The use and interpretation of Figure 3 assumes that the value judgments of all participants are equally relevant. This assumption is unlikely to be valid. There was no attempt to include proportional or full representation of stakeholders at the workshop. The decision scores of individuals (and the contributions of criteria to those scores) are recorded in Appendix 2.

The rank order of preference for each alternative among all participants is pooled in Figure 4. The distribution of rankings makes plain the divergence of views associated with Alternative 1 (no closures). Four of the 13 participants considered it the best option. Five considered it the worst. Contrasts were driven essentially by different emphases on losses to fishers and protection of species or broader ecosystem benefits. The breadth of opinion regarding the merit of Alternative 5 was likewise driven by these contrasting emphases (see Appendix 2 for details of the contributions of criteria to decision scores). Alternative 4 involved special arrangements for the charter sector. Seven participants rated it the worst option.

Alternative 6 had the broadest support. Ten of the 13 participants ranked it in their top three. One participant ranked it fourth best. Two ranked it fifth best. No-one considered it the worst option.

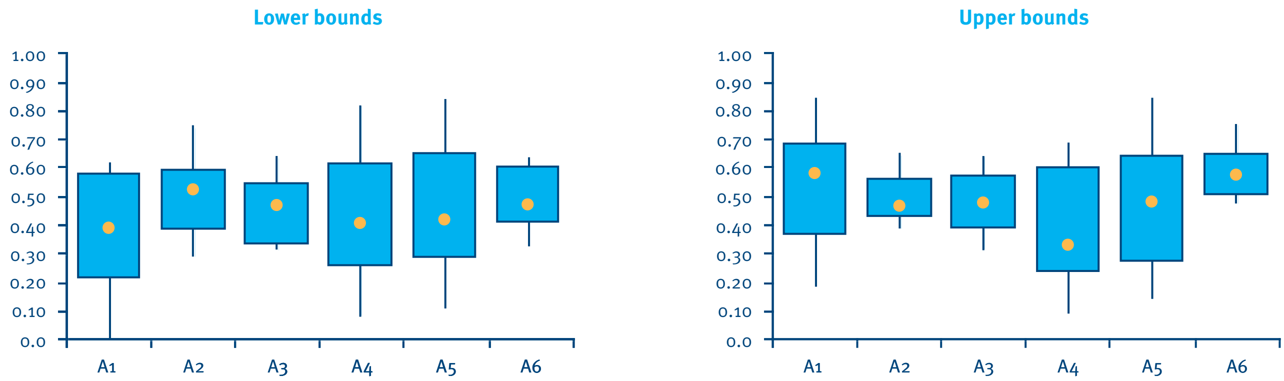

Figure 3. Participants' decision scores for the six alternatives. Lower (and upper) bounds refer to decision scores calculated using the lower (and upper) bound of performance score intervals reported in Table 2. Median score is indicated by a dot, the box shows the range of 9 of the 13 participants, and whiskers indicate the full range of the 13 participants.

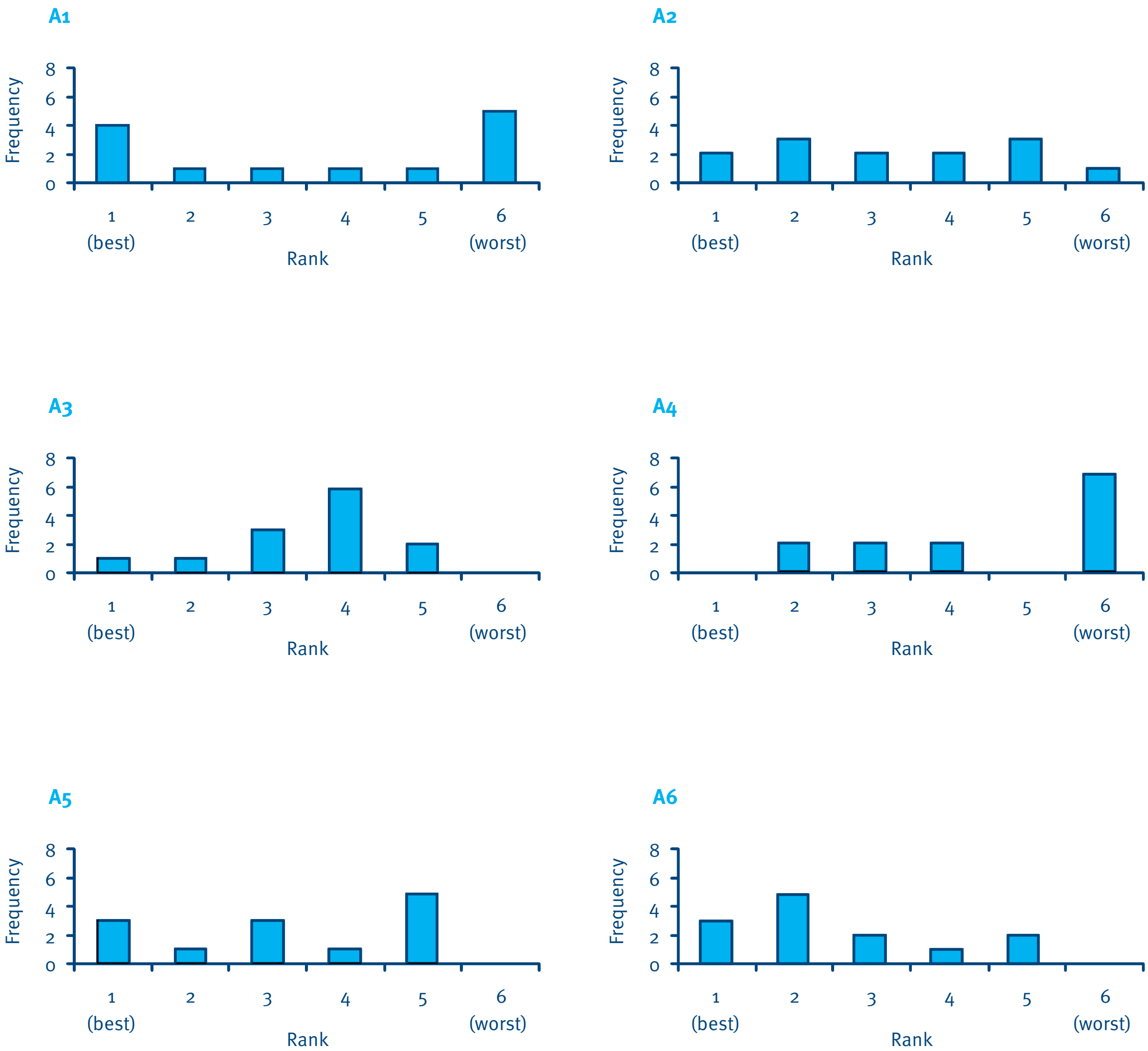

Figure 4. The frequency of rankings for each of the six alternatives among the 13 participants. Rankings were derived from the average of lower and upper bound calculations.

Discussion

In many circumstances, informal and imprecise processes are used to adjudicate on decisions in natural resource management. The approach adopted here provides a framework in which uncertainty may be characterised and carried through the logical steps that lead to a decision. A decision option that may yield a higher return might be declined in favour of an alternative with lower expected value but lesser uncertainty of outcome (Morgan and Henrion 1990). Decision-makers may choose to minimise potential adverse outcomes, to be risk-averse. Such decision-making under uncertainty can only be undertaken if the extent of uncertainty associated with alternatives is understood and communicated clearly. Sensitivity analysis explores the degree to which choices (decisions) might be affected by changes in the various elements of the decision structure.

Analyses were not without their limitations. Weighting is a demanding task. It requires participants to clearly understand the merit of each alternative against each criterion, and then assign weights that reflect personal or organisational trade-offs. In a relative sense, the indicators used to characterise performance associated with fish protection and costs to fishers were reasonably clear. The percentage chance of maintaining fish numbers, and days lost to fishing are natural and accessible indicators. But the assignment of weights may have been problematic for the three criteria assessed on an arbitrary four-point Likert scale.

The criterion *Ecosystem benefits* in part duplicated criteria pertaining to the protection of specific species. The protection of fish species is an end in itself for traditional fisheries management based around non-declining harvests. For conservation and broader ecological sustainability, the maintenance of fish species is only one component, or a means to a broader ecological end. The workshop did not directly address these complexities. It is likely that the failure to resolve underlying ambiguities in the inclusion of species-specific protection *and* broader ecosystem benefits lead to double counting (Keeney 2002).

These problems did not distort results substantially. Figure 5 shows decision scores after omitting 'ecosystem benefits', 'ease of enforcement', and 'prospects for learning'. Results are qualitatively similar to Figure 3. No single alternative is strongly recommended. Alternatives 1, 4 and 5 have large ranges. Alternative 6 would be marginally preferred over Alternative 3 if the 'Maxi-Min' strategy is used.

A more fundamental problem may have been incomplete listing of relevant objectives. Exhaustive elicitation of objectives is typically the most difficult step in MCA (Bond et al. 2008). The worst ranking assigned by seven of the participants to Alternative 4 (involving special arrangements for the charter sector) (Figure 4) may have been motivated by perceived inequities in the treatment of fishery sectors. Regulatory equity was not identified as an objective. Nevertheless, participants' judgments may have been coloured by their views on this issue.

While this report does not provide a clear and definitive outcome, it does provide the decision-maker with information on which to base a decision. Figure 5 illustrates the limitations associated with the adoption of Alternatives 1, 4 and 5, and to a lesser extent Alternative 2. Alternatives 3 and 6 provide more risk-averse options for consideration. Alternative 6 performed marginally better than Alternative 3 under the adoption of a 'Maxi-Min' strategy. Along with the formally captured views of participants, the decision-maker will have to give due consideration to other information, including the workshop discussions that form part of this report (Appendix 3) and the criteria that were removed from the adjusted decision scores (ecosystem benefit, enforceability and prospects for learning).

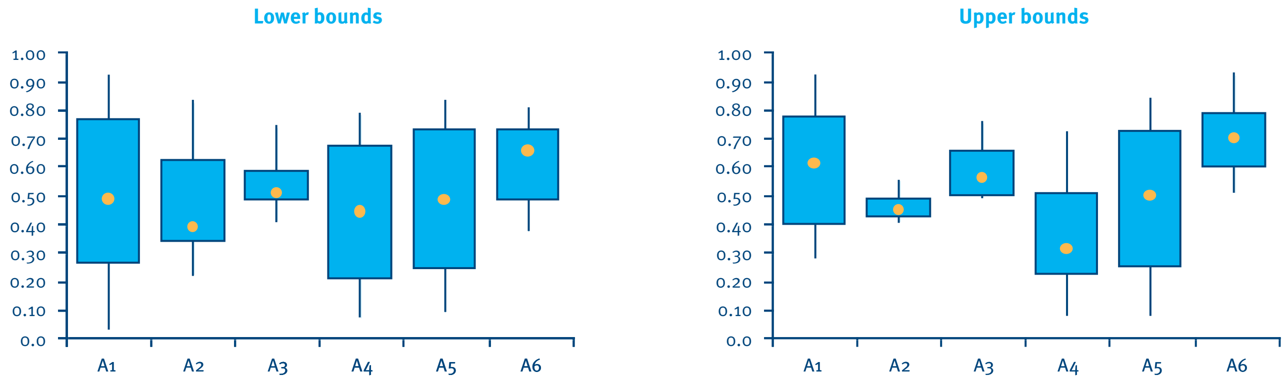

Figure 5. Adjusted decision scores, after removal of poorly characterised criteria ('ecosystem benefits', 'ease of enforcement', and 'prospects for learning'). Median score is indicated by a dot, the box shows the range of nine of the 13 participants, and whiskers indicate the full range of the 13 participants.

We note the following additional qualifications regarding Alternative 3:

- It is among the best options for protection of red emperor, large mouth nannygai, spangled emperor and camouflage cod/flowery cod (Figure 2), noting that there was very little difference between the alternatives for red throat emperor. There was also very little difference between Alternatives 3–6 in protecting coral trout.
- Protection is afforded to all coral reef fin fish, therefore catch and release of coral trout while fishing for other species will be minimised as will disruption to spawning fish. Those species other than coral trout that spawn around the new moons of October and November would be protected during periods of peak spawning activity.
- Alternative 3 imposes a relatively low impact on all fishery sectors and the ecosystem benefits and ease of enforcement are moderately high.

We note the following additional qualifications regarding Alternative 6:

- It provides a relatively high level of protection to coral trout (Figure 2).
- The inclusion of specific 'if-then' configural rules relating to lunar phase in September and December represents a more sophisticated biologically-based, cost-effective approach to protection than the status quo (Alternative 5).
- Alternative 6 is the worst alternative with respect to 'ease of enforcement'. The high costs of detecting non-compliance may need to be offset by improved deterrence through introduction of stronger penalties.
- The effectiveness of Alternative 6 as a protective measure rests on high survivorship of caught and released coral trout and assumes minimal disruption to spawning fish as a result of fishing. The post-release survivorship of coral trout and the effect of fishing on spawning behaviour would be high priorities for research should this alternative be adopted.

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Appendix 1: Workshop attendees

Participants

Tony Ayling, research scientist.

David Bateman, recreational fisher (Sunfish).

Alex Campbell, senior fisheries scientist, Primary Industries and Fisheries.

Howard Choat, School of Marine and Tropical Biology, James Cook University.

Jay Clark, AustAsia Seafood.

Peter Doherty, Australian Institute of Marine Science.

Shaun Hanson, commercial fisher (Queensland Seafood Industry Association).

Anthony Roelofs, fisheries biologist, Primary Industries and Fisheries.

Martin Russell, Great Barrier Reef Marine Park Authority.

Stephanie Slade, senior fisheries management officer, Primary Industries and Fisheries.

Bruce Stobo, charter operator.

Andrew Tobin, Fishing and Fisheries Research Centre, James Cook University.

Eric Wolanski, School of Marine and Tropical Biology, James Cook University.

Brigid Kerrigan, Manager (Fisheries Resources), Primary Industries and Fisheries (*unable to participate on the second day*).

Observers

Nicole Flint, Department of the Environment, Water, Heritage and the Arts.

Peter McGinnity, Great Barrier Reef Marine Park Authority.

Yvonne Sadovy, University of Hong Kong *(involved only in early stages of problem formulation)*.

Ian Yarroll, general manager, Harvest Management, Primary Industries and Fisheries.

Support

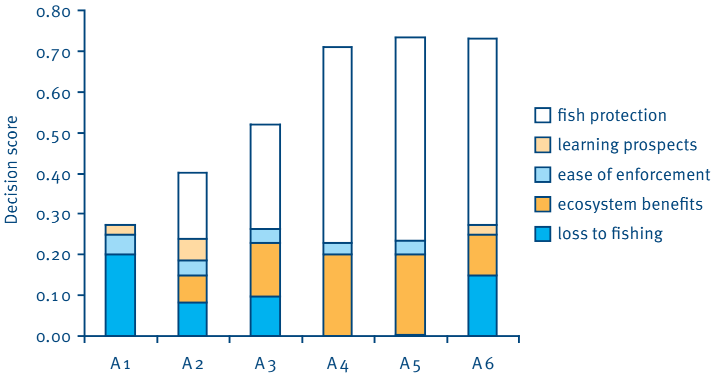
John Kung, senior fisheries management officer, Primary Industries and Fisheries.

Tracy Rout, Applied Environmental Decision Analysis, University of Melbourne.

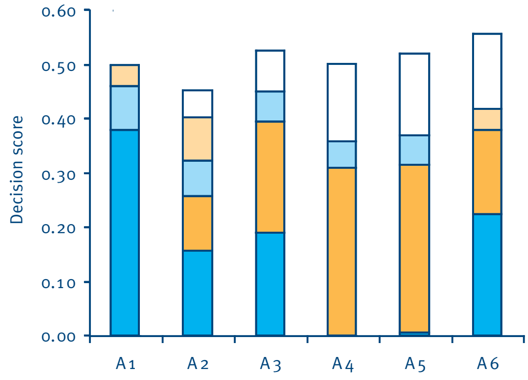
Terry Walshe, Australian Centre of Excellence for Risk Analysis, University of Melbourne.

Appendix 2: The contribution of criteria to decision scores of individual participants.

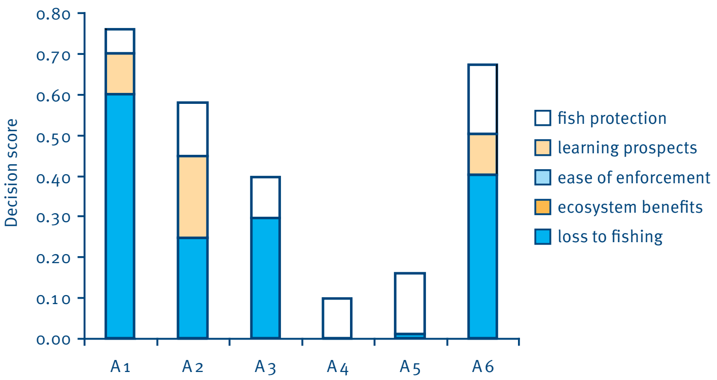
Scores refer to weights applied to the average of lower and upper bound calculations.



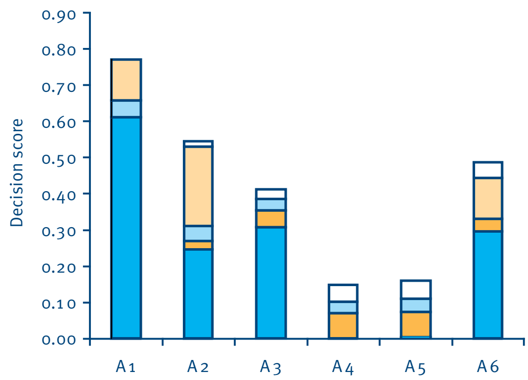
Tony Ayling, research scientist



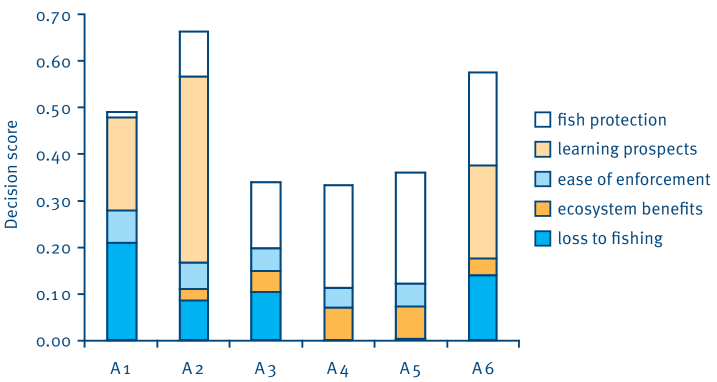
Howard Choat, School of Marine and Tropical Biology, James Cook University.



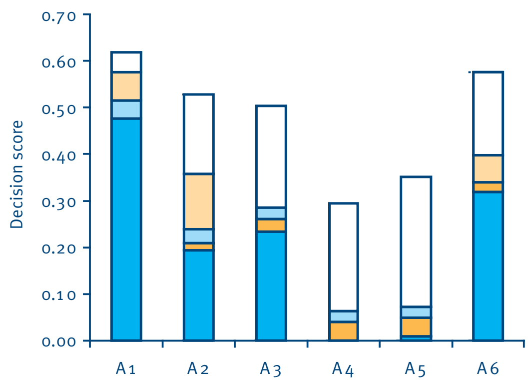
David Bateman, recreational fisher (sunfish)



Jay Clark, AustAsia Seafood.



Alex Campbell, senior fisheries scientist, Queensland Primary Industries and Fisheries



Peter Doherty, Australian Institute of Marine Science.