Providing social science objectives and indicators to compare management options in the Queensland trawl planning process

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1 Non Technical Summary

2009/100	Providing social science objectives and indicators to compare management options in the Queensland trawl planning process

Project details

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Objectives

1. Identify social objective and indicators of relevance to the Queensland trawl fishery.
2. Test and verify applicability of social objectives and indicators using semi-quantitative analyses with stakeholder groups.

Outcomes achieved to date

The project contributed to a stakeholder process that allowed open and transparent discussions about the future management options for developing a new management plan for the trawl fishery.

The project has defined, through broad stakeholder consultation, the objectives and indicators of this fishery and their relative weight across social, economic, sustainability and governance structure components. This is a major development in this fishery.

The project team, with stakeholders, developed future management strategies and evaluated their impact relative to all indicators for each objective. It highlighted one strategy above all others and this has been the basis for new management options.

A review of stakeholder opinion at the end of the process showed that the large majority of stakeholders were extremely satisfied with the process.

Background

Fisheries management has traditionally been directed by ecological and, more recently, economic objectives. However, a need for consideration also of social objectives has become apparent with the increasing interest in triple bottom line assessments of industry and government performance. These, however, have remained largely unaddressed in terms of integration into management plans for specific fisheries. A key aim of this study is to redress this problem and to develop a framework in which social, economic and ecological considerations can be incorporated into the formulation of management plans. The framework is applied to the Queensland East Coast Trawl fishery, which is currently undergoing a revision of its management plan.

Consideration of the social impacts of different management options is important for the Queensland East Coast Trawl fishery. The fishery includes communities where trawling is the major source of income as well as communities in which trawling is only a minor component of the community's activities and income. While it is managed as one fishery, several distinct sub-fisheries (termed sectors) exist based on different species and using different fishing methods in some cases. Some fishers operate in several sectors while others specialise in just one. The fishery is currently managed through a transferable effort unit system, where vessels are allocated a given number of effort units to operate each night based on their vessel size. Effort units can be deployed across any or all of the different sectors, with no effective cap on effort applied to any particular sector. This complex multi-species, multi-fleet fishery also spans almost the whole length of the eastern Queensland coast (incorporating the Great Barrier Reef Marine Park). The fishery has an annual catch worth about $100M – making it Queensland's most valuable fishery.

The fishery is currently managed under the Fisheries (East Coast Trawl) Management Plan 2010, which was made on expiry of the original Fisheries (East Coast Trawl) 1999 that commenced in 2000 and established the effort control system currently in place. Consultation with stakeholders in 2009, on expiry of the 1999 plan, suggested that a substantial revision of the management plan would be appropriate. The 1999 plan was subsequently remade (without change) into the 2010 plan until a comprehensive review of the management arrangements could be completed. Management options under the future plan need to balance community, economic and biological needs, as any changes to the management of the fishery can substantially change the biological status of stocks and fishery profitability, and also influence equity between fleets and communities.

This project facilitated key components of the management review. In particular, it identified the objectives and indicators relevant to the new management plan and assessed a range of alternative management systems against these objectives. The project team worked with a broad range of stakeholder groups, including commercial fishers, recreational fishers, processors, conservation groups, and fisheries managers to help identify strengths and weaknesses of different management alternatives and facilitate the development of a new management system for the fishery.

Overview of the process

A staged approach was used in which a set of management objectives, including social, were identified and then different management strategies were assessed against the set of management objectives. The process involved, first, elicitation of a) objectives and indicators, and b) their relative weighting in regard to perceived performance. The next step used stakeholder and expert groups to c) develop management strategies, and to d) assess the relative performance of these against each management objective. This latter process meant that the strengths and weakness of each strategy could be identified. Finally, the objective weights were applied to determine which strategy also best met the objectives of each stakeholder group and e) to develop an overall performance score for each management strategy.

Two expert driven committees, one being a subset of the other, were formed and were essential to the broader process undertaken in this project. The smaller strategic group (called the Trawl Scientific Advisory Group - SAG) consisted of scientists (biological, economic and social), fisheries managers, and industry (both fishing and post harvest activities), while the larger tactical group (called the Technical Advisory

Group - TAG) included several SAG members but also additional industry participants, as well as marine park management, compliance, recreational and conservation interest groups. The SAG worked as a think tank to develop and refine several management "strawmen" (broad alternative management strategies that were to be tested and analysed). The larger TAG was more representative of the key stakeholders in the fishery. Critical feedback on the likely efficacy of the strawmen was given by this tactical group.

Information on the biological status of the resource, trends in catch and effort, risks to the marine ecosystem, external pressures on both managers (e.g. desired legislative reforms) and industry (e.g. input and output prices), boundaries (e.g. individual transferable quota system would not be considered acceptable) and specific issues and concerns relating to particular sectors, were provided to both SAG and TAG members, but are not part of this project.

Social and other management objectives

As with fisheries management in most countries, multiple objectives were implicit in policy statements relating to the fishery, but were poorly specified in some areas (particularly social objectives) and strongly identified in others (e.g. an objective of sustainability). This project undertook an analysis of what objectives the management system should aim to achieve. A review of natural resource management objectives employed internationally was used to develop a candidate list, and the objectives most relevant to the fishery were shortlisted by the SAG. Additional objectives specific to Queensland fisheries management, but not identified in the international review, were also identified and incorporated into the objective set. These objectives were placed in a hierarchy covering four broad components, namely “Maximise economic performance of the east coast trawl fishery”, “Simplify and improve management structures”, “Maximise social outcomes” and “Ensure sustainability”. Each of these had several sub-objectives that were more specific to the fishery. Under the general social objective of "Maximise social outcomes", three broader social objectives were identified, namely "Maximise employment", "Ensure Equity", and "Maximise other social benefits from the use of the resource to the local community".

A stakeholder elicitation process was used to further refine the set of objectives, and then weight their relative importance. This relative weighting was undertaken by the SAG, TAG and an external set of stakeholders from the conservation arena, recreational fishers, commercial fishers, processors, scientists, managers and representatives of the broader community - 90 valid respondents. The relative importance of the different objectives to different stakeholder groups was assessed using the Analytic Hierarchy Process. As with other studies of fisheries management objectives, the relative importance of the different objectives varied both within and between the different stakeholder groups, although general trends in preferences could be observed, for example the high importance of economic and sustainability objectives relative to the low importance of social objectives.

Management indicators

A literature review of indicators used in natural resource management was also undertaken. As is quite common in the literature, a distinction was made between *ex post* (what can be collected to monitor management changes after its implementation) and *ex ante* (indicators about expectations of management performance) indicators. The analysis undertaken in this project mostly used the latter indicators to help determine management performance of the alternative management options. The SAG and TAG reviewed the list of indicators for each objective. Although the TAG and SAG refined the initial list, the result still produced several indicators for each objective – highlighting the complex nature of the different objectives. Both committees were asked to qualitatively assess the performance of a management scenario against the cluster of indicators per objective. In the case of the TAG, this was done individually but in a workshop setting. The facilitator explained each indicator, objective and management strategy step-wise and the member filled in the direction and degree of change on a scale of -3 (worse) to 3 (better). This avoided the need to weight each of the indicators as well. In other words, qualitative estimates of the degree of change to be expected (over the next ten years) in these indicators were provided by stakeholders in a complex

and comprehensive engagement process. The review, Queensland specific objectives and possible indicators were provided to the National Social Objectives project (FRDC 2010/040). This was used as an input to further developing nationally applicable objectives and indicators that are most relevant to stakeholders.

Management strawmen

Multi-species fisheries are complex to manage and the ability to develop an appropriate governance structure is often seriously impeded because trading between sustainability objectives at the species level, economic objectives at the fleet level, and social objectives at the community scale, is complex. Many of these fisheries also tend to have a mix of information, with stock assessments available for some species and almost no information on others. The fleets themselves also comprise fishers from small family enterprises to large vertically integrated businesses.

The present management system has a tradable effort (input) unit system at the whole of fishery level. This means that although there are several reasonably distinct sectors within the fishery (e.g. scallop, eastern king prawn etc.) an effort unit enables a vessel to fish in any of these sectors. This has historically presented difficulties in managing for sustainability at the sector level, as no mechanism exists to control access to each of the sectors. As a result, the strawmen had to initially define at which spatial scale the tradable unit comes into effect, and if, at the whole of fishery level, how each sector would be managed as an economical and sustainable unit. The remaining components of a strawman would then be set in the context of this decision.

The SAG was used to develop different governance strawmen (or management strategies) and these were assessed by the TAG using multi-criteria decision analysis techniques against the different objectives.

The SAG and TAG initially developed four strawmen: modified status quo (MSQ); decrementation system (DECR); separate sectors (SECT); and sector access levies (SAL). These were designed to be fairly different in their approach, but avoided (by agreement of SAG/TAG members and managers) an individual transferable quota system because it was considered inappropriate for the fishery at this time. All strategies still relied on a tradable effort unit. Within each governance structure, additional measures were also proposed to address particular issues identified. The four strawmen were fleshed out in enough detail so that they could be assessed against each objective using a qualitative indicator approach. This indicator was a subjective assessment of the ability of the strawman to achieve the objective relative to the current situation. Once the strawmen were assessed in terms of their relative impact compared to the *status quo* using a qualitative scoring system, they could be assessed using an overall score or by objective. One strawman clearly provided the best overall set of outcomes given the multiple objectives, but was not optimal in terms of every objective, demonstrating that even the “best” strawman may be less than perfect. This process resulted in the identification of clear directions in which the fishery management plan needs to go and issues it needs to address.

KEYWORDS: social objectives, qualitative management strategy evaluation, Queensland trawl fishery.

2 Acknowledgements

We wish to acknowledge the invaluable assistance of the Technical Advisory Group (TAG), Trawl Scientific Advisory Group (SAG) and various stakeholders who completed the objectives weighting spreadsheet and provided valuable input. We also thank all stakeholders who attended our road show, providing us with a wealth of knowledge. We are also thankful for the dedicated input to this process from DEEDI non-project staff, notably Ian Jacobsen and Shane Fava. This work was funded by the Fisheries Research Development Corporation, CSIRO Wealth from Oceans Flagship, the Queensland Government (Department of Employment, Economic Development and Innovation) and the Great Barrier Reef Marine Park Authority (under the Great Barrier Reef Climate Change Action Plan 2007-2012).

3 Background

In 2010 Queensland Primary Industry and Fisheries (QPIF) contacted FRDC regarding their research needs for the review of the Queensland Trawl Management plan. The main issue QPIF faced was a significant lack of social objectives around which to comprehensively model any new management approaches.

This project team was formed to investigate these social objectives. The team brought with it knowledge of social sciences and the Queensland Trawl fishery, and an understanding of how social objectives interact with economics and environmental objectives.

This Tactical Research Fund project was developed with the assistance of the Department of Employment, Economic Development and Innovation (DEEDI) and the Great Barrier Reef Marine Park Authority (GBRMPA).

This project linked directly with a similar project being run by the Department of Primary Industries and Resources of South Australia (PIRSA). To ensure good communication and links between projects, several project team members sat on both projects.

This project was supported by Fisheries Queensland (FQ), the Queensland Seafood Industry Association (QSIA) and GBRMPA. Both FQ and GBRMPA co-invested in this project with both a cash contribution and in-kind support. GBRMPA has a particular interest in ensuring that any outcomes of this project enhance adaptability of the fishery to longer-term changes.

4 Need

Fisheries management has mostly been directed by economic and ecological objectives. With the introduction of the call for triple bottom line assessments of industry and government performance, a need for social objectives has become apparent which has remained largely unaddressed in terms of integration into management plans for specific fisheries.

In addition, consideration of the social impacts of different management options is very important for the Queensland Trawl fishery. The reason for this is that the fishery ranges from having communities where trawling is the major source of income to the opposite case where trawling is only a minor component of a community's activities and income. The fishery also spans almost the whole length of the eastern Queensland coast with a complex multi-species, multi-fleet fishery, which is worth about $100M - Queensland's most valuable fishery. Management options need to balance community, economic and biological needs as any changes to the management of the fishery can substantially change the biological status of stocks, fishery profitability but also equity between fleets and communities.

Queensland DEEDI is presently developing a new draft Plan for comment and input to this process was essential and urgent.

There is therefore a need for specific social objectives and associated relevant indicators for Queensland DEEDI to use in the development of management plans and the assessment of them.

5 Objectives

The objectives of this project were:

1. Identify social objectives and indicators of relevance to the Queensland trawl fishery;
2. Test and verify applicability of social objectives and indicators using semi-quantitative analyses with stakeholder groups.

6 Methods

A staged approach similar to that described in Pascoe *et al*. [1] was used in which a set of different management strategies were assessed against a set of management objectives. The first steps in the process involved elicitation of a) objectives, b) related indicators (Appendix 3) and c) the objectives' relative weighting. The derivation and weighting of the objectives are described in detail by Appendix 5. The next steps used stakeholder and expert groups to d) develop management strategies and to e) assess the relative performance of these against each management objective (Appendix 4). This latter process means that one can derive the strengths and weakness of each strawman. Finally, the objective weights were applied to determine which strawman also best met the objectives of each stakeholder group and f) to develop an overall performance score.

Two expert driven committees, one being a subset of the other, were formed and were essential to the broader process undertaken in this project. The smaller strategic group (called the Trawl Scientific Advisory Group - SAG) consisted of scientists (biological, economic and social), fisheries managers, and industry (both fishing and post harvest activities), while the larger tactical group (called the Technical Advisory Group - TAG) included several SAG members but also additional industry participants, as well as marine park management, compliance, recreational and conservation interest groups. The SAG worked as a think tank to develop and refine several management "strawmen" (broad alternative management strategies that were to be tested and analysed). The larger TAG was more representative of the key stakeholders in the fishery. Critical feedback on the likely efficacy of the strawmen was given by this tactical group.

In order for stakeholders to make informed decisions, a mixture of information was provided to the stakeholders from the output of stock assessment models, a bycatch risk assessment approach, as well as basic data such as catch and effort. However, this information was not complete since the above information for some species was well known whereas that for others was only based on opinion elicited from experts. The whole process can be graphically described in Figure 1.

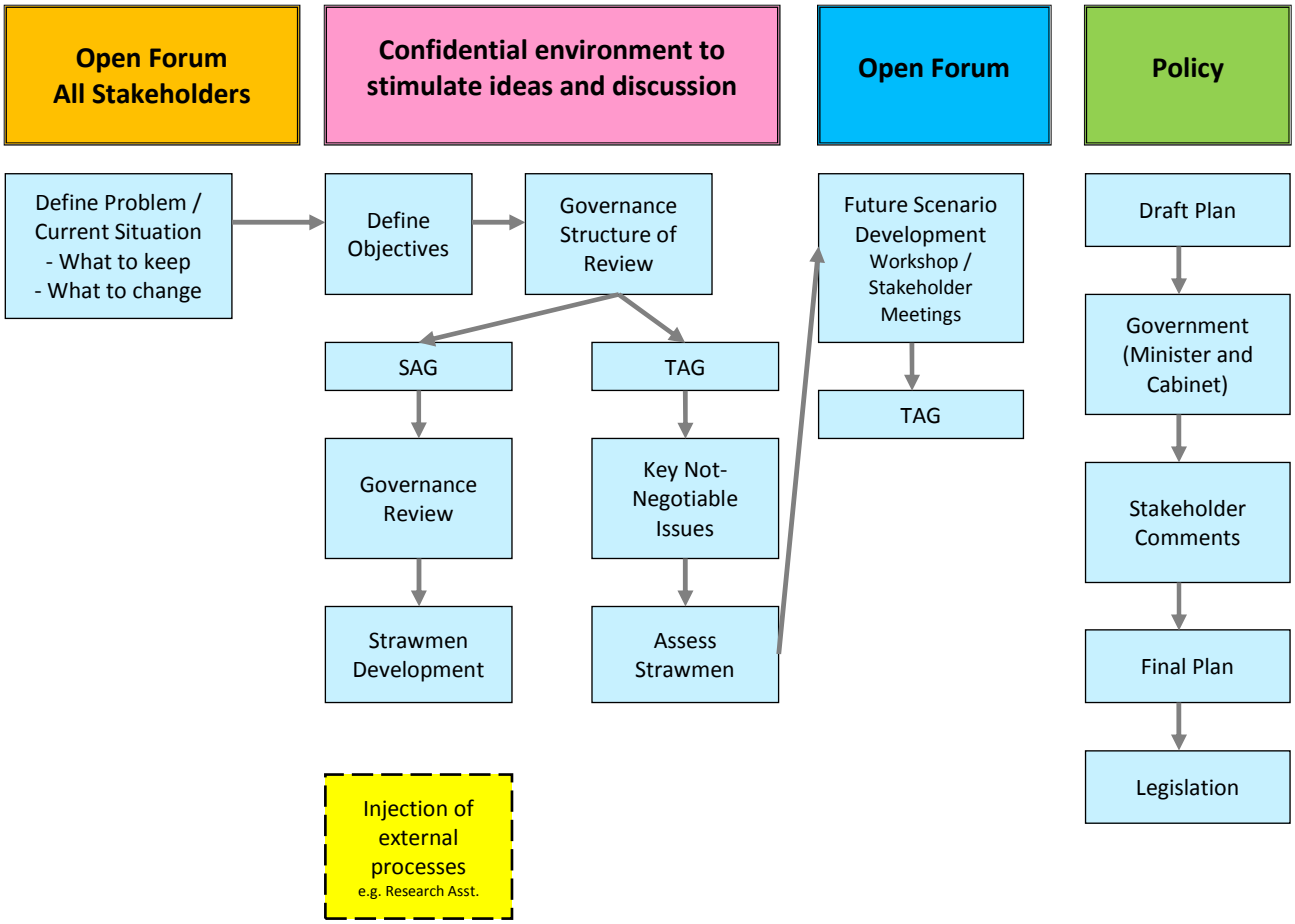

Figure 1. Stakeholder process undertaken by this project and DEEDI. This project was involved in the Confidential environment and the Open fora.

Four high level objectives were identified (Appendices 3,4 and 5), namely "Maximise economic performance of the east coast trawl fishery", "Simplify and improve management structures", "Maximise social outcomes" and "Ensure sustainability". Each of these had several sub-objectives that were more specific to the fishery. The relative importance of individual objectives was assessed using the Analytic Hierarchy Process (AHP) [2] through a mail out to individuals representing seven different stakeholder groups, being the fishing industry, the on-shore industry, managers (state fishery), conservation (marine park managers and conservation NGOs), recreational fishers, local communities and scientists. The weightings for each of the sub management objectives were assessed for each of the stakeholder groups.

6.1 Development of the management objectives hierarchy

An objectives hierarchy was developed initially through a comprehensive review of natural resource management objectives, including fisheries, forestry, water resources, agriculture and mining, and reference to ESD frameworks such as Fletcher[3]. The full set of objectives identified is presented in Appendices 3 (social objectives only), 5 (all objectives including their associated hierarchy and weightings) and 7 (Objectives with a short description). The set of objectives were cross-referenced with existing policy documents relevant to the fishery and the Great Barrier Reef Marine Park [4-7], as well as key legislation,[1] and a preliminary objective hierarchy was developed by the project team. The project team itself consisted of a biologist, social scientist, economist, fisheries manager and marine park manager. The preliminary objective hierarchy was presented to the SAG, which consisted of additional scientists, fisheries managers

1 Fisheries Act 1994; Great Barrier Reef Marine Park Act 1975

and industry members (both catching and processing sectors) established as part of the management review, and a revised objective hierarchy was agreed through consensus. This in turn was presented to the policy group of the government department responsible for the management of the fishery (the Department of Employment, Economic Development and Innovation, or DEEDI) who, after some minor additional adjustments, accepted the final hierarchy (see Figure 3).

6.2 Social objectives and their associated indicators

A number of social objectives and relevant indicators have been proposed in the fisheries and other natural resource management[2] literature (see Appendix 3, Table 2 for further details). There is considerably greater variety and scope in the social objectives and indicators than those generally used for economic and sustainability based objectives.

There is some disagreement about the appropriate classification of some objectives, particularly between economic and social objectives. For example, most economics based papers considered employment as a social objective, while some social science based papers considered it an economic objective. In terms of incomes, fisher income was generally considered a social indicator (as it related to the well being of the family), while vessel based measures of income (i.e. profitability) were considered an economic performance indicator. For example, in a national triple bottom line assessment that included fisheries, Foran *et al.* [8] considered only employment generation, income and government revenue as social indicators.

The social objectives and associated indicators identified in the literature review were presented to the SAG and TAG associated with the review of the Queensland East Coast Trawl fishery management plan. The SAG and TAG considered which social objectives and associated indicators may be most applicable to the fishery taking into consideration the Queensland Fisheries Strategy [4] as well as the needs of the fishing industry. The SAG decided on three broader objectives with several sub-objectives and indicators under the general objective of "Maximise social outcomes". These were also provided to the larger tactical group – the Technical Advisory Group (TAG). In all cases, a cluster of indicators was agreed upon for each objective. This is because the objectives were still reasonably high level and complex i.e. no single indicator was seen as being able to assess a strategy's future performance nor used for future monitoring purposes.

As a separate process, these social objectives and indicators were assessed for their utility in the context of climate change (Appendix 6).

6.3 Weighting of management objectives

The Analytic Hierarchy Process (AHP) [2] was used to derive the individual objective weights. AHP has been used in a number of fisheries applications to determine management objective importance and assist in decision making [6, 9-14]. AHP is based upon the construction of a series of pairwise comparison matrices, which compare sub-objectives to one another. One of the advantages of the pairwise comparison method is it makes the process of assigning weights much easier for participants because only two elements or objectives are being compared at any one time rather than all objectives having to be compared with each other simultaneously.

6.4 Elicit management strategies

The Queensland trawl fishery (Figure 2) was spatially divided into different fishery sectors that roughly correspond to different major species groups e.g. scallops, eastern king prawns etc. The design principle of

2 Given the criticism that social objectives are poorly defined in fisheries [4] Symes D, Phillipson J. Whatever became of social objectives in fisheries policy? Fish Res. 2009;95:1-5. Social objectives used in other natural resource management studies were also considered.

the process was to ultimately develop management strategies that would allow for an economically and ecologically sustainable fishery, but still consider social impacts.

The SAG and TAG developed the strawmen. The SAG worked as a think tank to develop and refine several strawmen, given critical feedback on the likely efficacy of the strawmen by the tactical group. The larger TAG was more representative of the key stakeholders in the fishery.

Information on the biological status of the resource, trends in catch and effort, risks to the marine ecosystem, external pressures on both managers (e.g. desired legislative reforms) and industry (input and output prices), parameters (e.g. individual transferable quota system would not be considered acceptable) and specific issues and concerns relating to particular sectors, were provided to both SAG and TAG members. The present management system has a tradable effort (input) unit system at the whole of fishery level. This means that although there are several reasonably distinct sectors within the fishery (e.g. scallop, eastern king prawn etc.) an effort unit enables a vessel to fish in any of these sectors. This has historically presented difficulties in managing for sustainability at the sector level, as no mechanism exists to control access to each of the sectors. As a result, the strawmen had to initially define at which spatial scale the tradable unit comes into effect, and if at the whole of fishery level, how each sector would be managed as an economical and sustainable unit. The remaining components of a strawman would then be set in the context of this decision.

The SAG developed strategies that would stretch the thinking of the larger TAG, for example managing the fishery through a series of decrementation systems linked to the effort unit system as opposed to the traditional spatial and temporal closures. The idea was to develop options that would stimulate innovative thinking and, although controversial, allow for new ideas to be explored and to move the fishery away from the *status quo,* given its present difficulty, to more effectively address sustainability issues or achieve economic goals.

6.5 Qualitative impact assessment

The SAG and TAG rated each strawman in terms of performance over the next 10 years *relative to the current situation* against each objective on a scale of -3 (“Considerably worse than current situation”) to +3 (“Considerably better than current situation) following the approach applied by Pascoe *et al*. [12]. This scoring was undertaken in a facilitated workshop where the facilitator explained each indicator, objective and management strategy step-wise and the member filled in the direction and degree of change The output of this process is an impact matrix $I^s_{i,j}$ where *s* is strawman, *i* is the number of objectives and *j* is the total number of TAG and SAG members. These members also rated their confidence in their score for each objective (but not by strawman), from 1 which is “very unsure” to 5 being “certain” termed the confidence score.

Applying the confidence scores, $C^s_{i,j}$, to the impact matrix is simply done by adding the impact matrix to the average (over *j*) of the confidence scores and normalising i.e. $\left(I'^s_{i,j} + \overline{C}_i\right) / \overline{C}_i$. This results in higher weight being applied to strategies where participants scores were more certain, and lower weight to those where scores were less certain.

The relative weights per respondent (from the SAG, TAG and mail out group) for each objective were combined into a single relative weight matrix, $W^t_{i,r}$ by stakeholder group, *t*, where *r* is the number of respondents to the survey (which is of course a larger number than *j*). The overall results can therefore be combined, $W'I$ for each stakeholder group and strawman. Where the sums of all the objectives are a positive score, an overall positive contribution is indicated and a negative score indicates an overall negative result relative to the current situation. The scale of the confidence score indicates the degree of a positive or negative change expected.

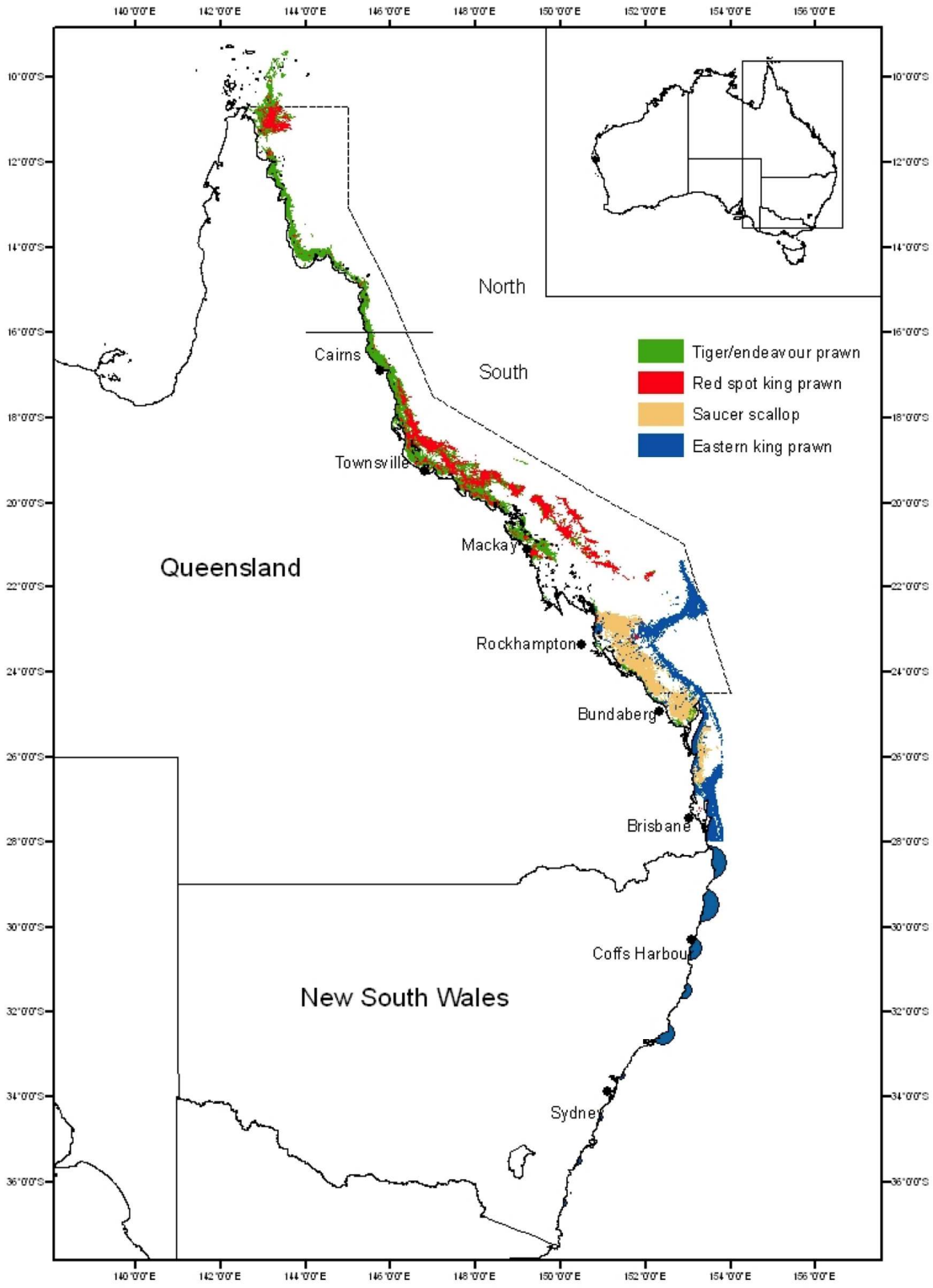

Figure 2. Map of the Queensland trawl fishery showing the different sectors and the reef and Marine Park boundary of the Great Barrier Reef. Source: Queensland Department of Employment, Economic Development and Innovation.

7 Results/Discussion

Detailed results are provided in Appendices 3 to 7.

7.1 Results

7.1.1 SOCIAL OBJECTIVES AND INDICATORS

The overview of social objectives and relevant indicators used in the fisheries and other natural resource management literature is provided in Appendix 3, Table 2, potential economic objectives and indicators are provided in Appendix 3, Table 3, and potential sustainability objectives and indicators are in Appendix 3, Table 4.

The SAG and TAG decided on three broader social objectives with several sub-objectives and indicators under the general objective of *"Maximise social outcomes"*, namely:

a. Maximise employment:

- Maximise employment in the fishing sector: crew, skippers etc – will the management scenario affect the amount of direct employment in the fishery?
- Maximise associated onshore employment: in processing or supplying sectors of the fishing industry – will the management scenario affect associated on shore employment e.g. net makers, processors, gear suppliers and other businesses that rely on the fishery?

POTENTIAL INDICATORS:

- Number of people employed in the sector
- Proportion of seasonal verses fulltime employment
- Employee satisfaction in the industry
- Proportion skilled versus unskilled labour
- Number and type of boats

b. Ensure Equity:

- Ensure equitable access to the resources – will people have a fair and equitable access to all resources?
- Minimise conflicts with competing users: e.g. other gears, recreational fisheries, traditional fisheries, conservationists, tourism etc. – will the management of the fishery minimise conflict between these users/stakeholders?
- Respect customary fishing (e.g. fishing activity that has a long social history in the area) – will the management promote the retention of fishing activities that have a long social history and encourage the continuation of long term fishing operations including family owned and operated businesses?

POTENTIAL INDICATORS:

- Equity of income distribution
- Equitable allocation of resource access in relation to changes in access to fishing areas.
- Industry employee attachment to lifestyle (length of residence, continuity of work etc.)
- Changes in public perception of the industry (positively or negatively)
- Number of complaints/actions against the industry (number of letters to the Minister/negative media releases)

c. Maximise other social benefits from the use of the resource to the local community:

- Enhance community resilience: the ability to adapt to change – will the management scenario affect the ability of the community to adapt to changing conditions and does it provide sufficient flexibility to maintain economic flexibility?
- Improve quality of life in coastal communities (including health and safety as well as general quality of life) – will the management scenario improve or support the quality of life of people in communities in, or associated with, the industry?

POTENTIAL INDICATORS:

- Community perceptions of risk
- Ability to plan and manage changes in circumstances
- Level of Interest in alternative strategies/management practices
- Number of accidents/fatalities in the industry
- Regularity of employment
- Population changes and net migration of fishing related communities
- Length of residence in communities
- Social networks and social capital of fishers
- Lifestyle /job satisfaction of fishers
- The list of indicators for each objective was not narrowed down to a single indicator. Stakeholders viewed this as not appropriate given the high level and complex nature of the objective. For example, "*Maximise other social benefits...*" could include many aspects such as physical and mental risks, for certain regions a large enough industry to keep various facilitates such as schools etc. However, producing more objectives would have made assessing their relative weights too complicated. This method of several indicators within relatively broad objectives was seen as an appropriate balance between detail and tractability.

7.1.2 MANAGEMENT OBJECTIVES HIERARCHY

The hierarchy of objectives that was developed for East Coast Trawl Fishery is presented in Figure 3. Under the four high level objectives, namely "Maximise economic performance of the east coast trawl fishery", "Simplify and improve management structures", "Maximise social outcomes" and "Ensure sustainability", are several sub-objectives that were more specific to the fishery. The full set of objectives identified is presented in Appendix 5, Table 9.

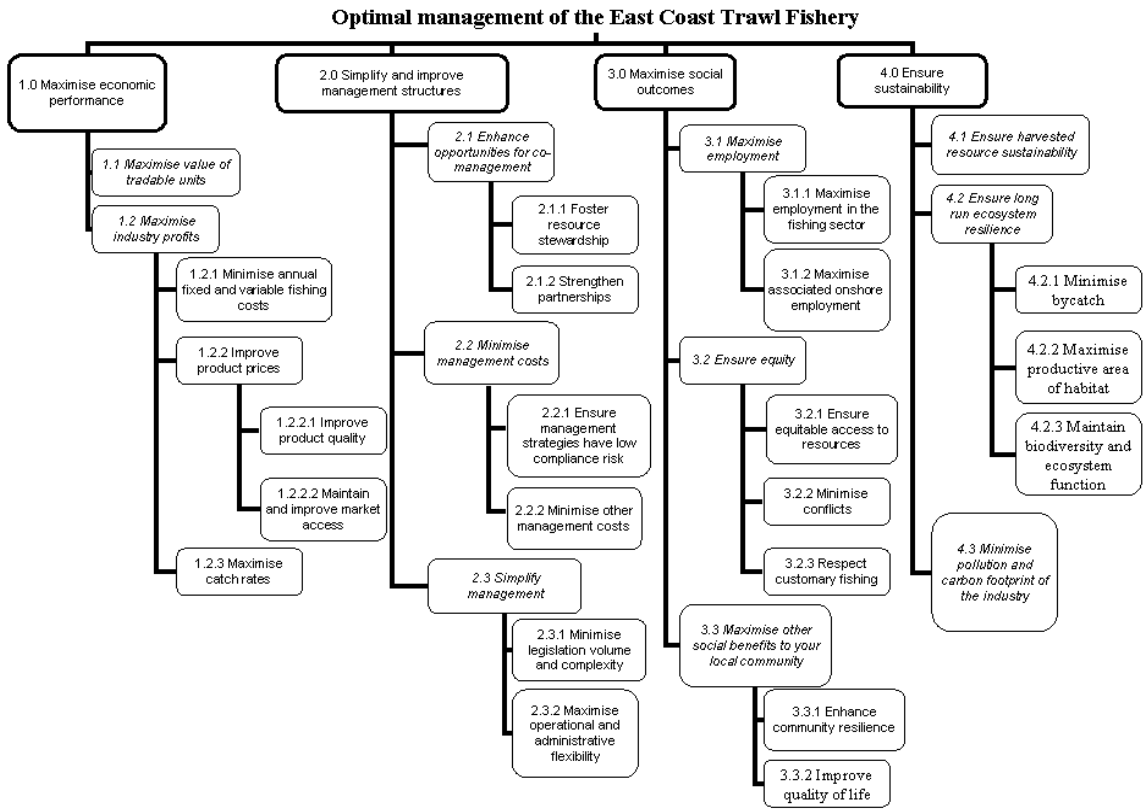

Figure 3. Objective hierarchy for the Queensland East Coast Trawl Fishery.

7.1.3 OBJECTIVES IN THE CONTEXT OF CLIMATE CHANGE ADAPTATION

As a separate process, for the East Coast Trawl Fishery, these objectives were treated in a climate change context (Appendix 6). Figure 4 illustrates the links between the socioeconomic vulnerability to climate change and relevant fishery management objectives for adaptation planning. The figure shows how achieving selected fishery management objectives would act to reduce vulnerability to climate change. Specifically, ensuring long run ecosystem resilience and minimising pollution and carbon footprint of the fishery will contribute to reducing ecological vulnerability and in turn, to reducing socioeconomic exposure. Additionally, enhancing opportunities for co-management, maximising operational and administrative flexibility and enhancing community resilience all contribute to increasing the adaptive capacity of individuals and the community. However, only some aspects of exposure and adaptive capacity are under the control of fishery managers, and resource dependence and hence sensitivity is generally not controlled by fishery managers. These limitations on what fishery managers have control over are recognised in Figure 4 through the inclusion of external factors.

The work here is now being used to inform a joint climate change adaptation project for the fishery.

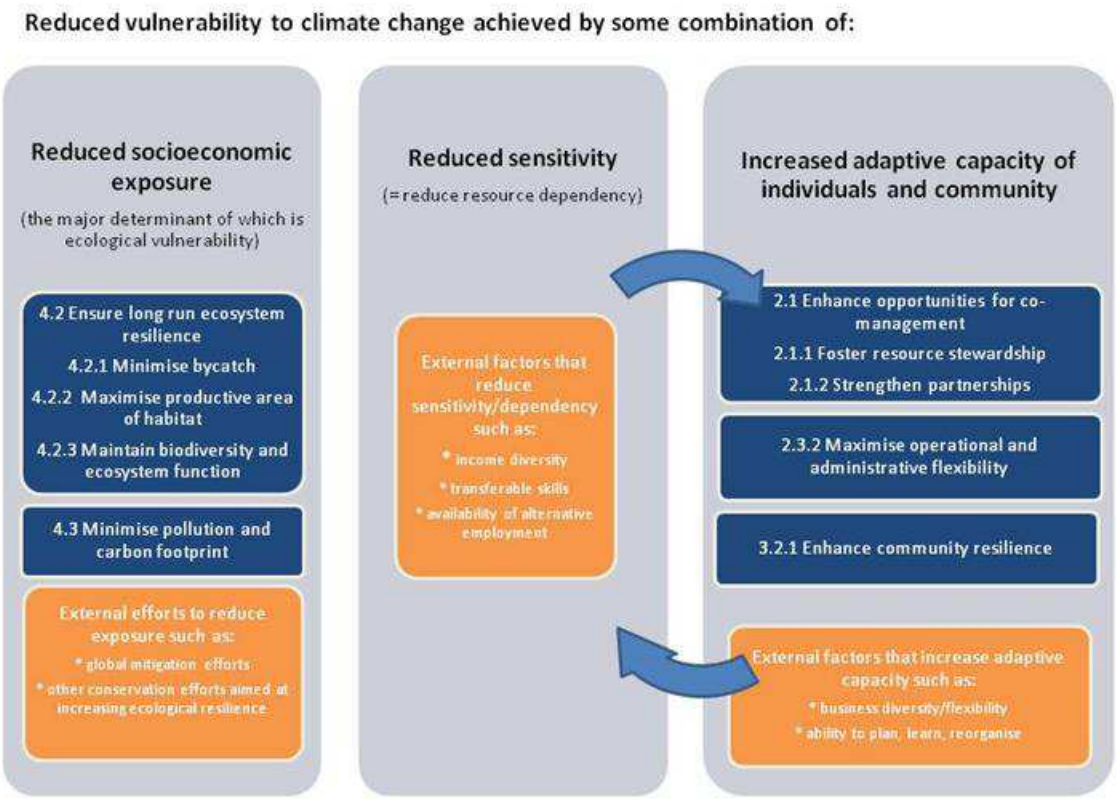

Figure 4. Links between socioeconomic vulnerability framework and relevant trawl fishery management objectives for adaptation planning (numbers in the figure refer to sub objectives in Figure 3).

7.1.4 OBJECTIVE WEIGHT RANKING

Individual's weights for each objective were estimated as above, and group average priorities were calculated (Appendix 5, Table 9). Economic objectives were weighted highly by industry groups (both fishers and on-shore) and fishery managers (Figure 5). Fisheries policy in Queensland has an explicit objective of maximum economic yield [4], following the lead of Australia's Commonwealth harvest strategy policy [15], and this no doubt influences the objective weightings of fishery managers. The preferred mechanism by which economic performance is to be achieved, however, varies between stakeholders. Fishery managers' preference is to reduce costs of fishing, whereas industry prefer higher prices and catch rates.

The objective of simplifying management received fairly strong support from the fishing industry and on-shore industry, both of which are affected by management, but slightly less so from the fishery managers themselves who are responsible for implementing management. The preferences were distributed fairly evenly across the sub-objectives; although the on-shore industry had a stronger preference for ensuring management had a low compliance risk and reducing legislation complexity and volume.

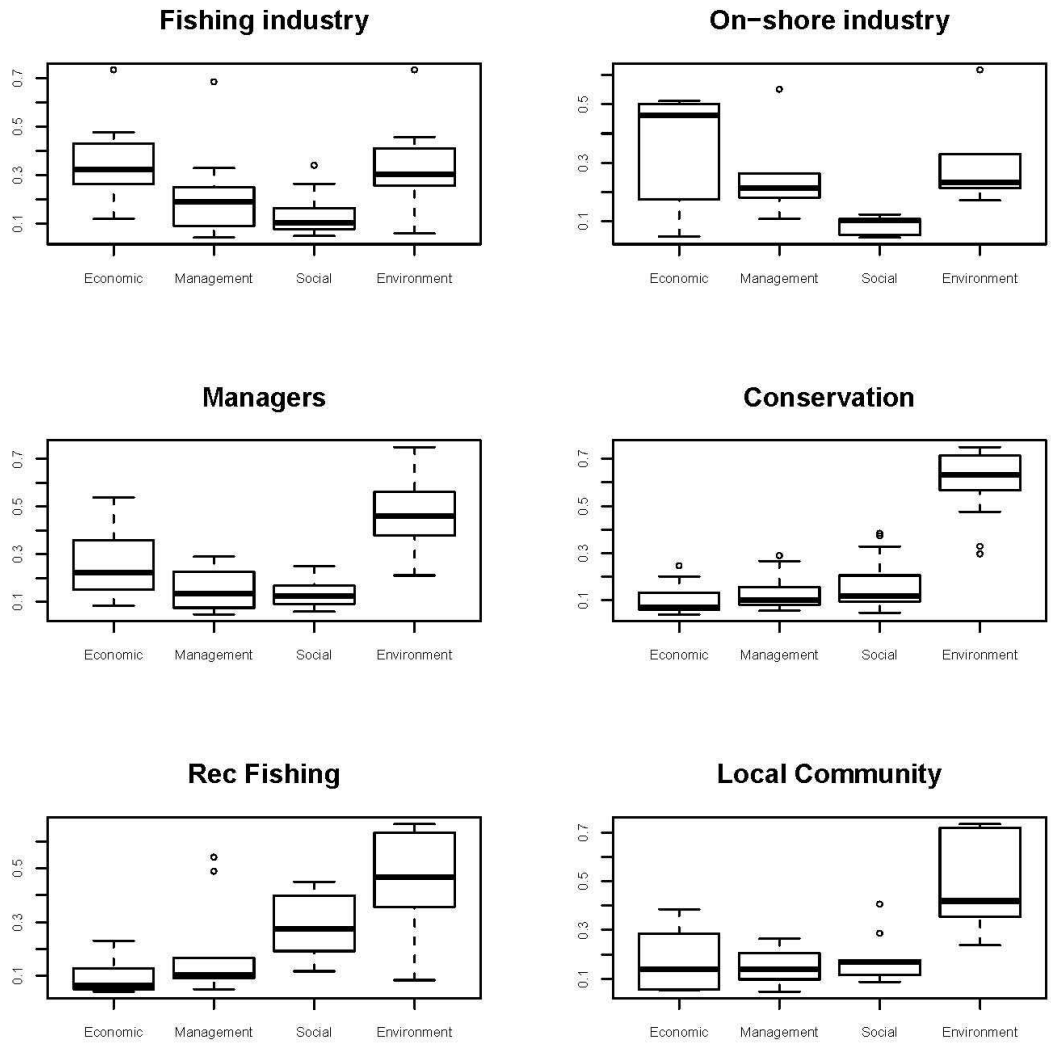

Figure 5. Distribution of weightings for higher-level objectives by stakeholder group.

7.1.5 ELICITED MANAGEMENT STRATEGIES

The SAG and TAG initially developed four strawmen: modified status quo (MSQ); decrementation system (DECR); separate sectors (SECT); and sector access levies (SAL). These were designed to be fairly different in their approach, but avoided (by agreement of SAG/TAG members and managers) an individual transferable quota system. The fishery as a whole is seen as not being mature enough to move to such a complex system given that many of the species have no stock assessment, and are short-lived and highly variable. All strategies still relied on a tradable effort unit. Within each governance structure, additional measures were also proposed to address particular issues identified.

As outlined in Section 6.4, an important first consideration was at what level the tradable effort units would apply. There were essentially two choices: that of keeping the present whole of fishery level or apply them to the sector level (or some spatial surrogate). The former was seen as valuable in that it allowed free movement of fishing operations between sectors and therefore enhanced resilience of fishers to deal with pressures both acute and chronic within the fishery. The weakness was that this system made it difficult to use an approach based on effort units as a measure to control the sustainability of a single sector. Thus it was decided that at least two of the strategies should include one of each of the above options.

The first strawman developed, “MSQ”, explicitly maintained this tradable system, but included seasonal controls and options for in-season management of a set of catch rate triggers or a total sector effort cap to address the issue of still managing the sectors (roughly species groups) at sustainable and economically profitable levels. Changes to existing season closures were also made. This potential closure regime meant

that the fishery sector start date was determined by a season date whereas its closure date was determined either by reaching a pre-agreed economically profitable catch rate trigger, a sustainability based effort cap or the end of season date. The system was designed to reach the economic trigger first as this allowed for a data poor Maximum Economic Yield equivalent target.[3]

Very different to MSQ, was the proposed strategy to separate the fishery into regions that roughly translated into the different sectors (SECT). Only fishers with history in the sectors would be given a proportional allocation in effort units to this sector but the total effort units transferred would be set at sustainable levels. This would therefore require an allocation process (the nature of which was not determined in the analysis as this is often controversial), but would allow management at the fishery sector level (i.e. roughly at the species level) for sustainability.

In order to reduce the amount of legislation and increase fisher's choice, the third strawman was to develop a decrementation system (DECR) of in-season management and movement between sectors, but still retain most of the other aspects of the MSQ system. When catch rates are low within a sector (e.g. where the MSQ would have shut the fishery), when a resource is in poor condition, or when greater levels of fishing effort are applied in a sector than is desired by managers for any other reason, the effort units required per day fishing in that sector would be increased to act as an incentive to fish elsewhere. The degree of change would depend on the degree to which excessive fishing was occurring. This system could also entice fishers into a region or time by reducing the decrementation rate if effort levels were lower than desired. This allows a choice by the fisher whether they remain and fish with lower/higher penalties, or move elsewhere to minimise or avoid penalties.

The final strawman (SAL) was developed much later in the process and was introduced by an industry member. The system maintained the elements of MSQ but added an industry funded buy-back system. This strawman required fishers to pay an access levy when entering each sector for the first time in a year. Although the government would administer this levy in practice, it would be guided and managed essentially by industry, requiring a strong co- or self-management model. The funds generated were proposed to be used mainly for buying out latent effort units (thereby increasing the value of remaining units), but also for industry funded surveys and other research to support the fishery.

3 The triggers were based on the principle that profits in a depletion fishery (such as the prawn fisheries) are maximised when the marginal revenue is equal to the marginal cost. While both measures were unknown, it was agreed that a critical catch rate could be determined that would be a suitable proxy for this measure.

7.1.6 ASSESSING RELATIVE MERITS OF THE STRATEGIES

The final set of objectives used in the analysis is described in detail in Appendix 5. These objectives are also shown in Appendix 4, Figure 10, which is a snapshot of the "whole of fishery" spreadsheet used by the SAG and TAG for scoring the strategies against each objective. The overall impact score by strawman (Figure 6) combines the scores by strawman for each objective (Figure 7).

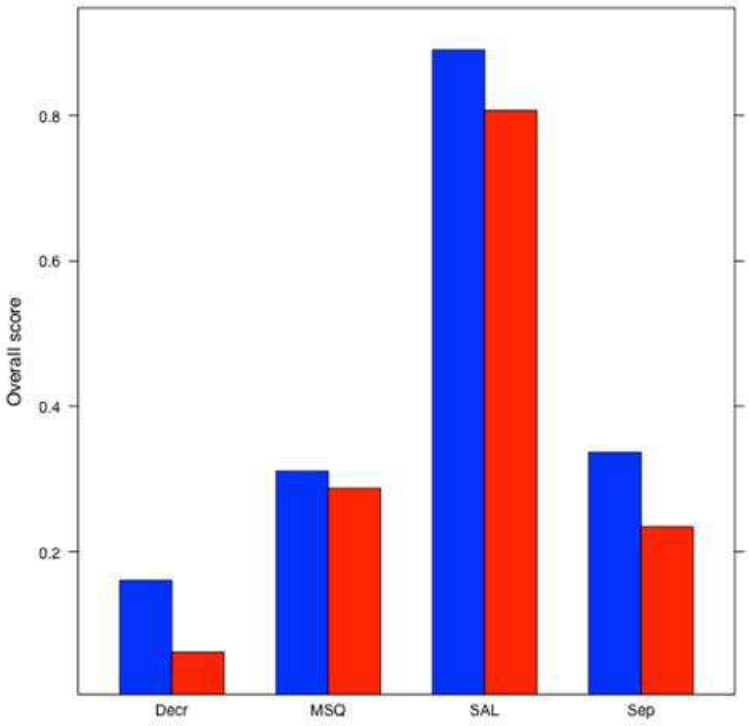

Figure 6. Overall impact score of different management strategies with (blue) or without (red) confidence scores. "Decr" is the Decrementation system, "MSQ" is the Modified Status Quo, "Sep" is Separate Sectors and "SAL" is Separate Access Levies.

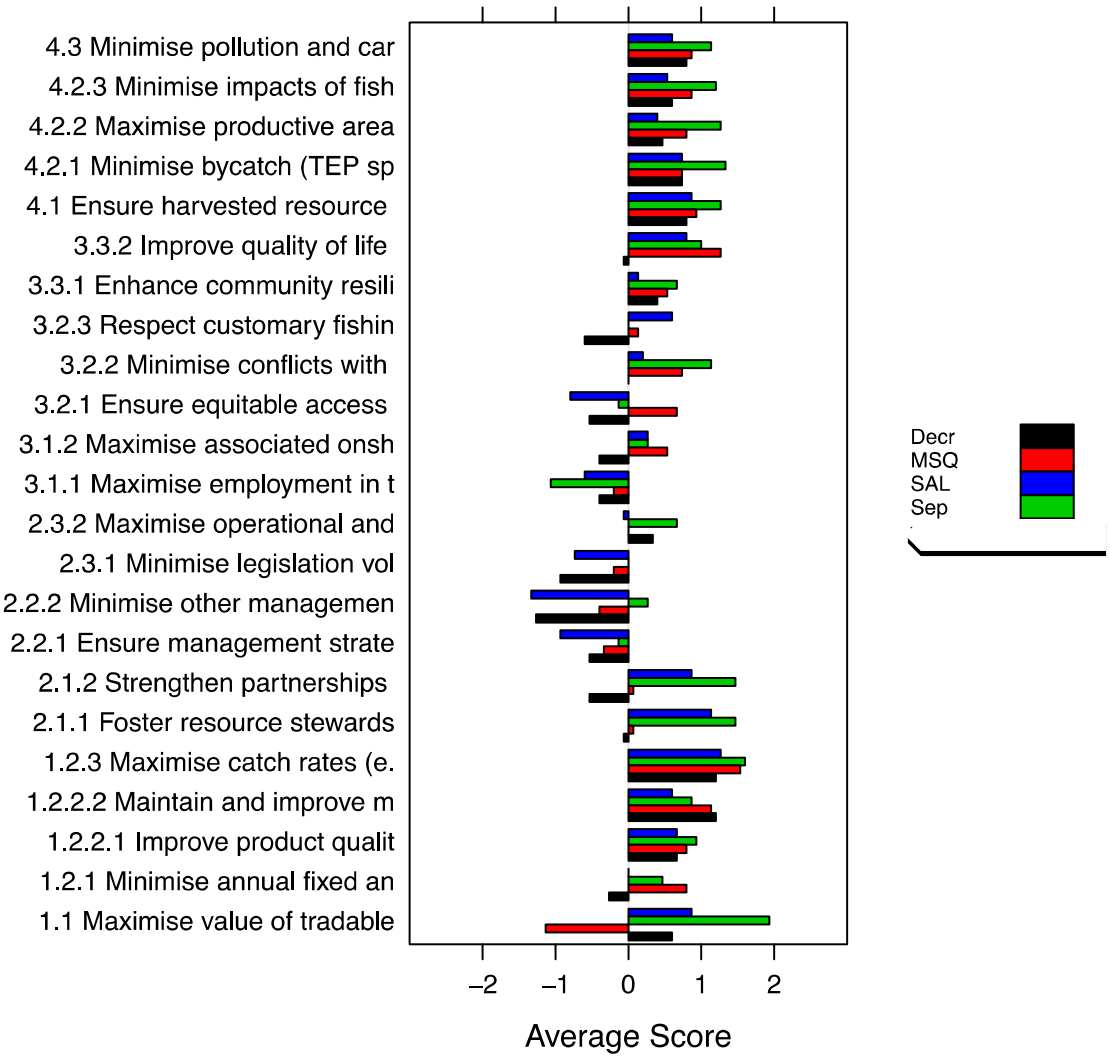

Figure 7. Overall weighted impact score by strawman for each objective. "Decr" is the Decrementation system, "MSQ" is the Modified Status Quo, "Sep" is Separate Sectors and "SAL" is Separate Access Levies. Due to length, only a section of each objective is displayed.

All the strategies provide overall positive results compared with the *status quo*. This is not surprising, as the committee that designed the different strawmen knew the weaknesses of the present system well and expressly endeavoured to produce a system that would be an improvement, if at all possible, across all the upper level objectives. The SAG and TAG members rated the SAL strawman as the best of the systems considered, with little difference between the next two strategies, MSQ and SECT. However, when the confidence scores (the SAG and TAG members' view of their ability to predict the impact of a strawman against an objective) are considered, the overall score of the SECT strawman (that of breaking the fishery into sectors which would require an allocation system with an unknown process) was reduced. The DECR system was believed to provide little improvement over the current system.

Given the difficulties in comparing one person's subjective assessment of magnitudes of change with another's, an alternative is to just count the number of perceived positive, neutral or negative impacts (i.e. better, same or worse) (Table 1). This resulted in a similar ordering of outcomes as from the previous analysis: the SAL scored much higher than any of the other strawman (19 positive from a total of 23 objectives), while at the other end of the scale, DECR had 11 positive and 12 neutral or negative scores for those 23 objectives.

Table 1. Number of objectives using the overall weighted scores that are better (positive) or either the same or worse (negative) than current.

OBJECTIVES	SCORE RANGE	MODIFIED STATUS QUO	DECREMENTATION	SEPARATE SECTORS	SECTOR ACCESS LEVIES
No. positive	1 to 3	15	11	15	19
No. negative/no change	-3 to 0	8	12	8	4

At the sub-objective level, ratings for the social objectives were mixed with negative, neutral and positive scores with no consistent pattern between strategies. On the other hand, all the strategies scored positively against all the sustainability objectives, and most of the strategies were rated as producing positive benefits against the different economic objectives (Figure 7). The opposite is true for management objectives with the notable exception that SECT and SAL were positively rated against objectives "Foster resource stewardship" and "Strengthen partnerships".

The scores for the objectives (Figure 7) can be summarised in terms of their worst and best overall scores (see Appendix 4, Table 6). Considering positive scores as representing benefits, and negative scores to represent costs, the greatest perceived "benefit" of MSQ was that catch rates are likely to be high, whereas the greatest "cost" was that the tradable unit value would remain low. The low tradeable unit was more seen as a symptom of the remaining issue of latent effort which could enter the fishery when the fishery becomes profitable dissipating all the work undertaken by the active fishers over time. The key perceived benefit of DECR was increasing market access, with the greatest cost being increased management costs. The key perceived benefit of the SECT strategy was to maximise catch rates but, even more so than DECR, the cost was believed to be an increase in management costs. The greatest expected benefit of the system that includes an access levy (the SAL strategy) was to maximise the value of the tradable unit, but at the greatest cost of decreasing employment.

The SAL strawman received positive scores for most of the management objectives with the exception of "Maximise employment in the fishing sector", "Ensure management strategies have low compliance risk" (although all strategies were negative for this objective), "Minimise legislation volume and complexity" and "Ensure equitable access to resources". The latter is because the buyback scheme is based on how many sectors are accessed in a year and varies with the size of fishing vessel – the latter is seen as a way of maintaining the small-scale businesses within the fishery. From discussions within the TAG, access levies were seen to disadvantage the smaller vessel owners who had less capacity to pay for access to more than one sector compared to their larger counterparts. Administering this system was also seen as increasing management costs.

A cumulative probability function of the scores can be calculated for each of the strategies by six of the seven stakeholder groups (here we excluded scientists as their numbers were too low) (Figure 13). This is based on each of the SAG and TAG member's set of impact scores (*N*) being multiplied by each of the SAG, TAG and survey respondent's set of objective weightings (*M*), giving an *N*M* set of possible outcomes. This provides some indication of the effects of uncertainty in subjective scoring and heterogeneity in objective preferences within the different stakeholder groups. Although more than the final seven stakeholder groups were initially identified, the 90 respondents from the objectives weighting survey were divided into stakeholder groups consisting of "Fishing Industry", "On-shore industry" (including processors and other businesses associated with the fishing industry), "Managers" (State fishery managers), "Conservation" (including both marine park managers and conservation NGOs), "Recreational Fishing", "Local Community" (represented by local council members from different councils along the coast) and "Scientists".

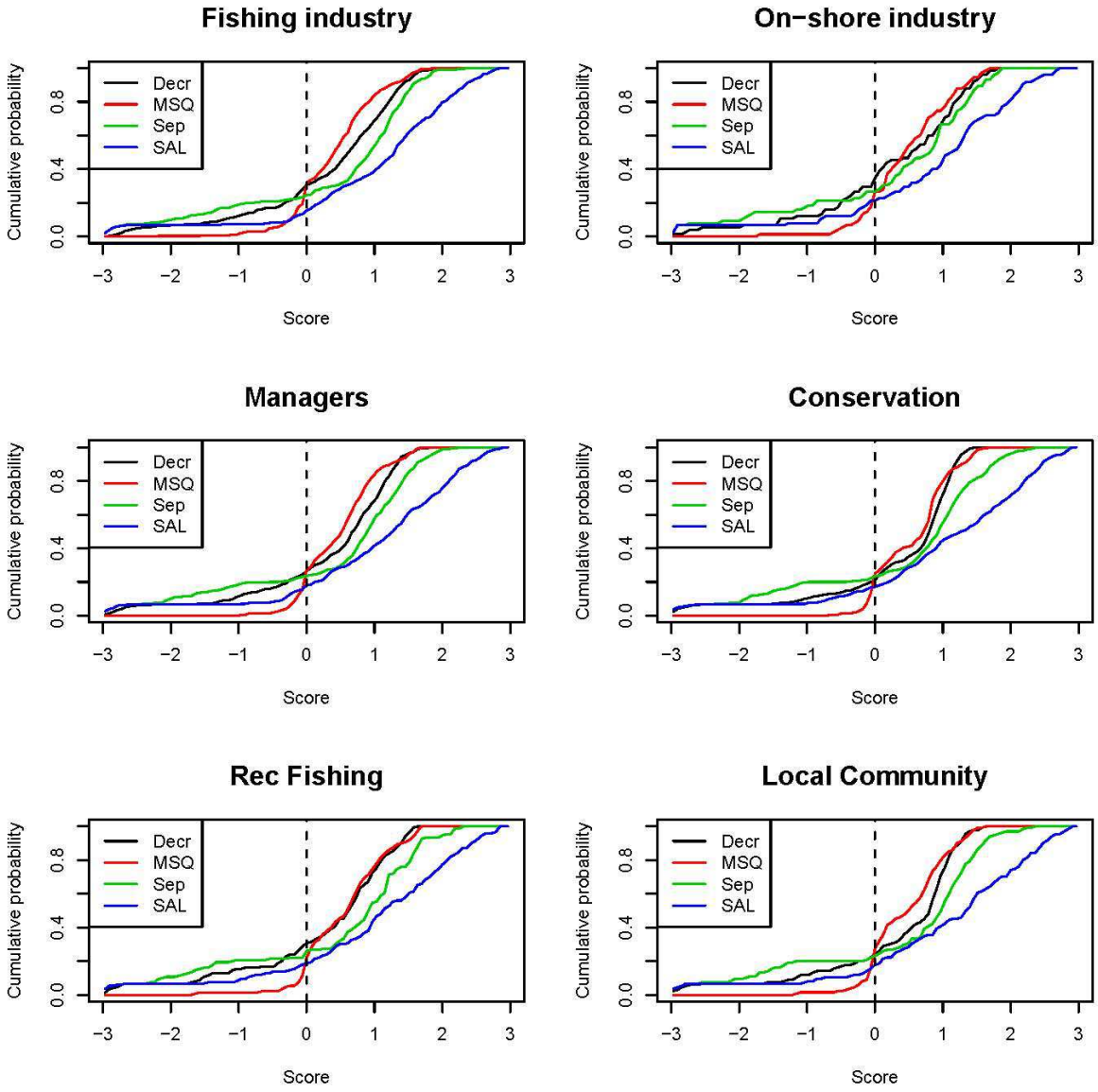

Figure 8. Cumulative probability distributions of the overall score (-3 is substantially worse and 3 is substantially better) for each strawman. "Decr" is the Decrementation system, "MSQ" is the Modified Status Quo, "Sep" is Separate Sectors and "SAL" is Separate Access Levies.

Figure 8 identified that there was not a substantial difference in the responses to the merit of the strategies in relation to the objectives between the different stakeholder groups. The SAL strawman was consistently scored better by each of the different stakeholder groups. The figure also indicates the perceived potential risks of any large negative impacts. For example, the probability of scores less than zero for the MSQ scenario quickly approach low values as scores decrease, suggesting that while it was not expected to create the greatest benefits, it is believed to have the lowest downside risk. The other strategies were perceived to have higher probabilities of a more negative result with SECT consistently indicating people's perception of a higher risk of large negative impacts.

As Figure 8 shows cumulative probabilities, the score at the break-even point (zero on the x axis) indicates the cumulative probability of obtaining a zero or negative score, and hence the lower the score the better the strawman is considered to be compared to the current situation and that positive scores are more likely. A comparable method is to produce the probability at, for example, the break-even point (see Appendix 4, Table 7). From Table 1, the SAL has the greatest expectation of positive outcomes (the lowest expectation of zero or negative outcomes), but also shows that there is some difference between the ratings by stakeholder groups.

A survey of stakeholder opinion at the end of the process (Appendix 8) showed that the large majority of stakeholders were extremely satisfied with the process.

7.2 Discussion

There is now a means to be able to evaluate the social performance of the fishery and any management plan applied to it that is understandable to all stakeholders. Having an objectives hierarchy provides a framework to explicitly integrate social concerns into both the process of developing a revised management plan and with further work into the ongoing review and assessment of the plan.

Having social objectives for fishery management is not necessarily about maximising every objective. At times these objectives may be useful to ensure social outcomes are considered while acknowledging that circumstances may dictate that the greater good across the overall community is served by allowing a particular objective not to be met or maximised [16-18]. For example, there are issues around the maximisation of customary fishing and employment that cannot necessarily be addressed directly. This is because it is not beneficial to other objectives such as sustainability, profitability and efficiency. However, it remains important to have these objectives to ensure no damage is done, rather than to artificially 'prop up' these sectors. The advantage of having identified social objectives and indicators is the ability to understand the effects of a resource management strategy on different sectors of the community and environment, before a critical situation occurs that brings it to the attention of resource managers, governments and politicians. In this way, such an approach can contribute to the minimisation of conflict and marginalisation of groups.

In applying a process such as this, there is a fundamental need to ensure fisheries management capacity exists to affect outcomes in relation to the social and other objectives. Consequently the objectives selected were done so, being cognisant of both the ability of fishery managers to affect outcomes in the selected areas, or how they may be able to do so indirectly. While some of the objectives identify such things as 'maximise employment' (which in this case was a State Government policy requirement) these requirements must always be interpreted in the context of the department's area of responsibility, and are also mediated by the achievement of other objectives.

Although resource and environmental conservation remains paramount, the perceived failure of biologically oriented management [19] aimed at controlling how much of the resource is removed annually, has resulted in increased attention to instruments that provide appropriate social and economic incentives. Using governance systems that align fishers' objectives with those of management has been found to be a significant success factor underlying stock recovery in most fisheries (Worm *et al.* 2009). With this change in focus has come increased interest in incorporating economic and social analyses into fisheries policy development, and, more recently, an increased interest in the dimensions of healthy biological populations impacted by fishing; the economic health of fishers and their associated industries; and management performance and equity [20]. Good governance requires stakeholder empowerment not only in terms of providing their input to the operational management process, but also through the ability to influence core policy development [21].

Traditionally, moving to a new management system often involved evaluation using quantitative models such as Management Strategy Evaluation [22] [23, 24] or other quantitative approaches when the former is lacking. However, many of the world's fisheries are data limited to some degree [25]. Also the institutions associated with these fisheries often do not have the capacity or resources to undertake high-end quantitative analysis. As such there is a growing application of expert driven, qualitative approaches to evaluating management strategies of fisheries [9, 12, 26], water, mining, forestry and other resources [27] [28]. Many of these approaches use stakeholder engagement and analysis of qualitative data using multi-criterion decision analysis techniques (see [29]).

In this study, a tiered stakeholder elicitation approach was undertaken from using a small expert committee (SAG) to a larger committee with broader representation (TAG) and then to the broader community and industry. The process involved multiple iterations between each of these groups (especially the SAG and TAG) both taking and providing input at each step – developing objectives, weighting these

objectives, developing management strategies, scoring the relative impact of these strategies against each objective and then discussing the overall results. The overall results show a surprising similarity especially with respect to the favoured strawman.

The overall score shows that an expert consultation process was able to produce strategies that were reasonably different but still were, to varying degrees, better than the current system. Interestingly, after participating on the advisory groups for some time, an industry committee member suggested the strawman that produced the best overall rating. This shows the value of experts from several stakeholder groups including industry, being involved from the outset of the process and being able to directly contribute ideas. Although this method is, at its basis, subjective and expert driven, all available scientific information and input was provided to participants throughout the process, which helped, reduce issues of subjectivity. This information was largely biological, with relatively little external information available in relation to social or economic impacts as few relevant previous studies have been undertaken on this, or a similar, fishery.

Based on the weighting of the objectives and their impact scores against the management objectives, it is clear that all four management strategies are expected to deliver on economic and sustainability benefits reasonably successfully. However, the management strategies were not as successful in clearly producing social benefits. While explicit social objectives were identified and assessed, these objectives were not highly weighted by stakeholder groups against the other major objectives. From the discussion about this finding with the SAG and TAG, there was a general view that the social aspects of this fishery are very important, but that they were *in part* captured through a sustainable resource and a profitable fishery. As an example, a profitable fishery can maintain better onshore facilities and employment, and therefore a region's social capital. On the other hand, many fishers did not want a fishery consisting of large, economically efficient operators at the expense of small, family owned operators (see [30] for more detail).

The fishery currently has large amounts of unused effort units and most stakeholders see the present active level of effort units as either just enough or too much. This means that only a very large removal (i.e. beyond latent) of effort units would result in the sustained decrease in actual effort. The SECT and, especially, SAL are the only strategies that addressed the removal of latent unutilised units (although through very different mechanisms) and therefore scored well. With regard to the value of the unit, breaking the fishery into regions that roughly translate to the sectors (and also species groups) is rated as being the best strawman to increase the value of the fishery. SECT reduces latent effort and is also the best to manage for ecological sustainability and fishery viability without having to address the movement of effort from other regions. However, an allocation process was seen as a large risk.

The MSQ was expected to result in higher catch rates but to also produce low tradable unit values, which initially seemed counter-intuitive. The MSQ incorporated a system where the sector is closed when catch rates fall below a (more economically driven) trigger point. This will mean that fishers either have to move to another sector or go back to port. This system does not decrease latent effort units thus keeping the tradable unit values low. It can be argued that as the resource recovers to higher catch rate levels, it would entice more vessels to enter the sector and thereby reduce the profitability of the existing vessels (referred to as "the waterbed effect" by some SAG and TAG members).

There was not a substantive difference in the overall scores for each strawman between the different stakeholder groups, despite this fishery operating partially within the Great Barrier Reef Marine Park - which is of particular interest to conservation and community groups. When the influence on scores of objective weightings by the appropriate stakeholder group was considered, it became clear that different stakeholder groups liked the same strategies but for different reasons. The break-even point was also reasonably similar between stakeholders and highlights that combining the results are reasonable in this example. Clearly, combining results when the results by stakeholder are very different would not be appropriate.

Multicriteria decision analysis has been used extensively in the fisheries context [12, 13, 31]. Pascoe *et al.* (2009) [12] applied a very similar method to that used within this study, but towards developing different spatial management options. They argued that the benefit of the approach is that it focuses attention on impacts relative to specific objectives, thus reducing potential bias. However, they also recognised that the

method is not objective and that the scale of an impact is not necessarily the same for different respondents. In this study, we have attempted to overcome this deficiency in two ways. First, we asked those assessing the impacts to provide a subjective assessment of their own level of confidence in their scores, and re-weighted the impacts giving higher weight to those who claimed greater confidence. Second, we developed a probability distribution rather than single outcome measure that took into account heterogeneity in both the impact scores and also the objective preference weightings. In this regard, the analysis is more robust than that in the previous study.

The strengths of the method used in the governance review part of this study are that it elicited clear descriptions of potential management strategies and was able to assess these against a hierarchy of objectives across social, economic, sustainability and management axes. The qualitative method developed here has application in complex and data poor fisheries and other natural resource management. A further benefit was seen that the stakeholder elicitation process made many of the stakeholders that started as critics, better understand the complexities of management. The process also moved thinking away from only modifying the status quo to more innovative options such as an industry funded buy-back scheme and variable effort unit decrementation systems as an alternative to seasonal closures.

A key factor in gaining effective stakeholder participation and support for this work was the 'ground truthing', which was undertaken at each stage of the process. This was to ensure the applicability of the approach being adopted and the acceptability by the industry of the outcomes from the previous stage. It ensured that all parties had an opportunity to be 'heard' and their views taken into account, even if their perspective was not adopted. This is a fundamental element to improving adoption and support of final management plans, as it is expected that the stakeholders will be able to see their 'signatures' on the final outcome.

8 Benefits and Adoptions

8.1 Benefits

1. The stakeholder engagement process from this project facilitated discussion in a creative environment overcoming any personality and extreme view issues while allowing for an open and balanced debate where change is a real option.
2. Through a stakeholder driven process, the project identified the key social objectives of relevance to the fishery. Since these objectives are, on their own, not a complete set of management objectives, the project also developed economic, ecological and governance objectives. These objectives were weighted by stakeholders both within the category itself, and also between categories. This project allowed an open and transparent discussion of the vision for this fishery by stakeholders.
3. A series of potential indicators for each objective were developed for the Queensland trawl fishery. Also, a literature review of objectives and indicators used in natural resource management was completed. The review has been provided to a National Social Objectives project (FRDC 2010/040).
4. Stakeholders developed proposed management strategies, or Strawmen, for the new Queensland Trawl Management Plan. At the start of the process, many members of the TAG and SAG (formed by DEEDI for the Trawl Management Plan review) were of the opinion that only limited changes were required. This was despite concerns being expressed about the management of individual species within the existing system. After a structured program of assessing the performance of Strawmen against each objective (including the social objectives) was complete, the majority of members had agreed to a much more ambitious change.

8.2 Adoption

1. Queensland DEEDI has adopted a modification of one of the management strategies developed from the strawmen within this project, to be further developed in their Management Review options paper for stakeholder review.
2. Furthermore, the process highlighted the need for a buy-back scheme which has resulted in a separate project to investigate the economic benefits and costs of such a program.

9 Further Development

1. This project is being followed up by the FRDC funded national project that will include interviews with different stakeholders related to the Queensland trawl fishery. This work will build on the findings of the current project and provide information that will allow updating of the set of objectives developed during the project. It has provided to the national project the list of objectives and indicators obtained from the literature review, and also those developed for the Queensland trawl fishery.
2. This project also resulted in a subsequent project investigating the economic value of a buyback scheme as this was suggested to be the best strawman from this study. This work has been completed but is confidential.
3. Building on the current project, we also took the opportunity to consider fishery management objectives in relation to climate change adaptation planning, a process just starting for the East Coast Trawl Fishery (further detailed provided in Appendix 6). This work has been completed under an external project [32] and will benefit from the stakeholder process already developed through this project.
4. Adoption of the stakeholder process and methods into a GBR NERP project undertaken jointly with GBRMPA, DEEDI, DERM and JCU (PI: Dichmont).

10 Planned Outcomes

The planned outcomes of undertaking a qualitative analysis of different management strategies were achieved. This was specifically undertaken with regard to the social objectives that are simultaneously linked to environmental and economic objectives incorporated in the Queensland Trawl Plan Regulatory Impact Statements. This will allow DEEDI to assess potential management options for their new Queensland trawl management plan in terms of social objectives.

11 Conclusion

The combination of qualitative and semi-quantitative methods used to a) develop and weight different objectives and indicators, and b) develop management strawmen and assess their relative performance using an extensive stakeholder engagement process has been successful as applied to the Queensland trawl fishery. Overtly including social objectives, but as part of a package that included ecological, economic and governance objectives meant that there was extensive discussion and analyses on the relative importance of social objectives and also how best to achieve social outcomes. During the process, stakeholders gained an understanding of the importance of different objectives to other stakeholders. Similarly, this process never rejected a strawman that was proposed by stakeholders, but rather developed them further to assessment. This quickly highlighted where the issues or benefits lay (if any) of the proposed idea. It is not surprising that the best strawman came from an industry member. The use of this combined methods approach is therefore a relatively quick means of engaging stakeholders and working them through an organised process. It does not replace quantitative methods such as Management Strategy Evaluation, but can be a valid step towards it and sometimes highlights issues such as governance structure issues that a model would not necessarily show in a timely manner.

12 References

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13 Appendices

Appendix 1 Intellectual Property

This project has identified a hierarchy of objectives for the Queensland trawl fishery that is likely to be applicable to other fisheries. It has also further developed a method and a process of elicitation, using a semi-quantitative method to develop management strategies and evaluate these against objectives.

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Appendix 3 Social objectives and indicators for fisheries and natural resource management: an overview

Fisheries management, and natural resource management in general, is characterised by multiple objectives. These generally fall into three main categories: social, economic and environmental – the so called "triple bottom line" – although some also add political objective to this list [1, 2].

The evolution of fisheries management has largely derived from a perceived need to protect the resource in instances of overexploitation. Early fisheries management was predominantly biological focused, with objectives around sustaining the stocks and maximising yields. Early economic analyses [3] in response to persistently low income levels in fisheries demonstrated that inclusion of economic objectives were also warranted, although it took several decades for these to become incorporated in many management plans, and even today relatively few countries have economic objectives as their primary objectives.

Social objectives are less well defined in fisheries management. Some claim this is due to a lack of understanding of social ethos, context and relationships of the fishing industry and related communities [4], and/or a lack of a critical mass of social scientists with an interest in fisheries and fisheries policy [5]. Others argue that, unlike economists and ecologists who share a common ontology based on quantitative methodologies and models, social scientists tend to employ more perceptive, inductive and qualitative approaches that are less structured, measurable and replicable [6]. As a result, a consistent set of objectives and indicators has not evolved in the same way as they have in the more quantitative management components. Hence, measuring outcomes against social objectives is also more difficult than against economic or environmental objectives.

This difficulty was highlighted at a FRDC funded workshop in 2008, 'Geelong Revisited: from ESD to EBFM – Future Directions for Fisheries', which identified that while large advances had been made in the area of ecological assessment, there had been "minimal progress in the social and economic area" [7]. That being said, many researchers have been working in the area of developing social indicators to inform the performance of the management of natural resources [4, 8-14]. These indicators have, however, rarely been tied to formal frameworks for integration into policy development or ongoing management assessments. Consequently the relevance of such indicators has a tendency to be lost.

Organisations such as the World Wildlife Fund (WWF), International Labour Organisation (ILO), Global Reporting Initiative (GRI), the Food and Agriculture Organisation (FAO) or the ISEAL Alliance have proposed many indicators. However, even with these organisations, the objectives against which those indicators will be assessed are implicit rather than explicit, and the connection between objectives and specific indicators is often not apparent. As identified by a number of authors [2, 4, 15-17], indicators of sustainability or development are only helpful when there is an established framework of objectives that management can refer to. In 2009, Symes and Phillipson [4] decried the lack of social objectives defined or used in fisheries policy throughout the developed world. They called for "government policy to instil confidence in the industry and set out explicit social objectives for attaining an equitable profitable and sustainable future" [4]. Without such objectives it is impossible to ascertain how indicators are informing the aspirations of the managing agencies and other stakeholders. While in the past fisheries agencies, both in Australia and internationally, have had economic objectives and to a lesser degree, though more increasingly, environmental objectives; having social objectives has often been cast as beyond the realm of fisheries management responsibilities. However, as identified by Hillborn [2], an objective of one agency can inhibit or support the achievement of others objectives, or vice versa. Consequently, taking a holistic approach to management of our natural resources (encompassing economic, environmental and social objectives) is now not only a legislative requirement, but also a practical one.

A3.1: SOCIAL OBJECTIVES AND INDICATORS IN THE NATURAL RESOURCE LITERATURE

A number of social objectives and relevant indicators have been proposed in the fisheries and other natural resource management[4] literature (Table 2). There is considerably greater variety and scope in the social objectives and indicators than those generally used for economic (Table 2) and sustainability (Table 4) based objectives (provided for the purpose of comparison).

There is some disagreement about the appropriate classification of some objectives, particularly between economic and social objective. For example, most economics based papers considered employment as a social objective, while some social science based papers considered it an economic objective. In terms of incomes, fisher income was generally considered a social indicator (as it related to the well being of the family), while vessel based measures of income (i.e. profitability) were considered an economic performance indicator. For example, in a national triple bottom line assessment that included fisheries, Foran *et al.* [18] considered only employment generation, income and government revenue as social indicators.

A3.2: POTENTIAL SOCIAL OBJECTIVES AND INDICATORS FOR QUEENSLAND FISHERIES

The social objectives and indicators identified in the literature review were presented to the Strategic Assessment Group (SAG) associated with the review of the Queensland East Coast Trawl fishery management plan. The SAG consisted of marine scientists, fisheries economists, social scientists, fisheries managers and industry representatives (both harvest and post harvest). The SAG considered which social objectives and associated indicators may be most applicable to the fishery taking into consideration the Queensland Fisheries Strategy [4] as well as the needs of the fishing industry. The SAG decided on three broader objectives with several sub-objectives and indicators under the general objective of "*Maximise social outcomes*", namely:

a) Maximise employment:

a. Maximise employment in the fishing sector: crew, skippers etc – *will the management scenario affect the amount of direct employment in the fishery*?
b. Maximise associated onshore employment: in processing or supplying sectors of the fishing industry – *will the management scenario affect associated on shore employment e.g. net makers, processors, gear suppliers and other businesses that rely on the fishery?*

POTENTIAL INDICATORS:

- Number of people employed in the sector
- Proportion of seasonal verses fulltime employment
- Employee satisfaction in the industry
- Proportion skilled versus unskilled labour
- Number and type of boats

b) Ensure Equity:

a. Ensure equitable access to the resources – *will people have a fair and equitable access to all resources?*
b. Minimise conflicts with competing users: e.g. other gears, recreational fisheries, traditional fisheries, conservationists, tourism etc – *will the management of the fishery minimise conflict between these users/stakeholders?*
c. Respect customary fishing (e.g. fishing activity that has a long social history in the area) – *will the management promote the retention of fishing activities that have a long social*

4 Given the criticism that social objectives are poorly defined in fisheries [4] Symes D, Phillipson J. Whatever became of social objectives in fisheries policy? Fish Res. 2009;95:1-5. Social objectives used in other natural resource management studies were also considered.

history and encourage the continuation of long term fishing operations including family owned and operated businesses?

POTENTIAL INDICATORS:

- Equity of income distribution
- Equitable allocation of resource access in relation to changes in access to fishing areas.
- Industry employee attachment to lifestyle (length of residence, continuity of work etc)
- Changes in public perception of the industry (positively or negatively)
- Number of complaints/actions against the industry (number of letters to the Minister/negative media releases)

c) *Maximise other social benefits from the use of the resource to the local community:*

a. Enhance community resilience: the ability to adapt to change – *will the management scenario affect the ability of the community to adapt to changing conditions and does it provide sufficient flexibility to maintain economic flexibility?*

b. Improve quality of life in coastal communities (including health and safety as well as general quality of life) – *will the management scenario improve or support the quality of life of people in communities in, or associated with, the industry?*

POTENTIAL INDICATORS:

- Community perceptions of risk
- Ability to plan and manage changes in circumstances
- Level of Interest in alternative strategies/management practices
- Number of accidents/fatalities in the industry
- Regularity of employment
- Population changes and net migration of fishing related communities
- Length of residence in communities
- Social networks and social capital of fishers
- Lifestyle /job satisfaction of fishers

A3.3: *EX ANTE* VERSUS *EX POST* INDICATORS

The indicators identified by the SAG and also in Table 2, Table 3 and Table 4 are primarily *ex post* indicators. That is, they are measured at a point in time and reflect the management system currently in place. Similarly, changes in these indicators reflect management changes as well as other changes in the general coastal and wider economy. Evaluating management strategies requires *ex ante* measures. These are estimates of outcomes under different management options *before* they occur. Multi-objective models have been developed that have been used to estimate *ex ante* indicators such as total fleet profitability, average vessel profitability and employment to capture changes in key economic and "social" objectives [20-22]. Attempts at incorporating broader social objectives have generally not been undertaken in fisheries modelling research, as appropriate indicators are difficult to estimate in models.

Qualitative approaches such as the analytic hierarchy process (AHP) use expert opinion to estimate the relative performance of alternative management strategies against the full set of objectives, including social objectives where these are specified [23-27]. These provide indicators of expected relative outcomes against objectives [27-29], thereby allowing an assessment of the overall likely performance of different management options. An advantage of the AHP approach is that it enables objectives without clear independent indicators to be included in the consideration of the overall (expected) performance of a management strategy. Further, it allows for problems on non-commensurability (both social and technical) between indicators to be addressed through integration of input from a wide range of disciplines [30].

A criticism of the AHP and most other multicriteria approaches is that they do not allow for positive and negative effects to be explicitly considered, only the relative performance. Hence, potential "problem"

areas (i.e. those where substantial decreases in performance are expected) can not be readily identified. An alternative approach is to develop a set of expert opinion based indicators that allow for both the magnitude and direction (i.e. positive or negative) of impacts. An approach using subjective based indicators on a -3 to +3 scale were developed for assessing the performance of spatial management options in Australia given a wide range of objectives, including social objectives [31]. In this framework, management scenarios were compared against the current situation, with a positive score indicator an improvement relative to the current situation and a negative score indicator a worse outcome.[5] An additional advantage of this approach is that it also allows for uncertainty in the outcomes to be assessed through consideration of the variability in the indicator values provided by the individual respondents.

Combining management objective weights and the subjective indicators of performance relating to these management objectives provides indicators of the overall performance of a management scenario [27-29, 32].

Table 2. Social objectives relating to natural resource management from the literature.

OBJECTIVE	INDICATOR	SECTOR AND REFERENCES
Maintain (or maximise) employment	Number of people employed in the sector	NRM in general [33] Agriculture [34, 35] Mining [8] Fisheries [2, 4, 9, 17, 36-38]
	Seasonal versus full time employment	Agriculture [34]
	Employee satisfaction	Mining [8]
	Proportion skilled/unskilled labour	Agriculture [35]
	Number of boats	Fishing [39]
	Security of employment	Fishing [6]
Maintain communities	Proportion of income derived from the sector	Fisheries [40]
	Proportion of regional employment in the sector	Fisheries [17, 36, 41] Forestry [29]
	Community involvement in management	Forestry [29, 42] Fisheries [11, 40]
	Indirect economic impacts (on local economy)	Forestry [29, 42] Recreational fishing [43]
	Number of small vessels (symbiotic relationship between small vessels and the community)	Fisheries [4]
	Not specified	Agriculture [44] Mining [8] Fisheries [2]
	Profitability of the sector/ viability of the fishing enterprise (necessary for strong local communities)	Fisheries [4, 11]

5 Comparison against the current situation was considered an important feature of effective multicriteria analysis [30] Munda G. Social multi-criteria evaluation: Methodological foundations and operational consequences. European Journal of Operational Research. 2004;158:662-77., although most other studies have undertaken an absolute ranking approach [27] Sheppard SRJ, Meitner M. Using multi-criteria analysis and visualisation for sustainable forest management planning with stakeholder groups. Forest Ecology and Management. 2005;207:171-87, [29] Mendoza GA, Prabhu R. Multiple criteria decision making approaches to assessing forest sustainability using criteria and indicators: a case study. Forest Ecology and Management. 2000;131:107-26, [32] Mendoza GA, Prabhu R. Qualitative multi-criteria approaches to assessing indicators of sustainable forest resource management. Forest Ecology and Management. 2003;174:329-43.

OBJECTIVE	INDICATOR	SECTOR AND REFERENCES
	Index of activity (catch) flowing through port	Fisheries [39]
	Tourism links to fisheries	Fisheries [6]
Maintain social capital	Level/intensity of social networks	Forestry [42] Agriculture [35]
	Social networks (bonding, bridging and linking)	Fisheries [45] Aquaculture [46]
	Education level (stock of social capital)	Fisheries [40, 47]
	None given/ not specific	Fisheries [6, 48]
Maintain (or enhance) family income/ livelihoods	Family (fishing) income	Forestry [42] Agriculture [44] Fisheries [2, 4, 9, 13, 38, 48, 49]
	Resource dependency (share of income from resource)	Fisheries [6, 40]
	Security of fishing rights (could also be a sub-objective)	Fisheries [4, 6, 11, 25, 47, 50]
Equity	Equal distribution of income	Fisheries [11, 40, 51]
	Equitable allocation	Fisheries [13, 17]
	Perception of equitable allocation/access to the resource	Fisheries [17] Forestry [29]
	Changes in access to fishing areas	Fisheries [39]
	Not specific	Fisheries [48]
Ensure health and safety	Safety at sea Ensure safe working conditions	Fisheries [36, 47] Aquaculture [46] Forestry [27, 29]
Conserve traditional activities, culture and products	Not specified	Agriculture [44] NRM in general [33] Fisheries [48]
	Importance of fishing to fishers (survey) (attachment to lifestyle)	Fisheries [6, 9, 11, 25] Aquaculture [46] Recreational fishing [43]
	Relationship between [forest] and local human cultures is acknowledged as important	Forestry [29]
Maintain/improve recreational access	Recreational catch rates Charter boat catch rates Probability of catching "big" fish Recreational access (forestry)	NRM in general [33] Fisheries [25, 52] Forestry [27]
Maintain/enhance resilience	Links to maintaining social capital	Fisheries [6, 45]
	Perception of risk, ability to plan, ability to cope, level of interest (links to maintaining communities)	Fisheries [40, 53, 54] Aquaculture [46]
	Resilience scoring (fishers' resilience)	Fisheries [11, 53]
Enhance quality of life	Not specified	Mining [8]
	Indicators of quality of life: overall satisfaction,	Fisheries [11, 25, 50, 55]

OBJECTIVE	INDICATOR	SECTOR AND REFERENCES
	satisfaction with their employment, satisfaction with their fishing activities (catches), satisfaction with access arrangements, physical and mental health, measures of social capital that reflect community life	
Avoid social exclusion	Public perception of the industry	Fisheries [4, 39]
Minimise conflicts between alternative users Gear conflicts Interacting fisheries Rec/commercial	Number of conflicts [Foresters] and local users of the resource	Fisheries [17, 25, 36, 39, 41, 48, 51] Recreational fishing [43] Forestry [29]
Food supply	Quantity and quality supplied to the market Diversity of landed catch	Fisheries [9]
Management stability	Number of management changes per year	Fisheries [39]
Management acceptability	Participation in management process Level of awareness Number of fishers in an organisation Accepted by all stakeholders	Fisheries [51] Forestry [29]
Ease of management implementation	Existence of comprehensive laws and regulations Frequency of information dissemination Financial support for enforcement Performance of enforcers	Fisheries [51] Forestry [29]
Social profile baseline information has been established (Links to vulnerability and community resilience)	Education level; years participating in fishing; generations of family involved in fishing; fishing methods/licences held/equipment; length of residence in current hometown; household spending profile; ethnic characteristics; number participating in relevant fishing sector; number of people dependent on those employed or participating; median age; gender; income.	Fisheries [55] Forestry [29]
Traditional/indigenous fisheries		
Conserve traditional activities and products	Proportion of diet acquired from “wild” foods	Forestry [56]
Maintain social capital	Level of involvement with decision making	Forestry [29, 56]
	Level of interaction with industry	Aquaculture [46]
	Long term rights for indigenous use	Aquaculture [46]
Development/ provision of alternative livelihoods	Level of financial support for additional livelihoods Success of additional livelihood implementation Inclusion of women in the management process	Fisheries [51]

Table 3. Economic objectives relating to fisheries management from the fisheries literature.

OBJECTIVE	INDICATOR	SECTOR AND REFERENCES
1. Maximise economic profits for fisheries as a whole	• Economic profits in the fishery • Return on investment	[2, 4, 17, 31, 36, 37, 39, 41, 47, 50]
2. Maximise economic profits for particular fleet segments	• Economic profits in the different fleet segments (objective and weightings differentiated by fleet segment)	[25]
3. Ensure vessels are economically sustainable	• Positive vessel profits • Gross revenues from fishing	[13, 52] [51]
4. Maximise economic performance of supporting sectors (included as a social/community objective above)	• Economic performance of local supporting industries	[25]
5. Minimise management costs industry compliance costs Government costs	• Compliance costs to industry (e.g. new VMS, new gear) • Total management costs (recoverable and non-recoverable)	[31, 38, 39, 41, 47]
6. Maximise employment (usually seen as social objective)	• Level of employment in fishing • Number of vessels • Level of employment in associated sectors	[25, 48, 51] Recreational fishing [43]
7. Improve productivity	• CPUE • Profit per day fished • Profit per tonne landed • Average revenue per boat	[13] [39] [39] [38]
8. Improve industry value	• GVP	[38]
9. Minimise variability	• Variability in harvest	[52]

Table 4. Resource sustainability/conservation objectives relating to fisheries management from the fisheries literature.

OBJECTIVE	INDICATOR	SECTOR AND REFERENCES
1. Ensure sustainable target/byproduct species	• Sustainable target species • Biomass of each group	[2, 9, 13, 17, 38, 39, 41, 47, 50, 52] Recreational fishing [43]
2. Achieve maximum sustainable yield	• MSY (special case of 1)	[25, 52]
3. Minimise bycatch TEP species All species	• Bycatch of TEP species (number) • Total bycatch (number, weight)	[2, 9, 17, 25, 39, 41, 47] Recreational fishing [43]
4. Minimise habitat damage	• Habitat damage • Area trawled	[9, 17, 41, 50] Recreational fishing [43]
5. Maintain biodiversity	• Biodiversity index? • Count of groups present • Depletion index	[2, 17, 37, 39, 47, 48]
6. Minimise pollution	• Pollution level	[47, 50] Recreational fishing [43]

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Appendix 4 Choosing a fishery's governance structure using data poor methods

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A4.1: ABSTRACT

Multi-species fisheries are complex to manage and the ability to develop an appropriate governance structure is often seriously impeded because trading between sustainability objectives at the species level, economic objectives at the fleet level, and social objectives at the community scale, is complex. Many of these fisheries also tend to have a mix of information, with stock assessments available for some species and almost no information on other species. The fleets themselves comprise fishers from small family enterprises to large vertically integrated businesses. The Queensland trawl fishery in Australia is used as a case study for this kind of fishery. It has the added complexity that a large part of the fishery is within a World Heritage Area, the Great Barrier Reef Marine Park, which is managed by an agency of the Australian Commonwealth Government whereas the fishery itself is managed by the Queensland State Government. A stakeholder elicitation process was used to develop social, governance, economic and ecological objectives, and then weight the relative importance of these. An expert group was used to develop different governance strawmen (or management strategies) and these were assessed by a group of industry stakeholders and experts using multi-criteria decision analysis techniques against the different objectives. One strawman clearly provided the best overall set of outcomes given the multiple objectives, but was not optimal in terms of every objective, demonstrating that even the "best" strawman may be less than perfect.

Keywords: Qualitative, management strategy evaluation, stakeholder engagement, trawl, data limited, governance.

A4.2: INTRODUCTION

Fundamental problems in the way fishery governance is implemented can have an enormous impact on sustainability [1]. The theory behind good governance and what it constitutes has become a topic that is now reasonably well understood by fisheries managers and progress has been made in this regard in some parts of the world [2]. It has also resulted in a shift in focus from the biological resource to the resource users, and from use of top down management systems to those based on co-management and industry participation. Good governance, for example, incorporates multiple objectives, brings time horizons of the industry into line with those of the public, enables effective adaptive responses, and promotes equity [1].

Fisheries management is seen by some as a wicked problem [3, 4] because interactions within and among the social, economic, and ecological systems are highly complex, nonlinear and therefore deemed unsolvable. However, there is evidence that the complexities of management can be addressed through, amongst other things, direct involvement of stakeholders in the management process [5, 6] and the application of the adaptive management loop (or learning by doing) [7].

When studies have been undertaken where fisheries are deemed to be well managed, often the key ingredients have been information, identity, institutions and incentives [8, 9]. Stakeholders need to be informed about the current understanding of the environment and the limits to this understanding. Strong

institutional arrangements are often needed to enable stakeholders to influence management, and the management system must create the right incentives to achieve at least some of the stakeholders' objectives.

When an opportunity exists (whether by legislation or not) to modify a fishery's governance structure in some way, it is clear that strong stakeholder engagement in the process is essential. All stakeholders should have as much information about the fishery as possible, and the impact of proposed changes should be analysed across a full range of objectives (i.e. ecological, economic, social and governance), with mechanisms in place to ensure that this process has an influence on the outcome. However it is often seen as an impediment to management modifications when a system lacks the detailed information to produce sophisticated stock assessment models or is unable to quantitatively investigate management strategies through a management strategy evaluation process [10-12]. Despite this, and rather than maintain *status quo* while this information is developed, the precautionary approach [13] states that lack of information should not be an impediment to taking action. As a result, expert opinion [14, 15] and data limited approaches are being developed and used in the fishery context [16, 17].

The Queensland East Coast Trawl Fishery (ECTF) (Figure 9) is used here as a case study to further this stakeholder elicitation process and develop a new governance and management system for a data limited fishery. This commercial fishery occurs along the tropical and sub-tropical east coast of Australia, with fishers and their associated community all along the east coast of Queensland – a distance of about 5200km. A large part of the fishery (about 60%) operates within the Great Barrier Reef Marine Park (GBRMP) which is managed for its conservation values and assets by an independent Authority (Great Barrier Reef Marine Park Authority) of the Australian Federal (Commonwealth) government. Although the fishery is managed by Queensland, it has to conform to Great Barrier Reef Marine Park legislation as well.

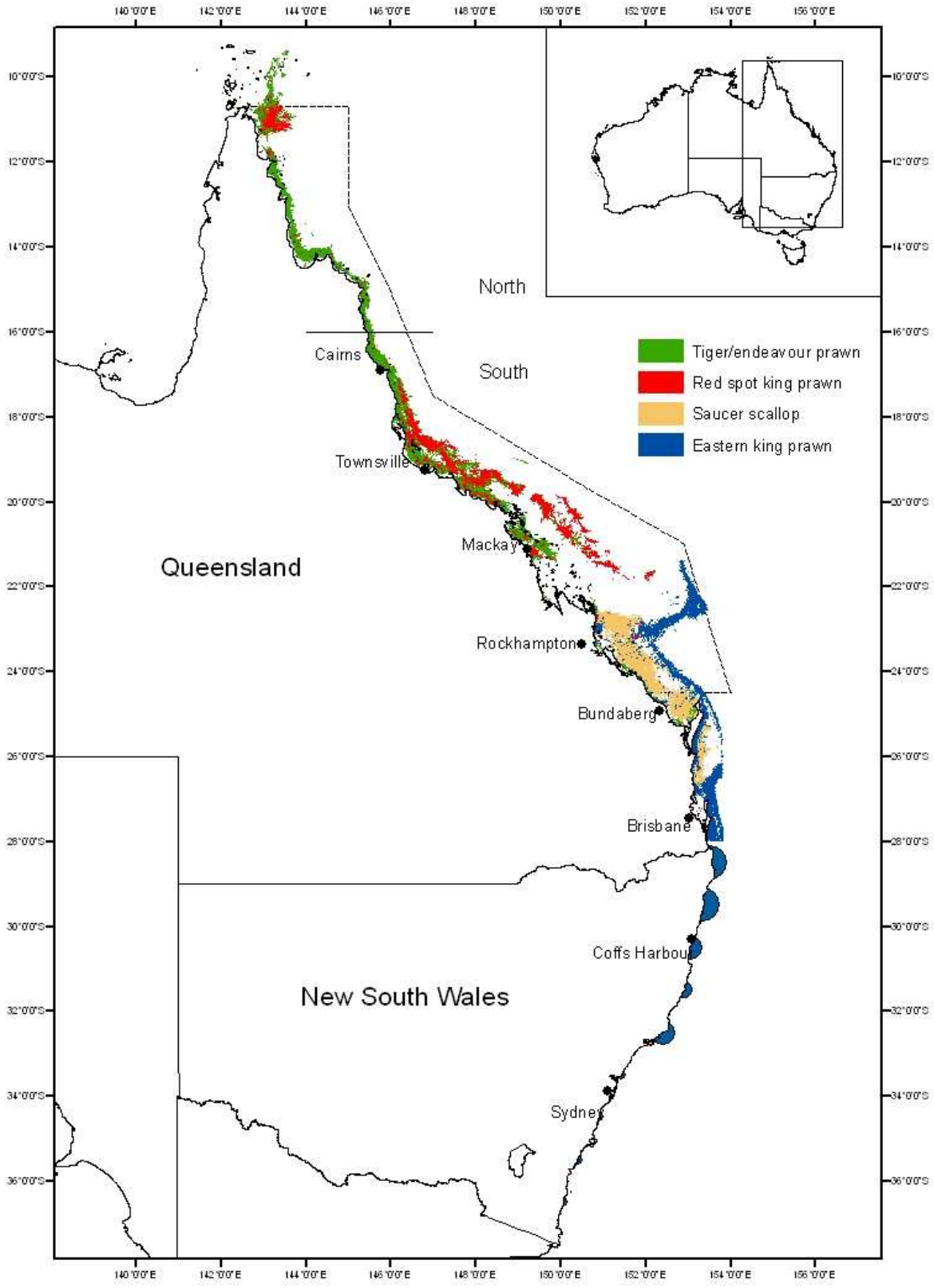

Figure 9. Map of the Queensland trawl fishery showing the different sectors and the reef and Marine Park boundary of the Great Barrier Reef. Source: Queensland Department of Employment, Economic Development and Innovation.

The ECTF targets several prawn, scallop and bug[6] species. The fishery has several sectors roughly divided by location and main target species: the Northern fishery targeting redspot king prawns inshore and tiger prawns offshore; the scallop fishery, the banana prawn fishery and the eastern king prawn fishery. There are also separate endorsements within the fishery - the Moreton Bay trawl fishery and the beam trawl fishery within the estuaries. The Moreton Bay and beam trawl fisheries were excluded from this process as they were a separate licence and were part of another review process.

The fishery is managed by a tradable input control system (fishing days referred to as 'effort units') at the whole of fishery level. Although the number of fishery licences has reduced in the past decade, there are 1.76million active effort units and 1.14m unutilised effort units. The trade value of these units is low given the large amount of unused units most often due to the high costs of fishing and low price obtained for prawns. Furthermore, the fishery is socially complex with some ports within large cities, such as Cairns and Brisbane, that do not rely on the revenue generated by the fishery, whereas in other regions the local community depends heavily on the economic and social capital the fishers provide.

This paper details the combination of scientists', managers', conservationists' and industry knowledge into a tiered stakeholder elicitation process that was used to develop of detailed fishery objectives and their relative weights; development of new management strategies to achieve these objectives; assessment of their perceived impact over a 10-year period against the objectives; and derivation of an overall score for each strawman, while also eliciting further strategies given the results of these processes.

A4.3: METHODS

A staged approach similar to that described in [15] was used in which a set of different management strategies were assessed against a set of management objectives. The complete process involved elicitation[7] of a) objectives and b) their relative weighting. The derivation and weighting of the objectives and are described in detail by [19]. The next step used stakeholder and expert groups to c) develop management strategies and to d) assess the relative impact of these against each management objective. This latter process means that one can derive the strengths and weakness of each strawman. Finally, the objective weights were applied to determine which strawman also best met the objectives of each stakeholder group and e) to develop an overall impact score. In order for stakeholders to make informed decisions, a mixture of information was provided to the stakeholders from the output of stock assessment models, a bycatch risk assessment approach, as well as basic data such as catch and effort. However, this information was not complete since the above information for some species was well known whereas that for others were only based on opinion elicited from experts. In this paper, we concentrate on the development and assessment of the management strategies.

Four high level objectives were identified in [19], namely "Maximise economic performance of the east coast trawl fishery", "Simplify and improve management structures", "Maximise social outcomes" and "Ensure sustainability". Each of these had several sub-objectives that were more specific to the fishery. The relative importance of individual objectives was assessed using the Analytic Hierarchy Process (AHP) [20] though a mail out to individuals representing seven different stakeholder groups, being the fishing industry, the on-shore industry, managers (state fishery), conservation (marine park managers and conservation NGOs, recreational fishers, local communities and scientists. The weightings for each of the sub management objectives were assessed for each of stakeholder groups.

6 "Bugs" are crustaceans with a small prehistoric lobster-like appearance that are found in the tropical and sub-tropical waters of Australia and parts of south east Asia.

7 More detail on the elicitation process, the description of the structure of the committees and philosophy behind the role of each, as well as the successes and failure of the process are provided in [18] Jebreen E, Dichmont C, Pears R, Pascoe S, Brooks K, Perez P. Does elicitation and comanagement works to develop a new management system: a case study? Mar Policy. in Prep.

A4.4: ELICIT MANAGEMENT STRATEGIES

Two expert driven committees, one being a subset of the other, developed the strawmen. The smaller strategic group (called the Trawl Scientific Advisory Group - SAG) consisted of scientists (biological, economic and social), fisheries managers, and industry (both fishing and post harvest activities), while the larger tactical group (called the Technical Advisory Group - TAG) included several SAG members but also additional industry participants, as well as marine park management compliance, recreational and other conservation interest groups. The SAG worked as a think tank to develop and refine several strawmen, given critical feedback on the likely efficacy of the strawmen by the tactical group. The larger TAG was more representative of the key stakeholders in the fishery.

Information on the biological status of the resource, trends in catch and effort, external pressures on both managers (e.g. desired legislative reforms) and industry (input and output prices), boundaries (e.g. individual transferable quota system would not be considered acceptable) and specific issues and concerns relating to particular sectors, were provided to both SAG and TAG members. The present management system has a tradable effort (input) unit system at the whole of fishery level. This means that although there are several reasonably distinct sectors within the fishery (e.g. scallop, eastern king prawn etc.) an effort unit enables a vessel to fish in any of these sectors. This has historically presented difficulties in managing for sustainability at the sector level, as no mechanism exists to control access to each of the sectors. As a result, the strawmen had to initially define at which spatial scale the tradable unit comes into effect, and if at the whole of fishery level, how each sector would be managed as an economical and sustainable unit. The remaining components of a strawman would then be set in the context of this decision.

The SAG developed strategies that would stretch the thinking of the larger TAG, for example managing the fishery through a series of decrementation systems as opposed to the traditional spatial and temporal closures. The idea was to develop options that would stimulate innovative thinking and, although controversial, allow for new ideas to be nurtured and to move the fishery away from the *status quo* given its present difficulty to easily address sustainability issues.

A4.5: QUALITATIVE IMPACT ASSESSMENT

The SAG and TAG rated each strawman *relative to the current situation* against each objective (Figure 10) on a scale of -3 (“Considerably worse than current situation”) to +3 (“Considerably better than current situation) following the approach applied by [21]. The output of this process is an impact matrix $I^s_{i,j}$ where *s* is strawman, *i* is the number of objectives and *j* is the total number of TAG and SAG members. These members also rated their confidence in their score for each objective (but not by strawman), from 1 which is “very unsure” to 5 being “certain” termed the confidence score.

Applying the confidence scores, $C^s_{i,j}$, to the impact matrix is simply done by adding the impact matrix to the average (over *j*) of the confidence scores and normalising i.e. $\left(I'^s_{i,j} + \overline{C}_i\right) / \overline{C}_i$. This results in higher weight being applied to strategies where participants scores were more certain, and lower weight to those where scores were less certain.

The relative weights per respondent (from the SAG, TAG and mail out group) for each objective were combined into a single relative weight matrix, $W^t_{i,r}$ by stakeholder group, *t*, where *r* is the number of respondents to the survey (which is of course a larger number than *j*). The overall results can therefore be combined, $W'I$ for each stakeholder group and strawman. Where the sums of all the objectives are a positive score, an overall positive contribution is indicated and a negative score indicates an overall negative result relative to the current situation. The scale of the confidence score indicates the degree of a positive or negative change expected.

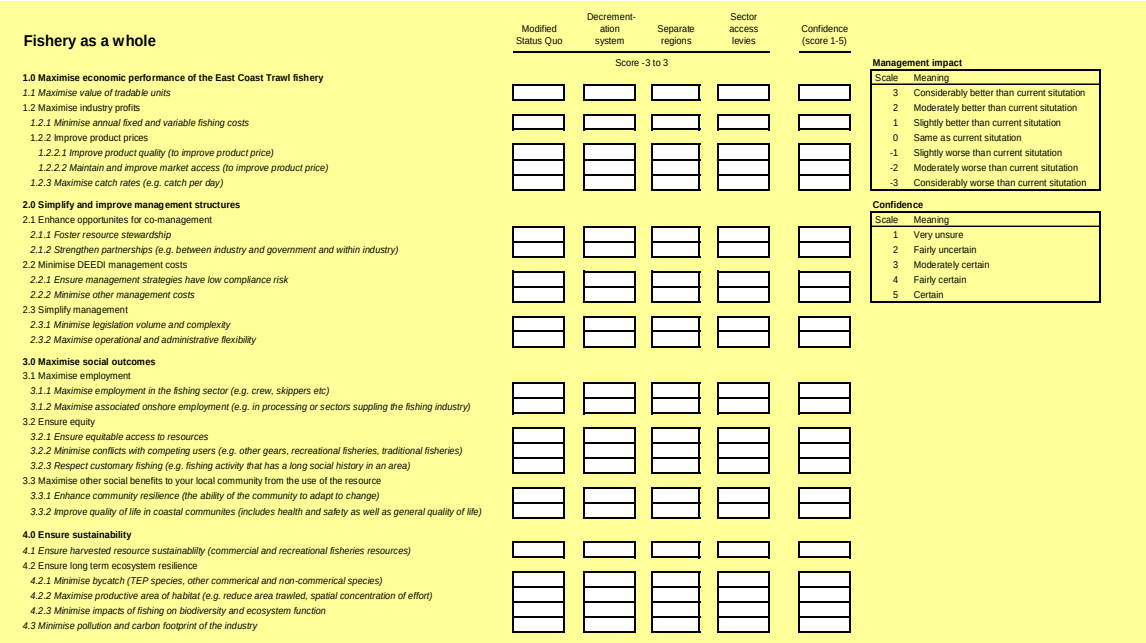

Figure 10. Impact matrix sheet showing the hierarchy of objectives in the first column, the definition of the scores and the confidence of these.

A4.6: RESULTS

Elicited management strategies

The SAG and TAG initially developed four strawmen: modified status quo (MSQ); decrementation system (DECR); separate sectors (SECT); and sector access levies (SAL). These were designed to be fairly different in their approach, but avoided (by agreement of SAG/TAG members and managers) an individual transferable quota system. The fishery as a whole is seen as not being mature enough to move to such a complex system given that many of the species have no stock assessment, and are short-lived and highly variable. All strategies still relied on a tradable effort unit. Within each governance structure, additional measures were also proposed to address particular issues identified.

An important first consideration was at what level the tradable effort units would apply. There were essentially two choices: that of keeping the present whole of fishery level or apply them to the sector level (or some spatial surrogate). The former was seen as valuable in that it allowed free movement of fishing operations between sectors and therefore enhanced resilience of fishers to deal with pressures both acute and chronic within the fishery. The weakness was that this system made it difficult to use an approach based on effort units as a measure to control the sustainability of a single sector. Thus it was decided that at least two of the strategies should include one of each of the above options.

The first strawman developed, “MSQ”, explicitly maintained this tradable system, but included seasonal controls and options for in-season management of a set of catch rate triggers or a total sector effort cap to address the issue of still managing the sectors (roughly species groups) at sustainable and economically profitable levels. Changes to existing season closures were also made. This potential closure regime meant that the fishery sector start date was determined by a season date whereas its closure date was determined either by reaching a pre-agreed economically profitable catch rate trigger, a sustainability based effort cap or the end of season date. The system was designed to reach the economic trigger first as this allowed for a data poor Maximum Economic Yield equivalent target.[8]

8 The triggers were based on the principle that profits in a depletion fishery (such as the prawn fisheries) are maximised when the marginal revenue is equal to the marginal cost. While both measures were unknown, it was agreed that a critical catch rate could be determined that would be a suitable proxy for this measure.

Very different to MSQ, was the proposed strategy to separate the fishery into regions that roughly translated into the different sectors (SECT). Only fishers with history in the sectors would be given a proportional allocation in effort units to this sector but the total effort units transferred would be set at sustainable levels. This would therefore require an allocation process (the nature of which was not determined in the analysis as this is often controversial), but would allow management at the fishery sector level (i.e. roughly at the species level) for sustainability.

In order to reduce the amount of legislation and increase fisher's choice, the third strawman was to develop a decrementation system (DECR) of in-season management and movement between sectors, but still retain most of the other aspects of the MSQ system. When catch rates are low within a sector (e.g. where the MSQ would have shut the fishery), when a resource is in poor condition, or when greater levels of fishing effort are applied in a sector than is desired by managers for any other reason, the effort units required per day fishing in that sector would be increased to act as an incentive to fish elsewhere. The degree of change would depend on the degree to which excessive fishing was occurring. This system could also entice fishers into a region or time by reducing the decrementation rate if effort levels were lower than desired. This allows a choice by the fisher whether they remain and fish with lower/higher penalties, or move elsewhere to minimise or avoid penalties.

The final strawman (SAL) was developed much later in the process and was introduced by an industry member in the SAG. The system maintained the elements of MSQ but added an industry funded buy-back system. This strawman required fishers to pay an access levy when entering each sector for the first time in a year. Although the government would administer this levy in practice, it would be guided and managed essentially by industry, requiring a strong co- or self-management model. The funds generated were proposed to be used mainly for buying out latent effort units (thereby increasing the value of remaining units), but also for industry funded surveys and other research to support the fishery.

Assessing relative merits of the strategies

The final set of objectives used in the analysis is described in detail in [19]. These objectives are also shown in Figure 10, which is a snapshot of the "whole of fishery" spreadsheet used by the SAG and TAG for scoring the strategies against each objective. The overall impact score by strawman (Figure 10) combines the scores by strawman for each objective (Figure 11).

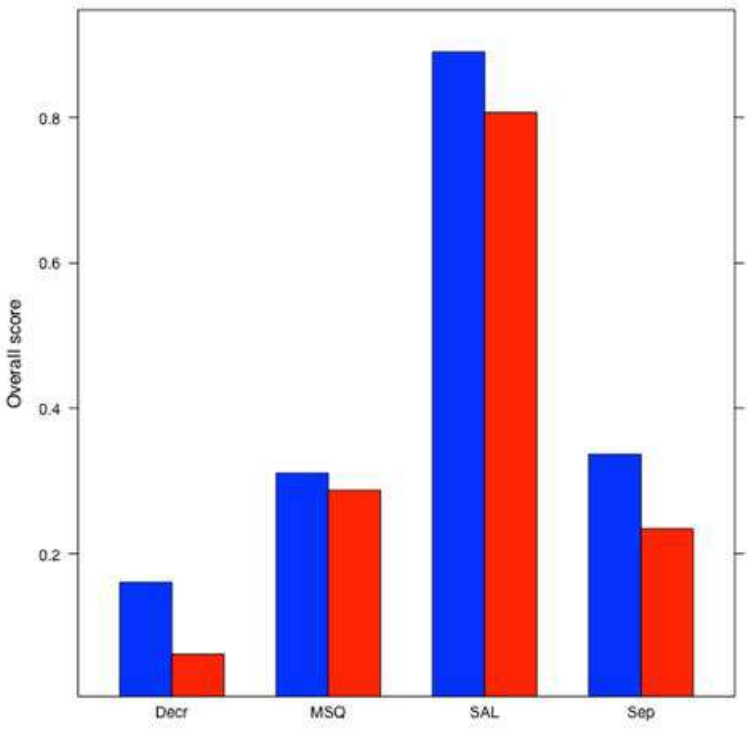

Figure 11. Overall impact score of different management strategies with (blue) or without (red) confidence scores. "Decr" is the Decrementation system, "MSQ" is the Modified Status Quo, "Sep" is Separate Sectors and "SAL" is Separate Access Levies.

All the strategies provide overall positive results compared with the *status quo*. This is not surprising, as the committee that designed the different strawmen knew the weaknesses of the present system well and expressly endeavoured to produce a system that would be an improvement, if at all possible, across all the upper level objectives. The SAG and TAG members rated the SAL strawman as the best of the systems considered, with little difference between the next two strategies, MSQ and SECT. However, when the confidence scores (the SAG and TAG members' view of their ability to predict the impact of a strawman against an objective) are considered, the overall score of the SECT strawman (that of breaking the fishery into sectors which would require an allocation system with an unknown process) was reduced. The DECR system was believed to provide little improvement over the current system.

Given the difficulties in comparing one person's subjective assessment of magnitudes of change with another's, an alternative is to just count the number of perceived positive, neutral or negative impacts (i.e. better, same or worse) (Table 5). This resulted in a similar ordering of outcomes as from the previous analysis: the SAL scored much higher than any of the other strawman (19 positive of the 23 objectives), while at the other end of the scale, DECR had 11 positive and 12 neutral or negative scores for those 23 objectives.

Table 5. Number of objectives using the overall weighted scores that are better (positive) or either the same or worse (negative) than current.

OBJECTIVES	SCORE RANGE	MODIFIED STATUS QUO	DECREMENTATION	SEPARATE SECTORS	SECTOR ACCESS LEVIES
No. positive	1 to 3	15	11	15	19
No. negative/no change	-3 to 0	8	12	8	4

At the objective level, most of the strategies were rated as producing positive benefits against the different economic objectives (Figure 12). The opposite is true for management objectives with the notable exception that SECT and SAL were positively rated against objectives "Foster resource stewardship" and "Strengthen partnerships". The ratings to the social objectives were mixed with negative, neutral and positive scores with no consistent pattern between strategies. On the other hand, all the strategies scored positively against all the sustainability objectives.

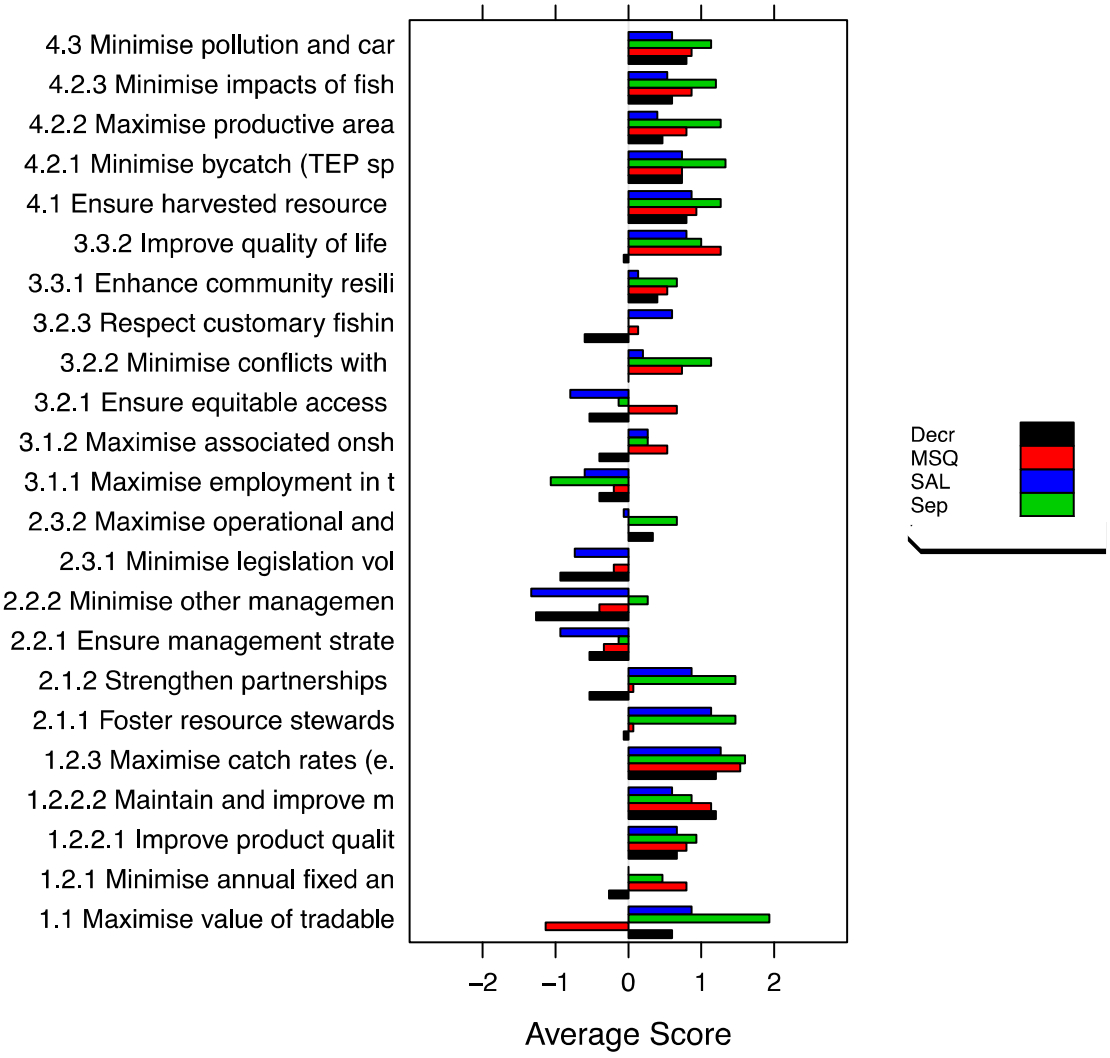

Figure 12. Overall weighted impact score by strawman for each objective. "Decr" is the Decrementation system, "MSQ" is the Modified Status Quo, "Sep" is Separate Sectors and "SAL" is Separate Access Levies.

The scores for the objectives (Figure 12) can be summarised in terms of their worst and best overall scores (Table 6). Considering positive scores as representing benefits, and negative scores to represent costs, the greatest perceived "benefit" of MSQ was that catch rates are likely to be high, whereas the greatest "cost" was that the tradable unit value would remain low. The low tradeable unit was more seen as a symptom of the remaining issue of latent effort which could enter the fishery when the fishery becomes profitable dissipating all the work undertaken by the active fishers over time. The key perceived benefit of DECR was increasing market access, with the greatest cost being increased management costs. The key perceived benefit of the SECT strategy was to maximise catch rates but, even more so than DECR, the cost was believed to be an increase in management costs. The greatest expected benefit of the system that includes an access levy (the SAL strawman) was to maximise the value of the tradable unit, but at the greatest cost of decreasing employment.

Table 6. Objectives with the highest and lowest average score for the different management strategies (Average score in brackets).

STRAWMAN	OBJECTIVE WITH HIGHEST SCORE	OBJECTIVE WITH LOWEST SCORE
Modified status quo	Maximise catch rates (1.66)	Maximise value of tradable units (-1.150)
Decrementation	Maintain and improve market access (1.32)	Minimise other management costs (-1.397)
Separate sectors	Maximise catch rates (1.27)	Minimise other management costs (-1.500)
Sector access levies	Maximise value of tradable units (1.808)	Maximise employment in the fishing sector (-1.283)

The SAL strawman received positive scores for most the management objectives with the exception of "Maximise employment in the fishing sector", "Ensure management strategies have low compliance risk" (although all strategies were negative for this objective), "Minimise legislation volume and complexity" and "Ensure equitable access to resources". The latter is because the buyback scheme is based on how many sectors are accessed in a year and varies with the size of fishing vessel – the latter is seen as a way of maintaining the small-scale businesses within the fishery. From discussions within the TAG, access levies were seen to disadvantage the smaller vessel owners who had less capacity to pay for access to more than one sector compared to their larger counterparts. Administering this system was also seen as increasing management costs.

A cumulative probability function of the scores can be calculated for each of the strategies by six of the seven stakeholder groups (here we excluded scientists as their numbers were too low) (Figure 13). This is based on each of the SAG and TAG member's set of impact scores (*N*) being multiplied by each of the SAG, TAG and survey respondent's set of objective weightings (*M*), giving an *N*M* set of possible outcomes. This provides some indication of the effects of uncertainty in subjective scoring and heterogeneity in objective preferences within the different stakeholder groups. Although more than the final seven stakeholder groups were initially identified, the 90 respondents from the objectives weighting survey were divided into stakeholder groups consisting of "Fishing Industry", "On-shore industry" (including processors and other businesses associated with the fishing industry), "Managers" (State fishery managers), "Conservation" (including both marine park managers and conservation NGOs), "Recreational Fishing", "Local Community" (represented by local council members from different councils along the coast) and "Scientists".

Figure 13 identified that there was not a substantial difference in the responses to the merit of the strategies in relation to the objectives between the different stakeholder groups. The SAL strawman was consistently scored better by each of the different stakeholder groups. The figure also indicates the perceived potential risks of any large negative impacts. For example, the probability of scores less than zero for the MSQ scenario quickly approach low values as scores decrease, suggesting that while it was not expected to create the greatest benefits, it is believed to have the lowest downside risk. The other strategies were perceived to have higher probabilities of a more negative result with SECT consistently indicating people's perception of a higher risk of large negative impacts.

As Figure 13 shows cumulative probabilities, the score at the break-even point (zero on the x axis) indicates the cumulative probability of obtaining a zero or negative score, and hence the lower the score the better the strawman is considered to be compared to the current situation and that positive scores are more likely. A comparable method is to produce the probability at, for example, the break-even point (Table 7). From Table 5, the SAL has the greatest expectation of positive outcomes (the lowest expectation of zero or negative outcomes), but also shows that there is some difference between the ratings by stakeholder groups.

Table 7. Comparison of the different stakeholder groups' break even points i.e. the cumulative probability where the overall score is zero.

STAKEHOLDERS (ROW) STRAWMAN (COLUMN)	MODIFIED STATUS QUO	DECREMENTATION	SEPARATE SECTORS	SECTOR ACCESS LEVIES
Industry (Fishing/On-shore combined)	32%	32%	25%	17%
Managers	28%	28%	25%	20%
Conservation	25%	22%	24%	18%
Recreational Fishing	22%	31%	26%	19%
Local Government	24%	25%	25%	19%
Scientists	26%	22%	22%	12%
Average	26%	27%	25%	18%

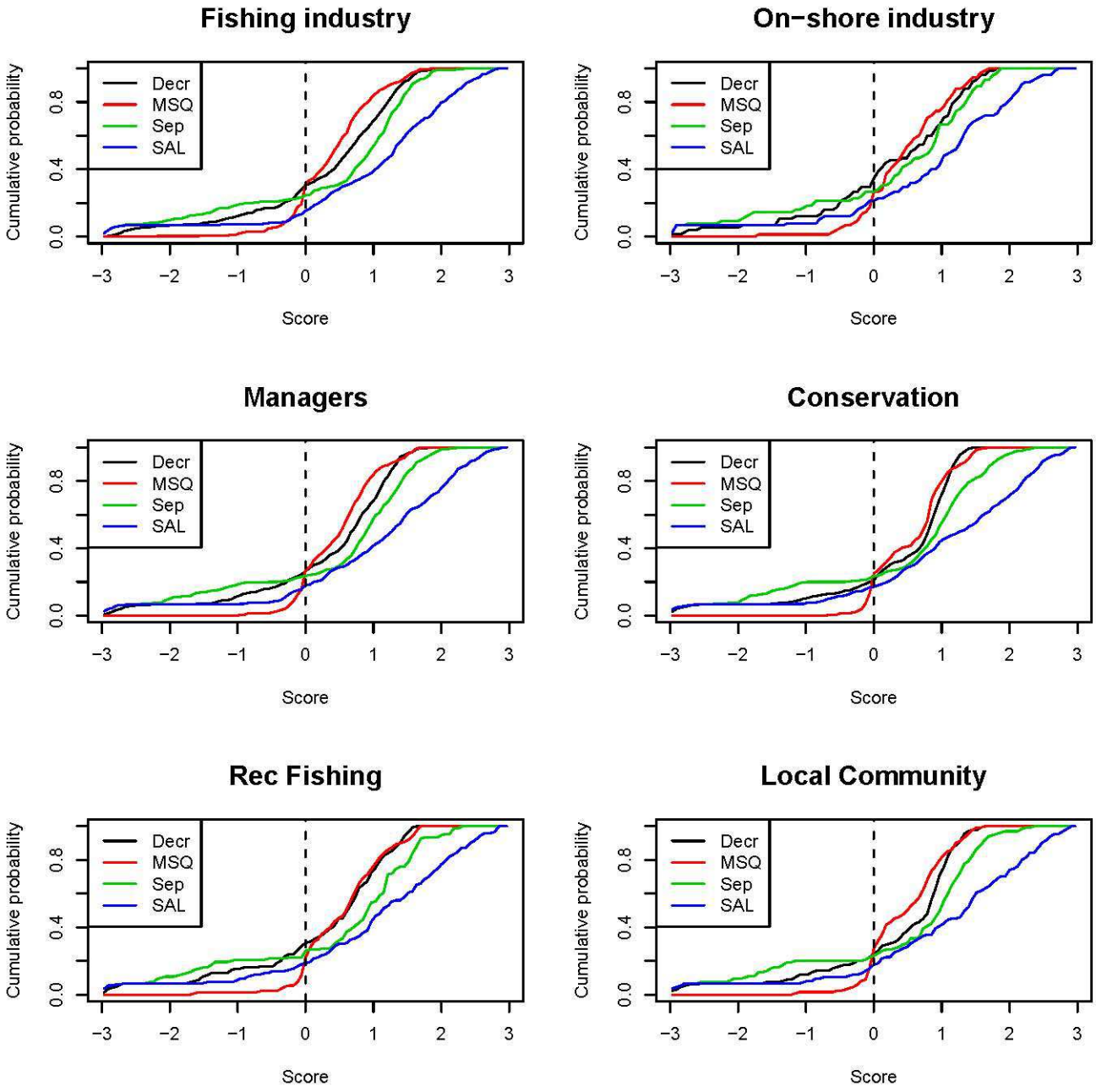

Figure 13. Cumulative probability distributions of the overall score (-3 is substantially worse and 3 is substantially better) for each strawman. "Decr" is the Decrementation system, "MSQ" is the Modified Status Quo, "Sep" is Separate Sectors and "SAL" is Separate Access Levies.

A4.7: DISCUSSION

Although resource conservation remains paramount, the perceived failure of biologically oriented management [5] aimed at controlling how much of the resource is removed annually, has resulted in increased attention to instruments that provide appropriate social and economic incentives. Using governance systems that align fishers' objectives with those of management has been found to be a significant success factor underlying stock recovery in most fisheries (Worm *et al.* 2009). With this change in focus has come increased interest in incorporating economic and social analyses into fisheries policy development, and, more recently, an increased interest in the dimensions of healthy biological populations impacted by fishing; the economic health of fishers and their associated industries; and management performance and equity [1]. Good governance requires stakeholder empowerment not only in terms of

providing their input to the operational management process, but also through the ability to influence core policy development [8].

Traditionally, moving to a new management system often involved evaluation using quantitative models such as Management Strategy Evaluation [12] [10, 22] or other quantitative approaches when the former is lacking. However, many of the world's fisheries are data limited to some degree [17]. Also the institutions associated with these fisheries often do not have the capacity or resources to undertake high-end quantitative analysis. As such there is a growing application of expert driven, qualitative approaches to evaluating management strategies of fisheries [14, 21, 23], water, mining, forestry and other resources [24] [25]. Many of these approaches use stakeholder engagement and analysis of qualitative data using multi-criterion decision analysis techniques (see [26]).

In this study, a tiered stakeholder elicitation approach was undertaken from using a small expert committee (SAG) to a larger committee with broader representation (TAG) and then to the broader community and industry. The process involved multiple iterations between each of these groups (especially the SAG and TAG) both taking and providing input at each step – developing objectives, weighting these objectives, developing management strategies, scoring the relative impact of these strategies against each objective and then discussing the overall results. The overall show a surprising similarity especially with respect to the favoured strawman.

The overall score shows that an expert consultation process was able to produce strategies that were reasonably different but still were, to varying degrees, better than the current system. Interestingly, participating on the SAG for some time, an industry committee member suggested the strawman that produced the best overall rating. This shows the value of experts from several stakeholder groups including industry, being involved from the outset of the process and being able to directly contribute ideas. Although this method is, at its basis, subjective and expert driven, all available scientific information and input was provided to participants throughout the process, which helped, reduce issues of subjectivity. This information was largely biological, with relatively little external information available in relation to social or economic impacts as few relevant previous studies have been undertaken on this, or a similar, fishery.

Based on the weighting of the objectives and their impact scores against the management objectives, it is clear that all four management strategies are expected to deliver on economic and sustainability benefits reasonably successfully. However, the management strategies were not as successful in clearly producing social benefits. While explicit social objectives were identified and assessed, these objectives were not highly weighted by stakeholder groups against the other major objectives. From the discussion about this finding with the SAG and TAG, there was a general view that the social aspects of this fishery are very important, but that they were *in part* captured through a sustainable resource and a profitable fishery. As an example, a profitable fishery can maintain better onshore facilities and employment, and therefore a region's social capital. On the other hand, many fishers did not want a fishery consisting of large, economically efficient operators at the expense of small, family owned operators (see [27] for more detail).

The fishery currently has large amounts of unused effort units and most stakeholders see the present active level of effort units as either just enough or too much. This means that only a very large removal (i.e. beyond latent) of effort units would result in the sustained decrease in actual effort. The SECT and, especially, SAL are the only strategies that addressed the removal of latent unutilised units (although through very different mechanisms) and therefore scored well. With regard to the value of the unit, breaking the fishery into regions that roughly translate to the sectors (and also species groups) is rated as being the best strawman to increase the value of the fishery. SECT reduces latent effort and is also the best to manage for ecological sustainability and fishery viability without having to address the movement of effort from other regions. However, an allocation process was seen as a large risk.

The MSQ was expected to result in higher catch rates but to also produce low tradable unit values, which initially seemed counter-intuitive. The MSQ incorporated a system where the sector is closed when catch rates fall below a (more economically driven) trigger point. This will mean that fishers either have to move to another sector or go back to port. This system does not decrease latent effort units thus keeping the tradable unit values low. It can be argued that as the resource recovers to higher catch rate levels, it would

entice more vessels to enter the sector and thereby reduce the profitability of the existing vessels (referred to as “the waterbed effect” by some SAG and TAG members).

There was not a substantive difference in the overall scores for each strawman between the different stakeholder groups, despite this fishery operating partially within the Great Barrier Reef Marine Park - which is of particular interest to conservation and community groups. When the influence on scores of objective weightings by the appropriate stakeholder group was considered, it became clear that different stakeholder groups liked the same strategies but for different reasons. The break-even point was also reasonably similar between stakeholders and highlights that combining the results are reasonable in this example. Clearly, combining results when the results by stakeholder are very different would not be appropriate.

Multicriteria decision analysis has been used extensively in the fisheries context [21, 28, 29]. Pascoe *et al*. (2009) [21] applied a very similar method to that used within this study, but towards developing different spatial management options. They argued that the benefit of the approach is that it focuses attention on impacts relative to specific objectives, thus reducing potential bias. However, they also recognised that the method is not objective and that the scale of an impact is not necessarily the same for different TAG or SAG members. In this study, we have attempted to overcome this deficiency in two ways. First, we asked those assessing the impacts to provide a subjective assessment of their own level of confidence in their scores, and re-weighted the impacts giving higher weight to those who claimed greater confidence. Second, we developed a probability distribution rather than single outcome measure that took into account heterogeneity in both the impact scores and also the objective preference weightings. In this regard, the analysis is more robust than that in the previous study.

The strengths of the method used in this study are that it elicited clear descriptions of potential management strategies and was able to assess these against a hierarchy of objectives across social, economic, sustainability and management axes. The qualitative method developed here has application in complex and data poor fisheries and other natural resource management. A further benefit was seen that the stakeholder elicitation process made many of the stakeholders that started as critics, better understand the complexities of management. The process also moved thinking away from only modifying the status quo to more innovative options such as an industry funded buy-back scheme and variable effort unit decrementation systems as an alternative to seasonal closures.

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Appendix 5 Management objectives of Queensland fisheries: putting the horse before the cart

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A5.1: ABSTRACT

A review of future management arrangements for the Queensland East Coast Trawl fishery was undertaken in 2010 to develop a management plan for the next 10 years. A key question raised at the start of the review process was: what should the management plan achieve? As with fisheries management in most countries, multiple management objectives were implicit in policy statements, but were poorly specified in some areas (particularly social objectives) and strongly identified in others (e.g. an objective of sustainability). As a start to the management review process, an analysis of what objectives the management system should aim to achieve was undertaken. A review of natural resource management objectives employed internationally was used to develop a candidate list, and the objectives most relevant to the fishery were short-listed by a scientific advisory group. Additional objectives specific to Queensland fisheries management, but not identified in the international review, were also identified and incorporated into the objective set. The relative importance of the different objectives to different stakeholder groups was assessed using the Analytic Hierarchy Process. As with other studies, the relative importance of the different objectives varied both within and between the different stakeholder groups, although general trends in preferences were observed.

Keywords: multiple objectives, fisheries management, analytic hierarchy process, stakeholder preferences, Queensland fisheries.

A5.2: INTRODUCTION

Management by objectives was a popular business management system in the latter decades of the last century, and has been demonstrated to increase productivity in a wide range of industries [1, 2]. The traditional model of management by objectives involves a retrospective analysis of how different strategies (or individuals) performed against the agreed set of goals determined at the start of the process. The approach has been criticised in the business environment as it created incentives for unrealistic goals to be set by business managers (rather than agreed with staff), although in more recent years the advent of greater empowerment of stakeholders has created a renewed interest in this management system [3]. In the revised system, stakeholders are more directly involved in the development of both objectives and the strategies themselves with the aim of achieving the agreed goals.

The principles underlying management by objectives are as applicable to natural resource management as they are to a commercial business. Increased interest in developing co-management arrangements with the industry is giving stakeholders a substantially greater involvement in management decision making, particularly in fisheries [4, 5]. Further, stakeholder involvement in the development of fisheries management objectives and assessment of their relative importance has been shown to be essential for the development of appropriate management plans [6]. However, in fisheries management, the stakeholder group can be defined as the industry, but more recently, as a broad group of industry and onshore facilities, other users of the resource (e.g. recreational fishers), and groups with a conservation interest.

While, fisheries management policy in most countries is largely concerned with achieving a similar set of objectives, namely biological, economic, social, political and environmental objectives [6-8], these are generally vague in both their definition and relative importance. Such was the case for the Queensland East Coast Trawl Fishery, the management of which was subject to review in 2010. The aim of the review was to develop a management plan for the fishery that would operate over the next decade. The overall management objective for Queensland's fisheries, as stated in the aims of Queensland Fisheries Strategy 2009-2014 [9], is to get the best possible economic and social benefits for society through effective management and sustainable exploitation of the fishery. Economic targets were specified as achieving the maximum economic yield from the fisheries [9], however the social objectives were undefined. Further, the revision of the fisheries management plan required broader consideration of other factors. Broader Queensland government objectives [10, 11] included expanding employment in resource based industries, while pressures existed within the fisheries management agency to simplify management processes in order to reduce management costs [11]. Fishers themselves sought a greater role in management decision making and a direct involvement in the management review, and this was also supported by the Queensland Government's Fisheries Strategy [11]. Fisheries management in Queensland is also of interest to recreational fishing groups as well as conservation groups and agencies. In the case of the latter stakeholder group, parts of the fishery operate within the Great Barrier Reef Marine Park, and the Great Barrier Reef Marine Park Authority has an active interest in the management of the fishery as part of the agency's mandate to ensure use of the Great Barrier Reef is ecologically sustainable and consistent with long term protection of this World Heritage Area.

Given the complexity in terms of a number of vague but competing objectives, and the diversity of stakeholder groups with a direct interest in the review process, definition of explicit management objectives and an assessment of their relative importance by individual stakeholders was a critical first step in the review process. The preference for a particular management option by a particular stakeholder group depends on their perceptions of the overall net benefit (or cost) given the set of outcomes against each objective and priorities given to these objectives. Conflicts and disagreements between (and potentially within) stakeholder groups largely arise as a result of differing importance placed on different objectives. Making these objective preferences explicit assists in the reduction of conflicts and help to develop consensus, as different stakeholders can evaluate their own proposals from the others' perspective.

The purpose in this paper is to detail the process undertaken to identify the set of objectives deemed relevant to the management of Queensland fisheries and in the context of the review of the East Coast Trawl Fishery. Further, it discusses the relative objective preference structure of the different stakeholder groups influential in the development of a fisheries management plan. A previous study identified and weighted management objectives for Australian Commonwealth fisheries [6]. However, differences between State and Commonwealth fisheries policy (particularly in regard to social considerations) and environmental issues unique to Queensland (e.g. the involvement of commercial fishing activity within the Great Barrier Reef Marine Park) do not allow these objectives and weights to be transferred to the State fishery level. As with the previous study, preferences were derived using the Analytic Hierarchy Process (AHP) [12] across a range of different stakeholders. The coherency of the preference structures within the different stakeholder groups was also examined to determine the degree to which the stakeholder groups are uniform in their viewpoints.

A5.3: THE QUEENSLAND EAST COAST TRAWL FISHERY AND MANAGEMENT REVIEW

The Queensland East Coast Trawl Fishery is a multi-species fishery that primarily targets several prawns species, Moreton Bay bugs and scallops. The trawl fishery is Queensland's largest commercial fishery, with about 600 licensed vessels catching product valued at approximately $100 million in 2008-09 [13]. While managed as one fishery, several distinct sub-fisheries (termed sectors) exist, with some fishers operating in several sectors while others specialise in just one sector. The fishery is currently managed through a transferable effort unit system, where vessels require a given number of effort units to operate each night based on their vessel size. Effort units can be deployed across any or all of the different sectors, with no effective cap on effort applied to any particular sector.

The fishery is currently managed under the Fisheries (East Coast Trawl) Management Plan 1999, which commenced in 2000 and established the effort control system currently in place. This plan formally expired at the end of 2009, and consultation with stakeholders in 2009 suggested a substantial revision of the management plan would be appropriate. The subsequent 2010 management review aimed to identify the objectives of the management plan (the subject of this paper) and assess a range of alternative management systems against these objectives with the aim of implementing a new management plan during 2011 (see Dichmont *et al.* [14], this volume).

The initial consultation and review process with a group of stakeholders identified a number of key issues. Falling prawn prices and increasing fuel costs have resulted in a substantial decrease in fishing effort in the fishery over recent years and a shift of effort to less remote areas. In 2010, only 345 boats (of the set of 600 licensed boats) were active and only 1.8 million effort units were used out of a total available pool of 2.9 million. The substantial latent effort in the fishery is of considerable concern to both managers and industry, the former in terms of their lack of ability to effectively control fishing effort in different sectors of the fishery (if required) and the latter in terms of the loss of asset values. With around 37 per cent of the effort units being unutilised, unit trading values and the quantity traded have fallen to negligible levels.

The fishery also faces a number of environmental challenges in terms of ecological interactions, societal acceptability, complexity and uncertainty. Part of the fishery operates within the Great Barrier Reef Marine Park, where marine park managers work in partnership with fishery managers and the industry to protect the natural values of the Marine Park and World Heritage Area and ensure fishing activities are ecologically sustainable. The trawl fishery has an associated bycatch of sea-snakes and marine turtles, both protected species. While levels of turtle bycatch have been greatly reduced through the use of turtle excluder devices, the bycatch of sea-snakes is an ongoing area of concern [15], with managers and industry working to further improve bycatch reduction devices and practices to help mitigate this interaction. The fishery is also subject to considerable scrutiny by environmental groups that have questioned the appropriateness and acceptability of trawling in marine parks of world heritage significance.

While negative externalities associated with environmental impacts generally do not affect fishers' decision making processes, Australia has strong environmental legislation that links to export accreditation. Failure to adequately address environmental impacts of Australian fisheries could ultimately result in the fishery's permission to export its products being withdrawn[9] or potentially even stronger measures such as an outright closure being applied in some sectors. As a result, environmental issues are taken seriously by operators in the fishery.[10]

A5.4: DEVELOPMENT OF THE MANAGEMENT OBJECTIVES HIERARCHY

Previous studies of fisheries management objectives (and natural resource management objectives in general) identify that generally a hierarchy of objectives is developed, with higher level objectives being the typical triple bottom line categories of economic, social and environmental objectives, and lower level objectives being more detailed or specific objectives for the fishery in question [6, 7, 17-19]. A similar approach was adopted for this study, although a fourth higher level objective – simplifying management – was identified early in the analysis.

The objectives hierarchy was developed initially through a comprehensive review of natural resource management objectives, including fisheries, forestry, water resources, agriculture and mining. The full set of objectives identified is presented in the supplementary information. The set of objectives were cross-referenced with existing policy documents relevant to the fishery and the Great Barrier Reef Marine Park [10, 11, 20, 21], as well as key legislation,[11] and a preliminary objective hierarchy was developed by the project team. The project team itself consisted of a biologist, social scientist, economist, fisheries manager

9 Export licences for Australian fisheries products are subject to approval by the Department of Sustainability, Environment, Water, Population and Communities (SEWPAC), under the Environment Protection and Biodiversity Conservation Act, 1999.
10 A review of the use of trade instruments to provide incentives to reduce bycatch and environmental damage is given in Pascoe et al. [16].
11 Fisheries Act 1994; Great Barrier Reef Marine Park Act 1975

and marine park manager. The preliminary objective hierarchy was presented to a Scientific Advisory Group (SAG), which consisted of additional scientists, fisheries managers and industry members (both catching and processing sectors) established as part of the management review, and a revised objective hierarchy agreed through consensus. This in turn was presented to the policy group of the government department responsible for the management of the fishery (the Department of Employment, Economic Development and Innovation, or DEEDI) who, after some minor additional adjustments, accepted the final hierarchy (Figure 14).

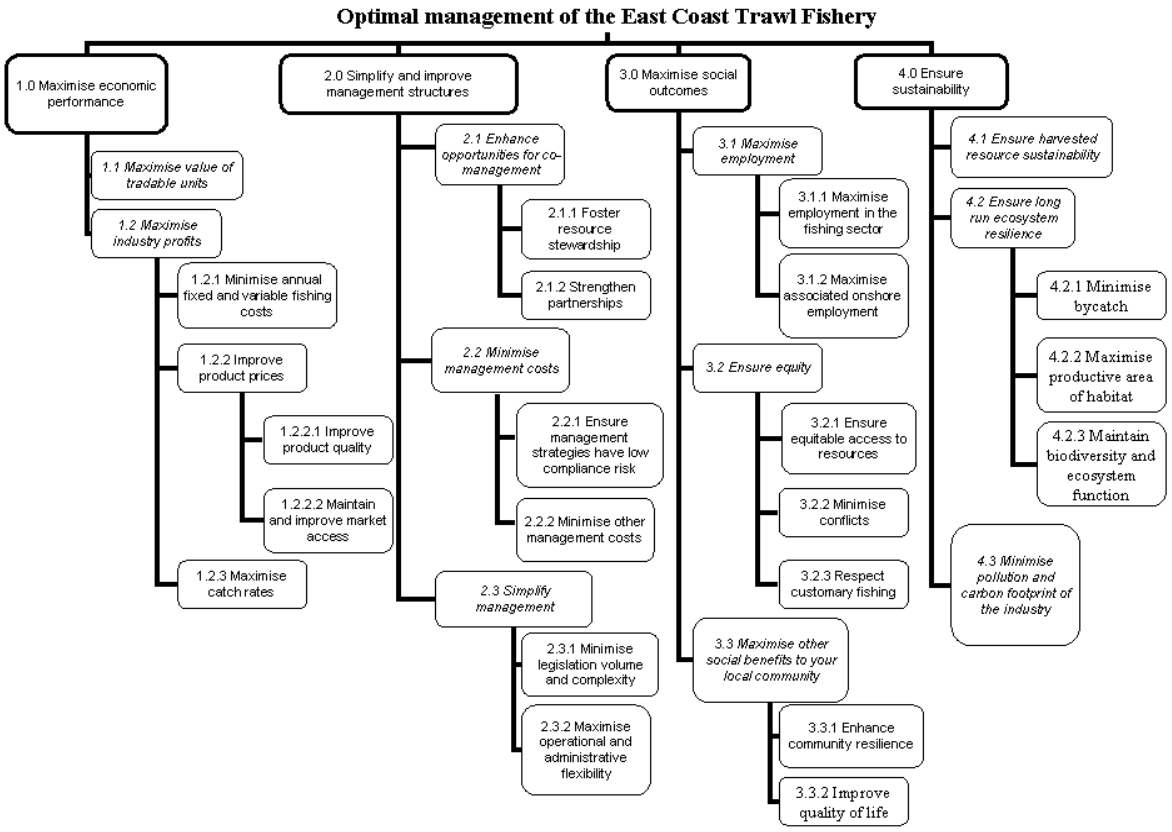

Figure 14. Objective hierarchy for the Queensland East coast trawl fishery.

A5.5: WEIGHTING OF MANAGEMENT OBJECTIVES

The Analytic Hierarchy Process (AHP) [12] was used to derive the individual objective weights. AHP has been used in a number of fisheries applications to determine management objective importance and assist in decision making [6, 17, 19, 22-26]. AHP is based upon the construction of a series of pairwise comparison matrices which compare sub-objectives to one another. One of the advantages of the pairwise comparison method is it makes the process of assigning weights much easier for participants because only two elements or objectives are being compared at any one time rather than all objectives having to be compared with each other simultaneously.

Collection of preferences

The most common (and generally recommended) means of eliciting preference structures for AHP studies is to use a nine-point “Intensity of Importance” scale [12, 27]. The scale is based on psychological experiments and is designed to allow for, as closely as possible, a reflection of a person’s true feelings in making comparisons between two items whilst minimising any confusions or difficulties involved [12, 28].

An interactive survey instrument was designed as an Excel spreadsheet that enabled immediate feedback to participants on the implications of their preferences on objective weights and their level of consistency (an example of part of which is presented in Figure 15). The feedback enabled participants to re-assess their preferences if problems of inconsistency[12] were apparent or if the resultant weightings were not as anticipated. The nine-point scale was not explicitly represented, but determined by the degree to which a slider could be moved one way or another.

The spreadsheet was trialled (and modified as necessary) by the SAG, and then applied to a larger and broader advisory group involved with the management review – the Technical Advisory Group (TAG) – that consisted of additional fisheries managers, conservation managers, conservation/environmental NGOs, compliance officers and additional industry representatives. The latter group included fishers (both commercial and recreational representatives), as well as marketing and processing representatives. TAG members were also asked to provide email addresses of potential survey respondents and to also encourage participation of these people in the survey. In addition, local councils in coastal regions were approached as representatives of the broader (general) community to provide an indication as to what they saw as important when revising the management plan for the trawl fishery.

A total of 220 surveys were distributed, mostly by email (i.e. except for those completed in session by the SAG and TAG members) and a response rate of around 50 per cent was achieved (Table 8). Of the responses, several were unusable due to inconsistency problems not being resolved,[13] leaving a usable set of 90 responses.

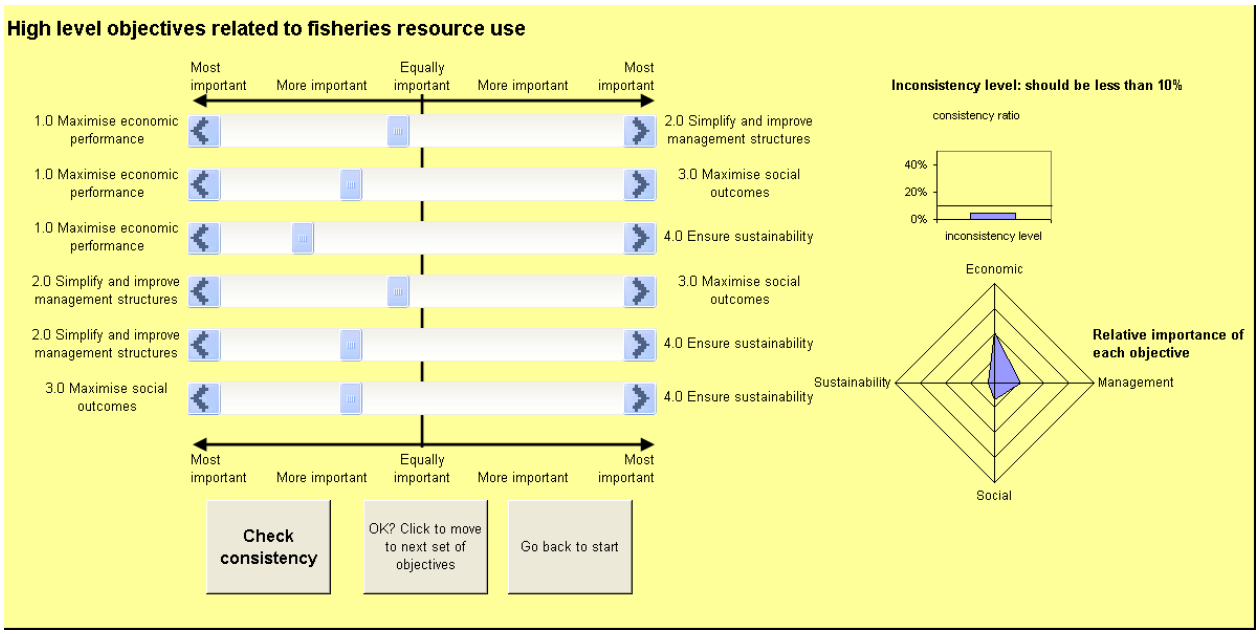

Figure 15. Example of the survey instrument.

12 The issue of inconsistency is addressed in further detail below.

13 The surveys were not anonymous and attempts at resolving the inconsistencies were made with the individuals concerned.

Derivation of weights

A matrix of scores can be developed from the individual survey responses for each set of comparisons, given by:

$$A = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix} \qquad (1)$$

The scores are normalised by dividing through each element of the matrix by the sum of the column *j* (i.e. summed over *i*, such that $\bar{a}_{ij} = a_{ij} / \sum_i a_{ij}$), and the weight associated with each objective can be estimated as the average of the normalised scores across the row *i*. That is, $w_i = \sum_j \bar{a}_{ij} / n$, where n is the number of objectives being compared.

The pair-wise comparisons and analyses are undertaken at the different levels of the hierarchy. That is, pair-wise comparison and analyses are made between the higher order objectives, and the weight w_i^1 is estimated (the superscript *1* indicating the level of the objective in the hierarchy, in this case the first or highest level of the hierarchy). The analysis within each higher order objective is then undertaken, and initial weights for the lower order objectives estimated. For example, $\hat{w}_{i2}$ is the initial weight of a second order objective compared with other second order objectives within the same higher order objective. The overall weight of the lower order objectives are determined by the product of their initial weight estimate multiplied by the weight of the higher order objective. For example, $w_i^2 = \hat{w}_{i2} w_i^1$, where w_i^2 is the final weight of a second order objective, while $w_i^3 = \hat{w}_{i3} w_i^2 = \hat{w}_{i3} \hat{w}_{i2} w_i^1$ is the final weight of a third order objective. This reduces the number of direct comparisons that need to be made, as only objectives at the same level and within the same broader objective need to be compared in the survey.

As can be expected, it may be difficult for decision makers to have a mathematically exact and consistent set of weightings for all of the objectives. For example, if objective 1 is strongly favoured over Objective 2 and Objectives 2 and 3 are considered the same, then Objective 1 should be strongly favoured over Objective 3 as well. However, respondents do not necessarily cross check their responses, and even if they do, when many objectives are compared ensuring a perfectly consistent set of responses is difficult,[14] so some inconsistencies are common.

To check whether or not the weightings have been carefully considered and compared a consistency index (CI) is used, such that

$$CI = \frac{\lambda_{\max} - n}{n - 1} \qquad (2)$$

where $\lambda_{\max}$ is the maximum eigenvalue of the matrix A, given by $\lambda_{\max} = \sum_i \sum_j a_{ij} w_i$ [29]. This is compared to a randomly generated value for an n x n matrix (Random Indicator or RI) to derive a consistency ratio, CR, where CR=CI/RI. Values of CR≤0.1 are generally considered acceptable [12], although higher measures are often accepted in fisheries analyses [22]. In cases where higher values are obtained, respondents are generally asked to review and revise their pair-wise comparison ratings. With the interactive Excel-based survey instrument, respondents were immediately fed back information on their level of consistency and, if the measure was greater than 10 per cent, a message appeared asking them to

14 The discrete nature of the 1-9 scale also contributes to inconsistency, as a perfectly consistent response may require a fractional preference score.

reconsider their preferences. This resulted in a high return rate of usable preference sets. In some instances (less than half a dozen), respondents returned their survey spreadsheet with one or two groups of objectives with inconsistencies of less than 15 per cent with a message that they could not get the score lower without substantially changing their preferences.[15] These were also accepted as usable as the respondents demonstrated that they at least had tried to reduce the inconsistency. Some survey spreadsheets were also returned with substantially higher inconsistencies and these were not used in the final results (Table 8).

Table 8. Response rate from the email survey by stakeholder group.

	SENT	RETURNED - USABLE	RETURNED - UNUSABLE	RESPONSE RATE
Industry	46	21	2	50%
Management	33	24	0	73%
Conservation	32	23	0	72%
Recreational Fishing	23	9	0	39%
Local Communities	22	9	1	45%
On-shore industry	46	4	9	28%
	202	90	12	50%

Group Coherence

The level of group coherence indicates the degree to which members of a given stakeholder group have similar or dissimilar objective preferences. Zahir [30, 31] developed a measure of group coherence for use in AHP studies, given by

$$\overline{\rho} = \left\langle v_i \bullet v_j \right\rangle \quad i \neq j \qquad (3)$$

where v_i and v_j are vectors comprising the square root of the objective weights of individuals *i* and *j*; $\bullet$ indicates the dot product of the two vectors, and $\langle\ \rangle$ indicates the average of the set of dot products [30]. The coherence measure, $\overline{\rho}$, represents the average angle between the individual vectors ($\cos\theta = \rho_{i,j} = v_i \bullet v_j$ for a pair of individuals), such that $\cos 0^o = 1$ implies identical preferences and $\cos 90^o = 0$ implies orthogonal preferences. Hence, the closer the value is to 1, the greater the average agreement in opinion of the individuals. While this has the appearance of a statistical measure, there is no generally accepted critical value. Some authors have adopted 99%, 95% and 90% as critical measures [23], in line with statistical definitions of significance levels, while others have developed other definitions of strong and weak coherence with wider intervals [22].

In contrast, Zahir [31] defines extreme cases, given Saaty's [12] nine point scale (i.e. 1-9), as those that have individual coherence measures $\rho_{ij} < (n+4)/(n+8)$, where *n* is the number of objectives being examined. These effectively indicate substantial differences of opinion between individuals within a group. Hence, the proportion of comparisons between individuals that are considered extreme is another indicator of group coherence.

15 This was generally only a problem when there were four objectives being compared as this involved six pairwise comparisons, and deriving a consistent set of preferences was more difficult than when three or two objectives were compared.

A5.6: ANALYSIS AND RESULTS

Objective weight rankings

Individual's weights for each objective were estimated as above, and group average priorities were calculated (Table 9). Economic objectives were weighted highly by industry groups (both fishers and on-shore) and fishery managers (Figure 16). Fisheries policy in Queensland has an explicit objective of maximum economic yield [11], following the lead of Australia's Commonwealth harvest strategy policy [32], and this no doubt influences the objective weightings of fishery managers. The preferred mechanism by which economic performance is to be achieved, however, varies between stakeholders. Fishery managers' preference is to reduce costs of fishing, whereas industry prefer higher prices and catch rates.

The objective of simplifying management received fairly strong support from the fishing industry and on-shore industry, both of which are affected by management, but slightly less so from the fishery managers themselves who are responsible for implementing management. The preferences were distributed fairly evenly across the sub-objectives; although the on-shore industry had a stronger preference for ensuring management had a low compliance risk and reducing legislation complexity and volume.

The Queensland fisheries policy explicitly identifies the needs to consider social impacts, although which aspects to consider (other than employment) are less specific. The objectives identified in this study generally received a low weight by most stakeholder groups, the key exception being recreational fishers who align themselves more with social than economic benefits. For most stakeholder groups, the preferences were fairly equally distributed (on average) across the different sub-objectives, although recreational fishers had a strong preference for improving the quality of life.

The ecological sustainability objectives are strongly supported by all groups, and in most cases received the highest weighting on average. Sustainability objectives dominated the preferences of the conservation stakeholders, as might be expected, but also those of the local community (represented by the local councils). This latter result is more surprising as, *a priori*, it might be expected that this group would be more concerned with social objectives, particularly employment and improved quality of life. The result may reflect a community view that protection of the environment, particularly the Great Barrier Reef, is important [33, 34], or a general negative attitude towards commercial fishing in Australia [35] in terms of its perceived environmental damage.

Link [36] suggests that an ethic of stewardship permeates society which involves a priority ordering of ensuring human existence; other species existence (e.g. biodiversity); individual stock/population health (sustainability of the exploited resource); persistence of particular human cultures (i.e. cultural values); equity across individuals (i.e. fairness in competition); and, finally, profits of individuals as the lowest priority. This ranking is generally consistent with those groups who do not have a direct financial association (e.g. onshore and offshore industries) or policy mandate (e.g. fishery managers) involving the use of the resource.

Table 9. Average management objective weights by stakeholder group expressed as percentages.

OBJECTIVE	FISHING INDUSTRY		ON-SHORE INDUSTRY		FISHERIES MANAGERS		CONSERVATION		RECREATIONAL FISHING		LOCAL COMMUNITIES	
	mean	CV	mean	CV	mean	CV	mean	CV	mean	CV	mean	CV
1. Maximise economic performance	**35%**		**34%**		**26%**		**10%**		**10%**		**17%**	
Maximise value of tradable units	13%	64%	6%	51%	9%	64%	5%	58%	5%	70%	9%	95%
Minimise annual fixed and variable fishing costs	4%	67%	8%	138%	6%	119%	2%	101%	2%	95%	3%	85%
Improve product quality to improve product price	4%	95%	5%	119%	3%	110%	1%	74%	1%	133%	1%	85%
Maintain and improve market access to improve price	7%	155%	6%	102%	2%	100%	1%	98%	1%	85%	1%	108%
Maximise catch rates	7%	72%	9%	155%	5%	109%	1%	107%	1%	124%	2%	90%
2. Simplify and improve management structures	**20%**		**26%**		**15%**		**13%**		**18%**		**15%**	
Foster resource stewardship	3%	122%	1%	76%	2%	76%	3%	56%	4%	121%	2%	39%
Strengthen partnerships between and within industry and government	3%	75%	2%	81%	2%	83%	2%	74%	2%	89%	4%	103%
Ensure management strategies have low compliance risk	3%	153%	9%	162%	3%	123%	2%	64%	1%	114%	2%	71%
Minimise other management costs	3%	122%	2%	110%	2%	122%	1%	184%	1%	105%	1%	95%
Minimise legislation volume and complexity	5%	144%	7%	53%	4%	96%	3%	111%	7%	143%	4%	100%
Maximise operational and administrative flexibility	4%	85%	6%	109%	3%	72%	2%	58%	2%	82%	3%	82%
3. Maximise social outcomes	13%		9%		14%		16%		28%		18%	
Maximise employment in the fishing sector	2%	79%	1%	61%	3%	81%	2%	114%	2%	95%	2%	97%
Maximise associated onshore employment)	1%	77%	2%	73%	2%	67%	2%	95%	2%	101%	2%	79%
Ensure equitable access to the resource	3%	76%	2%	66%	2%	63%	2%	71%	3%	76%	2%	66%
Minimise conflicts with competing users	2%	112%	1%	44%	1%	77%	2%	92%	4%	68%	2%	46%

OBJECTIVE	FISHING INDUSTRY		ON-SHORE INDUSTRY		FISHERIES MANAGERS		CONSERVATION		RECREATIONAL FISHING		LOCAL COMMUNITIES	
Respect customary fishing	1%	82%	2%	162%	1%	77%	2%	71%	2%	97%	1%	56%
Enhance community resilience	2%	109%	1%	120%	3%	88%	3%	88%	6%	63%	5%	78%
Improve quality of life in coastal communities	2%	79%	1%	86%	1%	75%	3%	103%	10%	49%	3%	128%
4. Ensure sustainability	32%		31%		45%		61%		44%		51%	
Ensure harvested resource sustainability	16%	72%	14%	41%	19%	43%	13%	67%	23%	84%	12%	72%
Minimise bycatch	3%	88%	2%	111%	7%	86%	11%	55%	5%	93%	7%	80%
Maximise productive area of habitat	4%	61%	5%	40%	5%	113%	5%	88%	1%	91%	4%	82%
Minimise impacts of fishing on biodiversity and ecosystem function	3%	63%	2%	119%	8%	104%	20%	52%	4%	71%	13%	100%
Minimise pollution and carbon footprint of the industry	6%	60%	8%	99%	8%	55%	12%	74%	11%	117%	15%	64%

Note: CV is coefficient of variation

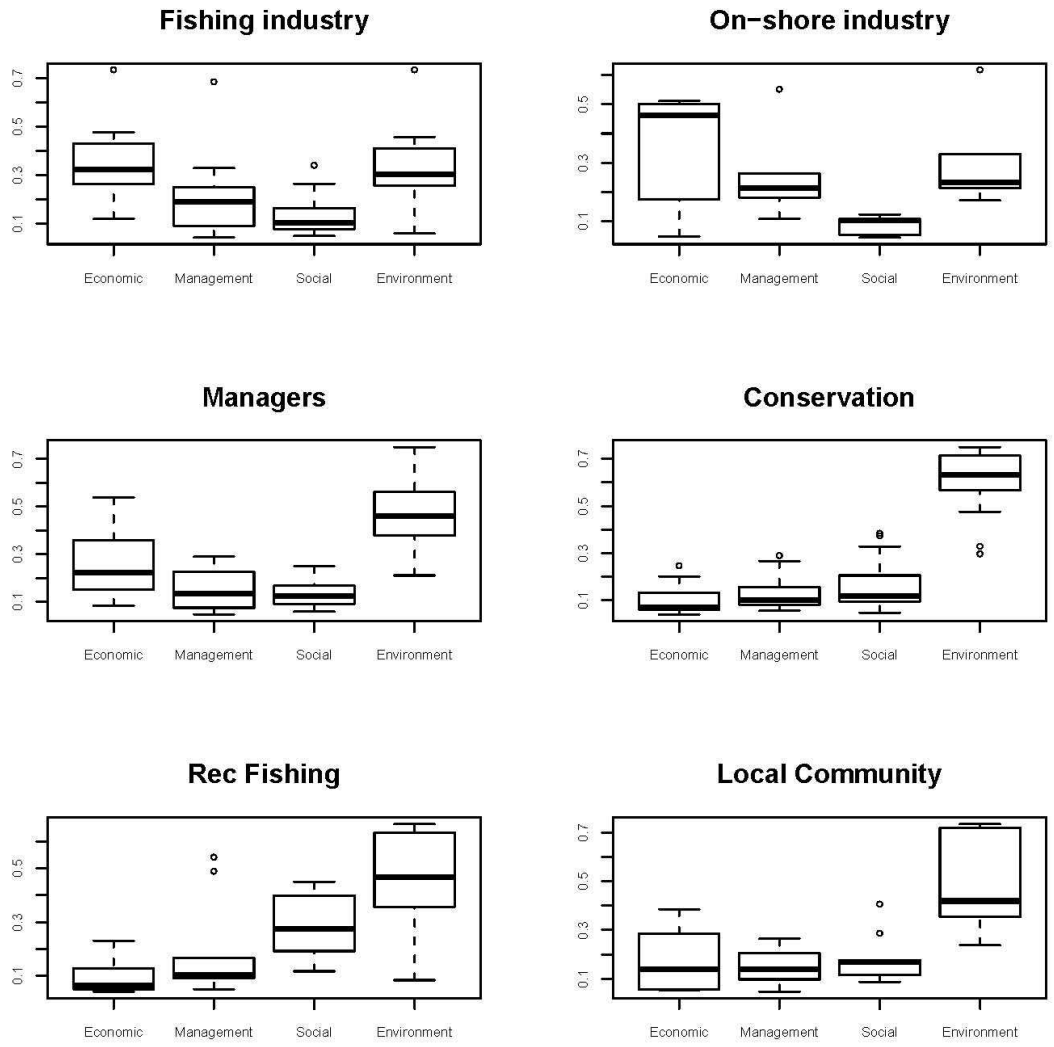

Figure 16. Distribution of weightings for higher level objectives by stakeholder group.

Group coherence

The average coherence of the groups and the proportion of extreme comparisons are given in Table 10. As with the previous study of Commonwealth fisheries [6], average coherence of the groups was generally higher when considering only the higher order objectives compared to considering the lower level objectives. For the higher order objectives, no extreme cases were observed for any of the stakeholder groups, while all groups had at least some extreme differences in preference structures at the lower order objective level and in most cases a high proportion of stakeholder group members were in disagreement about the relative importance of the detailed objectives. This suggests that the groups are relatively in agreement when considering the relative importance of broader issues related to economic performance, simplifying management, social outcomes and sustainability issues, but less in agreement with regard to the more detailed sub-categories (e.g. “ensuring equitable access to the resource” compared with “minimising conflicts” under the broader social objective).

Although the lower level of consistency is often seen as a problem when assessing “average” objective weightings, this was less of a problem in this case as individual weightings were used when assessing management options. Variability in objective preferences also allowed an assessment of the degree of variability in preference for one option over another. Details of this further analysis are provided by Dichmont *et al.* [14].

Table 10. Average group coherence and proportion of "extreme" cases.

STAKEHOLDER GROUP	AVERAGE COHERENCE		EXTREME CASES (%)	
	HIGHER ORDER OBJECTIVES	LOWER ORDER OBJECTIVES	HIGHER ORDER OBJECTIVES	LOWER ORDER OBJECTIVES
Fishing industry	0.94	0.83	0%	59%
On-shore industry	0.95	0.85	0%	57%
Fisheries Managers	0.96	0.88	0%	34%
Conservation	0.91	0.82	0%	73%
Recreational fishers	0.93	0.84	0%	58%
Local Community	0.90	0.76	0%	100%

A5.7: DISCUSSION AND CONCLUSIONS

Although undertaken as a separate exercise with a completely different set of stakeholders and also a very different fishery management, economic and political environment, the results of the study were largely consistent with those undertaken at the Australian Commonwealth fisheries level in the previous study [6]. While the detailed sub-objectives varied between the two studies, there was general agreement in the relative importance of the economic and sustainability/environment objectives between fishers and fishery managers at both the Queensland State and Federal level. This suggests that, at least for these two levels of fisheries management, industry and fisheries managers are largely pursuing similar objectives with similar importance weightings when developing management strategies. This finding, in part, reflects the largely commercial nature of Australia's fisheries (excepting the recreational fishing sector).

The State level analysis explicitly included social objectives, although some of the lower-level social objectives were present in the Commonwealth objective set as sub-objectives of maximising economic benefits (e.g. the employment objectives) or minimising externality (e.g. minimising conflicts). The State policy explicitly includes social considerations in the fisheries legislation, whereas the Federal policy includes only economic and sustainability objectives. Despite being explicit in the policy, social objectives were generally given a low importance, even by managers. Similarly, the industry (both on-shore and offshore) raised many concerns about the need to consider social impacts of management change during the consultation period, but also give these objectives the lowest weighting. Their ex-post justification for this (after the results had been presented to the TAG, SAG and at workshops involving additional industry members) was that getting the economics and the environment right would result in a beneficial social outcome (i.e. higher incomes, better employment conditions etc.). A more detailed analysis of the social objectives is given in Brooks/Pear *et al.* [37] (this issue).

On average, the preferences of the stakeholder groups included in the study reflected what might be expected: industry were most concerned with maximising industry profits and the value of their assets, while conservation stakeholders were most concerned with ensuring ecological sustainability of fisheries. The strongest weighting given to any high level objective was by the conservation stakeholders, who were most concerned with protecting the environment. This group included marine park managers, and the result is not surprising given their mandate under the *Great Barrier Reef Marine Park Act 1975*, which clearly identifies long term protection of the environment as the primary objective, and supports other objectives (e.g. ecologically sustainable use) only in so far as they are consistent with protecting the environment.

Variation in individual preferences within stakeholder groups is to be expected, and the levels of group coherence are similar to other studies in fisheries [6, 22, 23]. Greater coherence is achieved at the broader objective level than at the detailed sub-objective level as might also be expected. Fisheries managers had the highest degree of consistency, which is less surprising as they work in a common environment and within a firm legislative and policy framework. While these frameworks do not explicitly identify the relative importance of the objectives (and are also often vague about the objectives themselves), a

corporate culture has developed that has implicitly weighted these objectives. Conversely, local councils had the lowest level of coherency. These are geographically disparate groups, with fisheries activities having differing levels of economic and social importance within their council boundaries. Councils also tend to see fisheries in a more multiple use context. For example, fisheries contribute only a very small proportion of the economic activity within the Brisbane City Council area, but a more significant role in the regional economies in central and northern Queensland.

The use of an Excel-based interactive survey instrument had both advantages and disadvantages. The key advantage was that respondents were able to obtain immediate feedback about the implication of their choices on the relative importance of the objectives, and also a measure of their consistency. The returned spreadsheet also had the set of objective weights calculated, and these could be easily imported into other programs for analysis. There were several disadvantages also. Foremost of these was that a number of potential respondents were unable to either use or, in some cases, access Excel so were unable to complete the survey.[16] There were also some suspicions when a message about activating macros made some respondents think the file had viruses. Some others felt that the consistency index was trying to force them into some pre-defined (conspired) response, and therefore did not believe that the survey was truly trying to capture the preference structures of the individuals. These two problems were particularly prevalent for the industry members (both onshore and offshore).

The objective of this study was to examine the differences in management objective preferences between different stakeholder groups active in shaping Queensland fisheries management, and in particular the management of the East Coast Trawl Fishery. These objectives were used as a guide to both the development and analysis of a range of management governance structures [14]. The weighted objectives gave individuals within the SAG and TAG – who were responsible for developing these systems – an explicit framework around which they could understand what they were trying to achieve as well as an appreciation as to the importance of delivering (or attempting to deliver) certain outcomes to different stakeholder groups. By putting the horse before the cart, the groups were able to consider radically different management structures to what they currently had, and identify the key strengths and weaknesses in each.

A5.8: ACKNOWLEDGEMENTS

This work was undertaken as part of a study jointly funded by the Fisheries Research and Development Corporation, the CSIRO Wealth from Oceans National Research Flagship, the Department of Employment, Economic Development and Innovation, and the Great Barrier Reef Marine Park Authority. The authors would like to thank the large number of individuals and organisations who participated in the survey, as well as Toni Cannard and James Innes who provided useful comments on an earlier draft of the paper.

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Appendix 6 Links between fishery management objectives and climate change adaption planning

Fishery climate change adaptation is about taking actions to reduce vulnerability to changes to resources and degradation of the environment as a result of a changing climate. It is also about dealing with direct pressures on operations and markets or any changes to fishery regulations required as a result of broader climate change impacts on the ecosystem. Adaptation actions can occur across a range of levels from the individual to government.

Building on the main work delivered under the FRDC project described in the body of this report, we also took the opportunity to consider fishery management objectives in relation to climate change adaptation planning, a process just starting for the East Coast Trawl Fishery. The purpose of adaptation planning is to help the industry be better prepared for future climate change.

The East Coast Trawl Fishery operates in increasingly tight economic circumstances, with many licence holders becoming inactive or operating below profitable levels in recent years. The industry has made considerable progress in reducing environmental impacts (Pears *et al*. 2012), however the fishery has also been subject to considerable scrutiny from the wider community about potential fishing effects on the marine environment. A large number of the participants in the fishery operate in the Great Barrier Reef World Heritage Area and Marine Park, and the overall outlook for the Great Barrier Reef has recently been assessed as poor, in the light of serious threats, especially from climate change (GBRMPA 2009). Although efforts are being made to reduce the effects of climate change on marine ecosystems including the Great Barrier Reef, some level of impact from climate change is unavoidable. Through partnerships, managers are working to help dependent industries and communities understand and adapt to these changes (GBRMPA 2007). This operating environment highlights many needs in relation to adaptation planning for the fishery so that participants are better prepared for changing economic, environmental and associated social pressures of operation.

Figure 17 shows the relationship between the social, economic, management and environmental objectives for the East Coast Trawl Fishery and the process of climate change adaptation planning. How well management of the fishery is supporting climate change adaptation can be tracked by monitoring the achievement of selected objectives (indicated by solid boxes in Figure 17). Pre-requisite objectives (indicated by dashed boxes in Figure 17) that need to be achieved to support climate change adaptation planning were also identified. Identifying these linkages is expected to help integrate adaptation considerations into fisheries management.

The pre-requisites (in dashed boxes in Figure 17) are concerned with industry profitability, equitable access to resources, minimising conflict and ensuring resource sustainability. This recognises that the social and economic impacts of climate change will be strongly influenced by current socio-economic conditions, as well as management, as these strongly influence current performance and are likely to also influence adaptation to future changes (Reidsma *et al.* 2010). Capacity to adapt to future change, including climate change, may be dependent on other processes first addressing any issues affecting economic viability and social issues for the trawl fishery.

The links between adaptation planning and fishery management objectives identified in Figure 17 are concerned with those aspects that are under the control of fishery managers (e.g. maximise operational and administrative flexibility). Adaptation planning is likely to require identification of additional objectives from the perspective of other stakeholders (e.g. increased preparedness of industry members for future changes).

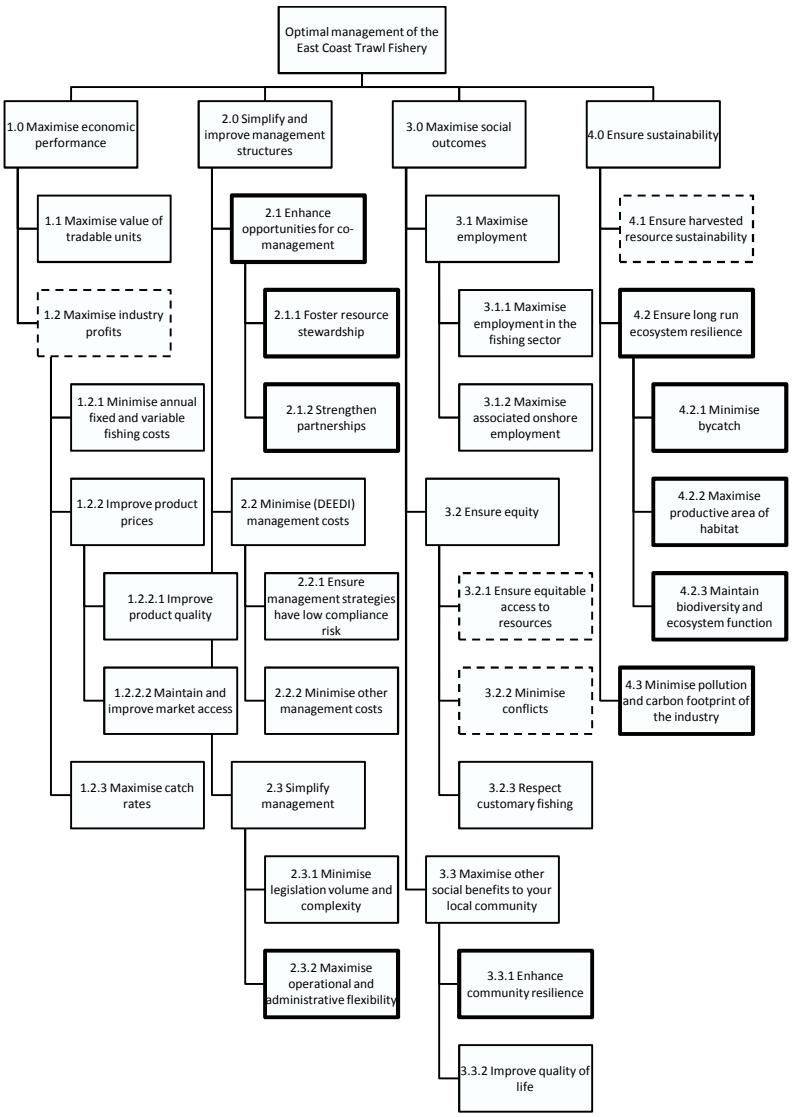

Figure 17. Diagram indicating which trawl fishery management objectives are pre-requisites to climate change adaptation (indicated by dashed boxes), and which are the key objectives (indicated by solid boxes) to monitor to determine how well fishery management arrangements are supporting climate change adaptation.

The established approach used by the Intergovernmental Panel on Climate Change to evaluating vulnerability to climate change is as a function of exposure, sensitivity and adaptive capacity. Building on this approach, ecological and socioeconomic vulnerability to climate change can be explicitly linked (see Figure 18).

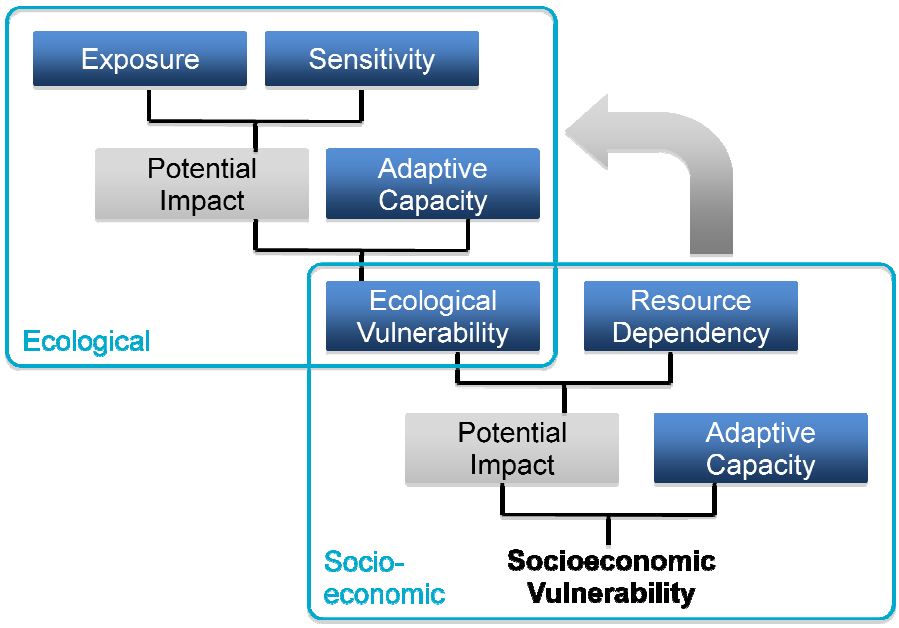

Figure 18. Vulnerability framework recognising the co-dependency between ecological and socioeconomic systems. Source: Marshall *et al.* 2010.

In considering socioeconomic vulnerability of a fishing industry to climate change, the major determinant of exposure will be ecological vulnerability of the fishery resources and supporting ecosystem to climate change; and sensitivity is determined by the present dependency of individuals and the community on marine ecosystem goods and services, including the fishery resources (Marshall 2009; Marshall *et al.* 2010). Adaptive capacity can be thought of as a measure of future potential of individuals and the community to cope and adapt to change (Marshall *et al.* 2010). Socioeconomic vulnerability to climate change can be reduced by a combination of reducing socioeconomic exposure and sensitivity (i.e. resource dependency), and/or increasing adaptive capacity of individuals and the community.

For the East Coast Trawl Fishery, Figure 19 illustrates the links between the socioeconomic vulnerability to climate change and relevant fishery management objectives for adaptation planning. The figure shows how achieving selected fishery management objectives would act to reduce vulnerability to climate change. Specifically, ensuring long run ecosystem resilience and minimising pollution and carbon footprint of the fishery will contribute to reducing ecological vulnerability and in turn, to reducing socioeconomic exposure. Additionally, enhancing opportunities for co-management, maximizing operational and administrative flexibility and enhancing community resilience all contribute to increasing the adaptive capacity of individuals and the community. However, only some aspects of exposure and adaptive capacity are under the control of fishery managers, and resource dependence and hence sensitivity is generally not controlled by fishery managers. These limitations on what fishery managers have control over are recognised in Figure 19 through the inclusion of external factors.

The work here is now being used to inform a joint climate change adaptation project for the fishery.

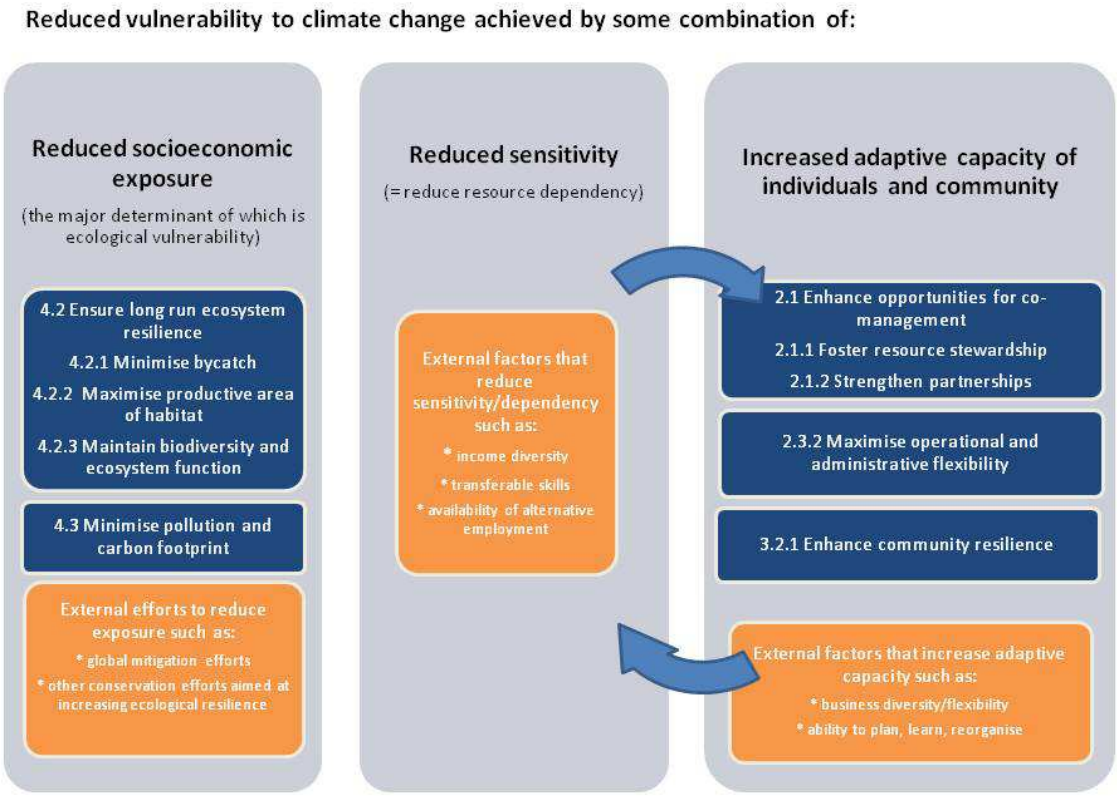

Figure 19. Links between socioeconomic vulnerability framework and relevant trawl fishery management objectives for adaptation planning (numbers in the figure refer to sub objectives in Figure 17).

Human adaptation is underpinned by the ability to be flexible and responsive to actual and expected changes in circumstance; both in taking advantage of new opportunities and devising defences against challenges to previous circumstances. Through considering explicit triple bottom line objectives, not only will this help to ensure the environment is maintained in a sustainable state but people and industries are also given maximum opportunity to adapt to any necessary changes in access, or resource availability. This is facilitated by ensuring flexibility in management and industry ability to respond to changes in climate are valued along with environmental objectives.

Unfortunately, valuing the environment – particularly those aspects of it that are not directly utilised or observed by natural resource users or the general community – often comes second to our basic needs as a society, or as individuals within it. Maslow's hierarchy of needs[17] is potentially a useful way of thinking about the development of natural resource management plans, in that the basic needs of users or the society need to be taken care of before individuals can begin to engage with the need to protect what are perceived to be the more esoteric aspects of their environment. The pre-requisites discussed earlier in relation to adaptation planning can also be thought of as basic needs that need to be satisfied for individuals to cope with current pressures and be able to engage in thinking about the actions required to adapt for the future. By evaluating all the objectives simultaneously it was possible to ensure basic needs were addressed, and in doing so, that environmental values were not compromised. As users could see that their basic needs and objectives were accounted for under the fishery management review, they were more willing and open to consider and collaborate on options to improve environmental protection. An example is industry participation in the design and trialling of improved bycatch reduction devices to reduce bycatch levels and interactions with protected sea snakes. Additionally, undertaking planning with not only the resource users, but also marine park managers tasked with protecting the marine

17 http://www.abraham-maslow.com/m_motivation/Hierarchy_of_Needs.asp

environment, had the advantage of raising awareness and appreciation of the need to build ecosystem resilience, rather than simply seek mitigation or restorative measures down the track.

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Appendix 7 Descriptions provided to TAG and SAG members of all objectives and their indicators

In evaluating the strawmen it is important to have a clear set of objectives against which you are assessing their capability. The research team has resolved the following set of objectives for this purpose. A schematic representation of the objective hierarchy is contained in Figure 17Figure 9

1.0 Maximise economic performance of the East Coast Trawl fishery

1.1 Maximise value of tradable units

1.2 Maximise industry profits

1.2.1 Minimise fishing costs

1.2.2 Improve product prices

1.2.2.1 Improve product quality (to improve product price)

1.2.2.2 Maintain and improve market access (to improve product price)

1.2.3 Maximise catch rates (e.g. catch per day)

2.0 Simplify and improve management structures

2.1 Enhance opportunities for co-management

2.1.1 Foster resource stewardship

2.1.2 Strengthen partnerships (e.g. between industry and government and within industry)

2.2 Minimise DEEDI management costs

2.2.1 Ensure cost effective compliance (achieve high levels of compliance at least cost)

2.2.2 Minimise other management costs

2.3 Simplify management

2.3.1 Minimise legislation volume and complexity

2.3.2 Maximise operational and administrative flexibility

3.0 Maximise social outcomes

3.1 Maximise employment

3.1.1 Maximise employment in the fishing sector (e.g. crew, skippers etc)

3.1.2 Maximise associated onshore employment (e.g. in processing or sectors suppling the fishing industry)

3.2 Ensure equity

3.2.1 Ensure equitable access to resources

3.2.2 Minimise conflicts with competing users (e.g. other gears, recreational fisheries, traditional fisheries)

3.2.3 Respect customary fishing (e.g. fishing activity that has a long social history in an area)

3.3 Maximise other social benefits to your local community from the use of the resource

3.3.1 Enhance community resilience (the ability of the community to adapt to change)

3.3.2 Improve quality of life in coastal communities (includes health and safety as well as general quality of life)

4.0 Ensure sustainability

4.1 Ensure resource sustainability (commercial and recreational fisheries resources)

4.2 Ensure long term ecosystem resilience

4.2.1 Minimise bycatch (TEP species, other commercial and non-commercial species)

4.2.2 Maximise productive area of habitat

4.2.3 Maintain biodiversity and ecosystem function

4.3 Minimise pollution and carbon footprint of the industry

It is important in ensuring a consistent evaluation of there is a clear understanding of what is meant by each of the objectives. The research team in conjunction with the SAG have developed the following interpretive guide to the objectives.

MAXIMISE ECONOMIC PERFORMANCE OF THE EAST COAST TRAWL FISHERY

1.1

How will the Governance Scenario affect "effort unit values" *i.e.* will it increase / decrease the price per unit?

1.2.

Will the Governance Scenario held to maximise the overall difference between annual costs (fixed and variable) and profits?

1.2.2.1

Will the Governance Scenario help the industry optimise their fishing operation to target and harvest the best product *i.e.* larger scallops etc. ?

1.2.2.2

Will the Governance Scenario maintain, improve or diminish current market practices (selling, buying, storage etc)?

1.2.3

Will management arrangements proposed under the Governance Scenario be able to maintain and maximise long term catch rates for the fishery *i.e.* for the life of the new management plan?

SIMPLIFY AND IMPROVE MANAGEMENT STRUCTURES

2.1.1

Will the Governance Scenario facilitate a greater sense of ownership / long-term security over fishing entitlements and provide greater incentive to look after the resource?

2.1.2

Does the Governance Scenario propose management arrangements that rely and build upon stronger partnerships between Government and Industry and within industry such as through co and/or regional management, or through shared decision making?

2.2.1

Does the Governance Scenario propose management arrangements that will a) be difficult to enforce, b) require a high degree of compliance and/or c) increase the risk of non-compliance?

2.2.2.

Will the Governance Scenario minimise costs associated with the short and long term management of the ECTF *i.e.* administration costs, monitoring, stock assessments etc?

2.3.1.

Will the Governance Scenario have any affect (none, increase, decrease) on the volume and complexity of legislation?

2.3.2

Will the Governance Scenario impact (none, increase, decrease) on the flexibility of current management arrangements?

MAXIMISE SOCIAL OUTCOMES

3.1.1

Will the Governance Scenario affect the amount of direct employment in the fishery *i.e* the number of skippers, crews, boats in the fishery?

3.1.2

Will the Governance Scenario affect associated onshore employment *e.g.* net makers, processors, gear suppliers and other businesses that rely on the fishery?

3.2.1

Will the Governance Scenario ensure people have fair and equitable access to the available resources?

3.2.2

Will the Governance Scenario help to minimise conflict between competing users (stakeholders) *i.e.* between commercial fishers, recreational fishers, traditional fishing, tourism, conservation etc?

3.2.3

Will the Governance Scenario promote the retention of fishing activities that have a long social history in the area *i.e.* encourage the continuation of long-term fishing operations including family owned and operated businesses?

3.3.1

Will the Governance Scenario affect the ability of local communities to adapt to changing conditions, and does it provide sufficient flexibility to maintain economic flexibility?

3.3.2

Will the Governance Scenario Improve quality of life in coastal communities? This objective includes health and safety as well as general quality of life and is influenced by things such as the quality of employment opportunities, availability of fresh local produce, local services and infrastructure etc.

ENSURE SUSTAINABILITY

4.1

Will the Governance Scenario ensure the sustainability of commercial and recreational fisheries resources?

4.2.1

Will the Governance Scenario minimise bycatch (TEP species, other commercial and non-commercial species? Principally this is related to 1) the amount of effort, 2) where and when the effort is used, and 3) the type of gear being used.

4.2.2

Will the Governance Scenario affect the temporal and spatial distribution of effort in the fishery (*i.e.* no effect on the swept area, increases the total swept area, decreases the total swept area)?

4.2.3

Will the Governance Scenario help to minimise the impacts fishing has on biodiversity and ecosystem functioning?

4.3

Will the Governance Scenario minimise pollution and carbon footprint of the industry?

POTENTIAL INDICATORS FOR EX POST EVALUATION OF THE OBJECTIVES

Potential *ex post* indicators relating to each of the objectives were derived in the initial workshop with the SAG. These are presented below. Initially, the management objectives were considered part of the social objectives, although these were later separated out as a separate objective category for the purposes of weighting and the subsequent analysis.

Table 11. Potential *ex post* indicators relating to each of the objectives.

OBJECTIVE	INDICATORS
SOCIAL (INCLUDING MANAGEMENT)	
1. Maximise employment	Number of people employed in the sector Seasonal vs fulltime employment Employee satisfaction Proportion skilled/unskilled labour Number and type of boats
2. Minimise legislation (volume and complexity)	Number of pages Reduced number of rules around Spatial & Temporal fishery closures A reduced number of gear regulations Understanding of management arrangements
3. Exploring opportunities for co-management	Coverage of Co-management agreement Coverage of Codes of Conduct
4. Enhance communities resilience	Perceptions of risk Ability to plan Ability to cope Level of Interest in alternative strategies/mgt practices
5. Ensure equity	Equal distribution of income Equitable allocation Changes in access to fishing areas
6. Maximise operational & administrative flexibility	Extent of alternative administrative tools Administrative response time Level of access to sectors
7. Minimise conflict with other sectors and within the fishery	Number of letters to the Ministers Number of negative media releases

OBJECTIVE	INDICATORS
8. Enhance net social value the community receives from access to community resources	Number of small vessels (symbiotic relationship between small vessels and the community) Population and net migration levels of communities Length of residence in current community
9. Improve quality of life (including health and safety)	Number of work accidents Number of fatalities Regularity of employment Social networks Satisfaction
10. Fostering resource stewardship	Statutory fishing rights Security of future resource access Participation in industry driven initiatives/requests Number of resource stewardship initiatives
11. Respecting customary fishing	Number of active ports Attachment to lifestyle (length of residence, continuity of work etc.) Public perception of the industry
ECONOMIC	
12. Maximise fisheries profitability	Economic profits in the fishery Return on investment Incidence of bankruptcy
13. Maximise economic profitability for particular fishing sector	Economic profits in the fishing sector Return on investment in the fishing sector Incidence of bankruptcy in the fishing sector
14. Enhance net value the community receives from access to community resources	Proportion of income derived from the sector Proportion of regional employment in the sector Indirect economic impacts (on local economy)
15. Maintain access to existing markets and gain access to new markets	Resource price Duration of storage Volume of landed catch
16. Minimise management costs	Extent of consultation obligation Cost of adapting to new management regime Total management costs recoverable and non recoverable (incl compliance)
17. Achieve acceptable level of compliance	Number of infringements Number of formal warnings (EJ check correct name) Enforceability of management arrangements Ability to comply with regulations
18. Maximise value of effort units	Value of effort units
SUSTAINABILITY	
19. Ensure sustainable harvested species	Stock status reporting Performance in relation to sustainability reference points Level of residual risk for harvested species (GBRMPA ERA)
20. Minimise bycatch (residual risk, SOCI, total bycatch)	Number SOCI interactions Weight of total bycatch

OBJECTIVE	INDICATORS
	Level of residual risk for bycatch species Proportion of retained vs discarded catch
21. Maximise productive area of habitat	Level of residual risk for at risk habitat (PMS) Level of effort increase into areas with no historical record of trawl effort. (PMS) Level of effort increase into areas supporting higher risk benthic species assemblages. Spatial footprint of the fishery (area not intensity)
22. Maintain biodiversity and ecosystem function	Level of residual risk for biodiversity and ecosystems (GBRMPA ERA)
23. Building ecosystem resilience	Addressing known risks Precautionary management (risk prone / averse)
24. Minimise pollution & carbon footprint	Total effort - days fished Emission calculator (GBRMPA, QSIA) Number of fishing operations working to waste handling procedures

Appendix 8 Questionnaire of the Technical Advisory Group's opinion of the process

The TAG and SAG were asked their opinion of how well the process went to address their concerns and move the fishery towards addressing the trawl plan review. The questionnaire is provided below.

Table 12 provides a high level summary of the seven key questions asked of the TAG and SAG. The worst scores were regarding whether the documents were timely – the project team themselves would agree that time pressures during the process were such that supporting documents often arrived within days of meetings. More than 86% of the scores for all the questions by all the respondents were neutral or better, and 60% scored a 4 or 5 (favoured or strongly favoured) (Table 13). All respondents were happy about the process to develop management strategies. An interesting aspect was the speed with which TAG/SAG members understood the process was very variable – from understanding at the start to only near the end.

Table 12. Number of respondents (of 13 people) that answered "Yes" or "No" to 7 key high level questions regarding the process.

QUESTION	"YES"	"NO"
Are you supportive of the process taken to develop management options?	13	0
Did you learn anything from the process?	12	1
Was the process transparent?	11	1
Did you feel you could openly raise issues?	13	0
Did you feel your perspective was listened to?	12	1
Did you feel your suggestions were comprehensively considered?	11	2
Were your perspectives addressed?	11	2

Table 13. Total score for all respondents and questions that scored a 1 ("significantly worse") to a 5 ("significantly better").

SCORE	TOTAL	PERCENTAGE
1	4	2
2	20	12
3	47	25
4	82	45
5	29	16

TAG MANAGEMENT REVIEW ASSESSMENT

Sector Represented: _____

The objective of the TAG was to advise on redevelopment of the Trawl Management Plan.

1. Were /Are you supportive of the process taken to development management options to consult?
   YES / NO
2. How far through the process did you get before you understood it? _____

Please rate the following elements of the project from 1(strongly disliked) to 5 (strongly favoured) in terms of how well the part identify from the following components if you agreed with the process?

1. Did the strawmen assist in improving your understanding of relative implications of different management scenarios? 1 2 3 4 5
2. Did the strawmen scenarios assist the group in developing Better future management scenarios? 1 2 3 4 5
3. The stakeholder engagement process 1 2 3 4 5

(October workshop and the regional TAG meetings)?

4. The provision of documentation
   a. Length 1 2 3 4 5
   b. Easy to understand 1 2 3 4 5
   c. Quality 1 2 3 4 5
   d. Timeliness 1 2 3 4 5
5. The requirement for confidentiality? 1 2 3 4 5
6. Were you able to engage with your stakeholders about the options to bring their perspectives back into the TAG process? 1 2 3 4 5
   Why and can you suggest improvements? _____
   _____
7. How useful was the information provided (information in terms of data, presentations, expert advice, etc.)
   a. Comprehensiveness 1 2 3 4 5
   b. Was it provided at the right time in the process? 1 2 3 4 5
   c. Did the synthesis of the information provide enough context 1 2 3 4 5
8. The mix of expertise in the SAG and TAG 1 2 3 4 5
9. Was the time invested worthwhile? 1 2 3 4 5
10. Did you learn anything from the process? YES / NO
    If so, what did you learn? _____
    _____
11. Was the process transparent? YES / NO
12. Did you feel you could openly raise issues? YES / NO
13. Did you feel your perspective was listened to? YES / NO
14. Did you feel your suggestions were comprehensively considered? YES / NO
15. Were your perspectives addressed? YES / NO