Stochastic population dynamics of beaked redfish (*Sebastes mentella*)

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Commercial fish stocks have suffered from dramatic declines from historical levels and depletion of marine resources due to overfishing is one of the major threats to the marine ecosystem. Developing sustainable management strategies of harvested natural populations requires reliable estimates of population abundance and identification of the factors, both deterministic and stochastic, that generate fluctuations in abundance. Here we estimated the historical abundances at age and important population parameters for the beaked redfish (*Sebastes mentella*) in the Barents Sea, and constructed population prediction intervals for this stock under different harvesting regimes. Being at historical low abundance levels due to previous over-exploitation, the stock is considered as vulnerable by the Norwegian red list. The management of the population is currently based on survey data that only indicate abundance trends, and no analytical assessment is done. We first estimated the unobserved population process of the beaked redfish of ages 6-18 during 1992-2009 by fitting a Bayesian hierarchical model to data on reported catches and survey indices. This model is a stochastic age structured population model which separates natural mortality from fishing mortality and incorporates variances related to the population process and several sources of errors including observation errors. Our results indicate that the population increased from app. 300 million to app. 800 million individuals during 1992-1997, and gradually decreased to app. 200 million individuals in 2009. The last strong cohorts were born in the late 1980’s and early 1990’s and the population have subsequently shifted the age distribution from being dominated by young individuals to being dominated by older individuals. Then we simulated the population according to the estimated process under different harvesting regimes. Using estimated parameters, generating recruits from a Ricker stock-recruitment curve, and conditioning on the current estimated age distribution, we constructed population prediction intervals by stochastic simulations of the adult population size 100 years forward in time. We did simulations of the population process in the absence of harvest and in the presence of harvest with different effort levels representing different management regimes that have occurred the last two decades. Irrespective of harvesting regime the simulated population processes starting in 2010 decreased a few years, before they began to fluctuate with relatively large amplitudes and periods varying between 20-40 years among the simulations. However, the predicted population size after running the simulations for 100 years decreased with increasing fishing effort. Our analyses show that fluctuating age structure, which is often a result of harvesting, may have consequences for population sizes of commercial stocks. When older individuals are removed from the stock, either as a result of aiming for the largest individuals or catching individuals before reaching adulthood, resulting in a younger spawning stock with lower recruitment potential, recruitment may decline to insufficient levels to maintain a viable stock for which commercial harvest can be justified. However, provided that harvest is maintained at current levels for the beaked redfish in the Barents Sea, subsequent years are predicted to show an increase in adult abundance due to increased contribution to recruitment from the strong cohorts born in the late 1980’s and early 1990’s.