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Quantifying economic values of coastal and marine ecosystem services and assessing their use in decision-making: applications in New Caledonia and Australia

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Abstract

Coastal and marine ecosystems are some of the most heavily exploited with intense and increasing degradation. This alarming situation appeals for urgent and effective actions. The optimal balance between use and conservation of ecosystems theoretically requires all costs and benefits to be considered in decision-making, including intangible costs and benefits such as non-market use and non-use values. The broad aim of this PhD is to examine how these economic values associated with coastal and marine ecosystem services can be measured, and how the economic valuation exercise may be considered and influence management decision-making.

The first analytical part of the thesis focuses on assessing non-market use and non-use values, through econometric methods. The characterization and estimation of the latest are complex and controversial; especially when the valuation exercise is focusing on individuals who are users of the ecosystem services being considered. An original approach based on a stated preference method, namely choice experiments, is developed then empirically applied in quantifying non-market values for marine and coastal ecosystems in two areas in New Caledonia. It allows the estimation of non-use values for populations of users in an implicit way. An in-depth analysis of the individuals' choice heuristics during the valuation exercise is also conducted, with a focus on payment non-attendance. This issue is dealt with by comparing multiple modelling approaches in terms of: (1) inferred attendance, in relation to stated attendance; (2) attendance distribution according to several socio-economic variables; and (3) welfare estimates.

After noting that the potential influence of economic valuation in decision making is unclear and largely unexplored in the literature, the second major component of this PhD aims to examine if, how and to what extent various types of economic information on ecosystem services, including measures of non-use values, influence decision making regarding coastal and marine ecosystems management in Australia. Based on two nation-wide surveys, the perceived usefulness of the economic valuation of ecosystem services by the general public and decision-makers is studied, and the reasons why decision-makers may or may not fully consider economic values are elicited. Using a multi-criteria analysis, a part of the surveys also aims at examining the relative importance of different evaluation criteria (ecological, social and economic) when assessing the consequences of a hypothetical coastal development project on commercial activities, recreational activities and marine biodiversity.

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List of Abbreviations

AHP: Analytic Hierarchy Process

CBA: Cost Benefit Analysis

CME: Coastal and Marine Ecosystems

CV: Coefficient of Variation

CVM: Contingent Valuation Method

CR: Consistency Ratio

DCE: Discrete Choice Experiment

EC-RPL: Error Component Random Parameters Logit model

ES: Ecosystem Services

ESV: Ecosystem Services economic Valuation

IA: Inferred Attendance

INA: Inferred Non-Attendance

LCM: Latent Class Model

MCA: Multi Criteria Analysis

MNL: Multinomial Logit Model

NUV: Non-Use Values

RPL: Random Parameters Logit model

RUT: Random Utility Theory

SA: Stated Attendance

SNA: Stated Non Attendance

SP: Stated Preference

TEV: Total Economic Value

WTP: Willingness-To-Pay

WTA: Willingness-To-Accept

Statement of Original Authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

Signature:

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Introduction

We are currently facing a series of major global environmental challenges: climate change (IPCC, 2007; Stern, 2007), depletion of environmental resources (Meadows, 1972; Millennium Ecosystem Assessment (MA), 2003, 2005; Food and Agricultural Organization [FAO], 2007, 2009, 2012; International Energy Agency, 2011), and a persistently high rate of biodiversity loss (Mace et al., 2005; MA, 2005). Failure to adequately respond to these challenges is likely to lead to continued degradation and over-exploitation of ecosystems and the benefits they provide to humans i.e. ecosystem services (MA, 2005).

Response to these challenges is not costless, and in order to take appropriate measures, it is necessary to examine the consequences of such declines in terms of social welfare, which also means examining what are the costs or benefits of preserving or losing ecosystem services. The economy has an important role to play in determining these; as Georgescu-Roegen noted: "apt though we are to lose sight of the fact, the primary objective of economic activity is the self-preservation of the human species" (1971, p. 277).[1]

While human activities are largely guided by market incentives, these markets generally fail to capture costs implied by degradation of common pool resources and ecosystems. These degradations are traditionally referred to as “externalities”, since they escape exchanges on the market, and as such are not captured in the prices at which goods and services are produced and consumed in the economy. Thus, economic activities are a source of societal benefits and costs, some of which are external to private economic decisions, and relate in particular to the impacts of these activities on ecosystems. The quantitative evaluation of these impacts can help characterise their global or local consequences for social welfare. Similarly, slowing down the decline in ecosystems and the services they provide is often advocated through conservation measures (e.g. Marine Protected Areas or protection of endangered species[2]), alongside other measures that aim to “internalize externalities”; and this implies costs and benefits, some of which occur mainly over the long term. Determining the appropriate level of conservation requires balancing these costs with the benefits that are produced from preserving ecosystems services (Hanley and Spash, 1993).

This is the origin of the Ecosystem Services Economic Valuation (ESV) approach, which has rapidly developed as a pragmatic way to support decision-making in the domain of

[1] A more recent transcription of this statement is the sustainability concept (e.g. Brundtland report, World Commission on Environment and Development 1987).

[2] See for example http://www.iucnredlist.org/about/red-list-overview

biodiversity conservation compared to other ecological or moral argumentation (Pearce and Moran, 1994; Costanza et al., 1997; Boyd and Banzhaf, 2007; TEEB, 2008; Liu et al., 2010). Non-market valuation (Adamowitz, 2004) was designed to account for the changes regarding Ecosystem Services (ES), which would usually escape the market and therefore imply no economic signals regarding their contributions to social welfare or threats in their capacity to do so.

The rationale is that where no prices exist, values must be assessed and quantified whenever possible in order to appropriately guide decision to effectively manage ecosystems and to strike an optimal balance between use and conservation. Though the concept of value has many different meanings to different groups, estimating a monetary value using a common numeraire[3] allows for simple comparisons between groups to be made, and as such it contributes to bridge different systems of knowledge (science, policy and common public).

In particular, the call for increased economic valuation of ES has especially been observed for coastal and marine ecosystems (CME). These ecosystems are some of the most heavily exploited globally (UNEP, 2006; Halpern et al., 2008): as an example coastal zones make up just 4% of the earth's total land area and 11% of the world's oceans, yet they contain more than a third of the world's population and account for 90% of marine fisheries catch (MA 2005). As Barbier (2012) noted, the degradation and loss of CME are intense and increasing worldwide, with 50% of marshes, 35% of mangroves, 30% of coral reefs, and 29% of sea grasses either lost or degraded (FAO, 2007; MA, 2005; Orth et al., 2006; UNEP, 2006; Waycott et al., 2009). This decline of CME goes along with the growing concerns due to overfishing (Worm et al., 2009; FAO, 2009; Swartz et al., 2010) and water quality issues (MA, 2005; Halpern et al., 2008). Thus, services provided by those ecosystems to humans are threatened: provision of renewable resources through the number of viable fisheries, filtering and detoxification provided by suspension feeders, submerged vegetation, and wetlands, protection against shore erosion, coastal flooding or storm events (Koch et al., 2009), recreational, cultural, existence as well as aesthetic values (MA, 2005), and more broadly resilience to external shocks. The strong dependence of populations towards this huge flow of services necessary to human welfare clearly exacerbates the issue. In addition to this, several factors dramatically complicate the design of potential management responses, such as a high

[3] It is necessary, however, to be aware of what these dollar values actually represent. For example, marginal and total dollar values cannot be directly compared. A certain level of knowledge or understanding of the techniques might be required.

degree of "connectivity" with land ecosystems, cross border and jurisdictional issues, an important lack of understanding of these interactions and impacts as well as subsequent uncertainty, and strong links with climate change issues.

Benefits associated with these services, or the costs of losing these services and associated values, have been estimated worldwide (e.g. Barbier et al. 2007, Barbier 2011, 2012; MA, 2005; Brander et al., 2007), as a way to legitimate conservation. It is indeed crucial to measure the value of these ecosystem services so we can better understand what is at stake if these habitats are lost and to incorporate these values into coastal and marine management and planning (Barbier, 2012). Yet many of the benefits of CME habitats are undervalued or even ignored in coastal and marine development decisions (Barbier, 2012; Brander et al., 2006).

The broad aim of this thesis is hence to examine how some intangible economic values associated with coastal and marine ecosystem services and their conservation can be measured, and how the economic valuation exercise may be considered and influence management decision-making.

1. The development of economic valuation of ecosystem services

Ecosystem Services Economic Valuation (ESV) was originally developed as a tool within environmental economics (see Appendix A for a brief historical review of environmental valuation), and is based on utilitarianism. As such, ESV is ideologically grounded in anthropocentrism, both philosophically and ethically.

The development of typologies and techniques for estimating robust monetary values, reflecting the actual contribution of ES to social welfare has become an increasingly important area in environmental economics, and, for the past thirty years, economists have committed important theoretical and empirical efforts to reliably classify and quantify these costs and benefits (Liu et al., 2010). Environmental valuation methods based on neoclassical economic theory were continuously developed and theoretically refined (e.g. progress on taking into account uncertainties), as well as more and more applied worldwide.

In parallel, several international agreements and declarations such as the United Nations Conference on Environment and Development (1992), the multiple Conference of the Parties[4]

[4] The Conference of the Parties is the governing body of the Convention of Biological Diversity (CBD), and advances implementation of the CBD through the decisions it takes at its periodic

or the Convention on Biological Diversity[5] have demonstrated the increased international recognition of biodiversity and ecosystems protection and sustainable use as a common concern of Human Kind. At national levels, legislations evolved in order to account for and limit ecosystem degradation (e.g. Comprehensive Environmental Response, Compensation, and Liability Act in the US[6]). This growing recognition in public policy of the need to protect biodiversity has led to the development of a number of valuation typologies, defining the different sources of values derived from ecosystems (e.g. MA 2005; Turner et al., 2003; de Groot et al., 2002; Costanza et al., 1997; Pearce and Moran, 1994). The growing number of practical applications of these typologies over the last three decades has largely confirmed the predominant interest for such tools in support of decision making at different scales.

- **Value typologies and valuation methods**

The Total Economic Value typology is commonly encountered in the literature (e.g. Costanza et al., 1997; Garrod and Willis, 1999; Turner et al., 2003; Bateman et al., 2002), and is based on the multiple types of humans' interactions with ecosystems. Total economic value is defined as the sum of use, option and non-use values. The former can be measured by revealed preference techniques since they relate to uses which leave a behavioural trace even if only indirect; the latter, by definition, can only be measured by stated preference methods since there is no behavioural trace (Carson, Flores and Mitchell, 1999). Indeed, use values refer to current (and future depending on the specified time frame considered) direct or indirect physical interactions with the good (thus divided into direct or indirect use values). Option values refer to the current value of maintaining several futures possible uses (either a willingness-to-pay to preserve the possibility of using the good later, or the expected economic rent of future planned activities). Non-use, also known as passive-use, values refer to economic values held for the good independently of any direct or indirect uses (in the present as well as in the future, which also means independently of any expected uses from the value holder).

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meetings. To date the Conference of the Parties has held 10 ordinary meetings, and one extraordinary meeting.

[5] http://www.cbd.int/

[6] The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (42 United States Code 9601–9675) consists of Public Law 96–510 (Dec. 11, 1980) and the amendments made by subsequent enactments. http://www.epa.gov/oecaagct/lcla.html

Links have since been established between this typology and the ecosystem services typologies that arose with the development of an ecosystem services science. For a historical review of the ecosystem services theory and practice, the reader can refer to the article of Gómez-Baggethun et al. published in 2009. The concept of ecosystem service emerged in the economic valuation literature in the late 1990s. The Millennium Ecosystem Assessment (MA, 2003) was a critical landmark that firmly established the ecosystem services concept on the policy agenda (Gómez-Baggethun et al., 2009). While based on an anthropocentric approach, the MA framework stressed human dependency not only on ecosystem services, but also on the underlying functioning of ecosystems, making visible the role of biodiversity and ecological processes in human well being (MA, 2005). Since then, the literature on ecosystem services and its uptake at all policy levels has increased dramatically (Fisher et al., 2009). The new challenge of economic valuation became to estimate, in monetary terms, the value of these ecosystem services. Efforts were made to better classify ecosystems services and their associated values, with distinctions between functions, processes and benefits (e.g. Fisher et al., 2009; Balmford et al., 2011), also in order to avoid possible double counting issue that arose for example with the well-known MA classification (Fisher et al., 2009). Several typologies (see Appendix B for an example) regarding ecosystem services and associated economic values were proposed (e.g. de Groot et al., 2002; Balmford et al., 2011), with the objective of being integrated into governance to improve decision-making (Daily et al., 2009).

In addition, methods aimed at establishing monetary measures of each group of values and associated services were developed and refined. Techniques and methods can be broadly grouped into two categories: revealed preference (RP) methods and stated preference (SP) methods. The former attempts to value public goods using actual consumer behaviour by examining marketed goods that are related to the public good (Freeman, 2003). Market data can be retrieved regarding purchased goods that are complementary to the public good, or through inputs to the household's production function, to derive a demand curve (Garrod and Willis 1999). RP approaches include (Liu et al., 2010): market methods (also known as Adjusted market prices), productivity (or Dose-Response) approaches, travel cost methods and hedonic pricing methods (details on these methods are given in Appendix B). The second type of approach, namely SP methods, is used in the valuation of public goods where limited (or no) real or associated market data exists. Thus values are based on willingness to pay (WTP) or willingness to accept (WTA) that are generally elicited through a questionnaire. SP methods are the only methods available for estimating non-use values, or any WTP/WTA when no behavioural data exists. They include: the Contingent Valuation Method (CVM) where people are directly asked their willingness to pay or accept compensation for some change in ES, and Discrete choice experiments (DCE) where people are asked to choose or rank different scenarios concerning ES, or ecological conditions that differ in the mix of those conditions.

In addition to revealed and stated preference methods, other commonly employed approaches in ESV should be mentioned. The first are commonly referred to as cost-based methods: replacement cost and avoidance cost (also known as Avoided damages). The second is benefit transfer, which is based on the adaptation of existing ESV information or data to new policy contexts that have little or no data, and thus estimate values in a far less expensive process. The latter method has raised many issues and concerns, and the possibility of its application is carefully discussed and studied within a specific part of the academic literature (e.g. Plummer, 2009)[7].

- **Application to coastal and marine ecosystem services**

The different values of coastal and marine ecosystems services, and the most frequently encountered valuation methods, are synthesized in Figure I-1 below.

Numerous works have focused on valuing services associated with CME, using the various methods available. Several general reviews have already been undertaken regarding these applications (e.g. Barbier, 2012; Barbier et al., 2011; TEEB, 2010; Pendleton et al., 2007; Brander et al., 2007; and Heal et al., 2005 among others). Other reviews have focused on specific areas. For example, Schuman (2011) undertook valuation studies in the Caribbean, Laurans et al. (2013a) reviewed coral reefs economic valuation in the South Pacific, Stoeckl et al. (2011) presented the state of knowledge concerning economic value of ecosystem services in the Great Barrier Reef, and Gillespie and Bennett (2011) reviewed economic valuations studies through the use of DCE in Australia concerning Marine Protected Areas (MPA).

[7] An associated issue is the meta-analysis techniques, which is a statistical analysis of results from multiple but similar empirical studies. In environmental valuation contexts, this can help determining what factors statistically influence values and thus better guarantee the success of benefit transfers (see Brander et al., 2007, for an example on the recreational value of coral reefs).

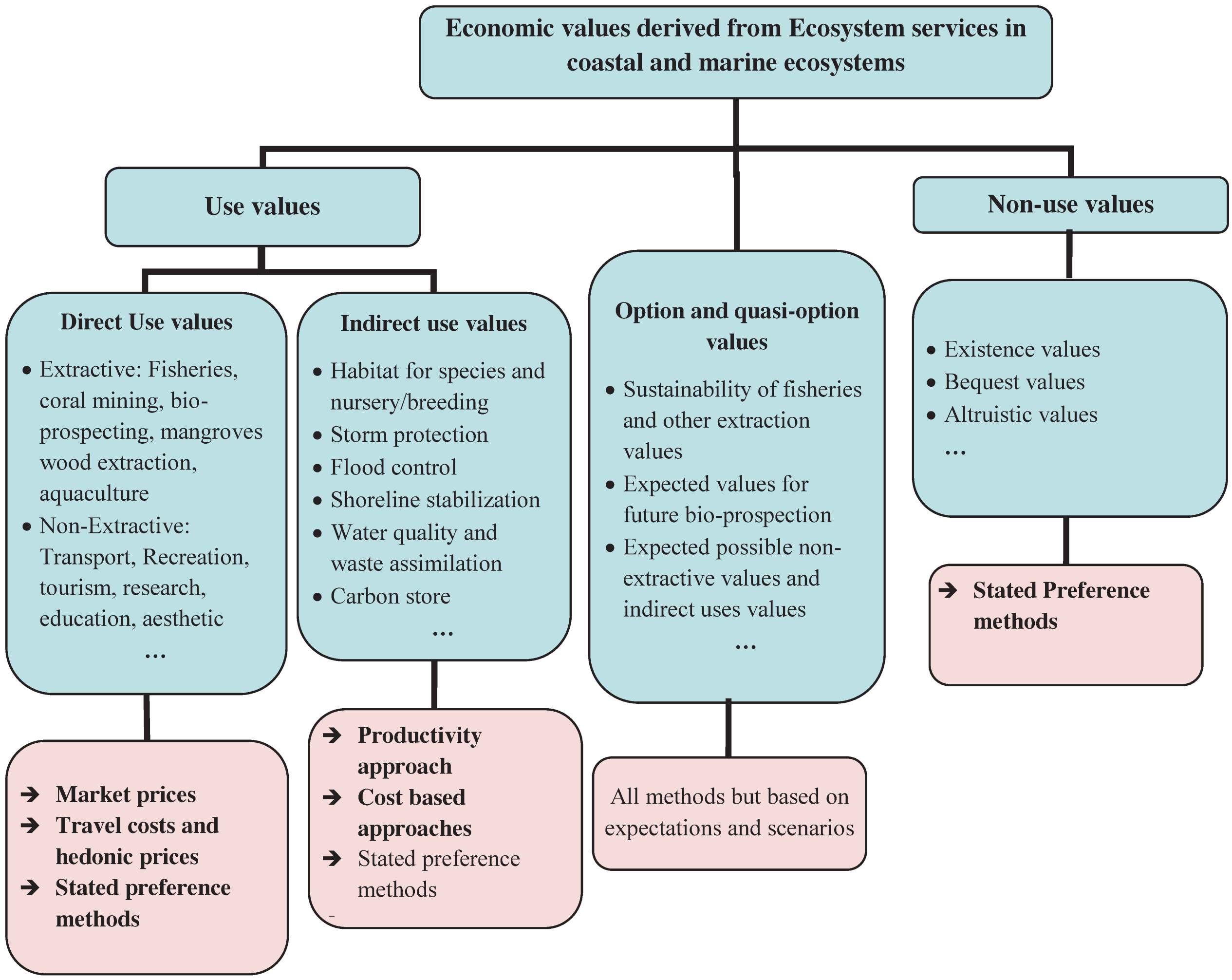


Figure I-1 Economic values for coastal and marine ecosystems and most frequently associated valuation methods

- **The coral reefs example**

In particular, since the 1980s, there has been a rapid expansion in the number of coral reef valuation studies and now hundreds of studies have appeared on this issue. The main specific services of coral reefs that have been valued include (Barbier, 2012): near-shore fisheries from coastal communities (e.g. Cesar and van Beukering 2004; Rodwell et al., 2003; Wilkinson et al. 1999; Zeller et al., 2007), aquarium trade (e.g. Sadovy et al., 2002; White et al., 2000), important shoreline protection (e.g. Chong, 2005; Cesar and van Beukering, 2004), recreational benefits including tourism, snorkelling, diving and sport fishing (e.g. Doshi et al., 2012; McCartney, 2011, Tapsuwan and Asafu-Adjaye, 2008; Brander et al. 2007; Cesar and van Beukering 2004; Mathieu et al., 2003), and cultural services implying non-use values (e.g. O'Garra, 2009; Windle and Rolfe, 2005; Bath, 2003). Studies by Costanza et al. (1997) and Cesar et al. (2003) have estimated the value of coral reefs worldwide.

The economic values associated with these services have been shown to be substantial. For example, in Hawaii, fisheries benefits have been estimated to be \$1.3 million per year, and total net benefits for all services of \$360 million a year (Cesar and van Beukering, 2004). In American Samoa, the total economic value of reefs has been estimated to US\$14,300 per km^2 in American Samoa (Spurgeon, 2004). Regarding aquarium trade, global benefits have been estimated to reach \$90 to \$300 million per year in 2002 (Sadovy et al., 2002). Barbier (2012) presents other examples in his review.

Regarding tourism and recreational activities, Brander et al. (2007) reviewed 166 studies estimating recreational values, and noted that the average value of coral reef recreation is US\$184 per visit. However, they also found that the median value is US\$17 per visit, showing that the distribution of values is skewed with a long tail of high values (Brander et al., 2007), thus highlighting substantial value variations among studies. For example estimates range from around US\$1000 per km2 in the Philippines (Samonte-Tan et al., 2007) to around US\$50,000 per km^2 in some Caribbean islands (Burke et al., 2008).

Another crucial ecosystem service provided by coral reefs is the protection of coastal human populations, property, and economic activities from storms. Values found are usually substantially higher in comparison to other services, sometimes estimated as one third of the total economic value of the reef (Laurans et al., 2013a): as such they have been shown to range from around 10 US\$ per km^2 in Indonesia (Riopelle, 1995) or Vanuatu (Laurans et al., 2013a) to more than US\$ 10,000 per km2 in the Caribbean (Burke et al., 2008). Unfortunately, the reliability of many economic estimates of storm protection has been questioned because they tend to use benefit transfer and replacement cost methods in an ad hoc way (Chong, 2005).

Finally, regarding non-use values, although some work has been conducted (e.g. Ahmed et al., 2004; Curtis, 2004; van Beukering et al., 2006; O'Garra, 2009), it is clear that there is still an important lack of estimates in the literature (Spurgeon, 2004; Schuman, 2011; McCartney, 2011; Laurans et al., 2013a), which is mainly due to various challenges associated with their estimation. However, non-use values have been argued of being of the utmost importance as they can potentially outweigh use values in coral reefs regions inhabitants (Spurgeon, 2004).

2. Key challenges

In parallel to this rapid development of ESV, controversies on monetization and commodification of nature's benefits have also arisen. Growing concerns – from economists as well as scholars from other disciplines (e.g. ethics and philosophy, ecology, anthropology) – about valuation methods and more broadly about the application of the neoclassical economics framework of analysis to environmental management issues have been expressed. This led to the development of Ecological Economics, which share some common ground with other economic schools and paradigms such as Post-Keynesianism or institutional economics (Vatn, 2010), as well as ecology (e.g. resilience), environmental ethics (e.g. the precautionary principle) and philosophy (e.g. incommensurability) (O'Neil et al., 2007). Founders of this new school of thought argued the crucial need for a more trans-disciplinary academic research agenda regarding ES management issues, and for greater interdisciplinary cooperation between economists and natural scientists. A brief summary of the main limits and debates that arose during the development of Ecological Economics is given in Appendix C. Those include discussions about: sustainability and Natural capital, limits to the underlying model of economic behaviour and systemic approaches to social-ecological interactions.

Environmental and ecological economics have strongly interacted all along, with criticism or concerns from one domain feeding new theoretical or methodological developments in the other. In relation to this, the past decades saw the development of new valuation techniques (e.g. Discrete Choice Experiment) and continuous refinement of previous existing ESV methods as well as decision-making tools (e.g. Cost-Benefits Analysis and Multi-Criteria Decision Analysis). However, strong debates and criticism about the validity and robustness of valuation exercises persist, especially regarding non-market valuation. These debates mainly focus on the capacity for economic valuation methods to provide relevant information, in view of the extreme complexity of: (1) the functioning of ecosystems (e.g. non-linearity, irreversibility, adaptability, uncertainty and interconnectivity); and (2) Human interactions with ecosystems. The second point also relates to the multi-dimensionality of the value concept. While in some cases there is an obvious monetary dimension in an ES value (e.g. provision of food through commercial fisheries), it is less obvious in others (e.g. cultural importance of landscape features, and benefits associated with the preservation of species or ecosystem never to be encountered or used), and it is certainly harder to estimate. This is typically the case for non-use value: on one hand this constitutes one of the most compelling reason for ecosystem preservation, on the other hand its characterisation and estimation are complex and controversial.

More broadly, such concerns about the reliability or even the relevance of ESV raise the issue of its use and usefulness in support of decision-making. Indeed, these concerns may hinder the economic valuation exercise as well as the uptake of estimated values by decision-makers.

The aim of this PhD is to progress understanding in these two key areas of ESV applied to CME management and preservation: the estimation of non-use values, alongside non-market use values; and the use and influence of ESV in decision and policy-making.

- **Estimating non-use values**

Non-use values and their estimation through stated preference methods crystallize an important part of the debates and criticism concerning the validity and robustness of ESV valuation methodologies and theory.

The concept of non-use values (as originally introduced by economists) has been widely discussed by researchers from multiple disciplines (economists, biologists, philosophers and social scientists), and was described as involving several dimensions, some of which may be incommensurable. Although present in all major typologies, confusions and conflations amongst non-use values' dimensions are frequently encountered (Chan et al., 2012), and issues about the economic definition of non-use values and subsequent quantification have been debated intensively in the academic literature (e.g. Loomis, 1988; Kahneman and Knetsch, 1992; Castle et al., 1994; Lazo et al., 1997; Chan et al., 2012).

The question of quantitatively estimating non-use values (NUV) arose because of the need to justify conservation in a cost benefit analysis framework. NUV became a crucial component of ESV, and were increasingly estimated in non-market valuation, especially when assessing the socio-economic impacts of natural resource damages (Carlson et al., 1992) or of conservation actions (Hoagland et al. 1995). Indeed, even if in some cases, terrestrial and marine based conservation could be shown to produce substantial use values that justify the cost of their establishment; in many others, use values generated by ecosystems are much more limited and the cost of preservation might well be justified mainly from non-use benefits. In marine ecosystems, for example, offshore marine conservation provides almost totally non-use benefits, especially if fishing activity is removed from the area as part of the conservation plan (e.g. McVittie and Moran, 2010).

In practice, since no real market behaviours are observable, non-use values are estimated through stated preference methods. Their estimation is especially complex when the valuation exercise focuses on individuals who interact directly or indirectly with the ecosystem services being considered (i.e. users); and the standard approach for estimating non-use values of users has substantial shortcomings, which undermine the robustness of its results (Cummings and Harrison, 1995). Their estimation is also complex when focusing on marine ecosystems, where in some cases the issue is further complicated by the fact that many individuals will never observe the key ecological features protected, nor know what functions they have.

Therefore, several issues related to non-use values entail a need for further research:

- There are still some debates regarding non-use values and their associated economic quantification alongside non-market use values;
- Non-use value estimations should be able to account for the preferences of both non-users and users, without obfuscation by use values for the latter;
- The theory and method behind the estimation of non-use values should be able to account for possible concerns regarding standard behavioural model assumptions, notably incommensurability and non-compensatory preferences;
- There is a need for robust and reliable non-use value estimates regarding marine and coastal ecosystems, especially coral reef and associated ecosystems. There is also a lack of estimates for coastal indigenous communities, which may hold extremely important non-use values for marine ecosystems.

- **Use and influence of ESV**

The substantial amount of valuation work that has been done, as well as the different challenges faced by ESV, raise the crucial issue of the use and actual role which economic valuation can play in ES management and policy-making, since the main raison d'être of ESV is to support decision-making.

After decades of continuous practice and progress, growing concern has developed among academics and practitioners regarding the actual impact of valuation on decision-making and its implementation into the "Real World" (e.g. Lopes and Videira, 2013; Rogers et al., 2013; Laurans et al., 2013b; Billé, 2012; Goldstein et al., 2012; Balmford et al., 2011; de Groot et al., 2010; Liu et al., 2010; Daily et al., 2009). Consequently, several decision-making tools based on ESV or including ESV were developed and implemented (e.g. InVEST software[8]).

Despite the growing interests and efforts in bridging ESV and decision-making, it is clear that there is still a significant paucity of work looking at the actual utilization of economic valuation by decision-makers in the academic literature (Laurans et al., 2013b), by which we mean: what values are actually utilized, how are they used (for what precise purpose, in which decision context and by whom) and to what extent? This is a crucial unexplored research direction in the economic valuation literature. In most valuation work, it is in fact uncommon to encounter a detailed examination of the actual or potential use of the values that were estimated. Usually methods are discussed, values are estimated, and presented as potentially useful, with no specification regarding actual decision-making contexts where these will/could be used in specific ways, or without mentioning if these are answering a need for a precise management objective. In short, their ultimate influence on decision-making remains largely unexplored.

Even if there is obviously a demand for economic valuation from decision makers or stakeholders, it is also possible that there is a far bigger supply from academics and practitioners, or that this supply is not completely adapted to decision-makers needs. Very few studies conducted an in-depth analysis of the perceptions of different stakeholders regarding the usefulness and contextualized utilization of ESV, and about the factors that could promote or limit the extent to which economic valuation results are actually considered or referred to (e.g. Rogers et al., 2013).

Furthermore, since ESV is certainly not exhaustive and sufficient to fully support decision-making, there is also a need to compare the role of economic valuation in comparison to other kinds of descriptors of values, such as social acceptability or opinion polls, or ecological indicators. Indeed, decision-making relies on many different kinds of information processing associated with different – and often competing – objectives. As Liu et al. (2010, p.69) noted: "The key issue here comes down to trade-offs. If one does not have to make trade-offs between ecosystem services and other things, then valuation is not an issue. If however, one does have to make such trade-offs, then valuation will occur, whether it is explicitly recognized or not. Given this, it seems better that the trade-offs be made explicit." In establishing the actual and potential role of ESV in decision-making, it is thus necessary to

[8] http://www.naturalcapitalproject.org/InVEST.html

identify the relative importance which may be granted to this information, alongside alternative types of information To our knowledge, no previous study has examined the weight placed on ESV among other indicators in a specific decision-context.

All these observations are also true for CME, where even less work concerning the interface between ESV and decision has been realized. The question still remains: what impact did it have on marine management? In other words, what do we know about the use and influence of economic valuation on decision making regarding CME? Is ESV perceived as having answered or having the capacity to answer decision-makers and associated stakeholders needs?

3. Research objectives

This PhD research aims to progress understanding of ESV, based on two complementary perspectives: first, address one of the most challenging ESV quantification problems; and second, assess the actual and potential use of ESV in decision-making. In short: is economic valuation able to estimate all the non market values it claims it does, and to what extent is it actually making a difference in decision-making regarding ES management? More precisely our first aim is to explore the potential and limitations of economic valuation in addressing the contested issue of non-use values and the way to measure them alongside non-market use values through stated preference methods. Our second aim is to explore the actual and potential influence of ESV on decision-making, alongside other types of economic and ecological information.

These two objectives are tackled with a focus on CME, and a focus on two case studies, namely New Caledonian and Australian marine and coastal areas. The two case studies were selected taking advantage of the joint status of this PhD, between the Université de Bretagne Occidentale (France) and Queensland University of Technology (Queensland, Australia).

The proposed approach to cope with our first objective is to focus on the capacity for non-market valuation to estimate both use and non-use values, with an application to New Caledonian coral reef ecosystems. Three major challenges addressed relate to (i) the quantitative estimation of non-use values alongside use values, (ii) the issue of non-compensatory preferences and limits of the standard rational behaviour model underlying economic valuation, especially as regards the hypothetical payment involved, and (iii) the impacts of socio-economic, cultural and environmental contexts on values and underlying preferences.

These challenges are addressed through two different pieces of research. The first focuses on the measurement on non-use values by: (1) critically reviewing the literature on non-use values in ESV; (2) filling an important gap in the literature by offering a pragmatic economic interpretation of non-use values which allows estimating these values for users in addition to and separately from use values; (3) offering a methodological framework using Discrete Choice Experiment to put this interpretation into practice; (4) conducting an empirical application in two coastal areas of New Caledonia, for heterogeneous population mostly composed of users of the coastal ecosystems; and (5) critically discussing the approach used, including the econometric specification of the models retained to analyse the results of the experiments, and the potential role for non-use values in support of decision making, given the results obtained.

The second piece of research focuses on an important issue that can arise when studying non-use values or more broadly when using stated preference methods: dealing with possible lexicographic or non-compensatory preferences through the issue of payment non-attendance in Discrete Choice Experiment, which precludes the estimation of welfare estimates. Based on several techniques available in choice modelling, it offers a methodological strategy to cope with payment non-attendance and apply it using the data from the New Caledonian case study.

With respect to the second research objective, we examine how and to what extent the Australian general public as well as different Australian stakeholders involved in conservation decision-making processes actually apprehend and use ESV in specific management contexts regarding CME in Australia. After having conducted a literature review on the use of ESV, both at the international and Australian levels, we develop a methodology to investigate this question. A quantitative and qualitative survey is designed to collect data on the perceived usefulness and use of ESV for decision-making. This survey aims at: (1) Documenting the knowledge and perceived usefulness of different types of ES values; (2) Studying the demand and preferences of stakeholders regarding information available through economic valuation; (3) Studying the preferences of stakeholders regarding ESV information, relative to other kinds of information such as ecological indicators/predictions and social acceptability or opinion polls; and (4) Comparing the knowledge, use and perceived usefulness of ESV information by the general public and decision-makers.

4. Structure of the thesis

This PhD is structured as follows. The first part, which is about the quantification of ecosystem services economic values, contains two chapters. Chapter 1 examines the issue of measuring non-use values, alongside non-market use values, and presents an empirical application conducted in New Caledonia based on Discrete Choice Experiments. Chapter 2 examines, both methodologically and empirically, the issue of non-compensatory preferences in Discrete Choice Experiments, more precisely the payment non-attendance issue. It presents results from the New Caledonian case study.

The second part, which is about assessing the use of ecosystem services values, contains two chapters. Chapter 4 presents a study about the perceived usefulness of ESV in decision-making, based on the design and results of two surveys: one focusing on the decision-makers, the other one focusing on the general public, in Australia. Chapter 5 presents the methodology developed as part of these surveys to assess the weight attached to the relative importance of ESV among other ecological and socio-economic indicators in decision-making by the decision-makers and the general public, and its results.

Finally, the last part presents an overall discussion and conclusion, in relation to our objectives, based on the various methods developed in this research work and the results from our different case studies.

Part 1: Quantifying ecosystem services values

New Caledonian application

Introduction

This part presents the motivations and results of a survey work carried out in New Caledonia from December 2010 to February 2012. This survey was funded and conducted under the French National Initiative For Coral Reefs (IFRECOR) program (see Appendix D), and the results were expected in 2012 by French and New Caledonian public institutions (French Ministry for Ecology and Sustainable Development, French Ministry for Overseas Territories, French Republic High Commission of New Caledonia). It is therefore important to note that this work was subject to two distinct contexts: the supervision, coordination and implementation of a study for a non strictly academic program with pre-defined objectives, timing, and expected outputs, and an academic PhD research work that aimed at exploring the issue of estimating both non-market use and non-use values for users in a theoretically and methodologically sound way.

The first chapter focuses on the issue of measuring non-use values (i.e. economic values assigned by individuals to ecosystem goods and services independently from his current or future uses) alongside non-market use values using a stated preference method. Indeed, the standard approach for estimating non-use values of users has substantial shortcomings, which undermine the robustness of their results. After conducting a literature review on non-use values, it presents: (1) a new methodological framework developed to assess both non-market use and non-use values based on a pragmatic interpretation of non-use: any value/willingness to pay for preserving an ecosystem beyond a person's expected life can be assumed to be a minima but exclusive means of non-use values; (2) the practical steps followed to apply this method using the discrete choice experiment (DCE) technique, which is widely and increasingly used in ecosystem services valuation; (3) the empirical application in two coastal areas in New Caledonia with different institutional, environmental and socio-economic contexts; and (4) the econometric analysis conducted to derive welfare estimates and isolate a non-use values component for users, through different choice models, with subsequent conclusions and discussions.

The second chapter looks at the issue of payment non-attendance in Discrete Choice Experiment (DCE), which is of paramount importance since it pertains to the mere existence of welfare estimates and thus can have some significant consequences on the main conclusions given by the valuation study. We propose a methodology that allows an in-depth analysis of this issue by comparing multiple modelling approaches in terms of: (1) inferred attendance, in relation to stated attendance; (2) attendance distribution according to several socio-demographic variables; and (3) welfare estimates. With respect to the second point, an innovative approach applying a Tobit model on individually estimated probabilities of non-attendance derived from Latent Class Modelling with parameters restrictions is developed. An empirical application is conducted using the DCE data from the New Caledonia study.

As such, both chapters aim at examining in detail two important issues related to the quantification of ecosystem services values: the estimation of non-use values alongside non-market use values, and the study of non-compensatory preferences that invalidate the values derived. They both offer methodological approaches to cope with these issues, and present an application using the data from the DCE section of survey conducted in New Caledonia.

Therefore, we note that, with respect to the New Caledonian survey work, the chapters presented here focus exclusively on the DCE application, and the details of all other results regarding surveyed individuals (e.g. study about the frequency of and perception related to marine activities, study of the perceptions regarding the preservation of species and habitat) obtained from the overall questionnaire used in the New Caledonian survey will not be presented here, since they are already examined in details in a French report for the IFRECOR and associated public authorities (Marre and Pascal, 2012).

Publications arising from this work

A one hundred and fifty pages report in French was produced (Marre and Pascal, 2012) as part of the study, available online (**http://www.ifrecor.nc/spip.php?article88**). This report also includes guidelines for the use of the choice experiment method, which is currently rarely employed (and relatively unknown by decision-makers) in France.

Two academic papers (Marre et al., 2014a; Marre et al., 2014b) have also been developed: one has been accepted for publication in Ocean and Coastal Management journal, the other one has been submitted to Environmental and Resource Economics journal and is under review.

Chapter 1 Measuring Non-Use values

1. Introduction

The costs or benefits of losing or preserving ecosystem services have been broadly classified into use values (direct or indirect), option values and non-use values (e.g. Turner et al., 2003; Bateman et al., 2002). The latter are recognised to be an important component of the total economic value of ecosystems and an important motivation for enhanced conservation. However, there are still challenges involved in their identification and quantification (Chan et al., 2012). This is especially the case when valuation is focused on users of the ES (Cummings and Harrison, 1995), a user being defined as any individual who directly (through physical or visual contact) or indirectly benefits from an ecosystem of interest, either passively or actively, and therefore holds direct and indirect use values for the ecosystem services considered.

Non-use values have been the subject of a growing economic literature since Krutilla (1967) first discussed the importance of existence and aesthetic values to conservation. Originally, existence value was the main component of non-use values that was considered (Attfield, 1998; Aldred, 1994; Stevens et al., 1991; Loomis, 1988; Krutilla and Fisher, 1985; Brookshire, 1983) and this was commonly presented as the value assigned by an individual to the good's continued existence, independent from its use(s) or possible use(s). Other dimensions and terminologies have also been considered, including aesthetic value (Chan et al., 2012; MA, 2005; Krutilla, 1967), bequest value which represents the value attached to preserving a good or service for use by future generations, independent of one's own use (O'Garra, 2009; MA, 2005; Aldred, 1994; Loomis, 1988), altruistic value (Ojea and Loureiro, 2007; MA, 2005; Aldred, 1994), biospheric value (Ojea and Loureiro, 2007) and intangible and cultural values (Chan et al., 2012; Daniel et al., 2012; MA, 2005). Other authors have also referred to passive-use values (e.g. Hanley et al., 1998; Adamowitz et al., 1998; Carson et al., 1992), in an attempt to emphasize the instrumental or utilitarian dimension of those values in economics. Despite this somewhat confusing diversity in terminology, in recent years, non-use values have often been simply defined as encompassing existence and bequest values (O'Garra, 2009; Wattage and Mardle, 2008).

Within the neoclassical economics framework, upon which environmental economics and valuation methods are based, non-use values are defined and measured in monetary units of willingness-to-pay (WTP) or willingness-to-accept (WTA). Non-use values as WTP are estimated through stated preference methods, including both the contingent valuation method (CVM) and discrete choice experiments (DCE).

Within the CVM framework, non-use values have been estimated for landscape services (e.g. Walsh et al. 1984; Vesely 2007), cultural heritage (e.g. Ruijgrok 2006) or biodiversity (e.g. Sattout et al. 2007) including charismatic species (Kontogianni et al., 2012). The latter are especially interesting examples: Hageman (1985) estimated the average WTP per household for the protection of the current populations of gray and blue whales, bottlenose dolphins, California sea otters, and northern elephant seals with associated relative proportion of use/non-use values for each species (e.g. pure existence value was stated to be 11.6 times as great as use value for the seals); similar results can be found in Langford et al. (1998) with existence values reaching almost 70% of their total WTP (use values representing less than 5%); another example is Kontoleon and Swanson (2003) who estimate that the existence value of giant pandas represents 73% of respondents' total economic value (TEV). Kontogianni et al. (2012) reported all these estimations in a review table, and pointed out that these impressive percentages of existence values within TEVs gave reason to be concerned about their validity (in relation with the warm glow effect). The author also stressed that this raised as well the issue of unfamiliarity with ecosystem services, thus ignoring systemic/functional role of particular species (Martin-Lopez et al., 2008),

Non-use values have also been estimated for marine protected areas, using both methods. DCEs' examples include among others McVittie and Moran (2010) with an application to the UK Marine Bill, or Windle and Rolfe (2005) who found a WTP of AU$3.21 per household for each one per cent improvement in the environmental health of an estuary in the Great Barrier Reef (which extrapolates to a State level value of approximately AU$674,100). A recent CVM example is given by Gillespie and Bennett (2011) with another Australian application concerning Marine Protected Areas in New South Whales. All of these studies estimate non-use values for non-users. Hargreaves-Allen (2010) used a combination of the market price method and CVM to estimate the total economic value associated with a Marine Reserve in Belize to the local community and tourists. They estimated a total value of over US$4 million per year, of which nearly 70% was associated with non-use values. In Australia again, Gazzani and Marinova (2007) estimated non-use values associated with management scenarios of Ningaloo Reef Marine Park through DCEs, and found an average WTP for an increased protection of sanctuary zone AU$26.12 per year. In another recent DCE work also applied to Ningaloo Reef Marne Park, McCartney (2011) highlighted the need but also the difficulty of estimating non-use values in an exclusive way using such a method. Indeed, non-use values estimates are still scarce within the academic literature applied to coral reef ecosystems, in comparison with other estimated economic values. In regards of marine ecosystems, Spurgeon (2004) suggests that (1) there needs to be more emphasis on marine non-use values, which may outweigh some of the use values, and (2) the reliability of the valuation techniques used needs to improve. Schuman (2011) also reviews non-use values estimates for coral reef ecosystems in the Caribbean, and concludes that much more work is needed. Laurans et al. (2013a) reach the same conclusion in a review of coral reef valuation in the South Pacific. The lack of non-use values (NUV) estimates especially the case for coastal communities, including those in poor economies, who hold important NUV associated with mangroves (Barbier, 2012). For example, a contingent valuation study of mangrove-dependent coastal communities in Micronesia demonstrated that the communities ‘‘place some value on the existence and ecosystem functions of mangroves over and above the value of mangroves marketable products’’ (Naylor and Drew 1998, p. 488).

It is thus important to point out that NUV have usually been estimated for high-income groups, and less frequently for low-income ones or indigenous people (O’Garra, 2009). More work is thus needed in this area, since such communities typically hold important non-use or cultural values for their natural environment (O’Garra, 2009). Among the very few studies that focused on this issue, O’Garra (2009) found that bequest values for traditional fishing ground of indigenous communities in Fiji are estimated at US$106.91 per household per year, using monetary as well as time-based contributions within a CVM framework. Zander and Straton (2010) showed using DCE that the willingness-to-pay of Aboriginal Australians was significantly higher than that of non-Aboriginal Australians for some river attributes, particularly those related to cultural values.

In practice, two commonly used approaches have been used to estimate non-use values. The first is to ask how much respondents are willing-to-pay for an ES (or several of its attributes in case of DCE) which it is absolutely certain they will never use - in this case interviews are based on what we will refer to hereafter as ‘non-users’. The second is to ask respondents, including users, to partition their total WTP for an ES into various categories, such as bequest, existence, own use etc. (e.g. Sattout et al., 2007; Togridou et al., 2006; Walsh et al. 1984).

Such stated decomposition approaches have been applied in numerous CVM applications concerning ES and have been helpful in understanding the relative shares of value categories in WTP estimates (e.g. Kontogianni et al., 2012; O'Garra, 2009; Sattout et al., 2007; Kaoru, 1993) or in identifying warm glow effects (Chilton and Hutchinson, 2000). Most of the time, the proportions of non-use values in WTP are found to be quite substantial, representing between 40 and 90% of total WTP (Kontogianni et al. 2012; Wattage and Mardle, 2008). Recently, Wattage and Mardle (2008) and Wattage (2010) offered an original version of the stated decomposition approach, using the Analytical Hierarchy Process to decompose Total Economic Value between use and non-use values.

Despite its popularity, the stated decomposition approach has substantial shortcomings and is highly controversial, mainly because of the cognitive difficulty of addressing unfamiliar and non-separable aspects of the valuation process (Carson et al., 1999; Cummings and Harrison, 1995; Silberman et al., 1992). An individual's total WTP for an ES is usually a consequence of different overlapping and interrelated motivations, which may be inseparable and as such inaccessible to the researcher (O'Garra, 2009; Cummings and Harrison, 1995; Carson et al., 1992).

As a consequence of these limitations, the first approach (i.e. directly estimating non-use values by deriving non-users' WTP/WTA) has been deemed to be more appropriate by some authors (e.g. Carson et al., 1992) and is more frequently encountered in the literature (e.g. McVittie and Moran, 2010; Windle and Rolfe, 2005). Although this approach is simpler, since it avoids having to deal with motivations and definitional issues, it constrains the valuation exercise to non-users, which implies a loss of information regarding the non-use values of users. Compared to non-users, we argue that users may be less subject to a number of biases which have been described in the literature on valuation for non-use values or stated preference methods, such as the "warm-glow" effect described by Kahneman and Knetsch (1992), "yea-saying" (Blamey et al., 1999), part-whole bias (Hanley et al., 2003), insensitivity to scope and unfamiliarity problems (Barkmann et al., 2008): this is because users have a better knowledge of the ES and a priori defined preferences. They will also tend to feel more concerned by management issues, and this can facilitate the credibility of the valuation exercise[9].

[9] Or make it more complex in case of a polemic issue, with possible strategic behaviours or protests answers.

There is thus a need to develop new frameworks for assessing non-use values that would also allow differentiation and estimation of non-market use and non-use values for users. To our knowledge, no studies have attempted to estimate this decomposition implicitly, i.e. without directly asking individual respondents. Furthermore, applying empirically such framework in the CME context, and with different socio-economic groups that also include indigenous people would also contribute significantly to the non-use values literature.

In this chapter, we propose a methodology to differentiate between use and non-use value components in stated willingness to pay (WTP) estimates, based on time decay. The methodology is tested in an empirical application to the estimation of non-use values associated with preserving New Caledonian coral reef ecosystems, in two different areas with different institutional, environmental and socio-economic contexts.

It is organized as follows. Section 2 first presents the two main stated preference methods and their underlying theory that allow estimating non-use values. Section 3 provides a pragmatic economic interpretation of non-use values based on the time-horizon over which ES preservation is considered. It also presents how this definition can be applied using discrete choice experiments and its associated modelling approaches. Section 4 details the materials and methods. It first presents our empirical application, using the protection of coral reef ecosystems in two coastal areas of New Caledonia as a case study, and then the different specification used in our econometric analysis. Section 5 gives our main results and the estimation of both use and non-use values for the populations living in these coastal areas. Finally, section 6 provides a critical discussion of our methodology and the results obtained, alongside the main conclusions.

2. Stated preference methods

2.1 Random Utility Theory

As noted before, a stated preference study typically involves individuals providing discrete responses to questions asking them directly or indirectly how much they are willing to pay (or willing to accept) for some hypothetical scenario involving changes in the ES of interest, with their responses recorded as a yes/no answer to a particular cost amount and associated scenario. Measures of WTP/WTA are then achieved by modelling the data based on utility theory, where choice is explained in regards of the maximization of utility, based on traditional neoclassical assumptions of rational behaviour. This implies a precise definition and understanding of the utility function, which can be simple in some circumstances but usually involves an unobservable component, since only specific aspects underlying the choices made are measurable, and the entire reasoning behind a decision cannot be entirely captured: it is unobservable to all but the individual making the choice (Hensher et al. 2005).

In order to deal with this issue Random Utility Theory (RUT) was proposed by Thurstone in 1927, then developed and improved within the economic literature initially by McFadden (1974), followed by multiple other contributions. The individual's utility function is described as the sum of two different components: a rational or systematic one (i.e. corresponding to explainable factors of choice), and a random one (i.e. unexplainable factors of choice). Thus, utility (U) for an individual n facing alternative i, is a function of the systematic component $\boldsymbol{V_{in}}$ and of an unobservable component $\boldsymbol{\varepsilon_{in}}$, both associated with the individual and alternative.

$$\boldsymbol{U_{in} = V_{in} + \varepsilon_{in}} \qquad \textbf{(1)}$$

It is then assumed that the probability of an individual n choosing alternative i depends upon the utility of i in relation to the utility of all other possible alternatives j within a choice set C_n. Therefore, following the maximization principle, individual n will choose an alternative i over alternative j if the individual's utility for i exceeds the utility associated with j. This gives the following formulation:

$$\boldsymbol{P(i/C_n) = P[(V_{in} + \varepsilon_{in}) > Max(V_{jn} + \varepsilon_{jn})]}, \text{ for all alternatives } i \neq j \text{ in a choice set } C_n \qquad \textbf{(2)}$$

Assumptions have then to be made in order to detail the form of this probability, first regarding the rational component. The most commonly made assumption is the additivity and linearity of the attributes or characteristics relative to the alternative (Lancaster, 1966), thus describing this component as a vector of attributes X (Hensher et al. 2005): $\boldsymbol{V_{in}=\beta X_i}$, where β is the vector of parameters associated with each attributes. This multi-attribute utility theory also forms the basis of the choice experiments method presented below, where a good is described as a bundle of attributes, or characteristics, with associated levels (Bateman et al. 2002).

Then, in order to allow for discrete choice modelling and econometric analysis, assumptions must be made regarding the random/error component, since it is unobservable, by specifying a random distribution. The most commonly encountered assumption is that error terms are independently and identically distributed (IID) and take on the form of a Gumbel distribution, also known as the type I extreme value distribution (Hensher et al. 2005), initially proposed by McFadden in 1974, following Thurstone's normal distribution.

Several other distributions associated with the IID assumptions have been proposed and studied, such as for example the multivariate normal distribution that implies the Probit Multi-Nomial discrete choice model (Hausman and Wise, 1978) or a generalized extreme values distribution implying Nested Multinomial Logit Models (McFadden, 1981) or Generalized extremes values models (Small and Rosen, 1981).

However, the assumption of IID is often debatable in practice (Hensher et al., 2005). An important implication of this assumption is the Independence from Irrelevant Alternatives (Luce, 1959), which states that the ratio of the choice probabilities of any pair of alternatives is independent of the presence or absence of any other alternative in a choice set. As Hensher et al. (2005, p. 479) note: "A particularly important behavioural implication of IIA is that all pairs of alternatives are equally similar or dissimilar. For the set of attributes that are not observed, this amounts to assuming that all the information in the random components is identical in quantity and relationship between pairs of alternatives and hence across all alternatives (hence the IID condition)." If a violation of the IIA hypothesis is observed in practice (through the use of a statistical test such as the one described by Hausman and MacFadden in 1984), then more complex models have to be used like the Nested Logit model (Hensher et al., 2005) or the most commonly encountered Random Parameters Logit model (Train, 1998; Train, 2003; Hensher et al., 2005).

Therefore, RUT implies a probabilistic choice in order to estimate individuals' preferences through the recognition of an unobserved component in the utility, implying a new formulation of the utility maximization problem using a probabilistic framework and random distributions. This theory underpins the econometric analysis of stated preference methods, the two main techniques of which are presented below.

2.2 From Contingent Valuation Method to Discrete Choice Experiment

2.2.1 Contingent Valuation

The idea of using surveys to estimate value of ES dates back to the 1940's (Adamowicz, 2004), with for example Ciriacy-Wantrup (1947). The aim is to estimate the value of a public good by surveying a sample of respondents and directly asking how much, if anything, they are willing to pay for the good of interest (similarly one can ask how much compensations they are willing to accept in case of a degradation). CVM is therefore the oldest stated preference technique, and eventually became the most well known one. Since then, the collected literature on stated preference valuation methods and applications has grown exponentially and there are now over 7,500 papers and studies from over 130 countries (Carson, 2011) on the approach and its application.

In the context of valuing ES, a CVM questionnaire includes a description of the current or status quo situation regarding the good, followed by a description of a proposed change in the management and/or policy relating to the good. Respondents are thus presented with a hypothetical scenario where they are asked to consider paying a sum of money either to maintain the status quo or to make the proposed changes, which may be real, or can be hypothetical if the good is not undergoing any current changes. WTA scenarios can also be built. Of course, it should be noted than when focusing on hypothetical changes, CVM is usually undertaken when there is a need or reason justifying a valuation exercise. Various question formats exist in order to elicit a hypothetical WTP response for CVM, ranging from open-ended questions where respondents are asked openly to state a sum of money to the more common discrete choice questions where they are asked to answer 'yes' or 'no' to various amounts of money to pay for the ES and its related changes. The later has become the more acceptable application (Hanemann, 1994): it indeed represents a more realistic situation since people are normally faced with making discrete choices when purchasing market goods. Finally, a mechanism for, and description of, the hypothetical market (i.e. payment) used to derive WTP/WTA is then necessary. Open-ended question turned out to be an unfamiliar format for respondent, as empirical evidence showed that it has been associated with large non-response rates, protest answers and outlying values (Bateman *et al.*, 2002): respondents usually find it difficult to express the most they will pay for something as opposed to whether they will pay a particular specified amount (Hanemann, 1994). Furthermore, a CVM questionnaire also includes various socio-demographic questions that have the potential to moderate respondents' WTP estimates: for example, income, age and gender.

Refinements have been made to the CVM technique over time (see Carson, 2011), but a more significant international academic focus arose with the famous Exxon Valdez issue and associated debates and concerns (Carson et al., 1992 and 2003), initiating the influential NOAA guidelines regarding CVM by Arrow et al. in 1993. Concerning the WTA/WTP issue for example, those guidelines recommended targeting on WTP rather than WTA when conducting an stated preference valuation, even where a WTA measure would be more appropriate due to property rights. This is indeed confirmed by a large volume of empirical evidence, showing that WTA estimates are typically higher (and often much higher) than WTP estimates (e.g. Knetsch, 1990, 1991); the so-called "endowment effect", fundamental to prospect theory (Kahneman and Tversky, 1979, 2000).

Total WTP for the good is estimated according to random utility theory. Referring to equations in the section above, the status quo and proposed change to the good can be considered as the alternatives, *i* and *j*, for econometric modelling purposes.

2.2.2 Discrete Choice Experiments

More recently, Choice Modelling and its most encountered application technique discrete choice experiments (DCE) have been added to the toolbox of stated preference practitioners. Based on the integration of discrete choice econometrics (McFadden, 1974; Manski and McFadden, 1981), attribute-based utility theory (Lancaster, 1966), and the conjoint methods used in marketing, the DCE approach was initially developed by Louviere and Hensher (1983) and Louviere and Woodworth (1983), and more and more intensively in the following years (e.g. McFadden 1986, 1996; McFadden and Train, 2000; Hensher et al., 2005). It has since spread to a diverse range of applications (Hensher et al., 2005), with early applications in the field of environmental valuation by Adamowicz et al. (1994) and Boxall et al. (1996).

DCE technique differs from CVM in that it focuses on valuing the different attributes of the good rather than the good as a whole (Morrison et al. 1996, Bateman et al., 2002). The questionnaire is designed in a similar format to that of CVM, but here the respondent is typically presented with a series of alternatives representing various proposed changes to the attributes of the good (Bennett and Blamey, 2001) involving a payment/compensation, amongst which he has to choose his most preferred one. These various changes are described by the several levels of the attributes listed. Ranking the alternatives can also be another option. Typically, when a large number of alternatives are involved, the respondent is showed successively several choice cards involving two or more alternatives/options (usually about three) between which he has to choose. Generally one of the options in each choice card is a status quo, or 'choose none' type alternative (Bennett and Blamey, 2001). The inclusion of a status quo is generally advocated in the context of scenarios relative to ES (e.g. Bennett and Blamey, 2001; Louviere et al., 2000) as it has several advantages: it reinforces the realism of the exercise (Carson et al., 1994), it allows better consistency with the theoretical validity of welfare estimations and it allows a more efficient statistical estimation of choice parameters (Louviere et al., 2000). However it can also implies specific bias that must be dealt with in the econometric analysis (Adamowicz et al., 1998). A typical choice card format is presented in Table 1-1.

Table 1-1 Typical example of questionnaire format in DCE

	Option A *(With or without label)*	**Option B** *(With or without label)*	**Status Quo** **or Choice Refusal**
WTP/WTA	Payment/compensation P_1	Payment/compensation P_2	Zero Payment/Compensation
Attribute 1 **Attribute 2** . . . **Attribute i**	Associated with a combination X amongst the levels relative to each attribute	Associated with a combination Y amongst the levels relative to each attribute, with X≠Y	Associated with the Status quo levels of the different attributes
Choice of preferred option	❑	❑	❑

Then, in accordance with RUT, the choice data collected are modelled to estimate preferences. WTPs are first estimated as marginal WTPs; total WTP can then be computed for specific scenarios. In other words, DCE allows estimating how much people are willing to pay to receive one unit (quantitative or qualitative) more of a particular attribute, as well as the relative values of different attributes.

Comparatively to contingent valuation, DCE offers several advantages (Adamowicz et al. 1998; Hanley et al. 1998), amongst which we identify the following non-exhaustive but important list:

- DCE focuses on trade-offs between the different attributes considered and their associated characteristics, and not solely on payment or quantitative valuation issue. Furthermore, they identify marginal values of attributes that are usually difficult to identify using other methods;

- Many management decisions are more concerned with preferences over scenarios of multi-attribute changes than changes occurring to the environmental good as a whole. It is easier and sometimes more relevant to estimate the values of the individual attributes (or several dimensions) that contribute to make up an environmental good such as landscape or coral reefs[10]. As such DCE also increases information provision, communication of the scope of issues considered and realism of the stated preference scenarios (Hanley et al., 2001);
- DCE allows avoiding the "yea-saying" problem relative to most contingent valuation designs, since valuation is more implicit with its repetitive framework and respondents are not faced with an "all or nothing" choice;
- The repeated sampling approach of DCE allows for internal consistency tests in the sense that models can be fitted on sub-sets of the data (Hanley et al., 1998);
- DCE allows reduction in hypothetical bias in comparison to CVM (Murphy et al., 2005) and strategic behaviour (Morrison et al., 1996);
- DCE allows reduction in embedding effects as respondents are constantly reminded of the range of levels of attributes (Hanley et al 1998; Hanley et al 2001).

As such DCE have been more and more employed recently as an alternative to the CVM, especially in the context of ES (e.g. Hoyos, 2010). Both techniques have been now widely applied all around the world to an important variety of the ES (Carson, 2011).

2.3 Validity and reliability of stated preference methods

As discussed before, an accumulation of evidence suggests that the neoclassical model of preferences itself may be inadequate (e.g. Kahneman and Tversky, 2000 or Lichtenstein and Slovic, 2006). A main issue here is the fact that preferences are reference-dependent (Kahneman and Tversky, 2000; Bateman et al., 1997), rather than defined on states of the world per se; and that preferences appear to be heavily influenced by framing and anchoring effects, to the extent that many authors view them as purely constructed (Lichtenstein and Slovic, 2006). Obviously this is not specific to surveys, but it contributes to the questioning

[10] Those first two points also imply that DCE offer advantages over CVM in terms of benefits transfer (in the case ES can be decomposed into measurable attributes and context variable such as socioeconomic are included in the models used).

of stated preference methods reliability regarding their main valuation objective in support of decision-making. Those issues are complex; however, it has been argued by several authors that questions about preference formation do not necessarily invalidate the use of stated preference methods, providing sufficient attention is paid to put them back in the right context (e.g. Bateman et al., 2002; Barkmann et al., 2008).

Furthermore, within the DCE framework, development in econometric models and methods allowed for considerable progress in refining preference analysis, with for example the possibility to account for preference heterogeneity (e.g. Campbell et al., 2008; Beharry-Borg, 2010), cultural context effects (e.g. Hoyos et al., 2009; Zander et Straton, 2010) or lexicographic or discontinuous preferences (e.g. Sælensminde, 2006; Campbell et al., 2008, 2008; Scarpa et al., 2009a,b,c; Hoyos, 2010).

Amongst challenges regarding stated preference methods (common to both CVM and DCE at different degree), the most prominent ones concerned: (1) lack of sensitivity to scope (Carson, 1997); (2) large context effects including concerns about existing knowledge and preference formation (e.g. Barkmann et al., 2008); (3) too large a disparity between WTP and WTA; (4) starting point bias (Kahneman and Knetsch, 1992; Diamond and Hausman, 1994; McFadden, 1996); and (5) "too small" income effects. Several explanations have been suggested for these effects, as well as associated solutions to deal with them in practice, including internal and external validity testing (e.g. Bateman et al., 2002; Hoyos, 2010).

The main types of validity testing are content validity, and construct validity (Bateman et al., 2002). Content or internal validity tests are based on: the conformance of the survey instrument, implementation approach and analysis with best practice approaches based on the existing literature (Bateman et al., 2002); and evidence from debriefing responses concerning how well the respondent understood the survey, believed the scenario and, as far as one can tell from this information, gave meaningful value responses (test and focus group discussions can be very helpful here). Construct or external validity tests examine the conformance of results with expectations (e.g. WTP is expected to increase with income), and with the results from related studies, e.g. revealed preference studies (the comparison of both revealed preference and stated preference results for a same case study is often encountered in the choice experiment literature, e.g. Adamowicz et al., 1994). In the case of non-use values, external validity test could only be achieved through looking at other studies estimated value in comparable contexts, or eventually in some specific cases by looking at data on charitable giving to recipient organizations or legacies data (Atkinson et al. 2012)

Another main practical concern regarding stated preference valuation studies is that they typically are performed at one point in time, with their results then used for decision making several months or even years later, making it necessary for values to be stable over time (or predictably different based on observable covariates). Empirical evidence suggests that this is often the case: several studies have administered similar questionnaires to independent samples at two points in time, and found that the estimated values, or valuation function, remained unchanged (e.g. Carson et al., 1997). Those results however can only apply provided there is no major external change regarding the ES of interest.

All in all, it seems that the continued progress on stated preference techniques and methods allows ensuring validity and reliability to a satisfying degree, provided sufficient effort and attention during the survey implementation, and provided the objective of the survey itself does not invalidate the reliability of the results.

3. A pragmatic approach to measuring non-use values

3.1 Proposed approach

We contend that the main characteristic of non-use values for a given ES is the wish (from both users and non-users) that it continues to exist during an indefinite period of time, which will extend beyond the life of the people considered in the evaluation. This does not refer only to existence values, since, for example, it could be mainly motivated by a bequest motivation or be based on other moral grounds (e.g. biocentrism) (Mazzotta and Kline, 1995). In economic terms, this can be measured via the WTP to preserve the ES over a period of time extending beyond the person's life expectancy. For users, any WTP for preserving the ES during their expected life duration may be linked to both use and non-use values (as well as possibilities for future use i.e. option values). But any WTP for preserving the ES beyond one's expected lifetime can be assumed to an exclusive, although conservative, measure of the non-use values associated with preserving the ES. This can provide an "*a minima*" estimate, which captures several important dimensions of non-use values, at least the ones commonly considered in the economic valuation literature (bequest and existence values). For non-users, in a temporal dimension, the economic quantification of non-use values can simply be estimated in terms of WTP to preserve any ES over any period of time. Table 1-2 synthesizes our interpretation in comparison to the commonly encountered estimation procedures of non-use values presented in the introduction. We note that our interest in this work lies in being able to characterise NUV for users, and it is the main motivation behind this interpretation.

Table 1-2 Estimating Non-use values for users and non-users: a new estimation procedure

	Commonly encountered estimation procedures: spatial distance and stated decomposition	**Proposed estimation procedure: temporal distance and implicit decomposition**
Estimation of non-use values for non-users	WTP for preserving ES that are unreachable or never to be encountered.	WTP for preserving ES over any time
Estimation of non-use values for users	Stated percentage of total WTP for ES currently used	WTP for preserving ES within life-expectancy: use, option and non-use values; WTP for preserving ES beyond life-expectancy: exclusive non-use values

3.2 Application through Discrete Choice Experiment

Estimating WTP over several time periods involves using stated preference methods. In order to quantify non-use values, applying the above definition, we propose to use DCE (in view of DCEs' advantages over CVM) and specify scenarios involving a payment for preserving several ES attributes over time, from the present until a time that lies beyond the individual respondent's expected lifetime.

For example, in one scenario, the individuals' payments would allow to preserve the ES in the near future only, but without any insurance concerning a more distant future. In another case, the payments could be used in a way that guarantees preservation over the next few years, but also over a long-term period: part of the money could be kept and secured (e.g. as a trust fund) in order to insure the success of a long lasting preservation. In order to illustrate this with a commonly encountered example, let us take the case of life insurance, in which the individual has three possibilities: (1) he uses all his money directly to insure present or short-term consumption; (2) he uses a part of his money only and saves the rest in order to use it later during his life-time; or (3) he uses a part only, saves another part for future use, and secures the rest as a life insurance for his children, family or friends when he will pass away. What we are interested in is finding the weight of each part, in case the last solution is chosen.

Furthermore, DCE also allows for testing of several assumptions regarding choice behaviour and the interactions between payment, characteristics/dimensions of the ES and non-use values.

The methodology we offer to put our non-use values interpretation into practice follows several steps listed below.

1- Identify through focus group discussions and multiple interviews the different relevant non-monetary attributes of the ES that is to be preserved. Since we are mostly interested in users, these attributes should correctly represent the preferences of the population relative to preservation issues. They should also allow some links to be established with possible management actions allowing preservation of the ES (e.g. water quality versus water clarity).

2- Choose the levels of these attributes, in such a way that they represent different preservation durations, which encompass the life expectancy of the population. These can be either qualitative (e.g. preservation during all your life, preservation during all your life and also for your children) or quantitative (e.g. preservation for 10, 20, 50, 100 years). A status quo level has to be defined for each attribute (i.e. what would happen if nothing is done in addition to current preservation efforts, if any).

3- Identify a monetary attribute, again with the help of focus groups or interviews. This attribute would usually take the form of a payment (although compensation and willingness to accept scenarios can also be interesting). As usual this payment should imply a range of quantitative levels (e.g. 5, 10, 20, 50 $) per month or year, and, in the case where the populations are not familiar with such monetary payments, other contributions could be used (e.g. time, constraints, efforts). An important point is that the payment should also be presented in such a way that it can guarantee preservation, or not, over several time periods (e.g. part of the money can be secured for insuring future preservation, or used to fund long-term preservation projects). Finally, answers to questions about a possible implementation of the payment should be anticipated (e.g. who will pay, is it compulsory, what specific forms, equity issues…).

4- Anticipate a choice model and design the choice experiments: choose the number of options, include and clearly define a status quo, build choice scenarios, select the number of choices any individual will have to make.

5- Create a questionnaire, with several sections, which aims at gathering data (socio-economic, demographic, environmental perceptions and awareness, uses and activities regarding the ES…), which could help understand choices and qualitatively study non-use values.

6- Test the questionnaire and choices, and after final reviews, launch the final survey with an appropriate representation of the different contextual elements we want to study (areas of survey, populations' characteristics, types of users…).

7- Analyse the results: test several choice models, from the Multinomial Logit model (MNL) to, if necessary, more complex models (e.g. Random Paramaters Logit, or Latent Class models) depending on assumptions and fit to the survey data. Examine choice behaviours and heuristics (especially regarding the cost attribute), and look critically at how choice models and all those assumptions can affect WTP estimates (e.g. Campbell et al., 2008; Rose et al., 2011; Carlsson et al., 2010), and thus quantitative NUV. Those lasts steps are especially important to allow for a critical analysis of the initial objectives, and a discussion about what conclusions to give to decision makers.

4. Data collection and econometric methods

4.1 Conservation of New Caledonian coral reef ecosystems

Our empirical application focuses on the conservation of coral reef ecosystems in two coastal areas of New Caledonia (Figure 1-1).

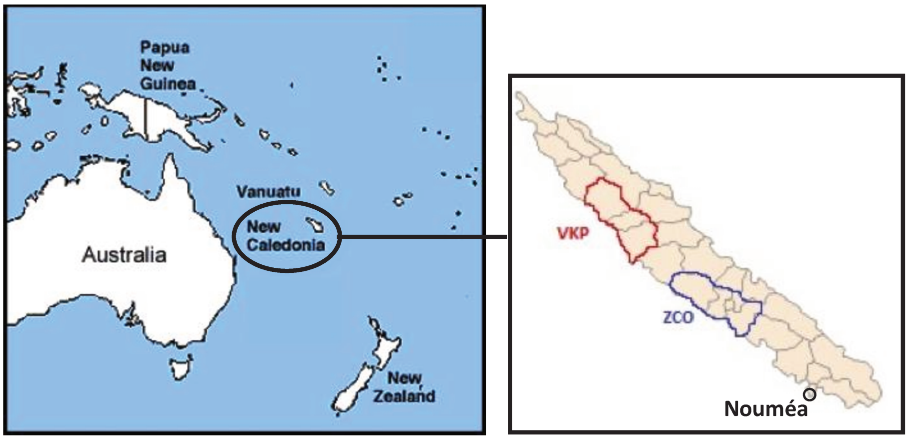


Figure 1-1 Localization of New Caledonia

A substantial coral reef complex with more than 4.500 km^2 of reef and more than 20.000 km^2 of lagoon zones surrounds this territory. New Caledonia has a low-density population of 13.6/km^2, with 245.000 habitants, of which around two thirds are located in or around the capital city of Nouméa. Interactions between people and the reef vary amongst the different cultural groups present in New Caledonia. Part of the population, mostly New Caledonians of European descents and European expatriates, is involved in a service-based economy with a moderate to high purchasing power. Another part, mostly indigenous Kanak people, participates in an economy that partly relies on subsistence agriculture and fishing, and occurs mainly within a tribal system. Thus, New Caledonian marine ecosystems are characterised by a high diversity of uses, populations (from a cultural as well as socio-economic perspective), anthropogenic pressures (which can vary from almost none to intense due to important mining industries and urbanization) and associated ecological status. In recognition of its outstanding biodiversity, considered to be of international importance, almost two-thirds of the lagoon area is listed as a UNESCO World Heritage site.

Two sites were selected to represent the different economic, social, institutional and development contexts of the territory (Figure 1-2 and 1-3). The area selected in the Southern Province is called “Zone Côtière Ouest” (ZCO) for West Coastal Area. It includes five districts: La Foa, Moindou, Bourail, Farino, Sarraméa. This area is among the sites listed as UNESCO World-Heritage, covering around 500 km^2 of coral reefs, mangroves, sea grass and estuaries, with a further 300 km^2 listed as UNESCO marine buffer zone. In addition, 1700 km^2 of terrestrial lands are listed under UNESCO buffer zones. Besides its beauty, the ZCO was listed in recognition of its significant role in New Caledonian coastal biodiversity: it encompasses some of the most important nesting sites for Loggerhead and Green Sea turtles, and it is home to one of the biggest populations of Dugongs in New Caledonia. The area also provides nesting sites for several sea bird species. Furthermore, compared to other areas in New Caledonia, the lagoon is especially narrow in this area, with the reef being close to the shore. That makes it more sensitive to anthropogenic pressures (e.g. erosion, domestic pollution), which are becoming more important as the population of the area is growing with a subsequent increase of marine uses and activities. In addition, the area is also facing a growing number of people coming from Nouméa for the weekends. Finally, a hotel "mega complex" development project on the coast of Bourail (Gouaro Deva), right near the beach and in front of an important marine reserve, has been started after long discussions and various polemics.

Figure 1-2 Map of ZCO area and associated UNESCO world-heritage zones

The area selected in the Northern Province is called VKP, in relation to its three districts: Voh, Koné and Pouembout. This is an especially crucial area for the Northern Province as it is hosting a considerable mining project (several nickel extraction sites and the building of a processing plant), which is supposed to redress the economic imbalance between the South and North of New Caledonia. This mining project aims – in addition to the resource rent it is expected to generate – at creating a socio-economic dynamic in the area, with a growing urbanization and immigration from other Northern areas (as well as foreign countries), thereby securing the economic independence for the Northern Province. The vast lagoon in VKP is therefore increasingly subject to external pressures, the main concerns being erosion, the dredging for vessels' channel and the waste release of the Nickel processing plant into the sea. Those marine ecosystems host an important biodiversity (coral reefs, sea grasses, huge areas of mangroves) with several protected species (e.g. green and hawksbill turtles, dugongs). Further, several populations present in this area are highly dependent on these ecosystems, with several coastal Kanak tribes whose people life is almost entirely based on traditional and subsistence fisheries activities. It is worth noting that there is also an important quantity of frequent recreational users (mainly fishers), amongst other populations. All in all, this is an area facing rapid economic development, with growing mining industry as well as domestic pressures, and where preserving coral reef and associated ecosystems becomes a crucial issue due to the number of recreational and traditional uses.

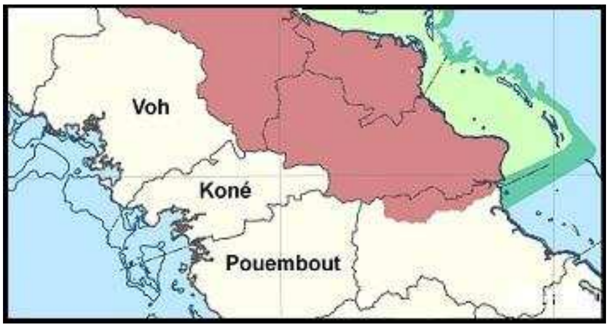


Figure 1-3 Map of Voh-Koné-Pouembout (VKP) area

It is important to note that each province in New Caledonia has its own independent political authority with considerable prerogatives, which include managing the economy and the environment.

Individuals in both areas are concerned about future development projects, which imply new conservation issues and a need for management. This was used as the basis for the conservation scenarios presented in the choice experiments. The same survey and choice experiments were conducted in these two areas, in order to study the role of several contextual elements in individuals' preferences regarding ecosystem protection over time.

4.2 Selection of attributes, levels and DCE design

The selection of attributes and their levels is undeniably one of the most crucial step in a choice experiment, since the choice processes that we are interested in will be based on them (Hensher et al., 2005). As Lancaster (1966) noted, to consider an attribute relevant means that if it was ignored, our conclusions concerning the individual's preferences would be different. If choices of individuals are in reality based on other attributes we did not consider, then our results will be seriously biased. Thus we must select attributes that explain the decisions of the individuals we are interested in regarding the preservation of the lagoon and coral reef ecosystems over time.

The difficulty is that the chosen attributes have to be defined in the most objective way, so that there are not different interpretations amongst individuals: the language used to define and describe the attributes should minimize the different possible interpretations. A related issue is the number of attribute to consider, as well as the numbers of their levels, which illustrates a compromise to be done between precision and handiness. These numbers have to be limited in order avoid too complex choices (Adamowicz et al., 1998), but also sufficiently high to allow for correct and consistent explanations and understanding of individuals' choices. As an example, to limit to only two the numbers of levels would force the analyst to conclude that the relation between utility and the selected attribute is exclusively linear for a change between level one and two (Hensher et al., 2005).

The selection of attributes and their levels involved several focus group discussions and interviews with different stakeholder groups, followed by tests in the two areas selected.

4.2.1 Attributes selection process

Several interviews with various scientists and coral reef and associated ecosystems preservation stakeholders were organized[11], as well as four focus group discussions: two with the IFRECOR local committee[12] (composed of scientists from different fields and institutions, representative of the provinces and French government, representative of conservations associations, and other stakeholders from different socio-professional fields), and two with the UNESCO committees from two different areas (the ZCO local UNESCO committee and another one from the east coast in the Northern Province) made up of a dozen representatives of users and populations. Discussions were also conducted with resource users (recreational and professional fishermen, scuba-divers, general recreational users) and individuals within

[11] These interviews and discussions were realized with members of all research institutions present in New Caledonia: the international French research organism IRD (Institut de Recherche pour le Dévelopment), the IFREMER (Institut Français de Recherche pour l'Exploitation de la Mer) and the University of New Caledonia (UNC), from various disciplines (marine biology, anthropology, geography, economy, geology…). Several discussions have also been conducted with the program manager of the Coral Reef Initiative for South Pacific (CRISP) as well as with members of local preservation associations, diving centres and even economic and development agency (ADECAL).

[12] The IFRECOR local committee is composed from 37 representatives of member institutions. Half of them participated in the focus groups, with at least one representative of each type of institution. Its detailed composition is provided on:
http://www.ifrecor.nc/IMG/pdf/Composition_CL_IFRECOR_2012.pdf

target populations (Kanak people living in tribe or not, New Caledonian white people, European people) were also conducted in ZCO, VKP and Noumea.

Following the different focus group, discussions and interviews, a wide range of possible attributes were suggested and examined, which were ultimately classified into different groups:

- Monetary attributes: several possibilities were explored for this attribute, from classic WTP payment (on a monthly or yearly basis) to other kind of possible money-equivalent contributions like time or specific efforts or constraints at individual levels. Indeed several problems arose concerning the commonly used WTP attribute: representative from the province and other stakeholders highlighted the fact that it is highly improbable and certainly not in the public agenda to create a tax or compulsory payment for all the inhabitants in order to help and sustain the coral reef ecosystems and lagoon preservation. Concerns were also raised that it could go against the current public policies basis which aims at developing individual awareness and commitments: several people mentioned in the discussions that such a payment could justify a kind of "I paid so I can do whatever I want" behaviour. Another issue was the important diversity of livelihoods and cultures present in New Caledonia, with subsequent possible different concepts regarding money: the Kanak clan and tribe system does also strongly rely on a non-monetary socio-economic system with important gifts and exchanges.
- Attributes regarding the populations' perception relative to the coral reef ecosystems and lagoon state such as water clarity, beauty of lagoon or coastal landscapes, pristine or healthy conditions (often associated with frequentation or pollutions), number of animal fished or observed, observation of emblematic species such as dolphin, manta rays, dugongs, turtles, etc.
- Attributes relative to scientific or more factual description of the lagoon or coral reef ecosystems state, such as water quality (with scales or associated indicators), stock of species targeted by fisheries, diversity and abundance of species for the different ecosystems (mangroves, sea grass, coral reefs) through different possible indicators, abundance of threatened species, measured degradation (due to frequentation, fisheries, erosion) in terms of habitat, diversity or abundance losses.

- Attributes relative to uses, activities and associated management measures such as areas of practices (surface), areas of marine protected areas (number and surface), construction and development on the lagoon or on the coast relative to marine activities or tourism, constraints and regulations (size and limited catches for fisheries, green zones, protected species...). Kanak traditional activities in relation to the coastal marine environment were also identified. These included tribal marine reserve, taboo marine zones, turtle fisheries (part of the traditional customs, called "La Coutume"), mangrove crabs fisheries (a woman traditional activity), and the presence and abundance of marine species that plays a role in the Kanak tradition (turtles, whales, marine totemic species).
- Attributes relative to coastal economic activities and development that impact the lagoon or coral reef ecosystems such as urbanization or specific pollutions (e.g. mining industry with waste and erosion, domestic and industrial pollution through garbage dump near rivers, pollution from agriculture).

Although the list of different possible attributes is considerable, it was necessary to choose a priori a maximum number of attributes to be selected in order to practically facilitate the survey. In most of the choice experiment literature applied to different kind of ES, the number of the attributes usually ranges from three to six, including the monetary attribute. Given the multiple characteristics of coral reef ecosystems and the lagoon, and the number of dimensions under which the problem can be studied, two non monetary attributes would be too few, while six attributes would add too much complexity in the choice sets (especially in view of the initial and quite simple purpose which aims at studying choice regarding preservation over time), as well as too many choice situations that each individual would have to face (budget and complexity constraint). As a result, it was decided that the final list would be comprised of four or five attributes, including payment.

Furthermore, in order to keep the exercise as policy relevant as possible, it was decided to concentrate on CRE and lagoon characteristics that can be actually managed through different measures. As a result, attributes involving management measures themselves or those that are impossible to manage because they too subjective (e.g. beauty of landscapes) were dropped. Further, the selected attributes had to be relevant for both areas (e.g. any attributes referring to UNESCO label could not be introduced).

Several possible lists of attributes were then tested on a range of stakeholders (on users, ZCO, VKP and Noumea populations, other scientists, ZCO Unesco committee...), and critically examined (also in view of what kind of results it could generate). In the end, the following list of attributes was finally selected:

1. A ***monthly payment***, which would take the form of a monthly monetary contribution; mainly in order to keep the exercise simple and generic, the DCE being conducted in two areas with different institutional and socio-cultural contexts. The monthly basis was preferred to a yearly basis for several reasons: households usually tend manage their budget and expenses more on a monthly basis that on a yearly basis; it is a more common way of contribution since several taxes are currently paid on a monthly basis; and an equivalent yearly basis would imply large sums of money that could lead to more negative perceptions of individuals. Concerning all the previously mentioned reasons that could invalidate the use of such an attribute, several points can be made. A time equivalent framework has been studied, but was found that it would probably result in more perception diversity than a payment: the relation with time is certainly more diverse in terms of interpretation and perceptions than the relation with money in New Caledonia, which was making the usual money-time equivalent with the average wage rate less relevant. Furthermore, all the tribes in the coastal areas studied are not really isolated, allowing a growing importance of, and interactions with, the market economy and a common use of money in everyday life. The fact that WTP could go against the awareness rising effort launched by public institutions was taken into account, and it was specified during the choice experiment exercise that any payment is made in addition to daily efforts and commitments to behave properly regarding coral reef ecosystems and the lagoon. The last concern regarding the fact that WTP through a tax or any compulsory regular contribution is not really realistically expected from the current institutions in New Caledonia (and thereby threatening the credibility of our methodology) was definitely a major problem. However, this does not necessarily mean that such a payment would be perceived as such by all the population so that we decided to keep the payment attribute and study properly during the analysis how it was specifically handled and accounted for by individuals during their choices.

2. The ***quantity of animals fished***, referring to the total catches of finfish, crustaceans, molluscs etc. from the different fisheries (recreational, commercial, subsistence/traditional) in the area, which can be sustained over the long term
3. The ***health and richness of marine life***, referring to ecological conditions of coral reef and associated ecosystems: abundance and diversity of habitats and species, as well as water quality.
4. The ***coastal and lagoon natural landscapes***, referring to the natural aspect of current coastal (mangroves, beaches, estuaries, bays) and lagoon (islets, reefs) landscapes.
5. The ***areas of practice***, referring to places (coast and lagoon) that people and the community currently use for common activities.

4.2.2 Levels selection process

In parallel of the attributes selection, the question regarding their description through different levels was studied. As stated before, the levels should be defined as describing the preservation of selected attributes over time, allowing a distinction between the current situation, and that over the life expectancy of the respondent. Furthermore, the initial idea was to describe all our non-monetary attributes in exactly the same way since the objective is to study preservation over time for each attribute. Doing it in a similar way for each of them simplifies greatly the choices exercise for respondent, and allows also interesting and easier comparison between preferences over the different attributes regarding their preservation through time. From a methodological perspective, it also simplifies greatly the issue of the choice experiment design.

The selection of the levels involved three issues: the number of levels, the choice between qualitative or quantitative descriptions of the levels (and following relevant levels selections) and the definition of a status quo, which has to be common to both areas.

Concerning the number of levels, as noted above there is a trade-off between too few and too many levels. Two levels are not enough to allow detailed and robust characterisation of the attribute's relation to individuals' utilities. However, the more levels we include for each of the attributes, the more complicated becomes the choice process for individuals since they will be facing more choice situations involving many possible outcomes. Furthermore, concerning the "price" attribute, it is generally recommended to allow for a sufficient range of possible payments in order to account for the diversity of possible WTP and associated budget constraints among respondents: in the choice experiments academic literature regarding ES, the payments are usually described through 4 and 6 levels, including a zero/no payment. For our study, and in regards of our context and objectives, we thus decided to limit to four the numbers of levels for our non-monetary attributes, and to five the levels of the payment attributes.

Regarding the quantitative versus qualitative issue, two kinds of levels descriptions were thus imagined for the non-monetary attributes:

- Qualitative descriptions with three levels: 1. "No additional preservation and following consequences" (status quo), 2. "Preservation guaranteed during my lifetime", 3. "Preservation guaranteed during and over my life-time";
- Quantitative descriptions with four levels: 1. Status Quo 2. Preservation for 10/20 years 3. Preservation for 50 years 4. Preservation for/over 100 years.

Several possibilities were tested on populations and during interviews, and while initial discussions did suggest that the qualitative descriptions were simpler, it appeared that they were finally raising several questions for the respondents (e.g. "what do you mean by over my life-time?") and not especially relevant in terms of policy-making and also credibility of the exercise, since individuals appear to perceive in quite different ways their "lifetime". Replacing the word lifetime by the more precise expression "life-expectancy" was also tested but still pointed out as unclear by certain respondents. All in all, the quantitative descriptions seemed to work best on the field, as well as allowing for a more precise computation and mathematic representation of preservation demand over time. The time horizons of preservation for **20**, **50** and **100** years were finally selected, after hesitations between 10 or 20 years[13].

Finally the status quo was interpreted and presented to respondents as "what would happen in the future if no additional preservation measures were taken". This involved progressive

[13] The 10 years duration, though interesting because involving a short term perspective, was abandoned in regards of the status quo considerations (which was defined qualitatively as serious degradation over the long term if no additional preservation measures are undertaken) and also because of the important gap between 10 and 50 years: after several tests on the field, we concluded that 10 years was perceived as still pretty close from today, whereas 20 was perceived as already a bit far in terms of guarantees; thus selecting 20 years over 10 years for our levels would minimize the risk of having too many people choosing 50 years because 10 years was too short, although they would have maybe preferred to choose 20 years.

degradation of marine ecosystems due to the rapid undergoing changes in both areas, in view of the different local development projects under way, the growing number of recreational users in the lagoon and external environmental pressures (e.g. climate change).

We finally note that another consideration during the attributes and levels' selection was about their independence, i.e. we did not want respondents to see them as related to one another. If this would be the case, the statistical design would have to account statistically for such a dependency. Since one could potentially assume functional dependency between several of our attributes (for example quantity of animals fished and health and richness of marine life or areas of practice), we checked this during the choice experiment pre-testing phase. More precisely we asked the respondents directly whether they saw a specific relationship between the attributes and associated levels when being presented with the choice sets, and if this would make some combinations unrealistic, or reduce the credibility of the choice sets. This was not the case, so that we decided to consider these attributes and their levels as independent in our design.

4.2.3 DCE design

The list of selected attributes and associated levels is presented in Table 1-3. It was presented in as a small booklet during the surveys (see Appendix F). Regarding the monetary attribute, a monthly payment in Pacific Francs[14] (CFP) was selected with the different amounts of the payment being chosen during the interviews and focus group, in relation to the important diversity of income. The payment was presented as being per household, but the respondents were asked to answer as the household's representatives and according to their own preferences. In order to put in perspective these payment levels, we note that the median monthly net income was around 404,600 CFP per household in 2008 (with a median monthly salary of 204,000 CFP) (ISEE, 2008).

The scenarios thus implied a monthly payment that could be used by local organisations to guarantee the preservation of coral reefs and associated ecosystems in each area during 20, 50 or 100 years. Each month, part of the payment could be secured (e.g. in a trust fund) to guarantee preservation over longer periods of time (i.e. 50 or 100 years). The potential lack of credibility of the choice experiment was carefully considered: for example by reminding respondents of their budget constraint or justifying the relevance of the choices in view of the

[14] In 2013, 100 CFP was equal to around 0.84 € or 1.08 US$.

broad context of international (e.g. climate change) and local (e.g. mining, growing marine activities) pressures, and associated risks for the future. The questionnaire and choice scenarios were also presented as being endorsed by the IFRECOR program, to reinforce the legitimacy of the exercise. The creation of the scenarios involved the generation of a statistical design.

Table 1-3 Attributes and levels

Attributes	Levels	Status quo
Payment	**500**, **1000**, **1500**, **2000** CFP per month	0 CFP
Quantity of fished animals	Preservation for **20**, **50** or **100** years	Progressive decline over time
Health and richness of marine life	Preservation for **20**, **50** or **100** years	Progressive degradation over time
Coastal and lagoon natural landscapes	Preservation for **20**, **50** or **100** years	Less natural areas and more constructions
Areas of practice	Secured for **20**, **50** or **100** years	Sufficient areas of practice not guaranteed for future

Statistical designs (also called experimental design) describe the various combinations of attributes' levels that make up the alternatives within each choice set, and the combinations of choice sets within each version of the survey. Since the total number of combinations of attribute levels, even in relatively simple choice models, can be very large it is necessary to use some systematic approach to select the combinations of attribute levels in alternatives and choice sets in order to provide sufficient information to allow estimation of relative effects within the constraints of practical sample sizes (Scarpa and Rose, 2008). Alternative statistical designs can be described in terms of their efficiency, which relates to the precision with which parameters in the choice model can be estimated.

Our statistical design for the choice experiment was generated using SSI Web 6.0 Sawtooth Software. As traditionally encountered in the choice experiments literature, the number of random alternatives in each choice task was set initially to two, in order to allow for easier choices, with a third fixed alternative corresponding to the status quo which was added once the design was generated. Two random alternatives and a status quo imply easier choices than three or more random alternatives. Given our context, we used an "unlabelled experiment", i.e., alternatives are referred to as Option 1 and Option 2 rather than given descriptive labels, and a generic utility function will be applied to both alternatives in the estimation.

A 48 choice cards design was generated and blocked into six different versions of eight choice cards. This final number of choice tasks was selected after field tests, design simulation, and design efficiency comparisons with lower choice tasks. The selected method by which the random choice tasks were generated is complete enumeration[15], allowing us to produce an orthogonal main effects fractional factorial design, which was balanced (i.e. each level of an attribute is used exactly the same number of times) and with minimal overlap. The statistical design was tested and found to be efficient. It was found to be efficient using D-efficiency comparisons and allow estimation of statistically significant main effects given a sample size of 500 respondents, assuming 15% of no-response (based on the experience from our field tests). In testing our design we examined four criteria:

- The frequency with which each attribute level appears (optimal in this case, as noted before);
- The standard errors of the main effects using a Multinomial Logit Model (MNL) and simulated response data for our design;
- A comparison of D-efficiency with another design with 30 versions instead of 6 - same test specifications (MNL and simulated response data). This is to test whether the number of version was a significant limitation on the design (the restriction on the number of versions of the survey to six may also be a source of inefficiency);
- A comparison of D-efficiency with a random design (instead of full enumeration that we used) and with the same test specifications. This is to test whether the full enumeration design is a significant improvement on a random design.

The results of the statistical design tests are given in Appendix E. From these tests, we can conclude that our design is fine regarding all the previous criteria. We thus have a design that includes 48 choice situations (presented in a choice card), divided in 6 groups (choice sets) of eight choice cards. An example of a choice card is given in Figure 1-4, and one of six versions of the different choice sets is presented in the Appendix F (in French).

15 This design strategy considers all possible alternatives and chooses each one so as to produce the most nearly orthogonal fractional factorial design, in terms of main effects (Chrzan et Orme, 2000). The concepts within each task are also kept as different as possible (i.e., there is minimal overlap).

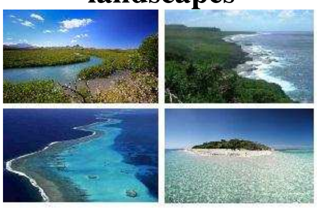
	Option 1	Option 2	Status Quo: future without any additional management
Payment 	**500 CFP / month**	**1500 CFP/month**	**0 CFP/month**
Quantity of animals fished 	**Preservation for the next 20 years**	**Preservation for the next 50 years**	**Progressive decline**
Health and richness of marine life 	**Preservation for the next 50 years**	**Preservation for the next 100 years**	**Progressive degradation**
Coastal and lagoon landscapes 	**Preservation of current natural landscapes for the next 20 years**	**Preservation of current natural landscapes for the next 50 years**	**Less natural areas and more constructions**
Areas of practice 	**Sufficient areas of practice not guaranteed for future**	**Sufficient areas of practices guaranteed for the next 20 years**	**Sufficient areas of practice not guaranteed for future**
Preferred Choice	❑	❑	❑

Figure 1-4 Example of a choice card

Within the survey itself, another option of "Choice refusal" was added, so that the individuals who refused to participate in the exercise could say so (with a follow up question asking for their reasons). This avoided the assumption that these individuals had a preference for the status quo, while they were in fact opposed to the choice exercise itself, or to the formulation of the management problem (for example they could be opposed to a compulsory payment, which does not necessarily mean that they have a preference for the status quo since alternatives management are certainly possible). This is an important point that will facilitate the analysis.

4.3 Questionnaire, sampling strategy and survey

4.3.1 Development of the questionnaire

A robust SP questionnaire typically includes the following main components (Bateman et al., 2002): an introductory section on usage and experiences; a section of demographic questions; the main valuation section; and a set of debriefing questions asking how valuation questions were made. It is also common to include a debriefing section at the end of the questionnaire to give interviewers an opportunity to comment on the respondent's understanding of the questionnaire and level of concentration shown, immediately after they have completed the survey. The questionnaire for this study was developed in a similar way.

The development of the questionnaire was done progressively over a period of several months, in which several field tests (on different populations representative of the two areas selected) in order to make sure the questions were clear and understandable. This was indeed necessary in order to cope with the complexity of targeting various populations from totally different socio-cultural background. The questionnaire was also sent to various stakeholders for final reviews comments (IFRECOR local committee, the professional survey company with which our final field work was planned, as well as several researchers from the different New Caledonian institutions). The final version, in French, is presented in Appendix G. It included several sections:

- An introductory text for the interviewed individuals presenting the survey and its context;
- A first "General Information" section which aimed at collecting several information from the individual and his household: place of childhood, current residence, satisfaction factors in their daily life, types of activities practiced on the lagoon

(different types of fisheries, diving, snorkelling, boat trips, beach) and their associated activities;

- Three sections - one for fishing activities, one for diving and snorkelling, one for other general recreational activities - that aimed at getting more detailed information regarding these activities if practiced on a regular basis (more than once per month for diving/snorkelling, at least once per week for fishing and other recreational activities): mainly frequented types of ecosystems and areas on the lagoon and the various factors of satisfaction regarding these activities (with an associated qualitative scale ranging from not important to very important);
- A "Demographic and Socio-economic section" which aimed at collecting data regarding the individual's household (number of persons, children, grandchildren…), the age, sex, education level and professional activity of the individual, the net mensal income of the household, and finally the origin of the food consumed in the household (fishing, hunting, home-grown, bought in supermarket…);
- A section regarding the "Marine Environment and preservation", which aimed at capturing the individual's perceptions and awareness regarding the marine environment and associated preservation issues (main perceived threats on the lagoon, daily "green" actions in favour of the environment, personal motivations that justify the lagoon's preservation, perceptions regarding emblematic species…);
- The DCE section, where the eight scenarios were presented to each individual (6 individuals are thus necessary to complete all the 48 choice cards), with the necessary explanations insuring the good understanding of the exercise (introductory explanations to be made by the interviewer along a plasticized booklet including the presentation of the attribute and a choice card example). It was also mentioned that once the individual had begun to make some choices, it was absolutely crucial that he or she was going through the full eight choices.
- A last section relative to the choices made by the individuals that aimed at collecting data regarding their choice processes: the differential consideration or importance they attached to the various attributes (to what extent they took them into account during choice), their interpretation of the attributes and associate levels (e.g. perception of each different duration), their suggestions concerning a possible implementation of the hypothetical payment, the reasons in case of a systematic refusal to choose or selection

of the status quo. This section is absolutely crucial for the analysis to be conducted. An objective behind these questions was to help cope with the main potential limit of our methodology, namely the potential lack of credibility of our scenarios and the associated payment mentioned earlier, by looking at the way individuals considered the payment attribute (or not).

4.3.2 Sampling strategy

The base population of the survey covered all the residents in the areas selected (ZCO and VKP), and hence excluded any individual who is not living in the area (e.g. tourists). As the survey budget was limited, and it was considered important to study contextual effect, it was thought that it is better to focus on actual inhabitants of the areas, as working on two different areas with associated populations is complex enough. Moreover the survey was limited to individuals who were more than 20 years old, which were identified as the individuals of interest, mainly because of the hypothetical payment implied in the choice experiments.

A random stratified sampling method based on quotas derived from the last population and socio-economic census data from the "Institut de la Statistique et des Etudes Economiques" (ISEE, 2009 and 2004) was used for sample selection. Several representative quotas for the surveys were thus identified for each area and each district, in view of several criteria:

- Age, divided into five groups: 20 to 29, 30 to 39, 40 to 49, 50 to 59 and more than 60 years old;
- Gender;
- Cultural origin, divided into four categories: European people, white New Caledonian people, Kanak people and others (mostly from other South-Pacific communities, Indonesia and China);
- Populations living in tribes;
- Socio-professional categories (10 in total).

The population's percentages based on census data were identified for each criterion and then multiply by the number of total interviewed to be conducted in each area, per district). Indeed, the objective was to establish and respect all the quotas for each district in each area. In addition to all these criteria, the sample selection aimed at being representative of the populations' geographical distribution as much as possible.

The detailed quotas per zone and districts are presented in Appendix H. In total, eight districts were surveyed from two distinct areas. The total target number of surveys was set to be 250 for the ZCO area[16], and 300 for the VKP area, leading to a total of 550 surveys. The final sampling frame thus included a substantial amount of quotas to be respected, hence allowing our survey to be highly representative and insuring the capacity to conduct future possible analysis regarding all these populations' categories.

In addition to the quotas, each choice set version was utilized the same number of times, in order to respect the experimental design and avoid any subsequent bias in case one version is more used than another.

4.3.3 Conducting the surveys

The 550 surveys were conducted through face-to-face interviews. 400 surveys were conducted by a professional survey company ("Enquêtes statistiques Sondages Calédoniens", ESCAL). The PhD student conducted 150 surveys himself, and participated in the supervision of the others. The face-to-face interviews were conducted from September 2011 to February 2012.

Local experienced interviewers were selected by the Survey Company, as well as supervisors. A formation was organized with all the interviewers and supervisors, in order to explain them the main objectives of the survey and to review the questionnaire so that they are perfectly comfortable with it. General interviews procedures were also reviewed, and a specific amount of time was spent to explain and make the interviewers familiar with the choice experiment, the realization of which demands indeed specific knowledge and skills. Intensive trainings through tests interviews were also conducted.

Surveys were then conducted during a first field work period, during September and October 2011. The PhD student conducted his 150 surveys within two districts of the VKP area (Voh and Pouembout) with an especially important amount of time dedicated to interviewing individuals living in tribes (authorization from each tribe's headman had to be obtained, through the traditional "Coutume"). It should be noted that conducting surveys in this area was complicated by the fact that there are important tensions within the populations, due to

[16] Though both population have almost the same number of more than 20 years old inhabitants (around 6700 inhabitants for ZCO et 6400 for VKP), it was decided to conduct more survey in VKP in order to allow us to interview enough individual living in tribes, thus insuring that we have collect enough choice data for analysis regarding this population.

the mining project, especially in some tribes. A progressive and cautious approach was thus strongly needed, in order to account for existing tensions and irritation among the populations, notably through attentive conversations and discussions. Regular contact was established with the Survey Company, as well as a few days supervision by the PhD student of a team of interviewers to make sure the job was correctly done. Two full-time supervisors from ESCAL were also supposed to control the work of the interviewers on the field.

Following this first fieldwork period, some anomalies and problems (e.g. contradictions and logic problem within one interview) were discovered within the survey database from ESCAL, with almost half of the database not corresponding to the actual information in the questionnaire. Several interviewers and supervisors did not do their job properly, especially in relation to the choice experiment sections, which were often not completed. In view of this major problem, it was then agreed that ESCAL would re-conduct entirely more than half of the original surveys, this time under the complete and full-time supervision of the PhD student, and the director of ESCAL herself.

A second survey period was thus organized in February 2012. New local interviewers were carefully selected and a sample formation conducted. Several measures were taken to avoid any problem, such as the systematic collection of phone numbers from the interviewed individual (in complete anonymity) in order to check that every interviewer did make a good job, in addition to an intensive supervision on the field. Specific procedures were adopted in view of the situation (for example, in case the individuals had already been interviewed before). Finally, during this new survey, around 250 new interviews were conducted which allowed us to remove all the suspicious previous survey data from the ESCAL initial database, thus minimizing possible bias. Each questionnaire from these new surveys was examined closely, with particular attention paid to the choice experiment section and the following section. This time no problem was discovered, as the interviews were conducted in a very robust way. During the analysis, specific tests were implemented in order to check for eventual bias linked to interviewers and survey periods[17].

[17] By including dummy variables associated with the two surveys periods or with each interviewer in the utility functions, or by running separate models for each survey period and comparing the results.

4.4 Econometric analysis

The econometric analysis of the DCE results is based on Random Utility Theory, which was presented in section 2 above.

In the first stage of the analysis, a range of different conditional and MNL models (McFadden, 1974) were used to examine the data and specify the utility functions. These were run for both regrouped areas, each area, and several pre-defined specific groups of individuals (age, tribe versus non-tribe, cultural origin). MNL models also allow studying the role of various context variables through their inclusion in the utility function. Then more complex models were run, including the Error Component Logit model, the Random Parameters Logit model (RPL) (Train, 2003) and the Latent Class Model (Swait, 1994). Here again, these models were run on different groups (pooled sample, each area, socio-demographic categories etc.).

4.4.1 Conditional and Multinomial Logit Model

The MNL model is based on the assumption that the unobservable component ε is independently and identically distributed through Gumbel distribution (McFadden, 1974), implying that the probability of choosing alternative i can be calculated by the equation (McFadden, 1974):

$$\text{Prob}(i) = \frac{\exp^{\mu v_i}}{\sum_{j \in C} \exp^{\mu v_j}},$$

Furthermore, within the MNL model, the observable component of utility (V) is usually expanded as follows:

$$V_{in} = ASC_i + \beta_{1i}X_{1i} + \beta_{2i}X_{2i} + \ldots + \beta_{ki}X_{ki}\ .$$

ASC$_i$ is an alternative-specific constant which represents the mean effect of the unobserved factors in the error terms for each alternative (Hensher et al., 2005). The X_k are associated with each attribute used in the choice experiment, while the β_k coefficients are included to capture the corresponding part-worth utility associated with each attribute for all k attributes. In our case, the *ASC* is associated to the Status Quo alternative, with both option A and B having exactly the same utility functions. We thus have:

$U_{option\ 1\ or\ 2}$ = β_1* Payment + β_2*Preservation Quantity of animals fished + β_3*Preservation Health and Richness of underwater life + β_4*Preservation Coastal and lagoon landscapes + β_5*Preservation Areas of practice + IID Gumbel distributed errors

$U_{statu\ quo}$ = ASCsq + β_1* Payment + β_2*Preservation Quantity of animals fished + β_3*Preservation of Health and Richness of underwater life + β_4*Preservation of coastal and lagoon landscapes + β_5*Preservation of areas of practice + IID Gumbel distributed errors

During the econometric analysis, the β_k coefficients are derived using a maximum likelihood analysis, by fitting the choice model to the observed data on the stated choice probabilities (aggregated over all respondents) and the experimental design used to define the attribute levels seen by respondents for each choice set. Then, marginal WTP can be estimated for each attribute through the following formula (Hensher et al., 2005):

$$WTP = -\beta_{kj} / \beta_{payment}$$

Furthermore, different part-worth utilities can be observed depending on attributes levels, or attributes part-worth utility might not be continuous. Non-continuity or non-linear effects can thus be accounted for and modelled through the equation below. In that case marginal WTP can be estimated for each attribute level.

$$V_{in} = ASCi + \beta_{1.1\,i}\, X_{1.1\,i} + \beta_{1.2\,i}\, X_{1.2\,i} + \beta_{1.j\,i}\, X_{1.j\,i} + \ldots + \beta_{k.1\,i}\, X_{k.1\,i} + \beta_{k.2\,i}\, X_{k.2\,i} + \beta_{k.j\,i}\, X_{k.j\,i}$$

For an alternative *i* with *k* attribute and associated *j-1* levels.

Interactions between attributes can be added to the equations. We used mainly this last specification for our MNL, although we will also try to make our attributes enter the utility through a non-linear and continuous form. Indeed it is possible that in view of the current theory and understanding of time-preference, the marginal utility for preservation over time might decrease, leading to another type of (non-linear) utility function for our attributes and associated levels.

From a more general perspective, the utility might also be depending on other observable characteristics w_h, like socio-demographic variables for example. These might even interact with the attributes part-worth utilities. We thus have the following general formula for the MNL:

$$V_{in} = ASCi + \beta_{1.1\,i}\, f(X_{1.1\,i}, \mathrm{w_h}) + \beta_{1.2\,i}\, f(X_{1.2\,i}, \mathrm{w_h}) + \beta_{1.j\,i}\, f(X_{1.j\,i}, \mathrm{w_h}) + \ldots + \beta_{k.1\,i}\, f(X_{k.1\,i}, \mathrm{w_h}) + \beta_{k.2\,i}\, f(X_{k.2\,i}, \mathrm{w_h}) + \beta_{k.j\,i}\, f(X_{k.j\,i}, \mathrm{w_h}) + \sum_h \mu_i\, \mathrm{w_h}$$

In our case, we tested for example for the impact of age, sex, cultural origin, tribe and non-tribe population on overall utility as well as possible interaction with the attributes (e.g. age with different preservation duration).

The MNL model is the most widely used in the field of choice modelling, due to the ease and speed with which the model can be estimated. Indeed, it is the simplest choice model available, and it allows for a good understanding and exploration of the data (Hensher et al., 2005), thus helping formulating hypothesis or further analysis that would need a more complex model to be tested or implemented correctly.

Despite its common use, there are severe limitations to this model with respect to its ability to capture random taste heterogeneity across individuals, in particular the panel nature of repeated choices and the well-known assumption of independence of irrelevant alternatives (Train, 2003). Therefore, in the second phase of this analysis two more flexible econometric models were used and tested, namely the latent class model (LCM) and Random Parameters Logit models (RPL).

4.4.2 Latent Class Logit Model (LCM)

The LCM allows accounting for the possibility that preference heterogeneity can be explained in terms of several groups of preferences. Indeed, the LCM sorts decision makers by different classes based on similar choice behaviours, and simultaneously estimates their utility parameter conditional on class membership (Swait, 1994). For each decision maker, probabilities to belong to each segment are thus estimated.

Two different kinds of LCM can be used: either the analyst chooses to specify some observable variables (e.g. age) to predict an individual's membership in a class, thereby capturing observed taste heterogeneity (e.g. Ruto et al., 2008; Boxall and Adamowicz, 2002); or there are no obvious observable variables and the model accounts for only unobserved taste heterogeneity based on the influence of the attributes that were captured (e.g. Beharry-Borg and Scarpa, 2010). In both ways the analyst is defining the number of classes, based on judgments as well as on comparing models with different number of classes and examining the Akaike Information Criteria (Beharry-Borg and Scarpa, 2010). In our analysis, we used the LCM to account for unobserved taste heterogeneity. Besides, a panel specification was used to account for the repeated choices.

Furthermore, the LCM allows the estimation of ‘individual-specific’ or ‘conditional’ parameters (i.e. based on the individual's choices), thus identifying the distribution of preferences among the sample (Train, 2003). As such, based on Bayes’ theorem, it is possible to calculate the probability of an individual n being in a class c conditional on the choices made by that individual (Q^*_{nc}) (Greene, 2005; Scarpa and Thiene, 2005) and it is then possible to derive individual-specific posterior estimates of marginal WTP through the β parameters (Scarpa and Thiene, 2005; Beharry-Borg and Scarpa, 2010):

$$WTP_{n,att} = \sum_{C} Q^*_{nc}\left(-\frac{\beta_{c,att}}{\beta_{c,payment}}\right)$$

where $\beta_{c,att}$ and $\beta_{c,payment}$ are respectively the parameters for a non-monetary attribute and for the payment in class c.

Within our analysis, we used this conditional parameters estimation procedure in order to be able to estimate non-use values at the individual level, in accordance to our definition. Although less flexible than the random parameters logit model approach presented below (in terms of examining preference heterogeneity and the impact of socio-demographic variables), we choose to use LCM during our analysis and present some of its results because of their simplicity and ease of interpretation.

4.4.3 Random Parameters Logit models (RPL)

The RPL assumes that preference intensities vary continuously across respondents. When using an RPL, the analyst has to specify the distribution of the attribute coefficients. Normal distributions are the most commonly encountered within the literature (Hensher et al., 2005), and we initially tested such distributions for our non-monetary attributes. However, when the sign of the coefficient is not expected to change and stays either positive or negative, constrained distributions can be used, such as the constrained triangular distribution. If heterogeneity is observed for the cost parameters, it is usually recommended that the constrained triangular distribution be used (e.g. Beharry-Borg and Scarpa, 2010; Scarpa et al., 2012): this leads to more behaviourally plausible WTP estimates, and also insures a negative cost parameter (Hensher and Greene, 2003). We therefore used constrained triangular distributions for our payment attribute.

Due to our design involving repeated choices with a fixed alternative (status-quo), an error component specification was also used. This type of model has been shown in the literature to produce higher model fit and robustness in this context (Hess and Rose, 2009), by incorporating a zero-mean normally distributed random parameter (i.e. the error component, usually noted μ) additional to the usual Gumbel-distributed error term in the non-status quo alternatives. The error component aims at capturing any status quo effects in the stochastic part of the utility, i.e. any additional variance associated with the process of choosing experimentally designed alternatives over the status quo (Scarpa et al., 2005; Train, 2003).

In the end the utility function takes the form below, with three alternatives $i=1, 2, 3$ (the third being the status quo), for individual n, and choice set s. In this utility function, β_k are randomly distributed.

$$U_{sin} = \begin{cases} V_{sin}(\beta_k, X_k, \mu) + \varepsilon_{sin} \ , \ i=1,2 \ ; \\ V_{sns}(ASCsq, \beta_k, X_k, \mu) + \varepsilon_{sin} \ , \ j=3(status\ quo) \end{cases}$$

In deriving WTP, once the parameters have been estimated, the analyst must take into account the fact that some parameters are randomly distributed. Both unconditional and individual-specific WTP estimates can be estimated (Hensher et al., 2005). Estimating WTP at the individual level (rather than averaging WTP on all the population), produces more accurate estimates since this takes into account taste heterogeneity at the individual level (Hensher et al., 2005; Green et al., 2005). Based on Bayes' theorem, the simulation-based estimator for the individual WTP is defined by the ratio of the non-monetary attribute's distribution and the cost attribute distribution weighted by the likelihood function (Green et al., 2005), and the produced estimates are thus conditional on the observed individual choices y_n and attribute values x_n (Train, 2003).

Again, this conditional parameters estimation procedure was used in order to estimate non-use values at the individual level, in accordance with our definition of such values.

All our econometric analysis was conducted using NLogit 4.0.

5. Results

5.1 Perceptions about coastal and marine preservation

The results regarding the main motivations cited by respondents to preserve CME are presented in table 1-4 below. On average, populations placed higher importance scores on motivations related to bequest then existence values, and motivations related to personal use values came only at the fourth position. Therefore, non-use values were perceived to be of primary importance for the majority of respondents with respect to CME preservation. This tends to justify our focus on such values.

Table 1-4 Main motivations to preserve New Caledonian coastal and marine ecosystems: average scores (0=Not important; 4=Very important)

	ZCO	VKP	TOTAL
Bequest value (children)	**3.90**	**3.88**	**3.89**
Bequest value (population in more than 50 years)	**3.87**	**3.91**	**3.89**
Personal use values	3.67	3.55	3.61
Because the lagoon is linked to our life-style and culture	3.62	3.44	3.53
Because the coastal and marine ecosystems represent a wealth that is important for economic development	3.56	3.41	3.48
Because coastal and marine ecosystem have an existence value	**3.80**	**3.87**	**3.83**

5.2 Individuals retained for choice modelling

Of the 550 individuals surveyed, 116 were discarded as they either did not complete all the choice tasks, completed the tasks but stated that they did it randomly (no understanding of the exercise), or stated that they refused to make choices for various reasons that cannot be considered as a preference for the status quo (e.g. they did not understand the CE, they were firmly opposed to such a payment scenario, they thought the choices were not relevant or not realistic). Almost all our respondents were users of the reef i.e. individuals who interact directly or indirectly with coral reef and associated ecosystems (e.g. fishing, diving, aesthetic pleasure), and the very few non-users (mostly very old individuals or Kanak people from the mountain tribes in VKP) were among the discarded individuals.

Socio-economic characteristics of individuals retained for our analysis are presented in table 1-5, for each area. Socio-economic characteristics from the overall sample (that is, retained and discarded individuals) are shown in red colour. We can see that for each area, the sample retained for the analysis remained representative.

Table 1-5 Socio-economic characteristics of individuals retained for analysis, for each area

	VKP	ZCO
Age (average)	40 (s.d.=14) *41*	43 (s.d.=15) *44*
Gender (average frequency)	49% male *50%*	51% male *50%*
Monthly net income per household (average category)	260,000 to 310,000 CFP (s.d.: 70,000 to 510,000 CFP) *260,000 to 310,000 CFP*	170,000 to 260,000 CFP (s.d.: Less than 70,000 to 410,000 CFP) *170,000 to 260,000 CFP*
Level of Education (average score out of 5[i])	2.1 (s.d. = 1.6) *2.1*	1.7 (s.d. = 1.4) *1.7*
Living in Tribe (average frequency)	50% *48%*	22% *22%*

[i] *5 being post graduate and 0 being no diploma; s.d.: standard deviation*

In addition, around half of the individuals who completed the eight choices declared having not paid serious attention to the payment attribute and its associated levels, implying that no WTP can be derived for these individuals if their statements are correct (Scarpa et al., 2009a). Two sub-groups were therefore identified and differentiated during the second stage of the analysis where panel EC-RPL models were used to estimate individual WTP: one sub-group having stated attendance to payment (SA group), the other one having stated non-attendance (SNA group).

5.3 Utility specification

5.3.1 Generic models

Here, we present the results from three MNL models (one for each area and one for both areas together), and two EC-RPL models (one for each area) (table 1-6).

While almost all model parameters are significant in the MNL models, the fit is poor with an adjusted pseudo-R^2 equal to 0.108 (Hensher et al., 2005), suggesting that not all of the important information is being captured. This is probably linked to the simplicity of the MNL and the assumption of independent choices and preference homogeneity. The "price" parameter (only significant at the 10% level for the ZCO area) was also found to be very low, resulting in the WTP estimates being unrealistically high and far higher than the actual maximum payment proposed within the experiment (2000 CFP/month) for both the pooled model and the area specific models.

The poor model fits and predictions encountered with the MNL models imply a need for further analysis in two directions: relaxing the MNL assumption regarding preference homogeneity and including the panel nature of our data, both of which are addressed with the panel EC-RPL models. Results from these models are presented in table 1-6.

The model fits are substantially higher in the panel EC-RPL models (table 1-6). Again, almost all parameters are significant and with significant associated standard deviations, implying important preference heterogeneities within the populations of each area. A constrained triangular distribution where the standard deviation equals the mean was used for the payment parameters in order to take into account the potentially important level of heterogeneity associated with consideration of the payment during the choices. Estimated WTP with these models were also found to be unrealistically high.

This could probably be explained by the fact that some individuals may not have considered the payment during their choices (which would confirm the attendance statements in the follow-up questions), i.e. that there is a strong cost-attribute non-attendance.

Table 1-6 MNL and Panel EC-RPL model results for each area with non monetary attributes under non continuous form

	MNL			EC-RPL				Distribution
	Pooled (coeff. normalized)	VKP (coeff. normalized)	ZCO (coeff. normalized)	VKP		ZCO		
				Mean	S.D	Mean	S.D	
Payment	-0,00015***	-0.00020***	-0.00010*	-0.00044***	0.00044***	-0.00025***	0.00025***	**t,1**
Catches 20 years	0,615**	0,638*	0,613	0.166**	0.392***	0.187*	0.652***	**n**
Catches 50 years	0,736***	0,776***	0,709***	0.350***	0.392***	0.366***	0.652***	**n**
Catches 100 years	0,756***	0,780***	0,826***	0.340***	0.392***	0.629***	0.652***	**n**
Health 20 years	0,899***	0,972*	0,828**	0.216*	0.655***	0.319**	0.849***	**n**
Health 50 years	1,053***	1,215***	0,893***	0.550***	0.655***	0.404***	0.849***	**n**
Health 100 years	1,131***	1,274***	0,993***	0.677***	0.655***	0.758***	0.849***	**n**
Landscape 20 years	0,663***	0,632***	0,706*	0.203**	0.444***	0.225**	0.549***	**n**
Landscape 50 years	0,674***	0,647***	0,720**	0.304***	0.444***	0.277***	0.549***	**n**
Landscape 100 years	0,792***	0,645***	0,984***	0.321***	0.444***	0.865***	0.549***	**n**
Areas 20 years	0,311	0,342	0,283**	0.058	0.183	-0.325***	0.610***	**n**
Areas 50 years	0,647***	0,634***	0,674***	0.540***	0.570***	0.505***	0.094	**n**
Areas 100 years	0,451**	0,226	0,707***	-0.0820	0.254	0.715***	0.785***	**n**
ASCsq	0, 299***	0.036	0.602***	-5.620***		-7.133***		
Sigma Option 1,2				0.431		5.937***		
Sigma Status Quo				6.023***		5.560***		
Final Log-Likelihood		-1509.6	-1419.3	-1213.1		-1138.8		
AIC		1.561	1.682	1.265		1.362		
Adjusted Pseudo-R^2	0,108	0,111	0,115	0.431		0.388		
Halton Draws				350		350		
N	457	244	213	244		213		

**** Significant at the 1% level** Significant at the 5% level * Significant at the 10% level*

5.3.2 Non-linear specification

An interesting result from the generic models is that the first three non-monetary attributes (Quantity of animals fished, Health and richness of the marine life, Coastal and lagoon natural landscapes) could all be considered as continuous, but in a non-linear way. A graphic representation of the different part-worth utilities of those three first attributes is shown in Figure 1-5, extrapolated from our four points through time in the pooled MNL. In this figure, the base level of the attributes (status quo) is set as 0 in terms of part worth utilities (dummy coding), and corresponds to a protection period of around 4 months. The three curves clearly have a logarithmic shape.

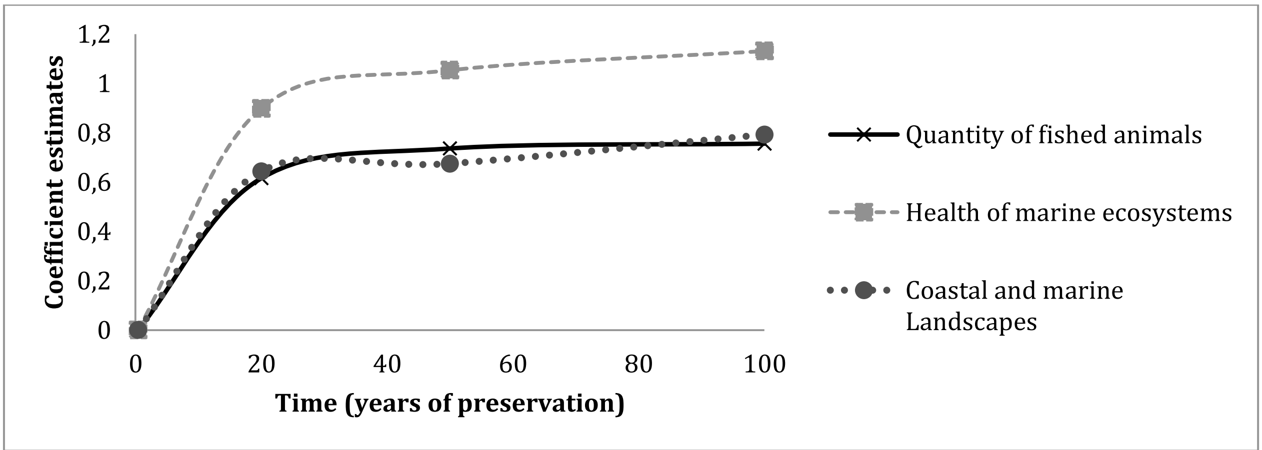


Figure 1-5 Part-worth utilities (dummy coding) of three attributes over time: Quantity of animals fished, Health and richness of the marine life, Coastal and lagoon natural landscape

Based on this initial set of results, we considered that the three attributes could enter the utility function as a logarithm function, with a value defined as -1 for the status quo level (corresponding to preservation for around 4 months). There are however significant differences between the two areas, in particular regarding the attribute "areas of practice". For the ZCO, this attribute displays similar logarithmic shaped part-worth utilities. For VKP, however, only the 50 years preservation level is significant. This result can be interpreted in relation to the contexts of these areas: in ZCO, the lagoon is very narrow, with significant parts being marine reserves, thus implying conflicts of uses and concerns from the populations regarding their potential areas of practices, thus strong attention is paid to this attribute during the choices. In VKP, however, there are no reserves and the lagoon is large, with limited conflicts regarding areas of practice, thus explaining the lower attention paid to this attribute.

To take this into account in the analysis, the last non-monetary attribute (areas of practice) was kept under its previous non-continuous form for VKP, and entered as a logarithm function for ZCO. This new utility specification with logarithmic functions was then tested using MNL and panel EC-RPL models for each area (table 1-7). Again, almost all the parameters were highly significant, and the WTP estimates appeared unrealistic, given very low payment parameter values (see tables 1-7 and 1-8 for estimated WTP with the log-linear specification). As mentioned above, this is likely due to a potentially strong cost-attribute non-attendance, which requires adapting our estimation procedure (see next section).

The model fits and predictions were similar for both kinds of models, suggesting that the log-linear specification of the utility functions works as well as the linear non-continuous version. Using this specification enables us to estimate WTP for each additional year of preservation for the continuous non-monetary attributes.

5.3.3 Integrating socio-economic variables

Results from different models with several socio-economic variables integrated in the utility functions (with the two previous specifications) are presented in table 1-9, 1-10 and 1-11. In comparison to other models, table 1-11 focuses on testing possible interactions between age and the different attributes under a linear form for both areas. For these models, all of the non-monetary attributes (with no interactions) were considered under a log linear form, including the Areas of practice attributes for VKP, in order to simplify interpretation.

According to table 1-9 and 1-10, the MNL models show significant effects for the socio-economic variables, which differ between the two areas. In the pooled model, younger individuals are more willing to choose alternatives with preservation over time, as well as individuals with higher income, higher education level and individuals living in tribe. However, almost none of the socio-economic variables are significant in the EC-RPL models, the socio-economic effects being captured by the random parameters.

According to table 1-11, we can see that no interaction between age and non-monetary attributes are found to be significant for the ZCO area, although some are for the pooled model. For the VKP areas, interactions between age and the Quantity of animals fished, Landscapes or the Areas of Practice are all significant and imply that younger people have higher part-worth utilities for these attributes, which relate to the use of CME.

Table 1-7 MNL and Panel EC-RPL models for each area with log-linear utility specification (WTP are in CFP/month)

	MNL				EC-RPL				
	VKP		ZCO		VKP		ZCO		Distribution
	Coeff.	WTP	Coeff.	WTP	Mean	S.D.	Mean	S.D.	
Payment	-0.00024***		-0.00010*		0.00037***	0.00037***	0.00015***	0.00015***	t,1
Ln Catches	0.146***	616	0.135***	1290	0.168***	0.168***	0.153***	0.153***	t,1
Ln Health	0.229***	965	0.180***	1723	0.299***	0.299***	0.232***	0.232***	t,1
Ln Landscapes	0.124***	521	0.163***	1558	0.158***	0.158***	0.193***	0.193***	t,1
Ln Areas (ZCO only)			0.129***	1233			0.150***	0.150***	t,1
Areas 20 years (VKP only)	0.0545				0.047				fixed
Areas 50 years (VKP only)	0.337***[1]	2808			0.416***	0.416***			t,1
Areas 100 years (VKP only)	-0.059				-0.063				fixed
ASCsq	-0.0376		0.57***		-7.837***		-6.529***		
Sigma Option 1,2					2.509		7.077***		
Sigma Status Quo					7.006***		3.516***		
Final Log-Likelihood	-1514.8		-1426.1		-1230.5		-1163.6		
AIC	1.560		1.681		1.271		1.375		
Adjusted Pseudo-R^2	0,112		0,107		0.425		0.377		
Halton Draws					350		350		
N	244		213		244		213		

**** Significant at the 1% level** Significant at the 5% level * Significant at the 10% level*

[1] *Effect coded*

Table 1-8 Panel EC-RPL models with log-linear utility specification: individual WTP estimates (CFP/month) and standard deviation estimates of individual WTP for all individuals, in each area

	ZCO		VKP	
	WTPi	SDWTPi	WTPi	SDWTPi
Ln Fished animals	Mean: 1200 SD: 141 Min: 793 Max: 1491	Mean: 559 SD: 37 Min: 446 Max: 631	Mean: 500 SD: 59 Min: 300 Max: 629	Mean: 125 SD: 7 Min: 95 Max: 147
Ln Health of marine life	Mean: 1797 SD: 311 Min: 951 Max: 2375	Mean: 807 SD: 122 Min: 518 Max: 1231	Mean: 890 SD: 188 Min: 399 Max: 1185	Mean: 210 SD: 21 Min: 131 Max: 305
Ln Coastal and marine landscapes	Mean: 1542 SD: 190 Min: 1080 Max: 1950	Mean: 698 SD: 55 Min: 569 Max: 892	Mean: 471 SD: 56 Min: 288 Max: 608	Mean: 118 SD: 10 Min: 96 Max: 171
Ln Areas of practice for ZCO / Areas of practice 50 years for VKP	Mean: 1190 SD: 130 Min: 876 Max: 1404	Mean: 554 SD: 31 Min: 475 Max: 705	Mean: 2439 SD: 265 Min: 1619 Max: 3075	Mean: 600 SD: 29 Min: 493 Max: 681

Table 1-9 MNL and Panel EC-RPL models with non-continuous non-monetary attributes and socio-economic variables

	MNL			EC-RPL				
				VKP		ZCO		
	Pooled	VKP	ZCO	Mean	S.D	Mean	S.D	Distribution
Payment	-0.00017***	-0.00023***	-0.00011*	-0.00043***	0.00043***	-0.00017*	0.00017*	t,1
Catches 20 years	0.061	0.071	0.055	0.130*	0.339***	0.127***	0.566***	n
Catches 50 years	0.232***	0.264***	0.206***	0.326***	0.339***	0.322***	0.566***	n
Catches 100 years	0.233***	0.164**	0.309***	0.283**	0.339***	0.542***	0.566***	n
Health 20 years	0.102**	0.058	0.152**	0.098	0.523***	0.292***	0.690***	n
Health 50 years	0.324***	0.422***	0.224***	0.614***	0.523***	0.381***	0.690***	n
Health 100 years	0.385***	0.423***	0.358***	0.654***	0.523***	0.591***	0.690***	n
Landscape 20 years	0.117***	0.148**	0.073*	0.193**	0.353***	0.126***	0.458***	n
Landscape 50 years	0.162***	0.154***	0.180***	0.265***	0.353***	0.341***	0.458***	n
Landscape 100 years	0.268***	0.194***	0.365***	0.313***	0.353***	0.648***	0.458***	n
Areas 20 years	-0.035	0.053	-0.137**	0.067	0.255	-0.318**	0.298***	n
Areas 50 years	0.286***	0.347***	0.223***	0.478***	0.594***	0.364***	0.385***	n
Areas 100 years	0.126**	-0.068	0.351***	-0.089	0.055	0.680***	0.678***	n
Age	-0.019***	-0.038***	-0.005	-0.125*		0.058		
Gender	-0.232	-0.104	-0.402**	-0.099		-2.063		
Income	0.080***	0.057	0.110***	0.385		0.131		
Education level	0.205***	0.227***	0.141*	0.3821		1.019		
Tribe	0.633***	0.732***	0.461*	2.324		3.080		
ASCsq	0.212	-0.781	0.978**	-9.823		-1.311		
Sigma Option 1,2				1.593		0.444		
Sigma Status Quo				8.037***		8.491***		
Final Log-Likelihood	-2458.8	-1265.4	-1167.1	-1066.5		-957.5		
AIC	1.556	1.487	1.629	1.265		1.352		
Pseudo-R^2	0.131	0.141	0.129	0.434		0.396		
Halton Draws				350		350		
N	398	216	182	216		182		

**** Significant at the 1% level** Significant at the 5% level * Significant at the 10% level*

Table 1-10 MNL and panel EC-RPL models results with log-linear utilities specifications and socio-economic variables

	MNL		EC-RPL				
	VKP	**ZCO**	**VKP** Mean	**VKP** S.D.	**ZCO** Mean	**ZCO** S.D.	Distribution
Payment	-0.00026***	-0.00011*	-0.00040***	-0.00040***	-0.00015**	-0.00015**	t,1
Ln Catches	0.142***	0.1423***	0.163***	0.163***	0.164***	0.164***	t,1
Ln Health	0.239***	0.197***	0.307***	0.307***	0.246***	0.246***	t,1
Ln Landscapes	0.130***	0.168***	0.163***	0.163***	0.199***	0.199***	t,1
Ln Areas (ZCO only)		0.136***			0.161***	0.161***	t,1
Areas 20 years (VKP only)	0.059		0.056				fixed
Areas 50 years (VKP only)	0.338***		0.425***	0.425***			t,1
Areas 100 years (VKP only)	-0.042		-0.053				fixed
Age	-0.038***	-0.0046	-0.109*		0.026		
Gender	-0.103	-0.398**	0.250		-0.230		
Income	0.057	0.108***	0.178		0.303		
Education level	0.228**	0.142*	0.400		0.802*		
Tribe	0.733***	0.461*	0.883		4.010		
ASCsq	-0.832	0.959**	-9.928*		-1.144		
Sigma Option 1,2			5.431***		5.452***		
Sigma Status Quo			3.669**		2.910		
Final Log-Likelihood	-1270.6	-1172.1	-1080.6		-978.1		
AIC	1.486	1.625	1.268		1.361		
Adjusted Pseudo-R^2	0.139	0.128	0.428		0.386		
Halton Draws			350		350		
N	216	182	216		182		

**** Significant at the 1% level** Significant at the 5% level * Significant at the 10% level*

Table 1-11 MNL and Panel EC-RPL models with log-linear utility specifications and Age interacting with non-monetary attributes

	MNL			EC-RPL				
				VKP		ZCO		
	Pooled	VKP	ZCO	Mean	S.D	Mean	S.D	Distribution
Payment	-0.00014***	-0.00018***	-0.00010*	-0.00031***	-0.00031***	-0.00016**	-0.00016**	t,1
Ln Catches	0.156***	0.184***	0.126***	0.190***	0.190***	0.142***	0.142***	t,1
Ln Health	0.221***	0.235***	0.199***	0.324***	0.324***	0.265***	0.265***	t,1
Ln Landscapes	0.164***	0.168***	0.164***	0.201***	0.201***	0.183***	0.183***	t,1
Ln Areas	0.124***	0.134***	0.118***	0.141***	0.141***	0.109***	0.109***	t,1
Catches * Age	-0.00003	-0.00008***	0.00001	-0.00005		0.00003		
Health * Age	-0.00002	-0.000005	-0.00003	-0.00003		-0.00005		
Landscapes * Age	-0.00004*	-0.00008**	0.000008	-0.00007*		0.00003		
Areas * Age	-0.00004*	-0.0001***	0.00001	-0.00008**		0.00007*		
ASCsq	0.296***	0.032	0.581***	-9.553***		-4.4214***		
Sigma Option 1,2				8.577***		3.758***		
Sigma Status Quo				2.019		2.940**		
Final Log-Likelihood	-2960.4	-1513.8	-1425.4	-1238.1		-1165.4		
AIC	1.625	1.561	1.685	1.281		1.382		
Pseudo-R^2	0.105	0.110	0.105	0.421		0.375		
Halton Draws				350		350		
N	457	244	213	244		213		

**** Significant at the 1% level** Significant at the 5% level * Significant at the 10% level*

In Table 1-11, we focused only on the interactions between age and the various attributes. We note that we also included "Age" as a continuous independent variable in the utility function in addition to the interaction terms during our econometric analysis, and the results did not change much; this is why they are not detailed here. "Age" was found to be highly significant in the MNL models for both ZCO and VKP, with the interaction between Catch and Age becoming insignificant for VKP. In the EC-RPL models, all interactions as well as "Age" were insignificant for ZCO area, whereas "Age" and the interactions between age and Landscapes as well as Areas of practice remained all significant at the 5% level with negative signs.

Although these results are not presented here, we also tested the interaction between the payment and income (see Appendix I, table I1), which in both areas is significant (at 5% and 10% level) in the MNL and with the expected positive sign: individuals with a higher household income are willing to pay more. However, when preference heterogeneity is taken into account via EC-RPL model the interactions become insignificant for both areas.

In order to test for possible heterogeneity regarding the way the payment was taken into account depending on the age of the individuals, we also looked at the interaction between Age and Tax (Appendix I, table I2): again the coefficient is highly significant in the MNL models with a negative sign, but not significant in the panel EC-RPL models, for both areas.

5.4 Panel EC-RPL and LCM with stated cost attendance groups

In order to arrive at more credible WTP estimates, we sought to isolate a group of respondents that did consider the payment during their choices using the non-attendance statements. Two groups were identified: one group who stated none or really low consideration of the payment (SNA group), and another group who stated medium to very strong consideration of the payment (SA group). The SA group represents 82 individuals in the ZCO area (of 213 surveyed), and 113 individuals for the VKP area (of 244 surveyed).

5.4.1 Panel LCM

Several panel LCM were run considering only the individuals who had stated consideration of the payment during their choices. Results of panel-LCM with two classes for these individuals are presented in table 1-12, along with the derived WTP, for each area and with the non-linear utility specifications previously selected.

The low number of classes (two) was selected using the AIC criteria, and so as to keep interpretation of the results simple. Both groups (for ZCO and VKP) present a good homogeneity with a first class membership probability of 85% and 90% for ZCO and VKP respectively, the second classes regrouping unexplained choices (with non significant parameters). Adjusted pseudo R-squared are, once again, much higher compared to MNL model, confirming the major benefit of allowing for preference heterogeneity and considering the panel nature of our data.

For the attributes that enter the utility function under a logarithm form, the associated WTP corresponds to the logarithm of one year of preservation. Based on this, an estimate of WTP for any duration period between 20 and 100 years for the preservation of each of these attributes can be given.

The estimated mean WTP presented in table 1-12 are more realistic than those obtained with the MNL models (i.e. closer to the actual payment range proposed within the experiment), so that we can now start computing robust use and non-use values at the individual level.

Table 1-12 Panel LCM results for each area: individuals who stated attendance or non-attendance of payment

	ZCO		VKP	
	Stated attendance		Stated attendance	
	Parameters	*WTP* (CFP/month/household)	*Parameters*	*WTP* (CFP/month/household)
Class 1				
Payment	-0.00024**		-0,00048***	
Ln (Quantity of animals fished)	0.112***	**477**	0,137***	**285**
Ln (Health of marine life)	0.159***	**675**	0,208***	**434**
Ln (Coastal and lagoon landscapes)	0.145***	**616**	0,090***	**187**
Ln (Areas of practices)	0.094***	**401**		
Areas of practice: 20 years			0,215***	**896**
Areas of practice: 50 years			0,317***	**1320**
Areas of practice: 100 years			-0,104 (NS)	Not defined
ASCsq	-0.934***		-1.479***	
Class probability	0.88***		0.9***	
Class 2				
All attributes	NS		NS	
Class probability	0.12***		0.1***	
McFadden Adjusted *Pseudo-R^2*	0.36		0.39	
AIC criteria	1.45		1.37	
Number of individuals	82		113	

NS: Not significant

5.4.2 Panel EC-RPL

We then affected each group (SNA and SA groups) a separate parameter for the payment, and ran the MNL and panel EC-RPL models again for each area. Results are presented in table 1-13. The model fits are significantly higher than the previous models. Both payment coefficients (SNA and SA) were first considered as following a constrained triangular distribution, but only the payment's coefficient for the SA group was kept under a random form since both the payment's coefficient and its associated standard deviation for the SNA group were not significant for each area. The payment parameter for the SA group was strongly significant in each area, confirming the stated cost attribute attendance or non-attendance.

Table 1-13 Panel EC-RPL models with different payment coefficients for individuals who stated attendance or not to payment

	EC-RPL Stated Attendance Group				Distribution
	VKP		**ZCO**		
	Mean	S.D	Mean	S.D	
Payment SNA group	-0.000092		-0.0000045		fixed
Payment SA group	-0.00064***	0.00032***	-0.00037***	0.00019***	t,0.5
Ln Catches	0.165***	0.165***	0.151***	0.151***	t,1
Ln Health	0.296***	0.296***	0.231***	0.231***	t,1
Ln Landscaoes	0.154***	0.154***	0.198***	0.198***	t,1
Ln Areas			0.151***	0.151***	t,1
Areas 20 years	0.059				fixed
Areas 50 years	0.399***	0.399***			t,1
Areas 100 years	-0.064				fixed
ASCsq	-8.031***		-6.505***		
Sigma Option 1,2	0.532		4.738*		
Sigma Status Quo	7.143***		6.030***		
Final Log-Likelihood	-1222.9		-1157.9		
AIC	1.264		1.370		
Adjusted Pseudo-R^2	0.428		0.380		
Halton Draws	350		350		
N	244		213		

**** Significant at the 1% level** Significant at the 5% level * Significant at the 10% level*

All the other parameters for this final model were still strongly significant (except for Areas 20 and 100 years in the case of VKP area, as before).

In both models (LCM and RPL), differences observed between the two areas can be interpreted as reflecting their different socio-economic and ecological contexts. In VKP, an existing mining project will have impacts on the coastal landscapes even with conservation, whereas in ZCO the coastal and marine landscapes have some very distinctive features that are clearly linked to its world-heritage label and that inhabitants clearly wish to preserve. Furthermore, the particularly strong preference for the preservation of the health and richness of marine life in the VKP area is also certainly linked to the mining project, which represents a considerable and immediate threat to CME. Finally recreational and indigenous fishing practices are more present in VKP compared to ZCO.

5.5 Individual WTP and non-use values

Using the above models results, we are now able to derive WTP estimates for all the different attributes, for the SA groups (considering only the payment coefficient for the SA group in the case of the panel EC-RPL model), for each area and with the non-linear utility specifications previously selected. For the attributes that enter the utility function under a logarithm form, the associated WTP corresponds to the logarithm of one year of preservation. Based on this, an estimate of WTP for any duration period between 20 and 100 years for the preservation of each of these attributes can be computed. Indeed, the expressions for WTP are obtained by equating $U(\Delta Xk) = Un\ (\Delta Payment)$, leading to the following expressions:

$$\beta_k * log(\Delta X_k) = \beta_{price} * \Delta Payment \Leftrightarrow \Delta Payment = (\beta_k / \beta_{price}) * log(\Delta X_k)$$

As mentioned before, both EC-RPL models and LCM allow deriving WTP at the individual level. For the panel LCM, individual WTPs are exactly the same than the one computed at the sample level and presented in table 1-12, because the probabilities of being in class 1 are all equal to 1 for these individuals (this is due to the simplicity of our model with only two classes, the second one being random choices). For the panel EC-RPL model, results are reported in table 1-14, where the mean, the standard deviation, as well as the minimum and the maximum of estimated individual WTP (and of the estimated Standard Deviation of individual WTP) are presented. The resulting estimates are much lower than the previous estimates (as can be seen from comparing the results presented in tables 1-7 and 1-8).

Using these estimates, we then computed, for each individual, a WTP during and strictly beyond life-expectancy, taking into account the individual's current age, in order to assess individual non-use values as per our definition.

Average life expectancy at birth in New Caledonia is 76 years so for each individual we calculated WTPs for preservation strictly beyond their expected remaining years of life (76 - Individual's age) and until 100 years, as a measure of the non-use value component, and WTPs for preservation during their expected remaining years of life, measuring a combination of use and non-use values as well as option values. To be consistent with our definition, for the very few respondents who were actually older than 76 years, we considered their WTPs for any additional year of preservation as non-use values. The validity of this assumption is reinforced by the fact that these individuals stated in the questionnaire very little interaction with the CME, due to their age and location. For both areas WTPs during and after life expectancy were thus calculated for each non-monetary attribute. However, for the VKP area, since the attribute area of practice could not be considered under a continuous form, non-use values were estimated only for people over 76 years old (through the WTPs for 50 years of preservation), which explains why their part in total WTP is smaller compared to ZCO area. Similarly, the WTPs for 50 years of preservation of the areas of practice in VKP were considered as entering WTPs during life expectancy for individuals below 76 years old. Total individual WTPs were then derived by adding up WTP estimates for the different attributes.

The Kernel density estimator plots for individual WTPs estimates (Hensher et al., 2005), both during and beyond life-expectancy for each area, are shown in figures 1-6 and 1-7, respectively for the estimates derived from the panel LCM and panel EC-RPL models. The mean of individual specific WTPs are shown on each graph. Table 1-15 presents the descriptive statistics of both WTPs during and over life expectancy, for both areas and both estimation methods.

Table 1-14 Panel EC-RPL models with log-linear utility specification for each area: Individual WTP (CFP/month) for individuals who stated attendance to payment and associated standard deviation

	ZCO		VKP	
	WTPi	SDWTPi	WTPi	SDWTPi
Ln Fished animals	Mean: 422 SD: 47 Min: 278 Max: 507	Mean: 196 SD: 12 Min: 154 Max: 243	Mean: 269 SD: 31 Min: 173 Max: 338	Mean: 125 SD: 7 Min: 95 Max: 147
Ln Health of marine life	Mean: 635 SD: 111 Min: 329 Max: 835	Mean: 284 SD: 26 Min: 181 Max: 338	Mean: 477 SD: 98 Min: 223 Max: 643	Mean: 210 SD: 21 Min: 131 Max: 305
Ln Coastal and marine landscapes	Mean: 552 SD: 71 Min: 387 Max: 690	Mean: 247 SD: 22 Min: 173 Max: 283	Mean: 252 SD: 29 Min: 158 Max: 331	Mean: 118 SD: 10 Min: 96 Max: 171
Ln Areas of practice for ZCO / Areas of practice 50 years for VKP	Mean: 420 SD: 46 Min: 305 Max: 506	Mean: 193 SD: 13 Min: 156 Max: 218	Mean: 1297 SD: 134 Min: 951 Max: 1665	Mean: 600 SD: 29 Min: 493 Max: 681

Table 1-15 Computed WTP (CFP/month) during and over life expectancy for ZCO and VKP areas using panel LCM or EC-RPL models individual WTP estimates

	Panel LCM		**Panel EC-RPL**	
	ZCO	**VKP**	**ZCO**	**VKP**
Total WTP during life expectancy	Mean: 7096 Min: 0; Max: 8727	Mean: 4662 Min: 0; Max: 5432	Mean: 6515 Min: 0; Max: 9037	Mean: 4620 Min: 0; Max: 6518
Total WTP over life expectancy	Mean: 2888 Min: 1257; Max: 9984	Mean: 1102 Min: 509; Max: 4384	Mean: 2704 Min: 1054; Max: 10678	Mean: 1230 Min: 408; Max: 5670

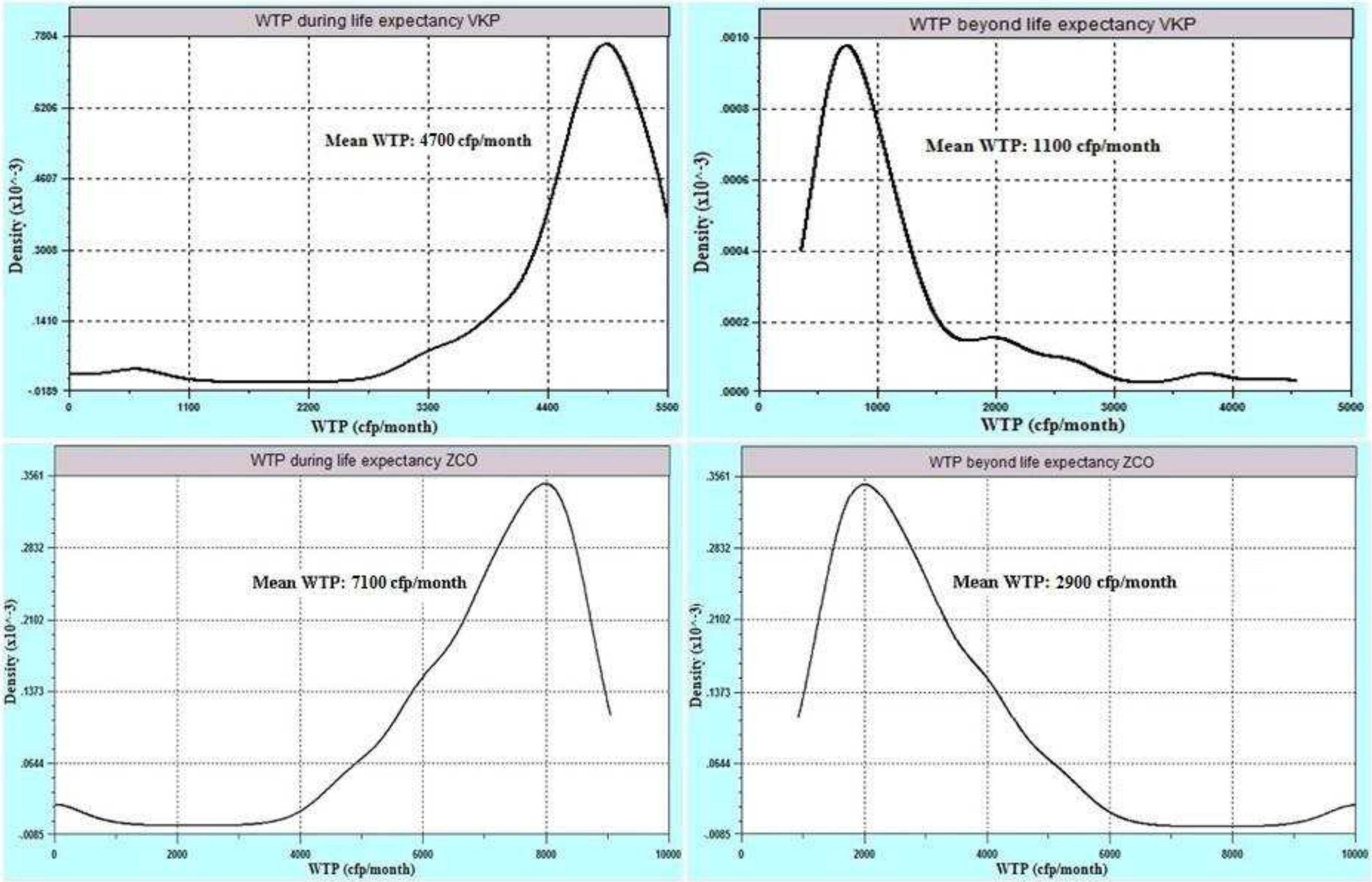


Figure 1-6 Distribution of individual use and non-use values for VKP and ZCO, from panel LCM. Kernel density plots on the left represent individual WTP during life expectancy (use, option and non-use values), the ones on the right represent individual WTP beyond life expectancy (non-use values)

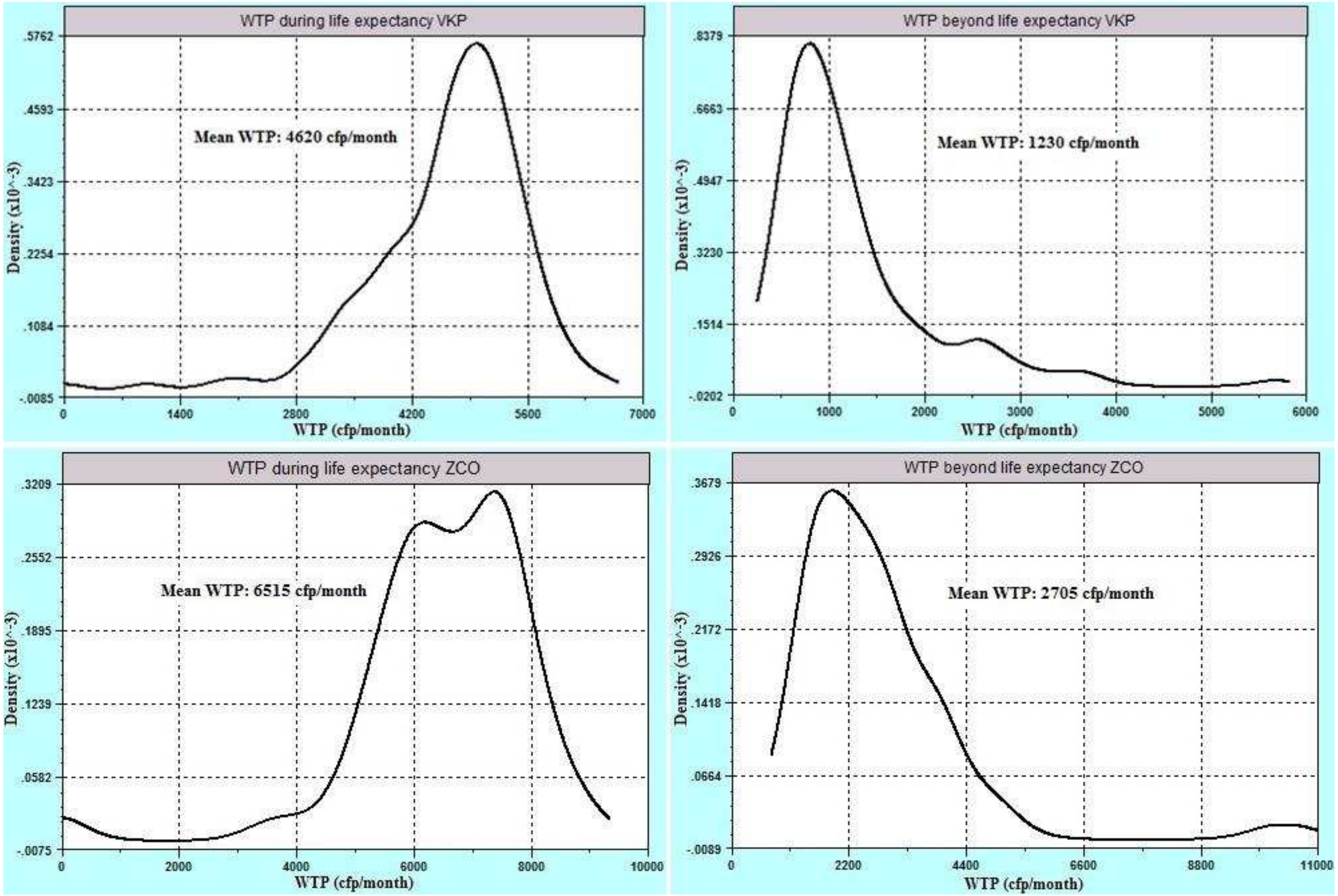


Figure 1-7 Distribution of individual use and non-use values for VKP and ZCO from EC-RPL model. Kernel density plots on the left represent individual WTP during life expectancy (use, option and non-use values), the ones on the right represent individual WTP beyond life expectancy (non-use values)

For the panel LCM the calculated non-use values component at our sample level represents at least between 25 and 30% of total WTP for preserving all the attributes over 100 years. As mentioned before, we have to put these estimates in perspective of our definition and empirical application, which implied a quantitative approach with preservation over time being described in terms of several preservation durations. As such, the estimated “a minima” component of non-use values depends exclusively of the age of the individuals, since there is a maximum preservation time (100 years). It is therefore important to consider as well the minimum and maximum of the non-use values estimated, which are respectively around 1250 and 10000 CFP/month/household for ZCO; and around 500 and 4400 CFP/month/household for VKP (table 1-15). As such, they range from around 10% to 100% of total individuals WTP for preserving the different attributes over 100 years.

For the panel EC-RPL model, the calculated non-use value component of total WTP for preserving all the attributes over 100 years at the level of our sample represents at least 27% of total WTP for VKP and 41% for ZCO. The minimum and maximum estimated non-use values are respectively around 1000 and 10500 CFP/month for ZCO; and around 400 and 5700 CFP/month for VKP (table 1-15). Here again, they range from 11% to 100% of individuals total WTP for preservation of the different attributes over 100 years.

6. Discussion and conclusions

6.1 Discussion of the main results

Regarding our main objective, which was to examine a pragmatic approach to measuring non-use values, several key results can be highlighted.

- **Marginal utilities for preservation over time are decreasing**

Our analysis allowed us to specify part-worth utilities regarding the preservation of the different attributes over time under a logarithmic form. This is in itself a significant contribution to the DCE literature, where it has been argued that linear utility function specifications are not likely to be robust due to the existence of diminishing marginal utilities or gain-loss asymmetries, which is an important limit of current practice in DCE (Hoyos, 2010). This also confirms the theoretical basis of our approach.

- **Our a minima estimate of NUV represents 25 to 40% of total WTP**

We were able to implicitly isolate a minima but exclusive non-use WTP component at the individual level with both discrete and continuous mixing modelling approaches (ranging from 10 to 100% of total WTP to preserve the attributes over 100 years), which represents between 25 and 40% of total mean WTP estimates, at our sample level. This is a more conservative estimate than the ones usually found in the literature[18].

We also note that the two estimation procedures (discrete and continuous mixed logit models i.e. LCM and EC-RPL models) used in our application yield to similar mean estimates of NUV at the sample level and at the individual level. However, we argue that the modelling approach combining both Error Component and Random Parameters Logit model (EC-RPL) is superior for two main reasons[19]: (1) it is the one providing some of the highest model fits as well as the best predictions amongst the models tested (in terms of pseudo-R^2 as well as comparison of predicted and real choices using contingency tables); and (2) it allows coping with preference heterogeneity with much more details at the individual level, which is crucial and certainly more realistic in view of the different populations and areas targeted by our survey (see table 1-4 in 5.2, and quotas presented in Appendix H).

- **Total NUV could actually represent 50 to 80% of total WTP**

It is of course necessary to examine critically our approach through this case study implementation. As stated before, we are able through our method to securely capture exclusive non-use values for users through WTP for preservation beyond life expectancy, but the complementary WTP before life expectancy also certainly includes non-use components. This is the main limit of our definition of non-use values.

A possible interpretation could be to consider that non-use values held at a specific moment are perceived by the holder as being absolute and universal, and as such held continuously through time (even if the motivations underlying non-use values and their intensity are subject to changes over the individual's lifetime). In other words, most non-use values would usually appear "timeless" for the individual and would be perceived as independent of any

[18] Please refer to the Introduction of this chapter for a comparison with NUV estimates found in the literature.

[19] In the prospect of further analysis, the EC-RPL framework does also offer the possibility to deal with potential attribute non-attendance issues with more flexibility than Latent Class Models with parameters restrictions (Hess and Hensher, 2010; see Chapter 2).

considerations regarding their temporal existence, so that these values motivate both a WTP during and after life expectancy, in an equivalent way. That is, most non-use values that motivate a wish to preserve an ES today or in coming years would motivate in an equivalent way the wish that the ES will be preserved over a long time (after death). This would mean that the non-use value to preserve an ES strictly beyond life expectancy (the one we estimated) is present in an equivalent proportion in the WTP to preserve it strictly before life expectancy (which we defined as entailing a mix of use, option and non-use values). In other words, to protect the ES until after one's life expectancy, one would first have to pay for it to be preserved while still alive. In that case, at our sample scale, non-use values would also represent at least between 25-40% of the WTP during life expectancy, so that they would represent between 50 and 80% of the total WTP. This comes closer to some estimates found in the literature.

More broadly, it could be argued that non-use values do not actually depend on an individual's life expectancy, but on perceptions associated with the different preservation durations considered, or on the motivations behind their commitment to preserve CME over time. During the surveys, most respondents associated 100 years with somewhat of an ideal[20] that would guarantee the continued existence of these ecosystems and continued benefits to future generations. And when asked to rate different possible reasons behind their commitment to preserve CME, all individuals gave a higher score to existence and bequest motivations, compared to use or option consideration. If 100 years is interpreted as pertaining to similar values by many individuals, it could be argued that age and life-expectancy do not matter, and non-use values could in the end represent a more substantial part of WTP (since it can represent more than 90% for older individuals).

- **Contextual effects and socio-demographic factors influence preferences and NUV**

The survey results show that several contextual elements seem to have affected individuals' preferences and WTP. Substantial differences between both areas were observed, although these areas are very close geographically and share some characteristics in terms of environment and populations.

[20] For some groups, 100 years preservation was perceived as something that must be guaranteed, from a deontological perspective. For others, it was more perceived as an utopist wish that would be great to fulfil but unrealistic since too far from the present.

In addition, different choices among similar types of population (age, income, tribe or non-tribe) were observed. Age as a socio-economic variable was found to be significant in several of our models (tables 1-9 and 1-10), including when interacted with the non-monetary attributes under a continuous form for utility (table 1-11), and when interacted with the payment (although this last interaction is not significant when using EC-RPL models). These results imply that younger individuals have a higher utility associated with preservation options, and higher part-worth utilities for longer preservation periods concerning several attributes; principally those that are more focused on use values. This would tend to confirm our hypothesis that age plays a role in WTP, and influences use and non-use values. Regarding the influence of other socio-economic variable, income was also found to have the usual positive influence on the payment, and individuals living in tribe were found having higher utility associated with preservation options. But these two results disappear when heterogeneity is taken into account with the EC-RPL models.

Our models worked well in explaining and illustrating the different contextual elements of each area. The results confirm that during an economic valuation exercise, institutional, socio-economic and cultural contexts, as well as the status of the environment play a crucial role, which needs to be accounted for. This supports concerns that have been voiced regarding benefit transfer, which even within a small regional context need careful consideration before being implemented.

- **There is a potential issue with payment non-attendance**

Another important result concerns the cost attribute non-attendance issue, which precludes the possibility of deriving WTP for an important part of our sample. This payment non-attendance issue is examined extensively in the next chapter.

6.2 Further work and limitations

- **Other levels could have been used for the attributes**

In this application, we chose to quantitatively describe preservation over time, but alternatives could have been used. It would for example be interesting to compare our results with a similar choice experiment involving qualitative levels of time commitment for the attributes (such as "preservation during my life-time" and "preservation beyond my life-time", or from an intergenerational perspective as used in Scarborough and Bennett, 2008). In addition, shorter time horizons (e.g. 5 years) could also help differentiate further between use, option and non-use values for WTP during life expectancy.

- **The long time period involved in our experiment raises potential issues**

A potential limitation of the approach we propose relates to the importance of discounting, since we are considering long time periods. Our study took place at a specific point in time, and our estimates are based on choices involving a simple monthly payment that individuals considered at this particular point in time, so that one could argue that no discounting is involved in the choices leading to the estimated values. If such discounting affects the choices, its effects concerning the preservation of attributes over longer time-periods are likely to be intrinsically taken into account via the log-linear specification of the utility function. One could argue that rather than relating strictly to time preference, the log-linear specification might also take into account the fact that the further distant in time the benefits considered, the greater the uncertainty. Respondents may in fact have considered this uncertainty when making their choices. Studying respondent's perceptions in further detail with regards to the different time frames used in this choice experiment could be an interesting topic for further research.

Another potential limit of our approach concerns the duration of the payment vehicle. We did not specify any duration of the payment when conducting the choice experiments, and it was simply stated it would go on for several years with a maximum of 20 years. This was mainly because of the hypothetical nature of the experiment. This raises two problems. First, it does not give the possibility to estimate a robust net present value of the sum of WTP over a specific period of time that would correspond to the exercise. We acknowledge this problem, but we also point out that our aim was not to estimate such a value but rather to look at the share of non-use values in WTP. The second problem is that it could imply some heterogeneity regarding the way the payment was taken into account. For example, if respondents believed that they would pay for 20 years, this introduces heterogeneity in perceived costs, as young persons would have a larger sum of payments than older persons who are over 70 years old. Two points can be made with respect to this issue: (1) Among all the individuals surveyed, none of them did ask about the payment duration, or express any concerns regarding this issue when the choice experiment was explained; (2) Our results show that younger individuals are actually willing-to-pay more than older individuals (negative interaction between payment and age, see Appendix I), which tends to indicate that they did not feel penalized by the payment vehicle[21].

- **Some WTP estimates are unrealistically high**

Finally, it is clear that the absolute value of the estimated WTP during life expectancy is still substantially high, especially for the ZCO area. As such, these estimates could still be perceived as unrealistic, although we limited the exercise on individuals who stated attendance to payment. An explanation could be that even individuals who stated attendance to payment did actually ignore it. This is why we focus on this specific issue in our second chapter. In this first chapter, we were more interested in presenting a new methodology, testing it and getting an estimate of the share of non-use values in total WTP, rather than estimating the most credible absolute values. The in-depth study of the payment non-attendance issue in Chapter 2 provides a way to derive more credible estimates.

6.3 Conclusion

All in all, the approach presented in this chapter provides a means of measuring an a minima non-use value for both users and non-users of an environmental asset. The approach is more robust than a subjective proportioning of value as in other studies, and leads to suggest that the average proportion of non-use value in total WTP may be lower than found in previous studies, although it remains substantial. By providing estimates of use and non-use values associated with the protection of several coral reef ecosystem services, this study also contributes to the literature on coral reef valuation where a need for more valuation work has recently been advocated (Barbier, 2012; Brander et al., 2007), especially when involving indigenous communities (O'Garra, 2009).

Developing this approach also led us to ask ourselves what was behind such computed WTP, and what was the NUV concept referring to. As mentioned before, many authors challenged the traditional economic interpretation of non-use values (WTP or WTA as a measure of bequest and existence value), and other values and dimensions were identified and discussed (Attfield, 1998; Chan et al., 2012; Daniel et al., 2012). For example, several authors

[21] Since we also saw that younger individuals are willing to pay more in order to enjoy the preservation of some attributes during their lifetime, it becomes necessary to test for both effect simultaneously (i.e. having interactions terms between age and all attributes included payment in a single model). Results show that both effects (negative interaction between age and payment, and positive one between age and some attributes) are found to be present simultaneously.

mentioned the existence of higher values such as intrinsic values, or biocentric values; while others highlighted the need to distinguish between values being held by individuals versus values held by groups, or to distinguish between "self-orientated versus other-orientated values" (Chan et al., 2012, p.11). The main consequence of these multiple dimensions is that it is hard to clearly identify what is measured by the welfare estimates, and that the economic definition of non-use values and their subsequent quantification necessarily fails to capture all of them in a single metric. A general conclusion is that a quantitative valuation exercise of non-use values is necessarily non exhaustive and strongly needs additional information and insights from other disciplines such as philosophy, anthropology and sociology (Chan et al., 2012): we argue that the claim of the quantitative and static principle underlying the estimation of non-use values through WTP has to be moderated by a more dynamic (i.e. change in values and preferences) and multi-dimensional analysis.

More broadly, those discussions about NUV illustrate also quite well the concerns of many authors that the neoclassical model of individual rational behaviour presents some fundamental and substantial limits (e.g. Van den Bergh et al., 2000; Gowdy et Mayumi, 2001), especially when dealing with intangible values. The next chapter examines partly this issue by focusing on non-compensatory preferences. Our methodology indeed raised several issues related to payment non-attendance (e.g. reliability of individuals statements, reasons behind non-attendance, how to derive robust WTP), for which we now offer a methodology to deal with.

Chapter 2 Dealing with payment non-attendance in DCE

1. Introduction

Discrete Choice Experiments (DCE) are now widely used in the ecosystem services economic valuation literature (Hoyos, 2010). Among the recent developments and work related to this technique, a specific attention has increasingly been paid to the potential limits of the continuity axiom underlying Random Utility Theory, which forms the base of choice modelling methods. Indeed, a crucial assumption in random utility theory, as in the standard neoclassical model of rational behaviour, is that individuals' decisions follow compensatory rules. In the case of DCE, this implies a complete substitutability between the selected attributes (Campbell et al., 2011a). However, different studies (e.g. Kahneman and Frederick, 2002; Sælensminde, 2006; Campbell et al., 2008; Scarpa et al. 2009a; Araña and Leon, 2009) have provided empirical evidence where this assumption does not hold, and where individuals refuse to make trade-offs, demonstrate lexicographic preferences or do not consider all of the attributes during their choices. One of the simplified decision rules of respondents to choice experiments that has gained increasing attention in the literature is the tendency to ignore one or more of the attributes in the experiment, a behaviour that has become known as attribute non-attendance (Hole et al, 2013).

The observation of discontinuous preferences and the associated issue of attributes non-attendance has received growing attention in the DCE and choice modelling literature and has been increasingly documented (Hoyos, 2010), in the field of transportation (Hensher, 2008; Hensher and Rose, 2009; Hensher and Green, 2010 Hensher et al., 2012a, 2012b ; Hess and Hensher, 2013), health (Lagarde, 2013), food (Scarpa et al., 2012) and environmental, resource and ecological economics (Scarpa et al., 2009a, 2009b, 2010; Hoyos, 2010; Campbell et al., 2011a; McNair et al., 2012; Hussen Alemu et al., 2012; Oh, 2013). These recent research works attend to this issue both from a behavioural and analytical perspective, through offering suitable surveys designs and econometrics analysis methods. The main reason for such an increasing research topic is that attribute non-attendance can have substantial consequences on – and thus leading to biased – welfare estimates (Hensher and

Rose, 2009; Scarpa et al., 2009a; Puckett and Hensher, 2009; Campbell et al., 2011a), and more broadly on the main conclusions given by the DCE study (Scarpa et al., 2009a; Carlsson et al., 2010). Many empirical works found that taking into account attribute non-attendance both increase model fits, the consistency of the results (Hess and Hensher, 2010) and yield to lower willingness-to-pay (WTP) estimates (Hensher, 2005; Hensher et al., 2007; Campbell, 2008, 2010; Campbell et al., 2008; Puckett and Hensher, 2008, 2009; Hussen Alemu et al., 2012; Scarpa et al., 2009a, 2009b, 2011, 2012), while a few others found substantially higher model fits as well but no unidirectional change in WTP (Carlsson et al., 2010; Scarpa et al., 2010) or higher WTP (Hensher and Rose, 2009; Hensher and Greene, 2010; Oh, 2013). Delivering robust welfare estimates or more broadly preference assessment is of paramount importance from a decision-making point of view, especially when dealing with ecosystem services valuation. In the academic literature, all of the studies that looked at possible attribute non-attendance we are aware of did find existing discontinuous preferences, and highlighted significant subsequent impacts in the choice analysis' outputs.

In particular, we argue that extra-attention should be paid to cost-attribute attendance (i.e. non consideration of the payment in DCE), because it pertains to the mere existence of welfare estimates (Scarpa et al., 2009a, 2009b; Hensher et al., 2012). Cost attribute non-attendance has been reported in several studies. For instance, Scarpa et al. (2009c) found in their empirical application that for a significant number of individuals interviewed (from 40 to 80%), WTP cannot even be defined since they did not consider the payment attribute during their choices. In the studies using the stated non-attendance approach reviewed by Hussen Alemu et al. (2012), cost attribute stated non-attendance goes from 5 to 55%, and is equal to more than 20% for 10 out of the 16 papers examined. Finally Gilbride et al. (2006), Hensher (2008), Puckett and Hensher (2008), and Scarpa et al. (2009a) respectively found non-attendance to payment equal to 57%, ranging between five and 30%, up to five per cent and ranging between 80 and 90%. Although non-attendance behaviours regarding non-monetary attributes have been dealt with increasingly in recent years' literature, very few studies in the ecosystem services literature precisely focus on attendance issues regarding monetary attributes (Scarpa et al., 2009a)[22].

[22] It is worth mentioning two works that did focus on the cost attribute: Campbell et al. (2011) who looked at attendance to cheap or expensive alternative and Doherty et al. (2013) who examined different approaches to model cost heterogeneity.

This chapter offers an in-depth analysis of the payment non-attendance issue, both from a stated and an inferred non-attendance perspective, through the comparison of different modelling approaches based on discrete and continuous mixture models. It is motivated by the fact that payment non-attendance yields to some drastic consequences on DCE conclusions. As such, it aims at providing a methodology to cope with the two following issues: quantifying payment non-attendance and deriving robust welfare estimates, both at the sample and individual levels. It also econometrically examines the potential socio-economic drivers underlying payment non-attendance. Again, an empirical application is conducted with the DCE data from the two coastal areas in New Caledonia. The modelling approaches are thus compared in terms of non-attendance predictions and WTP estimates, and one is found to perform better than the others. A surprising result concerning the socio-economic characteristics of the individuals who attended or did not attend to the payment is presented.

The chapter is organized as follow. Section 2 presents the method used in our analysis, based on the recent developments in the literature, and its application to the selected data. Section 3 displays the choice modelling results obtained with the different approaches. Section 4 provides a discussion of the results. Section 5 presents the main conclusions.

2. Materials and methods

2.1 Quantifying attributes non-attendance

In practice, two approaches have been offered in the literature to deal with the non-attendance issue (Hussen Alemu et al., 2012; Scarpa et al., 2012): they are referred to as stated (through observed variables) or inferred non-attendance (through econometric analysis) approaches. The first approach aims at collecting information on respondent's choice heuristics through follow-up questions (asking them for example whether they consider or not the different attributes) either at the choice task level (i.e. after each choice task) as in Meyerhoff and Liebe (2009) or Hensher (2006), or at the overall choice experiment level (i.e. after all choice tasks), which is the case in most applications. Scarpa et al. (2010) found significant improvements in model fit when accounting for stated non-attendance (SNA) at the choice task level. The percentage of SNA varies among studies, but is usually substantial and can go from 15 to 80% of respondents stating non-attendance for any single attribute (Hussen Alemu et al., 2012). One can then use the stated attendance information prior to the econometric analysis and adapt the models to the stated attendance patterns or groups of individuals, although, as Hess and Hensher (2013, p. 398) noted: "conditioning model specification on such information may lead to endogeneity issues which could in turn lead to biased parameter estimates".

However, this follow-up questions method has some other limits[23], the main concern being whether individuals are able to assess their choice behaviour correctly or not, i.e. whether their attributes attendance statements were actually corresponding to their choices. Therefore, a second approach – inferred non-attendance (INA) – has been proposed to derive attributes non-attendance behaviours from econometric analysis through different choice models. Several modelling techniques have been used: latent class model with parameters restriction – constraining coefficients to zero – (Scarpa et al., 2012, 2009a; Hensher et al., 2012; Campbell et al., 2011a, 2008), random parameters logit models (RPL) (Balcombe et al., 2011; Hess and Hensher, 2010) and error components (Scarpa et al., 2012; Scarpa et al., 2007), discrete mixture logit models (Campbell et al. 2011b) and Bayesian estimation procedures (Balcombe et al., 2011) with stochastic attributes selection (Scarpa et al., 2009a). The latent class technique with parameters restriction has probably been the most widely used, mainly because it allows taking into account many different choice heuristics and attendance patterns at the same time, and because it provides individuals or mean probabilities of belonging to the different attributes attendance groups. However, two limits should be mentioned (Scarpa et al., 2012): the analyst's decision about the different constraints and number of classes to define non-attendance patterns is arbitrary; and by constraining parameters to zero, it does not give the possibility to differentiate between respondents who ignore an attribute and the ones who did consider it but have a very low marginal utility for it, i.e. it does not allow the parameters to be freely estimable (Campbell and Lorimer, 2009). Hess and Hensher (2010) demonstrated that several individuals who stated non-attendance to one or several attributes did end up considering the attributes during their choices, but less importantly than others. In other words, the parameters associated with these attributes are significantly different to zero. Therefore their results suggest that the RPL specification might be more adapted as it allows distinguishing between discontinuous and low preferences. In the end, depending on the different methods used, inferred attendance methods may also yield to biased results (Hussen Alemu et al., 2012).

[23] Follow-up questions increase the length and the cost of the survey. They are also "prone to procedural invariance (How do you ask the question? How is it interpreted? How well can the respondent recalls?)" (Scarpa et al., 2012, p. 177).

When examining both stated and inferred attendance methods, several studies showed that there were some divergences between non-attendance statements and attendance inferred from econometric analysis (e.g. Scarpa et al., 2012; Hensher et al., 2012; Hussen Alemu, 2012; Hess and Hensher, 2010; Carlsson et al., 2010; Campbell and Lorimer, 2009). In particular, multiple empirical applications showed that respondents who indicate non-attendance to a specific attribute still exhibit a non-zero sensitivity to that attribute (Hess and Hensher, 2013). In a recent work, Scarpa et al. (2012) examined in detail differences concerning results between SNA and different inferred attendance approaches, and found that stated attendance is informative and explains much of unobserved heterogeneity. With respect to the comparison of the inferred attendance methods, their results are more ambivalent.

In the end, the choice of the right method to tackle discontinuous preferences is far from being straightforward, and there is an agreement that more research is needed, at least in three directions: (1) by examining factors and reasons underlying SNA and using this information to condition the models during the econometric analysis (Hussen Alemu et al., 2012; Carlsson et al., 2010) [24]; (2) by improving inferred attendance methods and comparing their performances (Scarpa et al., 2012) and (3) examining in greater detail the consequences of discontinuous preferences on welfare estimates. This chapter provides a methodology and empirical results that contribute to the three of them.

2.2 Modelling approaches

As in chapter 1, we use and compare several types of models: the Multinomial Logit model (MNL), the Random Parameters Logit model (RPL), the Error Component Logit model (ECL), and the Latent Class logit Model (LCM). Both RPL and LCM also allow studying potential attributes non-attendance. We select both for our analysis, under a panel form.

2.2.1 Latent class models

The LCM sorts decision makers into different classes based on similar choice behaviours and simultaneously estimates their utility parameter conditional on class membership (see Chapter 1).

[24] Non-compensatory preferences have been shown to be mainly due to the complexity of the choice task and several contextual factors (Hussen Alemu et al., 2012; Hoyos, 2010).

The LCM is particularly useful when examining potential attributes non-attendance, through parameters restriction (Campbell et al., 2008, 2011a). By constraining some of the utility attributes coefficients to zero the analyst is able to specify the number of classes depending on pre-determined attendance rules. For example, parameters can be restricted in order to get one class for individuals who attended to all attributes, then a certain number of classes for all other possible attributes attendance rules (e.g. only one attributes attended, or a couple) and a last class with no attributes being considered. The main advantage of this approach is that it is quite straightforward and easy to compute. It also allows estimating probability of attendance at the individual level.

In our case, this approach is selected with the use of three classes: the first one with all attributes parameters freely estimable, the second one with the same parameters except for the cost attributes being constrained to zero, the third one with all parameters being equal to zero. Probability of being in class 2 gives the probability of payment non-attendance (inferred).

This can then be compared to stated attendance data. In addition, another way to test respondents' statements is to run panel LCM with (or without as a first step) parameters restrictions on the different groups of stated attendance, and look at probability of being in the class of attendance to check whether they fit to stated attendance groups.

Similarly, in order to examine the role of several socio-economic variables on payment attendance, a strategy is to run several panel LCM with (or without as a first step) a parameters restriction on different groups according to socio-economic categories (i.e. groups of age, income, gender etc.) and compare the probabilities of attendance among the groups.

Another interesting use of the LCM output to identify potential respondents' characteristics that may determine payment non-attendance is to examine potential relationships between individual probabilities of attendance or non-attendance derived from the panel LCM with parameters restrictions and several socio-economic variables. This can be achieved by using a double-censored Tobit model (see Appendix J) with individuals' probabilities of payment attendance or non-attendance (i.e. probabilities of being in class 1 and 2) as the dependent variable, and socio-demographic characteristics as regressors. In particular, variables such as gender, age, income, education level, or other variables could influence the way individuals apprehend and carry out the choice experiment (for example: variables that relate to the knowledge of, or familiarity with the ecosystems being considered). In addition, including in the list of regressors some dummy variables that represent stated consideration or importance of the payment attribute could allow examining whether such statements do correspond to infered probability of attendance or non-attendance.

2.2.2 Random parameters models

RPL or EC-RPL models have also been used in order to examine potential attributes non-attendance, using stated attendance data to condition the model (Balcombe et al., 2011; Hess and Hensher, 2010).

The RPL model assumes that preference intensities vary continuously across respondents and the error component aims at capturing any status quo effects in the stochastic part of utility (see Chapter 1). A combination of both models can be used (see Chapter 1).

In order to study payment non-attendance, we follow here the method advocated by Hess and Hensher, who suggested two approaches. The first one is to compute the coefficient of variations (CV) of individual estimates of normally distributed parameters (the coefficient of variation is equal to the ratio between the standard deviation and the mean of the conditional distribution) and selecting the ones that correspond to individuals who did consider the attributes (i.e. the ones that are inferior to a specific threshold, which the authors specify as equal to 2). With respect to our objective, having the payment coefficient following a normal distribution, we are able to compute CV associated with the payment parameter at the individual level. We then set a threshold value equal to 2[25], implying that individuals with a CV greater than 2 (in absolute value) are considered as not having attended to the payment, thus allowing us to identify an inferred attendance (IA) group. However, since we are focusing on the payment attribute, which should be strictly negative in order to derive meaningful interpretation, we also reject from this group individuals who exhibit a positive CV (corresponding to a positive payment coefficient). As such, our IA group is defined as having a CV comprised between -2 and 0. The share of individuals being in the IA group can then be compared to the share of the stated attendance (SA) group, and more generally to the individuals' statements regarding the importance of the attributes.

[25] This is the value used by Hess and Hensher (2010). This threshold value is rather arbitrary but 2 can be considered as a conservative value. During the analysis, we also used a threshold of 1 as a comparison, and this gave much more conservative results with lower percentage of attendance (corresponding to half or a third of the percentages of attendance with 2 as a threshold value).

The second method is to use statements indicator in the utility function to condition parameters on attendance statements. As such, for respondent n and attribute *k*, we have $1_{nk}(A=1)$ if respondent n stated attendance to attribute *k* in his choices, implying that the utility parameters conditional on SA are indicated with the superscript *1*, while those conditional on SNA are 0 (Scarpa et al., 2012).

$$U_{sin}= \begin{cases} V_{ins}((1_{nk}(A=1)+1_{nk}(A=0))\beta_k, X_k, \mu) + \varepsilon_{sin} \text{ , i=1,2 ;} \\ V_{ins}(ASCsq, (1_{nk}(A=1)+1_{nk}(A=0))\beta_k, X_k, \mu) + \varepsilon_{sin} \text{ , j=3(status quo)} \end{cases}$$

In addition to giving the possibility to examine the veracity of attendance or non-attendance statements, this second method gives more flexibility than restricting parameters in LCM since it allows estimating coefficients for both groups who stated attendance or non-attendance to the different attributes. As such, if both coefficients are significantly different from *0* (i.e. if the stated non-attendance statements actually corresponds to low marginal utility/disutility instead of genuine zero preference for the attributes), it is possible to test whether the one for the SA group is significantly higher than the one for the SNA group, which should a priori be the case if statements are consistent with the choices. This can be achieved using a one-tail test on the difference between the two coefficients $\Delta=abs(\beta_k|A=1 - \beta_k|A=0)$ to see whether $\Delta>0$ or $\Delta = 0$, or restricting both coefficients to be equal and conduct a likelihood ratio test (Hess and Hensher, 2010, Scarpa et al., 2012). As previously, we apply this method with a focus on the payment parameters, thus estimating two distinct coefficients with EC-RPL models.

As for the LCM, we can also examine attendance statements by running separate EC-RPL models on the different SA groups, and comparing IA results through the CV method for each models. Similarly, a set of EC-RPL models can be run to test previous results from panel LCM regarding the impact of the socio-demographic variables on attendance to payment, by deriving CV and comparing IA for the different socio- demographic groups.

2.3 Case study

Here again, we use from the discrete choice experiment (DCE) study presented in Chapter 1. As a reminder, the list of attributes and associated levels of the DCE is presented in table 2-1 below. As in Chapter 1, 116 individuals were dismissed from our analysis, because of choice refusal or incomplete choices. All the analysis was conducted using NLogit 5.0. The log-linear specification presented in Chapter 1 was used for the deterministic parts of our utility functions:

$V_{Option\ 1\ or\ 2,\ ZCO} =$
$\beta_1 \times \text{Payment} + \beta_2 \times Ln(\text{Quantity of animals fished}) + \beta_3 \times \ln(\text{Health and richness of marine life}) + \beta_4 \times \ln(\text{Coastal and lagoon landscapes}) + \beta_5 \times \ln(\text{Areas of practice})$

$V_{Option\ 1\ or\ 2,\ VKP} =$
$\beta_1 \times \text{Payment} + \beta_2 \times Ln(\text{Quantity of animals fished}) + \beta_3 \times \ln(\text{Health and richness of marine life}) + \beta_4 \times \ln(\text{Coastal and lagoon landscapes}) + \beta_5 \times \text{Areas of practice 20 years} + \beta_6 \times \text{Areas of practice 50 years} + \beta_7 \times \text{Areas of practice 100 years}$

$V_{Status\ quo, ZCO/VKP} = ASC_{sq} + V_{Option\ 1\ or\ 2,\ ZCO/VKP}$

Table 2-1 Attributes and levels

Attributes	Levels	Status quo
Payment	**500**, **1000**, **1500**, **2000** CFP[26] per month	0 CFP
Quantity of fished animals	Preservation for **20**, **50** or **100** years	Progressive decline over time
Health and richness of underwater life	Preservation for **20**, **50** or **100** years	Progressive degradation over time
Coastal and lagoon natural landscapes	Preservation for **20**, **50** or **100** years	Less natural areas and more constructions
Areas of practice	Secured for **20**, **50** or **100** years	Sufficient areas of practice not guaranteed for future

With respect to our methodology, several panel LCMs (without and with payment parameter restriction) are first used for each area, either on the whole sample, or on specific sub-samples, considering two objectives: (1) check for cost attribute non-attendance, and compare inferred with stated attendance results; and (2) look at how this potential attendance or non-attendance is distributed among our population. This second objective is dealt with by examining results of several panel LCMs run on different socio-demographic groups (life in tribe versus non-tribe, age and income categories) and by running for each area a Tobit model on estimated individuals' probabilities of non-attendance with the following potential

[26] Pacific Franc. In 2013, 100 CFP is equal to around 0.84 € or 1.08 US$.

explanatory variables: age, income, educational level, life in tribe, stated importance of payment, frequency of fishing activities and frequency of recreational non-extractive activities.

Then, as the second main modelling approach, a set of EC-RPL models is run. A general panel EC-RPL model for each area is first used, with the payment attributes normally distributed and all other attributes following a constrained triangular distribution, in order to apply the CV-based IA method. A second set of EC-RPL models is then run on subgroups to confirm the impact of specific socio-demographic variables on attendance to payment, based on the results from LCM. The CV method is used again in order to look at IA for both the different socio-demographic categories studied. Finally a last set of panel EC-RPL models is implemented using the second IA method presented above to test the reliability of stated attendance statements, with separate payment coefficients for SA and SNA groups.

The last step is to compute WTP, both at the sample and individual levels, and compare the different modelling approaches in terms of two criteria: the magnitude of the WTP estimates (which relates to its credibility) and the number of individuals for which the WTP can be estimated. Regarding the first criteria, an interesting measure to look at is the ratio between the total estimated WTP and the maximum amount of payment offered in the choice experiment. Ideally we do not want this ratio to be too high, since it would imply that the estimated WTP cannot be realistically expected. The models compared in terms of WTP are: the MNL model, the panel LCM with and without restrictions, and several panel EC-RPL models. These include: a generic one with all parameters following constrained triangular distribution; a panel EC-RPL model run on the IA group derived from the previous EC-RPL model; and a panel EC-RPL model focusing on the SA group.

3. Results

3.1 Stated choice behaviour

We first examined attribute processing rules and attendance issues. The results are detailed in tables 2-2 and 2-3. According to table 2-2, more than half of the individuals who completed the eight choices declared having not paid serious (none to medium importance) attention to the payment attribute and its associated levels. All other attributes were considered in a reasonably homogeneous way, with very few individuals who stated very low or non-attendance.

Furthermore, it can be noted that the differences between the different payment statements in table 2-2 from one area to the other are all statistically different according to t-tests.

According to table 2-3, around 57% of the individuals declared having considered all attributes. This would correspond to the results regarding payment consideration of table 2-2 if the medium importance statements do imply a consideration, but not the low importance statements. Similarly the 27.4% of individuals having stated they considered only some attributes (reported in table 2-3) would correspond to the individuals who stated no consideration at all to the payment plus a few individuals having stated low importance of the payment (reported in table 2-2).

Table 2-2 Stated payment attribute consideration during choice process for each area (% with no responses excluded from sample)

	All sample				ZCO				VKP			
	No importance	Low importance	Medium importance	Important to decisive	No importance	Low importance	Medium importance	Important to decisive	No importance	Low importance	Medium importance	Important to decisive
Payment	**23.6%**	**14.2%**	23.4%	**38.8%**	**31%**	**16.5%**	18%	**34.5%**	**17.1%**	**12.3%**	28.1%	**42.5%**
Fished Animals	2.3%	3.2%	13%	81.5%	4%	2%	10,4%	83.6%	0.9%	4.3%	15.2%	79.6%
Health Marine life	0.2%	0.4%	1.6%	97.8%	0%	1%	2.5%	96.5%	0.4%	0%	0.9%	98.7%
Landscapes	0.2%	0.7%	2.8%	96.3%	0.05%	0.05%	2.5%	96.5%	0%	0.9%	3%	96.1%
Areas of practice	0%	3.2%	10%	86.8%	0%	3.5%	10%	86.5%	0%	3%	10%	87%

Table 2-3 Stated attributes attendance behaviours for each area (percentages exclude no responses)

	All sample	ZCO	VKP
Attendance to all attributes	58.1%	61%	55%
Attendance to only one attributes	14.5%	18%	12%
Attendance to some attributes	27.4%	21%	33%

Concerning the 15% of the individuals who declared having considered only one attribute (table 2-3), it means they only considered the payment concerning table 2-2. If these statements are indeed corresponding to their choices, it would imply that these individuals would have selected the cheapest option or even the status quo systematically.

It is important to note that, in the econometric analysis presented in this chapter, we only focus on examining attendance or non-attendance to payment as it is the major result in terms of non-attendance (as suggested in table 2-2), and because it can change drastically the conclusions of the DCE in terms of welfare estimates. An econometric analysis focusing on attendance or non-attendance patterns involving all the attributes has been conducted and is presented in Appendix K (based on the same modelling approaches than the one described above). The results (especially the ones from the EC-RPL IA approaches detailed in table K2, K3, K4, K5) confirm the fact that payment non-attendance really is the major issue at stake here.

During the econometric analysis, the results from table 2-2 were used in order to test individuals' statements of attendance or non-attendance. After testing several MNL, LCM and RPL models for each importance groups presented in table 2-2, we finally broke our sample into two categories: individuals who stated nil to medium attendance to the payment, corresponding to the SNA group; and individuals who stated important and systematic consideration, corresponding to the SA group. Results from the different models presented below run on SA and SNA groups confirm the pertinence of these two categories.

3.2 Panel LCM results

Both types of panel LCM (with and without restrictions) were used in order to allow comparisons between their results. Simple panel LCM for each area were first run, either on all sample, or on specific groups of individuals. Results from these generic models are presented in tables 2-4 and 2-5. Then panel LCM with a restriction on the payment parameters were run, considering the entire sample as well as the same pre-identified groups. Results for these models are presented in tables 2-6 and 2-7.

For all the models, adjusted pseudo R-squared are much higher compared to MNL model (see chapter 1 for MNL results). Model fits are globally higher for the LCM without parameters restriction.

Concerning the results on entire samples, the generic LCM (tables 2-4 and 2-5) exhibit three classes of preferences for each area. For both areas, the third class corresponds to individuals whose choices cannot be explained by the model. For the VKP area, both classes 1 and 2 show significant parameter associated with payment, whereas for the ZCO areas, only the second one does. The estimated probability for individuals being in this class 2 for the ZCO area is significant and equal to 0.15, implying that around 15% of individuals are predicted as attending to the payment. For VKP area, it is not possible to derive any result concerning attendance or non-attendance to payment from this generic model on the whole sample, but comparing parameters estimates of class 1 and 2 shows that individuals in class 1 seem to have a lower consideration of payment than individuals in class 2 when looking at the ratio between non-monetary attributes and payment.

The results on the entire sample from the panel LCM with parameters restriction on payment imply respectively 74% and 77% of non-attendance to payment, at the sample level (tables 2-6 and 2-7). When examining estimated probabilities at the individual level, results are quite similar: the probability of non-attendance (i.e. the probability of being in class 2) is the highest for 79% of individuals for both areas, and the probability of attendance is the highest for 15% for VKP area, and 10% for ZCO areas. The comparison between IA from these models and SA at the individual level are provided in tables 2-8 and 2-9. Results also show a limited correspondence between respondents' payment importance rating and inferred attendance for both areas, although there is a better correspondence for the VKP area.

Looking at the results of each of the model run on the SA and SNA groups confirms that correspondence between stated non-attendance and model results is good, whereas this does not seem to be the case for stated attendance. Indeed payment parameters are never significant for the SNA group in all LCM in ZCO. The same results can be observed for VKP, with the exception of the payment parameter of the first class in the LCM with parameters restriction, which is significant at the 10% level.

Table 2-4 Panel LCM for different groups of populations in VKP area

	VKP: All	Stated attendance		Tribe/Non Tribe		Age				Income			
		SA group	SNA group	Tribe	Non Tribe	20-30	30-40	40-50	50 +	Low	Low-Med	Mid	High
CLASS 1													
Payment	-0.00035**	-0,00048***	-0.00012	-0.00063***	-0.00002	-0.00068***	0.00003	0.00091	-0.00052***	0.00085*	-0.00057***	-0.00012	-0.00041***
Ln Catches	0.267***	0,137***	0.269***	0.256***	0.116***	0.253***	0.144***	0.295***	0.175***	0.189**	0.171***	0.124***	0.193***
Ln Health	0.563***	0,208***	0.533***	0.533***	0.233***	0.489***	0.200***	0.422***	0.236***	0.131	0.237***	0.255***	0.354***
Ln Landscape	0.311***	0,090***	0.342***	0.313***	0.104***	0.270***	0.127***	0.482***	0.127***	-0.115	0.149***	0.173***	0.130***
Areas 20 years	0.14	0,215***	0.069	0.121	-0.049	0.186	-0.065	-0.169	-0.062	-0.231	-0.107	0.131	-0.062
Areas 50 years	0.500***	0,317***	0.449***	0.683***	0.313***	0.275	0.445***	0.640*	0.268**	0.299	0.379***	0.192*	0.472***
Areas 100 years	0.103	-0,104	0.098	-0.004	-0.052	0.406*	-0.15722	0.677*	0.085	-0.567*	0.085	0.007	0.127
ASCsq	1.302**	-1.479***	0.824	0.795	-3.798***	-0.246	-1.158***	-25.633	-1.887***	-29.75	-1.910***	-1.38***	-1.366*
CLASS 2													
Payment	-0.00026***	NS	-0.00011	-0.00032*	-0.0016***	-0.00027**	NS	-0.00082***	NS	-0.00084***	NS	NS	NS
Ln Catches	0.062***	NS	0.029	0.052	0.510***	0.046	NS	0.169***	NS	0.165***	NS	NS	NS
Ln Health	0.049***	NS	0.0008	-0.040	0.453***	-0.001	NS	0.504***	NS	0.576***	NS	NS	NS
Ln Landscape	0.021	NS	-0.013	-0.003	0.308***	-0.042	NS	0.147***	NS	0.458***	NS	NS	NS
Areas 20	0.062	NS	-0.093	0.078	0.668**	0.211	NS	0.17598	NS	0.628***	NS	NS	NS
Areas 50	0.245***	NS	0.274***	0.415489***	0.196	0.268**	NS	0.284**	NS	1.200***	NS	NS	NS
Areas 100	-0.22***	NS	-0.257	-0.296	-0.183	-0.462***	NS	-0.15825	NS	0.074	NS	NS	NS
ASCsq	-3.235***	NS	-2.62***	-4.838***	2.508**	-1.580***	NS	0.19636	NS	2.566***	NS	NS	NS
Pseudo-R2	0.439	0.388	0.467	0.462	0.419	0.35	0.4	0.47	0.44	0.41	0.42	0.4	0.43
AIC	1.252	1.369	1.195	1.220	1.312	1.49	1.38	1.23	1.3	1.46	1.32	1.39	1.29
Prob CLASS 1	0.56**	0.90**	0.74***	0.68***	0.80***	0.62***	0.96	0.39**	0.9*	0.35	0.94	0.97	0.91
Prob CLASS 2	0.39**	0.10***	0.26***	0.29***	0.13***	0.38***	0.04*	0.61***	0.01***	0.51	0.06**	0.03	0.09**
Prob CLASS 3	0.05***			0.03**	0.07***					0.14**			
N	244	113	131	122	122	60	72	54	58	38	61	59	59

Very low income: from less than 600$ to 1200$ per month per household
Low income: from 1200$ to 2500$ per month per household
Average/Middle-Class income: from 2500$ to 4000$ per month per household
High income: more than 4000$ per month per household
NS =Non Significant

Table 2-5 Panel LCM for different groups of populations in ZCO area

	Panel LCM ZCO	Stated attendance		Tribe/Non Tribe		Age				Income			
		SA group	SNA group	Tribe	Non Tribe	20-30	30-40	40-50	50 +	Low	Low-Med	Middle Class	High
CLASS 1													
Payment	-0,00008	-0.00024**	-0.000012	-0,00007	0,00007	0,00003	-0,00007	-0,00013	-0,0015	-0,00014	0.00012	-0,00095	-0,00019
Ln Catches	0,124***	0.112***	0.142***	0,041	0,157***	0,096**	0,090***	0,181***	0,176***	0,159***	0.079*	0,493**	0,252***
Ln Health	0,159***	0.159***	0.184***	0,030	0,220***	0,114***	0,143***	0,318***	0.150***	0,194***	0.196***	0,622*	0,742***
Ln Landscape	0,146***	0.145***	0.166***	0,101***	0,174***	0,131***	0,098***	0,252***	0.179***	0,172***	0.199***	-0,147	0,363***
Ln Areas	0,118***	0.094***	0.144***	0,091***	0,137***	0,103***	0,138***	0,176***	0.110***	0,107***	0.163***	0,970***	0,406***
ASCsq	-115,98	-0.934***	-19.69	-31,40	-59.45	-30,23	-2,806***	-1,104	-0.212	-0,022	-34.97	-25,60	2,999**
CLASS 2													
Payment	-0,00041**	NS	-0.00025	-0,00019	-0,00048*	-0,00087***	0,00047	-0,00037	NS	NS	-0.0025**	-0.00007	NS
Ln Catches	0,282***	NS	0.249***	0,102	0,314***	0,074	-0,055	0,566***	NS	NS	0.785**	0,101*	NS
Ln Health	0,482***	NS	0.458***	0,017	0,578***	0,322***	0,111	0,765***	NS	NS	1.034**	0,194***	NS
Ln Landscape	0,416***	NS	0.450***	0,302**	0,454***	0,248***	0,124	0,749***	NS	NS	0.529**	0,369***	NS
Ln Areas	0,305***	NS	0.317***	0,268	0,314***	0,239***	0,075	0,498***	NS	NS	0.777**	0,140**	NS
ASCsq	5,036***	NS	5.331***	3,924***	5.565***	1,720***	3,043***	10,42***	NS	NS	10.39***	0,216	NS
Pseudo-R2	0,39	0.352	0.400	0,34	0,417	0,34	0,35	0,46	0,359	0,32	0,436	0,51	0,33
AIC	1,36	1.449	1.335	1,51	1,302	1,53	1,45	1,24	1,440	1,51	1,298	1,23	1,59
Prob CLASS 1	0,79*	0.88***	0.83***	0,89*	0,76***	0,81***	0,9*	0,83***	0,88***	0,93	0,87***	0,43***	0,6***
Prob CLASS 2	0,15***	0.12***	0.17***	0,11**	0,18	0,19***	0,1**	0,17***	0,12***	0,07***	0,13***	0,57***	0,4***
Prob CLASS 3	0,6***				0,06								
Number ID	213	82	131	47	166	41	48	58	66	98	38	20	27

Low income: from less than 600 AU$ to 1650 AU$ per month per household
Low-Medium income: from 1650AU$ to 3000AU$ per month per household
Average/Middle-Class income: from 3000$ to 4000$ per month per household
High income: more than 4000$ per month per household

Table 2-6 Panel LCM with parameters restrictions for different groups of populations in VKP area

	All sample	Stated attendance		Living in tribe or not		Age				Income			
		SA group	SNA group	Tribe	Non Tribe	20-30	30-40	40-50	50 et +	Very low	Low-Med	Mid	High
Payment (Class 1)	-0.0014***	-0.0013***	-0.0013*	-0.0013***	-0.0014***	-0.0012***	0.0011	-0.0012***	-0.0016***	-0.079	-0.0016***	0.049	-0.0012**
Ln Catches	0.204***	0.194***	0.215***	0.225***	0.188***	0.184***	0.187***	0.205***	0.247***	0.145***	0.287***	0.121***	0.225***
Ln Health	0.329***	0.305***	0.340***	0.319***	0.338***	0.267***	0.272***	0.479***	0.337***	0.238***	0.403***	0.318***	0.388***
Ln Landscape	0.194***	0.162***	0.222***	0.218***	0.177***	0.159***	0.182***	0.259***	0.205	0.173***	0.209***	0.244***	0.172***
Areas 20 years	0.055	0.255***	-0.096	0.061	0.043	0.266**	-0.083	0.078	-0.084	0.146	-0.150	0.247	0.012
Areas 50 years	0.452***	0.494***	0.415***	0.589***	0.370***	0.326**	0.612***	0.497***	0.396***	0.310***	0.586***	0.220***	0.474***
Areas 100 years	0.014	-0.065	0.069	0.012	0.004	0.045	-0.150	0.058	0.190	-0.045	0.154	-0.145	0.119
Class 1 Probability (All attributes ≠ 0)	0.18***	0.31***	0.08	0.25**	0.11***	0.26**	0.14	0.33**	0.24**	0.06**	0.27***	0.05	0.29*
Class 2 Probability (Payment=0)	0.74***	0.55***	0.90	0.68***	0.79**	0.69***	0.75***	0.65***	0.63***	0.94***	0.61**	0.90***	0.65***
Class 3 Probability (all attributes = 0)	0.08***	0.14***	0.02	0.07**	0.10***	0.05	0.11**	0.02	0.13***	0.00	0.12**	0.05	0.06*
Final LL	-1352.4	-702.67	-630.67	-646.09	-701.63	-344.86	-405.94	-240.12	-340.27	-335.81	-278.4	-222.33	-302.42
Adj Pseudo-R^2	0.368	0.289	0.450	0.397	0.343	0.340	0.353	0.489	0.326	0.388	0.407	0.374	0.411
AIC	1.395	1.574	1.221	1.342	1.456	1.474	1.441	1.153	1.505	1.368	1.331	1.411	1.320
Number of classes	3	3	3	3	3	3	3	3	3	3	3	3	3
N Individuals	244	113	131	122	122	60	72	54	58	63	54	41	59

Low income: from less than 600 AU$ to 1650 AU$ per month per household
Low-Medium income: from 1650AU$ to 3000AU$ per month per household
Average/Middle-Class income: from 3000$ to 4000$ per month per household
High income: more than 4000$ per month per household

Table 2-7 Panel LCM with parameters restrictions for different groups of populations in ZCO area

	All sample	Stated attendance		Living in tribe or not		Age				Income			
		SA group	SNA group	Tribe	Non Tribe	20-30	30-40	40-50	50 et +	Very low	Low-Med	Mid	High
Payment (Class 1 only)	-0.0015***	-0.0013***	0.058	0.0598	-0.0016***	-0.0015***	0.0035	-0.0018***	-0.0013***	0.060	0.0023*	-0.00028	-0.000055
Ln Catches	0.175***	0.171***	0.164***	0.096***	0.186***	0.132***	0.124***	0.185***	0.222***	0.172***	0.157	0.184***	0.141***
Ln Health	0.243***	0.232***	0.229***	0.087***	0.279***	0.191***	0.206***	0.324***	0.201***	0.186***	0.236	0.291***	0.264***
Ln Landscape	0.215***	0.208***	0.207***	0.214***	0.223***	0.202***	0.162***	0.261***	0.221***	0.182***	0.240***	0.228***	0.190***
Ln Areas	0.174***	0.154***	0.161***	0.170***	0.1693***	0.167***	0.195***	0.182***	0.151***	0.133***	0.121***	0.278***	0.148***
Class 1 Probability (All attributes ≠ 0)	0.11***	0.14**	0.02	0.06	0.10***	0.15	0.05	0.08	0.150**	0.03	0.11	0.96	0.91
Class 2 Probability (Payment=0)	0.77***	0.66***	0.89	0.83	0.78***	0.83	0.84	0.84	0.648***	0.79***	0.71***	0	0
Class 3 Probability (all attributes = 0)	0.12***	0.20***	0.08**	0.11**	0.12***	0.02	0.11**	0.08*	0.202***	0.18***	0.18***	0.04	0.09
Final LL	-1287.2	-549.6	-735.3	-304.9	-967.4	-249.5	-293.3	-304.9	-427.5	-607.2	-343.6	-166.3	-161.2
Adj Pseudo-R^2	0.311	0.233	0.359	0.255	0.355	0.300	0.298	0.397	0.258	0.261	0.309	0.453	0.309
AIC	1.519	1.697	1.417	1.689	1.467	1.564	1.564	1.344	1.646	1.634	1.538	1.238	1.558
Number of classes	3	3	3	3	3	3	3	3	3	3	3	3	3
N Individuals	213	82	113	47	166	41	48	58	66	94	57	35	27

Low income: from less than 600 AU$ to 1650 AU$ per month per household
Low-Medium income: from 1650AU$ to 3000AU$ per month per household
Average/Middle-Class income: from 3000$ to 4000$ per month per household
High income: more than 4000$ per month per household

Table 2-8 Inferred versus stated attendance to payment for VKP area using panel LCM with parameters restrictions

	IA at individual level	Payment importance rating in IA group	SA*
All sample	15%	Imp0: 12%; Imp1: 6%; Imp2: 16%; Imp3: 20%; Imp4: 46%	39.8%

Imp0: no importance, Imp1: low importance, Imp2: medium importance, Imp3: important, Imp4: strong importance
**: The percentage presented in this column is a proportion of all sample, which includes individuals who did not answer to the stated attendance question, which is why it differs slightly from the percentage of the last column of table 2-2.*

Table 2-9 Inferred versus stated attendance to payment for ZCO area using panel LCM with parameters restrictions

	IA at individual level	Payment importance rating in IA group	SA*
All sample	11%	Imp0: 22%; Imp1: 14%; Imp2: 14%; Imp3: 23%; Imp4: 27%	32.4%

Imp0: no importance, Imp1: low importance, Imp2: medium importance, Imp3: important, Imp4: strong importance
**: The percentage presented in this column is a proportion of all sample, which includes individuals who did not answer to the stated attendance question, which is why it differs slightly from the percentage of the last column of table 2-2.*

Nevertheless, results from panel-LCM (with and without restrictions) models show a higher attendance from the SA group of individuals that stated the payment as being “important to decisive”, when compared to the other group. For both areas, generic LCM results (tables 2-4 and 2-5) for individuals who stated no or slight attendance to payment attribute show two classes with insignificant payment parameter, and results for individuals who stated consideration of cost show a good homogeneity with a major dominant class (90% of individuals) with significant payment parameter (the second class regrouping unexplained choices). However, in tables 2-6 and 2-7, results show that there is a significant proportion of non-attendance to payment in the stated attendance group, so that there are less similarities between inferred and stated attendance.

Regarding the results for the other sub-groups, corresponding to various socio-demographic categories, it can be noted that in both areas, payment consideration is mainly coming from people between 20 and 30 years old, or between 40 and 50 years old, with a low to medium household income. Furthermore, in VKP area, payment consideration seems to be mainly coming from people living in tribe. Results from generic panel LCM show that more than 95% of individuals who are living in tribes (Kanak people) did consider the payment, with a bit less than 15% for people living in villages or farms (mainly white Caledonian people). This is somehow tempered by the results from table 2-4, with parameters restrictions, although individuals living in tribe still do seem to show more attendance to payment. Payment non-attendance in VKP seems to come mostly from individuals aged between 30 and 40 years old (as in ZCO), with either a very low or middle-class household income. Since both individuals with very low and high household incomes in this area did consider the payment, it tends to prove that non-attendance was not due to insufficient payment levels. It was worth checking this issue even if the levels were selected properly through focus group discussions.

In order to examine more broadly the impact on socio-demographic variables on non-attendance, the results from the Tobit model run on the probability of non-attendance are presented in table 2-10. All explanatory variables are highly significant for each area (with the exception of the frequency of recreational activities for the ZCO area).

The variables that have a positive influence on probability of non-attendance for both areas are income, level of education and stated none, low or medium importance to payment. The positive sign of the latest confirm that the broad statements regarding attributes consideration are reliable, although their associated marginal effects tend to show that the importance rankings are less reliable. In other words, all individuals that stated either none, low or medium importance of the payment attribute during their choices do have a higher probability of non-attendance, but not in a decreasing way. The "life in tribe" variable has a negative influence for both areas, which confirms previous results, i.e. that individuals living in tribe attend significantly more to payment than individuals not living in tribe. Another variable that would explain lower attendance to payment is the level of education. Furthermore, two variables have opposite effects depending on the area: gender (male) which exhibits a negative effect for ZCO area (positive for VKP), and age, which exhibits a negative effect for VKP area (positive for ZCO). Finally two points can be made regarding the influence of marine activities on attributes non-attendance: for both areas the more the individuals are involved in fishing the less they attend to payment, and for VKP area, the more people are involved in non-extractive recreational activities, the more they attend the payment.

We also applied the same Tobit models on the probabilities of attendance, with similar results (table 2-11) but considerably lower model fits and predictions, certainly because there is significantly less variation in these individuals' probabilities, since very few individuals were actually assigned a high probability of attendance to payment.

Table 2-10 Tobit model on individuals' probabilities of non-attendance to payment computed with the LCM: results for VKP and ZCO areas

X	VKP			ZCO		
	Coeff. (sandwich)	Marginal Effects	Mean of X	Coeff. (sandwich)	Marginal Effects	Mean of X
Age	-0.001***	-0.0009***	41 yo	0.002***	0.001***	44 yo
Gender	0.044***	0.035***	49% Male	-0.079***	-0.059***	47% Male
Income	0.004***	0.003***	Category 6: 3200$/household/month	0.010***	0.007***	Category 4-5: 2200$/household/month
Tribe	-0.054***	-0.042***	52% Living in Tribe	-0.039***	-0.029***	27% Living in Tribe
Level of education	0.022***	0.018***	Category 2: Baccalaureate	0.028***	0.020***	Category 2: Baccalaureate
"No importance of payment" statement	0.133***	0.106***	15%	0.081***	0.060***	28%
"Very little importance of payment" statement	0.189***	0.150***	12%	0.101***	0.075***	16%
"Medium importance of payment" statement	0.157***	0.125***	25%	0.094***	0.069***	15%
Fishing	0.025***	0.020***	Category 1: Every two months	0.0537***	0.040***	Category 1: Every two months
Non-extractive recreational activities	-0.046***	-0.036***	Category 1: Every two months	-0.005	-0.004	Category 1: Every two months
Constant	0.618***	0.491***		0.555***	0.412***	
σ		0.298***			0.333***	
N		215			170	
Pseudo-R^2 ANOVA[1]		0.242			0.227	
Pseudo-R^2 DECOMP[2]		0.433			0.406	

[1]*: variance of predicted conditional mean/variance of observed variable*

[2]*: variance of predicted mean/(variation of predicted mean + residual variation)*

Table 2-11 Tobit model on individuals' probabilities of attendance to payment computed with the LCM: results for VKP and ZCO areas

X	VKP			ZCO		
	Coeff. (sandwich)	Marginal Effects	Mean of X	Coeff. (sandwich)	Marginal Effects	Mean of X
Age	-0.0002	-0.0002	41 yo	-0.001***	-0.001***	44 yo
Gender	-0.052***	-0.040***	49% Male	0.030***	0.021***	47% Male
Income	-0.002**	-0.002**	Category 6: 3200$/household/month	-0.002	-0.001	Category 4-5: 2200$/household/month
Tribe	0.027***	0.021***	52% Living in Tribe	0.014	0.009	27% Living in Tribe
Level of education	-0.010***	-0.008***	Category 2: Baccalaureate	-0.024***	-0.017***	Category 2: Baccalaureate
"Importance of payment" statement	0.106***	0.082***	15%	0.058***	0.041***	28%
"Strong importance of payment" statement	0.116***	0.090***	27%	0.049***	0.034***	16%
Fishing	0.021***	0.017***	Category 1: Every two months	0.002	0.002	Category 1: Every two months
Non-extractive recreational activities	0.008	-0.006	Category 1: Every two months	-0.007	-0.005	Category 1: Every two months
Constant	0.191***	0.149***		0.196***	0.412***	
σ		0.236***			0.196***	
N		215			181	
Pseudo-R^2 ANOVA[1]		0.004			0.005	
Pseudo-R^2 DECOMP[2]		0.212			0.093	

[1]: variance of predicted conditional mean/variance of observed variable

[2]: variance of predicted mean/(variation of predicted mean + residual variation)

3.3 Panel EC-RPL models results

Results from the general panel EC-RPL model (with 500 Halton draws) are presented on the left side of tables 2-12 and 2-13. Model fits are once again quite high and, for both areas, all parameters are highly significant (except for the payment coefficient which is only significant at 10% level for the ZCO area), as well as their associated standard deviation, implying important preference heterogeneity in our sample.

Results for both areas based on the CV method are presented in tables 2-14 and 2-15 (first row), and allow comparison between stated and inferred attendance based on the percentage of individuals from our sample that are in each group. For VKP, the IA group is larger compared to the SA group with 8% difference; for ZCO it is the opposite and both groups represent very similar shares of our sample. This could suggest that stated and inferred attendance would give similar results, but when looking at the corresponding stated importance of the payment attribute for the individuals in the IA group, we have in both areas a significant percentage of individuals that actually stated either nil or low important consideration of the payment during their choices (imp0 and imp1 in table 2-10 and 2-11). As such, the correspondence between IA (based on the CV method with k=2) and SA seems to be limited.

Regarding the potential impact of socio-demographic categories on payment non-attendance, we now test the particularly interesting result from LCM and Tobit models regarding tribe and non-tribe individuals. Results of the EC-RPL models for these two subgroups are presented on the right column of tables 2-12 and 2-13, and corresponding CV-based IA results for individuals living or not in tribe in tables 2-14 and 2-15 (last two rows). Model fits are similar to previous EC-RPL models.

Table 2-12 Panel EC-RPL models results for VKP area with normally distributed payment coefficient: all sample and for tribe versus non-tribe populations

	All sample		**Tribe**		**Non-Tribe**		Distribution
	Mean	S.D	Mean	S.D	Mean	S.D	
Payment	-0.00038***	0.00084***	-0.00055***	0.00069****	-0.00024*	0.00098***	n
Ln Catches	0.183***	0.183***	0.205***	0.205***	0.173***	0.173***	t,1
Ln Health	0.327***	0.327***	0.324***	0.324***	0.338***	0.338***	t,1
Ln Landscapes	0.175***	0.175***	0.190***	0.190***	0.163***	0.163***	t,1
Areas 20 years	0.031		0.017		0.0436		fixed
Areas 50 years	0.468***	0.468***	0.595***	0.595***	0.348***	0.348***	t,1
Areas 100 years	-0.046		-0.052		-0.035		fixed
ASCsq	-6.871***		-6.560***		-6.835***		
Sigma Option 1,2	3.23756		2.741		3.375		
Sigma Status Quo	5.80955**		5.014*		6.420***		
Final Log-Likelihood	-1218.2		-593.2		-619.9		
AIC	1.259		1.238		1.293		
Adjusted Pseudo-R^2	0.430		0.444		0.418		
Halton Draws	500		500		500		
N	244		122		122		

Table 2-13 Panel EC-RPL models results for ZCO area with normally distributed payment coefficient: all sample and for tribe versus non-tribe populations

	All sample		**Tribe**		**Non-Tribe**		Distribution
	Mean	S.D	Mean	S.D	Mean	S.D	
Payment	-0.00014*	0.00070***	-0.00011	0.00094***	-0.00014	0.00052***	n
Ln Catches	0.162***	0.162***	0.0566	0.0566	0.199***	0.199***	t,1
Ln Health	0.246***	0.246***	0.036	0.036	0.325***	0.325***	t,1
Ln Landscapes	0.212***	0.212***	0.134	0.134***	0.249***	0.249***	t,1
Ln Areas	0.169***	0.169***	0.137	0.137***	0.189***	0.189***	t,1
ASCsq	-5.310***		-18.96		-4.061***		
Sigma Option 1,2	6.849***		7.236		6.262***		
Sigma Status Quo	1.668		14.89		1.682		
Final Log-Likelihood	-1156.9		-262.2		-866.7		
AIC	1.368		1.443		1.319		
Adjusted Pseudo-R^2	0.380		0.357		0.404		
Halton Draws	500		500		500		
N	213		47		166		

For VKP area, most of the attributes are highly significant (including their associated standard deviation), with the exception of the payment coefficient for the individuals not living in tribe, which is only significant at 10% level. Looking at IA and SA groups for tribe and non-tribe individuals in VKP confirms the same results as before: individuals living in tribe did attend to payment more than the ones not living in tribe, both from an inferred (respectively 72% against 41%) and stated attendance (respectively 56% against 37%) perspective. Again, the share of respondents in IA groups is higher, and correspondence between inferred attendance (IA) and individuals' stated importance of payment attribute is weak. For ZCO area, all non-monetary coefficients are highly significant (including their standard deviation) but both coefficients associated with the payment for tribe and non-tribe individuals are insignificant. As such, it is impossible to confirm our previous results for this area using the EC-RPL model and the IA method.

Table 2-14 Inferred versus stated attendance to payment for VKP area using panel EC-RPL models: all sample and tribe versus non-tribe results

	VKP		
	IA group: -2<CV <0	Payment importance rating in IA group	SA*
All	47.9%	Imp0: 10%; Imp1: 10%; Imp2: 24%; Imp3: 16%; Imp4: 29%	39.8%
Tribe	72%	Imp0: 9%; Imp1: 9%; Imp2: 23%; Imp3: 14%; Imp4: 40%	56%
Non-Tribe	41%	Imp0: 10%; Imp1: 12%; Imp2: 30%; Imp3: 16%; Imp4: 16%	37%

Imp0: no importance, Imp1: low importance, Imp2: medium importance, Imp3: important, Imp4: strong importance
: The percentage presented in this column is a proportion of entire sample, which includes individuals who did not answer to the stated attendance (SA) question, which is why it differs slightly from the percentage of the last column of table 2-2.

Table 2-15 Inferred versus stated attendance to payment for ZCO area using panel EC-RPL models: all sample and tribe versus non-tribe results

	ZCO		
	IA group: -2<CV <0	Payment importance rating in IA group	SA*
All	29.1%	Imp0: 19%; Imp1: 16%; Imp2: 11%; Imp3: 21%; Imp4: 21%	32.4%

Imp0: no importance, Imp1: low importance, Imp2: medium importance, Imp3: important, Imp4: strong importance
: The percentage presented in this column is a proportion of entire sample, which includes individuals who did not answer to the stated attendance question, which is why it differs slightly from the percentage of the last column of table 2-2.

Results of panel EC-RPL models with separate payment coefficients for SA and SNA groups are presented in table 2-16, for both areas (this corresponds to the second EC-RPL IA method presented in section 2.2). A constrained triangular distribution was chosen for the payment parameter associated with the SA group (in order to allow for the possibility to estimate WTP later), and the payment parameter associated with the SNA group was set as fixed since insignificant under both random distribution or fixed form. As such, the test between the two payment coefficients was unnecessary. For both areas, all coefficients and standard deviations are highly significant, except for the SNA group, thus confirming previous results from the panel LCM results, indicating that stated attendance is reliable at the sample level.

Table 2-16 Panel EC-RPL models with different payment coefficients for individuals who stated attendance or not to payment

	EC-RPL				
	VKP		**ZCO**		Distribution
	Mean	S.D	Mean	S.D	
Payment SNA group	-0.000092		-0.0000045		fixed
Payment SA group	-0.00064***	0.00032***	-0.00037***	0.00019***	t,0.5
Ln Catches	0.165***	0.165***	0.151***	0.151***	t,1
Ln Health	0.296***	0.296***	0.231***	0.231***	t,1
Ln Landscapes	0.154***	0.154***	0.198***	0.198***	t,1
Ln Areas			0.151***	0.151***	t,1
Areas 20 years	0.059				fixed
Areas 50 years	0.399***	0.399***			t,1
Areas 100 years	-0.064				fixed
ASCsq	-8.031***		-6.505***		
Sigma Option 1,2	0.532		4.738*		
Sigma Status Quo	7.143***		6.030***		
Final Log-Likelihood	-1222.9		-1157.9		
AIC	1.264		1.370		
Adjusted Pseudo-R^2	0.428		0.380		
Halton Draws	350		350		
N	244		213		

**** Significant at the 1% level** Significant at the 5% level * Significant at the 10% level*

3.4 WTP results

WTP is first derived for all attributes using the following models: generic MNL (see Chapter 1), Panel LCM (models in tables 2-4 and 2-5), panel LCM with parameters restriction (models in tables 2-6 and 2-7), and a generic panel EC-RPL model (i.e. with no group distinction and all attributes following a constrained triangular distribution, see results Appendix L). Results are presented in table 2-17. Concerning the EC-RPL model, WTPs were estimated at the individual level and then the mean was computed.

Table 2-18 also presents individual WTP estimates (with detailed statistics) for each area from two other panel EC-RPL models:

- The first one is a model run on the individuals from the CV-based IA group obtained from the previous EC-RPL models presented in tables 2-12 and 2-13, with the payment parameters following a constrained triangular distribution (see results in Appendix L). As such, the computed WTPs actually come from a two-step EC-RPL model: a IA group was first isolated using the CV method on a panel EC-RPL run on all sample, then another EC-RPL was run on the this IA group;
- The second one is the model presented in table 2-18, with WTP estimates statistics derived only for the SA group.

In order to compute the ratio between the total estimated WTP and the maximum amount of payment offered in the choice experiment, we first have to take into account the fact that WTP estimates presented in tables 2-17 and 2-18 correspond to the attributes taken under a logarithmic form. That is, they have to be multiplied by the logarithm of the number of years of preservation (e.g. 20, 50 and 100 years) in order to get WTP estimates that correspond to the preservation of different attributes for a certain number of years (see Chapter 1). Then, if we compute this ratio for the MNL model and for a 100 years preservation period, we see that total WTP is more than 6 times the maximum payment amount in the DCE for VKP area, and more than 10 times for ZCO area, which is highly unrealistic. In comparison, if we use the WTP estimates from the LCM with parameters restriction, total WTP for 100 years preservation is equal to 1.5 (for VKP) or 1.2 (for ZCO) times the maximum payment amount, which is much more credible. For both areas the smallest estimates of WTP are produced by the EC-RPL models run on the IA groups (with the ratio mentioned above being equal to 1 for ZCO area and1.4 for VKP area).

Table 2-17 WTP (CFP/month) obtained with different models for each area: MNL, panel LCM, panel LCM with parameters restriction on payment

	VKP					ZCO				
	MNL	Panel LCM		Panel LCM with restrictions	EC-RPL payment (t,1)	MNL	Panel LCM		Panel LCM with restrictions	EC-RPL payment (t,1)
		Class 1	Class 2	Class 1			Class 1	Class 2	Class 1	
Ln Catches	616	767	240	146	500	1290	694	ND	118	1200
Ln Health	965	1617	189	235	890	1723	1184	ND	164	1797
Ln Landscapes	521	895	ND	139	471	1558	1024	ND	145	1542
Ln Areas for ZCO / Areas of practice 50 years for VKP	2808	1438	948	644	2439	1233	750	ND	117	1190
N individuals	244	~137	~95	~44	244	213	~32		~24	213

Table 2-18 Panel EC-RPL models with log-linear utility specification: Individual WTP (CFP/month) and standard deviation of individual WTP for each area (payment (t,0.5) distributed and other attributes (t,1) distributed)

	VKP				ZCO			
	Panel EC-RPL on IA group (n=117)		Panel EC-RPL on SA group (n=113)		Panel EC-RPL on IA group (n=68)		Panel EC-RPL on SA group (n=82)	
	WTPi	SDWTPi	WTPi	SDWTPi	WTPi	SDWTPi	WTPi	SDWTPi
Ln Fished animals	Mean: 112 SD: 14 Min: 74 Max: 146	Mean: 51 SD: 4 Min: 43 Max: 63	Mean: 269 SD: 31 Min: 173 Max: 338	Mean: 125 SD: 7 Min: 95 Max: 147	Mean: 89 SD: 9 Min: 70 Max: 110	Mean: 42 SD: 3 Min: 35 Max: 51	Mean: 422 SD: 47 Min: 278 Max: 507	Mean: 196 SD: 12 Min: 154 Max: 243
Ln Health of marine life	Mean: 268 SD: 69 Min: 114 Max: 392	Mean: 72 SD: 16 Min: 64 Max: 177	Mean: 477 SD: 98 Min: 223 Max: 643	Mean: 210 SD: 21 Min: 131 Max: 305	Mean: 127 SD: 18 Min: 100 Max: 168	Mean: 58 SD: 4 Min: 49 Max: 63	Mean: 635 SD: 111 Min: 329 Max: 835	Mean: 284 SD: 26 Min: 181 Max: 338
Ln Coastal and marine landscapes	Mean: 113 SD: 16 Min: 67 Max: 151	Mean: 52 SD: 5 Min: 39 Max: 68	Mean: 252 SD: 29 Min: 158 Max: 331	Mean: 118 SD: 10 Min: 96 Max: 171	Mean: 132 SD: 16 Min: 108 Max: 180	Mean: 60 SD: 5 Min: 50 Max: 79	Mean: 552 SD: 71 Min: 387 Max: 690	Mean: 247 SD: 22 Min: 173 Max: 283
Areas of practice 50 years for VKP / Ln Areas of practice for ZCO	Mean: 615 SD: 72 Min: 453 Max: 822	Mean: 277 SD: 24 Min: 211 Max: 159	Mean: 1297 SD: 134 Min: 951 Max: 1665	Mean: 600 SD: 29 Min: 493 Max: 681	Mean: 100 SD: 11 Min: 80 Max: 126	Mean: 46 SD: 3 Min: 40 Max: 55	Mean: 420 SD: 46 Min: 305 Max: 506	Mean: 193 SD: 13 Min: 156 Max: 218

As such, the WTP estimates provided in the panel LCM with parameters restriction and the panel EC-RPL models on IA groups presented in table 2-18 are by far the most credible ones for both areas. Furthermore, for both of these models, the WTP estimates for VKP area are higher than the ones for ZCO area, whereas in all other models it is the opposite. This is an interesting result, and it seems to guarantee robust WTP estimates for ZCO areas especially in view of the fact that attribute non-attendance as well as low preference for payment are both higher in ZCO area.

In terms of number of individuals for whom WTP estimates can be derived, the panel LCM with parameters restriction is the one that performs the worst, since it allows welfare estimates for only a very small proportion of our sample. The EC-RPL model on IA groups is more useful since it allows welfare estimates for 48% of our sample in VKP, and 32% in ZCO area.

The EC-RPL model on IA groups is therefore the one that performs the best both in terms of credibility of welfare estimates, and in terms of the proportion of individuals for whom WTP can be derived. As stated before, its continuous mixing nature also allows us to model more precisely preference heterogeneity for all attributes, and have much more precise information, at the individual level.

4. Discussion

4.1 Quantifying payment non-attendance

- **There is a substantial payment non-attendance in each area**

All results from the discrete and continuous mixed models show a substantial inferred payment non-attendance, in different proportions: between 50 and 70% of inferred non-attendance for VKP area, and between 70 and 80% for ZCO area.

- **There is a limited correspondence between stated and inferred attendance**

When compared to stated non-attendance, results of both the generic panel LCM and the EC-RPL models on the two different groups SA and SNA tend to show a good correspondence between attendance statements and econometric output, in each area. However, results from the panel LCM with parameters restriction are more ambiguous and show that in the SA group there are a significant proportion of individuals who did not consider the payment. When run on entire samples, these models also predict significantly higher proportions of non-attendance than the ones derived from respondents' statements, and show at the individual level a rather limited correspondence between inferred attendance and stated importance rating of the payment. But since this type of model does not allow differentiating between poor consideration and non-attendance, it is necessary to examine the results from our second modelling approach. The results from the CV-based IA analysis using panel EC-RPL models do confirm a much more limited correspondence between stated and inferred attendance: while the total share of respondents can be perceived as remaining quite close between the two, there are important differences at the individual levels between stated importance attached to the payment attribute and inferred attendance. In addition, it is also interesting to note that correspondence between IA and SA is better in one area than another. All these results sit well alongside other results from the literature regarding stated and inferred non-attendance, where several limits associated with both approaches have been pointed out, and where correspondence between stated and inferred attendance has been deemed to be varying among studies.

- **Other modelling approaches exist and could be used for further research**

However, there are other recently developed modelling techniques that are making use of respondents statements or inferring non-attendance, such as the latent variable scaling approach offered by Hensher et al. (2013) or the discrete mixture logit approach proposed by Campbell et al. (2011b). As such, these could have been used in order to develop and refine our analysis, but we decided to keep focusing on the two more classical modelling approaches used in this analysis for two reasons: (1) because they might probably be the ones that are the most widely used when dealing with non-attendance issue as they are fairly straightforward and easy to implement; and (2) because using and comparing more recent modelling approaches would be the subject of an entirely new extensive analysis[27]. Besides, we also developed in our analysis a new and simple econometric approach to link individual's probability of attendance with socio-demographic variables and stated choice heuristics, and we conducted the first detailed comparison of WTP estimates we are aware of in the ecosystem services valuation literature between the different modelling approaches. All in all, as Scarpa et al. (2012) recently pointed out, further research is definitely needed regarding all these issues.

[27] During the analysis, we also tried to use an approach combining LCM and random parameters, but without success since this model was found to be volatile and identification fragile.

4.2 Determininants of payment non-attendance

Our methodology also aimed at refining the quantification of payment non-attendance by examining the potential socio-demographic determinants of payment non-attendance. The analysis presented is the first one we are aware of that focus on this issue, within the literature applied to ecosystem services economic valuation.

- **Payment non-attendance is influenced by several socio-demographic factors**

The factors identified as influencing payment non-attendance by the Tobit models were for both areas: age, gender, education level, living in tribe, participation in fishing activities, participation in non-extractive activities (only for VKP), as well as stated non-attendance. Some of the effects shown can be intuitively interpreted:

- For both areas: the higher the income, the less attention to payment, which could indicate that some individuals have enough money to afford any level of payment, and therefore did not consider it during their choices. This effect is problematic since it would mean that, on average, it might not be possible to define WTPs for richer individuals based on the DCE exercise. However this effect appears to be very small in comparison to other variables in the Tobit results (the variable "income" has the smallest marginal effect after the variable "age"), and results from panel LCM in VKP area are actually showing that both individuals with low and high income did attend to the payment in similar proportions.
- For both areas: the higher the education level, the less attention to payment. An interpretation could be that the more highly educated people are, the more they might doubt the credibility and potential real-world implementation of the payment vehicle in practice.
- For ZCO area: the older the individual, the less attention to payment. An interpretation could be that older individuals might be more reluctant to the DCE exercise and its payment framework (for example, due to cognitive burden or fatigue), or more reluctant to any payment implementation that would imply a change perceived as significant (for example, due to an aversion to change regarding their income via additional taxes).

- **There is more attendance to payment among indivudals living in tribe**

A key finding from our application, confirmed by the different modelling approaches, is that individuals living in a tribe system did attend more to the payment than the ones not living in tribe. This goes against the common intuition that individuals whose economic activity is less grounded within the modern monetary system (and living in a traditional tribal system) would find such a payment unacceptable or would not consider it in a rational economic way.

However, one could argue that this is mainly due to the fact that individuals living in tribe have a significantly lower income on average, thus leading to more consideration of the payment attribute. This would meet up with the results from the Tobit models on the probability of non-attendance, which show that the higher the income is, the higher the probability non-attendance is. Furthermore, from the field experience during the face-to-face interviews, many individuals living in tribe did actually insist on the fact that they would be happy to pay a significant amount of money to insure the preservation of the coastal areas (providing this payment would have the output it was designed for), mainly because of the strong cultural values attached to coastal and marine areas associated customary uses and systems of beliefs. This could suggest that these populations did consider the payment significantly more during their choices mainly as a way to put an emphasis on the strong values they have for the coastal and marine ecosystem.

- **Some factors increase non-attendance in one area, and decrease it in the other**

Another important finding is that some socio-demographic variables are found to have opposite effects on the payment non-attendance probabilities depending on the area considered. Even if both areas are located not far from each other and involve communities with some common social backgrounds, their preferences and choice heuristics do differ in some ways, as well as the potential drivers that would explain payment attendance.

In particular, the variables “age” and “gender” have opposite effects on payment non-attendance in each area, and this is a surprising result. We suggest two possible explanations: (1) it is due to socio-cultural (e.g. Kanak dominant versus white Caledonian dominant populations) or institutional (e.g. different province and associated institutions) differences between both areas, which do exist even though these are both geographically very close (see section 4.1 in chapter 1); (2) it is due to exogenous factors linked to the way the survey and DCE were conducted in each area, such as differences in interviewers.

With respect to explanation (2), we tested the difference between the interviews conducted by the PhD student (mostly in VKP area) and the other interviewers from the survey company. We found that the negative sign of the "age" variable in the Tobit model run on the probability of non-attendance in VKP (which might be perceived as counter-intuitive) is clearly linked to interviews conducted by the PhD student. For other interviewers, the sign becomes positive, as for the ZCO area. An interpretation is that the DCE presentation given by the PhD student, who had a better understanding of the survey design and DCE framework, might have facilitated "compliance" of older people with the exercise and its associated payment, for example through diminishing cognitive burden.

However, regarding the "gender" variable opposite effects, no specific "exogenous" effects were identified when running a serie of additional tests and models, so that explantion (1) might be more relevant with respect to this issue.

4.3 Reasons behind non-attendance

Our results also lead us to wonder more broadly about the potential reasons behind this strong non-attendance behaviour to payment. In this respect, two qualitative points can be made in view of the design and context of the DCE survey that generated the data used to apply our methodology.

- **Payment non-attendance is linked to a lack of crediblity**

Firstly, it is clear that the payment non-attendance is probably due to the hypothetical nature of the scenarios, mostly because of the potential lack of credibility associated with the very long term preservation periods involved in the experiment (due to the objective of the study which was to study non-use values – see chapter 1) and because a payment through a tax or any compulsory regular contribution is not realistically expected from the current institutions in New Caledonia[28]. This could be related with the fact that for both areas the level of education was found to play a positive role on probability of non-attendance: the highest the level of education is, the highest is the scepticism regarding the hypothetical scenarios presented by the DCE.

[28] However, this does not necessarily mean that such a payment would be perceived as unlikely to exist in the longer term by the population, which is why we decided to keep this payment vehicle and study how it was perceived and accounted for by individuals during their choices.

Furthermore, it is also possible that some individuals were sceptical or disagreed with the scenarios and their associated design for other reasons than their lack of credibility, even though they still completed the eight choices. One could speculate that they would have then ignored the payment as an act of protest but still considered the other attributes in order to claim the importance of their preservation. In that case, the payment non-attendance for these individuals does not relate to a genuine zero preference for the payment, as in the lack of credibility issue.

- **Payment non-attendance pertains also to incommensurability**

Secondly, one could argue that the preservation over the long term as suggested by the level of the attributes could induce a moral commitment that would possibly make any monetary schemes irrelevant. In other words, part of the cost non-attendance observed could be related to lexicographic preferences. This also concurs with the fact that all respondents involved in the DCE also stated that preserving coastal and marine ecosystem in their area is predominantly justified by the idea that ecosystems must continue to exist independently of human uses and considerations. Such an ethical position would thus explain partly the refusal to consider the payment attributes levels, while accepting to complete the choices. This second issue would meet up with arguments from several authors that some values fall into the domain of incommensurability (Chan et al., 2012; Martinez-Alier et al., 1998). More broadly, this relates to the fact that payment non-attendance could illustrate also quite well the concerns of many authors that the neoclassical model of individual rational behaviour present some fundamental and substantial limits (e.g. Van den Bergh et al., 2000), especially when dealing with cultural values (Chan et al., 2012).

- **There is a need to distinguish hypothetical bias from true lexicographic preferences**

Unfortunately, there were no data from this DCE about the potential reasons of attending to payment or other attributes, and so we cannot precisely conclude about which of these two reasons is the most valid one. In the end, this last issue is about being able to differentiate hypothetical bias from genuine zero or lexicographic preferences. Although it might not be especially the case with payment non-attendance, it has been shown in the literature that attributes non-attendance can also be the result of passive bounded rationality. An interesting contribution regarding this issue is the analysis proposed by Hussen Alemu et al. (2012), which highlights the importance of having such follow-up questions, the results of which can be used when specifying the models or utility functions in order to deal with attributes non-attendance.

4.4 Welfare estimates

The second main objective of our methodology was to derive robust WTP. We examined the consequences of the different models in terms of welfare estimates. These were examined in terms of estimates credibility with respect to the maximum amount of payment allowed during the choices, and the different models were compared based on the most realistic estimates for the largest shares of populations, which would probably be the two main objectives underlying any valuation studies.

- **One modelling approach is performing better in terms of producing welfare estimates with a situation of payment non-attendance**

According to our empirical application, the best modelling approach identified through our results is a two steps approach: first running a panel EC-RPL model to identify an inferred attendance group using the coefficient of variation, then re-running an EC-RPL model on this group with the payment parameter following a constrained distribution. Although most of the studies dealing with attributes non-attendance issues did examine the resulting impact on WTP, few studies did actually compare predictions of different modelling approaches in terms of social welfare. We therefore argue that more work is needed in that direction since delivering robust and reliable WTP estimates is the main raison d'être of stated preference methods.

- **WTP is defined for only 20 to 50% of the respondents in both areas**

We finally note that, with respect to this empirical application, the substantial proportions of the non-attendance only allows us to estimate credible WTP for a very small part of our sample, and as such the outreach of the case study in terms of welfare becomes very precarious (this point will be discussed in further details in the overall discussion section at the end of this manuscript). For all cases that would have similar results, this raises two important issues: how to interpret this result, and what can we say about the other part of the populations for which no WTP can be estimated? The answer to these questions can be explored by discussing the potential reasons behind the non-attendance pattern, as above.

4.5 Further research

We are not aware of other ecosystem services valuation studies that would help putting our results in perspective by providing other comparisons about non-attendance patterns and associated drivers, also between different geographical areas, within the same DCE application.

Thus, we argue that examining the determinants of attendance or non-attendance definitely represents an interesting area for further research, in order to refine and adapt the design of such studies to targeted populations. Other approaches could be developed and tested, depending on the modelling techniques selected to deal with attributes non-attendance, such as directly interacting socio-demographic variables in the utility function with attributes coefficients and subsequently looking for non-attendance or low consideration, or running regression models on the coefficient of variation with socio-demographic variables. Specially designed follow-up questions can also be used at the end of DCE surveys to document reasons of non-attendance.

5. Conclusions

Accounting for cost attribute non-attendance in DCE is of paramount importance, especially in view of its main objective, which is to deliver robust and reliable welfare estimates in support of decision-making. In recent years, a growing and extensive body of literature has been coping with the issue of attributes non-attendance, but few studies focused precisely on the cost attribute, although many reported a significant proportion of respondent that ignored the payment during their choices.

In this chapter, we examined the attendance or non-attendance to payment in a methodological perspective in order to answer two questions that guarantee the robustness of DCE conclusions: how to best quantify payment non-attendance; and how to derive reliable welfare estimates since payment non-attendance precludes the possibility of deriving WTP. We presented different modelling strategies to cope with these two issues, based on discrete and continuous mixing (panel LCMs or EC-RPL models) and involving different types of constraints (constraints on payment parameters, constraining the analysis on specific groups, or inferring attendance using a threshold on the coefficient of variation associated with the payment). These modelling approaches were applied and compared using data from a DCE application in two different coastal areas in New Caledonia focusing on coastal and marine ecosystem services. In this empirical application, we found between 50 and 80% of respondents ignored the payment during their choices in both areas, although in different proportions and for different groups of individuals depending on the area and on the modelling approach used. In addition to respondents' stated importance rating of the payment, several socio-demographic factors seems to explain the probabilities of non-attendance to payment, including gender, participation in marine activities, living or not in a tribe system, age, level of education and income. The difference between people who live in a tribe system and those who don't is particularly interesting: according to our results, the former do attend more to the payment than the later.

In addition, we found that attendance and non-attendance statements do not correspond to individuals' choice heuristics inferred from econometric analysis, although collecting these statements certainly gives useful indication for the analysis. Finally, we computed WTP estimates using each modelling approach and compared the results, with the conclusion that using two panel EC-RPL models to first derive IA groups and then compute WTP on these groups was the best approach according to our criteria.

However, these findings are specific to the data from the DCE application used in this analysis, so that there is a need to conduct and discuss similar types of analysis on other data sets. There are also several other and more recently developed modelling approaches that would need to be compared, so that our method could be extended and refined. Further research is thus needed at least in the three following directions: (1) Comparing the different modelling approaches to cope with attributes non-attendance, particularly the most recently developed, both in terms of model predictions and welfare estimates (2) Comparing stated and inferred attendance; and (3) Examining in greater detail the potential reasons and socio-demographic drivers of attributes non-attendance (particularly cost attribute). All these will contribute to help DCE practitioners delivering more robust and reliable conclusions. In this respect, we argue that DCE studies should systematically test for attribute non-attendance as a routine check, especially for cost attribute non-attendance in order to guarantee the mere existence of WTP.

All in all, the approach we developed to estimate non-use values led us to examine in details how to deal with payment non-attendance, and this raised the issue of true non-compensatory preferences versus hypothetical bias. It is clear that being able to distinguish between the two in stated preference valuation is absolutely crucial in order to deliver reliable information in support to decision-making or management. More broadly, the complexity of defining and measuring NUV while dealing with payment non-attendance raises the issue of the perceived usefulness and of the use of such estimates in decision-making. This is examined in Chapter 5 and 6, which focus more largely on the use of ESV in decision-making.

Part 2: Assessing the use of ecosystem services economic valuation

Australian application

Introduction

This part presents the main results from a research work conducted in Australia during the second period of this PhD. Its objective was to examine the question of the use of the economic valuation of ecosystem services (ESV) in the case of coastal and marine ecosystems management in Australia.

As seen in the introduction, and as will be demonstrated in Chapter 3 in more detail, very little is known about the actual utilization and influence of ESV in decision-making although the raison d'être of ESV is precisely to support ecosystems preservation and management. Thus, this second part is articulated around two main questions, which are explored in two different chapters:

- What is the perceived usefulness and utilization of ESV by different groups of stakeholders involved in management decision-making processes? (Chapter 3)
- What weight do these stakeholders grant to ESV, in comparison with other types of indicators (e.g. ecological and social indicators) in support of decision-making? (Chapter 4)

Both questions are examined with the management of coastal and marine resources and areas as a case study, for which ESV has been largely advocated. Consideration of this question in the Australian context is motivated by the following reasons: a contingent reason, linked to the joint French-Australian context of this PhD; but also because a substantial amount of ESV work has been carried out in Australia (e.g. Bennett, 2011), including in the coastal and marine domains (e.g. Stoeckl et al., 2011); and because the issue of ESV utilization for decision making in Australia has recently been identified as an important research question (e.g. Rogers et al., 2013) as a result of growing interest for such evaluations in the scientific as well as the decision-making communities. In particular, a mini-symposium on this issue was held at the 2012 Annual Conference of the Australian Agricultural and Resource Economics Society. The issue was also identified as an important research item within the marine biodiversity hub of the National Environmental and Research program.

Our methodological approach to answer these questions was a nation-wide online survey with two questionnaires, one focusing on a decision-makers sample and the other on a general public sample. We note that "decision-makers" is used here as a very broad term that refers to individuals directly involved in the decision-making process regarding coastal and marine areas management (either in an informative, consultative, contributive or decisive way). The surveys were funded by the Research Student Funding Scheme from the Queensland University of Technology, and by the marine biodiversity Hub of the National Environmental Research Program. These surveys took place between August and October 2013.

Chapter 3 details the motivations, the methodology and the results associated with the first part of the survey, which includes two sections that aim at collecting data on the perceptions of ESV by both decision-makers and the general public. Questions addressed in this chapter are: is ESV useful and for what purposes? What are the limits of ESV? What is the importance of valuing the different types of ES, and how reliable these measures can be? It also aims at documenting the utilization of ESV by decision-makers in various management contexts and for different purposes, based on past and current experiences.

Chapter 4 presents the method and the results of a multi-criteria analysis – namely an Analytic Hierarchy Process (AHP) – developed in the second part of the survey. It aims at examining the underlying preferences of decision makers and of the general public regarding economic valuation information in comparison to other types of information usually conveyed and advocated when managing ecosystem services. In particular, the AHP approach provides a way to assess the relative importance of economic, ecological and socio-economic indicators for these populations. This allows ESV to be put into perspective, alongside other common decision criteria when facing a management decision.

Publications arising from this work

Four academic papers have been produced (Marre et al., 2014c, 2014d, 2014e, 2014f). One has been submitted to Marine Policy. The other targeted journals are Global Environmental Change, Journal of Environmental management and Ecological Economics journal.

Chapter 3 Exploring the use and influence of economic valuation in decision-making: application to coastal and marine ecosystems services in Australia

1. Introduction

Economic valuation methods applied to ecosystem services are now highly mature in many areas of application. Their increasing development was fed by the growing need to deal with ecosystems degradation globally, and valuation studies have increasingly been advocated to support decision-making and management. In particular, coastal and marine ecosystems (CME) are some of the most heavily exploited globally with intense and increasing degradation, and this alarming situation appeals for urgent and effective actions, thus leading to an increasing call for more coastal and marine ESV (Barbier, 2012; Schuman 2011; Brander et al., 2007).

After decades of continuous progress, there has been growing concern among academics and practitioners regarding the actual impact of valuation on decision-making and its implementation in the "Real World" (e.g. Laurans et al., 2013b; Goldstein et al., 2012; Balmford et al., 2011; de Groot et al., 2010; Liu et al., 2010; Daily et al., 2009; Pendleton et al., 2007). In a recent contribution, Costanza et al. emphasize: "[ecosystem] services must be (and are being) valued, and we need new, common asset institutions to better take these values into account." (Costanza et al., 2014, p.152).

Several tools implemented for decision-makers have been developed in this respect, such as the Natural Capital Project (www.naturalcapitalproject.org) and its associated software InVest (Goldstein et al., 2012; Daily et al., 2009), or online data bases from empirical economic valuation studies for benefit transfer, such as the international Environmental Valuation Reference Inventory (www.evri.ca), the Marine Ecosystem Services Partnership database (http://www.marineecosystemservices.org/explore), or the EnValue database from the New-South Whales government in Australia (http://www.environment.nsw.gov.au/envalueapp/).

This recent emphasis on making valuation results useful for practical decision-making also concerns CME economic valuation, although very few studies have focused on the use of ESV in this context (Waite et al., 2014; Börger et al., 2014). For example, an initiative from the World Resource Institute aimed at studying the influence of past coastal economic valuations in the Caribbean, through a detailed review of past valuation work already carried out, and semi-structured interviews of expert and project partners (Kushner et al., 2012). The objective was to identify the key enabling conditions for valuations to influence policy, management, or investment decisions in the Caribbean.

In general, economic valuation can be used in different ways: first for advocacy and communication purposes, second as a decision making tool to assess the outcomes of alternative management decisions (e.g. in Cost-Benefits Analysis – CBA), third as a technical tool in price setting or in the definition of compensation instruments. Laurans et al. (2013b) present a refined characterisation of these different types of use, and also distinguish between use a priori and a posteriori, with respect to the decision being taken.

Surprisingly, however, very little is actually known regarding the precise influence of economic valuation on decision-making. When examining the literature, it is frequent to encounter claims that emphasize the need and supposed influence of economic valuation with case studies examples, but most of the time there are no accurate details regarding the extent to which a particular valuation exercise contributed to management decisions. The paucity of the literature regarding the issue of the ESV use is demonstrated by Laurans et al. (2013b) who constituted a database of 5028 references from 1419 sources, mostly composed of peer-reviewed scientific journals, and then examined in greater detail this issue through an in-depth bibliographic search focusing on 650 academic articles from the journal Ecological Economics. They showed that the scientific literature only very rarely reports cases where ESV is put to actual use (2% of the papers studied), even though such utilization is frequently referred to as constituting the goal and justification of ESV. Hence "the common rule is to present an economic valuation, then suggest that it be used for decision-making, but without this use being either explicited or contextualized, and without concrete examples being provided or analyzed" (Billé, 2012, p 4). Laurans et al., (2013b) propose two hypotheses in order to explain this result: either the utilization of economic valuation is in fact more widespread than it appears, but escapes the attention of scientific publications[29]; or it may indeed be relatively rare for various possible reasons (Laurans et al., 2013b).

These potential factors of limited use or no-use of ESV have been discussed in several works (e.g. Rogers et al., 2013; Laurans et al., 2013b; Dehnhardt, 2013; Kling et al., 2012; Hausman, 2012; Spangerberg and Settele, 2010), and can be broadly classified as follows: (1) ESV has some fundamental problems (i.e. conceptual, theoretical or ethical issues) that make it unadapted to decision-making or that could have unwanted effects; (2) ESV have some methodological issues that question its validity or make it hard to use; (3) Institutional and legal framework are not conducive to its use; (4) ESV information and estimates may be difficult to access or apprehend by decision-makers; (5) Existing ESV do not answer decision-makers' needs.

Overall, there are thus few studies that examine in more details the use of ESV, and even fewer that examine decision-makers opinion or perceptions about this issue. Liu et al. (2010) emphasized that the utilization of ESV depends on the specific areas of environmental policy which are of concern, and in fact, there are a few areas in which ESV is well established: in the United States example, these include Natural Resource Damage Assessment (NRDA) cases, and CBA of water and forest resource-use planning. This is a good illustration of the role played by institutions and legislations in providing legal framework and incentives to use economic valuation (Spash and Carter, 2001). In the US context, NRDA is an implementation approach of the Comprehensive Environmental Response Act (CERCLA) and the Oil Pollution Act (OPA). Furthermore, in a number of European countries, CBA has been used as a decision tool in public work schemes, especially in road construction (Navrud and Pruckner, 1997). In France in particular, ESV is used in decision-making applied to transport issues, where benchmark values exist in order to account for some costs on ecosystem services within a cost benefits analysis framework (Quinet et al., 2013). In other areas however, as noted by Liu et al. (2010), there have been few documented applications of ESV in Europe where it was used as the only or the main justification for environmental decisions, though McCollum (2003) provides some examples. Regarding biodiversity conservation, a recent report for the French government presents benchmark values for different types of ecosystems

[29] With this respect, we note the importance of examining as well the grey literature (i.e. literature from various origins where no peer-review process was conducted as in academic journals), and especially reports produced and used by governments and associated agencies, in order to be able to have a much broader picture of the use of ESV (see the discussion at the end of this chapter).

to be used in socio-economic evaluation of public investments, but highlights several important limits of the economic valuation exercise and consequently the need to consider other indicators or valuation approaches (Chevassus-au-Louis et al., 2010). From a general point of view, the extent of both academic and applied work in ESV in Europe is much more limited than in the United States (Liu et al., 2010), including in a CBA contexts (Turner 2007; Pearce et al., 2006). Liu et al. (2010) also provide examples where natural capital accounting has proven influential in policy making and they examine the Payment for Ecosyetm Services (PES) issue, as a direct practical application of valuation, but conclude that ESV results have rarely been applied in setting payment amounts.

In another recent work, Fisher et al. (2009) carried out a survey of 14 case studies of the interaction of ESV research and policy, which ranged from "no action" all the way to "influencing federal policy design" (p. 2064), although the precise nature of the ESV use is not systematically documented i.e. in what ways exactly the numbers produced were used.

In the Caribbean context, the World Resource Institute's first findings (Kushner et al., 2012) show that valuation studies have helped to raise awareness about the economic importance of coastal ecosystems in the Caribbean, but very few of them (around 5% of the more than 200 studies that exist in the Caribbean) have been recognized as having influenced policy, legislation, or investment in the region, and not within precise CBA or price-setting schemes. As such this influence seems to come under a rather "diluted" form of use, and the authors noted that valuation results are often perceived and used as a "ballpark figure to guide decision-making" (Kushner et al., 2012, p.2).

In the UK and the US, although the role of ESV in marine planning is acknowledged and referred to in policies and legislation, the actual utilization of valuation estimates for marine ecosystem services is still rare (Börger et al., 2014).

Barbier (2012), in a recent review about CME economic valuation, presents a section that "highlights selected case studies in which the valuation of CME services influenced important policy decisions concerning the management of coastal and marine environments" (Barbier, 2012, p.5). Among the cases listed are: aquaculture versus mangrove ecosystems in Thailand, Storm Protection Value of Mangroves in India, valuation of use and non-use benefits associated to mangroves and coral reef, Valuation of the Impacts of Coastal Pollution and Degradation on CME, and NMV of Marine Reserves and Protected Areas. In each of these the author reviews the substantial amount of work that has been done, and contextualizes the way they can potentially impact (or could have impacted) management, although we do not learn much about the way ESV was actually used (i.e. if decision was really influenced by ESV among other possible factors, and if yes in what way). The author gives some more precise examples of ESV influence in the case of marine pollution however (where for example cap-and-trade schemes or household fees have been implemented).

Furthermore, several recent or current research projects worldwide are investigating the use of economic valuation, or more broadly the perception of and uptake by decision-makers of the different valuation frameworks (ecological, social and economic valuation). An example is the recent BRIDGE research project (within the National Environmental Research Council Valuing Nature Network in the UK) that aimed to "investigate how ecosystem service values obtained from natural, social and economic sciences can best be integrated into governance to improve decision-making and implementation" (http://www.valuing-nature.net/projects/bridge). Similarly part of the current ValuES project ("Methods for integrating ecosystem services into policy, planning, and practice"), implemented in Germany is about the analysis of "successful" ecosystem services assessments and their use in decision-making to develop guidance for future users with a focus on influencing decisions and political processes in developing countries (and on monetary and non-monetary valuation, and a range of different methodologies and techniques). Another relevant project is the European POLICYMIX project ("Assessing the role of economic instruments in policy mixes for biodiversity conservation and ecosystem services provision"), which also examines the role of economic valuation (and non-market valuation) in the implementation of economic instruments such as ecological fiscal transfers or PES (Barton et al., 2010). A last example is the currently ongoing VALMER (Valuing Ecosystem Services in the Western Channel) project (www.valmer.eu) that aims at examining how marine ecosystem services assessment can best support marine management and planning in six different coastal and marine case studies in England and France, with a particular emphasis on the link between the usefulness and use of ESV with respect to decision-makers and stakeholders' need.

In Australia, a considerable amount of ESV and non-market valuation work has been undertaken in the past decades (Bennett, 2011; Rogers et al., 2013). Bennett (2011) conducted a review on the different valuation works conducted in Australia to support decision-making, although the precise use of these is not clearly documented. In terms of policy-making, the Australian Government has implemented requirements for reporting on CBAs, and so non-market valuation (NMV) may become an important component of future decision-making, although it is not yet required (Australian Government 2007, 2010). As an example, The New South Wales Government has reflected this, drawing on various SP studies to help inform CBAs for environmental flows concerning rivers (Bennett, 2011) or MPA establishment (Gillespie and Bennett, 2011). Within Queensland, various valuation studies using various methods have been conducted regarding the Great Barrier Reef, at the demand of local authorities or of the Government, mostly focusing on recreation and fishing (see Stoeckl et al., 2011 for a recent review). Choice Experiments have also been applied recently in other policy-relevant contexts and Bennett (2011) gives several examples where decisions to establish protected areas, or to set up a waste recycling scheme were underpinned by a CBA that included choice modelling estimates of environmental benefits and costs.

All in all, with the advances made to date, it seems that policy-makers show a growing confidence in using ESV estimates as an input into decision-making, and as such, these value estimates are certainly increasingly being used as "ingredients in the policy formulation mix" (Bennett, 2011). However, although there is obviously a demand for economic valuation from decision makers or stakeholders, there is certainly a far bigger supply from academics and practitioners, and the extent to which economic valuation results are actually considered or referred to and their ultimate influence on decision-making remains largely unexplored. More precisely, there is a need to study the credibility, outreach and impacts associated with the various kinds of economic values in decision-making: what values (e.g. use, non-use) are actually considered and utilized, for what purpose, in what ways, in which context and to what extent? One of the best ways to get an answer to these questions is to ask directly the different stakeholders involved in the decision-making process their opinion and perceptions about this issue since little evidence or data can be found (Rogers et al., 2013; Kushner et al., 2012).

To our knowledge, there is only one published study providing a detailed examination of the extent to which ecosystem services economic values have actually been used by decision makers in Australia. Rogers et al. (2013) conducted surveys and interviews on non-market valuation (NMV) experts and on decision-makers in Australian environmental bodies, and compared both results, with the following conclusions. Even if decision-makers do believe that NMV can benefit environmental policy and management decision, it appears that they have a clear lack of knowledge relative to NMV. Furthermore, their interviews suggest that NMV is little used in decision-making with limited evidence of NMV use having an influence, implying a mostly weak impact (i.e. recommendations), and that NMV is most often used to justify existing decisions; thus a posteriori, and with smaller social benefits in terms of outcomes. On the other hand, the results from the surveys on researchers suggest that they are excessively optimistic regarding the impact of NMV, and that they misperceive the main factors driving limited use of NMV (which do not seem to relate to academic debates about the theory and methodology underlying NMV). As such the authors highlight an important gap between decision-makers' and researchers' systems of knowledge, and more precisely between their perceptions about NMV and its use in the policy process. The authors finally propose possible strategies to promote the use of NMV by bridging this gap.

The above analysis focused on terrestrial ecosystems, and it appears that this question has not been examined in the context of marine and coastal ecosystems, although the management of Australian coastal and marine areas and associated preservation measures is an especially important issue. The Australian Government has indeed committed to expand Australia's existing marine reserve system through the establishment of a National Representative System of Marine Protected Areas (NRSMPA) by 2012; and very recently, the Government has finally stepped up the Marine Bioregional Plan (after public consultancy and stakeholders reviews), implementing the creation of new Marine Protected Areas and extension of current existing reserves (thus creating the World‘s largest MPA network[30]). This necessarily implies a range of costs and benefits for the community, some of which have already been estimated locally. The extent to which ESV is likely to be used and to influence decision-making in developing and implementing marine conservation policies in the Australian context however remains unknown.

Our main objective is to document the perceived usefulness, the utilization and the influence of economic valuation of ecosystem services in making decisions regarding CME management in Australia by different categories of stakeholders. More precisely, we developed nation-wide surveys that aim at:

(1) Collecting information about decision-makers perceptions regarding past and present use of ecosystem services economic valuation with respect to the reliability of the methods used to estimate these values, the availability of these values and their types of utilization, namely in which contexts, for what purposes and to what extent they eventually influenced a decision;

[30] Currently, there are over 200 MPAs in Australian Waters covering approximately 88 million hectares or 10% of Australia's exclusive economic zone, excluding the Australian Antarctic Territory (Gillespie and Bennett, 2011).

(2) Examining the perception of the general public regarding ESV and its utilization, because populations are usually also concerned by and increasingly involved in management decisions (Rogers, 2013);

(3) Comparing the results obtained for the different groups surveyed.

With respect to our first objective, we also argue that it is also important to collect precise examples or references to real-world case studies and decisions where ESV has been used. With respect to our second objective, we also note that, to our knowledge, no work examined the perceptions of the general public about ESV (all the studies we are aware of focused on looking at researchers and decision-makers work or perceptions), although we argue it is an important issue (Rogers, 2013; Reed, 2008). In particular, this allows a comparison of the perceptions by the two categories of stakeholders, which is valuable to shed light on the expectations and preferences of both sides. On one hand, the need for "social license" of policies imply that decision-makers could seek to have information tools that are well understood and accepted by the general public. Besides, transparency and understanding of the issues and information at stake in a decision problem are certainly perceived as extremely important by the general public: these are factors of the trust given to decision-makers. On the other hand, the need of decision-makers to choose the indicators that best track the performance of their decisions assessed against the objectives of a particular policy they are being asked to implement imply that that they could select indicators even if these are not very well understood or accepted. In addition, there may be indicators that emphasize distributional trade-offs between different social groups, and which antagonize conflicts, which is not something decision-makers are likely to seek. The general public could also be afraid about possible manipulation of any indicators by decision-makers to suit a predefined agenda.

This chapter is organized as follow. Section 2 presents the material and method used to cope with this objective, namely the design and data collection of two national online surveys: one targeting the Australian population and the other one targeting a sample of carefully selected stakeholders involved in marine management and the decision making process. Section 3 shows the different results from these two surveys. Finally section 4 presents the discussion and conclusion, where the results from both surveys are analysed and compared with respect to the different populations targeted, and critically discussed with respect to the existing literature on ESV and its use.

2. Material and method

2.1 Surveys design

2.1.1 General approach

After having carefully weighted the pros and cons of alternative survey approaches (face-to-face interviews, telephone or online surveys, focus group discussions or workshops…), we decided to conduct a nation-wide online survey in order to be able to target a variability of scales (federal, state and regional) and stakeholders, while minimizing the costs of our approach. Even if online surveys allow a more limited control over responses and less details in the answers than oral interviews, the approach chosen was deemed necessary to provide a first, broad description of the issue under study, which can serve as the basis of further work if necessary. Furthermore, implementing our surveys at the national scale avoided the risks associated with a potential lack of local experience or knowledge of ESV that could have been encountered if we had focused on more detailed interviews carried out at a smaller scale (since value estimates regarding coastal and marine ES are still uncommon in many decision contexts; see Gillespie and Bennet, 2011 or Stoeckl et al., 2011). Besides, it gave the possibility to compare experiences between different States and different kinds of coastal ecosystems. It also allowed us to account for the use of ESV at multiple geographical and institutional levels.

Finally, since we aimed at studying perceptions of two broad categories of population (namely decision-makers and the general public), we also decided to develop two different questionnaires, and thus two parallel surveys, with common sections allowing comparisons between the two categories.

2.1.2 Main challenges

The approach adopted raised several important challenges and questions. The first was about the populations to target, and whether to focus on a representative sample of the Australian population or only on the inhabitants of coastal and marine areas. In addition, we also faced the question of identifying the decision-makers that the survey should target.

Regarding the general public, we decided to keep our focus as broad as possible by studying the perceptions of a representative sample of the overall Australian population, considering that anybody might be concerned about the preservation or management of coastal areas: inhabitants of non-coastal areas could travel to the coast and enjoy benefits from the marine ecosystems, or might hold non-use or cultural values regarding the preservation the Australian coastal and marine environment (especially in view of the recent implementation of the Commonwealth marine reserve network).

Regarding the decision-makers, the various types of stakeholders we identified were:

- Members of governments (from different Departments, and in different positions such as manager, scientists, executive director...) and associated agencies/bodies involved in coastal and marine management, at both national and state levels;
- Members of regional and local governments and committees in charge of coastal and marine management issues;
- Researchers (from different research organizations) who are part of committees or consultation processes;
- Important marine industry or marine activity representatives (e.g. recreational or commercial fishing).

This list was quite broad, and this was to reflect the complexity of a decision process that usually involves an important diversity of stakeholders, with different roles at different steps and levels of decision. We point out that we did not target representatives of Non-Governmental Organizations (NGO) since it was difficult to delimit which type of NGO should or should not be included in the survey. Building a sample with a focus on all these stakeholders was challenging because it involved the selection of appropriate individuals as well as finding their contact details, and thus implied an in-depth study and review of coastal and marine institutions across Australia. This was crucial to control the reliability of answers and to avoid common sense or conventional answers: it minimized the risk of getting irrelevant or “yeah-saying” answers from people not involved in actual decision-making processes. It therefore implied a careful selection of our decision-makers and building the right list of people that our survey should target was the main way to control the reliability of our results.

The second and probably the major difficulty we faced was that the knowledge and perceptions of respondents to our two surveys relative to ESV and to coastal and marine ecosystem management more broadly were likely to vary substantially, the gap being expected to be particularly strong between decision-makers and the general public. Our samples were highly likely to include individuals that had never heard about ESV, as well as some that were familiar with it and even with its use. In the former cases, especially given the complexity of ESV terminology and valuation methodologies, one could question the ability of respondents to be able to give an opinion on what it implies, and on how it should be used, and the ensuing reliability of the answers given to more technical questions. Hence we faced a difficult trade-off between having the possibility to compare results to similar questions posed to the two different categories of respondents, and adapting questions to each category, according to their anticipated level of knowledge of the topic. This issue was carefully considered during the design of our questionnaires, and in the interpretation of our results.

Furthermore the perceptions we aimed at studying (about the usefulness and use of ESV) are bound to depend on what we may call the "context" of decisions, including the institutional, policy and economic background, as well as the ES considered and associated values. Management decision-making is a complex process that involves many dimensions that can influence the use of ESV. For example the role of ESV in a decision process might differ depending on the:

- Socio-economic and demographic context: urbanization, economic development (e.g. industrial activities), populations (e.g. issues of transport, domestic pollutions), as well as uses and activities (direct and indirect) related to CME;
- Ecological context: types of ecosystems, state of the ecosystems (e.g. pristine versus alarming), uniqueness and related perception (e.g. iconic assets);
- Social context: acceptability, conflicts, opinion of ES beneficiaries;
- Political context: ESV can be instrumentalized in various ways, or its role can be limited in view of other decision criteria (lobbying, social opinions, budget consideration…);
- Information and knowledge context: available data and knowledge (e.g. poor-medium-high) and associated uncertainty issue (e.g. low, strong).

The perceived usefulness and use of ESV might also depend on the scale and scope of the decision context, such as local (e.g. Moreton Bay in front of Brisbane), regional (e.g. Queensland), national (e.g. marine bioregional plan) or even international scales (e.g. climate change).

The complexity and influence of management or decision contexts therefore needed to be taken into account, when designing our survey and interpreting our results. It was clear that our general approach did not allow us to go into so many details, but having them in mind helped us to design the questionnaires, and it also helped determine the boundaries of our analysis.

2.1.3 Design of the questionnaires

The two questionnaires were developed taking stock of our literature review, and in view of the mentioned challenges. Given the heterogeneity of our respondents' potential knowledge regarding ESV applied to CME, efforts were made to minimize the use of specific terminology related to ESV in the questionnaires. Nevertheless, it seemed hard to avoid mentioning key concepts, so we developed a glossary providing explanations and information on specific concepts and terminologies involved in the surveys. More precisely, the glossary included the definition of: "CME", "ecosystem services", "economic valuation of ecosystem services", "willingness-to-pay", "use values", "non-use values"; as well as some explanatory examples. The final version of the glossary is presented in Appendix M. Since the surveys were then conducted online, respondents were told that additional explanations or definitions were available as a box that would pop up when simply placing the cursor on the words or concepts highlighted in blue in the question. Furthermore, the first page of the surveys also included additional information about the objective and underlying motivations of the surveys (as part of the participant information sheet, presented in Appendix M). Both the glossary and the participant information sheet were included in the two questionnaires.

In order to allow for possible comparison between the results from each survey (general public and decision-makers), both questionnaires were developed having a very similar structure, and similar sections with some questions being exactly the same. During the development steps, researchers that had worked on the issue of the utilization of ESV were contacted for advice. Several researchers from CSIRO and from the marine biodiversity hub of the NERP program, as well as a few stakeholders involved in coastal and marine management reviewed both questionnaires. We also conducted various tests on the general public (around 15 questionnaires in Brisbane and on the coast) and various researchers (around 15 researchers from CSIRO and the NERP program, some of whom are actually involved in management decisions). All this helped refine our questionnaires (especially in terms of question formulation and comprehension) and also provided us with interesting first insights.

2.1.4 Structure of the questionnaires

The two final questionnaires are presented in Appendix N. They both had respectively 6 and 7 sections.

- **First section**

The first section for both questionnaire aimed at collecting general information such as age, gender, postcode, level and field of education (based on the categories of the Australian Bureau of Statistics – See questionnaires in Appendix N), work experience in economics, business, finance or environmental management and in the case of decision-makers the types of organizations they are working for.

- **Second section**

The second section in the general public questionnaire aimed at collecting information on their perceptions regarding the preservation of CME: if they think it is an important issue, their three main motivations for their commitment to preserve these ecosystems, if they actively support their preservation, if they think current management is sufficient to guarantee their preservation and if not why, and if they think current coastal development has to slow down. All this information allowed us to characterize the respondent's commitment to preserve marine ecosystems, and eventually to examine if this commitment is correlated with perceptions related to ESV. This section of the questionnaire also prepared the respondents to the next section, about ESV applied to CME, by first getting them familiarised with the subject and to build confidence in their ability to respond to the survey.

The second section in the decision-makers questionnaire aimed at collecting information regarding their role and experience in management: to which marine jurisdictions their work related and what aspects of management they were involved in, years of experience, and how they characterized their role in the decision-making process (from informative to decisive). It is important to note that the information collected in this section regarding the management context the respondent was involved in determined the future questions he was asked about the use of ESV in such contexts.

- **Third section**

The third section was the same for both questionnaires. It aimed at examining the respondents' perceptions about ESV and its usefulness: have the respondents heard about ESV (and used it in the case of decision-makers)? Do they think it is necessary, useful or useless and if yes in what ways or for what reasons? Do they see any limits to its use, and for which ES they think it is important to measure an economic value (and the level of trust associated with these values for decision-makers)? For the general public, a last question in the third section of the questionnaire was about whether they think willingness to pay can be a good measure of economic values associated with some services.

The material underlying the first series of questions is summarized in table 3-1 below, which presents the motivation behind the use or lack of use of ESV, and the potential limits to its use, according to our literature review.

Table 3-1 Possible reasons for using or not ESV and potential limits to its use

Use ESV!	Potential limits to the use of ESV	Do not use ESV!
• As a way to communicate, advocate or raise awareness about the contribution of ecosystems to Human well-being • As a way to include ecological costs or benefits in the monetary evaluations supporting management decisions • As a basis for discussions during management decision-making processes • As a basis for implementing financial instruments such as subsidies, taxes or fees • As a basis for establishing levels of monetary compensation for ecological damages	• The decision-making framework/guidelines may not allow this information to be used • The validity of ESV may not be widely enough accepted • ESV is not accessible enough • The information may increase conflicts between stakeholders during the decision-making process • ESV is too simplistic given the complexity of interactions between humans and ecosystems (too uncertain and intrinsic lack of reliability) • ESV has to be improved in terms of techniques and methods • The cost of ESV may restrict its use • ESV may lead to undesirable consequences (privatizing ecosystems services, allowing the purchase of rights to pollute…) • ESV is morally or ethically questionable	• Management should be supported on grounds other than ESV, for instance through a focus on ecological indicators or on community consultation • ESV is not relevant enough to ensure informed and coherent choices about ecosystem services and their conservation • ESV cannot put an economic value (in dollars) on most ecosystem services due to their complexity so that economic valuation is incomplete and inaccurate • ESV will allow polluters to simply buy their way out • ESV will allow some financial instruments to be implemented which will end up having destructive effects • Such exercises are not morally or ethically acceptable

- **Fourth section**

In the general public questionnaire, this section contained one question that aimed at collecting information on respondent participation (in terms of frequency) in various marine activities. This question was also asked of the decision-makers, but in the last section (section 7).

Section 4 in the decision-makers questionnaire was the one that coped with the use of ESV. As noted before, examining the extent of actual ESV utilization involves several issues that needed to be accounted for: what kind of utilization (to what end), in what management context, what factors of success or reasons of failures in this use? As such, the first question aimed at examining whether the respondents considered ESV often, rarely or never during a decision-making process in which they participated, for the different management contexts they stated being involved in in section 2. Whenever they declared ESV was used, they also had the possibility to differentiate between three types of utilization: ESV as a way to communicate, advocate and raise awareness; ESV for evaluation and decision-making (e.g. CBA) and ESV for establishing taxes, subsidies, fees or damage compensation. An additional set of questions focused on whether respondents knew of ESV work(s) regarding marine and coastal ecosystems that did have a significant impact on policy or management in a specific region, and about decision-making processes where ESV information existed but was not used (for various reasons). In each case, respondents were asked to provide at least one example with, if possible, a reference to a publication. This was primordial as it provided a much more detailed description of what respondents had in mind when mentioning utilization of ESV. In addition, responses to this question were also intended to help us build a list of actual ESV utilizations, with the associated set of study references. Finally, respondents were also asked to state if they think ESV should be used more in decision-making and if yes for what kinds of values.

- **Last sections**

Finally section 5 and 6 in both questionnaires related to a pair-wise comparison exercise (see next chapter). At the end of each questionnaire, respondents had the opportunity to comment on the overall exercise or give additional information if they wanted to.

2.2 Data collection

2.2.1 General public and decision-makers samples

Our surveys targeted two populations, samples of which were selected using a different approach depending on the population. Participants from the general population in Australia were randomly selected using quotas, following a random stratified sampling approach based on age, gender and geographical location and using a representative panel of an Australian survey company (ORU[31]). The sample size was set to 250 individuals.

Our sample of individuals involved in decision-making processes regarding marine and coastal area management, was developed as a list of contacts within the different organisations and institutions which had initially been identified at the local, State and Federal levels in Australia. The list was carefully developed through in-depth personal research from publicly available information (mostly by using the Internet) and research/industry networks: for example examining Internet sites of pre-identified organisations or government Departments (identifying people through organisational structures or publications for example), consulting governments directories, and various types of publications regarding coastal and marine management (in particular the grey literature such as management plans or reports on specific management or decision issues, but also the academic literature). The list was then checked and refined with the help of a few researchers who have a good knowledge of this issue (at the Commonwealth scale and for certain States), and submitted for final refinement and approval to the NERP Marine Biodiversity Hub.

The list contained: members of States and Commonwealth governments including people working in all the relevant departments (e.g. fisheries, environment, tourism, land management), members of governmental agencies and associated organization involved in marine and coastal management at the national or federal levels (Australian Fisheries Management Authority, Australian Marine Safety authority, Environmental Protection Agencies, Fisheries Research and Development Corporation…), members of marine park authorities, members of various advisory committees and commissions (fisheries council and committees, natural resource management commissions, planning commissions, regional committees), representatives of marine industry sectors such as fisheries, recreational activities and tourism, or mining and petrol (e.g. The Australian Petroleum Production &

[31] http://www.theoru.com/

Exploration Association), members of coastal city councils, and researchers from different research organisations who play a role in decision-making (working in governmental organisations or who are part of advisory committees etc.).

When developing the list, we took two competing criteria in consideration: making sure (as much as possible) that the individuals selected were indeed involved in decision-making related to coastal and marine ecosystem management (at least in an informative or consultative way, and at best in a decisive way), and keeping the sample as broad as possible in order to reflect the heterogeneity of stakeholders and the various scales (national, federal, regional, local) involved in decisions. We also considered the risk that an important part of these targeted respondents might have a limited amount of time to devote to the survey; thus we anticipated a substantial non-participation rate, and we dedicated an important amount of time building this list to guarantee a sufficient amount of responses.

In total, the final list included names, positions and contact details of around 450 individuals involved decision-making regarding coastal and marine management all over Australia. It also included around 230 generic email contacts of all the coastal city councils in Australia.

2.2.2 Running the survey

Once ethical approval was gained (see Participant information sheet on Appendix M), the survey was programmed online with the help of the survey company ORU that hosted the two questionnaires and managed the data collection. In this phase, special care was given to the design and appearance of the questionnaire, with the objective of keeping it as user-friendly as possible. Many logical and conditional relations were implemented between the different questions, as well as their sub-questions (for example the lists of pre-identified potential utilizations or limits of ESV in section 3 were only presented to the respondents once they gave an answer regarding ESV usefulness or regarding the existence of some limits).

Meanwhile, support was gained from the former Australian government Department of Environment (Department of Sustainability, Environment, Water, Population and Communities) regarding participation in the survey focusing on decision-makers, in order to maximize the number of respondents.

Both targeted populations were contacted by email. For the general public, individuals were not given any information about the survey until they clicked on the link to start it (except information about consent to participate and un-indentifiable data). For the decision-makers, the contacted individuals were given a very brief introduction on the survey and its motivations[32], and invited to answer the questionnaire by clicking on a link. All were able to choose whether to participate in the survey or not. Both questionnaires lasted approximately 25 minutes. The questionnaires were anonymous, and designed to produce strictly un-identifiable individual data.

In order to expand the potential number of respondents, the contact email for the decision-makers survey invited respondents to share the link to the survey with other appropriate persons in their organisation (this was also necessary when sending the survey to coastal local councils through their generic email address).

As mentioned earlier, a document (participant information sheet, see Appendix M) with all necessary information about the survey (description of the research, expected benefits, participation, risks, privacy and confidentiality) was provided to participants once they started the survey, just before the beginning of the questionnaire.

The surveys took place between September and October 2013. ORU took care of the data collection for the general public by running the survey among their representative panel of respondents and checking whether the quotas were filled with an objective of getting 250 completed questionnaires. The PhD student sent the contact email to the decision-makers sample, in order to allow for questions or feedback. Three reminders were sent to the decision-makers, before closing the survey.

2.3 Profile of respondents

Among the general public, 256 respondents completed entirely the questionnaires out of 615 individuals that clicked on the survey. The remaining 359 opened the survey but stopped at the beginning[33]. Regarding the decision-makers survey, we collected a total of 88 complete

[32] We are aware that this could cause sample selection bias. Nevertheless, this approach was deemed necessary for the decision-maker sample in view of their limited available time to complete such a survey and in order to maximize the response rate. The survey was presented as being about ecosystem services valuation as a decision-making tool.

[33] It would be interesting to compare the socio-demographic characteristics of respondents who completed the questionnaire to the ones of those who dropped out. However, most of the individuals who dropped out did so after the participant information sheet presenting the survey, so without providing socio-demographic information. Having the participant information sheet before the actual questionnaire, due to ethics approval issue, may thus have caused a sample selection bias.

answers out of 450 people initially contacted. Socio-economic characteristics of these individuals retained for our analysis are presented in table 3-2 below, for each sample.

Table 3-2 Socio-economic characteristics of the general public and decision-makers samples used for this analysis

	General public	Decision-makers
Age (average based on categories)	44 yo	42 yo
Gender (average)	49% male	70% male
Level of Education (average score out of 6[i])	Level 3 [i] (s.d. =1.6)	Level 5 [i] (s.d. =1.2)
Field of education	All fields, but mainly management and commerce (24%)	Natural and physical science: 33%, Agriculture & environmental studies: 36%, Management and commerce: 10%, Society and culture: 9%, Engineering and technologies: 6%
Work experience	Business: 20%, Finance: 15%, Environmental management: 4%, Economics: 3%, Biological conservation: 2%,	Environmental management: 92%, Biological conservation: 51%, Economics: 22%, Business: 20%, Finance: 7%
Geographic Location	NSW: 31%, Vic: 25%, Qld: 21%, SA: 8%, WA: 9%, NT: 0.4%, Tas: 3%, ACT: 2%	NSW: 28%, Vic: 8%, Qld: 15%, SA: 13%, WA: 16%, NT: 5%, Tas: 9%, ACT: 6%

[i] *6 being "post graduate" and 1 being "secondary"; 3 corresponds to "diploma"; 5 to "Graduate Diploma"*
s.d. : standard deviation

The general public sample was found to be representative of the Australian population as described by the set of socio-demographic variables identified by ORU (age categories, gender and geographical location). In comparison, the actual share of populations of the different states in Australia are: 32.1% for New South Wales (NSW), 24.8% for Victoria (Vic), 20.1% for Queensland (Qld), 10.7% for Western Australia (WA), 7.3% for South Australia (SA), 2.2% for Tasmania (Tas), 1.6% for Australian Capital Territory (ACT) and 1% for the Northern Territory (NT) (Australian Bureau of Statistics, 2013). The median age is 38 yo and the male/female ratio is one (Australian Bureau of Statistics, 2013).

The decision-makers sample was also found to be highly diverse in terms of field of education, work experience and geographical location. Figures 3-1 to 3-3 provide additional details about this sample. The majority of respondents were currently working for government and associated agencies, although other categories of stakeholders were also represented (figure 3-1). Their work related to all jurisdictions (all States as well as the Federal level) and focused on various types of management contexts: in total 58% of individuals declared working on marine areas and species conservation, 48% on coastal development, 39% on recreational activities and tourism, 25% on coastal and marine pollution, 24% on commercial fisheries and 14% on indigenous and customary use. Figure 3-2 presents the jurisdictions (i.e. States) in which respondents declared being involved by types of management (the complementary figure i.e. the types of management respondents declared being involved in by jurisdictions is presented in Appendix O).

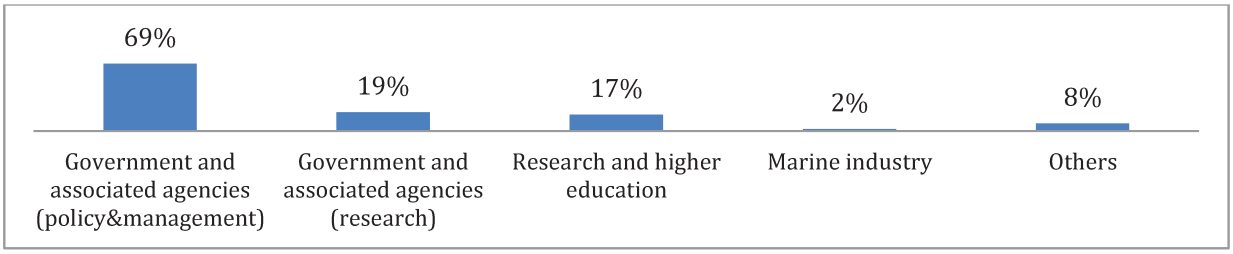


Figure 3-1 Decision-makers sample: types of organizations represented (n=88)

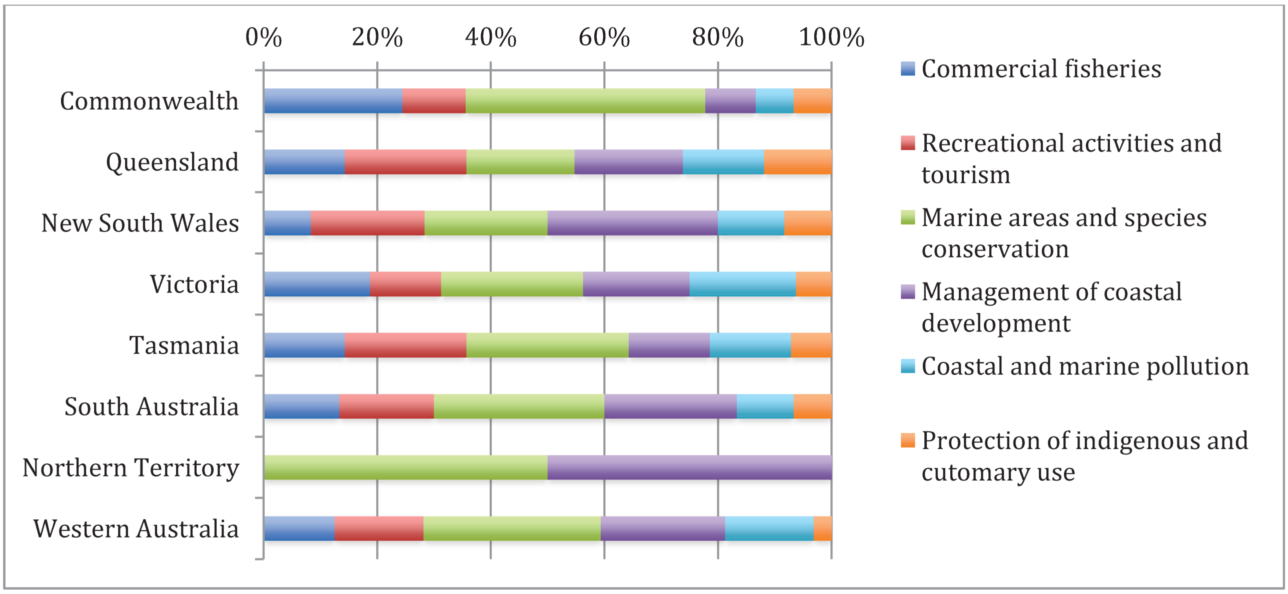


Figure 3-2 Decision-makers sample: jurisdictions in which respondents are involved by types of management

With respect to their possible roles in decision-making (figure 3-3), the respondents were asked to select at least one option that would best describe these roles among four possible ones:

- Informative: collating information and delivering it to others;

- Consultative: providing advice and recommendations to others;
- Contributive: contributing to the final decision and/or management plan;
- Decisive: deciding whether or not a decision is implemented.

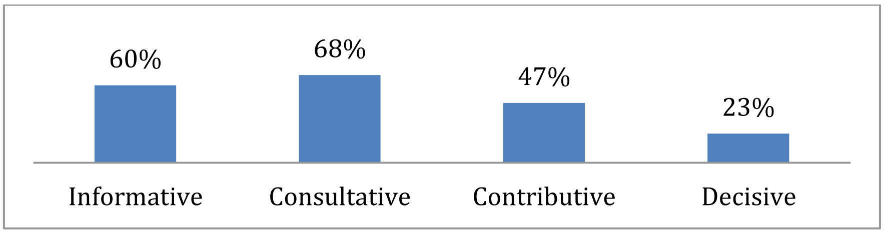


Figure 3-3 Decision-makers sample: role in decision-making (n=88)

There was also an important variability across our respondents in terms of years of experience in coastal and marine management (26% stated between 0 and 5 years of experience, 22% between 6 and 10 years, 24% between 11 and 20 years and 28% more than 20 years), and of their role in decision-making.

2.4 Statistical analysis of results

Descriptive statistics were derived for the different questions. Whenever needed, Student t-tests and chi-squared tests were used to test for equality or difference between means and proportions, respectively.

In addition, we also examined in greater details socio-demographic characteristics that could either explain the decision-makers and the general public's knowledge of ESV (i.e. if they heard about it or not), and the decision-makers' knowledge and use of ESV (i.e. if they never used ESV, or if they used ESV, sometimes or often). For the decision-makers, the variable that describes the perceived knowledge and use of ESV had five possible outcomes: never heard about ESV, only heard about ESV, familiar with ESV (but no use), already used ESV but not often, often used ESV.

Examining the potential influence of various factors on the knowledge and use of ESV was done by: (1) looking at the socio-demographic decomposition of the respondents from the general public and decision-makers who were familiar or not with ESV (and who used ESV or not in the case of decision-makers); and (2) running statistical models to check for potential explanatory variables.

For both samples, an important number of variables were considered as being potentially able to influence the knowledge about or use of ESV. As a consequence, stepwise procedures were used during the regression analysis. This is mostly because we did not find precise documentation in the literature about socio-demographic factors that would influence the familiarity with or use of ESV. Our analysis were thus conducted more as an exploratory approach than by testing pre-determined models or hypothesis regarding the influence of a small set of pre-selected variables.

The variables considered in both steps for the general public were: age, gender, geographical location, active support of CME preservation, educational background, level of education and work experience.

For the decision-makers, the same variables were considered (except the one regarding the support of CME conservation) alongside additional ones: types of organizations they were working for, working experience in specific management contexts, years of experience in decision-making and role in decision-making.

For the general public, Logit models[34] (Greene, 2003) were run using forward and backward stepwise model selection procedures based on AIC and BIC criteria. The stepwise selection procedures were used to select simple combinations of variables that allowed the best predictions (given the numerous variables that were initially considered).

For the decision-makers we ran two types of stepwise regression models. First we estimated an ordered logistic regression model (Greene, 2003) with the dependent variable detailing the knowledge and use of ESV, its levels being coded: 0 for “only heard about ESV”, 1 for “familiar with ESV”, 2 for “used ESV rarely” and 3 for “used ESV often”. However, such a model relies on a particularly strong assumption - the proportional odds ratio assumption. As such it was used more as an exploratory approach. Second we used a Logit model (Greene, 2003) to look more precisely at the factors that could explain the use (or lack of use) of ESV. For this second model, the dependent variable is taking the value 0 if the respondent heard about ESV but never used it, and 1 if he already used it (rarely or often). Forward and backward stepwise model selection procedures based on AIC and BIC criteria were applied for both models.

[34] We actually tested both Logit and Probit models, and the Logit models were found to perform better with higher model fits.

3. Results

3.1 General public's perception about the preservation of coastal and marine ecosystems

98% of the individuals surveyed declared that preserving CME is an important issue. When asked to select and rank among a pre-defined list the three most important reasons for their commitment to preserve CME, a large majority (around 65%) of the respondents indicated that their first most important motivations strictly pertained to non-use or "non utilitarian" values (bequest value, moral responsibility, existence value, biocentrism). Results are similar for the second and third most important motivations with respectively around 70% and 65% of individuals that justify coastal and marine preservation in view of non-use concerns. In addition, between 15 and 20% of the respondents considered that preserving these ecosystems is crucial because humans need them to live, which entails both a mix of use (e.g. provision of food) and non-use concerns (e.g. bequest and survival of humanity). Only 7 and 16% indicated that CME must be preserved so that they can continue enjoying the benefits provided by CME during their lifetime. Detailed answers to this question are presented in figures in Appendix O.

Figure 3-4 synthetises these answers by presenting for each reason to preserve CME the proportion of individuals who selected it as being the "number one most important", and a normalized weighted index based on the proportions of individuals who selected it as "number one, number two or number three most important". This index is comprised between 0 and 1, and the closest to one, the most important is the reason to preserve CME (the closest to one, the most frequently the reason to preserve CME was cited as the "number one most important"). Clearly, non-use or moral concerns were largely the main motivations behind the preservation of CME, and substantially more than use concerns.

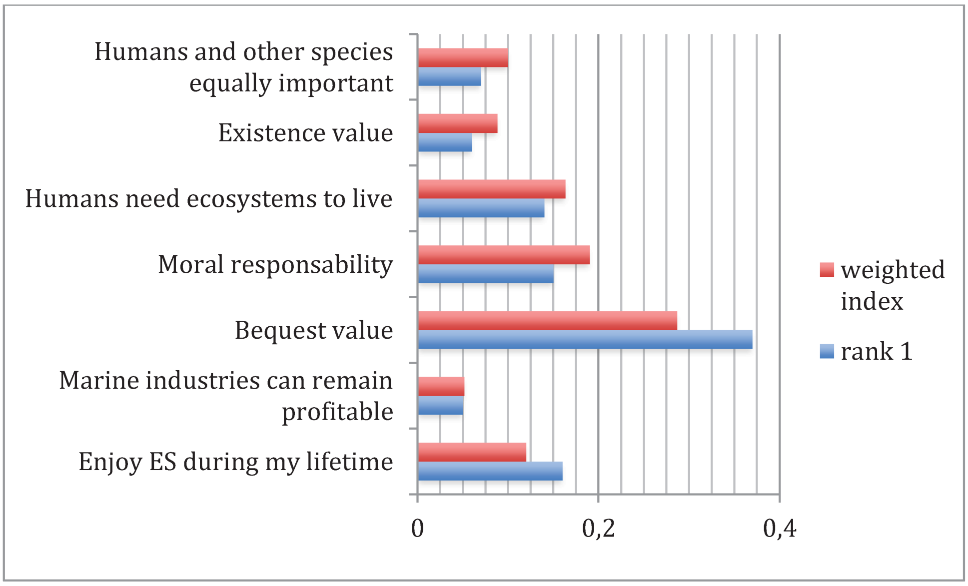


Figure 3-4 Most important reasons to preserve coastal and marine ecosystems: normalized weighted indexes based on proportions of stated importance

Furthermore, 75% of the respondents declared that they actively support the preservation of CME (e.g. by volunteering time, financial subscription or donation, or voting for party/individuals who support the preservation of coastal and marine ecosystems).

39% of the respondents stated that current management of CME in Australia is not sufficient to guarantee their preservation, whereas 20% think it is and 41% declared they did not know. Among these 39%, around 65% declared that this was due to the growing pressure on CME (mostly fishing pressure and pollution, as well as climate change but this was selected by less individuals: 45%), or because of a lack of commitment from both policy makers and the general public. Indeed, 50% of respondents declared that more investment and efforts are needed. Finally, 52% of the respondents stated that they think all coastal development would have to slow down now in order to preserve coastal and marine ecosystems, against 20% who said they did not think so (and 28% who did not know).

3.2 Populations' and decision-makers' perceptions about ESV

When asked if they had heard about ESV work regarding coastal and marine ecosystems, respondents' answers differed substantially between the two samples. Results are presented in Figure 3-5. Around 80% of the general public had never heard about ESV, whereas this fell to only one individual among the group of decision-makers surveyed.

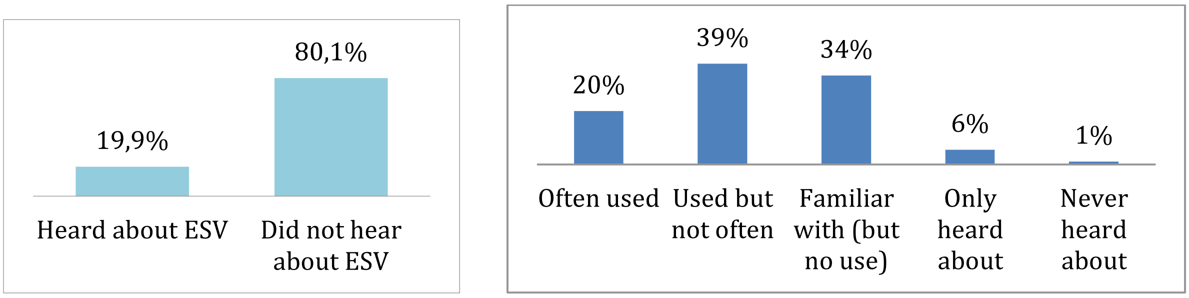


Figure 3-5 Stated familiarity with ESV: proportions of general public (left, n=256) and decision-makers (right, n=88)

After having explained ESV (through the glossary) to the individuals who stated that they had never heard about it, we asked both samples their opinion about the usefulness of ESV. The main results are presented in figure 3-6 below. Here again, results differ significantly.

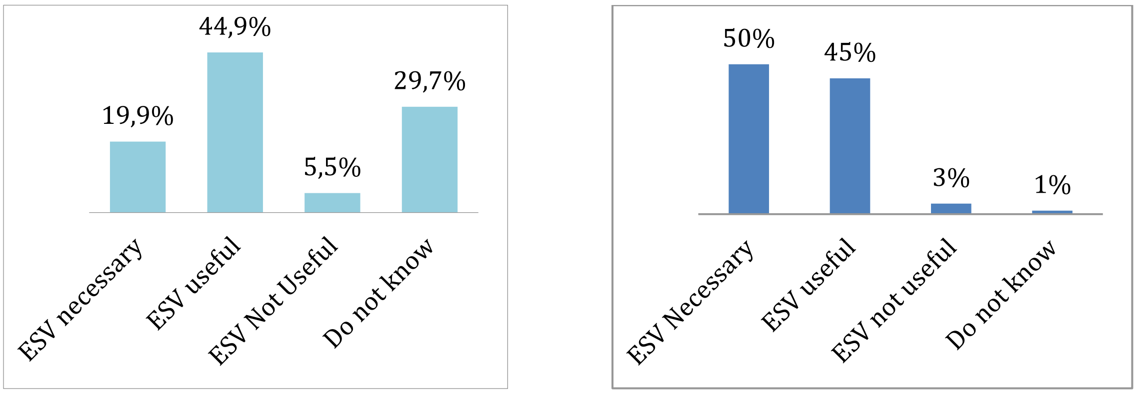


Figure 3-6 Stated usefulness of ESV: proportions of general public (left, n=256) and decision-makers (right, n=88)

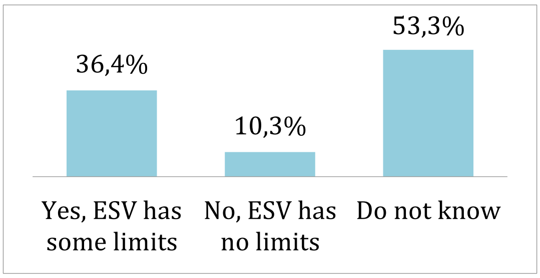
The respondents had the choice between several options listed in order to characterise more precisely the reason(s) why ESV would be necessary, useful or useless. Table 3-3 below presents these results, with the percentages representing the proportions of respondents who selected each reason among the ones who stated ESV as necessary or among the ones who stated ESV as useful. As one can notice, a significant part of the decision-makers surveyed expressed other reasons underlying the usefulness of ESV. These include: ESV as a tool to help with offsets, ESV as a tool to help with trade-offs involved in decision-making ("*As a means to assess the relative merits of options (not absolute values)*"), or more broadly ESV as information to help defining and guaranteeing the sustainability of present and future developments. An individual also pointed out that ecosystem functions or services that are hard to monetize should not be left out. Furthermore additional comments were made regarding the "advocacy and communication" option: some decision-makers insisted on the fact that ESV, as a monetary approach, is particularly well adapted to political concerns and language (for example: "*Money is the only concept that some decision-makers understand*"; "*As a way of convincing Ministers with no scientific background of the value of conservation measures*"); and others on the fact that ESV plays a social role ("*To help societies to value natural capital").*

Table 3-3 Proportions of individuals in the general public and decision-makers samples who stated ESV as "necessary" or "useful" for each reason behind ESV usefulness

	General Public		Decision-makers	
	ESV Necessary	ESV Useful	ESV Necessary	ESV Useful
ESV for communication or advocacy	**78%**	**62%**	70%	**79%**
ESV for CBA	**59%**	**63%**	**84%**	**79%**
ESV as a basis of discussion in decision-making processes	51%	49%	**79%**	72%
ESV for implementing financial instrument	33%	31%	47%	28%
ESV for monetary compensation	51%	30%	51%	38%
Others	0%	0%	7%	21%
N	51	115	43	39

For the individuals in both samples who perceived ESV as "not useful" (17 in total: 14 in the general public, 3 in decision-makers) the following reasons were chosen by the majority: (i) ESV is incomplete and inaccurate because ES are too complex (42% for the general public and 100% for decision-makers); (ii) ESV is not relevant to decision-making (42% for the general public and 66% in the decision-makers) and decisions should be taken on other grounds (58% for the general public and 33% in the decision-makers). Some individuals from the general public also selected the following reasons: (i) it would allow polluters to buy their way out (33%) or have some destructive effects via financial instruments (25%); and (ii) ESV is not morally or ethically acceptable (17%); to which some added that they had concerns about the reliability of indicators that *"would be skewed to suit the aim of government or developers"* or about the fact that better management first needs *"correct corrective actions".*

We then asked those individuals who agreed on the usefulness of ESV to state if they perceived limits to ESV, and if so, which limits these were. Figure 3-7 and table 3-4 detail the results. Interestingly, the top five limits cited were the same for the general public and decision-makers, although except for the first one, they were cited in a different order. We also noted a much bigger proportion of respondents from the general public who did not know about such limits.



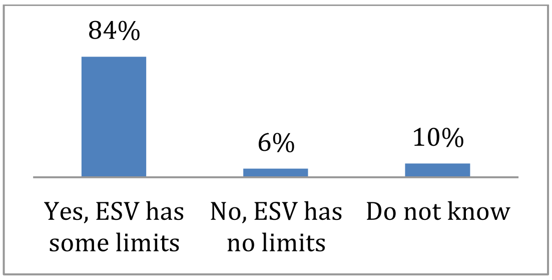


Figure 3-7 Proportions of general public (left, n=242) and decision-makers (right, n=83) who stated there were limits to the use of ESV

Table 3-4 Limits of ESV selected by the general public and decision-makers: proportions in each sample

	Limits of ESV	
	General public	**Decision-makers**
Validity of ESV not accepted widely enough	**55%**	**64%**
Too simplistic (ES too complex)	30%	**50%**
Has to be improved (methods and techniques)	27%	**44%**
The decision-making framework/guidelines may not allow ESV to be used	28%	43%
Too costly	28%	34%
Undesirable consequences	**44%**	34%
Creates conflict between stakeholders in DM process	**39%**	17%
Morally or ethically questionable	13%	7%
Others	2%	23%
N	88	70

Additional comments on the limitations of ESV and the potentially undesirable consequences of their use were related to ethical issues, e.g.: "*Some communities believe they can sell the asset for the quoted ESV*"; "*ESV may put focus of value on inappropriate aspects of the matter*"; "*Ultimately, dollar values may skew the intent of conservation and attention away from the moral obligation to conserve species and habitat*". The second quotation echoes some concerns often made in an ecological perspective, in particular the one that ESV focus on ecological services and not on ecological functions, do not consider resilience or threshold issues, and as such do not reflect the complexity and dynamics of ecosystems. This relates to several concerns mentioned about the inability of ESV to correctly cope with risk and uncertainty, thus potentially leading to misuse; and also with its inability to deal with fundamental cycles and the fundamentals of life itself ("*the very large values of some aspects (e.g. o2 production) mean they are typically ignored*"). In addition, an issue was raised about the usefulness of ESV when producing estimates for impacted ecosystems: *"The receiving environment is already degraded from a legacy of discharges and no cost was placed on* *the environment before an industry discharges. It is difficult to put an ESV on impacted ecosystems"*

Moreover, other issues regarding ESV that could hinder its use in the decision-making process were mentioned: "*"there may not be agreement on the best ESV model to apply, which leads to arguments at the expense of action*"; "*the time taken to apply ESV may hinder its application as part of the policy cycle*".

Finally several decision-makers emphasized the fact that ESV is "A way" and not "THE way", that is to say there are other information and indicators to consider, especially in view of ESV's serious risks and limits. Illustrative comments about this issue included: "*decisions should not be made solely on a financial perspective*"; "*some decisions (e.g. species conservation) should mainly be based on other information/indicator (ecological)*"; "*other factors (such as employment, potential revenue) may have a much higher priority than environmental considerations*". In addition, concerns were raised about the other factors that usually greatly influence policy-making such as lobbying, power struggles, personal interests, conflicts ("*even a perfect ESV measure does not resolve conflicts*", *"Industry profits often beat environmental values"*) etc., thus minimizing the influence ESV and scientific information may have in the decision-making process in the end ("*Politics will always dictate the decisions that are made, not science or logic*"). An interesting statement from a respondent summarized well the issue of the "instrumentalization" of ESV to suit stakeholder positions, once there is a disagreement on a proposal:

"The real limit to ESV is how it is used by practitioners and this is driven by the political instructions received. When used in an open, collaborative decision making model it is very useful. When used to justify predetermined positions or to bully stakeholders in a manipulative decision making process you get the outcomes/complaints you have listed above."

Respondents in both questionnaires were finally asked to indicate how important they think it is to consider an economic value during the decision-making process in Australia for an exhaustive list of coastal and marine ecosystem services. We also asked the decision-mares to indicate the level of trust they would have in each of these values according to their experience. Results are presented in figures 3-8, 3-9 and 3-10 below. We note the substantial proportions of individuals that declared they did not know about this issue for the general public. For the decision-makers, these were globally largely smaller, although still quite significant regarding option, non-use and indigenous values.

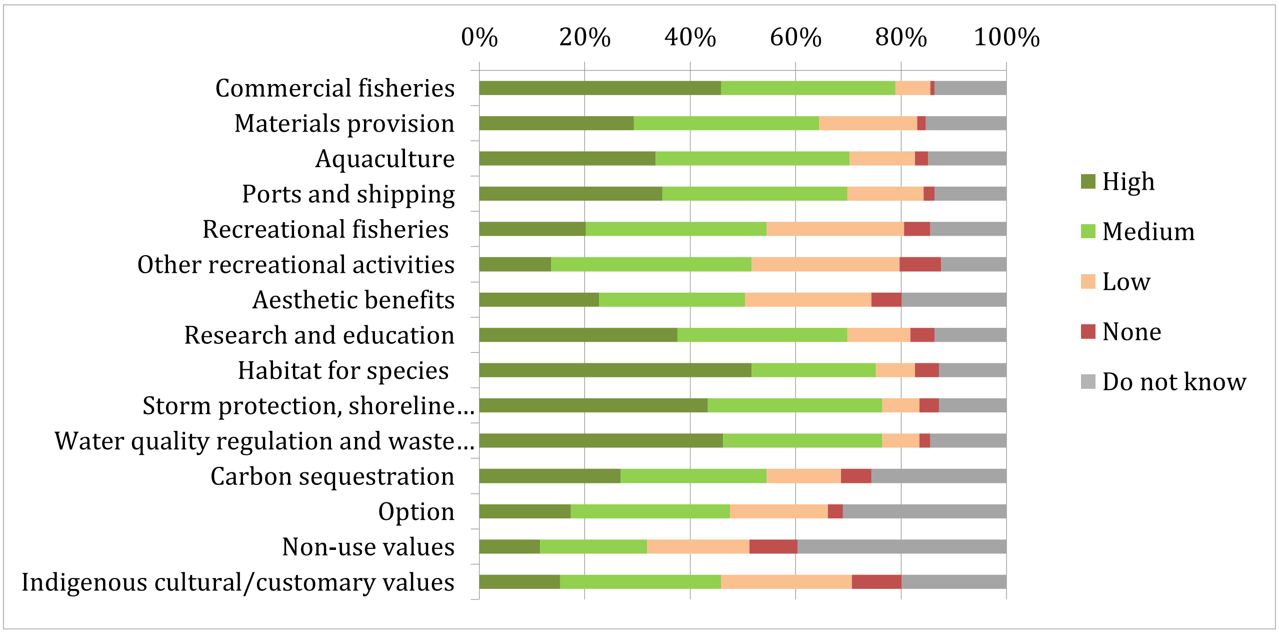


Figure 3-8 General public' stated importance of estimating an economic value for the different types of services provided by coastal and marine ecosystems

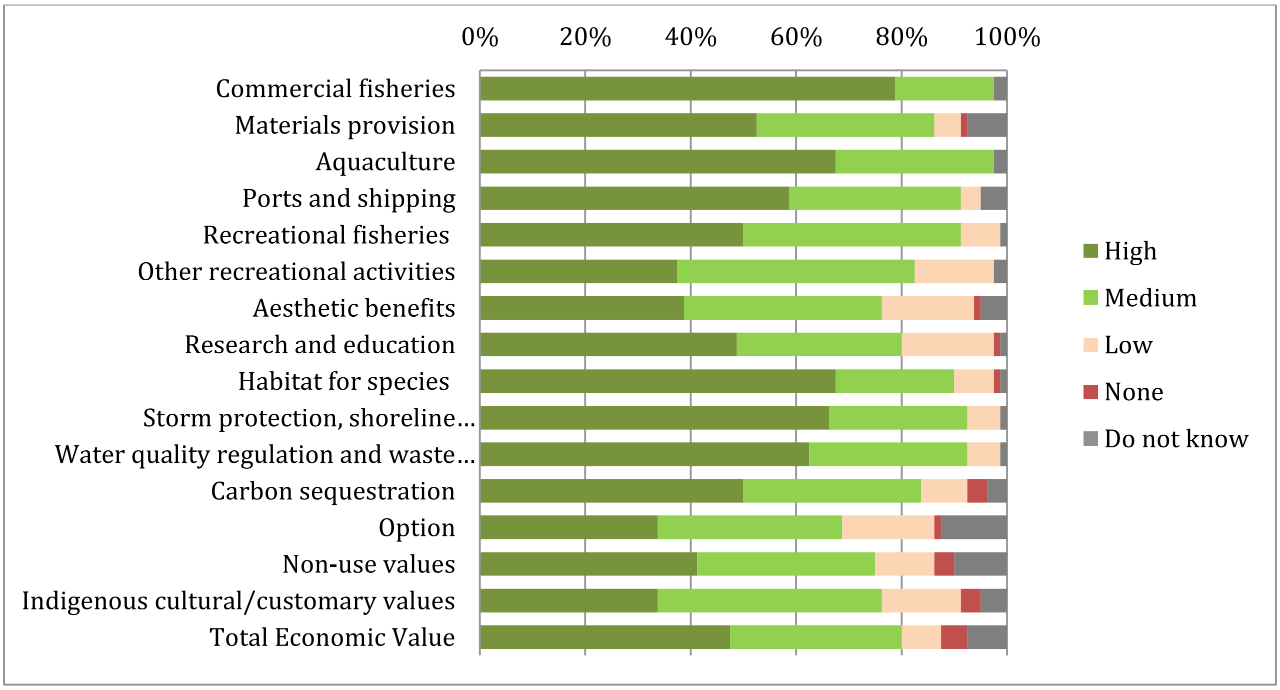


Figure 3-9 Decision-makers' stated importance of estimating an economic value for the different types of services provided by coastal and marine ecosystems

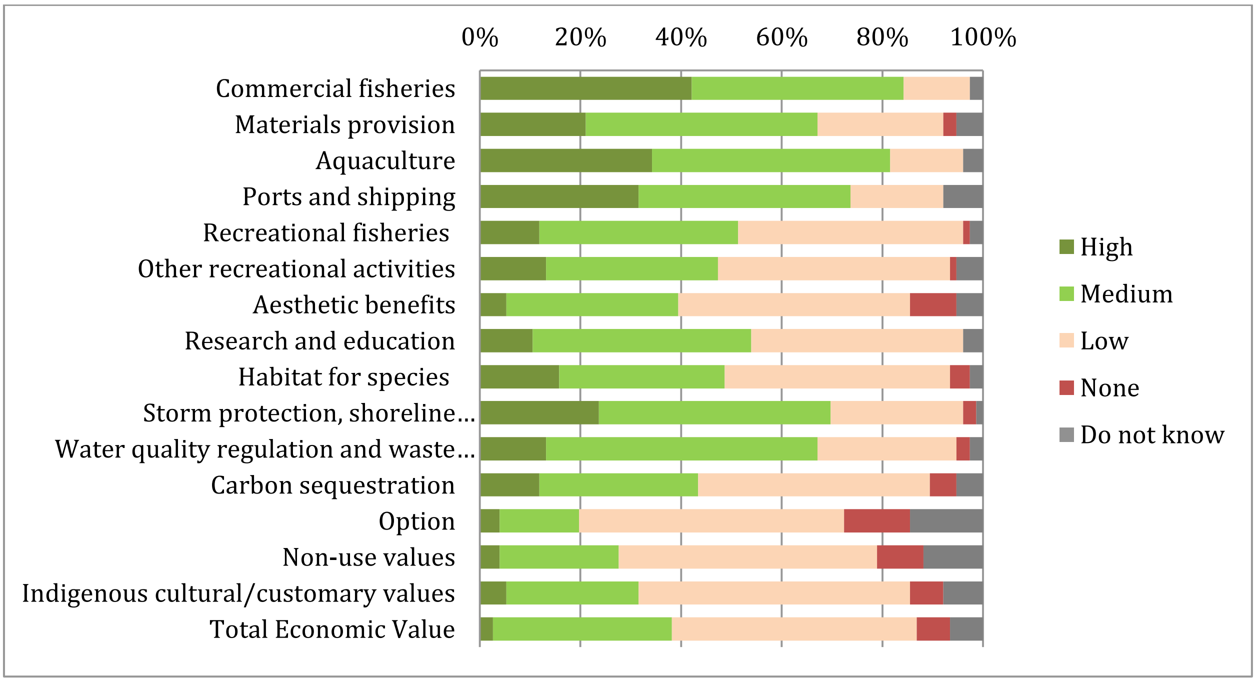


Figure 3-10 Decision-makers' stated level of trust in each economic values associated with different types of services provided by coastal and marine ecosystems

Table 3-3 below summarizes these results with average scores based on frequency. In this table, the types of ecosystem services are presented hierarchically depending on the average scores of the decision-makers (from the highest to lowest average scores).

When looking at this table, it appears that the importance of estimating an economic value was different depending on the ecosystem services considered, as expected[35]. Most of the scores that looked significantly different were shown to differ statistically from one another with student t-tests, for both samples. This heterogeneity seemed even larger for the general public population. Although almost all the scores were found to differ statistically between the general public and decision-makers as shown with the t-test results presented in table 3-5 (except from the "research and education" service), we note that both perceived commercial fisheries as being the most important service to estimate an economic value for (and with the most reliable estimates according to decision-makers). Most regulating services came next in terms of importance, as well as port and shipping and aquaculture. These were followed by recreational activities and aesthetic benefits and finally option, non-use and indigenous cultural values, for which the estimates were perceived as less reliable by decision-makers.

[35] Within each sample, all pairs of scores were compared using student t-tests. When the difference between two scores was equal to or greater than 0.20 in absolute value or more, these scores were shown to differ statistically from one another (at the 5% level).

Table 3-5 Average scores (0=Not important, 3=Highly important) associated with estimating an economic value for each coastal and marine ecosystem services, based on decision-makers and general public' statements (excluding individuals having stated "Do not know")

	Importance level						Trust level	
	General public		Decision-makers		t-stat	sig	Decision-makers	
	Mean	*s.d.*	Mean	*s.d.*			Mean	*s.d.*
Commercial fisheries	**2.44**	*0.68*	**2.81**	*0.40*	5.73	***	**2.30**	*0.70*
Aquaculture	2.19	*0.79*	2.70	*0.47*	6.61	***	2.21	*0.69*
Storm protection, shoreline stabilization, flood control	**2.34**	*0.81*	2.61	*0.61*	3.14	***	1.92	*0.79*
Habitat for species	**2.41**	*0.86*	2.59	*0.70*	1.84	*	1.63	*0.81*
Ports and shipping	2.19	*0.80*	2.58	*0.58*	4.58	***	**2.15**	*0.73*
Water quality regulation and waste assimilation	**2.42**	*0.75*	2.57	*0.62*	1.84	*	1.80	*0.71*
Materials provision	2.09	*0.80*	2.49	*0.67*	4.17	***	1.91	*0.78*
Recreational fisheries	1.82	*0.87*	2.44	*0.64*	6.59	***	1.64	*0.72*
Carbon sequestration	2.02	*0.94*	2.36	*0.81*	2.90	***	1.53	*0.79*
Research and education	2.20	*0.87*	2.30	*0.81*	0.92		1.68	*0.67*
Non-use values	1.57	*0.97*	2.25	*0.84*	5.37	***	1.26	*0.71*
Other recreational activities	1.66	*0.85*	2.24	*0.71*	5.84	***	1.63	*0.74*
Aesthetic benefits	1.85	*0.93*	2.20	*0.79*	3.20	***	1.38	*0.74*
Option	1.90	*0.83*	2.16	*0.80*	2.27	**	1.13	*0.72*
Indigenous cultural/customary values	1.65	*0.93*	2.12	*0.82*	4.13	***	1.33	*0.70*

**** Significant at 1%; ** Significant at 5%; * Significant at 10% with Two Sample t-tests (no equal variances)*

When having a look at the standard deviations in table 3-5, it is interesting to note that these differed between the two samples: they were globally higher for the general public. This variability could either reflect a bigger heterogeneity within this group, either more uncertainties in their way to answer the question (which would accord with the high proportion of "do not know" observed). Besides, we note that the standard deviations were bigger for the ecosystem services that were considered as low important to economically value.

3.3 Socio-economic factors of knowledge and use of ESV

3.3.1 General public

For the general public, table 3-6 presents the socio-economic characteristics of individuals that never heard about ESV and the ones who did.

Table 3-6 Socio-economic characteristics of individuals having heard (or not) about ESV in the general public: proportions and average categories

	Never heard about ESV (n=200)	Heard about ESV (n=50)
Gender (male)	47%	58%
Education Level (average category) [i]	2.8	3.3
Age Category (average based on categories)	**43 yo** **	**50 yo** **
State NSW	31.0%	34.0%
State Vic	23.0%	32.0%
State Qld	**24.0%****	**10.0%****
State SA	7.0%	14.0%
State WA	10.0%	6.0%
State NT	0.5%	0.0%
State Tas	3.0%	2.0%
State ACT	1.5%	2.0%
Support preservation	**20.0%*****	**46.0%*****
Work experience Economy	**1.5%*****	**10.0%*****
Work experience Environment	**5.0%****	**16.0%****
Education in environmental sciences	4.5%	6%
Education in business and management	28.5%	26.0%
Education field society & culture	10.0%	18.0%

**** Significant at 1%; ** Significant at 5%; * Significant at 10% with chi-square tests or Two Sample t-tests (no equal variances)*

[i] *6 being "post graduate" and 1 being "secondary"; 3 corresponds to "diploma"; 5 to "Graduate Diploma"*

According to student t-tests or chi-square tests between the means or proportions of each sub-group, the factors that influenced the knowledge of ESV were: being older, actively supporting the preservation of CME, and having a work experience related with economics or environmental management. On the other hand, the educational level and background did not seem to play a role. Individuals living in Queensland seemed to have significantly less heard about ESV, in comparison with other states.

Final results of the stepwise Logit models are presented in table 3-7 below. As suggested by previous observations, age, actively supporting CME preservation and having a work experience in economics all played a positive influence on having heard about ESV. Moreover, living in New-South-Wales, in Victoria and South Australia were also shown to have positive role on having heard about ESV. In terms of quantitative effects, the exponentiated coefficient represents the change in odds[36] of having heard about ESV for a unit increase in the predictor variable holding other variables at a fixed value. Living in NSW, Vic or SA thus respectively increases the probability of having heard about ESV by roughly 0.75, 0.77 or 0.84. Similarly, having a work experience in environmental management increases this probability by roughly 0.78 and having a work experience in economics increases this probability by 0.87.

Table 3-7 Logit model on the perceived knowledge of ESV for the general public (n=250)

	Estimates	**Std. Error**
(Intercept)	-4.676***	0.786
Age Category	0.352***	0.107
StateNSW	1.127**	0.474
StateVic	1.238**	0.492
StateSA	1.646***	0.629
Support	1.262***	0.374
Work experience in environmental management	0.845	0.586
Work experience in economics	1.889**	0.886
Pseudo-R^2: *variance of predicted mean/(variation of predicted mean + residual variation)*	0.597	

****: Significant at 1% level; ** Significant at 5% level; * Significant at 10%*

3.3.2 Decision-makers

Socio-economic characteristics of the respondents who chose each category are given in table 3-8. Some differences between the groups can be observed, for example when looking at the educational background in business and management, or in society and culture, or when looking at researchers. Results of chi-square tests between the proportions of respondents that are familiar with ESV but did not use it and the ones that used ESV often are also presented. These tests were only significant for two socio-demographic variables: education in environmental sciences and working experience in economics, business or finance.

[36] The odds of success (e.g. having heard about ESV) are defined as the ratio of the probability of success over the probability of failure (e.g. never heard about ESV).

Table 3-8 Socio-economic characteristics of individuals having heard (or not) about ESV in the decision-makers

	Only heard about ESV (n=5)	**Familiar with but no use of ESV (n=30)**	**Used ESV often But not often (n=34)**	**Used ESV often (n=18)**
Gender (male)	100%	60%	61.3%	89.9%
Education Level (average category) [i]	4.0	5.0	5.0	5.5
Age (average based on categories)	37 yo	41 yo	42 yo	44 yo
State NSW	16.7%	20.0%	32.3%	38.9%
State Vic	33.3%	10.0%	3.2%	11.1%
State Qld	0.0%	10.0%	19.4%	16.7%
State SA	33.3%	6.7%	12.9%	16.7%
State WA	16.7%	23.3%	16.1%	5.6%
State NT	0.0%	10.0%	3.2%	0.0%
State Tas	0.0%	10.0%	9.7%	5.6%
State ACT	0.0%	10.0%	3.2%	5.6%
Education in environmental sciences	83.3%	43.3%*	45.2%	72.2%*
Education in business and management	16.7%	**0.0%**	**19.4%**	**27.8%**
Education field society and culture	**16.7%**	**6.7%**	**9.7%**	**27.8%**
Work experience in economics, business or finance	**16.7%**	**13.3%*** **	**29.0%**	**66.7%*** **
Work experience in conservation	33.3%	40.0%	51.6%	44.4%
Work for government (policy and management)	100%	70%	77%	50%
Work for government (research)	0%	20%	22%	22%
Work for research	0%	17%	16%	33%
Work for marine industries	0%	3%	6%	5%

**** Significant at 1%; ** Significant at 5%; * Significant at 10%*

[i] *6 being "post graduate" and 1 being "secondary"; 3 corresponds to "diploma"; 5 to "Graduate Diploma"*

Results from the final ordered logit regression model predicting the knowledge and use of ESV (dependent variable) as a function of key socio-demographic factors are presented in table 3-9.

Table 3-9 Ordered logit regression on the perceived knowledge and use of ESV for the respondents (n=88)

	Estimates	Odds ratios	Std. Error
Intercept 0:1	-1.089		0.689
Intercept 1:2	1.565**		0.679
Intercept 2:3	3.817***		0.781
Education in society and culture	1.612**	*5.015*	0.721
Years of experience in decision-making	0.681***	*1.975*	0.200
Work experience in economics, business or finance	1.955***	*7.066*	0.506
Work for government (policy and management)	-1.626***	*0.197*	0.544
Contributive role to decision-making	1.072**	*2.921*	0.506
Mc Fadden Pseudo-R^2		0.173	
Cox & Snell Pseudo-R^2		0.355	

****: Significant at 1% level; ** Significant at 5% level; * Significant at 10%*

Years of experience: 1=between 0 and 5 years, 2=between 6 and 10 years, 3= between 11 and 20 years and 4=more than 20 years. All other variables are binary.

All parameters were significant (most of them at the 1% or 5% level), and model fit was satisfying given the simplicity of the model (e.g. there are other non-measured variables that could have an influence on the knowledge and use of ESV). According to these results, the variables identified as playing a positive role in determining the knowledge and use of ESV for decision-makers were: having a field of education in economic, political or social sciences (variable “Education field Society & culture”), the years of experience in decision-making, having a work experience in economics/business/finance and having a “contributive” role in decision-making (contributing to the final decision and/or management plan). Working in government and associated agencies in policy and management (which does not include research activities) played a negative role: familiarity with and use of ESV decreased for individuals who work in these organizations.

The proportional odds assumption was assessed using a graphical method recommended by Harrell (2001). This approach suggested that the proportional odds assumption may not hold for some of the predictors (“education in society and culture”, “contributive role to decision-making”), especially for the transition from "never or only heard of ESV" to "familiar with ESV" and "familiar with ESV" to " rarely used ESV ". Therefore we cannot use this model for prediction, and this ordered logit approach only allowed us to identify potential factors that may have an influence on the various level of familiarity with and use of ESV.

In terms of prediction, a simpler approach is thus necessary, and this is why we also examined factors explaining decision-makers choice whether or not to use ESV. Results of our final Logit model with the use of ESV as a dependent binary variable (0 for no use, 1 for use) are presented in table 8 below. We note that the variables used in this model did not initially differ than the previous linear model, but we ended up selecting different variable according to our stepwise regressions process.

Table 3-10 Logit model on the perceived use of ESV for the respondents (n=88)

	Estimates	**Odds ratios**	**Std. Error**
(Intercept)	-1.907***		0.715
Educational background Business Management	1.912*	6.764	1.136
Educational background in society and culture	1.390*	4.017	0.849
Years of experience	0.539**	1.714	0.234
Work experience in economics, business or finance	1.240**	3.457	0.631
Work in management of commercial fisheries	1.075*	2.931	0.618
Mc Fadden Pseudo-R^2		0.197	
Pseudo-R^2: *variance of predicted mean/(variation of predicted mean + residual variation)*		0.641	

****: Significant at 1% level; ** Significant at 5% level; * Significant at 10%*

Years of experience: 1=between 0 and 5 years, 2=between 6 and 10 years, 3= between 11 and 20 years and 4=more than 20 years. All other variables are binary.

All the parameters were significant. The model fit was relatively high, according to the pseudo-R^2. Again, the years of experience in decision-making, the work experience in economics/business/finance and the field of education in social sciences were shown to have a positive influence on ESV being use. Two other variables with positive influence were also significant in comparison to the previous model: work experience in management of commercial fisheries, and the field of education in Business and Management. In terms of quantitative effects, having an educational background in business and management or in society and culture respectively increases the probability of having used ESV by roughly 0.88 and 0.83. Having work experience in economics, business or finance roughly increases this probability by roughly 0.77 and having work experience in the management of commercial fisheries increases it by 0.76. Finally, having between 0 and 5 years of experience in decision-making roughly increases the probability of having used ESV by 0.64 while having more than 20 years of experience increases it by 0.9.

3.4 The use of ESV by decision-makers

3.4.1 Frequency and types of utilization of ESV

The decision-makers surveyed were also asked to answer several questions regarding the use of ESV. The first question aimed at collecting information on the frequency of the different potential uses of ESV (mentioned above i.e. ESV as a communication and advocacy tool; ESV for evaluation and discussion in decision-making, such as CBA; ESV in support of designing economic and financial instrument) in different coastal and marine management contexts. Results are presented in figures 3-11, 3-12 and 3-13.

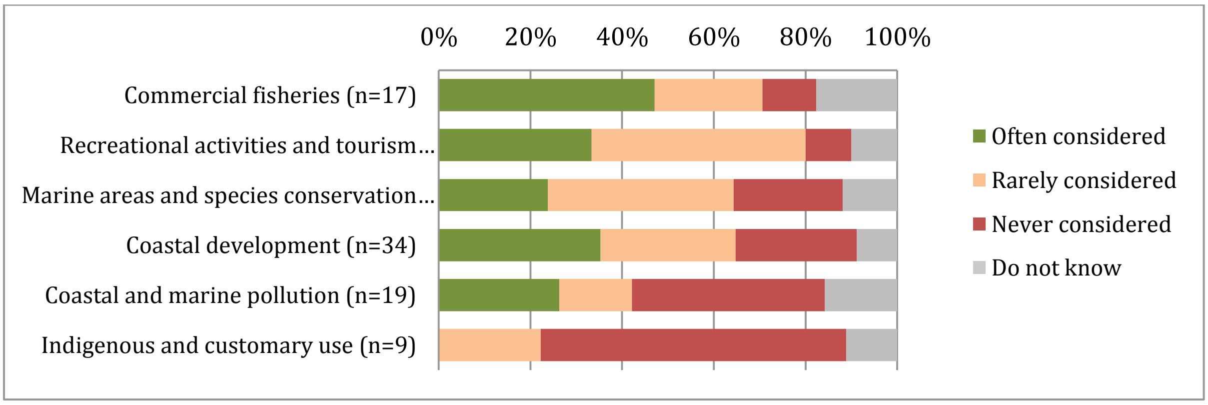


Figure 3-11 Stated use of ESV as a way to communicate, advocate or raise awareness, by different management context

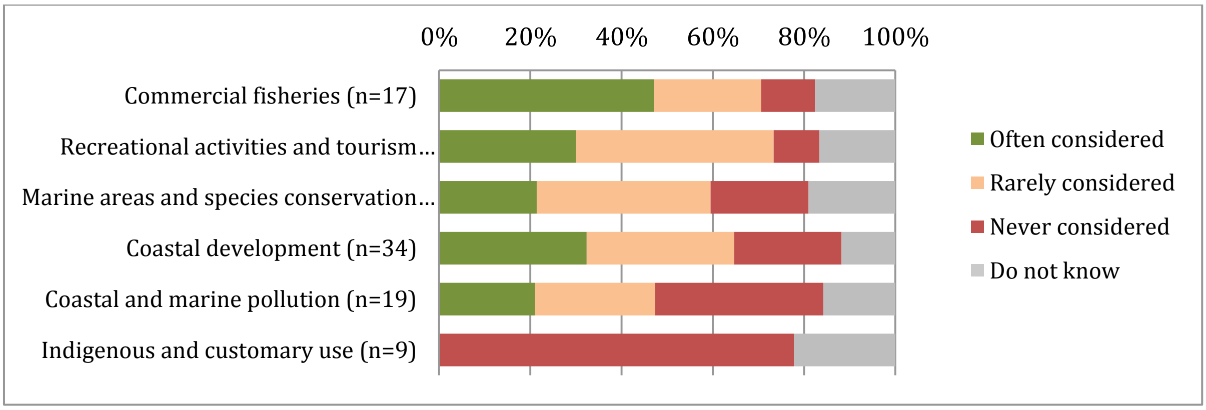


Figure 3-12 Stated use of ESV for evaluation and decision-making, by different management context

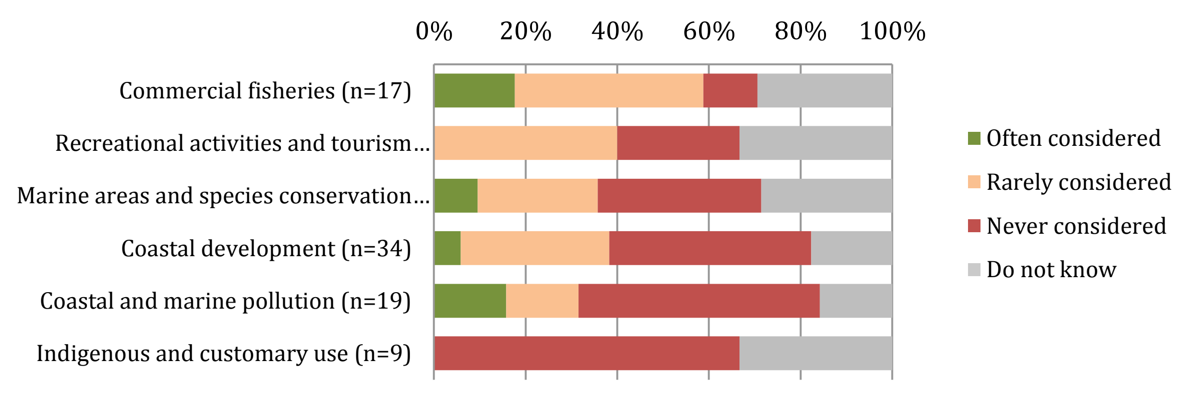


Figure 3-13 Stated use of ESV for establishing taxes, subsidies, fees or damage compensation, by different management context

Table 3-11 gives a summary of these figures where average scores were calculated with the different percentages of stated frequency of use. The average scores representing the frequency of use decreased from the first column to the last, indicating that, in general, ESV was used slightly more for communication or advocacy than for evaluation and decision-making, and rarely to set up economic and financial instruments. The management context in which ESV was the most often considered (in all categories of use) was the management of commercial fisheries. We also observed some relatively high standard deviations that indicated a significant variation of stated frequency of use in our sample. These deviations were globally lower for the last category of ESV utilization i.e. ESV for economic and financial instruments. These were also especially high in the coastal and marine pollution management domain.

Table 3-11 Average stated frequency scores (1=Never considered; 3=Often considered) for the different types of use of ESV by management contexts

	ESV for communication and advocacy		**ESV for evaluation and decision-making**		**ESV for economic and financial instruments**	
	Mean	*s.d.*	Mean	*s.d.*	Mean	*s.d.*
Commercial fisheries	2.43	*0.76*	2.43	*0.76*	2.08	*0.67*
Recreational activities and tourism	2.26	*0.66*	2.24	*0.67*	1.60	*0.51*
Coastal development	2.10	*0.75*	2.10	*0.74*	1.54	*0.72*
Marine areas and species conservation	2.00	*0.84*	2.00	*0.81*	1.64	*0.64*
Coastal and marine pollution	1.82	*0.92*	1.82	*0.84*	1.57	*0.82*
Indigenous and customary use	1.25	*0.47*	1.00	*0*	1.00	*0*

3.4.2 Examples of ESV use

In addition, respondents were also asked to provide a reference to a specific valuation study as an example, including location and year when possible. This was done in order to build a database of case studies, by types of use and management context. More than 100 answers were collected; some with precise examples or references to specific ESV work, some others with simple comments or precision about the use of ESV. Almost all of these are presented in Appendix P, and whenever possible their original formulation and the way they were listed in the survey were kept unchanged (although a quick revision of the citations was carried out to ensure enough information is available to trace the work). Examining and discussing all of them in detail is beyond the scope of this chapter, and will be the object of further work. Here, we focus on presenting selected examples that we believe represent a good illustration for each management context and types of use. These are presented in table 3-12 below. Note that all the precise references or examples showed in this table have been checked.

A second question aimed at identifying any specific ESV work(s) regarding marine and coastal ecosystems that did have a significant impact on policy or management. Only 25% of the 71 decision-makers that answered this question declared they were aware about such work (63% declared they were not aware of any, the others did not know), and table 3-13 presents the few studies cited in Australia.

Table 3-12 Stated Australian cases of ESV uses by management context and types of uses

	ESV as a way to communicate, advocate or raise awareness	**ESV for evaluation and decision-making**	**ESV for establishing taxes, subsidies, fees or damage compensation**
Commercial fisheries	• Queensland, Great Barrier Reef Marine Park (GBRMPA): 2006-07 *Access Economics report*. *Measuring the economic & financial value of the Great Barrier Reef Marine Park* • Western Australia: Western Rock Lobster Fisheries Maximum Economic Yield considerations in the fisheries management • South Australia: incorporating economic aspects of fisheries into the development of management plans	• Queensland, Great Barrier Reef Marine Park (GBRMPA): 2006-07 *Access Economics report to GBRMPA* 2000 Planning for GBR Representative Areas • South Australia, Pipi fishery, 2013: setting Total Allowable Commercial Catch • Southern Rock Lobster Fisheries harvest strategy evaluation	• Southern and Eastern Scalefish and Shark Fisheries: ESV used to consider economic incentives (*e.g. Hutton et al., 2010*) • South Australia, 2013: buy-back of commercial fishing activity due to establishment of marine parks *Econsearch et al.. 2012. Marine Park Regional Impact Statements. Main Report.* • Southwest Marine Region Commonwealth Marine Reserves Network, 2012-2013: quotas and license buy-out *Australian Bureau of Agricultural and Resource Economics and Sciences report. 2012. Social and economic assessment of the impacts on commercial and charter fishing.*
Recreational activities and tourism	• State-wide Beach and Surf Tourism and Recreation Values studies from Bond and Griffith University (*e.g. Anning et al., 2013*) • State-wide recreational fishing evaluation (*Raguragavan et al., 2013*)	• Western Australia: Ningaloo reef fisheries management arena (*e.g. Gao and Hailu, 2011*) • South Australia, 2013: Closure of snapper fishing to all sectors including recreational fishing	• Queensland, Gold Coast, 2005: Infrastructure charging Stormwater Quality

	• Queensland, Gold Coast, 1998: benefits and costs for beach nourishment, Surfers Paradise • Queensland, GBRMPA: 2012/2013 *Deloitte Access Economics reports*. *Economic contribution of the Great Barrier Reef*. 2006 and beyond zoning of marine park *Stoeckl et al., 2011* • Victoria, Portland, 2011: estimation of the Recreational Use Value Gained from Recreational Fishing of Southern Bluefin Tuna (*Ezzy and Scarborough, 2011)*	• Queensland, GBRMPA: 2012/2013 *Deloitte Access Economics reports*. *Economic contribution of the Great Barrier Reef*. *Stoeckl et al., 2011* • South Australia: considered in developing new water quality policy • New South Wales, Clarence Valley, 2013: beach and surf tourism project (*e.g. Anning et al., 2013*) • New South Wales, Port Stephens, 2005-2007: Great lakes Marine Park Zoning Plan	
Conservation of marine areas and species	• South Australia, 2005-2012: design and implementation of 19 marine protected areas through the use of Marxan software with layer of ESV work (*Kirkman, 2013a*) • New South Wales, Batemans Marine Park, 2006: economic valuation of fisheries industries in the establishment of the marine park	• Victoria, Western Port Bay, 2004-2012: review of mangrove planting activities around Westernport (*Kirkman and Boon, 2012*) • South Australia, 2011-2013: marine park regional impact statements, including economic impacts (*Kirkman et al., 2012*) • New South Wales, 2008/2009: values placed by stakeholders on marine parks used in marine park zoning plan review (phone surveys) • South Australia, 2012: commercial fishing economic values from catch and effort displaced due to establishment of marine parks	• Queensland, southern Great Barrier Reef and Hervey Bay/Tin Can Bay, 1998: establishment of buy out schemes for dugong protected area as part of the Structural Adjustment Package from Commonwealth Government • South Australia, 2000s: the Native Vegetation council applied an offset for seagrass loss during a development application, taking stock on estimated seagrass economic values (seagrass workshop 2001).

Table 3-13 Stated Australian case studies where ESV was considered to have a significant impact on policy or management

With readily accessible reference	With no readily accessible reference
Queensland, Great Barrier Reef Marine Park valuation studies used among others for marine park zoning *Stoeckl et al., 2011 for a review of valuation works*	Queensland, Great Barrier Reef Marine Park (GBRMP) commercial fisheries buy-backs and GBRMP representative areas
South Australia, Adelaide costs and benefits of seagrass meadows to coast protection and beach and harbour management *Deans and Murray-Jones, 2002*	South Australia - Development of marine parks and its impact on fishing activities; - Economic contributions of aquaculture development when considering development proposals.
Queensland, Gold coast, 1997 costs and benefits of beach nourishment and restoration *Maitra and Walker, 1972*	Western Australia - Since 1995 ESV were used in Environmental Protection Agency policies concerning Cockburn Sound area; - Pilbara mining valuation studies.
South Australia, 2012 economic impacts of marine parks zoning *Econsearch et al. 2012.*	Western and Southern Rock Lobster fisheries use of ESV for Maximum Economic Yield and translocation
Queensland, Moreton Bay, 2012. Harvest strategy evaluations and co-management for the Moreton Bay Trawl Fishery *Courtney et al. 2012*	Tasmania bioeconomics of Giant crab management changes
Western Australia, Ngari Capes Marine Park, 2006 Abalone survey (biomass and annual commercial catches) *Work conducted by Murdoch University in 2006 for the Departments of Fisheries and Environment and Conservation in Western Australia (Loneraga et al, 2006.)*	Social and Economic Long Term Monitoring Programme within the National Environmental Research Program (early stage)

In addition to these Australian studies, three respondents mentioned another example in a different area of the world to illustrate other cases where ESV had substantial influence on policy or management. Unfortunately, these were not precise enough so that it is not possible to examine this influence in more detail. The first that was mentioned is “mangrove restoration in Thailand”, which probably refers to the impact of the various valuation studies that highlighted the important economic values of mangrove in Thailand: as mentioned earlier Barbier (2012) gives a good overview on this subject, and also states that ESV influenced important policy decisions. The second reference was about “some valuation based work in the Caribbean and United States”. Even if this a very broad assertion, it can be clearly related to several points already discussed in our introduction in reference to the work of Liu et al. (2010) and Kushner et al., (2012). Finally the last reference was more specific but unfortunately did not refer to an ESV study: one respondent cited the work from Worm and al. (2006) that looked at the impacts of biodiversity loss on ocean ecosystem services, probably in order to highlight the awareness that this work raised about incorporating “insurance values” linked to biodiversity in economic valuation.

3.4.3 Examples where ESV was ignored

Then, respondents were asked if they have been involved in a decision-making process where ESV information existed but was not used, and, if so, to provide at least one reference to a specific valuation study, including location and year, if possible. Answers are summarized by figure 3-14 below.

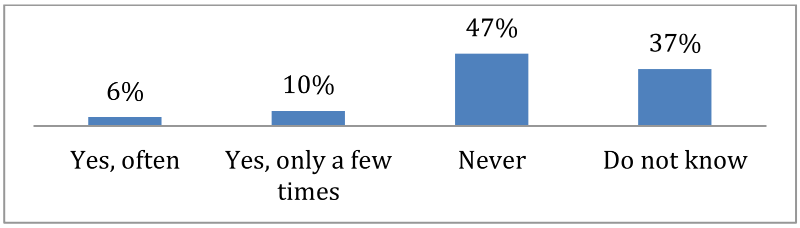


Figure 3-14 Respondents involved in a decision-making process where ESV existed but was not used (N=70)

To those who answered “yes”, we asked to choose among a list of possible reasons that would explain the fact that ESV was not used. Their answers, by decreasing order of frequency of choice, were: the decision makers preferred to base decision-making on other types of information (for 9 respondents out of 11), the information was not perceived as robust enough or the decision-making framework/guidelines did not allow this information to be used (5 out of 11), the information was not relevant to the need of decision makers or management e.g. not answering specific questions from decision-makers or not valuing specific relevant changes (4 out of 11), and finally the information was not accessible (1 out of 11). A few respondents added that this was also due to the resistance from industry or other bodies since the use of ESV would have hindered development. An individual mentioned that "*ESV is understood as a technique but there is no political will to back it up".*

Among the examples provided where ESV information existed but was ignored (according to the reasons mentioned), two of them included a more precise reference. The first was "*Gold Coast Oceanway 2003 – NIMBY vs Green Transport*" (NIMBY: Not in My Back Yard; the Gold Coast Oceanway is a shared use pedestrian and cyclist pathway on the Gold Coast), which refers to a conflict of values: the Gold Coastal city council has come several times into conflict with the beachfront home and land owners who do not necessarily want a pathway to run in front of their properties, despite the Oceanway's economic values as a green transportation system and a boon to tourists. The second example cited was about the Coastal Zone management plans in Eurobodalla from 2010 to current where "*ESV info available was very coarse and subjective and therefore only given limited weight in decision making process*" (more information can be found at http://projects.umwelt.com.au/Eurobodalla/index.html). In addition, other examples were cited with less precise references in terms of dates and geographical location. A respondent indicated that existing literature of *"ESV for estuaries appears not to be used in decision-making processes on the NSW South Coast"* (although he mentioned that *"ESV was used during the economic valuation of fisheries industries in the establishment of the Batemans Marine Park"*). Other respondents indicated ESV of seagrass is often ignored in spatial planning for aquaculture in South Australia or for example when approving dredging for marina entrances or boat ramps. Regarding South Australia, another respondent mentioned that *"SA management decisions rarely used "econsearch" reports"*, referring to the numerous reports that have been produced by the economic research and consulting services company EconSearch Pty Ltd on various issues such as economic indicators on Fisheries, impact assessments of marine parks etc. (see http://www.econsearch.com.au/). Another example that was mentioned concerns the ESV work realized about the Ningaloo Marine Park in Western Australia: an individual mentioned that "*existing ESV work was not used for some sectors*". More broadly two individuals pointed out that ESV was not used in Queensland, in marine Park planning processes since 1997 and in assessing ports dredge impacts.

3.4.4 Need for more ESV

Finally, respondents were asked whether they thought that coastal and marine ESV should be used more often in decision-making and if yes for what kind of values. 81% of the 69 decision-makers answered "Yes", 3% answered "No" and 16% that they did not know.

In particular, individuals who answered positively also noted that ESV should be used more often for commercial use values (75%), for recreational use values (70%), for indirect use values – especially regulating services – (98%) and for non-use values (71%). A few also mentioned that they would like ESV to be used more often, when assessing the economic costs of various impacts on ecosystems (and cumulative impacts).

4. Discussion and conclusion

4.1 Comparing decision-makers and general public results

One section of the survey was kept identical in both questionnaires to allow comparisons between the perception and preferences of the general public and those of decision-makers regarding the usefulness and importance of ESV.

- **The general public do not know about ESV; decision-makers are familiar with it**

As one could expect, 80% of individuals from the general public had never heard about ESV studies applied to coastal and marine ecosystems, whereas this was not the case for decision-makers since all of them but one already heard about such work, and more than half of them already used ESV.

- **There is a positive attitude towards ESV and its use**

Interestingly however, the answers regarding the perceived usefulness of ESV present strong similarities between the two samples, although one third of the individual public stated they did not have any idea about this issue. Indeed, 45% of both decision-makers and general public samples declared that ESV was useful, whereas around 5% thought it was useless. Furthermore, both groups mostly saw ESV as being useful or necessary for the same three types of utilization: ESV for communication and advocacy, ESV for cost-benefits analysis, and ESV as a basis of discussion in decision-making processes (although this last reason was significantly more selected by decision-makers).

- **There are various percieved limits to the use of ESV**

Furthermore, a substantial proportion of respondents in both samples declared that there are limits to the use of ESV (although this proportion was clearly more important for the decision-makers). The mostly cited limit was the same one: both groups agreed in equal proportions with the fact that the validity of ESV is not accepted widely enough. This can actually be interpreted in two ways: either ESV is not known enough to be used and accepted as a support to decision-making ESV (there is a lack of communication or information); or there are concerns with ESV that limit its acceptability. Other limits mostly cited by the decision-makers were the following: ESV is too simplistic in view of ecosystem complexity, ESV has to be improved in terms of methods and techniques, and the decision-making framework/guidelines may not be conducive to its use. These are in accord with some of the hypothesis offered by Laurans et al. (2013b) when looking at the factors that could limit ESV utilization. For the general public, the other mostly cited limits to ESV use were: ESV can have undesirable consequences for ecosystems (e.g. allowing the purchase of rights to pollute) and ESV can create conflict between stakeholders in a decision-making process. These last two points also illustrates that a significant part of the public was worrying about potential manipulation of ESV by stakeholders in order to satisfy their own private interests or a pre-established agenda, which also echoes some concerns mentioned by decision-makers.

- **ESV is perceived as mostly needed for ES related to commercial activities and for regulating services**

When asked to state the importance of estimating economic values for the different coastal and marine ecosystem services, the general pattern of the answers was again comparable between the general public and decision-makers: provisioning services involving commercial activities and most regulating services (e.g. water quality/waste assimilation, storm protection/shoreline protection, habitat for species) were the ones that are mostly perceived as very important to value; whereas estimating option and non-use values were perceived as of low importance or not important at all. Regarding recreational services, decision-makers mostly saw the estimation of an economic value as medium to highly important, although most did not really trust these values, which reflected their stated concerns about methods and techniques. In comparison, the majority of individuals from the general public considered the estimation of economic value for these services as of low to medium importance. A significant part of the general public (around 18% on average) stated they did not know about the importance of estimating a dollar value for the different ecosystem services.

- **NUV are perceived as the most compelling reasons to perserve ecosystems but as the least important values to measure**

The low importance granted to estimating a monetary value for non-use values contrasts with the fact that these were by far the mostly stated motivation to preserve CME (in comparison to other use values) by the general public. This seems to imply that even though the population perceived these cultural ecosystem services as the most compelling reason for ecosystem preservation, they did not think these should be quantified in monetary terms. In the case of decision-makers, the low importance attributed to the estimation of non-use values could be linked with the important lack of trust in these values, but one could argue that their answers regarding the reasons to preserve CME would probably not differ much from that of the general public.

- **Work experience and education are factors of knowledge about, and familiarity with, ESV**

Finally, regarding the potential socio-economic factors that could influence the familiarity about ESV (having heard or not about ESV in the case of the general public, or having used it or not in the case of the decision-makers), there were two similar factors that seemed to play a key role for both groups: age for the general public or years of experience for the decision-makers; and having worked in economics, business or finance.

- **There is a clear need to inform the general public about ESV**

Therefore, as one could have expected, the familiarity with and knowledge about ESV differed greatly between decision-makers and the general public, but their reasoning regarding its potential usefulness and limits to its use were much more similar. As such, it is clear that more work is needed in terms of communication, to inform the general public about ESV in view of the increasing participative role of populations in decision-making processes (Reed, 2008).

In addition, it would be interesting to check whether the general public and decision-makers' perceptions would be similar when focusing on other types of ecosystems. More broadly, we argue that comparing public and decision-makers preferences regarding ES management processes is generally of great interest in view of the call for more participatory approaches or better integration of the different systems of knowledge that exist, between communities, researchers and decision or policy-makers (Lynam et al., 2007; Rogers, 2013; Lopes and Videira, 2013).

4.2 Usefulness and use of ESV in decision-making

- **ESV is perceived as useful and necessary by decision-makers in Australia**

We provided empirical evidence that ESV was globally perceived as being useful and necessary by decision-makers involved in coastal and marine management in Australia. This concurs with some of the conclusions from Rogers et al. (2013) who showed that non-market valuation was perceived in an increasingly positive way by decision-makers. However, where Rogers et al. found little evidence of potential concerns among the decision-makers interviewed regarding technical or methodological limits of non-market valuation (mostly because of a certain lack of knowledge), we found that many decision-makers were actually seeing this as an important issue. This was also confirmed by an important stated lack of trust in most economic values associated with the different ecosystem services, especially for services where non-market valuation is involved, although the demand for such valuation seemed to be high.

- **Decision-makers are relatively well-informed about ESV**

Our results regarding decision-makers' perceived levels of importance and levels of trust of economic values associated with various coastal and ecosystem services showed that most values thought to be less reliable were actually those for which most concerns had been raised in the academic literature, i.e. the ones based on estimated WTP or WTA (such as aesthetic benefits) and especially non-use values. More broadly, most of decision-makers' stated level of importance or trust in estimated values seemed to correspond well with the current state of ESV practice and theory (for example there is a high demand for valuing regulating services but a currently low reliability of such values due to ecosystem complexity and methodological difficulties). This would tend to show that many Australian decision-makers in coastal and marine management are relatively well informed about ESV.

- **There is a strong empirical evidence of ESV utilization**

Furthermore, according to decision-makers' comments and examples concerning the utilization of ESV, it is clear that ESV was perceived to have been used both as a way to communicate and raise awareness, and as a way to support evaluation and discussion during decision-making processes in various contexts. A list of applications based on the examples directly mentioned by decision-makers during our survey included: engaging with communities in marine conservation, planning marine park zoning and management, setting fisheries management targets, evaluating impact (change in values) of conservation measures on fisheries and other marine activities, justifying the protection of habitats (seagrass and mangroves) or species based on their economic values, weighing up the costs/benefits of economic development in policy making (e.g. shipping ports) or of various and sometimes competing management options, helping policy-making to assess competing values in coastal development, discussing the importance of maintaining or improving estuary health and selecting appropriate responses to coastal hazards, and help assessing or even compensating the impact of various terrestrial activities on habitats, species or marine activities. Many respondents were able to cite precise examples with location and date in each pre-identified types of ESV utilization and for different types of management contexts. Besides, in many cases the same examples were cited across several categories, which implies that some ESV studies have been used in several ways and for different management questions. This also illustrates that the complexity of decision-making and management necessarily implies inter-relation between our pre-identified categories.

- **ESV use is limited when it comes to establishing economic or financial instruments**

Our results also showed that ESV was much less frequently used when establishing economic or financial instruments, or compensation. This could correspond to the fact that such instruments are not that well-developed in Australia with respect to the marine and coastal context (although we highlight that these are actually used in Australia with for example quotas in fisheries or permits for recreational activities in marine protected areas); and it could also meet up with some observations in the literature showing that ESV does not seem to play an important role in setting up prices or levels of instruments such as payment for ecosystem services or access fees (e.g. Liu et al., 2010). In our case, the few specific examples cited by decision-makers mostly referred to some specific damage compensation (where ESV was considered among other criteria in implementing offsets), as well as economic incentives or marine park buy-back program regarding commercial fisheries.

- **ESV use varies importantly across coastal and marine management contexts**

On average the frequency of ESV use was perceived to decrease along the following types of management: commercial fisheries (where ESV was mostly cited as frequently used), recreational activities and tourism management, coastal development, marine areas and species conservation, coastal and marine pollution (where ESV was mostly cited as rarely used), and indigenous and customary use issues (mostly cited as never used).

- **There is a globally weak impact of ESV on policy**

In addition, we saw that even though ESV seemed to have been considered in decision-making processes, it was rarely perceived as having a significant impact on policy or management. Nevertheless several examples of strong ESV impacts were mentioned, mostly in the context of commercial fisheries management all around Australia, but also in marine park zoning and implementation.

An interesting direction for further research would be to re-examine in detail all the different case studies mentioned by respondents, including through a follow-up survey of people who might be/have been involved in the associated decisions, in order to better understand how ESV has actually been used and what influence it has had.

- **The role of peer-reviewed literature to support ESV utilization in practice is limited**

Within all the examples and references provided by the decision-makers, a few academic publications in peer-reviewed journals were also cited (e.g. Stoeckl et al., 2011), but far less frequently than reports developed for government or other institutions (either from consulting companies or researchers). In addition, a few respondents referred to *"informal use"* of internal evaluations, which were not published or accessible. This highlights the substantial role played by the grey literature (such as reports, policy briefs, or other non-academic documents) in providing information to decision-makers, in comparison to peer-reviewed publications. This concurs with the observation that many stakeholders involved in decision-making processes (especially at the policy level) rarely consult articles published in peer-reviewed journals (Gibbons et al. 2008); or with the possibility that many peer-reviewed academic ESV publications do not focus on the potential uptake and subsequent utilization of their results by decision-makers (Laurans et al., 2013b); or again with the possibility that the peer-reviewed literature on coastal and marine ESV is still insufficiently developed so that more reliable valuation work is needed to support the needs of coastal and ocean managers and policy analysts (Pendleton et al., 2007). The limited role of peer-reviewed literature could also be a consequence of the fact that "academic economists can prioritise activities (or are required to prioritise activities) that would exacerbate their isolation from potential non-academic end-users of their research", for various reasons (Cherney et al., 2013, p.14).

However, in our case, it is worth noting that a substantial number of grey literature references cited by the decision-makers actually corresponded to work conducted by researchers from universities or other institutions. Decision-making tools such as INVEST or the ESV database were also mentioned in comments and examples by some of our decision-makers working in policy and management. This tends to accord with the increasing efforts of ESV practitioners to engage with decision-making and policy (e.g. Goldstein et al., 2012; Balmford et al., 2011; de Groot et al., 2010; Daily et al., 2009), including from Academia.

- **There is a need to strengthen the link between decision-makers and ESV practionners**

Although it is clear that the decision-makers in our sample seemed to have a rather good awareness of ESV, we also observed through several comments that there was confusion about what was actually measured by ESV (e.g. profits versus added value, marginal versus non-marginal values, or consumer surplus versus social perceptions), or between ESV and other approaches such as cost-effectiveness or socio-economic impact studies. This is confirmed for example when looking at all examples cited and presented in Appendix P. This could concord with the hypothesis that decision-makers have insufficient training in economics (Driml, 1997 with a focus on Australia; Laurans et al., 2013b from a more general perspective), and a clear lack of knowledge regarding non-market valuation, as found by Rogers et al. (2013) in Australia.

More broadly, our results raise the issue of the differences between the systems of knowledge of the academic and the decision-making worlds in terms of language and apprehension of management issues (Briggs, 2006), and in our case between their understanding of valuation techniques and the associated theoretical background (Rogers et al., 2013). This emphasizes the importance of proposed strategies and practices to enhance collaborations between researchers and decision-makers, as well as research transfer, uptake and impact within policy contexts (Cherney et al., 2013; Rogers et al., 2013; Pannell and Roberts, 2009; Pendleton et al., 2007).

4.3 Limits

- **The strong lack of knowledge of the general public about ESV is an important limit to our approach**

A limit of our study that could be pointed out when comparing the answers from both samples to the same questions about ESV in the questionnaire relates to the important lack of knowledge from the general public regarding ESV, and potentially also regarding coastal and marine management (since around 80% of respondents from the general public never heard about ESV). As such the reliability of their answers could be questioned. We believe that the responses to the survey are informative enough in view of two arguments: first because of the similarities between answers from both decision-makers and the general public when asked to think about the potential utilizations of ESV and their limits, as well as the importance of valuing different categories of coastal and marine Ecosystem Services; and second because many individuals from the general public expressed additional opinions or raised additional questions whenever possible (for example by suggesting other potential limits or reasons for ESV not to be used).

Nevertheless, it is clear that the survey instrument administered to the general public was too academic, and it would have benefited from a revision that made it more understandable and pragmatic[37]. How to clearly explain ESV to a population of individuals who are completely unfamiliar or unaware about this issue is an important but non-trivial point to consider for further research.

- **The survey was a complicated task for decision-makers**

We also acknowledge that this concern regarding the lack of familiarity for ESV is applicable to the decision-makers, since a significant proportion never used ESV. More broadly, it is clear that the core subject of this survey was not a commonly encountered one, and that it involved very specific and complex terminologies that could threaten the perceived interest of respondents for such a survey. This was reflected by some of the comments from both groups of respondents at the end of the questionnaire, although a significant number of comments also highlighted their interest in the survey, and the importance of the use of ESV issue. Besides the complexity of the issue, the large number of questions could also generate fatigue and lack of concentration, especially for the decision-makers where they were asked to provide examples with references and location. Some respondents took up to 40 minutes to complete the entire questionnaire[38]. Although unavoidable, all these risks were taken into account, both during the development of the questionnaires (for example with the introduction

[37] As an aside, we note that the two publications based on the work presented in this chapter (Marre et al., 2014c, 2014d) are focusing only on the results from the decision-makers survey.

[38] This includes the completion of the Analytic Hierarchy Process (AHP) sections, described in the next chapter.

of a glossary and through a user-friendly online design of our questionnaires), and during the analysis of the results where all the different comments from the respondents were considered carefully.

In addition, a few respondents pointed out that the survey was somehow disconnected from the reality of the policy or decision processes, which is naturally far more complex in comparison to what was conveyed by most questions with their pre-established response categories. This was also part of the risk of conducting online surveys with closed-form questions that were designed to target a broad and diversified range of respondents. In most questions however, respondents had the possibility to specify their answers or express another opinion that could not have been captured by the questions. Collecting examples and references of real-world ESV utilizations was also a way to cope with this issue.

- **There is a potential selection bias**

Another potential concern when drawing conclusions form our results is about a potential selection bias. For the general public, having information about the survey (participant information sheet) at the start of the questionnaire may have caused a selection bias since many of the 359 individuals who dropped out did so before the first questions. Among the decision-makers sample, we saw that we encountered a small participation rate (88 respondents with an initial list of more than 450 contacts), and as such it could be argued that most respondents who answered the questionnaire did so because they were interested in this issue, and thus also because they were already relatively well aware about ESV. However, we argue that the important diversity of decision-makers that answered our questionnaire in terms of educational background, work experience, role in decision-making, and the diversity of their perceptions about and experience with ESV might have limited this problem.

- **Our work is limited to the context of coastal and marine management**

We also highlight that most general results regarding the perceived usefulness of ESV and its limits were collected in the context of coastal and marine ecosystems management. This must be kept in mind, even if we believe that responses regarding the perceived usefulness and limits of ESV may be interpreted as reflecting some more general perceptions about ESV (especially in the case of the general public).

Finally, it is important to note that the work presented here focuses only on ESV, and as such deliberately ignored other non-monetary valuation methods. We already justified this focus, but it is clear that it would be interesting to examine perceptions about valuation as a whole and to contextualize this first work in view of some other available information or factors involved during a decision making process such as ecological indicators, socio-economic indicators (e.g. expenditure, employment) or opinion poll. This is the objective of the following chapter.

4.4 Conclusions

Our surveys provide decision-makers and economic valuation practitioners with results regarding the extent to which economic valuation is used in decision-making processes: importance of and trust level in various estimated economic values, what utilization, how frequently, and in what context. All in all, ESV was globally perceived as being useful by decision-makers involved in coastal and marine management in Australia, and as such was considered in various ways depending on management contexts, sometimes with significant impact on policy or decision. In all cases, when available, ESV seemed to be rarely ignored. This should come as a rather comforting observation for ESV practitioners, and can be probably be linked to the efforts dedicated to the development of ESV during the last decades, both theoretical and methodological, as well as its implementation in decision-making.

Nevertheless, there is still a need to make ESV more accessible, reliable and trustworthy, especially in the case of regulating services; and potentially for non-use values even though these were considered as being less important in terms of economic valuation. This means a need to continue building up bridges between decision-making and research, and for researcher and economists to continue improving their understanding of the decision-making and policy world.

According to our results, concrete recommendations on how to make ESV more useful can be made:

i. Do not assume that ESV is necessarily needed or relevant;
ii. Anticipate precisely the input needed in terms of ESV (if any) by the stakeholders. This implies a precise understanding of the decision or management problem, the policy process, the potential conflicts and the objectives of key stakeholders;
iii. Be aware of the legal and regulatory framework relevant to the ESV work being conducted;
iv. Consider the costs and benefits of providing and obtaining information, with respect to the demand. This includes transaction costs and opportunity costs. It can help defining

when to use ESV or not, which ESV technique to use, and the level of precision required;

v. Develop decision-making framework or guidelines that would explicitely consider the points above;

vi. Continue developing decision-making tools that includes ESV information among other ES assessment indicators;

vii. Develop the knowledge and familiarity with ESV of decision-makers and other potential ESV users by offering training and support. This also means being aware of the stakeholders' current understanding of ESV, which is also linked to their educational and professional backgrounds;

viii. Facilitate the understanding of ESV work by paying attention to terminologies, and by being transparent on hypothesis. Excellent communication is crucial.

We believe this work can contribute to a better understanding of the need and demand of economic valuation by individuals involved in decision-making processes, and also enhance the capacity of academics or practitioners to deliver useful results. We argue however that more work is needed to continue filling the existing gap in the academic literature about the practical utilization of ecosystem services economic valuation in support of decision-making, in the marine context and beyond, as well as in different national contexts. This could take the form of a similar set of surveys if the objective is to get a broad description, or it could take the form of more in-depth interviews. Besides, it could also be interesting to conduct such surveys at different points in time to measure possible changes in perceptions and ESV uses, and possibly correlate them to specific institutional changes or events. We also point out that more literature review work is clearly needed with a focus on grey literature, both at a country-specific and at a broader scale. Comparisons across countries (e.g. Börger et al., 2014) would be especially interesting in order to study the role played by institutions and legislations in providing guidelines and framework to the use of ESV. Finally, it would also be crucial to complete such work by examining the issue of the use of ESV with respect to the other assessment indicators available in ES management; this is the main objective of the next chapter.

Chapter 4 Assessing the relative importance of the economic valuation of ecosystem services in coastal and marine decision-making

1. Introduction

Despite its growing application by environmental and resource economists, ESV has also been subject to many concerns and criticisms (e.g. Vatn and Bromley, 1994; Vatn, 2009; Spangerberg and Settele, 2010; Norgaard, 2010; Sagoff, 2011; Spash and Aslaksen, 2012), and there has been a call for additional methodologies and approaches to assessing and integrating ecosystem services into interdisciplinary evaluation frameworks (Spash, 2008; Vatn, 2009; Lopes and Videira, 2013). In particular, ES values pertain to multiple dimensions (O'Neill et al., 2008; Vatn, 2009; Chan et al., 2012; Martín-López et al., 2014), some of which may be considered incommensurable (Martinez-Alier et al., 1998; O'Neill et al., 2008). Hence, it has increasingly been argued that a process of ecosystem services assessment should not be reduced to an economic monetary valuation (e.g. Martín-López, 2014), but should also encompass ecological assessments (measured, e.g., via biophysical indicators) and socio-cultural assessments (tracked, e.g., via qualitative analyses), alongside institutional analyses (Spash and Carter, 2001; De Groot et al., 2002; Vatn, 2005 & 2009).

All this raises the issue of the utilization of ESV in decision-making and ES management, as compared to other assessment criteria that may be available. In particular, how ESV is balanced with ecological and social criteria when assessing the consequences of changes in ES?

This is typically the type of question that multi-criteria analysis (MCA) can help answer. MCA actually encompasses a collection of theories, methodologies and techniques to explicitly integrate and balance a set of various decision criteria (MCA: state of the art surveys, 2005). MCA has been widely used in ES management (e.g. Vaidya and Kumar, 2006; Bryan et al., 2010; Prato and Herath, 2012; Fontana et al., 2013), because the complexity, the uncertainty, the sometimes-irreducible conflicts as well as the diversity of stakeholders involved in ES management call for such procedures (Martinez-Alier, 1998;

Munda, 2004; Gowdy and Erickson, 2005; Liu et al., 2010). There are many cases where MCA allowed an in-depth analysis and quantification of the trade-offs between various economic, ecological and social management objectives or criteria involved in a specific case study.

However, we are not aware of any MCA study that precisely examined the issue of the utilization of ESV alongside other competing ecological or social assessment indicators in a more general management perspective. More broadly, we could not identify studies that examined this issue quantitatively, i.e. that aimed at estimating the relative importance attached by stakeholders to various indicators tracking the consequences of changes in ES, for management decision-making. This was the general objective of the research work presented in this chapter, with a focus on coastal and marine ecosystems (CME) in Australia[39].

More precisely, we aimed in this work at examining the weights attached by different stakeholders to three main categories of indicators to assess changes in ES values in a coastal development context that we perceived as being the most commonly encountered "on the field" in ES management, and mostly conveyed by mainstream economists, ecologists, the social media and politician. These were: (1) economic valuation indicators which correspond to ES value estimates based on standard economic measures of surplus (i.e. the indicators that are the focus of this PhD); (2) ecological indicators proposed by experts in natural sciences to monitor consequences of changes in the availability and quality of ecosystem services and functions; and (3) socio-economic indicators which correspond to descriptors used on a daily basis by stakeholders to monitor the effects of decisions on the socio-economic activity associated with specific sectors or regions.

We chose to focus on the management of coastal development for various reasons: because it necessarily involved consequences on marine Ecosystem Services that are usually studied using the three types of assessment indicators (in impact studies or CBAs that usually precede most development projects) and because it is an important issue at stake world-wide and especially in Australia (e.g. port development and dumping of dredge spoil in the Great Barrier Reef), causing important degradation on CME.

[39] This focus is justified by the fact that the call for more ESV work is especially important for CME in Australia and elsewhere (e.g. Spurgeon, 2004; Brander et al., 2007; Laurans et al., 2013a), and that there is no existing study of the use of ESV in support of CME management in Australia (see Chapter 3).

Our approach was based on a nation-wide online survey using a specific MCA technique: the Analytic Hierarchy Process (AHP), which allows evaluating the relative priorities placed on different competing criteria that can be organized hierarchically (Saaty, 1977). The AHP referred to a hypothetical coastal development scenario, which was kept broad enough to relate to a substantial range of real-worlds case studies and to elicit "aggregated" preferences associated with CME all around Australia that could potentially be extrapolated to various coastal management contexts. In particular, our approach aimed at eliciting and comparing the weights placed by the decision-makers and the general public on the usefulness and utilization of various valuation indicators that could be used to assess the consequences of such a coastal development project on coastal and marine ES. The types of impacts considered related to marine commercial activities, marine recreational activities and marine biodiversity.

The chapter is organized as follows. Section 2 presents the AHP technique, the development and design of our AHP-based survey, the data-collection and the different statistical methods we used to analyse the AHP results. Section 3 shows the results of the AHP for the decision-makers and the general public, and their subsequent analysis: the elicitation of weights of stakeholders' preferences, their distribution among the population and their possible socio-economic determinants. Finally, section 4 provides a discussion of these results and presents the limits of the exercise as well as some possibilities for further research.

2. Material and methods

2.1 Analytic Hierarchy process

We selected the AHP technique[40] in view of all its numerous applications in the coastal and marine management field, and also because surveying pairwise comparisons is easy to implement. Besides several coastal and marine AHP work were actually successfully conducted in Australia, involving various stakeholders (e.g. Pascoe et al., 2009a, 2009b; Gao

[40] In the early stage of this research project, we actually hesitated between two different methodologies to quantitatively assess the preference associated to ESV in comparison to other valuation indicators: the AHP technique and the Discrete Choice Experiments (DCE). Both had their strengths and weaknesses, but unlike the AHP, which can evaluate the importance of objectives or criteria singly, DCE involves comparison of groups of objectives or criteria in alternatives, with various levels (Mardle and Pascoe, 2004). This is mainly why the AHP was finally selected, in view of our objectives. Using DCE would have also generated some unnecessary complications in the descriptions of our management scenarios.

and Hailu, 2012). Furthermore, the methodology (see below) accords well with our objective to study assessment criteria within a hierarchical framework.

2.1.1 A brief literature review

The Analytic Hierarchy Process (AHP), alongside multi-attribute utility theory, is one of the most commonly applied MCA techniques (Wattage and Mardle, 2005; MCA: state of the art surveys, 2005), and was introduced by Saaty (1977). It proposes a framework for the elicitation and analysis of preferences for criteria, objectives or various management alternatives in a hierarchical manner (Saaty and Vargas, 2001). AHP has several main advantages (Saaty, 1994; Ishizaka and Labib, 2011; Gao and Hailu, 2012): (1) it helps stakeholders and decision makers synthetize and organize a problem into a hierarchical structure making it easy to apprehend and handle; (2) pair-wise comparisons in the AHP are easy to handle and are often preferred by the decision makers because they do not impose a direct quantification of weights (these are derived implicitly from scores and rankings of alternatives); (3) it is the only known MCA technique that provides a measure of consistency in the decision makers' judgements; and (4) due to its flexibility, the AHP technique can be integrated or associated with other techniques or approaches (Vaidya and Kumar, 2006; Sipahi and Timor, 2010). In particular, AHP has been combined with Fuzzy Logic (Gao and Hailu, 2012), Linear Programming, SWOT (Strengths, Weaknesses, Opportunities, and Threats), GIS (geographic information systems) (Ying et al., 2007), or other MCA methods such as TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) (Gao and Hailu, 2012).

AHP has been used in many fields (Vaidya and Kumar, 2006), especially in natural resources management (e.g. Herath, 2004; Wattage and Mardle, 2005; Diaz-Balteiro and Romero, 2008; Pascoe et al., 2009a and 2009b), environmental risk assessments (Linkov et al., 2006) and alternative land-use assessments (e.g. Fontana et al., 2013). Several works review the utilization of AHP in different domains (Vaidya and Kumar, 2006; Ho, 2008; Sipahi and Timor, 2010).

In the case of coastal and marine ecosystems, MCA techniques and AHP have been used to help balance the conflicting goals of environmental conservation and business development with regards to coastal development (Linkov et al., 2006). AHP has also been used in the management of commercial fisheries (e.g. Soma, 2003; Mardle et al., 2004; Le Gallic et al., 2005; Nielsen and Mathiesen, 2006; Pascoe et al., 2009a and 2009b; Innes and Pascoe, 2010), recreational fisheries in coral reef ecosystems (Gao and Hailu, 2012) and aquaculture (e.g. Whitmarsh and Wattage, 2006); in the management of marine protected areas (e.g. Himes, 2007); in the assessment of political risks in port management (e.g. Tsai and su, 2005) or coastal beach exploitation (e.g. Tian et al., 2013); and in economic valuation, coupled with contingent valuation, as a technique to distinguish between use and non-use values (Wattage, 2010).

The strengths and weaknesses of the AHP method in comparison to other methods have been discussed extensively (e.g. Saaty, 1994; MCA: state of the art surveys, 2005; Linkov et al., 2006; Vaidya and Kumar, 2006; Ho, 2008; Sipahi and Timor, 2010). The reviews point to the fact that even though AHP has received strong criticisms that questioned its ability to reflect people's true preferences (for example in relation to the judgments scales it involves or regarding its consistency index), there are a substantial number of successful applications in many management or decision domains (Ishizaka and Labib, 2011).

2.1.2 Steps to develop and conduct an AHP

Developing and conducting an AHP involves four main steps (Wattage and Mardle, 2005). Since there are no traditional statistical tools that one can rely upon to assess the quality of the AHP model, crucial attention is required at several points of the development and implementation stages (Mardle et al., 2004).

First step

The first step is the identification of the management problem and the selection of the different competing criteria, objectives or alternatives, followed by their organization within a hierarchical tree. This implies decomposing the complexity of the management problem into different levels or components of objectives and assessment criteria, and synthesizing their mutual relations as a hierarchical tree. The development of the hierarchy must be conducted based on strong background research, and interaction with experts in the management field. As noted by Mardle and Pascoe (2004), the tree must exhibit the following properties: completeness, operationality, decomposability, non-redundancy, and minimality (Keeney and Raiffa 1976). It usually takes the form presented in figure 4-1 below.

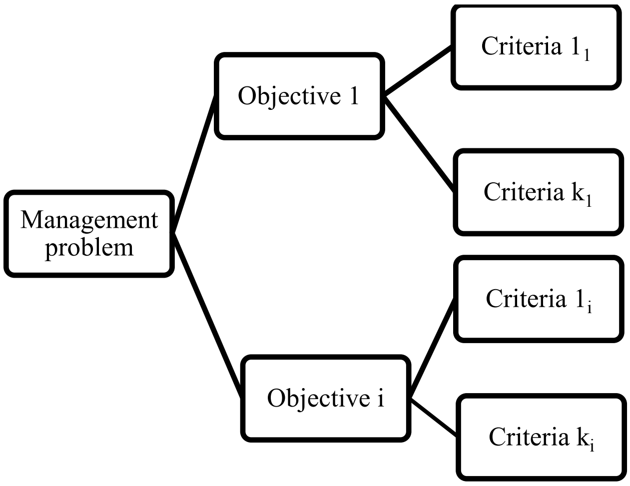


Figure 4-1 Classical structure of an AHP hierarchical tree

Second step

The second step is the development of the pairwise comparisons that will be used to determine the individuals' priorities or preferences towards the criteria, objectives or alternatives, based on the hierarchical tree. These pairwise comparisons are usually based on a nine-point intensity of importance scale[41], presented in table 4-1; and their usual generic format is presented in figure 4-2. This step involves the design of the survey where the pairwise comparison will be presented.

Table 4-1 Scale of pairwise comparison intensity of importance

Intensity of importance	Definition	Explanation
1	Equal importance	Both criteria are equally important in view of the objective
3	Moderate importance	Experience and judgement slightly favour one over another
5	Strong importance	Experience and judgement strongly favour one over another
7	Very strong importance	Demonstrated importance in practice of one element over another
9	Absolute importance	The importance of one over another is affirmed without doubt, on the highest possible order
2, 4, 6, 8	Intermediate values	Used to represent compromise between the priorities listed above

Source: Saaty (1980)

[41] Other types of scales have been developed, and are presented and discussed in Ishizaka and Labib (2011). The scale presented here is the most commonly employed.

Criteria/Objective 1																Criteria/Objective i
								Q1								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Significantly more important								Equal								Significantly more important

Figure 4-2 Typical pairwise comparison used in an AHP

The scale of importance is based on psychological experiments and was designed to minimise confusions or difficulties and to reflect an individual's judgement in making comparisons as much as possible (Saaty, 1980; Ishizaka and Labib, 2011).

Third step

Once the data are obtained by surveying stakeholders involved in the decision problem (using a set of pairwise comparisons), the third step is the analysis of the individual preferences obtained, based on the relative weights they attributed to each criteria. At this step, it is necessary to check whether respondents were inconsistent in completing the pairwise comparisons, and an important task during an AHP is to calculate the consistency level of the estimated relative weights. We detail these different steps below.

The relative weights are derived from a pairwise comparison reciprocal matrix (A) of judgements (see example presented in Appendix Q). They are found by solving (Saaty, 1977):

$$\sum_{j=1}^{n} a_{ij}\, w_j = \lambda_{max} w_i \quad \forall i (a_{ji} = {}^{1}/_{a_{ij}}\ and\ a_{ij} > 0) \qquad (1)$$

where indices i and j represent the number of criteria, λ_{max} the principal eigenvalue, and the weights w_j are normalised appropriately (i.e. they sum to one). The solution is typically known as the principal right eigenvector[42].

The estimation of relative weights makes sense only if derived from consistent or near consistent matrices. Consistency check must thus be applied. The matrix A is said to be consistent when $w_{ji} = a_{ij} w_{ij}$ and its principal eigenvalue, λ_{max}, is equal to n (i.e. the dimension of A). When A is inconsistent, we have $\lambda_{max} > n$ and the variance of the error

[42] Johnson et al. (1979) showed a rank reversal problem for scale inversion with the eigenvalue method, and in order to avoid this problem, Crawford and Williams (1985) proposed another approach based on the geometric mean (also sometimes known as Logarithmic Least Squares Method). This second method has been advocated by many authors but since no clear differences were generally observed between these two methods when simulations were applied, the eigenvalue method has remained supported and mostly used (Ishizaka and Labib, 2011).

incurred in estimating a_{ij} can be shown to be $(\lambda_{max} - n)/(n - 1)$ (Saaty and Vargas, 2001). Saaty (1977) defined this variance as the consistency index (CI). In order to measure the inconsistency present within an individual's AHP answers, he proposed to divide this CI by a random index (RI) corresponding to the average CI of 500 randomly filled judgement matrices using the 9-point scale (table 4-2).

Table 4-2 Average random indexes

n	3	4	5	6	7	8	9	10
RI	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Source: Saaty (1977)

The consistency ratio[43] (CR), the ratio of CI and RI , is given by:

CR = CI/RI

If CR is less than 10%, then the matrix is considered to have an acceptable level of consistency and the weight results are valid as their variance is low enough. With a CR > 10%, the paired comparisons matrix should be revised (i.e. the respondents should be asked to review and revise their comparisons ratings to make them more consistent). If this is not possible, the relative weights should be considered invalid and must not be used when analysing preferences.

This cut-off rule to declare the matrix inconsistent is flexible up to a certain extent and has been discussed and debated by several authors (Ishizaka and Labib, 2011; Whitmarsh and Wattage, 2004). Saaty (1994) set the acceptable CR values for different matrix sizes. While it is clear that low values of CR are desired, rejecting an expressed preference that would not imply a lack of understanding is more problematic since it could be interpreted as valid in its own terms.

Finally, once the weights corresponding to consistent judgements have been estimated, global weights can be defined in order to derive preferences associated with the whole management problem. Indeed, the weights obtained from the different pairwise comparisons corresponding to each level of the tree can then be associated to one another in view of their hierarchical relation. This is the strength of the AHP. For example, in the case of figure 4-1, the pairwise

[43] Other methods have been offered to measure consistency (see Ishizaka and Labib, 2011 for a discussion), based on the determinant of the matrix (Peláez and Lamata, 2003) or a Geometric Consistency Index (Crawford and Williams, 1985). The CR method offered by Saaty is easy to implement and has been used extensively, which is why we decided to use it here.

comparisons would allow deriving the weights associated with the different objectives $w_{obj\ i}$, and the weights associated with the different assessment criteria $w_{crit\ k}$ within each of these objectives. In view of the problem formulation, it is then possible to estimate overall weights $w_{overall\ i\ k}$ associated with each objective assessed by each criteria at the whole management scale: $w_{overall\ i\ k} = w_{obj\ i} * w_{crit\ k}$.

Fourth step

The last stage is the aggregation of the different groups of preferences. Once we made sure all the relative weights derived come from consistent judgements and are valid, it is possible to aggregate these individual weights at the stakeholders' group level. Another possibility is to derive the mean of the individual judgements by averaging the 1 to 9 scores for each comparisons and deriving weights from these. Both methods suppose important assumptions: the aggregation of individual weights allows for differences of opinion within group, whereas the aggregation of judgements implies a homogeneous group with a single-like opinion (Mardle et al., 2004, Innes and Pascoe, 2010). Both the arithmetic and geometric mean can be used during these aggregation processes (Forman and Peniwati, 1998).

2.2 Survey design

This AHP research project was conducted alongside the survey work about the perceived usefulness and use of ESV in coastal and marine decision-making detailed in chapter 3. The AHP was included in the surveys presented in chapter 3. For further details on the organisation of these surveys, we invite the reader to refer to this previous chapter. Here, we focus on the development and conduct of the AHP itself.

2.2.1 Targeted populations

The stakeholders targeted by this AHP were the same as in the general survey (see Chapter 3). We thus had two targeted populations: the general public through a representative sample of the Australian population, and management decision-makers through a sample of more than 450 pre-identified individuals and contacts from various institutions involved in coastal and marine management decision-making around Australia (governments and associated agencies at various institutional scales, research bodies, marine industries). Again, we were interested in examining and comparing the preferences of these two groups.

2.2.2 Development of the AHP framework

The design of this AHP was a long process. The approach was based on a detailed literature review concerning MCA and AHP, with special emphasis on the coastal development context. The creation of the tree and associated management framework involved several meetings and focus group discussions with researchers from CSIRO. In addition, several reviews of intermediate versions of the AHP [44] were conducted by researchers (economists and ecologists, familiar with decision-making processes) from the marine biodiversity hub of the National Environmental Research Program (NERP), which partly funded and supported this research work (see chapter 3).

When developing the AHP framework, the desired properties of a hierarchical structure mentioned above were all carefully considered. Another criteria was to keep the AHP as simple as possible to avoid cognitive burden and fatigue from respondents, and to keep the exercise brief enough, especially in view of the other objectives of the survey as part of which the AHP was conducted (thus minimizing the number of pairwise comparison). Given the diversity of respondents, it was necessary to ensure the terminology used in the AHP was easily understandable, and that respondents had access to precise definitions or explanations regarding the objectives and management criteria.

- **Hypothetical scenario and management problem**

Since it is clear that the elicited preferences could differ significantly depending on the coastal development context, we developed the AHP based on a compromise between the precision involved in the description of the coastal development scenario and the need of a simply framed hypothetical management problem that could related to numerous coastal development cases, in Australia and elsewhere.

Our AHP was based on a hypothetical scenario involving an important coastal development project, currently being planned in a coastal and marine area in Australia, and expected to have consequences on marine ecosystems and associated marine activities. The management problem was the nature of the assessment of these consequences that should be implemented in order to help choose among various options being considered for this development project.

[44] The final design was also reviewed by researchers and individuals involved in coastal and marine management in France.

The coastal area where this project was taking place was presented as well known from the respondents. This was to call for better-defined preferences and mitigate the hypothetical nature of the exercise. This was also meant to make the respondents feel more concerned by the exercise, and potentially make it easier for them to rely on pre-existing preferences.

This area was assumed to be used intensively for many marine activities (e.g. commercial fisheries, recreational fisheries, recreational and tourism activities), and to shelter ecosystems of international significance with an important diversity of habitats (e.g. wetlands, coral reefs, rocky reefs, mangroves, sea grass) and popular or unique species (e.g. whales, dolphins, turtles, dugongs). This could potentially correspond to many coastal areas in Australia.

The consequences of the project were synthetised in three categories: consequences on commercial activities (i.e. commercial fishing operations, diving and snorkelling operations, charter recreational fishing operations); consequences on recreational activities (i.e. non-commercial: recreational fishing, diving, snorkelling, surfing, boating, beach use); and consequences on marine biodiversity (e.g. diversity of marine habitats and species).

- **Assessment criteria**

As in many cases, several options were presented as being considered for this development project, including alternative ways of managing project impacts. To help decision-makers chose which development option to approve (if any), the consequences of each option was to be assessed using three types of information: economic indicators, ecological indicators and socio-economic indicators. Naturally, for each type of consequence (on commercial activities, recreational activities and marine biodiversity), it was necessary to carefully select and define these indicators, as they could refer to numerous potential components.

After having listed the various possible indicators that could be used to value the changes associated with the three types of consequences, we decided to select the ones that were commonly used and encountered within the previously mentioned categories: (1) standard monetary values of ES (for example: profits of commercial activities); (2) ecological assessment indicators (for example: stocks of biomass targeted by commercial fisheries); and (3) socio-economic descriptors used on a daily basis by stakeholders (for example: social media, politicians and lobbies often use the revenue of commercial activities and employment when discussing economic issues). Once selected, special attention was given to the definition of these indicators, in view of the diversity of the targeted respondents and their potential lack of knowledge (see chapter 3). Whenever possible, complex terminology was avoided, and if this was not possible, definitions of specific concepts or expressions were provided in a glossary (see chapter 3) accessible all along the survey. The various indicators presented in the AHP are defined in box 1, 2 and 3 below.

- **AHP structure an pairwise comparisons**

Figure 4-3 below shows the hierarchical tree of the AHP, based on the hypothetical scenario. In effect, the AHP aimed to elicit: (1) the relative weights attached by stakeholders to the various types of consequences to be assessed; (2) the relative weights associated with the different assessment criteria based on the three types of values indicators; and therefore via the aggregation of these weights (3) the preference regarding the different values (economic, ecological and socio-economic) associated with ES changes (described here as changes in marine activities and marine biodiversity).

An important aspect of this AHP was its symmetrical and balanced nature, which aimed at facilitating the understanding of the management problem.

Based on this hierarchical tree, 12 pair-wise comparisons were developed using the 9 points judgement scale presented above. The first group of three comparisons was related to the different types of consequences of the development project to be assessed (consequences on commercial activities, non-commercial recreational activities or marine biodiversity), and aimed at rating the relative importance of including them in the assessment process. The second group of comparisons aimed at assessing the relative importance of using the three types of indicators to assess the consequences on commercial activities. The third group of three pair-wise comparisons aimed at assessing the relative importance of using the three types of indicators to assess the consequences on recreational activities. Finally the last group of comparisons aimed at assessing the relative importance of using the three types of indicators to assess the consequences on marine biodiversity. These sets of pairwise comparisons can be seen in the section 5 of the questionnaires presented in Appendix N.

Box 1: Definition of the indicators to assess the consequences on commercial activities

Economic indicator: Profit (revenue-costs) of commercial activities including fishing operations, diving and snorkelling operations, charter and recreational fishing operations

Ecological indicator: Condition of the stock and habitats of the species targeted by commercial fisheries and chartered recreational fisheries (e.g. abundance of commercial fish); and condition of the stock and habitats of the species supporting recreational activities offered by operators (e.g. whales)

Socio-economic indicator: Local employment in the commercial activity sector, and revenue* from commercial activities (e.g. value of sales directly derived from landings)

Box 2: Definition of the indicators to assess the consequences on non-market recreational activities

Economic indicator: Recreational use values*, that is to say asking people through surveys or estimating through people's behaviours their willingness to pay* for recreational marine activities and associated marine ecosystem features

Ecological indicator: Condition of the stock and habitats of species that are of primary importance to recreational activities (specific fish species targeted by recreational fishing, popular species for diving/snorkelling); condition of specific aesthetic assets (such as water clarity, specific underwater or beach landscapes…)

Socio-economic indicator: Participation rates in non-commercial recreational activities (from local users and tourists) and expenditures of recreational users

Box 3: Definition of the indicators to assess the consequences on marine biodiversity

Economic indicator: Non-use values*, that is to say asking people through surveys how much they are willing to pay for preserving marine ecosystems without any consideration of their current or future uses

Ecological indicator: Condition of marine biodiversity assessed by several indicators (condition of species that have special conservation status, condition of key species or structural components of the ecosystem, or condition of physical-chemical components of the ecosystem)

Socio-economic indicator: Information through opinion polls and surveys about social perceptions of the status of marine biodiversity, and about the importance of marine biodiversity for populations (such as moral or spiritual importance)

**Defined in the glossary*

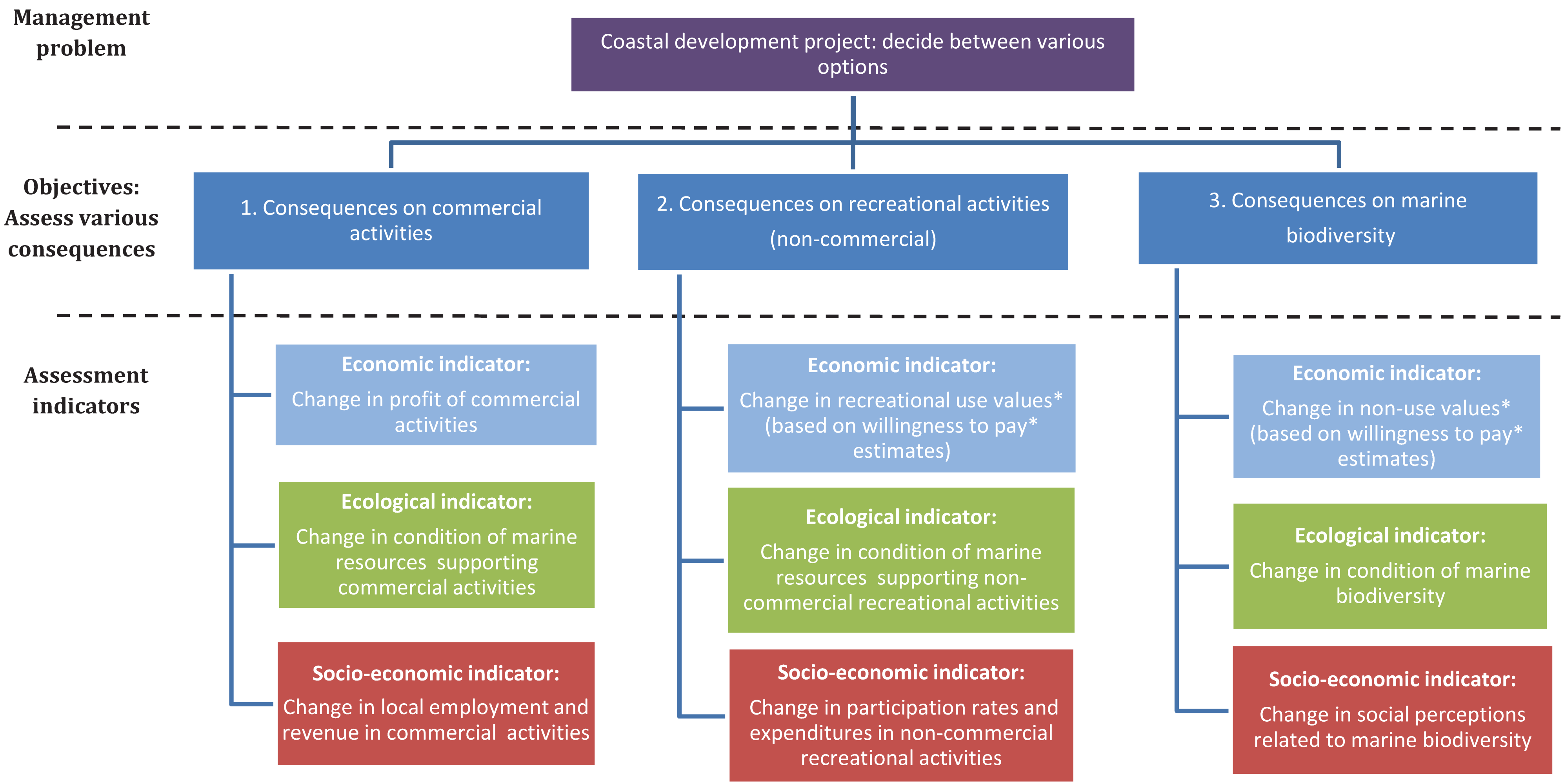


Figure 4-3 AHP Hierarchical structure

- **Development of the questionnaire**

As mentioned above, this AHP was included in two questionnaires (one for the general public, one for the decision-makers) designed for the surveys presented in chapter 3. These questionnaires and the AHP were first tested using a pen and paper format on the general public (around 15 questionnaires in Brisbane and on the coast around) and various researchers (around 15 researchers from CSIRO and the NERP program, some of them being actually involved in management decisions) before programming them online (see chapter 3).

For a detailed presentation of the different sections of questionnaires, the reader is directed to chapter 3 and to Appendix N, which contains both questionnaires. Here, we only present the two AHP sections but all other sections ("General information", "Perceptions related to marine preservation"/ "Experience in decision-making", "Perceptions about the use of ESV") also provided useful information in analysing the results of the AHP.

The AHP was presented in a fifth section of both questionnaires, in exactly the same way. First the hypothetical management problem was presented (see Box 4 below). The respondents also had access to the hierarchical tree as presented in figure 4-3, in order to facilitate apprehension of the entire management problem.

Then the 12 different pairwise comparisons were presented by groups of three (each set being introduced by a question), starting with the objectives and followed by the various assessment criteria within each objective (see Appendix N). In order to help with the process of programming the questionnaire online (see section 2.3 below), a tool based on an excel file was also developed as a model for presenting and conducting the pairwise comparisons. This was designed to allow the automatic computation of AHP weights and inconsistency index[45] when a button was pressed by the user, and these were shown and explained to the respondents, so that they could adjust their answer in case of inconsistency. A screenshot of this excel file is provided in Appendix R as an example.

[45] This was done by first converting the scores of comparison in reciprocal judgement matrices, and computing its principal right eigenvector as well as the eigenvalues λ_{max} as explained in section 2.1.

Box 4: Description of the management problem underlying the AHP in the questionnaires

An important coastal development project is being planned in a coastal and marine area which you know well. This area is used intensively for many marine activities: commercial fisheries, recreational fisheries, boating, diving, snorkeling and tourism activities. The area contains ecosystems of international significance with an important diversity of habitats (e.g. wetlands, coral reefs, rocky reefs, mangroves, sea grass) and popular or unique species (for example: whales, dolphins, turtles, dugongs).

The development project is expected to have consequences on the following:

- **commercial activities**: commercial fishing operations, diving and snorkeling operations, charter recreational fishing operations;
- **recreational activities (non-commercial):** recreational fishing, diving, snorkeling, surfing, boating, beach use;
- **marine biodiversity:** diversity of marine habitats and species.

Several options for the development project are being considered (including an alternative way of managing project impacts). To help decision-makers choose which development option to approve (if any), the consequences of each option is to be assessed using three types of information: **economic indicators, ecological indicators and socio-economic indicators**. The diagram below highlights the three types of consequences and the corresponding assessment indicators.

In this section, we would like you to tell us which type of information you believe should be given priority when assessing the consequences of the development project options.

Please bear in mind that this exercise only focuses on the project's consequences on marine ecosystems and associated marine activities.

Finally a quick section after the AHP aimed at gathering information regarding the respondents' choices during the AHP, and more particularly if they were confident or not about their answers and if they thought the way they assessed the relative importance of each types of consequences or assessment criteria during the various pairwise comparisons actually corresponded well to their preferences. If not, they were asked to explain why. Several options were proposed with a possibility to make any other personal comments. In particular, being unconfident with their answer could be due to a misunderstanding of the exercise (e.g. the AHP was perceived as unclear or too difficult), a disagreement with the AHP framework (e.g. with the need to have consistent answers through the consistency ratio) or a perceived need for more information regarding the different components of the AHP (e.g. about the hypothetical coastal project, about its different types of consequences or about the various assessment criteria and indicators involved).

2.3 Online survey and data collection

Since our targeted populations involved a large number of individuals all over Australia, the AHP and the surveys in which it was included were conducted online. This online procedure would also guarantee a maximum number of respondents for the AHP, which is usually low in existing AHP applications to coastal and marine ecosystem management issues (Innes and Pascoe, 2010). A survey company (ORU) was in charge of programming and hosting the questionnaire online, as well as hosting the data being collected (see Chapter 3). ORU also provided an access to their representative panel of the Australian population, with the objective of collecting 250 representative questionnaires from the general public (see Chapter 3).

The objective of developing and conducting a web-based AHP is challenging for two main reasons: first because it does not give the possibility for the interviewer to explain to the respondents the concept of the pairwise comparison and the associated consistency issue; and second because it involves some programming to be able to compute directly the consistency ratio of the pairwise comparisons to help the respondents adjust their answers in cases of inconsistency, as well as visualize afterwards the weights implied by their rankings if consistent choices were made. In both cases the simple format of our AHP was a substantial benefit.

In order to deal with the first challenge, an instruction sheet was created and placed just before the beginning of the AHP description. It is presented in Appendix S. The aim of this sheet was to prepare the respondents for the AHP by explaining the types of questions he is going to answer. The rationale and format of pairwise comparisons was explained through a simple example (comparing apple, banana and pear), as well as the principle of relative importance and consistency implied by a set of pairwise comparison. This AHP instruction sheet was accessible by respondents all along the AHP exercise (by simply clicking on a link in the page).

With respect to the second challenge, we provided ORU with the AHP excel tool we developed, and with all the necessary explanations regarding the computations involved. The objective was to build a web-based tool that worked in a similar way, and after several tests and reviews, the AHP was finally developed online. Therefore, in each set of pair-wise comparison, the respondents were able to access a consistency ratio indicating the consistency of their answers. This was crucial to maximize the understanding of the exercise by respondents, and so the consistency of their answers. Furthermore, the consistency of their answer was finally assessed and presented using a ratio equal to 1-CR[46] (see section 2.1), thus showing a percentage of consistency rather than inconsistency (for example, the recommended objective was to answer a set of pairwise comparison with more than 90% consistency, instead of having inconsistency below 10%). Our tests showed that by presenting 1-CR (rather than inconsistency), respondents were more willing to revise their responses, probably in view of the more optimistic and less demoralizing formulation of the measure compared to "inconsistency". This resulted in a greater proportion of acceptable results.

For each set of comparisons, when the scores were inconsistent (inferior or equal to 90%) the percentage of consistency appeared in red, and respondents were offered to change their ranking. However, we did not force respondents to change their rankings, since we did not want them to blindly submit to the consistency rule. When the scores were consistent (superior or equal to 90%), the percentage of consistency were presented to the respondents in green. Once respondents clicked to go to the next set of comparisons, the resulting relative weights of the three completed comparisons were shown only in the case of consistent scores, to make sure they were aware of what was implied by their answers. Respondents were invited to rank all pairwise comparisons of the AHP, before being able to continue and finish the questionnaire. If they did not want to participate in the AHP, they could either close the questionnaire, or set all weights randomly or as being equal. Completing the AHP randomly would without doubt generate inconsistent answers at one point so such individuals would be discarded from our analysis. However, we wanted to be able to identify respondents who would have systematically selected the "equally important" ranking for all pairwise comparisons to finish the survey rather than because this reflected their true preferences. To do so, we added follow-up questions regarding their perception of the AHP.

The online version of the AHP was tested by several researchers from the NERP marine biodiversity hub and by 50 random Australian residents from the representative panel of ORU. The online questionnaire was then slightly refined in view of these last test results.

[46] In the case where 1-CR would give very low or even negative results, the consistency was presented as being less than 5%, in order to not discourage respondents.

The surveys took place between September and October 2013. In total, all 256 respondents from the general public and 64 among the 86 respondents from the decision-makers completed the entire questionnaire and the AHP. For further details on the data collection procedure, please refer to chapter 3.

2.4 Statistical analysis of AHP results

All our statistical analyses were conducted with R.

2.4.1 Deriving robust weights

A first step in our analysis was to look at the consistency of individuals' judgements, and to reject both inconsistent and unreliable answers from our analysis. The weights corresponding to consistent preferences were then computed, and aggregated using the arithmetic mean. This aggregation method on weights was used because we expected heterogeneity at both the group and individual level, as observed in various coastal and marine applications (e.g. Mardle et al., 2004; Wattage and Mardle, 2005; Pascoe et al., 2009a, Innes and Pascoe, 2010).

Two types of weights were first derived:

- Weights relative to the types of consequences, corresponding strictly to the higher tree level with its three pairwise comparisons and one associated consistency ratio (CR);
- Weights relative to the various assessment criteria taken separately (thus ignoring the hierarchical formulation of our problem), corresponding strictly to the lower level of the tree with three sets of three pairwise comparisons (economic, ecological and socio-economic indicators) and therefore three CR;

We then estimated what can be called overall weights by multiplying the weights associated with each type of consequence with the weights associated with each of its assessment criteria. Four CR were considered when deriving these weights, which implied a lower number of individuals than the two other types of weights, since more inconsistency was observed across the different CRs.

As these overall weights synthetise the preferences elicited during the AHP regarding the entire management problem, our statistical analysis then focused exclusively on the individuals for whom these weights could be derived. Hence, we considered in our analysis both the weights regarding the higher level objectives (types of consequences) and the overall weights regarding the lower level objectives (various assessments of all consequences) for these individuals. In what follows we referred to those weights as "final weights" (to distinguish them from the weights estimated independently for each set of pairwise comparison).

Several statistical analyses were conducted to explore important questions related to the preferences of stakeholders. How are these final weights distributed across our populations? What are the main socio-demographic characteristics that could explain such distribution? More broadly, are these weights influenced or explained by some variables related to socio-demographic factors or perceptions? Indeed, it can be expected that preferences relative to the objectives or criteria depend on several characteristics of the respondents or some groups they belong to. Within the AHP literature, various statistical methods have been used to answer such questions, and we used most of them for our analysis.

2.4.2 Cluster analysis

Cluster analysis is the most commonly employed method (e.g. Mardle at al., 2004; Wattage and Mardle, 2005; Tsai and Su, 2005; Pascoe et al., 2009a; Zoppi, 2012; Salazar-Ordonez et al., 2013). Indeed, it has been used in many AHP studies to look for and define homogenous groups of preferences among the overall sample. Both K-means partitioning and hierarchical clustering methods are used. The first aims at segmenting the data by minimizing within-cluster variation (i.e. the sum of squares from observations to the assigned cluster centres): the method starts by randomly assigning observations to a pre-defined number of clusters, and these are successively reassigned to other clusters to minimize the within-cluster variation (if reassignment decreases the within-cluster variation, the observation is reassigned to that cluster). The second aims at repetitively examining the distances between all the observations, initially considered as individual clusters and then sequentially merged according to their similarity (or dissimilarity) in a hierarchical manner (which can represented as a dendrogram). Several techniques have been offered and used to do this and, among these, the Ward's minimum variance method that aims at finding compact, spherical clusters has probably been the most widely used in AHP weights analysis.

In our analysis, we used both clustering techniques but finally retained the hierarchical method to present our results, since it is not subject to the variability of K-means clustering (so that results are fixed from one model run to another). Clustering was conducted for all final weights obtained from the AHP (i.e. elicited weights associated with higher level and lower level objectives). The number of clusters was selected by looking at the structure of the dendrogram obtained from the hierarchical method, and in view of the potential interest of their interpretation.

Once a cluster analysis has been conducted, it is interesting to examine statistics of the socio-demographic variables or opinions that characterise the individuals in these clusters (such as age, gender, educational level, professional activities). We are only aware of a few studies that specifically attempt to analyse or aggregate different social (or interest) groups (Mardle at al., 2004; Wattage and Mardle, 2005; Pascoe et al., 2009a; Salazar-Ordonez et al., 2013). Salazar-Ordonez et al. (2013) used Chi-squared tests and one-way ANOVA to distinguish between socio-demographic proportions of clusters. Wattage and Mardle (2005) looked at the spatial distribution of the different clusters.

In our case, we carefully examined the main socio-demographic characteristics for each cluster, and conducted one-way ANOVA as well as overall and pairwise chi-squared tests. we also tried to use multivariate analysis such as linear discriminant analysis (Duda et al., 2000), or classification trees, in order to determine which socio-demographic or opinion-based variables help define and distinguish the clusters[47] (if any). However, we did not get any satisfying results from these approaches, probably because both of these approaches are usually data demanding and we have a small number of observations in both samples (especially in the decision-makers sample).

2.4.3 Coherence analysis

An alternative or complementary approach to traditional cluster analysis is to work on a priori defined social or stakeholder groups within the overall sample, for which we could expect homogenous preference structures. Indeed, it is interesting to examine whether there is a general agreement (i.e. coherence) in the allocation of weights at a stakeholders' group level even if there is variation in the weights allocated to individual objectives. For example, among the decision-maker sample we could distinguish some groups depending on the management domain they are working on, or depending on the types of organizations they are working in (e.g. government, research). Innes and Pascoe (2010), Pascoe et al. (2009a) and Mardle et al. (2004) used a coherence analysis to assess the degree to which individuals are representative of a priori defined stakeholder group they belonged to, in the context of fisheries management. They used a method proposed by Zahir (1999a, 199b), which was

[47] Backward and forward stepwise procedures can be used in order to identify the variables that play the most important role in explaining clusters distribution.

originally proposed as a clustering technique in order to examine (dis)similarities in preference structures. It is based on the measurement of the angle of difference between individual group members' overall preference vectors, which is then averaged at the group level. The global coherence level ρ of a group is defined as follow (Zahir, 1999a), with Vi and Vj being the preference vectors of individuals i and j:

$$\rho = \langle V^i . V^j \rangle = \langle \left(V^i\right)^T V^j \rangle \quad \forall (i, j = 1, \dots N), i \neq j \text{ and where } \langle\, \rangle \text{ implies average}$$

When all preference vectors are equal, ρ is equal to one; and when the vectors are orthogonal it is equal to zero. Therefore, the closer ρ is to one, the more coherent a group is. But critical values must be defined to assess coherence or substantial difference of opinions, especially given the limited range of the Saaty's nine point scale comparison which cannot yield to purely orthogonal vectors (Zahir, 1999b). Zahir (1999b) defines extreme cases when $\rho_{ij} < (n + 4) / (n + 8)$ with n being the number of objectives or criteria being compared, which allow to define near-to-orthogonal preferences vectors and thus effectively indicate substantial differences of opinion between individuals within a group. In our case, n can equal to 3 or 9, and thus looking at the proportion of comparisons between individuals that fall below 0.636 or 0.765 is an indicator of group coherence.

We also note that other approaches have been adopted with respect to these critical values of coherence. Mardle et al. (2004) used an approach to critical measures in accordance with statistical definitions of significance levels (i.e. 99%, 95% and 90%), while Himes (2007) and Innes and Pascoe (2010) based their critical values on the coherence distribution of randomly generated groups from the survey data.

We used this coherence analysis in two ways: first to assess the coherence of preferences for each sample, then to assess coherence of several a priori defined groups.

2.4.4 Regression models

It is interesting to work directly on the weights themselves, and to examine whether they can be influenced by several variables. As these weights are bounded between 0 and 1, double-censored Tobit models (Greene, 2000) can be used to look at possible independent variables that could predict their value (see Appendix J for a presentation of the Tobit model). This was done for example in the work of Atis et al. (2013).

We ran Tobit models with the computed final weights for the various consequences and assessment criteria taken as the dependent variables, with socio-demographic variables or opinions as explanatory variables. Since there were numerous factors that could potentially influence the different weights, and since we found no pre-existing information available in the literature that could allow us to specify a priori a precise set of variables, we chose to conduct our statistical analysis within an exploratory approach. We thus used backward and forward stepwise regression based on AIC and BIC criteria were used to select the most relevant ones (after having checked for possible multicollinearity issues) in view of two criteria: explanatory power of the model and interest of the problem formulation. Our objective was to select a small combination of variables among these factors that would best explain each weight, with a positive role whenever possible. Model fits were measured by the ratio between the variance of predicted mean and the sum of the variance of predicted mean and the variance of the residuals. Since the quantitative impact of the explanatory variables on the dependent variable is difficult to interpret directly from the estimated parameters, marginal effects were computed (effects on the expected value of the dependent variable evaluated at the mean values of the explanatory variables). When developing the models and interpreting their results, it is important to bear in mind that this Tobit modelling approach only allows to study each weight taken independently.

Another way to represent the problem is through the use of Multinomial Logit models (MNL). As already seen in Chapters 1 and 2, the MNL (Greene, 2000) is used to model a choice among several alternatives, and explains this choice using multiple variables X_i. In the case of the AHP, the dependent variable (Y_i) could represent respondents' strongest preferences among the various objectives and associated criteria, with socio-demographic features or opinions as explanatory variables (X_i). Salazar-Ordonez et al. (2013) used such a model on the main weights derived in their AHP. Another approach could be to define the dependent variable as being equal to the different groups from the cluster analysis (i.e. $Y_i = 1,\dots k$ for cluster $1,\dots k$), in order to identify a set of variables that would allow distinguishing between individuals membership to these clusters. Although these MNL approaches are interesting, they are quite data demanding and imply sufficient observations for each values taken by the dependent variable. We only experimented both approaches[48] for the general public sample, but these models did not give satisfying results.

We therefore only present here the results from the Tobit models.

[48] We ran a MNL to explain the strongest preferences for the three types of consequences, and we ran MNL models to explain the various clusters found in our analysis.

3. Results

3.1 Elicitation of weights of stakeholder preferences

3.1.1 Consistency and relevant preferences

In total, 256 individuals from the general public and 64 from the decision-makers completed the surveys. Scores from the AHP were examined carefully in both samples to distinguish between true and irrelevant preferences in view of the consistency of AHP scores and of respondents' answers to the question about their choices during the AHP.

We first examined the general consistency of all respondents' answers, in order to reject inconsistent responses. These are presented in tables 4-3 and 4-4 below, for each level of the tree and for consistency ratios inferior or equal to 10 and 20%.

Table 4-3 Consistency breakdown General Public: proportions of consistent individuals across the different set of comparisons based on the consistency ratios

	Types of consequences (1 CR)	Assessment criteria (3 CR)	Both consequences and assessment criteria (4 CR)
All CR between 0-10%	77%	70%	64%
All CR between 0-20%	80%	76%	69%

CR= Consistency ratio

Table 4-4 Consistency breakdown Decision-makers: proportions of consistent individuals across the different set of comparisons based on the consistency ratios

	Consequences (1 CR)	Assessment criteria (3 CR)	Both consequences and assessment criteria (4 CR)
All CR between 0-10%	89%	81%	77%
All CR between 0-20%	92%	86%	81%

CR= Consistency ratio

As recommended by Saaty (1994), and as in most application, 10% was considered as the threshold regarding consistency. We considered extending this limit to 20% to include more respondents (especially in view of the small size of the decision-makers sample) since this was used by some authors (e.g. Wattage and Mardle, 2005), but instead chose to prioritize reliability of the computed weights, especially in view of the small size of our judgement matrices (3 by 3) and in view of the small number of observations discarded in comparison to the 20% level.

The proportions of inconsistent answers among our respondents are substantial: between 23 and 36% of the general public, and between 11 and 23% of the decision-makers. This was probably due to the fact that the AHP was conducted online, although our results are actually better in this respect than in other AHP work involving face-to-face interviews, where inconsistency reached more than 50% of the sample (e.g. Wattage and Mardle, 2005). More broadly, inconsistency is often substantial in many AHP studies (e.g. Whitmarsh and Mardle, 2005; Pascoe et al., 2009), especially concerning the general public (e.g. Qureshi and Harrison, 2003; Wattage and Mardle, 2005)

Furthermore, around 20% of respondents in the entire decision-makers sample and 25% from the general public indicated that their answers in the AHP might not reflect their preferences for various reasons (with a majority stating this was because they did not understand the consistency issue, especially in the general public). Responses by these individuals were all carefully examined, by looking at both the reasons they mentioned and their AHP scores and associated consistency, in order to distinguish between solid or irrelevant preferences. Among the 25% decision-makers, more than half actually expressed concerns that did not refer to their preferences but to the AHP methodology or the questionnaire itself (they stated that it was "complex", or time consuming, or that there would have been other ways to analyse the problem). Besides, in both samples, many scores from these individuals were either inconsistent or set to be equal among all alternatives. In the later case, this was interpreted as a form of "protest answer" (i.e. as a refusal to make any comparisons). These inconsistent or "protest answers" were discarded from our analysis.

Tables 4-5 and 4-6 present the final proportions of robust preferences for both the general public and decision-makers, for each level of the tree and for consistency ratios below 10%.

Table 4-5 Proportions of robust preferences in the general public sample

	Types of consequences (1 CR)	Assessment criteria (3 CR)	Both consequences and assessment criteria (4 CR)
Consistent and solid preferences	63%	55%	49%

Table 4-6 Proportions of robust preferences in the decision-makers sample

	Consequences (1 CR)	Assessment criteria (3 CR)	Both consequences and assessment criteria (4 CR)
Consistent and preferences	84%	78%	73%

3.1.2 Weights observed

We now examine and compare the various computed weights for the individuals with robust preferences from the decision-makers and general public samples. Basic statistics regarding the weights of the high level and low level objectives taken independently are presented in tables 4-7 and 4-8. Table 4-9 presents the basic statistics of the nine lower level overall weights. Two Sample t-tests were run to compare the mean values observed for the two groups. Boxplots corresponding to the different weights are presented in Appendix T.

Table 4-7 Relative weights associated with the types of consequences to be assessed (taken independently): general public and decision-makers

	General public (n=162)			**Decision-makers (n=54)**		
	median	mean	s.d.	median	mean	s.d.
Com	0.256	0.330***	0.241	0.143	0.192***	0.141
Rec	0.158	0.234	0.179	0.143	0.217	0.174
Bio	**0.400**	**0.437*****	0.268	**0.669**	**0.591*****	0.232

**** Significant at 1%; ** Significant at 5%; * Significant at 10% with Two Sample t-tests between the general public and decision-makers*
Com=Consequences on Commercial Activities; Rec=Consequences on Recreational Activities; Bio=Consequences on Marine Biodiversity

Table 4-8 Relative weights associated with the economic, ecological and socio-economic indicators (taken independently): general public and decision-makers

	General public (n=141)			**Decision-makers (n=50)**		
	median	Mean	s.d.	median	mean	s.d.
Com Econ	0.193	0.289*	0.220	0.161	0.256*	0.208
Com Ecol	**0.411**	**0.430*****	0.252	**0.621**	**0.540*****	0.227
Com SE	0.234	0.281***	0.195	0.166	0.204***	0.126
Rec Econ	0.175	0.260**	0.199	0.111	0.206**	0.205
Rec Ecol	**0.462**	**0.462****	0.234	**0.576**	**0.537****	0.214
Rec SE	0.241	0.278	0.192	0.177	0.257	0.171
Bio Econ	0.143	0.259***	0.208	0.100	0.174***	0.164
Bio Ecol	**0.443**	**0.460*****	0.239	**0.731**	**0.641*****	0.211
Bio SE	0.213	0.281***	0.192	0.129	0.185***	0.136

**** Significant at 1%; ** Significant at 5%; * Significant at 10% with Two Sample t-tests*
Com Econ=Economic assessment of consequences on commercial activities; Com Ecol=Ecological assessment of consequences on commercial activities; Com SE=Socio-economic assessment of consequences on commercial activities…

Table 4-9 Overall weights associated with the economic, ecological and socio-economic assessment of the different types of consequences: general public and decision-makers

	General public (n=126)			Decision-makers (n=47)		
	median	mean	s.d.	median	mean	s.d.
W Com Econ	0.035	0.116***	0.155	0.023	0.049***	0.057
W Com Ecol	0.081	0.108	0.088	0.083	0.097	0.061
W Com SE	0.061	0.086***	0.085	0.024	0.042***	0.051
W Rec Econ	0.030	0.060	0.073	0.017	0.050	0.091
W Rec Ecol	0.073	0.097	0.089	0.077	0.111	0.101
W Rec SE	0.044	0.074	0.096	0.038	0.057	0.079
W Bio Econ	0.071	0.085	0.073	0.068	0.079	0.063
W Bio Ecol	**0.167**	**0.248*****	0.224	**0.430**	**0.412*****	0.202
W Bio SE	0.075	0.125	0.115	0.075	0.104	0.091

**** Significant at 1%; ** Significant at 5%; * Significant at 10% with Two Sample t-tests*
W=overall weights

For both samples, the relative weights associated with the pairwise comparison regarding the consequences on marine biodiversity were significantly more important (table 4-7). Similarly, when looking at the relative weights associated with the assessment criteria for each types of consequences taken independently (table 4-8), the ecological indicators were systematically largely preferred for assessing each type of consequences, followed most of the time by the socio-economic indicators and then the economic values (with an exception for commercial fisheries where economic values are given more weight on average). For the overall weights (table 4-9), results were similar.

Differences were observed between the responses of decision-makers and the general public. Marine biodiversity consequences and all ecological indicators were given more weight by decision-makers, whereas they gave less weight to almost all socio-economic indicators and economic indicators. For the overall weights (table 4-9), conclusions were the same for the ecological assessment of marine biodiversity, and the socio-economic and economic assessment of commercial activities.

Finally there was substantial variability among these weights and an important degree of dispersion and skewness (see boxplots in Appendix T). This high diversity of weights in each sample means that a more detailed analysis is required within each sample: by looking at possible more homogenous groups of preferences and by looking at possible socio-demographic or opinions variables that could explain this heterogeneity.

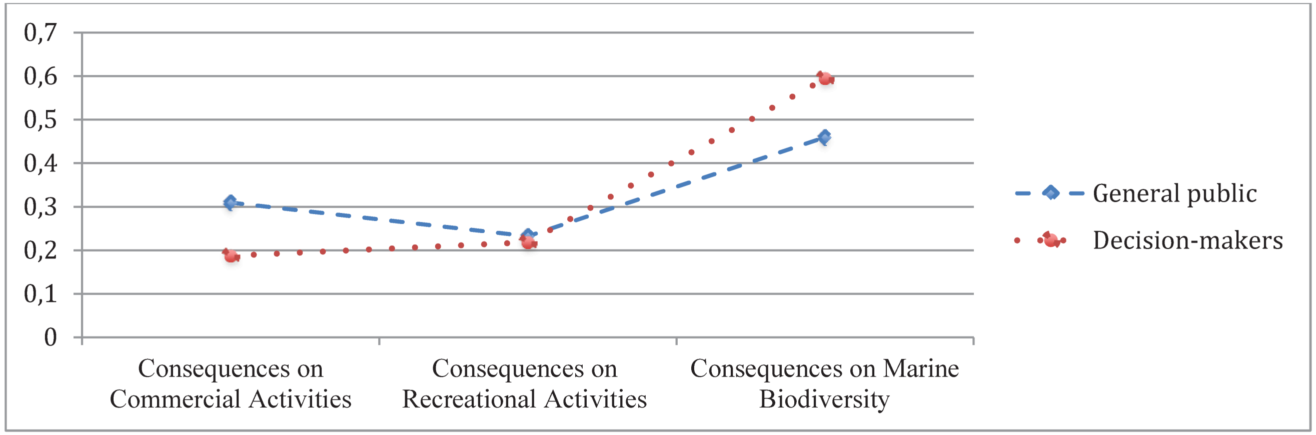


Figure 4-4 General public and decision-makers final weights: higher level objectives (types of consequences to be assessed)

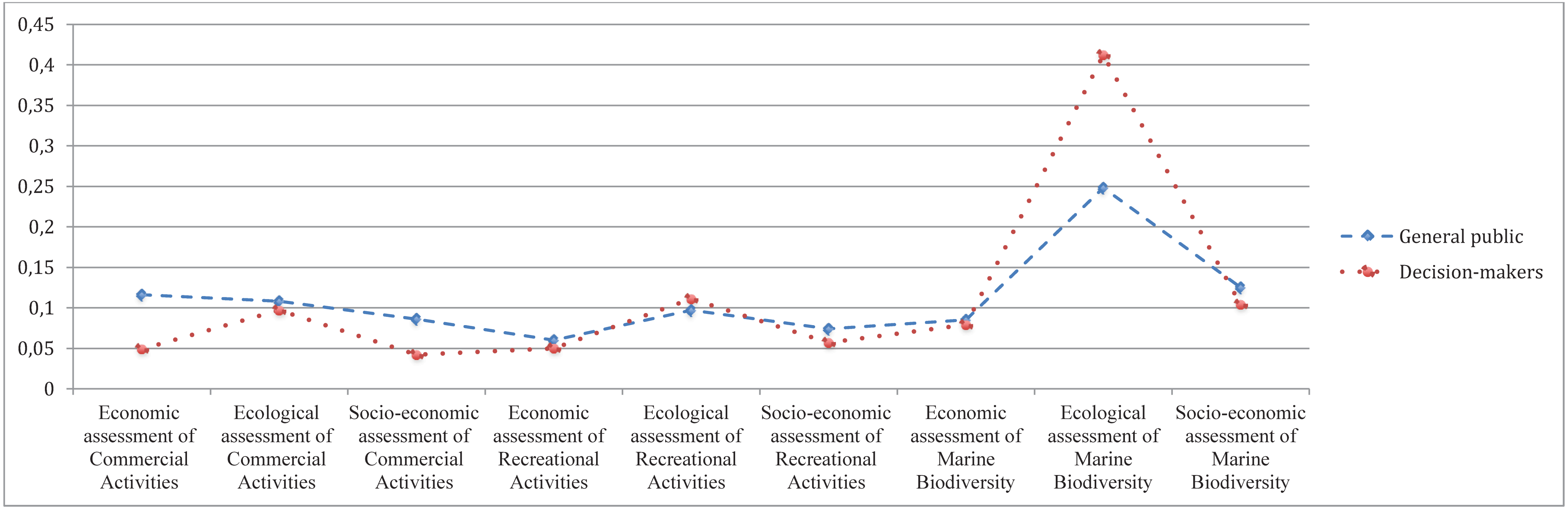


Figure 4-5 General public and decision-makers final weights: lower level objectives (various assessment of the different types of consequences)

As we then focused exclusively on the individuals for whom overall weights were computed, figures 4-4 and 4-5 above represent and compare the final weights graphically for the higher level and lower level objectives for both the decision-makers and general public samples.

3.2 Cluster analysis results

The socio-demographic composition of both the 126 individuals from the general public and 47 individuals from the decision-makers group for whom the overall weights were computed is presented in table 4-14 and 4-16 below[49].

3.2.1 Final weights clusters for the general public and decision-makers

- **Higher level objectives**

Results from the hierarchical cluster analysis for the higher-level objectives weights (types of consequences to be assessed) are presented in table 4-10 for the general public and table 4-11 for the decision-makers[50]. The numbers of clusters were chosen in view of the dendrogram structures obtained (see Appendix V), and in view of their relevance for our analysis in comparison to lower or higher numbers of clusters. We named each cluster according to its dominant priority/priorities following a simple coding system referring to the types of consequences to be assessed ("Com", "Rec", "Bio") and the assessment indicators ("Eco", "Ecol", "SE"), as well as the degree of priority (+, ++, or +++).

Table 4-10 Hierarchical clusters for general public's final weights associated with consequences to be assessed

Higher level objectives	Cluster 1 *"Bio ++"*	Cluster 2 *"Rec ++"*	Cluster 3 *"All equal"*	Cluster 4 *"Com ++"*
Com	0.139	0.139	**0.356**	**0.706**
Rec	0.132	**0.693**	**0.316**	0.135
Bio	**0.729**	0.168	**0.328**	0.159
Proportions of individuals in cluster	**45.3%**	**9.5%**	**24.6%**	**20.6%**
Average coherence level	0.987	0.981	0.943	0.987
Proportion of extreme cases (%)	0	0	0	0

[49] We also provide in Appendix U a detailed composition of this sample by States in order to have a better overview of our decision-makers distribution (since the decision-makers sample is not initially based on quotas as the general public one).

[50] The hierarchical cluster analyses are all based on Euclidean distance and Ward method.

Table 4-11 Hierarchical clusters for decision-makers' final weights associated with consequences to be assessed

Higher level objectives	Cluster 1 *"Bio + and Com +"*	Cluster 2 *"Bio ++"*	Cluster 3 *"Rec ++"*
Com	**0.353**	0.125	0.209
Rec	0.250	0.136	**0.657**
Bio	**0.397**	**0.739**	0.134
Proportions of individuals in cluster	**23.4%**	**66%**	**10.6%**
Average coherence level	0.963	0.987	0.973
Proportion of extreme cases (%)	0	0	0

Regarding the weighting of the higher level objectives for the general public (table 4-10), there are 4 distinct subgroups with homogenous preferences: a dominant one (45% of individuals) with a high priority for the consequences on marine biodiversity; a second one (in minority: 10%) with the highest priority for recreational activities; a third one with relatively equal priorities for the different consequences (25%); and a last one with the highest priority for commercial activities (20%).

For the decision-makers (table 4-11), we identified three distinct subgroups with homogenous preferences: a first one that contained around 25% of individuals, with significant weights attached to all three types of consequences but a priority on commercial activities and marine biodiversity; a second largely dominant one that contained around 65% of individuals with the highest priority given by far to the consequences on marine biodiversity; and a last one in minority that contained around 10% of individuals with a largely dominant priority attributed to the recreational activities. An alternative classification based on five clusters was also considered, but then considered as not so beneficial in comparison to the complexity of identifying two additional groups. It is presented in Appendix V.

Therefore, for both the general public and the decision-makers, there was a majority of individuals (around 70%) who placed a dominant priority on the assessment of consequences on marine biodiversity.

In addition, our clustering approach is completely satisfying in terms of coherence, with high coherence levels and null proportions of extreme cases.

- **Lower level objectives**

Results for the lower level objectives final weights (assessment of consequences) are presented in table 4-12 for the general public and table 4-13 for the decision-makers (these are illustrated respectively by two corresponded figures presented in Appendix V).

Regarding the weighting of the lower level objectives for the general public, we compared a five clusters classification (table 4-12) to a more simple three clusters classification (the later is presented in Appendix V). In the three cluster classification, the second cluster (with on average relatively equal weights attributed to all the various assessments) corresponded actually to the clusters 2, 3 and 4 from the five cluster classification and exhibited low coherence level with high diversity of opinions which is why we finally retained the five cluster option.

The five homogenous subgroups thus were as follow (table 4-12):

- Cluster 1 (around 30% of individuals) with a largely dominant priority for the ecological assessment of the consequences on marine biodiversity (followed by the socio-economic and economic assessment of these with lower priorities);
- Cluster 2 (around 15% of individuals) with dominant priorities attributed to the assessment of the consequences on recreational activities, first with ecological, then with socio-economic and finally with economic indicators;
- Cluster 3 (around 15% of individuals) with dominant priorities attributed to the assessment of the consequences on marine biodiversity, first with socio-economic, then with ecological and finally with economic indicators;
- Cluster 4 (around 30% of individuals) with dominant priorities attributed to the assessment of the consequences on commercial activities, first with ecological, then with socio-economic and economic indicators (all the other weights being distributed across assessments objectives in a relatively homogenous way);
- Cluster 5 (around 10% of individuals) with a largely dominant priority for the assessment of the consequences on commercial activities with the economic indicator (and with the other indicators with lower priorities);

Priorities within the assessment of each type of consequences were almost systematically given to ecological indicators (with the exception of cluster 5 where priority is systematically given to the economic indicator).

For the decision-makers (table 4-13), we also identified 5 subgroups:

- Cluster 1 (around 20% of individuals) with weights being distributed across all the assessment objectives in a relatively homogenous way, although being larger for all ecological indicators and with the highest priority being on the ecological assessment of recreational activities;
- Cluster 2 (around 30% of individuals) with a dominant priority attributed to the ecological assessment of the consequences on marine biodiversity, followed by the economic and socio-economic assessment of these and the ecological assessment of recreational and commercial activities;
- Cluster 3 (around 35% of individuals) with a largely dominant priority attributed to the ecological assessment of the consequences on marine biodiversity;
- Cluster 4 (around 5% of individuals) with a dominant priority attributed to the economic assessment of the consequences on recreational activities, followed by the ecological assessment of marine biodiversity and economic assessment of commercial activities;
- Cluster 5 (around 5% of individuals) with a dominant priority on the socio-economic assessment of the consequences on marine biodiversity, followed by the ecological assessment of these and the socio-economic assessment of recreational activities.

Therefore, we have in both samples at least one important subgroup of individuals whose main priority is the ecological assessment of the consequences on commercial fisheries, although the overall proportion of the individuals concerned is significantly higher for the decision-makers (around 65% against 30% for the general public). Furthermore, the cluster 3 for the general public is almost identical to the cluster 5 of decision-makers: in both cases, there is a dominant priority on the socio-economic assessment related to marine biodiversity. Cluster 2 for the general public, and cluster 1 for the decision-makers also have strong similarities. Nevertheless, there are also some important disparities between the two groups. While no subgroup in the decision-makers considered the economic assessment of commercial activities as a really important priority, this is not the case for the general public. And no subgroup in the general public did consider the economic assessment of recreational activities as a really important priority, whereas this was the case for a minority of decision-makers.

In addition, coherence analysis results are quite satisfying for both samples with high levels of coherence and proportions of extremes cases that are null in most cases or around 10%. For both samples the highest proportion for extreme cases (12% and 14%) concerns the cluster where weights are relatively homogenously distributed across the different assessments (cluster 2 for the general public and cluster 1 for the decision-makers).

Table 4-12 Hierarchical clusters for general public's final weights associated with the assessment of development consequences

Lower level objectives	**Cluster 1** *"BioEcol+"*	**Cluster 2** *"Rec All"*	**Cluster 3** *"BioSE+ and Bio All"*	**Cluster 4** *"Com All"*	**Cluster 5** *"ComEco+ and Com All"*
W Com Econ	0.018	0.056	0.028	**0.157**	**0.465**
W Com Ecol	**0.082**	0.062	0.050	**0.177**	**0.136**
W Com SE	0.029	0.050	0.073	**0.158**	**0.109**
W Rec Econ	0.016	**0.163**	0.025	0.061	0.084
W Rec Ecol	**0.082**	**0.234**	0.060	0.084	0.039
W Rec SE	0.030	**0.202**	0.055	0.077	0.034
W Bio Econ	0.086	0.043	**0.148**	0.080	0.072
W Bio Ecol	**0.554**	0.089	**0.225**	0.117	0.035
W Bio SE	0.104	**0.102**	**0.336**	0.089	0.024
Proportions of individuals in cluster	**29.4%**	**15.1%**	**15.1%**	**29.4%**	**11.1%**
Coherence level	0.965	0.851	0.914	0.873	0.965
Proportion of extreme cases (%)	0	12	0.6	7	0

Table 4-13 Hierarchical clusters for decision-makers' final weights associated with the assessment of development consequences

Lower level objectives	**Cluster 1** *"RecEcol, AllEcol and All equal"*	**Cluster 2** *"BioEcol+ and All MB and Ecol"*	**Cluster 3** *"BioEcol++"*	**Cluster 4** *"RecEco +, BioEco and ComEco"*	**Cluster 5** *"BioSE+, BioEcol+, RecSE"*
W Com Econ	0.074	0.059	0.014	**0.133**	0.030
W Com Ecol	**0.148**	0.103	0.069	0.086	0.036
W Com SE	0.086	0.039	0.019	0.019	0.026
W Rec Econ	0.075	0.028	0.012	**0.414**	0.029
W Rec Ecol	**0.229**	0.084	0.076	0.055	0.038
W Rec SE	**0.113**	0.045	0.024	0.055	**0.092**
W Bio Econ	0.057	0.107	0.078	0.022	0.055
W Bio Ecol	**0.149**	**0.432**	**0.625**	**0.169**	**0.297**
W Bio SE	0.068	0.102	0.083	0.048	**0.397**
Proportions of individuals in cluster	**23.4%**	**31.9%**	**34%**	**4%**	**6%**
Coherence level	0.863	0.935	0.987	0.885	0.923
Proportion of extreme cases (%)	14	0	0	0	0

3.2.2 Socio-economic characteristics of clusters for lower and higher level objectives

- **General Public**

The socio-demographic characteristics of general public respondents in the different clusters are detailed in table 4-15 (for the 4 clusters related to the higher level objectives) and table 4-16 (for the 5 clusters related to the lower level objectives). In both cases we checked for potential differences among respondents with respect to the following socio-demographic variables: gender, age category, geographical location (by State), working experience, education level and the frequency of marine activities practiced. As a baseline, the average socio-demographic distribution of the considered general public sample (n=126) is also provided.

<u>Higher level objectives</u>

Regarding the weights attributed to the various consequences, one can notice some differences in proportions or means when comparing these variables between the clusters. Cluster 1 (dominant priority on marine biodiversity) seemed to include more individuals from New South Wales and Victoria (and very few individuals from Western Australia), as well as younger individuals and more female than male in comparison to other clusters. Cluster 2 (dominant priority on recreational activities) included significantly higher proportions of individuals form Western Australia as well as a low proportion of individuals having worked in economics, business and finance. Interestingly, although individuals in this cluster globally placed their priorities on recreational activities, they were on average the ones that practice all marine activities the less frequently. Cluster 3 (relatively homogenous priorities) exhibited some higher proportions of individuals form South Australia and from Queensland, but other than that this cluster seemed close to the overall sample in terms of socio-demographic composition. Finally cluster 4 (dominant priority on commercial activities) included on average the oldest individuals and more individuals form Western Australia, Tasmania and Australian Capital Territory. It had also the highest proportions of individuals involved in economics, business and finance, and, on average, individuals in this cluster practiced more frequently all the different marine activities.

Table 4-14 Socio-demographic characteristics of clusters for general public's final weights associated with types of consequences to be assessed

	Gender (% male)	Age category	State (% of individual living in the different States)	Worked in environmental management or conservation	Worked in economics, business, finance	Level of education	Marine activities
Cluster 1 *"Bio ++"*	**45.6**	**3.4** [d]	NSW: **37**, Vic: **32**, Qld: 17, SA: 7, WA: **2** [b], NT: 2, Tas: 2, ACT: 2	7.0%	35.1%	3.2	++ ComFish:0.19, ComAct:0.35, RecFish:0.82, RecAct:2.46, IndiUse:0.25
Cluster 2 *"Rec ++"*	58.3	4.0	NSW: 25, Vic: 25, Qld: 8, SA: 8, WA: **33** [a], NT: 0, Tas: 0, ACT: 0	8.3%	**25.0%**	3.2	+ ComFish:0.00, ComAct:0.33, RecFish:0.67, RecAct:1.50, IndiUse:0.00
Cluster 3 *"All equal"*	58.1	4.3	NSW: 19, Vic: 13, Qld: 29, SA: **19**, WA: 16, NT: 0, Tas: 3, ACT: 0	9.7%	41.9%	3.2	++ ComFish:0.10, ComAct:0.16, RecFish:1.23, RecAct:2.00, IndiUse:0.29
Cluster 4 *"Com ++"*	61.5	**4.5** [a]	NSW: 19, Vic: 11, Qld: 31, SA: 8, WA: 15, NT: 0, Tas: **8**, ACT: **8**	11.5%	46.2%	3.1	+++ ComFish:0.23, ComAct:0.54, RecFish:1.04, RecAct:2.42, IndiUse:0.23
Whole sample	53.2	3.9	NSW: 28, Vic: 22, Qld: 22, SA: 10, WA: 11, NT: 1, Tas: 3, ACT: 2	8.7%	38%	3.2	++ ComFish:0.16, ComAct:0.34, RecFish:0.95, RecAct:2.24, IndiUse:0.23

[a] Significant difference at 5% (multiple chi-square tests or t-test with Holm p-value adjustments) when compared to cluster 1
[b] Significant difference at 5% (multiple chi-square tests or t-test with Holm p-value adjustments) when compared to cluster 2
[d] Significant difference at 5% (multiple chi-square tests or t-test with Holm p-value adjustments) when compared to cluster 4
Age Category: from 1 (18 to 24 yo) to 6 (65 to 74 yo)
Level of education: 6 being "post graduate" and 1 being "secondary"; 3 corresponds to "diploma"; 5 to "Graduate Diploma"
Marine activities: ComFish=Commercial Fisheries; ComAct=Commercial Activities; RecFish=Recreational Fisheries; RecAct=Recreational Activities; IndiUse= Indigenous use. Frequency of marine activities: 0=never; 1=less than once per year; 2=once per year; 3=several times per year; 4=several times per month; 5=several times per week

Table 4-15 Socio-demographic characteristics of clusters for general public's final weights associated with the assessment of development consequences

	Gender (male)	Age	State	Worked in environmental management	Worked in economics, business, finance	Level of education	Marine activities
Cluster 1 *"BioEcol+"*	**40.5%**	**3.5**	**NSW:41**, Vic:32, Qld:16, SA:3 , WA:0 [d], NT:3, Tas:3, ACT:3	8.1%	29.7%	3.1	++ ComFish:0.13, ComAct:0.30, RecFish:0.73, RecAct:2.40, IndiUse:0.13
Cluster 2 *"Rec All"*	57.9%	4.4	NSW:21, Vic:21, Qld:26, SA:10, **WA:21**, NT:0, Tas:0, ACT:0	5.3%	26.3%	3.2	+ ComFish:0.00, ComAct:0.32, RecFish:0.80, RecAct:1.95, IndiUse:0.00
Cluster 3 *"MBSE+ and Bio All"*	57.9%	**3.4**	NSW:26, **Vic:32**, Qld:21, **SA:16**, WA:5, NT:0, Tas:0, ACT:0	5.3%	47.4%	**3.4**	+++ ComFish:0.32, ComAct:0.47, RecFish:1.00, RecAct:2.63, IndiUse:0.47
Cluster 4 *"Com All"*	**59.5%**	4.1	NSW:19, Vic:13, Qld:16, SA:19, WA:**22** [a], NT:0, **Tas:8,** ACT:3	10.8%	43.2%	3.3	++ ComFish:0.08, ComAct:0.27, RecFish:**1.27**, RecAct:2.00, IndiUse:0.24
Cluster 5 *"ComEco+ and Com All"*	57.1%	4.4	NSW:29, Vic:7, **Qld:50**, SA:0, WA:7, NT:0, Tas:0, **ACT:7**	**14.3%**	50%	**2.8**	+++ ComFish:**0.43**, ComAct:**0.5**, RecFish:0.86, RecAct:2.36, IndiUse:0.43
Whole sample	53.2%	3.9	NSW:28, Vic:22, Qld:22, SA:10, WA:11, NT:1, Tas:3, ACT:2	8.7%	38%	3.2	++ ComFish:0.16, ComAct:0.34, RecFish:0.95, RecAct:2.24, IndiUse:0.23

[a] *Significant difference at 5% (multiple chi-square tests or t-test with Holm p-value adjustments) when compared to cluster 1*
[d] *Significant difference at 5% (multiple chi-square tests or t-test with Holm p-value adjustments) when compared to cluster 4*
Age Category: from 1 (18 to 24 yo) to 6 (65 to 74 yo)
Level of education: 6 being "post graduate" and 1 being "secondary"; 3 corresponds to "diploma"; 5 to "Graduate Diploma"
Marine activities: ComFish=Commercial Fisheries; ComAct=Commercial Activities; RecFish=Recreational Fisheries; RecAct=Recreational Activities; IndiUse= Indigenous use. Frequency of marine activities: 0=never; 1=less than once per year; 2=once per year; 3=several times per year; 4=several times per month; 5=several times per week

Nevertheless, when conducting statistical tests, there were only a few variable where proportions or means were shown to differ among all clusters (overall chi-squared tests or one-way ANOVA): being resident in Western Australia (at 1% level), age category (at 1% level) and the frequency of participating in recreational activities (at 10% level).

Lower level objectives

Regarding the weights attributed to the multiple assessments of the various consequences, there also seemed to be some differences when comparing the socio-demographic composition of clusters. Cluster 1 (dominant priority on marine biodiversity ecological assessment) included more individuals from New South Wales and Victoria (and no individuals from Western Australia), as well as younger individuals and more female than male in comparison to other clusters. It had also a low proportion of individuals having a work experience in economics, business and finance. Cluster 2 (dominant priority on all recreational activities assessment) included significantly higher proportions of individuals form Western Australia. It had the lowest proportion of individuals having worked in economics, business and finance as well as the less frequent marine users. Cluster 3 (dominant priorities on all marine biodiversity assessments, with a preference on socio-economic assessment) exhibited some higher proportions of individuals form South Australia and from Victoria, and contained on average the youngest individuals with the highest level of education and with frequent practice of marine activities (this cluster has the highest frequency of practice of marine recreational activities). Cluster 4 (dominant priority on all commercial activities assessments) included more individuals form Western Australia and Tasmania, and contained the highest proportions of males. Individuals in this cluster also practiced various marine activities quite frequently on average, with the highest frequency of practice of recreational fishing. Finally, cluster 5 (dominant priorities on the economic assessment of commercial activities, followed by the other assessments of these) had the highest proportions of individuals living in Queensland and Australian Capital Territory, the highest proportion of individuals having worked in environmental management or conservation, the lowest average education level. Individuals in this last cluster also practiced various marine activities quite frequently on average, with the highest frequency of practice of commercial activities and fishing.

Again, according to statistical tests, these clusters were not shown to differ much in their socio-demographic composition with only two variables with unequal proportions (overall chi-squared tests): being resident in Queensland (at 10% level) and being resident in Western Australia (at 5% level).

- **Decision-makers**

The socio-demographic characteristics of decision-makers respondents in the different clusters are detailed in table 4-16 (for the 5 clusters related to the higher level objectives) and table 4-17 (for the 5 clusters related to the lower level objectives). In both cases we checked for potential differences among respondents with respect to the following socio-demographic variables: gender, age category, education level, geographical location (by State), work area (by management domain), types of organizations they are currently working for, working experience, role indecision-making, years of experience in decision-making, and the frequency of marine activities practiced. As a baseline, the average socio-demographic distribution of the considered decision-makers sample (n=46) is also provided. Although we had an important diversity of stakeholders, we note that we still had globally a majority of individuals working for government and associated agencies in policy and management (66%), with a consultative or contributive role (around 65%), with a work experience in biological conservation (49%) and who worked on marine areas and species conservation (64%).

We also point out that the geographical distributions of the decision-makers in the various clusters should not be interpreted in a straightforward way because there are already some significant differences in terms of decision-makers profiles for each state in the considered sample (see Appendix U). In other words, there are some correlations between some geographical locations and some other variables: for example all the respondents in New South Wales were individuals working in policy and management for government and associated agencies.

Higher level objectives

For higher level objectives (various types of consequences), one can notice several differences between the three clusters (table 4-16). The socio-demographic composition of the alternative and more complex five clusters classification is presented in Appendix V.

We first note that researchers were quite evenly distributed among clusters.

In comparison to others, cluster 1 (dominant priorities on commercial activities and marine biodiversity, followed by recreational activities) included high proportions of individuals from South Australia, the highest proportion of male, and individuals that practiced frequently the various marine activities (especially commercial ones and recreational fishing). More interestingly, it exhibited the highest proportions of individuals working in the marine industries, and the highest proportions of individuals with a decisive role in decision-making (36%). Besides, cluster 1 exhibited the highest proportion of individuals working on commercial fisheries, and the highest proportion of individuals working on the management of coastal development. It also contained the lowest proportion of individuals involved in the conservation of marine areas and species (although still substantial with around 45% of individuals). It is interesting to note that it also had the highest proportion of individuals with a work experience in economics, business or finance (36%).

Cluster 2 (largely dominant priority on marine biodiversity) contained relatively diverse individuals in terms of geographical location (with the highest proportion of individuals living in NSW), management domain (though mostly involved in marine conservation and with the highest proportion of individuals working on marine pollution), institutions (though marine industries are absent) and role in decision-making. It contained a high proportion of individuals with a work experience in biological conservation, and a low proportion of individuals with work experience in economics, business and finance. Individuals in this cluster also had on average the longest experience in decision-making.

Finally, cluster 3 (largely dominant priority on recreational activities) contained individuals who are only from Queensland, South Australia, Western Australia or Australian Capital Territory (with the highest proportion from all clusters for the later). It was also the only cluster with a majority of females, and the individuals in this cluster had on average the highest education level. Not surprisingly, this cluster contained the highest proportion of individuals working on recreational activities (60%). It also had the highest proportion of individuals working on marine conservation (80%), the highest proportions of individuals with a work experience in biological conservation, and the highest proportions of individuals with informative, consultative or contributive role. This cluster also mostly contained individuals working for government and associated agencies (80% in policy and management and 40% in research) and researchers. Finally, individuals in this cluster do not frequently practice marine activities, except from recreational activities (around once a month).

Table 4-16 Socio-demographic characteristics of clusters for decision-makers final weights associated with the development consequences

	Gender (%male)	Edu. level	Age Category	State (%)	Work area (%)	Currently work for (%)	Work exp (%)	Role (%)	Exp.	Marine activities
Cluster 1 *"Bio+ and Com+"*	**73**	4.9	4.4	NSW: 9, Vic: 9, Qld: 18, SA: **27**, WA: 18, NT: 0, Tas: 18, ACT: 0	**ComFish: 27,** RecAct: 45, Cons: 45, **CDev: 64**, MPol: 27, Indi: 9	Gov: 54, GovRes: 18, Research: 18, **Industry: 18**	EBF: **36** Cons: 27	Info: 64, Consul: 54, Contrib: 54, **Decis: 36**	2.1	+++ **ComFish: 0.40, ComAct:0.90**, **RecFish:2.10**, RecAct:3.00, IndiUse:0
Cluster 2 *"Bio ++"*	64	5.3	4.7	NSW: **26**, Vic: 6, Qld: 16, SA: 10, WA:16, NT: **10**, Tas: 13, ACT: 3	ComFish: 19, RecAct: 35, **Cons: 68**, CDev: 55, **MPol: 39**, Indi: 13	Gov: 68, GovRes: 23, Research: 19, Industry: 3	EBF: 26 Cons: **55**	Info: 58, Consul: 71, Contrib: 58, Decis: 26	**2.4**	++ ComFish:0.19, ComAct:0.58, RecFish:1.71, RecAct:3.35, IndiUse:0.29
Cluster 3 *"Rec ++"*	**40**	**6.0**	5.2	NSW: **0**, Vic: **0**, Qld: 20, SA: 20, WA: 20, NT: 0, Tas: 20, ACT: **20**	ComFish: 20, **RecAct: 60**, **Cons: 80,** CDev: 40, MPol: 20, Indi: 0	**Gov: 80**, **GovRes: 40**, Research: 20, Industry: 0	EBF: 20 Cons: **60**	**Info: 80, Consul: 80, Contrib: 100,** Decis: 20	2.0	+ ComFish:0, ComAct:0, RecFish:0.80, **RecAct:3.40**, IndiUse:0
Whole sample	63.8%	5.3	3.7	NSW: 19, Vic: 6, Qld: 17, SA: 15, WA: 17, NT: 6, Tas: 15, ACT: 4	ComFish: 21, RecAct: 40, Cons: 64, CDev: 55, MPol: 34, Indi: 11	Gov: 66, GovRes: 23, Research: 19, Industry: 6	EBF: 28 Cons: 49	Info: 62, Consul: 68, Contrib: 62, Decis: 27	2.3	++ ComFish:0.22, ComAct:0.58, RecFish:1.69, RecAct:3.28, IndiUse:0.19

Level of education: average based on categories, with 6 being "post graduate" and 1 being "secondary" (3 corresponds to "diploma"; 5 to "Graduate Diploma")
Age Category: from 1 (18 to 24 yo) to 6 (65 to 74yo), the minimum value in this sample being 3
Work area: ComFish=Commercial Fisheries; RecAct=Recreational Activities; Cons=Conservation; CDev=Coastal Development; MPol=Marine pollution; Indi= Indigenous use
Work for: Gov=government and associated agencies (policy and management); Govres=government and associated agencies (research); Industry= Marine industry
Work exp.: work experience; EBF: Economics, Business, Finance; Cons: Conservation;
Role in decision-making: Info=informative; Consul=Consultative; Contrib=Contributive; Decis=Decisive
Exp.: years of experience in decision-making; from 1 (0-5 years) to 4 (more than 20 years)
Frequency of marine activities: 0=never; 1=less than once per year; 2=once per year; 3=several times per year; 4=several times per month; 5=several times per week

Table 4-17 Socio-demographic characteristics of clusters for decision-makers final weights associated with the assessment of development consequences

	Gender (%male)	Edu. Level	Age Cat.	State (%)	Work area (%)	Currently work for (%)	Work exp (%)	Role (%)	Exp.	Marine activities
Cluster 1 *"RecEcol, All Ecol and All equal*	63.6	5.1	3.6	NSW: 9, **Vic: 9**, Qld: 18, **SA: 27**, WA: 18, NT: 0, Tas: 18, ACT: 0	ComFish: 9, RecAct: 36, Cons: 54, CDev: 54, MPol: 18, Indi: 0	**Gov: 91,** GovRes: 9, Research: 9, Industry: 9	EBF: **18** Cons: 45	Info: 64, Consul: 64, **Contrib: 91, Decis: 45**	2.0	+++ ComFish:0.40, ComAct:0.60, RecFish:1.90, RecAct:3.40, IndiUse:0
Cluster 2 *"BioEcol+ and All Bio and Ecol"*	73.3	5.7	3.7	NSW: 7, Vic: 7, **Qld: 27**, SA: 13, WA: 7, NT: 13, **Tas: 27**, ACT: 0	ComFish: **33**, RecAct: **47**, Cons: 67, CDev: 53, MPol: 27, Indi: 13	Gov: 53, GovRes: 27, Research: 27, Industry: 7	EBF: 27 Cons: 53	Info: 53, **Consul:** 53, Contrib: 53, Decis: 20	2.6	+++ ComFish:0.33, ComAct:0.93, RecFish:2.13, RecAct:3.13, IndiUse:0.27
Cluster 3 *"BioEcol++"*	56.2	5.0	3.8	**NSW: 38**, Vic: 6, Qld: 6, SA: 6, **WA: 25**, NT: 6, Tas: 6, ACT: 6	ComFish: 19, RecAct: 37, Cons: 62, CDev: 62, MPol: **50**, Indi: 12	Gov: 69, GovRes: 25, Research: 12, Industry: 6	EBF: **19** Cons: **56**	Info: 56, Consul: 81, Contrib: 56, Decis: 25	2.4	++ ComFish:0ComAct:0.37, RecFish:1.50, RecAct:3.62, IndiUse:0.06
Cluster 4 *"RecEco +, BioEco and ComEco*	50	6.0	3.5	NSW: 0, Vic: 0, Qld: 0, SA: 0, **WA: 50**, NT: 0, Tas: 0, **ACT: 50**	**ComFish: 50**, **RecAct: 50,** Cons: 50, CDev: **0**, MPol: **0**, Indi: 0	Gov: 0, **GovRes: 50,** Research: **50,** Industry: 0	EBF: **100** Cons: 0	**Info: 100,** Consul: 50, Contrib: 50, Decis: **0**	1.0	+ ComFish:0, ComAct:0.00, RecFish:1.00, RecAct:1.50, IndiUse:0.00
Cluster 5 *"BioSE+, BioEcol+, RecSE"*	66.7	5.0	3.0	**NSW: 33**, Vic: 0, **Qld: 33**, **SA: 33**, WA: 0, NT: 0, Tas: 0, ACT: 0	ComFish: 0, RecAct: 33, Cons: **100**, CDev: **67**, MPol: **67**, Indi: **33**	Gov: 67, GovRes: 33, Research: 33, Industry: 0	EBF: **67** Cons: 33	**Info: 100, Consul: 100,** Contrib: 33, Decis: **33**	2.0	++ ComFish:0.33, ComAct:0.33, RecFish:1.00, RecAct:3.00, IndiUse:1.33
Whole sample	63.8%	5.3	3.7	NSW: 19, Vic: 6, Qld: 17, SA: 15, WA: 17, NT: 6, Tas: 15, ACT: 4	ComFish: 21, RecAct: 40, Cons: 64, CDev: 55, MPol: 34, Indi: 11	Gov: 66, GovRes: 23, Research: 19, Industry: 6	EBF: 28 Cons: 49	Info: 62, Consul: 68, Contrib: 62, Decis: 27	2.3	++ ComFish:0.22, ComAct:0.58, RecFish:1.69, RecAct:3.28, IndiUse:0.19

Level of education: average based on categories, with 6 being "post graduate" and 1 being "secondary" (3 corresponds to "diploma"; 5 to "Graduate Diploma")
Age Cat: Age Category, from 1 (18 to 24 yo) to 6 (65 to 74yo), the minimum age category in this sample being 3
Work area: ComFish=Commercial Fisheries; RecAct=Recreational Activities; Cons=Conservation; CDev=Coastal Development; MPol=Marine pollution; Indi= Indigenous use
Work for: Gov=government and associated agencies (policy and management); Govres=government and associated agencies (research); Industry= Marine industry
Work exp.: work experience; EBF: Economics, Business, Finance; Cons: Conservation;
Role in decision-making: Info=informative; Consul=Consultative; Contrib=Contributive; Decis=Decisive
Exp.: years of experience in decision-making; from 1 (0-5 years) to 4 (more than 20 years)
Frequency of marine activities: 0=never; 1=less than once per year; 2=once per year; 3=several times per year; 4=several times per month; 5=several times per week

Lower level objectives

For the lower level objectives (assessment), we also noticed some patterns when comparing the socio-demographic composition of clusters (table 4-17).

Cluster 1 (relatively homogenous distribution of weights with dominant priorities for the ecological assessment of the various consequences) included the second highest proportion of individuals from South Australia (27%), and had the highest proportions of individuals working for government and associated agencies in policy and management (91%) as well as for marine industries (9%). It also exhibited the highest proportions of individuals having a contributive (91%) and decisive role (45%) in decision-making. It contained individuals working in various management domains (with only 9% in commercial fisheries). Finally this cluster contained only 18% of individual with a work experience in economics, business or finance, which was the lowest proportion.

Cluster 2 (with a dominant priority on the ecological assessment of marine biodiversity) contained principally individuals from Queensland and Tasmania (27% in both case, which is the highest proportion among all clusters concerning Tasmania). It contained individuals that worked for all kinds of institutions and in all management domains, with the second highest proportions of individuals working in commercial fisheries (33%) and recreational fisheries (47%). These individuals had also declared various roles in decision-making (53% informative, consultative and contributive), with only 20% of them who declared playing a decisive role in decision-making (this is the second lowest proportion). They also had the longest experience in decision-making. As in the general sample, this cluster exhibited significant proportions of individuals working on CME conservation and having work experience in conservation.

Cluster 3 (with a largely dominant priority on the ecological assessment of marine biodiversity) contained the highest proportion of individuals living in New South Wales (38%) as well as a substantial proportion of individuals from Western Australia (25%). Only 19% of the individuals in this cluster had a work experience on economics, business or finance, whereas 56% have worked in biological conservation. Besides, these individuals declared having various roles in decision-making, although 81% declared a consultative one. They mostly worked on CME conservation, coastal development and marine pollution.

Cluster 4 (with dominant priorities on the economic assessment of recreational activities, followed by the economic assessment of marine biodiversity and commercial activities) was only composed of 2 individuals, one from Western Australia or one from the Australian Capital Territory. Both were researchers who were working only on the management of commercial fisheries or recreational activities, and in CME conservation. They both declared an informative role, and a work experience in economics, with no work experience in biological conservation. Besides, these two individuals did not often practice any marine activities.

Finally, cluster 5 (with a dominant priority on the socio-economic assessment of marine biodiversity) included only three individuals from New South Wales, South Australia and Queensland. Two were working for government and associated agencies, both in policy and management and one in research, the last one being a researcher from other institutions. They were all working on CME conservation, with two of them also working on coastal development and marine pollution and one working on indigenous use. The one solely working for the government in policy and management had work experience in economics and biological conservation and declared having an informative to decisive role in decision-making. The others declared a consultative or contributive role, with one who had work experience in economics and the other in environmental management.

No statistical tests were run to assess the difference in proportions or average categories in each cluster in view of the small number of observations in the clusters (falling to 2 and 3 individuals for cluster 4 and 5).

3.3 Coherence analysis results

An alternative approach to latent homogenous groups (clusters) in terms of final weights was to look at specific pre-defined stakeholders groups for which we could expect homogenous preferences.

3.3.1 Overall coherence in general public and decision-makers sample

We noted an important variation of weight taken individually for both general public and decision-makers sample. It is also interesting to look at possible variation or agreement in the preference structure over all the weights in both samples (i.e. look at the diversity of opinion within groups). This is measured by the coherence level and the proportion of extreme cases. Table 4-18 presents coherence results of both the general public and decision-makers sample.

Table 4-18 Coherence level and proportion of extreme cases

	Average Coherence	Proportion of extreme cases
General public sample		
• Weights on higher level objectives (types of consequences)	0.881	1%
• Weights on lower level objectives (assessment criteria for each type of consequences)	0.789	40%
Decision-makers sample		
• Weights on higher level objectives (types of consequences)	0.924	0%
• Weights on lower level objectives (assessment criteria for each type of consequences)	0.868	20%

For both samples, there was substantially greater coherence for the higher-level objectives (types of consequences to be assessed) than for the lower level objectives (assessment criteria). There were almost no extremes cases for the higher-level objectives, whereas these were significantly present in the lower level objective. This can be noticed when examining the distribution of individual coherence scores between respondents' choices presented in Figure 4-6 for the general public and figure 4-7 for the decision-makers sample. In both cases, the distribution is skewed to the right with respectively 60% (figure 6) and 80% (figure 4-7) falling above the value estimated as equivocal to orthogonal (respectively equal to 0.64 and 0.76). This confirms the low coherence among the general public regarding the assessment indicators to use for the various types of consequences (40% of the respondents exhibit substantial differences of opinion).

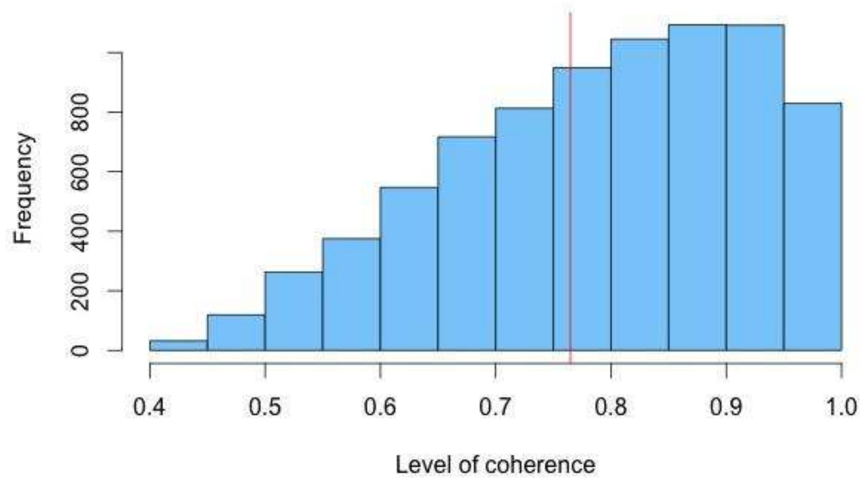


Figure 4-6 Distribution of coherence scores for all general public overall weights (lower level objectives)

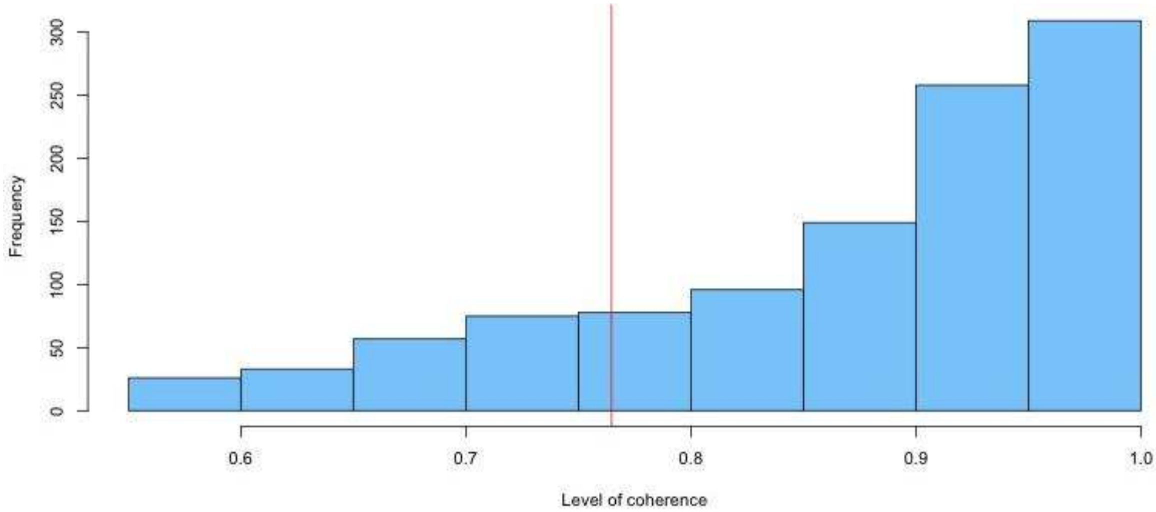


Figure 4-7 Distribution of coherence scores for all decision-makers overall weights (lower level objectives)

These results also show that opinions are more coherent in the decision-makers group in comparison to the general public groups.

3.3.2 Coherence within groups in general public and decision-makers sample

We then looked at coherence levels in various groups within our two samples, for which it would be interesting to examine diversity or common grounds in opinions related to the overall weights (lower level objectives).

- **General public**

We first separated the general public sample by geographical locations. Indeed, one could be expect that individuals would have less diverse opinions within one State. Overall weights, coherence levels and proportions of extreme cases are presented in table 4-19. As expected, the level of coherence within these groups was globally better than for the general public taken as a whole, although it is still globally poor. There were no substantial differences in terms of coherence between the different States from which most of the respondents come from (Qld, NSW, Vic). Residents in WA exhibited the most coherent opinions, both in terms of coherence level and proportion of extreme cases, followed by SA and Tas.

In terms of weights, we can see that there were some differences between the individuals from the different States, although they all had a dominant priority for the ecological assessment of marine biodiversity. This priority was especially high for individuals from NSW, Vic and

WA. It fell to 35-38% for individuals in Qld, ACT and Tas; and to only 26% for SA residents. The later were the one who exhibited the most homogenously distributed weights across all assessments. The socio-economic assessment of marine biodiversity was the second dominant weight for the individuals living in Qld, NSW and SA. The weights attributed to the ecological assessment of recreational and commercial activities were all around 10% in all States (except from ACT). Finally, we point out that the individuals from Tas attributed a 12% weight on the economic Non-Use values indicator, while the individuals from ACT gave a substantial priority (28%) to the economic value assessment of recreational activities through WTP.

Table 4-19 Overall weights, coherence level and proportion of extreme cases for the general public by geographical location

	Qld	**NSW**	**Vic**	**SA**	**WA**	**Tas**	**ACT**
W Com Econ	0.045	0.039	0.035	0.091	0.041	0.051	0.061
W Com Ecol	0.116	0.078	**0.114**	**0.126**	0.086	0.091	0.048
W Com SE	0.042	0.028	0.021	0.097	0.027	0.047	0.013
W Rec Econ	0.034	0.022	0.034	0.044	0.056	0.059	**0.283**
W Rec Ecol	**0.122**	0.091	**0.133**	0.110	**0.113**	**0.136**	0.080
W Rec SE	0.043	0.039	0.029	0.068	**0.093**	0.061	0.045
W Bio Econ	0.064	0.075	0.067	0.071	0.083	**0.124**	0.043
W Bio Ecol	**0.385**	**0.513**	**0.489**	**0.257**	**0.437**	**0.352**	**0.360**
W Bio SE	**0.149**	**0.116**	0.078	**0.135**	0.064	0.079	0.069
N	28	35	28	13	14	4	3
Average coherence level	0.786	0.798	0.816	0.801	0.819	0.819	0.662
Proportions of extreme cases	39%	38%	35%	31%	26%	33%	67%

In addition to geographical locations, other criteria were examined to define subgroups for the general public such as education level, field of education, work experience, motivations to preserve coastal and marine ecosystems, active support for marine preservation or types of and frequency of marine activities practised. However, coherence level did not vary much across these, and stayed most of the time quite low with important number of strong divergence in opinions. In view of this, it seems that defining subgroups a priori for the general public did not help much in categorizing their overall preferences in terms of opinion convergence.

- **Decision-makers**

For the decision-makers, we examined the weights and coherence levels for several subgroups based on the types of organizations they were working for (table 4-20), on the types of management they were involved in (table 4-21), on the types of role they had in decision-making (table 4-22), and on their years of experience in decision-making (table 4-23).

<u>Types of organizations</u>

Table 4-20 Overall weights, coherence level and proportion of extreme cases for the decision-makers by types of organizations they are working for

	Government and associated agencies: policy & management (1)	**Government and associated agencies: research (2)**	**Research and higher education (3)**	**(2) and (3)**	**Marine industry (4)**
W Com Econ	0.037	0.042	0.061	0.049	**0.155**
W Com Ecol	**0.104**	0.068	**0.104**	**0.078**	**0.109**
W Com SE	0.036	0.027	0.026	**0.071**	**0.114**
W Rec Econ	0.044	**0.106**	0.073	0.006	0.010
W Rec Ecol	**0.140**	0.086	0.052	0.051	0.067
W Rec SE	0.054	0.054	0.024	0.043	0.021
W Bio Econ	0.078	0.059	**0.118**	0.058	**0.105**
W Bio Ecol	**0.396**	**0.480**	**0.455**	**0.463**	**0.349**
W Bio SE	**0.112**	0.077	0.087	**0.181**	0.069
N	28	6	5	3	3
Average coherence level	0.887	0.841	0.882	0.912	0.760
Proportions of extreme cases	13%	33%	0%	0%	33%

With respect to table 4-20, the two subgroups of researchers are not mutually exclusive: some individuals were working for both government and non-governmental research institutions. The results of this table show that the subgroup of 8 decision-makers working for non-governmental research and higher education or both non-governmental and non-governmental research had the highest (and quite good) level of coherence, with no extreme cases. Interestingly, we also note that the researchers in (3) were from different background: there were 67% of researchers with work experience in biological conservation and 33% in economics, and 60% who had an educational background in environmental science, 40% in business and economics.

In comparison, the 6 individuals working exclusively as researchers for governments and associated agencies showed poor coherence (respectively 33% of extreme cases). Furthermore, the 28 decision-makers solely involved in government and associated agencies in policy and management (no research) exhibited rather high coherence levels with only 13% of substantially different opinions. Finally, decision-makers working for the marine industry exhibited the lowest (and quite poor) coherence level as well as a high proportion of extreme cases (33%). This last results can be explained by the small number of these marine industry representatives (only 3) and the fact that they were all from different industries (one commercial fishing, one recreational fishing, and one tourism).

In terms of average weights, there were some interesting differences between the members of the different types of organizations, although for all of them the ecological assessment of marine biodiversity was the dominant priority (the lowest being for the marine industries members). For the individuals working in policy and management for government or associated agencies, the other dominant priorities were for the socio-economic assessment of marine biodiversity and for the ecological assessment of recreational and commercial activities. Regarding the individuals working in research for these organizations, the second dominant priority was the economic assessment of recreational activities, with all other weights being relatively equally distributed. In comparison, the second dominant priorities attributed by researchers from non-governmental organizations were for the economic assessment of marine biodiversity and for the ecological assessment of ecological consequences. Finally, as could be expected, the marine industries members attributed significant weight to the various assessments of commercial activities, and especially to the economic one (15%). These individuals also attributed a 10% weight to the non-use values assessment for marine biodiversity.

Types of management

Regarding table 4-21, the large majority of decision-makers in our sample stated their work involved several management domains, and the categories are not mutually exclusive. Whenever possible, the coherence of the decision-makers who stated to be strictly involved in one of the management domain was also assessed.

Table 4-21 Overall weights, Coherence level and proportion of extreme cases for the decision-makers by types of management they are involved in

	Commercial fisheries	Recreational activities	Marine conservation	Coastal development	Coastal and marine pollution	Indigenous uses
W Com Econ	0.083	0.049	0.038	0.044	0.034	0.030
W Com Ecol	**0.097**	0.111	0.091	0.092	0.074	0.075
W Com SE	0.064	0.036	0.035	0.042	0.038	0.042
W Rec Econ	0.072	0.063	0.050	0.029	0.019	0.016
W Rec Ecol	0.073	**0.133**	0.109	**0.111**	0.090	0.086
W Rec SE	0.032	0.042	0.063	0.069	0.068	0.048
W Bio Econ	0.096	0.091	0.074	0.081	0.086	0.079
W Bio Ecol	**0.400**	**0.394**	**0.422**	**0.433**	**0.477**	**0.488**
W Bio SE	0.083	0.081	**0.116**	0.10	**0.115**	**0.136**
N	10	19	30	26	16	5
Average coherence level	0.829	0.862	0.866	0.898	0.905	0.931
Proportions of extreme cases	33%	19%	22%	10%	10%	0%

The five decision-makers involved in the protection of indigenous cultural and customary uses exhibited the highest level of coherence with no significant divergence in opinions. The 26 and 16 decision-makers working respectively on coastal development or on coastal and marine pollution also exhibited a good level of coherence with only 10% of extreme cases. Decision-makers working on recreational activities and tourism, and in marine area and species conservation, had a lower level of coherence with around 20% of strongly different opinions were observed. One could object that the lower coherence of the marine conservation group could have been linked to the possibly strong diversity of decision-makers within this group (since more than half of our decision-makers declared being involved in marine areas and species preservation among other various management issues). However, this was not the case since the 11 individuals who declared being strictly involved in conservation did exhibit a similar level of coherence (although slightly better). Finally, the decision-makers involved in commercial fisheries management were the group with the lowest and rather poor coherence, with one out of three overall preferences that was substantially different in terms of allocation of weight. This could be explained with the fact that this group was mostly composed with individuals from various organizations (governments and various agencies, research, marine industry) and involved in other management domains.

If we consider the individuals that declared working only on one management domain, we have: 2 individuals who worked solely on commercial fisheries and these showed two strongly divergent opinions (with one individual working for government in Queensland and the other for the industry in South Australia[51]); 11 individuals who worked solely on marine areas and species conservation with medium coherence (Consistency level =0.877 and 18% of extreme cases); 6 individuals who worked solely on coastal development with a strong coherence in opinions (Consistency level = 0.919 and no extreme cases). Besides, there was only 1 individual who was working solely on recreational activities, and none that worked solely on marine pollution or indigenous uses.

In terms of overall weights, we note interesting differences with respect to the second dominant priorities among these various groups (the dominant priority was again on the ecological assessment of marine biodiversity for all of them, with the lowest ones for individuals involved in the management commercial fisheries and recreational activities). Not surprisingly the second dominant priorities were attributed to the ecological assessments of commercial and recreational activities by the individuals involved in the management of these. This was also the case for individuals involved in coastal development management. The individuals working on marine conservation, marine pollution or indigenous customary uses attributed their second dominant priority to the socio-economic assessment of marine biodiversity (perceptions of populations and opinion polls).

Role in decision-making

With respect to table 4-22, the presented role-based categories are as follow: the “informative role” group contains individuals who only declared having an informative role in decision-making; the “consultative role” group contains individuals who declared having a consultative in addition to a possible informative role; the “contributive role” group contains individuals who declared having a contributive role, with some of them who mentioned having informative and/or consultative role(s) as well; the “decisive role” group contains individuals who declared having a decisive role in addition of having any other roles mentioned. The

[51] In terms of global weights, the one working in the marine industry attributed a 30% priority to each economic and socio-economic assessment of commercial activities, while the other one working for government in policy and management attributed a 40% weight to the ecological assessment of marine biodiversity, a 20% weight to their socio-economic assessment and a 20% weight to the ecological assessment of commercial activities.

results from this table show that the subgroup of decision-makers with an informative role had the highest coherence level with no extreme cases. The individuals in this group were mostly researchers that worked for both governments or associated agencies and other research institutions (4 in total), with also 2 individuals who worked for policy and management and 1 from the marine industry. In addition, individuals with a decisive role had a higher coherence level and a good convergence in opinion in comparison to decision-makers with consultative to contributive roles.

Table 4-22 Overall weights, coherence level and proportion of extreme cases for the decision-makers by types of role in decision-making

	Informative role	Consultative role	Contributive role	Decisive role
W Com Econ	0.057	0.040	0.057	0.038
W Com Ecol	**0.106**	**0.080**	0.089	**0.115**
W Com SE	0.032	0.038	0.046	0.044
W Rec Econ	0.048	0.019	0.076	0.035
W Rec Ecol	0.077	0.062	**0.126**	**0.142**
W Rec SE	0.037	0.057	0.069	0.053
W Bio Econ	0.063	0.070	0.082	**0.088**
W Bio Ecol	**0.508**	**0.470**	**0.369**	**0.378**
W Bio SE	0.073	**0.164**	0.085	**0.106**
N	7	9	18	13
Average coherence level	0.912	0.905	0.822	0.889
Proportions of extreme cases	0%	17%	36%	7%

In terms of overall weights, there was convergence in opinions between individuals with informative and consultative roles, as well as between individuals with contributive and decisive roles. The later had a lower dominant priority for the ecological assessment of marine biodiversity than the former.

Experience in decision-making

Finally table 4-23 shows that level of coherence increased with the years of experience in decision-making, although it stayed around the same level after 5 years of experience. The lowest proportion of extreme cases was for individual with 11 to 20 years of experience. In terms of overall weights, the individual with the shortest experience had the lowest dominant priority for the ecological assessment of marine biodiversity. They then attributed a 15%

weight to the ecological assessment of recreational activities and a 10% one to their economic assessment (whereas all the other group with longer experienced attributed a 2 to 3% weight to this economic assessment). They also placed an important priority on the socio-economic assessment of marine biodiversity, as did the decision-makers with more than 20 years of experience. The later also considered the socio-economic assessment regarding recreational activities as being important with a 10% weight. The individuals with 6 to 10 years and 10 to 20 years of experience both attributed their second dominant priorities to the ecological assessment of commercial activities (10 and 12%), followed closely by the one of recreational activities (9 and 10%). We also point out that the former attributed a 9% preference for the socio-economic assessment of marine biodiversity, while the later did the same for the economic one.

Table 4-23 Overall weights, coherence level and proportion of extreme cases for the decision-makers by groups of years experience in decision-making

	0 - 5 years	6 – 10 years	11 - 20 years	More than 20 years
W Com Econ	0.040	0.064	0.059	0.031
W Com Ecol	0.088	**0.117**	**0.099**	0.082
W Com SE	0.039	0.051	0.040	0.037
W Rec Econ	**0.095**	0.028	0.026	0.033
W Rec Ecol	**0.145**	**0.087**	**0.098**	**0.103**
W Rec SE	0.070	0.031	0.035	**0.098**
W Bio Econ	0.070	0.080	**0.094**	0.071
W Bio Ecol	**0.331**	**0.451**	**0.477**	**0.413**
W Bio SE	**0.122**	**0.090**	0.072	**0.132**
N	15	12	11	9
Average coherence level	0.824	0.891	0.898	0.882
Proportions of extreme cases	29%	15%	13%	16%

3.4 Determinants of final weights

In view of the focus on ESV within this PhD work, we only present in this section the results from the double-censored Tobit models that were run on the computed final weights placed on the economic assessments of the different consequences for the general public, then for the decision-maker. We also run some Tobit models on all other final weights (higher level and lower level objective): these and their results are presented in Appendix W.

3.4.1 General Public

For the general public, the explanatory variables first considered in our modelling approach were the following: gender, age category, geographic location (by State), level of education, fields of education (business and management, environmental sciences or society and culture), working experience (in economics business or finance as well as in environmental management or conservation), stated motivations to preserve CME (see Chapter 3), active support or not of CME preservation, frequency of practised marine activities, and perceptions related to the usefulness of ESV.

Results from the Tobit models run on the weights associated with the economic assessments of commercial activities, recreational activities and marine biodiversity are presented in tables 4-24, 4-25 and 4-26.

Model fits were all relatively low (especially for the economic assessment of recreational activities). In terms of geographical location, we note that living in Qld and ACT had a positive influence on the weight attributed to the economic assessment of commercial activities (respectively 0.04 and 0.13 increase), while living in WA increased the weight placed on the economic assessment of recreational activities by 0.04 and living in Vic increased the weight placed on the economic assessment of marine biodiversity by 0.04.

Table 4-24 Tobit regression results on the AHP weight associated with the economic assessment of commercial activities (general public)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	-0.009	0.039		
Age Category	0.017**	0.007	0.013**	0.005
State Qld [bi]	0.050*	0.028	0.039*	0.023
State ACT [bi]	0.161**	0.080	0.128**	0.064
Involved in commercial fisheries	0.016	0.019	0.013	0.015
Support [bi]	-0.052*	0.027	-0.041*	0.021
Useful ESV	0.031*	0.018	0.025*	0.014
Preserve CME for marine industries [bi]	0.109**	0.050	0.086**	0.040
Pseudo-R^2	0.145			
N	126			

[bi] *Binary variable; Useful ESV: 0=Useless or Do not know, 1=Useful, 2=Necessary;*

Table 4-25 Tobit regression results on the AHP weight associated with the economic assessment of recreational activities (general public)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	0.064***	0.012		
State WA [bi]	0.045**	0.019	0.036**	0.016
Involved in commercial activities	0.013*	0.007	0.010*	0.006
Involved in recreational activities	-0.008	0.005	-0.006	0.004
Preserve CME for use reasons [bi]	0.030*	0.016	0.024*	0.013
Pseudo-R^2	0.085			
N	126			

[bi] *Binary variable*

Table 4-26 Tobit regression results on the AHP weight associated with the economic assessment of marine biodiversity (general public)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	0.082***	0.013		
State Vic [bi]	0.041***	0.014	0.037***	0.013
Education level	-0.006	0.004	-0.005	0.003
Edu. field Environmental sciences [bi]	0.068**	0.034	0.062**	0.031
Work experience in CME management [bi]	0.071**	0.028	0.064**	0.026
Preserve CME for use reasons [bi]	0.057**	0.018	0.051**	0.016
Pseudo-R^2	0.182			
N	126			

[bi] *Binary variable*

In addition, two other variables had a positive influence on the priority given to the economic assessment of commercial activities (table 4-24): having considered ESV as useful or necessary (0.02 increase), and having considered the profitability of marine industry as one of the most important reason to preserve CME (0.09 increase). Actively supporting CME preservation had a negative influence. In this respect, we note that this variable was actually found to positively influence the weight placed on the ecological assessment of marine biodiversity.

Considering the use of marine ecosystems as the most important reason to preserve CME[52] played a significant and positive role in attributing priorities to the economic assessment of

[52] This refers to individuals having declared that the most important reason to preservation was "So I can continue to enjoy marine activities and/or other benefits derived from these ecosystems during my lifetime"; see chapter 3, section 3.2.

recreational activities (0.04 increase) and of marine biodiversity (0.05 increase). The later result can surprise, but it has to be noted that all individuals who mentioned that the most important reason to preservation was the use of CME also stated that the second or third most important reason was linked to non-use motivations. This could imply that non-use values were definitely important for users as well, or for individual who thought about their use values in priority.

Results from table 4-25 showed that being involved in recreational activities (in terms of increasing frequency of practice) do not influence on the weight placed in recreational activities economic assessment, while being involved in commercial activities (excluding fisheries) had a positive influence (0.01 increase). Besides, we also checked wether we would have had similar results with variables showing participation only in these marine activities, and in that case both effects become insignificant. The second result regarding the positive influence of being involved in commercial activities could be explained by the interest of individuals involved in marine activities industries (diving, charter, snorkelling etc.) for users willingness-to-pay.

In addition, having a work experience in CME management and an educational background in natural sciences both increased the weight attributed to the economic assessment of marine biodiversity. This can be related to the positive influence of both on the weight associated to the assessment of marine biodiversity (see Appendix W).

3.4.2 Decision-makers

For the decision-makers, the explanatory variables first considered in our modelling approach were the following: gender, age category, geographic location (by State), level of education, fields of education (business and management, environmental sciences or society and culture), working experience (in economics business or finance as well as in environmental management or conservation), role in decision-making, organization currently involved in, work area by management domains, and utilization of ESV. During the models formulation, two problems were encountered due to the small number of observations in this sample: first we faced multicollinearity issues; second we had over fitting issues. To limit both problems, we tried to minimize the number of variables selected for each model.

Results from the Tobit models run on the weights associated with the economic assessments of the different consequences are presented in tables 4-27, 4-28 and 4-29. The tobit models run on all the other weights are presented in Appendix W.

Table 4-27 Tobit regression results on the AHP weight associated with the economic assessment of commercial activities (decision-makers)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	0.023**	0.009		
Having used ESV	0.018*	0.009	0.015	0.008
Working on Commercial Fisheries [bi]	0.026*	0.017	0.023	0.015
Working for a marine industry [bi]	0.105***	0.027	0.091	0.023
Pseudo-R^2	0.379			
N	46			

[bi] *Binary variable*

Table 4-28 Tobit regression results on the AHP weight associated with the economic assessment of recreational activities (decision-makers)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	-0.073**	0.037		
State ACT [bi]	0.240***	0.045	0.190***	0.038
Education level	0.025***	0.010	0.020**	0.008
Education field Society and Culture [bi]	0.066***	0.026	0.052**	0.020
Working on Recreational Activities [bi]	0.047**	0.020	0.037**	0.016
Working on Marine Pollution [bi]	-0.063***	0.022	-0.050***	0.017
Having an informative role [bi]	0.035*	0.019	0.027*	0.015
Pseudo-R^2	0.254			
N	46			

[bi] *Binary variable; Education level: 1=Advanced diploma or Diploma to 4=Post-graduate level*

Table 4-29 Tobit regression results on the AHP weight associated with the economic assessment of marine biodiversity (decision-makers)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	0.060***	0.022		
State WA [bi]	0.054***	0.020	0.051***	0.019
State Tas [bi]	0.066***	0.020	0.063***	0.020
Education field Business and Management [bi]	0.108***	0.024	0.103***	0.023
Having heard about ESV [bi]	0.042***	0.015	0.040***	0.014
Years of experience	-0.015**	0.007	-0.014**	0.007
Working on Commercial Fisheries [bi]	0.044**	0.018	0.042**	0.017
Working on Coastal Development [bi]	0.030**	0.015	0.029**	0.014
Having an informative role [bi]	-0.041***	0.015	-0.039***	0.014
Pseudo-R^2	0.441			
N	46			

[bi] *Binary variable. Years of experience in decision-making; from 1 (0-5 years) to 4 (more than 20 years)*

Regarding the weight attributed to the economic assessment of commercial activities, three factors had a positive influence. These were, by decreasing effect on the weight: working for a marine industry (0.09 increase), working on commercial fisheries (0.02 increase), and having used ESV (0.01 increase).

The variables that positively influenced the weight attributed to the economic assessment of recreational activities were (table 4-28): living in Australian Capital Territory (implying a high probability of being involved in CME management in Australian Government related institutions) which increased the weight by 0.19; having an educational background in economics, social or political sciences (0.05 increase); working on recreational activities (0.04 increase); having a higher education level (from 0.02 to 0.1 increase); and having an informative role in decision (0.03 increase).

Being resident in Western Australia or Tasmania both increased the weight attributed to the economic assessment of marine biodiversity by around 0.05 (table 4-29). The other variables that influenced the weight attributed to the economic assessment were: having an educational background in business and management (0.10 increase), having heard of ESV (0.04 increase), being involved in the management of commercial fisheries or in coastal development (increase by respectively 0.04 and 0.03), having an informative role in decision-making (0.04 decrease), and the years of experience in decision-making (between 0.01 and 0.05 decrease).

4. Discussion and conclusion

4.1 Preferences for economic valuation, ecological and socio-economic indicators: decision-makers and general public

- **Ecological indicators are systematically preferred**

For the three types of consequences of the development project on CME, the assessments through ecological indicators were systematically largely preferred on average to the other two indicators in both samples, with the socio-economic indicators coming next in terms of priority and finally the economic ones (except for the consequences on commercial activities where the economic indicator is preferred on average to the socio-economic one for both sample). In this context, ecological indicators were largely "wining" over economic valuation and various types of socio-economic indicators frequently encountered. Therefore, it seems that the ecological discourse is far from being left aside in such decision context when it comes to assess changes in the values of ecosystems and biodiversity, although this result is naturally strongly dependent on the hypothetical and simplistic nature of our scenario.

- **Decision-makers have higher preference for marine biodiversity assessments, to the detriment of those relating to commercial activities**

While both decision-makers and general public attributed on average a dominant priority to the consequences on marine biodiversity and their ecological assessment, the former placed on average substantially more weight on these. This was to the detriment of the weights placed on the economic and socio-economic assessment of the consequences on commercial activities. Both decision-makers and general public attributed on average the same weights to the consequences of recreational activities and their economic, ecological and socio-economic assessments. The lower priorities given to commercial activities by decision-makers was certainly due to the fact that that our sample included a majority of individuals working on conservation of marine areas and species (60%) in comparison to individuals working in commercial activities (20%), and a majority of individuals with a work experience in biological conservation in comparison to economics, business or finance. Besides, 80% of the decision-makers working on the management of commercial fisheries were also working on CME conservation.

- **ESV indicators are the least important except for commercial activities assessment**

ESV as a decision indicator to assess the consequences on CME of a development project was perceived as the least important one for both recreational activities and marine biodiversity assessments. Nevertheless, one could argue that the globally low weights placed on economic valuation indicators could also be partly due to a lack of knowledge or familiarity with ESV. In the case of the general public, we indeed saw in chapter 3 that around 80% of the individuals in this sample had never heard about ESV. Besides, around 15% of individuals in the general public stated that they felt they needed more information about the indicators being compared. For the decision-makers, this might have been due to a lack of familiarity with the use of ESV, since all of them seemed to be relatively well aware about ESV and related issues. Besides Rogers et al. (2013) showed that decision-makers had a significant lack of understanding and knowledge about non-market valuation, which could explain why the economic values indicators were especially low for both the assessment of recreational activities and marine biodiversity (through measure of WTP). This would also accord with the fact that the economic valuation assessment of commercial activities was given more weight in comparison to the other two: profit is a much more commonly used and well-understood indicator. The key issue here is to discern whether the low weights attributed to economic valuation indicators is due to a lack of familiarity with ESV or simply to low perferences for ESV. Our answer to this question is ambivalent: in comparison to ecological indicators, the weights attributed to ESV clearly indicate lower preference (due to the significant difference between the two); but our regression results also indicate that having heard of or used ESV has a positive impact on the weight attributed to two of the economic valuation indicators.

In addition, in our AHP formulation, the economic valuation indicators for the various consequences were defined as actually containing only one type of information whereas the ecological and socio-economic assessment indicators were defined as containing several types of information. The comparison exercise was thus somehow unbalanced and this must be kept in mind when analysing the results. Hence, one could argue that this would have tended to give more credit to the weights attributed to ESV in comparison to the other indicators.

- **Coherence in opinion is high for the types of consequences to assess and low for the indicators to use**

It is interesting to note that for both samples the preferences regarding the three types of consequences to be assessed were highly coherent, whereas low coherence levels were observed in the opinions regarding the various assessments of the different consequences. This was probably due to the number of criteria being compared, and the lack of familiarity with such criteria. Besides, decision-makers showed substantially higher coherence than the general public for the assessment criteria, with 20% of individuals with strongly divergent opinions and 40% for the general public. In addition to low coherence levels, we also observed for both samples a high variability for each of the individual relative weights, for both the types of consequences to be assessed and the assessment criteria.

- **Four to five latent homogenous groups of preference are identified in both samples**

We examined in more details the preferences distribution of both decision-makers and general public samples through two approaches: (1) revealing several latent clusters with homogenous distribution of weights; and (2) partitioning our sample into predefined stakeholders' subgroups for which we could expect more homogenous preferences and coherent opinions. For both approaches, the groups' coherence was assessed. In this respect the first approach was found to perform better (especially in the case of the general public).

In particular the cluster analysis revealed from four to five homogenous groups for both the weights attributed to the various types of consequences and the ones attributed to their measurement through the three types of indicators. These groups were shown to have strong coherent opinions, and we examined in details their socio-demographic composition to check whether they would correspond to specific social categories. Although for the general public we highlighted several differences between clusters composition, their composition was not shown to differ much in socio-demographic terms according to statistical tests. For this sample it seemed that the membership to different homogenous groups of preferences among the individuals was not really determined by simple socio-demographic variables. In other words the observed heterogeneity of preferences was more at the individual level, although many individuals had similar preference structures and could be regrouped according to these. This also concurred with the fact that dividing the general public sample into various pre-identified categories (such as age, geographical location, gender, educational background) yielded to groups with globally low coherence and high diversity of opinions (although they exhibit slightly better coherence than the overall sample).

The cluster analysis for the decision-makers sample identified five clusters with similar weights and high coherent opinions for the multiple assessments of the various consequences. Two of them contained the majority of the sample and exhibiting a largely dominant priority (40 to 60%) for marine biodiversity. These included various stakeholders working in different organizations (but no marine industry representatives), and working on different management domains although they were more involved in conservation, coastal development or marine pollution management. As could be expected, the majority of them had a background in biological conservation. Besides, it interesting to note that in these two clusters the most preferred economic assessment indicators was actually the one for the marine biodiversity assessment, that is to say the estimation of non-use values. This was clearly due to the strong priority placed on consequences on marine biodiversity. The other three decision-makers clusters differed significantly. In the first one that includes 20% of our sample, the dominant priority was for the ecological assessment of recreational activities, followed by more or less homogenously distributed weight with ecological assessment being globally preferred. This cluster included a large majority of individuals involved in policy and management with a contributive to decisive role in decision-making. The second cluster was shown to be composed of economist researchers from various organizations with dominant priorities for all economic indicators, and with a higher one placed on the economic assessment of recreational activities. These researchers were working on commercial fisheries or recreational activities (with some working on CME conservation as well). Finally the last cluster contained researchers and members of public institutions involved in policy and management (with a decisive role) who were mostly concerned by general public perceptions and opinion: they placed a dominant priority on populations' perceptions regarding the consequences on marine biodiversity, followed by priorities on their ecological assessment and the participation rates of populations in recreational activities. These individuals had a dominant background in economics and all worked on CME conservation.

- **For the decision-makers, coherence and preference structure differ across different stakeholders groups based on management context, types of organization, experience and role in decision-making**

We found several interesting results regarding the preference and coherence of pre-defined subgroups of our decision-makers sample. First, the groups with the highest coherence levels were the researchers who did not work exclusively for government or associated agencies, and with in majority an informative role indecision-making. Interestingly these worked in different management domains and had different educational or professional backgrounds. In terms of preferences they placed a highly dominant weight on the assessment of marine biodiversity, especially on its ecological assessment (45% weight). Then the members of government and associated agencies involved in policy and management also exhibited high coherence in their opinions. This is especially true for the ones with decisive role and longer experience in decision-making. In comparison to other groups, these placed on average slightly less weight on the ecological assessment of marine biodiversity (35%). Individuals in policy and management placed higher weight on a greater number of criteria, which is not surprising in view of their usual need to consider various competing management goals. Finally we also observed that coherence in opinions varied depending on the management domain: in some coherence was high (coastal development and marine pollution management), in other it was low with high proportions of diverging opinions (marine conservation, commercial fisheries). More broadly, we observed medium to low coherence in several pre-defined sub-groups of decision-makers.

- **Revealed latent groups of preference exhibit higher coherence in opinion than pre-defined stakeholders groups**

The division of both samples in latent mixed homogenous groups yield to more coherent groups in terms of opinions than with our simple pre-defined categories of stakeholders. Himes (2007) found a similar result in an AHP applied to marine protected areas management.

Several other AHP studies on fisheries pointed out medium to very low coherence in opinions among several pre-identified stakeholders groups (Mardle et al., 2004; Pascoe et al., 2009; Innes and Pascoe, 2010). All this might raise an issue in terms of representativeness of the various stakeholders groups, since important divergence of opinions within specific stakeholders groups implies that no representative could properly represent their constituencies (Himes, 2007; Fletcher, 2003). Besides it might indicate potential difficulties in implementing participatory approaches. Nevertheless, it must also be noted that our pre-identified stakeholders were quite large and thus potentially not selective enough in terms of their composition. One could argue that they were not representing properly the variety of stakeholders in terms of backgrounds diversity: at a finer scale, we may have obtained better coherence. This might be an interesting direction for further work. In all cases, it is clear that the issue of defining coherent representative stakeholders groups is a complicated one.

4.2 Determinants of individual relative preferences

The individual heterogeneity in terms of preferences was examined through studying the potential influence of socio-demographic and opinion variables for each weight taken independently through various Tobit models. Such an approach is interesting since the estimated marginal effects of the models allowed determining quantitatively the positive or negative impact of a variable on each weight. We are not aware of many AHP studies that run such models, and none focusing on CME.

We ran Tobit models on each of the 12 weights (3 types of consequences and 9 assessment criteria) for the general public and decision-makers. Variables that played the most important role on the weights were selected. In both samples we found that several factors were actually influencing the priority placed on each higher or lower level objectives in our AHP.

- **Work experience and education, among other several socio-demographic factors, positively influence the perceived importance of ESV**

In the main body of this chapter we focused solely on the weight placed on the economic assessments of the different consequences, and showed that several socio-demographic and opinions variables had a positive influence on these. For example, on average, the respondents from Qld and ACT in the general public significantly placed more weights on the economic valuation of consequences on commercial activities, while those from WA did so for the conquences on recreational activities and those from Vic for the consequences on marine biodiversity. This could be because the individuals from these areas were more informed about ESV, but this does not concur with results from Chapter 3 (section 3.3.1), except for Vic where respondents were shown to be more familiar with ESV. Another interpretation could be that Qld populations are mostly coastal communities usually well aware of changes affecting commercial marine activities such as fisheries, while ACT population have on average a higher education level (this is also observed in our sample) that could imply a better knowledge about economics and common economic indicators such as profits. Also, WA population is known for its important participation in coastal recreational activities. Individuals from the decision-makers sample involved in marine industries, as well as individuals working on commercial fisheries, recreational activities and coastal development, and individuals with an educational background in business/management or economics were the ones that significantly placed more weight on average on one or several of the economic assessments.

A key finding is that educational background (in environmental sciences or economics) and working experience (in CME conservation for the general public, or in marine industries or specific management fields for the decision-makers) were shown to make a positive difference in the weights placed on ESV indicators. This helps understanding how the relative importance placed on ESV as an assessment indicator varies across different social sectors. It also meets up with results from chapter 3, where these factors were identified as enhancing the familiarity with and use of ESV.

- **Socio-demographic factors such as work experience, education, and institutional context are shown to influence the perceived importance of each assessment indicator by the general public and decision-makers**

More broadly, from all models taken altogether (presented in Appendix W), we can see that for the general public, several socio-demographic factors were shown to play either a positive role or negative role: age category, gender, geographic location (by State), educational background (in either “Environmental sciences”, “Business and management”, or “Society and culture”), work experience (in conservation, CME management or economics, business and finance), and the frequency of practice or various marine activities (commercial activities, commercial fishing, recreational activities, recreational fishing). Besides some opinion factors were also shown to play a significant role. Interestingly, the stated most important motivation to preserve CME had an impact on several weights. Thinking that CME should be preserved mainly in order to keep marine industries profitable significantly increased the weights placed on the consequences on commercial activities and their economic assessment. Thinking that CME should be preserved mainly for use reasons significantly increased the weights placed on the consequences on recreational activities and their economic and socio-economic assessment. Finally, thinking that CME should be preserved mainly for non-use and ethical reasons significantly increased the weight placed on the ecological assessment of marine biodiversity. In addition, perceptions related to ESV also influenced preferences: thinking that ESV was useful or necessary to support the management of CME increased the priorities given to the consequences on commercial activities and their economic assessment.

For the decision-makers, several socio-demographic variables were shown to play a significant positive or negative role: age category, geographical location, education level, educational background (“Business and Management” or “Society and culture”) and working experience in biological conservation. In addition to these, several variables related to the work and role of decision-makers were also shown to sometime greatly influence some of the weights: types of organization they were working for (working in policy and management or in research for government and associated agencies, working for marine industries), management domain they were working on (management of commercial fisheries, recreational activities, coastal development, marine pollution and conservation of marine areas and species), years of experience and role in decision-making (informative, contributive, decisive roles).

- **Knowledge of and familiarisation with ESV use increase its relative perceived importance as an assessment indicator**

It is interesting to note that having used ESV (not often or often) significantly increased the weight attributed to the consequences on recreational activities as well as the weight attributed to the economic valuation of the consequences on commercial activities. In addition, having only heard about ESV (without having actually used it) significantly increased the weight attributed to economic valuation of the consequences on marine biodiversity (non-use values). This could suggest that further work by economists in demonstrating and promoting ESV may result in its increased adoption.

- **There is a good correspondence between the results obtained from the different statistical approaches**

Finally for both samples, these results from the Tobit models reflected globally well the results concerning the socio-demographic compositions of the clusters. Many of the factors that were shown to influence the various weights in the Tobit models were also the ones that seemed to help differentiating the clusters in terms of socio-demographic composition. Besides, for the decision-makers, results from the Tobit models were also corresponding quite well to the differences observed when looking at the weights of the different pre-identified subgroups.

4.3 Limits and further research work

- **There is a cognitive burden associated with the AHP framework**

Some limits concern the AHP technique chosen for our methodological approach. In addition to the previously (and commonly) mentioned limits regarding the AHP, we highlight that many of our surveyed individuals expressed concerns with respect to the pairwise comparison and associated consistency issues, especially in the general public. Indeed, many individuals found it difficult to complete the pairwise comparisons in a consistent way and complained about finding themselves adjusting their initial answers to comply with the exercise. Some others complained about the methodology itself and the pairwise comparison framework. In total, 50% of our general public sample and 27% of our decision-makers sample were lost, largely because of inconsistency and in a smaller extent because of protest answers. We point out that such a high rate of inconsistent answers is probably due to the online format of our survey. Nevertheless, several AHP studies applied to CME management and not necessarily based on online surveys did end up with high proportions of discarded observations (e.g. Wattage and Mardle, 2005; Pascoe et al., 2009).

Therefore, alternative approaches than AHP could be imagined in order to deal with our objective. For example, another approach could have been to specify a fixed number of points to allocate between different criteria instead of each set of pairwise comparisons. This might have been easier to implement and respondents might have found it easier to complete. Nevertheless it does not offer the advantage of a hierarchically structured problem with the possibility to compute overall weights. Besides, we argue that AHP has a robust and sound theoretical base in terms of preference elicitation and analysis.

- **The hypothetical and generic nature of our AHP is also a source of cognitive burden**

Another limit of our approach concerns the hypothetical nature of the AHP management problem. A few individuals in both sample actually stated that their preferences might have changed with additional information on the coastal development scenarios. Others stated that they felt they needed more information about the indicators being compared. Therefore, as mentioned before, the potential lack of familiarity or knowledge with the indicators being compared might also be an issue. In total 10% of decision-makers and 15% of the general public samples stated that their answers may not reflect really well their true preferences because they felt they needed more information regarding the coastal development scenarios or indicators being compared.

- **It is important to take into accont a potential selection bias for the decision-makers sample**

In addition, the representativeness of the decision-makers sample is another issue that must be kept in mind as mentioned above and in chapter 3. Although we do believe that our sample did include a significant diversity of stakeholders, and that most groups were actually represented, we also point out that the sample retained for the AHP analysis is not necessarily well balanced with a dominant proportion of individuals involved in the conservation of CME, and with a work experience in biological conservation in comparison to economics or business. Hence, one could argue that there might be a bias regarding our elicited preferences: these would logically be in favour of the assessment of marine biodiversity consequences and ecological indicators. Nevertheless, we point out that even the individuals who were not involved in the conservation of CME also placed a dominant priority on the ecological assessment of marine biodiversity. In addition, our analysis explicitly accounted for possible heterogeneity in weights, and for the existence of possible sub-groups of preferences.

- **The number of clusters selected is key to results interpretation**

Regarding the cluster and coherence analysis, it is also important to note that their results depended strongly on the number of clusters and the definition of pre-defined groups. Hence, some other results could be presented and discussed based on different groups definition. However, we argue that our choices regarding these groups represented a good compromise between an in-depth and precise analysis of preferences and the need to deliver concise and relatively easily interpretable results.

- **There are limits to our Tobit modelling approach**

Finally, with respect to our analysis of the socio-demographic factors that influenced the final weights, almost all the Tobit models exhibited relatively low model fits. Although these models represented interesting and useful results to examine quantitatively the effects of some socio-demographic and opinion factors on the priority given to each weight, they did not perform well in terms of prediction. This was probably related to the fact that these weights were actually intrinsically related to each other, and therefore the extent to which some factors explained them independently is only a part of the global picture. A more comprehensive modelling approach through multinomial Logit could be used to account for this problem. However, in our case, it did not give satisfying results, partly because of our small number of observations.

4.4 Conclusion

The objective of this chapter was to examine the preference associated to ESV in comparison to other value assessment criteria in a specific management context. An original multi-criteria analysis approach based on the AHP technique was developed and applied in a national online survey in Australia focusing on two populations: a representative sample of the general public and a sample of various decision-makers involved in CME management. The AHP proposed a hypothetical coastal development scenario where the main development project consequences on CME (consequences on commercial activities, recreational activities and marine biodiversity) had to be assessed though three competing evaluation criteria: economic valuation, ecological assessment and socio-economic assessment.

Preferences for the three types of consequences and assessment criteria were elicited and thoroughly analysed for 126 individuals from the general public and 47 decision-makers. Although we showed that there were some important differences between both samples, a conclusion is that a largely dominant priority was attributed on average to the ecological assessment of marine biodiversity.

Besides, ecological assessment indicators were systematically preferred. We also observed a strong heterogeneity in these preferences, which we better explained in terms of homogenous latent sub-groups for both samples. We also dealt with this heterogeneity at the individual level in both samples by looking at the determinant of these preferences. Several socio-demographic and opinion factors were shown to influence the weight placed in the various valuation indicators for both decision-makers and general public. Besides, familiarisation with ESV also seemed to increase the acceptability and demand for the various values.

To our knowledge, this is the first work that attempts to quantitatively characterise the preference for ESV among other values assessment indicators in a broad case of CME management. We argue that more work is needed in that direction, especially if applied on real-world management scenarios. These could take the form of similar approaches, or could be based on other multi-criteria analysis methods. With this respect, social multi criteria analysis (Munda, 2004; Garmendia et al., 2010) or more broadly participatory and deliberative approaches have been argued to play a valuable role (James and Blamey, 2005; Spash, 2008; Vatn, 2009; Antunes et al., 2011; Lopes and Videira, 2013), and this rationale is now supported and integrated in various recent coastal and marine policies.

Discussion and conclusion

The balance between use and conservation of ecosystems and associated biological resources requires all costs and benefits to be considered in decision-making, including intangible costs and benefits such as non-market use and non-use values. This is the main rationale for the economic valuation of ecosystem services (ESV). The broad motivation behind this research was to explore the capacity of ESV to provide robust and useful results to support decision-making.

In the following sections, we summarize the work conducted in this PhD in terms of objectives, results and contributions of the research. Areas for future research and limitations of the study are also outlined.

1. Study Objectives

Within ESV, the characterisation and estimation of non-use values are complex and controversial, especially when the focus of valuation is on individuals who also hold non-market use values. In addition, there is an important lack of information regarding the actual use of ESV in decision-making: although it is the raison d'être of ESV, this issue has been largely unexplored in the academic literature.

This study focused on two main issues related to ESV:

i. The simultaneous estimation of non-market use and non-use values related to the preservation of ecosystems;

ii. The usefulness and use of ESV in decision-making.

Both issues were examined in the case of coastal and marine ecosystem (CME) management, with two empirical applications involving two surveys using different and widely used techniques: a discrete choice experiment and multi-criteria analysis (MCA). One application was about coastal ecosystem preservation in New Caledonia, the other was about coastal management in Australia. Working on CME is both challenging and necessary for four reasons: (1) these ecosystems are some of the most heavily exploited globally with substantial and alarming levels of degradation; (2) the services provided by these ecosystems still suffer from a significant lack of understanding in the general public, and in many cases also in the scientific community; (3) there is a general lack of valuation studies concerning these ecosystems (Spurgeon, 2004; Brander et al., 2007; Barbier, 2012; Pendleton et al., 2007; Laurans et al., 2013a), especially concerning non-use values; and (4) there is limited documented evidence of the role played by ESV in the coastal and marine management domain.

The first part of the thesis (chapters 1 and 2) dealt with the simultaneous measurement of non-market use and non-use values through a stated preference method. It proposed a new pragmatic definition of non-use values based on time decay and a methodological approach based on a choice experiment to estimate these. The approach was applied in a survey that aimed at quantifying non-market values for marine and coastal ecosystems in two areas of New Caledonia with different institutional, cultural, environmental and socio-economic contexts. Chapter 1 presented this approach, the 550 surveys conducted in New Caledonia and the resulting estimation of non-use values for the populations. Chapter 2 presented an in-depth analysis of the individuals' preferences as assessed based on the valuation exercise, in view of deriving robust welfare estimates in the presence of attribute non-attendance in the choice experiment.

The second part of the thesis was aimed at examining the perceptions related to the usefulness of ESV applied to coastal and marine ecosystems management in Australia; and how ESV was perceived to perform alongside other competing decision indicators. It also aimed at examining the use of ESV in Australian CME management: namely if, how and to what extent various types of economic value information, including measures of non-use values, influenced decision-making. A methodological approach based on two nationwide online surveys targeting both the general public and decision-makers was developed to collect information about the perceived usefulness and use of ESV in support of CME management in Australia. Chapter 3 presented both surveys and the results from 256 representative respondents from the general public and 88 decision-makers from various institutions all over Australia. As part of the surveys, a MCA was also designed to provide insights regarding the relative importance of different evaluation criteria (ecological, social and economic) when assessing the consequences of a hypothetical coastal development project on commercial fisheries, recreational activities and marine biodiversity. Chapter 4 presented the development and results from the multi-criteria analysis approach based on the Analytic Hierarchy Process (AHP) technique. In both chapters (3 and 4), opinions and preferences from the general public and decision-makers were compared.

2. Main results

The methodology developed in chapter 1 and the econometric analysis from the New Caledonian application allowed us to compute individual willingness to pay, and to derive individual non-use values estimates for users in an implicit way through two main modelling methods. In particular, we showed that the utility of preserving various ecosystem services over time followed a logarithmic form, implying diminishing marginal utilities with time. After having accounted in several ways for the heterogeneity of preferences in our samples, we were able to implicitly isolate *a minima* but exclusive non-use WTP at the individual level, corresponding to WTP to preserve CME over the individual's lifetime. This represented between 25 and 40% of total mean WTP estimates at sample level. The remaining 60-75% were interpreted as a mix of both use and non-use values for protecting CME within the individuals' lifetime, implying that total non-use values could potentially be much higher. The results were discussed in view of our interpretation of non-use value, and of the hypothetical nature of our choice experiment. The results suggested significant differences in terms of preferences between the two coastal areas, and highlighted the importance of accounting for various contextual elements in a valuation exercise.

In chapter 2, we developed and successfully applied a methodological approach to study and quantify payment non-attendance and to derive robust WTP estimates. We observed substantial stated and inferred payment non-attendance among respondents; we examined the socio-demographic distribution of this non-attendance as well as the factors that influenced the probability of attendance. The payment was found to be mainly considered by individuals living in traditional tribe systems with a less developed market-based economy. When considering the entire sample, a wide range of WTP estimates was obtained through the different modelling approaches, and these were unreasonably high. The alternative of restricting the WTP estimation to those respondents that attended the attributes improved welfare estimates at the cost of limiting the proportion of the population to which they can be applied. In this respect, an inferred attendance approach based on a two-steps error-component random parameters logit model was found to perform better. Finally, the payment non-attendance was interpreted as being mostly due to both lexicographic preferences and hypothetical bias.

The main results in chapter 3 showed that perceptions of ESV were globally positive for both decision-makers and general public, although the large majority of the Australian population had never heard about ESV before. ESV was considered as being useful or necessary in support of decision-making by both samples mostly for communication and advocacy purposes, for cost-benefits analysis, and as a basis for discussion in decision-making processes. Several socio-demographic factors were shown to play a significant role on the degree of familiarity with ESV of the general public and decision-makers. In addition, our results showed that a majority of decision-makers had already used ESV in decision-making, and allowed us to document the various ways in which ESV is being utilized: frequency of use, types of utilization, types of management domain, subsequent influence (or lack of influence) on decision making. We were also able to develop several lists of specific real-world examples of ESV and its use in decision-making. Both populations saw the economic estimation of provisioning and regulating services as being mostly important. Both populations also highlighted several limits to the use of ESV, either related to inherent shortcomings or to the way in which it is/can be used by stakeholders.

In chapter 4, we showed on average that for both the general public and decision-makers, the priority in terms of assessing the consequences of a coastal development project go predominantly to the ecological assessment of marine biodiversity, and that ecological assessment indicators are globally preferred to economic values or socio-economic indicators. However, we also showed the existence of significant heterogeneity in both populations' preferences, both at the individual level and across different stakeholder groups. Our analysis showed that this heterogeneity was best explained in terms of five homogeneous latent sub-groups for both samples. Several socio-demographic and opinion factors were shown to influence the weights granted to the various valuation indicators by both decision-makers and the general public.

3. Main contributions

The thesis contributes to knowledge on several fronts. First, the results contribute to the development of non-market valuation techniques, and provide insights regarding the way in which economic valuation of ecosystem services can best contribute to decision making. Although we focused our applications on coastal and marine ecosystems, we stress that all methodological approaches developed in this PhD could be applied to other types of ecosystems and in other countries.

The work presented in chapter 1 contributes to the non-market valuation literature by (1) proposing a new pragmatic economic interpretation of non-use values which makes their estimation possible alongside use values; (2) developing a methodology to estimate these values through the use of choice experiments in variable institutional, socio-economic, cultural and environmental contexts, which is useful with regards to the application of benefit transfer; (3) being amongst the first contributions to quantitatively study individual preferences and associated utility curves for preservation over time (after the work of Scarborough and Bennett, 2008); and (4) critically examining the capacity for non-market valuation and the underlying standard theory of economic behaviour to deal with non-use values, and offering subsequent recommendations. With respect to the second point, our work provided WTP estimates for both European and indigenous coastal populations characterized by an important diversity of income. It also contributed to fill gaps that have been pointed out in the non-market valuation literature applied to coastal and marine ecosystems (O'Gara, 2009). With respect to the third point, our work proposes an innovative application of the choice experiment literature where it has been argued that more work using non-linear utility functions is needed (Hoyos, 2010).

The work presented in chapter 2 also significantly contributes to the choice experiment literature by proposing the first thorough analysis of payment non-attendance using different modelling approaches, and comparing their results in terms of the credibility and performance of welfare estimations. It is the first study we are aware of that offers a methodology to explain and statistically quantify the effects of socio-demographic or socio-economic factors on the probability of attendance or non-attendance to the payment attribute. In this respect, the result concerning the significantly higher attendance to payment from the New Caledonian indigenous population is especially interesting. Finally, this chapter also provides an in-depth comparison of stated and inferred attendance, which is an issue that has been recently pointed out as needing further research (Scarpa et al., 2012).

The case study application also contributes to the almost inexistent economic valuation work in New Caledonia, with the production of the first WTP estimates for preserving New Caledonian coral reefs and associated ecosystems. No previous studies in the area had been undertaken, to our knowledge.

The survey work presented in chapters 3 and 4 is the first we are aware of aimed at providing a broad-scale, comparative description of the perceived usefulness and of the utilization of ESV in decision making applied to marine ecosystems preservation in Australia, and one of the first studies of this internationally. We argue that this work provides decision-makers and economic valuation practitioners with valuable results regarding the extent to which economic valuation is used in decision-making processes. Our results provide a better knowledge of the need and demand for economic valuation by individuals involved in decision-making processes. It also enhances the capacity of academics and practitioners to deliver useful ESV results. In addition, the AHP approach we used is the only one we are aware of that explicitly allows quantitatively assessing the relative preference for ESV and other commonly encountered ecological and socio-economic evaluation criteria in a broad coastal and marine management context. We believe it provides interesting insights regarding information demand by decision-makers when faced with different management evaluation criteria (ecological, social, economic). Lastly, we argue that comparing the perceptions and preferences of the general public and decision-makers regarding the importance of economic valuation ultimately benefits both populations as this contributes to an improved knowledge of individuals' expectations regarding decision-making, and vice versa.

4. Implications for policy and research

4.1 On the estimation of robust non-use values and their relevance for decision-making

Non-use values are often perceived as the most compelling reason for ecosystem preservation (Chan et al., 2012), as well as playing an important part in wellbeing. As such, they are often presented as key values to measure, or at least as values for which more economic valuation work is needed (e.g. Barbier, 2012; Laurans et al., 2013a). Both applications conducted in this PhD confirmed the first point: in New Caledonia as well as in Australia, the most important stated reasons behind coastal and marine ecosystem preservation were linked first to bequest then to existence value, and biocentric values (on average, use values only arrived in third or fourth position on the list of most important reasons). Nevertheless, there are still several major issues associated with the estimation of non-use values, as discussed in chapter 1.

Foremost of these issues is that of attribute non-attendance. In a more general perspective, we argue that both the incommensurability of some dimensions of the non-use values concept and hypothetical bias linked to the often hypothetical nature of the scenarios (e.g. in a stated preference method involving WTP for a good or service that is not and will not be be used) or the rather conceptual framing of questions (e.g. in stated decomposition approaches) that non-market valuation would usually involve when estimating non-use values, may weaken the reliability of the estimates obtained. Both issues must be seriously considered before and during any valuation work. Attention should be paid in particular to the possible issue of payment non-attendance.

To date, most of the focus of non-market valuation research has been on improving the econometric techniques and measurement approaches. While this has been important in order to increase the credibility of such values, it is also necessary to consider who would use such values, in what way, and in what context. In particular, with respect to non-use value estimates, what is their perception by decision-makers? What influence do these estimates have in practice? Besides, is it really relevant to distinguish quantitatively between use and non-use values once a value has been estimated in a decision-making context?

To an economist, in principle, examining and quantifying non-use values should be important, especially in cost-benefit analyses frameworks. However, in practice, decision-making contexts might not be conducive to this type of application, and decision-makers might also be sceptical about the estimates produced (especially in view of the fact that a significant part of the academic community is).

The context of the New Caledonian survey is interesting with respect to this issue. This valuation study took place within a broad total economic valuation exercise focusing on coastal and marine ecosystems in New Caledonia, conducted for the French government under the IFRECOR program, and as part of other similar valuation studies concerning a number of French overseas territories. These total economic valuation studies were clearly motivated by a communication and advocacy perspective, that is to say in order to get detailed quantitative figures of the substantial economic values generated by coastal and marine ecosystem services in French overseas territories that could be used to alert other stakeholders, justify the need for more resources or justify budget allocations towards management and conservation. As such, our survey was carried out to respond to a demand from the French government, rather than for New Caledonia's local institutions. These actually showed a strong scepticism about the usefulness of quantifying such values (and about the robustness of any WTP values), and based no expectations on these value estimations. This illustrated a conflict of scale, in terms of the demand for valuation and the interest placed on the estimation of Non-Use Values. When delivering the results of our study (Marre and Pascal, 2012) to local institutions and decision-makers in New Caledonia, most people agreed on the interesting nature of the experiment but were sceptical about any possible use in practice of such estimated values, even in terms of communication or advocacy. In short, even though there was a demand from local decision-makers for the collection of information regarding the non-use values held by the New Caledonian populations, they were globally not interested by monetary measures, mainly because they did not see the potential utilization they could make of such values. In comparison decision-makers showed much more interest in the direct and indirect use value measures identified within the IFRECOR program in New Caledonia (Pascal, 2010).

Our research work in Australia presented in chapters 3 and 4 also contained some interesting results with respect to these questions. First the measurement of non-use values was not perceived as important by decision-makers and the general public: in fact, the majority of respondents in both populations saw the importance of economic measures of non-use values as low or medium, in comparison with other values associated with ecosystem services. In addition, a majority of decision-makers attributed a low level of trust to the measurement of non-use values. Even if these observations related to the coastal and marine management context, we argue that they might reflect broader concerns that could relate to all kind of ecosystems.

Therefore, taking stock of both applications, it seems that although non-use values are perceived and acknowledged as crucial motivations for ecosystem preservation, their quantification in monetary terms is not necessarily perceived to be of primary importance. However, one could argue that this might be due to lack of knowledge regarding such economic values, and the associated estimation methods (e.g. Rogers et al., 2013).

All in all, our answer to the previously raised issues is somehow ambivalent. Non-use values definitely represent values that policy makers or stakeholders as well as any scientific disciplines that aim at supporting decision-making have to consider very seriously, regarding both users and non-users of any ES. Besides, when some uses cause degradations of the ecosystems, ignoring non-use values may imply a sub-optimal allocation of the ecosystem services, and a potential loss of welfare. Whether or not the measurement of NUV in monetary terms is perceived as necessary, we argue it must not be considered as sufficient in a decision support context in view of the multidimensionality of these values (Chan et al., 2012). In order to gain a better understanding of this problem, it would be interesting to ask decision-makers or stakeholders themselves about the extent to which they would consider such values in their decision-making, and through which descriptors, before such valuation exercises are undertaken.

4.2 The role and use of economic valuation of ecosystem services in decision-making

Beyond the specific question of NUV estimation and subsequent utilization, our research showed that, in general, the economic valuation approach was largely perceived as useful and even necessary to support coastal and marine ecosystem management in Australia, and was used in various ways, although not so often.

As several authors suggested (e.g. Pendleton et al., 2007; Rogers et al., 2013; Waite et al., 2014), an important way to foster ESV utilization by the various stakeholders involved in decision-making processes is to continue increasing the availability of high-quality ESV studies (e.g. through the use of valuation database, and quality and relevance assessment of accessible ESV works) and developing collaboration between ESV practitioners and decision-makers. We argue that better collaboration implies: (i) for decision-makers, to make their information needs explicit; and (ii) for ESV practitioners, to provide clear information about available methodological tools to answer such needs, and about their strengths and potential pitfalls (e.g. assumptions of the valuation exercise). Potential lack of knowledge and misunderstandings about ESV and especially non-market valuation are important issues to focus on. More broadly, as discussed in chapter 3 of this PhD, continuing the development of decision frameworks and guidelines that would allow ESV to be more widely used is of paramount importance to insure it usefulness and utilization. A good example of this is the new guidebook from the World Resource Institute about the valuation of CME in the Caribbean (Waite et al., 2014), where key enabling conditions to ESV uptake by decision-makers are presented.

In view of some comments from decision-makers in our Australian surveys and based on our experience regarding the economic valuation works conducted in New Caledonia, we agree with several authors that ESV practitioners should always be concerned about ESV not becoming "an end in itself" (Spangerberg and Settele, 2010; Lopes and Volteira, 2013): the main raison d'être of ESV is to support decision-making and to help evaluate the achievement of clearly defined management objectives. Although one could argue that any ESV work that does not answer a precise need in terms of management can be useful in any case, as a communication or advocacy tool or even for strictly academic purposes, we think that advocacy should not be the main motivation of ESV.

Our work also highlighted that the role of ESV is to be considered in relation to other assessment indicators, in order to articulate the different biophysical, economic and socio-cultural value domains (Martín-López et al., 2014). When assessing the consequences on CME from development projects, our work showed that ecological indicators are given priority in comparison to economic or socio-economic indicators. Ecological assessment indicators might have been perceived as providing the most "objective" information, or as the criteria guaranteeing that desired level are reached for economic and socio-economic indicators on the long run: economic and socio-economic indicators might have been perceived as depending on the ecological indicators, the later reflecting more the importance of ecological processes behind the delivery of ecosystem services (de Groot et al., 2010). Therefore, in the context studied in this research, the ecological discourse seems to still be strongly established when dealing with the value of ecosystems and biodiversity, as has been recommended by several authors (e.g. Spash and Aslaksen, 2012).

Our conclusions support the claim that integration of various value domains and associated assessment indicators is necessary for managing ecosystem services (Martín-López et al., 2014). Examples of such integrated valuation frameworks include the one proposed by Maynard et al. (2014) in the case of regional ES valuation; or that suggested by Lopes and Videira (2013) in the case of coastal and marine ES valuation. Such integrated frameworks allow dealing with three levels of complexity: complexity of the ecosystem processes and functions; complexity of the economic and socio-cultural interactions between humans and the ecosystem; and complexity of the valuation process, which is influenced by institutions. More broadly, when planning for a management-driven valuation approach, we argue that one must clearly identify in chronological order: (1) the management objective(s) or issue(s) that need to be dealt with, as well as the various management actions that could be taken; (2) the values or changes in values that would need to be assessed with respect to such objectives; (3) the beneficiaries of such values (as well as distributional issues); and (4) the most suitable metrics to assess these values.

With respect to the second point, a triage approach as proposed for example in the European VALMER project[53] is useful to determine where best to focus effort in valuation case studies: what are the changes of values that are worth assessing with respect to several criteria such as the significance of the change in values, the costs of the valuation approach, the dependency

[53] http://www.valmer.eu/wp-content/uploads/2013/08/Valmer-summary-recommendations_Final.pdf

of such values to other factors, and the possibility of this change to be influenced by management actions.

The choice of the assessment methods (and metrics) is especially important, and in this respect several authors argued that ecosystem services assessment methods are actually value-articulating institutions in the sense that they do not simply reveal values but also participate in constructing them (Vatn, 2009; Martín-López et al., 2014). This is why we believe that considering various assessment methods is especially important when managing ecosystems in order to provide a set of indicators that are able to reflect the multiple dimensions of values. Multi-criteria analysis has been advocated to be a useful tool to cope with the choice and then trade-offs between various indicators in view of a specific management problem (e.g. Munda, 2007; Vatn, 2009). This was the main rationale of the last chapter of this PhD.

In addition, our work demonstrated the substantial lack of knowledge from the general public regarding ESV in the Australian context; and showed that populations were interested in critically reflecting on ESV and related issues after having been provided with minimum information. Therefore, we think that communicating and informing the populations about ESV objectives and results is essential to both guarantee a successful and informed participation of the populations in the decision-making process whenever necessary and a better transparency in decisions.

5. Limitations of the study

In the first part of this research we proposed a new approach to estimate non-use values in a context where individuals also hold use values, and we presented an interesting application in New Caledonia where we derived a minima but exclusive non-use WTP estimates. However, we were only able to derive monetary values for less than half of our sample, in view of a substantial cost attribute non-attendance. This raised an important concern in terms of the potential use of such results in decision-making or management: what could be said about individuals for whom we were not able to estimate any values? We were not able to distinguish precisely between the individuals for whom WTP cannot be derived due to true lexicographic preferences and individuals who did not consider the payment because of the framing of our choice experiment and its hypothetical nature. As such, this question cannot be answered precisely for our case study.

In order to get more reliable estimates of non-use values in our application, we could have applied the two-steps inferred attendance modelling approach that was found to work best in terms of WTP estimation in chapter 2. This would have reduced even more the number of individuals for whom these could be computed, and this would have had significant consequences on the values estimated, especially for the ZCO area where estimates were especially high in chapter 1. This would be an interesting possibility for further work, although we note that our main interest was not to derive absolute values but rather to estimate credible relative proportions of the non-use component in a total WTP.

With respect to the second part of this research and the Australian application, we highlighted several potential limitations in chapters 3 and 4. The main ones were: (1) the complexity of the different questions involved in the surveys in view of the respondents lack of knowledge or familiarity with ESV, which could have limited the reliability of some answers; (2) the representativeness of the decision-makers sample, which was hard to assess; and (3) the hypothetical nature of the AHP developed in the survey, which was perceived as too general by some respondents.

6. Recommendations for future research

The research identified several areas that require further investigation:

- In chapter 2, we hypothesized two very different reasons for attribute non-attendance: first this could be due to a hypothetical bias, second it could be due to some true non-compensatory preferences. The former refers to a methodological flaw (the credibility of our choice experiment approach), the latter relates to the issue of incommensurability. Identifying what are the main causes of payment non-attendance is an area for further consideration.
- We offered several possible ways to derive robust welfare estimates in view of the payment non-attendance issue, and compared them in terms of performance. We think more research work is needed in comparing modelling approaches both in terms of welfare estimates credibility and predictions when facing non-attendance issues.
- In terms of empirical application of ESV, our work in chapter 3 showed the importance of continuing the development of robust valuation methods to measure the economic values of regulating services in the case of coastal and marine ecosystem services such as storm protection, water quality regulation, or the role of habitats. This links with other

similar conclusions in the literature (e.g. Liu et al., 2010; Stoeckl et al., 2011; Barbier, 2012, Laurans et al., 2013a).

- A substantial part of this work focused on the issue of ESV utilization in coastal and marine management decision-making. As other authors, we argue in conclusion of this research that much more work is needed in that direction (e.g. Laurans et al., 2013b; Rogers et al., 2013), for various ecosystem services, worldwide and at different scales. This could take the form of broad surveys such as the one we proposed, face-to-face interviews, and in-depth grey and academic literature reviews. Furthermore, collecting precise real-world examples is especially important as it can contribute to a better understanding of the use of ESV in the decision-making process. This is important to identify the type of decisions for which ESV can inform the decision-making process and the role of the affected stakeholder groups. We believe all this would greatly help ESV in fulfilling its role to support decision-making and ES management, and help ESV practitioners to deliver results that are needed and useful.
- We noted in our literature review and in our Australian surveys that ESV was especially used as a communication and advocacy tool. An interesting further research direction in this respect could be to look at the impact of monetary value-based information on the preferences of stakeholders and compare it to the impact of other types of information.
- Participative approaches have been argued by many authors to be extremely valuable in integrated management frameworks (Vatn, 2009; Maynard et al., 2014) and this is reflected in various marine policies (Lopes and Videira, 2013). With respect to the participation of multiple stakeholders and the subsequent consideration of their preferences during decision-making via MCA or other deliberative methods, two important challenges arose during our research and are worth further research work:
    - The first is about representation, that is: how to appropriately represent a specific stakeholders group? This issue was first raised when scoping the population of decision-makers targeted by our surveys in chapter 3 and 4, and then when dealing with the latent heterogeneity of preferences and opinion in our AHP analysis.
    - The second is about the weight to place on the various stakeholders' preferences: if preferences and opinions substantially differ between stakeholders, whose preferences count most?

- Both the use of DCE and AHP in our surveys raised the issue of cognitive burden for respondents. This is a common and significant issue, for those who want to conduct stated preference valuation techniques, or for those who want to quantify the relative importance of various criteria in a complex management problem. While continuing developing powerful statistical methods to increase the robustness of both models and welfare estimates, future research might also seek to focus on ways to cope with this issue, such as developing simpler methods to elicit values, or coupling existing methods with more participatory or informative approaches. This implies examining whether such methods would actually be capable of generating estimates that are comparable to and more reliable than those derived from more complex techniques.

7. Final comments

All in all, this PhD examined some key issues that arise when considering the economic values of ecosystem services. The multi-dimensional aspect of ecosystem services and associated values as well as the trade-offs between these dimensions and various decision objectives were discussed and illustrated through two applications focusing on coastal and marine ecosystems. These ecosystems, as many others, are increasingly threatened with alarming degradation. The services they provide are the cornerstone of human survival and wellbeing. Urgent and effective actions are thus needed, but often face substantial challenges. These can be answered through the articulation of the various existing ecosystem assessment and valuation methods, and the development of adapted institutional settings.

Appendix A: Brief history of the neoclassical framework of environmental valuation

A brief look at the historical development of environmental valuation is insightful, and necessary in order to understand the economic theory underlying it.

It is essential to note that environmental valuation is initially and fundamentally motivated by a cost benefit analysis perspective. As such, environmental economics is deeply rooted in the theoretical body of neoclassic welfare economics. Among others' contributions in the 1930s and 1940s, welfare economics as we currently know it was established by Hicks (1939, 1943), Kaldor (1939) (Pearce, 2002). Those two contributions also offered the base to the Willingness-To-Pay (WTP) or Willingness-To-Accept (WTA) concept, through the definition of compensating or equivalent variations/surpluses[54]. The "hypothetical compensation test" of Kaldor (1939) and Hicks (1939) remains the standard CBA decision rule used by economists today, namely that interventions (policies, change in quantity/quality) could be evaluated in terms of their costs and benefits, with costs and benefits defined in terms of human preferences and WTP. More precisely, this test states that a specific intervention/change is recommended if the sum of the compensating or equivalent variations or surpluses for all affected parties is greater than zero, which means the winners could potentially compensate the losers and everyone would be at least as well off as before. If compensation did take place, then this would represent an actual Pareto improvement, although the general Kaldor-Hicks criterion for a welfare enhancing project is that benefits exceed the costs, and actual compensation is only hypothetical, i.e. it is necessary only that it could take place. In short, changes in well being arising from a project should be accounted for and included in a CBA.

When those projects imply any environmental changes, subsequent estimations of variations in surplus have to be computed. This is the starting point of environmental valuation methods and techniques developments, which aimed at correcting the fact that the welfare changes associated with changes in the availability of non-marketed goods could initially not be estimated, in order to properly account for all costs and benefits. All this should also be linked

[54] Compensating variation refers to the amount of additional money (or income) an agent would need to reach its initial utility after an intervention (e.g. a change in prices, or a change in product/goods/services quality, or the introduction of new products…). Equivalent variation is the amount the household/agent would be willing to pay, or by which it would need to be compensated, in order to avoid having the intervention take place. Compensating/equivalent surplus are defined exactly the same except that quantities are held fixed.

to earlier insights such as the concept of externality (producing suboptimal levels of human wellbeing), encountered for example in Pigou's work back in 1920 (Pigou, 1920). One of the first objectives of environmental valuation becomes very clear: accounting quantitatively for externalities concerning the environment in support of decision-making. As such, it was mostly in the 1960s that environmental economics truly came of age, where several academic works focused on warning and accounting for pollutions (Pearce, 2002). As Pearce (2002, p. 66) notes, "two of the triumphs of environmental economics have been to emphasize the incompleteness of [CBA] appraisals that omit environmental change and to develop the means of incorporating environmental values into appraisal". The ability to measure these goods in such a quantitative way provides the opportunity to directly compare their value against environmental costs or the value of other goods and services.

Within this theoretical framework, environmental changes are thus considered at the margin in order to determine their consequences on human welfare: change in quality or quantity in environmental goods (considered as substitutable goods) either implies change in the benefits associated with human activities or change in costs of those activities. Environmental valuation is therefore grounded within the traditional economic production models, with marginal changes in costs/benefits associated with changes in supply/demand, involving changes in producer surplus, defined as net rent in this case, and changes in consumer surplus i.e. the amount of welfare the consumer receives over and above the price paid in the market, thus in comparison with his WTP. It should be noted here that in the case of a private good, this WTP would include the actual payment or the good (at market price) and the consumer surplus – which is the additional value of the WTP after consideration of the price, or the net gain to the individual who purchased the good (Pearce et al., 2002). In the case of public goods where there is no actual price paid for the good, [55] the entire WTP is the consumer surplus or net gain. This concept is illustrated diagrammatically, at the equilibrium, in Figure A1. Environmental changes are thus considered through changes in producer and consumer surplus. It should be noted that this is only a simplified representation of reality, as there are evidence that environmental goods or services are only substitutable until a point, implying great difficulties to compute proper demand curves (Costanza et al., 1997).

[55] Though costs associated with the good can be factored in as a price in some circumstances, for example, the cost of driving to a national park.

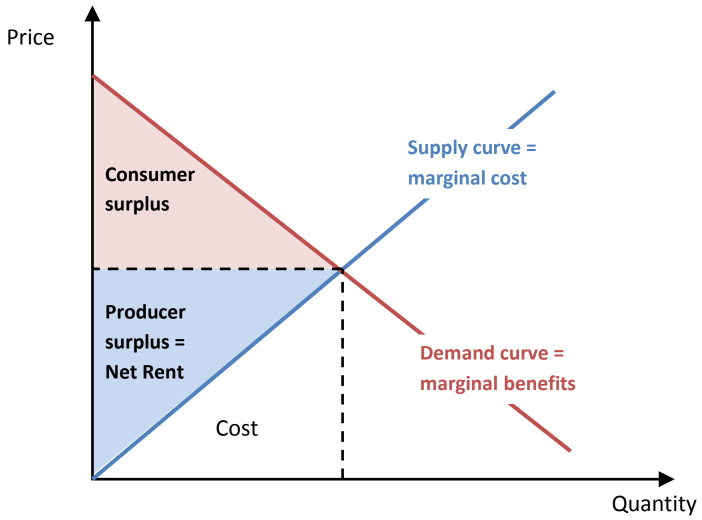


Figure A1 Consumer and producer surplus

Methods for environmental valuation date back to the end of the 1940's (Adamowicz, 2004), which involved the first non market valuation suggestions or discussions (e.g. travel costs methods with Hotelling, 1949 and stated preference techniques with Ciriacy-Wantrup, 1947) with the aim of estimating values, in specific currency terms, of public environmental assets with no existing price within the market. From then on, continuous and progressive development and application of methods for estimating individuals' values for environmental changes, based on revealed and stated preferences (see Appendix B below for a detailed presentation of the methods) were undertaken.

It is therefore crucial to highlight that economic valuation of environmental features is thus originally grounded in a system of optimal allocation in a near-to-equilibrium framework (welfare theory), and based on the well-known set of axioms which constitute the neoclassical theory of rational consumer behaviour (constrained maximization of utility or profits), where the consumer becomes *Homo economicus*. As discussed before, the classic approach to the theory of consumer demand has been initiated by Hicks in 1939, developed by Samuelson in 1947, with an axiomatic approach further developed by Arrow and Debreu in the 1950s (van den Bergh et al., 2000). It is important to note that further theoretical developments (such as game theory and rational expectations, for example) have enriched the standard paradigm. Preferences are referred to here in the sense that they determine whether or not the good impacts on the individual's wellbeing, and hence the value an individual holds for the good (Pearce et al., 2002): typically a benefit to a person is measured in terms of the individual's WTP for the good, or their WTA some form of compensation if they must forego the good (Bateman et al. 2002). Alternatively, if an individual has a negative preference for the good, or public bad, its value is measured according to the individual's WTP to avoid the good or WTA compensation for the good to remain.

In short, the modern theory of consumer behaviour on which environmental valuation is based starts from this notion of "consumer preference", to which "rationality" conditions are imposed, thus forming the theory of choice (Varian, 1992). Rationality is regarded as consistent maximization of a well-ordered function and the main requirements are that preferences are complete and transitive (van den Bergh et al., 2000). The common encountered set of assumptions (or axioms) underlying preference relations is presented below (and should be born in mind since most economic valuation work is based on those assumptions):

- "Completeness", i.e. for any pair of bundles the consumer is always able to express a preference or indifference relation;
- "Reflexivity": any bundle is preferred or indifferent to itself;
- "Transitivity" which is a consistency requirement (e.g. if a is preferred to b, and b to c, then a must be preferred to c);
- Invariance of preferences;
- Continuity i.e. complete substitution between goods is always possible;
- "Monotony" (weak or strong) i.e. the bundle with more good is preferred (this is subject to non-satiety). This implies well-ordered preferences;
- "Non-satiation" i.e. one consumption bundle is always preferred to another if it has more of one good and equal amounts of all other goods;
- "Convexity of preferences" i.e. indifference curves associated with particular levels of utility for a given utility function are convex (which means that the consumer is supposed to have a preference for diversity).

In a different perspective, environmental economics and the associated issue of non-market valuation can also be seen as an extension of natural resource economics (e.g. Hotelling, 1931). As a focus on exhaustible and renewable natural resource economics developed (e.g. fisheries, with the major contribution of Gordon, 1954), mainly with respect to the optimality of uses, transfers of methods and theoretical models supported environmental economics' progress, which progressively became a major economic sub-discipline in its own. Those developments also laid the foundations of what would later become Hardin's "tragedy of the commons" in 1968.

Further expansion in environmental economics also appeared with the interest in larger scale economic growth models, initially motivated by Boulding's 1966 "spaceship Earth" essay, where Earth is viewed as a finite source of energy, water and materials, thus justifying careful attention to the maintenance of stocks of assets, for example through re-use and recycling. This essay thus introduced the basis of what would then be presented as the sustainable development concept, with a first emphasis on the crucial role of knowledge and technologies to achieve this goal. Further economic growth models accounting for resource endowments gave similar conclusions: the systems optimality might require significant intervention or technological change. All this contributed to growing developments and interests regarding proposed instruments for achieving optimality, such as pollution taxes, or even Coasian bargains (Coase, 1960). This forms the basis of a second main objective of environmental valuation: to justify (e.g. CBA) and help (e.g. price setting) setting up such instruments. At the same time, Boulding's work also raised the idea that human capital formation cannot compensate assets' stocks depletions, thus making technological change and growth possibly unable to escape from Earth spaceships limits (see section below for the parallel development of ecological economics).

In the 1980s, important developments of environmental economics and the initiated switch from a microeconomics perspective to a more macroeconomic one (Azqueta and Sotelsek, 2007) continued with the introduction of the sustainable development concept (Brundtland, 1987). Important efforts were thus engaged in order to build a proper economic approach to sustainability, giving birth to "the welfare economic theory of green national accounts" (Dasgupta, 2009). Pearce and Atkinson (1993) were the first to employ basic intuitions concerning assets and sustainability, owing much to theoretical contributions by, for example, Solow (1986) and the asset accounting study of Repetto et al. (1989). They argued that sustainability required non-declining values of all assets of an economy including natural resources. Consequently, changes in asset values, measured by net saving, should signal whether an economy is on a sustainable path. The stock of all natural assets (i.e. natural resources, lands and ecosystems) was designated by the generic term Natural Capital. A significant part of environmental valuation then focused on developing tools related to Natural Capital valuation and green national accounting (Azqueta and Sotelsek, 2007). Thus, at a macro level, environmental valuation objectives become to estimate the quantitative contribution of natural assets to national/regional economies, as well as the quantitative impacts of their consumptions within an economic sustainability framework (e.g. World

Bank's work "Where is the Wealth of Nations?" in 2006).

In parallel to all this, environmental valuation methods based on neoclassical economic theory were continuously developed and theoretically refined (e.g. progress on taking into account uncertainties), as well as more and more world-widely applied. Indeed, economic valuation became one of the most significant and fastest evolving areas of research in environmental economics (Turner et al., 2003). Since Hotelling's first contribution, hundreds of travel cost studies have been carried out, mainly, but far from exclusively, in the United States, where various pieces of legislation have required that the benefits of natural sites be demonstrated (Pearce, 2002), with techniques extended to cover benefit estimation in the context of multiple recreational sites. In addition, another revealed preference method, the hedonic price approach, was developed and increasingly employed, this time applied to market goods (such as land and housing) in order to derive preference for non-market ones. Similarly, Stated Preference Methods (aiming at estimating WTP or in less cases WTA) theory and applications developed rapidly, especially after the well-known Exxon Valdez case in 1989 (Carson et al., 1992), mainly through the use of the traditional Contingent Valuation Method and the more recent Choice Experiments Method (Carson et al., 1999). In view of the growing number of applied valuation studies and subsequent estimated values, other techniques relative to environmental valuation were also developed such as meta-analysis and benefits transfers.

By 1997, enough data were available to allow Costanza et al. to develop a rough estimation of the value of the world's ecosystem services and natural capital, giving rise to numerous concerns and to the identification of needs of further research. Furthermore, in the last few years several initiatives have studied global environmental problems in economic terms and conducted global cost-benefit analysis. Some relevant examples are the Stern Review on the Economics of Climate Change (Stern, 2007) and the Postdam Initiative – Biological Diversity 2010. The project Economics of Ecosystems and Biodiversity (www.teebweb.org), arising from this initiative, aimed at estimating the costs of ecosystem services-decline from inaction to halt global biodiversity loss (TEEB, 2008).

All in all, we can conclude that economic valuation was developed within the neoclassic environmental economics literature as a tool that provides different methods to value the impact on social welfare of changes in the flow of goods and services that the natural environment (or more recently referred as biosphere) offers to humans, directly or indirectly, at different scales: from the individuals' values perspective to the natural capital valuation.

This is all based on a utilitarian argumentation that rests upon societal dependence on natural ecosystems (Gómez-Baggethun et al., 2009), although with environmental economics, technical changes or economic growth can theoretically compensate for their degradation. Environmental valuation was thus designed to inform decision making about individuals or aggregated social values expressed in monetary terms, in a cost-benefits analysis perspective, as well as to help the design of specific economic instruments such as environmental tax or more recently tradable permits. Expressing values as a monetary measure is seen as a convenient way to represent these values through a single, simple and common quantitative language. In short, the idea is to use the logic of markets to cope with environmental problems.

Finally, in order to put things back into their context, it is worth noting that the expansion of economic valuation is also linked to increasing knowledge from ecology and other sciences (informatics, physics, mathematics and all kind of modelling developments). It is also necessary to recall that all those efforts which conducted to significant methodological and theoretical developments arise mainly because of the growing concerns regarding human impacts on natural environment which eventually became a global environmental crisis: climate change, ecosystems degradations, biodiversity loss, and decrease in natural resource stocks. In relation to this, institutional changes occurred, involving evolution legislation and increasing demands from decision makers at different scale, from local to international. International and national commitments (e.g. Rio's Earth summit in 1992 with the Convention on Biodiversity, Conference of the Parties) emphasized responsibility towards the biosphere, and formed the starting point of several major international works and collaborations such as the Millenium Ecosystem Assessment (2005) regarding the management of ecosystems. All this contributes greatly to environmental valuation justification and practices.

Appendix B: Typologies and methods

The total Economic Value typology is presented in Figure B1.

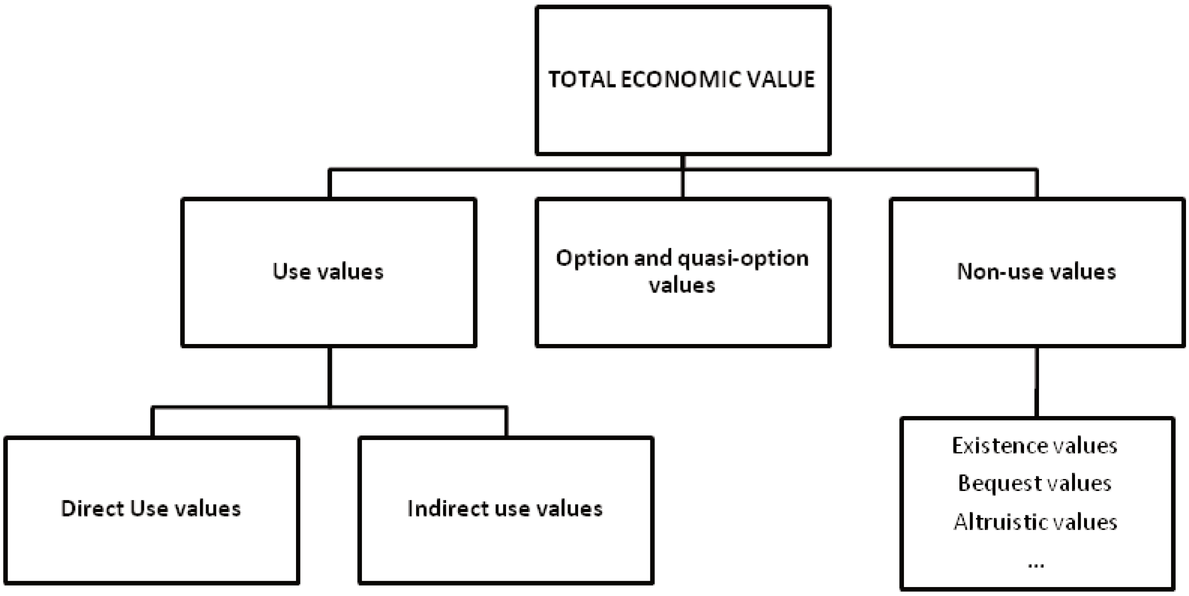


Figure B1 Conceptual hierarchy of total economic value

The second category of typologies concerns the Ecosystem Services valuation framework. An example, adapted from Balmford et al. (2011), is given in Figure B2.

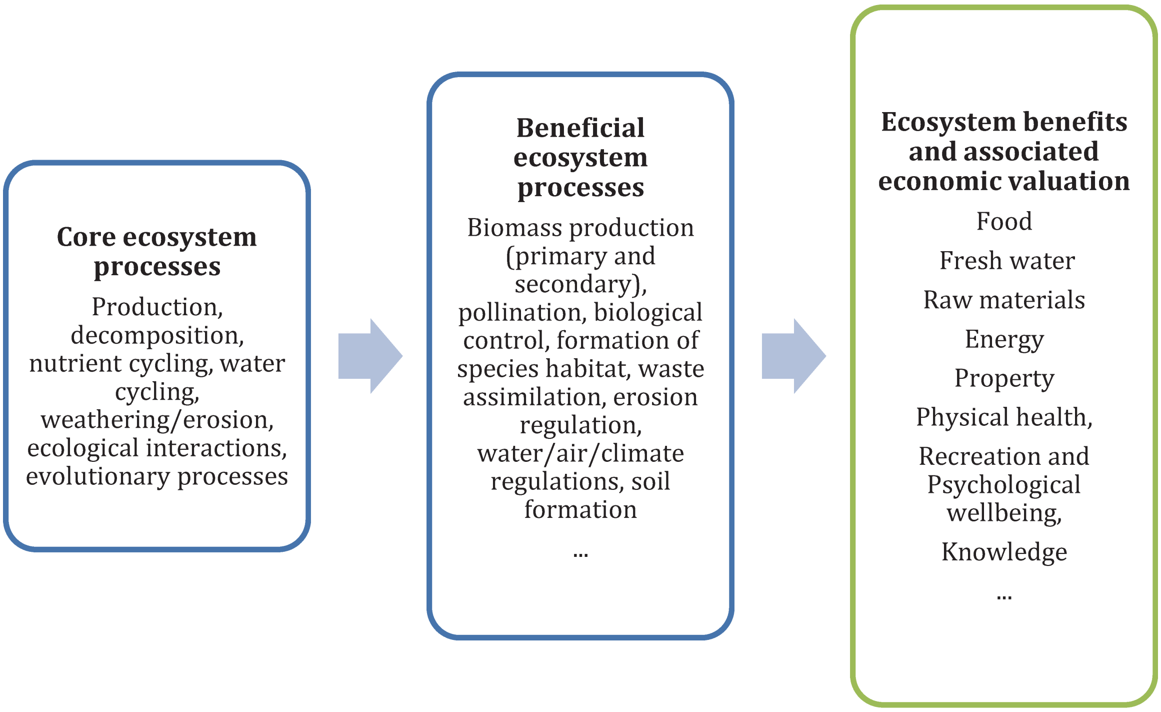


Figure B2 Ecosystem services valuation framework

Each group of values associated with benefits can be quantified in monetary terms using several techniques and methods, which can be broadly grouped into two categories: revealed preference (RP) methods and stated preference (SP) methods. RP approaches include (Liu et al., 2010):

- Market methods (also known as Adjusted market prices): For goods traded in markets and hence that have prices, examining the reaction of demand to observed variations in prices allows estimating WTP (e.g., timber harvest, seafood product). Adjustments need to be made for distortions arising from imperfect (non-competitive) markets, policy interventions (e.g. taxes and subsidies), etc This allows the analyst to estimate consumer surplus and thus values (mostly direct or indirect use values).
- Productivity (or Dose-Response) approaches: ES values are assigned from their impacts on economic outputs (e.g. increased shrimp yields from an increased area of wetlands). Indeed, ES often provide the factors of production required to produce marketed goods; this requires however that production functions relating inputs to the output of goods can be estimated and the contribution of individual services assessed.
- Travel cost methods: Valuations of site-based amenities are implied by the costs people incur to enjoy them. This is typically applied to recreation sites, for example, parks and beaches, where although there may be no cost associated with entry to the site there will be costs associated with the purchase of private goods to get to the site (Garrod and Willis 1999), and possibly the opportunity cost of time (this is a debated issue). These purchases commonly involve a transport cost (e.g. fuel). A demand curve (usually a downward sloping demand curve since costs increase with distance) is derived by accounting for the costs involved with the distance to travel to visit the recreation site, as well as the number of visits made by individuals.
- Hedonic pricing methods: The value of a service is implied by what people will be willing to pay for the service through purchases in related markets, such as housing markets (e.g. what is the impact on real estate's prices of a beach view from a house). Thus it relies on the complementary nature of certain private and public goods that can be tied together in particular situations, using the concept of amenities. The assumption behind this is that as the amount of amenities increases, the demand for the private good will increase and this will be observed through the market (Freeman 2003). Using consumer theory, the analyst can determine for example how a buyer's value for a house depends on a range of attributes (house's physical characteristics,

the socio-economic characteristics of the surrounding neighbourhood, and amenity values) and levels of those attributes (Garrod and Willis 1999), and by considering the broader housing market, isolate the value derived from the amenity component.

The last two methods (Travel Cost and the Hedonic Pricing) are certainly the most commonly used methods.

The second type of approaches, namely SP methods, include (Adamowicz, 2004):

- The Contingent Valuation Method (CVM) where people are directly asked their willingness to pay or accept compensation for some change in ecological services (e.g. willingness to pay for preserving a specific species) (Carson, 2011);
- Discrete choice experiments (Hensher et al., 2005) and conjoint analysis (Louvriere, Flynn and Carson, 2010) where people are asked to choose or rank different scenarios concerning ES or ecological conditions that differ in the mix of those conditions (e.g., choosing between marine protected areas scenarios with differing levels of green zone and fishery yields).

In addition to revealed and stated preference methods, other commonly employed approaches in ESV should be mentioned. The first are commonly referred to as cost-based methods:

- Replacement cost: The loss of a natural system service is evaluated in terms of what it would cost to replace that service (e.g. natural treatment of both water and specific pollutions by mangroves and sea grass).
- Avoidance cost (also known as Avoided damages): A service is valued on the basis of costs avoided, or of the extent to which it allows the avoidance of costly averting behaviours, including mitigation (e.g. coral reefs allow coastal protection against storms).

The second is benefit transfer, which is based on the adaptation of existing ESV information or data to new policy contexts that have little or no data, and thus estimate values in a far less expensive process. An example would be to use ecosystem service values obtained by tourists viewing wildlife in one natural park in order to estimate the ones from viewing wildlife in a different but similar park. An associated issue is the meta-analysis technique, which is a statistical analysis of results from multiple but similar empirical studies. In environmental valuation contexts, this can help determining what factors statistically influence values and thus better guarantee the success of benefit transfers. An example can be found in Brander et al., 2007, for the recreational value of coral reefs.

Appendix C: Limits, debates and the birth of Ecological Economics

- **Sustainability and Natural capital valuation**

As already stated, Boulding's article on "Spaceship Earth" (1966) put a new emphasis on resource limitations, followed by the Meadows et al. famous contribution in 1972 (Meadows et al., 1972). Though at a more fundamental level, this issue was then also raised by Georgescu-Roegen (1971) in his work on the implications of the law of entropy for the economic process, thus questioning the feasibility of economic growth in the long run, and suggesting a need of fundamental reform of economic development policy. This reinstated previous concerns relative to the size and growth of populations and the associated pressure on social, economic and ecological systems. In 1977, Daly established the concept of a steady-state economy, in the perspective of avoiding environmental disaster. This was echoed during the 1980's and 1990's in the discussions relative to the notion of weak versus strong sustainability. The issue at stake was whether there is perfect substitutability between the different forms of capital, including natural capital, strong sustainability supporters claiming that different capital stocks are complementary (it is thus not possible to substitute one stock in its totality by another one) and that natural capital displays specificities, such as thresholds or irreversible changes that imply a need to maintain critical stocks of natural capital. As Stern (1997) noted, substitutability in utility is a strong assumption, as certain environmental functions have obviously no human-made substitutes such as climate regulation or hydrological cycles. Weak sustainability supporters consider perfect substitutability between natural and man-made capital, mainly due to technological progress associated with economic growth. More broadly, in addition to the concern that endless economic growth is unsustainable both socially and environmentally, ecological economists have highlighted the need to recognize the role of all types of accumulated capital (natural and social) for well being and sustainability of the economy, environment and society (Holt and Spash, 2009).

Ecological Economics arose because of concerns regarding the interaction between the economic system and the ecological or biophysical process on which it is based. As discussed before, the response of mainstream economics to those initial concerns was the development of economic non-market valuation in order to account for externalities and the social costs associated with environmental degradation, within a cost benefits framework. But

Ecological Economics also stressed the fact that impacts of human activities and subsequent changes in the natural environment imply uncertainty (including irreducible ignorance or Knightian radical uncertainty), nonlinearity and possible irreversibility, in addition to a need to take into account longer time horizons (which gave birth to an important literature concerned with discounting issues in regards to ES). All this complicates severely the task of environmental valuation, which is sometimes perceived as being unable to deal with such complexity, even with recent methodological and theoretical improvements, hence implying the necessary use of additional indicators in support of decision making, alongside the CBA framework to capture the major issues at stake which economic valuation fail to capture. Recent criticism has also arisen concerning the Ecosystem Services valuation framework (e.g. Norgaard, 2010; Sagoff, 2011; Spash and Aslaksen, 2012), with a claim to re-legitimate ecological information in the decision-making and policy arena, for example through the use of ecologically based biophysical indicators (Spash and Aslaksen, 2012).

Furthermore, ecological economists also pointed out another issue concerning environmental values, namely the fact that they might often be incommensurable (O'Neill, 1993; Vatn and Bromley, 1994; Martinez-Alier, 1998) due to weak comparability (Martinez-Alier, 1998), thus suggesting the need of alternative decision making tools such as Multi-Criteria Decision Analysis (Martinez-Alier, 1998). It is worth noting here that this technique does not invalidate the use of environmental valuation in itself but simply allows for more criteria to be taken into account in a decision-making process. In addition to the incommensurability issue, emphasis has been placed on the ethical dimensions involved in environmental choices and the associated values (e.g. O'Neil, 1993; Mazzota and Cline, 1994; Vatn, 2000), in particular as regards the notion of intrinsic values (for further detail, see chapter 1 concerning non-use values).

- **Limits to the underlying model of economic behaviour**

The above developments also contributed to highlight some of the limits of the neoclassical standard behaviour model. Several works in ecological economics focused on this problem (e.g. Van den Bergh et al., 2000; Gowdy et Mayumi, 2001). Criticisms focused on several important points, of which we present a brief non-exhaustive list hereafter. A detailed review of these issues can be found in Van den Bergh et al., 2000. Firstly, methodological individualism on which the utility maximization principle underlying most economic valuation methods is based has been questioned in view of several arguments. A criticism focuses on the fact that aggregation of individual maximizing behaviour does not necessarily imply maximizing behaviour of the aggregate system (Hodgson, 1988), following Keynes' suggestion of "fallacy of composition", i.e. that the whole is not the sum of its parts (Van den Bergh et al., 2000). Another issue is based on the contrast between individual and social preferences: what a person as a consumer would do is not necessarily the same as what the same person would do as a citizen, i.e. the institutional-ethical-cultural context will influence individuals' decisions (Sagoff, 1988). A good example was found by Ackerman (1997) who argues that recycling can be considered a case of pure altruism or citizen behaviour (Van den Bergh et al., 2000). Other evidence can be found in Ostrom (2000) and Vatn (2005). As Vatn stated (Vatn, 2009, p.2208): "Choices are thus not simply about what is optimal for the individual — the 'I' rationality, they may also be about what is right to do in a certain institutional context. This is social rationality or 'We' rationality". Thirdly the rational capacity of individuals in itself has been discussed, with for example the concept of bounded rationality (Simon, 1957): the human mind is not powerful enough to account for all possibilities and knowledge involved in a choice situation in order to make a rational decision. This becomes especially relevant in the context of lack of crucial information. A final criticism concerns the fact that neoclassical economic utility theory is in contradiction with studies based on a human needs perspective and other insights of psychology (e.g. Georgescu-Roegen, 1966; Hodgson, 1988): for example a distinction has been made between lower (e.g. water) and higher (e.g. car) needs, where substitution and monotony axioms do not hold (no substitution is possible between lower and higher needs, and satiation exists). This created a new interest from ecological and environmental economics for an alternative approach based on lexicographic preferences (Gowdy and Mayumi, 2001), which can also be linked to the concept of hierarchy of needs (Georgescu-Roegen, 1966). This approach invalidates several neoclassical axioms, with the existence of satiation (monotony) and non-substitutability. An example is provided by Georgescu-Roegen (1966), who noted that "the second cocktail … may yield greater satisfaction than the first" (Georgescu-Roegen, 1968, p240), thus invalidating decreasing marginal utility. The "transitivity" axiom (i.e. consistency) was also showed to be invalidated by many empirical studies, based on stated preference methods. The development of experimental economics also led to invalidate several key assumptions underlying the neoclassical model of individual preferences, and provided evidence that individuals can demonstrate less free-riding behaviour than predicted on the basis of the neoclassical theory (e.g. Reeson and Tisdell, 2010).

- **Systems approaches to social-ecological interactions**

Another core concept in ecological economics thinking is the concept of resilience, as introduced by Holling (2001), which highlights the adaptability of ecosystems and their capacity to resist and handle external pressures. A number of attempts to value ecological resilience have been undertaken (e.g. Mäler et al., 2006). The concept of resilience has then been taken up in the study of social systems seeking to understand the capacity of socio-ecological systems to withstand external pressures and reorganize in the face of new challenge (Folke, 2006).

The notion of socio-ecological systems itself is central to Ecological Economics, and highlights the interconnections and dependencies between ecosystems and the economy. It allows to re-examine the question of Human’s relation to their environment, and challenge the traditional naturalist view opposing nature (defined as the “environment”) and culture/society, which has been extensively discussed in Philosophy, Ethics and Anthropology (e.g. Descolas, 2005). It also emphasizes the important interconnection between institutions and values. Ecological economists are also interested in how rights, power relations, legislation, communication and access to information influence access to resources (Martinez-Alier, 1987) as well as estimated environmental values such as monetary estimates based on contingent valuation (Vatn, 2004). As Jacobs (1997) stated, the way any valuation process is undertaken - the choice of value-articulating institutions (Vatn, 2009) - is seen in itself as influencing, which values will be emphasized and in which forms they may be expressed.

To conclude this section, we note that Ecological Economics did certainly not invalidate the use of environmental valuation, through all its criticism regarding its neoclassical foundations. In fact, this criticism contributed greatly to the development of valuation methods and approaches. However, it did raise some important concerns regarding the reliability of these methods (and the nature of the information they can produce), and challenged the idea of a decision-making solely based on CBA, with an emphasis on the multi-dimensionality of the value concept.

Appendix D: IFRECOR and New Caledonian economic valuation studies

The IFRECOR is a French national program (http://www.ifrecor.org/index.php), created in 2000 by the government by decision of the Prime Minister), in response of the International Coral Reef Initiative (ICRI) initiated in 1995 (**http://www.icriforum.org/**). The main goal of this program is to work for conservation and sustainable management of coral reef areas in French overseas territories. The IFRECOR is coordinated by a national committee composed of researchers, representatives for each of eight local committees (one for each French Overseas Territories), and decision-makers from the French Ministry for Ecology, Sustainable Development, Transports and Housing (MEEDDAT), from the French ministry of overseas territories and form local overseas governments. Its actions are structured into pre-identified thematic, one of which focuses on social and economic issues. The study conducted in this PhD was developed under this theme as it applies to New Caledonia, with a focus on the economic valuation of New Caledonian Coral Reef and other marine coastal Ecosystems (CRE). As such, it was conducted under both the approval of New Caledonian IFRECOR local committee (composed of several researchers from different disciplines, public decision makers, associations and NGOs), and the French national committee.

A first study was conducted in 2010 (N. Pascal, 2010) in order to estimate what the author of the study called the "global financial value" of CRE in New Caledonia. This work estimated the producer surplus regarding the use values derived from CRE services: fisheries (commercial, recreative and subsistence) and tourism (underwater, nautical and recreational). Economic values for indirect uses were also estimated: the services valued were Coastal Protection, Research and Education, as well as bio-prospecting.

Thus, this initial valuation exercise focused mainly on the estimation of added values generated by the ecosystem services supported by Caledonian coral reefs and associated ecosystems. As such, no general consumer surplus or WTP were estimated, nor were non-use values. This led to the funding of a second study, which aimed to:

- Estimate consumer surplus or general WTP for CRE in New Caledonia (which would be the first time this estimation is conducted in New Caledonia)
- Quantify non-use values for CRE in New Caledonia.

Given that the study was aimed at obtaining these measures for the New Caledonian population, the second objective was especially challenging, as New Caledonian populations are almost exclusively composed of people who use the coral ecosystem services in one way or another (i.e. direct and indirect interactions such as fishing, swimming, walking on the beach and aesthetic pleasure etc.). Of course, the non-use values of New Caledonian reefs are also partly held by people who do not live in New Caledonia and might never go there. For example, metropolitan French people, or even anyone in the world, could be willing-to-pay for preserving the New Caledonian coral reef and associated ecosystems given their world heritage status without any intention to go there. The study focused only on New Caledonian population since (1) it is the main population of interest for decision makers; (2) it raises new research challenges.

Furthermore, given the challenges of measuring non-use values for a very heterogeneous population mostly composed of users, and the academic objectives of developing a new framework for assessing them, we decided to focus on two coastal areas, that we believe could be representative of New Caledonian areas in terms of several contextual element, as mentioned in Chapter 1. In addition, both areas were especially interesting for local authorities in terms of management. Comparing results from our surveys in these two areas would also guarantee the possibility to study in further details the role of several contextual elements in the preference of individuals in these two areas and their associated WTP. Therefore, although this does not allow to satisfy the objective of deriving WTP and non-use values all around New Caledonia, it was seen as a compromise between the challenging objective, the experimental nature of the survey and the methodology developed, the limited budget and the need to control the accuracy of the results.

Appendix E: Tests of the experimental design

Table E1 Our design efficiency in comparison to other design (D-efficiency is computed as the ratio of design strength; Chrzan et Orme, 2000)

	Sawtooth Strength of design	D-efficiency (comparison with our design)
Full enumeration design: 6 choice sets versions with 8 choices (our design)	909.55	1,0
Alternative design: 30 choice sets versions with 8 choices	958.33	1,054 -> +5,4%
Random design: 6 choice sets versions with 8 choices	653.33	0,72 -> -38%

Table E2 MNL model outputs with simulated data

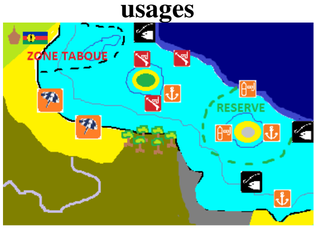
	Effect	Standard errors	t-ratio
Payment 500 CFP/month	0.029	0.038	0.777
Payment 1000 CFP/month	0.017	0.038	0.455
Payment 1500 CFP/month	-0.021	0.037	-0.581
Payment 2000 CFP/month	-0.025	0.041	-0.613
Progressive degradation of fished animals	-0.005	0.037	-0.142
Preservation Fished animals 20 years	0.009	0.037	0.233
Preservation Fished animals 50 years	-0.039	0.036	-1.098
Preservation Fished animals 100 years	0.036	0.038	0.945
Progressive degradation of Health marine life	-0.016	0.037	-0.416
Preservation Health marine life 20 years	-0.028	0.037	-0.755
Preservation Health marine life 50 years	0.009	0.037	0.231
Preservation Health marine life 100 years	0.035	0.038	0.928
Less natural areas	0.019	0.036	0.538
Preservation Landscapes 20 years	0.046	0.036	1.257
Preservation Landscapes 50 years	-0.048	0.036	-1.350
Preservation Landscapes 100 years	-0.017	0.037	-0.459
Areas of practice not guaranteed	-0.024	0.038	-0.634
Preservation Areas of practice 20 years	0.041	0.036	1.133
Preservation Areas of practice 50 years	0.0103	0.039	0.266
Preservation Areas of practice 100 years	-0.028	0.039	-0.712

Appendix F: Description of the attributes and choice set example

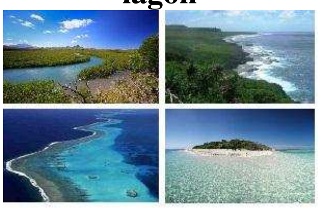
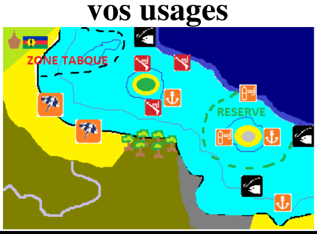
ATTRIBUTES	DESCRIPTON	LEVELS
Monthly Payment 	Compulsory monthly contribution for all the New Caledonian inhabitants. Several possibilities can be imagined for such a payment in practice, around two possibilities: - Part of a new environmental tax going directly to the Province - Specific contribution to an independent institution representative of the area's population and public institutions, in charge of managing local preservation *The **entire contributions** would be used in a **transparent** way to preserve over the time the following attributes, through different possible management measures. Each month, a part of the contributions could be secured (as a trust fund) in order to **guarantee the success of preservation over specific period of time.** A part of the money would be also used to **control polluting activities** or individuals that do not respect appropriate management measures or rules.*	0 CFP 500 CFP/ month (around 5 AU$) 1000 CFP/ month (around 10 AU$) 1500 CFP/ month (around 15 AU$) 2000 CFP/month (around 20 AU$)
Quantity of fished animals 	Total catches of fishes, crustaceans, mollusks etc. from the different fisheries (recreative, commercial, subsistence/traditional) on the area This total catch level can be sustained or not over the long term	Status Quo: Progressive decline Preservation for the next **20** years Preservation for the next **50** years Preservation for the next **100** years
Health and richness of marine life 	Global health of coral reefs, mangroves, sea grass, and associated species: - Water quality linked to human pollutions (urbanization and domestic pollution, pollution from industries and agriculture, erosion) - Quantity and diversity of different species of fishes, crustaceans, mollusks… - Quantity and diversity of corals, sea grass, mangroves' trees species + Presence of emblematic species such as dugongs, turtles, dolphins…	Status Quo: Progressive degradation Preservation for the next **20** years Preservation for the next **50** years Preservation for the next **100** years

Coastal and lagoon natural landscapes 	Preservation of the natural aspect of current coastal (mangroves, beaches, estuaries, bays) and lagoon (islets, reefs) landscapes facing economic development and growing populations Conservation of current wild and pristine areas	Status Quo: Less natural areas and more constructions Current coastal and lagoon landscapes preserved for the next 20 years Current coastal and lagoon landscapes preserved for the next 50 years Current coastal and lagoon landscapes preserved for the next 100 years
Areas of practices 	Preservation of areas and places (coast and lagoon) that you and your community are using for common activities: sufficient areas allowing you or your community to practice your activities in satisfying conditions (as perceived by the majority of the community) can be guaranteed or not over the future. Underwater fishing Scuba-diving and snorkelling Nautic activities and water sport Fisheries (recreative, commercial, traditional) Swimming and beach activities Taboo areas or Kanak traditional reserve	Status Quo : Sufficient areas of practice not guaranteed for future Sufficient areas of practices guaranteed for the next **20** years Sufficient areas of practices guaranteed for the next **50** years Sufficient areas of practices guaranteed for the next **100** years

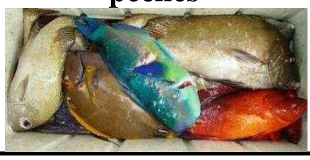
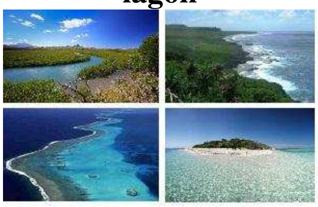
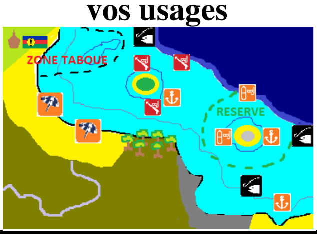
Choix n°1

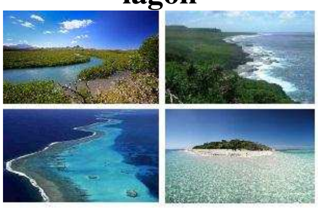
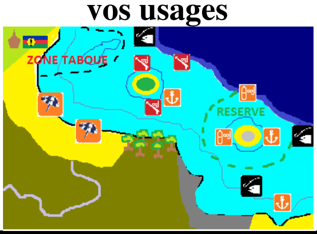
	Option 1	Option 2	Statu Quo : ce qui va probablement se passer si on ne fait rien
Paiement mensuel 	**2000 CFP / mois**	**1000 CFP/mois**	**0 CFP/mois**
Quantité d'animaux pêchés 	**Préservation pour les 50 ans à venir**	**Préservation pour les 20 ans à venir**	**Diminution progressive**
Santé et richesse de la vie sous-marine 	**Préservation pour les 100 ans à venir**	**Préservation pour les 20 ans à venir**	**Dégradation progressive**
Préservation des paysages côtiers et du lagon 	**Paysages actuels préservés pour les 100 ans à venir**	**Paysages actuels préservés pour les 50 ans à venir**	**Moins de zones sauvages et plus de constructions**
Espaces suffisants pour vos usages 	**Espaces suffisants pour vos usages pendant les 100 ans à venir**	**Espaces suffisants non assurés pour le futur**	**Espaces suffisants non assurés pour le futur**
Choix préféré	❑	❑	❑

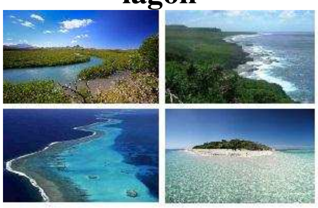
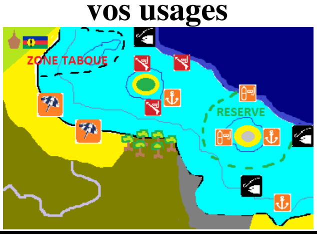
Choix n°2

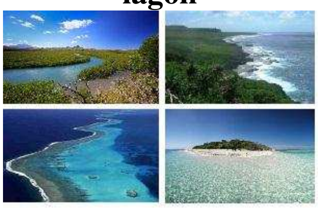
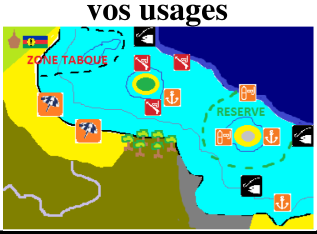
	Option 1	Option 2	Statu Quo : ce qui va probablement se passer si on ne fait rien
Paiement mensuel 	**1500 CFP / mois**	**500 CFP/mois**	**0 CFP/mois**
Quantité d'animaux pêchés 	**Préservation pour les 100 ans à venir**	**Diminution progressive**	**Diminution progressive**
Santé et richesse de la vie sous-marine 	**Préservation pour les 50 ans à venir**	**Dégradation progressive**	**Dégradation progressive**
Préservation des paysages côtiers et du lagon 	**Moins de zones sauvages et plus de constructions**	**Paysages actuels préservés pour les 20 ans à venir**	**Moins de zones sauvages et plus de constructions**
Espaces suffisants pour vos usages 	**Espaces suffisants pour vos usages pendant les 20 ans à venir**	**Espaces suffisants pour vos usages pendant les 50 ans à venir**	**Espaces suffisants non assurés pour le futur**
Choix préféré	❑	❑	❑

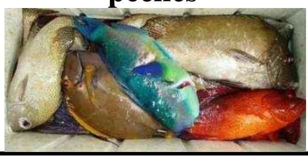
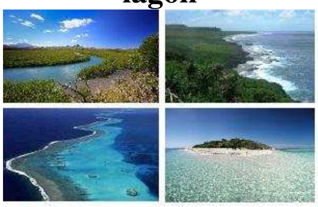
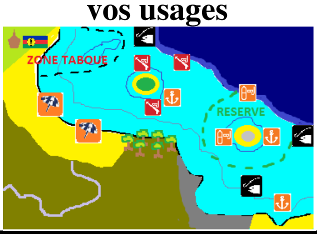
Choix n°3

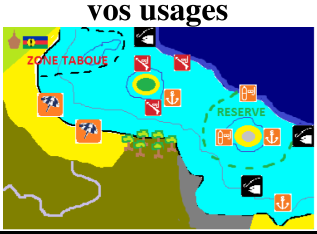
	Option 1	Option 2	Statu Quo : ce qui va probablement se passer si on ne fait rien
Paiement mensuel 	**500 CFP / mois**	**1000 CFP/mois**	**0 CFP/mois**
Quantité d'animaux pêchés 	**Préservation pour les 20 ans à venir**	**Préservation pour les 50 ans à venir**	**Diminution progressive**
Santé et richesse de la vie sous-marine 	**Préservation pour les 100 ans à venir**	**Préservation pour les 20 ans à venir**	**Dégradation progressive**
Préservation des paysages côtiers et du lagon 	**Moins de zones sauvages et plus de constructions**	**Paysages actuels préservés pour les 20 ans à venir**	**Moins de zones sauvages et plus de constructions**
Espaces suffisants pour vos usages 	**Espaces suffisants non assurés pour le futur**	**Espaces suffisants pour vos usages pendant les 20 ans à venir**	**Espaces suffisants non assurés pour le futur**
Choix préféré	❑	❑	❑

Choix n°4	Option 1	Option 2	Statu Quo : ce qui va probablement se passer si on ne fait rien
Paiement mensuel 	**1500 CFP / mois**	**2000 CFP/mois**	**0 CFP/mois**
Quantité d'animaux pêchés 	**Diminution progressive**	**Préservation pour les 100 ans à venir**	**Diminution progressive**
Santé et richesse de la vie sous-marine 	**Dégradation progressive**	**Préservation pour les 50 ans à venir**	**Dégradation progressive**
Préservation des paysages côtiers et du lagon 	**Paysages actuels préservés pour les 50 ans à venir**	**Paysages actuels préservés pour les 100 ans à venir**	**Moins de zones sauvages et plus de constructions**
Espaces suffisants pour vos usages 	**Espaces suffisants pour vos usages pendant les 100 ans à venir**	**Espaces suffisants pour vos usages pendant les 50 ans à venir**	**Espaces suffisants non assurés pour le futur**
Choix préféré	❑	❑	❑

Choix n°5	Option 1	Option 2	Statu Quo : ce qui va probablement se passer si on ne fait rien
Paiement mensuel 	1000 CFP / mois	1500 CFP/mois	0 CFP/mois
Quantité d'animaux pêchés 	Diminution progressive	Préservation pour les 50 ans à venir	Diminution progressive
Santé et richesse de la vie sous-marine 	Préservation pour les 50 ans à venir	Préservation pour les 20 ans à venir	Dégradation progressive
Préservation des paysages côtiers et du lagon 	Paysages actuels préservés pour les 100 ans à venir	Moins de zones sauvages et plus de constructions	Moins de zones sauvages et plus de constructions
Espaces suffisants pour vos usages 	Espaces suffisants non assurés pour le futur	Espaces suffisants pour vos usages pendant les 50 ans à venir	Espaces suffisants non assurés pour le futur
Choix préféré	❑	❑	❑

Choix n°6	Option 1	Option 2	Statu Quo : ce qui va probablement se passer si on ne fait rien
Paiement mensuel 	500 CFP / mois	2000 CFP/mois	0 CFP/mois
Quantité d'animaux pêchés 	Préservation pour les 100 ans à venir	Préservation pour les 20 ans à venir	Diminution progressive
Santé et richesse de la vie sous-marine 	Préservation pour les 100 ans à venir	Dégradation progressive	Dégradation progressive
Préservation des paysages côtiers et du lagon 	Paysages actuels préservés pour les 50 ans à venir	Paysages actuels préservés pour les 20 ans à venir	Moins de zones sauvages et plus de constructions
Espaces suffisants pour vos usages 	Espaces suffisants pour vos usages pendant les 20 ans à venir	Espaces suffisants pour vos usages pendant les 100 ans à venir	Espaces suffisants non assurés pour le futur
Choix préféré	❑	❑	❑

Choix n°7	Option 1	Option 2	Statu Quo : ce qui va probablement se passer si on ne fait rien
Paiement mensuel 	500 CFP / mois	1500 CFP/mois	0 CFP/mois
Quantité d'animaux pêchés 	Préservation pour les 50 ans à venir	Préservation pour les 100 ans à venir	Diminution progressive
Santé et richesse de la vie sous-marine 	Préservation pour les 50 ans à venir	Préservation pour les 100 ans à venir	Dégradation progressive
Préservation des paysages côtiers et du lagon 	Paysages actuels préservés pour les 50 ans à venir	Paysages actuels préservés pour les 20 ans à venir	Moins de zones sauvages et plus de constructions
Espaces suffisants pour vos usages 	Espaces suffisants pour vos usages pendant les 100 ans à venir	Espaces suffisants non assurés pour le futur	Espaces suffisants non assurés pour le futur
Choix préféré	❑	❑	❑

Choix n°8	Option 1	Option 2	Statu Quo : ce qui va probablement se passer si on ne fait rien
Paiement mensuel 	**2000 CFP / mois**	**1000 CFP/mois**	**0 CFP/mois**
Quantité d'animaux pêchés 	**Diminution progressive**	**Préservation pour les <u>20 ans</u> à venir**	**Diminution progressive**
Santé et richesse de la vie sous-marine 	**Préservation pour les <u>20 ans</u> à venir**	**Dégradation progressive**	**Dégradation progressive**
Préservation des paysages côtiers et du lagon 	**Moins de zones sauvages et plus de constructions**	**Paysages actuels préservés pour les <u>100 ans</u> à venir**	**Moins de zones sauvages et plus de constructions**
Espaces suffisants pour vos usages 	**Espaces suffisants pour vos usages pendant les <u>20 ans</u> à venir**	**Espaces suffisants pour vos usages pendant les <u>50 ans</u> à venir**	**Espaces suffisants non assurés pour le futur**
Choix préféré	❑	❑	❑

Appendix G: New Caledonian application questionnaire

Nom enquêteur : Code enquête : Jeu de choix utilisé :

Date enquête : ☐ Heure début : ☐ Heure fin : ☐

Lieu enquête : ☐

Introduction (présentée par l'enquêteur)

Bonjour, mon nom est …. Avez quelques minutes à nous accorder ? Nous réalisons un sondage pour l'IFRECOR, programme national qui réalise des actions en faveur des récifs coralliens et de leurs écosystèmes depuis 10 ans. L'objectif du questionnaire vise à déterminer certaines valeurs sociales et économiques de nos récifs puis à informer les instances locales (mairies, chefferies …) et internationales.

Ce questionnaire est anonyme, il vous permet de vous exprimer sur votre usage et votre perception des récifs coralliens, mangroves et herbiers … Il vous permet également de vous exprimer sur les enjeux de préservation du lagon *de la Zone Côtière Ouest/de la zone Voh Koné Pouembout*. Votre avis est primordial sur ce sujet. Le questionnaire dure environ 30 minutes

Question filtre:

(Enquêtes ZCO) Etes- vous résident de la Zone Côtière Ouest (La Foa, Moindou, Bourail, Farino, Sarraméa) ? *Oui* ❑ *Non (arrêt du questionnaire)* ❑

(Enquêtes VKP) Etes- vous résident de la Zone VKP (communes de Voh, Koné, Pouembout) ?

Oui ❑ *Non (arrêt du questionnaire)* ❑

Section 1: Informations générales

Q1 Origine de votre famille ? ZCO : ❑ VKP : ❑ Autre (Précisez): ❑ ____________________

Q2 Où-avez-vous passé votre enfance? Village ❑ ville ❑ Tribu ❑ Autre ❑ ____________

Q3 Quel est votre ville/village (et tribu) de votre résidence principale ?
Ville/village ____________ *Tribu* ____________

Q4 Quelles sont les raisons principales pour lesquelles vous vous êtes installés ici?
Raisons Familiales :❑ Vous avez grandi ici et y êtes resté :❑
Environnement (Lagon, plage, paysages) :❑ Loisirs :❑ Raisons Professionnelles :❑
Raisons Culturelles :❑ Autres ❑ ________________________

Q5 Pourriez-vous me dire ce qui vous paraît important ici parmi les facteurs suivants (notez de 1 à 5 selon l'ordre d'importance) ?

	Pas du tout important	Peu important	Moyennement important	Important	Très important
La sécurité et la tranquillité pour ma famille, mes amis et moi	1	2	3	4	5
Mes activités sur le lagon	1	2	3	4	5
L'accès aux services	1	2	3	4	5
L'éducation et l'accès au soin	1	2	3	4	5
Le développement économique	1	2	3	4	5
Mes sources de revenus	1	2	3	4	5
Les paysages	1	2	3	4	5
L'état de l'environnement marin et terrestre	1	2	3	4	5
Autre (Précisez :)	1	2	3	4	5

Q6 Possédez-vous un ou plusieurs bateaux dans votre foyer? *Oui :* ❑ *Non :* ❑

Q7 Si oui **Q6**, combien? ___________

Q8 Quels sont les usages (et leur fréquence en moyenne) que vous avez du lagon? Précisez quelle est votre activité principale si vous avez une (si hésitations entre plusieurs, cochez jusqu'à deux activités)?

Usage / fréquence	Activité principale	Jamais	Entre 1 et 5 fois par an	1 ou 2 fois par mois	1 ou 2 fois par semaine	Pratiquement tous les jours
Plongée en bouteilles	❑	1	2	3	4	5
Pêche pour nourrir la famille (poisson, crabe etc.)	❑	1	2	3	4	5
Pêche récréative/sportive	❑	1	2	3	4	5
Pêche sous-marine	❑	1	2	3	4	5
Plongée en apnée (PMT)	❑	1	2	3	4	5
Plage et Baignade	❑	1	2	3	4	5
Excursion/promenade en bateau/scooter	❑	1	2	3	4	5
Autre (précisez :)	❑	1	2	3	4	5

Q9 Quels sont les usages (et leur fréquence en moyenne) que les membres de votre foyer ont du lagon?

Usage / fréquence	Jamais	Entre 1 et 5 fois par an	1 ou 2 fois par mois	1 ou 2 fois par semaine	Pratiquement tous les jours
Plongée en bouteilles	1	2	3	4	5
Pêche pour nourrir la famille (poisson, crabe etc.)	1	2	3	4	5
Pêche récréative/sportive	1	2	3	4	5
Pêche sous-marine	1	2	3	4	5
Plongée en apnée (PMT)	1	2	3	4	5
Plage et Baignade	1	2	3	4	5
Excursion/promenade en bateau/scooter	1	2	3	4	5
Autre (précisez :)	1	2	3	4	5

Section 2: Pêcheurs

<u>Pour enquêtés résidents pratiquant la pêche au moins une ou deux fois par semaine</u>

Q10 Pourriez-vous me dire pourquoi vous pêchez ? (Plusieurs raisons possibles)

Vous aimez vraiment pêcher et cela vous fait plaisir	❑
Vous pêchez mais c'est seulement une des activités que vous faites lors des sorties	❑
Vous en avez besoin pour vous nourrir ainsi que votre famille	❑
Vous avez l'habitude d'échanger votre pêche avec la famille ou autres	❑
Ma famille a toujours pêché. Cela fait partie de votre vie.	❑
Vous gagnez un peu d'argent en pêchant	❑
Vous pêchez surtout lors de moments spéciaux de la tribu ou du village	❑
Autre (Précisez :)	❑

Q11 Quels sont les facteurs qui influencent la fréquence et la qualité de vos sorties de pêche? Notez de 1 à 5 selon l'importance.

	Pas du tout important	Peu important	Moyennement important	Important	Très important
Quantité poissons ou autres capturés par sortie	1	2	3	4	5
Non-fréquentation des milieux (tranquilité)	1	2	3	4	5
Distance et accessibilité du site de pêche	1	2	3	4	5
Abondance de la vie sous-marine	1	2	3	4	5
Diversité des espèces	1	2	3	4	5
Qualité et vie des récifs coralliens, herbiers, mangroves	1	2	3	4	5
Observation d'espèces remarquables (requins, tortues, baleines, oiseaux, dugongs, dauphins…)	1	2	3	4	5
Non-pollution et propreté des milieux	1	2	3	4	5
Beauté des paysages	1	2	3	4	5
Autre (précisez :)	1	2	3	4	5

Section 3: Plongeurs et PMT

Pour enquêtés résidents pratiquant la plongée (en bouteille ou apnée) plus d'une fois par mois

Q12 Quel type de plongée pratiquez-vous? Bouteille : ❑ Apnée (PMT): ❑ Les deux : ❑

Q13 (Si « Les deux » **Q14**) Plongez-vous le plus souvent en bouteille ou en apnée? *Bouteille : ❑ Apnée : ❑*

Q14 Sur quel milieu plongez-vous et à quelle fréquence ?

	Jamais	Quelques fois	Souvent	Presque tout le temps
Pente externe	1	2	3	4
Lagon	1	2	3	4
Passe	1	2	3	4
Epaves	1	2	3	4
Autres (Précisez:)	1	2	3	4

Q15 Quels sont les facteurs qui influencent la fréquence et qualité de vos plongées? Notez de 1 à 5 selon l'importance.

	Pas du tout important	Peu important	Moyennement important	Important	Très important
Présence d'espèces remarquables (requins, tortues, baleines, oiseaux, dugongs, dauphins…)	1	2	3	4	5
Nombre d'espèces différentes observées par plongée	1	2	3	4	5
Qualité et vie des récifs coralliens	1	2	3	4	5
Visibilité	1	2	3	4	5
Pollution du milieu (visuelle ou non)	1	2	3	4	5
Accès et aménagements	1	2	3	4	5
Choix multiple de sites	1	2	3	4	5
Fréquentation des sites	1	2	3	4	5
Taille des palanquées	1	2	3	4	5
Autre (précisez :)	1	2	3	4	5

Section 4: Plaisanciers et activités nautiques (enquêté + famille)

Pour enquêtés résidents pratiquant ce type d'activité au moins une et deux fois par semaine

Q16 Quels sont vos lieux de destination?

	Jamais	Quelques fois	Souvent	Presque tout le temps
Ilots	1	2	3	4
Passes ou Récif barrière	1	2	3	4
Côtes et plages	1	2	3	4
Autres (Precisez:)	1	2	3	4

Q17 Quelles sont les activités que vous ou un membre de votre famille réalise sur votre lieu de destination ?

	Jamais	Quelques fois	Souvent	Presque tout le temps
Promenade terrestre	1	2	3	4
Promenade sous-marine (snorkelling)	1	2	3	4
Sports de glisse	1	2	3	4
Plage	1	2	3	4
Camping	1	2	3	4
Piquenique	1	2	3	4
Autres (Precisez:)	1	2	3	4

Q18 Quels sont les facteurs qui, selon vous influencent la fréquence et qualité de vos activités sur place ? (notez de 1 à 5 selon leur importance)

	Pas du tout important	Peu important	Moyennement important	Important	Très important
Présence d'espèces emblématiques	1	2	3	4	5
Nombre d'espèces observées	1	2	3	4	5
Qualité et vie des récifs coralliens	1	2	3	4	5
Non-pollution et propreté des milieux	1	2	3	4	5
Accès et aménagements	1	2	3	4	5
Offre multiple d'activités	1	2	3	4	5

Fréquentation des sites	1	2	3	4	5
Autre (précisez :)	1	2	3	4	5

Section 5: Socio-économique et démographique

Q19 Sexe : Homme ❑ Femme ❑

Q20 Quelle(s) est votre origine culturelle ?
Mélanésienne : ❑ Wallis et Futuna : ❑ Indonésienne : ❑ Européenne : ❑ Calédonienne : ❑
Kanak : ❑ Autre : ❑ (Précisez : _______)

Q21 Quel est votre âge ?_______

Q22 Combien de personnes compte votre foyer y compris vous-même? _____ dont enfant à charge? _____

Q23 Combien avez-vous d'enfants ? _______ De petits enfants? _______

Q24 Quel est votre diplôme le plus élevé ?
Aucun diplôme :❑ Baccalauréat :❑ Certificat :❑ BEPC :❑ CAP BEP :❑
1er cycle (DEUG, License) :❑ 2ème et 3ème cycle (Master et autres diplômes bac+5) : ❑
Autre : ❑ (précisez : __________)

Q25 Quelle est votre situation professionnelle ?
Agriculteur :❑ Aquaculteur :❑ Pêcheur :❑ Artisan, commerçant, chef d'entreprise :❑
Cadre, profession libérale, profession intellectuelle supérieure :❑ Ouvrier, manœuvre :❑
Profession intermédiaire (technicien, agent de maîtrise, infirmière, professeur des écoles…) :❑
Employé : ❑ Retraité : ❑ Étudiant : ❑ Femme/Homme au foyer : ❑ Inactif : ❑
Chômeur : ❑ Autre : ❑ (Précisez : __________)

Q26 Nous désirons analyser les résultats de cette étude en fonction des revenus mensuels des familles que nous avons interrogées : salaires, allocations familiales, pensions et revenus…Pouvez-vous situer dans cette liste le niveau des REVENUS MENSUELS NETS de votre FOYER ? **Cette information est très importante. Je parle bien des revenus de toute votre famille de votre foyer.**
Moins de 70,000 CFP par mois :❑ *De 70,000 à 120,000 CFP :❑* *De 120,000 à 170,000 CFP :❑*
De 170,000 à 210,000 CFP :❑ *De 210,000 à 260,000 CFP :❑* *De 260,000 à 310,000 CFP :❑*
De 310,000 à 360,000 CFP :❑ *De 360,000 à 410,000 CFP :❑* *De 410,000 à 460,000 CFP :❑*
De 460,000 à 510,000 CFP :❑ *De 510,000 à 600,000 CFP :❑* *Plus de 600,000 CFP :❑*
NSP/Refus de réponse : ❑

Q27 Précisez l'origine des **fruits, légumes, bétail** que vous consommez et la fréquence à laquelle vous vous les procurez?

	Jamais	Une fois par mois	Une fois par semaine	Tous les jours
Achetés en magasin	1	2	3	4
Cultivés ou chassés	1	2	3	4
Achetés directement aux producteurs	1	2	3	4
Donnés par la famille, amis ou tribu	1	2	3	4

Q28 Précisez l'origine des **produits de la mer (poissons, crabes, poulpes, trochas, bénitiers…)** que vous consommez et la fréquence à laquelle vous vous les procurez?

	Jamais	Une fois par mois	Une fois par semaine	Tous les jours
Achetés en magasin	1	2	3	4
Cultivés ou chassés	1	2	3	4
Achetés directement aux producteurs	1	2	3	4
Donnés par la famille, amis ou tribu	1	2	3	4

Section 6: Protection de l'Environnement

Q29 Pensez-vous que les enjeux de protection/conservation de l'environnement marin et terrestre de Nouvelle-Calédonie soient importants? *Oui : ❑ Non : ❑*

Q30 Selon vous, la santé et la richesse sous-marine du lagon sont-elles menacées? *Oui : ❑ Non : ❑*

Q31 (Si oui **Q32**) Quels sont selon vous les trois principales menaces qui pèsent sur le lagon?

1.
2.
3.

Q32 Lesquelles de ces actions en faveur de l'environnement pratiquez-vous? Précisez la fréquence pour certaines de ces actions.

Actions environnementales	OUI	NON	1 ou 2 fois par an	2 ou 3 fois par semestre	1 fois par mois	1 fois par semaine ou plus
Compostage	❑	❑				
Tris des déchets ménagers	❑	❑				
Faire attention à votre consommation en eau/électricité/carburant/déchet pour limiter votre impact sur l'environnement	❑	❑				
Achats réguliers de produit respectueux de l'environnement	❑	❑				
Dons pour des associations/organisations de protection de l'environnement marin	❑	❑	1	2	3	4
Bénévolat pour des associations/organisations de protection de l'environnement marin ou actions collectives (nettoyage de plage…)	❑	❑	1	2	3	4
Aller à des événements publics concernant l'environnement	❑	❑	1	2	3	4
Autres (Précisez :)	❑	❑	1	2	3	4

Q33 Classez selon leur importance les raisons pour lesquelles vous pensez que préserver le lagon en bon état est important?

	Pas important	Peu important	Moyennement important	Important	Très important
Pour pouvoir le transmettre à mes enfants	1	2	3	4	5
Pour que la population dans plus de 50 ans puisse en bénéficier de la même manière que nous	1	2	3	4	5
Pour continuer à pouvoir profiter de nos activités liées au lagon dans de bonnes conditions (pêche, plongées, nage etc.)	1	2	3	4	5
Parce que le lagon est lié à notre culture et notre mode de vie	1	2	3	4	5
Car le lagon est une richesse et a son importance pour le développement économique	1	2	3	4	5
Parce-que le lagon a une valeur qui lui est propre en dehors des usages qu'on peut en faire et qu'il doit continuer à exister	1	2	3	4	5

Si autres (précisez) : ____

Q34 Quels sont la ou les espèces remarquables les plus importantes pour vous (c-a-d que vous aimez rencontrer lors de vos activités sur le lagon)? Précisez pourquoi (plusieurs raisons possibles).

Espèces emblématiques	La ou les + importantes	Rôle écologique	Esthétique	Importance culturelle/spirituelle	Source de nourriture
Requins	❑	❑	❑	❑	❑
Tortues	❑	❑	❑	❑	❑
Oiseaux marins	❑	❑	❑	❑	
Dugongs	❑	❑	❑	❑	
Baleines	❑	❑	❑	❑	
Dauphins	❑	❑	❑	❑	
Autres (précisez:)	❑	❑	❑	❑	❑
Toutes aussi importantes	❑				

Section 7 : Expérimentation par les choix

Numéro du jeu de choix utilisé:

	Option 1	Option 2	Statu Quo	Refus de choisir
Choix n°1				
Choix n°2				
Choix n°3				
Choix n°4				
Choix n°5				
Choix n°6				
Choix n°7				
Choix n°8				

Questions sur les attributs et les choix effectués

Q35 Quel(s) serai(en)t le(s) moyen(s) de paiement le plus adapté(s) selon vous ?

Impôt spécifique pour la préservation du lagon et donc récupérés par les pouvoirs publics	❑
Contribution « environnent » sur le paiement de l'électricité, de l'eau ou autre et donc récupérés par les pouvoirs publics	❑
Contribution à une institution chargé de mettre en place les programmes *Dans ce cas, plusieurs possibilités :* *Une institution publique précisément identifiée (commune ou direction environnement Province Sud)* *Une institution indépendante et représentative chargée de redistribuer l'argent*	❑ ❑ ❑
Répartis entre des associations et ONG *Répartis entre tous les acteurs de préservation de l'environnement*	❑ ❑
Autre (Précisez :)	❑

Q36 L'attribut « Santé du lagon » fait référence à différentes composantes (qualité de l'eau, nombre d'espèces sous-marines, présence des différents habitats, espèces remarquables). Y en a-t-il une ou plusieurs qui vous paraissent plus importantes dans le cadre de vos usages?

Oui, espèces remarquables (tortues, requins, oiseaux, dugongs…)	❑
Oui, présence des différents habitats (mangroves, herbiers, récifs)	❑
Oui, qualité de l'eau	❑
Oui, nombre d'espèces différentes	❑
Non, il s'agit d'un tout, je n'ai pas de priorité	❑

Q37 Êtes-vous satisfaits du niveau actuel de la santé du lagon?

Oui : ❑ Non : ❑ NSP : ❑ Non informé : ❑

Q38 Pensez-vous que le niveau total de poissons pêchés ici soit trop important?

Oui : ❑ Non : ❑ NSP : ❑ Non informé : ❑

Q39 Êtes-vous satisfait des espaces dont vous bénéficiez sur le lagon ?

Oui : ❑ Non : ❑ Non concerné: ❑ NSP : ❑

Q40 Qu'est ce qui est important pour vous concernant ces espaces?

	Pas important				Très important
Surface	1	2	3	4	5
Accessibilité et distance	1	2	3	4	5
Santé et richesse de l'environnement dans ces espaces	1	2	3	4	5
Pas de conflits avec les autres usagers	1	2	3	4	5
Faible fréquentation (tranquilité)	1	2	3	4	5
Dimension historique, culturelle ou spirituelle de ces espaces	1	2	3	4	5
Autre (Précisez :)	1	2	3	4	5

Q41 Quels sont parmi les attributs suivants ceux que vous souhaiteriez préserver afin de les transmettre à vos enfants et à la génération qui arrive (notez de 1 à 5 selon l'ordre d'importance)?

	Pas important				Très important
Quantité de poissons pêchés	1	2	3	4	5
Santé et richesse du lagon	1	2	3	4	5
Paysages	1	2	3	4	5
Espaces suffisants pour leurs usages	1	2	3	4	5

Q42 **Dans le cas où l'enquêté a refusé de répondre ou a choisi systématiquement (ou presque uniquement) le statu quo.** Vous avez refusé de répondre aux choix proposé ou choisi exclusivement ou très majoritairement l'option statu quo. Pourriez-vous me dire pourquoi ?

Je ne suis pas responsable de la dégradation possible des récifs donc je ne veux pas payer	❑	Ce n'est pas à moi de payer	❑
Je ne pense pas que l'argent sera utilisé efficacement.	❑	Les choix ne me paraissent pas pertinents, ou sont trop vagues	❑
Je ne pense pas que le lagon ou mes usages soient réellement menacés donc je ne veux pas payer	❑	Trop compliqué de faire un choix (pas compris, trop d'attributs, tout me paraît important ou pas important)	❑
Les enjeux sont bien plus complexes en réalité, ces choix sont trop simplistes	❑	La situation actuelle ne me satisfait pas et donc si je paye ce n'est pas pour la préserver mais pour l'améliorer	❑
Les paiements sont trop élevés	❑	Autre (précisez)	❑

Q43 Comment avez-vous réalisé vos choix ?

J'ai pris mes décisions en considérant l'ensemble des attributs	❑	
Je ne me suis décidé que sur quelques attributs	❑	Si coché, lesquels ?
Je n'ai considéré qu'un attribut	❑	Si coché, lequel ?
J'ai fait un choix aléatoire	❑	
Je ne sais pas trop	❑	

Q44 Avez-vous aussi réalisé vos choix en fonction de la durée de la préservation? *Oui : ❑ Non : ❑*

Q45 (Si oui **Q44**) De manière générale (en dehors des choix effectués), quelle durée de préservation choisiriez-vous? ❑20 ans ❑50 ans ❑100 ans ❑Autre (Précisez :)

Q46 Pouvez-vous relier les phrases suivantes à la durée de préservation du lagon qui vous semble correspondre le mieux (plusieurs réponses possibles)?

Cette durée de préservation est suffisante!	❑20 ans ❑50 ans ❑100 ans ❑Autre (Précisez :)
Cette durée de préservation me permet à moi et mes proches de bénéficier du lagon en bon état jusqu'à ma mort	❑20 ans ❑50 ans ❑100 ans
Cette durée de préservation me permet de transmettre le lagon en bon état à mes enfants/petits-enfants	❑20 ans ❑50 ans ❑100 ans
Cette durée de préservation me permet de transmettre le lagon en bon état à la génération future (=ceux qui ne sont pas encore nés)	❑20 ans ❑50 ans ❑100 ans
Je veux que le lagon continue d'exister en bon état le plus longtemps possible, indépendamment de l'usage qu'en fera la génération future	❑20 ans ❑50 ans ❑100 ans

Q47 Lorsque vous avez réalisé vos choix, quels étaient les attributs/caractéristiques déterminants pour ces choix (notez de 1 à 5 selon l'ordre d'importance) ?

	Pas important				Très important
Paiement	1	2	3	4	5
Quantité de poissons pêchés	1	2	3	4	5
Santé et richesse de l'environnement	1	2	3	4	5
Préservation des paysages	1	2	3	4	5
Préservation d'espaces suffisants pour vos usages	1	2	3	4	5

Question Libre

Q48 Si vous avez des commentaires, remarques, ou toutes autres informations dont vous souhaiteriez nous faire part :

Remercier l'enquêté et prendre son contact si il souhaite obtenir un retour concernant les enquêtes effectuées (résultats etc.)

Appendix H: Quotas

Completed quotas (in red) versus aimed quotas (in blue) for the VKP area surveys are presented in the graph below.

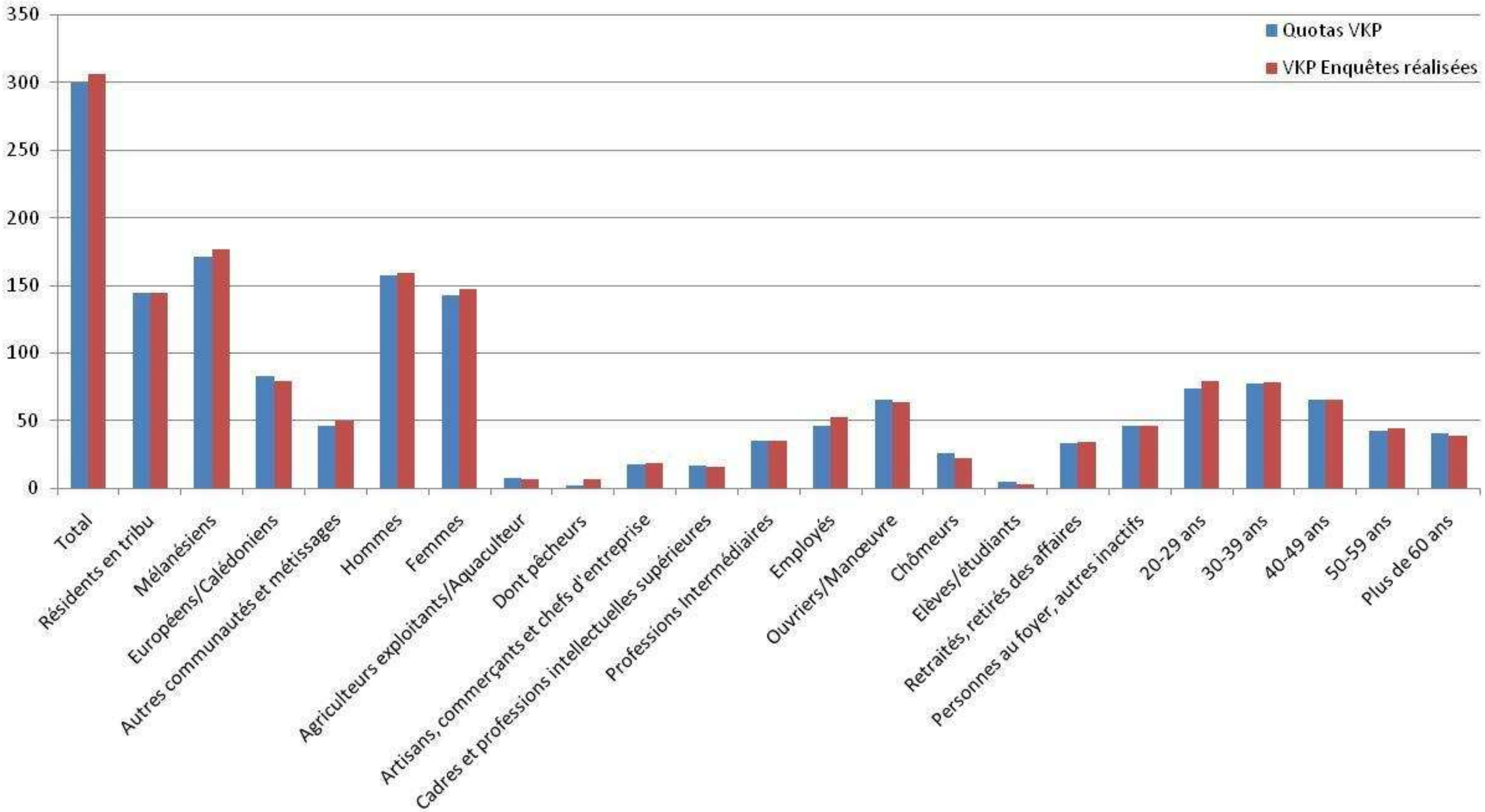


Figure H1 Completion of quotas for the VKP area

Completed quotas (in red) versus aimed quotas (in blue) for the ZCO area are presented in the figure below.

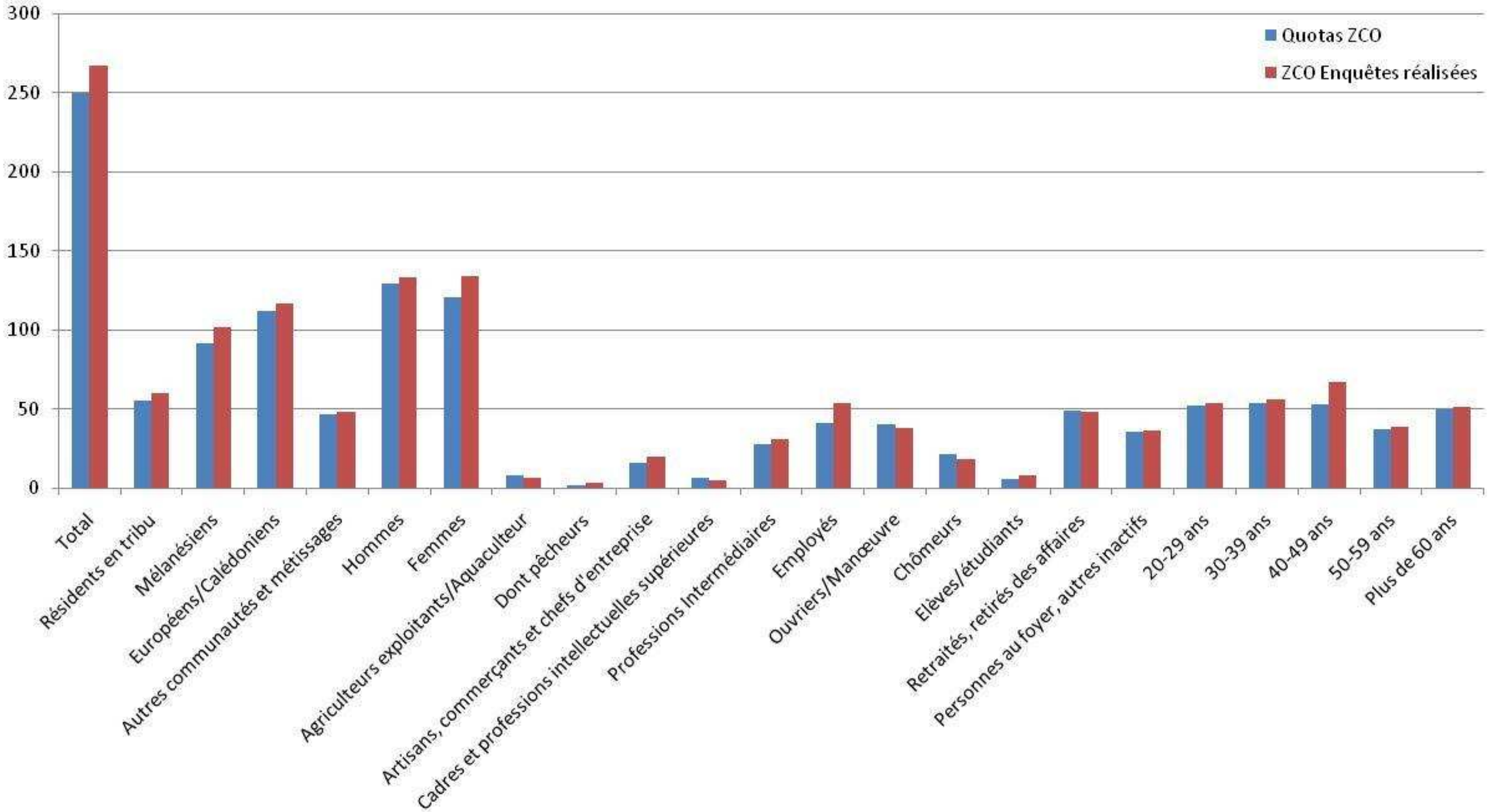


Figure H2 Completion of quotas for the ZCO area

Appendix I: Models with socio-economic variables

Table I1 MNL and panel EC-RPL models results with log-linear utilities specifications and interaction income/tax

	MNL		EC-RPL				
			VKP		ZCO		
	VKP	ZCO	Mean	S.D.	Mean	S.D.	Distribution
Payment	-0.00043***	-0.00028***	-0.00050***	-0.00025***	-0.00017*	-0.00008**	t,0.5
Ln Catches	0.143***	0.143***	0.162***	0.162***	0.161***	0.161***	t,1
Ln Health	0.238***	0.200***	0.305***	0.305***	0.246***	0.246***	t,1
Ln Landscapes	0.131***	0.170***	0.164***	0.164***	0.196***	0.196***	t,1
Ln Areas (ZCO only)		0.136***			0.157***	0.157***	t,1
Areas 20 years (VKP only)	0.059		0.054				fixed
Areas 50 years (VKP only)	0.346***		0.422***	0.422***			t,1
Areas 100 years (VKP only)	-0.041		-0.051				fixed
Income*Payment	0.0003*	0.0004**	0.0002		0.00006		
ASCsq	-0.153	0.627***	-8.559*		-6.429***		
Sigma Option 1,2			7.340***		7.016***		
Sigma Status Quo			2.753**		3.568**		
Final Log-Likelihood	-1306.6	-1186.4	-1087.4		-984.0		
AIC	1.516	1.630	1.265		1.357		
Adjusted Pseudo-R^2	0.119	0.121	0.428		0.386		
Halton Draws			350		350		
N	217	183	217		182		

**** Significant at the 1% level** Significant at the 5% level * Significant at the 10% level*

Table I2 MNL and panel EC-RPL models results with log-linear utilities specifications and interaction income/tax

	MNL		EC-RPL				
	VKP	ZCO	VKP		ZCO		Distribution
			Mean	S.D.	Mean	S.D.	
Payment	-0.00025*	-0.00017	-0.00041***	-0.00002***	-0.00032*	-0.00016*	t,0.5
Ln Catches	0.148***	0.135***	0.167***	0.167***	0.153***	0.153***	t,1
Ln Health	0.230***	0.180***	0.299***	0.299***	0.234***	0.234***	t,1
Ln Landscapes	0.123***	0.162***	0.159***	0.159***	0.201***	0.201***	t,1
Ln Areas (ZCO only)		0.129***			0.156***	0.156***	t,1
Areas 20 years (VKP only)	0.054		0.048				fixed
Areas 50 years (VKP only)	0.338***		0.417***	0.417***			t,1
Areas 100 years (VKP only)	-0.059		-0.066				fixed
Age*Payment	-0.0001***	-0.00006**	-0.00001		-0.00004		
ASCsq	-0.052	0.567***	-8.987***		-6.299***		
Sigma Option 1,2			7.094***		6.003***		
Sigma Status Quo			4.021		3.297*		
Final Log-Likelihood	-1507.6	-1423.9	-1229.5		-1161.9		
AIC	1.486	1.679	1.271		1.374		
Adjusted Pseudo-R^2	0.114	0.106	0.425		0.378		
Halton Draws			350		350		
N	244	213	244		213		

**** Significant at the 1% level** Significant at the 5% level * Significant at the 10% level*

Appendix J: Tobit Model

The Tobit model (Tobin, 1958) used in the statistical analyses presented in Chapter 2 and 4 of this PhD is a double-censored regression model where the dependent variable is bounded between 0 and 1. For all individual i in (0,n) this model supposes the existence of a latent variable y_i^* that linearly depends on k explanatory variables x_k contained in X_i and a normally distributed error term u_i (as in a linear regression model). The observable dependent variable y_i is defined to be equal to the latent variable y_i^* whenever y_i^* is above zero and below 1, and respectively 0 and 1 otherwise. The model is thus defined as follow:

$$y_i = \begin{cases} y_i^* & if\ 0 < y_i^* < 1 \\ 0 & if\ y_i^* \leq 0 \\ 1 & if\ y_i^* \geq 1 \end{cases}$$

$$y_i^* = \beta_k X_i + u_i \quad where\ u_i \sim N(0, \sigma^2)$$

Such a model is used because the ordinary least squares regression estimators are inconsistent if the relationship parameters β_k are estimated by regressing the observed variable y_i on X_{ik} (Tobin, 1958). The maximum likelihood estimator suggested by Tobin for this model has been shown to be consistent (Amemiya, 1973).

It is important to note that the coefficient β_k cannot be directly interpreted as the effect of the explanatory variables X_{ik}on the observed variable y_i in view of the censored nature of the problem (McDonald and Moffit, 1980): the linear effect is on the uncensored latent variable, not on the observed outcome. As such, the coefficient should be interpreted as a combination of changes in the observed variable and changes in the probability of being comprised between zero and one (see the decomposition presented in McDonald and Moffit, 1980).

In the models presented in Chapter 2 and 4 we computed marginal effects on the expected value for y. These are defined as follow, with ϕ being standard normal probability density function:

$$\frac{\partial E[y]}{\partial x_k} = \phi\left(\frac{X_i \beta}{\hat{\sigma}}\right) \beta_k$$

Appendix K: Attendance and non-attendance for all attributes

Before deciding to focus more particularly on payment non-attendance results, we also examined in details the issue of attendance or non-attendance for all attributes in the DCE, especially in view of the fact that a significant number of individuals stated that they considered only one attribute during their choices (chapter 2, table 2-3). Therefore we used the two inferred attendance modelling approaches presented in this chapter, based either on panel LCM or panel EC-RPL models.

For the LCM with parameters restrictions, many different combinations of classes can be imagined in terms of attributes consideration patterns. After having examined and tested several specifications, and based on the results from tables 2-2 and 2-3 (chapter 2) we selected 4 types of choice heuristics: complete attendance (the usual assumption), complete ANA (random choice), ANA for a single attribute (the coefficient of one attribute is set to zero), and attendance to only one attribute (only one out all attributes matters, the other having their coefficient set to zero). Since we have 5 attributes, this yields to 12 classes of parameters restrictions. Results from this model are presented in table J1. They confirm a substantial proportion (the largest) of payment non-attendance. Nevertheless, they also imply significant proportions of single attributes attendance, which would confirm the results of table 2-3 but go against the results of table 2-2 (chapter 2). However it is important to keep in mind that these predictions are based on a pretty strict dichotomous framework (coefficients are set to zero or not).

Results from EC-RPL models for entire sample on each area with all parameters normally distributed and with separate coefficients based on stated attendance groups (the SA and SNA groups used in Chapter 2) are presented in tables K2 and K4 (with 500 Halton draws). They also present results from the MNL models as a baseline for comparison. Parameters estimated at the individual level from the EC-RPL models with all attributes following normal distribution are then used to infer attendance based on the coefficient of variation method. We note that almost all attributes coefficients associated with the SNA group are not significant (with the exception of the “Areas of practice for ZCO area”, and “Quantity of fish caught” for VKP area), which imply that individuals having stated no to medium importance to the different attributes did not consider them during their choices (and thus confirm the logic of our SA/SNA categories).

Results from the CV-based IA method, as well as comparison with stated attendance, are presented in tables K3 and K5. Globally, at the sample scale, proportions remain roughly similar between the SA and IA groups. When looking in more details at the stated importance of each attribute during choices for the individuals in the IA group, the correspondence between stated and inferred attendance still globally hold except for the payment attributes where we found substantial proportions of statements implying no attendance. These results also imply that non-attendance exist also for the non-monetary attributes, in proportions that range between 2% and 18% of our samples.

All in all, both results from LCM and EC-RPL models do confirm that payment non-attendance seems to be the main issue at stake here, in terms of non-attendance; although we note that there might be a significant (up to 18%) number of individuals that may have not considered (an)other attribute(s) as well during their choices (when putting together both model predictions).

Table K1 Panel LCM with parameters restrictions (12 classes based on 12 attributes attendance patterns). Results for ZCO and VKP areas

	ZCO		VKP	
	Coeff	WTP	Coeff	WTP
Payment	-0.0044***		-0.0029***	
Ln Catch	0.429***	**98**	0.409***	**140**
Ln Health	0.652***	**149**	0.635***	**217**
Ln Landscapes	0.402***	**92**	0.473***	**162**
Ln Areas	0.447***	**102**	0.355***	**122**
Class 1: All Att	**4.8%****		**9.8%****	
Class 2: All Att - Tax	**33.2%*****		**32.2%*****	
Class 3: All Att - Catch	0.0%		0.0%	
Class 4: All Att - Health	0.0%		4.3%***	
Class 5: All Att - Landsc	0.0%		2.2%	
Class 6: All Att - Area	0.0%		0.0%	
Class 7: Only Tax	**5.2%*****		4.9%***	
Class 8: Only Catch	**10.0%*****		**13.2%*****	
Class 9: Only Health	**7.1%*****		**21.0%*****	
Class 10: Only Landscapes	**26.6%*****		**9.8%*****	
Class 11: Only Areas	**10.3%*****		2.5%	
Class 12: Nothing	2.8%		0.0%	
N Classes	12		12	
N Parameters	5		5	
Adj R2	0.355		0.41	
AIC	1.429		1.308	
Log Likelihood	-1201.09		-1260.33	

Table K2 MNL and Panel-EC-RPL models for ZCO Areas: results for overall sample and for attendance, non-attendance, no information groups

	Coeff.	MNL	MNL		EC-RPL	EC-RPL	
		All sample	SA	SNA	All sample	SA	SNA
Payment	μ	-0.00010*	-0.00020**	-0.000052	-0.00019* (n)	-0.00037***(t,1)	0.000021
	σ				0.00078***	0.00037***	
Ln Fish catch	μ	0.135***	0.157***	0.043	0.214*** (n)	0.223*** (n)	0.053
	σ				0.228**	0.202***	
Ln Health	μ	0.180***	0.198***	0.091	0.291*** (n)	0.279*** (n)	-0.004
	σ				0.306***	0.257***	
Ln Landscapes	μ	0.163***	0.180***	0.107	0.255*** (n)	0.248*** (n)	0.065
	σ				0.187***	0.170***	
Ln Areas	μ	0.129***	0.140***	0.148***	0.189*** (n)	0.191*** (n)	0.137**
	σ				0.162***	0.155***	
ASCsq		0.569***	-0.080		-5.725***	-2.876***	
Sigma Option 1,2					7.878***	1. 167	
Sigma Status Quo					7.476***	3.919***	
Final Log-Likelihood		-1426.14	-1189.96		-1137.40	-1114.71	
Adj Pseudo-R^2		0.105	0.249		0.390	0.401	
AIC		1.681	1.415		1.353	1.334	
N parameters		6	16		6	16	
N Individuals		213	213		213	213	

**** Significant at the 1% level** Significant at the 5% level * Significant at the 10% level*
SA: Stated Attendance; SNA: Stated Non-Attendance; NI: No information

Table K3 Comparison of EC-RPL inferred and stated attendance for ZCO areas

	IA group: -2<CV <0	Payment importance rating in IA group	SA group*
Payment	29,1%	No imp: 34%; Med imp: 14%; High imp: 45%	32,4%
Quantity of animals fished	81,7%	No imp: 6%, Med imp: 9%; High imp: 79%	78,9%
Health and richness of marine life	82,2%	No imp: 0%; Med imp: 2%; High imp: 91%	91,1%
Coastal and lagoon landscapes	96,7%	No imp: 3%; Med imp: 9%; High imp: 81%	91,1%
Areas of practice	93,0%	No imp: 3%; Med imp: 10%; High imp: 81%	81,7%

No imp: no importance, Med imp: little or medium importance, High imp: importance or strong importance
**: The percentage presented in this column is a proportion of entire sample, which includes individuals who did not answer to the stated attendance (SA) question, which is why it differs slightly from the percentage of the last column of table 2-2.*

Table K4 MNL and Panel EC-RPL models for VKP Areas: results for overall sample and for attendance, non-attendance, no information groups

	Coeff.	MNL	MNL		EC-RPL	EC-RPL	
		All sample	SA	SNA	All sample	SA	SNA
Payment	μ	-0.00021***	-0.00057***	-0.000025	-0.00044*** (n)	-0.00081*** (t,1)	-0.000094
	σ				0.0011***	0.00081***	
Ln Fish catch	μ	0.152***	0.190***	0.079**	0.243*** (n)	0.243*** (n)	0.100** (n)
	σ				0.171***	0.105**	0.105**
Ln Health	μ	0.224***	0.253***	0.167	0.410*** (n)	0.375*** (n)	0.101
	σ				0.366***	0.304***	
Ln Landscapes	μ	0.123***	0.147***	0.036	0.215*** (n)	0.212*** (n)	0.008
	σ				0.263***	0.177***	
Ln Areas	μ	0.123***	0.099***	0.044	0.120*** (n)	0.140*** (n)	0.023
	σ				0.131***	0.154***	
ASCsq		-0.057***	-1.140***		-5.459***	-2.842***	
Sigma Option 1,2					0.906	2.513***	
Sigma Status Quo					5.647***	0.146	
Final Log-Likelihood		-1526.96	-1239.80		-1213.5	-1173.96	
Adj Pseudo-R^2		1.103	0.270		0. 432	0. 449	
AIC		1.571	1.287		1.257	1.225	
N parameters		6	16		6	16	
N Individuals		244	244		244	244	

**** Significant at the 1% level** Significant at the 5% level * Significant at the 10% level*
SA: Stated Attendance; SNA: Stated Non-Attendance; NI: No information

Table K5 Comparison of EC-RPL inferred and stated attendance for VKP areas

	IA group: -2<CV <0	Payment importance rating in IA group	SA *
Payment	51,2%	No imp: 20%; Med imp: 24%; High imp: 46%	39,8%
Quantity of animals fished	98,0%	No imp: 4%; Med imp: 14%; High imp: 75%	75,0%
Health and richness of marine life	86,9%	No imp: 0%; Med imp: 0.4%; High imp: 84%	93,0%
Coastal and lagoon landscapes	75,4%	No imp: 1%; Med imp: 1.6%; High imp: 92%	90,6%
Areas of practice	88,1%	No imp: 3.2%; Med imp: 9%; High imp: 81%	82,0%

**: The percentage presented in this column is a proportion of entire sample, which includes individuals who did not answer to the stated attendance (SA) question, which is why it differs slightly from the percentage of the last column of table 2-2*

Appendix L: Panel EC-RPL models' results for both areas with all parameters following constrained triangular distributions

Table L1 Panel EC-RPL models' results for VKP area with all parameters following constrained triangular distributions: all sample and inferred payment attendance (IA) group

	All sample		IA group		Distribution
	Mean	S.D	Mean	S.D	
Payment	-0.00038***	-0.00038***	-0.0014***	-0.0014***	t,1 for left columns t,0.5 for right columns
Ln Catches	0.168***	0.168***	0.161***	0.161***	t,1
Ln Health	0.304***	0.304***	0.366***	0.366***	t,1
Ln Landscapes	0.158***	0.158***	0.164***	0.164***	t,1
Areas 20 years	0.049		0.178		fixed
Areas 50 years	0.413***	0.413***	0.427***	0.427***	t,1
Areas 100 years	-0.062		-0.052		fixed
ASCsq	-9.332***		-7.236***		
Sigma Option 1,2	8.409***		5.026		
Sigma Status Quo	1.840		8.508***		
Final Log-Likelihood	-1230.99		-584.76		
AIC	1.271		1.271		
Adjusted Pseudo-R^2	0.424		0.428		
Halton Draws	500		500		
N	244		117		

Table L2 Panel EC-RPL models' results for ZCO area with all parameters following constrained triangular distributions: all sample and inferred payment attendance (IA) group

	All sample		IA group		Distribution
	Mean	S.D	Mean	S.D	
Payment	-0.00015**	-0.00015**	-0.0012***	-0.0012***	t,1 for left columns t,0.5 for right columns
Ln Catches	0.154***	0.154***	0.104***	0.104***	t,1
Ln Health	0.234***	0.234***	0.151***	0.151***	t,1
Ln Landscapes	0.194***	0.194***	0.154***	0.154***	t,1
Ln Areas	0.150***	0.150***	0.118***	0.118***	t,1
ASCsq	-6.531		-7.696***		
Sigma Option 1,2	6.961		9.155**		
Sigma Status Quo	3.600		4.629		
Final Log-Likelihood	-1163.05		-333.76		
AIC	1.374		1.378		
Adjusted Pseudo-R^2	0.377		0.382		
Halton Draws	500		500		
N	213		68		

Appendix M: Glossary and participant information sheet

- **Glossary**

Coastal and marine ecosystems are the communities of living coastal and marine organisms (plants, algae, animals such as fish, mammals or crustaceans, corals, micro-organisms…) in conjunction with their different coastal and marine habitats

Coastal and marine ecosystem services are the benefits derived by people from coastal and marine ecosystems (e.g. provision of food through fisheries or aquaculture, features allowing all kind of recreational activities, aesthetic pleasure, cultural importance).

Economic valuation of ecosystem services: Estimating a dollar value for the services provided by ecosystems, even for those that are not traded in the market and have no price (e.g. aesthetic benefits, water quality). For example:

- The economic values associated with commercial fisheries is estimated by the profits of commercial businesses;
- The economic value associated with a change in water quality at a specific beach is measured based on the associated variation in visitors' willingness to pay to visit this beach.

Willingness-To-Pay: This is the total amount (in dollars) that an individual is willing to pay to benefit from a service. This can be estimated through observed payment behaviour (e.g. how much an individual is actually paying to visit a natural park or to snorkel on the Great Barrier Reef) or by interviewing people (e.g. asking how much they would be willing to pay in support of sea turtle conservation).

Use values: benefits derived from current uses of the ecosystems that can be

- Direct (e.g. commercial fishing, or recreational marine activities) or
- Indirect (e.g. carbon storage, water filtering or waste assimilation).

For example, <u>recreational use values</u> are the benefits derived by people when engaged in recreational activities, and are measured in dollar through people's willingness-to-pay to enjoy these activities.

Non-use values are benefits that are not derived from any current or future uses of ecosystems. They include <u>existence value</u> i.e. the value assigned by humans for the continued existence of ecosystem services. They also include <u>bequest value</u> i.e. the value attached to preserving ecosystem services for use by future generations.

- **Participant information sheet**

QUT Queensland University of Technology Brisbane Australia	**PARTICIPANT INFORMATION FOR QUT RESEARCH PROJECT**

Exploring the utilization and influence of economic valuation applied to coastal and marine ecosystems in decision-making in Australia

QUT Ethics Approval Number 1300000173

RESEARCH TEAM

Principal Researcher:	Jean-Baptiste Marre, PhD student, QUT School of Economics and Finance
Principal Supervisor:	Dr Sean Pascoe, Adjunct Professor at QUT and Economist at CSIRO Centre for Marine and Atmospheric Research, Brisbane
Associate Supervisors:	Dr Olivier Thebaud, Economist at CSIRO Centre for Marine and Atmospheric Research, Brisbane Dr Jean Boncoeur, Director of the AMURE Research Centre, Professor at the Université de Bretagne Occidentale, France Dr Louisa Coglan, Senior Lecturer at QUT School of Economics and Finance

DESCRIPTION

This project is being undertaken as part of the PhD research for Jean-Baptiste Marre at QUT; and in association with CSIRO and the Marine Biodiversity Hub of the National Environmental Research Program.

The purpose of this project is to document through national surveys the perceived usefulness, the utilization and the influence of economic valuation of services provided by marine ecosystems (e.g. fisheries, recreational activities, coastal protection, cultural values) in making decisions regarding coastal and marine areas/resources in Australia, by different categories of stakeholders. A second objective is to look at how different types of criteria (namely economic value indicators, ecological indicators, and socio-economic impact indicators) are balanced during a decision-making process within a fictitious marine area management scenario.

You are invited to participate in this project because you are either:

- A stakeholder involved in marine management and the decision making process. In that case your participation in this survey is crucial since your experience in being involved in decision-making process is useful to document the use of economic valuation information.
- A member of the Australian population. In that case your participation in this survey is crucial because populations are also involved in decision-making either directly (e.g. through public consultation process) or indirectly (public opinion is crucial for decision-makers and politicians).

PARTICIPATION

Participation will involve completing an anonymous questionnaire that will take approximately 20 minutes of your time. Questions will include: providing brief details about your professional and educational background, ranking the importance of different possible uses of or reasons for the use of economic valuation in a decision-making process in managing coastal and marine areas, comparing the importance of different competing criteria in a fictitious marine area management scenario. The questionnaire only involves submission of non-identifiable information.

Your participation in this project is entirely voluntary. If you agree to participate you do not have to complete any question(s) you are uncomfortable answering, although it would be better to do so for the sake of the analysis. Your decision to participate or not participate will in no way impact upon your current or future relationship with QUT, CSIRO or with the Marine Biodiversity Hub of the National Environmental Research Program (NERP), which is partly funding this project. If you do agree to participate you can withdraw from the project without comment or penalty. However as the questionnaire is anonymous, once it has been submitted it will not be possible to withdraw.

EXPECTED BENEFITS

It is expected that this project will not directly benefit you. However, there are several more general benefits of this research:

- It will provide decision-makers and economic valuation practitioners crucial results regarding the extent to which economic valuation is used in decision-making process. It will help the process of decision-making itself in better understanding the need and demand for economic valuation by individuals involved in decision-making process, and also enhance the capacity of academics or practitioners to deliver useful results to them. It will also provide more insight regarding the trade-offs made by decision-makers when facing different management criteria (ecological, social, economic).
- It will provide some comparison between the perception and preferences of general public and decision-makers regarding the importance of economic valuation, which ultimately benefits institutions and general public as marine and coastal area management is a crucial public concern. Comparisons between the relative importance of different decision indicators for these populations will also be made. This will contribute in getting a better knowledge of individuals' expectations regarding decision-making, and vice et versa.

The final report describing the survey's results will be sent to you on request to the principal researcher.

RISKS

There are no risks beyond normal day-to-day living associated with your participation in this project.

PRIVACY AND CONFIDENTIALITY

All comments and responses are anonymous and will be treated confidentially. The names of individual persons are not required in any of the responses, and data are strictly non-identifiable. No results will be attributable to any current or previous employers of the respondents. Any data collected as part of this project will be stored securely as per QUT's Management of research data policy. Only the direct project team identified above will have access to the collected raw data.

Since the project is partly funded by the Marine Biodiversity Hub of the National Environmental Research Program, a report with main results will be provided to the Marine Biodiversity Hub.

Please note that non-identifiable data collected in this project may be used as comparative data in future projects.

CONSENT TO PARTICIPATE

Submitting the completed online questionnaire is accepted as an indication of your consent to participate in this project.

QUESTIONS / FURTHER INFORMATION ABOUT THE PROJECT

If have any questions or require further information please contact one of the research team members below.

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CONCERNS / COMPLAINTS REGARDING THE CONDUCT OF THE PROJECT

QUT is committed to research integrity and the ethical conduct of research projects. However, if you do have any concerns or complaints about the ethical conduct of the project you may contact the QUT Research Ethics Unit on 07 3138 5123 or email ethicscontact@qut.edu.au. The QUT Research Ethics Unit is not connected with the research project and can facilitate a resolution to your concern in an impartial manner.

Thank you for helping with this research project. Please keep this sheet for your information.

Appendix N: Questionnaires Australian Application

- ## Questionnaire General Public

*The symbol * indicates that the word/concept is defined in the glossary*

1. General information

1.1. What is your home post code?

1.2. What is your Gender? ☐ Male ☐ Female

1.3. What is your Age?

1.4. What is your educational background? Please indicate

1.4.1. The highest level attained:

☐Secondary ☐ Certificate ☐ Advanced Diploma and Diploma ☐ Bachelor Degree

☐ Graduate Diploma and Graduate Certificate ☐ Postgraduate Degree ☐ Other

1.4.2. The field of education (several answers possible):

☐Natural and physical sciences (e.g. mathematics, physics, chemical, biological and earth sciences…)

☐Information technology (e.g. computer science, information system and technology)

☐Engineering and related technologies

☐Architecture and Building

☐Agriculture, Environmental and related studies (e.g. forestry, fisheries, environmental management…)

☐Health

☐Education

☐Management and commerce (e.g. accounting, business, sales and marketing, tourism, finance…)

☐Society and culture (e.g. political sciences, economics, social sciences, anthropology, justice and low, language and literature, sports and recreation…)

☐Creative arts

☐Food, Hospitality and Personal Services

☐Mixed Field Programmes (e.g. primary and secondary education programmes, personal development education programmes such as social and employment skills)

1.5. Do you have work experience in any of the following areas (several answers are possible)?

☐ Economics ☐ Finance ☐ Business ☐ Biological conservation ☐ Natural resource/Environmental management

1.6. Have you ever had a job related to *coastal and marine ecosystems** management? ☐ Yes ☐ No

2. Coastal and marine conservation

2.1 Do you think it is important to preserve Australian *coastal and marine ecosystems**? ☐ Yes ☐ No

2.2 (If Yes in 2.1) Please select among the following the three most important reasons for your commitment to preserve coastal and marine ecosystems. Indicate the first most important as 1., the second most important as 2., and the third most important as 3.

I think it is important to preserve coastal and marine ecosystems:

☐ So I can continue to enjoy marine activities and/or other benefits derived from these ecosystems during my lifetime

☐ So Marine industries can remain profitable

☐ So future generations can benefit from these ecosystems in the same way that we can today

☐ Because it is our moral responsibility to preserve these ecosystems

☐ Because Humans need these ecosystems to live

☐ Because these ecosystems should continue to exist independently from any Human consideration

☐ Because Humans and other species are all equally important

☐ Other. Please specify

2.3 (If Yes in 2.1) Do you actively support the conservation of coastal and marine ecosystems (e.g. by volunteering your time, financial subscription or donation, voting for party/individuals who support the preservation of coastal and marine ecosystems)? ☐ Yes ☐ No

2.4 Do you think current Australian management of coastal and marine ecosystems is sufficient to guarantee their conservation? ☐ Yes ☐ No ☐ Do not know

2.4.1 If not, why do you think it is the case (several answers are possible)?

☐ Not enough money is spent/effort is dedicated to coastal and marine ecosystem preservation

☐ Enough money is spent/effort dedicated but management processes need to be improved

☐ Not enough commitment from policy makers

☐ Not enough commitment from the general population

☐ Because of growing pressures on these ecosystems (e.g. fishing pressure, coastal and marine pollution)

☐ Because of climate change

☐ Other. Please specify

2.5 Do you think all coastal development would have to slow down now in order to preserve coastal and marine ecosystems? ☐ Yes ☐ No ☐ Do not know

3. Economic valuation of Coastal and Marine Ecosystems

3.1 Have you heard about studies that aim at giving an economic value (in dollars) to *coastal and marine ecosystem services** (for example commercial and recreational fisheries, other marine activities, scenic beauty…), or to specific habitat or endangered species? ☐ Yes ☐ No

3.2 Do you think *economic valuation of ecosystem services** (ESV) is a useful thing to do?

☐ Yes, ESV is <u>necessary</u> to support better management. Please specify (several answers are possible):

☐ As a way to communicate, advocate or raise awareness about the contribution of ecosystems to Human well-being

☐ As a way to include ecological costs and benefits in the monetary evaluations supporting management decisions

☐ As a basis for discussions during management decision-making processes

☐ As a basis for implementing financial instruments such as subsidies, taxes or fees

☐ As a basis for establishing levels of monetary compensation for ecological damages

☐ Yes, ESV is <u>useful</u> to support better management. Please specify (several answers are possible):

☐ As a way to communicate, advocate or raise awareness about the contribution of ecosystems to Human well-being

☐ As a way to include ecological costs or benefits in the monetary evaluations supporting management decisions

☐ As a basis for discussions during management decision-making processes

☐ As a basis for implementing financial instruments such as subsidies, taxes or fees

☐ As a basis for establishing levels of monetary compensation for ecological damages

☐ No, ESV is <u>not useful</u> to support better management. Please specify (several answers are possible):

☐ Management should be supported on grounds other than ESV, for instance through a focus on ecological indicators or on community consultation

☐ ESV cannot put an economic value (in dollars) on most ecosystem services due to their complexity so that economic valuation is incomplete and inaccurate

☐ ESV is not relevant enough to ensure informed and coherent choices about ecosystem services and their conservation

☐ ESV will allow polluters to simply buy their way out

☐ ESV will allow some financial instruments to be implemented which will end up having destructive effects

☐ Such exercises are not morally or ethically acceptable

☐ Other:__________

☐ Do not know

3.3 (If answered <u>Not useful</u> in 3.2, skip this question) Do you think there are limits to the use of ESV in decision-making? ☐Yes ☐No ☐Do not know

3.3.1 If yes, please indicate these limits (several answers are possible):

☐ The decision-making framework/guidelines may not allow this information to be used

☐ The validity of ESV may not be widely enough accepted

☐ The information may increase conflicts between stakeholders during the decision-making process

☐ ESV is too simplistic given the complexity of interactions between humans and ecosystems

☐ ESV has to be improved in terms of techniques and methods

☐ The cost of ESV may restrict its use

☐ ESV may lead to undesirable consequences (privatizing ecosystems services*, allowing the purchase of rights to pollute…)

☐ ESV is morally or ethically questionable

☐ Other:__________

3.4 (If answered Not useful in 3.2, skip this question) For each ecosystem service listed below, please indicate how important you think it is to consider an economic value during the decision-making process in Australia.

Ecosystem services	**Importance of quantifying these services through economic values (in dollar)**				
	high	**medium**	**low**	**none**	**Do not know**
Commercial fisheries	☐	☐	☐	☐	☐
Materials provision such as timber harvesting from mangroves, aquarium and ornamental harvesting, collection of pharmaceuticals	☐	☐	☐	☐	☐
Aquaculture	☐	☐	☐	☐	☐
Ports and shipping	☐	☐	☐	☐	☐
Recreational fisheries	☐	☐	☐	☐	☐
Other recreational activities such as diving, swimming, surfing…	☐	☐	☐	☐	☐
Aesthetic benefits	☐	☐	☐	☐	☐
Research and education	☐	☐	☐	☐	☐
Habitat for species (e.g. breeding and nursery areas)	☐	☐	☐	☐	☐
Storm protection, shoreline stabilization and flood control	☐	☐	☐	☐	☐
Water quality regulation and waste assimilation	☐	☐	☐	☐	☐
Carbon sequestration	☐	☐	☐	☐	☐
Future services which we do not yet benefit from (e.g. bioprospecting)	☐	☐	☐	☐	☐
*Non-use values**(e.g. existence values)	☐	☐	☐	☐	☐
Indigenous cultural/customary values	☐	☐	☐	☐	☐

3.5 In order to estimate the value of some *ecosystem services** that are not priced on markets (e.g. non-commercial recreational activities, aesthetic benefits, *non-use values**), economists often use surveys to ask the population about their *willingness to pay** (WTP) for such services (without actually having them pay anything). Do you think such WTP estimates can be taken as a good measure of the economic value attached by the population to these services? ☐ Yes ☐ No ☐ Do not know

4. Use of marine and coastal areas

4.1 Do you participate in the following marine activities and if yes how frequently?

	Never	Less than once per year	Once per year	Several times per year	Several times per month	Several times per week
Commercial fishing	☐	☐	☐	☐	☐	☐
Other marine commercial activities	☐	☐	☐	☐	☐	☐
Recreational fishing	☐	☐	☐	☐	☐	☐
Snorkeling/Scuba Diving	☐	☐	☐	☐	☐	☐
Surf sports	☐	☐	☐	☐	☐	☐
Swimming/Beach	☐	☐	☐	☐	☐	☐
Boating/Sailing	☐	☐	☐	☐	☐	☐
Indigenous customary uses	☐	☐	☐	☐	☐	☐
Other(s). Please specify:	☐	☐	☐	☐	☐	☐

5. A hypothetical Coastal and Marine Ecosystems management problem

An important coastal development project is being planned in a coastal and marine area which you know well. This area is used intensively for many marine activities: commercial fisheries, recreational fisheries, boating, diving, snorkeling and tourism activities. The area contains ecosystems of international significance with an important diversity of habitats (e.g. wetlands, coral reefs, rocky reefs, mangroves, sea grass) and popular or unique species (for example: whales, dolphins, turtles, dugongs).

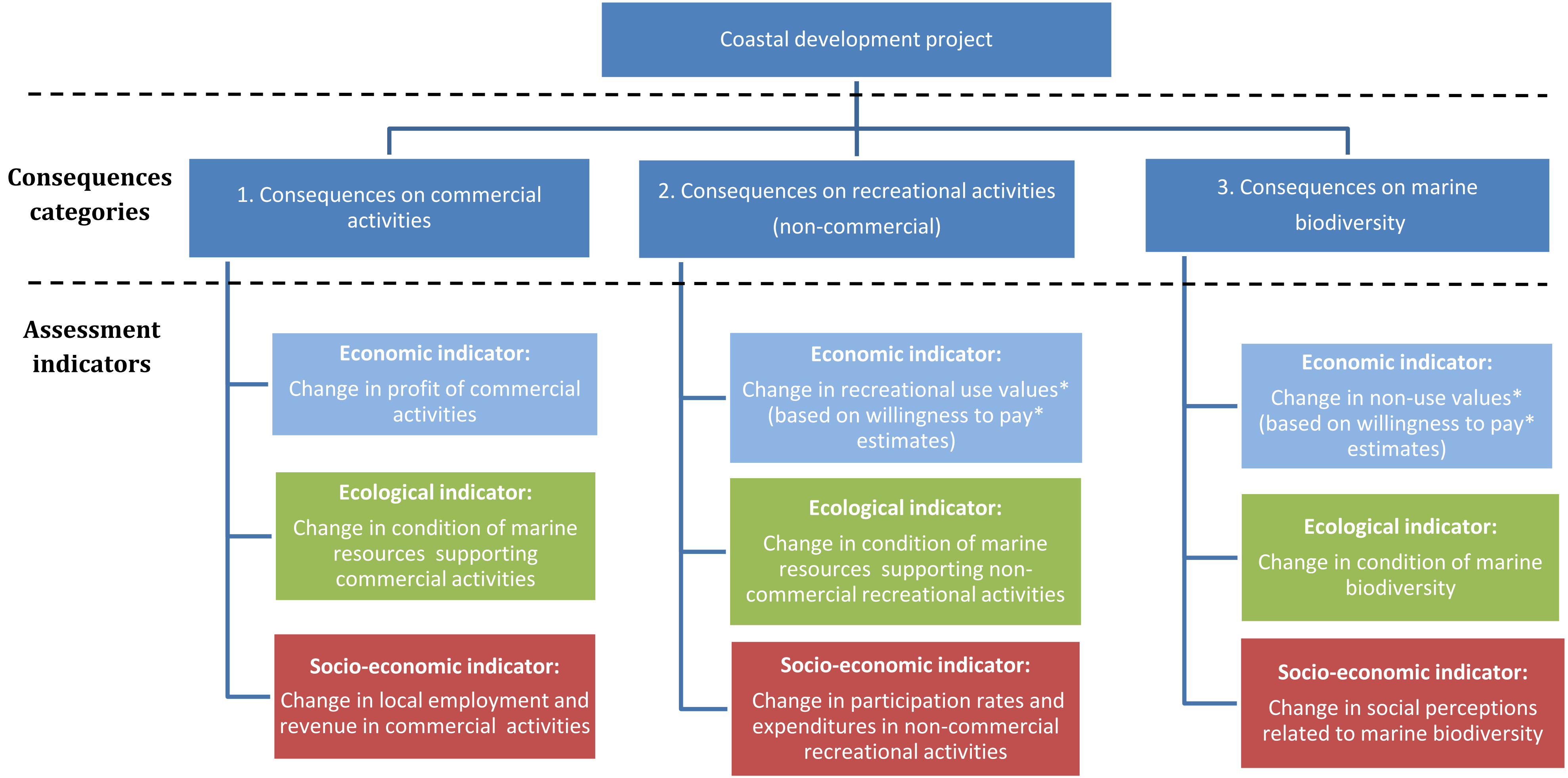
The development project is expected to have consequences on the following:

- **commercial activities**: commercial fishing operations, diving and snorkelling operations, charter recreational fishing operations;
- **recreational activities (non-commercial):** recreational fishing, diving, snorkelling, surfing, boating, beach use;
- **marine biodiversity:** diversity of marine habitats and species.

Several options for the development project are being considered (including an alternative way of managing project impacts). To help decision-makers choose which development option to approve (if any), the consequences of each option is to be assessed using three types of information: **economic indicators, ecological indicators and socio-economic indicators**. The diagram below highlights the three types of consequences and the corresponding assessment indicators.

In this section, we would like you to tell us which type of information you believe should be given priority when assessing the consequences of the development project options.

Please bear in mind that this exercise only focuses on the project's consequences on marine ecosystems and associated marine activities.


Coastal development project
Consequences categories
1. Consequences on commercial activities
2. Consequences on recreational activities (non-commercial)
3. Consequences on marine biodiversity
Assessment indicators
Economic indicator:
Change in profit of commercial activities
Ecological indicator:
Change in condition of marine resources supporting commercial activities
Socio-economic indicator:
Change in local employment and revenue in commercial activities
Economic indicator:
Change in recreational use values* (based on willingness to pay* estimates)
Ecological indicator:
Change in condition of marine resources supporting non-commercial recreational activities
Socio-economic indicator:
Change in participation rates and expenditures in non-commercial recreational activities
Economic indicator:
Change in non-use values* (based on willingness to pay* estimates)
Ecological indicator:
Change in condition of marine biodiversity
Socio-economic indicator:
Change in social perceptions related to marine biodiversity

5.1 **Which consequences of the development project (consequences on commercial activities, non-commercial recreational activities or marine biodiversity) do you consider more important to include in the assessment process?**

Consequences on commercial activities | **Consequences on recreational activities (non- commercial)**

								Q1								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Significantly more important | Equal | Significantly more important

Consequences on commercial activities | **Consequences on marine biodiversity**

								Q1								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Significantly more important | Equal | Significantly more important

Consequences on recreational activities (non- commercial) | **Consequences on marine biodiversity**

								Q1								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Significantly more important | Equal | Significantly more important

5.2 **Which indicator do you consider more important to use when assessing consequences of the development project on marine commercial activities?**

Economic indicator: change in profit of commercial activities — **Ecological indicator: change in condition of marine resources supporting commercial activities**

								Q1								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Significantly more important — Equal — Significantly more important

Economic indicator: change in profit of commercial activities — **Socio-economic indicator: change in local employment and revenue in commercial activities sector**

								Q1								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Significantly more important — Equal — Significantly more important

Ecological indicator: change in condition of marine resources supporting commercial activities — **Socio-economic indicator: change in local employment and revenue in commercial activities sector**

								Q1								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Significantly more important — Equal — Significantly more important

Definition of the indicators

Economic indicator: Profit (profit=revenue -costs) of commercial activities including fishing operations, diving and snorkeling operations, charter and recreational fishing operations

Ecological indicator: Condition of the stock and habitats of the species targeted by commercial fisheries and chartered recreational fisheries (e.g. abundance of commercial fish); and condition of the stock and habitats of the species supporting recreational activities offered by operators (e.g. whales)

Socio-economic indicator: Local employment in the commercial activity sector, and revenue from commercial activities (e.g. value of sales directly derived from landings)

5.3 **Which indicator do you consider more important to use when assessing consequences of the development project on marine non-commercial recreational activities?**

Economic indicator: change in recreational use values (based on willingness to pay estimates) — **Ecological indicator: change in condition of marine resources supporting non-commercial recreational activities**

								Q1								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Significantly more important — Equal — Significantly more important

Economic indicator: change in recreational use values (based on willingness to pay estimates) — **Socio-economic indicator: change in participation rates and expenditures in non-commercial recreational activities**

								Q1								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Significantly more important — Equal — Significantly more important

Ecological indicator: change in condition of marine resources supporting non-commercial recreational activities — **Socio-economic indicator: change in participation rates and expenditures in non-commercial recreational activities**

								Q1								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9

Significantly more important — Equal — Significantly more important

Definition of the indicators

Economic indicator: Recreational use values*, that is to say asking people through surveys or estimating through people's behaviors their willingness to pay* for recreational marine activities and associated marine ecosystem features

Ecological indicator: Condition of the stock and habitats of species which are of primary importance to recreational activities (specific fish species targeted by recreational fishing, popular species for diving/snorkeling); condition of specific aesthetic assets (such as water clarity, specific underwater or beach landscapes…)

Socio-economic indicator: Participation rates in non-commercial recreational activities (from local users and tourists) and expenditures of recreational users

5.4 **Which indicator do you consider more important to use when assessing consequences of the development project on marine biodiversity?**

Economic indicator: change in non-use values (based on willingness to pay estimates)								Q1								**Ecological indicator: change in condition of marine biodiversity**
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Significantly more important								Equal								Significantly more important

Economic indicator: change in non-use values (based on willingness to pay estimates)								Q1								**Socio-economic indicator: change in social perceptions related to marine biodiversity**
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Significantly more important								Equal								Significantly more important

Ecological indicator: change in condition of marine biodiversity								Q1								**Socio-economic indicator: change in social perceptions related to marine biodiversity**
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Significantly more important								Equal								Significantly more important

Definition of the indicators

Economic indicator: Non-use values*, that is to say asking people through surveys how much they are willing to pay for preserving marine ecosystems without any consideration of their current or future uses

Ecological indicator: Condition of marine biodiversity assessed by several indicators (condition of species that have special conservation status, condition of key species or structural components of the ecosystem, or condition of physical-chemical components of the ecosystem)

Socio-economic indicator: Information through opinion polls and surveys about social perceptions of the status of marine biodiversity, and about the importance of marine biodiversity for populations (such as moral or spiritual importance)

6. Question related to the choice made in section 5

6.1 Are you confident in your answers to the comparison exercise you have completed?

☐ Yes, I understood what was required and my answers are a good reflection of my preferences

☐ No, I found the exercise unclear and/or difficult and my answers may not reflect my preferences correctly

6.1.1 (If No answered in 6.1) Was this because?

☐ I felt I needed more information on the coastal development project that is being planned

☐ I felt I needed more information on the commercial activities, recreational activities and marine biodiversity in the area considered

☐ I felt I needed a better understanding of the different indicators being compared

☐ I felt I needed a better understanding of the inconsistency index

☐ Other:

7. Comments

7.1 Please indicate the approximate time spent to complete the questionnaire:

7.2 If you have any comments concerning the questionnaire, please mention them below:

- **Questionnaire Decision-makers**

*The symbol * indicates that the word/concept is defined in the glossary*

1. General information

1.1 What is your Gender? ☐ Male ☐ Female ☐ Prefer not to say

1.2 What is your Age?

☐ Under 18 ☐ 18-24 ☐ 25-34 ☐ 35-44 ☐ 45-54 ☐ 55-64
☐ 65-74 ☐ 75+ ☐ Prefer not to say

1.3 Which state do you live in?

☐ New South Wales ☐ Victoria ☐ Queensland ☐ South Australia ☐ Western Australia
☐ Northern Territory ☐ Tasmania ☐ ACT ☐ Prefer not to say

1.3.1 What is your home post code?___________ ☐ Prefer not to say

1.4 What is your educational background? Please indicate

1.4.1 The highest level attained:

☐Secondary ☐ Certificate ☐ Advanced Diploma and Diploma ☐ Bachelor Degree

☐ Graduate Diploma and Graduate Certificate ☐ Postgraduate Degree

☐ Other. Please specify:

1.4.2 The field of education (several answers are possible):

☐Natural and physical sciences (e.g. mathematics, physics, chemical, biological and earth sciences…)

☐Information technology (e.g. computer science, information system and technology)

☐Engineering and related technologies

☐Architecture and Building

☐Agriculture, Environmental and related studies (e.g. forestry, fisheries, environmental management…)

☐Health

☐Education

☐Management and commerce (e.g. accounting, business, sales and marketing, tourism, finance…)

☐Society and culture (e.g. political sciences, economics, social sciences, anthropology, justice and low, language and literature, sports and recreation…)

☐Creative arts

☐Food, Hospitality and Personal Services

☐Mixed Field Programmes (e.g. primary and secondary education programmes, personal development education programmes such as social and employment skills)

☐ Other. Please specify:

1.5 Do you have work experience in any of the following areas? (several answers are possible)

☐ Economics ☐ Finance ☐ Business

☐ Biological conservation ☐ Natural resource/Environmental management ☐ None of the above

1.6 Do you currently work for (several answers are possible):

☐ Government and associated agencies (policy & management)

☐ Government and associated agencies (research)

☐ Research and higher education

☐ A marine industry

☐ Other. Please specify: ______________________________________

2. Experience in Coastal and Marine Ecosystems decision-making

2.1 Which of the following marine jurisdictions does your work relate to and what aspects of management are you involved in? Please tick the different boxes relating to your current and previous situations (several boxes can be ticked).

	Commonwealth	Queensland	New South Wales	Victoria	Tasmania	South Australia	Northern Territory	Western Australia
Management of commercial fisheries	☐	☐	☐	☐	☐	☐	☐	☐
Management of recreational activities and tourism	☐	☐	☐	☐	☐	☐	☐	☐
Marine areas and species conservation	☐	☐	☐	☐	☐	☐	☐	☐
Management of coastal development	☐	☐	☐	☐	☐	☐	☐	☐
Management of coastal and marine pollution	☐	☐	☐	☐	☐	☐	☐	☐
Protection of indigenous cultural and customary uses	☐	☐	☐	☐	☐	☐	☐	☐
Other. Please specify:	☐	☐	☐	☐	☐	☐	☐	☐

2.2 How long in total have you been involved in coastal and marine resources management?
___Years

2.3 Which of the following best describes the role that you generally, primarily play in decision-making processes involving *coastal and marine ecosystems** in your work (several answers are possible)?

☐ Informative (collating information and delivering it to others)

☐ Consultative (providing advice and recommendations to others)

☐ Contributive (contributing to the final decision and/or management plan)

☐ Decisive (deciding whether or not a decision is implemented)

☐ Other:_____________

3. Economic valuation of Coastal and Marine Ecosystems

3.1 There are studies that aim at giving an *economic value* (in dollars) to *coastal and marine ecosystem services** (for example commercial and recreational fisheries, other marine activities, scenic beauty…), or to specific habitat or endangered species. Which of the following best describes your experience with such studies?

☐ I used such studies often ☐ I have used such studies before, but not often ☐ I am familiar with (but have never used) such studies ☐ I have only heard of such studies

☐ I never heard of such studies

3.2 Do you think *economic valuation of ecosystem services** (ESV) is a useful thing to do?

☐ Yes, ESV is <u>necessary</u> to support better management. Please specify (several answers are possible):

☐ As a way to communicate, advocate or raise awareness about the contribution of ecosystems to Human well-being

☐ As a way to include ecological costs and benefits in the monetary evaluations supporting management decisions

☐ As a basis for discussions during management decision-making processes

☐ As a basis for implementing financial instruments such as subsidies, taxes or fees

☐ As a basis for establishing levels of monetary compensation for ecological damages

☐ Yes, ESV is <u>useful</u> to support better management. Please specify (several answers are possible):

☐ As a way to communicate, advocate or raise awareness about the contribution of ecosystems to Human well-being

☐ As a way to include ecological costs or benefits in the monetary evaluations supporting management decisions

☐ As a basis for discussions during management decision-making processes

☐ As a basis for implementing financial instruments such as subsidies, taxes or fees

☐ As a basis for establishing levels of monetary compensation for ecological damages

☐ No, ESV is <u>not useful</u> to support better management. Please specify (several answers are possible):

☐ Management should be supported on grounds other than ESV, for instance through a focus on ecological indicators or on community consultation

☐ ESV is not relevant enough to ensure informed and coherent choices about ecosystem services and their conservation

☐ ESV cannot put an economic value (in dollars) on most ecosystem services due to their complexity so that economic valuation is incomplete and inaccurate

☐ ESV will allow polluters to simply buy their way out

☐ ESV will allow some financial instruments to be implemented which will end up having destructive effects

☐ Such exercises are not morally or ethically acceptable

☐ Other:____________

☐ Do not know

3.3 (If answered <u>Not useful</u> in 3.2, skip this question) Do you think there are limits to the use of ESV* in decision-making? ☐Yes ☐No ☐Do not know

3.3.1 If yes, please indicate these limits (several answers are possible):

☐ The decision-making framework/guidelines may not allow this information to be used

☐ The validity of ESV may not be widely enough accepted

☐ The information may increase conflicts between stakeholders during the decision-making process

☐ ESV is too simplistic given the complexity of interactions between humans and ecosystems

☐ ESV has to be improved in terms of techniques and methods

☐ The cost of ESV may restrict its use

☐ ESV may lead to undesirable consequences (privatizing ecosystems services, allowing the purchase of rights to pollute…)

☐ ESV is morally or ethically questionable

☐ Other:_____________

3.4 (If answered Not useful in 3.2, skip this question) For each ecosystem service* listed below, please indicate how important you think it is to consider an economic value during the decision-making process in Australia. Given your experience, please also indicate the level of trust you would have in each of these values.

Ecosystem services	**Importance of quantifying these services through economic values (dollar)**				**Level of trust in the values**				**Do not know**
	high	**medium**	**low**	**nil**	**high**	**medium**	**low**	**nil**	
Commercial fisheries	☐	☐	☐	☐	☐	☐	☐	☐	☐
Materials provision such as timber harvesting from mangroves, aquarium and ornamental harvesting, collection of pharmaceuticals	☐	☐	☐	☐	☐	☐	☐	☐	☐
Aquaculture	☐	☐	☐	☐	☐	☐	☐	☐	☐
Ports and shipping	☐	☐	☐	☐	☐	☐	☐	☐	☐
Recreational fisheries	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other recreational activities such as diving, swimming, surfing	☐	☐	☐	☐	☐	☐	☐	☐	☐
Aesthetic benefits	☐	☐	☐	☐	☐	☐	☐	☐	☐
Research and education	☐	☐	☐	☐	☐	☐	☐	☐	☐
Habitat for species (e.g. breeding and nursery areas)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Storm protection, shoreline stabilization and flood control	☐	☐	☐	☐	☐	☐	☐	☐	☐
Water quality regulation and waste assimilation	☐	☐	☐	☐	☐	☐	☐	☐	☐
Carbon sequestration	☐	☐	☐	☐	☐	☐	☐	☐	☐
Future services which we do not yet benefit from (e.g. bioprospecting)	☐	☐	☐	☐	☐	☐	☐	☐	☐
*Non-use values** (e.g. existence values)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Indigenous cultural/customary values	☐	☐	☐	☐	☐	☐	☐	☐	☐

Total value of all ecosystem services (for example economic value per hectare or per species)	☐	☐	☐	☐	☐	☐	☐	☐	☐

4. Utilization of economic valuation results

(If answered "I never heard of such studies" in question 3.1, please skip this section)

4.1 In the following management contexts, what type of coastal and marine ESV have you considered during decision making processes in which you were involved? When possible, please provide a reference to a specific valuation study as an example (including location and year).

Whenever you do not know or have never considered ESV, do not tick any box.

	ESV as a way to communicate, advocate or raise awareness		ESV for evaluation and decision-making		ESV for establishing taxes, subsidies, fees or damage compensation	
	Often considered	Rarely considered	Often considered	Rarely considered	Often considered	Rarely considered
Management of commercial fisheries	☐	☐	☐	☐	☐	☐
	Example:		Example:		Example:	
Management of recreational activities and tourism (including recreational fisheries)	☐	☐	☐	☐	☐	☐
	Example:		Example:		Example:	
Marine areas and species conservation	☐	☐	☐	☐	☐	☐
	Example:		Example:		Example:	
Management of coastal development	☐	☐	☐	☐	☐	☐
	Example:		Example:		Example:	
Management of coastal and marine pollution	☐	☐	☐	☐	☐	☐
	Example:		Example:		Example:	
Protection of indigenous cultural and customary uses	☐	☐	☐	☐	☐	☐
	Example:		Example:		Example:	

4.2 Are you aware of any specific ESV work(s) regarding marine and coastal ecosystems that did have a significant impact on policy or management in a specific region? ☐ Yes ☐ No ☐ Do not know

4.2.1 If yes, please cite the main or most important one(s) you have in mind (if possible, please provide a reference to a specific valuation study, including location and year)?

☐ In Australia. Please specify:

☐ Elsewhere. Please specify:

4.3 Have you been involved in a decision-making process where ESV information existed but was not used? If yes, please provide at least one reference to a specific valuation study, including location and year, if possible.

☐ Yes, often. Please specify:

☐ Yes, only a few times. Please specify:

☐ Never

☐ Do not know

4.3.1 If yes, for what reason in your opinion?

☐ The decision-making framework/guidelines did not allow this information to be used

☐ The information was not accessible

☐ The information was not relevant to the need of decision makers or management (e.g. not answering specific questions from decision-makers, not valuing specific relevant changes…)

☐ The information was not perceived as robust enough/was too uncertain

☐ The decision makers preferred to base decision-making on other types of information

☐ Other. Please specify:___________________

4.4 Do you think that coastal and marine ESV should be used more in decision-making?

☐ Yes ☐ No ☐ Do not know

4.4.1 If yes, for what kind of values (several answers are possible):

☐ Economic value of commercial activities (i.e. profits of commercial fishing, aquaculture, charter and recreational operators)

☐ Economic value of recreational activities (i.e. willingness-to-pay* of individuals participating in marine recreational activities)

☐ Economic values of coastal protection, carbon storage, research and education

☐ *Non use values** associated with marine biodiversity conservation (existence and bequest values)

☐ Other. Please specify:___________________

5. A hypothetical Coastal and Marine Ecosystems management problem

See Questionnaire General Public above: this section containing the AHP was exactly the same in both questionnaires

6. Question related to the choice made in section 5

6.1 Are you confident in your answers to the pair-wise comparison exercise you have completed?

☐ Yes, I understood what was required and my answers are a good reflection of my preferences

☐ No, I found the exercise unclear and/or difficult and my answers may not reflect my preferences correctly

6.1.1 (If No answered in 6.1) Was this because?

☐ I felt I needed more information on the coastal development project that is being planned

☐ I felt I needed more information on the commercial activities, recreational activities and marine biodiversity in the area considered

☐ I felt I needed a better understanding of the different indicators being compared

☐ I felt I needed a better understanding of the inconsistency index

☐ Other:

7. Marine activities

7.1 Do you participate in the following marine activities and if yes how frequently?

	Never	Less than once per year	Once per year	Several times per year	Several times per month	Several times per week
Commercial fishing	☐	☐	☐	☐	☐	☐
Other marine commercial activities	☐	☐	☐	☐	☐	☐
Recreational fishing	☐	☐	☐	☐	☐	☐
Snorkeling/Scuba Diving	☐	☐	☐	☐	☐	☐
Surf sports	☐	☐	☐	☐	☐	☐
Swimming/Beach	☐	☐	☐	☐	☐	☐
Boating/Sailing	☐	☐	☐	☐	☐	☐
Indigenous customary uses	☐	☐	☐	☐	☐	☐
Other(s) (please specify):	☐	☐	☐	☐	☐	☐

8. Comments

8.1 If you have any comments concerning the questionnaire, please mention them below:

Appendix O: Additional information from surveys

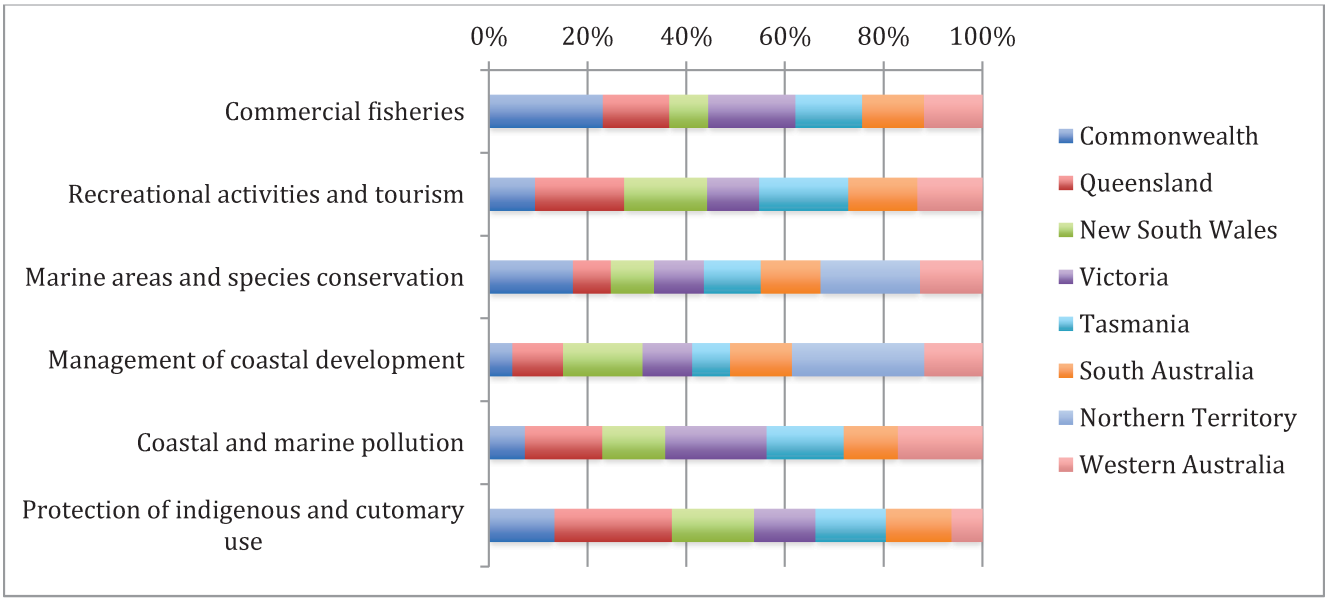


Figure O1 Decision-makers sample: types of management in which respondents are involved by jurisdictions they are working on

The detailed answers to the question concerning the three most important motivations to preserve coastal and marine ecosystems are presented in figures O2, O3 and O4 below.

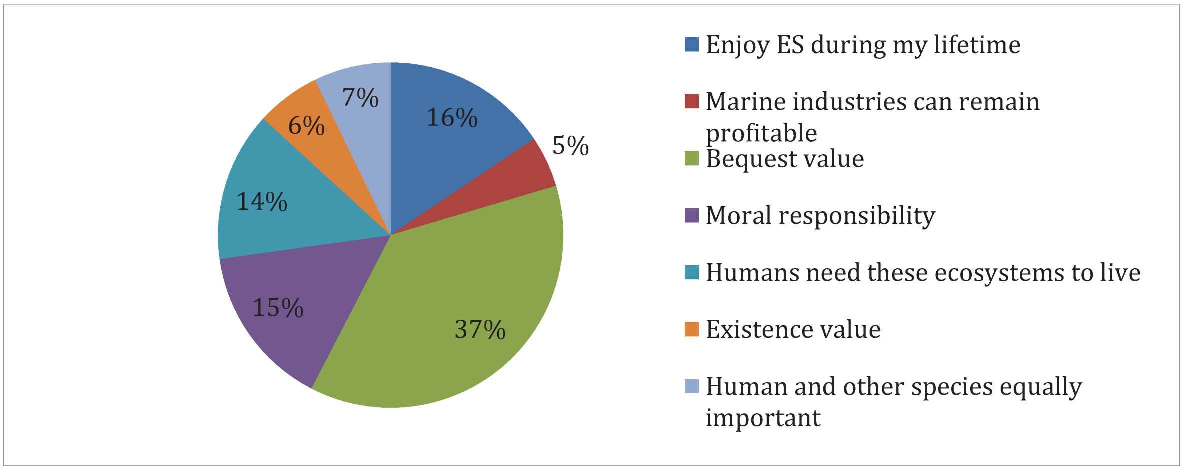


Figure O2 Stated first most important reasons to preserve coastal and marine ecosystems

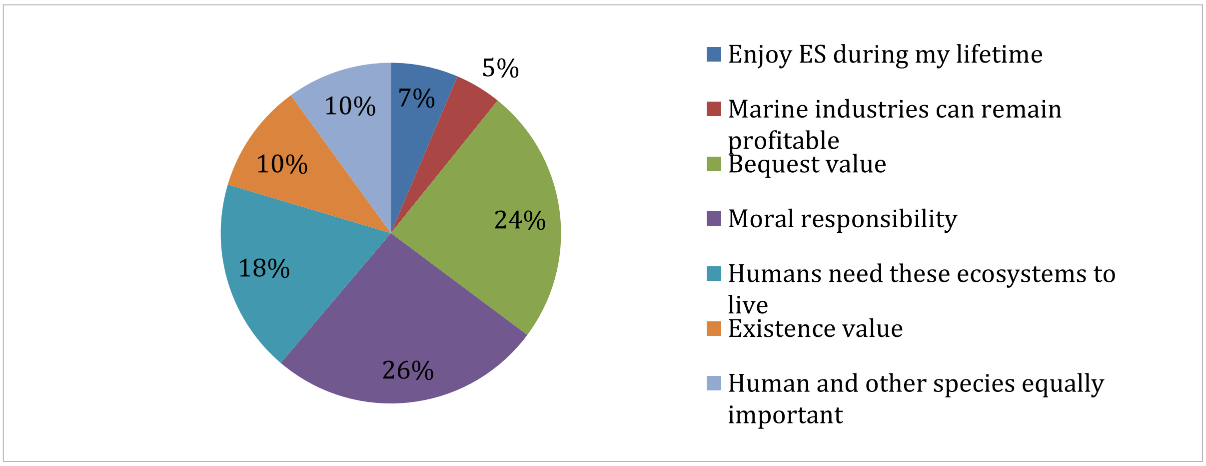


Figure O3 Stated second most important reasons to preserve coastal and marine ecosystems

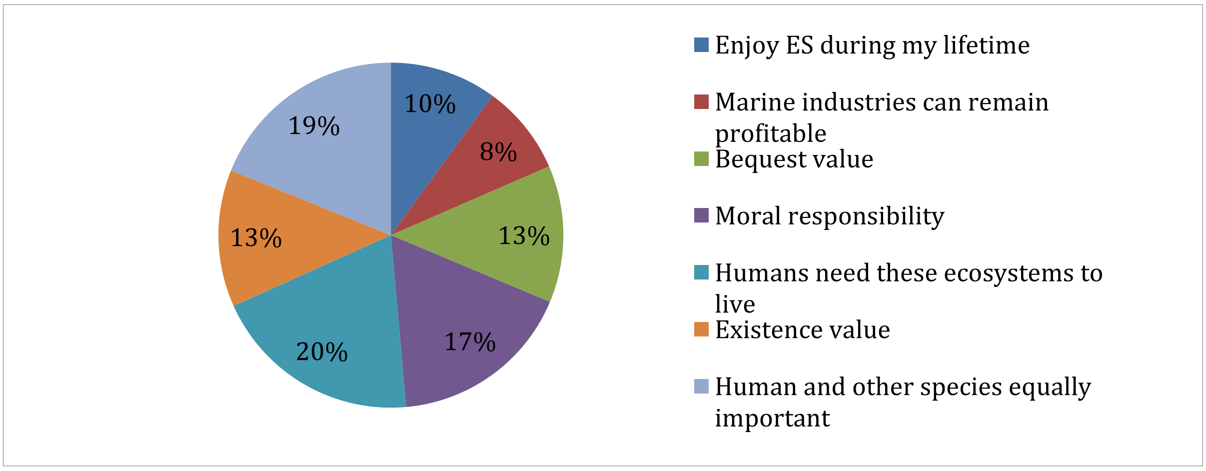


Figure O4 Stated third most important reasons to preserve coastal and marine ecosystems

Appendix P: Example of ESV use by types of utilization and management context

	ESV as a way to communicate, advocate or raise awareness	ESV for evaluation and decision-making	ESV for establishing taxes, subsidies, fees or damage compensation
Commercial fisheries	Incorporating economic aspects of fisheries into the development of management plans Access Economics 2006/2007 report to Great Barrier Reef Marine Park (GBRMPA) Maximum Economic Yield considerations in Western Rock Lobster Fisheries Establishment of buy out schemes for dugong protected area, 1990s Value of Indigenous commercial fisheries NSW 2012	Was used as a discussion point in Ningaloo and commonwealth fisheries management arena - work by Atakelty Hailu.(University of Western Australia) Economic aspects for setting TAAC for Pipi fishery in South Australia in 2013 Economic value of the Great Barrier Reef- Access Economics Harvest strategy evaluation in SRL Planning for GBR Rep Areas 2000	Has been used to consider economic incentives in Australian Southern and Eastern Scalefish and Shark Fishery - e.g. work by Thebaud and Hutton for FRDC *(Bio-economic modelling)* Buy-back of commercial fishing activity due to establishment of marine parks in South Australia in 2013 SA Marine Parks Econsearch report South West Bioregion Commonwealth Marine Reserve Network ABARES report Rarely used in fisheries unfortunately. Some good discussions, e.g. Bromley
Recreational activities and tourism	Beach and Surf Tourism and Recreation Values - Bond and Griffith University (2012-13) Access economics 2012/2013 report to GBRMPA Benefits and costs for beach nourishment (Surfers Paradise 1998) Zoning of marine park (GBR) 2006 and beyond During preparation and communication of a conservation management plan 2010-12 Used in public comment phase of new water quality policy in South Australia Clarence Valley Beach and Surf Tourism project 2013	Was used as a discussion point in Ningaloo and commonwealth fisheries management arena - work by Atakelty Hailu.(University of Western Australia) *(Bio-economic modelling)* Closure of snapper fishing to all sectors including recreational fishing in South Australia in 2013 Which campus to locate a Research Centre for coastal management (Griffith University Parklands 1998) Anonymous phone surveys conducted (2009? Tan?) regarding values placed by stakeholders on NSW marine parks used in marine park zoning	There is work being done by Pete Mumby in coral triangle at present Infrastructure Charging Stormwater Quality (Gold Coast 2005) ESV have considered but not applied in a practical sense

	Off-road use of vehicles along the coast and its contribution to regional economies used as an argument particularly by local councils in South Australia i.e. in attracting tourism	plan review Used for the GBRMPA. Occasionally considered as ongoing in terms of promoting the sustainable use of marine areas for nature based tourism as a means of promoting marine values and conservation (ongoing no specific year) Considered in developing new water quality policy in South Australia Clarence Valley Beach and Surf Tourism project 2013 Port Stephens Great lakes Marine Park Zoning Plan - economic analysis	

Conservation of marine areas and species	Cost-effectiveness of monitoring and cost-effectiveness of invasive species control Ningaloo Marine Park 2009-13 Kirkman, H. 2013 Choosing boundaries to marine protected areas and zoning the MPAs for restricted use and management. Journal of Ocean and Coastal Management. 81, 38–48. There is all the INVEST work around the world and the uses of some of the valuations as layers in MARXAN etc. studies. This approach has influence in how things are done at the research size Marine parks sanctuary zones and their economic impact Tallebudgera Greenspace 1995 Anonymous phone surveys conducted (2009? Tan?) regarding values placed by stakeholders on NSW marine parks used in marine park zoning plan review EZZY, E. & SCARBOROUGH, H. (2011) Estimation of the Recreational Use Value Gained from Recreational Fishing of Southern Bluefin Tuna at Portland, Australia.Australian Agricultural and Resource During preparation and communication of a conservation management plan 2010-12 We have just been through the process of setting up marine parks. Ecosystem value was often referred to but not quantified	Construction of new infrastructure in the marine environment where protected species are established. The only allowance is not to build during breeding season, the effects of ongoing use of the facility on the species population is unknown but still going ahead. Ningaloo Marine Park 2009-13 Kirkman, H. and Boon, P. 2012 Review of Mangrove Planting Activities around Westernport 2004-2011. Report to Western Port Seagrass Partnership Inc. 43 pp Kirkman, H. 2013 Choosing boundaries to marine protected areas and zoning the MPAs for restricted use and management. Journal of Ocean and Coastal Management. 81, 38–48 Calculating the amount of displaced catch and effort due to establishment of marine parks in South Australia in 2012 Gold Coast Commercial Fishing Licences 1995 Anonymous phone surveys conducted (2009? Tan?) regarding values placed by stakeholders on NSW marine parks used in marine park zoning plan review Commercial fishing economic value from catch and return data provided by Dept of Fisheries, WA in most marine conservation reserve decision making processes over the last 10 years. All marine park planning in WA. "We want to use this but there isn't time" was the quote from the planners in DEC. Too hard to put numbers to it, but certainly give lip service to it	Kirkman, H., Bryars S.and Brook, J. 2012 Marine Park Regional Impact Statements Main Report Department of Environment, Water and Natural Resources, South Australia. 283 pp Kirkman H. 2013 Impact of proposed Port of Hastings Expansion on Seagrass Mangroves and Saltmarsh. Report to Victorian National Parks Association Inc. 35 pp. Marine parks buy-back program Broadwater Parklands Mangrove compensatory habitat 2010 Southport Abalone survey in Ngari Capes Marine Park conducted by Murdoch University, approx 2006 There is work being done by Pete Mumby in coral triangle at present Valuation of the abalone fishery in the Capes Area of WA ESV considered but not apply in practical sense Seagrass economic values in South Australia have been estimated to be worth between $15,000 to $25,000 per hectare per year depending on meadow size density and species (seagrass workshop 2001). The Native Vegetation council applied an offset for seagrass loss during a development application, 3 variables considered were area cleared, significant environmental benefit and determination of management costs (re-vegetation). The value of $50 per hectare was given, it is not known how this amount was reached.

Coastal Development	Kirkman H. 2013 Impact of proposed Port of Hastings Expansion on Seagrass Mangroves and Saltmarsh. Report to Victorian National Parks Association Inc. 35 pp. Aquaculture zone policy development in South Australia During development of coastal zone management plans in Eurobodalla (NSW) 2010 - current Address the concept of ESV generically in community engagement events and publications (NSW) Seawall condition >$25,0000 trigger for development upon erosion prone land 1994 GC Planning Code (Gold Coast???) Byron Shire Coastline Management Study (WBM, 2004) Cost Benefit Analysis of management Options Current state planning reforms in Queensland. These decisions are implemented by all political shades and levels of government in WA. Money talks Specifically included in our coastal management plans eg Adelaide Living Beaches. A Strategy for 2005–2025 Ochre Point Moana 2013 ESV is used when weighing up the costs/benefits of economic development in policy making (i.e. shipping ports in key environmental areas such as gulfs) Clarence Valley Beach and Surf Tourism project 2013	Dredging of marina entrances and boat ramps can cause turbidity issues that can have an effect on seagrass, approval still given even in areas where beach and cliff erosion occurs. Loss of seagrass in this area will only speed up erosion. Kirkman H. 2013 Impact of proposed Port of Hastings Expansion on Seagrass Mangroves and Saltmarsh. Report to Victorian National Parks Association Inc. 35 pp. Aquaculture zone policy development in South Australia During development of coastal zone management plans in Eurobodalla (NSW) 2010 – current Refer to ESV generically when discussing the importance of maintaining or improving estuary health and selecting appropriate responses to coastal hazards National environmental offsets policy, although the method for calculations is not specified except for a few matters of national environmental significance. CBA to be undertaken for the development of the Byron Bay Embayment Coastal Management Study Specifically included in our coastal management Living Beaches strategy ESV is considered when making policy decisions regarding competing developments in undeveloped areas (i.e. mining vs agriculture - economic yield comparisons). Informal use - internal evaluations not published	Kirkman H. 2013 Impact of proposed Port of Hastings Expansion on Seagrass Mangroves and Saltmarsh. Report to Victorian National Parks Association Inc. 35 pp. Considering economic issues of different sectors for the purpose of cost recovery Hypothetically, the CBA to be undertaken for the Byron Bay Embayment Coastal Management Study (in preparation) may be used to inform a coastal management policy and to determine funding arrangements for the implementation of this policy Stoeckl et al 2011; etc Lip service too but fines etc based on very old Coastal Management Act 1972. ESV has also been applied when looking at environmental protection considers impacts to existing industry (i.e. protection of key commercial fishing grounds and compensation for displacement). Wooli Village draft Coastal Zone Management Plan 2011

Coastal and marine pollution	Kirkman, H. 2011 Seagrasses. In: Vulnerability of South Australian Marine Habitats. Marine Parks, Department of Environment, Water and Natural Resources South Australia.65–71. Kirkman, H.2011. Mangroves. In: Vulnerability of South Australian Marine Habitats. Marine Parks, Department of Environment, Water and Natural Resources South Australia. 30–35. Kirkman H. 2013 Impact of proposed Port of Hastings Expansion on Seagrass Mangroves and Saltmarsh. Report to Victorian National Parks Association Inc. 35 pp. WESTERN PORT , VIC Kirkman, H. 2013. Near-coastal Seagrass Ecosystems In: Ecology and the Environment. Springer. GLOBAL Kirkman, H and Scoresby A. Shepherd, S.A. Further Efforts to Protect Biodiversity in Coastal Waters of South Australia. Journal of Ocean and Coastal Management. In preparation Clean Beach Challenge - cost of pollution` WA EPA policy statements intend these to inform developers, but again money talks.	Economic value and industry profits often beat environmental values. Kirkman, H. and Boon, P. 2012 Review of Mangrove Planting Activities around Western Port 2004-2011. Report to Western Port Seagrass Partnership Inc. 43 pp Kirkman H. 2013 Impact of proposed Port of Hastings Expansion on Seagrass Mangroves and Saltmarsh. Report to Victorian National Parks Association Inc. 35 pp. WESTERN PORT VICTORIA Land Development Guidlines for Justied Gross Pollution traps as part of public estate Gold Coast 2007 Regulations are in place and we are better off for these processes.	In most cases the receiving environment is already degraded from a legacy of discharges and no cost was placed on the environment before an industry discharges. It is difficult to put an ESV on impacted ecosystems Kirkman, H., Bryars S.and Brook, J. 2012 Marine Park Regional Impact Statements Main Report Department of Environment, Water and Natural Resources, South Australia. 283 pp Kirkman H. 2013 Impact of proposed Port of Hastings Expansion on Seagrass Mangroves and Saltmarsh. Report to Victorian National Parks Association Inc. 35 pp. WESTERN PORT VIC Stoeckl et al 2011; etc
Indigenous and customary use	There is all the INVEST work around the world and the uses of some of the valuations as layers in MARXAN etc studies. This approach has influence on the research steps. Tallebudera Creek Burial Grounds land use 1995		

Appendix Q: Example of weight computation

We have three pairwise comparisons involving the comparison of three objectives A, B and C. A was selected to be moderately more important than B (Intensity=4), A was selected to be slightly more important than C (Intensity=2), and C slightly more important than B (Intensity=2). The judgements matrix will take the form of the one presented in table Q1. The relative weights individuals attributed to each criteria are computed by the normalized eigen vector: first each column of the matrix is normalized (i.e. the elements of each column of the matrix are divided by the sum of that column), then the eigen vector is obtained by summing the elements in each resulting row and dividing this sum by the number of elements in the row.

Table Q1 Example of a judgment matrix

	A	B	C	Relative Weights
A	1	4	2	0.57
B	1/4	1	1/2	0.14
C	1/2	2	1	0.29

Then the eigen value is computed by multiplying the vector of relative weights by the vector of the sum of each column of A. In our case, the matrix is perfectly consistent and the eigen value is logically found equal to 3. We therefore have CR=CI=0.

Appendix R: Pair-wise comparisons tool developed in Excel

Which indicator do you consider more important to use when assessing consequences of the development project on marine non-commercial recreational activities?

Absolute importance	Very strong importance	Strong importance	Moderate importance	Equally important	Moderate importance	Strong importance	Very strong importance	Absolute importance

9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9

A. Economic indicator: change in recreational use values (based on willingness to pay estimates) — **B. Ecological indicator: change in condition of marine resources supporting non-commercial recreational activities**

A. Economic indicator: change in recreational use values (based on willingness to pay estimates) — **C. Socio-economic indicator: change in participation rates and expenditures in non-commercial recreational activities**

B. Ecological indicator: change in condition of marine resources supporting non-commercial recreational activities — **C. Socio-economic indicator: change in participation rates and expenditures in non-commercial recreational activities**

9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9

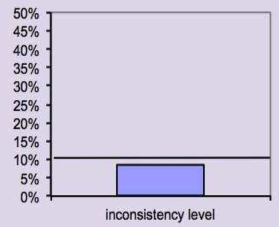
Absolute importance	Very strong importance	Strong importance	Moderate importance	Equally important	Moderate importance	Strong importance	Very strong importance	Absolute importance

Hit "F9" to check consistency

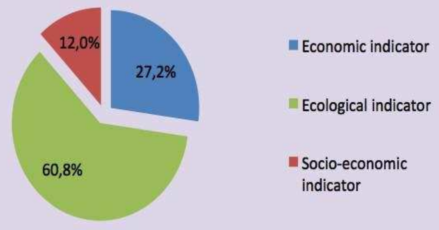
OK? Please go to next tab "Commercial activities"

Summary outcomes

Inconsistency level
(should be less than 10%)



Relative importance



Community definitions

Economic indicator	Recreational use values*, that is to say asking people through surveys or estimating through people's behaviors their willingness to pay* for recreational marine activities and associated marine ecosystem features
Ecological indicator	Condition of the stock and habitats of species which are of primary importance to recreational activities (specific fish species targeted by recreational fishing, popular species for diving/snorkeling); condition of specific aesthetic assets (such as water clarity, specific underwater or beach landscapes...)
Socio-economic indicator	Participation rates in non-commercial recreational activities (from local users and tourists) and expenditures of recreational users

A note on the inconsistency index

The inconsistency index measures how consistent the choices are as a set (rather than each individual pairwise comparison). If your inconsistency level is greater than 10%, then there are some problems with consistency that need to be addressed.

Example: if we say that both A. and B. are both more important than C. with intensity 7, then we are also implying that A. and B. are equal. So if we state that A. is more important than B., then we have inconsistency. In this case, we would either adjust A. and B. to be equal, ***OR*** reduce the importance of B. against C. ***OR*** increase the importance of A. against C.***OR*** a combination of these. There are many possible ways of reconsiling this to give a consistent response - the choice is yours.

Appendix S: Instruction sheet for the AHP

In the following questions, we are going to ask you to assess the **importance of three different items, in comparison to each others,** with a ranking scale presenting relative important scores different score of importance.

For example:

Using the scale below, if you select the score '9' for **APPLE** compared to **PEAR**, this indicates that an **APPLE** has your "absolute preference" as compared to a **PEAR**.

Apple																Pear
								Q1								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Much more delicious								Equal								Much more delicious

In choosing the relative importance scores, we ask that you consider all three items as a set rather than individually. This is why you will have to check the consistency of your score through the consistency index.

The consistency index measures how consistent your scores are as a set (given each individual pair-wise comparison). The best is to have a consistency index of at least 90%.

After completing set of comparisons, you can click on the "Check" button and the consistency level will appear. If the consistency level is lower than 90%, then a message will appear offering you to adjust your scores before proceeding to the next question.

Example:

If we say that an **APPLE** and **BANANA** both hold a very strong preference over a **PEAR** with a score of 7 as shown below, then we are also implying that an **APPLE** and **BANANA** are equally preferred

So if we state that an **APPLE** is more delicious than a **BANANA**, then the set of scores is not consistent enough.

Apple																**Pear**
								Q1								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Much more delicious								Equal								Much more delicious

Banana																**Pear**
								Q1								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Much more delicious								Equal								Much more delicious

INCONSISTENT!!

Apple																**Banana**
								Q1								
9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9
Much more delicious								Equal								Much more delicious

In this case, we would either…

1. Adjust our score so that **APPLE** and **BANANA** are equally preferred, ***OR***
2. Reduce the score of **APPLE** or **BANANA** against **PEAR**, ***OR***
3. A combination of these.

Appendix T: Box plots of the different AHP weights

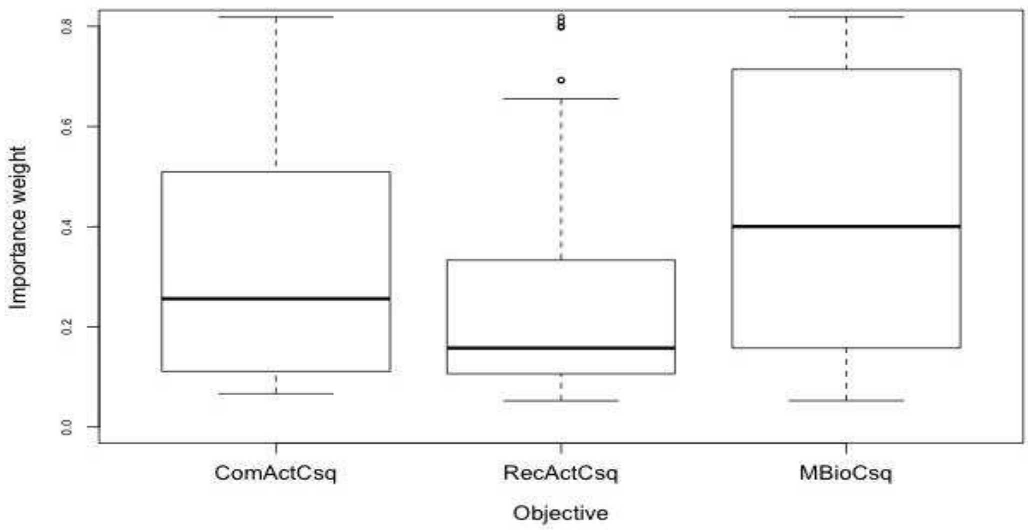


Figure T1 Box plot: general public relative final weights associated with the types of consequences to be assessed

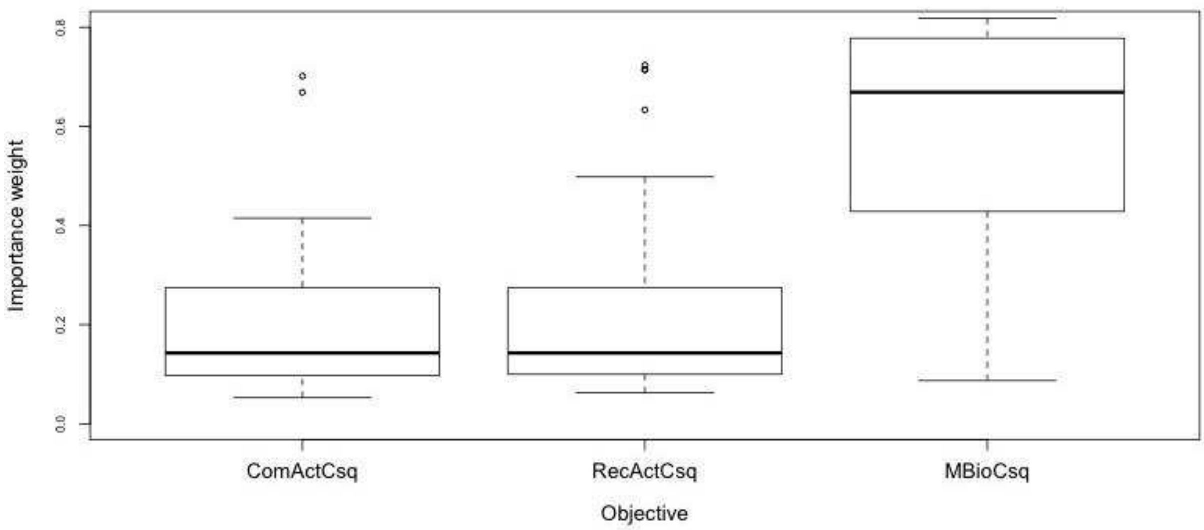


Figure T2 Box plot: decision-makers relative final weights associated with the types of consequences to be assessed

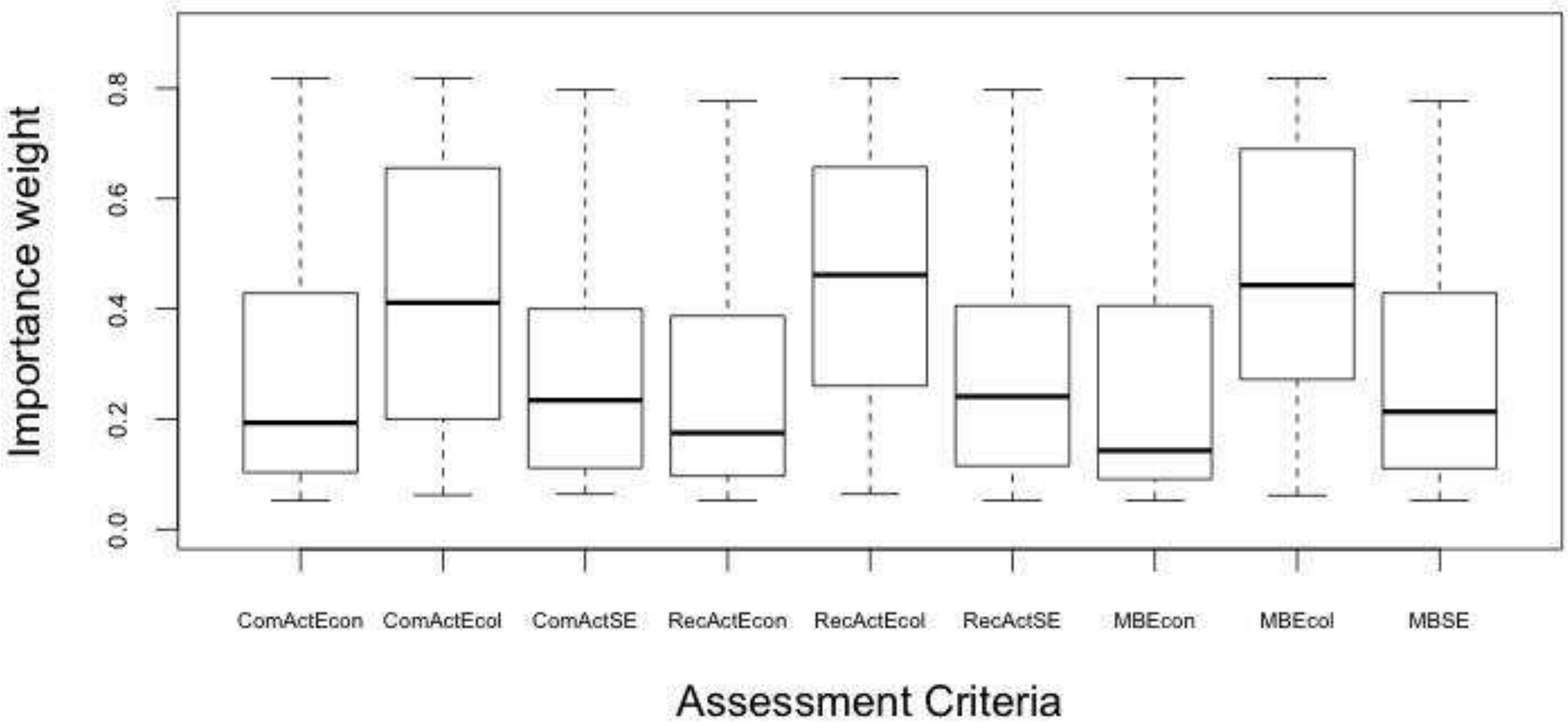


Figure T3 Box plot: general public final weights associated with the economic, ecological and socio-economic assessment of the different types of consequences

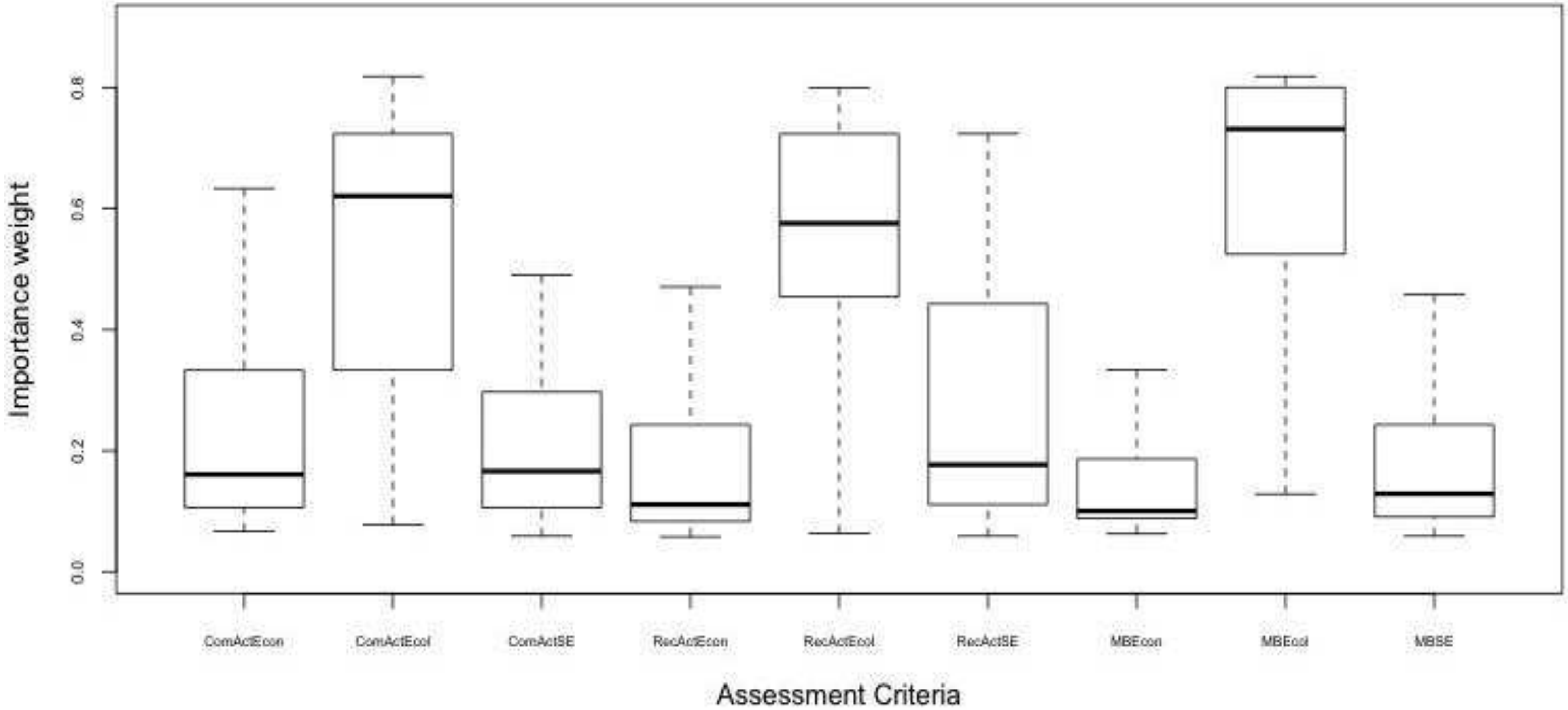


Figure T4 Box plot: general public final weights associated with the economic, ecological and socio-economic assessment of the different types of consequences

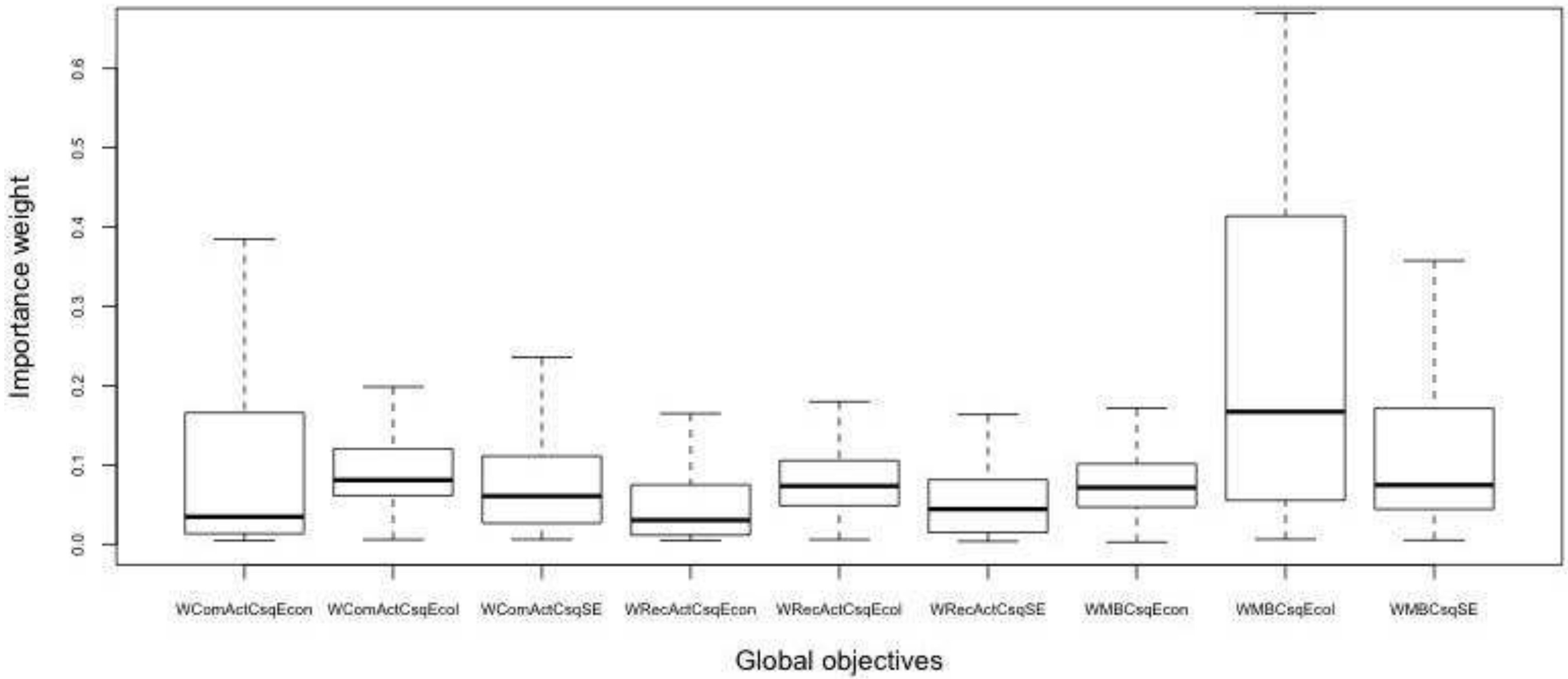


Figure T5 Box plot: general public final weights associated with the economic, ecological and socio-economic assessment of the different types of consequences

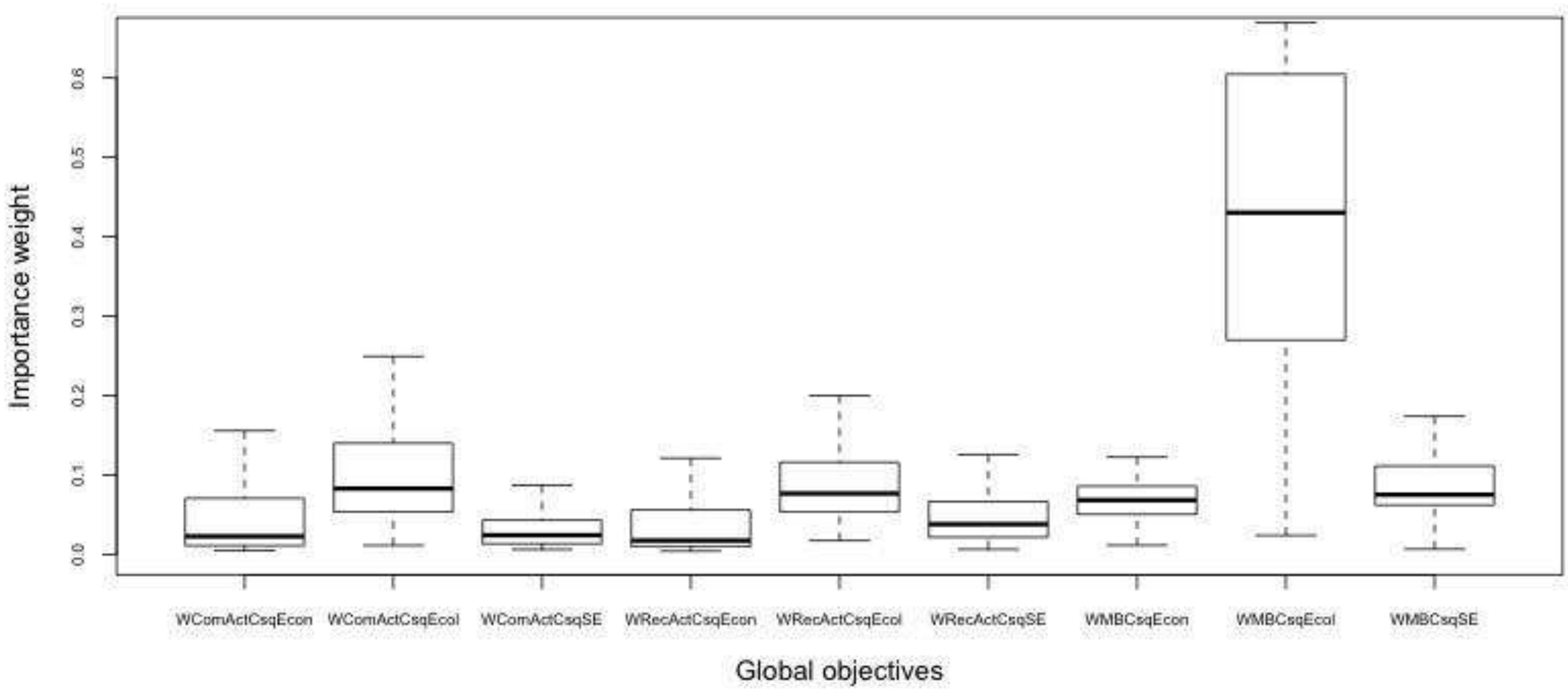


Figure T6 Box plot: general public final weights associated with the economic, ecological and socio-economic assessment of the different types of consequences

Appendix U: Socio-demographic composition of decision-makers by State

Table U1 Socio-demographic composition of decision-makers respondents with robust and consistent preferences by State

	Gender (%male)	Edu. level	Age Category	Work area (%)	Currently work for (%)	Work exp (%)	Role (%)	Exp.
NSW	33	4.4	3.9	ComFish: 11, RecAct: 44, Cons: 33, CDev: 100, MPol: 44, Indi: 11	Gov: **100**, GovRes: **0**, Research: **0**, Industry: **0**	EBF: 44 Cons: 44	Info: 67, Consul: 89, Contrib: 67, Decis: 33	2.6
Vic	**100**	4.3	4.3	ComFish: **0**, RecAct: **0**, Cons: 33, CDev: 67, MPol: 33, Indi: 0	Gov: **33**, GovRes: 0, Research: **67**, Industry: 0	EBF: **0** Cons: 67	Info: 67, Consul: 67, Contrib: 67, Decis: **0**	2.0
Qld	75	4.7	3.5	ComFish: 25, RecAct: 50, Cons: 62, CDev: 50, MPol: 50, Indi: 25	Gov: 62, GovRes: 25, Research: 12, Industry: 12	EBF: 37 Cons: 25	Info: 62, Consul: 75, Contrib: 62, Decis: 25	2.4
SA	86	4.3	3.3	ComFish: **57**, RecAct: **57**, Cons: 71, CDev: 71, MPol: 29, Indi: 0	Gov: 57, GovRes: 29, Research: 14, Industry: 14	EBF: 29 Cons: 57	Info: 43, Consul: 43, Contrib: 43, Decis: 43	2.3
WA	75	5.0	3.6	ComFish: **0**, RecAct: 37, Cons: 50, CDev: 37, MPol: 37, Indi: 0	Gov: 75, GovRes: 25, Research: 37, Industry: 12	EBF: 25 Cons: 62	Info: 87, Consul: 62, Contrib: 75, Decis: 50	2.3
NT	67	6.0	3.7	ComFish: **0**, RecAct: **0**, Cons: **100**, CDev: 33, MPol: 0, Indi: 0	Gov: 33, GovRes: **100**, Research: 0, Industry: 0	EBF: **0** Cons: **100**	Info: 67, Consul: 33, Contrib: 33, Decis: **0**	1.3
TAS	60	6.0	3.9	ComFish: 19, RecAct: 43, Cons: **100**, CDev: 29, MPol: 29, Indi: 29	Gov: 57, GovRes: 14, Research: 29, Industry: 0	EBF: 14 Cons: 43	Info: 43, Consul: 71, Contrib: 71, Decis: 14	2.7
ACT	**0**	3.0	3.5	ComFish: 50, RecAct: 50, Cons: 100, CDev: **0**, MPol: **0**, Indi: 0	Gov: 50, GovRes: 50, Research: **0**, Industry: **0**	EBF: **50** Cons: **0**	Info: 50, Consul: 100, Contrib: 50, Decis: **0**	1.0
Whole sample	64	5.3	3.7	ComFish: 21, RecAct: 40, Cons: 64, CDev: 55, MPol: 34, Indi: 11	Gov: 66, GovRes: 23, Research: 19, Industry: 6	EBF: 28 Cons: 49	Info: 62, Consul: 68, Contrib: 62, Decis: 27	2.3

Appendix V: Cluster analysis

- **General public cluster analysis results**

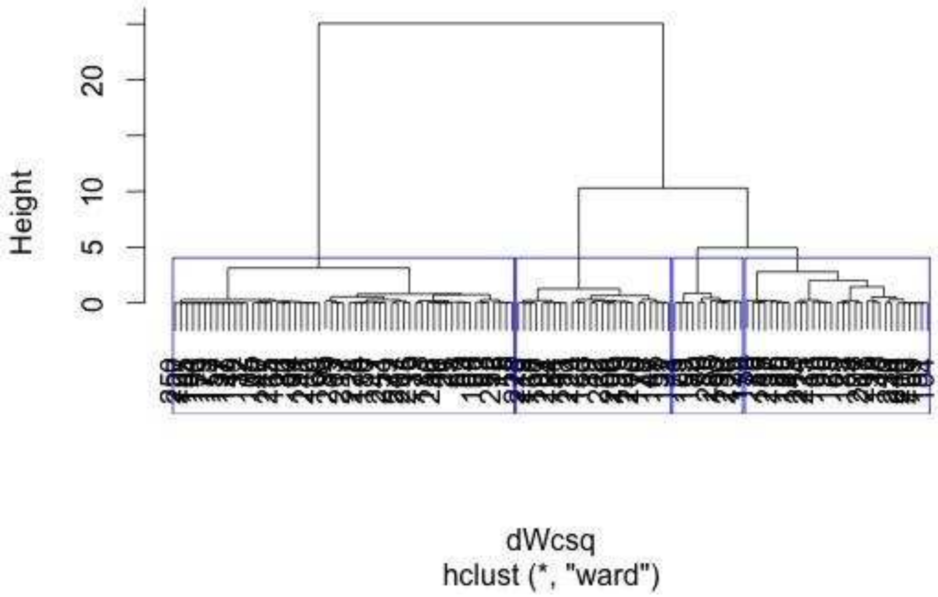


Figure V1 Hierarchical clustering dendrogram (Euclidean distance and Ward method) for general public's final weights associated with the consequences to be assessed

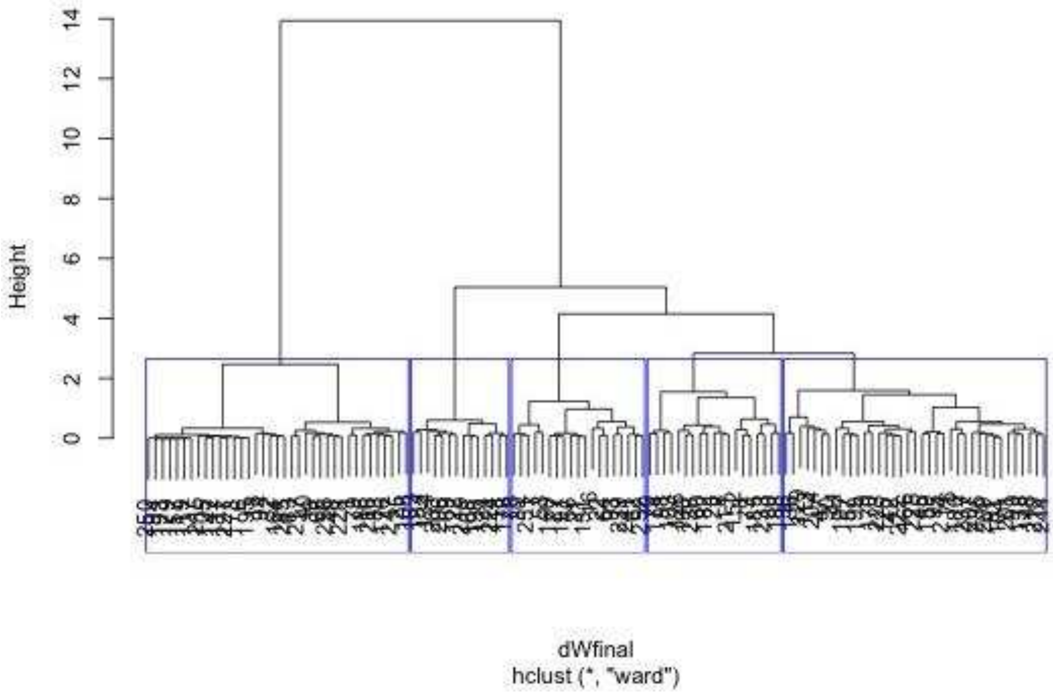


Figure V2 Hierarchical clustering dendrogram (Euclidean distance and Ward method) for general public's final weights associated with the assessment criteria of development consequences

- **Decision-makers cluster analysis results**

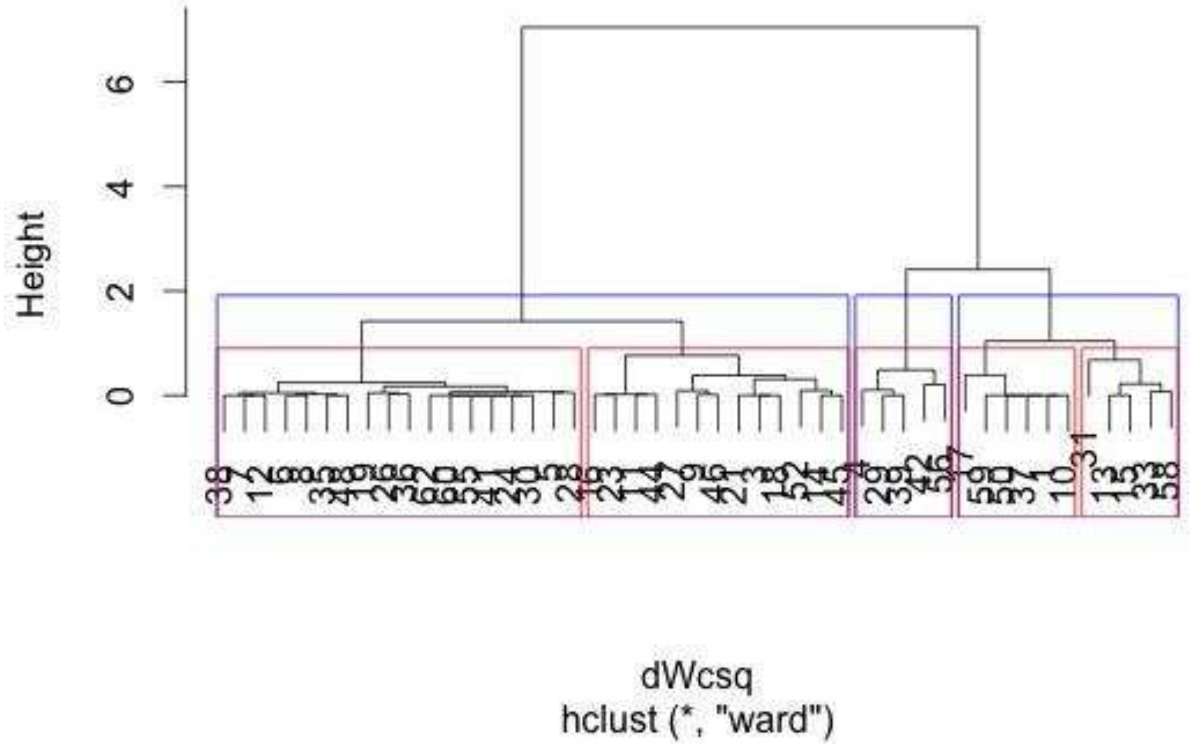


Figure V3 Hierarchical clustering dendrogram (Euclidean distance and Ward method) for decision-makers' final weights associated with the consequences to be assessed

Table V1 Hierarchical clusters for decision-makers' final weights associated with consequences to be assessed

Higher level objectives	**Cluster 1** *"All equal"*	**Cluster 2** *"MB ++"*	**Cluster 3** *"Rec +"*	**Cluster 4** *"MB +++"*	**Cluster 5** *"Com and MB +"*
Com	**0.302**	0.159	0.209	0.101	**0.415**
Rec	**0.349**	0.173	**0.657**	0.109	0.131
Bio	**0.349**	**0.668**	0.134	**0.790**	**0.454**
Proportions of individuals in cluster	**12.8%**	**27.7%**	**10.6%**	**38.3%**	**10.6%**
Average coherence level	0.991	0.980	0.974	0.998	0.968
Proportion of extreme cases (%)	0	0	0	0	0

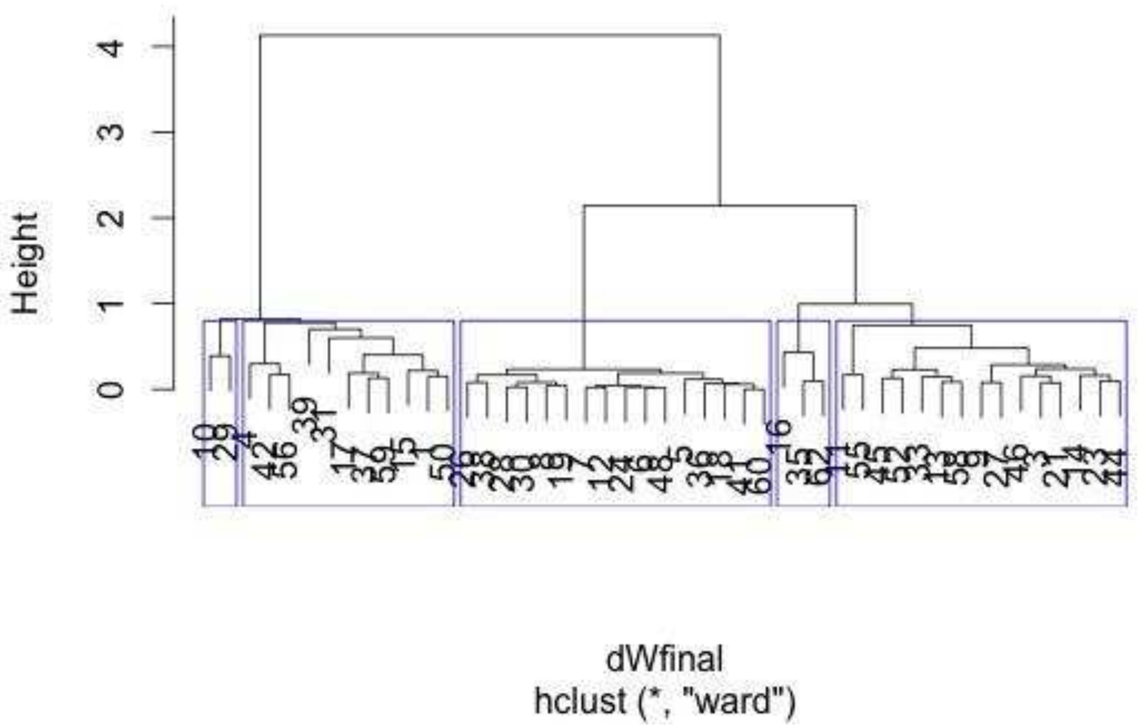


Figure V4 Hierarchical clustering dendrogram (Euclidean distance and Ward method) for decision-makers' final weights associated with the assessment criteria of development consequences

Table V2 Hierarchical clusters for decision-makers' final weights associated with the assessment criteria of the different consequences

Lower level objectives	**Cluster 1** *"BioEcol+"*	**Cluster 2** *"All equal"*	**Cluster 3** *"Com All"*
WComEcon	0.018	0.099	**0.465**
WComEcol	0.082	0.115	**0.136**
WComSE	0.029	0.109	**0.109**
WRecEcon	0.016	0.078	0.084
WRecEcol	0.082	0.116	0.039
WRecSE	0.030	0.103	0.034
WBioEcon	0.086	0.088	0.072
WBioEcol	**0.554**	0.137	0.035
WBioSE	0.104	0.155	0.024
Proportions of individuals in cluster	**29.4%**	**59.5%**	**11.1%**
Coherence level	0.965	**0.811**	0.965
Proportion of extreme cases (%)	0	**31%**	0

- **Decision-makers cluster analysis results**

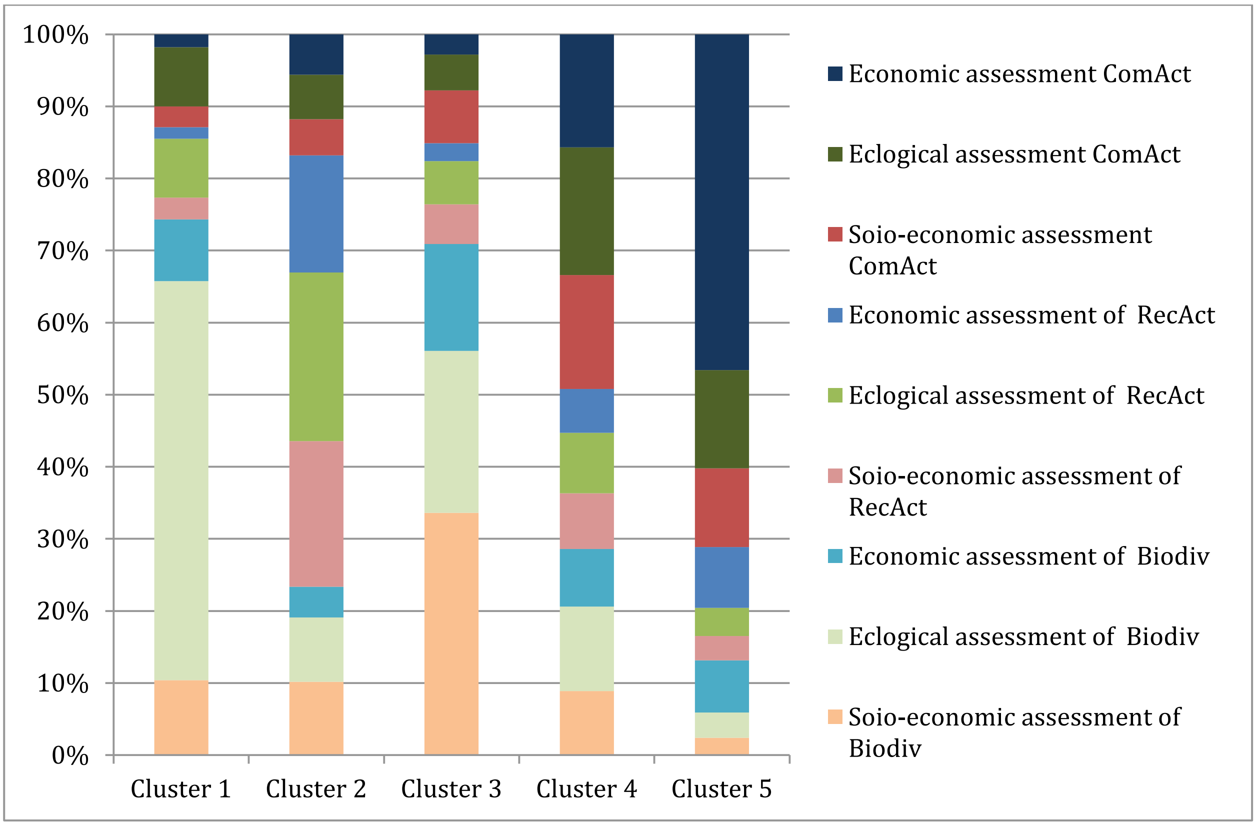


Figure V5 Average weight allocation between lower order objectives of the cluster groups for the general public

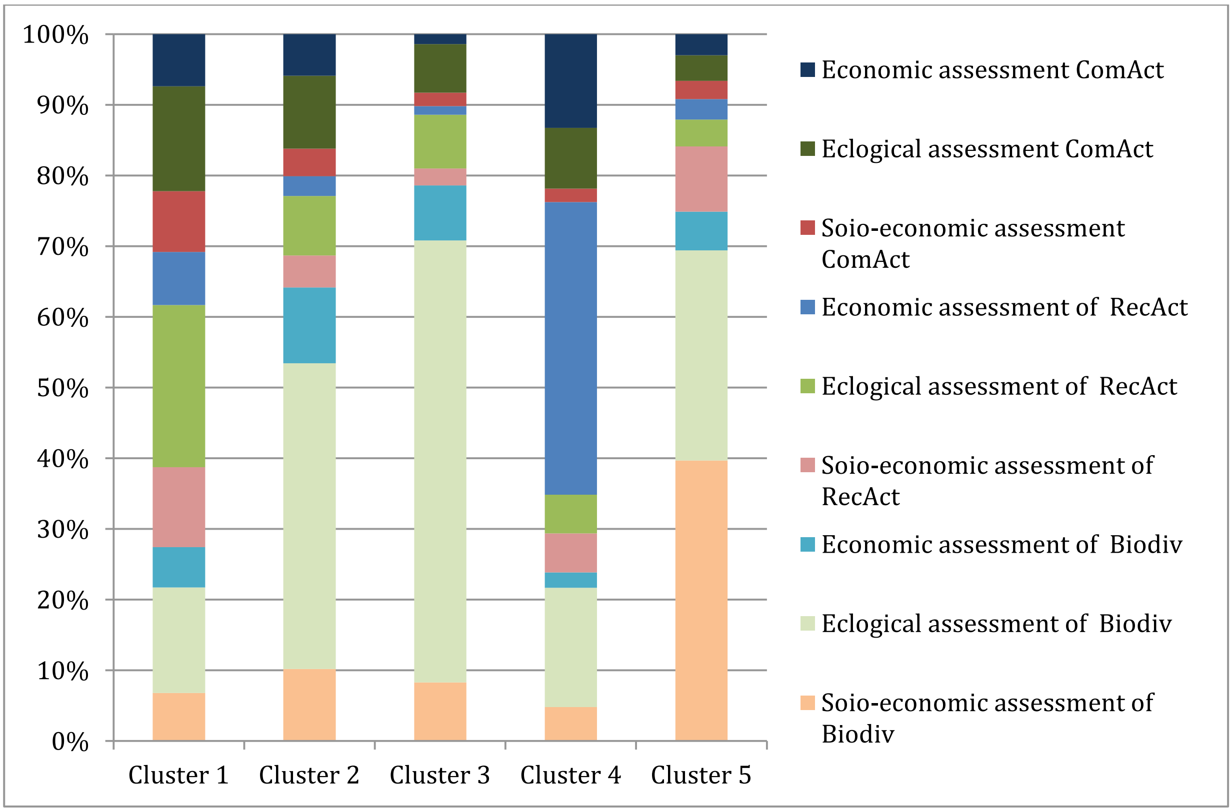


Figure V6 Average weight allocation between lower order objectives of the cluster groups for the decision-makers

- **Decision-makers higher level objectives five cluster groups composition**

The socio-demographic decomposition of the more complex five clusters classification that was finally not retained in chapter 4 regarding the higher level objective for the decision-makers (presented in table V1 above) is presented in table V3 below.

In comparison to others, cluster 1 (relatively homogenous priorities) includes high proportions of individuals from Western Australia and Victoria (and no individuals from Queensland), the highest proportion of male, and individuals that do not practice frequently the various marine activities. More interestingly, it exhibits the highest proportions of individuals working in policy and management for government and associated agencies, and with a decisive role in decision-making (50%). Besides, the individuals in cluster 1 only work in three management domains: coastal development, recreational activities and marine conservation. It is interesting to note that it has the lowest proportion of individuals involved in marine conservation.

Cluster 2 (dominant priority on marine biodiversity) contains relatively diverse individuals in terms of geographical location, management domain (though mostly involved in marine conservation), institutions (though marine industries are absent) and role in decision-making. It has however among the highest proportions of individuals with a work experience in biological conservation, and the lowest proportion of individuals with work experience in economics, business and finance.

Cluster 3 (dominant priority on recreational activities) contains individuals who are only from Queensland, South Australia, Western Australia or Australian Capital Territory (with the highest proportion from all clusters for the later). It is also the only cluster with a majority of females, and the individuals in this cluster have on average the highest education level. Not surprisingly, this cluster contains the highest proportion of individuals working on recreational activities (60%). It also has the highest proportion of individuals working on marine conservation (80%), the highest proportions of individuals with a work experience in biological conservation, and the highest proportions of individuals with informative, consultative or contributive role. This cluster also mostly contains individuals working for government and associated agencies (80% in policy and management and 40% in research). Finally, individuals in this cluster do not frequently practice marine activities, except from recreational activities (around once a month).

Cluster 4 (largely dominant priority on marine biodiversity) has the highest proportion of individuals from New South Wales (33%) and the lowest proportion from South Australia

(6%). It also has the second highest proportion of individuals working on marine pollution (57%), a high proportion of individuals working on marine conservation (71%) and on coastal development (61%). Besides 56% of individuals in this cluster have worked in biological conservation. They have diverse roles in decision-making, and work for all kind of institutions.

Finally, cluster 5 (dominant priorities on both commercial activities and marine biodiversity) contains only individuals living in Queensland, South Australia and Tasmania. It has the highest proportions of individuals working on commercial fisheries (60%), recreational activities (60%), coastal development (80%) and marine pollution (60%). Interestingly this cluster contains almost all individuals working for marine industries (40%, by far the highest proportions) and has the lowest proportions of individuals working in policy and management for government and associated agencies. The individuals in this cluster are also the ones that practice the most frequently the various marine activities (this is especially the case for commercial activities including fisheries, as well as recreational fishing, which is not surprising in view of the high proportions of marine industry representatives).

Table V3 Socio-demographic characteristics of clusters for decision-makers final weights associated with the development consequences

	Gender (%male)	Edu. level	Age Category	State (%)	Work area (%)	Currently work for (%)	Work exp (%)	Role (%)	Exp.	Marine activities
Cluster 1 *"All equal"*	**83**	4.8	3.5	NSW: 17, **Vic: 17**, **Qld: 0**, SA: 17, **WA: 33**, NT: 0, Tas: 17, ACT: 0	ComFish: 0, **RecAct: 33,** **Cons: 33, CDev: 50,** MPol: 0, Indi: 0	**Gov: 83**, GovRes: 0, Research: 17, Industry: 0	EBF: 33 Cons: 33	Info: 67, Consul: 50, Contrib: 67, **Decis: 50**	1.8	+ ComFish:0, ComAct:0.60, RecFish:1.80, RecAct:2.60, IndiUse:0
Cluster 2 *"MB +"*	69	**4.5**	3.6	NSW: 15, Vic: 8, Qld: 23, SA: 15, WA: 8, NT: 15, Tas: 15, ACT: 0	ComFish: 15, RecAct: 23, Cons: 61, CDev: 46, MPol: 15, Indi: 8	Gov: 77, GovRes: 15, Research: 15, Industry: 0	EBF: **15** Cons: 54	Info: 54, Consul: 54, Contrib: 61, Decis: 23	2.3	++ ComFish:0.38, ComAct:0.85, RecFish:1.85, RecAct:3.00, IndiUse:0.31
Cluster 3 *"Rec +"*	**40**	**6.0**	3.2	NSW: **0**, Vic: **0**, Qld: 20, SA: 20, WA: 20, NT: 0, Tas: 20, ACT: **20**	ComFish: 20, **RecAct: 60**, **Cons: 80,** CDev: 40, MPol: 20, Indi: 0	**Gov: 80**, **GovRes: 40**, Research: 20, Industry: 0	EBF: 20 Cons: **60**	**Info: 80,** **Consul: 80,** **Contrib: 100,** Decis: 20	2.0	+ ComFish:0, ComAct:0, RecFish:0.80, **RecAct:3.40**, IndiUse:0
Cluster 4 *"MB +++"*	61	5.2	3.8	NSW: **33**, Vic: 6, Qld: 11, SA: 6, WA: 22, NT: 6, Tas: 11, ACT: 6	ComFish: 22, RecAct: 44, Cons: 72, CDev: 61, **MPol: 57**, Indi: 17	Gov: 61, GovRes: 28, Research: 22, Industry: 6	EBF: 33 Cons: **56**	Info: 61, Consul: 83, Contrib: 56, Decis: 28	2.5	++ ComFish:0.06, ComAct:0.39, RecFish:1.61, **RecAct:3.61**, IndiUse:0.28
Cluster 5 *"Com and MB +"*	60	5.0	3.2	NSW: 0, Vic: 0, **Qld: 40,** **SA: 40**, WA: 0, NT: 0, **Tas: 20**, ACT: 0	**ComFish: 60**, **RecAct: 60**, Cons: 60, **CDev: 80,** **MPol: 60**, Indi: 20	**Gov: 20,** GovRes: **40,** Research: 20, **Industry: 40**	EBF: **40** Cons: **20**	Info: 60, Consul: 60, Contrib: 40, Decis: 20	2.4	+++ **ComFish:0.80**, **ComAct:1.20**, **RecFish:2.40**, RecAct:3.40, IndiUse:0
Whole sample	63.8%	5.3	3.7	NSW: 19, Vic: 6, Qld: 17, SA: 15, WA: 17, NT: 6, Tas: 15, ACT: 4	ComFish: 21, RecAct: 40, Cons: 64, CDev: 55, MPol: 34, Indi: 11	Gov: 66, GovRes: 23, Research: 19, Industry: 6	EBF: 28 Cons: 49	Info: 62, Consul: 68, Contrib: 62, Decis: 27	2.3	++ ComFish:0.22, ComAct:0.58, RecFish:1.69, RecAct:3.28, IndiUse:0.19

Level of education: average based on categories, with 6 being "post graduate" and 1 being "secondary" (3 corresponds to "diploma"; 5 to "Graduate Diploma")
Age Category: from 1 (18 to 24 yo) to 6 (65 to 74yo), the minimum value in this sample being 3
Work area: ComFish=Commercial Fisheries; RecAct=Recreational Activities; Cons=Conservation; CDev=Coastal Development; MPol=Marine pollution; Indi= Indigenous use
Work for: Gov=government and associated agencies (policy and management); Govres=government and associated agencies (research); Industry= Marine industry
Work exp.: work experience; EBF: Economics, Business, Finance; Cons: Conservation;
Role in decision-making: Info=informative; Consul=Consultative; Contrib=Contributive; Decis=Decisive
Exp.: years of experience in decision-making; from 1 (0-5 years) to 4 (more than 20 years)
Frequency of marine activities: 0=never; 1=less than once per year; 2=once per year; 3=several times per year; 4=several times per month; 5=several times per week

Appendix W: Determinants of final weights

This appendix presents the result from the double-censored Tobit models that were run on all the computed final weights for the general public, then for the decision-makers.

General Public

- **Higher level objectives**

Results of the Tobit model on the final weights associated with the higher level objectives are presented in tables W1, W2 and W3 below. Both coefficients and marginal effects of the explanatory variables are presented.

Table W1 Tobit regression results on the AHP weight associated with the consequences on commercial activities (general public)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	0.192***	0.037		
State Tas [bi]	0.257**	0.108	0.238**	0.100
State Qld [bi]	0.073’	0.047	0.067’	0.044
State ACT [bi]	0.279**	0.125	0.258**	0.116
Work experience in conservation [bi]	-0.239**	0.110	-0.222**	0.102
Edu. field Environmental sciences [bi]	-0.196*	0.109	-0.182*	0.101
Useful ESV	0.055**	0.023	0.051**	0.022
Preserve CME for marine industries [bi]	0.121**	0.049	0.112**	0.045
Pseudo-R^2	0.180			
N	198			

[bi] *Binary variable; pseudo-R^2: variance of predicted mean/(variation of predicted mean + residual variation)*

Table W2 Tobit regression results on the AHP weight associated with the consequences on recreational activities (general public)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	0.203***	0.019		
State WA [bi]	0.133***	0.052	0.120**	0.046
Preserve CME for use reasons [bi]	0.075*	0.042	0.067*	0.038
Pseudo-R^2	0.075			
N	126			

[bi] *Binary variable*

Table W3 Tobit regression results on the AHP weight associated with the consequences on marine biodiversity (general public)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	0.376***	0.089		
Age Category	-0.021*	0.013	-0.020*	0.012
State NSW [bi]	0.226***	0.058	0.218***	0.056
State Vic [bi]	0.211***	0.063	0.203***	0.060
State Qld [bi]	0.091'	0.061	0.088'	0.059
Work experience in conservation [bi]	0.272**	0.122	0.262**	0.118
Edu. field Environmental sciences [bi]	0.295**	0.122	0.284**	0.118
Preserve CME for non-use reasons [bi]	0.055	0.046	0.053	0.045
Pseudo-R^2	0.230			
N	126			

[bi] *Binary variable*

Several factors played a significant positive role on the weights associated with the consequences on commercial activities: being resident in Tas (increased the weight by 0.24) or in ACT (0.26 increase), having declared ESV as useful or necessary (0.05 increase), and having selected in the top 3 motivations to preserve CME: "So that marine industries can remain profitable" (see chapter 3, section 3.2) (0.11 increase). However having an educational background in environmental sciences[56] and some work experience in conservation had a negative influence on these weights (0.18 decrease), whereas they positively influenced the priority given to the consequences on marine biodiversity (0.26 increase). Being resident in NSW and Vic also had a positive influence on the latter (0.22 and 0.20 respectively) Younger individuals also seemed to have given more weight to the consequences on marine biodiversity (negative sign of the age category coefficient).

Regarding the weights given to the consequences on recreational activities, we found only two explanatory variables that were significant with a positive role: being resident in Western Australia (0.12 increase), and having declared that the most important reason to preservation was "So I can continue to enjoy marine activities and/or other benefits derived from these ecosystems during my lifetime" (see chapter 3, section 3.2) (0.07 increase). Interestingly, participating in recreational activities (in terms of frequency or simply participating or not) was not found as having any influence.

[56] We note that this actually refers to a very broad range of studies or education (agriculture, horticulture, forestry, fisheries, environmental management etc.) as defined by the Australian Bureau of Statistics.

Finally, all model fits assessed by pseudo-R^2 were quite low (especially for the model on the priority given recreational activities due to the small number of significant variables) with the model related to the priorities on marine biodiversity having better predictions than the one on commercial fisheries.

- **Lower level objectives**

Commercial activities assessment

Results from the Tobit models run on the weights associated with the economic, ecological and socio-economic assessments of commercial activities are presented in tables W4, W5 and W6.

Table W4 Tobit regression results on the AHP weight associated with the economic assessment of commercial activities (general public)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	-0.009	0.039		
Age Category	0.017**	0.007	0.013**	0.005
State Qld [bi]	0.050*	0.028	0.039*	0.023
State ACT [bi]	0.161**	0.080	0.128**	0.064
Involved in commercial fisheries	0.016	0.019	0.013	0.015
Support [bi]	-0.052*	0.027	-0.041*	0.021
Useful ESV	0.031*	0.018	0.025*	0.014
Preserve CME for marine industries [bi]	0.109**	0.050	0.086**	0.040
Pseudo-R^2	0.145			
N	126			

[bi] *Binary variable; Useful ESV: 0=Useless or Do not know, 1=Useful, 2=Necessary;*

Table W5 Tobit regression results on the AHP weight associated with the ecological assessment of commercial activities (general public)

	Coeff.	Std. Error	Marginal effects	Std. Error
Intercept	0.124***	0.011		
Gender [bi]	-0.037**	0.015	-0.034**	0.014
State SA [bi]	0.068***	0.024	0.062***	0.022
State Tas [bi]	0.086**	0.041	0.078**	0.037
State ACT [bi]	0.103**	0.047	0.094**	0.043
Edu. field Society and Culture [bi]	-0.059***	0.021	-0.053***	0.019
Pseudo-R^2	0.164			
N	126			

[bi] *Binary variable*

Table W6 Tobit regression results on the AHP weight associated with the socio-economic assessment of commercial activities (general public)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	0.053***	0.011		
Gender [bi]	0.032**	0.014	0.028**	0.012
State Tas [bi]	0.133***	0.040	0.115***	0.034
Involved in recreational fishing	0.012**	0.006	0.010**	0.005
Pseudo-R^2	0.156			
N	136			

[bi] *Binary variable*

Model fits were all similar, and again quite low. In terms of geographical location, we note that living in Queensland and Australian Capital Territory had a positive influence on the weight attributed to the economic assessment of commercial activities (respectively 0.04 and 0.13 increase), while being resident in Tasmania had a positive influence on the priorities given to their ecological assessment (0.08 increase) and even more on their socio-economic assessment (0.11 increase). In addition, two other variables had a positive influence on the priority given to the economic assessment (table W4): having considered ESV as useful or necessary (0.02 increase), and considering the profitability of marine industry as one of the most important reason to preserve CME (0.09 increase).

Furthermore, being a male had positive influence on the priority given to the socio-economic assessment while it had a negative one on the weight given to the ecological assessment. Regarding the later, having an educational background in economics, social and political sciences also had a negative influence (0.05 decrease) (table W5).

Being involved in marine activities did not seem to have a significant influence, with the exception of individuals practising recreational fishing that attributed higher weights to the socio-economic assessment of commercial activities (0.01 increase) (table W6). One could imagine that these individuals may have been concerned by the charter recreational industry, or that they felt somehow concerned about commercial fishers.

Recreational activities assessment

Now we present results from the Tobit models on the weights associated with the economic, ecological and socio-economic assessments of recreational fisheries in tables W7, W8 and W9.

Table W7 Tobit regression results on the AHP weight associated with the economic assessment of recreational activities (general public)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	0.064***	0.012		
State WA [bi]	0.045**	0.019	0.036**	0.016
Involved in commercial activities	0.013*	0.007	0.010*	0.006
Involved in recreational activities	-0.008	0.005	-0.006	0.004
Preserve CME for use reasons [bi]	0.030*	0.016	0.024*	0.013
Pseudo-R^2			0.085	
N			126	

[bi] *Binary variable*

Table W8 Tobit regression results on the AHP weight associated with the ecological assessment of recreational activities (general public)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	0.109***	0.013		
Gender [bi]	-0.021	0.016	-0.018	0.014
State SA [bi]	0.048*	0.026	0.042*	0.023
Work experience in economics, business, finance [bi]	-0.030*	0.016	-0.026*	0.014
State Qld [bi]	0.027	0.019	0.024	0.016
Pseudo-R^2			0.085	
N			126	

[bi] *Binary variable*

Table W9 Tobit regression results on the AHP weight associated with the socio-economic assessment of recreational activities (general public)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	0.062***	0.021		
Involved in recreational activities	-0.013*	0.007	-0.010*	0.005
Involved in recreational fishing	-0.003	0.007	-0.002	0.006
State WA [bi]	0.095***	0.025	0.076***	0.020
Preserve CME for use reasons [bi]	0.034*	0.021	0.027*	0.017
Education level	0.008*	0.005	0.007*	0.004
Pseudo-R^2			0.167	
N			126	

[bi] *Binary variable*

Again, these results confirm what we previously noticed: residents in Western Australia gave higher weights to the assessment of recreational activities, and we can actually see that this was for economic and socio-economic assessment (respectively 0.03 and 0.08 increase) (tables W7 and W9). To explain this result, one could hypothesise that individuals living in Western Australia from our sample were particularly involved in various recreational activities (including fishing). This was partly true: they were indeed significantly involved in recreational marine activities but not more than in some other States.

Besides, being involved in recreational activities (in terms of increasing frequency of practice) was only significant (at the 10% level) regarding the priorities attributed to the socio-economic assessment of recreational activities (table W9). We also checked wether this would be the case with variables showing participation only, and in that case the effect insignificant. As such, participation in recreational marine activities did not seem to play much role in the priority given to the various assessments of recreational consequences. Nevertheless, considering the use of marine ecosystems as the most important reason to preserve CME played a significant and positive role in attributing priorities to economic and socio-economic assessment of these (respectively 0.04 and 0.03 increase).

Furthermore, living in South Australia had a positive influence on the priority given to the ecological assessment of recreational activities (0.04 increase), whereas having a work experience in economics, business or finance had a negative one (0.03 decrease) (table W8). In addition, the higher the educational level, the higher will be the priority given to their socio-economic assessment (table W9). Finally, the priority attributed to the economic assessment (table W7) slightly increased (from 0.01 to 0.05) when being involved in commercial activities (excluding Fisheries): this could be explained by the interest of individuals involved in marine activities industries (diving, charter, snorkelling etc.) for the willingness-to-pay of users.

Marine biodiversity assessment

Finally tables W10, W11 and W12 present the results from the Tobit models on the weights associated with the economic, ecological and socio-economic assessments of the consequences on marine biodiversity.

Table W10 Tobit regression results on the AHP weight associated with the economic assessment of marine biodiversity (general public)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	0.082***	0.013		
State Vic [bi]	0.041***	0.014	0.037***	0.013
Education level	-0.006	0.004	-0.005	0.003
Edu. field Environmental sciences [bi]	0.068**	0.034	0.062**	0.031
Work experience in CME management [bi]	0.071**	0.028	0.064**	0.026
Preserve CME for use reasons [bi]	0.057**	0.018	0.051**	0.016
Pseudo-R^2	0.182			
N	126			

[bi] *Binary variable*

Table W11 Tobit regression results on the AHP weight associated with the ecological assessment of marine biodiversity (general public)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	0.083**	0.040		
State NSW [bi]	0.206***	0.043	0.184***	0.038
State Vic [bi]	0.117***	0.045	0.105**	0.041
Work experience in conservation [bi]	0.222**	0.104	0.199**	0.093
Actively support CME preservation [bi]	0.039	0.040	0.035	0.036
Preserve CME for non-use reasons [bi]	0.095**	0.039	0.085**	0.035
Pseudo-R^2	0.208			
N	126			

[bi] *Binary variable*

Table W12 Tobit regression results on the AHP weight associated with the socio-eoconomic assessment of marine biodiversity (general public)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	0.109***	0.033		
Age Category	-0.012**	0.006	-0.011**	0.005
Gender [bi]	0.043**	0.020	0.038	0.018
State Vic [bi]	0.038	0.024	0.034*	0.021
State Qld [bi]	0.045*	0.024	0.040**	0.021
Involved in Commercial Fisheries	-0.051**	0.023	-0.046**	0.021
Involved in Indigenous Use	0.046**	0.021	0.041**	0.019
Edu. field Environmental sciences [bi]	0.135**	0.053	0.121**	0.047
Edu. field Society and Culture [bi]	0.069**	0.028	0.062**	0.025
Work experience in economics, business, finance [bi]	0.050**	0.021	0.044**	0.019
Pseudo-R^2	0.208			
N	126			

[bi] *Binary variable*

From the geographical location point of view, living in Victoria increased both the weights attributed to economic and ecological indicators for assessing the consequences on marine biodiversity (respectively 0.04 and 0.10 increase), while living in NSW increased the priority given to ecological assessment (0.18 increase) and living in Queensland the priority to socio-economic assessment (0.04 increase).

In addition, having a work experience in CME management or conservation respectively increased the weight attributed to the economic or to the ecological assessment (by 0.06 and 0.20 respectively), while having a work experience in economics, business or finance increased the weight attributed to the socio-economic assessment (by 0.04). Besides, having an educational background in environmental sciences increased both the weights given to the economic and socio-economic assessment (table W10 and W12), the effect on the second being substantially stronger (0.12 increase). Having an educational background related to society and culture also increased the socio-economic weight (by 0.06) (table W12).

Again, the opinion regarding the most important reasons to preservation played a role: reasons related to use values contributed to a higher priority to the economic assessment, while those related to non-use values contributed to the weight attributed to the ecological assessment.

Finally being involved in commercial fisheries has a negative influence on the weight attributed to the socio-economic assessment, while being involved in indigenous use has a positive one. An interpretation for these results could be that commercial fishermen would prefer to attribute smaller weight to public opinions related to marine biodiversity since such opinions might be perceived as threatening their activities, while indigenous users would actually prioritize this weight as a way to have their traditional perceptions and relations to these ecosystems considered publicly.

All in all, most of these results regarding the determinants of lower weight priorities accords with the socio-demographic statistics of the different clusters observed in table 4-15 from chapter 4.

Decision-makers

- **Higher level objectives**

Results of the Tobit model on the final weights associated with the higher level objectives are presented in tables W13, W14 and W15 below.

Table W13 Tobit regression results on the AHP weight associated with the consequences on commercial activities (decision-makers)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	0.157***	0.018		
State SA [bi]	0.132***	0.045	0.127***	0.043
Work for marine industry [bi]	0.177***	0.065	0.170***	0.063
Pseudo-R^2	0.286			
N	46			

[bi] *Binary variable*

Table W14 Tobit regression results on the AHP weight associated with the consequences on recreational activities (decision-makers)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	0.116	0.080		
Having used ESV [bi]	0.065**	0.032	0.059**	0.029
Years of experience	-0.036*	0.022	-0.033*	0.020
Working for government and agencies (policy and management) [bi]	0.166***	0.063	0.151***	0.058
Working for government and agencies (research) [bi]	0.104*	0.067	0.095*	0.061
Pseudo-R^2	0.177			
N	46			

[bi] *Binary variable; Having used ESV: 0=never used but heard of, 1=used a few times, 2=used often*

Table W15 Tobit regression results on the AHP weight associated with the consequences on marine biodiversity (decision-makers)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	0.560***	0.058		
State NSW [bi]	0.130*	0.076	0.126*	0.074
Having worked in conservation [bi]	0.091*	0.061	0.089*	0.059
Having a contributive role [bi]	-0.115*	0.062	-0.112*	0.060
Working on marine pollution [bi]	0.111*	0.063	0.108*	0.062
Pseudo-R^2	0.195			
N	46			

[bi] *Binary variable*

We can see from these results that living in South Australia implied higher priority given to the assessment of consequences on commercial activities (0.13 increase on the weight), whereas living in New South Wales increased the weight attributed to the assessment of consequences on marine biodiversity (by 0.13). Working for marine industry had a significant positive impact on the priority given to commercial activities (0.17 increase), while working for government and associated agencies increased the one given to recreational activities (for individuals involved in policy and management more than individual involved in research: increase by 0.15 for the former and 0.09 for the later). Besides, in the model explaining the weight attributed to the recreational activities assessment, having more years of experience in decision-making had a negative impact while having already used ESV (from a few times to often) had a positive influence on the priority to recreational activities (0.06 increase).

In the model explaining the weight attributed to the assessment of consequences on marine biodiversity (table W15), two other factors had a positive influence: working about marine pollution (0.11 increase) and having some work experience in biological conservation (0.09 increase), while having a contributive role in decision-making decreased the weight (by 0.11). We also note that the intercept was especially high in this model, which accord with the globally important priority attributed to marine biodiversity within the whole sample.

- **Lower level objectives**

<u>Commercial activities assessment</u>

Results from the Tobit models run on the weights associated with the economic, ecological and socio-economic assessments of commercial activities are presented in tables W16, W17 and W18.

Table W16 Tobit regression results on the AHP weight associated with the economic assessment of commercial activities (decision-makers)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	0.023**	0.009		
Having used ESV	0.018*	0.009	0.015	0.008
Working on Commercial Fisheries [bi]	0.026*	0.017	0.023	0.015
Working for a marine industry [bi]	0.105***	0.027	0.091	0.023
Pseudo-R^2	0.379			
N	46			

[bi] *Binary variable*

Table W17 Tobit regression results on the AHP weight associated with the ecological assessment of commercial activities (decision-makers)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	0.080***	0.012		
State Vic [bi]	0.075**	0.038	0.073	0.037
State Qld [bi]	0.041**	0.020	0.040	0.020
State SA [bi]	0.029	0.022	0.028	0.021
Working on Recreational Activities [bi]	0.039**	0.018	0.038	0.017
Working on Marine Pollution [bi]	-0.065***	0.018	-0.063	0.017
Having a decisive role [bi]	0.030*	0.018	0.029	0.018
Pseudo-R^2	0.327			
N	46			

[bi] *Binary variable*

Table W18 Tobit regression results on the AHP weight associated with the socio-economic assessment of commercial activities (decision-makers)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	0.029***	0.007		
State SA [bi]	0.059***	0.018	0.050***	0.015
Working for a marine industry [bi]	0.065**	0.026	0.055**	0.022
Pseudo-R^2	0.304			
N	46			

[bi] *Binary variable*

Regarding the weight attributed to the economic assessment of commercial activities, three factors had a positive influence. These were, by decreasing effect on the weight: working for a marine industry (0.09 increase), working on commercial fisheries (0.02 increase), and having used ESV (0.01 increase). Concerning the weight attributed to their ecological assessment, the model pointed out four significant positive factors (presented again by decreasing effects, from 0.07 increase to 0.03): being resident in Victoria, being resident in Queensland, working on recreational activities (which implies being concerned about recreational activities industries), and having a decisive role in decision-making. Besides, one variable had a negative effect: working on marine pollution (0.06 decrease). In this respect, we note that "Working on Recreational Fisheries" and "Working on Marine Pollution" are positively correlated (pearson correlation coefficient = 0.41). Finally, working for a marine industry and living in South Australia were both found to increase the weight of the socio-economic assessment of commercial activities by 0.05.

Recreational activities assessment

Results from the Tobit models run on the weights associated with the economic, ecological and socio-economic assessments of recreational activities are presented in tables W19, W20 and W21. From these models, we can see that having an educational background in economics, social or political sciences both increased the weights attributed to the economic and ecological assessment of the consequences on recreational activities by respectively 0.05 and 0.09, while working on recreational activities increased them by around 0.04. The other variables that positively influenced the weight attributed to the economic assessment were (W19): living in Australian Capital Territory (implying a high probability of being involved in CME management in Australian Government related institutions) which increased the weight by 0.19; having a higher education level (from 0.02 to 0.1 increase); and having an informative role in decision (0.03 increase). The other variables that positively influenced the weight attributed to the ecological assessment were (table W20): age category with an increase from 0.07 for being between 25 and 34 years old to 0.14 for being between 55 and 64 years old; and working in government and associated agencies (in policy or management so excluding research) with an increase in weight of 0.06.

Finally, the model explaining the weight attributed to the socio-economic assessment (table W21) was quite simple with a negative intercept and a 0.07 increase if working for research and higher education, 0.08 increase if working for government and associated agencies in research and 0.09 increase if working for government and associated agencies in policy and management. Not many variables were found to influence this weight.

Table W19 Tobit regression results on the AHP weight associated with the economic assessment of recreational activities (decision-makers)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	-0.073**	0.037		
State ACT [bi]	0.240***	0.045	0.190***	0.038
Education level	0.025***	0.010	0.020**	0.008
Education field Society and Culture [bi]	0.066***	0.026	0.052**	0.020
Working on Recreational Activities [bi]	0.047**	0.020	0.037**	0.016
Working on Marine Pollution [bi]	-0.063***	0.022	-0.050***	0.017
Having an informative role [bi]	0.035*	0.019	0.027*	0.015
Pseudo-R^2	0.254			
N	46			

[bi] *Binary variable; Education level: 1=Advanced diploma or Diploma to 4=Post-graduate level*

Table W20 Tobit regression results on the AHP weight associated with the ecological assessment of recreational activities (decision-makers)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	-0.097	0.068		
Age Category	0.026**	0.013	0.024**	0.012
Education field Society and Culture [bi]	0.101***	0.034	0.092***	0.031
Working on Recreational Activities [bi]	0.054**	0.025	0.049**	0.022
Working for government and agencies (policy and management) [bi]	0.068***	0.025	0.062***	0.023
Pseudo-R^2	0.323			
N	46			

[bi] *Binary variable*

Table W21 Tobit regression results on the AHP weight associated with the socio-economic assessment of recreational activities (decision-makers)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	-0.061**	0.027		
Working for government and agencies (policy and management) [bi]	0.118***	0.028	0.096***	0.024
Working for government and agencies (research) [bi]	0.098***	0.027	0.080***	0.022
Working for research and higher education [bi]	0.089***	0.029	0.072***	0.024
Pseudo-R^2	0.329			
N	46			

Marine biodiversity assessment

Results from the Tobit models run on the weights associated with the economic, ecological and socio-economic assessments of the consequences on marine biodiversity are presented in tables W22, W23 and W24.

From a geographical location point of view, results from these models show that being resident in New South Wales or Victoria both increased the weight attributed to ecological (respectively by 0.21 and 0.10) and socio-economic assessment (respectively by 0.13 and 0.10). Being resident in Western Australia or Tasmania both increased the weight attributed to the economic assessment by around 0.05. Being resident in South Australia increased the weight attributed to the socio-economic assessment (0.10 increase) whereas it decreased the weight attributed to the ecological assessment (0.24 decrease).

The age category had a negative impact on the ecological (from around 0.15 to 0.30 decrease depending on the category) and socio-economic assessments (from around 0.12 to 0.24 decrease).

Being involved in the management of commercial fisheries or in coastal development increased the weight attributed to the economic assessment of the consequences on marine biodiversity (respectively by 0.04 and 0.03), while it decreased the weight attributed to the socio-economic assessment (by 0.08 and 0.07). Besides, being involved in marine areas or species conservation increased the later by 0.08

The other variables that influenced the weight attributed to the economic assessment were (table W24): having an educational background in business and management (weight increase by 0.10, having heard of ESV (0.04 increase), having an informative role in decision-making (0.04 decrease), and the years of experience in decision-making (between 0.01 and 0.05 decrease).

Finally the other variables that influenced the weight attributed to the ecological assessment were (table W23): having an educational background in economics, social or political sciences (weight increase by 0.16) having worked in CME conservation (0.13 increase), and having an informative role in decision-making (0.12 decrease).

Table W22 Tobit regression results on the AHP weight associated with the economic assessment of marine biodiversity (decision-makers)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	0.060***	0.022		
State WA [bi]	0.054***	0.020	0.051***	0.019
State Tas [bi]	0.066***	0.020	0.063***	0.020
Education field Business and Management [bi]	0.108***	0.024	0.103***	0.023
Having heard about ESV [bi]	0.042***	0.015	0.040***	0.014
Years of experience	-0.015**	0.007	-0.014**	0.007
Working on Commercial Fisheries [bi]	0.044**	0.018	0.042**	0.017
Working on Coastal Development [bi]	0.030**	0.015	0.029**	0.014
Having an informative role [bi]	-0.041***	0.015	-0.039***	0.014
Pseudo-R^2	0.441			
N	46			

[bi] *Binary variable. Years of experience in decision-making; from 1 (0-5 years) to 4 (more than 20 years)*

Table W23 Tobit regression results on the AHP weight associated with the ecological assessment of marine biodiversity (decision-makers)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	0.686***	0.132		
Age Category	-0.048*	0.026	-0.048*	0.026
State Vic [bi]	0.214*	0.120	0.213*	0.120
State NSW [bi]	0.104*	0.058	0.104*	0.058
State SA [bi]	-0.246***	0.067	-0.245***	0.067
Education field Society and Culture [bi]	-0.160**	0.065	-0.160**	0.065
Having worked in conservation [bi]	0.135***	0.047	0.135***	0.047
Having a contributive role [bi]	-0.124***	0.047	-0.124**	0.047
Pseudo-R^2	0.441			
N	46			

[bi] *Binary variable*

Table W24 Tobit regression results on the AHP weight associated with the socio-economic assessment of marine biodiversity (decision-makers)

	Coeff.	Std. Error	Marginal effects	Std. Error
(Intercept)	0.227***	0.062		
Age Category	-0.039***	0.012	-0.037**	0.012
State NSW [bi]	0.135***	0.036	0.127**	0.034
State Vic [bi]	0.106*	0.058	0.099*	0.054
State Qld [bi]	0.103***	0.030	0.097**	0.028
State SA [bi]	0.116***	0.035	0.108**	0.032
Working on coastal development [bi]	-0.073***	0.025	-0.068**	0.024
Working on commercial fisheries [bi]	-0.081***	0.028	-0.076**	0.026
Working on marine conservation [bi]	0.083***	0.024	0.077**	0.023
Pseudo-R^2	0.419			
N	46			

[bi] *Binary variable*

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