The application of qualitative risk assessment methodology to prioritize issues for fisheries management

ICES Journal of Marine Science
Volume 62, Issue 8
Pp. 1576-1587.
W.J. Fletcher∗

Abstract

Implementing more holistic forms of fisheries management (e.g. Ecologically Sustainable Development (ESD), Ecosystem-Based Fisheries Management) usually increases the number and scope of impacts requiring assessment. This study examined the effectiveness of a qualitative risk assessment process, developed as part of a National ESD framework, for prioritizing issues across the seven most valuable Western Australian commercial fisheries. Structured stakeholder workshops were used to identify issues across three ecological areas: retained species (i.e. target and by-product), non-retained (i.e. discarded and protected) species, and the broader ecosystem for each fishery. The risk associated with each issue was assessed using one of five sets of consequence criteria specifically developed to cover fishery-related impacts. The risk scores, for which suitably detailed justifications were written, determined the level of reporting and management required for each issue. Despite an additional 96 “non-target species issues” being identified at the workshops from a total of 115 issues, of the 27 issues requiring explicit management actions, just six new issues were added by this process. In addition, it identified where modifications of some of the existing arrangements were necessary. Finally, the system significantly improved stakeholder involvement and therefore acceptance of the outcomes. Given this success, risk assessment has now been applied to all Western Australia's export fisheries and to the development or review of many other systems, thereby improving the entire management process.

Introduction

Some form of risk assessment is used to make all management decisions. This includes what needs to be managed and how much effort should be focused towards achieving adequate performance and avoiding undesirable events. Whilst formal techniques for completing these assessments have been common in some sectors for many years (e.g. insurance, engineering, medicine), in others, the process is often done implicitly. For most natural resource managers, including fisheries management agencies, the level of public scrutiny of decisions and their expectations of performance have increased greatly in recent years. This has resulted in a shift to more structured and transparent evaluation techniques to both determine and justify decisions (e.g. disease management; Stephen, 2001).

The necessity to have more formal decision-making processes has also been intensified through recent initiatives to implement the principles of sustainable development (WCED, 1987), known in Australia as ecologically sustainable development (ESD; Commonwealth of Australia, 1992). This concept, which includes ecosystem-based management, has significantly increased the number of issues relevant to each fishery because it not only covers impacts on target species, but also impacts on bycatch species and habitats, plus potential indirect impacts of these removals on the broader ecosystem (Ward et al., 2002; Garcia et al., 2003; Fletcher et al., 2005). In Australia, the development of a National ESD framework was initiated in 2001 to assist the process of ESD implementation across all fisheries and aquaculture sectors. Initially, there were concerns whether this would result in a substantial increase in the management and/or research requirements for each fishery (e.g. Commonwealth of Australia, 2001). This generated a strong incentive to develop a process to ensure that additional management actions and monitoring systems were only implemented where necessary, and only to an appropriate level. Consequently, formal risk assessment techniques were suggested as a sensible approach given the large number of potential issues and the impossibility of gaining a perfect understanding for any of these.

The concept of using risk assessment approaches to assist with fisheries management is not new (e.g. Lackey, 1994; Francis and Shotten, 1997; Lane and Stephenson, 1998). Quantitative risk assessments are often employed in stock assessment analyses, allowing advisory/management committees to link their recommended actions to the probability that stock abundance will meet some agreed level of performance (e.g. Francis, 1992). Such quantitative analyses can be highly robust, but they require significant levels of information and can only be applied in a small number of situations; usually in the assessment of a small number of target species. It could be argued, however, that the assessment of risk is possibly of greatest importance in data-poor situations.

Given the large number of potential issues that were being identified as part of the ESD process, many of which had minimal data, an alternative method of assessing priorities was required. In situations where there are only low or variable levels of information, qualitative risk analysis methods are often used, for which standard procedures are already available (e.g. Standards Australia, 2004a). The general procedures for ecological risk assessment, as outlined in these standards, were adapted for use within a fishery context to form a module of the National ESD framework (Fletcher et al., 2002).
This module provided a disciplined and consistent approach for the calculation of the relative level of "risk" associated with each ecological issue, which was used to prioritize issues and lead to better management decisions. Thus, the calculated risk value of an issue assists in determining whether it requires direct management and monitoring, a decision that is critical for the long-term performance of any fishery.

This study examined how effectively qualitative risk assessment functioned within a fisheries management context by assessing the results of risk analyses completed for a range of Western Australian (WA) fisheries. These assessments covered WA's largest and most valuable fishery, the western rock lobster fishery, along with two trawl fisheries that operate in a World Heritage Area, another that operates within a Marine Park, and a dive fishery that operates offshore from a capital city. The study also examined the impact that the risk outcomes had on the management and research requirements for each of these fisheries. Finally, the lessons learned while undertaking the process, including the benefits/problems for stakeholder involvement and acceptance of using such a system, are discussed.

Methods

Risk analysis in the fisheries context

The risk analysis methods developed were based on the Australian and New Zealand Standard Risk Analysis (Standards Australia, 2000, 2004a, b), which were adapted for use in a fisheries context (see Fletcher et al., 2002, for complete details). This process involves the examination of the sources of risk (issue identification), the potential consequences (impacts) associated with each issue, and the likelihood (probability) of a particular level of consequence actually occurring. This combination produces an estimated level of comparative risk which can then be used to assist in determining the level of management response required.

The key element for any valid risk analysis is having procedures for determining appropriate consequence and likelihood levels. For qualitative analyses, this requires having adequate descriptions for each level of consequence and likelihood; the more precise, the less ambiguity in assigning ratings. To assist with the robustness of this process, the general concepts of assigning consequence and likelihood outlined in the

Risk Management Guidelines (Standards Australia, 2000, 2004b) were adapted into five comparable sets of criteria that specifically deal with the issues from the three environmental categories (Table 1).

Table 1. Summary descriptions of the five sets of consequence levels covering the three environmental categories. Full descriptions are presented in Fletcher *et al*. (2002, 2004).

Consequence level	A. Target/vulnerable	B. By-product/other non-retained	C. Non-retained – protected species	D. Ecosystem	E. Habitat[a]
0 – Negligible: No recovery time needed	Undetectable for this population	Area where fishing occurs is negligible compared with where the relevant stock of these species reside (<1%)	Almost none are impacted	Interactions may be occurring but it is unlikely that there would be any change outside of natural variation	Affecting ≪ 1% of area of *original* habitat area
1 – Minor: Rapid recovery would occur if stopped – measured in months	Possibly detectable but little impact on population size and none on their dynamics	Take in this fishery is small (<10% of total) compared with total take by all fisheries; species are covered explicitly elsewhere. Take and area of capture by this fishery is small compared with known area of distribution (<20%)	Some are impacted but there is no impact on stock, and this is well below society's acceptable levels	Captured species do not play a keystone role – only minor changes in relative abundance of other constituents	Measurable but localized; affects <1–5% of total habitat area
2 – Moderate: Recovery probably measured in months – years if activity stopped	Full exploitation rate where long-term recruitment/dynamics not adversely impacted	Relative area of, or susceptibility to capture, is suspected to be less than 50% and species do not have vulnerable life history traits	Level of interaction/impact at the maximum acceptable level	Measurable changes to the ecosystem components without there being a major change in function (i.e. no loss of components)	Impacts more widespread but still acceptable; 5–50% of habitat area is affected
3 – Severe: Recovery measured in years if stopped	Affecting recruitment levels of stocks/or their capacity to increase	No information is available on the relative area or susceptibility to capture or on the vulnerability of life history traits of this type of species or the relative levels of susceptibility >50%, and species should be examined explicitly using Set A criteria	Level of impact at above maximum acceptable level. Refer to Set A criteria for any higher levels associated with threatened species.	Ecosystem function altered measurably and some function or components are missing/declining/increasing well outside historical acceptable range and/or allowed/facilitated new species to appear.	Impact larger than sensible; 20–60% of habitat is affected/removed
4 – Major: Recovery period measured in years to decades if stopped	Likely to cause local extinctions if continues	N/a	N/a	A major change to ecosystem structure and function. Different dynamics now occur with different species or groups now the major targets of the fishery	Removal may result in major changes to ecosystem; 60–90% affected
5 – Catastrophic: Long-term recovery period to acceptable levels will be greater than decades or never, even if stopped	Local extinctions are imminent/immediate	N/a	N/a	Total collapse of ecosystem processes	Entire habitat in region is in danger of being affected; >90% affected/removed

The five sets of criteria were designed to assist the process by having levels that were relevant to the issues being assessed. Thus, the assessments of retained species either used Set A 'target species' – where these were of highly targeted/vulnerable species; or used Set B 'by-product/other non-retained' – where these were minor by-product species. Set B was also used to assess most of the non-retained species with the main exception being for the assessment of non-retained species that are classed as 'Protected Species' (for either cultural or conservation reasons) – these were completed using Set C. The general ecosystem issues were assessed using either Set D for 'ecosystem (food chain)' issues or Set E for 'habitat' related issues.

Each of the sets has six ordinal levels of impact ranging from negligible (virtually no impact with a score of 0) to catastrophic (irreversible with a score of 5), with moderate (a score of 2) being defined as the highest acceptable level of consequence. The qualitative likelihood table (Table 2) also has six ordinal levels ranging from remote (never heard of, but not impossible; with a score of 1); to likely (expected to occur; with a score of 6). The decision only to use six levels was a compromise between potentially increasing the precision of the outcomes against the likely increased confusion/complexity for participants associated with the use of a greater number of levels.

Table 2. Summary descriptions of the five sets of consequence levels covering the three environmental categories. Full descriptions are presented in Fletcher *et al*. (2002, 2004).

Level	Descriptor
Likely (6)	It is expected to occur
Occasional (5)	May occur sometimes
Possible (4)	Some evidence to suggest this is possible here
Unlikely (3)	Uncommon, but has been known to occur elsewhere
Rare (2)	May occur in exceptional circumstances
Remote (1)	Never heard of, but not impossible

Table 2. Likelihood definitions (derived from Standards Australia, 2000, 2004b).

Risk ratings and management outcomes

The Risk Value for each issue was calculated as the mathematical product of the consequence and likelihood levels, producing possible risk values between 0 and 30. Based upon the evidence provided at the workshop, issues were assigned to an appropriate combination of consequence and likelihood levels. If more than one combination was considered appropriate, the combination with the highest risk score was chosen.

To correctly assign these levels, it was important to recognize that the likelihood of a consequence occurring is a conditional probability. In this context, we assessed the likelihood that, given a particular fishing management strategy (e.g. the current allowable trawling activities of a fishery), a particular level of consequence (e.g. removal of x% of habitat) may ultimately be the result (either from a cumulation of small events over time, or from a single large event). It is a common error when beginning this process to mistakenly assess the likelihood that the particular fishing activity (i.e. trawling on the bottom) will occur; this tendency must be avoided. Similarly, the assessment must determine the likelihood that a particular consequence may happen sometime in the future (usually within the lifetime of the current management plan/assessment period), not just assess its current status.

To standardize the management outcomes that result from these risk analyses, the risk values were separated into five Risk Categories ranging from negligible to extreme (Table 3). The categories identify the level of reporting needed and, more importantly, whether direct management of the issue (e.g. imposing increased levels of restrictions, collecting more data) would be required to reduce or maintain the current level of risk.

Table 3. Risk categories and outcomes (modified from Fletcher et al., 2002)

Risk category	Value	Reporting	Likely management response
Negligible	0	Short justification only	No direct management needed
Low	1–6	Full justification needed	No specific management actions needed, indirect management likely
Moderate	7–12	Full performance report	Specific management needed, some additions to current levels possible
High	13–20	Full performance report	Increases to current management activities probably needed
Extreme	20–30	Full performance report	Significant additional management activities needed

Conducting the risk assessment

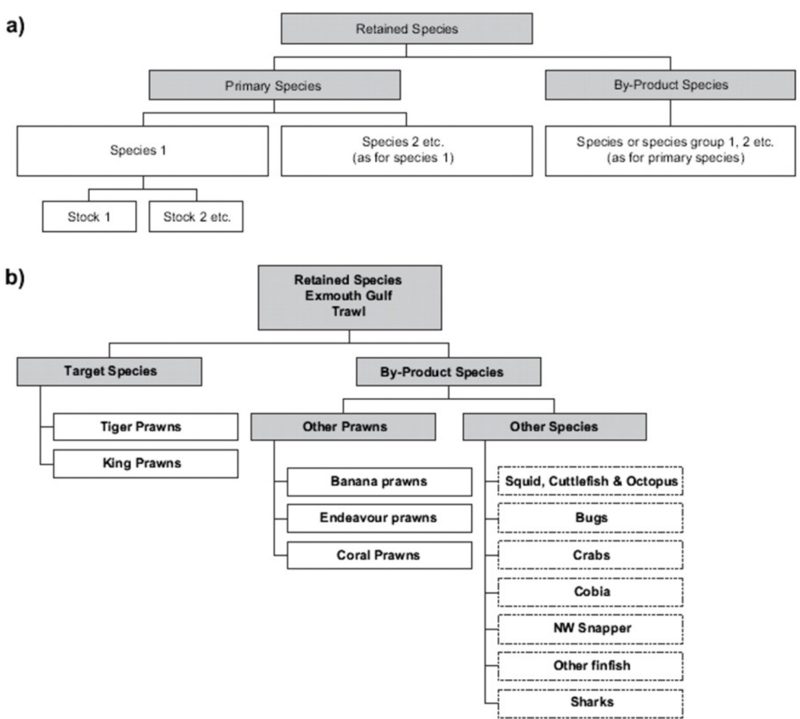
Workshop

The identification of issues and the initial assessment of their risk level were completed during 2001–2002 through a series of workshop style forums (see Fletcher et al., 2004, for details on workshop processes and aids) usually with one workshop per fishery. The participants at these workshops included invited scientific and technical experts, representatives of relevant government agencies (fishery managers, researchers, environmental agencies), and the main stakeholder/community groups, the commercial industry plus recreational, conservation/Non-Government Organizations (NGOs), and indigenous groups. There were usually 20–25 participants per workshop.

Issue identification

Issues to be assessed for each fishery were identified using the assistance of the component tree approach (see Figure 1 for an example). Three generic component trees, which outline the common issues within each of the three ecological components: (i) retained species (all species landed by the fishery), (ii) non-retained species (species caught but never landed – i.e. they are all discarded), and (iii) the General Ecosystem (indirect impacts of the fishery), were used as starting points. Issue identification involved group tailoring each of these trees to suit the individual circumstances of the fishery being examined by adding/expanding some components and collapsing or removing others, depending upon the fishing methods, areas of operations, and the species involved.

Figure 1. An example of (a) a generic component tree (modified from Fletcher et al., 2002) and (b) a completed component tree for the retained species of the Exmouth Gulf Prawn trawl fishery. The solid boxes indicate those issues that the risk assessment determined required direct management and/or monitoring. The dashed boxes indicate issues that were assessed as being of negligible risk from this fishery and therefore not requiring direct management by this fishery.



This approach improves the process of issue identification by moving through each of the ecological components in a comprehensive and structured manner, maximizing consistency and minimizing the chances of missing issues. During this stage there is no discussion of the importance of an issue, any issue raised by a participant is added to the relevant tree for subsequent assessment during the Risk Analysis phase.

Scope of the risk analysis

For the purposes of this prioritization process, a relatively high level approach was taken by asking 'what was the risk generated/added for each issue from having the fishery?' Moreover, because "risk is the chance of something happening that will have an impact on objectives" (Standards Australia, 2000, 2004a), we needed to be clear about "whose" objectives were being assessed. For these analyses, the assessments were made against meeting the legislative objectives of the fisheries management agency in Western Australia (FRMA, 1994). Different outputs may have been achieved if another set of objectives had been used. Similarly, the consequence and likelihood levels were determined in the context of what existing control measures were already in place. Again, the outcomes of a risk analysis should be different depending upon whether the current management arrangements are, or are not, included in the assessment.

Fisheries examined

The seven fisheries examined using these risk analysis techniques covered a variety of fisheries types, including three trawl fisheries, two dive-based fisheries, a line-based fishery, and a pot-based fishery (see Table 4 for summary). This set of fisheries covers most of the potential categories of ecological issues associated with fishing, along with a range of information levels and management methods, and therefore provided an effective test of the methodology. It should be noted that the risk analysis procedure for the first fishery assessed (Rock Lobster) was facilitated by a consultant group (IRC), who used a single set of consequence criteria, but these values have subsequently been converted to be consistent with the current system.

Table 4. Summary descriptions of each of the seven fisheries examined (full descriptions in Penn et al., 2003) and a summary of the extra management actions that arose from the risk assessment process.

Fishery	Fishing method	Target catch[*]	Main management method[†]	Summary of significant additional management actions required
Western rock lobster	Pot	9–14 000 t of western rock lobster	ITEs – limited pot numbers and closed seasons	Develop mitigation mechanisms for the capture of sea lions
				Examine mechanisms for monitoring ecosystem impacts of the fishery in deeper water
				Research changes in fishing efficiency
Shark Bay prawn trawl	Otter trawl	1 500–2 500 t of tiger, king and other prawns	ITEs – limited entry, gear restrictions, complex spatial and temporal closures	Biodiversity surveys inside and outside trawled areas.
				Monitor area of trawl activities each year
				Increased protection of tiger prawn spawning stock
				Monitor all protected species interactions
Exmouth Gulf prawn trawl	Otter trawl	700–1 300 t of tiger, king, and other prawns	ITEs – limited entry, gear restrictions, spatial and temporal closures with real-time management.	Ongoing monitoring to identify long-term trends in bycatch between fished and unfished areas
				Monitor area of trawl activities each year
				Monitor all protected species interactions
Shark Bay scallop trawl	Otter trawl	100–1 000 t of saucer scallops	ITEs – limited entry, gear restrictions, spatial and temporal closures	Develop decision rule for closing the fishery or preventing commencement when annual recruitment is too low
				Monitor all protected species interactions
Abalone	Hand collected	300 t of brownlip, greenlip, and roe's abalone in up to three zones	ITQs – on all abalone species (based on tonnage)	Develop enhanced fishery independent monitoring programmes
				Develop decision rules or strategies to prevent serial depletion
Pearl oyster	Hand collected	570 000 silver lipped pearl oysters	ITQs – on pearl shell (based on numbers)	Nil

Fishery	Fishing method	Target catch[a]	Main management method[b]	Summary of significant additional management actions required
Shark Bay snapper	Line	750 t of snapper and other demersal fish	ITQs – on snapper (based on commercial tonnage – TAC)	Include all sources of mortality in assessments and determination of TAC Develop a precautionary spawning biomass as performance measure.

[a] The catch levels and quotas are for the 2002–2003 season.

[b] ITE indicates individual transferable effort units, ITQ indicates individual transferable quota units.

Risk assessment reports

Each of the completed risk assessment reports was not just the levels and risk values generated during the workshops, but included an appropriate level of documentation to justify each of the risk levels selected. Usually, summaries of this information were provided at the workshops to determine the risk values, with the written reports providing full details backed up with references to relevant scientific publications. This was done to allow stakeholders and external auditors not present at the workshop to understand why issues were accorded the values and because it allows for more effective review of risk values at some later date.

These risk assessment reports formed the basis of applications for each fishery against the Australian Government's sustainable fisheries criteria (Commonwealth of Australia, 2001), which are required for a fishery to maintain its export accreditation. Consequently, each of the risk values and its justifications have been externally reviewed and accepted as part of this process. These applications (plus an additional 20 WA fishery applications submitted) are available from http://www.deh.gov.au/coasts/fisheries/assessment/wa/index.html.

Results

General

Across the seven fisheries, 115 issues were identified and assessed. There was a substantial difference in the number of issues identified among the different fisheries, with only five issues identified for the dive-based, single species Pearl Oyster fishery compared with over 30 for the multispecies, Exmouth Gulf Prawn trawl-based fishery. The issues were distributed relatively evenly across all three categories of ecological impacts with 38 retained species (target and by-product) issues, 32 non-retained (discard and protected) species, and 45 ecosystem/habitat issues.

The various consequence and likelihood values identified for each of the issues covered a wide range of the possible combinations (Figure 2) and risk values (Figure 3). The outcomes, and any lessons identified in conducting the assessments within each of the three environmental categories, are outlined below.

Figure 3. The number of issues assessed as being within each risk category for all three ecological categories combined.

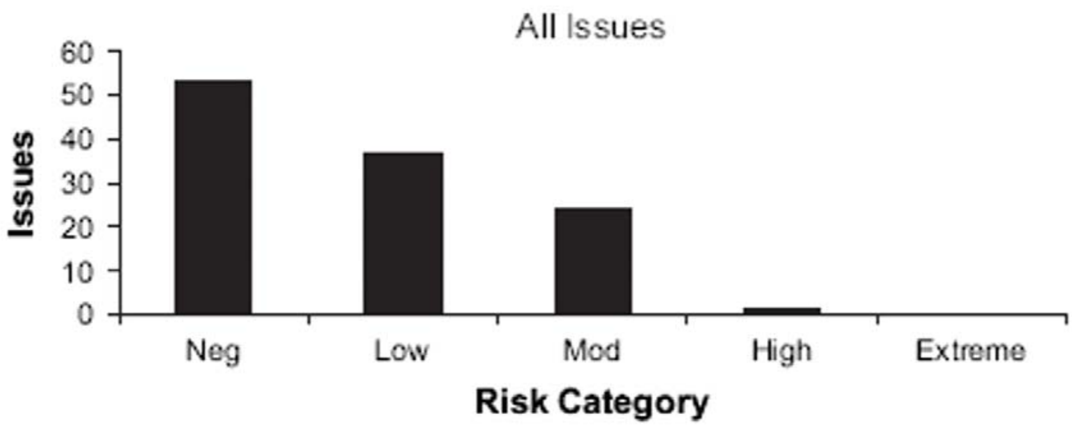
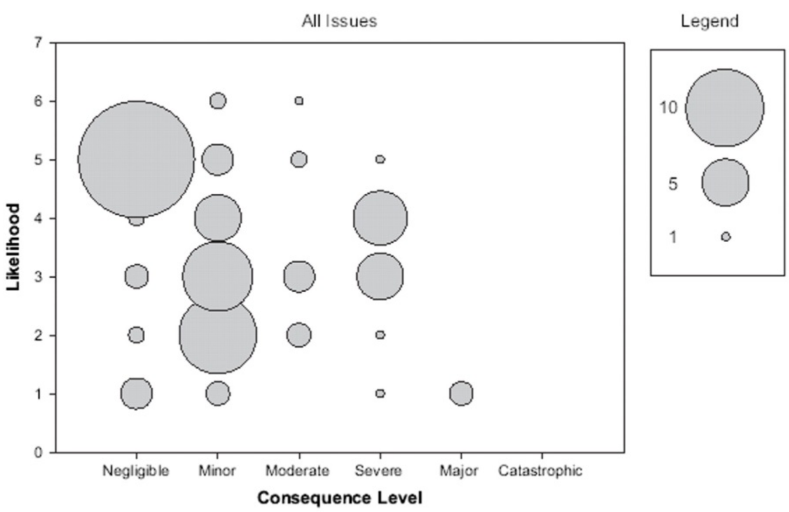


Figure 2. The consequence and likelihood pairs for each of the 115 issues assessed across the seven fisheries. The size of the circle is proportional to the number of issues with that combination of scores.

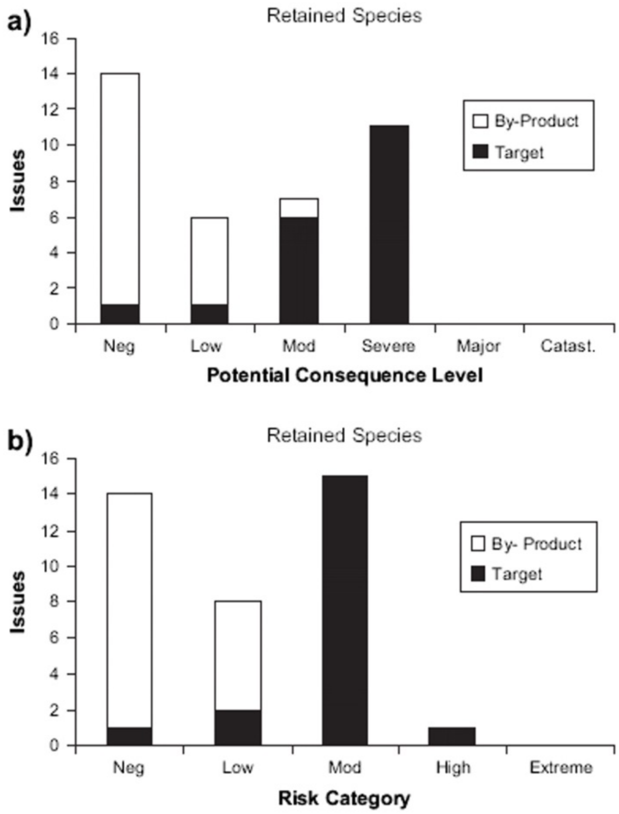


Retained species (target and by-product species)

To generate an appropriate consequence and likelihood score for each of the target species, the analysis of the risk values needed to consider and integrate a number of elements. Firstly, the assessments were completed at the level of the locally reproducing population, or what is often defined as the unit stock for management purposes, and included all removals by any fishery (not just the capture by the fishery being assessed). This required having information on how many fisheries captured this species and what amounts each landed and discarded. The analysis also took into account how the biology and distribution of the species affected its susceptibility to overfishing and also whether the current management arrangements, including compliance with rules and any effort/catch limitation methods, were working effectively or not.

The range of potential consequence values assigned to the different targeted stocks reflected the objectives of most commercial fisheries, which is to fully harvest target stocks but not overfish them (Figure 4a). Therefore, across the seven fisheries, 19 target stocks were examined and nearly all had potential consequences of at least a moderate level, with some, especially the abalone stocks, having potential consequence values in the ‘severe’ category, because they are especially prone to overfishing (Fletcher et al., 2003).

Figure 4a. The number of retained species issues (both target and by-product species/stocks) that were assessed (n = 38) as being within (a) each of the potential consequence levels, and (b) each risk category.



The potential consequence level assigned to most by-product species was usually negligible or low, reflecting that most were not classed as particularly vulnerable to the fishery and, therefore, only relatively small amounts were caught from small areas compared with their total distribution (if this was not the case they should have been assessed as 'target species', see Table 1 – Set B for details). The exception was where the by-product species in the fishery being examined was the target for another fishery. This usually resulted in the analysis of these species being referred to the targeted fishery where this by-product catch would be included as part of a full assessment.

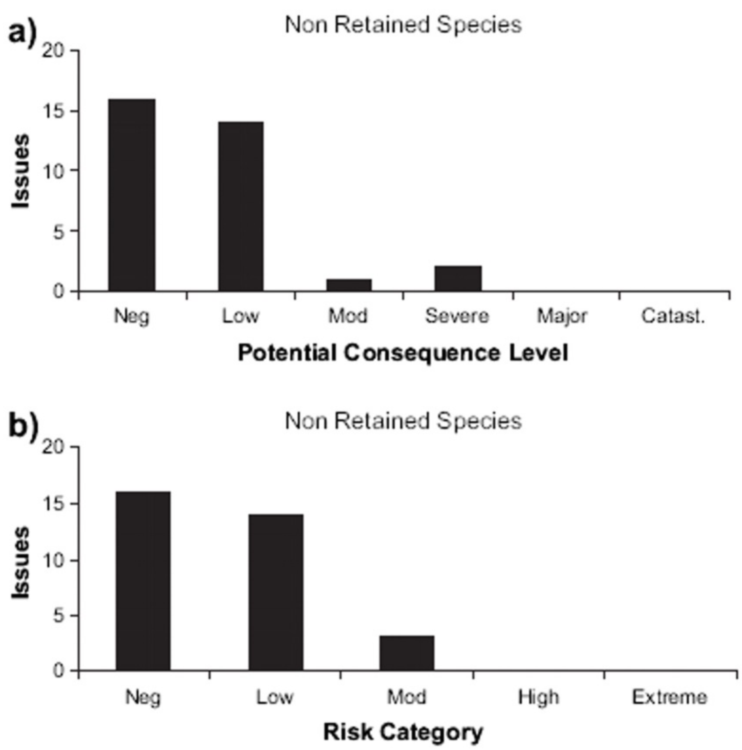
For some of the retained species it was determined that while the impact of the fishery may have potentially severe consequences, the likelihood of this outcome actually occurring was sufficiently low (given the assessment of current management effectiveness) that in only one case did the risk value exceed the moderate level (Figure 4b). In this instance, the management regime needed to increase the level of protection for the tiger prawn stock through the implementation of 'real time' catch rate triggers which determine when to close areas to the fishery. For the other targeted stocks, the main impact on their management from this assessment process was the requirement to generate more robust annual performance indicator levels for five of these 19 stocks (Table 4) to lessen the chance that the stocks will become overfished in the future.

For the by-product species, the risk ratings were mostly either negligible or low and therefore did not require specific additional management controls to be developed. The process did, nonetheless, identify that an annual assessment of catch levels of each of the by-product species was needed to monitor any changes in targeting practices and, therefore, the risk.

Non-retained species (discards and protected species)
The questions covered (and the types of data used) for the assessment of the issues within this category were generally similar to those for retained species. For some issues, the analysis was complicated by the need to assess 'icon' protected species, such as cetaceans and pinnipeds, which not only have different dynamics from finfish, but for which different levels of impact are accepted by the public. There was also a need to assess the relative impact on these species from the fishery being examined compared with the distribution of the species and other impacts on the stocks (including other fisheries), often with limited levels of information available1.

In the majority of cases, the potential consequence level on non-retained species was negligible or low. In two cases, one related to impacts on sea lion populations which have very localized distributions and the other for a species already endangered by other factors (leatherback turtles), the potential consequence level was moderate or severe (Figure 5a). Given the management actions already in place or proposed, the risk values for these two issues were determined as moderate. The majority of other non-retained species issues were rated as having only a negligible or low risk mostly because it was assessed that the fishery only impacted on a small proportion of the stock(s) and/or only affected a small proportion of their range (Figure 5b).

Figures 5a and 5b. The number of non-retained species (discards and protected species) issues that were assessed (n = 32) as being within (a) each of the potential consequence levels, and (b) each risk category.

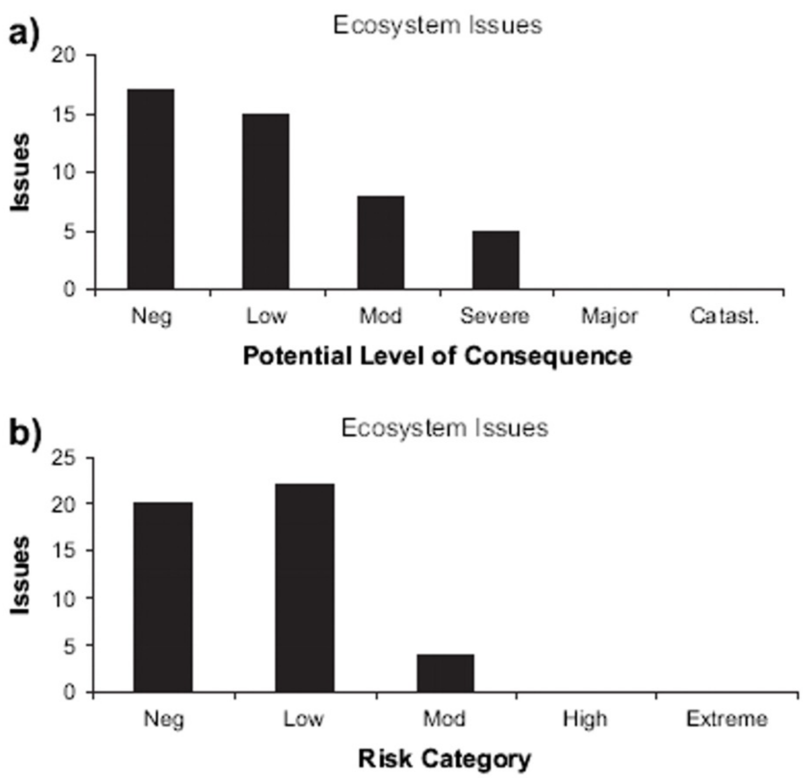


The two major initiatives resulting from the risk analyses included the development of a research programme to ameliorate the impacts on sea lion pups by the rock lobster fishery and a survey to confirm or refute that the non-retained species caught by the three trawl fisheries are widely distributed in regions beyond the areas fished and therefore provide more information for the next risk analysis (Table 4). There were few additional management outcomes related to non-retained species issues, apart from the general need for each fishery to record their interactions with protected species.

General ecosystem (habitat and ecosystem issues)
Assessing the habitat impacts that may result from each fishery was done at a regional level, with impacts judged against the best estimate of the original extent of each of the habitats, not their current distribution. Similarly, the assessment of potential overall consequences on the ecosystem from the removal of biomass by the fishery was done at the level of the entire ecosystem. This was often assisted by separately assessing the potential impacts on any prey and predator species and by determining whether any potential "keystone species" (sensu Paine, 1966; which is not equivalent to just being a higher order predator) are being affected.

There was a large spread of consequence levels for ecosystem-based issues across the seven fisheries (Figure 6a). A small number of potentially moderate and severe levels were identified, mostly related to impacts on the benthos and the impacts on scavenger species feeding on discards, plus there was also potential translocation/disease importation issues associated with the use of imported bait.

Table 6a. The number of ecosystem and habitat issues that were assessed (n = 45) as being within (a) each of the potential consequence levels, and (b) each risk category.



In all but four cases, the consequence and likelihood combinations resulted in the ecosystem issues being categorized as low or negligible risks, requiring little or no additional monitoring or management (Figure 6b). The major new initiatives that resulted from the risk analysis of the seven fisheries included the need to initiate research on the deep-water trophic interactions that may result from rock lobster fishing, and to monitor the area trawled by the two prawn fisheries on an annual basis to ensure that the habitat structure and biodiversity of the regions are likely to remain within acceptable levels (Table 4).

The qualitative risk assessment techniques used in this study were successful in identifying and prioritizing issues across a wide range of Western Australian commercial fisheries, and more importantly, across the full range of ESD/Ecosystem related issues. The potential impacts assessed included impacts on protected species caught by pots, impacts on benthic habitats from trawling, and trophic impacts from removals of target and bycatch species. Previous implementations of risk assessment in fisheries have been more restricted in scope, mostly covering just the key target species (e.g. Lane and Stephenson, 1998) or analyses of the inherent vulnerability of individual bycatch species (Stobutzki et al., 2001). Having a system that can cover all issues, in a consistent and transparent fashion at a fishery level, will become increasingly important as the level of public scrutiny continues to increase (Stephen, 2001).

Impact on management

Despite initial concerns that the assessment of fisheries against ESD principles would generate the need for a significant increase in resources, of the total of 115 issues identified and assessed across the three components and seven fisheries, only 27 had moderate and higher level risk values that required direct management. Moreover, while the increased breadth of topics resulted in 96 “non-target species” issues (of the 115) being examined, only six of these required additional direct management or a major research commitment, with minor adjustments being made in others (see Table 4 for summary). Consequently, the application of this risk analysis module has allowed the implementation of ESD for all commercial fisheries in Western Australia to proceed without causing an unrealistic, and importantly, unnecessary increase to the costs of management.

It is recognized, however, that the modest increase in issues needing management generated in this study may not be reflected in all circumstances. Clearly, the level of increase will be dependent upon the fishery being examined and the management arrangements already in place. In some jurisdictions and locations where current restrictions (or compliance) on the fishing methods allowed and controls on the total effort/catch are not as robust, such assessments may highlight many areas requiring improvements. Even in these cases, the scoring system can discriminate among these to identify the higher risks and help prioritize which issues need to be addressed first.

Stakeholder acceptance

In addition to prioritizing issues, one of the main benefits of using this system has been the significant engagement of the various stakeholder groups through the process. This occurred at a number of stages: including issue identification, the initial rating of risks, and also in the review of the risk reports that are generated.

At the issue-identification stage, all participants were encouraged to raise any potential issues for assessment, including those where only rumours of an impact were available. It was considered beneficial to formally address all issues raised because if someone at the workshop believed it was a problem, others may also hold this view. While such issues were often found to have low risk values, and in some cases the assumed impact did not even occur, the reports show that it was raised and dealt with fairly.

The determination of the risk values included input from all stakeholders, rather than being a purely expertise-based process. For most issues, a consensus was used for determining the appropriate risk values based on the available evidence, which was mostly provided by the relevant experts. At times, however, there were differences of opinion and consensus could not be achieved, in which case, each proposed risk combination and the rationale for this position were recorded. The ultimate risk combination used was determined after each proponent had the chance to provide more detailed written submissions; with the final view being the one most supported by the submitted information. In most cases where parties suggested more extreme views (either significantly higher or lower than the majority) they were generally unable to provide sufficient direct evidence or inferential information to support their position. Nonetheless, the risk assessment report still recorded that alternative views were provided, which should assist reviews at some point in the future.

Differences of opinion sometimes arose where there was insufficient supporting evidence available at the workshop. In these cases, the environmental groups often wanted either a higher risk recorded until they saw the extra material, or a conditional agreement was reached whereby if sufficient material were produced in the written report to support the statements, they would agree with the proposed risk values.

The high level of involvement has, in most cases, assisted in the acceptance by stakeholders of the outputs from this process. It has also provided a forum for the various groups to “clear the air” by explicitly giving the opportunity to assess anything that may have been thought to be an issue. For some fisheries, there was ultimately full agreement about the risks, and even in cases where this was not achieved, the number of contentious issues was usually only one or two, considerably smaller than before the process was initiated.

Ecological or social values?

The risk assessment process was in some cases made more complicated where, in addition to the potential ecological consequence, the impact also evokes a strong public reaction based on societal values. Similar difficulties were identified for the interpretation of risk assessment within the fish health area (Stephen, 2001) and reflect that all assessments of the level of acceptability are affected to a greater or lesser extent by societal values.

In Australia, there is a category of species classed as “protected” for which capture is prohibited, but they may be neither threatened nor endangered. This includes all cetaceans and pinnipeds, many seabirds, and even syngnathids, and these species commonly interact with fisheries (e.g. five of the seven fisheries examined here identified issues relating to one or more of these groups). Assessing the risk of a fishery's impact on these species is more difficult because the level of “acceptable” capture is often affected more by public opinion rather than a strict ecological assessment, and this is inherently more difficult to define. Given the penalties involved for the unlawful capture of these species, this category of issues has the potential to shut fisheries down without an actual ‘ecological’ threat being documented. Such situations are likely to increase in scope over coming years in line with changes in the public's opinions, in which science is now frequently being seen as only one of the inputs to the decision-making process.

For management purposes, it is important to recognize which type of objective (societal or ecological) is being assessed and, therefore, which consequence scales need to be used (which is why a separate Protected Species table was developed). For example, there is little value using resources to determine the ecological impact from the capture of ‘x’ number of a protected species by a fishery if the community will not tolerate, for moral reasons alone, that level of capture. In these cases, reducing the levels of capture may be the only option for continued access.

Levels of data and uncertainty

Many of the assessments outlined in this study were completed with relatively little quantitative data. This is not uncommon. Even fisheries that have significant levels of data for their target species generally have limited information for many of their by-products, bycatches or ecosystem issues (Whitworth et al., 2003). In such circumstances, scientific inference from the literature, and management experiences associated with similar issues and impacts elsewhere, can be used effectively. There are very few issues for which no information is available to make an informed assessment. The key point of the process is to try and ensure that the level of resources applied to the future management and/or monitoring of an issue should be matched with the level of risk (this may include the need to collect more data to reduce the uncertainty – see below).

The level of uncertainty can be factored into the score combination that is chosen to best reflect this understanding. For example, if there is some uncertainty about the effectiveness of management for a target stock, it is probably more appropriate to score the fishery as possibly having a severe impact (consequence levels of 3 and likelihood levels of 4) rather than expressing it as likely to have only a moderate impact (consequence levels of 2 and likelihood levels of 6). While the risk scores are the same (i.e. 12), the former combination more appropriately reflects the current knowledge of its status.
It is also important to recognize that these techniques may be just the first step in the process. Once an issue is rated as moderate or higher risk, then it requires a more detailed assessment to determine what management, research, and monitoring are necessary. Where the process initiates the collection of more information, more precise, quantitative assessments of risk may be possible. In such cases, these reviews could either confirm the need for direct management, identify that an even greater level of control is needed, or suggest that the initial risk rating was too high and that direct management may not be required. Where greater management controls are needed, this system should help the focus of additional measures to either reduce the potential consequence level resulting from the activity, or reduce the likelihood of the unacceptable consequence occurring, or both.

Conclusion

The risk assessment techniques outlined in this paper have now been effectively applied to the remainder (a further 20) of WA's export fisheries and also for a number of wild capture fisheries in other jurisdictions (e.g. Fletcher et al., 2003; Zeller, 2005). Moreover, this system has also been successfully adapted for use in identifying and assessing the risk of issues associated with the development of management plans for aquaculture (Fletcher et al., 2004).

The key elements for the success of this system are that it is relatively simple to apply and all issues can be assessed, even where minimal data are available. The inclusive nature of the process and the need to fully document outcomes increase both the transparency and discipline of management decision-making, and also the acceptance by stakeholders. Given this success, the use of formal risk assessment techniques have now become regular methods for the development or review of many operational systems, thereby improving the entire fisheries management process in WA.

Acknowledgments

This work was completed with the assistance of many individuals and groups. This included the Fisheries Research and Development Corporation (FRDC) funded, ESD Reference group, and, particularly, the ESD project team who were responsible for the development of the National ESD framework, of which the risk assessment module was a component. The various WA researchers, managers, fishers, and stakeholder representatives who participated in these workshops and provided the supporting data to justify the various risk scores. Two anonymous reviewers provided extremely useful comments to clarify the descriptions provided in the text. Finally, IRC (Perth, WA) were the consultants who facilitated the first risk assessment workshop, the outcomes of which inspired and assisted in the development of the process presented here. This forms publication number 12 in the ESD Reporting and Assessment Subprogram Series.

Footnotes

In some other assessments (e.g. Zeller, 2005) it has been identified that a separate assessment of the cumulative risk to some bycatch species from all fisheries/activities in the region (not just the fishery being examined) may need to be done where a full understanding of all impacts was not possible at the workshop.