

# **Identifying management objectives hierarchies and weightings for four key fisheries in South Eastern Australia**

**Sarah Jennings, Sean Pascoe, Ana Norman-Lopez, Bastien Le Bouhellec, Sophie Hall-Aspland, Andrew Sullivan and Gretta Pecl**

**FRDC Project No 2009/073**

Copyright Fisheries Research and Development Corporation and the University of Tasmania 2013.

This work is copyright. Except as permitted under the Copyright Act 1968 (Cth), no part of this publication may be reproduced by any process, electronic or otherwise, without the specific written permission of the copyright owners. Information may not be stored electronically in any form whatsoever without such permission.

#### Disclaimer

The authors do not warrant that the information in this document is free from errors or omissions. The authors do not accept any form of liability, be it contractual, tortious, or otherwise, for the contents of this document or for any consequences arising from its use or any reliance placed upon it. The information, opinions and advice contained in this document may not relate, or be relevant, to a readers particular circumstances. Opinions expressed by the authors are the individual opinions expressed by those persons and are not necessarily those of the publisher, research provider or the FRDC.

The Fisheries Research and Development Corporation plans, invests in and manages fisheries research and development throughout Australia. It is a statutory authority within the portfolio of the federal Minister for Agriculture, Fisheries and Forestry, jointly funded by the Australian Government and the fishing industry.

### **Statement of contributions**

**PRINCIPAL INVESTIGATOR:** Dr Sarah Jennings,  
**ADDRESS:** School of Economics and Finance  
Private Bag 85 Hobart, TAS 7001  
Phone: 03 62262828 Fax: 03 62267587

#### *University of Tasmania*

Dr Sarah Jennings led the project and contributed to all stages of the work. Bastien Le Bouhellec contributed to the development of the survey instrument, data analysis and report writing. Dr Sophie Hall-Aspland contributed to general project management, workshop facilitation, report writing and data analysis. Dr Greta Pecl provided a link between this project and the *Preparing fisheries for climate change: identifying adaptation options for four key fisheries in South Eastern Australia* project thereby facilitating access to species level Industry and Management Committees, Scientific Working Groups and case study leaders.

#### *CSIRO Marine and Atmospheric Research (CMAR)*

Dr Ana Norman-Lopez contributed to report writing, workshop facilitation, development of the survey instrument and data analysis. Dr Sean Pascoe provided overall expert guidance with respect to the implementation of the methodology, survey design and data analysis. He also contributed to workshop facilitation, data analysis and report writing.

Andrew Sullivan (*Fish Focus Consulting*) assisted with the administration of the survey and final report preparation.

This Project was funded through the El Nemo – South Eastern Australia Program. This Program is supported by the Victorian Department of Primary Industries, Primary Industries and Resources South Australia, Industry and Investment New South Wales, Tasmanian Department of Primary Industries, Parks, Water and Environment, Australian Fisheries Management Authority, Fisheries Research and Development Corporation, CSIRO, South Australia Research and Development Institute and the Tasmanian Aquaculture and Fisheries Institute, Commonwealth Department of Agriculture, Fisheries and Forestry and is also supported through funding from the Australian Government’s Climate Change Research Program.



**Australian Government**  
**Department of Agriculture,  
Fisheries and Forestry**



**Australian Government**  
**Fisheries Research and  
Development Corporation**



## Contents

Non Technical Summary proforma .....	5
<i>Acknowledgments</i> .....	9
<i>Background</i> .....	10
<i>Need</i> .....	11
<i>Objectives</i> .....	11
<i>Introduction</i> .....	12
<i>Methods</i> .....	14
Development of objective hierarchy .....	14
Weighting of management objectives.....	15
Group Coherence .....	18
<i>Results</i> .....	19
Objective Hierarchy for SEAP Adaptation Case Study Fisheries .....	19
<i>Discussion</i> .....	28
<i>Planned outcomes and benefits</i> .....	30
<i>Further development</i> .....	31
<i>References</i> .....	32
<i>Appendix 1: Intellectual Property</i> .....	35
<i>Appendix 2: Summary of management objectives as found in policy/legislation for SEAP commercial fisheries by species and state</i> .....	36
<i>Appendix 3: Management objectives list</i> .....	42
<i>Appendix 5: Definition of Objectives</i> .....	45

## NON TECHNICAL SUMMARY

**2009/073      Identifying management objectives hierarchies and weightings for four key fisheries in South Eastern Australia**

**PRINCIPAL INVESTIGATOR:** Dr S. Jennings  
**ADDRESS:** University of Tasmania  
School of Economics and Finance  
Private Bag 85  
Hobart TAS 7001  
Telephone: 03 6226 2828 Fax: 03 6226 6655

### **OBJECTIVES:**

To provide a clear articulation of management objectives in each of four South Eastern Australian fisheries (abalone, blue grenadier, snapper and southern rock lobster) for use in evaluating alternative management arrangements, by

- a. developing a management objective hierarchy and
- b. eliciting a set of management objective weights for each fishery.

### **Non Technical Summary:**

Changes to fisheries management and governance arrangements will form an important part of climate change adaptation responses in the South East Australian region and will impact on various aspects of fishery systems and on their associated values. The ability to comprehensively evaluate management changes requires clear definition of a framework of objectives and of the relative importance of these often competing objectives. This framework is often missing from climate change adaptation evaluation, and adaptation priorities and plans are often developed without reference to either adaptation goals or to the general aims of fisheries management.

The aim of this project was to develop a transparent and clearly articulated framework of weighted objectives, against which the performance of selected management adaptations can be assessed as part of DCC/FRDC Project 2011/039 *Preparing fisheries for climate change: identifying adaptation options for four key fisheries in South Eastern Australia*. The method used was the Analytical Hierarchy Process (AHP) and comprised two stages. The first stage involved developing an overarching, generalised hierarchy of objectives (Figure 1).

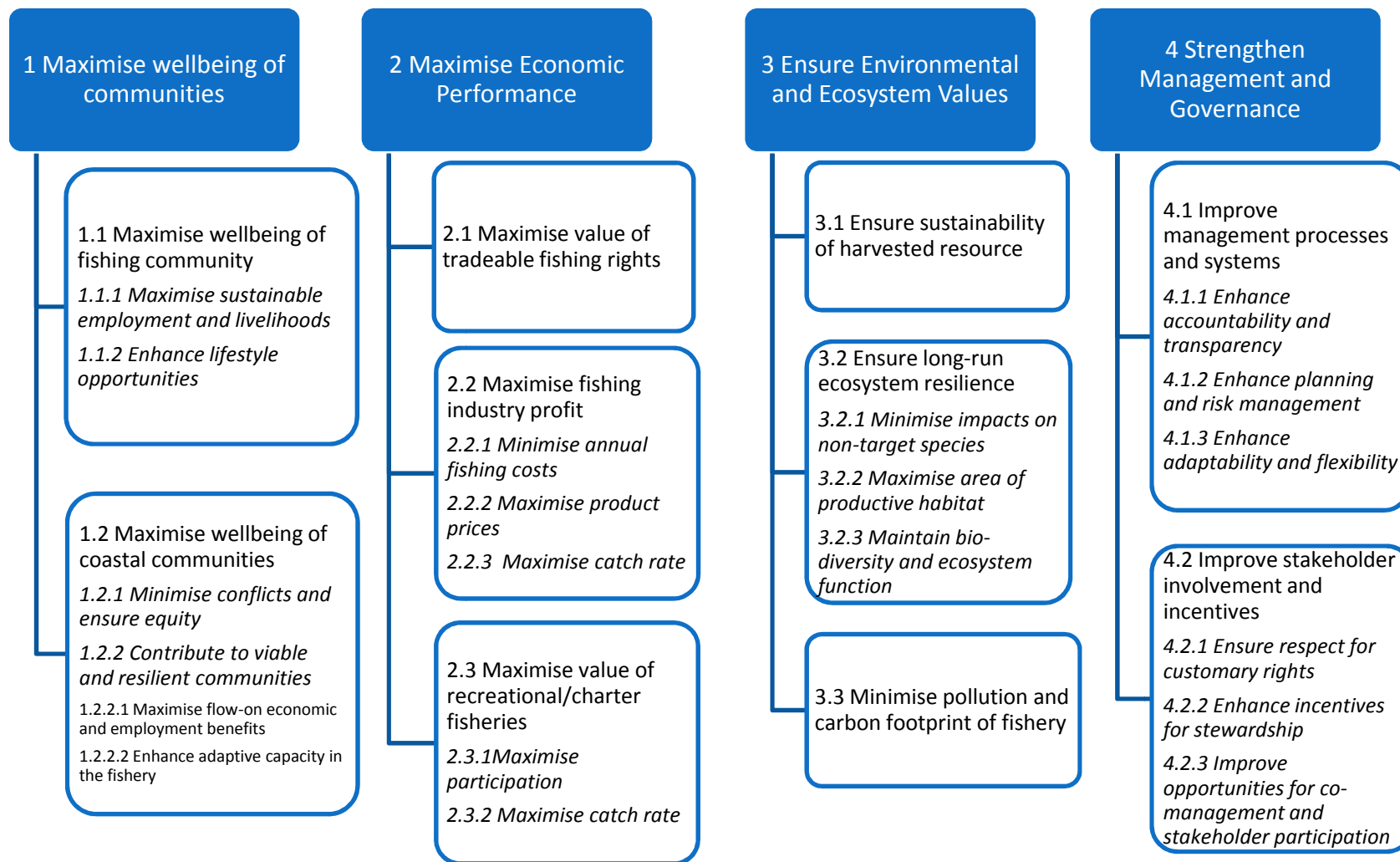


Figure 1 SEAP Adaptation Case Study Fisheries Objective Hierarchy

The hierarchy developed comprised four general, or high-level, objectives, three of which mapped broadly to the triple bottom-line objectives of environmental, economic and social performance. The hierarchy also included the objective of strengthening management and governance as a high-level objective as a way of capturing the importance of these aspects of fisheries systems to effectively respond to pressures arising from climate change and other stressors. Lower level objectives reflected more detailed or specific objectives related to each of the general objectives.

In the second stage, an interactive, Excel-based AHP survey was designed to measure individual preferences across the range of high and lower-level objectives detailed above. The AHP survey required respondents to make a series of pair-wise objective importance comparisons and provided a relatively simple yet powerful means of deriving individual level objective preference structures or weightings.

A letter of invitation to participate in the survey was sent to 131 individuals, 50 of whom were members of SEAP Industry and Management Committees and Scientific Working Groups. A total of 64 useable surveys were returned for the four fisheries and for a group who had responded generally, or for no particular fishery.

Average weightings attributed to various objectives were quite consistent across the different fisheries groups, with a very strong preference shown in all fisheries for ensuring that adaptations sustain environmental and ecological values, particularly through sustaining the harvested population. This may reflect a general belief that the environmental component of the 'triple bottom line' is a pre-requisite for ensuring sustainable economic and social outcomes and, in the face of climate change, that adaptations that contribute to this objective should be given priority. While there was some variation in the average ranking of other high level objectives there was a high degree of coherency across all respondents when considering the broad objectives, suggesting that a single high level assessment framework across the region might be acceptable.

Our results indicated a strong level of agreement about the relative importance of the high level objectives within each fishery group, but revealed strong differences between individuals' preferences about the relative importance of lower level objectives, particularly in the abalone, blue grenadier and southern rock lobster fisheries. Over all groups, there is

stronger agreement about relative weights for lower level objectives in the areas of community wellbeing and management and governance, with less agreement on detailed objectives for environmental and economic objectives.

## **OUTCOMES ACHIEVED TO DATE**

- This project provides weighted fisheries management objectives frameworks for each of four key fisheries species in South Eastern Australia (abalone, blue grenadier, snapper and southern rock lobster) and for a general fishery group.
- Providing these frameworks will enable selected management adaptation options identified in *DCC/FRDC Project 2011/039 Preparing fisheries for climate change: identifying adaptation options for four key fisheries in South Eastern Australia*, and in other studies, to be assessed consistently and transparently against weighted objectives, averaged across individuals involved in each fishery.
- The frameworks will also assist in the identification of areas of potential conflict that might act as barriers to adoption of management changes across diverse fisheries.
- The exercise of developing objective hierarchies and of participating in the objective weighting survey has also served as a capacity building process as individuals involved are forced to consider the trade-offs between often competing environmental, social and economic objectives as is required in fisheries management.

**KEYWORDS:** fisheries management objectives, analytic hierarchy process, climate change adaptation, South Eastern Australian Program



## Acknowledgments

Our thanks to the many members of the industry and management committees, scientific groups and case study leaders for the four SEAP fisheries who participated in the workshop discussion of species level objectives. Thanks also to everyone who gave willingly of their time to complete the interactive, online objectives weighting survey.

Special thanks to Eriko Hoshino who assisted in the facilitation of the workshop discussions.

This project was undertaken under the guidance of the El-nemo SEAP Project Management Committee. Particular thanks to Dallas D'Silva for coordinating and overseeing the direction of the program.

## Background

Climate change is already having considerable impacts on marine life and ecosystems. The eastern and south eastern Australian marine waters have been identified as being the most vulnerable geographic area to both climate change impacts and overall exposure in Australia. In response, State and Commonwealth marine resource management agencies and research organisations (DPI Victoria, PIRSA Fisheries, DPIPWE Tasmania, IMAS, SARDI, and CMAR), together with the FRDC and DAFF, established a formal collaborative structure to facilitate effective adaptation of fisheries to potential impacts. The resulting program, Elnemo South East Australia Program (SEAP <http://www.frdc.com.au/environment/south-east>) has the primary aim of improving understanding of the biophysical, social and economic implications of climate change and facilitating the preparation and adaptation of the sectors and fisheries management arrangements in the region to these changes.

Following the results of a formal assessment of the relative risk to climate change impacts of key fisheries species of south eastern Australia, four species (abalone, blue grenadier, snapper and southern rock lobster) were selected as case studies. A central element of the case studies, which are being conducted in DCC/FRDC Project 2011/039 *Preparing fisheries for climate change: identifying adaptation options for four key fisheries in South Eastern Australia*, is to identify possible changes to management that could reduce negative impacts and maximise uptake opportunities that climate change may provide in these fisheries. This will involve evaluating identified options for adjusting management arrangements using a mixture of quantitative and qualitative techniques. Climate change adaptation related changes to management and governance will take place within the broader context of fisheries management in these fisheries, and the evaluation of alternative options will need to be made within a framework that reflects both the broader goals of fisheries management and the more targeted aim of preparing the fisheries of South East Australia for the impacts of climate change.

The study reported here acts as a companion project to DCC/FRDC Project 2011/039 *Preparing fisheries for climate change: identifying adaptation options for four key fisheries in South Eastern Australia* in that it develops a framework of objectives, weighted in terms of their importance, against which the performance of alternative management adaptation options can be assessed as part of the SEAP case studies. This will allow an element of

transparency and consistency in the evaluation of options that is often lacking in the identification of adaptation priorities.

## Need

A core component of DCC/FRDC Project 2011/039 *Preparing fisheries for climate change: identifying adaptation options for four key fisheries in South Eastern Australia* involves evaluating a range of fisheries management changes aimed at reducing negative impacts and maximising uptake of opportunities that climate change may provide to commercial and recreational fisheries for the four SEAP case study species. Each management adaptation examined will have different impacts on various components of the region's complex socio-ecological fishery systems and on their associated ecological, social and economic values. The ability to comprehensively evaluate adaptation options developed as part of DCC/FRDC Project 2011/039 *Preparing fisheries for climate change: identifying adaptation options for four key fisheries in South Eastern Australia* requires clear definition of a framework of fisheries management objectives and of the relative importance of these often competing objectives. Assessment of the performance of management adaptation options within such a framework must underpin the development of adaptation priorities for the region. It is important that management objectives and their relative weights be identified early in the evaluation process, thereby enabling relevant performance indicators and metrics (both qualitative and quantitative) to be identified, and modelling capacity to be developed, in a transparent and contextually relevant framework.

## Objectives

The overarching objective of this project was to provide a transparent and clearly articulated framework of weighted objectives for each of four SEAP case study species (abalone, blue grenadier, snapper and southern rock lobster) against which the performance of identified management adaptations could later be assessed.

## Introduction

Climate change has emerged as a major threat to the ecological, biophysical and human components of fisheries systems worldwide. This is particularly evident in South Eastern Australia where climate drivers, such as temperature, ocean currents and wind patterns, are all contributing to changes in the productivity, distribution and life cycle events of marine species. The marine environment in the South Eastern Australian region underpins a wide range of ecological, economic and social values, and supports important commercial and recreational fisheries. The threats and opportunities posed by climate change to these activities and to their associated values necessitate the development of clear adaptation pathways to prepare governments and industry for the changes ahead.

The commercial and recreational fisheries of South Eastern Australia are managed by State and Commonwealth governments, and are subject to a wide range of governance and management arrangements. These include a variety of controls on inputs (such as season and gear restrictions), outputs (such as catch limits and quota management systems) and spatial management arrangements. Ensuring that the fisheries of South Eastern Australia adapt effectively to climate change will require changes to existing management systems to ensure that fishers and managers can respond to mitigate negative, and seize positive, opportunities. While some changes to existing management and governance systems may involve the adoption of already proven management arrangements, others may require more transformational change to accommodate climate change impacts and allow for greater flexibility in fisher behaviour. Regardless of the nature of change proposed, however, sound management adaptation planning requires that the performance of adaptation options be evaluated against the broad objectives of fisheries management.

Pascoe et al. (2009a) describe a staged approach in which a set of alternative management strategies can be assessed against a set of management objectives. The approach involves firstly eliciting a set of management objectives and their relative weightings. The next step is to develop possible changes to the management system and to assess the relative impact of each of these against each management objective. The final step involves applying the objective weights to determine which of the proposed alternatives best meets the objectives. Two important strengths of this approach lie in the high level of stakeholder engagement involved and the ability to combine the results of quantitative modelling (such as stock assessment and bioeconomic modelling) with qualitative assessments based on the opinions

of experts within a transparent multiple objective framework. This approach is subsequently illustrated in Dichmont et al. (2012) where a series of governance straw men (or management strategies) for the Queensland trawl fishery were assessed by a group of experts against an agreed set of weighted objectives. Innes and Pascoe (2010) also illustrate this approach where the relative importance of the environmental impact of fishing using different gears was quantified by different stakeholder groups (ecologists, biologists, economists, gear technologists, fishers and fisheries managers) through a qualitative, multi-criteria survey process.

In this project we conduct the first stage of the process described by Pascoe (2009a). More particularly, we elicit a set of objectives and their relative importance weights for each of four key commercial species in south eastern Australia for which the subsequent stages of the assessment process will be conducted for selected climate change related management adaptation options.

A strong common theme in fisheries management policy and legislation across many countries is concern with the triple bottom line of economic, social and environmental objectives (Pascoe et al. 2012). Nevertheless, the definition of these high-level objectives is often unclear and the way in which sometimes conflicting objectives are to be weighted remains undefined. In this project we use the Analytic Hierarchy Process (AHP) to develop weighted objective hierarchies for each of the four SEAP fisheries. This method has found a number of applications in the management and planning of fisheries and aquaculture (DiNardo, Levy and Golden 1989; Leung, Muraoka, Nakamoto and Pooley 1998; Mardle and Pascoe 1999; Mardle et al. 2002, Mardle and Pascoe 2003; Soma 2003; Mardle, Pascoe and Herrero 2004; Nielsen and Mathiesen 2006; Whitmarsh and Wattage 2006; Himes 2007; Lane 2007; Utne 2008; Halide, Stigebrandt, Rehbein and McKinnon 2009; Pascoe, Bustamante, Wilcox and Gibbs 2009; Pascoe, Proctor, Wilcox, Innes, Rochester and Dowling 2009; Whitmarsh and Palmieri 2009, Dichmont et al. 2012, Pascoe et al. 2012). In addition it has been used to assess recreational site choice (Kangas 1995; Ramos, Santos, Whitmarsh and Monteiro 2006) and fish product quality (Setala, Saarni and Honkanen 2000; Saarni, Setala and Honkanen 2001).

We provide a specific climate change adaptation context to the objective hierarchies developed in this project through the inclusion of a number of objectives shown to have been important to effective climate change adaptation. We also include the objective of

strengthening management and governance as a high level objective as a way of capturing the importance of these aspects of fisheries systems to effectively respond to pressures arising from climate change and other stressors.

## Methods

The method used in this study comprises two stages. The first stage involves development of a generalised, overarching objective hierarchy; the second stage uses the Analytic Hierarchy process (AHP) to derive the set of individual objective weights specific to each of the four SEAP fisheries.

### Development of objective hierarchy

The objective hierarchy developed was informed by the following:

- A comprehensive literature review of natural resource management objectives as conducted by Pascoe et al. (2012).
- A review of management objectives as stated in a range of management and policy documents for each of the four SEAP species by jurisdiction (Appendix 2).
- Consideration of fisheries management objectives already identified at the Commonwealth (Pascoe et al. 2009b) and Queensland State (Pascoe et al. 2012) levels.
- Draft species-level objective hierarchies developed by Industry and Management Committees at the SEAP Fisheries Adaptation Workshop March 15/16<sup>th</sup> 2012. Workshop participants were initially presented in a plenary session with a ‘strawman’ hierarchy (based on hierarchies developed in comparable studies of other Australian fisheries) and had the aims of the project and workshop exercise explained to them. Project team members then led breakout sessions with each SEAP species Management and Industry Committee, during which draft species specific hierarchies were developed. A compilation of all objectives from all four groups is given in Appendix 3.

- A consideration of the need to include objectives that may be linked to supporting effective climate change adaptation and to building adaptive capacity and enhance resilience in fisheries.

## Weighting of management objectives

The Analytic Hierarchy Process (AHP) is a method that allows individual preferences to be measured and converted into ratio-scale weights (Forman and Gass 2001). It is one of several multi-criteria decision making techniques (MCDM) available and provides a relatively simple yet powerful means of deriving individuals' preferences for one attribute over another (pair-wise comparison of options). AHP has been widely used in fisheries where studies have largely determined the relative importance of different management objectives (e.g. (Mardle et al. 2004; Nielsen and Mathiesen 2006)) or preferences for different management options (e.g. Leung et al. 1998; Soma 2003). It has been used to compare the sustainability of alternative fishing fleets (Utne 2008) and to quantify the relative importance of the environmental impacts of demersal gears to different stakeholder groups (Innes and Pascoe, 2010). In their study, Innes and Pascoe analyse the responses of 48 individuals representing 6 different stakeholder groups (biologists, ecologists, economists, gear technologists, fishers, and fisheries managers).

One of the advantages of the pairwise comparison used in AHP is that it makes the process of assigning weights much easier for participants. This is because only two elements or objectives are being compared at any one time rather than all objectives having to be compared with each other simultaneously. The following figure represents one of the pairwise comparison questions in Innes and Pascoe's (Innes and Pascoe 2010) questionnaire. Their questionnaire used the most common (and generally recommended) means of eliciting preference structures for AHP studies by using a nine-point "Intensity of Importance" scale. The scale is based on psychological experiments and is designed to allow for, as closely as possible, a reflection of a person's true feelings in making comparisons between two items whilst minimising any confusions or difficulties involved (Saaty, 1980b).

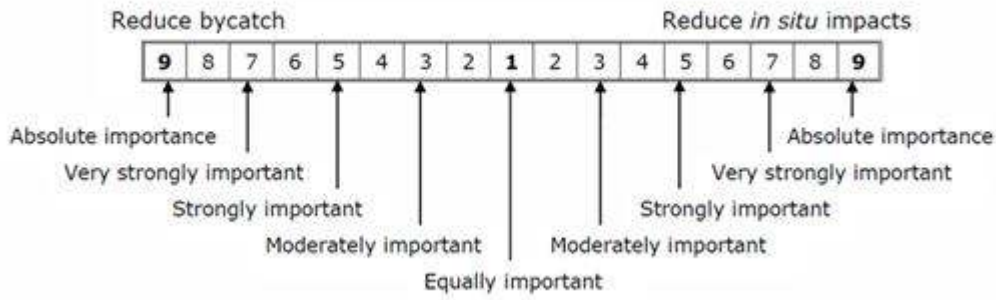


Figure 2 Pair-wise comparison of objectives

### Collection of preferences

Individual level preferences were collected using an interactive survey instrument, designed as an Excel spreadsheet. This enabled immediate feedback to participants on the implications of their preferences on objective weights and on the level of consistency of their responses across pairwise choices. The instant feedback provided by the Excel spreadsheet let participants re-assess their preferences if problems of inconsistency<sup>1</sup> were apparent or if the resultant weightings were not as anticipated. The nine-point scale (Figure 2) was not explicitly represented in the survey, but rather determined by the degree to which a slider could be moved one way or another.

### Derivation of weights

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

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

The scores are normalised by dividing through each element of the matrix by the sum of the column  $j$  (i.e. summed over  $i$  such that  $\bar{a}_{ij} = a_{ij} / \sum_i a_{ij}$ ), and the weight associated with each

<sup>1</sup> The issue of inconsistency is addressed in further detail below.



objective can be estimated as the average of the normalised scores across the row  $i$ . That is,  $w_i = \sum_j \bar{a}_{ij} / n$ , where  $n$  is the number of objectives being compared.

The pair-wise comparisons and analyses are undertaken at the different levels of the hierarchy. That is, pair-wise comparison and analyses are made between the higher order objectives, and the weight  $w_i^1$  is estimated (the superscript  $1$  indicating the level of the objective in the hierarchy, in this case the first or highest level of the hierarchy). The analysis within each higher order objective is then undertaken, and initial weights for the lower order objectives estimated. For example,  $\hat{w}_{i_2}$  is the initial weight of a second order objective compared with other second order objectives within the same higher order objective. The overall weight of the lower order objectives are determined by the product of their initial weight estimate multiplied by the weight of the higher order objective. For example,  $w_i^2 = \hat{w}_{i_2} w_i^1$ , where  $w_i^2$  is the final weight of a second order objective, while  $w_i^3 = \hat{w}_{i_3} w_i^2 = \hat{w}_{i_3} \hat{w}_{i_2} w_i^1$  is the final weight of a third order objective. This reduces the number of direct comparisons that need to be made, as only objectives at the same level and within the same broader objective need to be compared in the survey.

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

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

---

<sup>2</sup> The discrete nature of the 1-9 scale also contributes to inconsistency, as a perfectly consistent response may require a fractional preference score.

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

where  $\lambda_{\max}$  is the maximum eigenvalue of the matrix A, given by  $\lambda_{\max} = \sum_i \sum_j a_{ij} w_i$ . This is compared to a randomly generated value for an n x n matrix (Random Indicator or RI) to derive a consistency ratio, CR, where CR=CI/RI. Values of CR≤0.1 are generally considered acceptable (Saaty 1980a), although higher measures are often accepted in fisheries analyses (Himes 2007). In cases where higher values are obtained, respondents are generally asked to review and revise their pair-wise comparison ratings. With the interactive Excel-based survey instrument, respondents immediately receive feedback on their level of consistency. At the end of the survey, respondents were asked to check for any measures greater than 10 per cent, and to reconsider their preferences for these choices. This will result in a high return rate of usable preference sets. Surveys may also be accepted as usable where there are inconsistencies of more than 10 per cent when respondents indicate that they are unable to reduce the inconsistency without substantially changing their preferences.

### Group Coherence

The level of group coherence indicates the degree to which members of a given group of respondents have similar or dissimilar objective preferences. Zahir (1999a; 1999b) developed a measure of group coherence for use in AHP studies, given by

$$\bar{\rho} = \langle v_i \bullet v_j \rangle \quad i \neq j \quad (3)$$

where  $v_i$  and  $v_j$  are vectors comprising the square root of the objective weights of individuals  $i$  and  $j$ ;  $\bullet$  indicates the dot product of the two vectors, and  $\langle \rangle$  indicates the average of the set of dot products (Zahir 1999a). The coherence measure,  $\bar{\rho}$ , represents the average angle between the individual vectors ( $\cos \theta = \rho_{i,j} = v_i \bullet v_j$  for a pair of individuals), such that  $\cos 0^\circ = 1$  implies identical preferences and  $\cos 90^\circ = 0$  implies orthogonal preferences. Hence, the closer the value of  $\bar{\rho}$  is to 1, the greater the average agreement in opinion of the individuals. While this has the appearance of a statistical measure, there is no generally accepted critical value. Some authors have adopted 99%, 95% and 90% as critical measures (Mardle et al. 2004), in line with statistical definitions of significance levels, while others

have developed other definitions of strong and weak coherence with wider intervals (Himes 2007).

In contrast, Zahir (1999b) uses the proportion of all individual coherence measures that exceed a threshold value as an alternative indicator of group coherence. Extreme cases, given Saaty's (1980b) nine point scale (i.e. 1-9), are defined as those that have individual coherence measures  $\rho_{ij} < (n + 4)/(n + 8)$ , where  $n$  is the number of objectives being examined. A high proportion of extreme cases indicate substantial differences of opinion between individuals within a group.

## Results

### Objective Hierarchy for SEAP Adaptation Case Study Fisheries

The relationship between objectives for the assessment of climate change adaptation options in the four SEAP case study fisheries is shown Figure 1. The hierarchy reflects a compromise between the need to be extensive enough to capture the breadth of objectives across a range of diverse fisheries and the need to be simple enough to form the basis of an AHP survey that would produce reliable results when administered in an unsupervised, online environment. In addition, given the context in which the framework is to be used (assessment of management adaptation options) the developed hierarchy also reflects a balance between general fisheries management objectives and those required to support effective climate change adaptation and to build adaptive capacity.

The hierarchy comprises four general (high level) objectives, three of which map broadly to the triple bottom line environmental, economic and social domains of fisheries management. These objectives are to enhance economic performance (defined to include the economic value of both commercial and recreational fisheries), ensure environmental and ecological values and to ensure the wellbeing of communities (defined to include the 'community of fishers' and the broader concept of a 'coastal community'). We also include strengthening management and governance as a high level objective as a way of capturing the importance of these aspects of fisheries systems to effectively respond to pressures arising from climate change and other stressors. Lower level objectives reflect more detailed or specific objectives related to each of the general objectives.

Importantly, given the generalized nature of the hierarchy, not all objectives are relevant to all four fisheries. For example, the blue grenadier fishery does not include a significant recreational component. Similarly, the snapper fishery is not currently subject to a tradable quota. While the applicability of particular objectives to any one of the four fisheries will be reflected in the assigned weights, individuals were also given the opportunity within the survey to indicate any objective that they considered to be irrelevant<sup>3</sup>.

### *Survey Sample and Administration*

The interactive survey was trialled initially by several individuals who had either general fisheries experience or were familiar with the AHP method. Several modifications were made to both the objective hierarchy and the survey instrument based on their feedback. The final survey was emailed to a total of 50 SEAP species Industry and Management Committee and Scientific Working Group members, including case study and project leaders, as well as 81 other industry members (recreational and commercial) suggested by the participants at the SEAP Fisheries Adaptation Workshop (March 15/16<sup>th</sup> 2012). A letter explaining the purpose of the survey; including key instructions, a project Information Sheet and the list of objective definitions were also provided.

In total, 64 usable responses were obtained, with an additional two surveys being unusable due to the presence of unacceptably high inconsistency scores. The distribution of the returned surveys by fishery and respondent category is summarised in Table 1. The greatest number of responses was returned from researchers, representing almost 35% of the total responses, and reflecting the dominance of researchers in the original contact list (i.e. the Industry and Management Committee and Scientific Working Groups). Fishers (commercial and recreational) comprised around 40% of the responses and the remainder were fisheries managers. A significant proportion (almost 30%) of respondents preferred to respond generally rather than for a specific fishery. The generalists were quite evenly distributed among each of the four respondent groups.

---

<sup>3</sup> Three respondents identified one or more objectives as irrelevant to the fishery for which they nominated objective preferences. Since the minimum weighting attributable to any objective in the survey instrument was X%, these weightings were set to zero, and other objectives in the relevant objective set adjusted accordingly.

Several respondents commented positively about the survey, indicating that they had found the process of considering tradeoffs interesting and indicated an interest in the results. Two commercial fishers declined to participate citing frustration and disappointment with fisheries research and management processes, in particular Government decision making in regard to marine parks. Two respondents queried the reasonableness of particular pairwise choices and one individual indicated that they had difficulty making tradeoffs between objectives that they felt they had no direct control over. Two respondents queried the rationale for the consistency score linking the intensity of preferences across pairwise choices.

**Table 1 Summary of the total number of returned surveys by fishery and respondent group**

	<b>Commercial fishers</b>	<b>Recreational fishers</b>	<b>Fisheries Researchers</b>	<b>Fisheries Managers</b>	<b>Total Returned</b>
<b>Abalone</b>	2		7	2	11
<b>Blue Grenadier</b>	3		2		5
<b>Snapper</b>	4	3	5	3	15
<b>Southern Rock Lobster</b>	4	2	4	5	15
<b>General (no particular species)</b>	4	4	4	6	18
<b>Total responses</b>	17	9	22	16	64

### *Weighting of objectives for SEAP case study fisheries*

Individual's weights for each objective were estimated as described above and SEAP fisheries average weightings were calculated (Table 2). Average weightings for the group of respondents who completed the survey for SEAP fisheries in general (no particular species) are also reported. Box plots showing median objective weightings, the first and third quartile and 95% confidence intervals for high-level objectives and lower order objectives for each fishery are shown in Figures 3 and 4.

**Table 2 Average objective weights and coefficients of variation for SEAP fisheries (expressed as percentages)**

Objective	Abalone		Blue Grenadier		Snapper		Southern Rock Lobster		General (no particular species)	
	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
<b>Maximise wellbeing of communities</b>	8.8%	69.3%	20.4%	35.3%	14.3%	60.1%	15.4%	102.6%	17.8%	57.3%
Maximise sustainable employment and livelihoods	2.9%	69.0%	4.9%	24.5%	3.5%	51.4%	3.6%	69.4%	4.5%	64.4%
Enhance lifestyle opportunities	1.5%	113.3%	3.6%	61.1%	3.0%	93.3%	2.0%	105.0%	3.6%	75.0%
Minimise conflicts and ensure equity	2.3%	87.0%	5.8%	69.0%	4.1%	90.2%	3.3%	87.9%	3.9%	92.3%
Maximise flow-on economic and employment benefits	0.9%	88.9%	2.0%	55.0%	1.4%	71.4%	2.8%	228.6%	2.7%	92.6%
Enhance adaptive capacity in the fishery	1.3%	69.2%	4.0%	70.0%	2.3%	108.7%	3.5%	185.7%	3.1%	71.0%
<b>Maximise Economic Performance</b>	24.5%	50.6%	28.1%	79.0%	23.4%	76.1%	22.9%	51.5%	19.8%	73.7%
Maximise value of tradeable fishing rights	10.9%	72.5%	10.1%	98.0%	5.5%	85.5%	8.2%	54.9%	7.9%	143.0%
Minimise annual fishing costs in fishing industry	3.7%	73.0%	5.9%	94.9%	2.9%	120.7%	3.3%	97.0%	1.5%	73.3%
Maximise product prices in fishing industry	4.0%	70.0%	5.2%	94.2%	4.3%	160.5%	3.0%	146.7%	2.6%	88.5%
Maximise (commercial) catch rates	2.6%	126.9%	3.9%	143.6%	2.3%	139.1%	4.8%	85.4%	2.1%	109.5%
Maximise(recreational/charter) participation	2.2%	77.3%	1.6%	43.8%	5.1%	135.3%	1.9%	57.9%	3.8%	73.7%
Maximise (recreational/charter) catch rates	1.0%	80.0%	1.4%	114.3%	3.3%	109.1%	1.8%	66.7%	1.9%	57.9%

<b>Ensure Environmental and Ecosystem Values</b>										
Ensure sustainability of harvested resources	41.4%	36.2%	36.1%	46.5%	42.7%	45.9%	42.2%	41.7%	45.4%	40.3%
Minimise impacts on non-target species	19.3%	41.5%	13.8%	70.3%	21.6%	61.6%	17.0%	45.3%	16.7%	61.7%
Maximise area of productive habitat	4.2%	154.8%	3.2%	37.5%	3.9%	82.1%	4.8%	114.6%	4.4%	81.8%
Maintain bio-diversity and ecosystem function	5.9%	72.9%	5.9%	84.7%	6.6%	78.8%	6.4%	104.7%	4.8%	50.0%
Minimise pollution and carbon footprint of fishery	7.4%	75.7%	8.1%	55.6%	5.4%	70.4%	7.9%	91.1%	12.4%	75.0%
	4.7%	40.4%	5.2%	76.9%	5.1%	54.9%	6.1%	63.9%	7.1%	62.0%
<b>Strengthen Management and Governance</b>										
Enhance accountability and transparency	25.2%	53.6%	15.4%	35.7%	19.6%	52.0%	19.5%	62.1%	17.0%	44.7%
Enhance planning and risk management	3.6%	77.8%	3.0%	36.7%	2.9%	86.2%	3.9%	76.9%	2.2%	77.3%
Enhance adaptability and flexibility	5.2%	105.8%	1.8%	83.3%	1.9%	63.2%	2.8%	103.6%	2.4%	133.3%
Ensure respect for customary rights	3.5%	74.3%	1.9%	73.7%	2.8%	78.6%	4.1%	68.3%	3.4%	100.0%
Enhance incentives for stewardship	2.4%	145.8%	1.1%	81.8%	2.7%	174.1%	1.1%	72.7%	2.4%	91.7%
Improve opportunities for co-management and stakeholder participation	3.8%	57.9%	3.8%	28.9%	3.8%	71.1%	3.4%	91.2%	2.7%	55.6%
	6.7%	92.5%	3.8%	36.8%	5.5%	78.2%	4.2%	95.2%	3.9%	69.2%

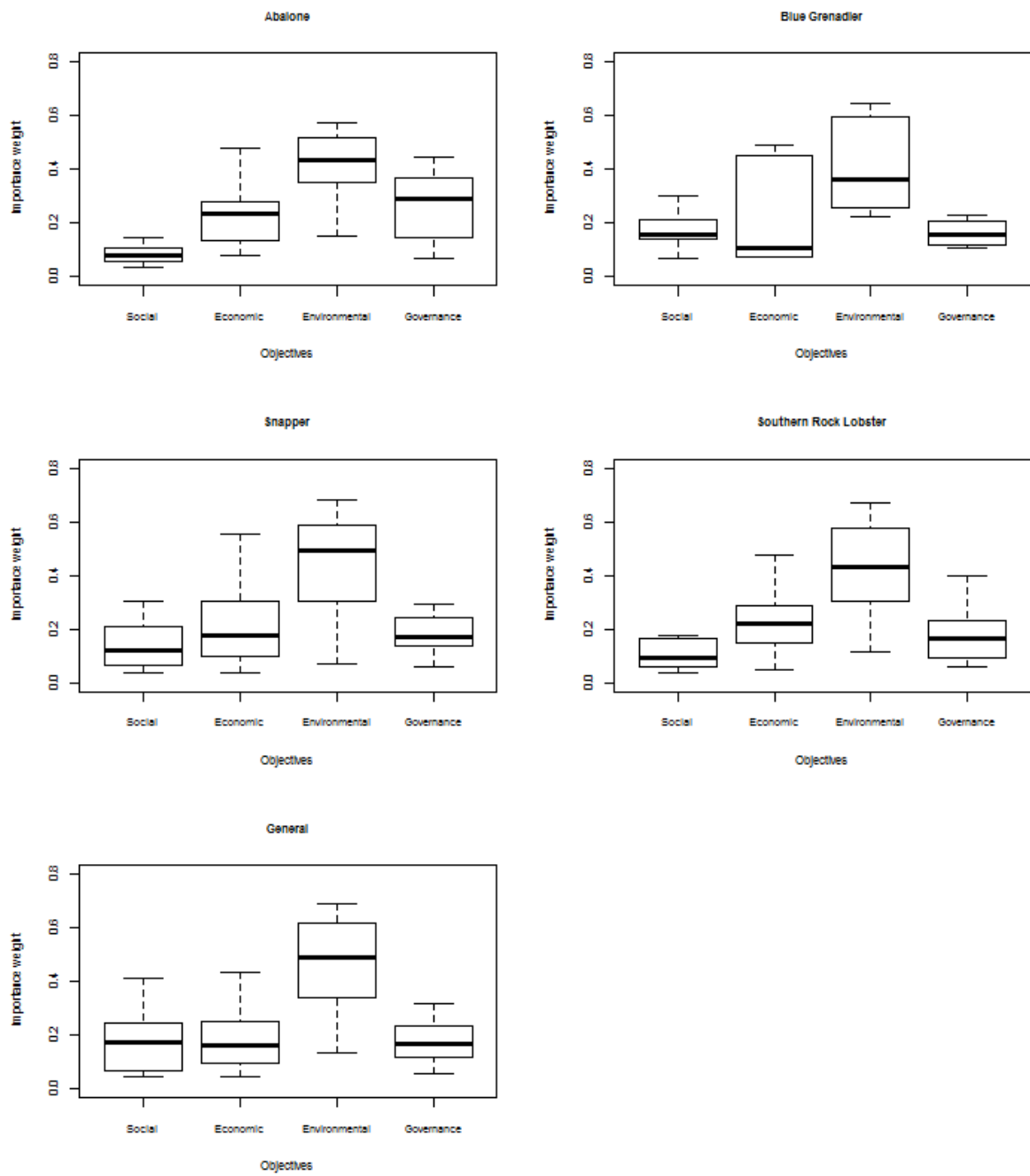
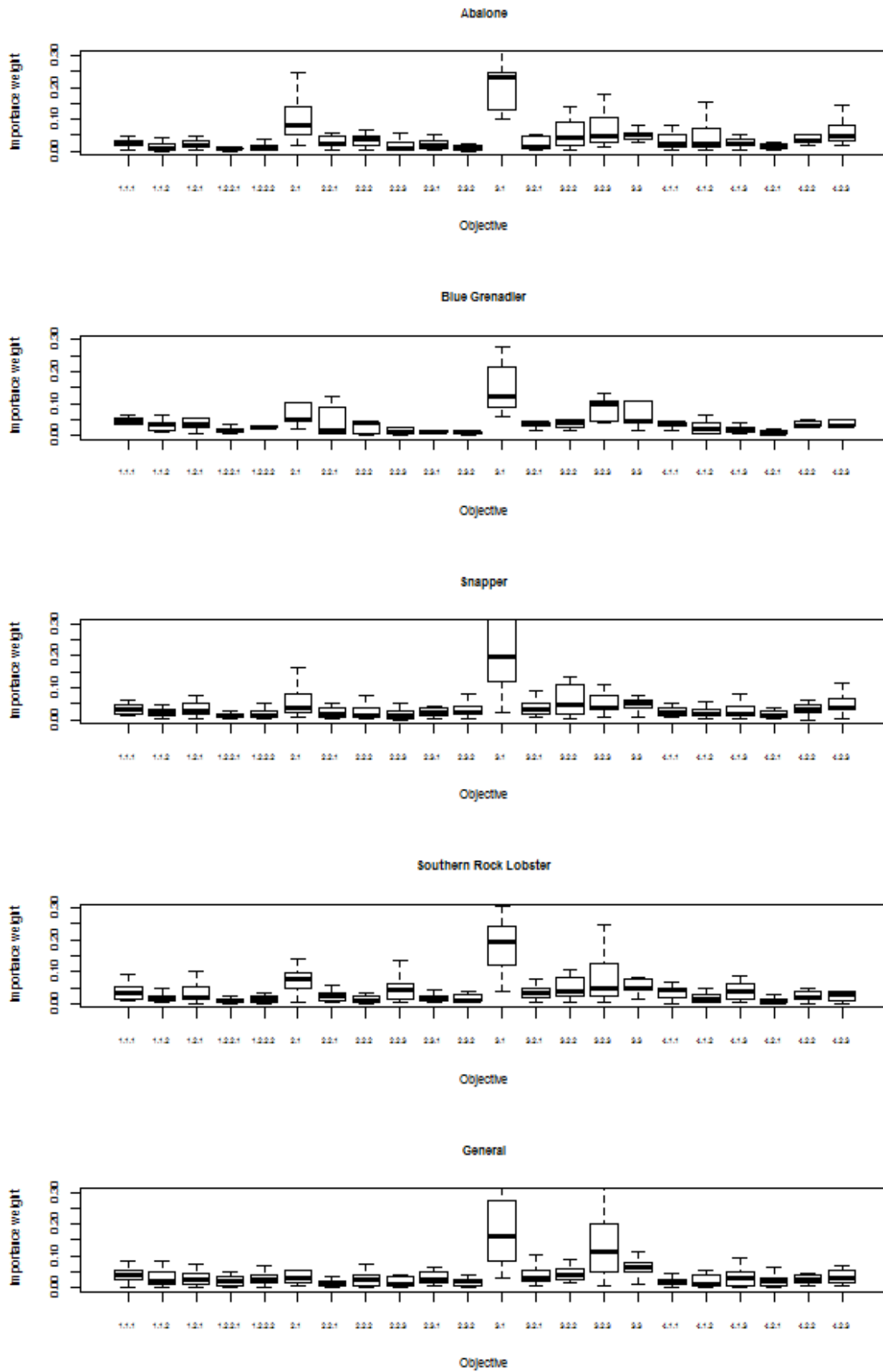


Figure 3. Distributions of higher level objectives





»

Figure 4. Lower level objectives

The objective of ensuring environmental and ecosystems values received the highest weighting for all fisheries, with generalists and the snapper fishery giving this objective the highest relative weight (Table 2, Figure 3). Maximising economic performance was the second most heavily weighted objective in the abalone, blue grenadier and southern rock lobster fisheries, while adaptations that strengthen management and governance were given higher priority than both social and economic objectives in the adaptation evaluation framework in the snapper fishery and by those who responded generally.

A strong preference for assessing adaptations against objectives that ensure the sustainability of the target resource was evident across all fishery groups, with the relative weighting given to this lower order objective exceeding one or more of the high-level objective weightings in all fisheries other than blue grenadier. In the case of the group who responded generally, the lower order objective of maintaining biodiversity and ecosystem function was also weighted more heavily than any of the high-level community, economic or management and governance objectives. On average, preferences were generally uniform across the various lower order community wellbeing and economic performance objectives (Table 2), although this masks differences in individuals' preferences for these lower level objectives which average out over the set (Figure 4). A weighting of over 9% given to the objective of maximising the value of tradable fishing rights for abalone and blue grenadier fisheries was an exception. Lower order objectives related to strengthening management and governance were also fairly uniformly weighted within each fishery group.

### *Group Coherence*

The average coherence of responses for each of the fisheries and the proportion of extreme comparisons are given in Table 3. When considering only the four high level objectives the average coherence exceeded 0.914 for all fishery groups, suggesting high levels of agreement about how they should be weighted in assessing adaptation options. For all fishery groups the overall level of agreement about the relative importance of lower level objectives is weaker. This result is similar to that found in other Australian studies (Pascoe et al. 2013, Pascoe et al. 2009), where greater agreement at a higher level has been observed across and within stakeholder groups, but generally low levels of agreement at the more detailed objective level.

A similar pattern of the extent to which members of fisheries groups allocate their weights over all objectives emerges when we examine the occurrence of extreme cases. No extreme differences in preference structures were observed within fishery groups for the higher order objectives, while all groups, had some extreme differences in preferences at the lower order objective level. The large proportion of extreme differences for lower order objectives for the abalone, blue grenadier and southern rock lobster fisheries suggests that individual respondents have different views about how these objectives should be weighted.

Furthermore, when we compare higher order objective weightings of all respondents, regardless of the fishery group they belong to, the average coherency score was 0.926 and no individual comparisons had coherency scores that can be considered extremely different. This suggests that, an assessment framework based on a single regional set of high level objective weights might win broad acceptance<sup>4</sup>.

**Table 3 Average group coherence and proportion of ‘extreme’ cases**

Fishery	Average coherence		Extreme cases (%)	
	Higher order objectives	Lower order objectives	Higher order objectives	Lower order objectives
<b>Abalone</b>	0.940	0.851	0	65%
<b>Blue Grenadier</b>	0.914	0.846	0	70%
<b>Snapper</b>	0.914	0.827	0	62%
<b>Southern Rock Lobster</b>	0.917	0.824	0	70%
<b>General (No particular species)</b>	0.930	0.845	0	52%
<b>All data combined</b>	0.926	0.836	0	61%

<sup>4</sup> Average high level objective weights calculated over all respondents are 14.6 % (maximise wellbeing of communities), 21.9% (maximise economic performance), 43.9% (ensure environmental and ecosystem performance) and 19.6% (strengthen management and governance).

## Discussion

Changes to fisheries management and governance arrangements will form an important part of climate change adaptation responses for fisheries in South Eastern Australia where climate-related changes in key bio-physical variables have already been observed and where further impacts are predicted. Adaptations may include changes to fisheries assessment, monitoring and management that are aimed at improving fisheries performance under likely climate change scenarios, but may also include changes to management and governance that are expected to better equip these fisheries to make the incremental and transformational changes required to reduce negative impacts and to seize opportunities that climate change may present. If adopted, such adaptations will themselves impact on various aspects of fishery systems and on their associated values. The ability to comprehensively and consistently assess proposed management adaptation options requires clear definition of a multi-criteria evaluation framework which incorporates information about the relative importance of these often competing criteria, or objectives. Such a framework is often missing from climate change adaptation evaluation, and adaptation priorities and plans are often developed without direct reference to the general aims of management.

The AHP has now been used a number of times in Australian fisheries (Pascoe *et. al.*, 2009a; Pascoe *et. al.*, 2012; Pascoe *et. al.*, 2009b) as a way of elucidating fisheries management objectives and of deriving relative weights. This has been done as a way of exploring differences between the preference structures of various stakeholder groups, but has also been used to establish the framework for qualitative management strategy evaluation (Dichmont *et. al.*, 2012; Pascoe *et. al.*, 2009a). In this project we have used the AHP to develop a weighted objective framework for each of the four key SEAP fisheries to be used subsequently to evaluate climate change adaptations in these fisheries. Differences between fisheries were captured by comparing the average preferences for individuals whose expertise and experience relates to each of the four fisheries separately, but using a common, generalised objective hierarchy. The hierarchy included general fisheries management objectives as routinely articulated in various policy and management documents. It also included objectives that may underpin effective adaptation and adaptation planning, are likely to contribute to the ongoing adaptive capacity and resilience of fisheries and their associated communities.

Overall, the average weightings attributed to various objectives were quite consistent across the different fisheries groups (abalone, blue grenadier, snapper, southern rock lobster and a general SEAP fishery group); with a very strong preference shown in all fisheries for ensuring that adaptations sustain environmental and ecological values, particularly through sustaining the harvested population. This emphasis on these aspects of fisheries management is consistent with the results of other Australian studies (Pascoe *et. al.*, 2012; Pascoe *et. al.*, 2009b) and with the emphasis that ESD is given in fisheries management policies and legislation. It may also reflect a general belief that the environmental component of the ‘triple bottom line’ is a pre-requisite for ensuring sustainable economic and social outcomes in the face of climate change, and that adaptations that contribute to this objective should be given priority. While there was some variation in the average ranking of other high level objectives (for example economic performance was given a slightly higher relative weighting for the abalone, blue grenadier and southern rock lobster fisheries; greater relative emphasis was placed on the objective of maximising the wellbeing of communities for the blue grenadier and southern rock lobster fisheries; and the relative weighting on strengthening management and governance was higher for the abalone and snapper groups) there was a high level of coherency across all respondents when considering the broad objectives, suggesting that a single high level assessment framework across the region might be acceptable.

Our observations about the level of variation in individual preferences within fisheries group is similar to that reported in other studies in fisheries (Leung *et. al.*, 1998; Mardle *et. al.*, 2004; Raakjær Nielsen and Mathiesen, 2006; Soma, 2003). Strong coherence at the level of broad objectives masks strong differences between individuals about the relative importance of lower level objectives, particularly in the abalone, blue grenadier and southern rock lobster fisheries. Over all groups, there is stronger agreement about relative weights for lower level objectives in the areas of community wellbeing and management and governance, with less agreement on detailed objectives for environmental and economic objectives. It is important to note that differences within fisheries groups may reflect variations in the preferences of stakeholder groups or inter-jurisdictional differences. It is possible that the emphasis of this report on key fisheries or species frameworks might take focus from possibly more important source of heterogeneity, namely preference differences across stakeholder groups.

## Planned outcomes and benefits

The project comprises a small component of a suite of projects that will contribute to the outcomes of the SEAP plan:

- Effective incorporation of fisheries in marine ecosystem based management arrangements
- Fisheries and aquaculture management that is responsive to climate change
- A community that is supportive of fisheries management arrangements
- A fishing and aquaculture industry that is adapting to climate change

The project is closely aligned to DCC/FRDC Project 2011/039 *Preparing fisheries for climate change: identifying adaptation options for four key fisheries in South Eastern Australia*, in that the objective hierarchies developed here for each of the four key SEAP fisheries will provide a framework within which to assess the performance of identified management adaptations that are to be proposed in response to the predicted effects of climate change in the South Eastern Australian region. The key outcome of developing this objectives framework and associated objective weights for each of the four species is that it will enable the consistent and transparent assessment of alternative management changes, help identify potential areas of stakeholder conflict that might present barriers to adoption, and improve the quality of management adaptation responses and potentially increase the speed at which adaptation responses will be implemented.

The benefits of having developed the assessment frameworks will also spill over beyond their immediate use in DCC/FRDC Project 2011/039 *Preparing fisheries for climate change: identifying adaptation options for four key fisheries in South Eastern Australia*, as they can also be used to assess the performance against objectives of a wider range of proposed management changes in these fisheries.

In addition, participation in the process of developing objective hierarchies and weighting can build awareness of individual stakeholders as to the complexity of the trade-offs between objectives that are inherent in the fisheries management evaluation process and of the challenges associated with effective climate change adaptation planning.

## Further development

The process of developing the generalised, overarching objective hierarchy used in this project involved drawing on four draft species-specific hierarchies which were developed by Industry and Management Committees at the SEAP Fisheries Adaptation Workshop March 15/16<sup>th</sup> 2012. These draft hierarchies are available for further development, either at the species or individual fisheries level.

The management adaptation assessments conducted as part of DCC/FRDC Project 2011/039 *Preparing fisheries for climate change: identifying adaptation options for four key fisheries in South Eastern Australia* are not scheduled to take place until 2013. The opportunity therefore exists for the results of this study to be supplemented and extended through the inclusion of further survey responses and for specific groups of stakeholders to complete the survey in a supported workshop environment. This would enable us to further explore the possibility that differences between objective weightings are better explained by stakeholder group than they are by fishery group.

## References

- Dichmont, C.M., Pascoe, S., Jebreen, E., Pears, R., Brooks, K. and Perez, P. (2012) Choosing a fishery's governance structure using data poor methods, *Marine Policy* 36.
- Di Nardo, G., Levy, D., Golden, B. (1989) Using decision analysis to manage Maryland's river herring fishery: an application of AHP. *Journal of Environmental Management*.29, pp. 193-213
- Forman, E.H., Gass, S.I. (2001) The Analytic Hierarchy Process - An Exposition. *Operations Research* 49, 469-486
- Halide H., Stigebrandt A., Rehbein M. and McKinnon A.D. (2009) Developing a decision-support system for sustainable cage aquaculture. *Environmental Modelling and Software* 24, pp. 694-702
- Himes, A.H. (2007) Performance indicator importance in MPA management using a multi criteria approach, *Coastal Management* 35, 601-618
- Innes, J.P., Pascoe, S. (2010) A multi-criteria assessment of fishing gear impacts in demersal fisheries. *Journal of Environmental Management* 91, 932-939
- Kangas J. (1995) Supporting the choice of the sports fishing site. *Journal of Environmental Management* 43, pp219-231
- Lane D.E. (2007) Planning in fisheries-related systems. In: *Handbook of Operations Research in Natural Resources* (ed. by A. Weintraub, C. Romero, T. Bjorndal and R. Epstein), pp. 237-271. Springer Science and Business Media, New-York, NY, USA
- Leung P.S, Muraoka J., Nakamoto S.T. and Pooley S. (1998) Evaluating fisheries management options in Hawaii using analytic hierarchy process (AHP). *Fisheries Research* 36. pp. 171-183
- Mardle S. and Pascoe S. (1999) A review of applications of multiple criteria decision making techniques to fisheries. *Marine Resource Fisheries* 14. pp.41-63
- Mardle S. and Pascoe S. (eds.) (2003) *Multiple objectives in the management of EU fisheries: preference elicitation*. CEMARE Report 64, University of Portsmouth, UK.
- Mardle, S., Pascoe, S., Boncoeur, J., Le Gallic, B., Garcia-Hoyo, J.J., Herrero, N., Jimenez-Toribio, R., Cortes, C., Padilla, N., Nielsen, J.R. and Mathiesen, C. (2002) Objectives of fisheries management: case studies from the UK, France, Spain and Denmark, *Marine Policy* 26, 415-428.
- Mardle S., Pascoe, S., Herrero, I. (2004) Management objective importance in fisheries: an evaluation using the analytical hierarchy process (AHP). *Environmental Management* 33, 1-11



- Nielsen, J.R., Mathiesen, C. (2006) Stakeholder preferences for Danish fisheries management. *Fisheries Research* 77, 92-101
- Pascoe, S., Bustamante, R., Wilcox, C. and Gibbs, M. (2009a) Spatial fisheries management: A framework for multi-objective qualitative assessment, *Ocean and Coastal Management* 52, 130-138.
- Pascoe, S., Proctor, W., Wilcox, C., Innes, J., Rochester, W. and Dowling, N. (2009b) Stakeholder objective preferences in Australian Commonwealth managed fisheries, *Marine Policy* 33, 750-758.
- Pascoe, S., Dichmont, C.M., Brooks, K., Pears, R. and Jebreen, E. (2012) Management objectives of Queensland fisheries: putting the horse before the cart, *Marine Policy*.
- Ramos, J., Santos, M.N., Whitmarsh, D and Monteiro, C. (2006) The usefulness of the analytic hierarchy process to understand reef diving choices: a case study. *Bulletin of Marine Science* 78, pp. 213-219
- Raakjær, J.N, and Mathiesen, C. (2006) Stakeholder preferences for Danish fisheries management of sand eel and Norway pout, *Fisheries Research*, 77(1), pp 92-101.
- Saarni, K., Setälä, J and Honkanen, A. (2001) *An application of AHP to strategic planning Improvement of quality fish products*. Paper presented at the XIIIth Conference of the European Association of Fisheries Economists (EAFE), Salerno, Italy, April 18-20
- Saaty, T.L. (1980a) *The Analytic Hierarchy Process* McGraw-Hill, New York.
- Saaty, T.L. (1980b) *The Analytic Hierarchy Process*. McGraw-Hill, New York.
- Setälä, J., Saarni, K. and Honkanen, A (2000) *The quality perceptions of rainbow trout defined by different fish market sectors*. Paper presented at the Tenth Biennial Conference of the International Institute of Fisheries Economics and Trade (IIFET), Corvallis, Oregon, July 10-15.
- Soma, K. (2003) How to involve stakeholders in fisheries management – a country case study in Trinidad and Tobago. *Marine Policy* 27, pp 47-58
- Utne, I.B. (2008) Are the smallest fishing vessels the most sustainable? trade-off analysis of sustainability attributes. *Marine Policy* 32, 465-474
- Whitmarsh, D and Palmieri, M.G. (2009) Social acceptability of marine aquaculture: the use of survey-based methods for eliciting public and stakeholder preferences. *Marine Policy* 33, pp. 452-457
- Whitmarsh, D and Wattage, P. (2006) Public attitudes towards the environmental impact of salmon aquaculture in Scotland. *European Environment* 16, pp. 108-121
- Zahir, S. (1999a) Clusters in a group: Decision making in the vector space formulation of the analytic hierarchy process. *European Journal of Operational Research* 112, 620-634.

Zahir, S. (1999b) Geometry of decision making and the vector space formulation of the analytic hierarchy process. *European Journal of Operational Research* 112, 373-396.

## **Appendix 1: Intellectual Property**

This is not applicable to this project.

## Appendix 2: Summary of management objectives as found in policy/legislation for SEAP commercial fisheries by species and state

Fishery	Tasmania	Victoria	New South Wales	South Australia	Commonwealth
Abalone	<ul style="list-style-type: none"> <li>• Maintain biomass and recruitment</li> <li>• To maintain fish stocks at sustainable levels</li> <li>• Sustain yield and economic return</li> <li>• Commercial fishing interactions</li> <li>• Access to fish stock by non commercial fishers</li> <li>• To enable the farming and the harvesting of wild stocks to co-exist</li> <li>• Maintain the marine ecosystem</li> <li>• Prevent the combined take from exceeding the Sustainable productivity of the Tasmanian abalone stocks</li> <li>• Cost recovery and return to the community</li> <li>• Quality assurance</li> </ul>	<ul style="list-style-type: none"> <li>• Capacity sustained into the future with low level of risk.</li> <li>• Cost effective management</li> <li>• Opportunities for commercial production fully utilised</li> <li>• Ecosystem health not jeopardised by fishery practices</li> <li>• Management adequately responsive to changes in ecosystem health</li> <li>• Commercial production to be economically efficient</li> <li>• Productive capacity directly enhanced through appropriate activities ie. Aquaculture, ranching, enhancement</li> <li>• Equitable assignment of productive capacity between commercial rec, indigenous and non exploitative uses</li> <li>• Recognition of past access by indigenous community return where there is commercial use of publicly owned abalone stocks</li> <li>• Recovery of attributable management costs</li> <li>• Stakeholders and government sharing responsibility and involvement in management</li> </ul>	<ul style="list-style-type: none"> <li>• Manage commercial harvesting of abalone to promote the conservation of biological diversity in the coastal environment.</li> <li>• Maintain or rebuild the biomass of abalone to ensure stock sustainability.</li> <li>• Facilitate effective management arrangements and provision of an efficient fisheries management service.</li> <li>• To promote the economic viability of the fishery</li> <li>• To increase the appropriate level of ownership capacity in the fishery.</li> <li>• To appropriately share the resource and harvest abalone in a manner that minimises negative social and economic impacts.</li> <li>• Facilitate appropriate research and monitoring of the Abalone Fishery</li> <li>• Achieve a high level of compliance within the Abalone Fishery</li> <li>• Ensure adequate stakeholder involvement and community consultation.</li> </ul>	<ul style="list-style-type: none"> <li>• Ensure that abalone stocks are harvested within sustainable limits</li> <li>• Optimum utilisation and equitable distribution of the abalone resource</li> <li>• Minimise impacts on the ecosystem</li> <li>• Cost effective and participative management of the fishery</li> </ul>	

Fishery	Tasmania	Victoria	New South Wales	South Australia	Commonwealth
	<ul style="list-style-type: none"> <li>•</li> </ul>	<ul style="list-style-type: none"> <li>• Compliance targets for licenced sectors achieved and monitored</li> <li>• Prevention of illegal activity targets for nonlicenced sectors achieved and monitored</li> </ul>	<ul style="list-style-type: none"> <li>•</li> </ul>	<ul style="list-style-type: none"> <li>•</li> </ul>	
Rock lobster	<ul style="list-style-type: none"> <li>• Re-build the biomass</li> <li>• Maintain the ecological integrity of marine ecosystems</li> <li>• Promote commercial use for economic prosperity</li> <li>• Provide recreational opportunities</li> <li>• Provide opportunities for indigenous communities to access the resource for traditional purposes</li> <li>• Ensure equity for future generations</li> <li>• Monitor fisheries performance and implement management arrangements</li> <li>• Promote stakeholder participation in decision making</li> <li>• Ensure compliance with legislation</li> <li>• Provide a public information service</li> </ul>	<ul style="list-style-type: none"> <li>• Sustainability of the resource</li> <li>• Cost effective participatory management</li> <li>• Resource access and utilisation.</li> </ul>	<ul style="list-style-type: none"> <li>• Manage the Lobster Fishery in a manner that promotes the conservation of biological diversity in the marine environment</li> <li>• Maintain the stock of eastern rock lobster at a biologically sustainable level and manage byproduct taken in the Lobster Fishery</li> <li>• Promote the conservation of threatened species, populations and ecological communities and protected species likely to be impacted by the operation of the Lobster Fishery</li> <li>• Appropriately share the resource and carry out fishing in a manner that minimises negative social impacts</li> <li>• Promote a viable commercial fishery, consistent with ecological sustainability</li> <li>• Facilitate effective and efficient compliance, research and management of the Lobster Fishery</li> </ul>	<ul style="list-style-type: none"> <li>• To maintain rock lobster populations at sustainable levels across the fishery.</li> <li>• To harvest rock lobster at a size likely to provide for adequate levels of recruitment.</li> <li>• To maintain the economic return from the southern zone rock lobster fishery at a level which provides for fair and reasonable benefits to licence holders.</li> <li>• Optimise yield from the fishery.</li> <li>• To recover an economic return from licence holders sufficient to cover attributed costs of management, research and compliance for the fishery.</li> <li>• To provide for economic efficiency and flexibility in management arrangements by developing harvesting strategies that minimise costs.</li> <li>• To protect the resource through the provision of adequate compliance resources.</li> </ul>	

Fishery	Tasmania	Victoria	New South Wales	South Australia	Commonwealth
	<ul style="list-style-type: none"> <li>•</li> </ul>	<ul style="list-style-type: none"> <li>•</li> </ul>	<ul style="list-style-type: none"> <li>• Improve knowledge of the Lobster Fishery and the resources upon which the fishery relies.</li> </ul>	<ul style="list-style-type: none"> <li>• To minimise the environmental impact of rock lobster fishing.</li> <li>• To minimise potential conflict with other users of marine resources.</li> <li>• To maintain and provide for reasonable levels of public access to the rock lobster resource.</li> <li>• To ensure a high level of awareness of occupational health, safety and welfare issues in the fishery.</li> <li>• To keep the community informed regarding the status of the rock lobster fishery.</li> <li>• To maintain the regional development nature of the rock lobster fishery.</li> </ul>	
Snapper	<ul style="list-style-type: none"> <li>•</li> </ul>	<ul style="list-style-type: none"> <li>•</li> </ul>	<ul style="list-style-type: none"> <li>• Manage the Ocean Trap and Line Fishery in a manner that promotes the conservation of biological diversity in the marine environment</li> <li>• Maintain stocks of primary and key secondary species harvested by the OTLF at sustainable levels</li> <li>• Promote the conservation of threatened species, populations and ecological communities and protected species of fish likely to be impacted by the operation</li> </ul>	<ul style="list-style-type: none"> <li>• Sustainable harvest of marine scalefish fish stocks</li> <li>• Minimise adverse impacts of all fishing operations on the ecosystem upon which the Marine Scalefish Fishery depends.</li> <li>• Optimal utilisation of Marine Scalefish Fishery resources within the constraints of sustainability imperatives.</li> <li>• Good governance of the Marine Scalefish Fishery.</li> <li>•</li> </ul>	

Fishery	Tasmania	Victoria	New South Wales	South Australia	Commonwealth
			<p>of the OTLF</p> <ul style="list-style-type: none"> <li>• Appropriately share the resource and carry out fishing in a manner that minimises negative social impacts</li> <li>• Promote a viable commercial fishery, consistent with ecological sustainability</li> <li>• Facilitate effective and efficient compliance, research and management of the OTLF</li> <li>• Improve knowledge about the OTLF and the resources on which it relies</li> </ul>	<p>To develop and implement cost-effective management of the fishery, support co-management of the fishery, provide an effective compliance program for the fishery, increase knowledge of the Marine Scalefish Fishery.</p>	<ul style="list-style-type: none"> <li>•</li> </ul>
Blue grenadier					<ul style="list-style-type: none"> <li>• Stocks are at sustainable levels.</li> <li>• Recovery of overfished stocks is occurring.</li> <li>• Bycatch species are not threatened.</li> <li>• Impacts on protected species are avoided.</li> <li>• Impacts on the broader ecosystem (eg habitats and related species) are minimised.</li> </ul>

## Recreational fishing

Document	Objectives of the policy
<p>Rec fishery The National Recreational fishing policy, DAFF 1994 Note: Recreational fishing in Australia – 2011 and beyond: a national industry development strategy (the Strategy) was developed to replace the 1994 strategy. It retains some important features of the former 1994 policy including contemporary statements of the recreational fishing sectors vision, clear principles, goals and objectives. However in keeping with the main criticism of the 1994 policy, the clear focus of this document is on coordinating the efforts and resources of recreational fishers, industry and governments on actions and outcomes that improve recreational fishing and promote a thriving industry.</p>	<ul style="list-style-type: none"> <li>• Recreational fishing should be managed as part of the total fisheries resource to ensure quality fishing, and to maintain fish stocks and their habitats, for present and future generations of Australians.</li> <li>• Our aquatic habitats and ecosystems are part of the environmental endowment of all Australians, and are the key to a healthy fisheries resource which requires protection, restoration and enhancement.</li> <li>• Government, in its stewardship role, must encourage and assist the community to be involved in all aspects of fisheries management.</li> <li>• Recreational fishers and the recreational fishing industry should participate in the protection and management of their fishing heritage to ensure that it is available for future generations.</li> <li>• Community consultation at Federal, State/Territory and local levels should be a key component of recreational fisheries management programs.</li> <li>• Recreational fishers are entitled to a fair and reasonable share of Australian fish resources taking into account long term sustainable yields; the rights and entitlements of others; and the need to optimise community returns from available stocks.</li> <li>• Recreational fishers throughout Australia should be encouraged to adopt their own Codes of Practice consistent with the goals of this policy.</li> <li>• Preference should be given to recreational fishing methods in which the fisher is present and which aim to catch target species.</li> <li>• The catching of fish for sale or profit, including barter, by recreational fishers is unacceptable.</li> <li>• Programs, consistent with the goals of this policy, which seek to increase recreational fishing opportunities throughout Australia should be encouraged.</li> <li>• Reasonable physical access to recreational fishing areas should be provided for throughout Australia.</li> <li>• Community awareness, education and enforcement programs should focus on encouraging positive changes in community attitudes to develop a stronger conservation ethic.</li> <li>• The economic, educational, health and other social benefits of recreational fishing should be widely recognised and actively promoted.</li> <li>• Fisheries management decisions should be based on sound information including fish biology, fishing activity, catches, and the economic and social values of recreational fishing.</li> <li>• Adequate funding and support should be provided to manage recreational fishing as part of integrated resource and environmental management strategies.</li> <li>• Recreational fishers should continue to contribute to the cost of managing and developing recreational fishing.</li> </ul>



<b>Document</b>	<b>Objectives of the policy</b>
Recreational fishing in Australia 2011 and beyond: a national industry development strategy, Rec fishing advisory committee	<ul style="list-style-type: none"> <li>• Recreational fishing is acknowledged as an important activity that contributes to the health and wellbeing of Australian society.</li> <li>• Recreational fishers are respected partners in the stewardship of Australia’s aquatic environment, along with government, Indigenous Australians, commercial fishers, conservation groups and the broader community.</li> <li>• Rec fishers have access to a reasonable share of Australia’s fish resources.</li> <li>• An information base is available at national, state and regional levels on recreational fishing to meet the needs of government and the community.</li> <li>• Stewardship of fish and their environment ensures quality and sustainable recreational fishing opportunities into the future.</li> <li>• The recreational fishing industry is attractive, vibrant and adaptive, encouraging investment and participation.</li> </ul>

### Appendix 3: Management objectives list

	<b>Environmental</b>	<b>Social</b>	<b>Economic</b>	<b>Governance/Management</b>
Abalone	<ul style="list-style-type: none"> <li>• Minimise impacts from fishing (maintain ecosystem function and minimise operational impacts)</li> <li>• Achieve resource sustainability (maximum sustainable yield in the long-term and maintain recruitment and biomass)</li> <li>• Minimise external impacts (e.g. growing impacts between salmon farming and adjacent fishing grounds)</li> </ul>	<ul style="list-style-type: none"> <li>• Maximise benefits to fishing community (collaborative management, equitable allocation, sustainable processor, sustainable quota holder, sustainable catching and sustainable livelihoods)</li> <li>• Maximise benefits to broader community (Minimise conflicts with recreational fishers)</li> </ul>	<ul style="list-style-type: none"> <li>• Maximise asset value</li> <li>• Maximise sustainable profits (maximise price and minimise costs)</li> </ul>	
Blue Grenadier	<ul style="list-style-type: none"> <li>• Minimise bycatch (TEP species, species with residual risk and non commercial species)</li> <li>• Minimise habitat damage (specific habitat, overall impacts)</li> <li>• Minimise carbon footprint</li> <li>• Sustain target species stock</li> <li>• Sustain commercial by product stock</li> </ul>	<ul style="list-style-type: none"> <li>• Minimise spill over effects to other fisheries</li> <li>• Minimise impacts on indigenous communities</li> <li>• Minimise conflicts with recreational fishers</li> <li>• Minimise impacts on coastal communities</li> </ul>	<ul style="list-style-type: none"> <li>• Enhance economic performance (maximise industry profit and community returns, minimise management costs, AFMA costs and compliance costs to industry)</li> </ul>	

	<b>Environmental</b>	<b>Social</b>	<b>Economic</b>	<b>Governance/Management</b>
Snapper	<ul style="list-style-type: none"> <li>• Target resource sustainability (maintain minimum critical biomass)</li> <li>• Minimise ecosystem impacts (minimise bycatch, protect TEP's, ensure habitat protection and environmental enhancement)</li> </ul>	<ul style="list-style-type: none"> <li>• Broader community (maximise access to fish products)</li> <li>• Fishing community (in terms of commercial fishery: ensure viable fishing communities, maximise employment to fishers, processors etc., maximise lifestyle; in terms of recreational fishery, maximise wellbeing, enjoyment and subsistence)</li> </ul>	<ul style="list-style-type: none"> <li>• Ensure viable commercial fishers</li> <li>• Ensure access to markets</li> <li>• Maximise value adding</li> <li>• Maximise recreational fishers non-market benefits</li> <li>• Ensure viable charter fishing</li> </ul>	<ul style="list-style-type: none"> <li>• Flexibility (able to switch to fisheries if stock decline)</li> <li>• Simple and effective rules to allow cost effective management</li> <li>• Industry and community engagement</li> <li>• Enhance stewardship</li> <li>• Ensure science underpins most management decision</li> </ul>
Southern Rock Lobster	<ul style="list-style-type: none"> <li>• Minimise ecosystem effect of fishing</li> <li>• Minimise impacts on non target species and TEP's</li> <li>• Minimise pollution and carbon footprint</li> <li>• Minimise habitat damage</li> <li>• Maintain recruitment of target species</li> <li>• Target stock sustainability</li> </ul>	<ul style="list-style-type: none"> <li>• Maximise employment</li> <li>• Minimise conflict between sectors</li> <li>• Successional pathways</li> <li>• Sustainable regional communities</li> <li>• Involvement in management consultation</li> <li>• Equitable and fair access to resources</li> <li>• Lifestyle of fishing</li> <li>• Safety at sea</li> </ul>	<ul style="list-style-type: none"> <li>• Maximise industry profit (maximise fish revenue and minimise fishery cost)</li> <li>• Maximise community returns</li> <li>• Minimise management costs</li> <li>• Maximise supply of seafood to consumers</li> <li>• Maximise sustainable catch for recreational fishers</li> <li>• Maximise economic benefit to non-extractive recreational divers)</li> </ul>	<ul style="list-style-type: none"> <li>• Minimise sovereign risk</li> <li>• Interface with other jurisdictions</li> </ul>

## Appendix 4: Example of the survey instrument

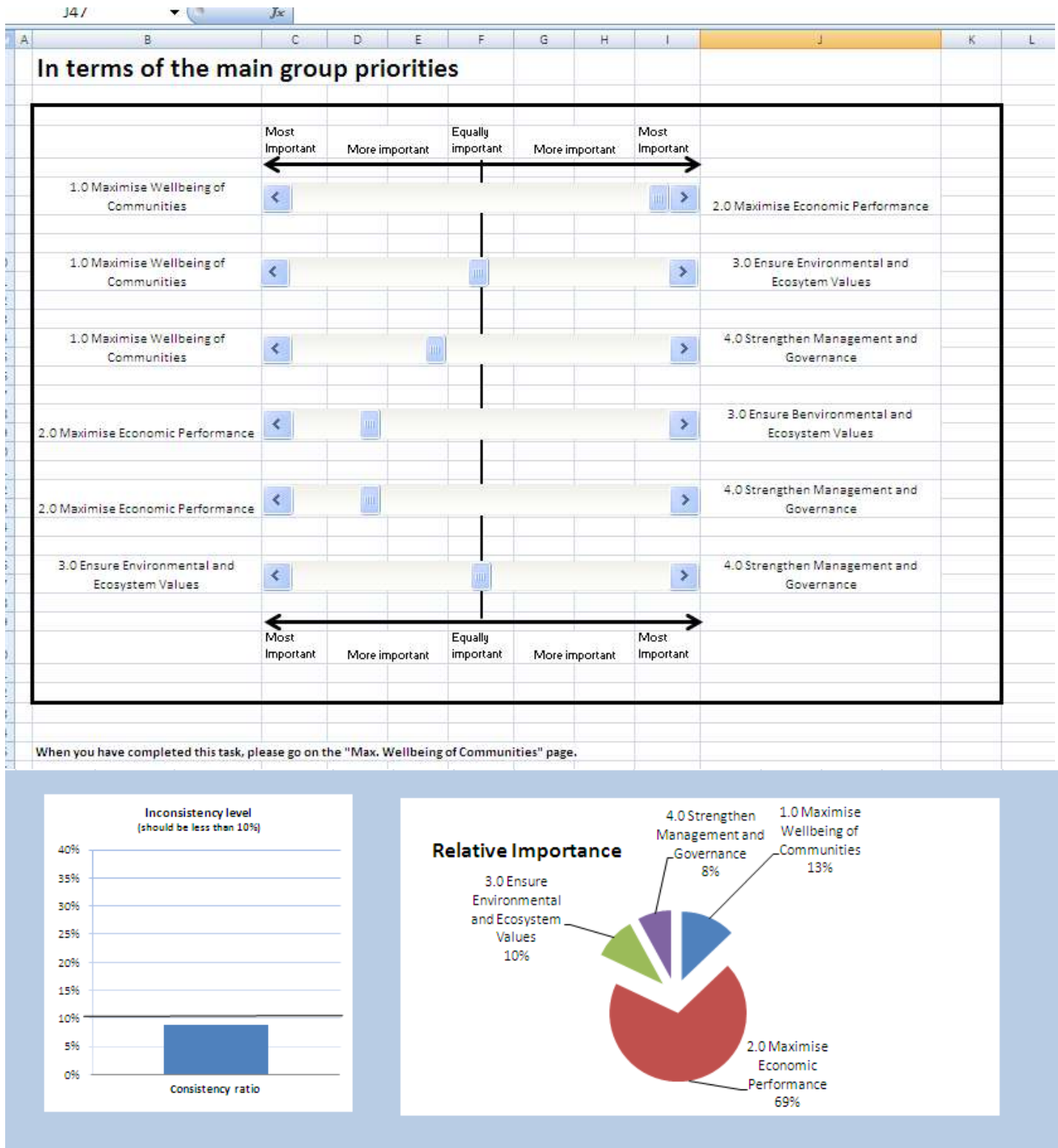


Figure 2 Example of the survey instrument

## Appendix 5: Definition of Objectives

### High Level Objective definitions:

#### 1 Maximise Wellbeing of Communities

Maximise social outcomes (employment, livelihood, lifestyle, etc) in coastal communities, including wellbeing of members of the fishing industry as well as other groups.

#### 2 Maximise Economic Performance

Maximise the economic benefits from the fishery, including those to the fishing industry, recreational and charter fishers and to the owners of fishing rights.

#### 3 Ensure Environmental and Ecosystem Values

Ensure the sustainability and the resilience of the ecosystem by maintaining sustainable harvests; reducing harvest impacts on the ecosystem and reducing the carbon footprint of the fishery.

#### 4 Strengthen Management and Governance

Enhance the involvement of stakeholders in the management of the resource and ensure the governance methods are flexible, transparent and adequately account for the risk of undertaking different measures.

#### 1 Maximise Wellbeing of Communities

- 1.1 Maximise wellbeing of fishing community
  - 1.1.1 Maximise sustainable employment and livelihoods
  - 1.1.2 Enhance lifestyle opportunities
- 1.2 Maximise wellbeing of coastal communities
  - 1.2.1 Minimise conflicts and ensure equity
  - 1.2.2 Contribute to viable and resilient communities
    - 1.2.2.1 Maximise flow-on economic and employment benefits
    - 1.2.2.2 Enhance adaptive capacity in the fishery

#### Within 1 Maximise Wellbeing of Communities

There is the choice between objectives **1.1** and **1.2**

1.1 Maximise social outcomes for those who are directly involved in the fishery.

1.2 Maximise social outcomes for local/coastal communities, including the broader fishing sector.

#### Within 1.1 Maximise Wellbeing of Fishing Community

There is the choice between objectives **1.1.1** and **1.1.2**

1.1.1 Maximise the number of people who are directly employed in, and derive a sustainable livelihood from the fishery.

1.1.2 Enhance opportunities for healthy, safe (including at sea) and fulfilling lifestyles associated with direct involvement in the fishery.

#### Within 1.2 Maximise Wellbeing of Coastal Communities

There is the choice between objectives **1.2.1** and **1.2.2**

1.2.1 Minimise conflicts between competing resource users, and ensure equitable treatment of different user groups and fair rules of access to resources.

1.2.2 Contribute to the economic and social viability and resilience of coastal communities.

### **Within 1.2.2 Contribute to Viable and Resilient Communities**

There is the choice between objectives **1.2.2.1** and **1.2.2.2**

1.2.2.1 Maximise the indirect and flow-on employment and other economic effects of the fishing sector (commercial and recreational) to the broader community.

1.2.2.2 Enhance ability of the fishery to adapt to adversity and to transform itself in ways which makes it more sustainable in the future and contribute to community resilience.

## **2 Maximise Economic Performance**

2.1 Maximise value of tradeable fishing rights

2.2 Maximise fishing industry profit

2.2.1 Minimise annual fishing costs

2.2.2 Maximise product prices

2.2.3 Maximise catch rate

2.3 Maximise value of recreational/ charter fisheries

2.3.1 Maximise participation

2.3.2 Maximise catch rate

### **Within 2 Maximise Economic Performance**

There is the choice between objectives **2.1, 2.2** and **2.3**

2.1 Maximise the unit value of fishing quota, licenses and other fishing rights.

2.2 Maximise the difference between total annual costs (fixed and variable) and total revenues of commercial fishers.

2.3 Maximise the net benefits (benefits less costs) to recreational and charter fishers and the profit of charter operators.

### **Within 2.2 Maximise Fishing Industry Profit**

There is the choice between objectives **2.2.1, 2.2.2** and **2.2.3**

2.2.1 Minimise total annual costs of fishing included fixed (e.g. insurance, harbour fees) and variable (e.g. fuel, bait) costs, and compliance and other charges.

2.2.2 Maximise the price received for fish and fish products.

2.2.3 Maximise catch per unit of effort.

### **Within 2.3 Maximise Value of Recreational/ Charter Fisheries**

There is the choice between objectives **2.3.1** and **2.3.2**

2.3.1 Maximise the number of people participating in recreational and charter fishing activities.

2.3.2 Maximise the catch per day of recreational and charter fishers.

## **3 Ensure Environmental and Ecosystem Values**

3.1 Ensure sustainability of harvested resource

3.2 Ensure long run ecosystem resilience

3.2.1 Minimise impacts on non-target species

3.2.2 Maximise area of productive habitat

3.2.3 Maintain biodiversity and ecosystem function

3.3 Minimise pollution and carbon footprint of fishery

### **Within 3 Ensure Environmental and Ecosystem Values**

There is the choice between objectives **3.1, 3.2** and **3.3**

3.1 Ensure that current levels of resource use do not compromise the biological sustainability of the resource.

- 3.2 Ensure the ecosystem can cope with long term stresses and shocks (e.g. climate change) and can rebuild itself when necessary.
- 3.3 Minimise negative effects of pollution and greenhouse gas emissions resulting from commercial and recreational fishing.

#### **Within 3.2 Ensure Long run Ecosystem Resilience**

There is the choice between objectives **3.2.1, 3.2.2 and 3.2.3**

- 3.2.1 Minimise bycatch of, and other impacts on, other commercial and non-commercial species.
- 3.2.2 Maximise the area of productive habitat through minimising destructive practicing, protection and enhancement.
- 3.2.3 Maintain richness and composition at species level and at the level of groups of species that are important for ecosystem function.

### **4 Strengthen Management and Governance**

- 4.1 Improve management processes and systems
  - 4.1.1 Enhance accountability and transparency
  - 4.1.2 Enhance planning and risk management
  - 4.1.3 Enhance adaptability and flexibility
- 4.2 Improve stakeholder involvement and incentives
  - 4.2.1 Ensure respect for customary rights
  - 4.2.2 Enhance incentives for stewardship
  - 4.2.3 Improve opportunities for co-management and stakeholder participation

#### **Within 4 Strengthen Management and Governance**

There is the choice between objectives **4.1 and 4.2**

- 4.1 Improve aspects of management and governance that relate to effective decision-making.
- 4.2 Improve aspects of management and governance that relate to stakeholder involvement and incentives to use resources sustainably.

#### **Within 4.1 Improve management processes and systems**

There is the choice between objectives **4.1.1, 4.1.2 and 4.1.3**

- 4.1.1 Enhance processes/systems for ensuring that decisions taken at all levels meet their stated objectives and that decision-making processes and outcomes are clear to all stakeholders.
- 4.1.2 Enhance processes/systems for fishery-level planning, including processes for effective risk identification, evaluation and treatment.
- 4.1.3 Enhance adaptive management processes, and operational and administrative flexibility.

#### **Within 4.2 Improve stakeholder involvement and incentives**

There is the choice between objectives **4.2.1, 4.2.2 and 4.2.3**

- 4.2.1 Respect rights of access/use in the fishery that are associated with a long social history or tradition.
- 4.2.2 Enhance the use of incentives, including those created through the better definition of fishing rights, to motivate individuals and groups to use resources sustainably.
- 4.2.3 Improve engagement and strengthen partnerships (e.g. industry/management) through greater stakeholder involvement.