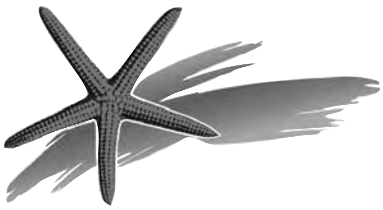
CIESM Workshop Monographs



Economic valuation of natural coastal and marine ecosystems

Bodrum, 22 - 25 October 2008

CIESM Workshop Monographs ◊ 37.

To be cited as: CIESM, 2008. Economic valuation of natural coastal and marine ecosystems. N° 37 in *CIESM Workshop Monographs* [F. Briand, Ed.], 112 pages, Monaco.

This collection offers a broad range of titles in the marine sciences, with a particular focus on emerging issues. The Monographs do not aim to present state-of-the-art reviews; they reflect the latest thinking of researchers gathered at CIESM invitation to assess existing knowledge, confront their hypotheses and perspectives, and to identify the most interesting paths for future action.

A collection founded and edited by Frédéric Briand.
Publisher : CIESM, 16 bd de Suisse, MC-98000, Monaco.

Contents

I - Executive Summary of CIESM Workshop 37

"Economic valuation of natural coastal and marine ecosystems"

by

Sala E., Becker N., Boero F., Doss M., Galil B.S., Henocque Y., Luisetti T., Nunes P., Pavlinovic S., Scapini F., Tosun C. and F. Briand

This synthesis was drafted, under the coordination of Enric Sala, by all workshop participants. The Monograph Series Editor, Frédéric Briand, reviewed and edited the entire volume, assisted by Valérie Gollino for the physical production process.

1. Introduction

The workshop took place from 22 to 25 October 2008 in Bodrum, the ancient Halicarnassus of historical fame, now a major touristic center on the Anatolian coast. An original mix of resource economists and marine biologists from eight countries (see list at the end of volume) attended this four-day exploratory seminar at the invitation of CIESM. As Dr Frederic Briand, Director General of the Commission, and Dr Enric Sala, Chair of the CIESM Committee on Coastal Systems, made clear in introducing the meeting, the choice of the venue was deliberately set on a prime touristic destination of the eastern Mediterranean, illustrating both the economic benefits derived from very attractive shores and the significant environmental costs associated with huge tourism and market pressure.

Obviously the challenge of ensuring the sustainability of fragile, highly impacted coastal habitats is too complex to be the exclusive province of economists and ecologists, but it requires that both sets of experts at least exchange their own vision of a world-wide problem and assimilate the 'peculiar' language of the other at the scale of the Mediterranean. That objective alone was worth the voyage but the meeting went beyond by reaching areas of consensus on the multi-dimensional nature of the issue and on the set of tools that looked most promising.

2. Definition of issue – *"Economic valuation of natural coastal and marine ecosystems"*

Scientists have been warning about the impacts of human activities on ecosystems and about their repercussions on humans for decades (climate change is a great example), but a precautionary approach to management has not been adopted yet. A major reason is that natural ecosystems have typically been perceived as renewable, exploitable resources to be used for human benefit, and most people take for granted the many vital services that marine ecosystems provide for our well-being. This wrong perception is starting to change although marine ecosystems are still considered by many as less vulnerable and inexhaustible despite clear warning signals (see for example Sala and Knowlton, 2006; Worm *et al.*, 2006).

Because of the growing disconnect between humans and the natural world, the services provided by marine ecosystems are often ignored, and therefore their intrinsic value is poorly appreciated. Marine biodiversity is inherently irreplaceable, and its intrinsic value cannot be expressed in monetary terms. In contrast, the instrumental value of marine biodiversity, estimated as the services that marine ecosystems provide, can be defined in terms that most people relate to (see Table 1). Valuation is a compromise, it is not about absolute values (any economic valuation of marine ecosystem services will be an underestimation), and it should be considered as a process, which empowers stakeholders in decision making.

Table 1. Summary of ecosystem services and their relative magnitude provided by different Mediterranean marine habitats. The larger circles represent higher relative magnitude (adapted from Agardy and Alder, 2005).

Direct and Indirect Services	Beach-dune systems	Estuaries and marshes	Littoral hard bottom habitats	Seagrass beds	Pelagic (offshore) waters	Deep Sea
Food	•	●	⬤	●	⬤	
Fiber, timber, fuel	●	●	•			
Medicines		•	•			⬤
Biodiversity	•	●	⬤	●	●	●
Biological regulation	●	●	●	●	●	●
Freshwater storage & retention	•	•				
Biochemical		•		•	●	●
Nutrient cycling & fertility	●	●	●	⬤	●	⬤
Hydrological	•	●				
Atmospheric & climate regulation	•	●	•	●	⬤	•
Waste processing	●	⬤	•	•	⬤	⬤
Flood/storm protection	⬤	⬤	•	⬤		
Erosion control	⬤	●		●		
Cultural and amenity	⬤	●	●	•		
Recreational	⬤	⬤	⬤	●	•	
Aesthetics	⬤	●	⬤	●		

For instance, the Mediterranean Sea has served the riparian countries for waste disposal, decomposition and detoxification, but we have never internalized the true cost of these processes in economic models. The region generates large volumes of wastewater, with urban water alone accounting for about 38×10^9 m^3/year (UNEP/MAP, 2004). Wastewater also comes from industry and agriculture and includes toxic, persistent and bioaccumulable pollutants. Economic instruments can be used to estimate the value of the capacity of the Mediterranean ecosystem to dilute, disperse and break down pollutants. The cost of effluent management, from prevention and minimization to rectification and effluent re-use, to a level similar to that already provided by the Mediterranean ecosystem is the true value of that service.

What are the challenges of conducting economic valuation of marine ecosystems? The uses of marine ecosystems differ from those of terrestrial ecosystems, and the economic valuation of their services is difficult. For instance, while hunting land animals as the main source of protein for humanity was abandoned by most societies thousands of years ago, marine fisheries continue an industrial-scale hunting operation. According to recent statistics, aquaculture delivers an amount of protein comparable to wild fisheries (FAO, 2006), but aquaculture is not true farming since much of the feed of farmed fishes is fishmeal obtained from wild fisheries, thus further reducing natural resources. Property rights are not clearly established in the sea, and activities in the high seas outside of the exclusive economic zones are generally not properly regulated. Finally, access to underwater habitats is limited in time and space, impeding a greater understanding of the functioning of marine ecosystems and of the impact of human activities. Therefore, importing the paradigms, assumptions and methods used on land to marine systems may not be appropriate. CIESM Workshop 37 explored the challenges and opportunities of economic valuation from the perspective of Mediterranean marine ecosystems.

3. Tools and perspectives

3.1 Values, environmental damage and valuation

Ecosystem services play a crucial role in offering a wide range of benefits, and are therefore important steering forces of human well-being. The Millenium Ecosystem Assessment (Breitbart *et al.*, 2002) distinguishes four broad categories of benefit: provisioning services, cultural services, regulating services and supporting services.

Monetary value assessment of marine ecological damage has its foundations in welfare economics since it establishes the concept of marine ecological value in terms of its impact on the welfare of human beings. In a conceptual framework, one can define the total value (TV) of the damages in terms of the use value (UV) and non-use value (NUV) (Figure 1). The use value component refers to the set of damages that arise from the actual impact of the marine ecological damage. These damages can be further divided into direct use, indirect use, and option use value, respectively DUV, IUV and OUV. Direct use values of damages include: (a) the loss of marine tourism and coastal recreation benefits; (b) the loss of natural and cultured marine species with commercial value, and (c) the value of risks to human health. Indirect use values of damages refer to damages that relate to the functioning of the marine ecosystem and the survival of marine living resources, even if these have no direct commercial value.

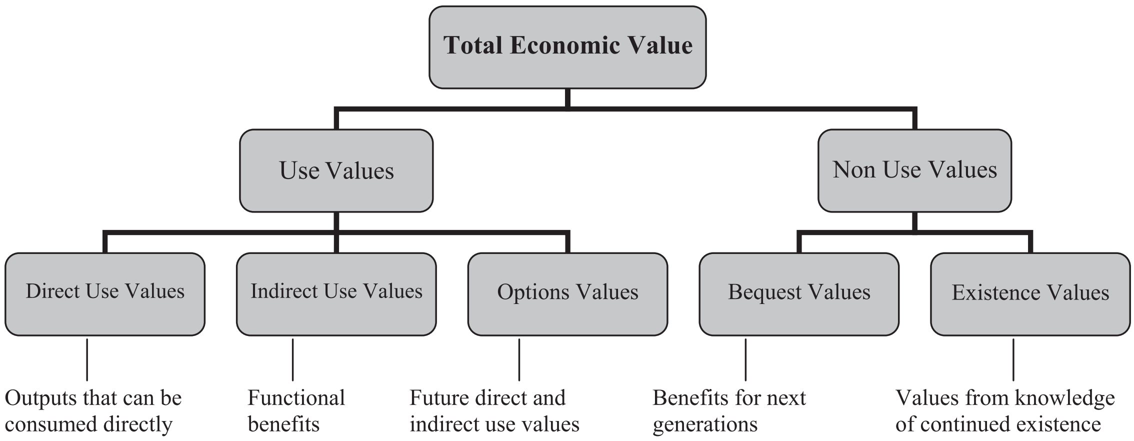


Figure 1. Types of values of marine ecosystems, including instrumental values and intrinsic values (adapted from The World Bank, 1998).

Non-use values of damages can be divided into a bequest value (BV) and an existence value (EV). Bequest value refers to the benefit accruing to any individual from the knowledge that future generations might benefit from a marine ecosystem being free from marine ecological damages. Existence value refers to the benefit derived simply from the knowledge that marine species are protected without even being used. This leads to the following equation

$$TV = UV + NUV = (DUV + IUV + OUV) + (BV + EV)$$

Note that non-use values of damages have a public good character, i.e. they do not have a market price. As a consequence, market price evaluation of marine ecological damages provides an undervaluation of the associated negative impacts. This can be interpreted as signaling a misallocation of financial resources in marine prevention, restoration or amelioration programs. An accurate and complete monetary assessment of environmental-economic damages requires the application of specific monetary valuation tools. In the absence of market prices, economists use specific monetary valuation techniques to measure use and non-use damages. Since the consequences of marine ecological damages are multifaceted, the techniques must cover a broad range of effects, including economic, cultural, and ecological effects (Nunes *et al.*, 2000). The tools that have been identified in the literature are hedonic pricing, aggregate market analysis, contingent valuation, the travel cost method, production functions, and the averting behavior method (Nunes and van den Bergh, 2001). Most of these tools have seen few applications to value marine ecological damages. Bearing in mind both the described damage categories and the scope of each valuation technique, it is possible to suggest the most suitable valuation methodology for each value or damage type (Table 2).

Table 2. Classification of marine ecological damages and appropriate valuation techniques.

Economic Value		**Examples of damages**	**Most suitable valuation technique**
Use value (UV)	Direct use value (DUV)	Loss of tourism and recreational benefits (e.g., visits to the beach, sport fishing, swimming and sailing)	Travel cost method, contingent valuation
		Destruction of marine living resources with commercial value, e.g. fish (codfish, salmon), shellfish, mollusk	Aggregate price analysis*, hedonic pricing
		Risks to human health, e.g. food poisoning	Averting behavior method, contingent valuation
	Indirect use value (IUV)	Effects on marine ecosystem health (e.g., changing local chemical composition of the water, toxicity accumulation along the food chain, loss of biodiversity)	Production function method, averting behavior method
	Option use value (OUV)	No insurance that marine coastal areas are free from HABs (e.g., beach with foams during tourist season)	Travel cost method, contingent valuation
Non use value (NUV)	Bequest Value (BV)	Risk of loss of legacy benefits (e.g., no legacy of marine species for future generations)	Contingent valuation
	Existence Value (EV)	Risk of loss of existence benefits (e.g., no knowledge guarantee that some marine species are locally extinct)	Contingent valuation

*Also known as a market price valuation technique.

As one can see, contingent valuation (CV), a survey based valuation technique that is widely used in the context of environmental valuation (Carson *et al.*, 1992; Nunes and de Blaeij, 2005) can fulfill an important potential role in the overall assessment of damages. Indeed, it can be applied to assess the monetary value of most types of damages, and it is the only valuation method that is capable of shedding light on bequest and existence values related to marine ecological damages. In addition, CV has the advantage that marine policies may be valued even if they have not yet been adopted or lie outside current institutional arrangements. Thus, it offers much scope and flexibility for specifying different restoration and amelioration programs. For monetary value assessment of the damages to ecosystem health however, CV does not emerge as the most suitable valuation technique. This is because the involved effects cannot be easily described in a questionnaire survey (e.g. toxicity accumulation along the food chain) and are often related to complex issues with which the general public is unfamiliar.

If the marine ecological damage is reflected in the output of an economic activity such as fishing, the production function method provides a suitable alternative. This method translates physical changes in relationships between environmental inputs and economic outputs through markets prices, production costs, profits and producer and consumer surpluses into damages values. An example is the mass mortalities of commercial fish caused by harmful algal blooms that produce a toxin (also known as ‘fish killers‘). Finally, monetary value assessment of tourism and recreational damages can be performed by using the cost of travelling to a non-priced coastal site (Nunes and van den Bergh, 2004). Questionnaire surveys are used to collect data on the number of visits that the household makes to the site, on the money spent in travel time and on costs of gaining access to clean beaches, free from foams and repellent odors.

3.2 The challenge of evaluating biodiversity

The shortcomings of evaluating biodiversity are manifold, in addition to the ethical problem of doing so. Many species are yet unknown, and we cannot evaluate the unknown. A potential mechanism for assigning value to species could be to measure the role of the species in the ecosystem, “keystone“ species (those with the strongest per capita interaction strength in the community) or “foundation“ species (those providing a key architectural role) being the highest valued. The problem is that the roles of most species are unknown.

We may put forth the argument that species should be valued equally. However, our perception of value depends on the characteristics of the species in question. If we had to choose between an inconspicuous and unknown species that is the sole representative of a family (such as the Mediterranean hydrozoan *Tricyclusa singularis*), and a large commercially important species that has close relatives in the same region (such as the Mediterranean dusky grouper, *Epinephelus marginatus*), the general focus would be on the large, charismatic grouper. Charismatic species are given great emotional and even monetary value. Such “triage“ is based upon subjective ‘beauty‘, commercial interest and familiarity. However, biodiversity can be valued through its impact on the ability of ecosystems to provide services (see Reid, 2005).

3.3 Modeling vs. scenario building

Economic valuation, and in particular stated preference methods, requires models to forecast the impact of a particular activity on the environment and the economy. Unfortunately a major intrinsic barrier to communication between ecologists and economists makes valuation difficult. Ecologists tend to believe that they are expected to produce accurate forecasts for their part and economists do not understand why a good number of ecologists are uncomfortable making forecasts while others do so even with systems that are highly nonlinear. While traditional linear models are impractical for forecasting, non-linear forecasting models have been shown to predict future outcomes with more success (Sugihara and May, 1990). A limitation is that they require relatively long time series, which are largely missing in the marine ecological realm.

An alternative to quantitative forecasts is scenario building, which consists in postulating a sequential series of events by using verbal models, graphic models, or both. Scenarios do not pretend to predict the future with accuracy but, being more flexible than mathematical models, allow for weak inference on what might happen in the future. They are working hypotheses, and also negotiating tools between stakeholders. The Intergovernmental Panel on Climate Change (IPCC) and the Millennium Ecosystem Assessment have been successful in building multiple scenarios based on a range of human activities, and by combining quantitative models and qualitative assessments.

Several issues make it difficult for valuation studies to be fully acceptable by decision makers:

a) Welfare change vs. monetary change: the idea that one can put on balance fishermen’s loss vs. society benefit through willingness to pay (WTP) sounds odd to most decision makers. While fishing losses are given in “real“ terms, WTP is also given in monetary units but is a mere reflection of benefits, not real currencies.
b) In order to estimate non-use values, one has to rely on stated preferences which are hypothetical by nature. This by itself causes decision makers to hesitate.
c) Even if we accept the hypothetical nature of the analysis, there is still the standing issue. Non-use values are associated with people that did not visit the area concerned and probably will not in the future. The idea to take those individuals into account sounds odd to most decision makers. This is also related to the issue that follows.
d) While the costs of nature protection are concentrated with a small group (e.g., a group of fishermen), the benefits are spread over a much larger number of people. Therefore, even if the benefit of preservation is higher in total, the average benefit per capita will generally be lower than the average cost. In such cases lobbying will be stronger in the group who is standing to lose.

3.4 Non-linearity and thresholds

One highly challenging aspect of economic valuation of marine ecosystems is the non-linearity of ecological-economic systems. Much classical theory in both disciplines relies heavily on locally linear methods to estimate stability and times of return to equilibria, thereby ignoring many phenomena of overriding importance such as the potential for catastrophes.

The most extreme form of convex relationships is a threshold. In a non-linear systems, small perturbations can become magnified and lead to qualitatively unexpected behaviors at macroscopic levels. Identifying the thresholds, or tipping points, on which one system shifts from the influence of one ecological attractor to another is thus essential for evaluating the impacts of human activities on marine ecosystems. Furthermore, an ecological phase shift is associated with a shift in value. Therefore, unpredictable, putative future phase shifts may make estimation of present value impractical, and present serious problems for management.

For instance, an unexpected consequence of overfishing is that fish could be replaced by jellyfish. This, in turn, will cause a further decrease in fish abundance, since jellyfish feed on fish larvae and their planktonic food. Until recently jellyfish had never been considered in fisheries models (Boero *et al.*, 2008); only now are they starting to receive proper attention (Pauly *et al.*, 2009). What is the threshold leading to the shift from a fish to a jellyfish coastal sea? Is this shift reversible? Are there any management actions that can be implemented to help reverse this shift?

Is it possible to predict the timing and location of thresholds and thus estimate the present value of marine ecosystem services more accurately? In general, it is difficult to detect strong signals of change early enough, and so to develop scientific consensus in time for implementing effective solutions. The quantification of thresholds requires knowing what keeps a system into a more or less predictable domain where changes are mostly fluctuations (e.g. seasonal fluctuations) and not variations (i.e. the emergence of a new attractor, leading to a new condition). But typically the passage from one attractor to another is determined by an episodic, often unpredictable event (Boero *et al.*, 2008). The identification of trends, however, allows for some weak inference about the future.

The concave non-linearity case offers different challenges. We refer here mainly to what is defined in economics as the marginal benefit, and the marginal cost, of preservation. The interrelationship of ecosystem structure, function, and economic value is also of great importance to decision makers who are often concerned with how much natural habitat to “preserve“ and how much to allocate for economic development. In assessing such trade-offs, it is frequently assumed that ecosystem services change linearly with critical habitat variables such as size. This assumption can lead to a misrepresentation of the economic values inherent in the resources; it can overestimate or underestimate the service value, resulting in an “all or nothing“ habitat scenario as the only decision choice. A common reason for invoking such an assumption is that few data exist for examining the marginal losses associated with changes in nonlinear ecological functions, making it difficult to accurately value the changes in ecosystem services in response to incremental changes in habitat characteristics.

An example of misuse of the linearity assumption is provided in this seminal paper of Costanza *et al.* (1997) which attempted to estimate the total value provided by the world’s ecosystem services. This value was estimated at about three trillion USD, three times the world’s GDP at that time. However, the analysis overlooked the non-linearity of the ecological system, assuming that each ecosystem unit is worth the same. Economic analysis would measure the benefits and costs of preservation only at the *margin* and not on *average.* In the case of mangrove preservation in Thailand, it was shown (Barbier *et al.*, 2008) that total preservation results in a net loss to society vs. only partial preservation when devoting the other part to shrimp farming. This is precisely because of the concavity relationship: it turned out that the last units of mangroves were worth less than shrimp fishing while the other units were worth more.

In summary, taking benefits and costs at the margin is more likely to get support from the general public. However, one must be careful not to apply the concavity case when one is in the convex part. To avoid this, a very important challenge for ecologists will be to understand better where the non-linearity actually occurs; that is, where thresholds are. When we will have a better understanding of the issue, valuation studies will be better accepted in the concave range.

3.5 How to evaluate highly complex systems?

In addition to the unpredictability of chaotic dynamics, marine ecologists have to deal with very complex ecosystems composed of thousands of interacting species. The good news is that, while individual species may have chaotic dynamics, food webs have emergent properties that can be predictable and change in understandable ways at the ecosystem level. For instance, prohibition of fishing in a marine reserve causes populations of target species to increase in abundance, but their prey may consequently decrease over time. The relative abundance of different target species will also change with time along a process called ecological succession, and total biomass will often increase, unless an event (e.g., fishing in the reserve) reverses the predictable ecological trajectory. It is very important to understand that, while the abundance of individual species may not be predictable over time, there are emergent properties that can be forecast with more certainty as long as the system remains under the influence of a known attractor. Economic valuation will require that ecologists identify the minimum number of parameters (dimensions of the ecosystem) that can explain the general behavior of the ecosystem and allow for reliable modeling and scenario-building. Linking food web and ecosystem theory with empirical marine ecology will be fundamental to achieve this goal.

3.6 The syndrome of the shifting baselines

Our perception of what is a natural environment changes across generations: we believe that what is natural is what we experienced at an early age, or the first time we visited a place or ecosystem. As humans increasingly degrade the environment, our expectations of what is natural are lowered (Pauly, 1995). Thus, our baseline of what is natural slides across generations. The problem is that baseline shifting affects evaluation of environmental states and changes by scientists as well as by other people, paving the way for lower valuation of marine ecosystems' services.

The effects of shifting baselines can be exacerbated by modern production techniques that alienate end-consumers from marine ecosystems, so that they do not perceive the changes in the environment. For instance, because of economic subsidies and imports of seafood from other seas, Mediterranean populations have not yet realized that fish stocks are plummeting. Society and culture will also shape the perception of the desired state of the environment. The greater environmental awareness in some countries has also reshaped our perception of value of marine life. For instance, when Moby Dick was written, the hunted whale was typically perceived as evil and dangerous; whereas today many readers would consider the whale hunter as cruel.

Certain economic models formulate past consumption as complement to present consumption capturing in that way the effect of shifting baselines on valuation. But how to account for baseline shifting in valuation studies? Does environmental change coincide with variance in valuation across respondents' age (in surveys), knowing that those exploiting a resource are more likely to perceive a change in real time than end-consumers detached from the natural environment?

3.7 Developing a new common toolkit in a fast-changing world

To cope with the new challenges imposed by the complexities of global change, an interdisciplinary approach integrating science, economics and sociology is needed. This new approach includes techniques such as the DP-S-I-R (Driving Pressures-States-Impacts-Response), and increased focus on ecosystem services. The analysis of driving pressures on an ecosystem and their impacts on the environment and on society requires fundamental information both from the ecological and the sociological side. Economics, through the valuation of the ecosystem services involved, provides an important component of this interdisciplinary decision support system.

In this context, an important question is when and where the valuation of ecosystem services fits into existing environmental policies. Whenever possible, environmental impacts should be valued in monetary terms. Where this is not possible, these impacts should be expressed either in quantitative terms or as a mere qualitative assessment of potential impacts.

The joint initiative in regard to the global economic benefits of biodiversity and the costs of ecosystems degradation (European Communities, 2008) proposed a valuation framework as a future policy toolkit for policy-makers and practitioners. Combined with practical guidebooks (DEFRA, 2007), the approach could be as follows:

• **Establish an environmental baseline to examine the causes of biodiversity loss:** ecosystem services are identified and grouped into functional categories (provisioning, regulating, cultural and supporting). A quantitative and/or qualitative assessment of the potential impacts of human activities on ecosystem services requires a rigorous baseline against which to assess putative changes expected from different policy options.

• **Evaluate alternative policies by quantifying the impact of policy options on specific ecosystem services:** this approach is also used on impact assessments and cost-benefit analysis to ensure that decision-makers can make informed decisions on the basis of a systematic analysis of all the implications of various policy choices. While the focus of valuation should be on marginal changes rather than on the "total" value of an ecosystem, it is important to take a broad view of the ecosystem and the spatial scale of possible impacts.

• **Assess the costs and benefits of actions on human welfare:** the analysis will need to assess the effects of changes in the identified ecosystem services. It is important to note that there could be both costs and benefits for human welfare. As some services might be incompatible (e.g. water extraction and groundwater recharge), combining these values would over-estimate the ecosystem services.

• **Consider the distribution of impacts of ecosystem services loss and conservation:** the beneficiaries of ecosystem services are often not the same as those who incur the costs of conservation ('positive externalities'). Mismatches can lead to taking decisions that are right for some people locally, but wrong for others and for society as a whole. In the name of effective and equitable policies, these spatial dimensions should be recognized and corrected with appropriate tools, such as payments for ecosystem services and redistribution to those who actually maintain these services.

4. Governance

The Mediterranean basin is a complex geopolitical system involving 21 countries, which implies several layers of governance with different degrees of overlap. Like ecosystems, local societies are complex: they may be multi-level and include competing groups and different interests by social and ethnic groups, as well as gender and age discrimination. These complex communities are embedded in larger complex systems at national, regional, and global scales, with accelerating changes that influence both property rights dynamics at the local level, the role of traditional governance, and social values. Among others, the case of the tuna fishery in the Mediterranean (Fromentin and Powers, 2005) exemplifies a shift from artisanal to industrial fisheries, and from regional to international actors.

The general shift from subsistence and livelihood use of local resources towards the pursuit of economic growth and international markets created rifts among local communities and also conflicts with the outside world, as the interests of Mediterranean communities have been colliding with the interests of a larger system of resource users. The increase in the spatial scale of resource use increases the heterogeneity of users, inducing commons governance to become multi-scale and multi-jurisdictional.

The functioning of the Mediterranean ecosystem (including humans) is source of debate, making difficult consensual agreement over the future of the region. Scenario-building should be a tool to stimulate dialogue about external pressures and internal dynamics of the sub-region or locality, to help build capacity for resource management. Besides vulnerabilities, the scenario planning should also reveal previously unconsidered opportunities for enhanced learning and collaboration among the many associations and organisations that work in the same area or on the same type of system (e.g., marine protected areas) in each of the Mediterranean sub-regions (see Becker, this volume). Throughout this planning process, economic valuation is likely to contribute to building a common background not only within communities but also between scientists, managers and policy-makers.

Environmental and resource management is a socio-political undertaking (Nadasdy, 2007). At the beginning of the twentieth century, state wildlife management was linked to the expansion of state power and new forms of governance will need to build trust by seriously considering culture and identity. In this context four categories of factors, identified by Folke *et al.* (2003) for building resilience in social-ecological systems are relevant:

(1) learning to live with change and uncertainty: in a changing, non-linear world, accurate forecasts are unlikely;

(2) nurturing diversity as a means of ensuring greater options for renewal and reorganization: diversity, in fact, contains the possibility of unexpressed solutions to unforeseen problems, from rare species to unhorthodox social-economic practices, preadapted to future conditions;
(3) combining knowledge types to enhance learning: for instance the blend of scientific and traditional culture has much to offer;
(4) creating conditions and opportunities for self-organization.

Social dynamics are as difficult to predict as ecological dynamics, due to the diversity of human values, the rapid pace of social change, and the reflexive nature of people (Westley *et al.*, 2002). Cooperation between different populations, organizations, and types of management requires mechanisms for linking social and ecological knowledge, such as the history of coastal uses, with more universal knowledge, such as the dynamics of sediment accretion/erosion cycles (see Scapini, this volume). This requires that stakeholders have some minimal level of trust in one another, and some shared vision of the management issues that they face.

In the Mediterranean, a variety of cross-scale ecological issues, like the spread of invasive species (see Galil, this volume), and a lack of ecological regional management emphasize the need for trusted mechanisms linking local and more general socio-ecological knowledge.

To quote Berkes *et al.* (2007) "Resource management is at a crossroads. Problems are complex, values are in dispute, facts are uncertain, and predictions are possible only in a limited sense. The scientific system that underlies resource management is facing a crisis of confidence in legitimacy and power. Top-down resource management does not work for a multitude of reasons, and the era of expert-knows-best decision making is all but over". Stakeholders' values and expectations must be properly identified and communicated to policy makers. Stakeholders are more likely to participate in management if the policies and strategies are generated by their direct contribution. Although participatory management is costly in terms of money and time, this approach is sine-qua-non for fair distribution of cost and benefit of valuation of environmental resources (Tosun, 2006). In complex, adaptive systems, disequilibrium and surprise are the rule, and failure is as instructive as success. "The devil is not just in the details, it's in the dynamics" (Westley, 2002).

5. Case studies of Mediterranean ecosystem services valuation

This section presents three case studies exploring the valuation of (1) rocky shore habitats threatened by illegal date-mussel fisheries, (2) coastal ecosystems affected by jellyfish outbreaks, and (3) a charismatic species that has no market value.

5.1 Case study 1 – Destructive date mussel fishery on rocky habitats

This study considers the case of the rocky shore in south-western Apulia (SE Italy), highly impacted by the illegal fishery (prohibited since 1988) of the date-mussel *Lithophaga lithophaga* (Linnaeus, 1758) a mollusk considered a delicacy in many Mediterranean countries. Date-mussels live inside galleries that they bore in the rocks. The only way to collect them is to dismantle the rocks (Fanelli *et al.*, 1994). As a consequence, the biological covering of the marine substrate is eradicated, explaining why this fishery is considered as the most destructive of the entire planet (Dayton *et al.*, 1995). It has been shown that rocky substrates impacted by date-mussel fisheries may remain void of any biological covering for a long time with potential negative effects for fishes using this habitat for shelter, food, nesting and nurseries (Guidetti and Boero, 2004; Guidetti *et al.*, 2003; 2004). Because of the high catch (around 100 kilograms of date-mussels per day) the rate of depletion was two kilometres per year before the ban (Fanelli *et al.*, 1994).

The economic valuation of the rocky shore ecosystem in south-western Apulia should be carried out via the following steps:
1) identifying the ecosystem services provided by the rocky shore;
2) collecting quantitative data on mussel fisheries and on other fisheries lost each year and their market price or economic valuation (via revealed or stated preference techniques);
3) a cost-benefit analysis on a specific proposed policy.

If a protection plan were suggested, a cost-benefit analysis of the plan would show the economic feasibility of the proposal. In this case study the ecosystem services and benefits of the rocky shore in south-western Apulia are identified in Table 3. For each service/benefit, possible economic valuation methods are proposed, and some quantitative data currently available reported. The policy analysis would consider enhanced controls on illegal fishing of date-mussels.

Table 3. Ecosystem services and benefits of the rocky shore in south-western Apulia, Italy. Based on Table 19.2 of the Millennium Ecosystem Assessment (Reid, 2005: chapter 19), modified to avoid double counting of ecosystem services.

Ecosystem services	Economic Valuation Method	Explanation of the valuation method	Fishing date mussels	Prohibition of date mussel fisheries	Quantitative data currently available
Provisioning services					
Food (date-mussel).	Market prices.	Approximated value of date-mussels based on the current price on the 'illegal' market.	+ The current price of date mussels in the illegal market can be used as a proxy for valuation purposes, but cannot be considered as a gain from an economic point of view because it is an illegal market.	- The loss of jobs related to this illegal activity could be taken into account by policy makers to avoid social conflicts.	?40.00/kg
Date mussel-driven tourism.			+ Italians travel to Albania to eat date mussels.	-	
Food (marketed fish).	Market prices.	This is an approximated value of the fish, molluscs, and crustaceans based on their current market price.	- Fish, mollusks, and crustaceans are deprived of their habitats (at various stages of their life cycles) so becoming rarer and less exploitable by fisheries.	+	
Medicines (potential).	Market prices (if any; or substitutes).	This is the price at which the drugs derived by the organisms, or the price of similar drugs, are sold.	- no drugs have been isolated from the organisms that live in the habitats affected by date mussel fisheries, but they might be in the future.	+	Currently no data are available.
Raw materials (sponges).	Market prices.	The market price of commercial sponges.	- Commercial sponges are destroyed.	+	
Regulation services					
Atmospheric and climate regulation (carbon dioxide control) depending on the scale.	Damage cost avoided.	This is the cost of carbon dioxide emissions (the price of carbon) based on the estimated damage because of CO_2 emissions (Pearce *et al.*, 1996; Tol, 2005; Stern, 2006).	- The destruction of biological covering impairs production of oxygen and consumption of carbon dioxide.	+	
Erosion control.	Market prices / damage cost avoided.	This can be either the price of artificial defence protection, if the rock is eroded, or the cost to avoid damages in absence of any coastal protections from the rock.	- Date mussels erode the rock and cause it to collapse; the biological covering retards the process, whereas fisheries accelerate it.	+	

Table 3. Continued

Ecosystem services	Economic Valuation Method	Explanation of the valuation method	Fishing date mussels	Prohibition of date mussel fisheries	Quantitative data currently available
Cultural services					
Recreation, amenity and aesthetics (for illegal consumers).	Revealed (travel cost) and stated preference methods (contingent valuation, choice experiments).		+ These people are happy to find date mussels, and go to places where they can be found. This has a beneficial effect on the local economy, beyond the price paid for the date mussel meal (accounted for in another section). These persons travel to Albania just for this.	- These people are not happy with the ban on date mussels. They go to Albania where date mussels are available with no limitation, which contributes to the destruction of Albanese and Croatian habitats.	
Recreation, amenity and aesthetics for people who value environmental integrity.	Revealed (travel cost) and stated preference methods (contingent valuation, choice experiments)	This can be inferred by the cost sustained to travel to the area, or the willingness to pay of individuals to preserve/restore the area.	- Loss of tourists not willing to spend their vacation in a place where nature is being eradicated.	+ The restoration of the environment, if any, will attract sensitive people to environmental integrity (also with the presence of MPA).	
Cultural (possible cultural loss).	Survey of affected community.	People can be asked if they feel this loss and how much they value it.	- The "culture" of eating this dish is lost.	+ A culture of respect of nature is gained.	
Supporting services					
Nursery (other species not sold in the market).	Stated preference methods; benefit/value transfer.	This is the value people put on the fisheries that are not sold in the market but that have a function as biodiversity. The value can be obtained with a specific study or using previous studies (value transfer).	- Habitat destruction impairs the support provided to species of commercial interest such as fish, crustaceans and molluscs.	+ The stopping of habitat destruction might lead to an improvement in these services, even though full restoration seems difficult to obtain due to the presence of sea urchins which contribute to the persistence of barrens.	
Resilience/stability.	Non-monetary indicators.		- The removal of biological covering leads to barrens that are kept stable due to sea urchin grazing. Even the stopping of the fisheries does not lead to improvement because the barrens are then caused by sea urchin grazing.	+ This positive effect is real if the sea urchins are removed, for instance by allowing the growth of populations of fish that predate on the sea urchins.	

5.2 Case study 2 – Mediterranean coastal ecosystems and the prevention of jellyfish outbreaks damages

Mediterranean countries are facing more extensive and more frequent jellyfish outbreaks (CIESM, 2001). The analysis of possible benefit/loss due to jellyfish outbreaks is done by examining their impacts on coastal ecosystem services (see Table 4). At high densities, jellyfish

Table 4. Impact of jellyfish outbreaks on coastal ecosystem services.

Ecosystem services	Economic Valuation Method	Explanation of the valuation method	With jelly fish outbreaks	Without jelly fish outbreaks
Provisioning services				
Food (sea food).	Market analysis.	This is an approximated value of the fish, molluscs, and crustaceans based on their current market price.	- Diminish and damage seafood availability.	+ Some large species of jellyfish are consumed in SE Asia.
Coastal installations.	Damage cost avoided.	This is the cost to be sustained if jellyfish enter seawater intake pipes in coastal installations.	- Clearing jellyfish from intake pipes; stoppage of seawater cooles power plants.	+
Regulation services				
jellyfish stings.	Cost of illness and loss of earnings.	Costs of medical treatment of jellyfish stings, and earnings lost by patients	- Painful stings, can lead to hospitalization and scarring.	+
Human mortality from jellyfish stings.	Costs of premature mortality as value of statistical life.	This value is subject to estimation.	- Possible but too rare to be of concern.	+
Cultural services				
Recreation, amenity and aesthetics.	Revealed (travel cost) and stated preference methods (contingent valuation, choice experiments).	This can be inferred by the cost sustained to travel to the area, or the willingness to pay of individuals to preserve/restore the area.	- See the text for reference.	+ See the text for reference.
Cultural (perceived loss of beach amenity and cultural symbolism).	Survey of affected communities.	People can be asked if they feel this loss and how much they value it.	- If the jellies are stingers.	+ A potential for attraction.
Supporting services				
Nursery (other species not sold in the market).	Stated preference methods; benefit/value transfer.	Value of the bycatch fisheries that have a function as biodiversity.	- Jellies may cause the depletion of fish populations.	+
Resilience/stability.	Non-monetary indicators.		- The ecosystems may be dominated by dinoflagellates and procaryotes (e.g. bacteria that cause mucilage events).	+

may cause the ecosystem to shift towards states that are usually not considered as positive for humans (Boero *et al.*, 2008). Jellyfish prey on zooplankton, including fish eggs and larvae, and at the same time compete with fish for the same food resources. Large annual jellyfish shoals are vast consumers of zooplankton and, especially in the more oligotrophic parts of the sea, may have dramatic impact on the fisheries. The loss to commercial fisheries stems from predation and competition on the fish stock, prevention of certain modes of fishing (trawling, purse seining) during shoaling periods, difficulties in sorting the catch and damaging it. When the shoals are driven ashore they can clog the seawater cooling systems of power plants, leading even to local interruption of electricity supplies (Galil *et al.*, 1990; 2007). The venomous stinging cells of certain jellyfish species harm humans. The native mauve stinger, *Pelagia noctiluca*, and the Erythrean alien, *Rhopilema nomadica* Galil, 1990, inflict painful stings that may necessitate medical treatment (Galil, this volume), and increase costs of illness and loss of earnings. Jellyfish outbreaks negatively affect tourism and reduce the recreational attractiveness of entire coastlines. Some cultural loss may be involved considering that the locals' traditional recreational use of the beach is replaced by swimming pools or shopping malls.

5.3 Case study 3 – The non-market value of a charismatic species: application to the Mediterranean monk seal

There are quite a few examples of species that have dramatically greater appeal to humans than others. These species are immediately identifiable by name and often have some charismatic or symbolic attributes. They are commonly associated with a particular geographic location or habitat. Because of this association between the species and their habitats, these charismatic species are also sometimes referred to as "flagship" species. For humans, they are the leading representatives of the habitats from which they derive.

Meta-analyses of the willingness to pay for individual species have shown a significant preference for a few charismatic species relative to the vast majority of species. Flagship species are often used as representatives of the general problem of habitat transformation and biodiversity conservation. For example, conservation organizations often focus their appeals for funding around the plight of a particular charismatic species. These species are thus not just highly valued for themselves, but also highly valued as representative of entire ecosystems. In other words, the demand for individual species conservation can be either a complement to or a substitute for the demand for habitat conservation.

A valuation study considered the willingness to pay for the endangered Mediterranean monk seal (*Monachus monachus*) in the island of Lesvos, Greece. In spite of numerous restrictions, regulations and conservation measures imposed by Greek authorities, the seals are killed by inshore fishermen because they damage fishing gear whilst trying to extract fish from fishing nets. The problem can be seen as an example of competition between fishermen and seals for the fish resource.

The mean willingness to pay to help preserve the seals was estimated at 12 Euros but, interestingly, only 5% of this amount was associated with use value (Langford *et al.*, 1998; 2001). The authors of the study are skeptic about the use of their study to help preserve the species, although the positive side of this study is that people express their willingness to pay for a species even though they expect never to get in direct contact with a seal at sea. Another question is whether the conservation of monk seals will help preserve other less charismatic species.

6. Glossary

The workshop participants decided early on to draw a list of terms commonly used in their discussions so as to make sure that both economists and environmental biologists used the same semantic references.

---

alien (non-indigenous) species: a species living outside its known natural range, introduced intentionally or unintentionally by humans.

amenity: any tangible or intangible benefits of a property or a place, especially those which increase the attractiveness or value of the good or which contribute to its comfort or convenience.

assets: something possessed by an entity from which future economic benefits may be obtained. Everything owned by a person or company (all tangible and intangible property) that can be converted into cash.

attractor: a set to which a dynamical system evolves after a long enough time. In an ecosystem, an attractor would be the endpoint of ecological succession towards which any state of that ecosystem will evolve to, in the absence of disturbance.

bequest value: the personal or social benefit received by the present generation from leaving a resource for future generations to enjoy or use.

biodiversity: the full range of natural variety and variability within and among living organisms, and the ecological and environmental complexes in which they live; it includes genetic diversity within species, the diversity of species in ecosystems, and the diversity of habitats and ecosystems.

biodiversity asset: a living entity or group of entities that is of (perceived) value to humans.

common and public goods: goods that are non-rival and non-excludable. This means that consumption of the good by one individual does not reduce the amount of the good available for consumption by others; and no one can be effectively excluded from using that good. A public good is one which, if made available to one person, automatically becomes available to all others in the same amount.

carrying capacity: the maximum number of organisms that can be supported in a given area or habitat.

consumer surplus: an estimate of total economic benefits from consuming a good or service. It is measured by the maximum willingness to pay over and above the actual cash cost of consumption.

contingent valuation: a technique used in the valuation of environmental goods, to estimate either the willingness to pay for an improvement in the quantity or quality of some environmental good, or the willingness to accept compensation for the deterioration in environmental provision. It is an analytic survey technique that relies on hypothetical situations to place a monetary value on goods and services.

cost-benefit analysis: a process to assess the desirability of public interventions ex-ante. Benefits and costs are estimated by taking into account both private and external impacts of the intervention.

discount rate: rate at which the future value is discounted to estimate the present value.

ecosystem: the entire biological and physical content of a biotope interacting as an ecological unit (including humans).

ecosystem function: basic ecological processes necessary for the self-maintenance of an ecosystem (such as primary production, nutrient cycling, and decomposition) and all the evolutionary processes contributing to the basic ones (e.g., species interactions).

ecosystem services: the fundamental life-support services provided by ecosystems; the benefits people obtain from ecosystems; these include provisioning services such as food and water; regulating services such as flood and disease control; cultural services such as spiritual, recreational, and cultural benefits; and supporting services such as nutrient cycling that maintain the conditions for life on Earth.

endemic species: species native of and restricted to a particular geographical region.

existence value: value from knowledge of continued existence based on moral conviction.

externalities: the impact of one person's actions on the wellbeing of a bystander (can be positive or negative). A side effect or consequence of industrial or commercial activities that affects other parties without this being reflected in the costs of the goods and or services involved.

goods: any object, service or right that increases utility, directly or indirectly, not to be confused with the adjective "good" as used in a moral or ethical sense. Goods and services are those things produced by human or nature that yield benefits or increase our well being. They may be tangible or intangible.

habitat: the environment on which a given species or ecological community depends for its survival. The environment can be physical (e.g., rocky reefs, marine caves) or created by living organisms (e.g., seagrass meadows, deep coral banks).

instrumental value (or extrinsic value): the value of objects, both physical objects and abstract objects, not as ends-in-themselves but as means of achieving something else.

intrinsic value: the inherent worth of something, independent of its value to anyone or anything else.

invasive species: an alien species whose population has undergone exponential growth and is extending its range.

linearity: attribute of a system in which causes of a given size produce effects of proportional size. Linear systems are predictable, if initial conditions are known.

marginal changes: small incremental adjustments to a plan of action.

marginal cost: the increase in total cost associated with the production of an additional unit of the good produced. Marginal cost = Change in total cost / Change in quantity produced.

marginal damage: the damage caused by an additional unit of disturbance (e.g., pollution).

market failure: a situation in which a market left on its own fails to allocate resources efficiently.

marginal revenue: the contribution to total revenue associated with the production (and selling) of an additional unit of the good produced by the firm. Equals change in total revenue / Change in quantity produced.

maximum sustainable yield: the maximum yield that can be harvested from a renewable resource stock without reducing the size of the stock.

market value: price at which an asset would be traded in a competitive setting.

non linearity: a system whose functioning cannot be modeled as a linear sum of independent variables. Non linear systems are extremely sensitive to initial conditions.

non renewable resources: resource that exists in a fixed amount (stock) in various places in the earth's crust and has the potential for renewal only by geological, physical, and chemical processes taking place over hundreds of millions of years.

opportunity cost: what must be given up to obtain a certain item. It is the second best alternative foregone.

phase: a distinct period in which a given system maintains its features either by remaining stable or by undergoing cyclical changes along a predictable sequence of events (e.g. seasonal cycles).

phase shift: an abrupt transition from one ecological state to another (i.e. from top-predator dominated food web to a gelatinous predator dominated one).

price: the intersection of supply and demand. The amount of money or goods asked for or given in exchange for something else.

private benefits: benefits that are obtained directly by the consumer from its consumption activities or by the producer in its production activities.

private costs: costs that are directly supported by the consumer in its consumption activities or by the producer in its production activities.

property rights: set of rights that ensures/allows the specific use/management of a renewable or a non-renewable resource.

renewable resource: a natural resource that is replenished by natural processes at a rate comparable or faster than its rate of consumption by humans or other users.

scenarios: account or synopsis of a projected course of action, events or situations. Scenarios are widely used to understand different ways in which future events might unfold.

social benefits: all benefits created by a consumption activity or a production activity. Equals private benefit + external benefit.

social costs: all costs involved in a consumption activity or a production activity. Equals private cost plus external cost.

sustainable development: economically viable development that does not result in the degradation of the environment, and loss of resources or native biodiversity; it must not compromise the welfare of future generations for the benefit of present generations.

threshold: the minimum level or value of a stimulus necessary to illicit response.

use value: the value people place on the actual use of an environment.

value: the preferred end-states of existence, which taken together circumscribe human well-being.

willingness to pay: the maximum amount that a buyer will pay for a good.