2002 Coleraine assessment of the Icelandic cod stock

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Background

Coleraine is a generalized statistical catch at age model, developed at the University of Washington (Hilborn et al. 2001). The model generates the population structure in the first year from parameters and then uses the Baranov catch equation and a chosen form of recruitment to calculate the rest of the age-structured population history. The annual recruitment can be modelled as free parameters, deterministic Beverton-Holt, or an intermediate where large deviations from Beverton-Holt are penalized. Gear selectivity is modelled with an asymmetric normal curve.

The objective function is a product of likelihood components, which are based on the model fit to biomass indices and the catch at age data. Furthermore, the objective function is modified by penalties when informative Bayesian priors for any parameters are supplied. The model is programmed in the AD Model Builder language, which has built-in C++ libraries to perform the function optimization. Coleraine has mainly been used in New Zealand, as well as in modelling workshops with simulated data, although this is the third Icelandic cod assessment using Coleraine (Hilborn et al. 2000).

Data

The data was received in email attachments from Hafro: landed catch 1971–2001, catch at age 1971–2001 and weight at age 1971–2001, as well as spring trawl survey indices 1985–2002 and autumn trawl survey indices 1997–2001. Following Hafro instructions the survey data were processed in two different ways, these are termed ‘base case’ survey data and ‘offset’ survey data.

One datapoint was manually changed, the number of 5 year olds in the 1989 commercial catch at age data. Based on earlier discussions, the actual value of 50059 was used instead of the doctored Greenland-migration value of 16800.

Model

In total, 55 parameters are estimated in the model, and of those 47 determine the initial age structure and recruitment. The other 8 parameters are spring survey q, autumn survey q, and two selectivity parameters (age at full selectivity and left hand decline) for each gear: commercial fleet, spring survey, and autumn survey.

Several constants have to be arbitrarily chosen to weight the different likelihood components. These constants are recruitment variability, biomass index CV, and effective sample sizes for the catch at age data. Recruitment variability was set at high a high value ($\sigma = 1.0$), which makes the estimated recruitment virtually independent of the Beverton-Holt function. Natural mortality rate was assumed to be 0.2. The spawning season data (weight and maturity) was used outside the model, and the biomass of 4+ year olds was used as the default model output instead of spawning biomass.

Results

The biomass of 4+ year olds at the beginning of the 2001/2002 fishing year is estimated as 632 thousand tonnes, a slight increase from the year before. Given a catch of 190 thousand tonnes in the current fishing year, the biomass of 4+ year olds at the beginning of the next fishing year is estimated to be around 728 thousand tonnes and considerable growth is also expected in the following years.

These optimistic forecasts are based on the age structure in the commercial and survey catches during recent years. The cohorts spawned in 1997–2000 are all estimated to be at or above average recruitment, in sharp contrast to the small 1996 cohort, and the first signs of the 2001 cohort indicate a weak year class. The increasing biomass of 4+ year olds is a reflection of each of the 1997–2000 cohorts entering the adult part of the population.

The figures above are from the model run using the 'base case' survey dataset, but using the 'offset' gave very similar results. The base case seemed to correspond slightly better to the landed catch data (higher likelihood of the fit to survey biomass time series) and indicated a more stable solution in the MCMC analysis. That analysis placed the 90% confidence bounds around the current biomass at 510 and 930 thousand tonnes.

Discussion

This is the third year that Coleraine has been used to model the Icelandic cod stock, and each time some new approaches have been explored. The robustness of the results is comforting, and is probably not least due to the amount and quality of the available data. Looking back at the catch history it can be determined that even the youngest age classes in the survey data are good indicators of the size of individual cohorts.

The current age distribution has some important implications for the management of the stock. Although a series of good recruitment classes gives reason for optimism about the biomass of 4+ year olds, it will take several years until the 1997–2000 cohorts start contributing to the spawning. According to the model results, the number of cod 7 years and older is quite low and decreasing. Another concern, perhaps equally important, is that while these cohorts are young there is going to be an unusually high proportion of undersize fish in the catch.

The reference point of age 4 and the 25% harvest control rule are highly useful to regulate the fishery, but additional creative management actions are likely to bring economical benefits, given the extreme skewness of the age distribution of the cod stock.

References

Hilborn, R., A. Magnusson, and B. Ernst. 2000. Coleraine assessment of the Icelandic cod fishery. Annex 5 in J.A. Pope (ed.) An overview of additional studies made on Icelandic cod, summer 2000. Working Group Paper presented to Hafrannsóknastofnunin.

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