REVIEW OF THE HARVEST STRATEGY AND MCDA PROCESS FOR THE TASMANIAN ABALONE FISHERY

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TRANSLATING**NATURE**INTO**KNOWLEDGE**

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RECOMMENDATIONS

1. The development of the eHS provides an integrated, objective approach to the setting of TACs in the Tasmanian abalone fishery. It represents a significant improvement over the current approach which relies primarily on the subjective interpretation of the available data. Ultimately this eHS should replace the current approach, however, further development and refinement of the eHS is required before it could be adopted as a formal HS. It is therefore **recommended** that the eHS initially be run alongside the current workshop process as a means of improving TACC setting. This recommendation is made on the basis that:

    i) The eHS should adhere to best practice guidelines for developing harvest strategies and is conceptually and structurally sound;
    ii) The eHS represents an improvement on the current *ad hoc*, subjective analyses of CPUE trends; and
    iii) The eHS overcomes the difficulties of developing a model-based HS at appropriate spatial scales.

2. To refine the eHS it is **recommended** that the following work be undertaken:

    i) Determine all of the numerous 'settings' in the eHS;
    ii) Develop an integrated model for selected stocks of high importance to the fishery (e.g. the Acteons) where sufficient data to support robust model outputs are available. This will complement current testing of the eHS using MSE by allowing comparisons between the eHS spatial TACC changes and the assessment output;
    iii) Diversify the eHS performance indicators by incorporating performance indicators based on alternate data sources such as size composition data, particularly of both the catch and under-size animals, spatial data from the GPS/depth logger combination and fishery-independent abundance data. This will reduce the reliance of the eHS on:
        - using the same data (CPUE) in various combinations, and
        - using only lag indicators.
    iv) Examine means of developing an index of recruitment.
    v) Investigate alternative assumptions regarding the relationship between CPUE and stock abundance in the MSE testing.

3. To finalise the eHS it is **recommended** that clear operational objectives be developed as a priority including translation of the legislated MSY into catch/CPUE targets at appropriate spatial levels, and desired rates of rebuilding. Following development of these operational objectives, the 'settings' in the eHS may need to be re-considered to

ensure the eHS has a high probability of achieving those objectives. The MSE testing will be critical to these evaluations.

4. To ensure engagement and endorsement, it is **recommended** that DPIPWE and industry are fully involved in the development and adoption of the MCDA eHS including having input into:
    i) the establishment of operational objectives, performance indicators (including their relative weighting) and reference points;
    ii) the development of clear decision rules;
    iii) economic considerations, such as rates of rebuilding to achieve target reference points and constraints on changes in annual TAC settings.

5. To prevent duplication of effort and to capitalise on research efforts in other states, it is **recommended** that developments in the collection, analysis and use of logger data in other States be identified and, where appropriate, considered for adaptation and use in the Tasmanian eHS process.

BACKGROUND

The Tasmanian wild abalone fishery is the largest of its kind in the world, providing approximately 25% of the global annual production. It is a major contributor to the Tasmanian economy, in 2013 harvesting 2,149 tonnes (Tarbath *et al.* 2014) valued at around $97m (Stephan & Hobsbawn 2014). The abalone fishery is managed under the provisions of the Living Marine Resources Management Act 1995 and the Fisheries (Abalone) Rules 2009.

The fishery comprises multiple functionally independent local populations with biological parameters and fishery characteristics (size at maturity, growth rates, maximum size of animals, potential yields, etc), that are common across geographic scales (100's of kilometres) but can vary at local scales (100's of metres) in a few geographic regions. Abalone abundance is also patchy in space at local scales across Tasmania and the dynamics of adjacent populations can show some temporal divergence. However, productivity of reef systems on a geographic scale is relatively stable, creating an apparent spatial-paradox of local scale variability with geographic scale stability.

The status of the fishery is currently assessed using two empirical performance measures (catch and catch rates) from diver returns, and supplemented by length-frequency samples from commercial catches. The abalone industry also provides comment on relative stock status, particularly where local knowledge or market preference assists with interpretation of trends (Tarbath *et al.* 2013).

Formal length-based models are available for blacklip abalone (Gorfine *et al.* 2006), but are not used for assessment purposes in Tasmania due to the inability (cost, time) to acquire adequate biological and fishery independent data to underpin the model. Modelling a target species at regional scales currently requires combining biological and fishery data from sampled populations that are generally independent at local scales. Such averaging over the details of spatial heterogeneity often fails to capture the dynamics appropriately, and thus have not been applied to provide direct management advice on Total Allowable Commercial Catch (TACC).

The reliability of catch per unit effort (CPUE) as a proxy for abundance is entirely dependent on the quality and spatial resolution of the catch and effort components. In the case of the Tasmanian abalone CPUE is thought to be more reliable as an index of abundance when applied on smaller spatial scales than applied at the regional or whole of fishery scale.

For this reason, FRDC funded a pilot project on developing geo-referenced fishery-dependent data collection for the Tasmanian Abalone Fishery (Mundy 2012). Its success led to a fishery-wide operational trial of the method in 2011 (FRDC 2011/201). As part of the second project, a harvest control rule system is being developed that could incorporate the new spatial information in a formal decision process.

In response to the challenge of developing a formal decision process, Drs Mundy and Haddon developed an empirical Harvest Strategy (eHS) based on a Multi-Criteria Decision Analysis (MCDA) approach with associated Harvest Control Rules (HCRs). The eHS currently utilises three performance measures; Target CPUE, rate of latest 12 month annual change in CPUE, and CPUE gradient. Initial testing of the MCDA based eHS and HCR has been performed by a) application to historic data, and b) by inclusion in a management strategy evaluation (MSE) developed by Malcolm Haddon (FRDC 2007/020) and taken further in FRDC 2013/200.

In the development of this eHS and HCR, several issues have come to light, including lag times (decision, implementation, fishery response, review), and building the equivalence of target and limit reference points for spatial performance measures. Some of these issues existed prior to the development of the eHS and HCR as it is a feature of the use of a lag indicator such as CPUE as the primary decision-making data source.

Prior to implementation as a tool to assist with TACC determinations in the Tasmanian Abalone Fishery, the Department of Primary Industries, Parks, Water and Environment (DPIPWE) requested an independent external review of the MCDA eHS process.

SCOPE OF REVIEW

Based on the available information, the objective of the workshop is to review:

1. Rationale for not using an assessment model to determine TACC.
2. The adequacy of current *ad hoc*, subjective analyses of CPUE trends.
3. The logic of using this eHS to assess abalone fishery status in a defensible manner.
4. Structure of the eHS
    a. Scoring functions (Targets and interpolated limits).
    b. Weighting process for each Performance Measure (PM).
    c. Asymmetric Harvest Control Rules.
5. The eHS process for new spatial PM (given the short time-series available).
6. Time lags and review of fishery (fishers/stock) response to management action based on HCR.

The review focussed on the logic and science of CPUE and spatial performance measures, as well as the defensibility of the MCDA approach to synthesizing an array of empirical PMs.

It took the form of a workshop held on the 19 and 20th January 2015 (Appendix 1), and was attended by Industry, DPIPWE, researchers from IMAS and CSIRO, and the independent review Panel. Material provided to the panel ahead of the meeting is provided in Appendix 2.

This report summarises the findings of the Panel against each of the above objectives.

FINDINGS

1. Rationale for not using an assessment model to determine TACC

Several aspects of the biology and ecology of abalone complicate the assessment of their fisheries. Perhaps most importantly, the short-distance dispersal of larval abalone leads to dis-aggregated populations with a limited ability to re-populate depleted areas. Further, the ability of commercial divers to differentially exploit spatially-separated sub-populations allows them to maintain catch rates despite reduced stock abundance (Gorfine *et al.* 2005).

Globally, experience with abalone fisheries has shown that fishery-dependent data (catch and CPUE) are poor indicators of stock abundance, with hyper-stability in catch rates, often followed by sudden, rapid and unpredicted declines, which frequently lead to fishery collapse (Prince & Shepherd 1992). These factors are particularly problematical in areas where effort and catch data are sparse and compounded by the use of arithmetic means that are sensitive to skewed data (Tarbath *et al.* 2014).

The poor quality of CPUE data is due to two primary issues. The first and most important is that the scale at which fishing effort is reported (block, map code etc.) is much larger than the area fished by a diver on a given day (1 – 10 km's vs. 100's of metres). The mismatch between scale of unit stocks and scale of data collection on fishing effort is recognised as a key management weakness for most fisheries (Hilborn *et al.* 2005). The second issue relates to quality of CPUE data and that catch and/or effort are rarely recorded accurately. In Australian abalone fisheries it is normal practice to obtain an accurate weight of each diver's catch. The effort recorded, however, is an estimate of the hours fished and may be of variable quality. Consequently CPUE data can provide a poor resolution picture of stock trends (Mundy 2012).

Current harvest strategy simulation models used in Australia (e.g. AbModeller, Gorfine *et al.* 2005) require independent abundance and size frequency data in addition to catch-effort and commercial catch length-frequency data. Without fishery-independent data, the accuracy and utility of model predictions is thought to be significantly reduced. The collection of fishery-independent data should permit an unbiased assessment of trends in abalone abundance, and enable robust modelling of fishery performance and simulation of effects of management change through collection of density and size frequency data (Mundy *et al.* 2006).

Fishery-independent surveys of abalone abundance in Tasmania have been the subject of considerable investigation over an extended period of time. Basic trials undertaken by Nash (1995), concluded that abundance estimation of abalone in Tasmania was too difficult, and that variability among replicate sample units prohibited robust comparisons of abalone abundance in space or through time. Subsequent research by Mundy *et al.* (2006) developed a statistically reliable radial transect method but concluded that while the modified radial transect technique can provide robust data on abalone density, a single annual survey of abalone density may provide an inaccurate estimate of stock abundance due to unpredictable temporal variation in fishing effort at each study site. This they predicted would lead to substantial variability among years that was not necessarily related to any actual variability in stock abundance.

There is presently anecdotal evidence that across southern Australia from some abalone biologists and supporting fishery modellers who consider that the assumptions required to run a population dynamic assessment model for abalone fisheries (especially when applied at larger scales) are not well met, and that there are insufficient biological data to underpin the dynamics model or fisheries dependent data to validate the model.

NSW - has abandoned the use of an assessment model after using one in conjunction with a fisheries-independent data program for many years.

VIC - use one for the Central and Eastern Zones as a ‘check and balance’ and have a long time-series of fishery-independent data (although its value is often questioned), but have limited biological data.

SA - briefly used an assessment model, but have adopted an empirical harvest strategy. A model has been considered for some parts of their fishery (e.g. Tiparra Reef in the Central Zone).

TAS – have developed an assessment model but consider there is insufficient biological or fishery independent data for the assumptions to be met and for there to be confidence in the model outputs (a case in point being that the model predictions never really predicted the sharp decline in CPUE in 2012/2013).

Above we have summarised from the literature and other abalone assessments in Australia potential problems and cautions in using CPUE as the primary index of abundance when fitting an assessment model. However there are situations where CPUE data can be informative, particularly in situations where the trends have been validated by comparison with fishery-independent information (cf Plagányi & Butterworth 2010). Moreover, if CPUE are used as an input to an assessment model, there are several methods which could be used to account for these problems, to address uncertainty and to explore the sensitivity to alternative assumed relationships (eg hyperstability) between CPUE and stock abundance, as well as model structural uncertainty. However, even if CPUE data are reliable, a reasonably long time series with at least some contrast in the data (see e.g. one way trip - Hilborn and Walters 1992), plus additional information (e.g. growth parameters, stock-recruitment relationship) are required in order to accurately assess stock status and productivity (with this complicated further if there are regime shifts or changes in the underlying productivity of a region due to environmental drivers for example). This is an extremely data intensive and onerous task if an assessment model is to be developed for a very large number of zones, characterised by known differences in growth rate, recruitment and carrying capacity, but no reliable way of parameterising these processes. Hence, whereas an integrated model could be developed for a few selected, more data-rich regions, this is likely not a viable approach for every zone. On the other hand, by utilising short-term trend information contained in within-zone scale CPUE data (and doing associated sensitivity and robustness testing), one can obtain an index of changes in local stock abundance that are useful for adjusting TACCs up or down. Where additional information are available, it’s then possible to use an assessment model to also estimate the stock status relative to some reference or carrying capacity level. Moreover, in order to make longer-term forecasts for a long-lived species (such as abalone) with an assessment model, the recruitment (of new individuals entering the population) needs to be estimated within the model, and recruitment specific information is needed for its estimation in a model. If such information is not available, then it needs to be borne in mind that the CPUE trend information indexes a component of the population only, and the trend reflects increases in somatic growth and annual survival but ignores recruitment increases or decreases, which will be dampened to some extent by the time animals reach the age at first capture i.e. it is more likely to be a lag indicator. In summary, an assessment model is only as good as the data available to parameterise it, and where there are insufficient or unreliable data, it may be better to use a simpler approach and to rather invest effort in rigorously testing it. Regardless of whether or not an assessment model is used, the reliability of any method used for recommending a TACC will be substantially strengthened by utilising an additional data source such as size composition data particularly of both the catch and smaller animals, or fishery-independent data.

2. The adequacy of current *ad hoc*, subjective analyses of CPUE trends

Current process for analysing CPUE trends and TAC setting

The abalone TACC setting process in Tasmania represents one of the more advanced forms of collaborative decision making in Australian fisheries due to the spatially variable nature of abalone biology, which precludes uniform governance over geographic scales (e.g. zones, regions). Fine scale[1] monitoring and assessment used to inform larger scale management decisions is now widely considered a necessity for the effective management of abalone fisheries. In common with other abalone fisheries, consultative meetings are used in Tasmania to obtain industry input to augment data from the fishery to develop advice on catch settings to the Minister.

The TACC setting process involves two consultative/advisory bodies:

1. **The Abalone Fisheries Resource Advisory Group (FRAG)**. The FRAG is convened and funded by industry. It is independently Chaired and membership comprises the board members of the Tasmanian Abalone Council, fisheries researchers and fisheries managers. Observers are encouraged and divers with experience of working in areas of interest are particularly welcome. The FRAG provides advice on catch levels, catch caps, minimum sizes and related matters to the Tasmanian Abalone Council (TAC) and to the FAC (see below). The annual FRAG cycle follows a progressive, multi-meeting process.
2. **The Fisheries Advisory Committee (FAC).** This is a Ministerially appointed committee, as defined in the Fisheries Act and has a wider membership and mandate than that the FRAG, including additional members (processers, compliance staff and an environmental member). It considers advice from the FRAG and provides its own recommendations to the Minister, usually in accordance with the FRAG advice.

There are four meetings per annum of each of these groups as the fishing year progresses, with advice developed progressively before being finalised at the fourth meeting. The FAC and TAC Board provide advice to the Minister independently, again generally with a high level of agreement. The fisheries manager has input into both groups and in the Departmental brief to the Minister.

The annual fisheries assessment document provides a qualitative assessment of the status and trends in abalone abundance based on fisheries-dependent data, principally catch and catch rate data.

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[1] 'Fine scale' in the context of monitoring and assessment of abalone fisheries refers to a scale appropriate to the biological scales of abalone population dynamics (e.g. a population or group of populations). Fine scale management is management at a scale that balances biological scales with management complexity and cost (e.g. Blocks, regions or Zones).

IMAS presents catch and catch rate data, including occasional outputs from CSIRO modelling (Blocks 09-12 only), for each block or group of blocks (spatial management units or SMUs). Based on this information, IMAS provides opening remarks on stock status and trends. Increasingly IMAS has also provided suggestions of drivers of CPUE change including patterns of fishing behaviour driven by factors such as divers finishing off small amounts of quota by diving in places of convenience, market preferences for fish of specified size and location of harvest, seasonal changes (e.g. weed cover) and the impact of catch caps.

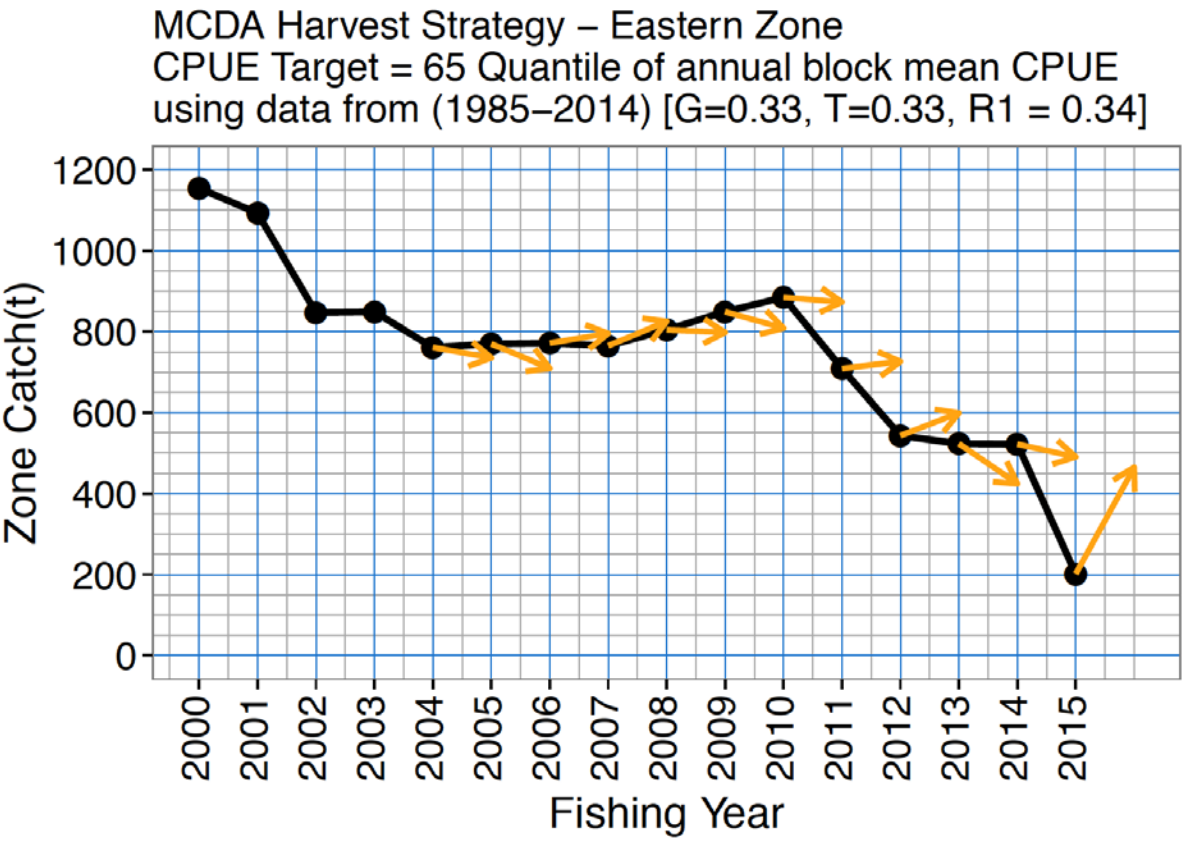
Industry are then invited to provide comments on the data and conclusions drawn by IMAS, based on their observations during commercial diving and knowledge of other drivers that, in their view, affect the conclusions drawn from the fishery dependent data.

There is heavy reliance on catch and CPUE data in arriving at TAC recommendations. In recent years, IMAS has added detailed conclusions concerning stock status in the annual fishery assessment based on a qualitative analysis of CPUE trends in the abalone fishery.

Consensus based on ‘expert opinion’ is then sought on a sustainable catch target for each reporting block or group of blocks. This process can be somewhat protracted, as divers and quota holders in the fishery tend to hold diverse opinions about stock status, the urgency with which management action is required, including on the degree to which catch and catch rate data are indicative of stock status and trends. This diversity of opinion, in the absence of a more objective decision making framework including clear operational objectives makes reaching a consensus position challenging.

The recommended TAC for a given zone is then progressively built using a bottom-up approach based on the sum of the sustainable catch targets determined for each SMU. These targets are arrived at by consensus wherever possible, through compromises between those with greater and lesser tolerance of the risk posed by different catch settings. Industry members tend to convert and discuss probable TACs into kg/Quota Unit (i.e. the direct impact of any change on their investment) and an informal short term-economic trade-off vs long term sustainability is weighed up by members individually – a natural tendency, but clouds the conclusion of stock status with economically tolerable actions.

In a retrospective analysis of the draft MCDA Harvest Strategy and Control Rule framework (HS&CR) for the Eastern Zone between 2004 and 2015, the HS&CR suggested TACC outcomes that were surprisingly close to the decisions made under the current *ad hoc* expert working group process. Deviations from the *ad hoc* process by the MCDA HS&CR framework are driven by two key components; firstly the gradient CPUE tends to continue to push TACC down at the point of inflection (e.g. downward – 2004, 2005; upward – 2011, 2012), and secondly when CPUE is stable following management action but at a level well below the CPUE target, the MCDA framework will push TACC lower. Fine tuning of the weightings applied to the gradient and target performance measures will be essential to avoid unwanted behaviour, as well as further develop the decision tree to provide an objective basis for when to change the PM weightings.



Weaknesses with the current analysis of CPUE trends

Lag effects Falling CPUE tends to be given insufficient consideration during industry analysis at the FRAG, particularly in relation to expectations arising from management actions. Industry is frequently content to see continued reductions on CPUE (inferring fishing mortality is likely to be greater than recruitment to the available population) on the basis that any reduction in TAC will ‘take time to have effect’ and that continued falls in CPUE are tolerable under expectation that stocks take four or more years to respond based on previous patterns. This has tended to lead to insufficient action being recommended to address falling abundance and successive catch reductions being insufficient to address increasing harvest fractions, and a failure to act in a timely manner.

Weight of opinion. FRAG recommendations tend to be highly dependent on the mix of divers, quota owners and processor managers present at the meeting. The absence or presence of individuals can alter the outcome of the discussions on some areas significantly. Divers will often cite operational (‘fishing to market’) or environmental (urchins) or seasonality (degree of weed cover, weather) as reasons for declines in CPUE. The most recent analysis of CPUE by quarters has assisted the process, allowing for last/first quarter comparisons and comparisons across years.

Lack of weighting of performance measures. There is no explicit weighting of CPUE and other the performance measures (including catch, size structure, diver opinion, logger information) being considered, and the weighting given to each of these measures can often depend on how convinced individuals, including IMAS researchers and, at times the Department, are of their view.

Governance. While the FRAG minutes provide a record of the decision for a given SMU and some general comments surrounding the discussion leading to decision on target catches, it does not provide a clear audit trail of how the decision was arrived at, or how catch and catch rate was explicitly used to underpin those decisions.

Lack of reference points. Despite a number of attempts, the fishery remains without a harvest strategy, including CPUE reference points, and in particular limit reference points. There has long been discussion of limit reference points beyond which TAC reductions will be required, but with a reluctance to agree to management action. Without a harvest strategy, what is an acceptable CPUE target to one group may be unacceptable to others who have a higher risk tolerance.

Inability to assimilate fishery indicators. The process relies on the ability of the workshop participants to assimilate in their own minds, the patterns for each performance measure in use. Even for two performance measures (catch, CPUE) some difficulties have been experienced, and in particular decisions on the weighting to be given to i) the most recent fishery data and ii) the trends from recent years. As other performance measures come on line, and most notably from logger data, it will become far more challenging to assimilate patterns, apply value (weights) and arrive at defendable and repeatable decisions. It has also been challenging to convince industry to consider the long-term effects of management actions, with an overwhelming focus on short-term outcomes of any decision taken (or delayed).

Volatility. The ability and willingness of managers to react to changes in CPUE in an appropriate time is limited and the Tasmanian industry has had a long history of following CPUEs down, only to introduce relatively large catch reductions, which have led to stock rebuilding over time. This process tends to repeat, placing the fishery at some risk during low catch rate/biomass periods, particularly when political pressure is brought to bear not to reduce TACs.

In summary, the current practice of *ad hoc*, subjective analyses of CPUE trends, driven by industry views, has played a major role in determining TACs that have, on balance, eventually assured stock rebuilding. The process is, however sub-optimal for the reasons described above. The proposed MCDA analysis-based empirical harvest strategy, when fully developed, will address many of these shortcomings.

3. The logic of using this eHS to assess abalone fishery status in a defensible manner

Australia's national harvest strategy (HS) guidelines defines a HS as follows: "a framework that specifies the pre-determined management actions in a fishery for defined species (at the stock or management unit level) necessary to achieve the agreed ecological, economic and/or social management objectives." A key principle is that fishery managers, fishers and key stakeholders utilise pre-agreed (and preferably pre-tested) rules as to how to adjust management recommendations given updates of data and/or model outputs. Hence adopting a formal HS overcomes many of the problems outlined above (Section 2), that arise from the current practice in the Tasmanian abalone fishery of utilising *ad hoc*, subjective analyses of CPUE trends, driven by industry views. Recognised advantages of a HS include increased certainty and transparency. A carefully developed HS should consistently outperform an *ad hoc* approach to management, and hence the review panel recommends moving towards replacing the current *ad hoc* approach with a formal HS approach, subject to consideration of the points below. The focus of the eHS on blacklip abalone alone is considered sensible given that this species comprises some 95% of the catch.

Moving towards adoption of a HS is therefore a logical next step in improving management of this fishery. However, an important foundational step involves identifying over-arching management objectives as a priority as clear enunciation of these is lacking from the current process. Hence, whereas developing a HS is logical, finalising the development of the HS and interpreting trade-offs and optimal outcomes is impeded to some extent by the lack of clear operational objectives, for example, what level to maintain stocks at or what the desired level of stock rebuilding is. Such objectives should be established by the Department.

Using an empirical rather than model-based HS.

With regard to developing an empirical HS as opposed to a model-based HS, this is considered a defensible approach given that: a) there is a clear rationale for not developing an assessment model as outlined in (1) above; and (2) empirical HS's have been shown to perform adequately or almost as well as model-based approaches (Rademeyer *et al*. 2007, Dichmont and Brown 2010). Both model-based and empirical HS's typically include free parameters that can be adjusted to tune their performance to achieve desired optimal trade-offs between performance statistics.

Empirical harvest strategies have demonstrated an ability to achieve objectives such as reversing a decline in a population, but can suffer from a lack of information about the exact level the resource abundance will approach. They can aim for a proxy target level, but additional analyses are required to determine how the proxy target relates to the biomass at MSY or MEY if, for example, such biological reference points are selected as objectives for the fishery. For the Tasmanian abalone fishery, there is the advantage that there is a relatively long time series available to inform on an appropriate target CPUE per block that is sufficiently risk averse and accounts for the operational efficiency of the fishery. Similarly, there are some data available to inform on an appropriate CPUE based limit reference point. Nonetheless, given changes over time, as well as longer term changes and trends in underlying environmental parameters, it is advisable to regularly revisit and simulation test the harvest strategy, as is planned for this fishery.

A potential disadvantage of empirical HS's is that they can perform worse than model-based approaches in terms of the level of inter-annual variability in output recommendations (Butterworth and Punt, 1999; Punt and Smith, 1999). This is because model-based methods typically consider the behaviour of the resource over a long time period and hence variability in forecasts is dampened, whereas empirical approaches typically estimate short-term trends, taking into account only data for the most recent years. Given that large interannual variability in management recommendations can be problematic for many fisheries[2], this needs to be borne in mind in designing an empirical HS, and is another reason it is useful to simulation test beforehand the overall performance of the HS using management strategy evaluation. The set of performance measures selected should ideally be based on both the most recent information, as well as consideration of trends over a longer period. This is achieved to some extent in the HS being reviewed because the choice of target CPUE is informed by CPUE back to 1985, as well as recent (current year relative to previous year) and medium term (gradient over past four years) trends. The simulation testing will help determine the weight to be placed between a quick (but potentially being influenced by noise) or a slow response time (but potentially then requiring large TAC changes).

An advantage of empirical approaches is that they are relatively simpler to develop and often more easily understood by all stake-holders. Furthermore, they can be quicker and easier to run and hence many alternative simulations and scenarios can usually be tested quickly. This is particularly helpful in this case because of the large number of spatial areas that the HS needs to be applied to.

Selecting PMs for use in an empirical HS

Ideally, a model-based or empirical harvest strategy should integrate all available information from a range of sources to inform on stock status relative to a target reference level, and set changes in management levers such as catch or effort to move the stock in a desired direction (decreasing catch and/or effort if stock rebuilding is required, increasing if under harvesting is occurring, or maintaining at the same level). In this regard, there are two main challenges in designing an effective empirical HS. Firstly, it is preferable if at least two independent sources of information can be used to inform on stock status in case a primary variable alone does not always provide a reliable index of stock abundance. Hence, for example, if CPUE is the sole performance measure used (albeit with variants thereof), interpretation may be confounded by hyperstability, catchability changes or increases in fishing efficiency, or if the

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[2] Although large in the context of the Tasmanian abalone fishery is ~ 20%, this is low compared to many other scalefish or crustacean fisheries. The key question is, whether the magnitude of inter-annual TAC change in this abalone fishery is of a magnitude consistent with other long-lived species.

fishers alter their strategies this could mask stock declines. An empirical HS could thus be strengthened by utilising an additional data source such as size composition data, or fishery independent data. The HS under review currently utilises three CPUE-based PMs but discussion is also focused on other PMs under development such as the utilisation of commercial catch length frequency data and spatial PMs derived from diver GPS units.

The second challenge is to ensure that the action recommended by the HS to achieve a desired outcome has the intended effect in practice. For example, if a certain level of stock rebuilding is required, an empirical HS might recommend a decrease in catch for that area, but if the prediction is based on an underlying assumption of a linear relationship between catch and biomass, the realised outcome may differ from the intended outcome due to other nonlinear effects, such as a nonlinear stock recruitment relationship, or the effect of variable environmental drivers. This is another reason for pre-testing a HS with an MSE. Moreover, if available, information on the relationship between environmental drivers and stock productivity and catchability could be used to refine the model, HS or HS recommendations. For the HS under review, the resilience of the HS to changes in environmental drivers could be examined as part of the MSE testing. In some cases, exceptional circumstances clauses could be developed and used to override the recommendations of a HS for example if environmental conditions change such that the conditions observed outside the range of the values used in testing the HS, or in setting up the structure.

Guidelines for HS development

To evaluate the defensibility of using this empirical HS to assess abalone fishery status, it is important to consider whether the HS adheres to recommended best practice guidelines for developing HS. Australia’s national HS guidelines recommend that a harvest strategy be:

a. consistent with the legislative objectives, including the principles of Ecological Sustainable Development:
b. pragmatic and easy to understand;
c. cost-effective;
d. transparent and inclusive;
e. unambiguous;
f. precautionary; and
g. adaptive.

The eHS under review generally adheres well to all these guidelines. Certainly, it is a pragmatic and cost-effective approach given that it needs to be applied to a large number of individual blocks, and needs to be tailored for each of these because of spatial differences in the underlying physical and biological environment, as well as location and activities of fishers. Utilising a pre-agreed harvest strategy is more transparent than annually basing decisions on a changing mix of divers, quota owners and processor managers present at a workshop. Importantly, the eHS will also include pre-agreed (and hopefully pre-tested) weightings of performance measures, based on the best available science, all rendering the process more objective and transparent than a subjective stakeholder driven weighting that may change from year to year. The current iterative process of refinement and development has already demonstrated that the approach is adaptable in terms of refining targets, and the framework is set up so that additional PMs can sequentially be added as they become available, or after suitable testing (for example, the size-based and spatial information referred to above). However, the lack of operational objectives is hampering the choice of weights and target settings within the eHS framework. This makes determining which of performance measures from the MSE testing is important or even whether they are appropriate.

4. Structure of the eHS

The empirical multi-criterion decision analysis method as applied for abalone used a stepwise approach to set the final TACC, starting at the block level to obtain block catches and summing these over block within a region to set the regional TACC. Each step of the framework is described in Box 1 of the report and thus this section will review the steps starting with the selection of the performance measures (PMs). The full set of required decisions and assumptions for the framework is provided in Table 2.

It should be first stated that the description of the method could be much more exact and specific. This is especially the case for the Target CPUE description which, for example, is a bit confusing if one relies on the equations.

This section is divided into comments on a) the selection of the Performance Measures (PMs) indices, b) the scoring system, c) relative PM weighting and composite index score, d) the harvest control rule and e) a summary of the settings assumptions and calculations required. This is followed by a set of recommendations.

Selection of the PM indices

In the worked example, three PMs are used – Target CPUE, Rate1 and Gradient CPUE. These three indices use CPUE data by block in a different manner and have different purposes. To calculate the PMs, CPUE data from 1980 to present for each block are needed at least initially (to calculate the target CPUE) and thereafter the past 4 years' CPUE by block data. The example does not currently use length or any other information, but (in principle) these data are not excluded for use by the proposed method.

Target CPUE

The Target CPUE aims to move the fishery to a target CPUE level for each block. It will adjust the catch in a block depending on where the present CPUE is relative to this target. This PM has been used in several fisheries, including the Commonwealth Southern and Eastern Scalefish and Shark Fishery (SESSF) and the Tropical Tuna (TT) fisheries. Several methods have been used to obtain the target CPUE; for example, Delphic approaches to historical data that choose a period that best represents resource sustainability and industry profitability (SESSF; initially TT) or using a regional assessment model to infer the years in which the fishery was closest to the target reference point (TT).

The method assumes that CPUE by block is proportional to biomass and that the target CPUE used in the formulation of the PM places the resource in each block at a biologically sustainable level as defined by the management objectives. Both of these assumptions are likely to be difficult to justify in all of the blocks, given their history. Since an assessment is possible using some of the more commonly fished blocks, there is an implication that an assumption of proportionality may be reasonable in some blocks.

In order to calculate this PM, an annual CPUE is calculated using the mean CPUE in a year. This method of calculating the mean CPUE was agreed upon with industry and the FRAG, but the reason is not provided in the documentation. It assumes that the within-year pattern remains similar between years in a block or is similar on average. This method may not be appropriate in blocks where there has been a major change to the within-year fishing pattern over years.

A percentile approach was suggested to obtain the target reference value for each block – 50th, 65th and 75th percentiles are tested using retrospective analyses. The available assessments for broader areas are not used as a guide to test whether these are appropriate. Given the amount of blocks, the present approach tries to use some consistent approach between blocks. The percentile values varied substantially between blocks. However, when these values are turned into a difference between the selected percentile and the 75th percentile in each block, in most blocks the biggest difference between the percentiles is choosing between the 50th and 65th percentile (see Table 1). In other words, there was little difference between the 65th and 75th percentile by block (as one would expect). Obvious exceptions are block 12 in the western zone and blocks 24, 26 and 27 in the eastern zone. However, there is an issue in that the history of exploitation will be highly influential on the value of the target chosen. In principle, if a block has a history of over-exploitation then the percentile values could be lower than those that were lightly fished; and therefore the over-exploited block will have a lower CPUE target and a higher implied target TACC. In practice, all blocks have been over-exploited, but some more consistently than others. Those blocks under sustained pressure tend to be more resilient (naturally). In the East and North, the pattern of exploitation is a little more volatile, with fishers serially exploiting blocks as performance in the preferred blocks falls away.

It would possibly be a better approach to ground-truth the targets, at least for the major blocks, based on stock assessments for those blocks or some other process such as using size-frequency analyses.

If the percentile approach is used, the retrospective analyses showed, as expected, that the 50th percentile value was less conservative than the 65th with the 75th percentile value being the most conservative. It is argued that the overall decline in CPUE in the two zones means that a more conservative measure than that taken should be considered. However, the retrospective analysis does place question on the use of the 50th percentile and points to the use of a larger number. Given the slight difference between the 65th and 75th percentile, an argument can be made to keep the 65th value. The reality is that the impact of a series of decisions to create a PM can only be tested in the MSE and the MSE results should be used in making this final decision.

Table 1: Difference between the 75 percentile and the 50th or 65th percentile within a block

Zone	Block number	50th	65th	75th
Western Zone	6	25	15	0
Western Zone	7	5	0	0
Western Zone	8	0	0	0
Western Zone	9	0	0	0
Western Zone	10	5	0	0
Western Zone	11	25	5	0
Western Zone	12	15	10	0
Western Zone	13	15	5	0
Eastern Zone	13	15	5	0
Eastern Zone	14	15	5	0
Eastern Zone	15	10	5	0
Eastern Zone	16	15	0	0
Eastern Zone	17	10	5	0
Eastern Zone	18	10	5	0
Eastern Zone	19	5	0	0
Eastern Zone	20	10	5	0
Eastern Zone	21	10	0	0
Eastern Zone	22	10	5	0
Eastern Zone	23	10	5	0
Eastern Zone	24	20	10	0
Eastern Zone	25	5	5	0
Eastern Zone	26	20	15	0
Eastern Zone	27	25	10	0
Eastern Zone	28	10	5	0
Eastern Zone	29	10	5	0
Eastern Zone	30	10	5	0
Eastern Zone	31	10	5	0

The preliminary MSE tests show that this PM on its own displays large oscillations around the target and does not provide stability in the fishery nor that it stabilises the fishery at the target CPUE. It is unclear whether this oscillation dampens over time, but in the short- to-medium term this oscillation may be too extreme. This oscillatory behaviour can be moderated by extending the implied period of achieving the goal.

In the example, no economic or social PMs are included. In many fisheries, the economic component is in part included in the target of the CPUE. It should therefore be investigated whether there is a link between the choice of percentile value and economic performance that can be made in the MSE. The potential that there are two possible economically optimal performance values (depending on whether the divers or quota holders economic drivers are favoured) should be considered and traded off against where these apply from a sustainability point of view.

Rate1

The Rate1 is the percentage change in CPUE in the current year over the previous year. Unlike the Target CPUE PM, which is steadily moving the fishery to a CPUE reference point, this is a reactive PM that is trying to adjust the TACC when there are large changes to the recent CPUE. One would assume that blocks with high catch and large oscillations in catch would dominate this PM. This PM would be reactive while there are changes and keep things unchanged if recent CPUE has stabilised – irrespective of whether this stability is at a good point or not.

Gradient CPUE

This PM is based on the gradient of linear regression of CPUE against a recent set of years – in this case 4 years. This PM measure has been used in many fisheries including the Queensland spanner crab. It tends to emphasise stability and does not have a target or limit concept. It has also been shown to be very sensitive to the period chosen – too long; the PM is very slow to change; too short, and it starts reacting in a way that is similar to Rate1 – and to any additional control rules that result in lack of symmetry e.g. a rule that decreases TAC more reactively than increasing it. Similar to the Target CPUE, without any between-year weighting in the regression (see section below), it also has a strong lag effect, which means it is much less reactive to recent changes than the Rate1 PM.

The preliminary individual MSE tests showed that this PM had the most stable (and higher catches) of the PMs, but was accompanied by (often) poorer overall catch rates.

Preliminary MSE testing

The preliminary MSE testing using a matrix of weightings between the three PMs showed that a) the Gradient CPUE alone did not respond much, b) the Target CPUE is effective at reacting to CPUE changes, but can be highly reactive when the resource is depleted and c) hen the weights of [0.6, 0.2,0.2] for [gradient CPUE, Target CPUE, Rate 1] is used, the eHS performs well by leading to reasonably stable and productive fishery and can rebuild a depleted stock, if required. However, without clear objectives the final choice of weights and targets – which is highly influential to the outcome – is still needed to help with the choice of the most appropriate HS tested within the MSE.

Other PMs

The system does not preclude the use of other PMs such as the output from an assessment or sampled length data (the FRAG has started looking at it as an indicator, but finding inconsistencies – as evidenced by the conflict in the size-based assessment). However, importantly all the PMs are lag indicators based on essentially the same data – CPUE. **It is very important to get a lead indicator – an independent survey or independent length frequency sampling. This would greatly enhance the framework.**

Scoring system

Given the PMs have different scales, a conversion is undertaken to produce a consistent scoring scale between 0 and 10. This can also be done through the relative PM weighting system, but then the role of the weight tends to be more obscure. This conversion requires a choice of an upper and lower bound for all the PMs used.

The Target CPUE scoring system is a little unclear based on the description. However, although a single ΔCE is described in the equation notation there are actually an upper and lower value. In actual fact there is a more complex rule being:

$$\Delta\mathrm{CE}_{lower} = \begin{cases} \mathrm{CPUETarget} * 0.55 & \mathrm{CPUETarget} \geq 90 \\ \mathrm{CPUETarget} * 0.50 & otherwise \end{cases}$$

$$\Delta\mathrm{CE}_{upper} = \begin{cases} \mathrm{CPUETarget} * 1.45 & \mathrm{CPUETarget} \geq 90 \\ \mathrm{CPUETarget} * 1.50 & otherwise \end{cases}$$

The ΔCE defines the upper and lower bounds of the score system. Great care needs to be used when selecting any of the range values, but particularly for the Target CPUE PM where the target is set at a percentile of the same data from which the range values are chosen. The choice of upper and lower ΔCE means that some of the data (especially for noisy CPUE values in some blocks) may extend beyond the upper and lower ΔCE values thus the 0 and 10 bins are a plus group. This in itself may not be a difficulty but if the probability of being in this plus group is not similar then this may cause biases in the results. Of special concern would be if the lower bin is a very large plus group i.e. there are numerous historically low CPUE values that fall within this group. The extent of this issue will depend on the CPUE Target value chosen given it is a percentile of the data. In other words, the scoring system is confounded by the historical data series, the target CPUE value and the range. It may therefore be worth either not placing this system on a consistent scoring system or ensuring that symmetry around [0;5;10] is demonstrated. This issue may also arise with the other PMs, but less so for Rate1 where there is no particular reason why one would not assume symmetry if the assumption that CPUE is proportional to biomass is correct. The Rate1 and Gradient CPUE range in the example is ±0.4.

Relative PM Weighting and composite index score

The example provided in the text runs the process with equal weighting between the three PMs, but does acknowledge that this is something that needs to be determined. Since the three PMs have different purposes one would expect that weighting can be done to achieve overall operational objectives. However, operational objectives do not seem to be clearly stated (from the documents the reviewers were provided or online), which makes it extremely difficult to know how to balance the PMs appropriately. **It is urgent therefore that operational objectives are produced.** The MSE can therefore report against those objectives allowing for a more open and transparent debate on which framework settings best move the fishery to these objectives.

Harvest control rule

This block-level composite index score is based on a vector of score and percentage change to the block catch. There is asymmetry in the rule as documented. The decrease far outweighs the increase. A 1-2 score would change the catch by 35% whereas a 7-8 score would increase the catch by only 10%. This rule can be useful for recovering a stock but does seem to compound the effects of the role of the Target CPUE PM. By comparison, in the spanner crab fishery, a natural medium term cycle was observed over time which resulted in an overall decay of the TAC without being able to return to previous TACs when the CPUE increases. MSE tests should highlight this issue but heavy skewness such as demonstrated here should be carefully tested.

A buffer in the scoring system of not changing the score for scores around 5 is developed but it too is asymmetric. Again, this asymmetry should be tested especially when a series of these could be cumulatively too precautionary. An MSE can test whether this issue is important.

Blocks versus region?

All the PMs are calculated at the block level for a region. This means that each block has the same settings applied but the applicability of the associated assumptions may vary by block. There is value in working at block level: small scale changes can be followed which is appropriate for localised depletion, to which abalone can be susceptible. However, block level decisions could also mean that noise is more likely to be followed. For example, it may not be able to distinguish between short-term recruitment and industry behaviour changes. The reverse is true for region-level PMs – there could be small scale but important changes lost in following such a large part of the fishery. Precedence in management of other abalone fisheries would point to using smaller scales. Dispersal and connectivity work in Tasmanian abalone has shown that there is limited larval dispersal with about 95% self-recruitment. Adults also do not move much. This points to a small-scale system. However, there may a case for combining some blocks or checking these against relevant stock assessments when available.

Summary of Settings, Assumptions and Calculations required for the PM score calculations

Below is a list of the settings required to calculate the PM scores for the example provided, including the associated assumptions.

Table 2: Summary of settings required within the presented MCDA approach, their associated assumptions and comments

Step	Value required	Method applied	Data needed	Assumptions	Comment
All PM calculations	Annual CPUE by block - $CE_{y,b}$	Mean annual CE_b	CPUE	Pattern of CPUE within a year by block is reasonably similar	Would be an issue if there were major drifts in the data e.g. fishing pattern change
PM calculation	Target CPUE - CE_{yT}	65th percentile of mean annual CPUE by block	Annual CPUE from 1985 to present	Pattern of CPUE within a block follows a reasonable distribution (noting the use of percentiles does not assume a distribution) and is reasonably similar between blocks	Choice of percentile is arbitrary, however would be most sensitive in blocks where there is a clear pattern in the CPUE over time e.g. a declining resource
PM	Target CPUE - CE_{yT}	Number of years to use in calculation is from 1985 to 2014	Annual CPUE from 1985 to 2014	Unclear why this period from documents provided	Affected by the management economic and biological history of the blocks. The values are standardized.
Score	Target CPUE - Upper and lower Target CPUE score value	When target CPUE < 90 kg/hr then ±50% of the target value; Else ±45% of the target value	CPUE target	Assumes symmetry around the target CPUE	May create a bias in the probability of falling in a score especially at the upper and lower ends. Strong link with Target CPUE chosen.
Score	Rate1	Maximum percentage increase and decrease of -0.4 to 0.4	CPUE	Assumes symmetry around the changes in CPUE	Would need to expanded or reduced if the range is not appropriate
Score	Gradient CPUE	Upper and lower bounds of -0.4 and 0.4 conditioned on the region being assessed	CPUE		
PM	Gradient CPUE	Number of recent years used is 4	CPUE	This period is the best trade-off between stability and reactivity That a decline or increase over this period is	Sensitive to this assumption which can be highly influential

Step	**Value required**	**Method applied**	**Data needed**	**Assumptions**	**Comment**
				reflective of harvest levels exceeding or being too low given the recruitment levels	
All PMs scores	Relative PM weight	No weighting i.e. weighting is 1	Additional information on relative weights	All PMs are equally important	These need to be related to operational objectives and MSE testing
Harvest control rule	Composite index score	Vector of block catches against each score band	PMs	Resource is overexploited and that the asymmetry is required to compensate for this	There may be unusual behaviours as found in other fisheries which can only be highlighted using an MSE

5. The eHS process for new spatial PM (given the short time-series available)

The currently proposed MCDA eHS relies entirely on commercial catch rate data. This is because the initial performance indicators are the relationship between the current and a target CPUE, and the rates (and direction) of CPUE change over the previous two (rate 1 CPUE) and four (gradient CPUE) fishing seasons. Aside from the general concerns of the relationships between CPUE and stock abundance in these fisheries, CPUE is widely used to assess stock status, based on the assumption that changes in this measure reflect changes in the relative abundance of the fishable stock (Tarbath *et al.* 2005). CPUE can be strongly influenced by numerous factors which may be unrelated to, or lag, changes in abundance. Consequently this measure is often viewed as a biased index of relative abundance (Harrison 1983; Breen 1992; Prince and Shepherd 1992; Gorfine *et al.* 2002). For example, catch rates may remain high as a result of re-aggregation of abalone or improved knowledge of fishing areas by fishers, leading to hyperstability (Officer *et al.* 2001; Shepherd and Rodda 2001; Dowling *et al.* 2004). Alternatively, catch rates could reduce because economic circumstances force a change to more efficient fishing operations (e.g. two divers operating off the same vessel and air supply). In addition, the relationship between relative abundance and CPUE is also not likely to be consistent over time as factors influencing CPUE vary among years (e.g. effort creep and changes in market demand). Limiting the MCDA eHS to performance indicators from effectively the same data source with similar issues is problematic. In general, harvest strategies should be based around multiple data sources.

To overcome these deficiencies, there has been considerable investment in alternative performance indicators. IMAS propose the development, validation and use of novel ‘spatial’ performance measures derived from GPS and depth-logger data, synchronised through a date/time stamp, providing base data at the scale of each fishing event. The GPS data are obtained for each fishing day from a ‘GPS tracker’ on the diver’s tender vessel. The Sensus Ultra Pro logger is attached to the diver and records diving depth and time. Both loggers record data every 10 seconds, with data record having a date and time stamp. These date and time stamps are used to synchronise the data streams, and enable GPS data when the diver was not underwater to be discarded.

There has been considerable investment by FRDC (projects 2006/029 and 2011/201), IMAS, DPIWE, TAC and others into the (1) development of appropriate technology for collecting these data; (2) associated software systems for data management, archival and analysis; and (3) identification and exploration of spatial performance measures. The first FRDC-funded project focussed explicitly on the first two key components and yielded appropriate tools and systems for cost-effective implementation. This project also identified putative performance indicators. The second FRDC-funded project is scheduled for completion in June 2015. That project aimed to collect data across the Tasmanian abalone fleet (loggers being mandatory from January 2012) and to use the three full years of data to determine performance indicators for use in the MCDA eHS. The projects, data collection and data analysis span (at least) three States – Tasmania, New South Wales and Victoria.

While at a ‘base case’ these data can be used to validate the commercial CPUE data, and potentially to correct for systematic bias (either for each individual fisher, or collectively across the fleet), they appear extraordinarily powerful with enormous potential to revolutionise abalone stock assessment. The key challenge to achieving this is to convert the enormous datasets (e.g. approximately 23,000 annual dive events) into information – and subsequently into performance indicators for the MCDA eHS. However, this is an important step given the extensive investment to date, the need for additional performance indicators for assessment of this fishery and the impracticality (scale and cost) of fishery-independent surveys.

Several potential spatial performance indicators have been identified. These have been identified through consultation with active divers, literature reviews (e.g. home range analyses) and through exploration of the existing data. The potential spatial performance indicators based on individual dive events include changes in the number of dives per day, frequency of short, unproductive dives, changes in swimming speed and/or distance, weight of catch harvested per metre of swimming distance, and the frequency of long dives with little catch. Across the fleet and assessment blocks, alternative metrics such as the number of divers per cell (e.g. 1 ha of fishable reef), total effort/unit area and the weight of catch harvested from each cell (i.e. kg/Ha) may also yield informative indices of stock status.

Following identification (and validation) of spatial performance measures, there is a need for them to be incorporated into the MCDA eHS. This will require determination of the scoring function including shape, score distribution and appropriate target reference point. The currently limited time series of data (essentially three complete years) will make this difficult to do empirically. However, this difficulty needs to be overcome such that the spatial performance indicators can be scored and contribute to the MCDA eHS in a similar manner to those for CPUE. There are at least two alternative approaches which may yield interim scoring functions. The first would be to use the existing data along with IMAS’s knowledge of the fishery and its functionality to develop the scoring function. An alternative would be to use the FRAG process (or another workshop) to use the collective knowledge of the fleet to undertake a similar process. The advantage of the latter is that it will create a high degree of industry ‘buy in’ to the use of these performance indicators, and for the scoring consequences of their utilisation – particularly given the likely need for the metrics to be interpreted differently in different areas of the fishery (i.e. shapes and values) due to the variable influences of weather and reef structure. For both approaches, however, it would be useful to test application using the existing MSE framework. This is likely to be essential to understand the weighting that should be applied to spatial indices, both individually and collectively. This approach could also be used to determine the level of logger utilisation required for the information to be reliable (e.g. is 80% coverage sufficient, degree of representivity etc).

New South Wales and Victoria are currently investigating the use of logger data, in combination with catch, to estimate harvestable biomass levels and exploitation rates. While this approach is not yet formally implemented or used for TACC setting, its proponents consider that it also has enormous potential for improving abalone stock assessments. Validation against fishery-independent survey data is required and a project proposal is being developed by New South Wales to pursue this objective. The outcomes from that project are likely to have direct relevance to Tasmania.

6. Time lags and review of fishery (fishers/stock) response to management action based on eHCR

The present eHCR example uses CPUE data in different ways to produce a composite index per block and therefore an overall regional TAC. Abalone live for many years and therefore there is a large gap between the effects of fishing on the stock and subsequent recruitment. This means that CPUE would only react reasonably long after an issue occurs and will contain a series of runs based on past decisions before it would react to a management change. This means that the eHCR can result in over-steering that seems to be present in this management system as well. This is unavoidable given that CPUE is a lag indicator. By having a PM index that reacts quickly to recent changes does help, but would still suffer from the same problem. There are two possible solutions - develop a PM using other sources of data such as a recruitment index or length-frequency of smaller abalone, or combine larger TAC changes with multi-year TACs. The latter is often more difficult for industry (when cutting TACs), but there would be a clearer signal through the system. This is similar to the approach used in SA where TACCs are set for two years unless stock status changes.

Time lags can also occur in the decision making process where delays in responding to a CPUE decline could further exacerbate the problem. In that regard, clear and well-designed HS would alleviate this implementation issue.

Again, the decision as to which option is best depends on the availability of other indicators and also MSE tests. It may also be prudent to examine the approach used in WA. Briefly, their HS continues to reduce TACCs annually in response to declining standardised CPUE.

7. Acknowledgements

The review panel thanks the workshop participants for the open and transparent spirit in which the review was conducted. Background information on the Tasmanian abalone fishery and on abalone biology and ecology were kindly provided by the science team Drs Craig Mundy, Malcolm Haddon and Hugh Jones.

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APPENDIX 1: WORKSHOP AGENDA and ATTENDEES

Review of Possible Harvest Strategies and Multi-Criteria Decision Analysis process for the Tasmanian Abalone Fishery

<u>Workshop agenda</u>

Location: Freycinet Room, CMAR

Day 1 – Monday 19th Jan 2015

Session 1 (0900 – 1030)

1. Introductions (Chair)
2. Adoption of agenda (Chair)
3. Intent (TOR & our objectives) (Chair)
4. Summary of blacklip abalone biological knowledge (Craig Mundy)
5. Summary of the Tasmanian fishery & assessment (Craig Mundy)
6. Overview of geo-referenced FD data (Craig Mundy)
7. Overview of intended use of MSE (Malcolm Haddon)
8. Why we are proposing to use Empirical Performance Measures (Craig Mundy)
    a) Strengths
    b) Weaknesses

Session 2 (1100- 1230)

9. Multi-Criteria Decision Analysis: Introduction and logic (Craig Mundy)
10. Components
    a) Data - (Any PM)
    b) CPUE
        - Quota Dockets vs GPS
        - Time Lags
    c) Scoring functions for CPUE PMs
    d) Developing scoring functions for spatial metrics
    e) Weighting coefficients

11. Including Decision Trees (Craig Mundy)

Session 3 (1330 – 1500)

12. Control Rules (Craig Mundy)
13. Decision timeframe – lags between implementing decision and making next decision

Session 4 (1530 – 1700)

14. MSE testing of the HCR (Malcolm Haddon)

Day 2 - Tuesday 20th Jan 2015

Session 1 (0900-1030)

15. Preparatory Time for Reviewers
    - Private session for panel members to discuss material presented and prepare a list of questions/comments

Session 2 (1100-1230)

16. Q & A

Session 3 (1330-1500)

17. Industry and Reviewer question session
    - Opportunity for stakeholders and panel members to quiz the science team

Session 4 (1530-1700)

18. Overview of review to date
    - General acceptance of components to the MCDA
    - Concerns over other components etc.

Workshop Close (1700)

Independent Review Panel

Prof Colin Buxton (chair) – Colin Buxton and Associates
Ian Cartwright – Thallassa Consulting, Chair Abalone Fishery Advisory Committee
Dr Cathy Dichmont – CSIRO
Dr Eva Plaganyi-Lloyd – CSIRO
Dr Stephen Mayfield – SARDI

Stakeholders

Dean Lisson – Industry
Greg Woodham – Industry
Darvin Hansen – Industry
Paul Richardson – Industry
John Hoult – Industry
Joey McKibbon – Industry
Dr Craig Mundy – IMAS
Dr Malcolm Haddon – CSIRO
Dr Matt Bradshaw – DPIPWE

APPENDIX 2 – BACKGROUND MATERIAL

Mundy, C., Jones, H. and Haddon, M. 2015. Multi-Criteria decision analysis based harvest strategy for the Tasmanian abalone fishery. Abalone Technical report. 33 pp.

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Abalone Fisheries Research Advisory Group documentation from 2013 – 2014, 5pp.

APPENDIX 4 – ACRONYMS

Definitions below mainly taken from Rademeyer et al (2007).

Assessment: A mathematical population model coupled to a statistical estimation process that integrates data from a variety of sources to provide estimates of reference points and the past and present abundance, fishing mortality and productivity of a resource

HCR: Harvest Control Rule – a set of well-defined rules used for determining a management action in the form of a *TAC* or allowable fishing effort given input from an *estimator*, or directly from data

HS: Harvest Strategy – the combination of pre-defined data, together with an algorithm to which such data are input to provide a value for a *TAC* or effort control measure; this combination has been tested by simulation to show robust performance in the presence of uncertainties

eHS: An empirical harvest strategy where resource monitoring data (such as catch rates) are input directly into a formula which generates a control measure such as a *TAC* without an intermediate (typically population model based) *estimator*

***FAC*:** Fisheries Advisory Committee

FRAG: Abalone Fisheries Resource Advisory Group

MCDA: Multi-Criteria Decision Analysis

MSE: Management Strategy Evaluation – the process of testing alternative *harvest strategies* by simulation, in particular for robust performance in the presence of uncertainty

Objectives: General objectives for the management of a resource as set by decision makers – these often include the aims of maximizing catches, and minimising large inter-annual changes in catch limits and the risk of unintended depletion of the resource and related species, as well as considerations of transparency and cost effectiveness

Performance statistics: Statistics that summarise different aspects of the results of a *simulation trial* used to evaluate how well a specific *harvest strategy* achieves some or all of the general *objectives* for management for a particular *scenario*

TACC: Total Allowable Commercial Catch to be taken from a resource within a specified period and region

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