Evaluation of Harvest Control Rule for golden redfish

Höskuldur Björnsson and Kristján Kristinsson
Marine Research Institute, Skúlagötu 4, Reykjavík, Iceland. Presenter contact details: hoski@hafro.is, Phone +345 575 2106

Summary
Evaluation of Harvest Control Rule (HCR) for golden redfish in the area East Greenland-Iceland-Faeroe Islands is described. The operating model is size based, modelling growth, taking into account size selective removal of incoming cohorts. The observation model is true stock-size model multiplied by an autocorrelated lognormal error. The operating model is used to evaluate F_{MAX} that is then used for target in the HCR. Stochastic simulations are conducted taking assessment error and variability in recruitment into account.

Introduction
Golden redfish (*Sebastes marinus*) in the East Greenland-Iceland-Faeroe Islands area is considered as one management unit and ICES gives annually advice for the whole area. In recent two decades, over 90% of the catches have been taken in Icelandic waters and the evaluation of the state of the stock is based on the Icelandic data. Stock assessment has been done by the Gadget model since 1999 (Björnsson and Sigurdsson, 2003; Anon, 2005). Advice based on the Gadget model has been rather consistent since 1999. Assessment of this long-lived, moderately harvested stock converges slowly so state of the stock for the last 5-10 years might change when more data from other areas are added.

Abundance indices of small redfish (1-5 years old) were for many years part of the tuning data in the assessment. In recent years cohorts that were considered small based on the Icelandic surveys, have appeared as medium to strong as adult fish indicating higher proportion of recruits originating from areas outside the Icelandic continental shelf, most likely from East Greenland waters.

Material and methods
The assessment is based on the Gadget model tuned with data from the Icelandic bottom trawl survey in March 1985-2013. Time Series Analysis (Gudmundsson, 2004) based on age disaggregated catch in numbers 1995-2012 and age disaggregated survey indices 1996-2012 has also been used.

Yield from a single cohort as function of fishing mortality is estimated from the Gadget model. The model predicts reduced mean weights of survivors by removing the largest individuals of recruiting cohorts and F_{MAX} obtained is therefore lower and more realistic than F_{MAX} calculated in the traditional way. Spawning stock-recruitment relationship is obtained from the Gadget model. Assessment error is assumed to be lognormal, modelled with first order AR model. The standard deviation is obtained from the TSA model. No data is available to estimate autocorrelation of assessment error, but is assumed to be high or 0.85. The TSA estimate for assessment error is for the year before the assessment year and is raised to get the uncertainty in fishing mortality in the advisory year for a given TAC.

The Gadget model is used to simulate the stock forward with given fishing mortality, taking into account stochastic recruitment. The intended fishing mortality each year is multiplied by the estimated assessment error. Stochastic growth, natural mortality and selection is not accounted for, but partly included in the assessment error. Spawning stock is calculated based on fixed length-based maturity ogive. Uncertainty in current status of the stock is not included but the simulation time is long enough for those effects to be negligible in the latter part of the simulation period.

Results and discussions

The spawning stock and recruitment do not indicate any relationship within the range of spawning stock size observed from 1975-2003 and autocorrelation of the residuals are small (Figure 1). Therefore, SSB_{loss} (160 thousand tonnes) is suggested as candidate for B_{lim} and future recruitment is based on a Hockeystick function with breakpoint SSB_{loss} and residuals selected randomly from observed recruitment. Assumed assessment error is quite large, with long periods of over and under estimation (Figure 2).

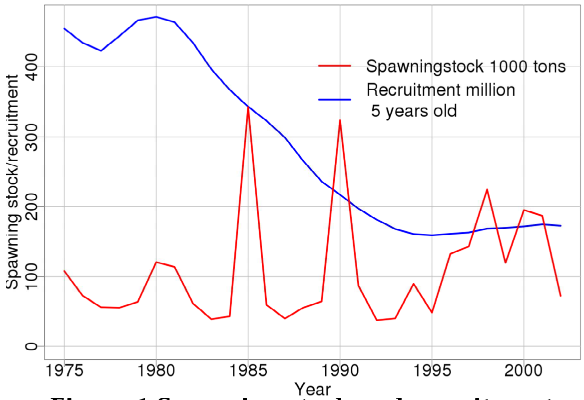

Figure 1 Spawning stock and recruitment 1975 – 2003.

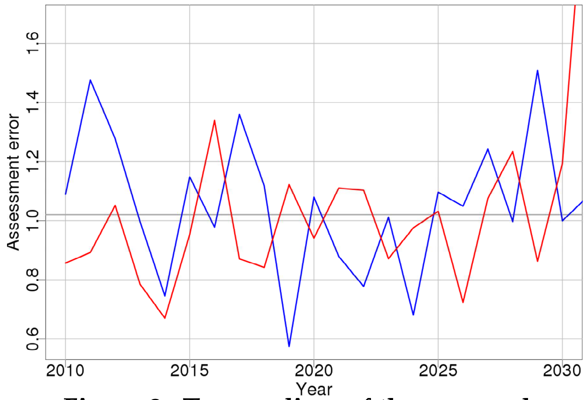

Figure 2. Two replicas of the assumed assessment error.

Deterministic simulations of yield/recruit as a function of fishing mortality is F_{max}=0.097 (Figure 3). Suggested HCR was based on $F_{9\text{-}19}$=0.097 and $B_{trigger}$=220 thousand tonnes. Stochastic simulations based on this HCR indicate less than 1% probability of SSB<B_{lim} (Figure 4).

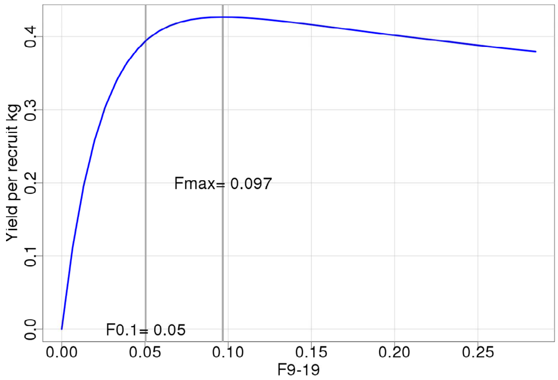

Figure 3. Yield per recruit as function of average fishing mortality 9-19 years old fish

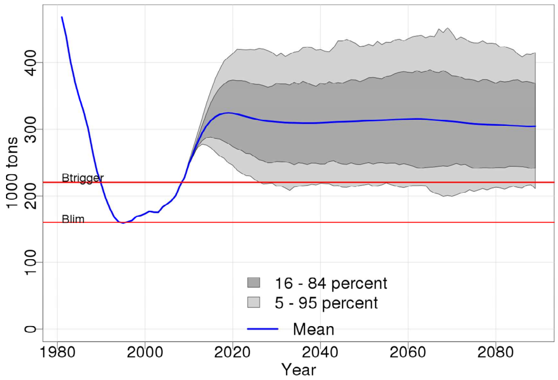

Figure 4. Propability distribution of the spawning stock.

The result shown here are preliminary. The most important problem is with the assessment that is only based on the Icelandic data while there are indications that the proportion of redfish originating from East Greenland to Icelandic waters is increasing. Including data from other areas is therefore important and if it can not be done, it is important that the assumed assessment error is large enough, both magnitude and autocorrelation.

References

Björnsson, H. and Sigurdsson, Th. 2003. Assessment of Assessment of golden redfish (*Sebastes marinus* L.) in Icelandic waters SAP Symposium held in Bergen, Norway 4-6 December 2000. Scientia Marina, 67 (Suppl. 1): 301-314.

Gudmundsson, G. 2004. Time-series analysis of abundance indices of young fish. ICES journal of marine science, 61:176-183,

Anon. (2005). dst² Development of Structurally Detailed Statistically Testable Models of Marine Populations. QLK5-CT1999-01609. Final report 1 January 2000 to 31 August 2004. Vol. 1. Reykjavík 2005. 323 pp.