Preliminary estimates for horse mackerel biological reference points in Division IXa

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Current reference points

The MSY Btrigger has not been identified for this stock and the ICES MSY approach is applied without consideration of SSB in relation to MSY Btrigger. Given the apparent stability in the exploitation and dynamics of this stock during the assessment time period, and the lack of a well-defined stock-recruitment relationship, $F_{35\%SPR}$ is adopted as a proxy for F_{MSY} for this stock (Table 1).

Table 1. Summary table of current stock reference points

Type	Reference point	Value	Technical basis
MSY approach	Current F_{MSY}	0.11	Proxy based on F35%SPR
	Current $MSYB_{trigger}$	NA	
Precautionary approach	Current B_{pa}	NA	
	Current B_{lim}	NA	
	Current F_{pa}	NA	
	Current F_{lim}	NA	

Methods and model settings

Recent state-of-the-art workshops promoted by the International Council for the Exploration of the Sea (ICES, 2014a; ICES, 2014b) recommend that suitable MSY Biological Reference Points should be evaluated with stochasticity in a number of biological parameters and typically, a recent period should be chosen that reflects the current productivity and fishery regimes.
EqSim is a stochastic equilibrium reference point software that provides a collection of methods to estimate MSY reference points based on the equilibrium distribution of stochastic projections. Each simulation is run independently and projected forward for a range of F's values. Error is introduced within the simulations by randomly generating process error in the stock recruit fitted model and by using historical variation in biological/productivity parameters. This MSY approach analysis uses the information and assessment results available at ICES, 2014c. The range of fishing mortalities compatible with an ICES MSY approach to fishing were defined as the range of fishing mortalities leading to no less than 95% of MSY and which were precautionary in the sense that the probability of SSB falling below B_{lim} in a year in the long term simulations was ≤5% ($F_{P.05}$). For the purpose of this study and to establish an F_{MSY} candidate in relation to precautionary limits, B_{lim} was derived as $B_{trigger}/1.4$ where $B_{trigger}$ is the S-R segmented regression breakpoint (B_{loss} could be also applied as a B_{lim} proxy but the stock time series does not suggest any recruitment impairment within the observable stock levels) (table 2)

Table 2. Model and data selection settings

Data and parameters	settings	Technical basis/comment
S-R relationship	Ricker and Segmented regression	Weighted combinations of both S-R models were also tested (see ICES, 2014a – Buckland method)

Stock and recruitment data	Full time series	
Mean weights at age and proportion mature at age	2004-2014	
Exploitation pattern	2008-2014	Change in the selection pattern to increased selectivity of young ages and decreased selectivity of older ages
Assessment error in the advisory year. CV of F	0.131 (2011-2014)	Changes in stock boundaries and assessment method prior to 2010
Autocorrelation in assessment error in the advisory year	0.043 (2011-2014)	Changes in stock boundaries and assessment method prior to 2010
$B_{trigger}$ suggestion	306 500t	S-R Segmented regression breakpoint
B_{lim} suggestion	218928t	Blim= $B_{trigger}$ /1.4

Scenario results

Table 3 shows the results from the two management scenarios tested with: i) fixed F exploitation and ii) applying an ICES HCR Btrigger which triggers a reduced fishing mortality when SSB is below $B_{trigger}$. Both management scenarios were simulated for different S-R relationships.

Table 3. Summary table of *EqSim* results for fixed F (upper) and HCR Btrigger (lower) scenarios. In bold are the estimated F_{MSY} and SSB_{MSY} (in ´000t).

Reference point	Ricker + Segmented (weighted)	Ricker	Segmented
Fixed F scenarios			
F_{MSY} (without $B_{trigger}$)	0.16	0.17	0.07
F_{MSY}Lower (without $B_{trigger}$)	0.13	0.13	0.06
F_{MSY}Upper (without $B_{trigger}$)	0.20	0.21	0.08
$F_{P.05}$ (without $B_{trigger}$)	**0.08 (322)**	**0.09 (319)**	**0.06 (416)**
HCR scenarios			
F_{MSY} (with $B_{trigger}$)	**0.10 (396)**	**0.09 (401)**	**0.10(470)**
F_{MSY}Lower (with $B_{trigger}$)	0.08	0.07	0.07
F_{MSY}Upper (with $B_{trigger}$)	0.11	0.10	0.11
$F_{P.05}$ (with $B_{trigger}$)	0.15	0.15	0.13

Discussion / Sensitivity

S-R relationships

The *EqSim* standard stock recruitment fit, using three S-R models (Ricker, Beverton-Holt and segmented regression) weighted by the default Buckland method estimated the B-H as a horizontal "straight line", so B-H was not considered further in the simulations. Additionally, the segmented regression breakpoint was well outside the observed SSB ranges. For this particular model it was possible to change the software code to replace for an independently modeled segmented regression. There are some doubts about the suitable S-R model for this stock. In the absence of strong *a priori* biological reasons for choosing a S-R, using the segmented regression may be a more "neutral" assumption (e.g. there is no confirmation of high-density effects for this resource)

Sensitivity of the model

Recruitment for this stock has occasional very high values, ICES (2014b) suggests that extreme observations can lead to different F_{MSY} and $F_{P.05}$, further analysis should be made to investigate

the sensitivity of the results to the occasional high recruitments. The sensitivity of the model to the inclusion of additional stochastic variability in biological parameters (e.g. proportion mature) should also be further tested.
When an HCR $B_{trigger}$ is used, the estimated $F_{P.05}$ is higher, allowing a slightly higher average yield in cases where $F_{MSY} > F_{P.05}$. In practice the higher yield will only occur when SSB is high as F will be reduced when SSB is low (ICES, 2014b).

The estimated F_{MSY} ranges in the majority of the scenarios are consistent with the values from the ICES proxy based on $F_{35\%SPR}$. The estimated SSB_{MSY} levels are in the range of the observed mean stock levels.
Overall if implementing F_{MSY} implies a major change of the state of the stock (e.g. if the SSB expected is outside the mean historic values without regarding the error in assessment) the results of the evaluation may be expected to be valid for the current state and during the early stages of any transition, but may require checking again (in a benchmark group) once the change of state in the stock has further advanced.

References

ICES 2014a. Report of the Workshop to consider reference points for all stocks (WKMSYREF2), 8-10 January 2014, ICES Headquarters, Copenhagen, Denmark. ICES CM 2014/ACOM:47.

ICES 2014b. Report of the Joint ICES-MYFISH Workshop to consider the basis for FMSY ranges for all stocks (WKMSYREF3) 17–21 November 2014 Charlottenlund, Denmark. ICES CM 2014/ACOM:64

ICES 2014c Report of the Working Group on Southern Horse Mackerel, Anchovy and Sardine (WGHANSA), 20-25 June 2014, Copenhagen, Denmark. ICES CM 2014/ACOM:16.