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WS2023-HSMO-01

An introduction to harvest strategy management objectives

SIOFA Scientific Committee Chair and vice-Chair, SIOFA Meeting of the Parties Chair

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Abstract

At their 10th annual meeting, the SIOFA Parties endorsed the development of harvest strategies for selected SIOFA stocks and agreed to hold a joint MoP-SC intersessional workshop to define management objectives. This paper provides an introduction to harvest strategies and the associated management objectives and describes types of management objectives for the consideration of WS2023-HSMO.

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1. Introduction

At MoP10, the Meeting of Parties endorsed the development of harvest strategies for selected SIOFA stocks and agreed to hold joint MoP-SC intersessional workshop to define management objectives (MoP10 report, paragraph 91).

Harvest strategies are an important tool that informs sustainable fisheries management decisions. They include the following elements (Tingley 2023):

- Management objectives that set the outcomes for the fish population and fishery.
- A monitoring program to collect data.
- Performance indicators of the fishery's status and population health, with associated reference points.
- Management actions using pre-defined rules that are based on the performance indicators.

This paper provides an introduction to harvest strategies and the associated management objectives.

2. Harvest strategies

Harvest strategies provide a more predictable approach than the traditional use of stock assessments to provide management advice. The effectiveness of harvest strategies relies on a set of agreed management objectives for the fishery and the stock, and then using management strategy evaluations (MSE, also known as management procedures, MP) to select the Harvest Control Rule (HCR) that is most likely to achieve these goals.

As the HCR is used to set the harvest rate (i.e., the annual catch limit), harvest strategies provide a structured framework for determining the scientific management advice. This approach allows managers to identify the most important management objectives, that are then used to determine the most effective HCR to meet these objectives. See https://ofp-sam.shinyapps.io/AMPLE-intro-hcr/_w_5d6010bd/tutorials/intro_hcr.html for an introductory tutorial on HCRs developed by SPC for the WCPFC using the AMPLE package. Other similar on-line apps include;

- WCPFC South Pacific Albacore (https://ofp-sam.shinyapps.io/spample/),
- New England Groundfish (https://jjesse.shinyapps.io/hcr_app/), and
- the MSE Game for EPO Bigeye tuna (https://valeromaspez.shinyapps.io/tunamse_epo_eng/).

Harvest strategies use a pre-agreed framework for making fisheries management decisions, and includes the following core elements:

i. A monitoring programme (e.g., CPUE, surveys, and/or age composition data).
ii. An approach to estimate stock status (e.g., a stock assessment).
iii. Reference points.
iv. An HCR evaluated using MSE.

MSE is a tool or procedure that uses simulation models to help compare the expected performance of different HCRs and guides the process of harvest strategy development (Figure 1).

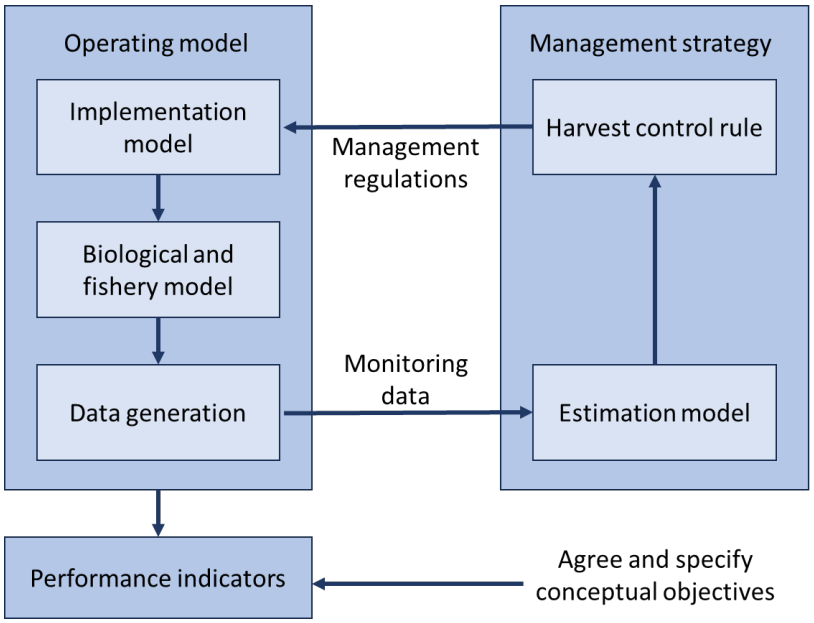

Figure 1: Conceptual overview of the management strategy evaluation modelling process (Figure 1 in Punt et al. 2016).

3. Reference points

Reference points is one of the main tools for the evaluation of an HCR. Usually there are three types: target reference points (TRP), limit reference points (LRP), and finally, trigger reference points that inform a management action (Figure 2).

TRPs define the ideal stock status. In a fishery, management actions should be designed to allow the stock to achieve this state over the medium or long term with a high degree of certainty. The stock is likely to fluctuate around the target due to natural variability and uncertainty but should not systematically deviate from it (e.g., be consistently either above or below the TRP).

The TRP is usually set to be the biomass that supports maximum sustainable yield (B_{MSY}) or a suitable proxy. Regional fisheries management organizations, such as SIOFA, are generally guided by a mandate to maintain populations at the level that can produce B_{MSY} and Article 4(d) of the SIOFA agreement states "the fishery resources shall be managed so that they are maintained at levels that are capable of producing the maximum sustainable yield, and depleted stocks of fishery resources are rebuilt to the said levels".

In 2023, the MoP agreed interim TRPs of 40% B_0 for orange roughy and 50% B_0 for toothfish with a 50% probability of being above the target (MoP10 report, paragraphs 77-78).

Limit reference points set boundaries which are intended to constrain harvesting within safe biological limits within which the stock can produce MSY.

In 2023, the MoP agreed an interim LRP of 20% B0, with a 90% probability of being above the limit, for orange roughy and toothfish (MoP10 report, paragraphs 77-78).

Trigger reference points are stock status points where management action is required to help ensure that the fishery remains close to the TRP and avoids breaching the LRP. For example, management actions may adjust the catch limit as the current stock status fluctuates above or below the TRP by raising or lowering the catch limit to ensure the stock remains close to the TRP and away from the LRP. Trigger reference points are usually specified by the Harvest Control Rule (HCR) that is used to manage a fishery. Trigger reference points have not yet been defined for any SIOFA fisheries and would be determined as a part of the MSE and be part of the final harvest strategy.

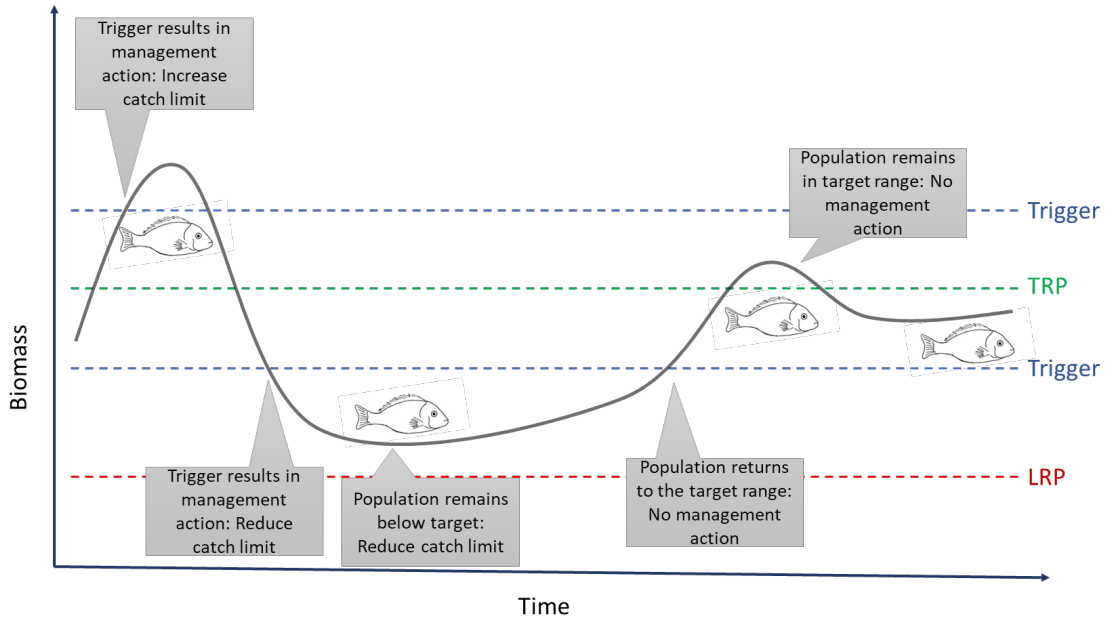

Figure 2: Example of a HCR and the effect of TRP, LRP, and trigger reference points with resulting management actions for a theoretical stock.

4. Timeline for the development of harvest strategies

In 2023, the MoP endorsed timeline for the development of harvest strategies (given in Annex 2 below, reproducing Annex G of the SC8 report).

The timeline encompassed six steps:

Step 1: Define management objectives.
Step 2: Determine appropriate fisheries monitoring regime.
Step 3 Develop candidate HCRs.
Step 4: Test HCRs with MSE.
Step 5: Implement the harvest strategy.
Step 6: Improve assessment and harvest strategy.

The first part of Step 1 is defining management objectives (e.g., biological and socio-economic), with the following components: proposing and selecting reference points (e.g., TRPs and LRPs); characterising uncertainties associated with the estimation of TRPs and LRPs; and specification of acceptable levels of risk.

5. Terms of reference for WSHSMO-2023

The Terms of Reference for the MoP Workshop on Harvest Strategy Management Objectives (WS2023-HSMO) were given in SIOFA Circular-2023/40 rev 1, and were:

The Terms of Reference for WS2023-HSMO are:

1) The aim of the workshop is for the MoP to agree on Management Objectives for the development of Harvest Strategies for selected SIOFA stocks (MoP10 report, paragraph 91).

2) To do so, WS2023-HSMO needs to develop management objective categories and, within these, preliminary management objectives in the development of harvest strategies.

3) The workshop will focus on management objectives for orange roughy and toothfish (MoP10 report, paragraph 76). In particular, WS2023-HSMO will have the following specific objectives for orange roughy and toothfish:
   a) Agree on specific management objectives for the development of harvest strategies for orange roughy and toothfish.
   b) Identify any other relevant management objectives, for example bycatch objectives, ecosystem objectives, and fishery impact objectives for harvest strategies for orange roughy and toothfish.

4) Identify potential responses to exceptional circumstances, such as dropout or breakout rules, in the implementation of harvest strategies (MoP10 report, paragraph 89), that should be considered by the Scientific Committee.

6. Management objectives

Management objectives identify the outcomes that managers want to achieve in a managed fishery and are also used to determine the measure of successful management of a target species. These are commonly grouped into five categories: status, safety, yield, abundance, and stability.

6.1 The five categories of management objectives

6.1.1 Status objectives

Status objectives are aimed at maintaining the stock at or near the target reference point (TRP).

The Scientific Committee had recommended a TRP ≈ B_{MSY} for orange roughy and alfonsino using a proxy of = 0.4×B_0 with a probability of being above the target at least 50% of the time, as this was a common surrogate used in other regions (SC8 report, paragraph 176). The Scientific Committee noted that proxies for MSY have been proposed for operationalising target reference points based on the assumption that the assessment methods would calculate depletion better than MSY, but that other equivalent operational targets may be appropriate depending on the assessment method used. The Scientific Committee also recommended a TRP = 0.5×B_0 for toothfish, with a probability of being above the target at least 50% of the time (SC8 report, paragraph 177), as this was the target used by CCAMLR in its decision rules for toothfish (Constable et al. 2000).

In 2023, MoP10 agreed that the interim TRP for orange roughy and alfonsino as a 50% probability of being above 40% B_0, and the interim TRP of 50% probability of being above 50% B_0 for toothfish (MoP10 report, paragraphs 77-78).

6.1.2 Safety objectives

Safety objectives are aimed at maximising the probability that the stock is above the limit reference point (LRP).

In 2023, MoP10 defined an interim LRP for orange roughy, alfonsino, and toothfish as a 90% probability of being above 20% B_0 (MoP10 report, paragraphs 77-78). The choice of the interim LRPs was based on advice from the SIOFA Scientific Committee (SC8 report, paragraphs 176-177).

6.1.3 Yield objectives

Yield objectives typically are aimed at maximising the catch (or sometimes effort) for a stock across regions and/or fishing gears.

6.1.4 Abundance objectives

Abundance objectives are aimed at maximising catch rates or other economic outcome to enhance fishery profitability. For example, high abundance usually leads to higher catch per unit effort and hence higher profitability of the catch.

6.1.5 Stability objectives

Stability objectives are aimed at maximising the stability of catches by minimising variability in catch from year to year, and hence reduce commercial uncertainty in annual catch limits.

6.2 Other objectives

Socio-economic, bycatch, and ecosystem objectives can be included within the categories above. Examples include:

- socio-economic objectives, e.g., requiring a minimum catch in order to ensure economic activity for a specific fleet.
- benthic impact objectives. E.g., restricting effort to ensure that the benthic footprint does not expand beyond an acceptable amount.
- Health and safety objectives, e.g., restricting vessel or other activities (vessel types, gear, locations and seasons) to ensure health and safety of vessel crew and operators.

These objectives can be included within the target species objectives, along with performance indicators, and included within the MSE to evaluate competing harvest control rules.

6.3 Examples of management objectives

Management objectives have usually been set at a high level, with the focus on outcomes from the application of performance indicators, monitoring strategy, and management strategy evaluations defining the specific management objectives for a stock. Hence, in practise, many fisheries management organisations specify high level management objectives with specific operational objectives that are encoded into the choice of performance indicators. Examples of the management objectives for WCPFC tuna species are given below, and Table 1 shows an example from the WCPFC for South Pacific albacore from Yao et al. (2019) with management objectives categorised as Biological, Economic, Ecosystem, and Social.

Table 1: Example of management objectives and performance indicators for the southern longline fishery (WCPFC14 Summary Report Attachment K) (source: Table 1 in Yao et al. 2019).

No.	Objective type	Objective Description	Performance Indicator (WP14)
1	Biological	Maintain ALB (and SWO, YFT and BET) biomass at or above levels that provide fishery sustainability throughout their range	Probability of SB/SB{F=0} > 0.2 as determined from MSE.
2	Economic	Maximise economic yield from the fishery	Predicted effort relative to E{MEY} (to take account of multi-species considerations, BET and other spp. may be calculated at the individual fishery level). B{MEY} and F{MEY} may also be considered at a single species level.

3	Economic	Maximise economic yield from the fishery	Average expected catch (may also be calculated at the assessment region level)
4	Economic	Maintain acceptable CPUE	Average deviation of predicted ALB CPUE from reference period levels
5	Economic	Taking Article 30 of the WCPFC convention into account: Maximise SIDS revenues from resource rents	Proxy: average value of SIDS/non-SIDS catch
6	Economic	Catch stability	Average annual variation in catch
7	Economic	Stability and continuity of market supply	Effort variation relative to reference period level (may also be calculated at the assessment region level)
8	Economic	Stability and continuity of market supply	Probability of and deviation from SB/SB{F=0} > 0.56 (ALB) in the short-, medium- and long-term as determined from MSE (may also be calculated at the assessment region level)
9	Social	Food security in developing states(import replacement)	As a proxy: average proportion of CCMs-catch to total catch for fisheries operating in specific regions
10	Social	Avoid adverse impacts on small scale fishers	• MSY of ALB, BET, YFT • Possible information on other competing fisheries targeting ALB (may also be calculated at the assessment region level) • Any additional information on other fisheries/species as possible
11	Ecosystem	Minimise by catch	Expected catch of other species
12	Economic	Optimise capacity	Vessel numbers targeting ALB
13	Social	Maintain/develop domestic fishery	Ratio of domestic catch to total catch
14	Social	Human resource development	Ratio of domestic catch to total catch

7. Fisheries monitoring regime

Fishery monitoring regimes are a key feature of harvest strategies and specify the programs for the scientific data collection and monitoring a stock in order to evaluate performance objectives and identify management actions to meet the management objectives. While these are not required for setting of management objectives, the choice of performance indicators and methods for evaluating harvest strategies will influence the scientific data monitoring program required. Similarly, cost and practicality of monitoring may impact the choice of performance indicators.

Haul and set catch and effort data, observer sampling for catch composition, otoliths, sex, length, and maturity are currently mandated in CMM-02 (2023).

Analyses of these data and otolith ageing for growth estimation and for age composition analyses, resource survey (e.g., acoustic surveys), and CPUE analyses are also carried out. These are not mandated in CMMs but have previously been a scheduled as Member and SIOFA activities and projects.

The current schedule for formal assessments for demersal stocks are defined in CMM-15 (2023) for orange roughy (every 3-5 years, CMM-15 (2023), paragraph 5), toothfish (annually, CMM-15 (2023), paragraph 30 & 47), and alfonsino (on a regular basis, CMM-15 (2023), paragraph 49).

8. Management strategy evaluation

Management strategy evaluation (MSE) is widely considered to be the most appropriate way to evaluate the trade-offs achieved by HCRs and to assess the consequences of uncertainty for achieving management goals. Butterworth et al. (2010) list three primary uses for MSE:

i. Development of the management strategy for a particular fishery,
ii. Evaluation of generic management strategies, and
iii. Identification of HCRs that will not work and should therefore be eliminated from further consideration.

The steps that should to be followed when conducting a MSE (Punt et al. 2016) are:

1. Identification of the management objectives and representation of these using performance indicators.
2. Identification of uncertainties (related to biology, the environment, the fishery and the management system) to which the HCR should be robust.
3. Development of operating models which provide a mathematical representation of the system to be managed. The operating models must represent the biological components of the system to be managed, the fishery which operates on the modelled population, how data are collected from the managed system and how they relate to the modelled population.
4. Selection of the parameters of the operating models and quantifying parameter uncertainty (ideally by fitting or 'conditioning' the operating models to data from the actual system under consideration).
5. Identification of candidate HCRs which could realistically be implemented.
6. Simulation of each HCR for the operating models.
7. Summary and interpretation of the performance indicators to evaluate the performance of each HCR —this may lead to refinement of the management objectives and informs the trade-offs among competing objectives.

9. Acknowledgements

Thank you to the SIOFA Scientific Committee Heads of Delegation and the SIOFA Secretariat for advice and input into the development of this background paper.

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Annex 1: Glossary of terms

Table 2: Glossary of terms

Symbol	Definition
Abundance Index	A quantitative measure of fish density or abundance, usually as a relative time series. An abundance index can be specific to an area or to a segment of the stock (e.g., mature fish), or it can refer to abundance stock-wide; the index can reflect abundance in numbers or weight (and when in weight, it is often called a biomass index)
B	Biomass. The weight of a defined part of the population (e.g., spawning or vulnerable biomass)
B_0	Average (mean) pre-exploitation (virgin) spawning stock biomass. The average biomass likely to exist before fishing or the long-term average biomass that would occur in the absence of fishing. This is the theoretical average carrying capacity of the spawning biomass of a fish stock
$B_{current}$	Current biomass in the year of the assessment (usually the mid spawning season biomass)
B_{MSY}	The long-term average biomass that is achieved by fishing at a constant fishing mortality rate equal to F_{MSY}., for example the biomass able to produce Maximum Sustainable Yield (MSY)
B_{target}	The long-term average biomass that is achieved by fishing at a constant fishing mortality (F) or constant exploitation rate (U) equal to B_{target} (see $B_{X\%}$ and B_{MSY})
B_{limit}	The biomass that defines the biomass at the limit reference point (LRP). Typically, $B_{10\%}$ or $B_{20\%}$
$B_{vulnerable}$	Vulnerable biomass. Refers to that portion of a stock's biomass that is available to fisheries. Can also be called exploitable biomass or recruited biomass
C	Catch. The total weight (or sometimes number) of fish caught by fishing operations in a year
Catch limit	The catch limit is the maximum catch allowed for a given year
CPUE	Catch per unit effort (CPUE). An abundance index and is the amount of catch taken per unit of fishing effort, such as the biomass of fish per 1000 hooks or biomass per tow per hour. Often used as a proxy for relative stock abundance or biomass
CV	Coefficient of variation. A statistic commonly used to represent variability or uncertainty. For example, if a biomass estimate has a CV of 0.2 (or 20%), this means that the standard deviation of the uncertainty is equal to 20% of the estimate
F	The instantaneous fishing mortality rate, often expressed as a rate per year. This is a measure of the proportion of the vulnerable biomass that is expected to be caught at a point in time. The annual fishing mortality rate is calculated using the formula 1-exp(-F). See also the definition of fishing exploitation rate, U
U	The fishing exploitation rate. This is the proportion of the vulnerable biomass that is expected to be caught at a point in time. See also the definition of instantaneous fishing mortality rate, F
$F_{0.1}$	The fishing mortality rate at which the slope of the yield per recruit (YPR) curve is reduced to 10% of the value at the origin (the intercept of the x and y axes on a graph). $F_{0.1}$ is an arbitrary mortality rate that was developed to protect the spawning stock potential (see $F_{40\%}$) while providing high yield per recruit. The choice of 10% value is arbitrary but commonly used as a proxy for a target
F_{MAX}	The fishing mortality rate that produces the maximum yield per recruit (YPR). While this maximizes the YPR, this rate does not necessarily protect against a reduction in the number of recruits (i.e., may lead to recruitment overfishing) and consequent over-depletion. $F_{0.1}$ was developed as F_{MAX} was sometimes unsustainable
F_{MSY}	The fishing mortality rate that, if applied constantly, would result in B_{MSY} on average over the long term and hence is the maximum sustainable yield (MSY) on average over the long term
$F_{X\%}$	The fishing mortality rate (F) that leads to X% of the maximum spawning potential that would be obtained with no fishing. For example, $F_{40\%}$ is the fishing mortality rate that would lead to an average spawning stock biomass (SSB) of 40% B_0 over the long term
HCR	Harvest control rule. A rule that describes how the harvest is to be managed based on selected indicators of stock status. Also known as a decision rule
HS	Harvest strategy. A framework for making fisheries management decisions, such as setting catch limits, that is designed to achieve the management objectives. The strategy typically includes a monitoring program, stock assessment model, reference points, and harvest control rules (HCRs). Also known as a management procedure or management strategy

Symbol	Definition
Indicator	A quantity that is informative, directly or indirectly, about the status of a stock (for example SSB as a % of B_0). Indicators can be quantitative or qualitative. When desired and undesired outcomes for the indicator are specified, the combination can be used to provide a performance indicator or performance measures. Used to measure the success in achieving management objectives. See Performance metric
Kobe plot	A four-quadrant graphic that shows the status of a stock, the trajectory of the stock through time, or both. Stock abundance is on the horizontal axis, and either exploitation rate or fishing mortality is on the vertical axis. The axes are typically divided at B=B_{target} and either F=F_{target} or U=U_{target}, respectively, and hence can graphically depict whether the stock was overfished and/or was subject to overfishing
LRP	Limit Reference Point. The threshold stock status that defines an undesirable status of the stock. To keep the stock safe, the probability of violating an LRP should be very low. LPRs are usually defined as either 10% or 20% B0 with a high probability of being above that point (e.g., an LPR could be a 90% probability of being above 20% B_0)
M	The instantaneous natural mortality rate, e.g., mortality due to natural causes including disease, predation, and senescence
Management objectives	Formally adopted objectives for a stock and its associated fisheries. They include high-level or conceptual objectives often expressed in legislation, conventions, or similar documents. They also include operational objectives that are specific and measurable, with associated timelines and minimum required probabilities that they can be achieved. When management objectives are referred to in the context of harvest strategies, the latter, more specific definition is usually used. For example, The SIOFA defines the overall management objective as "the fishery resources shall be managed so that they are maintained at levels that are capable of producing the maximum sustainable yield, and depleted stocks of fishery resources are rebuilt to the said levels" (Article 4 (d), Anon 2006)
MP	Management procedure. See Harvest strategy (HS)
MSE	Management strategy evaluation. A simulation-based, analytical framework used to evaluate the performance of harvest strategies relative to the specified management objectives
MSY	Maximum sustainable yield. The largest long-term average yield that can be taken from a stock under existing environmental conditions and a constant fishing mortality rate
OM	Operating model. A component of the management strategy evaluation (MSE) process used to evaluate a harvest strategy. The OM uses computer simulations to simulate the relevant aspects of the population so that the effects of alternative harvest strategies can be measured and compared. Typically, the OM includes the resource/ecosystem dynamics, the observation process, the assessment process, the management decision process, and the implementation of the management decision. Uncertainties in each of these processes are usually included. Multiple OMs are often used within a single MSE process to test the robustness of alternative harvest strategies to uncertainty in the true population dynamics
Overfishing	A situation where the fishing mortality or exploitation rate is higher than target level
PM	Performance metric. A quantitative expression of a management objective used to evaluate how well the objectives are being achieved by determining the proximity of the current value of an indicator to the objective. Also known as performance statistics or performance indicators. See Indicator
Precautionary approach	A management philosophy that requires consideration of risk reduction in decision-making, so that in the absence of full information, the decision taken results in a precautionary risk to the stock
Recruitment	The number or biomass of new fish that enter the population each year due to birth and/or migration
Recruitment overfishing	Fishing that could occur that results in adults being depleted to the point that they cannot replenish themselves. Without remedy, recruitment overfishing can lead to stock collapse
Reference points	Benchmarks in relation to indicators that are used to compare the current status of a fishery management system. Typically defined as a target reference point (TRP, i.e., the status of the stock that associated with the target F or U, for example see F_{target} or U_{target}), trigger reference point (), and a limit reference point (LRP, i.e., the threshold that the stock must be above with a high probability, for example see $B_{20\%}$)
Selectivity	A function that measures the relative vulnerability of different age (or length) classes to being caught by a specific fishing gear or fleet

Symbol	Definition
SPR	Spawning potential ratio. The lifetime contribution of spawning output (e.g., eggs) that a recruit is expected to provide under the stated fishing mortality, relative to its lifetime production without fishing. Often expressed as a percentage. For example, SPR50% means that under the specified fishing mortality rate, a recruit will on average produce half the eggs in its lifetime that it would have produced without fishing. See $F_{X\%}$
SSB	Spawning stock biomass. The total weight of the sexually mature part (i.e., adults) of a population
Stock	Can either mean a the fish within a management unit or a biological stock. A biological stock of a given species that forms a reproductive unit and spawns little if at all with other units. The term "stock" is often synonymous with an assessment/management unit, even if there is some migration or mixing of between assessment or management units
Trigger reference point	An indicator that defines the target fishery state that results in a management action, for example an increase or decrease in the catch limit. Generally, a biomass, fishing mortality or exploitation rate that when observed will result in a change of catch limit to achieve the TRP or avoid the LRP
TRP	Target reference point. An indicator that defines the target fishery state that should be achieved and maintained. Generally, a biomass, fishing mortality or exploitation rate that management actions are designed to achieve with at least a 50% probability. Can be based on one or more biological, ecological, social, or economic considerations
Uncertainty	Results from a lack of perfect knowledge about one or more factors that affect stock assessments, estimation of reference points and management. Four main types of uncertainty are considered in fisheries: observation error (caused by biased data), process error (caused by natural population variability), model error (caused by incorrect assumptions or model structure) and implementation error (caused by failure to fully implement management measures)
YPR	Yield per recruit. The expected yield (measured by numbers, biomass, etc.) that a new recruit will produce over its lifetime under a stated fishing mortality and selectivity

Annex 2: Timeline for implementation

Table 3: Development of harvest strategies and the timeline for the implementation of pre-assessments, assessments, management objectives and implementation of harvest strategies (reproduced from SC8 report, Annex G)

Step	SC	MoP
Step 1 Define management objectives		1. Specify management objectives: biological (including ecosystem considerations) e.g., ensuring long-term sustainability and productivity; recovering heavily depleted stocks socio-economic e.g., maintaining reasonable stability in catches for the industry
	2. Propose reference points based on management objectives: limit reference points (B_{lim} and/or F_{lim}), and target reference points (B_{TARGET} and/or F_{TARGET})	
		3. Select reference points
	4. Characterise the sources and values of uncertainties associated with the estimation of reference points (target and limit)	
		5. Specify acceptable levels of risk to be used in evaluating possible consequences of management actions, and time horizons for fishing mortality adjustments to avoid stock collapse, breaching limit reference point or achieve the target reference.
Step 2 Determine appropriate fisheries monitoring regime	1. Identify data collection and monitoring activities required to reliably evaluate resource status with respect to reference points	
		2. Implement data collection and monitoring programme to deliver consistent, high-quality data into the future.
	3. Determine how frequently to monitor (survey and/or assessments)	
Step 3 Develop candidate Harvest Control Rules	1. Propose candidate Harvest Control Rules (HCR): actions for controlling fishing mortality (F) or adjusting catch with respect to pre-defined, stock-specific, precautionary reference points for both biomass (B) and fishing mortality (F) were possible.	
		2. Select HCR
	3. Conditions for Re-Evaluating Reference Points and HCR	
Step 4	1. Test HCR and compare expected performance of harvest strategies	

Test HCR with MSE		2. Adopt appropriate harvest strategy
<u>Step 5</u> Implement Harvest Strategy		1. Implement management changes based on HCR
	2. Monitor (survey and/or assessment) and assess stock(s)	
	3. Determine stock status relative to reference points	
		4. Determine if Harvest Strategy delivers the objectives
<u>Step 6</u> Improve assessment and harvest strategy	1. Review reference points and HCR if needed	
	2. Define research requirements to improve the quantification and evaluation of uncertainty (i.e., risk analysis), as well as methodological developments required to reduce uncertainty.	