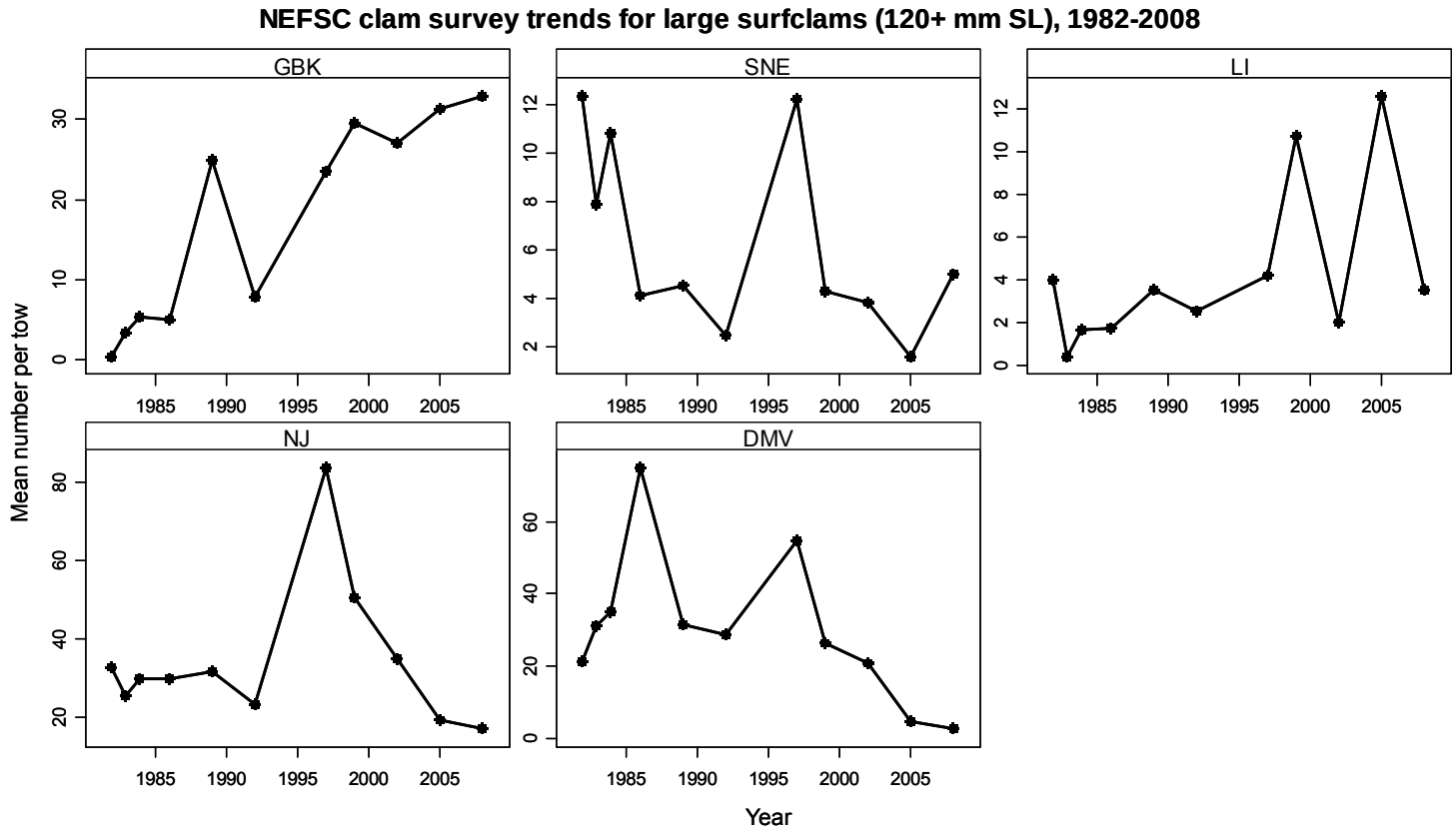

Figure A22. Trends in mean number of large (120+ mm SL) surfclams in the NEFSC clam survey during 1982-2008 by region, excluding 1994 and without confidence intervals to facilitate comparison of trends.

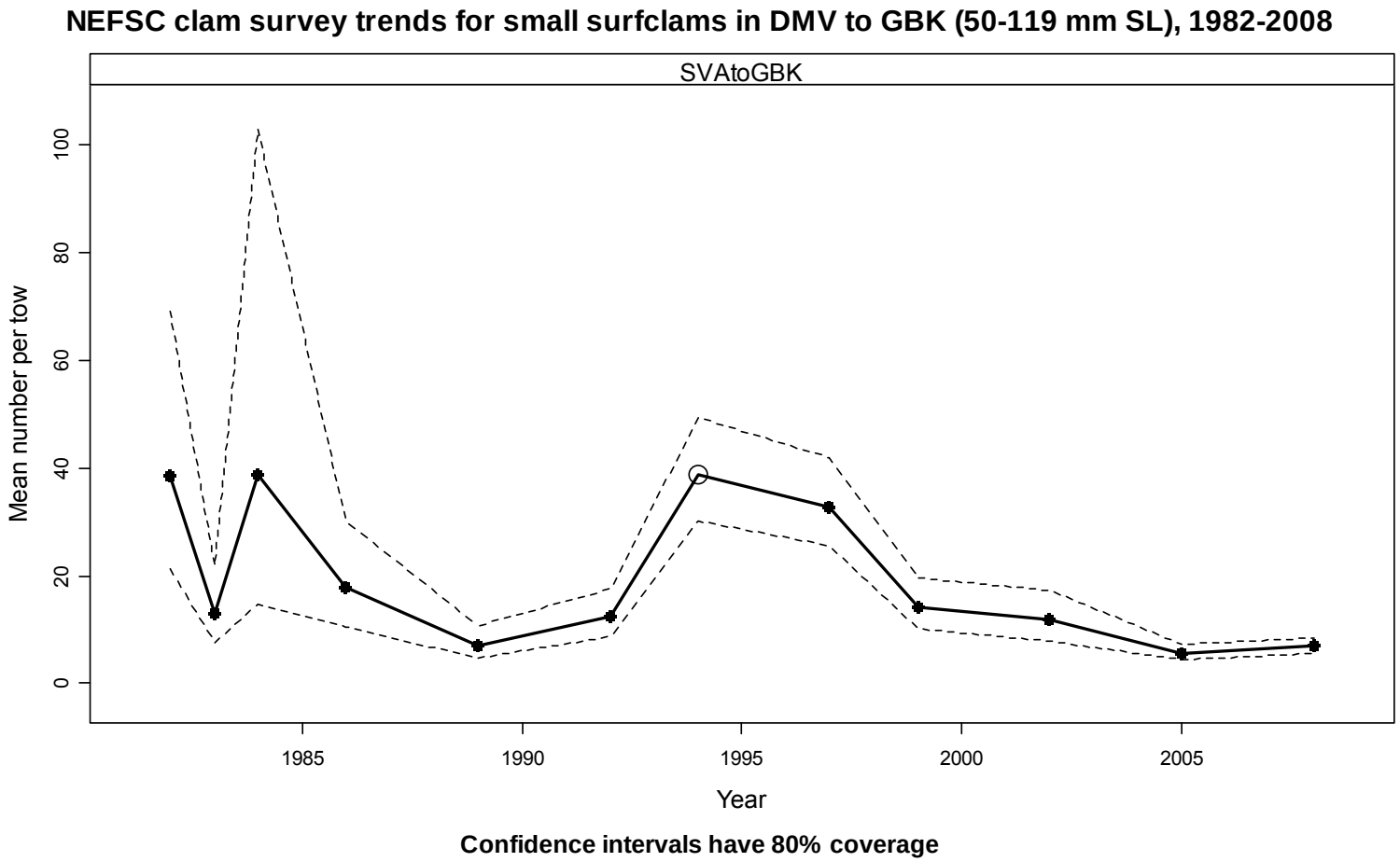

Figure A23. Trends in mean number of small (50-119 mm SL) surfclams in the NEFSC clam survey during 1982-2008 for the entire stock area with approximate 80% confidence intervals (data not adjusted for survey dredge selectivity). Data for 1994 (open circle) may not be comparable to other years because of a problem with pump voltage that increased capture efficiency in some regions.

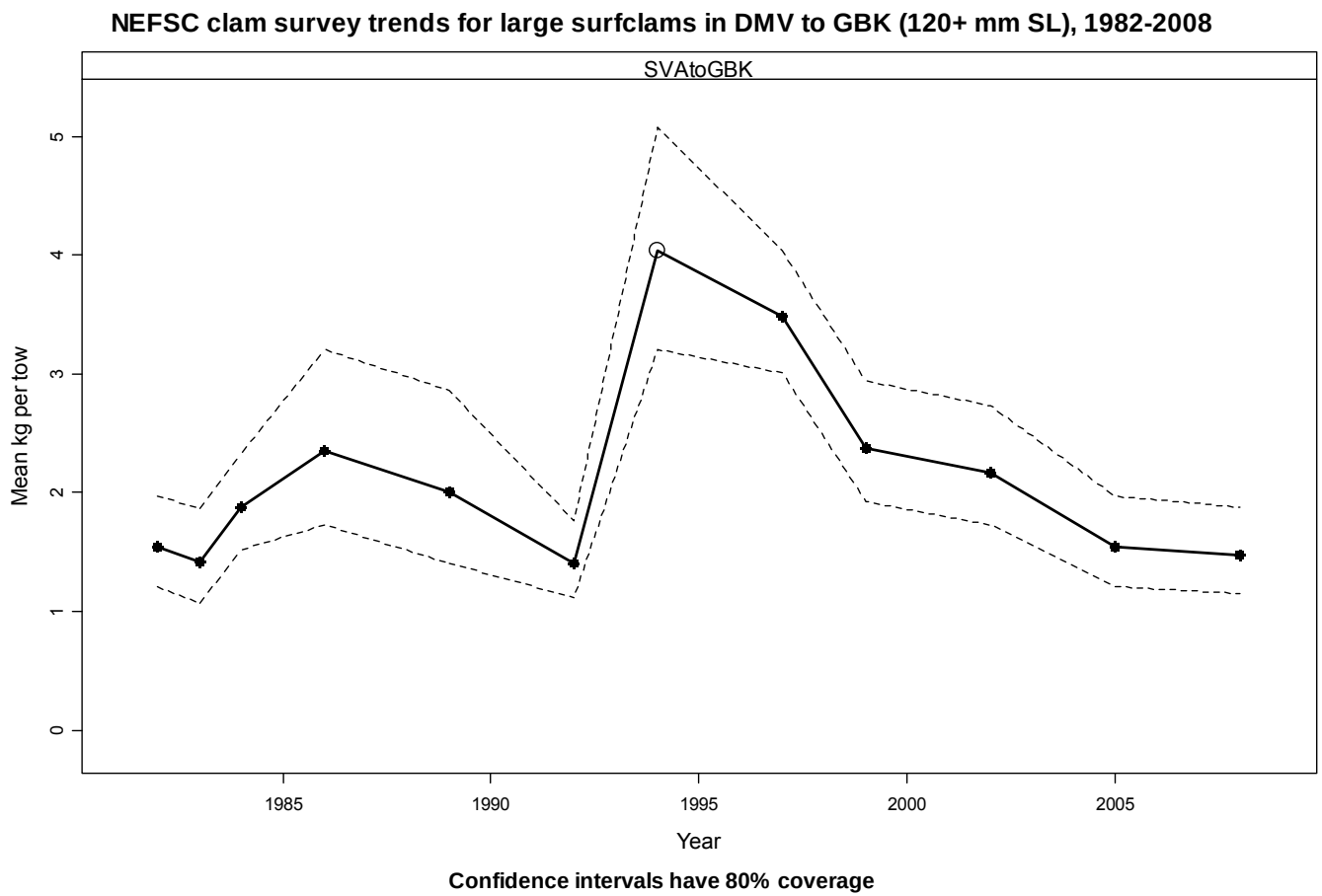

Figure A24. Trends in mean biomass of large (120+ mm SL) surfclams in the NEFSC clam survey during 1982-2008 for the entire stock area with approximate 80% confidence intervals (data not adjusted for survey dredge selectivity). Data for 1994 (open circle) may not be comparable to other years because of a problem with pump voltage that increased capture efficiency in some regions.

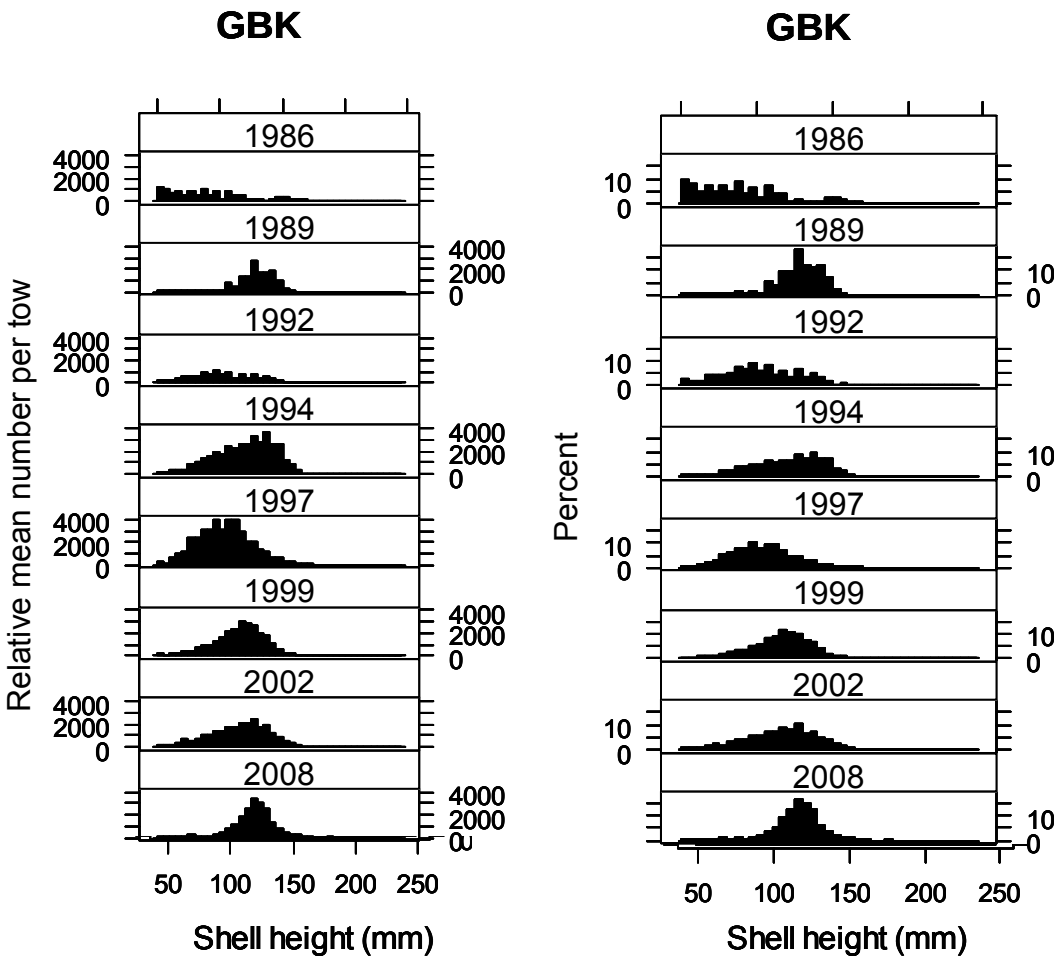

Figure A25. NEFSC survey length composition data for surfclams in the GBK region. The y-axes for graphs on the left are relative numbers per tow that can be compared between shell length bins and years. The y-axes for graphs on the right are standardized as percentages to clearly show relative frequencies in the same year.

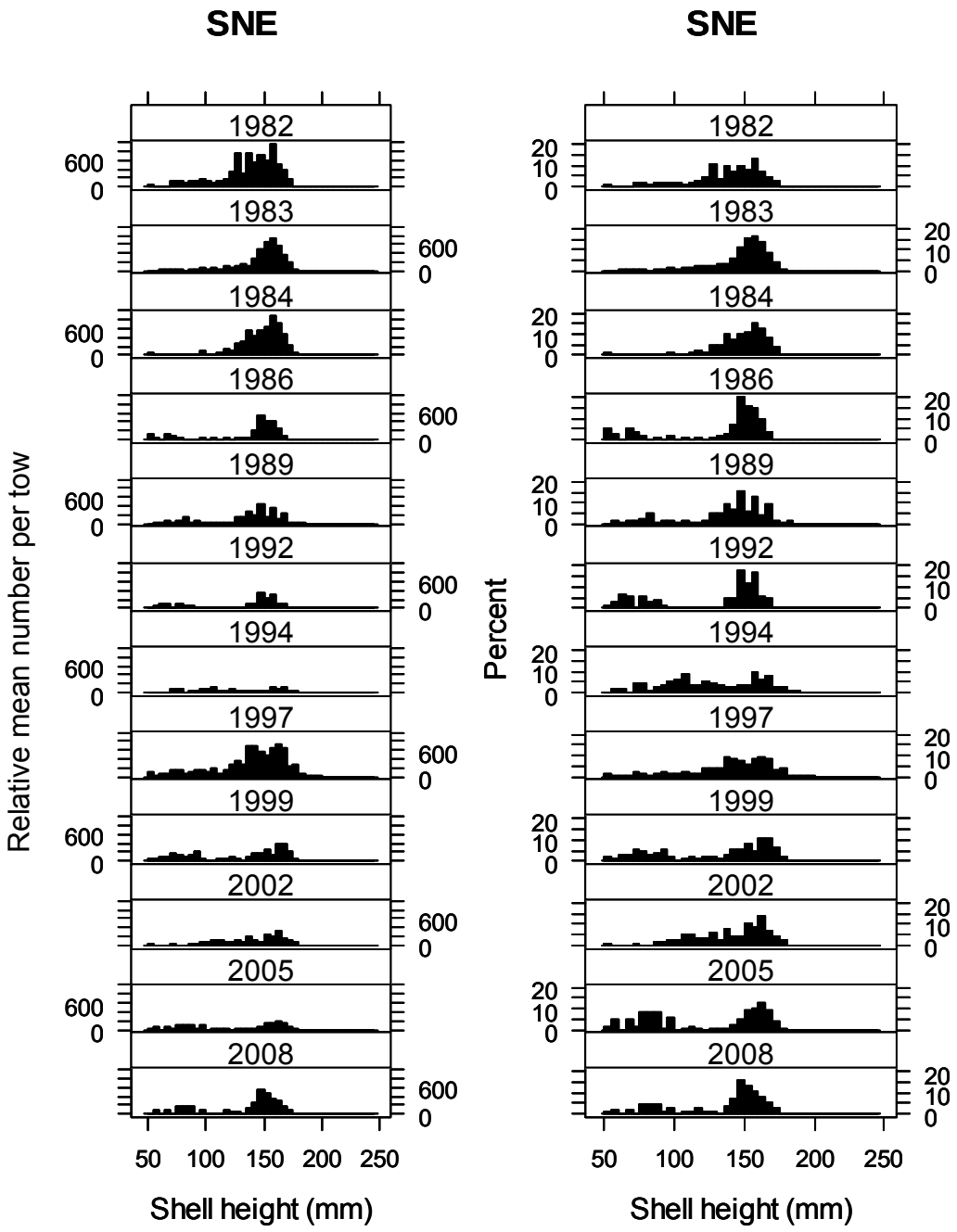

Figure A26. NEFSC survey length composition data for surfclams in the SNE region. The y-axes for graphs on the left are relative numbers per tow that can be compared between shell length bins and years. The y-axes for graphs on the right are standardized as percentages to clearly show relative frequencies in the same year.

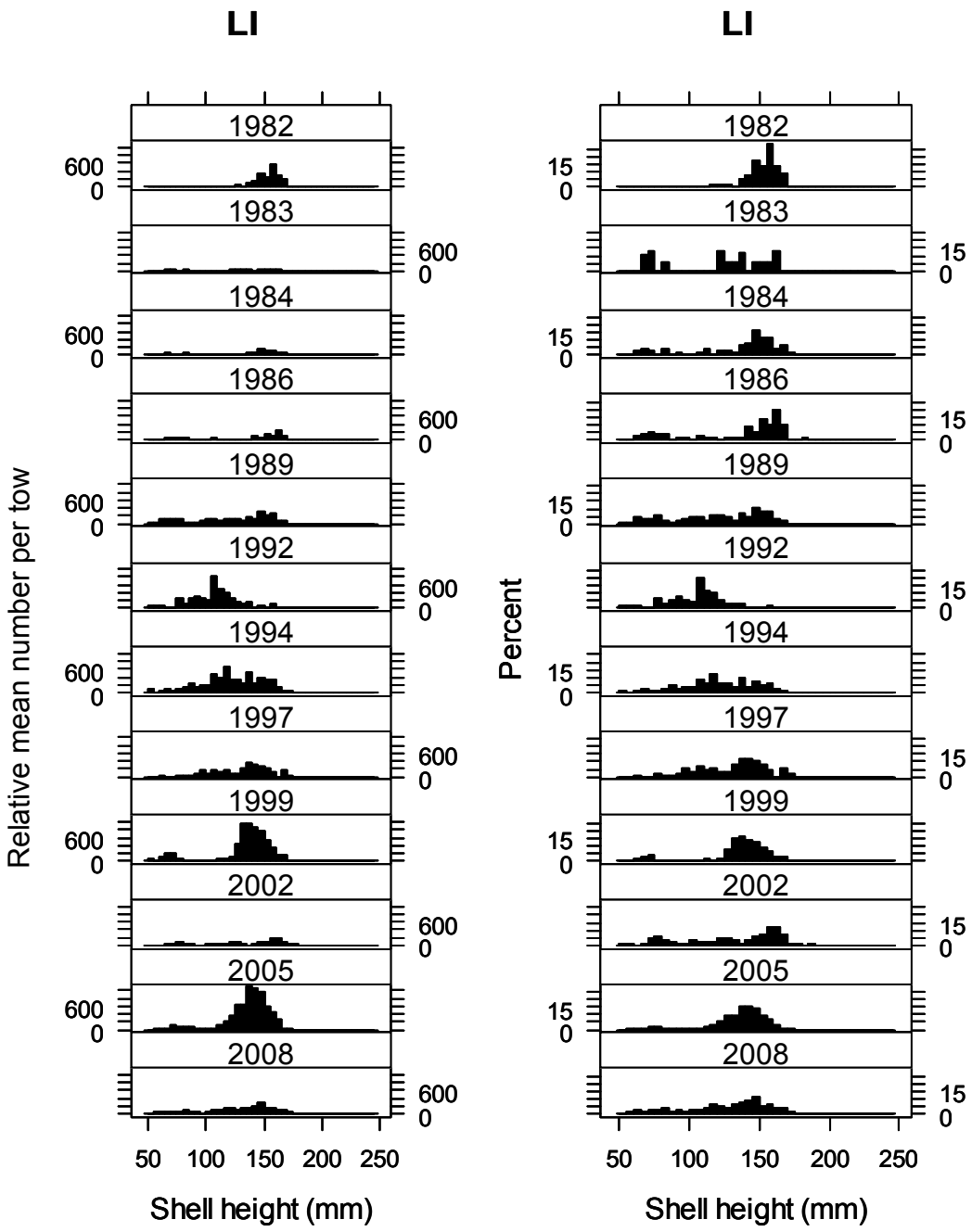

Figure A27. NEFSC survey length composition data for surfclams in the LI region. The y-axis for graphs on the left is relative numbers per tow that can be compared between shell length bins and years. The y-axes for graphs on the right are standardized as percentages to clearly show relative frequencies in the same year.

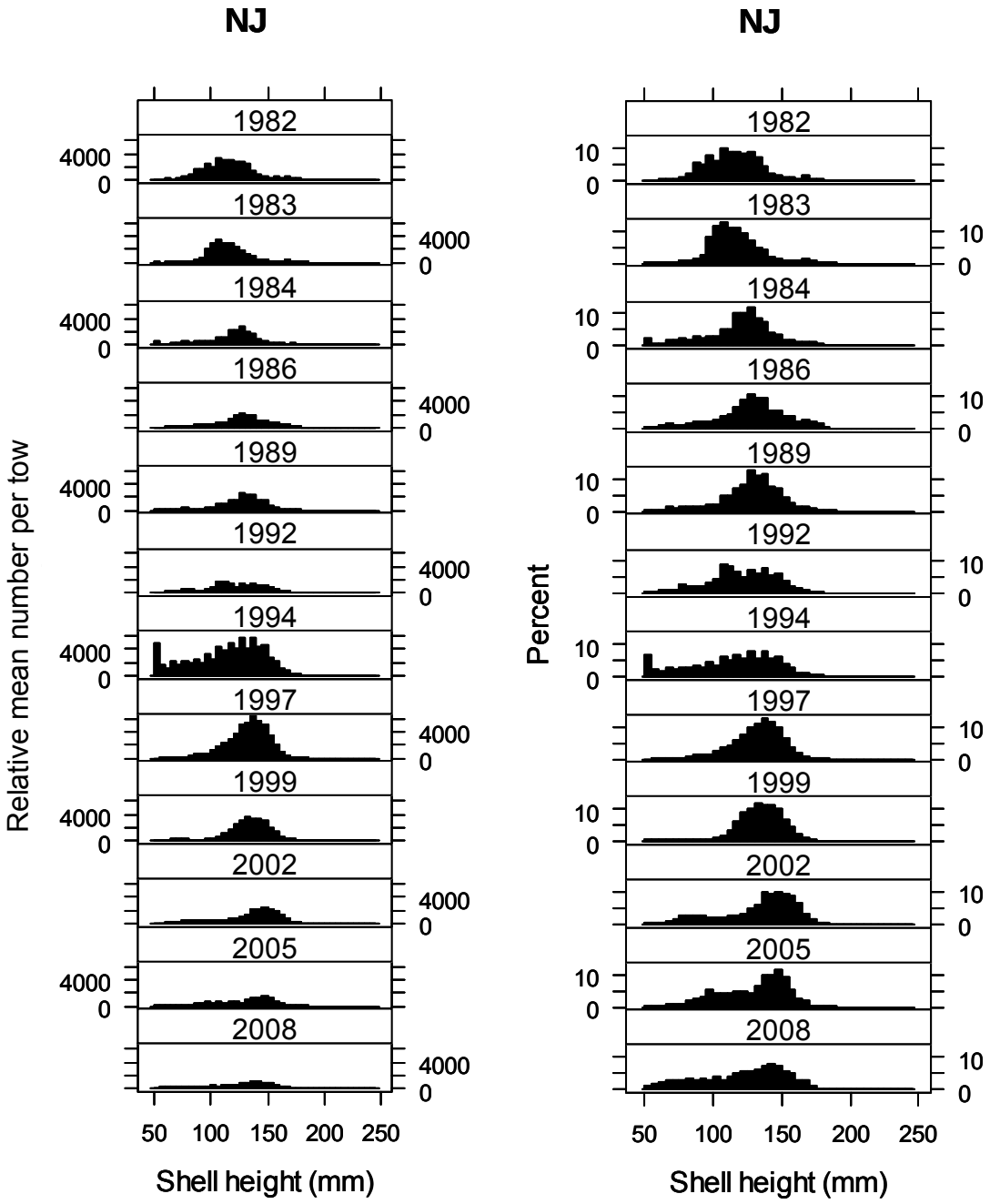

Figure A28. NEFSC survey length composition data for surfclams in the NJ region. The y-axes for graphs on the left are relative numbers per tow that can be compared between shell length bins and years. The y-axes for graphs on the right are standardized as percentages to clearly show relative frequencies in the same year.

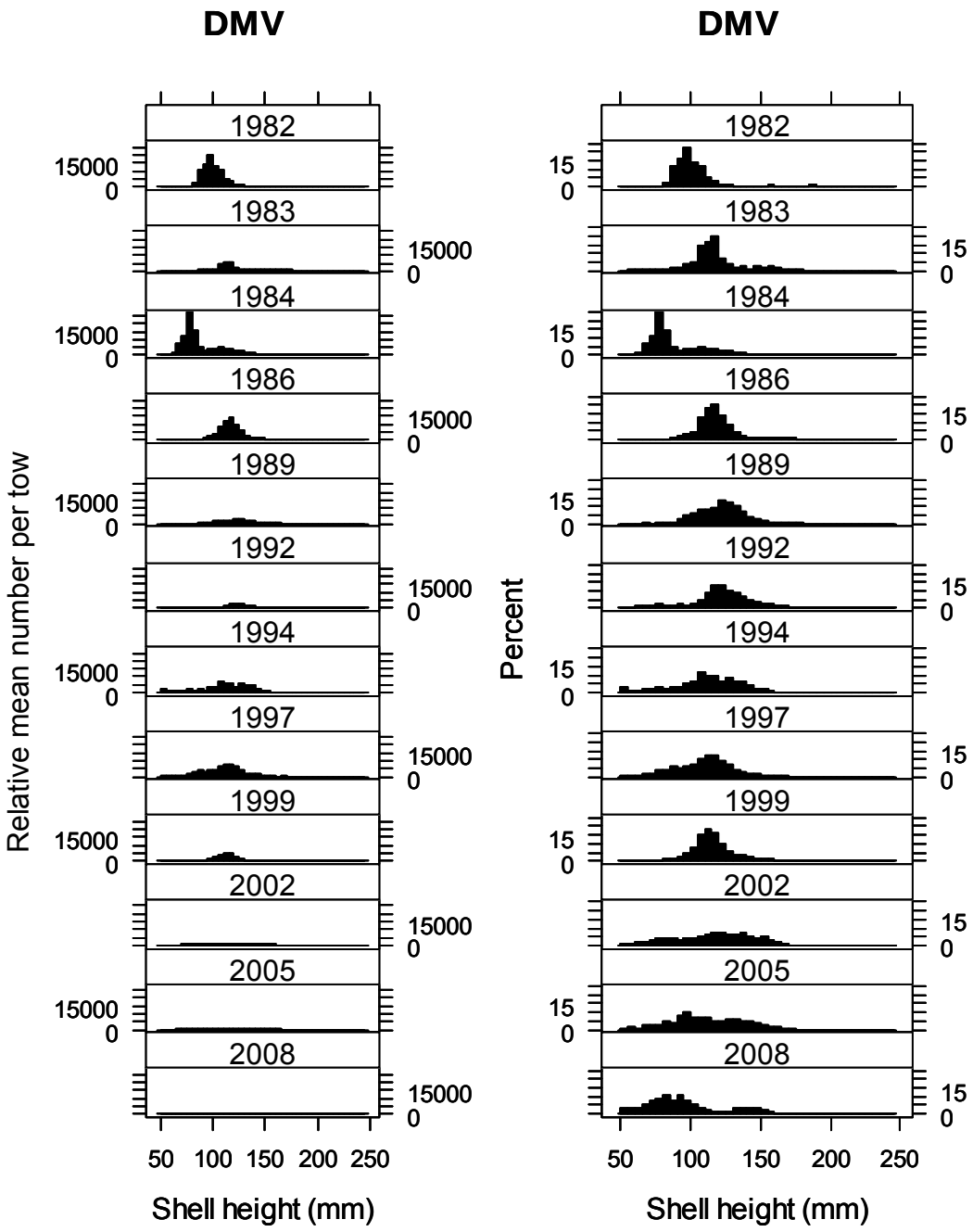

Figure A29. NEFSC survey length composition data for surfclams in the DMV region. The y-axes for graphs on the left are relative numbers per tow that can be compared between shell length bins and years. The y-axes for graphs on the right are standardized as percentages to clearly show relative frequencies in the same year.

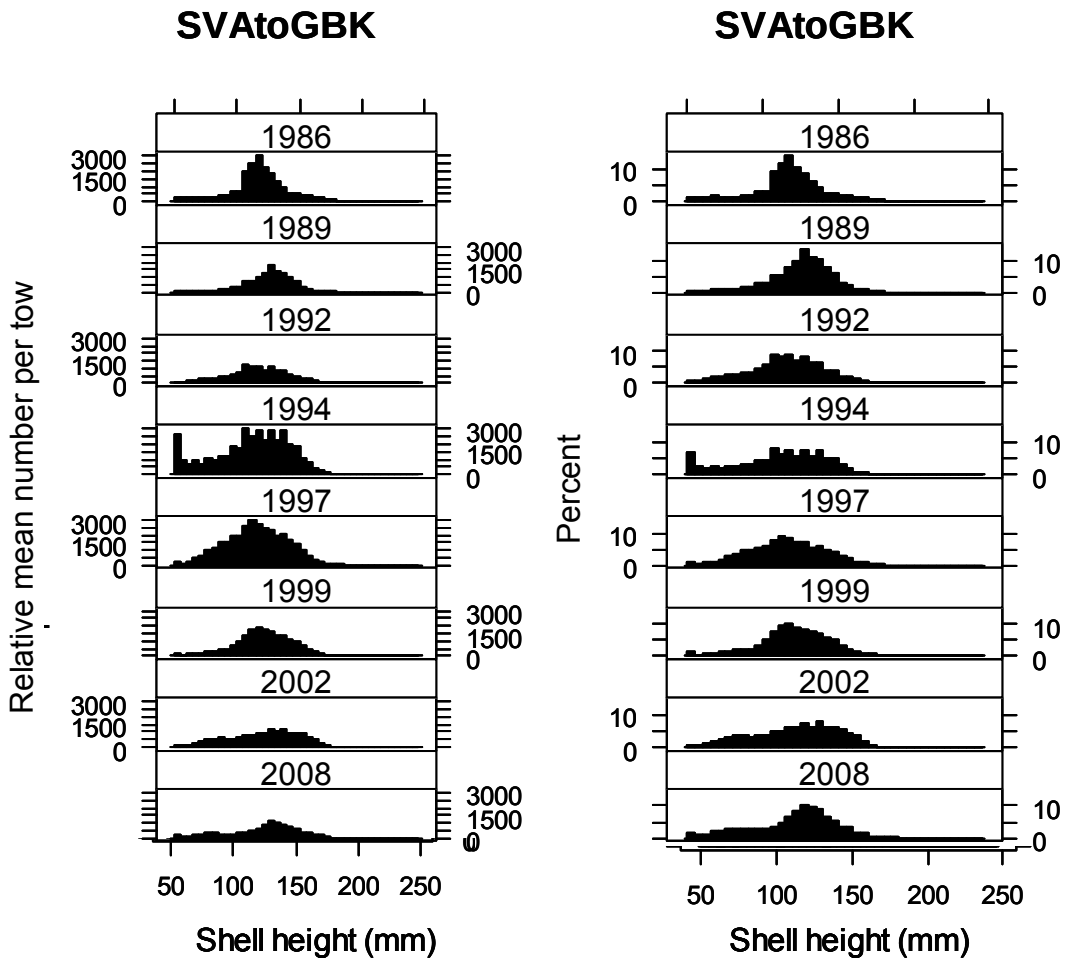

Figure A30. NEFSC survey length composition data for surfclams in the entire stock region (SVA to GBK). The y-axes for graphs on the left are relative numbers per tow that can be compared between shell length bins and years. The y-axes for graphs on the right are standardized as percentages to clearly show relative frequencies in the same year.

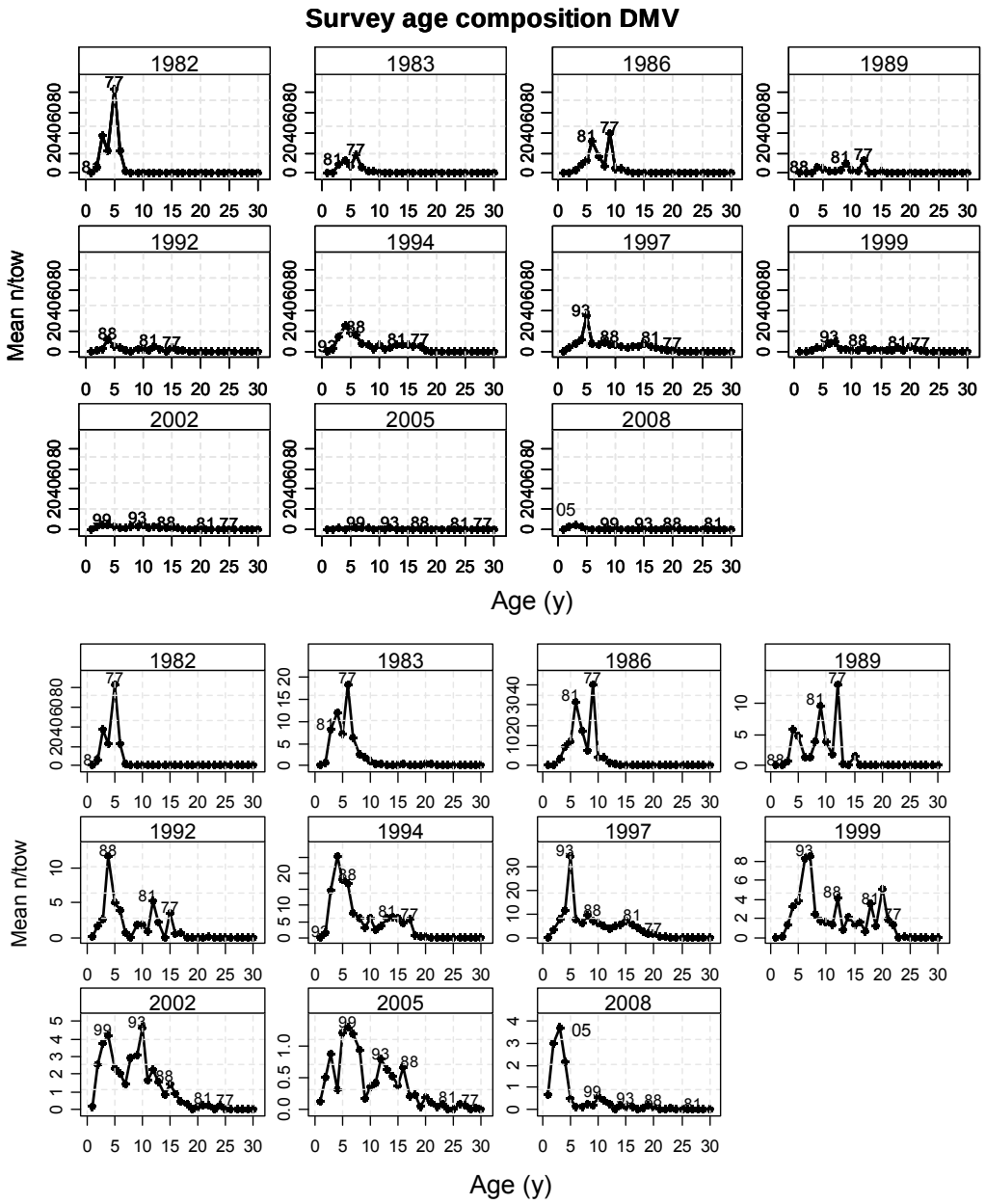

Figure A31. Mean numbers per tow at age for surfclams in DMV from survey data (no adjustment for survey dredge selectivity) with recognizable and strong year classes identified. The scale of the y-axis is the same in for all graphs in the top panel to enhance comparability across surveys. The scale varies by year in the bottom panel to facilitate comparisons of age groups during the same survey.

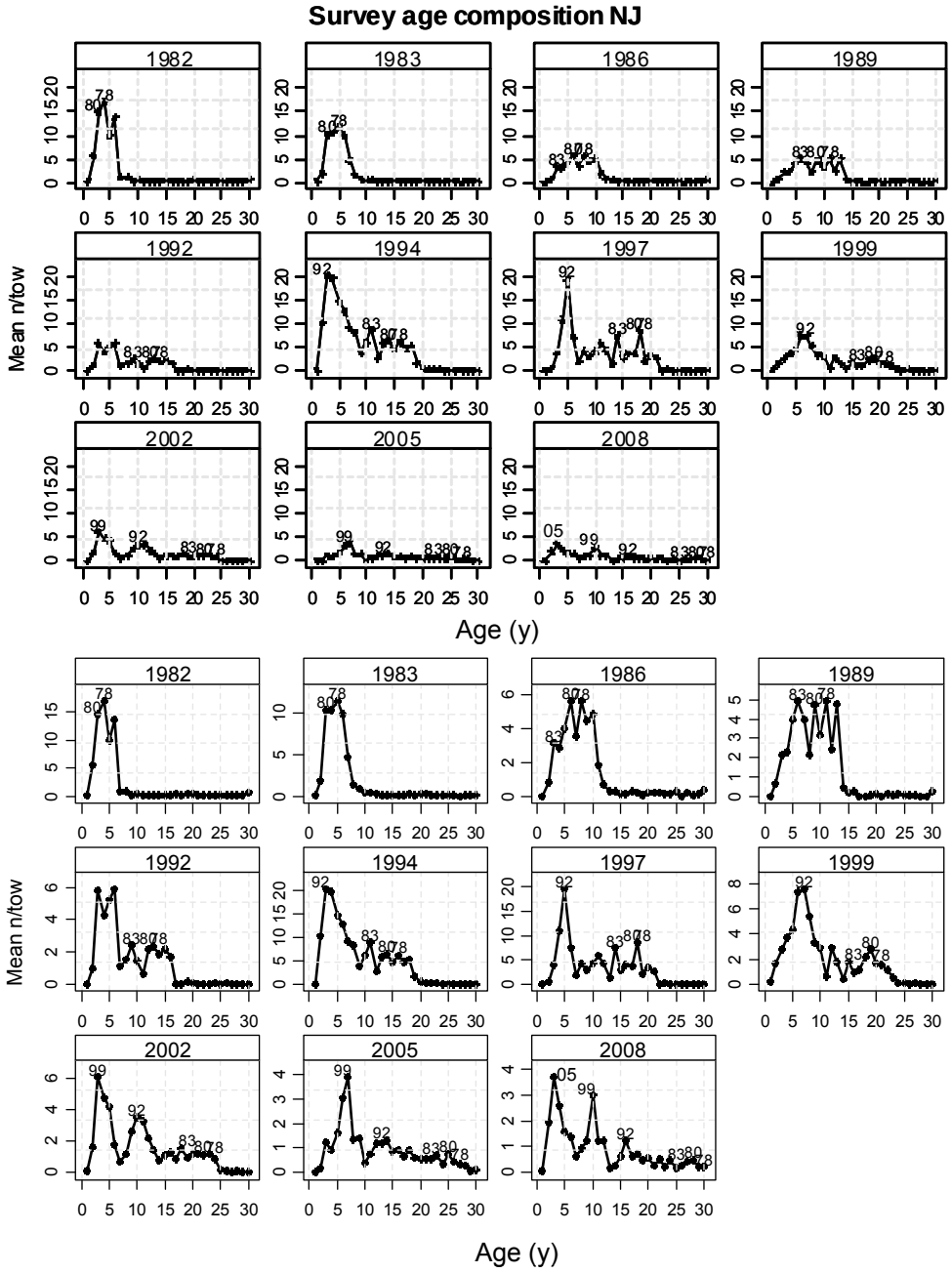

Figure A32. Mean numbers per tow at age for surfclams in NJ from survey data (no adjustment for survey dredge selectivity) with recognizable and strong year classes identified. The scale of the y-axis is the same in for all graphs in the top panel to enhance comparability across surveys. The scale varies by year in the bottom panel to facilitate comparisons of age groups during the same survey.

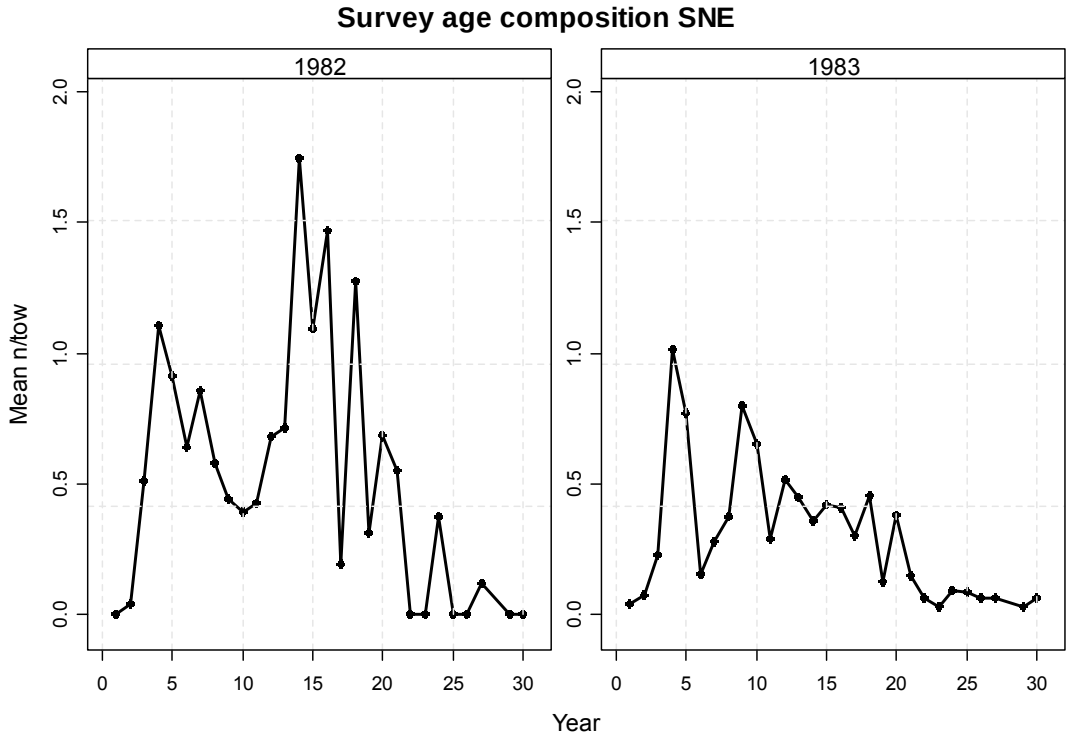

Figure A33. Mean numbers per tow at age for surfclams in SNE from survey data (no adjustment for survey dredge selectivity).

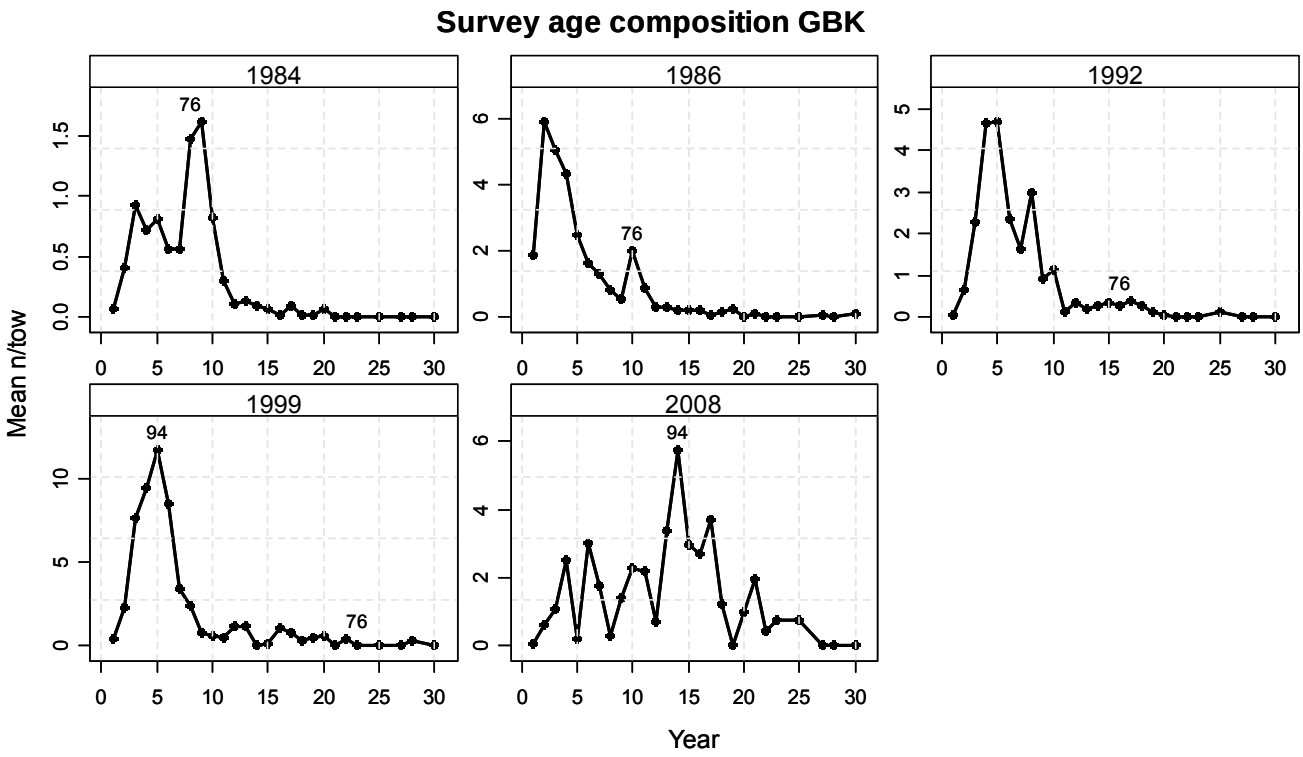

Figure A34. Mean numbers per tow at age for surfclams in the GBK region from survey data (no adjustment for survey dredge selectivity) with strong year classes identified.

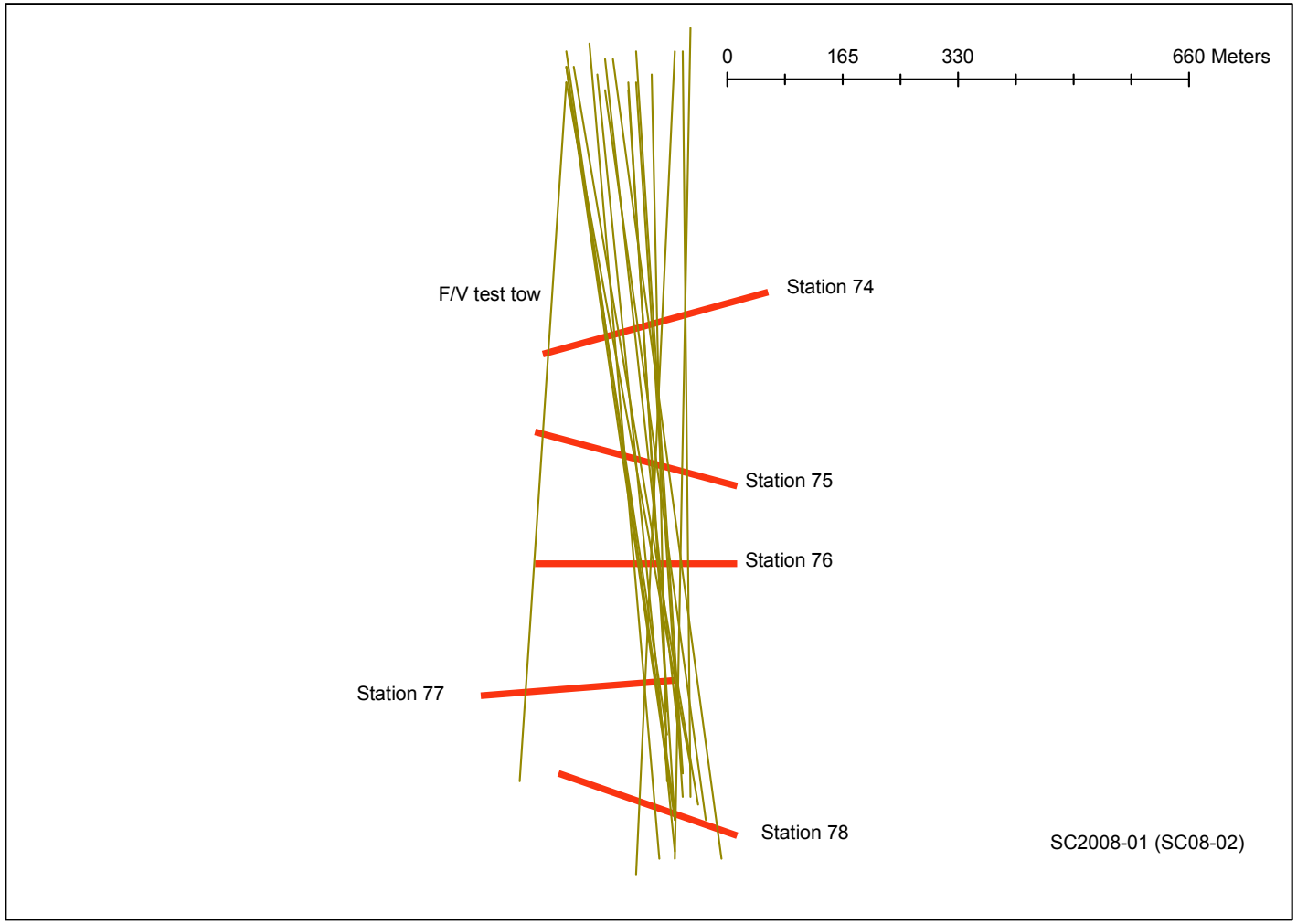

Figure A35. Depletion, setup and test tows for the SC2008-1(originally SC08-02) commercial depletion experiment for surfclams.

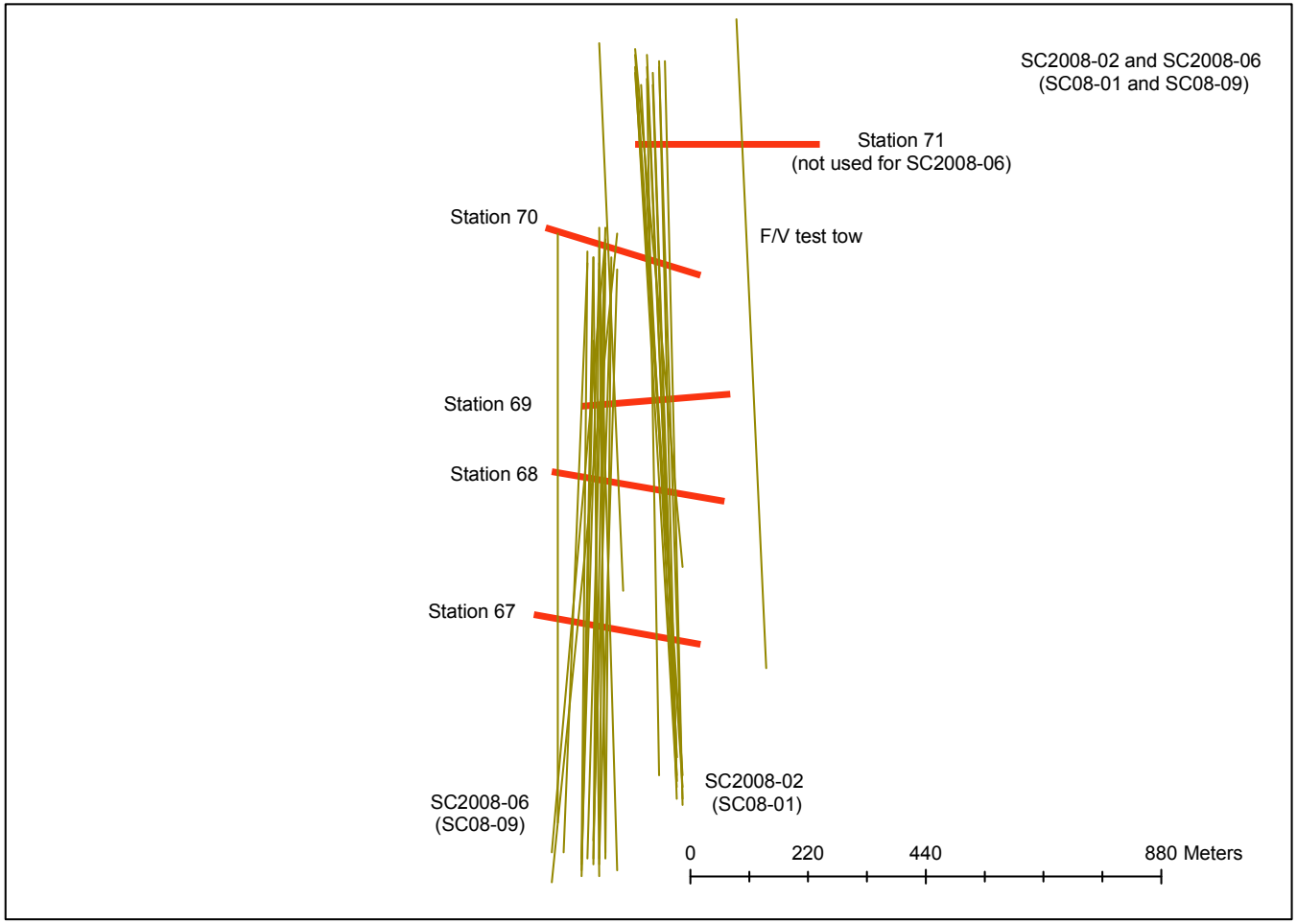

Figure A36. Depletion, setup and test tows for the SC2008-2 and SC2008-6 (originally SC08-01 and SC08-9) commercial depletion experiments for surfclams.

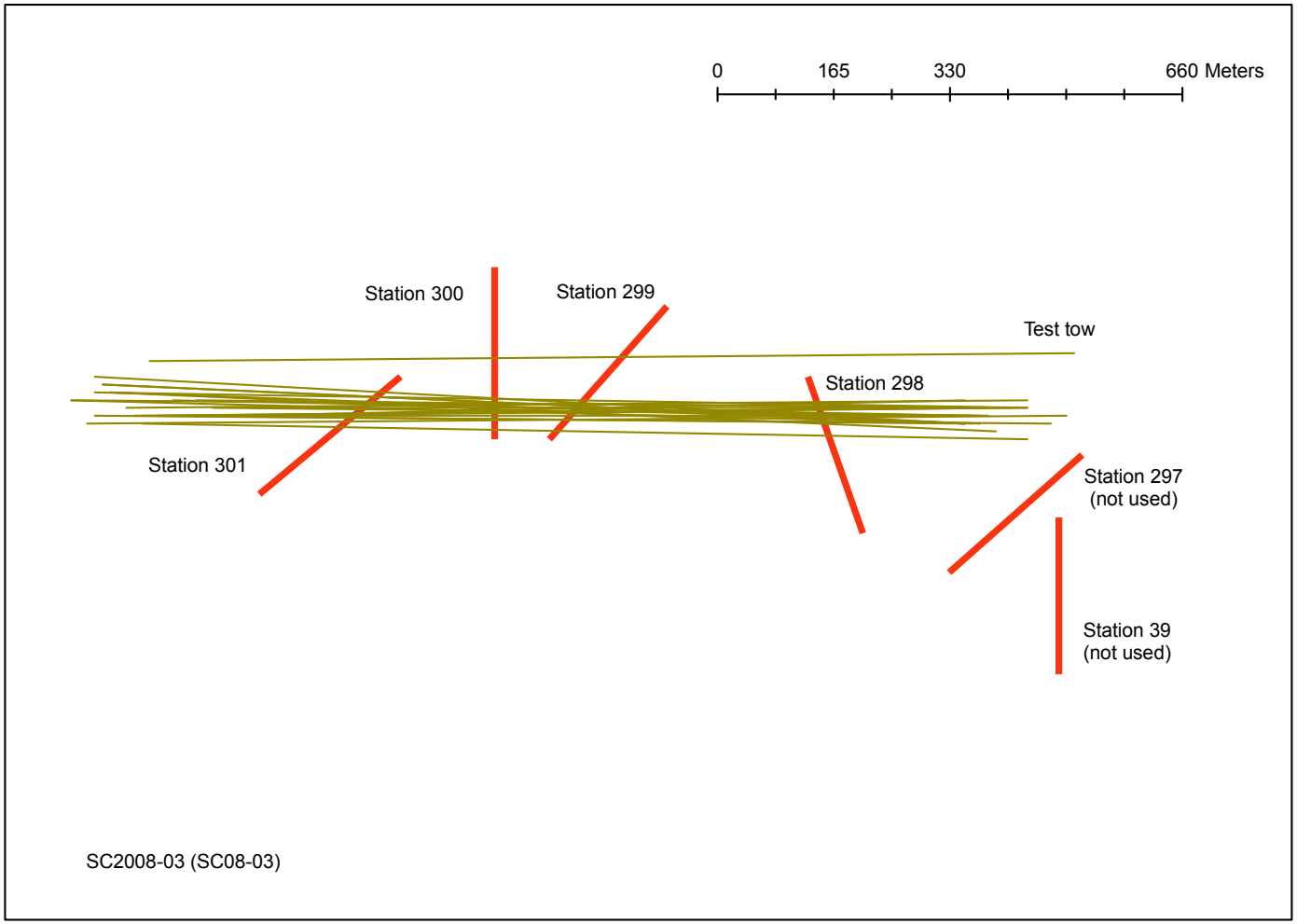

Figure A37. Depletion, setup and test tows for the SC2008-03 (originally SC08-03) commercial depletion experiment for surfclams.

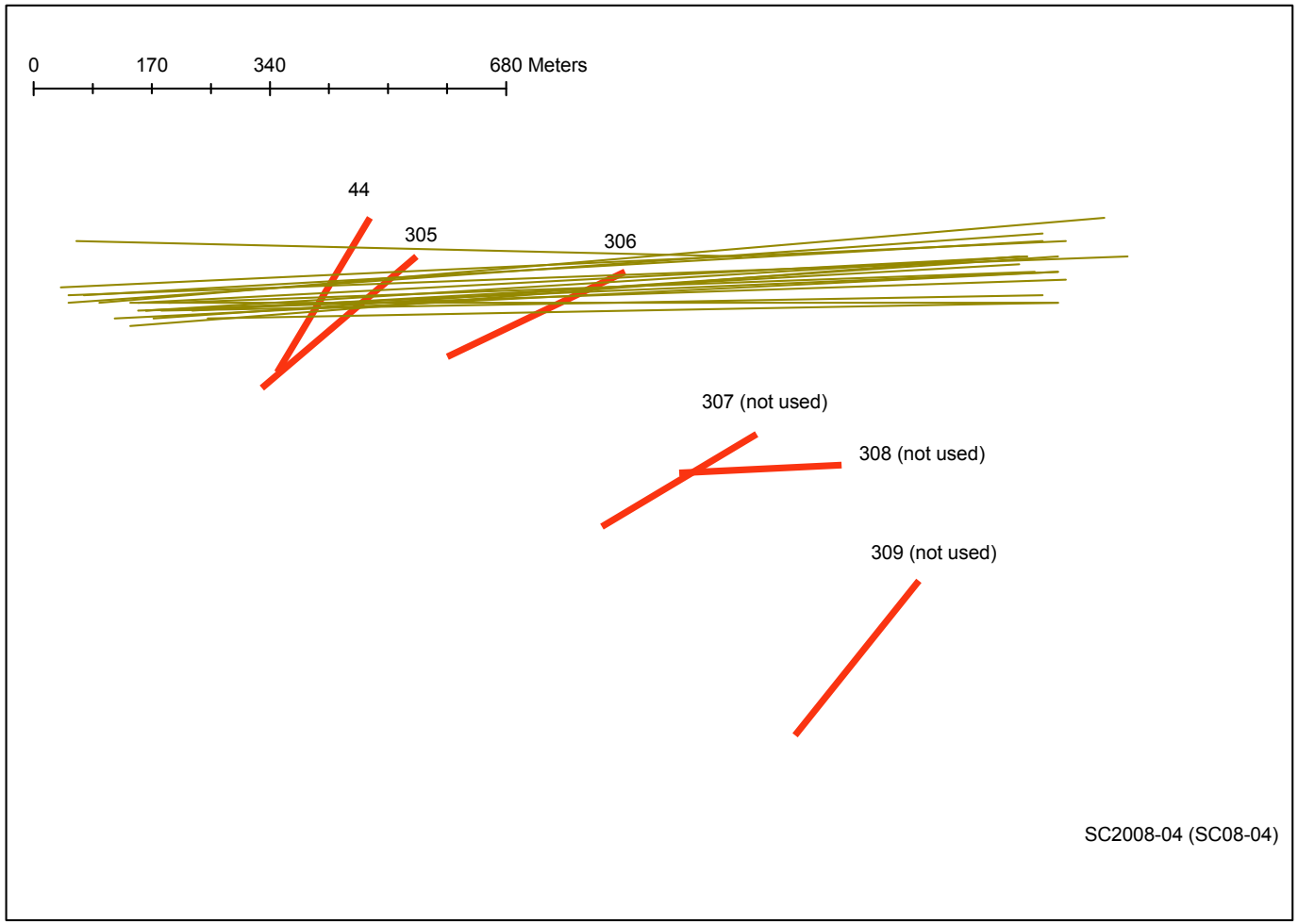

Figure A38. Depletion, setup and test tows for the SC2008-4 (originally SC08-04) commercial depletion experiment for surfclams.

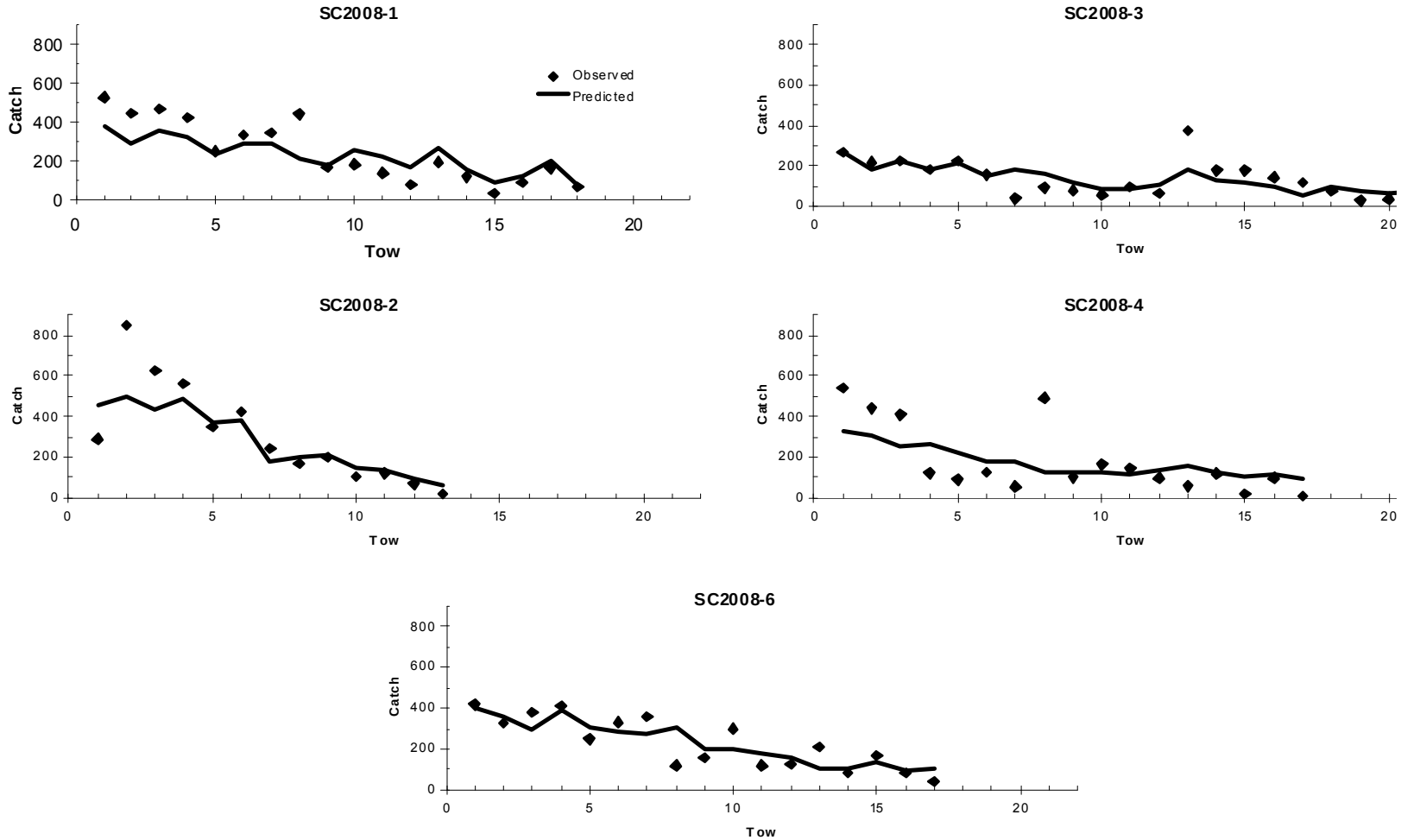

Figure A39. Observed and predicted catch by tow for surfclams in 2008 commercial depletion studies.

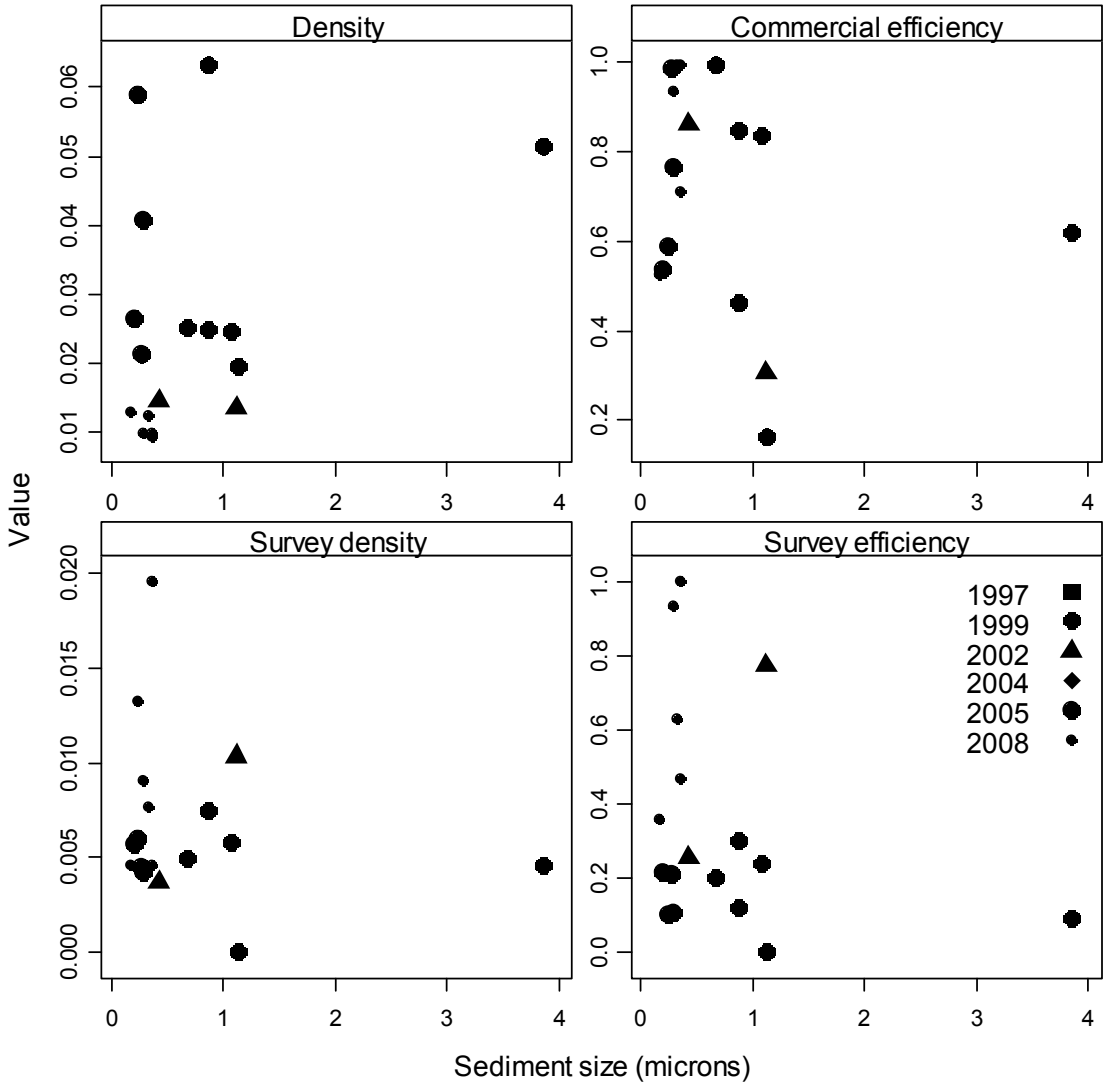

Figure A40. Relationships between efficiency estimates and sediment size in millimeters in depletion experiments for surfclams. The variable plotted on the y-axis is identified in the strip at the top of each panel. Sediment size data are not available for depletion experiments during 1997 and 2004.

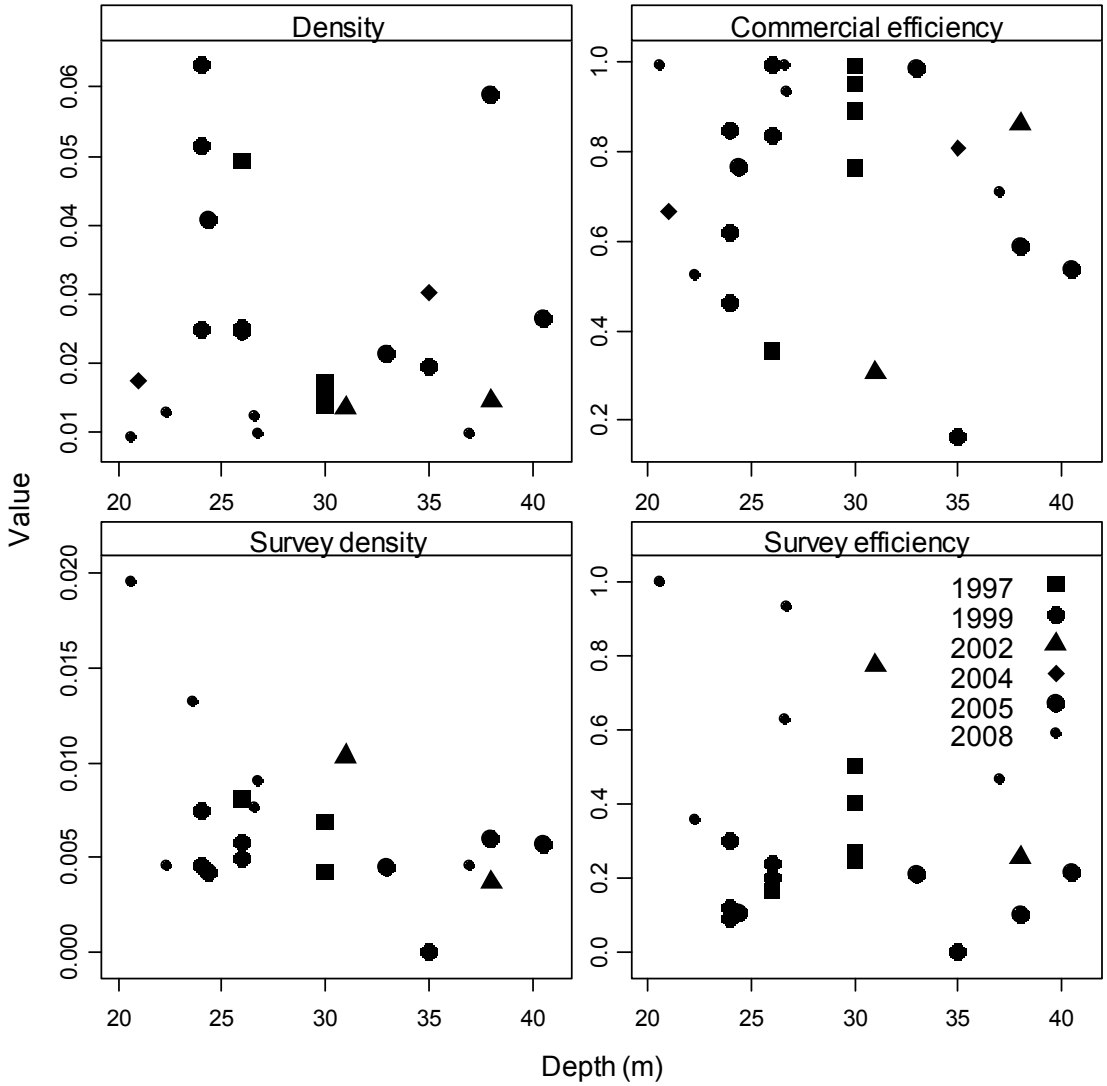

Figure A41. Relationships between efficiency estimates and environmental variables in depletion experiments for surfclams. The variable plotted on the y-axis is identified in the strip at the top of each panel.

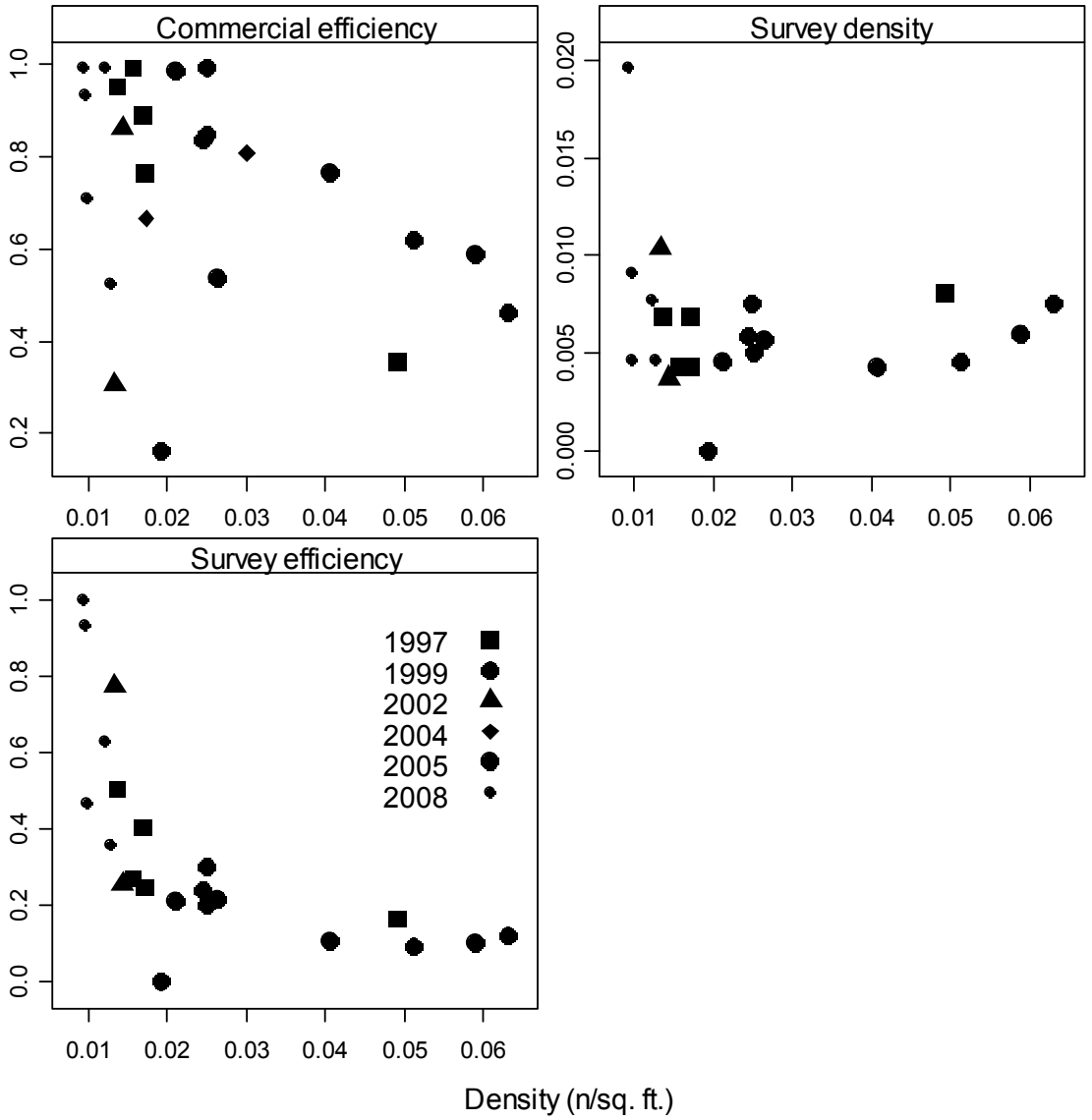

Figure A41. (cont.)

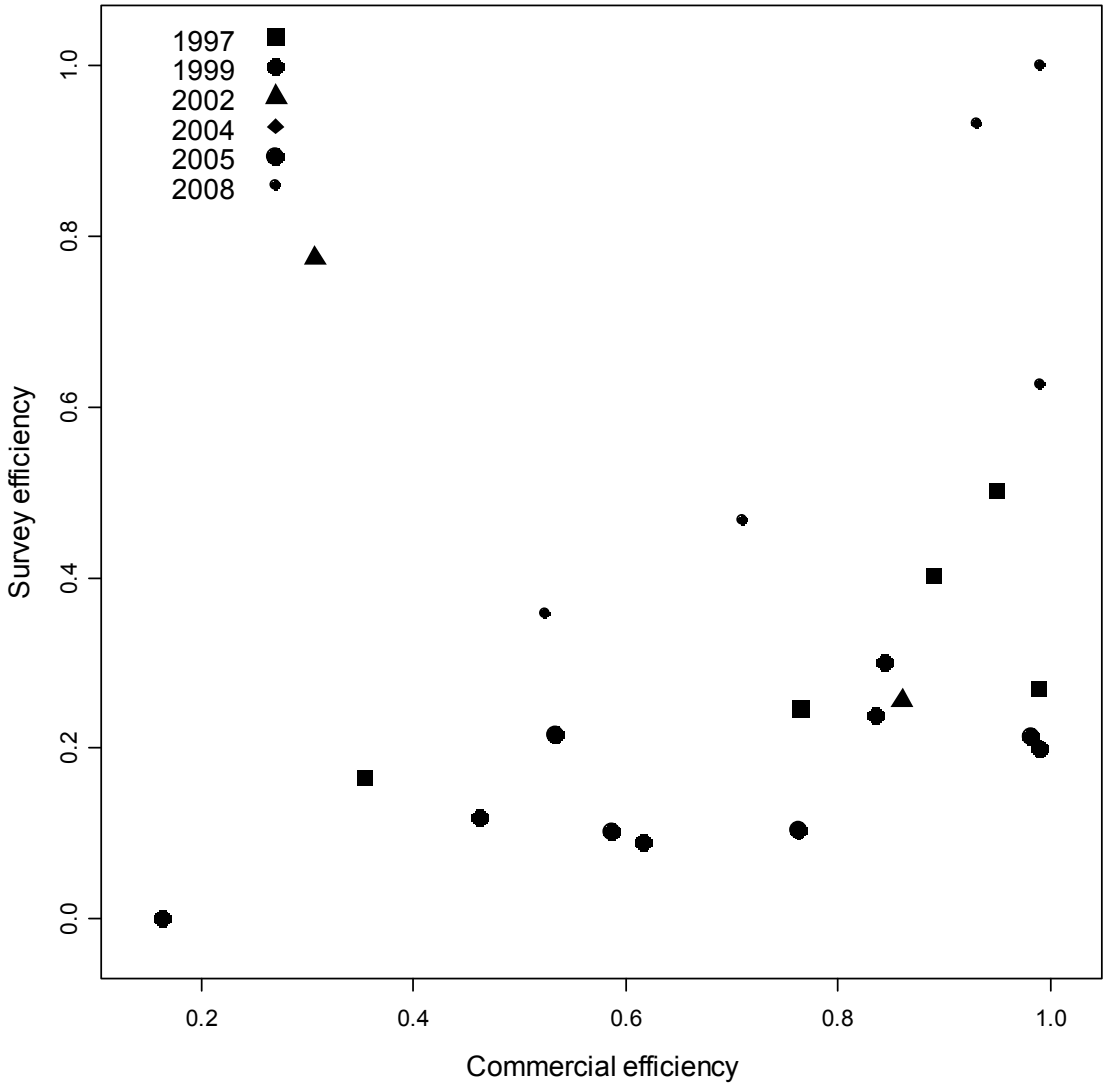

Figure A41. (cont.)

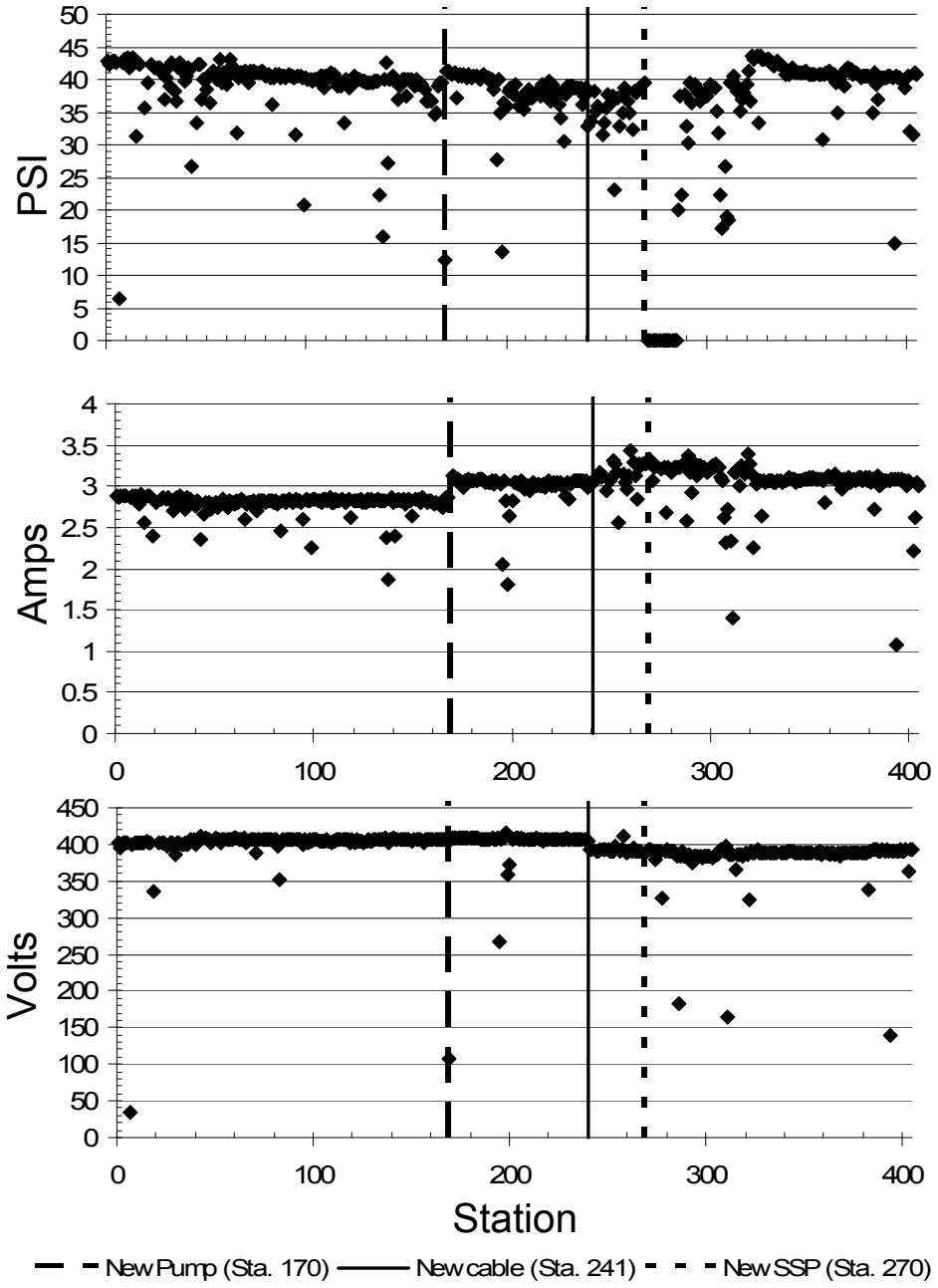

Figure A42. Mean survey dredge sensor data during periods when the dredge was fishing based on y-tilt sensor data, for stations 1-405 in the 2008 NEFSC clam survey.

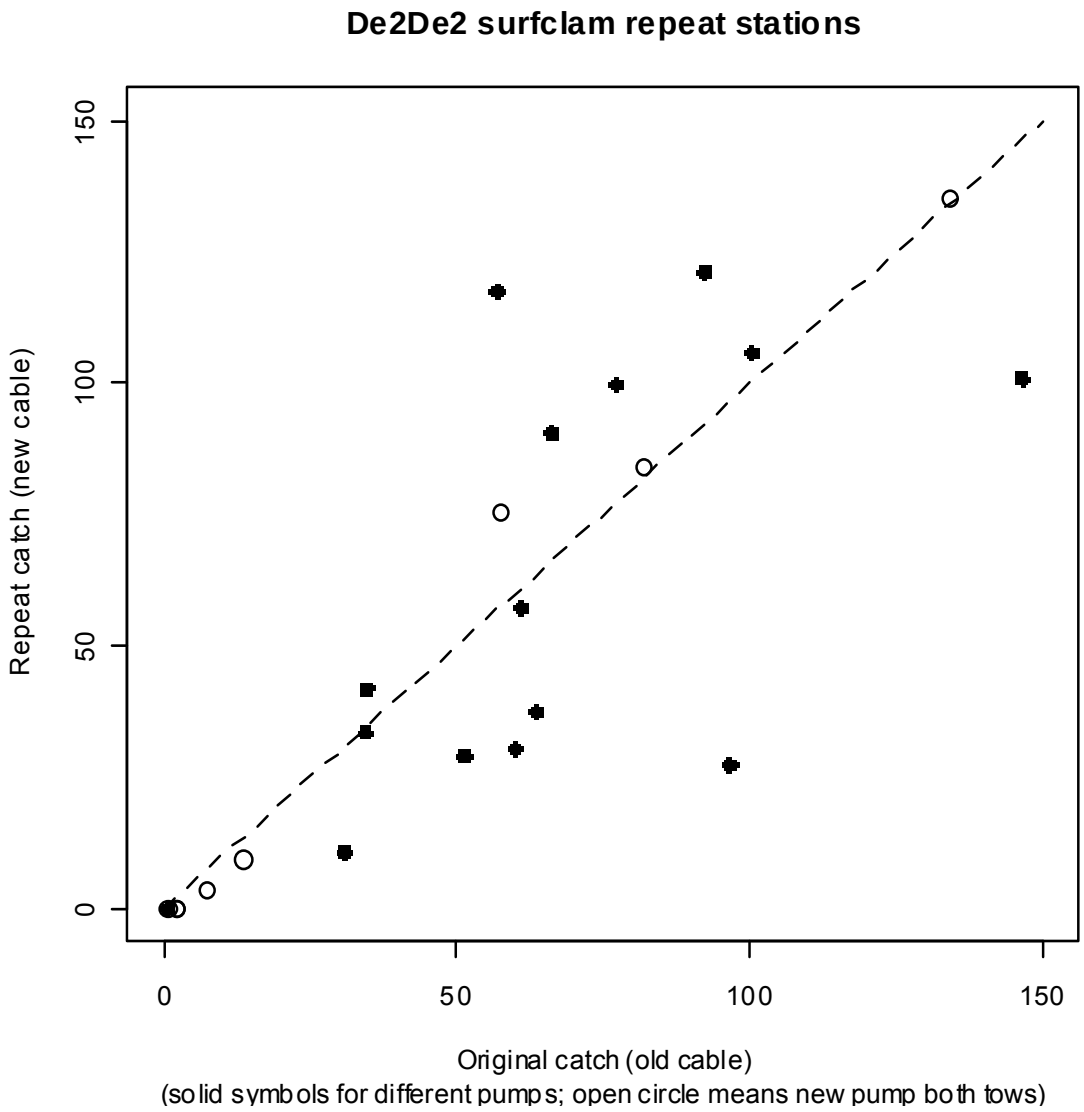

Figure A43. Delaware II-Delaware II (De2De2) repeat station results for surfclam in the 2008 NEFSC clam survey. Solid circles indicate that the original tow used the old pump while the repeat tow used the new pump. Open circles indicate that both the original and repeat tows used the new pump. All repeat stations used the new cable and all original stations used the old cable.

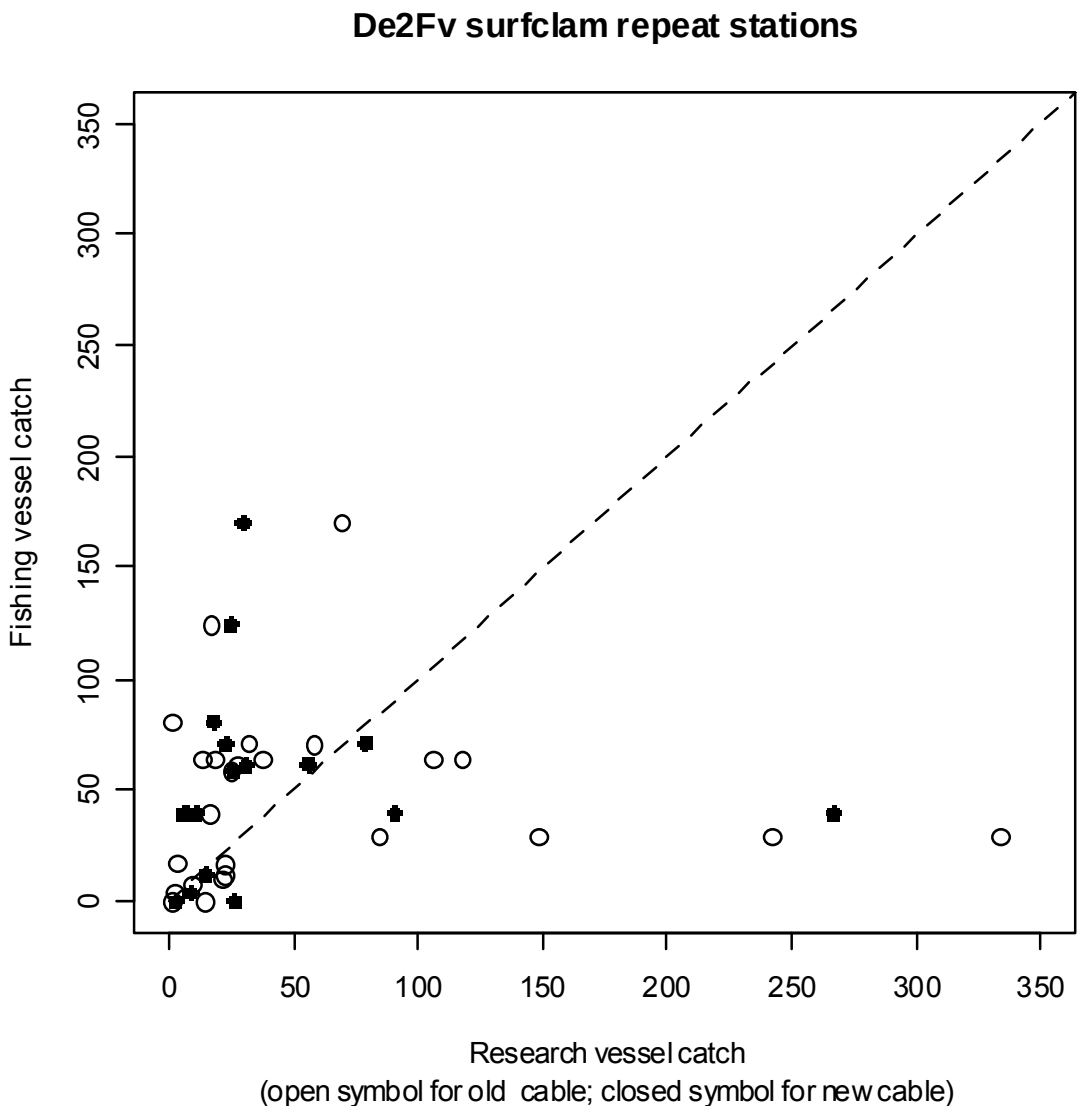

Figure A44. *R/V Delaware II-F/V Endeavor* (De2Fv) repeat station experiment results for surfclam in the 2008 NEFSC clam survey. Open circles indicate that the *R/V Delaware II* original tow used the old pump and closed circles indicate that the *R/V Delaware II* used the new cable. The dashed line is $y=x$, where the original and repeat catches are identical.

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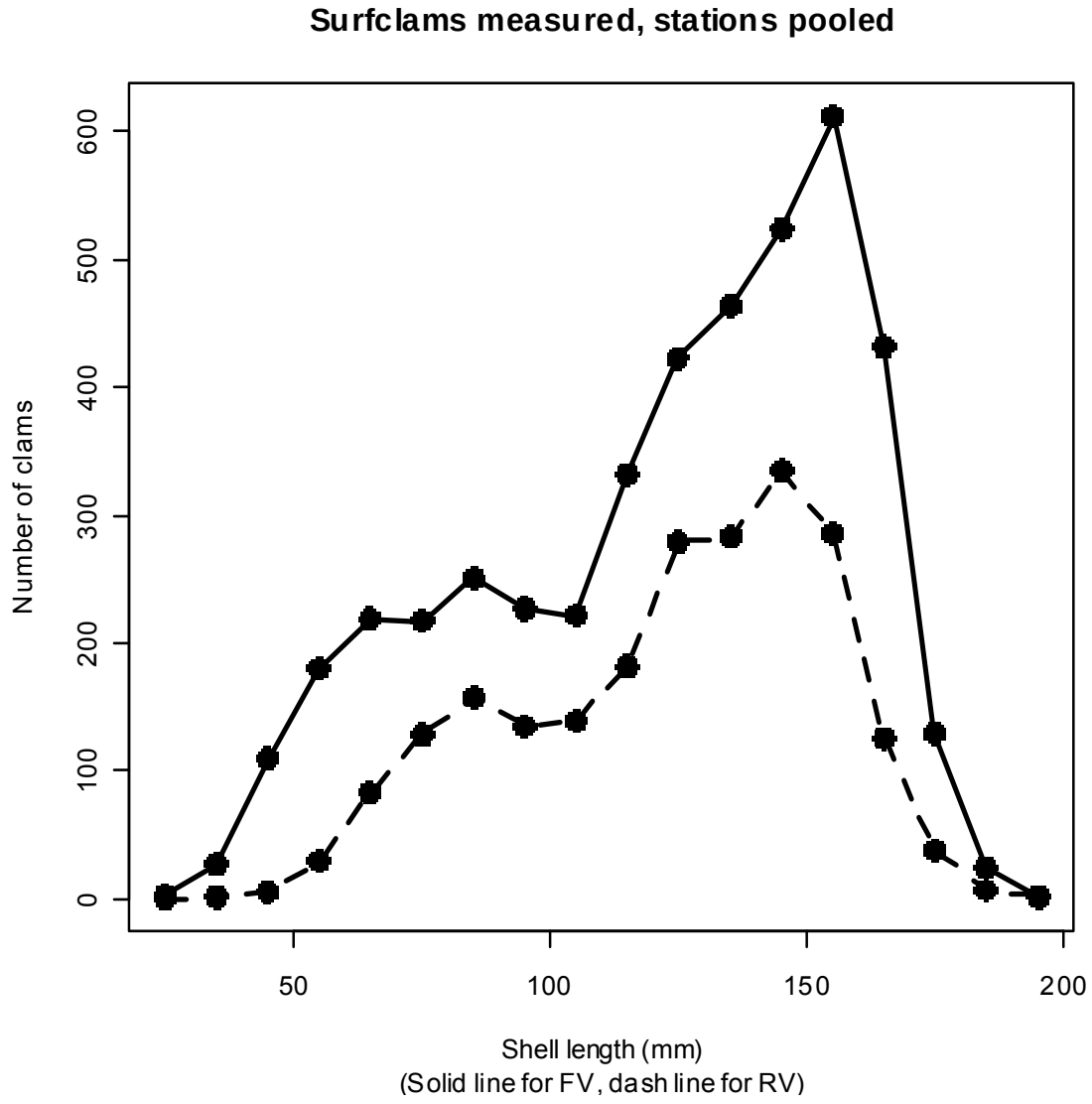


Figure A45. Surfclam shell height composition data used to estimate selectivity of the NEFSC survey clam dredge.

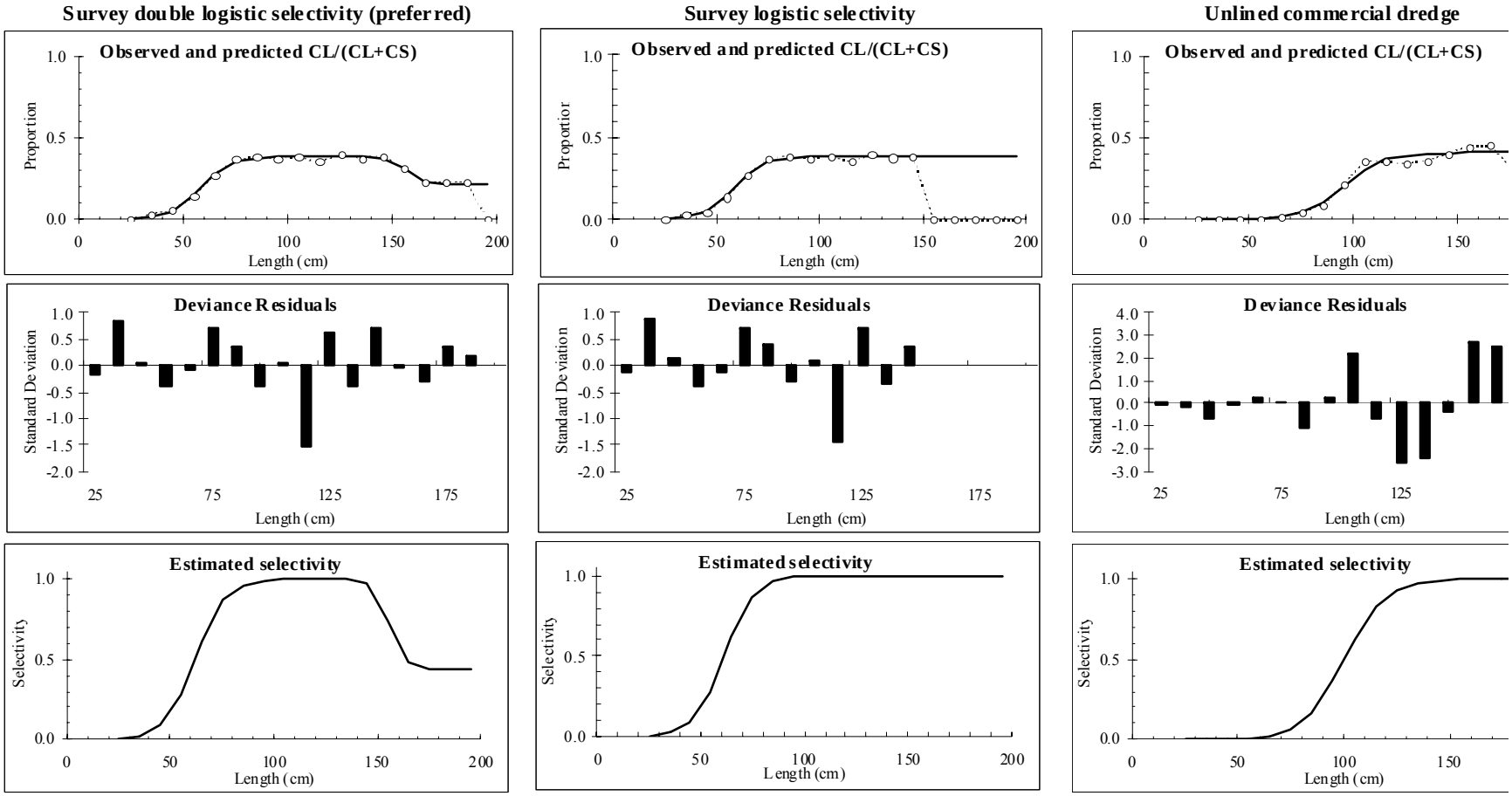


Figure A46. Data, diagnostics and estimated selectivity curves for surfclams in the NEFSC clam survey dredge. The unlined commercial dredge was configured for survey work and not representative of dredges used during commercial fishing.

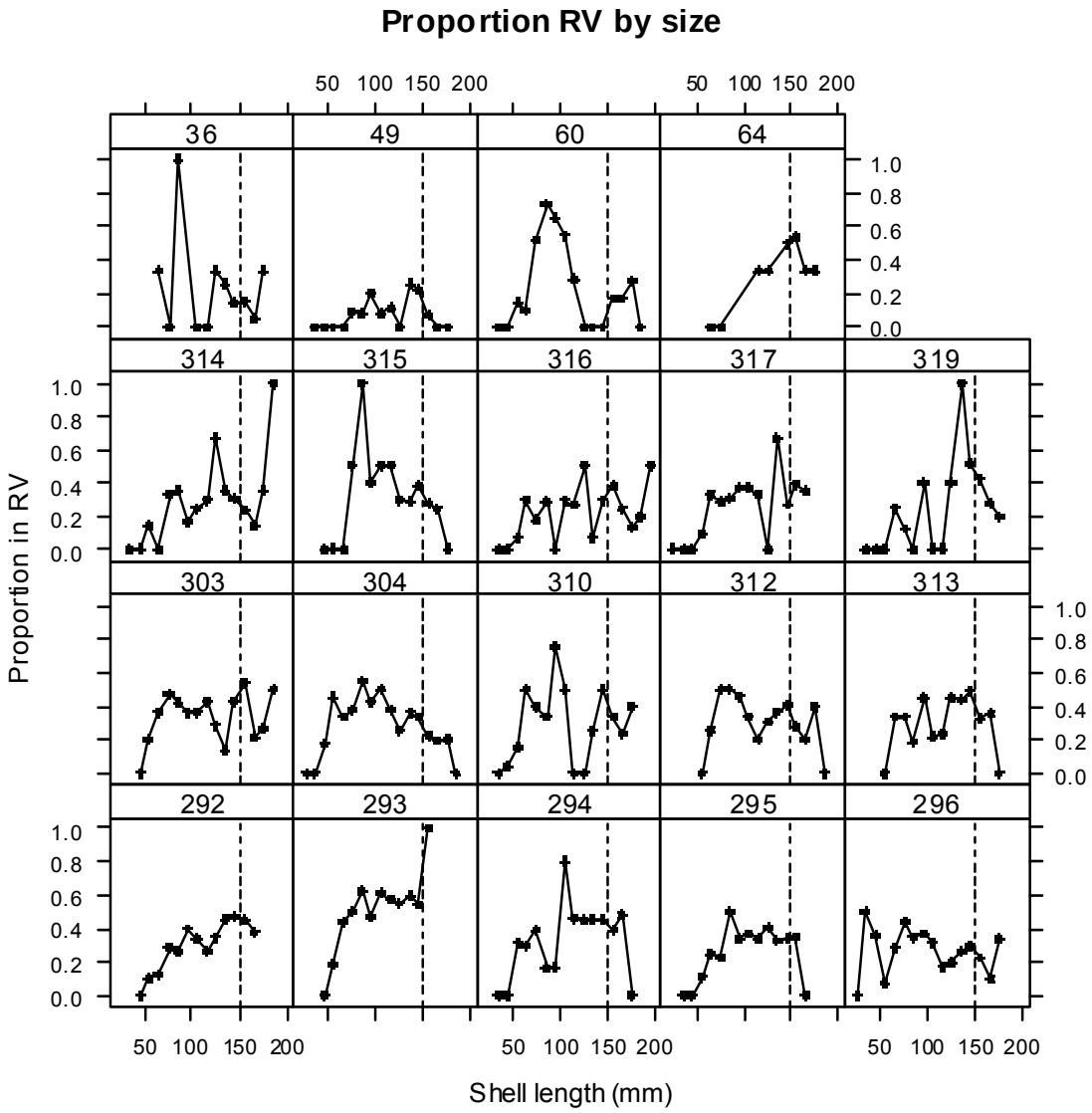


Figure A47. Ratios of R/V over total catch (R/V + F/V) for selectivity experiments during 2008 (labels at the top of each panel are selectivity experiment IDs). The dashed vertical line is at 150 mm SL.

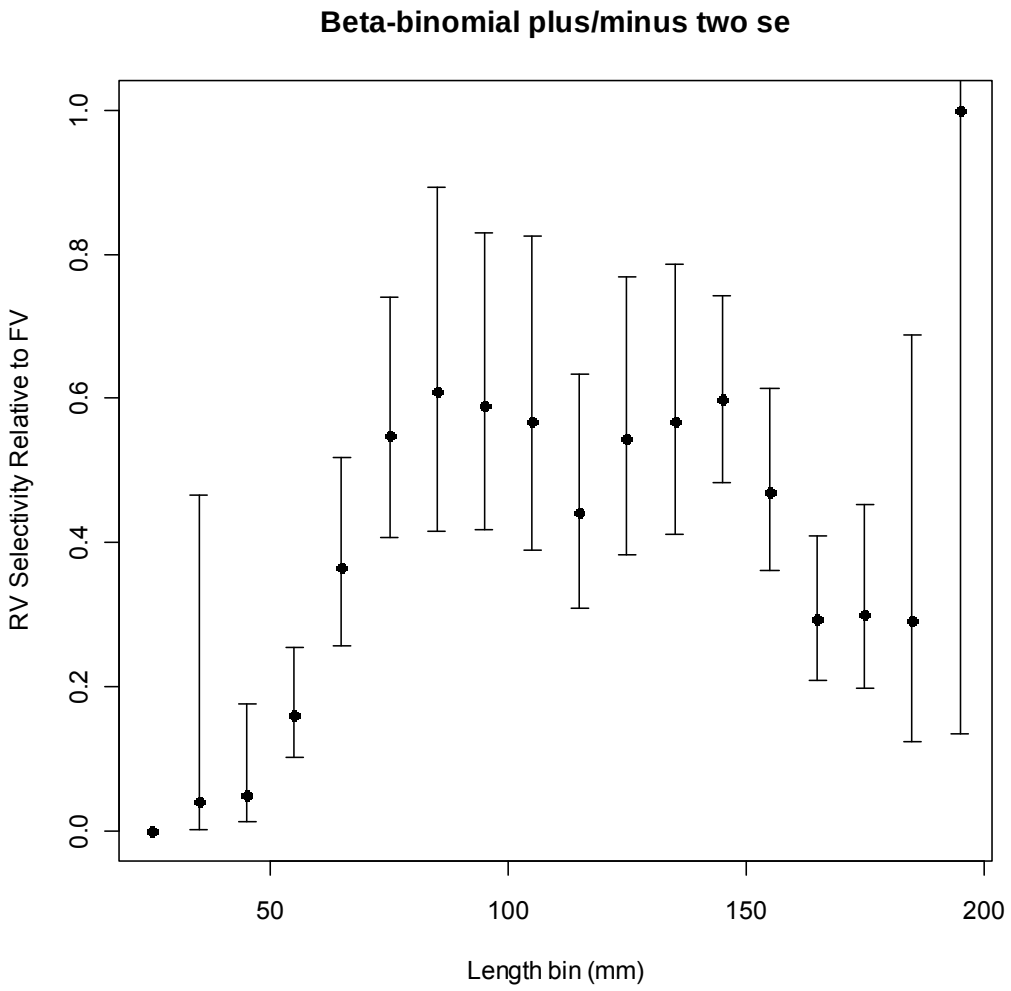


Figure A48. Beta-binomial estimates for selectivity of the NEFSC clam survey dredge, with 95% confidence interval, by shell size group.

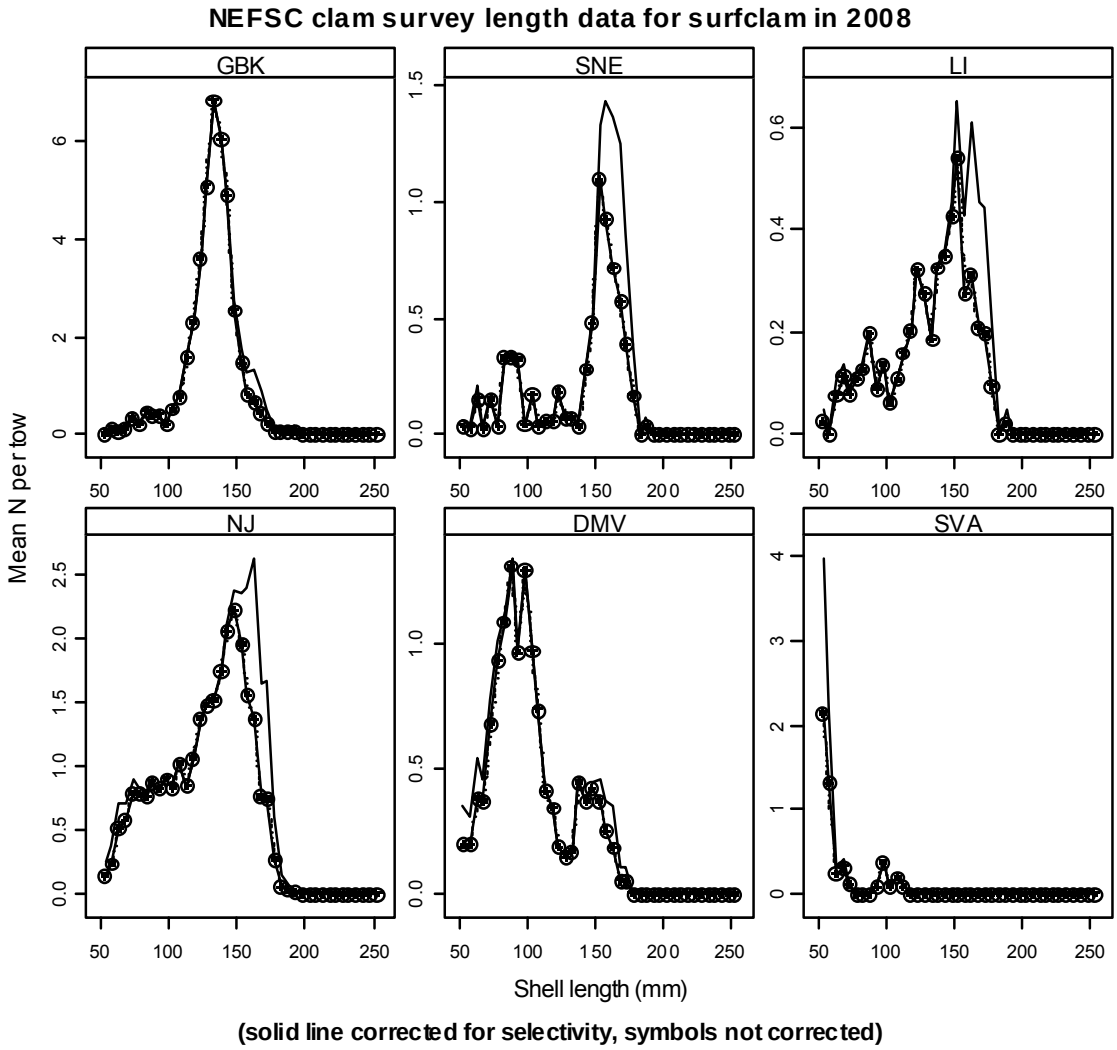


Figure A49. NEFSC survey length composition for surfclams in the 2008 survey with (solid line) and without (symbols) correction for dome shaped survey dredge selectivity.

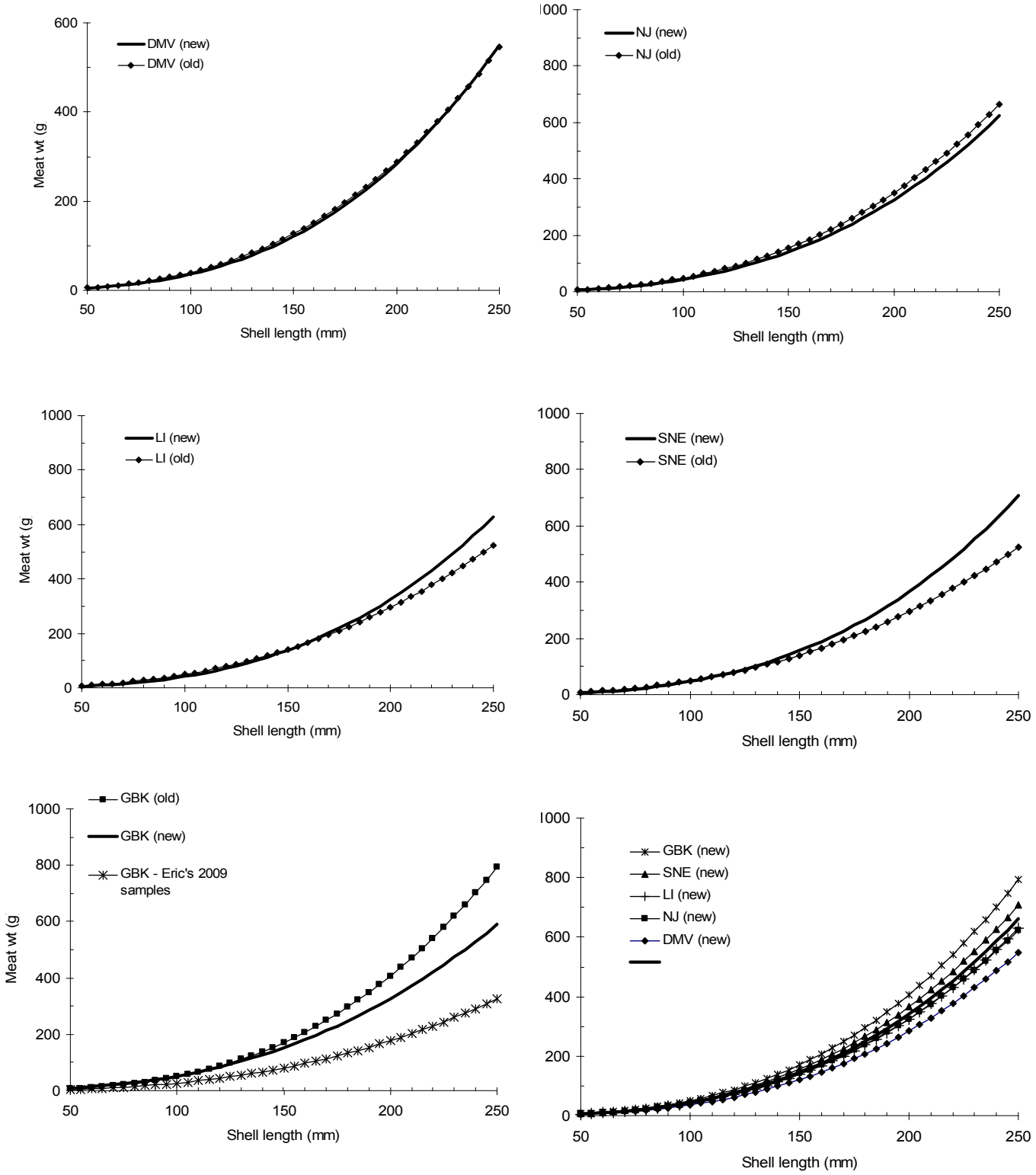


Figure A50. Updated and original shell length/ meat weight relationships by region.

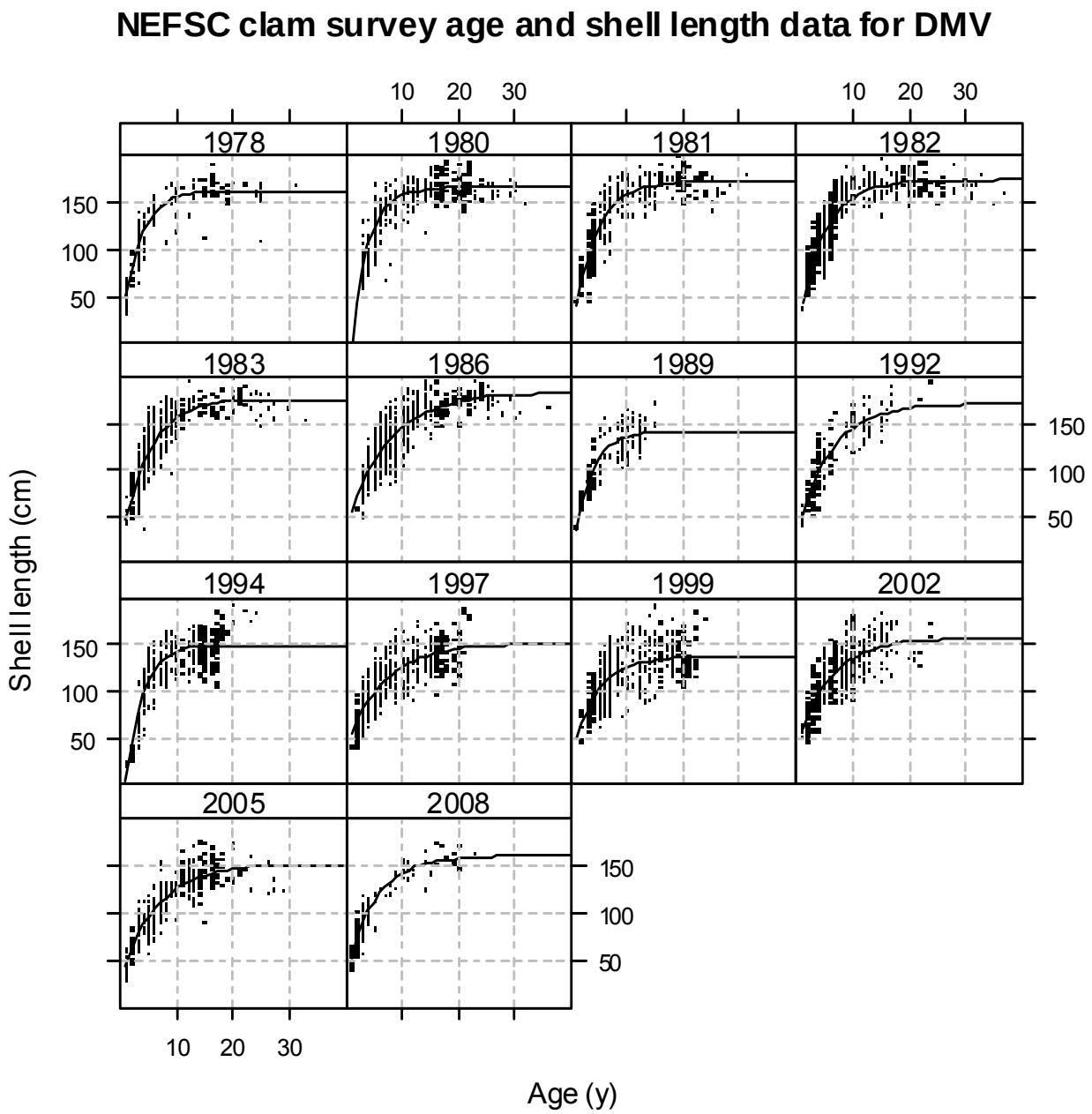


Figure A51. NEFSC surfclam size at age data for the DMV region with von Bertalanffy growth curves fit using nonlinear regression, by year.

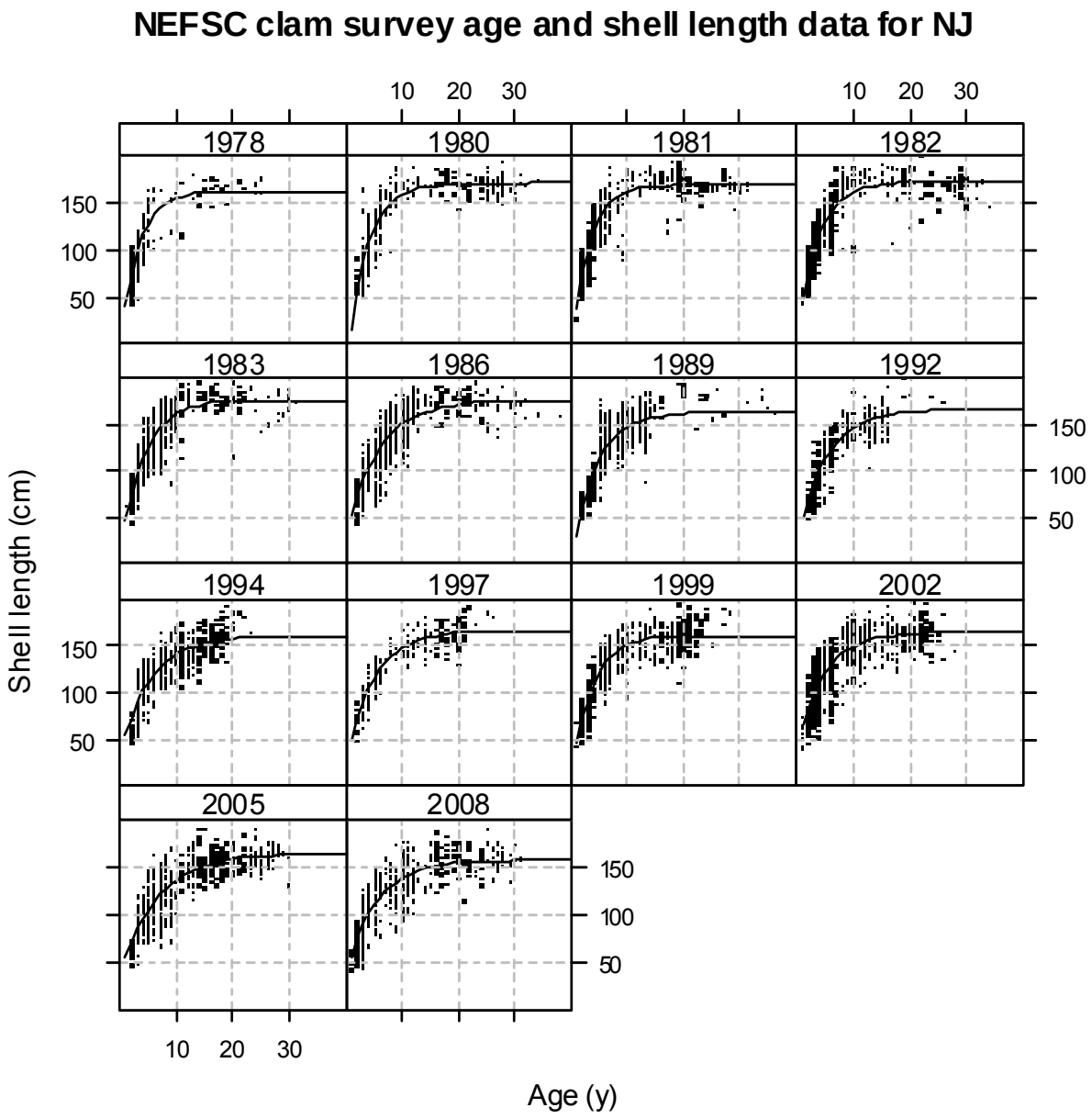


Figure A52. NEFSC surfclam size at age data for the NJ region with von Bertalanffy growth curves fit using nonlinear regression, by year.

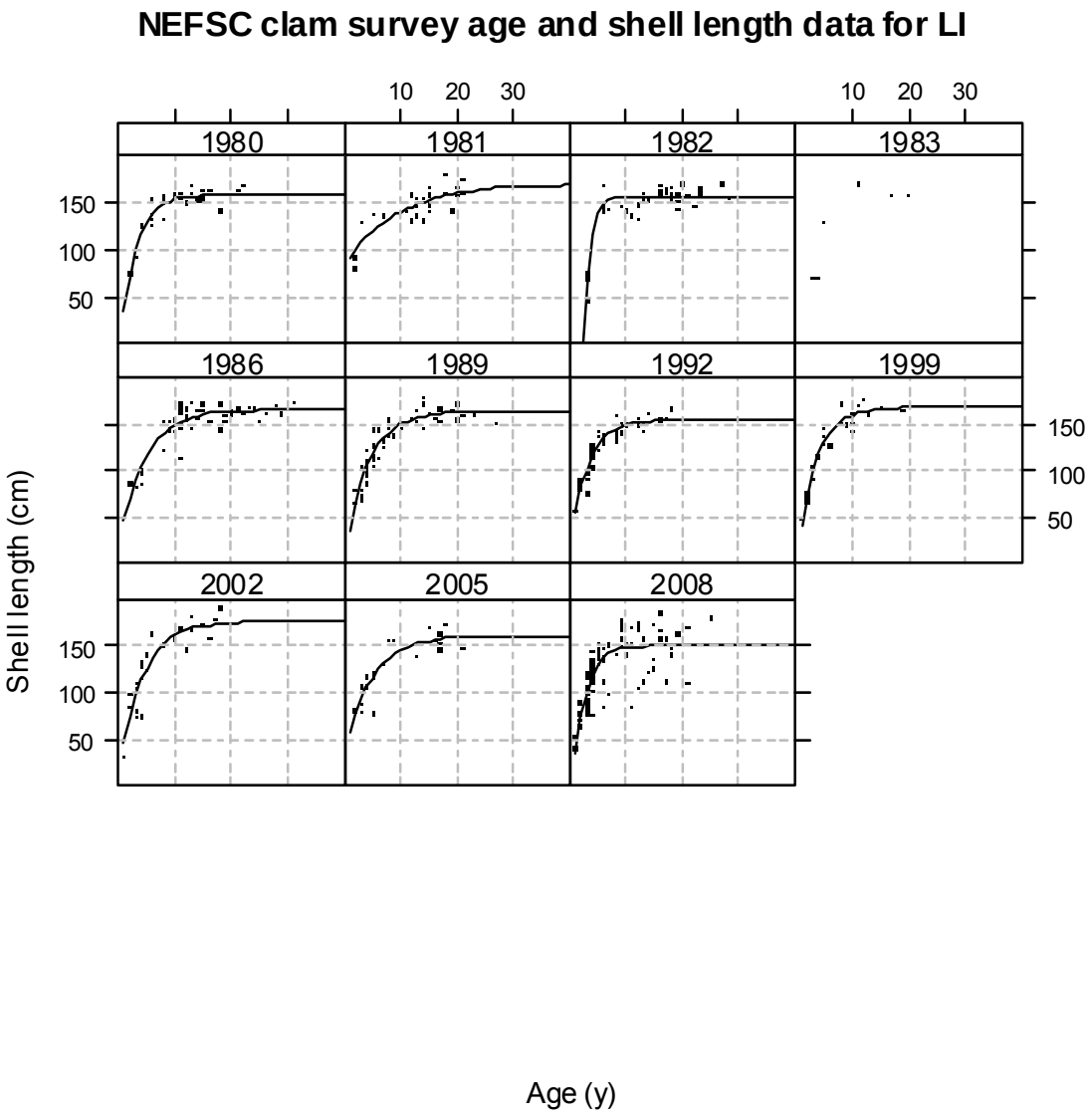


Figure A53. NEFSC surfclam size at age data for the LI region with von Bertalanffy growth curves fit using nonlinear regression, by year. There was not enough data for 1983 to draw a curve.

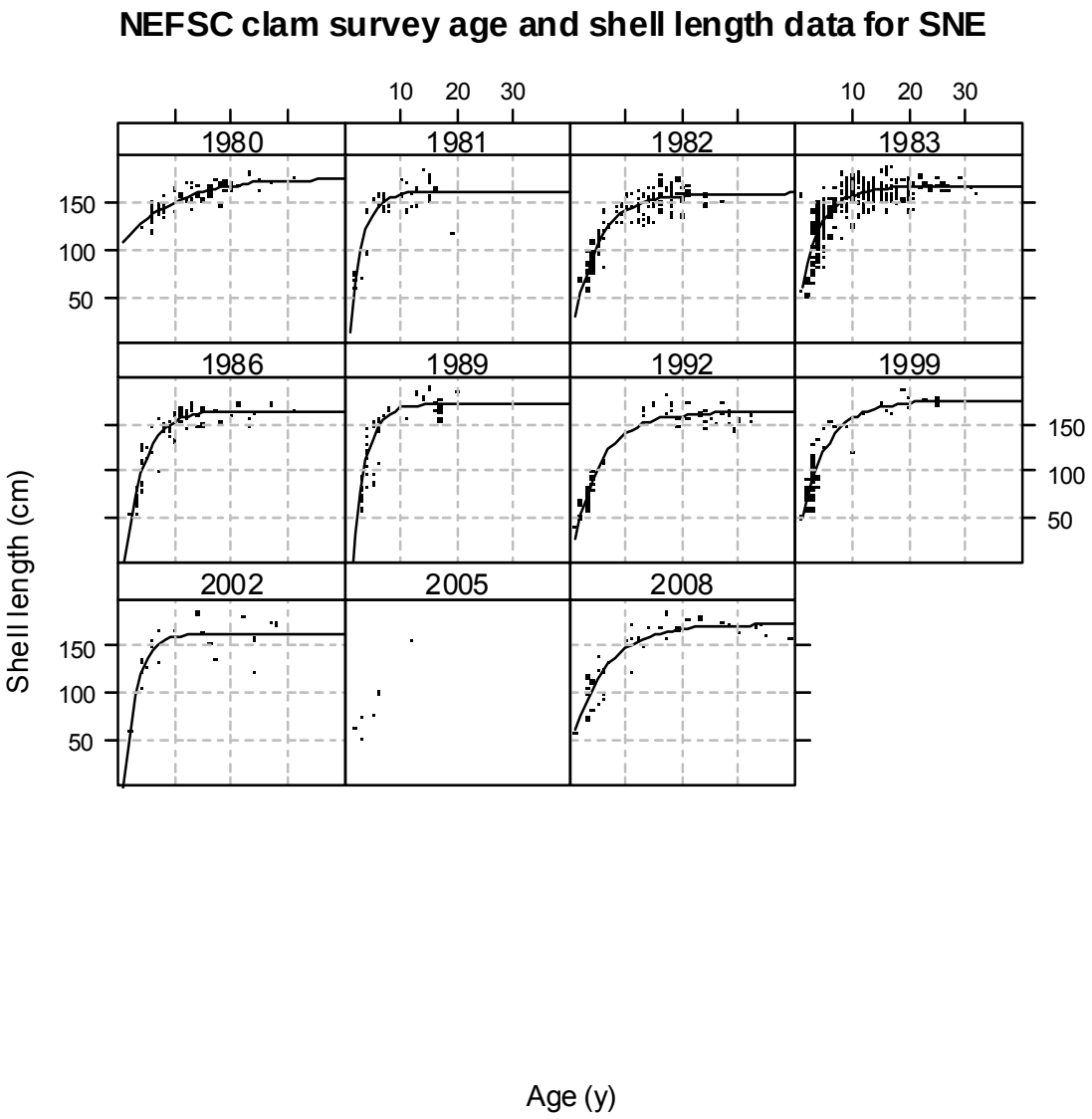


Figure A54. NEFSC surfclam size at age data for the SNE region with von Bertalanffy growth curves fit using nonlinear regression, by year. There was not enough data from 2005 to draw a curve.

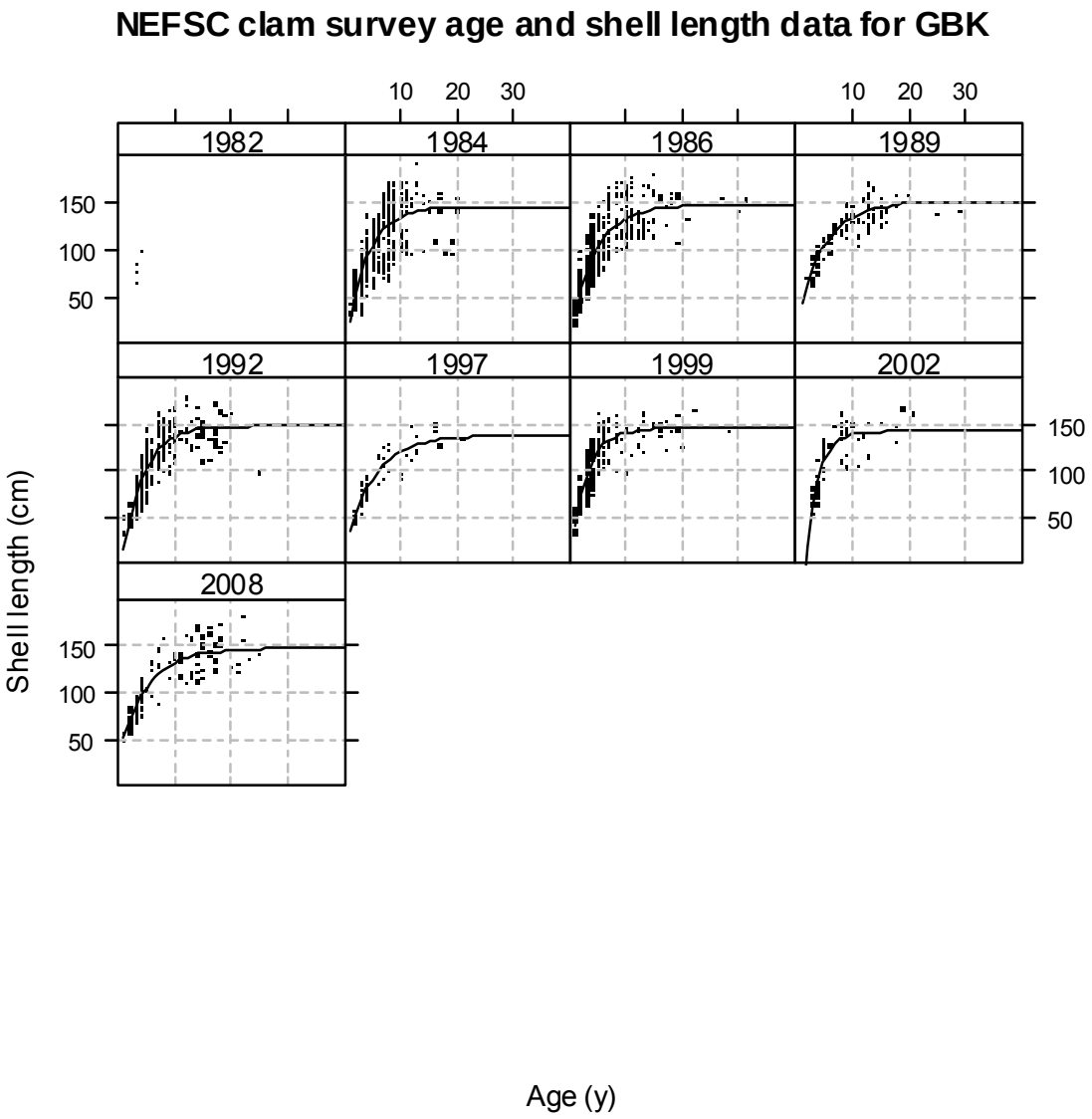


Figure A55. NEFSC surfclam size at age data for the GBK region with von Bertalanffy growth curves fit usng nonlinear regression, by year. There was not enough data from 1982 to draw a curve.

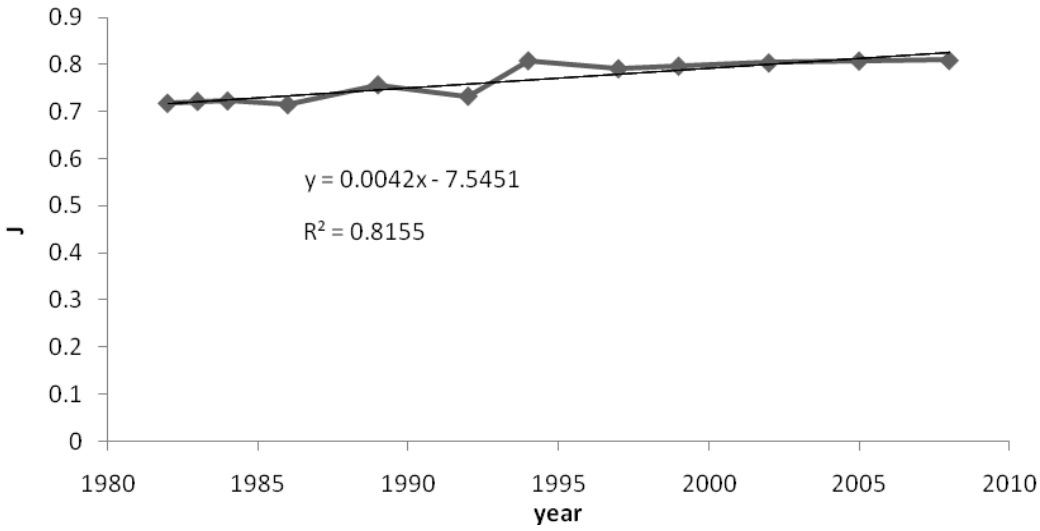


Figure A56. Annual estimates and linear regression analysis for the growth parameter *J*, which is used in the KLAMZ model for the entire surfclam stock.

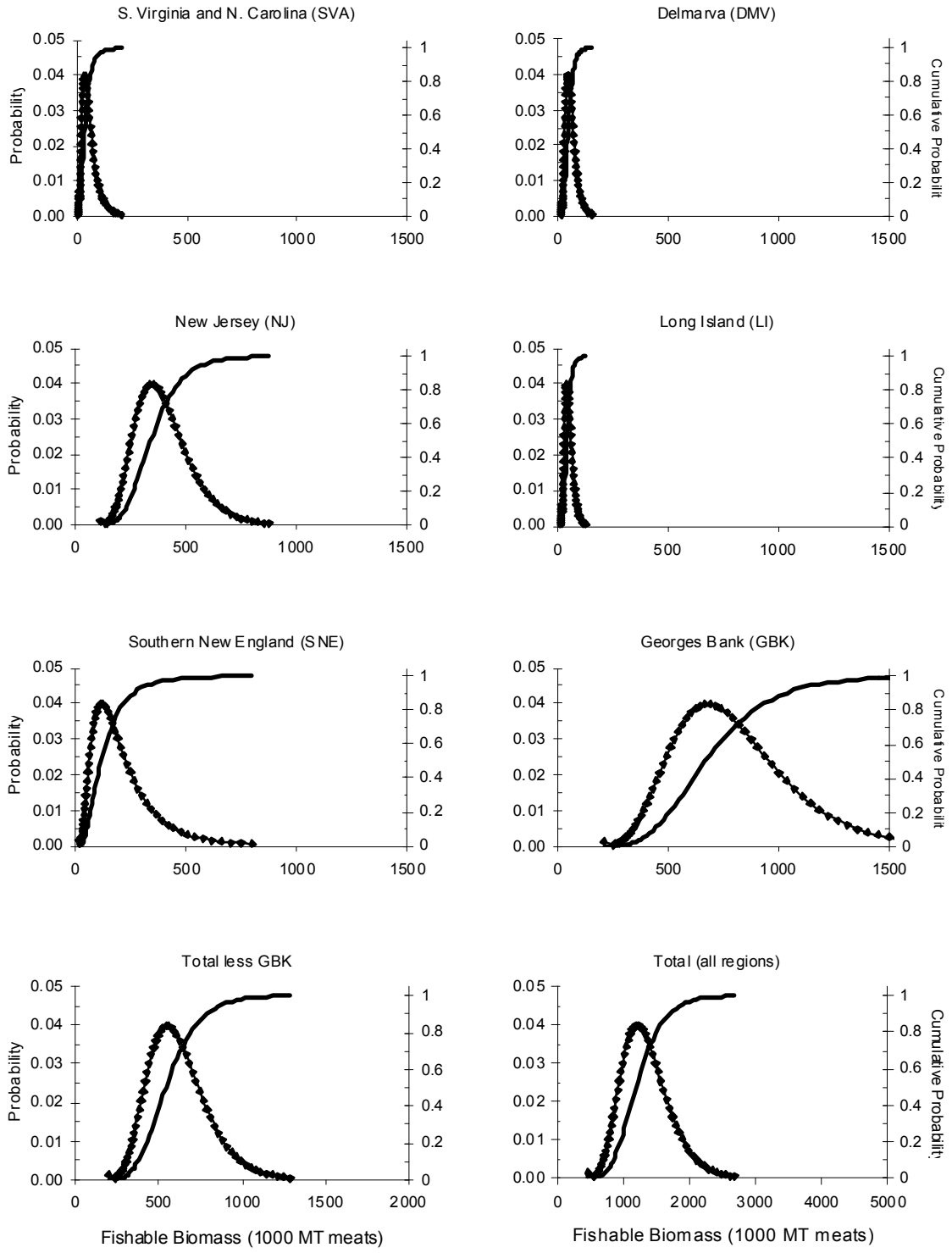


Figure A57. Uncertainty in efficiency corrected swept-area biomass estimates for surfclams.

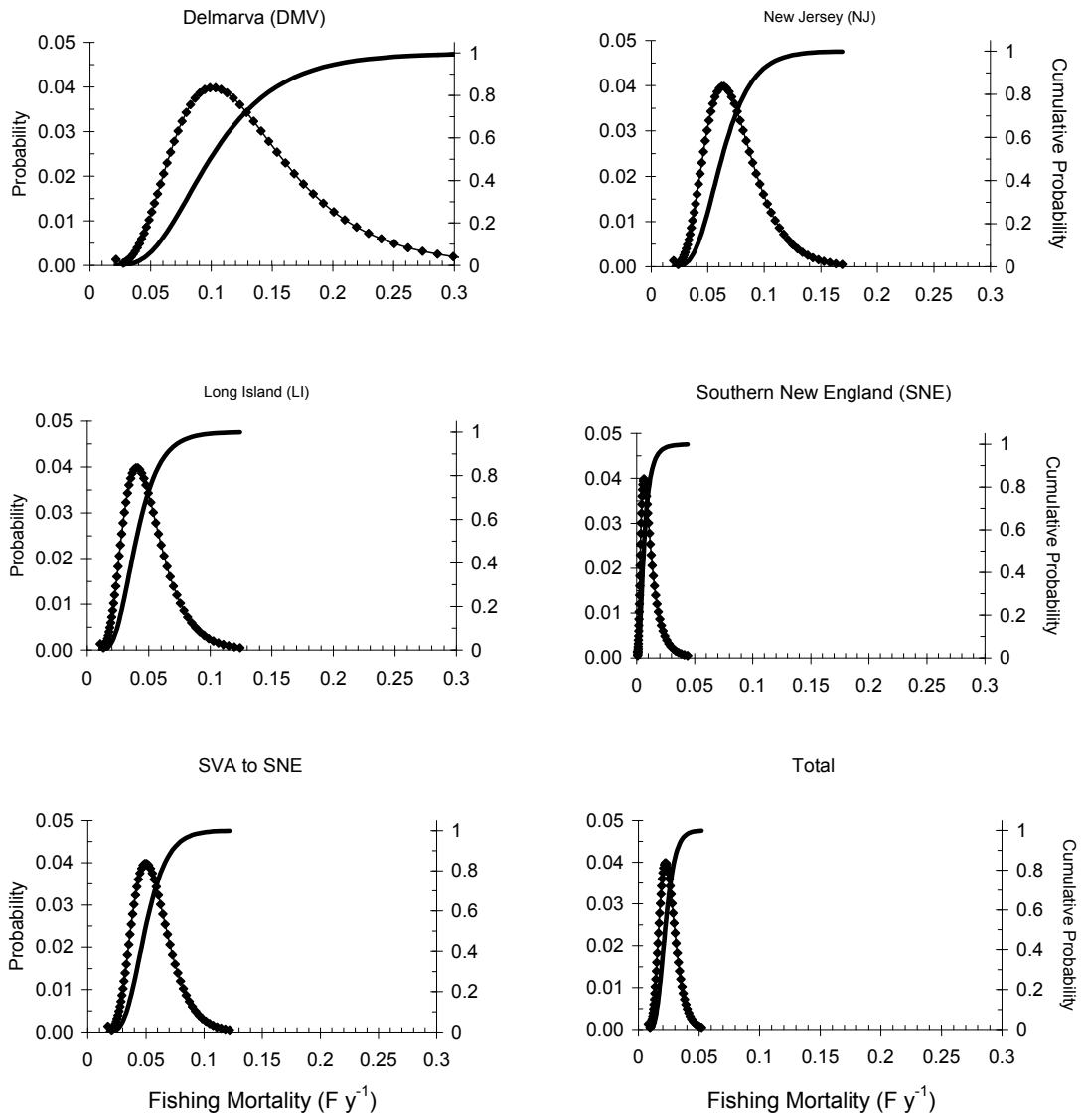


Figure A58. Uncertainty in fishing mortality estimates for surfclams based on catch and efficiency corrected swept-area biomass estimates.

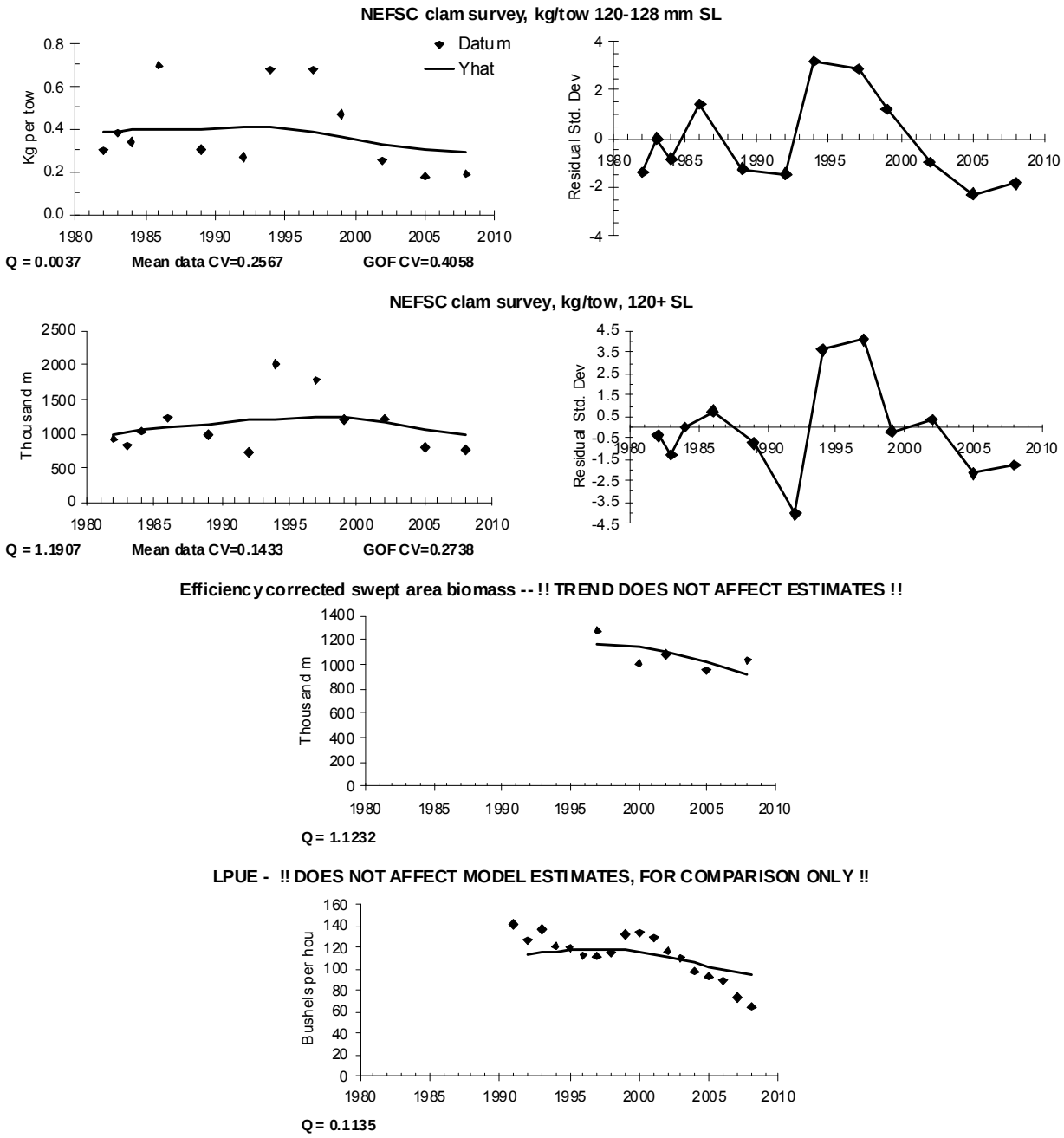


Figure A59. Goodness of fit to biomass trend data for the entire stock of surfclams in the basecase KLAMZ model.

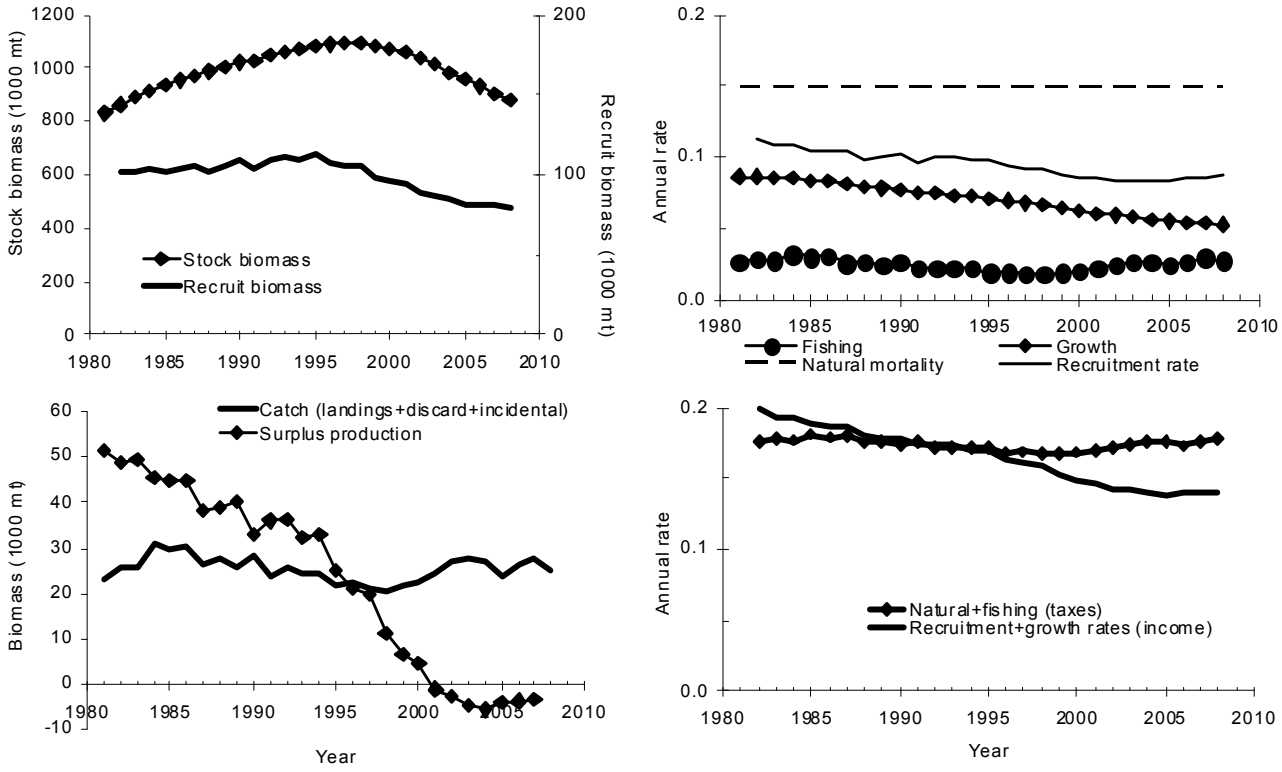


Figure A60. Population dynamics for the entire stock of surfclams estimated in the basecase KLAMZ model, including stock and recruitment biomass (top left), catch and surplus production (bottom left), instantaneous annual rates for fishing mortality, somatic growth, natural mortality and recruitment (top right). The bottom right panel shows combined natural and fishing mortality rates (which decrease stock biomass) with combined recruitment and growth rates (which increase stock biomass).

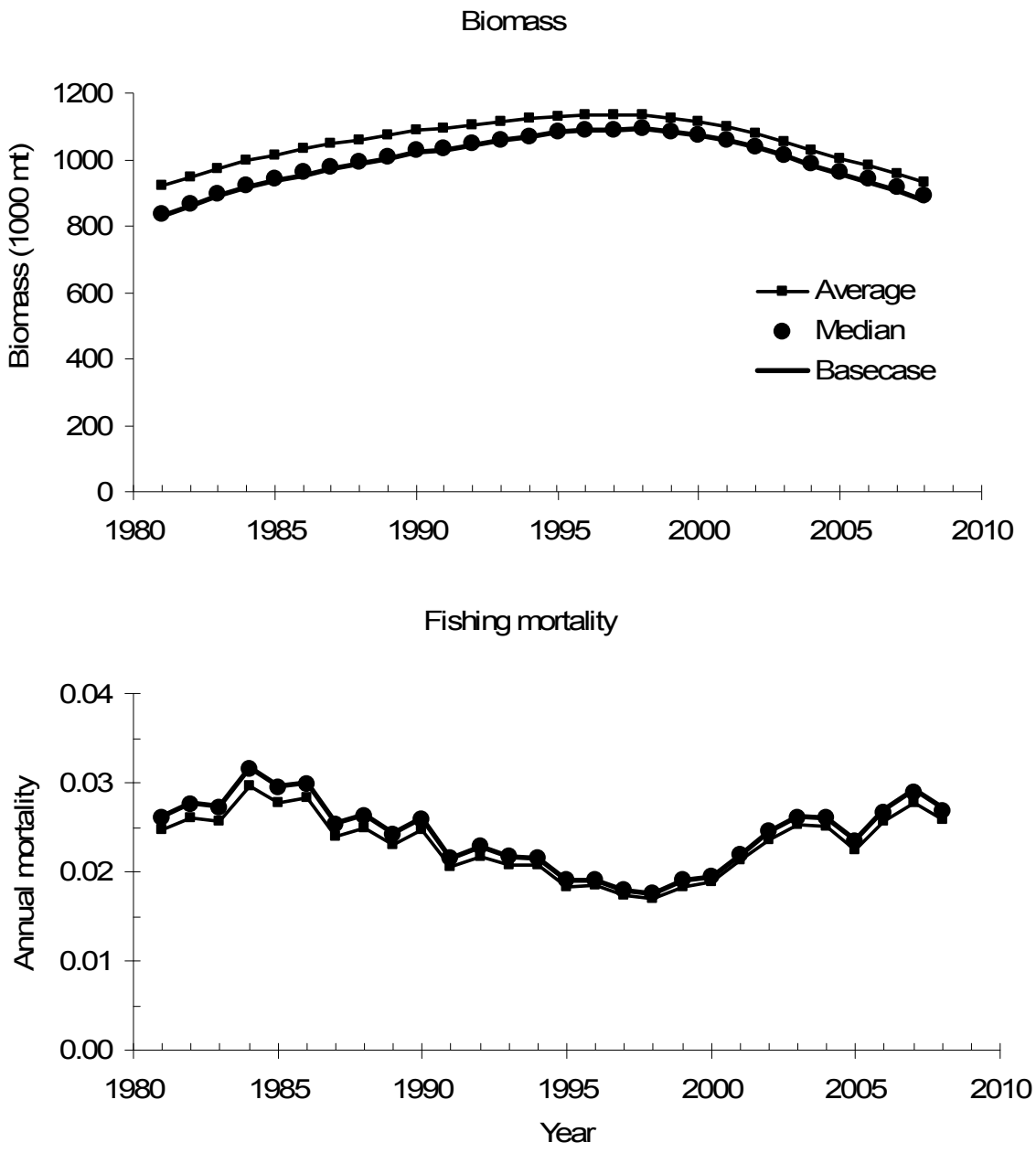


Figure A61. Basecase biomass and fishing mortality estimates compared to the means and median of 2000 bootstrap estimates.

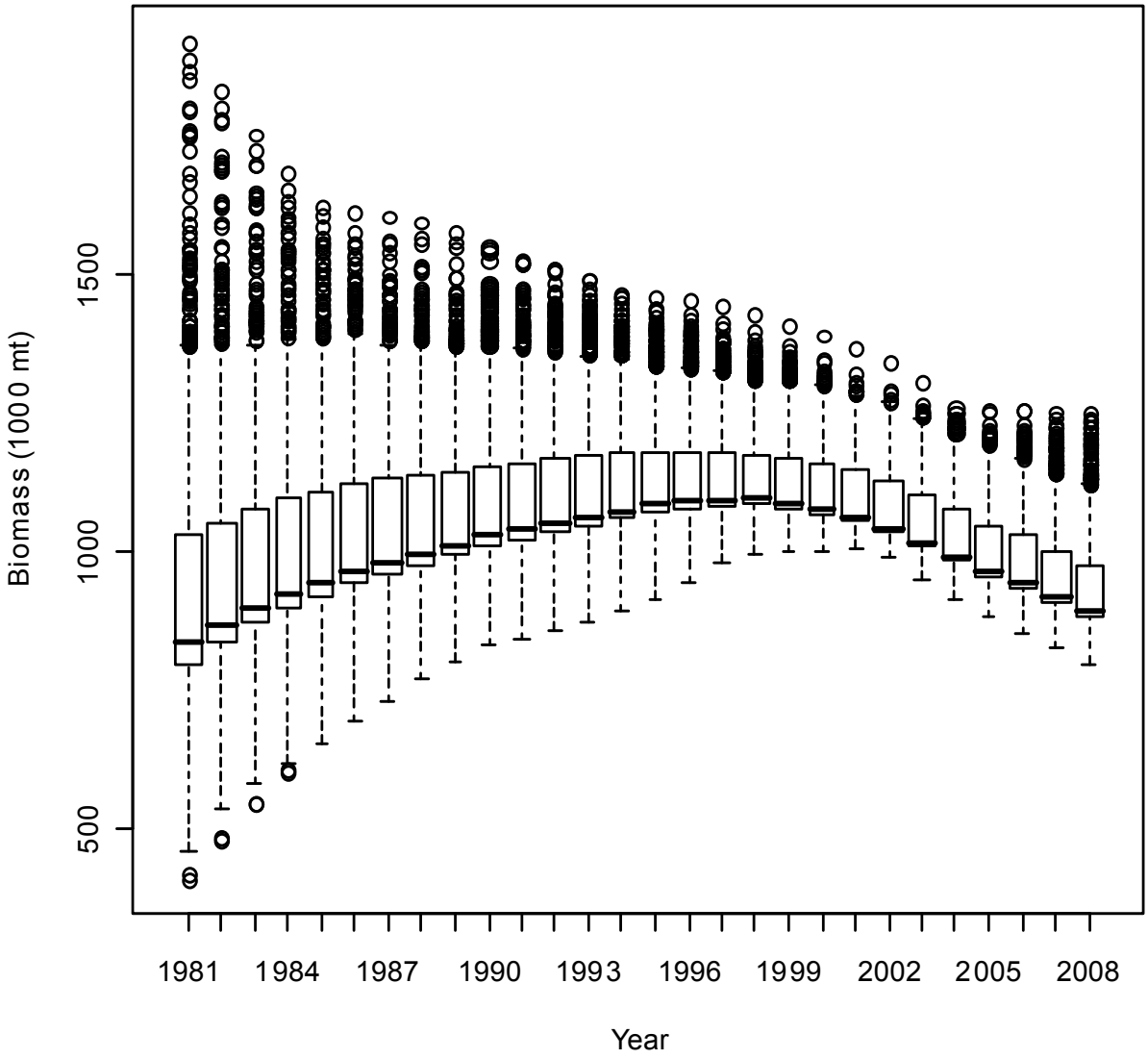


Figure A62. Boxplots showing the distribution of bootstrap biomass estimates for surfclams from for the basecase KLAMZ model.

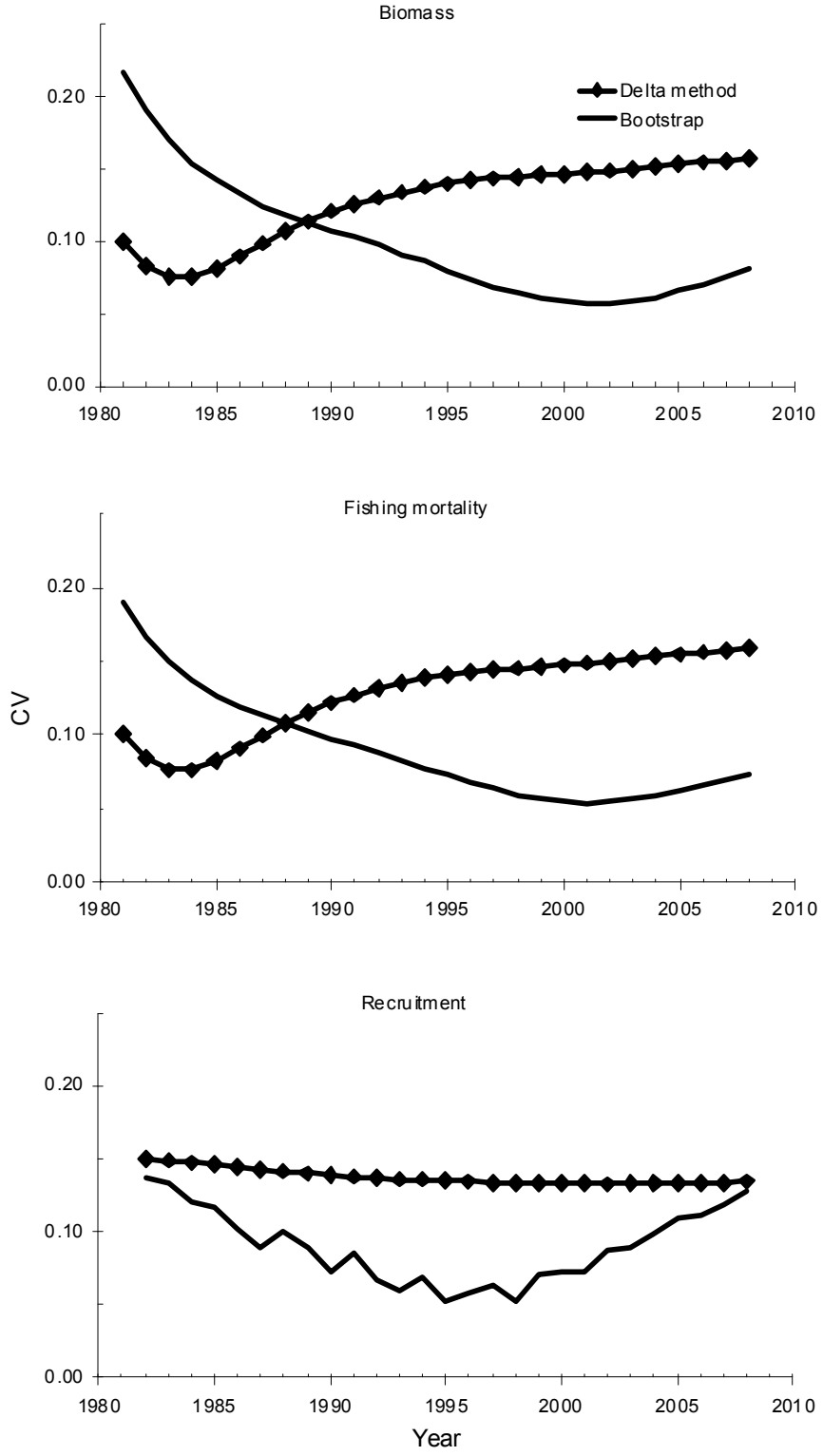


Figure A63. CVs for biomass, fishing mortality and recruitment estimates for the entire surfclam stock from the basecase KLAMZ model, calculated by two methods.

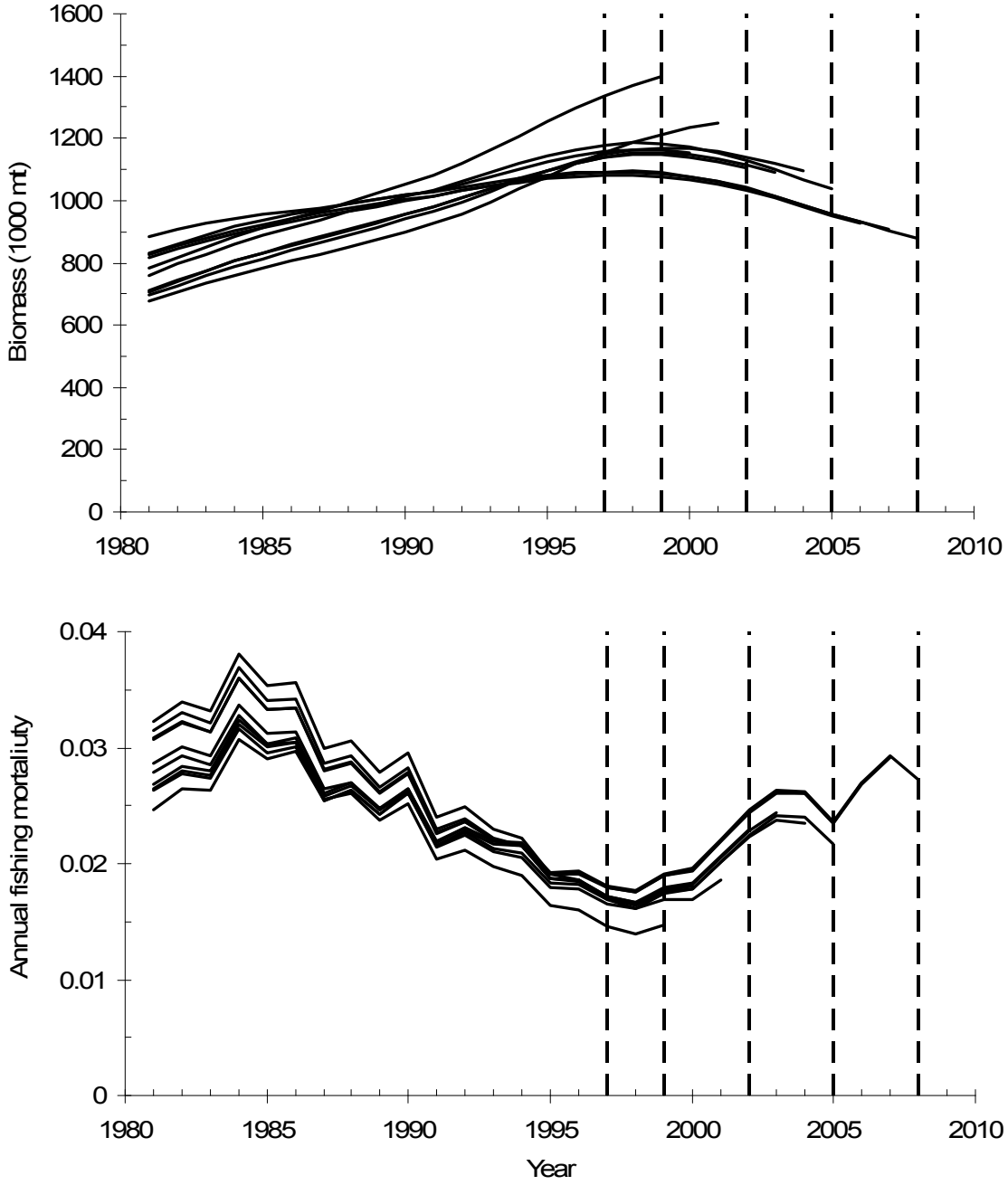


Figure B64. Retrospective analysis with the basecase KLAMZ model for surfclams. The vertical dashed lines show the timing of NEFSC clam surveys.

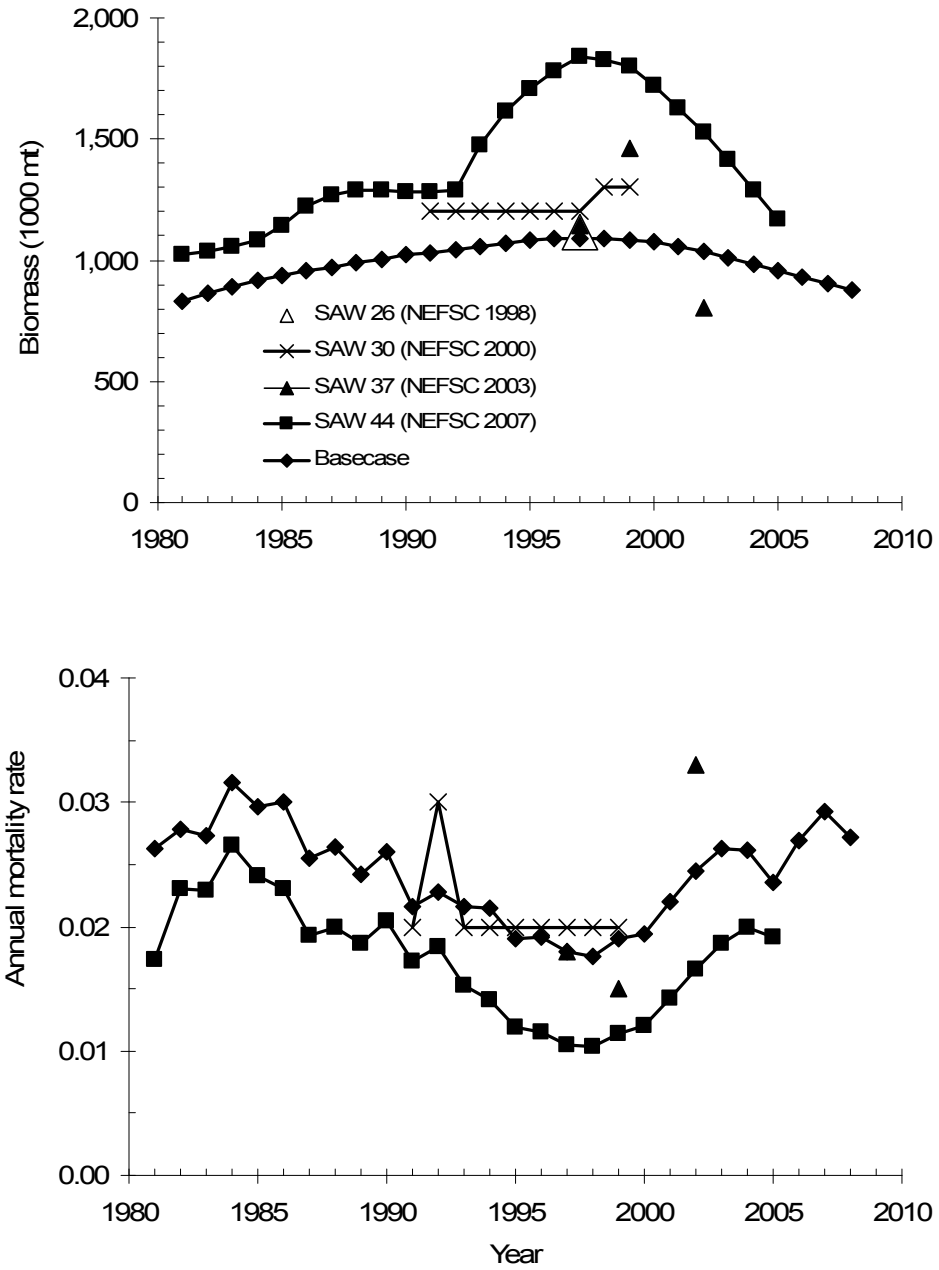


Figure A65. Historical retrospective analyses for biomass (top) and fishing mortality (bottom) estimates from surfclam stock assessments carried out during 1998-present. Estimates in the basecase model (this assessment) and from SAW 44 are from KLAMZ models for surfclams 120+ mm SL. Estimates from SAW 30 (KLAMZ model) and SAW 37 (efficiency corrected swept-area biomass) are for surfclams 120+ mm SL in NJ and 100+ mm SL elsewhere. The estimate from SAW 26 (efficiency corrected swept-area biomass) is for all sizes.

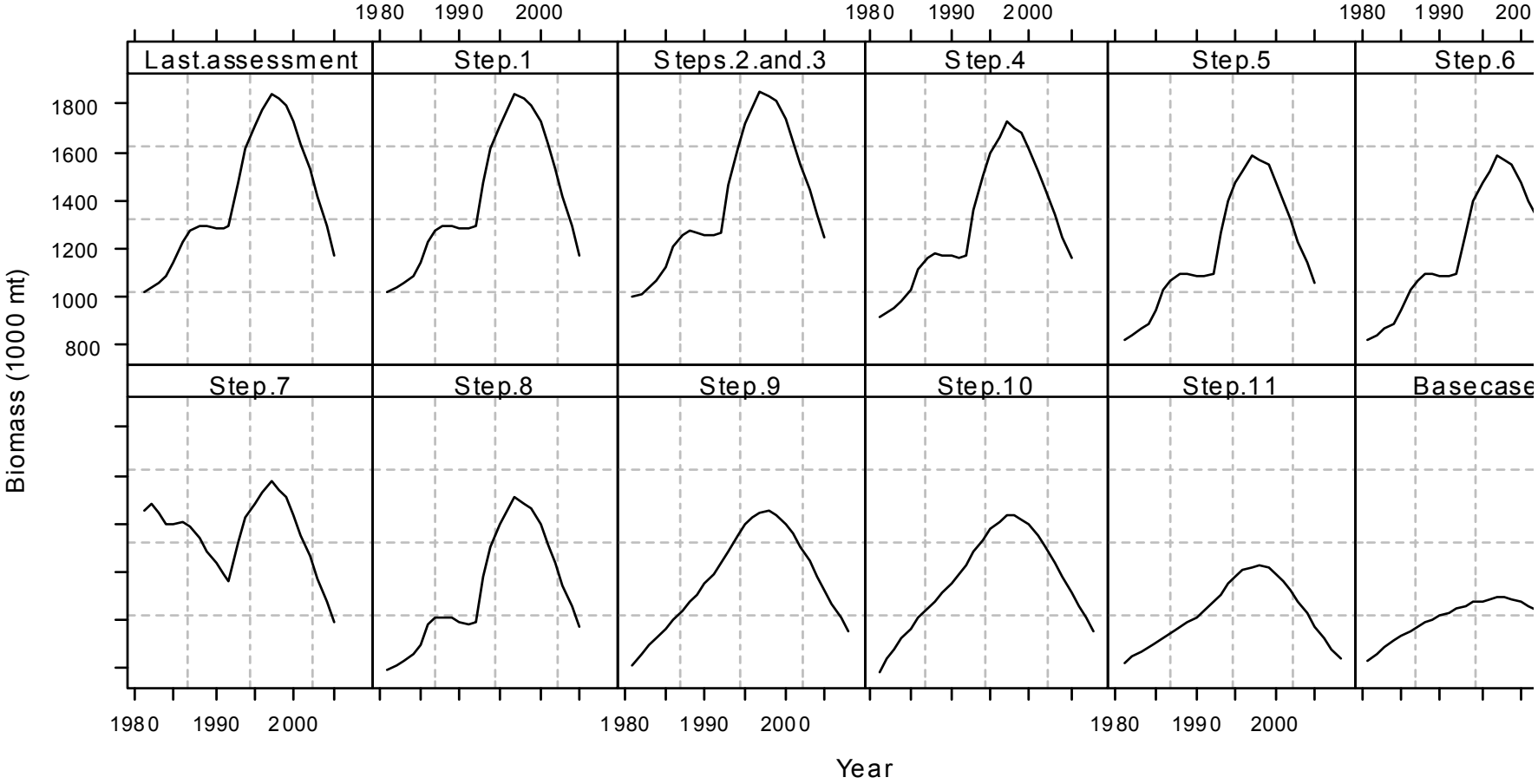


Figure A66. Changes in KLAMZ model data and configuration ("Steps") responsible for differences between basecase biomass estimates and biomass estimates in the last assessment (NEFSC 2007). See table KLAMZ-2 for details.

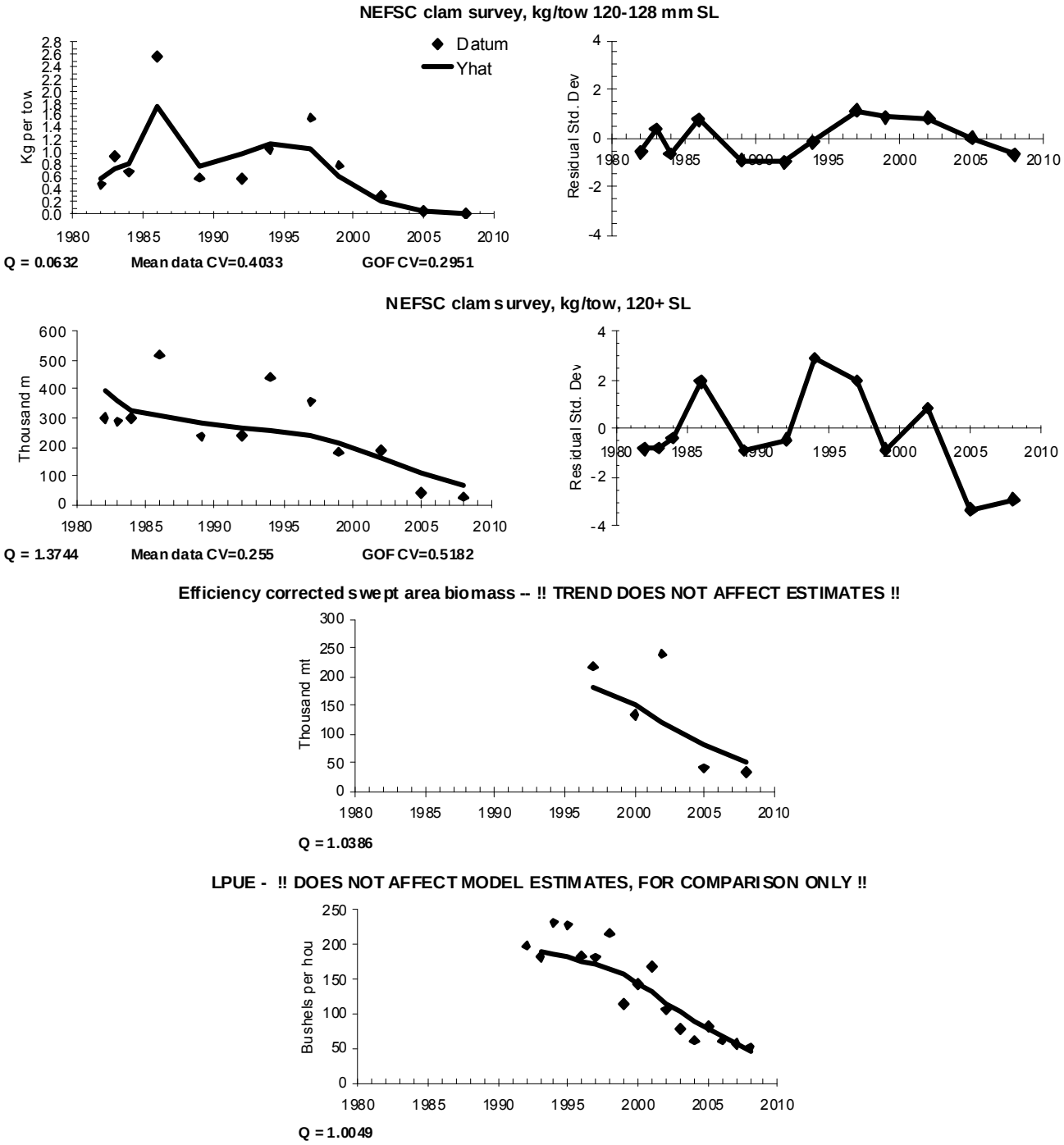


Figure A67. Goodness of fit to biomass trend data for the surfclams in the DMV region.

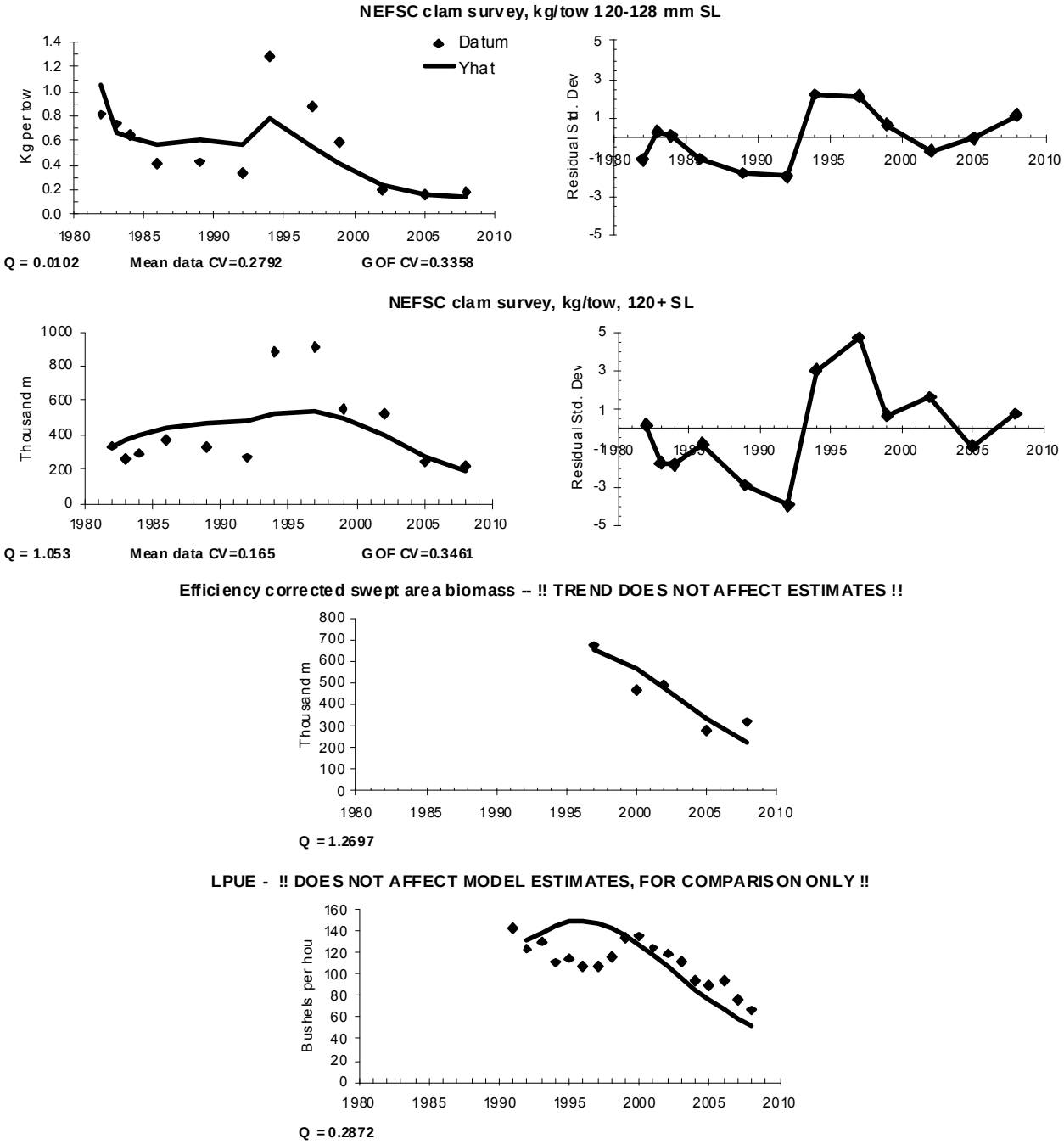


Figure A68. Goodness of fit to biomass trend data for the surfclams in the NJ region.

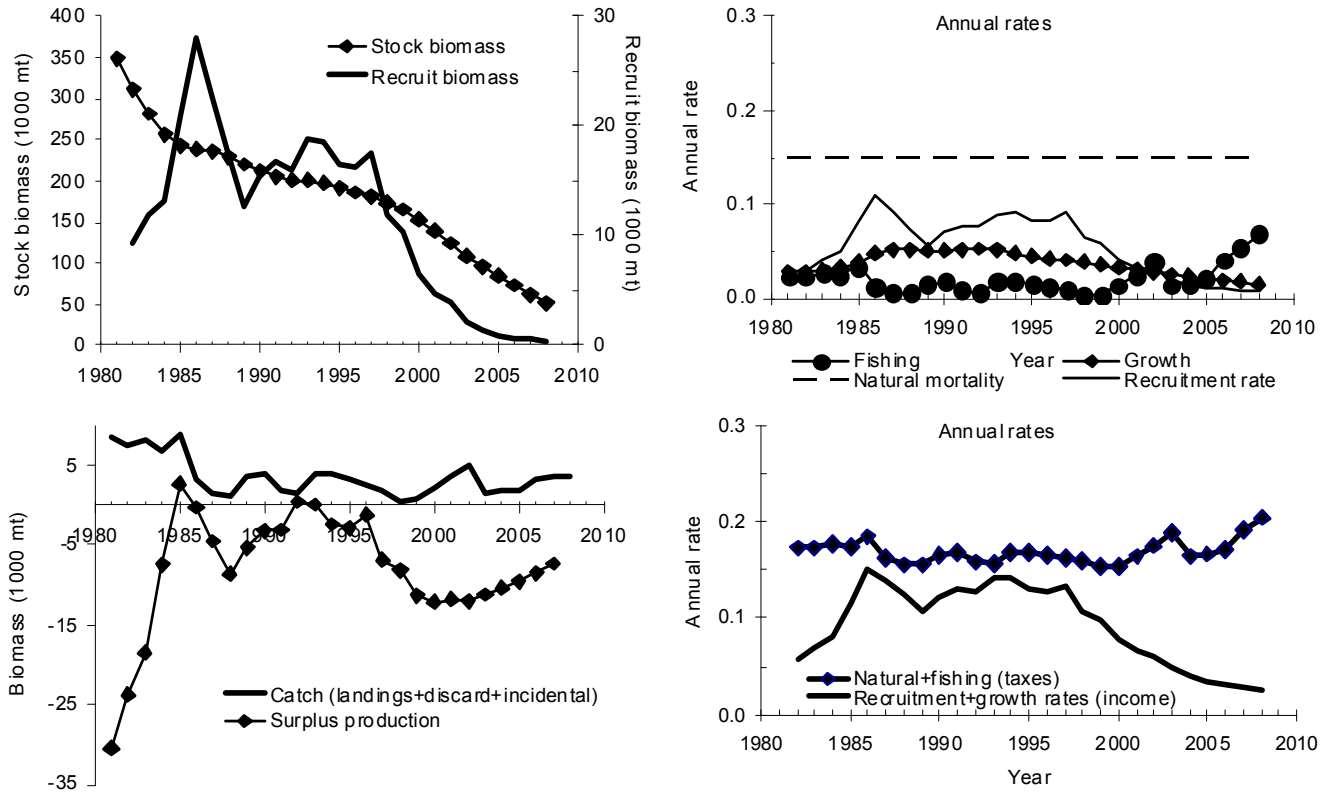


Figure 69. Population dynamic estimates from the KLAMZ model for surfclams in the DMV region. Estimates include stock and recruitment biomass (top left), catch and surplus production (bottom left), instantaneous annual rates for fishing mortality, somatic growth, natural mortality and recruitment (top right). The bottom right panel shows combined natural and fishing mortality rates (which decrease stock biomass) with combined recruitment and growth rates (which increase stock biomass).

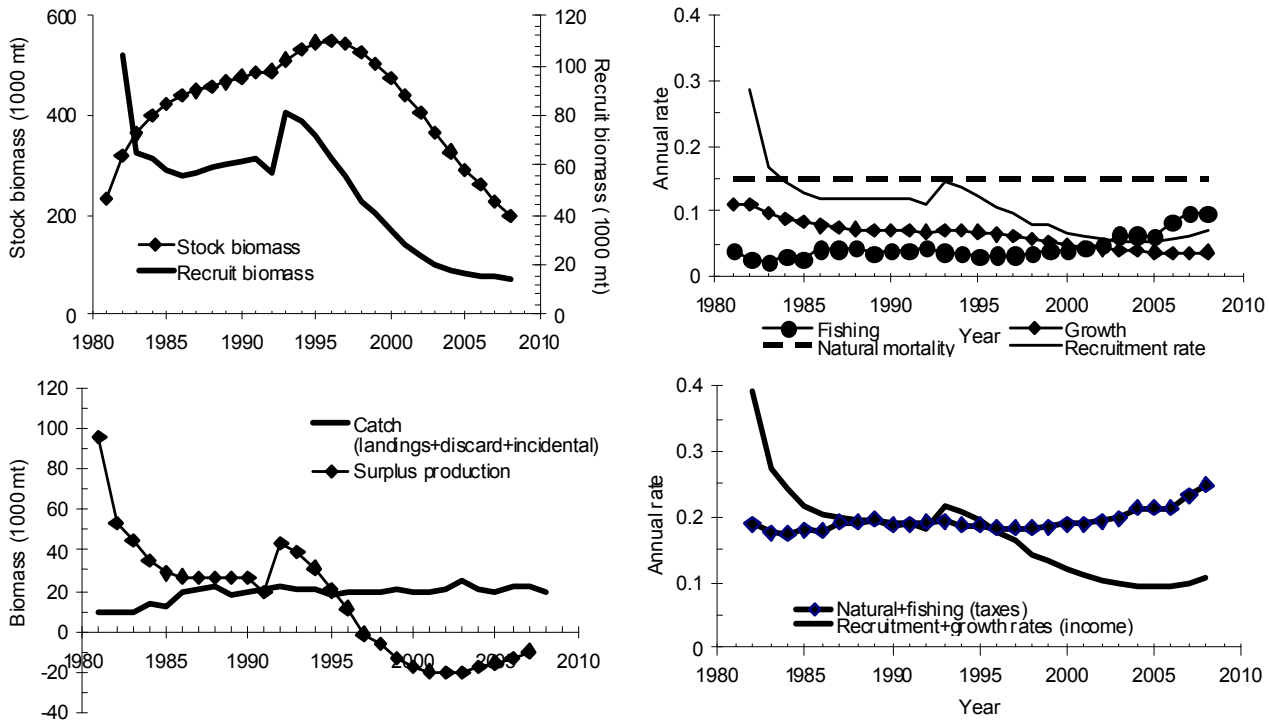


Figure A70. Population dynamic estimates from the KLAMZ model for surfclams in the NJ region. Estimates include stock and recruitment biomass (top left), catch and surplus production (bottom left), instantaneous annual rates for fishing mortality, somatic growth, natural mortality and recruitment (top right). The bottom right panel shows combined natural and fishing mortality rates (which decrease stock biomass) with combined recruitment and growth rates (which increase stock biomass).

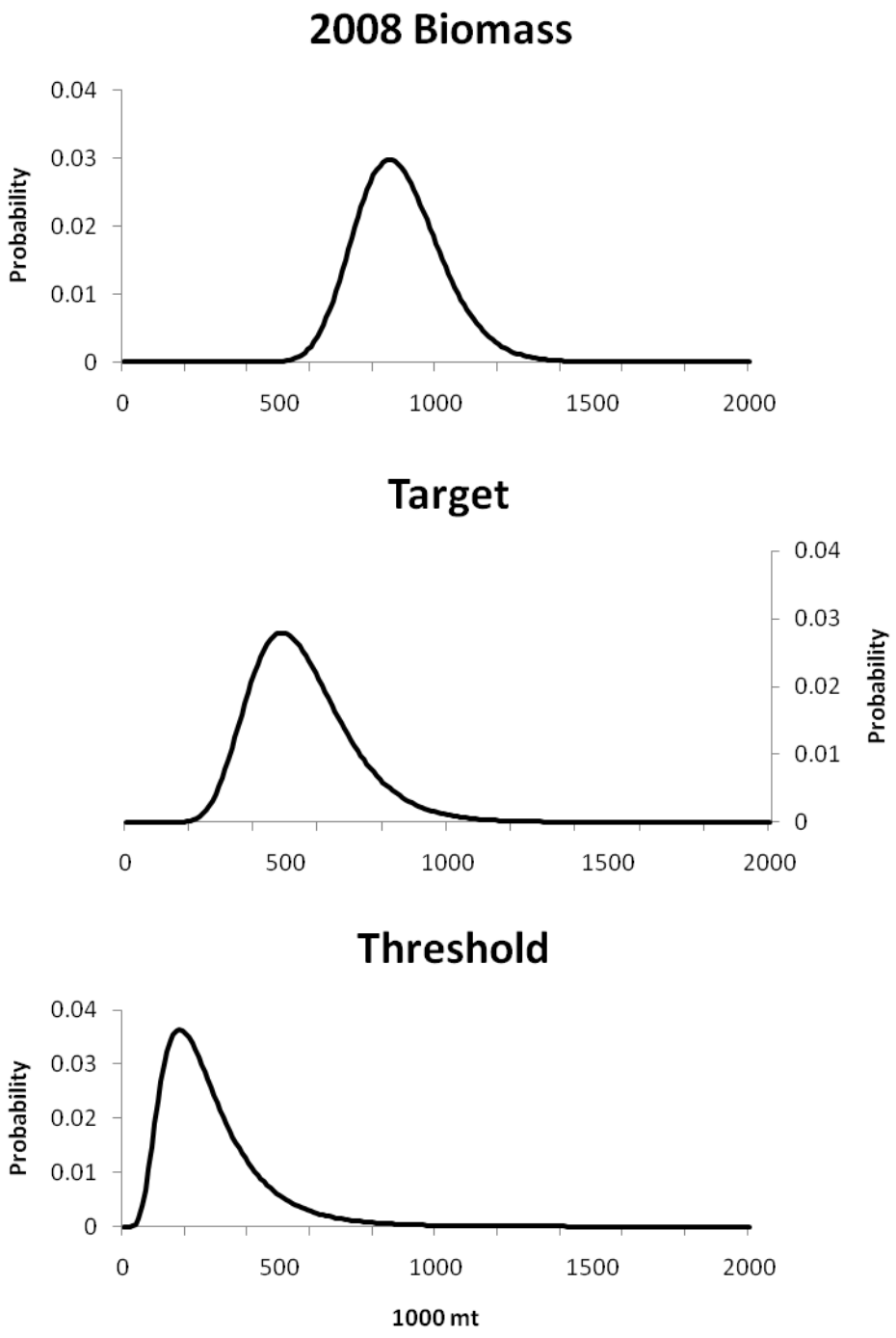


Figure A71. Probability distributions for basecase KLAMZ model estimates of surfclam biomass in 2008, the biomass target ($B_{1999}/2$) and the biomass threshold ($B_{1999}/4$).

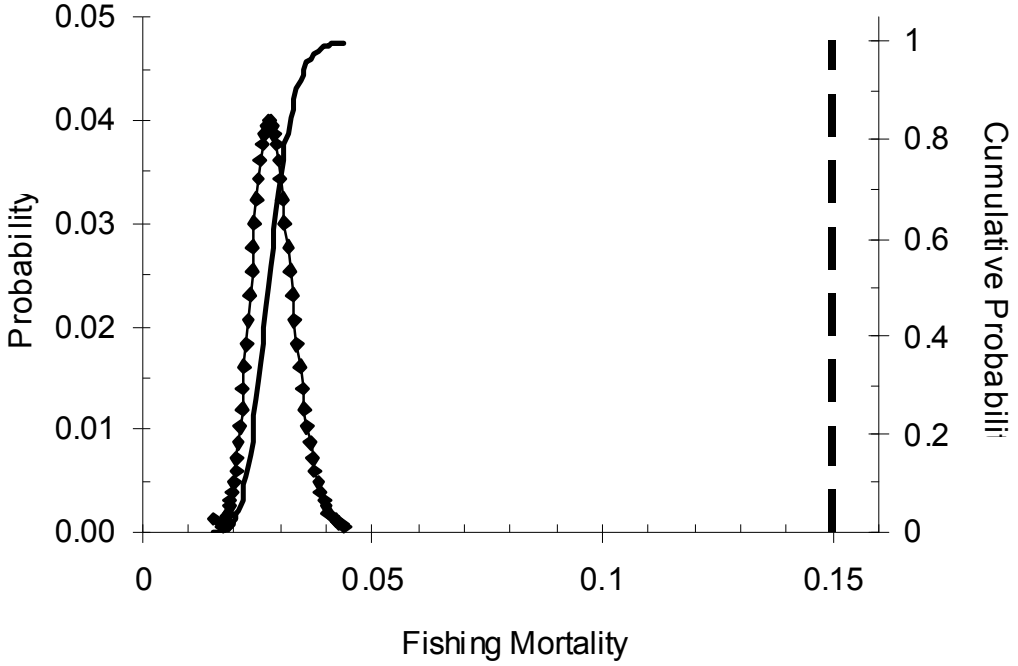


Figure A72. Probability and cumulative probability density functions for estimated fishing mortality during 2008 from the KLAMZ model. The vertical dashed line is the F_{MSY} threshold reference point.

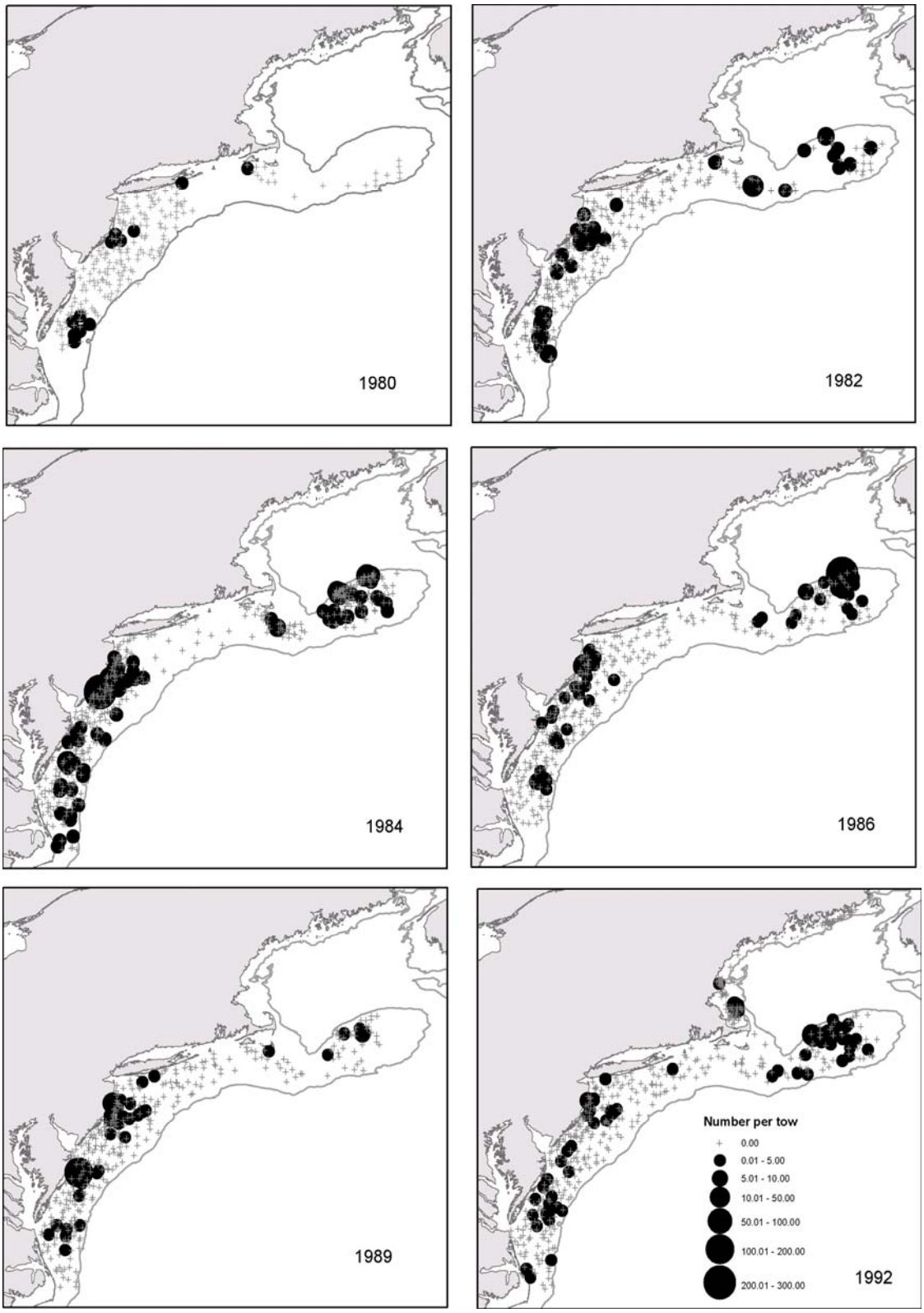


Figure A73. Mean numbers per tow for very small surfclams (≤ 60 mm SL) taken in NEFSC clam surveys during 1994-2008. Not all regions were surveyed in each year.

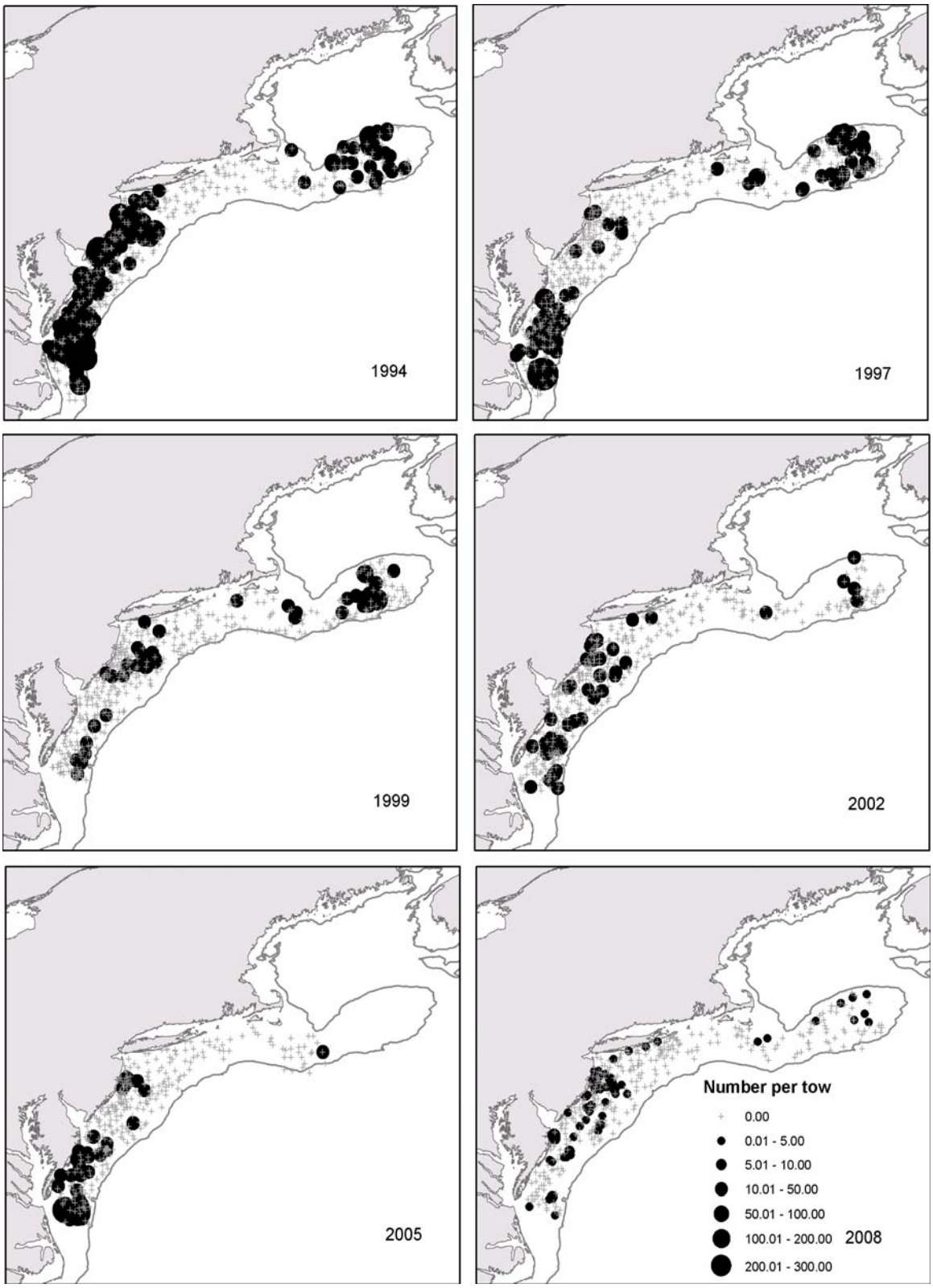


Figure A73. (continued)

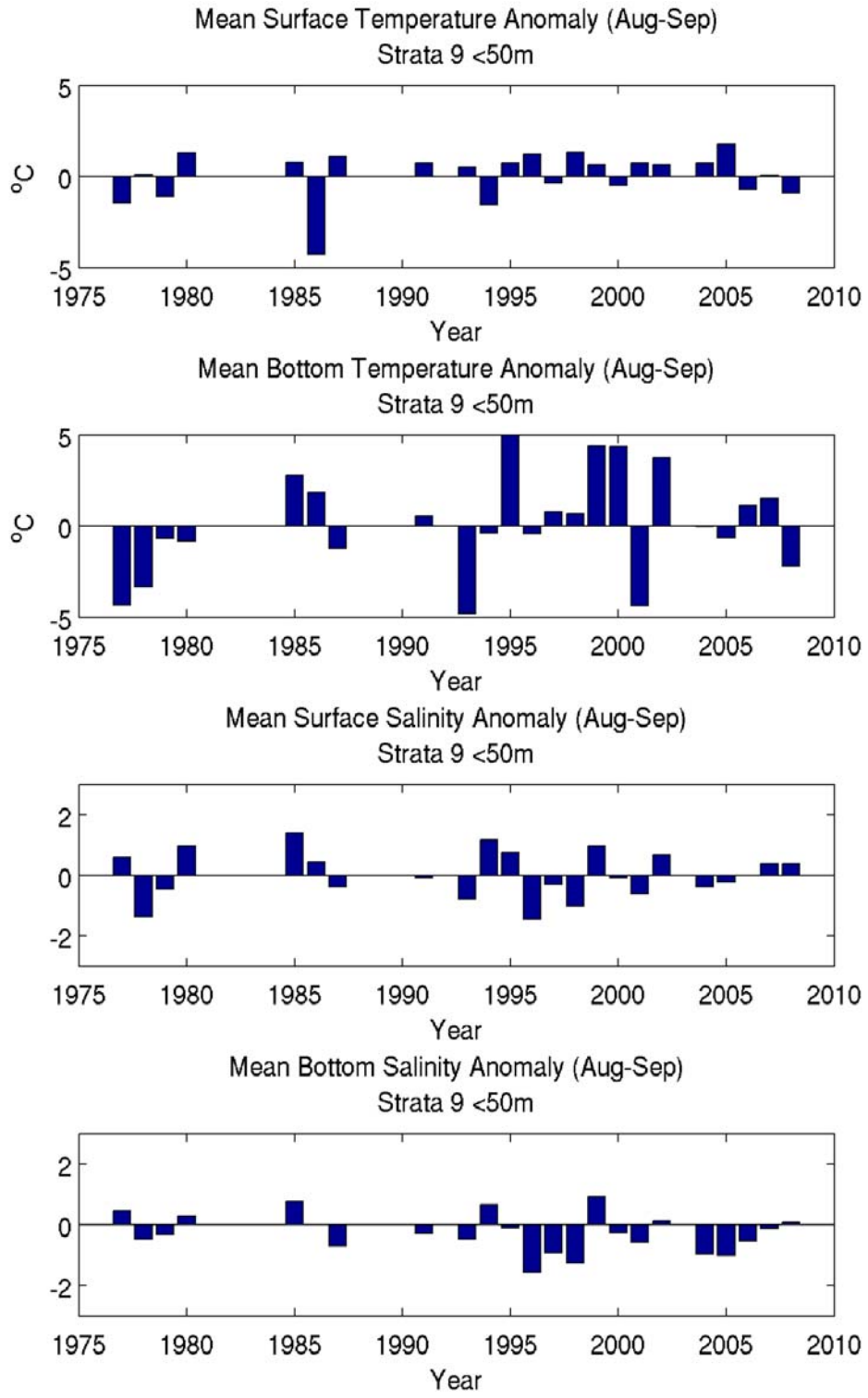


Figure A74. Summer (August-September) temperature and salinity anomalies for NEFSC shellfish stratum 9 (DMV region) at depths ≤ 50 m, during 1976-2009, based on data collected during NEFSC surveys.

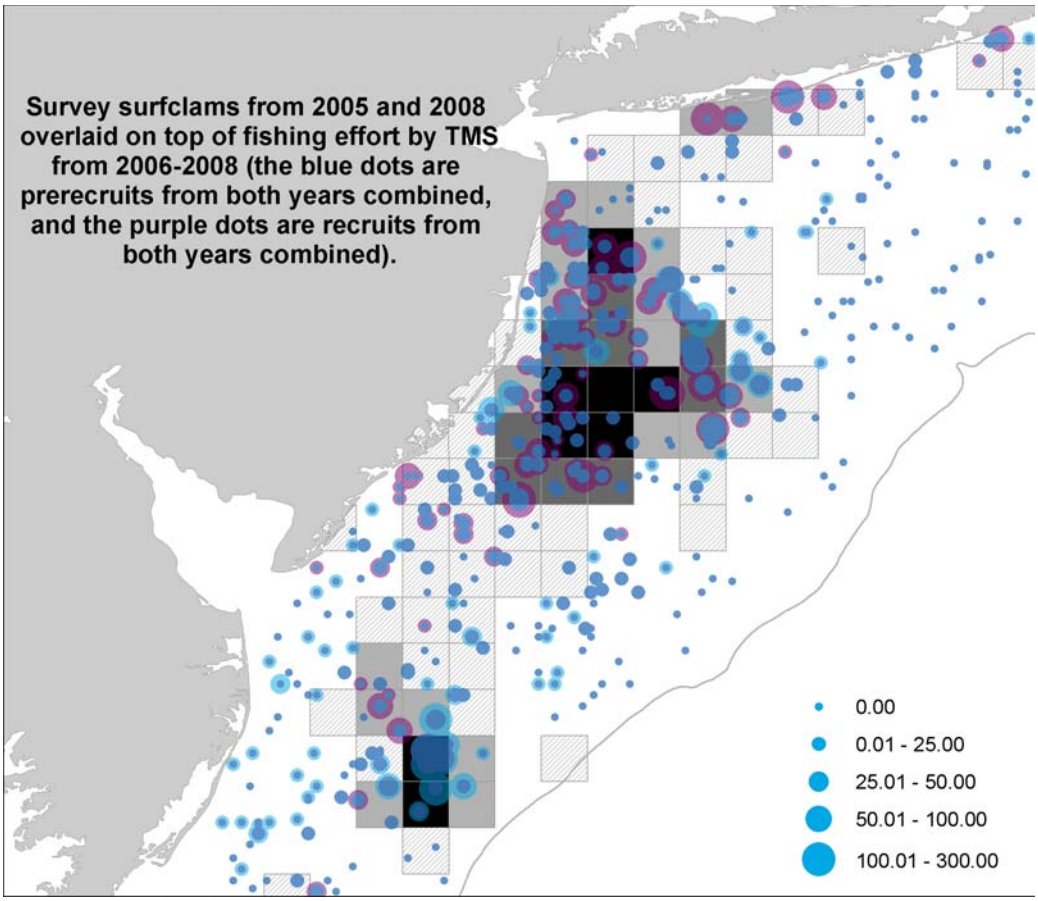


Figure A75. Locations of NEFSC survey catches for surfclams 50-119 mm SL in the 2005 and 2008 NEFSC clam surveys and fishing effort during 2006-2008 based on logbook data. Note that most of the DMV region south of Hudson Canyon was not sampled during 2008.

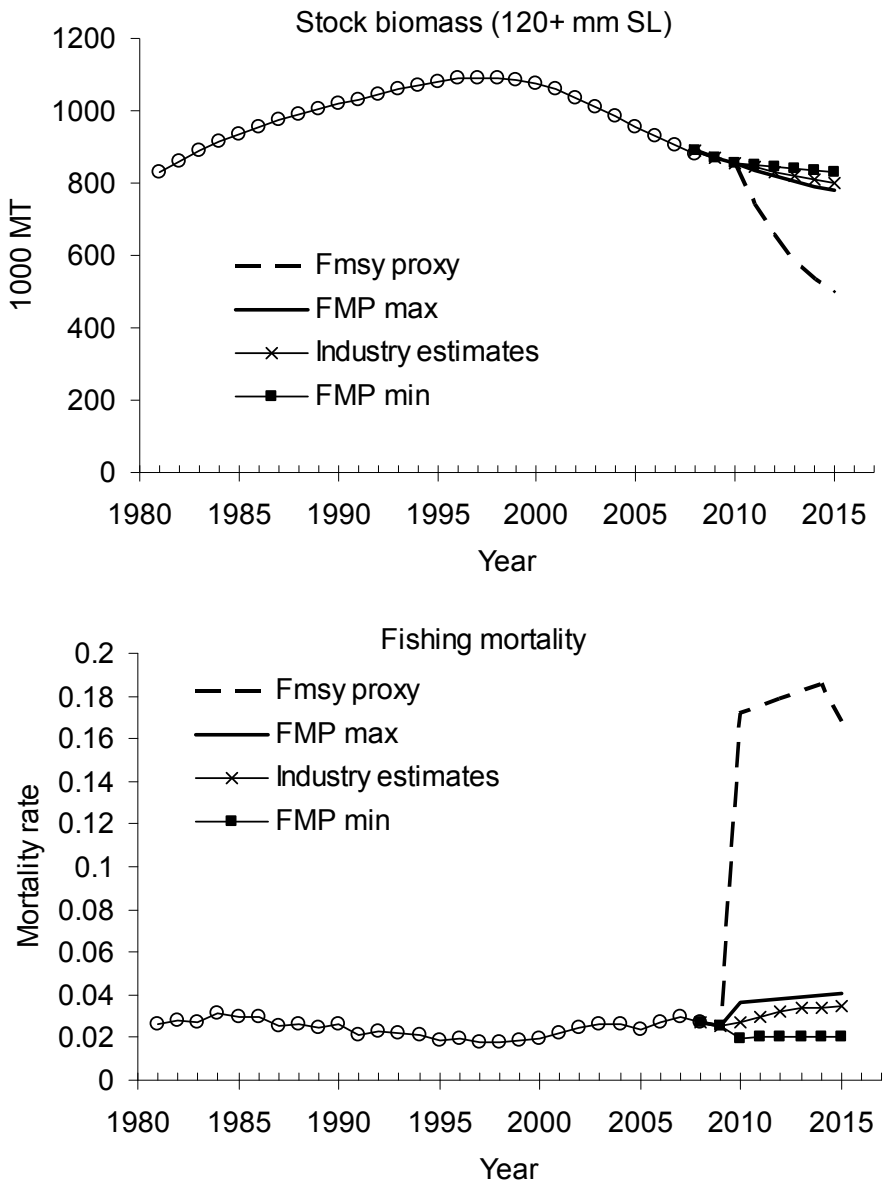


Figure A76. Stock biomass and fishing mortality forecast results for surfclams during 2010-2015 (medians from 2000 iterations), using the basecase KLAMZ model and assuming landings during 2010-2015 that correspond to four different management strategies.

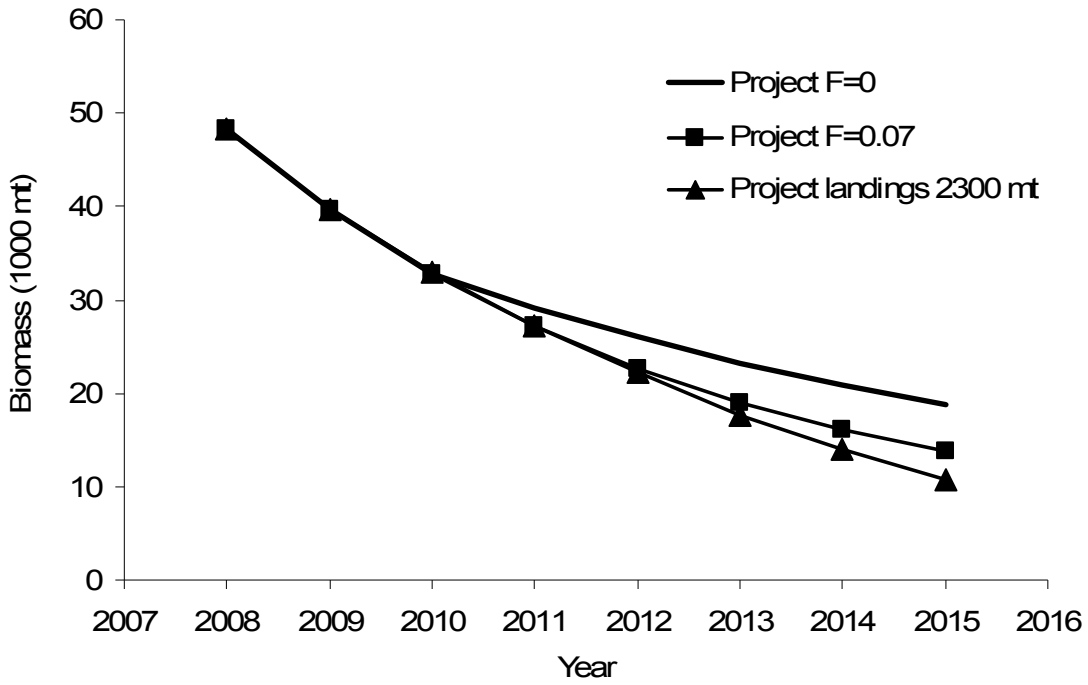
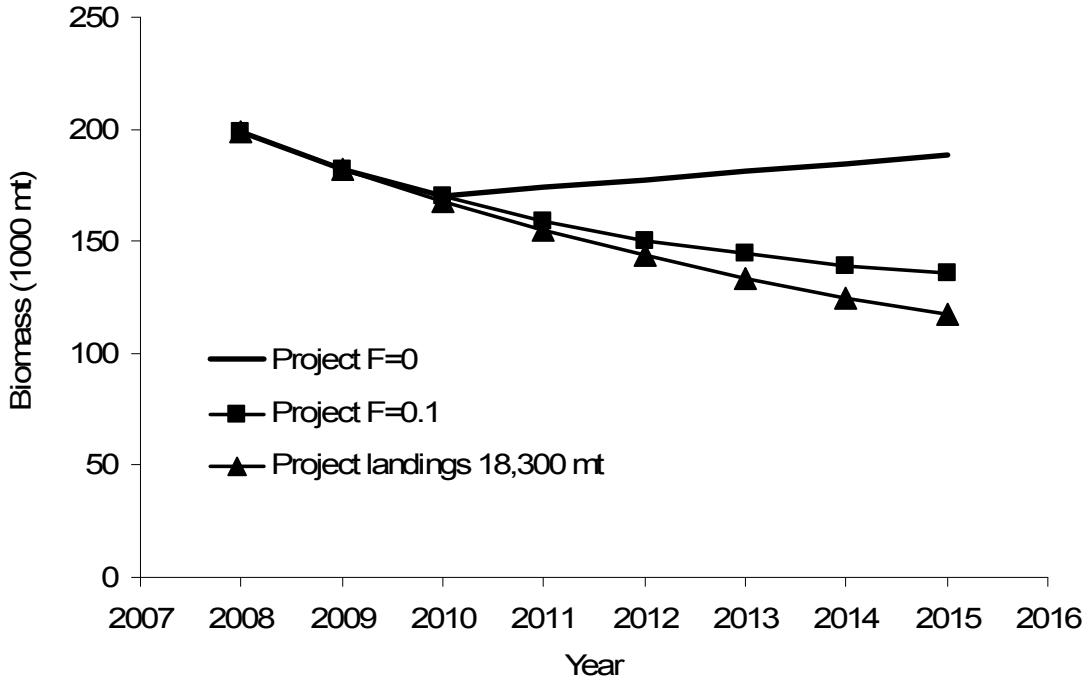


Figure A77. Forecast projection results for DMV under three harvest scenarios.



A78. Forecast projection results for NJ under three harvest scenarios.