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Marine and coastal ecosystem services

Valuation methods and their practical application

UNEP WCMC

Regional Seas

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Preface

Marine and coastal ecosystems provide a wide range of services to human society including supporting, regulating, cultural and provisioning services. These services influence human welfare both directly, through human use, and indirectly, via impacts on supporting and regulating services in other environments. But they are increasingly under threat from widespread and growing pressures on marine and coastal resources such as overfishing, water contamination, coastal habitat destruction, and general loss of biodiversity.

The principal means for communicating the consequences of ecological change for human well-being is to document the impacts on ecosystem services. This improves understanding of the importance to humans of coastal and marine ecosystems, informs decision making processes, and supports attempts to influence human behaviour. Impacts on ecosystem services can be examined in qualitative terms, by quantitative measurements, or through economic valuation.

Economic valuation seeks to quantify the ways in which ecosystem services provide benefits to human populations, and expresses these values in monetary units that can be compared with other sources of value to society.

Several methods have been developed and refined over recent decades: the choice of valuation method will depend the service under consideration and also on factors such as the scale of assessment, the policy context and the resources available. Economic valuation methods are useful tools, provided they are treated appropriately as methods for developing and structuring evidence in a decision-making process. They are not a substitute for deliberation and decision-making.

This report sets out some of the most commonly used methods for economic valuation of ecosystem services, and explore their pros and cons in practical contexts for assessing management interventions in marine and coastal environments. Examples are used to illustrate a range of applications in policy development, decision making and communication, and to highlight some of the main challenges for valuation, and solutions. The aim is to provide initial guidance on the ways in which valuation can be useful in practical decision-making and management contexts.

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Women collecting fish at sunset in Dili District, Timor-Leste. Photo: UN Photo/Martine Perret

Chapter 1
Marine and coastal ecosystem services: why and how to value them

The main purpose of this document is to set out some of the most commonly used methods for economic valuation of ecosystem services, and to explore their pros and cons in a practical context in marine and coastal environments.

Measurement of ecosystem services and their values to humans is rapidly becoming the principal means for communicating the impacts of ecological change on human well-being.

- **Change** can be externally driven, or in response to human activities and/or management.
- **Values** can be estimated and expressed in monetary or non-monetary terms.
- Reliable and appropriate **valuation and appraisal methods** are needed to take these services into account.
  - Valuation can be useful and/or relevant at all levels of **governance**, including strategic policy setting, project appraisals, decision making, day to day management, and communication with stakeholders.
  - The **choice of valuation method** used in a practical situation can depend on governance scale, decision context, scientific understanding, and various other factors.

Why value marine services?

The ultimate aims of defining and measuring the value of the natural environment are to better inform management choices, and/or influence human behaviour. There are two main types of reason for valuing ecosystem services:

- **To assess the costs and benefits of an action or policy, as an aid to decision making;**
- **To improve understanding of the value of benefits to society from an ecosystem or series of linked ecosystems.**

Ecosystem valuation can assist in a wide range of tasks, including:

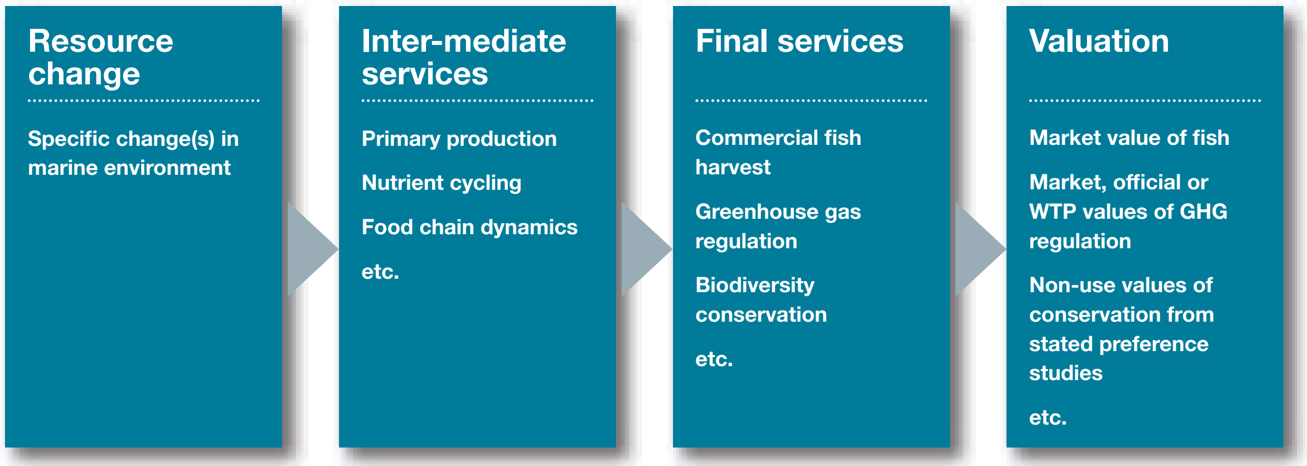
- Demonstrating and communicating the importance of an ecosystem;
- **Guiding national development plans;**
- Policy, programme and project appraisal;
- Setting priorities within a sector plan or across different sectors;
- Green national and corporate accounting;
- **Setting a framework to establish market-based instruments such as taxes, charges, fees, fines, penalties, subsidies and incentives and tradable permit schemes;**
- **Determining liability and compensation in environmental litigation.**

A simple framework for valuation is illustrated in Figure 1 (p. 8) – elements in this figure are explained in more detail in the following sections. In essence, changes in the marine environment result in changes in the delivery of intermediate and final services.

Valuation methods are selected based on their suitability to assess change in ecosystem services. Note that this does not imply that only final services are of value, but simply that the value of intermediate services is experienced and measured via their impact on final services (see also "Double counting", p. 39). Depending on the purpose of the valuation exercise, there may be further steps involved in carrying out appraisal, summing costs and benefits over time, in communication and dissemination, in design of policy instruments such as entrance fees, and so on.

Figure 1 Steps in valuation

If a change in the marine environment occurs ('resource change'); the potential impacts of this change on specific ecosystem services are identified and assessed ('intermediate service'); then, the effects this change of ecosystem services has on human welfare are considered ('final services'); and finally, the economic value of changes in ecosystem services are calculated ('valuation').



What ecosystem services do we need to value?

For assessing the value to humans of changes in the marine environment, we need to focus primarily on changes in those ecosystem services that directly influence human health, welfare and economic activities.

The concept of ecosystem services is covered in considerable detail in the Millennium Ecosystem Assessment (2005), in previous work (such as Daily, 1997), in many subsequent publications (see for example Silvestri and Kershaw, 2010; Turner and Daily, 2008; Boyd and Banzhaf, 2007), and in the recent work of The Economics of Ecosystems and Biodiversity programme (TEEB, 2010), and so is not repeated here.

- Marine environments provide **ecosystem services** that can be classified as:
  - **Supporting**: ecosystem functions that support and enable the maintenance and delivery of other services;
  - **Regulating**: natural regulation of ecosystem processes and natural cycles;
  - **Cultural**: benefits associated with experiences of natural environments; or
  - **Provisioning**: raw materials, food, energy.
- These influence human welfare:
  - **Directly**, through human use or experience of the service (these may be called 'final services'); or
  - **Indirectly**, via impacts of supporting and regulating services on other services and environments (these may be called 'intermediate' services).
- Services are often enhanced by **human inputs** of labour and manufactured capital.

Any ecosystem processes or service contributing to the maintenance of healthy ecosystems and human well-being can be considered 'valuable' to humans. Nevertheless, when assessing the value to humans of changes in the marine environment, we would typically focus only on the **final services directly influencing human welfare**, because the values of the intermediate services are already reflected via the final services or benefits that they support.

The measurement of basic ecosystem processes can be necessary for reasons other than valuation: providing data for management decisions (for example, measuring fish stocks for setting quotas), or for monitoring change (for example, measures of nutrient concentrations). But for any appraisals in which we will add up values across different service categories, focusing on final services means we avoid 'double counting' the same values twice.

> "When assessing the value to humans of changes in the marine environment, we would typically focus only on the final services directly influencing human welfare."

The specific ecosystem goods and services we need to consider in a practical valuation exercise depend on the boundaries in space and time of that specific assessment. Often, values within these boundaries will influence ecological processes and/or human activities occurring outside the boundaries (and vice versa). The clearest example is climate regulation, because climate change will impact all ecosystems and their services, across the globe, from now into the distant future. When considering the role of a particular management change in a critical marine area, it would be impossible to follow through and value all these final effects. Instead, we would focus on the **change** in carbon emissions and sequestration, and value that (see Box 1).

Box 1

Economic valuation of global climate regulation ecosystem services

Ecosystem services: climate regulation
Valuation methods: value transfer using market or proxy values for carbon
Implications: simple unit values can be used for all changes in climate regulation services

Marine and coastal environments play a vital role in regulating the global climate via the carbon cycle. But for marine and coastal management and decision making, it is neither feasible nor necessary to attempt to work out the full chain of cause and effect from climate regulation services to the final impacts of future climate change damages avoided. Rather, we can recognise that climate change is a global problem and that the specific location of emissions, or sequestration, does not influence the impact on climate change and associated future damages (though it may be important from a current political perspective).

This means that in most assessments a single value per unit of carbon emitted or absorbed is applied. The value estimate can come from various sources: global damage calculations, carbon trading markets, or official figures. In the UK, for example, there is official guidance on carbon values from DECC (2009) setting out in some detail the official rates for valuation of carbon. This includes an increasing carbon price over the next 40 years, rising from £52/tCO2e at present, to £200/tCO2e by 2050. This is the price of carbon that is factored in to public sector appraisals.

Although this is a 'shortcut' approach to valuation, using a single value across all public sector assessments has the distinct merit of facilitating consistency in decision making. In effect this is a form of "value transfer" (see Table 1, p. 14), and ensures that the valuation effort is kept proportionate to the task at hand. Similar arguments can be made for other ecosystem services, wherever the decision or project under consideration has an impact that can be seen as one small piece in a much larger regional or global picture.

A man maintains a fish farm in Tanzania. Photo: UN Photo/Evan Schneider

What is 'value'?

'Value' can cover a wide range of related concepts. What economists aim to measure is the values that humans hold for changes in ecosystem services. This is measured in terms of the amount of other goods and services people are willing to give up (or accept) in order to secure (or avoid) the ecosystem service change. This is known as their 'Willingness to Pay' (or 'Willingness to Accept' compensation) for a particular change.

The ecosystem services framework focuses on the flows of valuable goods and services provided by the stock of natural resources. This is analogous to the stock value of a capital asset and the flow or rent or interest that it provides.

- **Flow values** are the values that can be derived over a defined time interval (usually one year).
- **Stock values** can be thought of in terms of the net present value sum of all flow values that could be derived from an ecosystem over all future periods.

Stock and flow are therefore different facets of the same phenomenon. We can estimate the economic value of either, but it is important not to confuse the two, or to compare stock values of one resource with flow values of another.

The distinction also gives an insight to the management-dependent nature of the values of ecosystems. For example, the flow of value from an over-exploited fishery will be much lower than it could potentially be. Leaving the fishery to recover could result in short term reductions in flow value, but the stock value would increase, reflecting the higher future potential. An economic assessment should take this into account.

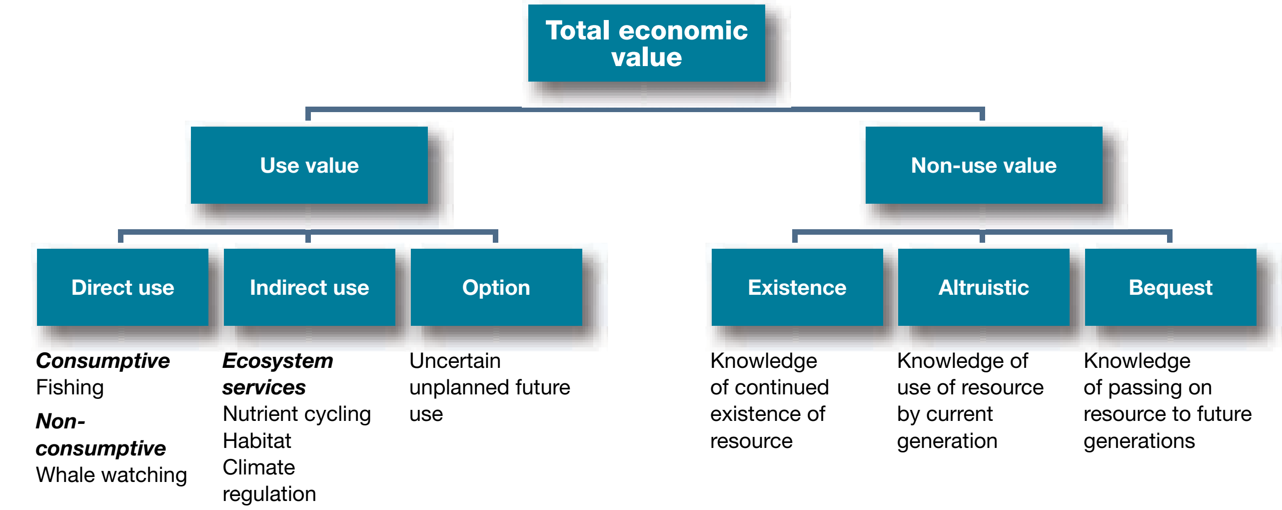
"Stock and flow are different facets of the same phenomenon, but it is important not to confuse the two."

Estimating economic values is based on working out how individuals are willing to trade-off between resources. The measure of value used is individual Willingness to Pay (WTP), a monetary expression of how individuals are willing to trade-off across different goods and services. In practical cases, it is also necessary to aggregate these values across individuals in society.

- **Total value** refers to the entire value of flow of a good or service during a defined time period, or the entire value of a stock at a given point in time.
- **Average value** is the per unit value, calculated by dividing the total by the physical quantity, e.g. area, mass, volume.
- **Marginal value** is the additional value gained or lost by an incremental change in provision of a flow, or in the level of a stock.

Figure 2 Total Economic Value Framework (TEV)

Adapted from Defra, 2007



The presiding framework for valuation is the Total Economic Value Framework, illustrated in Figure 2. "Total" in Total Economic Value does not imply the "value of the entire resource", but rather the "sum of all types of economic value" for the resource. It is possible, therefore, to estimate the TEV of a small change in a resource. "Marginal TEV" is generally more policy relevant than "total TEV". This is because the decisions we have to make generally involve creating, or responding to, incremental changes (improvements or deteriorations) in the provision of environmental goods and services, and it is these marginal changes that actually matter to policy decisions. On a practical level, marginal values can be much easier to estimate than total values: valuation methods are reasonably good at dealing with relatively small changes in provision. They are not suited to dealing with such large changes that people have severe problems imagining the impacts of the change, or where there are thresholds at which values change very rapidly.

TEV consists of various types of use and non-use values (Figure 2). Use value involves some interaction with the resource, either directly or indirectly. Non-use value is derived simply from the knowledge that the natural resources and aspects of the natural environment are maintained. It is not associated with any personal use of a resource; non-use values are held by people for unselfish reasons.

"'Marginal TEV' is generally more policy relevant than 'total TEV'."

Many people further consider the natural environment to have 'intrinsic' value. Such values are fundamentally beyond human knowledge. Both the TEV framework, and the whole ecosystem services concept, are human-centric perspectives of the environment and how we interact with, and depend and impact upon it. They do include non-use values associated with conservation, bequest to future generations and so on, but these remain human values. This focus is not necessarily in conflict with moral arguments for conservation, indeed the arguments are often used together.

Deep sea fishing boats in their berths in Buenos Aires, Argentina. Photo: UN Photo/P Teuscher

Chapter 2
Methods for taking environmental values into account

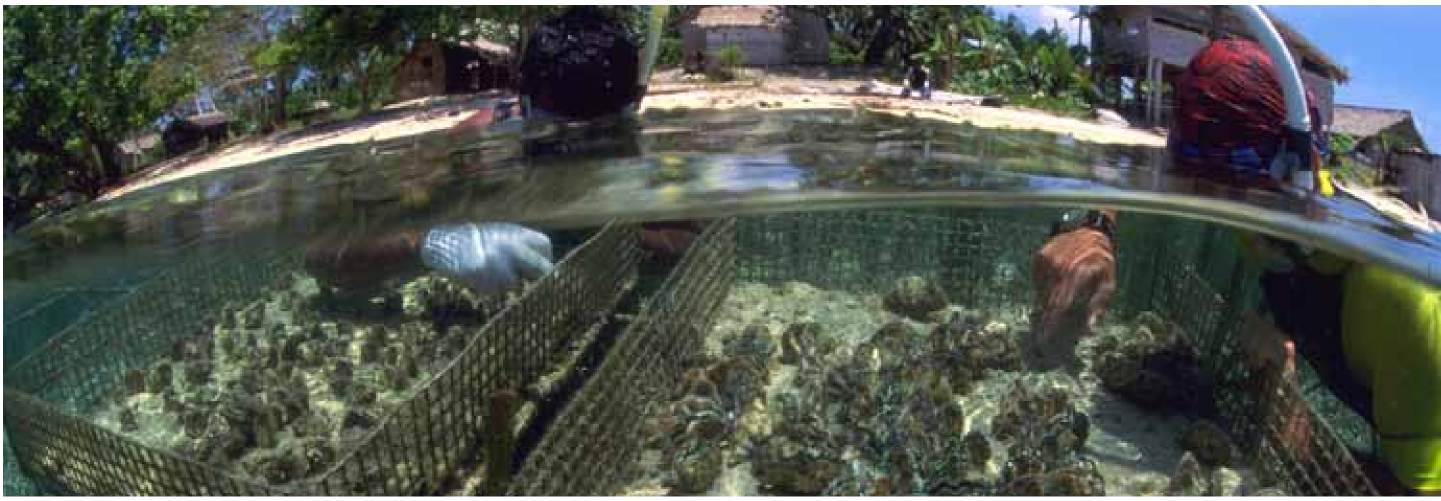
All methods for ecosystem services valuation have advantages and disadvantages, with different levels of time and resource costs, data requirements, accuracy, acceptability to stakeholders, and applicability to specific contexts.

The main focus of this report is to provide guidance on available methods for economic valuation and appraisal, and how and when to apply them (see Table 1, p. 14, for a summary). Valuation techniques essentially seek to estimate Willingness to Pay through different ways developed for different types of data. **There are three main families of valuation technique:** market based, revealed preference, and stated preference. Expenditure measures are also used, although these measure **costs**, not values (i.e., not Willingness to Pay). Value transfer methods are used to enable the application of existing value estimates to new contexts. And economic appraisal methods seek to draw together evidence on values of all impacts of a plan, policy, or project.

In addition to these economic methods, there are also a number of methods available for assessing and taking into account the ways in which ecosystems are valuable to humans, without using Willingness to Pay measures of value. These include deliberative methods such as focus groups and citizens' juries, and various participatory methods in which stakeholders become more intimately involved in the valuation, planning, and management decisions.

Although sometimes seen as conflicting, economic and deliberative or participatory methods can work well together. In fact, economic valuation methods increasingly make use of focus groups or other techniques as part of the valuation process.

"Valuation techniques essentially seek to estimate Willingness to Pay."



Divers caring for clams farmed in a cage on the Solomon Islands.
Photo: ReefBase/Mike McCoy

Table 1.

Approaches to measuring and using marine ecosystem service values	
Family and methods	**Notes and examples (Refer to the boxes for practical application examples)**
Market-based techniques • Market prices • Production functions • Avoided costs • Replacement costs	Market prices are rarely equal to values. Market information may require substantial analysis to deliver usable values: for example correcting for taxes and subsidies, or estimating how values change with quantity. Box 1 (p. 9): Economic valuation of global climate regulation ecosystem services Box 2 (p. 16): Economic value of coastal and marine resources in the Bohol Marine Triangle Box 3 (p. 17): Values from mangroves in Thailand (expressed in $ at 1996 prices) Box 8 (p. 26): Valuation for Guinea Current Large Marine Ecosystem Box 9 (p. 27): Valuation for the ‘Plan Bleu’ in the Mediterranean
Expenditure measures • Employment measures • Costs	Measure expenditure, not economic value (TEV). Although this does not estimate TEV, this information is nonetheless useful and relevant to decision makers who are interested in local or regional economic impacts of changes in ecosystem services. Employment or other social indicators may also be important. Box 4 (p. 18): Wadden sea estimates of expenditure
Revealed preference (RP) techniques • Travel cost • Hedonic pricing • Random utility model	Methods based on values for environmental resources that are ‘revealed’ by behaviour in associated markets. For example, the values humans place on outdoor recreation can be estimated from information about the time and travel costs incurred to engage in that activity. Box 5 (p. 20): Eutrophication reduction in the Stockholm archipelago Box 6 (p. 23): Value of recreational sea angling in the UK
Stated preference (SP) techniques • Contingent valuation • Choice experiments	Methods based on surveys in which people give valuation responses in hypothetical situations. Box 6 (p. 23): Value of recreational sea angling in the UK Box 10 (p. 29): Valuation and cost-benefit analysis for the Blackwater Estuary
Value transfer • Point, function and meta-analysis transfer methods	Allow existing value evidence to be applied to new cases without the need for primary valuation studies. Box 2 (p. 16): Economic value of coastal and marine resources in the Bohol Marine Triangle Box 7 (p. 25): “The perfect spill”: economic value of Deepwater Horizon damage Box 8 (p. 26): Valuation for Guinea Current Large Marine Ecosystem Box 9 (p. 27): Valuation for the ‘Plan Bleu’ in the Mediterranean
Appraisal methods • Cost benefit analysis • Cost effectiveness analysis • Multi-criteria methods • Impact appraisals	Key step in “putting it all together”, combining valuations of individual service changes to make a holistic assessment of overall effects. Box 11 (p. 30): Cost-benefit analysis and critical natural capital

Numerous other methods exist that are beyond the scope of this report, which focuses on economic valuation and appraisal methods. However, they can be used in combination with the methods presented here, and some appear in the boxed examples presented. Such methods include:

- Expert assessments to identify and ‘value’ impacts;
- Survey approaches to assessing people’s views and preferences (but stopping short of economic valuation surveys used in stated preference or revealed preference);
- Focus groups, citizen’s juries and other deliberative methods assessing stakeholder views on resource management and values;
- Bioeconomic models and Integrated Assessment models seeking to model whole systems (although these can be viewed as forms of production function modelling.

Market-based techniques

Market-based techniques use evidence from markets in which environmental goods and services are traded, markets in which they enter into the production functions for traded goods and services, or markets for substitutes or alternative resources.

- **Market prices** can be used for traded goods, for example fish (see Box 2, p. 16). However, market price is not equal to value:
  - It is therefore necessary to correct market value for 'distortions' such as subsidies or taxes;
  - Prices do not reveal the 'consumer surplus', i.e., the profit or value to the consumer over and above the price paid;
  - Prices include the resource cost (for example the cost of boats, fuel, nets and labour) that do not form part of value (this is often dealt with by reporting 'value added', i.e., price net of costs);
  - Prices arise in markets by the interaction of demand and supply, and an environmental change that alters this balance. For example, changing supply often causes price to change;
  - A full analysis using markets therefore requires estimation of a demand curve and a supply curve, explaining how values and costs change with quantity;
  - In many cases, it may also be necessary to assess whether or not the exploitation of a resource is sustainable (and if not, there is an additional 'resource cost' associated with reducing natural capital stocks).
- **Market proxies** can be used for some goods, where there is no direct market but there is a market in a closely related good. For example, subsistence fishing could be valued using analyses of markets for traded fish. Similar caveats apply as for 'market prices' above.
- **Production functions** use statistical analysis to determine how changes in some ecosystem function affect production of another good or service which is a traded resource, or which can be valued using another technique. The primary difficulty in this method is the availability of scientific knowledge and/or data, necessary to allow estimation of the production function. An example is the importance of accounting for non-linear relationships between value and area, as in the case of mangrove conservation (see Box 3, p. 17), where the use of marginal values in the calculation of overall values yields better results than a simple linear extrapolation of the data. To that end, the Natural Capital Project (Ruckelhaus and Guerry, 2010) is developing production functions for a wide range of ecosystem services, including in marine environments. Their approach is based on 'production function' modelling, linking spatially explicit maps of habitat types to specific service outputs. The main advantage of the production function approach over value transfer methods (see "Value transfer", p. 22) is that here, the services are explicitly modelled for the area under assessment.

- **Cost of illness** methods are a particular class of production function where environmental services are linked to health measures, as part of estimating the health damage of pollution, or the health benefits of a clean environment. To give a monetary value, the health impacts need to be valued using additional methods, such as the avoided costs of treatment that is rendered unnecessary by the management intervention, and/or estimates of willingness to pay to avoid illness.
- **Avoided cost** methods value an ecosystem service through the reduction in costs that would be incurred if those services were no longer available/ delivered (see Box 10, p. 29).
- **Replacement cost** methods estimate a value based on the cost to replace an ecosystem function or service. This can be applied to entire ecosystems (for example, the cost of providing new habitats to compensate for habitat losses) or more often to replace specific ecological functions with human-engineered alternatives, e.g. the cost of wastewater treatment plants instead of wastewater processing by natural systems such as saltmarshes.

Box 2

Economic value of coastal and marine resources in the Bohol Marine Triangle

Ecosystem services: several market and non-market services (see below)
Valuation method: market methods where appropriate, value transfer for non-market values
Implications: estimates of ecosystem service values used for several policy purposes (see below)

Samonte-Tan et al. (2007) report research seeking to develop information on the economic benefits generated from coastal and marine habitats and ecosystems in the Bohol Marine Triangle (BMT) in the Philippines as a basis for sustaining the use of natural resources in the area. The BMT area has a high level of biodiversity and the local community is dependent on the coastal and marine resources of the area.

The study combined market-based valuation of economic activities (fisheries, tourism, gleaning, and seaweed farming) and value transfer methods for non-marketed impacts (biodiversity conservation, flood protection, fish nursery function).

The accumulated total net benefit for the BMT natural resources over a 10-year period was found to be US$11.54 million (with a 10% discount rate). Annual revenues were estimated by type of ecosystem (coral reefs, beach/intertidal area, marine waters, mangroves and seagrass), by benefit category (showing tourism and fisheries as the dominant benefits), and by type of beneficiary.

The results of the economic valuation of the Bohol Marine Triangle in the Philippines have been taken into account for the management activities of the area. These results were used in:

- Developing strategies for communication with stakeholders;
- Management planning decisions at local government level;
- The establishment of users fees for two marine protected areas;
- Policy advocacy for the conservation and protection of Panglao Island's natural resources;
- Motivating similar economic valuation exercises carried out in other coastal and marine areas of the Philippines, aiming to support decision making those areas.

Box 3

Values from mangroves in Thailand (expressed in $ at 1996 prices)

Ecosystem services: food production, wood products, coastal protection and fish nurseries
Valuation method: market and production function approaches
Implications: mangrove conservation is more beneficial than conversion for shrimp farms, but if non-linearities are taken into account, limited conversion for shrimp farming has relatively little impact on coastal protection

Barbier et al. (2008) demonstrate the practical importance of taking into account non-linear relationships between value and area. They show that using an average value for the storm protection value of mangroves in an area of Thailand ($1879 per ha), mangrove conservation clearly dominates conversion for shrimp farms. However, using the marginal values, and therefore taking into account that small reductions in mangrove area have relatively limited impact on flood protection values, this result is nuanced: the highest values overall occur if there is, in this case, 20% mangrove conversion for shrimp farms, and 80% conservation.

Of course there is a strong spatial component to the value – the flood defence value of any given hectare depends strongly on where it is and what people and infrastructure it protects, as well as on the extent of mangrove nearby: the 20% earmarked for conversion should be carefully chosen to incur the smallest reduction in coastal protection values.

Taking non-linear values into account is also very important in determining the appropriate level of mangrove restoration where they have already been destroyed. Barbier (2009) reports restoration costs with a present value of around $9000 per ha. Considering the average value of flood protection (present value around $11000 per ha) would suggest that restoration is profitable. Looking at marginal values would reveal the more accurate conclusion that it is profitable up to a point. This reasoning can help ensure that scarce resources for restoration and conservation activities are optimally allocated.

Fisheries play an important role in the economies of Mediterranean countries. Here a fisher off the coast of Githeon, Greece. Photo: UN Photo/Michos Tzovaras

Fishing boats near Dar-es-Salaam, Tanzania. The proximity to large urban areas may reduce the ecosystem services provided by marine ecosystems. Photo: UN Photo/Milton Grant

Expenditure measures

Some assessments of the "economic value" of ecosystem services focus on contributions to local or national economies. This is especially the case for tourism and recreation, and extractive industries such as fishing. Expenditure is not the same as economic value, both because it often includes resource costs, and because it ignores any additional benefit to resource users. But expenditure measures can serve different purposes, in particular assessing impacts on local communities, or securing funding from organisations with a focus on economic development. Other indicators may also be used, in particular employment (See Box 4).

"Estimating expenditure measures involves defining a spatial boundary for the impact."

When estimating expenditure measures, there are several additional factors that are often taken into account. These depend on defining a spatial boundary for the impact. For example, analysis at a sub-national regional level would ignore benefits and costs arising in other regions within the same country. Additional factors include:

Multiplier effects: direct expenditure within an area will lead to additional indirect and induced spending, leading to further economic and employment benefits. These are typically accounted for using multipliers on the basic spend.

Displacement: where some benefit arises at the expense of a reduction in spending/employment elsewhere in the target area.

Leakage: where part of the benefits accrue outside the target area, these can be excluded from the calculations.

Box 4

Wadden Sea estimates of expenditure

Ecosystem services: recreation and tourism

Valuation methods: expenditure and employment (not estimates of TEV)

Implications: demonstrates importance of national park tourism to local/regional economy

WWF (2008) reports on the Wadden Sea National Park as an example of a tourist-based economy, with over 10 million tourists per year. They stress the added value arising through tourists' additional expenditures, stating that tourists who visit the area purely because of the National Park generate a regional added value of about US$ 5,050,000, corresponding to 280 full time jobs. Furthermore, tourists for whom the national park plays an important (but not exclusive) role in their choice of destination generated added value of US$131,000,000 or about 5.900 full time jobs. However, these expenditures are related to the National Park as a whole, and it is difficult to determine the extent to which specific marine ecosystems services and/or aspects of biodiversity influence tourists' decisions.

Revealed preference (RP) techniques

Revealed preference methods are based on deducing the value of ecosystem services by interpreting observed human behaviour.

Revealed preference methods estimate demand for an ecosystem good or service through statistical analysis of individuals' willingness to incur the costs associated with benefiting from the good or service. Values of certain cultural ecosystem services, notably recreation and aesthetic enjoyment, are often assessed using these methods, but revealed preference techniques may also be applied to any ecosystem service that involves incurring a measurable cost. **These methods only measure use values.** There are two main methods:

- **Travel cost methods** use data on the costs of travelling for recreational activities (both market costs, e.g. fuel, and non-market costs, e.g. personal time), and participation rates, and;
- **Hedonic pricing** estimates the implicit price paid for environmental characteristics of the area a property is in, through the differences in the property prices in different areas.

Stated preference (SP) techniques

Stated preference methods are based on surveying representative samples of a population in order to estimate willingness to pay for hypothetical changes in ecosystem service provision.

SP techniques are very widely applicable, used for example for biodiversity, and are the most commonly used techniques to capture non-use values. Careful design and pretesting of the questionnaire used to survey respondents is vital to ensure responses are focused accurately on the ecosystem service change of interest.

The 2004 Indian Ocean Tsunami not only devastated coastal communities like here in Indonesia, but also had long-term negative impacts on marine and coastal ecosystem services in the affected areas. Photo: UN Photo/Evan Schneider

- **Contingent valuation** uses a direct question of willingness to pay for a specified change.
- **Choice experiments** estimate implicit values from choices between options with different specified characteristics.

Revealed and stated preference studies have different strengths and weaknesses and are often used together, either in order to value different services with the most appropriate methods (see Box 5, p. 20) or as a means of cross-checking estimates using different methods (see Box 6, p. 23).

Applicability to marine ecosystem services

Table 2 (p. 21) shows how each direct valuation method may commonly be applied to marine ecosystem services.

Most provisioning services give rise to marketed products, and appear relatively straightforward to measure and to value in physical and in monetary units. However, even in these cases careful interpretation can be necessary, due to the distorting effects of subsidies, and because of the need to consider the sustainability of the exploitation rate. Valuation can be based on market information, provided that corrections are made for any possible distorting effects, such as taxation or subsidies.

Box 5

Eutrophication reduction in the Stockholm archipelago

Ecosystem services: recreation, general benefits of conservation
Valuation methods: market costs of measures, benefits estimated through travel cost and stated preference
Implications: in this case, benefits of a management intervention significantly exceed costs, but this is location-specific

Söderqvist et al. (2004) present an analysis of the benefits and costs of reducing eutrophication in the Stockholm archipelago (see also ‘cost-benefit analysis’, p. 28). For this valuation, it was assumed that a reduction in eutrophication would lead to an increase in water transparency, which would increase both ecological health and human enjoyment of the area. It was also assumed that a 40 per cent reduction in nitrogen load was needed to achieve a one-metre increase in transparency, through a combination of measures including increased sewage water treatment and reduced fertilizer use. The total costs of such measures were estimated to be SEK 57 million per year. The benefits of the reduction of eutrophication were estimated to be about SEK 60 million per year for recreational benefits (travel cost method) and SEK 500 million per year for all conservation benefits (contingent valuation method).

There is a risk of double-counting if the results of the travel cost valuation (which accounts only for recreation values) are combined with the contingent valuation (which accounts for a wider range of values, including non-use, but could also cover recreation). However, the analysis indicates that the costs of reducing eutrophication could be justified purely by the recreation values, and that when taking a full range of values into account the benefits could outweigh the costs by a ratio of 8:1 or more.

This is very useful information for decision makers faced with the specific issue of eutrophication in the archipelago. However, it should also be noted that the location near the capital city means the use values are going to be much higher than in less populated regions, so this result could not simply be transferred to other parts of the Baltic.

It is also often desirable to take into account where values are sustainable flows (for example from a well-managed fishery) and where they are unsustainable (for example fossil fuels, or an over-exploited fishery). In the latter case, it can be necessary to adjust values downwards, to account for the reduction in future welfare potential arising through unsustainable exploitation today.

Other services may not be directly marketed, but may be measurable in physical units that can be given economic value through some of the methods of environmental economics. For example, **coastal flood protection** from mangroves, reefs, intertidal wetlands and so on can be valued by replacement cost methods (considering the capital and maintenance costs of replacing the service with human-made defences) or via damage costs methods (considering the value of flood damage expected in the absence of the defence service). **Recreation services** can be measured in visit numbers, and valued via travel cost techniques.

Some services can not be measured in simple physical units, or can only be estimated in economic terms through stated-preference methods. This applies in particular to all non-use values, for example associated with cultural heritage or marine biodiversity conservation.

“Some services can not be measured in simple physical units.”

Table 2

Applicability of valuation methods to marine and coastal ecosystem services

Valuation method	Value captured	Points to note	Ecosystem services
Market based approaches: based on market prices and other data			
Market prices	Direct use values	Adjust for costs, subsidies, taxes	Provisioning services, provided these are marketed, e.g. fisheries, aquaculture, renewable energy, aggregates, fossil fuels
Market proxies	Direct use values	Adjust for costs, subsidies, taxes	Where a service is not marketed, one can sometimes use a proxy market value: for example, valuing subsistence fishing at the market value of fish
Production functions	Use values	Data hungry	For example, nursery habitat for fisheries is often valued via a production function
Cost of illness	Varies depending on how health impact is valued	Production function linking change to health impact	Any ecosystem change that impacts on human health or mortality (e.g. wastewater treatment)
Avoided costs	Cost, not value	Presumes replacement would be appropriate	For example, the cost of recreating coastal wetlands to compensate for losses
Revealed preference methods: based on actual behaviour			
Hedonic property pricing	Use values within home	Depends on awareness of impacts	Seascapes, amenities, peace and quiet, general environmental quality
Travel cost	Use values for recreation	Based on visits to a site	Recreation and ecosystem services that contribute to it
Random utility model	Use values for recreation	Based on choice among sites	Recreation and ecosystem services that contribute to it
Stated preference methods: based on hypothetical behaviour			
Contingent valuation	All use and non-use	Based on pricing single option	All services. The only methods able to estimate non-use values. Often used for biodiversity, cultural and heritage values
Choice modelling	All use and non-use	Based on choice from options	Same as for “contingent valuation”

Oyster farming on the Solomon Islands.
Photo: ReefBase/Idris Lane

Value transfer: an alternative to primary studies

Value transfer means using information regarding economic value from one site as a proxy estimate for economic value in another.

Value transfer is cheaper and quicker than an original study. A value transfer study based on a careful meta-analysis of several good-quality studies may be more accurate or reliable, on average, than a single primary study, especially if resources are limited. It is also very useful for rapid assessment, where there is a policy need to derive estimates more quickly than would be possible using primary valuation studies. See Box 6 (p. 23).

The simplest type of value transfer, called unit transfer, directly applies an estimate of value made for one site or location to another. A more sophisticated approach transfers a value function that describes the relationship between value and the factors influencing it. If several studies are available, a 'meta-analysis' can be used to estimate a composite value function based on all the studies. In Figure 3 (p. 24), the decision about the transfer method is made at Step 4: the red dashing stresses that the choice of appropriate valuation evidence depends crucially on the change in ecosystem services under consideration (the "policy good") and the affected population. Value transfer works best when these factors match the original study well.

Value transfer is widely used on an ad hoc/case by case basis (see Boxes 2, p. 16; 8, p. 26; 9, p. 27; 10, p. 29); there are also initiatives to make it more systematic, by making available large databases of valuation studies and providing tools for their use.

It is essential in value transfer to consider not only the type of habitat and ecosystem function, but also the human uses and demands that make this a valuable service. Human demands vary greatly according to population densities and socio-economic factors, so the value to humans of particular physical services may vary greatly depending on the location, wealth, technologies and preferences of human populations. To take an extreme example, flood defence, wood and food services from mangroves may be extremely valuable on the coast in front of a large town, but largely irrelevant (to humans) around an uninhabited island, even though the physical and ecological factors may be very similar.

Box 6

Value of recreational sea angling in the UK

Ecosystem services: recreation (sea angling)
Valuation methods: travel cost, stated preference
Implications: different networks provide broadly convergent estimates of the significant non-market values of recreational sea angling, increasing confidence in decision making

Drew Associates (2004) apply both revealed preference (travel cost) and stated preference (contingent valuation and choice experiments) methods to produce a breakdown of estimated angling days, expenditure and value by sea angler type (shore, charter boat and private boat) in the UK. Reported value estimates from the travel cost analysis range from approximately £26 - £110 per day per angler (depending on the type of activity), with an average value across all angling types of approximately £70 per day.

Revealed preference results (Travel cost):

- Basic travel cost results: based on travel from home to angling site or embarkation point, estimated average value of £26 per day per shore angler, £90 per day per charter boat angler and £108 per day per private boat angler. The average across all angler types was £69 per day.
- Extended travel cost results: based on travel from home to angling site or embarkation point plus car parking charges, charter boat or private boat costs, estimated an average value of £35 per day per shore angler, £42 per day per charter boat angler and £104 per day per private boat angler. The average across all angler types was £105 per day.
- The estimated annual aggregate benefits of recreational fishing from the Travel Cost analysis are worth £216 million to shore anglers, £50 million to charter boat anglers and £336 million to private boat anglers, giving £602 million in total.

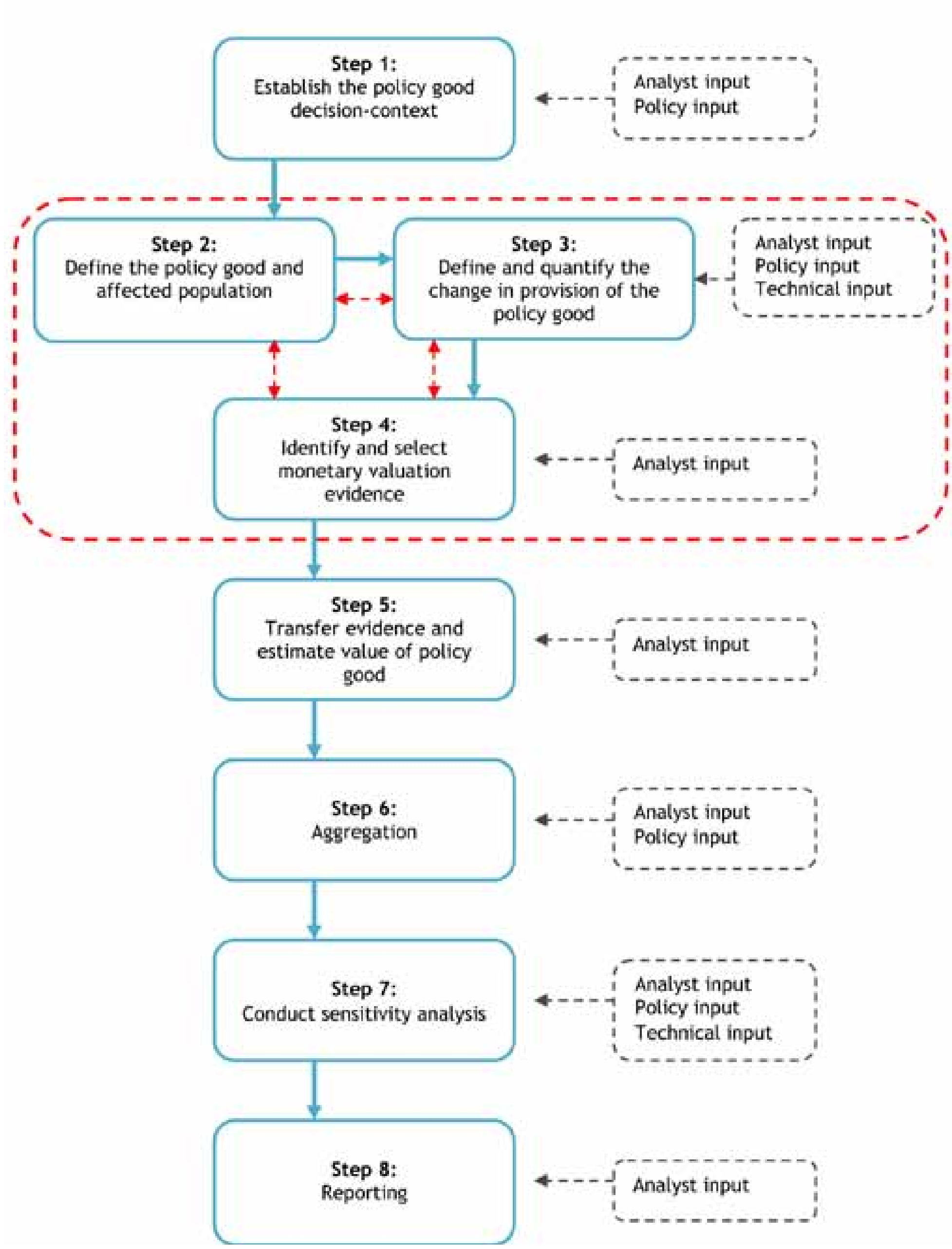
Stated preference results (Contingent valuation):

- Value estimates for sea angling per angler (per year) ranged from £38 per shore angler to £885 per private boat angler. By aggregating the mean value estimate nationally (across all angler types), this implies an annual benefit of approximately £600 million.

Thus both the stated preference and the revealed preference analyses point at approximately £600 million as the annual value to anglers per annum (equivalent to approximately £700 million at current prices). In addition, some part of the expenditure will represent profits to suppliers (boat owners, tackle shops, hoteliers and so on) that are in addition to the resource cost of providing services to anglers. This is additional value, beyond the benefits to anglers.

Figure 3 Steps in benefits transfer

eftec, 2010



Box 7

"The perfect spill": economic value of Deepwater Horizon damage

Ecosystem services: 'all 'ecosystem services from the Mississippi River Delta
Valuation method: value transfer based on several methods
Implications: rapid assessment demonstrating the significant, but highly uncertain, losses of ecosystem service values following the oil spill

Costanza et al. (2010) provided quick, approximate estimates of the damage that could arise through the recent Deepwater Horizon oil spill in the Gulf of Mexico. They based their calculations on Batker et al. (2010) who estimated the total value of marine ecosystem services for the Mississippi River Delta to be in the range of $12-47 billion per year. Summing the flow of these services into the indefinite future, at a 3.5% discount rate, gives an estimated value of the Delta as a natural asset in the range of $330 billion to $1.3 trillion – which, Costanza et al. note, is far more than the total market value of BP ($189 billion) before the spill.

For an approximate calculation, they assume that the Mississippi River Delta will be the most affected region and that there will be a 10 to 50 percent reduction in the ecosystem services provided by the Delta. This amounts to a loss of $1.2 – $23.5 billion per year into the indefinite future until ecological recovery. This is clearly a "rough and ready" estimate, developed rapidly in order to inform debate and awareness over the consequences of the spill. The figures can be seen as fit for that particular purpose. For the different purpose of estimating compensation payments, more refined methods would be necessary.

An oil rig on the Santa Barbara Channel in Califronia, USA. Oil extraction is a highly profitable use of natural resources, but also represents grave threats to marine and coastal ecosystems when spills occur. Photo: UN Photo/Brownie Harris

Box 8

Valuation for Guinea Current Large Marine Ecosystem

Ecosystem services: range of the most important services (see below)
Valuation method: market and value transfer approaches
Implications: demonstration of major benefits from the marine ecosystem accruing to human populations

The Guinea Current Large Marine Ecosystem (GCLME) valuation project (Interwies, 2010) aimed to develop an initial assessment of the costs and benefits deriving from conservation at the large scale of an entire LME. The 16 GCLME countries face issues of unsustainable fisheries and marine resource management generally, and degradation of marine and coastal ecosystems by human activities. To combat the resulting environmental and social problems, environmental and sustainability concerns must be integrated into policies and decision making, and economic valuation of ecosystem services is one important step towards this.

Given time and resource pressures, the benefits of the using a value transfer approach were considered to outweigh the costs of possible inaccuracies in this approach. The valuation is based on the current flow of ecosystem services, raising awareness of current flows and providing the background and motivation for conservation initiatives and specific policy options (which may require separate, more detailed cost-benefit calculations).

Ecosystem services valued in the study include:

- Fisheries
- Fish nurseries
- Tourism
- Timber and non-timber forest products
- Flood and erosion control
- Sewage treatment
- Drinking water
- Carbon sequestration
- Biodiversity and other non-use

Overall, the 253 million hectare area is estimated to yield annual benefits of $14 billion from marine environments (mostly from fisheries) and $3.5 billion from coastal environments (mostly fish nurseries, coastal protection and tourism).

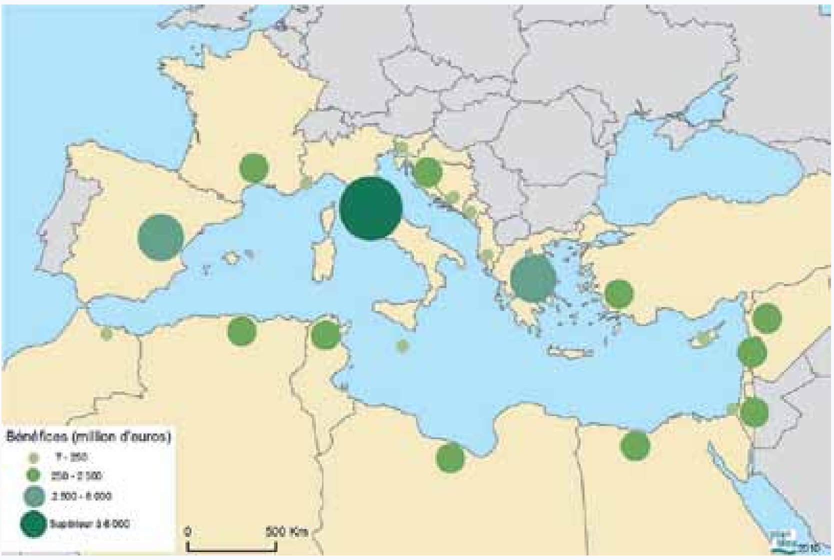
The estimates are used to demonstrate the importance of the marine and coastal environment to the human populations living around it, feeding in to work on policy instruments for conservation and resource management. In addition to the aggregate value estimates, some headline calculations are presented with clear policy relevance: for example, it is estimated that one hectare of destroyed mangrove ecosystem in the GCLME represents losses of US$32,000 (4% discount rate) to US$38,000 (3% discount rate).

Garbage covers a beach in Anse-à-Foleur, Haiti, causing great damage to the local marine environment. Photo: UN Photo/ Sophia Paris

Box 9

Valuation for the 'Plan Bleu' in the Mediterranean

Ecosystem services: six key services (see below)
Valuation method: value added, avoided cost, value transfer
Implications: demonstration of important benefits, and their distribution across countries, and also of data gaps



The map shows how countries bordering on the Mediterranean Sea benefit from its ecosystem services. Plan Bleu, 2010

High levels of exploitation and other human activities, coupled with climate change, are threatening sensitive biodiversity and habitats in the Mediterranean. In addition to conservation concerns, the human and economic costs are potentially very significant. To illustrate this, the Plan Bleu has carried out research to establish a first estimation of the annual value of economic benefits flowing from the whole Mediterranean marine environment.

Six types of marine ecosystems were studied, each characterised by the biodiversity and surface they cover and the ecological services they provide.

The economic valuation of the benefits those ecosystems provide focused on six ecological services: **production of food resources, amenities, support to recreational activities, climate regulation, mitigation of natural risks and waste assimilation.**

At the regional level, the aggregate value amounted to over €26 billion in 2005; an average of about €10,000 per square km per year, though this varies significantly across different habitats and areas. And, due to a lack of data, the value of benefits from ecological services provided by marine ecosystems in the Mediterranean was probably underestimated.

The distribution of the value by benefit types shows that 68% of benefits would come from the provision of amenities and recreational support (€18 billion). The distribution of the value of benefits by country shows that 8 countries would capture about 90% of the value of benefits provided by marine ecosystems: Italy, Spain, Greece, France, Turkey, Israel, Egypt and Algeria.

Appraisal methods

Value measurements can be incorporated into policy- and decision-making, using formal methods of appraisal.

Values can be used in a wide range of practical decision-making contexts, for example to help decide on courses of action such as coastal development proposals, to determine where and how much of the marine environment to protect from exploitation, to formulate resource management policies, to determine compensation payments for damage to marine features, and so on. Appraisal methods that capture values include:

- **Cost-benefit analysis (CBA)** is a decision support method which compares, in monetary terms, as many benefits and costs of an option (project, policy or programme) as feasible, including impacts on environmental goods and services. Its application to any natural environment category is limited by the availability of the necessary data. CBA is designed to target two of the most crucial appraisal questions: "Is a given objective worth achieving?" and if so, "What is the most efficient way of doing this?" (See Boxes 10, p. 29; 11, p. 30);
- **Cost-effectiveness analysis (CEA)** is a decision support method which relates the costs of alternative ways of producing the same or similar outcomes to a measure of those resulting outcomes. CEA is equivalent to one dimension of CBA in that it reveals the cheapest or most cost-efficient way of achieving a given objective, but not whether an objective is worth attaining;
- **Multi-criteria assessment (MCA)** covers a variety of approaches which involve: (i) developing a set of criteria for comparing policy or management options; (ii) evaluating the performance of each of the options against each criterion; (iii) weighting each criterion according to its relative importance; and (iv) aggregating across options to produce an overall assessment. Deliberative or participatory approaches are commonly used for developing weights or valuations;
- **Regulatory Impact Assessment (RIA)** is a framework for complete assessment of a proposed policy or decision, covering appraisal, implementation and ex-post valuation. Valuation evidence can be important at each of these stages.

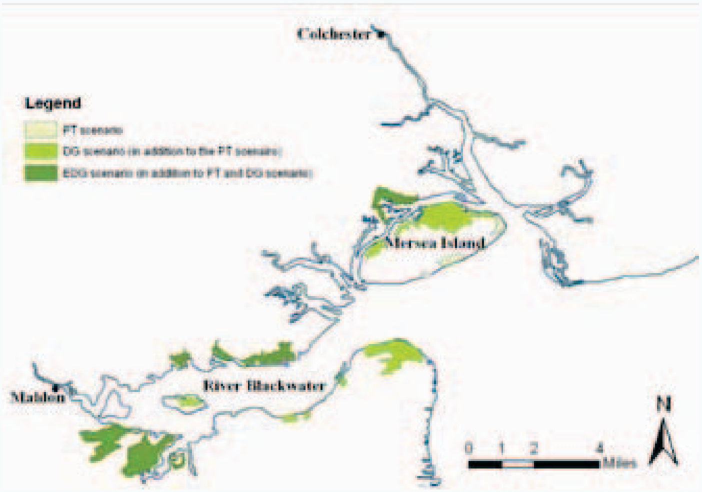
Economic appraisal and the use of environmental valuation techniques should be guided by the following principles:

- **Fitness for purpose:** the choice of method should be guided by the decision-making context, legal requirements, option characteristics, location, habitats, services, human populations and scale of impacts;
- **Sensitivity analysis:** explores different scenarios that enable a better understanding of the limitations of data and uncertainty over environmental effects and monetary values. The complexity of a sensitivity analysis should be proportionate to the decision in-hand;
- **Transparency:** it is important to ensure an 'audit trail' of methods used and full reporting of key assumptions, limitations, omissions and uncertainties;
- **Decision-support:** CBA and valuation methods involve approximations of value based on imperfect indices of social welfare. Other information will also often be relevant. These methods are decision support tools, and an aid to structuring certain types of information. They are not a replacement for deliberation or consideration of other evidence.

Box 10

Valuation and cost-benefit analysis for the Blackwater Estuary

Ecosystem services: **several specific services and a composite 'environmental quality' benefit**
Valuation method: **market, production function and stated preference, in cost-benefit framework**
Implications: **the benefits of managed realignment scenarios exceed costs when non-market ecosystem service values are taken into account.**



The map shows which regions are suitable for conversion under the three different scenarios. Liusetti, 2008

Luisetti (2008) applies CBA methods to assess four different options for the Blackwater Estuary in East England, with varying levels of managed realignment and habitat creation: 'hold the line', 'policy targets' (PT) (meeting existing targets), 'deep green' (DG), 'extended deep green' (EDG).

Market prices are used to value coastal defence work (costs avoided), fisheries (modelled via a production function), and agricultural land lost (after adjustment for subsidies). Three carbon price estimates are used for the carbon, methane and nitrous oxide fluxes. A stated preference study is used for a "composite environmental benefit" that is intended to cover a wide range of impacts without double-counting: recreation, aesthetics, water quality, and biodiversity. The study breaks total value down into use and non-use components, and the aggregation methods allowed for distance-decay and non-linear relationship with wetland area. Thus the estimates for the composite environmental benefit showed the diminishing marginal value of provision of additional areas of high environmental quality: in the PT scenario (81.6ha wetlands) the value estimate is £6.3m/yr of which £4.4 is use value; in the DG scenario, with 10 times more wetlands, the value is only a little higher at £7.7m/yr, of which £5.8m is use value, while in the EDG scenario, with 30 times more wetland than PT, value is £8.3m/yr of which £6.4m is use value.

Results of the CBA show that managed realignment can be cost-beneficial if non-marketed benefits are accounted for, particularly for conservation and recreation. With a constant 3.5% discount rate, the highest NPV is the "deep green" scenario (£106m over 25 years, £192m over 100 years); much higher values arise using a declining discount rate, making the "extended deep green" scenario preferable (because the lower discounting of long-term future makes it easier for long-term environmental benefits to outweigh near-term costs). The study is well grounded in scientific analyses of fisheries and sediment transport, and is exemplary in exploring sensitivities to different time horizons, discount rates, values and assumptions.

A local woman collects fish at sunset in Dili District, Timor-Leste.
Photo: UN Photo/Martine Perret

Box 11

Cost-benefit analysis and critical natural capital

Ecosystem services: **wide range of services, not including non-use values**

Valuation method: **value transfer methods, based on land-use/land-cover**

Implications: **where a particular area makes a vital contribution to large-scale sustainable ecosystem service provision, accounting for the value of off-site impacts is important.**

The North Wind's Weir (US, Washington State) salmon habitat restoration project aims to restore 2 acres of critical habitat in the freshwater/saltwater transition zone by excavating and replanting native vegetation. This type of habitat is extremely scarce (located only where freshwater meets tidal salt water, 5.5-7 miles from the river mouth) and vital to maintaining viable salmon populations.

Cost-benefit calculations for this project (Batker et al. 2005) estimated the value of the site-specific ecosystem service improvements at $13,388 – 47,343 per year, presently totalling $384,000 – $1.36 millon. As the site is in a high development value area, land acquisition costs ($1.9 million) plus estimated restoration costs ($1.79 million) were $3.69 million, notably greater than the benefit (BCR of 0.1 to 0.36).

However, this figure did not account for the off-site impacts, and in particular the fact that the transition habitat is critical for salmon conservation in the whole watershed. Taking its rarity into account, the authors estimated that it would be worth paying up to $19 million per acre for the restoration.

This restoration project went ahead, with contaminated soil removed in 2008/9, construction work in 2009, and planting throughout 2010. It highlights the importance of ensuring that the boundaries – both spatial and temporal - of any cost-benefit calculations allow the full effects of any decision to be taken into account. Here, this required critical natural capital to be evaluated by considering the interdependence of this project and many other actions leading to salmon conservation in the watershed: i.e., the project was treated as one piece in a bigger picture.

Fishers in the Philippines returning home at sunset.
Photo: UN Photo/Oddbjorn Monsen

Discounting

Discounting allows comparison of costs and benefits that are experienced in different time periods, based on the principles of time preference (people prefer to receive goods and services now rather than later) and the opportunity cost of capital (resources invested now can give a profitable rate of return in the future). Mathematically, discounting is basically the reverse of compound interest.

If you could invest $1000 today and get a return in 10 years of $1500, then you could say that $1500 in 10 years is 'worth' $1000 today. Discounting takes all the different value flows for future years and converts them into today's equivalents, so they can be compared, and added, to give "Net Present Value" (NPV), the discounted sum of all future costs and benefits of a project or decision.

$$NPV = \sum_t \frac{(B_t - C_t)}{(1+r)^t}$$

Where B is benefits, C is costs, t is time period and r is discount rate

"Discounting takes all the different value flows for future years and converts them into today's equivalents."

Discounting has nothing to do with inflation. Generally, inflation can be ignored in economic analysis, with all prices and values being expressed at today's price levels. It is only necessary to account for price changes for specific resources if these are expected to change out of line with inflation – that is, if the relative prices are expected to change.

- Weighting values across time, using discounting, is almost universally applied, both because it is theoretically strongly justified, and because using no discounting leads to counter-intuitive results (for example, minimising use of a non-renewable resource, because technological improvements will make it more productive in the future).

- Although discounting may seem to diminish the consideration given to future values – and therefore to be 'unfair' to future generations – in fact the aim is to allow for the fact that, on average, investments now will yield positive returns in the future, so if we are to divert resources from those investments to invest in natural resources, we need to demonstrate that the returns can be at least as high.
- Discounting has even been called "the friend of the conservationist" because it discourages large-scale infrastructure investments with heavy up-front costs (such as tidal barrage schemes); though it also reduces the consideration given to distant future costs (such as decommissioning nuclear power stations).

The exact choice of discount rate is a source of perpetual debate, and will vary from place to place, and over time. For economies that are growing rapidly, and with scarce capital resources, discount rates of 10% or more are quite common. In industrialised countries lower rates tend to be used.

"Discounting has even been called 'the friend of the conservationist' because it discourages large-scale infrastructure investments."

In many countries, and international organisations, there are official discount rates that should be used: in the UK, for example, official guidance is for a 3.5% discount rate (see Box 8, p. 26), but for projects with long-term impact – over 30 years – the guidance requires use of a declining discount rate, primarily as a way of accounting for uncertainty about the future. Discount rates used in the private sector are usually much higher than the 'social' discount rates used to assess public sector investments.

A man shows off a crab at a market in Côte d'Ivoire.
Photo: UN Photo/Ky Chung

Villagers transporting seaweed in Sampela Village, Indonesia.
Photo: Romina Da Costa

Intra-generational fairness

There are also concerns about fairness within the present generation. Economic valuations generally reflect the current distribution of income, with those with higher ability to pay being better able to reflect their preferences through higher willingness to pay. The same is also true of all goods that are traded in markets: wealthier people can afford more. However, there can be fairness reasons for avoiding extending income inequalities into assessment of non-marketed environmental goods, and sometimes this is used as an argument against economic valuation (though it can also be argued that fairness and distribution objectives of policy can be achieved in other ways, for example through the tax and benefits systems).

Solutions are available that allow valuation to remain useful, in particular income weighting of values, which gives higher weights in the overall assessment to values and costs accruing to low income groups, thereby redressing the balance. In practice such methods are rarely implemented in economic analyses of ecosystem services, but this may be changing. The UK National Ecosystem Assessment, for example, seeks to undertake such adjustments where data permit (Bateman et al. 2010).

"Economic valuations generally reflect the current distribution of income."

Often, equity objectives are considered separately, with groups of "winners" and "losers" from specific projects or policies being identified, and this information considered alongside valuation and other information in decision-making processes.

Canned fish is one of Senegal's most important exports, rendering the marine ecosystem services of the country's waters extremely valuable. Photo: UN Photo/J.Mohr

Chapter 3
Practical steps in valuation

In practical terms, valuation starts with identification of a problem or decision context. It requires assessment of available information relating to ecosystem changes and their effects on services to humans, determination of appropriate valuation methods, and careful application and reporting. The effort and resources expended in a given valuation exercise should be proportionate to the implications of the decision for the ecosystems and communities affected.

Identify the problem

- Define the issue or policies under consideration and the rationale for the valuation exercise;
- Consult as appropriate with interested stakeholders;
- Determine the need for economic value evidence, and time and resources available to collate this evidence;
- Define the ecosystem changes to be valued.

The requirement for a valuation exercise generally arises in the context of a wider strategic, policy, management or communication problem. Clearly establishing this context, including consultation with other parties involved, will help to establish the appropriate boundaries for the assessment.

"The requirement for a valuation exercise generally arises in the context of a wider strategic, policy, management or communication problem."

Defining the type, scale, and timing of changes in the environment, the resulting changes in ecosystem goods and services, and the human populations affected, are central to valuation and appraisal. The initial outline of these features can be sketched at the problem identification stage, leading on to a more detailed assessment of information needs and availability.

Assess available information

- What are the baseline conditions (without the change)?
- What is the change described in qualitative and in quantitative terms?
- Is there supporting data to allow value transfer or market-based valuation?
- What important data gaps remain, and how could they be filled?

An important challenge with implementing any appraisal or valuation exercise (economic or other) is overcoming gaps in natural science knowledge regarding the processes and interactions through which ecosystem services are provided and maintained. It is important to use the best scientific information available to assess the likely physical and ecological impacts of the option under consideration, and to get as close as possible to final services that people understand and can value.

On the economics side, the potential usefulness and reliability of economic valuations are crucially dependent on not only scientific assessments, but also on individuals' awareness of the ways in which the object of valuation influences their personal welfare. This holds for stated preference methods, but also for revealed preference and market-based methods: human behaviour can only reveal accurate values for things people know about and understand.

"No valuation is ever 'perfect', the key question is whether or not the information is good enough to allow useful, appropriate and reliable decisions to be made in response to the problem."

A comprehensive review of knowledge and evidence will help to determine the extent to which this is sufficient to support economic valuation methods, the existence of important knowledge gaps, and possible ways for filling these. It should be kept in mind that no valuation exercise is ever 'perfect': there are always uncertainties and gaps. The key question is whether or not the information is good enough to allow useful conclusions within the context of the problem.

A boat used by locals in Negombo, Sri Lanka. Photo: Nicola Barnard

Determine appropriate valuation method(s)

- What methods are applicable for each ecosystem service to be valued?
- Is value transfer adequate or are primary studies required?

Different ecosystem service changes can be valued in different ways: some are well suited to market valuation (e.g. fish catches), some to avoided cost methods (e.g. flood regulation), some to revealed preference (e.g. recreation), and some to stated preference (the only method capable of detecting non-use values).

Generally speaking, detailed studies focusing on a change in a specific ecosystem service might use one or another of these primary valuaton methods. In practical policy and management settings, however, where values are required for a wide range of ecosystem services changing at the same time, it is more common to use value transfer methods in place of primary revealed and stated preference studies. For services that can be valued using market methods, this may be done directly, or through value transfer, depending on the case. The guiding principle here is that the choice of methods should be proportionate with the policy context and the resources available. Value transfer methods are much quicker, easier and cheaper than primary studies, and this drives their popularity. But where the stakes are high, or where suitable data for value transfer are lacking, a good quality primary study may be a better option.

Other decision support tools (such as multi criteria analysis, cost effectiveness analysis, environmental impact assessment) can provide input to economic valuation (including value transfer) but they can also be considered as alternatives especially when environmental costs and benefits need not be expressed in monetary terms.

Application and reporting

- Valuation methods are applied for each ecosystem service change under consideration. If cost-benefit methods are used, values are estimated for each period over the horizon of the assessment, discounting is applied, and net present value sums are calculated.
- Sensitivity analysis is usually carried out to check the robustness of conclusions.
- Clear, transparent reporting with a full audit trail is essential for informing decision-making of the likely accuracy of evidence provided.

"Clear reporting is essential."

Depending on the context and resources, valuation and sensitivity analysis can range from very simple presentations of possible ranges of values or confidence intervals, to more formal 'Monte Carlo' simulation methods exploring the implications of uncertainty in a range of parameters. 'Switching analysis' is often used, assessing the levels of key parameters at which the policy conclusions change (in particular, the level at which the benefit:cost ratio falls below one). This can also help to identify those areas in which further research to resolve key uncertainties would be justified.

Clear reporting is essential, and should cover all data sources and assumptions used, the ecological and economic valuation methods used, the identified strenths, weaknesses and uncertainties in the analysis, the results and sensitivities, and the policy implications.

A fisher shows off his day's catch in Timor Leste.
Photo: UN Photo/Martine Perret

A fishing boat off Atauro Island, Timor-Leste.
UN Photo/Martine Perret

Chapter 4
Challenges and solutions in practical valuation

Challenges can arise with valuation and assessment methods, whether monetary or not. Care is required to ensure that values incorporated in policy and decision making address these issues in the best way possible.

Issues include:

- The treatment of risk and uncertainty;
- Avoiding the risk of 'double counting' the same values;
- Scale-dependence of values for certain services, and;
- Dealing with cumulative impacts.

Risk and uncertainty

Very often, policy decisions must be made under conditions of significant economic or ecological uncertainty in which future outcomes, either good or bad, are unknown.

Uncertainty encompasses risk (where the probability of outcomes is known or can be estimated) and ambiguity (where the sorts of outcomes are generally known but there is no reliable information on which to estimate probabilities), as well as radical uncertainty (the 'unknown unknowns'). Uncertainty in marine ecosystem services assessment and valuation can be due both to imperfect knowledge of ecological and economic relationships in the marine environment, and to fundamental and irreducible randomness (for example, flood events, or random climate effects on fish stock-recruitment relationships).

The solutions:

There are different ways of dealing with risk/uncertainty within the valuation approaches. In practical terms, economic valuation and cost-benefit analysis deal with risk reasonably well, and with ambiguity to some extent, through the use of expected values and various forms of sensitivity analysis. But economic methods are quite limited under situations of radical uncertainty, where it is not possible to enumerate all of the likely consequences of a decision, nor its probabilities (Weitzman, 2009).

One response to such uncertainty is to include 'insurance' in management programs, trying to avoid the worst outcomes. It may be worth giving up some service, for example reducing fish catches, in order to reduce the risk of unpleasant 'surprises', such as fish stock collapses. This can be achived by setting 'safe minimum standards' and using a precautionary approach to management, ensuring that we do not risk crossing uncertain thresholds that could lead to potentially catastrophic and irreversible outcomes.

Double-counting

'Double-counting' of values can result from valuing intermediate services and final services, or if using techniques where it is not clear exactly what services are included in a value.
This requires careful treatment.

Double-counting is a particular risk when applying valuation techniques to intermediate services (notably supporting services and some regulating services), where the benefit to humans is indirect, accruing through the impact of these services in enhancing final services (notably provisioning and cultural services).

Another form of double-counting may arise if it is not clear exactly what services are "covered" by a given value estimate. For example, if a stated preference survey asks specifically about protecting a particular species, people may nevertheless formulate their response based on the more general habitat and environmental conservation that they believe would be necessary to protect that species. Similar issues can arise in revealed preference work where it may not be possible to determine the separate influence of features that are closely correlated.

The solutions:

The double-counting issue concerns the boundaries of any given assessment – if the final services are included in the assessment, then it is double-counting to include separate values for the intermediate services. But if the final services are not included – as is often the case, for example, where dealing with the role of the marine environment in supporting services on land – then the intermediate services should be valued separately. Of course, it is often desirable to identify and quantify intermediate services, even if only the final services are included in monetary value terms.

Where double-counting can arise through ambiguity in the coverage of a stated preference survey, careful questionnaire design can limit the extent of the problem. Alternatively, values can be estimated for composite environmental goods/services, covering several features that are difficult to separate out, and therefore avoiding any double-counting risk (see Box 10, p. 29).

Young boys wearing wooden goggles to fish off Atauro Island, Timor-Leste. Photo: UN Photo/Martine Perret

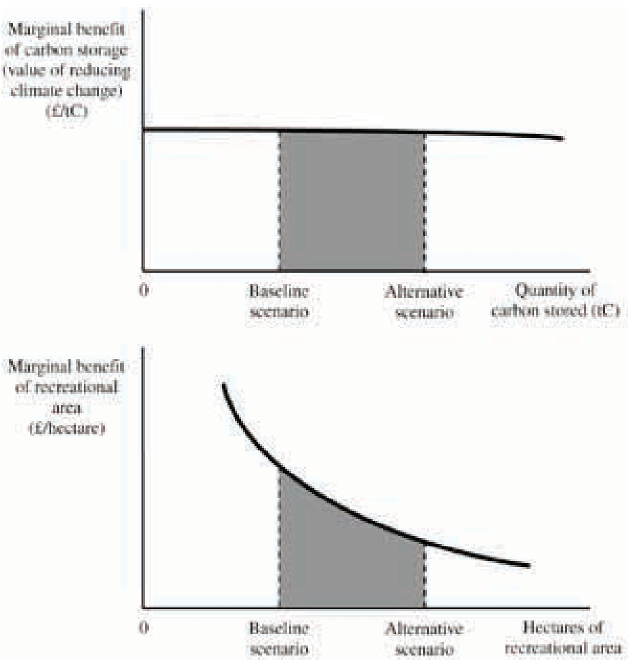
Scale-dependence of values

Marginal values for some services can vary significantly depending on the scale of a change. This can make scaling values up or down challenging.

Whether services are measured in biophysical or economic units, scaling of values up or down spatial scales can be an important issue. If marginal values change depending on the total level of provision, this means that values can be highly scale dependent. Figure 4 shows different possible relationships: for some services, such as carbon storage, marginal values will be constant over an enormous range, easily enough for most decisions about marine and coastal zone management.

Figure 4 Different relationships of value and area

Bateman et al., 2010



We would only need to consider changing marginal values for carbon when considering decisions about international climate policy. Other services will show very steep relationships with area, for example recreation, where the provision of the first few sites brings huge benefits, but adding more and more area soon adds relatively little to total values.

Scale-dependency also occurs locally where the level of service is non-linear in the provision of the resource – for example, the flood protection benefits of mangroves. See Box 11 (p. 30) for an illustration of the importance of this.

The solutions:

Scale-dependency means that independent valuation at lots of different sites might lead to inappropriate assessments and outcomes overall, by failing to account for changing marginal values as total quantities change over a region. This is particularly important where several decisions are taken separately, because the appropriate decision at one location may very well depend on decisions taken at many other locations. For example, the conservation benefit of a new marine protected area may be highly dependent on whether or not there is already a protected area existing or planned nearby.

Value transfer methods can attempt to account for such influences, for example by including 'availability of substitute sites' in value transfer functions. But spatially explicit modelling is more powerful. Recent progress has been made on better incorporation of spatial elements in marine ecosystem service assessment, for example within the Natural Capital Project, where the Marine InVEST toolbox is under development, and being applied to the West Coast of Vancouver Island, Canada (Ruckelshaus and Guerry, 2010).

Cumulative impacts

Ecosystem service levels may be strongly affected by the cumulative impacts of different drivers, and this must be taken into account in valuation and decision making.

Cumulative impacts can lead to similar concerns as the scale-dependence issues outlined above. The same resources may be subject to multiple ongoing pressures, and also to possible shocks (such as storms or disease outbreaks), and analysis of values focusing on just one pressure could miss the dangers associated with the overall impacts. For example, when determining fisheries policy it may be necessary to consider not only the level of fishing effort or harvest, but also the impacts of marine pollution, destruction of fish nursery habitats, climate change and so on.

The solutions:

Including cumulative impacts, accounting for spatial scale factors, and incorporating aspects of the demand for ecosystem services based on locations and preference of human populations, can be complex. Ideally, these factors should be taken into account via formal 'production function' models that link particular ecosystem and management characteristics to specific ecosystem service outputs. This can be data-demanding and difficult, and 'value transfer' offers an alternative, less resource intensive approach. Alternatively, scenario-based analysis can be used to explore the possible impacts of cumulative pressures and shocks.

Fishing boats in Mombasa, Kenya. Photo: UN Photo/Milton Grant

Critical natural capital

Where resources become very scarce, marginal values may change so rapidly that valuation becomes difficult; if dealing with thresholds and essential resources and services, valuation may become inappropriate.

There are limits to the realm within which valuation techniques make sense. When imminent ecological thresholds threaten vital natural resources, conservation is essential, and marginal valuation becomes inappropriate. A resource that is abundantly available, such as oxygen to breathe, will have low or zero marginal economic value (even though the total value is essentially infinite). An abundant fish resource may likewise command a lower price per fish than a depleted stock, because it will not be as scarce. Generally speaking, as a resource or service becomes very scarce, it is likely to become very valuable; and in some cases, there may be some minimum level of provision that is essential to avoid catastrophic consequences. Figure 5 shows a caricature "demand curve for natural capital": at high levels, marginal values change slowly, and valuation is appropriate and easier; as provision falls, marginal values rise more rapidly, and valuation, while still possible, becomes harder, with higher likely errors.

The solutions:

As illustrated in Figure 5, if a threshold level of 'critical natural capital' exists beyond which catastrophic losses occur, valuation may become largely meaningless. The 'solution' here may be to use other methods – safe minimum standards, sustainability constraints – limiting the use of valuation methods to zones within which values change more gradually.

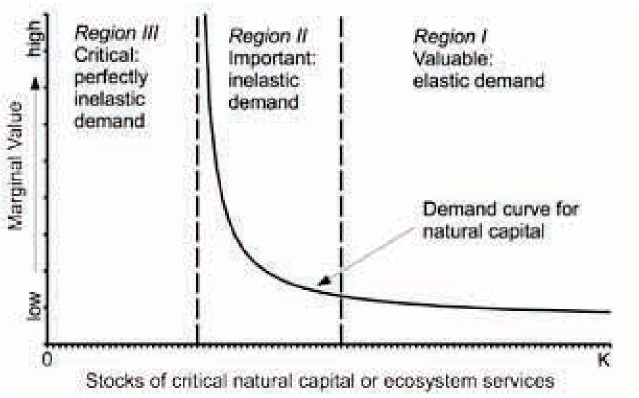
But there can also be scale-related aspects to 'critical natural capital', in the sense of natural capital that is critical from a specific local or regional perspective, but not globally.

"If a threshold level of 'critical natural capital' exists beyond which catastrophic losses occur, valuation may become largely meaningless."

Box 11 (p. 30) gives an example of a small area of habitat critical to salmon conservation in a watershed. This is not critical from a global perspective – salmon exist in many other watersheds – but is critical from the local and regional perspectives. In such cases, valuation methods can still be useful, provided the link from the critical natural capital to the whole benefit chain supported by it is recognised and valued.

Figure 5 Demand curve for natural capital

Farley, 2008



Cut mangroves in Timor-Leste. Mangroves are an important source of coastal ecosystem services. Photo: UN Photo/Martine Perret

Chapter 5
Conclusions

This report has set out the ways in which economic analysis can be used to provide values and appraisals for ecosystem service changes in marine and coastal environments. The examples given throughout this report illustrate the range of applications and how these can be of practical use across a range of scales, in policy development, decision making and communication. Practical guidance on how to implement a valuation exercise, and how to overcome common challenges, is also provided.

At a simple level, financial assessments can be used to demonstrate the contribution marine and coastal ecosystems make to local, regional or national economies, in terms of expenditure, value added and employment. Economic valuation goes further, seeking to quantify all the ways in which ecosystem services provide benefits to human populations. Valuation can be applied for many purposes, at various levels of governance, spatial and temporal scales, and for a range of sectors or beneficiaries. The specific choice of methods depends on the type and scale of assessment, the policy context and the resources available.

"Economic valuation goes further, seeking to quantify all the ways in which ecosystem services provide benefits to human populations."

Cost-benefit methods are especially useful for evaluating the economic implications of specific management options, such as environmental restoration or coastal realignment at specific sites. They can also be used for more strategic policy development, especially when used in conjunction with scenario analysis. Ecosystem service assessments and value transfer methods can be used to provide broad assessments of the costs and benefits of national policies, as part of the impact assessment process.

Value evidence can also be used in more detailed assessments for implementing policy, for example feeding into decisions about marine spatial planning.

"Valuation methods should be seen as one way of structuring and processing information about the ways in which ecosystem services influence human welfare."

At an even broader spatial scale, assessing current value flows across a whole large marine ecosystem can be useful for assessing specific policy options, but also for the communication goal of raising awareness of the importance of marine ecosystem services across the whole area.

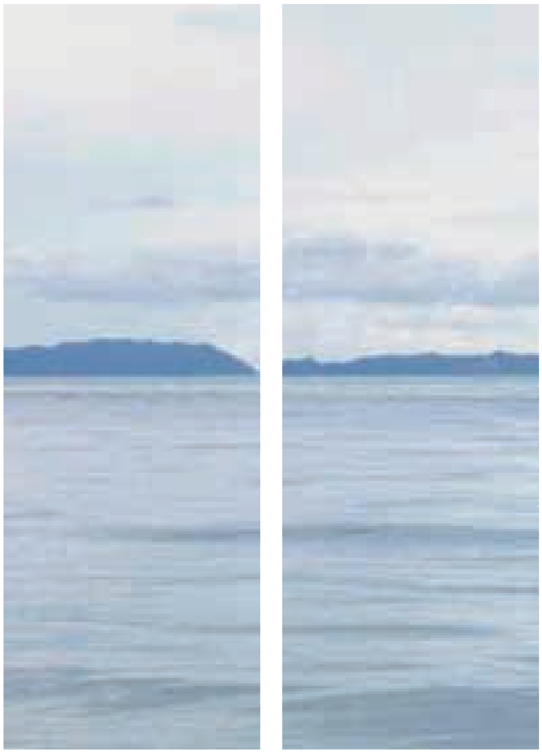
Economic arguments can be used at all levels of governance for a wide range of purposes, and can be very useful tools. But it is important to remember that they are tools, and should be used with care. Some possible pitfalls, and limitations to the applicability of valuation methods, are outlined here. More generally, valuation methods should be seen as **one way** of structuring and processing information about the ways in which ecosystem services influence human welfare. This information can be of great use and interest to stakeholders and decision-makers, provided it is treated appropriately: as information feeding in to a decision-making process, and not a substitute for deliberation and decision-making.

Sources

- **Barbier E.B. et al. (2008)** Coastal ecosystem-based management with nonlinear ecological functions and values. *Science*, 319: 321–323.
- **Barbier, E.B. (2009)** Ecosystems as natural assets. *Foundations and Trends in Microeconomics,* 4: 611–681.
- **Bateman, I.J. et al. (2010)** Economic analysis for ecosystem service assessments. *Environmental and Resource Economics.* doi: 10.1007/s10640-010-9418-x.
- **Batker, D. et al. (2005)** *Ecosystem services enhanced by salmon habitat conservation in the Green/Duwamish and Central Puget Sound Watershed.* Asia Pacific Environmental Exchange.
- **Batker, D. et al. (2010)** *Wetlands, hurricanes and the economy: the value of restoring the Mississippi River Delta*. Tacoma, WA: Earth Economics.
- **Boyd, J. and Banzhaf, S. (2007)** What are ecosystem services? The need for standardized environmental accounting units. *Ecological Economics*, 63: 616-626.
- **Costanza, R. et al. (2010)** The perfect spill: solutions for averting the next Deepwater Horizon. *Solutions*. Retrieved June 16, 2010, from http://www.thesolutionsjournal.com/node/629
- **Daily, G.C. (ed.) (1997)** *Nature's services: societal dependence on natural ecosystems.* Washington: Island Press.
- **DECC (2009)** *Carbon valuation in uk policy appraisal: a revised approach*. pp. 128. Retrieved from www.decc.gov.uk/assets/decc/What we do/A low carbon UK/Carbon Valuation/1_20090715105804_e_@@_CarbonValuationinUKPolicyAppraisal.pdf
- **Defra (2007)** *An introductory guide to valuing ecosystem services*. pp. 68. London: Crown Copyright. Retrieved from www.defra.gov.uk/environment/policy/natural-environ/documents/eco-valuing.pdf
- **Drew Associates (2004)** *Research into the economic contribution of sea angling*. London: Defra. p. 71.
- **eftec (2010)** *Valuing environmental impacts: practical guidelines for the use of value transfer in policy and project appraisal.* London: Defra. pp. 7.
- **Farley, J. (2008)** The role of prices in conserving critical natural capital. *Conservation Biology*, 22: 1399-1408.
- **Interwies, E. (2010)** Combating living resources depletion and coastal area degradation in the Guinea Current Large Marine Ecosystem through Ecosystem-based regional actions. Final report for UNIDO Project GPRAF04004 BL 1186. pp. 125.
- **Luisetti (2008)** A policy analysis for the Blackwater estuary. In *Alternative economic approaches to the assessment of managed realignment coastal policy in England* (doctoral dissertation). University of East Anglia.
- **Millennium Ecosystem Assessment (2005)** *Ecosystems and human well-being: current state and trends assessment.* Washington: Island Press. pp. 838. Retrieved from www.maweb.org/en/condition.aspx
- **Plan Bleu (2010)** Les écosystèmes marins méditerranéens : valeur économique des bénéfices soutenables. *Les Notes du Plan Bleu*, 17. Retrieved from www.planbleu.org/publications/notesDuPlanBleu.html
- **Ruckelshaus, M. and Guerry, A. (2010)** *Marine InVEST: a decision-making tool for mapping and valuing ecosystem services provided by coasts and oceans.* Natural Capital Project. pp. 4. Retrieved from: www.naturalcapitalproject.org/marine/MarineInVEST_Apr2010.pdf
- **Samonte-Tan, G.P.B. et al. (2007)** Economic valuation of coastal and marine resources: Bohol Marine Triangle, Philippines. *Coastal Management*, 35: 319–338.
- **Silvestri, S. and Kershaw, F. (eds.)(2010)** *Framing the flow: innovative approaches to understand, protect and value ecosystem services across linked habitats*. UNEP World Conservation Monitoring Centre, Cambridge, UK. pp. 62.
- **Söderqvist, T. et al. (2004)** *Economic valuation for sustainable development in the Swedish coastal zone.* Stockholm: Beijer International Institute of Ecological Economics, The Royal Swedish Academy of Sciences. pp. 32. Retrieved from www.beijer.kva.se/PDF/45510919_Disc183.pdf
- **TEEB (2010)** *The economics of ecosystems and biodiversity: mainstreaming the economics of nature: a synthesis of the approach, conclusions and recommendations of TEEB*. pp. 29.
- **Turner, R. K. and Daily, G. (2008)** The ecosystem services framework and natural capital conservation. *Environmental and Resource Economics*, 39: 25-35.
- **Weitzman, M.L. (2009)** On modelling and interpreting the economics of catastrophic climate change. *The Review of Economics and Statistics*, MIT Press, 91: 1-19.
- **WWF (2008)** *The value of our oceans: the economic benefits of marine biodiversity and healthy ecosystems.* Frankfurt am Main: WWF Germany. pp. 21.

Marine and coastal ecosystem services

Economic valuation of marine and coastal ecosystem services is increasingly being considered to be of critical importance for informed decision-making and effective management of marine and coastal resources. However, the translation of scientific theory to policy in practice can be challenging. This report provides an overview of the main methods of economic valuation, their strengths and weaknesses, and practical applications. Theoretical concepts are illustrated with a number of practical examples throughout this report, to demonstrate how these approaches can be of practical use across all scales, in policy development, decision making and communication. Practical guidance on how to implement a valuation exercise, and how to overcome common challenges, is also provided.



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