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Department of Agriculture Fisheries and Forestry

Literature study and review of international best practice in fisheries harvest strategy policy approaches

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The **Australian National Centre for Ocean Resources and Security (ANCORS**) is Australia's only multidisciplinary university-based centre dedicated to research, education and training on ocean law, maritime security and natural marine resource management providing policy development advice and other support services to government agencies in Australia and the wider Asia-Pacific region, as well as to regional and international organizations and ocean-related industry.

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Executive Summary

In 2007, the Australian Government's harvest strategy policy (HSP) was produced in response to the 2005 Ministerial Direction to address overfishing. The HSP was a policy response applying science to management regimes to assure that Commonwealth fisheries were being sustainably managed and to a standard of "world's best practice".

After the first five years of the HSP, this study examines current sources and standards for international best practice (IBP). Few other nations have a central policy for harvest strategies, but the key elements can be still be compared. The HSP can be seen to meet the requirements of international agreements and is meeting and in some areas is exceeding the standards in other countries with a reputation for good fisheries management practices.

Best practice in fisheries management has three components: (A) providing evidence; (B) how decisions are made; and (C) achieving compliance (IEEP 2010). A HSP provides and requires standards of evidence for stock sustainability, but achieving IBP is made more complex by the decision making system and the extent of achievement or compliance, often measured by stock status reports.

This study compares IBP for both the common fishery reference points and control rules and also other less developed policy areas are also examined, such as:

1. *multi-species fisheries – target, byproduct, bycatch*
2. *data poor fisheries (including exploratory fisheries)*
3. *low value species and fisheries*
4. *managing discarding (target and non-target species)– approaches, implementation, control and monitoring*
5. *different productivity levels of various species (e.g. sharks; prawns)*
6. *different trophic levels and roles, including keystone species (e.g. small pelagics)*
7. *application of risk based approach".*

There are common stock management reference points that apply to all fisheries and have been those traditionally emphasised in harvest strategies internationally. Many of the less developed reference points only impact a portion of the total number of fisheries nationally and hence have received less emphasis, but are of emerging importance.

The study examines international legal obligations as sources of IBP and the harvest strategy features, or equivalent, in several countries and regional bodies that are regarded to have strong fisheries management, namely New Zealand (NZ), the United States of America (US), the European Union (EU), Norway and Iceland. There are a range of international codes of conduct developed by the Food and Agriculture Organisation (FAO) of the United Nations and eco labelling guidelines and certification schemes which were examined for IBP.

Only NZ has an equivalent harvest strategy standard across it fisheries, though the US has a range of national standards in place. Information in other countries on the HSP elements requires access to a less centralised range of documents overseas, where policies may be at a regional or fishery level, making information more difficult to retrieve.

The United Nations Convention on the Law of the Sea (LOSC), together with other international legal instruments, and the United Nations Fish Stocks Agreement have required nations States to achieve sustainable fishing. Legislation has become more specific through time, with subsequent "soft law" international instruments existing in the form of FAO guidelines. The specification of overfishing in international conventions involving fishing mortality, F_{MSY} has been problematic in interpretation and generally biomass (B_{MSY}) is being adopted as the preferable stock status benchmark.

The rise of eco-labelling and seafood certification schemes are also beginning to contribute to international best practice as they have brought consumer power to bear on the overfishing of stocks. The Marine Stewardship Council is now focusing on more explicit scientific evidence measures of stock status and is enabling the level of practice for their existing standards to be recognised in a scoring system, exceeding their standard pass/fail assessment in order to encourage continuous improvement.

Reference points

This study details and compares reference points used in most fisheries finding the following results for the reference points used in all fisheries.

No.	HSP Area	Reference criteria	HSP settings	What is IBP?	Minimum International requirement
	Established policy areas				
1	Management objective	Biomass level, B	B_{MEY} (or 1.2 * B_{MSY} proxy)	B_{MEY} (1.2 * B_{MSY} proxy)	B_{MSY} (eg. LOSC)
1	Biomass Objective	Biomass level, B	B_{MSY}	B_{MSY}	towards B_{MSY} (eg. LOSC)
2a	Biomass Limit	Biomass level, B	B> B_{LIM} (1/2 B_{MSY} or B20)	B> B_{LIM} (1/2 B_{MSY} or B20)	B> B_{LIM} (eg. NZ 1/4 B_{MSY} or B_{10})
2a	Fishing target	Fishing mortality, F	F_{TARG}	F_{TARG} much < F_{LIM}	F_{TARG} < F_{LIM}
2a	Stock recognised as overfished	Biomass level, B	B< B_{LIM}	B< B_{LIM}	B< B_{LIM}
2b	Stock recognised as subject to overfishing	Fishing mortality, F	F> F_{MSY}	F> F_{MSY}	F> F_{MSY} (eg. UNFSA)
2c	Probability around controls	% probability of achieving targets	50% probability of reaching target	50% probability of reaching target	lower probabilities of reaching target, eg. 20%, 30%
2c	Probability around controls	% probability of avoiding limits	90% probability of avoiding limits	90% probability of avoiding limits	lower probabilities of avoiding limits, 50%-70%
3a	Stock rebuilding	Biomass level, B	B < B_{MSY}	B < B_{MSY}	B< B_{LIM}
3b	Threatened species/ closed fishery	A % of biomass level B	0.7 B_{LIM}	0.7 B_{LIM}	B< B_{LIM}
4	Economic objective	Biomass level, B	B_{MEY} (or 1.2 * B_{MSY} proxy)	B_{MEY} = 1.2 * B_{MSY}	B_{MSY} with economic and social considerations (eg. LOSC)

IBP focuses on B_{MSY} as a biomass objective, with an increasing amount of evidence and published analysis advising that targets should be set above B_{MSY}, for a number of reasons (Sainsbury 2008).

Australia is unique in prioritising B_{MEY}, which is both a management objective and an economic objective, having a proxy of 1.2* B_{MSY}. Internationally B_{LIM} has been adopted as the "overfished" reference point, being measured as fraction of B_{MSY}. Below $B_{LIM,}$ the stock is considered to be overfished. Internationally, the attainment of B_{MSY} and keeping fish stock levels above the overfished threshold limit (B_{LIM}), represents IBP.

For overfishing, $F>F_{MSY}$ is regarded internationally as a target limit, but not as a reference limit. Countries seek to keep control of F within a percentage probability of not exceeding F_{Lim}, with 50% being IBP. Australia pursues a 90% probability of avoiding being below B_{LIM} which may be a higher standard than other nations examined depending on how B_{LIM} is defined (i.e. a fraction of MSY etc).

There is no international consensus about if and when stock rebuilding plans should commence and over what time period recovery arrangements should be in place. Most harvest strategy approaches include a requirement for rebuilding plans when stocks move towards, or drop below, certain agreed limits (B_{MSY}, B_{LIM}). The US has formal legislated species recovery plans and appears to have one of the best records of stock recovery (Wakeford et al. 2009). Australia and other nations expect their remedial harvest strategies and stock plans to enable stock recovery, this approach being less formal

than the US. The governance frameworks in each of the nations examined is a key part of the policy response to threatened and endangered species, recovery plans and bycatch. Most countries have endangered species legislation for marine species such as in the US where there are separate marine mammal or coral conservation acts. Australia has legislation protecting listed species under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act), which could be considered analogous to some of the prescriptive US approach.

Australia prioritises B_{MEY} as its economic objective which is IBP, as other nations generally have B_{MSY} taking account of social and economic considerations.

The results from overseas should not lead to complacency, as there are several larger ecosystem and environmental trends in international fishery management that may impact the future role and development of the Australian HSP. There are also a range of HSP reference points, IBP and minimum international standards for policy issues which may not impact all fisheries as shown below.

No.	HSP Area	Reference criteria	HSP reference point	What is IBP?	Minimum International requirement
	Other developing areas				
5a	Multi-species approaches	B for target and by catch species	$B_{MEY\ target}$ and B> B_{LIM} other species	$B_{MEY\ target}$ and B> B_{LIM} other species	$B_{MSY\ target}$ and B> B_{LIM} other species (eg. LOSC)
5b	Discards	Degree of impact	Minimum impact	Zero discards or deemed value system	Mimimum impact
6a	Data poor fisheries	Available information	Precaution	Use of several scientific proxies	Use of past average catch levels
6b	New or developing fisheries	Available information	Precaution	High degree of precaution, (F< or =F_{MSY} if known)	Precaution
6c	Differing levels of productivity	Numerical guides for species productivity and resilience	High or low	Recognise productivity differences; F< or =F_{MSY}	Recognise productivity differences
6d	Different Trophic levels	Developing	Developing	Recognition of trophic effects in setting target and limit reference points	Limited recognition of trophic effects in setting target and limit reference points
6e	Low value fisheries	Fishery viability	Fishery viability	Precautionary catches	Limited awareness of issue
7	Application of risk based approaches	A staged risk based approach	Multi-tier approach	Multi-tier approach	Basic assessment of risk
		A numerical assessment	MSE	MSE	Basic numerical assessment of risk
8	Stock Status information	Exploitation levels	No species overfished	No species overfished	Minimise overfished stocks

We find that a wide range of stock management, multi-species fishery and environment issues are handled differently by different nations, particularly target and non-target species, bycatch and discarding issues. States have focused on developing single species management and have gradually addressed monitoring of fishing impacts such as bycatch in multi-species stocks, discarding of catch and the need to account for and minimise ecosystem impacts. Australia's HSP specifies B_{MSY} for target species biomass and monitors the levels of associated non-targeted species also. All of the nations examined suggest IBP on the ground for multispecies and ecosystem impacts measures is still being fully developed.

Discarding policy varies between countries, with zero discards and having a deemed value, or similar adjunct discard minimising system, being IBP. Data poor and newly discovered or developing fisheries require precaution and have to lean on the available information or past proxies, such as average catches, which may be less precautionary than is desirable. Policy on stocks with high and low productivity recognises the characteristics of the fish species in the policies adopted. Similarly

trophic effects are recognised in setting targets and limit reference points. Low value fisheries policies are only specified in Australia and are related to cost recovery.

In the area of risk based approaches, the HSP has a strategic multi-tiered policy that makes a risk management policy framework more apparent than in the other nations examined. The practice of management strategy evaluation (MSE) is recognised internationally as being a significant component of Australia's contribution to IBP, but is information intensive and comes at a cost. Other nations have risk management frameworks and modelling approaches which seem to be less centralised than Australia's adoption of MSE.

Although not part of the HSP, each nation produces stock status reports and these become a crude measure of policy success. The number and extent of overfished stocks is the common international measure, though inter-country comparisons may be misleading due to differences in definitions.

Discussion

This review of IBP confirms that Australia's HSP is a strong strategic policy approach. The original HSP (2007) included issues such as new and developing fisheries, managing stocks with low productivity and low value fisheries on which there is less information internationally. In contrast the EU's inclusion of biodiversity and explicit trophic measures under the broader marine agency environmental approach of the Marine Strategy Framework Directive in Europe may have implications for the Australian HSP. It appears that the EU intends to address impacts on non-target species, bycatch, discards, stock structure and environmental impacts on trophic levels more fully in the next decade.

The HSP was not seen as being part of Australia's international undertakings to implement an EAF, under the Convention for Biodiversity and FAO guidelines for responsible fisheries (HSP 2007). Fuller reconciliation is required to enable the HSP to provide guidance when trying to address trophic level or broader ecosystem criteria if agency responsibilities overlap or are uncertain.

There are several areas that are emphasised overseas and could be considered in the Australian HSP:

- Stock recovery plans internationally;
- There is a trend towards more quantitative measurement of the impacts on non-target species, the ecosystem and tropic structure of fish stocks;
- The management of risk and cost implications in applying more advanced risk assessment approaches, such as MSE;
- This fishery environment information produced for the EPBC assessment process could be profiled and tabled as a measure of environmental fisheries status to support the HSP; and
- Reporting on stock status, environmental impacts, biodiversity and stock structure. The cost of additional fisheries and environmental information for higher standards in the HSP is a cost recovery issue for Australian fisheries, whereas overseas, research is often a government expense.

International legal requirements and non-binding commitments to manage marine resources were first set by the LOSC and further specified in the subsequent UNFSA. There are then a range of non-binding "soft law" international documents, such as the FAO Code of Conduct, which set further benchmarks and provide implementation guidelines for sustainable resource management that includes non-target species, ecosystems and environmental concerns. Concerns for non-target species and the environment also appear in the FAO eco-labelling guidelines. Non-government organisation certification of fisheries is maturing, the MSC certification system now applies more

scientific reference points in their assessment framework, and is gradually developing from a pass/fail assessment basis into recognising graded levels of IBP.

Conclusions

Australia took an internationally significant step in producing the first fisheries HSP in 2007. This study of IBP confirms that Australia's HSP exceeds the minimum obligations arising from international legal fishery instruments which give general guidance on objectives and have become more specific through time. Guidelines have developed in documents such as the FAO's Code of Conduct and the UNFSA which uses Annex conditions to be more specific on details.

Australia's key reference criteria and standards are sound by international standards, but to meet the definition of IBP in fisheries management (IEEP 2010), need to be supported by sound decision making and a well communicated stock status profile showing no overfished stocks. IBP shows the HSP to be a strong strategic policy approach meeting IBP for objectives, overfishing and overfished reference points. This study focuses on international developments in policy issues which generally impact some fisheries (e.g. multi-species, discarding, low value, data poor and low productivity).

Possible areas where practices observed overseas could influence Australia, are in increasing the effectiveness of stock recovery plans, continued improvement and cost effectiveness of risk assessment, continuous improvement of stock status reporting and some environmental and ecosystem areas, such as trophic levels.

Within Australian fisheries there is a multi-agency approach to environmental issues. The HSP is not part of an EFBM framework and this may limit the scope of the HSP. The HSP may benefit from using the current information provided by fisheries for the EPBC assessment process to address some of the emerging trophic level requirements in ecosystem based fisheries management approaches.

The last five years have seen improvements in the IBP contribution of NGO certification organisations, with the MSC gradually providing accreditation to higher scored standards above the apparent pass/fail approval level. The MSC certification process represents both a policy standard and a fishery specific assessment process.

International trends suggest there will need to be a greater emphasis on the marine ecosystem biodiversity and environment in the future. Further progress in HSP environmental areas may require some clarity in the role of the HSP in Australia's whole of government approach to the ecosystem assessment of fisheries.

1 Introduction to harvest strategies

In the past fifty years approaches to fisheries management have been based on the intervention of government to control the open access harvesting of commonly held fish resources. Historically regulations have been used to restrain levels of fishing effort in order to limit the catch taken by fishers and hence control the levels of the fish stock, avoiding overfishing. The measurement of fish stock, or biomass, is the central challenge of stock assessment and scientists are asked to indicate the state of the fish stock, or fish biomass, in comparison to different reference points.

The past decade has seen a public and political imperative placed on fishery management and fishery science requiring evidence that 'over-fishing' is not occurring and that fish stocks are at sustainable levels. Since the year 2000, fisheries management has moved to have catch based management through output controls, with total allowable catches (TACs) being set as part of Individual Transferable Quota (ITQ) regimes or containing catch indirectly by limited fishing effort. This has required an explicit determination of the available levels of sustainable catch which is formalised by the fisheries management system. Fishery scientists are required to produce these TAC recommendations as part of TAC setting procedure, which also has to take into account other economic and social influences.

Fishery biological reference points are not new, but in the past decade the fisheries management system needed to have this information in order to apply it in fishery management. This has inevitably led to a revisiting of the basis of stock reference points and the concepts surrounding levels of catches and the potential downside risks to the fish stock from any management recommendations made. Historically fisheries management has been rather deterministic in its approach. More recently fishery science has contributed ways to incorporate risk based approaches.

Most countries are aware of the need to control fishing effort and fishing capacity in order to ensure profitable and sustainable fishing industries. Fishing effort produces harvests and the terms "harvest controls" or "harvest rules" are used internationally to indicate limits on harvesting (catch limits). Fisheries management has also started to move towards management plans and has called on corporate management models, where strategies are used to address objectives, deliver output targets and pre-determined outcomes.

In the fishery science literature of the 1990's the term harvest strategies is often used (NRC 1998), but is a less management related term than has subsequently developed (Smith 1997; Smith and Smith 2005). By 2005 the term harvest strategy was being seen not only as controlled level of harvest, but as part of a strategic approach where alternative reference points could trigger prescribed management actions in response to changes in information (Smith and Smith 2005). However the political reality in both Europe (EU 2002) and through the Ministerial Direction to AFMA (HSP 2007) was a concern that simple reference points that identified overfishing of fish stocks were being exceeded in many fisheries (EU 2002, HSP 2007). Management, scientific and policy attention was required to promptly address this situation.

In Australia the Ministerial Direction of 2005 called for *"...a more strategic, science-based approach to setting total allowable catch and or effort levels in Commonwealth fisheries, consistent with world's best practice …"*(HSP 2007). This led to a minimum standard being proposed, but also the concept of having a policy for harvest strategies across different species, being reflected in the term "Harvest Strategy Policy" (HSP 2007).

Australia's systemised approach was more directly strategic than that applied in other nations where often a range of harvest strategies were in place under species-specific management plans. The most similar thinking was in NZ were the ITQ management system had revealed the need to have "standards" in fisheries policy and New Zealand produced a "Harvest Strategy Standard" in 2008 (MAF 2008).

Fishery policy standards and practice

Best practices in fisheries management have received little attention in the literature. Given the diversity of fishery characteristics and backgrounds to management they are most readily seen in "*examples, which create incentives that address the identified issues in ways which support long-term sustainability*" (IEEP 2009). The international workshop in the IEEP (2009) study identified three stages in best practice in fisheries management: A) providing evidence; B) how decisions are made; and C) achieving compliance. Implementing reference points is evidence of stewardship of the stock and harvest strategies contribute to the decision making required to maintain sustainable stock levels. Compliance ensures the maintenance of stocks as seen in stock status information.

The national HSP approach taken by Australia is significant intentionally, as a policy framework overarching a wide range of harvest strategy measures. Many of these harvest strategy measures in other nations, have agreed reference points for key stocks under management plans and these may be comparable with the common reference points used under Australia's HSP for Commonwealth fisheries. However these reference variables can have different standards of reference point.

New Zealand's HSP equivalent, the harvest strategy standard, uses the term "standard" as *"the minimum performance level determined by Government to be acceptable"* (MF 2009). The use of standard is as a threshold, hurdle or benchmark concept, though standards can also be continuous, with high levels of standard being envisaged.

The use of the terms standards and strategies in fisheries policy internationally has generally been to describe basic threshold measures that prevent overfishing (limits), with higher optimal standards (targets) being less immediately realisable. The Australian HSP has several standards, some of which are thresholds and others are objectives. The combination of standards and information on the actual stock levels achieved can constitute proof of best practice, but other factors such as economic and social considerations can also be included.

What is the Australian Harvest Strategy Policy?

The HSP is defined as "*a framework for the development of harvest strategies for key commercial species taken in Australia's Commonwealth fisheries*" (HSP 2007). The HSP is a "*consistent framework*" that aims to assure the Australian community "*that commercial fish species are being managed for long-term biological sustainability and economic profitability*" (HSP 2007).

According to the HSP, harvest strategies must contain both:

- "*a process for monitoring and conducting assessments of the biological and economic conditions of the fishery; and*
- *rules that control the intensity of fishing activity according to the biological and economic conditions of the fishery, referred to as control rules*" (HSP 2007)."

A fishery stock assessment can indicate conditions in the fishery in comparison with reference points and acceptable standards. In a strategic approach, controls on fishing activity are applied to meet management objectives and the stock impact can be monitored against reference points. A strategic approach enables pre-agreed management actions to be taken relative to these reference points.

Common fishery reference points are expressed in terms of biomass (B) and the fishing mortality rate (F), the rate of deaths of fish due to fishing.

The HSP has 'target' and 'limit' reference points:

- "*Target reference points express the desired status of stocks (B_{TARG}) and desired fishing intensity (F_{TARG}):*
- *Limit reference points (B_{LIM} and F_{LIM}) express situations to be avoided because they represent a point beyond which the risk to the stock as the basis of a commercial fishery is regarded as unacceptably high*" (HSP, 2007).

Figure 1 Illustrates how harvest control rules and stock status are linked.

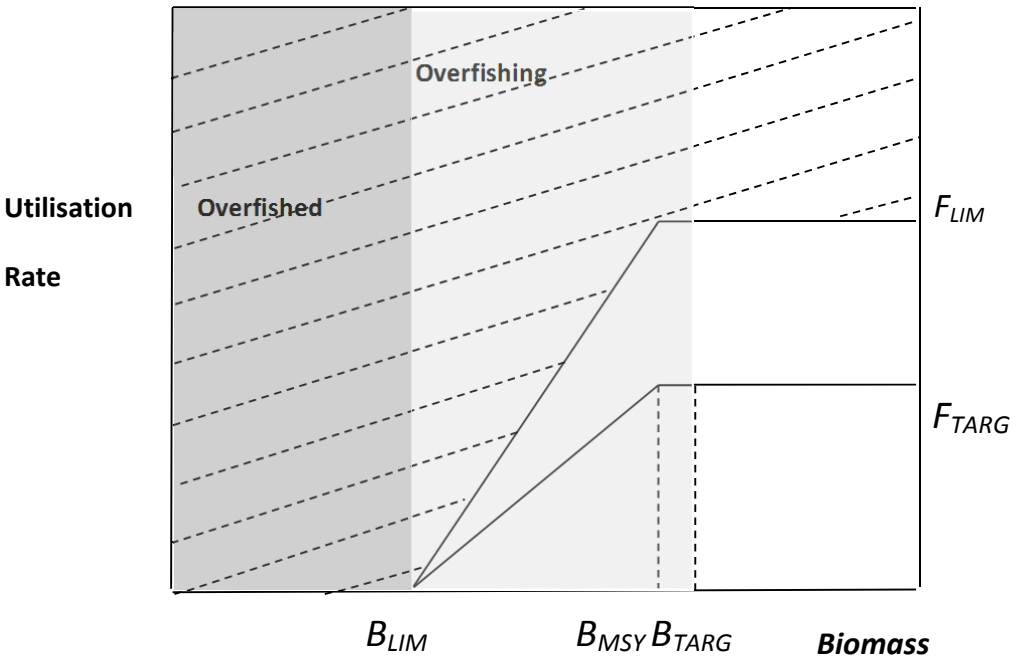


Figure 1: An example of a harvest control rule that is consistent with the HSP (HSP, 2007). B_{LIM} is the limit biomass reference point, B_{MSY} is the biomass that gives the maximum sustainable yield, and B_{TARG} is the target biomass. The HSP specifies B_{TARG} as B_{MEY}, the biomass that gives the maximum economic yield. F_{LIM} and F_{TARG} are the limit and target fishing mortality rates respectively. In this example, the recommended biological catch (RBC) is calculated by applying F_{TARG} to the current biomass (assumed to be available from a stock assessment). The control rule specifies that as the biomass reduces below B_{MSY}, F_{TARG} is reduced to zero at B_{LIM}. In this figure, the dark grey area indicates overfished ($B < B_{LIM}$), the diagonal hatched area overfishing ($F > F_{LIM}$), the white area where the stock is at or above the target, and the light grey area where management action is required to rebuild the stock to B_{TARG}. (Adapted from HSP, 2008)

The HSP pursues maximum economic yield (MEY) from the fishery, ensuring that stocks remain at acceptable levels. The E_{MEY} reference point, which corresponds to the MEY level of catch, is illustrated in Figure 2 and is recommended by HSP (2007) as it ensures maximum economic efficiency in sustainable resource utilisation, provided that a catch level associated with fishing effort is set and a management regime is in place that enables fishers to minimise input costs (HSP 2007).

Other countries have not generally prioritised the E_{MEY} objective, as it requires significantly less effort and lower catches to be taken in the fishery than under the E_{MSY} objective. MEY requires reduced catches limited by output controls and management regimes that enable fishers to adjust and to minimise costs. These are fishery management and structural adjustment steps which involve more than scientific stock assessment and have been difficult to achieve in many countries.

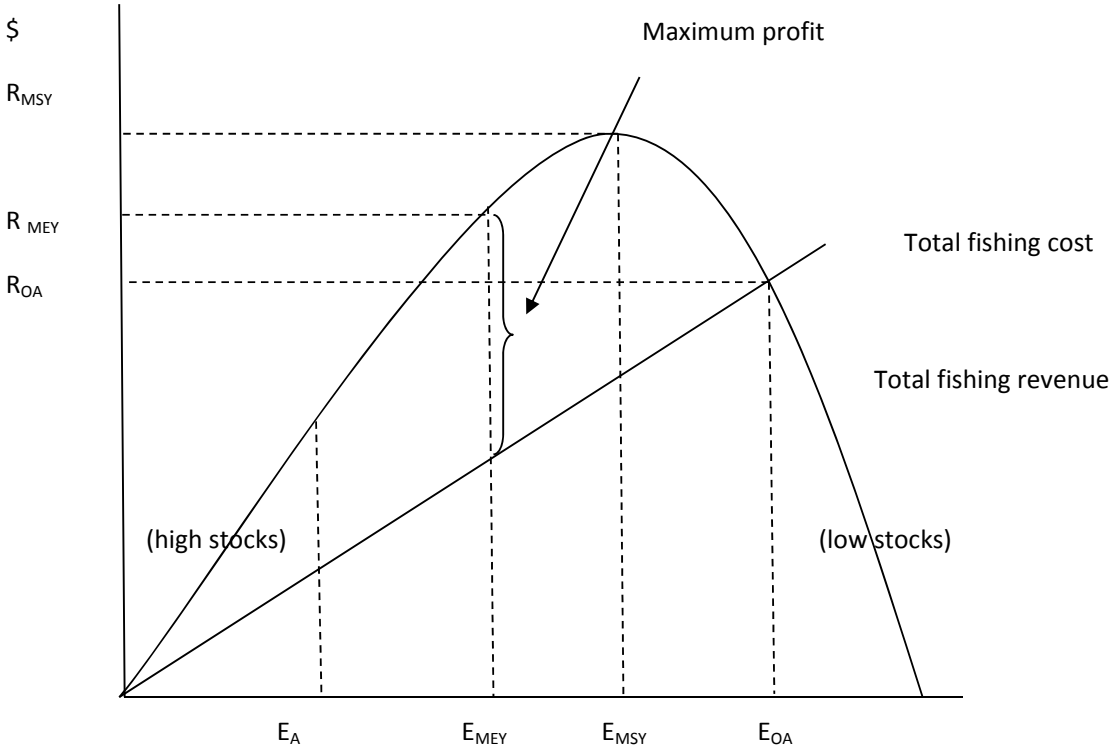


Figure 2: The level of effort, revenue and costs associated with the maximum economic yield (E_{MEY}) as described in HSP (2007).

Discussion

The Commonwealth has adopted an Ecosystem Based Fisheries Management (EBFM) approach which includes ecological risk assessments (ERA). The Ministerial Direction provides for "*further initiatives in support of EBFM, including reductions to bycatch, fishery independent monitoring, and increased focus on spatial management. Harvest strategies, in combination with this package of measures, constitute a whole of government approach to sustainable fisheries management*" (HSP 2007).

Harvest strategies are also required to consider ecosystem interactions in the marine food web or communities, enabling the biomass reference points to be adjusted appropriately. The framework for fisheries management includes the harvest strategy, along with management tools such as Total Allowable Catches (TACs) or Total Allowable Efforts (TAEs), and other tools such as reducing effort levels on target species, being aware of potential spatial depletion that may occur under such limits. The management of discarded or bycatch species requires reduction of effort on target species, effective gear controls and spatial management considerations in the design of single species harvest strategies.

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) has criteria for threatened species (conservation dependent, vulnerable, endangered or critically endangered). However, if a stock is at or below B_{LIM}, then the stock could be addressed through both the Fisheries and EPBC legislation. If the stock biomass falls more substantially below B_{LIM}, there is an increased risk of irreversible impacts on the species and it will likely be considered for listing in a higher threat category (i.e. vulnerable, endangered or critically endangered) and require development of a formal recovery plan under the EPBC Act. Where the biomass of a listed stock is above B_{LIM} and rebuilding towards B_{TARG}, consideration is given to removing the species from the EPBC Act list of threatened species, or amending the category it is in (HSP 2007).

Harvest strategies for key commercial species in Commonwealth fisheries are designed to pursue maximising the economic yield from the fishery, and ensure fish stocks remain above levels at which the risk to the stock is unacceptably high.

HSP Objectives

The objective of the HSP is "*to stop overfishing, to recover overfished stocks, and to promote longer term profitability for the fishing industry*" (HSP, 2007). However the policy brought a more strategic approach to addressing overfishing issues through prescribed actions in response to reference points showing that stock has reduced or fishing mortality increased to less acceptable levels. The HSP is implemented through the HSP Guidelines document which "*sits between the HSP itself and the implementation of harvest strategies fishery by fishery*" (HSP 2007). The detail of reference points and the breadth of the HSP policy can be seen in the range of topics covered in the HSP Guidelines as reported in Table 1 below.

Table 1: HSP Guidelines for the Implementation of the Commonwealth Harvest Strategy Policy (HSP 2007)

HSP section	**HSP Content**
1	Introduction
2	Harvest strategies- HS and management measures; HMS/ Straddling/ joint stocks
3	HSP - Key operational objectives; Reference points, stock rebuilding, HSP development process, costs
4	HS design criteria: efficient and cost effective; ESD consistent; Maximises net economic returns of the community; transparency in decision making; confidence that objectives will be met; Treatment of species life histories
5	Maximum Economic Yield: MEY, calculation and use of MEY, updating and its application to multi-species and multi-method fisheries
6	Types of management tools available for use in implementing a HS; … can be applied to input-managed fisheries as well as output-managed (e.g. quota) fisheries.
7	Different levels of information, assessments and data poor species and fisheries.
8	Dealing with uncertainty and risk
9	Dealing with highly variable species – short lived; long lived;
10	Stock rebuilding strategies and outlines stock recovery plans.
11	Recommended Biological catches into TACs, TAEs and spatial issues.
12	Developing fisheries
13	Exceptional circumstances
14	Management Strategy Evaluation (MSE); when should MSE be used?
15	Amending Harvest strategies

HSP reference points

Reference points show the level of fishing or stock size and are used as benchmarks in interpreting results of assessments (HSP 2007). The HSP also has defined control rules that determine the level of fishing allowable for a given level of biomass (see box 1).

Box1: HSP reference points and control rules (HSP 2007)

The HSP (2007) specifies minimum standards for reference points as detailed below*:*

"• B_{TARG} (or proxy) equal to or greater than B_{MEY}. In cases where B_{MEY} is unknown, a proxy of

1.2B_{MSY} (or a level 20% higher than a given proxy for B_{MSY}) is to be used[1]. AFMA may approve the use of an alternative proxy for B_{MEY} if it can be demonstrated that a more appropriate alternative exists;

• B_{LIM} (or proxy) equal to, or greater than, ½ B_{MSY} (or proxy);

• F_{LIM} (or proxy) less than or equal to F_{MSY} (or proxy)[2] ; and

• F_{TARG} (or proxy) at the level required to maintain the stock at B_{TARG}" (HSP 2007)*.*

The HSP also has defined control rules that determine the level of fishing allowable for a given level of biomass. HSP (2007) states that control rules should:

"• ensure that the fishery is maintained at (on average), or returned to, a target biomass point B_{TARG} equal to the stock size required to produce maximum economic yield (B_{MEY}), or an appropriate proxy (see above);

• ensure fish stocks in the long term will remain above a biomass level where the risk to the stock is regarded as too high, that is B_{LIM}, or an appropriate proxy (see above);

• ensure that the stock stays above the limit biomass level at least 90% of the time (i.e. a 1 in 10 year risk that stocks will fall below B_{LIM}). The 90% probability will form a key performance criterion in evaluating prospective harvest strategies when conducting management strategy evaluation analyses. It is important to note that this is a minimum standard, and that most harvest strategies that achieve the targets on average should perform better than this standard with regard to the probability of exceeding the limits. For highly variable species that may naturally (i.e. in the absence of fishing) breach B_{LIM}, the harvest strategy for these species must be consistent with the intent of the Policy. Stocks that fall below B_{LIM} due to natural variability will still be subject to the recovery measures as stipulated in the HSP; and

• progressively reduce the level of fishing when a stock moves below B_{MSY} and moves toward

B_{LIM}" (HSP 2007).

[1] *B_{MSY} is a significant interim goal between stocks rebuilding from B_{LIM} to B_{TARG}. Once a stock has reached B_{MSY}, it is the responsibility of the individual MAC and AFMA board to ensure that the stock is on a trajectory to achieve B_{MEY}.*

[2] *'Fish down' strategies (where $F_{CURRENT}$>F_{LIM}) are acceptable only where there is strong evidence that stock biomass is well above B_{TARG} and there are effective monitoring arrangements in place to ensure that as B_{TARG} is approached, $F_{CURRENT}$ is reduced to F_{TARG}. For stocks above B_{TARG}, the rate of 'fish down' toward the target level will be determined by fishery specific harvest strategies.*

The report approach - Developing benchmarks of international best practice (IBP)

This report will identify international best practice in Harvest strategy policies, or their equivalent. There is no one source of IBP reflecting the complexity and history of marine resource management in many countries. Other countries do not have an explicit harvest strategy policy, but work with a range of different approaches to stock issues which Australia incorporate under the HSP title. It is likely that we are then examining a range of practices used internationally, such as reference points. The current HSP (2007) was developed to address Commonwealth commercial fisheries. We would expect that the first five years of the policy may have revealed the adequacy of coverage and standards in the current HSP. This is not assessed in this study.

This review will seek to address some of the areas that had limited treatment in the 2007 HSP document and to gain information on what is happening in these areas internationally. For example:

"Reference points (including proxies), control rules and other settings for achieving and maintaining ecological and economic sustainability,

8. *multi-species fisheries – target, byproduct, bycatch*
9. *data poor fisheries (including exploratory fisheries)*
10. *low value species and fisheries*
11. *managing discarding (target and non-target species)– approaches, implementation, control and monitoring*
12. *different productivity levels of various species (e.g. sharks; prawns)*
13. *different trophic levels and roles, including keystone species (e.g. small pelagics)*
14. *application of risk based approaches"*.

Our approach to determine IBP has two contributing elements.

In section 2 we consider the question "*What are we required to do in respect of harvest strategies?*". Are we obliged by international agreements, soft law and other agreements in the international arena? There are also developments in the standards of fisheries management practice seen through the increasing trend of "certification" of fisheries to a range of standards.

In section 3 we then compare the fishery management and harvest strategy practices of other countries noted for their fisheries management.

This will enable IBP to be determined from these current obligations and best practices in other countries across a range of specific policy areas.

2. Requirements for international best practice (IBP)

We investigated the following sources of potential IBP requirements:

- International fisheries legal obligations;
- Other international instruments and market based certification; and
- The fisheries management practices of other countries that have harvest strategies or analogous policies setting criteria and standards (US, NZ, EU, Iceland, and Norway) in section 3;.

These sources of international legal obligations will be investigated for their harvest strategy requirements.

2.1 International fisheries legal obligations

There are several international conventions which are binding on Australia. They have been in place for some time now, but continue to influence fishery strategy policy.

United Nations Convention on the Law of the Sea (LOSC)

The United Nations Convention on the Law of the Sea (LOSC) came into force in 1994 and has several provisions in respect of harvesting and conservation of living marine resources.

In Art 61: 2 "*The coastal State, taking into account the best scientific evidence available to it, shall ensure through proper conservation and management measures that the maintenance of the living resources in the exclusive economic zone is not endangered by over-exploitation*". LOSC does not dictate how these objectives are achieved, but a harvest strategy would be an example of a "*proper conservation and management measure*", as it ensures stocks are *"not endangered by over-exploitation"*.

More specific stock recommendations are presented in Art 61:3 and are relevant to when harvest strategies have stock control objectives. Art 61:3 requires that conservation and management measures "….*shall also be designed to maintain or restore populations of harvested species at levels which can produce the maximum sustainable yield, as qualified by relevant environmental and economic factors…*". This supports the basis of harvest strategies in "*maintaining and restoring populations*" and harvest levels that can produce maximum sustainable yield (MSY), "*qualified by relevant social and economic factors*" which influence harvest strategies. There is also a need to take into account "*any generally recommended international minimum standards*" and the *"interdependence of stocks"*.

Multi-species conservation issues are noted in Art 61:4 where, in taking conservation and management measures, "*the coastal State shall take into consideration the effects on species associated with or dependent upon harvested species with a view to maintaining or restoring populations of such associated or dependent species above levels at which their reproduction may become seriously threatened*".

This requirement has been in place since 1994, but is still challenging to implement in a stock strategy policy. Harvest strategies internationally have generally focussed on a single commercial species with less information being available for non-commercial and other species impacted. The convention does not explicitly refer to any B_{LIM} reference point, but this could be a reference point required for *"restoring populations of associated or dependent species…".* The impact of fishing on *"dependent species"* is an area that many single species commercial harvest strategies may not yet fully address.

LOSC Article 64 deals with highly migratory species that are listed in Annex I of the LOSC. The coastal state is required to ensure "*…. conservation and promoting the objective of optimum utilization of such species throughout the region",* The UN Fish Stock Agreement (below) deals further with these issues.

In terms of the current review, LOSC does not explicitly address specific issues of data poor fisheries, low value, discards and trophic issues and subsequent soft law documents are more detailed and prescriptive. However LOSC has core obligations in respect of species not being endangered or overexploited, with populations being restored to "*levels that can produce MSY… qualified by relevant social and economic factors*"(Art. 61(3)). There are also requirements for *"restoring populations of associated or dependent species…….above levels at which their reproduction could be seriously threatened"* (Art. 61(4)). Many subsequent international instruments include some of these key parts of the LOSC and add more specific materials. These objectives in the LOSC have become minimum harvest strategy standards internationally, underpinning the stock assessment reference points approaches which are common today.

United Nations Fish Stocks Agreement (UNFSA)

(Full title: The United Nations Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks).

The UNFSA was negotiated in 1995 and is binding on State parties. It takes a precautionary approach to the management of straddling and highly migratory species that was not fully developed by Article 64 of the LOSC. UNFSA has implications for both commonly accepted overfishing reference points, but also trophic considerations, bycatch and discards policies. For example in Article 5, General principles:

- Article 5 (d) requires an environmental assessment of "*the impacts of fishing, other human activities and environmental factors on target stocks and species belonging to the same ecosystem or associated with or dependent upon the target stocks*".
- Art. 5 (e) repeats Art 61:4 of the LOSC (above) requiring restoration of species;
- Art. 5 (f) addresses discards and non-target species, requiring fishers to *"minimize … catch of non-target species, both fish and non-fish species, and impacts on associated or dependent species, in particular endangered species, …"*;
- Art. 5(g) states the need to "*protect biodiversity in the marine environment*"; and Art 5(h) to "*take measures to prevent or eliminate overfishing and excess fishing capacity and to ensure that levels of fishing effort do not exceed those commensurate with the sustainable use of fishery resources"*;

Article 6 is entitled "Application of the precautionary approach". Under Article 6:3 (b) states are to "*apply the guidelines set out in Annex II*[3] *and determine, on the basis of the best scientific information available, stock-specific reference points and the action to be taken if they are exceeded*". The Annex II requirement imposes obligations to manage to specific reference points. For example:

Annex II:2 imposes *"Two types of precautionary reference points should be used: conservation, or limit, reference points and management, or target, reference points. Limit reference points set boundaries which are intended to constrain harvesting within safe biological limits within which the stocks can produce maximum sustainable yield. Target reference points are intended to meet management objectives".* This incorporates both precautionary reference points in the standard "limit" or "target" framework that is common in harvest strategy policies internationally.

Policy for data poor fisheries is considered in Annex II:6 as follows: *"When information for determining reference points for a fishery is poor or absent, provisional reference points shall be set. Provisional reference points may be established by analogy to similar and better-known stocks. In such situations, the fishery shall be subject to enhanced monitoring so as to enable revision of provisional reference points as improved information becomes available"*.

Annex II (3) also has implications for different stock productivity levels:" *Precautionary reference points should be stock-specific to account, inter alia, for the reproductive capacity, the resilience of each stock and the characteristics of fisheries exploiting the stock, as well as other sources of mortality and major sources of uncertainty*". This requires low productivity of stocks to be considered.

The other important benchmark is that the fishing mortality rate (F) that generates maximum sustainable yield shall be regarded as a minimum standard for limit reference points (Annex II: 7).

Article 6:3(c) requires uncertainty about species productivity, reference points and impacts on non-target species to be taken into account.

- Article 6: 3.(c) *"take into account, inter alia, uncertainties relating to the size and productivity of the stocks, reference points, stock condition in relation to such reference points, levels and distribution of fishing mortality and the impact of fishing activities on non-target and associated or dependent species, as well as existing and predicted oceanic, environmental and socio-economic conditions*";

Article 6:3 (d) requires data collection to assess the impact of fishing on non target species and the ecosystem.

- 3. *(d) "develop data collection and research programmes to assess the impact of fishing on non-target and associated or dependent species and their environment, and adopt plans which are necessary to ensure the conservation of such species and to protect habitats of special concern*."

Article 6:6 addresses measures for new or exploratory fisheries.

- *"6. For new or exploratory fisheries, States shall adopt as soon as possible cautious conservation and management measures, including, inter alia, catch limits and effort limits. Such measures shall remain in force until there are sufficient data to allow assessment of the impact of the fisheries on the long-term sustainability of the stocks, whereupon conservation and management measures based on that assessment shall be implemented. The latter measures shall, if appropriate, allow for the gradual development of the fisheries."*

UNFSA takes the requirements for fishery management to a new level in respect of reference points, the precautionary approach and multi-species stock issues. UNFSA applies primarily to straddling fish

[3] See Appendix 1

stocks and highly migratory species, for which it is likely that fishing mortality limitation measures will be more achievable than measures related to maintaining particular stock levels.

However it has specific recommendations on precautionary fisheries management, data poor fisheries, bycatch and new or exploratory fisheries. In having more specific and measurable sustainability criteria, UNFSA has specified standards which influence international fisheries management, and influence fisheries which are not HMS and straddling stocks.

FAO Code of Conduct for responsible fisheries

The FAO Code of Conduct for Responsible Fisheries (Code of Conduct) was developed by FAO in 1995 and is a voluntary agreement (soft law). Of its 11 chapters, the General principles (Ch6) and Fisheries Management (Ch7) chapters have relevance for fisheries management using harvest strategies.

Article 6.2 has eco-system and trophic considerations that:

- "*…Management measures should not only ensure the conservation of target species but also of species belonging to the same ecosystem or associated with or dependent upon the target species."*

In Article 6.5 the requirement for a precautionary approach has implications for data poor, low value or fisheries with different productivity levels and risk management.

- "*…conservation, management and exploitation of living aquatic resources in order to protect them and preserve the aquatic environment, taking account of the best scientific evidence available. The absence of adequate scientific information should not be used as a reason for postponing or failing to take measures to conserve target species, associated or dependent species and non-target species and their environment".*

Ecosystem impacts, bycatch and discarding requirements are set out in Article 6.6 and 7.6.9

- 6.6 "*States and users of aquatic ecosystems should minimize waste, catch of non-target species, both fish and non-fish species, and impacts on associated or dependent species"* and
- 7.6.9 "*States should take appropriate measures to minimize waste, discards, catch by lost or abandoned gear, catch of non-target species, both fish and non-fish species, and negative impacts on associated or dependent species, in particular endangered species…".*

Fisheries management is addressed in Section 7 of the Code of Conduct. Those parts most relevant to the development of the Australian HSP are indicated below.

Article 7.2 is on Management objectives and Article 7.2.1 requires that countries

- "*… adopt appropriate measures, based on the best scientific evidence available, which are designed to maintain or restore stocks at levels capable of producing maximum sustainable yield, as qualified by relevant environmental and economic factors…*".

In Article 7.2.3 the code requires that

- "*States should assess the impacts of environmental factors on target stocks and species belonging to the same ecosystem or associated with or dependent upon the target stocks, and assess the relationship among the populations in the ecosystem*".

Fisheries management is addressed in Article 7.3. In Appendix 2 the Code indicates that the whole biological stock over an area of its distribution should be considered, and long term management objectives should be "*put into action through fishery management plans*". States are required to "*apply the precautionary approach*" taking into account a range of reference points (7.5.2).

The most relevant section to general harvest strategies reference points is 7.5.3

- "*States and subregional or regional fisheries management organizations and arrangements should, on the basis of the best scientific evidence available, inter alia, determine:*
  - *stock specific target reference points, and, at the same time, the action to be taken if they are exceeded; and*
  - *stock-specific limit reference points, and, at the same time, the action to be taken if they are exceeded; when a limit reference point is approached, measures should be taken to ensure that it will not be exceeded"*

For new and exploratory fisheries, Article 7.5.4 provides:

- *"States should take into account, inter alia, uncertainties relating to the size and productivity of the stocks, reference points, stock condition in relation to such reference points, levels and distribution of fishing mortality and the impact of fishing activities, including discards, on non-target and associated or dependent species, as well as environmental and socio-economic conditions"* (7.5.4).

The COC also has requirements for endangered species (7.6.9):

- *"States should take appropriate measures to minimize waste, discards, catch by lost or abandoned gear, catch of non-target species, both fish and non-fish species, and negative impacts on associated or dependent species, in particular endangered species. Where appropriate, such measures may include technical measures related to fish size, mesh size or gear, discards, closed seasons and areas and zones reserved for selected fisheries, particularly artisanal fisheries. Such measures should be applied, where appropriate, to protect juveniles and spawners. States and subregional or regional fisheries management organizations and arrangements should promote, to the extent practicable, the development and use of selective, environmentally safe and cost effective gear and techniques"* (7.6.9).

and restoring species (7.6.10):

- *"States and subregional and regional fisheries management organizations and arrangements, in the framework of their respective competences, should introduce measures for depleted resources and those resources threatened with depletion that facilitate the sustained recovery of such stocks. They should make every effort to ensure that resources and habitats critical to the well-being of such resources which have been adversely affected by fishing or other human activities are restored".* (7.6.10)

Discussion

The objectives of the LOSC were negotiated a decade before coming into force in 1994. However the LOSC has been instrumental in setting minimum standards for marine resource management by "*ensuring species are not endangered*", or fisheries "*over exploited*" and "*maintaining and restoring populations*" at the MSY stock level, "*as qualified by social and economic considerations"*. The LOSC set objectives for management in multiple species fisheries with the "*maintaining and restoring populations*" requirement for those species impacted. The LOSC has provided international benchmarks that have been incorporated in subsequent more specific international initiatives in the mid 1990s such as UNFSA and the FAO Code of Conduct

The UNFSA followed the LOSC and recognised the need to address human impacts *"and environmental factors on target stocks and species belonging to the same ecosystem or associated with or dependent upon the target stocks"* Article 5(d*)*. UNFSA brought an eco-system perspective in "*maintaining or restoring populations of such species above levels at which their reproduction may become seriously threatened"* Article *5(e).* However it is in UNSFA where we see the precautionary approach requiring that States to "a*pply the guidelines set out in Annex II guidelines and determine, on the basis of the best scientific information available, stock-specific reference points and the action to be taken if they are exceeded*". UNFSA Annex II is a significant development towards a fishery

harvest strategy in terms of stock reference points being specified and their subsequent call for remedial action by signatories and specification of minimum standards for levels of fishing mortality.

The Code of Conduct also adds detail to the LOSC requirements to conserve both target and non-target dependent species and incorporate a precautionary approach. In section 6, general principles, many issues relevant to the Australian HSP are identified - ecosystem and trophic considerations, the precautionary approach and it implications for data poor or low productivity fisheries and bycatch and discarding requirements (Articles 6.6 and 7.6.9).

Article 7 of the Code of conduct has implications for fisheries management with Article 7.2 confirming the need for biological reference points and consideration of ecosystem impacts. Article 7.5 seeks to apply the precautionary principle in practice and requires "*stock specific target (and limit) reference points, and, at the same time, the action to be taken if they are exceeded".* The COC specifies conditions for new or exploratory fisheries (Article 7.5.4), endangered species (Article 7.6.9) and restoring species (Article 7.6.10).

2.2 Other international instruments (FAO and RFMOs)

Other documents that influence fisheries strategies come from a range of international sources. The FAO is responsible for global food and fisheries supply and produces statistical data, technical papers and documents on fisheries for the international community. Regional Fisheries Management Organisations (RFMOs) are generally based in ocean and High seas areas and have either been developed from former fishery commissions, or in the past decade following the UNFSA.

Regional Fisheries Management Organisations (RFMOs)

Following the UNFSA only a few former fishery commissions have formed RFMOs, for example in Europe the North East Atlantic Fisheries Commission became an RFMO in 2006.

In the Pacific area, the two RFMOs are The Western and Central Pacific Fisheries Commissions (WCPFC) and the recently formed South Pacific RFMO (SPRFMO). We will concentrate on the WCPFC which has had discussions in respect of harvesting rules and controls.

WCPFC is guided by the WCPFC convention, which draws on UNFSA including Annex II. Acting on a directive agreed by the Commission at WCPFC-5 in December 2008, a Special Workshop on Reference Points was held at Scientific Committee 5 (SC5) in 2009. The aims of this workshop were to provide more capacity building on this issue and review some of the technical characteristics of reference points. Campbell (2010) noted that:

"the following work program should be undertaken during 2010 to assist in the identification of candidate reference points (both type and value) for each of the key target species in the WCPFC and to help SC6 make a suitable recommendation to the Commission:

1. Identify candidate indicators (e.g. $B_{current}/B_o$, SB/SB_{MSY})[4] and related limit reference points (e.g. $B_{current}/B_o$=X, SB/SB_{MSY}=Y), the specific information needs they meet, the data and information required to estimate them, the associated uncertainty of these estimates, and the relative strengths and weaknesses of using each type within a management framework.

2. Using past assessments, evaluate the probabilities that related performance indictors exceed the values associated with candidate reference points.

3. Evaluation of the consequences of adopting particular limit reference points based on stochastic projections using the stock assessment models.

[4] SB refers to Stock Biomass

4. Undertake a literature review / meta-analyses to provide insights into levels of depletion that may serve as appropriate limit reference points and other uncertain assessment parameters (e.g. steepness) (Campbell 2010)."

The process has been progressing with reports by Harley and Davies (2011) in respect of applying biomass reference points to yellowfin, bigeye and skipjack fisheries. Berger et al. (2012) have examined introducing harvest control rules for WCP Ocean tuna fisheries. However a formal HSP for the WCPFC has yet to be produced.

The definition of overfishing in the WCPFC has followed the fishing mortality ($F>F_{MSY}$) approach arising from UNSFA. The consideration of harvest rules and potential harvest strategy policy is being accelerated by the Parties to the Nauru Agreement (PNA) as part of their Marine Stewardship Council (MSC) process for skipjack tuna (pers. comm. S. Harley, SPC).

Discussion

The WCPFC is considered to be one of the most progressive RFMOs internationally. The nature of RFMOs and their high transaction costs in committee sessions means the development of harvest strategies has been slow. The use of F_{MSY} as an overfishing limited reference point follows from Annex II of the UNFSA, despite this not being as well regarded as a biomass based reference point, such as B_{MSY}. The proposal for reference points by Campbell (2010) has influenced the development of stock status reference points that are stock based, as opposed to the mortality based measures under the UNFSA.

The WCPFC harvest control system is still developing and in the Australian HSP context does not include HSP for multi-species fisheries, discards, data poor stocks, productivity and trophic level considerations. The provisions of the UNFSA are currently the best guide of best practice for these elements of HSP in the WCPFC. Discussions with those in the process confirm the HSP process is in its early stages (pers. comm. S. Harley, SPC).

Certification and ecolabelling

In the past decade third party certification of fisheries has developed to support the potential commercial advantages that may be had from consumers being assured of sustainably produced seafood as signified by an eco-label (MSC 2012). In this section we look at the FAO guidelines for eco-labelling and the development of several seafood certification schemes that have been involved in assessing the sustainability of different fisheries worldwide. While not harvest strategies *per se*, these "supply chain" initiatives can contribute to the development of HSP as they impact the sourcing of fish by putting pressure to keep harvesting resources in an environmentally sustainable manner.

FAO Guidelines for Ecolabelling of Marine Fisheries Products

The FAO Guidelines for ecolabelling have impacts on the certification of fisheries as they incorporate both sustainability and eco-system principles and the requirement to allow for restoration within reasonable time frames (Box 2).

Box 2: FAO Eco labelling guideline (extracts for Articles 30 and 31)

"*The "stock under consideration" is not overfished, and is maintained at a level which promotes the objective of optimal utilization and maintains its availability for present and future generations, taking into account that longer term changes in productivity can occur due to natural variability and/or impacts other than fishing. In the event that biomass drops well below such target levels, management measures (Code of Conduct Article 7.6) should allow for restoration within reasonable time frames of the stocks to such levels (see also paragraph 29.2.bis)" (Article 30).*

The following criteria are applicable:

"30.1 The "stock under consideration" is not overfished, if it is above the associated limit reference point (or its proxy).

30.2 If fishing mortality (or its proxy) is above the associated limit reference point, actions should be taken to decrease the fishing mortality (or its proxy) below that limit reference point.

30.3 The structure and composition of the "stock under consideration" which contribute to its resilience are taken into account."

Article 31 includes ecosystem considerations with the requirement that:

"Adverse impacts of the fishery on the ecosystem should be appropriately assessed and effectively addressed. Much greater scientific uncertainty is to be expected in assessing possible adverse ecosystem impacts of fisheries than in assessing the state of target stocks. This issue can be addressed by taking a "risk assessment/risk management approach".

The following criteria are to be interpreted in the context of avoiding high risk of severe adverse impacts:

31.1 Non target catches, including discards, of stocks other than the "stock under consideration" are monitored and should not threaten these non-target stocks with serious risk of extinction; if serious risks of extinction arise, effective remedial action should be taken.

31.2 The role of the "stock under consideration" in the food web is considered, and if it is a key prey species in the ecosystem, management measures are in place to avoid severe adverse impacts on dependent predators.

31.4 In the absence of specific information on the ecosystem impacts of fishing for the unit of certification, generic evidence based on similar fishery situations can be used.

The inclusion of Article 30.3 goes beyond a simple stock biomass or fishing mortality management approach requiring consideration of the structure of the stock and its resilience. This trend is continued in Article 31 which requires risk assessment for adverse impacts including on non target species or discards, avoiding impacts on key predators and the use of "generic evidence" from other fisheries to enable certification of ecosystem impacts.

The FAO Ecolabelling guidelines are more specific than UNSFA about ecological issues and seek re-assurance about stock resilience and ecosystem impacts of several types.

2.3 NGOs and certification schemes

A range of non-government organisations have developed in the area of seafood certification, enabling consumers to influence fish producers via sustainability marketing logos and product information. These certifying schemes have the capacity to put demand side pressure on producers to follow sustainable best practice standards in fisheries management.

Global Trust

Global Trust is an international fishery certification organisation based in Ireland that follows a model it calls "FAO based" as it is directly derived from:

> (a) the FAO Code of Conduct for Responsible Fisheries 1995;
>
> (b) the FAO Guidelines for Ecolabelling of Fish and Fishery Products from Marine Capture Fisheries 2005/2009; and
>
> (c) The FAO Fisheries Circular No. 917. A Checklist for Fisheries Resource Management Issues Seen From the Perspective of the FAO Code of Conduct for Responsible Fisheries. J. Caddy, October 1996.

The fisheries are assessed against criteria directly derived from these three documents claiming they are an internationally recognized standard developed by the United Nations (UN) Food and Agriculture Organization (FAO). The Global Trust has certified several large fisheries, including Icelandic cod and the North Pacific pollock fishery in Alaska. These have been assessed on a pass/fail standard against FAO guidelines.

Friend of the Sea

Friend of the Sea is a certification organisation and promotes seafood from sustainable fisheries and sustainable aquaculture, having a common certification logo for both wild and farmed seafood. Friend of the Sea started as a project of the Earth Island Institute, the NGO which operates the International Dolphin-Safe project and has support from some major seafood retailers.

The Friend of the Sea website (FOS 2012) states that Criteria for Sustainable Fisheries require:

"*- target stock to be not overexploited (nor depleted, data deficient or recovering) stocks; fishery to generate maximum 8% discards; no bycatch of endangered species; no impact on the seabed; compliance with regulations (TAC, IUU, FOC, minimum size, etc); The fishery should respect all legal requirements; social accountability; and gradual reduction of carbon footprint"* (FOS website)."

Criteria compliance is verified by independent accredited certification bodies. Friend of the Sea accreditation is compliant with Article 30 of the FAO Guidelines for Ecolabelling of Marine Fisheries Products (see box 2 above).

Marine Stewardship Council (MSC)

The MSC is the largest of the fishery eco-labelling schemes and seeks to bring positive environmental change through consumers buying products from certified fisheries holding the MSC logo. MSC was established in 1997 with the primary goals of ensuring the sustainability of fish stocks globally, minimizing environmental impacts and promoting the effective management of fisheries.

There were 166 certified fisheries in the MSC program as at June 2012 that comprise approximately 6% of all wild caught seafood globally (MSC 2012). These fisheries supply companies in 80 countries,

producing over 12,000 products sold in seafood markets globally. The MSC uses independent third party certification assessors to determine if the fishery meets the "MSC Standard". The process involves a confidential pre-assessment and a full assessment against the MSC principles (see box 3).

Box 3: The MSC principles (MSC 2012) – see Appendix 2.

The organization sets standards based on three principles:

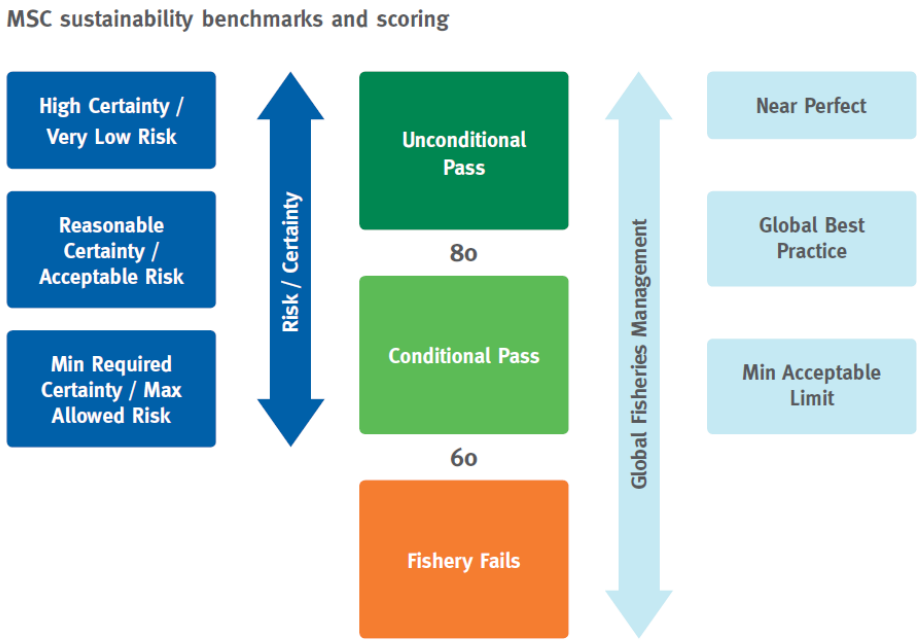
Principle 1: A fishery must be conducted in a manner that does not lead to over-fishing or depletion of the exploited populations and, for those populations that are depleted, the fishery must be conducted in a manner that demonstrably leads to their recovery

Principle 2: Fishing operations should allow for the maintenance of the structure, productivity, function and diversity of the ecosystem (including habitat and associated dependent and ecologically related species) on which the fishery depends; and

Principle 3: The fishery is subject to an effective management system that respects local, national and international laws and standards and incorporates institutional and operational frameworks that require use of the resource to be responsible and sustainable. (MSC 2012).

Fisheries meeting the standards become certified for up to five years before requiring a full reassessment against the MSC standard. After an independent assessment by a third party, the MSC uses a pass/fail system, where passes can be given conditionally or unconditionally. The minimum MSC standard that must be met (i.e., conditionally, with the requirement for improved performance over a specified timeframe) has come to be known as the "60 Scoring Guidepost" , meaning that a fishery must score a minimum of 60 to pass. Should a fishery score between 60 & 79, the fishery (the managers, the fishers, etc) have up to five years to improve performance to the unconditional "80 Scoring Guidepost" level, which is meant to characterise 'international best practice'. The main components of the standard are embodied within the MSC's Performance Indicators and Scoring Guideposts (MSC 2009)-see Figure 3.

Figure 3: The MSC sustainability benchmarks and scoring (MSC 2012).



The MSC standard and scoring system is:

" A score of 80 conforms to the sustainability outcomes expected from fisheries management systems performing at 'global best practice' levels and confers increased certainty about the fishery's continuing sustainability. A score of 100 represents the performance expected from a 'near perfect' fisheries management system; one that has high levels of certainty about a fishery's performance and a very low risk that current operations will result in detrimental impacts to the target stocks and supporting ecosystem.

A minimum score of 60 is required on each of the 31 PIs to qualify MSC certification. However, the MSC program requires a higher level of assurance and performance than this minimum benchmark. To pass an MSC assessment a fishery must achieve an average score of 80 for each one of the three Principles, determined by the average of the PI scores under that Principle.

Further, any PI that scores less than 80 must be improved to the 80 level over the course of the fisheries certification and usually within five years. The MSC program very consciously allows fisheries to qualify for MSC certification without meeting the 80 level on all indicators. MSC believes the movement of fisheries from the 60 to 80 levels is a positive outcome for the world's fisheries and directly in line with the MSC's vision. This is one of the tenets of MSC's theory of change. Similarly the MSC program does not require performance at the 100 level in order to become certified. The 100 level recognises that higher performance is possible on any given indicator, but there are very few, if any, fisheries in the world that could achieve that level of performance across all PIs defined in the MSC standard"(MSC 2012).

The MSC principles and assessments

The MSC's Certification Requirements and the accompanying guidance make reference to specific reference points. For example the content of Principle 1, Performance Indicators (PI) 1.1.1 on stock status; 1.1.2 on reference points; 1.1.3 on stock rebuilding. In Table 2, aspects of Target species Harvest strategy (Management) 1.2 are examined with 1.2.1 being harvest strategy. The accreditor gathers relevant information against these criteria using best available information in the scientific literature.

Table 2: Example of MSC principle 1.2.1 "Harvest strategy" and score guideposts (SG). For example these have used in assessing a range of fisheries such as the New England Deep-Sea Red Crab fishery (SCS 2009) and the recent MSC Australian Northern Prawn Fishery Assessment (MRAG 2012).

1.2.1 There is a robust and precautionary harvest strategy in place.		
SG 60	**SG 80**	**SG 100**
The harvest strategy is <u>expected</u> to achieve stock management objectives reflected in the target and limit reference points. The harvest strategy is <u>likely</u> to work based on prior experience or plausible argument. <u>Monitoring</u> is in place that is expected to determine whether the harvest strategy is working.	The harvest strategy is responsive to the state of the stock and the elements of the harvest strategy <u>work together</u> towards achieving management objectives reflected in the target and limit reference points. The harvest strategy may not have been fully tested but monitoring is in place and <u>evidence</u> exists that it is achieving its objectives.	The harvest strategy is responsive to the state of the stock and is <u>designed</u> to achieve stock management objectives reflected in the target and limit reference points. The performance of the harvest strategy has been <u>fully evaluated</u> and evidence exists to show that it is achieving its objectives including being clearly able to maintain stocks at target levels. The harvest strategy is <u>periodically reviewed and improved</u> as necessary.

In the MSC accreditation process the certification body gathers all relevant information against the appropriate MSC principles. The 60 and 80 Scoring Guideposts, along with additional guidance and explanatory material, give detail of what is required as the minimum to pass, as well as the international best practice (IBP) level, and any improvements that must be made to bring performance up to IBP standards.

The MSC principles and criteria are generic so as to cater for a great diversity in fisheries. Specific elements of interest to the development of the Australian HSP are within the broader principles and criteria. The MSC principles and criteria are presented in Appendix 2.

In relation to the Australian HSP, in MSC principle 1;

- Criteria 1 the productivity of the fish target population has to be considered and *"the associated ecological community relative to its productivity."* An MSC assessment would identify low and differing productivity issues between species under this criteria. The MSC system is not like the HSP in that it does not have a prescribed policy on less productive species but assesses this as part of the whole fishery assessment.
- Criteria 2 requires recovery of depleted fish populations consistent with the precautionary approach and within specific time limits. The HSP could consider more explicit use of the precautionary principle and times on stock recovery.

Trophic structure is addressed by criteria 3, that *"Fishing is conducted in a manner that does not alter the age or genetic structure or sex composition to a degree that impairs reproductive capacity".* Likewise in Principle 2, Criteria 1, *"The fishery is conducted in a way that maintains natural functional relationships among species and should not lead to trophic cascades or ecosystem state changes".* These criteria put significant emphasis on the need for assessors to identify trophic impacts and the Australian HSP needs more clarity in this area. Is consideration of trophic levels part of EBFM or should it be included in the Australian HSP?

Multi-species fisheries are addressed in Principle 2, criteria 2. *"The fishery is conducted in a manner that does not threaten biological diversity at the genetic, species or population levels and avoids or minimises mortality of, or injuries to endangered, threatened or protected (ETP) species".* This has implications for HSP as it impacts target species catch levels, bycatch, byproduct, and managing discarding control and monitoring. The assessor has to provide information in respect of biological diversity and ETP species and the MSC is not prescriptive on what is acceptable, but leave the assessment and accreditation process to decide.

Principle 3 involves management regimes and has 17 criteria. Criteria 9 requires *"that assessments of the biological status of the resource and impacts of the fishery have been periodically conducted".* The current Australian HSP is separate from the stock status report system. Criteria 9 does not specify stock reference points and these would be provided by accreditors in addressing these criteria. In criteria 10(c) *"providing for the recovery and rebuilding of depleted fish populations to specified levels within specified time frames"* is required. The use of the term "specified levels" implies the use of biological reference points. The MSC has recently confirmed the reference point B_{MSY} as an objective and keeping stocks above $B_{LIM,}$ as a means of avoiding the need for recovery plans (pers. comm. David Agnew). The MSC has taken steps to clarify and raise reference point

standards, which arises from having the certification undertaken by external certifiers applying the MSC standard.

Principle 3, criteria 17 requires the fishery *"assist and cooperate with management authorities in the collection of catch, discard and other information of importance to the effective management of the resources and the fishery".* This is one of the MSC's Operational criteria and clarifies the need for sufficient data on catches, discards and other key management information. This fuller data and information is a challenge for the HSP, as it is a measure of management effectiveness.

Environmental certifications are issued on a pass/fail basis, meaning that if a fishery meets the required standard, there is no requirement for improvements in a fishery's environmental performance. The MSC "theory of change" suggests that the majority of environmental improvements may be made prior to formal assessment, as fisheries seek to meet the minimum standard (Martin et al, 2012).

Martin et al (2012) indicate that the MSC has significantly revised its certification methodology "*creating more explicit performance criteria directly linked to scientifically defined environmental outcomes and introducing means for assessing elements of fisheries that are data deficient using a risk-based framework (RBF)*". This is one of few references to data poor fisheries, with no references to exploratory fisheries or low value species in the criteria. The application of risk based approaches to managing uncertainty is seen in recent assessments (MRAG 2012). Martin et al. (2012) note that the revisions have "…*improved the robustness and consistency of application of the MSC standard, particularly with respect to the impact of the fishery on the ecosystem (Principle 2), which has been a criticism of the MSC (Ward, 2008a,b)*". A study by Agnew et al., (2006) was able to partially detect actual environmental benefits arising from MSC certification (Martin et al. 2012).

Discussion

Developments from RFMO's and implementation of harvest standards have generally focused on reducing overfishing pressure by reducing fishing mortality to sustainable levels. RFMOs have been working towards developing formal harvest standards and strategies, but internationally the implementation of these has not been uniform and has been gradual. RFMOs involved with tuna fisheries have generally followed the approach required by UNFSA, Annex II, in regards to harvest limit controls or rules. The use of F_{MSY} as an overfishing limited reference point follows from Annex II of UNFSA, despite this parameter not being as well regarded as a biomass based reference point, such as B_{MSY} (Campbell 2010).

The FAO guidelines on eco-labelling have significant sustainability and ecosystem implications for fisheries applying for certification by providing a clearer baseline of key features that are audited in accreditation schemes. Certification by MSC and other bodies has been established on a pass or fail basis. It seems that Global Trust and Friend of the Sea are responding to the large scale seafood processing industry's need for a sustainability pass/fail accreditation process for eco-labelling and product marketing.

The MSC system explicitly ranks management practices in a numerical scoring system, whereas others have a simple pass/fail assessment as a threshold limit to indicate sustainability only. Some basic eco-labelling schemes are a societal marketing requirement, and while involving industry, have

had limited influence in the development of harvest strategies. In contrast the MSC program appears to be in a developing process where assessments are being scored at levels higher than the basic pass/fail requirement seeking continuous improvement in standards. The MSC's contribution to the pursuit of IBP is based around keeping broad principles and criteria which enable accreditors to make a best case. This process means that assessors gather scientific evidence at IBP levels.

The influence of certification NGOs, particularly the MSC, is affecting management approaches taken in many fisheries such as the North East Atlantic red crab fishery (SCS 2009) and the Australian Northern Prawn fishery (MRAG 2012).

In early 2012 the certification of the Western Pacific skipjack fishery resulted in the use of reference limit points, such as B_{MSY} and $B_{LIM.}$ (Pers. Comm. D. Agnew). This represents a more formal approach to specific points and harvest standards by the MSC.

The MSC's recent steps to specify clearer scientific benchmarks, such as $B_{MSY,}$ and the development of the scoring system which requires 60 points to qualify for accreditation, with a five year requirement to introduce improvements to achieve a score of 80 points, which represents international best practice for eco-certification schemes. The MSC system is gradually measuring best practice at levels above their apparent pass /fail criteria and is influencing the recognition of international best practice due to the certification efforts being applied under their Performance Indicators and Scoring Guideposts (MSC 2009).

3 The harvest strategy practices of other countries that have internationally recognised fisheries management

This section briefly reviews developments in fisheries management and harvest strategies in a range of countries that are known for their high standard of fishery management practices: US, NZ, Iceland, Norway and the European Union (EU). International practices in each country will be identified in relation to the following aspects relevant to the Australian HSP 2007:

"Reference points (including proxies), control rules and other settings for achieving and maintaining ecological and economic sustainability,

1. *multi-species fisheries – target, byproduct, bycatch*
2. *data poor fisheries (including exploratory fisheries)*
3. *low value species and fisheries*
4. *managing discarding (target and non-target species)– approaches, implementation, control and monitoring*
5. *different productivity levels of various species (e.g. sharks; prawns)*
6. *different trophic levels and roles, including keystone species (e.g. small pelagics)*
7. *application of risk based approaches"*. (DAFF Terms of reference)

There is little information on the low value fisheries and these will be discussed in section 4.

3.1 United States of America

3.1.1 Management

In the United States (US) fisheries in the Exclusive Economic Zone are conserved and managed by the National Oceanographic and Atmospheric Administration (NOAA Fisheries), operating through the National Marine Fisheries Service (NMFS). States are responsible for management within three nautical miles.

US fisheries are managed under the Magnuson-Stevens Fishery Conservation and Management Act 1996 (MSA). Fisheries management is actioned by a number of Fisheries Management Councils, which cover different geographical areas of the EEZ nationally. The ideal Council appointee candidate is "*knowledgeable in fishery conservation management and the commercial or recreational harvest of fishery resources through occupational experience, scientific expertise, or related training*" (NMFS website). US federal fisheries do not have a HSP, but have key National Standards (NS) for fishery management.

The guidelines for National Standards are listed by NS number and subject: NS 1 (optimum yield), NS 2 (scientific information), NS 4 (allocations), NS 5 (efficiency), NS 7 (costs and benefits); and adding new guidelines for NS 8 (communities), NS 9 (bycatch), and NS 10 (safety of life at sea).The guidelines for NS1 were revised extensively in the final rule published on May 1, 1998, to bring them into conformance with revisions to the MSA, as amended in 1996 by the Sustainable Fisheries Act (SFA).

3.1.2 Reference points

Concerns about over fishing led to the SFA amendment to the MSA which created a legal mandate to end overfishing and to rebuild depleted fish stocks (UNCOVER 2010). Fisheries Management

Councils use Fisheries Management Plans (FMP) incorporating the objectives of B_{MSY} and also maintaining the biomass associated with Optimum Yield (B_{OY})[5], specified in NS1 (NMFS 2012).

A definition of overfishing must be specified both in terms of reference points reflecting the maximum fishing mortality threshold (MFMT) and the minimum stock size threshold (MSST) (NMFS 2012).

"*MFMT means the level of fishing mortality (F), on an annual basis, above which overfishing is occurring. MSST means the level of biomass below which the stock or stock complex is considered to be overfished. If the current fishing mortality rate (F) is above the MFMT, then overfishing is occurring. If the stock size is below the MSST, then the stock is overfished*"(NMFS 2012).

The definition for the biomass threshold in the FMP, along with trends in fishing effort, is usually the basis for determining whether a stock is approaching an overfished condition (NMFS 2012). An overfished stock is where B is below the MSST, B_{LIM}, with the default B_{LIM} being 50% of $B_{MSY.}$ Overfishing is where the MFMT, $F > F_{MSY}$.

The US system uses several key terms in defining catch limits in relation to stock levels. These are Overfishing Limit (OFL), Acceptable Biological Catch (ABC), Annual Catch Limit (ACL) and Annual Catch Target (ACT). Figure 4 reports the relationship between these catch levels, MSY and stock levels.

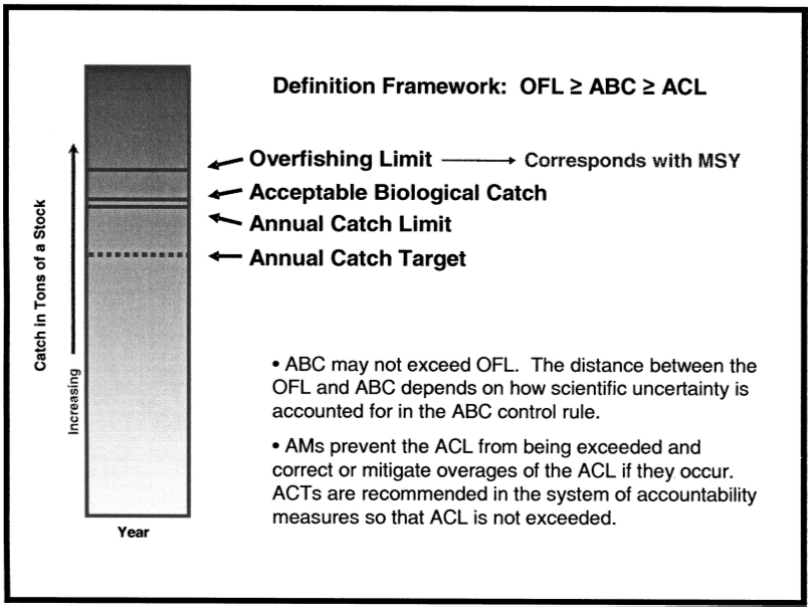


Figure 4: Relationship between OFT, ABC, ACL and ACT (NOAA 2009).

The catch limits for stocks under each Fishery Management Council are set through a process involving the Scientific and Statistical Committee. Scientific peer review is used to ensure the quality and integrity of scientific assessments that are used to determine biologically acceptable catch limits. After reviewing the stock assessment document and receiving the respective report of the Fishery Management Council plan team that also reviewed the stock assessment, *"the* Scientific and

[5] Optimum Yield (B_{OY}) is the amount of fish that: (1) will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems; (2) is prescribed on the basis of the MSY from the fishery, as reduced by any relevant economic, social, or ecological factors; (3) in the case of an overfished fishery , provides for rebuilding to a level consistent with producing the MSY in such fishery (NMFS 2012)

Statistical Committee *shall make the final determination regarding the tier level of the assessment and will recommend ABC and OFL limits for ground fish or OFL limits for crab and scallops for each assessed stock or complex"* (NMFS 2007) .

Typically, three Scientific and Statistical Committee members, who are not directly responsible for the production of the stock assessment, will be assigned as the lead reviewers for each stock proposing recommendations. The October Scientific and Statistical Committee meeting examines any new stock assessment models and resolves any outstanding technical questions. The stock assessments are reviewed for setting ABC and OFLs at the December meetings (NMFS 2007).

3.1.3 Recovery plans

It is the responsibility of NMFS to notify the relevant regional Fishery Management Council when fisheries are overfished or approaching an overfished condition. Rebuilding plans for commercial stocks are administered under the MSA and are normally implemented as amendments to an existing FMP with a definition of overfishing being specified both in terms of the maximum fishing mortality threshold and the minimum stock size threshold (UNCOVER 2010). A rebuilding plan has to specify a target year for recovery based on the time required for the stock to reach the optimal yield (UNCOVER 2010).

Within the US framework, "recovery plans" for bycatch species, are mandated under the Endangered Species Act (ESA) and Marine Mammal Protection Act (MMPA) [6] (NMFS 2012).

The MSA requires that the rebuilding time period shall be as short as possible, and usually may not exceed 10 years unless there are mitigating factors such as the biology of the stock or social considerations that require a longer time frame. If a stock falls below the minimum stock size threshold, the regional Fishery Management Council has one year to develop and implement a stock rebuilding plan. If a rebuilding plan is not submitted within the specified time period, it is then the responsibility of NMFS to develop and implement a plan within nine months.

An MSA amendment in 2010 was made so that FMPs are required to specify annual catch limits to ensure that overfishing does not occur. Fishery Management Councils are to avoid overfishing by setting ACLs not exceeding recommendations of the councils' scientific advisers. *"To meet that requirement, the scientific advisers will need to know the overfishing limit (OFL) estimated in each stock assessment, with OFL being the catch available from applying the limit fishing mortality rate to current or projected stock biomass. The advisers then will derive ''acceptable biological catch'' (ABC) from OFL by reducing OFL to allow for scientific uncertainty, and ABC becomes their recommendation to the council"* (Prager and Shertzer 2010).

For rebuilding stocks under the MSA, the ABC and the ACL recommended by each Council's scientific and statistical committee[7] should be set at lower levels during rebuilding, than when a stock is

[6] Administered by the Environmental Protection Authority (EPA). There does not seem to be a formal environmental fishery assessment process of all Fisheries, but the EPA are notified of species which have fallen below critical limits and will take over the recovery plan for that species.

[7] **16 U.S.C. 1852 MSA § 302101-627, 109-479** (g) establishes committees and advisory panels.—
(1)(A) Each Council shall establish, maintain, and appoint the members of a **scientific and statistical committee** to assist it in the development, collection, evaluation, and peer review of such statistical, biological, economic, social, and other scientific information as is relevant to such Council's development and amendment of any fishery management plan. (B) Each scientific and statistical committee shall provide its Council ongoing scientific advice for fishery management decisions, including recommendations for acceptable biological catch, preventing overfishing, maximum sustainable yield, and achieving rebuilding targets, and reports on stock

rebuilt (UNCOVER 2011). The Fishery Management Council managers can only determine annual catch limits "at or below" the recommended ABC and ACL.

Environment and fisheries management

The US have a strong Endangered Species Act (ESA) and the scientific basis of fisheries management has led to the development of policy relating to both fishing and endangered species. There are extensive listing criteria developed by an ESA-NMFS working group (De Master et al. 2004).

The US also have a unique phrase "*reasonable and prudent alternative*". If NMFS finds that a proposed action is likely to jeopardize a listed species or adversely modify its critical habitat, the ESA requires NMFS to suggest those reasonable and prudent alternatives that it believes would enable the project to go forward in compliance with the ESA.

"The regulations implementing section 7 of the ESA (50 CFR 402.02) define reasonable and prudent alternatives as alternative actions, identified during formal consultation, that (1) can be implemented in a manner consistent with the intended purpose of the action, (2) can be implemented consistent with the scope of the action agency's legal authority, (3) are economically and technologically feasible, and (4) would, NMFS believes, avoid the likelihood of jeopardizing the continued existence of listed species and avert the destruction or adverse modification of critical habitat" NMFS website 2012. The need for reasonable and prudent alternatives have arisen in many salmon fishery impact disputes (De Master et al. 2004).

3.1.4 Reporting on stock status

The status of all stocks managed under FMPs implemented under the MSA, or under an international agreement, is reported in the annual *"Status of U.S. Fisheries"* Report to Congress (NMFS 2012).

The NMFS Annual Report (NMFS 2012) and its appendices contain comprehensive information on fishery stock status and measures for assessing US fisheries. NMFS measures the sustainability of the nation's fisheries through the Fish Stock Status Index (FSSI) (NMFS 2012).

The FSSI is to *"track the outcome of building and maintaining fish stocks and complexes at productive levels and to incorporate the critical components of managing fish harvest rates and increasing knowledge about the status of fish stocks and complexes"* (NMFS 2012). Stocks and complexes to be reported on were selected for the FSSI using various criteria, including (1) the stock is a major stock (landings > 200,000 pounds p.a.), (2) the stock was either overfished or subject to overfishing, (3) the stock was scheduled to be assessed within the next 5 years, and (4) the stock had been identified previously as important. The FSSI tracks 230 key stocks and stock complexes of multiple species and includes a national recovery index, which has recorded a significant improvement in stock recovery in the past decade (NMFS 2012).

In addition to the FSSI, the stock status reports include advice as to whether fishing mortality is above the threshold (F_{MSY}), biomass is below the threshold (B_{MSY}) and the fishery is approaching overfishing. The report also considers what management action is required and the status of rebuilding strategies.

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status and health, bycatch, habitat status, social and economic impacts of management measures, and sustainability of fishing practices. (C) Members appointed by the Councils to the scientific and statistical committees shall be Federal employees, State employees, academicians, or independent experts and shall have strong scientific or technical credentials and experience.

Table 3: The US Fish stock status and rebuilding index score system (NMFS, 2012)

Jurisdiction	FMP	Stock	Overfishing? (Is Fishing Mortality above Threshold?)	Overfished? (Is Biomass below Threshold?)	Approaching Overfished Condition?	Management Action Required	Rebuilding Program Progress	B/Bmsy or B/Bmsy proxy	Official FSSI Score
NPFMC	Bering Sea/Aleutian Islands King and Tanner Crabs	Blue king crab - Saint Matthews Island ++	No	No	No	NA	N/A	2.2	4
NPFMC	Bering Sea/Aleutian Islands King and Tanner Crabs	Snow crab - Bering Sea *	No	Rebuilt	No	NA	Rebuilt	1.33	4
NPFMC	Bering Sea/Aleutian Islands King and Tanner Crabs	Blue king crab - Pribilof Islands++	No	Yes	NA	Continue Rebuilding	Year 8 of 10-year plan	0.07	2
NPFMC	Bering Sea/Aleutian Islands King and Tanner Crabs	Golden king crab - Aleutian Islands	No	Undefined	Unknown	NA	N/A	not estimated	1.5
NPFMC	Bering Sea/Aleutian Islands King and Tanner Crabs	Southern Tanner crab - Bering Sea **	No	Yes	NA	Rebuilding Program	To be developed	0.32	2
++ Footnote NPFMC	*Blue King Crab Saint Matthews &Pribilof Islands*	*Fishery in the EEZ is closed; therefore, fishing mortality is very low.*							
Footnote: NPFMC	*Snow crab - Bering Sea*	*The North Pacific Fishery Management Council is revising the rebuilding plan for snow crab, which will extend the rebuilding target date . There is no directed fishing for snow crab and the majority of blue king crab habitat is closed to bottom trawling*							
Footnote: NPFMC	*Southern Tanner crab - Bering Sea*	*The North Pacific Fishery Management Council was notified by the Alaska Regional Office on October 1, 2010 that Southern tanner crab is overfished. The NPFMC has 2 years from this date to implement a rebuilding plan for Southern Tanner crab - Bering Sea.*							

In Table 3 several stocks are covered under the same FMP. The FSSI score (1-4) indicates stock status. B/B_{MSY} is another index of stock status where a number less than 1 (0.32) is over fished. When B/B_{MSY} =1 or above, is B equalling or exceeding great B_{MSY}.

Using these indices, the Snow crab stock (line 2 Table above) is considered to have been rebuilt. The Blue King crab (Pribilhof Islands) is rebuilding under a 10 year plan. Golden King crab illustrates a fish stock that lacks stock information, with a low FSSI score being recorded. Southern Tanner crab – Bering Sea still requires the development of a rebuilding plan with FSSI (2) and B/ B_{MSY} (0.07) values being low.

3.1.5 Multi-species and bycatch issues

Many of the US fisheries on the Pacific, particularly the US east coast trawl fisheries, involve multi-species assemblages and inevitable bycatch issues. There is considerable literature on bycatch in US fisheries, such as in national reports by NMFS (1997; 2011). Past management initiatives have been in response to marine mammals and to implement a system of commercial fishery Categories I, II, and III to fisheries managed under the Marine Mammal Protection Act. For example "*Category I is a commercial fishery with frequent incidental mortality and serious injuries of marine mammals. A Category I fishery is by itself responsible for the annual removal of 50% or more of any stock's potential biological removals* " NMFS (1997). Categories II and III are less impacting.

Notices in the Federal Register propose policy amendments under the MSA which have implications for managing fish bycatch (NOAA, 2008). "*NMFS wants to encourage ecosystem approaches to fishery management and believes that clarification of what constitutes the ''fishery'' would be helpful. As such, NMFS is proposing guidance pertaining to ''stocks in the fishery'' and ''ecosystem component (EC) species,'' which are described in detail below* (NOAA 2008). The amendments define the following:

"*(3) ''Target stocks'' are stocks that fishers seek to for sale or personal use, including ''economic discards'' as defined under Magnuson-Stevens Act section 3(9).*

(4) ''Non-target species'' and ''non target stocks'' are fish caught incidentally during the pursuit of target stocks in a fishery, including ''regulatory discards'' as defined under Magnuson-Stevens Act

section 3(38). They may or may not be retained for sale or personal use. Non-target species may be included in a fishery and, if so, they should be identified at the stock level. Some non-target species may be identified in an FMP as ecosystem component (EC) species or stocks.

(5) ''Ecosystem component (EC) species'' are generally not retained for any purpose, although minimal amounts might occasionally be retained. EC species may be identified at the species or stock level, and may be grouped into complexes. EC species may be included in an FMP or FMP amendment for any of the following reasons: For data collection purposes; for ecosystem considerations related to specification of OY for the associated fishery; as considerations in the development of conservation and management measures for the associated fishery; and/or to address other ecosystem issues.

While EC species are not considered to be ''in the fishery,'' a Council should consider measures for the fishery to minimize bycatch and bycatch mortality of EC species consistent with National Standard 9, and to protect their associated role in the ecosystem. EC species do not require specification of reference points, but should be monitored on a regular basis, to the extent practicable, to determine changes in their status or their vulnerability to the fishery" (NOAA 2008).

Currently Bycatch[8] is addressed in National Standard 9—Bycatch. *(a) Standard 9. Conservation and management measures shall, to the extent practicable: (1) Minimize bycatch; and (2) To the extent bycatch cannot be avoided, minimize the mortality of such bycatch* (see appendix 4).

An example of implementing bycatch policy can be seen in the US North Pacific fisheries. The North Pacific Fishery Management Council has addressed a large scale bycatch issue involving Chinook salmon being taken by the pollock fishers in the Gulf of Alaska. The NPFMC has developed a series of options to put to the sectors involved and the specification of the problem and potential resolutions proposed to industry are presented in Box 4.

Box 4: Gulf of Alaska (GOA) Chinook salmon bycatch - FINAL Council motion – December 2010
The Council adopts the following problem statement and moves the following alternatives for initial review.

Problem statement:
Chinook salmon bycatch taken incidentally in GOA groundfish fisheries is a concern, and no salmon bycatch control measures have been implemented to date. Current observer coverage levels and protocols in some GOA groundfish trawl fisheries raise concerns about bycatch estimates and may limit sampling opportunities. Limited information is available on the origin of Chinook salmon taken as bycatch in the GOA; it is thought that the harvests include stocks from Asia, Alaska, British Columbia, and lower-48 origin.

Despite management actions by the State of Alaska to reduce Chinook salmon mortality in sport, commercial, and subsistence fisheries, minimum Chinook salmon escapement goals in some river systems have not been achieved in recent years. In addition, the level of GOA Chinook salmon bycatch in 2010 has exceeded the incidental take amount in the Biological Opinion for ESA-listed Chinook salmon stocks.

The sharp increase in 2010 Chinook bycatch levels in the GOA fisheries require implementing short term and long-term management measures to reduce salmon bycatch to the extent practicable under National Standard 9 of the Magnuson-Stevens Act. In the short term, measures focused on the

[8] Bycatch includes the discard of whole fish at sea or elsewhere, including economic discards and regulatory discards, and fishing mortality due to an encounter with fishing gear that does not result in capture of fish (i.e., unobserved fishing mortality) NS9.

GOA pollock fisheries are expected to provide the greatest savings. In the long term, comprehensive salmon bycatch management in the GOA is needed.

Alternatives for expedited review and rule making:
The below alternatives apply to directed pollock trawl fisheries in the Central and Western GOA.

Alternative 1: Status quo.

Alternative 2: Chinook salmon Prohibited Species catch) limit and increased monitoring.

Component 1: 15,000, 22,500, or 30,000 Chinook salmon prohibited species catch limit (hard cap).

Option: Apportion limit between Central and Western GOA
a) proportional to the pollock TAC.
b) proportional to historic average bycatch rate of Chinook salmon (5 or 10-year average).
c) proportional to historic average bycatch number of Chinook salmon (5 or 10-year average).

Component 2: Expanded observer coverage.
Extend existing 30% observer coverage requirements for vessels 60'-125' to trawl vessels less than 60' directed fishing for pollock in the Central or Western GOA.

Alternative 3: Mandatory salmon bycatch control cooperative membership.

In order to fish in the Central or Western GOA pollock fisheries a vessel must be a member of a salmon bycatch control cooperative for the area where they are participating. Cooperative formation will be annual with a minimum threshold (number of licenses).

Cooperative contractual agreements would include a requirement for vessels to retain all salmon bycatch until vessel or plant observers have an opportunity to determine the number of salmon and collect any scientific data or biological samples. Cooperative contractual agreements would also include measures to control Chinook salmon bycatch, ensure compliance with the contractual full retention requirement, promote gear innovation, salmon hotspot reporting, and monitoring individual vessel bycatch performance.

This management approach defines an agreed problem statement and then develops alternative options for a resolution by those in the fishery management process.

Alternative legislated responses to bycatch involve fines and incentives within the MSA. For example **104-297** (g) Bycatch Reduction Incentives.

"*(1) Notwithstanding section 304(d), the North Pacific Council may submit, and the Secretary may approve, consistent with the provisions of this Act, a system of fines in a fishery to provide incentives to reduce bycatch and bycatch rates; except that such fines shall not exceed $25,000 per vessel per season. Any fines collected shall be deposited in the North Pacific Fishery Observer Fund, and may be made available by the Secretary to offset costs related to the reduction of bycatch in the fishery from which such fines were derived, including conservation and management measures and research, and to the State of Alaska to offset costs incurred by the State in the fishery from which such penalties were derived or in fisheries in which the State is directly involved in management or enforcement and which are directly affected by the fishery from which such penalties were derived*".

Other legislated bycatch approaches are given in MSA (2007) 109-479 Sec. 316. Bycatch reduction engineering 16 u.s.c. 1865 program.

"*(a)* ***bycatch reduction engineering program*** *: … establish a bycatch reduction program, including grants, to develop technological devices and other conservation engineering changes designed to minimize bycatch, seabird interactions, bycatch mortality, and post-release mortality in Federally managed fisheries. The program shall (1) be regionally based; (2) be coordinated with projects conducted under the cooperative research and management program established under this Act; (3) provide information and outreach to fishery participants that will encourage adoption and use of technologies developed under the program; and (4) provide for routine consultation with the Councils in order to maximize opportunities to incorporate results of the program in Council actions and provide incentives for adoption of methods developed under the program in fishery management plans developed by the Councils.*

(b) ***Incentives****—Any fishery management plan prepared by a Council or by the Secretary may establish a system of incentives to reduce total bycatch and seabird interactions, amounts, bycatch rates, and post-release mortality in fisheries under the Council's or Secretary's jurisdiction, including— (1) measures to incorporate bycatch into quotas, including the establishment of collective or individual bycatch quotas; (2) measures to promote the use of gear with verifiable and monitored low bycatch and seabird interactions, rates; and (3) measures that, based on the best scientific information available, will reduce bycatch and seabird interactions, bycatch mortality, post-release mortality, or regulatory discards in the fishery.*

(c) ***Coordination on Seabird Interactions****... authorized to undertake projects in cooperation with industry to improve information and technology to reduce seabird bycatch, including - (1) outreach to industry on new technologies and methods; (2) projects to mitigate for seabird mortality; and (3) actions at appropriate international fishery organizations to reduce seabird interactions in fisheries*".

3.1.6 Data poor fisheries

The NMFS describe data poor stocks as:

"*Stocks for which there is inadequate data to complete a stock assessment that could estimate biomass and fishing mortality reference points. NMFS has provided guidance that recent average catch can be a basis for establishing the OFL and ABC* "(NOAA 2009). The NS1 Guidelines also allow for grouping data poor stocks into an appropriate stock complex that is managed and monitored using one or more indicator stocks (i.e., stocks that can be assessed) NMFS 2009.

According to the NMFS (2009), the ACL can be specified at a level higher than recent average catch unless the best available information indicates that past fishing depleted the stock below the level that would support MSY, and if the best available information supports a finding that recent average catch levels are sustainable without depleting the stock below the level that would support MSY.

"*Even though the stock abundance and fishing mortality rates cannot be quantified for data poor stocks, the status of the stock and the fishery should be considered in the context of maintaining an abundant stock that is not subject to overfishing. A key consideration in setting the ACL higher than recent average catch is the appropriate ACL that would allow the average catch in the fishery to be maintained. In other words, if it is determined that the recent ACL is an appropriate target catch level, the ACL can be set at an appropriate amount above the target level to allow the fishery to maintain recent average catch levels*" NMFS (2009).

3.1.7 Managing discards

As a default the MSA considers all stocks currently identified in an FMP as "*stocks in the fishery"* (NMFS 2009). "*Stocks in the fishery*" would include *"target stocks (i.e., stocks that fishers seek to catch for sale or personal use, including "economic discards" as defined under MSA section 3(9)[9]), non-target stocks that are retained for sale or personal use, and non-target stocks that are not retained for sale or personal use and that are either determined to be subject to overfishing, approaching overfished, or overfished, or could become so, according to the best scientific information available, without conservation and management measures"* (NMFS 2009).

3.1.8 Differing levels of productivity

NMFS (2009) relates productivity to vulnerability:- *"A stock's vulnerability is a combination of its productivity, which depends upon its life history characteristics, and its susceptibility to the fishery. Productivity refers to the capacity of the stock to produce MSY and to recover if the population is depleted, and susceptibility is the potential for the stock to be impacted by the fishery, which includes direct captures, as well as indirect impacts to the fishery (e.g. loss of habitat quality). Councils in consultation with their scientific and statistical committee, should analyse the vulnerability of stocks in stock complexes where possible"*.

3.1.9 Different trophic levels

The US MSA documentation does not emphasise the term "trophic levels" but covers similar material in its ecosystem –based approach to fishery management (EBFM).

"*The MSA gives Councils considerable discretion in defining the "fishery" under their FMPs. Some FMPs include one or a few stocks, whereas others include hundreds of species in an effort to incorporate ecosystem approaches to management. The MSA provides authority to manage fisheries using an ecosystem-based approach. NMFS wanted to encourage ecosystem-based management approaches, so it established the ecosystem component species as a possible classification a Council may – but is not required to – consider. NMFS considers all stocks in an FMP to be "in the fishery", unless a stock has been specifically identified through an FMP or FMP amendment as an "ecosystem component species." To be considered an ecosystem component species, the species should: Be a non-target species or non-target stock; not be subject to overfishing or overfished nor likely to become so; and generally not be retained for sale or personal use*" (NMFS 2011a). Ecosystem component species are not considered to be in the fishery and are not required to have ACLs.

3.1.10 Application of risk based approaches

The MSA (2007) has many references to the requirement that Fishery Management Councils have the "*best scientific information available*" in making decisions. The NS1 guidelines state that the ABC control rule[10] should account for the scientific uncertainty in the estimate of the OFL. The choice of

[9] In the MSA "Economic discards" are targeted fish that aren't retained because the harvester doesn't want them (undesirable size, sex, quality, etc.). "Regulatory discards" are fish (targeted or not) required by regulation to be discarded, or to be retained but not sold. (MSA, 1996).

[10] "*An ABC control rule is established by the Council, based on advice from its Statistics and Scientific Committee and is a specified approach to calculate the ABC for a stock. When setting an ABC control rule, the Council and/or its Statistics and Scientific Committee should consider reducing the fishing mortality rate as stock size declines (especially when a stock is overfished) and establishing a stock abundance level below which fishing would not be allowed*"(NMFS 2011a).

the ABC control rule must be adequately described in the FMP. The scientific and statistical committees will take the uncertainty into account in recommendations to each FMP. In NMFS (2009) several questions about setting ACLs and NS1 are answered to assist Fishery Management Councils.

"*In the case where the scientific uncertainty cannot be calculated, what should be the basis for the ABC control rule?*

The fact that uncertainty cannot be calculated is, in fact, important evidence of a high level of uncertainty. The ABC control rule should therefore be appropriately conservative to account for this uncertainty. If the OFL or the scientific uncertainty in the OFL cannot be estimated, expert judgment and sound conservation principles can be utilized to determine the ABC" NMFS (2009).

In practice recent average catch data and trends in annual catch could provide the basis for estimating ABC (NMFS 2009). The probability bounds around control points in the US is a 50% chance B will go below B_{LIM} (<50% of B_{MSY}) in next two years.

3.2 New Zealand

In NZ, management of fisheries is carried out by the Ministry for Primary Industry (MPI), a new ministry formed in 2012 from the merger of the Ministry of Agriculture and Forestry, the Ministry of Fisheries and the New Zealand Food Safety Authority. Under the Fisheries Act, 1996, a Quota Management System (QMS) is used to manage the commercial fish stocks in New Zealand's waters, and presently includes 95 species, representing 90% of the commercial harvest by weight. The NZ system allocates a freely tradeable share of the TAC quota in perpetuity to quota holders. Fishing under these quotas is facilitated by a system of annual catch entitlements (ACE), whereby fishers who do not own quotas can lease ACE from quota holders, allowing them to fish during the season/s for which ACE is leased. There are institutional arrangements for stakeholder-led management in consultation with all relevant parties (government; commercial, customary Maori and recreational fishers; and environmental groups and interests). The TAC is made up of all sources of fishing including Maori customary fishing, recreational fishing and a Total Allowable Commercial Catch (TACC).

In 2008 New Zealand developed the Harvest Strategy Standard and the companion document entitled "*Operational Guidelines for New Zealand's Harvest Strategy Standard*" (MAF 2008b). Important issues addressed by the Harvest Strategy Standard include:

> "*> Recognising and encompassing all MSY-compatible reference points;*
>
> *> Providing a scientific and technical basis for rebuilding stock; and.*
>
> *> Providing the ability to specify biomass limits below which formal, time-constrained rebuilding plans should be implemented"* (MAF 2008).

3.2.1. Management

There have been two forms of management plan in NZ fisheries:

- Stock strategies are developed by the Ministry which define management objectives, instruments, research, compliance and administration services; and
- Fisheries Plans can be developed with and implemented by relevant stakeholders.

New Zealand's waters are divided into Fisheries Management Areas, with a stock as the basic management unit. For any fish stock, the TAC may be set such that the stock is fished down to sizes that support MSY, or that enables a stock to recover to a size that supports MSY. Thus for commercial fisheries, the management strategy allows for fish stock recovery. Rebuilding plans are required if the stock declines below the soft limit reference points established under the New Zealand Harvest Strategy Standard (HSS). Depletion below the soft limit triggers a requirement for a formal, time-constrained rebuilding plan.

Fishery assessment working groups generate advice for each status category: stock "above", "at", or "below" a level that can produce MSY. The terms of reference for stocks below MSY, and that therefore require recovery are to:

- "*Determine if recent total removals and the current TAC and/or TACC are at levels which will allow the stock to rebuild to a level that can produce the MSY or to some appropriate larger stock level;*
- *Identify any factors relating to the interdependence of stocks of fish that would determine whether a stock level above that which can produce the MSY is appropriate; and,*
- *Determine any biological characteristics of the stock or environmental conditions that would influence the rate of rebuild*" (HSS, 2008).

The New Zealand system "*explicitly includes consideration of the multispecies nature of fish stocks (interdependence) and biological and environmental factors that may contribute to recovery*" (MAF 2008a). Dr Pamela Mace, MFish's Chief Scientist commented at the launch of the NZHSS, "*In developing the Harvest Strategy Standard the best-practice approaches of other countries, and international fisheries organisations, were considered and adapted to suit our unique management system…Adopting this best-practice approach helps ensure New Zealand's fisheries management keeps its place at the forefront of fisheries management internationally.*" (The Bite NZ 2008).

3.2.2 Reference points

The NZ HSS requires 'MSY-compatible' target reference points to be established, and refer to B_{MSY} as a compatible target (MAF, 2009; S13-3).

The overfished stock reference point in NZ is a soft limit of $B< 1/2B_{MSY.}$ In NZ the term "depleted" is used in preference to "overfished", because "*stocks can become depleted through a combination of overfishing and environmental factors*"(MAF 2008). Overfishing in NZ, is expressed as a level of $F> F_{MSY}$.

3.2.3 Recovery plans

The Ministry of Agriculture and Fisheries characterise the status of fisheries and stocks in the following way:

"*If the MSY-compatible fishing mortality rate, F_{MSY}, or an appropriate proxy is exceeded on average, overfishing will be deemed to have been occurring, because stocks fished at rates exceeding F_{MSY} will ultimately be depleted below B_{MSY}. A stock that is determined to be below the soft limit [default: $^1/_2$ B_{MSY} or 20% of the unfished level, whichever is higher] will be designated as depleted [or overfished] and in need of rebuilding. A stock that is determined to be below the hard limit [default: $^1/_4$ B_{MSY} or 10% of the unfished level, whichever is higher] will be designated as collapsed.*" (MAF 2011a,b).

The harvest strategy standard requires a probability of at least 50% of achieving target reference levels and rebuilding plans are required to demonstrate a 70% probability that rebuilding has been achieved to the rebuilding target. An example of a stock rebuilding plan for Bluenose is presented in Appendix 4.

3.2.4 Reporting on stock status

In April 2009, the Ministry of Fisheries' Stock Assessment Methods Working Group adopted a probabilistic scale for categorising the "*..at or above target levels*", depleted, collapsed and overfishing indicators (based on the scale developed by the Intergovernmental Panel on Climate Change (IPCC) in 2007). While these probability categories are best applied in situations where models give appropriate quantitative outputs, they can also be used subjectively, based on expert opinion, when such model outputs are not available, or are highly uncertain. The stock status table uses the IPCC criteria, coded according to the following key in Table 4.

Table 4: Stock status key used in NZ fisheries following IPCC (2007).

At or above target levels?	Probability	Description	Deleted? Collapsed? Overfishing?
●●●●	> 99 %	Virtually Certain	■■■■
●●●	> 90 %	Very Likely	■■■
●●	> 60 %	Likely	■■
●	40 - 60 %	About as Likely as Not	■
■	< 40 %	Unlikely	●●
■■■	< 10 %	Very Unlikely	●●●
■■■■	< 1 %	Exceptionally Unlikely	●●●●

The following is a sample of different species status in the NZ stock status report 2011.

In Table 5 the stock status of a range of NZ stocks is illustrated using the key system illustrated in Table 4. The species are qualified by regional area and date of assessment is indicated. Alfonsino, blue cod stocks and blue mackerel are near target levels and have a likely probability of meeting hard and soft limits. This contrasts with bigeye and bluenose where there is a high probability overfishing is occurring. The key system is effective at communicating stock status, probability of stock indicator accuracy and is likely international best practice.

Table 5: Examples of NZ Stock status for different species in 2011.

2011 Stock Status (as at the stated 'last assessment date')

Species name	Plenary stock	Last assessment date	At or above target levels?	Below the soft limit?	Below the hard limit?	Overfishing?	Corrective management action
Alfonsino	BYX1	2010	●●	●●●	●●●	●●	-
Bigeye tuna	Western & Central Pacific Ocean BIG1	2010	■■	●●	●●	■■■	Conservation and management measures adopted at WCPFC 5
Blue cod	BCO4	2011	●	●●	●●●	●●	-
Blue cod	BCO7	-	● - local depletion in some parts of Marlborough Sounds	●●	●●	-	Recreational catch of BCO in the Marlborough Sounds (and Tory Channel) was prohibited from 1 Oct 2008. Re-opened under new rules on 1 April 2011.
Blue mackerel	EMA1	2006	-	●●	●●	-	-
Bluenose	BNS1, BNS2, BNS3, BNS7, BNS8	2011	■■■	■	●●	■■■	TAC and TACC reductions made in 2008; more proposed in 2011

3.2.5 Multiple species and Bycatch

The NZ QMS has a TAC for each species and in reconciling quota has a deemed value system to cater for the bycatch of non target commercial species. Under the deemed values system, deeming values per kilogram are determined for each species annually, and fishers are required to pay deemed values for their catch in excess of quota, unless they can obtain additional ACE to cover the excess catch. This bycatch balancing through the deemed value system reduces discarding. This system is designed to reduce the incentive to take bycatch species, acknowledging that non target species are taken by fishers in the fishing process. The QMS process requires reporting of the amount of different bycatch species taken and this feeds into the stock assessment process.

Section 14A of the NZ Fisheries Act sets out the conditions for listing stocks under section 14B, which states that the Minister must set a TAC that is "*no greater than that which will allow taking of another stock or stocks in accordance with the TAC and TACC set for that other stock or stocks*", and in all instances the TAC that is set must maintain the stock "*above a level that ensures its long-term viability*". In practice, sections 14A and 14B allow catches of key target species to be maintained without being unduly constrained by the need to apply targets based on MSY-compatible reference points or better to minor bycatch stocks (HSS 2008).

Fisheries and Environment

The New Zealand system does not have a formal assessment process for the environmental assessment of fisheries. Key environmental issues, such as seabird or mammal bycatch, are formally assessed and reported on by the Aquatic Environment Working Group. General environmental issues arising from fishing are identified and reviewed annually by the individual fisheries assessment working groups for each fishery sector. This information is all collated into an Aquatic Environment and Biodiversity Review report, the first of which was produced in 2011 (MAF 2011b), which provides a summary of environmental interactions between fisheries and the aquatic environment. The review "*has been developed over the past three years and is a conceptual analogue of the Ministry's Reports from the Fisheries Assessment Plenary. The review summarises the most recent data and analyses on particular aquatic environment issues and, where appropriate, assesses current status against any specified targets or limits*" (MAF 2011b). Several significant issues arise for the fishing industry including the physical impacts of bycatch excluding devices causing damage to NZ fur seals and sea lions (MAF 2011b).

3.2.6 Data poor fisheries

The HSS guidelines state "*When information for determining reference points for a fishery is poor or absent, provisional reference points shall be set. Provisional reference points may be established by analogy to similar and better-known stocks. In such situations, the fishery shall be subject to enhanced monitoring so as to enable revision of provisional reference points as improved information becomes available"* (MF, 2011). In reporting stock status, "nominal" stocks (fish stocks for which a significant commercial or non-commercial potential has not yet been demonstrated), have low TACs and receive no formal assessment.

3.2.7 Managing discards

Discarding is not mentioned in either the HSS or guidelines. Ballara et al. (2010) quantify fish discards and non-target fish catch in the trawl fisheries for hoki, hake and ling in New Zealand waters. Peacey (2007) explains the policy intention of the deemed value system to reduce discards and suggests that discarding has remained at similar levels under the deemed value bycatch balancing system.

3.2.8 Differing levels of productivity

In the 2011 version of the NZ HSS guidelines (MF 2011) productivity guidelines are presented as in Box 5.

Box 5: Productivity in the NZ HSS guidelines (MF 2011):

"*..productivity is considered to be an operational substitute for resilience. (This assumption may be revisited in the future). Two sets of guidelines for categorising species in terms of low, medium and high productivity levels are presented in Table 1 (from FAO 2001).*

Table 1. Guidelines for categorising productivity levels for exploited fish species. Numbers outside brackets are from FAO (2001); numbers in brackets are from Musick (1999). M is natural mortality; r is the intrinsic rate of natural increase; K is the Brody growth coefficient; t_{mat} *is the average age of maturity;* t_{max} *is the expected maximum age in the absence of fishing, approximated by the formula corresponding to the age at which a cohort drops to 1% of its original number; and G is the average generation time approximated by the formula given. From FAO (2001) and MF (2011).*

Parameter	Productivity		
	Low	Medium	High
M	< 0.2	0.2–0.5	> 0.5
r	< 0.14 (< 0.16)	0.14–0.35 (0.16–0.5)	> 0.35 (> 0.5)
K	< 0.15 (< 0.16)	0.15–0.33 (0.16–0.3)	> 0.33 (> 0.3)
t_{mat} (years)	> 8 (> 4)	3.3–8 (2–4)	< 3.3 (< 1)
t_{max} (years) (t_{max}=4.6/M)	> 25 (> 10)	14–25 (4–10)	< 14 (1–3)
G (years) (G=t_{mat}+1/M)	> 10	5–10	< 5
Examples	orange roughy, many sharks	cod, hake	sardine, anchovy

"*Both categorisations are based on global considerations of a wide range of commercially exploited species, including many species with much higher productivity levels than those that are typical for most New Zealand species. In fact, few New Zealand species would fall in the global high productivity category. Four examples that probably do are anchovy, pilchard, red cod and squid.*

At the other end of the spectrum, there are several low productivity New Zealand examples with life history characteristics that are far away from the bounds given in Table 1 for low productivity stocks (e.g. orange roughy and oreos).

*For such stocks (e.g. stocks with M < 0.1 and/or tmat > 15), an additional "very low productivity" category needs to be created. Note that some species may fall into different categories depending on which life history parameter is considered. When this happens it will be necessary to exercise scientific judgement to determine the most appropriate category overall" (*MF 2011*).*

3.2.9 Different trophic levels

The NZ HSS (MAF 2008) or HSS guidelines (MF 2011) have no mention of trophic considerations and minimal mention of ecological guidelines.

3.2.10 Application of risk based approaches

NZ fishery management concentrates on improving the reliability of assessments and the accuracy of status estimates, with formal reporting of the probability of biomass levels for each species and area within its management system. The harvest strategy standard requires a probability of at least 50% of achieving target reference levels and rebuilding plans are required to demonstrate a 70% probability that rebuilding has been achieved to the rebuilding target.

The HSS (MAF 2008) states:

"*MSEs should be designed to ensure that:*

- *the probability of achieving the MSY-compatible target or better is at least 50%;*
- *the probability of breaching the soft limit does not exceed 10%,and*
- *the probability of breaching the hard limit does not exceed 2%"*

Amalgamating soft and hard limit metrics is also addressed:

"A potential problem with requiring management strategies to incorporate a maximum acceptable probability of 2% for breaching the hard limit is that this may require large numbers of computations for evaluating alternative management strategies designed to meet the HSS. Therefore, for the

purpose of the Harvest Strategy Standard, management strategies that collapse the requirements of "no more than a 10% probability of breaching the soft limit" and "no more than a 2% probability of breaching the hard limit" into a single requirement of "no more than a 5% probability of breaching the soft limit" will generally be acceptable" (HSS 2008).

The potential use of MSE is accepted and Australia's strength in this area is acknowledged by MAF. Formal management strategy evaluations have been conducted, and management procedures with formal decision rules have been implemented for most of the NZ rock lobster stocks. NZ has several risk-based approaches contributing to policy, but "*not necessarily fully formalised or standardised*" (pers. comm. Pamela Mace).

Summary

In discussions with senior NZ Fisheries staff they indicated that "*we've mostly been involved in implementing the harvest strategy standard at the single-species level. Our Fisheries Plans are attempting to deal with data poor fisheries, discards and other issues, but for the most part I think they've got quite a way to go*" (pers. comm. Pamela Mace). This view is supported by the available NZ literature which shows a concentration on achieving higher levels of single stock status and the difficulties seen in other nations in implementing complex multi-species issues into actions on the ground.

3.3 European Union (EU)

3.3.1 Management

The European Union has a Common Fisheries Policy (CFP) between member nations. Over the last decade the CFP reforms initiated in 2002 have sought to address overfishing through capacity reduction initiatives (EC 2009). The CFP manages fisheries through annual fishing quotas and TAC set by the European Council. These measures are based on both scientific advice and relevant social, economic and political considerations (EC 2009).

The nations in the CFP rely on International Council for the Exploration of the Sea (ICES) to provide scientific advice to the European Commission (EC) on the status of commercially important fish stocks and the management of the associated fisheries. Other non-EU nations, such as Norway and Iceland, are also part of the ICES science and expert working group system.

The 2002 reforms of the CFP gave the EC powers to address overfishing, including emergency measures to prevent stock collapse (Uncover 2010). The CFP has introduced concepts of long term sustainability including reference points, the development of multi-annual fisheries management plans (called long term management plans/LTMP) as stock recovery plans (Wakeford et al. 2007, 2009).

New CFP reform by 2015

In April 2009, an EC green paper sought to reform EU fisheries with a "Vision to 2020" (EC 2009). The green paper identified both the contributions and shortcomings of the CFP 2002, noting that fishing capacity exceeded sustainable effort levels in most fisheries (EC, 2009). By 2009 the EC green paper confirmed that 88% of EC stocks are being fished beyond MSY, and that they could increase economic output if fishing pressure can be reduced, even for only a few years. Some 30% of stocks are below safe biological limits, and so their capacity to recover may be jeopardised; and most of Europe's fishing fleets are either running at a loss or returning low profits (EC 2009), being sustained only by EU fishing subsidies. In July 2011, the European Commission presented its proposals for the reform of the EU common fisheries policy for the period 2014-2020 (EU 2011). Since 2010 the

Commission has based its proposals for annual TACs and quotas on scientific advice related to achieving MSY by 2015.

Individual member States of the EU subscribed to the MSY objective almost thirty years ago in the 1982 UN Convention on the Law of the Seas. They then reiterated this commitment in becoming signatories to the 1995 UN Fish Stock Agreement, supporting the 2002 Johannesburg Declaration and the Aichi targets adopted in Nagoya in 2010. This has prompted the observation that "*Important international partners, such as the United States and Australia, have already moved in this direction and the EU is lagging behind*" (EC 2011a). Moving towards MSY objectives requires a socially hard transition period, with short-term job losses expected in "*EU fleets dependent on overfished stocks and showing overcapacity, which characterises the majority of EU stocks*" (EC 2011b).

Marine Strategy Framework Directive

In 2008 the EC's processes to address the environment and marine sector in the EU led to a Marine Strategy Framework Directive (MSFD) which aims to achieve "good environmental status" in Europe's seas by 2020. *"The idea is to integrate planning and management actions across human activities (e.g. fisheries, renewable and non-renewable energy development, mineral extraction, transportation etc.) to take account of the cumulative impact of all of these activities on ecosystems. The MSFD is an important challenge for the scientific community, and ICES welcomes the MSFD as an opportunity to apply the ecosystem approach. In the coming years, ecosystem-based advice and management will certainly increase in importance"* (ICES 2011d). The Directive sets out 11 high-level descriptors of GES of which the following four have implications for fisheries (EC 2008).

Qualitative descriptors 1 to 4[11], for determining good environmental status are:

> *(1) Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions;*
>
> *(2) Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems;*
>
> *(3) Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock; and*
>
> *(4) All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity (EC 2008).*

Piet *et al*. (2010) examined the proposed good environmental status standards for the "commercial fisheries and shellfish" under the MSFD.

Discussion on EU management approaches

There are now two seemingly parallel processes in the EU – the CFP and the MSFD. In an explanatory fact sheet to UK fishers, the Department for Environment, Food and Rural Affairs explain *"The majority of Member States acknowledge that the reformed CFP is the mechanism for achieving good environmental status under the MSFD, providing a robust framework for the sustainable management of marine biological resources and ensuring a level playing field in Community waters"* (DEFRA, 2012).

[11] *(referred to in Articles 3(5), 9(1), 9(3) and 24)*

The MSFD is a piece of secondary legislation under the EC's environmental policy area. Both the CFP and the MSFD are policy areas with different settings under which participants such as the Member States and the EU institutions have different tasks. Given the lack of success of the CFP over the last decades, there are concerns regarding implementing the MSFD framework with a revised CFP (Ernst 2011). The current and the reformed CFP institutional policy capacity and approach will still be significantly different from that of the wider marine sector industries in the MSFD. The MSFD is a widening of fisheries policy within the marine environment and will impact fisheries policy and management processes due to more explicit consideration of the impacts of fishing on biodiversity, ecological stock structure and the seabed (EC 2008).

3.3.2 Reference points

ICES has investigated and recommended limit reference points to indicate the biomass level below which recruitment may be impaired (Uncover 2010). ICES defines a higher precautionary biomass reference point (B_{pa}), such that when assessments indicate the spawning stock to be at B_{pa}, "*there is a high probability that the true biomass is above* B_{LIM}", referred to as a safe biological limit (Uncover 2010).

An upper limit for fishing mortality has been defined (F_{LIM}). If this limit is exceeded over a long period, there is a high probability that the stock will fall below B_{LIM}, to a level where poor recruitment can be expected (ICES 1998). There have been objections to the adoption of these reference points by some EU members and they have not yet been formally adopted. In 2006 and 2009, the EU "*had not yet identified target reference points and the relationship between* B_{pa} *and* B_{MSY} *is unknown for most stocks*", though they also note this may be changing (Wakeford et al. 2007, 2009; UNCOVER 2010).

ICES have an MSY approach using both a fishing mortality rate and a biomass reference point. In general, F_{MSY} should be lower than F_{pa}, and the B_{MSY}-trigger should be equal to or higher than B_{pa}. "*In most situations, the ICES MSY approach will be more cautious with respect to future stock status than the ICES precautionary approach. This is appropriate since* B_{pa} *is a necessary, but not sufficient, condition for MSY"* (ICES 2011c).

"*Although the World Summit on Sustainable Development (UN, 2002) called for stocks to be restored to levels that can produce MSY by 2015 where possible (which requires that overfishing relative to MSY be ended well in advance of 2015; for many stocks it is already too late), this is not the policy of the European Commission (see EC, 2006). The EC and other management bodies that request advice from ICES have indicated they favour a gradual transition to implementing the MSY approach*" (ICES 2011d).

3.3.3 Recovery plans

The first set of EU recovery plans in 2002 aimed to recover the stock to Sustainable Biological Limits (SBLs) within a 10-year period (Wakeford et al. 2009). After achieving safe biological limits for two consecutive years, the fishery should be moved from a recovery plan to a long term management plan. Recovery plans were intended to apply to stocks whose biomass falls below SBLs, whereas management plans were intended for non-vulnerable stocks.

By 2009, the EU had dropped this distinction between recovery and management plans and now refers only to 'long-term' or 'multiannual plans' (Wakeford 2009). In period since the 2002 CFP

reforms to 2007, the CFP review green paper identified that no stock had yet formally recovered under an EU recovery plan (EC, 2009).

Under the most recent CFP reforms, long term management plans are required to control exploitation rates to *maintain or restore stocks to levels that can produce the maximum sustainable yield: for depleted stocks on an urgent basis and where possible not later than 2015"* (EC 2009). This reflects the EU Member States pledge at the 2002 World Summit on Sustainable Development, Johannesburg, South Africa to rebuild stocks to levels supporting MSY by 2015.

Hammer et al. (2010) examined the recovery of 33 fish stocks in Aus (10) NZ (3) US(6) and EU (13) *"to understand prospects for recovery, to enhance the scientific understanding of the mechanisms of recovery, and to formulate recommendations on how best to implement long-term management/recovery plans"*. Discriminant analysis indicated that "*the four best additive predictors of successful recovery were "rapid reduction in fishing mortality", "environmental conditions during the recovery period", "life-history characteristics" of the target stock, and "management performance criteria*" Hammer et al. (2010).

*For some stocks at low sizes, ICES has previously recommended a zero catch to promote recovery above B_{pa} in the next management year, or as soon as possible. However, such recommendations are often sensitive to the estimate of recent recruitment. That is, the recommended catch is likely to be low or zero when the stock is below B_{pa} if estimated recruitment is poor, whereas no decrease of even an increase in catch might be indicated if recruitment is estimated to be good. This makes sense if estimates of recruitment are reliable, but such estimates are usually among the most imprecise elements of an assessment. Thus, this approach can create instability in advice (changes from year to year that are more a reflection of noisy data rather than a signal). As an alternative, when stock size is low such that the risk of impaired recruitment is high (e.g. at or below B_{lim}), the ICES MSY harvest control rule (depicted by a broken line) calls for careful examination of the causes for the low stock size and the future outlook, and for the implementation of additional conservation measures if appropriate (*ICES 2011d).

3.3.4 Reporting on stock status

Stock status is reported via the ICES system and published in a series of "books" (ICES 2011c and d). The stock status information *use catch at age information from the commercial fisheries and use research survey indicators or catch rates in the commercial fishery (CPUE) information to "calibrate" the assessment* (ICES 2011c). Management strategies in the ICES area rely on some forecast of the outcome of fisheries management in the management year.

A Management Option table, as presented in Table 6, is an important part of the ICES advice on stock status. *"The catch options rely on estimates of recent stock size and fishing mortality and require an assumption about the total catch in the current or "assessment" year, because the fishery is rarely over when the assessment is carried out"* (ICES 2011c).

In Table 6 state of the stock is displayed on the left hand side and the recommended options for stock management on the right hand side.

This approach to displaying stock status information is integrated with management requirements. The EU would access such ICES documents in compiling stock status information within EU fisheries.

Table 6: A Management Options stock status table for demersal fish species in the North Atlantic fishery (ICES 2011d) Key: grey circle unknown; red circles below limits; green circles above limits.

Stock	State of the stock				Outlook options			ICES advice for 2012 (in tonnes or effort)
	Fishing mortality in relation to F_{MSY}	Fishing mortality in relation to precautionary limits (F_{PA}/F_{lim})	Spawning biomass in relation to MSY $B_{trigger}$	Spawning biomass in relation to precautionary limits (B_{PA}/B_{lim})	MSY approach (within the precautionary appraoch)	Precautionary approach / considerations	Management plan	
Greenland cod	Unknown ?	Unknown ?	Undefined ?	Undefined ?	-	no fishery should take place in 2012 to improve the likelihood of establishing offshore spawning stocks in West and East Greenland	-	no fishery should take place in 2012 to improve the likelihood of establishing offshore spawning stocks in West and East Greenland
Icelandic cod	Appropriate ✓	Harvested sustainably ✓	Above trigger ✓	Full reproductive capacity ✓	-	-	landings in the fishing year 2011/2012 should be no more than 177 000 t.	Management plan: landings in the fishing year 2011/2012 should be no more than 177 000 t.
Icelandic haddock	Undefined ?	Harvested unsustainably ✗	Undefined ?	Full reproductive capacity ✓	-	- catches in 2012 should be no more than 42 000 t	-	catches in 2012 should be no more than 42 000 t
Icelandic saithe	Above target ✗	Undefined ?	Above trigger ✓	Full reproductive capacity ✓	catches in 2012 should be no more than 45 000 t	-	-	MSY approach: catches in 2012 should be no more than 45 000 t
Greenland halibut	Above target ✗	Undefined ?	Undefined ?	Undefined ?	-	no directed fishery in 2012	-	no directed fishery in 2012

3.3.5 Multi-species, bycatch and discarding in the EU

Discards are defined by ICES as *"those components of a fish stock thrown back after capture e.g. because they are below the minimum landing size or because quota have been exhausted for that species. Most of the discarded fish will not to survive"* ICES (2011c).

The EU quota system has allocated individual species TACs for designated areas across the fleets and producers. Once the sectoral total catch quotas for species have been reached, the EU has required additional catch of these species to be returned to the sea as discarded. The discarding of dead fish has led to much adverse public outcry about fish wasted and the impacts on the fish stocks. The 2009 green paper indicates that "*..decisions on certain principles and standards such as fishing within MSY, adapting fleet capacity to available resources or eliminating discards could remain at Community level, but it would then be left to Member States to regulate their fisheries within these Community standards".* The Green Paper proposes new initiatives to eliminate discards and protect sensitive species and habitats and the use of quota based fisheries to reduce discards.

Authorities indicate that discarding has also been due to:

- "highgrading" to keep the high priced species;
- catching fish below minimum size;
- low market prices for a given species; and
- incidental catch of other species (e.g. birds; and species that are just part of the benthos (DEFRA 2011).

Data on discards is an issue as it may impact stock assessments. ICES indicates some of the issues in gaining accurate discard data. "*ICES does not accept the responsibility for quantifying non-reporting fisheries or ensuring access to proper discard data. The responsibility for discards and non-reporting and the uncertainty regarding the extent of these phenomena rests with the national authorities and the industry"* ICES 2011c.

3.3.6 Data poor fisheries

When fish stocks are without population estimates, ICES practice has been to base advice on recent average catches when there is no quantitative or qualitative evidence of declining abundance. The ICES MSY approach calls for a determination of the status of exploitation relative to FMSY (overfishing or no overfishing) and consideration of the stock trend (ICES 2011d).

3.3.7 Managing discards

As explained under 3.3.5 the EU have had a rule whereby fish over quota amount held or below length limits have to be discarded overboard into the sea. The 2012 revisions of the CFP will prioritise changing the discarding rule. First, pelagic species in 2014, then the most valuable demersal species (cod, hake and sole) in 2015 and finally other species in 2016 (EC 2011d). The ways this will be implemented, have been the subject of an EU enquiry (Gillmann 2011).

Denmark and the UK have trialled an alternative system of managing fish stocks in the North Sea. Rather than using the traditional method of counting catches on land, catches are counted at sea so as to test if this type of management system is possible in EU fisheries, if it can reduce discards, and encourage fishermen to fish more selectively (Defra 2012).

3.3.8 Differing levels of productivity

For long-lived stocks with population size estimates ICES seek to *attain a fishing mortality rate at or below F_{MSY}. In this approach, both fishing mortality and biomass reference points are used; these reference points are F_{MSY} and $B_{MSY\text{-}trigger}$. The approach does not use a B_{MSY} estimate. B_{MSY} is a notional value around which stock size fluctuates when $F=F_{MSY}$. Recent stock size trends may not be informative about B_{MSY}, e.g. when F has exceeded F_{MSY} for many years or when current ecosystem conditions and spatial stock structure are or could be substantially different from those in the past"* (ICES 2011d).

3.3.9 Different trophic levels

ICES state that "*MSY is not necessarily sufficient to assure some aspects of a healthy ecosystem. Therefore, MSY may need to be supplemented with measures to mitigate undesirable impacts on ecosystems. This need for supplementary measures is also considered in the ICES advice. Reducing fishing mortality should also reduce: (a) bycatch of non-target and sensitive species; (b) impacts on habitat and biodiversity; (c) the risk of truncated age structure; and (d) alterations that could possibly affect ecosystem functionality*" (ICES 2011c). The risk of truncated age structure in fish populations is a common trophic impact, as well as other such as trophic cascades (ICES 2011a).

3.3.10 Application of risk based approaches

In the EU system there are a range of risk based fishery assessment models that are available through the fishery science influence of ICES. The advice provided by ICES on fisheries management has consisted of a dual system of limit and 'precautionary approach' reference points, the latter

providing a buffer to safeguard against natural variability and uncertainty in the assessment, and ensuring that limit reference points are avoided with high probability (Uncover 2009). Risk and uncertainty needs to be balanced with appropriate application of the precautionary approach (Uncover 2009).

"*Deterministic and stochastic multi-species models of different complexity (4M,SMS, ECOSIM, GADGET, STOCOBAR) have been applied to reconstruct the historical stock dynamics encompassing periods of regime shifts. Thus, the ability of models to reconstruct the timing and rate of stock changes has been tested. Multi-species models with proven hind cast capabilities have been used to project future stock recovery potentials. Alternative, yet similarly plausible, environmental and anthropogenic scenarios have been tested to provide a suite of alternative recovery paths. A synthesis of recovery paths has, in turn, provided uncertainty levels. The multi-species models have delivered input into data for fisheries management evaluation tools (WP4), but produced also self-standing predictions on stock recovery paths"* (Uncover 2009).

3.4 Iceland

Fisheries management in Iceland is the responsibility of the Ministry of Fisheries and Agriculture. The Fisheries Ministry decides on the annual TACs, receiving advice from the Marine Research Institute (MRI) which is the main stock assessment advice body. Iceland is also part of the ICES science system (MRI 2011). Iceland have applied for European Union (EU) membership and have recently had their fishing industry sector, as opposed to fish stocks, profiled in preparation for entry to the EU (Popescu and Polsen 2012).

The MRI produces assessments of marine stocks and publishes an extensive report in May of each year on the status of the marine stocks and prospects for the coming quota year (MRI, 2011). The document contains numerous references to harvest control indices.

The work of the MRI is organised into three main sections:

- **The Marine Environment Section** mainly focuses on environmental conditions (nutrients, temperature, salinity) in the sea, marine geology, the ecology of algae, zooplankton, fish larvae, fish juveniles and benthos;
- **The Marine Resources Section** mostly works on estimating stock sizes and TACs for each exploited stock of fish, crustaceans, molluscs and marine mammals. Recently an extensive program concentrating on multi-species interactions of exploited stocks in Icelandic waters has also been carried out; and
- **The Fisheries Advisory Section** scrutinizes stock assessments and prepares the formal advice on TACs and sustainable fishing strategies for the government.

The TAC reports bring management, policy and science together around the predicted TACs. The reports focus on Species plans, the Cod Plan being the most important, and stock assessment and harvest strategy terms are contained in the species management plans. The harvest strategy terminology used in Iceland is the "harvest control rule", a central part of a given species' management plan. There is no comprehensive HSP document across all fisheries, a species by species plan approach is preferred instead. On asking our contact in Iceland about this he commented:

"*There is a harvest policy (as distinct from fisheries management policy etc.) in place in Iceland. For cod, our most important species, there is a harvest control rule. For the other species, the MRI recommends annual (usually) TACs to the Ministry which usually follows the advice. The TACs are set*

basically according to a harvest control rule implicit in MRI's thinking, but not explicitly stated. It seems to me that the MRI follows a precautionary principle of sorts and aims for long run stock levels that correspond to the optimum economic yield[12]*. There is some adjustment for species interactions in the policies*" (pers. comm. Ragnar Arnason).

The reference points used in Icelandic fisheries follow the ICES system (See EU). An insight into the relationship between quota setting by management in Iceland and the interaction with the ICES process is given in Box 6.

Box 6: The Quota recommendation for Saithe in the Icelandic ITQ system (MRI 2011).

In 2009, landings of Saithe (*Pollachius virens*) were 61 000 t; a decrease of approximately 13% compared to 2008. The annual landings have exceeded 60 000 t since 2004, having then increased from an average of 30 000 t in the years 1998–2001. Mean weight at age has been low since 2005 but since 2008 an increase for most age groups has been observed.

The spawning stock biomass at the beginning of 2010 is estimated to be 89 000 t and fishing mortality in 2009 is estimated at 0.47, well above the target of 0.3. In recent years, increased targeting of small saithe has been observed, which reduces yield and spawning stock biomass per recruit.

ICES hosted a meeting earlier in 2010 where a benchmark assessment of the Icelandic saithe stock took place. The results of the meeting were that the assessment method was changed and a harvest control rule was suggested and tested. F_{MSY} for the stock is now estimated to be 0.28. Landings in 2010 are predicted to be around 45 000 t and the spawning stock to increase to 94 000 t in 2011.

The advice in recent years has aimed at keeping the fishing mortality at or below 0.3. Considering both the benchmark results and the change in emphasis from biological reference points in ICES, the MRI recommends that the TAC should not exceed 40 000 t in the quota year 2010/2011. This yield is likely to correspond to a fishing mortality (F4–9) close to 0.28.

In Box 6 saithe, a species less prized than cod in Iceland, is noted to have been subject to a higher level of fishing mortality than desired. An ICES meeting led to a revised harvest control rule being adopted and implemented. This illustrates the process by which the Icelandic management system addresses specific harvest control issues, when not having a formal HSP across all species that forces common standards to be applied.

Iceland has clear rules on discards and the disposition of bycatch. Since 1996 a total ban on discards has been in force. Vessels without catch quota for bycatch have to buy quota from other fishers or suspend fishing.

"Collecting and bringing ashore any catches in the fishing gear of fishing vessels is obligatory. Discarding catch overboard is prohibited and such conduct is subject to penalty according to law. If a vessel catches any species in excess of its fishing permit, the relevant fishing company has the option of obtaining additional quota within a certain period of time after landing the catch. Vessels are authorized to land a small percentage (5%) of the catch, usually bycatch, without the use of quota. The catch in question is sold at auction and the proceeds go to a research fund that supports marine research" (Icelandic Fisheries 2007).

[12] OEY is MEY reduced by social factors i.e. $B_{OEY} < B_{MEY}$

Technical measures, such as closure of fishing grounds for a short period of time, are increasingly being used to protect juvenile fish that may otherwise be discarded. According to Popescu and Polsen (2012), Icelandic public opinion considers discarding fish as immoral seeing it as a waste of the resource. The Directorate of Fisheries undertakes surveillance of fishing activities to curb discards, which is carried out by on-board inspectors (Popescu and Polsen 2012).

3.5 Norway

The information on harvest strategy policies in Norway was limited to the study due to language and access to literature. The Ministry of Fisheries and Coastal Affairs are responsible for Norwegian fisheries. The Directorate of Fisheries implements management and has a resource management section with the following objective "... *to set the parameters of a harvesting policy which provides for the optimal and sustainable utilisation of marine resources as a basis for marine business development, while at the same time taking due account of the need to protect the marine ecosystem. Resource management shall also ensure that fishing activities are in accordance with stipulated quotas and in compliance with prevailing regulations*" (www.fiskeridir.no).

Stock assessments for Norway are undertaken by the Institute of Marine Research (IMR) in Bergen (www.imr.no). Most of Norway's stocks are shared with other countries and so the assessment work is done in collaboration with ICES, the results being reported in the ICES working group, or expert group system. Norway's most important working groups are the Arctic working group, the working group for widely distributed stocks, and the herring assessment working group for the area south of 62 N (pers. comm. Ron Hannesson). On asking our Norwegian contact about harvest management strategies in Norway he indicated:

"*I doubt there is a central policy document in English for Norway's strategies, but almost all stocks are shared with other countries, so to the extent there is a strategy (harvest rules, etc.) it would be common with other countries. You'll probably find some on this in the reports from the ICES working groups. From time to time the Ministry of Fisheries issues white papers on fisheries policy, but they're all in Norwegian*" (pers. comm. Ron Hannesson).

The reference points used in Norwegian fisheries are assumed to be similar to the ICES system (See section on the EU).

4 International Best Practice

4.1 Determining International best practice

In this section the harvest strategy features in different countries described in Section 3 will be examined to determine IBP. The goals set for fisheries management are common and can be compared within the differing policy back grounds. The countries reputed as having progressive fishery management measures in place are Australia (AUS); New Zealand, United States, European Union, Iceland and Norway. In many fisheries scientific issues, Iceland, Norway and the EU follow ICES scientific advice and are considered jointly for comparisons with AUS, NZ and the US.

Management regimes

There has been considerable international debate on the merits of fisheries management by either input or output controls as fisheries management best practice (Cochrane and Garcia 2009). It is proposed that fisheries managed by ITQs can more accurately restrict catch and hence have superior sustainable harvests. The TAC setting and compliance processes then become important in realising sustainability. Under input controls the total fishing effort may lead to catches that are above the desired level. The approaches of the different countries are given below:

- AUS has a range of management regimes which use limited entry licensing, input controls, including tradeable effort and output controls, including ITQs;
- NZ fisheries uses ITQ management through the NZ quota Management system.
- Iceland and Norway have ITQ managed fisheries also;
- The EU has sectoral management with regional TACs and these fall short of the individual nature of ITQs as seen in other countries; and
- The US has management through Fishery Management Councils generally using a suite of input controls and has several limited access privilege (LAP) programs, another term for both ITQs and Individual Fish Quotas (IFQs).

The NZ and Icelandic system have full ITQ management, whereas other countries are a mix of input and output controls. The ITQ system increases the requirement for accurate or precautionary stock estimates from scientists for the TAC setting requirement. The merits of input and output controls are still debated, though there is increasing evidence that there is less overfishing associated with output control rights based fisheries (Costello et al 2008). Countries which have implemented ITQs consider it to be IBP. In Australia there are a mix of input and output management regimes and moving completely to management by ITQs in Commonwealth fisheries has met impediments, such as the cost of administering an ITQ scheme for a small fishery (Grafton and McIlgorm 2010). In NZ and Iceland all fisheries are under output controls. The strongest argument in favour of ITQs is that they can give fishers clear rights based incentives to be part of long term fish stock management which will require ITQ owner involvement in reaching sustainable reference points, as opposed to fishing mortality regulations to address stock levels under input control approaches.

Examining Reference points

Reference points have been the subject of debate among fishery scientists and the following comparisons between the countries we have examined in section 3 can be made to determine IBP.

1 Objectives expressed as reference points.

- Australia prioritises B_{MEY} as the objective of Commonwealth fisheries management. Where this has not been formally determined using a bio-economic assessment, the HSP provides for a default proxy of $1.2*B_{MSY}$ (HSP 2007);
- The NZ HSS requires 'MSY-compatible' target reference points to be established, and refer to B_{MSY} as a compatible target (MAF, 2009; S13-3). The NZ HSS provides for proxies of the soft limit ($20\%B_0$) and hard limit ($10\%B_0$) reference points;
- US has B_{MSY} and also B_{OY} in NS1 (NMFS 2012); and
- EU/ICES prioritises F_{MSY} as the reference level for exploitation, as a limit reference point, not a target. It has targeted B_{MSY} to be achieved by 2015.

Discussion

IBP focuses on B_{MSY} as a biomass objective, with an increasing amount of evidence and published analysis advising that targets should be set above B_{MSY} (Sainsbury 2008), for a number of reasons. Australia prioritises B_{MEY}, which is interpreted as $1.2*$ B_{MSY} and is designed to optimise the economic yield of fisheries by maintaining stocks at high levels, thereby reducing fishing costs and increasing profitability. The US has both B_{MSY} and B_{OY} (optimum yield) which takes account of social and economic factors and national wellbeing. The EU is currently aiming to reach the B_{MSY} level by 2015 and uses mortality based F_{MSY} as a limit reference point, not a target. The prioritisation of B_{MEY}, proxy of $1.2*B_{MSY}$, by Australia, is both meeting the international practice of other nations, which is generally B_{MSY} and is IBP in this area.

2a Overfished expressed as reference points.

- Australia reduces fishing when B is between B_{LIM} and B_{MEY} ($=1.2*B_{MSY}$) [13]
- NZ has a "soft" limit" of $B< 1/2B_{MSY}$[14];
- In the US, depletion is where B_{LIM} is below the minimum stock size threshold i.e. B_{LIM} <50% of $B_{MSY;}$ and
- EU/ICES stocks falling below $B_{LIM,}$ "safe biological limits" and uses a higher criteria (B[15]$>B_{pa}$ $F<F_{pa}$)[16].

Discussion

Internationally B_{LIM} has been adopted as the "overfished" reference point, a biomass below this level is overfished. B_{LIM} is generally <50% B_{MSY} in the US, NZ, EU and Australia. The EU's precautionary criteria $B> B_{pa}$ ($SBB>S_{pa}$) is slightly above this level, but is not being achieved (EC, 2009). Nations recommending B_{LIM} reference points around 50% B_{MSY} are promoting IBP**.**

2b Overfishing expressed as reference points.

- Australia defines subject to overfishing as $F>F_{LIM}$;
- Overfishing in NZ is expressed as a level of $F> F_{MSY}$.

[13] Target reference point is 40% of unfished biomass (HSP 2007).

[14] *"The term "depleted" is used in preference to "overfished" because stocks can become depleted through a combination of overfishing and environmental factors"*(MAF 2008).

[15] The EU literature often uses SSB Standing Stock Biomass instead of B.

[16] *ICES has developed a limit reference point to indicate the biomass level below which recruitment may be impaired (B_{LIM}). Taking into account the uncertainty inherent in any stock assessment, ICES further defines a higher precautionary reference point, B_{pa} such that when assessments indicate the spawning stock to be at Bpa, there is a high probability that the true biomass is above B_{LIM} (usually this approximates a 10% probability level) (Uncover, 2010).*

- In the US overfishing is an F above the maximum fishing mortality threshold , $F>F_{MSY}$; and
- EU/ICES prioritises reducing fishing mortality overfishing when $F>F_{MSY.}$

Discussion

There has been international agreement as seen in the UNFSA for the past decade that overfishing is when $F>F_{MSY.}$ Other countries have adopted this measure, and Australia exceeds this with $F>F_{LIM.}$

2c Probability around **controls** can be expressed as reference points.

- Australia keeps stock biomass above B_{LIM} 90% of time;
- NZ accepts a 50% probability of biomass going below a soft or hard limit (see above);
- In the US more than a 50% chance B will go below B_{LIM} (<50% of B_{MSY}) in next two years; and
- EU/ICES prioritises a "high probability 80-95%" (MFSD) and "within safe biological limits" B_{LIM} and $B>B_{pa}$, $F<F_{pa}$;

Discussion

The US and NZ aim to keep a percentage probability of going below a biomass limit 50% of the time, although NZ requires rebuilding plans to demonstrate a 70% probability of reaching the target. The EU indicates an 85% per cent probability around safe biological limits (B_{LIM}). Australia pursues a 90% probability of not being below B_{LIM} which is a higher standard than other nations examined and represents IBP among the nations compared.

3a Stock rebuilding expressed as reference points.

- Australia requires stock rebuilding when $B< B_{LIM}$;
- The NZ default soft limit is ½ B_{MSY} (or 20% B_{0}), and triggers a time-constrained rebuilding plan (should be rebuilt back to at least the target level in a time frame between T_{min} and 2 * T_{min} with an acceptable probability)[17].
- In the US, if a stock goes below maximum fishing mortality threshold (where B <50% B_{MSY}), it has to have a formal recovery plan[18]; and
- EU/ICES prioritises rebuilding when stocks go below "safe biological limits" B_{LIM}, and $B<B_{pa}$, $F>F_{pa;}$

Discussion

Stock rebuilding requirements generally relate to actions required if a stock declines below an established B_{LIM} reference point, such as in Australia, or for NZ soft limits. Falling below B_{LIM} in the EU may lead to a recovery plan, while a stock below maximum fishing mortality threshold (B_{LIM} <50% of B_{MSY}) in the US has to have a formal recovery plan. B_{LIM} is the agreed point below which a stock needs rebuilding. The US has the most formal process of stock rebuilding and Australia and NZ are less formal in this area.

[17] *"T_{min} is the theoretical number of years required to rebuild a stock to the target in the absence of fishing and is a function of three primary factors: the biology of the species, the extent of stock depletion below the target, and prevailing environmental conditions"*(MAF 2008). NZ the Fisheries Act (1996) prescribes rebuilding of stocks that are below the B_{MSY} target or the fishing down of biomass when stocks are above B_{MSY}. [17]

[18] *"Any stock that has previously been listed, or is currently listed, as overfished is required to have a rebuilding program until the stock has been rebuilt to levels consistent with supporting MSY on a sustainable basis"* (NMFS 2012- App. 1).

3b Threatened species /fishery closure expressed as reference points.

- Australia's reference point at which listing as threatened and/or closures may occur is B< B_{LIM} (HSP 2007);
- In NZ the default hard limit is ¼ B_{MSY} or 10% B_0, whichever is higher, and the fishery is considered for closure (MAF 2009);
- In the US fish stocks where B< B_{LIM} may be managed under the ESA[19]; and
- EU/ICES examine stocks where B<B_{LIM} and B<$B_{pa,}$ F>$F_{pa.}$

Discussion

There is no internationally recognised lower limit to mark a threatened species, or the point at which a fishery should be closed. Obviously all "threatened species" measures are where B <$B_{LIM.}$ Australia's falling below 0.75 of B_{LIM} indicates markedly increased risk of irreversible impacts on the species and likely consideration of listing as vulnerable, endangered or critically endangered under the EPBC Act. The hard limit in NZ appears to allow a stock to be depleted to 10% B_0 before considering closure, but rebuilding plans should be implemented before this, when the stock declines below the 20% B_0 soft limit (pers. comm. Pamela Mace). In the US a biomass falling below $B_{LIM,}$ comes under the ESA, triggering a formalised legal process for recovery plans.

4. Economics

- Australia defines as B_{MEY} of the target species, with a proxy of 1.2*$B_{MSY.}$ Industry and government are responsible for moving from B_{MSY} to B_{MEY};
- NZ has no formal policy for addressing economic considerations; "*the Minister considers social and economic factors*" (MAF, 2009 S13-3);
- The US states an objective of $B_{MSY,}$ but NS1 states that B_{OY} is recommended[6]; and
- In the EU, economic impacts by region are prioritised, particularly in rebuilding and long term management plans (LTMP) (Uncover, 2010).

Discussion

Australia is the only nation examined which prioritises economic efficiency and states the economic resource management objective of B_{MEY} > B_{MSY} as a stock management target. The US has an objective of $B_{OY,}$ but this is less than $B_{MEY,}$ assumed to be between B_{MSY} and B_{MEY} being a mixed objective with "national benefit" considerations.

In New Zealand and in the US, the assessment of the socio-economic impacts of options for rebuilding stocks is a significantly different use of economic information than the stock related Australian B_{MEY} approach, being more about policy costs and benefits in fisheries where catch is all under TACs and ITQs. Other nations may have spent more efforts on economic impacts assessment than in Australia, rather than the economic restructuring required to reach B_{MEY}.

Other policy areas where reference points are developing

Much of the emphasis on harvest strategy reference points has been on traditional reference points for stock. There are also a range of other reference points developing in a range of areas.

5a. Multispecies fisheries have target and non-target reference points or other considerations

[19] Other stocks are listed as threatened or endangered under the ESA, and management for these stocks is conducted under the ESA.

- Australia defines as B_{TARG} and at B_{MEY} of the target species, the second species must be at $B>B_{LIM}$;
- NZ produces B_{MSY} for target species "having respect to the interdependence of stocks"[20];
- In the US, standard maximum fishing mortality threshold and the minimum stock size threshold rules apply, $B>B_{LIM}$ and $F> F_{MSY}$[21]; and
- EU/ICES requires $F=F_{MSY}$ on all stocks (under development).

Discussion

International practices range from a "having respect to the interdependence of stocks" to a more specific measure of the impact on non-target or secondary species ($B>B_{LIM}$), which is best practice. In the US general harvest rules (e.g. $B>B_{LIM}$) are to be applied to all species, whereas Australia specifies "the second species". NZ and the EU are less prescriptive.

5b Managing discards expressed as reference points**.**

- Australian recommended biological catches are based on total target mortality which takes discards into account;
- In NZ, discards are monitored or reported and included in stock assessments, but there are no discard limits[22].
- In the US, Fishery Management Councils follow NS9, Bycatch and standard maximum fishing mortality threshold and the minimum stock size threshold rules apply to bycatch species;
- In the EU/ICES system fish over quota or below length limits, are discarded - EU overturning current discard ban in 2014.

Discussion

International best practice takes discards into account in species stock assessments. The US has the fullest bycatch and discard policy in National Standard 9 (see appendix 3).

6a. Data poor fisheries

- In Australia *"scientifically defensible proxies that achieve the intent of the HSP*" should be adopted and a precautionary approach to control rules;
- In NZ, provisional reference points are set from other analogous stocks. Enhanced monitoring is required to revise provisional reference points.

[20] The Fisheries Act sections 14A and 14B allow catches of key target species to be maintained without being unduly constrained by the need to apply targets based on MSY-related reference points to minor bycatch stocks. *" Setting targets for mixed species above B_{MSY} and well below F_{MSY} (**Appendix II**) would provide an additional buffer that minimises the risk of any one species falling below its biomass limit" (MAF 2008).*

[21] *"A single species in an FMP may have multiple stocks, and each stock may be reported separately. Multiple species may be grouped into stock complexes, and the status of the stock complex is reported as a single unit"* NMFS (2012).

[22] The Harvest Strategy Standard is concerned with the application of best practice in relation to the setting of fishery and stock targets and limits, but it is focussed solely on single species biological considerations and related uncertainties, and does not include any considerations of economic, social, cultural or ecosystem issues (MAF 2008).

- In the US, data poor stocks are one where there is inadequate data to complete a stock assessment. Under NS1 grouping data poor stock into stocks complexes is allowed. Recent average catch levels are following providing they are not below B_{MSY};
- EU/ICES base advice on recent average catch and fishing mortality and stock trends if available.

Discussion

IBP requires awareness of the lack of data available and a process set in place to use acceptable proxies. These vary between countries in terms of completeness**.**

6b. New or developing fisheries

- Australia applies a precautionary approach to new and developing fisheries (HSP 2007).
- In NZ, new or developing fisheries should be "*managed cautiously because there is generally little known about the size of the stock, or stock productivity, or stock status*", advising that F should be less than, or equal to F_{MSY}.
- The US and the EU literature accessed provided no information on management approaches to new or developing fisheries.

Discussion

Australia and NZ have similar policy in this area and likely represents IBP, as the US and EU have no policies in this area**.**

6c. Differing levels of productivity

- Australia MSY related reference points *"must take account of the stock productivity*";
- NZ requires MSY-based targets, and advocates a policy that avoids "fishing down". Low productivity is factored into rebuilding plans. Productivity is considered to be an operational substitute for resilience (HSS 2008) NZ recognises it has species (orange roughy and oreo dory) which are very low productivity and would take long times for stock recovery.
- In the US, low productivity of species is related to fish stock vulnerability and is recognised in the times taken for stock recovery;
- In the EU, for long lived stocks ICES bases its approach to make F equal or less than F_{MSY}.

Discussion

Nations are currently developing IBP in respect of low stock productivity. This involves the interpretation of low productivity levels, resilience and their relationship within developing stock recovery responses**.**

6d. Different trophic levels

- Australia – the HSP 2007 does not address trophic level criteria but this is part of the wider environmental considerations under EBFM and ERAs (HSP 2007).
- In NZ the HSS (2008) has no reference to trophic levels and minimal mention of ecological guidelines;
- The US address trophic levels issues in its ecosystem based approach to fisheries management (EBFM). The NMFS can encourage the Fishery Management Council to identify an "ecosystem component species" that is not considered to be in the fishery.

- ICES literature proposes that MSY is not necessarily a sign of a healthy ecosystem suggesting that bycatch of non-target species, impacts on biodiversity, the risk of truncated age structure and other alterations that may affect ecosystem functionality should be considered.

Discussion

IBP in the area of trophic levels, is part of ecosystem considerations in fisheries management, which crosses fishery and environmental responsibilities. The incorporation of trophic considerations into fishery policies differs between countries.

6e. Low value fisheries

- Australia – "*catches will remain precautionary with supporting fishery research at low levels, to better match the management costs to the business environment for that fishery*" (HSP 2007);
- The NZ HSS does not make any allowance for a different approach to 'low value' stocks, requiring all stocks to be managed under the QMS, with established TACs and quotas. Low value stocks are dealt with by referring to these as "nominal" stocks, with default low TACs, and no effort at formal assessment.
- The US does not appear to use the term low value fisheries. The FSSI does not record fisheries which have a catch less than 200,000 lbs (~ 91 tonnes) per annum.
- No references are found to low value fisheries in EU/ICES fishery policy documents.

Discussion

Low value fisheries do not appear to be significant issues internationally and are related to costs recovery policies within management systems rather than stock related considerations.

7. Application of risk based approaches

- Australia defines multiple fisheries assessment tiers, depending on the amount and type of information available to assess stock status (HSP 2007). These range from full assessments for Tier 1 species, to simple CPUE or catch trend analyses for Tier 3 or Tier 4 species. TACs that may be set become increasingly precautionary for lower tier assessments, directly addressing the risk associated with weaker assessments for low information species. In addition, MSE is used when appropriate.
- NZ does not have a formal risk assessment approach to fisheries assessments and does not have a formal process for a precautionary approach to lower information assessments. NZ does evaluate certainty and risk for full stock assessments and evaluates the status of the stock in relation to B_{MSY} or other agreed target levels. Full MSEs have been done for most rock lobster stocks.
- In the US "stocks with a B/B_{MSY} above 80% are considered to be within the range of natural fluctuation around B_{MSY}". Some use of MSE; and
- The EU uses ICES that has a range of risk based frameworks using MSE or equivalent models.

Discussion

The multi-tier risk based approach in the HSP is a significant policy approach to dealing with uncertainty in on ground fisheries management. The approaches to risk are less transparent in other countries, but this may be due to being applied in individual fishery management plans. The use of MSE as a tool is still seen as IBP, with other nations having forms of this approach. The Australian

approach of applying increasingly precautionary approaches to estimating RBCs and TACs represents IBP in this regard.

8 Reporting on stock status

A central HSP is a key part of IBP in fisheries management. Over the past decade government fisheries agencies in all the countries examined have become more aware of displaying information on the status of fish stocks in order to reassure the public that both policies and remedial strategies are in place to protect fish stocks from overfishing. While not part of the HSP, the annual reporting of the percentage of fish stocks that are "not overfished", or not "subject to over fishing" has become a gross measure of the effectiveness of fisheries management in the nations we examined.

Any assessment of IBP in stock status should include how the reports are produced and what they are communicating about sustainable stock status. The difficulties in comparing stock status reports internationally can be illustrated using the stock status information for each country in Section 3. In comparing overfishing data internationally the number of "stocks" sampled has to be considered.

Comparing stock status reporting we find:

- Australia chooses to include some species for which information is uncertain, so any international comparisons would have to account for these assumptions.
- In the NZ QMS, there are more than 600 stocks (multiple stocks per species), but the stock status reports on 127 of these stocks, from which 91% of the commercial harvest volume was from stocks above the soft limit (MAF 2011a).
- The US annual fish stock status reports provide an overview of stock status for the general public, as well as technical appendices on individual stock status details for 258 species of the 537 stocks and stock complexes under management, with 214 being assessed (NMFS 2012).
- In the EU /ICES system ICES compile stock status and management options advice and the EU compile stock status reports (IEC 2011d).

The reporting of stock status in such broad categories, as "not overfished", remains the main performance indicator of the effectiveness of national fisheries management through harvest strategies or other measures. International reporting must, however, be compatible with standards to meet international obligations, and to ensure that reporting of stock status is directly comparable with other countries. A commonly accepted international stock status ranking system would assist comparisons.

The pass/fail assessment in respect to over "overfishing" or a stock being "overfished", remains the core information required internationally and by the public from fishery management. It is not really a measure of best practice in HSP, but to communicate the sustainability of fisheries to the public. Ideally there would be more consistency between countries in this area enabling IBP comparisons of total stock status to be made.

4.2 Overview of international HSP and best practice

The results of the policy comparisons in this section are presented in Table 7a and b below. The comparisons in Table 7a are policies that apply to all stocks, whereas Table 7b has other policy issues that only apply to some fisheries (e.g. data poor fisheries, low value, low productivity, extent of multi species interactions, bycatch and extent of discards).

In Table 7a and b the HSP area is stated and the reference criteria that is used internationally is identified. The Australian HSP settings are displayed and can be compared with the column for IBP

and the final column showing minimal international standards, originating from both legal agreements and the practice in other countries as seen in this study.

IBP focuses on B_{MSY} as a biomass objective, with an increasing amount of evidence and published analysis advising that targets should be set above B_{MSY}, for a number of reasons (Sainsbury 2008).

Australia is unique in prioritising B_{MEY}, which is both a management objective and an economic objective, having a proxy of 1.2* B_{MSY}. Internationally B_{LIM} has been adopted as the "overfished" reference point, being measured as fraction of B_{MSY}. Below $B_{LIM,}$ the stock is consider to be overfished. Internationally, the attainment of B_{MSY} and keeping fish stock levels above the overfished threshold limit (B_{LIM}), represents IBP.

Table 7a: A summary table of the reference criteria, IBP and minimum international practice for the core HSP measures.

No.	HSP Area	Reference criteria	HSP settings	What is IBP?	Minimum International requirement
	Established policy areas				
1	Management objective	Biomass level, B	B_{MEY} (or 1.2 *B_{MSY} proxy)	B_{MEY} (1.2 *B_{MSY} proxy)	B_{MSY} (eg. LOSC)
1	Biomass Objective	Biomass level, B	B_{MSY}	B_{MSY}	towards B_{MSY} (eg. LOSC)
2a	Biomass Limit	Biomass level, B	B> B_{LIM} (1/2 B_{MSY} or B20)	B> B_{LIM} (1/2 B_{MSY} or B20)	B> B_{LIM} (eg. NZ 1/4 B_{MSY} or B_{10})
2a	Fishing target	Fishing mortality, F	F_{TARG}	F_{TARG} much < F_{LIM}	F_{TARG} < F_{LIM}
2a	Stock recognised as overfished	Biomass level, B	B< B_{LIM}	B< B_{LIM}	B< B_{LIM}
2b	Stock recognised as subject to overfishing	Fishing mortality, F	F> F_{MSY}	F> F_{MSY}	F> F_{MSY} (eg. UNFSA)
2c	Probability around controls	% probability of achieving targets	50% probability of reaching target	50% probability of reaching target	lower probabilities of reaching target, eg. 20%, 30%
2c	Probability around controls	% probability of avoiding limits	90% probability of avoiding limits	90% probability of avoiding limits	lower probabilities of avoiding limits, 50%-70%
3a	Stock rebuilding	Biomass level, B	B < B_{MSY}	B < B_{MSY}	B< B_{LIM}
3b	Threatened species/ closed fishery	A % of biomass level B	0.7 B_{LIM}	0.7 B_{LIM}	B< B_{LIM}
4	Economic objective	Biomass level, B	B_{MEY} (or 1.2 *B_{MSY} proxy)	B_{MEY} = 1.2 *B_{MSY}	B_{MSY} with economic and social considerations (eg. LOSC)

For overfishing, F>F_{MSY} is regarded internationally as a target limit, but not as a reference limit. Countries seek to keep control of F within a percentage probability of not being above F_{Lim}, with 50% being IBP. Australia pursues a 90% probability of avoiding being below B_{LIM} which may be a higher standard than other nations examined depending on how B_{LIM} is defined (i.e. a fraction of MSY etc).

There is no international consensus about if and when stock rebuilding plans should commence and over what time period recovery arrangements should be in place. Most harvest strategy approaches include a requirement for rebuilding plans when stocks move towards, or drop below, certain agreed limits (B_{MSY}, B_{LIM}). The US has formal legislated species recovery plans and appears to have one of the best records of stock recovery (Wakeford et al. 2009). Australia and other nations expect their remedial harvest strategies and stock plans to enable stock recovery, this approach being less formal than the US. The governance frameworks in each of the nations examined is a key part of the policy response to threatened and endangered species, recovery plans and bycatch. Most countries have endangered species legislation for marine species such as in the US where there are separate marine mammal or coral conservation acts. Australia has legislation protecting listed species under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC), which could be considered analogous to some of the prescriptive US approach.

Australia prioritises B_{MEY} as its economic objective which is IBP, as other nations generally have B_{MSY} taking account of social and economic considerations. Table 7b presents the reference criteria, HSP

reference points, IBP and minimum international standards for policy issues which may not impact all fisheries.

Table 7b: A summary table of the reference criteria, IBP and minimum international practice for the other developing HSP measures.

No.	HSP Area	Reference criteria	HSP reference point	What is IBP?	Minimum International requirement
	Other developing areas				
5a	Multi-species approaches	B for target and by catch species	$B_{MEY\ target}$ and B> B_{LIM} other species	$B_{MEY\ target}$ and B> B_{LIM} other species	$B_{MSY\ target}$ and B> B_{LIM} other species (eg. LOSC)
5b	Discards	Degree of impact	Minimum impact	Zero discards or deemed value system	Mimimum impact
6a	Data poor fisheries	Available information	Precaution	Use of several scientific proxies	Use of past average catch levels
6b	New or developing fisheries	Available information	Precaution	High degree of precaution, (F< or =F_{MSY} if known)	Precaution
6c	Differing levels of productivity	Numerical guides for species productivity and resilience	High or low	Recognise productivity differences; F< or =F_{MSY}	Recognise productivity differences
6d	Different Trophic levels	Developing	Developing	Recognition of trophic effects in setting target and limit reference points	Limited recognition of trophic effects in setting target and limit reference points
6e	Low value fisheries	Fishery viability	Fishery viability	Precautionary catches	Limited awareness of issue
7	Application of risk based approaches	A staged risk based approach	Multi-tier approach	Multi-tier approach	Basic assessment of risk
		A numerical assessment	MSE	MSE	Basic numerical assessment of risk
8	Stock Status information	Exploitation levels	No species overfished	No species overfished	Minimise overfished stocks

In Table 7b, we find that a wide range of stock management, multi-species fishery and environment issues are handled differently among nations, particularly target and non-target species, bycatch and discarding issues. Nations have focused on developing single species management and have gradually addressed monitoring of impacts such as bycatch in multi-species stocks, discarding of catch and the need to account for and minimise ecosystem impacts. Australia's HSP specifies B_{MSY} for target species biomass and monitors the levels of associated non-targeted species also. All of the nations examined suggest IBP on the ground for multispecies and ecosystem impacts measures are still being formed.

Discarding policy varies between countries, with zero discards and having a deemed value, or similar adjunct discard minimising system, being IBP. Data poor and newly discovered or developing fisheries require precaution and have to lean on the available information or past proxies such as average catches, which may be less precautionary than is desirable. Policy on stocks with high and low productivity recognises the characteristics of the fish species in the policies adopted. Similarly trophic effects are recognised in setting targets and limit reference points.

In the area of uncertainty and risk based approaches, the HSP has a strategic multi-tiered policy that makes risk management more apparent than in the other nations examined. The practice of management strategy evaluation (MSE) is still recognised internationally as being a significant component of Australia's contribution to IBP, but is information intensive and comes at a cost. Other nations have risk management frameworks and modelling approaches which seem to be less centralised than Australia's adoption of MSE.

Although not part of the HSP, each nation produces stock status reports and these become a crude measure of policy success. The number and extent of overfished stocks is the common international theme, though inter country comparisons may be misleading.

5 Overall discussion and conclusions

The development of Australia's harvest strategy policy (2007) was a policy step which gathered together a range of measures which influenced sustainable fisheries and their management. NZ formed their HSS arising from their quota management regime and its information requirement for TAC setting. The US have gradually put together many of the components of a HSP through a long time series of national standards on a range of fishery management and policy issues. The EU have benefitted from having the scientific expertise of ICES in promoting direction in harvest strategies, even if lacking fishery management success through the CFP (EU 2009). The current HSP document is a more centralised summary of national policy objectives than in other nations which generally have a less overarching harvest strategy policy framework.

This review of reference criteria used in other leading countries clarifies IBP and confirms Australia's HSP is a strong strategic policy approach. Australia's HSP has the core sustainability reference points at internationally comparable best practice standards and has addressed other less frequent issues (e.g. data poor, low value etc) at standards which are likely IBP. The original HSP (2007) included issues such as new and developing fisheries, managing stocks with low productivity and low value fisheries. There is generally less information on these areas internationally and this study has been conservative in interpreting a lack of available information as meaning Australia is automatically proposing IBP.

There may also be issues which other countries address and which the HSP (2007) does not include to the same degree. For example, the EU's inclusion of biodiversity and explicit trophic measures under the broader marine agency environmental approach of the Marine Strategy Framework Directive in Europe. It appears that the EU intend to address impacts on non-target species, bycatch, discards, stock structure and environmental impacts on trophic levels more fully in the next decade. Both the ICES, EU and MSC literature have significant awareness of trophic issues and their impacts. This has implications for the HSP, as trophic level considerations are an important environmental issue underpinning fishery management objectives and are not explicit in the HSP (2007).

The HSP may be limited in being only one part of Australia's approach to EBFM and not functionally integrated as part of Australia's EAF. Fuller reconciliation is required to enable the HSP to provide guidance when trying to address trophic levels or broader ecosystem criteria that are on the edge of its current environmental policy mandate. The relationship between environmental and fishery agencies is also important in the development of the HSP. In the Australian context the environmental management of fisheries includes several government departments and has been developing over the past 20 years. The Australian Fisheries Management Authority (AFMA) has a certain level of environmental responsibility associated with fishing operations, fisheries and their environment. The Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) are responsible for land and marine environment and the assessment of fisheries under the EPBC Act 1999. The Department of Agriculture Fisheries and Forestry are responsible for fisheries policy and associated advice to government.

The HSP was not seen as being part of Australia's international undertakings to implement an EAF, under the Convention for Biodiversity and FAO guidelines for responsible fisheries (HSP 2007). AFMA

has adopted EBFM as its overarching framework for Commonwealth fisheries management. EAF requires the setting of broader societal and ecosystem objectives, with associated reference points, performance measures and adaptive management. The current HSP does not explicitly address any of these more formal EAF approaches. The HSP does not implement an ecosystem approach, and does not attempt to be, nor constitute best practice in this regard, as stated in HSP (2007). The HSP and the ecosystem approach need to be assessed as the HSP looks to refine policy on some of these ecosystem and environment issues.

The HSP (2007) explains that "*The Ministerial Direction provides for further initiatives in support of EBFM, including reductions to bycatch, fishery independent monitoring, and increased focus on spatial management. Harvest strategies, in combination with this package of measures, constitute a whole of government approach to sustainable fisheries management". "Other processes are in place in Commonwealth fisheries management to help achieve broader ecosystem objectives, including undertaking comprehensive ecological risk assessments (ERA) accompanied by appropriate risk management responses"* (HSP 2007). The framework for policies on top of the HSP's responsibilities is held across several agencies and may limit the effectiveness of the HSP to address environmental issues if agency responsibilities overlap or are uncertain.

There are several areas that are emphasised overseas and could be considered in the Australian HSP.

- Stock recovery plans internationally were compared by Wakeford et al (2009) and conclude that "*Of the four regions studied*[23]*, the United States was the only country to have a legal framework within which clear guidelines are given to establish a recovery process within a pre-defined time period. Recovery is more effective when the recovery plan is part of a legal mandate, which is automatically triggered on reaching pre-defined limit reference points."* The Australian HSP is less formal on recovery plans than in the US, and the HSP could be revisited if assessments showed slow progress in stock recovery. Wakeford et al. (2007, 2009) also noted a lack of international consistency in when governments should implement recovery plans.
- There is a trend towards more quantitative measurement of the impacts on non-target species, the ecosystem and trophic structure of fish stocks, and are areas that have been highlighted by government environmental agencies internationally. In Europe, the CFP has struggled with controlling fishing mortality and the revisions to the CFP are being matched by the MSFD seeking to achieve good environmental status in marine environments, including more rigorous fish stock measures that have traditionally been problematic for the CFP process (EU 2009).
- The management of risk is also important and there are some differences between nations in this area of basic predictions of errors around B_{MSY} and $B_{LIM,}$ and cost implications in applying more advanced risk assessment approaches, such as MSE.
- The HSP may not currently include much of the information used in the existing EPBC fishery assessments to communicate the wider range of environmental achievement already in place in Australian fisheries. This fishery environment information produced for the EPBC assessment process could also be profiled and tabled as a measure of environmental fisheries status to support the HSP.
- It is desirable that all nations produce and report comparable information on stock status, environmental impacts, biodiversity and stock structure. The cost of additional fisheries and

[23] Australia, EU, US and NZ. Australian fisheries studied were in years prior to the HSP 2007.

environmental information for higher standards in the HSP is a cost recovery issue for Australian fisheries, whereas in the US and EU research is a government expense.

In reviewing and improving the HSP there will likely be cost implications for management to improve research and data collection. This information requirement is already an issue in NZ inshore fisheries where more science than can be cost-recovered would be required to assess stock status for all inshore stocks (pers. comm. Pamela Mace). Both NZ and Australian fisheries management have a cost recovery process for research, which means that additional management expenditure for recovery plans and research into additional information for more stock status information is likely sourced from industry. In contrast internationally, the level of stock status information and the frequency of updates of stock status information in the US is "*updated quarterly on the NOAA Office of Sustainable Fisheries web site*" (NMFS 2012) and the research cost are paid by government[24]. There are also economic issues arising from additional monitoring of non-target species and environmental impacts. Requirements relating to sustaining trophic stock structure of fish populations and ecosystem biodiversity have been included in the EU's MFSD policy and in the FAO eco-labelling guidelines. It is likely that information required in these two policy areas will increase the future costs of conforming to sustainability standards.

Legal and certification influences on IBP

This report has also examined the international legal requirements and non-binding commitments to manage marine resources. The minimum requirements were first set by the LOSC, which has established basic standards for marine resource management internationally. The subsequent UNFSA agreement goes into more specific detail of fishing mortality limitation and stock management,(UNSFA Annex II), which provides the first reference points for stock and mortality management at this level of international law. Government policy is not the only driver of harvest strategy development. The influence of LOSC and UNFSA is mixed in that they *"consider F_{MSY} to be both a target and limit reference point"*[25]. When F_{MSY} is a target level of fishing mortality, it has more sense than as a limit reference point, which implicitly means the exploitation rate should instantly reduce.

There are then a range of non binding "soft law" international documents, such as the FAO Code of Conduct, which set further benchmarks and provide implementation guidelines for marine resource management practice. These widen the scope of sustainable resource management to include non-target species, ecosystems and environmental concerns. Concerns for non-target species and the environment appear in more detail in the FAO eco-labelling guidelines.

The international developments in harvest strategy standards have been guided by UNFSA and the FAO Code of Conduct and FAO Guidelines for eco-labelling. The influence of the certification process in implementing accepted LOSC and UNFSA measures is seen in *"The tuna RFMOs have previously worked with F_{MSY}, but are starting to see the need for B_{LIM} points, largely as a result of the MSC certification process"*[26]. The MSC certification system has developed to apply more scientific reference points to their assessment framework, and is gradually developing from a pass/fail assessment basis into recognising graded levels of IBP.

[24] Pers comm. Dale Squires and Sam Herrick, NMFS.
[25] pers. comm. D. Agnew. This point is made by other stock assessment reports also.
[26] Pers. comm. D. Agnew MSC.

In the five years since the Australian HSP was implemented, there have been developments in IBP in NZ, the US and the EU. Australia's key reference criteria and standards are sound by international standards, but their effectiveness needs to be supported by a well communicated stock status profile showing no overfished stocks.

Conclusions

Australia took an internationally significant step in producing the first fisheries HSP in 2007. Only NZ has a similar harvest strategy standard document, while the US has had a series of national standards to guide fishery management councils in their management system.

This study examined both the duties arising from international legal instruments and the current policies in place in several countries overseas with a reputation for good fishery management as sources of IBP. The study confirmed that Australia follows the obligations arising from international legal fishery instruments. In determining IBP in the core management, biological and economic objectives, the Australian HSP is well represented.

This study focuses on international developments in policy issues which generally impact some fisheries (e.g. multi-species, discarding, low value, data poor and low productivity). For these measures stocks are less likely to have a commonly agreed IBP, as they are less numerous and may be less suited to a national reference point approach primarily designed to indicate core sustainable fishing objectives. International law gives general guidance on objectives and has become more specific through time. Guidelines have developed in documents such as the FAO's Code of Conduct and the UNFSA which uses Annex conditions be more specific on details.

Possible areas where practices observed overseas could influence Australia, are in increasing the effectiveness of stock recovery plans, continued improvement and cost effectiveness of risk assessment, continuous improvement of stock status reporting and some environmental and ecosystem areas, such as trophic levels.

Within Australian fisheries there is a multi-agency approach to fishery and marine environment issues. The HSP is not part of an EBFM framework and this may limit the scope of the HSP. The HSP may benefit from using the current information provided by fisheries for the EPBC assessment process to address some of the emerging trophic level requirements in ecosystem based fisheries management approaches. Overseas experience indicates a need to adjust institutional delivery and agency responsibilities in addressing more integrated ecosystem and marine environmental policy.

The last five years have seen improvements in the role of NGO certification organisations, with the MSC gradually providing accreditation to higher scored standards above the apparent pass/fail approval level. The MSC certification process represents both a policy standard and a fishery specific assessment process. In the future the HSP should be able to support its HSP standards with evidence of fishery performance as seen in stock status measures.

The comparisons of the HSP with IBP indicate the HSP is a strong strategic policy approach and still meets IBP for objectives, overfishing and overfished reference points. Other reference points are developing with IBP in areas such as new and developing fisheries, low productivity and low value fisheries. International trends suggest there will need to be a greater emphasis on the marine ecosystem biodiversity and environment. Further progress in HSP environmental areas may require some clarity in the role of the HSP in Australia's whole of government approach to the ecosystem assessment of fisheries.

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Appendix 1: UNFSA- ANNEX II: Guidelines for the Application of Precautionary Reference Points In Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks.

1. A precautionary reference point is an estimated value derived through an agreed scientific procedure, which corresponds to the state of the resource and of the fishery, and which can be used as a guide for fisheries management.

2. Two types of precautionary reference points should be used: conservation, or limit, reference points and management, or target, reference points. Limit reference points set boundaries which are intended to constrain harvesting within safe biological limits within which the stocks can produce maximum sustainable yield. Target reference points are intended to meet management objectives.

3. Precautionary reference points should be stock-specific to account, *inter alia*, for the reproductive capacity, the resilience of each stock and the characteristics of fisheries exploiting the stock, as well as other sources of mortality and major sources of uncertainty.

4. Management strategies shall seek to maintain or restore populations of harvested stocks, and where necessary associated or dependent species, at levels consistent with previously agreed precautionary reference points. Such reference points shall be used to trigger pre-agreed conservation and management action. Management strategies shall include measures which can be implemented when precautionary reference points are approached.

5. Fishery management strategies shall ensure that the risk of exceeding limit reference points is very low. If a stock falls below a limit reference point or is at risk of falling below such a reference point, conservation and management action should be initiated to facilitate stock recovery. Fishery management strategies shall ensure that target reference points are not exceeded on average.

6. When information for determining reference points for a fishery is poor or absent, provisional reference points shall be set. Provisional reference points may be established by analogy to similar and better-known stocks. In such situations, the fishery shall be subject to enhanced monitoring so as to enable revision of provisional reference points as improved information becomes available.

7. The fishing mortality rate which generates maximum sustainable yield should be regarded as a minimum standard for limit reference points. For stocks which are not overfished, fishery management strategies shall ensure that fishing mortality does not exceed that which corresponds to maximum sustainable yield, and that the biomass does not fall below a predefined threshold. For overfished stocks, the biomass which would produce maximum sustainable yield can serve as a rebuilding target.

Appendix 2: MSC Fishery Standard Principles and Criteria for Sustainable Fishing (MSC 2010)

PRINCIPLE 1

A fishery must be conducted in a manner that does not lead to over-fishing or depletion of the exploited populations and, for those populations that are depleted, the fishery must be conducted in a manner that demonstrably leads to their recovery

Intent:

The intent of this principle is to ensure that the productive capacities of resources are maintained at high levels and are not sacrificed in favour of short term interests. Thus, exploited populations would be maintained at high levels of abundance designed to retain their productivity, provide margins of safety for error and uncertainty, and restore and retain their capacities for yields over the long term.

Criteria:

1. The fishery shall be conducted at catch levels that continually maintain the high productivity of the target population(s) and associated ecological community relative to its potential productivity.

2. Where the exploited populations are depleted, the fishery will be executed such that recovery and rebuilding is allowed to occur to a specified level consistent with the precautionary approach and the ability of the populations to produce long-term potential yields within a specified time frame.

3. Fishing is conducted in a manner that does not alter the age or genetic structure or sex composition to a degree that impairs reproductive capacity.

PRINCIPLE 2:

Fishing operations should allow for the maintenance of the structure, productivity, function and diversity of the ecosystem (including habitat and associated dependent and ecologically related species) on which the fishery depends.

Intent:

The intent of this principle is to encourage the management of fisheries from an ecosystem perspective under a system designed to assess and restrain the impacts of the fishery on the ecosystem.

Criteria:

1.The fishery is conducted in a way that maintains natural functional relationships among species and should not lead to trophic cascades or ecosystem state changes.

2. The fishery is conducted in a manner that does not threaten biological diversity at the genetic, species or population levels and avoids or minimises mortality of, or injuries to endangered, threatened or protected species.

3. Where exploited populations are depleted, the fishery will be executed such that recovery and rebuilding is allowed to occur to a specified level within specified time frames, consistent with the precautionary approach and considering the ability of the population to produce long-term potential yields.

PRINCIPLE 3:

The fishery is subject to an effective management system that respects local, national and international laws and standards and incorporates institutional and operational frameworks that require use of the resource to be responsible and sustainable.

Intent:

The intent of this principle is to ensure that there is an institutional and operational framework for implementing Principles 1 and 2, appropriate to the size and scale of the fishery.

A. Management System Criteria:

1. The fishery shall not be conducted under a controversial unilateral exemption to an international agreement.

The management system shall:

2. demonstrate clear long-term objectives consistent with MSC Principles and Criteria and contain a consultative process that is transparent and involves all interested and affected parties so as to consider all relevant information, including local knowledge. The impact of fishery management decisions on all those who depend on the fishery for their livelihoods, including, but not confined to subsistence, artisanal, and fishing-dependent communities shall be addressed as part of this process;

3. be appropriate to the cultural context, scale and intensity of the fishery – reflecting specific objectives, incorporating operational criteria, containing procedures for implementation and a process for monitoring and evaluating performance and acting on findings;

4. observe the legal and customary rights and long term interests of people dependent on fishing for food and livelihood, in a manner consistent with ecological sustainability;

5. incorporates an appropriate mechanism for the resolution of disputes arising within the system3;

6. provide economic and social incentives that contribute to sustainable fishing and shall not operate with subsidies that contribute to unsustainable fishing;

7. act in a timely and adaptive fashion on the basis of the best available information using a precautionary approach particularly when dealing with scientific uncertainty;

8. incorporate a research plan – appropriate to the scale and intensity of the fishery – that addresses the information needs of management and provides for the dissemination of research results to all interested parties in a timely fashion;

9. require that assessments of the biological status of the resource and impacts of the fishery have been and are periodically conducted;

10. specify measures and strategies that demonstrably control the degree of exploitation of the resource, including, but not limited to:

a) setting catch levels that will maintain the target population and ecological community's high productivity relative to its potential productivity, and account for the non-target species (or size, age, sex) captured and landed in association with, or as a consequence of, fishing for target species;

b) identifying appropriate fishing methods that minimise adverse impacts on habitat, especially in critical or sensitive zones such as spawning and nursery areas;

c) providing for the recovery and rebuilding of depleted fish populations to specified levels within specified time frames;

d) mechanisms in place to limit or close fisheries when designated catch limits are reached;

e) establishing no-take zones where appropriate;

11. contains appropriate procedures for effective compliance, monitoring, control, surveillance and enforcement which ensure that established limits to exploitation are not exceeded and specifies corrective actions to be taken in the event that they are.

B. Operational Criteria

Fishing operation shall:

12. make use of fishing gear and practices designed to avoid the capture of non-target species (and non-target size, age, and/or sex of the target species); minimise mortality of this catch where it cannot be avoided, and reduce discards of what cannot be released alive;

13. implement appropriate fishing methods designed to minimise adverse impacts on habitat, especially in critical or sensitive zones such as spawning and nursery areas;

14. not use destructive fishing practices such as fishing with poisons or explosives;

15. minimise operational waste such as lost fishing gear, oil spills, on-board spoilage of catch, etc.;

16. be conducted in compliance with the fishery management system and all legal and administrative requirements; and

17. assist and co-operate with management authorities in the collection of catch, discard, and other information of importance to effective management of the resources and the fishery.

Appendix 3: United States- National Standard 9; Bycatch.

(a) Standard 9. Conservation and management measures shall, to the extent practicable:

(1) Minimize bycatch; and

(2) To the extent bycatch cannot be avoided, minimize the mortality of such bycatch.

(b) General. This national standard requires Councils to consider the bycatch effects of existing and planned conservation and management measures. Bycatch can, in two ways, impede efforts to protect marine ecosystems and achieve sustainable fisheries and the full benefits they can provide to the Nation. First, bycatch can increase substantially the uncertainty concerning total fishing-related mortality, which makes it more difficult to assess the status of stocks, to set the appropriate OY and define overfishing levels, and to ensure that OYs are attained and overfishing levels are not exceeded. Second, bycatch may also preclude other more productive uses of fishery resources.

(c) Definition—Bycatch. The term "bycatch" means fish that are harvested in a fishery, but that are not sold or kept for personal use.

(1) Inclusions. Bycatch includes the discard of whole fish at sea or elsewhere, including economic discards and regulatory discards, and fishing mortality due to an encounter with fishing gear that does not result in capture of fish (i.e., unobserved fishing mortality).

(2) Exclusions. Bycatch excludes the following:

(i) Fish that legally are retained in a fishery and kept for personal, tribal, or cultural use, or that enter commerce through sale, barter, or trade.

(ii) Fish released alive under a recreational catch-and-release fishery management program. A catch-and-release fishery management program is one in which the retention of a particular species is prohibited. In such a program, those fish released alive would not be considered bycatch.

(iii) Fish harvested in a commercial fishery managed by the Secretary under Magnuson-Stevens Act sec. 304(g) or the Atlantic Tunas Convention Act of 1975 (16 U.S.C. 971d) or highly migratory species harvested in a commercial fishery managed by a Council under the Magnuson-Stevens Act or the Western and Central Pacific Fisheries Convention Implementation Act, that are not regulatory discards and that are tagged and released alive under a scientific tagging and release program established by the Secretary.

(d) Minimizing bycatch and bycatch mortality. The priority under this standard is first to avoid catching bycatch species where practicable. Fish that are bycatch and cannot be avoided must, to the extent practicable, be returned to the sea alive. Any proposed conservation and management measure that does not give priority to avoiding the capture of bycatch species must be supported by appropriate analyses. In their evaluation, the Councils must consider the net benefits to the Nation, which include, but are not limited to: Negative impacts on affected stocks; incomes accruing to participants in directed fisheries in both the short and long term; incomes accruing to participants in fisheries that target the bycatch species; environmental consequences; non-market values of bycatch species, which include non-consumptive uses of bycatch species and existence values, as well as recreational values; and impacts on other marine organisms. To evaluate conservation and management measures relative to this and other national standards, as well as to evaluate total fishing mortality, Councils must—

(1) Promote development of a database on bycatch and bycatch mortality in the fishery to the extent practicable. A review and, where necessary, improvement of data collection methods, data sources, and applications of data must be initiated for each fishery to determine the amount, type, disposition, and other characteristics of bycatch and bycatch mortality in each fishery for purposes of this standard and of section 303(a)(11) and (12) of the Magnuson-Stevens Act. Bycatch should be categorized to focus on management responses necessary to minimize bycatch and bycatch mortality to the extent practicable. When appropriate, management measures, such as at-sea monitoring programs, should be developed to meet these information needs.

(2) For each management measure, assess the effects on the amount and type of bycatch and bycatch mortality in the fishery. Most conservation and management measures can affect the amounts of bycatch or bycatch mortality in a fishery, as well as the extent to which further reductions in bycatch are practicable. In analysing measures, including the status quo, Councils should assess the impacts of minimizing bycatch and bycatch mortality, as well as consistency of the selected measure with other national standards and applicable laws. The benefits of minimizing bycatch to the extent practicable should be identified and an assessment of the impact of the selected measure on bycatch and bycatch mortality provided. Due to limitations on the information available, fishery managers may not be able to generate precise estimates of bycatch and bycatch mortality or other effects for each alternative. In the absence of quantitative estimates of the impacts of each alternative, Councils may use qualitative measures. Information on the amount and type of bycatch should be summarized in the SAFE reports.

(3) Select measures that, to the extent practicable, will minimize bycatch and bycatch mortality.

(i) A determination of whether a conservation and management measure minimizes bycatch or bycatch mortality to the extent practicable, consistent with other national standards and maximization of net benefits to the Nation, should consider the following factors:

(A) Population effects for the bycatch species.

(B) Ecological effects due to changes in the bycatch of that species (effects on other species in the ecosystem).

(C) Changes in the bycatch of other species of fish and the resulting population and ecosystem effects.

(D) Effects on marine mammals and birds.

(E) Changes in fishing, processing, disposal, and marketing costs.

(F) Changes in fishing practices and behaviour of fishermen.

(G) Changes in research, administration, and enforcement costs and management effectiveness.

(H) Changes in the economic, social, or cultural value of fishing activities and non-consumptive uses of fishery resources.

(I) Changes in the distribution of benefits and costs.

(J) Social effects.

(ii) The Councils should adhere to the precautionary approach found in the Food and Agriculture Organization of the United Nations (FAO) Code of Conduct for Responsible Fisheries (Article 6.5), which is available from the Director, Publications Division, FAO, Via delle Terme di Caracalla, 00100

Rome, Italy, when faced with uncertainty concerning any of the factors listed in this paragraph (d)(3).

(4) Monitor selected management measures. Effects of implemented measures should be evaluated routinely. Monitoring systems should be established prior to fishing under the selected management measures. Where applicable, plans should be developed and coordinated with industry and other concerned organizations to identify opportunities for cooperative data collection, coordination of data management for cost efficiency, and avoidance of duplicative effort.

(e) Other considerations. Other applicable laws, such as the MMPA, the ESA, and the Migratory Bird Treaty Act, require that Councils consider the impact of conservation and management measures on living marine resources other than fish; i.e., marine mammals and birds. [63 FR 24235, May 1, 1998, as amended at 73 FR 67811, Nov. 17, 2008]

Appendix 4: Stock rebuilding plans: example of Bluenose in NZ.

The NZ HSS requires formal, time-constrained rebuilding plans to be developed for any stock assessed as having declined below the established or default proxy soft limit reference point for the stock. For example, recent stock status reports have highlighted that bluenose (known as blue eye trevalla in Australia) requires rebuilding.

Box 11: Rebuilding bluenose (MPI, 2012) (known as blue eye trevalla in Australia)

The stock status report confirmed previous evaluations. MPI considered:

"*The combined TACs for the bluenose QMAs are considered to be unsustainable. When assessed as a single biological stock, current bluenose stock size ($B_{CURRENT}$) is below the target (40% B_0[27]) and as likely as not to be below the soft limit (20% B_0)*".

Rebuilding Plan

"…According to the HSS, where a stock size is below the soft limit, a formal time-constrained rebuilding plan is required. The Draft Operational Guidelines for New Zealand's B_0 is the virgin biomass; the average biomass of the stock in the years before fishing started".

"As likely as not" means there is a 40 to 60% probability of the stock being below the soft limit. Current stock size has been estimated at 14-27% B_0 the HSS default soft limit for bluenose.

The HSS guidelines set out the recommended timeframe for such rebuilding plans. This is expressed relative to the time that it would take the stock to return to the target level in the absence of fishing (T_{MIN}). The HSS Guidelines suggest the plan should allow stocks to be rebuilt to the target level between T_{MIN} and $2xT_{MIN}$.

In 2011, the Minister of Fisheries and Aquaculture agreed to a plan aimed at rebuilding bluenose stocks to the target within $2xT_{MIN}$ (20-26 years). This involved a three-year phased reduction to catch limits. The first stage has already been carried out, with reductions to TACs, TACCs, some allowances and recreational bag limits, and increases to deemed values to incentivise fishers to balance catch with annual catch entitlement. However, separate decisions are required in regard to catch limits for 2012 (and again in 2013, if relevant). "*A range of options are available based on different ways and rates to promote a rebuild of bluenose stocks. The different approaches give rise to different sustainability risks and different levels of socio-economic impacts*".

The options were:

"Option1

Retain the combined TAC of 1685t. At this TAC, the stocks are not projected to rebuild to 40% B_0 within $2xT_{MIN}$. Therefore, MPI considers further reductions will be required in 2013. But, this option allows for more information to be gathered that might support an alternative management approach. It also reduces short-term economic impacts and gives fishers more time to adjust to lower catch limits.

Option 2

Reduce the combined TAC to 1194 tonnes in 2012/13, as the second of three staged reductions. The third reduction to the combined TAC is planned to be to 704 tonnes (from 1194 tonnes) in 2013/14. This would require separate consideration by the Minister based on information available at that time. At this TAC, the stock assessment projects that bluenose stocks will rebuild to 40% B0 in 15-29

[27] B_0 is the biomass or stock level associated with an unfished fishery.

years, which is within 2xT_{MIN}. It mitigates short-term socio-economic impacts by giving fishers time to adjust to lower catch limits.

Option 3

Reduce the combined TAC in one step – to 704 tonnes (i.e. the target TAC for 2013/14 under Option 2, but one year earlier). Projections are not available in regard to the rebuild rate at this TAC. However, it will likely be faster than under Option 2 and within 2xT_{MIN}. This option has the highest short-term socio-economic costs and it does not allow further time for fishers to adjust to lower catch limits."

The socio-economic impacts of each of the options were part of the review paper.

Conclusion

In July the MPI 2012 review of sustainability and other control measures for bluenose was issued after consultation in June 2012.

***"** MPI's preferred option is currently Option 2; to proceed with the planned second step of the three-year phased reduction on catch limits that was begun in 2011. MPI considers the phased reduction provides a balance between ensuring stocks rebuild (within 2 x T_{MIN}) and mitigating the impacts on the commercial fishing industry by allowing time to adjust to reduced catch levels"*.

Stakeholders are considering alternative reductions to propose to the ongoing consultation process.

Appendix 5: Glossary of Terms (adapted from HSP 2007)

ABARE: Australian Bureau of Agricultural and Resource Economics and Science

AFMA: Australian Fisheries Management Authority.

(B) - Biomass: total weight of a stock or of a component of a stock; for example, the weight of spawning stock biomass is the combined weight of mature animals.

(B_{LIM}) - Biomass limit reference point: the point beyond which the risk to the stock is regarded as unacceptably high.

(B_{MEY}) - Biomass at maximum economic yield: average biomass corresponding to maximum economic yield as estimated from the assessment model applied.

(B_{MSY}) - Biomass at maximum sustainable yield: average biomass corresponding to maximum sustainable yield.

(B_{OY}) Biomass at optimum yield (United States)- The amount of fish that: (1) will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems; (2) is prescribed on the basis of the MSY from the fishery, as reduced by any relevant economic, social, or ecological factors; (3) in the case of an overfished fishery, provides for rebuilding to a level consistent with producing the MSY in such fishery.

(B_{TARG}) - Target biomass: the desired condition of the stock.

(B_0) - **Mean equilibrium unfished biomass:** average biomass level if fishing had not occurred. Sometimes the pre-exploitation level is used as a proxy.

Bycatch: species taken incidentally in a fishery where other species are the target, and which are always discarded.

Byproduct: species taken incidentally in a fishery that have some commercial value and are retained for sale.

Control rules: (also referred to as harvest control rules and decision rules) agreed responses that management must make under pre-defined circumstances regarding stock status.

DAFF: Department of Agriculture, Fisheries and Forestry.

EAF: Ecosystem assessment of fisheries

EBFM: Ecosystem based fisheries management.

EPBC Act: Environment Protection and Biodiversity Conservation Act 1999.

Fish down: a fish stock that has not been heavily fished may have a large number of older fish. When such stocks are fished, catches are highest at first, but the rate cannot be sustained once the abundance of older fish has been reduced. Removing the older fish in this way is termed fish down [note: it could also be defined as the period of fishing from B_0 to when B_{TARG} is reached].

FMA: Fisheries Administration Act 1991.

(F) - Fishing mortality: the instantaneous rate of deaths of fish due to fishing a designated component of the fish stock. F reference points may be applied to entire stocks or segments of the stocks and should match the scale of management unit.

(F_{LIM}) - Fishing mortality limit reference point: the point above which the removal rate from the stock is too high.

(F_{MEY}) - Fishing mortality at maximum economic yield: fishing mortality rate which corresponds to the maximum economic yield.

(F_{MSY}) - Fishing mortality at maximum sustainable yield: fishing mortality rate which achieves the maximum sustainable yield as estimated by the assessment model applied. Note: F_{MSY} is generally

greater than F_{MEY}.

(F_{TARG}) - Fishing mortality: the target fishing mortality rate.

FAO: Food and Agriculture Organization: of the United Nations.

Input controls: indirect restraints placed by management to reduce amount of fish caught; for example, gear restrictions and closed seasons.

Keystone species: an organism that has a greater role in maintaining ecosystem function than would be predicted based on its abundance.

Key commercial species: a species that is, or has been, specifically targeted and is, or has been, a significant component of a fishery.

Management Strategy Evaluation (MSE): a procedure whereby alternative management strategies are tested and compared using simulations of stock and fishery dynamics.

Maximum Economic Yield ($_{MEY}$): The sustainable catch or effort level for a commercial fishery that allows net economic returns to be maximised. Note that for most practical discount rates and fishing costs $_{MEY}$ will imply that the equilibrium stock of fish is larger than that associated with $_{MSY}$. In this sense $_{MEY}$ is more environmentally conservative than $_{MSY}$ and should in principle help protect the fishery from unfavourable environmental impacts that may diminish the fish population.

Maximum Sustainable Yield ($_{MSY}$): the maximum average annual catch that can be removed from a stock over an indefinite period under prevailing environmental conditions.

OY - Optimum Yield (United States)- The amount of fish that: (1) will provide the greatest overall benefit to the Nation, particularly with respect to food production and recreational opportunities, and taking into account the protection of marine ecosystems; (2) is prescribed on the basis of the MSY from the fishery, as reduced by any relevant economic, social, or ecological factors; (3) in the case of an overfished fishery, provides for rebuilding to a level consistent with producing the MSY in such fishery.

Output Controls: management measures directly limiting fish catch or landings (for example by quota).

Overfished: a fish stock with a biomass below the biomass limit reference point.

Overfishing: A stock is experiencing too much fishing and the removal rate from the stock is unsustainable.

• Fishing mortality (F) exceeds the limit reference point (F_{LIM}). When stock levels are at, or above, B_{MSY}, F_{MSY} will be the default level for F_{LIM}.

• Fishing mortality in excess of F_{LIM} will not be defined as overfishing if a formal 'fish down' or similar strategy is in place for a stock and the stock remains above the target level (B_{TARG}).

• When the stock is less than B_{MSY} but greater than B_{LIM}, F_{LIM} will decrease in proportion to the level of biomass relative to B_{MSY}.

• At these stock levels, fishing mortality in excess of the target reference point (F_{TARG}) but less than F_{LIM} may also be defined as overfishing depending on the harvest strategy in place and/or recent trends in biomass levels.

• Any fishing mortality will be defined as overfishing if the stock level is below B_{LIM}, unless fishing mortality is below the level that will allow the stock to recover within a period of 10 years plus one mean generation time, or three times the mean generation time, whichever is less.

Precautionary approach: (not to be confused with what is also sometimes referred to as the precautionary principle) where there are threats of serious irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary approach, public and private decisions should be guided by (i) careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment and (ii) an assessment of the risk-weighted consequences of various options.

RBC: Recommended biological catch: The total mortality from fishing by all sources – derived from application of the harvest control rule.

Reference point: an indicator of the level of fishing (or stock size), used as a benchmark for interpreting the results of an assessment.

SSB: Spawning stock biomass

Stock: a functionally discrete population of a species that is largely distinct from other populations of the same species. Such a population may be regarded as a separate entity for management or assessment purposes. Some species form a single stock (e.g. southern bluefin tuna), while others form several stocks (e.g. albacore tuna in the Pacific Ocean are divided into separate northern Pacific and southern Pacific stocks).

Stock recovery plan: a formal management process put in place under the EPBC Act to rebuild a stock when the measure of its status (e.g. its biomass) is substantially below the biomass limit point (B_{LIM}, i.e. it is assessed as overfished). Stock recovery plans should include elements that define rebuilding targets, rebuilding time horizons and control rules related to the rate of progress.

Stock rebuilding strategy: a management process developed by AFMA to rebuild a stock to the target biomass reference point (B_{TARG}) when the measure of its status is at or is below the biomass limit point (B_{LIM}). The strategy is required to be approved by AFMA and the Minister for the Environment and Water Resources.

Sustainable Yield: the average catch that can be removed from a stock over an indefinite period without causing a further reduction in the biomass of the stock. This could be either a constant yield from year to year, or a yield that fluctuates in response to changes in abundance.

TAC: total allowable catch.

TAE: total allowable effort.

Targeting: fishing selectively for particular species or sizes of fish.

Target species: see key commercial species.

United Nations Fish Stocks Agreement: The Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, 1995.