



Australian Government

Department of Agriculture, Fisheries and Forestry

Final report on the review of the Commonwealth Fisheries Harvest Strategy Policy and Guidelines May 2013



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Cataloguing data

DAFF 2013, *Report on the review of the Commonwealth Fisheries Harvest Strategy Policy and Guidelines*, Department of Agriculture, Fisheries and Forestry, Canberra.

ISBN: 9781760030049

Name: Harvest Strategy

Medium: Online

Internet

Report on the review of the Commonwealth Fisheries Harvest Strategy Policy and Guidelines is available at: daff.gov.au/publications.

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Acknowledgements

The review was conducted by the Department of Australian Agriculture, Fisheries and Forestry (DAFF) including the Australian Bureau of Agricultural Resource Economics and Sciences (ABARES), with support from the Department of Sustainability, Environment, Water, Population and Communities, the Australian Fisheries Management Authority (AFMA) and stakeholders representing commercial fishing, recreational fishing, research and environmental non-government agencies. The Commonwealth Scientific and Industrial Research Organisation (CSIRO), ABARES and the Australian National Centre for Ocean Resources and Security undertook commissioned research to support this review.

Some of the cover photographs were provided by AFMA.

Contents

Executive summary	6
Conclusions	7
1 Introduction	14
Fisheries management in Australia.....	14
Commonwealth Fisheries Harvest Strategy Policy and Guidelines	15
Review of the Commonwealth Fisheries Bycatch Policy and of Commonwealth Fisheries: Legislation, Policy and Management	16
National Harvest Strategy Guidelines Project.....	17
2 Review methodology	18
Consultation.....	19
Outcomes.....	20
3 Technical review reports.....	21
4 The scope of the policy	24
Conclusions	28
5 Harvest strategy implementation	29
Conclusions	46
6 Rebuilding overfished stocks	47
Conclusions	64
7 Discarding of commercial species.....	65
Conclusions	72
8 Shared stocks	73
International shared stocks	73
Stocks shared with domestic commercial fishers.....	79
Stocks shared with non-commercial fishers	82
Conclusions	88
9 Reference points	90
Conclusions	99
10 Optimising economic yield in multi-species fisheries	100
Conclusions	106
11 Managing byproduct and data-poor commercial fish stocks	107
Conclusions	118
12 Spatial management	119
Conclusions	123

13 References	124
14 Acronyms and Abbreviations	130
15 Glossary	131
Attachment 1. Terms of Reference.....	134
Appendices.....	135

Executive summary

On 28 March 2012 the Minister for Agriculture, Fisheries and Forestry announced the review of the *Commonwealth Fisheries Harvest Strategy Policy and Guidelines 2007* (harvest strategy policy). The policy aims to ensure:

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 Australian community (HSP 2007, p. 4).

The 2007 harvest strategy policy incorporates the relevant requirements of the *Fisheries Management Act 1991*, the *Fisheries Administration Act 1991* and the *Environment Protection and Biodiversity Conservation Act 1999*. It also incorporates the requirements of various binding and non-binding international agreements, including the United Nations Convention on the Law of the Sea, the United Nations Fish Stocks Agreement and the Food and Agriculture Organization of the United Nations' Code of Conduct for Responsible Fisheries.

While, the harvest strategy policy has generally been accepted as a successful initiative, it included a commitment to its review within five years of commencement:

The Policy is to be reviewed with a report to be provided to the Minister for Fisheries, Forestry and Conservation and the Minister for Environment and Water Resources within five years of commencement. DAFF [the Department of Agriculture, Fisheries and Forestry] will initiate the review and ensure that stakeholders are involved in the review process (HSP 2007, p. 8).

The review of the harvest strategy policy was conducted by the Department of Agriculture, Fisheries and Forestry (DAFF) with the assistance of the Australian Government Department of Sustainability, Environment, Water, Population and Communities, the Australian Fisheries Management Authority (AFMA) and the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES). The review was also informed by an advisory committee with representatives from the commercial and recreational fishing industry, environmental non-government organisations, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Fisheries Research and Development Corporation.

Importantly, this document, including its conclusions, is a report of the outcomes of a review of the policy and its guidelines conducted by the Department of Agriculture, Fisheries and Forestry with the assistance of relevant government organisations and a stakeholder advisory committee (as described above). As such it does not reflect government policy but is expected to inform the preparation of a revised Commonwealth harvest strategy policy statement and updated guidelines. It is anticipated that a revised policy statement would be a matter for further public consultation.

DAFF released a discussion paper to assist interested stakeholders make a submission to the review. The discussion paper was released on 9 November 2012 and submissions were accepted until 11 January 2013. Eleven submissions to the review were received from a range of stakeholders including commercial and recreational fishers; environmental non-government organisations, scientists and state fisheries departments. The discussion paper and submissions to the review can be accessed online at daff.gov.au/fisheries/domestic/harvest_strategy_policy/review.

The public consultation process, along with existing and commissioned research, helped inform the review of the harvest strategy policy. Projects commissioned as part of the review included technical reviews of the science behind harvest strategies undertaken by CSIRO and ABARES; a desktop literature study of world's best practice harvest strategies undertaken by the Australian National Centre for Ocean Resources and Security; a review of the implementation of the harvest strategy policy undertaken by ABARES; and a report on risk-based approaches, reference points and decision rules for managing fisheries bycatch and byproduct species also undertaken by ABARES. Final reports are available at daff.gov.au/fisheries/domestic/harvest_strategy_policy/review.

The review occurred concurrently with the review of the *Commonwealth Policy on Fisheries Bycatch 2000* (bycatch policy). In September 2012, a third review was announced, the review of Commonwealth Fisheries legislation undertaken by Mr David Borthwick AO PSM. Mr Borthwick delivered his report titled *Review of Commonwealth Fisheries: Legislation, Policy and Management* (fisheries management review) to the Minister for Agriculture, Fisheries and Forestry in late December 2012. In the fisheries management review, Mr Borthwick emphasised the importance of the harvest strategy policy as the primary driver of fisheries policy, the need to update and expand the bycatch policy and the importance of managing the impact of fishing on ecosystems. Mr Borthwick recommended that the Australian Government should set an overarching fisheries framework, capitalising on the reviews of the harvest strategy policy and bycatch policy and developing a 'third policy pillar' that addresses ecosystem impacts in a fisheries context. More information on the fisheries management review and the bycatch policy review can be found online at daff.gov.au/fisheriesreview and daff.gov.au/fisheries/environment/bycatch/review.

Conclusions

Overall, the review found that the harvest strategy policy and guidelines remain a solid foundation for Commonwealth fisheries management. The harvest strategy policy is widely regarded as having been a very successful initiative for improving the management of Commonwealth fisheries (Borthwick 2012; Haddon et al. 2013; McLoughlin & Rayns 2009; Smith et al. 2008; Ward et al. 2013). The policy and guidelines meet or exceed the standards of relevant international obligations and continue to represent world's best practice in most respects. However, fisheries management and science continues to develop. Some aspects of the policy and guidelines could be further refined and updated to capture new developments and address any weaknesses to ensure their settings continue to allow the government to pursue fisheries management objectives in way that represents world's best practice.

Scope of the policy

The Commonwealth harvest strategy policy is one of only a few comprehensive policies that have been implemented by any country to direct the development of harvest strategies across managed fisheries. The policy and guidelines are together designed to direct the development of harvest strategies across the broad range of Commonwealth fisheries, from data-rich to data-poor, high to low value and single species to multi-species fisheries. The policy and guidelines set out the general requirements of harvest strategies but allow considerable flexibility in individual strategy development and application, in order to accommodate implementation across the diverse range of Commonwealth fisheries.

The harvest strategy policy and guidelines have made a significant positive contribution to Commonwealth fisheries management.

The policy and guidelines meet or exceed the standards of relevant international obligations and continue to represent world's best practice in most respects.

However, fisheries management and science continues to develop, including in relation to target and limit reference points, fisheries economics and the management of data-poor stocks. Some aspects of the policy and guidelines could be further refined and updated to capture new developments and address any weaknesses, to ensure they better assist the pursuit of legislative objectives and continue to represent world's best practice for productive, sustainable and profitable fisheries. The policy could also benefit from incorporating relevant elements of the guidelines and 2005 ministerial direction, particularly around overfishing and the recovery of overfished stocks, at a high level and in relatively simple terms.

Updates to the policy and guidelines should be developed with input from stakeholders and fisheries experts and be subject to further consultation.

Harvest strategy implementation

The development, implementation, testing and review of harvest strategies across Commonwealth fisheries under the current policy over a relatively short time have been a significant achievement. However, it has not been without its challenges, particularly in relation to data-poor, low value and complex multi-species fisheries.

AFMA has implemented harvest strategies that are consistent with the policy across most Commonwealth fisheries.

Difficult circumstances such as cost limitations, limited data availability or a need for further scientific development, rather than inappropriate settings in the policy itself have impeded effective application of some aspects of the policy in some fisheries. The existence and application of a cost recovery policy necessarily limits the effort that can be put into managing small and less valuable fisheries (noting that these are often subject to lower levels of fishing activity).

Harvest strategy settings and performance are not always well understood by stakeholders. There should be greater opportunity for consultation during the development of non-technical elements of harvest strategies. This might be achieved by including high-level aspects of harvest strategies (for example, those relating to 'policy' and non technical elements) in management plans.

The policy would benefit from being supported by performance indicators and a reporting regime to report on the implementation and performance of harvest strategies. If this was to occur, industry and stakeholders should be consulted during the development of any performance indicators or changes to reporting, to design a system that is practical and cost-effective. The information to support this will generally already be available in many fisheries and should be incorporated in any new reporting systems to avoid unreasonable reporting burden.

Rebuilding overfished stocks

The 2005 ministerial direction included a requirement that AFMA take immediate action in all Commonwealth fisheries to cease overfishing and recover overfished stocks to levels that will ensure

long term sustainability and productivity and avoid further species from becoming overfished in the short and long term. The policy and guidelines also require that stocks below their limit reference points be rebuilt to target levels but provide limited guidance in this respect. Rebuilding strategies have had mixed success. Stocks such as the eastern stock of orange roughy and smooth oreo dory outside the Cascade Plateau have improved since the policy's release.

A number of overfished stocks subject to rebuilding strategies are not showing clear signs of rebuilding. While there are a number of reasons for this, several overfished stocks continue to be subject to fishing mortality levels that may be too high to allow rebuilding within the required timeframe.

Additional policy direction would be valuable on rebuilding strategies; including on rebuilding timeframes, appropriate rebuilding actions and reporting against rebuilding strategies.

Consideration could be given to providing the fisheries minister with an increased oversight role and powers to initiate a review of arrangements for stocks where rebuilding is not demonstrated within the timeframe of the rebuilding strategy.

Consideration could be given to elevating aspects of rebuilding strategies into legislative instruments and to increasing protections for overfished stocks whose biomass has fallen below some acceptable risk threshold.

Discarding of commercial species

The discarding of commercial species has both sustainability and 'social licence' aspects. In addition to the unquestionable need to ensure sustainability, there are also strong community expectations to reduce wastage of commercial species through discarding. There is also growing international support for minimising or eliminating discards of commercial species. A number of international fisheries jurisdictions, such as the European Union, are currently working towards implementing systems that minimise or prevent discards, while in other jurisdictions, such systems are already well established.

AFMA already seeks to manage the sustainability of discarding by factoring estimates of commercial species discards (where available) into total allowable catch settings for a number of stocks. While the ministerial direction requires this, the policy does not.

Some level of unwanted incidental catch of commercial species is unavoidable. Reliable estimates of discards of commercial species should continue to be factored into recommended biological catch settings, as part of total fishing mortality, to ensure the sustainability of discarded stocks.

The policy could also be improved by providing greater direction on the need to minimise the discarding of commercial species. Discarding of commercial species should ideally be kept to the minimum practical and cost-effective level consistent with sustainability.

Mechanisms to further reduce discarding should be explored. Where appropriate, management arrangements—such as catch sharing arrangements and total allowable catch levels for individual species in multi-species fisheries—should be set with regard to minimising incentives for discarding, noting that this must be balanced with other fisheries objectives. Avoidance of

unwanted catch, such as through spatial measures or improved gear selectivity, should be encouraged.

Shared stocks

Difficulties can arise with aspects of the management of shared stocks, such as setting catch levels that maintain sustainability of and equitable access to such stocks. These challenges reflect the broader challenges of operating in ‘the commons’ that are inherent to wild fisheries. Nevertheless managing shared stocks is an issue that needs to be addressed, particularly as demand for seafood continues to increase, quota management becomes more widespread, fishing technology continues to improve, demands for some stocks by other users increases, and climate change results in spatial and productivity shifts in fish populations.

It is difficult, and possibly undesirable for the policy to prescribe directions for setting catch levels for shared stocks. Each situation is likely to be characterised by a unique set of circumstances.

While the policy and guidelines can provide direction, the greatest difficulties of managing shared stocks arise from a lack of agreement between the different jurisdictions or user groups on how to manage and share the stocks. These problems cannot be solved by the harvest strategy policy.

There is confusion among some stakeholders about how the policy should be applied to fisheries that access internationally managed stocks. The policy could provide improved guidance about how domestic catch levels should be set where there is no appropriate international catch allocation.

Inter-jurisdictional catch setting problems could be comprehensively addressed through reform of offshore constitutional settlement arrangements (as recommended by Borthwick 2012). Unless and until this happens, issues with setting total allowable catches for stocks shared with other domestic jurisdictions are only likely to be significantly overcome where clear and appropriate catch sharing arrangements are developed that appropriately constrain catches in all jurisdictions.

It would be valuable if the guidelines provided information on when and how to account for non-commercial users when setting commercial catch levels.

In setting catch limits where there is significant shared use with the non-commercial sector, lack of data on non-commercial catches can impede the policy’s application and should be addressed. Reliable and current data on recreational catch, in particular, is important for managing a growing number of fisheries but its collection cannot be charged to the commercial sector. Options for funding surveys of recreational fishing could be explored with the recreational fishing sector and state and territory governments.

Reference points

In the harvest strategy policy context, a ‘reference point’ is a specific level of an indicator of stock status or economic condition (such as level of current biomass) against which the current level of that indicator can be compared. Two types of reference points are specified in the policy: ‘target reference points’ and ‘limit reference points’.

Reference points provide a key link between harvest strategies and fisheries management objectives, describing the desired biological and economic conditions in a fishery, and those to be

avoided. Harvest strategies should set out both a meaningful measure of stock status against reference points, and clear triggers for management action to ensure that stocks are maintained above limits, and managed towards targets.

The target and limit reference points, and their proxies, currently described in the policy and guidelines appear to be generally appropriate and should be largely retained in any possible policy update. However, consideration should be given to:

- **specifying a minimum biomass limit reference point value of 20 per cent of unfished biomass, unless there is strong scientific support for lower values**
- **whether the policy's current maximum economic yield proxy; 1.2 times the size of the biomass that supports maximum sustainable yield or 48 per cent of unfished levels; is optimal for maximising economic returns in most situations**
- **incorporating a description of appropriate fishing mortality reference points into the policy.**

The policy could benefit from being more explicit about ensuring that targets and limits are appropriate for different stocks and fisheries, including stocks with different productivity levels and those that perform an important ecosystem function. It would be beneficial if the guidelines provided more advice on how this could be implemented.

Optimising economic yield in multi-species fisheries

The harvest strategy policy's objective seeks to maintain key commercial stocks at sustainable levels and, within that context, maximise the economic returns to the Australian community.

Individual fish stocks within a multi-species fishery are likely to differ in their biological and economic characteristics. The biomass that supports maximum economic yield is likely to vary from species to species and be achieved at different fishing levels. As a result, the effort level to achieve the biomass that supports maximum economic yield for a fishery's main commercial stock might see other stocks being fished at higher or lower levels than would be required to maximise economic yield if they were fished individually.

Further work is required to better implement the maximum economic yield objective in complex multi-species fisheries.

Developments continue to be made on managing multi-species fisheries and the science that underpins these management arrangements. The policy could benefit from providing scope for the adoption of new information and management approaches as they are developed.

Managing some stocks in multi-species fisheries at levels below maximum *sustainable* yield in order to achieve fishery-wide maximum economic yield is well established in theory. However, doing so increases the risk to such stocks and is not a preferred approach in most circumstances. The policy could be amended to indicate that this should only be done where risks are constrained and the needs of other user groups has been appropriately considered, there is a sound scientific basis to do so and other cost effective options such as gear modifications or spatial/temporal management measures are unavailable.

Managing byproduct (and data-poor stocks)

The harvest strategy policy has been a successful initiative for pursuing sustainability and economic objectives for target stocks in Commonwealth fisheries. However, there is no clear Commonwealth policy that interprets objectives and describes mechanisms for managing byproduct stocks (stocks with commercial value that are not generally targeted but are taken incidentally when fishing for another species).

There was strong stakeholder support for ensuring that all Commonwealth species should be managed consistently, irrespective of whether they are key commercial, byproduct or bycatch.

The revised harvest strategy policy and bycatch policy could together clearly address the effects of fishing on all species caught in Commonwealth fisheries, recognising that the level of active management will vary across species depending on risk.

The fisheries policy framework could be extended to incorporate byproduct stocks; applying cost-effective and risk-based approaches that ensure the sustainability of stocks and maximise economic returns from the fishery.

Byproduct could be managed through a combination of ecological risk assessment and ecological risk management approaches and, where appropriate, low information harvest strategies to identify and manage risks on a stock by stock basis while maximising economic returns at a fishery level. Selection of the most appropriate approach to managing each stock could follow a tiered approach, informed by the level of risk, information availability and risk (certainty)-catch-cost considerations.

The harvest strategy policy could be revised to encompass the management of byproduct species, recognising that in most cases this will include a tiered approach requiring formal risk management based on the level of available information.

Spatial management

Spatial management involves limiting fishing in an area; for a limited period of time or 'permanently'; for the purpose of managing the effects of fishing. Spatial management tools are commonly used to protect or rebuild commercial stocks (or parts of stocks, such as juvenile fish), their habitat and/or bycatch species.

The harvest strategy policy recognises that spatial management may be used in various ways including closures to protect spawning seasons or nursery areas, rotational harvesting, setting separate total allowable catches by area (zoning) and protecting key habitat areas.

The guidelines could benefit from including clearer direction on the use of spatial (and temporal) management arrangements. This includes guidance on evaluating the effect of spatial or temporal closures and the management of stocks in open areas.

However, the development of guidance would require further work and research into:

- **how spatial and temporal management arrangements can be used to help meet the objectives of the policy and provide flexibility for individual harvest strategies**
- **how harvest strategies could appropriately account for the effects of closures**

- **how spatial closures could assist harvest strategies in meeting the objectives of the policy for species whose stocks are highly variable and show strong spatial structuring.**

1 Introduction

Fisheries management in Australia

Australia's Commonwealth, state and territory governments manage fisheries on behalf of the Australian people. They do this in consultation with the fishing industry, scientists, economists and other user groups including recreational and Indigenous fishers and environmental non-government organisations.

The management of Australia's Commonwealth fisheries is governed by the *Fisheries Management Act 1991* and *Fisheries Administration Act 1991*. The state and territories have their own legislation for fisheries management.

The Department of Agriculture, Fisheries and Forestry (DAFF) is responsible for Commonwealth fisheries policy, including the *Commonwealth Fisheries Harvest Strategy Policy and Guidelines 2007* (harvest strategy policy) and the *Commonwealth Fisheries Bycatch Policy 2000* (bycatch policy). These policies underpin the management of commercial fishing in Commonwealth fisheries.

The Australian Fisheries Management Authority (AFMA) is an independent authority established under the Fisheries Administration Act and is responsible for the efficient management and ensuring sustainable commercial fishing practices in Commonwealth fisheries on behalf of the Australian community. Together, the Fisheries Administration Act and Fisheries Management Act outline AFMA's objectives, functions and powers.

The Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) sits within DAFF and provides professionally independent research, analysis and advice for government and private sector decision-makers on significant issues affecting Australia's primary industries. In the fisheries sphere this includes the annual production of Fishery Status Reports. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) also provide expert scientific and technical advice to fisheries managers and work closely with government and other organisations to achieve conservation and management gains supported by science.

The Australian Government Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) administers the *Environment Protection and Biodiversity Conservation Act 1999*. This Act contains a number of provisions relevant to the sustainable management of commercial fisheries including in relation to strategic assessment for impacts on matters of national environmental significance, impacts on protected species and export of products derived from fisheries.

The Environment Protection and Biodiversity Conservation Act also provides for the listing and recovery of nationally threatened species and ecological communities. In line with the threatened species listing guidelines, when considering listing thresholds for assessing commercially harvested marine fish species, reference is made to the harvest strategy policy.

State and territory governments are responsible for the management of recreational and Indigenous fishing and a number of commercial fisheries. The Australian Government manages Commonwealth commercial fisheries. Fisheries rules vary between the Commonwealth, states and territories. By default, fishing within three nautical miles of the coast would be managed by the states and

Northern Territory, with the Australian Government managing fisheries beyond three miles. However, offshore constitutional settlement arrangements have been widely implemented, which alter these default arrangements for particular species, gear types or areas. In general, the states and Northern Territory tend to manage commercial fishing for stocks that often occur in more inshore areas, while the Commonwealth tends to be responsible for offshore fisheries, particularly those that target internationally managed species. The states and Northern Territory currently manage all recreational fishing, irrespective of distance from shore.

Commonwealth Fisheries Harvest Strategy Policy and Guidelines

In 2007, the Australian Government released the *Commonwealth Fisheries Harvest Strategy Policy and Guidelines*. The aim of the harvest strategy policy is to ensure:

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 Australian community (HSP 2007, p. 4).

The policy incorporates the relevant requirements of the Fisheries Management Act, the Fisheries Administration Act, the Environment Protection and Biodiversity Conservation Act, and various binding and non-binding international agreements, including the United Nations Convention on the Law of the Sea, the United Nations Fish Stocks Agreement and the Food and Agriculture Organization of the United Nations' Code of Conduct for Responsible Fisheries.

The policy was developed as a direct response to a ministerial direction given to AFMA in December 2005 by the then Minister for Fisheries, Forestry and Conservation, under section 91 of the Fisheries Administration Act (Appendix A). The direction states, among other things, that:

AFMA must take a more strategic, science-based approach ... consistent with a world's best practice Commonwealth Harvest Strategy Policy that has the objectives of managing fish stocks sustainably and profitably, putting an end to overfishing, and ensuring that currently overfished stocks are rebuilt within reasonable timeframes ...

A harvest strategy, as defined by the policy, sets out the management actions necessary to achieve defined biological and economic objectives in a given fishery and must contain:

- a process for monitoring and conducting assessments of the biological and economic conditions of the fishery
- rules that control the intensity of fishing activity according to the assessed biological and economic conditions of the fishery (referred to as control rules).

The policy is intended to provide a consistent framework that allows a strategic, science-based and precautionary approach to setting harvest levels in all Commonwealth fisheries on a fishery by fishery basis. The policy requires that an evidence-based approach be taken to setting management targets, limits and decision rules, in order to maintain fish stocks at safe and productive levels that maximise net economic returns to the Australian community.

The policy is designed to be read in conjunction with the *Guidelines for Implementation of the Policy* (the guidelines). The guidelines provide practical information on how to interpret and apply the

policy to Australia's fisheries and contain details of the science behind the fisheries management decisions. Harvest strategies for domestic and some internationally-managed fisheries have been developed and implemented by AFMA. A review of the implementation of the harvest strategy policy was undertaken by ABARES, while the policy's implementation is described in Chapter 5.

The ecological risk management framework is a key initiative that has been developed in recent years to support the implementation of ecologically sustainable development. This framework outlines a process for assessing and addressing the impacts of fisheries on five aspects of the marine ecosystem:

- target species
- byproduct and discard species
- threatened, endangered and protected species
- habitats
- communities.

Ecological risk assessments form part of the ecological risk management framework and are used to assess the risks of a fishery's activities on the different components of the marine ecosystem. AFMA has completed ecological risk assessments for all major Commonwealth managed fisheries.

Review of the Commonwealth Fisheries Bycatch Policy and of Commonwealth Fisheries: Legislation, Policy and Management

The review of the harvest strategy policy occurred concurrently with the review of the Commonwealth Policy on Fisheries Bycatch (bycatch policy), from March 2012 to March 2013.

In September 2012, a third review was announced as a review of Commonwealth fisheries legislation (the fisheries management review). Mr David Borthwick AO PSM was appointed to undertake this review and consulted widely in the last quarter of 2012. He delivered his report titled *Review of Commonwealth Fisheries: Legislation, Policy and Management* to the Minister for Agriculture, Fisheries and Forestry, Senator the Hon. Joe Ludwig, in late December 2012.

The fisheries management review was the first of its kind in over twenty years, and examined a range of issues to identify what improvements were needed to ensure community and industry expectations of the Australian fisheries management regime can be met into the future. Minister Ludwig released the fisheries management review report on 21 March 2013 and announced his in principle agreement with the direction of the review's 15 recommendations. A ministerial statement has been issued on the government response to the review. A public consultation process will follow on the implementation of the fisheries management review's recommendations. This consultation will also be informed by the reviews of the harvest strategy policy and bycatch policy and will occur after their release.

In the fisheries management review, Mr Borthwick emphasised the importance of the harvest strategy policy as the primary driver of fisheries policy, the need to update and expand the bycatch policy and the importance of managing the impact of fishing on ecosystems. Mr Borthwick recommended that the Australian Government should set an overarching fisheries framework, capitalising on the reviews of the harvest strategy policy and bycatch policy and developing a 'third' policy pillar that addresses ecosystem impacts in a fisheries context. The fisheries management

review identified high level policy gaps that should be addressed. Submissions were received that raised the need for an ecosystems policy, greater clarity on where species sit on the policy continuum from key commercial to incidental bycatch and highlighting the role of ecological risk assessment/ecological risk management in ecosystems based fisheries management.

An overarching fisheries policy that describes the high level objectives and principles for Commonwealth fisheries management would complement the individual policy components for harvest strategy and bycatch in a fisheries policy framework. This framework could indicate how the policies and procedures interact and relate with one another in a way that is clear to fisheries managers, users and the general community.

The fisheries management review report noted that the integration of all policy elements (harvest strategy, bycatch and a potential new ecosystems policy) should be fundamental to fisheries management planning and decisions.

National Harvest Strategy Guidelines Project

A National Harvest Strategy Guidelines Project was initiated through the Australian Fisheries Management Forum and is a national (cross-jurisdictional) project not directly related to the Commonwealth Fisheries Harvest Strategy Policy or its review.

The National Harvest Strategy Guidelines Project has developed a high level document to describe what harvest strategies are, what the authors consider to be 'best practice' in setting harvest strategies, and how harvest strategies might be applied to a range of fisheries situations that can be agreed and can influence fisheries management across all domestic jurisdictions.

These guidelines are intended to help increase the application of the robust harvest strategy approaches such as those applied in Commonwealth fisheries, to fisheries across all Australian jurisdictions. The guidelines are anticipated to encourage closer alignment of fisheries management approaches nationally. As part of this work, the Fisheries Research and Development Corporation is producing a research report titled *Development of a national harvest strategy framework*.

2 Review methodology

The harvest strategy policy was generally accepted as a successful initiative, however the policy and guidelines may require refinement over time as lessons are learnt from their implementation and as fisheries science evolves. The policy includes a commitment to review within five years of commencement:

The Policy is to be reviewed with a report to be provided to the Minister for Fisheries, Forestry and Conservation and the Minister for Environment and Water Resources within five years of commencement. DAFF will initiate the review and ensure that stakeholders are involved in the review process (HSP 2007, p. 8).

By reviewing the harvest strategy policy, DAFF is evaluating whether the policy is meeting its objectives and identifying the strengths of the policy as well as any lessons learned and possible areas for future improvement.

The Minister for Agriculture, Fisheries and Forestry initiated the review of the policy and guidelines, releasing the terms of reference (Attachment 1) on 28 March 2012.

Throughout the review, technical analysis and consultation with stakeholders helped to identify the strengths of the current harvest strategy policy and guidelines and identify areas of possible improvement.

Steering committee and advisory committee

Steering and advisory committees were formed to provide direction and advice for the review.

Membership of the steering committee comprised AFMA, SEWPaC, ABARES and DAFF's Sustainable Resource Management Division. Its role was to:

- support the review of the Commonwealth Fisheries Harvest Strategy Policy and Guidelines
- guide and oversee the review and possible revision of the Commonwealth Fisheries Harvest Strategy Policy and Guidelines, in accordance with the review's terms of reference
- consult and seek technical and policy advice from the advisory committee and other stakeholders
- decide on whether working groups or the advisory committee would be convened to focus on specific elements of the review process
- promote and contribute to meaningful engagement with all relevant stakeholders, including the advisory committee to ensure their active participation in the review process.

The advisory committee included representation from the commercial fishing sector (the Commonwealth Fisheries Association and the National Seafood Industry Alliance, including the Australian Southern Bluefin Tuna Industry Association and the Great Australian Bight Fishing Industry Association), the recreational fishing sector (represented by the Amateur Fishermen's Association of the Northern Territory), environmental non-government organisations (WWF-Australia and the Australian Marine Conservation Society), CSIRO and the Fisheries Research and Development Corporation, as well as the organisations represented on the steering committee.

The role of the advisory committee was to review and provide advice to the steering committee on any technical and policy matters that may arise during the review of the harvest strategy policy.

The advisory committee:

- assessed and provided advice on material generated by the review in line with the review's terms of reference (particularly the discussion paper, final report and its conclusions)
- provided advice to the review (as requested) on any scientific, economic and policy-based issues that arose
- supported the review of the Commonwealth Fisheries Harvest Strategy Policy and Guidelines.

Commissioned research

As part of the review of the harvest strategy policy, DAFF considered existing research and commissioned several new projects to evaluate the policy and the science behind it. These projects included technical reviews of the science behind harvest strategies undertaken by CSIRO and ABARES; a desktop literature study of world's best practice harvest strategies undertaken by the Australian National Centre for Ocean Resources and Security; a review of the implementation of the harvest strategy policy undertaken by ABARES; and a report on risk-based approaches, reference points and decision rules for managing fisheries bycatch and byproduct species also undertaken by ABARES. More information on these projects can be found in Chapter 3 and all reports will be made publicly available on the DAFF website at daff.gov.au/fisheries.

Consultation

Overview

Representatives from across the fisheries sector were consulted during the review of the harvest strategy policy, including government, the commercial fishing industry, environmental non-government organisations, the recreational fishing industry, state fisheries departments, scientific research organisations and government organisations.

A discussion paper was developed to promote wider discussion and feedback to the review and was released online and emailed to over 100 people from the above sectors. Throughout the consultation process, information about the review and how to make a submission was available online and in hardcopy on request. The review was advertised in several mediums including the Fisheries Research and Development Corporation's *Fish Magazine* and the AFMA website. The public consultation period was open for six weeks to give stakeholders the opportunity to consider their submissions and provide input. DAFF continued to accept submissions for three weeks after the end of the six week consultation, after which no further submissions were received. Feedback from the public consultation process was used to inform and develop the review of the harvest strategy policy.

Discussion paper

DAFF developed a discussion paper for the harvest strategy policy review with the assistance of the review's steering and advisory committees and in consultation with a number of fisheries scientists and managers close to the development and implementation of the policy. The discussion paper was released on 9 November 2012 to assist interested parties to make a submission to the review. It identified a broad range of potential issues in the policy and guidelines and their implementation that might require refinement, elaboration or further development.

The discussion paper can be accessed online at daff.gov.au/fisheries/domestic/harvest_strategy_policy/review-submissions.

Summary of public submissions

Eleven submissions were received for the review of the harvest strategy policy from a range of stakeholders, including commercial fishers, recreational fishers, environmental non-government organisations, industry bodies, scientists, state fisheries agencies and other members of the public.

Stakeholders commented on a number of issues during the public consultation process, many of which were similar to those identified in the discussion paper. Key issues raised included rebuilding strategies; the management of byproduct species; discarding; target and limit reference points; and the application of the policy to shared stocks.

A summary of some of the key points raised in the public submissions, and the full submissions can be found on the DAFF website at daff.gov.au/fisheries/domestic/harvest_strategy_policy/review-submissions and at Appendix C. Please note the information reflected in the summary and in the public submissions does not represent the government's position nor does the government make any claims to the accuracy of the information provided in the submissions and reflected in the summary.

Outcomes

The key conclusions from the review of the harvest strategy policy are outlined in Chapters 4–12. These findings recognise the policy's success and suggest areas for further development. Some of these conclusions can be addressed immediately whilst others require further research, work, consultation with affected stakeholders and consideration of cost implications to enable their implementation and can only be implemented over time.

Importantly, this document is a report of the outcomes of a review of the harvest strategy policy and its guidelines, conducted by the Department of Agriculture, Fisheries and Forestry with the assistance of the Department of Sustainability, Environment, Water, Population and Communities and AFMA and from a stakeholder advisory committee. As such the report and its conclusions do not reflect government policy. Rather, the review is intended to help inform government considerations about the Commonwealth's current fisheries management under the harvest strategy policy and provide information and evidence for any future revisions to the policy.

3 Technical review reports

As part of the review of the harvest strategy policy, DAFF commissioned six independent reports on policy settings and the fisheries science and economics that underpin the policy and guidelines. The technical reports were provided to the steering and advisory committees and will be made publicly available at daff.gov.au/fisheries.

The following technical reports were commissioned as part of the review of the harvest strategy policy.

Implementation review (Ward et al. 2013)

The ABARES review of the implementation of the harvest strategy policy's implementation in Commonwealth and jointly managed fisheries was developed in close consultation with AFMA, and includes case studies that highlight the key issues with the policy's implementation. The review focuses on the technical aspects of the implementation of the policy and includes information on whether fishery management actions and decisions have been consistent with the policy, challenges encountered in implementing the policy and changes in the status of fisheries that might be a result of the policy's implementation. It notes that since the policy's introduction in 2007, AFMA has implemented harvest strategies for 72 fish stocks that are managed in all active Commonwealth fisheries solely managed by AFMA and that in several fisheries multiple stocks are assessed and managed together as 'basket' stocks. The review also highlights the improvements in the status of Commonwealth fish stocks since the late 2000s. However there are difficulties in determining whether these improvements are a direct result of the implementation of harvest strategies and/or changes to fishing effort and structural adjustment in the industry.

Literature study and review of international best practice in fisheries harvest strategy policies (McIlgorm 2013)

The Australian National Centre for Ocean Resources and Security, from the University of Wollongong conducted a desktop study of international best practice harvest strategy policy approaches and settings. The Commonwealth harvest strategy policy was assessed in the context of international obligations and policies in countries considered to have strong fisheries management, including New Zealand, the United States of America, the European Union, Norway and Iceland. The desktop study found that the harvest strategy policy meets or exceeds relevant international obligations and international best practice requirements particularly in relation to objectives, overfishing and overfished reference points. Several areas of the policy were identified as good practice but could be developed further, including for low productivity, low value and developing fisheries.

Technical reviews for the Commonwealth Harvest Strategy Policy (Haddon et al. 2013)

The CSIRO review of the technical aspects of the harvest strategy policy considered matters such as reference points and life history characteristics; buffers and meta-rules; data-poor fisheries and the tiered approach to harvest strategies; total allowable catches; rebuilding strategies and spatial management. This review provides information on how the requirements of the harvest strategy policy have been technically interpreted in the harvest strategies developed for Commonwealth fisheries. Where difficulties have been experienced with harvest strategy development or implementation, technical reasons for this are analysed and advice is provided on how these may be addressed. The report found that in relation to the requirement to rebuild overfished stocks,

meeting the guidelines has been problematic for at least three conservation dependent species. The review also explores some of the difficulties in managing multi-species fisheries, including total allowable catch setting; the degree to which fishers can target a specific species; and increased discarding because of the difficulties in balancing quotas with actual catches when multiple species are being caught.

Technical reviews for the Commonwealth Harvest Strategy Policy: economic issues (Vieira & Pascoe 2013)

This paper was a collaboration between ABARES and CSIRO and considered economic definitions and understanding in the harvest strategy policy; challenges to implementing maximum economic yield; data-poor species; multi-species fisheries; variable stocks; market power and internationally managed fisheries. Estimating maximum economic yield requires a bioeconomic model, which has high biological, fishery and economic data requirements. Due to this high level of data requirement it is often difficult to estimate maximum economic yield and proxies have been used instead. This report considers circumstances under which the current interpretation of maximum economic yield, and the targets used, could be modified to better achieve the economic objective and intent of the harvest strategy policy. Further research is underway to look at proxy measures for maximum economic yield in multi-species fisheries when there is not enough information for bioeconomic models. The aim of this project is to develop rules of thumb that will allow better estimates of target reference points to be made in the absence of complete data. The report also notes that updating the guidelines with new research findings may assist with targeting maximum economic yield.

Note: The technical reviews by Haddon et al. (2013) and Vieira & Pascoe (2013) were peer reviewed by an independent fisheries expert.

Risk-based approaches, reference points and decisions rules for managing fisheries bycatch and byproduct species (Penney et al. 2013a)

This ABARES paper considers the principles, framework and processes of risk management as well as risk-based approaches to bycatch and byproduct management. It also explores reference points and decision rules for bycatch and byproduct; low information analytical approaches to bycatch and byproduct assessment; and monitoring and performance evaluation. It highlighted difficulties in finding consistent international definitions of byproduct and bycatch and explored definitions to be used in Australian fisheries management. This paper also considers the information requirements for monitoring fishery impacts on target, byproduct and bycatch species and the feasibility and cost of collecting this data for species that are not always retained. A tiered approach to fishery impact assessments is investigated, with approaches ranging from qualitative risk assessments for low information species through to high-information statistical stock assessments.

Technical overview report (Penney et al. 2013b)

This ABARES paper (Appendix B) identifies technical areas where the harvest strategy policy might be improved. It synthesises the conclusions of the technical reports mentioned previously, with other studies, to provide evidence to support possible changes to the policy. The key issues identified in the technical documents have been categorised, the current situation reviewed and areas of the policy and/or guidelines that might benefit from improvement identified. The paper considers where further work might be required before other options for improvement can be identified. Most of the potential improvements discussed relate to the guidelines, and not the policy

itself. However, some of the options for improvement in the guidelines may require supporting or enabling text in the policy itself.

Together with the feedback from public consultation (Appendix C), these technical reports have informed the findings identified in the following chapters of this report. The technical reports identify aspects of the policy that are working well as well as identifying areas for improvement and alternative approaches to address these including areas for future research and development.

4 The scope of the policy

The Commonwealth harvest strategy policy is one of only a few centralised fisheries policies that have been implemented by any country to direct the development of harvest strategies across managed fisheries. New Zealand has a similar centralised Harvest Strategy Standard across its fisheries while the United States of America has a number of applicable national standards (McIlgorm 2013).

The policy applies specifically to the ‘key commercial species’ (a species that is, or has been, targeted and is, or has been, a significant component of a fishery) of all Commonwealth fisheries managed solely by AFMA. The guidelines also provide some direction on the application of harvest strategies to ‘secondary’ (lower value) species.

The policy and guidelines are together designed to direct the development of harvest strategies across the broad range of Commonwealth fisheries, from data-rich to data-poor, high to low value and single species to multi-species fisheries. The policy sets out the general requirements of harvest strategies but allows considerable flexibility in individual strategy development and application, in order to accommodate implementation across the diverse range of Commonwealth fisheries.

Policy settings and international best practice

McIlgorm (2013), from the Australian National Centre for Ocean Resources and Security (University of Wollongong), conducted an independent literature review of international best practice in fisheries harvest strategy approaches. The review investigated international binding and non-binding instruments to which Australia is a party, including the United Nations Convention of the Law of the Sea, the United Nations Fish Stocks Agreement and the Food and Agriculture Organization of the United Nations’ Code of Conduct for Responsible Fisheries. McIlgorm’s findings indicate that **the policy meets or exceeds Australia’s international obligations for the harvesting of commercial species**. McIlgorm (2013) also considered issues, such as ecosystem management and discarding, that are currently addressed in Commonwealth fisheries through mechanisms other than the harvest strategy policy.

McIlgorm (2013) also investigated international best practice policy settings in a number of leading international fisheries jurisdictions, including the United States, New Zealand and Europe. The investigation indicates that **the harvest strategy policy meets or exceeds international best practice for policy settings in fisheries management in most aspects**, including its objectives, reference points and other settings (such as the need to develop rebuilding strategies for overfished stocks and the defined likelihood for avoiding limit reference points). McIlgorm (2013) recognised that Australia’s harvest strategy policy and guidelines also seek to address a number of issues for which fisheries management and science are still developing and international best practice is yet to be determined, such as multi-species, low productivity and low value fisheries.

McIlgorm (2013) identifies a number of areas in which the harvest strategy policy may not currently meet international best practice. These include ensuring the implementation and success of rebuilding strategies, the management and reduction of discards, cost effective risk assessment approaches and setting reference points based on trophic roles, and ecosystem based fisheries management. With the exception of ecosystem based fisheries management, all of these issues are addressed elsewhere in this report.

While the policy addresses some aspects of ecosystem based fisheries management, such as pursuing the sustainability of targeted fish stocks and having regard to their ecosystem role, the policy is not intended by itself to meet Australia's domestic or international undertakings to pursue ecosystem based fisheries management. The policy states:

... implementing a harvest strategy of itself will not achieve ecologically sustainable or profitable fisheries. Other processes are in place in Commonwealth fisheries management to help achieve broader ecosystem objectives, including undertaking comprehensive ecological risk assessments accompanied by appropriate risk management responses. The ministerial direction provides for further initiatives in support of EBFM [ecosystem based fisheries management], including reductions to bycatch, fishery independent monitoring, and increased focus on spatial management. Harvest strategies, in combination with this package of measures, constitute a whole of government approach to sustainable fisheries management (HSP 2007, pp. 2–3).

The fisheries management review (Borthwick 2012) also recognises this and recommends that the government should develop an overarching fisheries framework that includes the harvest strategy policy, bycatch and discards policy, as well as a third pillar addressing ecosystem impacts in a fisheries context to address aspects of ecosystem based fisheries management.

Despite there being no specific policy direction addressing the impacts of fishing on byproduct stocks and ecosystems, AFMA has taken steps to manage these by developing (with CSIRO) and implementing an ecological risk management framework. This provides a process for assessing and progressively addressing the impacts that fishing activities have on target species, byproduct and discard species, protected species, habitats and ecological communities.

The policy's current scope and format

Prior to the 2005 ministerial direction to AFMA that led to the development of the policy, both the biological and economic performance of many Commonwealth fisheries was declining. While the legislative framework in place required the pursuit of ecologically sustainable development and economic efficiency, it gave little or no guidance on the level of risk to stocks that was acceptable to the Australian Government or on the acceptable level of economic performance of Commonwealth fisheries (McLoughlin & Rayns 2009).

The development and implementation of harvest strategies has been critical to improving fisheries management in Australia (Borthwick 2012; Haddon et al. 2013; McLoughlin & Rayns 2009; Smith et al. 2008). The economic and biological performance of Commonwealth fisheries has improved substantially since harvest strategies were widely implemented (Ward et al. 2013; Woodhams et al. 2012). Ward et al. (2013) note that many improvements in stock status are likely to be due to the implementation of harvest strategies, although it is not possible to separate the effects of the harvest strategy policy from other factors such as the significant structural adjustment package implemented in 2006; fluctuations in the demand for seafood; fluctuating currency exchange rates and changing operating costs.

The fisheries management review (Borthwick 2012) noted:

There are a number of reasons for the HSP's [harvest strategy policy] positive and quite dramatic impact on Commonwealth managed fisheries, in the context of its role ...

- The HSP was a clear and unequivocal policy initiative of the then Minister for Fisheries. AFMA and fisheries management stakeholders were left in no doubt of the requirements outlined in the ministerial direction and the HSP itself.
- The HSP is not prescriptive in the imposition of management arrangements. Rather, it requires outcomes, but not the management process for achieving those outcomes.
- It has significant buy-in from key contributing stakeholders.
- Ongoing technical evaluation of harvest strategies is required and provides a process for certainty and predictability (requiring strategies to be established for at least three years), while recognising flexibility may also be required where new information becomes available that allows for better assessment of the status of fisheries.
- The associated Guidelines are transparent and cover the broad range of elements necessary for the development of sound harvest strategies.
- The Guidelines outline the roles and responsibilities of the MACs [management advisory committees] and RAGs [resource assessment groups] in the harvest strategy development process, including their relationship to AFMA. They make clear that AFMA is expected to consult widely in the process of decision making (i.e. not just with the RAGs and MACs).
- The design criteria are straightforward and cover all criteria necessary for developing a harvest strategy to [maximise] economic yield for commercial target species, while taking into account the imperatives for ecologically sustainable development and the precautionary principle.

Despite the difficulties separating the individual effects of various factors on fisheries performance, it is clear that **the harvest strategy policy is widely held to have been a very successful initiative for improving the management of Commonwealth fisheries** (Borthwick 2012; Haddon et al. 2013; McLoughlin & Rayns 2009; Smith et al. 2008; Ward et al. 2013).

Format of the policy and guidelines

The harvest strategy policy sets out the fundamental policy requirements in relatively high level and simple terms. The policy is accompanied by implementation guidelines that describe much of the technical detail associated with harvest strategy development and implementation. **The separate policy and guidelines structure is effective and should be retained. The policy allows an appropriate high level of flexibility, given the broad range of situations for which it applies, which should be retained in any revised policy.** The policy and guidelines could be improved by increasing the consistency of the language used and clearly defining relevant terms. The guidelines could benefit from more clearly setting out the intended application of the policy across the broad range of Commonwealth fisheries.

Updating the guidelines

Haddon et al. (2013) and Vieira & Pascoe (2013) reviewed the science and economics that underpin the policy and guidelines and identified areas where progress has been made since the policy was released, as well as areas that would benefit from further development. These areas include determining appropriate target and limit reference points relevant to a stock's productivity and ecosystem role; managing data-poor stocks; approaches for setting total allowable catches in multi-

species fisheries; rebuilding strategies and indicators of economic performance and spatial management. These and other issues are summarised in Penney et al. (2013b) (Appendix B), and issues of particular relevance to the review are outlined elsewhere in this report. **The guidelines would benefit from being updated to reflect recent developments in fisheries science and management since their release.** This could include updating the case studies in the guidelines to demonstrate the range of applications of the policy across different fisheries.

The importance of the policy and the technical nature of the guidelines are such that any review of them warrants further consultation with stakeholders and fisheries experts. The current policy's technical settings and the guidelines were subject to peer review by independent fisheries experts prior to release and consideration should be given to applying a similar approach to future updates of the technical aspects of the policy and guidelines.

Fisheries science continues to evolve and the guidelines play an important role in explaining how the policy can be implemented. **It is important to ensure that the science underpinning the guidelines remains up to date.** Considering this, and the high level nature of the policy relative to the technical nature of the guidelines, **future reviews of the guidelines and the science underpinning them should not necessarily be directly coupled to reviews of the policy. This might be achieved by updating the guidelines more frequently than the policy or by providing a flexible mechanism to incorporate new scientific developments in the guidelines outside a formal policy review.**

Updating the policy

There are elements of the 2005 ministerial direction that are not fully reflected in the current policy statement. One aspect that could be more clearly outlined in the policy is the explicit direction to cease overfishing, avoid other species becoming overfished in the short and long term and recover overfished stocks to levels that will ensure long-term sustainability and productivity. While stock recovery is frequently a long term process and may be affected by factors other than fishing, the requirement to cease overfishing and recover overfished stocks was an important element of the direction and a matter of broader public interest.

While these requirements are reflected in the policy's approach, an explicit statement to this effect would be valuable, particularly given that a number of stocks that are classified as overfished are still subject to overfishing. Similarly, the ministerial direction's guidance on the policy's application to internationally-managed fisheries with acceptable scientific catch setting processes, and on minimising incentives for discarding, should be captured in the policy. These matters are discussed in more detail elsewhere in this report.

The guidelines advocate a risk-based management approach whereby exploitation levels are reduced as uncertainty around stock status increases and *vice versa*. Risk-based approaches are an appropriate way to deal with uncertainty and such approaches are central to harvest strategy implementation. This is explicitly provided for by the application of the tiered approach to harvest strategies, which depends on information availability. The risk-based approach is also reflected in the precautionary principle as applied to fisheries legislation:

In the application of the precautionary principle, public and private decisions should be guided by ... assessment of the risk-weighted consequences of various options.

However, the policy itself is currently silent on the use of risk-based approaches for dealing with uncertainty. Similarly, the policy is not explicit about accounting for all sources of mortality, such as discards, in total allowable catch settings. These issues are discussed in greater detail elsewhere in this report.

Conclusions

The harvest strategy policy and guidelines have made a significant positive contribution to Commonwealth fisheries management.

The policy and guidelines meet or exceed the standards of relevant international obligations and continue to represent world's best practice in most respects.

However, fisheries management and science continues to develop, including in relation to target and limit reference points, fisheries economics and the management of data-poor stocks. Some aspects of the policy and guidelines could be further refined and updated to capture new developments and address any weaknesses, to ensure they better assist the pursuit of legislative objectives and continue to represent world's best practice for productive, sustainable and profitable fisheries. The policy could also benefit from incorporating relevant elements of the guidelines and 2005 ministerial direction, particularly around overfishing and the recovery of overfished stocks, at a high level and in relatively simple terms.

Updates to the policy and guidelines should be developed with input from stakeholders and fisheries experts and be subject to further consultation.

5 Harvest strategy implementation

The harvest strategy policy was released in September 2007. The then minister indicated at the time that the policy should be implemented in all relevant Commonwealth fisheries by January 2008.

During 2007–08 AFMA implemented 13 harvest strategies across 10 fisheries (AFMA 2008). A number of harvest strategies have been consolidated since 2007–08 and new strategies developed (AFMA 2012). By late 2012 AFMA had implemented harvest strategies for 72 fish stocks in 12 of the 13 Commonwealth fisheries managed solely by AFMA (Ward et al. 2013); no harvest strategy has been implemented in the Norfolk Island Demersal Finfish Fishery, which has not operated since 2003 (Woodhams et al. 2012). While the policy does not prescribe arrangements for fisheries jointly managed by the Australian Government and other Australian jurisdictions or an international management body/arrangement, harvest strategies have also been implemented for a number of stocks in jointly managed fisheries.

The policy requires that harvest strategies be implemented for key commercial species, which are defined as ‘a species that is, or has been, specifically targeted and is, or has been, a significant component of the fishery’. The fish stocks under harvest strategies include all quota-managed species and several other commercial species, including rebuilding stocks that were previously commercial species, for example, eastern gemfish. Harvest strategies have been implemented for several byproduct species, for example, squid in the Northern Prawn Fishery, while there are other species that are sometimes retained for sale but are not under harvest strategies, such as ocean jacket in the Commonwealth Trawl and Scalefish Hook sectors.

Harvest strategy implementation and associated challenges

Having developed and implemented harvest strategies for stocks across a broad range of fisheries between the December 2005 ministerial direction and early 2008, AFMA has since reviewed and updated many of these. This was usually done in response to improved assessments, management strategy evaluation testing and better knowledge about reference points.

Ward et al. (2013) found that the harvest strategies in most Commonwealth fisheries are consistent with the policy. About two-thirds of the harvest strategies implemented in Commonwealth fisheries have specified target and limit reference points. Harvest strategies for some more data-rich fisheries apply full quantitative assessments and two have been designed and tested to directly achieve the policy’s maximum economic yield objective.

The harvest strategies of most low-value fisheries or data-poor fisheries have triggers instead of reference points (noting that basic strategies, such as those that use catch triggers rather than quantitative target and limit reference points, are explicitly provided for in the guidelines).

Ward et al. (2013) note that harvest strategies of several small, low-value fisheries (for example, the Western Deep Water Trawl Sector) are somewhat rudimentary but nonetheless consistent with the policy’s intent and affordable.

Management strategy evaluation is a formal scientific procedure for testing and comparing management strategies under a range of scenarios using simulations of stock and fishery dynamics. The policy requires that harvest strategies be tested and advocates the use of management strategy evaluation to demonstrate that the strategies meet the requirements of the policy. Many harvest

strategies have been subjected to management strategy evaluation testing and this has demonstrated that the harvest strategies of most Commonwealth fisheries are robust to uncertainty (Ward et al. 2013).

An overview of harvest strategy implementation across Commonwealth fisheries is provided in Table 1 for fisheries solely managed by AFMA. Ward et al. (2013) provide a similar summary for fisheries jointly managed with other domestic or international bodies.

The development of harvest strategies across key commercial stocks has been a significant achievement. However, it has not been without its challenges, particularly in relation to data-poor, low value and multi-species fisheries.

Fishery-wide maximum economic yield targets have only been quantitatively estimated for two fisheries. Most Commonwealth fisheries apply the proxy target values defined in the policy. Rebuilding the seven overfished stocks that were depleted prior to the policy's development has also been problematic. These issues are considered in more detail in Chapter 6.

Ward et al. (2013) and Haddon et al. (2013) identify a number of challenges that have been faced implementing harvest strategies, including determining appropriate reference points, monitoring against reference points, testing harvest strategies, interpreting catch and effort data and managing highly variable and/or spatially structured stocks. Ward et al. (2013) point out that although harvest strategies have been implemented for virtually all key commercial stocks in all fisheries, harvest strategies for small fisheries and data-poor fisheries are rudimentary or not routinely run. In the relatively small Coral Sea Fishery, which harvests numerous species, harvest strategies have been developed but not implemented for several species.

Ward et al. (2013) also point out:

... the most appropriate levels of triggers for many of [the fisheries that use them] ... are unknown and have not been MSE [management strategy evaluation] tested. The existing triggers may also not be regularly monitored or the data required for assessments or implementing management measures when a trigger is reached may not be routinely collected and such assessments may not be feasible within a suitable timeframe

However, they also point out that despite these challenges, no stocks have deteriorated to an overfished or overfishing classification while managed under a trigger based harvest strategy.

Where triggers or other control rules are established, appropriate monitoring and data collection should be put in place to identify when the rule is triggered and to allow the triggered response to be implemented in an appropriate timeframe.

In relation to harvest strategy testing, Ward et al. (2013) note:

... insufficient information has precluded testing of the harvest strategies of some small fisheries and data-poor stocks, alternative targets in multi-species fisheries, discount factors [predetermined reductions in recommended catches implemented to account for uncertainty] and some multi-year TACs [total allowable catches]. These aspects of current harvest strategies still require testing.

Table 1 Summary of the implementation of the Commonwealth fisheries harvest strategy policy 2007 in fisheries managed solely by AFMA, as at December 2012—Commonwealth fisheries (from Ward et al. 2013)

Fishery	Implementation year	Number of stocks under a harvest strategy ^a	Target reference point(s)	Limit reference point(s)	MSE testing	Fishing mortality status ^{a,b}		Biomass status ^{a,b}		Economic status	
						2007	2011	2007	2011	2007–08	2010–11
Bass Strait Central Zone Scallop Fishery ^c	2007 (first applied in 2009)	1	Not defined	One 'viable area' containing at least 500 t	Haddon (2011)	0 0 1 1	0 0 1 1	1 0 0 1	0 1 0 1	Fishery was closed	Negative NER
Coral Sea Fishery	2008	Not defined	Not defined	Not defined	Plagányi et al. (2011b)	0 9 1 10	0 2 7 9	0 10 0 10	0 7 2 9	Low catch and effort suggest low NER	Catch and effort increased substantially; NER uncertain
Macquarie Island Fishery	CCAMLR Harvest Strategy for toothfish implemented in 2010	1	$0.50B_0$	$0.20B_0$	Fay & Tuck (2011)	0 0 1 1	0 0 1 1	0 0 1 1	0 0 1 1	NER uncertain	NER are likely to be positive
Norfolk Island Fishery	No harvest strategy because there is no offshore fishery	N/A	N/A	N/A	N/A	— — — —	— — — —	— — — —	— — — —	No offshore fishery	No offshore fishery
Northern Prawn Fishery ^c	2007	6	Dynamic MEY for tiger prawn sub-fishery; Banana prawn sub-fishery has a target of 'adequate escapement'	Tiger and blue endeavour prawns $0.5B_{MSY}$; red-legged banana prawns $0.5B_{MSY}$	Dichmont et al. (2008); preliminary MSE completed for banana prawn during 2012	0 4 4 8	0 1 5 6	0 4 4 8	0 1 5 6	NER were negative in 2005–06; economic performance is likely to have improved in 2007–08	Positive and increasing NER for tiger prawn; stocks building toward B_{MEY}

Fishery	Implementation year	Number of stocks under a harvest strategy ^a	Target reference point(s)	Limit reference point(s)	MSE testing	Fishing mortality status ^{a,b}		Biomass status ^{a,b}		Economic status	
						2007	2011	2007	2011	2007–08	2010–11
North West Slope Trawl Fishery ^c	2008 (revised in 2011)	11	Not defined	Not defined	Dowling (2011)	0 1 1 2	0 0 1 1	0 2 0 2	0 0 1 1	Low fishery GVP; low catch and effort suggest low NER	High latency and low GVP suggests low NER
Small Pelagic Fishery	2008 (rev 2009)	7	Tier 1 0.2–0.1 B depletion; Tier 2 0.075 B depletion	Not defined (highly variable stocks)	Giannini et al. (2010)	0 3 3 6	0 0 7 7	0 3 3 6	0 1 6 7	High latent effort suggests low NER	High latent effort suggests low NER
SESSF: Commonwealth Trawl and Scalefish Hook Sectors (CTS) ^c	Implementation of SESSF Harvest Strategy Framework commenced in 2005 ^d	27	Tier 1: B_{MEY} or $1.2B_{MSY}$ or $0.48B_0$; Tier 3: proxy equivalent to FB_{MEY} ; Tier 4: CPUE (fully fished, sustainable) or half of the unfished CPUE	Tier 1 $0.5B_{MSY}$ or $0.2B_0$; Tier 3 $0.5B_{MSY}$ (or proxy); Tier 4 proxy of $0.4CPUE_{TARG}$	Punt & Smith (1999), Smith et al. (2008), Wayte (2009), Smith (2009), Little et al. (2011), Klaer & Wayte (2011)	1 8 18 27	2 4 22 28	6 11 10 27	6 6 16 28	NER became positive in 2005–06 and increased in 2006–07 due to higher fish prices	Increases in productivity and NER suggest a move toward MEY; key stocks close to B_{MEY}
SESSF: East Coast Deepwater Trawl Fishery		1	Same as SESSF CTS; MEY estimated for deepwater flathead and Bight redfish; orange roughly is under the ORCP			0 0 1 1	0 0 1 1	0 1 0 1	0 0 1 1	High latent effort suggests low NER	Minimal activity suggests low NER
SESSF: Great Australian Bight Trawl Sector ^c		3	Same as SESSF CTS; MEY estimated for deepwater flathead and Bight redfish; orange roughly is under the ORCP			0 0 3 3	0 0 4 4	0 1 2 3	0 1 3 4	NER estimates not available	NER are likely to be positive and to have increased. Key stocks above B_{MEY} targets

Fishery	Implementation year	Number of stocks under a harvest strategy ^a	Target reference point(s)	Limit reference point(s)	MSE testing	Fishing mortality status ^{a,b}		Biomass status ^{a,b}		Economic status	
						2007	2011	2007	2011	2007–08	2010–11
SESSF: Shark Gillnet and Shark Hook Sectors ^c		4	Same as SESSF Commonwealth Trawl Sector			0 3 1 4	1 1 2 4	1 2 1 4	1 1 2 4	NER remained positive	NER consistently positive when based on school shark, but may be affected by an overfished stock and bycatch issues
Southern Squid Jig Fishery ^c	2007	1	Not defined	Not defined	No testing	0 1 0 1	0 0 1 1	0 1 0 1	0 0 1 1	High latent effort suggests low NER	Increased effort suggests increased profitability, but NER likely to remain low
Western Deepwater Trawl Fishery ^c	2008 (revised in 2011)	10	Not defined	Not defined	No specific testing	0 0 3 3	0 0 3 3	0 3 0 3	0 3 0 3	High latent effort suggests low NER	High latent effort. NER likely to be low
Total	12 of 13 fisheries with harvest strategies	72 stocks under harvest strategies	48 stocks with target reference points	50 stocks with limit reference points		1 29 37 67	3 8 55 66	8 38 21 67	7 21 38 66		

Notes:

^a The stocks classified in annual Fishery Status Reports (Woodhams et al. 2012) sometimes differ from those recognised by AFMA. For example, AFMA has implemented harvest strategies for 27 stocks that are under quota in the Commonwealth Trawl Sector. By contrast, the Fishery Status Reports classifies the status of those 27 stocks, plus an additional stock (ocean jacket), which meets ABARES criteria for inclusion in status reporting. The North West Slope and Western Deepwater trawl fisheries have developed harvest strategies for many stocks that are not currently fished and are not assessed in Fishery Status Reports. Between 2007 and 2011, several stocks ceased

being classified in the Fishery Status Report (for example, deepwater prawns in the North West Slope Trawl Fishery), while additional stocks have been added (for example Australian sardine in the Small Pelagic Fishery). Some ‘stocks’ also contain multiple stocks or multiple species, for example the east and west stocks of jackass morwong are managed under a single total allowable catch and are reported as a single stock in the Fishery Status Reports and in the table above.

^b Assessments usually estimate spawning stock biomass (the mass of reproductively mature individuals in the population). For brevity we refer to ‘biomass’ instead of ‘spawning biomass’ in this table.

Fishing mortality status classification (Woodhams et al. 2012):

0	number of stocks classified as subject to overfishing
1	number of stocks where fishing mortality status was classified as ‘uncertain’
2	number of stocks classified as not subject to overfishing
3	total number of stocks assessed

Biomass status classification (Woodhams et al. 2012):

0	number of stocks classified as overfished
1	number of stocks where biomass status was classified as ‘uncertain’
2	number of stocks classified as not overfished
3	total number of stocks assessed

^c Indicates fisheries that were reviewed as a case study by Ward et al. (2013)

^d The Southern and Eastern Scalefish and Shark Fishery’s Tier 2 assessment has been phased out.

^e In this report the term CPUE is used to refer to standardised catch per unit of fishing effort. Annual CPUE values are often averaged over several years or fishing seasons.

Source: information presented in this table was sourced from Woodhams et al. (2012) and from documents available on AFMA’s website (afma.gov.au).

Abbreviations and acronyms:

B	spawning stock biomass	E_{MSY}	level of fishing effort corresponding to MSY	MSY	maximum sustainable yield
B_0	unfished biomass	F	fishing mortality rate	N/A	not applicable
B_{MSY}	biomass at maximum sustainable yield	FB_{MEY}	fishing mortality rate that will produce B_{MEY}	NER	net economic returns
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources	GVP	gross value of production	OCS	Offshore Constitutional Settlement
CCSBT	Commission for the Conservation of Southern Bluefin Tuna	ITQ	individual transferable quota	ORCP	Orange Roughy Conservation Program
CPUE	catch-per-unit-effort	MEY	maximum economic yield	SESSF	Southern and Eastern Scalefish and Shark Fishery
$CPUE_{targ}$	target catch-per-unit-effort	MSE	management strategy evaluation	SPR_{40}	40% of spawning potential ratio

While both the policy and guidelines state that harvest strategies should be formally tested, the guidelines also recognise that testing may not always be practical (emphasis added):

Even for minor or data-poor fisheries, it *may* still be worthwhile to develop MSE [management strategy evaluation] analyses ... [which] can be updated as more reliable information becomes available (HSP 2007, p. 49).

and

Ideally, harvest strategies should be tested using scientifically defensible methods (e.g. management strategy evaluation including the use of operating models) (HSP 2007, p. 40).

The guidelines also recognise that management strategy evaluation is time and resource intensive and that management strategy evaluation approaches for data-poor stocks were not well developed when the policy was released.

McIlgorm (2013) notes that while the practice of management strategy evaluation is recognised internationally as being a significant Australian contribution to international best practice, it is costly and information intensive. He suggests that closer consideration be given to the management of risk and the cost implications of applying management strategy evaluation.

Haddon et al. (2013) make the point that management strategy evaluation may not be affordable for all fisheries or species and that a more generic testing approach is required. They note:

Two approaches are possible:

- a) Generic MSEs [management strategy evaluations] have been developed (NOAA's PopSim; Haddon and Dowling, 2012, and others), but are either at very early stages or require further work. Further research in this area would be of value.
- b) A risk-cost-catch trade-off framework where many data-poor methods are tested in an MSE framework and then potentially generalised (if at all possible). A start to this process has recently been funded by the FRDC [Fisheries Research and Development Corporation] but this work will only report at the end of 2014.

While issues such as cost and lack of data have impeded the testing of some harvest strategies, as the range of tools available expands it is likely that testing will be able to be extended to harvest strategies in data-poor fisheries.

Risk-catch-cost trade-off

It is widely accepted that the harvest strategy policy has been a successful initiative in Commonwealth fisheries management. The common issue underlying the above points is the difficulty of implementing the policy's requirements equally over the full range of Commonwealth fisheries, particularly for low value and data-poor fisheries. Ward et al. (2013) point out that **difficult circumstances such as cost limitations, limited data availability or a need for further scientific development, rather than inappropriate settings in the policy itself have impeded effective application of the policy in all fisheries**. They also noted that priorities for harvest strategy implementation have tended to reflect the economic value of stocks rather than the level of risk.

The challenges of implementing the policy for data-poor, low value stocks were anticipated when the policy and guidelines were developed:

... the [policy] advocates a risk management approach, whereby exploitation levels reduce as uncertainty around stock status increases. This will ensure fisheries are managed at an acceptable level of risk to the Australian Government irrespective of our level of knowledge. For a low value fishery, AFMA and stakeholders may accept that catches will remain precautionary with supporting fishery research at low levels, to better match the management costs to the business environment for that fishery.

The guidelines explicitly promote an approach where uncertainty around stock status, the costs of collecting additional information (to provide greater certainty) and catch levels settings are 'traded off':

Where information to quantify risk levels is unavailable, a precautionary approach will be taken to fishery management leading to more conservative outcomes to account for the uncertainty ... Having little information regarding the biological and economic characteristics of a stock does not necessarily justify that additional information be collected. The benefit of collecting further information needs to be set against the cost of collecting the additional information.

and

... there is an obvious trade-off that must be made concerning the quantity and quality of information that decision makers require and the level and cost of risk protection that is likely to result ... The benefit of collecting further information (to improve the harvest strategy and perhaps increase profits) needs to be set against the cost of collecting the additional information. The collection of additional information should only occur if these benefits are likely to outweigh the costs.

In practice, however, it appears as though some fisheries have such limited value that even basic data entry and manipulation is prohibitively expensive. Haddon et al. (2013) describe the situation as follows:

... there are fisheries or species within multi-species fisheries managed by the Commonwealth that are sufficiently complex that the costs of moving beyond very little data make the move almost impossible. For example, there are minor fisheries of such relatively low value that there are insufficient resources to even enter all data into databases or query those databases and do the analyses necessary to fulfil the existing data-poor HS [harvest strategy] requirements (Dowling et al. 2008).

Commonwealth fisheries are managed on a cost recovery basis, in accordance with broader government cost recovery policy and achieving cost recovery targets is also an objective of the *Fisheries Management Act 1991* that AFMA must pursue. AFMA's Cost Recovery Impact Statement (AFMA 2010) recognises that the beneficiaries of its domestic fisheries management arrangements, including harvest strategy development and implementation, are the concession holders in each fishery. It directs that the cost of domestic fisheries management should be recovered from industry via a fishery-based levy.

While an analysis of funding models is beyond the scope of this review, it is clear that **the cost recovery model currently applied constrains AFMA's capacity to implement management arrangements, particularly in low value fisheries**. This was identified by McIlgorm (2013) who

identified that issues with management standards for low value fisheries only arose under the cost recovery model. Issues with cost recovery and perceived cross-subsidisation of fisheries were also raised during the public comment process. In their technical reviews for the harvest strategy policy, Haddon et al. (2013) noted that:

... the issue is whether even lower Tiers than those used within AFMA are required and whether these still conform to the intent of the policy. If not, then a funding model needs to be provided that allows all components of those fisheries that implement the harvest strategy to be appropriately resourced. Fulfilling the requirements of the Harvest Strategy Policy for all Commonwealth fisheries has obvious resource requirements.

Borthwick (2012) explored these matters in some detail and recommended considering changes to the current cost recovery arrangements for Commonwealth fisheries. Mechanisms to fund these outcomes could be explored.

Notwithstanding the inherent restrictions associated with the current funding model, **the requirements should be retained that the policy and guidelines should apply across all Commonwealth fisheries managed solely by AFMA and that harvest strategies should meet the intent of the policy or be demonstrably precautionary.** Not doing so could lead to a substantial weakening of the benefits realised by the policy's implementation and a loss of rigour in Commonwealth fisheries management more generally.

However, this does not mean that all stocks require full quantitative assessments. A tiered approach has been applied under which high value stocks for which there is relatively good information are assessed quantitatively (at a high information tier), with less expensive and data intensive assessment tiers applied to lower value species.

Fisheries performance under harvest strategies

When the ministerial direction was given to AFMA in December 2005, the then minister wrote that:

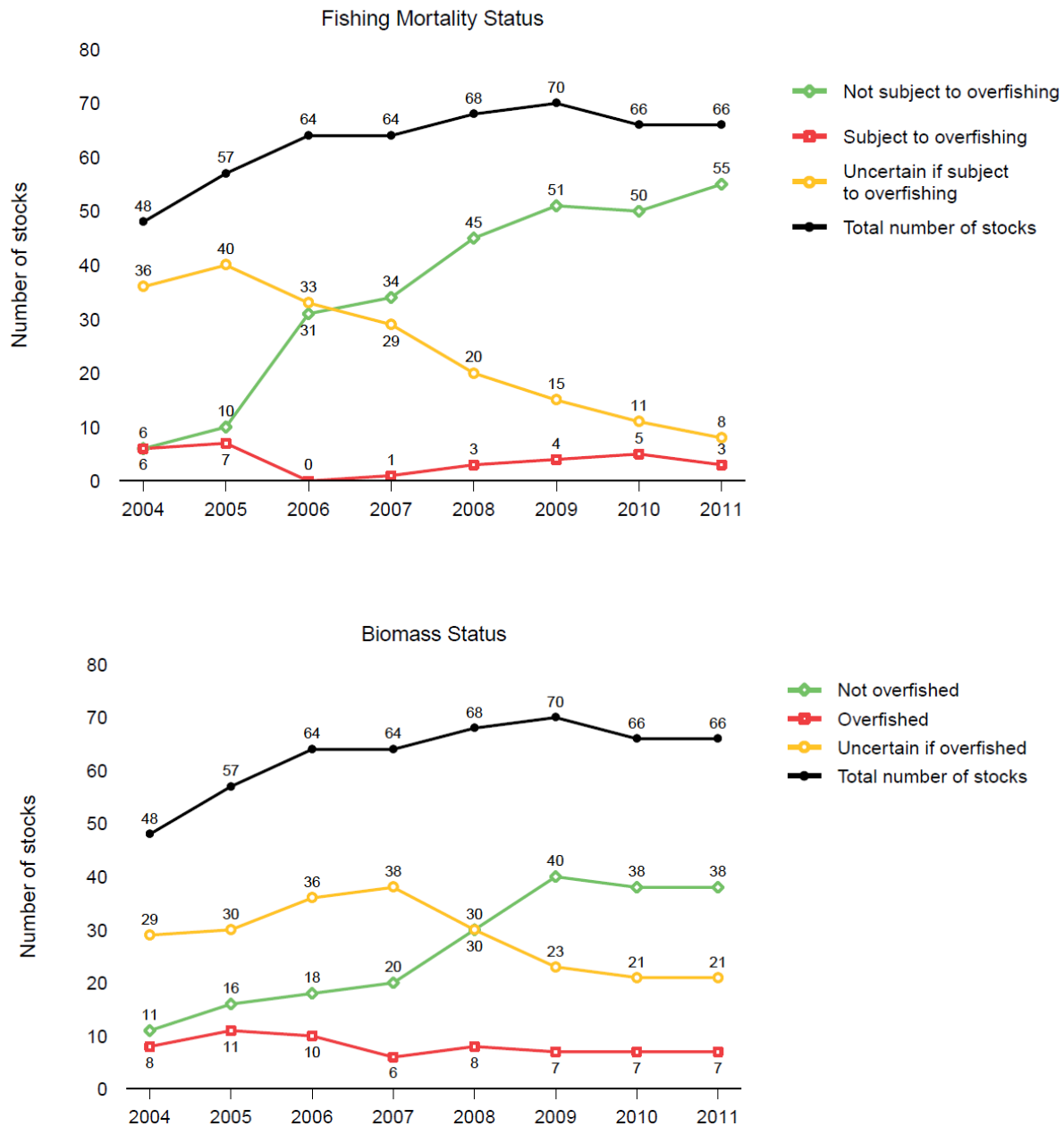
... current trajectories for stock recovery in many fisheries are very long, indicating that a faster pace of recovery is necessary if fisheries are to return to sustainable and profitable circumstances in the medium term ... because of the poor biological and economic status of a number of the fisheries ...

From the time that the policy was released in 2007, until 2011 (the most recent year for which stock status analyses have been published), the number of stocks classified as 'not overfished' or 'not subject to overfishing' in fisheries managed solely by AFMA has increased substantially (Figure 1). Of those stocks assessed in 2011, 55 were classified as not subject to overfishing (compared to 34 in 2007) and 38 were classified as not overfished (compared to 20 in 2007). Most of the difference was due to stocks whose status had previously been classified as uncertain or not assessed, being re-classified as either not overfished or not subject to overfishing following improved assessment.

Ward et al. (2013) note that many of the improvements in stock status are due in part to the implementation of harvest strategies but that it is difficult to distinguish the impact of harvest strategies from the influence of other factors such as a reduction in fishing effort as a result of structural adjustments. They also conclude that harvest strategies are likely to have prevented many stocks from falling below their limit reference points and becoming overfished.

Figure 1 Biological stock status classification totals (number of stocks) managed solely by AFMA since 2004 for a) biomass status and b) fishing mortality status

Note: Orange roughly eastern, southern and western zones which are classified as overfished, were reported as a single 'stock' in 2007 but as three separate 'stocks' in 2011.



While the total number of stocks classified as not overfished or not subject to overfishing has reduced significantly since the policy's development, the number of species classified as either overfished or subject to overfishing has changed little (Woodhams et al. 2012). Ward et al. (2013) provides a fishery by fishery breakdown of biomass and fishing status across Commonwealth domestic fisheries as well as in jointly managed fisheries.

Table 2 shows all stocks solely managed by AFMA that were overfished or subject to overfishing in either 2007 or 2011. In 2011, seven stocks solely managed by AFMA were considered overfished, compared to eight in 2007 (one stock, smooth oreo dory outside the Cascade Plateau, moved from being overfished to not overfished over this time). Three stocks were classified as subject to overfishing in 2011 (school shark, gulper sharks and eastern gemfish, each of which is also overfished), compared to only one (pink ling) in 2007. This is discussed further in Chapter 6 of this report that considers rebuilding stocks. Chapter 5 also discusses issues such as the suitability of rebuilding timeframes described in the guidelines, rebuilding targets and data availability which affect the development and monitoring of rebuilding strategies.

Ward et al. (2013) provides a fishery by fishery breakdown of biomass and fishing status across Commonwealth domestic fisheries as well as in jointly managed fisheries.

Table 2 All stocks solely managed by AFMA, classified as overfished and/or subject to overfishing in 2007 and/or 2011

Stock	Fishery	Fishing mortality		Biomass	
		2007	2011	2007	2011
Commercial scallop (<i>Pecten fumatus</i>)	Bass Strait Central Zone Scallop Fishery				
Blue warehou (<i>Seriotelella brama</i>)	SESSF: Commonwealth Trawl and Scalefish Hook sectors				
Gemfish, eastern zone (<i>Rexea solandri</i>)	SESSF: Commonwealth Trawl and Scalefish Hook sectors				
Gulper sharks* (<i>Centrophorus harrissoni</i> , <i>C. moluccensis</i> , <i>C. zeehaani</i>)	SESSF: Commonwealth Trawl and Scalefish Hook sectors				
Orange roughy, eastern zone [†] (<i>Hoplostethus atlanticus</i>)	SESSF: Commonwealth Trawl Sector				
Orange roughy, southern zone [†] (<i>Hoplostethus atlanticus</i>)	SESSF: Commonwealth Trawl Sector				
Orange roughy, western zone [†] (<i>Hoplostethus atlanticus</i>)	SESSF: Commonwealth Trawl Sector				
Oreodory: smooth, non-Cascade Plateau (<i>Pseudocyttus maculatus</i>)	SESSF: Commonwealth Trawl Sector				
Pink ling (<i>Genypterus blacodes</i>)	SESSF: Commonwealth Trawl and Scalefish Hook sectors				
School shark (<i>Galeorhinus galeus</i>)	SESSF: Shark Gillnet and Shark Hook sectors				

Note: * endeavour, Harrison's and southern dogfish reported as a single group. † eastern, southern and western zones were reported as a single 'stock' in 2007 but as three separate 'stocks' in 2011.

Source: Woodhams et al. 2012

Fishing mortality : ■ Subject to overfishing ■ Uncertain ■ Not subject to overfishing
 Biomass: ■ Overfished ■ Uncertain ■ Not overfished

Economic performance

As the policy's objective relates to sustainability as well as profitability and economic returns, the economic performance of Commonwealth fisheries is also relevant to the policy's performance. Assessing this performance, and the effect of the policy on it, is complex (Box 1).

Box 1 Assessing the effect of the policy on the economic performance of Commonwealth fisheries

The economic performance of fisheries is influenced not only by fisheries management arrangements but by external factors such as labour costs, fuel prices and exchange rates. For example, since the policy was released in 2007 until 2011, off road diesel prices fluctuated but decreased by around 9 per cent in real terms overall. The value of the Australian dollar similarly fluctuated against the US dollar but ended the period around 25 per cent higher than its 2007 value (ABARES 2013).

Assessing fishery performance relative to maximising economic returns is also complex. It requires a comparison between the potential net economic returns available from the fishery and those realised under the prevailing management system. However, for most fisheries, there is considerable uncertainty around the estimate of potential net economic returns and the actual returns in a fishery. No single indicator or methodology is universally appropriate for assessing the economic performance of all fisheries and so there are no simple, comprehensive indicators of fisheries economic status available to the review, that can be compared across fisheries in a manner similar to stock status reporting. However, Woodhams et al. (2012) report that larger, more valuable fisheries tend to have many more indicators than small fisheries due to the greater amount of data generally available from such fisheries.

Table 1 provides some information on the net economic returns from those fisheries managed solely by AFMA. Net economic returns have been positive and increasing in the Commonwealth Trawl Sector and Gillnet, Hook and Trap Sector of the Southern and Eastern Scalefish and Shark Fishery and the Northern Prawn Fishery, which together account for around 51 per cent of the value of fisheries managed solely by AFMA.

This has been partly driven by increases in economic productivity (Skirtun & Vieira 2012). Woodhams et al. (2012) indicate that stocks in the Northern Prawn Fishery are growing towards the levels that will maximise economic yield. They also indicate that the biomass of the most valuable target species in the Commonwealth Trawl and Gillnet, Hook and Trap Sectors are not constraining profits, but point out that a number of overfished stocks in these sectors (for example, school shark, orange roughy, blue warehou and eastern gemfish) are probably reducing economic returns.

The economic status of many small fisheries has been mixed or uncertain. Economic returns in the Great Australian Bight Trawl Sector seem to be improving and are not constrained by stock biomass of important species. Net economic returns in the Macquarie Island Toothfish Fishery are also likely to have been positive.

However, the Bass Strait Central Zone Scallop Fishery has been producing negative net economic returns and, while stock status is classified as uncertain, episodes of 'die-off' have reduced the density of known scallop beds. The inherent variability of stock levels and the strong spatial

structuring of scallops stock make it difficult to apply 'typical' harvest strategy policy settings. Haddon et al. (2013) describe the challenges in applying the policy to this fishery. The harvest strategy for this fishery is currently under review, to consider how a harvest strategy for these stocks can better meet the economic objectives of the harvest strategy policy.

Economic returns in other Commonwealth fisheries managed solely by AFMA, such as the North West Slope Trawl and the Small Pelagic Fishery, are likely to be low. Returns in these fisheries are likely to be constrained by the relative costs and returns of fishing rather than by low biomass levels.

Some stakeholders have indicated that understanding the objective of 'maximising returns to the Australian Community' needs to be further explored, evaluated and measured as part of a revised policy and guidelines.

Performance reporting

The harvest strategy policy does not define performance indicators or requirements for reporting on the implementation and performance of harvest strategies. McIlgorm (2013), noted that the annual reporting on the biological status of fisheries is a common overall measure of the effectiveness of fisheries management in the nations he examined (the US, New Zealand, the European Union, Iceland and Norway). Along with economic performance evaluation (given the policy's objective of maximising economic returns), assessment of the biological status of stocks is a key indicator of the success of harvest strategies in achieving the objectives of the policy.

The 2005 ministerial direction indicated that AFMA's performance in implementing the direction (including in relation to harvest strategies) would be monitored in a number of ways, including through the annual Fishery Status Reports describing the biological and economic status of Commonwealth fisheries; the then ABARE Fishery Survey Reports which analyse the financial and economic performance of key Commonwealth fisheries; AFMA's annual reports, and assessments of Commonwealth fisheries under environmental legislation.

While the information in reports such as AFMA annual reports and ABARES Fishery Status Reports is very useful for assessing the status of fish stocks, supplementing this information with **reporting against pre-defined indicators relating to harvest strategy implementation and the objectives of the policy itself would be useful for monitoring the policy's performance.**

Ward et al. (2013) suggest a suite of indicators for evaluating the implementation of individual harvest strategies (Box 2) and for monitoring the policy's overall performance. These would represent a useful basis for consultation with a view to inclusion in any updated policy.

Improved performance reporting against indicators such as those proposed by Ward et al. (2013) will help demonstrate that harvest strategies compatible with the policy have been implemented and are being appropriately applied across Commonwealth fisheries. Noting that developing simple economic performance indicators remains a challenge, it could be useful if further work was undertaken to develop these.

However consideration will also need to be given to the cost of reporting against indicators, such as stock status, economics and bycatch aspects, and further stakeholder consultation will be needed during the development of any performance indicators to ensure they are practical, build on existing data collection where possible and are cost effective.

Box 2 Harvest strategy performance measures proposed by Ward et al. (2013)

Coverage

1. Which species or stocks does the harvest strategy cover?
 - Are there any key commercial species that are not under a harvest strategy?
 - Are there any multispecies stocks?
2. Does the harvest strategy apply throughout the stock's entire range?
 - Is the RBC adjusted for fishing mortality that occurs outside the fishery's control?

Reference points and indicators

1. Are the adopted proxies consistent with the policy?
 - What evidence is there that the harvest strategy's proxies are correct?
2. Are there any ambiguities in the indicators specified in the harvest strategy?
 - Do assessments take into account mortality resulting from all types of fishing?

Harvest control rules

1. To what extent are control rules linked directly to the biological and economic status of the fishery relative to reference points?
2. To what extent do control rules express objectives in the form of quantifiable reference points?
3. Will fishing mortality be reduced when the fishing mortality rate rises above the level of fishing mortality that produces maximum sustainable yield?
 - Do TACs take into account removals by all types of fishing?
4. Will targeted fishing cease when biomass falls below the limit reference point?
5. Will targeted fishing cease when the fishing mortality rate rises above the fishing mortality limit reference point?
 - What is the probability of the harvest strategy maintaining fishing mortality rates below the limit?
6. For stocks below the biomass limit, is there a rebuilding strategy?

Management strategy evaluation and testing

1. What range of uncertainties has been tested?
 - How do those uncertainties relate to the full range of uncertainties for the stocks or species group concerned?
 - Have a broad range of stakeholders and independent experts been consulted?
 - Do fisheries on the same or similar species in other parts of the world provide any insights into uncertainties?
2. Will the harvest strategy achieve the target?
 - Are there estimates of the probability of the harvest strategy maintaining stock biomass at or around the target for the species?

3. Will the harvest strategy maintaining biomass above the limit reference point estimated?
4. Have meta-rules been tested and are they consistent with the policy?

Application

1. Has the harvest strategy been run?
2. Is the schedule of assessment and management advice timely?
3. Have control rules and RBCs been implemented?
4. Are any data, which are required for setting the RBC, missing or uncertain?
 - Do they reflect increasing uncertainty at higher tiers?
5. Has the use of meta-rules been consistent with the policy?
6. Are triggers regularly checked?

Transparency and reporting

The issue of performance reporting raises the related issue of the transparency of policy implementation. The policy is intended to provide public confidence and transparency in decision making:

... The Policy also provides the fishing industry and other stakeholders with a more certain operating environment where management decisions for key species are more consistent, predictable and transparent. (HSP 2007, p. iv)

and

Harvest strategies consistent with the Policy will provide the Australian community with a high degree of confidence that commercial fish species are being managed for long-term biological sustainability and economic profitability (HSP 2007, p. 2)

The linkage of agreed control rules to assessments through harvest strategies certainly appears to have increased the transparency and certainty of management decision-making and increased confidence in Commonwealth fisheries management (Borthwick 2012; McLoughlin & Rayns 2009; Smith et al. 2008; Ward et al. 2013). For example, the review of Commonwealth fisheries legislation, policy and management (Borthwick 2012) noted:

The Review has found that the benefits of the instigation of the HSP [harvest strategy policy] have resulted in strong support for it from stakeholders.

While McLoughlin and Rayns (2009) state:

Since the implementation of the policy and associated development of clear decision rules for setting total allowable catch limits, management decisions have become more transparent.

Harvest strategy processes, settings and implementation would generally be well understood by the fisheries managers, scientists, industry representatives and other stakeholders on AFMA's resource assessment groups and management advisory committees. However, it is clear from the consultation process for the review that not all stakeholders are comfortable with the degree of reporting and transparency surrounding both harvest strategy settings and implementation,

including where the settings in individual harvest strategies vary from the default settings of the policy.

While harvest strategies necessarily include a description of their settings, they do not necessarily adequately describe or reference the justifications for those settings. Nor are management strategy evaluations or other testing necessarily described or referenced in the harvest strategies or in documents easily accessed with the harvest strategy. The harvest strategy for the Eastern Tuna and Billfish Fishery provides a good example of this. This harvest strategy does not specify limit reference points and its targets differ from the policy's default settings. Significant scientific work has gone into developing and testing this harvest strategy. However, while the document attempts to describe the settings in non-technical terms, it provides no analysis or references to support the settings chosen. Similarly, while the strategy indicates that management strategy evaluation has been applied, it provides no information to point readers to this work and no explanation of the outcomes.

Improved transparency of harvest strategy settings could increase wider understanding and confidence in fisheries management. This is particularly relevant for decisions made under the policy where discretion has been applied at some stage in the process, such as where the policy's 'default' settings have not been applied.

While this review was underway, there was significant public concern and confusion over a proposal to operate a large factory trawler in the Small Pelagic Fishery. While this review makes no attempt to analyse this particular issue, the event highlighted concerns of a number of stakeholders over harvest strategies more generally. In particular, while harvest strategies such as that in the Small Pelagic Fishery were developed and tested to ensure they met the objectives of the policy and legislation, some stakeholders and the public raised concerns about elements of the harvest strategy and its approval process during debate over the proposal.

There were also some expectations that harvest strategies should require some type of ministerial approval and be subject to Parliamentary disallowance as is the case for fisheries management plans that 'sit above' the policy and total allowable catch settings that are determined under the policy.

AFMA has consultation mechanisms in place to seek input from scientists and a wide range of stakeholders on management settings, including harvest strategy design and implementation. These mechanisms were analysed in some detail by the fisheries management review (Borthwick 2012) and, while beyond the scope of this review, are relevant to the issue of transparency and inclusivity.

Increased stakeholder involvement in the development of harvest strategies, such as a period of public comment, may alleviate some of the concerns. However there are a number of potential problems associated with this approach. These include, for example, the technical complexity of the science behind harvest strategies, and that harvest strategy settings based on economics and science and bound to the policy and legislation may be difficult to reconcile with the breadth of opinions across the community. In many cases harvest strategy settings will have been subject to extensive management strategy evaluation which could make changing them both difficult and expensive. Nevertheless, consideration should be given to providing for public input on the less technical elements of harvest strategy design, such as those that describe 'policy' and general (non-technical) management settings. For some strategies and decision rules under strategies, wider

consultation could increase public and stakeholder understanding and confidence in fisheries management.

The fisheries management review (Borthwick 2012) recommended that fisheries management plans be made more substantive and placed particular emphasis on greater transparency, accountability and meaningful public consultation processes. If management plans were to recognise some of the higher level aspects currently described in some harvest strategies, such as those relating to 'policy' and non technical elements, this may help alleviate potential problems with consultation and inclusivity of harvest strategies for those fisheries with management plans, given the legislative requirements for public consultation over these plans.

The transparency of the policy may also be improved by the development of a simplified plain English guide to the policy and guidelines, to help improve stakeholder and public understanding of harvest management arrangements in Commonwealth fisheries. In addition to a high level description of what harvest strategies are and how they work, such a guide may describe issues including the role of harvest strategies in fisheries management (for example, relative to legislation, management plans), consultation processes, how harvest strategies are implemented and process for reviewing strategies. While the audience for such a guide is likely to be somewhat limited, the information would be useful to interested stakeholders including fishers, conservation groups and interested members of the public.

Conclusions

AFMA has implemented harvest strategies that are consistent with the policy across most Commonwealth fisheries.

Difficult circumstances such as cost limitations, limited data availability or a need for further scientific development, rather than inappropriate settings in the policy itself have impeded effective application of some aspects of the policy in some fisheries. The existence and application of a cost recovery policy necessarily limits the effort that can be put into managing small and less valuable fisheries (noting that these are often subject to lower levels of fishing activity).

Harvest strategy settings and performance are not always well understood by stakeholders. There should be greater opportunity for consultation during the development of non-technical elements of harvest strategies. This might be achieved by including high-level aspects of harvest strategies (for example, those relating to 'policy' and non technical elements including operational 'objectives', information on fishing methods and management targets) in management plans.

The policy would benefit from being supported by performance indicators and a reporting regime to report on the implementation and performance of harvest strategies. If this was to occur, industry and stakeholders should be consulted during the development of any performance indicators or changes to reporting, to design a system that is practical and cost effective. The information to support this will generally already be available in many fisheries and should be incorporated in any new reporting systems to avoid unreasonable reporting burden.

6 Rebuilding overfished stocks

The harvest strategy policy has a clear objective of managing key commercial fish stocks for long-term biological sustainability and economic profitability. Both sustainability and profitability depend on the long-term productivity of the stock being maintained. This balance is placed at risk when stocks are reduced to a level where the recruitment of young fish is substantially reduced as a result of the reduction of the breeding adult population (referred to as 'recruitment failure') (HSP 2007, p. 3).

The policy contains two mechanisms to protect stocks against this—the first (designing harvest strategies to avoid limit reference points) is proactive and the second (implementing stock rebuilding strategies) is reactive.

The harvest strategy policy recognises the biomass limit reference point as the point beyond which the risk to stocks as the basis of a commercial fishery is unacceptably high. Stocks whose biomass fall below the limit reference point are classified as overfished. Overfished stocks face an unacceptably high risk of recruitment failure, diminished economic returns and may present increased risk to ecological function.

The harvest strategy policy requires that AFMA must develop and implement a strategy to rebuild each overfished stock to its target reference point (HSP 2007, p. 24). Rebuilding strategies are usually separate but complementary to the existing harvest strategy for that stock. The policy also recognises that overfished stocks may be subject to action under both fisheries and environment legislation—including listing at a 'conservation dependent' or higher level on the List of Threatened Fauna under the *Environment Protection and Biodiversity Conservation Act 1999* and being subject to a stock rebuilding strategy or formal recovery plan under that legislation.

The December 2005 ministerial direction recognised that a number of overfished stocks under the management arrangement in place at that time had very long recovery trajectories and that a faster pace of recovery was needed to return affected fisheries to sustainable and profitable circumstances in the medium term. To this end, the direction required that:

AFMA must take immediate action in all Commonwealth fisheries to:

- a) cease overfishing and recover overfished stocks to levels that will ensure long term sustainability and productivity;
- b) avoid further species from becoming overfished in the short and long term ...

The harvest strategy policy, which was released in September 2007, allowed transitional arrangements to be put in place for stocks that were overfished at the time. These required that management actions be directed to rapid rebuilding of these stocks, but allowed for some ongoing targeting of stocks determined to be 'overfished' prior to 31 December 2008.

Rebuilding strategies have now been implemented for overfished stocks of orange roughy, 'eastern' gemfish, school shark and blue warehou, and a 'management strategy' for overfished upper slope dogfish (gulper sharks) has also recently been developed. All of these stocks were significantly depleted before the harvest strategy policy was developed.

While the vast majority of Commonwealth managed stocks are assessed as either not overfished or not subject to overfishing, as noted earlier, there is a small number of stocks, including seven managed solely by AFMA which remain overfished (Ward et al. (2013) provides a fishery by fishery breakdown of biomass and fishing status across Commonwealth domestic fisheries as well as in jointly managed fisheries.

Table 2). These stocks were generally depleted during or prior to the 1990s (before the 2005 ministerial direction or 2007 harvest strategy policy) and several have since been found to be less productive in their currently depleted state than initially predicted. The combination of depleted spawning stock populations and low productivity means that rebuilding can be slow, especially for stocks where fishing mortality is difficult to control, as is the case in multi-species fisheries where the overfished stock is incidentally caught when targeting others.

Rebuilding depleted stocks will take some time. For stocks with low natural productivity, such as orange roughy, school shark and gulper sharks, rebuilding will necessarily be slow due to the biological characteristics of the species and it is expected that it will take decades for these stocks to rebuild to their biomass limit levels, let alone their targets. It is possible that the depleted state of some stocks can reduce their resilience and lower their productivity, so that environmental conditions might result in the stock remaining at depleted levels for extended periods, regardless of historically low levels of fishing (Penney et al. 2013b).

Rebuilding strategies for depleted stocks have had mixed success. Overfished stocks of orange roughy (those stocks outside the Cascade Plateau) have been closed to fishing, other than research surveys, since 2007, which should allow them to rebuild at close to the 'fastest' rate consistent with their biology. Rebuilding does seem to be occurring, at least for the eastern orange roughy stock, as evidenced by recent acoustic survey results suggesting this stock may be recovering more rapidly than initially projected by the stock assessment model (Ward et al. 2013).

While no stocks have shown clear signs of further decline since rebuilding strategies were introduced, some have not shown the expected rebuilding within required timeframes.

Penney et al. (2013b) noted that eastern gemfish, school shark and blue warehou had 'so far shown no clear evidence of rebuilding'. Figure 1 shows trends over time in the number of domestically managed stocks overfished or subject to overfishing. Woodhams (2012) indicate that several of these stocks have remained subject to overfishing (that is, remain subject to levels of fishing mortality that are too high to allow rebuilding in required timeframes) in most or all years since the 2005 ministerial direction was made. In 2011, three stocks solely managed by AFMA (eastern gemfish, school shark and gulper sharks) remained subject to overfishing, down from five stocks in 2010.

There are several reasons why some stocks may not be showing evidence of rebuilding. Ward et al. (2013) indicate that these include that the rebuilding timeframes described in the guidelines may not be biologically appropriate for some stocks; confusion over the target to which the rebuilding times apply; limited time for stock recovery to have occurred since rebuilding strategies were introduced; variable recruitment and reduced resilience at low stock levels; limited data available for assessing the status of rebuilding stocks; stock productivity may have been initially overestimated; and productivity changes or environmental regime shifts may have occurred. For some stocks, catches in fisheries that are not managed by the Commonwealth may also impede rebuilding.

However, and perhaps more importantly, Haddon et al. (2013) and Ward et al. (2013) point out that **ongoing fishing mortality on several overfished stocks may have simply been too high to allow rebuilding in the required timeframes.**

Rebuilding a stock involves a number of important considerations including determining the level of fishing mortality that will allow the stock to recover within the specified timeframe, the actions to be taken to support rebuilding, the biomass level to which the stock must rebuild and the time frame for that rebuilding. Other important considerations include how to monitor rebuilding, how to adjust management arrangements in response to changes in abundance and how to appropriately deal with changes in fish stocks productivity.

From the public consultation process and the technical and implementation reviews, it is apparent that **more explicit direction may be valuable on rebuilding targets, biologically appropriate rebuilding timeframes, incidental catch allowances for rebuilding stocks and trade-offs with catch levels of other target species, and the range of management actions available for rebuilding stocks.**

Incidental fishing mortality and rebuilding actions

In order for a rebuilding strategy to succeed it is necessary to limit total fishing mortality to a level that allows the stock to recover in the required timeframe. The policy requires that targeted fishing cease where a stock's biomass is below the biomass limit reference point. However, allowance can be made for some level of incidental catch as part of a suite of management measures to rebuild the stock. The guidelines note that:

Clearly, a zero RBC [recommended biological catch] below B_{LIM} [the stock's biomass limit reference point] provides the maximum possible recovery rate. However, achieving zero catches in a multi-species fishery may be difficult. The rebuilding strategy may impose additional constraints on bycatch allowance, up to and including closure of the fishery. (HSP 2007, p. 44)

Rebuilding strategies may be straight forward for stocks that can be largely avoided when fishing for other species (as was the case for orange roughy). However, in fisheries or sectors whose economic returns rely on a complex species mix, or where secondary (non-target) species become overfished, constraining the fishing mortality of overfished species will generally impact on the take of other species across the fishery and its overall economic performance. This has proven to be a particular problem in trying to minimise incidental catches of school shark, which are caught in association with the targeted and economically important gummy shark.

The policy recognises these difficulties but neither the policy nor guidelines include clear direction on how the appropriate level of incidental catch should be determined. In their analysis of harvest strategy policy implementation, Ward et al. (2013) explain that, in practice:

Incidental catch allowances are set in the CTS [Commonwealth Trawl Sector] to cover the unavoidable bycatch of rebuilding stocks that may occur when fishers are targeting other species ... and, in some cases, this allowance may be above the levels estimated by assessments that would allow recovery of the stock in accordance with the adopted rebuilding strategy, e.g. school shark.

Despite these settings, levels of fishing mortality on these species have frequently exceeded incidental catch allowances, in some cases quite substantially (Table 3).

Table 3 Fishing mortality and biomass status of overfished domestic stocks in Commonwealth fisheries (from Ward et al. 2013)

Stock	Biological status, catches and plans								Reasons for 2011 classification	Assessment type	Assessment and management issues
	Indicator*	2005	2006	2007	2008	2009	2010	2011			
Gemfish (east)	<i>F</i> landings (t)	97	87	102	118	125	108	70	Total removals exceeded levels that would facilitate recovery	Quantitative stock assessment model, including projections	Reliability of survey catch per unit effort as an abundance index; poor model fit to discards; recently poor recruitment, which is below model predictions
	<i>F</i> other (t)	78	46	129	115	168	181	122			
	<i>F</i> total (t)	175	133	231	233	293	289	192			
	allowance (t)	100	100	104	100	100	100	100			
	<i>B</i>					CD	CD	CD	Estimated biomass below 20 per cent of unfished biomass		
Blue warehou (east)	<i>F</i> landings (t)	33	17	15	48	25	20	13	Uncertain if reductions in fishing mortality will facilitate rebuilding	Catch per unit effort trends	Reliability of catch per unit effort as an index of abundance; reliability of discard estimates
	<i>F</i> other (t)	275	110	25	266	17	23	44			
	<i>F</i> total (t)	308	127	40	314	42	43	57			
	allowance (t)	100	100	100	40	40	40	40			
	<i>B</i>								Catch per unit effort below limit reference point		

* F = fishing mortality, B = biomass

Stock	Biological status, catches and plans								Reasons for 2011 classification	Assessment type	Assessment and management issues
Gulper sharks (upper slope)	<i>F</i> landings (t)	na	na	5	5	6	3	4	Incidental catches likely to be exceeding levels that would facilitate recovery	Depletion estimates from habitat mapping and carrying capacity modelling	Stock structure; unreported discarding
	<i>F</i> other (t)	na	na	na	na	na	<1	<1			
	<i>F</i> total (t)	na	na	>5	>5	>6	3	4			
	allowance (t)	TL	TL	TL	TL	TL	TL	TL			
	<i>B</i>								Surveys indicate historical depletion exceeded 98 per cent for some species in several areas		
Orange roughy (east)	<i>F</i> landings (t)	654	513	12	4	9	2	25	Very low catches and closure of most areas deeper than 700 m	Egg surveys and acoustic surveys	Assessment not updated since 2007 due to a lack of fishing and survey costs
	<i>F</i> other (t)	100	100	0	0	0	0	0			
	<i>F</i> total (t)	754	613	12	4	9	2	25			
	allowance (t)	738	700	70	25	25	25	25			
	<i>B</i>		CD	CD	CD	CD	CD	CD	Remains depleted from historical overfishing		

Stock	Biological status, catches and plans								Reasons for 2011 classification	Assessment type	Assessment and management issues
	Indicator*	2005	2006	2007	2008	2009	2010	2011			
Orange roughy (south)	<i>F</i> landings (t)	99	5	22	<1	17	16	17	Very low catches and closure of most areas deeper than 700 m	Egg surveys and acoustic surveys	Assessment not updated since 2000 due to a lack of fishing and survey costs
	<i>F</i> other (t)	0	0	0	0	0	0	0			
	<i>F</i> total (t)	99	5	22	<1	17	16	17			
	allowance (t)	100	10	25	25	35	35	35			
	<i>B</i>		CD	CD	CD	CD	CD	CD	Remains depleted from historical overfishing		
Orange roughy (west)	<i>F</i> landings (t)	281	159	31	6	25	28	34	Very low catches and closure of most areas deeper than 700 m	Egg surveys and acoustic surveys	Assessment not updated since 2002 due to a lack of fishing and survey costs
	<i>F</i> other (t)	0	0	0	0	0	0	0			
	<i>F</i> total (t)	281	159	31	6	25	28	34			
	allowance (t)	487	250	60	50	60	60	60			
	<i>B</i>		CD	CD	CD	CD	CD	CD	Remains depleted from historical overfishing		

Stock	Biological status, catches and plans								Reasons for 2011 classification	Assessment type	Assessment and management issues
	Indicator*	2005	2006	2007	2008	2009	2010	2011			
School shark	F landings (t)	209	203	172	229	204	228	163	Incidental catch levels unlikely to be facilitating recovery	Quantitative stock assessment model, including projections	Historical under-reporting of catches and trawl bycatch; reliability of current CPUE index, productivity may have been under-estimated
	other (t)	na	na	na	na	na	na	na			
	total (t)	>209	>203	>206	>229	>204	>228	>163			
	allowance (t)	249	228	213	213	240	216	176			
	B					CD	CD	CD	Estimated pup production below $0.20P_0^+$		

Sources: Status classifications and notes on assessments are from annual Fisheries Status Reports (Woodhams et al. 2012). EPBC Act listing status from SEWPaC (2012). Catch and removals are from a variety of sources, including Woodhams et al. (2012), Haddon (2012), Upston & Klaer (2012) and AFMA logbook and landings data.

Status is classified for each calendar year, whereas allowances and catch estimates are usually for each fishing season. The 2011 column, for example, shows status for the 2012 calendar year and allowances and catches for the 2011-12 fishing season.

Prior to 2008, the Fishery Status Reports classified orange roughy as a single stock in the SESSF Commonwealth Trawl Sector. Biological status was subsequently reported separately for the orange roughy eastern zone, southern zone and western zone. In this report, the status of Commonwealth Trawl Sector orange roughy is counted as if it was reported for three stocks throughout the period of interest so that the status of the Commonwealth Trawl Sector stock applies to each of the three stocks. The Status Reports have treated a fourth orange roughy stock (Cascade Plateau) as a separate stock throughout the period.

allowance: incidental catch allowance for overfished stocks or actual total allowable catch (TAC). Includes nominal east-west stock splits where appropriate.

'other' removals may include estimated discards, state and recreational catches, but usually exclude research or survey catches.

[†] P_0 is unfished pup production

subject to overfishing		overfished
uncertain		uncertain
not subject to overfishing		not overfished
na		not available
CD		listed as Conservation Dependent
TL		trip limit (a 150 kg trip limit in place for gulper sharks)
EW		no distinction between east and west stocks

At least two rebuilding strategies (eastern gemfish and school shark) explicitly identify that incidental catch allowances are set at the estimated level of unavoidable incidental catch (after the specified management controls have been implemented). However, they are not clear about the level of incidental catch that will allow rebuilding in the required timeframe.

An unambiguous intention of the 2005 ministerial direction was to immediately end overfishing, rebuild overfished stocks in reasonable timeframes and prevent stocks from becoming overfished in the future. Doing so requires that incidental catches should be constrained to levels that allow rebuilding, even if this impacts on catches of other species (although noting the issues associated with determining 'reasonable' timeframes discussed above).

However, the guidelines statement that a 'rebuilding strategy may impose additional constraints on bycatch allowance up to and including closure of the fishery' provides no clear indication under what circumstances such action would be required, how the potential economic impacts are to be considered or what processes should be followed for setting catch limits. Furthermore, the policy's requirement to 'cease targeted fishing' for these stocks after January 2009 does not address ongoing non-targeted fishing.

The policy would benefit from including more guidance on how mortality levels for overfished stocks should be set, including when constraining the catch of these overfished stocks is likely to impact fishing for other key species. The policy could benefit from a clear statement that for overfished species, incidental mortality from all sources of fishing should be constrained to levels that allow rebuilding to the target in the specified timeframe. However, the policy should retain some flexibility in this regard, for example to deal with unusual circumstances or situations in which the stock is subject to significant fishing mortality from sources outside Commonwealth control. Transparent processes for developing rebuilding strategies will be an essential component of this process, as outlined earlier, particularly given the likelihood of high stakeholder interest.

Constraining catches to levels that allow rebuilding may require total allowable catches for other species to be reduced if other cost effective avoidance strategies have been exhausted (such as spatial, depth and/or temporal management arrangements and gear controls). However, this will also provide strong incentives to improve the effectiveness of avoidance measures (noting that these are already applied for all rebuilding stocks) and to avoid stocks becoming overfished in future. If arrangements are developed which trigger catch reductions of other species, careful consideration will need to be given to the risks of unreported discarding and how this could be monitored, quantified and managed.

The appropriate level of mortality that will allow rebuilding is not always well understood. Ideally, incidental catches should be tested using management strategy evaluation or stock assessment projections, to ensure that a given level of catch will not jeopardise the stock rebuilding plan. Haddon et al. (2013) note that recent assessments and projections suggest that the total fishing mortality for eastern gemfish, school shark and blue warehou has not been reduced sufficiently to allow rebuilding within the specified timeframes. However, Ward et al. (2013) point out that data limitations or the absence of an agreed quantitative stock assessment model have prevented this from being done for some species, such as blue warehou.

Cost restrictions limit the amount of work that can be done on monitoring and assessing rebuilding species under the current cost recovery model. Management arrangements to reduce catches and promote avoidance by fishers can reduce data availability and make interpretation of catch and effort time series' difficult and unreliable, requiring new mechanisms for data collection and assessment. Haddon et al. (2013) described the situation as follows:

... since the introduction of recovery plans targeted fishing [on overfished stocks] is supposed to stop ... this means that information and data about these species becomes greatly reduced. This lack of information means the difficulty in managing these species and pushing the recovery plans forward becomes greater. This is an unintended consequence of the HSP [harvest strategy policy]. In a cost recovery setting, it becomes even more difficult to fund research on fisheries for which directed commercial activity has ceased.

Nevertheless, improved data would allow rebuilding strategies to be better monitored and, if necessary, adjusted as well as providing for improved reporting. Given the elevated risks that overfished stocks face, consideration should be given to how data collection and monitoring could be achieved and funded for rebuilding stocks. Fishery independent surveys, such as those which have been conducted since 2008 in the Southern and Eastern Scalefish and Shark Fishery, may help in this regard when sufficient data become available and are included in analyses.

Where the appropriate level of catch to allow rebuilding is unknown, a conservative approach could be taken to incidental catch allowances, consistent with the policy's broader approach of increased caution in the face of uncertainty. Further work is required to address the data needs for rebuilding stocks where constraints arising from the necessity for cost recovery are impacting on data capture.

Incidental catch quotas and incentives for targeting

AFMA uses catch allowances (often referred to as 'bycatch total allowable catches') in the form of tradable quota units to manage the incidental take of overfished stocks. Provided that these catch levels are set appropriately, this can provide a useful mechanism for allowing incidental catches to be retained and landed, reducing wasteful discarding, encouraging accurate reporting and providing a potential source of fisheries and biological data.

However, incidental catch allowances have several drawbacks. Ward et al. (2013) point out that catches of overfished species may be potentially economically valuable, encouraging targeting. Wilson et al. (2010) and Woodhams et al. (2011) report that targeted fishing for school shark is likely to have occurred in 2009 and 2010, while targeted fishing for blue warehou is similarly likely to have occurred, particularly prior to 2008. While AFMA and industry have sought to address this issue, incidental catch allowances can create incentives for targeting. In addition, as seen from Table 3, incidental catch quotas do not necessarily constrain overall fishing mortality to the desired level and the approach to determining incidental catch levels has varied from fishery to fishery (A. Penney, P. Ward, pers. comm.). Given these issues, **the guidelines may benefit from direction on how to set incidental catch allowances and catch quotas (noting that other sources of mortality such as discards and catches from state-managed commercial fisheries and recreational fishers may also need to be factored in to catch settings).**

Mechanisms to create incentives against both targeting and discarding of overfished species are discussed in Chapter 7. These mechanisms are likely to be relevant to managing the incidental catch of rebuilding stocks.

Rebuilding strategy design

While rebuilding strategies have been developed for all overfished stocks managed solely by AFMA, these vary significantly in their form and content. All rebuilding strategies identify management controls in place to constrain the catch of rebuilding species (for example, spatial and/or temporal closures and gear modifications). However, only a few explicitly outline additional measures that could be implemented if rebuilding is not successful. Of these, the rebuilding strategy for eastern gemfish is the only one that describes when these might be triggered.

Most, but not all, rebuilding strategies identify rebuilding timeframes to the limit reference point and to an interim maximum sustainable yield target. Rebuilding strategies also vary in how well they describe data collection and monitoring requirements and future research needs. They also differ in their guidance on how incidental catch levels should be set.

The broad variation between rebuilding strategies probably reflects, to some extent, differences in the circumstances and rebuilding requirements between stocks. However, the requirements for effective rebuilding strategies would benefit from a more uniform approach. **While rebuilding strategies generally already include defined targets, timeframes, management arrangements and data collection mechanisms, they could benefit from taking a form more analogous to a harvest strategy.** Where feasible, this might include specifying uniform control rules clearly linked to indicators of stock status; clear and adequate data collection and monitoring requirements; reporting requirements and performance indicators, and they could be tested (for example, through management strategy evaluation or some other means) to evaluate their performance.

However, as noted by Penney et al. (2013b), an unintended problem of implementing rebuilding strategies and preventing targeted fishing under a cost recovery system, is that it becomes difficult to fund research on fisheries for which directed commercial activity has ceased. **Further consideration will need to be given to how the necessary additional monitoring and assessment of these species to measure performance and demonstrate that recovery is occurring could be funded.**

Performance, monitoring and reporting

The management of overfished stocks attracts considerable community interest. Stocks that do not meet rebuilding strategy requirements or that fail to show signs of recovery are potentially exposed to stronger action under environmental and/or fisheries legislation. Such stocks also present focus points for lobbying campaigns purportedly representing community value and attitudes toward the fishing industry's operations and government's fisheries management responsibilities.

This is reflected in the stakeholder submissions, which included conflicting views on the success or otherwise of stock rebuilding and sought greater transparency and accountability around the development and implementation of rebuilding strategies.

There are ongoing difficulties associated with rebuilding a small number of stocks that were overfished prior to the policy's implementation. AFMA has taken actions to reduce fishing mortality

and to seek to rebuild each stock to its target level, as described in the rebuilding strategy for each stock. These strategies seek to balance short and long term economic considerations. Fisheries management is, by its nature, an adaptive process and in some cases where stocks have failed to rebuild (for example, blue warehou) AFMA has reviewed rebuilding strategies or implemented stronger actions.

However, the December 2005 ministerial direction was clear that overfishing should immediately cease and overfished stocks be recovered. The direction was supported in 2006 by significant government investment to restructure key Commonwealth fisheries, which has contributed to improved economic conditions in Commonwealth fisheries. Together, these have provided an opportunity to take strong action to end overfishing. However, **the fact that a small number of overfished stocks have remained subject to overfishing since the ministerial direction suggests that the direction's requirements may not have been met for these species.**

The challenge of addressing overfishing of certain stocks is significant and to some degree has proved intractable. In such circumstances it may need to be recognised that a special effort by more than just industry and the regulator is required. It is also possible that in these circumstances the normal fisheries advisory arrangements of the management advisory committee and resource assessment group may not be well placed to address the problem.

For stocks that do not appear to be rebuilding in a 'biologically reasonable' timeframe, consideration should be given to providing the minister with a power to convene an independent expert panel to evaluate the strategy and its implementation, and make recommendations to strengthen rebuilding actions where appropriate.

In terms of the transparency of rebuilding strategy performance, information on stock rebuilding is currently available from a variety of sources such as stock assessments, resource assessment group and management advisory committee minutes, client reports and scientific papers and fishery status reports. However, there is no easily accessible, standardised central source of information currently available on rebuilding performance.

In light of the risks associated with overfished stocks and the lack of easily accessible and understandable information, **the policy would benefit from the inclusion of stronger reporting requirements for rebuilding stocks, to improve their transparency to stakeholders and the wider community. This could involve reporting against performance indicators. Reporting should ideally occur through a centralised mechanism such as the ABARES fishery status reports, AFMA annual reports or regular, publicly available reports to the minister.** Reports should be readily accessible and could include information on current stock assessments, estimates of discarding, current rebuilding trajectory relative to targets and timelines, new research findings, management controls triggered or otherwise implemented, impediments or problems with rebuilding and other relevant information.

In a review of international best practice harvest strategies, McIlgorm (2013) found that by regulating rebuilding strategy requirements, the United States appeared to have had greater success than the 'less regulatory' approaches used by other nations. To provide greater accountability and transparency, the principles of the rebuilding strategies could also be prescribed in legislative

instruments, such as the management plan for the fishery. This could ensure appropriate consultation and make the principles of the rebuilding strategy subject to Parliamentary scrutiny.

Rebuilding targets

The policy requires that each overfished stock be rebuilt to its target biomass level, as described in its harvest strategy:

For a stock below B_{LIM} [the biomass limit reference point], a stock rebuilding strategy will be developed to rebuild the stock to B_{TARG} [the biomass target].

This requirement provides the policy with rigour, creates a further incentive against overfishing and should maximise long term economic returns from the fishery. The requirement to rebuild overfished stocks to their biomass targets under the harvest strategy policy, even when the fishery no longer has the same economic importance, should be retained.

Although all currently overfished stocks were depleted prior to the implementation of the policy, it is possible that other stocks may become overfished in the future. This raises a number of issues. Firstly, if a stock managed under a harvest strategy becomes overfished, the question arises as to whether that harvest strategy provides appropriate protection. **For stocks whose biomass has declined below the limit reference point while subject to a harvest strategy, the settings of the harvest strategy should be re-assessed to ensure they are appropriate under the range of prevailing and foreseeable conditions**, noting that stock declines may occur, wholly or partly, due to factors other than fishing.

A second issue is whether it is appropriate to re-commence targeted fishing on the stock immediately after stock levels rebuild above the limit reference point. Haddon et al. (2013) notes that there has been some confusion about this. The policy states:

Once such a stock is above B_{LIM} [the biomass limit reference point] it may be appropriate for targeted fishing to re-commence in-line with the stock rebuilding strategy and harvest strategy.

The guidelines similarly state:

The issue of when to allow targeted fishing after a stock recovers to above B_{LIM} [the biomass limit reference point] is also pertinent. For stocks that have recovered from below B_{LIM} , and have not been listed in vulnerable or a higher threat category, targeted fishing will be allowed as long as fishing does not interfere with the agreed stock rebuilding strategy ...

However, while the policy and guidelines both imply that targeted fishing could occur as soon as the stock rebuilds above the limit reference point, the policy also includes a requirement that harvest strategies maintain stocks above the limit reference point 90 per cent of the time. Recognising this, Penney et al. (2013b) states:

Targeted commercial fishing of these [overfished] stocks should cease until they have recovered to above B_{LIM} [the biomass limit reference point]. Although this is not explicitly stated, this should be interpreted as requiring that targeted fishing not be permitted until there is a 90% probability that stocks have recovered to above B_{LIM} .

If a stock is subject to a rebuilding strategy developed under fisheries legislation or policy, **consideration should be given to requiring that targeted fishing of that stock not recommence**

until it is rebuilt to a level that provides an acceptable likelihood that it will remain above the limit reference point when subject to the total level of fishing mortality it is likely to experience. For stocks that are listed under the Environment Protection and Biodiversity Conservation Act, the requirements under that Act will prevail.

Haddon et al. (2013) also suggest that the policy may imply a rebuilding target of 48 per cent of a stock's unfished biomass, reflecting the policy's default 'proxy' target. This definition is suitable for single species fisheries and for key target stocks in multi-species fisheries. However, in multi-species fisheries, the policy and guidelines provide flexibility for setting target reference points, especially when distinguishing between 'key commercial' and 'secondary' species. In these cases, the policy allows target reference points for some secondary stocks to be set above or below the biomass level that would produce those stocks' maximum sustainable yield (as described by the default proxy levels) in order to maximise economic yield across the fishery. If the policy is updated, it could be useful if it clarified that the rebuilding target for any stock is its target biomass level, whatever this value is (noting that targets must be set at levels that provide at least a 90 per cent probability of avoiding limit reference points and may be re-examined if stocks have become overfished).

Rebuilding timeframes

The ministerial direction of 2005 requires that the harvest strategy policy is designed to ensure that 'currently overfished stocks are rebuilt within reasonable timeframes'. The policy itself does not provide guidance on what constitutes 'a reasonable' rebuilding timeframe, however the guidelines describe a number of relevant considerations:

There are likely to be a number of alternative time paths to rebuild a stock that has been fished down to a level below its B_{TARG} [target biomass level]. One option may be to rebuild the stock in the shortest possible time frame (harvests would be zero) ... [however] the optimal time path to rebuild a stock has an economic component. In determining the optimal time path to rebuild a stock, there is a trade-off between lost profits in the short term and the speed at which the stock is rebuilt ... The analysis of rebuilding strategy options and timelines can be complex and is further complicated by the social, economic and policy dimensions of such decisions (HSP 2007, p. 44).

The guidelines go on to describe 'typical' recovery times:

Typically recovery times are defined as the minimum of 1) the mean generation time plus ten years, or 2) three times the mean generation time.

While these 'typical' timeframes may balance the short- and long-term economic and biological aspects of stock rebuilding, **the rebuilding timelines provided in the guidelines do not adequately account for differences in productivity between species, variability in recruitment and the relationship between spawning biomass and recruitment**. Haddon et al. (2013) note that the scientific basis of the timelines described in the guidelines has been debated. One generation could be sufficient for significant population growth for highly productive species but much less growth for species with lower productivity. The specification of 'ten years' on top of one generation time is also potentially problematic, as this may represent several generation times for some species (for example, prawns) or a fraction of a generation for others (for example, orange roughy). Nor do they appear to account for how far below the reference point currently overfished stocks have fallen.

The guidelines appropriately indicate that the circumstances surrounding the rebuilding of each stock are unique and should be factored into harvest strategies and rebuilding strategies:

The HSP recognises that each stock/species/fishery will require an approach tailored to fishery circumstances. ... This is particularly relevant ... in developing stock specific stock rebuilding strategies and stock recovery plans for overfished stocks ... less productive stocks should be managed more conservatively to ... ensure stock recovery within acceptable timeframes for depleted stocks.

Ward et al. (2013) noted that unrealistic recovery timelines are one of several probable reasons that stock rebuilding has not always occurred within required timeframes. Haddon et al. (2013) noted that **some stocks, such as eastern gemfish would not recover within the ‘typical’ timeframes described in the guidelines, even in the absence of fishing**. It is clear, therefore, that an appropriate definition of recovery time is required that can account for differences in biological productivity as well as economic considerations.

There is no international consensus on the time period over which recovery arrangements should be in place (McIlgorm 2013), with various countries implementing different rebuilding timeframes (Haddon et al. 2013). The New Zealand approach is designed to adjust rebuilding timeframes in direct response to the biological productivity of different species, basing recovery times on the minimum possible time to recover under zero fishing mortality. The New Zealand Harvest Strategy Standard states:

where the probability that a stock is at or below the soft limit [20 per cent of its unfished biomass] is greater than 50%, the stock should be rebuilt to the target [40 per cent of unfished biomass] within a time period between T_{min} and $2 \times T_{min}$ (where T_{min} is the theoretical number of years required to rebuild a stock to the target with zero fishing mortality).

The USA applies a related approach (Restrepo et al. 1998):

The maximum rebuilding period, T_{max} , should be 10 years, unless T_{min} (the expected time to rebuilding under zero fishing mortality) is greater than 10 years, when T_{max} should be equal to T_{min} plus one mean generation time.

These approaches appear to allow for recovery timeframes that are more biologically appropriate than those described in the guidelines, with the New Zealand approach seeking to better balance sustainability and economic considerations.

The related question of whether the rebuilding timeframes should apply to rebuilding the stock to its limit or target reference points was widely raised during the review. Targeted fishing on stocks that have rebuilt above the limit reference point will clearly prolong rebuilding timeframes. Similarly, the ‘typical’ rebuilding timeframes described in the guidelines have less biological relevance for target reference points compared to limits, as rebuilding to targets may take several ‘mean generation times’ to reach.

These factors could considerably influence the application of the stated ‘typical’ timeframes in relation to rebuilding targets. However, this issue would largely be eliminated if rebuilding timeframes were calculated as some multiple of T_{min} (the minimum timeframe for rebuilding in the absence of fishing) as this point would vary according to both the productivity of the stock and the

rebuilding target to which it is applied (that is, T_{min} could be estimated and applied separately for rebuilding to limit and target levels).

In light of these considerations, the **policy and/or guidelines would benefit from specifying rebuilding timeframes as a multiple of the minimum timeframe for rebuilding in the absence of fishing (T_{min})** where this can be estimated. **A maximum rebuilding timeframe of no more than twice T_{min} would seem appropriate in most cases**, although sufficient flexibility should be retained to allow rebuilding strategies to be tailored to the unique combination of economic and biological considerations (for example, as has been done for the upper slope dogfish management strategy).

Consideration should be given to rebuilding overfished stocks to the limit reference point faster than twice T_{min} , given the increased risks associated with maintaining stocks at such low stocks levels. In practice, a number of rebuilding strategies already identify one mean generation time as an appropriate rebuilding timeframe to the limit reference point.

Non-fishing factors

There is an implicit assumption in the policy and guidelines that all stocks are able to recover to their former biomass levels. Haddon et al. (2013) point out that this assumption may not hold true. There may be stocks that, once depleted, may not be able to recover within expected timeframes due, for example, to reduced survival or production of eggs or recruits (depensation).

Penney et al. (2013b) discusses natural variations in productivity, and how this can affect the need for and success of rebuilding strategies. This effect appears to have been seen in jackass morwong in the Southern and Eastern Scalefish and Shark Fishery, which exhibited 20 years of below average recruitment and failed to rebuild as total allowable catches were progressively reduced. This was eventually characterised as a change in the species productivity due to a regime change, or at least an alteration in prevailing conditions that has lasted for decades (Haddon et al. 2013).

Factors, other than those related to fishing pressure, that can impact on rebuilding strategies include climate effects, changes in prevailing conditions, ecological factors, the biology of the species and the level of depletion. Any of these factors or others not listed here may combine, to impact on the ability of stocks to recover in the required timeframe. However, separating natural productivity changes from depensation (reduced survival and production of offspring) may be difficult.

Penney et al. (2013b) make the following point:

Persuasive evidence of a change in productivity resulting from some external environmental factor is required before an environmental change can be adopted as the justification for changing the productivity parameters, targets and limits, for a species under a rebuilding plan. Reduced recruitment as a result of spawning depensation in a depleted stock does not necessarily alter the productivity of the stock.

A requirement for persuasive evidence that a productivity change was due to external factors and not to depensation could be incorporated into an updated policy. Updated guidelines could include direction on the evidence required to determine that productivity declines are due to environmental factors rather than reduced resilience and depensation arising from stock depletion.

Species listed under the Environment Protection and Biodiversity Conservation Act

The policy and guidelines provide a valuable explanation of how fisheries legislation integrates with the Environment Protection and Biodiversity Conservation Act and associated regulations. Both the policy and guidelines indicate that if the biomass of a stock is at or below its limit level, it may be subject to action under both fisheries and environment legislation—including listing at a ‘conservation dependent’ or higher level on the Environment Protection and Biodiversity Conservation Act List of Threatened Fauna—as the risk to the species may be regarded as unacceptably high. The policy and guidelines similarly contain references to ‘delisting’ of previously overfished species whose biomass has been rebuilt above limit reference point levels, recognising that this is a decision made under environmental legislation.

Some stakeholders have questioned the value of the inclusion of this description in the policy or guidelines. The Australian Government recently considered this matter in its 2011 response to the report of the independent review of the Environment Protection and Biodiversity Conservation Act by Dr Allan Hawke (SEWPAC 2011). The report states:

... the government agrees that there should be a link between the HSP [harvest strategy policy] framework and the threatened species listing process for marine fish ... [and] considers that this link should remain a policy matter and not be legislative. The government notes that this link is already explicit in both the HSP and the Threatened Species Scientific Committee’s public interpretive guidelines ...

The description of the relationship between the policy and the Environment Protection and Biodiversity Conservation Act should be retained to describe how the Environment Protection and Biodiversity Conservation Act relates to the management arrangements made under fisheries legislation.

While stakeholders had opposing views as to whether or not species whose biomass levels exceeded limit reference points species should be subject to listing, policy statements such as the harvest strategy policy can only help interpret legislation and cannot override it. The *Guidelines for Assessing the Conservation Status of Native Species* (TSSC 2010) clarify:

When considering thresholds for assessing commercially harvested marine fish, the [Threatened Species Scientific] Committee [which advises the environment minister on threatened species and communities listings] refers to the Commonwealth Government Harvest Strategy Policy ... The Committee is informed, but not bound, by a series of biological reference [target and limit] trigger points (commonly referred to as B_{LIM} and B_{TARG} [biomass limit and biomass target reference points]) provided in the policy for management intervention for species

Some stakeholders sought increased clarity on the process for removing species from the List of Threatened Fauna. If the policy is updated, the Department of Agriculture, Fisheries and Forestry should work with the Department of Sustainability, Environment, Water, Population and Communities to provide information on when it might be appropriate to apply for de-listing of conservation dependent species that are recovering toward their limit reference point and on the process for making such an application.

Ministerial approval of rebuilding strategies

The harvest strategy policy requires that rebuilding strategies for overfished stocks be developed by AFMA and approved by the environment minister. However, the species concerned are commercial species and AFMA is already operating under a direction from the fisheries minister to recover all overfished stocks and cease all overfishing. Accordingly, the policy could provide that the fisheries minister should also be consulted on the rebuilding strategy. For stocks that are not listed under environmental legislation, it may be more appropriate that rebuilding strategies should be approved by the fisheries minister in consultation with the environment minister.

Triggers for stronger rebuilding action

Fishers must take all reasonable steps to avoid killing or injuring species that are included on the Environment Protection and Biodiversity Conservation Act List of Threatened Fauna at a level above 'conservation dependent' (that is, 'vulnerable' or higher).

The fisheries management review (Borthwick 2012) recommended that the Australian Government:

... should give effect to its in-principle agreement to accredit AFMA's processes for managing fisheries under the EPBC [Environment Protection and Biodiversity Conservation] Act, rather than for there to be separate assessments [of individual fishery management arrangements].

In a similar context, for highly depleted species, consideration could be given to requiring strong action under the fisheries legislative framework.

To this end, consideration could be given to introducing management measures similar to those required for threatened species under environmental legislation; that is, requiring that fishers take all reasonable steps to avoid mortalities to the species through actions up to and including fishery closure. This could be triggered, for example, for species whose biomass has fallen below some critical limit or that have demonstrated prolonged recruitment failure.

However, consideration would first need to be given to the risks of regulatory duplication with environmental legislation and the associated 'double jeopardy' situation this could create.

Conclusions

A number of overfished stocks subject to rebuilding strategies are not showing clear signs of rebuilding. While there are a number of reasons for this, several overfished stocks continue to be subject to fishing mortality levels that may be too high to allow rebuilding within the required timeframe.

Additional policy direction would be valuable on rebuilding strategies; including on rebuilding timeframes, appropriate rebuilding actions and reporting against rebuilding strategies.

Consideration could be given to providing the fisheries minister with an increased oversight role and powers to initiate a review of arrangements for stocks where rebuilding is not demonstrated within the timeframe of the rebuilding strategy.

Consideration could be given to elevating aspects of rebuilding strategies into legislative instruments and to increasing protections for overfished species whose biomass has fallen below some acceptable risk threshold.

7 Discarding of commercial species

Discarding, in the context of this report, is the returning to the water of dead or dying specimens of commercial species. This does not include the returning to the sea of incidental catch of non-commercial species (bycatch) or of live and vigorous specimens of commercial species.

The discarding of commercial species occurs for both economic and/or regulatory reasons. Economically motivated discarding can occur when certain species are discarded in favour of retaining higher value species.

Regulatory discarding occurs where regulations prevent, or create incentives against, the retention of some fish that are incidentally caught in excess of held quotas or when fishing for other species. This often arises when fishers make incidental catches of one stock for which they do not have quota, when seeking to fulfil quotas of higher value stock. It can also occur where jurisdictional arrangements between states and the Commonwealth are implemented in a way that results in an unbalanced mix of total allowable catches for species caught together, preventing fishers from retaining all incidentally caught fish.

High-grading, where lower value individuals (for example, fish whose size or condition attracts a lower price) are discarded in order to allow higher value individuals of the same stock to be retained for sale, can have both regulatory and economic drivers.

The discarding of commercial species can have biological, economic, social and ethical implications. Discarding may affect the pursuit of legislative objectives and may be inconsistent with shifting community expectations for the use of the resource. These issues were raised in the discussion paper for this review.

Discarding and stock sustainability

Fishers are often limited in their ability to target or avoid particular species or groups of fish, particularly when using less selective fishing methods such as trawling. An element of unwanted incidental catch is unavoidable. Haddon et al. (2013) recognised this:

Fishers can usually 'target' to some degree through fishing different areas and depths, seasons, times of day and by modifying gear. But it is the degree to which fishers can target that is the issue. The species mix in catches may not necessarily match the mix in combined TACs [total allowable catches] or in quota holdings. This difficulty in balancing quotas for multiple species with actual catches may then lead to increased discarding TAC over-runs, effort restrictions or fishery closures ...

At present, unwanted incidental catch of commercial species is generally discarded.

Notwithstanding the economic, social and ethical implications of discarding, a primary consideration in managing discarding is to ensure that it does not diminish the sustainability of a fishery. This emphasises the importance of ensuring that discards are adequately monitored, reported and incorporated into stock assessments and total allowable catch settings.

McIlgorm (2013) identified that policy approaches to discarding vary between countries, but considered that a zero discards approach or discard minimising system were international best practice.

Key species in most major Commonwealth fisheries are now managed through total allowable catches and individual transferrable quotas. The sustainability impacts of discarding can be managed by factoring appropriate estimates of discarding into total allowable catch settings (for example, by setting total allowable catches at recommended biological catch levels minus best estimates of discards), ensuring that total mortality from fishing, including discarding, is constrained within sustainable levels.

Factoring estimates of discarding into total allowable catch settings was a requirement of the 2005 ministerial Direction to AFMA. However, while the harvest strategy policy indicates that it is intended to apply to all sources of fisheries related mortality, it does not include a clear statement about how this is to be done and makes no specific reference to discards:

The Policy ... takes into account mortality resulting from all types of fishing, including recreational and state managed-catches. (HSP 2007, p. 6)

The guidelines are more explicit in this respect:

When setting TACs/TAEs [total allowable catches/total allowable effort levels] from RBCs [recommended biological catches], catches attributable to all types of fishing must be taken into account. This includes all fishing-induced mortality (for example, discards or state catches, and recreational catches). (HSP 2007, p. 45)

While AFMA already factors estimates of discarding into total allowable catch settings for a number of stocks (Ward et al. 2013), it would be beneficial for the policy to explicitly require this, for the sake of uniformity of approach and transparency to all stakeholders.

Fishers are required to record discards of various species, including quota species, in logbooks. However, the accuracy and completeness of logbook data can be difficult to validate. Observers can be used to gather information on discarding and other aspects of fishing, but have high costs associated with their use.

Ward et al. (2013) note that:

For several species, reliable estimates have not been available for significant sources of mortality, particularly recreational catches and discards.

and

... the reliability of discarding estimates is highly dependent on the level and representativeness of observer coverage.

The fisheries management review (Borthwick 2012) notes:

... discarding and high grading prevent fisheries managers from effectively monitoring and recording the impact that commercial fishing has on target and non-target species, including through accurate stock assessments.

Reliable estimates of fishing mortality from all sources, including discarding, should continue to be factored into total allowable catch settings; particularly where such mortality is significant relative to landed catches. It is important that AFMA seeks to ensure that estimates of discarding are sufficiently robust and that they are appropriately accounted for when setting catch levels or

monitoring for changes in the risk to a stock. (For example, if total catch levels including discards change substantially, this may mean that the stock is at a higher or lower level of risk from fishing than previously assessed). **This may include checking the veracity of data from logbooks and other sources.** The guidelines could provide further direction on these matters.

Initiatives such as electronic logbooks, as well as recent legislative changes to allow improved electronic monitoring, including cameras, may assist in this respect. However it will take some time and further work (and expense) for this to be implemented, and for systems to be developed that are, for example, able to help identify all components of the catch or process video footage for instances of discarding.

Economic and regulatory discarding

Even when the sustainability impacts of discarding are appropriately managed, discarding is still widely considered to be a wasteful practice that can diminish community confidence in fishing and fisheries management and can impact negatively on other user groups. Borthwick (2012) states:

Bycatch and interactions with other non-target species are an inevitable outcome of commercial fishing, but policies ... should work to minimise the occurrence of wasteful and damaging discarding as much as possible.

Commonwealth fisheries legislation currently provides limited guidance on the matter of commercial species discards. Examination of material put before the Australian Parliament when the *Fisheries Management Act 1991* and *Fisheries Administration Act 1991* were introduced and when objectives were subsequently amended suggests that wastage arising from discarding of commercial species has never been an explicit consideration in drafting Commonwealth fisheries legislation. Similarly, it does not appear that the 'wastage' or 'ethical' aspects of discarding explicitly influenced the outcomes of the United Nations Convention on the Law of the Sea (Nordquist 1989), which are reflected in Commonwealth legislation.

Indeed, while minimising wastage and discarding is consistent with various international documents and resolutions including the (non-binding) Code of Conduct for Responsible Fisheries (FAO 1995), it is scarcely addressed in Commonwealth fisheries legislation. The only Commonwealth legislative provision that directly addresses discarding appears in a schedule to the Fisheries Management Act that reproduces the United Nations' Fish Stocks Agreement. This includes a provision relating specifically to reducing discarding of straddling and highly migratory stocks. The Fisheries Management Act does however include the requirement that fishery management plans 'must contain measures directed at reducing to a minimum ... the incidental catch of fish not taken under ... that plan'. While the absence of a clear legislative mandate does not preclude policy decisions to constrain discarding, it may limit the scope of such arrangements if these are considered inconsistent with legislative objectives.

There is growing international support for minimising or eliminating discards of commercial species. A number of international fisheries jurisdictions, such as the European Union, are currently working towards implementing systems that minimise or prevent discards, while in other jurisdictions, such systems are already well established.

Borthwick (2012) was of the view that discarding was most appropriately managed through a bycatch policy. However, harvest strategy policy settings and implementation can also impact on commercial species discards.

CSIRO's Technical Reviews for the Commonwealth Harvest Strategy Policy (Haddon et al. 2013) note that a number of solutions have been proposed or implemented in Commonwealth fisheries to reduce regulatory discarding. These include measures to improve transferability of quota; incentives to reduce over-quota fishing and discarding; and fishing gear modification. Both McIlgorm (2013) and Haddon et al. (2013) note that measures such as spatial and temporal closures to avoid unwanted catch can also be used to reduce incidental interactions with unwanted fish in some situations. AFMA and industry have implemented a range of measures over the years to improve gear selectivity and this area of should work continue to be explored.

Haddon et al. (2013) suggests that regulatory discarding and related issues could be addressed in part by focusing on compatible quota settings for individual species in multi-species fisheries. They cited a study of the Commonwealth Southern and Eastern Scalefish and Shark Fishery using 'companion species analysis' that identified primary and secondary species that tend to be caught together and their relative proportions in the catch. The study found that companion species analysis could be used to examine the impact of individual species catch level decisions across all quota species in the fishery.

Setting quotas in multi-species fisheries at levels that take account of likely catch compositions can help reduce discarding. However, this needs to be balanced with other fisheries objectives such as ensuring sustainability and maximising economic returns. This has resulted in further work on setting alternative targets for secondary species in mixed species fisheries (Vieira & Pascoe 2013) to reduce the constraints that total allowable catches for secondary species may have on fishing for target species.

Other management settings that are relevant to the harvest of commercial species, but not directly addressed by the harvest strategy policy, can also reduce the incentives for discarding. These include providing for a small amount of quota to be carried over from one season to the next (a matter that has been considered in AFMA's quota administration policy; AFMA 2013) and the implementation of compatible management arrangements for species taken across different jurisdictions (see Box 3).

Box 3 Cross-jurisdictional catch arrangements

Regulatory discarding can arise when species managed in one jurisdiction are also taken in another but fishers are not allowed to land it. Offshore constitutional settlement arrangements between the Commonwealth and the states and Northern Territory—which describe which jurisdiction has responsibility for managing a particular species, area and/or gear type—do not precisely reflect the species distribution of catches. It is common therefore, that fishers in one jurisdiction will incidentally catch species that are managed by another jurisdiction. This is recognised in agreements between the jurisdictions that describe agreed incidental catch levels for each jurisdiction.

In Commonwealth fisheries, incidental catches of state managed species are often constrained through mechanisms such as trip limits (although in some cases retention is prohibited). These measures allow a small amount of the catch to be landed, thereby reducing discarding while avoiding incentives for fishers to target the species. This inevitable tension between allowing incidental catch to be landed and avoiding targeting leads to regulatory discarding when incidental catches exceed catch allowances.

Unless and until offshore constitutional settlement arrangements are revised to more closely reflect catch mixes, any new agreements between jurisdictions on incidental catches would benefit from being drafted with regard being given to reasonable and likely incidental catches. Management arrangements to give effect to such agreements should also have regard to discarding, for example by applying flexible incidental catch allowances where this is practical and consistent with other fisheries objectives. The importance of more flexible ‘incidental catch’ arrangements with other jurisdictions was recognised in the Queensland (state) Department of Agriculture, Fisheries and Forestry’s submission to the review and AFMA has taken this approach for the incidental catch of snapper in the Southern and Eastern Scalefish and Shark Fishery.

Given the relationship between management settings and regulatory discarding of commercial species, **the policy could benefit from a principle that management arrangements for commercial species should be set with regard being given to minimising discarding to the minimum practical and cost-effective level, within the context of stock sustainability.**

It needs to be recognised however, that management arrangements are implemented to achieve a variety of outcomes, not all of which create incentives against discarding. For example, allowing fishers to carry over large amounts of over- and under-caught quota from one season to the next could reduce discarding but may undermine quota trading and annual total allowable catches. Similarly, allowing fishers to retain unlimited quantities of state-managed species may avoid discarding but in the absence of other measures would create incentives to target these species, potentially resulting in unsustainable catches and weakening fisheries access rights.

Growing societal concern over discarding affects community’s attitudes to the industry in the longer term. In the interests of transparency, **it would be beneficial if AFMA established a reporting system to collect and publicly publish data on discarding to ensure transparency and encourage operators to reduce discarding.** This should include annual reporting of discarding estimates in each fishery, including indicating where reliable estimates are unavailable.

While much of this information is already available in management documents, it would be useful if this could be used to supplement existing centralised reports such as the ABARES fishery status report or AFMA annual reports. However, consideration must be given to the cost of this approach.

In the interests of transparency, consideration should also be given to making reports of significant discarding events public. In determining whether and how to implement such an approach, consideration should be given to the importance of transparency and the incentives that public reporting may create to reduce discarding. However, these considerations should be balanced against any disincentives (which cannot be reasonably managed through other mechanisms) that public reporting may create for fishers to report discards to AFMA as well as against the costs involved.

The public's understanding of discarding could also be improved by communicating that some level of incidental catch of unwanted species is an unintended but generally unavoidable result of providing affordable fresh seafood.

The 2005 ministerial direction to AFMA under section 91 of the Fisheries Administration Act recognised that factoring discarding of commercial species into total allowable catch settings can provide incentives against discarding; a point supported by experience in the Southern and Eastern Scalefish and Shark Fishery (Smith et al. 2008).

AFMA does this by subtracting estimates of discards from recommended biological catches when calculating fishery-wide total allowable catch levels. AFMA's Quota Administration Policy (2013) recognises that deducting discards of quota species from individual quota holdings would provide greater incentives against discarding. While doing this in a way that does not create incentives for non-reporting may not be feasible at this time, this may change in the future when electronic monitoring systems (including on-board cameras) and associated procedures are developed.

McIlgorm (2013) notes that a number of countries have developed, or are developing, systems to minimise or prevent discards.

Such systems are in place in a number of countries including Canada, Norway, Iceland and New Zealand, with the European Union currently working toward implementing discard reduction measures. These are implemented in a variety of ways in different countries. For example, New Zealand uses a market based system that requires fishers to land all catch of quota species and charges them a 'deemed' rate for catches in excess of held quota. Canada uses a system for groundfish in which individual fishers quotas are decremented at a determined 'discard' rate based on their catch history which provides incentives to reduce discarding. Iceland and Scotland have quite different discarding schemes in the cod fisheries (Box 4).

Box 4 Approaches to discarding in Iceland and Scotland

Iceland and Scotland have implemented systems to reduce discarding in their cod fisheries. These demonstrate two quite different approaches to the same problem (European Commission 2011).

Iceland

In the 1980s, Iceland introduced a quota management program and a total ban on discarding has been in place since 1996. Under the Icelandic system, if a vessel catches a species for which it does not have sufficient quota, this catch is automatically deducted from its cod quota using 'a cod-equivalent' index (cod appears to have been selected as it is a principal species driving the economics of the fishery and had declining biomass when the system was implemented). This can be done for up to two per cent of the total cod quota held by that operator and does not work in reverse (that is, other species' quota cannot be used to 'create' cod quota).

Operators can reverse the cod-equivalent transaction by purchasing quota for the over caught species. Other measures in place include the mandatory retention of all undersize catch (not to exceed 10 per cent of the quota) which counts against the operator's quota at a 50 per cent rate.

At the end of the season, when operators run out of quota, as an extra incentive to report and land all their catch, operators are allowed to sum all their catch (all species) and land an extra percentage (from two to 10 per cent according to gear type) of any species regardless of whether they have quota for that species.

This extra catch is auctioned off with 80 per cent of the sale value being kept by the Ministry of Fisheries to be used in a fisheries development fund. Any catch beyond that incurs a post-season cost and the operator is invoiced for it with the government keeping one hundred per cent of the auctioned value of the catch.

Should operators have quota left at the end of the year, they are able to carry up to 15 per cent over to the following year.

It has been suggested that the Iceland discard ban may have led to increased prices being received for certain species due to the improved selectivity of the catch and reduction of small fish being caught reflecting market needs. This increase in selectivity may have occurred either through the avoidance of high risk areas for juvenile fish or through improved gear selectivity.

An important factor in this scheme is the emphasis on at-sea inspections and port observers. Even though not all trips carry observers or are monitored, being able to compare catches of monitored and non-monitored trips carried out at the same place and time has proven to be a useful tool in identifying high-risk vessels for inspection.

Overall the Ministry of Fisheries in Iceland considers the ban on discards to be successful and that the flexibility of quota trading and target buffers have been important aspects of the fisheries management measures that allowed the ban to succeed.

Scotland

Scotland has also implemented a system of incentives to reduce discarding of cod. Cod was estimated to be subject to discarding at a rate of 35 per cent of the retained catch prior to these measures being introduced.

The scheme provides increased quota and allowable effort for vessels that commit to landing all cod caught regardless of the size (that is, no discarding), cease fishing once the quota for cod or any other species was reached and allow the installation of electronic monitoring devices such as cameras and winch sensors.

An increasing number of vessels are joining the scheme. The results have included an increase in cod landing, more vessels being able to fulfil their quotas for other species in the fishery and a change in fisher behaviour. Fishers have also used their participation in the scheme as a marketing tool, selling their fish as 'discard-free'.

Appropriate mechanisms to further reduce or eliminate discarding, such as those applied in a number of foreign jurisdictions, should be investigated with a view to identifying actions appropriate to the broad range of Australia's Commonwealth fisheries. Ideally any such system would benefit both industry and public interests.

Developing and implementing any such system would require consideration of costs and benefits and extensive consultation. In all probability, it would also require enabling provisions in the policy and supporting legislation. While implementing any such system in Commonwealth fisheries is likely to be a longer term goal, the policy and guidelines could be drafted with sufficient flexibility to accommodate new approaches to discards in the future.

Conclusions

Some level of unwanted incidental catch of commercial species is unavoidable. Reliable estimates of discards of commercial species should continue to be factored into recommended biological catch settings, as part of total fishing mortality, to ensure the sustainability of discarded species.

The policy could also be improved by providing greater direction on the need to minimise the discarding of commercial species. Discarding of commercial species should ideally be kept to the minimum practical and cost-effective level consistent with sustainability.

Mechanisms to further reduce discarding should be explored. Where appropriate, management arrangements—such as catch sharing arrangements and total allowable catch levels for individual species in multi-species fisheries—should be set with regard to minimising incentives for discarding (noting that this must be balanced with other fisheries objectives). Avoidance of unwanted catch, such as through spatial measures or improved gear selectivity, should be encouraged.

8 Shared stocks

In the context of this report, 'shared stocks' are those stocks that are accessed and managed by the Australian Government under the *Fisheries Management Act 1991*, as well as by other international or domestic fisheries management jurisdictions. Shared stocks in Commonwealth fisheries can broadly fall into three categories:

- international stocks: for example, the Eastern and Western Tuna and Billfish Fisheries, Southern Bluefin Tuna Fishery, the Macquarie Island Toothfish Fishery and the Heard Island and McDonald Islands Fishery all represent Commonwealth fisheries where target stocks are also fished by other fishing nations and/or managed according to decisions made by an international management body
- state/territory commercial stocks: for example, stocks of eastern school whiting and Australian sardine are shared by both Commonwealth and state commercial fisheries
- non-commercial stocks: for example, tunas and striped marlin are target species in Commonwealth commercial fisheries and are important game fish species for state and territory government managed recreational and charter fishers.

Difficulties can arise with aspects of the management of shared stocks, such as setting catch levels that maintain sustainability and provide equitable access to such stocks. These challenges reflect the broader challenges of operating in 'the commons' that are inherent to wild fisheries. The nature of these issues makes it difficult, and possibly undesirable, for the policy to prescribe directions for setting catch levels for shared stocks. Nevertheless managing shared stocks is an issue that needs to be addressed, particularly as demand for seafood continues to increase, quota management becomes more widespread, fishing technology continues to improve, demands for some stocks by other users increases, and climate change results in spatial and productivity shifts in fish populations.

International shared stocks

The December 2005 ministerial direction to AFMA states that:

... for internationally-managed fisheries to which Australia is a party (such as the Southern Bluefin Tuna Fishery and the Heard Island and McDonald Islands Fishery) the relevant international agreement will prevail where it includes an acceptable scientific process for setting sustainable catch levels.

However, this is not captured in the policy or guidelines. Rather, the policy explicitly states that it does not prescribe management arrangements for shared stocks (international or domestic).

The policy goes on to describe, in very general terms, the basis for the government's negotiating positions for shared stocks in international fisheries. It states that the government will negotiate within relevant management bodies to ensure sustainable management of fisheries by 'advocating this policy as an example of best practice in setting sustainable catch levels' and that the negotiating position taken to international management bodies is underpinned by the government's domestic legislation.

The policy also describes how domestic catch levels should be set:

...for internationally-managed fisheries to which Australia is a party (such as the Southern Bluefin Tuna Fishery and the Heard Island and McDonald Islands Fishery) the relevant international agreement will prevail where it includes an acceptable scientific process for setting sustainable catch levels. In such fora, Australia will advocate its domestic policy settings as an example of best practice (HSP 2007, p. 6).

The policy indicates that the government supports 'catch level decisions' made by those bodies and that where agreement is not reached:

... Australia's domestic catch allocation decisions would be consistent with the agreed whole of government position.

For fisheries issues that are not decided by an international management body or arrangement, DAFF [the Department of Agriculture, Fisheries and Forestry] and AFMA will consult on the management arrangements that will apply and AFMA will implement those arrangements (HSP 2007, p. 6).

From the context, it seems that the 'whole of government' position referred to here is the negotiating position taken to the international body, however this is not explicitly stated and appears to have caused some confusion among stakeholders and managers.

More generally, there has been confusion over how and when the policy's settings should be applied to shared stocks in internationally-managed fisheries and what constitutes an 'acceptable scientific process' that would 'prevail' over domestic catch setting arrangements.

Government position for internationally managed stocks

In formulating Australia's position to take to international management bodies, the Australian Government employs the principles applied through the harvest strategy policy and guidelines and seeks to ensure that Australia's domestic standards are promoted through international forums (Ward et al. 2013).

Developing a government position to take to regional fisheries management organisations and other international meetings is an involved process that includes consultation and active engagement with a range of government, industry and non-government organisations. For example, in preparation for each regional fisheries management organisation commission meeting, invitations to participate in stakeholder meetings are made to relevant parties including environmental non-government organisations, commercial fishers, members of the relevant AFMA management advisory committees and, where required, recreational fishing bodies. These consultations are used to inform Australia's approach to each of the commission meetings, which must then be agreed to by the Minister for Agriculture, Fisheries and Forestry and any other relevant ministers. This negotiating position is necessarily confidential, as its release would undermine Australia's position in international negotiations.

Key stakeholders are also invited to participate in the regional fisheries management organisation meetings as an observer on the Australian delegation. At the meetings, and if participating as a part of the Australian delegation, stakeholders may be provided with information on the approach being taken by Australia and are able to discuss any issues or concerns with the Australian delegation.

Stakeholders have expressed confusion over the process. In the interests of clarity, **the policy could benefit from outlining that Australia’s international negotiating position requires a whole-of-government approach with the agreement of the fisheries minister and other relevant government ministers and generally incorporates a stakeholder consultation process.**

The policy states that the Australian Government will negotiate for sustainable fisheries by advocating the policy as an example of best practice. This has been interpreted by some to imply that the policy’s settings should be promoted at every international meeting, irrespective of relevance or implications for negotiated outcomes. However, advocating the policy in all instances is unlikely to be appropriate or relevant.

Different management arrangements, different reporting arrangements and different levels of data on shared stocks makes rigorous implementation of the harvest strategy policy’s settings difficult in an international context.

While the government promotes the policy and its settings in seeking to achieve sustainable catch decisions by international bodies, each negotiating situation is unique and Australia cannot dictate the outcomes of negotiated processes. For example, maximum sustainable yield (as opposed to the policy’s target of maximum economic yield) is the management target specified in the United Nations’ Convention on the Law of the Sea, and so gaining agreement to catch level decisions that achieve maximum sustainable yield will usually be a more realistic aspiration and allow negotiations to focus on more pressing priorities (such as constraining overall catch to sustainable levels).

In addition, there are many aspects of sustainable fisheries management that Australia promotes, such as managing bycatch and interactions with protected species, that do not fall within the scope of the policy. Advocating the policy in such instances is unlikely to be appropriate or relevant.

Negotiating positions may also be affected by other considerations consistent with the national interest, such as supporting a viable domestic fishing industry and supporting positive economic outcomes for small island states. In some cases it may not be necessary or appropriate for Australia to make any intervention in international meetings, whether to promote the policy’s settings or not.

Given these considerations, the policy’s requirements should be clarified with respect to its use in international negotiations but some flexibility must be retained. Rather than the current text (described above), **the policy could clarify that Australia will negotiate for sustainable fisheries by adopting a position consistent with its broad domestic legislative and policy requirements, recognising that the harvest strategy policy represents best practice in setting sustainable catch levels.**

International catch level decisions

Having ratified international agreements in domestic legislation, it is Australia’s obligation under domestic law to comply with any measures adopted by relevant international organisations. Australia does have discretion to set more stringent domestic catch levels in accordance with legislation or policy, however the harvest strategy policy is silent on this and does not describe the circumstances, if any, in which Australia would do so. Importantly, a unilateral decision taken by Australia may not make a significant difference to stock levels but may significantly impact on broader negotiating positions.

Australia is currently actively represented in all relevant regional fisheries management organisations. Australia generally advocates conservation and stock management standards similar to those applied to Commonwealth fisheries as these usually represent world's best practice and often already apply to our domestic fishers.

The harvest strategy policy states that Australia will support 'catch level decisions' made at international fisheries organisations. However, it does not clarify what constitutes an acceptable 'catch level decision' for the purposes of setting domestic catch levels. The ministerial direction clarifies that the relevant international agreement will prevail 'where it includes an acceptable scientific process for setting sustainable catch levels' but it does not clarify what is or is not 'acceptable'.

This ambiguity has caused confusion about appropriate catch settings for some internationally managed stocks, such as in the Eastern Tuna and Billfish Fishery, which targets species managed under the Western and Central Pacific Fisheries Commission regional fisheries management organisation. In this instance, there was debate around the connectivity of the Australian and broader international 'components' of these stocks and the impact the Australian catch has on broader stock. Another issue that has been raised in connection to the management of this stock is whether Australia should establish a greater catch history in the Western and Central Pacific Fisheries Commission, that may influence potential future national allocation decisions. Following discussion between the Department of Agriculture, Fisheries and Forestry and AFMA, total allowable catches in this fishery have been set on the basis of domestic harvest strategy settings or at levels that broadly reflect historical catches (the approach taken to each species has been influenced by matters such as stock connectivity and the relative magnitude and effect of the Australian catch on the wider stock).

In reality, a number of harvest strategies consistent with many aspects of the policy have been implemented by regional fisheries management organisations/arrangements of which Australia is a member (Ward et al. 2013). In particular, for southern bluefin tuna in the Commission for the Conservation of Southern Bluefin Tuna and for Patagonian toothfish and mackerel icefish in the Southern Ocean that are managed according to decisions made by the Commission for the Conservation of Antarctic Marine Living Resources. However, as Ward et al. (2013) point out:

Other RFMOs [regional fisheries management organisations], such as the Indian Ocean Tuna Commission (IOTC) and the Western and Central Pacific Fisheries Commission (WCPFC) have yet to implement harvest strategies and TACs [total allowable catches] for their target species.

The policy could be improved by specifying when 'catch level decisions' made by international organisations should be adopted for determining domestic catch settings where such settings are based on adequate science. This could be supported by examples in the guidelines informing what an appropriate 'catch level decision' may involve and how it could be implemented, including details of the scientific process required to underpin the decision.

Giving examples in the policy or guidelines of which regional fisheries management organisations have an acceptable scientific process for determining catches, may represent a simple way of providing a 'snapshot' of which organisations meet these criteria. However this may be subject to

change, for example, if an organisation improves its management processes or if agreement is not reached in a body that currently has acceptable standards.

The guidelines could also provide advice on what factors and processes may be considered in setting a total allowable commercial catch lower than the recommended biological catch or international allocation, or in the absence of an international catch level decision, and provide examples as appropriate.

Setting catch levels without an appropriate international allocation

In the absence of an international catch level decision, the policy requires that ‘Australia’s domestic catch allocation decision would be consistent with the agreed whole of government position’. However, it provides no guidance on how to quantify a domestic catch level on the basis of the broad ‘whole of government’ position taken to international negotiations (particularly given, for example, that catch limits may not be actively discussed at some international commission meetings).

Regardless of whether an international catch allocation has been made, Commonwealth fisheries must be managed according to domestic legislation and policy. If no appropriate international catch level allocation is available, then legislative objectives such as the pursuit of ecologically sustainable development, maximising economic returns to the Australian community and efficient and cost-effective management should guide domestic management decisions.

The policy could be improved by explicitly clarifying that in the absence of an internationally agreed catch level based on acceptable science, Australia's domestic catch allocation decision must be consistent with Australia’s domestic legislation and policy requirements.

The harvest strategy policy integrates and interprets relevant legislative requirements in Commonwealth fisheries and is widely accepted as being a successful development (Borthwick 2012; McLoughlin & Rayns 2009; Smith et al. 2008; Ward et al. 2013). Vieira & Pascoe (2013) point out that for internationally-managed stocks ‘maximising economic returns from the Australian allocation is still achievable’ while Ward et al. (2013) describe some of the considerations that could be incorporated into a harvest strategy for the domestic component of an international stock. Furthermore, determining appropriate catch levels outside a harvest strategy framework would generally require dealing with many of the same uncertainties that would need to be addressed in a harvest strategy.

Given these considerations, the policy could benefit from a statement to clarify that **in the absence of an agreed national allocation, the use of a harvest strategy developed and tested under the policy would, in principle, be the most appropriate way to set total allowable catches for the component of an international fishery in Australian waters. However, there may be impediments to doing so in practice.**

The relevance of applying domestic harvest strategies to such stocks is heavily influenced by considerations such as the level of connectivity (mixing rate) between the components of the stock in domestic and international waters, the relative size of the stock within and beyond the Australian fishing zone and the proportion of the Australian catch relative to international catches from the stock. Ward et al. (2013) provide the following example:

... there is a broad, Pacific Ocean stock of albacore that is fished by the Commonwealth Eastern Tuna and Billfish Fishery (ETBF), but also by other countries in the wider WCPFC [Western and Central Pacific Fisheries Commission], who take a much greater proportion of the catch. Introduction of an ETBF harvest strategy for albacore therefore has little chance of achieving management objectives without cooperation of other countries. In contrast, scientific evidence indicates that swordfish and striped marlin have localised Australian stocks or sub-stocks [and Australia takes a significant proportion of the catch]. It is therefore prudent to implement harvest strategies for the sub-stocks that occur in Australian waters, to ensure that exploitation of these localised stocks meets harvest strategy policy objectives. The issue of connectivity has not yet been resolved for yellowfin and bigeye tuna in the ETBF and harvest strategies have not been implemented for these species, either by the WCPFC or Australia.

It has been argued that domestic harvest strategies are not appropriate where the Australian component of a shared international stock is relatively small and Australian catches represent only a small proportion of the total international fishing mortality (Ward et al. 2013). However, while mortality from Australian fishing may have little impact on the overall sustainability of the stock in such cases, consideration also needs to be given to the effects of fishing of that component of the stock in Australian waters.

Inappropriate domestic catch levels could potentially deplete the component of the stock in Australian waters depending on the level of connectivity between the domestic and international components of a stock (particularly the rate of replenishment from the broader stock). This could have negative impacts on other user groups with legitimate rights to access the community resource (for example, recreational fishers) and may also have ecological consequences, particularly for high trophic level predators such as tuna and billfish.

Importantly, it may also impede economic yield from the Commonwealth fishery, as the cost per unit of catch will rise if catch rates fall due to depletion of the domestic component of the shared stock. Considering the effects of catch level settings on the economics of a fishery is particularly relevant not only given the legislative and policy objectives to maximise economic returns, but in light of the significant government investment in 2006–07 in restructuring major Commonwealth fisheries to improve economic and biological outcomes.

Australia seeks to set an example as a responsible fishing nation. Clearly, where there is no appropriate national catch allocation, catch levels should be founded on the best available scientific (and economic) evidence. Where there is uncertainty (for example, about connectivity or other aspects of an assessment) then a conservative approach should generally prevail.

The Australian Government pursues our national interest in international forums including in relation to national catch allocation. However, domestic catch allocations should reflect both the reality of our fishing capability and the sustainability of the stock. The policy and guidelines are currently silent on these matters.

The guidelines could elaborate on the factors that could be considered in determining domestic catch levels, including whether to apply a harvest strategy framework. These may include the level of connectivity between the Australian and international components of the stock, the relative effect of Australian fishing on the broader stock, the likelihood of depleting the domestic component of the stock (irrespective of the effect on the ‘international’ component of the stock), economic

factors (depleting fish locally will increase fishing costs), the ecology of the stock (regional depletion is a poor biological outcome), the needs of other user groups (localised depletion will disadvantage other users), local population dynamics and broader government objectives.

The guidelines could also include advice, where appropriate, on how to maintain the component of stocks in Australian waters at target and above limit levels and how to pursue economic objectives in such instances.

However, each situation is likely to be characterised by a unique set of circumstances and it would be difficult, and may not be in the national interest, to prescribe management arrangements in the absence of an international catch level decision. As such, the policy and guidelines could retain an element of flexibility to address the variety of situations that may be faced and to ensure that Australia's negotiating position in international forums is not undermined.

Presently, the harvest strategy policy indicates that for fisheries issues that are not decided by an international management body or arrangement, the Department of Agriculture, Fisheries and Forestry and AFMA will consult on the management arrangements that will apply and AFMA will implement those arrangements. This approach provides appropriate scope for flexibility and was taken in the Eastern Tuna and Billfish Fishery to help determine appropriate catch levels for those target stocks that AFMA decided should not be subject to the harvest strategy (following uncertainty over stock connectivity). Explicit clarification in the policy that the range of 'fisheries issues' referred to in this passage of text includes catch level decisions may help avoid some of the confusion experienced in such situations in the past.

Stocks shared with domestic commercial fishers

Many stocks taken by Commonwealth fisheries are also commercially important in state fisheries. In many cases, particularly for stocks that are targeted in one jurisdiction and taken incidentally in another, agreements between the Commonwealth and other jurisdictions outline catch shares for commercial operators. However, for some Commonwealth target stocks, catches taken by non-Commonwealth commercial fisheries may not be set in agreement with the Commonwealth. Fishers in other jurisdictions may not always be regulated to a similar standard as the Commonwealth. Other jurisdictions may pursue different targets or objectives, catches may not be shared according to an agreed formula, may change over time or may simply be unknown (Ward et al. 2013).

There are a few stocks that are taken by commercial fishers in both the Commonwealth and other domestic jurisdictions, for which there is relatively high 'competition' between Commonwealth and state fisheries. Examples include eastern school whiting from the Southern and Eastern Scalefish and Shark Fishery and Australian sardine from the Small Pelagic Fishery, both of which are taken in considerable numbers in state fisheries.

The increased adoption of quota management in Commonwealth fisheries has increased incentives among the commercial sector for a resolution of catch sharing issues. A major reason for this is the economic imperative for commercial fishers to protect the value of quota statutory fishing rights. The reduction of total allowable catches (and hence quotas) to account for other sources of fishing mortality also increases the 'visibility' of the resource competition between the various sectors. Commonwealth fisheries operating under a quota based on a stock assessment risk having a quota allocation based on the residual after the state catch is removed from the total allowable catch.

While a stock may be taken in different jurisdictions, the harvest strategy policy only has influence over Commonwealth fisheries. The policy indicates that it ‘takes into account mortality resulting from all types of fishing’ including ‘state managed-catches’. The guidelines include a more explicit requirement to take all sources of fishing mortality into account when setting recommended biological catches (although they provide some flexibility for translating these into total allowable catches).

As the Commonwealth does not regulate state commercial (or recreational catches), increasing catches of shared stocks in state or territory fisheries can lead to total allowable catch levels in Commonwealth fisheries being unilaterally adjusted to maintain sustainability. This can result in a *de facto* allocation of resources from Commonwealth concession holders to the other jurisdiction, reducing the returns to Commonwealth fishers and potentially reducing the value of access rights. ‘Adding insult to injury’, it is often the Commonwealth that pays for and conducts the stock assessments (on a cost recovered basis).

While adjusting Commonwealth catch levels to accommodate state catches may lead to better immediate biological outcomes, it provides no incentive for other jurisdictions to appropriately manage their take of the stock. Similarly, requiring Commonwealth catches to be unilaterally reduced could undermine the Commonwealth position in any catch sharing negotiations.

In recognition of these various problems, the guidelines state:

Whilst fishing mortality from other sectors and jurisdictions is considered in setting RBCs [recommended biological catches] for Commonwealth fisheries, this does not necessarily mean that the TAC/TAE [total allowable catch/total allowable effort] determined for Commonwealth fisheries will be unilaterally reduced in the absence of appropriate stock based management action from other sectors and/or jurisdictions (HSP 2007, p. 45).

This provides flexibility to AFMA for managing shared stocks and may lead to more equitable outcomes for Commonwealth fishers. However, if combined state and Commonwealth catches exceed recommended biological catch levels for a prolonged period, this can undermine the sustainability of the fishery.

Other potential problems with the management of shared stocks can occur when different jurisdictions pursue different objectives or management targets, or where appropriate data from state fisheries doesn’t exist or is not available in timeframes required for assessment. In addition, potential inefficiencies in management could arise when the different jurisdictions with management responsibility for a stock run separate assessment and management models, leading to unnecessary duplication.

Catch levels for domestic shared stocks

Setting total allowable catch can be inherently problematic for stocks that are shared between jurisdictions.

Sustainability is central to government fisheries policy. Commonwealth fisheries legislation requires AFMA to pursue an objective of ecologically sustainable development. Accordingly, it is appropriate that **the policy and guidelines could continue to require that catches from other jurisdictions and sectors be incorporated into recommended biological catch settings.**

However, Commonwealth legislation also provides for the creation of statutory fishing rights. For those rights to be effective, their integrity must be maintained. Unilaterally dropping catch levels in Commonwealth fisheries to account for inappropriately constrained catches in other jurisdictions could undermine the Commonwealth access rights. Providing flexibility for setting catch levels in Commonwealth fisheries can create incentives for state management agencies to appropriately manage the catches of shared stocks. To this end, it is appropriate that **the guidelines should continue to recognise that total allowable catches need not be unilaterally reduced in the absence of appropriate stock based management action from other sectors and/or jurisdictions.**

AFMA has to make catch level decisions for such stocks, in an environment where the ‘right’ approach (assuming one exists) is rarely, if ever, clear. In practice, total allowable catches in Commonwealth fisheries have been reduced in response to increased catches by state fishers, including in situations where state catches have increased significantly. Ward et al. (2013) state:

... state catches are sometimes not actively managed, resulting in the possibility that escalating state catches can result in unpredictable reductions in Commonwealth TACs [total allowable catches].

and

For several species, state catches are deducted from RBCs [recommended biological catches] and the TAC [total allowable catch] available to Commonwealth fishers has been steadily reduced as state catches have increased in the absence of catch-sharing arrangements. With school whiting, for example, state catches exceed Commonwealth catches, leaving Commonwealth fishers with a small portion of the total, yet most of the costs of data collection and assessment of this stock are recovered from Commonwealth fishers.

Regardless of the guidance in the policy and guidelines, the problems associated with managing shared commercial stocks, including determining equitable catch shares and appropriate catch settings, is a broader fisheries management problem whose cause and ultimate solution both lie outside the policy’s scope. **While the policy can provide guidance on setting recommended biological catches in such situations, the difficulties of doing so will continue unless appropriate catch sharing arrangements are developed between jurisdictions.**

Offshore constitutional settlement arrangements and catch sharing

Issues of commercial catch sharing arise from the division of management responsibilities between the Commonwealth, states and the Northern Territory. This is given effect through offshore constitutional settlement arrangements. Depending on the particular arrangement, these may describe which jurisdiction has legal responsibility for managing a particular species, fishing method or area.

Offshore constitutional settlement arrangements were developed for practical reasons because ‘fish do not respect the jurisdictional lines that man might draw’ (Attorney General’s Department 1980). However, in many cases, management responsibility for a given stock is split across several jurisdictions.

Offshore constitutional settlement arrangements, as currently implemented, are complex and management under them is often inconsistent and inefficient. The Review of Commonwealth Fisheries: Legislation, Policy and Management (Borthwick 2012) noted:

The reality is that many fish stocks straddle boundaries: it is nonsensical to have separate and often incompatible management arrangements applying to the same fish stock across jurisdictions. The upshot of current OCS [offshore constitutional settlement] arrangements is that extra costs and uncertainties are imposed on fishers and environmental outcomes are jeopardised (as issues have not been addressed on a consistent or complementary basis) ... current Commonwealth/State fishery arrangements would have to be the most 'flaky' the Reviewer has come across in dealing with cross-jurisdictional issues.

The implementation of this policy to shared domestic stocks could be significantly improved by a reform of offshore constitutional settlement arrangements, as recommended by Borthwick (2012). Ideally, this would divide management responsibility among the Commonwealth and states/Northern Territory in a way that maximises management efficiency and simplicity and reflects the distribution of stocks. However, unless and until this happens, **problems associated with shared stocks can only realistically be resolved through developing catch sharing arrangements between the Commonwealth and state/Northern Territory fisheries management agencies.**

Such catch sharing arrangements should seek agreement on a broad range of issues. These include management objectives and targets, defined catch shares, data standards and data sharing arrangements, stock assessments, and if possible, harvest strategies. Importantly, agreement should also be sought on equitable cost sharing arrangements. Catch sharing agreements should be sufficiently flexible to allow each jurisdiction to meet the agreed management objectives in the most appropriate manner. To this end, AFMA is engaged in negotiations with state agencies over a number of stocks (such as school whiting).

Stocks shared with non-commercial fishers

A related issue is that of how fisheries resources are shared between Commonwealth commercial fishers and non-commercial (recreational and Indigenous) fishers, who are managed by the states/Northern Territory. (The term 'recreational fisher' as used here includes charter fishing operators which, while having a commercial aspect to their operations, are treated equivalently under Commonwealth fisheries legislation).

Australia's oceanic fish stocks are a community-owned resource, managed by governments on behalf of the Australian people. Recreational and Indigenous fishing represent significant active uses of commonly owned fisheries resources by members of the Australian community. An estimated 15 to 20 per cent of Australians participate in recreational fishing (Dominion Consulting 2005; Henry & Lyle 2003), while Indigenous fishers in the top end of Australia were estimated to have made over 670 000 'fishing trips' during one year-long survey (Henry & Lyle 2003).

Non-commercial fishers take a broad range of species that are also taken by Commonwealth commercial fishers. However, as many Commonwealth fisheries managed under the harvest strategy policy are located more than three nautical miles from shore, the extent of stock sharing between Commonwealth and non-commercial fishers is likely to be significantly lower than for many inshore species. Despite this, non-commercial fishers take a broad range of species that are also taken by Commonwealth commercial fishers. There is an element of 'resource competition' for Commonwealth commercial fishers for a number of species, particularly with recreational fishers.

In essence, most of the issues of sharing resource access with non-commercial fishers; such as determining equitable catch shares, agreed management targets and data access and availability; are similar to those faced for other stock sharing situations. However, non-commercial fishing has the added complication that precise regulation and monitoring tends to be far more difficult. This is due to factors such as the high number of individual participants, the wide range of locations and the non-commercial nature and scale of operations.

Although fishing by all sectors should be managed in an ecologically sustainable way, fisheries management objectives for Indigenous and recreational fishing can differ from those applied to commercial fishing. Outcomes such as achieving high strike rates, maximising the availability of large 'trophy' fish, maintaining populations of fish at important locations or preserving culturally important species may be more important to non-commercial fishers than to commercial fishers. Management settings to achieve these outcomes would generally require a higher standing biomass than required for the maximum economic return targets specified in the policy (and even more so the maximum economic yield target more broadly applied to fisheries globally) (García-Asorey et al. 2011).

Data limitations

Regardless of the principles of how recreational catch should be factored into assessments and catch level settings for any given stock, reliable data on recreational catch is often unavailable or dated which can hamper management. Ward et al. (2013) state:

Recreational catches are significant for several Commonwealth species, such as jackass morwong. However, estimates of recreational catches are not always available from the states responsible for managing the recreational sector or they are considered to be unreliable, and so assessments and TAC [total allowable catch] calculations do not always include estimates of recreational catches, e.g. silver trevally. Several tuna fisheries involve significant recreational catches of species that are targeted by commercial fishers. The Eastern Tuna and Billfish Fishery, for example, sets total allowable commercial catches (TACCs), which reflect that AFMA does not have direct control over recreational catches.

As the Commonwealth does not regulate recreational fishing, AFMA must rely on state fisheries agencies for catch data from this sector. Most states do some type of survey of non-commercial catches, albeit using different methodologies and at varying frequencies. However, not all of these provide sufficiently precise data on stocks managed by the Commonwealth, or with the timing required by the Commonwealth. As the harvest strategy policy does not apply to state fisheries, any requirements in the policy about data quality and availability are somewhat impotent in relation to the quality and timeliness of catch data.

Regular surveys of non-commercial catches of stocks managed by the Commonwealth would be valuable. However, Commonwealth fisheries management operates on a cost recovery model and there is no mechanism to fund AFMA to estimate recreational catches, should such data not be available from the states. A regular national recreational fishing survey would be valuable but has not been conducted since 2000–01, and no source of funding has been identified for these surveys to be regularly conducted.

Solving the problem of obtaining data outside the remit of the commercial sector is beyond the scope of this policy but one that the government may wish to consider as part of broader fisheries

management considerations. In particular, options for funding surveys of recreational fishing could be explored with the recreational fishing sector and state and territory governments.

Resource ‘competition’

While many stocks are taken by both recreational and Commonwealth commercial fishers, the strength of ‘competition’ between the sectors varies between stocks. Competition is arguably greatest for species that are managed under quota, fully fished, popular with both commercial and non-commercial users, and where the relative catches by non-commercial users is large and increasing. The most notable of these stocks is southern bluefin tuna, a species whose domestic catch settings are not prescribed by the policy (although the policy indicates that ‘the Australian Government will negotiate with the relevant body with an aim of ensuring sustainable fisheries by advocating this policy as an example of best practice in setting sustainable catch levels’). Box 5 provides some additional information on the application of the policy to internationally managed stocks.

Some level of competition also exists for other stocks. These include other tuna, billfish and a number of stocks that occur inshore or on the continental shelf such as silver trevally, jackass morwong, gummy shark and ‘small pelagic’ species which are variously targeted or taken for bait by Commonwealth commercial fishers. Commercial fishing also impacts on bycatch stocks, some of which may be important to the recreational sector; bycatch management has been considered through the review of the Commonwealth Policy on Fisheries Bycatch.

Box 5 International stocks: tuna and billfish

For internationally managed species such as tunas and billfishes, the impact of the domestic commercial catch settings on non-commercial users may be limited in some instances.

In particular, the settings of the harvest strategy policy itself may have little direct impact, as management arrangements for internationally managed stocks such as tuna and billfish may not be set according to the policy. This is particularly the case where an international catch level decision is applied.

Regardless of the policy's application, the abundance of these 'highly migratory' species in Australian waters depends not only on domestic catch levels but on the rate of mixing between those parts of the stock within and beyond Australian waters as well as on variable oceanic conditions. If only a small part of the stock is found in Australian waters and connectivity between the domestic and international components is high, then Commonwealth catches are likely to have, at most, a transient effect on abundance (noting that transient impacts can be important to other user groups).

In addition, management procedures and targets for stocks of highly migratory species are subject to international agreement among a diverse range of fishing 'entities'. These include small island states with strong economic reliance on the resource, major fishing nations from the developed world (such as the USA, Europe and Japan), and major fishing entities from the developing world (such as China, Taiwan, Thailand and the Philippines), among others.

Each of these various entities may have different interests and motivations. As such, it is unlikely that maintaining stocks at high levels to maximise strike rates and the production of trophy fish will feature highly in international agreements on biomass targets and catch settings. For these stocks, arguments for higher biomass targets may be effectively moot.

The Review of Commonwealth Fisheries: Legislation, Policy and Management (Borthwick 2012) recognised the need to consider the range of issues in the resource trade-offs between commercial and recreational fishers in Commonwealth fisheries. It noted:

There are many issues that need to be weighed. On one hand, the desire of the public to have continued access to sustainably harvested Australian seafood from the commercial sector. On the other hand, recreational fishing is an embedded part of "Australian culture": its economic spin-offs are large and increasing ...

The Fisheries Management Act and Fisheries Administration Act are largely silent on the matter of recreational and Indigenous fishing. To this end, Borthwick (2012) considered that:

Other objectives, as appropriate, should be incorporated into the Acts, including for AFMA to appropriately address and consider issues pertinent to indigenous and recreational fisheries (and other users of the marine environment).

and

... the fisheries Acts should give explicit acknowledgement to the need for AFMA to give consideration to the interests of recreational anglers. They contribute a lot to the economic and social life of our country, all the more so in regional areas.

Management targets and other settings

The objectives of Commonwealth fisheries legislation, as they relate to competing community uses of fisheries resources, are a matter beyond the scope of the harvest strategy policy and were not considered in this review.

Changing the harvest strategy policy targets or other settings to benefit the non-commercial sector could impact on the viability of fishing and the security of commercial fishing access rights. However, legislative reform will take time and there is a need for a harvest strategy policy that is consistent with current fisheries legislation. **There appears to be little basis at this time on which to recommend wholesale changes to the harvest strategy policy targets or other settings, that would move benefits from the commercial sector to non-commercial fishers.**

It is nevertheless recognised that all significant sources of mortality must be taken into account in stock assessments and catch setting. However, a shift of focus towards outcomes for non-commercial fishers may occur through other processes, such as the reforms proposed by Borthwick (2012) or as a result of resource sharing agreements for particular stocks.

There may be some stocks for which it might be reasonable to deviate from harvest strategy policy default settings to support improved outcomes for non-commercial fishers (for example, if a stock is popular with recreational fishers that, while taken in Commonwealth fisheries, is not a key driver of economic returns). In order to accommodate such situations and the possibility of resource sharing arrangements being developed in the future, as well as changes following the fisheries management review (Borthwick 2012), **the policy should provide the flexibility to accommodate alternative (potentially higher) biomass targets than those that support maximum economic yield.**

Higher standing biomasses will generally favour non-commercial sector outcomes. Relevantly, the policy's target of maintaining stocks at levels that produce maximise economic yield, and the proxy of 48 per cent of unfished biomass, is already a more favourable target for non-commercial users than the maximum sustainable yield target most commonly adopted in international and domestic fisheries outside the Commonwealth.

Maximising economic returns to the community

During consultation for the review, it was suggested that further consideration could be given to how non-commercial fishing activity maximises net economic returns to the Australian community as per the legislative objective. From the material provided to the Australian Parliament when the Bill to amend this objective to its current form was introduced, it is clear that the phrase 'maximises net economic returns to the Australian community' was to be interpreted as being equivalent to 'maximises economic efficiency in the exploitation of fisheries resources' (*Fisheries Legislation Amendment (Cooperative Fisheries Arrangements and Other Matters) Act 2006* (Cth)). This objective may not be an appropriate basis for optimising non-commercial fishing outcomes.

Economic comparisons are unlikely to be a valid way to fully compare commercial and non-commercial sectors, and particularly on which to measure the legitimacy of a sector's right to access the resource.

For example, some aspects, such as the social and cultural benefits arising from the recreational and Indigenous fishing and the value of having a wide variety of fresh seafood available for sale, are largely intangible.

Indigenous fishing is often conducted at a relatively low cost and for cultural reasons (including subsistence, ceremony and social obligation) that can't easily be measured in economic terms.

Economic activity associated with recreational fishing is measured exclusively in terms of expenditure. In contrast, the economic benefits of commercial fishing are largely 'downstream' of the fishing activity, arising from the value of the extracted resource (such as employment in processing, transport, sales, food service, and the generation of export income). While expenditure by the commercial fishing sector may also be significant, commercial reality and government fisheries policy both provide strong incentives to improve economic efficiency of the commercial sector, which drives down overall expenditure relative to production.

Non-market valuation measures of recreational fishing are available (for example, Ward et al. 2013) but provide limited insight into the relative merits of the activity of commercial versus non-commercial sectors. Considering these matters is outside the scope of this review. The recent Review of Commonwealth Fisheries: Legislation, Policy and Management (Borthwick 2012) considered these matters in more detail.

Catch shares and catch settings

Commercial fishery concession holders hold legal rights to access and commercially benefit from the community's fisheries resources. This right has been provided to generate economic and other benefits to the Australian community.

Recreational and Indigenous fishing are also appropriate uses of the community's fisheries resources, and these user groups also have legitimate rights to ongoing access.

Importantly, commercial fishers have the same level of 'ownership' of the resource as other members of the community and their level of access is subject to community expectations as reflected in legislation and policy.

The policy and guidelines indicate that all sources of mortality, including from recreational fishing, are accounted for. The guidelines also provide some flexibility (and ambiguity) about how this is accounted for in catch level settings:

When setting TACs/TAEs [total allowable catches/total allowable effort levels] from RBCs [recommended biological catches], catches attributable to all types of fishing must be taken into account. This includes all fishing-induced mortality (for example, discards or state catches, and recreational catches).

Whilst fishing mortality from other sectors and jurisdictions is considered in setting RBCs for Commonwealth fisheries, this does not necessarily mean that the TAC/TAE determined for Commonwealth fisheries will be unilaterally reduced in the absence of appropriate stock based management action from other sectors and/or jurisdictions.

When setting catch levels in Commonwealth fisheries, AFMA must make decisions about whether and how to account for non-commercial catches. As for other shared stocks, this must be done in an

environment of ambiguity about what is the 'right' decision. Where competition for a stock between commercial and non-commercial users is strong, what constitutes the 'right' decision is likely to depend on one's perspective. The guidelines attempt to leave the Department of Agriculture, Fisheries and Forestry (internationally) and AFMA (domestically) with some capacity to negotiate with other jurisdictions without being bound to accept a default outcome. At the same time there is an overriding requirement to provide for the sustainable management of the stocks.

For stocks where there is a strong competition between sectors, resource sharing arrangements could be a valuable development, particularly if the relative catch shares of the different sectors change significantly. Such arrangements should be developed through a process that recognises the rights and responsibilities of all users and in consultation with the affected sectors. These arrangements may address issues that include catch shares, spatial or temporal management arrangements and biomass targets and limits, as well as issues such as each sectors' responsibilities in terms of data provision and sharing the costs of assessment and management. However, this is a higher order issue than the harvest strategy policy.

More generally, **it would be valuable if the guidelines provided direction on when and how to account for recreational catch when setting commercial catch levels.** Noting that both commercial and non-commercial users have an established claim to a share in the community's fisheries resources, a useful starting point for developing such guidance may be on the basis that total allowable catches are set with consideration of 'reasonable' non-commercial community uses. While this leaves open the question of what is 'reasonable', established catch histories, where these are available, may be an appropriate starting point.

Consideration could also be given to the costs, benefits and objectives of developing formal resource sharing arrangements. These are likely to be of most value for stocks with particularly high levels of resource competition between the sectors and where the relative proportion of each sector's catch is significantly changing. However, these are also likely to be the most difficult circumstances in which to develop such agreements and the difficulty becomes magnified where an international catch level decision is in place. Consideration should also be given to developing resource sharing agreements before the need for them becomes particularly intense.

Pending the development of more detailed guidance or of formal resource sharing arrangements, the harvest strategy policy could be improved by explicitly recognising that recreational and Indigenous fishers, as well as non-extractive users, are legitimate user groups whose interests should be considered in the management of the commercial sector.

Providing increased opportunities for public comment (including by non-commercial users) during the development of harvest strategies may go some way to helping in this regard.

Conclusions

It is difficult, and possibly undesirable for the policy to prescribe directions for setting catch levels for shared stocks. Each situation is likely to be characterised by a unique set of circumstances.

While the policy and guidelines can provide direction, the greatest difficulties of managing shared stocks arise from a lack of agreement between the different jurisdictions or user groups on how to manage and share the stocks. These problems cannot be solved by the harvest strategy policy.

There is confusion among some stakeholders about how the policy should be applied to fisheries that access internationally managed stocks. The policy could provide improved guidance about how domestic catch levels should be set where there is no appropriate international catch allocation.

Inter-jurisdictional catch setting problems could be comprehensively addressed through reform of offshore constitutional settlement arrangements (as recommended by Borthwick (2012)). Unless and until this happens, issues with setting total allowable catches for stocks shared with other domestic jurisdictions are only likely to be significantly overcome where clear and appropriate catch sharing arrangements are developed that appropriately constrain catches in all jurisdictions.

It would be valuable if the guidelines provided information on when and how to account for non-commercial users when setting commercial catch levels.

In setting catch limits where there is significant shared use with the non-commercial sector, lack of data on non-commercial catches can impede the policy's application and should be addressed.

Reliable and current data on recreational catch is important for managing a growing number of fisheries but its collection cannot be charged to the commercial sector. Options for funding surveys of recreational fishing could be explored with the recreational fishing sector and state and territory governments.

9 Reference points

Harvest strategies stipulate the management actions designed to achieve defined objectives in a given fishery. They identify indicators of fishery or stock status which are monitored and assessed. Harvest strategies also specify pre-defined decision rules ('control rules') that trigger specific management actions.

A 'reference point' is a specific, pre-determined level of an indicator of stock status or economic condition (such as a target biomass level) against which the current level of that indicator can be compared. Two types of reference points are specified in the policy: 'target reference points' and 'limit reference points'. This reflects the United Nations Fish Stocks Implementation Agreement (UNFSA 1995) Annex II: Guidelines for the Application of Precautionary Reference Points, which notes that:

Limit reference points set boundaries which are intended to constrain harvesting within safe biological limits within which the stocks can produce maximum sustainable yield. Target reference points are intended to meet management objectives.

Target reference points express the desired biological and/or economic status of a stocks or fishery, whereas limit reference points express undesirable situations which should be avoided. In this way, reference points are a key link between harvest strategies and fisheries management objectives.

Harvest strategy control rules respond to chosen performance measures and are designed to ensure that stocks are maintained above limits and managed at or towards targets.

The policy and guidelines describe reference points in terms of both biomass and fishing mortality (although for simplicity, this report will focus principally on biomass reference points).

Policy settings

The term 'maximum sustainable yield' refers to the theoretical maximum annual catch that can be removed from a stock over an indefinite period, under prevailing environmental conditions.

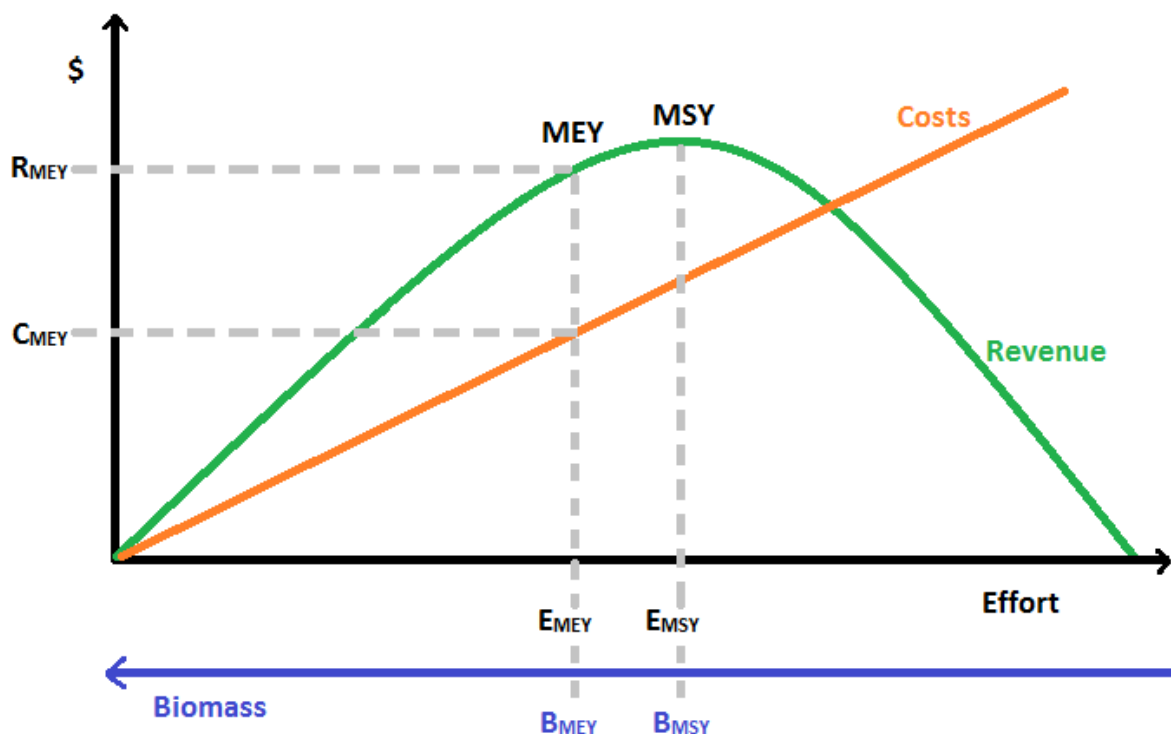
Maximum sustainable yield targets are widely applied to fisheries worldwide and are prescribed in the United Nations Convention on the Law of the Sea.

Maximum economic yield, on the other hand, is achieved when the sustainable catch or effort level for a commercial fisher allows net economic returns to be maximised. This occurs at the effort or catch level that creates the largest difference between the total revenue from fishing and total fishing costs. The Commonwealth is unique in pursuing a maximum economic yield as the default target across its fisheries

These concepts are demonstrated in Box 6 .

Box 6 Demonstrating maximum economic yield and maximum sustainable yield using a simple static, single period, single species model (from Vieira & Pascoe 2013).

The revenue curve below shows the relationship between stock biomass, effort and revenue for a fishery. As effort increases, the level of sustainable revenue that is earned increases up until a point where lower stock levels start to constrain catches and, therefore, revenue. This turning point occurs at the maximum sustainable yield. Maximum economic yield occurs at the level of effort and biomass where net economic returns — the difference between total revenue and total cost — are maximised.



MEY – maximum economic yield
 MSY – maximum sustainable yield
 R_{MEY} – revenue at the point of maximum economic yield
 C_{MEY} – cost at point of maximum economic yield
 E_{MEY} – effort level that produces maximum economic yield
 E_{MSY} – effort level that produces maximum sustainable yield
 B_{MEY} – biomass that produces maximum economic yield
 B_{MSY} – biomass the produces maximum sustainable yield

The harvest strategy policy requires that harvest strategies seek to:

- maintain fish stocks, on average, at a target biomass reference point (B_{TARG}) equal to the stock size required to produce maximum economic yield (B_{MEY})
- ensure fish stocks will remain above a limit biomass level where the risk to the stock is regarded as too high, that is B_{LIM} [the biomass limit reference point, below which stocks are considered overfished] (or proxy)

- ensure that the stock stays above the limit biomass level at least 90% of the time (HSP 2007, p. 4).

(Note: the policy indicates that the biomass proxies relate to adult or spawning biomass, although for simplicity, the policy and guidelines, as well as this report, generally refer simply to biomass).

McIlgorm (2013) suggests that the harvest strategy policy's maximum economic yield target reference point and proxy exceed international best practice for targets. He also found that the policy's limit reference point and proxy were consistent with international best practice.

In relation to fishing mortality reference points, Sainsbury (2008) explains that maximum sustainable yield is more appropriate as a mortality limit reference point than as a target reference point, if overfishing and stock declines are to be prevented. This is consistent with the guidelines, which indicate that the policy requires a fishing mortality limit reference point less than or equal to the mortality level that achieves maximum sustainable yield (or proxy). However, this is not immediately clear from the strategy described in the policy. **It would be beneficial if the description of the required biomass reference points in the policy was supplemented with an equivalent description of fishing mortality reference point settings.**

Maximum economic yield versus maximum sustainable yield

There is increasing evidence that biomass targets should be set above the levels that support equilibrium estimates of maximum sustainable yield for various reasons. Higher targets provide an additional buffer for unexpected changes to stock or environmental conditions and more closely reflect 'natural' population levels. Sainsbury (2008) noted:

In the ten world fishery management successes identified by Hilborn et al. (2003), all had biomasses that were held near or above B_{MSY} [the biomass that supports maximum sustainable yield], and all were intentionally taking yields that were lower than the maximum that appeared to be available. The biomass and fishing mortality in these successful fisheries are being managed to have a high chance of maintaining the fishery on the high-biomass, low-fishing mortality side of MSY [maximum sustainable yield].

For a given stock, the biomass level that supports maximum *economic* yield will usually be greater than that which supports maximum *sustainable* yield (the target specified in international marine law and most commonly applied to commercial fisheries not managed by the Australian Commonwealth). Therefore, while it is primarily an economic target, the maximum economic yield target is also more conservative from a biological perspective, achieving the outcomes of maintaining stocks about maximum sustainable yield.

Biomass targets above maximum sustainable yield; such as maximum economic yield targets; would generally also be expected to be more favourable for other extractive and non-extractive users, whose objectives usually favour a higher standing biomass, larger fish and higher catch rates.

The policy's maximum economic yield target also reflects the Fisheries Management Act objective which requires the pursuit of maximum economic returns to the Australian community. Vieira & Pascoe (2013) provide a discussion of how maximum economic yield is consistent with maximising net economic returns and its appropriateness as an objective in the policy.

Noting that the use of a maximum economic yield target as a default target is unique to Commonwealth fisheries, the considerations above suggest that **maximum economic yield should be retained as a target in any possible updated policy.**

Proxies

The policy recognises that the information required to estimate stock specific target and limit biomass levels may not be available, and allows for proxy reference points to be used (that is, default values of reference points that are believed to approximate target and limit levels for most stocks).

Where the biomass that supports maximum sustainable yield is not known, the guidelines suggest a default proxy of 40 per cent of the unfished biomass.

In relation to maximum economic yield, the policy states:

In cases where B_{MEY} [the biomass that supports maximum economic yield] is unknown, a proxy of $1.2B_{MSY}$ [a biomass level 20 per cent higher than the level that supports maximum sustainable yield] (or a level 20% higher than a given proxy for B_{MSY}) is to be used for a single species fishery and in the case of a multi-species fishery judgement needs to be exercised (HSP 2007, p. 4).

Although not explicitly stated in the policy or guidelines, this suggests; and has been widely interpreted to mean; that the policy provides a maximum economic yield biomass proxy of 48 per cent (1.2×40 per cent) of unfished biomass levels.

Alternative target proxies can be used if they are demonstrated to be more appropriate than the defaults specified in the policy.

The policy and guidelines indicate the proxy biomass limit reference point should be set at a level equal to or greater than half of that which supports maximum sustainable yield. Subsequently, a suitable default proxy biomass limit reference point is 20 per cent of the unfished biomass (HSP 2007, p. 23).

The maximum sustainable yield proxy

While the policy specifies a maximum *economic* yield target, it also provides a proxy value for maximum *sustainable* yield (and expresses the maximum economic yield proxy as a function of maximum sustainable yield). The maximum sustainable yield biomass proxy specified in the policy is a biomass 40 per cent of that of an unfished population.

Research has shown for a variety of stocks, that estimates of maximum sustainable yield can be less or greater than 40 percent of the unfished biomass, depending on productivity (Haddon et al. 2013). Penney et al. (2013b) note that:

Actual MSY [maximum sustainable yield] estimates for a range of teleost species groups range from $0.26B_0$ to $0.46B_0$ [26 per cent to 46 per cent of unfished biomass] (Thorston 2012). For chondrichthyans, Brooks et al. (2010) obtained similar values of $0.21B_0$ to $0.47B_0$, with most sharks lying towards the upper end of that range.

However, Punt et al. (in press) conclude that a maximum sustainable yield biomass proxy in the range 35–40 per cent of the unfished biomass minimises the potential loss of total catch compared

to the level of catch if the biomass that supports maximum sustainable yield was known exactly. Clark (1993) also found that 40 percent of unfished biomass was suitable for a range of groundfish species. Given the well understood difficulty of reliably estimating maximum sustainable yield (Haddon et al. 2013) and the risks of running relatively high fishing mortality rates at low stock sizes, the policy's proxy value of 40 per cent of the unfished biomass is an appropriate conservative compromise for most commercially fished teleost species. However, for some shark species a maximum sustainable yield proxy closer to 50 per cent of unfished biomass levels may be more appropriate (Penney et al. 2013b). **The current maximum sustainable yield proxy should be retained in the policy as this is still believed to be a good compromise between lower and higher values likely to apply to different species, however the policy should recognise that higher or lower values would more suitable for some species.**

For low information stocks, a precautionary approach is required, including conservative estimates of maximum sustainable yield. Conversely, in situations where there is sufficient information available to inform reliable estimates of maximum sustainable yield, then biomass values lower than the proxy may be appropriate in some cases.

The policy should continue to provide enough flexibility in its settings to allow for alternative maximum sustainable yield proxies. **It would be beneficial if the guidelines provided more advice on selecting appropriate maximum sustainable yield proxies, for example, for species with particularly low or high productivity, low data/high uncertainty cases and for those with highly variable productivity** where reference points based on equilibrium unfished biomass indicators may not be well suited. **Additional guidance could also be valuable on when it may be more appropriate to estimate maximum sustainable yield rather than applying a proxy, and the level of certainty appropriate to the application of such estimates.**

Maximum economic yield reference points and proxies

The information requirements and costs associated with calculating maximum economic yield through bioeconomic models are often prohibitive. Alternative approaches that are consistent with targeting maximum economic yield are available and could be investigated and provided for. The use of proxies can be viewed as one such low cost alternative approach. Some stakeholders have raised concerns about the policy specifying a maximum economic yield target given that it is costly and difficult to estimate. **The policy may benefit from a statement explicitly recognising that in most cases, target reference points will be set using proxy estimates of maximum sustainable yield.**

Vieira & Pascoe (2013), Haddon et al. (2013) and Penney et al. (2013b), discuss these matters in greater detail. Chapter 10 of this report also discusses issues associated with calculating maximum economic yield in multi-species fisheries.

The policy's recommended biomass proxy reference point should reflect the biomass level that will achieve maximum economic yield across the entire fishery. However, not only does the maximum sustainable yield biomass level vary considerably across stocks, but so does the appropriate biomass level to support maximum economic yield. The latter varies with factors such as the fishery's cost structure and revenue as well as the stock's biological productivity.

Vieira & Pascoe (2013) note that the policy's proxy of 1.2 times the biomass that supports maximum sustainable yield (taken to equate to 48 per cent of unfished biomass), may be too low based on the

findings presented in Zhou et al. (2013). Zhou et al. (2013) found that recommended maximum economic yield biomass proxy values around 1.3–1.4 times the biomass levels that support maximum sustainable yield may be more appropriate for most fishery types. Similarly, Punt et al. (in press) note that:

... as a result of the fact that cost information for these fisheries [those considered by Punt et al. (in press)] is ... particularly uncertain, the corresponding proxy for B_{MEY} [the biomass level that supports maximum economic yield] to minimise the ... potential loss in profit lies in the range 50% to 60% of carrying capacity.

These findings imply that, for many stocks, the policy's proxy target may be too low to optimise profits, at least on a 'single species' basis (noting that most fisheries take a number of commercially important species at the same time).

In addition, while limit reference points are typically set to constrain risks and target reference points are set to achieve management outcomes such as maximising yield or profit, for forage fish species (such as shoaling small pelagic species), targets of around 75 per cent of the unfished biomass have been identified as appropriate to ensure ecosystem function with greater certainty (Pikitch et al. 2012; Smith et al. 2011).

The policy indicates that alternative proxy values may be used if it can be demonstrated that they are consistent with policy objectives. The guidelines state:

In cases where it can be demonstrated that B_{MEY} [the biomass that supports maximum economic yield] is less than $1.2B_{MSY}$ [20 per cent more than the biomass that supports maximum sustainable yield], then such a target could be used' (HSP 2007, p. 30).

The review of harvest strategy policy implementation by Ward et al. (2013) notes that the widespread reliance on proxies for targets and limits for most stocks emphasises the importance of ensuring that the proxies provided in the policy appropriately reflect the different biology and productivity of various species groups. Similarly, in addition to such biological factors, economic proxies should also more appropriately reflect the relative profitability of a stock (that is, in terms of its price and cost structure).

One technique that has been developed to incorporate available or relatively accessible economic data to improve proxy estimates for maximum economic yield referred to by Vieira & Pascoe (2013) is work by Zhou et al. (2012). These authors developed a 'decision tree' based on the cost share of revenue (the cost per unit catch divided by the price) in single species fisheries to determine 'rule of thumb' targets for maximum economic yield.

More informed selection of targets may also be achieved using management strategy evaluation. As noted by Vieira & Pascoe (2013):

More recently, management strategy evaluation (MSE) approaches have also been used to inform management strategies against a MEY [maximum economic yield] objective. The MSE approach is a framework that models a fishery's various characteristics (biological, management, monitoring, economic) taking into account various sources of uncertainty ...

MSEs provide the opportunity to assess performance against economic management objectives together with other relevant management objectives.

The harvest strategy policy would benefit from being more explicit about ensuring that targets and limits are appropriate for different stocks and fisheries. It would be beneficial if the guidelines provided more advice on how this could be determined.

It is possible that the use of policy's default proxy target and limit reference points in existing harvest strategies may not be optimal for a number of stocks. As improved estimates for maximum economic yield become available, harvest strategies for some stocks may need to be revised to reflect these. The need, or otherwise, to update harvest strategies to reflect improved reference point estimates should be considered during regular revisions of each fishery's harvest strategy, in light of the likely costs and benefits of doing so.

Further work may be valuable in a range of areas, including:

- **practical guidance on the circumstances under which a maximum economic yield target should be estimated (rather than using its proxy), how it could be estimated for different fishery types and key principles of its successful implementation**
- **further guidance on how economic returns can be maximised for data-poor stocks and the appropriate level of research investment for such stocks**
- **improved guidance on how to apply maximum economic yield to fisheries targeting variable stocks and those with market power (that is, those from which the volume of supply has a substantial negative correlation to prices received for catch).**

Limit reference points

The United Nations Fish Stocks Agreement indicates that limit reference points represent the level beyond which the reproductive capacity of stocks becomes impaired. The policy reflects this, indicating that the biomass limit reference point should correspond closely to the spawning biomass level below which future recruitment levels may be jeopardised; that is, where recruitment overfishing may occur (HSP 2007, p. 55). However, in some cases, limit reference points should be set above the minimum level, in relation to other factors. For example, there is a growing body of evidence that limits for 'keystone' species that provide important forage fish resources to predators should be set at high levels in order to avoid risks to the trophic functioning of ecosystems (Pikitch et al. 2012; Smith et al. 2011).

The harvest strategy policy proxy for the biomass limit reference point is half the biomass that supports maximum sustainable yield (or 20 per cent of the unfished biomass for a target proxy of 40 per cent of unfished biomass). Haddon et al. (2013) present research that suggests that, as a 'rule of thumb', the risks of recruitment overfishing increase at biomass levels lower than half of those which support maximum sustainable yield. Haddon et al. (2013) conclude that a biomass level of 20 per cent of unfished biomass is an acceptable proxy for that figure.

For highly productive species, the biomass that supports maximum sustainable yield may be less than 40 per cent of unfished biomass levels, in which case limit reference points could potentially be set lower than 20 per cent of the unfished biomass using the above guidelines. However, estimates of maximum sustainable yield are inherently uncertain, rebuilding overfished stocks has proven difficult (both in Australia and elsewhere) and possible ecosystem effects of low stock levels are often poorly understood. Haddon et al. (2013) therefore note:

... the precautionary approach would firstly require good evidence that $0.5B_{MSY}$ [the biomass level equivalent to half of that which supports maximum sustainable yield] is indeed below $B_{20\%}$ [20 per cent of unfished levels]. In the face of these various doubts and uncertainties it would be difficult to argue that there would be no increase in the risk of depletion affecting consequent recruitment levels if the limit biomass reference point was permitted to vary below the current $B_{20\%}$.

Accordingly, it is probably appropriate to retain 20 per cent of the unfished biomass as the lowest proxy value for the biomass limit reference point, even in cases where a half the biomass level that supports maximum sustainable yield is less than 20 per cent of the unfished biomass, except where there is a strong scientific basis to do otherwise.

Haddon et al. (2013) also note:

For small pelagic fisheries, because of ecosystem based fishery management considerations, the limit reference point would tend to be either the same as or very close to the target (which has similarities to having a constant escapement strategy).

The harvest strategy policy requires that there be less than 10 percent probability that stocks decline below the limit reference point. However, in many instances, such as in the case of data-poor stocks, it is not possible to establish stock status in relation to a limit reference point with the level of certainty required to ensure that there is a less than 10 per cent chance of being below the limit.

Recognising this type of uncertainty, in 1997 the International Council for the Exploration of the Sea (a network of more than 4 000 scientists from almost 300 institutes) proposed the use of 'precautionary approach' reference points, set at a level above conventional biomass limit reference point levels to take into account the uncertainty in the estimation of the fishing mortality level. Where there is a high level of uncertainty around determining stock status in relation to a 20 per cent of the unfished biomass limit, or concerns that this may not be an appropriate proxy for low productivity species, the use of conservative reference points can provide an explicit way to apply appropriate caution. Penney et al. (2013b) discuss this matter further.

Improved guidance could be provided on alternative strategies for scenarios of high uncertainty and for highly variable species where reference points based on unfished biomass indicators may not be appropriate.

Other considerations

Multi-year total allowable catches

Multi-year total allowable catches offer a number of potential benefits. They can reduce the need to conduct annual assessments, resulting in cost savings and allowing available time and resources to be dedicated to assessments of other stocks on a 'rotational' basis. They can also provide greater certainty and stability for the industry.

However, there are risks associated with the uncertainty arising from less frequent assessments and these should be compensated for. For example, it may be appropriate to reduce the risks associated with this uncertainty by applying a discount factor (that is, reducing multi-year catch levels by a defined amount to account for the uncertainty resulting from less frequent assessments).

Haddon et al. (2013) noted that risks can sometimes be offset by the adoption of break-out rules under which a reassessment is triggered if an indicator of stock status goes outside the stipulated range. However, Penney et al. (2013b) noted that the effectiveness of these breakout rules in triggering a response that constrains risk has not yet been tested through a management strategy evaluation, and rules are currently set on an arbitrary and case-by-case basis. A Fisheries Research and Development Corporation project is currently exploring the risk cost catch trade-off of using multi-year total allowable catches and will evaluate the different options for setting these and provide insights on whether multi-year total allowable catches should always be reduced below single year total allowable catches to reduce the risk of overfishing.

Where multi-year total allowable catches are used, they should be explicitly built in to harvest strategy settings. Multi-year total allowable catches should be set on the basis of stock assessment projections, management strategy evaluation testing or should be demonstrably precautionary. To account for potential delays in assessments, multi-year total allowable catches would benefit from being projected for longer than the expected period between assessments, and include pre-determined exceptional-circumstance rules

The guidelines could recognise the benefits of multi-year total allowable catches and include direction on their use.

Target ranges and dynamic targets

The harvest strategy policy describes biomass reference points in terms of single values expressed as some proportion of the estimated unfished biomass. Proxies are also used and can be a proportion of the estimated unfished biomass or some proportion of an average fishing mortality over a chosen period during which the stock was considered to have been lightly fished and stable.

Penney et al. (2013b) note that, as a result of combination of natural stock fluctuations and uncertainty in estimating target reference points, stock status naturally fluctuates around reference points. This can result in determinations that stocks are above or below targets, when they are actually within the target uncertainty or natural stock variability ranges. It can be inappropriate and disruptive to fishery stability to translate these fluctuations into repeated total allowable catch decreases and increases.

There are various ways of dealing with uncertainty around equilibrium estimates of targets, or with natural variability in these targets in management strategies. Ward et al. (2013) describe how meta-rules have been applied to constrain small changes to total allowable catch levels. Haddon et al. (2013) describe how control rules can be set to provide a 'buffer' region over which changes in stock status do not result in recommended changes in allowable catches until the stock indicator reaches a pre-determined level. Alternatively, targets can be set as ranges, explicitly incorporating uncertainty or natural fluctuations, or dynamic targets (expressed as a percentage of estimated biomass under current conditions, in the absence of fishing) could be used.

Stock productivity may also change either cyclically or following long-term trends. In such cases, dynamic target and limit reference points can be more appropriate. Penney et al. (2013b) discuss these matters in greater detail.

There may be benefit in including information on target ranges and dynamic targets in the guidelines.

Further work could be undertaken to determine the conditions and criteria for applying dynamic targets and non-equilibrium estimates of unfished biomass for those variable stocks that show cycles or trends in recruitment and productivity, such as in response to environmental cycles, climate change or regime shift.

Limit ranges

During the review, some stakeholders suggested that limit reference points could take the form of a range rather than a single value. Penney et al. (2013b) note that the required probability (less than 10 percent) of not breaching limit reference points already constitutes a range. Accordingly, in contrast to target reference points where a target range may be useful, limit reference points should preferably remain as single specified values.

Conclusions

The target and limit reference points, and their proxies, currently described in the policy and guidelines appear to be generally appropriate and should be largely retained in any possible policy update. However, consideration should be given to:

- specifying a minimum biomass limit reference point value of 20 per cent of unfished biomass, unless there is strong scientific support for lower values
- whether the policy's current maximum economic yield proxy; 1.2 times the size of the biomass that supports maximum sustainable yield or 48 per cent of unfished levels; is optimal for maximising economic returns in most situations
- incorporating a description of appropriate fishing mortality reference points into the policy.

The policy could benefit from being more explicit about ensuring that targets and limits are appropriate for different stocks and fisheries, including stocks with different productivity levels and those that perform an important ecosystem function. It would be beneficial if the guidelines provided more advice on how this could be implemented.

10 Optimising economic yield in multi-species fisheries

The harvest strategy policy's objective seeks to maintain key commercial stocks at sustainable levels and, within that context, maximise the economic returns to the Australian community. The strategy for achieving this is described in the policy as follows:

To pursue the objective, harvest strategies for key commercial stocks taken in Australia's Commonwealth fisheries will be designed to pursue maximum economic yield from the fishery and ensure those stocks remain above levels at which the risk to the stock is unacceptably high (HSP 2007, p. 4).

The intent of this statement is provided later in the policy:

Where a harvest strategy applies to a multi-species fishery it may be appropriate for some species to be maintained below B_{MSY} [the biomass that supports maximum sustainable yield], but always above B_{LIM} [the biomass limit reference point, beyond which the government considers the risk to the stock as the basis of a commercial fishery to be too high], to ensure that the fishery maximises net economic returns (HSP 2007, p. 6).

This implies that some species will be utilised at relatively low levels, while other species will be fished at levels where the stock will be at higher risk of becoming overfished. The guidelines state that:

MEY [maximum economic yield] applies to the fishery as a whole and is optimised across all species in the fishery. As a result, some secondary species (e.g. lower value species) may be being fished at levels that will result in their biomass remaining below their target biomass reference point (i.e. B_{MEY} [the biomass that supports maximum economic yield]). In such circumstances, the estimated biomass of these secondary species **must** be maintained above their limit reference point, B_{LIM} (HSP 2007, p. 25).

Individual fish stocks within a multi-species fishery are likely to differ in their biological and economic characteristics. The biomass level that supports maximum economic yield is likely to vary from species to species and be achieved at different fishing levels.

As a result, the effort level to achieve the biomass that supports maximum economic yield for a fishery's main commercial stock might see other stocks being fished at higher or lower levels than would be required to maximise economic yield if they were fished individually.

Targeting maximum economic yield at a fishery level involves optimising biomass targets for individual stocks so that they are consistent with achieving the maximum economic return across the suite of species taken in the fishery. For some secondary species, targets closer to the biomass corresponding to maximum sustainable yield may be appropriate to ensure that their total allowable catches do not unnecessarily impede maximum economic yield at the fishery level.

The concept of managing economic returns for multi-species fisheries as a whole is well recognised (Anderson 1975; Clark 1976; Silvert & Smith 1977) although practical applications of this approach have been limited. For example, in Australia, multi-species bioeconomic models have been developed and used to provide management advice and estimates of fishery-level maximum economic yield for only a small number of fisheries (for example, Kompas & Che 2006; Kompas et al. 2009; Punt et al. 2002; Punt et al. 2011).

The management of multi-species fisheries is complicated by technological interactions where fishing effort directed towards one quota species will normally result in a mixed catch of fish that may include other quota species.

Haddon et al. (2013) note:

Fishers can usually 'target' to some degree through fishing different areas and depths, seasons, times of day and by modifying gear. But it is the degree to which fishers can target that is the issue.

Estimating biomass targets to support maximum economic yield in multi-species fisheries is further complicated where the same stocks are taken by different fishing methods (for example, trawl and auto-longline), which have different cost structures and take individual species at different rates.

Most Commonwealth fisheries are multi-species fisheries, targeting a suite of species of varying commercial importance, including byproduct species that are sometimes retained and sometimes released or discarded (Ward et al. 2013). In practice however, AFMA rarely, if ever, sets total allowable catch levels for individual species below the biomass that supports maximum economic yield or an associated proxy in multi-species fisheries.

In cases where fishery-wide maximum economic yield results in biomass levels for lower value species that are below the biomass that supports maximum sustainable yield, guidance is needed on best practice risk management.

Estimating maximum economic yield

The policy recognises that 'economic returns will only be maximised if a management regime is in place that allows for fishing costs to be minimised and fishing revenue to be maximised' (HSP 2007, p. 3). The guidelines clarify:

... two conditions must be met simultaneously to achieve economic efficiency in a fishery:

- MEY [maximum economic yield] catch level is set. This will account for the impact of current catches on future fish stocks, catches and fishing costs.
- A management regime is in place that allows fishers to apply the appropriate level of inputs in a fishery. This will help ensure that fishing costs are minimised and fishing revenue maximised for the given MEY catch level (HSP 2007, p.27).

Determining the biomass associated with maximum economic yield for a given stock is a data-intensive and modelling-intensive task. This is even more true for multi-species fisheries, with Vieira & Pascoe (2013) pointing out that deriving general analytical models to identify conditions for maximum economic yield in multi-species fisheries has often been considered as a formidable, if not impossible task. Most attempts to estimate maximum economic yield in multi-species fisheries have been empirically based, using bioeconomic models to estimate maximum economic yield across the set of species in the catch.

The ability to target certain species (or lack of it), and the generally highly complicated relationships between species in a mixed species catch, make it difficult to achieve single species based maximum economic yield reference points at an individual level in a multi-species fishery.

At present, maximum economic yield has only been explicitly calculated for key commercial species in the Northern Prawn Fishery and the Great Australian Bight Trawl Sector. Bioeconomic modelling was also used to estimate appropriate biomass targets for a number of species in the Southern and Eastern Scalefish and Shark Fishery. However, these estimates were done independently of the formal stock assessment process and not applied to the fishery.

The large number of species and the number of different gears that catch these species in differing combinations has impeded the application of bioeconomic modelling (Vieira & Pascoe 2013). Limitations in available economic data and difficulties in collecting adequate economic data to support bioeconomic modelling have also been identified as obstacles in determining maximum economic yield for many fisheries (Dichmont et al. 2010). For example, in the Southern and Eastern Scalefish and Shark Fishery, only a relatively small proportion of the key species have appropriate biological parameters available for bioeconomic analysis.

Vieira & Pascoe (2013) found that one of the key challenges to implementing maximum economic yield was the need for accurate economic data and the subsequent incorporation of that data in bioeconomic models.

The cost of determining appropriate biological parameters for all commercial species in the fishery is likely to be prohibitive. However, there is a legislative objective to maximise economic returns, and, as Vieira & Pascoe (2013) point out, abandoning the use of maximum economic yield as a target reference point would not resolve issues. Applying biological reference points such as maximum sustainable yield across a fishery as a whole results in similar problems.

Penney et al. (2013), citing Zhou et al. (2013), notes that the optimal maximum economic yield to maximum sustainable yield biomass level ratios in multi-species fisheries ...

... range from 0.5 for species with slow growth, high catchability and contributing a small share of total revenue to 1.7 for species with higher revenue shares, moderate growth rates and low catchability.

Vieira & Pascoe (2013) note that current research is looking at 'rule of thumb' based approaches to developing maximum economic yield proxy target reference points for individual stocks in multi-species fisheries, particularly for secondary species, when information to enable more appropriate bioeconomic models is unavailable. The general results from this project are likely to be available in mid-2013.

Other options for multi-species fisheries include using aggregated yield functions. This approach identifies target effort levels (rather than individual species biomass targets) for the fishery as a whole using only catch and effort data. Such estimates of effort at fishery level maximum economic yield have been shown to be less sensitive to assumptions about the function than catch based target reference points (Chae & Pascoe 2005). Other indicators that provide information about the potential excess level of capacity in multi-species fisheries can also be used (Pascoe 2007). These do not necessarily equate to either biological or economic reference points but contribute to an estimation of fishery level performance (rather than individual species reference points) and use approaches such as data envelopment analysis to evaluate how efficiently fleet capacity is being utilised to produce the fishery's total catch.

The policy should continue to provide scope for using bioeconomic models and for the inclusion of alternative approaches that can provide economic indicators and reference points that support maximum economic yield in multi-species fisheries. The guidelines should provide information on the approach to setting targets for individual species in multi-species fisheries. As alternative approaches are developed, the guidelines could be updated to include examples to guide fisheries management.

There is also a need to ensure that the policy and guidelines use consistent terminology throughout. Currently, both the policy and guidelines provide for some species to be fished below the biomass that supports maximum sustainable yield in order to optimise maximum economic yield across the fishery (HSP 2007, pp. 5, 31). However, on page 25 the guidelines also refer to fishing secondary species at biomass levels below the target reference point (for example, the biomass that sustains the maximum economic yield). Although it may be appropriate for the guidelines to maintain more consistent terminology with the policy, this difference does not limit the management of species at levels below the biomass that supports maximum sustainable yield if appropriate.

Data-poor stocks

The policy requires that all key commercial and secondary species in multi-species fisheries are maintained above the limit reference point. However, many byproduct species do not have defined limits.

The policy and guidelines provide direction on managing data-poor stocks (those that lack sufficient data to allow a quantitative stock assessment), particularly in regard to multi-species fisheries where information requirements and associated costs make determining target reference points difficult.

In these situations, as with all stocks, there is a need to demonstrate that the management arrangements are consistent with the objectives of the policy and such stocks should not be deliberately managed at biomass levels at which the risk to the stock is unacceptably high.

Biomass targets below the level that supports maximum sustainable yield

The policy provides for some stocks that are harvested in multi-species fisheries to be managed at biomass levels below those that support maximum sustainable yield where it achieves the objective of maximising economic returns across the fishery as a whole. This means that due to the different biological and economic characteristics of species in a multi-species fishery, secondary (lower valued) species may be fished at levels that result in biomass levels lower than those that support maximum economic yield or even maximum sustainable yield. However, enabling species within a multi-species fishery to be managed at levels below the biomass that supports maximum sustainable yield could expose such species to greater risks of being overfished than the more commercially valuable species that are managed at higher targets.

There is ample scientific evidence to support the use of maximum sustainable yield biomass targets, without unacceptable risk that the stock may breach its limit reference point. Allowing some species to be managed below maximum sustainable yield biomass targets to achieve fishery-wide maximum economic yield is well recognised in theory, provided risk to stock and ecosystem is appropriately accounted for. The ABARES implementation review noted (Ward et al. 2013):

... as a result of differences in the biology and economic characteristics of species in a multi-species fishery, optimising economic returns across the entire fishery might result in some incidentally caught secondary species being reduced below B_{MSY} [the biomass that supports maximum sustainable yield], due to harvest strategies being driven by the MEYs [maximum economic yields] of the main commercial species in the mix. It may be necessary to forgo some profits from one species to generate higher profits from other species in order to maximise profits across the entire fishery. While recognising these options, the harvest strategy policy requires the biomass of all species to be maintained above their limit reference points.

However, as stocks are fished below biomass levels that support maximum sustainable yield, the risk of breaching the limit reference point and the possible impact on the ecosystem increases. The guidelines indicate that before a stock's biomass target is set below default policy targets:

Consideration should also be given to:

- demonstrating that economic modelling and other advice clearly supports such action
- no cost-effective, alternative management options (for example, gear modification or spatial management) are available
- the associated ecosystem risks have been considered in full (HSP 2007, p. 25).

Setting appropriate total catch limits for each species within a multi-species fishery can also help constrain regulatory discarding. If total allowable catches are not set at levels that reflect the species composition and proportions in a complex mixed-species fishery, such as fish trawl, then the more susceptible species will be taken incidentally and are likely to be discarded in most cases. As Haddon et al. (2013) point out:

The species mix in catches may not necessarily match the mix in combined TACs [total allowable catches] or in quota holdings. This difficulty in balancing quotas for multiple species with actual catches may then lead to increased discarding, TAC over-runs, effort restrictions or fishery closures when quota is constrained on some species (Branch et al. 2006; Sanchirico et al. 2006). This may lead, therefore, to problems with achieving B_{MEY} [maximum economic yield biomass targets] for multiple species.

Vieira & Pascoe (2013) point out that this may also impede achieving any other biomass target.

However, there are a number of potential drawbacks associated with maintaining stocks at levels below those that support maximum sustainable yield. For example, the risk to a stock from fishing, and particularly the risk of recruitment failure, increases with decreasing spawning stock biomass.

Stocks maintained below the biomass that supports maximum sustainable yield are likely to be those inherently more susceptible to fishing, relative to their productivity, than the higher value species being fished to maximum economic yield. In addition, those species most likely to be managed at biomass levels below single-species maximum economic yield are generally lower value species and so may be data-poor. The combination of limited information and high susceptibility means managing stocks below maximum sustainable yield targets may pose a greater risk of breaching limit reference points.

Maintaining stocks at low levels can have other drawbacks such as diminishing the benefits of the resource to other user groups, potentially increasing ecological risk and making stocks and ecosystems more susceptible to environmental perturbations.

As such, it would be preferable, as a general principle, to set targets for any given species at biomass levels at or above single species maximum sustainable yield. However, in reality, if targets for individual species are set too high, those species are equally likely to be caught but discarded. As such, setting high targets for these stocks is likely to increase incentives for discarding, but not to reduce the risk to which they are exposed.

The policy and guidelines recognise the risks associated with setting biomass targets below 'single-species' maximum economic yield levels. The policy and guidelines also include explicit direction about the level of risk to a stock that the Australian Government considers is acceptable in allowing access to, and use of, fishery resources in Commonwealth fisheries:

Limit reference points (B_{LIM} and F_{LIM}) [biomass and fishing mortality reference points] express situations to be avoided because they represent a point beyond which the risk to the stock as the basis of a commercial fishery is regarded as unacceptably high.

In terms of biomass, the unambiguous requirement is that all key commercial and secondary stocks should be maintained above their limit reference point (generally taken as 20 per cent of the unfished biomass or higher), irrespective of their target. A key performance criterion specified in the policy is that there is a less than 10 per cent chance of the biomass falling below the limit reference point in the long term.

The likelihood of breaching the risk criteria can be assessed either through a high information tier stock assessment (which may not be available for secondary stocks) or through management strategy evaluation testing. The technical reviews (Haddon et al. 2013; Vieira & Pascoe 2013) noted that a suitable requirement for setting biomass targets at or below maximum sustainable yield in multi-species fisheries, was to apply appropriate testing to each species to ensure that risks from the fishing remain within acceptable levels.

If biomass targets are set below maximum sustainable yield levels, another important consideration is that should the stock become subject to overfishing (that is their biomass falls below the limit reference point), then it is likely that catches of key commercial species will need to be heavily constrained to rebuild the depleted stock. This is particularly likely given the guidelines direction that other cost effective options such as additional gear modification or spatial management should have been considered *before* lower targets were set. Consideration should therefore be given to setting a more conservative risk criterion than the default 10 per cent likelihood of breaching the reference point specified as the default.

The risk that fishing poses to a stock can also generally be constrained by reducing catch levels, for example, by reduced fishing activity, spatial or temporal management arrangements and/or gear controls.

Given these considerations, **it appears appropriate for the policy to continue to allow targets for individual stocks to be set below the levels that support maximum sustainable yield** in the context of the risk-catch-cost framework and overall policy objective of:

... 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 Australian community (HSP 2007, p. 4).

However, the policy could also reflect that sub-maximum *sustainable* yield targets should not be considered until consideration has been given to other cost effective approaches to protect the stock; the needs of other user groups (such as other Commonwealth fishers and non-commercial users) have been appropriately considered; that ecosystem risks have been considered and there is strong scientific evidence that the risk to the stock is appropriately constrained (for example, supported by quantitative stock assessments or management strategy evaluation).

Conclusions

Further work is required to better implement the maximum economic yield objective in complex multi-species fisheries.

Developments continue to be made on managing multi-species fisheries and the science that underpins these management arrangements. The policy could benefit from providing scope for the adoption of new information and management approaches as they are developed.

Managing some stocks in multi-species fisheries at levels below maximum *sustainable* yield in order to achieve fishery-wide maximum economic yield is well established in theory. However, doing so increases the risk to such stocks and is not a preferred approach in most circumstances. The policy could be amended to indicate that this should only be done where risks are constrained and the needs of other user groups has been appropriately considered, there is a sound scientific basis to do so and other cost effective options such as gear modifications or spatial/temporal management measures are unavailable.

11 Managing byproduct and data-poor commercial fish stocks

The harvest strategy policy currently applies to ‘key commercial species of all Commonwealth-managed fisheries’. The guidelines describe key commercial species as ‘a species that is, or has been, specifically targeted and is, or has been, a significant component of a fishery’. The approach applied to key commercial species under the harvest strategy policy is generally accepted to have been successful in managing stocks sustainably.

The intention of the harvest strategy policy is to ensure the risk to commercial fish stocks remains consistent across different management (and assessment) approaches. In the case of byproduct stocks and or stocks with limited data, AFMA has developed the Ecological Risk Assessment for Effects of Fishing framework to assess and progressively address the impacts of fisheries on the stocks and the marine environment. The framework details a number of steps and involves a hierarchy of risk assessment involving a tiered/hierarchical process with three levels: a qualitative analysis at Level 1, an indicator-based analysis at Level 2, and a model-based analysis at Level 3 (Box 7).

Different assessment approaches have different levels of uncertainty. The level of uncertainty usually increases as the amount and quality of data and information decrease. The risks associated with reduced certainty around the stock assessment might be addressed in the harvest strategy for a stock or group of stocks by reducing the maximum exploitation rate each year. The harvest strategy framework for the Southern and Eastern Tuna and Billfish Fishery explicitly addresses this data-uncertainty–risk trade-off in assessments by requiring the application of discount factors at each of the lower information assessment tier levels; in theory, a five per cent discount is applied to recommended biological catches derived from catch curve assessments (tier 3) and a 15 per cent deduction or ‘discount factor’ is applied to recommended biological catches derived from ‘catch per unit effort’-based assessments (tier 4) (Ward et al. 2013).

Commonwealth fisheries are also subject to the *Commonwealth Policy on Fisheries Bycatch*, which has different objectives to those of the harvest strategy policy. The harvest strategy policy seeks to maintain sustainable fisheries with an emphasis on maximising economic returns, whereas the bycatch policy seeks to maintain populations by reducing bycatch, improving protection for vulnerable species and determining acceptable ecological impacts.

While recognising that ‘bycatch can sometimes refer to non-targeted catch, byproduct, discards and other interactions with gear’, the bycatch policy deals specifically with ‘those aspects of catch that are not currently subject to commercial management provisions’. This has led to some uncertainty about the application of the two policies for species that are not considered key commercial species but which contribute to the economic returns to the fishery. For these species reducing catch may not be an appropriate objective.

It is the government’s intention that a revised harvest strategy policy and bycatch policy, will between them, address the effects of fishing on all key commercial, byproduct and bycatch species including protected species. An important task of the reviews has been to ensure that no gaps exist between the policies.

On this basis, a division of policy coverage has been proposed whereby non-commercial species would be managed under the bycatch policy, while commercial species would be managed under an amended harvest strategy policy (updated to better reflect low information and risk-based harvest strategy tiers). The division would be made according to the following classifications:

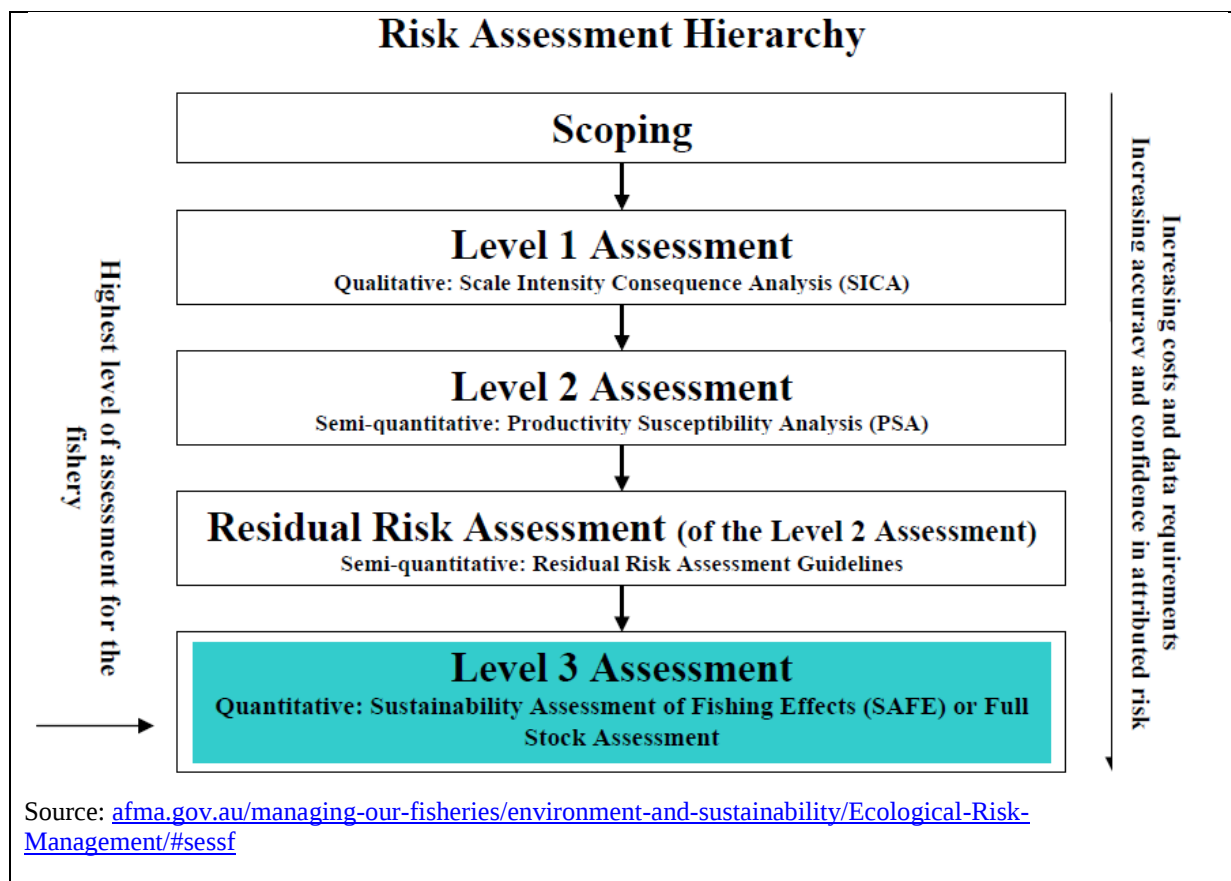
- commercial species: those that are caught and usually kept by commercial fishers
- bycatch species: those that physically interact with fishing vessels and/or fishing gear and which are not usually kept by commercial fishers.

Box 7 Ecological Risk Assessments

The Ecological Risk Assessment for Effects of Fishing framework was developed by CSIRO and AFMA (Hobday et al. 2011) involves a hierarchical process of risk assessment, with a qualitative analysis at Level 1, an indicator-based analysis at Level 2, and a model-based analysis at Level 3.

- Level 1: ‘Scale × intensity × consequence analysis’ is conceptually the same as the likelihood × consequence approach in the ecologically sustainable development reporting framework (Fletcher et al. 2002).
- Level 2: ‘Productivity-susceptibility analysis’ is a multi-species method that assigns to each species in each fishery a score on two axes, the first representing its susceptibility to being caught and the second its biological productivity. A number of different attributes are used to derive each of the indicator scores. Adopting a precautionary approach to uncertainty, high risk scores are assigned to attributes in the absence of information. This can lead to a bias towards ‘false positives’.
- Level 3: ‘Sustainability assessment for fishing effects’ is also a multi-species analysis but instead of using indicators it estimates fishing mortality based on the overlap between a species’ range and fishing effort, using the same biological attributes that are used to derive indicators in level 2. These estimates of fishing mortality may then be compared with estimates of species productivity (as indicated by estimated natural mortality), from which limit reference points can be expressed in terms of fishing mortality for each species. This approach is similar to a tier 3 (catch curve) stock assessment for commercial species and is consistent with a harvest strategy policy approach.

There is inevitable uncertainty in the results, with lower information and lower levels of assessment having higher uncertainty. Reducing this uncertainty requires additional monitoring or research to provide the additional data needed to move to higher assessment levels. There is therefore a direct monitoring or data collection cost associated with reducing the uncertainty in risk assessments. However, uncertainty is a key contributor to risk, and so reducing uncertainty also reduces the risk, resulting in a risk-cost trade-off. (Penney et al. 2013a)



The review recognises that further clarification will be required to effectively separate species according to the above classifications, to ensure consistency at the individual fishery level. The review also recognises that to ensure that stocks are appropriately classified an open and transparent process should be undertaken. The report of the bycatch policy review (DAFF 2013) provides a more detailed description of the proposed categories, approaches and transition mechanisms between the two policies.

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Considerations for incorporating byproduct under the harvest strategy policy

Currently, harvest strategies have been applied to approximately 100 stocks. Extension of the policy to all commercial stocks would increase this number and have associated cost implications. Any extension of the fisheries policy framework to incorporate byproduct stocks would require consideration of the costs including how, and from what sources, these costs could be met.

Expanding the scope of the harvest strategy policy to include all commercial stocks would require different assessment approaches and control rules to those currently employed for key commercial species. Many byproduct stocks will be data-poor. Incorporating these under the policy would need to be done in a way that is consistent with legislative objectives, including pursuing efficient and cost effective management and maximising net economic returns to the community as well as the principles of ecologically sustainable development. Further consideration would be required about

the application of the harvest strategy approach to all commercial stocks in a way that appropriately balances legislative objectives.

Care would also need to be taken to ensure that including byproduct under the policy does not undermine the robustness of the approach currently taken for the key commercial species. This might be achieved by ensuring that stocks already subject to a harvest strategy approach generally remain subject to that approach.

Managing risk

The harvest strategy policy has been applied to several byproduct species and the guidelines currently include direction on applying harvest strategies to secondary species. There are, however, many species taken in considerable numbers that are not currently covered by harvest strategies, such as angel sharks, gurnards and ocean jacket in the Commonwealth Trawl Sector of the Southern and Eastern Scalefish and Shark fishery (Ward et al. 2013).

The guidelines require approaches that seek to ensure an approximately consistent level of risk across all stocks, creating challenges for managing byproduct, particularly in data-poor fisheries. The policy states:

A tiered approach to control rules is encouraged in order to cater for different levels of certainty (or knowledge) about a stock ... Such an approach provides for an increased level of precaution in association with increasing levels of uncertainty about stock status, such that the level of risk is approximately constant across the tiers (HSP 2007, p. 36).

Haddon et al (2013) provides a review of tiered approaches, including assessment approaches for data-poor fisheries. They indicate that simulation testing already undertaken shows that the risk level by tier method is not always predictable and can also be very case specific. Research is underway to look into risk across different assessment tiers but this continues to be a developing area.

The tiered approach to stock assessments does not always perform as well as expected. For example, assessments based on catch per unit effort data can be difficult (and potentially impossible) to interpret where there has been deliberate avoidance or changed targeting patterns, in the absence of a suitable standardisation. Haddon et al. (2013) cites numerous international reviews that have been conducted of alternative indicators and assessment methods for data-poor species. Many of these have proposed tiered/hierarchical approaches to the selection of assessment methods, depending on data availability. Penney et al. (2013b) notes that:

Scandol (2003, 2005) investigated a wide range of potential indicators including total catch, catch rate, length distribution, age distribution, catch, catch per unit effort, mean age, mean length, recruitment fraction, total mortality and fishery independent surveys. Biomass surveys were found to perform best, followed by mean age, length and recruitment fractions. Time series of catch per unit effort and catch had the worst performance but were still acceptable.

Developing tiered systems to better account for data-poor species would allow for better management of both major and minor byproduct species under the harvest strategy policy. Haddon et al. (2013) point out that:

From a Tier perspective, there is ... a lot of scope for using or developing different Tier assessment methods. However, the various MSE [management strategy evaluation] tests have shown very case specific results indicating that a precautionary system should be applied unless these methods are tested through MSEs.

Ecological Risk Assessments

Despite the lack of clear policy guidance on identifying and managing risks of fishing, including on byproduct species, AFMA and CSIRO have developed the Ecological Risk Assessment for Effects of Fishing framework to help meet AFMA's legislative requirements. The framework details a process for assessing and progressively addressing the impacts that fisheries' activities have on five aspects of the marine ecosystem: target species, byproduct and discard species, protected species, habitats, and communities. The Ecological Risk Assessment for Effects of Fishing framework is described further in **Error! Reference source not found.** This framework has been increasingly adopted internationally for use in fisheries risk assessments (Penney et al. 2013a).

AFMA has conducted level 1 ecological risk assessments for species in all major fisheries, and then level 2 or level 3 assessments for medium and high risk species in those fisheries. Risk management responses are implemented to reduce or mitigate the identified risks. AFMA has developed an ecological risk management framework to guide and ensure consistency in the management process, responding to the outcomes of an ecological risk assessment.

The ecological risk assessment/management framework enables fisheries managers to identify priorities for management and research effort, while guiding the management response for addressing higher risk issues. The ecological risk management plan for each fishery is intended to respond directly to the results of the ecological risk assessment, and to then manage fishery impacts on species assessed to be at high risk from the effects of fishing (Penney et al. 2013a).

Uncertainties and gaps in risk assessments can be addressed by collecting additional information, either to fill the gaps or to enable a higher level quantitative assessment with lower uncertainty. However, collection of additional information can be expensive and there is a direct trade-off between the costs of reducing uncertainty versus the application of precautionary approaches to manage effectively under the uncertainty. Dichmont et al. (2013) describe steps for addressing uncertainty in the risk-cost-catch framework. If resources are not available to fund further research, methods such as expert overrides and residual risk assessments are needed.

A key challenge that arises from ecological risk assessments conducted for individual fisheries is the difficulty of estimating cumulative effects across fisheries or jurisdictions. The ecological risk assessments for individual fisheries may each indicate low or medium risks, however the combined risk across a number of fisheries including state and territory managed fisheries may actually be high. These cumulative risks can be difficult to manage. CSIRO is finalising a Fisheries Research and Development Corporation and AFMA funded research project titled *ERA [ecological risk assessment] extension to assess cumulative effects of fishing on species*, which may provide further direction on appropriately responding to cumulative risk.

Managing and assessing byproduct under the harvest strategy policy

Commercial catches are often made up of different components, and each component will have a different risk profile and economic value. Accordingly, the objectives and approaches used will vary between different stocks.

Extending the coverage of the harvest strategy policy to byproduct species could be managed using a tiered approach applying a combination of ecological risk assessment / management approaches and, where required, low information harvest strategies to identify and manage risks on a stock by stock basis while maximising economic returns at fishery level (Haddon et al. 2013; Penney et al. 2013b).

Under this approach, the guidelines could include criteria for identifying the appropriate management approach to apply to each given stock. To be successful, the approach should seek to avoid incentives for stocks to become or unnecessarily remain data-poor. Individual fishery harvest strategies should clearly identify which stocks will be classified under each category and the associated approaches to assessment and management.

The review of the bycatch policy has also recommended a tiered approach, recognising that different management and analysis responses are required to manage risk. Figure 2 shows a range of assessment approaches and information requirements for bycatch, commercial and byproduct species.

Figure 2 Range of assessment approaches and information requirements from discarded bycatch species managed under a Bycatch Policy to commercial target species managed under a Harvest Strategy Policy (Penney et al. 2013a)

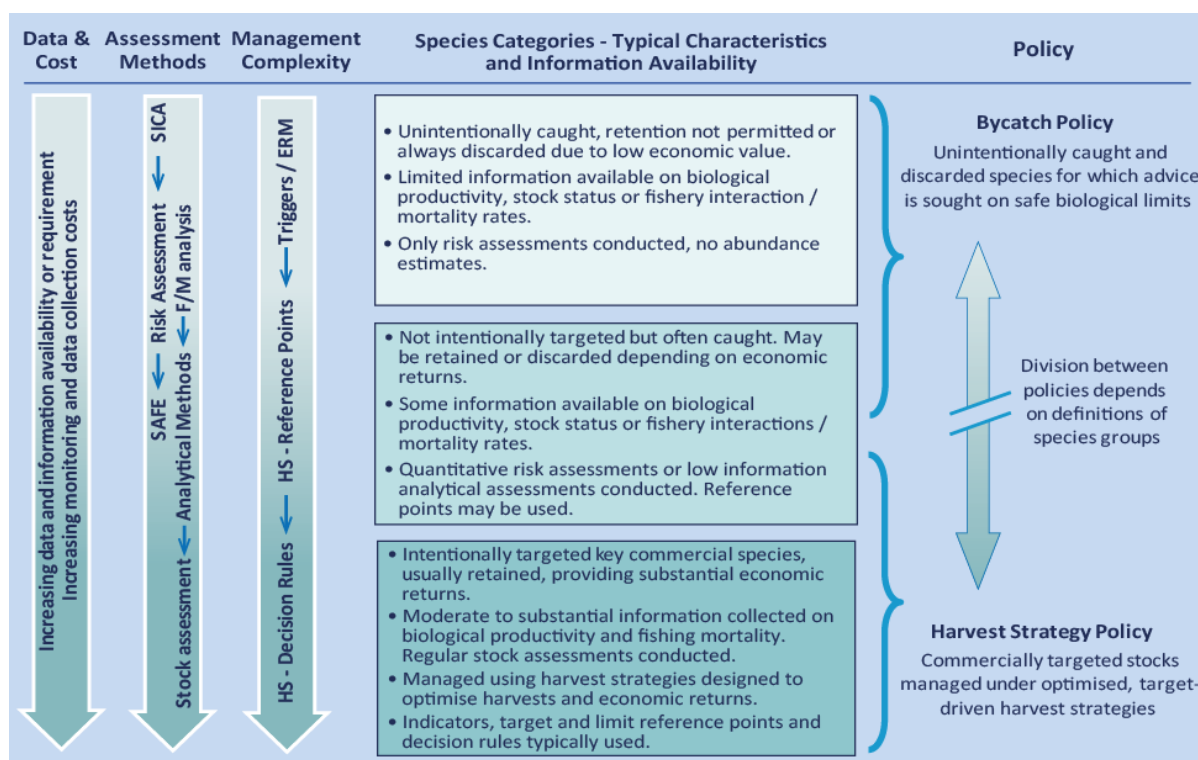


Table 4 outlines a possible division of different components of the catch, depending on information availability, catch volume and value. It suggests assessment methods and management approaches that may be appropriate for each species type. In summary, **a way of bringing all byproduct species under the harvest strategy framework, subject to consideration of costs, may be for a multi-part arrangement as follows:**

- **Primary commercial stocks:** stocks with total allowable catch or effort set using full harvest strategy approach; stocks are actively targeted and contribute substantially to the catch volume or value.
- **Secondary commercial stocks:** stocks with total allowable catch or effort set using low information tier harvest strategy approaches; stocks have lower contribution to economic revenues and may currently be discarded at times in favour of higher value species.
- **Minor byproduct stocks:** stocks that make occasional and minor contributions to revenue, to be screened using a tiered approach to identify risks that should be managed, for example by mitigating catches or applying harvest strategy approaches.

This is a proposed division of management arrangements and will require further refinement and consultation. Decisions on categorising and selecting appropriate management arrangements for individual stocks must be made on a stock by stock basis and informed by risk-catch-cost considerations.

Table 4 Schematic of Harvest Strategy Policy Components and Processes

	Species Category ¹	Description	Assessment Method	Management Approach	Transition Mechanism	Considerations
Increasing data collection, assessment level and management requirements ↑	Primary Commercial Stocks	Stocks that are managed under total allowable catches or total allowable effort controls, are actively targeted; provide ‘most’ of the catch and generate ‘most’ of the revenue in larger fisheries; ² all or most of the catch is retained.	High information stock assessments - tiers 0–1	These stocks would be managed using harvest strategies and decision rules; quantitative limit and target reference points established; usually actively managed towards ‘single stock’ maximum economic yield-based target; performance measures and projections used to assess current biomass status in relation to targets and limits; discards of these species should be minimised.	↓ These stocks could move to being secondary commercial stocks if they cease to contribute significantly to catch and revenue for an extended period of time.	Stocks could be identified on the basis of current fishing practices and targeting analyses.
					↓↓ These species could become listed as conservation dependent or higher level threatened species under the environmental legislation if stocks are depleted below limits.	Management arrangements for these stocks should generally retain existing monitoring and data collection requirements, reference points, performance measures, assessment methods and management approaches.

¹ Former commercial species that have become overfished and are being rebuilt towards the target reference point would continue to be considered commercial species and subject to the rebuilding requirements of the policy.

² The division between primary and secondary commercial species will depend on the catch weight and revenue thresholds chosen to distinguish secondary species from primary commercial species for each fishery.

	Species Category ¹	Description	Assessment Method	Management Approach	Transition Mechanism	Considerations
↑ Increasing data collection, assessment level and management requirements	Secondary Commercial Stocks	Stocks that are managed under total allowable catches or total allowable effort controls; do not contribute substantially to economic revenues and have a low level of active targeting (but may be target species in lower value fisheries) ² ; catch often retained but may be discarded at times, depending on profitability.	Usually low information analytical assessments –tiers 2–7, depending on data availability. Ecological risk assessment - level 3 ('sustainability assessment for fishing effects') assessments applied to stocks moved up from minor commercial species determined in level 1 or 2 ecological risk assessments ('scale × intensity x consequence analysis' or 'productivity-susceptibility analysis') to be at unacceptable risk of being overfished.	These stocks would be managed using proportional or proxy limit and target reference points; may be managed to an alternative reference point above or below the biomass that produces 'single stock' maximum economic yield to achieve fishery-level maximum economic yield in multi-species fisheries; low information assessments used to assess proportional status (catch per unit effort, fishing mortality estimates, catch weight) against chosen targets and limits; efforts should be made to reduce discards.	↑ Could move to being primary commercial stock if commercial interest and landed catch increases, such that the stocks become significant contributors to catch and revenue, and actively targeted. ↓ Could move to being minor commercial stock if catches decline below some defined level, and stocks are shown not to be at unacceptable risk at current catch and fishing mortality levels. ↓↓ Could become listed as conservation dependent or higher level threatened species under environmental legislation if stocks are depleted below limit reference points.	These stocks currently contribute to landings and revenue but fall below the catch and revenue contribution thresholds for primary commercial stocks. Management arrangements for these stocks should generally retain existing monitoring requirements, assessment methods and limit reference points; targets may be revised; stocks should be managed using appropriate low-information harvest strategies and decision rules.

	Species Category ¹	Description	Assessment Method	Management Approach	Transition Mechanism	Considerations
Increasing data collection, assessment level and management requirements →	Minor Commercial Stocks	Stocks that make occasional and minor contributions to commercial catch and little contribution to revenue; do not significantly affect fishery level maximum economic yield; catches or retained catches are low; discarding may often occur.	Ecological risk assessment - level 1 ('scale × intensity × consequence analysis') and level 2 ('productivity-susceptibility analysis') used to ensure these species are not at unacceptable risk of overfishing.	Shown by ecological risk assessments not to be at unacceptable risk of being fished to below safe biological limit at current catch and fishing mortality levels; may not have specified targets, limits or performance measures; catch triggers used to determine whether re-assessment of ecological risk is warranted, data collection/analysis and/or management actions to reduce risk to stock are required, or whether stocks would move directly to being secondary commercial species based on increased catch contribution; efforts should be made to constrain unwanted catches.	↑ Would move to being secondary commercial stocks if ecological risk assessments indicate unacceptable risk at current catch, effort or fishing mortality levels, or if catches increase to qualify as secondary commercial stocks. ↓ Could move to being bycatch species if catches are no longer retained, there is no commercial value and species do not require rebuilding. ↓↓ Could become protected species due to being listed under environmental legislation, or adoption of international conservation measures.	Species currently not clearly managed under either policy would be apportioned between this category and 'other bycatch species' under the bycatch policy depending on market value and retention; commercial species may need to be listed to clarify that they resort under the harvest strategy policy; ecological risk assessments may need to be updated for some of these species; some level of monitoring (of catch at least) will be required to respond to catch triggers and to ensure that risk remains low; may include exploratory fisheries.

Byproduct species not previously managed through harvest strategy approaches would need to be evaluated to determine whether current or expected catch levels exceed appropriate risk thresholds. For those stocks assessed as over the acceptable risk threshold, harvest strategies could be applied or interactions reduced. The appropriate approach to managing each stock should follow a tiered approach, informed by the available information, cost considerations and the precautionary principle. This approach will require further guidance on ecological risk assessments and ecological risk management before it can be implemented. Questions such as whether the existing scale-intensity-consequence analysis and productivity-susceptibility analysis approaches sufficiently screen out risks at an appropriate level will need to be answered.

It will not be feasible to undertake analytical assessments on some species that are rarely encountered or rated as 'high risk' because little is known about their life-history. In these situations AFMA should carefully monitor catch and implement precautionary trigger reference points for information collection and analysis.

Incorporating byproduct would require the development of a more complete approach for applying ecological risk assessment and management approaches in the policy and guidelines. For example, guidance would be necessary on the appropriate actions and thresholds to respond to identified risks for low information stocks assessed using ecological risk assessments. This could mean that ecological risk assessments are reviewed to determine whether the risk threshold applied approximates to a low probability of breaching the biomass limit under assessed fishing levels.

Guidance would also be required on maintaining and updating ecological risk assessment approaches to reflect the current risks to stocks as well as advise on the appropriate level of monitoring of stocks. This should lead to the continued strengthening of the ecological risk assessment process to avoid or at least minimise the impact of false positive and negative results, to address cumulative impacts, and lessen the need for expert overrides.

Relevant considerations in developing risk-based approaches for byproduct species include individual species' productivity, susceptibility to fishing gear and rates of incidental capture. Byproduct species may be taken incidentally in one fishery or fishery sector, but targeted in another. Such cumulative effects may influence the levels of risk, data requirement and the way it is managed.

Additionally, for some byproduct species, a harvest strategy may need to be developed. This would require additional work to develop and test harvest strategies that could be effectively applied to the lower information assessment tiers such as those described in Haddon et al. (2013).

Conclusions

The fisheries policy framework could be extended to incorporate byproduct stocks—applying cost-effective and risk-based approaches that ensure the sustainability of stocks and maximise economic returns from the fishery.

Byproduct could be managed through a combination of ecological risk assessment and ecological risk management approaches and, where appropriate, low information harvest strategies to identify and manage risks on a stock by stock basis while maximising economic returns at a fishery level. Selection of the most appropriate approach to managing each stock could follow a tiered approach, informed by the level of risk, information availability and risk (certainty)-catch-cost considerations.

The harvest strategy policy could be revised to encompass the management of byproduct species, recognising that in most cases this will include a tiered approach requiring formal risk management based on the level of available information.

12 Spatial management

Spatial management involves limiting fishing effort in a specified area for a limited or indefinite period of time. Spatial management tools are commonly used to protect or rebuild commercial fish stocks (or parts of stocks, such as juvenile fish), protect fish habitats or bycatch species. They may also be used to help support economic outcomes such as in the Northern Prawn Fishery (where banana prawn season length depends on maintaining catch rates).

Spatial and temporal management arrangements can provide a cost effective and flexible way to protect stocks and meet the objectives of the policy. Spatial management tools can be useful in fisheries where there is poor or inadequate data to set limits or limited resources are available to implement more complex management arrangements. Haddon et al. (2013) notes:

For some species a management scheme that controls fishing mortality with large spatial and temporal fishery closures offers a management strategy more robust to uncertainty than direct control of catch, since only a small component of the stock gets exposed to the fishery.

These management approaches can be particularly applicable to the protection of stocks of sedentary or spatially structured stocks such as scallops and sea cucumbers, or for aggregating species such as orange roughy.

AFMA has implemented a number of spatial closures across its fisheries. These include depth closures to protect and rebuild orange roughy, gulper sharks and school sharks; inshore closures to protect shark nursery areas in the Southern and Eastern Scalefish and Shark Fishery and a (voluntary) annual six week closure of blue warehou spawning grounds.

The harvest strategy policy and guidelines recognise spatial management arrangements, but provide limited guidance on how to incorporate these management tools into harvest strategies. For example, although the guidelines include a case study on the rotational harvest arrangements for Tasmanian scallops, they provide no information on how the policy's objectives and biomass-based strategy might be applied to such arrangements. The policy and guidelines are also silent on how to incorporate the effects of spatial closures into management.

Spatial closures

Spatial closures as fisheries management tools

CSIRO's Technical Reviews for the Commonwealth Harvest Strategy Policy (Haddon et al. 2013) note that:

Spatial management may be applied in various contexts within a harvest strategy. It can form the main harvest strategy framework (such as in a system of rotational closures), it can be used to augment a harvest strategy framework, or spatial management measures can be invoked as a control rule (a variation of rotational closures). For some species a management scheme that controls fishing mortality with large spatial and temporal fishery closures offers a management strategy more robust to uncertainty than direct control of catch, since only a small component of the stock gets exposed to the fishery ...

Haddon et al. (2013) also note that spatial management arrangements are often seen as a more cost effective method for managing small artisanal fisheries and data-poor fisheries. They indicate that for complex multi-species fisheries, spatial closures can also provide some refuge from fishing

mortality for those species not subject to direct management controls such as total allowable catches.

Spatial closures are also a useful tool for rebuilding stocks. Pitchford et al. (2007) showed that spatial closures can alleviate the susceptibility of overfished stocks to collapse. Areas of the Southern and Eastern Scalefish and Shark Fishery have been closed to fishing to prevent any further declines in the overfished gulper shark population and support its recovery; and extensive temporary closures have been put in place to protect Australian sea lions and other marine mammals. Again, however, closures such as this raise the question of how these measures affect the management of other stocks in the area.

Spatial closures not related to fisheries management

Fishers may also be excluded from operating or using certain gear types in an area for reasons other than fisheries management outcomes. Commonwealth marine reserves have been established under the Environment Protection and Biodiversity Conservation Act following a marine bioregional planning process, with 40 new reserves being established in November 2013. As required by the Act, management plans for the new Commonwealth marine reserves around Australia have been developed and will come into effect in July 2014 (the management plan for the South-east Commonwealth marine reserves network will come into effect on 1 July 2013).

Management of marine reserves includes a variety of different zoning arrangements, including zones where no commercial fishing is allowed and those that allow commercial and recreational fishing activities where these are consistent with the objective of the relevant management plan.

Marine reserve zones that exclude fishing can have substantial impacts on the availability of some stocks and the economic performance of fisheries, given the size and scale of those implemented in Commonwealth waters. Accordingly, their impact on fisheries management, and in particular on total allowable catch settings, need to be considered.

The December 2005 ministerial direction to AFMA under the *Fisheries Administration Act 1991* identified that spatial closures were likely (seemingly in reference to marine reserves, which were being developed in south eastern Australia at that time). However the focus was on taking a coordinated approach between agencies rather than on how closures may be accounted for in management:

AFMA must ... identify and implement any required spatial closures in fisheries [and] ensure that where ongoing exclusion of fishing is proposed there is a coordinated approach with other relevant agencies to the identification of the Marine Protected Areas ...

Implications of spatial closures on fisheries management

Whether implemented for fisheries management purposes or otherwise, where spatial closures are applied to part of a stock, the question arises of the extent of 'protection' that this provides to a stock and how management of the remaining stock in open areas should be revised to account for the effects of closures (Penney et al. 2013b). This is likely to depend on various factors including the degree to which stocks are resident in the closed area, the rate of 'spill over' to the fishery and the degree of larval connectivity.

Appropriate harvest strategy and management settings will depend both on the management objective for the stock and the degree of connectivity between the components of a stock within and outside a closed area. However, connectivity may be complex making it difficult to determine appropriate management settings (for example, there may be strong larval connectivity but little spill over of adult fish).

There is a need for greater understanding about matters such as the rate of movement between closed and open areas and objectives for how the remaining stock in open areas should be exploited.

With the increasing number of spatial measures in recent years, AFMA has had to implement harvest strategies and other management arrangements without clear direction from the policy or guidelines. The review of the policy's implementation (Ward et al. 2013) noted:

Several fisheries have attempted to deal with the effects of spatial management measures ... However, the treatment of ... closures has been inconsistent across fisheries. In particular, it has been difficult to determine how RBC [recommended biological catch] estimation and TAC [total allowable catch] calculations should take closed areas into account and to identify meaningful reference points in open areas for fisheries or species affected by closures.

Ward et al. also point out that while the effect of closed areas has, at times, influenced total allowable catch setting decisions, these effects have not always been quantified using management strategy evaluation.

Additional direction is required in the guidelines for evaluating the effects of closures on protection of stocks in closed areas and how management of remaining stocks in open areas should be revised to account for the closures.

Any such guidance will need to be informed by appropriate research. Research is currently underway to evaluate the extent to which fishing mortality has changed due to the increasing number closures (Penney et al. 2013b). It is anticipated that this work could provide an evidence base for any increased guidance about spatial management that may be included in the guidelines.

Harvest strategies for spatially structured stocks

The policy's objective requires that harvest strategies be used to maintain key commercial stocks at ecologically sustainable levels and, within this context, maximise the economic returns. The policy's strategy to achieve the objective is based on the use of target and limit reference points that relate to population size and fishing mortality.

However, Penney et al. (2013b) note that it has been difficult to identify meaningful reference points for spatially structured stocks. These difficulties are particularly apparent in the Bass Strait Central Zone Scallop Fishery, reflecting that scallops are largely sedentary, spatially structured and have highly variable recruitment.

Spatial management arrangements based on 'rotational harvest strategies' or pulse fishing have been applied to scallop and sea cucumber fisheries. Under this approach, the parts of the stock that meet certain criteria (for example, a high proportion of large specimens) are open to fishing for a

period or until some other condition (such as a catch rate trigger) is met. Fished areas are then closed for a period to allow stocks to recover. Haddon et al. (2013) note:

The fundamental idea of Limit and Target reference points assumes that there is such a thing as a long term average or that fishing mortality can be considered as continuous through time. Fishing a scallop bed usually means completely depleting it to low levels, while other beds are left alone ...

The nature of these management arrangements presents a challenge in meeting the policy's objectives and strategy of maintaining biomass between target and limit reference points. Haddon et al. (2013) describe how AFMA has sought to meet the policy's objective in the Bass Strait Central Zone Scallop Fishery:

... with extremely variable species such as Bass Strait scallops and squid the concept of unfished biomass (B_0) does not appear to have any meaningful interpretation. Haddon (2011), in an evaluation of scallop management strategies, interpreted the regulation of having at least 40% of viable areas closed to fishing at all times (with at least 500 t of biomass) as being a spatially explicit proxy for the B_{LIM} [biomass] limit reference point. This aims to achieve the intent of the sustainability objective. While this spatial proxy does not relate to ... [the policy's default settings], it is a pragmatic way forward. There are control rules for when to allow fishing in a scallop bed (there must be < 20% under the legal size), but defining a suitable target for scallops remains difficult.

The target for the fishery might be characterised as aiming to have a fishery each year and to achieve a catch level that matches the processor and market capacity. The first rule [minimum size requirement] acts to maintain profitability by avoiding waste and focusing on the larger scallops that generate a higher yield of scallop meat for a given number of scallops processed; in this manner the objective of achieving the most profitable fishery is approached, but this is difficult to interpret as a specific target. (Haddon, 2011, p 20)

Ward et al. (2013) point out that while the harvest strategy for the scallop fishery seeks to implement the policy, it does not target maximum economic yield.

Clearly, implementing the harvest strategy policy for such stocks is difficult and neither the policy nor guidelines provide information on how this should be achieved for scallops and similar species. **The policy could recognise that for stocks that are managed on a spatial basis, it is difficult to set target and limit reference points that demonstrably meet the intent of the policy. Further research would be required to determine more effective ways of implementing the policy's objective in harvest strategies for spatially managed stocks.**

Localised depletion

Ward et al. (2013) note that, while localised depletion may not be a problem from a stock sustainability point of view, there may be localised economic and ecological implications. Persistent or severe localised depletion can also impact negatively upon other resource users. The guidelines recognise that:

... harvest strategies at a stock or regional level may not prevent localised depletion even if overall stock sustainability objectives are achieved. In such cases, tools such as spatial management may need to be implemented separately or form part of the harvest strategy (HSP 2007, p. 18).

Clearly, harvest strategies should seek to avoid persistent and severe localised depletion, except where this is an explicit part of the fishing strategy, for example, using rotational closures. The risk of

localised depletion should be considered in harvest strategy development. Where the risk is too high, consideration could be given to using spatial management tools, such as zoning or 'move on' provisions to constrain localised effects.

The guidelines could benefit from a clear statement indicating that the risks of localised depletion should be considered in harvest strategy design. However, decisions on whether and how to incorporate these considerations will need to be made on a fishery by fishery basis depending on necessity and in consideration of cost effectiveness.

Conclusions

The guidelines could benefit from including clearer direction on the use of spatial management arrangements. This includes guidance on evaluating the effect of spatial closures and the management of stocks in open areas.

However, the development of guidance would require further work and research into:

- **how spatial and temporal management arrangements can be used to help meet the objectives of the policy and provide flexibility for individual harvest strategies**
- **how harvest strategies could appropriately account for the effects of closures**
- **how spatial closures could assist harvest strategies in meeting the objectives of the policy for species whose stocks are highly variable and show strong spatial structuring.**

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14 Acronyms and Abbreviations

ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
AFMA	Australian Fisheries Management Authority
ANCORS	Australian National Centre for Ocean Resources and Security
CSIRO	Commonwealth Scientific and Industrial Research Organisations
DAFF	Department of Agriculture, Fisheries and Forestry
EBFM	Ecosystem Based Fisheries Management
ENGO	Environmental Non-Government Organisation
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i>
ESD	Ecologically Sustainable Development
ERA	Ecological Risk Assessment
ERM	Ecological Risk Management
FAO	Food and Agriculture Organisation of the United Nations
FRDC	Fisheries Research and Development Corporation
MAC	Management Advisory Committee
MEY	Maximum Economic Yield
OCS	Offshore Constitutional Settlement
RAG	Resource Assessment Group
RBC	Recommended Biological Catch
SEWPaC	Department of Sustainability, Environment, Water Populations and Communities
TAC	Total Allowable Catch

15 Glossary

AFMA Commission. AFMA's responsibilities are shared between a Commission and the Chief Executive Officer. The Commission is responsible for domestic fisheries management while the Chief Executive Officer is responsible for foreign compliance and for assisting the Commission and giving effect to its decisions. The Chief Executive Officer is responsible for the agency that supports these functions.

Bycatch. A species that has no commercial value and is (a) incidentally taken in a fishery and returned to the sea, or (b) incidentally affected by interacting with fishing equipment in the fishery, but not taken.

Bycatch policy. *Commonwealth Policy on Fisheries Bycatch 2000*. See daff.gov.au/fisheries/environment/bycatch for more information.

Byproduct. A species taken incidentally in a fishery during fishing for another species but is sometimes or usually retained for sale as it has some commercial value.

Control rules. Agreed responses that management must make under predefined circumstances regarding stock status. Also called 'harvest control rules' or 'decision rules'.

Ecologically Sustainable Development. Using, conserving and enhancing the community's resources so that ecological processes are maintained and the total quality of life, now and in the future, is improved. The principles of ecologically sustainable development are descended in Section 3A of the Fisheries Management Act.

Environment Protection and Biodiversity Conservation Act 1999. Australia's national environment law. The legislation focuses on protecting matters of national importance, such as World Heritage sites, national heritage places, wetlands of international importance (Ramsar wetlands), nationally threatened species and ecological communities, migratory species, Commonwealth marine areas and nuclear actions.

Fisheries management review (Borthwick review). Review of Commonwealth Fisheries: Legislation, Policy and Management, announced in September 2012. See daff.gov.au/fisheries/fisheriesreview for more information.

Guidelines. *Guidelines for Implementation of the Commonwealth Fisheries Harvest Strategy Policy 2007*. The guidelines accompany the harvest strategy policy and provide detailed practical advice for the development and implementation of harvest strategies.

Harvest strategy. Strategy outlining how the catch in a fishery will be adjusted from year to year depending on the size of the stock, the economic or social conditions of the fishery, conditions of other interdependent stocks or species, and uncertainty of biological knowledge. Well-managed fisheries have an unambiguous (explicit and quantitative) harvest strategy that is robust to the unpredictable biological fluctuations to which the stock may be subject.

Harvest strategy policy. *Commonwealth Fisheries Harvest Strategy Policy 2007*. See daff.gov.au/fisheries/domestic/harvest_strategy_policy for more information.

Joint Authority. Jurisdictional arrangements established under an offshore constitutional settlement arrangement whereby a fishery is managed jointly by the Australian Government and one or more states or the Northern Territory under a single (Commonwealth, or state or territory) jurisdiction.

Maximum economic yield (MEY). The sustainable catch level for a commercial fishery that allows net economic returns to be maximised. For most practical discount rates and fishing costs, maximum economic yield implies that the equilibrium stock of fish is larger than that associated with maximum sustainable yield. In this sense, maximum economic yield is more environmentally conservative than maximum sustainable yield and should, in principle, help protect the fishery from unfavourable environmental impacts that could diminish the fish population.

Maximum sustainable yield (MSY). The maximum average annual catch that can be removed from a stock over an indefinite period under prevailing environmental conditions. Maximum sustainable yield defined in this way makes no allowance for environmental variability, and studies have demonstrated that fishing at the level of maximum sustainable yield may not be sustainable.

National Harvest Strategy Guidelines Project. A national project that developed a document describing what harvest strategies are, what the authors consider to be 'best practice' in setting harvest strategies, and how harvest strategies might be applied to a range of fisheries situations across all domestic jurisdictions.

Offshore constitutional settlement. The 1982 package of uniform national, state and territory laws that provides for states to manage coastal waters to three nautical miles from shore and the Australian Government manage from three miles to the edge of the exclusive economic zone. The offshore constitutional settlement also provides for Australian governments at those levels to enter into agreements for specified fisheries to be managed by a particular government or group of governments.

Offshore constitutional settlement arrangement. An arrangement between the Australian Government and state or territory governments that determines jurisdiction for management of a fish stock, type of fishing gear or area. Under offshore constitutional settlement arrangements, a fishery might be managed by the Australian Government, a state or territory governments or combination of the two acting through a joint authority.

Overfished. A fish stock with a biomass below the biomass limit reference point. 'Not overfished' implies that the stock is not below the threshold.

Overfishing, subject to. A stock that is experiencing too much fishing, and the removal rate from the stock is unsustainable.

Precautionary approach/principle. An approach to resource management in which, where there are threats of serious irreversible environmental damage, a lack of full scientific certainty is not used as a reason for postponing measures to prevent environmental degradation. In the application of the precautionary principle, public and private decisions should be guided by; careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment; and an assessment of the risk-weighted consequences of various options.

Rebuilding strategy. Management strategy to rebuild a stock when a measure of its status (for example its biomass) is below the biomass limit reference point (for example the stock is assessed as overfished). Stock rebuilding plans should include elements that define rebuilding targets, rebuilding time horizons and control rules related to the rate of progress.

Reference point. A defined level of an indicator of the economic or biological status of a fishery or stock (or stock size); used as a benchmark for assessment.

Sustainable yield. Catch that can be removed over an indefinite period without reducing the biomass of the stock. This could be either a constant yield from year to year, or a yield that fluctuates in response to changes in abundance.

Total allowable catch (TAC). For a fishery, a catch limit set as an output control on fishing.

Trigger points. Pre-specified quantities (such as total catch, spawning biomass) that indicate the need for a review of fishery management.

Uncertain. Status of a fish stock that might be overfished or not overfished, or subject to overfishing or not subject to overfishing, but for which there is inadequate or inappropriate information to make a reliable estimate.

United Nations Fish Stocks Agreement. The agreement for the implementation of the provisions of the United Nations Convention On The Law Of The Sea of 10 December 1982 relating to the conservation and management of straddling fish stocks and highly migratory fish stocks.

Attachment 1. Terms of Reference

The review is to evaluate the following matters:

The Policy Context

1. The role and functioning of the policy in relation to the broader legislative and policy environment, including:
 - Commonwealth fisheries legislation and policy, including those aspects relevant to other elements of ecologically sustainable development, such as how to manage byproduct
 - Commonwealth environmental legislation and policy
 - other relevant policies and commitments, including those relating to internationally-managed fisheries
 - harvest strategy frameworks and policies applied in other domestic and overseas jurisdictions.

The Guidelines to the Policy

2. The appropriateness and adequacy of the guidelines, including:
 - lessons learned from implementation, including any gaps or omissions identified
 - other areas for improvement, including whether additional guidance is warranted on proxy indicators, reference points and data-poor species
 - additional technical aspects of, or developments in, fisheries management that might improve the guidelines
 - whether the guidelines are sufficiently transparent to inform interested groups and individuals, other than those directly involved in its application.

Implementation

3. The implementation of the policy, including:
 - whether decisions and actions made by AFMA and the Australian Government have been consistent with the policy
 - any issues identified with applying the policy to stocks shared with other Australian jurisdictions
 - trends in biological and economic performance of fisheries managed under the policy
 - whether the policy has affected the efficiency, certainty and transparency of fisheries management and stakeholder confidence in fisheries management arrangements
 - how the policy has been used by Australia in international fisheries management bodies/arrangements
 - how implementation of the policy has been reported.

Outcomes of the review

A review report will be produced for the Australian Government ministers with responsibility for fisheries and environment. The report will consider issues raised during the review process, which may include consideration of technical aspects of the policy and guidelines, information on implementation and other information requested by the review committees. This report will inform a possible revision of the Commonwealth Fisheries Harvest Strategy Policy and Guidelines.

Matters outside scope of review

The setting of individual harvest strategies (for example decision rules and trigger points) and other matters particular to individual stocks and fisheries are generally outside the scope of this review.

However, lessons learnt from the implementation of individual harvest strategies can inform the review of the guidelines. The associated issue of the Commonwealth's policy in relation to bycatch will be the subject of a separate review.

The terms of reference is available online at daff.gov.au/fisheries/domestic/harvest_strategy_policy/terms-of-ref.

Appendices

Appendix A: 2005 Ministerial Direction to AFMA

Appendix B: Technical Reviews for the Commonwealth Harvest Strategy Policy: Technical Overview (draft)

Appendix C: Stakeholder comments from submissions to the review of the Commonwealth Fisheries Harvest Strategy Policy and Guidelines