ECOREGION Iceland and East Greenland
SUBJECT Iceland, Faroe Islands, and Greenland request to ICES on evaluation of a proposed long-term management plan and harvest control rule for golden redfish (*Sebastes marinus*)

Advice summary

ICES has reviewed the assessment methodology for *Sebastes marinus* (in Subareas V, VI, XII, and XIV). After evaluation of the proposed harvest control rule as part of a long-term management plan for this stock, ICES concludes that:

- the most recent development of the assessment model and available data allow a full analytical assessment to be performed and MSY reference points to be derived;
- the proposed harvest control rule is considered to be consistent with the ICES MSY approach and the ICES precautionary approach.

ICES recommends adding a five-year revision clause to the management plan, as well as a safety rule if SSB falls well below B_{lim}.

Request

*"The Governments of Iceland, Faroe Islands and Greenland propose the following management plan for golden redfish (*Sebastes marinus*) in Subareas V, VI, XII and XIV:*

*The management strategy for golden redfish (*Sebastes marinus*) in Subareas V, VI, XII and XIV is to maintain the exploitation rate at the rate which is consistent with the precautionary approach and that generates maximum sustainable yield (MSY) in the long term.*

In accordance with this strategy, the annual total allowable catch (TAC) will be set by applying the following harvest control rule (HCR):

1. The annual TAC will be set consistent with the average fishing mortality rate of 0.097 in the advisory year for age-groups 9-19, when the spawning stock biomass (SSB) in the assessment year (SSBy) is estimated to be above 220,000 tonnes (Btrigger).

2. When the SSB in the assessment year is estimated to be below 220,000 tonnes (Btrigger), the TAC will be set consistent with a fishing mortality rate in the advisory year equal to 0.097(SSBy/Btrigger).*

These HCR formulations are based on work of national experts and the NWWG and have been considered to be in accordance with the ICES MSY advisory framework.

The evaluation should also include review of input data and the applied assessment methodology (Benchmark) and the appropriateness of values assigned to reference points.

The Governments of Iceland, Faroe Islands and Greenland request ICES to evaluate whether this proposed harvest control is in conformity with its objectives.

ICES is also invited to propose alternative rules or modified rules on its own initiative and to evaluate these."

Elaboration on the advice

As a first step ICES reviewed the assessment methodology and accepted the model, settings, and results of the assessment, including the reference points derived from these. The results of the assessment were then used to inform the management plan evaluation, which was conducted in a second step.

Assessment model

The stock assessment used as basis for the forecast was an extension of the assessment method used previously to evaluate trends ("GADGET: *Globally applicable area-disaggregated general ecosystem toolbox*"). The extension of the methodology encompasses three main issues:

1) There are indications that redfish has been growing faster in recent years. As selection in the survey and catches is based on size, faster growth will lead to cohorts recruiting earlier to the catches and fisheries and hence, lead to overestimation of cohort size if changed growth is not taken into account. To account for the change in growth, mean length-at-recruitment (age 5) was estimated separately for year classes 1996–2000 and for 2001–present.
2) The autumn German Greenland groundfish survey was added to the assessment. In order to allow the inclusion of the results of the German survey in the assessment model, the area for which the survey is considered indicative has been revised. This area is selected to avoid extrapolation to areas not covered by the survey. The area (now 22 500 km^2) is about half the size of the area used previously, preventing each survey station to be given too much weight. Although the German Greenland survey only accounts for 10% of the total biomass of this stock, including it in the assessment model increases SSB by over 30% compared to the previous assessment. The reason for this relatively large increase is that the large fish observed in the German Greenland survey have not been observed in the Icelandic survey in recent years.
3) The weighting of the individual data sets in the GADGET model is now calculated using an iterative re-weighting algorithm. This process essentially assigns weights to each input data set on the basis of the inverse variance of the fitted residuals. This is done to reduce the influence of lower quality input data.

These three changes to the assessment were made in response to an earlier benchmark for this redfish stock (ICES, 2012). The resulting assessment is used as a starting point for the forecasts made to evaluate the proposed management plan. The ICES standard graphs for assessment results (not including 2013 catch data) are provided below (Figure 2.2.3.1.3).

Summary of assessment model results

The assessment results in time-series of SSB and fishing mortality that are largely similar to the previous assessment, apart from a stronger increase in SSB in the ten most recent years (Figure 2.2.3.1.1). The minimum and maximum observed SSB among different assessment runs are similar, with a < 10% difference among runs. Spawning-stock biomass in the 1970s was estimated to be between 350 and 450 thousand tonnes. After a decline in the 1980s the stock reached a low in the 1990s, at about 160 thousand tonnes. Since then, the assessment suggests an increase. The extent of this increase depends on the assumptions in the model. The assumptions chosen as the basis for the management strategy evaluation result in a current spawning-stock biomass estimate of about 360 thousand tonnes in 2013.

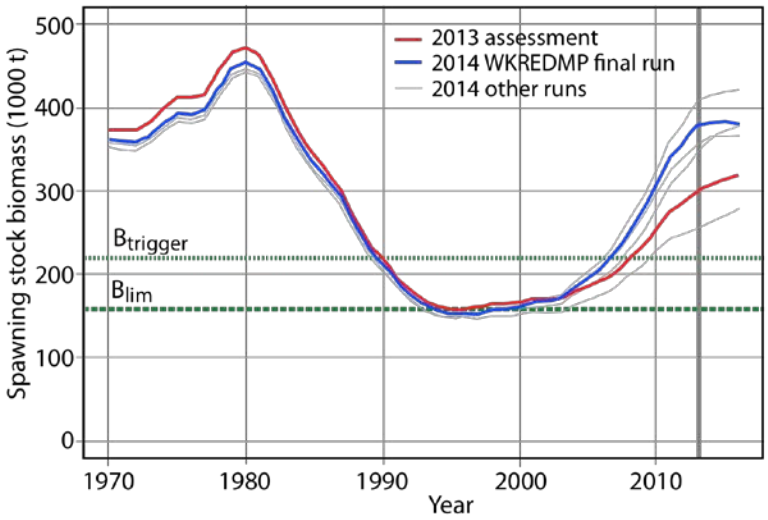

Figure 2.2.3.1.1 Time-series of spawning-stock biomass under different assumptions in the model and input data. The red line indicates the result of the assessment done in 2013. The blue line indicates the assessment done in 2014 by WKREDMP and used as the basis for the evaluation of the management plan.

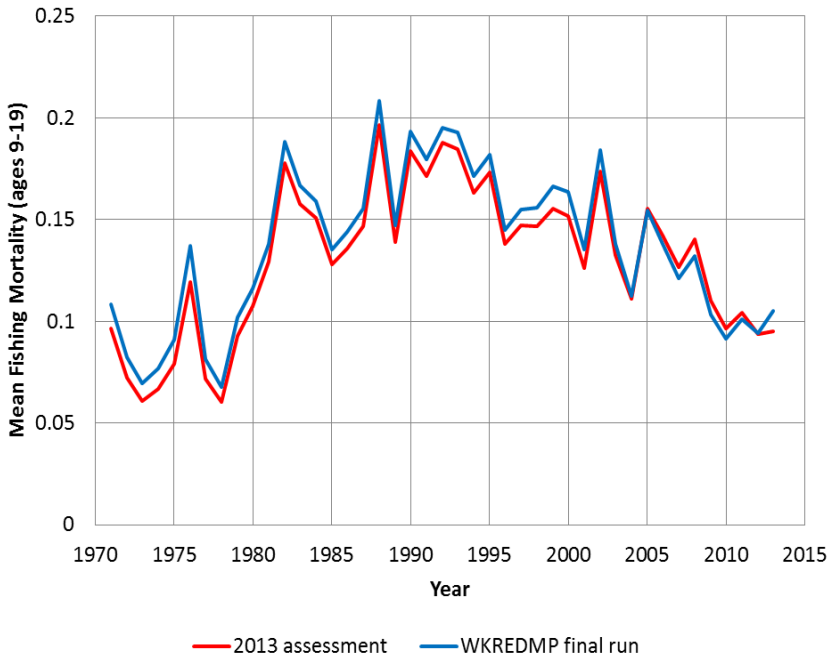

Figure 2.2.3.1.2 Time-series of fishing mortality under different assumptions in the model and input data. The red line indicates the result of the assessment done in 2013. The blue line indicates the assessment done in 2014 by WKREDMP and used as the basis for the evaluation of the management plan.

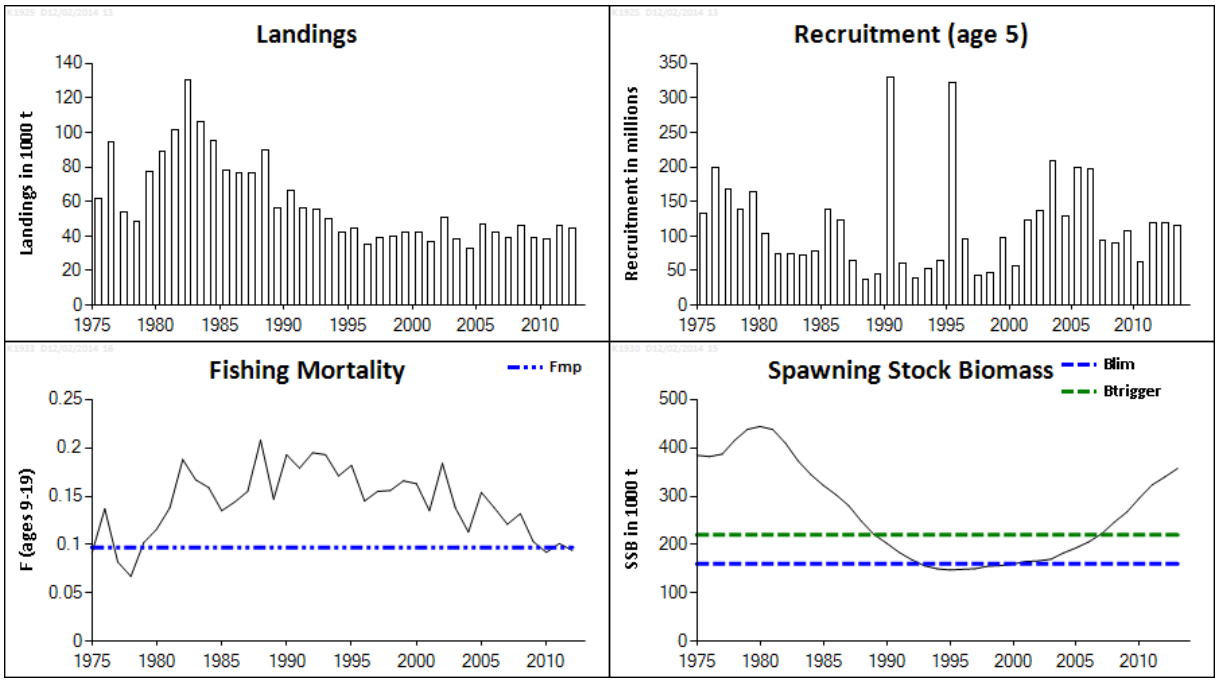

Figure 2.2.3.1.3 Golden redfish (*Sebastes marinus*) in Subareas V, VI, XII, and XIV. Summary of stock assessment used as the basis for the harvest control rule evaluation.

Reference points

A yield-per-recruit curve was estimated from the assessment, but no yield curve. The former curve provides estimates of F_{max}. The target fishing mortality of 0.097 year^{-1} in the proposed management plan is based on a point estimate of F_{max} from the 2012 assessment. With a value of 0.114 year^{-1}, the deterministic estimate of F_{max} from the new assessment is slightly higher than the target reference point in the plan.

The biomass limit reference point (B_{lim}) in the management plan is based on the lowest observed biomass (B_{loss}) in the 2012 assessment. Its value is 160 thousand tonnes. The updated assessment results in a less than 10% lower B_{loss}. The

$B_{trigger}$ reference point is set in the management plan using the B_{lim} as a basis and accounting for the assessment error, resulting in a $B_{trigger}$ of 220 thousand tonnes. The spawning-stock biomass has been above $B_{trigger}$ since 2007.

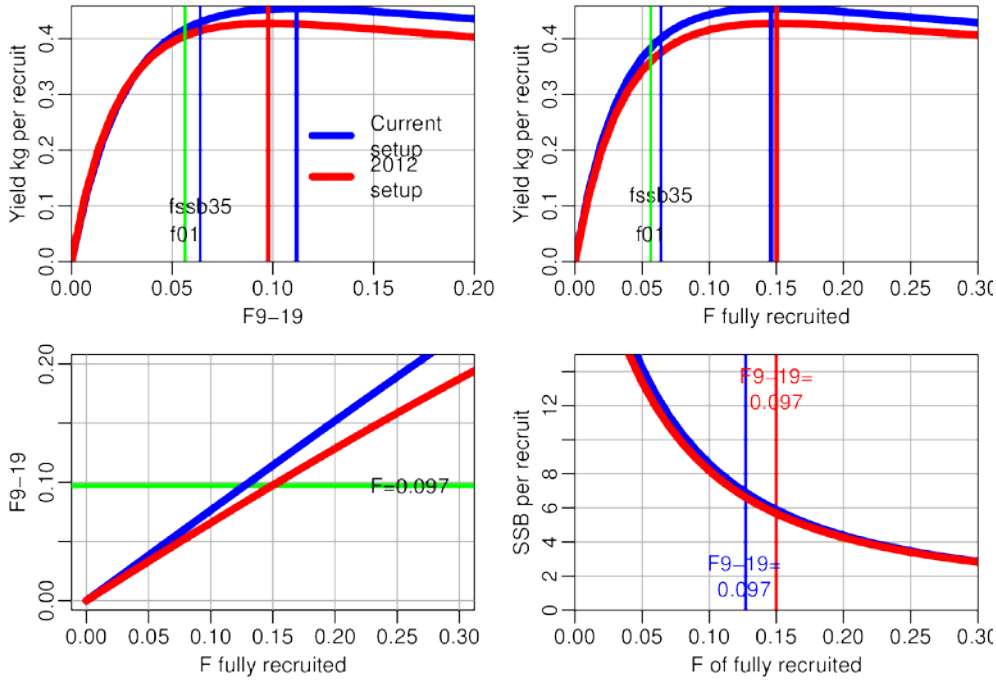

Figure 2.2.3.1.4 Yield-per-recruit as a function of average fishing mortality of 9- to19-year-old fish, yield-per-recruit as a function of fishing mortality of fully recruited fish, the relationship between fishing mortality of fully recruited fish and $F_{9–19}$, and spawning-stock-per-recruit as a function of fishing mortality. The blue curves are based on the new assessment, red curves on 2012 settings.

Harvest Control Rule evaluation

ICES has evaluated the proposed harvest control rule (F_{target} = 0.097, $B_{trigger}$ = 220 kt, linear reduction of F if B< $B_{trigger}$) using stock status and recruitment information from the recently accepted assessment model, and reference points derived from these results (B_{lim} = B_{loss} = 160 kt, F_{max} = 0.11). Details of the evaluation approach can be found in ICES (2014).

Results

ICES notes that the proposed HCR stabilizes SSB above $B_{trigger}$ until at least 2020, under a wide range of assumptions on recruitment, assessment errors, and stock definitions (Figure 2.2.3.1.5). Implementation error was not included in the evaluation. The HCR takes sufficient account of the uncertainties in the assessment model. The HCR should lead to a reduction of F below that observed in the last 30 years. Only if recruitment was at the lowest observed level since 2006 and at the same time F consistently underestimated (as could be caused by an inaccurate stock definition) could the biomass fall below $B_{trigger}$ before 2020. SSB could then fall below $B_{trigger}$ by 2017; at this time F would be reduced linearly with decreasing SSB, as defined in the HCR. Although ICES considers this scenario as unlikely, the available recruitment time-series is short, the stock identity is not resolved, and there is some uncertainty regarding the assumed stock dynamics. ICES therefore recommends an addition to the HCR, i.e. that the performance of the rule should be reviewed five years after implementation, an element which is usually included in ICES HCRs. An additional rule on management action required if SSB falls below B_{lim} would safeguard the stock in very unusual circumstances.

ICES notes that the proposed F_{target} (calculated from the 2012 assessment) is slightly lower than the most recent estimate of F_{max}, which could be seen as a proxy for F_{msy}. While numerically a higher yield could be achieved by setting the F_{target} to F_{max}, ICES offers the following arguments to keep the proposed F_{target}:

- ICES has not tested the performance of the HCR with an F_{target} of 0.11;
- the difference in yield between F = 0.097 and F = 0.11 is minimal and well within the estimation error of the assessment model;
- the basis for the proxy for F_{MSY} is F_{max}, which does not include considerations of recruitment overfishing.

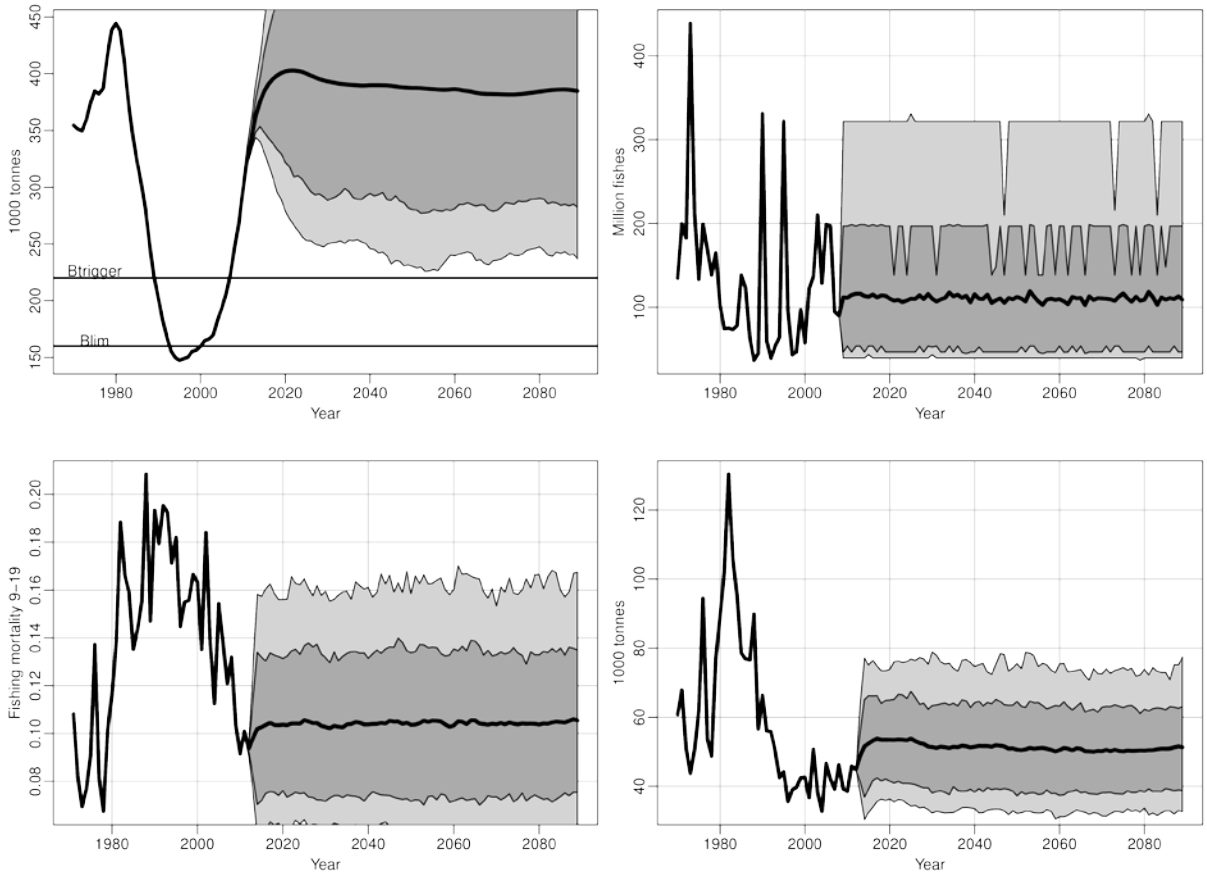

Figure 2.2.3.1.5 Development of the spawning stock (top left), recruitment (top right), fishing mortality (bottom left), and catches (bottom right) in the stochastic simulations where advice is given based on $F_{9–19} = 0.097$. The light grey area shows the fifth and 95th quantiles and the dark areas the 16th and 84th quantiles.

Methods

In these stochastic simulations, recruitment is drawn randomly from the observed recruitment. This approach is justified by the lack of relationship between historical recruitment and SSB and the absence of temporal autocorrelation.

Natural mortality in the forecast is assumed to be 0.05, as it is in the stock assessment. Weights are generated by a *von Bertalanffy* growth model and fixed length–weight relationship.

Selectivity in stochastic forecasts is the estimated selectivity of the Icelandic fleet that has accounted for over 90% of the catches from this stock over the last 3–4 decades. This size-based selection has been very stable, as indicated by inter-annual changes in L_{50} of less than ±0.5 cm.

Historically, uncertainty in stock size in the beginning of the assessment year was around 20%, as indicated by an independent assessment. Taking into account the additional uncertainty in the intermediate year assumptions leads to approximately 25–30% uncertainty in the stock size for the advisory year. The retrospective pattern of the GADGET model shows that assessment error from year to year appears to be correlated (i.e. periods of persistent over- or under-estimation). To ensure appropriate variability is present in the observation process in the management strategy evaluation, assessment error was modelled as auto-correlated lognormal with $\rho = 0.9$ and CV = 0.3, leading to substantial error with long periods of over and underestimation. ICES considers this assessment error to be at the higher end of historically observed errors.

Suggestions

ICES notes that the management plan is not explicit in situations where the SSB falls well below B_{lim}. It is therefore recommended to add a clause calling for management action in such a situation. Also, most management plans implemented in the recent past have a revision clause. This seems to be specifically useful in this case as ICES expects that the knowledge on stock dynamics and recruitment will increase over the next few years, and it should be tested whether the assumptions made during this evaluation still hold. ICES therefore proposes a scientific revision five years after implementation of the management plan.

Extra information

ICES expects that there will be significantly better information on stock dynamics of this stock within the next five years. This will mainly be achieved by increased age reading from the survey and catch in Subarea XIV, and from attempts to improve the species separation of juvenile *Sebastes marinus* and *S. mentella* in the German Greenland groundfish survey.

Sources

ICES. 2012. Report of the Benchmark Workshop on Redfish (WKRED 2012), 1–8 February 2012, Copenhagen, Denmark. ICES CM 2012/ACOM:48. 291 pp.

ICES. 2013. Report of the North Western Working Group (NWWG), 25 April–2 May 2013, ICES Headquarters, Copenhagen. ICES CM 2013/ACOM:07. 1538 pp.

ICES. 2014. Report of the Workshop on Redfish Management Plan Evaluation (WKREDMP), 20–25 January 2014, Copenhagen, Denmark. ICES CM 2014/ACOM:52.