THE ECONOMIC VALUE OF SUSTAINABLE BENEFITS FROM THE MEDITERRANEAN MARINE ECOSYSTEMS

Study report

Available versions: French (Original), English (*Provisional*)

A. Mangos, J-P. Bassino, D. Sauzade

Blue Plan
Regional Activity Centre

Sophia Antipolis
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OVERVIEW

LIST OF ACRONYMS

AFD : French Agency for the Development
AECID : Spanish Agency of international Cooperation for the Development
BP RAC: Blue Plan Regional Activity Centre
CICES : Common International Classification of Ecosystem Services
CIESM : Mediterranean Science Commission
CIHEAM : International Centre for Advanced Mediterranean Agronomic Studies
DEFI : Développement Economique et Finance Internationale (University of Aix Marseille II, France)
DEPI : Division of Environmental Policy Implementation (division of UNEP)
DTIE : Division of Technology, Industry and Economics (division of UNEP)
EC: European Commission
ECOMERS : Ecosystèmes Côtiers Marins et Réponses aux Stress (University of Nice Sophia Antipolis, France)
EEA : European Environment Agency
EIB : European Investment Bank
ETB: Economics and Trade Branch (branch of the DTIE, UNEP)
ETS : Emission Trading Schemes
EUNIS : EUropean Nature Information System
FAO : Food and Agriculture Organization
GDP: Gross Domestic Product
GFCM: General Fisheries Commission for the Mediterranean
GNP: Gross National Product
ICCAT: International Commission for the Conservation of Atlantic Tunas
ILO: International Labour Organization
ISEW: Index of Sustainable Economic Welfare
ISIC : International Standard Industrial Classification
IUCN : International Union for the Conservation of Nature
MAP: Mediterranean Action Plan
MEA : Millenium Ecosystem Assessment
MEECE : Marine Ecosystem Evolution in a Changing Environment
MSFD: Marine Strategy Framework Directive (of the EC)
MSY : Maximum Sustainable Yield
NAS: National Accounting System
NDP: Net Domestic Product
NUTS : Nomenclature of Territorial Units for Statistics
RSP : Regional Seas Programme (branch of the DEPI, UNEP)
SAP BIO : Strategic Action Plan for BIOdiversity
SEEA : System of Environmental and Economic Accounts
SPA RAC: Specially Protected Areas Regional Activity Centre
TAC : Total Allowable Catch
TEEB : The Economics of Ecosystems and Biodiversity
TEV: Total Economc Value
UNEP: United Nations Environment Programme
UNWTO: World Tourism Organization
VA : Value Added
WFD: Water Framework Directive (of the EC)
WWF: World Wildlife Fund

SUMMARY

Whilst the Mediterranean sea represents a mere 0.3% of the volume and 0.8% of the total surface area of the World Ocean, its position at the interface between three continents, the fact that it is a semi-closed sea and the marked seasonal nature of its climate have made it a melting pot for diversity. In full awareness of this variety, the Mediterranean Action Plan (MAP) has established a Strategic Action Plan for the Conservation of Biodiversity (SAP BIO 2003), identifying the strategic lines to be transposed by Mediterranean countries into their national policy in order to conserve this biodiversity, which is so seriously threatened by land artificialisation, the over-exploitation of resources, the proliferation of introduced species, the impact of human activity (pollution and disturbance of the environment) as well as climate change. MAP also wished to back up this action plan by gaining more in-depth knowledge about the links between the environment and the economy. To this end the Blue Plan, one of MAP's regional activity centres, has been entrusted with exploring these links by developing an economic approach to the environment. It has been supported in its work by MAP, the French GEF (FFEM), the French (AFD) and Spanish (AECID) Agencies for the Development.

This report sets out the results of an economic evaluation of the sustainable benefits related to the ecosystem services provided by the marine ecosystems in the Mediterranean in 2005. The results illustrate the economic potential of marine ecosystems as regards the sustainable development of the riparian countries. The assessment looks at the value of the flows produced by the environmental assets constituting the marine natural capital, without making any attempt to estimate the value of the stock of natural capital.

The methodological framework for this assessment (chapter 1) was established on the basis of a bibliographical analysis of numerous studies which addressed the economic evaluation of the services rendered by ecosystems. The main types of Mediterranean marine ecosystems were characterised and considered according to their role in producing resources, as a regulator and in cultural terms, as defined by the *Millennium Ecosystem Assessment* (MEA, 2005). For each of these three categories of ecological functions, various services rendered by the ecosystems under consideration were identified in respect of the human usages they allow or to which they contribute. In this study, the methods used to assess the benefits derived through the use of services rendered by the ecosystems have been drawn from the framework established by the United Nations for economic and environmental accounting (UN, 2003). A sustainability criterion for the usages of the services rendered by ecosystems was introduced, in line with concerns expressed about sustainable development in the Mediterranean.

Five ecosystems have been considered as a basis for this study: the Posidonia meadows (*Posidonia oceanica*), corallogenic concretions, rocky sea-beds with photophilic algae, sea-beds with a loose substrate and the open sea (over 100 m in depth), for which the area was estimated using a bibliographical analysis and after listening to experts. The benefits assessed fall into three groups of services provided by the ecosystems, as set out in the following table:

Categories of ecosystem services:	Ecological services:	Benefits evaluated:
Production services	Production of food resources	Resource rent relating to the production of food resources of marine origin
Cultural services	Amenities	Resource rent relating to the provision of amenities and recreational supports
	Support for recreational activities	
Regulatory services	Climate regulation	Value of man-made CO_2 sequestration
	Mitigation of natural hazards	Value of protection against coastal erosion
	Waste processing	Value of waste treatment

In this study, the value of the benefits rendered by ecosystems has been assessed either as a more or less important part of the value added created in the various sectors of the economy or as an equivalent to avoided expenditure or even as a reference value where the benefit is of a collective nature.

Each type of benefit was individually assessed (chapter 2). Benefits relating to the production of food resources were evaluated on the basis of data on the fisheries and marine aquaculture sector. Benefits relating to the provision of amenities and recreational supports were assessed on the basis of data on real estate rents, the hotel and restaurants service activities, and tourism. Benefits relating to climate regulation were assessed on the basis of the marine environment's capacity to absorb anthropogenic CO_2 valued at the price per tonne of CO_2 in force on the European Emission Trading Scheme in 2005. Benefits relating to the mitigation of erosion were evaluated on the basis of the proportion of the coastline exposed to this hazard and where Posidonia meadows are also present and efficient, the benefits being valued according to the cost of replacing defence structures. Finally, the benefits relating to waste processing by the marine ecosystems were valued by observing a reference value corresponding to a situation where waste disposals meet environmental standards.

Aggregation of these results provides an approximation of the overall value of the benefits resulting from the Mediterranean marine ecosystems (chapter 3). At regional level, the benefits are assessed at over 26 billion Euros for 2005, more than 68% of which comes from the benefits stemming from the provision of amenities and recreational supports. The benefits relating to the production of food resources account for 11% of the overall estimated benefit. The study also presents the results for two Mediterranean countries- Greece, for which the benefit amounted to 3 billion Euros in 2005, i.e. 1.6% of its Gross National Product (GNP) and Tunisia, for which the benefits rendered by the ecosystems amounted to over 520 million Euros i.e. 2.3% of its GNP for the same year. The study also provides a breakdown of the benefits relating to the production of food resources by ecosystem type. Thus for fisheries, the open seas account for over 70% of the value of the benefit in proportion to the volume of catches involved. On the other hand, basing itself on catch quantity, the study demonstrates that it is the Posidonia meadows and the rocky substrate which provide the best fishing productivity by area unit.

This exploratory study represents a first attempt to assess the contribution made by the marine ecosystems in the Mediterranean on an economic basis. The constraints under which it was drawn up, whether these be the application of the sustainability criterion for assessing the benefits considered or the lack of sound data for certain benefits, which consequently could not be included in the study, have led to what is probably a low initial assessment of the annual value of the sustainable benefits from marine ecosystems.

In this respect it calls for further work in relation to data collection and for a possible revision of the scope and methodology of the study. Some of these additional studies are currently undertaken by the Blue Plan.

INTRODUCTION

This document is the final report for the exploratory study undertaken by the Blue Plan, the aim of which is to provide an economic evaluation of the sustainable benefits[1] provided by Mediterranean marine ecosystems. It was supported by the Mediterranean Action Plan (MAP), the French Global Environment Fund (FFEM), the French Development Agency (AFD) and the Spanish Agency for Cooperation and Development (AECID) and also drew on the experience of the Blue Plan and other of MAP's Regional Activity Centres as well as the support of experts.

The report reproduces the scoping of the study, the evaluation techniques applied and the results obtained. It was jointly drawn up by Anaï Mangos (Marine Ecosystems Programme Officer at the Blue Plan), who was in charge of coordination, Didier Sauzade (Blue Plan Programme Officer "Sea", seconded by Ifremer) and Jean Pascal Bassino (Associate Professor at the University of Montpellier III and researcher at the DEFI, University of Aix Marseille II, Blue Plan consultant). Patrice Francour (Director of the ECOMERS laboratory, University of Nice Sophia Antipolis) and Odile Chancollon (ECOMERS laboratory,) contributed to the section on marine ecosystems under a specific agreement with the Blue Plan.

The study received the wise advices of the members of the Steering Committee for the Blue Plan's "Sea" programme, experts in marine ecology and economics, the list of which can be found in Annex 1.

The authors would also like to thank: Jean-Pierre Giraud and Karel Primard de Suremain (Blue Plan), for collecting and processing the geographic information on Mediterranean coastline; Elisabeth Coudert, Cécile Roddier-Quefelec, Gaëlle Thivet, and Patrice Miran (Blue Plan) for sharing their expertise on tourism, environmental data, water management, and climate change, respectively; as well as to Christine Pergent and Daniel Cebrian (Specially Protected Areas Regional Activity Centre SPA/RAC) for the information they provided on Mediterranean marine ecosystems.

Context and issues

Whilst the Mediterranean sea represents a mere 0.3% of the volume and 0.8% of the total surface area of the World Ocean, its position at the interface between three continents, the fact that it is a semi-closed sea and the marked seasonal nature of its climate make it a melting pot for diversity. In full awareness of this variety, the Mediterranean Action Plan (MAP) has established a Strategic Action Plan for the Conservation of Biodiversity (SAP BIO 2003), identifying the strategic lines to be transposed by the Mediterranean countries into their national policy in order to conserve this biodiversity, which is so seriously threatened by land artificialisation, the over-exploitation of resources, the proliferation of introduced species, the impact of human activity (pollution and disturbance of the environment) as well as climate change.

The risks associated with the loss of biodiversity are not only ecological, moral and socio-cultural, they are also economic. The work of the *Millennium Ecosystem Assessment* highlighted the links between biodiversity as an on-going provider of ecosystem services and the well-being of the individuals who enjoy them. The commitment made by the Parties to the Convention on Biological Diversity to curb the loss of biodiversity by 2010- made in The Hague in 2002 (6th conference of the parties)- echoes the recognition of the interdependence between individual well-being and biodiversity.

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1 The implications of the term sustainable are mentioned later, section I.2.

Moreover, UNEP's Regional Seas programme has developed a methodology for assessing what share of the economic activities of the countries bordering on the world's Large Marine Ecosystems comes from the goods and services provided by marine ecosystems. The Mediterranean is one of the regional seas studied.

In this context, the Almeria declaration (2008) made by the Contracting Parties to the Barcelona Convention decided to conduct studies aimed at *« estimating the economic value of the products derived from and the services rendered by the marine ecosystems »*. The Blue Plan thus committed itself to assessing the economic value of the sustainable benefits provided by the ecosystems which comprise the large Mediterranean marine ecosystem. This remit and the development programme for the eco-systemic approach which links MAP and some of the activity centres (SPA RAC and the Blue Plan) to the European Commission (EC) provided the framework within which the Blue Plan drew up this study, which draws in particular on several previous studies conducted under the aegis of the United Nations Environment Programme (UNEP).

Usefulness of the economic evaluation of the benefits rendered by ecosystems and general approach

The environmental economy tends to pool ecological and economic knowledge in order to blend the notions of the environment as both a provider of natural resources and as a plank for socio-economic development. The economic assessment of the benefits provided by ecosystems provides public decision takers with a common and quantitative language, which can be understood by a wide audience and which allows these figures to be included in the calculations relating to public policy (satellite accounts for national accounting, public policy evaluation...). Evaluating the contribution made by ecosystems also opens the way to shaping and testing the effectiveness of new regulatory policies for mitigating the environmental externalities linked to activities (the introduction of compensation systems, for example). The economic value of the benefits from ecosystems thus increases the visibility of the strategic role played by ecosystems- as well as the ecological processes which characterise them- in societal development and in particular highlights the risks to be avoided, which are commonly lumped together under the notion of the *« tragedy of the commons »* (Hardin, 1968).

The aim of this study is to assess at Mediterranean regional level the economic value of the sustainable benefits flowing from ecosystem services rendered by marine ecosystems in order to highlight their importance for the sustainable development of the Mediterranean riparian countries. The emphasis has been placed in particular on the benefits noted in the coastal zones.

The study was conducted in four stages, as set out in appendix 2. The first stage, which focused on the theoretical and methodological scoping, specified the aims of the study and selected a macro-economic approach. The second stage consisted in an assessment of the feasibility of the study, which allowed to experiment a tentative approach based on the transfer of benefits- the results of which are shown in appendix 3-, the nature of the ecosystem services rendered by Mediterranean marine ecosystems to be specified (see appendix 4) and an analytical framework to be drawn up for addressing the field of study (see appendix 5). During this stage, available data was collected. The third stage involved processing the available information and analysing the results, the reproduction of which comprises the bulk of the report. Finally, the fourth stage provided the opportunity to sum up what has been achieved and to identify further prospects for this work.

This report presents the theoretical and methodological framework adopted, explains the evaluation procedure followed for each type of benefit and sums up the main results.

I. Conceptual and operational framework

Evaluating the benefits from ecosystems in economic terms is a complex procedure in two respects:

- It looks at the services which may be affected by human action and for which there are few (if any) man-made substitutes;
- It must take account of ecosystemic processes, which are still poorly understood.

This section aims to clarify the concepts which underlie the economic evaluation of the benefits provided by ecosystems and to define the approach chosen for the study. Following an examination of the work of the United Nations Environment Programme (UNEP) to be considered within the framework of the study, the concepts used are clarified before the economic evaluation as such is then addressed.

1. UNEP's work on the economy and the environment

The work of UNEP in the field of the economy and the environment was examined before defining the conceptual framework of the study, with the aim of drawing as much inspiration from it as possible. UNEP is indeed globally recognised for its expertise in the relations between the economy and the environment and therefore provides a sound basis for analysis, which is compatible with its role as a support for public decision taking. UNEP was one of the UN agencies involved in the *Millennium Ecosystem Assessment* (MEA) initiative and made a significant contribution thereto.

The economic aspects are for the main part dealt with by two divisions of UNEP- the Division of Technology, Industry and Economics (DTIE) and the Division of Environmental Policy Implementation (DEPI).

The role of the DTIE is to encourage national and local authorities and decision makers in industry to draw up and adopt cleaner, safer, more natural resource friendly policies, strategies and practices, to guarantee the ecologically rational management of chemical products, to limit pollution and risks for man and the environment, to facilitate the implementation of international conventions and agreements and to factor in environmental costs. The work of its Economics and Trade Branch (ETB) focuses on the interface between trade, finance and the environment. The ETB is particularly responsible for encouraging and assisting the national authorities in using and implementing assessment tools and incentives, such as integrated environmental planning and assessment, the quantification of environmental and natural resources and economic instruments as contributors to sustainable development. The ETB was involved in the development of the *«System of Integrated Environmental and Economic Accounting»* (SEEA), whose recommendations were widely used in this study[2]. The ETB also approached subsidies as a vector for encouraging the over-exploitation of resources, particularly in the fisheries area (UNEP/ETB, 2007), the results of which partly clarified the issue of the fisheries resource rent addressed in this study. Moreover, the DTIE is party to the multi-agency initiative on the Green Economy, which also involves the TEEB project, one of the inspirations for this study.

[2] See section I.3 further on.

The DEPI is responsible for the implementation of environmental policy with a view to promoting sustainable development at global, regional and national levels. This division is responsible in particular for UNEP's Regional Seas Programme. Launched in 1974 in the wake of the United Nations Conference on the human environment held in Stockholm in 1972, this programme created a framework which allowed countries from the same region to engage in dialogue, to exchange experience and information and to express their formal commitment to objectives supported by specific practical measures. The Mediterranean is one of this programme's regional seas, which as early as 1975 became the first to adopt an action plan-MAP- to which the Blue Plan is attached as one of the Regional Activity Centres set up to foster MAP's activities. Numerous methodological tools have been developed under this programme, including one on economic activity accounting for the Large Marine Ecosystems and Regional Seas (UNEP, RSP 2006), which has served as a major source of inspiration for this project.

2. Definition of the concepts used

In order to clarify the vocabulary used in this report, it should be pointed out that the aim of the study is to assess the benefits provided by ecosystems in the sense commonly accepted by numerous reference authors (United Nations, 2003 ; Boyd and Banzhaf, 2007 ; Fisher *et al.*, 2008 ; Turner *et al.*, 2009 ; Haines-Young and Potschin, 2010).

Biodiversity, a key term in international conventions on conservation and public environment policies, refers to the quantity and variability within living organisms of the same species (genetic diversity), different species or different ecosystems. Biodiversity (or biological diversity) is the reflection of this biological variability and does not in itself constitute a service rendered by the ecosystem. Its existence, however, lies behind the provision of services rendered by the ecosystems. Thus the term biodiversity allows the entire living world to be brought together under a single expression. By adopting the unit which ecosystems constitute, the study sets the scale of observation at the level of interactions between the elements of biodiversity as well as interaction with the abiotic elements comprising the environment within which biodiversity evolves.

Under the approach adopted, ecological function, ecosystem services and benefits are not synonymous. The relations and differences between ecological functions, ecological services, benefits and the value of these benefits are closely linked to the existence of human intervention (Boyd, 2007).

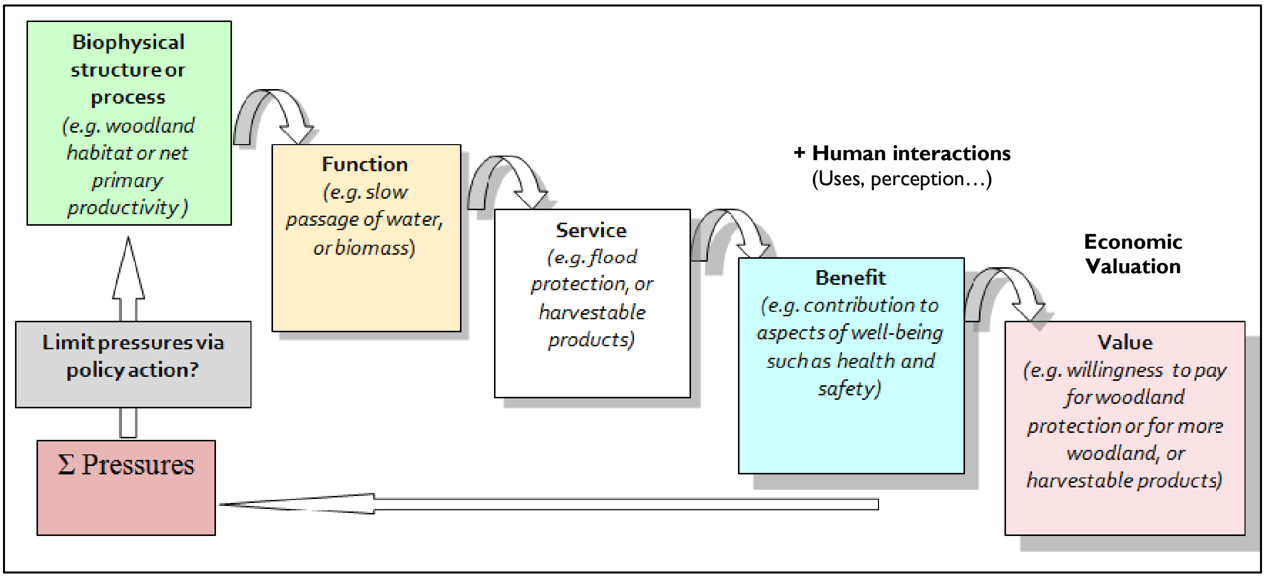
The economic approach to ecosystems and more specifically the evaluation of the benefits is defined in the light of the relations between four aspects: ecosystems, ecological services, benefits and their value.

Ecosystem services represent the ecological processes which supply all the benefits provided by ecosystems. Ecosystem services thus contribute to individual well-being, irrespective of whether they are used actively or passively (Fisher *et al.*, 2008). They ensure that life is both possible and pleasant (MEA, 2005).

The various types of ecosystem services are subject of numerous classifications[3] (appendix 4). These classifications usually refer to four major categories of services rendered by ecosystems (production of resources, regulation, cultural and support) of which only the first three provide a direct input into the human sphere.

Bouvron (2009) defines ecological functions as being *« biological processes for the functioning and maintenance of ecosystems »*, whilst ecosystem services are *« biological processes from which man can profit, which promote the maintenance of human activity »*. These profits comprise the benefits rendered by ecosystems (Boyd et Banzhaf 2007; Boyd 2007). The benefits provided by ecosystems, in other words the finished products provided by nature and about which users make choices, can be subjected to an economic evaluation (figure 1). **The estimated economic value reflects that of the benefit received, rather than the value of the ecosystem services and functions or the ecosystems themselves.**

Figure 1 : Relations between functions, services, benefits and values.



Source: adapted from Haines-Young and Potschin (2010).

Here, ecosystems are addressed from an economic point of view, which equates their existence to that of environmental assets. Taken overall, these assets constitute natural capital used by man either in conjunction with the other factors of production or not.

In environmental economics, the term "natural capital" refers to the entire set of environmental assets. The various theoretical and empirical studies which have looked at the services rendered by natural capital and enjoyed by man constitute one of the sources of inspiration for this study towards identifying the methods of evaluation potentially applicable to the various ecosystem services rendered by marine ecosystems and in line with the SEEA.

Socio-economic activities, which generate revenue and well-being, generally combine different types of capital[4] : physical capital, human capital (or labour) and very often natural capital. The

3 The issue of the classification of ecological services has been addressed by numerous studies, some of them still underway, in particular: Costanza et al. (1997) ; De Groot et al. (2002) ; MEA (2005) ; Wallace (2007) ; Beaumont et al. (2007), the TEEB (in preparation) and CICES (in preparation) (see AAppendix 4).

4 These factors are labour, man-made capital (resulting from investment in amenities, buildings or infrastructure) and human capital (resulting from investment in health, education or research and development). The study is exclusively anchored in the sphere of reality, thus an examination of the conditions for financing new production functions and

benefits derived from activities can therefore be attributed to different types of capital depending on their respective contribution to the production of benefit. The issue at stake for this study is to evaluate the benefits relating to the contributions made by the Mediterranean marine ecosystems and thus attributable to natural capital.

3. Economic assessment of sustainable benefits

The aim of this study is to produce an assessment of the benefits resulting from the services delivered by ecosystems throughout the Mediterranean, confined to the maritime areas; the assessment techniques must thus be tailored to both the object of the study and its scale- that of a regional sea.

The chosen framework of analysis and the proposed presentation draw on the recommendations set out in the United Nations' handbook of integrated environmental accounting (United Nations, 2003), a satellite account of the United Nations' System of National Accounts (SNA 1993 and the most recent 2008[5] version), the aim of which is to better describe relations between the economy and the environment.

In its present form, the *« System of Environmental and Economic Accounts »* (SEEA) comprises 4 categories of accounts:

- Flow accounts (divided into physical flow and hybrid accounts). These accounts only consider physical data relating to flows of materials and energy; hybrid accounts combine both physical and economic statistics. Emissions accounts for greenhouse gases, for example, are material flow accounts;
- Monetary accounts. They identify monetary transactions such as expenditure, taxes or fees, linked to the environment and not explicitly relayed in the national accounts;
- Natural resource assets accounts measured in physical and monetary terms according to the services delivered by these assets. Ecosystem accounts fall within this category;
- Environmentally adjusted aggregates. This last category of accounts examines how national accounts can be adjusted in order to take account of the impact of the economy on the environment. Three types of adjustment are considered- those relating to depletion, those relating to so-called defensive expenditure and those concerning degradation.

It is useful to mention the four dimensions of environmental assets identified in the SEEA:

- Natural resources (minerals and energy, land, water; in m^3);
- Terrestrial and aquatic surfaces covered (in hectares);
- Ecosystems (land, aquatic, atmospheric);
- Intangible resources related to the environment.

The SEEA is currently under revision; issues related to the construction of accounting for ecosystems and their services will be addressed in volume II of the revised SEEA dealing with non standard accounts[6]. This volume will address the politically relevant issues for which advanced practices exist in certain countries, but for which a methodological consensus does not exist. Although the elements under discussion have been taken into account, the study refers to the recommendations as formulated in the current version of the SEEA (UN 2003).

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their development do not fall within the scope of the study. Consequently, financial capital flows are seen only as the monetary counterpart of real flows and are thus ignored.

[5] United Nations, 2009.

[6] The revised version of the SEEA is expected in 2012.

Various methods of economic assessment are applied to the study of ecosystems, which differ according to the elements evaluated and the objectives pursued. Generally speaking, two types of approach can be identified, one based on cost and the other on value, both of them compatible with the SEEA framework.

The cost-based approach tends to assess the loss of benefit or well-being caused by the consumption of natural capital, in other words the destruction or deterioration of ecosystems. In this case, the assessment focuses on the cost of the depreciation, degradation or restoration[7] of the ecosystems when the aim is to maintain a certain level of provision of ecological services[8].

In parallel, the value-based approach strives to assess in economic terms the benefits and enhanced well-being which derive from ecosystems, as perceived by the individual. This assessment is based on the usefulness attached by the individual to the benefits they derive from the ecosystem services delivered by ecosystems.

In striving to measure the value of the sustainable benefits deriving from ecosystems, this study thus embraces the value-based approach and aspires to make a contribution applied to the SEEA by drawing on the framework proposed in the current version (UN 2003). This contribution addresses part of the ecosystem accounts, which are currently under discussion within the framework of the SEEA revision, proposing the evaluation of the sustainable benefits from Mediterranean marine ecosystems.

The benefits are measured as resulting from the use by the economies in the riparian countries (and possibly the rest of the world) of the annual flows generated by Mediterranean's marine environmental assets. The study is primarily based on the data collected or drawn up by the 22 countries which participate in MAP, taking 2005 as the year of reference. This year was chosen as being the most recent for which the large set of data produced by national statistics required for the study was available. Certain evaluations used the most recent data available, which may date back to before 2005.

The economic value of the benefits is estimated exclusively at macro-economic level. Consequently, the dependence of players on these benefits and their vulnerability in the face of potential change in the provision of ecosystem services and benefits are not addressed within the framework of this study.

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[7] The cost of depreciation refers to the decrease in stocks of natural assets. The cost of degradation refers to deterioration in the ecological processes which determine the level of provision of ecological services. Depreciation or degradation reduces the level of benefit. These phenomena can also produce negative effects (as opposed to the positive ones, which are the benefits), which are shown in negative externalities, particularly for health. The cost of restoration refers to the finances which would need to be committed in order to restore the level of production of the ecological services or reduce the negative externalities.

[8] In order to quantify the scale of natural capital consumption, *« it is important to distinguish what derives from resource depletion from what results from the degradation of the ecosystem which renews these resources, following the distinction introduced by Vanoli (2002). In the case of depletion, the rent is either positive or nil; it is within the price and the issue of sustainability relates to the use of part of the rent to generate an equivalent flow of resources (weak sustainability). In the case of the degradation of the ecosystem's functions/capacity, there is no rent included in the price of the product but rather an externality (a cost deferred to the community and future generations). In the case of non-renewable resources, it is possible to reason in terms of depletion alone. In the case of renewable resources, depletion is a sub-dimension of degradation »* (J-L. Weber, pers. com, 2010).

The following two sections address in greater detail the notions of natural capital and sustainability on the one hand, and the methods for assessing the benefits deriving from ecosystems on the other.

3.1. Services provided by natural capital and sustainability

It has been seen that natural capital constitutes a factor of production, as labour and man-made capital, but it is distinguished from these two factors by the following features:

- Payment for natural capital is critically dependent upon the conditions for appropriating the environmental assets. In practice, this payment often appears to be non-existent, given the lack of access or property rights.
- Natural capital is characterised by its scarcity: it cannot be produced by man and therefore cannot be substituted, thus its availability is limited. Certain assets are renewable, but under conditions which depend to a greater or lesser extent on human action, whilst other assets are non-renewable.

These features render the evaluation of the value of natural capital and its deriving benefits particularly difficult. But this study starts from many works conducted on assessing the cost of degradation and the flows corresponding to the consumption of natural capital, as well as on conditions for substituting between natural capital and physical produced capital.

Capital consumption and value of capital stock

For most of the environmental assets established in marine environments no right of access exists, which means agents make no payment for the use of this natural capital. To assess the value of the benefits deriving from this natural capital, it is possible to use the physical flows located at the interaction between the economy and the environment, and to calculate their value using available information concerning the unit values of the quantities of flow at work.

These flows are of two types:

- Benefits derived from environmental assets. Such flows can be directly measured in physical or monetary terms. Consumption of natural capital, negative variations in the stock of natural capital. Such flows tend to be easier to assess in physical and/or monetary terms than the benefits.

In certain cases, the benefit flow is equivalent to the natural capital consumption flow (in the case of oilfield exploitation, for example), and as such comparable to real flows and their monetary equivalent between economic agents. In most cases, however, the flows are not reciprocal. The benefits from ecosystems and the consumption of natural capital thus tend rather to be flows comparable to those identified within an economy by national accounting in terms of production on the one hand and consumption on the other.

Since it often proved impossible to assess benefits directly, an indirect assessment can conceivably be established based on the monetary value of the stock of natural capital from which said benefits emerge. The natural capital is then deemed to have been paid for at a rate comparable to that of other physical assets (physical produced capital) or financial ones. The rate of return must take account of the depreciation of the capital and the risk.

The value of the stock can be assessed by constructing a natural capital account within the framework of the environmental satellite accounts. This account allows trends in stock value to be measured as proposed by Hamilton and Clemens (1999). Based on studies conducted by the World Bank, they propose genuine saving estimates for various countries. The authors calculate changes over time in the value of physical assets produced, natural capital, and human capital. Amongst the resources comprising natural capital they include commercially exploited forests, oil and mineral deposits, and the atmosphere as a sink for CO_2.

The scale of variation in the stock of natural capital corresponds to the consumption of natural capital, thus to the destruction/degradation of certain assets. Taking this indicator into account allows the national revenue to be assessed, adjusted for the consumption of physical as well as natural[9] capital. This indicator is relatively useful in the economic assessment of the benefits resulting from natural capital. Indeed, the information can be directly used within this framework when the benefits received are the exact equivalent of the natural capital consumed, in other words when the total monetary benefits have resulted from the exploitation of non-renewable resources or the destruction of habitat, for example.

It has also been noted that the estimation of capital stock following the approach by Hamilton and Clemens (1999) takes no account of water resources, the role of the forests in carbon sequestration, fisheries, water, air and soil pollution and loss of biodiversity, etc. This therefore translates into an under-estimation of the total value of the stock of natural capital, possibly on a large scale (Dasgupta, 2003). Measuring benefits as payment for this stock of natural capital would therefore also result in the actual value of the benefits being largely under-estimated, particularly in the case of marine ecosystems, for which only deposits at sea and the carbon sequestrating function of the oceans would be taken into account.

Scarcity of natural capital and uncertainties concerning its renewal: implications in terms of sustainability

The implications of the scarcity of environmental assets and uncertainties concerning their renewal may be examined from the viewpoint of economic well-being. Economic agents have objectives in terms of intra but also inter-generational equity (Solow, 1991). They are therefore deemed to be altruistic and thus attach importance to the environmental assets which provide them with well-being, but also to those which they do not use themselves but which they know are used by others; they also care about the state in which future generations will find these assets. It is for this reason that this estimate has been conducted in exclusion of anything which corresponds to the consumption of natural capital, *in fine* retaining only the benefits emerging from sustainable uses.

As far as substitutability is concerned, two approaches can be envisaged: one examines the

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[9] The use of this indicator represents progress over measuring the gross domestic product (GDP) or even the net domestic product (NDP), which is adjusted for consumption of man-made capital. Bartelmus (2009) presents some recent results in international comparisons of NDP adjusted for the consumption of natural capital. Amongst the precursors, mention can be made in particular of the ISEW (Index of Sustainable Economic Welfare) developed by Daly and Cobb (1989) on the basis of Nordhaus and Tobin's proposals (1972), with applications for different countries (Diefenbacher, 1994; Castaneda, 1999; Hamilton, 1999) as well as for regions, for example Tuscany (Pulselli et al., 2006). The value of the ISEW is obtained by adjusting the GDP (expenditure-based approach), deducting military spending, adding the non-market services of households and subtracting the cost relating to the degradation of the environment and the depreciation of natural capital. This indicator therefore combines certain aspects of well-being, of which GDP takes no account, as in the Index of Economic Well Being (Osberg & Sharpe, 2005) and the loss of well-being resulting from unsustainable growth. The Genuine Progress Indicator has similar characteristics.

conditions for so-called weak sustainability, which corresponds to a situation where natural capital and man-made capital are substitutable; the other considers the implications of so-called strong sustainability, which corresponds to a situation where there are critical stocks of natural capital. In order to evaluate the benefits from ecosystems, criteria need to be identified on the basis of which a benefit flow could be deemed to be sustainable. It was decided to take a strong sustainability criterion for this study and to consider natural and physical capital as being non-substitutable[10]. This choice is justified in particular by the features of marine environmental assets and the fact that they are relatively little developed by human activity[11] as compared with terrestrial assets.

It therefore proved necessary to identify among the benefits from marine ecosystems the portion which can be regarded as sustainable and to measure it on the basis of sustainability coefficients according to experts judgements, based on ecological rather than economic criteria.

Ecological processes tend to be non linear and complex. The biophysical impact resulting from the degradation of an ecosystem can be weak up until a certain threshold of degradation. Nevertheless, once that threshold is crossed, even a slight increase in degradation can trigger a major biophysical change. This type of phenomenon, known in ecology terms as loss of resilience, indicates that the ecosystem has lost its capacity to absorb disturbances without its functional characteristics undergoing fundamental change. If an ecosystem has reached its resilience threshold, a relatively minor disturbance can push it into a new, irreversible state (Walker 1995; Levin 1999; Dasgupta, Levin, Lubchenko, 2000).

The thresholds and points of non-linearity in the ecological systems need to be taken into account in order to evaluate the consequences of a choice which would affect the structure or functioning of ecosystems, leading to the possible degradation or destruction of natural assets (Brock and Xepapadeas, 2003) thus equatable to the consumption of natural capital. Greater account could be taken of the evaluation of resilience thresholds and the non-linear dynamics of ecosystems within the framework of a diachronic approach which would further extend this study.

In this study, the sustainability conditions of the benefits relating to the services provided by ecosystems are thus examined for each service provided by the ecosystems before means for estimating the annual monetary value of the flows are proposed.

3.2. Diversity of approaches to the economic evaluation of the benefits and principles chosen for this study

The economic value of the benefits from environmental assets can be evaluated in various ways, with the possibility existing in particular of establishing estimates on the basis of surveys which

10 The framework of the 2003 version of the SEEA can be used for an analysis taking account of sustainability but, in its current version, the United Nations manual does not propose any choice between strong or weak sustainability (Dietz and Neumayer, 2006) and takes no account of the risk of loss of resilience (Walker and Pearson, 2007). With the conceptual framework of the SEEA undergoing revision, it can be supposed that these considerations will lead to change.

11 In the sense that land ecosystems can be, since farming or forest activity can lead to a relatively stable balance with a reduction in biodiversity but a degree of increase in productivity, from the point of view of the benefits that can be used by the economy..

use revealed or stated preference and possibly the transfer of values or benefits[12]. The choice of methods depends on the aims and scale of the study.

Since the aim is to evaluate the benefits linked to services provided by the ecosystems of a regional sea and to relate the value of these benefits to the national revenue of the countries concerned, the study is necessarily based on methods different from those used for a cost/benefit analysis conducted at local level. The approach and choice of evaluation methods are guided by the geographical scale of the study and the adoption of the SEEA recommendations. These features imply:

- First, to avoid the method of transfer of benefits[13]. Indeed, the transposition and extrapolation to the level of ecosystems bordering 22 countries of study outcomes relating to much smaller study sites (e.g. marine parks) involves considerable risk of abusive generalisation.
- Second, to favour measurement of values at market cost or at similar unit value, since national revenue is measured at market cost.

Adopting evaluation methods consistent with national accounting

In order to be consistent with the SEEA recommendations, methods using values commensurate with the aggregates or sectoral flow values from national accounting are preferred. The implication is that, in order to achieve the objective of relating the aggregate value of the benefits from marine ecosystems to the revenue of Mediterranean countries, the values to be measured should be comparable with national revenue.

The estimation of the national accounting flows is based on three complementary approaches:

- Production-based: the sum of value added,
- Expenditure-based: consumption and investment by the various types of agents,
- Revenue-based: provided by sharing the value added and paying the labour, capital and other factors[14].

The national revenue or possibly a component thereof may thus be estimated by combining these three approaches and producing consistent results. When sufficient data is available, the three approaches can be adopted in parallel, with the total likely to be roughly the same; any divergence, following adjustment to take account of the differences in definitions and flows with the rest of the world, is due to errors or omissions in the basic data.

This study is similar to the principles of national accounting on two essential points:

- The economic evaluation of the benefits is conducted by calculating the value of certain benefits using a revenue-based approach, whilst others are evaluated on the basis of production or expenditure, but each time there is commensurability with flows of the same type (revenue, expenditure and production) measured in national accounting.

12 For a summary of the evaluation methods see Pearce *et al.* (2006).
13 Where no results from the study on evaluating the benefits provided by ecosystems have been transferred to the study, certain parameters useful to the evaluation were transferred when the data was not available. In this case, the parameters were adapted where the context was structurally different.
14 It should be pointed out that it is the net value added which should be taken into account; in practice, assessment difficulties due to insufficient data have led to the gross value added being used in assessing the value of various benefits.

- Aggregation is possible whatever the approach used for estimating the benefits (based on revenue, expenditure or production), since these magnitudes are commensurable.

Valuing at market price as a condition for the commensurability of the benefits and national revenue

To the extent that this study aims to measure benefits which are commensurable with national revenue at market cost (or at unit values which reflect it where there is no market cost), the methods and scope of the study are different to the ones used to estimate annual flows at macro-economic level for all the services provided by a given ecosystem (or by a specific function).

Studies falling under the latter scope include the evaluations of the annual service flows from Mediterranean forests (Merlo and Croitoru, 2005; re-included in Merlo and Paiero, 2005), the evaluation of the benefits linked to coral ecosystems for the economies of Tobago and Saint Lucia, two islands in the West Indies (Bruke *et al.*, 2008) or the direct and indirect impact of coastal ecosystems on the economy of Zanzibar (Lange and Jiddawi 2009)[15]. Since this work involves global level assessments, apart from the evaluation of the economic value of the services rendered by ecosystems as a whole by Costanza *et al.* (1997) and its breakdown at coastal ecosystem level by state and by region by Martinez *et al.* (2007), reference can also be made to the study by Gallai *et al.* (2009), who propose an assessment of the contribution made by pollinating insects to global agricultural production.

At first sight, the aims of Merlo and Croitoru (2005) appear to be similar to those of our study. However, their choice to evaluate the Total Economic Value (TEV)[16] and more specifically the means for implementing this objective lead the authors to combine various evaluation methods and to aggregate values which are not necessarily compatible. Indeed, the authors measure certain benefits as being the value of production and others by using direct or indirect evaluation methods based on revealed or stated preference[17]. The same type of objection applies to other assessments, particularly those of Costanza *et al.* (1997) and therefore of Martinez *et al.* (2007), who use the same unit values.

One point which these studies all have in common is the evaluation of certain benefits on the basis of willingness to pay measures, which include the consumer surplus, which is not otherwise taken into account when the value is assessed on the basis of the market price.

Choosing to measure benefits based on market price logically leads to the consumer (or producer) surplus being excluded from the economic evaluation of the benefits provided by ecosystems. For this reason, benefits corresponding to existence values, for which evaluation is necessarily based on surveys assessing willingness to pay, are not evaluated.

Also in relation with the aim of consistency with the SEEA, the estimation method adopted by Gallai *et al.* (2009) was not adopted. These authors use market prices but their production-based approach takes an adjusted value of agricultural production as an indicator of benefits. They identify crops which have a critical dependence on the ecological service of pollination and evaluate the dependency coefficients[18]. The sum of the values calculated for the various crops is seen as the contribution made by pollinating insects at global scale.

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15 Which is also present in Naber et al. (2008).

16 The TEV corresponds to the sum of values relating to direct, indirect or optional uses and existence values (Pearce and Warford 1993).

17 See for example Pagiola et al. (2004) for a presentation of the various methods and their limits.

18 The value of the services rendered by pollinating insects is obtained for each product and each country by multiplying the production in volume by unit market prices and then, for each crop, applying the sum of the values at global level to the dependency coefficient. The coefficients are assessed on the basis of the values identified in a

Whilst it is true that this method of evaluation allows the scale of economic flows permitted by this ecological service to be measured, it leads to an over-evaluation of the value of the benefits derived from ecosystems[19]. Indeed, it would seem that:

- The value measured in this way corresponds to a potential loss in turnover for each producer, which is usually not equal to his income. In order to reflect the loss of revenue for the producer, intermediate consumption should be deducted from turnover in agriculture. Rather than the value of production, it is the value added which should be used[20].
- Production requires other assets which are involved in production by providing services, payment for which is not included in intermediate consumption, but which is nonetheless involved in the share-out of value added (payment for labour and physical produced capital). Hence only part of the value added corresponds to the benefits relating to the services provided by ecosystems[21].

This study tends to measure the value of benefits related to services rendered by marine ecosystems, leaving intermediate consumption out of the equation and therefore taking value added as the basis[22]. The same approach is also followed by Lange and Jiddawi (2009), although these authors do not distinguish within value added the contribution made by environmental assets and that of other factors. Once again, the result is an over-estimation of the benefits.

Value of benefits evaluated under the revenue or production-based approaches

Implementing the economic evaluation of the benefits from ecosystems may be a complex task; from the conceptual point of view, however, the value of benefits is relatively easy to formulate. There are two options:

- Either a situation in which the production of benefit needs natural capital to be combined with other factors;
- Or a situation in which the benefit provided by services rendered by ecosystems is obtained by only using services provided by natural capital.

In the first case, payment for the services provided by natural capital can be called a resource rent[23]. The more abundant the resources (there is a high volume of exploitation) and the easier to

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review of the available literature. Dependency is nil if the coefficient is equal to 0; the impact on production is then negligible. Dependence is total if the coefficient is equal to 1, the harvest in this case being nil in the absence of pollinating insects. In the studies mentioned, the values of this coefficient are strictly below 1.

19 Assessment procedures of the same type lead Bruke et al. (2008) to over-estimate the value of the benefits.

20 The value of production, including intermediate consumption, therefore, as an approximation of the value of benefits is frequently used in studies proposing an economic evaluation; this is particularly the case for Costanza et al. (1997, 1999) and Merlo and Croitoru (2005).

21 Moreover, in a situation where the service provided by an ecosystem disappears, part of the factors rendered inactive could be reallocated for use in other activities. The revenue produced by these factors would therefore not totally disappear. The inter-sectoral reallocation of production factors may be costly and take time, but that does not fundamentally challenge our objection.

22 Since it was not possible to calculate capital depreciation for every activity and Mediterranean riparian countries, it is the gross value added which is considered in the study.

23 The OECD glossary of statistical terms defines "*resource rent*" as follows: "*The economic rent of a natural resource equals the value of capital services flows rendered by the natural resources, or their share in the gross operating surplus; its value is given by the value of extraction. Resource rent may be divided between depletion and return to natural capital*". This appears to be the most complete and most relevant definition. It should be noted that the term is translated into French as resources rent (in the plural) but the glossary does not propose any translation of the definition in French.
Source : http://stats.oecd.org/glossary/detail.asp?ID=2332

exploit they are (the contributions from other factors are minimal), the higher the resource rent. It is paid to the natural asset holders when the assets can be appropriated (property rights). If that is not the case, a virtual resource rent can be deemed to exist in the sense that agents (public or private alike) acting as the representatives of natural capital could demand payment by the users. When no payment is made, it means that the holders of the other factors of production (labour, physical produced capital and possibly human capital) capture the resource rent.

There are two possible methods for evaluating the resource rent:

- If the natural capital is deemed to be a factor of production in the same way as physical (man-made) capital and labour, all the factors of production are paid for at their marginal productivity, with optimal quantities of factors, in other words for which the ratio marginal productivity to price is the same for all factors; labour and physical produced capital are paid for at their marginal productivity level, which correspond respectively to the wage level and the sum of the interest rate and the capital depreciation rate. Payment for natural capital can be identified by a right of access where such a right exists and if its price is fixed by a market mechanism. Where no right of access exists, the value of the benefit is implicitly nil.
- If the natural capital is deemed to be a factor with specific features because of its scarcity (since it cannot be produced by man or substituted), it is paid for by a scarcity rent, which can be identified as a Ricardian differential rent. This rent corresponds to what remains of the added value (difference between the value of the product and the value of intermediate consumption) after the services of labour and the physical produced capital have been paid for. Such is the case for agriculture, with the rent being determined by natural fertility, all things, in particular technology and the productivity of labour and the physical produced capital otherwise being equal[24].

As will be seen later, the SEEA takes an approach in terms of differential rent. But this results in practical difficulties, since for most economic activities the calculation can yield a nil or even negative rent. This calculation method does not seem satisfactory, but in the meantime it appears practically impossible to assess the value of natural capital and its productivity.

The study is therefore anchored in a revenue-based approach and the endeavour is made to evaluate that portion of value added which effectively depends on the contributions from ecosystems in the knowledge that, in practice, it may constitute part of the economic agents' revenue (households, businesses and public administrations), a share which corresponds to the resource rent captured by these agents.

In the second case, which corresponds to a situation in which the benefit is obtained by using the services of natural capital alone, the economic value of these benefits can be assessed using a production-based approach. Since the capital is the only factor of production, there is no payment for any other factors and the value of the benefit thus corresponds to the total value added created. Moreover, there is no intermediate consumption since the ecological contributions supporting the production of benefits are not traded on the market, thus the value added is equal

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In this study the term "resource rent" refers to this definition and is employed in the singular to indicate the ecological resource rent, including extraction resources and regulatory and cultural services.

24 *« The rent is governed by the fertility of land, the price of the produce, and the position of the margin: it is the excess of the value of the total returns which capital and labour applied to land do obtain, over those which they would have obtained under circumstances as unfavourable as those on the margin of cultivation. »* (Marshall 1890). *« There is therefore no surplus and the rent identifies fully with the rental for the land. »* (Clark 1899).

to the value of the product[25]. Thus in this case, the value of the benefit is equal to the physical flow produced multiplied by its unit value[26].

Disregarding the problems relating to the measurement of physical flows (mentioned in the following section and subsequently in more detail in part II), the unit value can be seen as the market price for this benefit when the ecosystems produce a benefit deemed to be comparable to the one provided by companies[27], i.e. to a finished product. When no unit market price exists, it is possible to adopt a variant, which consists of using reference prices (set by the authorities representing the company) as unit values. A further possibility consists of using social opportunity costs, known as *accounting prices* (Tinbergen, 1954) or even shadow prices (Dasgupta *et al.*, 1972)[28]. Finally, when there is no measurement of the opportunity costs nor any other measurement of the unit values estimated by direct evaluation methods, the substitution (or replacement) costs method can be used whilst observing the markets for goods or services which can be substituted for the benefits provided by ecosystems considered in relation to their main utility[29].

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25 Still under a production –based approach, it can also be taken that the economic value of the benefit corresponds to the value of the capital stock multiplied by its marginal productivity. However, since stock value and marginal productivity tend more often than not to be unknown, this method cannot be applied in practice.

26 The added value can also be deemed to be equal to the expenditure (effected or avoided) of economic agents using this service. In the report by Chevassus et al. (2009), this principle is applied to hunting, where the value of the benefits picked up by the hunters is equal to the value of the total expenditure incurred in order to hunt.

27 For example, carbon sequestration, with the unit value (per tonne) in the case of emissions reduction being seen as equivalent to the unit value of the carbon sequestered.

28 The shadow price of a resource is the theoretical price which the user is prepared to pay for an additional unit in an optimisation situation (equalisation of the marginal utility/price ratios for all goods and services in the case of the consumer and marginal productivity/price of the various factors in the case of producers). Shadow prices depend on 4 factors: the concept of social well-being, the size and composition of stocks of assets, possibilities for production and substitution between goods and services, and the provisions for allocating resources in the economy (Dasgupta, 2001: 123).

29 See in particular the section on the benefits relating to protection against erosion in part II.

4. Application to the Mediterranean marine ecosystems

This section presents the ecosystems, ecosystem services and benefits considered as well as the sustainability coefficients used to evaluate the contributions made by the ecosystems.

4.1. The marine ecosystems considered

The services which ecosystems provide depend to a great extent on their features. It was important to define certain major types of ecosystems for which information is accessible as regards their functional features and the area they cover so that the benefits related to these services can possibly be related to unit areas. In fact, there are enormous gaps in what we know about these ecosystems compared with our knowledge of terrestrial ones. Although plenty of one-off studies have been drawn up, information about the area covered is very limited. Indeed, the mapping of marine habitats makes use of relatively recent techniques (side-scan sonar, underwater video) which are expensive to use. Moreover, satellite imaging, which is widely used to portray terrestrial ecosystems, yields precious little information about marine ecosystems. It was therefore a case of making do with a handful of ecosystem types.

This section gives a broad overview of the features of the Mediterranean marine ecosystems and presents the classification chosen for this study.

4.1.1. Specific features of the Mediterranean marine ecosystems

This section has mainly been taken from the Marine Ecosystems chapter of the MAP-UNEP (2009) report on the state of the environment and development in the Mediterranean.

The Mediterranean is one of the world's 25 hot spots for biodiversity. Whilst constituting a mere 0.8% of the total area of the World Ocean and 0.3% of its volume, it is home to 7-8% on average of all marine species currently known. This vast wealth of biological diversity should be considered within the context of the basin's specific geo-morphological features, its geological history and its location as an interface between the temperate and tropical biomes, enabling it to support both warm and cold-adapted species able to cope with its marked seasonal nature. Over half the Mediterranean marine species are natives of the Atlantic Ocean, 4 % are « relic » species, testimony of times way back in history when the Mediterranean had a tropical climate, and 17 % have come from the Red Sea. The latter category contains both very ancient species, which date from the times when the Red Sea and the Mediterranean comprised a single entity, and species which recently entered the Mediterranean after the Suez Canal was built, for example, and which are deemed to be introduced species. The high percentage of endemic species[30] present (over 25 % of recorded species) can also be attributed to the history of the Mediterranean. This exceptional wealth of flora and fauna is relatively unequally distributed, depending on distance from the coast, longitude and depth. There is greater diversity, for example, in the western basin, whatever the taxonomic group being considered. Similarly, at bathymetric level, almost 90% of the known benthic plant species and over 75% of fish species are to be found in the shallow

30 Which only exist in the Mediterranean.

waters (from 0 to 50 m) although they account for a mere 5% of Mediterranean waters. The coastal zones (between 0 and 100 m) support some major ecosystems, the main ones of which are the magnoliophyte beds and the coral concretions.

Magnoliophytes are land-based flowering plants, which returned to the marine environment some 120 to 100 million years ago. There are about sixty species around the world, of which five are to be found in the Mediterranean (*Cymodocea nodosa*, *Halophila stipulacea*, *Posidonia oceanica*, *Zostera marina* and *Zostera noltii*), which form vast underwater meadows (also known as beds) at a depth of between 0 and 50 metres in the open seas and in the brackish and saltwater coastal lagoons.
Amongst these species, Posidonia (*Posidonia oceanica*), a species endemic to the Mediterranean, plays a key role, often compared to that of the forests. The Posidonia beds comprise the leading Mediterranean ecosystem in terms of biodiversity, since they support a quarter of its recorded marine species over an area estimated to cover almost 1.5% of the seabed. A spawning ground and nursery for many commercial species and the source of major primary production, the beds constitute one of the Mediterranean's sensitive habitats for preserving sustainable non-industrial fishing. Playing an important role in oxygenating the water, they trap and fix sediment (like beach-grasses on the dunes). By protecting the beaches against erosion (by reducing hydro-dynamism and by trapping sediment in the matte) and by encouraging water transparency, they are the guarantors of seaside tourism and provide an effective tool for monitoring the quality of coastal waters. Finally their roots, which grow in the substrate, together with rhizomes form the duff, which traps carbon at length, thus being instrumental in the sea's absorption of man-made CO_2.
The corallogenic reefs are the Mediterranean equivalent of the inter-tropical coral formations, albeit not as spectacular and without the same structure. Corallogenic concretions are built up through the accumulation of calcareous algae (mainly corallinales of the *Mesophyllum* and *Pseudolithophyllum* type), which grow in poor light conditions. Such concretions, which are common throughout the basin with the exception of the Israeli and Lebanese coasts, are mainly to be found at a depth of between 40 and 120 m, but also closer to the surface in caves, on the vertical walls and in poorly lit spots. They provide a home for a vast range of sessile invertebrates (bryozoans, gorgonians, sponges) and comprise the second Mediterranean ecosystem in terms of biodiversity, with over 1,700 species, a high percentage of which are endemic. The species associated with the corallogenic reefs comprise 75% invertebrates, 19% macrophyte algae and one hundred or so fish species[31]. A large number of the species present are of commercial interest and their traditional exploitation dates way back in history (e.g. sponges, red coral). The concretions also host many small sharks.
The Mediterranean deep-sea ecosystems have only recently started to be studied on a systematic basis (WWF/IUCN, 2004). Albeit relatively poor when compared with ecosystems in the Atlantic ocean, given the particular paleoecology and the marked oligotrophic nature of the Mediterranean sea, the Mediterranean deep-sea biological communities present a markedly endemic nature and some remarkable points of biodiversity, such as canyons, deep-water corals, seamounts or deep saltwater lakes, which house a unique fauna of which little is yet known. These particular ecosystems are exceedingly fragile, sensitive to macro-waste and chemical pollutants and are undergoing procedures to protect them, from certain types of fishing in particular.

With the exception of the habitats mentioned, the information available is extremely patchy and varies widely from one sector of the Mediterranean basin to the next. Looking at the Posidonia beds alone, which for two decades have benefited from numerous specific study programmes, it has to be said that, in spite of the fact that their theoretical distribution is known and they cover

31 S. Grimes (Pers. com. 2010).

an area estimated at 35,000 km², in some Mediterranean riparian countries only a tiny stretch of coastline has been inventoried.

4.1.2. Classification of the ecosystems used for the study

In order to gain clearer understanding and to better protect them, the Mediterranean marine ecosystems were classified. The Regional Activity Centre for Specially Protected Areas (SPA/RAC) thus drew up a reference list, which identifies 27 major types of benthic habitats in order to assist the Mediterranean countries with their inventories of natural sites of conservation interest.

This list draws to some extent on the one drawn up by EUNIS, the European Nature Information System. This system with its 4-level hierarchy ranks marine (A) and coastal (B) ecosystems at the very top. On the next level down, the marine ecosystems comprise 8 sub-classes, 7 of which apply to the Mediterranean, and with the categories depending on depth (coastal, infra, circalittoral, deep sea and the water column) and the nature of the substrate (loose or rocky). Some specifically Mediterranean marine ecosystems are on levels 3 and 4, which would give a total of twenty or so classes.

It was considered that the gaps in knowledge did not permit this level of detail to be established. Following a bibliographic study and scientific opinion, a compromise was reached between the available knowledge on the one hand and, on the other, those categories of ecosystem which are most characteristic of Mediterranean biodiversity and most subject to relations with human activity. This gave rise to the following classification, with an initial assessment of the area involved throughout the Mediterranean:

From the coastline to the 100 m isobath:

- Posidonia beds: 35 000 km²
- Corallogenic formations : 108 500 km²
- Rocky seabed with photophilic algae: 108 500 km²
- Seabed with a soft substrate: 217 000 km²

Beyond the 100 m isobath:

- Open seas, including both pelagic and benthic ecosystems, for the rest of the basin, i.e. around 2 066 000 km².

The area of Posedonia beds chosen has been the subject of assessments reported in scientific literature (Pasqualini *et al.*, 1998). For want of anything better, the area distribution between the following three circalittoral ecosystems was established within the framework of this study following scientific opinion. It is based on a proportion of the area measured on the bathymetric map (GEBCO) between the 0 and 100 m isobaths, inferred area of beds: corallogenic (25%), rocky seabed with photophilic algae (25%) and seabed with a loose substrate (50%).

Estuary and lagoon ecosystems were not specifically identified in this exploratory study and are therefore included amongst the sea-beds with a loose substrate.

Coastal ecosystems are defined as terrestrial ecosystems under the direct influence of the sea, including sea spray, featuring halophilic vegetation in particular. In EUNIS, they are broken down into three sub-classes. In this study, coastal ecosystems are deemed to be adjacent to marine ecosystems for the services generated by the so-called cultural function of benefit to activities in the coastal zone. Their features were not described in detail.

4.2. The benefits considered

The benefits taken into consideration in the study refer to two main situations:

- Dependant on the provision of ecological services,
- Being sustainable by reference to the state and functioning of marine ecosystems.

For the first alternative, it should be borne in mind that ecosystems are composed of biotic elements as well as abiotic ones (water, sediment, active chemical compounds, nutrients, plants, animals...). Interactive processes (physical, chemical or biological) between these components and between ecosystems allow them to perform these functions. In turn, the functions determine the capacity of the ecosystems to produce ecological services, which can themselves be instrumental in providing benefits to human users. Although no consensus exists, many authors believe that the notion of ecosystem services should be reserved for cases where the biotic elements are at least partly involved in the processes which generate these services (Haynes-Young, 2010). The term "natural structure" has been proposed for groups comprising purely abiotic elements, such as seawater, wind, rocky substrate, minerals... Unlike natural structures, ecosystems are characterised by their ecological resilience, their capacity to start functioning and developing again after having undergone a major disturbance, whether of human or natural origin. This notion is particularly useful for describing relations between the state of the environment and man's use of resources (Walker, 1995). Since this study aims at shedding light on ecosystem management policies, attention will be paid to the ecosystem services generated by ecosystems for which man has shown in practice his capacity to intervene in their resilience, either negatively through disturbances or positively through protection or even restoration activity.

The result of this approach is to exclude from the study those benefits which are generated by uses based on natural structures, as is the case for the production of marine wind energy, shipping or mining (aggregates, desalination…)[32].

A borderline case of an ecological service was addressed within the framework of this study. This ecological service contributes to the sea's function of regulating the local climate and is of benefit to agricultural activity in the Mediterranean and to terrestrial ecosystems, thus making a whole raft of activities possible; the case in point is the rain which falls on the catchment basin as a result of marine evaporation. The water cycle process is abiotic, however the useful portion of this rainfall generates a genuine ecological service in terms of the terrestrial ecosystems located in the catchment basins which receive this water from above. Moreover, this water, recharged with terrigenous nutrients, finds its way back to the sea where it feeds complex biotic and abiotic processes. Although this ecological process is mainly abiotic, this service was evaluated at an early stage of the study, before its contradiction with the framework of the study became clear. It was consequently decided to withdraw this evaluation from the body of the study but to retain it in the appendix 6 as an illustration of a specific valuation method using shadow prices.

As far as the use of renewable resources is concerned, or uses implying negative externalities on marine ecosystems, sustainability coefficients applicable to revenue relating to these uses were sought. Given the current state of knowledge and the exploratory nature of the study, it was not possible to assess coefficients for each of these uses.

Evaluating the benefits provided by ecosystems requires the beneficiaries to be identified. This study is based on data available for the direct beneficiaries of ecological services, usually located

32 These activities, based on natural structures, may lead to degradation in nearby ecosystems. Such activities should therefore be taken into account within the framework of a study on the cost of ecosystem degradation.

in the coastal zone of the Mediterranean riparian countries. Man-made CO_2 sequestration is the only exception, since the global population in its entirety benefits from this ecological service. It should be recalled at this stage that the study focuses on the economic value of the benefits and not on the beneficiaries. The dependent links between individuals and the benefits provided by ecosystems are therefore not addressed within this study.

Taking account of data availability, it was possible to evaluate five types of benefit. They refer to five generic ecological services[33] : production of food resources, provision of amenities, provision of support for recreational activities, climate regulation, the mitigation of natural hazards and the treatment of waste. The corresponding benefits were evaluated on the basis of either the resource rent attracted by private sector economic activities or value (reference value, cost of substitution, social opportunity cost, for example) when the benefits are collective.

The following table (table 1) illustrates the ecosystem services and activities considered in the study according to the estimated contribution or benefit.

Table 1: Affiliation of the benefits assessed

Categories of ecological services	Ecological services	Benefits evaluated
Production services	Production of food resources	Resource rent relating to the production of food resources of marine origin
Cultural service	Amenities and support for recreational activities	Resource rent relating to the provision of amenities and recreational support
Regulatory services	Climate regulation	Value of anthropogenic CO_2 sequestration
	Mitigation of natural hazards	Value of protection against coastal erosion
	Waste processing	Value of waste processing

4.3. Identification of the economic value of the benefits from marine ecosystems

The nature of the services rendered by marine ecosystems gives rise to specific difficulties as far as the evaluation of the ensuing benefits in economic terms is concerned. The physical flows from these ecosystems have been studied on many occasions, although they have not necessarily been identified in quantitative terms and converting them into monetary units usually gives rise to complex problems.

Lack of appropriation of natural capital

Even though there is no major problem with understanding the value of the benefits relating to the services rendered by marine ecosystems in theoretical terms, the monetary evaluation of the flows corresponding to these benefits runs up against difficulties. These relate to the fact that the very notion of property rights over natural capital finds few specific applications in the marine or even the coastal environment, unlike quite a number of terrestrial ecosystems, such as farming land and forests in particular. User rights for natural assets or services provided are rarely traded

33 Within the framework of a study taking account of changes in the provision of ecological services, other services and types of benefits could have been evaluated, such as stability or ensuring a certain level of provision for each of these services, allowing players to pre-empt the evolution of their environment and to make investments, to abandon certain uses to limit future losses, etc.

on the markets; only some products harvested within the framework of human productive activity have a market value. For most of the services identified, there is no cost of access to resources (in the sense of paying rights); and where this cost does actually exist, it cannot be directly observed[34]. In this respect, the distinction between non-market and market natural capital, established in particular in work on analysing sustainability conditions (appendix 7)[35] is of limited interest for this study.

Since the appropriation of natural capital is either impossible or unimaginable within the current institutional framework, the implicit value of the stock of natural capital revealed by collective choices is nil. There is no need to estimate marginal productivity to deduce that the benefits therefore have a nil theoretical value.

It is, however, useful to distinguish between those services for which appropriation is materially impossible and other services, which in practice are not subject to rights of access, but for which it would be technically possible to introduce such rights. This is notably the case for fisheries where, within territorial waters or Exclusive Economic Zones (EEZs), market mechanisms for accessing the resource are a possibility, through auctioning, for example[36].

The distinction between appropriable and non-appropriable assets largely overlaps with the distinction drawn in section 2-2 between:

- Assets that, in order to be effectively used, should be involved in a production function along with labour, human capital, and man-made physical capital (such is the case in fisheries, for example);
- Assets useful for mankind in the absence of any non-ecological intervention (carbon sequestration by the oceans, for example)[37].

As was seen in section I.2.2, this distinction overlaps with the distinction between benefits whose value can be identified as a resource rent paying for the natural capital and those benefits whose value needs to be estimated by a production-based approach. Economic valuation of these two types of benefit will be examined in the case of marine ecosystems, and the sustainability of these benefits will be assessed.

Sustainable benefits from marine ecosystems regarded as equivalent to the value of the sustainable resource rent

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34 One of the rare exceptions is shellfish farming, where the resale price of usage rights to the areas in which the farms are located can be compared to rights of access to the resource (Montgruel et al., 2008).

35 The term non-market natural capital is used here to refer to that share of renewable resources which corresponds to the environmental services of providing amenities, regulating and supporting the biosphere. The term market natural capital is used to refer to the other renewable resources as well as the non renewable resources used.

36 The implications of under-evaluating environmental resources in terms of guiding technical progress have been studied by Dasgupta (1996). The cost of substituting natural resources by physical capital may be high and affordable substitutes may prove prohibitive when shadow prices are used instead of the market price. The depletion of certain types of natural capital and the substitution by man-made capital can therefore prove socially costly. Thus the introduction of market mechanisms allows these social costs to be reduced.

37 However, it can be noted that in certain cases the amenities in the marine area, which depend on services provided by natural assets which cannot be appropriated, only generate benefits for man, which could give rise to an economic evaluation, when the natural capital is combined with human factors of production or ones produced by man. Such is the case when amenities linked to the aesthetic and climatic qualities of the coastal area are combined with terrestrial natural assets, with produced capital corresponding to residential constructions and labour factors and with human capital to produce services in the real estate sector.

The concept of resource rent, referring here to the payment which should be made in exchange for the services rendered by natural capital in a situation where several factors of production are involved, would appear to lend itself to evaluating the benefit provided by marine ecosystems in the fisheries sector (fisheries rent). This concept is also applicable to benefits received by other activities using natural capital, such as the hotels, real estate, and tourism.

The resource rent can be specifically measured under two conditions:

- Identifying the threshold of use for resources beyond which the rent can be deemed to be sustainable;
- Identifying the share of value added corresponding to the resource rent. In practice the latter can be captured by agents who do not represent environmental assets, meaning that the rent is actually used to pay for labour and the physical produced capital (in the real world, as opposed to the theoretical realm, factors are not necessarily paid for according to their marginal productivity).

The evaluation of sustainable benefits, taking account of the depreciation of environmental assets with prospects of strong sustainability, excludes that share of benefits corresponding to the consumption of natural capital. This approach can clearly be applied to the case of fisheries, where over-fishing corresponds to a non-sustainable activity leading to the consumption of natural capital. For certain abiotic assets, the rate of depreciation can be regarded as nil. This is the case, for example, with aesthetic and climatic type amenities, which are instrumental in increasing the value added in the hotel business in the coastal areas, compared with otherwise comparable establishments situated inland[38].

As noted in section I.2.2, identification of that part of value added corresponding to the resource rent may depend on measuring the differential rent. This is the approach adopted in the SEEA, which specifies that the fisheries rent may happen to be nil when nothing is left of the value added once the other factors have been paid for. It may even be negative if subsidies come into the equation.

It does not does acceptable to regard the resource rent as nil. Environmental asset productivity is clearly not zero; fishermen continue to land their catches. If natural capital is paid for at its marginal productivity or somewhere near that level, a nil figure for the resource rent would imply that the value of natural capital is nil.

As far as marine ecosystems are concerned, in its 2003 version the SEEA does not envisage the resource rent being evaluated for any other benefits apart from those relating to fisheries. There is, however, a resource rent in the tourism section and in real estate in the coastal zones, particularly in the Mediterranean. A calculation based on the assessment of the Ricardian rent would once again result in a nil value. The use of indirect methods for assessing the share of the rent in the value added of these sectors should therefore be envisaged.

Estimation of benefits from marine ecosystems according to a production approach

When the benefits from ecosystems are obtained using the services rendered by natural capital alone, the study gives priority to a production-based approach. As far as marine environmental

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[38] The services provided by these assets, however, are sometimes associated with the consumption of terrestrial natural capital; this could in particular refer to non-lagoon type wetlands close to the coast, which are known for their great value and provide remarkable services, since such areas are destroyed so that they can be converted into land for real estate. The scope of this study is limited to marine ecosystems and there is no suggestion of evaluating the impact on terrestrial ecosystems.

assets are concerned, this type of benefit corresponds to climate regulation and other services relating to regulatory functions. The benefit is then assessed as the product of physical flows by unit values. There is no intermediate consumption since only one factor of production is involved. Thus, as was seen in section I.2.2, this could also be taken as a expenditure approach.

Thus the monetary assessment of the flow of benefits must be based on information on physical flows and data or estimates of unit-prices. One initial method, which could be regarded as acceptable for certain services, involves assessing prices on the basis of substitution costs (replacement, avoidance, protection); this is the method mentioned in the SEEA for ecological services give rise to non-market or collective uses. In certain cases there is no substitution cost.

This study does not use prices assessed in surveys aimed at establishing stated preference and avoid as far as possible prices revealed by indirect methods. Consequently, in most cases the unit reference value corresponds to prices obtained by direct methods: market prices and, when unavailable substitution (or replacement) costs. For certain services, estimations of the social opportunity cost, otherwise known as shadow prices, are used.

Another method should be envisaged for other ecological services rendered by natural capital, for which substitution costs exist, when at first sight there are no physical flows for these services. The lack of information about quantities is either related to the lack of knowledge about flows in volume terms[39] or to the fact that assessment of these services depends on social standards, in other words on levels in volume terms determined by collective choices.

In the latter case, these services can thus be compared to merit goods, for which the socially desirable level does not necessarily correspond to the level of individual optimisation[40]. The benefits need to be assessed according to generalised practices or by public bodies or authorities. The physical flows of services are determined by the characteristics of ecosystems, but the acceptable level of use of these services is set according to collective choices at local, national or supranational level.

For certain benefits, particularly waste treatment, both price and quantity are set by the responsible authorities, since the cost of replacement depends on the volume and is not known with any precision. These are then reference values. This corresponds to the approach inspired by Ciriacy-Wantrup (1952) and also used by Baumol and Oates (1971) and Bishop (1978), who recommend that environmental safeguard standards[41] should be determined independent of any economic optimisation. These correspond to critical usage thresholds for natural capital, which agents strive not to exceed at the least economic cost and using available technology[42].

The second part of this report presents the assessment method used for each benefit assessed.

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[39] In which case, estimates must be used, as was notably the case when the benefits relating to protecting the coasts against erosion were calculated.

[40] A comparable situation can be seen in other areas, for example when household education expenditure may well turn out lower than what might be seen as socially desirable, thus justifying public funding in certain cases.

41 This approach was also adopted by the authors of the biodiversity assessment handbook (OECD 2002).

42 The green national accounting techniques developed by certain countries, the Netherlands in particular, are based on the combination of rents and standards, with a ratio between the net domestic product (NDP) expressed as Y and the NDP adjusted for the consumption of natural capital (expressed as Y*) corresponding to the following equation (Hueting, 1991) :

$Y^* = Y - Rr - Cnr - Cna$ (where Rr is the aggregated scarcity rent for non renewable resources; Cnr is the cost of compliance with environmental norms for renewable resources, which corresponds to their rate of renewal; Cna is the cost for achieving waste emission standards, which corresponds to the environment's assimilation capacity).

II. Evaluation of the various types of benefits generated by the Mediterranean marine ecosystems

This chapter presents the various types of benefits considered and describes the economic evaluation methods used.

1. Benefits linked to the production of food resources

The natural resources provided by marine ecosystems lend themselves to various extractive activities for food, ornamental or industrial ends. Fishing and aquaculture (shellfish and fish farming) are the leading activities which extract marine resources in the Mediterranean, far outstripping the harvesting of salt, red coral or aggregate. Aquaculture is mainly based on the support provided by the sea, but is nonetheless taken into account by this study for the following reasons:

- Fish farming at sea and in lagoon areas requires food resources produced by marine ecosystems[43] in order to feed the species being bred;
- Shellfish farming is based on physical support but also the use of local food resources, since breeding requires no food input for the species to be harvested. Production, moreover, is highly sensitive to variations in the quality of the environment and the quantity of locally available food resources;
- Statistical information (particularly value added and active population) is usually only available in aggregate form for fisheries and aquaculture.

1.1. Method of assessment and results

The contribution made by marine ecosystems to fisheries and aquaculture gives rise to an income captured by various economic agents as a resource rent. This rent represents a share of what has been identified as fishing rent. Moreover, only a share of the resource rent can be regarded as sustainable.

1.1.1. The composite nature of the resource rent in fisheries

The resource rent in fisheries has certain similarities with the land rent in agriculture or forestry use, but it is absolutely essential that the implications of the lack of access rights for the

43 In certain cases, these resources come directly from fisheries in local or geographically close ecosystems, without processing by manufacturing industry (for example, in Croatia, anchovies and sardines used to fatten farmed tuna); in most breeding centres, the food comes from the processing of fisheries products from more exotic ecosystems (catches of species used virtually exclusively by industry to produce food for farmed fish or a by-product from the processing of other species, the production of which is intended for human consumption).

exploitation of these resources[44] and the structure of the market for fisheries products should first and foremost be taken into account. The analysis proposed by Mongruel (2000), based on Clark and Munro (1980) takes account both the risks of the non-sustainability of the activity as a result of over-fishing, and the existence, downstream from fishing, of processing activities capturing part of the resource rent. Since most fishing zones are accessible without restriction to a large number of users, whose main aim is to maximise their net individual income, the lack of cooperation leads to overfishing. One of the first analyses of this phenomenon was conducted by Gordon (1954) and foreshadows Hardin's *tragedy of the commons* (1968)[45].

The fisheries industry typically comprises a highly competitive primary production sector facing a commercial (and manufacturing) sector, which usually enjoys oligopsonic powers over the fishermen, and an oligopoly over the market for finished goods[46]. The outcome of this is a composite fishing rent consisting into three types of components[47] :

- *Differential productivity rents*: it is, however, difficult to distinguish the share which can be attributed to the productivity of the resource from the share attributable to the productivity of factors of production other than the resource;
- *Resource rent as such*: all the factors of production, including natural resources, generate a revenue equal to the surplus of the marginal producer;
- *Monopoly (or oligopoly) rent*: this emerges from the concentration of demand for fisheries products and the supply of finished goods.

A tragedy of the commons mechanism is played out between the various categories of players in the same industry, the trigger being the unfair distribution of the composite rent. This results in a temporary advantage for a group of agents (or some of them), who prefers to adopt a short-term strategy for maximising the temporary advantage rather than a long-term strategy to maximise the rent. It is actually impossible to predict how the share of the rent captured by the fishermen, on the one hand, and in downstream activities, on the other hand; this is particularly due to uncertainties surrounding the volume of catches, even in a situation of sustainable resource management.

1.1.2. Assessing the resource rent in fisheries and aquaculture

Identifying the components of the rent does not, however, provide an answer about how to measure them. The aim is to assess the resource rent in monetary terms, the value of which corresponds to the contribution made by ecosystems to the fisheries sector. The 2003 version of the SEEA manual proposes a calculation method for a Ricardian differential rent for fisheries, based on national accounting data, which usually produces a nil value. In fact the entire value added is used to pay for the services of labour and capital (appendix 8). The SEEA specifies that the rent can even turn out to be negative due to subsidies (UNEP/ETB, 2007). This approach,

44 Unlike the situation prevailing in agriculture or forest exploitation, where it is easier for a producer to adopt strategic choices and techniques aimed at preserving the resource.

45 The efforts undertaken to limit the effects of overfishing have led to the creation of the Maximum Sustainable Yield (MSY). For reasons related to the dynamics of ecosystems, the MSY is not a satisfactory indicator of sustainability (Bell & Morse 2008, 57). It is therefore necessary to use a sustainability criterion other than the MSY.

46 This is a simplification; the wholesale trading sector tends to be separate from the manufacturing and retail trade sectors. Each of these three sectors has oligopsonic and oligopolic powers. This does not bring into question the existence of a composite rent and what ensues. In the case of small-scale fishing, it is often the fisherman himself (or a member of the same household) involved in the direct marketing of the product; in principle, it is possible to distinguish incomes from fishing from income related to the commercialisation of the marine products.

47 Mongruel (2000, 95-96).

which is based on the concept of residual rent, is not a satisfactory one, since it is simply the result of natural capital not being developed.

Ideally, in order to assess the value of the contributions made by marine ecosystems to the fishing sector, information should be available on the characteristics of the production functions in the fisheries sector, in order to assess the quantities of factors used, their unit price (shadow as far as natural capital is concerned), the marginal productivity curve for the factors in representative companies (all supposing that this concept is relevant; in terms of productivity, agents would appear to be highly heterogenic), as well as information concerning market structure.

Gross value added (VA) in fishing activity as such for each country is used as an initial rough estimate. This leads on the one hand to an over-assessment, since that share of the VA corresponding to the payment for labour and capital is not deducted; but on the other hand it also implies an underestimation, since what is probably a not insignificant share of the resource rent is actually captured downstream. Since most catches made by Mediterranean fishermen are intended for consumption rather than for processing by manufacturing industry, trade is the most important downstream sector. Not much is known about it, however, since circuits in the Mediterranean tend to be relatively short and are not channelled through auctions.

The SEEA takes the resource rent in aquaculture (fish and shellfish breeding) as nil. It is well documented, however, that shellfish production is sensitive to water quality. Moreover, fish farming uses the environment as a physical support for farming activity and the feed used comes from fishing. Thus aquaculture, like the fisheries sector, is based on the existence of a resource rent[48]. Since there is fundamentally little difference between the commercialisation of aquaculture products and fisheries products (significance of relatively short circuits, relatively small share of production intended for processing by the manufacturing sector), the method applied to approximate the rent in this study is the same as for fisheries.

1.1.3. Identifying the sustainable component of the rent

The SEEA manual mentions the non-sustainability of part of fishing, but does not provide guidelines for the calculation of the resource rent in the 2003 version of the manual. From the viewpoint of marine ecology, over-fishing has now been identified and recognised as a problem for numerous species. The European Environment Agency (EEA, 2009) states that 45% of European fish stocks have exceeded the biological safety threshold[49], as a result of over-exploitation. This over-fishing, which affects the quality of ecosystems and their resilience, is associated with a non-sustainable rent that should be distinguished from the sustainable fishing rent. The non-sustainable rent should be seen as the consumption of natural capital, not as a benefit.

Fisheries-related activities are a relatively important economic sector in the Mediterranean. According to the CIHEAM, there are some 300,000 fishermen, not including part-time jobs. The Mediterranean thus accounts for more than half of the number of fishermen recorded in the European Union. This result is a paradox since the Mediterranean Sea's is general an oligotrophic area. The highest level of primary production can be seen near areas of nutrient input (rivers in the north-western basin and the Black Sea) and also in the Alboran sea, which benefits from upwellings formed by the waters of the Atlantic entering the Mediterranean. Fishing is also

48 Several kilos of wild fish are needed to produce one kilo of farmed.

49 In any case, stocks of pelagic species (herring, grouper…) are in better state than the stocks of demersal species (cod, sole…) (EEA, 2009).

influenced by the size of the continental shelf, which is no more than a narrow strip apart from in the northern Adriatic, the Gulf of Gabes, the northern Aegean, the south of Sicily and the Gulf of Lion.

European countries such as Italy, Spain, France and Greece have large albeit shrinking fleets with high fishing capacity; the Maghreb countries (Morocco, Algeria and Tunisia), Libya, Egypt, Croatia and Turkey have considerable fleets but with lower fishing capacity; the other countries have only a limited coastline and small fleets.

It should be pointed out that fishermen from non-riparian countries such as Portugal but also Korea and Japan, the latter being a member of the General Fisheries Commission for the Mediterranean (GFCM), also operate in the Mediterranean. Although the catch volumes recorded- particularly in the case of Japan- look low compared with the overall volume, the species being sought tend to belong to the family of thonids, some species of which, like the bluefin tuna, are deemed to be over-exploited. Concerning Japan more specifically, although it declares a low rate of direct fishing, it plays a significant role as a reference buyer of bluefin tuna and as an investor and supplier of equipment.

Compared with other major global sectors, Mediterranean fishing is relatively stable overall, with landings peaking in 1995 to stabilise at around a million tons and lately following a downward trend.

The main species fished are: sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicholus*) for the small pelagics, hake (*Merluccius merluccius*), striped red mullet (*Mullus spp.*), blue whiting (*Micromesistius poutassou*), anglerfish (*Lophius spp.*), seabream (*Pagellus spp.*), octopus (*Octopus spp.*), squid (*Loligo spp.*) and the pink shrimp (*Aristeus antennatus*) for demersal fish species and, as far as the large pelagic species are concerned, bluefin tuna (*Thunnus thynnus*) and swordfish (*Xiphias gladius*) as well as other species of local interest at specific sites.

Although some highly migratory species such as tuna exist in the open seas, most fishing takes place within the coastal zone and therefore features large numbers of small boats engaged in multi-specific fishing, with many landing points. The complex nature of Mediterranean fisheries and the lack of EEZs facilitate neither the assessment of stocks and catches nor controls, and there is deemed to be a high level of illegal, unreported and unregulated fishing[50].

The Mediterranean is currently not affected by an international system of TACs (Total Allowable Catches), with the notable exception of the bluefin tuna. The GFCM makes recommendations concerning the Mediterranean fisheries with the International Commission for the Conservation of Atlantic Tunas (ICCAT).

To the north it is quite clear that fleets are overfishing resources. The populations of demersal fish are being overfished across the board: shallow areas (within 3 miles or at depths of less than 50 m) are often illegally trawled and illegal net sizes (undersized) are used (UNEP/SPA/RAC 2003). Driven by a highly profitable export market, the bluefin tuna is subject to massive overfishing in contradiction with ICCAT recommendations. A large share of catches is used to feed fattening farms, whose capacity now exceeds allocated quotas. Sea Around Us showed that for the year 2005, 55% of identified stocks were over-exploited and 20% had collapsed, the percentage reaching 20% and 2% respectively for catches. FAO in its 2004 annual report and the GFCM in its annual report provided a more detailed overview of the state of stocks and catches, based on one-off studies.

50 Regarding illegal, unreported and unregulated fishing see in particular (OECD 2004; Agnew 2009).

However, data available for the assessment of the rent only permits a global approach for all fisheries in the Mediterranean. With this constraint, it is suggested that the assessment proposed by Sea Around Us 2007 (Pauly, 2007) be taken i.e. 20% by value of non-sustainable declared global catches in 2005. The bluefin tuna is subjected to even more marked over-exploitation, which can be assessed at 50% of declared catches. To take account of the fact that aquaculture can be considered to be 100% sustainable (disregarding the growing scarcity of the resource used to feed farmed fish), the hypothetical catch sustainability coefficient of 80% has been established for all fishing and aquaculture activity, which brings the Mediterranean situation close to the global one. Due to a lack of information for the various zones, this coefficient has been homogeneously applied to all countries.

1.1.4. Data availability, extrapolation, and results

Data by volume concerning catches and aquaculture production is available for most countries, but other information is patchier. The available data therefore has to be used to extrapolate in order to assess the missing values for certain countries, with the assumption that producer prices and the technical features of the farms are comparable throughout the Mediterranean. Moreover, an adjustment is required in order to exclude activity in non-Mediterranean waters, particularly for those countries which, like Egypt, France, Israel, Morocco, Spain and Turkey, have a non-Mediterranean seafront.

Gross value added (VA) in the fishing sector (including aquaculture) is usually available in the Mediterranean countries' national accounts (harmonised data presented in the United Nations' UN Data[51] base) for 2005, which is the year of reference (or for years close by). VA is reported in UN Data in national currency and in US dollars. These figures have been converted into constant euro using the annual average national currency/dollar and dollar/euro conversion rates implicit in the national revenue figures reported in UN Data. In principle, the benefit should be assessed with tax included (the rent going to the State) and net of fishing subsidies (particularly for fleet modernisation). At this stage of the study, no adjustment has been made to take account of subsidies, given the lack of data at national level.

Catch volumes by country and by fishing area in the Mediterranean are available for the year of reference (2005) in the FAO and GFCM data bases. Apart from catches by volume at national level, it is therefore possible to calculate the catches made by the various countries in the Mediterranean and to estimate the share of VA corresponding to catches in the Mediterranean using a ratio of catches in the Mediterranean (GFCM)/total catches (FAO). The GFCM data on catches for Serbia has been used as a approximation of catches for Montenegro.

For certain countries such as Algeria, Egypt, Israel, Lebanon, Morocco, Montenegro, the Palestinian Territories and Syria the UN Data database does not contain any information about the VA for the fisheries and aquaculture sector (sector A_03 in the ISIC international classification of economic activities[52]). It only includes information for the A sectors in their totality (A representing farming and forestry activities). An extrapolation intended to estimate the VA for the A_03 sector was conducted using total catches in tonnes (FAO data), supposing the same VA (in Euros)/catches ratio as in Tunisia in the case of Algeria and Egypt, Italy in the case of Monaco, Cyprus for Israel, the Palestinian Territories and Lebanon, Croatia for Montenegro and Turkey in the case of Syria.

51 http://data.un.org/Data.aspx?d=SNA&f=group_code%3a203%3bsub_item_code%3a15
52 International Standard Industrial Classification of all Economic Activities

After applying a sustainability coefficient of 0.8 to the VA for the fisheries sector, a total of almost 3 billion Euros emerges for the Mediterranean as a whole. The data per country is presented in appendix 11.

1.2. Discussion of the results and prospects for revising the evaluation

1.2.1. Uncertainty regarding catches and the non-sustainable part of the rent

Various sources of information suggest an under-estimation of the catches measured by FAO. For species for which fishing quotas are set and checked, catches tend to be globally under-estimated[53]. This under-estimation of the amounts extracted from fisheries stocks is backed up by the existence of fishing practices, which are only slightly regulated if at all: recreational and sports fishing and subsistence fishing, which are common practices on all banks.

The difficulties with evaluating the non-sustainable part of the rent mainly stem from the wide range of local conditions:

- Sustainability varies by zone and species; knowledge about the interactions between species is limited and uncertainty exists regarding the loss of resilience and the risk of *hysteresis*.[54]
- There is, moreover, a tendency to underestimate catches for certain zones or species (illegal or unregulated catches)[55].
- The share of catches thrown back into the sea varies widely, since it depends on the regulations in force and the techniques used. It can be taken as being relatively low in the non-industrial fishing sector.
- Revenue transfers (subsidies) appear to be particularly high in the EU countries, where they can lead to activity being maintained even when the rent is low or even negative.

Non sustainable catches correspond to what the SEEA describes as the consumption of natural capital[56]. It would seem desirable to examine trends in resource rent and the consumption of natural capital in order to estimate a sustainability coefficient for the main species caught, which corresponds to the annual ratio of sustainable catches to total catches for a relatively long period of time covering, for example, the last two decades.

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53 For example, it is estimated that in 2004, 175t of sea urchins were removed from the north western Mediterranean basin as a whole (FishStat), whereas in the late 80s, Direac'h (1987) estimated that 350t of sea urchins were taken each year from the French Mediterranean coast alone. In France, 1 kg of sea urchins (the equivalent of about a dozen) sells for about 6€ ; in other words for 2004 to use FAO's figure, a turnover of about 1 050 000€.
54 The implications of these dynamics for the analysis of the value of services are underscored by Walker & Pearson (2007).
55 Agnew et al. (2009) propose estimates for the ocean areas alone, but their methodology appears to be transposable to the Mediterranean. Some information on the Mediterranean is also available from the OECD (2004).
56 The catches thrown back into the sea should thus be taken into account to estimate natural capital consumption in order to account for the degradation and effective depreciation of fishing stocks, since some of these throw-backs are no longer viable. Since this data is not available, the non viable rejected catches should thus be estimated on the basis of catches landed.

1.2.2. Uncertainties regarding value added (VA) and the share of rent in the VA, and prospects for improvement

For the countries for which there is no information in UN Data, the method applied is based on an extrapolation of the VA from catches. There is a possible alternative method, for active population and wage data are in fact available for the fishing sector for certain Mediterranean countries in the data collected by the International Labour Organisation (ILO-Laborstat). For the other Mediterranean countries, it would therefore be possible to extrapolate the VA from the active population, assuming the same VA/asset ratio as in a country for which all the data is available and which can be deemed comparable in terms of salaries in the sector and therefore in principle also of technology used in the fisheries sector.

The value of production tends to be under-estimated by FAO, particularly as far as non-industrial catches (or small-scale workers) are concerned. Since this type of fishing is widespread in the Mediterranean, this could lead to a general under-estimation of catches in this zone. In non-industrial fishing, the wage is often adjustable according to results.

It would be desirable to assess payments in kind (the fisherman's cut), since catches distributed in this way may well not be reflected in the trade flows measured by national accounting. Since sustainability levels have been determined as a function of an assessment of over-fishing thresholds, an upwards re-estimation of catches would not affect the level of the rent although it should lead to a reduction in its percentage share of VA.

A further source of under-evaluation of the VA would seem to lie in the difficulties with identifying revenue corresponding to the mixed income of skippers, particularly in non-industrial fishing (see for example Tzanatos *et al.* (2006) for Greece). Revenue is likely to be under-estimated, given the under-estimation of the volume of catches as a result of illegal fishing and undeclared catches, particularly for local fisheries and self-consumption (national accounting rules stipulate that self-consumption should be taken into account in the case of food products, but it is clearly difficult to apply them).

Depending on data availability, it would be possible for certain countries to recalculate the VA and to evaluate how sensitive results are to subsidies being taken into account. Data by Mediterranean state on subsidies can be found in Sumaila *et al.* (2006). Fixed capital consumption is shown in the national accounts of some Mediterranean countries. The stock of physical produced capital is not directly available, but it can be estimated for certain countries from the number of different types of vessels in the fishing fleets registered in the Mediterranean ports; the consumption of fixed capital can possibly be estimated from the stock. After adjusting production to take account of the probable under-evaluation of volumes, it would then be possible to recalculate the VA and check whether the implicit Ricardian rent is nil.

2. Benefits relating to the provision of amenities and recreational supports

Marine and coastal ecosystems provide ecological services in the form of amenities and recreational supports, which encourage various economic activities to set up on the coast or at sea. The marine ecosystems provide amenities linked to the landscape, the Mediterranean climate (including the sea breeze effect) and the clear waters[57], which are highly attractive. These amenities are conducive to the development along the coastline of hotel-related activities for non residents (meaning people not living in the neighbouring region) as well as restaurant-related activities, for residents and non residents alike. These amenities are also the reason why part of the physical produced capital accumulated in the real estate sector (again for both residents and non residents alike) has settled close to the coast. Turning to recreational supports, they open the way for specific leisure activities such as diving, water sports, swimming or Whale Watching[58].

For these economic sectors, the value added differential linked to the presence of marine and coastal ecosystems can be compared to a resource rent, which corresponds to the benefits yielded by these ecosystems captured by various economic players. The method adopted here aims at assessing this rent linked to the ecological services, taking as its basis revenue in three sectors of activity with a direct interface with the amenities and recreational supports on offer: hotels and restaurants, real estate, and tourism-related recreational activities. For each of these three sectors, the evaluation only looks at activity based in the Mediterranean coastal zone[59]. Adding together the estimated rents for these three sectors gives an assessment of the benefits provided by amenities and recreational supports.

For each sector of economic activity, the assessment of the value of the resource rent should ideally be based on the value added (VA) data reported in national accounting and an estimation of that share of the VA corresponding to the rent. However, given the international classification of economic activities (ISIC) and the ranking of activity categories, it was not possible to adopt the value added-based approach presented in the Mediterranean riparian countries' national accounting for all of the evaluations relating to the service of providing amenities and recreational supports. This approach was followed for hotels and restaurants on the one hand and for real estate on the other. The lack of information on value added in the various recreational activities meant that an indirect method of assessment had to be adopted, as presented hereafter.

2.1. Benefits in the hotel and restaurants and in real estate

The hotels and restaurants, on the one hand, and real estate, on the other, have the advantage of corresponding to two economic sectors identified as such by national accounts in compliance with international standards.

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57 Biologically speaking, this property does not point to the good ecological state of an ecosystem. Water clarity is, however, often cited as a major assessment factor, particularly for bathing activities. It is in this respect that water clarity is included here in the ecological service of providing amenities.
58 The flows of transient people have the knock-on effect of creating opportunities for other commercial activities (craft, clothing, transport), the rest of the economy also benefiting from the local dynamics generated by the attraction of the coast (food trade, real estate, energy, administration, infrastructure, etc.). These indirect effects are not taken into account within this study.
59 Defined for the European Union Member States as being all of the Eurostat regions in the territorial units nomenclature for level 3 Eurostat statistics (NUTS 3), typically comprising from 150 000 to 800 000 inhabitants, or their equivalent in the other Mediterranean countries.

2.1.1. Method of assessment and outcome

The amenities provided by marine and coastal ecosystems contribute to the well-being of residents and non-residents. The economic value of these amenities is often evaluated from the demand side, using information on willingness to pay, travel cost, or hedonic prices. This study adopts an estimation from the income side using prices revealed by direct methods, with a preference for market prices. This results in the value of the contribution made by ecosystems being assessed as a fraction of the value added (VA) achieved in the hotels and restaurants, and real estate.

For the share of activity in the hotels and restaurants located on the coast, the degree of attractiveness of an establishment depends critically on the presence of marine and coastal ecosystems[60]. Hence, part of the value added in this sector corresponds to a resource rent captured by entrepreneurs (and possibly to an extent by employees if the coastal establishments offer significant bonuses)[61].

Similarly, the value of real estate rental expenditures (and imputed rent calculated as part of national accounts) paid by residents and non-residents for housing occupied on a permanent or seasonal basis is influenced by the proximity of the coast. A real estate asset located close to the coast will have a higher value for certain given technical features for reasons relating to the ease of everyday or regular access to the coast, the effect of climate moderation (sea breeze) and aesthetic factors (landscape)[62]. These ecological factors are assigned to the ecological service of provision of amenities. An attempt could be made to assess the share of the housing expenditures (or imputed rents) corresponding to a resource rent captured by property owners.

Distinction between urban ground rent and resource rent

The means for shaping and distributing the rent relating to amenities are different to the ones which apply to the resource rent in the primary sector. In the hotels and restaurants, and real estate in the coastal zone, the resource rent is similar to the urban rent arising from real estate assets: the geographical location of the asset is the factor which really determines the rent. In certain sections of the coast, particularly on the Mediterranean islands, population density and the footprint of human activities on the environment are still low, whilst other sections are highly urbanised. It is therefore important to distinguish the purely coastal resource rent from the urban rent in the highly urbanised sections of the coastal zone. In the case of urban rent, hotels and restaurants, and real estate services enjoy positive externalities generated by activities in the geographic vicinity in other sectors. The hypothesis established is that, for hotels, restaurants and property located in the urban centres, the resource rent relating to the amenities provided by marine and coastal ecosystems is low, whilst the ecosystems make a major contribution to the VA in the areas only slightly urbanised.

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60 A study conducted in Israel shows that, all services being equal, room rates for hotels located at less than 2 km from the coastline are on average 39% higher than in hotels located further away from the coast (Gabbay, 2000).

61 It can also be taken that establishments located on the coast can attract more productive workers, without necessarily paying higher wages, owing to the existence of informal arrangements allowing workers to receive significant additional income in the form of much bigger tips than in comparable establishments at some distance from the coast; part of these tips can be regarded as resource rent.

62 A study conducted in the French *département* of Finistère (in Brittany) shows that the value of a property with equivalent material features was 78% higher if it also offered a « lovely seaview » (Muriel et al, 2006, quoted in Marandya et al, 2007).

The definition of coastal zone used here is based on the criterion of presence of halophilic plants. Since it is difficult to provide an accurate measure, this zone is approximated as a 100-metre strip, corresponding, in principle, to a *non aedificandi* area in a number of Mediterranean countries. This means that, barring exceptions, there are no business premises and residential buildings in the coastal zone in question[63]. Thus the resource rent does not include the urban rent; consequently, the services rendered by marine and coastal ecosystems can be regarded as sustainable if the impact of activities on these ecosystems depends less on density (which only affects terrestrial ecosystems) than on the techniques implemented to limit discharge below the critical threshold and more generally to avoid disturbing coastal and marine ecosystems. If this is assumed to be the case, there is therefore no need to apply a sustainability coefficient to isolate the share of VA which potentially corresponds to the rent.

Assessing the share of the resource rent in the value added

The coastal effect is assessed by multiple regression in order to identify the share of the coastal resource rent in the VA and to validate the hypothesis of there being a negative relationship between activity in the hotel industry (VA level) and the share of the rent in the VA (which would imply that the urban ground rent is excluded). The dependant variable applied is the number of establishments per NUTS 3 (Eurostat 2005 data) for four Mediterranean EU countries- France, Greece, Italy and Spain- the only ones for which NUTS 3 data is available. It is used as an approximation for value added in the hotel sector (assuming limited regional variation in the value added per establishment). Appendix 9 provides as detailed presentation.

The length of the coastline is used as explanatory variable allowing to assess the sensitivity of the number of establishments to the coastal effect; thus, for the four countries considered, NUTS 3 data for which the length of the coastline is nil (no Mediterranean seafront) is left out of the equation. This leaves 126 observations (126 NUTS 3), 9 in France, 40 in Greece, 61 in Italy and 16 in Spain. The variables available in the Eurostat database at the same NUTS 3 level, and which can be regarded as explaining activity in the hotel business, thus the number of establishments, are the resident population (pop), the NUTS area (km²), average per capita income of the NUTS at purchasing power standard (gdp_pps) and the average wage in hotel and restaurant (wht), also at the NUTS level. The population and area are combined in a measurement of the demographic density (pop_km2); density is expected to exert a positive influence on the number of establishments (the higher the density, the more activities outside tourism requiring hotel services). The same goes for per capita income (wealth effect and indication of the scale of superior services, which draw heavily on hotel services). Average wage, however, is expected to exert a negative influence (the establishments will be located in regions with the same features, but where labour costs are lower).

The results obtained by calculation (ordinary least square estimator method in log-log form) are satisfactory, with a relatively high adjusted correlation coefficient (0.48). The coefficient for the length of the coastline variable is positive and significant. The other results are also significant and have the right sign. A negative relationship between the share of the resource rent and a low level of urbanisation can also be observed. The results of this multiple regression are used to calculate a mean effect (not weighted by population or the number of establishments) at the level of the 126 NUTS 3. This coastal effect turns out to be 5% on average, which implies that the

63 The urban area located within the 100-metre zone excluded since it is legacy from days gone by and that, moreover, the impact on marine ecosystems is relatively low. In principle, economic activities within the 100 metre strip which involve temporary constructions which can be dismantled (« straw huts » and beach attendants' premises) have only a limited impact on the ecosystems.

presence of 5% of hotel establishments can be attributed to the presence of the coast (appendix 9 for a more detailed presentation). This percentage is used as part of the contribution made by the marine and coastal ecosystems to the value added in the hotel sector for the Mediterranean countries as a whole. It should be pointed out that part of the activity in the hotels and restaurants, and in real estate sectors (and even tourism, addressed hereafter) in the coastal regions may also depend on the provision of ecological services by terrestrial ecosystems. It is assumed here that using the length of the coastline allows only capturing the effect related to marine ecosystems, rather than the entire resource rent.

Since the current state of the data does not allow an estimation or restaurants and real estate, it is assumed that the share of amenity-linked services in the value added of these two sectors also amounts to 5%.

Available data, extrapolation of missing data, adjustments and results

Gross value added data for the year 2005 by country in the hotels and restaurants sector (sector I in the ISIC classification) has been obtained from the UN Data database and converted into Euros. This information is not available for Algeria, Montenegro, Monaco, the Palestinian Territories and Syria. For Algeria, the 2003 data has been used as an approximation. For Montenegro and Syria, the values have been extrapolated from the active population (ILO Laborstat data), assuming the same sector 1 VA-active population ratio as in Croatia in the case of Montenegro and as Turkey in the case of Syria. For Monaco and the Palestinian Territories, the VA has been assessed with the assumption that the VA in the sector represented the same percentage of net domestic revenue as in Greece (7.4%) and Egypt (3.1%), respectively.

An adjustment is needed to estimate the VA in the Mediterranean coastal regions. For France, Greece, Italy and Spain, this has been done by using the share of hotel establishments amongst the NUTS 3 located on the Mediterranean coast as a percentage of the total (Eurostat data). For the other countries, adjustment coefficients are used, which correspond to the share of the population in the Mediterranean coastal NUTS 3 as a percentage of the total population (calculation conducted on the basis of the data contained in Attané *et al.*, 2001). A 0.05 coefficient (5% of VA; result obtained by multiple regression for 4 countries) is subsequently applied to the VA for each country in order to estimate the share of the resource rent in the hotels and restaurants relating to the marine and coastal ecosystems. The total obtained for the Mediterranean amounted to 4 billion Euros in 2005. The data by country can be seen in appendix 11.

The benefits relating to amenities and captured as a resource rent in real estate have been assessed using UN Data figures on household accommodation spending in 2005[64] (rents and imputed rent), which corresponds to category 2-3 in the ISIC classification (presented in table 3-2 in UN Data). Data in national currency has been converted into Euros. No information is available in the UN Data database for Albania, Algeria, Bosnia, Egypt, Lebanon, Libya, Monaco, Montenegro, Morocco, the Palestinian Territories, Syria and Tunisia. The VAs have been extrapolated for Albania, Israel, Morocco, Monaco, Montenegro, the Palestinian Territories and Tunisia, assuming the same ratio of VA/national income (in Euros) as in Bosnia-Herzegovina, Greece, Algeria, Italy, Croatia, Egypt and Libya respectively. For Lebanon and Syria, the extrapolation was conducted on the assumption of the same VA/national income ratio as in Turkey. Expenditure was then assessed for the coastal regions using the share of the population in the NUTS 3 on the Mediterranean coast as a percentage of the total population (Eurostat data)

64 http://data.un.org/Data.aspx?d=SNA&f=group_code%3a203%3bsub_item_code%3a15

for France, Greece, Italy and Spain; for the other countries, the coefficient accounting for the share of the population in the Mediterranean coastal NUTS 3 as a percentage of the total population (calculated using data reported in Attané *et al.*, 2001). The total for the Mediterranean amounted to 11 billion Euros in 2005. The data by country is presented in appendix 11.

2.1.2. Discussion of results and prospects for revising the evaluation

It appears that the concept of resource rent has not been used thus far for the purpose of economic analysis of the contribution made by amenities linking to marine and coastal ecosystems to activity in the hotels and restaurants, and real estate in the coastal zones. Consequently, the figures presented here should be regarded as an initial assessment of the value of the services rendered by ecosystems to these sectors of the economy at either national or regional level, using national accounting data. The study shows that in monetary terms their importance is by no means insignificant.

The amount for each of the two sectors is greater than the estimated value of the resource rent in fisheries, which was nonetheless assessed as being equivalent to 80% of the value added, whilst a mere 5% has been established for the two sectors studied in this section. It can be seen that the services provided by the marine and coastal ecosystems give rise to resource rents, which are mainly paid out to the owners of terrestrial assets, if it is taken that the coastal zone as defined (100 metre strip) cannot be used as a support for establishments located outside the urban areas (ecosystems would appear to make a limited contribution in urban areas in terms of percentage of value added[65]). The relationship with terrestrial ecosystems does not stop there. Hotels and restaurants, and real estate activities may only have a limited impact on the workings of coastal and marine ecosystems, but their development necessarily gives rise to the major consumption of natural terrestrial capital in the zones set back from the areas defined as coastal.

For real estate more specifically, the assessment is based on household accommodation expenditure, which includes the amounts paid by households against the provision of services from electricity, gas and water networks. Thus the estimated value tends to be over-evaluated, although this is balanced out by the fact that rental and imputed rental costs for agents other than households are not taken into account. Yet amenities also have a value in the case of buildings occupied by businesses or administration.

The fact that household accommodation expenses are not reported for quite a large number of countries in the UN Data database implies that extrapolation is the only option available. An alternative assessment was conducted, using gross value added in real estate (sector L in the ISIC classification). As such, it includes the VA from non-financial service activities to companies (rental, leasing and research and development in particular, which have high values, particularly in the developed countries). It should be pointed out that this assessment is based on UN Data, where no information exists for Albania, Israel, Lebanon, Libya, Monaco, Montenegro, the Palestinian Territories, Morocco, Syria and Tunisia. For these countries, VA figures were extrapolated, assuming the same VA in the sector/total population ratio as in a country which is *a priori* comparable (Bosnia for Albania, Italy for Monaco, Serbia for Montenegro, Algeria for Morocco and Egypt for the Palestinian Territories). The resource rent has a value of 16 391 million Euros for the Mediterranean coastal regions as a whole, which is 46% higher than what was calculated using available information on household rental payments. This discrepancy could

65 In the case of establishments located in urban areas, what has mainly been noticed is an urban rent linked to the positive externalities of the activities located in the nearby urban area.

be attributed to the inclusion in sector K of activities relatively important in the EU countries, accounting for a considerable share of economic activity in the Mediterranean region.

UN Data contains information on VA in real estate (sector L) for three countries- Algeria, Libya and Egypt- for which household spending is not included in the same database. When the VA in the real estate sector/GDP ratio is calculated, this produces very low results for Algeria and Egypt (1.3% and 3.0% respectively), which would suggest that this indicator does not satisfactorily reflect household spending, probably because of the limits on rents received by trading companies (imputed rents and rents in the informal sector being more difficult to measure). Contrarily, the ratio stands at 7.8 % for Libya; this might indicate that a different calculation method was applied, which included imputed rent. Overall, the values which emerge from the assessment of the rent based on household accommodation spending do not appear to be contradicted by the results obtained from the data on VA in sector L. The first approach is the one which has been chosen here to avoid any risk of over-evaluation.

As far as prospects for revision are concerned, it seems desirable to assess the share of the resource rent in the VA produced in real estate from data that effectively applies to this sector, rather than using the estimated share for the hotels as an approximation. One feasible approach would be to use the Eurostat data from the Urban Audits conducted in several hundreds of conurbations in the European Union (some of them on or close to the Mediterranean coast). For certain countries these include average property prices (in Euros per square metre) and average rents for houses and apartments (again in Euros per square metre). The main difficulty lies in obtaining the same control variables for all countries (the Urban Audit data being very patchy), or approximation using NUTS 2 or NUTS 3 data for the region in which each conurbation is located.

2.2. Benefits in recreational activities

Marine and coastal ecosystems provide amenities and supports for recreational activities. No information is available about the value added generated in each of these activities (diving, sailing...). By way of approximation, information on international tourist spending[66] in the coastal zones has been used. In fact, tourist spending covers transport spending (apart from cross-border travel), accommodation, food, leisure and enjoyment, sectors whose activity is partly related to the attraction of the sea-related amenities and the recreational supports provided.

According to the statistics from the World Tourism Organisation, the Mediterranean basin is one of the main tourist destinations, receiving 30% of international tourist flows and their spending in 2005 (UNWTO, 2009 and 2008) as well as being the leading destination for tourists of European origin[67]. Tourist intensity is unequally distributed between countries, although the attraction of the coast would appear to be a feature common to tourism throughout the Mediterranean. At regional level, over half of all tourists spend their stay in coastal areas (an average of 54% for the region; Blue Plan, 2005). It is thus interesting to investigate how the presence of marine ecosystems affects the dynamics of tourist activities on the Mediterranean coast, in other words to assess the contribution made by ecosystems, which enables the tourist sector to offer attractive services.

2.2.1. Method of assessment and results

To assist consistency in the study, the evaluation of these benefits should be based on the value added generated by tourist activities, as is the case for fisheries or the hotel industry. However, not all Mediterranean countries have as yet developed tourism satellite accounts within their national accounting. For this reason, and given that the tourism sector largely comprises service activities, the hypothesis has been established that for each Mediterranean state the value added represents 50% of the tourist spending recorded by the UNWTO (which corresponds to a mean value for the share of VA in the hotel and restaurants in Mediterranean riparian countries: 40% for Italy, 60% for the countries to the south of the Mediterranean).

On this basis of calculation, the first step in assessing the resource rent originating from marine ecosystems that is captured in tourism related activities requires identification of what share of tourist activities takes place in the coastal zone. To measure this share, the estimated value added from tourism (based on UNWTO data) is crossed with the estimated share of coastal tourism relative to each Mediterranean riparian state at NUTS 3 level (Blue Plan, 2005) (table 2).

The second stage in the evaluation involves measuring the coastal effect[68] on tourist spending. There are two main methods for measuring the effect of the amenity and recreational support

66 The tourism considered here should be understood according to the World Tourism Organisation's (UNWTO) meaning, according to which tourists are people who arrive in a foreign place to spend at least one night. It should be noted that UNWTO data uses the information provided by the national authorities who in most countries define international tourists as non-residents. Certain countries however, particularly Algeria, Morocco and Tunisia, define international tourists on the basis of nationality rather than usual residence. This therefore results in an under-evaluation, since spending by national tourists who usually live outside the national territory (in the European Union, for example) is not taken into account.

67 In 2001, 82% of tourists in the Mediterranean were of European origin (Benoit and Comeau, 2005).

68 Here, the notion of coastal effect covers the effects relating to the presence of marine ecosystems and therefore to the ecological services provided.

services provided by the marine and coastal ecosystems: using statements from tourists about their reason(s) for choosing their destination/place of stay and observing how their spending is distributed or testing the effect of the presence and importance of certain factors on the level of activity. With the hypothesis that tourist spending reacts to the same structural determinants as the hotels and restaurants, the same coefficient for the influence of marine and coastal ecosystems has been transferred to the tourist sector in the coastal zone, i.e. 5% of the value added created.

The regional economic assessment of the benefits provided by marine ecosystems calculated here is based on an aggregation of national assessments of such benefits, and thus takes account of specific national features. In the end, it is estimated that these benefits reached a value of almost 3 billion Euros in the coastal zone in 2005. The data for each country is presented in appendix 11.

Table 2 : Assessment of the value added generated by the tourist sector in the Mediterranean coastal zone.

Country	Tourist spending (in millions of €)	Share of coastal tourism (in %)	Coastal tourist spending (in millions of €)	Value added from coastal tourism (in millions of €) (*)
Albania	854	50%	427	213
Algeria	184	30%	55	28
Bosnia Herzegovina	512	10%	51	26
Cyprus	2 318	100%	2 318	1 159
Croatia	7 370	72%	5 306	2 653
Egypt	6 851	10%	685	345
France	43 942	20%	8 788	4 394
Greece	13 334	95%	12 667	6 334
Israel	2 797	70%	1 957	979
Italy	35 319	65%	22 957	11 479
Lebanon	5 532	65%	3 596	1 798
Libya	250	95%	238	119
Malta	754	100%	754	377
Morocco	4 610	15%	692	346
Monaco	-	100%	-	(**) 7
Montenegro	-	-	-	(***) 134
Palestinian Ter.	121	10%	12	6
Slovenia	1795	25%	449	224
Spain	47 789	70%	33 452	16 726
Syria	1 944	10%	194	97
Tunisia	2 124	95%	2 018	1 009
Turkey	18 152	65%	11 799	5 899
Total Mediterranean	**196 552**	**53%**	**108 417**	**54 349**

Source: UNWTO, Compendium 2002-2006; UNWTO Tourism Highlights, 2008 edition; Blue Plan, 2005.

(*): Assuming that coastal tourism VA = 50% of coastal tourist spending. (**): Estimated on the basis of Italy, according to GDP. (***): Estimated on the basis of Croatia, according to coastline.

2.2.2. Discussion of results and prospects

Assessing the value of the benefits for recreational activities through tourism leads to the adoption of too broad a perimeter (since transport activities are included in tourist statistics, for example) and gives rise to double counting with the benefits in the hotels, restaurants, and real estate. In fact, accommodation and food spending has already been taken into account (as least partly) in the hotels, restaurants, and real estate sectors. Ideally these latter activities are the only ones which should be dissociated in order to isolate spending linked to recreational activities alone, but the available information does not allow for this. The result is therefore an over-estimation of the value of the benefits provided by marine and coastal ecosystems in recreational activities. However, limiting the scope to international tourists alone leads to an under-evaluation of the economic significance of recreational activities, which goes some way towards balancing out the over-evaluation linked to the double inclusion of transport and accommodation spending in tourism. The consumption of market services in recreational and leisure activities linked to marine and coastal ecosystems is not only a matter for international tourists- it also concerns domestic tourists as well as the permanent residents of the coastal regions. It is therefore likely that in most cases an approximation using the value added from international tourism leads to the value added achieved in the recreational activities being under-evaluated. This claim is strengthened by the fact that the recreational activity sector also includes the activities for producing the equipment used in the course of these recreational activities.

Moreover, in order to assess the value of the benefits for recreational activities through tourism, the applied coastal effect parameter was transferred on the basis of a study of this effect on hotels in certain Mediterranean coastal NUTS 3 (appendix 9). The existence of structural levers common to behaviour on the hotel business and tourism services can be questioned. Whilst it is true that part of these markets overlap (as previously mentioned), it is likely that other tourist markets are subject to different behavioural structures on both the supply and the demand side. The study of the coastal effect of tourism and the value added generated in this sector should be further refined.

In the case of Greece and Tunisia (appendix 11) for example- countries featuring marked coastal tourism- the value of the benefits would appear to be under-estimated. At national level, the study of the value of benefits rendered by the marine ecosystems to the tourism sector should be covered by national sectoral studies which illustrate in more specific terms the geographical distribution of tourist activity, the value added generated and the market's reaction to various structural determinants.

Finally, with the prospect of the assessment of the benefits which emerge from the provision of amenities and recreational supports being revised, it would be desirable to collect the results of sectoral analyses of those activities which are directly linked to ecological services. In parallel, given that these activities are not exclusively based on the contribution made by marine and coastal ecosystems, information should also be collected with the aim of establishing the extent to which these activities depend on the provision of such ecological services.

3. Value of benefits linked to climate regulation

The existence of the large Mediterranean marine ecosystem influences climate features irrespective of human activities. However, certain ecological flows contribute to economic activities and peoples' well-being.

Such benefits are evaluated at global scale, with the assessment focusing on the ecosystems' capacity to sequester the carbon dioxide (CO_2) emitted by socio-economic activities, thus being instrumental in reducing human influence on climate change. The evaluation of such benefits is traditionally part and parcel of the economic assessments of the benefits rendered by ecosystems.

Marine ecosystems exert a major influence on the climate and on air quality, as sources and sinks of pollutants, active gaseous substances, greenhouse and aerosol gases. Thus one of the main services provided by marine ecosystems relates to their capacity to sustainably sequester the carbon dioxide emitted by human activity. The scientific community believes that the Ocean has been the most important carbon sink of the Anthropocene, holding about one third of all anthropogenic CO_2 emissions. Recently, several United Nations organisations, supported by scientists, cooperated under UNEP's aegis within the *« Blue Carbon »* initiative, intended to highlight the crucial role played by the oceans and marine and coastal ecosystems in regulating the world climate. The report was published in late 2009 (Nellemann *et al*, 2009).

Similarly, the international community has agreed to combat climate change, proposing in particular the gradual reduction of greenhouse gas emissions. In this respect it is striving to promote binding legal instruments and at the same time to endorse market mechanisms. Through what are rather complicated procedures, the CO_2 emissions rights market makes it possible to establish a monetary value per tonne of CO_2.

The proposal has been made to evaluate the benefits provided by this ecological service, using the cost of avoiding the reduction of CO_2 emissions or its man-made sequestration as a substitute which can be calculated.

3.1. Methods and results

The ocean's capacity to assimilate atmospheric CO_2, which varies from one ocean zone to another, is the focus of scientific work on climate change, particularly within the framework of the Joint Global Oceanic Flux Study programme. Carbon is an element essential to life, which is sourced from respiration in living beings, combustion or volcanic emissions. Many complex processes are involved in carbon development, and multiple measurements feeding powerful digital models are required in order to study them, particularly if the focus is on CO_2 of human origin, which represents only a minor fraction of the CO_2 involved in the global carbon cycle. To put it simply, the Ocean has two highly interconnected CO_2 absorption circuits: the biological pump and its physico-chemical counterpart. The latter has been responsible for most of the capture of CO_2 of human origin, with an initial approximation establishing that the biological pump continues to work as it did before the dawn of the industrial age.

Since the Mediterranean Sea accounts for a mere 0.8% of ocean area, its contribution to world climate regulation is limited, which explains why scientists have still not completed the tricky evaluation of its specific anthropogenic CO_2 sequestration capacity. A recent estimate (Huertas, 2009) proposes the value of 78 kilo moles of carbon ±15% per second for the area of the Mediterranean Sea as a whole. This estimate corresponds to an annual average rate of anthropogenic CO_2 sequestration amounting to 11.8 t/km²/yr, in other words around twice the average for the World Ocean (Gruber, 2009). It has been proposed that, in order to quantify this ecological service, the estimate provided by Huertas (2009) should be used, which gives a total sequestered volume of 108 million tonnes of CO_2[69] per year for the Mediterranean as a whole. It should be noted that this quantity represents a mere 5% of the CO_2 emitted by activities in the Mediterranean riparian countries (UN Data).

Choice of the reference value for a tonne of CO_2

The definition of the reference economic value for a tonne of CO_2 is the subject of numerous international studies because of its important role in the environmental evaluation of projects, particularly in the transport field: European HEATCO project, DEFRA study (2005) in the United Kingdom or in France the work of the Quinet commission on the shadow value of carbon (CAS, 2008).

Moreover, since January 2005, Europe has had a quota trading system in place (ETS[70]), which covers almost 45% of CO_2 emissions, mainly from the fuel-intensive energy and industry sectors. This market has led to the emergence of a price for CO_2 which, before the financial crisis, was fluctuating between 17 and 25 Euros[71]. Since it is the result of transactions on a global market, the average price for the year 2005, which is the reference year for the study, i.e. 20.5€/t of CO_2 (World Bank, 2006), was taken as the value for this study. It should be pointed out that this value is not very different to those which emerged from the studies mentioned for the same period.

Monetary assessment of the climate regulation service

The method proposed for evaluating the economic benefit for this ecological service (SErc), which does not involve any human activities for its implementation, is particularly simple:

$SErc = F_{CO_2} \times Vcref$

where F_{CO_2} is the annual flow of CO_2 of human origin sequestered by the Mediterranean sea and Vcref is the reference value per tonne of CO_2 selected for the study.

Annual regional value: 108 Mt x 20.5 €/t = 2.2 billion Euros.

Value of benefits per country

It is currently not possible to evaluate the quantity of CO_2 of human origin sequestered by the territorial waters of the riparian countries. Moreover, this type of approach would leave out large swathes of the Mediterranean, which do not belong to these territorial waters. The proposal is to distribute the value of the ecological service by riparian state in accordance with their respective share in the total volume of CO_2 emitted by the riparian countries as a whole, based on the statistical data provided by UN Data on CO_2 emissions per country. These results are presented in appendix 11.

69 One tonne of carbon corresponds to 11/3 or 3.67 tonnes of CO2.
70 Emission Trading Schemes
71 The World Bank publishes an annual report on trends on this market, from which it is possible to extract an average price per tonne of CO_2.

3.2. Discussion and further studies

Climate regulation by the oceans does not boil down to CO_2 sequestration alone. However, the choice taken to focus on this process as an initial approach can be justified as follows:

- There is justification for not taking the ocean's thermo-dynamic operations into account, to which the Mediterranean Sea contributes and which play a considerable role in the world climate, since current marine ecosystems do not intervene directly in this function.
- Looking at the other greenhouse gases listed in the Kyoto protocol, it can be seen (i) that the ocean is a net producer of methane and nitrogen oxide (Rhee, 2009) and this study only considers the positive benefits from ecosystem services (ii) the other gases listed (CFC, SF_6) barely interact with the ocean.
- The ocean also acts as a sink for numerous pollutants present in the atmosphere, but this service was not assessed in this study as it is deemed to be non-sustainable.

The monetary assessment conducted may change enormously over time as a result of fluctuations in price and quantity. The carbon market fell in 2009 but is expected to show a marked rise over the coming decade. The quantity of CO_2 of human origin sequestered by the Mediterranean Sea should be specified at the end of scientific work currently underway.

The capacity for human intervention in the sustainability of this service needs to be addressed at various levels. At global level, the flow of anthropogenic CO_2 sequestered by the ocean is linked to human activities which generate CO_2. Moreover, this sequestration has largely been achieved at global level through a process of solubility (the physico-chemical pump), which shows little dependence on ecosystem quality. However, this process leads to the gradual acidification of the oceans, which will have a considerable effect on marine ecosystems and the living resources produced, particularly in the Mediterranean (CIESM, 2008; Gambaiani et al, 2009). This issue, about which little is yet known, is the subject of many initiatives currently underway (Orr, 2009) and a European research programme including the socio-economic consequences is set to be launched in the near future. It should be noted that the biological pump does not have the drawback of leading to the acidification of the environment.

At local level, the flow of carbon from the surface towards the sediment depends on biological processes, which in turn depend on ecosystem quality. Thus a recent study (Wilson, 2009) showed that the importance of fish in the carbon cycle had been hugely under-estimated. In fact, through their capacity to constantly produce relatively insoluble carbonates in their intestines, they are also instrumental in sequestering carbon in seawater. It has been shown in the Mediterranean that the matte (sheaths and rhizomes) produced by the Posidonia meadow store a carbon flow on a sustainable basis (several centuries), which has been estimated at 1.2 million tonnes of carbon per year (Pergent, 1997), in other words almost 5% of the total sequestered quantity calculated above. Thus the preservation or restoration of these coastal ecosystems contributes to the sustainability of this ecological service.

By way of conclusion, the Mediterranean Sea as a fraction of the World Ocean plays a role in regulating the world climate. If the exercise is limited to the issue of the sequestration of CO_2 of human origin, then the method for evaluating this service is relatively straightforward and does not raise any problems of principle. In its application, the economic value is the product between a highly fluctuating market price and a physical quantity, currently of uncertain assessment. However, scientific work currently in the pipeline will allow the global quantity of anthropogenic CO_2 sequestered annually by the Mediterranean Sea to be more clearly identified in the near future. Further research work should allow the issue of the sustainability of this service to be better determined as well as the specific role of each type of ecosystem.

4. Value of protection against coastal erosion

Marine and coastal ecosystems are generally recognised as providing protection to coastal zones against storms or erosion phenomena, for example. This ecosystem service secure the durability of infrastructures and investments on a threatened coastline by contributing to the stability of the coastline.

Within the framework of this study, valuation focuses on the benefits produced by the erosion defences provided by marine ecosystems. Coastal erosion is a natural phenomenon widely observed in the Mediterranean, particularly in coastal zones with soft substrate. The European Environment Agency (EEA, 2006) states that 20% of European coasts are threatened by erosion (i.e. around 20 000 km). The threat is felt differently from one country to another, with 37.8% of the Cypriot coast being under threat, for example, as compared with 24.9% in France, 28.6% in Greece, 22.8% in Italy and 11.5% in Spain. Various local scientific observations have shown that coastal erosion is also affecting the southern and eastern shores of the Mediterranean basin.

Although coastal erosion is a natural phenomenon, it is nonetheless a cause of public concern in the Mediterranean, given the marked concentration of socio-economic activities on the coasts[72]. Thus the fact that the marine ecosystems provide a service which limits harmful impact of erosion, it produces benefits for all socio-economic activities present on the threatened coastline.

Whithin the marine ecosystems identified in the Mediterranean, only the Posedonia meadows have been scientifically recognised as providing protection against erosion. The provision of this ecosystem service hings on three properties inherent to Posidonia. Firstly, its foliage, which limits hydrodynamics by 10 to 75% under the leaf cover (Gacia *et al.*,1999). Then the banquettes formed by its dead leaves and rhizomes[73] on beaches - that can reach a height of between 1 and 2 metres - which builds a structure both rigid and flexible that protects the coatline against erosion (Guala *et al.*, 2006, Boudouresque *et al.*, 2006). Finally, the matte of Posidonia [74] traps sediment (Dauby *et al.*, 1995, Gacia and Duarte, 2001), thus contributing to their stability. According to a study conducted in 1984 (Jeudy de Grissac, 1984), depending on the underwater profile and for a sandy coast, degradation of one metre thickness of Posidonia duff could lead to the coastline retreating by twenty metres or so.

Evaluating the benefits attached to the protection line against coastal erosion afforded by the Posidonia medows requires that the risk of coastal erosion is a matter of concerne, and that the Posidonia meadows present in the area are effective in mitigating erosion phenomena. The value of the benefits provided by this service is considered here as the equivalent of the avoided defence expenditures (investment and maintenance).

72 Moreover, the recurrence of public policies dedicated to combat coastal erosion within the riparian countries shows, that most countries feel affected by this risk.
73 The rhizome is the underground stem of certain perennial plants (different from the root).
74 The matte is the structure made of comprising rhizomes, sheaths and the dead leaves (Boudouresque et al., 2006).

4.1. Method of assessment and results

The valuation of the benefits flowing from coastal protection against erosion provided by the Posidonia meadows is based on a three step process - firstly, determining the scale of the built-up coastline affected by erosion, then assessing the presence of effective Posidonia meadows along this coastline and finally the monetary assessment of the value of the protection provided.

To begin with, the scale of the built-up Mediterranean coastline under threat of erosion needs to be assessed, in other words estimate the area over which protection would be useful. The Mediterranean coastline is heavily built up, thus the section of the coast exposed to the threat of erosion is relatively large (table 3).

Table 3: Urbanised Mediterranean coastline in 1995

Geographical area	Coastal strip (0-10 km, in km²)	Cumulative area of coastal towns	ratio in %
Spain	25800	14182	55%
France	17030	4042	24%
Italy	73750	28320	38%
Greece	150210	3041	2%
Lebanon	2250	1287	57%
Egypt	9550	3116	33%
Average for the NMCs (*)			from 60 to 70%
Average for the SEMCs (**)			from 20 to 45%

Source: Geopolis and Blue Plan 2005 (Benoit *et al.*, 2005).
(*) Northern Mediterranean countries.
(**) Southern and Eastern Mediterranean countries.

Since the density of coastal urbanisation was not available for all Mediterranean countries, it was decided to estimate the scale of the eroded coastline using the 20% erosion figure established for the European coasts (EC, 2004) as well as an urbanisation coefficient for the eroded coasts. Given the massive urbanisation of the coastline in the Mediterranean and since erosion phenomena are usually noticed where they are considered as a threat, a coefficient of 80% was applied to the estimated eroded coastline. On this basis it emerges that coastal erosion is affecting 16% of the Mediterranean coasts, i.e. 7 360 km.

As a second step, the presence of Posidonia meadows along this built-up and eroded coastline needs to be established along with the genuine provision of a protection service against erosion. Pasqualini *et al.* (1998) estimated that the Posidonia meadows covered some 35 000 km² in the Mediterranean. Given the size of the 0-50 m bathymetric section in which this plant can thrive[75], it would thus cover some 40% of the benthic area corresponding to 0-50 m depth. As Posidonia tends to be abundant in areas with soft substrate (which represent about 50% of the coast[76]) - which are in themselves more vulnerable to erosion (40% of loose substrate areas are affected; source EC, 2004) - , and given the geographical dispersal[77] of Posidonia, it is estimated that 90% of the Posidonia beds are established in coastal zones threatened by erosion.

75 It should be noted that Posidonia beds tend to establish themselves at depths of between 5 and 25 m
76 EC, 2004.
77 Posidonia is present virtually throughout the Mediterranean, with the exception of the Moroccan coasts and in the extreme south of Spain (Atlantic influence), the coasts of Egypt (to the east of the Nile delta), Palestine, Israel, Lebanon and no doubt Syria (Pergent, 2009). It has not penetrated into the Black Sea and is rare or non-existent in

However, the presence of Posidonia alone does not guarantee the provision of an effective protection service against erosion. In fact, this provision depends on various characteristics such as the size of the meadow, its maturity or the intensity of the erosion affecting the coast. Taking as a basis that over 10% of the European coasts demonstrate the existence of protection mechanisms against erosion (EEA, 2006) – which represents half of the European coasts subject to erosion – and in order to circumvent the lack of available information on the matter, the hypothesis has been established that 50% of the Posidonia meadows provide an effective protection against erosion. It has thus been estimated that at the regional level, 3 312 km of Posidonia meadows provide an effective protection service against coastal erosion.

Finally, the third stage of the valuation aims at establishing the economic value of the benefits received from Posidonia meadows. The assessment technique based on shadow prices (here avoided costs) has been applied and and suppose that the economic value of these benefits is equivalent to the avoided expenditures (investment and maintenance costs). In 2001, expenditures on coastal erosion defence observed along European's coastlines have been rose up to 3.2 billion Euros[78] (EC, 2004; EUROSION programme). It can thus be estimated that European spending on erosion defences amounts to about 160 000€ per coastline km. This unit cost per km was transferred in this study.

Results

At the regional level, the valuation shows that the Posidonia meadows allow the riparian countries to avoid an annual spending of about 530 billion €/yr, covering investment and other costs (i.e. maintenance costs).

Value of benefits by country

The results are presented in annex 11. It can be noted that due to the valuation technique applied, the value of protection against erosion depends mainly on the length of the coastline and thus does not directly reflect the risk of erosion. In the case of Greece, for example, where the coastline is very long but the coastal strip is not particularly built-up, it is likely that the method applied produces an over-estimation. In this case, the erosion coefficient established for the Mediterranean as a whole should be modulated in order to better reflect the real risk encountered along the coasts of this kind of specificities.

4.2. Discussion and further works

The valuation of the benefits flowing from the protection against erosion provided by the Posidonia meadows shows how important it is to have precise information about the sectors in which erosion constitutes a threat (thus where infrastructure does exist) and where the meadows are established. Some data exists on the erosion of specific coasts, on coastal urbanisation and on the amounts spent to defend against or prevent the risk of erosion. However, whilst being useful in order to address the issue, these data could not be used for this study since it did not cover an area enough large or representative to allow an extrapolation to all of the Mediterranean

the extreme north of the Adriatic as well as along the coasts of Languedoc, between the Camargue and Port-la-Nouvelle (Boudouresque et al., 2006).

[78] This expenditure breaks down as 53 % for new investment, 38 % for maintenance and 9 % for the purchase by the public authorities of property threatened by coastal erosion (EC, 2004).

coasts in consideration. The lack of information was circumvented by establishing likely but not checkable hypotheses and by the transfer of coefficients stated by European projects and institutions. To improve the valuation of these benefits, more information would be needed at both regional and local level, dealing with coastal urbanisation, area affected by erosion, settlement of Posidonia meadows, their effectiveness in defending the coastline against erosion and the amounts spent on protection activities or infrastructures.

The evaluation method used here and which is recommended by the SEEA (2003) based on replacement costs does not totally satisfy the methodological approach. Indeed, different substitutable activities to the ecosystem service has to be pointed and valuated (i.e. dykes and other techniques in the case of erosion) but these substitutes rarely do constitute absolute substitutes for environmental assets, in fact they do not provide the other ecosystem services provided by one ecosystem and involve other kind of externalities (change of landscape, shifting the erosion problem elsewhere...) that are not taken into account in the valuation of one specifique benefit but that can harm the overall benefits received (i.e. loss of amenities due to a dyke). Other valuation techniques could be used, such as insurance based approaches observing prices on these markets when erosion is considered as a risk or conducting field surveys. Although these methods introduce other kind of bias, it would be interesting to compare the results from the various approaches.

5. Value of waste treatment

Marine ecosystems provide a service by receiving a large share of the waste from human activity, which would need to be more thoroughly treated and neutralised it if were to be taken up by terrestrial ecosystems. The respective features of the waste, the ecosystems which receive it and consequently the capacity of these ecosystems to absorb, detoxify, process and sequester vary enormously. Some toxic pollutants, such as heavy metals, cannot be converted into anodyne substances, whereas other inputs can more or less rapidly be degraded or recycled into harmless components. Marine ecosystems thus have a great capacity to recycle a substantial volume of nutrient inputs, such as those produced by urban waste and agriculture, by ploughing nitrogen and phosphorus back into the food chain. Organic waste can even encourage ecosystem development through its biomass and, in this case, ecosystems benefit from waste. It is taken here that as long as waste is not harmful to them, ecosystems provide an ecological service for the quantity of waste below this threshold. In fact, if the threshold were to decrease the waste would need to be further purified in order to avoid any health risk, thus driving up the cost of waste treatment.

In an initial approach to the evaluation of this service, the study will only consider liquid waste produced by human activities, which represent the main source of pollutant input into the marine environment.

5.1. Methods and results

The approach recommended for the treatment and elimination of wastewater both by the European Commission (EC) and MEDPOL is the so-called combined one (MEDPOL, 2004), both based on the emission threshold for waste and the quality objective of the receiving environment, in this case the marine environment. Under the sustainability hypothesis, it is presumed that this approach is implemented for all the riparian countries, which is actually far from being the case (MEDPOL, 2004; Blue Plan, 2005; EIB, 2008).

In the event that the combined approach has been fully implemented and the necessary treatments provided for, which already would amount to a great expense (EIB, 2008), a fraction of the waste would still have been inadequately treated and would have an impact on the marine environment, which would correspond:

- To diffuse waste, for which no viable treatment solution has been found,
- To the limits of the treatment techniques applied,
- To flaws and shortcomings in the sanitation networks and treatment plants,
- To delays in regulating compared with the level of knowledge, in determining emission limit values as well as quality objectives, particularly for known pollutants not taken into account by current treatment techniques (dissolved fraction of chemical pollutants, medicine residues) and pollutants for which little is known as yet about their effects on marine ecosystems.

The sustainability hypothesis means that there is no option but to use a desirable albeit realistic situation, which makes it difficult to assess this fraction and to evaluate it economically on the basis of the monetary values noted. At this stage of the study, the proposal is to value this service on the basis of an environmental tax.

The principle behind this type of tax is to allow environmental costs to be included in water pricing for the user, particularly in order to ensure the good ecological state of aquatic environments. In Europe, the EC's Water Framework Directive (EU_WFD, 2000/60/CE) requires EU members to introduce water pricing policies which reflect in particular the following costs (D4E, 2006):

- Financial costs: direct costs including provision, administration, operational and maintenance costs as well as capital costs.
- Environmental costs: the cost of the damage caused by water uses to the environment and ecosystems, as well as to people who use the environment.

In practice, pricing policies gradually introduce taxes for water consumption. The result is to drive up the price of water paid by the user, sometimes considerably, which creates resistance. In France, these taxes are set by the Basin Committees and levied by the Water Agencies according to a rate which depends on the specific situation and usage (domestic or non domestic pollution, diffuse pollution or breeding). This point is developed further in the discussion section which follows. In 2005 and for the Mediterranean seafront, the environmental tax for domestic use stood at 0.18€/m^3.

The proposal is to use this basis to value the service which marine ecosystems render by taking up waste polluted through use for all of the Mediterranean riparian countries. The benefit provided by this service is thus valued by a substitute applied to protection expenditures, the amount of which is set by a tutelary authority.

It was estimated that in 2005 the Mediterranean coastal population stood at about 148 million inhabitants (adapted from Attané and Courbage, 2001), for a total population in the riparian countries of 420 million inhabitants (UN Data), in other words about 38% of the Mediterranean population was living in the coastal zones. Average domestic water consumption for these countries stands at 99 m^3/yr per inhabitant (FAO Aquastat, 2000), which means that it can also be calculated for the coastal population, assuming that it is identical *per capita*, at an estimated total of 14.5 km^3 per year. At regional level, the value of the service for domestic consumption is thus estimated at 2.6 billion Euros.

An attempt was made to value the service for industrial use on the basis of the volume of industrial water discharged directly into the Mediterranean sea, as assessed by MEDPOL, (*in Blue Plan 2005, statistical appendix*), i.e. 557 million m^3 per year (or 0.56 km^3/yr). As an initial approach, this service can be evaluated on the same basis as for domestic consumption at 0.18€/m^3, i.e. 100 million Euros. If agriculture (intensive breeding in particular) is left out of the equation, the total value for the service is evaluated at almost 3 billion Euros.

Value of the benefits by country

The value of waste treatment per country is calculated on the basis of the estimated consumption per country of domestic water by the coastal populations and discharge of industrial water into the Mediterranean Sea, breaking down the overall assessment of the benefit by country according to the method previously described (appendix 11).

5.2. Discussion

For some authors, particularly Costanza *et al* (1999) nutrient recycling represents the biggest unit economic evaluation per km² of all the ecosystem services provided by the various marine ecosystems apart from coral reefs. These values are justified both by the large quantities of nutrients and the high cost of substitution treatments. Thus the preliminary study (appendix 3) based on the application of Costanza *et al's* unit values to the areas of the various large Mediterranean ecosystems estimated by Martinez *et al* (2007) values this service, which represents 78% of the total for the Mediterranean.

The choice was made for this study to take the hypothesis of the sustainability of the services provided by ecosystems, which means that the absorption by marine ecosystems of toxic substances (heavy metals, organic pollutants, persistent organic pollutants...) or the treatment of recyclable substances such as nutrients rendered beyond the reprocessing capability of these ecosystems should not be counted as a service.

According to this hypothesis, this service thus boils down to the treatment of recyclable matter, within the limits of these ecosystems' capacities. It was taken that this limit is not exceeded when the upstream treatment of waste is in line with the so-called combined approach recommended by both MEDPOL and the European Commission, considering both the waste emission threshold and the objective regarding the quality of the receiving environment.

Within this context it is proposed that this service (treatment of acceptable waste) should be valued on the basis of a tax paid in order to consolidate and perpetuate a situation which is already acceptable from an environmental point of view.

In France, the domestic pollution tax brought in by the 2006 water and aquatic environments law[79] meets this objective, since it aims at ensuring that treatment plants are correctly run and contributes to the funding of action and works to preserve the aquatic environment. It corresponds to a reference value, the level of which has been capped by decree, and is then modulated according to coherent geographical units by the Water Agencies Board (basin agency), where the users are represented, making this tax similar to a "willingness to pay".

It was decided to choose a geographic zone which is representative of the French Mediterranean front- Bouches du Rhône- which features both highly urbanised and industrialised sectors (Marseilles, Fos) and other protected ones (Camargue, Calanques).

This value was transferred to the whole of domestic water consumption in the riparian countries. It can effectively be taken for initial approximation that the sums involved in investment, plant maintenance, operations and installations for treating water prior to its discharge , depend only to a minor degree on the specific conditions prevailing in each riparian countries. In fact, the variable maintenance costs are low in comparison with the investment costs. Since the cost of raw materials and technology included in the investment were similar across the board, it can be presumed that there is little divergence.

The application of this same tax rate to industrial water uses represents a further extrapolation. It should be pointed out that the figure arrived at is low compared with the figure for domestic pollution.

These issues should be studied in further depth in cooperation with MEDPOL, in order to take better account of the various Mediterranean situations.

In contrast, the physical data on which this evaluation is based (domestic water consumption by the Mediterranean coastal population and, to a lesser extent, the volumes of industrial water discharged directly into the Mediterranean Sea) appear to be relatively robust.

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79 Law n° 2006-1772 of 30 December 2006 on water and aquatic environments.

III. Results and discussion

The results of the study are synthesised and commented on here.

1. Results at regional level

The values of the benefits assessed for the various ecological services dealt with in this study have been aggregated in order to build (or constitute) a value significant at the regional level. This aggregated value should be seen as an order of magnitude, rather than a measurement, because of the following constraints:

- Scarcity of relevant data, with restrictive implications both in terms of the applicable methods and the valuation realized;
- Loss of information due to the aggregation of ecosystem services, which essentially differ in their respective contribution to human well-being;
- Aggregation of results coming from the valuation methods that are coherent in their principles but heterogeneous in their implementation;
- Accumulation of non-quantified lack of precision in case by case valuation, as previously discussed;
- Uncertainty about the nature and consistency of all the services provided by the Mediterranean marine ecosystems.

Bearing these cautions in mind, the aggregated economic value of all the benefits considered generated by the Mediterranean marine ecosystems was estimated at over 26 billion Euros in 2005 for all of the riparian states (table 4). This amount equates almost 13% of Greece's Gross National Product (GNP) or 120% of Tunisia's GNP. Considering that the Mediterranean Sea covers 2.5 million km², the large Mediterranean marine ecosystem seems to enable a global benefit estimated over 10 450€/km²/yr.

Table 4: Value of the benefits flowing from Mediterranean marine ecosystems

Contributions evaluated:	**Assessment mode (see chapter II):**	**Intermediate value (in millions of €/yr):**	**Value (in millions of €/yr):**
Resource rent related to the production of food resources	VA fisheries and aquaculture * sustainability coefficient (=0.8)		2 871
Resource rent related to the provision of amenities and recreational supports	5 % VA hotel and restaurant service activities in coastal zones	4 139	17 808
	5 % of housing expenditures in coastal zones	10 951	
	5 % VA tourism in coastal zones	2 717	
Value of climate regulation	Quantity of anthropogenic CO_2 * market value per tonne of CO_2		2 219
Value of protection against coastal erosion	Avoided expenditures * coastline protected		527
Value of waste treatment	Consumed water * protection expenditure		2 703
Total :	**Aggregation**		**26 128**

Depending on the options chosen for this exploratory study, the largest portion of the value of the benefits provided by Mediterranean marine ecosystems comes from the provision of amenities and recreational supports (about 68%). The final beneficiaries of this ecological service are the people permanently or temporarily located in coastal zones, who benefit from the landscape, the local climate and the access to marine and coastal areas for their leisure and well-being. As for the value of these benefits, it is harnessed by the marketed activities that are based on the ecological services of providing amenities and recreational support, such as the hotel and restaurant service activities, housing expenditures (by household) or tourism. The suppliers of these services constitute the direct beneficiaries of the economic benefits generated by the provision of the associated ecosystem services.

The value of the benefits related to fisheries represents about 11% of the overall value of the benefits considered. Fishermen (employers and workers) are the direct beneficiaries of the economic benefit resulting from the provision of food services by marine ecosystems. All other actors who also benefit from this ecosystem service in a leaded or indirect way can also be included in this category. In contrast, the final beneficiaries of this ecosystem service are those who actually consume the food resources, in other words those who benefit from the nutritional input, the fish or fish product final consumers.

The protection of coastal zones against erosion appears being the lowest economic value of benefits (2% of the total value). The level of this value clearly demonstrates the need to improve data availability for this type of study in order to implement valuation method which would better fit with the specificities of the context. For instance, a risk based-approach or the estimation of local opportunity costs for coastal defence expenditure would better reflect the value of this ecosystem service which is sometime of strategic importance.

2. Results at country and ecosystem levels

As far as possible, the valuation methods and results of the study were broken down to reach a country level of application, which is more meaningful for decision-takers and the public itself and which is more widely used in macro-economics. The results obtained are commented for two countries. The value of the benefits provided by ecosystems can also be allocated to each different ecosystem providing these ecological services.

2.1. Value of the benefits illustrated by country

Two countries were selected, Greece and Tunisia, for which most of the primary data needed was available, and whose seafronts are entirely Mediterranean (table 5 and annex 11 for a breakdown results by country).

Table 5: The value of the benefits flowing from the Mediterranean marine ecosystems for Greece and Tunisia

Contributions evaluated		**Value of the contributions for Greece (in millions of €/yr)**		**Value of the contributions for Tunisia (in millions of €/yr)**	
Resource rent related to the production of food resources			588		165
Resource rent related to the provision of amenities and recreational supports	Hotel and restaurant service activities	680	2 075	125	252
	Housing expenditures	1 078		77	
	Tourism	317		50	
Value of climate regulation			98		23
Value of protection against coastal erosion			173		15
Value of waste treatment			212		61
Total :			**3 147**		**516**
GNP in 2005 (in millions of €) :			**194 624**		**22 035**
Value of the benefits in % of GNP:			**1.6%**		**2.3%**

The links between economic development and ecosystem contributions vary from one country to another. According to the results of the study, it seems that Greece take more advantage of the contributions made by marine ecosystems, since the value of its benefits is 6 times greater than those of Tunisia. Tunisia, in contraste, appears to depend more on the marine ecosystem's contributions since the value of these contributions represents 2.3% of its GNP (compared with 1.6% for Greece).

The structure of the value also differs from country to country. For example, Greece shows that the value amenities and recreational supports' provision covers 66% of the overall value of the benefits received, whilst in the case of Tunisia this ecosystem service only accounts for 49% of the received benefits. Moreover, the value of the benefits related to amenities and recreational supports seems to be differently made up. For Greece, the housing sector draws the greatest value of benefit from this ecosystem service, whilst in Tunisia, it would appear to be the hotel and restaurant service activities. It can also be seen that, despite the large numbers of tourists visiting the Greek and Tunisian coasts[80], the benefits picked up by this sector are rather modest in respect of hotel and restaurant service activities, for example.

The other ecosystem services appear to provide benefits of equivalent value for both countries. Those benefits are in both cases lower than the regional value, except for the production of food resources, with fishing being relatively important for these two countries compared to the regional average. The similarity of these two countries facing climate regulation could stem from the fact that the contribution made by both countries to CO_2 emissions is relatively low within the region. As far as erosion is concerned, the value of this service by country depends on the length of the coastline and the rate of coastal urbanisation. In both cases the latter is low, even very low in the case of Greece[81].

The valuation of the benefits provided by ecosystems to countries would be greatly facilitated by the development of environmental satellite accounts and a generalised application of the SEEA recommendations.

80 For these two countries, 95% of tourism is coastal (Blue Plan, 2005).
81 The urbanisation rate on the coastal strip (0-10 km) in Greece stands at about 2% (Benoit et al., 2005).

2.2. Value of the benefits illustrated by ecosystem

A further objective in breaking down the results of the study is to address the distribution of the value of the benefits by type of ecosystem providing the related ecosystem services.

Ideally, studying the contribution of each ecosystem to the provision of different benefits should enable to establish a matrix showing the distribution of the value of benefits flowing from the different ecosystems through the services provided (table 6). In other words, the point is to define the production function of the different benefits supplied by each ecosystem.

Table 6: Matrix of the contributions provided by the ecosystems

Ecosystem 1							Ecosystem n							Large Mediterranean marine ecosystem						
Benefits	Ecosystem services					Total	Benefits	Ecosystem services					Total	Benefits	Ecosystem services					Total
…	…	…	…	…	…		…	…	…	…	…	…		…	…	…	…	…	…	
…							…							…	Sum					
…							…							…						
Total							Total							Total						

Given the current state of knowledge about ecosystems and their ecological processes, it is often not possible to come up with a reliable assessment of these production functions. In certain cases, it is possible to relie on approximations to estimate the magnitude of the contributions made by ecosystems. These estimations produce significant results, which can, however, lay no claims to being either exhaustive or exact. At the current time, exhaustiveness cannot be an objective, for two main reasons: (i) with the current state of scientific knowledge and the available data, it is not possible to cover the full range of benefits produced and (ii) little is known about the indirect diffusion and spinoffs from the benefits throughout countries' economy and development, and so cannot be evaluated in its whole. Using approximations to assess the production function of ecosystems for the different services they provide requires sound knowledge of the contribution made by each ecosystem and its components to the production of each specific type of service and benefit at the end.

In this study, it was only possible to try a breakdown of the value of the benefits provided by the production of food resources by type of marine ecosystem. To this end, the preferred ecosystem types for the capture of different species group (listed by FAO) were identified by experts according to the ecosystems frequented by adult individuals in these groups (table 7 and annex 10 for the breakdown of catchments by ecosystem in the Mediterranean).

Table 7: Distribution of the value of the benefits relating to the production of food resources by type of ecosystem providing fisheries resources

	Heading	**Total**	**Posidonia meadows areas**	**Soft substrate areas**	**Area of Hard substrate areas**	**Corallogenic areas**	**Open water**
A	Catchment (in t)	1 070 993	27 210	133 746	48 003	37 483	710 542
B	Catchment distribution (in % of tonnes)	100%	3%	14%	5%	4%	74%
C	Value of the benefits (in millions Euros) (total benefits*B)	2 871	83	399	144	112	2 133
D	Area covered (km²)	2500000	35000	217 000	108 500	108 500	2031000
E	Area distribution (in % of km²)	100%	1%	9%	4%	4%	81%
F	Value of benefits per unit of area covered (in €/km²) (C/D)	1 148	2 379	1 839	1 323	1 032	1 050
G	Quantitative productivity (t/Km²) (A/D)	0.4	0.8	0.6	0.4	0.3	0.3
H	Economic productivity (€/km²) (C/D)	1.1	2.4	1.8	1.3	1.0	1.1

According to this distribution, the pelagic ecosystems seems to contribute to 74% of the benefits value related to the provision of food resources harnessed by fishing and aquaculture activities. However, it should be noted that this distribution takes no account of the differences in value added for fishing in each of these different areas since it is only based on the catchments. It considers neither the value of the catches on the market nor the level of the costs involved in these catches. Moreover, the distribution fails to address the eco-systemic links which exist when the individuals of one species frequent various ecosystems during their lifetime.

Conclusion

This exploratory study and the results which issue from it are a first attempt to assess the benefits from the marine ecosystems in the Mediterranean in economic terms. The constraints faced in drawing up the study, be these in terms of applying the sustainability criterion to evaluate the benefits under consideration or the lack of sound data for some potential benefits, which as a result could not be included in the study, have given rise to what is probably a low initial assessment of the value of all the sustainable benefits from marine ecosystems.

As such, this study calls for further work to be conducted on the data availability and for a possible revision of the scoping and the method of evaluation.

Although the evaluation approach applied to the contributions issued from ecosystems shows room for improvement and aggregates the results issued from various evaluation methods, as discussed in part II of this report, the results arrived at nonetheless provide an initial scale of magnitude for the value of the benefits flowing from the marine ecosystems in the Mediterranean. This evaluation focuses on the value of the flows created by the environmental assets comprising the natural marine capital, without making any attempt to estimate the value of the stock of natural capital.

This initial evaluation reveals the need to dig deeper as a result of gaps observed in relevant data for the basin as a whole, but also in terms of backup from additional studies, which would allow the micro-economic processes to be better reflected. For this purpose, particular efforts should be made to further the knowledge base, both at ecological level (data relating to ecosystems, the ecological processes- as in the European MEECE project, Marine Ecosystem Evolution in a Changing Environment –, the quantities of flows used…) and at economic level (value added created in the various maritime activities, non-market uses of marine and coastal ecological services, the jobs created by these activities, the taxes and subsidies relating to these activities, etc.). This additional knowledge could be gleaned from case studies on specific sites in the Mediterranean or by sector of economic activity (fishing, tourism...). Some of these studies are already included in the Blue Plan programme (local studies on Marine Protected Areas and a regional one on the sustainability of Mediterranean maritime activities).

Moreover, the study is scoped to assess the exclusively sustainable portion of the benefits flowing from the marine ecosystems and therefore does not address the income created by the non-sustainable exploitation of natural resources and other ecosystem services of marine origin. However, for knowledge-related and data reasons, it was only possible to apply this principle to fishery-related benefits and to the regulatory service relating to waste treatment. Since the aim of this type of study is to provide public decision-takers with information which will assist them in their task, further work will need to be undertaken in order to better quantify the various levels of consumption of natural capital and to extend the scope of observation in order to cover the interaction between activities on land and at sea. The Blue Plan also intends to conduct works in this sense, focusing its efforts on maritime activities.

These efforts could lead to the development of an economic evaluation of the contributions made by ecosystems at a more significant level for public decision-makers and could lead to a more specific focus on certain remarkable types of ecosystem such as the Posidonia meadows or certain ecosystem services such as waste treatment. Such furtherance could in parallel be instrumental in supporting the implementation of environmental satellite accounts in the national accounting of various Mediterranean countries, in application of what is recommended by the United Nations in the SEEA 2003 and its development. The SEEA would then make it possible to provide significant national aggregates in terms of sustainable benefits from ecosystems, drawing a distinction between the sum of benefits received and the sum of the consumption of natural capital, and allow them to be tracked over time.

Moreover, it would also be useful to study the temporal dynamics of the relations between ecosystem services and economic activities or well-being. The continuity of these flows is influenced by changes coming about in the ecosystems (changes to the physico-chemical environment and in food chains, for example) and depends on the resilience of these ecosystems to change. Natural and economic sciences will also need to assist in furthering this knowledge, as a basis for the assessment of how economic development depends on the ecological situation. The interaction between these two disciplines would also allow greater account to be taken of potential ecosystem trends along with qualitative and quantitative variations in the ecosystem services provided, and for a better evaluation of the economic implications of these phenomena within the framework of cost/benefit analyses, for example. This work could be taken as a basis for defining regulatory mechanisms aimed at mitigating environmental externalities and increasing the sustainability of maritime and coastal economic activities in the Mediterranean.

Generally speaking, it seems important that the knowledge base and the tools of analysis should be enhanced in four areas:

- The ecosystemic approach, which would make for a better understanding of intra and inter-ecosystem relations, paying particular interest to the land-sea continuum (ecological interactions) and threshold effects (irreversibility). Such advances would make a major contribution to dynamic studies, forward-looking ones in particular. It should be pointed out that MAP has committed to implement an ecosystemic approach to the management of human activities potentially affecting the marine and coastal environment.
- The dynamic evaluation of the benefits from ecosystems, based on retroactive and forward-looking studies, modelling and scenarios.
- The evaluation of the cost of degradation and depreciation in order to take better account of the effects of a drop in the provision of ecosystem services (relating to the consumption of natural capital or climate variations, for example).
- The evaluation of restoration costs, protection costs or the cost of mitigating effective and potential environmental externalities, reflecting the steps taken towards maintaining a certain level of provision of ecological services.

The ecosystemic approach would thus back up scenarios from an ecological point of view and would provide relevant indicators for ecosystem monitoring and management, whilst the three economic approaches allow for the provision of assistance in decision-making for the allocation of resources at the time of investment or public spending as well as in the shaping of development policy.

APPENDIX 1: List of Members of the Steering Committee associated with this study

In alphabetical order:

Lucien CHABASON, President of Blue Plan and Director of the Institute for Sustainable Development and International Relations (Iddri), France. Chairman of the Steering Committee.

Laurent CHAZEE, Coordinator of the « Mediterranean Wetlands Observatory » programme, Tour du Valat, France.

Elisabeth COUDERT, Programme officer, Tourism, Blue Plan, France.

Christophe DU CASTEL, Head of the Mediterranean project, French Global Environment Fund (FFEM), France.

Abderrahmen GANNOUN, Director, Specially Protected Areas Regional Activity Centre (SPA RAC), Tunisia.

Samir GRIMES, Lecturer- researcher in marine biology, Ecole Nationale Supérieure des Sciences de la Mer et de l'Aménagement du Littoral (ESSMAL), Algeria.

Alain JEUDY de GRISSAC, Coordinator of the programme for conservation in the marine environment, Centre for Mediterranean Cooperation, International Union for the Conservation of Nature (IUCN), Spain.

Harold LEVREL, Economic research officer, French Research Institute for the Exploitation of the Sea (Ifremer), France.

Chedly RAIS, Senior expert on marine biology, OKIANOS consultancy, Tunisia.

Jean-Louis REIFFERS, Vice President of Blue Plan and Professor in economics, Centre de recherche en Développement Economique et Finance Internationale (DEFI), University of Aix-Marseille II, France.

Jean-Michel SALLES, CNRS environmental economic research officer, Laboratoire Montpelliérain d'Economie Théorique et Appliquée, University of Montpellier I, France.

Henri-Luc THIBAULT, Director, Blue Plan, France.

Jean-Louis WEBER, Senior expert in environmental accounting, EEA, Denmark.

APPENDIX 2: Programme of Work

The programme of work for this experimental regional study was organised in four successive stages:

Stage 1: scoping (January –March 2009)

- Theoretical and methodological inventory. Choice of a macro-economic approach.
- Choice of options for scoping the field of study in accordance with the Blue Plan remit:
    - Regional scope: all Mediterranean marine ecosystems.
    - Sustainable development: taking account of the sustainable benefits.
- Identification of partners and launch of cooperation.

Stage 2: Feasibility study (March-August 2009)

- Preliminary study: roll-out of Costanza *et al.* (1999) at Mediterranean level, applying it to the marine and coastal areas of the Mediterranean countries proposed by Martinez *et al.* (2007). Results presented in appendix 3.
- Development of a macro-economic type approach and drawing up of a methodology to assess the value of the benefits provided based on the SEEA (UN 2003).
- Identification of the ecosystem services provided in the Mediterranean (appendix 4) and drawing up of an analytical framework (ecosystems/ecological services/benefits provided) in order to bring together and interpret the results (appendix 5).
- Identification of needs in terms of data and the collection of ecological data (ecosystems, their geographical representation, the ecosystem services provided) and economic data on use (level of activity, manpower...).

Stage 3: Processing and results (September-December 2009)

- Data processing
- Analysis of the results
- Circulation of the results: drafting of a report.

Stage 4: Participant feedback (January-May 2010)

- Circulation of the study (report and oral communications)
- Lessons learned
- Future prospects

APPENDIX 3: Preliminary Study

The preliminary study, consisting of a calculation based on global unit values reported in Costanza *et al.* (1997 and in Costanza *et al.* 1999)[82] and area by Mediterranean riparian state (Martinez *et al.* 2007), provides an order of magnitude at regional level. These values should not be taken as alternative results to those of this study (the reasons why Costanza *et al.*'s (1997) unit values do not appear to be usable are mentioned in part I section 2-2). The preliminary study was conducted purely in order to indicate the implicit state of knowledge; the article by Costanza *et al.* (1997) is in fact one of the most often cited (and criticised) regarding benefit evaluation and Martinez *et al.*'s (2007) data is available on the internet. When the Blue Plan study on the benefits relating to the services provided by the Mediterranean marine ecosystems was launched, no other easily accessible data base appropriate to this study was available.

Methodology applied:

- The unit values (in dollars US (USD) per hectare for 1997) per type of service chosen by Costanza *et al.* (1999) are as follows:
  - N, P and K processing (*nutrient cycling*): 118 USD per ha in the high seas, 1 431 on the continental shelf, 19 000 in the sea-grass beds, 21 100 in estuaries.
  - Food production: 15 USD per ha in the high seas, 68 on the shelf, 52 in estuaries.
  - Raw material production: 2 USD on the shelf and in the sea-grass meadows, 20 in estuaries.
- The areas for the various types of ecosystem in km² per state are the ones used by Martinez *et al.* (2007). An extrapolation based on the coastline per country allows the missing data for Cyprus, Malta, Monaco, Montenegro and the Palestinian Territories to be generated. An adjustment which was needed in order to assess the area of the Mediterranean zones alone was carried out in approximate terms for Egypt, France, Israel, Morocco, Spain and Turkey.
  The following area sizes were arrived at:
  - Continental shelf: 539 000 km²
  - Sea-grass meadows: 11 400 km² (extrapolation of the missing data using the length of coastline in Martinez *et al.*, 2007). It should be pointed out that this assessment is way below the one used for the study (35 000 km²)
  - Estuaries: 10 000 km² (extrapolation using the global area indicated by Costanza)
  - High seas: 1 960 000 km² (calculated as the difference between the total area and that of the shelf).

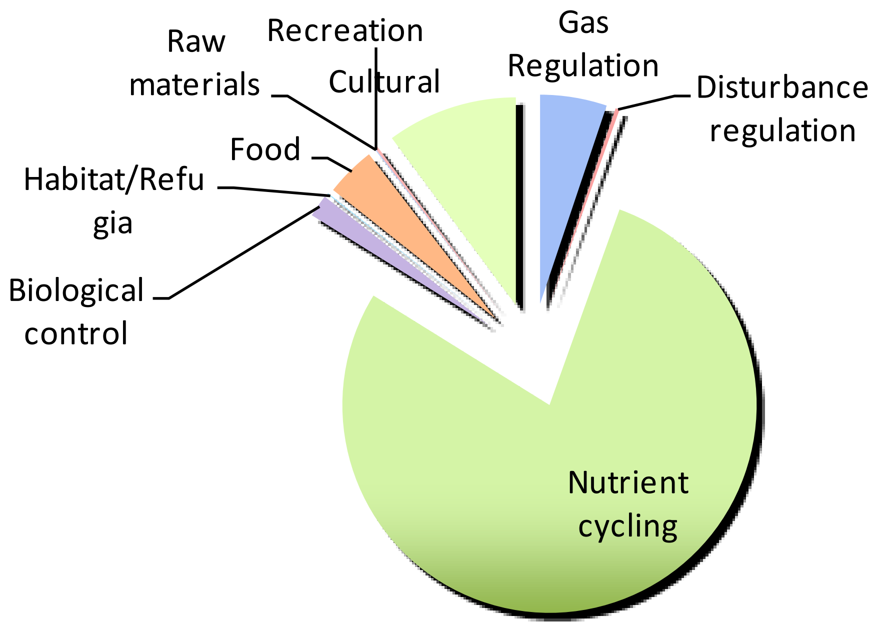
The main results are as follows:

- The value of the services provided by the Mediterranean marine ecosystems represents about 60% of Greece's GNP or 6 times that of Tunisia.[83]
- N, P and K processing represents 78% of the total of the value in the Mediterranean; this high value can be attributed to the size of the continental shelf areas in relation to the high

82 These values have been converted into Euros-2005 (US consumer price index and exchange rate in 2005). http://www.bea.gov/index.htm
83 World Bank data from the following sites:
For GDP: http://siteresources.worldbank.org/DATASTATISTICS/Resources/GDP.pdf
For population : http://siteresources.worldbank.org/DATASTATISTICS/Resources/POP.pdf

seas, compared with the oceans. Climate regulation represents 5% of the total, food products 4%[84] and cultural services from nature 10% (Figure 2).

Figure 2: Distribution of the value of ecosystem services provided by marine ecosystems, combining the values chosen by Costanza and the areas used by Martinez.



84 The per hectare unit value used by Constanza et al. (1997) is a global average value, which produces a tendency to under-evaluate (on average, the value of one ton of fish landed on the quayside is higher in the Mediterranean); It should, however, be noted that using the price of catches landed on the quayside leads to an over-assessment of the value of the services provided by ecosystems, since it includes intermediate consumption (particularly fuel) and the flows of capital and labour services (this issue is discussed in greater detail in section 1-1 of the second part of this report) .

APPENDIX 4: Comparison of the ecosystem services chosen for this study with those proposed by various reference sources

For this study: in green when evaluated, in yellow when included in a broader category, in red when not evaluated.

	Costanza et al. (1997)	*De Groot et al. (2002)*	*MEA (2005)*	*Wallace (2007)*	*Beaumont et al. (2007)*	*TEEB (underway)*	*This study*
	17 Global ESs	***23 Global ESs***	***24 Global ESs***	***16 Global ESs***	***13 Marine ESs***	***22 Global ESs***	***11 Marine ESs***
Production function	Production of food resources	Production of food resources	Crops (agriculture)	Food resources	Production of food resources	Production of food resources	Production of food resources (fisheries, shellfish and fish farming)
			Breeding				
			Fishing				
			Aquaculture				
	Production of raw materials		Construction timber	-	Production of raw materials	Production of raw materials	Production of raw materials (including medicinal and ornamental)
			Cotton, hemp, silk…	-			
			Freshwater	Drinking water		Freshwater	
			Firewood	Energy		-	Renewable energies
	Production of genetic resources		Genetic resources	-	-	Production of genetic resources	Genetic and biochemical resources
	-	-	Bio-chemical products	-	-	-	Included under raw materials
	-	Production of medicinal resources	Natural medicines, Pharmaceutical products	-	-	Production of medicinal resources (biochemical products, test organisms …)	
		Production of ornamental resources	-	-	-	Production of ornamental resources	
Cultural and informational function	Recreation	Recreation	Recreation and ecotourism	Leisure and recreation	Leisure and recreation	Recreation and tourism	Provision of support for recreational activities
	Non market cultural uses	Aesthetics	Aesthetics	Aesthetics	-	Aesthetic information	Provision of amenities (including landscape, local climate, water cycle)
		Cultural and artistic information	-	-	Cultural and identity heritage	Cultural and artistic inspiration	Cultural and spiritual support
		Spiritual and historical information	Spiritual and religious contentment	Spiritual and religious contentment	Feeling of well-being, of living well	Spiritual experiences	Included in cultural and spiritual support
		Scientific and educational information	-	-	Information towards cognitive development	Information towards cognitive development	Included in cultural and spiritual support
	-	-	-	A benign social group	-	-	-
	-	-	-	Meaningful occupation	-	-	-
	-	-	-	Option value (possibility of developing further uses in the future)	Option value (possibility of developing further uses in the future)	-	Not taken into account in this study but nonetheless borne in mind.

<table>
<tr><th></th><th>Costanza et al. (1997)</th><th>De Groot et al. (2002)</th><th>MEA (2005)</th><th>Wallace (2007)</th><th>Beaumont et al. (2007)</th><th>TEEB (underway)</th><th>This study</th></tr>
<tr><td rowspan="14">Regulatory function</td><td colspan="3">Air quality regulation</td><td>Oxygen</td><td rowspan="2">Air and climate regulation</td><td>Air quality regulation</td><td>Air quality regulation</td></tr>
<tr><td colspan="3">World climate regulation</td><td>Chemical environment</td><td>Climate regulation</td><td>World climate regulation</td></tr>
<tr><td colspan="3" rowspan="2">Regulation of the local climate and natural hazards</td><td>Temperature</td><td rowspan="2">Disturbance prevention (flood and storm protection)</td><td rowspan="2">Mitigation of extreme events</td><td>Local climate included in amenities</td></tr>
<tr><td>Light</td><td>Mitigation of natural hazards (including erosion)</td></tr>
<tr><td colspan="2">Water cycle regulation</td><td rowspan="2">Water cycle regulation</td><td>Humidity</td><td>-</td><td rowspan="2">Water cycle regulation</td><td>Water cycle regulation included in amenities</td></tr>
<tr><td colspan="2">Water provision</td><td>-</td><td>-</td><td>Not applicable</td></tr>
<tr><td colspan="3">Mitigation of erosion</td><td>-</td><td>-</td><td>Prevention of erosion</td><td>Erosion included in Mitigation of natural hazards</td></tr>
<tr><td colspan="2">Soil formation</td><td>-</td><td>-</td><td>-</td><td>Soil formation</td><td>Not applicable</td></tr>
<tr><td colspan="2">Nutrient recycling</td><td>-</td><td>-</td><td>Classed under support function</td><td>-</td><td>Considered as a support function</td></tr>
<tr><td colspan="2">Waste treatment</td><td>Water purification and waste treatment</td><td>-</td><td>Waste treatment</td><td>Waste treatment (water purification)</td><td>Waste treatment</td></tr>
<tr><td colspan="2">Pollination</td><td>Pollination</td><td>-</td><td>-</td><td>Pollination</td><td>Not applicable</td></tr>
<tr><td colspan="2">Biological control (maintaining the structure and workings of the food chain)</td><td>-</td><td>-</td><td>-</td><td>Biological control (maintaining the structure and workings of the food chain)</td><td>Considered as a support function</td></tr>
<tr><td>-</td><td>-</td><td>Disease regulation</td><td>-</td><td>-</td><td></td><td rowspan="2">Regulation of disease and parasites destined for humans: included in Waste treatment</td></tr>
<tr><td>-</td><td>-</td><td>Parasite regulation</td><td>Protection against predation</td><td>-</td><td>-</td></tr>
<tr><td rowspan="4">Support function</td><td>Refuge/habitat</td><td>Refuge</td><td>-</td><td>-</td><td>Habitat</td><td>Nursery</td><td rowspan="4">Function not assessed as deemed to be intermediate ecological processes towards the final ecological services</td></tr>
<tr><td>-</td><td>Spawning ground/Nursery</td><td>-</td><td>-</td><td>-</td><td>Protection of genetic diversity</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>-</td><td>Resilience and resistance (life support)</td><td>-</td></tr>
<tr><td>-</td><td>-</td><td>-</td><td>-</td><td>Nutrient recycling</td><td>-</td></tr>
</table>

APPENDIX 5: Contributions made by Mediterranean marine ecosystems to the provision of the ecosystem services covered by the study

Type of ecosystem	Ecological functions and services										
	Extraction function			Regulatory function					Cultural and recreational function		
	Production of food resources	Production of raw materials	Production of genetic and biochemical resources	Production of renewable energy	Air quality regulation	Global climate regulation	Mitigation of natural hazards	Waste treatment	Amenities	Support for recreational activities	Cultural and spiritual support
Posidonia meadows	Habitat, spawning ground, Nursery for fisheries resources		?	?	?	CO_2 sequestration in the duff	Mitigates erosion	Contribution to the absorption of organic discharge	Contributes to the coastal landscape and to the presence of a specific biocenosis	Diving, swimming,…	?
Corallogenic concretions	Habitat, spawning ground, Nursery for fisheries resources	Production of red coral, sponges…	?	?	?	CO_2 sequestration by carbonate formation	?	Contribution to the absorption of organic discharge	Contributes to the coastal landscape and to the presence of a specific biocenosis	Diving, swimming,…	?
Sandy seabed	Habitat, spawning ground, Nursery for fisheries resources	[Aggregate(*)]	?	?	?	CO_2 sequestration in sediment	?	Contribution to the absorption of organic discharge	Contributes to the coastal landscape and to the presence of a specific biocenosis	Swimming,…	?
Rocky seabed with photophilic algae	Habitat, spawning ground, Nursery for fisheries resources	?	?	?	?	?	?	Contribution to the absorption of organic discharge	Contributes to the coastal landscape and to the presence of a specific biocenosis	Diving, swimming,…	?
Open sea	Habitat for fisheries resources	[Oil drilling (*)]	Deep-lying habitat genetic resources?	Swell?	?	CO_2 sequestration in water and sediment + rainfall from evaporation	?	Contribution to the absorption of organic discharge and to the dilution of other discharges	Contributes to the coastal landscape + presence of a specific biocenosis + affects local climate (sea breeze…)	Yachting, cruising, Whale watching, Water sports…	?

(*) : In this study, the production of raw materials by the marine ecosystems is not seen as a benefit, since it is the result of non-sustainable use, based on the extraction of a resource which constitutes the basis for an ecosystem's existence.

APPENDIX 6: Value relating to rainfall following evaporation from the Mediterranean Sea

The ocean plays a major role in the water cycle. At global level, evaporation from the ocean surface is greater than from the surface of the land, although relatively speaking there is more rainfall over the land than over the sea. The presence of the Mediterranean Sea has a considerable influence on the rainfall system affecting the riparian countries and therefore also on the regional climate, which benefits the people living in the Mediterranean catchment basins. Without it, the climate in the coastal zones would be much drier than it already is. It should be noted that this ecological service only involves abiotic processes and therefore does not depend directly on the quality of marine ecosystems. The suggestion is that the benefits provided by this ecological service should be assessed on the basis of a substitute which can be calculated: willingness to pay for agricultural water in the Mediterranean catchment basins, for a quantity corresponding to the rainfall which can be attributed to evaporation from the Mediterranean Sea. Water is taken to acquire an economic value when essential needs are covered and the users are willing to pay in order to obtain an additional unit rather than do without (United Nations, 2007[85]).

Method:

Evaluation of the amount of rainfall received by the Mediterranean countries:

The Mediterranean water cycle has been the subject of numerous studies. Compared with other seas, the Mediterranean experiences major evaporation, exceeding the rainfall and river input it receives. The resulting deficit is compensated for by the input from the Black Sea and the Sea of Marmara through the Dardanelle Straits, from the Red Sea through the Suez Canal and particularly from the Atlantic Ocean through the Strait of Gibraltar.

Mariotti (2001) proposes a summary of water balances for the Mediterranean, drawn up according to different methods, which provide in particular the amount of humidity which leaves the atmosphere over the Mediterranean Sea[86] on an annual basis. This net amount of water is by definition that which enters the general atmospheric system, which feeds rainfall over the surface of the earth as a whole, with the exception of the Mediterranean. Varying from year to year, it was assessed on the basis of observations conducted from 1979 to 1993, on various hypotheses, at between 488 and 659 mm per year (expressed in terms of height related to the surface of the Mediterranean sea), in other words an average annual quantity of 573 mm or a volume of 1.44 10^3 km^3.

This quantity should be compared with the rainfall received by the Mediterranean countries. Based on FAO/Aquastat data, the Blue Plan and Margat (2008) have provided an assessment of the annual volume of rainfall for the Mediterranean riparian countries: 2.4 10^3 km^3 for the entire area and 1.1 10^3 km^3 for that portion which falls on the Mediterranean catchment basins. It can be seen that the latter value is close to the net quantity of water evaporated by the Mediterranean Sea. Consequently, in order to simplify and bearing in mind the temporal variability and uncertainty which affects these evaluations, it is proposed that for the rest of the evaluation the quantity of water evaporated from the Mediterranean sea is equal to the quantity of rainfall received by the Mediterranean catchment basins in the riparian countries.

85 This document sets out the SEEA conceptual framework applied to water. It includes various implementation aspects.
86 Moisture divergence.

Assessing the benefits provided by this service:

The rainfall received does not contribute in even fashion to people's well-being[87]. A distinction can mainly be drawn between (i) water evaporating from forests and uncultivated land, (ii) water benefiting rain-fed crops and (iii) the so-called « blue » water for other uses, irrigation, industry and domestic uses, the annual volumes of which are available in the annual water balances drawn up for each riparian state by the Blue Plan and Margat (Blue Plan, 2007, 2008).

Assessing the value of water is a particularly complex issue, set out in the SEEAW manual, which applies the SEEA conceptual framework to water (United Nations, 2007). In the absence of a free market for water, as is the case for the Mediterranean riparian countries just as for most countries around the world, the SEEAW proposes various assessment methods including the so-called shadow price one. Establishing the shadow price for water, however, requires a large amount of empirical physical and economic data in order to establish a matrix (input/output) for water uses then a generalised programming model. Consequently, very few country-level studies have been conducted. The SEEAW happens to present a study on Morocco (Bouhia, 2001), which amongst other things provides shadow prices for water for different sectors and different abundance conditions. It is proposed that the results of this study should be used for want of anything better, extrapolating them to the Mediterranean countries as a whole.

A particularly cautious approach has been chosen:

- Evaluation limited to the benefits provided for the agricultural sector, which is the main water user in the Mediterranean (the available data on volumes for other uses being subject to caution for this evaluation).
- Shadow price for water chosen in Bouhia (2001) corresponding to an average year with no particular water constraints based on observations from the 90s. Bouhia (2001) shows that this price presents a flexibility which decreases sharply with resource availability (decreases only slightly when there is more availability than in an average year, but rises sharply when availability is below average). Some World Bank forecasts quoted in Bouhia (2001) point to a 50% drop in *per capita* availability for Morocco in 2020 compared with the reference year of 1997, characterised by a situation of chronic water stress. It can therefore be assumed that the current shadow price for agricultural water is already much higher than what was assumed for the calculation.
- Basic scenario drawn up in 1997. Back then, non sustainable uses of water were already coming in for sharp criticism (use of groundwater resources, with no other constraints apart from the cost of pumping), although these uses were already very widespread and often in the majority, which tends to drive the shadow price for water down.

In 1997, the marginal value of an additional cubic metre of water for the agricultural sector in Morocco was assessed at 0.36 DH/m^3 (where DH= Moroccan Dirham), i.e. updated and converted into euro-2005: 0.036€/m^3. This price is well below the observed production cost of irrigation water, which was evaluated at 1.14 DH/m^3 for groundwater resources at the same moment in time, and is also below the cost of mobilising water for surface resources.

In determining the quantities of agricultural water used in the Mediterranean catchment basins, the FAO/Aquastat statistics meant that water use in agriculture could be assessed for each Mediterranean country on the basis of the 2000 data for the whole of their national territory. Based on Blue Plan and Margat (2008) data, the portion relating to their Mediterranean catchment basin

87 And even regularly produces damage- if not disasters- not considered here.

was calculated by establishing the share between (i) the renewable water resources which can be mobilised in an average year throughout the national territories of these countries and (ii) these same resources for that portion of their territory which belongs to the Mediterranean catchment basin. The necessary adjustments were made in order to take account of specific cases (e.g. in Egypt, taking account of rainfall alone, leaving aside input from the Nile) and to complete the tables. It was ascertained that the total quantity obtained through the use of connate water (not groundwater) in agriculture is close (+ 12%) to the quantity assessed by the Blue Plan and Margat (2008) for the catchment basins of each Mediterranean state. The annual total amounts to 72.65 km^3, with three countries accounting for 60%: Italy (28%), Turkey (17%) and Spain (15%).

Finally, in 2005, the value of the benefits provided for agriculture at regional level amounted to some 3 billion Euros.

Results:

The national value of the benefits is a function of the consumption of agricultural water estimated for the Mediterranean catchment basins of each country, breaking agricultural water consumption down by country according to the method described earlier for the assessment of the benefit as a whole.

Discussion and prospects:

The assessment of the contribution made by the Mediterranean to the large water cycle is still the subject of scientific study. The data used for this study is relatively recent and is still being discussed within the scientific community, as is shown by the dispersal of the results presented by Mariotti (2001). Scientific research currently underway on the global climate and its regional roll-out in the Mediterranean should result in the rainfall assessment becoming more finely tuned. It should be pointed out that rainfall varies widely from one year to the next and depends on climate trends. In the absence of specific data for the year of reference for the study (2005), this is more of an evaluation of an average year as established on the basis of physical and economic observations carried out in the 80s and 90s.

The decision to stick to the agricultural sector alone was mainly dictated by the fact that this sector is the leading user of water in the Mediterranean. Moreover, the physical data available for the other sectors was subject to caution or difficult to use for certain countries. Thus the water used in large quantities to cool electricity production plants is frequently reused, which is not the case after certain other highly polluting industrial uses. Consequently, this study does not take account of the benefits provided by water in other sectors of activity such as tourism, energy and domestic use. The evaluation could be completed in this respect in collaboration with water use specialists in the Mediterranean.

The main difficulty with the evaluation stems from determining the value of water in economic terms. The shadow price-based approach looks particularly interesting, but it requires a considerable amount of analytical work upstream, which has been conducted in particular in China (Xiuli, 2008) and Morocco (Bouhia, 2001). The latter country has been the subject of in-depth study, which has the advantage of involving a Mediterranean country and of being quoted as an example by the SEEAW. The results of this work were therefore used for this study and, for lack of anything better, were extrapolated to all of the countries in the Mediterranean basin. The shadow price for agricultural water depends by definition on the function of agricultural production, which differs from country to country and particularly between countries to the north and those to the south. It can, however, be assumed that all the countries in the Mediterranean basin have developed modes of production tailored to their water availability in an average year, based on agronomic water efficiency, determining the economic efficiency of water in agriculture[88].

Although climate regulation is usually considered in the list of services provided by ecosystems, the benefits provided by rainfall are not generally taken into account by authors who have worked on marine ecosystems (Martinez, 2007; Beaumont, 2007). The assessment of the benefits provided by the Mediterranean's role in the regional water cycle is proposed here on an exploratory basis as it does not correspond to the scope of analysis selected. In fact, as was mentioned in section I.4.2, the water cycle cannot really be likened to an ecological service because the ecological processes underway are essentially abiotic and man has no direct hold on them.

88 The agronomic efficiency of water compares biomass yield with the water used (rainfall and irrigation) per surface unit.
The economic efficiency of water relates the value of the agricultural product and the opportunity costs of the water used for agricultural production.
An objection can be levelled at the hypothesis proposed, bearing in mind the influence which irrigation technology can have on the choice of type of agriculture and the crops grown. The Mediterranean riparian countries, which often face periods of water stress, have been developing such technology since antiquity. It should be noted that very often it has been the development of this technology which has allowed a specific agriculture to develop, rather than the structural climatic qualities of the area. The hydraulic efficiency of the irrigation network can thus balance out water needs for certain agricultural products and explain their cultivation, even in a context of water scarcity.

APPENDIX 7: Weak *versus* strong sustainability

Atkinson et al. (1997) and Neumayer (2003) present in detail the discussions having brought the supporters of weak or strong sustainability into conflict, notably Solow (1979) and Stiglitz (1979) and Geogescu-Roegen (1971, 1975)[89].

Economic sustainability analysis originated in Hotelling's work (1931) on the resource rent in the mining sector. A distinction can be drawn between market natural capital (non renewable resources and some renewable ones) and non-market natural capital (part of the renewable resources which correspond to environmental services such as amenities and the biosphere's absorption capacity). As far as market natural capital is concerned, depreciation is measured by aggregating the Hotelling scarcity rents[90].

In an optimisation situation, these rents provided by non-renewable resources come across as the price of the resource minus its marginal extraction cost. Hartwick's rule (1978) stipulates that they have to be fully ploughed back into the physical produced capital in order to keep the total capital intact. Solow (1986) shows that a non decreasing (sustainable) consumption path is in accordance with Hartwick's rule on intergenerational equity[91]. The concept of weak sustainability is thus a direct application to non renewable resources of the relationship between savings and growth within the growth theory (Cabeza-Gutés, 1996).

Pearce and Atkinson (1993) describe such a weak sustainability situation using the following equation:

$$Z = (S - \delta_m K_m - \delta_n K_n)/Y \geq 0 \qquad (1)$$

Where Z is a national sustainability indicator, S are the savings invested in a natural capital degradation compensation fund, K_m and K_n the physical produced capital and the natural capital, δ_m and δ_n the depreciation rates and Y is national income (it is assumed that the rate of depreciation for human capital δ_h is nil). As can be seen, the national weak sustainability indicator may remain constant (or even increase) in a situation where natural capital is destroyed. It can also be seen that Pearce and Atkinson's indicator takes no account of technical progress (Cabeza-Gutés 1996).

As far as non-market natural capital is concerned, most existing studies either do not measure the cost of depreciation or use heterogenic assessment procedures. Solow (1992) recommends applying the concept of scarcity rent to non market as well as to market capital, in order to preserve the coherence of the conceptual framework. The practical difficulty in assessing the scarcity rent stems, however, from the lack of ownership rights (and therefore the lack of resource access costs and of market price). A possible solution would be to use shadow prices, the use value (UV) or the total economic value (TEV). The intersection between the demand curve for non market assets (individual expressed demand; UV and TEV) and the curve for the marginal costs for restoring natural capital thus defines the optimal use point for which the shadow scarcity rent is nil. However, the assessment of a shadow rent creates the risk of confusion between economic optimisation and

89 Reference could also be made to Daly (1997).

90 Having been drawn up on the basis of an analysis of the conditions for exploiting mining deposits, Hotelling's rule does not well reflect a situation in which ecosystem destruction is induced by human activity. Chavassus-au-Louis et al. (2009) envisage a watered-down version of Hotelling's rule, which involves having prices evolve at the same rate as the discount rate minus the rate for reconstructing destroyed ecosystems. This approach leads, however, to the risks of irreversibility and loss of resilience being neglected.

91 See, for example, Faucheux and Froger (1994) for a non technical but nonetheless slightly more detailed presentation.

the sustainable use of natural capital. In fact, the short term economic optimum may exceed the sustainable use threshold (Hueting 1989).

In this study, natural capital and physical produced capital cannot be substituted and the sustainability approach is said to be strong; this requires *a minima* the preservation of a critical stock of natural capital (K^*_n), which is described by Pearce and Atkinson (1993) using the following equation:

$$\delta_n K^*_n \leq 0 \quad (2)$$

This constraint implies a nil or negative depreciation rate and the possibility of an appreciation of critical natural capital.

It should also be mentioned that certain recent approaches propose going beyond the two-way opposition between strong and weak sustainability.

Thus Hediger (1999, 2000) identifies four types of sustainability:

- « very weak sustainability », which corresponds to Hartwick-Solow sustainability: the economy's production capacity must be kept constant;
- « weak sustainability » : the value of the total capital, which comprises physical produced capital and natural capital must be preserved;
- « strong sustainability » : certain environmental functions must be preserved and the natural capital (or the quality of the environment) must be kept constant; strong sustainability therefore implies growth in the stock of renewable resources through recycling;
- « very strong sustainability » ; it requires a switch to a stationary state in the economy with constant population and production and the preservation of all types of natural resources.

Finally, Chevassus-au-Louis *et al.* (2009, 176) believe for their part that the issue can be broken down according to three hypothetical situations, which come back to the discussion of the substitutable nature of biodiversity:

- The irreversible loss of technically substitutable elements of eco-systemic services;
- Loss of irreplaceable elements of biodiversity, the imaginable consequences of which do not, however, threaten the survival of our societies;
- Loss of indispensible elements of biodiversity, the unforeseeable consequences of which put the survival of our societies as we know them at risk, if not the very future of mankind.

APPENDIX 8: Calculating the resource rent in the fisheries sector according to the SEEA

Since the rent is residual, the method of calculation is as follows:

(1) MI = Q - IC - w.N and thus (1') MI = VA - w.N

MI, is the mixed income. In the case of fisheries, MI is the mixed income of fishermen employers, combining payment for non-salaried labour and capital service flows, in other words equipment.

Q the value of production; $Q = \Sigma p_i . q_i$; p_i average unit prices at the quayside for species $_i$ and q_i catch quantity landed during the period under consideration (preferably one year).

IC intermediate consumption.

VA the value added in the sector, which corresponds to the service flows for the labour and capital factors (including production subsidies but excluding production taxes)

w.N payment for salaried work (w wage level and N the number of employees)

(2) GOS = MI - CL and thus (2') GOS = VA - w.N - CL

GOS the gross operating surplus

CL compensation of labour for fishermen-entrepreneurs

(3) NOS = GOS - CFC and thus (3') NOS = VA - w.N - CL - c.K

NOS net operating surplus.

CFC consumption of fixed capital CFC = c.K, with c being the depreciation rate and K the stock of fixed capital; c = 7.5% in the example referring to fisheries in the SEEA manual.

(4) RR = NOS - r.K and thus (4') RR = VA - w.N - CL - c.K - r.K

RR the rent from natural resources

r.K payment for fixed capital; r net rate of return on fixed capital; r = 4% in the case presented in the SEEA manual. Since VA = Q – IC, this then gives us

(4") RR = Q - IC - w.N - CL - c.K - r.K

APPENDIX 9: Assessing the role of natural capital as a determining factor in hotel activity

An assessment of the coastal effect on activity in the hotel business has been put forward. It is based on the one hand on the use of regional data for the Mediterranean regions equivalent to level 3 in the EU's nomenclature of territorial units for statistics (NUTS 3). Data are available in the Eurostat database for four EU countries: France, Greece, Italy and Spain (provincias in Spain, the equivalent of the départements in France, nomoi in Greece, provincie in Italy). It is also based, on the other hand, on measurements of the length of the coastline (lcote variable) by NUTS 3 conducted by the Blue Plan on the basis of Euromaps and GEBCO[92] (assessment obtained using GIS techniques by Karel Primard de Suremain). It seems appropriate to regard this effect as an indicator of the benefits of the services provided by ecosystems and therefore to use the portion related to the activity linked to the coast as an approximation of the resource rent related to these ecosystems as a percentage of the value added (VA). It should be pointed out that a further part of activity can be linked to the presence of services provided by terrestrial ecosystems. It is taken here that using the length of the coastline means that the effect relating to the marine ecosystems alone can be identified, rather than the resource rent in its entirety.

Hypothesis and data

The hypothesis adopted is that economic activity (explained variable) is positively influenced by the length of the coastline, all other aspects being equal (in other words by introducing control variables). Ideally, the aim would be to assess this relationship using micro-economic variables. The difficulty of accessing this type of data prompts the use of NUTS 3 level regional variables for various EU countries, despite the limited nature of the available data.

The data constraints concern both the explained variable and the control variables available at NUTS 3 level for the EU Mediterranean countries. The number of hotel establishments (« ettour » variable) is the only activity indicator available at NUTS 3 level. The variables available at the same level which can be seen to explain activity in the hotel business and therefore the number of establishments are the resident population (pop), the NUTS area (km²), the per capita income in purchasing power standard (gdp_pps) and the average wage in the hotel and catering sector (wht). Population and area are combined in a measurement of population density (pop_km2); density is expected to have a positive influence on the number of establishments (the greater the density, the greater the amount of activity excluding tourism which requires hotel services). The same applies to per capita income (wealth effect and indication of the importance of superior services, which draw heavily on hotel services). The wage level, on the contrary, is expected to have a negative influence (establishments will be located in regions with the same features but where wages are lower).

For 2005, the reference year for the study, the Eurostat database includes information on these variables for 4 EU Mediterranean countries: France, Greece, Italy and Spain. The sample size in total (126 NUTS 3; 9 observations in France, 40 in Greece, 61 in Italy, and 16 in Spain). The distribution by NUTS 3 of the relationship between the length of the coastline and the number of establishments (the two variables in log) is presented in figure 3. The distribution of the scattering of dots suggests the existence of a positive relationship.

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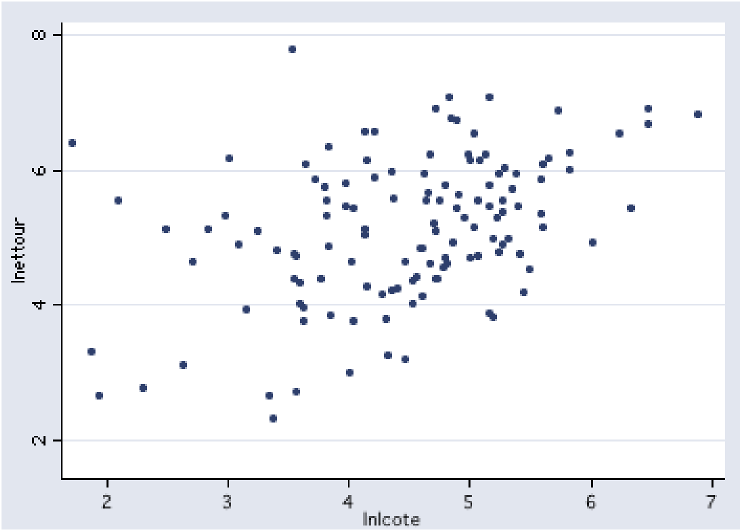
92 International Hydrographic Organization (IHO) and the International Oceanographic Commission (IOC) of UNESCO.

Figure 3: Relationship between length of coastline and the number of establishments (log-log)



Tests and results

Multiple regression is used to test the relationship between these variables. In order to take account of the different features of these 4 countries' national economies, country dummy variables are added, which are given the value 1 when the NUTS3 is located in the country under consideration and 0 if not; Greece is the omitted variable, which means that the value of the constant corresponds to Greece's situation (for the other countries, the sum of the constant and the dummy variable should be calculated).

The relationship tested thus takes the following form:

$$lnettour = \alpha + \beta.ln(lcote) + \gamma.ln(pop\_km2) + \delta.ln(gdp\_pps) + \zeta.ln(wht) + des + dfr + dit + \varepsilon$$

Where α is the constant, β, γ, δ, ζ, the coefficients of the variables they precede, *des, dfr* and *dit* are the dummy variables representing France, Italy and Spain and ε an error term. The multiple regression results in ordinary least squares are presented in table 1.

Given the heterogeneous nature of the NUTS, the R2 obtained is relatively high (0.48 for the adjusted R2). The coefficients are significant (at the 1% threshold except for density, whose coefficient is significant at the 10% threshold) and has the right sign for the four explanatory variables: positive effect for coastline length, per capita income and population density; negative effect for average wage. The coefficients for the dummy variables are positive and significant, which indicates a relatively higher number of establishments in France, Italy and Spain than in Greece, which is hardly surprising given the length of the Greek coastline. Constant (α) reflects the constant effect of the country whose dummy variable is omitted (Greece).

The coefficient with a value of 0.6 obtained for the length of the coastline can be interpreted as flexibility. In the sample under consideration, a 10% increase in a NUTS coastline is associated with an increase (significant at the 1% threshold) in the number of hotel establishments from 6% in this NUTS. This is a relative mean effect in variation. It is also possible to assess a relative mean level effect.

Measuring the level effect of the Mediterranean coastline on the number of establishments

In order to assess the relative mean level effect, the coefficient is multiplied by the mean value (in log) of the length of the coastline and the exponential of the value obtained is then calculated.

The value for the mean for the lcote log is calculated, giving 4.46959.

This mean (X) is multiplied by the coefficient β and is then expressed exponentially:

βX= .6004553 x 4.46959 = 2.683789

Exp(βX) = 14.64

The mean is calculated for the Ettour log, giving 281.3492.

The Exp(βX)/Ettour ratio is then calculated which is, in percentage terms, the number of additional establishments as a result of the effect relating to the length of the coastline.

Effect = 14.64/281.3492 = 5.2 %

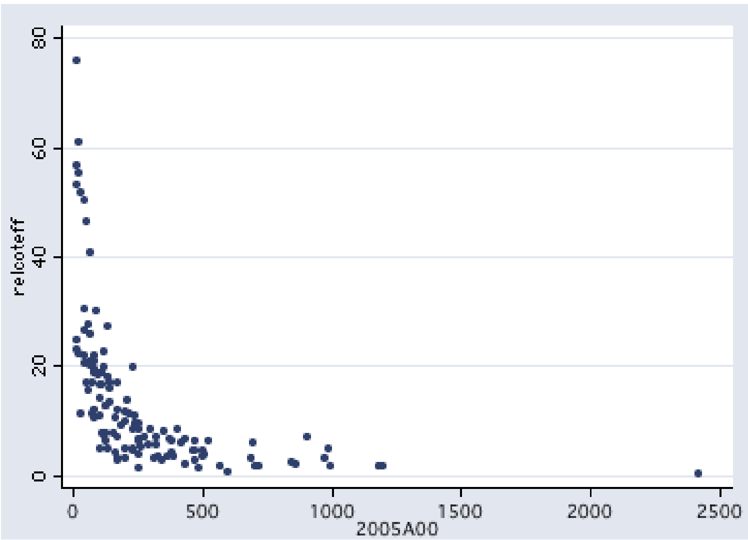
In other words an assessment of around 5%.

If the hypothesis of a linear relationship between the length of the coastline and the benefits attached to marine and coastal ecosystems is postulated, it can be taken that this percentage gives an indication of the share of the resource rent (natural capital from the marine and coastal areas alone) in the VA for the hotel sector. For want of anything better, this share can be used to assess the resource rent in restaurants, tourist activity and real estate in coastal NUTS 3 regions (a similar assessment not being possible for these activities given the lack of representative variables).

Tentative assessment of the coastal effect by NUTS

For each NUTS a predicted value (predicted by the equation) of the coastal effect (lcote effect variable) is generated, which is then expressed exponentially and measured in relation to the number of establishments in the NUTS. The results obtained are presented in figure 4.

Figure 4: Relationship between the number of establishments (x axis) and the coastal effect on the number of establishments by NUTS, in percentage terms (y axis)



It can be seen that the lower the number of establishments, the more marked the relative effect, which was the assumption. High values are obtained in the Greek islands, Corsica and Sardinia (particularly the NUTS3 corresponding to Costa Smeralda).

Results including the dummy variable for the Mediterranean island NUTS3

Similar results are obtained by adding a dummy variable for the island NUTS (disland); a positive effect can be expected, since a priori the islands are deemed to be more attractive, but the cost of crossing the divide nonetheless reduces access, which might suggest a negative effect.

Specific dummy variables are also introduced for the Balearics (taken together, the dummy variable applying to the 3 NUTS3 comprising the Balearics), Corsica (idem, 2 NUTS3), Sardinia (8 NUTS3) and Sicily (12 NUTS3). These variables are expressed as dbar, dcor, dsar and dsic. The Greek islands correspond to the omitted dummy variable, which means that the value of the disland dummy variable corresponds to the situation of the Greek islands.

It can be seen that the coefficient is no longer significant for population density and wage level. It is still significant, however, at the 1% threshold and at the same level for the coastline and per capita income. The coefficient is positive for the disland dummy variable (and therefore for the Greek islands) but negative for dbal, dcor and dsic ; the absolute values, which are considerably higher than the disland coefficient for dcor, dsar and dsic indicate that, in these 3 islands, the number of establishments is relatively lower than in the respective country. The main difficulty with this exercise relates to the differences which exist, for example between the Balearics and the Greek islands, in terms of the average size of establishments (number of beds). These differences are partly picked up by the country dummy variables but they cannot be checked at NUTS3 level due to the lack of data on the number of beds.

APPENDIX 10: distribution of fish catches by ecosystem type

Fish catches data distribution are from FAO statistics for year 2005 published in 2007 (table 8),.

Recorded catches correspond to catches in the groups of species which were attached to one or more ecosystems, following the behaviour of adult individuals of these species. The expertise was provided by Pr. Patrice Francour, ECOMERS laboratory, University of Nice Sophia Antipolis. Where the distribution produced figures with decimal points, the data was rounded off.

Table 8 : Catch distribution by ecosystem type

Groups of species	FAO data	Recorded catches	Sea-grass beds	Loose seabed	Rocky seabed	Corallogenic	Open sea
Albacore	3 657	3 658					3657
Angelshark	14	14		14			
Angelsharks, sand devils nei[93]	102	102		102			
Angler(=Monk)	5 762	5 762			2 881	2 881	
Aquatic invertebrates nei	4						
Argentines	109	109					109
Aristeid shrimps nei	3 174	3 174		3 174			
Atlantic bluefin tuna	23 886	23 886					23 886
Atlantic bonito	77 460	77 460					77 460
Atlantic horse mackerel	2 354	2 354					2 354
Atlantic mackerel	14 644	14 644					14 644
Atlantic pomfret	20	20					20
Axillary seabream	125	125	42		42	42	
Barracudas nei	2 668	2 668					2 668
Basking shark	4	4					4
Black goby	3	3		1	1	1	
Black seabream	284	284	95		95	95	
Blackmouth catshark	52	52		52			
Blackspot(=red) seabream	12	12	4		4	4	
Blotched picarel	820	820					820
Blue and red shrimp	2 413						
Blue ling	42	42		21			21
Blue shark	66	66					66
Blue whiting(=Poutassou)	8 805	8 805					8 805
Bluefish	2 783	2 783					2 783
Bogue	30 544	30 544					30 544
Brill	55	55		55			
Broadtail shortfin squid	44	44		44			
Brown meagre	139	139	46		46	46	
Brushtooth lizardfish	119	119		119			
Canary drum (=Baardman)	4	4	1		1	1	
Caramote prawn	6 649						
Carangids nei	473	473					473
Catsharks, nursehounds nei[94]	343	343		343			
Cephalopods nei	927	927					927
Chub mackerel	18 954	18 954					18 954
Clams, etc. nei	1 496	1 496		1 496			
Clupeoids nei	675	675					675
Common cuttlefish	9 740	9 740	3 247		3 247	3 247	
Common dentex	938	938			469	469	
Common dolphinfish	1 481	1 481					1 481
Common eagle ray	<0.5			<0.5			
Common octopus	12 856	12 856	4 285		4 285	4 285	
Common pandora	5 029	5 029		5 029			
Common periwinkle	4	4			2	2	
Common prawn	23	23			11	11	
Common shrimp	119	119			59	59	
Common sole	5 388	5 388		5 388			

93 nei = not elsewhere included
94 nei = not elsewhere included

Common spiny lobster	339	339	113		113	113	
Common squids nei	6 013	6 013					6 013
Groups of species	**FAO data**	**Recorded catches**	**Seagrass beds**	**Loose seabed**	**Rocky seabed**	**Corallogenic**	**High sea**
Croakers, drums nei	51	51	17		17	17	
Cuttlefish,bobtail squid nei	12 136						
Deep-water rose shrimp	16 326	16 326		16 326			
Demersal percomorphs nei	302						
Dogfish sharks nei	1 261						
Donax clams	257	257		257			
Dusky grouper	359	359			179	179	
Eagle rays nei	45	45		45			
European anchovy	102 814	102 814					102 814
European conger	2 695	2 695	898		898	898	
European eel	270						
European flat oyster	27	27			13	13	
European flounder	32	32		32			
European flying squid	5 293	5 293					5 293
European hake	27 430	27 430					27 430
European lobster	166	166			83	83	
European pilchard (=Sardine)	198 533	198 533					198 533
European plaice	5	5		5			
European seabass	2 608	2 608	869		869	869	
European sprat	268	268					268
Flatfishes nei	1 786	1 786		1 786			
Flathead grey mullet	3 700	3 700					3 700
Flying gurnard	4	4		4			
Forkbeards nei[95]	280	280			140	140	
Frigate and bullet tuna	3 029	3 029					3 029
Gadiformes nei	94						
Garfish	813	813					792
Gastropods nei	329						
Geryons nei	57	57			28	28	
Gilthead seabream	4 699	4 699		1 566	1 566	1 566	
Gobies nei	1 149	1 149	287	287	287	287	
Great Atlantic scallop	8	8		8			
Great Mediterranean scallop	78	78		78			
Greater amberjack	2 666	2 666					2 666
Greater forkbeard	452	452			226	226	
Greater weever	109	109		109			
Grey gurnard	632	632		632			
Grey triggerfish	111	111	37		37	37	
Grooved carpet shell	622	622		622			
Grooved sea squirt	3	3					
Groupers nei	4 952	4 952			2 476	2 476	
Groupers, seabasses nei	1 252	1 252	417		417	417	
Guitarfishes, etc. Nei	26	26		26			
Gulper shark	2	2					2
Gurnards, searobins nei	2 993	2 993		2 993			
Horned and musky octopuses	8 288	8 288	2 763		2 763	2 763	
Jack and horse mackerels nei	43 400	43 400					43 400
Jacks, crevalles nei	732	732					732
Jellyfish	42	42					42
John dory	386	386			193	193	
Kuruma prawn	104						
Large-eye dentex	456	456			228	228	
Largehead hairtail	782	782					782
Leerfish	734	734					734
Little tunny(=Atl.black skipj)	1 660	1 660			830	830	
Lizardfish nei	1 430	1 430		1 430			
Lobsters nei	1	1			0,5	0,5	
Mackerels nei	321	321					321
Marine crabs nei	3 629	3 629	1 210		1 210	1 210	
Marine crustaceans nei	1 089						
Marine fish nei	75 406						
Marine molluscs nei	5 535						
Marine shells nei	7,1						

95 nei = not elsewhere included

Marlins,sailfish,etc. nei[96]	50						
Meagre	1 281	1 281	427		427	427	
Group of species	**FAO data**	**Recorded catches**	**Seagrass beds**	**Loose seabed**	**Rocky seabed**	**Corallogenic**	**High seas**
Mediterranean horse mackerel	6 374	6 374					6 374
Mediterranean mussel	10 440	10 440			10 440		
Mediterranean shore crab	69	69			34	34	
Megrim	191	191		191			
Morays	11	11	4		4	4	
Mullets nei	16 719	16 719		16 719			
Murex	160	160		80	80		
Natantian decapods nei	8 339						
Norway lobster	5 569	5 569		5 569			
Octopuses, etc. Nei	10 171	10 171	3 390		3 390	3 390	
Oilfish	2	2					2
Palinurid spiny lobsters nei	140	140	47		47	47	
Pandoras nei	3 282	3 282		3 282			
Pargo breams nei	630	630	210		210	210	
Parrotfishes nei	22	22	7		7	7	
Picarels nei	8 968	8 968					8 968
Picked dogfish	26	26					26
Plain bonito	5	5					5
Pompanos nei	89	89					89
Poor cod	3 534	3 534			1 767	1 767	
Porbeagle	<0.5						<0.5
Porgies, seabreams nei	8 921	8 921	2 974		2 974	2 974	
Pouting(=Bib)	155	155			77	77	
Pullet carpet shell	<0.5			<0.5			
Raja rays nei	300	300		300			
Rays, stingrays, mantas nei	3 086	3 086		1 543			1543
Red bandfish	290	290		290			
Red gurnard	434	434		434			
Red mullet	14 064	14 064		14 064			
Red porgy	3 056	3 056	1 019		1 019	1 019	
Round sardinella	330	330					330
Rubberlip grunt	40	40			20	20	
Ruffs, barrelfish nei	12	12					12
Saddled seabream	850	850					850
Salema	2 275	2 275	2 275				
Salmonoids nei	<0.5						
Sand steenbras	1 138	1 138		1 138			
Sandeels(=Sandlances) nei	247	247		247			
Sardinellas nei	64 001	64 001					64 001
Sardinia coral	36	36			18	18	
Sargo breams nei	3 437	3 437	1 146		1 146	1 146	
Scallops nei	5	5		5			
Scarlet shrimp	45	45			22	22	
Scomber mackerels nei	6 972	6 972					6 972
Scorpionfish nei	2 287	2 287			1 143	1 143	
Sea cucumbers nei	4	4		4			
Seabasses nei	1 386	1 386	462		462	462	
Shads nei	2 418	2 418					2 418
Sharks, rays, skates, etc. nei	1 463	1 463		731			731
Shi drum	140	140	47		47	47	
Shortfin mako	17	17					17
Silver scabbardfish	412	412					412
Silversides(=Sand smelts) nei	7 360	7 360					7 360
Skipjack tuna	29	29					29
Small-spotted catshark	28	28		9	9	9	
Smooth-hounds nei	1 637	1 637					1 637
Soles nei	19	19		19			
Speckled shrimp	1 564	1 564		1 564			
Spinefeet(=Rabbitfish) nei	918	918	306		306	306	
Spinous spider crab	122	122	41		41	41	
Sponges	46	46			23	23	
Spottail mantis squillid	7 533	7 533		7 533			
Spotted seabass	642	642	214		214	214	

96 nei = not elsewhere included

Stingrays, butterfly rays nei	2	2		2			
Striped venus	15 345	15 345		15 345			
Surmullet	13 528	13 528		13 528			
Surmullets(=Red mullets) nei	7 271	7 271		7 271			
Swordfish	14 582	14 582					14 582
Thornback ray	330	330		330			
Thresher	15	15					15
Tope shark	15	15					15
Groups of species	**FAO data**	**Recorded catches**	**Seagrass bed**	**Loose seabed**	**Rocky seabed**	**Corallogenic**	**High seas**
Tub gurnard	30	30		30			
Tuna-like fish nei	4 739	4 739					4 739
Turbot	104	104		104			
Turbots nei	2	2		2			
Various squid nei	1 362	1 362		1 362			
Velvet belly	1	1					1
Wedge sole	2	2		2			
White seabream	927	927	309		309	309	
Whiting	2 511	2 511					2 511
Wrasses, hogfish, etc. nei	7	7	2		2	2	
Wreckfish	89	89			44	44	
Total catches	**1 070 993**	**957 006**	**27 210**	**133 746**	**48 003**	**37 483**	**710 542**
Share (in %) of FAO data	100%	89%	3%	12%	4%	3%	66%
Share in % of recorded catches	-	100%	2.9%	13.9%	5%	3.9%	74.3%

Comments on the data

FAO is responsible for collecting reliable information on global catches, in the knowledge that this data depends on the ability and the readiness of the countries involved to collect precise information in due time for their sector of national fisheries. These statistics should be handled with caution. They largely underestimate so-called small scale non-industrial fisheries, which exist on the coastline right around the Mediterranean and the socio-economic importance of which is recognised. It is particularly present over the Posidonia meadows, near coral reefs as well as over rocky sea-beds with photophilic algae.

Source : Chancollon, O. (2009). Study supervised by Pr. Francour, University of Nice Sophia Antipolis.

APPENDIX 11: Value of the various types of benefits provided by the Mediterranean marine ecosystems by riparian state

Country	Fisheries resource rent	Resource rent relating to the provision of amenities and recreational support				Value of the benefits relating to climate regulation (CO2 absorption)	Value of the benefits relating to protection against coastal erosion	Value of the benefits relating to waste treatment	TOTAL : Value of all the benefits together
		Resource rent in the hotel and restaurant sectors	Resource rent in real estate	Resource rent in coastal tourism	Total				
Albania	**5**	27	14	11	**51**	**4**	**5**	**34**	**99**
Algeria	**193**	13	159	1	**173**	**197**	**14**	**109**	**686**
Bosnia Herzegovina	**1**	1	5	1	**8**	**16**	**0**	**6**	**31**
Cyprus	**21**	45	66	58	**169**	**7**	**9**	**13**	**218**
Croatia	**45**	15	64	133	**212**	**24**	**67**	**42**	**389**
Egypt	**87**	43	139	17	**199**	**161**	**11**	**353**	**811**
France	**63**	294	1 178	220	**1 692**	**380**	**20**	**127**	**2 281**
Greece	**588**	680	1 078	317	**2 075**	**98**	**173**	**212**	**3 147**
Israel	**30**	170	682	49	**901**	**72**	**2**	**103**	**1 109**
Italy	**1 135**	1 235	4 888	574	**6 697**	**458**	**85**	**848**	**9 222**
Lebanon	**40**	182	80	90	**352**	**17**	**3**	**73**	**484**
Libya	**23**	4	145	6	**155**	**61**	**20**	**78**	**337**
Malta	**21**	12	19	19	**50**	**2**	**2**	**8**	**83**
Morocco	**18**	9	36	17	**62**	**42**	**6**	**23**	**151**
Monaco	**0**	3	6	0	**9**	**Na.**	**0**	**1**	**10**
Montenegro	**1**	3	6	7	**15**	**3**	**3**	**7**	**30**
Palestinian Territories	**20**	2	8	0	**11**	**Na.**	**Na.**	**9**	**40**
Slovenia	**3**	1	8	11	**21**	**17**	**0**	**3**	**43**
Spain	**161**	1 183	1 781	836	**3 801**	**336**	**30**	**353**	**4 680**
Syria	**7**	2	10	5	**17**	**70**	**2**	**12**	**108**
Tunisia	**165**	125	77	50	**252**	**23**	**15**	**61**	**516**
Turkey	**247**	89	503	295	**887**	**230**	**60**	**228**	**1 652**
Regional TOTAL:	2 871	4 139	10 951	2 717	17 808	2 219	527	2 702	26 128

Unit: in millions of Euros. Figures rounded off to one unit in this table.
Na: Not available

1. All the detailed calculations are available upon request from the authors in the form of an .xls format datasheet.

2. It can be observed that 8 Mediterranean riparian countries account for about 90% of the value of the benefits provided by marine ecosystems (Italy, Spain, Greece, France, Turkey, Israel, Egypt and Algeria). In fact, over half the riparian countries receive a quantity of benefits whose value did not exceed 500 million Euros per country for 2005. Italy accounts for 35% of the overall value of these benefits for a value in excess of 9 billion for 2005. This can be attributed to the scale of the activities and people benefiting from the services provided by the marine ecosystems in this country, whose Mediterranean seafronts comprise a large share of national territory.

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