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**Implications of the Revised NAFO PA Framework for the Scientific Council traffic light approach
to the provision of scientific advice**

by

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Abstract

Since 2023 the Scientific Council has used a Shiny Application to ensure a consistent approach for the production of traffic light summary tables in the Stock Summary Sheets. Several of the options and rules included in the app were based on the NAFO Precautionary Approach Framework (PAF) that existed at the time. In 2024 NAFO adopted a revised PAF, and its gradual implementation started in 2025. This revised PAF includes the definition of three stock status zones (Critical, Cautious, and Healthy), and includes a Harvest Control Rule (HCR) that changes fishing mortality (F) in the Cautious Zone as a function of stock size (the lower the stock, the lower the F). This HCR is often referred to as the “leaf HCR” because it provides a leaf-shaped range of acceptable Fs in the Cautious Zone. As part of the implementation process of the revised PAF, modifications to the options and rules in the Shiny Application are now needed. This work puts forward a series of proposals to address these needs. While some of the proposed changes are minor in nature and have very little influence on the functioning of the app, others are more substantial, and affect the way in which Scientific Council summarizes its advice. While attempts were previously made to incorporate the revised PAF in the 2025 science advice, these efforts did not fully capture how acceptable levels of fishing mortality differ between the three zones of the PAF. Changes to the app are proposed here to account for the specifics of the revised PAF and in particular the leaf HCR.

Introduction

NAFO Scientific Council (SC) adopted the use of the traffic light summary table as an integral component of the stock advisory sheet (a.k.a. stock summary sheet) in 2013 (NAFO 2013). The traffic lights are intended to be a simple and effective way to communicate the most important details pertaining to stock status, ecosystem considerations and fisheries aspects to managers (i.e. NAFO Commission). After demonstrating inconsistencies in how traffic light colours were being assigned, Rideout et al. (2023) developed a Shiny application that ensured consistency going forward by implementing within the application a set of agreed colour allocation rules. Both the rules and categories in the Shiny application were based on the version of the NAFO Precautionary Approach Framework (PAF) that was in effect at that time (NAFO 2004). The NAFO PAF has been recently updated (NAFO 2025a) and now includes reference points (e.g. $B_{trigger}$, F_{target}) that were not part of the previous PAF. The revised PAF also incorporates a harvest control rule (often referred to as the 'leaf' or the 'leaf HCR') when the stock is in the Cautious Zone that depicts how fishing mortality should decline as stock size declines towards B_{lim} (i.e. the start of the Critical Zone), below which there should be no fishing mortality (or as low as possible in practice). These changes are not accounted for in the procedures that are currently in place for assigning traffic light colours. Modifications are made here to attempt to bring the traffic light rules in line with the revised PAF and to make those modifications within the Shiny app.

Methods & Results

The summary table produced by the modified version of the Shiny application maintains the exact same format as the previous version (Figure 1), with three columns corresponding to 'Convention Principle', 'Status', and 'Comment', and six rows corresponding to different Convention Principles. Three of the convention principles ('Eliminate Overfishing (Ecosystem)', "Minimize harmful impacts on living marine resources and ecosystems", "Preserve marine biodiversity") are not impacted by the proposed changes to the Shiny application and are not discussed any further here.

For the Convention Principle to "Restore to or maintain at B_{msy} " the proposed changes are considered minor in nature. The proposed differences stem from the introduction of $B_{trigger}$ in the revised PAF ($B_{trigger} = 0.75B_{msy}$) as the boundary to the Healthy Zone. As a result, the proposed changes are to simply replace ' B_{msy} ' in the previous version of the app with ' $B_{trigger}$ ' in the new version (Figure 2). The default text has also been updated to include the appropriate zone of the PA where applicable. These changes do not have any traffic light implications. All options related to situations where the zones of the PA are not defined, etc. are also maintained.

Minor changes are also proposed for the Convention Principle to "Apply PA". These changes simply reflect that with the revised PAF there are additional reference points ($B_{trigger}$, F_{target}) to be considered. Hence the previous selection of 'Blim and Flim defined' has been changed to 'All PA reference points defined'. Likewise, the previous selection of 'Blim defined, Flim undefined' has been changed to 'Blim defined, other B and F reference points undefined' (Figure 3). Other options remain the same and there are no impacts on traffic lights.

The proposed changes for the Convention Principle to "Eliminate Overfishing (Stock)" are much larger and should be subject to closer scrutiny than the other revisions. The first proposed revision is a result of the fact that the addition of F_{target} to the revised PAF creates a new F-zone to assign traffic lights to. This new zone is represented by the option ' $F_{target} < F \leq F_{lim}$ ' and it is assigned a yellow traffic light (Figure 4). The previous selection of ' $F < F_{lim}$ ' has been replaced with ' $F \leq F_{target}$ '. The biggest changes, however, relate to the fact that the revised PAF suggests that sustainable levels of fishing differ depending on the zone of the PA that the stock is located. In the Healthy Zone, the value of F is evaluated relative to the defined reference points of F_{target} and F_{lim} (Figure 4). When the stock falls into the Cautious Zone, F is evaluated relative to the range of values suggested by the leaf HCR. If $F >$ the upper range of the values defined by the leaf HCR then F should be considered too high and proposed revisions to the Shiny application would assign a red traffic light (Figure 4). If $F <$ the upper range of the values defined by the leaf HCR then the traffic light should be green. The HCR suggests that the traffic light should be red when the stock is in the critical zone. More specifically, the traffic

light should be red when the stock is in the critical zone and $F > 0$ (always the case). A general depiction of the revised PA plot coloured to represent the proposed traffic light assignments is presented in Figure 5.

Discussion

The proposed changes to the Shiny application and the rules used to assign traffic lights are intended to bring the advice provided in the NAFO SC summary tables in line with the guidelines of the revised PAF (NAFO 2025a). It is noted that many proposed changes are minor and straightforward. This is the case for proposed changes to the Convention Principles ‘Restore to or maintain at Bmsy’ and ‘Apply PA’. It is noted that the proposed changes for those principles mirror on-the-fly attempts to manually update the summary tables to match the revised PA in 2025 (NAFO 2025b).

The suggested changes for the Convention Principle ‘Eliminate Overfishing (Stock)’, however, are much more significant and are based on the notion that the revised PAF suggests evaluating F differently depending on what PA zone the stock is in. The proposed revisions are based on an initial understanding of how the Leaf HCR in the PAF works. Based on the equations describing the HCR (NAFO 2025a), F should decline from F_{target} at the boundary between the Healthy Zone and the Cautious Zone down to $F=0$ at Blim (i.e. the boundary between the Cautious Zone and the Critical Zone). This would also suggest that no level of F above zero should occur in the Critical Zone. Hence red traffic lights should be assigned for any level of F above the upper range of the leaf when the stock is in the Cautious Zone and the traffic light should essentially always be red (unless F is actually zero) when the stock is in the Critical Zone. The initial application of the revised PAF in the provision of science advice for NAFO-managed fish stocks (NAFO 2025b) appears to be based on the same interpretation of the HCR (i.e. the leaf depicted in the STACFIS reports for stocks such as 3M cod and 3LNO yellowtail flounder meets Blim at $F=0$). However, the changes proposed here for how F is evaluated in the summary tables would be much different than the approach taken in 2025, where F was solely evaluated relative to Flim irrespective of the zone the stock was in (NAFO 2025b).

The proposal to assign a green traffic light for any F value below the upper edge of the leaf HCR reflects the testing of the PAF that was previously performed (NAFO 2024). The testing was based on the entire potential range of values within the leaf, and NAFO adopted the PAF based on this testing. From that perspective it makes sense that any level of F that falls within the leaf should be considered acceptable (Figure 5). On the other hand, one might consider it ineffective in practice to jump from a zone considered acceptable, with a green traffic light assignment (i.e. below the leaf upper value), to a zone that is considered not acceptable with a red traffic light assignment (i.e. above the leaf upper value) with no cautionary or warning zone in between. Still, this very situation also occurs with the Ecosystem Reference Point for the risk of ecosystem overfishing, which is assigned green for all catches below it, and changes to red when catches exceed it. Another option would be to consider assigning a yellow traffic light when the F value falls within the upper half of the leaf (Figure 6). This would be in line with simulations demonstrating that F values in this region delay rebuilding the stock to Bmsy. Support for such an approach would likely require further discussions within SC and with managers.

It also needs to be pointed out that there is no wording in the revised PAF to state that the value of F at or below Blim should be zero. The PAF actually indicates that “ F should be set as low as possible”, and that the primary focus of management should be to “rebuild the stock out of the Critical Zone”. Further, the Kobe plot used in the description of the PAF has no actual values on the y-axis, leaving the door open for some level of fishing mortality in the Critical Zone. While the simulation testing used to assess the performance of the PAF assumed $F=0$ in the Critical Zone (NAFO 2024), and hence the results are conditional to this assumption, the adopted PAF provides some allowance for some low level of fishing mortality in the Critical Zone.

It is obvious that an F value of zero is virtually impossible to achieve in real life even under a fishing moratorium due to bycatch in other fisheries. One interpretation along these lines, and given the language in the PAF, is that the leaf HCR reduces F to some very low value (but not zero) at Blim. Under this interpretation (Figure 7), very low levels of F in the Critical Zone might result in a yellow traffic light. At the

moment there is no explicit indication in the PAF of what an acceptable level of fishing mortality in the critical zone would be, and there is a clear inconsistency between the Kobe plot used to illustrate the PAF, and the language used to describe it (NAFO 2025a).

The above observations highlight that there are still questions and inconsistencies in the revised PAF that still need to be resolved. The proposal put forward here for revisions to the rules governing traffic light assignment is based on the premise of F reducing to zero at Blim, due to its alignment with the Kobe plot as depicted in the PAF and the structure of the simulation testing used to assess the PAF performance. Under this premise, the convention objective of “Eliminate Overfishing (Stock)” should always be assigned a red traffic light when the stock is in the Critical Zone, but given the inconsistencies that exist within the revised PAF, this premise remains open for discussion.

Acknowledgements

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References

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Convention Principle	Status	Comment
Restore to or maintain at Bmsy	●	$B_{lim} < B < B_{trigger}$
Eliminate Overfishing (Stock)	●	$F < F_{lim}$
Eliminate Overfishing (Ecosystem)	●	Total EPU catches < 2TCI
Apply Precautionary Approach	●	All PA reference points defined
Minimize harmful impacts on living marine resources and ecosystems	●	Directed fishery, VME closures in effect, Effectiveness of bycatch regulations uncertain
Preserve marine biodiversity	●	Cannot be evaluated

● OK

● Intermediate

● Not accomplished

● Unknown

Figure 1. Example of summary table produced with the Shiny Application and used in the provision of advice in 2025.

Figure 2 illustrates proposed changes to the traffic light colour allocation rules for the convention objective 'Restore To Or Maintain At Bmsy'. The figure shows two panels side-by-side, separated by a double-headed arrow, representing the previous and proposed versions of the application.

Left Panel (Previous Version):

- Convention Objective: Bmsy
- Restore To Or Maintain At Bmsy ⓘ
 - ☒ B > Bmsy (Green light)
 - ☐ Blim < B < Bmsy (Yellow light)
 - ☐ Bmsy undefined, B > Blim (Yellow light)
 - ☐ B < Blim (Red light)
 - ☐ Bmsy and Blim undefined, stock level not a concern (Yellow light)
 - ☐ Bmsy and Blim undefined, stock level low/depleted (Red light)
 - ☐ Bmsy and Blim undefined, stock status unknown (Grey light)
 - ☐ Inappropriate given life history (Grey light)

Right Panel (Proposed Version):

- Convention Objective: Bmsy
- Restore To Or Maintain At Bmsy ⓘ
 - ☒ B > Btrigger (Healthy Zone) (Green light)
 - ☐ Blim < B < Btrigger (Cautious Zone) (Yellow light)
 - ☐ B > Blim, Btrigger undefined (Yellow light)
 - ☐ B < Blim (Critical Zone) (Red light)
 - ☐ Bmsy and Blim undefined, stock level not a concern (Yellow light)
 - ☐ Bmsy and Blim undefined, stock level low/depleted (Red light)
 - ☐ Bmsy and Blim undefined, stock status unknown (Grey light)
 - ☐ Inappropriate given life history (Grey light)

Figure 2. Illustration of proposed changes to the traffic light colour allocation rules within the Shiny application for the convention objective to 'Restore to or Maintain at Bmsy'. The panel on the left represents the radio button selections in the previously accepted version of the application and the associated traffic light colours for those selections. The panel on the right represents the proposed changes (outlined in red) and the associated traffic lights.

Figure 3 illustrates proposed changes to the traffic light colour allocation rules for the convention objective 'Apply PA'. The figure shows two panels side-by-side, separated by a double-headed arrow, representing the previous and proposed versions of the application.

Left Panel (Previous Version):

- Convention Objective: Apply PA
- Apply PA ⓘ
 - ☒ Blim and Flim defined (Green light)
 - ☐ Blim defined, Flim undefined (Yellow light)
 - ☐ No reference points defined (Red light)
 - ☐ No suitable PA in place for life history strategy (Red light)

Right Panel (Proposed Version):

- Convention Objective: Apply PA
- Apply PA ⓘ
 - ☒ All PA reference points defined (Green light)
 - ☐ Blim and Flim defined, other B and F reference points undefined (Yellow light)
 - ☐ Blim defined, other B and F reference points undefined (Yellow light)
 - ☐ No reference points defined (Red light)
 - ☐ No suitable PA in place for life history strategy (Red light)

Figure 3. Illustration of proposed changes to the traffic light colour allocation rules within the Shiny application for the convention objective to 'Apply PA'. The panel on the left represents the radio button selections in the previously accepted version of the application and the associated traffic light colours for those selections. The panel on the right represents the proposed changes (outlined in red) and the associated traffic lights.

Convention Objective
Overfishing_stock

Eliminate Overfishing_stock ⓘ

- ☒ $F < F_{lim}$
- ☐ $F > F_{lim}$
- ☐ F_{lim} undefined, F level is not a concern
- ☐ F_{lim} undefined, F level is a concern
- ☐ F and F_{lim} undefined, catch levels not a concern
- ☐ F and F_{lim} undefined, catch levels are a concern
- ☐ Unknown

Convention Objective
Overfishing_stock

Eliminate Overfishing_stock ⓘ

Healthy Zone

- ☒ $F < F_{target}$
- ☐ $F_{target} < F < F_{lim}$
- ☐ $F > F_{lim}$

Cautious Zone

- ☐ $F < \text{Upper } F \text{ range indicated by the PA}$
- ☐ $F > F \text{ range indicated by the PA}$

Critical Zone

- ☐ $F > 0$

PA Zones Not Defined

- ☐ F_{lim} undefined, F level is not a concern
- ☐ F_{lim} undefined, F level is a concern
- ☐ F and F_{lim} undefined, catch levels not a concern
- ☐ F and F_{lim} undefined, catch levels are a concern
- ☐ Unknown

Figure 4. Illustration of proposed changes to the traffic light colour allocation rules within the Shiny application for the convention objective to 'Eliminate Overfishing_Stock'. The panel on the left represents the radio button selections in the previously accepted version of the application and the associated traffic light colours for those selections. The panel on the right represents the proposed changes (outlined in red) and the associated traffic lights.

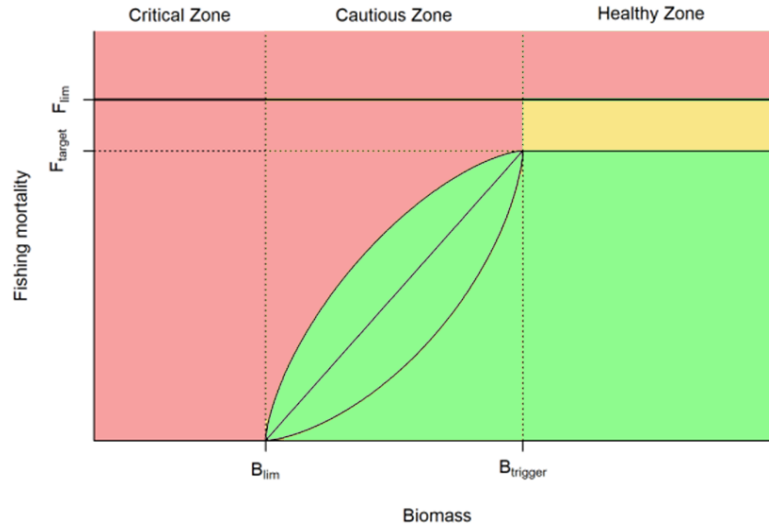


Figure 5. Illustration depicting how the revised NAFO PAF could be interpreted in terms of traffic light colours for the convention objective of 'Eliminate Overfishing (Stock)'. The proposed interpretation suggests that when the stock is in the cautious zone any F level above the upper range of the leaf would result in a red traffic light and that any F level above zero would result in a red traffic light when the stock is in the critical zone.

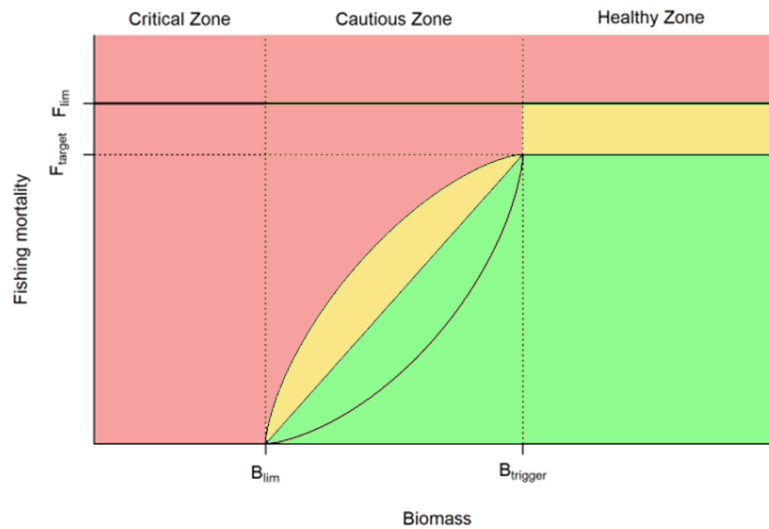


Figure 6. Illustration depicting an alternative for how the revised NAFO PAF could be interpreted in terms of traffic light colours for the convention objective of 'Eliminate Overfishing (Stock)'. This interpretation includes a yellow cautionary area in the upper half of the leaf HCR. All other aspects are the same as the previous proposal.

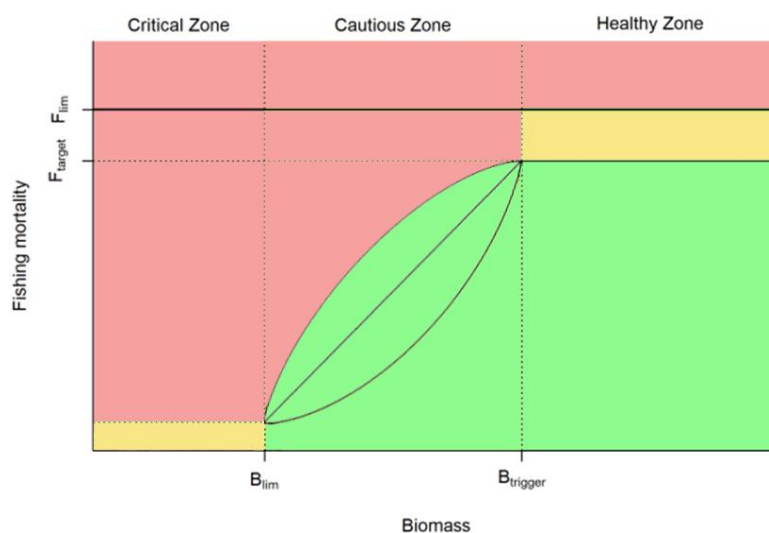


Figure 7. Inconsistencies in the revised NAFO PA could lead to an alternative interpretation for how traffic light colours could be assigned for the convention objective to 'Eliminate Overfishing (Stock)'. In this interpretation there is some small level of F in the critical zone that would result in a yellow traffic light. Note that this does not reflect the plot in the accepted revised PAF.