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**Representing uncertainty, risk and performance indicators against fishery management objectives and reference points**

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**WCPFC-SC10-2014/ MI-IP-02  
(MOW2-WP/05)**

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**WCPFC  
SECOND MANAGEMENT OBJECTIVES WORKSHOP**

Cairns, Australia  
28-29 November 2013

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**REPRESENTING UNCERTAINTY, RISK AND PERFORMANCE INDICATORS  
AGAINST FISHERY MANAGEMENT OBJECTIVES AND REFERENCE POINTS**

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**MOW2-WP/05  
14 Nov 2013**

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## MOW2 - Cairns November 2013

### WP5: Representing uncertainty, risk and performance indicators against fishery management objectives and reference points

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#### 1. Introduction

A management strategy seeks to provide a simple agreed framework that allows proactive management action to be taken in a fishery. It should consist of objectives, reference points and Performance Indicators (PIs) that anticipate potential changes in the fishery, provide pre-agreed responses and therefore guide timely decision-making.

Interpretation and communication of the behaviour of PIs and their status with regards to reference points can be greatly enhanced, and simplified, through graphical representation. The use of the Kobe plot (see figure 1) has been adopted by tuna RFMOs as a standard presentation and has enabled diverse audiences to better grasp the significance of stock assessment outcomes, particularly in relation to stocks performance against MSY related reference points. Further to that, as can be seen in the below example, a Kobe plot can display uncertainty to show the bounds or risk of possible stock status results. It is however a blunt tool which only presents a single management objective, stock status, and presents the fishery as either fine (in green) or not.

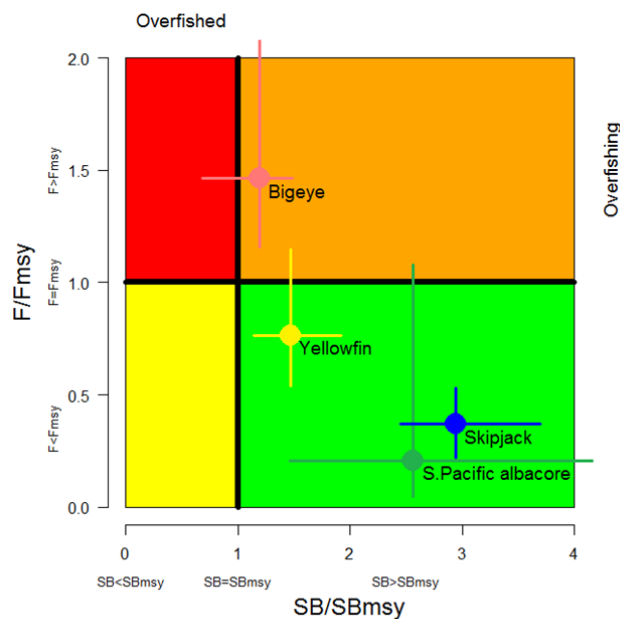


Figure 1: Kobe plot showing stock status of WCPO target species at a single point in time

The Kobe plot will continue to be an important tool for fisheries management. Yet in order to inform a more proactive response, additional tools that better represent both target and limit reference points, past and future time scales, and non-biological indicators would enhance our ability to interpret the past and predicted performance of the fishery and communicate the rationale for management decisions.

The purpose of this paper is to explore some alternative approaches for representing performance indicators, reference points, and risk for the purposes of informing management decisions. It is not a critique of the many valid approaches to representing scientific outcomes, which will continue to be used for many different purposes, and it will not consider the science of monitoring and assessment of performance indicators.

Visual communication tools can directly support fisheries management strategies by:

- Measuring PIs directly against multiple management objectives,
- Informing (and providing rationale for) a management response to the status of a performance indicator,
- Improving understanding of the status of the fishery among managers and stakeholders, and
- Recognise uncertainty and risk.

The options explored below focus on graphical tools that, either wholly or in part, achieve these criteria.

## 2. Options

### 2.1 Risk and uncertainty

There are many approaches to representing the risk and uncertainty in fishery science using visual tools, and even multiple approaches of doing this within a Kobe plot. Figure 1 shows the uncertainty related to the assessment of stock status for the key species within the WCPO, where despite the BET results indicating stock is in the orange overfishing quarter, the uncertainty bars clearly show that there is a risk that the stock is also overfished. Figure 2 is another way to display uncertainty based on the variable results of alternative plausible stock assessment model configurations.

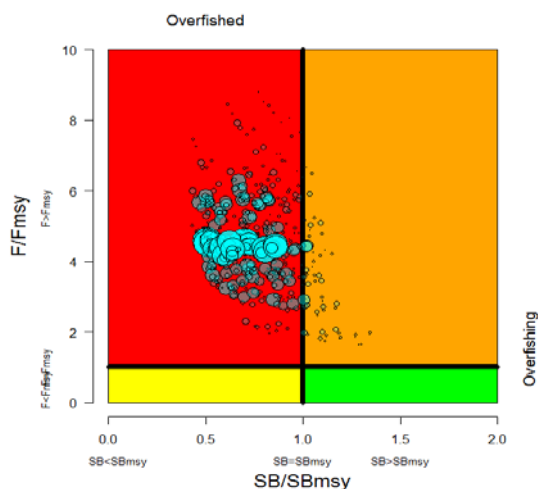


Figure 2 – A Kobe plot displaying the uncertainty across alternative stock assessment model configurations.

It is critical that uncertainty and risk are not only appreciated by managers, but understood by stakeholders and decision-makers. This is not only relevant to uncertainty in results or stock status at a point in time, but also to ensuring that managers and stakeholders understand the risk of stocks hitting LRPs, and the probability of reaching TRPs, over time. Visual tools that capture uncertainty and risk can highlight the need for precaution, display the risk in different management responses, and moderate expectations for the behaviour of the stock and fishery in response to management interventions.

There is a catch-22 in an increasing our understanding of uncertainty, in that efforts to better capture the uncertainties in a fishery system typically lead to a wider spread in the results and hence a greater potential risk. This can weaken the ability to derive clear messages from the science and therefore hamper decision-making, when perhaps a more precautionary approach based on imperfect science (i.e. that doesn't capture all uncertainty) may be more beneficial to getting robust management action and therefore maintaining sustainable fisheries.

## 2.2 Tracking over time

Decisions on management can be significantly enhanced by understanding what the stock (or other PI) has done in the past in response to management intervention or changes in the fishery, and how the stock (or PI) is expected to perform in future under different management regimes. A weakness of the Kobe plot is its limited ability to represent trends in the fishery over time. Figure 3 is an example of a Kobe plot with stock status over time. From a management perspective this plot has a limited ability to display the trends and performance of the stock over time, and any attempt to forecast stock status would further confuse the picture.

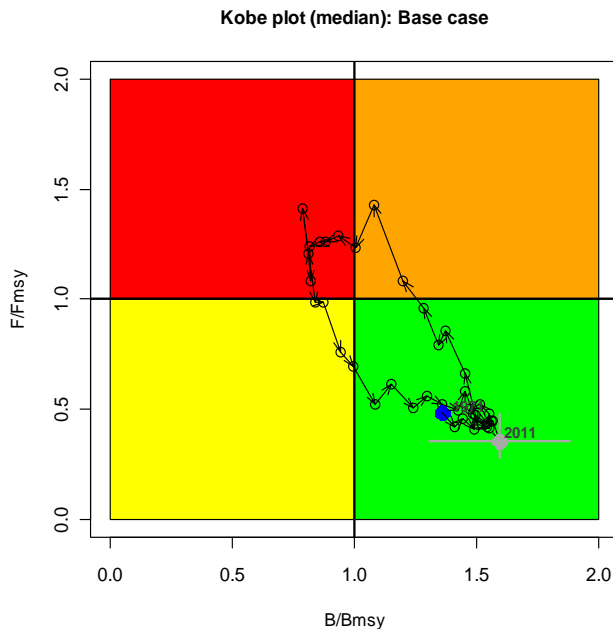


Figure 3 – Kobe with tracking over time

Tracking of a single PI over time can provide a clearer picture for management purposes. Figure 4 provides two examples of the tracking of a single PI, in this case biomass, over time against a reference point of  $B_{msy}$ .

This example of tracking a single indicator over time also displays the ability to clearly represent the uncertainty in the results, by building in the uncertainty in stock biomass over the plotted timeframe.

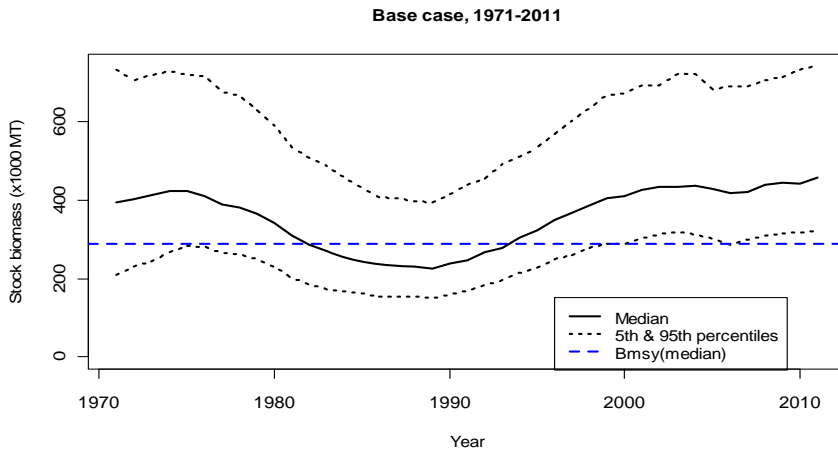


Figure 4 – Demonstrating stock biomass over time against  $B_{msy}$

Representation of trends over time can give management some indicator of the behaviour of the stock in response to different environmental changes, socio-economic shift, fleet changes and management interventions. Also a clear advantage of the single PI tracking approach is that it can be used to represent future stock projections under different management scenarios. Although scientifically challenging, and laden with uncertainties, projections of stock under different scenarios are particularly useful for informing management decision making. There are a number of projection methods that can be used for this purpose ranging from stochastic methods that simply apply an expected change to given starting point to deterministic models that use multiple starting points and apply a range of probabilistic scenarios that account for uncertainty.

### 2.3 Measuring against target and limit reference points

As presented in the draft Strawman document and re-created in figure 5 below, plotting the performance of an indicator against reference points directly informs the need for management intervention.

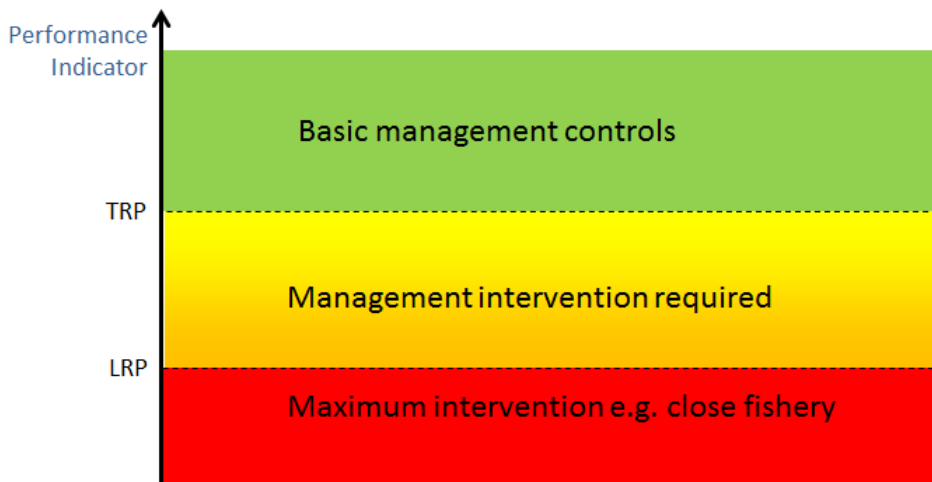
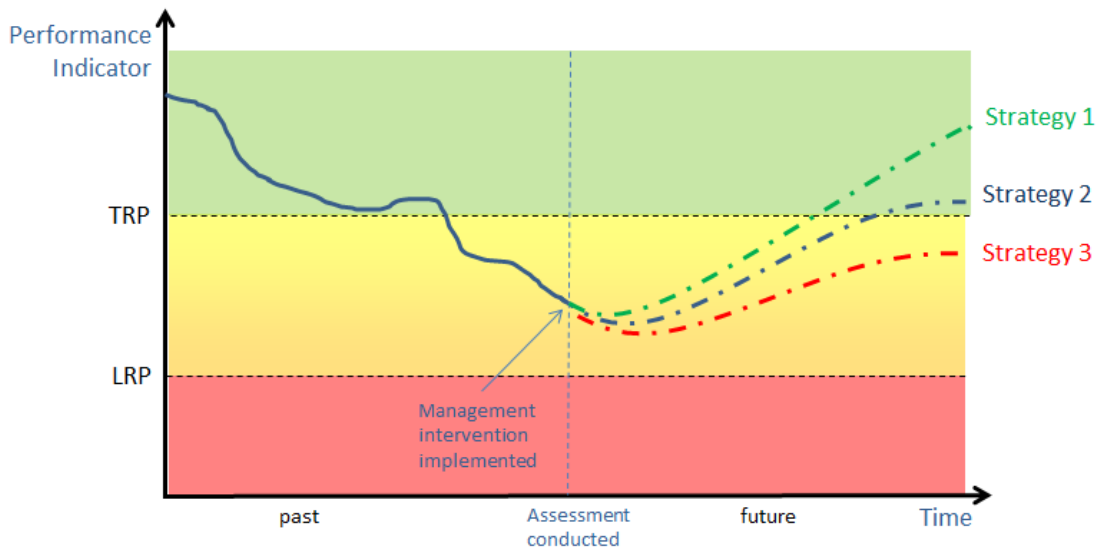


Figure 5 – Using performance indicators and reference points to guide management

This approach can also be used to guide the type of management intervention required if projections are introduced. Figure 6 below shows the plotting of an indicator against target and limit reference points over time, and demonstrates the projections for the indicator under three different management strategies. This shows that once objectives are clear and target reference points have been agreed, future projections of indicators can provide invaluable guidance to the management of a fishery.



*Figure 6 – Projections of performance indicators against reference points under three different potential management strategies*

Visual projections of stock status are particularly useful in triggering management action for an at risk stock, by portraying the future stock health under status quo scenarios. Although a stock may look healthy (i.e. be in the green) at present, projections can highlight the weaknesses in a management regime, for example the ability for sustainable levels to be maintained in a fishery subject to growing effort entering the fishery, decreasing ecosystem health or ENSO variability. As such projections can inform the implementation of management strategies that minimise (or negate) predictable impacts on healthy stocks, or remove current unacceptable impacts on unhealthy stocks.

The Kobe plot has become the primary graphical communication tool for demonstrating stock health in WCPO fisheries, due primarily to its ability to represent the two primary PIs adopted for the fisheries to date,  $F/F_{MSY}$  and  $SB/SB_{MSY}$ . A modified Kobe that reflects target and limit reference points has been suggested (see figure 7), however it presents a target range that is conceptually difficult to understand and practically difficult to achieve.

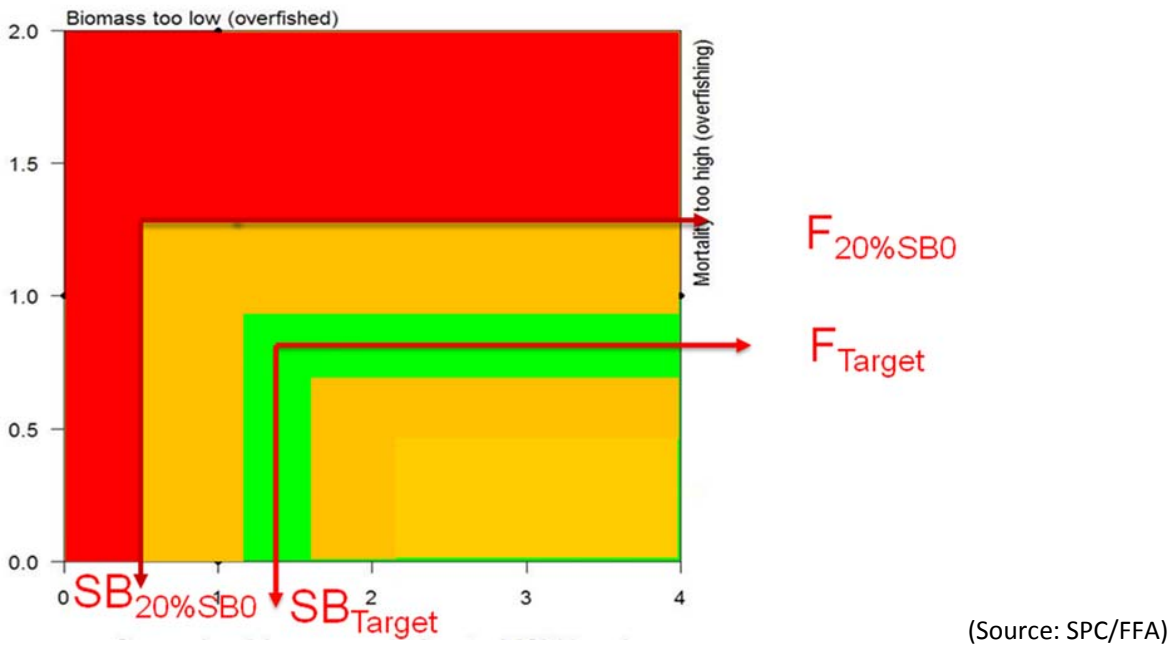


Figure 7 – A draft modified Kobe plot representing target and limit reference points.

### 2.3 Representing performance against multiple objectives

In reality, fisheries are likely to be managed in order to achieve more than just stock health. While stock objectives are critical to the long-term sustainability of the fishery, often the way in which the stock is maintained is informed by socio-economic considerations.

Socio-economic and biological analyses, and Management Strategy Evaluations, can provide an understanding of the impact of management strategy on a number of different outcomes. However both inputs and outputs to such analyses can be complex, so simplified communication mechanisms, such as graphical representations are necessary in order for the outputs to best be used.

A useful tool for displaying performance of multiple strategies against a set of diverse approach was demonstrated in the draft Strawman document, and reproduced in figure 8 below. The figure clearly shows the trade-offs between objectives for the different management approaches, with the strategy that provides the greatest catch clearly resulting in less stability and certainty for long term catch outcomes.



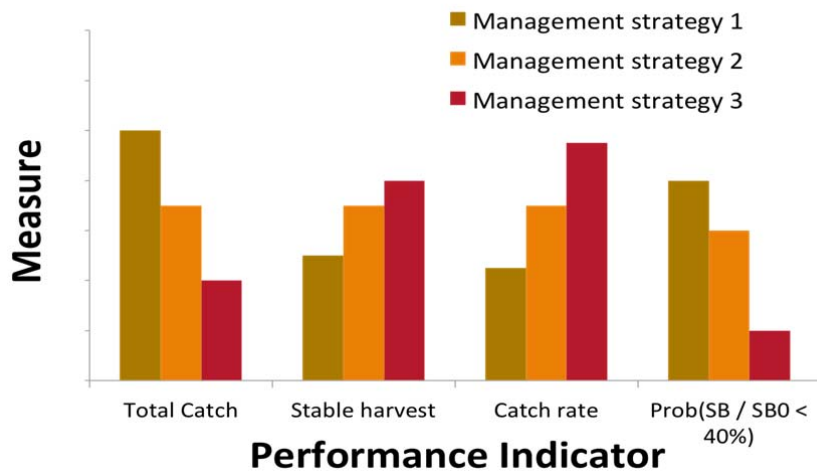


Figure 8 – Illustration of effects of management strategies on key performance indicators.

This approach is a useful way of portraying the likely outcomes at a certain fixed point in time after the strategy is implemented, and could be amended to incorporate any number of diverse indicators. It could also be used to show the risk of exceeding or falling below a key level, e.g. the number of times in 30 years the stock is predicted to fall below a limit level. Performance against reference points can be built into such an approach, as can trade-offs between fishery sectors, although the figure may become quite complex and lose some of the impact.

#### 2.4 Recognising trade-offs and using a modified Kobe to inform target reference points

In a fishery where there were two dominant objectives and associated performance indicators, for example a stock health objective and an economic objective, the Kobe approach could be utilised. To date the Kobe has been utilised primarily to display two indicators of stock health (typically fishing mortality  $F$  and spawning stock biomass  $SB$ ), however it could be modified to adopt some economic information or even simply the desirability of different levels of  $F$  could be interpreted through an economic benefit lens. And in this sense it could assist with the development of target reference points that recognise the trade-offs necessary between multiple objectives.

If  $F$  were reflected using the red/yellow/green approach with a recognition of the desirability being a gradual continuum rather than having defined boundaries, you might get a pattern similar to that in figure 9 below, with low levels of  $F$  considered somewhat undesirable as below a limit threshold (represented in the figure as  $F_{lim}$ ) that allows the establishment of a profitable industry sufficient to deliver a minimum level of processing, employment and export outcomes.

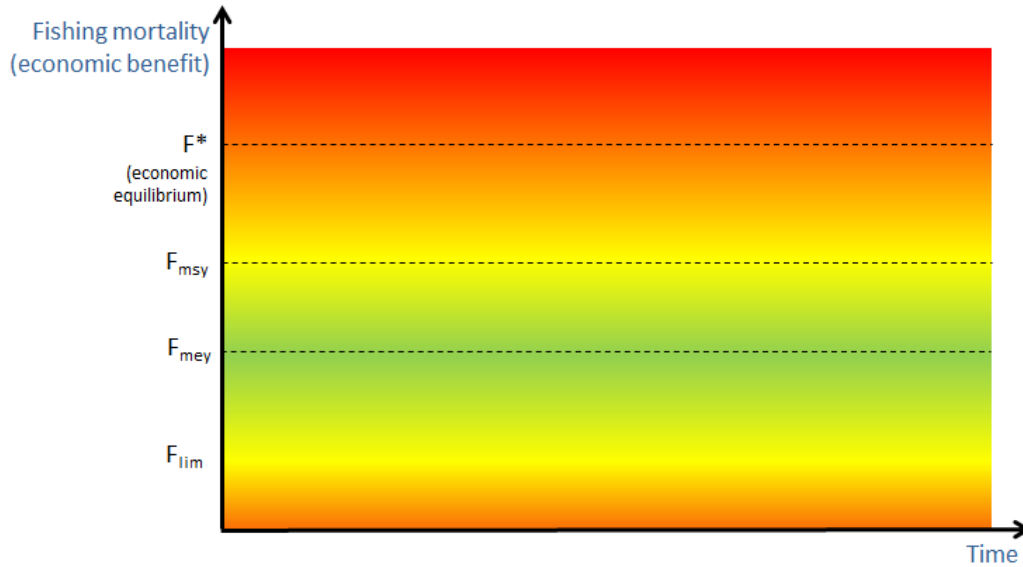


Figure 9 – Hypothetical desirability of different levels of fishing mortality ( $F$ ) from an economic perspective.

Although it adds complexity, the graduation in colour also assists in capturing some recognition of uncertainty that is inevitable both in the monitoring of an indicator and our understanding of reference points. A gradual colour shift more clearly demonstrates that the difference between good (green) and bad (red) does not occur at a single reference point.

If you were to combine figure 10 with an X-axis representing stock health, the resultant plot might look more like a target range (see figure 11).

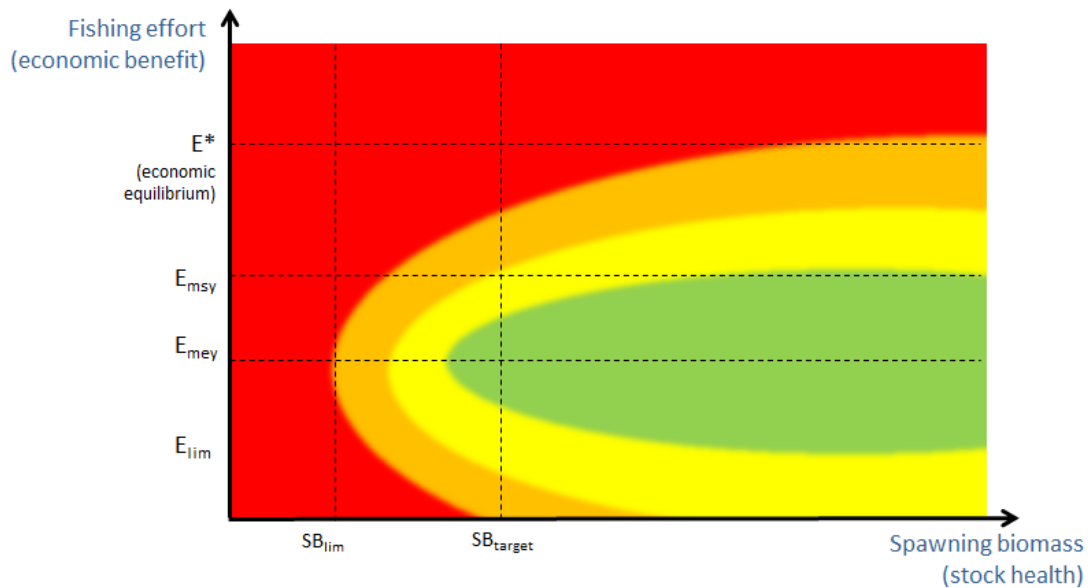


Figure 10 – A modified Kobe representing an economic indicator (Effort) on the Y axis and a stock health indicator (spawning biomass) on the X-axis, where  $E_{lim}$  represents the minimum effort required to achieve a profitable fishery.

As with the traditional Kobe plot, this approach would not display tracking over time well, nor uncertainty, its utility is primarily for demonstrating an update on present status. However the introduction of the graduation from green to red and rounded boundaries does have the advantage of recognising some trade-offs between objectives.

For example, figure 8 shows that effort levels greater than  $E_{MSY}$  on biomass levels below  $SB_{target}$  are undesirable, which better presents the risk that high effort level will further degrade the status of the stock. It also shows that high effort levels (i.e. above  $E_{MSY}$ ) are less of a concern on larger levels of spawning biomass, but as spawning biomass decreases then effort must be reduced to remain in the target area, therefore providing a more balanced perspective for management decision-making given the two equally important objectives.

What this figure primarily demonstrates is a continuum in which the target fishery performance is the crosshairs between  $E_{meq}$  and  $SB_{target}$ , but performance is also acceptable over an increasing range of effort levels as the spawning biomass increases. By presenting the two objectives and their respective primary indicators together, it shows that the target (or acceptable target range) for any one indicator is dependent on the performance of the other indicator.

If a similar exercise were undertaken for another common economic indicator, CPUE, against the same stock health indicator, a different pattern is produced (see figure 11).

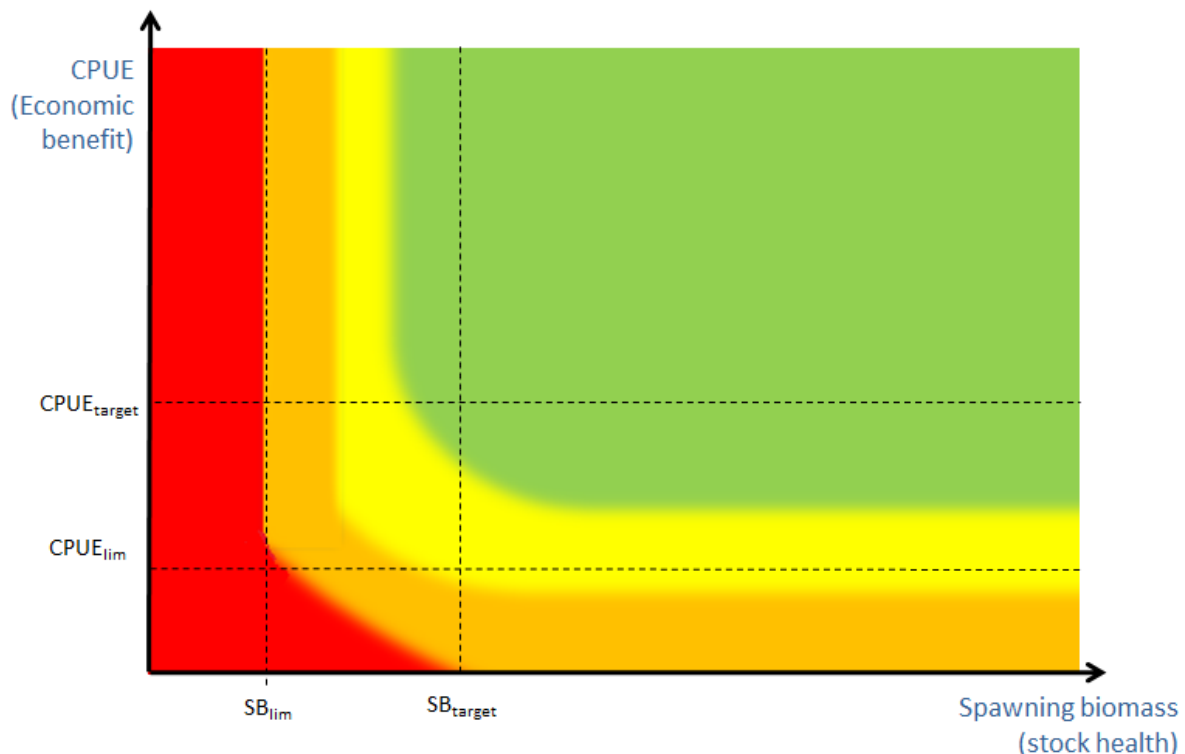


Figure 11 – A modified Kobe representing CPUE on the Y axis and spawning biomass on the X-axis.

The difference between these two figures (figures 10 and 11) clearly demonstrates the importance of selecting the primary indicators and their associated reference points against which the fishery's

performance is to be assessed, as it significantly impacts on the “target” and therefore the management response to a fishery’s status.

### **3. Conclusions**

A management strategy seeks to improve the ability of managers to make timely and proactive decisions for the management of a fishery. In order to do this, they need to understand the indicators coming from the fishery, as interpreted by scientists. Often visual tools assist not only managers to understand these scientific outputs and therefore what their objectives mean, but they also allow them to communicate that information to a broad audience including Ministers, industry and the public.

Where indicators demonstrate that management intervention is required, managers and stakeholders need to have some understanding of future consequences, trade-offs, and uncertainty associated with potential management responses. Visual tools that demonstrate these therefore complement the implementation of a fishery management strategy.

A single graphical tool is unlikely to meet all of these needs but building target and limit reference points, and some recognition of uncertainty, into commonly used tools (like the Kobe plot) would enhance their ability to support a management strategy approach. Management decision-making would also benefit from more regular use of secondary tools that allow for better presentation of performance over time and future projections.

The above discussion represents a few options to generate discussion and thinking on communication of reference points and fishery performance, however the use of any one (or more) approaches will have limited value before objectives and PIs have been agreed for the fisheries. It is only at that point that “performance” can truly be monitored and assessed, and the outputs used to inform proactive management responses.

Below are a few questions that could be considered in the future:

- Are the current Kobe plots adequate to illustrate current and predicted stock status? If not, how could they be improved?
- What other graphical tools could be used to demonstrate multiple or diverse indicators?
- How much uncertainty should be presented in the primary management strategy visual tools? Could the complexity of risk and uncertainty be simplified?
- Are there other types of indicators that would benefit from better graphical representation (e.g. spatial, socio-economic, or ecosystem indicators)?