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ABARES

Technical Review for the Commonwealth Policy on Fisheries Bycatch: risk-based approaches, reference points and decision rules for bycatch and byproduct species

Andrew Penney, David Kirby, Katherine Cheshire, Michelle Wilson & Shalan Bray

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Objectives

1. Assess the robustness and applicability of risk-based approaches to bycatch management for species or groups of species, taking into account their biological status, data availability and other factors.
2. Evaluate the efficacy and appropriateness of reference points and structured decision rules in meeting the legislative and policy objectives for some bycatch species and/or groups.
3. Initially assess approaches to incorporating and addressing the potential cumulative impacts of fisheries' interactions with bycatch.
4. Assess the robustness and application of risk-based approaches to byproduct management for species or groups of species, taking into account their biological status, data availability and other factors.

Outcomes achieved

This report contributes technical information in support of the 2012–13 review of the Commonwealth Policy on Fisheries Bycatch (2000). The review of the Bycatch Policy was conducted by the Department of Agriculture, Fisheries and Forestry (DAFF) between 28 March 2012 and 28 March 2013. ABARES conducted research and analysis on the four objectives of this contributory report.

A draft of this report provided input to an issues paper released as part of public consultation for the Bycatch Policy review. Drafts of this report were also provided to participants in the project Steering Committee, Advisory Committee and stakeholder workshops, to inform discussion by these groups of key issues pertinent to the Bycatch Policy review. Outcomes from these various meetings, particularly from the two stakeholder workshops (reports of which are appended to this report), in turn informed the drafting of this report, to ensure that relevant technical advice was provided to

inform proposals to address the key issues identified by those meetings.

This report provides a review of recent developments in methodology and implementation of risk-based and low-information analytical approaches to assessment of bycatch and byproduct species. A tiered approach to application of the range of available risk-based and analytical assessment approaches is developed, depending on the availability of information and the trade-off between levels or risk, management priorities and costs for application of alternative assessment methods and management approaches.

Methods are reviewed and examples provided of feasible low-information reference points and performance measures for bycatch and byproduct interaction rates or mortalities. The use of these performance measures to facilitate and improve regular reporting of trends in bycatch interactions rates, and thereby to improve the monitoring of effectiveness of bycatch mitigation and management measures, is discussed. Requirements, costs and options for evaluating cumulative impacts across multiple fisheries are addressed. This report therefore directly contributes to achievement of the planned project outcomes:

- Improved understanding of mechanisms in implementing bycatch management in Commonwealth fisheries, reducing regulatory burden and complexity associated with meeting the current range of domestic policy and legislative requirements;
- Development of predefined and transparent species- and fishery-specific reference points and decision rules potentially minimising competing advice; and
- Improved mechanisms and methods for determining the success of bycatch measures employed in fisheries.

Background

International obligations to ensure the long-term sustainable management of bycatch species caught in association with fished commercial species date back to the United Nations Convention on the Law of the Sea (UN 1982). These have been expanded upon in numerous international agreements, instruments and guidelines, including the United Nations Agreement for the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UN 1995); the Food and Agricultural Organisation's Code of Conduct for Responsible Fisheries (FAO 1995a); the International Guidelines on Bycatch Management and Reduction of Discards (FAO 2011); the UN Convention on Biodiversity (UN 1992); and the Strategic Plan for Biodiversity for 2011–2020, including the Aichi Biodiversity Targets (CBD 2011).

The Food and Agricultural Organisation of the United Nations (FAO) and technical committees to the Convention on International Trade on Endangered Species have provided periodically updated guidelines on monitoring, management and conservation of bycatch species. These have been used by various regional fisheries management organisations when developing conservation and management measures for bycatch species in their areas of jurisdiction. In response to these international obligations and guidelines, numerous countries and economic entities have developed bycatch monitoring, management and/or conservation measures of varying degrees of complexity. Key characteristics and aspects of the bycatch management approaches taken by Chile, Canada, the European Union, New Zealand, Norway, the United States, Japan, Korea, Mexico, Greece and Portugal are briefly summarised in this report.

The Australian Government developed the Commonwealth Policy on Fisheries Bycatch (DAFF 2000) (hereafter referred to as the Bycatch Policy). The 2000 Bycatch Policy seeks to ensure that bycatch species and populations are maintained by:

- reducing bycatch;
- improving protection for vulnerable species;
- deciding on the acceptable extent of ecological impacts by, among other things, monitoring the impacts of fishing on bycatch species, collecting appropriate data to reduce uncertainty

in the management decision process and using biological reference points or a precautionary approach for management of bycatch species.

The Bycatch Policy was reviewed concurrently with a review of the Commonwealth Fisheries Harvest Strategy Policy (DAFF 2007). The purpose of this report is to provide guidance on the applicability of various assessment methods to inform the management of bycatch and byproduct species in Commonwealth fisheries. The research conducted has been used to inform discussions at stakeholder workshops and to support the advisory and steering committees for the policy review.

Establishment of Steering and Advisory Committees

An interagency steering committee was established to oversee and support the Bycatch Policy review. The steering committee comprised senior executive officers from DAFF, ABARES, the Australian Fisheries Management Authority and the Department of Sustainability, Environment, Water, Population and Communities. The steering committee met five times, in 11 May 2012, 24 September 2012, 21 January 2013, 15 February and 21 March 2013.

An advisory committee was also established to review and provide advice to the interagency steering committee on technical and policy matters that arose during the review of the Bycatch Policy. Membership of the committee included industry, government, environmental nongovernment organisations, CSIRO and the Fisheries Research and Development Corporation. The advisory committee met on 25 May 2012 and 19 October 2012.

Development of issues paper

DAFF and ABARES jointly developed the *Review of the Commonwealth Policy on Fisheries Bycatch issues paper*, expanding on topics discussed at the first stakeholder workshop, with input from the steering and advisory committees. The issues paper was released for public comment from 9 November 2012 to 21 December 2012. The paper outlined possible methods and approaches for future management of bycatch species as well as posing a number of questions for respondents to consider. The issues paper included a proposed updated definition of bycatch species that was linked to the definition proposed for consideration under the review of the Commonwealth Fisheries Harvest Strategy Policy (2007), to ensure that all catch taken as result of commercial fishing operations is clearly covered by one or other of the policies.

Stakeholder workshops

The first stakeholder workshop was held on 21 June 2012 to identify and discuss issues for the review of the Bycatch Policy. The report of this workshop (Appendix D) contributed to the development of the issues paper for public consultation. The workshop was attended by representatives of industry, government, environmental nongovernment organisations, CSIRO and the Fisheries Research and Development Corporation. A second stakeholder workshop was held in February 2013 and was provided with a draft of this report on risk-based approaches to bycatch assessment to inform discussion on future management approaches for bycatch species. DAFF engaged an independent facilitator, Sandy Morison, to host both workshops and to provide workshop reports.

This project contributed to the development of discussion papers for the first stakeholder workshop and provided significant input to the second workshop. Discussion papers on definitions and risk-based approaches were provided at the first workshop, summarising the work to date, to initiate discussion and elicit stakeholder comments on these aspects of the review. The workshop included five sessions covering:

1. Stakeholder identification of issues.
2. What is fisheries bycatch?
3. Review of Bycatch Policy's objectives and principles.
4. Approaches to bycatch management and recent technical reviews.
5. Risk-based approaches to bycatch management.

The second stakeholder workshop on 4 February 2013 considered how issues raised in public submissions and the outcomes of commissioned research should inform the drafting of proposed key principles for a revised Bycatch Policy. The workshop included the following sessions:

1. Summary of submissions received on the issues paper.
2. Outcomes of commissioned bycatch research by ABARES and CSIRO.
3. Aims and objectives of a revised Bycatch Policy.
4. Key Principles of a revised Bycatch Policy.

The report of this workshop (Appendix E) was used to inform the drafting of the Bycatch Policy Review Report, particularly the proposed aims, objectives and key principles for a revised Bycatch Policy.

Definitions of Bycatch and Byproduct

Definitions of bycatch vary internationally. However, all relate to species that are not actively targeted by a fishery, but are caught and partially or completely discarded. Following from discussion of potential definitions of bycatch by the first Bycatch Stakeholder Workshop (Appendix D), a proposed catch component classification was included in both the *Commonwealth Fisheries Harvest Strategy Policy and Guidelines discussion paper* and the *Review of the Commonwealth Policy on Fisheries Bycatch issues paper*, under which the term 'bycatch' would refer to unintentionally caught species that may not be retained (protected species), or which are always discarded due to having no commercial value. The term 'byproduct' would be applied to non-targeted species that are occasionally retained for commercial purposes. Information availability for both of these categories is usually low, and species may conceivably move between categories over time as market acceptability or protection status changes. It is, therefore, appropriate to consider how low-information assessment approaches might be applied to both bycatch and byproduct species.

Assessment Approaches and Information Requirements

In principle, the information requirements for monitoring fishery impacts on target, byproduct or bycatch species are the same, irrespective of species. What differs substantially, however, is the feasibility and cost of collecting data on these different species groups, depending on whether they are retained or discarded. Substantially differing levels of data and information exist for different fishery components, ranging from sparse information for discarded unintentional bycatch, through to some information for occasionally retained byproduct species, and to a high level of information for commercial target species. This range in information level necessitates a tiered approach to assessment of fishery impacts.

Assessment approaches range from qualitative risk assessment for lowest information species, through scored (semi-quantitative) risk assessments, quantitative risk assessments, increasingly robust low-information analytical methods to high-information integrated statistical stock assessments. Australia and Canada have both developed tiered approaches and guidance for selecting the most appropriate bycatch and byproduct assessment methods, depending on data availability. Details of these methods and the information requirements of the various options under these two schemes are provided in this report. Around the centre of this information range there is overlap between the quantitative risk assessments and low-information analytical assessments that can be conducted using moderate information. This allows for alternative assessment approaches to be applied to validate or confirm results, or for hybrid assessment approaches to be applied by incorporating quantitative elements into a risk-based framework.

There is an explicit risk-catch-cost trade-off underlying the range of choices of assessment method, between management costs, level of precaution (level of effort or catch) and the risk of not achieving management objectives. Management costs generally increase as catch increases, with more information being required to allow larger catches while ensuring acceptable risk. Reducing the risks either requires fishing intensity to be reduced (precautionary management), or uncertainty to be reduced by collecting the additional data required to support a more

certain, higher information, assessment. The net economic returns to a fishery will determine what data a fishery can afford to collect to inform management decisions. In some cases, it may be more cost effective to address an issue by immediate, precautionary management action based on current information, rather than invest in additional data collection and improved understanding of the issue.

Without implementation of dedicated bycatch data collection programs, data demonstrating fishery impacts on bycatch species are usually sparse. Bycatch assessments, therefore, start at the data-poor end of the spectrum. Ecological risk assessment (ERA) methods have been designed to allow for evaluation of risk in broad categories (high, medium, low) when there are inadequate data or information to conduct quantitative analytical assessments. The Australian ecological risk assessment for effects of fishing (ERAEF) framework has been adopted for fisheries ERAs both in Australia and internationally. This consists of a three-level hierarchical process of risk assessment:

- Level 1—qualitative Scale, Intensity, Consequence Analysis (SICA)
- Level 2—indicator-based multispecies Productivity Susceptibility Analysis (PSA)
- Level 3—quantitative, model-based multispecies Sustainability Assessment for Fishing Effects (SAFE) or single-species population assessment.

The purpose of a hierarchical approach to ERA is to provide for screening out of low risks using cheaper, low-information, qualitative (SICA) approaches. The evaluation of medium and high risks is then improved by moving towards PSA and SAFE assessments, which have higher information requirements and become increasingly quantitative, incorporating elements of quantitative analytical approaches.

ERAs are used to inform ecological risk management (ERM) programs that are designed to manage medium or high risks identified by ERAs using a combination of monitoring, mitigation and adaptive management measures. These are analogous to fishery management plans for commercial fish stocks and can potentially include reference levels or reference points for acceptable risk or acceptable mortality, indicators and performance measures of status or trends against reference levels, and decision rules to trigger adaptive management when risks or mortality exceed acceptable levels. Demonstrating the effectiveness and performance of ERM programs in achieving the required outcomes for bycatch species is fundamental to demonstrating the sustainability of fisheries and effectiveness of the risk-catch-cost trade-off in management approaches. Determination of 'acceptable risk', estimation of acceptable levels of mortality for bycatch and byproduct species and evaluation of performance against these reference points is most effectively done using target and limit reference points, analogous to those that form the basis of harvest strategies implemented for commercial species under the Commonwealth Fisheries Harvest Strategy Policy (DAFF 2007).

In a risk-based approach, target and limit reference points can be used to specify the maximum acceptable level of risk (limit reference point) and the lowest achievable level of risk under the chosen objectives (target reference point). Establishment of such reference points, together with indicators of status in relation to those reference points, enables objective performance reporting. For fisheries or species with more data available, quantitative assessments can enable the development of quantitative reference points; for example, with respect to the level of fishing mortality. Potential biological removals (PBR) method is one such approach used to estimate the maximum acceptable levels of bycatch mortality that can be sustained by a population without preventing that population from reaching or maintaining 'maximum net productivity level'. Establishment of reference points, indicators and performance measures relies on the ability to measure those quantitatively, as well as on the availability of the data required to do so. The less information that is available, and the less quantitative and reliable the measures of fisheries-related and acceptable mortality are, the less feasible it is to quantify fisheries mortality and to evaluate performance against reference points.

Efforts to conduct higher levels of ERA and to develop estimates of acceptable risk, sustainability reference points and performance indicators, inevitably drive a requirement to collect additional data to support such analyses. Collection of these data allows for the implementation of a range

of increasingly reliable low-information analytical approaches, either in support of ERAs or as integrated analytical components of quantitative ERA approaches. Approaches to bycatch assessment for Canadian fisheries focus primarily on low-information analytical approaches rather than ERAs, using a hierarchical decision tree to select appropriate analytical methods depending on data availability. In Australia, a tiered approach to analytical assessments has been developed to guide the selection of analytical assessment methods for commercial species, again based on data availability, with lower information assessment tiers being applied to many byproduct species and some bycatch species.

Data requirements for application of each of the tiered ERA or analytical assessment methods are described in this report. The shortage of data necessary for quantitative risk assessments or analytical approaches is the key factor limiting the monitoring of performance and evaluation of the effectiveness of bycatch mitigation and management measures in Commonwealth fisheries. In particular, low levels or non-representative observer coverage in some fisheries has resulted in extrapolated estimates of bycatch from observer data up to the fishery scale being highly uncertain, preventing reliable performance evaluation. At an early stage in the assessment process, particularly if data-poor species appear to be approaching critical or concerning levels, data should be gathered to allow the application of analytical approaches. At-sea observer programs or effective electronic monitoring are particularly effective for collecting data on interactions with, and mortality of, bycatch species that are not retained on board, and for which there may be incentives to not report their capture in logbooks.

Assessment of Cumulative Impacts

One of the challenges resulting from the use of ERAs conducted for individual fisheries is the difficulty of evaluating cumulative impacts across fisheries or jurisdictions. The ERAs for individual fisheries may each indicate low or medium risks for a particular impact, whereas the combined impacts across a number of fisheries may actually be high. Qualitative ERAs for individual fisheries do not lend themselves to subsequent determination of cumulative impacts across fisheries. Where only qualitative assessments are possible and where there is no intention of collecting additional information, assessment of cumulative impacts essentially requires that risk assessment be redone across the fisheries or jurisdictions, focusing on medium-risk species for which cumulative impacts may be of concern.

The preferable way to evaluate cumulative impacts across fisheries is to generate quantitative mortality rate estimates that can be summed across fisheries or jurisdictions to generate cumulative assessments of total fisheries mortality rates. These can then be summed and compared with sustainability reference points to determine whether the cumulative mortality exceeds sustainable levels. This is the approach taken in Level 3 SAFE assessments conducted for high risk species, in which fishing mortality rates are estimated. Alternatively, low-information analytical approaches generate quantitative measures that can be summed across fisheries. The costs of collecting the additional data required for these higher level quantitative approaches may be justified if there are concerns that cumulative impacts may be unsustainable for a species group identified as being at medium or high risk.

KEYWORDS: Bycatch policy, bycatch, byproduct, ecological risk assessment, risk management, reference points, decision rules, low information, assessment, cumulative impacts, performance measures

Acknowledgements

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Background

International obligations to ensure the long-term sustainable management of bycatch species caught in association with fished commercial species date back to the United Nations Convention on the Law of the Sea (UN 1982). These were expanded upon in the subsequent United Nations Agreement for the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UN 1995) and the United Nations Food and Agricultural Organisation's Code of Conduct for Responsible Fisheries (FAO 1995a). At the request of the Food and Agriculture Organization's (FAO) Committee on Fisheries, the International Guidelines on Bycatch Management and Reduction of Discards (FAO 2011) were developed to guide nations and regional fisheries management organisations in implementing effective bycatch management and discard reduction plans consistent with an ecosystem approach to fisheries.

The FAO Bycatch Guidelines (FAO 2011) are voluntary and indicate that nations should establish and implement national policies for the effective management of bycatch and reduction of discards based on the application of the ecosystem approach to fisheries and should give consideration to all significant sources of fishing mortality. In addition to efforts to reduce bycatch, these guidelines also encourage efforts to ensure rational use of the remaining bycatch and discards that would otherwise be wasted.

Since adoption of the UN Convention on Biodiversity (UN 1992) (signed by Australia in June 1992 and ratified in June 1993), participants have adopted numerous decisions relating to conservation of biodiversity and implementation of an ecosystem approach. At the 10th Conference of Parties (COP) held in October 2010, in Nagoya, Aichi Prefecture, Japan, participants adopted a revised and updated Strategic Plan for Biodiversity for 2011–2020, including the Aichi Biodiversity Targets (CBD 2011). Aichi target six requires that

> *'By 2020 all fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem-based approaches, so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits'.*

Bycatch, being the unintentional capture and discarding of non-target species, has long been an issue of concern worldwide. Since the 1990s there has been increasing focus on bycatch issues and management; driven by increasing interest of seafood consumers and the general public and as information on bycatch has improved or become more available. Significant progress has occurred in recent years relating to increasing awareness, regulation and management actions focused on fisheries bycatch mitigation or abatement (Bensley et al. 2010; Brewer et al. 1998). Despite these advances, fisheries bycatch is still considered to be a significant worldwide threat to bycatch fish stocks, and associated or dependant marine seabirds, sea turtles, sharks and mammals (Bache 2003; Kelleher 2005).

In 1999, Australian jurisdictions developed a broad, strategic bycatch policy to provide a national framework for coordinating efforts to reduce bycatch. This described options by which each jurisdiction could manage bycatch according to individual requirements, in a nationally coherent and consistent manner. The Australian Government then developed the *Commonwealth Policy on Fisheries Bycatch* (DAFF 2000) (hereafter referred to as the Bycatch Policy), which was consistent with the national policy. In response to the changing policy environment and to facilitate a more streamlined regulatory environment, DAFF undertook a review of the Bycatch Policy between June 2012 and June 2013.

The key purpose of this project report is to provide guidance on the applicability of various assessment methods for the management of bycatch and byproduct species in Commonwealth fisheries. In doing so, this report provides guidance on the information requirements for various assessment approaches, the risk-catch-cost trade-off in selecting the most appropriate approach, options for evaluating cumulative impacts and the implementation of reference points or

reference points against which to measure the performance of management measures in ensuring the long-term sustainability of populations of bycatch or byproduct species.

The Australian Government also concurrently reviewed the Commonwealth Fisheries Harvest Strategy Policy (HSP) (DAFF 2007). The reviews were conducted concurrently to ensure compatibility in the policies and to facilitate integration. This report was expanded to consider byproduct species in recognition of the fact that the continuum of assessment methods, and particularly risk-based approaches, are also applicable to byproduct species. This report is therefore also considered to be a technical input to the HSP review.

The Commonwealth has implemented a range of measures to monitor, manage and reduce bycatch; these have focused on particular bycatch species or bycatch in general. Species-specific approaches, include threat abatement plans (e.g. to reduce the impact of incidental catch of seabirds in longline fisheries), mandatory adoption of turtle excluder devices in relevant fisheries, and the establishment of closed areas (e.g. to reduce the incidental catch of Australian sea lions and dolphins in the shark gillnet fishery). Other initiatives to reduce bycatch include agreements by industry for adoption of bycatch reduction devices and improvements to fishing gear technology and methods in several fisheries.

A recent stakeholder workshop (DAFF 2012; see workshop report in Appendix D) on bycatch identified a range of initiatives and measures that have, directly and indirectly, led to an increased awareness and a likely reduction in bycatch for most Commonwealth fisheries following the launch of the Bycatch Policy in (DAFF 2000):

- Implementation of strategic assessments and Wildlife Trade Operation approvals for Commonwealth fisheries under the *Environment Protection and Biodiversity Conservation Act 1999*.
- The requirement in the Bycatch Policy for Bycatch Action Plans (now bycatch and discarding work plans) for all Commonwealth fisheries.
- The *Threat abatement plan (2006) for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations* (DEWHA 2006).
- Australia's 2004 *National plan of action for the conservation and management of sharks* (Shark Plan 1, DAFF 2004).
- Use of ecological risk assessments as the key information source for prioritising monitoring, research and management responses in relation to bycatch species.
- The HSP (DAFF 2007) for target species, as pursuit of maximum economic yield (MEY) may reduce impacts for bycatch species because of reductions in fishing effort.
- Reduction in the number of vessels fishing, following the Australian Government–funded Securing Our Fishing Future structural adjustment package in 2006.
- Investment by Commonwealth research funding bodies and industry into bycatch reduction strategies and mitigation initiatives for protected species[1].
- An increasing emphasis in regional fisheries management organisations on bycatch management.

However, in recent years, the fishing sector has come under increasing scrutiny regarding actual outcomes of these various measures in reducing bycatch rates, particularly for threatened, endangered and protected species and incidentally caught shark species. The recent review of wildlife bycatch management in Commonwealth fisheries (Bensley et al. 2010) noted that there is a longstanding legislative and policy mandate to manage impacts on wildlife bycatch and there has been increased awareness of bycatch issues within management and industry. However, some key challenges remain, including the development of monitoring and reporting systems capable of demonstrating improvement and effectiveness of management measures.

[1] 'Protected species' are species that are listed as Protected under the *Environment Protection and Biodiversity Conservation Act 1999* ('EPBC Act'). Protected species are sometimes referred to as threatened, endangered or protected (TEP) species.

Need

In the ten years since the development of the Bycatch Policy, questions and priorities relating to bycatch management have changed considerably and the broader legislative and policy environment has evolved. In addition, the social and economic circumstances of fisheries have changed domestically and internationally.

Outputs and outcomes from a review of the Bycatch Policy will assist in delivering the following:

- Streamlining current approaches for the management of bycatch and threatened, endangered and protected species, to reduce regulatory and financial burden to fishers and fisheries managers while increasing the effectiveness of minimising bycatch.
- Increasing the confidence of consumers that the management of Australian fisheries and production of seafood can be sustainable.
- Further advancing claims that Australia has sustainably managed fisheries that link with domestic and international legislative and policy objectives.

The purpose of this report is to directly inform the Bycatch Policy Review regarding how risk-based approaches can be applied to the assessment and management of bycatch and byproduct species, thereby contributing to the above policy review outcomes.

Objectives

1. Assess the robustness and applicability of risk-based approaches to bycatch management for species or groups of species, taking into account their biological status, data availability and other factors.
2. Evaluate the efficacy and appropriateness of reference points and structured decision rules in meeting the legislative and policy objectives for some bycatch species and/or groups.
3. Initially assess approaches to incorporating and addressing the potential cumulative impacts of fisheries' interactions with bycatch.
4. Assess the robustness and application of risk-based approaches to byproduct management for species or groups of species, taking into account their biological status, data availability and other factors.

Methods

1. Establish an interagency steering committee and advisory committee including industry, environment nongovernment organisations and scientists.
2. Undertake a review of existing information and draft a paper that identifies options for the future assessment and management of bycatch. This will include the specific review of options for bycatch assessment and management outlined in the objectives of this project.
3. Use workshop(s) to discuss broader bycatch management and technical aspects of the review.
4. Review international obligations and practices relating to bycatch management.
5. Review relevant information on risk assessment and low-information analytical assessment to ascertain how these approaches can be applied to evaluation of bycatch and byproduct species in Australian fisheries.
6. Based on the information reviewed, draft a report addressing the objectives.

Results and Discussion

Review of international bycatch policies

Before turning to the review and evaluation of alternative approaches to monitoring, risk assessment and population status evaluation for bycatch species, it is useful to briefly review some key international agreements and guidelines relating to bycatch management, and the international obligations and expectations that emanate from these. It is then informative to review how these obligations and expectations have been addressed by countries that have formal, documented bycatch management policies, to provide a basis for comparison with the Australian approach to bycatch management under the current Bycatch Policy. This comparison helps provide a basis for evaluating where alternative or improved approaches, which are reviewed in subsequent chapters, might be beneficial for management of bycatch in Australian fisheries.

Fisheries bycatch generally refers to the incidental capture of non-target species (Bensley et al. 2010) most or all of which is discarded. Some bycatch is common in most fisheries; the bycatch species type and frequency of interactions vary with each fishery, fishing method and time and area fished. However, the definition of bycatch varies across different countries and sometimes across different policies. The Organisation for Economic Co-operation and Development (OECD) defines bycatch as:

> *'Fish or other fauna (e.g. birds or marine mammals) that are caught during fishing, but which are not sold or kept for personal use. In commercial fishing these include both fish discarded for economic reasons (economic discards) and because regulations require it (regulatory discards). Fish released alive under catch-and-release fishery management programs are not normally considered as bycatch'* (OECD 2012).

However, the Food and Agriculture Organisation (FAO) state that due to the diverse nature of the world's fisheries, historical differences in how bycatch has been defined previously, general ambiguities with related terms, and individual fishers' choice, it is not possible to develop a standard international definition of bycatch. In addition, the regulatory interpretation and functional interpretation of the term bycatch can vary and, therefore, may not coincide with an international definition (FAO 2010).

International treaties, conventions and instruments, such as the United Nations Food and Agriculture Organizations Code of Conduct for Responsible Fisheries are increasingly placing obligations on signatories to address bycatch. The code says 'States and users of aquatic ecosystems should minimize waste, catch of non-target species, both fish and non-fish species, and impacts on associated or dependent species'.

This report aims to identify the bycatch policies used by various countries or the methods that different countries take to manage bycatch. As a result, a comparison can be made to distinguish which countries are advanced in the progression of bycatch management.

This review was undertaken as a desktop study that involved a literature search primarily of government and international organisation web pages and associated documents. The methodology did not extend to individually contacting the relevant governments or organisations. As a result, this review may not accurately reflect the full extent of all fisheries management strategies and approaches implemented for the countries examined, but rather of the strategies and approaches that were readily accessible.

Current bycatch management in Commonwealth fisheries—Australia

The management of bycatch in Commonwealth fisheries is guided primarily by the *Commonwealth Policy on Fisheries Bycatch* (Bycatch Policy), which was released in 2000, building on the 1999 *National Policy on Fisheries Bycatch* and delivering on government initiatives at that time. The Bycatch Policy applies to Commonwealth fisheries and seeks to

assess and minimise the impact of fishing on non-target species as an integral part of fisheries management. Australian state and territory fisheries are covered by the relevant state or territory legislation and policy.

Management of bycatch in Commonwealth fisheries is principally governed by the *Fisheries Management Act 1991* and subject to environmental assessment under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Under the current Bycatch Policy, bycatch is defined as:

- 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 (DAFF 2000);
- that part of the 'catch' that does not reach the deck of the fishing vessel but is affected by interaction with the fishing gear (DAFF 2000);
- at a broader level, includes all material, living and nonliving that is caught while fishing, except for the target species (DAFF 2000).

In March 2012, the Minister for Agriculture, Fisheries and Forestry, Senator the Hon. Joe Ludwig, announced a review of the Bycatch Policy, which is currently being undertaken for Commonwealth-managed fisheries. The review of the Bycatch Policy seeks to improve management of bycatch in Commonwealth fisheries by developing a revised policy framework that intends to avoid, minimise and manage bycatch, which is practical and cost effective to apply and supports environmental and fisheries legislative requirements. This review will run concurrently with the review of the Commonwealth Fisheries Harvest Strategy Policy and Guidelines (HSP).

In 2005, a ministerial direction called for Australian Fisheries Management Authority (AFMA) to:

- manage the broader environmental impacts of fishing, including protected species
- minimise the incentives for discarding by ensuring it is factored into the setting of total allowable catch (TAC) levels
- enhance the monitoring of fishing activity, through increased use of vessel monitoring systems with daily reporting, onboard cameras and improved observer coverage.

In response AFMA has developed bycatch action plans (now called bycatch and discarding work plans) for all major Commonwealth fisheries.

In 2007, AFMA implemented a three-year Bycatch and Discard Program. The Bycatch and Discard Program aims to assist fisheries to tackle bycatch and discarding issues in a focused and cost-effective way. More specifically, the program develops fishery specific work plans which focus on potential 'high-risk' bycatch species which are identified through the ecological risk assessment/ecological risk management process (ERA/ERM). These work plans are developed in consultation with industry and research partners to find practical and affordable solutions.

Since 2001, AFMA has been implementing and continually developing the ERA/ERM process in its move towards ecosystem-based fisheries management. The ERAs help to prioritise research, data collection, monitoring needs and management actions for fisheries and provide information to assist the decision-making process so that the fisheries can be managed both sustainably and efficiently. The ERM framework assists with the implementation of ecosystem-based fisheries management and ensures that a consistent process is followed across fisheries when responding to the outcomes of the ERA. The ERM framework also streamlines fisheries' responses to the results of ERAs and incorporates other initiatives such as harvest strategies and bycatch and discard programs.

In addition to fishery specific bycatch and discarding work plans, taxa-specific management plans exist such as the *Threat abatement plan for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations* (TAP). The TAP was first released in 1998 and was reviewed in 2006. The TAP was developed under the EPBC Act, following the listing of 'incidental catch (or bycatch) of seabirds during oceanic longline fishing operations' as a key

threatening process under the EPBC Act. However, the TAP also aligns Australia with the requests outlined in the FAOs *International plan of action for reducing the incidental catch of seabirds in longline fisheries*.

International commitments

United Nations Convention on the Law of the Sea / United Nations Fish Stocks Agreement

The United Nations Convention on the Law of the Sea (UNCLOS) was established in 1982 and contains obligations for member states to abide by international commitments. For example, in establishing the right to declare exclusive economic zones and to fish in those zones and on the high seas, UNCLOS requires member states to:

> *… take into consideration the effects on species associated with or dependent upon harvested species with a view to maintaining or restoring populations of such associated or dependent species above levels at which their reproduction may become seriously threatened.*

This obligation is an example of how development of arrangements for managing bycatch in Commonwealth fisheries is closely linked to international commitments and how much international commitments are used to guide bycatch management decisions. This obligation to conserve bycatch species is further extended in the United Nations Fish Stocks Agreement (UNFSA). UNFSA was established in 1995 and applies to:

> *… species belonging to the same ecosystem or associated with or dependent upon the target stocks.*

Bonn Convention

In 1979, the Bonn Convention on the Conservation of Migratory Species of Wild Animals identified requirements for the international conservation and restoration of populations of threatened migratory species. Appendixes 1 and 2 list species of whales, dolphins, turtles, seabirds and sharks that are considered threatened or requiring international cooperation for their conservation. In 2004, the Agreement on Conservation of Albatrosses and Petrels was established under the Bonn Convention in order to provide guidance on implementing effective mitigations measures to reduce fisheries-related mortality of seabirds. In 2010, a memorandum of understanding on conservation of migratory sharks was established under the Bonn Convention to:

> *… achieve and maintain a favourable conservation status for migratory shark.*

A memorandum of understanding also exists for the conservation of turtles and dugongs.

Earth Summit

In 1992, at the United Nations Conference on Environment and Development, otherwise known as the Earth Summit, international requirements were established to adopt an ecosystem approach to bycatch reduction and conservation of endangered species. The requirements emphasise the role of ecosystems in supporting sustainable development and call upon member states to:

> *… promote the development and use of selective fishing gear and practices that minimize waste in the catch of target species and minimize bycatch of non-target species.*

These requirements were elaborated in decisions under the United Nations Convention on Biodiversity (CBD) which entered into force in 1992. In 2000, the CBD formally adopted the ecosystem approach as the fundamental basis for its activities. Participants considered the purpose of an ecosystem approach to be:

> *… to meet human requirements to use natural resources, whilst maintaining the biological richness and ecological processes necessary to sustain the composition, structure and function of the habitats or ecosystems concerned.*

Convention on International Trade in Endangered Species of Wild Fauna and Flora

The Convention on International Trade in Endangered Species of Wild Fauna and Flora, otherwise known as CITES, is an international agreement that aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival. CITES, of which Australia is a member state, was drafted as a result of a resolution adopted in 1963 at a meeting of members of The World Conservation Union. The final draft of the Convention was agreed to in 1973 and came into force in 1975.

Member states to CITES join voluntarily but, once entered, the Convention is legally binding on all parties. However, CITES does not take the place of national laws but rather provides a framework, which means that each party has to adopt its own domestic legislation ensuring that CITES is implemented at the national level.

United Nations Food and Agriculture Organization

The FAO aims to identify and work with different partners that have established expertise and assist communication of this knowledge to those who need it. As a result regional, national and global initiatives are evolved and reinforce a best-practice approach. In support of the fisheries management obligations established by UNCLOS and UNSFA, the FAO developed guidelines for implementing responsible fisheries management practices. These guidelines, along with the FAO Code of Conduct for Responsible Fisheries, which was introduced in 1995, includes measures to protect endangered species, reduce bycatch and protect ecosystems. The guidelines suggest fisheries management objectives should include a statement to the effect that 'biodiversity of aquatic habitats and ecosystems is conserved and endangered species are protected'. In support of this objective, recommended management measures say that member states:

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

Further to this Code of Conduct for Responsible Fisheries, the FAO also developed guidelines on implementing an 'ecosystem approach to fisheries' in 2003 which includes the objective of:

> *… minimizing fisheries impact on the structure, productivity, function and biological diversity of the ecosystem; does not threaten bycatch species; avoids mortality of, or injuries to, endangered, threatened or protected species; and minimizes the impact of fishing operations on the ecosystem generally.*

The FAO then defines bycatch as:

> *Part of a catch of a fishing unit taken incidentally in addition to the target species towards which fishing effort is directed. Some or all of it may be returned to the sea as discards, usually dead or dying* (FAO 1998).

The FAO defines discards as:

- *To release or return fish to the sea, dead or alive, whether or not such fish are brought fully on board a fishing vessel (FAO 1998).*
- *Portion of total catch which is thrown away or slipped (FAO 2010).*

Regarding the management of bycatch or byproduct species, the FAO Code of Conduct (FAO 1995a) prescribes the application of a precautionary approach to management of all fisheries, defining a precautionary approach as:

> *A set of agreed cost-effective measures and actions, including future courses of action, which ensures prudent foresight, reduces or avoids risk to the resources, the environment, and the people, to the extent possible, taking explicitly into account existing uncertainties and the potential consequences of being wrong*.

In response to these international requirements, the Commonwealth Harvest Strategy Policy (DAFF 2007) stipulates that '*a precautionary approach will be taken to fishery management leading to more conservative outcomes to account for the uncertainty*'.

With reference to the fishing industry, particularly the issue of bycatch, several other guidelines or initiatives have been established by the FAO such as:

- The *International plan of action for reducing incidental catch of seabirds in longline fisheries*
- This plan of action was introduced in 1999 after noting an increased awareness of the incidental catch of seabirds, particularly in longline fisheries, in addition to the potential negative effects on seabird populations.
- The *International plan of action for the conservation and management of sharks*
- This plan of action was introduced in 1999 after concerns were raised in response to an increase in effort and yield of shark catches in addition to an expansion of the areas fished.
- The international *Guidelines to reduce sea turtle mortality in fishing operations*
- These guidelines were introduced in 2010 as a means of increasing awareness of the conservation status of sea turtles and to provide assistance for the preparation of industry initiatives and management guidelines with the aim of reducing or avoiding interactions with these species.
- The *International plan of action for the ,management of fishing capacity*
- This plan of action was introduced in 1999 as concerns increased with respect to issues of excess fishing capacity in world fisheries.
- The *International guidelines on bycatch management and reduction of discards*
- These guidelines were introduced in 2012 to assist nations in establishing and implementing national policies for the effective management of bycatch and reduction of discards, based on an ecosystem-based approach to fisheries.

Regional fisheries management organisations

While tools such as the FAO Codes of Conduct, related guidelines and international/national plans are used to guide countries, they are not legally binding. However, many of the provisions relating to high-seas fisheries have been implemented by regional fisheries management organisations (RFMOs) as a means of conservation and management measures. Australia is a signatory and active participant of multiple RFMOs and, therefore, contributes to the implementation of such provisions.

Western and Central Pacific Fisheries Commission

The Western and Central Pacific Fisheries Commission have adopted many conservation and management measures including the implementation of many of the FAO's guidelines. These include the *International plan of action for reducing incidental catch of seabirds in longline fisheries, International plan of action for the conservation and management of sharks* and *International guidelines to reduce sea turtle mortality in fishing operations*. In addition, mitigation and management measures implemented aim to reduce seabird mortality, make full use of retained sharks (i.e. not just retain fins) and prohibit retaining, transhipping or landing of any part of a white shark.

Commission for the Conservation of Southern Bluefin Tuna

The Commission for the Conservation of Southern Bluefin Tuna has adopted mitigation measures to reduce seabird mortality during tuna longline fishing operations.

Indian Ocean Tuna Commission

The Indian Ocean Tuna Commission (IOTC) has adopted the FAO's *International plan of action for reducing incidental catch of seabirds in longline fisheries* and *guidelines to reduce sea turtle mortality in fishing operations* as part of mitigation measures. In addition, the IOTC have adopted

a prohibition on retaining on board, transhipping, landing, storing or selling any part of thresher sharks.

Commission for the Conservation of Antarctic Marine Living Resources

The Commission for the Conservation of Antarctic Marine Living Resources has adopted conservation measures for minimising fisheries interactions with and the mortality of seabirds, a prohibition on directed fishing for sharks and limitations on fishing for ice fishes.

South Pacific Regional Fisheries Management Organisation

The South Pacific Regional Fisheries Management Organisation entered into force in August 2012, and so conservation measures have not yet been adopted. However, the organisation requires fisheries management to be consistent with the ecosystem approach and provides for measures to restore populations of non-target and associated or dependent species to above levels at which their reproduction may become seriously threatened.

International bycatch management approaches

Chile

The management of bycatch in Chile by fisheries operations is currently not referred to specifically. While fisheries management does not specifically consider an ecosystem approach, the Chilean government have released the following management measures (OECD 2012):

- The *National plan for the conservation of sharks*. This plan represents a significant step taken to mitigate the impacts of fishing on chondrichthyans. In addition, the plan aligns Chile with the FAO's *International plan of action for the conservation and management of sharks*.
- The *National plan of action to reduce incidental catch of seabirds in longline fisheries.* The plan aligns Chile with the FAO's *International plan of action for reducing incidental catch of seabirds in longline fisheries*.

Canada

The management of bycatch in Canada is currently guided by aspects of multiple national and international policies including the *Policy for Selective Fishing in Canada's Pacific Fisheries 2001*, *National plan of action for reducing the incidental catch of seabirds in longline fisheries* and the *Policy for Managing Bycatch 2013*. These three policies are incorporated under the Sustainable Fisheries Framework.

The Sustainable Fisheries Framework represents the instigation of Canada's ecosystem-based and precautionary approach to fisheries management. The framework incorporates existing fisheries management policies with new and evolving policies and comprises two main elements:

- conservation and sustainable use policies—incorporates precautionary and ecosystem approaches into fisheries management decisions
- planning and monitoring tools—assists in the application of the conservation and sustainable use policies.

The *Policy for Selective Fishing in Canada's Pacific Fisheries* was implemented in 2001 with the objective that selective fishing technology and practices be adopted where appropriate in all fisheries and that associated harvesting gear and practices be continuously developed. Selective fishing has been established as a requirement of conservation-based fisheries and is defined as 'the ability to avoid non-target fish, invertebrates, seabirds, and marine mammals or, if encountered, to release them alive and unharmed'. The best options for selective fishing, as specified by the policy, are avoidance of non-target species with a secondary preference for release of non-target species in the best possible condition to maximise survival.

The *Policy for Selective Fishing in Canada's Pacific Fisheries* will be implemented through selective fishing standards; selective fishing gear and practices; and training and education; however, to achieve the objectives of the policy, the following principles have been established:

- **Principle 1:** Conservation of Pacific fisheries stocks is the primary objective and will take precedence in managing the resource.
- **Principle 2:** All Pacific recreational and commercial fisheries will adhere to selective fishing standards within set timeframes.
- **Principle 3:** In fisheries where selective harvesting standards are not met within prescribed timelines and bycatches prevent achievement of conservation objectives, fishing opportunities will be curtailed.
- **Principle 4:** Four fundamental strategies in fishing selectively to minimise mortalities and maximise chances of survival of non-target fish, invertebrates, seabirds, and marine mammals will be adopted through increased knowledge of fishing gear and practices.
- **Principle 5:** First Nations and the recreational and commercial fishing sectors will be responsible for continuous learning and skills development and transfer of responsible and selective harvesting practices.

As noted in the *Selective Fishing Policy* (DFO 2001), the term 'bycatch' is defined as:

- fish that are harvested in a fishery, but usually not sold or kept for personal use
- seabirds and marine mammals that become entangled or caught by fishing gear
- the discard of whole fish at sea or elsewhere, including those fish discarded for economic and/or regulatory reasons
- fishing mortality due to an encounter with fishing gear that does not result in capture of fish (i.e. unobserved fishing mortality).

The term 'bycatch' does not include:

- fish legally retained in a fishery and kept for personal or culture use
- fish that enter commerce through sale, barter or trade.

In March 2007, Canada established its *National plan of action for reducing the incidental catch of seabirds in longline fisheries* (DFO 2007). The plan focuses on techniques and technologies that work towards mitigating the incidental take of seabirds in longline fisheries. The policy implements a variety of mitigation measures to prevent the capture of seabirds, such as area closures, seasonal closures, use of integrated weighted longlines, paired bird-scaring streamers (tori lines), and night setting.

Although several policies exist that address the selectivity of fishing in Canada as well as conserving bycatch species and reducing discard mortality, a lack of adequate data or lack of readily available data raises questions as to the effectiveness of these policies in relation to bycatch management. Data that is adequate and readily available is vital for the process of identifying and assessing risks and their potential impacts. Therefore, in 2009, work began on developing the *Policy Framework on Managing Bycatch and Discards*, later called the *Policy on Managing Bycatch*, which aims to be consistent with the FAO's *International guidelines on bycatch management and reduction of discards*. These were released and adopted by the Canadian Government in 2011. The voluntary guidelines established by the FAO (FAO 2010), encourages nations to establish effective bycatch and discard management measures to:

- minimise the risk of fisheries causing serious or irreversible harm to bycatch and discard species
- account for total mortalities, including retained bycatch and discards.

The goals of the Canadian *Policy on Managing Bycatch*, released in April 2013, are to promote conservation and improve accounting of bycatch and discards while minimising the risk that bycatch and discard species could be seriously or irreparably harmed by fishing activities (DFO 2012). The following have been determined to be necessary in achieving these objectives:

- ensuring adequate reporting and monitoring of bycatch and discard mortality, with the development of systems to support full accounting
- evaluating the risks to bycatch species from fishing
- ensuring management measures minimise the capture and maximise the live release of species that will be discarded, to the extent practicable
- developing and implementing measures to manage bycatch and regularly evaluate their effectiveness.

The policy has two objectives:

- to ensure that Canadian fisheries are managed in a manner that supports the sustainable harvesting of aquatic species and that minimises the risk of fisheries causing serious or irreversible harm to bycatch species
- to account for total catch, including retained and non-retained bycatch (DFO 2013).

In addition, the *Policy on Managing Bycatch* does not apply to any catch retained by the fisher that a licence is held for or to the bycatch of sponges, corals or other benthic organisms. These types of catches are addressed by other policies listed under the Sustainable Fisheries Framework. The *Policy on Managing Bycatch* will be implemented in a similar process to other Sustainable Fisheries Framework policies as it will be phased in based on national, regional and fishery priorities.

European Union

In the European Union (EU), general fisheries policy remains a 'shared competence' of the Union and its member states. Decisions are made primarily by the European Commission. The *Common Fisheries Policy* (CFP) is the key fisheries policy of the EU. The policy was created to manage fish stocks for the EU as a whole and sets species-specific TACs for each member state (European Commission 2012).

The CFP was launched in 1970 by the six founding members of the European Community to provide a common market in fish. In 1983, TACs, species quotas and minimum net sizes were introduced, in an attempt to curb overfishing. The CFP was further revised in 2002 with a view to ensuring sustainable development of fishing activities from an environmental, economic and social perspective. The decision-making process was modified by basing it on scientific findings and involving it more closely with the fisheries sector and with nongovernmental organisations within regional advisory councils. The 2002 reform also sought to make the policy consistent with European environment and development policy. Despite the ambitions of the 2002 reforms, there was little improvement in the situation of community fishing activities (European Parliament 2009).

In April 2004, member states of the EU reached agreement on a new council regulation to reduce the level of cetacean bycatch—the incidental capture of whales, dolphins and porpoises as a result of fishing activities. The regulations came into force in July 2004 and set out the following action to be taken by member states:

- compulsory acoustic devices or 'pingers' required on fishing vessels over 12 metres using fixed gear in the North Sea, Channel and Celtic Sea
- the use of observers on certain sectors of the fishing fleet to improve knowledge of where bycatch occurs (this data will inform the review of the regulation)
- the setting up of pilot projects to monitor the impact of fisheries where pingers are used, and the bycatch from under 15-metre vessels
- in 2008, all data gathered by member states, including information from the pilot projects on the level of cetacean bycatch for the under-15-metre fleet, will be considered in a review of the regulation.

The EU does not currently have a comprehensive bycatch policy although the European Commission has expressed that it is committed to drawing up a long-term policy to encourage the reduction of bycatch and the elimination of discards in European Fisheries. Another reform of the CFP is currently under way, with expected implementation in 2014. The reform of the CFP provides an opportunity to address bycatch problems and establish a legal framework to move towards more sustainable management of fisheries. The European Commission released a proposal of the focus areas considered in the reform (European Commission 2012). These provisions of this proposal relevant to bycatch management are:

- take action against overfishing to ensure sustainable management of fish
- multiannual plans governed by ecosystem approach
- ban on discards
- up-to-date information on state of marine resources.

In June 2012, the ministers of the European Parliament and members of the Agriculture and Fisheries Council reached agreement in a partial approach to the reform of the CFP. In February 2013, a meeting of the Agriculture and Fisheries Council took place in Brussels and discussed the reform of the CFP, the main regulation of the European Parliament and of the council currently under way where agreement on remaining reform issues was reached. The council focused on the environmental obligations of member states and on the ban of discards foreseen from the reform process. The council foresees that all species will be covered by the discard ban.

New Zealand

The Fisheries Act 1996 provides the framework for fisheries management in New Zealand. The Act and the related legislation include the fishing interests of all fishing groups (commercial, recreational, and customary Maori) (OECD 2012). In respect to bycatch management in New Zealand, there is no overall national policy. A comprehensive bycatch policy has been avoided by allowing bycatch to be landed and surrendered at deemed values. However, there are multiple regulations for protected species such as seabirds and marine mammals that are caught incidentally in New Zealand fisheries.

In 2004, the Ministers of Conservation and Fisheries released New Zealand's *National plan of action to reduce the incidental catch of seabirds in New Zealand fisheries* (NPOA Seabirds), which was subsequently updated in April 2013. The NPOA Seabirds sets out a strategic framework to reduce seabird bycatch to sustainable levels, with the goal to:

- ensure that the long-term viability of protected seabird species is not threatened by their incidental catch in New Zealand fisheries waters or by New Zealand–flagged vessels in high seas fisheries
- further reduce incidental catch of protected seabird species as far as possible, taking into account advances in technology, knowledge and financial implications.

There are also a number of regulatory and non-regulatory mitigation measures of best practice that apply in various New Zealand fisheries. In addition, New Zealand also has an ongoing monitoring and research program and a risk assessment framework for identifying at-risk seabird species for specific fisheries.

Specific measures are also in place, such as closed areas, gear restrictions and prohibited species to assist in the management of the effects of fishing. Other protected species–specific measures include:

- a bycatch limit for New Zealand sea lions in the southern squid fishery
- an industry code of practice to reduce bycatch of New Zealand fur seals in the hoki fishery
- method restrictions in some inshore areas to reduce Hector's dolphin and Maui's dolphin bycatch.

Norway

The management of bycatch in Norwegian fisheries is currently addressed by multiple policies and regulatory measures. These measures include:

- mesh size limitations
- minimum catch size
- maximum bycatch of undersized fish
- maximum bycatch of non-target species
- closure of areas with high densities of juveniles
- other seasonal and geographic restrictions.

In the 1980s, an area closure system was established in the Norwegian exclusive economic zone (WWF 2008). This system consists of areas that are closed to fishing when the amount of fish below minimum landing size (MLS) in a single catch exceeds 15 per cent by number. In the cod and haddock fisheries, areas are permanently closed for groundfish trawling if the mixture of undersized fish exceeds 15 per cent by number. Purse seine areas for saithe are closed if the catch contains more than 10 per cent by weight of saithe below MLS. If the catch contains more than a certain percentage of undersized fish (30% for purse seine, 15% for other gears), then that particular fishing ground is temporarily closed. The criteria for closing a fishing ground in Norway are mostly based on biological factors.

In 1987, the Norwegian Government introduced a discard ban as one part of a larger package of policies regarding the management of bycatch and the reduction of discards (OECD 2012). The discard ban is viewed as an important precautionary measure to reduce the need to release or discard fish. In Norway, the discard ban is combined with other measures such as temporary closures of sensitive areas, obligation to change fishing grounds when the mixture of fish below MLS exceeds given levels, and the requirements of improved gear selectivity.

In 1997, sorting grids were made mandatory (WWF 2008) for the trawl fisheries in most of the Barents Sea and Svalbard area. This has seen a reduction of unwanted catch of fish under minimum size.

In March 2009, the Norwegian Government put forward a proposal to the FAO to develop international guidelines for bycatch management and reduction of discards. This proposal was progressed, with the FAO releasing *International Guidelines on Bycatch Management and Reduction of Discards* in 2011.

United States

The management of fisheries bycatch within the United States is currently addressed and guided by three key federal statutes: the Marine Mammal Protection Act, Magnuson–Stevens Fishery Conservation and Management Act (MSA); and Endangered Species Act. As a result of these statutes, taxa-specific regulations have been developed, such as the *United States national plan of action for reducing the incidental catch of seabirds in longline fisheries*. The plan is structured around three themes: action items, interagency cooperation, and international cooperation. The plan focuses on performing an assessment of each fishery for seabird bycatch, and if a problem is identified then particular measures are to be implemented within two years. These measures include data collection, prescription of mitigation measures, research and development of mitigation measures and methods, and outreach, education, and training about seabird bycatch.

In order to address their legislative mandates under each of the statutes, the National Marine Fisheries Service (NMFS) developed, a national approach to bycatch—*The National Bycatch Strategy*. This strategy was based partly on a report titled *Managing the nations bycatch*, which contains the following bycatch goal—'to implement conservation and management measures for living marine resources that will minimize, to the extent practicable, bycatch and the mortality of bycatch that cannot be avoided'. This means that if bycatch can be reduced without impacting fisheries operations or revenues, it should be, although it has been noted that in many cases it may not be practicable to eliminate all bycatch. In these instances, bycatch should be carefully

monitored to ensure that it does not affect the sustainability of bycatch species populations. This goal has been adopted and expanded upon by the modern policy.

The NMFS defines bycatch as:

> *'Discarded catch of any living marine resource plus unobserved mortality due to a direct encounter with fishing gear'*

However, the MSA defines bycatch as:

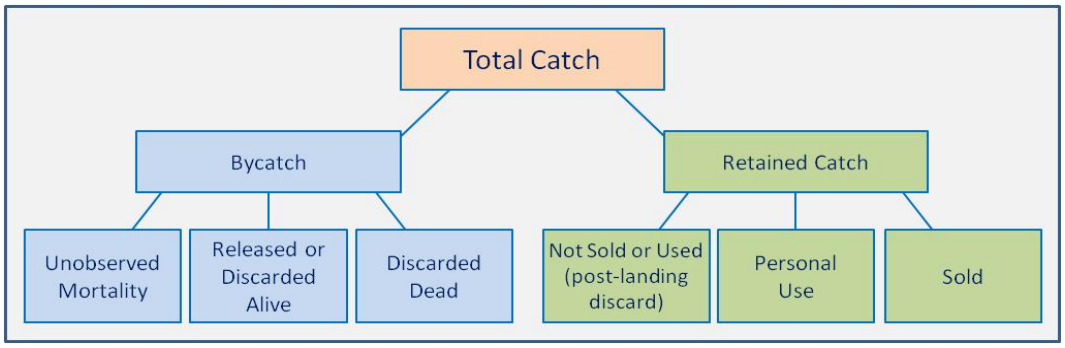
> *'Fish which are harvested in a fishery, but which are not sold or kept for personal use, and includes economic discards and regulatory discards. Such term does not include fish released alive under a recreational catch and release fishery management program'*

While the MSA does not specifically define discards, the NFMS defines discards as:

> *'Living marine resources returned unprocessed to the sea or elsewhere including those released alive'*

These definitions are depicted in Figure 1.

Figure 1 Definitions used in the *United States National Bycatch Report*.



Source: NMFS (2011)

In 2011, the United States released the first national bycatch report, which is a compilation of bycatch estimates in US commercial fisheries. It is expected that future editions of this report will assist the NMFS to identify and monitor bycatch trends and changes in the quality of bycatch data collection and estimation over time. The key recommendations to improve bycatch data collection and estimation noted in the 2011 national bycatch report are:

- develop and adopt best practices for estimating bycatch in US commercial fisheries
- improve national and regional catch databases
- review and modify the tier classification system for application to commercial and recreational fisheries included in future editions of the *United States National Bycatch Report*
- increase the number of fishery and species bycatch estimates in future editions of the *United States National Bycatch Report*
- implement specific bycatch data-collection and estimation improvements in regional programs
- maintain and expand existing regional observer programs
- implement new observer programs for fisheries and species with bycatch concerns
- evaluate electronic monitoring systems, conduct pilot studies, and operationalise electronic monitoring technology where appropriate.

Other countries

The following countries had limited information that could be found regarding bycatch. This is not to say that measures are not being taken or regulations implemented to make a conscious

effort to manage bycatch and reduce discards, but priority of the issue may be species-specific or limited. In addition, if measures are taken then these do not appear to be published.

Japan—the term 'bycatch' is not generally recognised in Japan (Ogi 2008). While Japan's policies are increasing their awareness of the importance of conservation of the natural environment, this tends to only extend to ecosystems and makes no mention of reducing the impacts of fishing on bycatch populations.

Korea—it appears that Korea does not have any policies relating to bycatch management or the reduction of discards, but take a different approach to sustainability and assessing the environmental impacts of fisheries and the environmental capacity for sustainable fisheries. In doing this, research is being carried out on factors such as water quality, sediments and distribution of benthic organisms (OECD 2102).

Both Korea and Japan seem to use TAC setting as their primary mechanism for managing the impacts of their fisheries.

Mexico—the National Fishing Institute has been working on making fishing gear more selective under the Experimental Fishing Program. In 2007, the standard NOM-061-PESC-2006 was included in the Official Mexican Standards, which specified the use of turtle exclusion devices in particular fisheries (OECD 2012).

Observations from the international review

Unwanted bycatch as a result of fishing operations continues to be an issue of concern. International treaties, conventions and instruments, such as the FAO's *Code of Conduct for Responsible Fishing* are increasingly placing obligations on signatories to address bycatch.

Countries such as the United States, Australia, Canada and Norway have comprehensive approaches to managing bycatch. In these countries, legislation has been amended to include the bycatch and relevant policies and strategies and programs have been introduced to accompany this legislative change and implement actions.

While some countries have introduced regulatory measures such as mesh sizes, the reasons documented are related to fishing more selectively for sizes of target species rather than minimising non-target species catch. Despite these measures potentially having a positive impact on reducing bycatch, this was not the intended purpose, and so awareness of the need to actually reduce bycatches may be limited.

The definition of bycatch is also something that causes variances in what types of policies each country produces. For Australia, when bycatch can be sold, it is deemed to be a 'byproduct', which is a useful term for management reasons but has not been used by other countries. The interpretation of the term bycatch and the related species from different countries will change how bycatch will be managed. Appendix G provides a summary of definitions of the term 'bycatch' that different countries and organisations use and whether a bycatch specific policy exists in those countries.

While it is evident from reports published by the FAO and the OECD that ecosystem conservation and methods such as TAC setting are becoming more recognised as priorities in fisheries management, the focus on managing bycatch is still to take hold in some countries. It is noted that many countries approach the issue of bycatch from the perspective of interactions with seabirds, marine mammals and other protected species only, and do not consider interactions with non-commercial fish species and marine invertebrates.

Risk management: principles, framework and processes

Formal risk management approaches are applied around the world, across all industries, to facilitate the correct identification of key risks, and guide subsequent management of those risks. Methods, definitions and objectives vary widely in the context of the area of application, including engineering, environment, economics, health and safety, industrial processes, natural resources, medical industry, project management and security. Frameworks for risk management have become important instruments of environmental policy and management of shared natural resources such as water, minerals and fisheries. There are now a range of international approaches to risk assessment and management that share key similarities, particularly in determining management objectives and the inclusion of some form of continuous monitoring-based feedback/response process, analogous to adaptive management.

There are many interpretations of risk management but it is useful to focus on one definition. This section refers throughout to the *Australian/New Zealand standard: risk* m*anagement—*p*rinciples and guidelines* (AS/NZS ISO 31000:2009) (the ANZ Risk Management Standard), which provides a framework for all aspects of risk management, environmental or otherwise. This standard describes risk management as a logical, iterative process, consisting of well-defined steps designed to support better decision-making, which includes a well-defined monitoring and review requirement designed to initiate iterative return to previous steps at any stage in the process.

What is risk, risk assessment and risk management?

Risk is defined as the effect of uncertainty on objectives. Noting that:

- an effect is a deviation from the expected (which may be positive and/or negative),
- objectives can have different aspects (such as financial, health and safety, and environmental goals) and can apply at different levels (such as strategic, organisation-wide, project, product and process).

Risk assessment and risk management are not the same, but are components of a process. Risk assessment is a component within the overall risk management process, and is the stage associated with risk identification, risk analysis and risk evaluation.

Risk management is defined by the ANZ Risk Management Standard as 'coordinated activities to direct and control an organisation with regard to risk' (AS/NZS ISO 31000:2009). The risk management process is intended to address the results of a risk assessment, and is the systematic application of management policies, procedures and practices to the activities of communication and consultation, establishing the context and identifying, analysing, evaluating, treating, monitoring and reviewing risk. Therefore, the entire risk management process comprises the definition and analysis of risk (risk assessment), followed by the cost-effective application of resources to minimise, monitor, and control the risk by minimising the likelihood or consequence of undesirable impacts. The effective management of objectively identified risks enables the user to minimise negative consequences and achieve objectives.

Implementing risk management

The ANZ Risk Management Standard centres on three main components:

- principles
- framework
- process

For risk management to be effective, the process should comply with the following principles (AS/NZS ISO 31000:2009):

- create and protect value(s); resources expended to mitigate risk should be less than the consequence of inaction
- be an integral part of the organisational processes

- be part of decision-making
- explicitly address uncertainty and assumptions
- be systematic and structured and timely
- be based on the best available information
- be tailored
- take human and cultural factors into account
- be transparent and inclusive
- be dynamic, iterative and responsive to change
- be capable of continual improvement and enhancement.

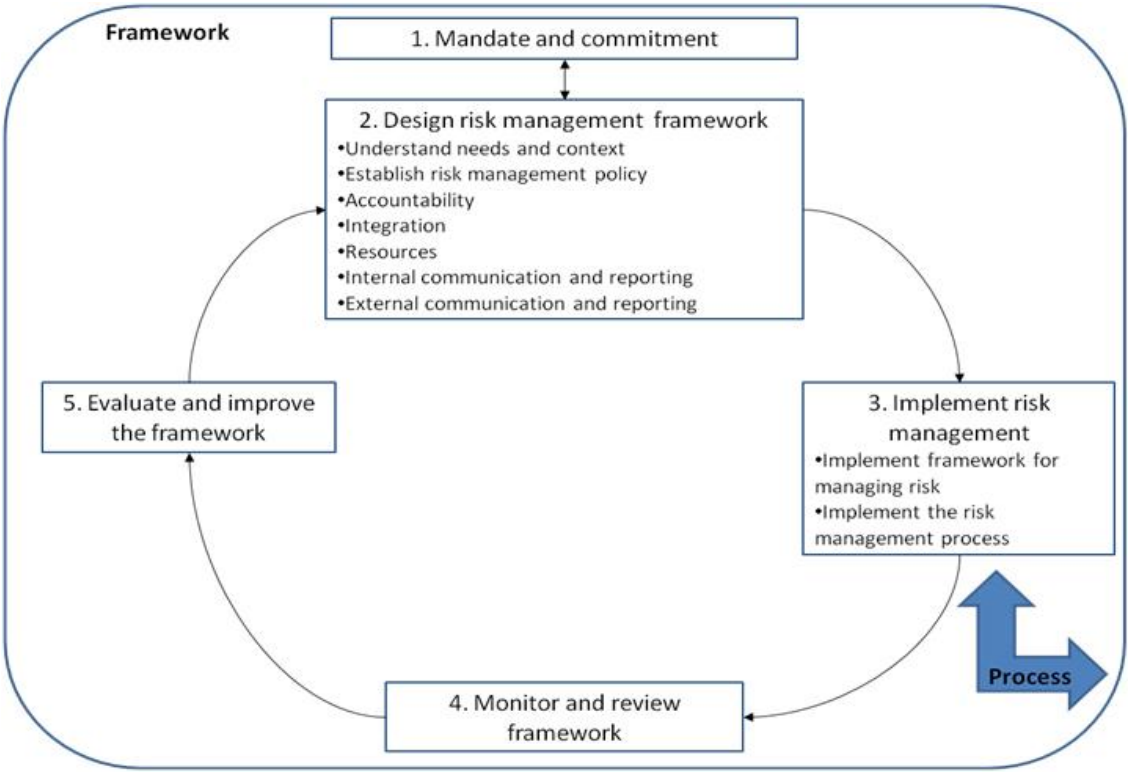
The risk management *framework* outlines a strategic method for integrating the defined *principles* into the objectives and provides a cyclical pathway for the design, implementation and assessment of the framework (Figure 2). The *process* is then the on-site implementation of the actual risk management measures (Figure 3).

Designing the framework should be an iterative process that builds from the initial mandate and commitment step and requires the consideration of a range of factors. Understanding the internal and external context of the objectives is important and includes the social, cultural, political, legal, regulatory, financial, technological, economic, natural and competitive environment, whether international, national, regional or local; key drivers and trends having impact on the objectives; and relationships with, and perceptions and values of, external stakeholders (Figure 2).

Risk assessment approaches

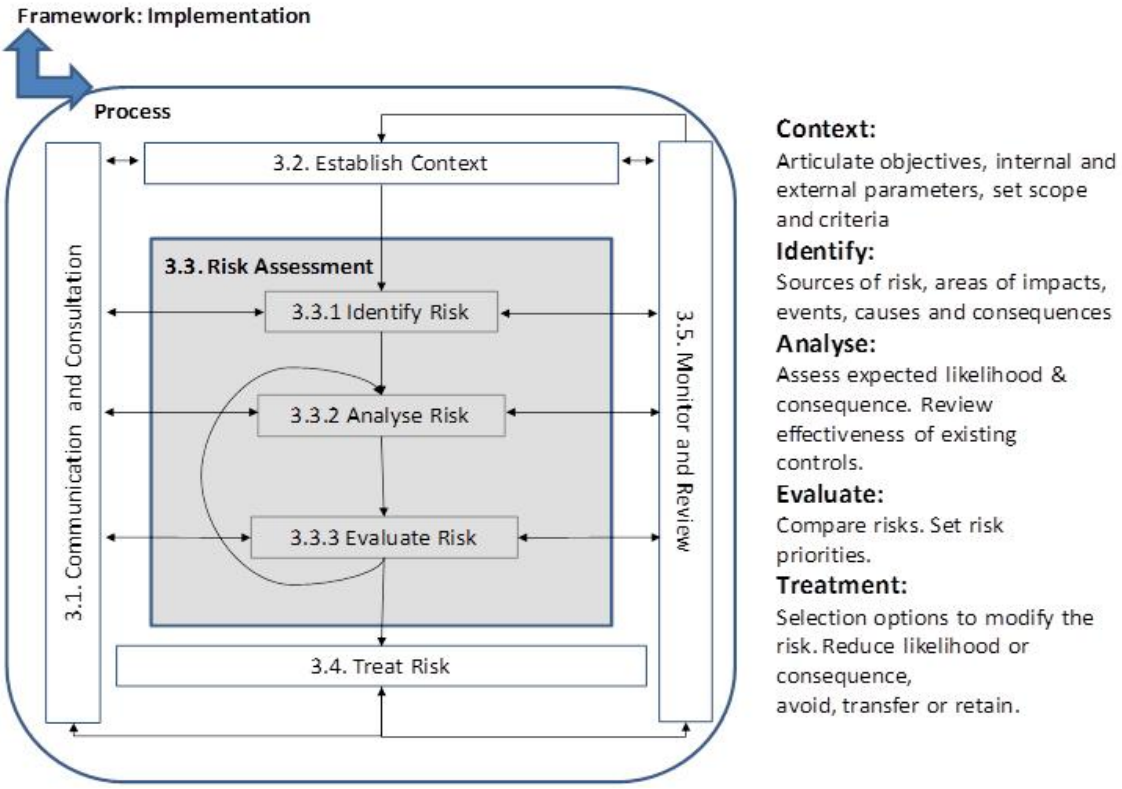
Risk assessment is the process of identification, analysis and evaluation of risks. Generally, risk assessment methodology follows a process designed to address the predefined objectives (Figure 3). The first step in a risk assessment is to identify the sources of risk, areas of impacts, events, causes and consequences, and to assess the risk of failing to achieve objectives as a result of specific risks (Figure 3). This step should generate a comprehensive list of risks based on events that may prevent, degrade or delay the achievement of objectives. This list should include risks that may not be able to be controlled. The consequences should also consider cumulative impacts and the consequence of not acting on known risks.

Figure 2 Overview of a risk management framework.



Source: AS/NZS ISO 31000:2009

Figure 3 Overview of a risk management process.



Source: AS/NZS ISO 31000:2009

The next step is to develop an understanding of the risks, to facilitate the evaluation and treatment of identified risks. Risk analysis requires the consideration of the causes and sources of risk, the expected likelihood and consequences of effects on the objectives and other attributes of the risk (e.g. interdependence of different risks and sources) (Figure 3). These should be consistent with the risk criteria used. Confidence in determination of the level of risk, preconditions and assumptions should be considered. This step may be undertaken in varying levels of detail from qualitative to quantitative, depending on the data and information available, and the resources available to conduct the risk analysis.

Risk evaluation is the process by which treatment options are assessed and prioritised (Figure 3). The level of risk identified during analysis should be compared with the risk criteria. Based on this comparison, the need for treatment can be defined. This determines whether the risks are acceptable or unacceptable. A risk that is determined to be acceptable must continue to be monitored and periodically reviewed to ensure that the factors contributing to that risk have not changed, and that the risk remains acceptable. A risk deemed unacceptable needs to be actively managed to mitigate and reduce the risk to acceptable levels. In some instances, evaluation may lead to further analysis and revision of the management measures. The reasons for the reassessment and management changes should be documented to provide a record of how each decision was made and to inform future risk assessments.

Unacceptable risks must then be managed. This generally includes selecting and implementing one or more actions to reduce risks (Figure 3). Selecting an appropriate treatment should balance the costs and effort of management against the benefits achieved, in accordance with legal and regulatory requirements, the defined objectives and the values and perceptions of stakeholders. The treatment plan should identify the priority order of treatment options. Monitoring of actual results or outcomes is an integral part of the risk management, particularly where management may introduce new or secondary risks. Risk management is an adaptive process where the risk management outcomes should be regularly assessed and new risks and levels of residual risk evaluated. If new risks or residual risk levels are not acceptable, or if management actions are not achieving the expected outcomes in terms of risk reduction, a new treatment should be applied and assessed. A risk management plan should be developed to document how management options were selected and how they were implemented.

Regular monitoring and review are essential throughout the process (Figure 3). Monitoring should be designed to measure the actual outcomes in terms of risk reduction, to ensure that management actions remain effective, and to identify factors which may improve future management practice. Responsibilities for monitoring should be clearly defined and resourced. This process should ensure that controls are effective and efficient, new knowledge is incorporated, lessons are learnt from events, changes, trends, successes and failures, changes can be detected and that any emerging or residual risks are identified early. The results of monitoring and review should be recorded and communicated internally and externally as appropriate.

Risk assessment techniques vary from qualitative through semi-quantitative to quantitative. The assessment approach adopted will be dependent on a number of factors including the needs of the user, amount of available information, data quality and resources available. The simplest and most commonly used approach is to use a risk analysis matrix, which allows for prioritisation of risk; this can include both qualitative and quantitative risk. Other more complex approaches have been developed and are applied to specific issues, these include referential, multivariate and hierarchical, among others.

Risk analysis matrices

Qualitative risk assessments usually rank risks from a group of scenarios using the likelihood and consequence of a risk occurring (e.g. Table 2). Purely qualitative analyses are often based on non-quantitative information and expert opinion, only producing a relative ranking of the risk. These approaches may produce different results when applied by different groups of people with different expertise, knowledge or values.

Table 1 Example of a qualitative, rank-based, environmental risk assessment matrix

Likelihood	**Consequence**					
	Negligible	**Minor**	**Moderate**	**Severe**	**Major**	**Catastrophic**
Remote	No risk	Low	Low	Low	Low	Low
Unlikely	No risk	Low	Low	Medium	Medium	Medium
Possible	No risk	Low	Medium	High	High	High
Occasional	No risk	Low	Medium	High	Extreme	Extreme
Likely	No risk	Low	High	Extreme	Extreme	Extreme

Note: The matrix requires that the user ranks the consequence and likelihood levels for each risk. The table can then be used to obtain the ranking for each risk level (e.g. Major consequence + Unlikely likelihood = Medium risk.

Semi-qualitative assessments can build on this by evaluating the likelihood and consequence ranges for each factor evaluated, to provide measures of confidence in the assessment ranks:

Likelihood ranges

- Remote: almost no chance of occurrence
- Unlikely: small chance of occurrence
- Possible: unlikely but could happen
- Occasional : will probably happen at some time
- Likely: will happen

Consequence ranges

- Negligible: no environmental impact
- Minor: perceived concern or speculation of environmental impact
- Moderate: short-term impact on organism or habitat
- Severe: severely effecting protected organism or habitat
- Major: long-term severe effect on protected organism or habitat
- Catastrophic: destruction of protected organism and habitat

This matrix can be made semi-quantitative by the inclusion of rankings that are not just based on opinion, but are numerically quantified based on data available. Depending on the availability of information, this can provide a mix of qualitative and quantitative results which may not allow for comparison between different risks. For example, the broad qualitative ranges for the consequence may be retained but the likelihood ranges may be numerically defined by probability of occurrence (P), for example:

Likelihood ranges

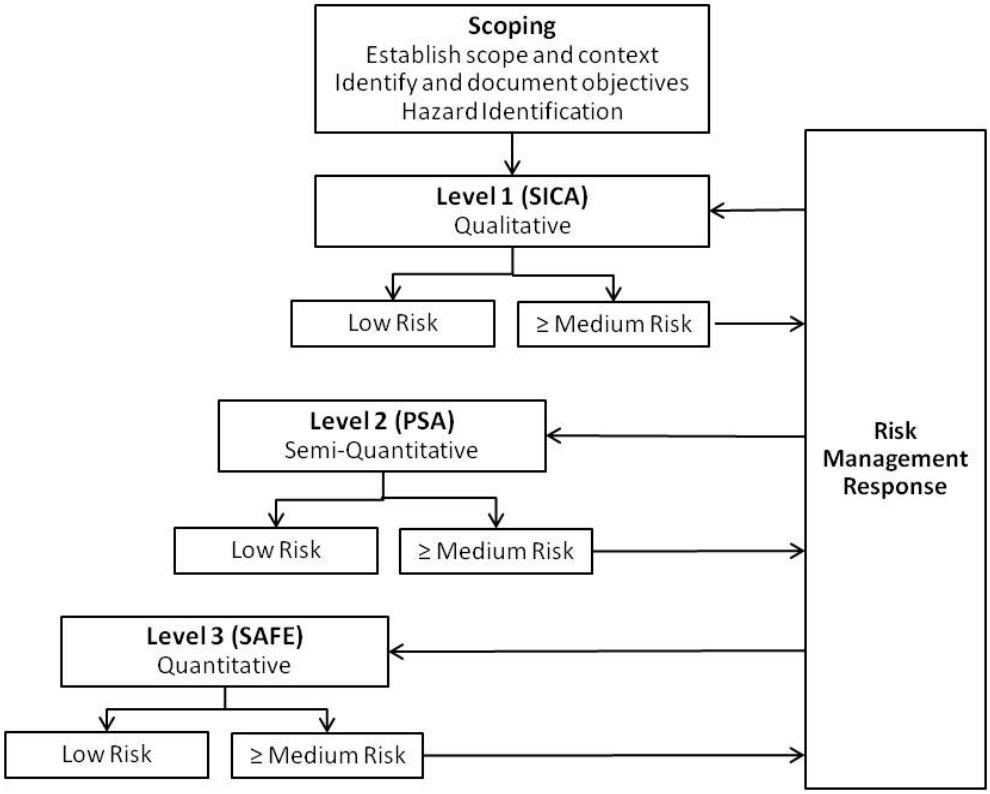
- Remote: $P < 0.001$
- Unlikely: $P > 0.001, < 0.01$
- Possible: $P > 0.01, < 0.05$
- Occasional : $P > 0.05, < 0.5$
- Likely: $P \geq 0.5$

Fully quantitative risk assessments are designed to rank and scale both the consequences and likelihoods numerically. Using a quantitative approach, each scenario will have a quantified risk value that allows all risks to be compared and ranked in order of impact and priority.

Hierarchical risk assessment approaches

Hierarchical risk assessment involves a process that progresses from a first stage comprehensive but largely qualitative analysis of risk, through a second stage more focused and semi-quantitative approach to evaluate key risks identified in the first stage, to a third stage highly focused and fully quantitative 'model-based' approach for key risks identified at the second stage. The ERAEF framework describes such a three-step hierarchical process of risk assessment (Hobday et al. 2011) (Figure 5). This approach is intended to ensure that assessment resources are focused on the key risks, with lower risks being filtered out during the less information intensive early stages. Level 1 is primarily based on expert interpretation of available information, often in a workshop setting; Level 2 requires quantified responses to an established set of questions; Level 3 requires substantially more quantitative data and may necessitate further research to quantitatively assess high risks identified at Level 2.

Figure 4 Overview of the hierarchy of the Ecological Risk Assessment for the Effects of Fishing framework.



Note: Level 1 Scale, Intensity, Consequence Analysis (SICA); Level 2 multispecies Productivity Susceptibility Analysis (PSA): and Level 3 multispecies Sustainability Assessment for Fishing Effects (SAFE) or single-species population/stock assessment.

Source: Hobday et al. (2011)

Estimation of acceptable risk

Risk is inherent in almost every action that is undertaken and, while it may be necessary to minimise certain key risks, it is unlikely that zero risk will ever be achievable. Activities related to human subsistence, such as fishing or farming, are likely to have some level of detrimental impact (directly or indirectly) on ecosystems and the natural resources they contain. During the risk assessment it is, therefore, necessary to determine whether the expected level of the identified risks is acceptable or unacceptable. This requires determination of what would be considered to be an 'acceptable level of risk'. These determinations need to be made within the wider context of risk assessment, the trade-off between the defined objectives and those of other stakeholders, and in accordance with legal and regulatory requirements.

A risk may be defined as acceptable if:

- risk is reduced until it is trivial, in which case the consequences can be ignored. In the operational safety environment, this goal is set as a probability of 10^{-6} or better;
- risk is as low as reasonably practical, i.e. risk levels are below a defined acceptable probability (e.g. water quality standards) or the process cannot be made any safer, given technical and commercial constraints;
- risk remains similar to other comparable acceptable risks, i.e. below an already tolerated level for a similar risk;
- the cost of reducing the risk would exceed the benefit of the action;
- risk level is considered acceptable by experts, key stakeholders, the general public and decision-makers.

Risk-based approaches to fisheries bycatch and byproduct management

Fisheries science is characterised by uncertainty, due to the inherent variability of natural ecosystems and the difficulty of monitoring fishing operations and quantifying ecological impacts in dynamic environments. Fisheries management has to be designed to explicitly deal with this uncertainty. Uncertainty creates the risk of not achieving objectives, and so fisheries management is risk-based. Management decisions must be made in the absence of certainty about the present state of fisheries resources, or the impacts of fishing on the environment, and perhaps even in the absence of mechanisms to assess the effectiveness of management decisions.

Throughout this report we focus on the management objective of ensuring that fishing activities do not contribute significantly to the decline of populations of bycatch species. In addition to conserving bycatch populations, Commonwealth fisheries management objectives include the minimisation of fisheries bycatch and avoiding causing the mortality of (or injury to) protected species. The information presented on conserving bycatch populations is generally applicable to those other objectives of minimising bycatch and avoiding the mortality of protected species.

Fishery impacts on the environment are, to a varying degree and extent, inevitable. Depending on the productivity of the natural resources or the resilience of the environment, certain levels of impact can be sustained without resulting in ongoing decline in populations, and may therefore be acceptable. Nonetheless, the generally stated approach is to 'avoid, minimise, and manage' impacts, in that order. Uncertainty in the information or assessment methods used to evaluate impacts creates risk, and so the impacts need to be evaluated, and subsequently managed, using the risk-based approaches and frameworks described previously.

Fisheries science places strong emphasis on reducing the uncertainty in the information provided to fisheries managers, so that they may make more certain evidence-based decisions. However, reduction in uncertainty requires improved data and information, and additional effort spent on improving assessment methods, both of which come at a cost. There is therefore a trade-off in the uncertainty associated with any fisheries assessment, and the cost of reducing that uncertainty. This is as true of managing the impacts of fisheries on bycatch as it is for key commercial species. The main difference is in the level of information available for target species and bycatch, and therefore on the levels of uncertainty in assessments, and levels of risk associated with meeting management objectives for bycatch versus target species.

A transparent, objective and robust risk monitoring, assessment and management framework that focuses fisheries science and fisheries management on the main risks should be cost-effective and inform and engage all relevant stakeholders in the process. In Australia there are at least two types of risk-based approach to fisheries bycatch:

- the national ecologically sustainable development (ESD) reporting framework
- the AFMA–CSIRO Ecological Risk Assessment for Effects of Fishing and/or ecological risk management (ERAEF/ERM) approach.

These two approaches were initially linked but have subsequently been separated and have developed in parallel over the last decade. Both the ESD reporting framework and the ERAEF/ERM approach are intended to form a comprehensive fisheries management planning approach. Both approaches start with a scoping stage that may include considerations beyond bycatch. However, the two assessment approaches differ: the ESD uses a qualitative Likelihood versus Consequences approach; whereas the ERAEF uses a hierarchical analysis that includes three different levels. The emphasis of the hierarchical ERAEF approach is on analytical methods to focus research and management on fewer and fewer issues of increasing importance at each assessment stage.

A risk-based approach is also used to set trigger limits for bycatch interaction rates for several marine species protected under the EPBC Act (see case studies in Appendix F). Trigger limits

may be set on the basis of acceptable interaction rates combined with the required level of precision in estimates of those rates as, for example, might be expected from a specified level of scientific observer coverage. Pre-agreed management actions may then follow from trigger limits being breached.

Over 10 years of ERA research and application of risk-based approaches to fisheries management, the risk assessment methods have evolved and improved. Lessons learnt from Australia and overseas should provide valuable input to the Bycatch Policy review. There may also be merit in looking for synergies and consistencies between the various risk assessment approaches, to improve the quality and consistency of risk assessments and to clarify management objectives, information needs and decision-making.

National Ecologically Sustainable Development Reporting Framework for Australian fisheries

The '*National ESD reporting framework for Australian fisheries: the "how to" guide for wild capture fisheries*' was published in May 2002 (Fletcher et al. 2002) as part of the development of the ESD Reporting and Assessment Subprogram. It represents the start of a parallel process of fisheries risk assessment that has been adopted in some Australian states.

The emphasis in the ESD reporting framework is on the specification of management objectives and on qualitative analysis of the risk (likelihood × consequence) of not achieving those objectives (Table 2).

Table 2 Ecologically sustainable development risk assessment matrix

		Consequence					
Likelihood		**Negligible**	**Minor**	**Moderate**	**Severe**	**Major**	**Catastrophic**
		0	**1**	**2**	**3**	**4**	**5**
Remote	**1**	0	1	2	3	4	5
Rare	**2**	0	2	4	6	8	10
Unlikely	**3**	0	3	6	9	12	15
Possible	**4**	0	4	8	12	16	20
Occasional	**5**	0	5	10	15	20	25
Likely	**6**	0	6	12	18	24	30

Note: This matrix is used to rank the consequence and likelihood levels for each risk to provide a qualitative analysis of the risk (likelihood × consequence) for each threat (red = high; yellow = medium; green = low; blue = no risk. Source: Fletcher et al. (2002)

Ecological risk assessment and/or ecological risk management

Ecological risk assessment

Various countries have developed alternative risk assessment and risk management approaches (e.g. DEFRA 2011; EPA 1998). While these may differ in individual information inputs and risk scoring methods used, they are all based on similar principles. The Ecological Risk Assessment for Effects of Fishing (ERAEF) framework developed by CSIRO and AFMA (Hobday et al. 2011) has been increasingly adopted internationally for use in fisheries risk assessments (e.g. MRAG 2009). This involves a hierarchical process of risk assessment, with a qualitative analysis at Level 1, an indicator-based analysis at Level 2, and a model-based analysis at Level 3 (Figure 4):

- Level 1—Scale, Intensity, Consequence Analysis (SICA) is conceptually the same as the Likelihood Consequence approach in the ESD reporting framework.
- Level 2—Productivity Susceptibility Analysis (PSA) is a multispecies method that assigns to each species in each fishery a score on two axes, the first representing its susceptibility to

being caught and the second its biological productivity. A number of different attributes are used to derive each of the indicator scores. Adopting a precautionary approach to uncertainty, high risk scores are assigned to attributes in the absence of information. This leads to a bias towards 'false positives'.

- Level 3—Sustainability Assessment for Fishing Effects (SAFE) is also a multispecies analysis but instead of using indicators it estimates fishing mortality based on the overlap between a species' range and fishing effort, using the same biological attributes as are used to derive indicators in Level 2. These estimates of fishing mortality can then be compared with estimates of species productivity using estimated natural mortality (M), from which limit reference points can be expressed in terms of 'acceptable' fishing mortality as some proportion of M for each species (e.g. $F < 0.5\ M$). This approach is similar to a catch-per-unit-effort (CPUE) based stock assessment for commercial species and is consistent with an HSP approach.

This approach is intended to be cost effective, with low risk species being screened out at Levels 1 or 2, reducing the number of species and costs for higher level assessments. There is an implicit management objective embedded in the PSA and SAFE methodologies that is consistent with national and international policy frameworks, which is 'to ensure that fisheries do not contribute to the decline of populations of bycatch species to levels at which their reproduction may become seriously threatened'. Both the PSA and SAFE methods provide information about which species are likely to be impacted by fisheries and whether such impacts may endanger populations. The PSA scores are ranked indicators of this risk, while the SAFE scores are quantitative measures of risk.

There is inevitable uncertainty in the results from both the PSA and SAFE methods, with lower information and lower levels of assessment having higher uncertainty. Reducing this uncertainty requires additional monitoring or research to provide the additional data needed to move to higher assessment levels. There is therefore a direct monitoring or data collection cost associated with reducing the uncertainty in risk assessments. However, uncertainty is a key contributor to risk, and so reducing uncertainty also reduces the risk, resulting in a risk-cost trade-off. Under a precautionary approach, higher uncertainty requires more conservative management decisions, typically resulting in management measures to reduce fishing effort or catch to reduce risk to acceptable levels, despite the uncertainty. This results in a risk-cost-catch trade-off (Dichmont et al. 2012; Dowling et al. in press; Sainsbury 2005).

Lower level (Levels 1 and 2) risk assessments are, by design, more precautionary, so that application of low-level approaches does not result in underestimation of risk. The initial application of lower-information, cheaper, Level 1 and Level 2 ERAEF approaches allows highest risks to be identified so that management decisions can be made regarding further costs, to reduce uncertainty, increase information and enable a Level 3 approach. Alternately, managers may choose to accept the lower-level assessment results and implement measures that have a high probability of reducing risk, such as closing areas to fishing or restricting use of certain gear types. Depending on management and stakeholder preferences regarding how to respond to this risk-cost-catch trade-off, the additional costs associated with obtaining the additional information required for more certain assessments may be justified, in order to reduce uncertainty and allow fishing effort to continue at higher levels than would otherwise be recommended under a precautionary approach to a highly uncertain assessment.

Being multispecies methods, the PSAs and SAFE assessments enable the relative prioritisation between species for further research or risk management. All levels incorporate a precautionary approach to uncertainty by assigning 'precautionary high risk' scores to attributes when data for that species or from closely related species were not available—that is, false positives (high risks) are considered preferable to false negatives (low risks). For bycatch species that overlap with, and are impacted by, several different fisheries it is important to consider cumulative impact across all fisheries. Where these fisheries occur across different jurisdictions (e.g. state, Commonwealth and international fisheries), evaluation of cumulative impacts requires assessments to be conducted across these jurisdictions.

Separate PSA assessments for individual fisheries cannot be easily combined after the fact, to try and assess cumulative impacts. For Level 1 (SICA) and 2 (PSA) approaches, cumulative impacts can only be assessed by conducting a risk assessment that covers all relevant fisheries. This requires that the data needed to identify and rank impacts and risks are available in consistent and comparable format across fisheries, and across jurisdictions if it is required to evaluate cumulative impacts across different jurisdictions. In contrast, being fully quantitative, fishing mortality estimates derived from individual SAFE analyses can subsequently be added for a number of different fisheries to generate cumulative estimate of bycatch mortality across all of the assessed fisheries.

Ecological risk management

At various stages in the ERA process, once risk assessment results are available, a risk management response may be implemented to reduce or mitigate the identified risks (Figure 4). AFMA has developed an ERM framework to guide and ensure consistency in the management process in response to the outcomes of an ERA (AFMA 2010a). ERA results inform the ERM framework and ERA updates are integral to effective adaptive management. The ERA/ERM framework enables identification of priorities for management and research effort, while guiding management response for addressing higher risk issues. The ERM for each fishery is intended to respond directly to the results of the ERA, and to then manage fishery impacts on species assessed to be at high risk from the effects of fishing. The ERM details the management measures to be implemented by AFMA to monitor, mitigate or manage high risks.

ERAs have been carried out at Level 1 (SICA) for each Commonwealth fishery (30 fisheries). These have been supplemented, where necessary, and where available information allows, with Level 2 (PSA) assessments for 24 of the fisheries and Level 3 (SAFE) assessments for 18 fisheries. PSA Residual Risk Assessments (updated assessments of remaining risks after management actions have been introduced) have been conducted for 19 of these fisheries (see Appendix H). ERM programs have been implemented for 21 of these assessed fisheries.

ERAs have identified key species that require attention in each fishery and the developed ERM programs address these (Appendix H). Under the environmental risk management framework, bycatch and discarding work plans (in addition to ERMs) have been prepared for each fishery. These plans outline specific action items to address areas of concerns within the fishery that have been identified through the ERA process. All work plans are structured to provide practical mitigation options for species identified as being at high risk, in order to reduce the impact and the risk on the species. Bycatch work plans generally rely on information already available. However, if lack of information is of concern in a fishery, research projects and data collection may be developed as action items under the work plan.

The species or groups that form the priority list for each fishery are either managed through fishery-specific arrangements, or under one or more of the following policies or measures:

- HSP and Guidelines
- Non-key Commercial Species (byproduct) Policy
- Bycatch and Discarding Work Plans
- Shark Policy and the Chondrichthyan Guide for Fisheries Managers
- Protected species under various international plans of action, recovery plans etc.

An important component of any ERM strategy is to monitor performance and evaluate the actual outcomes of mitigation measures. These outcomes should be assessed by defining short- and long-term measurable objectives, and then through the use of performance measures to monitor and report on performance against these objectives. For example, performance can be measured by comparing updated estimates of bycatch mortality (F) from SAFE assessments with natural mortality (M). Based on a meta-analysis of 245 species, The level of fishing mortality (F) producing maximum sustainable yield (F_{MSY}) for teleosts is about 87 per cent of M, while for chondrichthyans F_{MSY} is at about 41 per cent of M, (Zhou et al. 2012).

With a catch history and an estimate of *F* from SAFE assessments it is possible to estimate maximum sustainable yield (MSY) and to measure performance against MSY-related objectives,

making this approach compatible with requirements under the HSP. The AFMA ERM strategy highlights the importance of ongoing monitoring and review of the mitigation measures against defined performance measures. These performance evaluation results can be used to inform reviews of the status of a species, (e.g. if a bycatch species is going to change to become a target species). However, requirements or provisions for performance evaluation are not particularly transparent or clearly articulated in current ERMs.

Considerations for applying risk-based approaches

The ERA/ERM framework provides a structured and integrated way of assessing the risks to sustainability of bycatch species and addressing these with ERM programs. However, risk scores and levels of confidence can differ for low-information SICA or PSA assessments, depending on different levels of information and different approaches taken to ranking and combining scores. ERAs also only provide a snapshot of status and risks at the time of the assessment. Monitoring effectiveness and measuring progress in risk management requires ongoing monitoring and periodic ERA updates or analysis in order to support an adaptive management feedback loop.

AFMA has chosen to take a comprehensive approach to ERAs for Commonwealth fisheries, conducting Level 1 assessment for all major fisheries, and then Level 2 or Level 3 assessments for medium- and high-risk species in those fisheries (see Appendix H for summary of ERAs/ERMs conducted to date). The current AFMA–CSIRO ERA methodology adopts a precautionary approach to information gaps by assuming missing values are scored as high risk. Risk assessments in multispecies fisheries, where there are many gaps in data and information, can identify many species as being at high risk. A review of risk-based approaches for data-poor species (Scandol et al. 2009) has developed national guidelines for such circumstances.

Uncertainties and gaps in risk assessments can be addressed by collecting additional information, either to fill the gaps, or to enable a higher level quantitative assessment with lower uncertainty. However, collection of additional information can be expensive and there is therefore a direct trade-off between the cost of reducing uncertainty versus application of precautionary approaches to manage effectively under the uncertainty. The availability of resources may rule out further research to reduce uncertainty in which case there is a need for mechanisms, including expert overrides and residual risk assessments that avoid having to resort to widespread application of precautionary management measures when they may not be necessary. Consideration should be given to where precaution is most sensibly applied, either in the assessment itself or in the management response.

The Level 2 PSA and Level 3 SAFE analysis are not scaled by fishing effort but rely more on the spatial overlap of the fishery with the distribution of the species. These analyses may need to be redone periodically, in order to take into account any changes in spatial overlap of fisheries and bycatch species due to any time–area closures or the establishment of marine reserves. Updated assessments and management responses may need to account for the levels of protection already afforded to bycatch species through such closures.

National guidelines on risk-based approaches for data-poor fisheries

A recent FRDC-funded project (2007/016; Scandol et al. 2009) reviewed risk-based approaches for data-poor fisheries and developed national guidelines for their application. This work recognised the substantial investment in risk-based management by many fisheries agencies and noted that, while implementing risk assessments is a fundamental part of the process, unless policy and legislative frameworks exist to interpret and respond to the outcomes of those assessments, their value will be compromised. While not confined to fisheries bycatch, the guidelines provided by Scandol et al. (2009) are relevant and are listed below:

- Risk should be determined by combining the likelihood and the consequence of an uncertain outcome that will adversely affect objectives.
- All risk-based approaches in Australian fisheries should fit within the likelihood consequence model.

- Understand that consequences must have a frame of reference that, for a government agency, is determined by legislative and policy objectives.
- Recognise that the estimation of the likelihood of an uncertain outcome is an objective task and the influence of human-values in such estimates should be minimised.
- Appreciate that agency officers need to have the requisite skills in risk management to apply these approaches in research and management.
- Recognise data poverty is a broader concept than simply not having enough data.
- Acknowledge that the best response to data-poor fisheries is not always to collect more data, but in some situations it is better to implement management strategies that are robust to uncertainty and are able to achieve acceptable levels of risk.
- Recognise that there are minimum standards of data for species that are subject to some type of risk or stock assessment.
- Acknowledge that when interpreting risk assessments, adoption of the precautionary approach implies that when the likelihood of an outcome is uncertain and the environmental consequence of this outcome is serious or irreversible, then the interpretation of this likelihood should be the higher but still plausible estimate.
- Appreciate that risk-like approaches can be used for prioritising and scheduling research, monitoring and management tasks. Such approaches are often closely associated with multicriteria decision analysis.
- Recognise how risk assessments can be used to prioritise research. In particular, where potential outcomes are high risk because of an uncertain likelihood, research can be used to clarify the risk.
- Continue to apply fishery assessment methods that have a successful track-record in data-poor environments.
- Harvest strategy frameworks with explicit decision rules provide an effective risk management framework for fisheries.
- Develop and promote analyses that estimate the vulnerability of stocks, the productivity of stocks or the likelihood that stocks are being harvested at unsustainable rates.
- When direct support for a model is unavailable, then scientific arguments should be constructed using a weight-of-evidence approach.
- Individual scientists should apply risk management strategies to their own research and workflows.
- Continue to improve the efficiency of the workflows associated with stock assessment by adopting appropriate technologies.
- Risk management is usually carried out by reducing the likelihood of an undesirable outcome.
- Risk management may, in some cases, be carried out by reconsidering the consequence of an outcome.
- Within a multispecies fishery, directed management of an indicator species is an effective strategy to manage species at equal or lower risk than the indicator species.
- Managers should identify the factors that can cause decision-making processes to fail and develop risk management strategies to avoid these factors.

Reference points and decision rules for bycatch and byproduct

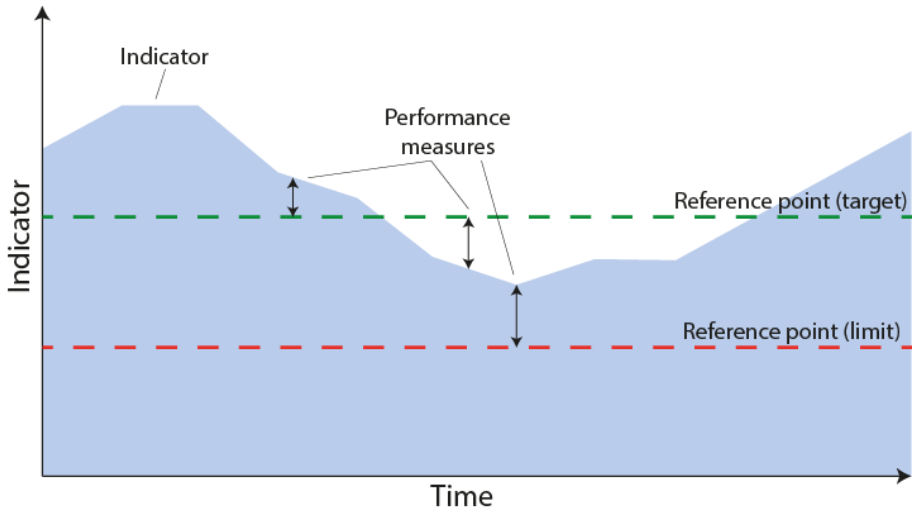
Reference points in fisheries management are indicators of the level of fishing (or stock size) used as a reference point against which to manage stocks. The FAO (1995b) defines reference points as '... a conventional value, derived from technical analysis, which represents a state of the fishery or population, and whose characteristics are believed to be useful for the management of the unit stock'. The HSP (2007) requires reference points for each key commercial stock to be estimated and established in accordance with MSY and MEY related objectives for all fisheries. Australian fisheries management uses a range of reference points, from those derived from model outputs (e.g.48 per cent of unfished biomass, $0.48B_0$) for high-information fisheries, to empirical proxies (e.g. catch-per-unit-effort) for medium-information fisheries, to empirical data (e.g. catch and effort) for low-information fisheries.

Similarly, depending on the information available, bycatch management may be assessment based (high information), risk-based (medium information) or precautionary (low information), or some combination of these approaches. The value of risk-based approaches is that they allow effective management decisions to be taken in the absence of full quantitative assessments, and despite high uncertainty. The risk assessment process is designed to respond to uncertainty by increasing estimates of risk in response to uncertainty in information, allowing management to respond directly to those higher estimates of risk under uncertain situations.

Under the HSP, harvest strategies and decision/control rules are developed for each fishery in relation to target and limit reference points. Similarly, the Bycatch Policy (DAFF 2000) 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.' It goes on to state that 'Where the use of biological reference points is not feasible, the precautionary principle will be used as a basis for decision-making.'

Irrespective of the actual reference points chosen, the purpose of all reference points is to provide reference points for good (target) and bad (limit) performance, against which some indicator of performance of the fishery, and how fishery performance responds to management measures, can be measured. Figure 5 shows how an indicator may be tracked over time and its value compared to target and limit reference points.

Figure 5 Indicators and performance measures in relation to limit and target reference points



Source: DAFF 2007

Empirical indicators

Where limited information does not allow for the estimation of quantitative indicators of population status, simple empirical indicators and reference points can be useful for bycatch management. Empirical indicators and reference points for bycatch may focus on easily measurable values, such as estimates of current bycatch levels compared to historical levels, or bycatch to harvest ratios. However, care needs to be taken in interpreting such indicators as they can be misleading and may not be representative of the measure of fishery performance of interest. Unless monitoring is continual and adequately representative, available bycatch data may be sparse and uninformative, leading to non-representative indicators. So, while it may be possible to track such indicators with little information, apparently meaningful indicators such as target catch to bycatch ratios can be inconclusive. Table 3 shows, for example, how changes in bycatch / harvest ratios may be interpreted in different ways.

Table 3 Potential explanations for changes in target catch, bycatch and target catch to bycatch ratios

Bycatch trend	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				

↔ = no change; ↑ = increase; ↓ = decrease; ↓↓ = large decrease

Note: 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).

If available, it is useful to include both fisheries data and fisheries-independent data, such as from research trawls or other scientific surveys, when estimating indicators. This will reduce bias and uncertainty resulting from limited or non-representative fisheries bycatch data for species that are not directly targeted. Ideally, data or indices on all sources of bycatch mortality (e.g. natural mortality, including disease and predation) are needed, in order to estimate the relative importance of fishing in comparison to other sources of mortality. Mortality from fishing may be negligible in comparison with other mortality, such that reducing impacts of fishing will have no beneficial effect. Alternatively, where a bycatch population is threatened and fishing mortality is significant in comparison with natural mortality, fishing mortality will need to be reduced.

It is important to identify an appropriate scale for monitoring indicators for particular species, sub-populations and communities of interest. Indicators that may index only a small and possibly non-representative part of a fishery or bycatch population, will not be useful. However, it may be expensive to expand monitoring or data collection to provide a more broadly representative indicator. Depending on the management objective, an indicator may need to be species-specific, or a suite of different indicators may be useful. However, the costs of annual monitoring of a suite of indicators may be significant and it may then be more cost-effective to

undertake periodic or intermittent monitoring, i.e. snapshots, to inform periodic adaptive management decisions.

Using catch data alone, it is not usually possible to indicate the extent of depletion unless the original unexploited state (B_0) is well estimated and there are reasonably reliable estimates of natural mortality against which to compare fishing mortality. It may be easier and more cost effective to measure the present state against some other reference period for which information is available, or to measure relative changes in an appropriate indicator, such as bycatch rate, between years, without attempting to estimate total mortality or depletion compared to the unexploited state. Evaluating annual mortality rates against some measure of sustainable mortality rate is often the most achievable way of evaluating trends and sustainability of impact. Reliable estimates of natural mortality (M) are an important component of such approaches, which are analogous to evaluating F against M, or some other sustainable F level (e.g. F_{MSY}), as often used in conventional fisheries management.

Application of Harvest Strategy Policy principles to bycatch

The HSP (DAFF 2007) contains several key elements, including objectives, indicators, performance measures, reference points, harvest strategies, decision rules and meta-rules for exceptional circumstances. All of these elements can potentially be applied to management of fisheries bycatch, provided these elements are adapted to deal with the limited and potentially partially representative nature of bycatch data.

The HSP is primarily intended to guide the management of key commercial species, but is also applied to many retained secondary commercial species caught in association with the target species. The primary objective of the policy is to attain MEY for each fishery. At present, this is evaluated by optimising economic yields for the key commercial species, those species that contribute the bulk of the catch and generate most of the revenue in a fishery. MEY, as presently calculated, excludes explicit evaluation of the nonmarket costs of bycatch (or bycatch reduction measures) and broader environmental impacts. Nonetheless, the pursuit of MEY (default $B_{MEY} = 0.48\ B_0$) for target species, rather than MSY ($B_{MSY} = 0.40\ B_0$) should result in reduced environmental impact due to overall reductions in fishing effort.

Bycatch management is generally data-poor and the costs to obtain better data may outweigh the benefits from improved information and reduced uncertainty in risk or population assessments. However, these additional costs may be justified in terms of meeting conservation or social objectives to conserve and rebuild protected species being managed under the requirements of the EPBC Act. Assessment of risks and impacts must be followed by effective and adaptive management to reduce risks to acceptable levels. This either requires precautionary management approaches to uncertain risk assessments (SICA and PSA), or collection of the information required to reduce uncertainty and move towards a SAFE assessment. In all cases, performance against appropriate reference points should be monitored to demonstrate that fishery impacts are sustainable over the long term.

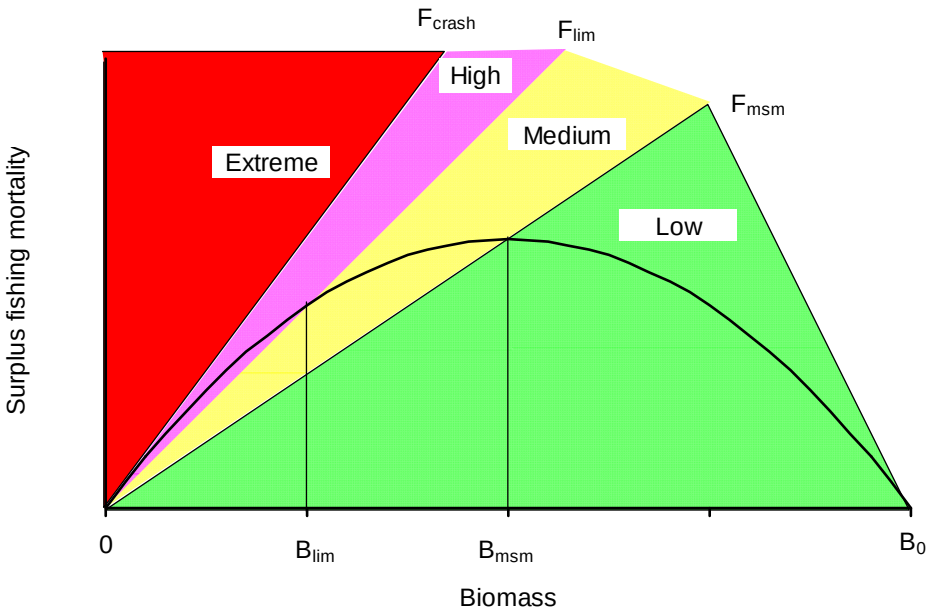
For low-value, low-risk bycatch species, a default objective might be to ensure that the chosen indicator does not approach some hard limit beyond which fishing impacts will result in unacceptable levels of bycatch mortality. For higher risk species there may be a need to improve analyses beyond those carried out, quantifying and incorporating all sources of mortality and maintaining impacts well away from hard limits and closer to sustainability target reference points. In either case, adaptive management between target and limit reference levels means that some acceptable level of mortality needs to be determined and agreed. Some case study examples of protected species management in Commonwealth fisheries involving reference points, indicators and decision rules are provided in Appendix F.

Setting of objectives and reference points related to acceptable levels of bycatch may be contentious, particularly where different stakeholder or interest groups have different preferred objectives, but negotiating agreed objectives and reference points, and then allowing adaptive management to maintain impacts below agreed limits, is essential to an effective risk-based bycatch management approach. It is therefore possible to develop harvest strategies around risk

scores, provided performance of an appropriate indicator of reduction in risk is monitored, and decision rules are implemented for how to respond to changes in this indicator. The indicator and decision rules used will need to account for the uncertainty of the assessments used to ensure that adaptive management is robust to that uncertainty.

Where there is enough information available to conduct a quantitative SAFE analysis, various reference points can be directly estimated, such as F_{MSM}: maximum sustainable mortality, similar in concept to F_{MSY}; F_{LIM}: soft limit reference point that could trigger a harvest control rule; F_{CRASH}: hard limit reference point denoting extinction risk (Figure 6). Where the SAFE assessment relates to a group of species, these reference points will relate to the entire group of species for which the assessment was conducted. Adaptive management against these reference points will necessarily relate to the entire group of species, and not to any one particular species within that group.

Figure 6 Bycatch reference points in Sustainability Assessment for Fishing Effects analyses, based on life history parameters and spatial overlap between fishing effort and species range



This shows the expected yield curve of sustainable surplus fishing mortality levels at different levels of biomass below the unfished biomass B_0. The lines and shaded areas designate areas of different risk resulting from fishing above those levels of fishing mortality. F_{msm} = maximum sustainable mortality, similar in concept to F_{MSY} (the level of fishing mortality producing maximum sustainable yield); F_{lim} = soft limit reference point that could trigger a harvest control rule; F_{crash} = hard limit reference point denoting extinction risk.

Source: Figure provided by Shijie Zhou, CSIRO

Application of reference points to bycatch and byproduct

A report for AFMA on *Best practice reference points for Australian fisheries* (Sainsbury 2008) discusses the potential use of target and limit reference points for bycatch. Given the international guidelines and Australian regulatory requirements to minimise bycatch, this report proposes that there should be an overall aspirational target of zero bycatch, which should be approached as far as is operationally feasible. To guide management towards this target, two reference points are then proposed, similar to those applied to target stocks under the HSP.

If specification of reference points is considered feasible for bycatch or byproduct stocks, there should at least be appropriate hard limits requiring active management intervention if fishing exerts a high risk of long-term or irreversible impact on bycatch populations and ecotrophic

system function. These should be supplemented with interim 'trigger' limits for reducing bycatch that are feasible with current technology and acceptable in the current situation. These would be analogous to targets under the policy, and should be set as low as practicable under current circumstances to promote reduction in bycatch, with the intention of revising these downwards as mitigation measures improve and the ability to further reduce bycatch increases.

Limit reference points need to be based on a species' capacity to recover from depletion to that limit level. Limit reference points for bycatch should therefore not be any less conservative than for target species, for which the default HSP limit reference level is 20 per cent of B_0. For protected species there is a target of zero bycatch and an obligation under the EPBC Act to ensure that species do not go extinct locally or globally. This means that there should be no intentional capture of protected species. However, where interactions or unintentional capture are unavoidable, appropriate interim trigger limits may allow for a minimal, acceptable level of interactions, while ensuring that these do not jeopardise the populations concerned.

Where species are unavoidably caught in association, it may be necessary to set interim reference points for one species low enough to minimise impacts on other more vulnerable species. This is similar in concept to the approach under the HSP, which allows a trade-off among target species in order to obtain MEY from the whole catch in a multispecies fishery, but acting in the opposite direction, focusing on ensuring that the most vulnerable, lowest productivity species are not unsustainably impacted. In all cases, there remains a requirement for limit reference points for each species based on their biological characteristics.

Estimating acceptable mortality

The third sub-objective of the current Bycatch Policy is 'To arrive at decisions on the acceptable extent of ecological impacts'. Notwithstanding the overall target under the EPBC Act to strive for zero bycatch for protected species, where bycatches are unavoidable there remains a requirement to determine what would be considered to be an 'acceptable' level of bycatch mortality. This would be the level of bycatch mortality that has been shown, using some appropriate assessment approach robust to limitations in the available information, to be sustainable, and which will not jeopardise the population or reproductive capacity of the population.

There are a number of approaches that can be used to provide estimates of acceptable levels of mortality, depending on data availability and the chosen assessment approach. The more quantitative information that is available, the more feasible it becomes to define quantitative bycatch mortality target reference points that can be used as estimates of acceptable mortality. Formal quantitative stock assessments undertaken for many target species provide a high-information approach to estimating sustainable mortality. Under lower information conditions, potential biological removal (PBR) is another approach to estimating maximum acceptable levels of bycatch mortality. This approach was developed by the US National Marine Fisheries Service in response to amendments to the US Marine Mammal Protection Act in 1994, which specified the use of a PBR approach for managing human-related mortality, particularly incidental bycatch mortality, in commercial fisheries (Wade & Angliss 1997).

PBR is the maximum human-induced mortality that can be sustained by a population without preventing that population from reaching or maintaining a population level above their maximum net productivity level with high certainty (Wade 1998). The standard PBR is calculated to achieve the management goal of allowing populations to stay above, or recover to, their maximum net productivity level, generally taken to be between 50 per cent and 80 per cent of carrying capacity. This approach has been used for determining maximum allowable mortality levels for marine mammals, seabirds and turtles in the US (Moore et al. 2008) and for dolphins in New Zealand (Currey et al. 2012).

PBR estimates are formal and quantified reference levels against which actual mortality can be compared to trigger management measures if the estimated PBR level is exceeded. Even if catch remains below the PBR, decision rules can be designed to trigger initial management responses, such as moving fleets to other areas, if PBR levels are approached. Stronger measures can follow

if initial management measures are unsuccessful and PBRs are actually exceeded. PBRs can be estimated cumulatively across multiple fisheries, but the contribution of each individual fishery should also be calculated to allow management actions to be separately triggered to limit impacts of each fishery. In this way, PBR estimates can be used to address both individual and cumulative (across fisheries) impacts.

Threatened, endangered and protected species and threat abatement plans

Threatened, endangered or protected species are those species that have been formally listed under one of the categories for threatened species specified in the EPBC Act, or which are required to be protected under the provisions of an international agreement. Under the EPBC Act, species facing an extremely high, very high or high risk of extinction may be eligible for listing under the Act in one of the following categories of threatened species: critically endangered, endangered or vulnerable.

Threatened species are generally identified and listed as a result of being significantly depleted from an earlier, pristine state, often due to historical overharvesting or high levels of incidental mortality. Other species can also be listed for protection under the EPBC Act, for instance being informed by species listed under the Convention on the Conservation of Migratory Species of Wild Animals. Despite listing on the EPBC Act and development of a variety of protection plans, populations of some threatened species are not recovering and some appear to still be declining. Listing establishes an obligation to prevent any further mortality, such that it is only legal to kill listed threatened species in a fishery which has EPBC Act accredited management arrangements as a result of an 'unavoidable accident'. This precludes any directed harvesting and generally requires restrictions on use of fishing methods that are known to cause injury or death.

Recovery plans are developed under the EPBC Act for listed threatened species or threatened ecological communities. Recovery plans set out the research and management actions necessary to stop the decline of, and support the recovery of, threatened species or 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 go about preparing a recovery plan and explaining the content requirements for a recovery plan. Threat abatement plans (TAPs) focus on reducing or preventing specific 'threatening processes'.

The Seabird Threat Abatement Plan (Appendix F) provides an example of reference points and decision rules for protected species. The first seabird TAP for bycatch in longline fisheries was adopted in 1998 and a second TAP was developed in 2006. The 2006 seabird TAP is currently under review and a new seabird TAP is expected to be implemented soon. The 2006 TAP specifies interim limit reference points and performance measures in terms of seabird bycatch rates in several Commonwealth fisheries. As long as these interim bycatch rate reference points are not breached, the relevant fisheries are able to continue operating while further improving mitigation methods or revising fishing practices to further reduce seabird bycatch. In the 2006 TAP, limit reference points apply only to nominal bycatch rates estimated from the observer data, rather than to a fishery-wide statistical estimation of bycatch rates.

Required levels of coverage by scientific observers in these fisheries are also specified, to ensure collection of the data needed to reliably monitor bycatch rate performance. At-sea scientific observation is considered to be the most reliable monitoring approach for the estimation of bycatch. However, where observer coverage is less than 100%, it has to be assumed that observed and unobserved trips are statistically similar. For low coverage rates, there is increased statistical likelihood that observer data will not be representative of the fishery. Non-random distribution of observers between areas, vessels or trips will result in non-representative data and the 'observer effect', where fishermen change fishing practices or locations when observers are present, will result in biased data. Both effects reduce the accuracy and precision of bycatch estimates derived from observer data and the magnitude and direction of the bias cannot be reliably estimated after the fact. Improving the quality of estimates derived

from observer data therefore requires improvements to the observer program, either by increasing observer coverage, improving the representative nature of coverage, or both.

Observed bycatch of protected species actually brought aboard is not the total mortality due to fishing. Unobserved mortality may occur due to loss during hauling (Ward et al. 2004), collisions with fishing gear (warp strikes), post-release mortality and loss of seabird breeding pairs or chicks when one mate is killed. Given the difficulty of trying to estimate these unobserved mortalities, limit reference points (acceptable mortalities or PBRs) need to be set low enough to ensure that the combination of observed mortality (measured against the PBR) and unobserved mortality does not jeopardise population status or recovery.

Low-information analytical approaches to bycatch and byproduct assessment

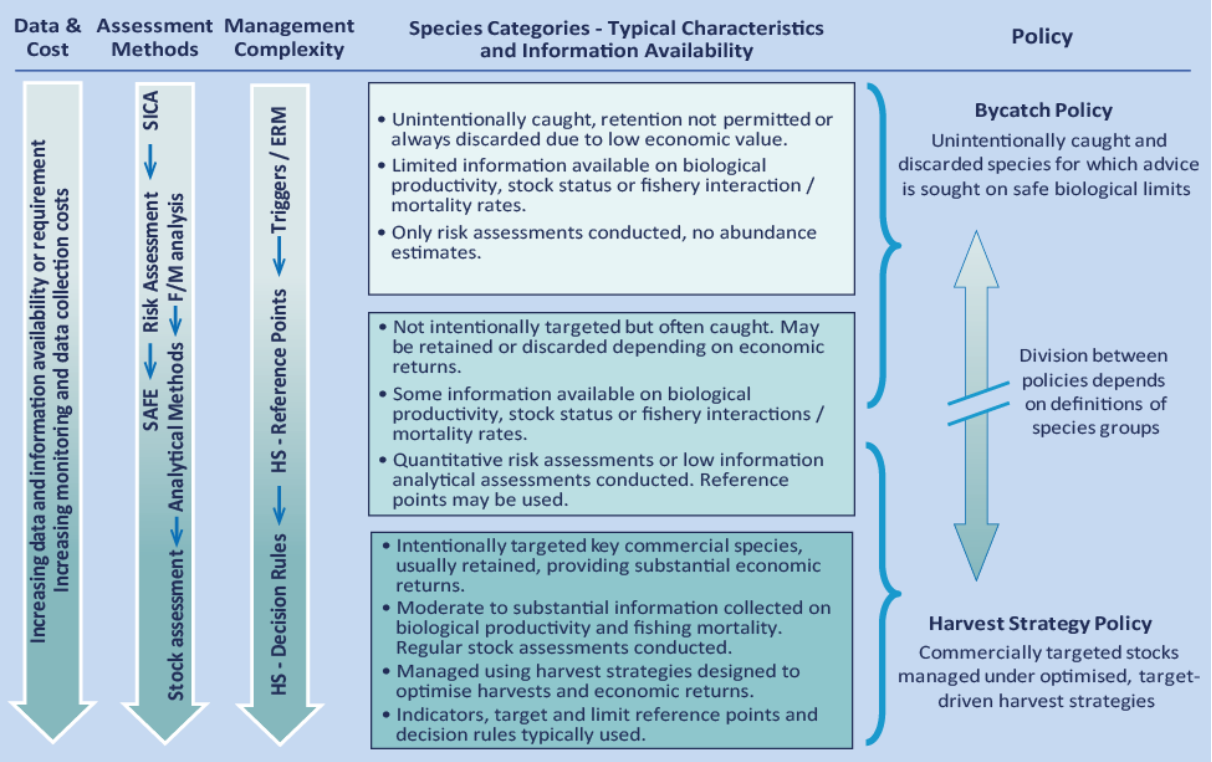
The section describes how a range of risk-based approaches can be applied to assessing the impacts of fishing on bycatch populations. The most appropriate assessment method to use depends on the type and amount of information available on the biology and population status of each bycatch species, the operational characteristics of the fishery and the bycatch rates.

The development of harvest strategies to manage commercial stocks under the HSP is similarly dependant on the type and amount of information available, with a tiered range of fishery-specific harvest strategies being applied to different stocks, depending on data availability. In the Southern and Eastern Scalefish and Shark Fishery (SESSF), for example, Tier 1 approaches require high levels of fisheries data and involve the application of statistical stock assessment models to quantitatively estimate indicators of stock status, usually expressed in terms of current biomass relative to some reference level (B/B_0, B/B_{MSY}, B/B_{MEY}). Tier 3 approaches use data on catch-at-age and catch-curve analyses to compare current fishing mortality with estimated target F levels (e.g. $F < F_{40}$ or F_{48}, see description in Klaer 2012). Tier 4 low-information approaches rely on defining some past period of the fishery over which catch and catch rate were stable, and the stock appeared to be at an acceptable target biomass level, as a target CPUE level. Current standardised CPUE is then compared with CPUE over the reference period (e.g. $CPUE_{Curr} < CPUE_{Targ}$, see description in Haddon 2012).

Although information levels for targeted key commercial and retained byproduct species are generally higher than for bycatch species, a tiered approach can still be applied to bycatch assessments. Bycatch assessments will often need to use risk-based approaches (described in the section on 'Risk-based approaches to bycatch management'), or semi-quantitative approaches relying on basic biological and/or productivity information. However, where actual mortality information is available, or where additional information can be collected, higher level assessment approaches can be adopted.

Figure 7 illustrates the progression in information level and assessment approach from management of incidentally caught, discarded, low-information bycatch species managed under the Bycatch Policy, through incidentally caught and either retained or discarded moderate information species, to commercially targeted, high-information stocks managed under the HSP.

Figure 7 Range of assessment approaches and information requirements from discarded bycatch species managed under the Policy on Fisheries Bycatch to commercial target species managed under the Harvest Strategy Policy



ERM = ecological risk management; HS = harvest strategy; SAFE = Sustainability Assessment for Fishing Effects; SICA = Scale Intensity Consequence Analysis

Note: The feasibility of alternate assessment approaches is dependent on the availability of data and information. At some point in the continuum, depending on definitions of the various species categories, species would shift from being managed as bycatch to being managed as commercial species.

Analytical methods for assessing bycatch

Risk assessment methods are designed to estimate the risk posed to a species or community as a result of some activity. In contrast, analytical assessments are designed to quantitatively estimate some measure of the actual population status (biomass or abundance), which can then be compared with target and limit reference levels.

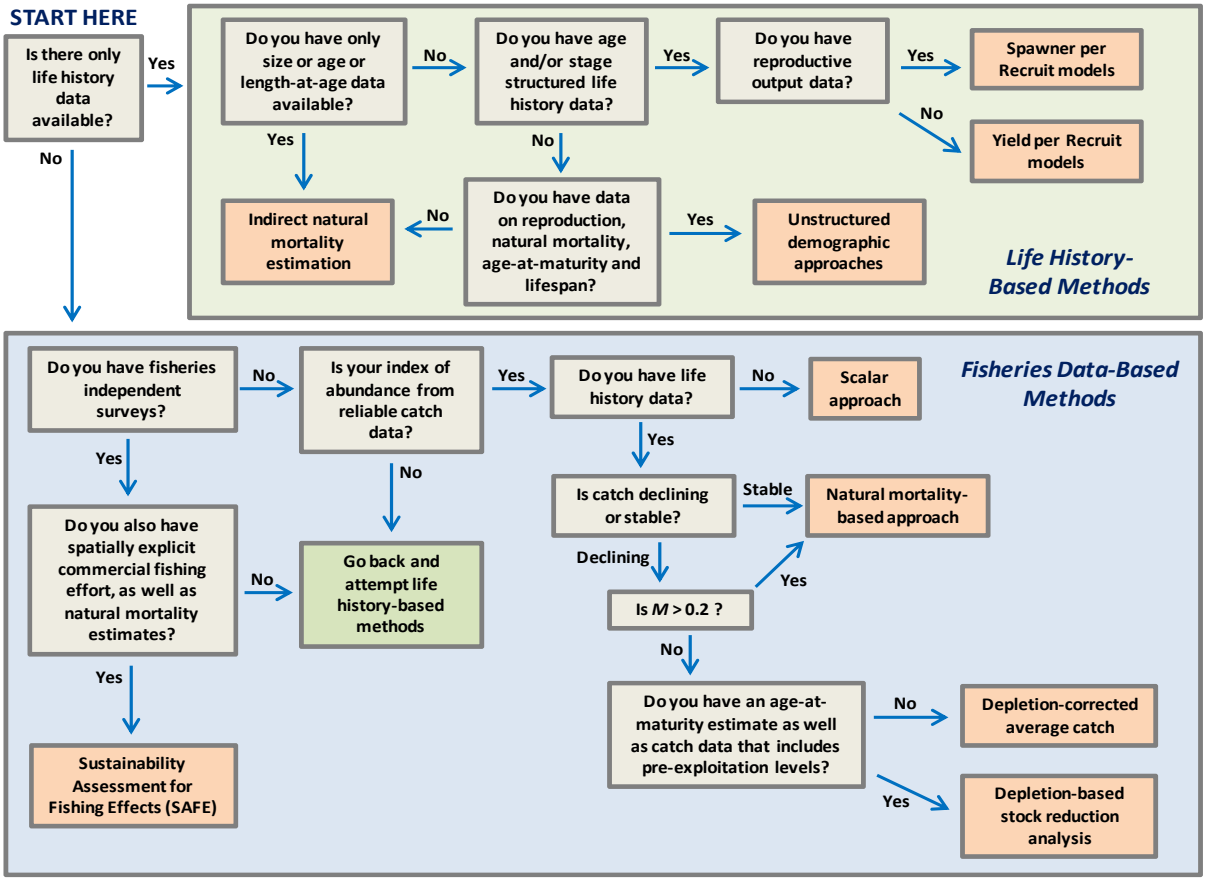
Many of the formal management approaches under tiered harvest strategies for commercial species can be adapted to a tiered approach to bycatch assessment, including the development of indicators and performance measures appropriate to the information available under each risk assessment approach, and the adoption of target and limit reference points against which to compare these indicators. This is easily done for SAFE assessments, where estimates of F can be compared to F-based reference points. Even for low-information approaches, reference levels or reference points can be set in terms of assessed risk for low-information species, with periodically updated residual risk assessments being used as the performance measure.

A variety of methods are available for setting reference points for bycatch depending on the type and quantity of information available. These approaches can span the full range shown in Figure 7, from discarded bycatch species, through occasionally retained byproduct species, to low-information, non-target, commercial species. As part of the process to develop the Canadian *Policy Framework on Managing Bycatch and Discards* under their Sustainable Fisheries Framework, the Canadian Science Advisory Secretariat of the Department of Fisheries and

Ocean, has produced useful guidance to methods for assessing bycatch (DFO 2012). Options for low-information analytical approaches are summarised below from that report.

Figure 8 shows a flowchart proposed to guide the selection of feasible and appropriate methods for assessing bycatch, depending on the information available (DFO 2012). This groups applicable methods into two main classes: life history-based methods, if only biological information relating to the life history of the bycatch is available; and fisheries data-based methods if fisheries or survey data are available.

Figure 8 Decision flowchart for selecting appropriate analytical methods for bycatch assessments depending on data availability



Note: Multiple options might be applicable if different data are available. Beige boxes denote questions, orange boxes denote methods and green re-directs back to life history-based methods.

Source: DFO (2012)

Methods for estimating natural mortality

Estimation of natural mortality is a useful first step towards analytical assessment approaches for bycatch populations. M is a key indicator of productivity and there are many ways to estimate M for different populations, depending on information availability. Comparison of estimates of M with estimates of mortality due to fishing can provide indicators of sustainability, even for low-information species. If data allow, a range of approaches should be used to provide a minimum value, range or distribution of estimates of M as sustainability reference points, taking uncertainty into account (DFO 2012).

Indirect methods for estimating natural mortality (M) can be used where only life history information is available (DFO 2012). In the absence of age information, approximate estimate of natural mortality can be derived from weight, or indirectly from length (Lorenzen 1996; Peterson & Wroblewski 1984). Average natural mortality (across all age classes) for a species

can be estimated using the Hewitt and Hoenig (2005) and Hoenig (1983) methods when maximum age is known. If age at maturity is also known, then M can be estimated using the Jensen (1996) method. If there is information on length-at-age to which a von Bertalanffy growth curve can be fitted to provide estimates of the growth rate (productivity) parameter K, then various additional methods become available, including average (size-independent) estimates of M (Pauly 1980).

When data are available on catch-at-length or catch-at-age, total mortality (Z) can be estimated using catch-curve analyses or year-class curves, as is done in Southeast Scalefish and Shark Fishery catch-curve assessments. Single or aggregate year catch-curve analyses can be used when only one or few years of catch data are available. Year-class curves are able to fit estimates of mortality to declining numbers at age of individual year classes, and so require multiple years of age-specific data across which cohorts can be followed. If catch data are available for multiple years across which fishing effort has varied considerably, and if the average can be assumed to be approximately constant over the years, then total mortality can be partitioned and M can be directly calculated using the SAFE method (Zhou et al. 2009; Zhou & Griffiths 2008).

Using natural mortality for bycatch reference points

There are a series of steps to take when using estimates of M to develop reference points for managing bycatch. Fisheries and Oceans Canada (2012) pose the questions in Box 1 to provide guidance on the level of concern and the approach to be taken. The answers to some of the questions assume some population estimate or population model is available for the species. In some cases it may be possible to develop simple population models from time series of catch data, from monitoring bycatch in the fishery or survey time series of abundance estimates. These can then contribute to setting more robust reference points for managing bycatch. Answers to these questions provide guidance on the level of analysis required. It is important to consider the entire area over which the bycatch species occurs, which may require integration of information from different fisheries (DFO 2012) to ensure that cumulative impacts are properly assessed (see section on Assessing cumulative impacts of fisheries bycatch).

Box 1 Questions to be addressed when estimating M for individual species or assemblages

1. *With M being used as an index of productivity, species with higher M are likely to be more productive and hence able to sustain somewhat higher exploitation rates. Therefore, is the M of the species being examined higher than the M of the target species of the fishery? If so, there is likely limited justification for immediate concern with the level of bycatch, unless the bycatch species are known to be both rare and have high catchability to the gear.*
2. *Does the fishery only occur in part of the bycatch species' range? If so, then one should review what is known about habitat preferences, aggregation behaviour, mobility of the bycatch species, spatial management measures, and other fishery or species-specific factors. It may be justified to consider the level of concern to be low when a substantial portion of the bycatch species is not exposed to fishing mortality.*
3. *Trends in post-recruitment abundance can provide an indication about whether present bycatch levels might be impairing the productivity of the population. To the extent that the trends are considered reliable, the following guidelines apply:*
    a) *Increasing trends: do any indicators (e.g. surveys or catch-per-unit-effort) show that the post-recruitment abundance of the bycatch species population is increasing? These trends should always be reviewed relative to possible changes in the fishery, markets, survey design, or other factors that may bias the indicator. If the trend shows an increase, then there is likely limited justification for concern with the level of bycatch.*
    b) *Stable trends: do any indicators show that the post-recruit abundance of the bycatch species is remaining constant (or relatively constant) or if the data do*

not have sufficient information to evaluate a trend? If yes, then it is appropriate to conduct additional analyses to determine if the population is already low enough to have suffered impaired productivity, or otherwise not sustain even low rates of bycatch.

c) *Decreasing trends: is the post-recruit abundance of the bycatch species population decreasing? If so, a more detailed population assessment for the bycatch species should be made a high priority.*

Source: DFO (2012)

When it is only possible to estimate M for a bycatch species and no other parameters, but there is good information for fishing mortality on target species driving the effort in the fishery, the scalar approach can be used (Berkson et al. 2011). Where applicable, the increase in F can be proportionally downscaled to account for reduced catchability of bycatch after introduction of mitigation measures. Depending on species biology, some proportion of M can then be used as a proxy limit reference level for the fishing mortality a species can sustain. From a meta-analysis of 245 different species and families, Zhou et al. (2012) recommend sustainability limits of F = 0.87 M for teleosts and F = 0.41 M for elasmobranchs.

For a species with a moderate level of concern (e.g. question 3b in Box 1, when abundance is stable), information on estimated mortality from a limited time period can be derived using depletion-corrected average catch analysis (MacCall 2009; NOAA 2011). Where abundance is declining or is remaining constant at a low level (questions 3b and 3c), time series of at least two of the following three pieces of information are required: total bycatch numbers caught, fishing effort and abundance of the bycatch species. Effort series can be derived from nominal effort (boat days or trawl hours) in the target fisheries (DFO 2012).

Time series of bycatch population abundance are least likely to be available, but can be much shorter than for analytical stock assessments and still be useful (DFO 2012). Simple models using three to five years of data can be used, such as an index method (NOAA 2011), to assess current conditions and to conclude whether the catch is within acceptable limits (DFO 2012). Short time-series applications of Schaefer models can be used to determine whether the stock is above or below maximum net productivity level (NMFS 2005; Wade 1998; Wade & Angliss 1997).

Application of these simple analytical approaches is particularly useful for screening bycatch issues to determine the level of concern. In this sense, analytical approaches can contribute to risk-based approaches, showing how the two can form part of an integrated continuum of assessment options. Only when risk assessments or the above simple modelling approaches indicate that the current level of bycatch may be of concern is there a need to apply more complicated models.

To account for uncertainty in the derived catch, effort or abundance data, a large number of alternate realisations of the chosen models should be run, exploring the range of plausible probability distributions of model input data and parameters. These realisations can then be sorted according to their likelihoods to produce Bayesian posterior distributions, which can then be used to assess the probability of further declines in bycatch abundance under the current fishing effort levels and uncertainty.

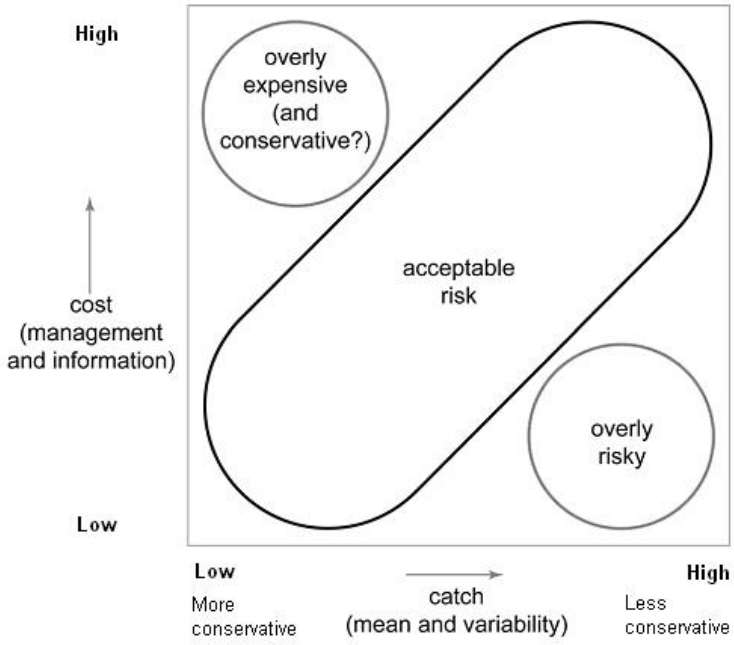
Tiered analytical assessment approaches

The tiered (Level 1–3) ERAEF approach to risk assessment (Hobday et al. 2011) was developed in response differing levels of data and information exist for different fishery components. Similarly, the range in available data has also resulted in a tiered approach to analytical assessments for Australian Commonwealth fisheries managed under the HSP.

Managers usually have a choice between making immediate decisions based on available information, or arranging to collect additional data and conduct further analyses to reduce uncertainty and improve decisions. Dichmont et al. (2012) recognise that there are different

cost, risk and catch implications for these broad options, and that each option will involve trade-offs between the risks of not achieving objectives, fishery management costs and the level or precaution required in management decisions. Sainsbury (2005) noted that there is an explicit risk-cost-catch trade-off underlying this range of choices between management costs, level of precaution (e.g. level of effort or catch) and the associated risk of not achieving management objectives. Figure 9 depicts this conceptual risk-cost-catch trade-off, showing the range within which risk would be considered to be acceptable and across which options exist to vary the risk, management costs (including research) and/or level or precaution of fishery management decisions, while still ensuring that risks remain acceptable.

Figure 9 Schematic of unacceptable catch-cost combinations and the spectrum of acceptable risk combinations extending from high catch-high cost to low catch-low cost



Source: Sainsbury (2005)

Risk-catch or risk-cost trade-offs have previously been examined for certain fisheries using management strategy evaluation, either for target species or for ecosystems. Results confirm the need for greater precaution as uncertainty increases. Uncertainty is an important component of the risk-cost-catch trade-off: as the level of uncertainty increases, the precautionary approach requires managers to take measures, usually by reducing fishing effort or catch. Dowling et al. (in press) have conducted statistical modelling of the risk-cost-catch trade-off for Commonwealth fisheries ranging from data-rich to data-poor. Risk was quantified for target species in terms of status against their limit (ecological risk) and target (economic risk) reference points, as well as for overall ecological impact, including risk to bycatch (ecosystem risk). The risk-cost-catch trade-off frontier was modelled for each of the three forms of risk. Results confirm that ecological, economic and ecosystem risks are all positively correlated with fishing intensity (catch and catch surrogates), as well as with uncertainty in stock status, as predicted by Sainsbury (2005). Reducing these risks therefore either requires fishing intensity (effort or catch) to be reduced, or uncertainty to be reduced by collecting the additional data required to support a more certain, higher tier, analysis.

This risk-cost-catch trade-off framework is intended to encourage consideration of alternative options for cost-effective management approaches that fall within an 'acceptable' range of risk, and the cost–benefit of collecting additional data. Sainsbury (2005) notes that management costs generally increase as catch increases, because more information is required to allow larger

catches while still ensuring acceptable risk. The net economic returns to a fishery will influence what the fishery can afford to spend to obtain data to inform management decisions. In some cases, it may be more cost effective to address an issue by immediate management action based on current information, rather than invest in improved understanding of the issue. A small and low-valued fishery may need a low-cost approach, because the potential for additional benefits (catch or profit) is low. A fishery with larger potential for increased net benefits may justify high-information management. A fishery maintained at maximum biological productivity, aimed at maximising long-term economic performance, would require close monitoring and regular adaptive management intervention to manage the risks (Dichmont et al. 2012).

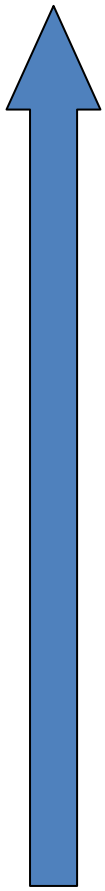
Analytical assessment tiers

Decisions about which stock assessment method to use will drive the data requirements, and therefore the costs of data collection, for a fishery (Smith et al 2012). The wide range in availability of data for different species caught in Commonwealth fisheries, and particularly the low information for most bycatch and byproduct species, has resulted in the proposal of eight analytical assessment tiers for Commonwealth fisheries (Dichmont et al. 2012), built on the existing assessment tiers in the SESSF. Each tier level has a specific set of data requirements and associated analysis costs. (Table 4), with lower numbered tiers requiring more information and providing more certain assessments, and higher numbered tiers requiring less data but providing less certain results.

The optimal tier level for each fishery would be determined by data availability and the trade-off between risk, cost and catch. This allows fisheries managers to consider at which tier each stock should be assessed and managed, with a clear understanding of what the associated data needs and costs will be. Generally, there is relationship between lower numbered assessment tiers, higher information requirements and higher fishing intensity. Lower assessment tiers have higher information costs but, as a result of reduced uncertainty, allow fisheries to operate at higher intensity (higher effort or catch) while still remaining within the acceptable levels of risk and impact. Harvest strategy control rules can then be devised that reduce F down from F_{MEY} as information decreases and assessment tier and uncertainty increase (Dichmont et al. 2012), to ensure that risks remain within acceptable range as information decreases.

Even for information poor fisheries where there are no measures of biomass or target mortality, results of low-information assessments (e.g. F/M comparisons) can provide guidance on establishing conservative triggers to limit mortality to below some estimated proportion of F_{MEY}. This is similar to the proposed Canadian hierarchical approach for selecting appropriate analytical methods for bycatch assessments depending on data availability (Figure 8, DFO 2012). These assessment tiers are already used to for a number of Commonwealth byproduct and some bycatch species, providing for an information-based transition from risk-based ERA approaches to analytical approaches as management requirements escalate (Figure 7). Trigger limits are already in place in some data-poor Commonwealth fisheries and breaching of the trigger limits prompts further assessment, including the option of moving to a higher information assessment tier with further data collection requirements if the trigger is reached.

Table 4 Hierarchical analytical assessment tiers proposed for Commonwealth fisheries, describing the assessments methods and data requirements for each tier

Information need	Tier	Assessment type	Data required	Data source
	Tier 0	Robust assessment of F and B based on fishery dependent and independent data.	C, E, CPUE	Fishery-independent surveys, logbooks
	Tier 1	Robust assessment of F and B based on fishery dependent data only. B_{MSY} / B_{MEY} estimated by integrated assessment.	High level of data: C, E and additional data	Logbooks, observers
	Tier 2	Assessment of F and B based on fishery dependent and/or fishery independent data. By estimated by dynamic production model, robust egg production model.	Low level of data: C, E, CPUE	Logbooks, observers
	Tier 3	Empirical estimates of F, M, and/or SBPR based on size and/or age data.	Age data ± length, growth, and reproduction data	Logbooks, observers
	Tier 4	Empirical estimates of proxies: relative biomass based on fishery dependent data, CPUE, mean size; depletion analysis, within season changes to relative biomass based on fishery dependent data; relative biomass from fishery independent spatial surveys.	Catch, effort, Size, length, age	Logbooks, observers, fishery independent surveys
	Tier 5	Empirical estimates of F based on spatial distribution of effort relative to species distribution. Estimates of F. SAFE → biology, spatial overlap.		Logbooks, observers
	Tier 6	No estimate of B. Uses fishery-dependent species-specific catch triggers.	Catch by species	Logbooks, observers
	Tier 7	No estimate of B or F. Uses fishery-dependent triggers for groups of species, e.g. C by group, E by group, spatial distribution of fishing activity, catch composition.	C and E by species group; spatial E distribution	Logbooks, observers

B = biomass; B_{MEY} = biomass producing maximum economic yield; B_{MSY} = biomass producing maximum sustainable yield; C =catch; CPUE = catch per unit effort; E = effort; F = fishing mortality rate; SAFE = Sustainability Assessment for Fishing Effects. Increasing tier numbers reflect increased uncertainty and assessment risk. Tier 0 has the highest data requirements and lowest uncertainty and risk. Tier 7 has the lowest data requirements but highest uncertainty and risk. Tiers 6 and 7 also use qualitative information for the fishery or similar fisheries elsewhere to confirm that the method has an acceptable level of risk.

Source: Dichmont et al. (2012)

Determining acceptable risk

In order to explicitly consider options within a risk-cost-catch trade-off, it is necessary to define what is meant by acceptable risk. For analytical approaches, this is best done by defining indicators and reference points for each component and evaluating the probability of meeting the target reference points (economic risk) and of breaching the limit reference points (ecological risk) (Dichmont et al. 2012). For the latter, it is also necessary to define the

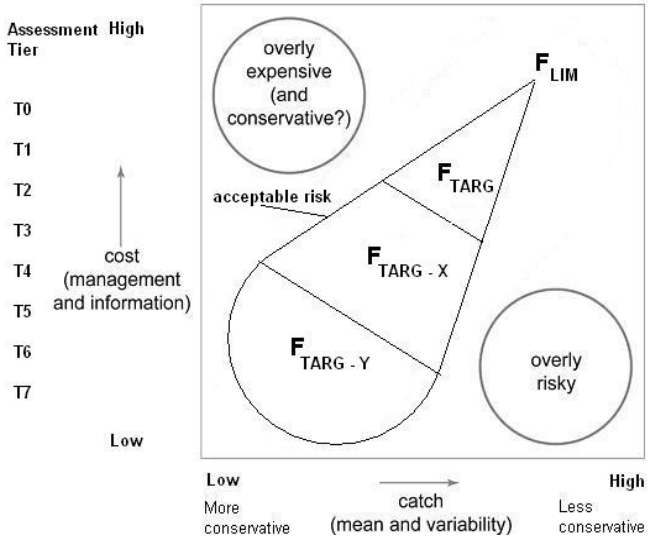
maximum acceptable probability (risk) of breaching the limit under particular fishery conditions (fishing intensity), taking account of uncertainty in estimates of status against the limit.

For commercial species, the HSP defines target and limit reference points, as well as the acceptable levels of risk of breaching limits. Implementation of the HSP involves developing harvest strategies for target and principal byproduct species that meet the requirements of the policy. Where setting target and limit reference points is not feasible as a result of data limitations, harvest strategies must still be designed to pursue the objectives of the HSP for sustainable, profitable fisheries. Each harvest strategy comprises a combination of a monitoring strategy, an assessment method to determine stock status, and a decision rule for altering management arrangements in response to stock status. Availability of data and information, or the cost of collecting additional data, dictates the assessment methods that can be applied, and the chosen assessment method then determines what sorts of decision rules can be used.

Even where a risk-based approach is used, the most effective way to define acceptable risk, and to define acceptable levels of impact or mortality for bycatch and byproduct species, is in terms of target and limit reference points (see section on application of reference points to bycatch and byproduct). In a risk-based approach, target and limit reference points translate directly into maximum acceptable level of risk (limit reference point) and the lowest achievable level of risk under the chosen harvest strategy objectives (target reference point). There are, however, biologically-imposed (productivity) limits to the amount of catch that can be taken, irrespective of the amount of information collected. Dichmont et al. (2012) explain this conceptually in a refinement of the Sainsbury (2005) risk-cost-catch trade-off schematic (Figure 10).

This amended risk-cost-catch trade-off graph, expressed in terms of F, recognises F_{lim} as corresponding to the highest catch that can be taken while staying within the range of acceptable risk. In accordance with the principles of the HSP, any catch greater than F_{lim} results in an unacceptably high risk of depleting biomass to below B_{lim}, which is the point at which the stock becomes overfished. The adjusted boundary of acceptable risk can then be conceptually divided into regions, the optimal target fishing mortality (F_{Targ}) region, plus additional regions depicting fishing mortality lower than the target (F_{Targ} – x and F_{Targ} – y) (Dichmont et al. 2012). In accordance with the precautionary approach, as available data and information decreases, forcing a move to a lower information assessment tier, F needs to be reduced further and further below optimal F_{Targ} levels to compensate for increased uncertainty in assessment results. This approach requires decision rules to intentionally reduce the target fishing mortality in relation to the level of uncertainty represented by what tier the fishery is assessed at.

Figure 10 Modified representation of the risk-cost-catch framework including reference points for fishing mortality (catch), an amended definition of acceptable risk and a measure of uncertainty (assessment tiers)



Source: Dichmont et al. (2012)

Assessing cumulative impacts of fisheries bycatch

Fishery-specific risk-based approaches are typically designed to assess the risk to particular bycatch species or groups posed by that fishery, and that fishery only. This is because individual fisheries are usually managed under specific fishery management plans, with monitoring, data collection, surveys, research, risk assessments and the funding for all these activities tied to that particular fishery. While this compartmentalised approach is useful to allow fishery managers to focus on effective management of fisheries directly under their jurisdiction, it creates difficulties for managing aspects that span across fisheries.

This is particularly relevant to management of bycatch populations that may be impacted by more than one fishery, perhaps across substantial geographic ranges, and which are managed under different management plans by different jurisdictions. Fully quantitative stock assessment approaches can be relatively easily adapted to ensure effective management of assessed species across regions or jurisdictions by defining different 'management units' or 'stocks' in these different areas, and then assessing and managing each of these sustainably using compatible data and harvest strategies. However, qualitative (Level 1) or semi-quantitative (Level 2) risk assessments generally do not provide quantitative estimates of, for example, bycatch mortality that can easily be partitioned or added to evaluate impacts in different areas or fisheries. These risk assessments provide a relative measure of risk that can only be applied to the fishery, species group or area for which the risk assessment was conducted.

The result can be that the individual fishery impacts on bycatch may all be individually assessed to be of only medium risk. However, there is no objective and reliable way of summing these risk assessments to determine whether the cumulative effect of all these medium risks might actually poses a high risk to the population. This can be done for quantitative approaches, such as Level 3 SAFE assessments, by summing the individual estimated fishing mortalities across fisheries and comparing this to a precautionary reference point or reference point.

The evaluation of cumulative impacts on bycatch is critically important for species considered to be vulnerable or for which evidence of substantial population declines already exists, such as for protected species. This is illustrated by international impacts of fisheries on seabirds on the high seas. Until work was done to try and quantitatively estimate mortality of seabirds across all international fisheries, there was little appreciation of the unsustainable mortality levels being exerted on some seabird species. Cumulative impact assessment has shown that historical mortality rates caused by pelagic longline fishing are substantial and unsustainable (see e.g. Brothers et al. 1999) resulting in international action to reduce seabird mortalities in high-seas fisheries, such as the *International plan of action for reducing incidental catch of seabirds in longline fisheries* (FAO 1999).

Approaches to cumulative risk assessment

There can be various non-fisheries related impacts, or indirect fisheries-related impacts, on bycatch populations. Bycatch populations are subject to natural mortality and may be vulnerable to other human activity. For example, marine turtles are subject to natural predation by sharks, disturbance of nesting sites by coastal developments, harvesting of eggs and predation by feral animals. Fishing activities may also indirectly affect bycatch populations through disturbance of habitats (e.g. demersal trawling), reduction in water quality (e.g. dredging), the release of organic matter (e.g. discarded fish catch or offal) and resulting alterations to the composition of animal communities and ecosystems. These indirect and other impacts are outside the scope of the Bycatch Policy and are therefore not considered in this report. There are, however, several dimensions across which fisheries-related cumulative impacts can occur:

- Impacts accumulate over time—if risks or mortalities are not expressed in terms of a rate, and compared against a reference point, then little information is provided on how those impacts will accumulate over time. Assessments need to be designed to determine mortality rates (i.e. some estimate of F) in order to allow the cumulative effects over time to be evaluated. Mortality caused by current fishing might seem quite low, but this needs to be assessed in relation to the bycatch population's current status. There may have been

historical impacts, sometimes unrelated to fishing, that need to be accounted for when evaluating current bycatch rates. For example, sealing during the 19th century substantially reduced the size of Australian sea lion populations. Current fisheries-related sea lion mortality is at much lower levels than that due to historical sealing, but is potentially sufficient to threaten small sea lion populations.

- Impacts occur across different fisheries—where the distribution of a bycatch population overlaps with the operating areas of a number of different fisheries, these will potentially have a cumulative impact. This is particularly applicable, for example, to seabird populations.
- Impacts occur in fisheries under different jurisdictions—international, Commonwealth, state or territory fisheries can all have impacts on a bycatch population with a wide distribution extending across multiple jurisdictions; these will have cumulative impacts.

To facilitate evaluation of cumulative impacts, assessments, whether they are risk-based or analytical, should be designed to provide estimates of bycatch interaction or mortality rates, or quantitative estimates of impacts over time. Combined with an appropriate ecological risk management program to limit impacts to sustainable levels, or to detect when they exceed some precautionary sustainability reference point, this will take care of the question of cumulative impacts over time. There are then two broad approaches that can be taken to evaluating cumulative impacts across fisheries or jurisdictions.

Qualitative risk-based cumulative impact assessment

For low-information bycatch issues, where only qualitative assessments are possible and where there is no intention of collecting additional information (perhaps as a result of cost), assessment of cumulative impacts essentially requires that risk assessment be redone across the fisheries or jurisdictions considered to have the potential to exert cumulative impacts. It is, however, unlikely that this will need to be done for all bycatch populations. Low-level risk assessments, such as SICA and PSA analyses, are typically used as initial screening processes, used to identify high risk species for which more quantitative assessments should be conducted

This approach can also be used to identify species for which cross-fisheries or cross-jurisdictional risk assessments need to be conducted. Under this approach, it must be assumed that, if risks have been assessed as high in any one fishery, then risks are high across all fisheries. Unless quantitative assessments or analytical approaches are used, this risk cannot be apportioned between fisheries. Management measures must therefore be designed to respond to the likelihood that risks are high across all fisheries or jurisdictions, and comparable measures put in place to reduce risks to acceptable levels in all fisheries.

Cumulative risks assessments across fisheries or jurisdictions need to focus on medium-risk species. Cumulative assessments may not be needed for low-risk species, where that low risk results from some factor that extends across all the fisheries of interest, and reduces the likelihood of bycatch mortality in all those fisheries, such as low vulnerability of the species mortality in all fisheries. Where there are indications of vulnerability in one or more of the fisheries, low risk species may need to be included in the cumulative assessment.

The cumulative reassessment of these medium-risk species across fisheries and jurisdictions should focus on determining the overall risk across those fisheries, in the same way as was done for individual fisheries. This requires that the information required for SICA or PSA analyses is available for all fisheries or jurisdictions, in comparable format, coverage and reliability. For example, problems with data availability and compatibility are complicating efforts currently under way to conduct a cumulative environmental risk assessment of fisheries that straddle Commonwealth and state jurisdictions (project underway on extension of ERA methods to assess cumulative effects of fishing on species, S Zhou, CSIRO, pers. comm. 2012).

Analytical cumulative impact assessment

The preferable way to evaluate cumulative impacts across fisheries is to generate quantitative mortality rate estimates that can then be summed across fisheries or jurisdictions to generate cumulative assessments of actual mortality rate. These can then be directly compared with

reference points. This is the approach taken in moving from Level 2 PSA assessments to quantitative Level 3 SAFE assessments for high-risk species, in which actual fishing mortality rates are estimated. SAFE or target species assessments have been conducted by AFMA for 19 of the 30 fisheries for which SICA assessments were done (See Appendix H), potentially allowing cumulative impacts to be evaluated across these fisheries.

There are additional information requirements for moving to higher level quantitative approaches, and additional costs associated with collecting such information. A substantial investment in monitoring and data is required to conduct full SAFE assessments or single species population assessments. However, some of the simple analytical approaches described in the section on 'Low-information analytical approaches to bycatch and byproduct assessment' require relatively little information and the investment in collecting this additional data may be justified where there are concerns that medium impacts across a number of individual fisheries actually represent a high cumulative risk or impact across all fisheries.

Monitoring and performance evaluation

Minimum data requirements

In principle, the information requirements for monitoring fishery impacts on target, byproduct or bycatch species are the same, irrespective of species. What differs substantially, however, is the feasibility and cost of collecting comprehensive data on different species, depending on whether they are retained or discarded. The information to meet the requirements and objectives of the HSP and Bycatch Policy therefore varies considerably between fisheries depending on the level of assessment chosen and trade-offs between the cost of obtaining information, the risk of not meeting the objectives and the desired level of catch. Dichmont et al. (2012) propose the following key questions to guide fisheries monitoring programs:

- What has been caught or impacted?
- How much has been caught or impacted?
- Where and when has it been caught?
- How has it been caught?
- Who has caught it or caused the impact?

These questions circumscribe the minimum data requirements to assess the impacts of fishing. Dichmont et al. (2012) go on to provide a summary of key data requirements under each of the main information categories in typical fisheries monitoring programs (Table 5). Specific data and/or information requirements for each analytical assessment tier are summarised in Table 4, which notes that most of these data can be collected using logbook programs or observer programs. Dichmont et al. (2012) note that a minimum standard for logbook data should include a record of all fishing operations, including where and when they occurred (at the finest spatial and temporal resolution possible), the type of fishing gear used, and a record of the amount of all species (or higher taxa, where identification is difficult) retained. An additional requirement particularly important to bycatch assessment, and which is better collected by means of at-sea observer programs or electronic monitoring, is a record of species caught by the gear but not retained, or observed to interact with the gear.

Table 5 Categories of fisheries and biological information requirements to support management decision-making

Information category	Data requirements
Fishery and operations	
Catch characteristics	Current and historical quantity and composition of catch
Fishing vessels and gear	Vessel details and gear used; gear setup and configuration; unit of effort
Fishing effort	Quantity or intensity of effort; spatial effort distribution; changes in effort over time
Biology and environment	
Stock size and structure	Biological data; catch-per-unit-effort
Community structure	Life history data; position, role, importance and interaction of species
Environmental conditions affecting recruitment and distribution	Water temperature, chlorophyll, depth, bottom structure, salinity, currents, wind, lunar cycle, season, El Niño and pacific decadal oscillation
Life history strategy, natural characteristics and biology of impacted species	Age, size, sex, maturity, behaviour and fecundity
Ecosystem impact	Protected species interactions; abundance of key indicator species and species interactions; fishing methods; habitat structure

Source: Adapted from Dichmont et al. (2012)

Monitoring to support ecological risk management

As noted by Dichmont et al. (2012), ERM is concerned with managing the broader ecological impacts of fishing beyond the target species managed under HSP harvest strategies. Depending on the scale and nature of the fishery, ERM programs need to deal with managing impacts on bycatch species, protected species, benthic habitats and ecological communities, including the trophic impacts of removing target species. For most fisheries, ERMs are less well defined than harvest strategies and the monitoring needs are often case-specific and harder to generalise. For a particular fishery, the issues dealt with in ERM programs generally arise from the results of ERAs, or from requirements under provisions of the EPBC Act, including strategic assessments, identification of key threatening processes, and listing of threatened species.

Dichmont et al. (2012) note that monitoring requirements to support ERM generally start at the data-poor end of the spectrum. Even the most basic information requirement, determining the level of interaction of the fishery with the bycatch species, may be difficult. Assessing the impact of the fishery on the bycatch species of interest is even more difficult. Where risks are evaluated as being high, and where information to quantify impacts is required, increased monitoring requirements may be quite intensive, at least initially. This may depend on the management measures adopted to mitigate the identified risks, but additional monitoring will generally be required to at least determine that the risk mitigation strategies are working as intended.

The shortage of data required for more quantitative risk assessments or analytical approaches to bycatch monitoring and management is the key factor limiting the monitoring of performance and evaluation of the effectiveness of bycatch mitigation and management measures in Commonwealth fisheries. In a scoping study to evaluate the ability to assess the cumulative capture of non-target species in multiple Commonwealth fisheries, Phillips et al. (2010) concluded that:

> *'Owing to very low levels of observer coverage in some fisheries, the extrapolation of catches from observer data up to the fishery scale was highly uncertain. A more informative cumulative assessment, which could better direct how bycatch policy and legislation should be applied more strategically in the interests of governments, fishers and the general community, may not be possible until observer coverage across fisheries is increased or logbook reporting of wildlife bycatch becomes more reliable.'*

High levels of observer coverage or electronic monitoring form an essential component of Canadian approaches to bycatch assessment. Fisheries and Oceans Canada (2012) noted that it is highly desirable to have direct estimates of bycatch obtained from complete monitoring programs that reliably monitor the fishery. There are various factors that may limit the availability of complete monitoring and the planning and allocation of monitoring resources should consider the risks of fisheries causing serious harm to bycatch species. At an early stage in the assessment process, particularly if data-poor species appear to be approaching critical or concerning levels, data should be gathered to allow the application of analytical approaches. For example, gathering of a limited quantity of age-composition data, such as ageing 100 individuals from the bycatch, may provide sufficient information to support improved estimates (DFO 2012).

Bycatch monitoring programs

The summary of data and information requirements for the various analytical assessment tiers applied to Commonwealth fisheries (Table 4) recognises that much of the required data can be collected using observer programs. At-sea observer programs are particularly effective for collecting data on interactions with, and mortality of, bycatch species that are not retained on board, and for which there may well be strong incentives to not report their capture in logbooks. In recognition of the importance of effective monitoring to support reliable bycatch estimation and performance reporting, Fisheries and Oceans Canada (2012) emphasise the importance of adequate and representative observer coverage as a key part of bycatch monitoring programs for monitoring and assessment of bycatch and discards in Canadian commercial fisheries (Box 2).

Box 2 Advice on bycatch monitoring programs and bycatch estimation

At-sea observation programs

Independent at-sea observation programs that include 100% coverage of a fishery provide a direct census of bycatch and represent an ideal monitoring approach. The main constraints on 100% at-sea coverage are the increased costs to industry and the feasibility of implementing this level of coverage on small operators. The main constraints on mandatory retention are enforceability, the cost to industry to retaining low value catch, and the conservation impacts of retaining organisms if they would have survived if returned to the water.

Many monitoring programs fall short of the ideal of complete coverage and therefore must be carefully designed to provide maximum value. The time, funding, and availability of monitoring may be limited and usually must meet several objectives, thus the allocation of resources for monitoring should take full account of assessments of the risks of causing serious harm to the bycatch species.

Estimation of bycatch

It is highly desirable to have direct estimates of bycatch obtained from monitoring programs. To be useful, monitoring programs for bycatch need to provide data that reliably reflect conditions in the fishery or the nature and magnitude of biases in the data need to be understood. Monitoring programs could include independent at-sea observation (fishery observers or video monitoring), fish harvester logbooks, surveillance by conservation officers, vessel monitoring systems, sighting/stranding networks, and dockside monitoring. There is a continuum in accuracy and precision of bycatch estimates across monitoring methods. Well-structured government or third-party at-sea observation programs with partial coverage are generally regarded as proving the most reliable estimates of bycatch, while data from non-validated logbook programs are generally regarded as being much less reliable. Where monitoring coverage is only partial, ancillary information (e.g. target species catch, fishing effort) may be required to scale up monitoring observations to the level of the fishery, underscoring the need for maintaining high quality fishery statistics.

A low level of monitoring may not properly characterise the scale and pattern of the impacts, and precision of estimates will generally be low if the bycatch of particular species has been observed to be clustered in space and time and may not be evenly distributed throughout a fishery. In addition, if the results of the monitoring program are to be extrapolated to the full fishery, the design and implementation of the monitoring program must be appropriate and include representative sampling of the fishery. The potential for an 'observer effect' (i.e. fish harvesters operating differently in the presence of onboard monitoring) should be considered when planning monitoring programs and when using the information from them. The validity of assumptions underlying a monitoring program should also be regularly assessed.

In addition to having representative samples from the fishery, reported incidentally-captured species need to have been properly identified. Therefore, adequate training of the people reporting bycatch and/or effective procedures to validate species identification should be in place. Where accurate species identification is not possible or is questionable in retrospect, habitat models could be used to estimate the species composition of bycatch where these models have been developed and validated.

There may be cases where there is good reason to believe that a species is both available (i.e. present in the area) and vulnerable to a fishing gear, yet no records appear in the bycatch data; such situations should be priorities for further investigation.

Source: DFO (2012)

Benefits

This project was intended to inform the review and revision of the Commonwealth Policy on Fisheries Bycatch. The benefits were therefore primarily intended to accrue to Commonwealth fisheries and to those participating in, monitoring, assessing or managing those fisheries. However, the technical information on alternative assessment approaches for bycatch species, the tiered approach to bycatch assessment and management, reference points, performance measures and cumulative impact assessments are applicable to bycatch and byproduct species in all fisheries. Some level of direct and ongoing benefit is therefore foreseen for State and Territory fisheries. The extent to which this occurs will depend on the degree to which these other jurisdictions take up the objectives and principles of a revised Commonwealth Policy on Fisheries Bycatch within their own fisheries management arrangements.

This report provided substantial input into all phases of the Bycatch Policy review process. Sections of the report contributed to the *Issues Paper* developed as part of the public consultation process. Earlier drafts of the report were provided to meetings of the project Steering Committee and Advisory Committee, informing the identification and discussion of key issues for the consideration of the policy review. Earlier drafts of this report were provided to the two stakeholder workshops to inform stakeholder discussion of alternative approaches to bycatch assessment and the risk-catch-cost trade-off in selecting appropriate assessment methods and management approaches for each species. The outcomes of those stakeholder workshops in turn informed the drafting of this report.

Representatives of DAFF, DSEWPaC, AFMA, conservation NGOs, commercial and recreational fishing associations participated in the stakeholder workshops and/or Advisory Committee meetings, resulting in early and wide dissemination of the information summarised in this report. Feedback from those representatives resulted in revision and improvement of the report to ensure that relevant interests and concerns of these various jurisdictions were addressed were addressed in the report.

The proposal for a tiered approach to assessment and management of bycatch and byproduct species, with emphasis on development of low information approaches, has been incorporated into the bycatch policy review report. In combination with the proposed definitions of bycatch and byproduct species, this tiered approach was used to develop a table showing the proposed species categories in the bycatch (protected species, bycatch species) and harvest strategy (key commercial species, secondary commercial species, minor byproduct species) policies, summarising the appropriate assessment methods (tiers), information requirements, management approaches and transition mechanisms for species in each category. This species categorisation table will help to guide the drafting of the revised policies themselves.

Further Development

This project proposes the application of a tiered approach to the assessment and management of bycatch and byproduct species, depending on information availability and the trade-off between risk, management priorities, and the cost of moving to alternative assessment methods and management approaches.

A range of assessment methods applicable to each tier, and their respective information requirements, are well developed and understood. However, less progress has been made on the development of tested and effective management approaches for bycatch and by-product, especially at the lower information tiers. Additional work is required to develop and test a range of harvest and other management strategies and decision rules could have a high probability of achieving management objectives, in particular at the lowest information tiers. This additional work should directly address the development of measurable and reliable reference points for the lowest information tiers, to enable meaningful performance reporting across the full range of assessment and management tiers.

The development and adoption of a revised bycatch policy (particularly if this results in inclusion of a wider range of species under any revised definition of bycatch), together with adoption of a tiered approach to the assessment and management of bycatch species, will require initial work to identify bycatch species or species groups resorting under the revised policy, and the most appropriate assessment tier for each species. An approach is required to develop a process for reviewing fisheries species and applying a range of assessment methods such as qualitative and quantitative risk assessments, analytical approaches and complex quantitative population assessments.

This would then be followed by a detailed process to develop a tiered range of management approaches which could range from simple, precautionary catch triggers, through to the establishment of reference points and performance measures, to operational management procedures and decisions rules designed to achieve specified objectives. This will require consideration of data and information availability, assessment methods, available information on risk and management priorities for each species / group. This analysis will be required to inform allocation of bycatch species to appropriate assessment tiers, or to prioritise additional monitoring to allow species to be managed at higher information tiers. This work should also include cumulative effects across and within fisheries.

Work will then be required to draft implementation guidelines for a revised bycatch policy, similar to the guidelines to the Commonwealth Harvest Strategy Policy. These should provide clarification of the key principles of the Bycatch Policy and how these might be addressed during implementation, as well as technical guidance on the application of assessment methods and development of appropriate reference points, performance measures and strategies at the various tiers.

In addition, further work is required for the development of a performance evaluation framework to enable the review and evaluation of future bycatch management and the effectiveness of a revised bycatch policy. This would form the basis of a performance evaluation framework, of which would evaluate progress on developing and implementing management plans and mitigation measures designed to achieve bycatch management objectives and evaluate performance of these measures in achieving those objectives, and minimising bycatch risk, interaction rates and mortality.

Planned outcomes

This report provides a review of recent developments in methodology and implementation of risk-based and low-information analytical approaches to assessment of bycatch and byproduct species. A tiered approach to application of the range of available risk-based and analytical assessment approaches is developed, with the most appropriate assessment tier being dependent on the availability of information and the trade-off between levels or risk, management priorities and costs for application of alternative assessment methods and management approaches.

Methods are reviewed and examples provided of appropriate low-information reference points and performance measures for bycatch and byproduct interaction rates or mortalities. The use of these performance measures to facilitate and improve regular reporting of trends in bycatch interactions rates, and thereby to improve the monitoring of effectiveness of bycatch mitigation and management measures, is discussed. Requirements, costs and options for evaluating cumulative impacts across multiple fisheries are addressed. This report therefore directly contributes to achievement of the planned project outcomes:

- Improved understanding of mechanisms in implementing bycatch management in Commonwealth fisheries, reducing regulatory burden and complexity associated with meeting the current range of domestic policy and legislative requirements;
- Development of predefined and transparent species- and fishery-specific reference points and decision rules potentially minimising competing advice; and
- Improved mechanisms and methods for determining the success of bycatch measures employed in fisheries.

Conclusion

This report contributes technical information in support of the 2012–13 review of the Commonwealth Policy on Fisheries Bycatch (2000). The review of the Bycatch Policy was conducted by the Department of Agriculture, Fisheries and Forestry (DAFF) between 28 March 2012 and 28 March 2013. A draft of this report provided input to an issues paper released as part of public consultation for the Bycatch Policy review. Drafts of this report were also provided to participants in the project Steering Committee, Advisory Committee and stakeholder workshops, to inform discussion by these groups of key issues pertinent to the Bycatch Policy review. Outcomes from these various meetings, particularly from the two stakeholder workshops (reports of which are appended to this report), in turn informed the drafting of this report, to ensure that relevant technical advice was provided to inform proposals to address the key issues identified by those meetings. The resulting report provides the following outcomes against each of the project objectives:

1. *Assess the robustness and applicability of risk-based approaches to bycatch management for species or groups of species, taking into account their biological status, data availability and other factors.*

4. *Assess the robustness and application of risk-based approaches to byproduct management for species or groups of species, taking into account their biological status, data availability and other factors.*

Based on a review of the application of risk assessment and risk management approaches to Australian fisheries and internationally, the report confirms that risk-based assessment and management approaches are applicable and appropriate for both bycatch and byproduct species. Risk assessments have been conducted for all Commonwealth fisheries, and have been used to identify species at risk from the effects of fishing, and which may require higher levels of analytical assessment. Tiered analytical assessment approaches developed in Australia and internationally are reviewed. An integrated tiered approach is described that extends from low-information risk assessment through moderate information quantitative risk assessment or analytical assessment to high-information population assessment. A framework is proposed whereby this tiered approach to assessment and management can be applied across all categories of species under both the Bycatch Policy and Harvest Strategy Policy, from bycatch species, to minor byproduct species, to secondary and key commercial species. The appropriate assessment and management tier for each species is dependent on information availability, and selection of which tier to apply to each species is driven by a risk-cost-catch trade-off.

2. *Evaluate the efficacy and appropriateness of reference points and structured decision rules in meeting the legislative and policy objectives for some bycatch species and/or groups.*

Depending on the amount of information available, reference points, performance measures and decision rules can be applied to bycatch species, in an approach similar to the harvest strategies applied to key commercial species. An explanation is provided of how these might be applied to bycatch species assessment and management, and examples provided of such approaches.

3. *Initially assess approaches to incorporating and addressing the potential cumulative impacts of fisheries' interactions with bycatch.*

Low-information risk assessments conducted for individual fisheries do not lend themselves to subsequent evaluation of cumulative risk across fisheries. Options for how cumulative impacts might be assessed are described. These depend on information availability and priorities and include re-doing low-information risk assessments using quantitative risk assessments or undertaking analytical assessment that can be aggregated to evaluate cumulative risk.

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Appendix A: Acronyms and abbreviations

ABARES	Australian Bureau of Agricultural Resource Economics and Sciences
AFMA	Australian Fisheries Management Authority
B	stock biomass
B_0	unfished stock biomass
B_{LIM}	minimum stock biomass limit reference point, below which reproduction is likely to be impaired and the stock is considered to be overfished
B_{MEY}	stock biomass producing maximum economic yield
B_{MSY}	stock biomass producing maximum sustainable yield
CBD	United Nations Convention on Biodiversity
CFP	Common Fisheries Policy of the European Union
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CPUE	catch-per-unit-effort
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAFF	Department of Agriculture, Fisheries and Forestry
EPBC Act	Environment Protection Biodiversity Conservation Act
ERA	ecological risk assessment
ERM	ecological risk management
ESD	ecologically sustainable development
EU	European Union
F	fishing mortality rate
F_{LIM}	Fishing mortality rate limit reference point
F_{MSY}	fishing mortality rate providing maximum sustainable yield
FAO	Food and Agriculture Organization of the United Nations
FM Act	Australian Fisheries Management Act
FRDC	Fisheries Research and Development Corporation
HSP	Commonwealth Fisheries Harvest Strategy Policy
IUCN	International Union for the Conservation of Nature
M	natural mortality rate
MEY	maximum economic yield
MSE	management strategy evaluation
MSY	maximum sustainable yield
NMFS	National Marine Fisheries Service
NPOA	National Plan of Action
PBR	potential biological removal
PSA	Productivity–Sustainability analysis
RFMO	Regional Fisheries Management Organisations
SAFE	sustainability assessment for fishing effects
SESSF	Southern and Eastern Scalefish and Shark Fishery
SICA	Scale–Intensity–Consequence analysis
TAC	total allowable catch
TAP	threat abatement plan
UNCLOS	United Nations Convention on the Law of the Sea
UNFSA	United Nations Fish Stocks Agreement

Appendix B: 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 C: Staff

Table C1 Staff supported by the project

Name	Organisation
David Kirby	Australian Bureau of Agricultural Resource Economics and Sciences
Andrew Penney	ABARES
Katherine Cheshire	ABARES
Michelle Wilson	Department of Agriculture, Fisheries and Forestry

Table C2 List of attendees at either of the Department of Agriculture, Fisheries and Forestry Stakeholder Bycatch Workshops—21 June 2012 and 4 February 2013

Name	Sector
Mr Sandy Morison	Facilitator (Chair)
Mr Anthony de Fries	Rapporteur
Ms Trixi Madon	Commonwealth Fisheries Association (CFA)
Mr Simon Boag	CFA, South East Trawl Fishing Industry Association (SETFIA)
Mr Brian Jeffriess	CFA, Australian Southern Bluefin Tuna Industry Association (ASBTIA)
Mr Jeff Moore	CFA, Great Australian Bight Industry Association (GABIA)
Mr Stuart Richey	Richey Fishing Company
Mr Craig Ingram	Amateur Fishermen's' Association of the Northern Territory
Mr Crispian Ashby	Fisheries Research and Development Corporation (FRDC)
Dr David Smith	Commonwealth Scientific and Industrial Research Organisation (CSIRO)
Mr Glenn Sant	TRAFFIC (wildlife trade monitoring network)
Ms Alexia Wellbelove	Humane Society International
Ms Lowri Pryce	Oceanwatch
Ms Shalan Bray	Department of Agriculture, Fisheries and Forestry (DAFF)
Mr Stuart Curran	DAFF
Mr Tim Karlov	DAFF
Mr Gordon Neil	DAFF
Ms Shalan Bray	DAFF
Mr Ian Thompson	DAFF
Ms Danielle Wills	DAFF
Ms Mandy Goodspeed	DAFF
Ms Mariana Nahas	DAFF
Ms Michelle Wilson	DAFF
Ms Cadie Artuso	DAFF
Dr David Kirby	Australian Bureau of Agricultural Resource Economics and Sciences
Dr Ilona Stobutzki	ABARES
Mr Simon Vieira	ABARES

Dr Peter Ward	ABARES
Mr Andrew Penney	ABARES
Mr Robert Kancans	ABARES
Ms Beth Gibson	Australian Fisheries Management Authority (AFMA)
Dr Nick Rayns	AFMA
Mr Patrick Sachs	AFMA / DAFF
Mr Paul Ryan	AFMA
Mr Nathan Hanna	Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC)
Mr Geoff Richardson	DSEWPaC
Ms Barbara Ross	DSEWPaC
Mr Peter Peterson	DSEWPaC
Mr Nigel Routh	DSEWPaC
Dr Neil Klaer	Commonwealth Scientific and Industrial Research Organisation (CSIRO)
Dr David Smith	CSIRO
Dr Cathy Dichmont	CSIRO

Appendix D: First stakeholder workshop report

Report of the First Bycatch Stakeholder Workshop—Review of the Commonwealth Policy on Fisheries Bycatch—Rydges Hotel Lakeside—Canberra 21 June 2012

Introduction

The Fisheries branch of the Department of Agriculture, Fisheries and Forestry (DAFF) convened a one-day stakeholder workshop to facilitate stakeholder engagement and inform an issues paper to be prepared as part of the review of the *Commonwealth Policy on Fisheries Bycatch* (the Bycatch Policy).

The intent of the workshop was to raise and discuss issues to be addressed through the policy review process and not to necessarily obtain agreement on any issue among stakeholders. There was general agreement on a number of issues at the workshop and this report aimed to capture such agreement when this was evident. Nevertheless, this report does not aim to fully represent all stakeholders' views that were either put forward at the workshop or that may be developed or conveyed during later stages of the policy review process, but rather to capture a summary of the main issues discussed.

The workshop was attended by representatives from the fishing industry, environmental nongovernment organisations, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the Fisheries Research and Development Corporation (FRDC), the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC), the Australian Bureau of Agricultural Resource Economics and Sciences (ABARES), the Australian Fisheries Management Authority (AFMA) and the Australian Government Department of Agriculture, Fisheries and Forestry (DAFF).

Mr Sandy Morison (independent consultant) chaired the meeting. The Chair observed that key stakeholders were well represented with the exception of the recreational fishing sector and noted advice that DAFF had received apologies from two recreational fishing invitees.

Overarching principles and approaches broadly discussed during workshop

- That DAFF harmonise the Bycatch Policy with the Commonwealth Fisheries Harvest Strategy Policy and Guidelines (HSP) where possible.
- That there should be no gaps between the revised policies and that the policies should address the transition of species between them.
- Provisional support for reviewing definitions for catch components to provide consistency across the policies, noting that the revised definitions will need 'testing' later in the context of revising both policies.
- That the Bycatch Policy reviews and seeks to confirm whether risk-based approaches such as the ecological risk assessment (ERA) process are preferred for identifying bycatch management priorities.
- That the Bycatch Policy be updated to reflect current obligations under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)[2,] and international fisheries and conservation conventions.
- That the revised Bycatch Policy acknowledges reductions in bycatch across Commonwealth fisheries since the initial policy was implemented (where appropriate).
- That a process be established for bycatch species that are also listed under the EPBC Act to facilitate a more consistent and transparent transition to successful mitigation outcomes.

[2] The EPBC Act is being reviewed and obligations under the revised Act may differ from those under the current Act.

Workshop outline

The workshop was broken into five main sessions that covered

1. Stakeholder identification of issues
2. What is fisheries bycatch?
3. Review of Bycatch Policy's objectives and principles
4. Approaches to bycatch management and recent technical reviews
5. Risk-based approaches to bycatch management.

Within each session there was a mix of brief presentations followed by discussion in groups and concluding with a brief reporting back from each group.

An initial list of issues was presented to the workshop which included issues that had been previously identified during a meeting of the Bycatch Policy's Advisory Committee; two background papers provided by environmental nongovernment organisations (including Humane Society International, TRAFFIC, World Wildlife Fund and the Australian Marine Conservation Society) and from discussions with some invited participants. Background papers were also provided for sessions 2 to 5.

Unsurprisingly, given the inter-related nature of the topics, issues were raised in some sessions which were also relevant to topics of other sessions. The report below has attempted to collate these issues regardless of the session in which they were raised. A summary of the issues raised during the workshop's breakout sessions is provided in point form in Attachment 2.

SESSION 1 allowed a representative of each of the main groups represented to provide an overview of what they saw as the main issues concerning bycatch that they thought should be addressed through the review of the Bycatch Policy. Any new issues were added to the initial list of issues as they were raised. At the end of this session all workshop participants were then invited to identify their most important issues or general areas of interest by placing three priority markers on the lists of issues. This process indicated the preliminary list of issues was relatively comprehensive and all the proposed workshop sessions covered issues of importance to stakeholders. The process also identified that environmental offsets were an issue of interest to the group and time was therefore allocated during the day to allow those who were interested to explore this issue. A representative from DSEWPaC agreed to provide this group with some background to how offsets were used in a terrestrial setting. A list of issues identified and the priorities assigned to them is attached using the headings under which they were presented to the workshop (Attachment 3).

SESSION 2 began with a brief introductory presentation by ABARES on potential principles and definitions for the revised Bycatch Policy. This included a proposal for a basic distinction between commercial species (species that are caught and kept by commercial fishers) and non-commercial species (those that are not kept by commercial fishers) with bycatch a subcomponent of this category (species taken incidentally in a fishery, and which are always discarded). Commercial species was proposed as a collective term to cover key commercial species (a term used in the HSP), rebuilding stocks and byproduct species.

The workshop appreciated work by DAFF and ABARES in reviewing the definitions for categories of catch affected by fishing operations, including how these might be simplified to suit contemporary settings. Participants observed that it was more about categorising operator behaviour, which applied across the continuum from commercial species, which were almost always retained to bycatch species, which were always discarded. The workshop recognised that industry and managers were cautious about this given that management obligations and workload might change depending on which policy a species or species group fell under and noting that species may move between categories over time. Participants at the workshop, however, generally accepted that standardisation and possible rationalisation of definitions would be an important step in establishing consistency across the Bycatch Policy and the HSP. Some participants indicated provisional support for the proposed terminology but recognised

that the revised definitions would need to be 'tested' with real examples and against the proposed management responses of both draft policies particularly with respect to cost effective management.

Environmental nongovernment representatives, however, reiterated the views they had expressed in their background paper that the Policy be renamed as the Commonwealth Discard Management Policy, that catch should be characterised as either 'retained' (whether it be always or sometimes) or 'discarded', that this terminology, rather than target, byproduct and bycatch, should be used to delineate the respective responsibilities of the HSP and Bycatch Policy, and that all retained species be subject to the policy settings of the revised HSP and that management of discards of all components of the catch be guided by the revised Bycatch Policy.

It was also noted that the proposed definitions did not explicitly deal with catches by the recreational sector other than to say that management (whether of commercial species or bycatch) must consider all sources of fishing mortality and that this may include recreational catches. Several workshop participants considered that recreational fish species required explicit recognition in the review of the Bycatch Policy. State and territory governments are generally responsible for the day-to-day management of recreational fisheries, nevertheless, the Australian Government is responsible for managing several species that recreational anglers catch (i.e. retain or release). These include species that might be considered bycatch in commercial fisheries (e.g. sailfish) or species that commercial fishers are not permitted to keep (e.g. black marlin) and shared species, like striped marlin, which are sought by recreational anglers and are also retained by commercial fishers.

The background report suggested the term 'threatened or otherwise protected species' as an alternative to the previously used 'threatened, endangered and protected species'. It was then suggested that the term 'protected species' would be sufficient to cover both 'threatened' and 'endangered' species as these were types of protected species.

SESSION 3 considered the context for the Bycatch Policy including potential general principles. These discussions were aided by a background paper that outlined the range of domestic and international instruments and contexts that are relevant to the proposed revised policy.

It was suggested that it would be valuable to aim for a level of consistency among the obligations and actions required for species listed under the EPBC Act and those required by the revised versions of the HSP and Bycatch Policy. A number of participants cautioned that measuring performance against bycatch management actions would often be characterised by uncertainty given our limited understanding of the biology of bycatch species, time-series data limitations and assessment capacity (resourcing).

It was suggested that the Bycatch Policy would also need to be updated to reflect the Australian Government's obligations**,** both under domestic legislation and international fisheries and conservation conventions. The workshop considered that a more contemporary policy would strengthen the Australian Government's input to the Food and Agriculture Organisation Committee on Fisheries and to regional fisheries management organisations (RFMOs). Participants suggested that the Bycatch Policy should also try and anticipate any domestic implications of changes in the status of species arising from decisions made in accordance with international conventions to which Australia is a signatory i.e. Bonn (migratory species) Convention, and RFMOs.

A number of stakeholders encouraged DAFF to place a greater emphasis on outcomes in the revised Bycatch Policy. The workshop was generally comfortable with a focus on outcomes (and performance criteria); however, this prompted consideration of whether the revised Bycatch Policy's objectives needed to be clarified. Participants suggested resolving the following would help define the revised policy:

- Was the reduction in the amount of bycatch the main objective?; or
- Was the aim to reduce bycatch rates? (noting fishing effort and hence total bycatch may vary over time); or

- Was the aim to reduce the risk to bycatch species to acceptable levels? (i.e. low risk in an ERA).

It was suggested that the management responses required by a revised Bycatch Policy should be consistent with any revised HSP approach to data-poor byproduct species.

It was noted that maximising net economic returns to the community was a legislative objective and part of the HSP and this objective could also be recognised in the Bycatch Policy. It was suggested that, particularly in the case of multispecies fisheries, any overriding objective for bycatch reduction could be contrary to the net economic returns.

There was concern expressed that the Bycatch Policy shouldn't be just about reduction as we were now in a situation where marine reserves could be implemented and these and other policy and management advances need to be taken into account when assessing risk to bycatch species.

The workshop noted mixed support for maintaining an emphasis on reducing what was characterised as waste by the better utilisation and market development for bycatch species. Some participants, however, considered that avoiding, minimising and managing bycatch should be the primary objectives of the Bycatch Policy. Others were comfortable with better utilisation within sustainable parameters supported by risk assessments.

The workshop recognised, however, that the social perception of waste, particularly of iconic species, had the potential to compromise the handling of these matters if adverse publicity or lobbying ensued. The workshop noted that having a robust evidence base would assist in informing public debate on such matters.

Industry participants expressed concern that the revised Bycatch Policy had the potential to increase imposts for domestic operations while having no influence on market access or product labelling requirements for imported product from countries with lower environmental standards. The workshop noted that trade issues were a matter for the Department of Foreign Affairs and Trade but acknowledged industry concern about processes that could create 'higher hurdles' for local industry but that could only be promulgated internationally through Australia's advocacy in RFMOs.

SESSION 4 was introduced by a background paper that provided a brief overview of some recent technical reviews of fisheries bycatch. The session focused on issues around management approaches to dealing with bycatch and whether a management strategy approach would be appropriate for bycatch.

SESSION 5 examined the use of risk-based approaches to bycatch management.

Issues raised in these sessions are presented together because of the extensive overlap between them.

The workshop noted that DAFF was also reviewing the HSP and there was support for the harmonisation of these policies where possible. It was suggested that it was important that policy principles, high level statements of intent, should be consistent across both the HSP and Bycatch Policy. Some participants supported maintaining separate policies and indicated that it was important to maintain a clear policy spotlight on bycatch reduction. Participants noted that a level of consistency at the national level would also assist with the development and periodic review of national plans of action that applied to all jurisdictions.

There were strong views expressed that both reviews need to ensure there were no gaps between the revised policies and that both policies provide explicit advice on the transition of species between them. It was recognised that there were significant scientific and economic reasons for not elevating the management of bycatch to standards set out in the HSP given it relied on stock assessment models and empirical assessments. It was also suggested, however, that there was scope for improvement and noted that recent reviews of bycatch management had identified the need for management actions to be referenced against quantitative or qualitative reference points. A number of participants, while supportive of better specification in

the Bycatch Policy cautioned against creating a situation where we could not deliver against policy commitments.

The workshop, noting some support for integration of the policies, acknowledged scientific advice that full alignment may not be possible in a technical sense. A quantitative framework (some form of stock assessment) was needed to operate in accordance with HSP whereas more qualitative processes were often used to inform management actions under the Bycatch Policy. Although it is not a formal part of the current Bycatch Policy, CSIRO and AFMA have developed an ERA process that is an evaluation of risk to a wide range of ecological components, including bycatch. The workshop acknowledged that biological reference points had been formally adopted for some bycatch species (gulper sharks) and that it was possible that high-risk bycatch species could form a basis for policy convergence/similar approaches between policies. The workshop recognised that gulper sharks were a complex example that had been driven largely by the nomination of two species for listing under the protected species provisions of the EPBC Act. The workshop also considered that a stand-alone Bycatch Policy may assist more cohesive engagement with state fisheries on bycatch issues which involved both jurisdictions by keeping bycatch elements separate from target species approaches.

The workshop noted that there was broad support for the ERAs[3] both in the international scientific community, across some Commonwealth agencies and amongst domestic stakeholders. Participants observed the initial Bycatch Policy had driven improvements in approaches to addressing bycatch problems and considered the revised policy would be strengthened by anchoring it to a science based approach. The workshop also recognised that risk assessments are usually qualitative and that the outcomes of management responses for species assessed at higher risk may need to be reconciled against quantitative approaches/data (biological reference points, reduction in bycatch amount and/or rates). The workshop acknowledged that the extension of ERAs through residual risk and Sustainability Assessment for Fishing Effects (SAFE) assessments had helped further refine risk profiles for higher risk species through a more detailed examination of risk against fisheries' footprints and relevant management safeguards.

The workshop while comfortable with ERA approach noted that these were qualitative snapshots and as such were not linked closely to the level of fishing effort in the relevant sector. The workshop noted that the policy may wish to provide guidance on criteria for their review (time period, changes in the scale of the fishery etc.).

Some participants at the workshop expected a revised Bycatch Policy could formalise the role of ERAs with respect to identifying and prioritising bycatch management responses and in this context noted a suggestion that the objectives could be aligned with risk status; that is, if a species is assessed as low risk then there should not be an obligation (or priority) to keep reducing catches. A number of participants considered that the obligation to pursue reductions in bycatch should continue to apply broadly but with effort and resources directed at higher risk species. Such actions should only be pursued to the extent that they are consistent with both the *Fisheries Management Act 1991* and the EPBC Act.

The workshop understood that CSIRO had recently extended the ERA process to habitats and communities in line with an increased international focus and trend toward ecosystem-based fisheries management. DAFF advised that while they were supportive of this work in terms of moving to ecosystem-based fisheries management, the department's intention was to confine the Bycatch Policy to species that were directly impacted by capture or contact with fishing gears.

It was noted that, since the inaugural Bycatch Policy was implemented, there had been a number of reforms and changes which had, for most fisheries, led to a significant reduction in bycatch. It was suggested that there had been a number of drivers behind this including the Bycatch Policy

[3] ERAs—includes the suite of ecological risk assessments, residual risk assessments and SAFE assessments

and bycatch action plans (BAPs) (listed in Attachment 2). It was suggested that the revised Bycatch Policy acknowledge this progress.

The workshop recognised that there had been significant improvements in the way Commonwealth fisheries were managed (including with regard to bycatch) since the current Bycatch Policy was launched in 2000.

The workshop observed that recent improvements in bycatch reduction had generally been achieved incrementally (improved monitoring, analysis, research, consultation and implementation of measures). Participants also recognised that for a number of bycatch situations, particularly in multispecies fisheries, achieving further reductions would require a ramping up of fisheries management effort and resources but may not produce proportional improvements because of the 'law of diminishing returns'.

The workshop noted that if the Bycatch Policy was to be more outcome focused then its objectives and performance criteria would need to be specified appropriately. A number of participants noted that the *Guidelines* to the Commonwealth Harvest Strategy had provided a valuable link between higher order policy and fishery settings and suggested a similar approach might help operationalise the revised Bycatch Policy.

In this context the workshop recognised calls for supporting the review with an analysis of trends in the volume and catch rates for bycatch species since the implementation of the current Policy. The workshop was broadly supportive of this in principle however noted differing views about such an exercise:

- That establishing robust trends for some fisheries or sectors, or some species categories (e.g. protected species) may be difficult based on data limitations, variations in fishing practices or gear, and changes in observer coverage and recording protocols.
- That there were substantial observer and survey datasets for a number of Commonwealth fisheries which contained reliable information on catch composition over much of this period.

A number of participants expressed support for a reference pointing analysis and considered it would help establish a basis and framework for measuring future progress on bycatch management.

The workshop noted that the initial policy required all Commonwealth fisheries to have an approved BAP and that AFMA had since expanded their scope to one of 'bycatch and discarding work plans'. The workshop noted that over this period that the BAPs had been supported with AFMA giving effect to a number of key bycatch related management measures in statutory instruments. The workshop noted a range of views on whether the revised Bycatch Policy should continue to mandate bycatch and discarding work plans. Industry participants noted that some fisheries with low bycatch levels really did not need bycatch and discarding work plans that is, the scallop fishery and Squid Jig sector. Other participants emphasised that it was important (for most fisheries) to have a tangible vehicle to get traction on bycatch issues.

There was general support for the use of risk-based approaches such as ERAs to underpin the Bycatch Policy and for identifying priorities at the fishery level. Industry participants also noted that for the Bycatch Policy and HSP, specific measures adopted in the individual fisheries and in particular the anticipated implementation of marine reserves could further reduce risks to many bycatch species and to the broader ecosystem, and that it was important that policy settings and management were recalibrated against the current reality.

The workshop identified a number of circumstances where social factors could override the risk-based framework normally relied upon to prioritise fishery-specific responses to their obligations under the Bycatch Policy.

Other issues raised

Protected species

The workshop noted advice from DSEWPaC that the EPBC Act requires fishers to take all reasonable steps to avoid the killing or injuring of protected species, and for a fishery as a whole to not affect the conservation status of a protected species. The workshop recognised that the EPBC Act did have the capacity to allow fishing operations to continue provided an effective mitigation/management strategy was approved by the Minster for the Environment as part of a decision to maintain the listing of a species as conservation dependent. Some participants at the workshop noted that the intent of the legislation was that impacts on protected species be avoided and minimised but suggested that, in the case of Australian sea lions, complexities associated with discrete sub-populations had now effectively changed the approach from one of continued bycatch reduction to one that was effectively based on an estimate of the maximum potential biological removal. The workshop noted that when issues became this acute the 'combined uncertainty' associated with estimating fishing impacts on a protected species population (whose population status may be also be uncertain) tended to drive highly precautionary management responses. The AFMA fishery managers added that this made it difficult to maintain industry access in these sort of situations and therefore harder to manage a transition to a future with much lower impacts.

The workshop encouraged DAFF and DSEWPaC, through the policy, to commit to the development of a 'whole of government position' on a risk-based approach for protected species in order to provide a more transparent framework for improving statutory management arrangements in order to reduce mortalities to an acceptable minimal level.

The workshop also noted that public reaction in response to mortalities of some protected species also had the capacity to overwhelm policy and legislative responses.

Research and allied initiatives

The workshop noted advice that there was an emerging area of scientific investigation examining whether ecological impacts from highly selective fishing methods were in fact, as has previously been believed, lower than those methods which tended to take a slice of species across trophic levels (being termed a 'balanced harvest' approach[4]). It was suggested that the current Bycatch Policy was premised on the paradigm that a selective harvest approach was preferable and that any reduction in bycatch was a positive environmental outcome. Developments in this area may have an important bearing on policy in the future but accepted that the broader scientific and social acceptability of this approach, necessary for its use as a base for new policy, would not be achieved in the short term. Participants noted that DAFF may want to consult more closely with relevant scientists with respect to when there might be some resolution and if this might coincide with next review period for the Bycatch Policy.

Use of environmental offsets

The workshop welcomed advice from DSEWPaC officers on the Department's consideration of environmental offsets[5] (for terrestrial settings). Participants noted that the potential for such approaches had been canvassed (there are published papers on the approach) in relation to fishery interactions with seabirds. Participants were interested in the potential for such offsets to recognise the variety of ways that risks to bycatch may be mitigated. The workshop also noted that in some circumstances further investment/regulation in mitigation could threaten industry viability whereas similar amounts spend on other activities (for example on eradicating feral pests from seabird rookeries) could deliver better conservation outcomes. Although the issue of environmental offsets may fall outside the remit of the Bycatch Policy it was suggested that the

[4] Garcia, SM et al. 2012, 'Reconsidering the consequences of selective fisheries', *Science* vol. 335, pp. 1045–1047.

[5] The Australian Government defines environmental offsets as 'actions taken outside a development site that compensate for the impacts of that development—including direct, indirect or consequential impacts'.

policy might incorporate some flexibility to recognise such arrangements if they were implemented under other mechanisms or through the marine bioregional planning process.

Other principles and approaches to be further discussed

Objectives—clarifying the overarching objective of the Policy on Fisheries Bycatch; is it to:

- reduce the amount of bycatch
- reduce the catch rate of bycatch species
- and/or reduce the risk to bycatch species.

There was some support for an outcomes-focused Bycatch Policy but it was suggested that, if the revised Bycatch Policy required that quantitative performance criteria be adopted at the fishery/sector level, then there also was a need for an analysis to reference point:

- improvements made during the term of the inaugural Bycatch Policy
- a basis for measuring future trends (and effectiveness of bycatch management measures).

Next steps

The Chair advised that the draft report of this meeting would be circulated to all participants for comment and once finalised would help DAFF's Fisheries Branch frame an issues paper for public consultation. Ms Bray (DAFF) confirmed that DAFF would develop the issues paper in conjunction with the Bycatch Steering Committee and Advisory Committee and advised that, subject to other consultative processes, DAFF hope to release the revised draft issues paper for public comment in late September or October 2012.

Attachment 2. Summary of the workshop sessions

Drivers of improvement of bycatch management

The workshop noted that a range of factors had contributed to improvements in fisheries management in the period since the launch of the Commonwealth Policy on Fisheries Bycatch—June 2000. Most participants considered that it would assist the review process to recognise those factors which had a positive impact on the management of bycatch. The workshop identified the following drivers (the list was not considered exhaustive):

- Implementation and ongoing application of strategic assessments and Wildlife Trade Operations for Commonwealth fisheries under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).
- Commonwealth Policy on Fisheries Bycatch and its requirement for Bycatch Action Plans, (now Bycatch and Discarding Plans) across Commonwealth fisheries.
- Longline Fishing Seabird Threat Abatement Plan, the National Plan of Action for the Conservation and Management of Sharks (Shark-plan) and the National Plan of Action for Reducing the Incidental Catch of Seabirds in Longline Fisheries.
- Adoption of ecological risk assessments as the key information source for prioritising monitoring, research and management responses in relation to bycatch species.
- Implementation of the Commonwealth Fisheries Harvest Strategy Policy (HSP)— the workshop noted that improvements in fisheries management arrangements for target species (pursuit of maximum economic yield [MEY]) would also usually reduce impacts for bycatch species (by way of effort reduction).
- Reduction in the number of vessels following the 2007 Australian Government–funded structural adjustment program.
- Significant investment by Commonwealth research funding bodies and industry into bycatch reduction strategies and mitigation initiatives for protected species.
- An increasing emphasis in regional fisheries management organisations (RFMOs) on bycatch management.

The workshop considered that these reforms and changes had, for most fisheries, led to a significant reduction in bycatch (both directly and indirectly).

The workshop also noted the recent announcement of the final Commonwealth Marine Reserves Networks Proposals by the Commonwealth Minister for the Environment.

Guiding principles

- Consistent definitions and understanding of policy apply between all Australian Government agencies.
- The Bycatch Policy needs to be linked and/or harmonised with the Commonwealth Harvest Strategy Policy.
- The Bycatch Policy needs to include performance evaluation and reference points.
- Tone of the Bycatch Policy—query the use of 'to maintain and improve' and suggest consideration of 'ensure and where appropriate and/or necessary'.
- Consideration needs to given to reconciling the HSP's approach to byproduct (can be managed below B_{MEY} in multispecies situations), the outputs of bycatch risk assessments with respect to ecologically sustainable development (ESD) and the application of the precautionary approach.
- An interpretation regarding the application of the precautionary approach in bycatch settings is important and needs to be 'reasonable'.
- The Bycatch Policy should support a risk management framework but avoid over-specification.
- Consistency with the Fisheries Management Act and the EPBC Act is important.
- Appropriate consideration needs to be given cost implications.

Objectives

A variety of objectives were proposed—suggesting that there is some divergence between stakeholders:

- Core objective should be to manage fishery impacts on bycatch (not to maintain populations).
- To reduce bycatch to minimal acceptable levels.
- Suggest keeping the overall objective simple 'reduce the risk to bycatch species'.
- Even once the risk-based approach is applied, other Bycatch Policy objectives can still apply, for example: even if the risk is low minimising bycatch might still be a valid management response.

Risk-based approaches

- The specification of risk is important (risk of extinction, probability of going below a reference point etc.).
- Awareness of different risk assessment approaches Productivity Susceptibility Analysis (PSA) versus Likelihood × Consequences.
- Experience has shown that the quality of information available will vary and note that the current ERA methodology (PSA), when faced with information gaps, adopts a precautionary approach:
    - That, noting the above point, recognising that risk assessments in multispecies fisheries can generate lots of higher risk results—however, practicalities and resources rule out resorting to research to add certainty so mechanisms are needed to avoid having to resort to a widespread application of precautionary management measures (expert override, residual risk etc.).
    - Consideration may need to be given to where precaution is most sensibly applied—in the assessment or by managers.
- PSA used in ERAs is not scaled by effort (size of fishery) but relies more on the relative spatial overlap of the area of operation of the fishery with the known distribution of the

species. These analyses may need to be redone to take into account the anticipated marine reserves network.
- Note that ERA toolkit includes residual risk and SAFE assessments.
- Recognise there will be limits for monitoring systems—statistical power to detect trends—reality check!
- Cost implications need to weighed up against risk, noting that there may be significant costs associated with:
  - monitoring to obtain sufficient reliable data (observers, e-monitoring)
  - analysis of data
  - developing management responses.
- Recognition that for some questions increasing monitoring (coverage) will not significantly improve the chance of determining if there is a trend in catches over time.
- Risk will never be fully known, we can try to reduce uncertainty but this must be cost-effective.
- Recognise that ERAs also cover target species, bycatch and are being extended to habitats and communities.
- Ecological risk management response needs to be flexible.
- The Bycatch Policy may wish to identify rationale for validation and/or cross-checking of risk assessment methodologies.
- Need for recognition in the Bycatch Policy that there are processes that can bypass a risk-based approach, that is, CITES listings, bycatch resolutions by RFMOs etc.
- There are a limited range of feasible responses—intervention for a particular species can be difficult without scaling back the whole fishery.
- Research initiatives might be best developed for species groupings (FRDC has already initiated this approach).
- Multispecies analysis may be required for multispecies fisheries.
- Different levels of acceptable risk (trade-offs).
- Suggest that the Bycatch Policy recognise (and take into account) that the network of proposed marine reserves (currently out for public comment) and other closures implemented since 2000 will provide varying levels of protection to bycatch species.
- Policy and risk assessment approaches need to be cognisant of cumulative impacts across fisheries and jurisdictions.
- Biological risk versus social concern (another type of risk).
- A robust evidence base will inform public debate.

Reference points / indicators

- Range from model derived outputs (i.e. B48), to empirical proxies (CPUE) for biological reference points to empirical data (i.e. catch) through to qualitative indicators (high, medium and low risk).
- Productivity based defaults B_{LIM}—may need to be varied for particular species or species groups (sharks).
- Hard versus soft limits will influence data needs and monitoring and analysis costs.
- ERAs provide a snapshot and measuring progress against higher risk issues will require ongoing monitoring and periodic analysis – to establish a feedback loop.
- Importance of spatial measures needs to be taken into account.

Attachment 3. List of Workshop issues & priorities assigned by the workshop participants

Topic 1: Context for the Bycatch Policy ● ● ● ● ● ● ● ●
Contribution to ESD
Demonstration of an ecosystem approach
Domestic obligations (some shared with the states)
- Fisheries Management Act ●
- EPBC Act ●
- Commonwealth Fisheries Harvest Strategy Policy
- Recreational catch
- Marine Bioregional planning

International obligations ●
- Regional fisheries management organisations
- Convention on Biodiversity
- International plans of action
- National plans of action
- CITES
- Convention on Migratory Species

Revised objectives for new Bycatch Policy
Trade issues regarding imports & bycatch in overseas fisheries.
How will new Bycatch Policy guide the Australian position in negotiations?

Topic 2: Definitions ● ● ● ●
Catch
Commercial species
Bycatch
Threatened or otherwise protected species
Discards ●

Topic 3: A Management strategy approach to bycatch? ●
Reference points and decisions rules ● ● ● ● ● ● ●
Monitoring and assessment requirements (is it technically feasible) ● ●
Performance measures ●
Cumulative impacts ● ● ●
Mitigations vs. management
Cost attribution ●
Cost effectiveness ● ● ● ●

Topic 4: A risk-based approach to bycatch ● ● ● ● ● ● ● ● ●
How to put into a management framework? ● ●
Strengths and limitations of the ERAEF
How far can a risk-based approach take us? ● ● ●
How should the policy deal with the remainder?
Risk vs. social concerns (what are the acceptable impacts?) ● ● ●
High risk species
Rates vs. amounts
Levels of confidence & uncertainty ●

Topic 5: Other issues

What has worked?

What are the problem species?

Test case examples for solving problems & avoiding unintended consequences

Environment offsets (do they have a role)? ● ● ● ● ● ●

Bycatch as a waste issue ●

A 'Balanced Harvest' approach ●

Topic 6: Future work needed

Trends in bycatch across fisheries ● ● ● ● ●

Future research and development ● ●

Appendix E: Second stakeholder workshop report

Report of the Second Bycatch Stakeholder Workshop—Review of the Commonwealth Policy on Fisheries Bycatch—Department of Agriculture, Fisheries and Forestry—4 February 2013

Summary

The second stakeholder workshop held on 4 February 2013 considered public submissions in response to the department's issues paper for the review of the Commonwealth Policy on Fisheries Bycatch (Bycatch Policy). The workshop also considered a range of research commissioned by the Department of Agriculture, Fisheries and Forestry (DAFF) and FRDC to inform the review and discussed draft key principles for a revised Bycatch Policy.

Workshop participants agreed that one key recommendation of the review would be the revision of the Bycatch Policy. This view was consistent with the sentiment of the public submissions received. The workshop recognised that the decision is vested jointly with the Minister for Agriculture, Fisheries and the Forestry and the Minister for Sustainability, Environment, Water, Population and Communities.

It was noted that the review is being conducted concurrent with the review of the Commonwealth Fisheries Harvest Strategy Policy (HSP) and that DAFF had, since the first workshop, further clarified the likely scope of the two policies and given consideration to mechanisms for the transition of species between them. The need for there to be no gaps in the coverage of all species taken under these policies has been emphasised.

Participants held some differing views about the aims and objectives for a revised Bycatch Policy but there was general agreement by most on a set of draft key principles to be used in the drafting of a revised Bycatch Policy.

There was general support (with some reservations) for the definition of bycatch proposed by DAFF to cover all non-commercial species. Environmental nongovernment organisation representatives favoured a definition that incorporated discards to focus on the need to reduce discarding. Some of the scientists present expressed reservations about the technical obstacles that may arise if decision rules were required to be implemented broadly across suites of bycatch species for which little information was ever likely to be available. There were also concerns expressed about the capacity of both industry and government to fund additional obligations or initiatives in the current economic climate. There was also some reservation around byproduct falling under the harvest strategy policy and any implications this may have.

There was support for a hierarchal approach to the assessment and management of bycatch and for the use of the ecological risk assessment toolkit as a basis for assessing priorities and informing research and management responses.

The use of standards for the effective mitigation of fisheries bycatch was recognised as having some merit but they may require further investigation before their implementation was attempted, possibly through guidelines to the Bycatch Policy.

Participants agreed that better reporting of bycatch was needed to allow improved evaluation of the effectiveness of bycatch management measures. There were challenges, however, in reporting trends in a way that could ensure that this information was not misinterpreted. Workshop participants also supported the need for improved performance monitoring.

The workshop participants noted that an overview of international progress on bycatch issues indicated that Australia was, by international standards, well advanced in its progression of bycatch management.

Social aspects to bycatch issues were noted as being of importance to the social licence of fisheries and public perceptions about the sustainability of fisheries.

DAFF gratefully acknowledge the input and ideas from individuals who attended the workshop and the work of the facilitator Mr Sandy Morison, and scribe Mr Anthony de Fries in the preparation of the draft workshop report.

Background

In March 2012, the Minister for Agriculture, Fisheries and Forestry, Senator the Hon. Joe Ludwig, announced a review of the Commonwealth Policy on Fisheries Bycatch (Bycatch Policy), and of the Commonwealth Fisheries Harvest Strategy Policy and Guidelines (HSP)—both of which will run concurrently.

In June 2012, the Department of Agriculture, Fisheries and Forestry (DAFF) hosted a stakeholder workshop to engage with a range of stakeholders including government officers, the commercial fishing industry, environmental nongovernment organisations and research agencies, to assist in the review of the Bycatch Policy.

On 9 November 2012 DAFF released the Bycatch Policy review's issues paper for public consultation. The issues paper was developed to promote discussion and feedback on issues relevant to the Bycatch Policy that may require refinement, elaboration or further development. Interested members of the public were invited to contribute by providing a submission on issues canvassed in the issues paper or other matters relevant to the review. The public consultation period closed on 21 December 2012.

A second stakeholder workshop held was convened on 4 February 2013 to further consider issues relevant to the review and to consider public submissions received in response to the department's issues paper.

Mr Sandy Morison chaired the workshop and Mr Anthony de Fries acted as rapporteur.

Workshop objectives

The objectives of the workshop were to draw out and discuss issues for the review of the Bycatch Policy to aid DAFF in its subsequent development of a review report for the Minister for Agriculture, Fisheries and Forestry.

The workshop drew on both the submissions received and scientific advice in providing stakeholder views on a range of matters including proposed definitions and a draft set of key principles that may be used when drafting a revised Bycatch Policy.

Workshop agenda

The workshop agreed to adopt the revised draft agenda circulated by DAFF on 1 February 2013 with the following amendments:

- No presentation was provided on the review of international bycatch policies (to be considered under Session 2) but DAFF welcomed feedback on the report provided.
- Sessions 4 and 5 were replaced with a single Session 4 that considered all the draft key principles sequentially rather than under the headings suggested for Sessions 4 and 5.

Presentations by scientists from the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) and Commonwealth Scientific and Industrial Research Organisation (CSIRO) on draft reports from research that was either commissioned by DAFF to assist the review or was otherwise relevant to the review of the Bycatch Policy were provided. These presentations were:

- Dr Peter Ward (ABARES): Improving the management of bycatch: standards for the effective mitigation of fisheries bycatch (Report authors, David Kirby & Peter Ward).
- Mr Andrew Penney (ABARES): Risk-based approaches, reference points and decisions rules for managing fisheries bycatch and bycatch species (Report authors, David Kirby, Andrew Penney & Katherine Cheshire).

- Dr Neil Klaer (CSIRO): Informing the review of the Commonwealth Policy on Fisheries Bycatch through assessing trends in bycatch of key Commonwealth fisheries (Report authors, Geoff Tuck, Ian Knuckey and Neil Klaer).
- Mr Robert Kancans (ABARES): A review of the Commonwealth Policy on Fisheries Bycatch—social and economic dimensions.

In addition to the above draft reports, workshop participants were provided with background papers for each of the proposed sessions including:

- the draft report from the first workshop (Canberra, 21 June 2012)
- a summary of responses received to the issues paper for the review of the Bycatch Policy
- a draft report reviewing international bycatch policies
- agenda papers the on aims and objectives of a Commonwealth Policy on Fisheries Bycatch
- performance monitoring and reporting
- the use of a hierarchical approach to bycatch management
- draft key principles for discussion.

Summary of workshop sessions

Mr Ian Thompson (DAFF) briefed workshop participants on the status of the review of the Bycatch Policy and how the department envisaged it would fit in with the review of the harvest strategy policy and the independent review into the legislation governing the Commonwealth's fisheries management system (Borthwick review).

Session 1: Summary of issues paper submissions received

DAFF's summary and analysis of the eight public submissions received (a ninth submission was marked confidential by its author and not released) by the department was noted but, rather than work through each one, the workshop participants were invited to identify any areas where participants thought the summary would benefit from amendments or additions. The following suggestions were noted:

- That the attributions in the report for various quotes be reviewed.
- Response: DAFF advised that the summary of public submissions provided to the workshop was a draft and the department would vet the attributions carefully when finalising the public version.
- Provide clearer recognition of the view from a number of respondents that bycatch should be minimised.
- Clarify CSIRO's position that key commercial species (target and major byproduct) should be covered by the HSP and all others (namely bycatch and minor byproduct species that are mostly discarded) are covered by the Bycatch Policy.
- Clarify the scope of the Bycatch Policy in relation to cumulative impacts given the understanding it cannot apply to state-managed fisheries or other users that impact on Commonwealth bycatch species that are not regulated by the Commonwealth.
- Acknowledge stakeholder concerns that obtaining access to bycatch data held by fisheries agencies is difficult. The workshop also noted that access to bycatch data from within or between government agencies is often complicated by technical barriers.

The workshop noted that the submissions were now available on the DAFF website.

Session 2: Presentations and summary of key outcomes of commissioned bycatch research by ABARES and CSIRO

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

Dr David Kirby and Dr Peter Ward (presenter) (ABARES)

Dr Ward advised that although the report was commissioned prior to the review of the Bycatch Policy was announced the findings were pertinent to the review. Dr Ward noted that a recurring

theme with bycatch problems had been a tendency to develop fishery specific responses when a new issue emerged.

Dr Ward suggested that the adoption of the proposed standards would provide a more systematic approach to bycatch issues. He suggested that this would help promote more cost effective approaches to managing problems, assist with third-party fishery certification and help maintain a social license for fisheries by facilitating performance assessment and reporting to stakeholders.

Dr Ward explained that the standards had been tested by applying them to the AFMA's efforts to manage shark bycatch in the Eastern Tuna and Billfish Fishery. Testing suggested that the management measures showed reasonable alignment with the report's standards except in relation to reviewing to see if the measures had been effective and then communicating the outcomes.

Dr Ward suggested that the report's standards might also provide a useful starting point for developing guidelines for the Bycatch Policy.

Responses from workshop participants:

- The report would be a useful tool for scientists and managers confronted with bycatch problems that were potentially significant.
- Concerns were expressed about specifying standards that could be meaningfully applied across whole suites of bycatch species. The challenge is defining standards that have the flexibility to cope with a wide range of circumstances across fisheries.
- There will be difficulties in applying standards that would be appropriate for dealing with species listed under the EPBC Act or the Bonn Convention for migratory species compared to those that, for example, would be appropriate for any of the hundreds of small fish or invertebrate species that might be caught in a trawl fishery.
- Concern about the costs and capability of applying an adaptive loop approach which would require decision rules being developed and imposed across a whole suite of bycatch species.

Noting these concerns, the workshop provided cautious support for using the standards to inform the overarching Bycatch Policy guidelines given the breadth of species to which the policy would apply.

Risk-based approaches, reference points and decisions rules for managing fisheries bycatch and byproduct species

Mr Andrew Penney (presenter), Dr David Kirby and Ms Katherine Cheshire (ABARES)

Mr Penney indicated that the research was intended to review current risk-based approaches used to assess and manage bycatch and evaluate if the development of reference points and decision rules would assist in dealing with bycatch species, taking into account their status under legislation, biological status and the amount of information available.

The project had been expanded to include byproduct species and Mr Penney observed that, although byproduct species may fall under a revised harvest strategy policy, there were similarities with bycatch species in that there was usually a limited amount of data available on which to base an assessment of species in either group.

Mr Penney described a hierarchy of assessment methods commonly employed in fisheries that extended from qualitative ecological risk assessments (ERAs) through to quantitative models. Mr Penney noted that the choice of the most appropriate assessment approach should be driven less by the category in which a species was placed than by the level and type of information that was available.

Mr Penney suggested that, although the definitions of target, byproduct and bycatch would define the bounds of the harvest strategy and bycatch policies, this did not mean there could not be overlap in the assessment approaches applied to species under both policies. Mr Penney anticipated that the same risk-based approaches or low-information analytical methods might be applied to both data-poor byproduct species and data-poor bycatch species.

Mr Penney noted that the ERAs were now established across AFMA-managed fisheries and were used internationally and that they provided an accepted way of prioritising risk.

Mr Penney concluded by noting that the research project's main influence on a revised Bycatch Policy would be to inform the preparation of the proposed set of guidelines to accompany the policy.

Responses from workshop participants:

- Concern was expressed over the frequent references in the public submissions to the necessity of having observers or e-monitoring approaches to gather this information and the related concern that industry was not in a position to fund additional at-sea monitoring in the current economic circumstances.
- A view was expressed that there is an issue around a lack of confidence in the logbook data and the reliability of this data source should be improved. There needed to be recognition in the Bycatch Policy that it is the responsibility of operators to furnish honest and reliable logbook returns given they are licensed to harvest a public resource.
- In some fisheries, like the Northern Prawn Fishery, (NPF) there were a range of uncertainties associated with the assessment and interpretation of data from monitoring bycatch. Even with 100 per cent observer coverage there would still be uncertainty associated with any species that the fishery only caught very rarely.
- There needed to be different objectives and assessment approaches for protected species than for other fish and invertebrate bycatch.
- It was reasonable to think of the range of assessment approaches described by Mr Penney as a continuum and desirable that the transition of a species from coverage by the Bycatch Policy to HSP (or vice versa) might not involve a great jump in data or assessment requirements.
- Level 1 and 2 ERAs were not able to deliver outputs which could be used to report on the performance of management programs.
- The application of indicators and performance measures does require the ongoing collection of additional data and the resourcing implications of this needs to be considered.

Informing the review of the Commonwealth Policy on Fisheries Bycatch through assessing trends in bycatch of key Commonwealth fisheries

Dr Geoff Tuck (CSIRO), Dr Ian Knuckey (Fishwell Consulting) and Dr Neil Klaer (CSIRO, presenter)

Dr Klaer explained that CSIRO had analysed bycatch trends across a range of Commonwealth fisheries to assist the review process. Dr Klaer emphasised that interpreting trends in bycatch data needed to be done carefully to account for changes in management arrangements, fishing method and variation in observer coverage over time. Dr Klaer noted, for example, that a decline in a discard rate might mean either that mitigation measures were reducing impacts or that the population of the species in question was declining.

Dr Klaer noted that both logbook and observer recording protocols often required information be collected on interactions including those where no injury or death occurred. Dr Klaer indicated it was also very important to distinguish these in reports and summaries.

Dr Klaer noted that a thorough statistical analysis was needed to get a handle on bycatch issues and identified work done on seabird bycatch by Japanese longline vessels fishing in the Australian Fishing Zone (AFZ) under Bilateral and joint venture arrangements (concluded in 1997) and analysis of sea turtle bycatch with regard to use of turtle excluder devices in the NPF as two of the few examples where full statistical rigour had been applied to bycatch issues.

Dr Klaer then provided summaries of the bycatch trends in the following fisheries:

- Macquarie Island Toothfish Fishery (full observer coverage and strict bycatch management)
- Heard and McDonald Island Toothfish and Mackerel Icefish Fishery (full observer coverage and strict bycatch management)
- Coral Sea Fishery (small fishery with many sectors and patchy observers coverage)

- Eastern Tuna and Billfish Fishery (good observer coverage—bycatch of seabirds has come down significantly since 2007, some marine turtle interactions)
- Northern Prawn Fishery (achieved a 50% reduction in the volume of bycatch since 1998, significant reduction in sea turtle bycatch since the 1990s)
- Small Pelagic Fishery (noted a reduction in interactions with dolphins with midwater trawl gear following introduction of mitigation strategies in 2005)
- Southern and Eastern Scalefish and Shark Fishery (bycatch measures and issues varied by gear type).

Dr Klaer concluded that although the data generally indicated there had been improvements in bycatch, in some cases the data were insufficient to assess if mitigation strategies had been effective and in others it was too early to tell.

Responses from workshop participants:

- Observation that those sectors that embraced engineering solutions had generally experienced successful outcomes. Dr Klaer acknowledged this but noted that for many bycatch issues the ability to detect changes in catch and/or catch rates was difficult due to the often broad confidence intervals around estimates from observer data.
- Participants noted the difficulties of reviewing trends in bycatch management and that this would need to be addressed in a new policy.

Mr Morison thanked the presenters and encouraged those present to provide any additional comments on the reports to the authors or to DAFF.

Session 3: Discussion of aims and objectives of a revised Commonwealth Policy on Fisheries Bycatch

Definition of bycatch

The workshop again considered the definition of bycatch proposed by DAFF at the first stakeholder workshop:

- Species that interact with fishing gear but which are not kept by commercial fishers.

Comments from participants:

- Question rose as to whether species that interact with the fishing gear but that are not kept by commercial fishers were included.
- Suggestion that the word 'interact' was inconsistent with 'bycatch' noting a range of species may come into contact with the gear (seabirds alighting on codends, fish entering and leaving traps etc.) as distinct from animals that might be caught by gear but then excluded (mesh size, excluder devices) and a suggestions that it was preferable that the policy should concentrate on animals that are caught or impacted by fishing gear.
- The view was expressed that the Bycatch Policy should not apply to discards of commercial species.
- There was general (but not universal) support for a species-based approach for the policy that excluded all byproduct species from a revised Bycatch Policy.

The workshop agreed that the definition decided on should ensure that there are no gaps in the coverage of species between the revised bycatch and harvest strategy policies even though there were challenges for implementation.

Overarching objectives

Alternative proposed overarching objectives for the revised Bycatch Policy were:

- To ensure the long-term sustainability of bycatch species and the marine environment by managing fishery-related impacts in a manner consistent with the principles of ecologically sustainable development (which includes the exercise of the precautionary principle), by
    - minimising, to the extent practicable, bycatch and the mortality of bycatch that cannot be avoided

  - managing the risk to bycatch species from fishing-relative impacts, to ensure that populations of bycatch species are maintained, and rebuilt where necessary, to levels consistent with maintaining their biological productivity and functional role in the ecosystem
  - considering the expectations of efficient and cost effective fisheries management.
- To ensure that fishing operations are conducted in a manner that avoids mortality of, or injury to species listed as threatened under the EPBC Act (i.e. those listed as vulnerable, endangered or critically endangered). This recognises the need to recover populations of species listed in those categories.

Comments from participants:

- It was emphasised it was important to recognise that simply managing fishery impacts could not secure the long-term sustainability of bycatch species and the marine environment firstly because it was a dynamic system and secondly because they are other non-fishery impacts.
- The reference to fishery-related impacts suggested that the policy would extend past the direct impacts of capture to include broader ecosystem impacts and clarification was needed on whether this was intended.
- AFMA and the Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) seemed to have established an operational agreement with respect to what was meant by 'interactions' and that this might assist in tightening up the definition.
- There was general support among participants for separate objectives for protected species and other bycatch species—noting there are also some fish and shark species protected under the *Fisheries Management Act 1991* (blue marlin and black marlin, black cod) that should also be covered.
- Currently the first of the proposed overarching objectives implies that information is available on the status and trends of populations of concern. It might be possible to reduce impacts on bycatch species and to demonstrate this it may still not be possible to assess trends in their populations.
- Concern was expressed over the phrase 'to the extent practicable' in the first sub-point and how this might be interpreted. It was noted that similar wording was used) in the EPBC Act with respect to Pt 13 accreditation on management arrangements and the requirement for management arrangements to require fishers to take all reasonable steps to avoid the capture or killing or injuring of protected species.
- It was suggested that it was important to note the international context behind some fishery terms noting 'minimise' rather than 'prevent'.
- The second overarching objective was considered to be potentially unnecessary as this objective is an AFMA legislative requirement.

Session 4: Discussion of the draft key principles

The workshop found DAFF's discussion paper '*Future bycatch policy considerations—draft key principles'* to be a good platform for discussion of higher order aspects of a revised policy. These were discussed in turn and the following comments provided. It was noted that some of the principles concerned the process of revising the Bycatch Policy whereas others needed to be reflected in a revised Bycatch Policy.

1. *The revised bycatch and harvest strategy policies should encompass the effects of fishing on all commercial and bycatch species (including protected species) and ensure clarity around which policy applies to individual species.*

- There was general support for this principle.
- There was a suggested amendment for it to read 'the direct effects of fishing' but also the suggestions that this point did not need to be included in a revised Bycatch Policy.

- The workshop suggested that the lifespan of this principle need only extend to when a draft Bycatch Policy is settled.

2. *Bycatch species that are afforded higher levels of protection under the EPBC Act are managed in accordance with the legislative requirements of the EPBC Act.*

- It was suggested that this principle was not needed in the policy as it is a legislative requirement (reminder to drafters)
- The existing policy does not explain how it relates to the EPBC Act very well and it was important that a revised Bycatch Policy (and HSP) clarify their relationships with the EPBC Act.
- It was suggested that this principle be reworded to ensure a revised Bycatch Policy clarifies its relationship with the EPBC Act.
- It was noted that the current principles are deliberately silent on conservation-dependent listings when it appears this is one of the areas where there is overlap between policy and the legislation and there is a need for guidance and/or clarification.

3. *Recognition that the government aims for efficient, profitable, competitive and sustainable fisheries.*

- Perhaps reword to reflect that it is in Australia's national interest to have fisheries that are sustainable.
- It was suggested that it was important that sustainability be given primacy in such a principle but it was also noted that there are multiple (potentially competing) legislative objectives and there is no implied primacy for any one of these objectives.
- It was also suggested that if the objectives are right then the principles can be more specific.

4. *The policy should be underpinned by implementation guidelines.*

- This was strongly supported by participants.

5. *A hierarchical approach would be applied to the management of bycatch species (excluding protected species)*

- Support was expressed for this principle with some concerns about how it would be implemented.
- It was suggested that it would be important to have options for implementation elaborated in the guidelines.
- There is a need to clarify when we are talking about the assessment of bycatch and when we are referring to the management of bycatch. There was a need to cover both but the requirements of each should be articulated separately.
- The hierarchal approach described in the principle refers to management approaches whereas prioritisation is based on species (following different but related processes), the guidelines may need to refer to the prioritisation process.

6. *Performance monitoring and reporting should be explicit and transparent at both the policy and fishery level.*

- Concern was expressed that access to even aggregated information was difficult even when bycatch of certain species may impact on the sustainability of a species valued by another sector.
- Conversely, it was suggested that management advisory committees and resource assessment groups have been well served with information—but that the main problem has more often been about time constraints to consider bycatch issues.
- There is an ongoing need for confidentiality relating to an individual's data on bycatch and it is an important safeguard.
- There was concern that the costs relating to external data requests are cost recovered from industry.

- It is important that reports provide details about how data are collected to avoid potential misinterpretation.

7. *The assessment and management of bycatch species should take into account the cumulative impact of all Commonwealth commercial fishing activities and the contribution of all management measures.*

- General support for clarification—noted that the HSP already requires catches from other fisheries to be taken into account.
- It was suggested that the important point was that assessments should take into account all sources of mortality but not necessarily management as it may be unable to address issues beyond jurisdictional boundaries. Therefore there was a need for separate clauses about assessment and management.
- DAFF informal response—the Bycatch Policy and HAP are not national policies and will only cover Commonwealth managed fisheries. There are Offshore Constitutional Settlement arrangements in place to address the issue of management responsibility.
- Note CSIRO is working on a cumulative approach for ERAs.

8. *Where appropriate, reference points and related decision rules could be developed to reduce uncertainty.*

- Note suggested changes to wording of Principle 8.
- It was suggested that transparency relates to communications and there is no need for reference to a communication strategy in these principles.

9. *Consideration of commercial fishery impacts on bycatch species of importance to the recreational or indigenous fishing sectors.*

- This principle appears to be a departure from the issues concerning sustainability and relates to the potentially competing interests and allocation issues among stakeholder groups.
- There was support for a future Bycatch Policy indicating the need to consider impacts on sectors other than the commercial fishing industry, and particularly the recreational sector, when decisions about management of bycatch were made.
- It was suggested that this is not an appropriate principle for a revised Bycatch Policy, that it is more a higher order resource sharing objective that is not just about bycatch but could equally apply to species considered under the harvest strategy policy.
- It was noted that some harvest strategies already explicitly respond to any impacts that might arise from other sectors and that this often impacts on commercial catches.
- There was a need for recognition that bycatch in one fishery could be important as byproduct or targeted catch in other fisheries or sectors such as recreational or indigenous fishers.
- There was question as to whether the Commonwealth has an obligation to monitor catches and assess status for recreational-only species such as Black Marlin.
- It was suggested to put this principle in square brackets to indicate that there is currently not general agreement about this being an appropriate principle for a revised Bycatch Policy or guidelines.

10. *Ensure alignment with international obligations with respect to bycatch management.*

- There is a need to preserve the ability to respond to any future changes in other relevant polices and mandatory instruments (e.g. regional fisheries management organisations resolutions, CITES listings, etc.).
- It was noted, however, that Australia usually manages to a higher standard than the minimum international requirements.
- The Bycatch Policy needs to be consistent with those National Plans of Actions that relate to bycatch management, that is

- the National Plan of Action for the Conservation and Management of Sharks
- the National Plan of Action for Reducing the Incidental Catch of Seabirds in Australia's Longline Fisheries (under development).

Other issues: including social and economic considerations

Review of Commonwealth Policy on Fisheries Bycatch—social and economic dimensions

Mr Robert Kancans (presenter) (ABARES)

Mr Kancans provided an analysis of the contemporary social context in which a revised Bycatch Policy would operate including issues of the public perceptions of fisheries bycatch, the social impacts of Bycatch Policy, management and mitigation strategies, and what motivates fishers in the adoption of sustainable management practices.

He noted that industry and government experience was that the concept of 'social license' was an emerging reality for fisheries particularly in relation to market access.

Mr Kancans explained the public perception can drive issues and referred to the recent case of the fishing vessel Abel Tasman. The workshop also noted that a longstanding public expectation was to reduce waste in fisheries. This is reflected in the existing Bycatch Policy despite 'wastage' not being directly linked to sustainability provided other fishery settings were sound.

Mr Kancans reported that recent surveys suggested a large proportion of the Australian public were doubtful about the sustainability of Commonwealth-managed fisheries.

Comments from participants:

- Participants noted that a more contemporary Bycatch Policy could provide government and industry with a stronger basis to convince the fish buyers and consumers that a lot of improvements have already being made in relation to fisheries bycatch and that Commonwealth fisheries are generally operating to much higher standards than international competitors.
- It was acknowledged that the government was committed to changing behaviour across a range of natural resource management areas to improve sustainability and environmental outcomes.
- It was recognised that projects to improve fisheries bycatch practices were being actively supported through the government's Caring for our Country program and that much of the focus was on research, training and extension initiatives for skippers and crew.
- The workshop considered that it would be beneficial if a revised bycatch policy recognised the need to keep industry engaged and informed to improve information flows and to encourage innovation in fishing practices in relation to bycatch.

Summary of workshop outcomes and next steps

The stakeholder workshops have provided valuable outcomes across a range of issues concerning a possible revised bycatch policy for Commonwealth-managed fisheries:

- information from a range of recent reviews and research projects has been made available to stakeholders
- views of different stakeholders have been aired and discussed
- areas of agreement (or least acceptance) on some important issues have been identified
- knowledge has been improved about the strengths and weaknesses of different Bycatch Policy approaches
- the benefits of the development and implementation of improved revised Bycatch Policy have been identified and acknowledged.

The next steps in the process include:

- Circulation of the draft workshop report to DAFF, the steering committee and workshop participants for comment.

- DAFF to draft a review report to the Minister for Agriculture, Fisheries and Forestry by the end of March.

Participants were advised that, should new policies emerge from these processes, stakeholders would be given the opportunity to consider the merits of the draft policies.

Conclusions

The following are general conclusions from the discussions at the workshop but should be read together with the more detailed comments provided above:

1. There is recognition and support of the need for a revised Bycatch Policy.
2. There is general (but not universal) agreement about the definitions that should apply to bycatch but agreement that there should be no gaps between a revised Bycatch Policy and a revised HSP.
3. The draft overarching objectives may require some rewording and not all of them are considered required in a revised Bycatch Policy.
4. The proposed draft key principles will provide a useful structure and guidance for the review report.
5. There was general comfort with the proposed hierarchal approach to the assessment and management of bycatch. There are, however, technical challenges for implementation and important implications to consider.
6. Monitoring performance and reporting:
    a. Both monitoring and reporting need to be substantially improved.
    b. Proposal that a revised Bycatch Policy should drive improvement in logbook reporting as a cost effective source of information on bycatch.
    c. Concern about the technical and resourcing challenges should the Bycatch Policy require the more widespread adoption of performance criteria and decision rules.

Appendix F: Bycatch management case studies

The 2006 Threat abatement plan for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations

Background: The incidental catch (or bycatch) of seabirds during oceanic longline fishing operations was listed as a key threatening process in 1995. The first *Threat abatement plan for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations* (TAP-Seabirds) operations was adopted in 1998. A second threat abatement plan (TAP) was developed in 2006, which is currently under review and an updated TAP is expected to be implemented shortly.

The TAP-Seabirds coordinates national action to mitigate the impact of longline fishing activities on seabirds all fisheries under Commonwealth jurisdiction. The ultimate aim of the TAP–Seabirds is to achieve a zero bycatch of seabirds, especially threatened albatross and petrel species, in all longline fisheries. Although this aim is yet to be achieved, research and other activities conducted under the TAP-Seabirds have significantly improved knowledge of the factors that increase or decrease the risk of seabird bycatch, and the effectiveness and limitations of current mitigation measures. Several promising new or improved mitigation measures are under development and likely to be commercially available soon, which offer significant potential to achieve further reductions in bycatch.

Recognising the efficacy of currently available mitigation methods, the objective of the TAP-Seabirds is 'to significantly reduce the bycatch of seabirds during oceanic longline operations in the Australian Fishing Zone (AFZ) at current fishing levels'. Within the TAP–Seabirds, performance criteria have been set for affected Commonwealth fisheries. These performance criteria are defined in terms of the number of birds caught per 1000 hooks. The criteria are based on existing fishing levels and so a change in effort of greater than 20 per cent up or down will trigger a review of these criteria.

There has been considerable progress over the period that the TAP-Seabirds have been in place. Under the first TAP:

- regulations were developed requiring seabird mitigation measures in pelagic tuna fisheries under the *Fisheries Management Act 1991*
- research trials of seabird bycatch mitigation techniques led to improved data on nature and level of seabirds interactions
- maximum permissible incidental catch rates of 0.05 birds per 1000 hooks were achieved in some fisheries, and an estimated overall 90 per cent reduction in seabird bycatch mortalities in longline fisheries was achieved across the AFZ
- awareness of the issue was heightened leading to increased cooperation by fishers.

With the introduction of the 2006 TAP-seabirds:

- permissible seabird bycatch limits revised to 0.01 birds per 1000 hooks in a number of fisheries
- night setting was no longer able to be used as the only single mitigation method, as despite dramatically reducing capture of albatrosses, it was found to not be sufficiently effective for flesh-footed shearwaters
- mitigation measures for the Eastern Tuna and Billfish Fishery were now required south of 25°S, compared to 30°S in the first TAP.

The Australian Fisheries Management Authority (AFMA) is the agency responsible for monitoring implementation of seabird mitigation strategies and initiating management responses under the TAP-Seabirds. The TAP includes defined responses that must occur within three months if seabird bycatch limits or requirements for observer coverage are not being met.

Summary & evaluation: The TAP–Seabirds is a multispecies and multifisheries conservation arrangement, which aims to eliminate bycatch of seabirds in all Australian longline fisheries. An important component of the TAP is that it includes a number of mitigation measures specifically directed at reducing bycatch of seabirds. Limit reference points, performance criteria and required observer effort are specified for each affected Commonwealth fishery, with required observer effort being proportional to the nature and level of bycatch in each area, season and fishery. The performance criteria were set on the basis of annual fishing levels at the time of formulation. The bycatch limit reference points are applied to all seabirds as a group and do not specify limits for interactions with individual species. As conservation status of seabird species caught on longlines is highly varied, the combined-species bycatch-rate limit may not ensure sustainability or recovery of individual threatened species. Consequently, very strict seabird bycatch limit reference points apply under the TAP.

Australian Sea Lion Management Strategy—Southern and Eastern Scalefish and Shark Fishery

Background: For the gillnet sector of the Southern and Eastern Scalefish and Shark Fishery (SESSF), five seal species (Australian fur seal, New Zealand fur seal, Australian sea lion, leopard seal, and elephant seal) were assessed as high risk through the AFMA ERA process. The Australian sea lion population was significantly depleted by sealing activities in the 18th and 19th centuries. The species was listed as vulnerable under the Environment Protection and Biodiversity Act 1999 (EPBC Act) in 2005. A recent report produced by the South Australian Research and Development Institute (SARDI) suggests that current bycatch mortality may be limiting the recovery of most colonies in South Australia (Goldsworthy et al. 2010). The *Australian Seal Lion Management Strategy—Southern and Eastern Scalefish and Shark Fishery* was developed in 2010 to monitor and reduce interactions between Australian sea lions and gillnets used by Commonwealth shark fishers in the SESSF.

The objectives of the strategy are to significantly reduce the ecological risk that the SESSF poses to Australian sea lions and to thereby enable their recovery (AFMA 2010b). Measures to achieve this include the implementation of formal fisheries closures around all 48 sea-lion colonies, increased independent observer monitoring of fishing activity and adaptive management arrangements for further closures in response to further sea lion interactions.

AFMA and industry have initiated a range of other management measures over time that, while not specifically directed at the conservation of sea lions, have afforded some level of protection to the species. These include reductions in fishing effort, spatial closure and gear restrictions, some of which are reported by industry to have substantially reduced the bycatch mortality of sea lions over time. Measures to monitor sea lion bycatch include increased observer coverage and development of electronic monitoring (camera) programs. These various measures are incorporated into bycatch work plans for the SESSF, as well as formal management strategies, statutory fishing rights and permit conditions. Further investigation and research is being conducted into the efficacy of other mitigation measures including further gear restrictions or modifications, trials using line methods rather than gillnets and shifting of fishing effort.

The adaptive management system is the core component of the sea lion management response and includes the provision for increased spatial closures if unacceptable levels of sea lion interactions are recorded. The trigger for further closures in each region is a pre-set number of observed sea lion mortalities. This level takes account of levels of uncertainties resulting from limited observer coverage and is based around the maximum bycatch rate (approximately 2% per year or 3% per breeding cycle) that should still allow population growth in each of the regions. These trigger points are difficult to reliably monitor in areas where low numbers of

interactions are expected, so observer coverage is increased in these areas to improve the likelihood of detecting rare interaction events. Initial trigger levels were adopted based on were developed based on population modelling, taking account of recovery rates of populations, limitations of observer coverage and uncertainty. A review by Goldsworthy and Lowther (2010) determined that the original trigger levels were above the expected number of observations. As a result, trigger levels have been reduced following further analysis of interactions, in some cases to one sea lion mortality, resulting in the closure of significant areas to fishing.

Summary & evaluation: The *Australian Seal Lion Management Strategy—Southern and Eastern Scalefish and Shark Fishery* is a single-species, single-fishery plan, which aims to reduce the ecological risk that the SESSF poses to Australian sea lions and enable their recovery. AFMA has undertaken ERAs for five seal species in the gillnet sector of the SESSF including the Australian sea lion, which is considered to be of greatest concern. Management measures implemented in response relate to increasing monitoring and reducing sea lion interactions through area closures triggered by observed interactions. Further research is under way into the efficacy of other mitigation measures, including gear restriction and shifting of effort. The strategy has defined trigger limits (bycatch rates) that operate under an adaptive management strategy, to initiate enhanced observer coverage (to improve efficiency) or initiate further area closures if trigger limits are exceeded. Initial trigger levels have been reduced following further analysis of interactions, in some cases to one sea lion mortality, resulting in the closure of significant areas to fishing.

Eastern Tuna and Billfish Fishery Sea Turtle Mitigation Plan

Background: Of the seven species of marine turtle occurring in the world, six are found in Australian waters. All of these sea turtles spend part of their life cycle, or are thought to have the potential to spend part of their life cycle, in the pelagic environment where they may come into contact with pelagic longlines used in the Eastern Tuna and Billfish Fishery (ETBF). Marine turtles are protected under Australian legislation and fisheries are required to report any interactions to the Australian Government. Historically the majority of reported interactions have been with green and leatherback turtles.

In 2005, to reduce mortalities resulting from sea turtle interactions in the ETBF, AFMA provided all vessels operating in the ETBF with line cutters and de-hookers to assist in the safe release of sea turtles hooked or tangled in pelagic longline fishing gear. This was accompanied by several education programs to inform skippers and crews on the appropriate way to handle and release sea turtles. Sea turtle species tend to continue to forage in close proximity to nesting beaches during inter-nesting periods (Hays et al. 1999), leading to suggestions for closures around known nesting sites. However, the known nesting sites occur within the boundaries of the Great Barrier Reef Marine Park and so are already protected.

In December 2008, the Western and Central Pacific Fisheries Commission (WCPFC) passed Conservation and Management Measure (CMM) 2008-03: Conservation and Management of Sea Turtles, which promotes sea turtle bycatch mitigation in shallow-set pelagic longline fisheries targeting swordfish. Under section 6 of this CMM, longline vessels must carry and use line cutters and de-hookers to handle and promptly release sea turtles caught or entangled, in accordance with WCPFC guidelines. Vessels are encouraged to carry and use dip-nets to assist with release in accordance with these guidelines. Section 7 of this CMM requires longline vessels that fish for swordfish in a shallow-set manner to use at least one of the following three mitigation methods:

- use only large circle hooks
- use only whole finfish for bait
- use any other mitigation measure that has been reviewed by the Scientific Committee (SC) and the Technical and Compliance Committee (TCC) and approved by the Commission.

In 2009, Australia formally submitted the Eastern Tuna and Billfish Fishery Sea Turtle Mitigation Plan (TMP) (AFMA 2009), for review by the WCPFC Scientific Committee (SC) and Technical

Compliance Committee (TCC), and approval by the WCPFC. The mitigation plan was designed to generate estimate of interaction rates and demonstrate that the Australian fishery interaction rates were below that of the Hawaiian longline fishery, upon which CMM 2008-03 was based. Both the SC and TCC recommended that the WCPFC approve the mitigation plan, and it was approved by the WCPFC at WCPFC 6 and took effect 1 January 2010.

The mitigation plan stated that observed sea turtle interaction rates in the ETBF would be reported as part of Australia's Annual Part 1 *Report to the Scientific Committee*. The plan provided for actions to be taken if the 'minimal levels' of sea turtle interactions approved by the WCPFC SC in 2009 are exceeded. In 2010, the interaction rate for leatherback turtles exceeded the minimal level; as a result, further measures were implemented to ensure the survival captured turtles were undertaken, such as line cutters and de-hookers supplied to ETBF vessels. The observed sea turtle interaction rates for 2011 indicate that the minimal levels for green turtles and leatherbacks were exceeded, as was the minimal level for 'all species combined'. The TTRAG (Tropical Tuna Resource Assessment Group) has since advised AFMA to revoke the mitigation plan and instead focus on the continued use of large circle hooks in Australia's shallow-set pelagic longline fisheries targeting swordfish, consistent with CMM2008-03.

Summary & evaluation: The *Eastern Tuna and Billfish Fishery sea turtle mitigation plan (TMP)* is a multispecies, single fishery plan, which aims to reduce the issue of turtle interactions. Australia has implemented the requirement for vessels operating in the ETBF to carry 'line cutters' and 'de-hookers' and supported the development of safe sea turtle handling procedures to assist in the safe release of sea turtles. Although there are no specific mitigation measures in place to reduce turtle interactions, the known nesting sites occur within the boundaries of the Great Barrier Reef Marine Park, and so are protected. The TMP originally defined trigger limits (interaction rates) for individual species based on historical interaction rates in the Hawaiian tuna fishery. The management response in the first year the trigger points are exceeded would result in the establishment of an AFMA–industry Sea Turtle Mitigation Working Group to establish what measures could can be implemented in the fishery to achieve an interaction rate less than that specified in the trigger points. Exceeding these trigger points in the following and subsequent years should initiate gear and trip restrictions. However, a subsequent review has concluded that fisheries-related mortality is small compared to turtle hunting and egg collection and the TMP has been revoked in response to advice by the TTRAG. Emphasis is now on the continued use of large circle hooks in Australia's shallow-set pelagic longline fisheries targeting swordfish, consistent with the WCPFC's CMM 2008-03.

Appendix G: Summary of definitions of bycatch and existence of bycatch policies for various countries

Source	Bycatch definition	Bycatch policy
Australia—Commonwealth Policy on Fisheries Bycatch	*'This policy deals specifically with those aspects of bycatch that are not currently subject to commercial management provisions, namely:* *i) 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, and ii) that part of the 'catch' that does not reach the deck of the fishing vessel but is affected by interaction with the fishing gear'* (DAFF 2000, p. 3). *'At a broader level, includes all material, living and non-living, that is caught while fishing, except for the target species.'* (DAFF 2000, p. 2)	Yes: *Commonwealth Policy on Fisheries Bycatch* *Threat abatement plan for the incidental catch (or bycatch) of seabirds during oceanic longline fishing operations*
FAO	*'Part of a catch of a fishing unit taken incidentally in addition to the target species towards which fishing effort is directed. Some or all of it may be returned to the sea as discards, usually dead or dying.'* (FAO 1998, p. 202)	*International guidelines on bycatch management and reduction of discards*
OECD	*'Fish or other fauna (e.g. birds or marine mammals) that are caught during fishing, but which are not sold or kept for personal use. In commercial fishing these include both fish discarded for economic reasons (economic discards) and because regulations require it (regulatory discards). Fish released alive under catch-and-release fishery management programs are not normally considered as bycatch'* (OECD 2001)	N/A
UNIA / UNCLOS	Not specifically defined	N/A
Chile	Not referred to	Yes: *National plan for the conservation of sharks of the Undersecretariat for Fisheries* *National plan of action to reduce incidental catch of seabirds in*

Source	Bycatch definition	Bycatch policy
		longline fisheries
Canada	*a) fish that are harvested in a fishery, but usually not sold or kept for personal use; b) seabirds and marine mammals that become entangled or caught by fishing gear; c) the discard of whole fish at sea or elsewhere, including those fish discarded for economic and/or regulatory reasons; d) fishing mortality due to an encounter with fishing gear that does not result in capture of fish (i.e. unobserved fishing mortality)*	Yes: *Policy on Managing Bycatch* *National plan of action to reduce incidental catch of seabirds in longline fisheries*
European Union	Not specifically defined	No
Norway	Not specifically defined	No
New Zealand	Not specifically defined	*National plan of action to reduce incidental catch of seabirds in New Zealand fisheries*
United States Magnuson–Stevens Act 1996	*'Fish which are harvested in a fishery, but which are not sold or kept for personal use, and includes economic discards and regulatory discards. Such term does not include fish released alive under a recreational catch and release fishery management program.'*	N/A
United States NOAA	*Discarded catch of any living marine resource plus unobserved mortality due to a direct encounter with fishing gear.* (NMFS 2011)	Yes: *The National Bycatch Strategy* *United States national plan of action for reducing the incidental catch of seabirds in longline fisheries*

Appendix H: Summary of ecological risk assessments and ecological risk management programs implemented by Australian Fisheries Management Authority for Commonwealth fisheries

Fishery		**Level 1** Scale, Intensity, Consequence Analysis (SICA)	**Level 2** Productivity Susceptibility Analysis (PSA)	**Level 2** Residual Risk Assessment	**Level 3** Sustainability Assessment for Fishing Effects (SAFE)	Target species assessment	Ecological risk management program (ERM)
Bass Strait Central Zone Scallop Fishery		Complete	Complete	Complete	Not required	Complete	Complete
Coral Sea Fishery	Aquarium	Complete		Not applicable			
	Auto Longline	Complete	Desktop study	Not applicable			
	Demersal Longline	Complete	Desktop study	Not applicable			
	Demersal Trawl	Complete	Desktop study	Not applicable			
	Lobster & Trochus	Complete		Not applicable			
	Other line	Complete	Desktop study	Not applicable			
	Sea Cucumber	Complete		Not applicable		Complete	
	Trap	Complete	Desktop study	Not applicable			
Eastern Tuna & Billfish Fishery		Complete	Complete	Complete	Complete	Complete	Complete
Heard and McDonald Islands Fishery	Demersal Trawl	Complete	Complete	Complete	Complete	Complete	Complete
	Midwater Trawl	Complete	Complete	Complete	Complete	Complete	Complete
	Demersal Longline	Complete	Complete	Complete	Complete	Complete	Complete
Macquarie Island Fishery	Demersal Trawl	Complete	Complete	Complete	Complete	Complete	Complete
Northern Prawn Fishery		Complete	Complete	Complete	Complete	Complete	Complete

Fishery		**Level 1** Scale, Intensity, Consequence Analysis (SICA)	**Level 2** Productivity Susceptibility Analysis (PSA)	**Level 2** Residual Risk Assessment	**Level 3** Sustainability Assessment for Fishing Effects (SAFE)	Target species assessment	Ecological risk management program (ERM)
North West Slope Trawl		Complete	Complete	Complete	Complete		Complete
Southern Bluefin Tuna		Complete	Complete	Complete	Complete	Complete	Complete
Small Pelagic Fishery	Midwater Trawl	Complete	Complete	Complete	Complete	Complete	Complete
	Purse Seine	Complete	Complete	Complete	Complete	Complete	Complete
Skipjack Tuna		Complete	Complete	Complete	Complete	Complete	Complete
Southern Squid Jig Fishery		Complete	Not required	Not required	Not required		Complete
Southern & Eastern Scalefish & Shark Fishery	Otter Trawl Fishery	Complete	Complete	Complete	Complete	Complete	Complete
	Gillnet, Hook & Trap	Complete	Complete	Complete	Complete	Complete	Complete
	Great Australian Bight Trawl	Complete	Complete	Complete	Complete	Complete	Complete
	Auto Longline	Complete	Complete	Complete	Complete	Complete	Complete
	Danish Seine	Complete	Complete	Complete	Complete	Complete	Complete
Torres Strait	Rock Lobster	Complete	Not required	Not required	Not required	Complete	Complete
	Prawn	Complete	Not assessed	Not assessed	Not assessed	Complete	
Western Deep Water Trawl		Complete	Complete	Complete	Complete		Complete
Western Tuna & Billfish Fishery		Complete	Complete	Complete	Complete		Complete
Totals		30	24	19	18	19	21

Legend: green - complete; orange - drafted; red - not started; grey - this level of assessment not required or not possible.
Source: http://www.afma.gov.au/managing-our-fisheries/environment-and-sustainability/ecological-risk-management/)