Northwest Atlantic Fisheries Organization

Serial No. N7498 **NAFO SCS Doc. 24/05**

Report of the NAFO Precautionary Approach Working Group (PA-WG)

04 April 2024, by Webex

Recommended Citation:

NAFO. 2024. Report of the NAFO Precautionary Approach Working Group Meeting (PA-WG), 04 April 2024, via WebEx. NAFO SCS Doc. 24/05.

NAFO Precautionary Approach Working Group (PA-WG)

04 April 2024. 08:00 Halifax time

WebEx

Chair: Fernando González-Costas

1. Opening.

The meeting was opened by the Chair Fernando González-Costas (European Union) at 08:00 hours (UTC/GMT -3 hours in Halifax, Nova Scotia) on Thursday, 04 April 2024.

The Chair welcomed representatives from Canada, the European Union, Japan, Russian Federation, United Kingdom and the United States of America, as well invited experts on Precautionary Approach Framework on Fisheries Management. A full participants list is presented in Appendix I.

a) Appointment of Rapporteurs.

The NAFO Secretariat (Dayna Bell MacCallum and Jana Aker) was nominated as rapporteur of the meeting.

The Chair thanked the former Scientific Council Coordinator, Tom Blasdale, for his work with the PA-WG group before his departure from the NAFO Secretariat.

b) Adoption of Agenda

The agenda was adopted as circulated (Appendix II).

2. PA Framework Proposal

a) General framework

The Chair presented the framework approved to be tested (Annex 5 of COM-SC Doc. 23-23) as well as the schematic for the PA Zones and management actions for each.

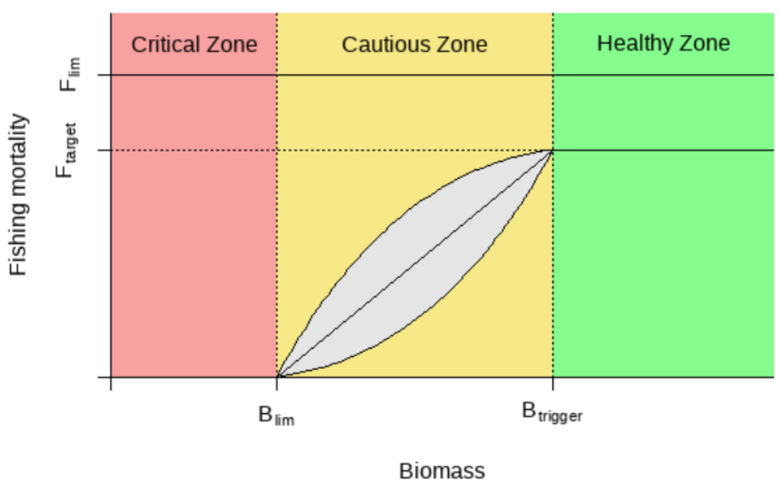


Figure 1. The PA Framework approved to be tested.

At the 2023 Annual Meeting the Scientific Council consolidated the options for simulation testing of the candidate PAF, and during its intersessional meeting in January 2024 it decided that the PAF testing would be carried out in two stages, one with a more general approach and the second with specific case studies (SCS Doc. 24/02).

3. PAF simulation contract

In January 2024, the Scientific Council (SCS Doc. 24/02) finalized the Terms of Reference and prepared a contract between the contractor and the NAFO Secretariat. The Secretariat provided an update to the meeting that the contract was signed by the contractor in March 2024 and the work has begun. The Chair welcomed the contractor to the project.

4. The generic approach PA framework testing

a) Progress made

Mariano Koen-Alonso and Andrea Perreault (Canada) presented an update on the generic simulation testing of the Candidate PAF for NAFO. They submitted a document (including supplementary information on Harvest Control Rule (HCR) formulation and generic population models), and gave a presentation that included the proposal for the main assumptions of the production and age-structured models (characteristics, types and levels of error, scenarios, projection period) that could be used in the generic simulations. The supplementary information presented can be found in Appendix III of this report. The group discussed the different points of the proposal and the agreements of the group are presented in subsequent sections of this report.

In the discussion of the presentation, the possibility of including summaries that include absolute values (e.g. F, TAC) in addition to relative ones (e.g. F/F_{msy}, B/B_{msy}) was brought up, and it was agreed that this will be looked at as part of this work.

The need to think about how to present the results in a clear and understandable way was also discussed.

It is important to highlight that this exercise, at least for the generic testing, should use a period of projections long enough to cover the generation time for all the species that are exploited in the area.

b) Tentative schedule to carry out the testing

The proposed schedule for the generic testing is outlined below. It was noted that there could be potential intersessional work required in July to prepare for the August 2024 WG-RBMS meeting.

4th April
- Finalize fish population formulations (parametrization, types of error)
- Finalize HCRs to be used (width of leaf)
- Finalize performance statistics

30th April
- Incorporate feedback from RBMS April meeting
- Run simulations based on discussions and agreements at RBMS
- Tidy plots for output

31st May (SC)
- Finalize SCR and related output
- Prep presentation for SC

31st July (RBMS)
- Incorporate feedback from SC discussion in June
- Presentation of final results at SC intersessional in July (if needed)
- Prep presentation for RBMS meeting in August

5. Specific PA framework testing

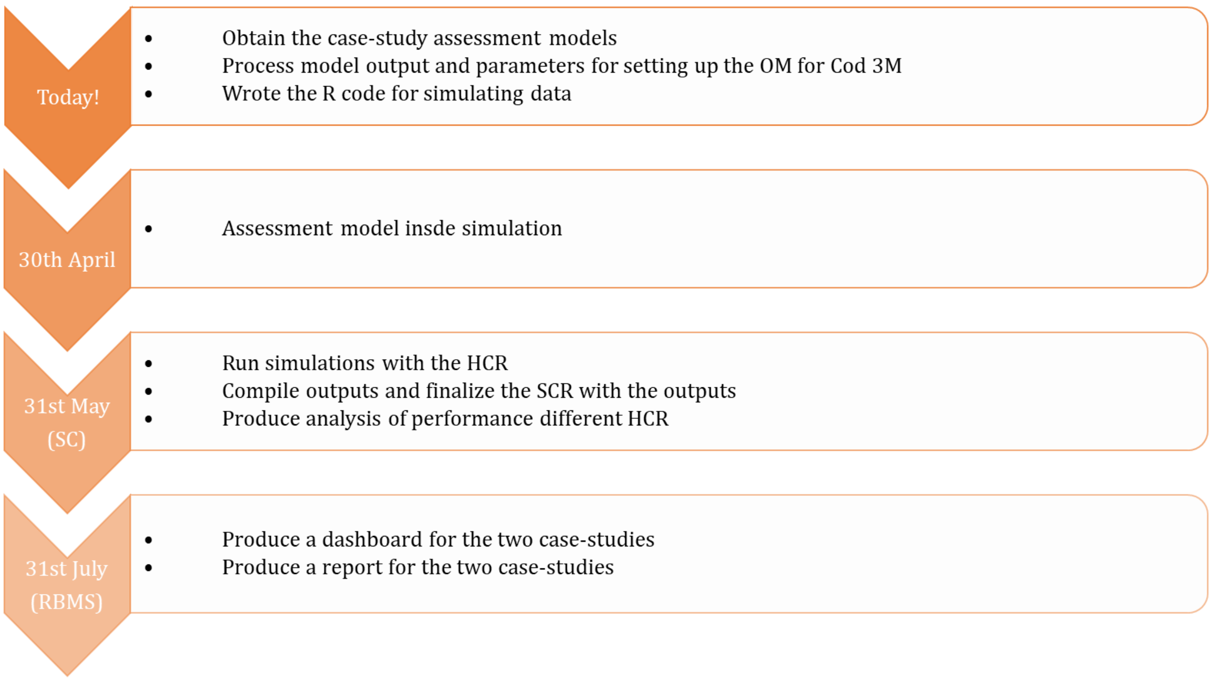
a) Progress made

Rajeev Kumar and Divya Varkey (Canada) presented an update on the progress of the specific PA framework testing. The presentation focused on the progress made and challenges found during the MSE implementation of the Division 3M cod (SCAA model) and Divisions 3NO witch flounder (production model) assessment models. The assessment models for both stocks were submitted by Designated Experts (DEs); the team was able to successfully run the Division 3M cod model, and is planning to run the Divisions 3NO witch flounder model by mid-April. The current challenge for the Division 3M cod model is the run time (currently it takes approximately 1 hour to run each simulation), and the team is presently working to find a solution to reduce the simulation run time. A possible solution to shorten the run time is expected to be found within one to two weeks.

The group began discussions on some of the general features of the MSE to be implemented to test the PA framework. It was agreed to create a small group to continue this discussion and to assist with stock specific questions that may arise during the testing, once the run time problem was solved.

b) Tentative schedule to carry out the testing

The proposed schedule for the specific testing is outlined below. It was noted that there could be potential intersessional work required in July to prepare for the August 2024 WG-RBMS meeting.



6. Formulation of the HCR to be tested

Mariano Koen-Alonso and Andrea Perreault (Canada) provided a document and presentation that also included a proposal of the possible formulation of the leaf Harvest Control Rule to be used in the Caution Zone of the PA framework to be tested. The formulation of this proposal of the HCR is the following (more details are present in the document in Appendix III):

An upper or lower leaf HCR can be obtained by defining $F_t = f(B_t)$ as:

$$F_t = \frac{a^*(B_t - B_{lim})}{(B_x^* - B_{lim}) + (B_t - B_{lim})} \qquad \text{Eq. 1}$$

where B_x^* is defined for the upper (B_x^{up}) and lower leaf (B_x^{low}) functions as:

$$B_x^* = B_{lim} + \left[\frac{(B_{50}^* - B_{lim})(B_{trigger} - B_{lim})}{\left|(B_{trigger} - B_{lim}) - 2(B_{50}^* - B_{lim})\right|}\right] \qquad \text{Eq. 2}$$

where B_{50}^{*}, defined for the upper (B_{50}^{upper}) and lower (B_{50}^{lower}) leaf edge functions, controls the width of the leaf. In order to maintain a symmetric leaf shape B_{50}^{*} needs to be set in a "complementary" way in the upper and lower edge functions (see below).

To facilitate the setup of the leaf width, this was implemented via B_{50}^{*} as determined by X_{50}^{*}, i.e. $B_{50}^{*} = X_{50}^{*}(B_{trigger} - B_{lim}) + B_{lim}$, where X_{50}^{*} represents the fraction within the $B_{lim} - B_{trigger}$ range where the B_{50}^{*} is located. For the upper leaf edge function, X_{50}^{upper} must fall between 0 and 0.5, while for the lower leaf edge function X_{50}^{lower} must fall between 0.5 and 1. As mentioned above, to maintain the symmetry of the NAFO Leaf HCR, the two X_{50}^{*} must be "complementary" in the sense that $X_{50}^{lower} = 1 - X_{50}^{upper}$.

Using B_{x}^{*} from Eq. 2, a^{*} can then be calculated for both the upper (a^{up}) and lower (a^{low}) leaf edge functions as:

$$a^{*} = \frac{F_{target}\,[(B_{x}^{*} - B_{lim}) + (B_{trigger} - B_{lim})]}{(B_{trigger} - B_{lim})}. \qquad \text{Eq. 3}$$

The working group agreed with this possible formulation of the HCR and discussed the possible leaf widths to be tested. Three possible leaf widths were proposed:

Wide: X_{50}^{up} = 0.1, X_{50}^{low} = 0.9

Mid: X_{50}^{up} = 0.25, X_{50}^{low} = 0.75

Narrow: X_{50}^{up} = 0.4, X_{50}^{low} = 0.6

The working group noted that the narrow option was very similar to the linear model, and that the wide option would cause the curve to change sharply, which could create a large change in TAC resulting in problems in practice. The working group agreed to move forward with the following options:

Generic testing	**Specific testing**
Three sets of X_{50}^{*} values selected for simulations Wide: X_{50}^{up} = 0.1, X_{50}^{low} = 0.9 Mid: X_{50}^{up} = 0.25, X_{50}^{low} = 0.75 Narrow: X_{50}^{up} = 0.4, X_{50}^{low} = 0.6 The order of priority of the scenarios will be: Mid, Wide, Narrow	Mid: X_{50}^{up} = 0.25, X_{50}^{low} = 0.75 Depending on the results of the generic testing, and feasibility, testing of the narrow and wide X_{50}^{*} values may be considered.
Three implementations of the NAFO leaf HCR: 1. selecting F at the upper edge of the leaf 2. selecting F at the lower edge of the leaf 3. for comparison, also consider the standard linear HCR (i.e. NAFO leaf midrib) If time allows: 4. selecting F using a uniform distribution to simulate randomly selecting between the leaf edges (i.e. no preference for upper or lower leaf)	Three implementations of the NAFO leaf HCR: 1. selecting F at the upper edge of the leaf 2. selecting F at the lower edge of the leaf 3. for comparison, we also consider the standard linear HCR (i.e. NAFO leaf midrib)

7. Working Group Agreements to continue with the testing process framework.

The working group noted that there were no clear reference points in the agreed framework, and decided to use the following values for the general and specific testing:

Reference Point	General Testing	Witch flounder specific testing	Cod specific testing
F limit (F_{lim})	F_{msy}	F_{msy}	$F_{30\%SPR}$
F target (F_{target})	default at 85% of F_{msy}	default at 85% of F_{msy}	default at 85% of F_{msy}
B trigger ($B_{trigger}$)	0.75*B_{msy}	0.75*B_{msy}	0.75*B_{msy}
B limit (B_{lim})	0.3*B_{msy}	0.3*B_{msy}	SSB_{2007}

Note that the limit reference points that will be used in the specific simulations will be the ones approved in the most recent SC assessments for those stocks.

The working group also discussed the main characteristics of the models and processes that will be used to test the framework. The agreements on these points were the following:

Historic and projection period for the simulation. It was agreed that for the generic testing the historic period will be run for 75 years and the HCRs will be applied for 50 subsequent years. For the specific testing it was noted that projecting out 50 subsequent years would substantially increase the computation time. The working group agreed that 25 years would be sufficient for the specific testing, subject to an increase to 50 years if that proves possible computationally. The historic period for the different specific stocks should be the same used in the last approved SC assessment.

Historic fishing scenario starting points for the generic approach. The working group agreed to use three different scenarios:

1. depleted stock that has suffered a very high fishing pressure. Fishing at two times F_{msy} (F_{crash})
2. pristine stock that has not been subject to any fishing pressure. Starting from an unfished biomass
3. a stock that has been exploited at a moderate fishing rate and reaches the starting point with a Biomass close to $B_{trigger}$. F levels around F_{msy}.

How to obtain future recruitments in age-structured models. In the generic case, it was agreed to use a Beverton and Hold model; the case of the cod 3M will be discussed in the future.

Values of the different types of errors to be implemented in the generic approach. It was agreed to revisit how to implement the process error (recruitment, numbers at age). It was also agreed that the proposed 20% observed error in the reference points may be a bit low, and that it would be advisable to undertake a literature review of the values used in other similar exercises. The possibility of using the same random numbers in the simulations for more precise estimates of the differences in results for different scenarios was also discussed.

8. Proposal for the Performance Statistics (PS) table to submit to RBMS

The working group discussed the Management Objectives and candidate performance statistics and noted that it was too early in the process to accurately define the specific performance statistics to be used. It was decided to present the table below outlining general Management Objectives to the WG-RBMS at the meeting scheduled to take place in April 2024. At this stage, these general Management Objectives are presented as an aid for defining the concepts that managers could be interested in as management objectives, and solely intended to serve as guide for the subsequent development of performance statistics for the simulation testing of the candidate PAF.

Management Objectives
Very low risk of stock depletion
Rebuild stocks to B_{msy}
Maintain stocks above B_{msy} more often than not
Maintain catches at approximately MSY in the long-term
Low risk of overfishing (fishing above F_{lim})
Good fishery performance (low interannual TAC variation, low yield loss while in the Cautious Zone)
Good stock recovery performance (good/rapid growth over time, good/short recovery times)

9. Other matters

No other matters were discussed.

10. Adjournment

The meeting adjourned at 13:00 hours.

APPENDIX I. LIST OF PARTICIPANTS

CHAIR	
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Thompson, Catherine	Fisheries Information Administrator - E-mail: cthompson@nafo.int

APPENDIX II. MEETING AGENDA

NAFO Precautionary Approach Working Group (PA-WG)

April 4th, 2024 (08:00-13:00 hours Halifax Time) by WebEx

Chair: Fernando González-Costas

Draft Agenda

1. Opening.
    1.1. Appointment of Rapporteurs.
    1.2. Adoption of Agenda
2. PA framework proposal.
    2.1. General framework.
    2.2. Formulation of the HCR to be tested.
3. PAF simulation contract
4. The generic approach PA framework testing.
    4.1. Progress made
    4.2. Possible schedule to carry out the testing
5. Specific PA framework testing.
    5.1. Progress made
    5.2. Possible schedule to carry out the testing
6. Proposal for the Performance Statistics (PS) table to submit to RBMS.
7. Other decisions to be taken by the PA or the RBMS to progress in the testing process.
8. Other matters.

APPENDIX III. SUPPLEMENTARY INFORMATION FOR THE GENERIC SIMULATION TESTING OF THE CANDIDATE PAF FOR NAFO

Presented by Mariano Koen-Alonso and Andrea Perreault (Canada)

Appendix A: Implementation of the Leaf HCR

Independently of the precise form of the HCR in the Cautious Zone, the basic generalized HCR definition for the standard PA framework is:

$$F_t \begin{cases} F_t = 0 & if \quad B_t < B_{lim} \\ F_t = f(B_t) & if \quad B_{lim} \leq B_t \leq B_{trigger} \\ F_t = F_{target} & if \quad B_t > B_{trigger} \end{cases}.$$

Within this generalized formulation, an upper or lower leaf HCR can be obtained by defining $F_t = f(B_t)$ as:

$$F_t = \frac{a^*(B_t - B_{lim})}{(B_x^* - B_{lim}) + (B_t - B_{lim})} \quad \text{Eq. 1}$$

where B_x^* is defined for the upper (B_x^{up}) and lower leaf (B_x^{low}) functions as:

$$B_x^* = B_{lim} + \left[\frac{(B_{50}^* - B_{lim})(B_{trigger} - B_{lim})}{(B_{trigger} - B_{lim}) - 2(B_{50}^* - B_{lim})}\right] \quad \text{Eq. 2}$$

where B_{50}^*, defined for the upper (B_{50}^{upper}) and lower (B_{50}^{lower}) leaf edge functions, control the width of the leaf. In order to maintain a symmetric leaf shape B_{50}^* needs to be set in a "complementary" way in the upper and lower edge functions.

To facilitate the setup of the leaf width, here we have implemented B_{50}^* as determined by X_{50}^*, i.e. $B_{50}^* = X_{50}^*(B_{trigger} - B_{lim}) + B_{lim}$, where X_{50}^* represents the fraction within the $B_{lim} - B_{trigger}$ range where the B_{50}^* is located. For the upper leaf edge function, X_{50}^{upper} must fall between 0 and 0.5, while for the lower leaf edge function X_{50}^{lower} must fall between 0.5 and 1. As mentioned above, to maintain the symmetry of the NAFO Leaf HCR the two X_{50}^* must be "complementary" in the sense that $X_{50}^{lower} = 1 - X_{50}^{upper}$.

Using B_x^* from Eq. 2, a can then be calculated for both the upper (a^{up}) and lower (a^{low}) leaf edge functions as:

$$a^* = \frac{F_{target}\,[(B_x^* - B_{lim}) + (B_{trigger} - B_{lim})]}{(B_{trigger} - B_{lim})}. \quad \text{Eq. 3}$$

Appendix B: Surplus production model

Under all scenarios, the historic period was run for 75 years (i.e. -Y, 0) and the HCR was applied for 50 (*1:Y*) subsequent years for 10000 replicates.

The population was modeled using a Schaefer surplus production model,

$$B_{y+1} = B_y + r(B_y - B_y/K) - F_y B_y$$

where B_y is the biomass in year y, r is the population growth rate, k is the carrying capacity, and F_y is the fishing mortality rate. For the first 75 years, F was based on the historic F (F_{crash} or F_0) and the HCR in subsequent years.

Process error was assumed from a lognormal distribution,

$$B_y \sim \ln(0, \sigma_{pe})$$

with the process error standard deviation fixed at 0.15 when turned on. Similarly, observation error was assumed from a lognormal distribution with standard deviation fixed at 0.15 when turned on.

Appendix C: Age structured population model

Biological inputs

Age at length was modeled using the von Bertanlaffy growth function,

$$l_a = L_\infty(1 - e^{-rate*a}(1 - a_0),$$

with asymptotic average length L_{inf}, growth rate $rate$ and age at length zero a_0. Weight at age was assumed as an allometric function of length at age,

$$w_a = al_a^b.$$

with parameters a and b. For simplicity, maturity was modeled as knife-edged, i.e.,

$$mat(a) = \begin{cases} 0, & \text{if } a < a_{50} \\ 1, & \text{if } a \geq a_{50} \end{cases}$$

and fishery selectivity from a logistic function of age

$$sel(a) = \frac{1}{1 + \exp^{-(a-a_{50})}}.$$

Recruitment

Recruitment was modeled using the Beverton-Holt stock recruit model, parametrized in terms of steepness h and unfished recruitment R_0,

$$R_y = \frac{4hR_0 ssb_y}{(1-h)R_0 SPR(0) + (5h-1)ssb_y}$$

for spawning stock biomass ssb_y and spawner per recruit $SPR(0)$ detailed below. Note that this formulation is identical to the standard BH SR model ($R_y = \frac{\alpha ssb_y}{1+\beta ssb_y}$) when

$$\alpha = \frac{4h}{SPR(0)(1-h)} \quad \text{and} \quad \beta = \frac{5h-1}{(1-h)R_0 SPR(0)}.$$

In this formulation, α/β gives the maximum recruitment (R_{max}). For redfish-like simulated stocks, sporadic recruitment was simulated based on a uniform distribution (Kelly, 2019), where in every N years (currently set at 20) there was a 10% probability of a large recruitment pulse,

$$\alpha = \begin{cases} \alpha, & \text{if } sr \leq 9 \\ \alpha^* & \text{if } sr > 9, \end{cases}$$

where sr is a random number between 0 and 1 in a uniform probability distribution, and α^* is rescaled such that the maximum recruitment is four times R_{max}.

Population Abundance

Population numbers at age were based on the standard cohort equations for years $y = -Y, \ldots, Y$ and ages $a = 1, \ldots, a_{max}$, where a_{max} was defined as the age where growth reaches 95% of L_∞, i.e. $a_{max} = a_0 - \log(0.05)/rate$ as in Fischer et al. (2020):

$$\log(N_{y,a}) = \log(N_{y-1,a-1}) - Z_{y-1,a-1},$$

where total mortality rates $Z_{y,a}$were the given by the sum of the natural $M_{y,a}$ and fishing $F_{y,a}$ mortality rates. For the first 75 years, F was based on the historic F (F_{crash}or F_0) given the fishery selectivity, and then the

HCR given fishery selectivity in subsequent years. For simplicity, natural mortality was assumed time and age invariant.

Process error was assumed from a lognormal distribution,

$$N_{y,a} \sim \ln\,(0, \sigma_{pe})$$

with the process error standard deviation fixed at 0.15 when turned on. Note that process error in recruitment was included in this assumption.

Spawning stock biomass was given by

$$ssb_y = \sum_a w_a \, mat(a) N_{y,a},$$

with maturity and weights described above. Observation error was assumed from a lognormal distribution,

$$ssb_y \sim \ln\,(0, \sigma_{obs})$$

with the observation error standard deviation fixed