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The Economic Valuation of Marine Ecosystems

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Summary

In a democratic system, policy makers have to take the preferences of the citizens into account. Since we live in a world with scarce resources, one is asked to make choices regarding the use and management of these resources. In this context, if policy makers decide to invest in the protection of marine ecosystems, less financial resources will be available for other policy areas, for example national health. Moreover, the investment in the protection of marine ecosystems brings along with it the provision of a wide range of benefits to humans though most are not priced in the existing markets – for example climate regulation and provision of habitat for biodiversity. Given that most human activities are priced in one way or other, in some decision contexts, the temptation exists to downplay or ignore these important marine ecosystem benefits on the basis of the non-existence of prices. The simple and simplistic idea in the minds of many policymakers is that a lack of prices is equivalent to a lack of values. Clearly, this is a biased perspective. Against this background, this paper explores the motivation for an economic valuation of this complex resource. The state-of-the-art economic valuation methodologies follow the guidelines proposed by the Millennium Ecosystem Assessment, taking into account the existing scientific knowledge on the functioning of marine ecosystems, marine ecosystem goods and services and its impacts on human welfare. Finally, we critically review some economic valuation studies, arguing that the economic valuation of marine ecosystem services and biodiversity can make sense if and only if important guidelines are observed.

Keywords: Economic Valuation, Marine Ecosystem, Millennium Ecosystem Assessment Approach, Europe

JEL Classification: Q50, Q57

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Abstract

In a democratic system, policy makers have to take the preferences of the citizens into account. Since we live in a world with scarce resources, one is asked to make choices regarding the use and management of these resources. In this context, if policy makers decide to invest in the protection of marine ecosystems, less financial resources will be available for other policy areas, for example national health. Moreover, the investment in the protection of marine ecosystems brings along with it the provision of a wide range of benefits to humans though most are not priced in the existing markets – for example climate regulation and provision of habitat for biodiversity. Given that most human activities are priced in one way or other, in some decision contexts, the temptation exists to downplay or ignore these important marine ecosystem benefits on the basis of the non-existence of prices. The simple and simplistic idea in the minds of many policymakers is that a lack of prices is equivalent to a lack of values. Clearly, this is a biased perspective. Against this background, this paper explores the motivation for an economic valuation of this complex resource. The state-of-the-art economic valuation methodologies follow the guidelines proposed by the Millennium Ecosystem Assessment, taking into account the existing scientific knowledge on the functioning of marine ecosystems, marine ecosystem goods and services and its impacts on human welfare. Finally, we critically review some economic valuation studies, arguing that the economic valuation of marine ecosystem services and biodiversity can make sense if and only if important guidelines are observed.

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1. Introduction

Natural marine ecosystems require our attention for two reasons. Firstly, they provide a wide range of benefits to humans, ranging from the provision of food to climate regulation, from coastal recreation to habitat conservation. Secondly, human activities have contributed, and still contribute, to an unprecedented strain on marine ecosystems, and the biodiversity they host. Our experience in the field of environmental economics teaches us that many marine ecosystem values cannot be incorporated in conventional market transactions. The question then is how to translate such values into monetary terms. This is a challenging question to be posed to economists. In order to provide an answer to such a question, economists first need to work with scientists from other disciplines so as to understand the complexity of the relationships between the functioning of marine ecosystems and their capacity to provide ecosystem goods and services. Economists, at a second stage, proceed with the valuation of these ecosystem goods and services, bearing in mind their impact on human welfare. This valuation is expressed in monetary terms, exploring a wide range of methodologies.

We will articulate the discussion as follows. In Section 2 the notion of marine ecosystems as a source of economic value is discussed, presenting the welfare-theoretical based approach as well the economic valuation methodologies. In Section 3 the Millennium Ecosystem Approach is presented and some economic valuation studies are critically reviewed against this integrated ecological-economic framework. In Section 4 the knowledge shortfall is reviewed, putting forward some suggestions for future research. In Section 5 the conclusions are drawn.

2. Marine ecosystem as a source of economic value

2.1. Motivation for economic valuation: why are economists in this picture?

The economic valuation of environmental assets, in general, and marine ecosystems and biodiversity, in particular, is among the most pressing and challenging issues environmental economics is confronted with (see Sudhkev et al. 2008). One of the main reasons for pursuing economic valuation arises from its potential for benefit-cost-analysis, which is a corner stone in the evaluation of any policy design. The basic rule of benefit-cost-analysis in decision-making is to approve any potentially worthwhile policy if the benefits of the policy exceed the costs. Therefore, there is the urgency to identify and estimate the economic values of the full range of benefits provided by the marine ecosystems. Major organisations across the world such as the World Bank, Conservation International, the Environmental Protection Agency, the European Commission and others promote the application of an economic value assessments and its use in the policy agenda. Environmental accounting is also recognised as an important steering factor in carrying out an economic valuation of marine ecosystems and biodiversity services. In this context, various efforts have been made to adjust national accounting systems and associated gross national product statistics to take into account the depreciation of environmental assets and the loss of biodiversity. Green accounting is one possible strategy. The underlying idea is to add information on physical flows and stocks of environmental goods and services to the traditional national accounting system – the so-called physical satellite accounts. Against this background, there is an ongoing Integrated Project that is synthesising and developing comprehensive estimates of the external costs for Europe of a broad set of economic activities, setting up a detailed environmentally extended input-output framework, with links to other socio-economic models, in which as many of these estimates as possible are included (EXIOPOL 2008). Finally, natural resource damage assessments (NRDAs) have also created a stimulus for the economic valuation of marine ecosystems. The core of a NRDA exercise is to appraise how much society values the destruction of natural resources. An important benchmark in the history of NRDA is the massive oil spill due to the grounding of the oil tanker Exxon Valdez in Prince William Sound in the northern part of the Gulf of Alaska on March 24,

1989. This was the largest oil spill from a tanker in US history. More than 1,300 km of coastline were affected and almost 23,000 birds were killed (Carson et al. 1992). The natural resource damage resulting from the Exxon Valdez oil spill was estimated at $2.8 billion at the time. For the first time, a governmental decision expressed the legitimacy of non-use values as a component of the total damage value. To date, NRDAs are mainly undertaken in the US and have not yet become an issue in the European policy agenda because of different legal/institutional arrangements.

2.2. General features of the economic valuation perspective

The economic valuation of marine ecosystem and biodiversity services (MEBs) is based on an instrumental perspective of the value. This means that the value of MEBs is anchored in a human perspective and therefore interpreted as the result of an interaction between who attaches value (humans) and the object of valuation (flows of ecosystem goods and services). In other words, the economic valuation perspective subscribes an anthropocentric value orientation, thus rejecting the notion of intrinsic values – see Nunes and van den Bergh (2001). Secondly, humans elicit MEBs in terms of their impact on human welfare, including human knowledge, use, experience, and consumption of MEBs. Thirdly, the economic valuation of MEBs has a reductionist approach since it is based on the idea that one is capable of subdividing the total economic value into use value and passive use value, reflecting the different human motivations with respect to the (non)use of biodiversity values – see Table 1. In a conceptual framework, one can define the total value (TV) of the marine ecosystem and biodiversity benefits in terms of the use value (UV) and non-use value (NU). The former can be further divided into direct and indirect use values (DUV and IUV). Direct use values include: (a) marine and coastal recreation benefits; (b) natural and cultured marine species with commercial value; and (c) insurance with respect to potential risks to human health. Indirect use values refer to benefits that relate to the good functioning of the marine ecosystem and the survival of marine living resources, even if these have no direct commercial value. Finally, non-use values of marine quality can be divided into a bequest value (BV) and an existence value (EV). Bequest value refers to the benefit accruing to any individual from the knowledge that future generations might benefit from a sustainable marine ecosystem. Existence value refers to the benefit derived simply from the knowledge that the marine ecosystem is protected without even being used. Fourthly, economic valuation of MEBs is pursued through explicit changes in the current state of the world. On average, these are described by the use of scenarios and economists focus on the welfare changes involved. In other words, an economic valuation of the system (in its current state) is not pursued but rather of the *changes* of the system. For example, in the field of climate change, one may be willing to assess the total economic value provided by MEBs when moving from an A1 to a B2 storyline scenario. Fifthly, economic valuation of MEBs is a monetary indicator. The reason is that from a theoretical perspective, economists assume that consumers are willing to trade changes in the level of provision of MEBs with variations in their income (e.g. compensation measures or payments for ecosystem services). This means that the economic valuation results can be easily fitted to benefit-cost-analysis, a crucial tool for the design of effective and broadly accepted management policy. Finally, a European review on the economic valuation of ecosystems and biodiversity (TEEB phase 1) points out that most of the economic valuation studies lack a uniform, clear perspective on MEBs as a distinct, univocal resource. Therefore, an integration of the economic valuation exercise within a fully integrated approach such as the one recently proposed by the United Nations, the Millennium Ecosystem Approach, is solicited. This will be considered in detail in Section 3. However, the different economic valuation methods that an economist can refer to are discussed before this.

Table 1: Classification of economic values provided by the marine ecosystems

Value components		Examples of benefits
Use value (UV)	Direct use value (DUV)	Tourism and recreational benefits, e.g. visits to the beach, swimming and sailing
		Marine resources with commercial value, e.g. fish, shellfish and molluscs
		Human health, e.g. prevention of skin allergies and gastrointestinal disorders
	Indirect use value (DUV)	Marine ecosystem and ecological functioning, e.g. climate regulation, protection of local marine living resources diversity
Non-use value (NUV)	Bequest Value (BV)	Legacy benefits, e.g. heritage of marine living resources for future generations
	Existence value (EV)	Existence benefits, e.g. knowledge guarantee that some marine living resources are not extinct

Source: van den Bergh et al. (2002)

2.3. Economic valuation tool box

Various valuation methods are available to give an economic value to environmental benefits. We can distinguish two groups of valuation methods: the direct and indirect or dose response valuation methods – see Table 2.

Table 2 : A classification of economic valuation methods

Revealed preference	Stated preference	Dose response
Travel cost	Contingent valuation	Production cost
Hedonic pricing	Stated choice	Production factor
Averting behaviour		

Source: World Bank (2004) pag. 11

The dose response methods are similar in that they put a price on environmental commodities without establishing people's preferences for these commodities. The production cost techniques such as the dose response methods rely on the presence of physical input-output relationships. For example, if one intends to estimate the monetary value of the benefits of clean air on human health, one can take into account the relationship between air pollution and the number of visits to physicians and the purchase of drugs. This valuation method results in underestimates as it omits preferences for health, the value of which cannot be easily estimated. Conversely, the direct methods rely on individual preferences. These methods are further divided into revealed preference methods and stated preference methods depending on the process by which the individuals' preferences are obtained. The group of revealed preference valuation methods consists of three methods: travel cost, hedonic pricing and averting behaviour (see Braden and Kolstad 1991, Mäler 1988). The common underlying feature is the dependency on a relationship between a market good and the environmental benefit. For example, when using the travel cost method, researchers estimate the economic value of recreational sites by looking at the costs of the trips made by the visitors to these sites. When using the hedonic price method to estimate the economic value of clean air, researchers examine the analysis of house market prices and surrounding air characteristics. Researchers who use the averting behaviour method try to estimate the economic value of clean air on the basis of expenditures on technological equipments made to avert or mitigate the adverse effects of air pollution.

Whereas economists who use revealed preference valuation methods have to carry out estimation exercises bearing in mind the existent market price data, economists who use stated preference valuation methods have to collect their own data by means of questionnaires, based on constructed markets. The underlying feature is the use of the questionnaire to ask the individuals directly to state their economic values for environmental commodities (Mitchell and Carson 1989). The use of questionnaires require economists to work closely with experts from market and survey research, sociology and psychology in order to guarantee the authority of the stated choice methods as a valid instrument to assess economic value of an environmental benefit (Carson *et al.* 1994, NOAA 1993). In contrast, revealed preference methods have remained an exclusive valuation tool for economists. Stated preference valuation methods are contingent valuation, contingent ranking, pairwise comparison and allocation games. The respective differences relate to the way in which the economic values are elicited. For example, whereas the contingent valuation method asks respondents to express their preferences for some defined environmental benefit in monetary terms, the contingent ranking method asks the respondent to rank a number of described environmental quality alternatives.

It is important to note that an alternative valuation method, *benefit transfer*, is currently popularised and applicable for any of the ecosystem goods and services in question. The development of benefit transfer technology provides a low cost and less time consuming opportunity for the economic valuation of most of the environmental goods and services. The idea underlying this method is to transfer the biodiversity benefit estimates from original CV studies to the policy site, where no original studies have been done but policy decisions need to be made. However, the validity and accuracy of the estimate results need to be improved. In Table 3, we display all the valuation methods mentioned so far, and list detailed information regarding the respective application fields, data requirements as well as main limitations of each individual method.

Table 3 : Main economic valuation techniques: a summary

Methodology	Approach	Applications	Data requirements	Limitations
Revealed preference methods				
Production function	Trace impact of change in ecosystem services on produced goods	Any impact that affects produced goods	Change in service: impact on production; net value of produced goods	Data on change in service and consequent impact on production often lacking
Replacement/Avoidance cost	Use cost of replacing the lost good or service	Any loss of goods or services	Extent of loss of goods or services, cost of replacing them	Tends to over-estimate actual value; should be used with extreme caution
Travel cost method (TCM)	Derive demand curve from data on actual travel costs	Recreation	Survey to collect monetary and time costs of travel to destination, distance travelled	Limited to recreational benefits; hard to use when trips are to multiple destinations
Hedonic pricing (HP)	Extract effect of environmental factors on price of goods that include those factors	Air quality, scenic beauty, cultural benefits	Prices and characteristics of goods	Requires vast quantities of data; very sensitive to specification
Stated preference methods				
Contingent valuation (CV)	Ask respondents directly their WTP for a specified service	Cultural values, Passive use values	Survey that presents scenario and elicits WTP for specified service	Many potential sources of bias in responses; guidelines exist for reliable application
Other methods				
Benefit transfer	Use results obtained in one contest in a different context	Any for which suitable comparison studies are available	Valuation exercises at another, similar site	Can be very inaccurate, as many factors vary even when contexts seem 'similar'; should be used with extreme caution

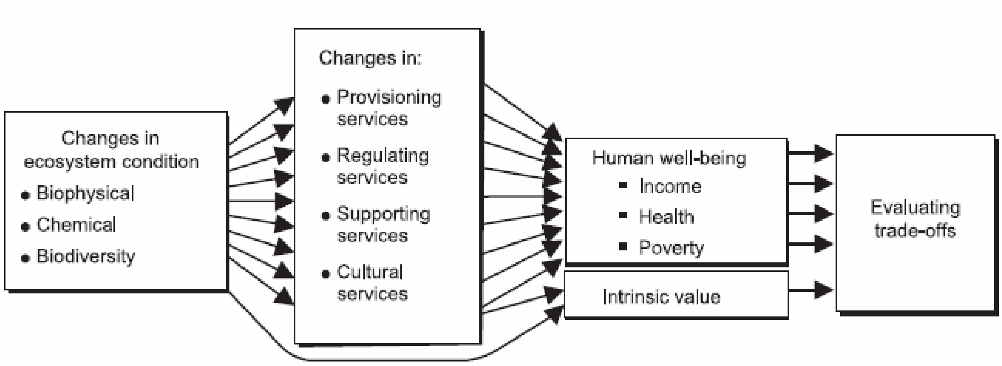
3. An ecosystem service based approach

3.1. The conceptual integrated ecological-economic framework

The Millennium Ecosystem Assessment (MEA, 2005) has fundamentally changed the approach that has characterised natural and social scientists, and has mapped the complex relationships between biodiversity, ecosystem functioning, and human welfare. The MEA distinguishes four broad categories of benefit: provisioning services, cultural services, regulating services and supporting services – see Figure 1[1].

[1] Although the prevailing orthodoxy now is to give ecosystem services centre stage and to view biodiversity as valuable when it enhances those services, one should note that not all scientists agree with this perspective. Indeed there is increasing scientific evidence that biodiversity has a more central role and in fact underpins the supply of ecosystem services, even though the issue remains controversial (Balvanera et al., 2006). Positive biodiversity effects have been

Figure 1: Mapping the links between biodiversity, ecosystem services and human wellbeing



Source: MEA (2005)

Following the MA approach, Beaumont et al. (2007) and Balmford (2008), identified a range of marine ecosystem goods and services for each category – see Table 4. An accurate, complete and reliable monetary assessment of marine ecosystem benefits also requires the application of specific monetary valuation tools. Bearing in mind both the classification of the economic value component and the respective marine benefits, Table 4 shows the most suitable valuation methodology to be used.

Table 4: Goods and services provided by marine biodiversity: a MEA approach

MEA Category	Goods or Services	Most suitable valuation method
Provisioning services	Food provision	Aggregate price analysis(1)
	Raw materials	Aggregate price analysis(1)
Regulating services	Gas and climate regulation	Avoidance cost
	Disturbance prevention (food and storm protection)	Aggregate price analysis(1), Avoidance
Cultural services	Cultural heritage and identity	Stated preference methods
	Cognitive, educational values	Aggregate price analysis(1)
	Leisure and recreation	Travel cost method
	Bequest and existence values of habitats and species	Stated preference methods
Supporting services	Resilience and resistance (life support)	Production function, Stated preference methods (2)
	Biologically mediated habitat	Production function, Stated preference methods (2)
	Nutrient cycling	Replacement/Avoidance cost, Stated preference methods (2)

Source: adapted from Beaumont et al. (2007), p.p. 256, van den Bergh et al. (2002), Sudhkev et al. 2008, Markandya et al 2008
(1) market price method, (2) no clear understanding of the potential of these economic valuation methodologies to fully capture the magnitude of the benefits due to high degree of uncertainty.

As one can see, the travel cost method is the most suitable valuation method for a monetary value assessment of marine quality benefits that relate to the provision of tourism and recreational opportunities. Moreover, stated preference methods can fulfill an important role in the overall

found on the productivity of many ecosystems – which are crucial to the provision of many services such as food or wood – and on their resilience, e.g. their capacity to respond to disturbances in a constructive way.

assessment of marine quality benefits. Indeed, stated preference methods can be applied to assess the monetary value of most of the types of benefits provided by the protection of marine quality, including both bequest and existence values. Furthermore, these methods have the advantage that marine policies may be valued even if they have not yet been adopted (*ex ante* valuation) or lie outside the current institutional arrangements. Thus, it offers much scope and flexibility for specifying different marine protection, restoration and amelioration programmes. For these reasons particular attention will be paid to the analysis and discussion of stated preference methods, including the stated choice method (SC) and contingent valuation method (CV). In addition, we will also focus on the use of the travel cost (TC) method to assess marine recreational values.

SC and CV are survey based valuation techniques that are widely used in the context of environmental valuation (Carson *et al.* 1992, NOAA 1993, Hanley et al. 2001). CV is a survey-based approach that directly estimates the preferences for risk reductions in the overall marine ecosystem quality. Therefore, CV gives an immediate monetary estimate of the willingness to pay (WTP) welfare measure associated with an increase in the marine quality. In short, CV and SC make use of a questionnaire that describes a survey market in which non-market goods can be traded. It is assumed that the values elicited with CV will correspond to those that would emerge on real markets. The contingent market defines the good itself, the institutional context in which it would be provided, and the way it would be financed. Respondents are then asked to express their maximum WTP for a survey-described change in the level of the environmental good. Alternatively, in the SC approach respondents are presented with a set of two or more survey-described alternatives that differ in terms of the respective attributes and attribute levels. The respondents are asked to select the alternative they prefer. Both a CV and a SC questionnaire contain two important elements. The first is a clear description of the environmental good to be valued. The second element is a mechanism for eliciting the WTP of the respondents. CV describes the elicitation process directly with a WTP question, while in SC, individual WTP is inferred from the choice of the described alternatives (or choice sets). Finally, the travel cost method (TC) can be used when the valuation exercise, and underlying policy proposals, refers exclusively to the recreational use values provided by protection of marine quality. In short, the travel-cost method is a demand-based model used for a recreation site – see Nunes and van den Bergh(2004).

3.2. Valuation studies

From the theoretical view point, climate change is expected to have *inter alia* an impact on the Arctic sea-ice cover and its thickness and on the Atlantic meridional overturning circulation. This may be translated *inter alia* into higher surface/water temperatures that, in turn, will strengthen near-surface stratification and decrease the ability of the winter winds to mix the water column (e.g. McClain et al. 2004; Llope et al. 2006) – see Figure 2. Several coupled ocean-atmosphere models have shown global warming to be accompanied by an increase in vertical stratification (IPCC 2001). These physical and biological impacts need to be clearly identified and measured – for example by exploring the use of climate scenarios (such as the Arctic Climate Impact Assessment: ACIA 2005, which uses the B2 intermediate scenario describing a world with moderate population growth, economic development and technology change. This scenario predicts a doubling of atmospheric CO_2 after approximately 80 years). Once the physical and biological impacts are mapped and quantified, an economist would then proceed with the economic valuation of these impacts, expressed in terms of their significance with regard to (changes in) human welfare.

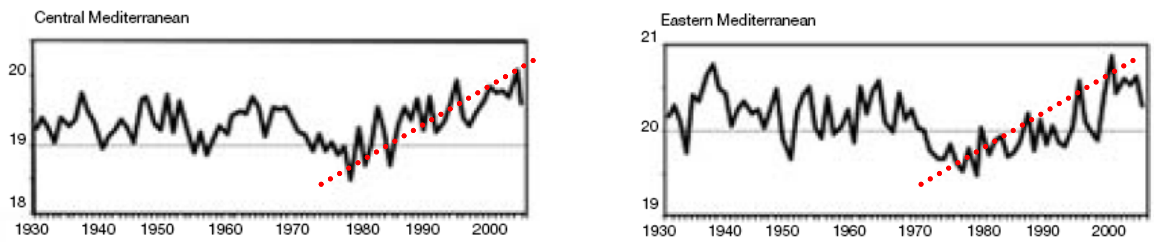


Figure 2 Long-term variations in area-averaged sea-surface temperatures (°C)
Source: ESF (2007)

In Figure 3, one can see that there are two basic levels of analysis that can be used to assess the net cost of impacts of climate change and marine biodiversity effects, namely partial equilibrium analysis and general equilibrium analysis.

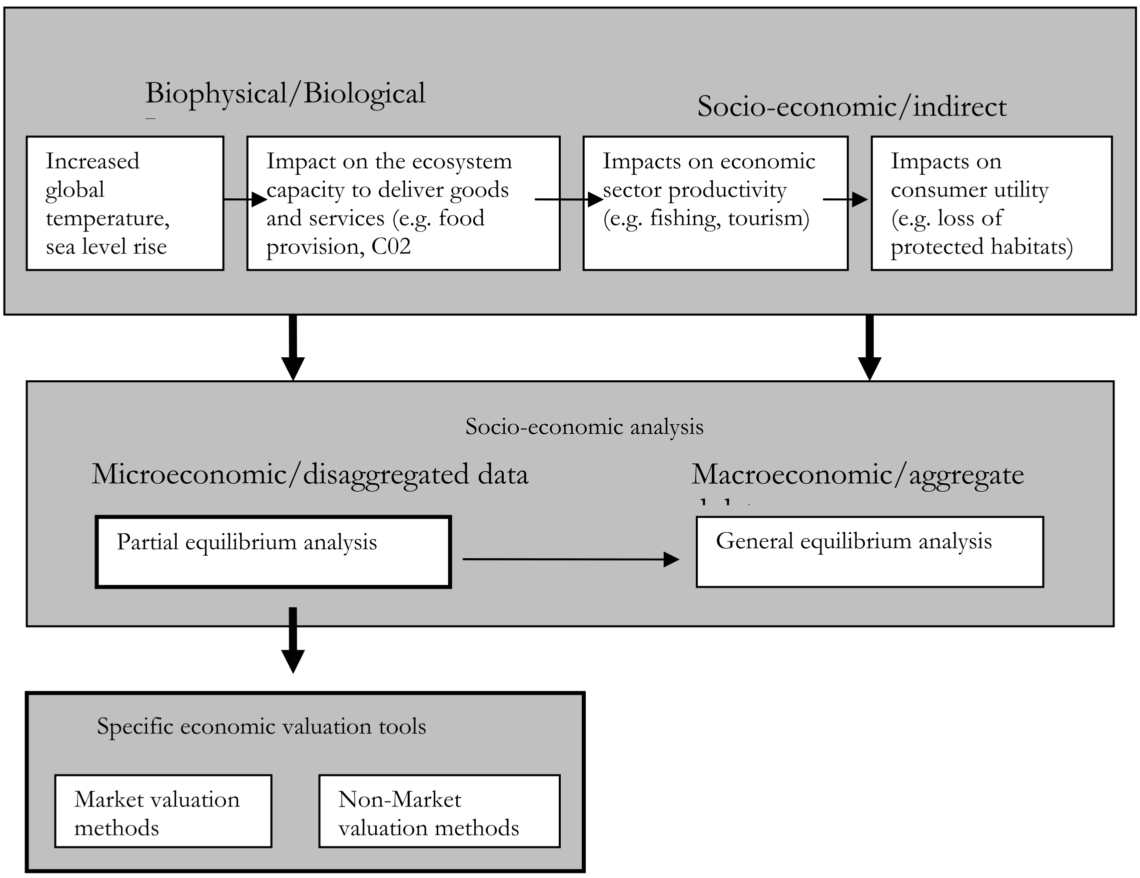


Figure 3 Framework for valuating climate change impacts on marine ecosystems and services
Source: Australian Greenhouse Office report (2004), adapted.

Partial equilibrium analysis: According to this economic analysis the impacts of climate change, and its implications in terms of the ecosystem provision of EGS, can be examined in terms of its direct effects on a specific, single market, an industrial sector or economic activity (e.g. the local or regional effect of a reduction of the supply EGS on forest recreation activity). *General equilibrium analysis*: This kind of economic assessment method is widely used for studying the indirect economic impacts or economy-wide impacts caused by climate change. Thus, the impacts of climate change can be assessed for a number of markets, economic sectors and respective trade patterns within an entire economy. This analysis considers the interactions among the different economic sectors and suggests that any climate change impact on one specific market will produce indirect impacts on many other markets, thus affecting prices in a wider context.

Box I: Studies of Marine Ecosystem Service in Europe

1. In the coastal waters of several European countries there is a notable loss of crayfish populations (*A Pallipes, A. Astacus, A. Torrentium*) due to pollution, habitat loss, overfishing and the introduction of alien species (mainly N. American). Services lost include food (domestic varieties fetch twice the price of non-native varieties), regulating services (trophic effects on prey and predators), recreation and cultural services. Although estimates of the loss have not been made, estimates of the costs of restoration have. They indicate modest costs (around €225,000 per stream over 5 years in France) that would be well below the value of the recovered crayfish populations.
2. Overfishing in the North Sea is a major threat to its biodiversity and ecosystem health and stocks of a number of fish are now under stress. Estimates of the benefits of recovery plans that would increase populations are about €600 million a year. This excludes benefits from fish processing and recreational fisheries.
3. Eutrophication of coastal marine ecosystems in Sweden is well known and studied. Services lost as a result of eutrophication include provisioning for commercial fishery species and reduced efficiency in regulating services such as cycling and deposit nutrients. In addition there is a loss of cultural services, notably recreation. The value of the loss of regulating services is estimated at €6-€52 million a year for the Stockholm archipelago (for a one metre improvement in summer *Secchi* depth i.e. depth to which water can be seen with the naked eye) while the value of provisioning services is estimated at €6-€8 million a year for the Kattegat and Skagerrak fishery areas. This is based on a reduction in the output of *plaice* juveniles as a result of eutrophication.
4. A marine protection programme that focuses on the prevention of harmful alga blooms along the coastline of the Netherlands, entailing the construction of a ballast water disposal treatment in the Rotterdam harbour and the implementation of a monitoring programme of the water quality in the open sea along the North Holland beaches, is valued in the 225 - 326 million euro range, and includes non-market benefits associated with beach recreation, human health and marine ecosystem impacts

Alternatively, from the empirical valuation perspective, today we find neither a partial equilibrium nor a general equilibrium application that focuses on the monetary value measurement of the wide range of impacts of climate change on marine ecosystems. A recent review of the economic valuation literature of ecosystems and biodiversity services showed that among the 291 valuation studies submitted to the international call for evidence issued by the European Commission, only 4 referred to marine and coastal valuation studies (Markandya et al. 2008, Sudhkev et al. 2008) – see Box I.

A further set of recent European market-based studies of marine biodiversity value and the value of marine ecosystem services not submitted to the call, but of relevance to the application of MEA is presented in Box II, which also includes valuation based on stated value approaches that estimate the value of various economic activities connected to marine ecosystem biodiversity and, more generally, to conservation– see Beaumont et al. (2006) for more information. In addition we include Box III that has details on an overview for the Mediterranean and Black seas – see SESAME (2008) for more information.

Box II: An overview of goods and services provided by UK marine ecosystems

<u>Food provision</u>

Food provision refers to the exploitation of marine plants and animals for human consumption. For instance, Defra sea fisheries statistics 2004 reported a total value of £513 million for the UK fishery industry. However, marine ecosystems have been disturbed by anthropogenic consequences, such as climate change, in terms of reduced provision of commercial fish stocks as well as loss of marine biodiversity. In economic terms, it refers to a decrease in fisheries productivity in association with a negative welfare impact. The magnitude of the welfare loss for this value aspect is underestimated as it considers only market prices.

Box II: An overview of goods and services provided by UK marine ecosystems (cont.)

Raw materials

Raw materials refer to the marine organisms extracted for all purposes except human consumption, e.g. pharmaceutical and ornamental uses. Even though this category of MEBs is highly underestimated due to a lack of market value data, it represents considerable market value. For example, figures show that the total value of fishmeal in the UK market in 2004 was £81 million (European Parliament Report 2004), whereas the estimated total gross income from seaweed was between £349,819 and £583,032. Therefore, any alteration of marine biodiversity will influence the provision of raw materials as well as the respective human welfare.

Gas and climate regulation

Gas and climate regulation is a consequence of the natural functioning of marine living organisms that balance and maintain the chemical composition of the atmosphere and oceans. However, the monetary magnitude of this value component is rather difficult to obtain by using market valuation methods; instead an avoidance cost method can be employed so as to estimate the savings from damage avoidance due to marine conservation policies. For instance, Beaumont et al. (2006) obtained a value estimate ranging between £420 million and £8.7 billion (UK£2004) for the UK territorial waters area.

Disturbance alleviation and prevention

The damage caused by flooding and storm events can be alleviated and prevented by biogenic structures. For instance, the salt marshes attenuate and dissipate wave and tidal energy and thereby substantially reduce the cost of flood defence measures (Morris et al.2004, Brampton 1992, and Möller et al. 1996). By using the avoidance cost method, King and Lester (1995) and Beaumont et al. (2006) have calculated cost savings from sea defence for the UK waters and obtained an estimated value between £17 billion and £32 billion. The authors acknowledge that this value estimate is underestimated as only salt marshes were considered.

Cultural heritage and identity

This service of marine ecosystems reflects the cultural value associated with marine biodiversity e.g. for religion, folklore, painting, cultural and spiritual traditions. However, little information is currently available on the cultural benefits of marine biodiversity, although this is believed to be indicative of a lack of documented research, as opposed to a lack of value.

Cognitive values

This value component refers to the economic values of cognitive development in marine science, including education and research. For example, in the UK, marine research and application areas involved total funding of about £292 million in 2002, in addition to £24.8 million generated in education and training in marine science (Pugh and Skinner, 2002).

Leisure and recreation

The leisure and recreation service provided by coastal marine biodiversity has significant economic value, including support to the related employment and small businesses. In the UK, the total net value of marine leisure and recreation was estimated to be £11.77 billion in 2002 (Pugh and Skinner, 2002). More specific valuation studies are undertaken for open marine waters, e.g. whale-tourism and seal watching. Statistical figures show that the whale-tourism in West Scotland generated total income at £7.8 million in 1994, whereas the seal watching provided at least £36 million to the UK economy in 1996 (Beaumont et al. 2006).

Bequest and Existence values

This value component captures the non-use value of marine ecosystems. Therefore, the stated preference method is considered the most appropriate valuation method, e.g. the contingent valuation method. Studies by Hageman (1985) and Loomis and White (1996) estimated an annual average household's willingness to pay for surviving species of sea mammals in the £19 - £46 range per species, depending on the mammal species. By multiplying the unit estimate by the total number of households, the non-use value of marine mammals was estimated to vary between £469 million and £1,136 million in the UK in 2004.

Nutrient cycling value

Nutrient cycling has an essential role in terms of alleviating excessive nutrient loading and sustaining the productivity rates of marine species. The economic valuation of this service is rather difficult due to the high degrees of uncertainty about anthropogenic effects. Costanza et al. (1997) employed a replacement cost method and estimated the value of marine nutrient cycling in the £0.10 - £0.29 per m^3 range, which corresponds to a total replacement cost between £800 billion and £2320 billion derived from the UK waters. However, this value estimate should be used with caution.

Biologically mediated habitat
A biologically mediated habitat is provided by living marine organisms supporting a large number of species. It has an essential role in the marine ecosystem functioning. The loss of these habitats will result in a decline of biodiversity due to a loss of nursery and refuge areas. However, the valuation of marine biologically mediated habitats is currently missing due to lack of information.

A number of points should be noted about these estimation results: (1) *Estimates of market values are partial and generally not comparable*. Sometimes the figures are given as net income, sometimes as gross income. Gains in terms of employment or increased local economic activity found in some reports are not necessarily economic benefits or they might be only partially (that depends on what alternative employment opportunities exist and what alternative economic activities are possible). With the current state-of-the-art, however, it is possible to carry out proper valuations based on economy-wide impacts of biodiversity loss or conservation and some studies have done this; (2) *In some cases estimates are based on the costs of restoring lost services*. Albeit useful, such estimates could be higher or lower than the market value that is lost. Indeed one of the purposes of valuing loss of biodiversity is to see if replacement or restoration is justified. Using the former as a measure of value does not allow you to answer that question; (3) Underlying the market-based approach are scientific studies linking the estimated impacts on biodiversity to certain causes (e.g. the effect of pests on forests, of forests on air pollution etc.). *We should recognise that there are still many uncertainties regarding these links, which should be reflected in the reported benefits*; (4) *The majority of the studies refer to marginal changes in local areas*. At the same time there are a few that value the broad scale of services provided globally. The numbers from the latter studies are extremely high; (5) *The purpose of many of the studies was to show that the services provided by nature are significant and either merit protection (where biodiversity is threatened) or merit expansion (where there is potential for it).* Estimates of the 'opportunity cost' of coastal habitat, wetlands – i.e. what it would be worth if it were not conserved - are often much lower than the value of the biodiversity services provided if it was conserved.

Box III: Overview on valuation studies in the Mediterranean and Black Sea

Food provision
Knowler et al (1997) developed a bioeconomic model of the Black Sea anchovy fishery and have estimated the benefits of pollution abatement in terms of fisheries revenues at €2.57 million annually in addition to the existing fisheries revenues of €12.57 million in the Black Sea. Alberini and Zannatta (2005) conducted a contingent valuation survey to estimate the welfare improvements associated with a 50% increase in catch rates resulting from a reduction in the discharge of industrial pollutants into the Venetian Lagoon. Using this information, the authors calculated the welfare improvements associated with a 50% improvement in catch rates to be €3.42 million annually.

Bequest and Existence values
Langford et al (1998) report the results of a contingent valuation survey carried out in Greece to estimate the public's willingness to pay for the conservation of the Mediterranean monk seal (*Monachus-monachus*) in the Aegean area. The authors estimate a median willingness to pay of € 12.

Leisure and recreation
Machado and Mourato (1998) use contingent valuation to determine the value of a reduction in health risks associated with recreating in polluted marine waters along the Estoril coast, Lisbon. Estimation results show that recreational/amenity use value per visit range from € 16 for changing from a bad to a good quality beach to € 7 for moving from average to good quality beaches. The mean expected willingness to pay to avoid an episode of gastroenteritis was € 8. Brau and Cao (2006) carried out a choice experiment on a sample of tourists at the end of their holiday on the island of Sardinia (Italy) to examine the feasibility of implementing sustainable tourism policies. As far as environmental quality is concerned, it is found to be an important determinant of destination choice. Tourists were willing to pay € 40 for proximity of the lodging to the sea, € 57 to avoid the risk of overcrowding and € 50 for the option of existence of a protected natural area in the surroundings.

Box III: Overview on valuation studies in the Mediterranean and Black Sea

Disturbance prevention

Alberini et al. (2004) administered a contingent valuation study to elicit willingness to pay for a theoretical project that would improve infrastructure on the island of S. Erasmo (in the Venetian Lagoon) to help control erosion, improve beach quality, refurbish sewage and water pipes, and restore a cultural monument. The value estimates show that the non-use portion of mean willingness to pay is € 36, and the values for users and potential users are € 56 and € 35, respectively.

Nutrient cycling

Jones, Sophoulis and Malesios (2007) conducted a contingent valuation survey to evaluate the benefits deriving from the improvement of the sea water quality around the city of Mitilini, an island located in the Northeast Aegean Sea, resulting from the construction of a Sewage Treatment Plant. Estimation results indicate that the residents of the city were willing to pay € 17 every four months over a period of four years.

3.3. Critical discussion of the valuation studies

Biodiversity is a complex, abstract concept. It can be associated with multiple, widely ranging benefits to the human society, most of them still poorly understood. From the economic valuation studies under review it is clear that the few empirical assessments of marine biodiversity and ecosystem values do not provide an unequivocal, unambiguous monetary indicator. In any case, one should always keep in mind that economic valuation of biodiversity values does not pursue total value assessment of biodiversity, but rather of biodiversity changes. Therefore, it is nonsense to try to value extremely large changes in biodiversity, and certainly a waste of time to examine extreme changes like one resulting in a situation in which there is no natural living creature. Economists have assessed the economic value of biodiversity through tradeoffs between money and changes in biodiversity at different levels of life diversity, including genetic, species, ecosystem and functional diversity. Most of the time, there are no market valuation mechanisms that price biodiversity values. Therefore, valuing biodiversity requires the use of special valuation tools. The choice of the valuation tool will, in turn, depend upon the biodiversity value category under consideration. For example, it will be hard to set a contingent valuation survey to elicit the economic value related to changes in ecosystem functions and ecological services that are far removed from human perceptions, such as CO_2 storage or groundwater purification processes. On the contrary, the contingent valuation method is the most appropriate method whenever one focuses on the monetary valuation of biodiversity non-use values. Having said this, we strongly believe that the (neo-classical) economic valuation of biodiversity does make sense. Nevertheless, it is important to mention that economic valuation studies have arrived at an important crossroad. On the one hand, one may opt for combining contingent and non-contingent valuation strategies so as to assess the complexity involved at multiple life organisation levels in more detail. This strategy signals the need for a multidisciplinary approach that seeks a clear perspective on the direct and indirect effects of changes in biodiversity on human welfare. This would contribute to more sturdy economic value estimates that could serve to guide biodiversity policies. On the other hand, researchers can continue to work on creating more sophisticated versions and applications of the non-market valuation methods.

4. Shortfalls in knowledge and suggestions for future research

From the above, and from a review of the valuation literature, we conclude that while methods have been developed and used widely for some environmental values (especially non-market values), there are still several gaps in the literature. Notable among these are the lack of valuation studies and of the assessment of economic value. In fact, we would argue that the following issues need to be addressed urgently:

i. to promote the development of valuation studies that focus on the valuation of loss of marine species other than keystone species; marine cultural and spiritual values; and the dynamic aspect of all ecosystems and values – changes over time are at the core of all ecosystems.

ii. equally important, information on the impact of climate change on the European marine and coastal environment is still patchy. Therefore, a greater effort has to be made to gather, store and analyse previously and currently collected marine environmental data (e.g. common open access database and annual pan-European reporting based on national contributions).

Given that there are thousands of ecosystems and sites of importance within the EU, let alone the whole world, it is impossible to conduct individual studies to obtain the relevant information in a timely way. Hence some kind of benefit transfer will be essential if the goal of obtaining national, regional and global estimates of the damages from biodiversity loss in the absence of any action is to be obtained. The same applies, *a fortiori*, to estimating the reductions in such damages when some actions to protect the ecosystems are implemented.

The solution to this problem is that one needs to improve the application of benefit transfer for specific evaluations of ecosystem service benefits. In this context, we need to establish a clear set of guidelines about which kinds of benefit transfer are possible. Such guidelines need to stipulate not only the kind of ecosystem services but the areas and countries where the transfer can be carried out, given the available set of valuation studies. Secondly, further research should be carried out on how 'packages' of ecosystem services may be valued without undertaking whole new studies. Where there is an adding up problem, it may be possible to develop approximations for adding up benefits that can only be transferred individually. Thirdly, where transfer is not possible, we should develop toolkits that can be used to carry out location specific studies. Given the large database of existing studies, these can help simplify and demystify the process of valuation so it can be conducted in a more routine and cheap manner. Finally, an inventory of all major ecosystems should be drawn up and the loss of services expected under different scenarios should be prepared. Some of this is underway for some ecosystems but not for all the important ones.

In any case, one should always keep at the back of one's mind that any economic valuation exercise refers to *an incremental value*. To be useful, the valuation of the service has to be an incremental one. There is little advantage in knowing the total value of an ecosystem unless there is a threat to eliminate it or a policy or reconstruct it in its entirety, which is rarely the case. Yet many valuation studies provide estimates of the total cost of whole systems and there is even one regarding the value of the ecosystems of the whole world (Costanza et al., 1997). Carrying out an incremental analysis (which may entail estimating significant non-marginal changes in ecosystems), however, is not as easy as it might sound. If one is using revealed preference methods, a link has to be established between a change in the environmental attribute and the demand for a visit to a site or the value of a property. If one is carrying out a stated preference analysis the respondent has to understand the nature of the incremental change, which is more difficult than asking for the value of access to a site or use of a particular recreational facility. Finally, any economic valuation exercise needs to address the *multiple services and the 'adding up' problem*. Many ecosystem services that individuals receive are multidimensional and there is an adding up problem. The value attached to one forest area for recreational or other use is not independent of whether another forest nearby is conserved or not. The implication is that studies need to be undertaken allowing for substitution effects, which makes them more specific to a particular application and less capable of being transferred to other applications.

5. Conclusions

This report has critically reviewed the economic valuation of marine ecosystem services and biodiversity. The main message is that the economic valuation of changes in the provision of marine ecosystem services and biodiversity can make sense. This requires, inter alia, that a clear ecosystem services approach is chosen, that a concrete scenario is formulated, that changes are within certain boundaries, and that the particular perspective on biodiversity value is made explicit. So far, relatively few valuation studies have met these requirements. As a matter of fact, most studies lack a uniform, clear perspective on marine ecosystem services and biodiversity as a distinct, unequivocal concept. Against this background, the Millennium Ecosystem Assessment is now recognised as a key reference for the economics of ecosystems and biodiversity. However, to date, we have insufficient knowledge about, for example, how the functioning of ecosystems relates to the production of ecosystem goods and services and what the underlying role of biological diversity is within this complex relationship, so that, for this reason alone, it is very difficult, if not factually impossible, to assess the total economic value of marine ecosystems. Even if we admit that a value could be placed on a set of goods and services represented by all marine ecosystems, and keeping in mind that at present scientists still do not have sufficient knowledge to map and calculate the full range of ecosystem goods and services (across all the different types of world ecosystems), we would be still unable to answer the question “What is the role of biodiversity in this picture?” To answer this question, we would also have to include: (a) the role of genetic variation within species across populations and its impact on the provision of ecosystem goods and services, (b) the role of the variety of interrelationships that exist between species in different ecosystems on the provision of ecosystem goods and services, and (c) the role of functions among ecosystems on the overall level of provision of ecosystem goods and services. Without any doubt, a full monetary assessment would be impossible or subject to much debate. All in all, the available economic valuation estimates should be considered at best as a lower bound to an unknown value of biodiversity, and always contingent upon the available scientific information as well as the global socio-economic context.

References:

Alberini A. and Zannatta V. (2005) “Combining Actual and Contingent Behaviour to Estimate the Value of Sports Fishing in the Lagoon of Venice.”*Nota Di Lavoro 44.2005*

Alberini A., Rosato P., Longo A. and Zanatta V. (2004). “Information and Willingness to Pay in a Contingent Valuation study: The Value of S. Erasmo in the Lagoon of Venice.” *Nota Di Lavoro*, Working Paper no. 19-2004.

Australian Government (2004) “Australian Greenhouse Office – Annual Report 2003-2004)”

Balmford A., Rodrigues A.S.L., ten Brink P., Kettunen M., Braat L. And R. de Groot (2008) “The Economics of Biodiversity and Ecosystems: Scoping the Science.” Cambridge, UK: European Commission (contract: ENV/070307/2007/486089/ETU/B2).

Balvanera P, Pfisterer A B, Buchmann N, He J-S, Nakashizuka T, Raffaelli D and Schmid B (2006) ‘Quantifying the evidence for biodiversity effects on ecosystem functioning and services’. *Ecology Letters*, (2006) 9: 1–11.

Beaumont N, Townsend M, Mangi S and MC Austen (2006) “Marine biodiversity: an economic valuation.” Defra report, UK, presented at BIO.ECON 2007, Cambridge (UK) and available at: www.defra.gov.uk/science/Project_Data/DocumentLibrary/WC04029/WC04029_4013_FRP.pdf

Beaumont, N.J., Austen, M.C., Atkins, J.P., Burdon, D., Degraer, S., Dentinho, T.P., Derous, S., Holm, P., Horton, T., van Ierland, E., Marboe, A.H., Starkey, D.J., Townsend, M. and T. Zarzycki (2007) “Identification, definition and quantification of goods and services provided by marine biodiversity: Implications for the ecosystem approach”, Marine Pollution Bulletin 54: 253–265

Braat, L., ten Brink, P., Bakkes, J., Bolt, K., Braeuer, I., ten Brink, B., Chiabai, A., Ding, H., Gerdes, H., Jeuken, M., Kettunen, M., Kirchholtes, U., Klok, C., Markandya, A., Nunes, P., van Oorschot, M., Peralta-Bezerra, N., Rayment, M., Travisi, C., and M. Walpole (2008) “The Cost of Policy Inaction: The case of not meeting the 2010 biodiversity target” for the European Commission, DG Environment under contract: ENV.G.1/ETU/2007/0044 (Official Journal reference: 2007 / S 95 – 116033).

Braden, J. B. and C. D. Kolstad (eds) (1991) “Measuring the Demand for Environment Quality”, Elsevier Science Publishers, North-Holland.

Brampton AH (1992) “Engineering significance of British saltmarshes. In: Allen JRL and Pye K(eds.) Saltmarshes: morphodynhamics, conservation and engineering significance.” Cambridge University Press, pp 115-122.

Brander, A., Ghermandi, A., Markandya, A., Nunes, P.A.L.D., Schaafsma, Vos, H. and A. Wagtendonk (2008) ‘Scaling up ecosystem services values: methodology, applicability and a case study’, Environmental Protection Agency Project Report, Copenhagen, Denmark, 64 pp.

Brau R. and Cao D. (2006) “Uncovering the Macrostructure of Tourists’ Preferences. A Choice Experiment Analysis of Tourism Demand to Sardinia.” Fondazione Eni Enrico Mattei Working Paper Series.

Carraro C., Bosello F., Nunes, P.A.L.D., Chiabai A., and H. Ding (2007) “Impacts of Climate Change and Biodiversity Effects: Università Ca' Foscari Venezia CLIBIO 2007 Annual Report.” EIB University Research Sponsorship Programme, European Investment Bank, Luxembourg.

Carson, R. T., R. C. Mitchell, W. M. Hanemann, R. J. Kopp, S. Presser and P. A. Ruud (1992) "A Contingent Valuation Study of Lost Passive Use Values Resulting from the Exxon Valdez Oil Spill", *Report prepared for the Attorney General of the State of Alaska*, Washington.

Carson, R. T., L. Wilks and D. Imber (1994) "Valuing the Preservation of Australia's Kakadu Conservation Zone", *Oxford Economic Papers*, Oxford, 46(5), pp. 727-749.

Costanza R, d'Arge R, de Groot RS, Farber S, Grasso M, Hannon B, Limburg K, Naeem S, O'Neill R, Paruelo J, Raskin R, Sutton P, and M. van den Belt (1997) "The value of the world's ecosystem services and natural capital." Nature 387: 253-260.

European Parliament Report (2004) "The fishmeal and fish oil industry - its role in the Common Fisheries Policy." Fish 113, Feb 2004.

European Science Foundation (ESF) (2007) "Impacts of Climate Change on the European Marine and Coastal Environment: Ecosystems Approach." Position Paper 9, Strasburg, France.

EXIOPOL (2008) "A New Environmental Accounting Framework using Externality Data and Input Output Tools for Policy Analysis", ", Integrated European Union Project, webpage http://www.feem-project.net/exiopol/index.php

Hageman R (1985) "Valuing Marine Mammal Populations: Benefit Valuations in a Multi-species Ecosystem." National Marine Fisheries Service, Southwest Fisheries Centre, La Jolla, California, 1985, pp.88

IPPC, 2001. Intergovernmental Panel on Climate Change, Climate Change 2001: The Scientific Basis. Cambridge University Press, Cambridge, UK, pp. 881

Jones, N., Sophoulis, C.M., Malesios, C. (2007). "Economic valuation of coastal water quality and protest responses: A case study in Mitilini, Greece."*Journal of Socio-Economics* (2007).

King SE and JN Lester (1995) "The value of saltmarsh as a sea defence." Marine Pollution Bulletin 30: 180-189

Knowler D., Strand I., Barbier E. (1997) "The effects of pollution on open access fisheries: the case of the Black Sea." Paper prepared for the 8th annual conference of European Association of Environmental and Resource Economists.

Langford I.H., Kontogianni A., Skourtos M.S., Georgiou S., Bateman I.J. (1998) "Multivariate mixed models for open-ended contingent valuation data: willingness to pay for conservation of monk seals."*Environmental and Resource Economics* 12:443-456.

Llope, M., Anadón, R., Viesca, L., Quevedo, M., González-Quirós, R. and N.C. Stenseth (2006) 'Hydrographic dynamics in the Southern Bay of Biscay: integrating multi-scale physical variability over the last decade (1993-2003)', *J Geophys Res*, 111, C0921

Loomis JB and DS White (1996) "Economic benefits of rare and endangered species: summary and meta-analysis." Ecological Economics 18(3): 197-206

Machado F and Mourato S. (1998) "Improving the Assessment of Water Related Health Impacts: Evidence from Coastal Waters in Portugal." Paper presented at the First World Congress on Environmental and Resource Economics, Venice, June 25-27, 1998

Mäler, K-B. (1988) "Production function approach in developing countries", in Valuing Environmental Benefits in Developing Countries, Vincent et al. (eds), Special Report, Michigan State University, pp. 11-32.

Markandya, A., Nunes, P.A.L.D., Brauer, I., ten Brink, P. Kuik, O. and M. Rayment (2008) "Review On The Economics Of Biodiversity Loss – Economic Analysis and Synthesis", Final report for the European Commission, Venice, Italy. 140 pp.

McClain, C.R., Signorini, S,R. and J.R. Christian (2004) "Subtropical gyre variability observed by ocean-color satellites", *Deep-Sea Res*, II 51, pp. 281-301.

Merino, G., Karlou-Riga, C., Anastopoulou, I., Maynou1, F. and Lleonart, J. (2007) "Bioeconomic simulation analysis of hake and red mullet fisheries in the Gulf of Saronikos (Greece)." Scientia Marina, 71(3),: 525-35.

Millennium Ecosystem Assessment (2003) "Ecosystems and Human Wellbeing: A Framework for Assessment." Chapter 2: Ecosystems and Their Services. World Resources Institute, Washington, D.C.

Millennium Ecosystem Assessment (2005) "Ecosystems and Human Wellbeing: Biodiversity Synthesis", World Resources Institute, Ashington, D.C.

Mitchell, R.C. and R.T. Carson (1989), Using Surveys to Value Public Goods: The Contingent Valuation Method (Washington, DC: Resources for the Future).

Möller I., Spencer T., French J.R. (1996) "Wind wave attenuation over saltmarsh surfaces: preliminary results from Norfolk, England." Journal of Coastal Research 12: 1009-1016.

Morris R.K.A., Reach I.S., Duffy M.J., Collins T.S. and R.N. Leafe (2004) "on the loss of saltmarshes in south-east England and the relationship with Nereis diversicolor." Journal of Applied Science 41: 787-791.

NOAA - National Oceanic and Atmospheric Administration (1993) "Report of the NOAA Panel on Contingent Valuation", Federal Register, 58(10), pp. 4601-4614, US.

Nunes, P.A.L.D. and J.C.J.M. van den Bergh (2004) 'Valuing non-market benefits for protection against exotic marine species in the Netherlands using TC and CV data', *Environmental and Resource Economics*, 28, pp. 517-532.

Nunes, P.A.L.D. and J.C.J.M. van den Bergh (2001) 'Economic Valuation of Biodiversity: Sense or Nonsense', *Ecological Economics*, vol. 39(2), pp. 203-222.

Pugh D and L Skinner (2002) "A new analysis of marine-related activities in the UK economy with supporting science and technology." IACMST Information Document No.10 August 2002.

SESAME (2008) "Southern European Seas: Assessing and Modelling Ecosystem Changes", Integrated European Union Project, webpage http://www.sesame-ip.eu/

Sukhdev, P. et al. (2008) 'The Economics of Ecosystems and Biodiversity', European Communities, Brussels, Belgium. 68 pp.

van den Bergh, J.C.J.M., Nunes, P.A.L.D., Dotinga, H.M., Kooistra, W.H.C.F., Vrieling E.G., and L.Peperzak (2002) "Exotic harmful algae in marine ecosystems: an integrated biological-economic-legal analysis of impacts and policies." *Marine Policy Journal* 26:59-74

World Bank (2004) "How Much Is an Ecosystem Worth?-Assessing the Economic Value of Conservation", the World Bank, Washington DC, USA.

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