Michigan Department of Natural Resources
Fisheries Research Report 2097, 2011

Assessing Model-based Indices of Lake Trout Abundance in 1836 Treaty Waters of Lakes Huron, Michigan, and Superior

Jonathan J. Deroba[1] and James R. Bence

Michigan State University, Department of Fisheries and Wildlife,
13 Natural Resources Building, East Lansing, Michigan 48824

Abstract.–Stock assessment models for lake trout in 1836 Treaty waters of the Great Lakes, located in Michigan, make use of annual indices of abundance derived from general linear mixed models (GLMMs) applied to fishery independent surveys. The GLMMs include categorical fixed effects of year, grid (spatial location), and depth, and a random year by grid interaction. Previously, a comprehensive evaluation of the distributional assumptions for the random effects and residual errors of these GLMMs, the sensitivity of the resulting indices to the constants added to catch per effort survey data before $\log_e$ transformation, and method of calculating denominator degrees of freedom had not been reported. Furthermore, alternative models to the current GLMM, based on the same dependent and categorical data, had not been systematically evaluated. To evaluate the validity of the distributional assumptions, we examined plots of the random effect estimates and residuals to see if frequency histograms were approximately normal (i.e., symmetric and bell-shaped) and if trends in the estimates exhibited any temporal (among years) or spatial (among adjacent grids) trends. We evaluated the sensitivity of the models to the constants that are added to catch per effort (CPE) values before $\log_e$ transformation by doubling and halving the constants currently used, and then comparing the values for the least square means and standard errors for each year (i.e., model output used in the stock assessments) among the models with different constants. The sensitivity of the models to the method of calculating degrees of freedom was evaluated by comparing the values for the least square means and standard errors for each year between the current method (Satterthwaite) and the Kenward-Roger's method. We evaluated the use of alternative models through the inclusion of different random effects in the model, as well as dropping depth and/or grid from the model. We found a lack of temporal independence in the year by grid effect in most assessment areas. Relative changes in the model output were nearly zero when the constant added to CPE values was altered and when the method of calculating degrees of freedom was changed. The combination of random effects in the status quo model provided the best or nearly best fit for almost all assessment areas in Lakes Huron and Michigan, except in one assessment area of Lake Michigan where a model with an autoregressive lag 1 error structure, *AR(1)*, in the year by grid effect provided the best fit. In Lake Superior large-mesh and graded-mesh surveys, the status quo model never provided the best fit or the most conservative estimates (i.e. larger standard errors), and the best model varied by assessment area and gear type. In assessment areas with a lack of temporal independence in the year by grid effect, modeling the year by grid effect as an *AR(1)* process significantly improved model fit, suggesting that this change was warranted. The fixed effect of depth improved model fit in all but one assessment area. The fixed effect of grid generally improved model fit in Lakes Huron and Michigan and for large-mesh surveys in Lake Superior, but not for graded-mesh surveys in Lake Superior. The status quo model often did not provide the best model fit and was often not the most conservative choice of models; so other models should be considered for some assessment areas.

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[1] Current Address: NOAA NEFSC, 166 Water Street, Woods Hole, MA 02543, Jonathan.Deroba@noaa.gov