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Report of the Basic Document Working Group (BDWG)

to the 36th Session of The Joint Norwegian-Russian Fishery Commission.

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on

Harvest Control Rule for Management of Fishery on North East Arctic Cod, North East Arctic Haddock, North East Arctic Saithe and Optimal Long Term Harvest in the Barents Sea Ecosystem

By:
K.Drevetnyak[1], Y.Kovalev[1], Y. Lepesevich[1], A. Filin[1],
S. Aanes[2], B. Bogstad[2], H. Gjøsæter[2], K. Korsbrekke[2], I.Røttingen[2], S.Tjelmeland[2]

1) Polar Research Institute of Marine Fisheries and Oceanography (PINRO), Russia
2) Institute of Marine Research (IMR), Norway

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 2007 and the current report has been made by correspondence. Additional evaluation of the Harvest control rules for Northeast Arctic (NEA) Cod with different levels of implementation error, review of work done on evaluation of Haddock Harvest control rules, results of evaluation of the Harvest control rules for Northeast Arctic Saithe, 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 considered.

Northeast Arctic Cod

ICES has made an additional evaluation the harvest control rule for NEA Cod taking into account the different levels of implementation error including the currently observed level. The present BDWG report gives the results from this evaluation. Based on these results ICES concluded that "*the agreed management plan has been found to be consistent with the precautionary approach and is therefore the basis for the advice*."

Northeast Arctic Haddock

ICES has reviewed the evaluation of the harvest control rule for NEA Haddock. During this review AFWG on its meeting in 2007 has decided:
"The 3-year-rule does not correspond to the precautionary approach as the level of risk to fish above F_{lim} is higher than 5%
...
One year rule is in correspondence with the precautionary approach if there no implementation error in stock management."

ACFM concluded that the 1-year rule is preferable compared to the 3-year rule. The BDWG advises the Commission to replace the 3-year rule with the 1-year rule.

Northeast Arctic Saithe

ICES has made an evaluation of the harvest control rule for NEA Saithe. The present BDWG report gives the results from the evaluation. Based on these results ICES concluded that "*The rule is considered consistent with the precautionary approach and shows only a very small risk of SSB falling below B_{lim}.*"

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 5.

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 specialists 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 2005 the harvest control rule for NEA cod, including measures for ensuring rebuilding of the stock in cases when SSB falls below Bpa was evaluated by ICES and found consistent with the precautionary approach to fisheries. At their 34th session, the joint Russian-Norwegian Fisheries commission agreed to set the TAC for NEA cod in accordance with the evaluated HCR.

In 2006 the ICES decided not to use the agreed HCR for recommendation of NEA cod TAC based on the fact that currently observed level of implementation error was higher than tested by ICES in HCR evaluation at 2005. In such a case the rule is not consistent with the precautionary approach to fisheries. The Basic Document Working Group during the AFWG-2007 meeting prepared an additional work on evaluation of the harvest control rule for NEA cod taking into account different levels of implementation error. The results of this evaluation were presented to ACFM.

In 2006 work has been carried out on the revision of historical data and on the evaluation of the agreed harvest control rule for NEA haddock. In 2007 ICES has reviewed this evaluation. The present BDWG report gives a summary of this work, and also recommends that modification of the HCR for NEA haddock, by replacing 3-year prediction with 1-year, is made by the 36th session of the Joint Russian-Norwegian Fisheries Commission.

In 2007 Norway has asked ICES to evaluate a proposal for a management strategy for Northeast Arctic saithe. This evaluation has been done by ICES and results of the evaluation are presented in this report.

The report contains also a description of progress in the work on scientific estimation of long term optimal yield from the important fish stocks in the Barents Sea.

2. Additional evaluation of the Harvest control rule for North East Arctic Cod

The HCR evaluation performed in 2005 found the HCR to be in agreement with the precautionary approach, provided that the assessment uncertainty, assessment error and implementation error are not greater than those calculated from historic data and used in the evaluation. It should be noted that an implementation error of 12% with a CV of 0.18 was used for all age groups in the testing of the HCR. In 2002-2006, the implementation error has been in the 20-35% range. Thus, the assumptions made in the evaluation may be violated.

The HCR evaluation from 2005 was re-run by AFWG in its meeting in 2007. Runs were made with 10%, 20%, 30%, 40% and 50% implementation error. The only setting which was changed was the CV of the implementation error which was set to 0. As in 2005, two sets of runs were made: With 'low' M on age 3 and 4 fish (M=0.2 for those age groups), and with 'high' M on age 3 and 4 fish (M=0.7 and 0.4, respectively). The high M levels are close to the highest M values calculated for these age groups in the period 1984-2006.

The results of the runs are given in the text table below. Catch and Biomasses in 1000 t.

Run No.	M	Error	Real. F	Catch	TSB	SSB	Recruits Age 3	% years SSB < Blim	% years SSB< Bpa	Average year-to-year % change in TAC
1	Low	10%	0.63	914	3140	749	690	0.001	4.0	11
2	Low	20%	0.73	916	2968	650	691	0.005	12.7	15
3	Low	30%	0.81	917	2821	573	690	0.05	24.2	21
4	Low	40%	0.86	919	2698	515	687	0.18	35.0	27
5	Low	50%	0.90	925	2606	476	686	0.48	43.3	34
6	High	10%	0.57	486	1894	451	687	0.11	48.7	17
7	High	20%	0.64	482	1794	395	682	0.69	62.9	23
8	High	30%	0.69	476	1709	355	674	2.4	71.0	29
9	High	40%	0.74	468	1633	325	660	5.7	75.2	34
10	High	50%	0.77	455	1556	300	640	10.6	77.5	37

A tentative conclusion is that the current levels of implementation error/IUU (according to Norwegian estimates) of around 30% are close to the level for which the agreed HCR no longer is precautionary, for a worst case scenario in terms of high mortality for age 3 and 4 cod.

The results of evaluation reviewed by ACFM and it was concluded that:

"Further evaluations made in 2007 concluded that the risk for SSB to drop below B_{lim} is low within a plausible range of conditions. Therefore, ICES considers the management plan to be in accordance with the precautionary approach.

If conditions change to outside the assumed range (with respect to biological conditions, assessment quality, or implementation error), the management plan may have to be revised. In particular, overfishing of the TACs derived from the management plan at levels that have been observed in the recent past is likely to lead to that situation."

3. Harvest control rule for Northeast Arctic Haddock

ICES has reviewed the evaluation of the harvest control rule for NEA Haddock made in 2006. During this review AFWG on its meeting in 2007 decided:
"The 3-year-rule does not correspond to the precautionary approach as the level of risk to fish above F_{lim} is higher than 5%
...
One year rule is in correspondence with the precautionary approach if there is no implementation error in stock management."

ACFM concluded that the 1-year rule is preferable compared to the 3-year rule.

The BDWG recommends that the Joint Russian-Norwegian Fisheries Commission at their 36th session, on the basis of the discussion in the BDWG reports 2006 and 2007, replace a 3-year rule with a 1-year rule. This suggests that the Joint Russian-Norwegian Fisheries Commission in the management of the NEA haddock should apply the following HCR:

- *TAC for the next year will be set at level corresponding to F_{pa}.*
- *The TAC should not be changed by more than +/- 25% compared with the previous year 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 and a year ahead) there should be no limitations on the year-to-year variations in TAC.*

ICES Advice on TAC for NEA haddock for 2008

Based on the assessment provided by AFWG-2007, the catch for 2008 should in accordance with the rule be less than 178 000 tonnes.

However, HCRs are not recommended by ICES for the management of NEA haddock in 2008. ICES stated in their 2007 report on the TAC level for 2008 the following:

"… the management plan was only in agreement with the precautionary approach in the absence of implementation error. Unreported landings have increased in recent years (2002-2006). When implementation errors of this order of magnitude are used

in the simulations, the agreed management plan is no longer in agreement with the precautionary approach."

"No stock assessment has been accepted since the revision of the catch data in 2006. This revision resulted in a substantially different perception of the stock dynamics."

Thus, due to the absence of a reliable assessment of stock status and high level of implementation error the advice from ICES on TAC for NEA Haddock for 2008 was not made on the basis of the agreed HCR but based on the other considerations:

"The recent increase in SSB (through the years 2001-2004) has been associated with catches less than 130 000 tonnes (including misreported catches). In the absence of a reliable assessment and since these catches appear to have led to an increase in the stock, ICES recommends keeping catches below this level."

The main reason why the haddock assessment was not accepted was that the trends in the stock abundance from the surveys and from the VPA are substantially different. This is illustrated in Fig. 1.

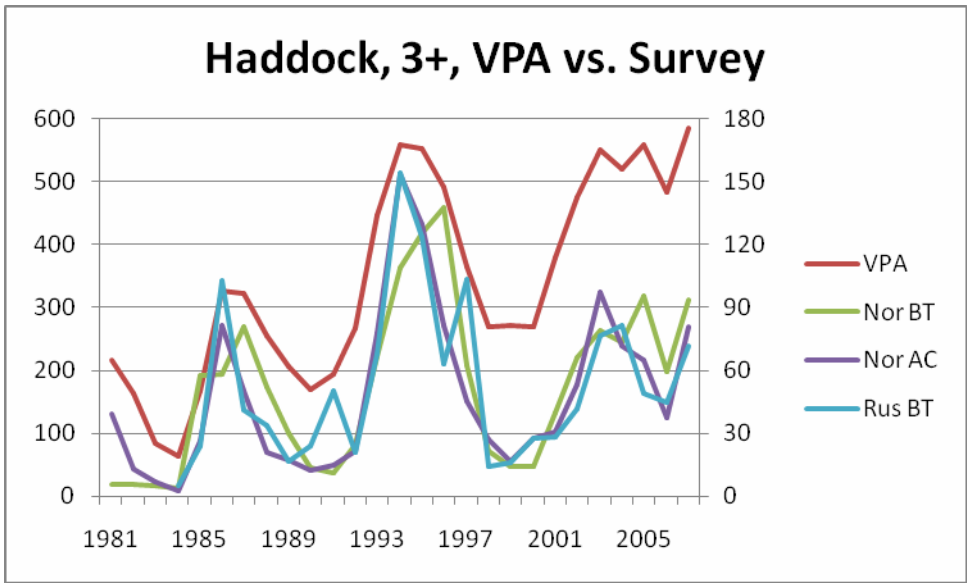

Fig. 1. Biomass of age 3 and older haddock (1000 tonnes), calculated from the VPA as well as from the survey indices. When calculating biomass from survey indices, the same weight at age as in VPA is used. VPA and Norwegian surveys are shown on the left axis, the Russian survey is shown on the right axis.

4. Harvest control rule for Northeast Arctic Saithe

Norway has asked ICES to evaluate a proposal for a management strategy for Northeast Arctic saithe:

"to evaluate whether the harvest control rule for setting the annual fishing quota (TAC) is consistent with the precautionary approach. The proposed harvest control rule contains the following elements:

- *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 +/- 15% compared with the previous year's TAC.*

- *If the spawning stock biomass (SSB) in the beginning of year for which the quota is set (first year of prediction), is below B_{pa}, the procedure for establishing TAC should be based on a fishing mortality that is linearly reduced from Fpa at SSB=B_{pa} to 0 at SSB equal to zero. At SSB-levels below Bpa in any of the operational years (current year and 3 years of prediction) there should be no limitations on the year-to-year variations in TAC."*

ICES concluded that the HCR is consistent with the precautionary approach for all simulated data and settings, including a rebuilding situation under the condition that the assessment uncertainty and error are not greater than those calculated from historic data. This also holds true when an implementation error (difference between TAC and catch) equal to the historic level of 3% is included.

The highest long-term yield was obtained for an exploitation level of 0.32, i.e. a little below the target F used in the HCR (F_{pa}), and ICES recommends using a lower value in the HCR. The HCR is expected to rebuild a depleted stock to a level above B_{lim} within three years.

Technical details of the evaluation of the harvest control rule are provided in the Appendix.

The advice on levels of catch and effort for 2008 is consistent with the harvest control rule for Northeast Arctic saithe provided in ICES advice.

5. 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 continues.

At the meeting in Svanhovd in September 2007, the work in the following subprojects was summarized: cod growth, recruitment, including fecundity and skipped spawning, and cannibalism. These subprojects have so far been the main ones. At the meeting in Svanhovd the approaches for implementation of regressions on cod growth rate and skipped spawning in the population models were agreed. Capelin abundance and temperature are identified as the main ecosystem factors that influence cod stock dynamics. During the first stage of the project these were the primary ecosystem

factors taken into account for estimation cod long-term yield. The inclusion in estimations of other ecosystem factors such as plankton, herring and marine mammals in estimations of long-term yield of cod will be realized in the next stage of the project.

During the first stage of the project, three models: **EcoCod**, **STOCOBAR** and **Bifrost** were developed as tools for estimation of long-term yield and optimization of the cod management strategies in the ecosystem aspect. The descriptions of these models are presented on the web-site of the project (www.assessment.imr.no/ Request/index.html). All of these models have both advantages and shortcomings. All models satisfactorily describe the necessary biological processes (growth, maturation, recruitment, cannibalism), however, they treat uncertainties to a different extent. In this respect **Bifrost** is the most advanced. It is planned to hold a joint meeting in February 2008 that will be devoted to testing the developed models and to estimating of reliability in calculations of maximum long-term yield for cod.

Two working meetings between the specialists from PINRO and IMR within the framework of the joint Programme of research were held in 2007(one in Murmansk and one in Svanhovd).

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 2008.

APPENDIX:

3.3.3 Special requests

3.3.3.1 Norwegian request for advice on Northeast Arctic saithe (Subareas I and II)

Norway has asked ICES to evaluate a proposal for a management strategy for Northeast Arctic saithe:

to evaluate whether the harvest control rule for setting the annual fishing quota (TAC) is consistent with the precautionary approach. The proposed harvest control rule contains the following elements:

- *Estimate the average TAC level for the coming 3 years based on Fpa, 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 +/- 15% compared with the previous year's TAC.*
- *If the spawning stock biomass (SSB) in the beginning of year for which the quota is set (first year of prediction), is below Bpa, the procedure for establishing TAC should be based on a fishing mortality that is linearly reduced from Fpa at SSB=Bpa to 0 at SSB equal to zero. At SSB-levels below Bpa in any of the operational years (current year and 3 years of prediction) there should be no limitations on the year-to-year variations in TAC.*

ICES comments

The evaluation of the harvest control rule is provided below. The advice on levels of catch and effort for 2008 consistent with the harvest control rule for Northeast Arctic saithe is provided in Section 3.4.4.

ICES concluded that the HCR is consistent with the precautionary approach for all simulated data and settings, including a rebuilding situation under the condition that the assessment uncertainty and error are not greater than those calculated from historic data. This also holds true when an implementation error (difference between TAC and catch) equal to the historic level of 3% is included.

The highest long-term yield was obtained for an exploitation level of 0.32, i.e. a little below the target F used in the HCR ($\mathbf{F}_{pa}$), and ICES recommends using a lower value in the HCR.

The HCR is expected to rebuild a depleted stock to a level above B_{lim} within three years.

Technical Annex to the ICES response

The evaluation of HCRs for Northeast Arctic saithe has been carried out 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.). The evaluation of the HCR takes the implementation error into account.

The model used for Northeast Arctic saithe was:

- A Beverton–Holt spawning stock–recruitment model with a log-normal error distribution.
- Assessment error and bias are estimated as age-dependent, normally distributed.
- Density-dependent weight-at-age in catch (average for 1981–2005 used for age groups where density-dependence was not found).
- Weight-at-age in stock is set equal to weight-at-age in catch.
- Time-series (1986–2005) average used for maturation-at-age without density-dependence.
- No uncertainty in weight-at-age, maturity-at-age, or natural mortality-at-age.
- Exploitation pattern: 1997–2005 averages used for all age groups in all years.

- Implementation of catch: First, the catch-at-age is calculated from the perceived stock using the fishing mortality derived from the harvest control rule and the given exploitation pattern. This catch-at-age is then applied to the actual stock.
- The implementation error and bias is estimated using the same percentage for all age groups.

Recruitment estimation

The recruitment dynamics show some relatively clear changes over time. A Beverton–Holt relationship with a log-normal error distribution was used for the long-term evaluations.

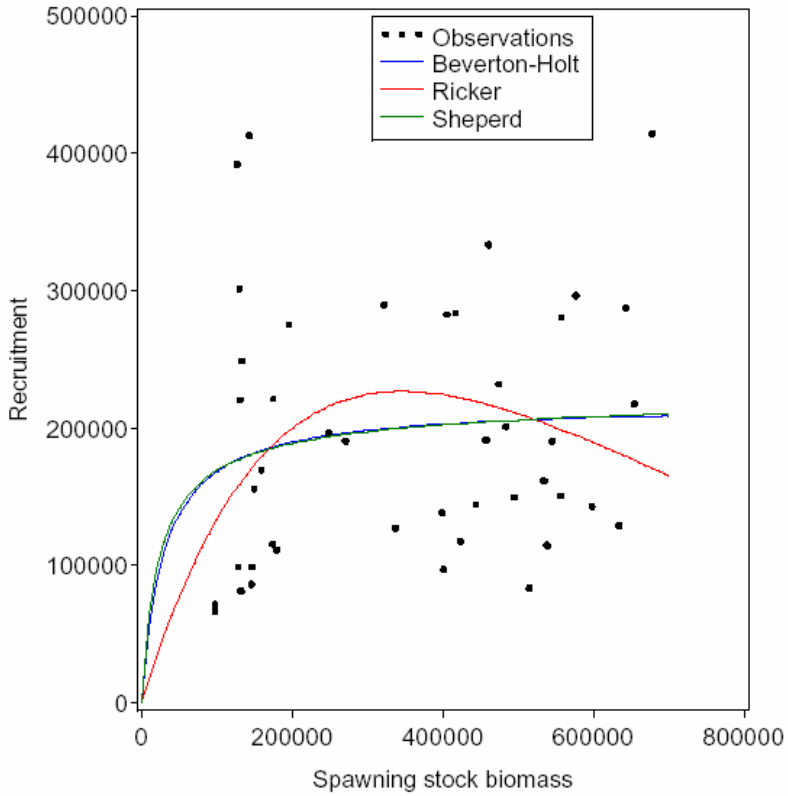

Figure 3.3.3.1.1 Spawning-Stock Recruitment (age 3) plot for Northeast Arctic saithe.

Reality check

The model was exposed to a reality check using $F_{4-7} = 0.38$ for all SSB levels, a 50% maximum year-to-year change in TAC, and three options for assessment error. $F_{4-7} = 0.38$ is equal to the average fishing mortality for the period 1960–2005. The runs indicate that the model performs reasonably well at this level of fishing mortality.

Scenarios

The various settings used in the long-term simulations are presented in Table 3.3.3.1.1 and the results of the simulations are described in Table 3.3.3.1.2. The starting point for these simulations is a stock in healthy condition.

To study the performance of the rule in a stock recovery situation runs were made starting in 1986 and ending in 1991; 1986 was chosen because it was a year when the stock size was fairly low. Settings for the recovery simulation runs are presented in Table 3.3.3.1.3 and the results of the simulations are described in Table 3.3.3.1.4.

Table 3.3.3.1.1 Settings for long-term simulation runs.

Run No.	F	3-year rule	Implementation error	Option for assessment error	Fishing pattern	Percent change in TAC	F below B_{pa}
1	0.35	No	No	1	97-05 av.	15	Flat
2	0.35	Yes	No	1	97-05 av.	15	Linear
3	0.35	Yes	Yes	1	97-05 av.	15	Linear
4	0.35	Yes	Yes	2	97-05 av.	15	Linear
5	0.35	Yes	Yes	3	97-05 av.	15	Linear
6	0.35	Yes	Yes	2	97-05 av.	10	Linear
7	0.35	Yes	Yes	3	97-05 av.	10	Linear
8	0.35	Yes	Yes	2	97-05 av.	20	Linear
9	0.35	Yes	Yes	3	97-05 av.	20	Linear
10	0.30	Yes	Yes	1	97-05 av.	15	Linear
11	0.30	Yes	Yes	2	97-05 av.	15	Linear
12	0.30	Yes	Yes	3	97-05 av.	15	Linear
13	0.25	Yes	Yes	1	97-05 av.	15	Linear
14	0.25	Yes	Yes	2	97-05 av.	15	Linear
15	0.25	Yes	Yes	3	97-05 av.	15	Linear
16	0.25	Yes	Yes	3	76-79 av.	15	Linear

Table 3.3.3.1.2 **R**esults of long-term simulations. Catch, TSB and SSB in 1000 tonnes, recruits in millions. The options for the error are 1: No assessment error, 2: assessment error estimates based on the period 1999–2005, i.e. underestimation of stock size, and 3: Opposite trend in assessment error.

Run No.	Option for assessment error	In-put F	Realised F	Catch	TSB	SSB	Recr.	% years SSB<B_{lim}	% years SSB<B_{pa}	Average year-to-year change in TAC
1	1	0.35	0.35	194	844	439	203	0	0	5
2	1	0.35	0.35	195	846	440	204	0	0	3
3	1	0.35	0.37	194	813	413	202	0	0.001	3
4	2	0.35	0.29	185	1015	602	209	0	0	10
5	3	0.35	0.48	193	703	317	195	0	3	8
6	2	0.35	0.29	184	1016	602	209	0	0	8
7	3	0.35	0.48	193	704	318	195	0.005	3	7
8	2	0.35	0.29	185	1017	603	210	0	0	11
9	3	0.35	0.48	193	702	317	195	0	3	9
10	1	0.30	0.32	196	917	499	206	0	0	3
11	2	0.30	0.25	181	1140	713	212	0	0	10
12	3	0.30	0.41	198	790	384	201	0	0.049	8
13	1	0.25	0.26	194	1044	609	210	0	0	3
14	2	0.25	0.21	174	1291	850	214	0	0	9
15	3	0.25	0.33	200	897	473	205	0	0	8
16	3	0.35	0.44	157	477	203	182	2.6	68	8

Table 3.3.3.1.3 Settings for recovery simulation runs. The options for the error are 1: No assessment error, 2: assessment error estimates based on the period 1999–2005, i.e. underestimation of stock size, and 3: Opposite trend in assessment error.

Run No.	F	3-year rule	Recruitment	Implementation error	Option for assessment error	Percent change in TAC	F below B_{pa}
1	0.35	Yes	Modelled	Yes	1	15	Linear
2	0.35	Yes	Modelled	Yes	3	15	Linear
3	0.35	Yes	Lowest obs.	Yes	3	15	Linear

Table 3.3.3.1.4 Results of simulations for 1986–1991. Catch, TSB, and SSB in 1000 tonnes, recruits in millions. The fishing mortality in 1986 is as assessed = 0.54.

Run No.	Input F	Mean Realised F 1987->1991	Range Mean Catch 1987->1991	SSB 1987->1991	Probability realisations with SSB<B_{lim} 1987->1991	Probability realisations SSB<B_{pa} 1987->1991
1	0.35	0.21->0.39	43->136	87->279	1->0	1->0.06
2	0.35	0.33->0.51	57->138	87->231	1->0	1->0.4
3	0.35	0.30->0.41	35->78	84->162	1->0.04	1->1

Results of the evaluation

Initial stock in healthy conditions

The rule is considered consistent with the precautionary approach and shows only a very small risk of SSB falling below B_{lim}.

Most of the results of the simulations are quite similar. Catches range from 157 000 to 200 000 tonnes, recruits from 182 to 214 millions, while the variations in estimated biomasses are larger, SSB ranges from 203 000 to 850 000 tonnes.

The historic implementation error (the difference between TAC and catch) is low (3% on average). Consequently, the result is not significantly different whether or not the implementation error is included.

The part of the HCR limiting the annual change in TAC to 15% is probably not too restrictive and large enough to maintain SSB above B_{lim} in practically all the simulated cases.

Initial stock depleted

The simulations indicate that management following the HCR can rebuild the stock to above B_{lim} within three years.

Source of information

ICES. 2007. Report of the Arctic Fisheries Working Group, 18–27 April 2007. ICES CM 2007/ACFM:16.