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Northwest Atlantic Fisheries Organization

Report of the Fisheries Commission and Scientific Council Joint Working Group on Risk-Based Management Strategies

5-7 February 2014
Halifax, Nova Scotia, Canada

NAFO
Dartmouth, Nova Scotia, Canada
2014

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1. Opening

The working group (WG) met at the Prince George Hotel, Halifax, Canada, during 5-7 February 2012. The meeting was attended by representatives from Canada, EU, Japan, Norway, the Russian Federation and the United States of America, as well as from the Scientific Council (SC). The NAFO Executive Secretary, Fisheries Commission (FC) Coordinator and Scientific Council (SC) Coordinator were in attendance. Observers from World Wildlife Fund and Dalhousie Univeristy were present. The meeting was co-chaired by Carsten Hvingel (Norway) and Kevin Anderson (Canada) (Annex 1).

The chairs opened the meeting at 10:00 hrs on Wednesday, 5 February.

2. Appointment of Rapporteur

With the agreement of the WG, the FC Coordinator, Ricardo Federizon, and SC Coordinator, Neil Campbell, were appointed as joint rapporteurs.

3. Adoption of Agenda

A proposal was made to add Div. 3L Shrimp to item 7c of the agenda. This was accepted and the agenda adopted otherwise as previously circulated (Annex 2).

4. Review of Terms of Reference

The terms of reference of the WG as documented in FC Doc 13/18 were reviewed. The WG considered membership, work form, reporting procedures, observers and future meetings. The chairs informed participants that at the suggestion of SC if the WG breaks from plenary session and reverts to delegation for the purpose of drafting recommendations, individual scientists would remain as part of their delegations and SC as a whole would be represented by the SC Chair or a designated alternate.

5. Review and Update of the Precautionary Approach Framework

The NAFO Precautionary Approach Framework (PAF) was reviewed (FC Doc 04/18). The WG received a presentation from Bill Brodie (Canada) on the history and development of the NAFO Precautionary Approach Framework (PAF) (Annex 3). As a matter for consideration in revising the PAF, the co-chair Carsten Hvingel (Norway) introduced a paper (FCSC RBMS WP 14/1) and made an accompanying presentation outlining the current scope of the PAF, highlighting discrepancies surrounding risk-based assessment of stocks and the inconsistency in treatment of target and limit reference points for biomass and fishing mortality under the current system (Annex 4).

It was emphasised that the PAF forms the basis of risk based management strategies and for this reason it is important to ensure the PAF and the General Framework for Risk Based Management Strategies are well aligned.

It was further recognized that application of PAF is dependent on the existence of reference points and, the importance of SC in determining the reference points for all stocks was underscored.

To initiate the revision of the PAF, it was determined that feedback from the SC is needed particularly regarding the relevance and implications of having F_{lim} at F_{msy} and F_{msy} as a target, and the utility of buffer reference points (see item 9).

The risk values highlighted in the current PAF were discussed. The WG agreed that the noted percentages were not to be interpreted as prescriptive values/ ranges but rather directional amounts. It was also agreed that FC retains flexibility to specify acceptable levels of risk and that the degree of risk tolerance may be context specific.

6. Review and Update of existing interim Conservation Plans and Management Strategies

a) Div. 3NO Cod

A review of the interim 3NO Cod Conservation Plan and Rebuilding Strategy (CPRS), which is embodied in Articles 7.6 – 7.11 of the NAFO Conservation and Enforcement Measures, was conducted. In the absence of B_{msy} reference point, it was proposed that: an interim B_{target} = 185 000 t and an interim F_{target} of $F_{0.1}$ = 0.19 be considered. Annex 5 reflects the revisions and represents the updated CPRS to be forwarded to FC with a recommendation for adoption (See item 9).

b) Div. 3LNO American Plaice

There were no changes proposed to the existing CPRS.

7. Follow-up to WGFMS-CPRS 2013 Recommendations

a) Evaluation and finalization of General Framework on Risk-based Management

In 2013, the FC adopted the *General Framework on Risk-based Management Strategies.* However, the section *Closing of Directed Fishing* still needed to be elaborated. The WG evaluated and finalized the *General Framework* by removing the brackets in the section and replace the word "fishery" with "stock". Annex 6 reflects the revision. It will be forwarded to FC with a recommendation for adoption (see item 9).

b) Discussion on development of alternative strategies for stocks that may not be suited to formulaic rules and/or for stocks where reference points do not exist or cannot be developed.

Alternative strategies would not be needed if robust reference points are determined. At its June 2013 meeting, SC indicated that reference points can theoretically be constructed for all stocks and that this work is given high priority. The WG agreed to recommend SC provide a status report and possible timeliness for this work for consideration of FC in September 2014 (see item 9).

It was noted that further discussion on alternate strategies for specific stocks may be required if SC's review determines that robust reference points are not likely to be established in a reasonable period of time.

c) Development of CPRS

The process towards management strategies for priority stocks was initiated. Draft plans for 3M cod and 3LN redfish were developed based on the *General Framework on Risk-based Management Strategies*. It was noted that the drafts plans (Annexes 7 and 8) represent a first step and may need further elaboration and adjustment once feedback is received from SC and FC. It was also noted that while a framework is in place to guide development of management strategies, the strategies themselves are stock-specific and no single strategy is likely to be appropriate for all stocks.

There was concern expressed by some CPs on the use of F_{msy} (or its proxy) as a target versus a limit as well as consideration of consequences of fishing above this level.

i. Div. 3NO witch flounder

There was no progress to report on the development of a risk-based management strategy for this stock. The importance of the upcoming stock assessment, in particular, efforts to develop a limit reference point was noted.

ii. Div. 3LN redfish

The WG initiated the development of a risk-based management strategy for 3LN redfish (Annex 7). As noted in the preamble, NAFO identified the development of a risk-based strategy for 3LN redfish as a priority in 2012, and reaffirmed that priority in 2013. As next steps, the WG requests SC to evaluate the management strategy relative to the performance statistics prior to the 2014 NAFO Annual Meeting, and to comment on likely by-catch levels associated with the implementation of the proposed Harvest Control Rule (HCR) for this stock (see item 9).

iii. Div. 3M cod

The WG initiated the development of a risk-based management strategy for 3M Cod (Annex 8). As noted in the *Background,* NAFO identified the development of a risk-based management strategy for Cod in Div. 3M as a priority in 2012, and reaffirmed that priority in 2013. As next step, the WG recommends SC to discuss selection of operating models and evaluate the 3M Cod management strategy prior to the 2015 Annual Meeting (see item 9).

iv. Div. 3L shrimp

Recognizing that this stock is currently thought to be near B_{lim}, the WG agreed to give further consideration to development of a management strategy, subject to the outcome of the 2014 stock assessment, and requested that the item be retained on the agenda for future meetings.

8. Approach and workplan to review the Greenland Halibut Management Strategy Evaluation in 2017

In order to provide the Fisheries Commission with the opportunity to approve the review of the Greenland halibut MSE during its 2017 September meeting, the following work plan was proposed:

1. Until 2016 Scientific Council will continue to evaluate the harvest control rule based on the primary indicators (catches and surveys indices).
2. During its 2016 June meeting Scientific Council should update two assessment models, one XSA based and one SCAA based, and evaluate the development of the stock since the introduction of the MSE.
3. FC/SC WGRBMS should review the results before September 2016 and determine the next steps.
4. In advance of the 2017 Annual Meeting, the working group will develop recommendations on the way forward.

Noting the priority given to this stock by the *ad hoc* FC-SC Working Group on Catch Reporting it is expected that catch estimates will be available to carry out the MSE review.

9. Recommendations to forward to FC and SC

1. In order for the WG to start the process of revising the PA framework the WG **recommends** SC provide feedback on the following*:*
   - Discuss the relevance and implications of:
   - having F_{lim} at F_{msy}
   - F_{msy} as a target

     These analyses should include situations where quantitative analysis of uncertainty are limited and situations where uncertainty has been well incorporated into evaluation of Harvest Control Rules.

- Consider the utility of buffers (particularly B_{buf}) in the framework and in management plans and provide advice on whether the use of buffers is considered appropriate for stocks which have B_{lim}.
  Note: the WG **recommends** that B_{isr} is not considered part of the PA (but may be used as an interim milestone to aid decision making).

- The working group noted that SC, in its 2013 June report, concluded that reference points can theoretically be constructed for all stocks, and that this work is given high priority. The WG recommends SC provide a status report and possible timelines for this work for consideration of Fisheries Commission in September 2014.
- In its assessments and advisory sheets, the working group **recommends** Scientific Council provide a table or list of reference points available for each stock that includes information on their derivation, and if reference points are missing, explain why.

2. The WG **recommends** FC adopt amendments to the interim management plan for Div. 3NO Cod (Annex 5).
3. The WG **recommends** FC adopt amendments to the General Framework on Risk Based management (Annex 6).
4. The WG **recommends** SC discuss selection of operating models and evaluate the Div. 3LN Redfish management strategy relative to the performance statistics prior to the 2014 Annual Meeting (Annex 7).
5. The WG **recommends** SC comment on likely by-catch levels associated with the implementation of the proposed HCR for 3LN Redfish (Annex 7)
6. The WG **recommends** SC to discuss selection of operating models and evaluate the Div. 3M Cod management strategy prior to the 2015 Annual Meeting (Annex 8)

10. Other Matters

There were no other matters raised.

11. Adoption of the Report

The report was adopted by correspondence following the meeting.

12. Adjournment

The meeting adjourned at 1030 hrs on 7 February. The chairs thanked the secretariat for their support and the participants for their cooperation and input. The participants in turn voiced their thanks to the chairs for their leadership.

Annex 1. List of Participants

WORKING GROUP CO-CHAIRS

Anderson, Kevin, A/Regional Director, Fish Management, Fisheries and Oceans Canada, P. O. Box 5667, St. John's, Newfoundland A1C 5X1
Phone: +709 772 4543 – Fax: +709 772 2046 – Email: kevin.anderson@dfo-mpo.gc.ca

Hvingel, Carsten, Institute of Marine Research, P. O. Box 6404, N-9294 Tromsø, Norway
Phone: +47 77 60 97 50 – Fax: +47 77 60 9701 – Email: carsten.hvingel@imr.no

CANADA

Anderson, Kevin, A/Regional Director, Fish Management, Fisheries and Oceans Canada, P. O. Box 5667, St. John's, Newfoundland A1C 5X1
Phone: +709 772 4543 – Fax: +709 772 2046 – Email: kevin.anderson@dfo-mpo.gc.ca

Chapman, Bruce, Executive Director, Groundfish Enterprise Allocation Council, 1362 Revell Dr., Manotick, Ontario K4M 1K8 Phone: +613 692 8249 – Fax: +613 692 8250 – Email: bchapman@sympatico.ca

Couture, Estelle, Senior Science Adviser, Fish Population Science, Fisheries and Oceans Canada, 200 Kent Street (Stn. 12S62C), Ottawa, Ontario K1A 0E6
Phone: +613 990 0259– Email: estelle.couture@dfo-mpo.gc.ca

Dauphin, Guillaume, Fisheries and Oceans Canada, Science Br., Newfoundland Region, P. O. Box 5667, St. John's, Newfoundland A1C 5X1
Phone: +709 772 7176 – Email: guillaume.dauphin@dfo-mpo.gc.ca

Day, Robert, Director, International Fisheries Management Bureau, Fisheries and Oceans Canada, 200 Kent St., Ottawa, Ontario K1A 0E6
Phone: +613 991 61 35 – Fax: +613 990 9574 – Email: robert.day@dfo-mpo.gc.ca

Dwyer, Shelley, Resource Policy & Development Officer, Government of Newfoundland and Labrador, 30 Strawberry Marsh Road, St. John's, Newfoundland, A1B 4J6
Email: shelleydwyer@gov.nl.ca

Gilchrist, Brett, Senior International Fisheries Officer, International Fisheries Management Bureau, Fisheries and Oceans Canada, 200 Kent St., Ottawa, Ontario K1A 0E6
Phone: +1 613 991 0218 – Fax: +1 613 990 9574 – Email: brett.gilchrist@dfo-mpo.gc.ca

Morgan, Joanne, Science Br., Newfoundland Region, Fisheries and Oceans Canada, P. O. Box 5667, St. John's, Newfoundland A1C 5X1
Phone: +709 772 2261 – Email: joanne.morgan@dfo-mpo.gc.ca

Sullivan, Loyola, Ocean Choice International, 1315 Topsail Rd., P. O. Box 8274, Stn. A, St. John's, Newfoundland A1B 3N4
Phone: +709 782 6244 – Fax: +709 368 2260 – Email: lsullivan@oceanchoice.com

Walsh, Ray, Regional Manager, Fisheries Management, Fisheries and Oceans Canada, P.O. Box 5667, St. John's, Newfoundland A1C 5X1
Phone: +709 772 4472 – Fax: +709 772 3628 – Email: ray.walsh@dfo-mpo.gc.ca

EUROPEAN UNION

Batista, Emilia, Direcao-Geral de Recursos Naturais, Seguranca, Servicos Maritimos, Avenida da Brasilia, 1449-030 Lisbon, Portugal
Phone: +351 742 3629 – Fax: +351 21 303 5922 – E-mail: ebatista@dgrm.mamaot.pt

Dross, Nicolas, International Relations Officer, International Affairs, Law of the Sea and Regional Fisheries Organizations, European Commission, Directorate General for Fisheries and Maritime Affairs (DG MARE.B.1), Rue Joseph II, 99, 1000 Brussels, Belgium
Phone: +32 2 298 0855 – Fax: +32 2 295 5700 – Email: nicolas.dross@ec.europa.eu

Duarte, Rafael, European Commission, Directorate General for Fisheries and Maritime Affairs, Rue Joseph II, 79 (02/217), B-1049, Brussels, Belgium
Phone: +32 2 299 0955 – Email: rafael.duarte@ec.europa.eu

Gonzalez-Troncoso, Diana, Instituto Español de Oceanografia, Aptdo 1552, E-36280 Vigo (Pontevedra), Spain
Phone: +34 9 86 49 2111 – Email: diana.gonzalez@vi.ieo.es

JAPAN

Nishida, Tsutomu (Tom), Assistant Researcher, National Research Institute of Far Seas Fisheries, Fisheries Research Agency, 5-7-1, Orido, Shimizu-Ward, Shizuoka-City, Shizuoka 424-8633
Phone/Fax : +81 54 336 6052 – Email : tnishida@affrc.go.jp

NORWAY

Hvingel, Carsten, Institute of Marine Research, P. O. Box 6404, N-9294 Tromsø, Norway
Phone: +47 77 60 97 50 – Fax: +47 77 60 9701 – Email: carsten.hvingel@imr.no

RUSSIAN FEDERATION

Savchenko, Igor, Representative of the Federal Agency for Fisheries of the Russian Federation in Canada
Phone: +1 902 999 1615 – Email: is5@mail.ru

USA

Christel, Doug, Fishery Policy Analyst, Sustainable Fisheries Div., US Dept. of Commerce, NOAA, National Marine Fisheries Service, 55 Great Republic Drive, Gloucester, MA 01930
Phone: +978 281 9141 – Fax: +978 281 9135 – Email: douglas.christel@noaa.gov

Sosebee, Katherine, National Marine Fisheries Service, NEFSC, 166 Water Street, Woods Hole, MA 02543
Phone: +508 495 2372 – Fax: - +508 495 2393 - Email: katherine.sosebee@noaa.gov

SCIENTIFIC COUNCIL

Stansbury, Don (SC Chair), Science Br., Newfoundland Region, Fisheries and Oceans Canada, P. O. Box 5667, St. John's, Newfoundland A1C 5X1
Phone: +709 772 0559 – Email: don.stansbury@dfo-mpo.gc.ca

Brodie, Bill, Senior Science Coordinator/Advisor on NAFO, Science Br., Newfoundland Region, Fisheries and Oceans Canada, 80 East White Hills Rd., P. O. Box 5667, St. John's, Newfoundland A1C 5X1
Phone: +709 772 3288 – Fax: +709 772 4105 – Email: bill.brodie@dfo-mpo.gc.ca

Gonzalez-Costas, Fernando, Instituto Espanol de Oceanografia, Aptdo 1552, E-36280 Vigo (Pontevedra), Spain
Phone: +34 9 8649 2239 – Email: fernando.gonzalez@vi.ieo.es

OBSERVERS

Janice Ryan, Fishery Advisor , WWF-Canada, TD Place, Suite 305, 140 Water Street, St. John's, Newfoundland A1C 6H6
Phone: +709 722 9453 Ext. 2224 – Email: jryan@wwfcanada.org

Soomai, Suzuette, Environment Information: Use & Influence Research Initiative, Dalhousie University, Rowe Building, School of Information Management, University Avenue, Halifax, Nova Scotia
Email: suzuette.soomai@dal.ca

NAFO SECRETARIAT

Kingston, Fred, Executive Secretary	fkingston@nafo.int
Campbell, Neil, Scientific Council Coordinator	ncampbell@nafo.int
Federizon, Ricardo, Senior Fisheries Commission Coordinator	rfederizon@nafo.int
Kendall, Matthew, IT Manager	mkendall@nafo.int
Lefort, Lisa, Office Manager	llefort@nafo.int
Marshall, Barbara, Senior Information Officer	bmarshall@nafo.int

Annex 2. Agenda

1. Opening
2. Appointment of Rapporteur
3. Adoption of Agenda
4. Review of Terms of Reference
5. Review and Update of the Precautionary Approach Framework
6. Review and Update of existing interim Conservation Plans and Management Strategies
   a) 3NO Cod
   b) 3LNO American Plaice
7. Follow-up to WGFMS-CPRS 2013 Recommendations
   a) Evaluation and finalization of General Framework on Risk-based Management
   b) Discussion on development of alternative strategies for stocks that may not be suited to formulaic rules and/or for stocks where reference points do not exist or cannot be developed.
   c) Development of CPRS
      i. 3NO witch flounder
      ii. 3LN redfish
      iii. 3M cod
      iv. 3L shrimp
8. Approach and workplan to review the Greenland Halibut Management Strategy Evaluation in 2017
9. Recommendations to forward to FC and SC
10. Other Matters
11. Adoption of the Report
12. Adjournment

Annex 3. The NAFO Precautionary Approach Framework

The NAFO Precautionary Approach Framework (PAF)

Modified from presentations at ICES Theme Session L, 2012 ICES ASC and at NAFO SC in June 2013 as SCR Doc13/24, by W. Brodie, P.A. Shelton, E.Couture, K.Dwyer

1

Joint SC/FC WG on the PA, 1998-2002

- Comprised of scientists and managers
- Identified specific roles of SC & FC in PA process
- Discussed decision rules, management strategies for 3 case studies (3M shrimp, 3NO cod, 3LNO yellowtail)
- Considered implementation plans for the 3 stocks. Considered criteria for reopening fishery under a PA.
- Clarified concerns with initial PAF, set groundwork for revised PAF adopted by NAFO in 2004 (FC Doc 04/18).

4

Original Framework for NAFO PA proposed by SC in 1997

Consisted of four main zones – with different courses of action proposed in each zone

Reference points (limit, buffer, and target) used for delineation of zones – some similarity with current PAF

Not adopted at that time

Roles of SC and FC in the NAFO PA process (Table 1 from FC Doc 98/02)

Scientific Council	Fisheries Commission
1. Determine status of stocks.	1. Specify management objectives, select target reference points, and set limit reference points.
2. Classify stock status with respect to biomass/fishing mortality zones.	2. Specify management strategies (courses of actions) for biomass/fishing mortality zones.
3. Calculate limit reference points and security margins.	3. Specify time horizons for stock rebuilding and for fishing mortality adjustments to ensure stock recovery and/or avoid stock collapse.
4. Describe and characterize uncertainty associated with current and projected stock status with respect to reference points	4. Specify acceptable levels of risk to be used in evaluating possible consequences of management actions.
5. Conduct risk assessments.	

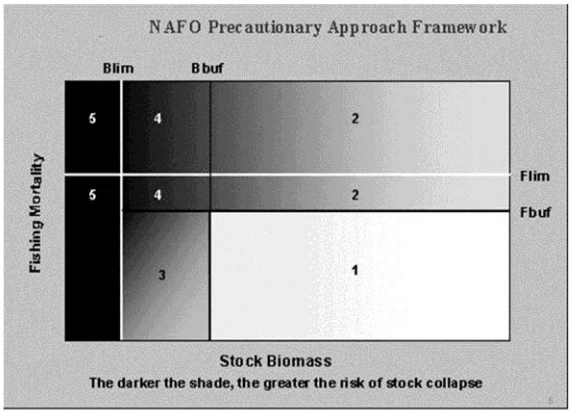
5

Original Reference Point Definitions

B_{lim}	Level of SSB that stock should not be allowed to fall below
B_{buf}	Level of SSB acting as buffer to ensure high probability that B_{lim} not reached
B_{tr}	Target recovery level for SSB (perhaps MSY ?)
F_{lim}	F that should not be exceeded (<= F_{msy})
F_{buf}	Level of F acting as buffer to ensure high probability that F_{lim} is not reached
F_{tr}	Target depends on mgmt objectives, but <= F_{buf}

3

NAFO - Current PAF – adopted 2004



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Some key elements in developing the NAFO PAF

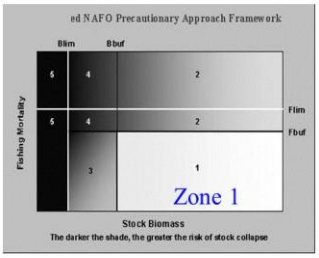
- No explicit targets for Biomass or F
- The PAF does not require Buffer reference points if the risk of being below Blim, or above Flim, can be determined
- Main zones demarcated by limit RPs, Blim is a key reference point
- Suggested risk levels, courses of action (HCR) are provided

7

Zone 1 – Safe Zone

Safe Zone:

Select and set F from range of values that have low probability of exceeding Flim (where SSB has low probability of being below Blim). Target RPs in this zone are selected by managers, based on criteria of their choosing.



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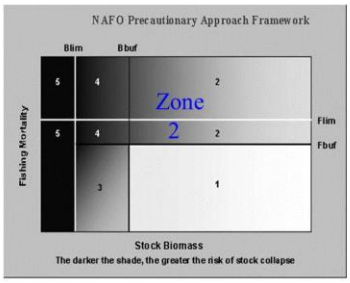
Zone 2 – Overfishing Zone

Overfishing Zone:

Reduce F to below Fbuf



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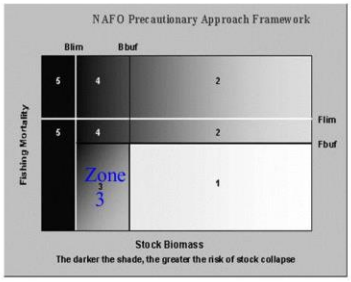
Zone 3 – Cautionary F Zone

Cautionary F Zone: The closer biomass is to Blim, the lower F should be below Fbuf to ensure there is a very low probability that biomass will decline below Blim within foreseeable future.



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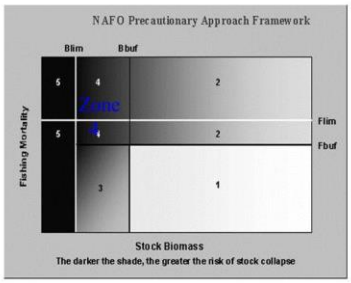
Zone 4 – Danger Zone

Danger Zone: Reduce F to below Fbuf. The closer biomass is to Blim, the lower F should be below Bbuf to ensure there is a very low probability that biomass will decline below Blim within foreseeable future.



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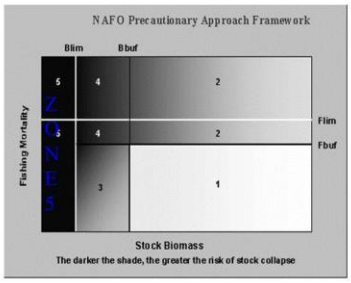
Zone 5– Collapse Zone

Collapse Zone:

B is below Blim.

F should be set as close to zero as possible



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Risk of exceeding LRPs must be low in the PAF

- Flim must be <= Fmsy in the PAF, corresponding to UN Fish Stock Agreement.
- Flim should only have a low (<20%) probability of being exceeded.
- There must be a very low risk (5-10%) of not falling below Blim in the next 5-10 years.

- low probability might be defined as 20%, but the actual level should be specified by managers
- very low probability might be defined as 5-10%, but the actual level should be specified by managers
- foreseeable future might be defined as 5-10 years, but the actual time horizon should be specified by managers

13

Reasons for continuing to advise that Flim <= Fmsy (from FC Doc 04/18)

- Perhaps most importantly, Fmsy as a limit is in conformance with the PA in UNFSA.
- F < Fmsy results in relatively small loss in avg catch, but a large increase in avg biomass.
- Traditional bio-economic models indicate that F associated with max economic yield (Fmey) is usually considerably less than Fmsy.

14

Reasons for continuing to advise that Flim <= Fmsy (from FC Doc 04/18)

- Ensuring no major stock is fished harder than the single-species Fmsy has often been recommended as a good first step towards ecosystem-based management
- Ecosystem-based management will likely require even more conservative fishing mortality targets than "traditional" single species- based management.

15

PA Implementation challenges

- Some stocks data poor. About half have any reference points defined. None have buffer RPs
- 3 stocks have rebuilding plans, 4 stocks have harvest control rules
- More HCR, rebuilding plans being developed – NAFO WG of managers and scientists on Conservation Plans and Rebuilding Strategies
- Consideration of catch vs stock growth. By-catch mortality a factor for some collapsed stocks with no directed fishery
- Determining risk levels

16

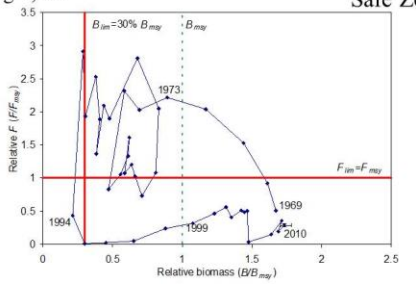
Application of NAFO PAF - 3LNO yellowtail.

(B and F are relative to MSY values, from 2011 SC assessment)

Fishery closed 1994-Aug 1, 98

F < 2/3Fmsy

Stock is in Safe Zone



17

PA and Rebuilding Plans

Recent Rebuilding Plans developed in NAFO have focussed some attention on PA

- Need for rebuilding targets (at or near Bmsy). What about timelines, risk levels?
- Additional ref pts proposed (Bisr - intermediate between Blim and Safe Zone). Properties?
- Explicit, testable HCRs desirable
- GHL HCR based on trend in survey data – not PA ref pts. Resulted from an MSE process.

18

Summary

- Blim is key ref pt in PAF – available for more stocks than other RPs
- Many stocks below Blim – NAFO has kept these under moratorium
- Buffer RPs not calculated for any stocks, but is start of Safe Zone
- PAF not yet implemented for many NAFO stocks
- Development of Rebuilding Plans has PA implications (e.g. Bisr definition)

19

Future Directions …?

- How to delineate Safe Zone, if no buffer RPs?
- Definition of targets (MSY-based?). What about Bmsy and Fmsy (target vs limit debate)?
- Consistency among PAF, generic framework for rebuilding plans, actual rebuilding plans, SC advice, HCRs
- Ecosystem approach? PAF is single species

20

Annex 4. Paper and presentation discussed in item 5

Limit reference Flim at Fmsy – a Flimsy point?
On some possible revisions of the NAFO Precautionary Approach framework
(FC –SC RBMS WP 14/1)

by

Carsten Hvingel and Michael C.S. Kingsley
Institute of Marine Research, Box 6404, N-9294 Tromsø, Norway

Abstract

The NAFO PA framework intends to specify "limit" reference points for stock status and exploitation as those implying "serious harm" to the resource. Limits for biomass comply with this definition. However, in descriptions of the PA framework, the limit for fishing mortality is stated to be the MSY rate (Fmsy), although it is sustainable without serious harm. At the same time, the MSY rate (Fmsy or its proxies e.g. F0.1 and Fmax) is in practice—i.e. for setting TACs—often taken as a target value instead. We suggest a revision of the PA framework to admit target reference points, and setting limit values for mortality that correspond more closely with limit values for biomass.

Introduction

The "Precautionary Approach" in fisheries management entails establishing reference points with which estimates of stock status and exploitation pressure can be compared—the results of the comparison then directing decisions for the management of the fishery. The key stock-status parameter monitored is typically (recruited) stock biomass (*B*), and fishing mortality (*F*) is the corresponding key tactical management parameter. Two sets of reference points may be set: a "target" level, which it is seen as desirable to reach, and a "limit" level, marking an area of "serious harm" which should to be avoided.

The NAFO PA framework (Anon., 2004) only specifies limit reference points. However, while this framework does not explicitly define target reference points, the present management plans for American place in Div 3LNO and cod in Div 3NO do implicitly define B_{msy} as a target reference point for biomass (see appendix).

Limit reference points, marking extreme boundaries for exploitation and stock size, function to protect stocks from recruitment overfishing and from stock sizes associated with a high risk of recruitment failure. In addition, target reference points, marking desired exploitation and stock size, can be considered to be a means of obtaining best long-term management of the stock. We think that the NAFO PA framework would be strengthened if they were formally included. But the explicit limit and implicit target reference points for biomass and fishing mortality presently existing in the NAFO PA and management frameworks are not complementary and they are not treated in a consistent manner in the scientific advice and in management actions.

Background

In a typical stock-production or stock-recruitment relationship (convex upwards for biomass below B_{msy} and non-increasing elsewhere) (Fig.1), fishing mortality and stock biomass inescapably constitute a linked pair of management objectives. Managing consistently at a given fishing mortality will converge (in a stable environment) on a certain corresponding stock biomass. Equally, taking a given stock biomass as a management objective will require the imposition of some corresponding fishing mortality (Fig. 1).

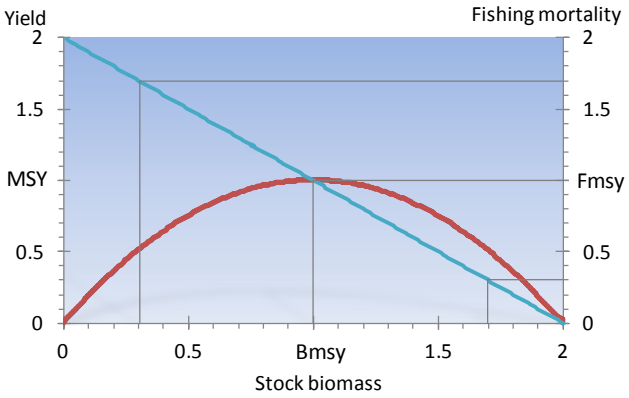


Fig. 1. Example dome-shaped stock-recruitment relationship: the production/yield according to the logistic model (*red curve*) and corresponding fishing mortality, F (*blue straight line*). For illustration three corresponding points of stock biomass and fishing mortality are shown. MSY=Maximum Sustainable Yield; B_{msy}=stock biomass at MSY; F_{msy}=fishing mortality corresponding to MSY.

But fishing mortality and stock biomass are not wholly interchangeable as management objectives. Stock dynamics and the effect of fisheries are such that biomass can not be changed in the short term. However much a stock assessment might show that biomass has diverged from a target level, we cannot by fiat restore it, and its target level has to remain a longer-term objective. On the other hand, fishing mortality is within reach, and can—within practical limits—be readily altered in the short term.

If precautionary reference points for both fishing mortality and for biomass are to be defined, it will be logical if the target reference point for biomass converges on the target reference point for fishing mortality—and vice versa—and similarly the limit reference point for biomass should logically correspond to the limit reference point for fishing mortality. In that way specifying fishing pressure relative to *F* reference points will determine evolution and final destination of stock development relative to the associated *B* references.

If limit and target reference levels are not corresponding pairs, difficulties will ensue in both the formulation of advice and the taking of management action: going after one target will mean abandoning another; respecting one limit could mean transgressing another.

Present specifications

Fishing mortality reference points

The NAFO PA framework specifies both that Flim is to be no greater than Fmsy *and* that Flim is to be exceeded 'with low probability'; *a fortiori*, Fmsy will also be exceeded with low probability. Although inconsistent with the 'serious harm' definition of limit reference points this specification has been defended (Anon. 2004a) by referring to UN fisheries agreements:

"Perhaps most importantly, Fmsy as a limit is in conformance with the Precautionary Approach as described in several United Nations agreements (in particular, Annex II of the United Nations Straddling Stocks Agreement)".

This Annex, cited in part below, explicitly uses the word 'limit' in connection with Fmsy as a reference point for mortality and requires that management strategies shall ensure that it is not exceeded.

Annex II of the UNFSA: *"The fishing mortality rate which generates maximum sustainable yield should be regarded as a minimum standard for limit reference points. For stocks which are not overfished, fishery management strategies shall ensure that fishing mortality does not exceed that which corresponds to maximum sustainable yield.*

As said above, the NAFO PA framework does not define target reference points. .

Taking Fmsy as a limit implies that it is considered to be associated with serious harm to the resource—which it isn't—and also means that any reference level accepted as a target would have to be much lower. In practice, other standard reference levels for fishing mortality—F0.1 or Fmax, sometimes considered proxies for Fmsy—are now already treated as acceptable target levels rather than as limits to be avoided (e.g. 3M cod).

Stock biomass reference points

A limit reference point for biomass in the NAFO PA framework for stocks managed with a production model is commonly taken as 30% of B_{msy}. For data-poor stocks managed without a quantitative assessment model, the lowest observed biomass may be taken as a limit biomass reference. For some stocks for which a stock-recruitment plot is available, its break-point is taken as B_{lim}. All are fully consistent with the definition as a "serious harm" level.

Target reference points are as mentioned before generally absent from the NAFO PA framework. However, the rebuilding strategy adopted by NAFO for 3LNO American Plaice and 3NO Cod seems to have B_{msy} as a long-term objective for biomass. Annex II of UNFSA also considers that Bmsy 'can serve as a rebuilding target' for overfished stocks.

Inconsistency

Therefore, the present definitions of limit values for biomass do not correspond to definitions of limit values for fishing mortality—but specified *targets* for biomass do.

Discussion

We propose two changes to the NAFO PA framework. The first is that target levels should be set in addition to limit levels. In their absence, there is a risk that limit levels, which should be avoided, become *de facto* targets because they are the only definite and specified values on the board, whereas considered target reference points marking desired exploitation and stock size should be the means of obtaining best long-term management of the stock.

Secondly, we propose that the pairs of reference levels should be made consistent: a target level for fishing mortality should in the long term lead to the target level for biomass; and the limit level for biomass should be efficiently avoided by avoiding the limit level for mortality. The present NAFO structure lacks this consistency. For example, a limit level for biomass set at 30% of Bmsy (e.g. for Northern Shrimp in Div. 0A and SA1, Yellowtail Flounder in Divs 3LNO) corresponds in the long term to a mortality of 170% of Fmsy. Instead, the limit level for mortality is set at 100% of Fmsy, and if this is to be 'exceeded with low probability', we should expect biomass to remain rather above Bmsy—or at three to four times what is now considered its limit level (Fig. 1). We regard the defence of this inconsistency by referring to the UN Straddling Stocks Agreement as weak, as it appeals to one part of a text which itself is internally inconsistent (the fishing mortality to achieve MSY, i.e. F_{msy}, is referenced as both a target and a limit – see appendix).

There is reason to suppose that for rationally managed commercial fisheries the economic optimum stock biomass lies above Bmsy. Stock assessments commonly assume that biomass is linearly related to the fishery catch:effort ratio; the corollary is that catch:effort (CPUE) is linearly related to stock, and that therefore fishing becomes more efficient as stock biomass increases. To be consistent with this biomass target, a tactical management target range for mortality should be slightly below Fmsy; or in risk-based advice, a moderately low probability of exceeding Fmsy. Incontrovertibly, the safety margin on fisheries management would also increase with increasing the biomass target.

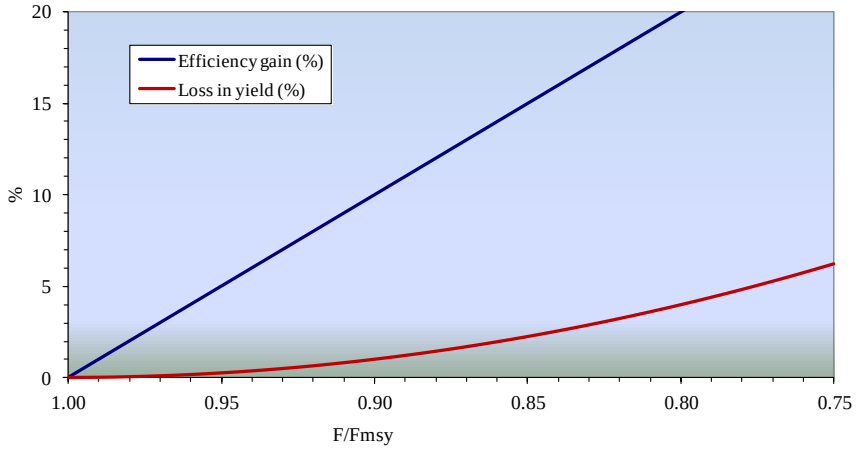


Fig. 2. Effect on fishing efficiency (CPUE) and on loss in yield of reducing fishing mortality (F) from Fmsy.

For a range of fishing mortalities slightly below Fmsy, the reduction in yield from the stock is small, but the gain in the efficiency of the fishery is much greater (Fig. 2). Estimation of economic optimum is outside the scope of this working paper, but it seems likely that there is little to lose by maintaining biomass slightly above Bmsy. These economic considerations were referred to (Anon 2004a):

> *Fishing somewhat below Fmsy results in a relatively small loss in average catch, but a large increase in average biomass (which, in turn, results in a decreased risk to the fish stock, an increase in CPUE, and a decrease in the costs of fishing).*
>
> *Traditional bio-economic models indicate that the fishing mortality associated with maximum economic yield (Fmey) is usually considerably less than Fmsy.*

but should properly relate to the defence of this range of values—'somewhat below Fmsy'—as an optimum-seeking target, not as a last-ditch-defence limit. The text has lost sight of the NAFO definition of limit values as those which indicate 'serious harm to the resource.' Our suggestion remains that mortalities 'somewhat below' Fmsy should be adopted as a target range in the NAFO PA framework.

The adoption, as a target, of a mortality range somewhat below Fmsy has also been recommended in the context of 'ecosystem-based management':

> *Ensuring no major stock is fished harder than the single-species Fmsy has often been recommended as a good first step towards ecosystem-based management (NRC, 1999; Mace, 2001). Ecosystem-based management will likely require even more conservative fishing mortality targets than "traditional" single-species-based management.* (Anon 2004a)

Conclusion

The precautionary reference points in use under the present NAFO interpretation of the precautionary principle do not match up. Target reference points, should be added, and the limit and target levels for biomass and for mortality should constitute consistent pairs.

References

Anon. 2004. NAFO Precautionary Approach Framework. NAFO/FC Doc. 04/18, Serial No. N5069. 5pp

Appendix

Annex 2 of the UNFSA: "The fishing mortality rate which generates maximum sustainable yield should be regarded as a minimum standard for limit reference points. For stocks which are not overfished, fishery management strategies shall ensure that fishing mortality does not exceed that which corresponds to maximum sustainable yield, and that the biomass does not fall below a predefined threshold. For overfished stocks, the biomass which would produce maximum sustainable yield can serve as a rebuilding target."

3LNO American Plaice and 3NO Cod Conservation Plans: "Long-term Objective: The long-term objective of this Conservation Plan and Rebuilding Strategy is to achieve and to maintain the Spawning Stock Biomass (SSB) in the 'safe zone', as defined by the NAFO Precautionary Approach framework, and at or near Bmsy."

Accompanying PowerPoint presentation:

FC-SC RBMS WP 14-1

NAFO and the Precautionary Approach – some considerations

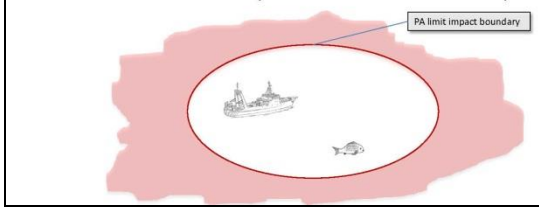
Carsten Hvingel & Michael Kingsley

NAFO fisheries management

- Precautionary Approach
  - Focus: Single stock impact
  - Aim: Manage stock productivity
  - Tool: Control *removals* of the target stock
- Ecosystem Approach
  - Focus: ecosystem impact
  - Aim: Manage biodiversity, habitat integrity, species interaction
  - Tool: Control the *fishing activity*

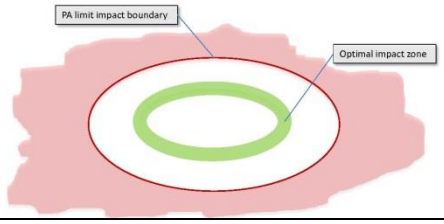
The role of PA in fisheries management

- PA *limit* references are for conservation
  - Purpose: Mark the extreme boundaries for exploitation and stock size
  - Indicate: Drastic action needed
  - Aim: avoid recruitment overfishing and high risk of recruitment failure (recruitment overfished stock)

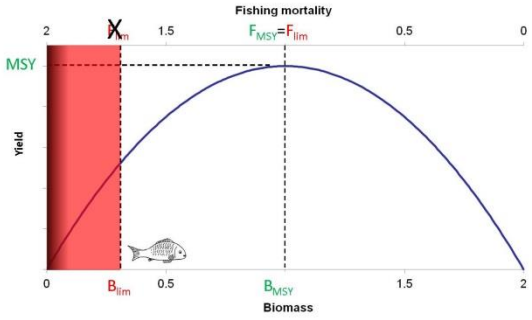


The role of PA in fisheries management

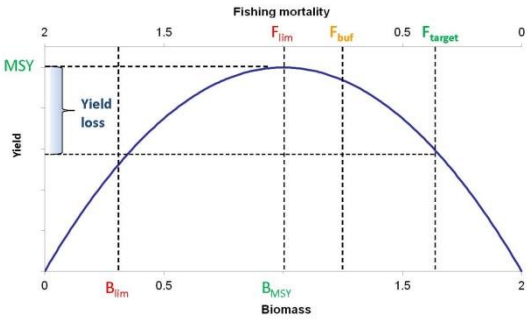
- PA *target* references are for optimal resource management –the balance between risk and yield.
  - Purpose: mark area of desired exploitation and stock size
  - Aim: Maximize probability of best long-term economical and social benefit.



Limit reference F at F_{msy} – logical or consistent?



Limit reference F at F_{msy} – where is the target then?

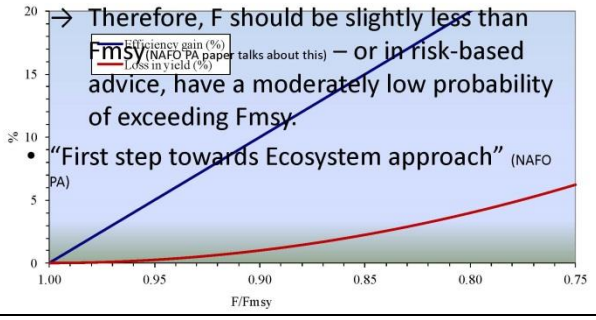


Conclusion

- Current Flim (=Fmsy)
  - does not indicate "serious harm".
  - does not correspond to the B-limit reference.
  - Instead it corresponds to the B-target references (implicitly defined in management plans
  - proxies (F0.1, Fmax) is not treated by NAFO as limits but rather as targets
  - Implies Ftarget at ~40%Fmsy →160%Bmsy →yield loss ~ 37%)
- Arguments for Flim=Fmsy:
  - UNFASA
    but is internally inconsistent: implicitly refers to Fmsy as both a limit and a target
  - History
    but does not show a Fmsy strategy to be harmful
- Suggested revision
  - Make Flim complementary to Blim
  - Set complementary F and B targets

What should Ftarget then be?

- Economic optimum B slightly larger than Bmsy
- → Therefore, F should be slightly less than Fmsy (NAFO PA paper talks about this) – or in risk-based advice, have a moderately low probability of exceeding Fmsy.
- "First step towards Ecosystem approach" (NAFO PA)



Annex 5. Updated 3NO Cod Conservation Plan and Management Strategy

Interim 3NO Cod Conservation Plan and Rebuilding Strategy

1. **Objective(s):**

   (a) **Long-term Objective**: The long-term objective of this Conservation Plan and Rebuilding Strategy is to achieve and to maintain the 3NO Cod Spawning Stock Biomass (SSB) in the 'safe zone', as defined by the NAFO Precautionary Approach framework, and at or near B_{msy}.

   (b) **Interim Milestone**: As an interim milestone, increase the 3NO Cod Spawning Stock Biomass (SSB) to a level above the Limit Reference Point (B_{lim}). It may reasonably be expected that B_{lim} will not be reached until after 2015.

2. **Reference Points:**

   (a) Limit reference point for spawning stock biomass (B_{lim}) – 60,000t[1]

   (b) An intermediate stock reference point or security margin B_{isr}[2] – [120,000t]

   (c) Limit reference point for fishing mortality ($F_{lim} = F_{msy}$) – 0.30

   (d) ~~B_{msy} – [248,000t]~~ Interim B_{target} – 185 000 t and interim F_{target} of $F_{0.1}$ – 0.19[3]

3. **Re-opening to Directed Fishing:**

   (a) A re-opening of a directed fishery should only occur when the estimated SSB, in the year projected for opening the fishery, has a very low[4] probability of actually being below $B_{lim.}$

   (b) An annual TAC should be established at a level which is projected to result in:

      (i) continued growth in SSB

      (ii) low[5] probability of SSB declining below Blim throughout the subsequent 3-year period, and

      (iii) fishing mortality < F0.1

4. **Harvest Control Rules:**

   Noting the desire for relative TAC stability, the projections referred to in items (a) through (d) below should consider the effect of maintaining the proposed annual TAC over 3 years. Further, in its application of the Harvest Control Rules, Fisheries Commission may, based on Scientific Council analysis, consider scenarios which either mitigate decline in SSB or limit increases in TACs as a means to balance stability and growth objectives.

   (a) When SSB is below B_{lim}:

      (i) no directed fishing, and

      (ii) by-catch should be restricted to unavoidable by-catch in fisheries directing for other species

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[1] The Fisheries Commission shall request the Scientific Council to review in detail the limit reference point when the Spawning Stock Biomass has reached 30,000t.

[2] A 'buffer zone' (B_{buf}) is not required under the NAFO PA given the availability of risk analysis related to current and projected biomass values; however, SC has advised that an additional zone(s) between B_{lim} and B_{msy} could be considered. An intermediate stock reference point (B_{isr}) is proposed to delineate this zone. The proposed value is set at a level equivalent to twice B_{lim} Should the SC review of the limit reference point (B_{lim}) result in a change to that value then the intermediate stock reference point (B_{isr}) should also be re-evaluated.

[3] B_{target} is a proxy of B_{msy}. The level of F has very low probability of being higher than F_{lim}. The B_{target} is the equilibrium SSB that results from F_{target}. These are interim targets until more stock recruitment and productivity regime information is available to better estimate MSY-based reference points.

[4] 'very low' means 10% or less

[5] 'low' means 20% or less

Before SSB increases above B_{lim}, additional or alternative harvest control rules should be developed, following the Precautionary Approach, to ensure the long-term objective is met, such as:

(b) When SSB is between B_{lim} and B_{isr}:

(i) TACs should be set at a level(s) to allow for continued growth in SSB consistent with established rebuilding objective(s)
(ii) TACs should result in a low probability of SSB declining below Blim throughout the subsequent 3-year period, and
(iii) Biomass projections should apply a low risk tolerance

(c) When SSB is above B_{isr}:

(i) TACs should be set at a level(s) to allow for growth in SSB consistent with the long term objective, and
(ii) Biomass projections should apply a risk neutral approach (i.e. mean probabilities)

(d) When SSB is above ~~B_{msy}~~ B_{target}:

- TACs should be set at a level of F that has a low probability of exceeding $F_{msy,}$ and
- Biomass projections should apply a risk neutral approach (i.e. mean probabilities)

5. **Ecosystem Considerations:**

Considering the importance of capelin as a food source, consistent with the ecosystem approach, the moratorium on 3NO capelin will continue until at least 31 December 2015.

6. **By-catch Provisions**

The by-catch provisions in the CEM for 3NO cod should be reviewed periodically, to coincide with scheduled assessments of the stock by Scientific Council, and adjusted to reflect the overall trend in spawning stock biomass.

Annex 6. Revised General Framework on Risk-based Management Strategies

1. **Introduction:**

The purpose of this document is to provide guidance on the development and implementation of risk management strategies based on the application of the Precautionary Approach framework.

While not intended to be a template, the following are recommended elements for the development and implementation of risk based management strategies

2. **Biological Synopsis / Fishery Overview:**

A brief overview outlining the main biological characteristics of the stock with emphasis on the aspects which impact rebuilding of the stock, as appropriate, including:

- A species' **life history characteristics** (e.g. growth rates, fecundity, longevity, age-at-maturity, size-at-maturity) - critical elements to consider in determining a stock's response to both fishing pressures and rebuilding measures
- **Multispecies interactions** – these can have a strong influence on stock recovery potential and ability of all stocks to reach MSY
- **Environmental conditions** (e.g. temperature, salinity) - will impact the rebuilding dynamics of a stock by affecting life history characteristics, such as fecundity, growth and general productivity. Environmental conditions will also influence predator and prey abundance, which in turn impacts a stocks' overall health and recruitment.

A brief overview of the fisheries in which the stock is captured, including both targeted catch and by-catch, including:

- Impacts of rebuilding on other fisheries - rebuilding efforts for a depleted stock harvested in a mixed-stock or multispecies fishery may have impact on / be impacted by fishing opportunities on targeted stocks/species whose populations are healthy

3. **Objective(s):**

Objectives (fishery and conservation related) should be clearly stated and direct the development of specific measures. Milestones may also be established as interim steps to achieving objectives.

Objectives and milestones may take into account the following components:

- A target, which is preferably quantifiable (e.g. specified biomass goal)
- A desired time to reach the target (e.g. specified # of years/ generations)
- An acceptable probability level for reaching the target within the specified timeframe

The long-term objective of a Risk-based Management Strategy is to achieve and to maintain the Stock Biomass and the Fishing Mortality in the 'safe zone', as defined by the NAFO Precautionary Approach framework and to ensure that fisheries resources are maintained at or restored to levels capable of producing maximum sustainable yields, according to the Convention objectives (resolution NAFO/GC Doc. 08/3).

4. **Reference Points:**

The level of information available to perform a quantitative assessment and to define biological reference points may vary considerably between stocks. There are currently stocks with an adopted quantitative assessment and with limit and/or potential target reference points defined but there are stocks with inadequate information to perform a quantitative assessment and for which the definition of reference points is difficult or not possible.

Where limit reference points can be defined, they should be calculated by the Scientific Council (SC).

SC should also provide advice and analysis in support of the development of other reference points (e.g. targets).

5. **Guidance on Management Strategies and Harvest Control Rules[1]**

a. Stocks below limit reference point

- no directed fishing, and
- by-catch should be restricted to unavoidable by-catch in fisheries directing for other species

b. Re-opening to direct Fishing:

A decision to reopen the fishery should only be considered when Biomass is above B_{lim}.

When a stock has recovered beyond B_{lim}, initial TAC levels should be set at conservative levels to allow for continued recovery and growth.

Decisions to reopen a fishery should take into account any available risk analysis.

Where quantitative risk analysis is available, reopening the fishery should only be considered when there is a very low[2] probability of Biomass actually being below B_{lim}.

In the absence of a quantitative risk analysis, a decision to reopen a fishery would only occur when FC has a high degree of confidence, taking into account any available advice/analysis from SC, that biomass is above B_{lim} or its proxy. Any subsequent increases in TAC should be gradual in order to allow for monitoring of the stock response to the fishery.

c. Open fisheries:

The NAFO Precautionary Approach framework should be applied and Harvest Control Rules (HCR) should be developed in order to specify actions to be taken.

Fisheries specific harvest control rules should be designed with the objective of keeping the fishery in the safe zone.

There should be a low probability that fishing mortality will exceed F_{lim}.

Scenarios may be considered which mitigate decline in biomass and/or limit increases in TACs as a means to balance fishery socio-economics and long-term conservation objectives.

d. Closing of Directed Fishing:

~~[~~As noted in NAFO's PA Framework, a ~~fishery~~ <u>stock</u> will be closed when it is below B_{lim}. Fisheries Managers will consider the probability and establish risk tolerance taking into consideration short term projections and stock fluctuations.~~]~~

e. Additional management measures

When practical, considerations may be given to specific management measures to reduce fishing mortality associated with bycatch including discards, and/or improve selectivity.

6. **Ecosystem Considerations:**

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[1] Noting the merits of quantifiable and testable harvest control rules, these aspects should be considered, on a stock by stock basis, in the development of risk-based management strategies.

[2] The actual level of risk should be specified by managers.

Risk-based management strategies should be consistent with the ecosystem approach and take into consideration the associated species.

7. **By-catch provisions:**

For closed fishery, by-catch provisions in the CEMs should be reviewed periodically, to coincide with scheduled assessments of the stock by Scientific Council, and adjusted to reflect the overall trend in spawning stock biomass.

8. **Monitoring and Review:**

Reviews should be completed on a regular basis at intervals such that failures of the plan (e.g. prolonged declining or stagnant stock growth) can be detected, and changes made as required.

On-going changes in stock status, resulting in implementation of associated harvest decision rules should be continuously examined; trends observed in long-term monitoring are an essential element for consideration in reviewing rebuilding plan performance.

Additional management action may be considered if the stock does not show signs that rebuilding is occurring.

Annex 7. Development of a Risk-Based Management Strategy for 3LN Redfish

(FC-SC RBMS WP 14/4 Rev 3)

Preamble

NAFO identified the development of a risk-based management strategy for 3LN redfish as a priority in 2012, and reaffirmed that priority in 2013.

1. Context

This is a recently re-opened fishery and the response of the stock to fishing at higher levels is uncertain at this stage.

In addition, a high percentage of the fish are juveniles. **Implementation of the proposed HCR should allow for an increase in the spawning stock biomass but it is not possible to test this element at this time.**

The proposed management strategy is intended to initially focus on the short to medium term. A review/ evaluation would be recommended at the end of the 7 year period (outlined below).

2. Objectives and Performance Statistics:

a) Objective(s): Maintain the stock at or above B_{msy}, achieve a TAC of 20 000t within 7 years, and maintain a TAC at or above[1] 20,000t for subsequent years.

- Rationale for 20 000t is that it represents the approximate average catch for the period 1965-1985 - a prolonged period of relative stability in the TAC/ resource.
- The current average fish size in the stock and fishery is low and a slow increase in the TAC should promote survival and growth. This should result in an increased SSB.

b) Performance Statistics:

i. Low (30%) probability of exceeding F_{msy} in any year
ii. Very low (10%) probability of declining below B_{lim} in the next 7 years
iii. Less than 50% probability of declining below 80% B_{msy} in the next 7 years

3. Harvest Control Rule:

Increase the TAC in constant increments starting in 2015 – i.e. $TAC_{y+1} = TAC_y + 1{,}900t$ to a maximum of 20 000t. This would provide the following annual TACs:

2015: 8 900
2016: 10 800
2017: 12 700
2018: 14 600
2019: 16 500
2020: 18 400
2021: 20 000

[1] Evaluating at 5 000t increments, *i.e.* 25 000, 30 000, etc.

4. Proposed Next Steps:

- The working group request Scientific Council to evaluate this management strategy relative to the performance statistics prior to the 2014 NAFO Annual Meeting.
- **SC is requested to comment on likely by-catch levels associated with the implementation of the proposed HCR for 3LN redfish.**

Annex 8. Development of a Risk-Based Management Strategy for 3M Cod

(FC-SC RBMS WP 14/2 Rev2)

Background

The cod stock in Division 3M (Flemish cap) experienced very low biomass levels in the 1990s and was under moratorium to direct fishing between 1999 and 2009. The stock rebuilt and the direct fishery reopened in 2010. The spawning stock biomass increased substantially since mid-2000s and is now well above the limit reference point and among the highest levels observed since the 1970s. The rebuilding of this cod stock was a success for NAFO. NAFO identified the development of a risk-based management strategy for 3M cod as a priority in 2012, and reaffirmed that priority in 2013. The development of such a management plan should be based on scientific advice.

This paper presents the outline of a future 3M Cod Risk-based Management Strategy, indicating reference points with associated risks, options of candidate Harvest Control Rules (HCR) and performance statistics and targets to evaluate these HCR. Two candidate HCRs are proposed: 1) a model based HCR, with different options of target fishing mortality (F_{target}) and 2) a model free HCR based on survey trends. The model based HCR would require a stock assessment each year, to estimate the necessary stock parameters, while the model free HCR would only be based on surveys and assessments would not be necessary.

These different HCR will give managers a wide range of options to choose from, based on the different risk and performances. The Scientific Council should review this plan, propose alternative HCRs and performance statistics and perform a Management Strategy Evaluation (MSE).

1. Objective

The objective of this Conservation Plan is to maintain the 3M cod Spawning Stock Biomass in the safe zone as defined by the NAFO precautionary approach framework and to assure the optimum utilization, rational management and conservation of the 3M cod stock.

2. Reference Points:

(a) A limit reference point for spawning stock biomass (B_{lim}) – 14 000 tons[1]

(b) A target reference point for fishing mortality (F_{target})

F_{target} is to be defined by Managers. Several options regarding risks of being above F_{MSY} are indicated in one of the HCRs.

Reference points should be calculated and updated by the Scientific Council (SC).

3. Harvest Control Rule:

(a) When SSB is above B_{lim}, the future total allowable catch (TAC) shall be adjusted each year according to the following harvest control rule (HCR):

- OPTION 1 (Model based HCR): TAC = Biomass X F_{target} X Probability of SSB above B_{lim}

F_{target}: Four different levels of F will be considered as F_{target}, corresponding to probabilities of 20%, 30%, 40% and 50% of exceeding F_{MSY}.

If F_{MSY} is not available, an appropriate proxi (e.g. Fmax, current proxi) should be used.

[1] STACFIS 2008

- OPTION 2 (Model free HCR): $TAC_{y+1}=TAC_y$ x (1 + λ x slope)

Biomass projections should apply a risk neutral approach (*i.e.* mean probabilities).

(b) When SSB is below B_{lim}, no directed fishing and by-catch should be restricted to unavoidable by-catch in fisheries directing for other species

For this purpose, fisheries managers will consider the probability and establish risk tolerance, noting that the probability of biomass to be above B_{lim} is an integral part of the HCR proposed in option 1.

(c) Noting the desire for relative TAC stability, TAC should be constraint to a fixed percentage of annual change (+- [XX]%)..

Level of constraint is to be defined by Managers. Different scenarii will be tested: 10%, 15% and 20%.

The management objectives, performance statistics (PS) and performance target (PT) are indicated in Annex 1.

4. By-catch Provisions

The by-catch provisions in the CEM for 3M cod are defined in Article 6.3.

5. Reviews

Reviews should be completed on a regular basis at intervals such that failures of the plan (e.g. prolonged declining stock) can be detected, and changes made as required.

6. Final provisions

The current Risk-based Management Strategy (RBMS) for Cod stock in Subarea 3M shall be applied in consistency with the Precautionary Approach Framework and the General Framework on Risk-based Management Strategies.

It shall be in force initially until 2019.

Annex 1: Parameters for the evaluation of the management strategy

The priority regarding management objectives is (ranked from higher to lower priority): 1) low risk of breaching B_{lim}, 2) low risk of overfishing and 3) low risk of steep biomass decline, 4) maximise average catch and 5) limited annual catch variation.

The HCRs, PS and PT are not fully mathematically specified and are left open for the Scientific Council to propose adequate formulation. The length of the evaluation period is to be defined by the Scientific Council.

Management Objectives	Performance Statistics (PS)	Performance Targets (PT)
Low risk of steep decline	SSB_{10}/SSB_0, where SSB_{10} = spawning stock biomass in year 10 and SSB_0 = spawning stock biomass in year 0, where year 0 is the current year SSB_5/ SSB_0 SSB_{lowest} / SSB_0, where SSB_{lowest} = lowest spawning stock biomass level during projected evaluation period	The probability of the decline of 25% or more of spawning stock biomass from year 0 to year 5 is kept at 10% or lower.
Very low risk of breaching B_{lim}	SSB / B_{lim}	The probability of a spawning stock biomass under B_{lim} at 10% or lower
Limited annual catch variation	Number of times the constraint (at the lower and at the higher boundaries) has been applied on average during the period.	This will be achieved through the constraint on the TAC variation.
Maximum average catch over the period	Yearly TAC for the period Average TAC over the period	The average TAC over the period should be maximized
Low risk of overfishing	F/F_{MSY} F_{max} is used as a proxy for F_{msy}.	For the model free HCR only: The probability of F exceeding Fmsy during the evaluation period should be kept at 30% or lower.