FIGURES

B. Stock assessment for ocean quahogs (*Arctica islandica*)

Invertebrate Subcommittee
SAW/SARC 48
Figure B1. Stock assessment regions for ocean quahog in the US EEZ, with NEFSC shellfish survey strata boundaries.
Figure B2. Commercial size-selectivity and maturity by length (*top panel*) and by age (*bottom panel*) assuming the von Bertalanffy growth curve for ocean quahogs in MAB (exploited region). Estimates in upper panel are from Thorarinsdottir and Jacobson, 1995.)
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Quahog Fishing Effort

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Figure B31 (cont.)
Figure B31 (cont.)
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Figure B36. Relationship between tow distance (based on sensor data) and depth for successful random tows in surveys with sensor data conducted between 1997 and 2009. The straight line shows the linear regression model Distance=0.1635+0.0014 x Depth. The nonlinear line is a spline meant to show underlying, potentially nonlinear, trends.
Figure B37. Relationship between tow distance and depth during the 2008 clam survey estimated using y-tilt data from the original (open symbols, stations 1-269) and replacement (dark symbols, stations 270-401) SSP units.
Sensitivity of tow distances to critical angle assumptions

Figure B38. Sensitivity of median survey tow distance to assumptions about the critical angle at which the survey dredge fishes effectively. Median tow distances are for all successful random survey tows with y-tilt data during the 1997-2008 surveys. Surveys during 1997 and 1999 surveys used an inclinometers attached to the dredge. Surveys during 2002, 2005 and 2008 used integrated SSP (survey sensor package) sensors. Over the range of dredge angles shown in the figure, $D = 0.731A - 7.947$, where $D$ is the blade depth (inches) and $A$ is the critical angle in degrees. This analysis updates Figure C21 in NEFSC (2003).
Figure B39. Box plots showing distributions of dredge performance variables from sensor data for successful random tows during the 2005 and 2008 NEFSC clam survey. For some variables that are highly skewed, two boxplots are presented with the plot at the top showing the distribution of all of the data and the plot at the bottom rescaled to exclude outliers and to better depict the relative distributions of most of the data.
Time on bottom while dredge was potentially fishing, by station

Random successful stations (SHG<=136) only

Time on bottom while dredge was potentially fishing, by station

Random successful stations (SHG<=136) only

Figure B39. (cont.)
Proportion of time with y-tilt < 5.16 degrees while dredge was potentially fishing, by station

Random successful stations (SHG<=136) only

Proportion of time with y-tilt < 5.16 degrees while dredge was potentially fishing, by station

Random successful stations (SHG<=136) only

Figure B39. (cont.)
Y-tilt while dredge was potentially fishing, by station

Random successful stations (SHG≤136) only

Y-tilt while dredge was potentially fishing, by station

Random successful stations (SHG≤136) only

Figure B39. (cont.)
Figure B39. (cont.)

Standard deviation for y-tilt while dredge was potentially fishing, by station

Random successful stations (SHG<=136) only

Figure B39. (cont.)
X-tilt while dredge was potentially fishing, by station

Random successful stations (SHG<=136) only

X-tilt while dredge was potentially fishing, by station

Random successful stations (SHG<=136) only

Figure B39. (cont.)
Standard deviation for x-tilt while dredge was potentially fishing, by station

Random successful stations (SHG<=136) only

Figure B39. (cont.)
Figure B40. Delaware II-Delaware II (De2-De2) repeat station results. Top: all data. Bottom: showing observations near the origin that are hard to see in the upper panel.
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Figure B45. SSP sensor data for a tow by the F/V Endeavor during the 2008 cooperative clam survey.
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Figure B47. Original and smoothed position data for the OQ2008-2 commercial depletion study.
Figure B48. Original and smoothed position data for the OQ2008-3 commercial depletion study.
Figure B49. Goodness of fit and likelihood profile confidence intervals for the Patch model estimates for the OQ2008-1 commercial depletion study.
OQ2008-2 Patch model estimates, goodness of fit and likelihood profiles.

Note: estimates for ocean quahogs 90+ mm SL.

Density 0.08633
Efficiency 0.78149
K 14.5478
Gamma 0.50001
NLL 115.002

Figure B50. Goodness of fit and likelihood profile confidence intervals for the Patch model estimates for the OQ2008-2 commercial depletion study.
Figure B51. Goodness of fit and likelihood profile confidence intervals for the Patch model estimates for the OQ2008-3 commercial depletion study.
Figure B52. Uncertainty in efficiency corrected swept area biomass (ESB) estimates for fishable ocean quahog during 2008. Note that the x-axis differs in the panel for SVA but is the same in all other panels to facilitate comparisons.
Figure B53. Uncertainty in fishing mortality estimates for ocean quahog during 2008 based on catch data and efficiency corrected swept-area biomass. X-axes are scaled to the same maximum to facilitate comparisons.
Figure B54. Trends in fishable biomass for ocean quahog from the "VPA" method during 1978-2009, by region. The VPA estimate for GBK is the mean of ESB estimates for 2002, 2005 and 2008 because no catch occurs in GBK.
Figure B55. Biomass estimates for ocean quahogs in the exploited region with survey trend data adjusted to the same scale. Estimates are from: i) the sum of best estimates in this assessment (VPA model for SVA and regional KLAMZ models for other areas); ii) VPA (sum of regional VPA estimates); and a KLAMZ model fit to the entire exploited region. The dashed lines show an asymmetric confidence interval for the KLAMZ model fit to the entire exploited region.
Figure B56. KLAMZ model results for ocean quahog in the DMV stock assessment region during 1977-2008. The bottom right panel shows population estimates. Other panels show goodness of fit to survey, LPUE and swept area biomass trend data. Results are for a KLAMZ model run with M=0.02 y⁻¹ and recruitment biomass fixed near zero. The survey scaling parameter estimate for ESB data is shown in the bottom left panel. The 1994 clam survey observation (open circle) was not used in fitting the model.
Figure B57. KLAMZ model results for ocean quahog in the NJ stock assessment region during 1977-2008. The bottom right panel shows population estimates. Other panels show goodness of fit to survey, LPUE and swept area biomass trend data. Results are for a KLAMZ model run with M=0.02 y⁻¹ and recruitment biomass estimated at a relatively low level. The survey scaling parameter estimate for ESB data is shown in the bottom left panel. The 1994 clam survey observation (open circle) was not used in fitting the model.
Figure B58. Preliminary results from a KLAMZ model with constant recruitment for ocean quahog in the LI stock assessment region during 1977-2008. Note the slight lack of fit to recent survey data (top left panel) and the anomalous survey scaling coefficient value ($Q = 0.48$) for efficiency corrected swept area biomass (bottom left panel).
Figure B59. Profile likelihood analysis to determine the change year for the step recruitment function in the KLAMZ model for LI.

Figure B60. Step function recruitment estimates from the KLAMZ model for LI.
Figure B61. KLAMZ model results for ocean quahog in the LI stock assessment region during 1977-2008. The bottom right panel shows population estimates. Other panels show goodness of fit to survey, LPUE and swept area biomass trend data. Results are for a KLAMZ model run with M=0.02 y⁻¹ and recruitment biomass estimated using a step function with the second period starting in 1994 (Figure K5). The survey scaling parameter estimate for ESB data is shown in the bottom left panel. The 1994 clam survey observation (open circle) was not used in fitting the model.
Figure B62. Preliminary results from a KLAMZ model with constant recruitment for ocean quahog in the SNE stock assessment region during 1977-2008. Note lack of fit to survey data (top left panel).
Figure B63. Profile likelihood analysis to determine the change year for the step recruitment function in the KLAMZ model for SNE.

Figure B64. Step function recruitment estimates from the KLAMZ model for SNE.
Figure B65. KLAMZ model results for ocean quahog in the SNE stock assessment region during 1977-2008. The bottom right panel shows population estimates. Other panels show goodness of fit to survey, LPUE and swept area biomass trend data. Results are for a KLAMZ model run with M=0.02 y⁻¹ and recruitment biomass estimated using a step function with the second period starting in 1994 (Figure K5). The survey scaling parameter estimate for ESB data is shown in the bottom left panel. The 1994 clam survey observation (open circle) was not used in fitting the model.
Figure B66. KLAMZ model results for ocean quahog in the GBK stock assessment region during 1977-2008. The bottom two panels show population estimates. Other panels show goodness of fit to survey and swept area biomass trend data. Results are for a KLAMZ model run with M=0.02 y⁻¹ and recruitment biomass estimated at a relatively low level. The survey scaling parameter estimate for ESB data is shown in the bottom left panel. Survey and swept area biomass data for 1989, 1994, 2002 and 2005 (open circles) were not used in fitting the model due to voltage problems in 1994 and poor sampling in other years.
Figure B67. Preliminary results from a KLAMZ model with constant recruitment for ocean quahog in the exploited stock area during 1977-2008. Note lack of fit to survey data (top left panel).
Figure B68. Profile likelihood analysis to determine the change year for the step recruitment function in the KLAMZ model for the exploited stock region.

Figure B69. Step function recruitment estimates from the KLAMZ model for ocean quahogs in the exploited stock region.
Figure B70. KLAMZ model results for ocean quahog in the LI stock assessment region during 1977-2008. The bottom right panel shows population estimates. Other panels show goodness of fit to survey, LPUE and swept area biomass trend data. Results are for a KLAMZ model run with M=0.02 y⁻¹ and recruitment biomass estimated using a step function with the second period starting in 1994 (Figure B69). The survey scaling parameter estimate for ESB data is shown in the bottom left panel. The 1994 clam survey observation (open circle) was not used in fitting the model.
Figure B71. Retrospective analysis with the KLAMZ model for ocean quahogs in the exploited region with 2000-2008 as the terminal year. Results for some terminal years are not visible because the estimates were exactly the same as in an adjacent run (estimates may not change unless a year with survey data is omitted).
Figure B72. Best biomass estimates for ocean quahogs during 1978-2008, with estimates for 1978-2005 and projections for 2006-2008 from the last assessment (NEFSC 2007a). The report for the previous assessment did not include projections with status-quo catches so the projections for 2006-2008 were rerun starting from the 2005 biomass estimate in the previous assessment and using actual catches during 2006-2008.
Figure B72. (cont.)
Figure B73. Best estimates of fishing mortality for ocean quahogs during 1978-2008.
Figure B74. Approximate asymmetric 95% confidence intervals for best biomass and fishing mortality estimates for ocean quahogs in the exploited and total stock regions.
Figure B75. Trends in ocean quahog biomass during 1978-2008, by region based on best estimates. SVA is excluded because biomass is negligible there.
Figure B76. Proportion of ocean quahog biomass by region during 1978 and 2008, based on best estimates. SVA is excluded because it contains negligible biomass.
Figure B77. Estimated ocean quahog recruitment during 1978-2008, based on best regional models. Recruitment trends follow a stair step pattern because KLAMZ models for SNE and LI assumed two periods of constant recruitment with changes in level after 1992. SVA and DMV are not shown because recruitment is negligible there.
Figure B78. Deterministic and median stochastic projected biomass with $M=0.02$ and the deterministic projection starting at the best estimates for 2008.
Projected biomass for entire stock (M= 0.02 )

Figure B79. Projected estimates of whole stock biomass for ocean quahogs during 2010-2015 under various harvest policies assuming the true state of nature is $M=0.02$. 
Figure B80. Projected estimates of fishing mortality for ocean quahogs in the exploited region during 2010-2015 under various harvest policies and assuming the true state of nature is $M=0.02$