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Improving the management of bycatch: standards for the effective mitigation of fisheries bycatch

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Non-technical summary

Project 2010/046	Improving the Management of Bycatch: Development and Testing of Standards for the Effective Mitigation of Bycatch in Commonwealth Fisheries

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Objectives

1) Develop standards for mitigating bycatch in Commonwealth fisheries, including an accompanying set of guidelines for establishing technical criteria for assessing the performance, ongoing monitoring and review of bycatch mitigation measures.

2) Test the proposed standards and guidelines on a bycatch issue in a key Commonwealth fishery.

Outcomes achieved to date

Objective 1 was achieved. The project concluded that clearly stated standards, with accompanying technical guidelines, would be useful for identifying, verifying, quantifying, mitigating and managing bycatch in Commonwealth fisheries.

For Objective 2, the funding application specified that 'the standards and guidelines will be tested on an existing bycatch mitigation measure'. This report includes a comparison of the proposed standards and the mitigation of shark bycatch in the Eastern Tuna and Billfish Fishery.

The review of the *Commonwealth Policy on Fisheries Bycatch* was not anticipated when the project was developed. The bycatch policy review is an appropriate vehicle for further discussion, testing and development of the bycatch standards and guidelines proposed by this project.

The motivation for this project was the potential benefits of adopting a more systematic, standardised approach to dealing with bycatch issues in Commonwealth fisheries. Potential benefits include minimising bycatch, sustaining the populations of bycatch species, introducing cost-effective bycatch mitigation measures that do not depress the catch rates of target species and increasing demand for seafood products through consumers recognising the fishing industry's environmental performance. In particular, past reviews have identified the need to demonstrate the effectiveness of bycatch management at all stages, from problem identification through evaluation of management options to the application of successful solutions.

The standards proposed in this report are intended as a benchmark for measuring performance and a checklist of actions for managing bycatch at a fishery level. They are based on the requirements of current Commonwealth legislation and policy. However, they are only proposals at this stage and are not a statement of Australian Government policy. The bycatch standards were developed through reviews of literature, policies and legislation, and through consultation with various experts. This consultation included five separate workshops that considered fisheries monitoring, experimental design, stakeholder engagement, economic evaluation, and indicators and reference points relevant to bycatch management.

Objectives of the Australian Government's *Fisheries Management Act 1991* and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) include minimising fisheries bycatch, ensuring that fisheries do not threaten bycatch populations and avoiding mortality of (or injury to) protected species. The proposed standards, which are listed below and depicted in Figure 1, are consistent with those objectives.

Standard 1. Fisheries bycatch is identified, quantified and prioritised.

Standard 2. Operational objectives, which are consistent with relevant policies and legislative requirements, are specified for managing fisheries bycatch.

Standard 3. The effects of fishing on bycatch populations are assessed.

Standard 4. The cost-effectiveness of bycatch mitigation measures is established.

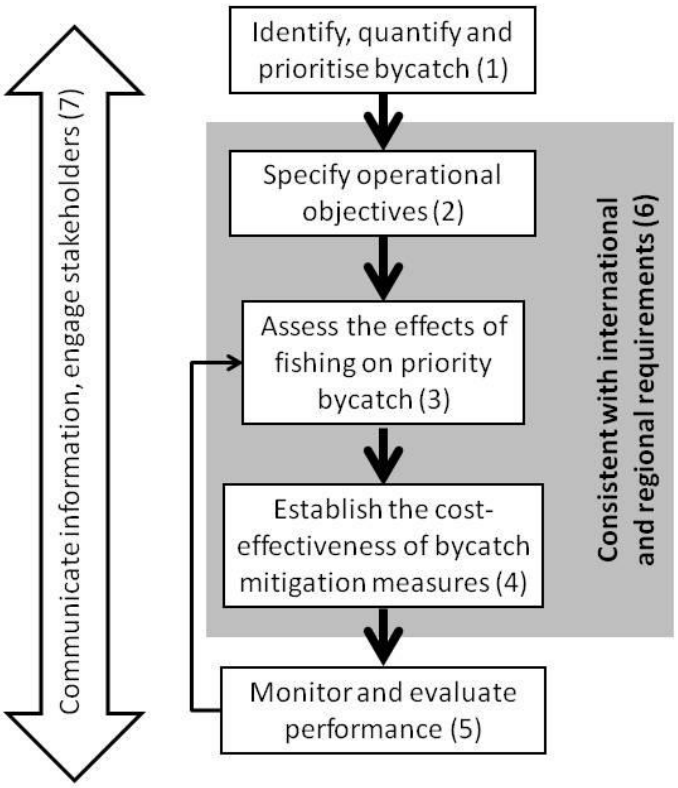
Standard 5. The effectiveness of bycatch management is monitored and evaluated.

Standard 6. Bycatch management is consistent with, and at least equivalent to, the requirements of international and regional fisheries management organisations of which Australia is a member.

Standard 7. Information on bycatch management is communicated and stakeholders are engaged.

This report includes guidelines that provide practical assistance for implementing each standard. The guidelines are based on observations and conclusions from the workshops and they reflect past lessons from managing bycatch in Commonwealth fisheries and elsewhere.

Figure 1 The proposed bycatch standards, which have an overarching aim of minimising bycatch, ensuring that fisheries do not threaten bycatch populations and avoiding the mortality of (or injury to) protected species



Note: Although the standards were not designed as sequential steps, this diagram shows the relationship between the seven standards proposed in this report. Numbers in parentheses are each standard's number.

Standard 1 recognises the need to gather information about fisheries bycatch to enable species and issues to be prioritised for management. The guidelines for Standard 2 suggest how the Australian Government's overarching aims for managing bycatch can be developed into operational objectives for each fishery or bycatch issue. Stakeholders need to be informed and engaged in the development of operational objectives and at all stages in the process shown in Figure 1.

Agreement on measurable operational objectives provides a basis for generating other components of bycatch management. This includes fishery monitoring systems that are used for quantifying bycatch, scientific analyses of these data, and performance measures for judging data quality and the adequacy of data collection programs. The Australian Government uses an evidence-based approach to policy development and decision-making. Depending on the information available, bycatch assessment may be quantitative or risk-based or a combination of these approaches. Quantitative approaches involve robust assessments and practical indicators of fishery impacts on bycatch. Where a rapid response is required or where data are insufficient to fully inform a quantitative approach—which is the situation in many fisheries—a risk-based approach should be used as the basis for decision-making. Risk-based approaches are especially useful for prioritising responses to the large numbers of species with which some fisheries interact.

Evaluation of benefits and costs may guide decisions on the level of resources devoted to addressing the bycatch issue, and may inform decisions over what level of bycatch is acceptable and what management measures should be implemented. At the highest level this system of operational objectives, indicators, performance measures, reference points and decision rules may be equivalent to the harvest strategies that have been established for many commercial species in Commonwealth fisheries. However, the proposed standards do not advocate the implementation of harvest strategies for all bycatch species. Instead, the standards recognise the need for a risk-based approach that can be tailored to each bycatch issue or situation. In large fisheries it may be cost-effective to thoroughly investigate and effectively mitigate a bycatch problem. In other cases the costs of bycatch mitigation may be considered out of proportion to the risk and the fishery's value. Regardless, robust analysis and consideration of all management options is required in such cases.

The proposed standards encourage bycatch mitigation measures that have a strong likelihood of success in typical operating environments. Their costs need to be assessed at an appropriate level and trials of mitigation measures must be designed to be statistically robust. Measures must result in statistically significant reductions in bycatch mortality that will contribute to sustaining populations of bycatch species. At the same time, measures designed to minimise bycatch of one species or species group must not adversely affect other high-risk or protected species. To facilitate their uptake, and thus effective management, mitigation measures should be at least cost to fishers and achieve the required bycatch management outcome.

When mitigation measures have been implemented their performance needs to be monitored and evaluated (Standard 5). Metrics are needed that measure the effectiveness of management responses in meeting their objectives. Monitoring needs to be adequate to assess the measure's effectiveness. Of relevance to the implementation of mitigation measures is the Australian Fishery Management Authority's ecological risk management approach, which provides for fishery-level Bycatch and Discard Work Plans. The Australian Government also encourages fishing industry sectors to develop codes of practice that provide detailed information on protocols for minimising bycatch, facilitate compliance with regulations and that are consistent with relevant policies.

This report includes an example of how the proposed bycatch standards might have been applied to a measure to mitigate shark bycatch in the Eastern Tuna and Billfish Fishery, which was first implemented in 2005. It shows that this measure would have met many of the proposed standards. However, it did not clearly identify performance measures and the effectiveness of the mitigation measure has not been monitored. Further work is needed to test the proposed standards and guidelines on an emerging bycatch issue in a Commonwealth fishery. In the meantime, the proposed standards and guidelines are being considered by the review of the *Commonwealth Policy on Fisheries Bycatch 2000*, which commenced in 2012.

Key words: fisheries bycatch, non-target species, incidental catch, marine wildlife, bycatch mitigation, fishery management

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1 Background

Project aims

The project's aim was to identify a consistent and transparent approach to managing bycatch in Commonwealth fisheries that is defined by operational standards and practical guidelines covering a range of aspects relevant to bycatch mitigation and management. These bycatch standards and guidelines were developed within the current legal, policy and management framework. A review of the *Commonwealth Policy on Fisheries Bycatch 2000* (DAFF 2000; 'Bycatch Policy') commenced toward the end of the project, in 2012. The work undertaken by the project is being used as information by the review and may contribute to policy development in the future.

This report uses the definition of 'bycatch' from the Bycatch Policy (DAFF 2000):

- that part of a fisher's catch which is returned to the sea either because it has no commercial value or because regulations preclude it being retained
- that part of the catch that does not reach the deck of the fishing vessel, but is affected by interaction with the fishing gear.

Commercial species include species under rebuilding plans and those discarded or released because they are damaged, poor quality, outside body-size regulations, an unmarketable size or in excess to quota. Discarding and incidental catches of commercial species were not considered in the current report because they are managed through the *Commonwealth Fisheries Harvest Strategy Policy and Guidelines 2007* (DAFF 2007; 'Harvest Strategy Policy').

Identification of the need to mitigate bycatch is outside this project's scope. Bycatch issues are identified by monitoring fishery performance against objectives (DAFF 2000), routine risk assessment or from ad hoc processes, such as the introduction of market access restrictions, conditions imposed through strategic assessments or lobbying by conservation, community or consumer groups.

Policy context

Objectives of the Australian Government's *Fisheries Management Act 1991* and the *Environment Protection and Biodiversity Conservation Act 1999 (*EPBC Act) include minimising fisheries bycatch, ensuring that fisheries do not threaten bycatch populations and avoiding mortality of (or injury to) protected species. Unlike commercial fish species, a systematic framework to assess and manage bycatch is in its infancy for fisheries managed by the Australian Government and elsewhere. Fisheries management needs to evolve to a cost-effective approach to all species directly affected by fishing regardless of whether the species is classified as 'bycatch', 'byproduct' or a 'key commercial species'.

The term 'protected species' refers to species listed under Part 13 of the EPBC Act. These include whales and other cetaceans and marine and migratory species that are considered threatened. As a result these species have been listed as vulnerable, endangered or critically endangered under the Act because they are facing a risk of extinction in the wild. Several other marine species are also protected under the EPBC Act as 'listed marine species'. Species listed as requiring protection under international conventions and agreements to which Australia is party are also protected under the EPBC Act. These include migratory species such as sharks,

birds and mammals. Protected species are sometimes referred to as Threatened, Endangered or Protected (TEP) species.

Bycatch management is the process of ensuring that fishing activities meet objectives. It involves implementing data collection programs, analysis, assessment and mitigation measures, and performance monitoring and reporting. Mitigation measures are specific management actions that are intended to minimise bycatch and protect bycatch populations. They include managing fishing effort (for example, time-area closures) and modifying fishing gear and practices.

The proposed bycatch standards and guidelines are intended to be consistent with the mandates and processes of the relevant Australian Government agencies, and to present a transparent outline of the overall approach for managing bycatch. Despite being developed in the 1990s and currently under review, the principles of Australia's *National Policy on Fisheries Bycatch 1999 (DAFF 1999)* and the Commonwealth Bycatch Policy remain current. However, the means by which they are implemented has evolved over time; there are now assessment methods and management procedures that differ from those originally envisaged in the policy. These include the scientific process of ecological risk assessment (ERA) and associated ecological risk management (ERM) response to these assessments. Bycatch Action Plans, which were identified in the Bycatch Policy, have also been superseded by AFMA's Bycatch and Discard Work Plans. These work plans are more detailed than Bycatch Action Plans and they focus on species identified in ERAs as being at higher risk.

This project focused on the Australian Government's objectives of minimising fisheries bycatch, ensuring that fishing does not threaten bycatch populations and avoiding mortality of (or injury to) protected species. The scope did not extend to managing wastage and the discarding of commercial species because this is not in the current Bycatch Policy and is an area of potential policy development.

Commonwealth fisheries management recognises that fishing operators are granted a 'social license to operate' by the public. The marine environment is a shared natural resource, so it is expected that the best balance of different interests should be achieved. However, inherent and unavoidable trade-offs make it difficult to reconcile diverse societal objectives so all stakeholders are satisfied. Government must implement legislative requirements that seek to safeguard and achieve a socially acceptable balance of all these interests, and there are various legislative, economic, environmental, social and political perspectives that need to be accommodated. Government is also expected to provide the most effective fisheries management for the least cost. It may be useful to assess the relative merits of different management options, with explicit recognition and evaluation of any unavoidable trade-offs.

Many factors, including fishery restructuring programs, closures and fluctuating currency exchange rates, fuel prices and market demand, have affected Commonwealth fisheries in recent years. This operating environment is not constant and there is considerable variability at all scales. The guidelines are intended to be non-prescriptive, as further innovation may result in alternative but equally suitable measures being developed by which the standards may be achieved.

The standards and guidelines proposed in this report are not a statement of Australian Government policy. In 2012, toward the end of the present project, the Minister for Agriculture, Fisheries and Forestry announced concurrent reviews of the Bycatch Policy and the Harvest Strategy Policy. The reviews are scheduled to present reports in 2013. The review of the Bycatch Policy allows further discussion and development of the bycatch standards and guidelines proposed by the present project.

What is a standard?

A standard is 'a level of quality that is regarded as normal, adequate, or acceptable' (The Concise Macquarie Dictionary 1982). Process standards provide guidance about the consistent use of agreed procedures. Performance standards provide guidance on expected levels of performance. Standards may be expressed as:

1) a qualitative description (such as ASSSA5300—Australian Fish Names Standard) or a standard operating procedure, such as a pilot's flight manual

2) a number or series of metrics, (such as BSEN60529—British standard finger is 12.5 mm in diameter by 80 mm in length)

3) criteria to determine how numerical values are derived (such as ISO14033 for compiling and communicating quantitative environmental information).

'Standards', as discussed in this report, are a framework of values that reflect the requirements of current Commonwealth legislation and policy for managing fishery bycatch. The standards proposed in this report can be thought of both as a benchmark for measuring performance and a checklist for structuring management actions. They are succinct statements of principle, supported by detailed guidelines that illustrate how the standards might be implemented. They are intended to be applicable across all Commonwealth fisheries, to a broad range of fishing gear types (such as trawl and longline) and natural environments (including tropical, temperate, demersal and pelagic). They cover several topics, including measures of the effectiveness of bycatch management, criteria for identification, evaluation and selection of mitigation measures, and procedures for using reference points to guide fisheries management decisions and calculate sustainable levels of fishing impact.

Standards should be operational, rather than aspirational. Performance measures should be met and standard operating procedures should be followed. Standards do not serve the same role as strategic plans, which normally identify long-term goals or medium-term targets. Standards reflect what should be expected in the present rather than in the future. They derive from the existing science base, reflect ongoing management practice and sit within the present legislative and policy context. If any of these factors (science, management or policy) change, the proposed standards may need to be reconsidered and revised.

Standards may be established as alternatives or supplementary measures to regulation, or they may be incorporated as components of regulations themselves. For example, the US *Magnuson–Stevens Fishery Conservation and Management Act 1996* (Magnuson–Stevens Act) presents 10 national standards to establish the framework for fisheries management (Box 1). Each standard has accompanying guidelines that expand on the issues to be addressed and the approaches to be used in implementing the standards. US National Standard 9 relate to fisheries bycatch and the guidelines for that standard are presented in abridged form in Box 2. The international Marine Stewardship Council (MSC) has published principles and criteria for sustainable fishing (Box 3). The MSC principles include the maintenance of ecosystems, including habitat and associated dependent and ecologically related species, on which fisheries depend.

Box 1 United States Magnuson–Stevens Act Provisions

National Standards for Fisheries Conservation and Management

1) Conservation and management measures shall prevent overfishing while achieving, on a continuing basis, the Optimal Yield from each fishery for the U.S. fishing industry.
2) Conservation and management measures shall be based upon the best scientific information available.
3) To the extent practicable, an individual stock of fish shall be managed as a unit throughout its range, and interrelated stocks of fish shall be managed as a unit or in close coordination.
4) Conservation and management measures shall not discriminate between residents of different states. If it becomes necessary to allocate or assign fishing privileges among various U.S. fishermen, such allocation shall be:

Fair and equitable to all such fishermen.
Reasonably calculated to promote conservation.
Carried out in such manner that no particular individual, corporation, or other entity acquires an excessive share of such privileges.

5) Conservation and management measures shall, where practicable, consider efficiency in the utilization of fishery resources; except that no such measure shall have economic allocation as its sole purpose.
6) Conservation and management measures shall take into account and allow for variations among, and contingencies in, fisheries, fishery resources, and catches.
7) Conservation and management measures shall, where practicable, minimize costs and avoid unnecessary duplication.
8) Conservation and management measures shall, consistent with the conservation requirements of the Magnuson–Stevens Act (including the prevention of overfishing and rebuilding of overfished stocks), take into account the importance of fishery resources to fishing communities in order to:

Provide for the sustained participation of such communities; and
To the extent practicable, minimize adverse economic impacts on such communities.

9) Conservation and management measures shall, to the extent practicable:

Minimize bycatch; and
To the extent bycatch cannot be avoided, minimize the mortality of such bycatch.

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

Source: US Government (1996)

Box 2 Guidelines for US National Standard 9-Bycatch from the Magnuson-Stevens Act Provisions

§ 600.350 National Standard 9—Bycatch [abridged]

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

11) Minimize bycatch; and
12) To the extent bycatch cannot be avoided, minimize the mortality of such bycatch.

(b) General. ... Bycatch can, in two ways, impede efforts to protect marine ecosystems and achieve sustainable fisheries and the full benefits they can provide to the Nation. First, bycatch can increase substantially the uncertainty concerning total fishing-related mortality, which makes it more difficult to assess the status of stocks, to set the appropriate [optimum yield] and define overfishing levels, and to ensure that [optimum yields] are attained and overfishing levels are not exceeded. Second, bycatch may also preclude other more productive uses of fishery resources.

(c) Definition—Bycatch. The term 'bycatch' means fish that are harvested in a fishery, but that are not sold or kept for personal use. Bycatch includes the discard of whole fish at sea or elsewhere, including economic discards and regulatory discards, and fishing mortality due to an encounter with fishing gear that does not result in capture of fish (i.e., unobserved fishing mortality). Bycatch does not include any fish that legally are retained in a fishery and kept for personal, tribal, or cultural use, or that enter commerce through sale, barter, or trade...

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

Councils must—

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

14) For each management measure, assess the effects on the amount and type of bycatch and bycatch mortality in the fishery. Most conservation and management measures can affect the amounts of bycatch or bycatch mortality in a fishery, as well as the extent to which further reductions in bycatch are practicable. In analysing measures, including the status quo, Councils should assess the impacts of minimizing bycatch and bycatch mortality, as well as consistency of the selected measure with other national standards and applicable laws. The benefits of minimizing bycatch to the extent practicable should be identified and an assessment of the impact of the selected measure on bycatch and bycatch mortality provided...

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

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

- Population effects for the bycatch species.
- Ecological effects due to changes in the bycatch of that species (effects on other species in the ecosystem).
- Changes in the bycatch of other species of fish and the resulting population and ecosystem effects.
- Effects on marine mammals and birds.
- Changes in fishing, processing, disposal, and marketing costs.
- Changes in fishing practices and behaviour of fishermen.
- Changes in research, administration, and enforcement costs and management effectiveness.
- Changes in the economic, social, or cultural value of fishing activities and non-consumptive uses of fishery resources.
- Changes in the distribution of benefits and costs.
- Social effects.

(ii) The Councils should adhere to the precautionary approach found in the Food and Agriculture Organization of the United Nations (FAO) Code of Conduct for Responsible Fisheries (Article 6.5), ...when faced with uncertainty concerning any of the factors listed in this paragraph (d)(3).

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

(e) Other considerations. Other applicable laws, such as the MMPA, the ESA, and the Migratory Bird Treaty Act, require that Councils consider the impact of conservation and management measures on living marine resources other than fish; i.e., marine mammals and birds.

Source: US Government (2010)

Box 3 Marine Stewardship Council Fishery Standard: Principles and criteria for sustainable fishing (Principle 2: maintenance of the ecosystem)

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

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

Criteria:
The fishery is conducted in a way that maintains natural functional relationships among species and should not lead to trophic cascades or ecosystem state changes.
The fishery is conducted in a manner that does not threaten biological diversity at the genetic, species or population levels and avoids or minimises mortality of, or injuries to endangered, threatened or protected species.

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

Source: MSC (2012)

Related studies

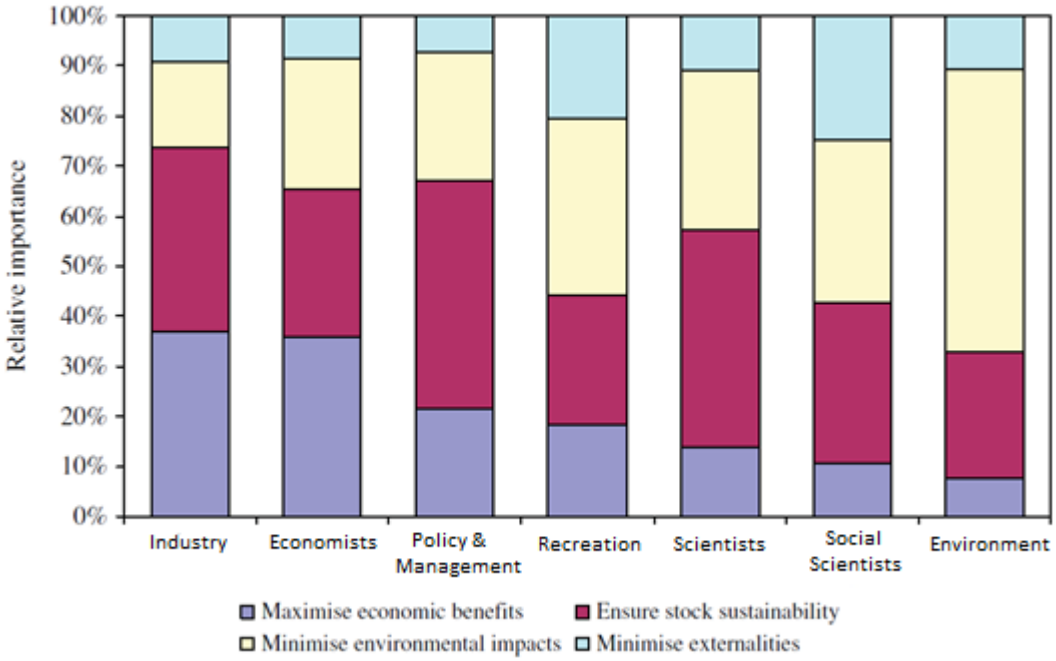
Examples of studies that have reported on the nature and extent of bycatch in Commonwealth fisheries are listed under Standard 1 of this report. They include Harris and Ward (1999), who reviewed information on bycatch in each Commonwealth fishery, Tuck et al. (2013) who reported trends in bycatch in selected Commonwealth fisheries, and studies of bycatch in specific fisheries, for example the Eastern Tuna and Billfish Fishery (Moeseneder et al. 2010) and the Northern Prawn Fishery (Dell et al. 2009; Stobutzki et al. 2002; Stobutzki et al. 2003; Tonks et al. 2008). There are several global reviews of fisheries bycatch. For example, Bache (2003) reviewed trends and international initiatives in mitigating marine wildlife bycatch. As detailed earlier in this introduction, Bensley et al. (2010) reviewed government performance in managing wildlife bycatch in Australia.

Brooks (2009) researched the perceptions and attitudes of members of government and environmental non-government organisations (NGOs) toward the South East Trawl Fishing Industry. Brooks noted the perception that bycatch levels were too high and a perceived lack of reporting by the fishery and lack of transparency in the industry's actions. Half the people interviewed did not know about or could not detail the bycatch mitigation measures used. Many respondents also felt that industry is suspicious of embracing new technology, and that 'due to the lack of monitoring data and benchmarks, it is not possible to demonstrate the effectiveness of these measures'. Brooks (2009) concluded that employment of bycatch mitigation measures must be embraced by industry as a continual process in order to be seen positively by the broader community.

Pascoe et al. (2009) is another study particularly relevant to this project and to the ongoing Bycatch Policy review. They surveyed 74 stakeholders with declared interests in fisheries: industry, economists, policy and management officers, recreational fishers, scientists, social scientists and representatives of conservation NGOs. An explicit hierarchy of management objectives for Commonwealth fisheries was developed (Figure 3) and the relative weighting given by stakeholder groups for those objectives was established.

The higher level objectives reflect a 'triple bottom line' approach, with economic issues covered under 'enhance economic performance', environmental issues under 'ensure resource sustainability (commercial)' and 'minimise environmental impacts' and social issues covered under 'minimise externalities'. The relative importance each stakeholder group placed on the different high-level objectives varied considerably (Figure 2). Economic objectives were relatively more important to economists and industry. There was consistency among groups on the relative importance of sustainable commercial stocks. This was the most important objective to fisheries managers and scientists. Environmental objectives were relatively more important to environmental NGOs. For most stakeholder groups, bycatch reduction and habitat protection were considered fairly equal. For bycatch, greater importance was given to protected species, and for habitat protection, greater importance was given to certain habitats, rather than habitat protection in general. For most groups, the relative importance of minimising externalities (such as spill over effects to other fisheries) was relatively low.

Figure 2 Relative importance of fishery management objectives to different stakeholder groups

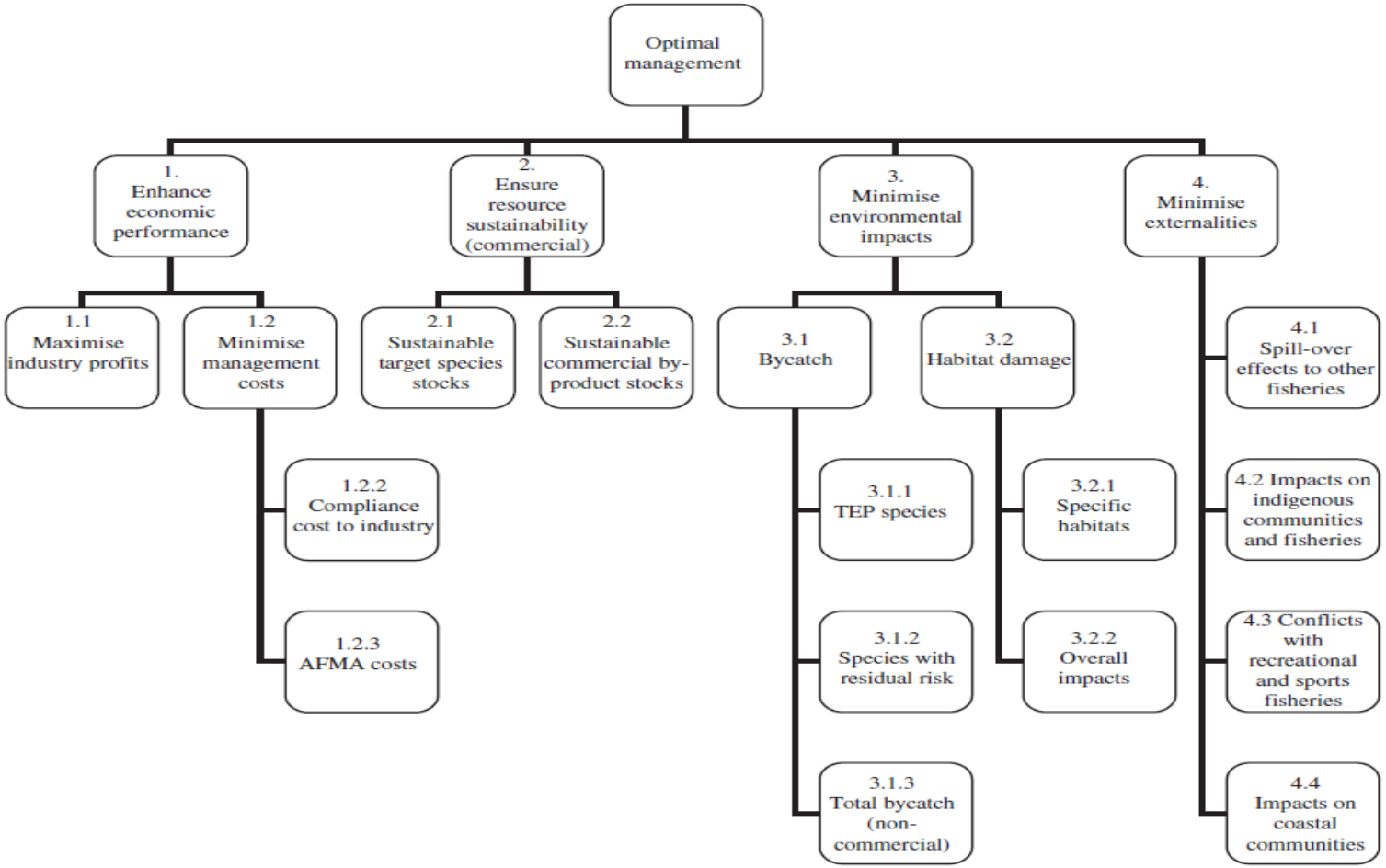


Note: Higher level objective weights are sorted from highest to lowest weight for economic objectives.

Data source: Pascoe et al. (2009)

The results show the differences in relative importance different stakeholder groups gave to the multiple objectives of fisheries management. However, higher order objective preferences of all respondents (irrespective of stakeholder group) were compared and there is a good chance of reaching agreement on the most important objectives (Pascoe et al. 2009). This suggests that transparent, evidence-based processes that are open to all stakeholders may help reconcile diverse objectives, and that bycatch management can be integrated into the core business of fisheries management.

Figure 3 A suggested hierarchy of management objectives for Commonwealth fisheries



Data source: Pascoe et al. (2009)

Need

The project *Improving the Management of Bycatch: Development and Testing of Standards for the Effective Mitigation of Bycatch in Commonwealth Fisheries* (referred to as the Bycatch Standards Project) was undertaken by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) in collaboration with the Australian Fisheries Management Authority (AFMA) and with input from various other individuals and government agencies (see Acknowledgements and Appendix 2).

The Bycatch Standards Project was developed in response to several issues identified by Bensley et al. (2010) about the management of bycatch in Commonwealth fisheries. Firstly, the management of fisheries bycatch, in particular wildlife bycatch (that is, bycatch of protected species), has often been reactive rather than proactive. Consequently, bycatch management has sometimes been confusing or confrontational and has not always been cost-effective. Standards and guidelines developed with broad stakeholder input should allow a more strategic and effective approach to bycatch to be developed, with defined goals, monitoring systems and management processes.

Secondly, Bensley et al. (2010) identified the need for performance standards to judge the effectiveness of technical methods developed to reduce bycatch ('input controls'). There will be diminishing returns in that each additional improvement will have a progressively higher cost as bycatch levels approach zero. There is no benefit in fishers being required to use gear modifications or to change fishing practices if bycatch is not reduced. It is also difficult for fishers to adopt mitigation measures at prohibitively high cost.

Thirdly, Bensley et al. (2010) recommended that management agencies be able to demonstrate the effectiveness of bycatch management and mitigation measures at all stages, from problem identification through evaluation of management options to application of successful solutions. This implies that indicators, performance measures and reference points (also known as benchmarks) should be identified for judging performance.

Objectives

4) Develop standards for mitigating bycatch in Commonwealth fisheries, including an accompanying set of guidelines for establishing technical criteria for assessing the performance, ongoing monitoring and review of bycatch mitigation measures.

5) Test the proposed standards and guidelines on a bycatch issue in a key Commonwealth fishery.

2 Methods

The project was guided by an advisory committee comprising representatives from ABARES, AFMA, the Commonwealth Fisheries Association, CSIRO, the Department of Agriculture, Fisheries and Forestry (DAFF), the South East Trawl Fishing Industry Association, the Department of Sustainability, Environment, Water, Populations and Communities (SEWPaC) and the wildlife trade monitoring network (TRAFFIC). The project reported to the advisory committee and to the AFMA Environment Committee. The proposed standards and guidelines should not be viewed as having been agreed by the above groups or agencies.

The proposed standards were developed following reviews of how bycatch is presently managed in Commonwealth fisheries, which included a series of projects on wildlife bycatch (Bensley et al. 2010), a review of the ecological risk assessment (ERA) and ecological risk management (ERM) processes of AFMA, consideration of the assessments done by SEWPaC, and consideration of the processes for listing threatened species for protection under the EPBC Act. The project also considered how standards are used for fisheries management in other countries and in other natural resource management systems. International standards from intergovernmental bodies such as the Food and Agriculture Organization of the United Nations (FAO), the Agreement on the Conservation of Albatrosses and Petrels, and the International Union for the Conservation of Nature were considered, as were bycatch management measures agreed by regional fisheries management organisations. The proposed standards in this report are based on existing Commonwealth legislation and policy because the authors were not in a position to propose new policy or propose linkages between Commonwealth legislation and international or state instruments.

To ensure the proposed guidelines provide thorough, practical and relevant advice on bycatch management, a series of workshops was held in late 2010 and early 2011 on the following themes: fisheries monitoring, experimental design, stakeholder engagement, economic evaluation, and bycatch indicators and reference points. Various experts and stakeholder representatives attended these workshops to discuss their experiences and lessons learned. A full list of participants for each workshop is in Appendix 2. The guidelines presented in this report were based on discussions at the workshops.

The Fisheries Monitoring Workshop discussed the various systems used to observe fisheries, how data are analysed and the extent to which statistically valid inferences may be drawn about the fishery from these data. The coverage and veracity of catch and effort data reported by fishers in logbooks, including interactions with protected species, were discussed, as were the benefits and costs of scientific observer programs. Electronic monitoring technology (such as onboard cameras) was also considered as a way to improve and validate logbook reporting while reducing observer monitoring costs.

The Experimental Design Workshop focused on how to undertake research trials of new bycatch mitigation measures so that statistically valid inferences may be drawn about their performance in reducing bycatch. Notes on the testing protocol for new turtle excluder devices and bycatch reduction devices in the Northern Prawn Fishery were a useful example of how experimental design criteria may be used to assess and approve technical bycatch mitigation measures.

The Stakeholder Engagement Workshop brought together key stakeholders in Commonwealth fisheries, including industry, environmental NGOs and government agencies. It gave them the opportunity to identify strengths and weaknesses in current processes for engaging in fisheries bycatch management. An overview of stakeholder engagement in natural resources

management was also provided by an ABARES social scientist. The workshop highlighted the need for early, continuous and well-informed engagement with all stakeholders.

The Economic Evaluation Workshop discussed the benefits of framing the management of fisheries bycatch, as in other areas of natural resource management, in terms of benefits and costs of fishing activities, comparison of the cost-effectiveness of alternative management actions and quantification of the marginal costs of incremental actions. It was recognised that bycatch is often considered as an externality to fisheries economics and a market failure as it is not usually costed, nor is this cost reflected in seafood prices. Perverse incentives may also operate. For example, sustainably produced seafood can be more expensive than seafood from fisheries with lower environmental standards. Several ways of addressing these problems were identified, along with a potential protocol for evaluating future bycatch management issues.

The Bycatch Indicators and Reference Points Workshop discussed the feasibility of different types of empirical and model-based indicators and the criteria by which appropriate reference points may be determined. The methods used in AFMA–CSIRO ecological risk assessments were reviewed and reference points used to derive management advice from these assessments were discussed. The framework approach presented in the Harvest Strategy Policy was considered because this policy is implemented through a system of specified objectives, control rules, tiered assessments and other technical measures that may be applicable to bycatch management. The workshop also reviewed other management measures that use explicit performance measures or trigger limits, such as the *Threat Abatement Plan 2006 for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations* ('the Seabird TAP'; DEWHA 2006).

3 Results and discussion

Standard 1: Fisheries bycatch is identified, quantified and prioritised

Bycatch is identified, quantified and verified through one or more of the following fisheries monitoring systems:
reporting of operational-level catch and effort data in logbooks
scientific or independent observer programs
electronic monitoring
self-reporting of bycatch interactions.

The design of fisheries monitoring systems is statistically robust, so as to permit the identification, quantification and verification of bycatch with a reasonable degree of confidence.
Fishery-wide bycatch management is prioritised through analyses of the data collected by these monitoring systems.

Guidelines for Standard 1

Overview

The purpose of this standard is to identify systems for detecting, quantifying and prioritising fisheries bycatch, which is fundamental to setting performance measures, evaluating performance and, ultimately, meeting the objectives of bycatch management. Standard 1 states that information about fisheries bycatch will be gathered, through various means, to enable species and issues to be prioritised and for management-relevant scientific questions to be addressed.

Standard 1.1 is supported by Standard 1.2, which sets a general performance measure for evaluating fisheries monitoring systems and the evidence they generate. Standard 1.3 involves risk-based analyses of the data obtained through fisheries monitoring. Risk-based approaches, including ecological risk assessments, facilitate the identification of high and medium-risk bycatch species that may need to be managed. Combined with information on fishery interaction rates, the listing of species under the EPBC Act is an overriding consideration in prioritising bycatch management.

Fisheries monitoring systems provide the data to support decision-making. There are various types of data, as well as options for data collection, each of which have merits such as accuracy, precision, practicality and cost. Integration of multiple data sources can allow more powerful analysis than any single data source. The quality of reporting may vary due to difficulties in identifying species, operational constraints or disincentives. Data quality on high-volume bycatch can be good because it is often easy to measure. In contrast, interactions with some species may be extremely rare or episodic; and there may be under-reporting or non-reporting of protected species, especially small species such as syngnathids (seahorses, pipefish and sea dragons). Increased reporting rates by fishers who are keen to demonstrate improved environmental performance must be handled sensitively by government, as better reporting rates could be misconstrued as increasing interactions.

This project's Fishery Monitoring Workshop noted progress in improving data management procedures and the databases used to store data from monitoring programs for Commonwealth

fisheries. Research has demonstrated that it is possible to automate the estimation of bycatch from observer data, for routine consideration by resource assessment and management advisory bodies (Moeseneder et al. 2010). Automated estimation is not presently operational, but is a priority for AFMA.

With the implementation of ERM, ongoing data collection should focus on what inputs are needed for ecological risk assessments of multiple species. It is likely that such assessments will be repeated every few years or whenever a significant change in fishing operations takes place. Such data collection or sampling needs to be representative of fishing activities. This should be an iterative process so that additional and more comprehensive data may be obtained on species or processes evaluated as high risk.

Types of fisheries monitoring systems

(a) Reporting of operational-level catch and effort in logbooks

Logbooks contain data on catches of target species, incidental catch of other commercial species and bycatch. They may also contain information on fishing gear and practices that are crucial for interpreting catch and effort data, such as trawl mesh size and operation times. Several studies have noted problems with the coverage or quality of bycatch data reported in logbooks (including Phillips et al. 2010). This project's Fishery Monitoring Workshop recognised that there are practical difficulties in relying on logbooks to cover all bycatch species. The main concerns are accuracy in identifying species and potential bias in reporting. Logbook data should be verified by comparing it with independent data, such as data from scientific observers and electronic monitoring.

(b) Scientific or independent observer programs

Scientific observers on fishing vessels provide comprehensive and independent data on bycatch. Catch composition can be recorded in detail along with important operational aspects of fishing operations, such as timing and location of sets, fishing gear configuration and use of mitigation measures. Observers can also collect biological samples for other studies, if needed (AFMA 2010a).

Participants of the Fishery Monitoring Workshop noted that the level of observer coverage required to obtain robust estimates of bycatch increases as the frequency of bycatch interactions diminishes or the variability increases. This was also demonstrated by Bravington et al. (2002) and Brewer et al. (2006). High levels of scientific observer coverage are expensive and efforts to minimise observer costs can jeopardise the usefulness of observer data through inadequate or unrepresentative coverage. Some fisheries (such as the Northern Prawn Fishery) have developed observer programs that involve crewmembers undertaking certain observer duties. Industry-based observer programs can extend observer coverage and are particularly useful when developing and implementing mitigation measures and improving the survival rates of animals that are released. Industry-based observer programs require considerable investments in training and validation. Industry observers cannot be expected to independently report on compliance and other issues that might directly affect their fishing vessel.

One reason for bycatch monitoring by observers is to demonstrate compliance with threat abatement plans (such as the Seabird TAP), other recovery plans or other management strategies for protected species. This may require high levels of observer coverage because statistically rare events may constitute a significant impact on species with small population sizes. For trigger-based management to be effective, the trigger levels must be set for the specific coverage levels of the monitoring systems. For example, the management strategy for Australian

sea lions (AFMA 2010b) specifies the trigger (the number of sea lions of either sex) and the minimum observer coverage (the percentage of fishing effort and number of observer days) in each of seven regions. A region is closed to gillnet fishing for the remainder of the fishing season if the trigger level is reached. The strategy also specifies an overall trigger that would result in the remaining open regions being closed to fishing for the duration of the season.

(c) Electronic monitoring

'Electronic monitoring', the remote observation of fishing activities using fixed, onboard automatic digital video cameras, is a new technology that has been trialled in several Commonwealth fisheries (for example, Lara-Lopez et al. 2012; Piasente et al. 2012). Several cameras are used to cover the most relevant areas of the vessel and the footage is reviewed onshore. Species identification is possible for visually distinct species. Electronic monitoring has the potential to supplement or replace some of the roles of observers and may lead to improved reporting in logbooks. Validation and practical trials are required for demonstrating the effectiveness and relative costs and benefits of electronic monitoring.

(d) Self-reporting of bycatch interactions

Self-reporting is specifically included in Standard 1 to cover the legal requirement for vessel operators to report interactions with protected species. For other bycatch species, section 1.1(a) provides guidance on self-reporting through logbooks and section 1.1(b) provides guidance on industry-based observer programs.

All Commonwealth fisheries have been assessed and accredited under the EPBC Act to demonstrate that planned management measures take all reasonable steps to ensure protected species are not adversely affected by fishing operations. It is not an offence to interact with a protected species provided an operator fishes in accordance with the accredited fishery management arrangements. However, this does not preclude management intervention and it is an offence not to report these interactions. Interactions with protected species are recorded in logbooks and AFMA provides quarterly summary reports of these to SEWPaC.

Designing bycatch monitoring systems

As a general principle, the sampling design, data collection protocols, data handling procedures, data analysis and methods for reporting bycatch must enable management-relevant scientific questions to be addressed adequately and cost-effectively. This project's Fishery Monitoring Workshop discussed how monitoring programs are often subject to multiple competing or conflicting demands. Sampling protocols may therefore differ depending on the subject of the study and need to be scaled to the assessed level of risk posed by the activity. If the multiple objectives are made explicit, the monitoring system can be designed so that useful information can be obtained on each objective and the best information on the most important objective. Alternatively, flexible allocation of observer duties, which depends on onboard activities or events, can allow multiple objectives to be separately addressed or prioritised at appropriate times.

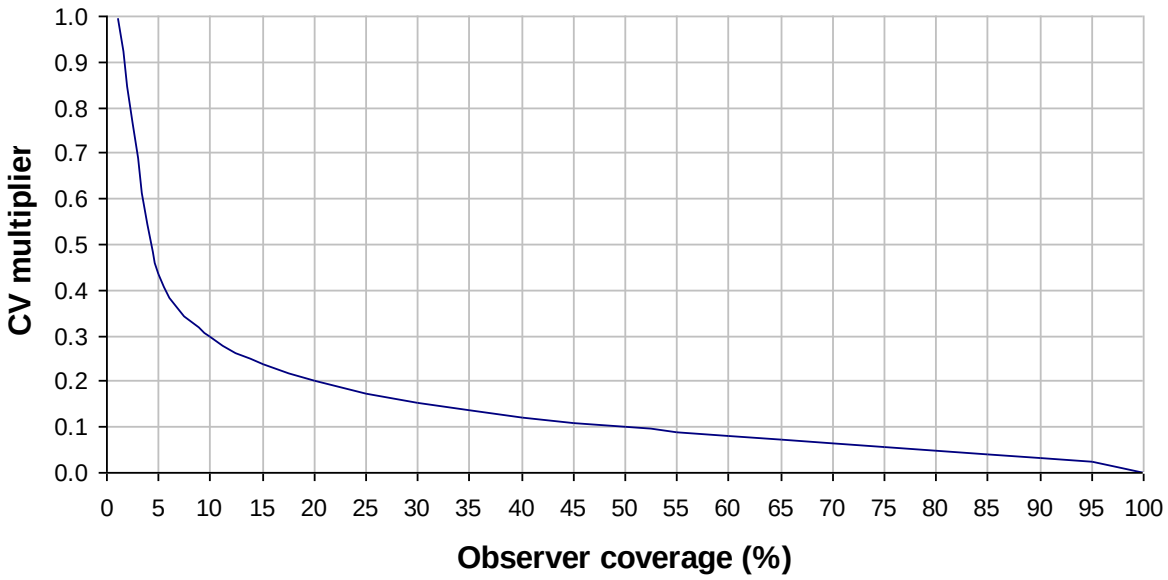
The extent to which the data sample is representative of the entire fishery needs to be considered. It is often necessary to raise observed sample fishery-level or population-level estimates (for example, where only part of a fishery is observed). This requires the design of monitoring systems to be determined by sampling theory, such that the events that monitoring is intended to detect (such as seabird bycatch), which may be statistically rare, have an acceptable likelihood of being detected. Statistical modelling can be used to adjust bycatch

estimates that are biased by any statistical deficiencies in program design. Examples of such analyses include Bravington et al. (2002), Lawrence et al. (2009) and Bergh et al. (2009).

The precision or uncertainty of point estimates of catches or catch rates requires an estimate of the coefficient of variation (CV) around the point estimate. Determining whether the analysis is useful and management action will achieve its objectives requires uncertainty (CVs) to be appropriately estimated, and then minimised. This ensures that scientific information is of known and adequate quality, with levels of accuracy and precision proportionate to the levels of risk.

A practical consideration is the cost and benefits of increased sampling. Sampling theory demonstrates that the greatest improvements in precision are realised as the percentage of events sampled increases from zero to some moderate level of coverage, after which there are diminishing improvements (Figure 4). The optimal level of sampling will need to be appropriate for the management objective(s) and will depend on the approach of decision-makers in accepting uncertainty in achieving those objectives.

Figure 4 Relationship between observer coverage and the coefficient of variation (CV)



Note: The generation of this relationship involves a multiplier applied to the actual CV, which depends on the catch rate.
Data source: Lawson (2004)

Examples of bycatch estimation

Harris and Ward (1999) and Tuck et al. (2013) reviewed the available information for non-target catch in Commonwealth fisheries, including the amount and composition of bycatch. There are various studies that have examined bycatch in specific fisheries. Moeseneder et al. (2010) reviewed bycatch in the Eastern Tuna and Billfish Fishery as part of a project to develop a framework to provide rapid estimates of catch and bycatch. Similarly, several studies have reported on bycatch associated with the Northern Prawn Fishery, including Dell et al. (2009), Stobutzki et al. (2002), Stobutzki et al. (2003) and Tonks et al. (2008).

Ecological risk assessment

The Ecological Risk Assessment for Effects of Fishing (ERA) comprises a suite of methods of increasing complexity, information requirement and cost, which have been used to assess the effect of Commonwealth fisheries on all the species that they may interact with (Hobday et al.

2011). The ERA process was developed as a hierarchical assessment to cater for different levels of complexity and cost, ranging from qualitative to quantitative, comprehensive to focused and inexpensive to costly (Box 4). The ERA results are the primary means by which AFMA assesses and prioritises the need for an ecological risk management (ERM) response. ERA and ERM also extend to assessment and to decision-making (Standard 3.4) where a rapid response is required or where data are insufficient for an analytical approach.

The Indicators and Reference Point Workshop noted that the Productivity–Susceptibility Analysis (PSA) and Sustainability Assessment for Fishing Effects (SAFE) analyses (Zhou & Griffiths 2008) enable priorities to be set for monitoring or conducting further research on particular species. Both methods incorporate a risk-based approach to uncertainty by assigning 'precautionary high risk' scores to attributes when data for that species or for closely related species are not available—that is, false positives, where the hypothesis is not rejected when it is in fact false, are more precautionary and considered preferable to false negatives.

Box 4 Stages in the AFMA–CSIRO Ecological Risk Assessment for Effects of Fishing

Level 1: Scale, Intensity, Consequence Analysis (SICA)—a qualitative approach based on stakeholder and expert opinion, to identify scale, intensity and consequence of all fishing activities on all ecosystem components.

Level 2: Productivity–Susceptibility Analysis (PSA)—an attributes-based method considering the direct effect of fishing on all species with which the fishery overlaps. For each species, several life history parameters are classed as high or medium or low risk and the productivity risk score is an average of these attributes. The susceptibility risk score is a product of other relevant attributes (for example, selectivity, post-capture mortality) each of which is also classified as high or medium or low risk. The final results rank the relative risk to each species posed by that fishery. Hobday et al. (2011) provide details of the method.

Residual risk assessment: technical factors, such as implementation of bycatch mitigation measures, which had not been considered in the Level 2 PSA, are identified at this stage and the Level 2 results modified accordingly.

Level 2+: Sustainability Assessment for Fishing Effects (SAFE)—is a quantitative analysis that uses similar attributes to the Level 2 PSA, but treats the input data in a more rigorous way. SAFE estimates actual fishing mortality rate and compares this with the maximum fishing mortality rate that a species could tolerate. The relative risk for each species compared with all other species is also presented. The method depends on species range distributions and the assumption about the distribution of density within the range.

Level 3: comprises a range of methods up to and including integrated population assessment models for single species.

Source: *Hobday et al. (2011)*

Standard 2: Operational objectives, which are consistent with relevant policies and legislative requirements, are specified for managing fisheries bycatch

Guidelines for Standard 2

The guidelines for Standard 2 are intended to reflect the overarching aims of bycatch management embodied in the current Commonwealth fisheries and environmental legislative and policy framework. For Commonwealth fisheries, all reasonable steps must be taken to:

- minimise fisheries bycatch
- ensure that fisheries do not threaten bycatch populations
- avoid mortality of (or injury to) species that are classified as protected under the Environment Protection and Biodiversity Conservation Act 1999.

The text of the above guidelines is drawn from the *National Policy on Fisheries Bycatch (DAFF 1999),* the Commonwealth *Bycatch Policy (DAFF 2000)* and the *Guidelines for the Ecologically Sustainable Management of Fisheries 2007* (DEWHA 2007). Fisheries management is expected to be consistent with the Commonwealth Bycatch Policy. Minimising fisheries bycatch in Commonwealth fisheries is required under the *Fisheries Management Act 1991*, the EPBC Act and other legal and policy instruments complementary or subsidiary to these Acts. AFMA is accountable for achieving this objective, and DAFF and SEWPaC are accountable for the policy framework. The assessment of fisheries management against the DEWHA 2007 guidelines forms the basis of the assessments carried out under the EPBC Act.

A literal interpretation of the present policy objective to minimise bycatch might suggest an imperative to utilise the entire catch rather than bycatch populations be sustained. However, 'to minimise' indicates a concerted effort to reduce bycatch to minimal levels, not necessarily to zero. Although zero bycatch may be the ultimate goal, there are many examples in the current management in Commonwealth fisheries where low, non-zero levels of bycatch might be considered sustainable and acceptable.

'To threaten' can be defined as contributing to the decline of populations to levels 'at which their reproduction may become seriously threatened' (1982 United Nations Convention on the Law of the Sea); that is, there is considerable risk that the population will not be able to replenish itself from a severely depleted state.

The guidelines for Standard 2 would need updating if Commonwealth legislation or policy objectives change. Similarly, the adoption of the proposed standards by another jurisdiction would require these guidelines to reflect that jurisdiction's legislation and policy objectives. Standard 7 shows how stakeholders can be engaged in operationalising these high-level objectives and Appendix C provides examples of operational objectives.

Standard 3: The effects of fishing on bycatch populations are assessed

Robust and practical indicators of fishery effects on bycatch are identified.
Indicators of fishery effects on bycatch are measured against established reference points.
Decision rules are developed to ensure that the bycatch management response is proportional to the risk of reference points being breached.
A risk-based approach is used as a basis for decision-making where a rapid response is required or where data are insufficient to fully inform a quantitative approach.

Guidelines for Standard 3

Overview

Standard 3 recognises that, depending on the information available, bycatch management may be based on quantitative assessments or risk-based or some combination of these approaches. Across government there is a preference for 'evidence-based policy making' (Banks 2009). Evidence-based decision-making suggests a clearly defined issue, good understanding of its causes and context and a high degree of confidence in options for its solution. While such a situation would be ideal, it may not represent the norm for bycatch management in all fisheries. The appropriate level of investment in bycatch management will depend on the fishery's value and the social, economic and environmental significance of the bycatch species. Alternative management approaches must be considered when evidence is not available or cannot easily or cost-effectively be obtained.

Risk-based approaches to fisheries management recognise that decisions must often be made without certainty about the present or historical state of fish resources or the effects of fishing on the environment, and without mechanisms to assess the effectiveness of decision-making. Nonetheless, decisions should be made following a concerted effort to assess the risk posed by fishing to particular species and ecosystems, or the risk of fishery management not achieving its objectives.

The precautionary approach to fisheries management, as defined in the FAO Code of Conduct for Responsible Fisheries (Article 6.5; FAO 1995) states that:

> 'The absence of adequate scientific information should not be used as a reason for postponing or failing to take measures to conserve target species, associated or dependent species and non-target species and their environment.'

Under the Commonwealth Harvest Strategy Policy, harvest strategies and decision or control rules are developed for commercial species for both target (that is, a desired state) and limit reference points (that is, a state to be avoided). Similarly, the Bycatch Policy states that:

> 'decisions and actions to address bycatch will ... use robust and practical biological reference points relating to bycatch, where possible, to make decisions on bycatch management. . . . Where the use of biological reference points is not feasible, the precautionary principle will be used as a basis for decision making.'

Standard 3.3 suggests how a risk-based approach to using bycatch indicators and reference points might be implemented. Standard 3 does not require decision rules or full harvest strategies to be implemented for every bycatch species or issue. Instead it promotes a risk-based hierarchy where high-risk species in some fisheries might require that level of management and other risk-based approaches are applied to other species or situations.

Protected species are a special case for bycatch management. Generally, they are species that have been significantly depleted by human activities. The listing of protected species is based on regional population status (Box 5). Listing also takes account of species listed under the international Convention on Migratory Species (DEWHA 2010). Standard 2 highlights the overriding requirement to avoid death of, or injury to, protected species. There is strict liability for impacts on protected species, such that it is only acceptable to kill them as a result of an 'unavoidable accident'. This precludes the use of methods that are known to cause injury or death, or to negatively affect their populations. Legislative instruments (such as TAPs) are available to reduce the effects of key threatening processes and to halt declines in populations of protected species (Box 6). Active recovery plans are required for species listed as 'endangered'.

Box 5 Process for listing species and key threatening processes under the EPBC Act

Listing procedure

Any person may nominate a native species, ecological community or threatening process for listing under the EPBC Act. An invitation to nominate is extended by the environment minister each year ahead of a new assessment cycle. Nominations submitted within the advertised invitation period and that satisfy the Environment Protection and Biodiversity Conservation Regulations 2000 (EPBC Regulations) are forwarded to the Threatened Species Scientific Committee. Nominations are considered by the committee and a recommendation made to the minister on annual priorities for assessment—the proposed priority assessment list. The minister considers the list and may make changes. The finalised priority assessment list is published on the [environment] department's website and nominators are notified of the outcome.

Nominations included in the finalised priority assessment list are assessed by the committee within a timeframe set by the minister. The committee invites public comment on each nomination during the assessment period. The committee provides its recommendations to the minister, and the minister then decides whether the species, ecological community or threatening process is eligible for listing under the EPBC Act. In providing advice and decision-making on a species nomination, respectively, both the committee and the minister are constrained by the EPBC Act, to consider only:

- matters relating to whether the species is eligible to be included in that category, and
- the effect that listing could have on the survival of the species.

In making its assessment, the committee uses its guidelines for assessment of nominations of:

- threatened species
- threatened ecological communities
- key threatening processes.

Section 179 of the EPBC Act provides the categories to which threatened species may be assigned and the EPBC Regulations describe the criteria for eligibility for those categories. The committee is informed by, but not bound by, indicative thresholds in its assessment guidelines, which have been adapted from the International Union for Conservation of Nature (IUCN) Red List Categories and Criteria.

Assessing the eligibility of fish species for listing

When considering whether to use the indicative thresholds, the Threatened Species Scientific Committee judges whether they are appropriate to the species in question. In relation to the eligibility of fish species for listing, the committee exercises judgement in determining the application of the criterion thresholds to take account of species specific biology, for example life history strategies (i.e. short life span, early maturation, high fecundity, versus long life span, late maturation, low fecundity). The committee's threatened species guidelines were revised in November 2010 to include specific guidance relevant to marine fish species and to provide a link between the threatened species listing assessments and the *Commonwealth Fisheries Harvest Strategy Policy and Guidelines*.

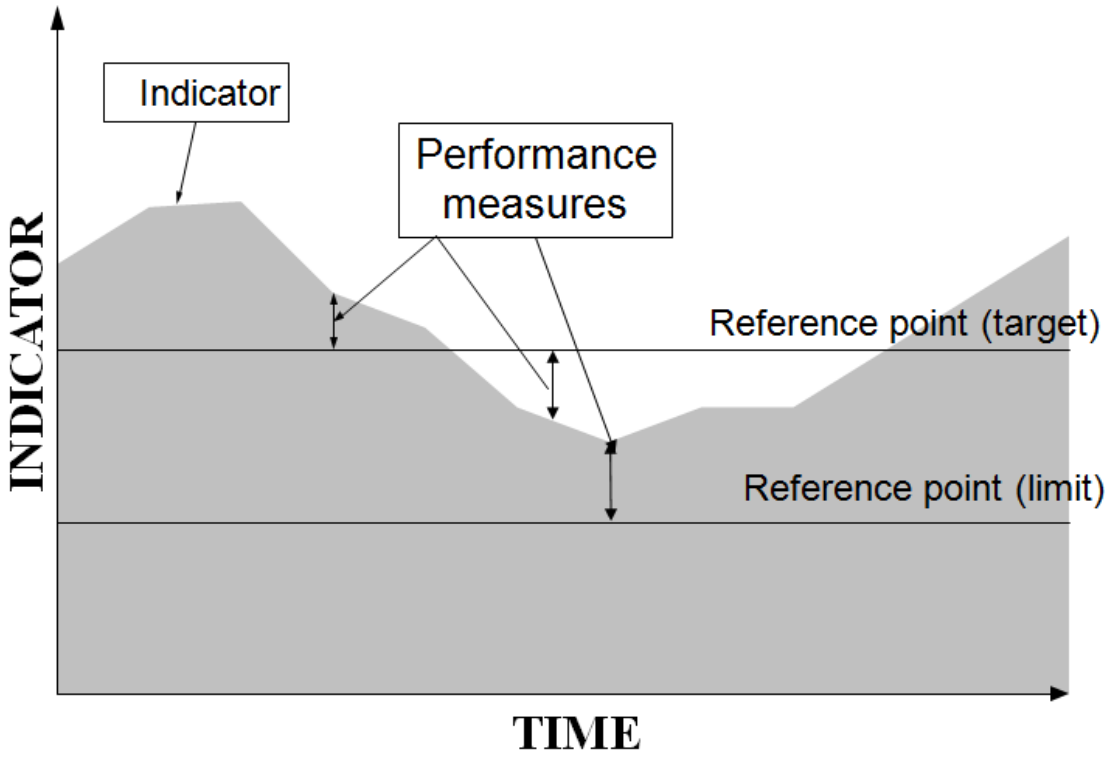
Sources: *SEWPaC (2012a, 2012b)*

Empirical indicators

This project's Indicators and Reference Point Workshop considered how empirical indicators with associated reference points (Figure 5) could be applied to bycatch management. Indicators

and reference points for bycatch may focus on the sustainability of the species directly affected by the fishery. Estimates of current bycatch levels compared with historical levels might be used as an indicator for judging whether bycatch levels are sustainable. These include estimates of total, fishery-wide bycatch or relative indicators, such as catch rates, the size composition of catches or the spatial and temporal distribution of catches. However, bycatch data may be sparse and uninformative, leading to low confidence in status, even when advanced quantitative analyses are applied. While it may be possible to track chosen indicators, simple indicators of status (such as target catch to bycatch ratios, Table 1) may be inconclusive. It is therefore important to know whether an indicator is capable of tracking the property of interest. The section on reference points later in this chapter provides further guidance that is relevant to empirical indicators.

Figure 5 Illustration of how an indicator may be tracked over time compared with target and limit reference points



Source: DAFF (2007)

It may be useful to include both fisheries data and fisheries-independent data, such as from research surveys, when developing indicators and performance measures. This may reduce error and uncertainty in estimates of the abundance of bycatch species. Ideally, data on all sources of mortality are needed to determine whether fishing is a significant cause of mortality.

Table 1 Potential explanations for changes in target catch and bycatch ratios

	Target catch is increasing		Target catch is static		Target catch is decreasing	
Bycatch is increasing	↑ fishing effort	↑ target abundance ↑ bycatch abundance	↑ fishing effort ↓ target selectivity	↑ bycatch abundance	↑ fishing effort ↓↓ target selectivity	↑ bycatch abundance ↓ target abundance
Bycatch is static	↑ target selectivity	↑ target abundance	↔ fishing effort ↔ bycatch selectivity	↔ abundance	↓ target selectivity	↓ target abundance
Bycatch is decreasing	↓ bycatch abundance ↑ fishing effort	↑ target abundance ↓ bycatch abundance	↑ target selectivity	↓ bycatch abundance	↓ fishing effort	↑ target abundance ↑ bycatch abundance
	↓ bycatch abundance ↑ target selectivity	↑ target abundance ↑ target selectivity				

Key: ↔ no change, ↑ increase, ↓ decrease, ↓↓ large decrease.

Notes: This table highlights how combinations of trends in target catch and bycatch may result in ambiguous conclusions about abundance. For example, observations of increasing bycatch (row 1) and increasing target catch (column 1) could be interpreted as an increase (↑) in fishing effort or an increase in both the abundance of bycatch and target species. The term 'fishing effort' includes variations in fishing power (e.g. skipper experience) as well as variations in the level of fishing activity (e.g. the amount of fishing gear deployed).

An appropriate level of temporal and spatial resolution needs to be identified for monitoring indicators of particular species, sub-populations and communities of interest. Depending on the management objective, an indicator may need to be species-specific, or a suite of relevant indicators may be useful. However, the costs of monitoring single indicators, let alone a suite of indicators, can be significant. It may be more realistic to undertake periodic or intermittent monitoring, generating multi-annual snapshots, rather than annual evaluation of all indicators.

Catch data alone may not indicate the extent of depletion from an unfished state, as catches do not provide a measure of the original unfished biomass or ecosystem structure. Instead of using a historical or pristine state as a reference point, it will often be more tractable and cost-effective to assess the current state against some other target and limit reference points that are useful for evaluating the sustainability of current effects. The development of appropriate reference points for monitoring bycatch species or the effectiveness of management measures is directly linked to operational objectives (Standard 2). The section of this report on Reference points provides further guidance on reference points for managing bycatch.

Applying a 'harvest strategy policy' approach to bycatch

The *Commonwealth Fisheries Harvest Strategy Policy and Guidelines (DAFF 2007)* require that harvest strategies contain several key elements: objectives, indicators, performance measures, reference points or 'benchmarks', decision rules and meta-rules for exceptional circumstances. A similar approach might be appropriate for managing bycatch in some situations and might provide stakeholders with improved certainty and clearer guidance on monitoring requirements and assessments. However, several key issues would need to be addressed before adopting a formal 'management strategy' approach to managing bycatch in Commonwealth fisheries.

The Harvest Strategy Policy focuses on key commercial species, with the primary objective of attaining maximum economic yield (MEY). MEY, as presently calculated, excludes the non-market costs of bycatch and broader environmental effects. Nonetheless, managing fisheries to achieve MEY for target species can result in reduced environmental because MEY-based catch levels are often lower than those based on maximum sustainable yield (MSY), resulting in lower fishing effort and reducing the overall effect of fishing on commercial species. It generally follows that reduced fishing effort should result in reduced bycatch, although there may be situations where effects increase in local areas or for particular species.

Bycatch management is made more complicated because data on bycatch is often sparse and non-representative; and the costs of obtaining better data may be disproportionate to the benefit of improved knowledge, except perhaps for high-risk species and protected species. Management of non-protected bycatch might therefore focus on ensuring that bycatch species do not become protected species. This would involve introducing mitigation measures to reduce bycatch, reducing the uncertainty in estimates of bycatch levels or demonstrating that bycatch levels are sustainable, or a combination of these approaches.

Clearly articulated objectives for bycatch management will facilitate the assessment of effectiveness of actions taken to achieve those objectives. For low-value, low-risk bycatch species, a default objective might be to avoid any hard limit, and to otherwise ensure that fishing impacts are sustainable; that is, that bycatch will not increase to an unsustainable level. It is unlikely that detailed single-species analyses of low-risk species will be available to guide management, so there is a role for approaches like SAFE analyses that can be applied to many species. For higher risk species analyses may need to be improved by identifying, quantifying and incorporating all causes of mortality. Setting objectives for acceptable levels of bycatch may remain contentious, but need not be intractable. Bycatch management strategies could also

anticipate adaptation as information improves. Trigger reference points can be identified to initiate management measures when interaction levels change and to reduce the chance of undesirable levels of bycatch occurring (Sainsbury 2008). It may be possible to develop management strategies in association with risk scores, but the precaution incorporated into the risk assessment would need to be considered, as well as the considerable uncertainty of those assessments, when deciding how to allocate and reduce the risk to bycatch species across fisheries.

The proposed standards do not advocate developing and implementing formal management strategies for all bycatch species. Instead, the standards encourage a risk-based approach that can be tailored to each fishery, bycatch issue or situation. For example, it might be appropriate to implement a formal management strategy to mitigate interactions between the valuable gillnet fishery for sharks and vulnerable Australian sea lions to protect breeding colonies (AFMA 2010b). By contrast, that level of management might not be justified for managing the bycatch of non-protected species.

Reference points for bycatch

Introduction

This section of the guidelines for Standard 3 outlines potential reference points for managing bycatch. Bycatch reference points include estimates of fishing mortality rates derived from the SAFE method and estimates of potential biological removals. Threat abatement plans provide an example of how reference points, indicators and decision rules might be used to manage bycatch. Sainsbury (2008) provides a useful introduction to the use of target and limit reference points for bycatch. He proposes that there should be an aspirational target of zero bycatch, to be approached as far as is operationally feasible and socially acceptable. A zero target is unlikely to be realistic in most fisheries and it would be misleading to suggest that such a target is achievable in the presence of any level of fishing activity.

Sainsbury (2008) identifies the need to apply two kinds of limit reference points: (1) interim limits that are feasible with current technology and acceptable in the current situation (that is, as small as is practicable, with an expectation of continuous improvement) and (2) a hard limit if fishing exerts a high risk of long-term or irreversible impact or extinction.

Trigger reference points should be selected to initiate management measures to reduce the chance of further interaction if undesirable levels of bycatch occur (Sainsbury 2008). For all bycatch species, the risk of exceeding hard limits should be minimal. The EPBC Act requires that there is no intentional take of protected species and there is an absolute requirement for species not to be extirpated (locally) or driven to extinction (globally). Sainsbury (2008) recommends that hard limits be chosen to reverse any further decline as a result of fishing and to enable rebuilding of the populations.

Interim trigger limits for one species may vary to minimise effects on other species: the Harvest Strategy Policy allows such trade-offs among key commercial species to obtain maximum economic yield from the whole catch, but individual hard limit reference points are retained for each species based on their biological characteristics.

Sainsbury (2008) suggests that limit reference points for bycatch, which are based on a species' capacity to rebound from depletion, should not be any less conservative than those for target species. Potential hard limits are 20–30 per cent of estimated unfished biomass (*B0*) for teleosts and 50 per cent of *B0* or higher for chondricthyans.

Ecological risk assessment

As outlined in the guidelines to Standard 1, the ERA is a suite of increasingly complex methods, information requirements and costs, which has been used to assess the effects of Commonwealth fisheries on all the species that they may interact with (Hobday et al. 2011). PSA was not designed to produce quantitative indicators and reference points for monitoring trends. This is because the actual biomass of each species is rarely known. However, with a catch history and an estimate of fishing mortality rate (F) from SAFE it is possible to approximate MSY. As long as the fishing mortality rate from given catch levels is less than the maximum sustainable mortality, such catch levels are sustainable, although they pose higher risk the closer they approach F_{crash} for each species. In SAFE outputs, vertical error bars indicate 90 per cent confidence intervals while horizontal bars show a plausible range using maximum and minimum parameter values. The sensitivity to structural assumptions can be tested, but the uncertainty analysis does not evaluate the spatial area of overlap. To reduce uncertainty and minimise the risk from allowing marginally sustainable catch levels to continue, the most important uncertainties in the SAFE analyses need to be subject to further research.

Another useful performance measure is to compare estimates of fishing mortality (F) with natural mortality rate (M). For teleosts, a limit reference point at F_{lim} = 75 per cent of M could be appropriate (Sainsbury 2008). However, for slow-growing and low productivity species, such as chondricthyans, F_{MSY} is around 45 per cent of M, so a more conservative limit reference point than for teleosts should be considered (Zhou et al. 2012). However, this approach requires M to be estimated with reasonable reliability, which is often not practically possible.

For bycatch species that are affected by several fisheries, the cumulative impact across all fisheries should be considered. This is not easily done for PSAs, but the SAFE analyses permit estimated fishing mortality to be summarised for each fishery and the cumulative mortality to be compared with reference points. The SAFE ERAs have been completed for many Commonwealth fisheries (Zhou et al. 2007, 2009), and an assessment of cumulative impacts across these fisheries is possible. A cumulative assessment has been completed for the Southern and Eastern Scalefish and Shark Fishery. However, the same analyses of state-managed fisheries have not been conducted, so cumulative assessment across jurisdictions remains difficult.

The SAFE method is applicable to the bycatch of non-protected teleosts, sharks and rays, and it has been applied to sea snakes. Other ERA methods can be used for marine mammals, seabirds and reptiles, but they may not generate the same outputs. The method has some similarities with the potential biological removals (PBR) approach; SAFE focuses on the rate of removal while PBR attempts to estimate absolute removals (Zhou & Griffiths 2008).

Potential biological removal

PBR has been extensively used to analyse and manage fisheries impacts on bycatch species, particularly in the United States and mainly for protected species (Finkbeiner et al. 2011; Warden 2010). PBRs are quantitative estimates of the maximum mortality (number of deaths) of a species that would pose low risk to the population (Wade 1998). The legislative framework in the United States makes a distinction between immediate and long-term goals and this allows interim measures to be developed. Strong measures, including fishery closures, can be triggered if catch is greater than the PBR. However, the bycatch is recognised as being sustainable as long as it remains below the PBR. It should be recognised that, for protected species, even this minimal level of catch may not be acceptable to some stakeholders, despite having been assessed as being biologically sustainable.

PBR is calculated using the following equation:

$PBR = N_{min} \times 0.5 (R_{max}) \times F_R$

where:

N_{min} = minimum estimate of population size

R_{max} = maximum growth rate of population

F_R = a 'recovery' factor ranging between 0.1 and 1.0.

The recovery factor F_R determines the rate of recovery of the population. It requires subjective input regarding acceptable levels of risk and desired rates of recovery. Different values of those quantities may be preferred for different species or in different circumstances. *FR* is therefore a 'management choice parameter' that is chosen by fishery managers and stakeholders, rather than by the analyst.

PBRs can be useful, but they can also be misunderstood. In the United States it took several years to develop consensus on how to use them, through workshops for stakeholders and technical experts. Calculation of PBR does not pre-determine how it is used. Portions of the PBR may be allocated to each fishery and mortalities can then be monitored, with the total mortality compared with the PBR. Alternatively, PBR can serve as background information in the broader debate on bycatch.

Threat Abatement Plans

Threat Abatement Plans (TAPs) are legislative instruments focused on a specific 'threatening process' (Box 8). They provide an example of how reference points, indicators and decision rules might be used to manage bycatch. For example, the 2006 Seabird TAP (DEWHA 2006) sets limit reference points and performance measures for seabird bycatch rates and specifies the required levels of coverage by scientific observers in the affected Commonwealth fisheries. The limit reference points apply to all seabird species combined. They were based on Japanese longline data pre-1977 where, before the introduction of night setting, seabird bycatch exceeded 1.0 seabirds per 1000 hooks on average. Seabird bycatch levels have since been reduced in the ETBF to less than 0.05 seabirds per 1000 hooks (Che et al. 2007, Giannini et al. 2008, Giannini et al. 2010, Lawrence et al. 2009). By establishing limit reference points, the fisheries are allowed to continue operating while seabird mitigation measures are improved and further research is undertaken to inform management.

While the 2006 Seabird TAP is generally considered to have been successful in reducing seabird bycatch (Baker & Finley 2010), there are several areas where this reference point–based approach might be improved. For example, it is not ideal that the limit reference points are for all seabird species combined. Some species are at significantly greater conservation risk than others. Consequently, identifying which populations are being affected is important. Seabird identification is difficult at sea, so seabird carcasses or beaks are retained where possible to verify species identification by observers and by fishers in logbooks.

Box 6 Recovery planning and threat abatement planning under the EPBC Act

The environment minister may make or adopt and implement recovery plans for listed threatened species (other than conservation dependent species) and threatened ecological communities listed under the EPBC Act. Recovery plans set out the research and management actions necessary to stop the decline of, and support the recovery of, listed threatened species or threatened ecological communities. The aim of a recovery plan is to maximise the long-term survival in the wild of a threatened species or ecological community.

Recovery plan guidelines have been developed to provide information on how to prepare a recovery plan and explaining the content requirements for a recovery plan. Before making a recovery plan for a listed threatened species or listed threatened ecological community, the minister must:

- consult with the appropriate minister of each state and territory in which the species or ecological community occurs
- consider advice from the Threatened Species Scientific Committee
- invite public comment on the proposed plan
- consider all comments received.

Within 90 days of listing a key threatening process, the environment minister must decide if a threat abatement plan should be made or adopted. This decision is based on whether having and implementing a plan is the most 'feasible, effective and efficient way to abate the process'. The minister consults with the Threatened Species Scientific Committee and interested government agencies before making this decision.

Threat abatement plans provide for the research, management, and any other actions necessary to reduce the effect of a listed key threatening process on native species and ecological communities. Implementing the plan should assist the long-term survival in the wild of affected native species or ecological communities. Before making or adopting a plan the minister must consult widely. This includes advertising and inviting comment on the plan during a specified period.

The EPBC Act requires the Australian Government to implement a recovery plan or threat abatement plan as it applies in Commonwealth areas. This requirement applies to all Australian Government agencies.

Sources: *SEWPaC (2012a, 2012b)*

The limit reference points refer to nominal observer data rather than fishery-wide statistical estimates of bycatch rates. Ensuring that bycatch rates reported by observers reflect the true situation is difficult because the temporal or spatial distribution of observer coverage might not be representative of the entire fishery or because fishing practices may vary among fishing vessels and on vessels when observers are on board (Lawrence et al. 2009). It is also difficult to determine whether bycatch rates reflect seabird abundance or variations in the success of bycatch mitigation (Tuck 2011).

Estimates of seabird bycatch based on observation might not always represent the total mortality due to fishing. Unobserved mortality may occur during the longline soak and hauling (Ward et al. 2004), through post-release mortality and as a result of the loss of seabird breeding pairs or chicks when one mate perishes. Limit reference points that are based on the observed bycatch of protected species may therefore need to be extremely low to account for unobserved mortalities and thereby reverse population decline and ensure an acceptably low level of risk.

The full range of impacts on threatened seabird species at sea and on land need to be considered, as do the interactions that can undermine the effectiveness of management measures for other protected species. Effective mitigation for one species might increase the risks to other species. For example, night-setting of pelagic longlines reduces interactions with albatrosses, but may increase the risk of catching migratory white-chinned petrel (Delord et al. 2005; Weimerskirch et al. 2000).

Empirical indicators selected for bycatch need to reflect the data and analyses available. Depending on the fishery and species, they might be based on ERA results, population modelling or approaches such as the SAFE and potential biological removal (PBR) approaches.

Standard 4: The cost-effectiveness of bycatch mitigation measures is established

4.1. There is sound logic or evidence for the performance of the mitigation measures.
4.2. Experimental designs for research trials of bycatch mitigation measures are statistically robust.
4.3. Differences between research trials and commercial fishing operations are anticipated.
4.4. The cost-effectiveness of mitigation measures is assessed at an appropriate level of detail.
4.5. Mitigation measures result in statistically significant reductions in bycatch mortality or prevent the decline of bycatch populations.
4.6. A mitigation measure designed to minimise bycatch of a high-risk species or species group does not increase fishery impacts on other high-risk or protected species.
4.7. Bycatch mitigation measures that are mandated as alternatives to each other have a similar level of performance in reducing bycatch.
4.8. Where multiple mitigation measures are required to be used together, their effects are at least additive.

Guidelines for Standard 4

Overview

Commercial fishers are often looking for a competitive edge and for ways to improve their product. Reduced bycatch can help improve the quality or reputation of their product and may lead to a price premium if consumers recognise low environmental effects and the sustainability of fished species. Mitigation measures may sometimes present other incentives, such as reducing the time spent sorting the catch. Fishers usually prefer to have a range of mitigation options from which to choose, so they can select which options best suit their fishing activities.

The purpose of Standard 4 is to ensure that only mitigation measures with a strong likelihood of success in typical operating environments are endorsed; to require that scientific and economic analyses are carried out at an appropriate level of detail; to recognise that ineffective measures should not be endorsed; and to ensure that fisheries bycatch is managed without placing an unnecessary burden on fishers. There is an inherent trade-off between these requirements.

Bache (2003) reviewed international initiatives in managing marine wildlife bycatch. Bycatch mitigation measures have sometimes been advocated in the absence of evidence for their cost-effectiveness. This may be due to 'policy transfer' from different jurisdictions, marketing by fishing gear suppliers, advocacy by interest groups or efforts to introduce measures that have the least effect on fishing operations. Policy transfer occurs when a measure, which has been established in one area (for example, large fish baits for mitigating turtle bycatch in the Hawaii longline fishery), is applied to another area without verifying that the measure will be effective in the second area. Mitigation measures that work in some circumstances may not work well in others, or they may have unintended or unforeseen consequences. The performance of mitigation methods is often established by carrying out experiments in large-scale facilities and field trials on fishing vessels. The experimental design attempts to quantify and control all sources of variability, uncertainty and error. However, operational conditions may be quite different to experimental conditions and may be difficult to simulate. Ideally, mitigation methods should be tested under a range of operational conditions, but this may only happen through onboard monitoring after implementation.

Several methods may be used simultaneously if they act in different ways to achieve an overall reduction of bycatch, for example some methods may reduce capture rates and others may

increase post-release survival. This standard recognises that if multiple methods are used, their effects should be at least additive, resulting in a net reduction in bycatch rather than cancelling out their effects. If alternative options are offered, each option should have a similar effect in reducing bycatch. The relative merits of different mitigation options should be identified. Cost-benefit analysis may also be useful. When considering several alternative mitigation options, or the desirable fleet or area coverage of a particular option, the cost-effectiveness of the options should be evaluated, including the marginal costs associated with incremental action.

Analytical approaches

Introduction

Ecological experiments usually follow some form of before–after–control–impact design (Green 1979). Some high-risk species or fishing activities may require a rapid response to deploy bycatch mitigation measures without prior evidence of their cost-effectiveness. In other circumstances, the work needed to demonstrate that a mitigation measure is effective may require experiments where mortality of bycatch species might be expected in the control studies. It can be difficult to obtain approval for this kind of experimentation. An alternative approach is to carry out sufficient fishery monitoring so that 'before–after' analyses can be conducted in the absence of 'control–impact' studies.

Baseline data

It can be expensive to obtain baseline data on the ecosystem being fished, such as target and bycatch species distributions and abundance, which are key inputs to ecological risk assessments. Detailed monitoring of fishing operations is also needed to quantify the variance in catches of target species and bycatch and to identify key variables that must either be eliminated or quantified and corrected for during the statistical design and analysis of experimental trials.

Before embarking on new studies it is useful to analyse existing data for the fishery and bycatch species of interest. This may include fishery independent data and simulation studies to determine the statistical power of different data collection or sampling regimes. Pilot studies may also be useful in identifying the most relevant sources of variation. Surveys of mitigation measures currently in use may also be helpful, as industry may innovate and managers may not know what practices are currently used voluntarily.

Experimental design

The power of an experiment to detect an effect is an important aspect of experimental design. Ideally, design should work back from the acceptable level of uncertainty in the results. The variables that may need to be measured span the following dimensions: spatial (latitude, longitude, depth), temporal (for example, time of day, season, decade, set time, moon phase), gear-related (for example, mesh size, number of hooks), vessel-related (for example, vessel size, engine rating and experience of skipper) and environmental (for example, water temperature, sea state, current velocity and habitat or substrate type). Statistical advice should be obtained at the early stages of experimental design before conducting expensive at-sea trials.

This project's Experimental Design Workshop stressed that, once a design has been determined and agreed to, the experiment needs to be adequately resourced, as funding constraints may compromise the statistical power of a study. Investigators should be clear about conditions under which it is not possible to answer the question being asked. When unexpected or undesired results are obtained, experiments should not be prematurely abandoned before analysis and reporting so that the results are not misrepresented.

Research trials usually occur in a small subset of the whole fishery. Analysis of the statistical power of experimental designs needs to take account of limited fleet or spatial coverage of the trials, so that their results can be correctly interpreted. This may be less important for frequently caught bycatch species ('high-volume bycatch'), but it will be crucial for statistically rare, but biologically significant events, such as fishery interactions with protected species.

There may be further operational and statistical issues requiring resolution as mitigation studies move from research to commercial trials. To minimise error, the experimental design must account for the specific operational characteristics of the gear type and fishery. For example, trials under the Northern Prawn Fishery's protocol involve paired trawl nets where the bycatch reduction device (BRD) is swapped between each net, providing direct 'control–impact' comparisons (Brewer et al. 1998). For many fisheries, a paired gear design may not be possible so other approaches must be used. Twin vessels can be used, although the effects of vessel, skipper or crew can be significant. Another approach is to sequentially alternate the use of mitigation devices in nets on the same vessel or to have different panels on the same net or different hooks along the same longline.

Behavioural aspects

Reporting of bycatch is one aspect of management that depends on behaviour. Better outcomes for bycatch species may be achieved through changes in operating procedures on fishing vessels and in behaviour of individual fishers; for example, handling techniques for turtles, offal management. To be implemented effectively, these behavioural mitigation measures require that incentives be considered. There may also be behavioural adaptation by fishers during an experiment or subsequent to a mitigation measure being implemented, which may enhance or impair effectiveness. Such changes also need to be monitored to ensure mitigation is not weakened as a result.

Problems may be encountered in research trials if the crew's pay is proportional to catch sales. This situation may arise when agreements are made with owners to conduct research trials, but the reward structure for crew is not changed. Successful trials often involve the skippers and crew members being informed, involved and compensated for any loss of income.

Communication and extension

There is an important role for training and extension services in propagating best practice. This may occur as a side-effect of bycatch mitigation research trials. However, until those trials have assessed the effectiveness of the mitigation measure being investigated, the training and extension outcome must be secondary to the science. When the cost-effectiveness of a mitigation measure has been established, further demonstrations can be carried out to increase understanding and uptake. In general, the role of effective extension work to promote best practice and compliance should be recognised. For this purpose, practical demonstration in person or through visual graphics will be more effective than scientific papers. 'Codes of practice' may be very effective in encouraging good practice and transferring ownership from researchers and managers to fishers, particularly if industry has been involved, or instrumental, in developing these codes (for example, Jussiet & Robinson 2003). If fishery management applies output controls for bycatch, peer-group pressure among fishers may act to promote best practice. The effectiveness of this will depend on social network characteristics of the fishery and on stability of staffing.

Northern Prawn Fishery's protocol for trialling bycatch mitigation devices

The Northern Prawn Fishery (NPF) has an established protocol for trialling and implementing bycatch mitigation measures (Box 7; AFMA 2012a). It is an operating standard with associated performance measures. The NPF protocol is a compromise between what is statistically ideal and operationally practical. A generic protocol could be developed for Commonwealth fisheries based on that of the NPF, specifying the key variables, statistical and operational aspects to be addressed.

The NPF protocol lists approved mitigation options, which can be further refined as new information is obtained. At-sea trials of new turtle excluder devices (TEDs) and BRDs last two weeks, with up to 56 trawls observed; usually only between 30 and 40 trawls are useable because of operational constraints (observer rest periods; TED blockages, so that catch is not representative of a normal TED plus BRD configuration). The main indicator is the weight of bycatch. The performance indicator is the difference in bycatch weight between the TED plus BRD and the TED-only nets. The reference point at which the BRD can be considered for approval is a 10 per cent reduction in bycatch on top of the reduction from currently approved measures.

There are areas of potential improvements to the NPF protocol. Firstly, the performance measure does not consider bycatch species' composition: potential effects on species must therefore be based on ecological risk assessments rather than simple monitoring. Secondly, there is no performance measure or reference point for effects on commercial catches. Thirdly, the protocol is not detailed enough to ensure that the control is standardised and that the two nets used in the paired trawl experiment are fishing equally. Finally, there is no consideration of the level of error that is acceptable in the results; the 10 per cent reference point is intended to account for any error, but a more rigorous approach to estimating uncertainty could be taken.

Box 7 Protocol for testing new turtle excluder devices (TEDS) and bycatch reduction devices (BRDs) in the Northern Prawn Fishery

- TEDs fail if they catch any turtles in two weeks of sea trials.
- Detailed, analysed report of TED and BRD trials produced by the observer and other AFMA staff.
- AFMA observer on board for two weeks (BRD and TED trials), usually determined by opportunities to move via a mothership.
- AFMA meets the observer costs, including relocation via motherships.
- Based on the trial's report, three members of the bycatch subcommittee assess whether the new device should be recommended for inclusion on the list of approved TEDs and BRDs for the fishery.
- If the new BRD is located in front of the TED, all BRDs located behind the TEDs must be closed for the trials.
- Testing BRDs requires weighing of all bycatch from two nets (separately) using lug baskets or a more accurate method; one net with the new BRD (& a TED) and the other (control net) with no BRD (TED only).
- Observers should attempt to collect data on every shot over the two-week period. At best this will yield around 56 trials (14 nights x 4 shots per night), of which a proportion will be effected by TED blockages and unusable).
- Prawn catch data will also be recorded from each net separately, usually weighed by the crew. The two nets' catch needs to be kept separate until they are weighed and recorded. These data are critical to assessing whether the trial is confounded by blockages on the TEDs. Similarly, any other information regarding the likelihood of a catch being affected by TED blockages must be recorded accurately—for example, 'Skippers says "Port net tedded that shot because …"'.
- All commercially important prawn species can be lumped together for this comparison, although keeping species groups separate is more useful.
- In boats with hoppers, weighing the bycatch from each net will necessitate the removal of the 'trash' chute so the bycatch spills from the conveyor into lug baskets (and not over the side).
- A lug basket of bycatch filled to the handles usually weighs about 40 kg, but this should be calibrated by weighing the full lug baskets periodically to confirm their 'filled weight', especially if the skipper moves fishing areas. Special lug basket inserts and raking tools are available to standardise the volume in lug baskets.
- The BRD should be swapped between nets to help remove any effects of catching differences between nets.
- BRDs will be considered for approval if they reduce the amount of small bycatch (bycatch weighed in lug baskets) by an extra 10 per cent compared with the control net with a TED only. This will be determined by statistical analyses of the data, required to account for the interaction between BRD performance and any bias between sides.

Source: *AFMA (2012a)*

Economic evaluation

Standard 4.4 proposes that the cost-effectiveness of bycatch mitigation measures is assessed at an appropriate level. Economics offers a useful framework and a suite of methods for evaluating the cost-effectiveness of bycatch management options and identifying likely outcomes. The project's Economic Evaluation Workshop reviewed methods for bycatch management and mitigation, including cost-benefit analysis, non-market valuation, linkages and input-output analysis.

Costs and benefits of bycatch management options

Management options with significant cost implications can be evaluated through analysing costs and benefits. The economic loss to society of not reducing bycatch can be substantial and constitutes a market failure when this loss is not borne by those fishers that create it. It also constitutes the potential benefit available if bycatch is reduced (Box 8). This may then be compared with the cost of addressing the issue, which comprises the cost of generating any necessary information, the direct cost of implementing the policy and the negative impact on the fishery's economic returns once the policy has been implemented. The economic value of the benefit may be estimated by non-market valuation methods.

Box 8 Market failure and the benefits of bycatch management

As fisheries bycatch involves the unintended removal of species from an ecosystem, it can constitute a 'negative economic externality' as it can have a negative impact on the environment and biodiversity, as well as a potential impact on other fishers that might depend on those species or ecosystem. Where this negative externality exists, bycatch can be considered as a market failure. Costs are being imposed on others external to the fishery so that the producer (the commercial fisher) does not bear the full costs of production. Reducing the external costs associated with bycatch is a benefit of addressing bycatch issues associated with fisheries.

Government has a role in addressing market failures where the benefits of doing so exceed the costs. There are various options for doing this in fisheries management, which involves managing commercial species, bycatch and environmental impacts. One option is to 'internalise' the externality associated with bycatch. Allocating property rights over bycatch (for example, bycatch quota) or implementing a tax on bycatch are ways of internalising such costs. Once these costs are internalised, the costs of fish production and the price of seafood will more accurately reflect the cost to society of producing seafood and associated bycatch. As a result, seafood production and bycatch will occur at a level that is closer to a socially optimum level. In some situations this might result in reduced seafood production, while in other situations internalising costs will result in incentives to reduce bycatch so as to maintain production. Another option is for command-and-control type approaches to reduce the level of production to some predetermined level that reduces the external cost associated with that activity to an acceptable level.

Source: OECD (1997)

The level and nature of costs and benefits of managing excessive bycatch will depend on:

- the current situation and the options for change being considered
- the economic value of the fishery
- the stock status of target and byproduct species (if known)
- the ecological risk assessment results for bycatch species
- the prevailing social value stakeholders and the community place on healthy marine ecosystems.

Comparing benefits and costs may guide decisions on the level of resources (time and funding) devoted to addressing the issue, and may inform decisions over what level of bycatch is acceptable and what management measures should be implemented to address the issue if necessary. In larger fisheries it may be cost-effective to thoroughly investigate and effectively mitigate a bycatch problem. In other cases the costs of well-informed implementation of bycatch management measures may be considered out of proportion to the fishery's value and the risk. Regardless, robust analysis and consideration of all management options is required in such cases.

Mitigation measures may negatively affect profitability by increasing the costs of fishing or reducing the total value of the catch. Understanding the expected impacts on fishery cost structures and prices under potential mitigation measures will allow a more informed comparison of options. Positive impacts can also occur. For example, where lower bycatch leads to better quality product (for example, prawns in trawl nets) and improved vessel-level efficiency (for example, less time spent sorting catch). Moreover, reduced environmental impact may produce a price premium, such as through product recognition or certification schemes (Roheim et al. 2011). Non-market valuation of the benefits of reducing bycatch can also provide information about the nature of benefits and can assist in identifying cost-effective mitigation options.

The same considerations apply to situations involving spatial management approaches; for example, marine parks and closures to protect species. However, the connectivity between closed areas and adjacent areas of the fishery is an important consideration—and often a key uncertainty—for evaluating spatial management as a bycatch management tool. For instance, the benefits of closures are likely to vary depending on the attributes of the species (for example, movement rates, migration patterns and growth rates) and fishery attributes (for example, distribution of fishing activities, exploitation rates and the relative profitability of closed and open areas).

Quantifying costs, benefits and cost-effectiveness

Sainsbury (2005) provides an overview of the concept of trade-offs between risk, catch and cost in fishery management:

> 'In fisheries there are likely to be feasible strategies to achieve sustainability and sustainable development goals at the high yield – high cost and low yield – low cost ends of the spectrum. For high valued fisheries the high yield – high cost may be appropriate, but in any event it should be an active and supportable decision. The outcome standards and risks should be the same across that spectrum, but the tools, information needs and cost of management may be quite different. And so would the level and variability of the catch.'

For bycatch management, expected changes in profitability will be an important determinant of whether particular mitigation measures are supported by fishers (Box 9). It can be informative to estimate the marginal cost of bycatch reduction; that is, the economic returns forfeited for every unit reduction in bycatch. Hawaii's longline fishery illustrates this approach (Pradhan & Leung 2006). For a mitigation approach based on increasing area closures, and estimating the number of mortalities that each closure would prevent, the fishery would sacrifice between US$77 000 and US$195 000 in net revenue for every loggerhead turtle saved (Figure 6).

Box 9 Steps in quantifying costs, benefits and cost-effectiveness

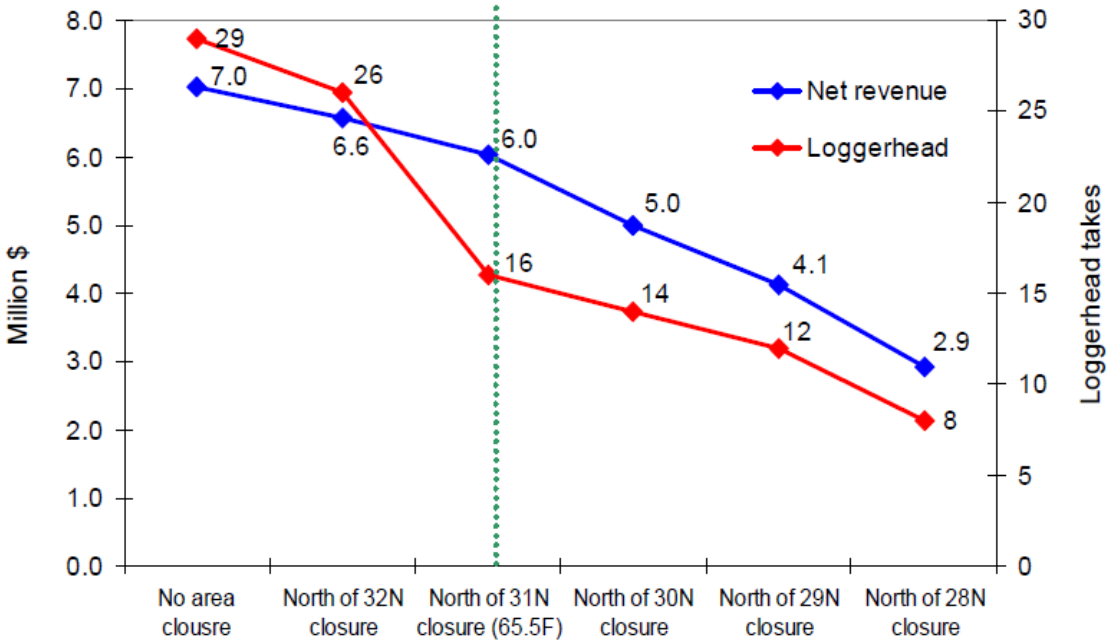
A standard operating procedure might step through the following stages in a situation where the level of bycatch reduction needs to be determined:
use non-market valuation techniques to assign values to the bycatch
carry out a cost-benefit analysis to determine what level of bycatch reduction is warranted and what management option would best be used to achieve this reduction.

If the required level of bycatch reduction has been pre-determined (for example, based on scientific evidence), then step 1 and step 2 will be replaced with the following step:

analyse the cost-effectiveness of available management options to determine the most cost-effective approach to achieving the bycatch reduction target.

There may be difficulties in estimating the direct costs and benefits of bycatch management, partly because it is hard to predict how some aspects will change as a result (including prices, effort levels in the fishery, upstream and downstream industries) and partly because it is inherently difficult to estimate monetary values for essential components, such as ecosystem services and biodiversity. There are several approaches to non-market valuation that can inform the consideration of the marginal benefits of various management options (Bateman 1993; Perman et al. 2003). Such methods place a non-use value on the resource that is subject to bycatch and therefore indicate the cost to society of removing or exploiting the resource. Such methods may include contingent valuation methods and choice modelling approaches that elicit a hypothetical value over a given resource from individuals (Bateman & Willis 1993; Bennet & Blamey 2001). However, all analytical techniques have strengths and weaknesses in completeness, accuracy and cost, and some methods can be misleading if considered on their own because the choice of methods can determine the results (Perman et al. 2003).

Figure 6 Marginal costs of mitigating sea turtle bycatch in Hawaii's longline fishery by progressively increasing the area of fishery closures



Note: As the effects of more extensive area closures are simulated, net revenue declines, as does the take of loggerhead turtles. Due to the association of the turtles with an oceanic front around 31–32°N, the decline in turtle take is non-linear, being greatest as the proposed closed area moves from 32°N to 31°N.

Data source: Li & Pan (2010)

Input-output models can identify region-wide or economy-wide impacts of fishery management changes aimed at dealing with a bycatch issue (Cai et al. 2005). They identify economic linkages along the supply chain. It is difficult to estimate direct costs and benefits and estimating the value of both upstream (supply) and downstream (demand) activities will be even more uncertain. The value of linked activities is often overestimated in input-output models because those models represent a snapshot in time and do not explicitly consider the potential for suppliers and consumers to switch to alternatives. Such tools can therefore inform policy changes, but they should not be used as the sole basis for decisions. Full input-output analysis is only relevant where the entire fishery is affected and there is little potential for redistribution of fishing effort and continuation or substitution of existing linkages.

Management of bycatch and the role of incentives

Quota management systems can allow for the incidental catch of species that may be targeted by one fishery, but are classified as bycatch or byproduct in other fisheries. Fishery-wide quotas or trigger limits for bycatch species may also create incentives for bycatch reduction when it becomes costly to encounter bycatch. This may be reinforced by peer-group pressure and formal enforcement, thereby promoting good practice throughout the fishery. However, trigger limits can also lead to a 'race to fish' as each fisher may seek to maximise their own catch before someone else triggers a fishery closure. Taxes in the form of penalties for bycatch create an incentive to minimise bycatch, but would also create an incentive for non-reporting by fishers, as would bycatch quotas or recommended biological catches. There are also issues associated with the costs and practicality of monitoring compliance with bycatch quotas. Electronic monitoring can improve the feasibility of such options in some fisheries, provided that the monitoring system is adequate to motivate better logbook reporting and to detect statistically rare events. Electronic monitoring may also allow monitoring of compliance and verification of self-reporting.

Incentives need to be used effectively, including penalties for bad practice and rewards for good practice. Incentives are driven by two main stimuli: rules, which may be costly to implement or feasible to evade, and market forces. Incentives may have associated costs (such as information requirements) and reducing the costs of complying may improve the incentives to comply.

An economic perspective also informs discussion of 'offsetting' bycatch by making investments in other areas of conservation; for example, removing invasive predators from island breeding colonies could save more seabirds for less cost than reducing fishing (Pascoe et al. 2011). However, such schemes are contentious as there may be an expectation that the fishing industry should minimise bycatch in conjunction with—rather than instead of—complementary conservation actions. Offsetting bycatch is not consistent with current government policy, with the EPBC Act requiring that all reasonable steps are taken to avoid mortality of (or injury to) protected species.

The potential to maintain or gain access to markets can also influence incentives to reduce bycatch. For example, there has been considerable effort directed toward raising the seafood awareness of consumers in North America and Europe to change consumer preferences toward sustainable seafood. However, the success of these awareness campaigns has varied as many consumers remain extremely sensitive to price and quality when selecting seafood products, particularly in developing Asian countries (Jacquet & Pauly 2007). In western developed regions there is some evidence that consumers are increasingly willing to pay a price premium for eco-labelled seafood (Roheim et al. 2011), and this can occur at sufficiently large scales to change production norms. In addition to fisheries status reporting by government agencies and marketing by fishing companies, several third-party certification or 'eco-labelling' schemes are now available. Demonstrating the effectiveness of mitigation measures and ongoing improvement in reducing bycatch form an important part of these certification schemes.

Examples of research on bycatch mitigation measures

There are many recent examples of research on bycatch mitigation measures, both in Australia and overseas. Patterson and Tudman (2009) reviewed mitigation measures for shark bycatch and provided options by gear type. Ward et al. (2008) demonstrated that nylon leaders reduced shark bycatch in a pelagic longline fishery. Using a similar experimental design, Ward et al. (2009) assessed the performance of using circle hooks on bycatch and target species. Many studies have researched bycatch mitigation methods in the Commonwealth Northern Prawn Fishery (including Brewer et al. 1998, 2006; Griffiths et al. 2006; Heales et al. 2008; Maynard &

Gaston 2010; Maynard et al. 2010; Milton et al. 2009). In addition, Australia has conducted extensive research on mitigation measures for seabirds in longline fisheries (for example, Robertson et al. 2006, 2008, 2010; Sullivan et al. 2012).

Standard 5: The effectiveness of bycatch management is monitored and evaluated

5.1. When bycatch management or a mitigation measure is implemented, subsequent monitoring is adequate to assess its effectiveness.
5.2. An ecological risk management response, including a bycatch and discard work plan, is developed for each fishery, or equivalent actions are contained in the fishery management plan.
5.3. Fishing industry sectors are encouraged to develop codes of practice that provide detailed information on protocols for minimising bycatch in that sector, that facilitate compliance with relevant regulations and that are consistent with the intent of relevant policy.
5.4. Metrics to measure the effectiveness of management responses in meeting their objectives are specified and monitored.

Guidelines for Standard 5

Standard 5 is intended to promote a culture of performance management in the monitoring and evaluation of bycatch management. It requires mechanisms for bycatch monitoring, analysis and response to facilitate adaptive bycatch management. The guidelines for this standard highlight several existing fishery management structures and plans that can be used.

The Bycatch Policy requires bycatch action plans to be developed for specified Commonwealth fisheries. The policy also provided a check list for developing bycatch action plans. Bensley et al. (2010) concluded that while bycatch action plans did contribute to raising awareness of the need to manage bycatch, their effectiveness in improving management, minimising bycatch and reducing interactions with wildlife species was limited.

In 2007, bycatch action plans were replaced with bycatch and discarding work plans as the key tool for implementing the Bycatch Policy. Bensley et al. (2010) note that bycatch and discarding work plans need to incorporate the lessons learned from the bycatch action plans, and particularly need to develop actions that are prioritised and achievable within the required timeframe, and which are appropriately resourced, measurable and accountable. Comprehensive ecological risk assessments were undertaken in parallel with the development and application of bycatch action plans and bycatch and discarding work plans. After further residual risk assessment, ecological risk management (ERM) plans have been developed for most Commonwealth fisheries. However, Bensley et al. (2010) observed that the evaluation of the effectiveness of management responses required further development.

In addition to the bycatch monitoring, assessment and management work of AFMA, several fishing industry sectors have developed their own codes of practice for managing the environmental effects of fishing. The codes of practice may be sector-specific and provide detailed technical information for fisheries in bycatch avoidance, handling and other operational aspects. Such initiatives by fishers may be useful for effective implementation of bycatch mitigation measures, especially where these relate to operating procedures on board commercial fishing vessels.

It is difficult to find published evaluations of the effectiveness of bycatch management, perhaps because this material is rarely published in peer-reviewed literature and because of a systematic failing to monitor the performance of bycatch management (Bensley et al. 2010). One of the few reports available for Commonwealth fisheries is Baker & Finley (2010), who assessed the reduction of incidental catch of seabirds in Australian longline fisheries. They concluded that there had been a significant reduction in the level of seabird bycatch since an initial assessment

was completed in 2003. The reduction in seabird bycatch was largely attributed to the implementation of the 2006 seabird TAP. Thus, it can be concluded that the suite of mitigation measures prescribed in the TAP are effective.

Standard 6: Bycatch management is consistent with, and at least equivalent to, the requirements of international and regional fisheries management organisations of which Australia is a member

6.1. Bycatch management and mitigation measures are at least as effective as those required by the regional fisheries management organisations of which Australia is a member.
6.2. Australia advocates for regional fisheries management organisations to adopt bycatch management and mitigation measures using domestic policy settings as an example of best practice to ensure that international standards are consistent with those required in Australia.
6.3. Engagement in international organisations or agreements relevant to fisheries bycatch is consistent across the relevant government agencies.

Guidelines for Standard 6

Australia's investment in fisheries management and conservation science, law, policy and practice and the benefits for bycatch populations can be undermined by poor practices in other countries, either in the management of their domestic fisheries or in the controls they exert as flag states of distant-water fishing vessels. Globally, there may be no significant conservation benefit if bycatch is reduced in Australian fisheries while product is imported to Australia from other countries with lower standards. Seafood imported from such countries may be cheaper than domestic product, perhaps as a result of less responsible management practices and lower management costs. This might then disadvantage Australian seafood producers through the higher standards and associated operating costs that are required here.

There may also be threats in international waters or the waters of other countries that affect the recovery of protected species in Australia. The Australian Government seeks to redress this imbalance through the promotion of global standards for bycatch management, working to ensure a level playing field for Australian seafood in the international marketplace and promoting global seafood sustainability. This is consistent with the 2005 Ministerial Direction to AFMA, which stated:

> 'in such [international] fora Australia will advocate its domestic policy settings as an example of best practice'.

Standard 7: Information on bycatch management is communicated and stakeholders are engaged

7.1. Information on bycatch management is communicated through appropriate media, including one or more of the following documents or processes:

6) ecological risk assessment report
7) ecological risk management report
8) bycatch and discard work plan
9) threat abatement plan
10) assessments carried out under the EPBC Act
11) recovery plan
12) national plan of action
13) industry codes of practice
14) issue-specific response papers.

7.2. Information is regularly released through newsletters, media releases or ad hoc updates.
7.3. Stakeholders are engaged through participation in AFMA's fishery management advisory committees, the Commonwealth Fisheries Research Advisory Board, issue-specific working groups, stakeholder meetings and direct communications.
7.4. Bycatch management actions are clearly and consistently communicated where the same issue is being addressed by different government agencies.

7.5. Stakeholders are consulted before international meetings that may take decisions that have potential implications for bycatch management in Commonwealth fisheries.

Guidelines for Standard 7

Overview

Standard 7 promotes effective methods of documenting and communicating information about bycatch management, encouraging transparency and improving consistency. Stakeholders are those individuals or groups that have a declared or implicit interest in the management of the fishery. This project's stakeholder engagement workshop noted that stakeholders need to have access to information and have opportunities to be involved in shaping fishery management responses to bycatch issue. The logic of bycatch management needs to be communicated and understood by scientists, managers, the fishing industry and non-government organisations (NGOs), as well as the general public.

Stakeholders should be actively engaged at most stages of bycatch management. Newsletters (hardcopy or electronic), social media and websites are examples of one-way communication, and serve an important role. Two-way communication involves listening to stakeholders' views and creating shared understanding. Subsequent decision-making need not necessarily be shared and solutions may be pursued by one partner only, taking into account views and opinions received during stakeholder consultation processes.

Stakeholder engagement refers to an ongoing process at each stage of management, from problem identification, to setting objectives and performance measures, to reviewing performance and developing adaptive management, involving a long-term commitment to collaboration. Effective engagement captures attention, engenders ownership, facilitates cooperation and promotes responsibility. The aim is to enhance the effectiveness of fisheries management by keeping stakeholders up-to-date with current issues, by seeking and incorporating their input and by shared ownership of outcomes. Stakeholders may contribute by

providing expert advice, reviewing management options, participating in monitoring and research or by increasing community awareness.

Standard 7.1 lists the main publications through which bycatch management actions are currently communicated in Commonwealth fisheries. There are various frameworks governing bycatch management, so there are various formats through which these actions may be communicated. Operational management is reported by AFMA in ecological risk management reports and bycatch and discard work plans, ad hoc reports, newsletters and minutes of committee meetings. Assessments of fisheries, recovery plans for endangered species and threat abatement plans (TAPs) for threatening processes are formal documents under the EPBC Act and are administered and published by SEWPaC. Current examples of detailed species, species group, area, fishery or fishing gear specific policies have also been developed and published by the responsible agencies. These include recovery plans for marine turtles (EA 2003), great white sharks (EA 2002), albatrosses and giant petrels (SEWPaC 2011a), the 2006 TAP for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations (DEWHA 2006) and the Australian Sea Lion Management Strategy (AFMA 2010b).

Standard 7.2 recognises that it is important to regularly inform the wider community. Standards 7.3 and 7.5 confirm that stakeholder engagement is an active and continuous process. Standard 7.4 encourages Australian Government agencies to ensure clarity and consistency in their communications with stakeholders and the wider community.

The Stakeholder Engagement Workshop noted that there are several AFMA standing committees that include stakeholder representatives, and this is recognised in the standard. These committees regularly review bycatch issues in their fisheries, in the case of the management advisory committee (MACs), and across all Commonwealth fisheries, in the case of the AFMA Commission. The commission maintains a strategic overview and is accountable for key management decisions. Standard 7 also recognises the role of ad hoc advisory groups, convened to address bycatch issues as they arise, and the importance of timely and direct communications between stakeholders and government. Standard 7 also links to international initiatives on bycatch, recognising that stakeholders should be engaged to inform Australian Government negotiating positions before international meetings.

Merits of stakeholder engagement

There is broad and substantial interest in bycatch issues among environmental NGOs, the fishing industry and the broader community. These groups can also contribute relevant expertise to bycatch management. Some stakeholders will be well placed to identify issues (including fishers and fishery observers), others will be able to contribute expertise toward solving particular issues (fishers, managers and scientists), while others may act as advocates in discussions about priorities and potential management responses (representatives of the fishing industry or conservation NGOs). Some individuals may play more than one of these roles. In this context, leadership may be exhibited by industry, NGOs, scientists, managers or other stakeholders.

This dynamic is already apparent in some Commonwealth fisheries, notably the NPF, and can lead to innovative solutions to bycatch issues. Effective engagement requires dedicated resources. Nevertheless, investment in consultation may be more cost-effective than the consequences of not consulting, such as having to resolve issues through the media or through legal action. Regular consultation with all stakeholders can also greatly increase support and ownership of proposed management arrangements, which is essential to effective co-management.

Key principles

The Australian Government's Office of Best Practice Regulation provides a useful list of key principles for stakeholder consultation (Box 10). The way engagement is conducted is important, but there is no single, ideal model. Much can depend on the personalities of individuals involved. There are some key principles that are worth recognising:

- Face to face contact and convenience are important, so the timing and location of meetings must be considered and all parties accommodated as far as possible. Busy periods should be avoided and meetings in familiar environments, such as stakeholder home towns, are often appreciated. Costs can be reduced by locating meetings closest to the most participants.

- Engagement often works best if it is treated as core business and integrated with related processes. Early engagement is appreciated and is useful for identifying interests and establishing expectations. Relevance is important to all stakeholders, as is trust and mutual respect—most people do not want to waste time discussing issues that are not of direct concern to them or where the consultation seems cursory. Consultation that commences at a late stage in the process is not appreciated, especially if stakeholders are expected to agree to outcomes that they have not been involved in generating. Engagement needs to be inclusive and responsive, flexible and adaptive. For example, the permanent inclusion of stakeholder representatives on all of AFMA's fishery resource assessment group (RAG) and MAC meetings encourages an ethos of communication and active participation among stakeholders.

- Sharing information can be a key to building trust and developing a constructive approach to problem solving. It can be useful to circulate draft discussion papers before meetings to stimulate and structure discussion. How such papers will be used and the extent to which they may be modified through consultation should be clear, as should the overall purpose of the engagement.

- There is an important role for peak industry bodies in propagating best practice, through word-of-mouth and more formal codes of conduct. They can also facilitate the process of stakeholder engagement. There is a need for specialised training in consultation and communication skills for public servants and for stakeholder representatives.

The identification of stakeholder preferences, followed by multi-criteria evaluation, is also a good way to analyse social impact and the likely degree of acceptance of bycatch management measures. There are several survey methods suitable for analysing stakeholder preferences. However, such assessments may stop short of identifying conflicting objectives and assigning relative weight to multiple objectives. Within stakeholder groups it is important to have a shared vision to present to other stakeholder groups—ideally this vision is also shared among stakeholder groups, although for Commonwealth fisheries, agreement may be stronger for high-level objectives than for specific, more detailed actions (Pascoe et al. 2009). The question of how to constructively challenge entrenched positions may need addressing if the purpose of the engagement is consensus-building. This may best be approached by each party attempting to consider the issue from each other's perspective.

Box 10 Australian Government principles for stakeholder consultation

Continuity: consultation should be a continuous process; for example, participation in RAGs and MACs.

Targeting: consultation should be widely based to ensure it captures the diversity of stakeholders.

Timeliness: consultation should start when objectives or options are first being identified. Where substantial changes are anticipated, stakeholders should have enough time to provide considered responses.

Accessibility: stakeholder groups should be informed of proposed consultation and be provided with information via a range of means.

Transparency: agencies need to explain clearly the objectives of the consultation process and provide feedback on how they have taken responses into consideration.

Consistency and flexibility: consistent consultation procedures make it easier for stakeholders to participate, but arrangements should suit the circumstances of the issue(s) under consideration.

Evaluation and review: agencies should evaluate the effectiveness of their consultation processes.

Source: Adapted from guidance developed by the Australian Government Office of Best Practice Regulation (Australian Government 2010)

Potential challenges

Fisheries bycatch competes with many other issues of public interest in natural resource conservation and management. The audience may only be receptive if the topic is relevant and they are motivated to listen. Stakeholders may respond better to approaches from researchers and managers if they see demonstrated commitment to a genuine consultation process. Stakeholders are unlikely to respond well to a process that gives an impression of selecting only those stakeholders likely to agree to a pre-conceived outcome. Trust can also be eroded if shared information is used for different purposes to that originally intended. It is a general challenge to maintain effective professional networks and good relations among stakeholders if there is high staff turnover or short-term funding of projects, as these can undermine confidence.

The Stakeholder Engagement Workshop stressed the importance of timely feedback for maintaining relationships. This is especially important when submissions have taken considerable time to prepare, otherwise the consultation may be counter-productive, serving to alienate rather than engage stakeholders. From a fishery manager's perspective, the most useful submissions during consultations do not just identify problems, but also suggest solutions; this can be seen as a tangible contribution from stakeholder engagement. For the partnership to work there must be shared ownership of the problem and participation in its solution.

The best examples of public consultation provide an explanation of the final decision made, as well as reasons why particular recommendations were or were not adopted (for example, the Australian Government's response to the report of the Independent Review of the EPBC Act; SEWPaC 2011b*)*. This requires considerable investment of time and resources and may not be realistic in all cases. Feedback may be absent at certain stages in the process as there can be inevitable delays and periods of confidentiality while comments are reviewed or briefs are being considered by ministers. It is therefore useful to have a clear timeframe for consultation and subsequent decision-making.

Application of the proposed standards to mitigating shark bycatch in the Eastern Tuna and Billfish Fishery

Background

The project's second objective was to 'test the proposed standards and guidelines on a bycatch issue in a key Commonwealth fishery'. In supporting the funding application, the Commonwealth Fisheries Research Advisory Board (ComFRAB) specified that 'once completed, the outcomes of this project should be reviewed to decide whether to develop a further project to deliver a larger body of work that is likely to test the guidelines developed in phase one on a number of case-studies'. The funding application subsequently indicated that 'the standards and guidelines will be tested on an existing bycatch mitigation measure; this will not involve fieldwork or "case studies" that were proposed in an earlier version of this application. Project outputs may form the basis for further work and case studies for testing proposed standards and guidelines, as foreshadowed by ComFRAB.'

This section addresses the project's second objective by comparing the proposed standards with the steps involved in mitigating shark bycatch through a ban on wire leaders or 'traces' in the Eastern Tuna and Billfish Fishery (ETBF) longline fishery. It illustrates how the proposed standards might have been applied to an existing mitigation measure.

The wire leader measure

Ward et al. (2008) provide the following background and description of the issue of wire leaders and shark bycatch.

> [An] effective way to reduce shark bycatch may be to ban wire leaders or "steel traces". Fishers have used wire leaders since the 1920s to reduce the loss of longline fishing gear and hooked animals that are able to sever leaders constructed from natural or synthetic fibres. Many longline fishers began using nylon monofilament leaders in the 1980s, although several fleets have continued to use wire leaders or use wire for a proportion of their branchlines (Gilman et al., 2008; Ward and Hindmarsh, 2007). To reduce shark bycatch, Australia banned the use of wire leaders in its eastern tuna longline fishery in 2005.

Ward et al. (2008) compared catches on nylon monofilament and wire leaders deployed by commercial longline fishing vessels in 2005–2006 off north-eastern Australia. These experiments involved equal numbers of wire and nylon leaders placed randomly along each longline. Scientific observers recorded the sequential hook number, leader type, species and size of each animal caught. Observers also counted the number of longline branchlines retrieved where the leader was severed ('bite-offs').

The ETBF measure provides a simple example for demonstrating how the standards might have been applied to bycatch mitigation. Table 2 relates the proposed standards to activities undertaken as part of the wire leader measure. It shows that the implementation of this measure would have met many of the proposed standards. However, it did not clearly identify performance measures or subsequently monitor the effectiveness of banning wire leaders in reducing shark bycatch.

Table 2 Example of how the proposed bycatch standards might have been applied to the 2005 measure on wire leaders for mitigating shark bycatch in the ETBF

Standard	Relevant actions in the ETBF wire leader example
1. Fisheries bycatch is identified, verified and quantified	
1.1 Bycatch is identified, quantified and verified through one or more of the following fisheries monitoring systems:	
(a) reporting of operational-level catch and effort data in logbooks	• Operational-level catch and effort data has been reported in logbooks since 1986. The logbooks allow the number of each shark species not retained, their fate and the number and weight retained to be reported.
(b) scientific or independent observer programs	• The ETBF has had a scientific observer program in place since 2001. In recent years coverage has ranged between 3.5 per cent and 8 per cent of fishing effort.
(c) electronic monitoring	• AFMA has conducted trials of electronic monitoring in the ETBF and is preparing to implement the technology.
(d) self-reporting of bycatch interactions.	• AFMA has systems in place for fishers to report interactions with protected species.
1.2. The design of fisheries monitoring systems is statistically robust, so as to permit the identification, quantification and verification of bycatch with a reasonable degree of confidence.	• The design of the ETBF observer program was based on analyses undertaken by Bravington et al. (2002). Using observer data from the Japanese longline fleet, they evaluated program designs for a range of observer coverage rates and levels of precision.
1.3 Fishery-wide bycatch management is prioritised through analyses of the data collected by these monitoring systems.	• An ecological risk assessment (AFMA 2011) classified several shark species as high-risk.
2. Operational objectives, which are consistent with relevant policies and legislative requirements, are specified for managing fisheries bycatch	
Current legislation and policies require that all reasonable steps are taken to:	
(a) minimise fisheries bycatch	• The objective of the ETBF measure on wire leaders was to reduce the bycatch of sharks in ETBF longlining activities. An operational objective should also include a reference point, for example 'to reduce annual shark catches below the historical average level'.
(b) ensure that fisheries do not threaten bycatch populations	• Quantitative assessments were not available to support an objective of ensuring that fisheries do not threaten these shark populations. Quantitative stock assessments of oceanic whitetip (Rice 2012) and silky sharks (Rice & Harley 2012) subsequently confirmed the need to mitigate fishery impacts on those species.
(c) avoid mortality of (or injury to) species that are classified as protected under the *Environment Protection and Biodiversity Conservation Act 1999*.	• The shark species that these longliners interact with were not listed under the EPBC Act. In 2010, longfin and shortfin mako shark and porbeagle shark were automatically listed as 'migratory' under the EPBC Act following their listing under the international Convention on Migratory Species.

3. The effects of fishing on bycatch populations are assessed	
3.1. Robust and practical indicators of fishery effects on bycatch are identified.	• Reference points, indicators and decision rules for the wire leader ban have not formally been defined. A suitable reference point might be a historical level of shark bycatch or an acceptable rate of fishing mortality.
3.2. Indicators of fishery effects on bycatch are measured against established reference points.	• Indicators of the measure's performance in reducing shark bycatch might include evidence of a statistically significant decline in observed catch rates of sharks following the ban. • Decision rules might include 'investigate alternative mitigation measures if shark catch rates increase above pre-ban levels'.
3.3. Decision rules are developed to ensure that the bycatch management response is proportional to the risk of reference points being breached.	
3.4. A risk-based approach is used as a basis for decision-making where a rapid response is required or where data are insufficient to fully inform a quantitative approach.	• AFMA's decision to ban wire-leaders may be seen as a risk-based approach to a situation where data were insufficient to fully inform a quantitative approach. Soon after the decision to ban wire leaders, research was conducted which justified AFMA's decision.

4. The cost-effectiveness of bycatch mitigation measures is established	
4.1. There is sound logic or evidence for the performance of the mitigation measures.	• There was sound logic for banning wire leaders as a way of reducing shark bycatch. For example, fishers acknowledged that wire leaders were often deployed to reduce gear loss from sharks; and observers reported that frequent bite-offs of nylon leaders indicated that sharks bite through nylon.
4.2. Experimental designs for research trials of bycatch mitigation measures are statistically robust.	• AFMA commissioned the former Bureau of Rural Sciences (BRS) to investigate the effects of the measure on longline catches. This involved preliminary analyses to determine the sample sizes necessary to deliver a specified level of precision for difference in catch rates.
4.3. Differences between research trials and commercial fishing operations are anticipated.	• The experiments involved commercial longliners. Ward et al. (2008) highlight potential pitfalls in transferring the results to other longliners and to other areas.
4.4. The cost-effectiveness of mitigation measures is assessed at an appropriate level of detail.	• Ward et al. (2008) estimated the effects of the measure on catches and the landed value of target species. They also mention operational and safety issues associated with the measure.
4.5. Mitigation measures result in statistically significant reductions in bycatch mortality or prevent the decline of bycatch populations.	• Ward et al. (2008) concluded that shark catch rates on wire were significantly higher than those on nylon leaders. However, they note that high bite-off rates indicate that many more animals escape from nylon leaders compared to wire. The fate of escaped animals, including sharks, is not known but total mortality potentially may have increased.
4.6. A mitigation measure designed to minimise bycatch of a high-risk species or species group does not increase fishery impacts on other high-risk or protected species.	• The wire leader trials did not encounter any protected species. Ward et al. (2008) showed that the measure would not increase catch rates of other bycatch species.
4.7. Bycatch mitigation measures that are mandated as alternatives to each other have a similar level of performance in reducing bycatch.	• No mitigation measures were presented as alternatives to the wire leader measure.
4.8. Where multiple mitigation measures are required to be used together, their effects are at least additive.	• A 20-shark trip limit on landing sharks is likely to have an additive effect with the wire leader measure in reducing shark bycatch.

5. The effectiveness of bycatch management is monitored and evaluated	
5.1. When bycatch management or a mitigation measure is implemented, subsequent monitoring is adequate to assess its effectiveness.	• Subsequent monitoring through routine logbook and observer programs and is likely to allow the comparison of pre- and post-ban catch levels and catch rates.
5.2. An ecological risk management response, including a bycatch and discard work plan, is developed for each fishery, or equivalent actions are contained in the fishery management plan.	• A ban on wire leaders is identified as a risk management strategy action in the ETBF's ERM (AFMA 2012b). A bycatch and discarding work plan is available for Australian Tuna and Billfish Longline Fisheries (AFMA 2008).
5.3. Fishing industry sectors are encouraged to develop codes of practice that provide detailed information on protocols for minimising bycatch in that sector, that facilitate compliance with relevant regulations and that are consistent with the intent of relevant policy.	• The ETBF Code of Practice for Responsible Fishing (Jussiet & Robinson 2003) was developed before the wire leader measure was introduced. The Code of Practice provides details on procedures for cutting leader to reduce shark mortality.
5.4. Metrics to measure the effectiveness of management responses in meeting their objectives are specified and monitored.	• Metrics are yet to be established to measure the effectiveness of the wire leader measure.

6. Bycatch management is consistent with, and at least equivalent to, the requirements of international and regional fisheries management organisations of which Australia is a member	
6.1. Bycatch management and mitigation measures are at least as effective as those required by the regional fisheries management organisations of which Australia is a member.	• Western and Central Pacific Fishery Commission (WCPFC), Indian Ocean Tuna Commission (IOTC) and Commission for the Conservation of Southern Bluefin Tuna (CCSBT) do not have mitigation measures that are more effective than the ban on wire leaders for mitigating shark bycatch.
6.2. Australia advocates for regional fisheries management organisations to adopt bycatch management and mitigation measures using domestic policy settings as an example of best practice to ensure that international standards are consistent with those required in Australia.	• In 2011 Australia unsuccessfully proposed a ban on wire leaders at IOTC. • Australia will propose a ban on wire leaders at WCPFC in 2012.
6.3. Engagement in international organisations or agreements relevant to fisheries bycatch is consistent across the relevant government agencies.	• Australia's position on wire leaders has been consistent across government agencies involved in international organisations or agreements.

7. Information on bycatch management is communicated and stakeholders are engaged	
7.1. Information on bycatch management is communicated through appropriate media, including one or more of the following documents or processes: a) ecological risk assessment report b) ecological risk management report c) bycatch and discard work plan d) threat abatement plan e) assessments carried out under the EPBC Act f) recovery plan g) national plan of action h) industry codes of practice i) issue-specific response papers.	AFMA has employed many of those documents or processes to inform stakeholders about the management of shark bycatch, including: • Ecological risk assessment report (AFMA 2011) • Ecological risk management report (AFMA 2012b) • Bycatch and discarding work plan (AFMA 2008) • AFMA's submission for the assessment carried out under the EPBC Act (AFMA 2010c) • National Plan of Action for the Conservation and Management of Sharks • ETBF industry code of practice (Jussiet & Robinson 2003) • AFMA also held a series of port visits where the wire leader measure was discussed among other issues.
7.2. Information is regularly released through newsletters, media releases or ad hoc updates.	• Communication through the ETBF's MAC and RAG was considered adequate for the dissemination of information about the mitigation measure. • Stakeholders were involved through direct communication and the ETBF's MAC and RAG largely after the initial decision to ban wire leaders.

7.3. Stakeholders are engaged through participation in AFMA's fishery management advisory committees, the Commonwealth Fisheries Research Advisory Board, issue-specific working groups, stakeholder meetings and direct communications.	• The key stakeholder supported research into the effects of wire leaders by making fishing gear and commercial longliners available and by providing advice on operational issues.
7.4. Bycatch management actions are clearly and consistently communicated where the same issue is being addressed by different government agencies.	• AFMA, DAFF and BRS were involved in communicating information about the measure.
7.5. Stakeholders are consulted prior to international meetings that may take decisions that have potential implications for bycatch management in Commonwealth fisheries.	• Stakeholders have been consulted on Australia's position on wire leaders before meetings of the WCPFC and IOTC.

Benefits

This project reviewed approaches to managing bycatch in Commonwealth fisheries and proposed standards and guidelines that are consistent with the Australian Government's legislative and policy framework and reflect the interests of diverse stakeholders. The proposed standards and guidelines are presented at an operational level; they are not intended to be aspirational. The standards provide a potential tool for enhancing or evaluating the performance of actual practice in individual fisheries. They incorporate past lessons from bycatch management in Commonwealth fisheries and elsewhere. The standards might provide a means to further progress AFMA's ERM initiative.

The proposed standards (Appendix C) provide fishery managers with a structured approach for ensuring bycatch management is robust and consistent, with a pathway to developing clear performance indicators and accountability. They aim to:

- demonstrate the effectiveness of bycatch management to seafood consumers and the wider Australian community
- provide industry with a greater level of certainty about their responsibilities
- enable industry to more readily demonstrate environmentally responsible practices, which may assist them in meeting the increasing demands for environmental certification.

Further development

As foreshadowed in this project's funding application, the application of the proposed standards and guidelines to bycatch issues is an important step in testing and further developing a standards-based approach to managing bycatch in Commonwealth fisheries.

The usefulness of establishing agreed standards and guidelines for bycatch management is likely to be considered during the current review of the Bycatch Policy. The proposed standards might provide a starting point for developing guidelines for a revised bycatch policy. This would depend on the review recommending a revised policy and ministers accepting that recommendation. Initial steps might then involve considering whether the structure of the proposed standards is appropriate for policy guidelines, and mapping proposed standards against policy objectives—whether additional standards need to be drafted and whether any standards proposed in this report should be omitted or modified.

The proposed standards could be treated as a checklist for assessing the performance of bycatch management in Commonwealth fisheries. A similar format was used by Grafton et al. (2007) to assess fisheries governance. The standards are also relevant to the national policy on fisheries

bycatch and to the policies of individual Australian states and territories. However, the standards developed by the current project were based on existing Commonwealth legislation and policies. To apply the proposed standards to a national policy or state situations it would be necessary to tailor the overriding objectives (Standard 2) to relevant national policies and legislation from those jurisdictions.

Planned outcomes

The project's funding application listed two key outcomes of the work:

> 'The project will provide fishery managers and policy makers with agreed procedures for ensuring that bycatch mitigation strategies are robust and consistent, with clear performance indicators and accountability.
>
> The project outputs will enable industry to more readily demonstrate environmental responsibility and help to ensure that mitigation measures are effective, practical and reliable. Industry should then be able to consistently demonstrate the effectiveness of bycatch mitigation, which will assist them in meeting the increasing demands from consumers for environmental certification and standards.'

The project provided Commonwealth fishery managers and policymakers with suggested standards and guidelines for ensuring that bycatch management is robust and consistent, including guidance on how to develop clear performance indicators. There was broad acceptance among project advisory committee and workshop participants that clearly stated operating standards, with accompanying guidelines, are desirable for managing bycatch in Commonwealth fisheries. The bycatch policy review provides a pathway for considering the proposed standards and their further development.

In addition to being considered by the stakeholders and Commonwealth agencies involved in the bycatch policy review, this report on bycatch standards and guidelines is to be included as one of the supporting documents for the review report's release for public comment. The authors are also drafting an international journal article that is based on this report, for circulation to a wider audience of fishery managers and policymakers.

Conclusions

We concluded that clearly stated standards, with accompanying technical guidelines, would be useful for identifying, verifying, quantifying, mitigating and managing bycatch in Commonwealth fisheries.The project achieved Objective 1 (develop standards for mitigating bycatch in Commonwealth fisheries, including an accompanying set of guidelines for establishing technical criteria for assessing the performance, ongoing monitoring and review of bycatch mitigation measures).

Objective 2 involved testing the proposed standards and guidelines on a bycatch issue in a key Commonwealth fishery. This report includes a comparison of the proposed standards and the mitigation of shark bycatch in the Eastern Tuna and Billfish Fishery. It shows that this measure would have met many of the proposed standards. However, it did not clearly identify performance measures and the effectiveness of the mitigation measure has not been monitored.

Bycatch can be among the most contentious issues faced by commercial fishers and fishery managers. The costs of inadequately addressing bycatch issues can be high. There appears to be broad stakeholder support for applying a more systematic approach to managing bycatch. The framework of standards and guidelines proposed here provide a clearly stated approach to bycatch management that is intended to be practical, feasible and transparent. They may therefore help to reduce conflict in bycatch management and to improve outcomes for bycatch species, for industry and for the Australian community.

Appendix A: Intellectual Property

The information compiled by this project is published, widely disseminated and promoted. There is no need to protect intellectual property beyond the Australian Government's standard copyright that applies to the project's report and other outputs.

Appendix B: Staff and workshop participants

Table B1 Staff supported by the project

Name	Organisation
Katherine Cheshire	ABARES
David Kirby	ABARES
Heather Patterson	ABARES
Peter Ward	ABARES

Table B2 Workshop participants

Name		Agency	Workshop(s) attended				
			Fisheries monitoring	Experimental design	Stakeholder engagement	Economic evaluation	Indicators and ref. points
Baker	Barry	Lat. 42		Yes			
Begg	Gavin	ABARES					Yes
Boag	Simon	SETFIA			Yes		
Bray	Shalan	DAFF					Yes
Bull	Tim	DAFF					Yes
Cameron	Kerry	SEWPaC		Yes			Yes
Campbell	Robert	CSIRO	Yes				
Chesson	Jean	ABARES	Yes				
Curtotti	Robert	ABARES				Yes	
Galeano	David	AFMA				Yes	
Giannini	Fiona	ABARES	Yes				
Goodspeed	Mandy	AFMA					Yes
Gerner	Mike	AFMA		Yes			
Hay	Ian	AAD					Yes
Hitch	Lorraine	DAFF			Yes		Yes
Karlov	Tim	DAFF					Yes
Keightley	Ryan	DAFF					Yes
Kirby	David	ABARES	Yes	Yes	Yes	Yes	Yes
Kruger	Heleen	ABARES			Yes		
Madon	Trixi	CFA			Yes		
McQueen	Anthea	AFMA				Yes	
Mathews	John	SEWPaC	Yes				
Maynard	David	AMC		Yes			
Moore	Andy	ABARES		Yes			
Penrose	Lindsay	ABARES	Yes	Yes			
Petersen	Peter	SEWPaC			Yes		
Proctor	Wendy	CSIRO			Yes	Yes	Yes
Read	Kathryn	SEWPaC				Yes	Yes
Rodgriguez	Veronica	ABARES	Yes				
Ryan	Paul	AFMA					Yes
Smith	Tony	CSIRO				Yes	Yes
Stobutzki	Ilona	ABARES					Yes
Stoute	Selina	AFMA			Yes		
Timmiss	Trent	AFMA	Yes				
Trott	Peter	WWF			Yes		
Tudman	Michael	AFMA	Yes	Yes			Yes
Vieira	Simon	ABARES			Yes	Yes	
Ward	Peter	ABARES	Yes	Yes	Yes	Yes	Yes
Wellbelove	Alexia	HSI			Yes		
Yates	Mike	AFMA	Yes				
Zhou	Shijie	CSIRO					Yes

Appendix C: Summary of proposed standards

1) Fisheries bycatch is identified, quantified and prioritised

Bycatch is identified, quantified and verified through one or more of the following fisheries monitoring systems:

a) reporting of operational-level catch and effort data in logbooks

b) scientific or independent observer programs

c) electronic monitoring

d) self-reporting of bycatch interactions.

The design of fisheries monitoring systems is statistically robust, so as to permit the identification, verification and quantification of bycatch with a reasonable degree of confidence.

Fishery-wide bycatch management is prioritised through analyses of the data collected by these monitoring systems.

2) Operational objectives, which are consistent with relevant policies and legislative requirements, are specified for managing fisheries bycatch

3) The effects of fishing on bycatch populations are assessed

3.1. Robust and practical indicators of fishery effects on bycatch are identified.

3.2. Indicators of fishery effects on bycatch are measured against established reference points.

3.3. Decision rules are developed to ensure that the bycatch management response is proportional to the risk of reference points being breached.

3.4. A risk-based approach is used as a basis for decision-making where a rapid response is required or where data are insufficient to fully inform a quantitative approach.

4) The cost-effectiveness of bycatch management and mitigation measures is established

4.1. There is sound logic or evidence for the performance of the mitigation measures.

4.2. Experimental designs for research trials of bycatch mitigation measures are statistically robust.

4.3. Differences between research trials and commercial fishing operations are anticipated.

4.4. The cost-effectiveness of mitigation measures is assessed at an appropriate level of detail.

4.5. Mitigation measures result in statistically significant reductions in bycatch mortality or prevent the decline of bycatch populations.

4.6. A mitigation measure designed to minimise bycatch of a high-risk species or species group does not increase fishery impacts on other high-risk or protected species.

4.7. Bycatch mitigation measures that are mandated as alternatives to each other have a similar level of performance in reducing bycatch.

4.8. Where multiple mitigation measures are required to be used together, their effects are at least additive.

5) The effectiveness of bycatch management is monitored and evaluated

5.1. When bycatch management or a mitigation measure is implemented, subsequent monitoring is adequate to assess its effectiveness.

5.2. An ecological risk management response, including a Bycatch and Discard Work Plan, is developed for each fishery, or equivalent actions are contained in the Fishery Management Plan.

5.3. Fishing industry sectors are encouraged to develop codes of practice that provide detailed information on protocols for minimising bycatch in that sector, that facilitate compliance with relevant regulations and that are consistent with the intent of relevant policy.

5.4. Metrics to measure the effectiveness of management responses in meeting their objectives are specified and monitored.

6) Bycatch management is consistent with, and at least equivalent to, the requirements of international and regional fisheries management organisations of which Australia is a member

6.1. Bycatch management and mitigation measures are at least as effective as those required by the regional fisheries management organisations of which Australia is a member.

6.2. Australia advocates for regional fisheries management organisations to adopt bycatch management and mitigation measures using domestic policy settings as an example of best practice to ensure that international standards are consistent with those required in Australia.

6.3. Engagement in international organisations or agreements relevant to fisheries bycatch is consistent across the relevant government agencies.

7) Information on bycatch management is communicated and stakeholders are engaged

7.1. Information on bycatch management is communicated through appropriate media, including one or more of the following documents or processes:

- ecological risk assessment report
- ecological risk management report
- bycatch and discard work plan
- threat abatement plan
- assessments carried out under the EPBC Act
- recovery plan

- national plan of action
- industry codes of practice
- issue-specific response papers.

7.2. Information is regularly released through newsletters, media releases or ad hoc updates.

7.3. Stakeholders are engaged through participation in AFMA's fishery management advisory committees, the Commonwealth Fisheries Research Advisory Board, issue-specific working groups, stakeholder meetings and direct communications.

7.4. Bycatch management actions are clearly and consistently communicated where the same issue is being addressed by different government agencies.

7.5. Stakeholders are consulted before international meetings that may take decisions that have potential implications for bycatch management in Commonwealth fisheries.

Glossary

Acronym	Details
AAD	Australian Antarctic Division
ABARES	Australian Bureau of Agricultural and Resource Economics and Sciences
AFMA	Australian Fisheries Management Agency
AMC	Australian Maritime College
BRD	Bycatch reduction device
BRS	Bureau of Rural Sciences
CFA	Commonwealth Fisheries Association
ComFRAB	Commonwealth Fisheries Research Advisory Board
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CV	Coefficient of variation
DAFF	Australian Government Department of Agriculture, Fisheries and Forestry
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
ERA	Ecological risk assessment
ERM	Ecological risk management
F	Fishing mortality rate
FAO	Food and Agriculture Organization of the United Nations
HSI	Humane Society international
IUCN	International Union for the Conservation of Nature
M	Natural mortality rates
MSC	Marine Stewardship Council
NGO	Non-government organisation
PBR	Potential biological removal
PSA	Productivity-susceptibility analysis
RBC	Recommended biological catch
SAFE	Sustainability Assessment for Fishing Effects
SESSF	Southern and Eastern Scalefish and Shark Fishery
SETFIA	South East Trawl Fishing Industry Association
SEWPaC	Australian Government Department of Sustainability, Environment, Water, Populations and Communities
SICA	Scale, intensity, consequence analysis
TED	Turtle excluder device

Acronym	Details
TRAFFIC	Wildlife trade monitoring network
WWF	Worldwide Fund for Nature

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