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Choosing a fishery's governance structure using data poor methods

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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.

1. 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

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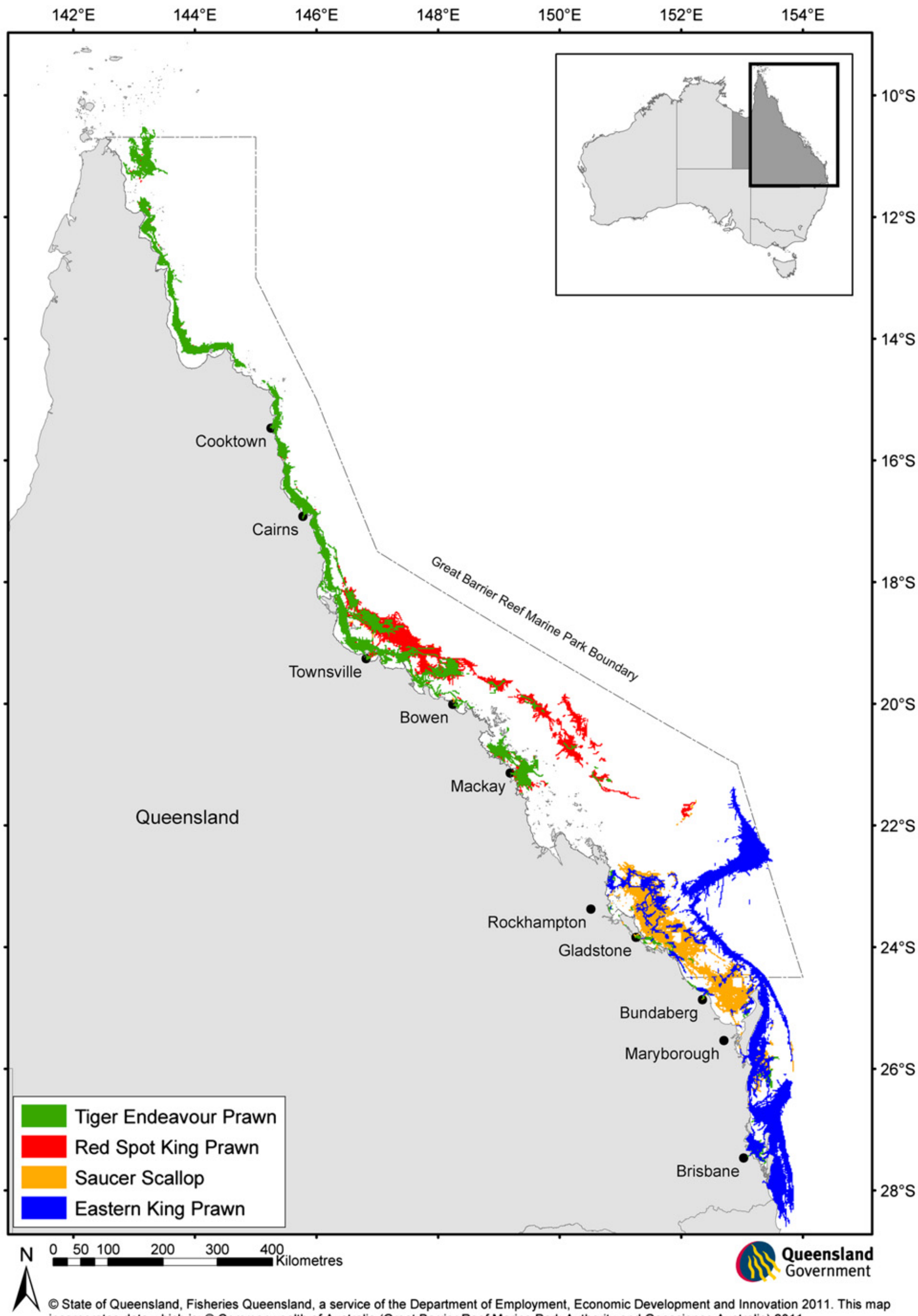

Fig. 1. Map of the Queensland trawl fishery showing the different sectors and the reef of the Great Barrier Reef. Source: Queensland Department of Employment, Economic Development and Innovation.

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) (Fig. 1) 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 5200 km. 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.

The ECTF targets several prawn, scallop and bug[2] species. The fishery has several sectors roughly divided by location and main

[2] "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.

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 1.76 m active effort units and 1.14 m 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 for the development 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.

2. Methods

A staged approach similar to that described in Pascoe et al. (2009) [15] was used in which a set of different management strategies were assessed against a set of management objectives. The first steps involved elicitation of (a) objectives and (b) their relative weighting. The derivation and weighting of the objectives and are described in detail by Pascoe et al. [18]. 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 weaknesses 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. This paper concentrates on the development and assessment of the management strategies.

Four high level objectives were identified, 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) [19] 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.

2.1. 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.

2.2. Qualitative impact assessment

The SAG and TAG rated each strawman *relative to the current situation* against each objective (Fig. 2) 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. [20]. 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., $(I'^{s}_{i,j}+\overline{C}_i)/\overline{C}_i$. 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

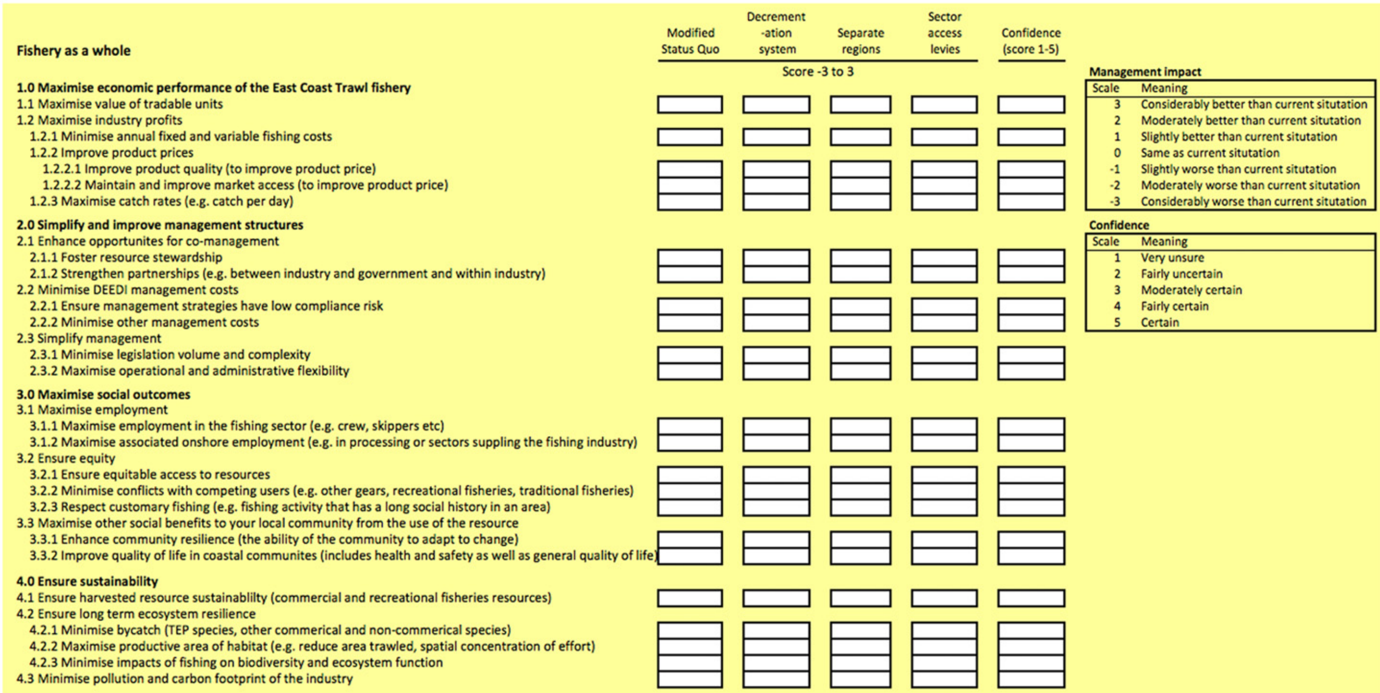

Fig. 2. Impact matrix sheet showing the hierarchy of objectives in the first column, the definition of the scores and the confidence of these.

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.

3. Results

3.1. 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.[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

[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.

degree of change would depend on the degree to which excessive fishing was occuring. 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.

3.2. Assessing relative merits of the strategies

The final set of objectives used in the analysis is described in detail in Pascoe et al. [18]. These objectives are also shown in Fig. 2, 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 (Fig. 2) combines the scores by strawman for each objective (Fig. 3).

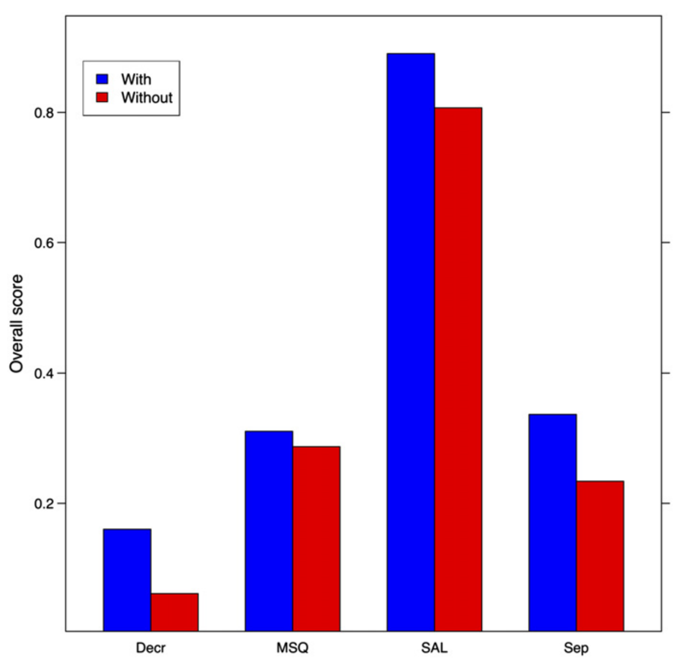

Fig. 3. Overall impact score of different management strategies with or without confidence scores. ''Decr'' is the Decrementation system, ''MSQ'' is the Modified Status Quo, ''Sep'' is Separate Sectors and ''SAL'' is Sector Access Levies.

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 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 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.

At the objective level, most of the strategies were rated as producing positive benefits against the different economic objectives (Fig. 4). 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.

The scores for the objectives (Fig. 4) can be summarised in terms of their worst and best overall scores, (Table 2). 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.

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

Table 1
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)

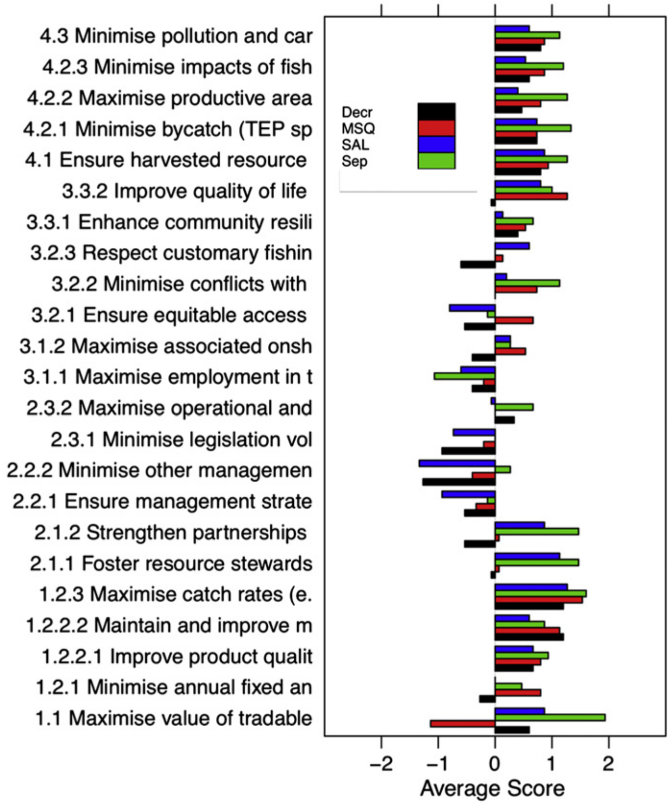

Fig. 4. Overall weighted impact score by strawman for each objective. "Decr" is the Decrementation system, "MSQ" is the Modified Status Quo, "Sep" is Separate Sectors and "SAL" is Sector Access Levies.

Table 2
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

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 vessels 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 scientists were excluded as their numbers were too low) (Fig. 5). 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".

Fig. 5 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 Fig. 5 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 3). From Table 3, 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.

4. 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 [2]. 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 [12,10,21] 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 [14,20,22], water, mining, forestry and other resources [23,24]. Many of these approaches use stakeholder engagement and analysis of qualitative data using multi-criterion decision analysis techniques (see [25]).

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

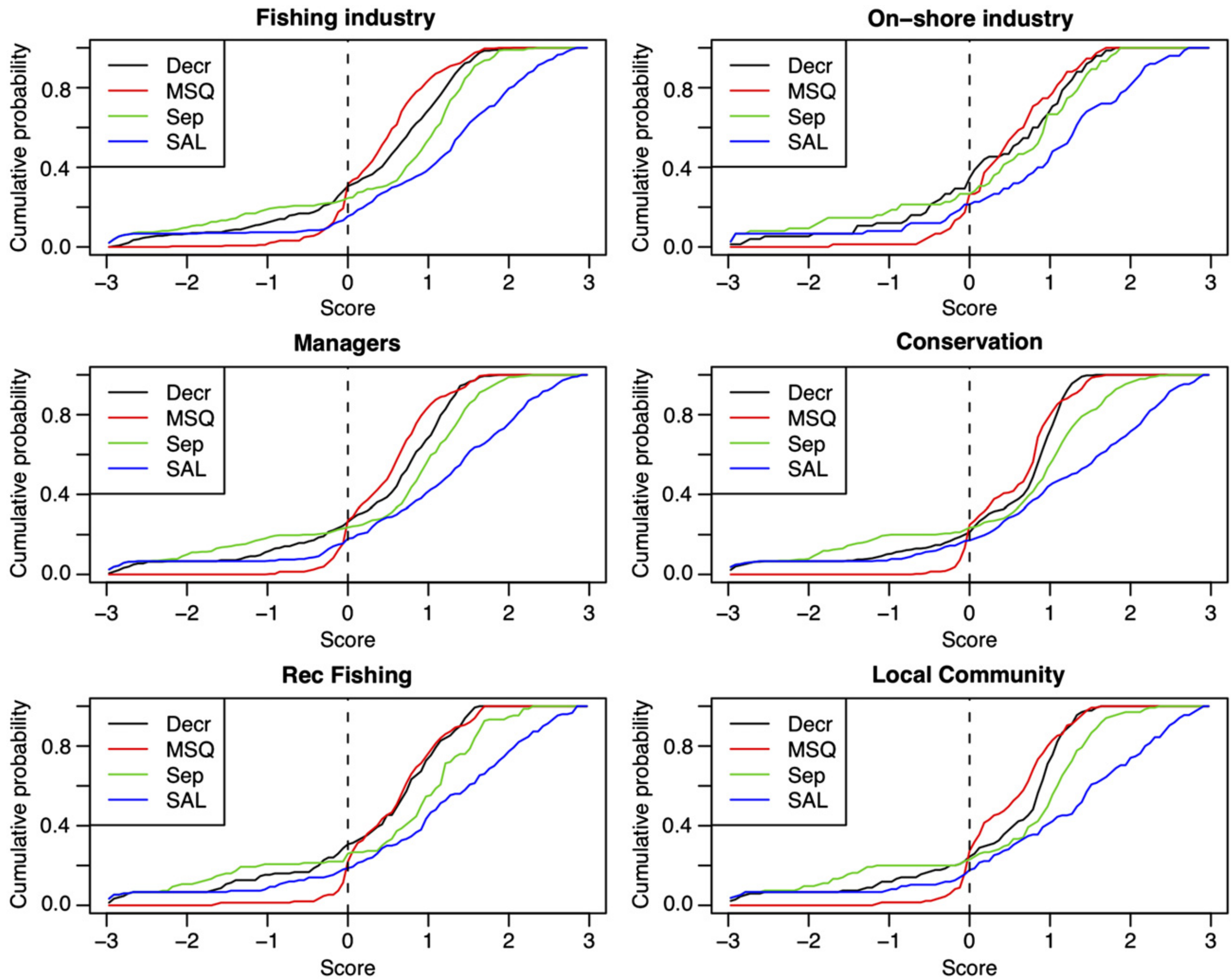

Fig. 5. Cumulative probability distributions of the overall score (−3 is substantially worse and 3 is substantially better) for each strawman. "Decr" is the Decrementation system, "MSQ" is the Modified Status Quo, "Sep" is Separate Sectors and "SAL" is Sector Access Levies.

Table 3
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

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, participating 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.

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 strategy 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 [20,26,27]. Pascoe et al. [20] 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, deficiencies have been overcome in two ways. First, those assessing the impacts were asked 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, a probability distribution was developed 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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