6.4.2 Norway request on management strategy evaluation for the *Pandalus* fishery in Subdivision 3.a.20 (Skagerrak) and Division 4.a East (Norwegian Deep)

Advice summary

ICES advises that the proposed Harvest Control Rule (HCR) is precautionary provided that the target fishing mortality is set at F = 0.52 or a lower value, and linearly reduced to zero at SSB levels below an MSY $B_{trigger}$ of 9900 tonnes. The evaluation found that including a 10% interannual quota flexibility ('banking and borrowing') in the HCR had an insignificant effect on the performance of the rule.

ICES notes that recruitment from 2008 to 2014 has been low. ICES advises that if this lower recruitment was to continue in the long-term, then a lower target fishing mortality of 0.32 would be required for the HCR to be precautionary. This lower target fishing mortality would be precautionary for any level of recruitment observed in the past.

ICES advises that because of uncertainty as to whether the stock is entering a phase of lower recruitment, a proposed HCR with target F = 0.52 should be re-evaluated within two to three years.

ICES could not formally evaluate the effect of in-year revisions on the assessment.

ICES was not able to investigate the effect of different discarding levels on the sensitivity of the results.

Request

This advice responds to a request from Norway to ICES regarding elements in a new long-term management strategy for Northern shrimp (*Pandalus borealis*) in Divisions 3.a West and 4.a East (Skagerrak and the Norwegian Deep).

The request:

The assessment of this stock is carried out in September each year, using survey results from January of the same year and catch statistics from the previous year. This means that the information used in the assessment was collected at least 9 months previously. In a short-lived species like Northern shrimp, this can be a significant source of uncertainty. The Parties would therefore like to explore the possibility of developing a management strategy for Northern shrimp that incorporates an in-year revision of the TAC including the results of the survey carried out January in the TAC year and catch statistics from the year previous to the TAC year.
The management strategy would have the following elements:

1. *The Parties shall set a TAC for Northern shrimp within the range of fishing mortalities that is consistent with fishing at maximum sustainable yield provided that this is forecast to result in a biomass equal to or greater than B_{pa} at the end of the TAC year.*
2. *Where fishing at F_{msy} would result in a biomass that is forecasted to be less than B_{pa}, the Parties agree that the lower and upper bounds of the fishing mortality range referred to in paragraph 1 are reduced linearly to zero.*

ICES is requested to evaluate whether or not this strategy would be precautionary with and without an inter-annual quota flexibility (banking and borrowing) of +/- 10%. When evaluating the impact of the inter-annual flexibility, ICES is asked to take into account assessment uncertainty as well as the inter-annual variability of stock size and recruitment.

ICES is further requested to assess the sensitivity of their analyses to presumed levels of discarding in numbers of [5%], [10%], [15%], [20%] and [30%], considering small, non-marketable shrimp and medium sized shrimp (high-grading) separately.

Finally, an in-year adjustment of the TAC based on the results of the survey carried out in January of the TAC year would largely depend on an estimate of the size of the incoming year class. Noting that the discarding of these 1 year old shrimps is

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prevalent in this fishery, ICES is requested to assess the possible consequences of in-year TAC increases on discard levels of respectively small and medium-sized shrimp, and whether the net effect would be positive or negative with regard to average yields and to the precautionary approach (B should remain above B_{pa}).

Elaboration on the advice

ICES interpretation of the request

Historical vs. current recruitment

All evaluations have been made relative to a base case simulation reflecting historical stock status and dynamics, as well as current assessment accuracy. Recruitment is set to the long-term level of stock productivity (1988–2014). Given the lower recruitment observed from 2008 to 2014, the impact of continued low recruitment in the long term was also assessed (Figure 6.4.2.1, Table 6.4.2.1).

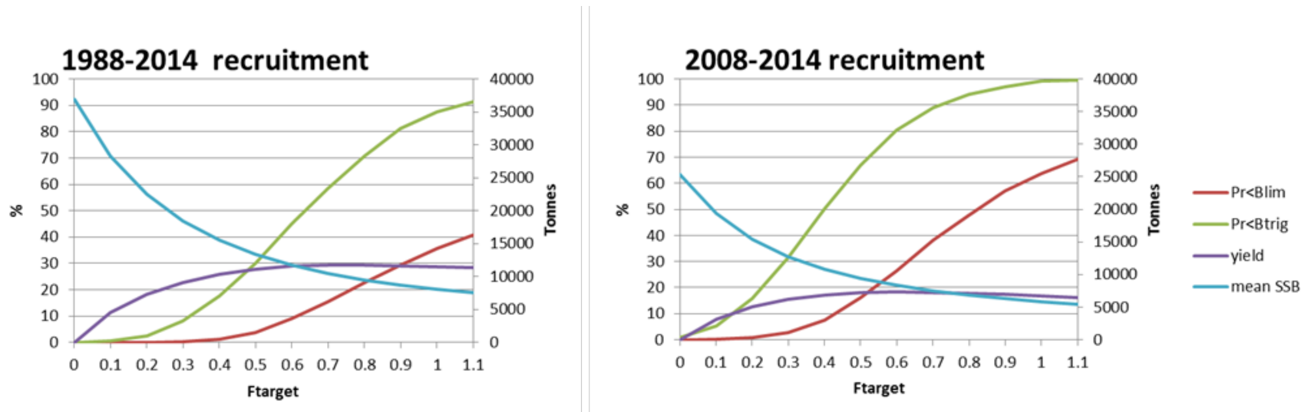

Figure 6.4.2.1 Risk levels (Pr), yield, and mean SSB for a range of target Fs – long-term (1988–2014) and the current low recruitment (2008–2014).

Table 6.4.2.1 Risk levels (Pr), yield, and mean SSB for a range of target Fs – long-term (1988–2014) and the current low recruitment (2008–2014).

Target F scenarios	1988–2014 recruitment levels				2008–2014 recruitment levels			
	Pr < B_{lim} (%)	Pr < $B_{trigger}$ (%)	Yield (tonnes)	MeanSSB (tonnes)	Pr < B_{lim} (%)	Pr < $B_{trigger}$ (%)	Yield (tonnes)	Mean SSB (tonnes)
0	0	0	0	36967	0	0.8	0	25361
0.1	0	0.4	4513	28259	0.1	5.2	3108	19367
0.2	0	2.5	7303	22484	0.8	15.8	5004	15437
0.3	0.2	8.0	9123	18459	2.8	31.5	6192	12755
0.32	0.3	9.9	9407	17803	4.8	43.2	6315	11470
0.4	1.1	17.7	10344	15552	7.4	50.2	6904	10842
0.5	3.6	30.0	11137	13379	16.0	67.0	7254	9414
0.52	4.7	32.4	11252	13010	23.3	77.9	7106	8496
0.6	9.1	45.0	11583	11710	26.3	80.3	7343	8328
0.7	15.5	58.4	11752	10418	38.1	88.9	7267	7488
0.8	22.7	70.8	11741	9422	47.7	94.1	7114	6836
0.9	29.2	81.2	11632	8651	57.1	96.9	6920	6307
1.0	35.7	87.5	11480	8052	63.7	99.1	6700	5862
1.1	40.8	91.5	11310	7575	69.1	99.5	6470	5480

The simulation using long-term recruitment from the full time-series (1988–2014) predicted optimum catch levels of up to 11 250 tonnes (i.e. landings of up to 10 125 tonnes assuming 10% discarding in weight) and F_{MSY} of 0.52 (higher F may offer higher yield, but also > 5% risk of SSB falling below B_{lim}).

The low recruitment scenario, which gives ca. 6300 tonnes of catches (ca. 5700 tonnes of landings) and F_{MSY} of 0.32, represents the optimum that can be achieved at the current recruitment level. If recruitment remains at this lower level in the long term, it seems unlikely that the stock will be able to sustain harvest levels similar to those obtained prior to 2008.

The analysis also allowed for an investigation of what would be likely to happen (i.e. the risk of SSB falling below B_{lim}) if the F_{MSY} from one recruitment scenario was applied to another scenario. This simulates the impact of misidentifying the recruitment scenario. Applying the F_{MSY} = 0.52 from the historical recruitment scenario to a lower recruitment scenario (i.e. recruitment is lower than anticipated) would give a risk level of 23.3% (compared with the precautionary threshold of 5%). Expected long-term average yield in this case would rise from 6300 tonnes to 7106 tonnes. Conversely, applying the F_{MSY} = 0.32 from the low recruitment scenario to a higher recruitment scenario (i.e. recruitment is higher than anticipated) reduces the risk to 0.3% and the long-term projected yield to 9407 tonnes (down from 11 250 tonnes). There is thus a modest loss of yield (1840 tonnes) from underestimating recruitment, but a high risk (23.3%) of going below B_{lim} if the higher recruitment is assumed, when recruitment is actually consistently low.

In general, there will be a range of F values within which one could expect broadly similar yields. However, in this case F higher than F_{MSY} gives a higher than 5% probability of the SSB falling below B_{lim}. The F_{MSY} value is therefore the highest F value that does not exceed this risk level.

Discards

ICES was not able to investigate the effect of different discarding levels on the sensitivity of the results. The request and the model capabilities both revolve around discarding a fixed fraction of the catch. This represents a poor reflection of reality, where discarding in practice should vary strongly according to the size of the incoming year class.

Banking/borrowing

The banking/borrowing scenarios are modelled as either banking or borrowing throughout the simulation time period. These represent the extreme cases. Banking 10% left the F_{MSY} unchanged at F = 0.52 and reduced the expected yield from 11 250 tonnes to 11 205 tonnes. Borrowing 10% reduced F_{MSY} to 0.51 and the expected yield to 11 233 tonnes. Therefore, including a 10% interannual quota flexibility ('banking and borrowing') in the HCR had an insignificant effect on the performance of the rule.

Issues with the advice

The evaluation of the HCR is based on the higher recruitment scenario, which has been observed over the longer term (1988–2014). It is noted that the recruitment from 2008 to 2014 has been lower and that if the situation were to continue, the HCR would need to be revised.

The HCR uses the estimated SSB from the end of the TAC year; this is largely composed of two year classes for which there is little or no information at the time of the assessment. The estimate of the 2-group in the SSB at the end of the TAC year is based only on the survey estimate of the 1-group at the time of the assessment, and this year class has not yet been seen in the fishery. The 1-group in the SSB at the end of the TAC year is not known at the time of the assessment and for prediction purposes is assumed to be the geometric mean of the recruitment for the time period 2008–2014.

The SSB in the HCR depends heavily on the variation around the mean size of the 2-year-olds. The assessment model has exactly the same issue. Small variations in the size distribution transfer into larger variations in the SSB. The biomass of age 2 and older shrimp, irrespective of size, could be considered as replacement for SSB in the HCR.

ICES cannot formally evaluate whether an in-year revision of the assessment will be precautionary or not, or estimate its impacts on discards or yield.

ICES notes that an increase in the TAC following an in-year revision owing to a large incoming year class could lead to either (1) increased discarding of small shrimp and a higher F on the bigger shrimp, or (2) no change in fishing behaviour if the increased TAC is not restricting. Yield-per-recruit analyses were carried out to explore the consequences of harvesting starting at different ages at first capture (Figure 6.4.2.2). A yield-per-recruit analysis, not taking discarding into account, shows that the overall yield, at any realistic F level, is higher if the shrimp are allowed to become 2-year-olds before being fished.

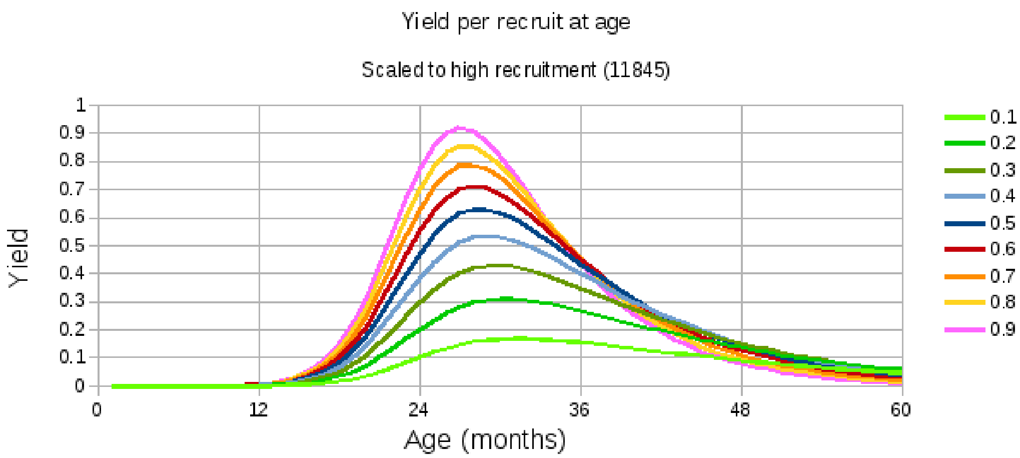

Figure 6.4.2.2 Yield-per-recruit for different ages at first capture and for a range of F (0.1–0.9).

Suggestions

Northern shrimp is a fast-growing stock. Especially the 1-group grows quickly and recruits to the fishery in the second half of the year. The annual Norwegian shrimp survey is conducted in January, while assessment takes place in September. The TAC is therefore based on one-year-old data, which is a concern for such a short-lived stock. More up to date information would be expected to increase the accuracy of the forecast. This can be achieved by either conducting an in-year revision of the assessment or by moving the assessment to February/March after the end of the survey.

Basis of the advice

Background

A length-based assessment model (formulated in the length-based version of SS3) was agreed in a benchmark in January 2016 to assess the status of the stock. In answering the request from Norway the outputs of the SS3 model were used as inputs to the HCS software.

Banking and borrowing is an integral part of the EU management system. In 2014, Norway borrowed 10% of the 2015 quota.

Methods

The HCS simulation program used in the evaluation is a single-stock, single-fleet program for simulating harvest control rules using an age-structured population model, with a monthly time step. The population model is structured by age groups, but with life history and selection modelled depending on length-at-age (which will vary over the course of a year). Life history mostly assumes that all shrimp are of exactly mean length-at-age, but when maturation is applied a distribution around the mean length is assumed. It is assumed that catches within the model include both landings and discards; there is no explicit retention curve within the model. The population model is adapted to the assessment for this stock with the length-based version of SS3 (NIPAG 2016). 1000 simulations were run for a 30-year time frame for each HCR investigated and the results from years 20–30 used to calculate expected outcomes.

Sources and references

ICES. 2016a. Report of the Joint NAFO/ICES *Pandalus* Assessment Working Group (NIPAG), 7–14 September 2016, Bergen, Norway. ICES CM 2016/ACOM:15.

ICES. 2016b. Report of the Benchmark Workshop on *Pandalus borealis* in Skagerrak and Norwegian Deep Sea (WKPAND), 20–22 January 2016, Bergen, Norway. ICES CM 2016/ACOM:39. 72 pp.

ICES. 2016c. Report of the Workshop on management strategy evaluation for the *Pandalus* in Subdivision 3.a.20 and Division 4.a East fishery (WKPANDMSE), 23–25 August 2016, Bergen, Norway. ICES CM 2016/ACOM:54.

Skagen, D. W., Skern-Mauritzen, M., Dankel, D., Enberg, K., Kjesbu, O. S., and Nash, R. D. M. 2013. A simulation framework for evaluating fisheries management decisions using environmental information. ICES Journal of Marine Science, 70: 743–754.