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**Framework for describing stock status and providing management advice
in relation to reference points**

INTRODUCTION

1. One of the main purposes of the Scientific Advisory Committee (SAC) of the GFCM is to assess the status of exploited populations of fish and other marine living resources in the Mediterranean and the Black Sea and provide management advice to ensure the sustainable exploitation of these resources. The SAC assessment of stock status and related management advice emanates from dedicated expert groups (e.g. the working groups on stock assessment for small pelagics and demersal species or the recent Subregional group for the assessment of Black Sea stocks), which are revised by the Subcommittee on Stock Assessment (SCSA) and provided to the SAC for endorsement and final advice to the GFCM Commission.
2. Within the expert groups on stock assessment, advice has been provided following terms of reference and recommendations from the SAC, and also in accordance with FAO and international standards and guidelines. In 2012, following several recommendations made on the management of different fisheries in the Mediterranean and Black Sea (e.g. Recommendations GFCM/27/2002/1, GFCM/30/2006/1 and Resolution GFCM 33/2009/1 on the management of certain fisheries exploiting demersal and small pelagic), and on the basis of SAC advice on the need to develop multiannual management plans based on agreed reference points, the GFCM formulated at its thirty-sixth session "Guidelines on a general management framework and presentation of scientific information for multiannual management plans for sustainable fisheries in the GFCM area"¹. These guidelines include clear indications on suitable objectives and procedures to implement a management plan, and provide a clear definition of the requirements to provide scientific advice useful for management. The framework is based on the definition of reference points related to key indicators of the status of stocks, such as stock biomass and fishing mortality.
3. In order to further standardize and simplify the definitions of stock status as well as management advice provided by the expert groups, the thirty-seventh session of the Commission agreed to organize a workshop on the definition and use of reference points to provide advice on stock status and management measures. The main conclusions of this workshop were revised by the both working groups on stock assessment and the SCSA and then endorsed by the SAC at its sixteenth session. This document contains a framework on how to describe status of stocks and provide management advice for those stocks for which reference points are adopted by the SAC.

¹ These guidelines are referred to as Resolution OTH-GFCM/36/2012/1 in the Compendium of GFCM decisions.

GENERAL CONSIDERATIONS

4. This document provides definitions for stock status and management advice on stocks for which reference points related to indicators of biomass and/or exploitation are available. The GFCM Guidelines on management plans define three categories of reference points to be used to provide advice:
- target reference point, i.e. a management objective that points to a state of a fishing and/or biological resource which is considered to be desirable. Target reference points should be set sufficiently far away from a limit reference so that the probability that the limits will be exceeded is low. The trajectory toward the target(s) may be represented either on a linear plot with a single target reference point or on a two-dimension plot using two target reference points or on a multidimensional plot when more than two target reference points are used.
 - threshold reference point, i.e. a precautionary reference point expressed either as fishing mortality rate or a level of biomass or another agreed indicator. They are between the limit and target reference points and used to reduce the probability that the limit reference point will be exceeded. They serve as a red flag and may trigger particular management actions designed to reduce fishing pressure and mortality. After this point pre-negotiated management measures to reverse the situation should be initiated.
 - limit reference point, i.e. a conservation reference point expressed either as a fishing mortality rate or level of biomass or another agreed indicator that indicates to a state of a fishery and/or a resource which is considered to be undesirable and which management actions should avoid with high probability. After this point pre-negotiated management measures to reverse the situation should be initiated.
5. In addition to these definitions, the following considerations are proposed in this document:

In relation to reference points and stock status:

- Suitable indicators for biomass can be either **Total Biomass** or **Spawning Stock Biomass**, while suitable indicators for exploitation can be either **Fishing mortality** or **Exploitation rate** (ratio between fishing mortality and total mortality). In all cases, reference points should be defined in relation to the indicator used. For simplification, in this document the acronym “**B**” refers to any biomass indicator, while the acronym “**F**” refers to any indicator of exploitation.
- Following the recommendations from the SAC, the advice should be based, if possible, on both indicators of biomass and exploitation, and for each indicator ideally target, threshold and limit (e.g. F_{tgt} , F_{thr} , F_{lim}) reference points should be defined. When only one indicator is available, there should be a clear advice to explore the possibility of having indicators for both biomass and exploitation.
- In general terms, a suggested target reference point for biomass and exploitation is that value of the indicator at which maximum sustainable yield (MSY) is obtained from the fishery, in accordance with the 1995 UN Fish Stocks Agreement (UNFSA), while limit and threshold reference points should be established based on precautionary principles.
- When only one reference point is available for a given indicator, the reference point is referred to as unique reference point (B_{unique} or F_{unique}), and it should refer to MSY.
- When the exploitation rate is used as an indicator, and in absence of a stock-specific reference point, F_{unique} for small pelagics can be defined as $E=0.4$ following the proposal of Patterson (1999).
- When fishing mortality is used as an indicator, $F_{0.1}$ (defined as the fishing mortality rate at which the slope of the yield-per-recruit curve is only one-tenth the slope of the curve at its origin) can be used as a proxy for F_{MSY} . If possible $F_{0.1}$ should be complemented with an additional estimate of F_{lim} (e.g. from an independent B_{lim} estimate) and F_{thr} should be defined

in relation to F_{lim} . In that case F_{MSY} will be considered as a target. Alternatively, if only $F_{0.1}$ is available, it will be considered as F_{unique} .

- For small pelagic fish, a threshold and limit reference point for biomass, based on reproductive capacity should be established to maximize probability of obtaining good recruitments. In the absence of precise stock recruitment relationships that allow estimating it, B_{lim} is proposed to be defined as the lowest biomass from which a recovery has been confirmed (B_{loss}), estimated from an analysis of time series of biomass estimates. Time series should be sufficiently long and only if the analysis provides consistent perspective in the historical and the recent part of the time series this reference points is to be considered. Whenever similar minima that meet the required criteria (recovery) exist in the time series the upper value should be chosen as a precautionary approach. B_{thr} is defined as a point at which the probability to be below B_{lim} is lower than 5%. In absence of precise estimates of the distribution of the biomass estimate, a lognormal distribution of B_{lim} should be assumed, with a coefficient of variation of 40%. This approximately results in $B_{thr} = 2 * B_{lim}$

In relation to management advice:

- Management advice is provided based on both the assessment of the status of the stock and the reference points used for this assessment. If the assessment is based on the full range of indicators (i.e. F and B) and reference points (i.e. target, threshold and limit), then a more precise advice can be provided. If on the other hand the assessment is based on a reduced number of indicators or reference points, then a more precautionary advice is provided due to limited information which could result in increasing risk for the sustainability of the fishery.
- When a reduction of fishing mortality is advised, it should be implemented by means of a multiannual management plan, done in accordance with the GFCM guidelines for management plans. The amount of reduction in fishing mortality resulting from the implementation of the plan should be proportional to the distance between the target fishing mortality and the current fishing mortality. Management advice emanating from the expert groups should therefore include the ratio between current estimate of the indicator of F and either its target or the unique reference point for F (i.e. F_{curr} / F_{target} or F_{curr} / F_{unique})
- When the status of stock is outside biological limits (as indicated by one or both indicators used), a recovery plan should be established. Minimum objectives for recovery plan should ensure that human pressure (direct and indirect) on the population is reduced to minimum and a close monitoring of population condition is established.

STOCK STATUS AND MANAGEMENT ADVICE IN RELATION TO REFERENCE POINTS

6. Stock status and proposed management advice for different combinations of indicators (only F, only B or both) and reference points (a unique reference point, precautionary – limit and threshold – reference points, or a full set of target, threshold or limit reference points) available for a given stock are provided in Tables 1 – 15. The diagram included in Figure 1 identifies the appropriate table for the different combinations of indicators and reference points available.

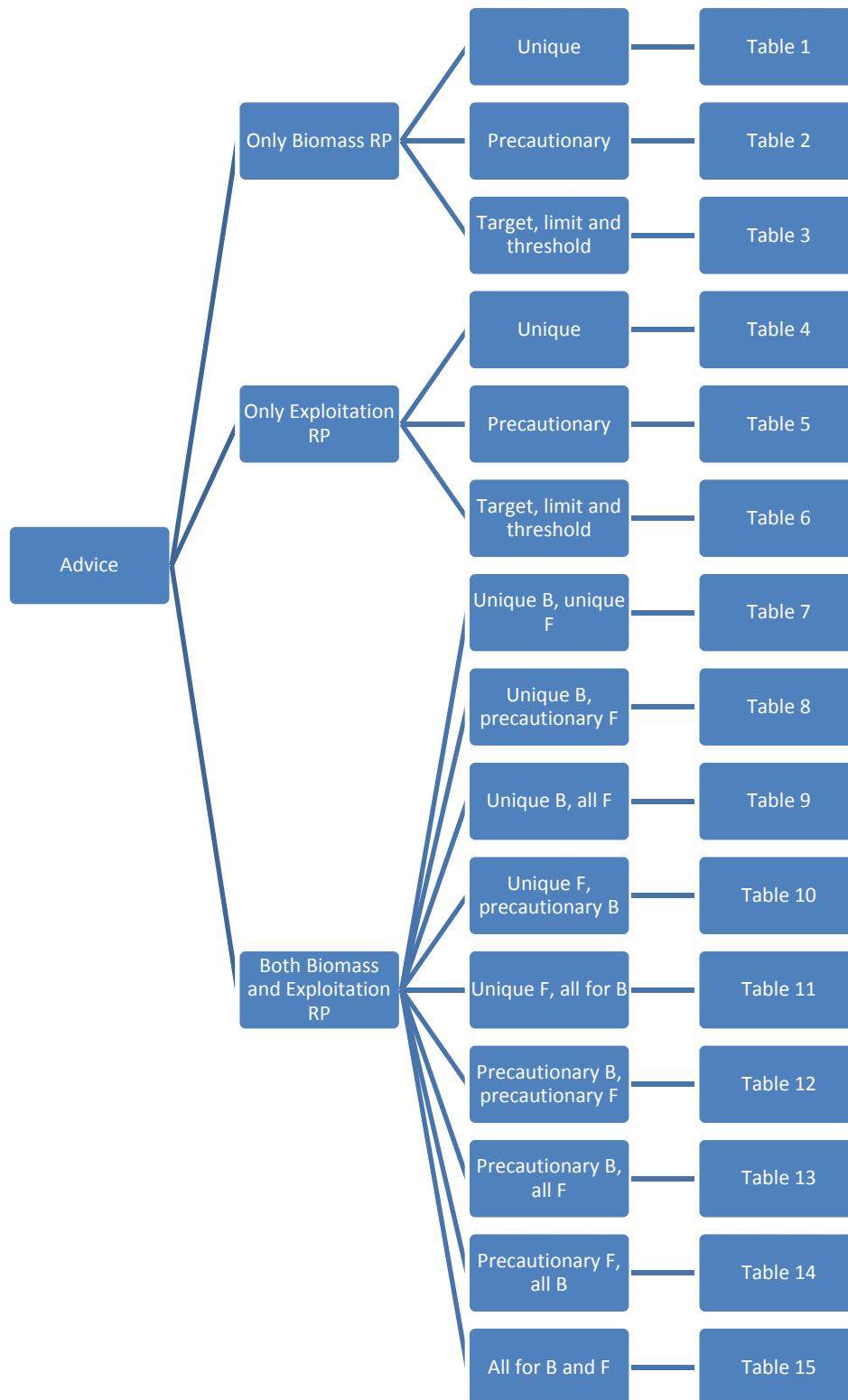


Figure 1: Diagram for the different stock assessment and management advice situations based on the indicators used and the reference points adopted. For each stock, the diagram indicates the adequate table to provide an assessment of stock status and its associated management advice.

Table 1: Advice for stocks that only have a single reference point for biomass

Current assessment	Status of stock	Advice
$B > B_{\text{unique}}$	No signals of overexploitation	Do not increase fishing mortality
$B < B_{\text{unique}}$	Overexploited	Reduce fishing mortality

Table 2: Advice for stocks that have precautionary reference points only for biomass (threshold and limit)

Current assessment	Status of stock	Advice
$B > B_{\text{thr}}$	No signals of overexploitation	Do not increase fishing mortality
$B_{\text{thr}} > B > B_{\text{lim}}$	Low biomass	Reduce fishing mortality
$B < B_{\text{lim}}$	Depleted / Collapsed	Implement a recovery plan

Table 3: Advice for stocks that have all reference points (target, threshold and limit) for biomass only

Current assessment	Status of stock	Advice
$B > B_{\text{trg}}$	Sustainably exploited	Do not increase fishing mortality
$B_{\text{trg}} > B > B_{\text{thr}}$	Biomass below target	Reduce fishing mortality
$B_{\text{thr}} > B > B_{\text{lim}}$	Low biomass	Reduce fishing mortality
$B < B_{\text{lim}}$	Depleted / Collapsed	Implement a recovery plan

Table 4: Advice for stocks that only have a single reference points for exploitation

Current assessment	Status of stock	Advice
$F < F_{\text{unique}}$	Sustainable exploitation	Do not increase fishing mortality
$F > F_{\text{unique}}$	In overexploitation	Reduce fishing mortality

Table 5: Advice for stocks that only have precautionary reference points for exploitation (threshold and limit)

Current assessment	Status of stock	Advice
$F < F_{thr}$	Sustainable exploitation	Do not increase fishing mortality
$F_{thr} < F < F_{lim}$	In overexploitation	Reduce fishing mortality
$F > F_{lim}$	In severe overexploitation	Immediate action to ensure a reduction in fishing mortality *

Table 6: Advice for stocks that have all reference points (target, threshold and limit) for exploitation only

Current assessment	Status of stock	Advice
$F < F_{trg}$	Sustainable exploitation	Do not increase fishing mortality
$F_{trg} < F < F_{thr}$	In low overexploitation	Reduce fishing mortality
$F_{thr} < F < F_{lim}$	In overexploitation	Reduce fishing mortality
$F > F_{lim}$	In severe overexploitation	Immediate action to ensure a reduction in fishing mortality *

*Monitoring that the level of fishing mortality actually decreases should be ensured.

Table 7: Advice for stocks with a unique reference point for both biomass and exploitation

Current assessment	Status of stock	Advice
$B > B_{\text{unique}}$	Sustainably exploited	Evaluate potential fishing opportunities*
$F < F_{\text{unique}}$		
$B > B_{\text{unique}}$	Biomass above reference point and in overexploitation	Reduce fishing mortality
$F > F_{\text{unique}}$		
$B < B_{\text{unique}}$	Overexploited with a low fishing mortality or ecologically unbalanced but with a low fishing mortality**	Reduce fishing mortality and/or implement a recovery plan
$F < F_{\text{unique}}$		
$B < B_{\text{unique}}$	Overexploited and in overexploitation	Immediate action to ensure a reduction in fishing mortality ***
$F > F_{\text{unique}}$		

- *Fishing opportunities should be evaluated taking into account ecosystem and socio-economic considerations and future risks for the target stock.
- ** Ecologically unbalanced refers to situations in which the low biomass is not believed to be caused by continuous human pressure, but else to changes in the ecosystem that prevents higher biomass.
- ***Monitoring that the level of fishing mortality actually decreases should be ensured.

Table 8: Advice for stocks with precautionary (limit and threshold) reference points for exploitation and unique reference points for biomass

Current assessment	Status of stock	Advice
$B > B_{\text{unique}}$	Sustainably exploited	Evaluate potential fishing opportunities*
$F < F_{\text{thr}}$		
$B > B_{\text{unique}}$	Biomass above reference point and in overexploitation	Reduce fishing mortality
$F_{\text{lim}} > F > F_{\text{thr}}$		
$B > B_{\text{unique}}$	Biomass above reference point and in severe overexploitation	Reduce fishing mortality immediately
$F > F_{\text{lim}}$		
$B < B_{\text{unique}}$	Overexploited with a low fishing mortality or ecologically unbalanced with a low fishing mortality**	Reduce fishing mortality and/or implement a recovery plan
$F < F_{\text{thr}}$		
$B < B_{\text{unique}}$	Overexploited and in overexploitation	Reduce fishing mortality and/or implement a recovery plan
$F_{\text{lim}} > F > F_{\text{thr}}$		
$B < B_{\text{unique}}$	Overexploited and in severe overexploitation	Immediate action to ensure a reduction in fishing mortality ***
$F > F_{\text{lim}}$		

- *Fishing opportunities should be evaluated taking into account ecosystem and socio-economic considerations and future risks for the target stock.
- ** Ecologically unbalanced refers to situations in which the low biomass is not believed to be caused by continuous human pressure, but else to changes in the ecosystem that prevents higher biomass.
- ***Monitoring that the level of fishing mortality actually decreases should be ensured.

Table 9: Advice for stocks with limit, threshold and target reference points for exploitation and unique reference points for biomass

Current assessment	Status of stock	Advice
$B > B_{\text{unique}}$	Sustainably exploited	Evaluate potential fishing opportunities*
$F < F_{\text{tr}}$		
$B > B_{\text{unique}}$	Biomass above reference point and in low overexploitation	Reduce fishing mortality
$F_{\text{thr}} > F > F_{\text{tr}}$		
$B > B_{\text{unique}}$	Biomass above reference point and in high overexploitation	Reduce fishing mortality
$F_{\text{lim}} > F > F_{\text{thr}}$		
$B > B_{\text{unique}}$	Biomass above reference point and in severe overexploitation	Reduce fishing mortality immediately
$F > F_{\text{lim}}$		
$B < B_{\text{unique}}$	Overexploited with a low fishing mortality or ecologically unbalanced with a low fishing mortality**	Reduce fishing mortality and/or implement a recovery plan
$F < F_{\text{tr}}$		
$B < B_{\text{unique}}$	Overexploited and in low overexploitation	Reduce fishing mortality and/or implement a recovery plan
$F_{\text{thr}} > F > F_{\text{tr}}$		
$B < B_{\text{unique}}$	Overexploited and in overexploitation	Reduce fishing mortality and/or implement a recovery plan
$F_{\text{lim}} > F > F_{\text{thr}}$		
$B < B_{\text{unique}}$	Overexploited and in severe overexploitation	Immediate action to ensure a reduction in fishing mortality ***
$F > F_{\text{lim}}$ or		

- *Fishing opportunities should be evaluated taking into account ecosystem and socio-economic considerations and future risks for the target stock.
- ** Ecologically unbalanced refers to situations in which the low biomass is not believed to be caused by continuous human pressure, but else to changes in the ecosystem that prevents higher biomass.
- ***Monitoring that the level of fishing mortality actually decreases should be ensured.

Table 10: Advice for stocks with precautionary reference points for biomass (B_{thr} and B_{lim}) and unique reference points for exploitation

Current assessment	Status of stock	Advice
$B > B_{thr}$	Sustainably exploited	Evaluate potential fishing opportunities*
$F < F_{unique}$		
$B > B_{thr}$	Biomass above reference point and in overexploitation	Reduce fishing mortality
$F > F_{unique}$		
$B_{lim} < B < B_{thr}$	Overexploited with a low fishing mortality or ecologically unbalanced with a low fishing mortality**	Reduce fishing mortality or implement a recovery plan
$F < F_{unique}$		
$B < B_{lim}$	Depleted with a low fishing mortality or ecologically unbalanced with a low fishing mortality**	Immediate reduction of fishing mortality and implement a recovery plan
$F < F_{unique}$		
$B_{lim} < B < B_{thr}$	Overexploited and in overexploitation	Reduce fishing mortality immediately
$F > F_{unique}$		
$B < B_{lim}$	Depleted and in overexploitation	Implement recovery plan
$F > F_{unique}$		

- *Fishing opportunities should be evaluated taking into account ecosystem and socio-economic considerations and future risks for the target stock.
- ** Ecologically unbalanced refers to situations in which the low biomass is not believed to be caused by continuous human pressure, but else to changes in the ecosystem that prevents higher biomass.
- ***Monitoring that the level of fishing mortality actually decreases should be ensured.

Table 11: Advice for stocks with limit, threshold and target reference points for biomass and unique reference points for exploitation

Current assessment	Status of stock	Advice
$B > B_{tr}$	Sustainably exploited	Evaluate potential fishing opportunities*
$F < F_{unique}$		
$B > B_{tr}$	Biomass above reference point and in overexploitation	Reduce fishing mortality
$F > F_{unique}$		
$B_{thr} < B < B_{tr}$	Increased risk of being overexploited	Do not increase fishing mortality and close monitoring of the stock status
$F < F_{unique}$		
$B_{thr} < B < B_{tr}$	Increased risk of being overexploited and in overexploitation	Reduce fishing mortality
$F > F_{unique}$		
$B_{lim} < B < B_{thr}$	Overexploited with a low fishing mortality or ecologically unbalanced with a low fishing mortality**	Reduce fishing mortality or Implement a recovery plan
$F < F_{unique}$		
$B < B_{lim}$	Depleted with a low fishing mortality or ecologically unbalanced with a low fishing mortality**	Immediate reduction of fishing mortality and implement a recovery plan
$F < F_{unique}$		
$B_{lim} < B < B_{thr}$	Overexploited and in overexploitation	Reduce fishing mortality immediately
$F > F_{unique}$		
$B < B_{lim}$	Depleted and in overexploitation	Implement recovery plan
$F > F_{unique}$		

Table 12: Advice for stocks with precautionary (limit and threshold) reference points for biomass and exploitation

Current assessment	Status of stock	Advice
$B > B_{thr}$	Sustainably exploited	Evaluate potential fishing opportunities*
$F < F_{thr}$		
$B > B_{thr}$	Biomass above reference point and in overexploitation	Reduce fishing mortality
$F_{lim} > F > F_{thr}$		
$B > B_{thr}$	Biomass above reference point and in severe overexploitation	Reduce fishing mortality immediately
$F > F_{lim}$		
$B_{lim} < B < B_{thr}$	Overexploited or ecologically unbalanced	Reduce fishing mortality or Implement a recovery plan
$F < F_{thr}$		
$B_{lim} < B < B_{thr}$	Overexploited and in overexploitation	Reduce fishing mortality
$F_{lim} > F > F_{thr}$		
$B_{lim} < B < B_{thr}$	Overexploited and in severe Overexploitation	Reduce fishing mortality immediately
$F > F_{lim}$		
$B < B_{lim}$	Depleted with a low fishing mortality or ecologically unbalanced with a low fishing mortality**	Immediate reduction of fishing mortality and implement a recovery plan
$F < F_{thr}$		
$B < B_{lim}$	Depleted and in overexploitation	Close the fishery and implement a recovery plan
$F_{lim} > F > F_{thr}$		
$B < B_{lim}$	Depleted with immediate risk of collapse	Close the fishery and implement a recovery plan
$F > F_{lim}$		

Table 13: Advice for stocks with precautionary (limit and threshold) reference points for biomass and limit, threshold and target reference points for exploitation

Current assessment	Status of stock	Advice
$B > B_{thr}$	Sustainably exploited	Evaluate potential fishing opportunities*
$F < F_{tr}$		
$B > B_{thr}$	Increased risk of overexploitation	Do not increase fishing mortality and close monitoring of the stock status
$F_{thr} > F > F_{tr}$		
$B > B_{thr}$	Biomass above reference point and in overexploitation	Reduce fishing mortality
$F_{lim} > F > F_{thr}$		
$B > B_{thr}$	Biomass above reference point and in severe overexploitation	Reduce fishing mortality immediately
$F > F_{lim}$		
$B_{lim} < B < B_{thr}$	Overexploited or ecologically unbalanced	Reduce fishing mortality or Implement a recovery plan
$F < F_{tr}$		
$B_{lim} < B < B_{thr}$	Overexploited and in risk of being in overexploitation	Reduce fishing mortality
$F_{thr} > F > F_{tr}$		
$B_{lim} < B < B_{thr}$	Overexploited and in overexploitation	Reduce fishing mortality
$F_{lim} > F > F_{thr}$		
$B_{lim} < B < B_{thr}$	Overexploited and in severe overexploitation	Reduce fishing mortality immediately
$F > F_{lim}$		
$B < B_{lim}$	Depleted with a low fishing mortality or ecologically unbalanced with a low fishing mortality**	Immediate reduction of fishing mortality and implement a recovery plan
$F < F_{tr}$		
$B < B_{lim}$	Depleted with unsustainable exploitation or ecologically unbalanced with unsustainable exploitation **	Immediate reduction of fishing mortality and implement a recovery plan
$F_{thr} > F > F_{tr}$		
$B < B_{lim}$	Depleted and in overexploitation	Close the fishery and implement a recovery plan
$F_{lim} > F > F_{thr}$		
$B < B_{lim}$	Depleted with immediate risk of collapse	Close the fishery and implement a recovery plan
$F > F_{lim}$		

Table 14: Advice for stocks with precautionary (limit and threshold) reference points for exploitation and limit, threshold and target reference points for biomass

Current assessment	Status of stock	Advice
$B > B_{tr}$	Sustainably exploited	Evaluate potential fishing opportunities*
$F < F_{thr}$		
$B > B_{tr}$	Biomass above reference point and in overexploitation	Reduce fishing mortality
$F_{lim} > F > F_{thr}$		
$B > B_{tr}$	Biomass above reference point and in severe overexploitation	Reduce fishing mortality immediately
$F > F_{lim}$		
$B_{thr} < B < B_{tr}$	Increased risk of being overexploited	Do not increase fishing mortality and close monitoring of the stock status
$F < F_{thr}$		
$B_{lim} < B < B_{thr}$	Overexploited or Ecologically unbalanced	Reduce fishing mortality or Implement a recovery plan
$F < F_{thr}$		
$B_{lim} < B < B_{thr}$	Overexploited and in overexploitation	Reduce fishing mortality
$F_{lim} > F > F_{thr}$		
$B_{lim} < B < B_{thr}$	Overexploited and in severe Overexploitation	Reduce fishing mortality immediately
$F > F_{lim}$		
$B < B_{lim}$	Depleted with a low fishing mortality or ecologically unbalanced with a low fishing mortality**	Immediate reduction of fishing mortality and implement a recovery plan
$F < F_{thr}$		
$B < B_{lim}$	Depleted and in overexploitation	Close the fishery and implement a recovery plan
$F_{lim} > F > F_{thr}$		
$B < B_{lim}$	Depleted with immediate risk of collapse	Close the fishery and implement a recovery plan
$F > F_{lim}$		

Table 15: Advice for stocks with limit, threshold and target accepted reference points for both biomass and exploitation

Current assessment	Status of stock	Advice
$B > B_{tr}$	Sustainably exploited	Evaluate potential fishing opportunities*
$F < F_{tr}$		
$B > B_{tr}$	Increased risk of overexploitation	Do not increase fishing mortality and close monitoring of the stock status
$F_{thr} > F > F_{tr}$		
$B > B_{tr}$	Biomass above reference point and in Overexploitation	Reduce fishing mortality
$F_{lim} > F > F_{thr}$		
$B > B_{tr}$	Biomass above reference point and in severe overexploitation	Reduce fishing mortality immediately
$F > F_{lim}$		
$B_{thr} < B < B_{tr}$	Increased risk of being overexploited	Do not increase fishing mortality and close monitoring of the stock status
$F < F_{tr}$		
$B_{lim} < B < B_{thr}$	Overexploited or ecologically unbalanced	Reduce fishing mortality or Implement a recovery plan
$F < F_{tr}$		
$B_{thr} < B < B_{tr}$	Increased risk of being both overexploited and in overexploitation	Reduce fishing mortality
$F_{thr} > F > F_{tr}$		
$B_{lim} < B < B_{thr}$	Overexploited and in risk of being in overexploitation	Reduce fishing mortality
$F_{thr} > F > F_{tr}$		
$B_{lim} < B < B_{thr}$	Overexploited and in overexploitation	Reduce fishing mortality
$F_{lim} > F > F_{thr}$		
$B_{lim} < B < B_{thr}$	Overexploited and in severe overexploitation	Reduce fishing mortality immediately
$F > F_{lim}$		
$B < B_{lim}$	Depleted with a low fishing mortality or ecologically unbalanced with a low fishing mortality**	Immediate reduction of fishing mortality and implement a recovery plan
$F < F_{tr}$		
$B < B_{lim}$	Depleted with unsustainable exploitation or ecologically unbalanced with unsustainable exploitation **	Immediate reduction of fishing mortality and implement a recovery plan
$F_{thr} > F > F_{tr}$		
$B < B_{lim}$	Depleted and in overexploitation	Close the fishery and implement a recovery plan
$F_{lim} > F > F_{thr}$		
$B < B_{lim}$	Depleted with immediate risk of collapse	Close the fishery and implement a recovery plan
$F > F_{lim}$		