Report of the Basic Document Working Group to The Joint Norwegian-Russian Fishery Commission, autumn 2003.

Final, October 2003

Abstract

At its 31 Session, The Joint Norwegian-Russian Fishery Commission formulated management strategies for Northeast Arctic cod and haddock. ICES was informed about the strategies, and asked to give advice accordingly. However, this could not be done by ICES until a proper evaluation of the strategies had been performed, an evaluation which will not be ready this year.

Furthermore, The Commission made a request that the "Basic Document Working Group" should evaluate the management strategies. The value of such an evaluation was considered by the Basic Document Working Group to be limited value until ICES had evaluated the strategies.

This report provides the status of the work related to the evaluation of the management strategies for cod and haddock. The Group will ask that The Commission prolongs the mandate of the group to 2004.

1. Introduction

At the 31 Session of The Joint Norwegian-Russian Fishery Commission (hereafter referred to as the Commission) the following decision was made:

"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 utilisation 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) from 2004 and onwards:

- *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 basing 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 Parties should consider a lower TAC than the decision rules would imply.*

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

The Parties agreed that the working group, which worked out the " Basic Document regarding the main principles and criteria for long term, sustainable management of living marine resources in the Barents and Norwegian seas" during the following year should illustrate how these decision rules will work. The working group shall, in particular, evaluate what level of percentage change in TAC from year to year will be reasonable to utilise.[1]"

This report contains the work, which the Basic Document Working Group (BDWG) have done in response to the request made by the Commission. The list of participants of the BDWG meeting(s) is given in Appendix 1. The decision to work out the Basic Document regarding the main principles and criteria for long term, sustainable management of living marine resources in the Barents and Norwegian seas (hereafter referred to as "Basic Document") is referred to below. Thereafter, work done within the International Council for the Exploration of the Seas (ICES) during 2003 in response to request from the Parties is reported. Finally, the Working Group will present various kind of material to aid the Commission in its decision on management measures for cod and haddock for 2004.

2. Relevant decisions at the 30th session of the Commission (November 2001)

At the 30th session of the Commission, the Parties agreed to compose "Basic Document". A working group was appointed to draw up a report to be finished before the 31st session of the Commission (primo November 2002).

3. Management Objectives in the "Basic Document".

The BDWG finalised its report in September 2002. The report, as adopted by the Commission, is attached as Appendix 2 in this report from the group work. The following is a quotation related to the management objectives for the joint stocks in the Barents Sea:

"

(i) *to attain* ***high sustainable catches*** *from exploited stocks in the ecosystems of the Barents and Norwegian seas without decreasing their productivity.*

Important element within this objective

- *A value of total allowable catch (TAC) of each exploited stock should not worsen its reproduction. This value should follow annual variations in stocks.*

(ii) ***to keep exploited stocks within safe biological limits*** *while maintaining the biodiversity and productivity of marine ecosystems.*

Important elements within this objective

[1] This quotation is taken from point 5.1, in the Protocol of the 31 session of The Joint Norwegian Russian Fishery Commission and translated to English. For an accurate interpretation, please consult the text in the official languages of the Commission (Norwegian and Russian).

- *Exploited marine stocks should be considered as a component of marine ecosystems which are object to changes under the influence of both natural and man-induced factors.*

- *The ecosystem approach when establishing TAC for the exploited stocks considers the inter-species relationships, "predator-prey" relations, changes of climatic regime and others.*

(iii) *to ensure* ***sustainable development of fishing industry*** *while exploiting the stocks within safe biological limits;*

Important elements within this objective

- *Regulation of fishing fleet in the area. At present there is an overcapacity of fleet that cause the decrease of catch per unit of effort, decrease of profit and difficulties in the fishing industry with the corresponding social problems in the coastal regions.*

- *Within safe biological limits, harvest control rule should be established with the aim to reduce variations in TAC from year to year.*

(iv) *to attain* ***sustainable social development*** *of maritime regions.*

Important element within this objective

- *To further develop fisheries to contribute as an important industry in the national economy (source of food, export earnings) and to sustain work and income for the population in coastal communities.*

"

The report included a table, which in principle can be used to evaluate some consequences of various management decisions for the cod stock and cod fishery.

4. Relevant decisions at the 31st session of the Commission (November 2002)

At the 31st session of the Commission, the Parties accepted the "Basic Document" (given in Appendix 2), as an important basis for a sustainable management of the fisheries on shared stocks between the two countries. The Parties further asked the BDWG to continue their work as described in the introduction.

5. Work of relevance to NEA cod, within ICES

Within ICES, several processes with relevance to the management of NEA cod have taken place in 2003. One is related to a request to ICES from the Commission. Another is related to biological reference points. In addition to those is the usual assessment work and advisory duties of ICES.

5.1 Request to ICES

The Norwegian Ministry of Fisheries sent a letter to ICES (February 2003), requesting that the advice for TAC on cod and haddock should correspond to the following:

On this basis, the Parties determined the following decision rules for setting the annual fishing quota (TAC) for Northeast Arctic cod (NEA cod) from 2004 and onwards:

- *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 basing 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 Parties should consider a lower TAC than the decision rules would imply.*

Although the letter contained a request that ICES should give advice according to the decision rules established by the Commission, ICES was not asked to evaluate if the decision rules are in accordance with the precautionary approach (PA).

5.2 Biological reference points

To evaluate whether the existing biological reference points for Northeast Arctic cod should be modified, a Study Group established by ICES met in Svanhovd, Norway in January 2003 (ICES, 2003a). The Study Group proposed the following new reference points for Northeast Arctic cod: Blim=220 000t, Bpa=460 000t, Flim=0.74 and Fpa=0.40. ACFM accepted the proposed revisions in June, 2003.

5.3 ICES' Arctic Fisheries Working Group

The Arctic Fisheries Working Group met in San Sebastian, Spain, 23 April - 2 May 2003. Their assessment indicated a revision of some year classes. However, the assessment was based upon several indices, not all of which showed an upward trend. The working group made prognoses and possible catch options both the usual way and in accordance with the request (see point 5.1). (Source: ICES, 2003b)

5.4 The Advisory Committee on Fisheries Management (ACFM)

The ACFM report on NEA cod as of May 2003 and its answer to the request for advice made by the Commission (Section 3.1.10) follow as Appendix 3 to this report (ICES, 2003c). ACFM gave the advice that the TAC on NEA Cod should not exceed 398.000 tonnes, corresponding to a fishing mortality of Fpa=0,40. ACFM did not implement the decision rules proposed by Russia and Norway in its advice, but gave the following comment:

"The 2004 catches calculated by applying the harvest rule imply a fishing mortality above Fpa. However, the precautionary reference points as currently used by ICES are defined in the context of advising on an annual TAC based on a predicted catch based on a maximum F.

The objective of this Harvest Control Law is to have a low risk of falling below a Blim point. The proposed harvest control rule or modifications of it may actually secure a low probability of SSB dropping below a Blim point and hence be in accordance with the Precautionary Approach because the decision rule is different from that implied in calculating Fpa. Simulation studies are needed to reveal if this is the case. ICES is prepared to review and evaluate results of such studies. "

To summarize, ACFM states that the decision rules may be in accordance with the precautionary approach, but conclusions cannot be drawn at the moment. As a consequence, advice for 2004 will be given on the basis of the existing "Form of ICES advice", that is, on an annual assessment of Fpa.

6 Evaluation of the suggested harvest control rule

As mentioned in point 5.4, the decision rules suggested by the Commission will not be used as a basis for ACFM-advice until they are thoroughly evaluated. However, the suggested harvest control rules cannot be evaluated using existing software. Thus, IMR has decided to develop new software for medium-term simulations based on the approach outlined in Skagen et al. (2003). This work is in progress, and testing of the software started in September 2003. A thorough evaluation of the proposed harvest control rule will be time-consuming and could not be presented at the October 2003 ACFM meeting. It can be expected that ICES will take a similar approach to the evaluation as done for some flatfish stocks (see Appendix 4), and some of those results may be valid also for Northeast Arctic cod and haddock.

Below, a time schedule for such a thorough evaluation is suggested.

October- December 2003: Discussion on assumptions to be made on uncertainty/bias when testing harvest control rules (SSB-R relationship, uncertainty in weights, maturity and fishing pattern, assessment bias etc.). Discussion on which harvest control rules (F values, constraints on annual change etc.) should be tested. Use of new simulation software to evaluate the proposed harvest control rules.

December 2003/January 2004: Meeting (of BDWG??) where results are discussed and a first draft of the report on the evaluation of the harvest control rules is made.

January-March 2004: Work on report, by correspondence.

March 2004: During or in conjunction with annual meeting between PINRO and IMR scientists, the final report on the evaluation of the harvest control rules is adopted. The report is sent to ACFM.

April- May 2004: ICES AFWG. Performs medium-term simulation and gives advice in accordance with the report on the harvest control rules.

May 2004: Report evaluated by ACFM.

7 Discussion and conclusions

The Commission has asked the BDWG to evaluate the decision rules. However, the fact that ICES has not been in a position to evaluate the decision rules thoroughly, makes it difficult for the BDWG to do so. The BDWG finds that the appropriate procedure now is to contribute to the evaluation that ICES has been requested to perform. When that evaluation is made, it will be possible to ask ICES for options of the decision rules, including other limits on year-to-year variation in TAC. To answer the questions raised by the Commission, the mandate for the BDWG should therefore be prolonged to 2004.

At the 32nd session of the Commission, scheduled to early November 2003, the Commission will therefore have to make a choice between following the ICES advice on TAC for 2004 or follow their own decision rule when deciding on the TAC for 2004. Appendix 5 gives the consequences, as they have now been calculated, of various strategies.

First, a clarification concerning the constraint on the change in quota from one year to the next is needed. It is not entirely clear to ICES whether the constraint of a maximum change of 10% from year to year also applies to the setting of TAC for 2004. In the following, applying this constraint to the 2004 TAC (less than 10% different from the 2003 TAC) is denoted as Catch Rule 1, while not applying this constraint to the 2004 TAC is denoted as Catch Rule 2.

Furthermore, BDWG draws the Commission's attention to one remaining contradiction, which means that on one hand TAC should take into account year-to-year fluctuations in the stock, that for cod stock may be up to 50% between two successive years, and on the other hand a 10% limitation of year-to-year change in TAC. The last aspect implies a risk of both underfishing in the years with increase in the stock and overfishing in the years with decline in the stock.

In this respect it should also be noted that the principle of calculating a TAC for the next year derived from a stock prediction three years ahead in time is new to ICES. The position of F_{pa} reflects uncertainty attached with the existing stock assessment and short-term prediction, and this uncertainty will naturally increase in medium term forecasts. A proper assessment of uncertainty is one of the difficult tasks, which ICES will have to solve before an evaluation of the harvest control rule can be made.

List of Appendices

1. List of participants at the BDWG meeting(s)
2. Final version of the Basic Document (November 2002)
3. Section 3.1.10 of the ACFM advice, June, 2003
4. Similar studies for other stocks
5. Preliminary studies on the effects of the decision rules

References

ICES, 2003a: Report of the Study Group on Biological Reference Points for Northeast Arctic cod. Svanhovd, Norway 13-17 January 2003. ICES CM 2003/ACFM:11.

ICES, 2003b: Report of the Arctic Fisheries Working Group, 23 April – 2 May 2003. San Sebastian, Spain. ICES CM 2003/ACFM:22.

ICES, 2003c. Section 3.5.17 in Report of the ICES Advisory Committee of Fishery Management, 2002. ICES Cooperative Research Report No. 255.

Kell, L., Smith, M., Scott, R., Pastoors, M., van Beek, F., Hammond, T., and O'Brien, C.M. 2001. Analysis of possibilities of limiting the annual fluctuations in TACs. FISH-2000-02-01. CEFAS, Lowestoft, UK and RIVO, IJmuiden, The Netherlands.

Skagen, D. W., Bogstad, B., Sandberg, P., and Røttingen, I. 2003. Evaluation of candidate management plans, with reference to Northeast Arctic cod. ICES CM 2003/Y:03.

Appendix 1 List of participants at the BDWG meeting(s)

A. During the meeting in Bergen, 25 and 26 August 2003, the following specialists participated:

From Russia

Vladimir M. Borisov
Alexander Zelentsov
Yuri Kovalev
Konstantin V. Drevetnyak
Vladimir Shibanov
Sergei A. Sennikov (interpreter)

From Norway

Åsmund Bjordal
Sigmund Engesæter
Bjarte Bogstad
Per Sandberg

B. During the meeting in Talinn, 24 and 25 September 2003, the following specialists participated:

From Russia

Vladimir Borisov
Konstantin Drevetnyak

From Norway

Åsmund Bjordal
Per Sandberg

Appendix 2 Final version of the Basic Document (November 2002)

BASIC DOCUMENT REGARDING THE MAIN PRINCIPLES AND CRITERIA FOR LONG TERM, SUSTAINABLE MANAGEMENT OF LIVING MARINE RESOURCES IN THE BARENTS AND NORWEGIAN SEAS

1. INTRODUCTION

According to the decision made at the 30th Session of the Joint Russian-Norwegian Fisheries Commission on the development of a Basic Document Regarding the Main Principles and Criteria for Long Term, Sustainable Management of Living Marine Resources in the Barents and Norwegian Seas, the Parties

- referring to the United Nations Law of the Sea (1982) and The Agreement for the implementation of the provisions of the United Nations Convention on the Law of the Sea relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (1995), FAO Code of Conduct for Responsible Fisheries (1995), as well as to the other relevant agreements on the marine law,

- allowing for a long term cooperation and bilateral agreements in fisheries, in particular of the Russian-Norwegian Agreement on Cooperation in Fisheries of 11 April, 1975, as well as the Russian-Norwegian Agreement on Mutual Relations in Fisheries of 15 October, 1976,

- considering that a large part of living resources of the Norwegian and Barents seas are integral ecological complex exploited by both states,

- being committed to secure long-term conservation and sustainable exploitation of living marine resources, and to improve the co-operation with this aim,

- following the principles of responsible fisheries, management and understanding the necessity to avoid the negative influence on the marine environment, to conserve biological diversity, to sustain the integrity of marine ecosystems and to minimize the risk of long-term or irreversible consequences of fisheries,

- allowing for the necessity to develop the national fisheries and potential fisheries possibilities aimed at the full and rational exploitation of fish resources,

- considering the absence of common, clearly expressed principles and criteria of the sustainable long-term management of such resources,

- recognizing that stocks may vary due to both natural factors which cannot be regulated and to fisheries that can be regulated,

agreed to formulate common principles and criteria of sustainable long-term management of fisheries which can be used by managers of Russia and Norway when developing annual measures of regulation of fishery for jointly harvested stocks of the Barents and Norwegian Seas.

This document should be regarded as a tool to conduct a rational management of living marine resources in the Norwegian and Barents seas. It should however, be emphasized that the document could be improved further at the request of the Joint Russian-Norwegian Fisheries Commission.

2. TERMS AND DEFINITIONS

In this document there are terms referring to biology, fisheries economics and management which are in need of precisely and adequate definitions. Such definitions are needed to achieve a common understanding between scientists, managers and fishermen:

Cost of regulation: cost of research, elaboration and introduction of regulatory measures and corresponding monitoring, control and enforcement.

Ecosystem based fishery management*:* management of fisheries based on best available knowledge of the relevant exploited populations, with the aim to conduct the fishing operation in a way that creates the least possible negative effect on the ecosystem.

Harvest control rule: a set of parameters (fishing mortality, TAC, fishing effort etc) annually adopted by managers in order to implement a certain stock management strategy. Applied to fluctuating fish stock, a harvest control rule based on a constant fishing mortality will imply fluctuating levels of TAC whereas a harvest control rule based on TAC or catch ceilings or maximum deviations in catch from year to year will imply a higher degree of catch stability. The choice of harvest control rule will generally reflect a trade-off between important objectives.

Limit biological reference points: minimum level of spawning stock biomass (SSB) and maximum level of fishing mortality (F) that should not be crossed in order to apply the precautionary approach to fisheries management.

Population: a long existing ecologically separated group of individuals of one species where gene exchange within the group is predominant due to its reproductive isolation. In fisheries terms population normally means stock. Temporarily separated from one another groupings (by size, age, feeding grounds, gonad stages) which having reached maturity share a common spawning area, constitute just parts of a whole population.

Precautionary approach to fisheries management: exercise prudent foresight to avoid unacceptable or undesirable situations, taking into account that changes in fisheries are only slowly reversible, difficult to control, not well understood, and subject to change in the environment and human values.

Safe biological limits**:** reference points established by scientists after conducting retrospective analysis of the dynamics in a given fish stock (usually on the basis of SSB and F). Such

analysis makes it possible to assess the present and expected development of the stock and recommend specific catch levels. Safe biological limits implies a high probability that;

- SSB shall be above the level where the recruitment is impaired
- F shall be below a level where an increase of SSB to safe biological limits can be expected

Shared stocks: are stocks that occur within the exclusive zones of two or more coastal states.

Stock and recruitment: is the relationship between the size of the (parent) spawning stock and the number of recruits joining that stock in later years. The probability is that a depleted stock will produce fewer recruits than an abundant stock of the same species but in a number of cases this relationship does not clearly manifest itself. However, the stock-recruitment relationship serves a theoretical ground for elaboration and application of the principle of precautionary approach in the practice of fish stocks management.

Sustainable management: is the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such development conserves land, water, plant genetic resources, is environmentally non-grading, technologically appropriate, economically viable and socially acceptable.

3. PRINCIPLES AND SCIENTIFIC BASIS FOR MANAGEMENT DECISIONS

3.1 Management obligations

As a basis for the management for the shared stocks managers should:

a) base their work on scientific recommendations and advice from ICES and NEAFC. However, the managers could maintain their right to independent decisions, taking account of the socio-economic aspects and other relevant aspects prevailing for the two Parties.

b) follow the provision for a responsible fishery as expressed in the FAO Code of Conduct for Responsible Fisheries, as well as:

- ensure that fisheries management measures are based on the best scientific data available and directed to maintaining and rebuilding the stocks at or to the levels at which maximum sustainable yield can be assured;

- apply the Precautionary Approach;

- cooperate in developing common measures, which regulate exploitation of shared stocks, having regard to:

    - biological unity and other biological and ecological characteristics of a stock with regard to the specificity of structural elements of its distribution area and life cycle stages;
    - interplay between stock distribution, fisheries and geographic features of a region, including occurrence of the stock and intensity of its harvesting in areas under national jurisdiction;

- pre-agreed measures for management and conservation of the stock, adopted for and applied in the region in question;
- established biological allowable levels and structure of harvest.

3.2 Research activities as a basis for management decisions

A solid scientific basis is necessary for the management of the fisheries in the Norwegian and Barents Seas. Below is a list of necessary data in the field of biological research for stock assessment, catch statistics and bio-economic analysis of fishery and marketing.

In order to improve management advice given by ICES, the parties should co-operate to

a) Make available retrospective analyses, analyses of the actual situation and prognoses of every exploited fish stock and on the environmental situation in this area.

b) Acknowledge the understanding that research into the fields of ichthyology, hydrobiology and oceanography is not only important as such, but also because they are a basis for a broader understanding of processes in the ecosystems and within the economical, technological, social and political areas.

c) Monitor long-time series of the environmental conditions (continuation of investigation on dynamic of temperature on standard sections, current intensity, polar front, year and seasonal variations in the biomass of plankton and other prey organisms).

d) Continue and possibly expand investigation on recruiting year classes to the fish stocks.

e) Carry out systematic surveys by use of hydroacoustic and trawl methodology that cover the largest possible part of the total distribution area of the exploited stocks.

f) Conduct biological analyses, which include age reading, length and weight increases, composition of prey in stomachs and fat content, based both on scientific surveys and commercial catches.

g) Make analyses of catch efficiency and selectivity of different fishing gears and on analyses of time series of catch per unit effort.

h) Make analyses and develop effective technical measures for protecting fry and immature individuals of exploited stocks.

i) Improve the existing models and develop new ones that incorporate quantitative interrelations between stocks and between stocks and the environment.

j) Obtain reliable catch statistics and to find ways for quantifying discards, unreported catches and by-catches.

k) Carry out investigations to map the species composition of the ecosystems as a basis for biodiversity analyses.

l) Proceed with accumulation and analyses of national and joint reliable scientific information on biology, stock structure and interspecies relations.

m) Survey economic indicators of relevance to the economics in the fisheries, such as prices and harvesting costs. Account for historic and social values of fisheries for maritime regions.

4. MANAGEMENT OBJECTIVES

The FAO Code of Conduct for Responsible Fisheries formulates objectives to ensure effective conservation, management and development of living aquatic resources with due respect for the ecosystem and bio-diversity in order to provide, both for present and future generations, a vital source for food, employment, recreation, trade and economic well being for people. These objectives are agreed and universally accepted by all fishing nations.

However, the objectives given in the FAO Code of Conduct are often too general to be applied directly in practical management work. At the same time, both Norway and Russia have concrete objectives for their national fisheries policy.

Many of the current problems in managing the fish stocks are due to lack of, or more commonly, low precision of the management objectives. This basic document defines four management objectives that may be relevant to the shared stocks in the Barents and Norwegian Seas. The suggested management objectives are given below in a non-prioritised order:

(iv) to attain **high sustainable catches** from exploited stocks in the ecosystems of the Barents and Norwegian seas without decreasing their productivity.

Important element within this objective

- A value of total allowable catch (TAC) of each exploited stock should not worsen its reproduction. This value should follow annual variations in stocks.

(v) **to keep exploited stocks within safe biological limits** while maintaining the biodiversity and productivity of marine ecosystems.

Important elements within this objective

- Exploited marine stocks should be considered as a component of marine ecosystems which are object to changes under the influence of both natural and man-induced factors.

- The ecosystem approach when establishing TAC for the exploited stocks considers the inter-species relationships, "predator-prey" relations, changes of climatic regime and others.

(**iii)** to ensure **sustainable development of fishing industry** while exploiting the stocks within safe biological limits;

Important elements within this objective

- Regulation of fishing fleet in the area. At present there is an overcapacity of fleet that cause the decrease of catch per unit of effort, decrease of profit and difficulties in the fishing industry with the corresponding social problems in the coastal regions.

- Within safe biological limits, harvest control rule should be established with the aim to reduce variations in TAC from year to year.

(iv) to attain **sustainable social development** of maritime regions.

Important element within this objective

- To further develop fisheries to contribute as an important industry in the national economy (source of food, export earnings) and to sustain work and income for the population in coastal communities.

5. DECISION-MAKING CRITERIA

The main objectives for rational fishery management are to seek highest sustainable catches, to keep exploited stocks within safe biological limits, to ensure a sustainable development of fishing industry and a sustainable social development. This implies that the objectives shall attain highest possible yield and economic benefit on the one hand and on the other hand low risk of stock depletion. Since these objectives may be conflicting **in the short term**, managers are required to find a balance between conflicting interests.

The Joint Russian-Norwegian Fisheries Commission needs to apply a **long term strategy** which can lead to the fulfilment of the objectives given the highest priority.

Management objectives are often general and in reality difficult to measure. When evaluating a specific management strategy, there is therefore a need for some indicators, which can be measured and which could be said to represent the various objectives in a fairly accurate manner.

In the table below, some measurable indicators for each of the objectives stated above are suggested. The advantage of the indicators is that they present information available from annual stock assessments. These indicators are, however, not perfect, and in the future, there is clearly a need to replace some of them with more accurate indicators, a process, which first and foremost stresses the need for more knowledge and better prognoses.

The table is organised such that Column 1 gives certain levels of F and TAC and the remaining columns show how these perform according to the different objectives.

- To represent the objective **"to keep exploited stocks within safe biological limits"** focus is set on indicators showing expected development of the exploited stock in a medium-term perspective. Three indicators are chosen; the expected spawning stock biomass (SSB)

in a medium term perspective (Column 2), the probability that this SSB should fall below the reference point Bpa (Column 3) and the expected total stock biomass (TSB) in 2006 (Column 4).

- To represent the objective **"high sustainable catches"** an indicator showing the average level of the total allowable catch in a medium term perspective is suggested. This indicator is shown in Column 6.
- To represent the objectives **"sustainable development of fishing industry"** and **"sustainable social development"** two indicators are chosen. These are; the level of TAC next year (Column 5) and the difference between the highest and lowest TAC during the forecasted period (Column 7).

1	2	3	4	5	6	7
Harvest control rule (parameters)	SSB 2006	P(SSB<Bpa) 2006	SB 2006	TAC 2003	Average TAC and Sum of TAC (2003-2006)	Difference in TAC during 2003-2006 (max-min)
F = a						
F = b						
F = c						
F =a, and TAC<nn tonnes						
F = b, and TAC<nn+ tonnes						
Et cetera						

- Bpa = Precautionary level of spawning stock biomass
- P = probability
- SB = Stock Biomass
- SSB = Spawning stock biomass
- TAC = Total allowable catch (annual)

This table is applied to Northeast Arctic cod in Appendix A where the figures are taken from the Arctic Fisheries Working Group. 16-25 April 2002 (ICES CM 2002/ACFM:18).

APPENDIX A

EXAMPLE OF A "DECISION-MAKING" TABLE TO EVALUATE VARIOUS MANAGEMENT STRATEGIES FOR NORTHEAST ARCTIC COD

Taking account of our best knowledge concerning natural parameters like recruitment, growth and natural mortality, we may calculate how the cod stock is expected to develop as a consequence of the human factor – the fisheries.

The table below shows the result of such analysis. The chosen consequences focus on biological effects that may be of relevance in the decision-making process of the managers. In addition to these biological consequences, economic consequences in terms of prices and costs in the fisheries should (in the future) be included in the decision making table.

Table A1: Prognoses of consequences of applying various harvest regimes during 2003-2006

1	2	3	4	5	6	7
Harvest control rule (parameters)	SSB 2006	P(SSB<Bpa) 2006	SB 2006 (Ages 3+)	TAC 2003	AverageTAC and Sum of TAC (2003-2006)	Difference in TAC during 2003-2006 (max-min)
$F = F_{0.1} = 0.13$	**1501**	**0.00**	**2448**	**105**	**178 / 712**	**144**
$F = F_{pa} = 0.42$	**786**	**0.06**	**1593**	**304**	**371 / 1484**	**109**
$F = F_{2001} = 0.84$	**354**	**0.84**	**1027**	**528**	**462 / 1848**	**135**
Fixed TAC=420.000 t	**561**	**0.44**	**1310**	**420**	**420 / 1680**	**0**
Fixed TAC = 300.000 tonnes	**957**	**0.06**	**1811**	**300**	**300 / 1200**	**0**
F =0.42 and TAC<400.000 tonnes	**788**	**<0.06**	**1596**	**304**	**367 / 1468**	**96**
F =0.42 and Max change from year to year < 15%	**801**	**<0.06**	**1612**	**304**	**369 / 1476**	**115**
Reduce F at low SSB (to be specified)						
Et cetera						

Input data concerning natural parameters:

- Stock abundance at January 1, 2002, as calculated by ICES AFWG in 2002.

- Predictions of weight in catch and stock, maturity ogive, fishing pattern and natural mortality are from ICES AFWG in 2002.
- Recruitment at age 3 in 2002 - 2004 is the same as in the short term prediction in the 2002 AFWG report.
- Recruitment at age 3 in 2005 and 2006 is as in the medium term analysis in the 2002 AFWG report.
- The uncertainty of the stock estimate in 2002 and later years was modelled using a lognormal distribution with a standard error on log scale of 0.3 for all age groups. The errors in numbers at age are assumed not to be correlated.
- No uncertainty is put on the other input data to the prognosis, and the weight, maturation, fishing pattern, natural mortality and recruitment is not made dependent on cod stock abundance.
- 2000 simulations were performed for each harvest control rule.

Appendix 3 Section 3.1.10 of the ACFM advice, June, 2003

3.1.10 Answer to request from the Joint Norwegian-Russian Fisheries Commission on northeast Arctic cod and haddock

ICES has been asked to base its management advice for northeast Arctic cod and haddock for 2004 on the following procedures:

Within Article 5.1 in the protocol from the 31st session of the Joint Norwegian-Russian Fisheries Commission, Norway and Russia have agreed upon the following procedure for the annual fixing of TACs for northeast Arctic cod from 2004:

- *Estimate the average TAC level for the following three years based on $\boldsymbol{F}_{pa}$. TAC for the following year is set on the basis of this average TAC level;*

- *The following year the estimation of the TAC level for the next three years is repeated based on updated information on stock development. However, the revision of TAC cannot be more than ±10% of the TAC level for the preceding year;*

- *If the spawning stock biomass falls below $\boldsymbol{B}_{pa}$ the Parties must consider fixing a lower TAC than the TAC set according to this procedure.*

According to Article 5.1, Norway and Russia also agreed upon a similar procedure for northeast Arctic haddock, but then based on $\boldsymbol{F}_{pa}$ and $\boldsymbol{B}_{pa}$ for haddock, and with a possible revision of TAC from the preceding year of ±25% due to higher natural fluctuations in the stock.

ICES' Comments

ICES' interpretation of the harvest rule specified above, based on a literal understanding of it, is that the constraint on inter-annual variations of TACs becomes operational in the second year of implementation of the rule, *i.e.* as applying to the TAC in 2005 and subsequent years. This is subsequently referred to as harvest rule 1. However, it is also possible to interpret the rule to provide for a constraint on inter-annual TAC variations in its first year of operation, *i.e.* as first applying to the TAC in 2004, hereafter referred to as harvest rule 2.

ICES presents catch options on the basis of both interpretations, with a view to providing sufficient information to the Joint Norwegian-Russian Fisheries Commission to cover the original intent of its request. Moreover, ICES has based its findings on the revised values for precautionary reference points with regard to northeast Arctic cod, see Section 3.1.2.a. Although under review by ICES, there have as yet been no proposals made for revised precautionary reference points for northeast Arctic haddock. Consequently, ICES' response to the special request from the Joint Norwegian-Russian Fisheries Commission as it relates to haddock is based on the existing values of the reference points.

1) Northeast Arctic cod

The standard ICES short-term catch forecast was modified to provide predictions of yield and SSB for the relevant years, 2004-2006 to enable a three-year average yield to be calculated based on $\mathbf{F}_{pa} = 0.40$. The average yield for 2004-2006 is 486 000 t; under harvest rule 2, the expected yield in 2004 becomes 110% of the 2003 TAC, *i.e.* 435 000 t.

A catch option table with both sets of results is presented below. From this, it can be seen that both in relation to the former and the revised precautionary reference points proposed by ICES, neither result is considered by

ICES to be consistent with a precautionary approach to management, as F is above both 0.40 and 0.42. ICES has additionally provided its usual form of advice in its standard stock summary format (Section 3.1.2.a).

Catch forecast for 2004:

Northeast Arctic cod catch options for 2004 based on two interpretations of the Joint Norwegian-Russian Fisheries Commission harvest law.

Basis: F(2003) =F_{sq} =0.70; Catch = 578 000 t; SSB(2004) = 652 000 t.

F	Basis	Landings 2004	SSB 2005
0.44	Catch rule 2 (=0.63*$\mathbf{F}_{sq}$): =1.10*2003 TAC	435	830
0.50	Catch rule 1 (=0.73*$\mathbf{F}_{sq}$)	486	788

Weights in '000 t.
Shaded scenarios considered inconsistent with the precautionary approach.
Catch rule 1 corresponds to ICES's interpretation of the new harvesting strategy in the first year of its operation.
Catch rule 2 corresponds to an application of the ±10% constraint in the first year of the new harvesting strategy.
W:\Acfm\Acfmwg\2003\May\Afwg\NEA Cod And Haddock Request.Doc 68
2) Northeast Arctic haddock

As with northeast Arctic cod, the standard ICES short-term catch forecast was modified to provide predictions of yield and SSB for the relevant years, 2004-2006 to enable a three-year average yield to be calculated based on a F_{pa} fishing mortality of 0.35. The average yield for 2004-2006 is 130 000 t. However, under harvest rule 2, the expected yield in 2004 becomes 125% of the 2003 TAC, i.e. 126 000 t.

A catch option table with both sets of results is presented below which shows that neither of the harvest rules is considered by ICES to be consistent with a precautionary approach to management. ICES has provided its usual form of advice in its standard stock summary format (Section 3.1.3).
Catch forecast for 2004:

Northeast Arctic haddock catch options for 2004 based on two interpretations of the Joint Norwegian-Russian Fisheries Commission harvest law.

Basis: F(2003)=F_{sq} = F(00-02) =0.48 ; landings =140 000 t ; SSB(2004) =133 000 t.

F (2004)	Basis	Landings (2004)	SSB (2005)
0.37	Catch rule 2 (=0.77*F_{sq}): 1.25*2003 TAC	126	146
0.38	Catch rule 1 (=0.795*F_{sq})	130	144

Weights in '000 t.
Shaded scenarios considered inconsistent with the precautionary approach.
Catch rule 1 corresponds to ICES's interpretation of the new harvesting strategy in the first year of its operation.
Catch rule 2 corresponds to an application of the ±25 % constraint in the first year of the new harvesting strategy.
Special Comment

On the basis of the proposed precautionary reference points ICES has:

1. calculated the expected yield under harvest rule 1 and harvest rule 2, and
2. concluded that the catch options for 2004 corresponding to either of these harvest rules do not conform to its interpretation of the precautionary approach.

The target fishing mortality and target SSB (in the harvest control rule called B_{pa} and F_{pa}) applied in the JNRFC harvest control rule should in conformity with the definition of the ICES precautionary reference points be set such that SSB will remain above B_{lim} with high probability.

ICES precautionary reference points were calculated with reference to a two-years-ahead catch forecast, assuming status quo fishing mortality in the intermediate year. Consequently, ICES values of F_{pa} and B_{pa} may not be the appropriate values to apply in a harvest rule that is based on a four-years-ahead catch forecast with averaging of the expected yield and constraints on the permissible inter-annual variation of TACs. Neither may ICES' F_{pa} be the appropriate value with which to calculate the forecast yields under the Joint Norwegian-Russian Fisheries Commission's harvest rule. Consequently, appropriate values of both the fishing mortality and reference SSB that are pertinent to the harvest control rule need to be calculated.

ICES revised its precautionary reference points for northeast Arctic cod. For the northeast Arctic haddock stock the ICES precautionary reference points are under evaluation. As a prerequisite to an evaluation of the appropriate targets to be used in the JNRFC harvest control rule, ICES needs to consider whether revised limit reference points should be adopted for this stock.

The Joint Norwegian-Russian Fisheries Commission should therefore be aware that for northeast Arctic cod, ICES has calculated the expected yields and conformity of the harvest rule to a precautionary approach according to precautionary reference values that may not be fully appropriate.

The 2004 catches calculated by applying the harvest rule imply a fishing mortality above F_{pa}. The objective of this harvest control rule is to have a low risk of SSB dropping below a B_{lim} point. The proposed harvest control rule or modifications of it may actually secure a low probability of SSB dropping below a B_{lim} point and hence be in accordance with the Precautionary Approach because the decision rule is different from that implied in calculating F_{pa}. The inertia of the catch rule will occasionally generate high fishing mortalities in periods with low recruitment and a sufficient stock buffer must be built to guard against stock depletion on such occasions. Simulation studies are needed to reveal if this is the case. ICES is prepared to review and evaluate results of such studies.

In 2003 a Norwegian-Russian working group will consider whether the percentages set for the annual revisions of TAC for northeast Arctic cod and haddock are the most appropriate. ICES notes that this may also provide a suitable forum for experts to review the haddock limit reference points and to calculate suitable precautionary reference points for both cod and haddock.

Appendix 4 Similar studies for other stocks

For 7 flatfish stocks in the North Sea, Skagerrak and the Irish Sea, CEFAS (Lowestoft, UK) and RIVO (IJmuiden, The Netherlands) have carried out an analysis of possibilities of limiting the annual fluctuations in TAC (Kell et al., 2001). In this analysis harvest control rules consisting of fixed F strategies with limitations on annual changes in TACs were considered. Thus, this work is of relevance to evaluation of the proposed harvest control rule for Northeast Arctic cod and haddock, although that rule also contains the additional feature of the '3-year-average' procedure.

The European Commission asked ICES to review the scientific, statistical, biological and technical basis for the results given in Kell et al. (2001). Further, ICES was asked to evaluate given harvest control rules consisting of fixed F strategies with limitations on annual changes in TACs, for 6 of these 7 stocks. This evaluation was done by ACFM in 2002 (ICES, 2003).

ACFM found the results to be reliable for providing management advice with some provisions. Because not all sources of bias and uncertainty were simulated and risk and bias may be underestimated, ACFM concluded that the results reported by Kell et al. (2001) should be interpreted with care and that conclusions should be based on comparative patterns rather than on absolute estimates of probability and risk.

In general, ACFM observed a non-linear relationship between risk of SSB being reduced to less than B_{pa} and the magnitude of TAC constraints. In most short- and medium-term simulations, a TAC constraint of 10% had substantially greater risk than a 20% constraint, but the difference in risk from 20% to 40% constraints was much less. It was also clear that the current state of the stock also had an important effect of the results. For stocks below B_{pa}, imposing a restrictive constraint on the TAC delayed recovery and thus led to an increased risk to the stock. Conversely, for stocks above B_{pa}, such a TAC constraint served to reduce the risk to the stock. For several stocks, the projections indicated a clear optimum target F for minimising risk and maximizing yield in the medium or long term.

It should be noted that the recruitment variability for Northeast Arctic cod and haddock is much greater than for the flatfish stocks evaluated by Kell et al. (2001), and thus the results obtained for those flatfish stocks may not be valid for Northeast Arctic cod and haddock.

Appendix 5 Preliminary studies on the effect of the decision rules for Northeast Arctic cod

Prognoses of consequences of decision rules for Northeast Arctic Cod during 2004-2006

1	2	3	4	5	6	7
Harvest control rule (parameters)	SSB 2007	P(SSB<B pa) 2007	SB 2007 (Ages 3+)	TAC 2004	Average TAC and Catch each year (2004-2006)	Difference in TAC during 2004-2006 (max-min)
F = 0.25	**1548**	**< 5%**	**3011**	**265**	**361(265-366-452)**	**187**
F = F_{pa} = 0.40	**1136**	**< 5%**	**2497**	**400**	**486(400-498-560)**	**160**
F = 0.70	**661**	**14%**	**1865**	**629**	**634(629-646-627)**	**19**
Catch rule 1: 10%> 2003 TAC	**1141**	**N/A**	**2507**	**435**	**480(435-479-527)**	**92**
Catch rule 1: 15%> 2003 TAC	**1024**	**N/A**	**2353**	**454**	**519(454-522-582)**	**128**
Catch rule 1: 20%> 2003 TAC	**997**	**N/A**	**2319**	**474**	**527(474-534-572)**	**98**
Catch rule 2, 10% year-to-year change	**989**	**N/A**	**2310**	**486**	**528(486-530-569)**	**83**
Catch rule 2, 20% year-to-year change	**989**	**N/A**	**2310**	**486**	**528(486-530-569)**	**83**

Catch rule 1: F_{pa}, with '3-year-average' rule, constraint (e.g. 10%) on percentage change in TAC from year to year, effective from 2004 onwards (i. e. 2004 TAC constrained by 2003 TAC).

Catch rule 2: F_{pa}, with '3-year-average' rule, constraint (e.g. 10%) on percentage change in TAC from year to year, effective from 2005 onwards (i. e. 2004 TAC **not** constrained by 2003 TAC).

For **Catch rule 1**, it is seen that increasing the constraint on maximum percentage change in TAC from 10% to 20% would increase the catches in 2004-2006. A 20% constraint would have approximately the same effect as no constraint in the present situation.

For **Catch rule 2**, it is seen that the 10% or a 20% constraint does not affect the TAC in 2005 and 2006, and thus increasing this percentage will not affect these deterministic predictions.

Before new software is developed, the risk associated with catch rules 1 and 2 cannot be calculated.

Input data to predictions

- Stock abundance at January 1, 2003, as calculated by ICES AFWG in 2003. 2003 catch=578 000 t (Fsq=0.70).
- Predictions of weight in catch and stock, maturity ogive, fishing pattern and natural mortality are from ICES AFWG in 2003.
- Recruitment at age 3 in 2003 - 2005 is the same as in the short term prediction in the 2003 AFWG report.
- Recruitment at age 3 in 2006 and 2007 is as in the medium term analysis in the 2003 AFWG report.
- The uncertainty of the stock estimate in 2003 and later years was modelled using a lognormal distribution with a standard error on log scale of 0.3 for all age groups. The errors in numbers at age are assumed not to be correlated.
- No uncertainty is put on the other input data to the prognosis, and the weight, maturation, fishing pattern, natural mortality and recruitment is not made dependent on cod stock abundance.
- 2000 simulations were performed for each harvest control rule.