

Dealing with unbalanced sampling through bivariate Bayesian regression models: maturity of European hake.

The proportion of mature fish at age or length is one of the most important population attributes in assessing reproductive potential. This proportion is usually named the maturity ogive. For the European hake (*Merluccius merluccius*) in the International Council for the Exploration of the Sea (ICES) divisions 8.c 9.a a combined maturity ogive is required as data is provided by two countries, Portugal and Spain. Usually a weighted average between the maturity ogive indicators of the two countries is carried out to obtain a combined ogive, although issues arise due to the difficulty to decide weight values for each country. In addition, the unbalanced sampling between countries and the latitudinal length-at-maturity gradient must be taken into account during the modelling process to avoid misleading results. Within this context we propose a bivariate Bayesian regression model using the integrated nested Laplace approximation (INLA, Rue et al., 2009) approach in the R-INLA software (<https://www.r-inla.org/>). The bivariate model response considers separately two maturity variables (0/1, immature/mature) one for each country. The two response variables are explained using the total length of the fish (TL) and year as covariables. TL is included as a random walk of second order process (RW2) whereas the temporal effect is tested in different forms: (1) year level fixed factor, (2) an i.i.d. (independent and identically distributed) year random effect and (3) as year categories factor set up with a structural change analysis. Results of the different modeling options are proposed to be tested in the stock assessment model to analyze their performance as any variability or bias is reflected in the spawning stock biomass estimates and, therefore, in the management measures. The main advantage of the proposed approach is that the model carried out a combined estimation of all the parameters of the common predictor providing a combined ogive and taking into account all the issues mentioned before.