National Guidelines to Develop Fishery Harvest Strategies

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Lianos Triantafillos, Brian Jeffriess and Nathan Kimber.

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March 2014

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In its simplest form, a harvest strategy provides a framework to ensure that fishery managers, fishers and key stakeholders think about, and document, how they will respond to various fishery conditions (desirable or undesirable), before they occur.

The national harvest strategy guidelines project developed the following formal definition for a harvest strategy:

"A harvest strategy is a framework that specifies the pre-determined management actions in a fishery for defined species (at the stock or management unit level) necessary to achieve the agreed ecological, economic and/or social management objectives".

This definition should be read in conjunction with the 'key elements of a harvest strategy', outlined in section 5.2 of the national harvest strategy guidelines.

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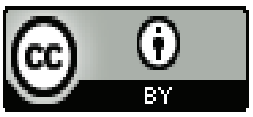

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ABBREVIATIONS

ABARES	Australian Bureau of Agriculture and Resource Economics and Sciences
ABS	Australian Bureau of Statistics
AFMA	Australian Fisheries Management Authority
AFMF	Australian Fisheries Management Forum
ASBTIA	Australian Southern Bluefin Tuna Industry Association
CPUE	Catch Per Unit Effort
CSIRO	Commonwealth Scientific Industry Research Organization
DOA	Australian Government Department of Agriculture
DOE	Australian Government Department of the Environment
EBFM	Ecosystem Based Fisheries Management
EEZ	Exclusive Economic Zone
ESD	Ecologically Sustainable Development
FAO	Food and Agriculture Organization of the United Nations
FRDC	Fisheries Research and Development Corporation
GVP	Gross Value of Production
ITQ	Individually Transferable Quota
MPA	Marine Protected Area
MEY	Maximum Economic Yield
MSY	Maximum Sustainable Yield
PIRSA	Department of Primary Industries and Regions, South Australia
TAC	Total Allowable Catch
TACC	Total Allowable Commercial Catch
TEPS	Threatened, Endangered and Protected Species
UTAS	University of Tasmania

1. EXECUTIVE SUMMARY

Harvest strategies offer an effective fisheries management tool to integrate the ecological, social and economic dimensions of fisheries management into a single framework for fisheries management decision making. As evidenced by their wide use internationally and throughout Australian fisheries management jurisdictions, harvest strategies represent a best-practice approach to fisheries management decision making (FAO 2011; Smith et al. 2013; McIlgorm 2013).

The objectives for this project were to:

1. Undertake a review and analysis of the present situation of harvest strategies in Commonwealth and State-managed fisheries.
2. Develop a common definition for nationally consistent harvest strategies.
3. Develop an agreed set of over-arching principles for Harvest Strategies across Australia

The National Guidelines to Develop Fishery Harvest Strategies (the National Guidelines), outlined in this report, provide a national framework to support a consistent and more harmonised approach to harvest strategy development across Australian fisheries jurisdictions.

The National Guidelines aim to provide practical technical assistance to all government fisheries management agencies in Australia (State, Territory and Commonwealth) to develop fishery-specific harvest strategies and to facilitate a consistent and more harmonised approach across fisheries throughout Australia. The National Guidelines aim to help inform policy makers involved in the development of over-arching harvest strategy policies and assist in ensuring a national best-practice approach to the development of such policies. A national approach to harvest strategy development will enable common challenges to be addressed in a consistent and coordinated manner, thereby avoiding unnecessary duplication of effort and resources, and ensuring more targeted investment in ways to address common challenges.

A working group was established to develop the National Guidelines, including a national cross section of fisheries management, policy, science and fishing industry expertise presently involved in harvest strategy development in Australia. A national technical stakeholder workshop was held in the early phase of the project to shape the approach to development of the National Guidelines.

A national qualitative audit was undertaken to evaluate the extent to which harvest strategies are being applied across Australian fisheries management jurisdictions. This audit identified that whilst harvest strategies are used widely in Australian fisheries their application is highly inconsistent, as is the use of terminology and language. The audit identified a need to more adequately integrate the economic and social aspects of fisheries management into harvest strategy development (particularly in relation to the use of social and economic performance indicators, target reference points and decision rules) to promote management of fisheries to broader ESD standards.

The project identified that a harvest strategy brings together all of the key scientific monitoring, assessment and management elements used to make decisions about the intensity of fishing activity to be applied, or catch to be removed from, a fish stock or fisheries management unit. When all of these components are brought together to form an integrated package, they create a formal harvest strategy. The following harvest strategy components have been developed to form the National Guidelines:

- A national harvest strategy definition;
- A description of the key elements of a harvest strategy;
- A set of harvest strategy design principles;
- A harvest strategy design process (the key steps to be followed); and

- Considerations for specific fishery scenarios.

In its simplest form, a harvest strategy provides a framework to ensure that fishery managers, fishers and key stakeholders think about, and document, how they will respond to various fishery conditions (desirable or undesirable), before they occur. Through a national technical workshop and follow up consultation with all jurisdictions the following national harvest strategy definition was developed:

"A harvest strategy is a framework that specifies the pre-determined management actions in a fishery for defined species (at the stock or management unit level) necessary to achieve the agreed ecological, economic and/or social management objectives".

This definition should be read in conjunction with the 'key elements of a harvest strategy', outlined in section 5.2 of the guidelines.

The National Guidelines identify the following key elements of a harvest strategy:

- Defined operational objectives for the fishery;
- Indicators of fishery performance related to the objectives;
- Reference points for performance indicators;
- A statement defining acceptable levels of risk to meeting objectives;
- A monitoring strategy to collect relevant data to assess fishery performance;
- A process for conducting assessment of fishery performance relative to objectives; and
- Decision rules that control the intensity of fishing activity and/or catch.

As the definition implies, a harvest strategy is designed to provide a formal and structured decision making framework, to ensure that key fisheries management objectives are effectively achieved. Importantly, the National Guidelines identify that harvest strategies do not need to be overly complex processes that require significant resources and complicated mathematical models to be successful, as is commonly perceived. A range of practical and cost-effective ways exist to apply harvest strategies to a broad cross section of fisheries, including data-poor fisheries with limited information. It is important, however, that harvest strategies of all types are tested for their robustness prior to implementation.

In an ideal setting, the mechanisms for fishery management decision making, at the individual fishery level (including harvest strategy frameworks), should be contained within a fishery management plan or other similarly structured documents that provide a high level of certainty and accountability for stakeholders. In this sense, a harvest strategy is considered to provide the 'nuts and bolts' of a fishery management plan and should form the basis of the adaptive management cycle. However, it is important to note that a harvest strategy must be reviewed periodically to take account of new information and to this end a degree of flexibility should be factored in. This does not imply that reviews should automatically take place when decision rules trigger difficult management actions in a fishery, such as catch or effort reductions, but rather that a process of continuous improvement should be adopted.

The National Guidelines recognise that 'one size does not fit all' and a tailored approach to harvest strategy development is required to meet individual fishery circumstances. To help support the development of tailored, fishery-specific harvest strategies across the full range of fisheries, including input- and output-managed fisheries, large and small-scale fisheries and in data-rich to data-poor situations, the key issues to be considered in different fishery scenarios have been documented. The National Guidelines also identify the design principles and processes that should be applied when developing a fishery-specific harvest strategy.

The National Guidelines identify the following key principles to be applied when developing a harvest strategy:

- Consistent with legislative objectives, including the principles of ESD;
- Pragmatic and easy to understand;
- Cost effective;
- Transparent and inclusive;
- Unambiguous;
- Precautionary; and
- Adaptive.

The National Guidelines identify the following key steps as best-practice process when developing a harvest strategy:

- Defining the fishery to which the harvest strategy applies;
- Establishing a mechanism to engage stakeholders in the process
- Identifying relevant legislation and over-arching policy objectives;
- Developing conceptual fishery management objectives;
- Determining the stock status and other ESD considerations for the fishery;
- Building the harvest strategy;
- Testing the robustness of the harvest strategy; and
- Periodic review.

A particular focus was given to those components of fisheries management considered most challenging and less developed than other areas. For example, there are common challenges across jurisdictions to develop and apply harvest strategies in fisheries based on trans-boundary stocks, multi-sector fisheries, fisheries based on stocks for which there is limited information available (data-poor fisheries) and non-commercial fisheries such as recreational and traditional or customary fisheries.

To assist development of harvest strategies across this broad range of fishery scenarios, a set of 'considerations' was developed for the following fishery scenarios:

- Multi-jurisdictional fisheries;
- Recreational fisheries (including as part of multi-sector fisheries);
- Customary/ cultural/ traditional fisheries;
- Multi-species fisheries;
- Data-poor fisheries;
- Fisheries based on fluctuating stocks (includes regime shifts, climate change, environmental flows and estuarine fisheries, highly productive stocks etc);
- Multi-gear fisheries;
- Enhanced fisheries;
- Fisheries based on ecologically important species;
- Exploratory and developing fisheries;
- Fisheries based on low productivity species;
- Spatially structured fisheries; and
- Fisheries recovering from overfishing or unfavorable environmental conditions.

The National Guidelines provide definitions, common language and important contextual information for stakeholders to assist interpretation of harvest strategies and their application. The identification of a common language for national application to harvest strategies will allow all stakeholders to better understand their purpose and how they are applied.

One of the main benefits of adopting a harvest strategy is the increased level of certainty and transparency provided for all fishery stakeholders, particularly in relation to how fishery management decision making processes operate. Creating improved certainty and transparency contributes to creating a climate of trust between fishery stakeholders, allows fishery managers and

fishers to operate with greater confidence and allows for greater business planning by commercial fishers, as the fishery management responses to various levels of fishery performance are documented and more predictable. In this light, the adoption of a well constructed harvest strategy allows for more efficient and proactive decision making to be adopted.

The National Guidelines have been used to inform the preparation of harvest strategy policies for Victoria, Western Australia and to assist the review of the Commonwealth harvest strategy policy and guidelines. The National Guidelines will also be used by South Australia to develop a harvest strategy policy. In South Australia the guidelines have already been used to assist the development of several fishery-specific harvest strategies.

The National Guidelines have been presented to: (a) the *National Seafood Directions Conference* held in Port Lincoln, South Australia in October 2013; (b) the national workshop on the *Practical Implementation of Social and Economic Elements in Ecosystem Based Fisheries Management* on 24/25 March 2014; (c) the *National Fisheries Management Conference and Workshop* on 26/27 March 2014; and (d) will be presented to the July 2014 *Australian Marine Science Association fisheries symposium on 'Beyond Jurisdiction-based Fisheries Management*'.

An article on the National Guidelines was published in the FRDC 'Fish' Magazine in September 2013. A plain English summary of the National Guidelines will be prepared in a brochure form, for wide circulation among government, industry and non-government stakeholders involved in the Australian fisheries management and policy development process. The final report will be widely distributed among fisheries management stakeholders in Australia. Further opportunities to communicate and extend the outcomes of the project will be pursued with Australian fisheries agencies and any international fisheries agencies that have an interest in the national guidelines.

Further work has been proposed to assist the implementation of the National Guidelines, including development of case studies to test their application in specific fishery scenarios. The Australian Fisheries Management Forum has endorsed the National Guidelines and recommended that Australian fisheries Ministers ratify the guidelines as a national best-practice approach, through the Primary Industries Standing Committee (PISC).

KEYWORDS: Fishery management, harvest strategies, national guidelines.

2. INTRODUCTION

Difficulties and high costs associated with observing changes in the marine environment, the uncertainty over the size and productivity of fish populations and the natural variation inherent to the ecosystems that support them, make fisheries management a challenging and complex task. Complicating this task further is the common property nature of fisheries resources and the variety of other competing uses in the aquatic environment surrounding and influencing fisheries management, which includes, but is not limited to, coastal development, aquaculture development, mineral resource development, wave energy development, shipping, biodiversity conservation and freshwater flow regulation. In addition, there are numerous external impacts on fisheries resources from man-made events such as sewage outfalls, storm water discharge, agricultural run-off, pollution and habitat modification. Added to this complexity are contemporary challenges such as climate change.

In this context, the role of fisheries management is to effectively manage fisheries resources, and the ecosystems that support them, in the face of uncertainty, to meet multiple and often competing objectives for a diversity of stakeholder groups. Harvest strategies offer an effective tool to integrate all of the ecological, social and economic dimensions of fisheries management into a single framework for fisheries management decision making. As evidenced by their wide use internationally and throughout Australian fisheries management jurisdictions, harvest strategies represent a best-practice approach to fisheries management decision making (FAO 2011; Smith et al. 2013; McIlgorm 2013)

2.1 INTERNATIONAL CONTEXT

Harvest strategies, in various forms, have been adopted in the United States (US), Canada, Iceland, New Zealand, Norway and South Africa. They are a required component for certification in the Marine Stewardship Council program (http://www.msc.org/). Formal harvest strategies are also used internationally in some Regional Fisheries Management Organisations (RFMOs) and in some national jurisdictions. Among RFMOs, they have been applied in the Commission for the Conservation of Southern Bluefin Tuna and the Commission for the Conservation of Antarctic Marine Living Resources. They have also been applied in the International Whaling Commission, where they are referred to as management procedures (Punt and Donovan 2007).

In South Africa, harvest strategies are referred to as operational management procedures (Butterworth and Punt 1999). Most of the South African harvest strategies are based on empirical data (catch rates or surveys) rather than on the output from formal model-based stock assessments. However, they are always thoroughly simulation-tested prior to implementation using management strategy evaluation methods (see section 5.4.7).

The Harvest Strategy Standard for New Zealand fisheries (New Zealand Ministry of Fisheries 2008a) was released in 2007 and was concerned with the application of best-practice in relation to the setting of fishery and stock targets and limits for New Zealand fish stocks in the Quota Management System. A key dimension of this policy is that, where proposed management options departed from the Harvest Strategy Standard, they must be justified in terms of the particular circumstances that warranted such departure.

A companion document entitled 'Operational Guidelines for New Zealand's Harvest Strategy Standard' incorporated both technical and implementation guidelines (New Zealand Ministry of Fisheries 2008b). The technical guidelines provided suggested default biological reference points, a more detailed basis and justification for the metrics specified in the Harvest Strategy Standard, and elaboration on how the Harvest Strategy Standard should be implemented. The implementation guidelines specified the respective roles and responsibilities of the managers, scientists and stakeholders in giving effect to the Harvest Strategy Standard. Although this Standard formed a core basis for the Ministry of Fisheries' advice to the Minister, other considerations such as environmental

principles and economic, social and cultural factors played a role in the final decision made by the Minister. This is because the Harvest Strategy Standard set a consistent and transparent framework for decision making aimed at achieving the objective of allowing utilisation of species while ensuring sustainability, but did not include any considerations of economic, social, cultural or ecosystem issues.

A recent study conducted by McIlgorm (2013) reviewed the Australian Commonwealth harvest strategy policy against the policy approaches used in the European Union, the US, Iceland, Norway and New Zealand. This review concluded that the Australian Commonwealth Harvest Strategy Policy meets and exceeds the minimum legal obligations arising from international legal instruments such as the FAO's Code of Conduct for Responsible Fisheries (FAO 1995).

2.2 AUSTRALIAN CONTEXT

Australia has a wide diversity of fisheries that support commercial, recreational, traditional and customary fishing activities. These include industrial-sized commercial fisheries that export high value products to overseas markets, small community-based commercial fisheries that supply local markets, recreational sport fisheries, recreational charter fisheries, traditional fisheries and customary fisheries. All of these fishing sectors provide for important social and economic activity in regional and associated communities throughout Australia.

Over the past decade, fisheries management has attracted wider community focus and attention. For this reason, explicit harvest strategies are becoming more important in Australian fisheries, to respond to the increased community concern about fishing harvests. Well-designed harvest strategies ensure that catches are managed based on the principles of ecological sustainable development (ESD) to deliver appropriate community benefits, as defined in the objectives of relevant legislation. They also allow fishery managers and fishers to operate with greater confidence because management decisions are more transparent and there should be fewer unanticipated outcomes necessitating hasty management responses. The use of clear operational objectives, performance indicators, reference points and decision rules means that the process of managing fishing activities and catches, in response to changes identified through monitoring and stock assessment, is more objective and less able to be influenced by external pressures.

Various components of formal harvest strategies are used widely in the Australian fisheries management context, however, their development and application has not been consistent. In 2002, the development of a *National ESD Reporting Framework for Australian Fisheries* (Fletcher et al. 2002) included a number of the key components of formal harvest strategies and contributed to increased uptake of harvest strategy concepts and improved management of fisheries to broader ESD standards. In 2007, the Australian Commonwealth Government introduced the *Commonwealth Fisheries Harvest Strategy: Policy and Guidelines* (Australian Government 2007), which drove considerable advancement of harvest strategy development in Australian Commonwealth fisheries (Rayns 2007). Although no States or Territories currently have overarching formal harvest strategy policies in place, such policies are currently being developed in a number of State jurisdictions (e.g. Victoria, Western Australia and South Australia) and harvest strategies have been applied widely to individual fisheries in the States and the Northern Territory.

In November 2009, the Australian Fisheries Management Forum held a workshop to address inconsistencies in the way harvest strategies are developed and implemented across Australian fisheries management jurisdictions. At this workshop, it was agreed that a coordinated, nationally-consistent approach to developing harvest strategies was required. Following this workshop, the Australian Fisheries Management Forum proposed a research project that would establish a consistent framework for the development of harvest strategies across Australian fisheries management jurisdictions, to build on the foundation established by the the *Commonwealth*

Fisheries Harvest Strategy: Policy and Guidelines (Australian Government 2007). This project (FRDC: 20010/061) was subsequently supported by FRDC in 2010.

In developing the National Guidelines, it was acknowledged that ESD is a common high level legislative objective across Australian fishery management jurisdictions. In this context, it was considered that Australian fishery harvest strategies should adopt an ESD approach and must also balance the need for flexibility (to allow for changing circumstances) with providing certainty to stakeholders for how a fishery will be managed.

3. OBJECTIVES

The specific objectives for this project were:

1. Undertake a review and analysis of the present situation of harvest strategies in Commonwealth and State-managed fisheries.
2. Develop a common definition for nationally consistent harvest strategies.
3. Develop an agreed set of over-arching principles for Harvest Strategies across Australia

An overall aim of this project was to establish a set of National Guidelines to provide practical assistance to fisheries management agencies in the development of fishery specific harvest strategies and to facilitate a common approach being applied across fisheries throughout Australia, to the extent possible, acknowledging the diversity in Australia's commercial, recreational and traditional customary fisheries and the different legislation in place in each jurisdiction.

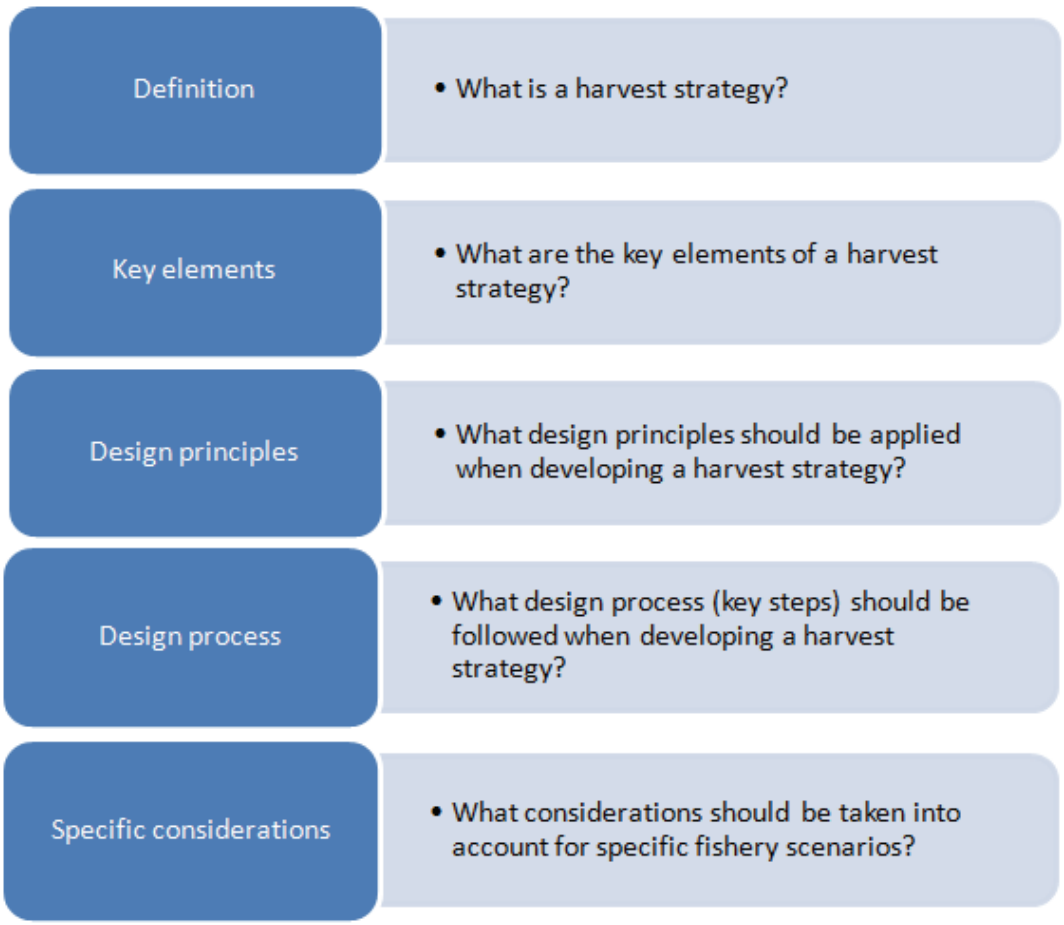
The National Guidelines make a distinction between a fishery-specific harvest strategy and an over-arching harvest strategy policy, which may be adopted by a jurisdiction to establish benchmarks and standards for that jurisdiction (e.g. the *Commonwealth Fisheries Harvest Strategy: Policy and Guidelines*-Australian Government 2007*)*. The National Harvest Strategy National Guidelines have been developed to describe the technical aspects of developing harvest strategies for individual fisheries, and to assist those involved in the development of jurisdictional level harvest strategy policies. However, the National Guidelines do not attempt to dictate the broad policy decisions, unique to each jurisdiction, which would need to be captured in a jurisdictional harvest strategy policy.

4. METHODOLOGY

A project working group to facilitate broader input to the development of the National Harvest Strategy Guidelines was established in late 2011. The working group included: Mr Sean Sloan, the Principal Investigator (PIRSA Fisheries and Aquaculture); Dr Tony Smith (CSIRO); A/Prof Caleb Gardner (University of Tasmania); Ms Kelly Crosthwaite (Fisheries Victoria); Mr Brian Jeffriess (Australian Southern Bluefin Tuna Industry Association); Mr Tim Karlov (Australian Government Department of Agriculture); and Mr Nathan Kimber, Project Officer (PIRSA Rural Solutions). In September 2012, Dr Lianos Triantafillos (PIRSA Fisheries and Aquaculture) replaced Mr Nathan Kimber as the project officer.

This working group met throughout the project to provide technical input into project planning, development of the National Guidelines and delivery towards each of the three objectives. Progress towards each of the three objectives was regularly disseminated by the Principal Investigator to the Australian Fisheries Management Forum (consisting of the heads of all fishery management agencies throughout Australia). The Australian Fisheries Management Forum provided a sounding board for draft versions of the guidelines, providing input at various steps during the project. An overview of the National Guidelines was presented to the National Seafood Directions Conference in Port Lincoln in October 2013.

The report is structured in a way that answers a series of key questions, for practical purposes, to assist fishery managers, fishers and key stakeholders to use the National Guidelines:



Objective 1: Undertake a review and analysis of application of the present situation of Australian harvest strategies

To review and analyse the present situation of harvest strategies in Commonwealth and State/ Territory-managed fisheries, a set of questions was developed by the working group and distributed to each of the Australian fisheries management agencies. This process facilitated a national audit or 'stock-take' of harvest strategy implementation across Australian fisheries jurisdictions. Each fisheries management agency was asked to respond to these questions for each of the fisheries/species/stocks under their management responsibility (see Appendix 1 for full list of fisheries). The questions asked were as follows:

1. Does the fishery/species/stock have a management plan?
2. What is the principal tool used to constrain catch in the fishery / of the species?
3. Does the fishery/species/stock have formal 'operational' management objectives to guide the setting of catch levels?
4. Does the fishery/species/stock have specified performance indicators to measure fishery performance against the stated objectives?
5. Does the fishery/species/stock have established limit reference point/s?
6. Does the fishery/species/stock have established target reference point/s?
7. Does the fishery/species/stock have established decision rules, linked to reference points, to guide management decisions?
8. Are economic or social considerations explicitly taken into account when selecting performance indicators, target or limit reference points or decision rules?
9. Does the fishery/species/stock have a formal stock assessment? If 'yes' does it incorporate the use of a quantitative stock assessment model or is it based on a more empirical assessment?

Background information and guidelines for answering these survey questions are provided in Appendix 2.

Objective 2: Develop a common definition for nationally consistent harvest strategies

Taking into consideration definitions from the international literature and a number of harvest strategy policies that are currently in existence (Australian Government 2007; New Zealand Ministry of Fisheries 2008a; Rayns 2007; Rademeyer et al. 2007), the working group developed a draft definition for nationally consistent harvest strategies. This definition was considered during a specific session at a national technical workshop held on 6 March 2012, to facilitate broad technical expert input to the development of the national guidelines. The delegates in attendance at this national technical workshop are listed in Appendix 3.

Objective 3: Develop an agreed set of over-arching principles for Australian harvest strategies

To meet this project objective, the following components were developed to form part of the national guidelines to develop fishery harvest strategies:

1. A set of key elements of a harvest strategy;
2. A set of harvest strategy design principles;
3. A harvest strategy design process (set of key steps to be followed); and
4. A set of considerations for fishery-specific scenarios.

Each of these components is described in detail in separate sections within this report.

5. RESULTS AND DISCUSSION

5.1 WHAT IS A HARVEST STRATEGY?

5.1.1 Definition

In its simplest form, a harvest strategy provides a formal and structured framework to guide fishery management decision making processes, to assist in achieving fisheries management objectives. A harvest strategy brings together all of the key elements and management functions used to make decisions about the level of fishing activity that should be applied to a fish stock or a fisheries management unit, to maximize the likelihood of achieving ecological, economic and social sustainability.

The existence of a harvest strategy ensures that fishery managers, fishers and key stakeholder groups involved in fisheries management processes think about, and document, how they will respond to various fishery conditions (desirable and undesirable), before they occur, to provide for greater certainty and to avoid *ad-hoc* decision making.

The term 'harvest strategy' is used widely in fisheries management and fisheries science literature (Cadrin and Pastoors 2008). Currently, only New Zealand and the Commonwealth of Australia have specific harvest strategy policies, though other countries such as the US effectively define harvest strategy usage through provisions of their *Sustainable Fisheries Act 1996* and a series of associated policy standards.

However, what defines a harvest strategy has been interpreted differently and has evolved to have very different meanings to different stakeholders. This has created considerable variability in their application, efficacy and, in some cases, has also created incorrect expectations among stakeholders. To address this problem, one of the key objectives of this project was to develop a nationally accepted definition for a fishery harvest strategy, to enable a common understanding among key stakeholders of the scope and purpose of harvest strategies. Through this project, the following national definition for a fishery harvest strategy was developed:

"A harvest strategy is a framework that specifies pre-determined management actions in a fishery for defined species (at the stock or management unit level) necessary to achieve the agreed ecological, economic and/or social management objectives".

For full context, the definition of a harvest strategy should be read in conjunction with the key harvest strategy elements listed in section 5.2.

5.1.2 Harvest strategies form part of a broader management framework

To understand the role of a harvest strategy, it is important to consider how they fit into the broader fisheries management framework. At the higher level, fisheries management is guided by international obligations contained in treaties such as the United Nations (UN) Convention on the Law of the Sea (1982)[1] and the UN Straddling Fish Stocks Agreement (UNCLOS 1995), the FAO Code of Conduct for Responsible Fisheries (FAO 1995), specific fisheries legislation in each jurisdiction, Commonwealth, State and Territory environment legislation, broad policy frameworks directed at addressing issues such as ESD, by-catch reduction, ecosystem based fisheries management and cost recovery.

Sitting beneath these higher-level legislative and policy arrangements, each individual fishery has a specific management framework such as a quota system or an effort control system to provide a set

[1] http://www.un.org/Depts/los/convention_agreements/convention_overview_convention.htm

of management controls, which are usually described in regulations, a fishery management plan or a fishery management policy. Fishery management plans (or fishery management policies, as may be the case in different jurisdictions) necessarily focus on the broader set of controls needed to manage a fishery, which may also include allocation arrangements, co-management arrangements, education and extension strategies and compliance and surveillance strategies, etc.

In this context, harvest strategies form an important component of broader fishery management frameworks, focusing on how decisions are made in setting exploitation levels to control fishing activities and catch for defined species. In an ideal setting, the mechanisms for fishery management decision making (at the individual fishery level) should be contained within fishery management plans or other documents of similar form that provide a high level of certainty and accountability. In this sense, a harvest strategy provides the 'nuts and bolts' of a fishery management plan and should form the basis of the adaptive management cycle.

Harvest strategies should be regularly reviewed and updated, so management plans need to be flexible enough to accommodate any adjustments that need to be made to harvest strategies to improve their efficacy over time. Harvest strategies need to be able to be updated and the instrument used to implement them therefore needs to change over time.

It is important to note here that whilst the approach outlined in these National Guidelines identify that a harvest strategy should form a central component of a fishery management plan, to maximise certainty and accountability, this does not always have to be the case and a pragmatic approach should be adopted when applying the guidelines, to match the scale and needs of the fishery.

To be effective at achieving the wider objectives that relate to ESD and other objectives in legislation such as EBFM, by-catch reduction, profit maximisation, and/or social welfare, harvest strategies should integrate the full set of biological, economic and social objectives relevant to a fishery, where they relate to harvest. This means that, for example, to achieve a fishery management objective of avoiding lethal interactions with threatened, endangered and protected species (TEPS), harvest strategies may need to consider incorporation of other management processes, such as the implementation of recording systems that monitor the number of fishing interactions with TEPS, developing management measures to avoid these interactions and decision rules to guide decision making.

A representation of how a harvest strategy fits within the broader fishery management context is provided in Figure 1.

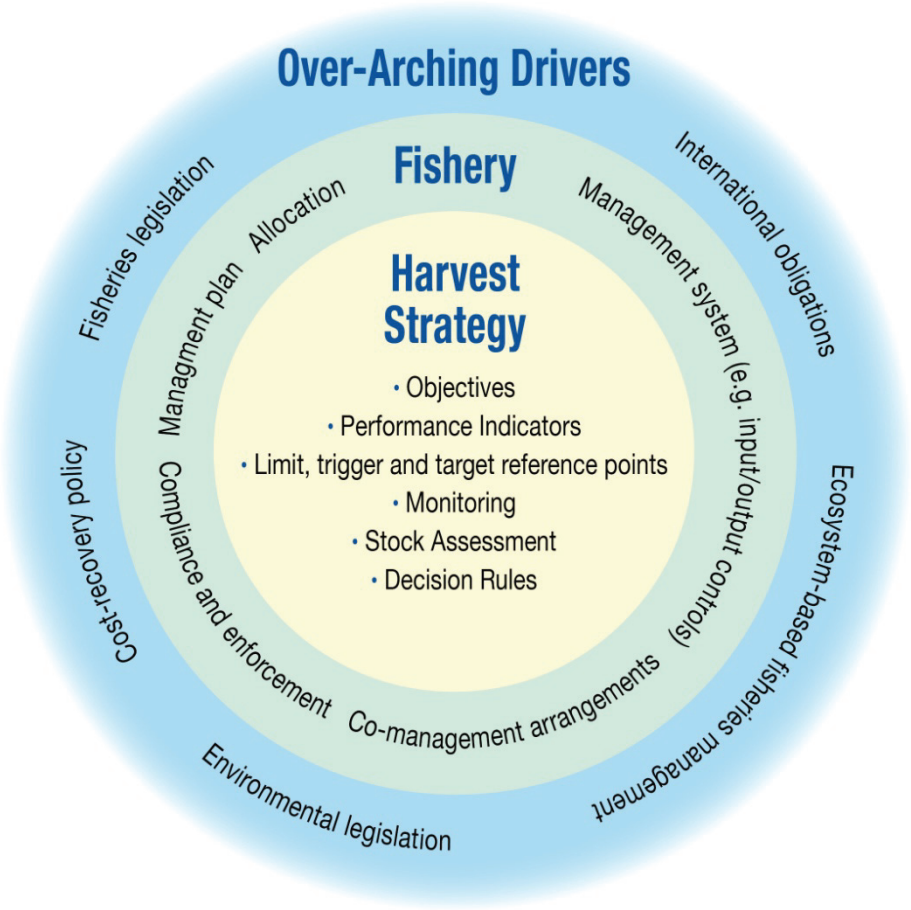


Figure 1. A schematic representation of how a harvest strategy fits within the overall fishery management framework (as a central component of the fisheries management process).

5.1.3 Current application of harvest strategies in Australia

The use of harvest strategies is not new in Australia – they have been applied in many jurisdictions during the last decade and have become more common across all Australian fisheries management jurisdictions (Smith et al. 2007; Smith et al. 2013), particularly following the development of the *Commonwealth Fisheries Harvest Strategy: Policy and Guidelines* (Australian Government 2007; Smith et al. 2013). However, there has been considerable variation in the way in which they have been applied across each jurisdiction.

In 2002, the development of a *National ESD Reporting Framework for Australian Fisheries* (Fletcher et al. 2002) included a number of the key components of formal harvest strategies, and although the main focus of this work was on promoting fisheries management within the broader ESD context, it led to greater use of some harvest strategy elements (e.g. operational objectives, performance indicators and reference points).

In December 2005, the Australian Government launched a new fisheries policy '*Securing our Fishing Future*' which aimed to cease over-fishing and rebuild over-fished fish stocks at the Commonwealth level. Coincident with this policy launch, the Federal Minister for Fisheries issued a Ministerial Direction to the Australian Fisheries Management Authority (AFMA), which included the requirement for AFMA to develop and implement formal harvest strategies for all Commonwealth Fisheries (Rayns 2007).

The announcement followed the implementation of formal harvest strategies in the Southern and Eastern Scalefish and Shark Fishery in 2005 (SESSF; Smith et al. 2008). One of the first harvest strategies developed under this policy was for the Eastern and Western Tuna and Billfish fisheries, the development of which was guided by the draft *Commonwealth Fisheries Harvest Strategy Policy*, released in June 2006, and was consistent with the final policy and guidelines (Australian Government 2007). By 1 January 2009, harvest strategies were implemented in all Commonwealth fisheries and are now central to the adaptive management process that operates at the Commonwealth level (Smith et al. 2013).

A number of State jurisdictions, including Victoria, Western Australia and South Australia are in the process of developing over-arching policies to guide harvest strategy development, using the national harvest strategy guidelines. These jurisdictions already have formal harvest strategies in place for many fisheries. Early examples of harvest strategy development at the State level include the South Australian Sardine Fishery (PIRSA 2005) and the Queensland Spanner Crab Fishery (Dichmont and Brown 2010). The Western Australian Western Rock Lobster Fishery (Reid et al. 2013), South Australian Lakes and Coorong Fishery (Sloan 2005) and the South Australian Southern Rock Lobster Fishery have also used formal harvest strategies for a number of years (Sloan and Crosthwaite 2007; PIRSA 2012; Punt et al. 2012).

A qualitative snapshot audit of the extent to which the key elements of formal harvest strategies are currently applied in Australia, by Commonwealth, State and Territory fisheries agencies, including whether pre-determined decision rules have (or have not) been adopted is provided in Table 2 and Appendix 4. The fisheries included in this assessment are listed in Appendix 1. It is important to note that this data was collected using a questionnaire circulated to all Australian fisheries agencies (refer to Appendix 2). Although significant efforts have been made to validate the data to ensure an accurate representation of the situation in each jurisdiction, it must be acknowledged that the data provided was subject to the interpretation of each jurisdiction completing the questionnaire.

Based on the data collected, most jurisdictions have management plans in more than three quarters of their fisheries, with Victoria (30%) and the Northern Territory (23%) the exceptions. Because management plans take various forms across fisheries jurisdictions in Australia, the following guidance was provided to fisheries jurisdictions when responding to this issue. "*A management plan may take the form of a statutory instrument or a policy document. A Management Plan should, in its simplest form, describe the fishery geographically, the species being managed, outline the relevant management arrangements/strategies for the fishery including the access arrangements in place, the specific objectives for the species being managed and any measures of management performance that are used.*"

For some jurisdictions (Queensland, New South Wales and Tasmania), management plans generally do not use target references points and decision rules. Similarly, social and economic indicators are rarely used in Queensland, Victoria and Tasmania, but are frequently considered in Northern Territory, Western Australia, South Australia and New South Wales. Note that all Commonwealth fisheries use the economic reference point of Maximum Economic Yield (MEY) under the Commonwealth harvest strategy policy.

In the jurisdictions where management plans are common, most reported that they have operational objectives (56-95%) and performance indicators (44-100%). Social and economic indicators are rarely, if ever, specified in Queensland, Victoria, the Commonwealth and Tasmania, but are frequently specified in Western Australia (68%), South Australia (69%), the Northern Territory (77%) and New South Wales (95%). The differences observed are not simply a function of the presence and/or absence of social and economic objectives in governing legislation because the legislation of all jurisdictions makes some reference to these objectives, specifically in the context of ecologically sustainable development. Rather, different jurisdictions have evolved different processes and have

adopted components of harvest strategies to varying extents to meet their specific needs, independently of the overarching need to meet legislative objectives.

Empirical assessments of stock status are more often used to assess status of stock or fisheries management units rather than quantitative stock assessment models (42% cf. 33%). Empirical assessments involve direct use of data that can be used to infer exploitation or stock status, such as catch per unit effort (CPUE), measures of age or size structure, or estimates derived from fishery independent surveys. This type of assessment is consistent with the 'weight–of-evidence approach' described in the Status of key Australian Fish Stocks Report by Flood et al. (2012). Empirical approaches are most often used due to the higher costs associated with producing and refining quantitative stock assessment models and the scale of the fisheries they are generally applied to. No formal stock assessment is undertaken in approximately one in four stocks or fisheries management units.

It is important to note here, that the use of empirical assessments can be a valid and reliable assessment approach. In many cases an empirical assessment may be as reliable as the output from a more sophisticated model-based assessment and may be the most suitable approach given the scale and intensity of a fishery, the data and the resources available to conduct the assessment. Importantly, empirical approaches offer a cost-effective and pragmatic way of addressing the fisheries management needs in many fisheries.

Table 1. A summary of the current (up to September 2012) harvest strategy application for each Australian fisheries management jurisdiction. The fisheries included in this assessment are those listed in Appendix 1.

	SA	QLD	NSW	VIC	WA	NT	TAS	Commonwealth	National
Number of fisheries management units/ stocks that are assessed	29	21	19	23	44	13	9	22	180
Number that have management plans	24	21	18	7	36	3	8	11	128
Number that have operational objectives	22	19	18	6	31	8	5	15	124
Number that have performance indicators (PIs)	21	21	18	6	44	8	4	7	139
Number that have limit reference points (LRPs)	18	10	18	6	38	6	3	10	109
Number that have target reference points (TRPs)	21	0	0	6	26	7	1	13	74
Number that have harvest control decision rules	17	4	3	6	22	9	0	14	75
Number that explicitly consider social and economic indicators	20	2	18	0	30	10	0	4	71
Number that have:									
(a) no formal stock assessment	6	10	0	13	0	3	3	7	42
(b) an empirical stock assessment	14	2	15	5	31	3	2	7	79
(c) a model-based stock assessment	9	9	4	5	13	7	4	8	59

It is important to note that this data was collected using a questionnaire circulated to all Australian fisheries agencies, to facilitate a qualitative snapshot audit of the current situation in relation to harvest strategy implementation across Australian fisheries jurisdictions. Although significant efforts have been made to validate the data to ensure an accurate representation of the situation in each jurisdiction, it must be acknowledged that the data provided was subject to the qualitative self assessment and interpretation of each jurisdiction completing the questionnaire.

5.2 WHAT ARE THE KEY ELEMENTS OF A HARVEST STRATEGY?

In order to create a structured framework to guide fishery management decision making processes, a harvest strategy brings together all of the key scientific monitoring, assessment and management elements used to make decisions about the intensity of fishing activity or catch that should be applied to, or removed from, a fish stock or fisheries management unit. When all of these components are brought together to form an integrated package, they create a formal harvest strategy.

The following key elements of a best-practice harvest strategy framework should be developed together to form an integrated package:

- Defined operational objectives for the fishery;
- Indicators of fishery performance related to the objectives;
- A statement defining acceptable levels of risk to meeting the objectives;
- Reference points for performance indicators;
- A monitoring strategy to collect relevant data to assess fishery performance;
- A process for conducting assessment of fishery performance relative to objectives;
- Decision rules that control the intensity of fishing activity and/or catch.

Although the data collected and assessments may refer to ecological, economic and social conditions of a fishery, the major focus of harvest strategies to date has been centred on biological considerations (Dowling et al. 2011). The key elements outlined in this section aim to broaden the scope and application of harvest strategies to encompass the ecological, economic and social dimensions of ESD-based fishery management.

5.2.1 Defined operational objectives for the fishery

In Australia, fisheries management is conducted under legislation that contains a set of high level objectives, to be achieved for all fisheries that fall within the specified jurisdiction to which the legislation applies. Traditionally, these high level 'legislative' objectives have been translated into guiding 'conceptual' fishery management objectives, usually contained within fishery-specific management plans, which are designed to be relevant at the fishery-specific level and to 'guide' management of individual fisheries, consistent with the overarching legislation (Sainsbury and Sumalia 2003). Alternatively, in some jurisdictions, such conceptual objectives may be contained in overarching policies.

Because the conceptual fishery management objectives are frequently expressed in broad terms and are typically too vague to be particularly useful as actual targets for a harvest strategy, they need to be translated into 'operational' management objectives that are relevant for defined species within a fishery. Operational management objectives are very precise and are formulated in such a way that the extent to which they have been achieved during a specified period should be easily measured (Fletcher 2002; Cochrane 2002).

For the purposes of applying the national guidelines, an operational objective is defined as "*An objective that has a direct and practical interpretation in the context of a fishery and against which performance can be evaluated*" (Fletcher et al. 2002).

Therefore, when developing a harvest strategy, it is important to establish clear and concise conceptual ecological, economic and/or social management objectives for how the fishery is carried out to benefit the community, consistent with overarching legislation, and for these to be translated into defined operational objectives, which can be used to track and measure performance.

Without the conceptual objectives, there is no clarity on how the fishery should be operated in terms of addressing ecological, economic and social performance outcomes and can result in *ad-hoc* decisions and sub-optimal use of resources, which increases the probability of serious conflicts as different interest groups jostle for greater shares of the benefits (Cochrane 2002).

When developing the conceptual management objectives, the trade-offs between the ecological, economic and social outcomes being sought must be surfaced and agreed upon (preferably in consultation with all key stakeholders) and any contradictions resolved so that they are simultaneously achievable, i.e. there should be no unreconciled conflicts between them (Cochrane 2002).

Following the establishment of agreed conceptual management objectives for a particular fishery, a set of operational objectives should be clearly defined for individual species in the fishery. These operational objectives should be easily measured and linked to the performance indicators, reference points and decision rules of a harvest strategy. The operational objectives should clearly identify the fish stock or fisheries management unit they apply to.

The following example is taken from the South Australian Pipi Fishery to demonstrate the linkages between the three tiers of management objectives: (1) overarching legislative objectives; (2) conceptual management objectives established for an individual fishery; and (3) 'operational' management objectives established for defined species (see Box 1).

Box 1: Example of the linkage between 'high-level' legislative objectives, 'conceptual' fishery management objectives and 'operational' management objectives for the South Australian Pipi Fishery

TIER 1-High level legislative objective (South Australian *Fisheries Management Act 2007*)
-To protect, manage, use and develop the aquatic resources of the State in a manner that is consistent with ecologically sustainable development

TIER 2-Conceptual fishery management objective (Lakes and Coorong Fishery Management Plan)
-Ensure the Lakes and Coorong Fishery resources are harvested within ecologically sustainable limits

TIER 3-Operational management objective for Pipi Fishery (Lakes Coorong Fishery Management Plan)
-Maintain a target Pipi relative biomass above 10 kg/ 4.5 m^2 and not less than 8 kg/ 4.5 m^2
-Ensure the Pipi relative biomass does not drop below 4 kg/ 4.5 m^2.
-Maximise Fishery Gross Margin

For countries or jurisdictions that have quite specific legislative objectives, such as in New Zealand where the legislative objective for all fisheries, as stated in the *Fisheries Act 1996*, is to manage fisheries in a way that will lead to production of the Maximum Sustainable Yield, the need to translate the legislation into operational objectives is more a technical exercise and may not require the step of developing 'conceptual' management objectives. For Australian Commonwealth fisheries, operational objectives are defined by adoption of the MEY target and the limit reference point whose default value is half the biomass corresponding to MSY.

A key factor in developing operational objectives for a harvest strategy is the status of the fishery. The 'Status of key Australian Fish Stocks Report 2012' (Flood et al. 2012) provides a national framework for classifying fish stock status and uses a limit reference point of recruitment overfishing.

There are five classifications of status relative to this reference point:

- Sustainable stock;
- Transitional – recovering stock;
- Transitional – depleting stock;
- Overfished stock; and
- Undefined stock.

The classicisation of a fishery is a preliminary step to designing a harvest strategy. In fisheries with existing long-term data sets and stock assessment programs this should be straightforward. For other fisheries, a 'weight-of-evidence' approach will be necessary. In data-poor fisheries it may not be possible to classify the stock.

Overfished fisheries require a rebuilding strategy to be put in place immediately. A rebuilding strategy is designed to rebuild the fishery quickly to the point where the biomass exceeds the limit reference point in the harvest strategy. A rebuilding strategy may require that the fishery be closed for a period of time. The timeframes for recovery will need to be clearly articulated in the operational objectives.

Likewise for depleting stocks, a rebuilding strategy will be required to be put into effect immediately to stop the decline in the fishery. In particular, limits on the amount of fishing pressure will need to be implemented in the short term. The timeframes for recovery will need to be clearly articulated in the operational objectives.

For recovering stocks, a rebuilding strategy is presumably already in place that has led to the recovery of the stock. In these situations the harvest strategy needs to be designed to continue this trend. The timeframes for recovery will need to be clearly articulated in the operational objectives.

Undefined stocks, by definition, do not have a harvest strategy against which to make judgements about its status. In most cases, these fisheries will require the implementation of a simple harvest strategy with a focus on collecting baseline information in the short term.

5.2.2 Indicators of fishery performance related to the objectives

A performance indicator is a quantity that can be measured and used to track changes with respect to achieving an operational objective (Fletcher et al. 2002). Performance is measured by comparing where a performance indicator sits in relation to a reference point (see Fig. 2). Performance indicators can be a direct measurement of performance or a surrogate (Fletcher et al. 2002). An example of a surrogate performance indicator is yearly commercial catch per unit of effort (CPUE; kilograms per pot lift) of southern rock lobster, which is used by all southern rock lobster fisheries in southeast Australia as an index of lobster abundance. The operational objective, indicator, and reference point form a package (Fletcher et al. 2002). Each of the three components of the package is essential to properly define and interpret an indicator and one or more reference points may form part of the system of measuring performance. It is important that when choosing performance indicators, the data used to estimate them is also defined, to ensure clarity and certainty and avoid any changes in relation to the application of a harvest strategy. A guide to the development, use, evaluation and reporting of indicators for fisheries management is provided by FAO Fishery Resources Division (1999) and the National ESD Reporting Framework (Fletcher et al. 2003).

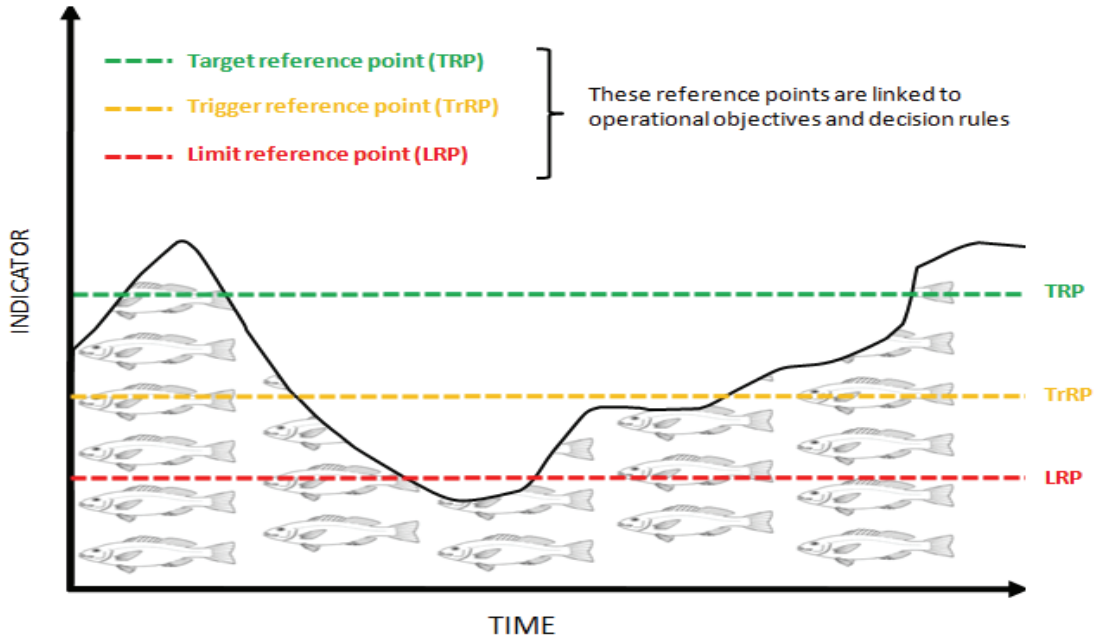


Figure 2. The relationship between a performance indicator (shown as dark grey line), the different types of reference points, operational objectives and decision rules.

5.2.3 Reference points for performance indicators

Reference points are essentially 'benchmarks' of performance and are linked to defining acceptable levels of biological impact on a stock or the desired social and/or economic outcomes. In this context, the operational objectives and reference points need to be explicitly linked. There are three main types of reference point against which fishery performance can be measured. These are commonly referred to as 'target', 'limit' and 'trigger' reference points. When monitoring and assessment indicates that the indicator reaches a trigger point or falls above the target reference point or below the limit reference point, pre-determined management actions should occur, consistent with established harvest strategy decision rules. Note that that not all reference levels are a specified amount, for example in the case of data-poor or multi-species fisheries, reference levels may instead refer to trends (e.g. if catch exceeds the historical catch for 3 consecutive years, then a management action is triggered).

5.2.3.1 Limit reference points

Limit reference points (LRPs) define the values of an indicator for a fish stock or fisheries management unit that are no longer considered acceptable. Limit reference points have been typically associated with operational objectives that are tailored towards biological sustainability rather than economic or social objectives and therefore mostly relate to whether the stock is recruitment overfished and therefore likely to put the stocks upon which the fishery is based at unacceptable risk (FAO Fisheries Resources Division 1999; Fletcher et al. 2003; Davies et al. 2007; Flood et. al 2012).

In assessing fish stock status nationally, the Status of Key Australian Fish Stocks Report (Flood et al. 2012) adopted 'recruitment overfished' as the biological limit reference point for determining whether or not a fish stock is overfished. Recruitment overfished was defined as *"the point at which a stock is considered to be recruitment overfished is the point where the spawning stock biomass has been reduced through catch, so that average recruitment levels are significantly reduced"* (Flood et al. 2012). Sainsbury (2008) also provides a very useful summary of the use of target and limit reference points in Australian fisheries. There are also cases where limit reference points can be set above biological sustainability values to meet economic or social standards. The *Commonwealth Fisheries Harvest Strategy Policy* stipulates that the limit reference point for biomass is equal to or greater than half of the biomass estimated for maximum sustainable yield (MSY), which defaults to 20% of the unfished biomass where B_{MSY} cannot be calculated (Australian Government 2007). In practice, the default value is widely used as it can be difficult to measure B_{MSY} accurately, and notional values can place limit reference points at very low levels.

5.2.3.2 Target reference points

Target reference points (TRP's) define the values of an indicator for a fish stock or fisheries management unit that are desirable or ideal and at which management should aim. (e.g. high catch rates, high long-term average yields). They typically relate to desired economic and/or social outcomes. A common economic objective is MEY. Target reference points for MEY are generally based on harvest rates, biomass targets or biomass proxies such as CPUE. The economic data required for establishing MEY targets are not always available, in which case proxies such as $1.2*B_{MSY}$, where B_{MSY} is the biomass that delivers MSY, can be used. This is applied to Commonwealth fisheries, as determined in the *Commonwealth Fisheries Harvest Strategy Policy* (Australian Government 2007). Historical levels of CPUE that occurred during periods of high economic yield have also been used as Target reference points.

Target reference points for MEY are therefore generally based on biomass targets, harvest rates or proxies such as CPUE. However, an example of a different approach to setting a target reference point to pursue MEY in the South Australian Pipi Fishery is provided in Box 2. In this harvest strategy a simple economic assessment of gross economic margin is used to determine if increases in catch should occur, when biological conditions support this.

5.2.3.2 Trigger reference points

Trigger reference points (TrRPs) are levels of an indicator, usually a stock status indicator, at which a change in management is considered or adopted. Trigger reference points play a particularly important role in harvest decision rules, where they identify a point (such as a biomass level) at which a substantial change in the exploitation rate occurs. For example, in the Tier 1 harvest decision rule adopted in the Southern and Eastern Scalefish and Shark Fishery, a constant exploitation rate $(F_{TARGET})^2$ is applied for all biomasses above a level just below B_{MSY}. Once this trigger point is breached, however, the exploitation rate declines linearly to B_{LIM} where it is zero (no targeted fishing below the

[2] F_{TARGET} is the target fishing mortality rate

limit reference point). So in this case the 'trigger' point lies below the target reference biomass B_{MEY}, but well above the limit reference biomass B_{20}.

In other harvest strategies, trigger points can mark the boundaries between 'green', 'amber' and 'red' zones – e.g. the harvest strategy for Western Australian rock lobster (Reid et al. 2010). Another example of trigger points is in the Great Australian Bight Trawl Fishery, where trigger catch levels have been set for several by-product species (Harrap et al. 2010). The catch exceeding the trigger initiates an increased research program to collect more data so that quantitative stock assessments could be undertaken in the future; this is an example of the catch/cost/risk trade-off, in practice.

In some circumstances a graded management response is appropriate as stock sizes reduce. This may involve a series of progressively more stringent management actions as a sequence of trigger reference points is exceeded. However if the stock falls below the limit reference point, drastic action (such as closure of the fishery) would be appropriate, until such time as the stock recovers. The intent of the graded response is to prevent the need for such drastic action. This graded approach, including reference triggers and reference limits, assists in reducing management shocks to a fishery. They lead to more orderly adjustments to fishing intensity and associated business activity when minor changes to the fishery are needed to respond to changes in stock size while also providing for a substantial management response when required to recover stocks.

An example harvest strategy using the key harvest strategy elements (operational objectives, performance indicators, limit and target reference points, monitoring, stock assessment and decision rules) for the South Australian Pipi Fishery is provided in Box 2. Further examples of harvest strategies using these elements are provided in Appendix 5 for the Commonwealth Blue Grenadier Fishery (model-based harvest strategy), the Commonwealth Southern Squid Jig Fishery (data-poor harvest strategy) and the South Australian Southern Rock Lobster Fishery (empirical harvest strategy, with model outputs used as supporting information).

Box 2: Key elements of the South Australian Pipi Fishery harvest strategy

Defined operational objectives for the fishery

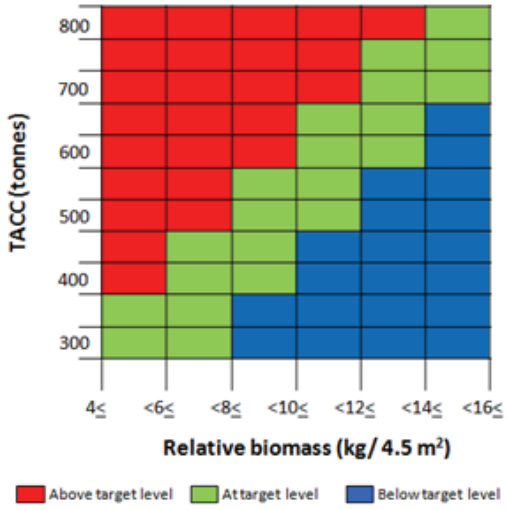
1. Maintain a target Pipi relative biomass above 10 kg/ 4.5 m² and not less than 8 kg/ 4.5 m².
2. Ensure the Pipi relative biomass does not drop below 4 kg/ 4.5 m².
3. Maximise Fishery Gross Margin

Indicators of fishery performance related to the objectives

Primary biological performance indicator: fishery-independent relative biomass of legal-sized Pipi
Secondary biological performance indicator: population size structure based on length frequencies from fishery-independent surveys.
Primary economic performance indicator: Fishery Gross Margin

Reference points for performance indicators

Limit reference point (biomass): relative biomass of legal-sized Pipi is < 4 kg/ 4.5 m².
Target reference point (biomass): mean relative biomass of legal-sized Pipi is ≥ 10 kg/ 4.5 m².
Trigger reference point (size structure): pre-recruits represent at least 30% of the overall length frequency



Statement defining acceptable levels of risk for the fishery

The figure of 8 kg/ 4.5 m² has been chosen as it represents a conservative level of relative biomass that would allow continued rebuiding of the stock. The figure of 4 kg/ 4.5 m² represents a historically low level of biomass that may result in a risk of recruitment overfishing.

Monitoring strategy to collect relevant data to assess fishery performance

Two main data types are collected and analysed. These are: (1) fishery-independent surveys to estimate relative biomass of legal-sized Pipi and index of relative abundance of pre-recruits; and (2) fishery economic indicators and market price estimates are used to analyse economic returns over a range of TACC levels

Fig.1: Fishery independent relative biomass of legal-sized Pipi from previous season determines the following season's maximum total allowable commercial catch (TACC) for the Pipi fishery with incorporated economic information.

A process for conducting assessment of fishery performance relative to objectives

Step 1-Biological performance indicators are used to assess the current status of the Pipi fishery
Step 2-Economic indicators and market price are used to analyse economic returns over a range of TACC levels
Step 3-Reference points and decision rules to guide the TACC setting process.

Decision rules that control the intensity of fishing activity

•TACC is increased by 50 tonnes when biomass has increased by one level or when biomass is in green range and pre-recruits are present or when fishery gross margin is expected to increase by at least 1.5% with increase in TACC
•TACC remains unadjusted when biomass is in blue or green range and fishery gross margin is not expected to increase by at least 1.5% with increase in TACC or biomass is in the green range and there is absence of pre-recruits
•TACC is reduced to corresponding green value immediately below when biomass is in the red range and pre-recruits are not present or where pre-recruits are present but biomass is below 10 kg/ 4.5 m² or fishery gross margin is expected to increase by at least 1.5% with a decrease in TACC.

5.2.4 A statement defining acceptable levels of risk for meeting objectives

Harvest strategies provide clear direction in relation to preferred exploitation rates and stock status for a fish stock or fisheries management unit. This is articulated through the specification of target and limit reference points, and the acceptable risk of not meeting objectives. In model based stock assessments, this may be assessed using probability thresholds for meeting target reference points and/or avoiding limit reference points. By doing this, harvest strategies provide direction on the level of risk acceptable to managers in relation to the stock status of a fishery. As the status of stocks relative to reference points (and ultimately relative to operational objectives) can often be uncertain, individual harvest strategies (or ideally, over-arching harvest strategy policies) should define acceptable levels of risk associated with breaching reference points, particularly limit reference points. For example, in the *Commonwealth Fisheries Harvest Strategy Policy and Guidelines* (Australian Government 2007), it is explicitly stated that there should be no more than a 10% chance of the stock falling below the limit reference point under the application of the harvest strategy. Similarly, the Marine Stewardship Council uses terms such as likely and highly likely in relation to achieving management targets or avoiding limits, and associates them with specific levels of probability (see for example, the MSC certification guidance document at http://www.msc.org/documents/scheme-documents/msc-scheme-guidance-documents/guidance-to-the-msc-certification-requirements-v1.3/view.

Because target reference points are generally more closely linked to economic and social objectives, they have tended to have higher levels of associated risk than limit reference points. For example, a 70% probability of meeting target reference points is applied in the Tasmanian Southern Rock Lobster fishery (thus a 30% risk of not meeting the target reference point). This is not to say that achieving economic objectives is not important, however, there is greater scope to balance the risk in achieving these objectives than there is with achieving biological objectives. Establishing bounds of acceptable levels of risk in situations where assessments are not model-based, or rely on a 'weight-of-evidence' approach to estimating stock status, requires a more qualitative approach. In these cases, the historical performance of the fishery can be used as a guide to possible future outcomes (Prince et al. 2011; Hilborn 2002).

In the *Commonwealth Fisheries Harvest Strategy Policy* (Australian Government 2007), the acceptable risk levels apply to all stocks managed under harvest strategies and the onus is placed upon the fishery to demonstrate that the strategy meets the intent of the policy, even for data-poor species. In practice, this has either relied on a 'weight-of-evidence' approach (applied to risk) or in some cases generic management strategy evaluation has been used to show that the strategy ought to meet the risk criterion. A tiered approach is a useful way to deal with different levels of information and uncertainty in assessments, as used in the Commonwealth Southern and Eastern Scalefish and Shark Fishery (e.g. Smith et al. 2008). Each tier corresponds to a given availability of data and a method to assess status. The decision rules also vary across tiers, and should be selected at each tier to achieve the same acceptable level of stock risk. This inevitably means that tiers based on less certain information will need to be more precautionary in nature. More detail on AFMA's approach to tiered harvest strategies can be found at the website http://www.afma.gov.au/managing-our-fisheries/harvest-strategies/southern-and-eastern-scalefish-and-shark-fishery-harvest-strategy.

5.2.5 A monitoring strategy to collect relevant data to assess fishery performance

A monitoring strategy is needed to collect the data that will inform how the performance indicators are tracking relative to the operational objectives and reference points. The form of monitoring required will depend on the choice of indicators and reference points used in the harvest strategy, as well as the scale and intensity of the fishery.

All mortalities due to fishing should be recorded (i.e. catch, including discards). In most fisheries, logbook data will also record the effort associated with taking the catch, which allows analysis of catch per unit of effort (CPUE), often used as an index of relative abundance. In other cases, the composition of the catch (such as species, size, sex, age) will be recorded and provides useful information to assess change in stock status. Ideally, fishery independent surveys of abundance will be undertaken, but this usually only occurs in high value fisheries. The FAO Ecosystem Approach to Fisheries Toolbox Fact Sheet provides an outline of suitable monitoring strategies in different fishery situations (FAO 2011).

For fisheries that use economic objectives and target reference points such as MEY, economic data also need to be collected on a routine basis. Similarly, if social objectives are established data would need to be collected to measure performance against these objectives as well. Economic and social data are often considered too complex or expensive to collect. It should be noted that this is not necessarily the case as such data collection processes can be tailored to the resources that are available and economies of scale can be achieved by collecting the data through periodical surveys, as occurs in the Commonwealth and in South Australia (Schirmer and Casey 2005; FAO 2011; Econsearch 2013; Skirtun et al. 2013). There are also many effective proxies for economic performance that can be collected at negligible cost (Hundloe, 2000).

In fisheries with tradable quota units the profits are capitalised into the sale price of units and also revealed by trends in the lease price. Trends in gross value of product and major costs such as fuel and labour can also be easily tracked. It must also be noted that there are trade-offs involved; for example, sometimes lower cost performance indicators are less robust or less transparent to external observers, than higher cost ones. The costs of different monitoring options will be relevant to the choice of performance indicators. The level of acceptable risk determined, in relation to breaching reference points, will also influence the extent of monitoring required.

5.2.6 A process for conducting assessment of fishery performance relative to objectives

A fundamental aspect of a harvest strategy is that the management responds to changes in the status of the resource. This requires some form of stock assessment, which can range (depending on the scale of the fishery and data availability) from a full quantitative model-based assessment to simple tracking of an empirical indicator (such as CPUE or mean length of landed fish), with a wide variety of methods in between (Prince et al. 2011; Hilborn 2002). Refer to section 5.4.7 for further guidance on the use of empirical assessments.

Within the context of a harvest strategy, the main requirement of a stock assessment is that it estimates the status of a stock or fisheries management unit, relative to one or more reference points. These assessments will have different levels of precision and accuracy and it is important that this is factored into the selection of the performance levels that are used as limits and targets. It is also very important for an assessment to be able to estimate or describe the uncertainty in an assessment. There can be many sources of uncertainty in stock assessments, even for data rich fisheries, including observation error, process error and model error. It is important that the uncertainties are described, to inform managers using the assessment to make decisions.

The more uncertain the assessment of stock status, the more precautionary the reference points and decision rules should be to meet the required ‘acceptable level of risk’ to achieve the objective for the fish stock or fisheries management unit. This also allows choices to be made by the management authority and by fishers about the level of required investment in monitoring and assessment for a particular fishery. This is where the catch-cost-risk trade off needs to be considered (referred to in section 5.3.3). In general, higher investment in monitoring and assessment will allow higher catch levels to be maintained because the stock status, and it’s response to management, is being monitored with greater precision. The costs of different stock assessment options will be relevant to the choice of performance indicators and the acceptable levels of risk that are defined for the fishery.

5.2.7 Decision rules that control the intensity of fishing activity and/or catch

A critical step in the development of a harvest strategy is to determine harvest decision rules (sometimes called control rules) that are designed to achieve the operational objectives, such as having a high likelihood of maintaining stocks at or near the targets, and meeting the probability or risk requirements in relation to avoiding depletion to, or below, the limits.

Management decision rules should be pre-determined management actions linked directly to the biological, economic and social performance of the fishery, relative to reference points. The performance of the fish stock is determined from the assessment, which is in turn derived from analysis of the monitoring data. Put simply, harvest decision rules should work in such a way that a pre-determined management action (e.g. a quota/effort decrease or increase) is implemented promptly when a reference point is reached, as identified through the assessment. It should also be noted that decisions rules may link to a range of management responses, including for example, increased monitoring or data collection.

Harvest decision rules can take many forms and the form that best suits a particular fishery is best determined by stakeholders in that fishery (Deroba and Bence 2008). The more precise and accurate the indicator and performance levels are, the more precise the pre-defined actions can be (FAO 2011).

All processes to develop harvest strategies involve making decisions on trade-offs (Prince et al. 2011), with a bottom line of ecological sustainability. Such trade-offs are best determined using some form of management strategy evaluation (MSE), also known as harvest strategy evaluation, to ensure overall robustness of the harvest strategy. This can involve the informal qualitative consideration of each option by those involved in the management of the fishery using some form of 'expert judgement' or where there are sufficient resources and it is warranted, a number of more formal qualitative, semi-quantitative and quantitative (such as simulation modelling) evaluation methods are available (Fletcher et al. 2013) (see section 5.4.7). Decisions rules can be designed to form part of a tiered system for decision making, linked to reference points.

5.3 WHAT DESIGN PRINCIPLES SHOULD BE APPLIED WHEN DEVELOPING A HARVEST STRATEGY?

The National Guidelines provided in this report have aimed to cover all of the main issues and challenges encountered when developing harvest strategies in the diverse Australian fisheries context. Because of the dynamic nature of fisheries management, one size does not fit all and there will always be situations that do not fit within a set of guidelines. For this reason a set of design principles has been developed to promote a pragmatic and common sense approach to developing harvest strategies. The design principles listed below could be applied to any fishery management exercise and are not exclusive to harvest strategy development. The design principles listed in this section build on earlier work undertaken to establish the *Commonwealth Fisheries Harvest Strategy Policy and Guidelines* (Australian Government 2007) and guidelines developed for application in data-poor fishery scenarios (Dichmont et al. 2011). It is proposed that the following design principles should be applied to all harvest strategies, and the processes used to develop them:

- Consistent with legislative objectives, including the principles of ESD;
- Pragmatic and easy to understand;
- Cost effective;
- Transparent and inclusive;
- Unambiguous;
- Precautionary; and
- Adaptive.

5.3.1 Consistent with legislative objectives, including the principles of ESD

ESD is a common high level legislative objective across Australian fishery management jurisdictions and is also incorporated in the *Guidelines for the ecologically sustainable management of fisheries*, to support fishery assessment for export under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. In this context, Australian harvest strategies should adopt a holistic ESD approach, to incorporate the ecological, social and economic dimensions of fisheries management. The objectives and broad principles set out in the *National Strategy for Ecologically Sustainable Development*[3]) are as follows:

National ESD Strategy Objectives

- enhance individual and community well-being and welfare by following a path of economic development that safeguards the welfare of future generations;
- provide for equity within and between generations; and
- protect biological diversity and maintain essential ecological processes and life-support systems.

National ESD Strategy Guiding Principles

- decision making processes should effectively integrate both long and short-term economic, environmental, social and equity considerations;
- where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
- the global dimension of environmental impacts of actions and policies should be recognised and considered;
- the need to develop a strong, growing and diversified economy, which can enhance the capacity for environmental protection should be recognised;

[3] http://www.environment.gov.au/node/13029 .

- the need to maintain and enhance international competitiveness in an environmentally sound manner should be recognised;
- cost effective and flexible policy instruments should be adopted, such as improved valuation, pricing and incentive mechanisms; and
- decisions and actions should provide for broad community involvement on issues which affect them.

The *National Strategy for Ecologically Sustainable Development*[4] stipulates that these core objectives and guiding principles need to be considered as a package and that no objective or principle should predominate over the others. A balanced approach is required that takes into account all of these objectives and principles to pursue the goal of ESD. This said, jurisdictional legislation will determine the limits of what can be taken into account in applying ESD in each State or Territory. For example, in some jurisdictions the biological component is given higher precedence, either through legislation (e.g. see section 7(2) of the South Australian *Fisheries Management Act (2007)* or through case law findings.

5.3.2 Pragmatic and easy to understand

For harvest strategies to be effective, they need to be easily understood and accepted by fishers and key stakeholders. They also need to take into account the current context of a fishery and the data and information available to monitor and assess the fishery and the performance of the harvest strategy. This means that harvest strategies need to be adapted in a pragmatic way to suit the individual fishery context. As stated earlier, formal harvest strategies do not need to rely on the outputs of complex mathematical procedures or model-based stock assessments. In many cases, a harvest strategy can be just as effective, sometimes more effective depending on the fishery context, when based on a more empirical approach (Prince et al. 2011; Hilborn 2002). One of the reasons for this is that model-based stock assessments are often viewed by fishers and other key stakeholders as a 'black box' that is not well understood. Empirical approaches to harvest strategy development and stock assessment offer the potential to enhance engagement and ownership of key stakeholders in the development and implementation of harvest strategies, which ultimately improves their effectiveness. This is not to say that model-based approaches should be avoided. The key point is that model based approaches have certain applications, particularly in data rich situations, and one size does not fit all. However consideration still needs to be given to demonstrating that empirical harvest strategies are likely to comply with policy or risk requirements, and this may require quantitative methods such as MSE (see section 5.4.7) or other approaches such analysis of historical data sets to identify what may have happened if certain harvest strategies were adopted. For example, South Africa uses empirical harvest strategies (referred to as management procedures) for all its major fisheries, with inputs to the decision rules being current levels of abundance based on fishery independent surveys or in some cases CPUE. All of these harvest strategies are rigorously tested using MSE methods (Butterworth and Punt 1999).

5.3.3 Cost effective

Cost-effective management is a common objective included in most fisheries legislation, throughout Australia. Therefore, it is important that any fisheries management activities, including harvest strategy development, are conducted in a cost effective manner, taking into account the current data available for assessment, the level of uncertainty that exists over the status of the resource to be managed, the subsequent risk associated with existing harvest levels, the business and operating environment and, in particular, the profitability in a fishery. This is often referred to as the catch-cost-risk trade-off (Sainsbury 2005; Dowling et al. 2013).

[4] http://www.environment.gov.au/resource/national-strategy-ecologically-sustainable-development

The national ESD framework (Fletcher et al. 2002) outlined that where risks are low, only crude indicators of fishery performance may be needed, but where risks are higher and the management approach is more aggressive leading to a relatively higher exploitation rate, more robust and precise measures of abundance will be needed. The relative level of exploitation therefore needs to be commensurate with the data quality and where there is a mismatch either the level of exploitation needs to be reduced accordingly or the data quality must increase to an acceptable level. The decision on which of these is most appropriate will be based on whether the fishery can afford the increase. What this means in practical terms, is that when there is a high degree of uncertainty associated with the status of a resource (such as in data-poor fisheries) a more conservative harvest strategy should be adopted that sets lower catch or effort levels, designed to improve understanding of the resource (Fletcher et al. 2002; Sainsbury 2005; Dichmont et al. 2011; Dowling et al. 2008).

There may also be cases where there is a low degree of uncertainty over resource status but where the economic constraints in a fishery require that monitoring and assessment activities are less intensive and more cost-effective. In these cases, it is also appropriate to adopt a conservative harvest strategy because less monitoring is occurring.

Where a conservative approach is adopted in pursuit of cost-effectiveness, in either of these scenarios, less intensive monitoring and assessment may be required and the costs associated with harvest strategy implementation and application may be reduced. Conversely, where there is a low level of uncertainty over the status of a resource, harvest strategies can be more readily designed to achieve optimum utilization of fisheries resources, with a higher degree of confidence that the resource is not going to be put at risk of over-fishing. The trade-off with these strategies is that higher levels of monitoring and assessment is necessarily required, which will be associated with higher costs. This inevitably requires judgments to be made that relate to the catch-cost-risk trade-off (Sainsbury 2005). Ever-increasing precision and complexity may not always be worth the investment (Cochrane 2002).

Development of a harvest strategy should therefore involve careful analysis of the costs and benefits of alternative harvest strategies and explicitly recognize the ongoing and future data and monitoring requirements associated with a particular harvest strategy approach; for example, whether the harvest strategy is to be empirical or model-based. It should be noted that, regardless of the individual fisheries context and the harvest strategy approach to be adopted, there should be a high degree of probability that the harvest strategy will achieve the stated operational objectives for the fishery and thus be ‘effective’.

5.3.4 Transparent and inclusive

Transparency and inclusiveness is a principle that should be applied to all facets of fisheries management and should not be limited to harvest strategy development. The process used to develop harvest strategies and the steps involved in implementation and ongoing application should be transparent and involve fishers and key stakeholders that are affected by the harvest strategy. In simple terms, this requires consultation and full disclosure of information with fishers and relevant key stakeholders during the design and implementation process.

A common approach to achieve this outcome is through stakeholder based working groups that involve relevant key stakeholders in the design of harvest strategies from the beginning. Another important aspect that should be considered relates to the processes used to make decisions in line with the harvest strategies. Such decision making processes will be different in each management jurisdiction and may range from Ministerial decisions, to expertise-based board decisions, decisions of senior Government officials based on advice from management advisory committees, or possibly decisions by fishers or stakeholder groups under delegated co-management agreements. The important point here is that these processes must be transparently documented in the harvest strategy and communicated in a timely manner to relevant stakeholders.

Adopting transparent and inclusive processes to harvest strategy development, implementation and application will lead to stronger stakeholder understanding and ownership of the harvest strategy, and the outcomes of decisions made in line with them. This will ultimately ensure greater effectiveness of the harvest strategy in achieving the desired fisheries management outcomes. Actively involving fishers and other stakeholders can not only bring otherwise unavailable traditional and local knowledge to the process, but also gives legitimacy to rules governing fisheries in question and is more likely to result in management strategies that are respected and complied with willingly (Matic-Skoko et al 2011; Smith et al. 1999).

5.3.5 Unambiguous

The main purpose of harvest strategies is to provide for a structured decision making framework. Towards this aim, harvest strategies should avoid being ambiguous, to limit the scope for different interpretations of their application or meaning. This is particularly important when developing the operational objectives and decision rules. To the extent possible, all of the possible decision making scenarios that could emerge in a fishery, in its current or future state, should be considered during the design of the harvest strategy, to avoid unanticipated issues emerging. Of course it may not be possible to anticipate all of the possible scenarios that could emerge, but attempts should be made to contemplate all possible future scenarios.

Thorough evaluation and testing of the harvest strategy should limit the scope for this to occur and allow for most situations to be covered in the harvest strategy. It should be noted that there does need to be a balance between the harvest strategy becoming too rigid and not providing enough scope for adaptation to issues that cannot be anticipated, even though the most rigorous testing and evaluation processes have been applied. This is covered in more detail under the description of the 'adaptive' principle (see section 5.3.7).

5.3.6 Precautionary

The precautionary principle is embedded in most fisheries legislation in Australia, which in short, requires that if there is a threat of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason to postpone measures to prevent environmental damage. In the context of harvest strategy development, the precautionary principle helps to guide how risk is managed, particularly when a high degree of uncertainty exists or when stocks are being recovered from overfishing. The precautionary principle can also help to guide the development of limit reference points, as part of harvest strategies, to avoid the scope for fish stocks to become overfished. Section 5.2.4 should be referred to when defining acceptable levels of risk and potential use of tiered approaches.

There is an important link to be drawn here between the guidance provided by these National Harvest Strategy Guidelines and the National Fish Stock Status Reporting Framework, in relation to the way in which overfishing is defined. In assessing fish stock status nationally, the Status of Key Australian Fish Stocks Report (Flood et al. 2012) adopted 'recruitment overfished' as the biological limit reference point for determining whether or not a fish stock is overfished. Recruitment overfished was defined as *"the point at which a stock is considered to be recruitment overfished is the point where the spawning stock biomass has been reduced through catch, so that average recruitment levels are significantly reduced".* This is important to note because all harvest strategies and, in particular, limit reference points, should be designed to ensure that recruitment overfishing is avoided.

5.3.7 Adaptive

Adaptive management practices are well documented as a fisheries management tool (Hilborn and Walters 1992). For Australian Commonwealth fisheries, and for a number of State and Territory managed fisheries, harvest strategies are now central to the adaptive management process that constitutes fisheries management (Smith et al. 2013). A key function of harvest strategies is to provide for increased certainty and predictability in the management of fisheries. However, this must also be balanced with the need for flexibility to allow for changing circumstances and for new information to be considered (Hilborn and Walters 1992). To this end, the process and methodology described in these National Guidelines reflects an adaptive management approach.

Adaptive management loops are applied to a range of real-world problems. Sainsbury (2005) describes their core elements as:

(i) specification of measurable (operational) objectives,
(ii) monitoring of indicators and calculation of performance measures in relation to the measurable objectives,
(iii) management interventions triggered on the basis of the performance measures that are designed to correct departures from the intended objective, and
(iv) periodic review of the management strategy described by steps i-iii.

Experience world-wide has demonstrated that irrespective of the amount of prior testing of a harvest strategy (Smith et al. 2008), periodic amendments to ensure optimal decisions are being made are likely and indeed necessary. For example, when there is new information that substantially changes understanding of the status of a fishery, when problems are identified in application of the harvest strategy or when uncertainties that were not previously understood arise (Australian Government 2007).

One way to build in flexibility is to identify the 'exceptional circumstances' that may trigger departure from or even suspension of the harvest strategy. This is one way to allow flexibility in a structured way, but not so much flexibility that it undermines the intent of having a harvest strategy. In this sense, understanding the boundaries of flexibility in a harvest strategy is a part of the iterative process to develop mutual understanding among managers, fishers and stakeholders about expectations from adopting a formal harvest strategy. Specifically, this would include defining the exceptional circumstances that may trigger such a change.

Having flexibility to change the framework to deal with unforeseen circumstances should not be confused with flexibility in interpreting the results of assessments and applying the harvest decision rules within years, which will tend to undermine the process itself (Smith et al. 2008). A formal review of a harvest strategy should be planned and undertaken on an agreed time frame (for example, every 3-5 years). The key point here is that harvest strategies need to be adaptive enough to address deficiencies, unforeseen circumstances and to allow for improvements (Walters and Hilborn 1978), but should not be changed to relax or vary the harvest strategy when the decisions are not suitable to some, or all, stakeholders.

5.4 WHAT DESIGN PROCESS (KEY STEPS) SHOULD BE FOLLOWED WHEN DEVELOPING A HARVEST STRATEGY?

The earlier section on the key elements of a harvest strategy (section 5.2) provided definitions and descriptions of each key component of a harvest strategy. Using those key elements, this section aims to provide an overview of the key steps that should be followed, as a guide to help fishery managers, fishers and key stakeholders on the 'process' to develop a harvest strategy. These steps may vary depending on whether a management plan (or equivalent) already exists, the relevance of that management plan and the context of reviewing the management plan and/or harvest strategy.

The following key steps are suggested when developing a harvest strategy, noting that some steps may not be necessary if comprehensive arrangements already exist:

1. Define the fishery	• Define the fishery to which the management plan or management strategy applies
2. Engage stakeholders	• Establish a mechanism to engage stakeholders in the process
3. Legislation and policy	• Identify relevant legislation and over-arching policy objectives
4. Determine objectives	• Develop defined conceptual management objectives
5. Establish ESD Context	• Determine the ESD status and context of the fishery
6. Harvest strategy construction	• Build the techncial elements of the harvest strategy
7. Testing	• Test the robustness of harvest strategy
8. Review	• Periodic review and update the harvest strategy

5.4.1 Define the fishery to which the harvest strategy applies

Defining the fishery to which the harvest strategy will apply is a critical initial step in determining the scope of the harvest strategy to be developed. This step involves compiling and reviewing all available information on the fishery. Some of the information that should be considered includes:

- Identify the target species, geographical (management unit) and biological stock boundaries;
- Identify whether multiple jurisdictions need to be involved;
- Life history characteristics for each species;
- Determine all sources of mortality;
- Method of fishing such as gear type, vessel numbers and vessel type;
- Location of fishing, taking note whether there have been spatial changers over time;
- User groups, including any information on catch shares;
- Identify any ecological impacts caused by fishing, including any TEPS interactions;
- Identify any environmental effects on the fishery; and
- Existing management arrangements in terms of the management framework currently in use (whether input or outputs controls are used, including any spatial management), the jurisdictions involved, any regulations, compliance arrangements and what management levers can be used to constrain fishing mortality.

Note that much of this information will need to be considered during the step of determining the stock status and other ESD considerations for the fishery.

5.4.2 Establish a mechanism to engage stakeholders in the process

The first step in the harvest strategy design process should be to determine an appropriate mechanism to engage fishers and relevant key stakeholders in the design process. How this is done will need to be assessed on a case by case basis and will be influenced by the resources available and the existing institutional arrangements in each jurisdiction (e.g. whether or not management advisory committees are used). Experience nationally indicates that expertise based advisory committees, with fishery managers, scientists, fishers and relevant key stakeholders involved, work well to achieve the desired level of engagement and expert input. Experience would also suggest that, where resources permit, involving independent expertise in the process (from outside of the jurisdictional arrangements) can be very beneficial, particularly for transparency. The respective roles of fishers, key stakeholders and government need to be clearly stated for harvest strategy design processes to work. In particular, the protection of long term biological sustainability (through the setting of reference limits) is a core government responsibility whereas the definition of the economic and social benefits sought from the fishery, and therefore the setting of targets, heavily involve fishers and other key stakeholders.

5.4.3 Identify relevant legislation and over-arching policy objectives

It is important at the beginning of the process to identify the high level over-arching legislative and policy objectives that will influence and shape the nature of the harvest strategy for each fishery. These high level objectives need to be taken into account when developing the defined management objectives for each fishery (see next section).

These will, of course, be different in each jurisdiction. Some relevant examples of overarching legislation, policy and codes of practice to consider here include the fisheries and environment legislation in each jurisdiction, Commonwealth environment legislation (the *Environment Protection and Biodiversity Conservation Act 1999*), the UN Convention on the Law of the Sea (1982)[5], the UN

[5] http://www.un.org/depts/los/convention_agreements/convention_overview_convention.htm

Fish Stocks Agreement (1995), the, the National Fisheries By-catch Policy, the National Strategy for ESD, and the UN Food and Agriculture Organisation Code of Conduct for Responsible Fisheries.

5.4.4 Developing conceptual fishery management objectives

The formation of an effective harvest strategy depends heavily on having well defined conceptual fishery management objectives that will guide the overall outcomes that the harvest strategy will work to achieve. The conceptual objectives referred to here are specific to each individual fishery and sit above the operational objectives needed for the purposes of harvest strategy development. These conceptual objectives should clearly identify the species, fish stock or fisheries management unit that they apply to and need to be developed in the context of the existing fisheries legislation, over-arching policy objectives and any relevant ministerial directives. These conceptual objectives should be defined and agreed upon by the various stakeholders early on in the development of a harvest strategy because they directly influence the management options suitable for the fishery (Dowling et al. 2011). Where there are multiple user groups, the impacts these objectives will have on the outcomes that each user group aspires to achieve should be considered at the beginning of the harvest strategy design process.

5.4.5 Determining the stock status and other ESD considerations for the fishery

Determining the status of the fishery being managed is an important step in the harvest strategy design process because the operational objectives used could vary based on fishery or stock status. For instance, an overfished fishery is likely to require additional resources for stock assessment and have more restrictive decisions rules than for one that is under-fished. To ensure consistency amongst jurisdictions, the guidelines in the National Fish Stock Status Reporting framework (Flood et al. 2012) should be used to assess fishery biological status. To enable a harvest strategy to incorporate all aspects of ESD, the economic and social dimensions of each fishery should also be considered, where appropriate.

An effective way to establish the overall ESD status and context of a fishery is to use the national ESD reporting framework tool developed by Fletcher et al. (2002) to conduct an assessment of the ecological, economic and social risks to the fishery. Conducting an ESD risk assessment will assist to identify and prioritise the full suite of ecological, economic and social issues in the fishery and help inform harvest strategy development in the context of achieving ESD outcomes for the fishery. Whilst conducting an ESD risk assessment is not considered to be critical to developing a harvest strategy, it is recommended because it will facilitate a holistic approach to ensure the full set of ESD characteristics of a fishery are incorporated in the harvest strategy.

Conducting an ESD risk assessment will also ensure issues such as by-catch, by-product and broader ecosystem impacts including TEPS interactions are taken into account and, where necessary or relevant, built into the harvest strategy. It is important to note that while issues like TEPS interactions may influence harvest strategy design, they should not be considered a determining factor, as there are many ways in which such issues can be managed within the overall fisheries management system. Other factors may affect aspects of the management system and therefore what types of harvest strategies can be developed.

5.4.6 Building the harvest strategy

As stated previously in sections 5.2 and 5.3, the key technical elements of a harvest strategy form an integrated package and should be developed together to create a formal structured decision making framework. This section should be read in conjunction with these sections and aims to provide further guidance to the ‘process’ of constructing the key elements of a harvest strategy.

Developing operational management objectives

As stated previously in section 5.2.1, conceptual fishery management objectives need to be translated into operational objectives, which are very precise and are formulated in such a way that they should be simultaneously achievable in an individual fishery. To be effective, operational objectives should be consistent with higher level legislative and conceptual fishery management objectives and be clearly linked to performance indicators and reference points.

Often, a particular reference level of a performance indicator can be translated directly into an operational objective. Establishing linkages between the operational objective, performance indicator and reference point in this way, helps to ensure that the performance of the fishery can be measured and audited against the operational objectives. Examples that show how a defined conceptual management objective is translated into an operational and measurable objective for many types of fisheries are presented in the National ESD Reporting Framework for Australian Fisheries: The How to Guide for Wild Capture Fisheries (Fletcher et al. 2002; 2003).

Another example is illustrated in the *Commonwealth Fisheries Harvest Strategy Policy* (Australian Government 2007). The Policy has a defined conceptual management objective stating that *"The objective of this policy is the sustainable and profitable utilisation of Australia's Commonwealth fisheries in perpetuity through the implementation of harvest strategies that maintain key commercial stocks at ecologically sustainable levels and within this context, maximise the economic returns to the community."* This conceptual management objective is translated into an operational management objective to *"maintain fish stocks, on average, at a target biomass point (B_{TARG}) equal to the stock size required to produce maximum economic yield (B_{MEY})."* This more specific objective operationalises the conceptual management objective in the policy and allows the achievement of the policy objective to be measured.

Developing performance indicators, reference points and acceptable levels of risk

The indicators and reference points selected for a particular fishery and stock will be largely determined by the availability of information to inform stock status. This will depend on both availability of past data, but also on decisions made about future monitoring and assessment methods to be used in the fishery, noting the 'catch-cost-risk' trade-off inherent in such choices (Fletcher et al. 2002; Sainsbury 2005). The performance indicators that are chosen should have a high chance of being able to monitor the extent to which the objectives are being achieved.

Importantly, the development of indicators and reference points is an iterative process. There will often be a range of available indicators and reference points and the choice of which to use will be influenced by the relative costs of data collection and stock assessment. Harvest strategies should be designed to meet the probability and risk thresholds specified in the over-arching policy or management plan governing management of the fishery, regardless of the level of uncertainty of assessments. This is an explicit recognition of the need for precaution in the face of uncertainty. In general terms, it requires that increasing assessment or management uncertainty will be mitigated by reducing exploitation rates.

The acceptable levels of risk determined (of breaching a reference point) will, in part, be influenced by the costs associated with different stock assessment options. In general, harvest strategies that adopt higher levels of risk should adopt higher levels of monitoring and more regular assessment, which inherently involves higher costs. Therefore, in a cost-limited context, a more cautious strategy should be adopted.

Developing the monitoring and assessment system and the decision rules

There will often be a range of available data collection, monitoring and stock assessment methods to consider when developing the harvest strategy. The right option will require judgement on a case by case basis to suit the individual fishery needs and will be influenced by the available data, future needs and the relative costs associated with the different methods. As noted in section 5.2.7, decision rules can take many forms and need to be part of the overall package. The decision rules are linked directly to the reference points and are dependent on the monitoring and assessment strategy that is chosen. These choices need to be quite pragmatic and take account of the design principles listed in section 5.3. As noted earlier, it is very useful to consider a range of alternatives, and undertake some evaluation prior to implementation.

5.4.7 Testing the robustness of a harvest strategy

In recognition of the inherent uncertainty in knowledge of the past and current status of fish stocks or fisheries management units, and their response to different levels of harvest and their current and future productivity, an evaluation of the likely performance of any proposed harvest strategy to achieve operational objectives should be undertaken prior to implementation (Davies et al. 2007). Such testing is particularly important when information is incomplete and imprecise, and when the relationship between the harvest decision rule and management actions is complex (Davies et al. 2007).

There are various quantitative, qualitative, empirical and experiential methods available to undertake an assessment of whether the harvest strategy is likely to be appropriate. Such assessments are often called management strategy evaluation (MSE). The most complex method is to use a simulation model to represent the assumed underlying dynamics of the resource and generate future data to evaluate how different harvest decision rules will impact on the future fishery performance (e.g. Punt et al. 2002; Punt et al. 2012) by comparing the relative performance of possible alternatives (commonly done by Monte Carlo simulation modelling). The MSE allows explicit calculation of the probability of breaching reference points, even for stocks where current biomass cannot be calculated (Australian Government 2007).

An evaluation of a harvest strategy need not just be simulation based. More qualitative methods can also be applied, and 'empirical' tests can also be undertaken to evaluate scenarios such as 'what if' the harvest strategy had been applied in the past, given the history of stock status observed (see Smith et al. 2004; Prince et al. 2011) or how well the approach worked in the past, in the fishery being assessed, or in other similar fisheries. The focus of the evaluation is to identify whether the proposed harvest strategy is likely to be suitably 'robust' based on known and plausible sources of uncertainty in the status and dynamics of the fishery. In other words, it provides a basis to identify the strategies that are most likely to meet objectives in spite of the uncertainty in the status and dynamics of the fishery and its response to different levels of harvest and management (Davies et al. 2007; Prince et al. 2011).

5.4.8 Periodic review

To ensure the harvest strategy is up to date and takes into account the best available information, knowledge and understanding of a fish stock or fishery management unit, a regular periodic review should be undertaken and a timeframe for such review should be established in the harvest strategy (e.g. every 3-5 years). This is covered in more detail in section 5.3.7, which describes the need for an 'adaptive' approach.

5.5 WHAT CONSIDERATIONS SHOULD BE TAKEN INTO ACCOUNT FOR SPECIFIC FISHERY SCENARIOS?

To date, most formal harvest strategies in Australia have typically been developed and applied to high value, data-rich fisheries (Dowling et al. 2008). To a certain extent, this reflects the challenges (some perceived and some real) faced by fishery managers when developing harvest strategies in other situations such as in data-poor fisheries, recreational fisheries and multi-jurisdiction fisheries etc.

Whilst the basic design characteristics (the key elements) of a harvest strategy are the same for any fishery, it is very important to identify the specific issues that need to be considered when applying the National Guidelines to a specific fishery and to tailor the harvest strategy to suit the specific fishery being managed.

To help support the development of tailored fishery-specific harvest strategies, the following set of considerations has been developed to assist fishery managers, fishers and key stakeholders to develop fishery harvest strategies in the following specific fishery scenarios, particularly where challenges or complexities may have created barriers to their development and implementation in the past. These include:

- Multi-jurisdictional fisheries;
- Recreational fisheries (including as part of multi-sector fisheries);
- Customary/ cultural/ traditional fisheries;
- Multi-species fisheries;
- Data-poor fisheries;
- Fisheries based on fluctuating stocks (includes regime shifts, climate change, environmental flows and estuarine fisheries, highly productive stocks etc.);
- Multi-gear fisheries;
- Enhanced fisheries;
- Keystone species;
- Exploratory and Developing fisheries;
- Fisheries based on low productivity species;
- Spatially structured fisheries; and
- Fisheries recovering from overfishing or unfavorable environmental conditions.

Note that the following considerations do not provide an exhaustive list of all considerations, but aim to capture key issues specific to each fishery scenario.

5.5.1 Multi-jurisdictional fisheries

For migratory fish that cross international or state jurisdictions or fish that occur as straddling stocks, one of the greatest management needs is collaborative action to regulate fisheries and maintain stocks. The effectiveness of governance structures at facilitating management of trans-boundary stocks depends on strong collaboration between management jurisdictions. As with all fisheries, effective management requires reliable information on life history and migratory behaviour, information on the relationship between fish ecology and fisheries production, an appreciation of the value of fisheries and other ecosystem services and capacity to predict how management measures will impact fish stocks. In this sense, many of the obstacles to effective management and conservation (e.g. lack of data on life history, general difficulty of study, and lack of appreciation of the value of fisheries) reinforce one another, illustrating the challenges ahead and the need to confront these issues in a comprehensive manner whenever possible. In the absence of effective regulation, trans-boundary or migratory fish may be particularly susceptible to overfishing. Trans-boundary governance and cooperation are therefore needed.

In the case of highly migratory stocks, there is an interaction between the technical validity of the use of the reference points and the geographic/stock scale at which they are applied. In brief, MSY is a 'whole stock' concept that is largely meaningless at a scale of less than an entire reproductive population. Hence, if harvest strategies are developed for a regional scale, consideration needs to be given to the usefulness of reference points, based on estimates of B_{MSY} or F_{MSY} from a global assessment in a harvest strategy for a regional component of the overall stock. When developing harvest strategies for shared/straddling stocks, the collaboration across jurisdictions to enhance stock management and data sharing needs to be considered.

The following are useful considerations in developing harvest strategies for straddling and highly migratory fish stocks:

1. Establish consistent common objectives across jurisdictions for shared stocks:
    a. Biological – develop common biological objectives and limit reference points (e.g. the National Fishery Status reporting project has agreed that the biological limit reference point should be linked to recruitment overfishing, which implies a common objective of avoiding recruitment overfishing).
    b. Economic and social – be explicit about what these are for each jurisdiction and understand how they impact on each other (note that there may be particular difficulties associated with developing common economic and social objectives across jurisdictions).
2. Establish formal catch sharing arrangements, where possible.
3. Establish cross-jurisdictional mechanisms (a recognized forum) to facilitate discussions on fisheries management (and assessment) of straddling stocks across jurisdictions and to develop shared objectives and ensure that impacts on other jurisdictions are being considered in management decisions.
4. Where possible, management arrangements should be consistent across jurisdictions (e.g. recreational bag and boat limits, input or output controls, etc).
5. Establish consistency in the data collected and used.
6. Establish consistency in the assessment process used to evaluate fishery performance against common objectives and reference points. It would be ideal to periodically conduct a joint assessment for the stock, unless there are strong justifications for this not to be the case.
7. Explicitly consider cost when considering harvest strategies across jurisdictions and the benefits of uniformity across jurisdictions.

5.5.2 Recreational fisheries (including as part of multi-sector fisheries)

A harvest strategy for a recreational fishery is essentially the same as for a commercial fishery but it may need to be structured around having less quantitative information because in most jurisdictions around Australia there is often a lack of current and reliable data on the total catch and effort of recreational fisheries (such as participation rates, catch estimates, etc.). Importantly, the biological objectives and limit reference points for a recreational fishery should essentially be the same as would be used for a commercial fishery, particularly in the multi-sector fisheries context. Importantly, many species targeted by recreational fishers are also caught commercially and, more generally, multi-sector fisheries need special consideration in developing harvest strategies as the management tools used often differ between sectors. Recreational fisheries may, however, have other management objectives and the focus of any targets in the harvest strategy may need to differ depending on whether the fishery is for purely recreational, trophy or subsistence purposes.

Catch and effort data for recreational fisheries are typically difficult to collect (due, for example, to a high diversity in participants, species targeted, areas fished), are not collected on a regular basis and tends to be less precise than data from commercial fisheries. However, for many of Australia's recreationally fished species, surveys of catch and effort have been undertaken and levels of uncertainties (standard errors) have been quantified, and these now accompany their catch and effort estimates. Furthermore, for multi-sector fisheries where there is a significant commercial

component, monitoring and assessment of commercial data may provide a sufficient understanding of stock dynamics to inform the harvest strategy for the recreational component of the fishery. The upshot of having less data is that harvest strategies for recreational fisheries should incorporate the estimates available, but need to be innovative to deal with the shortcomings – for example, decision rules may need to operate on a multi-year basis rather than assuming annual adjustments; and novel approaches to data collection may be developed.

The measurement of biological sustainability for recreational fisheries is typically measured by estimates of biomass (such as using catch rate as a proxy) or egg production, similar to commercial fisheries. Indicators of a change in catch composition (e.g. using length-frequency sampling) could also be considered, particularly as data collection could be more focused and therefore affordable. Measuring economic benefits on the other hand requires different methods because the goal is to increase utility or enjoyment rather than financial profit. There are standard methods for surveying recreational fishers to measure utility that are comparable to measuring profit in commercial fisheries. A proxy is the use of satisfaction surveys, which include catch rates, time spent fishing recreationally and catch levels. It should be noted that a common mistake in the discussion of recreational benefit is to equate total benefit with total expenditure – the services and goods purchased by this sector (Hundloe, 2004). An important step in designing a recreational fishery harvest strategy is translating measures of utility or satisfaction into catch-related operational objectives and measurements. One simple approach is use strike rates as targets, which is conceptually similar to using catch rate targets.

The following are useful considerations in developing harvest strategies for recreational fisheries (including as part of multi sectors):

1. Establish clearly articulated and measurable objectives that are tailored to the recreational sector that do not clash with objectives for other sectors. In general, maximum sustainable yield is appropriate for subsistence fishing while maximum recreational utility (e.g. measures of aggregate satisfaction with the fishing experience) is appropriate for others. Where possible, translate the broad objectives into simple operational objectives in terms of measures such as strike rate or catch rate.
2. If the recreational sector is one part of a multi-sector fishery, the process of articulating the objectives needs to be undertaken for each sector at the same time so that the objectives determined are compatible and not in conflict.
3. The objectives of different sub-sets of stakeholders in recreational fisheries can also differ and these differences need to be reconciled in the process. Fishery managers need to consider how to incorporate the range of stakeholder views into the design process. Recreational surveys consistently show that the majority of the catch is taken by a small percentage of ‘avid’ anglers who may have quite different objectives to the majority of anglers. For example, recreational fishers who fish mainly for pleasure, have diminishing marginal utility with catch, which is to say they receive less benefit from the last fish caught than from the first fish. This affects the development of performance indicators and reference points for this group and means for them that strike rate would be weighted higher than total catch.
4. One way of bringing the diversity of objectives together into something measurable is to use recreational utility as a performance indicator – recreational utility is maximised by a large number of recreational fishers having an enjoyable fishing experience. The measurement of a recreational fisher’s enjoyment is related to whether the fishing trip was successful, the strike rate and the size of the fish, etc.
5. The harvest strategy will vary depending on whether the recreational sector is the only sector accessing the stock/species or if the stock/species is accessed by multiple sectors. Recreational-only fisheries will require a more tailored harvest strategy development process, in part, because performance indicators from other sectors can’t be used (e.g. commercial catch rate as an index of abundance).

6. Allocation between fishing sectors assists the development of harvest strategies for recreational fisheries.
7. Given that recreational fishery data tends to be less available than for commercial fisheries, the development of recreational harvest strategies may also involve initiating data collection programs. Novel approaches to data collection may be developed.
8. If the fishery is multi-sector, biological limit reference points for the recreational fishery can be established based on data collected in the commercial fishery.
9. Given the diversity of interests in the recreational sector, harvest strategies may need to avoid technical complexity to encourage community ownership. As with commercial fisheries, performance indicators that relate directly to fishing, and the decisions that flow from measuring those indicators, are more likely to be supported by fishers than indirect and technically complex indicators.
10. Decision rules for recreational fisheries may be process-based – they trigger a process of review to decide on the best response to the reference level being breached, rather than prescribing specific actions. The decision rules are likely to link to a range of management tools that may be used to adjust effort and/or catch including bag limits, size limits, spatial and temporal closures and the process will determine the most appropriate mix of tools in the circumstances to achieve the specified adjustment.

5.5.3 Customary/cultural/traditional fisheries

Customary/cultural/traditional fisheries are often part of multi-sector fisheries. The ability to quantitatively analyse the extent of the take of most species for customary, cultural or traditional purposes is limited because indigenous people may partake in both recreational and fishing for customary, cultural or traditional purposes and the extent of fishing for each of these purposes is generally not well reported. It is important to recognise that customary rules for fishery management are common, such as thresholds at which fishing is initiated or stopped in an area or for a species, and these rules can be as basic harvest strategies.

In the past, fishing for customary, cultural or traditional purposes was derived from estimates of the recreational fishing take out of necessity due to the lack of data. Fishing for customary, cultural or traditional purposes is separate and additional to the recreational catch and therefore requires a separate allocation of the resource and consideration when developing a harvest strategy. In Western Australia, the allocation of the western rock lobster resource for customary, cultural or traditional purposes is considered by the Government to have priority over the commercial and recreational allocations (Western Australian Department of Fisheries (2010). The way that fishing for customary, cultural or traditional purposes is defined and allocated is subject to the legislation in each jurisdiction.

The following are useful considerations in developing harvest strategies for customary/cultural/traditional fisheries:

1. A customary/cultural/traditional fishing allocation should be dealt with before establishing a harvest strategy, so that the harvest strategy can work to meet the allocation. Note that this is not likely to be necessary in jurisdictions where the customary catch is given primacy in legislation over the catch of other fishing sectors.
2. Customary/cultural/traditional issues are often covered in a management plan but may not need to be considered in the harvest strategy for the fishery itself, particularly if the level of take is negligible.
3. Need to establish if the traditional Indigenous sector is the only sector accessing the stock/species or if the stock/species is accessed by multiple sectors. If it is the latter, the considerations in relation to multi-sector fisheries in the section above also apply. Customary/cultural/traditional-only fisheries will require a more tailored harvest strategy development process.

4. Need to work closely with the Indigenous community on how they want to manage the share and what objectives should be established.
5. Need to specifically consider cultural, educational, community awareness elements.
6. Need to consider the specific and unique data needs and establish tailored data collection methods.
7. Highly technical harvest strategies are unlikely to be necessary for customary fisheries, where harvest levels do not threaten sustainability and the primary objective is to manage to a total catch allocation.
8. Retro-fitting management arrangements to fit cultural fishing is inappropriate; rather recognition should be given to the fact that cultural fishing took place before any other type of fishing.
9. Cultural, educational and community awareness are the core elements in developing harvest strategies for customary/cultural/traditional fisheries.
10. If the level of take by this sector is very low, it is questionable whether limit reference points and performance indicators need to apply.

5.5.4 Multi-species fisheries

Many types of fishing gear such as trawls, longlines and gillnets) catch a range of species, some of which are target species, while others are retained but of less commercial importance (by-product) and some generally discarded (by-catch). The main challenge with multi-species fisheries management is to ensure that all species caught are fished sustainably and not just the target species. This is difficult to achieve because each species has different life-history characteristics and productivities, and also different susceptibility to being caught by the gear. Also, in many cases it is not possible to separately target individual species, so that protecting less productive species may limit fully exploiting more productive species. In addition, there is often little information available on by-product species (see problems inherent in data-poor fisheries). Nevertheless, by-product species should be considered in developing a harvest strategy because they contribute to the total commercial value of the catch and they can be vulnerable to overfishing. Such species may need to be considered separately in the harvest strategy because of the different data available and the different management objectives that apply. Western Australia deals with this issue using selected indicator species that define the risk status for the entire suite (Western Australian Department of Fisheries 2011).

While there is a significant degree of targeting involved in multi-species fisheries, the majority of target species will not always be caught during an individual set of the fishing gear, and the species composition of the catch may be spatially or temporally specific. The key steps in this process will involve establishing the performance measures for total catch, whilst still taking into account the status of each individual species. This could focus on maximising the value of the total catch. While simple in theory, this will be a complicated issue to resolve given the variation in value, costs of fishing for and dynamics of the different target species.

There are two other important issues that need further consideration. Firstly, a threshold level of catch and/or effort under which the harvest strategy is not invoked, and secondly, the challenge to define rules to deal with ‘by-catch TACs’, where recommended biological catch is zero (stocks are below limit reference points).

The following are useful considerations in developing harvest strategies for multi-species fisheries:

1. Establish which of the multiple species the harvest strategy applies to and which species it does not apply to.
2. Establish a consistent process to set target and limit reference points for species that have different susceptibilities to gear and fishing pressure.

3. Explicitly consider and address likely perverse incentives for discarding and/or high-grading.
4. Target reference points may be established for a subset of the species but limit reference points should generally apply across all the species in the fishery.
5. Consider grouping species together that are caught by common gear-types.
6. Establish the harvest strategy to manage/protect the lowest-productivity or most vulnerable stocks in the fishery.
7. Fishery independent monitoring may be more important in these types of fisheries due, for example, to differential targeting and avoidance behaviours.
8. Harvest strategies will vary among species depending on what the principal management tool is being used is (e.g. quota) and the differing species productivity and susceptibility to the fishing gear.
9. Total abundance is not always the best indicator to use when setting limit and target reference points.
10. Consider whether social and/or economic objectives should be established for each species or the fishery as a whole.
11. Optimising a multi-species group will involve (at least) modifying the target reference points from their 'single species' optima. In general, the target reference point would need to be modified but the limit references points would not (without very sound justification).
12. Gear types will often determine the target and limit reference points being established.
13. A harvest strategy doesn't have to apply to all species in a fishery and the species it does apply to may change over time.
14. Decision rules need to take in to consideration the flow-on effects to other species and the potential changes and influences on fishing behavior that may arise from application of species-specific decision rules.
15. It is useful to consider tiered harvest strategies in multi-species fisheries.

5.5.5 Data-poor fisheries

The term 'data-poor' is a relative term and can cover a range of conditions. For the purposes of the National Guidelines, data-poor fisheries are typically characterised by the following (Dichmont et al. 2011):

1. Classic (quantitative) stock assessment models are unable to be used, for reasons either of data availability, data quality and/ or analytical capacity;
2. A large uncertainty in the status and dynamics of the stock due to poor data;
3. uncertainty in the nature of fishing (e.g. in terms of fleet dynamics and targeting practices); or
4. Have a low gross value of production (GVP).

The development of harvest strategies for data-poor fisheries represents a significant challenge, that of reconciling available information and capacity against a formal and defensible harvest strategy that achieves the desired objectives for the resource and fishery (Dichmont et al. 2011; Dowling et al. 2011). The challenge, therefore, is developing harvest strategies that reconcile the reality and limitations of these fisheries with fishery objectives or policy. These objectives may include, but are not limited to, ceasing or avoiding overfishing, rebuilding overfished stocks and maintaining stocks at some target level (Bence et al. 2008). These objectives all imply some knowledge of the stock size or biomass (relative or absolute). However, a difficulty in managing by biomass-based decision rules is that, while the intention is to constrain risks to the stocks through fishery management, stocks often do not have adequate data and/or capacity to be managed in this way.

Data-poor fisheries should be managed cautiously because there is generally little known about the size of the stock, stock productivity or stock status. Explicit fishing down phases should be avoided because these are unsustainable in the long-term and result in a build-up of fishing capacity that often cannot easily be re-directed. The combination of poor information, high pressure and

overcapacity frequently results in targets being overshot, particularly for low productivity species. Management approaches based around empirical harvest decision rules are beginning to be accepted in a growing range of data-poor fisheries (Davies et al. 2007; Dowling et al. 2008; Dichmont and Brown 2010). There has also been some theoretical work done on the relative robustness and particular sensitivities associated with the different types of empirical indicators (Smith et al. 2009; Punt et al. 2002; Dowling et al. 2011). Dichmont et al. (2011) developed a set of guidelines for harvest strategy development in data-poor situations, which should be referred to when developing harvest strategies in this fishery scenario.

The following are useful summary considerations in developing harvest strategies for data-poor fisheries:

1. Risk should be reduced in data-poor fisheries, by limiting fishing intensity to conservative levels.
2. A cost-catch-risk analysis is required, where explicit consideration should be given to the trade-off between the intensity of monitoring, the level of harvest and the risk to the stock.
3. Where conservative trigger levels for catch or effort are exceeded, additional data should be collected at a level appropriate to inform both current and likely future assessment and harvest strategy needs (this requires that some mechanism for monitoring mortality is adopted).
4. A risk-based approach is required when 'developing' data-poor fisheries (i.e. one that is based on species productivity and susceptibility to fishing rather than on quantitative stock assessment).
5. A tiered/stepped approach to developing data-poor fisheries is required. The harvest strategy should specify the timeframes for the different phases of fishing.

5.5.6 Fisheries based on fluctuating stocks

Some short lived species have stocks comprised of one (e.g. squid) or very few year classes (e.g. prawns and sardines), whose stock abundance may vary an order of magnitude on an annual basis depending on the recruitment success in a particular year. For these types of species, it is important to develop a harvest strategy that meet the probability and risk thresholds specified in the management plan or overarching policy, regardless of the level of fluctuations. A number of adaptive management approached may be used to deal with this (Australian Government 2007).

The following are useful considerations in developing harvest strategies for fisheries based on fluctuating stocks:

1. The reason the stock fluctuates needs to be considered when developing objectives and targets for fluctuating stocks (e.g. climatic and environmental factors).
2. In general, it is more important to conduct fishery independent surveys of biomass to enable an understanding of the fluctuations in stock size and limit the risks of fishery-driven stock declines.
3. Interpretation of limit reference points is more crucial than normal; need to clarify when a closure of the fishery is necessary.
4. In setting objectives for these stocks consider the risk weighted trade-offs of highly variable catches vs stable, but lower catches.
5. Explicitly consider how to react to stock fluctuations when predictive capacity is poor.
6. Highly migratory stocks should also be considered as 'fluctuating stocks'.
7. Standard benchmarks might not be applicable for fluctuating stocks.
8. Consider use of pre-season surveys to provide estimates of abundance to which the decision rule is applied.
9. Consider establishing within season monitoring processes and management triggers.
10. Consider allowing a set number of spawning events prior to harvest.

5.5.7 Multi-gear fisheries

Many species are caught by a variety of gears and all sources of mortality should be accounted for in assessments. Where the gears occur in different fisheries, different jurisdictions, or overlap international fisheries, special considerations arise in developing harvest strategies. Apart from allocation issues, management measures should be harmonized, and ideally a single harvest strategy should apply across all fleets. Where a species is taken predominantly by one fishery and is only caught incidentally in others, the harvest strategy might apply only to the main fleet, so long as measures are in place to prevent increased targeting and manage mortality from the subsidiary fleets. In a general sense, many of the considerations that apply to multi-species fisheries apply to multi-gear fisheries, however, there are some specific issues that need to be considered.

The following are useful considerations in developing harvest strategies for multi-gear fisheries:

1. Consider all sources of mortality.
2. Consider the different life stages that different gear types target.
3. May need to adopt more precautionary reference points and decision rules where 'refugia' effect from a particular gear type or types is diminished by the use of multiple gears.
4. Similar considerations to multi-species fisheries.

5.5.8 Enhanced fisheries

Enhancement of fisheries involves the addition of animals or habitat to increase production. In some cases it is used to recover depleted populations that are below limit reference points, in which case the harvest strategy is identical to that for standard fisheries. In other cases, enhancement is used to increase production above what could be achieved otherwise. Enhancement has been considered in Australia within harvest strategies for sea-cucumber, abalone, rock lobster and inland freshwater species such as Murray cod and golden perch. In these cases the limit reference point was not adjusted but the target reference point or harvest was shifted higher to account for the increased productivity.

The following are useful considerations in developing harvest strategies for enhanced fisheries:

1. Establish and assess the status of the wild stock as well as the enhanced stocks.
2. Establish the objectives for the enhanced stocks as distinct from the wild stocks.
3. It may be important for the fishery assessment to include a cost/benefit analysis of the enhancement activity.

5.5.9 Fisheries based on ecologically important species

An ecologically important species is a species that has a disproportionately large effect on its environment relative to its abundance. Such species play a critical role in maintaining the structure of an ecological community. They affect many other organisms in an ecosystem and help to determine the types and numbers of various other species in the community.

Examples include small pelagic species such as sardines and anchovy that are near the base of the food chain and are eaten by many higher-trophic level species. Other examples include key predators (such as rock lobsters in some, but not all ecosystems), whose depletion can sometimes cause cascading effects in the food chain. The following are useful considerations in developing harvest strategies for fisheries based on keystone species:

1. The impact of fishing keystone species on other species in the food web or ecological community needs to be considered explicitly. In such circumstances the limit or trigger reference points may need to be increased (and mortality reference points decreased) to take into account the importance of a particular species to the maintenance of the food web or ecological community.
2. Risk to the ecosystem should be reduced in fisheries based on keystone species, by limiting fishing intensity and limit reference points to conservative levels.

5.5.10 Exploratory and developing fisheries

The main challenges faced by exploratory and developing fisheries are in many instances similar to those that are faced in data-poor fisheries – in essence that data is lacking to inform management decision making. Indeed, most exploratory fisheries are conducted specifically to collect data and to find out more information to inform decisions about whether a fishery resource can support a particular type of fishing activity – usually commercial. Developmental fishing activity usually follows a phase of exploratory fishing and is designed to develop a fishery, its infrastructure, markets and management arrangements, etc.

A key challenge in exploratory and developing fisheries is the lack of knowledge and certainty over the resource upon which the fishing activity is based and the overall business risk that fishers have to take when investing in an exploratory or developmental fishing activity. For this reason, harvest strategies for exploratory and developing fisheries must explicitly consider the risk/catch/cost trade-off. It is important that harvest strategies for these fisheries are sufficiently precautionary so as not to put the resource at risk or lead to over-capitalization. They also need to be flexible enough to allow for the fishing activity to collect sufficient data to test assumptions about resource distribution, abundance, resilience and its response to fishing pressure.

The following are useful summary considerations in developing harvest strategies for exploratory and developing fisheries:

1. The management objectives should be developed to specifically address the exploratory or developmental phase of the fishery.
2. The focus of fisheries management (and thus the management objectives) should be on collection of sufficient data to improve the reliability of scientific and economic assessment and to inform future management decisions.
3. The harvest strategy should be designed to ensure that there is a low risk that the intensity of fishing pressure determined will lead to overfishing or over-capitalization.
4. Risk to the fish stock or fisheries management unit should be reduced by limiting fishing intensity to precautionary levels.
5. It may be appropriate to establish conservative trigger catch or effort levels that require a review of management, monitoring or assessment arrangements.
6. Explicit consideration should be given to the trade-off between the intensity of monitoring, the level of harvest, the risk to the stock and the cost of the program to those fishers willing to invest in undertaking the exploratory or developmental activity.

5.5.11 Spatially structured fisheries

Many fisheries are spatially structured so that the status of the fishery can vary from region to region. This can occur where recruitment is patchy (e.g. scallops), where larval dispersal is limited (e.g. prawns and abalone), where habitat is patchy (e.g. abalone) or through regional differences in productivity (e.g. growth of rock lobsters or abalone). A challenge in these fisheries is balancing the need for management at small spatial scale against the pragmatic need to have harvest strategies based on reasonable sets of data and applied over an enforceable scale of areas. There is also the problem of dealing with spatial structure within a management area, such as where abalone sub-populations grow too fast to receive protection from size limits that are suitable for the wider area.

The following are useful considerations in developing harvest strategies for spatially structured fisheries:

1. Objectives should be consistent across the wider fishery but separate reference points are typically required for the smaller spatial scales.
2. Risk to the fishery should be reduced by basing the harvest strategy on the biology of the most vulnerable sub-population in the fish stock or fisheries management unit, rather than on the average biology across the fish stock or fisheries management unit.
3. Spatial management ideally places greater weight on protection of reproductive output in areas more important as larval sources.

5.5.12 Fisheries recovering from overfishing or unfavourable environmental conditions

Harvest strategies should deal with all situations, including where the stock becomes depleted through overfishing or unfavourable environmental conditions, or a combination of both, and needs to be recovered. Nonetheless, it is included here specifically because, in each of these instances, a stock rebuilding strategy will be necessary to rebuild the stock above the limit reference point and allow targeted fishing again. This rebuilding strategy is separate, but complementary, to the existing harvest strategy for that stock and is likely to require additional resources for monitoring and stock assessment. It is important that realistic timeframes are set for stock rebuilding against which the performance of the rebuilding strategy can be measured. Consideration should be given to whether fishery independent surveys are required, or practical, when targeted fishing is prohibited. The impacts of such surveys on stock recovery, and how fishery independent data can be interpreted against fishery dependent time series, should also be considered.

6. CONCLUSIONS

All three objectives of the project were achieved.

The first objective of the project was to undertake a review and analysis of the present situation of harvest strategies in Commonwealth and State-managed fisheries. This objective was met through the qualitative audit of all Australian fisheries management jurisdictions provided in section 5.1.3 of the report.

The second objective of the project was to develop a common definition for nationally consistent harvest strategies. This objective was met through the development of a national definition for harvest strategies, provided in section 5.1 1 of the report.

The third objective of the project was to develop an agreed set of over-arching principles for harvest strategies across Australia. This objective was met through the development of the following components of the national guidelines outlined in the report:

- Harvest strategy key elements (section 5.2) ;
- Harvest strategy design principles (section 5.3);
- Harvest strategy design process (section 5.4); and
- Harvest strategy considerations for specific fishery scenarios (section 5.5).

Harvest strategies are considered to represent a best-practice approach to fisheries management decision making, as evidenced by their wide use internationally and throughout Australian fisheries management jurisdictions (FAO 2011; Smith et al. 2013; McIlgorm 2013).
The National Guidelines have been designed to provide practical assistance to fisheries management agencies in the development of fishery-specific harvest strategies and to help ensure that a common approach is applied across fisheries throughout Australia. They will also help to inform policy makers involved in the development of over-arching harvest strategy policies and assist in ensuring a national best-practice approach to the development of such policies.

A harvest strategy brings together all of the key scientific monitoring, assessment and management elements used to make decisions about the intensity of fishing activity that should be applied to, or catch that should be taken from, a fish stock or fisheries management unit, to ensure its ecological, economic and social sustainability. The existence of a harvest strategy ensures that fishery management agencies, fishers and key stakeholder groups think about, and document, how they will respond to various fishery conditions, before they occur, to provide for greater certainty and to avoid *ad-hoc* decision making.

The qualitative audit undertaken as part of this project, to qualitatively measure the application of harvest strategies across all Australian fisheries, showed that whilst they are used widely in Australian fisheries at the Commonwealth, State and Territory level, their application occurs mostly in higher value fisheries and the extent to which key elements of formal harvest strategies are applied, is highly inconsistent, as is the terminology being used. The national qualitative audit also indicated that there is a need to more adequately integrate the economic and social dimensions of fisheries management into harvest strategy development, particularly in relation to the use of economic and social performance indicators, target reference points and decision rules, to promote management of fisheries to broader ESD standards.

Other fishery challenges linked to harvest strategies include the need to periodically collect basic data on catch and participation levels for recreational and customary fisheries and the greater need for fisheries independent monitoring in multi-species and multi-gear fisheries, as well as those based on fluctuating stocks. These challenges do not mean that harvest strategies should not be used in these fisheries, but rather, that tailored approaches are required.

To help overcome the inconsistencies in design, application and terminology used in the development of harvest strategies, the national guidelines provide a common language and important contextual information to assist interpretation, development and implementation.

For harvest strategies to be effective, they need to be easily understood and accepted by key stakeholders. They also need to take into account the current context of a fishery and the data and information available to monitor and assess the fishery and the performance of the harvest strategy. Harvest strategies also need to take account of the costs associated with any monitoring, assessment and management measures required as part of their implementation and these should be explicitly considered during the development process. This means that harvest strategies need to be adapted in a pragmatic way to suit the individual fishery context.

Importantly, harvest strategies do not need to rely on the outputs of complex mathematical procedures or model-based stock assessments. In many cases, a harvest strategy can be just as effective, sometimes more effective depending on the fishery context, when based on an empirical approach, particularly because they can be easier to grasp and therefore assist fishery managers with fostering fisher and stakeholder understanding and acceptance. A range of practical and cost-effective ways exist to apply harvest strategies to a broad cross section of fisheries, including data-poor fisheries with limited information. It is important, however, that harvest strategies of all types are tested for their robustness prior to implementation.

In an ideal setting, the mechanisms for fishery management decision making, at the individual fishery level (including harvest strategy frameworks), should be contained within fishery management plans, or other similarly structured documents that provide a high level of certainty and accountability for stakeholders. In this sense, a harvest strategy is considered to provide the 'nuts and bolts' of a fishery management plan and should form the basis of the adaptive management cycle. However, it is important to note that a harvest strategy must be reviewed periodically to take account of new information and to this end a degree of flexibility should be factored in. Importantly, this does not imply that reviews should automatically take place when decision rules trigger difficult management actions in a fishery, such as catch or effort reductions, but rather that a process of continuous improvement should be adopted.

The National Harvest Strategy Guidelines have aimed to cover all of the main issues and challenges encountered when developing harvest strategies in the diverse Australian fisheries context. However, because of the dynamic nature of fisheries management, one size does not fit all and there will always be situations that do not fit within a set of guidelines. For this reason a pragmatic and common sense approach is recommended when developing harvest strategies, to ensure a tailored approach to harvest strategy development to suit the specific needs of individual fisheries.

7. IMPLICATIONS

The National Harvest Strategy Guidelines provide a national framework to support a consistent and more harmonised approach to harvest strategy development across Australian fisheries jurisdictions. The National Guidelines also provide definitions, common language and important contextual information for stakeholders to assist interpretation of harvest strategies and their application. The identification of a common language for national application to harvest strategies will allow all stakeholders to better understand their purpose and how they are applied.

A long term benefit expected from the adoption of the national guidelines will be improvements over time for Australian fish stocks and the fisheries they support. A recent review by Smith et al. (2013) of Commonwealth fisheries five years after implementation of the Commonwealth Fisheries Harvest Strategy Policy demonstrates that fish stocks have improved at the Commonwealth level.

Application of the National Guidelines, whether through their use in individual fisheries and/or to inform the development of jurisdictional level overarching policies, is expected to assist fisheries management agencies with responding to the increased community concern about fishing harvests. The National Guidelines will assist with this through establishing improved and more consistent decision making frameworks that provide for improved accountability, transparency and certainty for all stakeholders involved. Overall, the adoption of a consistent national approach to harvest strategy development will assist in demonstrating to the wider community that Australian fisheries are well managed.

Application of the National Guidelines will contribute to providing greater certainty for commercial, recreational and customary/cultural/traditional fishers and for other key stakeholders such as conservation groups and the wider community, particularly in relation to the way in which fisheries management agencies will respond when certain conditions (desirable or undesirable) arise in a fishery. Creating improved certainty and transparency contributes to creating a climate of trust between fishery stakeholders, allows fishery managers and fishers to operate with greater confidence and allows for greater business planning by commercial fishers, as the fishery management responses to various levels of fishery performance are documented and more predictable. In this light, adoption of a well constructed harvest strategy allows for more efficient and proactive decision making to be adopted. This is a fundamental outcome expected from the adoption of well constructed harvest strategies, designed with input from fishers and key stakeholders from the beginning of the process.

Fishery managers, fishers and key stakeholders will all benefit from addressing areas of fisheries management that are currently considered less developed, particularly in relation to management of trans-boundary stocks and fisheries that form part of multi-sector fisheries including commercial, recreational and traditional or customary fishing activities. A national approach will enable such common challenges to be addressed in a consistent and more coordinated manner, thereby avoiding unnecessary duplication of effort and resources, and ensuring more targeted investment in ways to address common challenges.

The National Guidelines have been designed to support harvest strategy development across the full range of fisheries, including input and output managed fisheries, single and multi-species fisheries, large and small-scale fisheries, spatially managed fisheries and in data-rich or data-poor situations. To help support the development of tailored fishery-specific harvest strategies, the National Guidelines provide a set of specific considerations to assist fishery managers, fishers and key stakeholders in the development of harvest strategies in certain fishery scenarios, particularly where challenges may have created barriers to development and implementation of harvest strategies in the past, such as multi-jurisdictional, data-poor, recreational and customary fisheries.

In addition to assisting the development of fishery specific harvest strategies, the National Guidelines will help to inform policy makers involved in the development of over-arching harvest strategy policies and assist with ensuring a national best-practice approach to the development of such policies. The National Guidelines have already helped to inform the drafting of such policies in Victoria, Western Australia and to inform the review of the Commonwealth Harvest Strategy Policy. They will be used to develop a harvest strategy policy for fisheries in South Australia during 2014/15.

When used in conjunction with other national frameworks that have been developed to support fisheries management in Australia, such as the National Fish Stock Status Reporting Framework (Flood et al. 2012), the National Guidelines for co-management of fisheries (Neville et al. 2008) and the national ESD reporting framework (Fletcher et al. 2012), the National Harvest Strategy Guidelines will provide fisheries management agencies with a strong basis from which to formulate more harmonised and consistent fisheries management arrangements to meet contemporary fisheries management challenges.

The National Guidelines provide a key resource to assist the Australian Fisheries Management Forum and individual fisheries management agencies to promote the adoption of a consistent and more harmonised national approach across all fisheries management jurisdictions for developing harvest strategies.

8. RECOMMENDATIONS

It is recommended that the national guidelines are adopted as a best practice approach to harvest strategy development across Australian fisheries jurisdictions. It is recommended that the national guidelines are reviewed after a five year period, to incorporate any improvements that have occurred in harvest strategy development over this period.

8.1 Further Development

Further work is considered beneficial to support the implementation of the National Guidelines, through:

1. The development of specific case studies to test their practical application. Case studies that are considered to be a high priority include:

    - Fisheries based on trans-boundary stocks;
    - Multi-sector fisheries with significant recreational activity;
    - Multi-sector fisheries with significant customary, cultural or traditional fishing activity;
    - Recreational fisheries.

2. Development of cost-effective techniques to build economic information into harvest strategies. At present, the main use of economic information in harvest strategy development has involved the use of outputs from bio-economic models. It is suggested that alternative cost-effective methods be further explored.

3. Testing the robustness of empirical harvest strategy approaches. Empirical approaches to harvest strategy development and stock assessments are commonly used in the Australian fisheries context, mainly due to the higher costs that can often be associated with producing, maintaining and refining quantitative stock assessment models and the scale of the fisheries they are applied to. Because there are a large number of fisheries that have, or will, adopt empirical approaches to harvest strategy development, there may be merit to:

    - Investigate the scope to develop generic techniques to test the robustness of empirical harvest strategies; and/or
    - Test certain fishery scenarios where empirical approaches are common, through a series of case studies.

    A first step to address this gap could be to hold a workshop of relevant fisheries science and management experts to explore the best approach to address this challenge.

4. Establish a best practice toolkit of tried and tested limit reference points, for application in specific fishery scenarios. This would build on extensive work that has previously been done in this area, particularly in relation to performance indicators.

5. Establish a national library of fishery harvest strategies.

9. EXTENSION AND ADOPTION

The Australian Fisheries Management Forum will play a key role in promoting the adoption of the National Harvest Strategy Guidelines. The Australian Fisheries Management Forum has endorsed the National Guidelines and recommended that Australian fisheries Ministers ratify the Guidelines as a national best-practice approach, through the Ministerial Primary Industries Standing Committee.

Development of the National Guidelines involved technical staff from all fisheries management and science agencies in Australia, through a national technical workshop and follow up consultation. The project working group involved a good cross section of key science, management, policy and industry stakeholders involved in harvest strategy development in Australian fisheries jurisdictions.

The National Guidelines were presented to the following fisheries management forums: (a) the *National Seafood Directions Conference* held in Port Lincoln, South Australia in October 2013; (b) the national workshop on the *Practical Implementation of Social and Economic Elements in Ecosystem Based Fisheries Management* on 24/25 March 2014; (c) the *National Fisheries Management Conference and Workshop* on 26/27 March 2014; and (d) will be presented to the July 2014 *Australian Marine Science Association Fisheries Symposium on 'Beyond Jurisdiction-based Fisheries Management*'.

An article on the National Guidelines was published in the FRDC 'Fish' Magazine in September 2013. A plain English summary of the National Guidelines will be prepared in a brochure form, for wide circulation among government, industry and non-government stakeholders involved in the Australian fisheries management and policy development process. The final report will be widely distributed among fisheries management stakeholders in Australia. Further opportunities to communicate and extend the outcomes of the project will be pursued with Australian fisheries agencies and any international fisheries agencies that have an interest in the national guidelines.

10. GLOSSARY

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

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

Biomass at maximum economic yield (B_{MEY}): average biomass corresponding to maximum economic yield

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

Biomass target reference point (B_{TARG}): the desired biomass of the stock.

Empirical stock assessment: An assessment of the status of a stock based on the systematic consideration of a range of biological and fisheries information, based on direct interpretation of data. An empirical stock assessment does not use a population model to interpret data and cannot be used for future projections of the stock. This type of assessment is consistent with the 'weight-of-evidence approach' described in the 'Status of key Australian Fish Stocks Report 2012' by Flood et al. (2012)

Fishing mortality (F): 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 stocks and should match the scale of management unit.

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

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

Fishing mortality at maximum sustainable yield (F_{MSY}): fishing mortality rate which corresponds to maximum sustainable yield

Fishing mortality target reference point (F_{TARG}): target fishing mortality rate

Fish stock: A *fish stock* is a discrete population of a fish species, usually in a given geographical area and with negligible interbreeding with other biological stocks of the same species.

Fishery Management Unit: A *fishery management unit* is typically defined in terms of the area of water or seabed that is fished, the jurisdictional boundaries that exist, the people involved in the fishery, the species caught, the fishing methods and the types of boats used.

Harvest decision rule: Pre-determined management actions, linked directly to performance indicators and information about current status, and designed to maintain fishery performance in line with operational objectives. These management actions may also be linked to reference points.

Limit reference points: A *limit reference point* defines the values of an indicator for a fish stock or fisheries management unit that are no longer considered acceptable.

Management strategy evaluation: A qualitative or quantitative procedure whereby alternative management strategies are evaluated and compared before implementation.

Maximum Economic Yield (MEY): The theoretical catch or effort level for a commercial fishery that maximises average net economic returns over a number of years. Fishing to MEY will usually result in the equilibrium stock (biomass) of fish being larger than that associated with MSY.

Maximum Sustainable Yield (MSY): The theoretical maximum sustainable average annual catch that can be removed from a stock over an indefinite period under prevailing environmental conditions.

Operational objective: An objective that has a direct and practical interpretation in the context of a fishery and against which performance can be evaluated (in terms of achievement) (Fletcher et al. 2002).

Performance indicator: A quantity that can be measured and used to track changes in an operational objective.

Quantitative model-based stock assessment: An assessment that produces information on the status of a stock using a mathematical model of the population to make inferences from data. Common examples include the estimation of biomass and egg production, which are not usually measured directly but can be inferred through modelling observed patterns in catch rate, size structure, growth, etc.

Target reference points: A *target reference point* defines the values of an indicator for a fish stock or fisheries management unit that are desirable or ideal and at which management should aim.

Trigger Reference Point: A *trigger reference point* defines the values of an indicator, usually a stock status indicator, at which a change in management is considered or adopted.

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12. APPENDICES

Appendix 1: List of fisheries for each fisheries management jurisdictions.

South Australia:

Southern Zone Rock Lobster Fishery, Northern Zone Rock Lobster Fishery, Spencer Gulf Prawn Fishery, Gulf St Vincent Prawn Fishery, West Coast Prawn Fishery, Marine Scalefish (Snapper) Fishery, Marine Scalefish (King George Whiting) Fishery, Marine Scalefish (Garfish) Fishery, Marine Scalefish (Southern Calamary) Fishery, Marine Scalefish (West Coast Mud Cockle) Fishery, Marine Scalefish (Coffin Bay Mud Cockle) Fishery, Marine Scalefish (Port River Mud Cockle) Fishery, Marine Scalefish (Other) Fishery, Lakes and Coorong (Pipi) Fishery, Lakes and Coorong (Yellow Eye Mullet) Fishery, Lakes and Coorong (Mulloway) Fishery, Lakes and Coorong (Golden Perch) Fishery, Miscellaneous (Scallop) Fishery, Miscellaneous (Sea Urchin) Fishery, Miscellaneous (Salmon) Fishery, Miscellaneous (Beach Case and Seagrass) Fishery, Recreational Fishery, Blue Crab Fishery, Western Zone Abalone Fishery, Central Zone Abalone Fishery, Southern Zone Abalone Fishery, Australian Sardine Fishery, Marine Scalefish Fishery and the Giant Crab Fishery.

Queensland:

Rocky Reef Finfish Fishery, River and Inshore Beam Fishery, East Coast Pearl Fishery, Tropical Rock Lobster Fishery, Fin Fish Stout Whiting Fishery, Spanner Crab Fishery, Coral Reef Finfish Fishery, Coral Fishery, Blue Swimmer Crab Fishery, East Coast Otter Trawl Fishery, East Coast Spanish Mackerel Fishery, East Coast Trochus, East Coast Inshore Finfish Fishery, Deep water Finfish Fishery, East Coast Beche-de-mer Fishery, Marine Aquarium Fishery, Mud Crab Fishery, Eel Fishery, Gulf of Carpentaria Inshore Finfish Fishery, Gulf of Carpentaria Development Finfish Trawl and the Gulf of Carpentaria Line Fishery.

New South Wales:

Ocean Trawl (Eastern King Prawn) Fishery, Ocean Trawl (School Whiting) Fishery, Ocean Trawl (Other) Fishery, Ocean Trap and Line Fishery, Ocean Hauling (Sea Mullet) Fishery, Ocean Hauling (Eastern Sea Garfish) Fishery, Ocean Hauling (Other) Fishery, Estuary General (Pipi) Fishery, Estuary General (Yellowfin Bream) Fishery, Estuary General (Other) Fishery, Recreational Fishery, Abalone Fishery, Lobster Fishery, Estuary School Prawn Fishery, Hawkesbury Estuary Prawn (Squid)Fishery, Ocean Trap and Line (Spanner Crab) Fishery, Ocean Trap and Line (Gummy Shark) Fishery, Ocean Trap and Line (Snapper) Fishery and the Ocean Trap and Line (Shark) Fishery.

Victoria:

Eastern Zone Abalone Fishery, Central Zone Abalone Fishery, Western Zone Abalone Fishery, Eastern Zone Rock Lobster Fishery, Western Zone Rock Lobster Fishery, Scallop (Ocean) Fishery, Corner Inlet Fishery, Gippsland Lakes Fishery, Gippsland Lakes (Mussel) Fishery, Gippsland Lakes Bait Fishery, Port Phillip Bay Purse Seine Fishery, Port Phillip Bay Mussel and Bait Fishery, Inshore Trawl Fishery, Port Phillip Bay Fishery, Lake Tyers Bait Fishery, Snowy River Bait Fishery, Sydneham Inlet Bait Fishery, Mallacoota Lower Lake Bait Fishery, Ocean Access Fishery, Purse Seine (Ocean) Fishery, Wrasse (Ocean) Fishery, Recreational Marine Fishery and the Recreational Inland Fishery.

Western Australia:

Salmon Fishery, Shark Bay Scallop Fishery, Shark Bay Prawn Fishery, Shark Bay Beach Seine and Mesh Net Fishery, Shark Bay Experimental Crab Fishery, Developmental Octopus Fishery, Onslow Prawn Fishery, Nickol Bay Prawn Fishery, Northern Demersal Scalefish Fishery, Pilbara Fish Trawl Fishery, Pilbara Trap Fishery, Pilbara Line Fishery, Pearl Oyster Fishery, Tropical Shark Fishery, Rock Lobster Fishery, West Coast Beach Fishery, West Coast Purse Seine Fishery, Deep Sea Crab Fishery, West Coast Estuarine Fishery, South Coast Estuarine Fishery, South Coast Trawl Fishery, South Coast Purse Seine Fishery, Temperate Shark Fishery, West Coast Demersal Scalefish Fishery, Specimen Shell Fishery, Broome Prawn Fishery, Beche de mer Fishery, Abrolhos Island and Mid South West Trawl Fishery, Roe's Abalone Fishery, Marine Aquarium Fishery, Mackerel Fishery, Kimberley Prawn Fishery, Kimberley Gillnet and Barramundi Fishery, Exmouth Gulf Prawn Fishery, Cockburn Sound Line and Pot Fishery, Cockburn Sound Crab Fishery, Gascoyne Demersal Scalefish Fishery, Esperance Rock Lobster Fishery, Greenlip and Brownlip Abalone Fishery, Australian Herring Fishery, Mud Crab Fishery, Trochus Fishery, South West Trawl Fishery and the Lake Argyle Silvery Cobbler Fishery.

Northern Territory:

Trepang Fishery, Spanish Mackerel Fishery, Timor Reef Fishery, Demersal (Red and Golden Snapper) Fishery, Aquarium Fish Fishery, Barramundi Fishery, Mud Crab Fishery, Coastal Line (Black Jewfish and Golden Snapper) Fishery, Coastal Net (Mullet and Blue Threadfin) Fishery, Developmental Fishery, Offshore Net and Line Fishery, Recreational Fishery and the Fishing Tour Operators Fishery.

Tasmania:

Rock Lobster Fishery, Abalone Fishery, Scallop Fishery, Marine Plants Fishery, Commercial Dive Fishery, Shellfish Fishery, Scalefish Fishery, Giant Crab Fishery and the Recreational Fishery.

Commonwealth:

Northern Prawn Fishery, North West Slope Trawl Fishery, Southern and Eastern Scalefish and Shark Fishery, Southern Squid Jig Fishery, Small Pelagic Fishery, Coral Sea Fishery, Bass Strait Central Zone Scallop Fishery, Macquarie Island Toothfish Fishery, Eastern Tuna and Billfish Fishery, Torres Strait Turtle and Dugong Fishery, Torres Strait Pearl Shell Fishery, Torres Strait Crab Fishery, Torres Strait Prawn Fishery, Torres Strait Trochus Fishery, Torres Strait Rock Lobster Fishery, Torres Strait Beche de mer Fishery, Torres Strait Finfish Fishery, Western Tuna and Billfish Fishery, Southern Bluefin Tuna Fishery, Western Deep Water Trawl Fishery, Heard and McDonald Island Fishery and the CCAMLR New and Exploratory Fishery.

Appendix 2: Background information and guidelines for answering the survey questions sent to Commonwealth, State and Territory fisheries management jurisdiction in Australia as part of this project.

A REVIEW OF THE CURRENT LEVEL OF ADOPTION OF HARVEST SRATEGIES IN AUSTRALIAN FISHERIES

Background

The Australian Fisheries Management Forum (AFMF), through the Fisheries and Aquaculture Division of the Department for Primary Industries and Regions, South Australia (PIRSA), is undertaking a project funded by the Fisheries Research and Development Corporation (FRDC) to develop a national framework for harvest strategies in Australia (FRDC Project 2010/061). An initial step in the process is to take stock of the current situation in relation to the adoption of harvest strategies across all Australian fisheries management jurisdictions. To enable this stock take, the following questions have been developed to allow for a simple analysis of the extent to which formal harvest strategies have (or have not) been adopted in Australian fisheries. To ensure the exercise of completing the attached spreadsheet is not too onerous for fisheries agencies, the questions have been tailored to capture information on the essential components of harvest strategies by requesting simple yes/no answers or providing multiple choice answers. However, if time and resources permit, please feel free to provide more detailed responses to any of the questions, rather than simple yes/no answers. For example, in answer to question 4, which relates to the performance indicators (PI's) used for a fishery, a simple yes/no answer could be provided, or the actual PI could be provided (e.g. CPUE).

Please record answers to these questions in the excel spreadsheet provided for each of the fisheries/species/stocks managed within your jurisdiction. The following questions and a set of guidelines is provided to assist completion of the spreadsheet. The spreadsheet has been completed for South Australian fisheries to provide an example.

Guidelines for answering the questions and completing the spreadsheet

Fishery / species

It is important to detail the full name of the fishery/species/stock that you are commenting on. Where a single species fishery is distinguished by a zone it is important to detail that e.g. Southern Zone Rock Lobster Fishery (South Australia). Where a multi-species fishery exists it is important to name the fishery as well as the individual species being managed e.g. Marine Scalefish Fishery - Snapper.

Q 1. Does the fishery/species/stock have a management plan?

This question should be answered by inserting the word **yes** or **no** in to the spreadsheet. It is acknowledged that Management Plans take various forms across fisheries jurisdictions in Australia. For the purposes of answering this question a management plan may take the form of a statutory instrument or a policy document. A Management Plan should, in it's simplest form, describe the fishery geographically, the species being managed, outline the relevant management arrangements/strategies for the fishery including the access arrangements in place, the specific objectives for the species being managed and any measures of management performance that are used.

Q 2. What is the principal tool used to constrain catch in the fishery / of the species?

This question should be answered by inserting one of the following letters in to the spreadsheet:

- A (quota and/or ITQ management)
- B (gear restrictions)
- C (area closures or seasonal closures)
- D (combination of A and B or C)
- E (a combination of B and C)
- F (bag, boat and size limits)
- G (any other form of management tool)

Q 3. Does the fishery/species/stock have formal 'operational' management objectives to guide the setting of catch levels?

It is acknowledged that all fisheries management activities must follow legislative objectives, and that most fisheries legislation contains objectives relating to ecological sustainable development (ESD). With this in mind, this question is seeking to find out if there are more defined 'operational' objectives in place that relate specifically to the fishery/species/stock being managed. For the purposes of answering this question, a formal 'operational' management objective refers to one which has a direct and practical application/interpretation in the context of a specific species/stock/fishery and against which performance can be evaluated. This question should be answered by inserting in to the spreadsheet whichever one of the following letters best describes the situation for the fishery/species/stock:

- A (the only management objectives used for setting target catch levels are those contained in the overarching legislation, i.e. in the Act)
- B (operational management objectives are established, which are linked to defined target or limit reference points)
- C (operational management objectives are established to achieve MSY)
- D (operational management objectives are established to achieve MEY)
- E (operational management objectives are established to achieve or avoid a defined biomass level)
- F (operational management objectives are established to achieve or avoid a defined fishery mortality level)
- G (operational management objectives are established using recreational participation rate or strike rate targets)
- H (operational management objectives are established to achieve a defined social outcome)
- I (other management objectives are used, but they are not considered to be measurable).

Q 4. Does the fishery/species/stock have specified performance indicators to measure fishery performance against the stated objectives?

This question should be answered by inserting the word **yes** or **no** in to the spreadsheet. For the purposes of answering this question a performance indicator is defined as, a quantity which measures progress against achieving an objective for the fishery/species/stock.

Q. 5 Does the fishery/species/stock have established limit reference point/s?

This question should be answered by inserting the word **yes** or **no** in to the spreadsheet. For the purposes of answering this question a limit reference point is defined as, a point beyond which the risk to the fishery/species/stock is regarded as unacceptably high resulting in an undesirable situation and a need for remedial action (e.g. ceasing targeted fishing).

Q. 6 Does the fishery/species/stock have established target reference point/s?

This question should be answered by inserting the word **yes** or **no** in to the spreadsheet. For the purposes of answering this question a target reference point is defined as, a desirable position which management actions are designed to achieve or aspire to for a given fishery/species/stock.

Q. 7 Does the fishery/species/stock have established decision rules, linked to reference points, to guide management decisions?

This question should be answered by inserting the word **yes** or **no** in to the spreadsheet. For the purposes of answering this question a decision rule is defined as, a control that is enacted based on a pre-determined level of fishery/species/stock performance.

Q. 8 Are economic or social considerations explicitly taken into account when selecting performance indicators, target or limit reference points or decision rules?

This question should be answered by inserting the word **yes** or **no** in to the spreadsheet.

Q. 9 Does the fishery/species/stock have a formal stock assessment? If 'yes' does it incorporate the use of a quantitative stock assessment model or is it based on a more empirical assessment?

For the purposes of answering this question a stock assessment is defined as, a formal process undertaken to assess the biological status of the fishery/species/stock. This question should be answered by inserting one of the following letters in to the spreadsheet:

- A (no formal stock assessment)
- B (the assessment incorporates a model)
- C (the assessment is empirical)
- D (the assessment incorporates a combination of both B and C)

Q. 10 Are issues relating to threatened, endangered or protected species (TEPS), or ecosystem risks explicitly taken into account when selecting performance indicators (PI's) and/or target reference points (TRP's) or limit reference points (LRP's) for the fishery/species/stock?

This question should be answered by inserting one of the following letters in the spreadsheet:

- A (there are no known TEPS interactions or significant ecosystem risks in the fishery)
- B (TEPS or ecosystem risks are explicitly taken into account when selecting PI's TRP's and/or LRP's for the fishery/species/stock)
- C (PI's, LRP's or TRP's have been developed specifically for TEPS to address interactions in the fishery)
- D (there may be ecosystem risks but they are not explicitly considered)

Appendix 3: List of the delegates that attended the national technical workshop held on the Development of National Guidelines to Develop Fishery Harvest Strategies on 6 March 2012 in Adelaide.

Name:	**Organization:**
Mr Richard Stevens OAM	Independent workshop facilitator (FRDC)
Mr Sean Sloan (PI)	Primary Industries and Regions South Australia Fisheries and Aquaculture
Dr Tony Smith AM	Commonwealth Scientific and Industrial Research Organization
Ms Kelly Crosthwaite	Victorian Department of Primary Industries-Fisheries
A/Prof Caleb Gardner	University of Tasmania
Mr Brian Jeffriess OAM	Australian Southern Bluefin Tuna Industry Association
Mr Tim Karlov	Australian Department of Agriculture (Cth.)
Mr Crispian Ashby	Fisheries Research and Development Corporation
Dr David Galeano	Australian Fisheries Management Authority
Mr Jeff Moore	Great Australian Bight Trawl Fishery
Dr Ian Knuckey	Fishwell Consulting
Dr Kate Brooks	Fisheries Research and Development Corporation
A/Prof Stephan Schnierer	Southern Cross University, NSW. Aboriginal traditional/customary fishing
Prof Gavin Begg	South Australian Research and Development Institute
Dr Stephan Mayfield	South Australian Research and Development Institute
Dr Keith Jones	Sillago Research Pty Ltd
Mr Andrew Goulstone	NSW Department of Primary Industries-Fishing and Aquaculture
Mr Luke Cromie	Victorian Department of Primary Industries-Fisheries
Dr Paul Hamer	Victorian Department of Primary Industries-Fisheries
Mr Brent Wise	Department of Fisheries, Western Australia
Mr Kim Walshe	Department of Fisheries, Western Australia
Mr Brenton Schahinger	South Australian Recreational Fishing Advisory Council Inc
Mr David McKey	Fisheries-Northern Territory Government
Dr Lianos Triantafillos	Primary Industries and Regions South Australia Fisheries and Aquaculture
Ms Alice Fistr	Primary Industries and Regions South Australia Fisheries and Aquaculture
Dr Craig Noell	Primary Industries and Regions South Australia Fisheries and Aquaculture
Mr Nathan Hanna	Department of Environment (Commonwealth.)

Appendix 4: Response (and proportion) to the survey questions by Commonwealth, State and Territory fisheries management jurisdiction in Australia for each of the fisheries/species/stocks they were responsible for managing.

South Australia

Number of fisheries/ stocks that are assessed	**29**
Number that have management plans	24 (83%)
Number that have operational objectives	22 (76%)
Number that have performance indicators	21 (72%)
Number that have limit reference points	18 (62%)
Number that have target reference points	21 (72%)
Number that have harvest control decision rules	17 (59%)
Number that explicitly consider social and economic indicators	20 (69%)
Number that have no formal stock assessment Number that have an empirical stock assessment Number that have a model-based stock assessment	6 (21%) 14 (48%) 9 (31%)

Queensland

Number of fisheries/ stocks that are assessed	**21**
Number that have management plans	21 (100%)
Number that have operational objectives	19 (90%)
Number that have performance indicators	21 (100%)
Number that have limit reference points	10 (48%)
Number that have target reference points	0 (0%)
Number that have harvest control decision rules	4 (19%)
Number that explicitly consider social and economic indicators	2 (10%)
Number that have no formal stock assessment Number that have an empirical stock assessment Number that have a model-based stock assessment	10 (48%) 2 (10) 9 (43%)

New South Wales

Number of fisheries/ stocks that are assessed	**19**
Number that have management plans	18 (95%)
Number that have operational objectives	18 (95%)
Number that have performance indicators	18 (95%)
Number that have limit reference points	18 (95%)
Number that have target reference points	0 (0%)
Number that have harvest control decision rules	3 (16%)
Number that explicitly consider social and economic indicators	18 (95%)
Number that have no formal stock assessment Number that have an empirical stock assessment Number that have a model-based stock assessment	0 (0%) 15 (21%) 4 (19%)

Victoria

Number of fisheries/ stocks that are assessed	**23**
Number that have management plans	7 (30%)
Number that have operational objectives	6 (26%)
Number that have performance indicators	6 (26%)
Number that have limit reference points	6 (26%)
Number that have target reference points	6 (26%)
Number that have harvest control decision rules	6 (26%)
Number that explicitly consider social and economic indicators	0 (0%)
Number that have no formal stock assessment Number that have an empirical stock assessment Number that have a model-based stock assessment	13 (57%) 5 (22%) 5 (22%)

Western Australia

Number of fisheries/ stocks that are assessed	**44**
Number that have management plans	36 (82%)
Number that have operational objectives	31 (70%)
Number that have performance indicators	44 (100%)
Number that have limit reference points	38 (86%)
Number that have target reference points	26 (59%)
Number that have harvest control decision rules	22 (50%)
Number that explicitly consider social and economic indicators	30 (68%)
Number that have no formal stock assessment Number that have an empirical stock assessment Number that have a model-based stock assessment	0 (0%) 31 (70%) 13 (30%)

Northern Territory

Number of fisheries/ stocks that are assessed	**13**
Number that have management plans	3 (23%)
Number that have operational objectives	8 (62%)
Number that have performance indicators	8 (62%)
Number that have limit reference points	6 (46%)
Number that have target reference points	7 (54%)
Number that have harvest control decision rules	9 (69%)
Number that explicitly consider social and economic indicators	10 (77%)
Number that have no formal stock assessment Number that have an empirical stock assessment Number that have a model-based stock assessment	3 (23%) 3 (23%) 7 (54%)

Tasmania

Number of fisheries/ stocks that are assessed	**9**
Number that have management plans	8 (89%)
Number that have operational objectives	5 (56%)
Number that have performance indicators	4 (44%)
Number that have limit reference points	3 (33%)
Number that have target reference points	1 (11%)
Number that have harvest control decision rules	0 (0%)
Number that explicitly consider social and economic indicators	0 (0%)
Number that have no formal stock assessment Number that have an empirical stock assessment Number that have a model-based stock assessment	3 (33%) 2 (22) 4 (44%)

Commonwealth

Number of fisheries/ stocks that are assessed	**22**
Number that have management plans	11 (50%)
Number that have operational objectives	15 (68%)
Number that have performance indicators	17 (77%)
Number that have limit reference points	10 (45%)
Number that have target reference points	13 (59%)
Number that have harvest control decision rules	14 (64%)
Number that explicitly consider social and economic indicators	4 (18%)
Number that have no formal stock assessment Number that have an empirical stock assessment Number that have a model-based stock assessment	7 (32%) 7 (32%) 8 (36%)

National Wrap-up

Number of fisheries/ stocks that are assessed	**180**
Number that have management plans	128 (71%)
Number that have operational objectives	124 (69%)
Number that have performance indicators	139 (77%)
Number that have limit reference points	109 (61%)
Number that have target reference points	74 (41%)
Number that have harvest control decision rules	75 (42%)
Number that explicitly consider social and economic indicators	71 (39%)
Number that have no formal stock assessment Number that have an empirical stock assessment Number that have a model-based stock assessment	42 (23%) 79 (42%) 59 (33%)

Appendix 5: Examples of the key elements of the harvest strategies for two Commonwealth fisheries.

a) **South East Trawl Fishery (blue grenadier) harvest strategy**

Defined operational objectives for the fishery

1. Maintain blue grenadier stocks, on average, at a target biomass point (B_{TARG}) equal to 48% of the unfished spawning biomass

Indicators of fishery performance related to the objectives

Primary biological performance indicator: absolute size of spawning biomass (estimated using and age- and size-structured model)

Secondary biological performance indicator: population size structure based on length frequencies from Integrated Scientific Monitoring Program (ISMP).

Primary economic performance indicator: Maximum economic yield (B_{MEY}). Because B_{MEY} is unknown, the proxy of $B_{MEY} = 1.2\ B_{MSY}$ is used (which corresponds to 48% of the unfished spawning biomass)

Reference points for performance indicators

Limit reference point (biomass): 20% of unfished spawning biomass

Target reference point (biomass): 48% of unfished spawning biomass

Limit reference point (fishing mortality): F_{20} is the fishing mortality that gives to a spawning biomass that is 20% of the unfished spawning biomass

Target reference point (fishing mortality): F_{48} is the fishing mortality that gives to a spawning biomass that is 48% of the unfished spawning biomass

Statement defining acceptable levels of risk for the fishery

Blue Grenadier is assessed under the Tier 1 harvest decision rules of the Commonwealth Harvest Strategy Policy. The TAC for this fishery has been set at 5208 tonnes for the 2012/13 and 2013/14 fishing seasons. Multi-year TACs are designed to reduce stock assessment costs and provide more certainty around fluctuating TACs. A re-assessment will be triggered if substantial changes (break out rules) are noticed in fishery:

- if the most recent observed value for the standardised non-spawn CPUE falls outside of the 95% confidence interval of the value for the standardised non-spawn CPUE predicted by the most recent Tier 1 stock assessment;
- if the most recent observed value for the standardised non-spawn CPUE from the acoustic survey falls outside of the 95% confidence interval of the value for the standardised non-spawn CPUE predicted from the acoustic survey (when survey values are available);
- if less than 70% of the of TAC was caught; and,
- if the observed age composition is significantly different to that projected.

Monitoring strategy to collect relevant data to assess fishery performance

Estimates of spawning biomass are currently monitored through industry-based acoustic surveys. These surveys are typically undertaken on an annual basis and generate an absolute estimate of the size of spawning stock and provide an additional point in the relative index time-series established in previous surveys. Biomass estimation results are then included in a well-developed quantitative model. Recruitment is monitored through length frequency data collected by observers from the Integrated Scientific Monitoring Program (ISMP).

A process for conducting assessment of fishery performance relative to objectives

Undertaking a Tier 1 assessment as required by the RAG and comparing depletion levels with target ref points

Decision rules that control the intensity of fishing activity

•If the current spawning biomass is below the limit of 20% of the unfished spawning biomass, the RBC is 0 and no further targeting is allowed (there may be a TAC set on the basis of unavoidable incidental catch).

•If the current spawning biomass , or proxy, is below the target , the RBCs are set at an appropriate level to allow the stock to rebuild to the target.

•If the current spawning biomass is above the target, the RBCs may be set at a level to allow a fish down of the stock to the target.

•Under the Small and Large Change Limiting rules, TACs are prevented from changing by small (less than 10% or 50 tonnes, whichever is the lesser) or excessive (no more than 50%) amounts from year to year

b) Southern Squid Jig Fishery harvest strategy

Defined operational objectives for the fishery

Maximum economic yield (B_{MEY})., the target for most Commonwealth fisheries is

1. Ensure stocks will remain above a biomass level where the risk to the stock is regarded as too high (B_{LIM})
2. Ensure that the stock stays above (B_{LIM}) at least 90% of the time

Indicators of fishery performance related to the objectives

Primary biological performance indicator: Catch (tonnes)

Secondary biological performance indicator: Effort (number of vessels)

Reference points for performance indicators

Given the highly variable nature of squid availability and the lack of biomass estimates, there is no absolute target reference point defined. Instead, a suites of intermediate and limit catch and effort triggers are defined based on recent catch history. The intermediate trigger levels are not associated with "hard" decision rules to limit the fishery, but rather invoke data monitoring and/or analyses in order to better inform the fishery.

Southern Squid Jig Fishery (SSJF)

Intermediate trigger (catch) : 3000 tonnes

Intermediate trigger (effort) : 30 vessels

Limit trigger (catch) 5000 tonnes

Commonwealth Trawl Fishery (CTS)

Intermediate trigger (catch) : 2000 tonnes

Combined SSJF and CTS

Intermediate trigger (catch) : 4000 tonnes

Limit trigger (catch): 6000 tonnes

Limit triggers may be overridden to enable industry to take advantage of "boom" years, during which the stock is unlikely to be adversely affected by the fleet fishing at full capacity (CPUE> 200kg/hr and catch has been documented as occurring in the middle of the day and irrespective of moon phase. To mitigate against over-exploitation during periods of low availability, there is an additional limit trigger based on effort (45 vessels) and CPUE (<20 % of long-term average).

Statement defining acceptable levels of risk for the fishery

The harvest strategy is designed to have minimal impact and costs if the fishery remains at its status quo, but to reach triggers invoking decision rules if the fishery escalates, or to detect possible overfishing when stocks are low. It also enables the fishery to exploit and capitalize on a "boom" season, when squid availability is high.

Monitoring strategy to collect relevant data to assess fishery performance

Catch and effort monitored through logbooks. The implementation of electronic logbooks is being pursued because it can yield real-time data, facilitating within-season management (lifespan of squid is < 1 year).

A process for conducting assessment of fishery performance relative to objectives

In the absence of biomass estimates from survey or stock assessment, and in place of target and limit reference points, suites of precautionary intermediate and limit catch and effort triggers were defined based on recent catch history, with values well below historical high catch levels. These serve as checks against controlled expansion, whereby the limit trigger may not be revised higher without investing in a higher Tier level assessment, the results of which provide defensible justification for doing so.

Decision rules that control the intensity of fishing activity

If 3000 tonnes SSJF or 4000 tonnes combined SSJF+CTS catch trigger and/or the 30 vessel trigger are reached, a special Research Assessment Group (SquidRAG) meeting is held and a depletion analysis is undertaken. If depletion analysis indicates no impact then next trigger is monitored. If there is evidence of impact, a decision will be made regarding season length and/ or total catch. If the 5000 tonnes SSJF or 6000 tonnes combined SSJF+CTS catch trigger is reached, a special Squid RAG meeting is held with members of the SESSF and another depletion analysis is undertaken, as well as catch and effort data are monitored more closely (real-time spatially explicit data). the TAC will not be increased unless it is sustainable (in terms of depletion analysis). If there is evidence of impact, a decision will be made regarding season length and/ or total catch (trip limits). In years of low availability (effort >45 vessels and CPUE <20 % of long-term average), seasonal spatial closures will be imposed toredirect fishery to areas of potential higher density (in areas where effort is focussed;).

c) Southern Zone Rock Lobster Fishery of South Australia harvest strategy

Defined operational objectives for the fishery

1. Maintain the catch rates at, or above, target level (see figure below)
2. Improve business certainty and viability
3. Profitability

Indicators of fishery performance related to the objectives

Primary biological performance indicator: unstandardized yearly commercial-catch-per-unit-effort (CPUE) of legal-sized rock lobster (kg/ pot lift) - representative of lobster abundance.

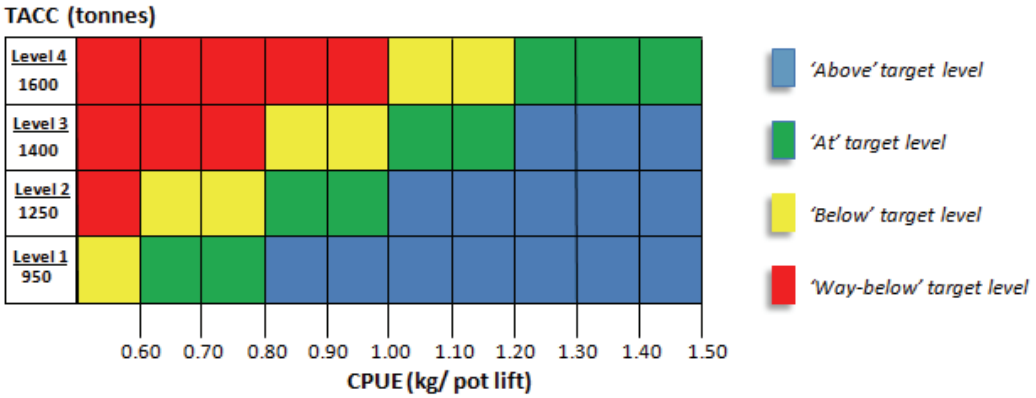
Secondary biological performance indicator: number of undersize rock lobster caught per pot lift - used as a pre-recruit index (PRI) and will assist with predictions about future performance of the fishery.

Reference points for performance indicators

Limit reference point (CPUE): 0.50 kg/ pot lift

Target thresholds (CPUE): the 'target' reference level is a band of values of combinations of catch and CPUE. It is represented by the green band in the figure below.

Trigger reference point (PRI): 1.30 undersize/ pot lift



Catch-per-unit-effort (CPUE) thresholds and corresponding total allowable commercial catch (TACC) levels for the Southern Zone Rock Lobster Fishery (SZRFL) of South Australia.

Statement defining acceptable levels of risk for the fishery

The figure 0.5 kg/ pot lift represents a level below which there is a significant risk to spawning stock egg production.

Monitoring strategy to collect relevant data to assess fishery performance

Two main data types are collected and analysed on an annual basis. These are: (1) fishery-dependent data such as commercial catch and effort log-book data and at-sea voluntary catch sampling data; and (2) fishery-independent data such as puerulus sampling and transect survey data.

A process for conducting assessment of fishery performance relative to objectives

Step 1-Biological performance indicators are used to assess the current status of the fishery and includes an opportunity for industry to provide direct input on external factors that may have contributed to variations in catch rate estimates

Step 2-Reference points and decision rules guide the TACC setting process ensuring the rock lobster resource is harvested within ecologically sustainable limits

Decision rules that control the intensity of fishing activity

•TACC is increased to next level when CPUE is above the target level and PRI is above 1.30 undersize/ pot lift.

•TACC remains unadjusted when CPUE is above the target level and PRI is below 1.30 undersize/ pot lift or when CPUE is at the target level.

•TACC is reduced one level when CPUE is below the target level, unless there is factual and credible evidence that would account for an increase of CPUE to the target level. TACC is reduced two levels when CPUE is way-below the target level, unless there is factual and credible evidence that would account for an increase of CPUE to the target level (no reduction in TACC) or below the target level (TACC is reduced one level).