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Coastal States request for ICES to re-evaluate the reference points for Norwegian spring-spawning herring

Advice summary

ICES advises, based on revised precautionary and MSY reference points, that the current B_{lim} value of 2.5 million tonnes for the Norwegian spring-spawning herring (NSSH) should be retained while B_{pa} and MSY $B_{trigger}$ should be revised to 3.184 million tonnes. ICES furthermore advises that F_{MSY} should be set to 0.102, with F_{lim} revised to 0.234 and F_{pa} revised to 0.182.

Request

Following the benchmark for Norwegian spring-spawning herring (NSSH) in 2016 (ICES, 2016), no new reference points were agreed upon. The Coastal States (CS) request that this work be completed to allow them to revise the long-term management strategy for this stock during summer 2018:

"The delegations agreed to request ICES to finish the process of re-evaluation of the reference points for Norwegian spring-spawning (Atlanto-Scandian) herring during the first quarter of 2018. Provided that ICES has completed their work on the reference points, the delegations agreed to meet before 15 May 2018 to discuss a possible revision of the long-term management strategy."

Elaboration on the advice

NSSH shows great variability in year-class strengths, and at any given time the stock is likely to be dominated by a small number of strong year classes. Because of this, the catch advice for NSSH has been provided with F values weighted by stock numbers. In previous evaluations of reference points and management strategies (e.g. ICES, 2013) unweighted Fs were used in the modelling, but in the present evaluation weighted Fs have been used throughout. Though this has led to improved consistency between the evaluation and the rest of the advisory process, it has also resulted in the present advised reference points not being directly comparable with the earlier reference points. The age range for mean F was furthermore changed at the last benchmark (ICES, 2016), from 5–14 to 5–11, following a change in the age range used in the assessment at the benchmark. Last year (2017) the unrevised reference points were therefore not in line with the mean F values reported for this stock. In the current evaluation an F range of 5–12 was used, as including a plusgroup is not considered problematic in the statistical assessment modelling framework, unlike in the older VPA-based approach. The new age range will be used consistently in future assessment outputs and reference points. This change in the F age range further contributes to the advised reference points not being directly comparable with the previous ones.

Suggestions

Following this reference point estimation, a management strategy evaluation is anticipated. ICES would like to highlight some issues regarding the upcoming evaluation:

1) The current management plan uses spawning-stock biomass (SSB) as the reference unit, i.e. the target F depends on the level of SSB. SSB is considered a very useful indicator of stock reproductive potential if maturity is well estimated. This means that it is of crucial importance that the maturation process is correctly presented in both assessment and forecast. However, there is uncertainty associated with this as the maturation process for this stock is dependent on year-class strength, but at the same time, the maturation ogive for a given year class can only be correctly estimated when all individuals have matured. ICES therefore suggests testing the suitability of using total biomass at ages 4+ or 5+ as an alternative reference harvestable biomass in the management plan.

2) Using F as the control variable in the management strategies has long traditions, but it is not easy to intuitively understand the impacts of different F-values in combination with changing selection patterns and stock dynamics. ICES therefore suggests testing harvest ratio (HR) strategies, where instead of a given F, a given proportion of the harvestable biomass can be taken. This is an intuitive and easy-to-understand measure of harvest pressure, and the discussion about weighted vs. unweighted F would become superfluous if the management strategy were based on the harvesting of a given proportion of the harvestable biomass.

3) In the current management plan, B_{pa} is used as the biomass trigger point. ICES suggests that a range of biomass trigger points are tested in connection with different target F or HR values.

Basis of the advice

Background

A new stock assessment method was adopted for the Norwegian spring-spawning herring at the benchmark assessment in 2016 (ICES, 2016). The benchmark only evaluated B_{lim}. In December 2017 the Coastal States sent a request to ICES for an evaluation of the reference points for the stock. This request was dealt with by the Workshop on the determination of reference points for Norwegian Spring Spawning Herring (WKNSSHREF – ICES, 2018), which met 10–11 April 2018.

Results and conclusions

The biomass and fishing mortality reference points were evaluated using long-term stochastic simulations, in accordance with the ICES guidelines (ICES, 2017). The results of the evaluation is presented in Table 1.

Table 1 Biomass and fishing mortality reference points for the Norwegian spring-spawning herring stock, as estimated at WKNSSHREF (ICES, 2018).

Reference point	Value	Explanation
Spawning-stock biomass (million t)		
B_{lim}	2.500	In the period 1950–2017 the stock size shows a wide dynamic range, with clear signs of impaired recruitment at low stock sizes. With a fitted segmented regression the estimates of B_{lim} are distributed around the current B_{lim} value of 2.5 million tonnes. Thus, ICES considers that the current B_{lim} remains appropriate.
B_{pa}	3.184	Derived from B_{lim}, using the model-estimated CV for SSB in the assessment year and averaged over the period 2002–2017, i.e. $B_{pa} = B_{lim} \times \exp(1.645 \times \sigma)$, where $\sigma = 0.147$.
MSY $B_{trigger}$	3.184	Set as the maximum value of B_{pa} and the 5th percentile of SSB when fishing at the F that maximizes annual yield, taking into consideration assessment/prediction error.
Fishing mortality (ages 5–12)		
F_{lim}	0.23	Calculated as the value that results in $P(SSB < B_{lim}) = 50\%$ in long-term equilibrium, assuming B_{lim} = 2.5 million tonnes, and without including any MSY $B_{trigger}$ (i.e. constant F exploitation) or any assessment error.
F_{pa}	0.182	Derived from F_{lim}, using the model-estimated CV for F in the last year of catch and averaged over the period 2002–2017. i.e. $F_{pa} = F_{lim} \times \exp(-1.645 \times \sigma)$, where $\sigma = 0.152$.
F_{MSY}	0.102	The value of F that maximizes the median long-term yield, without including any MSY $B_{trigger}$ (i.e. constant F exploitation) but including assessment error, was F = 0.152. However, this F resulted in long-term $P(SSB < B_{lim}) > 5\%$. Therefore, in accordance with ICES guidelines, F_{MSY} was set at the value of F that resulted in long-term $P(SSB < B_{lim}) = 5\%$ when that F was applied in combination with MSY $B_{trigger}$ = 3.184 million t; $F_{p05} = F_{MSY} = 0.102$ (Figure 1).

Methods

The XSAM assessment model fit yields estimates of recruitment-at-age 2 and SSB. With this output from the model for the period 1950–2017, spawning-stock recruitment relationships (i.e. numbers of recruits-at-age 2 as a function of SSB two years earlier) were used to estimate the reference points (Figure 2). No single stock–recruitment relationship obviously fit the data, so a method based on model averaging aided by the Akaike information criterion (AIC) was used to objectively find the probability of three different stock–recruitment models: segmented regression (weight ~25%), Beverton–Holt (weight ~45%), and Ricker (weight ~30%). This approach is also used within the ICES EQSIM software. The models were fitted to the data assuming log-normal error. The reference points were derived in accordance with medium-term ecosystem conditions (average stock weights and maturity in the period 1988–2017 and average catch weight in the period 1988–2016, including stochastic variability; Table 2).

A stochastic simulation model based on the current assessment model XSAM was used for the estimation of the reference points. This model includes a time-series model for fishing mortality as well as a model for selectivity. Thus, time-varying selectivity according to this model was simulated with the selectivity scaled to meet the target F, maintaining the variability in selection. As is common in such evaluations, natural mortality was assumed known and constant.

Table 2 Settings for the XSAM runs for NSSH.

Data and parameters	Setting	Comments
SSB–recruitment data	1950–2017	A time-series from 1907 exists, but with huge deviations in SSB in the early period between models. The period 1950–2017 was chosen since it represents a large spread in SSB values, with less deviations between models.
Mean weights and proportion mature	1988–2017	
Exploitation pattern	1988–2017	According to the XSAM model fit
Assessment error in the advisory year. CV of F and SSB	F: 0.26 SSB: 0.167	Average over the years since 2002, based on an average estimated by retrospective fits and predictions made by XSAM 2002–2017.
Assessment error in the assessment year Assessment error in the last year with catch data	SSB: 0.147 F: 0.152	Average over the years since 2002, based on an average estimated by retrospective fits and predictions made by XSAM 2002–2017.

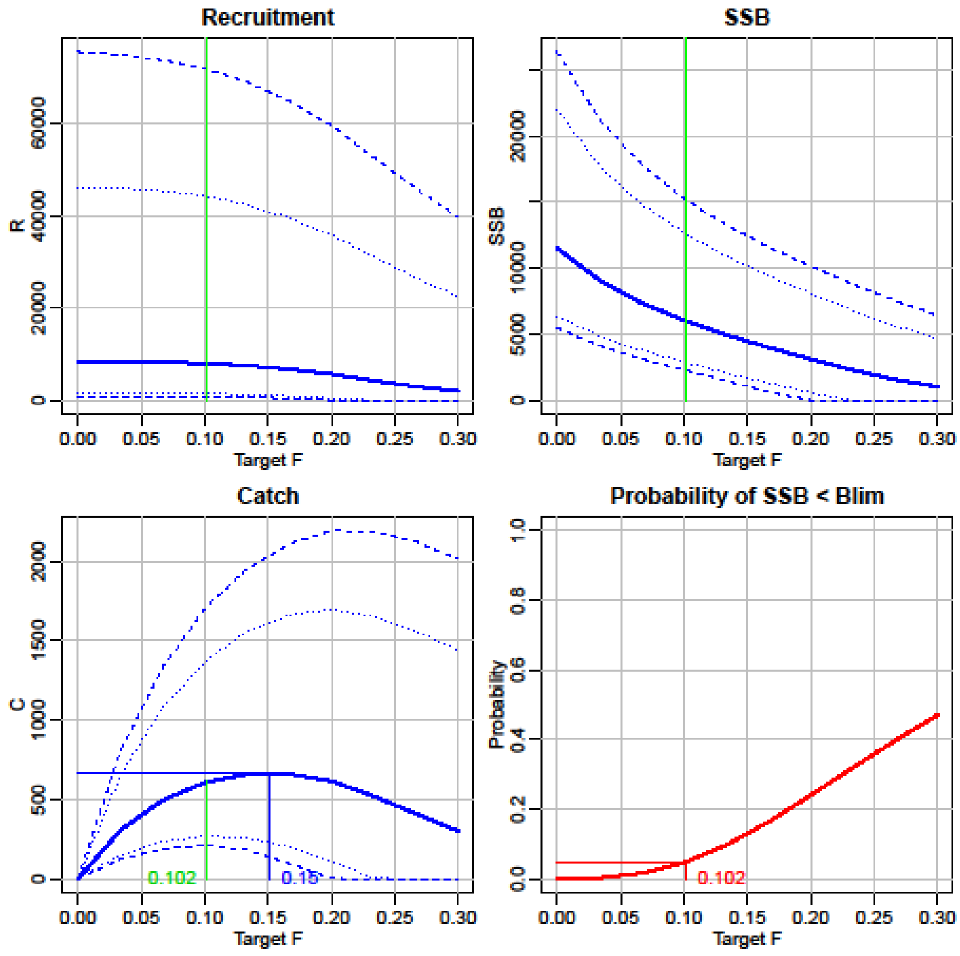

Figure 1 Median recruitment, SSB, and catch when fishing with constant target F without MSY $B_{trigger}$, including prediction error (blue solid lines) and the probability of falling below B_{lim} in any year using the MSY approach with MSY $B_{trigger}$ = B_{pa} (red line). The corresponding 5th and 95th percentiles are shown with dashed lines, and the 10th and 90th percentiles with dotted lines. The F_{MSY} point is indicated with the blue vertical line, while the F_{P05} value is indicated with the green vertical lines.

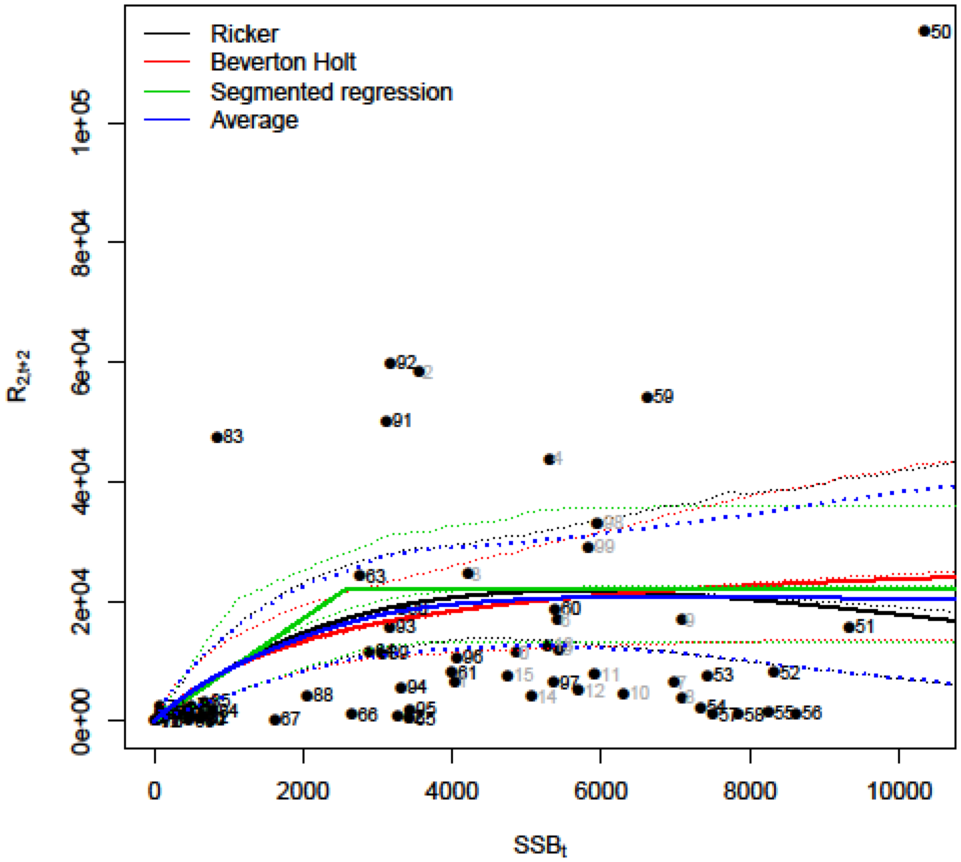

Figure 2 Recruitment (numbers-at-age 2) versus SSB (two years earlier), based on data XSAM estimates for 1950–2017. The cohort is indicated alongside the points. The lines are the mean in the fitted recruitment models Ricker (black), Beverton–Holt (red), segmented regression (green), and the model average (blue). The model average is based on the AIC-smoothed estimate (ICES, 2018). The broken lines are 95 confidence intervals of the mean, from 1000 replicates of pairs of stock recruitment data.

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