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**REPORT OF THE EXPERT WORKING GROUP: MANAGEMENT OBJECTIVES,
PERFORMANCE INDICATORS AND REFERENCE POINTS**

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Report of the Expert Working Group

Management objectives, performance indicators and reference points

WCPFC-SC9-2013/ MI-WP-05

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1. Introduction

In accordance with a direction from WCPFC7 that an informal workshop on management objectives be held, WCPFC8 subsequently agreed on a terms of reference and suggested that the workshop be convened immediately before WCPFC9.

In response, the Secretariat convened the first Management Objectives Workshop (MOW1) in Manila 28-29 November 2012, using an independent expert panel and input from CCMs and observers. The workshop sought to increase the understanding of, and interactions among management objectives, indicators and reference points, and develop a list of recommended management objectives.

Given the time available and the different levels of understanding between participants, MOW1 primarily served as an awareness raising exercise. There was preliminary discussion of the current management frameworks, as represented by CMM 2010-05 (South Pacific albacore) and draft CMM 2012-01 (Bigeye tuna and Yellowfin tuna). A candidate list of management objectives, broken down by biological, economic, social and ecological objectives, was developed using feedback from participants provided by questionnaires. A summary of the candidate list is provided in **Attachment 1**.

WCPFC9, in considering the outcomes of the MOW1, agreed to use the same group that provided input into that workshop, assisted by the Commission and SPC Secretariat, to develop a 'strawman' consisting of a candidate list of management objectives, performance indicators, and target reference points for each major fishery. These were:

- Tropical longline
- Purse seine
- Southern longline
- Pacific bluefin tuna
- North Pacific albacore

It is noted that the above list includes both species and fisheries. The WCPF Convention (the Convention) and the UN Fish Stocks Agreement (UNFSA) both focus on stock/species-based approaches to management. In some fisheries, where mixed species are taken either unavoidably due to the selectivity of the gear or for operational/economic viability reasons, it may be more appropriate to look at fishery-based objectives and reference points. For example, the purse seine fishery takes mixed species catches (yellowfin/skipjack), so a Maximum Economic Yield (MEY) objective for the fishery as a whole may be more appropriate than objectives for each single species. While a fishery-wide objective may replace the objectives for individual species, there would still be a need for limit reference points for each species to avoid overfishing and ensure stock/fishery sustainability.

The draft 'strawman' (this document) will be provided to all Commission members for review prior to being sent to the Scientific Committee (SC9) the Northern Committee (NC9) and the Technical and Compliance Committee (TCC), for comment and suggestions for improvement. These comments and suggestions will be provided to MOW2, along with a finalised version of the 'strawman'. MOW2 will be held immediately before WCPFC10.

The full Terms of Reference for the working group are provided in **Attachment 2**.

This paper seeks to provide an increased understanding of the interests and motivations of the major participants in particular fisheries and the range of objectives in particular fisheries. The process whereby CCMs will be able to agree on Commission objectives for species/fisheries will be challenging, particularly where large proportions of particular stocks or fisheries exist in the waters of, or are under the effective control of, one or more coastal States.

2. Why a management strategy/framework is necessary

To date, much of the work of the Commission has consisted of developing a range of conservation and management measures in response to scientific advice on the declining status of, or expanding fishing pressure on, certain target stocks (e.g. bigeye tuna and albacore). Bycatch has been another major focus of the Commission's work. In contrast, an effective management strategy or framework for the WCPFC including objectives, reference points and performance indicators, might lead to a greater emphasis on anticipatory arrangements characterized by more desirable outcomes for fisheries (e.g. food security, economic development, avoidance of overfishing and overfished stocks. This process is concerned with achieving what is desired from the fishery rather than responding to highly undesirable situations when encountered.

For instance, in the case of stocks that display high levels of recruitment variability, one management strategy might require a reduction in fishing mortality (through catch or effort controls) during periods of low recruitment, rather than heavily depleting a stock by maintaining constant effort and thereby creating a situation that would require more serious management intervention and fishing constraints later. Such a strategy would be expected to stabilise stocks, biological productivity, catch rates and catches and provide greater certainty to the industries and CCMs involved.

As discussed below, sub-regional arrangements have been implemented in an effort to meet the objectives of a group of CCMs. The PNA vessel days scheme is an example of this approach, which is currently being further refined and modelled by SPC to explore a range of possible targets and harvest strategies/control rules to achieve them.

In addition to enabling a more planned approach the key purposes and related components of a management framework are:

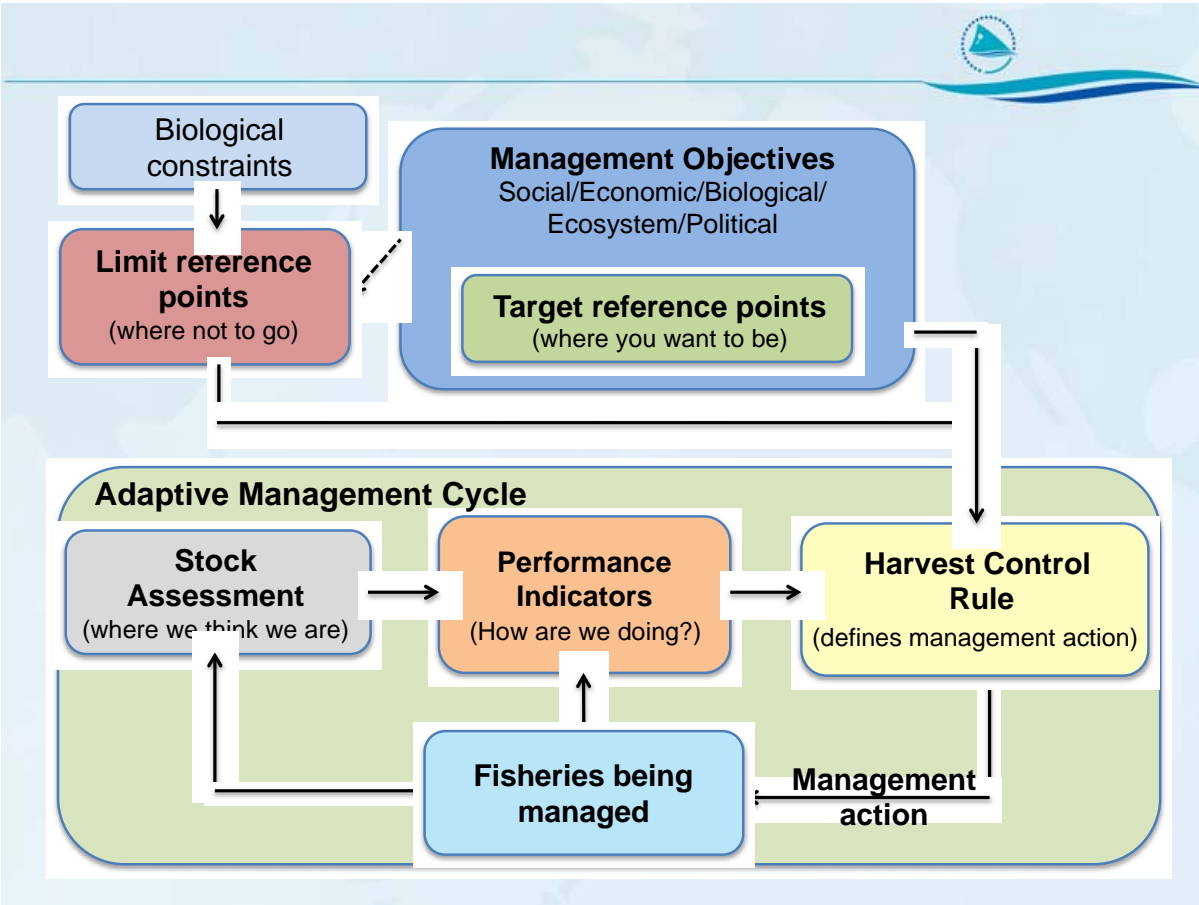
- To be clear on what CCMs want to achieve from management of their oceanic fisheries resources (**management objectives**); the framework must take into account the diversity of management objectives among CCMs and stakeholders, which will therefore negotiation and compromise will be necessary.
- To measure progress by the Commission and CCMs in achieving these objectives (**performance indicators**).
- To establish where CCMs would like the fishery to be (**target reference points** for the performance indicators) based on management objectives as measured by performance indicators and fishery situations they want to avoid (**limit reference points** for the performance indicators)
- To establish how fishing will be managed in response to the status of a performance indicator (**Harvest control rules (HCRs)**, currently expressed as CMMs).

In some fisheries, 'trigger' reference points are set at an intermediate fishery stock size or level of fishing that alerts managers and may initiate a management action to, for instance, reduce fishing mortality to avoid exceeding a limit reference point.

While frequently discussed in scientific forums, determining fisheries management objectives, which relate primarily to target reference points, is largely an issue for managers and other key stakeholders.

A simplified diagram of a management framework is provided in Figure 1 below.

A further consideration is that stock assessments have demonstrated that biomass is not distributed evenly throughout the region and that fishing mortality is significantly higher in some areas than in others. This is compounded by the fact that there is some degree of mixing between the sub-areas. When designing harvest strategy frameworks, and specifically when considering management responses to potential issues, it may be necessary for the WCPFC to incorporate some sub-regional independence to ensure that management action is directed mainly at fisheries requiring attention.



Source: SPC

Figure 1: Typical fisheries management framework

3. Progress at the Commission, subregionally and nationally

Commission

Through the work of the Commission, a number of CMMs have been generated and implemented to deal with overfishing or potential overfishing. Some CMM ‘objectives’ are akin to LRPs or TRPs, but without being explicit, suggest that catch and/or effort should be reduced (to rebuild stocks) or maintained (to avoid overfishing or maintain a particular level of benefits). Examples include:

- Pacific bluefin tuna: *...“to ensure that the current level of fishing mortality rate is not increased in the Convention Area “.*
- South Pacific albacore: *CCMs “shall not increase the number of their fishing vessels actively fishing for South Pacific albacore in the Convention Area south of 20°S above”*

The latter measure may be seen as establishing a target in the form of a cap at the current level of effort at which CCMs were comfortable with the status of the fishery, and was a measure to prevent expansion above the target (status quo) level. The agreed upon vessel day limit in the purse seine fishery established under CMM 2012-01 is also a form of status quo target.

Prior to the MOW process, there has been very little work at the Commission on determining and agreeing on management objectives and associated targets and processes. There has, however, been substantial progress with developing LRPs for a number of stocks. A summary of that progress is provided in **Attachment 3**.

Sub-regional

Sub-regional groups of CCMs have been more active in seeking to achieve management settings, including targets, that meet other than biological goals. These include the Vessel Days Scheme and the ongoing process seeking establishment of cohesive management of the albacore longline fishery by southern members of the FFA. Progress by these sub-regional groups reflects the cooperative efforts of like minded states with shared aspirations to achieve collective objectives from shared stocks rather than simply seeking to maximise catches or avoid limit reference points.

An limit on fishing mortality (F) for North Pacific albacore has been in place since 2008 along with an associated Harvest Control Rule (HCR) introduced in 2010). The HCR established that should action be required, such action be undertaken within one-year.

National

Nationally, some CCMs have well-developed management frameworks, including objectives, target reference points and indicators (see **Attachment 4** for examples) In many cases interactions with the EEZs of other CCMs and the high seas makes unilateral national management alone ineffective.

FFA members embarked on a series of formal EAFM (ecological approach to fisheries management) reviews of domestic fisheries arrangements between 2007 and 2010 with the purpose of broadening focus away from simple target stock sustainability to include consideration of wider ecosystem impacts, profitability and social issues. The implementation of the outcomes of these reviews through legislation and other avenues is an ongoing process.

Marine Stewardship Council

There are now sub-fisheries in the Pacific that have Marine Stewardship Council accreditation, namely the PNA free-school purse seine fishery for skipjack, the NZ albacore troll fishery and the Fiji albacore tuna longline fishery. Other sub-fisheries are considering MSE accreditation. Certain accreditation conditions have been placed on these fisheries, which include the development of reference points and harvest strategies/harvest control rules.

4. Progress by other RFMOs

Progress in other tuna RFMOs is variable (see **Attachment 5**).

In the case of the Commission for the Conservation of Southern Bluefin Tuna (CCSBT), extensive work has been undertaken among member country scientists and stakeholders to evaluate objectives and create a transparent TAC setting procedure. This represents the only formal management strategy among the five RFMOs considered. The SBT fishery is a single species fishery managed by a Commission with six members and direct comparison with the WCPFC is therefore problematic given the multi-species, multi-gear nature of the WCP tuna fisheries and the high levels of in-zone catch.

At its 17th meeting in May 2013, the IOTC replaced its recommendation on reference points with Resolution 13/10 on Target and Limit Reference Points and a Decision Framework. The Scientific Committee was tasked to develop and evaluate Harvest Control Rules and then recommend Harvest Control rules for fish stocks to the Commission on the basis of the previously evaluated management strategy.

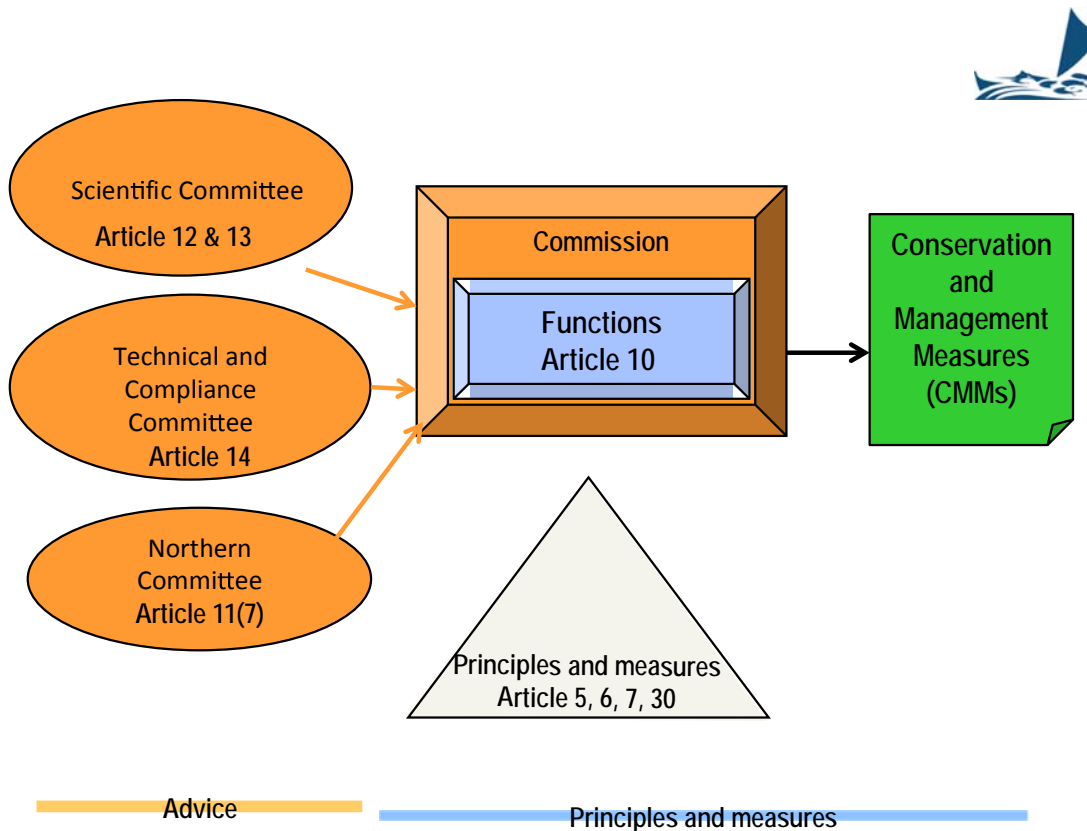
At its 85th meeting, the IATTC agreed to provide clear direction to the Scientific Staff to prepare candidate target and limit reference points and harvest control rules in advance of the 2014 Annual

Scientific Advisory Committee meeting. The Scientific Advisory Committee will then make stock-specific recommendations for harvest control rules and reference points to be considered at the 2014 Annual Commission Meeting. These recommendations should address issues of consistency with the decisions made by other RFMOs, especially in the Pacific Ocean, on reference points for the same species

ICCAT has requested its SCRS to develop a limit for one of its albacore stocks and has an implied target to be in the green zone of the Kobe plots. It also has, in its Recommendation 11-13 a framework for a harvest control rule, which has yet to be applied to any stock.

5. Role of the Commission

The Commission has the mandate and function to agree and implement binding conservation and management measures through CMMs, including under Article 10 of the Convention, as discussed above. This includes measures to ensure long-term sustainability of both target and non-target species, and optimum utilisation (Article 5), using international minimum standards for responsible fishing. The Commission develops these measures using the advice provided by its three committees (Scientific, Technical and Compliance and Northern) and guided by the principles contained in articles 5.6.7 and 30. (See Figure 2 below).



Source: WCPFC Secretariat

Figure 2. WCPFC Commission process for developing CMMs

The Convention states that CMMs under the Convention shall that be applied throughout the range of the stocks, or to specific areas within the Convention Area as determined by the Commission (Article 3.3).

There is a dual obligation on coastal States, groups of coastal States and the Commission to cooperate to ensure compatibility between fisheries management measures/frameworks (Article 8). The Commission, in developing a management framework, is required to take into account coastal state CMMs, previously agreed measures agreed for the high seas or applied by a subregional or regional fisheries management organisation or arrangement. (Article 7). Coastal States have obligations to manage fisheries in the EEZs in a way that meets the standards of UNCLOS/UNFSA, which means taking account of, for example, the impact of skipjack fisheries on bigeye tuna.

Around 60% of the catches of the four major species is currently taken in the national waters of SIDS, with another 20% taken in Indonesia and Philippines waters, and much of the balance taken in tropical high seas areas adjacent to the zones of SIDS and other developing countries. These countries, particularly SIDS, are highly dependent on fisheries exploiting these stocks for their long-term sustainable development. Accordingly, any framework of management objectives and management strategies developed at the Commission, including MSE, needs to acknowledge this pattern of special requirements, as recognised in the Convention. This is to ensure that the outcomes of the MOW process have the support of those Commission members in whose waters the management arrangements will apply. Other coastal States in the Convention area have particular interests in maintaining coastal fisheries, such as the Japanese artisanal fishery for Pacific bluefin tuna.

Given these obligations and realities, the Commission is likely to act as a forum to promote cooperation and coordination on the matter of developing objectives/management frameworks, thereby promoting compatibility through negotiation and agreement between CCMs.

6. Refining candidate management objectives

Fisheries management objectives for WCPFC fisheries will vary widely between CCMs, between and within major groups such as SIDS, DWFNs and PNA. Finding compromises and reconciling these differences in RFMOs is considerably more difficult than it is for national jurisdictions, where governments can unilaterally develop policy and legislation to implement fisheries management arrangements, including objectives and target reference points.

Objectives for individual CCMs may also change over time, particularly in the case of developing States as they develop their fisheries infrastructure, or as some fishing nations reduce or change fishing fleet structure.

Fisheries management objectives may be considered as falling into two broad categories:

- i. Overarching, global objectives* that relate to policy commitments such as those found in the Law of the Sea, UN Fish Stocks Agreement, the WCPF Convention, in regional and sub regional agreements and national fisheries Acts and other legislative instruments. These objectives are generally very broad and difficult to quantify. One overarching or global objective is contained in Article 2 of the WCPF Convention:

“To ensure, through effective management, the long-term conservation and sustainable use of highly migratory fish stocks in the western and central Pacific Ocean in accordance with the 1982 Convention and the [UN Fish Stocks] Agreement”.

- ii. Operational objectives*, which to a greater or lesser extent, are specific, measurable and have practical interpretation. They may include a specified timeframe for achieving the objective.

The MOW process, while mindful of the relevant overarching objectives, is focused on operational objectives. Some guidance for developing operational objectives is provided in Article 5(b)i which states that CMMs should be based:

*“...on the best scientific evidence available and are designed to maintain or restore stocks at levels capable of producing **maximum sustainable yield, as qualified by relevant environmental and economic factors**, including the special requirements of developing States in the Convention Area, particularly small island developing States, and taking into account fishing patterns, the interdependence of stocks and any generally recommended international minimum standards, whether subregional, regional or global”*

Further guidance is provided in Articles 5, 10 and 30 on socio-economic considerations and possible objectives to meet the special requirements of developing States, and in particular small island developing States. These include dependence on marine living resources to meet nutritional requirements and the employment needs of subsistence, small-scale and artisanal fishers. These Convention provisions indicate that the Commission’s interface with small-scale fisheries is intended to protect vulnerable parties (fishers, fish workers, communities) that are dependent on tuna resources. In order for the Commission to “take into account” these interests, needs, and dependencies there is the assumption that much is known about those subjects. This does not appear to be the case.

The issue of ‘disproportionate burden’ is noted in the Convention at Article 31 2. (c), which states that in cooperating in the establishment of CMMs, the Commission should ensure that any measures developed should not result in a disproportionate burden on developing States. In the Commission area, where a large proportion of fisheries/stocks are found in these states’ waters, this will be a significant consideration in developing options to meet objectives.

The outcomes of MOW1 and CCM statements made at previous WCPFC meetings have been used by the MOW Working Group as a basis for the candidate objectives, indicators and reference points presented in this paper. MOW1 selected a wide range of objectives, reflecting the various interests of CMMs and, in some cases, the fleets represented by them. These were summarised (**Attachment 1**) under the major groups of

- Biological e.g. minimise range contraction/stock fluctuation
- Economic e.g. maximise economic returns to CCMs
- Ecosystem e.g. minimise by catch impacts
- Social e.g. maintain coastal fisheries communities/employment

It should be noted that the division of these objectives into the four categories is somewhat artificial and some objectives will overlap. Employment, for instance has both economic and a social implications.

Objectives may be in conflict or competition with each other. It may not be possible, for example, to simultaneously maximise

- i) amount of product landed for processing (high vessel numbers) and
- ii) the generation of increasing volumes of revenue for government (generally achieved through fewer vessels operating more profitably).

These two approaches to fisheries management, the first focused on maximising sustainable catch to maximise employment and provide community development and welfare and the other on capturing wealth/economic benefits by limiting access, present contrasting policy approaches with different objectives.

Given the wide diversity of CCMs, their differing natural and other resource endowments and policy and political circumstances, the agreement of specific objectives with associated performance measures

and reference points will require considerable negotiation. See Section 9 for further discussion of this topic.

Fisheries management objectives need not be limited to target species and can include objectives for non-target and associated or dependent species (NTADS) and ecosystems. There are implicit objectives to manage the broader ecosystem effects of fishing on NTADS in the Convention including the Article 5c requirement to adopt measures to minimise the catch of NTADS¹. CMMs to deal with NTADS may include specific catch controls, or effort controls (e.g. certain operational practices encouraged/discouraged, times/areas avoided etc).

Finally, as discussed previously, objectives and associated indicators and reference points may be applied at the level of stocks or, in the case of mixed species fisheries, at the fishery level.

7. Selecting indicators

Performance indicators measure the effectiveness of fishery management actions implemented to meet policy objectives. They can also enhance communication, transparency, effectiveness and accountability in fisheries management. A good indicator should:

- be based on an understanding of what managers need;
- be appropriate to the species under management;
- have the data and / or associated models to estimate it;
- be able to be estimated reliably;
- be linearly related (ideally) with the aspect of the system it is a measure of (e.g. CPUE in relation to the size of the fish population; and
- be easily implemented and is useful in management of the fishery.

Ideally, there should be indicators for all objectives, but some will only require monitoring and not necessarily reference points (e.g. indicators for some bycatch species). Some objectives may have a number of indicators, particularly where a 'weight of evidence' approach using more than one indicator is used to inform management decisions (e.g. fishing mortality, biomass and spawning biomass).

Indicators may also be used to measure progress towards spatial objectives such as a viable coastal pole and line fishery where range contraction and interaction between coastal and distant water fleets are both significant factors.

The four types of candidate indicators suggested to measure progress towards achieving the management objectives for the five fisheries/stocks under this exercise are:

- **Biological indicators** such as fishing mortality and biomass are used at the Commission as an expression of stock status to inform decision-making and assess progress towards objectives such as optimum utilization. Biological indicators may be used to measure performance relative to an 'economic' objective – e.g. biomass as an indicator of economic yield. These are likely to provide the indicators (and basis of reference points) that will inform harvest control rules
- **Economic indicators** can be used to monitor the economic performance of a fishery. For example, they can track progress towards the maximum economic yield, or measure whether domestic development is occurring at the rate required for employment and economic development in developing States in accordance with Article 30 2. (a). Useful indicators include

¹ See also Article 10 (1) on adopting, where necessary, adopt CMMs... *with a view to maintaining or restoring populations of such species (NTADS) above levels at which their reproduction may become seriously threatened*.

resource rent or economic profits, CPUE, and contributions from fisheries to the Gross Domestic Product (GDP).

- **Social indicators** are of considerable importance to coastal communities, but setting operational social objectives and indicators is challenging. Indicators include employment in the fisheries and associated sectors, human capacity development, the maintenance of artisanal fisheries and consumption of pelagic fish by coastal communities. These indicators will be useful for monitoring, and where possible, considering the impacts of management decisions.
- **Ecosystem indicators** are at an early stage of development, as are the associated operational management objectives. Trends in bycatch rates and or ecological community indicators derived from catches and the biological characteristics of the species (e.g. trophic level) show promise in providing indicators of use for fisheries management. Ecosystem indicators that link climate and ocean processes to species composition, abundance and distribution will also be considered (see SC8-2012/EB-IP11).

Fisheries management objectives, as discussed in the introduction may be both stock/species specific, or, in the case of multi-species fisheries, fishery based. Indicators will need to include those relevant for specific species (e.g. fishing mortality, size composition and catch rates), as well as those for multi-species objectives (e.g. MEY for the fishery).

Consideration may be given to including indicators for governance, such as the level of national compliance with national legislation and measures implemented to comply with specific CMMs, as evidenced in fishery/FAD management plans.

8. Selecting target reference points

As discussed in Section 2, reference points can be defined as a pre-determined level of a given indicator (e.g. adult stock size or catch rate/CPUE) that management either seeks to achieve as a management objective (target reference point or TRP) or avoid (limit reference point).

Target reference points therefore attempt to make desired biological (ecosystem) and socio-economic objectives of management operational, and quantifiable. They are generally translated into the states of fish stocks and fisheries (biomass, fishing mortality) that would be required to achieve the objectives, allowing them to be related to the results of scientific stock assessment. The MOW process is concerned with identifying candidate target reference points, the key purpose of which is to identify the conditions for the indicators discussed above that achieve operational management objectives.

A target reference point is selected at a level that aims to balance the various, and often times competing, management objectives for the fishery. In many cases, these include biological and socioeconomic performance indicators that are informed by stock assessment model outputs or directly measurable quantities. Some examples are shown in Table 1 (for further details see [SC8-MI-WP-02](#)).

Table 1. Examples of indicators by type and source

Type	Indicator	Derived From	Example TRP
Biological	Biomass, spawning biomass, fishing mortality. Ratios relative to reference points (e.g. B_t/B_{MSY} ; SB_t/SB_{MSY} ; F_t/F_{MSY})	Stock assessment	$Prob[F_t / F_{MSY} < 1] > 0.5$ $Prob[SB_t/SB_{MSY} > 1] > 0.5$
	Size composition of catch	Empirical measurement	Average size of X in the catch
	Spawning Potential Ratio (also referred to as Spawner per Recruit; SPR) as well as fishing mortality expected to deliver various levels of SPR ($x\% F_{SPR}$)	Stock assessment	$40\%F_{SPR}$ (the Fishing mortality that would result in SPR being 40% of that of an unfished population)
Economic	Ratios relative to reference points (e.g. B_t/B_{MEY})	Bioeconomic assessment	B_t/B_{MEY}
	Catch rates (CPUE)	Empirical measurement	X kg/set
Social	Employment	Empirical measurement	X number of employees considered optimal for the fishery

Annex II of UNFSA suggests that, as a guideline, TRPs shall be met 'on average' (i.e. fluctuating around the target, on average) while the risk of exceeding the LRP shall be "very low". This risk takes into account the possibility of the stock size falling to a low level by chance and defines how often that is considered allowable. It also needs to account for the fact that stock assessment, including the underpinning models, is not an exact science, and there will always be some uncertainty in estimates of stock status in relation to the chosen limit.

Defining an acceptable risk of falling below a limit reference point has implications for setting the target reference point and thus is critical for the design of an acceptable management strategy (Figure 2). In some cases, specified management objectives (e.g. maintaining high catch rates) may define a target sufficiently far from the limit that the limit is unlikely to be exceeded. In other cases the separation of the target and limit reference points may not be sufficient to deal with the typical uncertainty in estimating fish stock status and the variability in fish populations. Similarly, simply avoiding a limit reference point with a high probability can result in average biomass levels that might be suitable target reference points in some cases.

The level of acceptable risk is not a biological (scientific) issue, but is defined by managers and other stakeholders (in our case, the Commission), and reflects the level of risk they are willing to take when managing the fish stock.

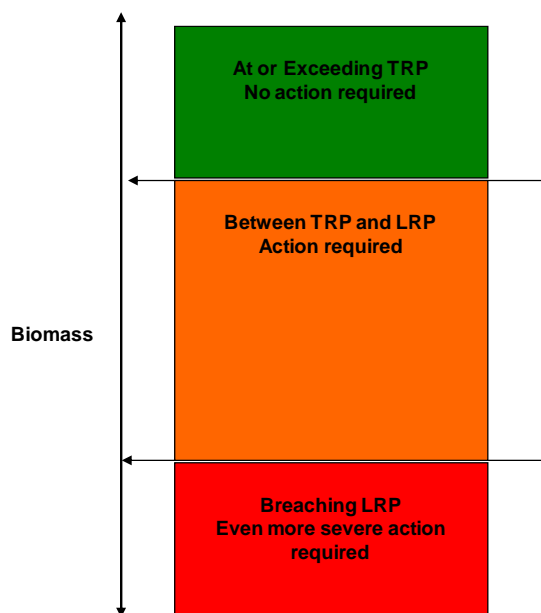


Figure 2: Generalization of how target and limit reference points guide rational management decisions (i.e., “operationalize” management action). Specific management actions are dictated by harvest control rules (Source: SPC)

Time is an important consideration in establishing TRPs and the harvest control rules (see Section 10 below) to achieve them. For instance if a TRP for a particular species was to maintain spawning stock biomass (SSB) at 75% of some previous level (SSB_{75}) and the SSB was well below this figure, the catch or effort set for the fishery to achieve the target would depend heavily on the time agreed to achieve that target. The longer the time frame, the less severe any reductions in catch or effort need to be.

9. Reconciling objectives and targets

The characteristics, issues and interactions of each fishery/species identified in Section 11 provide an indication of the complexity of the fisheries under consideration, and the wide range of possible objectives, measures and targets.

Some objectives may be common and compatible e.g. stock sustainability and vessel profitability, where the objective may be to maintain biomass at levels that provide high catch rates (low costs of capture), and in turn, a degree of ‘buffering’ against recruitment declines and reduced risk of overfishing.

However, not all objectives can be met fully and there is a need for trade-offs at a wide range of levels. A useful example is in the implicit objective to maximise the economic value of the purse seine fishery, while not exceeding maximum sustainable yield of all. The major trade-off in this case is likely to be around the targets in the multi-species mix while the limits (i.e. definition of overfishing) stay the same as their single species values. While it is quite possible to maximise the joint economic value and avoid fishing stocks to unsustainable levels, it will not be possible to maximise the joint economic value while maintaining all species at or above their individual MSY levels.

Using the purse seine fishery as an example, maximising economic benefits from a fishery may result in fishing for target species (skipjack) at levels that reduce secondary species populations to lower than B_{MSY} levels (bigeye). In this example, the status of secondary species requires a consideration of the tradeoffs (e.g. stock sustainability, maximising economic benefits, ensuring social benefits).

Tradeoffs may be particularly complex in the case of multispecies, multi-fleet fisheries where participating states have differing national policies and objectives. A particular example is the purse

seine and longline fisheries, where levels of mortality in either fishery will have implications in the other. Quantifying the acceptable trade-offs between different goals is important to allow testing and comparison of the performance of potential reference points and harvest control rules.

A second, more general, example is shown in Figure 3 below. Here a fishery has four objectives – maximise catch, maintain a sustainable harvest, achieve a target catch rate and maintain an acceptable risk of maintaining spawning biomass. It is clear that when catch is maximised under Management Strategy 1, this is achieved at the cost of less stable catches, lower catch rates and a much reduced probability that spawning biomass will be at some desired level. Foregoing total catch under Strategy 3, while reducing revenue, delivers a more stable harvest (and revenue stream), higher catch rates (and lower costs) and a greater probability of a larger spawning biomass. In a real fishery, different management strategies/harvest control rules (HCRs) can be tested using management strategy evaluation (MSE) as discussed in the next section below.

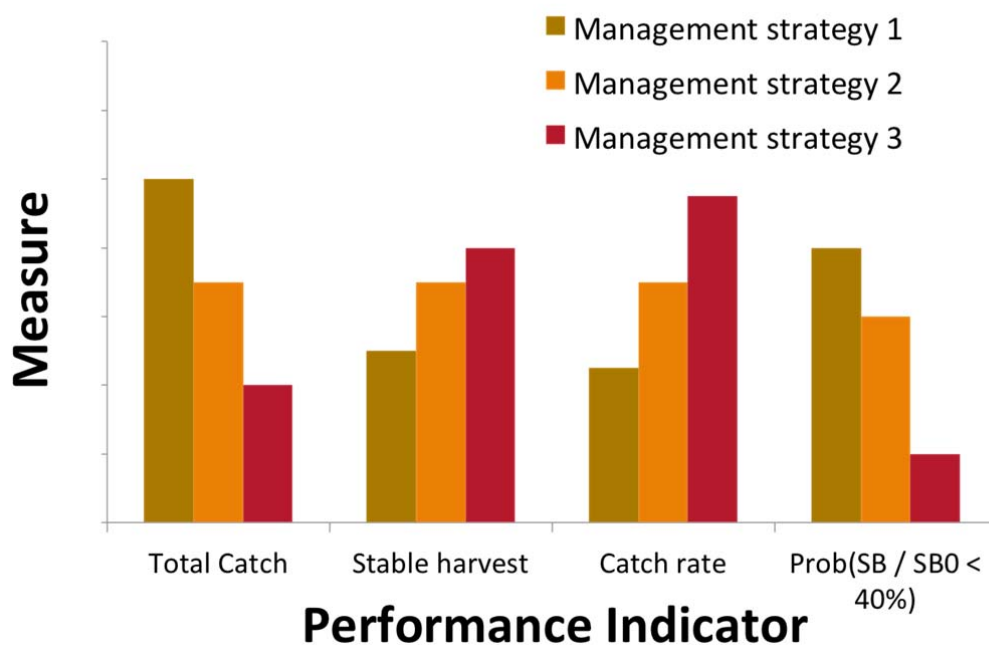


Figure 3: illustration of effects of management strategies of key performance indicators

10. Harvest control rules and CMMs

In many fisheries harvest control rules (HCRs) that are used have been tested against explicit (and often implicit) management objectives. Generally speaking, HCRs are a form of CMM and it is important that they have been subject to some form of testing (e.g. via simulation testing in a management strategy evaluation context) before consideration and adoption. It is envisaged that such CMMs will be designed to best satisfy the complex set of objectives for the Commission.

It is suggested that prospective future CMMs (and review of existing CMMs) should be tested using a management strategy evaluation (MSE) approach, to examine how the proposed measures contribute, positively and negatively, to achieving long term objectives. Prospective management measures should be evaluated in the broad context of how the resource may likely respond and the likely economic environment. The task can be broken into three main activities:

- 1) Development of a model, which captures the plausible range fish, stock dynamics including variability due to the environment, uncertainty in biological parameters, and uncertainty due to

real-world sampling processes. This simulation model should be capable of generating the types of data likely to be encountered within the present management systems (including the ability to add specific biases that may be likely). Where economic objectives are being examined the model must also include economic aspects of the fishery based on a plausible range of economic circumstances and relationships. This model is referred to as the operating model in MSE studies.

- 2) Develop a suite of management measures (or management procedures/HCRs) to apply and test using the operating model
- 3) Evaluate the measures against performance indicators (which should provide insight on achieving objectives).

As discussed above the MSE will need to consider the following trade-offs:

- within species between catch, stability of catch/effort, CPUE and stock depletion;
- between species in multi-species fisheries where the optimum for the combined species in the fishery may be different from the optimum of the species individually; and
- between participants where optimum outcomes for the fishery as a whole may differ from the optimum for individual participants (e.g. participants at national, subregional or fleet levels).

This analysis would aim to provide accurate probabilities of achieving specified objectives (and the risk of failing to remain above biomass limit reference points). These analyses should also reflect the different, often external, factors that affect the fisheries (e.g. the extent that effort by a particular gear type might be expected to increase in the absence of direct and effective controls) so as to bound the problem.

It is important to note that the CMM (e.g. as a HCR) need not only be implemented to achieve target reference points. Rather, the target reference points (and limits) should be used to evaluate the performance of the CMM. For example, if a stock is clearly being fished in excess of F_{MSY} then responses to two different CMMs may be more or less effective at lowering the rate in the longer term. For further illustration, if it was determined that the harvest rate was about 20% higher than the “target” F_{MSY} reference point, and a CMM which reduced effort by 20% was required. Two management options could be considered:

- Option A, a measure to reduce the number of vessels; and
- Option B, a measure to set (reduce) catch equal to the value that achieves F_{MSY} .

Option A may be undermined by fishermen changing to adapt and work longer days or develop more effective catching technology and so may have a result which differs from Option B in which a TAC was strictly enforced. In the former situation (simple effort reduction) the end result is that the fishing mortality (or fishing power) may still be excessive. Even without the change in effort as described, option A would be likely to have different consequences from option B.

11. Evaluating identified ‘fisheries’

The following sections refine identified candidate management objectives from MOW1. This includes an examination of the definitions, issues, indicators and potential reference points. As discussed above, considering objectives etc. for the selected fisheries/species in isolation is somewhat artificial, given the known interactions between them. This paper is very much a first step and as acknowledged in Section 9 above, there will be a need to consider interactions between fisheries, including the differential impacts of CMMs

Catch estimates for the Tropical Longline, Purse Seine and Southern Longline fisheries are based on annual average catches (2007-2010) and were provided by SPC. Values of catches were provided by FFA and are based on average catches for the same period.

Note that many of the indicators and target reference points will not be used in a formal management framework approach with harvest control rules. For instance there is unlikely to be prescribed management action in direct response to changes in indicators for developmental goals such as employment or onshore processing. Changes in these indicators will be monitored as management decisions (CMMs) restricting catch and/or effort are reflected in changes in other key indicators such as biomass and spawning stock.

1. Tropical longline (20N-20S; YFT, BET and ALB)

Fishery characteristics

- Total catch and value:
 - Total annual tuna catch = 196,000 t.
 - Total value = US\$ 1.58 billion
- Mainly a Bigeye tuna fishery in the eastern tropical areas, Yellowfin tuna is the predominant species caught in western tropical areas.
 - BET catch = 68,000 t. (35%)
 - YFT catch = 80,000 t. (40%)
- Diverse nationality of fleet:
 - Japan = 23,300 t. (12%)
 - Chinese Taipei = 37,100 t. (19%)
 - Republic of Korea = 24,500 t. (13%)
 - China = 29,000 t. (15%)
 - Indonesia = 27,822 t. (14%)
 - Others = 54,352 t. (28%)
- Predominantly equatorial:
 - (~ 55% and 107,000 t. from region between 10°N - 10°S)
- Predominantly ULT, some chilled (mainly domestic fleets):
 - Distant-water fleets mainly outside the EEZ of PICs and offshore mainly inside EEZs
 - Distant-water fleets mainly in the east and “offshore” fleets mainly in the west with some mixing of these two fleet categories in the central area
- Relatively high proportion from EEZs:
 - (64% from EEZs vs. 36% high seas) – including Indonesia
 - (57% from EEZs vs. 43% high seas) – excluding Indonesia

Key issues

- Low levels of observer coverage
- Data collection/verification systems extremely deficient including almost complete lack of operational data provided by key flag States above and concerns about underreporting of transshipment and its effect on data reliability
- Uncertainty regarding charter arrangements between SIDS and DWFN fleets and Territories and metropolitan fleet
- Bycatch (e.g. sharks, turtles, others)
- Entry point for developing States’ domestic fishing industries
- SIDS development aspirations
- Important fishery income for some SIDS (e.g. Kiribati, Tuvalu)
- Extent of targeting (e.g. hook depth)

Fishery interactions

- Juvenile BET and YFT catch (in purse seine and other fisheries)
- Overlap with IATTC, extent of interaction with BET and capacity
 - 7% of total tuna catch in tropical fishery is in the overlap area
- Downstream effect of the purse seine fishery
- Effect on domestic fisheries
- Other zones

Candidate objectives for tropical longline fishery

Type	Objective	Indicator	Target reference point	Comments		
Biological	Maintain YFT and BET biomass above levels that provide fishery sustainability throughout their range	Estimated biomass or CPUE (as proxy)	TBD	A HCR that provides a high probability of not exceeding a limit point for biomass may be sufficient to ensure the average biomass matches a suitable target reference point. Also related to B_{MEY} . Biological limits could be examined using SEPODYM modelling. CPUE may be a poor indicator of biomass and objective needs to be combined with a biomass target.		
Economic	Maximise economic yield from the fishery	Economic yield (costs and revenue evaluation) and biomass	Ideally B_{MEY} (for the multi-species fishery, conditioned on allocation by gear). Proxy might be BET+YFT biomass or index	MEY will change with allocation, fleet composition, costs, catch rates, and prices. MEY usually based on harvesting sector so difficult to ascribe for whole fishery. Levels of subsidies would be important. Proxies need to be tailored for each fishery taking into account the economics of each as well as the placement of LRPs.		
	Maintain acceptable CPUE	CPUE	Proxy BET and YFT CPUE relative to history (standardised)	CPUE is particularly important towards objectives of maintaining profitability and addressing current poor economic conditions.		
	Increase fisheries-based development within developing States' economies	% contribution of fisheries to GDP	Target linked to regional and national development plans and Resolution 2008-01	Opportunities need to be created for developing States to take up their participatory rights without increasing overall catch.		
					Amount and proportional contribution of SIDS fleet catch	Objectives will vary between states.
					Amount and value of product exported from SIDS	
	Optimize vessel capacity	Fishing mortality, Fleet size	F_{MEY} (business decision based on regulations and allocations); fleet capacity giving MEY or maximum economic efficiency.	Overcapacity will drive catches/effort beyond MEY. May lead to changes in development and other opportunities. Significant disparity in fishing power of vessels in various flag-fleets complicates determination of maximum efficiency.		
	Maximise SIDS revenues from resource rents	Value of SIDS' access fees	Appropriate share of fishery rents for SIDS	Important source of government revenue for many SIDS.		
Stability and continuity of market supply	Market throughput of tuna products	TBD	Important issue for States with high levels of historic demand for tuna products.			

Social	Affordable protein for coastal communities	Average national annual per capita fish consumption from pelagic fisheries	Target per capita fish consumption (e.g. 80kg /yr)	Tuna fisheries could contribute substantially more to food security in SIDS – but requires more appropriate fish handling and market structures. Overall fish consumption is already high, but over time as a result of population growth, climate change and inshore degradation, pelagic fisheries will play a more significant role.
	Employment opportunities	Employment in catching and processing sector	Target linked to regional and national development plans	Scope to include all members but noting provision for SIDS.
	Maintain/develop domestic fishery	Landings by locally based vessels	TBD	Need to avoid negative interactions of industrial fisheries on small-scale fisheries.
	Human resource development	Employment by category	TBD	Article 30.
Ecosystem	Minimise fishery impact on ecosystem function	Ecosystem indicators	TBD	Early stage of development. Indicators likely to be based on bycatch rate trends and on community indicators derived from catches and biological characteristics of the species (e.g. trophic level). Difficult to distinguish between ecosystem effects due to fishing and those due to environmental variability.
	Minimise catch of non-target species	Mortality of NTADs/ PETs, relative abundance	TBD	Article 10.1.c provides guidance on the placement of Limit Reference Points for bycatch species at a relatively low bar. Article 5.e provides some guidance on the objective for bycatch – being to minimise waste and discards.

2. Purse seine (20N-20S; including Indonesia and Philippines)

Fishery definition

Fishery definition

- Total catch and value:
 - Total annual tuna catch = 1,650,000 t.
 - Total value = US\$ 3.6 billion
- Primarily skipjack (~75%), followed by yellowfin tuna (~21%) and bigeye (~4%)
- Comprises modes of fishing (free-schooling and associated with floating objects; varies by fleet):
 - 57% of the catch from FAD sets
 - Order of magnitude larger catches of BET from FAD sets
 - Noting complexity/change over time
- Diverse national fleets:
 - Japan = 190,000 t. (12%)
 - Chinese Taipei = 255,000 t. (16%)
 - Republic of Korea = 200,000 t. (12%)
 - USA = 205,000 t. (13%)
 - Pacific Islands (combined) = 346,273 t. (21%)
 - Others = 440,000 t. (26%)
- Predominantly equatorial:
 - (about 97% from region between 10°N - 10°S)
- Seasonal fisheries at high latitudes:
 - (e.g. NZ and Japan; about 0.5% and 3% of total tropical PS fishery, respectively)
- Significant in-zone fishery components:
 - 86% EEZs vs. 14% high seas – 2007-2011
 - 96% EEZs vs. 4% high seas – 2010-2011
- Predominantly processed at canneries

Key issues

- Juvenile BET and YFT catch (associated objective fisheries)
- Bycatch of secondary and non-target species (and spatial differences)
- Effort increase (CPUE effects)
- Predominantly within EEZ (in-zone) fishery with strong PNA influence (2010-2011):
 - 94% catches from EEZs of PNA States in tropical PS fishery (20N-20S), excl. Indonesia and the Philippines
 - 83% catches from EEZs of PNA States in WCPFC Region
- MSC certification of free-schooling skipjack
- Critically dependent fishery income for some SIDS (e.g. Kiribati, Tuvalu)
- VDS effectiveness
- Archipelagic waters fisheries (including Philippines and Indonesia)
 - Approximately 15% of the tropical PS catch from archipelagic waters (PNG, Solomon Islands, Philippines and Indonesian domestic fisheries)
- Observer coverage and data collection systems influence on management:
 - (Target 100% observer coverage since 2010)
- SIDS fishery/processing development aspirations
- Overlap with IATTC RFMO, extent of interaction with BET and capacity:
 - Overlap is less of an issue with PS fishery than LL fishery

Fishery interactions

- Downstream effect on longline fishery
- Effect on small-scale artisanal fisheries
- Competition with pole-and-line fishing
- Other zones (e.g. purse-seine fisheries at high latitudes)

Candidate objectives for purse seine fishery

Type	Objective	Indicator	Target reference point	Comments
Biological	Maintain SKJ and YFT&BET biomass above levels that provide fishery sustainability throughout their range	Estimated biomass or CPUE (as proxy)	TBD	A HCR that provides a high probability of not exceeding a limit point for biomass may be sufficient to ensure the average biomass matches a suitable target reference point. Also related to B_{MEY} . Biological limits could be examined using SEPODYM modelling.
Economic	Maximise economic yield from the fishery	Economic yield (costs and revenue evaluation), MSC certification	Ideally B_{MEY} for the multi-species fishery Proxy would be SKJ biomass or index	MEY (sector-based) will change with costs/catch rates/prices. Subsidies info important. FAD fishing increases BET and YFT juvenile mortality, smaller fish (S) but higher CPUE.
	Increase fisheries-based development within developing States' economies, especially onshore processing capacity	% contribution of fisheries to GDP	Targets linked to regional and national development plans and Resolution 2008-01	May result in a different target to MEY unless transformative process and opportunities are created for developing States to take up their participatory rights without increasing overall catch.
		Amount and proportional contribution of SIDS fleet catch		
		Amount and value of product exported from SIDS		
	Maintain acceptable CPUE	CPUE	Proxy CPUE relative to history (standardised)	Note that CPUE may be a poor indicator of biomass, fishing mode (FAD vs. free-schools) will affect CPUE.
	Optimize vessel capacity	Fishing mortality, monitor fleet size	F_{MEY} (business decision based on regulations and allocations)	If VDS and other controls are effective, vessel capacity will not be an issue. If not, overcapacity will tend to drive catches/effort beyond MEY and will reduce profitability.
	Maximise SIDS revenues from resource rents	Value of SIDS' access fees	Appropriate share of fishery rents for SIDS	Important source of government revenue for many SIDS.
	Catch stability	Catch and catch variability	Average annual catch and target level of inter-annual variability (trade-off; acceptability TBD by members)	May require stocks to be above B_{MEY}/B_{MSY} levels. Recruitment variability and environmental effects may contribute to catch stability. Current variability increased by blunt management measures (single extended FAD closure).
Stability and continuity of market supply	Market throughput of tuna products	TBD	Important issue for States with high levels of historic demand for tuna products.	
Social	Affordable protein for coastal communities	Average national annual per capita fish consumption from pelagic fisheries	Target fish consumption (e.g. 80kg / yr / person)	Tuna fisheries could contribute substantially more to food security in SIDS – but requires more appropriate fish handling and market structures. Overall fish consumption is already high, but over time as a

				result of population growth, climate change and inshore degradation, pelagic fisheries will play a more significant role.
	Food security in developing States (import replacement)	Consumption of purse-seine caught tuna (including alternative processed products)	Target per capita fish consumption (e.g. 80kg /yr)	Potential for increased production of locally canned products such as Solomon Blue (SI) and Dolly (PNG), with export to other SIDS.
	Minimize impact on small- scale artisanal fisheries	Patterns in local catches (by species)	TBD	Anchored FADs may provide additional opportunities.
Ecosystem	Minimise fishery impact on ecosystem function	Ecosystem indicators	TBD	Early stage of development. Indicators likely to be based on bycatch rate trends and on community indicators derived from catches and biological characteristics of the species (e.g. trophic level). Difficult to distinguish between ecosystem effects due to fishing and those due to environmental variability.
	Minimise catch of non-target species	Mortality of NTADs/ PETs, relative abundance	TBD	Article 10.1.c provides guidance on the placement of Limit Reference Points for bycatch species at a relatively low bar. Article 5.e provides some guidance on the objective for bycatch – being to minimise waste and discards.

3. Southern longline fishery (WCPFC Area, south of equator)

Fishery definition

- Total catch and value
 - Total annual tuna catch = 144,000 t.
 - Total value = US\$ 940 Million
- Predominantly albacore by volume:
 - Catch 60,000 t. (42%)
 - Value = US\$210 million
- Secondary species: bigeye, yellowfin and billfish:
 - YFT - 34,000 t. (24%)
 - BET - 34,000 t. (24%)
 - Marlin - 7,000 t. (5%)
- Small distinct swordfish target fishery:
 - SWO - 8,000 t. (6%)
 - Value US\$ 84 million
- Minor species: mahi-mahi, wahoo
- South of 10° South
- Catch by Area
 - (55% EEZs vs. 45% high seas)
- Catch % by flag:
 - Japan = 18,000 t. (13%)
 - Chinese Taipei = 27,000 t. (19%)
 - Korea = 17,000 t. (12%)
 - China = 29,000 t. (20%)
 - Pacific Islands (combined) = 40,000 t. (27%)
 - Others = 13,000 t. (9%)

Key issues

- Interactions with IATTC (shared stocks and management)
- Domestic fleets, and sub-regional aspirations of SIDS
- Increased switching by ULT-capable vessels between albacore and yellowfin and bigeye
- Large high seas fishery in the south with very high mobility and seasonality; difficult to discern changes at a meaningful scale
- Range contractions of yellowfin and bigeye would have serious implications, particularly for SIDs based fleets
- Interactions with troll fishery (minor)
- Fishery based on adult (albacore) stock, potential yield per recruit losses
- Accuracy of data, specifically if total removals are inaccurately recorded (e.g. for target species and for discarded bigeye)
- Lack of operational data from the high seas
- Significant concerns with the level of high seas transshipment and data inadequacies
- Recent increases in catch and effort
- Ecological issues – seabirds in far south, some sharks, turtles

Candidate objectives for the southern longline fishery

Type	Objective	Indicator	Target reference point	Comments
Biological	Maintain ALB and SWO biomass above levels that provide stock sustainability	Estimated biomass or use CPUE (as proxy)	For southern ALB $B_{lim}=0.2B_0$	A HCR that provides a high probability of not exceeding a limit point for biomass may be sufficient to ensure the average biomass matches a suitable target reference point. Also related to B_{MEY} . Biological limits could be examined using SEPODYM modelling. CPUE may be a poor indicator of biomass and objective needs to be combined with a biomass target.
Economic	Maximise economic yield from the fishery	Economic yield (costs and revenue) and biomass	Ideally B_{MEY} Proxy would be ALB biomass or index	MEY will change with costs/catch rates/prices – costs of catching hard to obtain. MEY usually based on harvesting sector. Levels of subsidies would be important as would acceptable CPUE (as a potential proxy). Proxies need to be tailored for each fishery taking into account the economics of each as well as the placement of LRPs.
	Increase fisheries-based development within developing States' economies, especially the SIDS	% contribution of fisheries to GDP	Targets linked to regional and national development plans and Resolution 2008-01	Opportunities need to be created for developing States to take up their participatory rights without increasing overall catch. Objectives will vary between states
		Amount and proportional contribution of SIDS fleet catch		
		Amount and value of product exported from SIDS		
Maintain acceptable CPUE	CPUE	Proxy ALB CPUE relative to history (standardised) e.g. nominally 350kg / thousand hooks	May require stocks to be above MEY/MSY levels. CPUE is particularly important towards objectives of maintaining profitability and addressing current poor economic conditions. Because different fleets have different modes of operation and therefore wide variance in cost structures, a single target CPUE may not be achievable.	
Optimize capacity	Fishing mortality,	F_{MEY} (business decision	May lead to dissipation of	

		monitor fleet size	based on regulations and allocations)	rent, part of MEY consideration, number of hooks per vessel etc.
	Catch stability	Catch and catch variability	Average annual catch and target inter-annual variability (trade-off; acceptability TBD by members)	May require stocks to be above B_{MEY}/B_{MSY} levels. Recruitment variability and environmental effects are thought to have a significant effect on local fish availability.
	Maximise SIDS revenues from resource rents	Value of SIDS' access fees	Appropriate share of fishery rents for SIDS	Important source of government revenue for many SIDS
	Stability and continuity of market supply	Market throughput of tuna products	TBD	Important issue for States with high levels of historic demand for tuna products
Social	Affordable protein for coastal communities	Average national per capita fish consumption from pelagic fisheries	Target per capita fish consumption (e.g. 80kg / yr)	Tuna fisheries could contribute substantially more to food security in SIDS – but requires more appropriate fish handling and market structures. Overall fish consumption is already high, but over time as a result of population growth, climate change and inshore degradation, pelagic fisheries will play a more significant role.
	Employment opportunities	Employment in catching and processing sector	Target linked to regional and national development plans	Scope to include all members but noting provision for SIDS.
	Maintain/develop domestic fishery	Landings by locally based vessels	TBD	Need to avoid negative interactions of industrial fisheries on small-scale fisheries.
	Human resource development	Employment by category	TBD	Article 30.
Ecosystem	Minimise fishery impact on ecosystem function	Ecosystem indicators	TBD	Early stage of development. Indicators likely to be based on bycatch rate trends and on community indicators derived from catches and biological characteristics of the species (e.g. trophic level). Difficult to distinguish between ecosystem effects due to fishing and those due to environmental variability.
	Minimise catch of non-target species	Mortality of NTADs/ PETs,	TBD	Article 10.1.c provides guidance on the placement

		relative abundance		of Limit Reference Points for bycatch species at a relatively low bar. Article 5.e provides some guidance on the objective for bycatch – being to minimise waste and discards.
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4. Pacific bluefin tuna

Fishery definition

- Japanese Coastal Trawl fishery (juvenile)
- Japanese Purse seine fishery (adult and juvenile)
- Japanese handline fishery (adult)
- Japanese set net fishery (adult and juvenile)
- Korean purse seine fishery (juvenile)
- Taiwan and Japanese longline fishery (adult)
- Catch – predominantly in EEZs
- Catch by flag: Japan (37%), Taiwan (3%), Korea (3%) , U.S. 1%) and Mexico (13%)
- Primary market: fresh and seed for aquaculture

Key issues

- One stock throughout the Pacific Ocean (most fishing in N hemisphere; interaction with IATTC) with documented E-W migrations in the N Pacific.
- Long exploitation history, currently at historically low biomass and heavily overfished
- Strongly influenced by environmental conditions (stock variability)
- Yield per recruit (fisheries on juveniles)
- Diversity of fishery participants
- Dependence of complex artisanal and small-scale coastal fisheries

Fishery interaction

- Mexican purse seine fishery (and interaction w/ IATTC RFMO)
- U.S. purse-seine and recreational fishery

Candidate objectives and indicators for Pacific bluefin tuna

Type	Objective	Indicator	Target reference point	Comments
Economic	Rebuild and stabilize catches	Depletion level	Ideally B_{MEY} Proxy would be biomass or index	Key objective to rebuild stock.
	Stability and continuity of market supply	Market throughput of tuna products	TBD	Important issue for States with high levels of historic demand for tuna products.
Social	Maintain artisanal fishery	Landings by region; number of fishermen	TBD	Mainly Japanese but also some Korean and Taiwan.
Biological	Maintain biomass at levels that provide stock sustainability	Estimated biomass or use CPUE (as proxy)	B_{msy}	<p>This objective is accounted for in the LRP provided and adequate 'risk buffer' is added into the TRP, which is under development but has yet to be adopted.</p> <p>Model estimates of 2010 SSB are at or near their lowest level and SSB has been declining for over a decade; debate exists on the role of environmental effects.</p> <p>Low biomass even prior to 1950s appeared to succeed in generating recruitment and subsequent stock recovery.</p>
Ecosystem	Minimise catch of non-target species	Mortality of NTADs/ PETs, relative abundance	TBD	Likely to be minimal given the scale of fisheries.
	Maintain/restore ecosystem function	Small pelagic abundances	Ecological risk assessments and/or PSA (probability susceptibility analysis)	Concern with role of PBF in the broader pelagic ecosystem, in particular possible relationship with small pelagics.

5. Northern albacore

Fishery definition

- Pole and line (annual shift in targeting from SKJ to ALB, depending on availability, or lack thereof of SKJ in JPN coastal waters)
- US & Canadian troll (target species)
- Taiwan (2,200t and Japanese longline fishery (seasonal target species in JPN LL and non-target species in both TWN and JPN LL fisheries targeting BET, especially NE of Hawaii)
- US longline fishery (two components – shallow-set SWO and deep-set BET fisheries, ALB secondary species in both)
- North of 10°N but most north of 20°N
- Size of fish varies with latitude; large fish south of 25°N and smaller fish north of 25°N
- Catch – coastal and high seas
- Catch by flag: Japan (65%), Taiwan (4%), Canada (8%) and U.S. (17%), and other countries, including Korea, Mexico, China, and non-ISC member countries (6%)
- Primary market: canned, fresh, frozen sashimi and loining markets

Key issues

- Single north Pacific stock with eastern and western juvenile groups that mingle during winter and documented trans-Pacific migrations in the N Pacific
- Fishing activities targeting the species vary greatly depending on economical/environmental factors such as availability and price of skipjack (JPN Pole-and-line) and catchability of other species (longline)
- Role of environmental conditions on distribution, especially as it affects surface (pole-and-line in WPO, troll in EPO) fisheries
- JPN PL fishery – component targets albacore, other component targets SKJ but will switch to ALB depending on market and SKJ/ALB availability in JPN coastal waters
- Troll in EPO targets ALB exclusively;
- Most LL fisheries target BET, but will catch ALB secondarily; but some periods when ALB may be target, depending on market conditions and BET/ALB availability
- Target swordfish and target BET fishing north of main region [Unsure of the point? SWO only targeted by one sector of US LL fishery; switch in targeting practices by TWN LL in 1990s from ALB to BET]
- Bycatch of seabirds, sharks, and turtles in longline fisheries
- Interim reference point (on F – FSSB-ATHL) adopted by WCPFC [check] [ALBWG does not know if this is to be used as a limit or target RP – NC has not confirmed]
- Changes in operational areas of JPN PL and CAN/US troll in 2000s result in CPUE indices being out-of-phase and potentially no longer representative of north Pacific (or could mean that different things are happening in the eastern and western juvenile groups)

Fishery interactions

- Overlap with IATTC; Can/US troll fisheries primarily operate in IATTC convention area; longline fisheries primarily in WCPFC convention area, but more activity in EPO than troll in WCPO; JPN PL is primarily a WCPO fishery
- Downstream effects of troll and pole-and-line with longline fisheries

Candidate objectives and indicators for northern albacore

Type	Candidate Objective	Indicator	Target reference point	Comments
Economic	Maximise economic yield from the fishery	Economic yield (costs and revenue)	Ideally B_{MEY} Proxy would be ALB biomass or index	MEY will change with costs/catch rates/prices –costs of catching hard to obtain. MEY usually based on harvesting sector. Currently unable to estimate MSY due to lack of good estimate of the steepness parameter.
	Maintain acceptable CPUE	CPUE	Proxy ALB CPUE relative to history (standardised)	Less concern on stock status, including troll and pole-and-line potential in convention area. Maintaining acceptable CPUE difficult - largely a recruitment driven stock with > 60% of annual yield from surface fisheries targeting juveniles (troll, PL) in the EPO and WCPO, respectively.
	Stability and continuity of market supply	Market throughput of tuna products	TBD	Important issue for States with high levels of historic demand for tuna products.
Social	Employment opportunities	Employment, including associated commerce	Number of active participants	Workforce attrition a concern for pole-and-line operations, employment on industrial fleet.
	Maintain domestic fishery	Number of vessels	Number of vessels	Increasingly difficult to recruit young fishers in a variety of communities.
Biological	Maintain biomass at levels that provide stock sustainability	Estimated biomass or use CPUE (as proxy)	B_{msy} (value to be obtained from NC)	This objective is accounted for in an interim biological LRP.
Ecosystem	Minimise catch of non-target species	Mortality of NTADs/ PETs, relative abundance	TBD	Likely to be minimal given the scale of fisheries.

Attachment 1: Summary of some candidate management objectives by fishery arising from MOW1.

Parenthetical numbers represent the submissions by broad category.²

Objectives	Fishery				
	ALL	PS SKJ	TTL	SPALB	NFsh
Ecosystem (6)					
Minimise bycatch	X	X	X		
Minimise ecosystem impact	X	X		X	
Biological (21)					
Maintain biomass at target	X	X	X	X	X
Optimise spatial characteristics		X		X	
Economic (34)					
Minimise IUU	X				
Catch	X				X
Catch stability	X	X	X	X	X
CPUE	X			X	X
MEY	X	X	X	X	
Minimise management costs		X			
Development				X	
Food security	X				
Social (14)					
Employment	X			X	
SIDS	X	X		X	
Maintain small scale fisheries			X		X
Food security	X			X	

² While the figures in brackets indicate the numbers of objectives, they do not necessarily reflect priorities among the objectives.

Attachment 2: Terms of Reference

The expert working group has used Attachment X to the record of WPPFC9 record (see below) as the TORs for this report.

WCPFC9 Agreed process for future action on Management Objectives

Step 1: Finalise Development of Management Objectives, Performance Indicators and Reference Points.

Take outputs from workshop to develop a candidate list of management objective, performance indicators, and reference points for each major fishery i.e.:

- Tropical longline
- Purse seine
- Southern longline
- Pacific bluefin tuna
- North Pacific albacore

Process to finalise Management Objectives

Use an expert group of the current facilitator and the international experts to take the outputs from the MOW1 and develop these into refined candidate objectives, performance indicators, and reference points for the WCPFC fisheries. This expert group will be supported by the Secretariat and Science Service Provider.

The expert group will develop draft management framework options (refined candidate objectives, performance indicators, and target reference points (rather than limit reference points)). This 'strawman' will be referred to all Commission members for review prior to being sent to the SC9 and NC9, for comment and suggestions for improvement. These comments and suggestions will be provided to MOW2.

The expert group will not work in isolation in developing the above management framework options. They will interact extensively with CCMs, the Secretariat and SPC, industry and NGOs. In addition, the expert group will consult with relevant regional and sub-regional bodies, to ensure compatibility between the Commission and other existing and planned management frameworks.

In developing management frameworks, the expert group will also consult with regional and subregional groups on initiatives by these groups to consider how best to integrate these initiatives to ensure compatibility. The work of the expert group will take into consideration the need to involve CCMs who expressed an interest in the expert group

Step 2: MOW2

MOW2 will be conducted prior to WCPFC10 and provide a forum for Commission members, and subsidiary bodies/stakeholders to consider and provide feedback on expert groups refined candidate objectives, performance indicators, and reference points for the WCPFC fisheries.

Step 3: WCPFC 10

Recommendations from MOW2 to be considered by the Commission members at WCPFC 10.

Attachment 3: Limit reference point development in the WCPFC

While a range of reference points have been used to present the results from stock assessments in the WCPFC, the first formal consideration of reference points with WCPFC occurred at the 4th Regular Session of its Scientific Committee (SC) in August 2005. The Commission considered papers on various aspects on reference points in each subsequent meeting until its 7th session in August 2011 when it adopted in principle the “tiered” approach which was a slightly modified version of that proposed by Preece et al. (2011³)

Level	Condition	LRPs
Level 1	A reliable estimate of steepness is available	F_{MSY} and B_{MSY}
Level 2	Steepness is not known well, if at all, but the key biological (natural mortality, maturity) and fishery (selectivity) variables are reasonably well estimated.	$F_{X\%SPR_0}$ and either $20\%SB_0$ or $20\%SB_{current,F=0}$
Level 3	The key biological and fishery variables are not well estimated or understood.	$20\%SB_0$ or $20\%SB_{current,F=0}$

The key difference was the addition of the so-called depletion reference point $20\%SB_{current,F=0}$ as an alternative to the equilibrium version proposed by Preece et al. (2012). The original proposal of Preece et al. (2012) was that bigeye and yellowfin tuna be tier 2 and skipjack, albacore, and other species be tier three. Based on additional modelling work it was determined that striped marlin and south Pacific albacore tuna at least be considered tier 2. In December 2012, based on the recommendation of the SC, WCPFC adopted $20\%SB_{current,F=0}$ as a limit reference point for skipjack, south Pacific albacore, bigeye, and yellowfin tunas with the proviso that further work be undertaken to:

- determine an appropriate FSPR-based limit reference point for tier 2 stock which is consistent with the biomass one;
- determine the most appropriate time period over which to calculate $SB_{current,F=0}$; and
- recommend approaches to account for uncertainty when determining if a limit reference point has, or is likely to be, exceeded.

Work on these three areas will be considered by the 9th Regular session of the Scientific Committee in August 2013.

³ Preece, A., et al. (2011) Identification of candidate limit reference points for the key target species in the WCPFC. WCPFC-SC7-2011/MI-WP-03.

Attachment 4: Example management frameworks from different nations

New Zealand

In New Zealand, the Minister of Fisheries determines total allowable catches taking account of relevant factors in the Fisheries Act. The Minister has endorsed a *Harvest Strategy Standard for New Zealand Fisheries*⁴, which forms the basis of the advice from officials of the Ministry for Primary Industries.

The objective of the Harvest Strategy Standard (HSS) is to provide a consistent and transparent framework for setting fishery and stock targets and limits and associated fisheries management measures, so there is a high probability of achieving targets, a very low probability of breaching limits and acceptable probabilities of rebuilding stocks in a timely manner if they do become depleted.

- A specified target about which a fishery or stock should fluctuate
- A soft limit that triggers a requirement for a rebuilding plan
- A hard limit below which fisheries should be considered for closure.

For most stocks, the target is an MSY compatible reference point: i.e. B_{MSY} for stock size, F_{MSY} for fishing mortality and MSY for catch.

The default soft limit is 0.5 B_{MSY} or 20% B_0 , whichever is higher, which point is considered to be breached when the probability that the stock biomass is below the soft limit is greater than 50%. In that case the management must allow for rebuilding to the target level in a time frame between the theoretical time the stock would take to recover to the target with no fishing, and twice that time. For stocks that have fallen below the target level, but not as far as the soft limit, action is also necessary to rebuild back to the target.

The default hard limit is 0.25 B_{MSY} or 10% B_0 whichever is the greater, which limit is considered to be breached when the probability that the stock biomass is below the hard limit is greater than 50%.

United States of America

There are a diversity of approaches and levels of complexity for the six regional fishery management bodies that function within the USA.

Objectives

The National Standards are statutory principles that must be followed in any fishery management plan (FMP). The guidelines summarize interpretations by the Secretary of Commerce that have been applied under these principles. The guidelines are intended as aids to decision-making and thus link management objectives to management actions and are intended to comply with the Magnuson-Stevens Act along with other applicable laws. These guidelines (and paraphrased summary) are

1) Achieve Optimum Yield

Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the optimum yield (OY) from each fishery for the U.S. fishing industry

2) Scientific Information

Conservation and management measures shall be based upon the best scientific information available

3) Management Units

To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination.

4) Allocations

⁴ <http://www.fish.govt.nz/NR/rdonlyres/C596EF78-E762-4019-A21A-750156610066/0/HarvestStrategyStandard.pdf>

Conservation and management measures shall not discriminate between residents of different states.

5) Efficiency

Conservation and management measures shall, where practicable, consider efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose.

6) Variations and Contingencies

Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches.

7) Costs and Benefits

Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.

8) Communities

Conservation and management measures shall take into account the importance of fishery resources to fishing communities in order to: (1) Provide for the sustained participation of such communities; and(2) To the extent practicable, minimize adverse economic impacts on such communities.

9) Bycatch

Minimize bycatch mortality to the extent practicable

10) Safety of Life at Sea

Conservation and management measures shall, to the extent practicable, promote the safety of human life at sea.

Clearly many of these guidelines wind up with competing and conflicting objectives (e.g. one way to minimize bycatch would be to curtail fishing, hence NS9 could conflict with NS1). In practice, at the single species assessment level reference points and management measures focus primarily on NS1 but the impacts of the other play important roles. In most situations where hard limits (TACs) are applied, the reference points are based on proxy values, which typically have been tested against plausible counterparts. For example in the case of Alaska groundfish fisheries, proxy values for F_{MSY} are set as an upper limit and target fishing mortality rates (some value lower than the F_{MSY} proxy) have been demonstrated to perform reasonably well and appear to provide sufficient precaution relative to plausible ranges of F_{MSY} as determined from uncertainty in environmental conditions and the inherent productivity of the stocks. The overall management framework for Alaska groundfish was evaluated using models (along with alternative CMMs) which captured the multi-species nature of the fisheries, the array of gear types (and potential for growth), and over-arching constraints (e.g. bycatch of prohibited species such as salmon and Pacific halibut).

Australia

The move to adopt formal reference points and harvest strategies was motivated by deteriorating stock status and economic performance, and their introduction was accompanied by complimentary management actions to better align fishing capacity to sustainable production and to increase the use of spatial management. Default reference points and harvest strategies and guidance for their use and performance requirements, are provided through the Commonwealth Harvest Strategy Policy. A harvest strategy in this context is a combination of monitoring, analysis of monitoring data, and use of this analysis through a control rule to determine management measures (e.g. allowed catch or effort). The reference points and performance to be achieved through application of a harvest strategy are:

- Biomass target reference point – maximum economic yield B_{MEY} .
- Fishing mortality target reference point - F_{MEY} .
- Biomass limit reference point – half B_{MSY} .

- Fishing mortality limit reference point – F_{MSY} .

Other requirements of the policy are that:

- the control rule should progressively reduce fishing mortality between B_{MSY} and B_{LIM} , and below B_{LIM} there should be no targeted fishing; and
- There should be less than a 10% chance of the stock falling below the limit per generation time under application of the harvest strategy

Default proxies are provided in the policy for situations where reference points cannot be estimated:

- B_{MSY} is 40% of unfished level
- So B_{LIM} is 20% of unfished level
- B_{MEY} is $1.2 \times B_{MSY} = 48\%$ of unfished level.

Several approaches to applying the requirements of the Harvest Strategy Policy in data poor fisheries have been developed. These include:

- Tiered control rules, similar to those applied in Alaskan fisheries, for different levels of available information with an increasing ‘discount factor’ applied for decreasing information.
- Use of empirical harvest strategies that are based on direct use of measured indicators (catch rate, length distributions, etc.) and shown by MSE to achieve the performance required by the Harvest Strategy Policy.
- Tiered Ecological Risk Assessment methods, from qualitative through semi-quantitative to qualitative. These can be applied to all species and habitats to identify and focus on high-risk situations for targeted and Risk Management. The risk criteria for the high-risk category is analogous to a limit reference point, and the risk management response is analogous to a control rule in a harvest strategy.

Japan

Japan has examined the usefulness of historically-based Limit Reference Points (LRPs) such as F_{loss} to Pacific bluefin tuna (northern) stocks using operating model and contrasted these with maximum sustainable yield MSY-based LRPs such as F_{MSY} proposed for Western and Central Pacific southern tuna (southern) stocks. The numerical simulations indicated that historically-based LRPs are appropriate for northern stocks when recruitment compensation is high (i.e. when “steepness” in the stock recruitment relationship is high). In contrast, MSY-based LRPs often have a high risk of allowing recruitment overfishing of northern stocks when process errors are large. Based on these results, it is suggested that LRPs set with reference to historical stock sizes are worthy of consideration for temperate tunas in the North Pacific.

Attachment 5 . Summary of current status of management strategies in RFMOs. (Source: 2013 ISSF Stock Assessment Workshop: Harvest Control Rules and Reference Points for Tuna RFMOs. San Diego, California, USA, March 6-8, 2013)

Element	IATTC	ICCAT	IOTC	WCPFC	CCSBT
Management Objectives (Convention and CMMs)	Population level that can produce MSY. Apply the Precautionary Approach.	Maintain population at level that can permit maximum sustainable catch.	Conservation and optimum utilization of stocks. Adoption of PA in 2012 (Res. 12-01). "Dialogue initiated" on identifying clear management objectives.	Long-term conservation and sustainable use of HMS. Maintain stocks at levels capable of producing MSY, as qualified by environmental, economic and SIDS considerations. Includes guidelines for RPs based on best science.	Ensure, through appropriate management, the conservation and optimum utilization of SBT. The 2011 Commission meeting requires TAC setting to also take PA into account.
Limit Reference Points	None yet.	None yet. ALB: Under development by SCRS (Rec. 11-04)	Interim, non-binding limits: SKJ: $0.4B_{MSY}$, $1.5F_{MSY}$ BET: $0.5B_{MSY}$, $1.3F_{MSY}$ YFT and ALB: $0.4B_{MSY}$, $1.4F_{MSY}$	BET, YFT, ALB: $20\%SB_{current, F=0}$ and $F(x\%SPR_0)$ SKJ: $20\%SB_{current, F=0}$ Currently investigating F-based LRPs for SC9 in 2013	$20\%SSB_0$ is an interim rebuilding target, but would also become a limit at the end of the rebuilding program. The 2011 decision identifies the lowest observed stock size as the limit
Target Reference Points	None in place yet. Though F_{MSY} is an implied TRP.	None in place yet Though the "green" quadrant of the Kobe plot is implied as a target region in Rec. 11-03	Interim non-binding targets: SKJ, BET, YFT, ALB: B_{MSY} , F_{MSY}	None in place yet. 2013 MOW goal: developing TRPs. CMM-2012-01 indicates $TRP \leq F_{MSY}$ for BET, SKJ, YFT	"Interim rebuilding objective": $20\%SSB_0$ A long-term TRP will be considered once stock is rebuilt to $20\%SSB_0$.

Element	IATTC	ICCAT	IOTC	WCPFC	CCSBT
HCRs	None formal. "Informal" rule based on FMSY applied by Secretariat	Principles of Decision-making (Rec 11-13) provides HCR framework but parameters not defined ("high" or "low" probability, timeframes)	None formal. HCR development mentioned in the PA Resolution. "Informal" rule based on F_{MSY} or B_{MSY} being exceeded	None yet but SPC conducting PNA-requested review of alternative HCRs for SKJ. "Informal" rule based on F_{MSY} when it or B_{MSY} is exceeded	Harvest rules via a TAC, that is the average catch value from two formulas designed to achieve the recovery target and tuned to juvenile surveys and CPUE. 0.7 probability of rebuilding to 20%SSB ₀ .
Management Strategies / Procedures	None formal. Staff uses stock assessment results to determine how current F should be changed to obtain FMSY (e.g. change closure length).	None formal. SCRS advice via Kobe framework (Res 11-14) and strategy matrices.	None formal. SC provides management advice based on stock assessment and recommends catch limits to the Commission.	None formal. SPC provide stock assessments and projections to the SC, and ISC provides them to the SC and Northern Committee	Adopted in 2011. Sets TAC in 3-year intervals. An interim plan to rebuild the stock to the limit level.
Management Strategy Evaluations (MSEs)	None	Under SCRS development for BFT (Mediterranean) and ALB (N. Atlantic).	Under development SC for SKJ, ALB.	"Pseudo-MSE" (without feedback control) under development by SPC.	Completed for the measure adopted in 2013

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**SUMMARY OF SC INPUT TO THE MANAGEMENT OBJECTIVES
PROCESS**

The Commission (WCPFC9) directed the Management Objectives Working Group to obtain comments and suggestions from SC and NC on the draft report of candidate management objectives, performance indicators and reference points. It has also been proposed that the paper be considered by TCC.

The draft SC record contains the following advice:

- the paper lays out well the range of objectives of different Commission members and other stakeholders and the special requirements and aspirations of SIDS;
- support for the process to continue and the further development of the paper, particularly the proposals for target reference points, and the 2nd session of the Management objectives Workshop;
- further clarification of the difference between TRPs for fisheries and TRPs for species; and
- preference for use of a modified Kobe plot to illustrate the use of a ‘buffer’ around the TRP.

A small working group was convened and added the following suggestions to assist with progressing the report of the working group and the MOW2 workshop, which is to be held before WCPFC 10 in Cairns.

- Include a brief introductory session to ensure participants are aware of the process and key concepts, given the likely changes that will occur within delegations.
- It would helpful to explore the implications of ranges of TRPs for some species as a means of illustrating how objectives, PIs and reference points interact in a management framework.
- Support exploring ranges of TRPs for skipjack and southern albacore, and possibly Pacific bluefin, noting that in the case of Pacific bluefin, an approach based on an interim rebuilding target would be appropriate.

- MEY-based approaches require a range of economic data; this data is not available for a number of fisheries, and even where some data exists, there are considerable gaps, particularly with respect to operating costs and the relative values of access.
- Definitions of MEY will vary between CCMs and fleets depending on objectives e.g. maximising profits or employment, and whether or not just the harvesting sector or other sectors (e.g. processing) are included.
- To assist in the development of MEY-based approaches it would be helpful to identify current data holdings, where gaps exist and a strategy for collecting priority missing data.
- Current stock assessment models are based on spatial delineation and may not be suitable for considering the analysis of options for management strategies that take account of economic outcomes.

On the issue of the format of MOW2, the small working group suggested:

- a focus on options and ranges of values for TRPs for skipjack and southern albacore, and possibly Pacific Bluefin