ECOREGION **North Sea**
SUBJECT **Joint EU-Norway request on the evaluation of the long-term management plan for haddock in Subarea IV (North Sea) and Division IIIa West (Skagerrak)**

Request

ICES is requested to:

1) *Evaluate the performance of the plan in meeting its objectives, identifying any weaknesses in design or implementation that undermine its effectiveness.*
2) *Evaluate whether the values assigned to the precautionary reference points remain appropriate.*
3) *Indicate whether the target fishing mortality rate of 0.3 is consistent with MSY for the stock.*
4) *Suggest alternative methodologies which may be more consistent in defining TACs in relation to the stock status.*

The objective of the long term management plan for North Sea haddock agreed between Norway and the European Union is to provide for sustainable fisheries with high and stable yields in conformity with the precautionary approach. In 2008 the EU and Norway agreed to a revised management plan for this stock. The main elements of the plan are a target fishing mortality of 0.3, limits in TAC changes of ±15%, a minimum level of spawning stock biomass of 100 000 tonnes (B_{lim}) and a precautionary spawning biomass of 140 000 tonnes (B_{pa}). A sliding-F rule is to be applied if SSB is estimated to be below B_{pa} but above B_{lim}. Following a minor revision in 2008, interannual quota flexibility (banking and borrowing) of up to ±10% is permitted (although this option has not yet been used).

Due to lack of time it was unfortunately not possible to deal with question 2: "*Evaluate whether the values assigned to the precautionary reference points remain appropriate.*"

ICES Advice

ICES advises that a target fishing mortality of 0.3 within the management plan is consistent with the precautionary approach (high probability of SSB being above B_{lim} by 2015 and beyond) and conforms with the goal of achieving long-term maximum sustainable yield from the stock and ensuring low risk to SSB. The TAC constraint used does not appear to have a significant effect on the results.

Basis of advice

Background and method

The evaluation of the harvest rule was conducted using simulations of the projected population from 2010 to 2031 (20 years into the future, as requested, plus 2 years to allow for quota-setting forecasts). A Management Strategy Evaluation (MSE) approach was used to generate true and assessed catches and population sizes as follows:

(i) Reported landings (in weight and numbers-at-age) were generally determined by the quota for each year (set by the management module run in the previous year). If not enough fish were available for the quota to be taken, reported landings were adjusted downwards *pro rata* (in proportion). Otherwise, reported landings were assumed equal to the quota. Reported catch and discards were generated from reported landings by applying fixed proportions-at-age (average of proportions of catch and discards over 2007–2009);

(ii) True catch (in yield and number of fish-at-age) was generated by applying a fixed multiplier (average of the ratio of estimated to observed catches over 2006–2008) to reported catch generated in (i). True landings and discards were generated from true catch by applying fixed proportions-at-age (average of proportions landed and discarded over 2006–2008);

(iii) The assessed population was generated deriving stock size and fishing mortality by a) applying the same model (XSA) as used by the relevant assessment Working Group (WGNSSK), or b) applying random noise to the true underlying stock abundances. Assessed catch, landings and discards were derived from the assessed population estimates by first applying the catch equation, and then applying the proportion discarded.

In the first year of the simulations, the 2010 quota was used to generate reported landings. The reported landings were considered the intended landings and the true fishing mortality was used as the intended fishing mortality (for the first year only). Future recruitments were generated from a simple time-series model of random variation about a recent geometric mean (the "low" recruitment scenario), with the optional inclusion of two large year classes (the "high" recruitment scenario), following historical observations that a large year class occurs in the stock every ten years or so. Natural mortality (0.2), weights-at-age and proportion mature-at-age (averaged over 2007–2009) were assumed to be time-invariant and without error.

100 simulations were carried out for each of the requested combinations of run settings:

- Target F = 0.2, 0.3, 0.4, 0.5;
- TAC constraint = ±15%, ±25%;
- Assessment model = XSA, true stock size;
- Recruitment model = high, low.

The analysis was conducted by the Marine Laboratory, Aberdeen, using R (R Development Core Team, 2005) and FLR libraries (FLR Team, 2006).

Results and conclusions

The harvest rule was tested for several combinations of target fishing mortality (0.2, 0.3, 0.4, 0.5) and interannual variation in TAC (±15%, ±25%). The range of analyzed fishing mortality options included values encompassing proxies for F_{msy} ($F_{0.1}$-F_{max}). The main results of the evaluation are presented in the Table below. Figures 6.3.3.2.1 and 6.3.3.2.2 show the results from the simulations performed for the management plan in place (target F of 0.3 and TAC constraint of ±15%), using the current assessment model and assuming that occasional large year classes occur.

Summaries of risk (number of years in each iteration in which biomass was lower than B_{pa} and B_{lim}, averaged over simulations) and cumulative yield (summed true landings, averaged over simulations) for each of the target F and TAC limits combination, tested with simulated recruitment time-series with high and low values for each assessment type.

Run	Recruitment	TAC constraint	Assessment type	Target F	Num years B < Bpa	Num years B < Blim	Cumulative yield ('000 t)
1	High	15%	XSA	0.2	0.00	0.00	1579
2	High	15%	XSA	0.3	0.03	0.00	1842
3	High	15%	XSA	0.4	0.32	0.17	1930
4	High	15%	XSA	0.5	0.21	0.06	2069
5	High	15%	Truth	0.2	0.00	0.00	1828
6	High	15%	Truth	0.3	0.03	0.00	2012
7	High	15%	Truth	0.4	0.10	0.00	2172
8	High	15%	Truth	0.5	0.99	0.02	2205
9	High	25%	XSA	0.2	0.00	0.00	1588
10	High	25%	XSA	0.3	0.16	0.06	1851
11	High	25%	XSA	0.4	0.26	0.09	2004
12	High	25%	XSA	0.5	0.64	0.30	2073
13	High	25%	Truth	0.2	0.00	0.00	1895
14	High	25%	Truth	0.3	0.00	0.00	2129
15	High	25%	Truth	0.4	0.44	0.00	2208
16	High	25%	Truth	0.5	1.74	0.10	2223
17	Low	15%	XSA	0.2	0.02	0.00	1269
18	Low	15%	XSA	0.3	0.56	0.10	1444
19	Low	15%	XSA	0.4	0.82	0.21	1510
20	Low	15%	XSA	0.5	1.80	0.32	1518
21	Low	15%	Truth	0.2	0.02	0.00	1417
22	Low	15%	Truth	0.3	0.72	0.00	1531
23	Low	15%	Truth	0.4	3.56	0.02	1576
24	Low	15%	Truth	0.5	6.39	0.75	1615
25	Low	25%	XSA	0.2	0.02	0.00	1272
26	Low	25%	XSA	0.3	0.13	0.00	1446
27	Low	25%	XSA	0.4	0.78	0.24	1494
28	Low	25%	XSA	0.5	2.39	0.72	1555
29	Low	25%	Truth	0.2	0.00	0.00	1438
30	Low	25%	Truth	0.3	0.54	0.00	1547
31	Low	25%	Truth	0.4	3.63	0.02	1592
32	Low	25%	Truth	0.5	7.27	0.76	1635

Over all tested combinations of target F and TAC constraint, spawning biomass was below B_{pa} in fewer than eight years and below B_{lim} in fewer than one year of the 22 years in the simulations (on average). The probability of SSB in 2015 being above B_{lim}, $P(B_{2015} > B_{lim})$, is higher than 95% for all scenarios (not shown). Cumulative yield is also likely to increase for all analyzed combinations, from 1579 to 2223 thousand tonnes under the high recruitment scenario and from 1269 to 1635 thousand tonnes under the low recruitment scenario.

The harvest rule was tested under assumptions about stock biology, discard practices, exploitation pattern and assessment performance (as outlined above). If these assumptions do not pertain in the future, the rule should be revisited.

Discussion

The North Sea haddock stock exhibits sporadically high recruitment leading to dominant year classes in the fishery. These large year classes often grow more slowly than less abundant year classes, possibly due to density dependent effects. For the evaluation of the management plan, recruitment time-series were simulated assuming two recruitment scenarios: occasional large year classes and low recruitment along the entire simulated period (2010-2031). Although growth was kept constant in the simulations performed with high recruitment, the results from the simulations performed with the low recruitment values give robustness to the conclusions that the stock is likely to be sustainable if managed according to the current management plan.

Simulations were conducted for a range of options for target fishing mortality (from 0.2 to 0.5) that are within the range of values of $F_{0.1}$ and F_{max} estimated for the North Sea haddock stock (ICES, 2010), and these fishing reference points are generally considered proxies for F_{msy}. Results show that cumulative yield is highest (under all recruitment scenarios and TAC constraints) at target F of 0.4-0.5. The simulations indicate that if occasional large year classes continue to appear the risk to SSB is low at a target F of 0.4. However, the best combination of high long-term cumulative yield and low risk to SSB is obtained for a target F of 0.3, which is also robust to worst-case assumptions about recruitment and the quality of stock assessments, thus supporting the perception that, at current exploitation pattern, F_{msy} for haddock is around 0.3.

Sources

ICES (2010). Report of the ICES Working Group for the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK), 5-11 May 2010, ICES CM 2010/ACOM13.

Needle, C. L. (2008). Management strategy evaluation for North Sea haddock, *Fisheries Research* 94(2): 141–150.

Needle, C. L. (2010). Revised management strategy for North Sea haddock. Working paper to ICES ACOM, July 2010 (http://groupnet.ices.dk/RGNSHW-ADGNSHW2010).

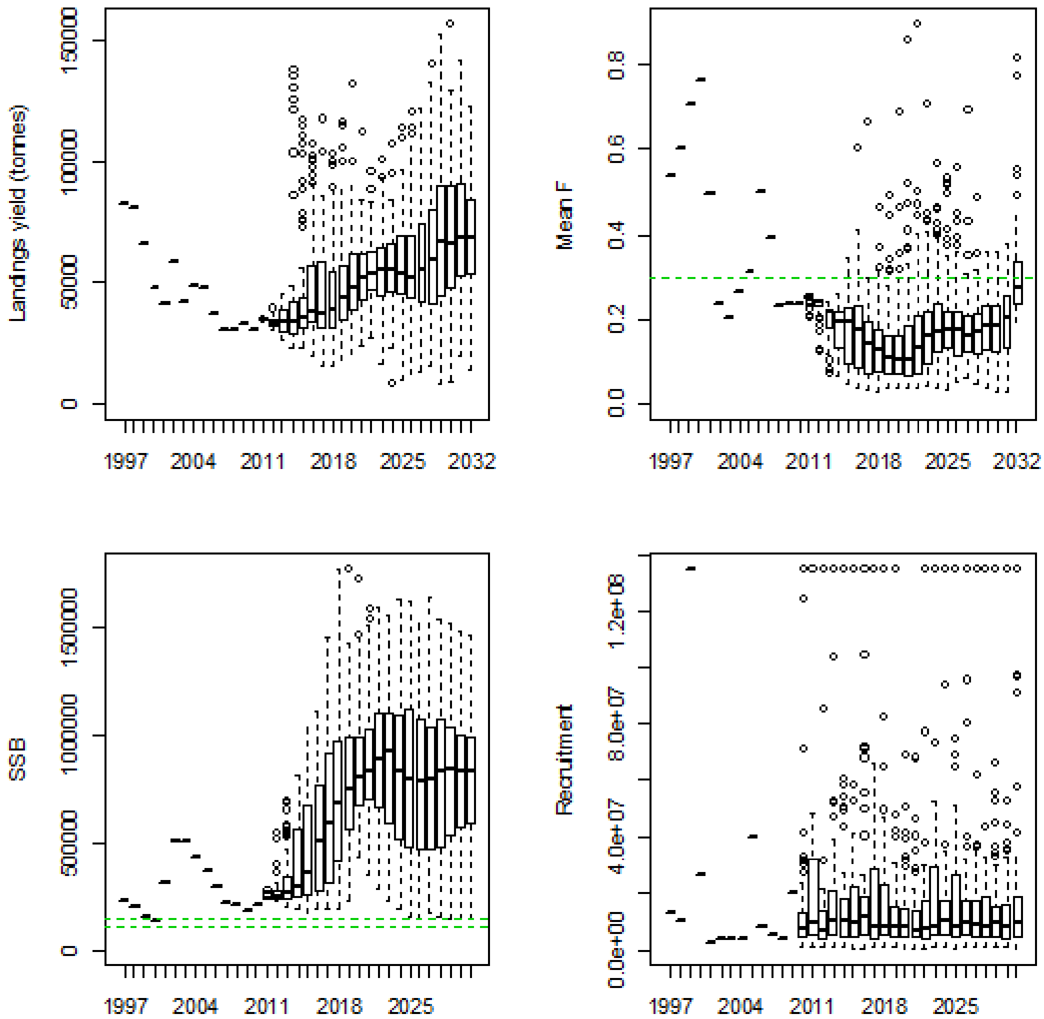
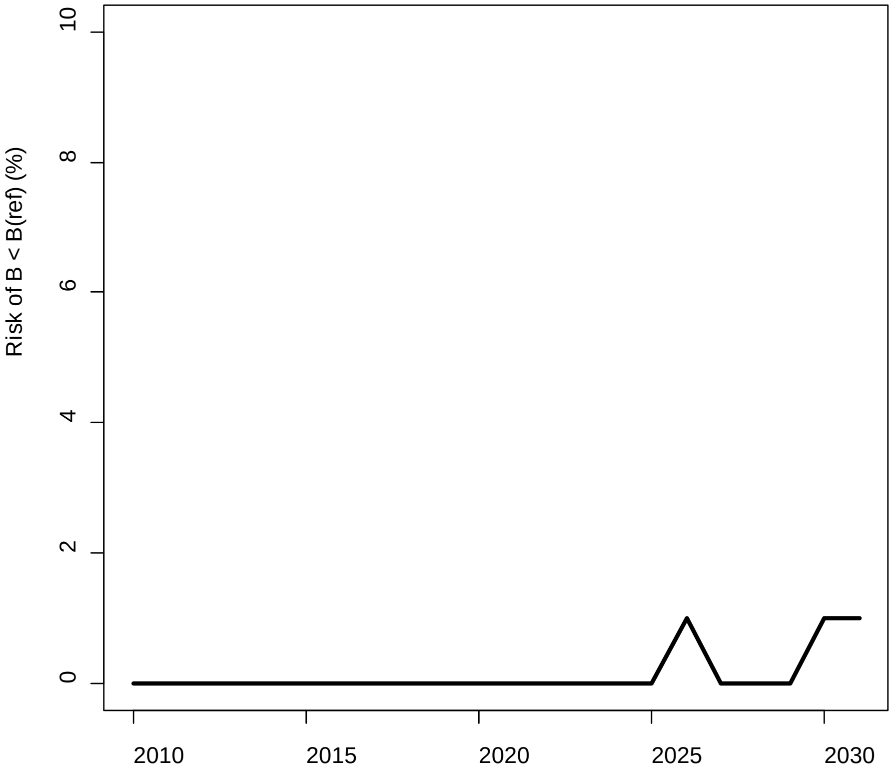


Figure 6.3.3.2.1 Landings (weight), mean $F_{(2\text{-}4)}$, spawning biomass (SSB) and recruitment for target F of 0.3 and TAC constraint of ±15%. The simulated recruitment time-series includes high values and the XSA assessment model is used in the simulations. The short horizontal lines indicate the medians, the boxes the quartiles (25^{th} and 75^{th} percentiles), and the whiskers the 5^{th} and 95^{th} percentiles. Outliers are shown by open circles. The dashed line on the top-right plot shows the target *F*, while those on the bottom-left plot show B_{pa} (upper) and B_{lim} (lower). Historical estimates (pre-2010) are shown as short horizontal lines only.

The simulations indicate that SSB is likely to rise initially before oscillating between 500 and 1000 kt, mean F is likely to remain below the target level (mostly due to a combination of the ±15% TAC constraint and the fixed discards model) and landings will rise steadily as the quota constraint allows. The median recruitment is low (as a result of smoothing across different realizations of recruitments) but the occasional large year classes are also evident.



Risk of B < B(ref) (%)
0
2
4
6
8
10
2010
2015
2020
2025
2030