Report of the Basic Document Working Group (BDWG)

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on

Harvest Control Rules for Management of Fisheries on Cod and Haddock – and Optimal Long Term Optimal Harvest in the Barents Sea Ecosystem

By;
B. Bogstad[1], T.Bulgakova[2], K.Drevetnyak[3],
A.Filin[3], K.H.Hauge[1], Y.Kovalev[3], Y. Lepesevich[3], I.Røttingen[1],
M.Shevelev[3], V.Shibanov[3], S.Tjelmeland[1]

1) Institute of Marine Research (IMR), Norway
2) Russian Federal Research Institute for Fishery and Oceanography (VNIRO), Russia
3) Polar Research Institute of Marine Fisheries and Oceanography (PINRO), Russia

Content:

Executive Summary

This is a report made by the Russian-Norwegian “Basic Document Working Group” (BDWG). There was not a particular meeting of the BDWG in 2005 and the current report has been made by correspondence. Harvest control rules for Northeast Arctic (NEA) Cod and Haddock, and work made in accordance to the working plan to provide a scientific assessment of optimal long-term yield of the most important commercial species in the Barents Sea, were discussed.

Northeast Arctic Cod

During 2005, the International Council for the Exploration of the Seas (ICES) has evaluated the harvest control rule for NEA cod amended by the Joint Norwegian-Russian Fishery Commission (The Commission) on the 33rd session in 2004. ICES states that the harvest control rule is consistent with the precautionary approach.

Northeast Arctic Haddock

ICES has not yet evaluated whether the harvest control rule for NEA Haddock is consistent with the precautionary approach. In accordance with the working plan the work on data revision for the stock is going on now and a special ICES Study Group on evaluation of the HCR and biological reference points for NEA haddock has been initiated. It is planned that the SG should take place in March 2006, and the results of the evaluation will be presented to ACFM in May 2006. The results of the HCR evaluation will be submitted to The Commission on its session in 2006. Until then, the traditional TAC advice based on F_{pa} is the current scientific advice for the stock.

Scientific assessment of optimal long term yield

A brief report on the research programme for estimation of long-term yield of marine organisms in the Barents Sea taking into account species interactions and effect of ecosystem factors is presented in section 4.

1. Introduction

According to point 12.2 in the protocol of the 30th session of the Commission it was agreement on the necessity to develop a "Basic document regarding the main principles and criteria for long term, sustainable management of living marine resources in the Barents- and Norwegian Seas" - and that this document should be regarded as a normative basis for a long term strategy for sustainable management of the most important joint fish stocks of the two nations. To develop this "Basic document" a working group of scientists from Russia and Norway was appointed.

The Basic Document Working Group (BDWG) submitted their report to the meeting of the 31st session of the Commission. The report formed a basis for discussions on the harvest control rule for cod and haddock which was decided at that meeting. The Parties agreed that the BDWG during the following year should illustrate how these decision rules would work. The working group prepared a progress report on the evaluation of the harvest control rule to the meeting of the 32nd session of the Commission.

At the 32nd session, the Commission confirmed that the joint stocks of NEA cod and haddock should be managed in accordance with the management strategies formulated at the 31st session of the Commission. In addition, the Commission agreed that BDWG should continue their evaluation of the management strategies.

In 2004 ICES evaluated the harvest control rule for Northeast Arctic cod and regarded the rule to be consistent with the precautionary approach, provided adequate measures to ensure rebuilding of the stock in cases when SSB falls below B_{pa}. Later in 2004 the BDWG met to discuss ICES' statements and proposed a number of possible options to amend the HCR for NEA cod for rebuilding situations. The BDWG-2004 report was submitted to the meeting of the 33rd session of the Commission.

At the 33rd session, the harvest control rule for Northeast Arctic cod was amended by including pre-agreed measures for a rebuilding situation. ICES was requested to consider if this amendment is satisfactory with regard to the precautionary approach.

Since the 33rd session of the Commission, BDWG has made intersessional work on preparation of evaluation of the harvest control rule for Northeast Arctic cod in ICES and to prepare this report. The report contains also a description of progress in the work on evaluation of the NEA haddock harvest control rule and in the work on scientific estimation of long term optimal yield from the important fish stocks in the Barents Sea.

2. Harvest control rule for NEA cod

2.1 ICES' evaluation of the harvest control rule for NEA cod

At its May 2005 meeting, ICES' advisory committee on fishery management (ACFM) has evaluated the harvest control rule for NEA cod.

The evaluation of the rule by ICES is given as Appendix A of this document. Based on this evaluation, ACFM gives the following comments in the annual report on NEA cod:

"Management plan evaluations

The decision rules proposed by the Commission in 2004 (JRNC-2004-rule) were evaluated using simulations that took account of variations in biological properties such as recruitment, weight, and maturity, as well as uncertainty in assessments. The results of that evaluation are presented in Section 1.4.3.1. A management plan based on these rules would be in agreement with the precautionary approach, provided that the SSB is above $\boldsymbol{B_{lim}}$*, and that the assessment uncertainty, assessment error and implementation error are not greater than those calculated from historic data and used in the evaluation."*

Based on the results of the evaluation using simulation model ICES states that for situations when SSB is below B_{lim}, the model may not capture the stock dynamic and ICES may therefore advise on a zero TAC in these situations.

The harvest control rule for NEA cod evaluated by ICES and found to be in accordance with the precautionary approach is shown in Figure 1. ICES states that although the rule allows for fishing when SSB is below B_{lim}, ICES may advice no fishing (F=0) in such situations.

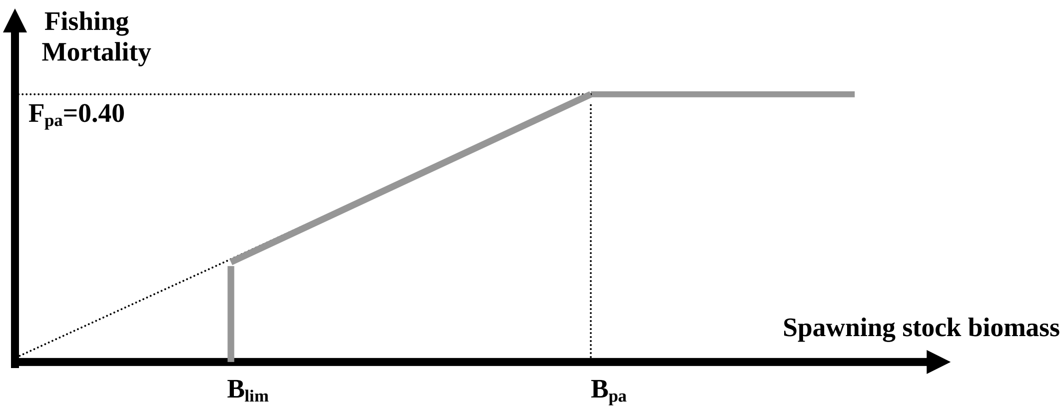

Figure 1 *Graphical representation of the ICES interpretation of the harvest control rule for cod to be consistent with the Precautionary Approach. For details, see Appendix A.*

The ICES also pointed out that the conclusions on the NEA cod harvest control rule "*are based on a risk level of 5%. They will hold also for higher risk levels. The risk level to use should be decided by managers. If a risk level lower than 5% is preferred, the harvest control rule should be evaluated against that level*."

2.2 Comments from the BDWG

The BDWG notes that during the process of testing the rule suggested by the Commission in 2004, it was noted that the definition of 'operational years' was inappropriate. The rule actually tested by ICES corresponds to the following wording in the Commission text: .. 'the operational years (current year and 3 years of prediction)…..' .

3. Harvest control rule for Northeast Arctic Haddock

The work of IMR and PINRO on revising historical data, revision of biological reference points, development of models and carrying out simulation runs in order to evaluate harvest control rule for NEA haddock is continued. This work is going in accordance with the plan adopted by the Commission in 2004.

Revised historical data on Northeast Arctic haddock will be presented at an ICES Study Group in March 2006, dedicated to this stock only. The reference points will be revised by this Study Group to prepare the evaluation of the suggested harvest control rule and alternative harvest control rules. The evaluation itself will be performed by the Arctic Fisheries Working Group in 2006. It is planned that the results will be presented to the attention of ACFM in May 2006 and to be submitted to The Commission on its session in 2006. (Update this if meeting date is agreed upon at ICES ASC).

ICES answer to the special request

The special request on comments upon aspects of the agreed experimental harvest rule for the North-East Arctic haddock stock and providing the catch options according to the experimental harvest control rule was sent to ICES after 33rd session of The Commission.

Answering to request the ICES states following:

"For Northeast Arctic haddock, ICES is requested to comment on aspects of the agreed harvest control rule in relation to the recruitment dynamics for the haddock stock. ICES has not yet evaluated the harvest control rule for that stock, but is prepared to provide such evaluation in 2006. This will be done using simulation studies similar to those provided for cod, taking into account the particularities of the dynamics of that stock. In particular, recruitment for this haddock stock has been sporadic, with the exception of recruitment for recent years which has been more stable. ICES observed that stocks exhibiting sporadic recruitment may need different measures to protect large year classes as they recruit to the fishery. Additionally, the retrospective pattern of this stock shows that the Northeast Arctic haddock assessment tends to overestimate stock size (and underestimate fishing mortality) to a significant degree in some years. These factors would need to be investigated through simulations mimicking the recruitment dynamics of this haddock stock, taking into account the assessment and implementation errors and biases."

In accordance with the request, ICES provided catch options for 2006 using the experimental harvest control rule but pointed out that because the evaluation of the rule is not finished, the traditional TAC recommendation based on F_{pa} was the current scientific advice for this stock.

4 Optimal long-term harvest in the Barents Sea Ecosystem

The work of IMR and PINRO on the joint Program for estimation of optimal long-term harvest in the Barents Sea Ecosystem adopted at the 33rd session of the Commission is started. The plan of work in 2005-2007 was made according to the Program. This plan includes estimation of long-term yield of NEA cod taking into account the effect of ecosystem factors. The objectives, tasks, expected results; methods of work and necessary data are defined for each of ten sub-projects. The leaders of sub-projects were appointed both at PINRO and at IMR. The joint plan of work on the project for the first three years (2005-2007) was discussed and adopted at the meeting of scientists from PINRO and IMR that was held in Archangelsk in March 2005. IMR designed a special website to publish information related to the work on this project. PINRO is accomplishing the design of a similar website. The work on these sub-projects is included in the national research plans of both institutions.

The estimation of maximum long-term yield of cod is performed with the single species model CodSim applying the PROST computer program. The results of this work were presented at the 11th Joint Russian-Norwegian Symposium that was held in Murmansk in August 2005. Based on the CodSim model the scientists have started to work on the design of the EcoCod model that by applying regression equations will incorporate the effects of ecosystem factors on cod stock dynamics. Based on a multispecies approach the scientists conducted work on improvement of the Bifrost and STOCOBAR models to evaluate harvest strategies for cod in the Barents Sea. Preliminary results of this work were also presented at the symposium in Murmansk.

With the framework of the joint project, IMR, with participants of scientists from PINRO, held a workshop in May on cod skipping spawning. In this workshop, the specialists exchanged viewpoints and results of research on year-to-year variations of development of cod gonads. Under conditions of insufficient capelin availability as prey species, the number of cod that skip spawning increases. During a joint meeting in April/May in Murmansk issues related to plankton investigations and the feeding of pelagic fish were discussed, with the aim of unifying laboratory and field methods. A meeting on the Norwegian side in Tromsø in October will address issues related to data on marine mammals and how knowledge of marine mammals can be incorporated into the multispecies models. During a joint meeting in Bergen in November the Russian model STOCOBAR will be implemented at IMR, and results from sub-projects will be made operational in the multispecies models, to the extent possible at present.

The annual report on joint work will be presented by the co-ordinators of the project in PINRO and IMR at the meeting of scientists in March 2006.

Appendix A: ACFM's evaluation of the harvest control rule for NEA cod

1.4 Assessment and Advice

1.4.1 Special requests

1.4.1.1 Long-term Management Advice on NEA cod and haddock (Norway)

The Joint Norwegian-Russian Fisheries Commission has requested ICES to:

"The harvest control rule for North-East Arctic Cod was evaluated by ICES in spring 2004. ICES regarded the harvest control rule to be consistent with the Precautionary Approach, provided adequate measures to ensure rebuilding of the stock in cases when SSB falls below B_{pa}.

At the meeting of the Joint Norwegian-Russian Fisheries Commission in October 2004, the harvest control rule was amended by including such pre-agreed measures for a rebuilding situation. ICES is requested to consider if this amendment is satisfactory with regard to the Precautionary Approach.

ICES is further requested to give advice on levels of catch and effort for 2006 consistent with the agreed amended harvest control rule for North-East Arctic Cod.

Finally we request assessment of the North-East Haddock stock, and comments upon aspects of the agreed experimental harvest rule in relation to the recruitment situation for this stock, and catch options according to the experimental harvest control rule and to an exploitation equal to F_{pa} *level."*

ICES comments

The evaluation of the amended harvest control rule is provided below. The advice on levels of catch and effort for 2006 consistent with the amended harvest control rule for North East Arctic cod and haddock is provided in Sections 1.5.1 and 1.5.3, respectively.

The amended harvest control rule (HCR) is as follows:

"The Parties agreed that the management strategies for cod and haddock should take into account the following:

conditions for high long-term yield from the stocks

achievement of year-to-year stability in TACs

full utilization of all available information on stock development

On this basis, the Parties determined the following decision rules for setting the annual fishing quota (TAC) for Northeast Arctic cod (NEA cod):

estimate the average TAC level for the coming 3 years based on F_{pa}. *TAC for the next year will be set to this level as a starting value for the 3-year period.*

the year after, the TAC calculation for the next 3 years is repeated based on the updated information about the stock development, however the TAC should not be changed by more than +/- 10% compared with the previous year's TAC.

if the spawning stock falls below B_{pa}, *the procedure for establishing TAC should be based on a fishing mortality that is linearly reduced from* F_{pa} *at* B_{pa}, *to F= 0 at SSB equal to zero. At SSB-levels below* B_{pa} *in any of the operational years (current year, a year before and 3 years of prediction) there should be no limitations on the year-to-year variations in TAC.*

The Parties agreed on similar decision rules for haddock, based on F_{pa} *and* B_{pa} *for haddock, and with a fluctuation in TAC from year to year of no more than +/-25% (due to larger stock fluctuations)."*

For Northeast Arctic cod, ICES evaluated the above decision rules through simulation studies, for details see the Technical Annex below. These studies indicate that a management plan based on these rules is in agreement with the Precautionary Approach, provided that SSB is above $\mathbf{B}_{lim}$ and that the assessment uncertainty and implementation error are not greater than those calculated from historical data. The decision rules seem to be effective in situations when SSB is close to $\mathbf{B}_{lim}$. The decision rules allow for fishing below $\mathbf{B}_{lim}$ and ICES may advise no fishing (F=0) in such situations.

For Northeast haddock, ICES is requested to comment on "*aspects of the agreed harvest control rule in relation to the recruitment dynamics for the haddock stock*". ICES has not yet evaluated the harvest control rule for that stock, but is prepared to provide such evaluation in 2006. This will be done using simulation studies similar to those provided for cod, taking into account the particularities of the dynamics of that stock. In particular, recruitment for this haddock stock has been sporadic, with the exception of recruitment for recent years which has been more stable. ICES observed that stocks exhibiting sporadic recruitment may need different measures to protect large year classes as they recruit to the fishery. Additionally, the retrospective pattern of this stock shows that the Northeast Arctic haddock assessment tends to overestimate stock size (and underestimate fishing mortality) to a significant degree in some years. These factors would need to be investigated through simulations mimicking the recruitment dynamics of this haddock stock, taking into account the assessment and implementation errors and biases.

The calculated catches and SSBs on the basis of the harvest control rule as amended are given in Sections 1.5.1 and 1.5.3.

Technical Annex to the response

For North-East Arctic cod, ICES evaluated the decision rules as amended at the meeting of the Joint Norwegian-Russian Fisheries Commission in October 2004.

In mathematical terms, the rule can be described in the following way:

Let y denote the year for which the quota is to be set. Let the term "3-year rule (F1, x)" denote applying the 3-year average rule described above with $\mathbf{F}_{5\text{-}10}$=F1 and an x % limit on year-to-year changes in TAC. The limit on increase of TAC from year to year could be set different from the limit on decrease from year to year, but such asymmetric rules were not tested. It is assumed that SSB(y) is not affected by F(y), which is in line with the current settings used by AFWG (the proportion of F and M before spawning is set to 0).

If SSB(y) > $\mathbf{B}_{pa}$ then
    if SSB(y-1) > $\mathbf{B}_{pa}$ and SSB(y+1) > $\mathbf{B}_{pa}$ and SSB(y+2) > $\mathbf{B}_{pa}$
        F(y) set by 3-year rule (0.40, 10%)
    else
        F(y) set by 3-year rule (0.40, unconstrained)
else
    F(y) set by 3-year rule (0.40 SSB(y) / $\mathbf{B}_{pa}$, unconstrained).

SSB(y+1) and SSB(y+2) in this calculation is derived using F=0.40 in years y and y+1.

The evaluation of HCRs for NEA cod has been done using simulation models. Important issues for the evaluation of harvest control rules are the choice of population model, inclusion of uncertainty in population model, the choice of initial values for simulations, the formulation of harvest control rules for use in the evaluation (constant F rules, how to reduce F when SSB<$\mathbf{B}_{pa}$, limit on year-to-year variation in catch, etc.), and performance measures for harvest control rules (yield, stock size, F, probability of SSB<$\mathbf{B}_{lim}$, annual variation in catches, etc.). This year's evaluation of the HCR takes into account the comments made by ICES in 2004 on the need to take assessment and implementation error and bias into consideration in the evaluation of harvest control rules.

Thus, in this evaluation, the assessment and implementation error and bias were modelled explicitly as percentages of stock overestimation and level of over-fishing. In particular, the simulations took into account the retrospective error observed historically (stock bias in the range of -9% to 30% depending upon ages, with CV ranging from 20% to 62%). The implementation error was based on the differences between the catch and quota for the 1987–2003 period (12% bias with a CV of 18%).

To evaluate the effect of the assessment and implementation errors, two situations were tested through long-term simulations using a fishing mortality of 0.4, i.e. without invoking HCR:

1) assuming a low natural mortality on ages 3 and 4 (M=0.2, Run 1)

2) assuming a high natural mortality on ages 3 and 4 (M+0.7 and 0.4, respectively, for Run 2).

Table 1.4.1.1 Results of long-term simulations

Run No.	Realised F	Catch	TSB	SSB	Recruits	% years SSB<$\mathbf{B}_{lim}$	% years SSB<$\mathbf{B}_{pa}$	Average year-to-year % change in TAC
1	0.61	921	3155	761	689	0.0	3.8	17
2	0.56	490	1895	452	689	0.1	48.5	22

In both runs, the realised F (when assessment and implementation errors have been taken into account) is around 0.6, but the total stock and the spawning stock are at a much higher level in Run 1, and consequently the catches taken are also much higher in this simulation. SSB falls below $\mathbf{B}_{lim}$ in 0.0 and 0.1% of the years for Runs 1 and 2, respectively. The proportion of years the SSB is below $\mathbf{B}_{pa}$ is also low for Run 1, while for Run 2 this happens in almost half of the years.

In addition, the performance of the amended rule was tested in a situation where stock rebuilding is needed. This testing of the JNRC-2004-rule was done using medium-term simulations of the NEA cod stock with initial levels below $\mathbf{B}_{pa}$. Two situations were simulated; one where the recruitment cycle was near its maximum during the years immediately following the start of the simulation (labelled "high recruitment" in tables), and one where the cycle was near its minimum (labelled "low recruitment"). In both cases an increased natural mortality on the youngest age groups (M_3=0.7, M_4=0.4) was assumed.

To study the performance of the rule in a stock recovery situation, simulations were started in 1985, when the total stock size was 957 000 tonnes and the SSB was 193 000 t, i.e. below $\mathbf{B}_{lim}$. The year 1985 was chosen because it was a year with a fairly low stock size, as well as a year when the stock was not dominated by a single year class. However, since the performance of the rule might be different in a situation where weak or strong year classes enter the stock in the beginning of the period, the runs made covered both these situations. Technically, because a cyclical recruitment function was applied, this was done by shifting the period of the cycle so that the start of the period either corresponded to a maximum or a minimum of the recruitment cycle.

The natural mortality for the two youngest age groups was set to 0.7 and 0.4, respectively, reflecting high cannibalism. This might seem unrealistic in a situation where the stock is at a low level or the recruitment level is low. However, this can be regarded as a worst-case scenario. The fishing pattern was set equal to the 1985 pattern. Uncertainty in initial stock size and future stock assessments was included in the same way as in the long-term simulations described above. In each case, 2000 simulations were performed.

The results of the simulations are given in the following tables.

Mean SSB (1000 tonnes) in 1986–1990 for different runs

Run no.	Mean SSB 1986	Mean SSB 1987	Mean SSB 1988	Mean SSB 1989	Mean SSB 1990
Low recruitment	173730	181096	453602	411426	485809
High recruitment	173357	176586	441973	446824	640728

Probability of SSB> B_{pa} in 1986–1990 for different runs

Run no.	P(SSB > B_{pa}) 1986	P(SSB > B_{pa}) 1987	P(SSB > B_{pa}) 1988	P(SSB > B_{pa}) 1989	P(SSB > B_{pa}) 1990
Low recruitment	0.00	0.00	0.44	0.19	0.58
High recruitment	0.00	0.00	0.35	0.40	0.94

Probability of SSB> B_{lim} in 1986–1990 for different runs

Model	P(SSB > B_{lim}) 1986	P(SSB > B_{lim}) 1987	P(SSB > B_{lim}) 1988	P(SSB > B_{lim}) 1989	P(SSB > B_{lim}) 1990
Low recruitment	0.00	0.01	1.00	1.00	1.00
High recruitment	0.00	0.00	1.00	1.00	1.00

Mean catches (1000 tonnes) in 1986–1990 for different runs

Model	Mean catch 1986	Mean catch 1987	Mean catch 1988	Mean catch 1989	Mean catch 1990
Low recruitment	119938	171849	356674	350897	372113
High recruitment	129442	185734	401360	417611	426942

Mean realized F values in 1986–1990 for different runs

Model	Mean F 1986	Mean F 1987	Mean F 1988	Mean F 1989	Mean F 1990
Low recruitment	0.39	0.38	0.67	0.62	0.60
High recruitment	0.43	0.42	0.69	0.61	0.57

For both situations (low and high recruitment), the probability of SSB being above $\mathbf{B_{lim}}$ is very low for the first two years. However, from the third year and onwards, both situations translate into a 100% probability of this happening. The probability for the SSB to be above $\mathbf{B_{pa}}$ is zero during the first two years, but then increases during the next three years. They are higher for the high-recruitment run, but vary somewhat with the varying strength of the incoming year classes

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These results are indicative of the trajectory of the stock in response to the application of the HCR, but the actual trajectory and time of response will depend on how far SSB is below $\mathbf{B_{lim}}$ and of the initial stock structure. However, in this region the model may not capture the stock dynamic and ICES may therefore advise on a zero TAC in these situations when SSB is below $\mathbf{B_{lim}}$.

It should be noted that the conclusions drawn here are based on a risk level of 5%. They will hold also for higher risk levels. The risk level to use should be decided by managers. If a risk level lower than 5% is preferred, the harvest control rule should be evaluated against that level.