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Supporting Environmental governance for the POSidonia oceanica Sustainable transplanting Operations

LIFE16 GIE/IT/000761

ACTION B.1

Technical Guide for Economic Assessment of Environmental Impacts on *Posidonia Oceanica* Meadows

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Key to abbreviations used

ARPA - Agenzie Regionali e Provinciali per la Protezione dell'Ambiente (EPA - Environmental Protection Agencies)

DVA - Direzione Valutazione Ambientale del Ministero dell'Ambiente e della Tutela del Territorio e del Mare (Environmental Assessment Division of the Ministry of the Environment and Protection of Land and Sea)

EEA - Experimental Ecosystem Accounting (Contabilizzazione Economica Sperimentale))

IPBES - Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

ISPRA - Istituto Superiore per la Protezione e Ricerca Ambientale (Italian Institute for Environmental Protection and Research)

GGLL - Guidelines

MATTM - Ministero dell'Ambiente e della Tutela del Territorio e del Mare (Ministry of the Environment and Protection of Land and Sea)

MSFD - Marine Strategy Framework Directive 2008/56/CE

EMP - Environmental Monitoring Project

PREI - Posidonia Rapid Evaluation Index

ES - Ecosystem Services

SEEA - System of Environmental Economic Accounting

EIS - Environmental Impact Statement

SNPA - Sistema Nazionale per la Protezione dell'Ambiente (NSEP - National System for Environmental Protection)

EU - European Union

WFD - Water Framework Directive 2000/60/CE

SEA - Strategic Environmental Assessment

EIA - Environmental Impact Assessment

AA - Appropriate Assessment

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1. Foreword

With regard to Action B1 "*The decision governance for transplanting* Posidonia oceanica *in Italy*" (project Life SEPOSSO - LIFE16 GIE/IT/000761), our aim is to draft a technical document able to provide guidelines for the economic assessment of the impacts on *P. oceanica*. At present, environmental impact legislation does not take into account the economic effects of the impacts on ecosystem services (ES) provided by potentially damaged ecosystems. This guide is thus meant as a support for the application of the existing Environmental Impact Assessment (EIA) legislation with regard to projects concerning the 1120* Meadows of *Posidonia oceanica* primary habitat (Habitats Directive 1992/43 /CEE), in the light of the knowledge concerning natural capital and ecosystem services provided by the habitat itself. In this context, it is also necessary to recall that, for projects subject to Environmental Impact Assessment that are liable to determine, directly or indirectly, any interference on the 1120* primary habitat, it is necessary for the required Appropriate Assessment (AA) to be combined with the EIA[1].

This document is the product of the collaboration among the Italian National Institute for Environmental Protection and Research (ISPRA), the SETIN Infrastructure Technical Services Limited Liability Company, and the Department of Earth, Environmental, and Life Sciences of the University of Genoa (DiSTAV).

This guide provides guidelines on how to combine the above-mentioned economic and environmental assessments in the AA and EIA procedures, starting from the Technical Standards for the execution of Environmental Impact Statements (EIS)(9), recently developed by the National System for Environmental Protection (SNPA). Following identification and description of the ecosystem services provided by *P. oceanica*, according to the classification of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) (1), both environmental indicators for the quantification of the ES, and methods for their economic assessment are proposed. Therefore for example, the proposed approaches can be used to compare economic costs due to potential impacts of design options of a submarine cable; or to evaluate consistency between mitigation and compensation costs foreseen in a port project and the economic value of the expected environmental impact; or even to compare costs and economic and environmental benefits of different mitigation and/or compensation options, such as *replanting* a meadow of *Posidonia oceanica* rather than other possible conservation measures.

1 In accordance with the provisions in Art. 6 of the Habitats Directive in conjunction with Art. 10 of the Legislative Decree 152/2006 and subsequent amendments to, or revisions (for more information on the supplementation of EIA and AA procedures, please consult the National Guidelines for the AA, MATTM, 2011.)

2. Introduction

In the context of the project LIFE SEPOSSO, within the planned activities for Action B1 "*The decision governance for transplanting* Posidonia oceanica *in Italy*", the "Technical Guide for Economic Evaluation of Environmental Impacts on *Posidonia oceanica* meadows" was drafted.

In the past few decades, *Posidonia oceanica* and the vast meadows that it is able to create have become one of the main objectives for the protection and management of the Mediterranean basin marine environment.

P. oceanica meadows represent an essential element for the quality of coastal environments; they play a key ecological role, and support directly and indirectly a variety of human activities, such as small-scale fishing and tourism. The latter, in particular, is a key element for the sustenance of some of the countries bordering on the Mediterranean. Small-scale fishing, even if of less economic relevance, can at the same time have positive repercussions on tourism.

The economic role of *P. oceanica* meadows generally stems from their importance in coastal environments. High biological production, the role as *nurseries* and shelter for the reproduction of a variety of species of commercial interest are all linked to activities such as small-scale fishing, while preservation of water quality to which they contribute, for example by ensuring its clarity, as well as their role in protecting the coastline against erosion, can be directly or indirectly connected to tourism development. Furthermore, just like tropical forests on Earth, *P. oceanica* meadows are home to incredibly high levels of biodiversity, estimated as approximately 25% of the Mediterranean marine species, some of which are protected and of high iconic value. (61). In addition, this plant also helps to mitigate climate change by capturing carbon dioxide and fixing it inside its structures, thus taking it out of the environment.

However, even if the ecologic role of *P. oceanica* is universally recognised, the economic one is harder to determine. The latter, in fact, must take into account direct benefits (e.g. fishing), indirect ones (e.g. protecting coastlines), and future uses.

The protection and conservation of *P. oceanica* meadows is thus justified not only for the high value of this ecosystem in terms of natural heritage, but also for economic reasons to which it contributes both directly and indirectly.

In the past few decades, we have witnessed a gradual implementation of standards for the protection of *P. oceanica*. This species is mentioned in Attachment I (strictly protected species) of the Bern Convention and in Attachment II (endangered species) of the Protocol of the Specially Protected Areas of the Barcelona Convention. *P. oceanica* meadows are also included among the primary habitats in Attachment I of the "Habitat" Directive 92/43/CEE of 21 May 1992 concerning Conservation of Natural Habitats and of Wild Fauna and Flora.

In Italy, starting in the eighties and nineties, the creation of Protected Marine Areas, many of which include vast meadows of *P. oceanica* within their boundaries, are a clear example of biodiversity conservation through active management.

P. oceanica meadows also represent a marine habitat subject to specific measures included in legislative instruments. Attachment V of the Water Framework Directive (WFD, 2000/60/EC) considers marine phanerogams as elements of biological quality, that can be used to define the ecological state of coastal waters, since they are particularly sensitive to human disturbance. National implementation of the European Marine Strategy Framework Directive (MSFD, 2008/56/CE), identifies *P. oceanica* meadows among the habitats being evaluated for ecological quality. This evaluation is conducted by defining a good environmental status (*GES*) to be reached through environmental targets with a view to a sustainable management of the marine environment. Lastly, even if it does not make any specific references to *P. oceanica* meadows, the Maritime Spatial Planning Directive (PMI 2014/89/CE) aims to encourage sustainable development of seas and oceans, while at the same time ensuring the achievement of a good ecological status, as provided for in the MSFD, through maritime spatial planning and implementation of an ecosystem-based approach that helps to promote sustainable development and growth of coastal maritime economies and sustainable use of marine and coastal resources.

During the last century, *P. oceanica* meadows have suffered a generalized decline in the entire Mediterranean basin, with regression being particularly noticeable close to large urban centres and port areas. It is obvious that human disturbance is the main factor causing the regression of *P. oceanica* meadows. The execution of coastal projects represents a threat for *P. oceanica*, since, operating on the stretch of sea overlooking the coast, included between zero and around the10 m. bathymetric line, can cause both direct and indirect impacts on the meadows, which can be more or less serious according to the areas affected and their potential irreversibility.

Procedures to evaluate the impact of an intervention before it is executed are therefore an essential management tool in order to conserve phanerogams meadows. However, the impact's economic evaluation still remains an essentially theoretical practice for many Mediterranean countries. In fact, it is not systematically present in national legislative instruments, and above all there are no specific references to *P. oceanica* meadows.

In Italy, the National System for Environmental Protection (SNPA), has recently produced a set of Technical Standards for drafting and evaluating Environmental Impact Statements (EIS) (9) for any projects included in attachments II and III of the second part of the Legislative Decree 152/06 as further amended and extended, in which there is mention of e.g. commercial maritime ports, sea defence interventions, gas pipelines, and submarine pipelines. The information included in the Technical Standards supplements the minimum contents for an environmental impact statement laid down in art. 22 and in Attachment VII of the Legislative Decree 152/06 as further amended and extended, refers to different environmental contexts, and is valid for the different categories of interventions.

Among the environmental factors taken into account in the EIS is biodiversity. Even though there are no references to *P. oceanica* meadows, there is a requirement for elements relating to the compatibility of projects affecting directly or indirectly areas included in the Natura 2000 protected areas network, which, for what concerns the marine environment, have been mainly created in the same location of *P. oceanica* meadows. Furthermore, for these projects, it is required to provide conservation objectives for habitats included in the areas of the Natura 2000 protected areas network provided for by the legislation in force (Presidential Decree 357/97 art. 5, as amended and supplemented by the Presidential Decree 120/03 art. 6).

At present, in environmental impact statements, an economic impact evaluation is not required, even if it would be able to translate the impact into a monetary value that would be easily recognized by anyone. In the Community, such evaluations are delegated to judicial bodies; where an environmental damage requiring monetary compensation occurs, sure enough the damage must be "monetized" in some form.

Outside of burdensome circumstances requiring legal action, economic evaluation of environmental impacts is not yet a common practice within the legislative frameworks of countries, and there are also no accepted standardized methodologies. However, it can represent an important support tool in decision-making with regard to environmental assessments, and can thus provide data and useful information to choose among project options/alternatives, to carry out economic assessments and prevent environmental damage, and to identify mitigation and compensation measures.

3. Objectives of the Guide

This guide is intended as a support tool for drafting technical documents with regard to EIA [2] procedures, able to provide an overview of all the approaches and available methods for economic assessment of environmental impacts of projects that could affect *Posidonia oceanica* meadows.

The main objectives of this technical guide are thus:

1. Identifying possible additions to an economic assessment of environmental impacts with regard to Environmental Impact Assessments.
2. Classifying and characterising the ES provided by *P. oceanica* based on the IPBES (1) model.
3. Defining some among the environment indicators more widely used to quantify the different ES of *P. oceanica*.
4. Describing the key methods of economic assessment used to calculate the value of natural capital and of the ES of *P. oceanica.*

2 Also including an Appropriate Assessment (AA), where required.

4. Theoretical Aspects

4.1.Ethical Principles and Economic Environmental Assessment

Why give an economic value to environmental impacts?

Among the principles driving the globally recognised objectives of sustainable development, are the precautionary principle, the intergenerational equity principle and the conservation of biodiversity and ecosystems (2).

The purpose of the precautionary principle, which emerged from the Convention on Biological Diversity (CBD, 1992) and is mentioned in article 191 of the Treaty on the Functioning of the European Union (3), is the guarantee of a high level of environmental protection by means of preventive decisions and actions to limit risks.

The application of the precautionary principle has a series of implications for economic analysis. The main objective is to minimise the risk of serious or irreversible damage to the environment. The assessment, also economic and monetary, of the expected effects, can be a supporting element to the application of this principle, especially in cases of scientific uncertainty[3].

Recourse to the precautionary principle is thus justified when three conditions are fulfilled, namely (3):

- identification of potentially negative effects;
- evaluation of available scientific data;
- level of scientific uncertainty.

This rule is based on the precondition that many of the potential benefits of the natural environment could be unknown, and it is cautious and ethical to use and manage natural resources by also taking into account the needs of future generations, as is for that matter established by the second of the ethical principles mentioned above. An economic analysis is able to produce information on the compromises between risks and different levels of potential damage (2).

Intergenerational equity can be considered within a cost-benefit analysis, applying explicit weights to benefits and costs incurred by the different groups involved in a project, a plan, a program, a human activity. Dealing with the concerns regarding intergenerational equity raises challenging issues on the use of discount rates, that are applied for two main reasons:

3 Analyses and assessments of the effects of impacts with regard to environmental assessments are, for the most part, distinguished by vagueness and scientific uncertainty at various levels (for example: in the availability of data and information, or in the simulations of expected effects and impacts.)

- people prefer present to future because of impatience, the risk of death, uncertainty about the future, and of the reduction of marginal utility of consumption (this reflects the social time preference rate and is for example, more common in populations of developing countries);
- there is an opportunity cost of capital, including the benefits lost on other investment opportunities. The discount rate is a measure of the opportunity cost incurred (2).

A discount rate is usually applied to economic evaluations of natural resources.

Lastly, the conservation of biodiversity and ecosystems[4] is a universally recognised topic and one of the main objectives of sustainable development. Markets and development policies do not yet sufficiently recognise the value of biodiversity and ecosystems when decisions on development initiatives are made (2). On the other hand, there are examples of a correct assessment of the value of biodiversity, in which conservation can bring greater economic and social benefits than exploitation[5]. In terms of an economic environmental assessment, conservation of biodiversity and of ecosystems has become a cornerstone, which can be measured through analysis, evaluation, and monetisation of the ES.

Lastly, with regard to the EU policy concerning the environment, the precautionary principle is complemented with the ones of preventive action, rectification at source of damages caused by pollution, and compensation of environmental damage[6], as well as the "the polluter pays" principle. These principles can be implemented also through instruments of economic and environmental assessment, able to support decision-making.

4.2. Environmental Assessment

Why evaluate environmental impacts? With regard to which processes and procedures?

EU policy concerning the environment is implemented through a variety of legislative instruments, regulatory instruments, and operational tools, among which the EIA (Environmental Impact Assessment) and the Appropriate Assessment.

4 *Posidonia oceanica* meadows are one of the primary habitats as laid down in the "Habitats Directive" and therefore represent a very important ecosystem from the perspective of biodiversity conservation and the maintenance of ES.

5 A relevant example of natural resources management and biodiversity conservation is the elephant: the value of ivory from a dead individual is much lower than the value of the same animal still alive and enjoyed by visitors in a protected area. (4)

6 About this specific point, it is a number of years already that it has become an established practice to make an assessment of the monetary value of the damage through economic and environmental assessment methodologies, with regard to procedures falling under the domain of environmental damage compensation (Directive 2004/35/CE.)

Some projects (private or public) that are likely to have significant effects on the environment, are made subject to an EIA. Similarly, projects, plans and programs that can have significant incidence on the conservation of the Natura 2000 network are subjected to an Appropriate Assessment. In this context, environmental considerations are already included in the planning and/or design phase, and any possible consequences are taken into account before a given project is approved or authorised, so as to ensure a high level of environmental protection.

At present, European legislation does not provide for the application of specific approaches, instruments and methodologies for an economic environmental assessment, or rather able to determine an economic value (= monetary) for the impacts caused by a work, a plan, a program. In the Union these assessments are delegated, if at all, to judiciary bodies, for example when a party who suffers an environmental damage requests an economic compensation that must be somehow measured in monetary terms.

In general, the economic assessment of environmental impacts is not yet a widespread instrument within the legal frameworks of nations; it is thus necessary to increase its use in order to transform it into a consolidated instrument as regards the technical-scientific basis[7].

4.3. Economic Assessment

Why determine an economic value for an environmental asset or service?

As we have seen previously:

- European and international environmental policies acknowledge some environmental ethics principles;
- environmental assessment instruments support decision-making and allow to put into practice these principles, providing operational guidelines to increase environmental sustainability of plans, programs, and projects;
- assigning an economic value (that is, monetary) to environmental assets and services susceptible to being affected by an environmental impact, is still not a prevalent approach, while instead, its application should be widened.

Furthermore, currency is the tool for the quantification of value more widespread and comprehensible. Claiming, for example that cutting down a forest entails a loss of value of 100,000 euros a year is more readily comprehensible to a greater number of people than claiming that the loss is estimated in in 4,000 tonnes of carbon a year that is not absorbed[8].

7 For an open-ended list of real life examples of economic assessment of environmental impacts, please see Attachment1.

8 In recent years, there has been an ongoing ethical debate within the political, technical and scientific fields on the opportunity of using currency as a tool to represent the value of assets and ES. In this guide, the authors chose not to take part in the debate, but to accept currency as the unit of measurement of value since this option was considered the most practical one.

By using currency as an indicator, it is possible to quantify and give a monetary value to environmental impacts, in a way that is comprehensible to all involved parties at any level.

Economic and environmental assessment, and, specifically referring to this guide, the economic assessment of environmental impacts, is a support tool for decision-making in the field of environmental assessment and authorisation (EIA, SEA, Appropriate Assessment, etc.), as well as in other instruments and processes (plans, policies, programs, disputes, pragmatic procedures, etc.), especially in 3 main areas of interest:

- choice among options/alternatives;
- assessment of economic and environmental impact and economic[9] damage, both current and for future generations;
- support to finding an agreement when identifying and quantifying the environmental mitigation and compensation measures (that is, proportional and/or of the same order of magnitude, in economic terms, of the environmental impact).

In particular, this Guide specifically refers to EIA and Appropriate Assessment processes.

4.4. Natural Capital and Ecosystem Services

What is Natural Capital? What are ES? How can they be used in the field of economic assessments of environmental impacts?

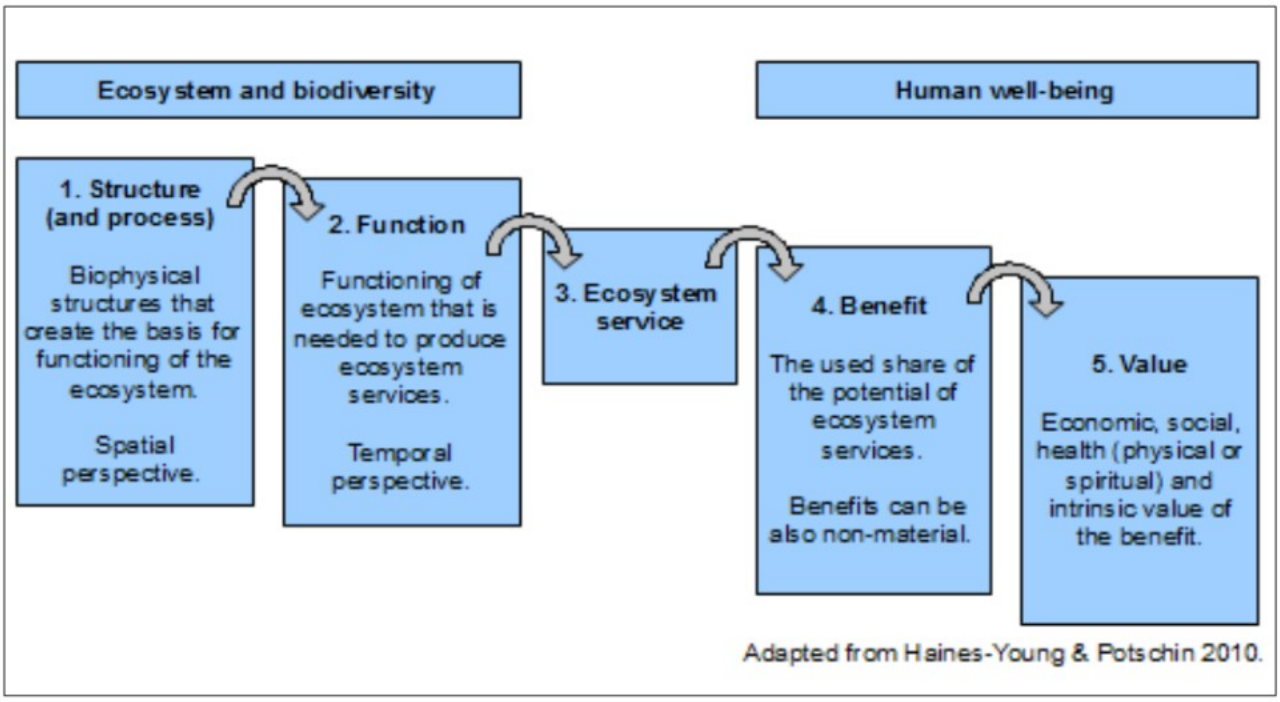
Natural capital can be defined, in accordance with the State of Natural Capital Report of the Ministry of the Environment and Protection of Land and Sea (5) as, *"the entire stock of natural assets - living organisms, air, water, soil and geological resources - that contribute to provide assets and services of value, direct or indirect, for humankind, and that are necessary for the survival of the environment itself from which they were generated ".*

Natural assets and their interactions generate ES, that is *"the multiple benefits provided by ecosystems to humankind"* (6).

ES have been classified using different approaches. This Guide will follow the most recent, the IPBES (1) approach, reported with reference to the *Posidonia oceanica* meadows in Chapter 7.

Picture 1 - Waterfall model of ecosystem services (7)

9 Including lost profits, lost rights of use, and lost benefits provided by ecosystems subjected to impacts caused by human projects or activities.



The approaches proposed in this guide are based on different paradigms:

- Natural capital has an economic value, that does not only include the mere value of physical assets;
- Ecosystems provide assets and services with an economic value, enabling environmental functionality, population wellbeing, production and conservation of means of sustenance and cultural values;
- Besides assets and services with an economic value, the environment can provide financial resources for an inclusive and sustainable growth of local people, and of the entire socio-economic system.

These paradigms are reflected in economic theory applied to ecosystem assets and services.

While assets (that is, an element of the natural capital, such as for example, a small plot of land with some fruit trees) can be assigned an absolute value (for example: 1.000 euro), ES, that are flows, are assigned a time-weighted value (for example: 500 euro/year given by the annual value of harvested fruit).

The value can be assigned through environmental economy methodologies, at times combined with the use of environmental indicators. It is important to point out that the value of an ecosystem service does not necessarily correspond to a price, as in the fruit example, and often does not follow market principles, such as for example, in the case of the value of coastal erosion mitigation provided by *Posidonia oceanica* meadows.

Environmental economy classifies environmental economic value in different categories. For each value, there are one or more assessment techniques, that will be covered with specific reference to *Posidonia oceanica* Meadows in chapter 7.

5. Methodology for Developing the Guide

The present Guide was created through the following steps:

- **bibliographic analysis and selection of the most appropriate references;**
- **analysis of EIA case studies pertaining to projects susceptible to cause environmental impacts on *Posidonia oceanica* meadows (a summary of the results is shown in Attachment 2), in order to understand how the ES have been considered thus far;**
- **drafting of assessment methodology and economic estimate of the ES, and of its application within the EIA and AA procedures.**

The Guide is mainly intended for writers of environmental impact statements and of appropriate assessment studies, and for public officials responsible for environmental assessments, or at any rate, for the expression of views with regard to EIA and AA procedures.

Since it also includes an assessment and estimate of monetary value methodology for *Posidonia oceanica* meadows that can be used outside of environmental assessments, the Guide can represent an orientation and support tool for all those officials and professionals who wish to analyse and assess this habitat from an economic and environmental perspective.

Lastly, the general approach and the specific value estimate methodologies of each ES can represent a support tool for decision-making, also with regard to other policy assessment tools, such as for example, cost-benefit analyses.

Lastly, in the future, the Guide, with the necessary adjustments, could become the base for assessing and estimating the monetary value of other ecosystems or habitats, especially with regard to the marine environment and environmental transitions.

6. Scope

The present Guide is applicable to *Posidonia oceanica* meadows in the Mediterranean, as defined by the Directive 92/43/CE, susceptible to being affected by environmental impacts caused by projects, and human activity in general.

The Interpretation Manual of Habitats (8) reports the following:

"Posidonia oceanica *(Linnaeus) Delile meadows are present on the infralittoral zone of the Mediterranean (at depths that vary from a few dozen centimetres to 30-40 meters) on hard or mixed*

substrates; these meadows represent one of the main climax communities. They can tolerate rather wide variations of temperature and hydrodynamics, but are sensitive to lack of salt; usually they need a salinity ranging between 36 and 39 ‰. [...] Marine Posidonia meadows represent one of the most important habitats of the Mediterranean, and take on a key role in the marine ecosystem with regard to primary production, biodiversity, equilibrium of sedimentation dynamics. They are a great indicator of the quality of a marine environment as a whole".

P. oceanica meadows are considered one of the most productive ecosystems of the planet; they produce huge quantities of vegetable matter, that is the base for a variety of trophic chains. However, the quantity of primary production directly consumed by herbivores is very limited. For the most part, in fact, this production is accumulated in the *matt*e, decomposed by detritivores, or exported towards other ecosystems in the form of dead leaves. Export of high quantities of dead leaves represents a source of nutrition in the deepest areas and creates a benefit for beaches.

Leaves also support a vast community of vegetal epiphytes, that besides being specific nourishment for a variety of animal species, also ensure a high primary production, which adds to that of the plant itself.

P. oceanica meadows, following photosynthesis, are an important source of oxygenation for the coastal environment, especially in surface waters. In addition, the sheltered environment that develops under the foliar *canopy* represents an ideal "*nursery*" area where juveniles of numerous species of commercial interest find protection. Besides supporting the first growth stage of a variety of members of coastal fauna, *P. oceanica* is the permanent habitat of numerous organisms, both animal and vegetable, and is therefore considered a biodiversity *hot-spot*.

P. oceanica meadows are real vegetable barriers along the coastal sea-bottoms that support the settling and sedimentation of particles suspended in water column, promoting a rise in water clarity of coastal waters. The sediment collected and retained at the rhizome and root level, becomes part of the *matte*'s volume (20-60 %), a single structure that causes the vertical growth of the meadow in order to avoid it being covered-up by sand.

The considerable vegetable biomass of *P. oceanica* meadows also represents an obstacle able to effectively reduce seabed hydrodynamics. In general, reduction of wave action and currents is such as to protect the coast from erosion and support stabilisation of the coastal line. In addition, there is the role of the dead leaves that, transported by currents and waves, tend to wash up on the seashore during autumn months. Thanks to the formation of real *banquettes* that can reach over one meter in height, the accumulation of leaves makes a further contribution to the protection of the coast from erosion.

Because of its wide distribution and sensitivity to human disturbance, *Posidonia oceanica* is considered an excellent bioindicator of coastal water quality. Its health and expansion provide important information linked to the state of the surrounding waters, in terms of average turbidity of water (for example connected to the position of the lower edge of the meadows and to shoot

density, currents and hydrodynamics (emphasised by erosive structures borne by the *matte*, sedimentation rate (shown by rhizome growth rate and/or their undermining, organic matter and nutrients (emphasised by the quantity of epiphytes present on the leaves).

P. oceanica meadows develop along coastal zones, which are often subject to intense human disturbance that inevitably influences their distribution, both directly, through physical and mechanical damage (e.g. moorings, execution of coastal projects) and indirectly, by influencing water quality (e.g. increase of water turbidity). In the last century, an alarming decline of *P. oceanica* meadows was recorded in the entire Mediterranean basin, especially in the North-Western area.

Picture 2 - Posidonia oceanica meadow

7. Assessment Methodology for the Ecosystem Services of *Posidonia oceanica* meadows

The legislative framework for Environmental Impacts Assessments (EIA) is the Legislative Decree 152/2006 and subsequent modifications and additions, among which those introduced by Legislative Decree 104/2017 implementing Directive EIA 2014/52/UE. The latter has made significant changes to the rules governing EIA procedures, providing for the adoption, "*Following the proposal of the National System for Environmental Protection, of national guidelines and technical rules for the drafting of documentation for the purposes of carrying out environmental impact assessments, also to supplement the contents of the environmental impact statements included in Attachment VII*" (Art. 25 paragraph 4).

In response to this mandate, the Guidelines were drafted and endorsed on July 9th 2019, and published on May 8th 2020 by the NSEP Board. The document "Environmental Impact Assessment. Technical rules for drafting Environmental Impact Statements" (9) has thus become the main methodological reference for the drafting and assessment of environmental impact statements.

The minimum contents of an Environmental Impact Statement, identified in Art. 22 of the Legislative Decree 152/2006, and the guidelines for its drafting contained in Attachment VII in Part II of the same Decree are supplemented with what is laid down in the Guidelines. In fact, these legislative provisions make no reference to ES.

A study conducted on the EIA documentation produced for the execution of projects undertaken in the last 20 years, with potential impacts on *Posidonia oceanica* meadows, has after all, emphasised how the ES approach has not been taken into account, if not for a few more recent studies (reference to Attachment 2). In some cases, in the EIA procedures examined, reference was made (although for the most part only vaguely) to the importance of *P. oceanica* owing to the functions it provides, but ES were hardly ever mentioned, and neither were impact evaluations carried out taking into account the economic value of such impacts.

7.1. Ante-Operam and Post-Operam Assessment

Two important changes introduced in the EIA procedure concern the level of detail of projects to be submitted for EIA procedures, and the role of the public.

Any project must be developed and presented with a degree of in-depth information corresponding to that of the feasibility project, as defined by the Legislative Decree 50/2016, art. 23, paragraphs 5 and 6, or in any case, with a level of detail such as to enable an actual assessment of impacts. This procedural change is particularly important since it supports a process of reorientation of project choices that can be relevant, owing to the possibility of the proposer to substantially change the project, at the earliest stage of development, by accepting comments and opinions, and identifying the best option, as well as by carrying out an impact assessment

that takes into account the ES, with regard to which it would be desirable for it to entail a greater involvement of stakeholders.

Concerning involvement of the public, it is worth noting that, for some projects, a consultative process should begin even before the EIA procedure, through a public debate procedure, carried out in accordance with Article 22 of the Legislative Decree n. 50 of April 18 2016, and governed by the "Regulation laying down detailed rules for the development, type, and thresholds of the projects open to public debate", approved with the Prime Ministerial Decree n.76 of May10 2018. For projects not open to public debate, the competent authority, in any case, has the ability to conduct a public enquiry (Legislative Decree 152/2006 Art. 24bis).

The contents of an EIS can be broken down according to the following:

- definition and description of the work, and analysis of reasons and consistency;
- analysis of the state of the environment (Baseline scenario);
- analysis of compatibility of the work;
- environmental mitigations and compensations;
- Environmental Monitoring Project (EMP).

The characterisation of the Baseline Scenario within the study area, intended as vast area and site area, is a crucial passage of an EIS since it is effective in (ref. National System for Environmental Protection Guidelines):

- "*providing a description of the environmental state and its concerns, to which significant effects can be compared and evaluated;*
- ***provide a basis for comparison for the Environmental Monitoring Project, in order to measure any changes once the activities for the execution of the project have begun.*"**

But how to define the study area, identify and analyse thematic components?

The Guidelines tell us that the vast area and the site area must be defined for each environmental concern analysed, and that, in particular, the vast area includes the area in which, "Any *significant effects, direct or indirect, caused by the intervention and in connection with the environmental concern being considered, are exhausted*", that must also be identified on the basis of an analysis of the planning and restrictions framework.

In relation to the environmental concerns to be analysed (Environmental factors: population and human health, biodiversity, land and use of land, geology and waters, atmosphere, landscape – Physical agents: noise, vibrations, electric, magnetic, and electromagnetic fields, optical radiation, ionising radiation), there is information provided "*of an indicative nature and not necessarily exhaustive*" (ref. Attachment 1 of the NSEP Guidelines) (9).

No other explicit reference is made to the "Ecosystem" component, referred to in Attachments I and II of the Prime Ministerial Decree 27 of December 1988, repealed by the Legislative Decree 104/2017.

In an EIS where one, in line with the methodological approach of the above mentioned Guidelines, wishes to carry out the analysis and evaluation of ES and of any potential impacts of the work on the ES themselves, the definition of the study area and the characterisation of the Baseline Scenario should be carried out taking into account the following:

a) mapping of potentially impacted ecosystems (→[10] definition of study area, Baseline Scenario);

b) identification of ES provided by potentially impacted ecosystems (→ definition of study area, Baseline Scenario);

c) identification and mapping of ES beneficiaries (→ definition of study area);

d) analysis of the planning and restrictions framework, to be carried out also with a focus on the legislative provisions and regulations that determine conditions for use and forms of protection of ES (→ definition of study area);

e) **analysis of environmental factors and physical agents, including description and quantification of ES (→ Baseline Scenario in the study area)**

The map of ecosystems, ES, and beneficiaries can be developed through Geographical Information System models and analyses, but also involvement of the public can contribute to its development (participatory mapping), as well as to the evaluation of the significance of each ES, according to potential impacts on the different categories of beneficiaries. Public debate, to be carried out before starting the EIA procedure, provides the opportunity to define, through a participatory process, a suitable study area from the very first draft of the EIS, by identifying the ES that are considered most significant[11], while comments and opinions, just as the public enquiry referred to in Art. 24 bis of the Legislative Decree 152/2006, provide the opportunity to trigger a revision process if the study area and ES characterisation are considered inadequate.

The analysis of compatibility of the work requires that the ES provided by potentially impacted ecosystems, after being mapped, also be quantified, in order to make an estimate of their economic value for the Baseline Scenario, just as for the "zero" Alternative (development of a baseline scenario in the absence of the project's implementation) and for all other project alternatives.

10 The symbol "→" emphasises a relation of functionality (the "mapping of potentially "impacted" ecosystems is functional to the "definition of the study area and of the Baseline Scenario.")

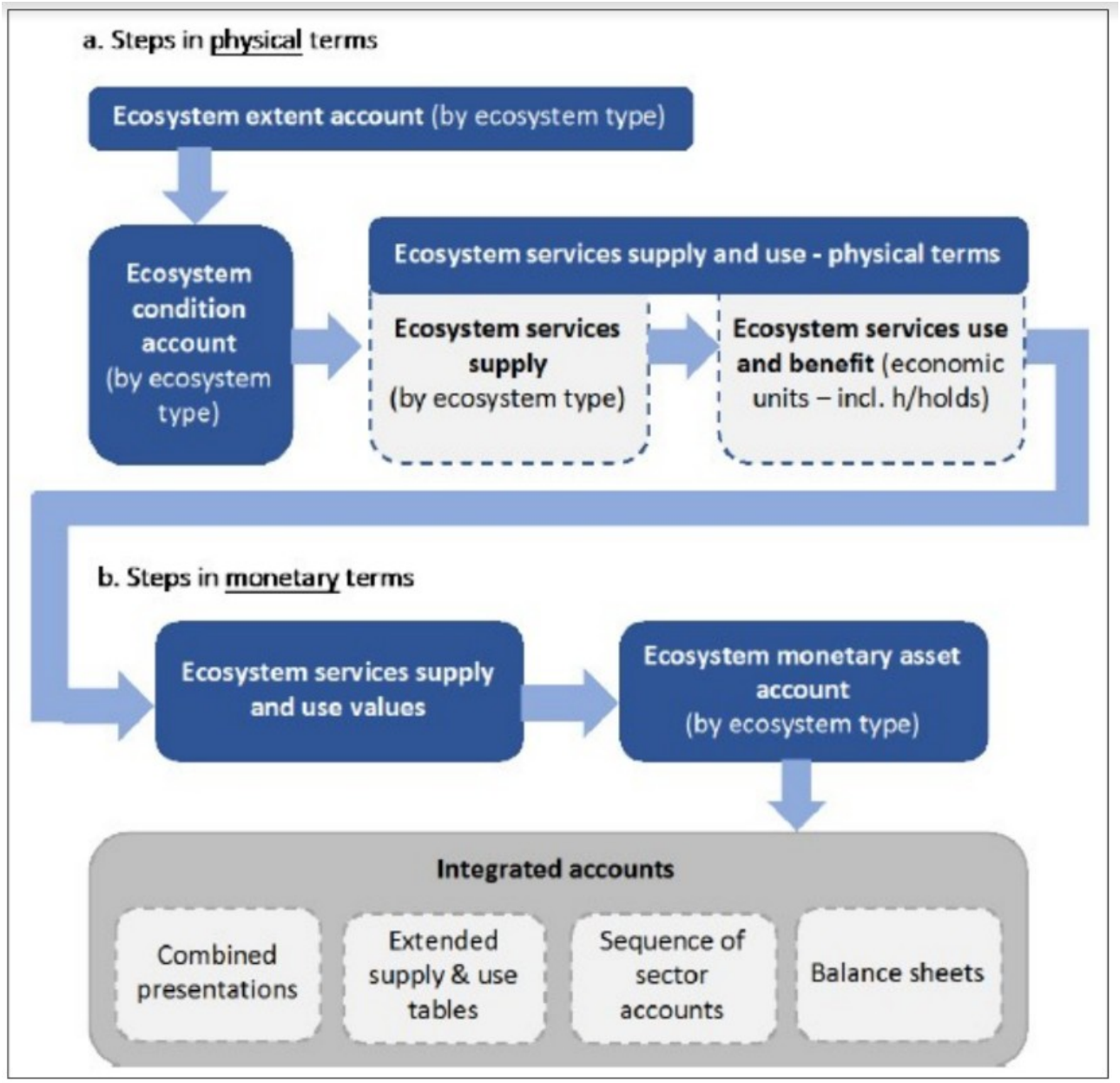
11 In this case, it would be beneficial if the process were simplified in oder to translate into everyday language classification, definitions, and technical and scientific descriptions of ES.

Specifically, still following the methodological approach of the above mentioned Guidelines, these analytical activities (quantification and evaluation of ES value) can be placed in the following stages of the process of EIS drafting:

- quantification of ES provided by potentially impacted ecosystems → Baseline Scenario;
- quantification of reduction of ES provided by potentially impacted ecosystems, by reason of the realisation of the work, in the construction phase as well as during operation → Analysis of compatibility of the work, Analysis of alternatives;
- **estimate of the economic value of ES that are expected not to be provided anymore by reason of the realisation of the work, in the construction phase as well as during operation → Analysis of compatibility of the work, Analysis of alternatives.**

The following picture provides a summary of the assessments that must be carried out to record the value of the ES, according to the SEEA EEA (*System of Environmental Economic Accounting - Experimental Ecosystem Accounting*) methodological approach, developed by the United Nations.

Picture 3 - Accounting process of ES (10)



With regard to the analysis of ES provided by *Posidonia oceanica* meadows, this Guide follows the IPBES (1) classification, carrying out a preliminary assessment of which ones are applicable.

Paragraph 7.4, thus includes a number of indicators useful to carry out the quantitative analysis of ES, as well as possible methods of economic evaluation and estimate of monetary value.

Basically, to prepare an EIS, and at the same time take into account ES analysis and assessment and the potential impacts of the work on them, entails providing information and data helpful when answering the following questions:

- which are the ecosystems that are potentially impacted by the work in the construction phase and during operation?

- to what extent the realisation of the work causes a reduction of the surface of ecosystems and/or any changes in their capacity to provide ES?
- **What economic impact is associated with the reduction of the surface of ecosystems and/or to any changes in their capacity to provide ES?**
- **What beneficiaries are primarily concerned by the potential impacts on ecosystems?**

If, as indicated in the Legislative Decree 152/2006 and in the NSEP Guidelines, no other explicit reference is made to the "Ecosystem" component, nor are ES mentioned, the importance to carry out ecosystem analyses is clear in the guidance provided by the Guidelines themselves to estimate impacts on the "Biodiversity" environmental factor (ref. GGLL, par. 3.2.1.2) (9):

"*Analyses for estimating impacts are carried out through:*

a) description of effects whether indirect, cumulative, short and long term, reversible and irreversible, potentially induced on the flora and fauna components and on the natural balances of present ecosystems, during the construction phase of the work under development;

b) description of effects whether indirect, cumulative, short and long term, reversible and irreversible, potentially induced on the flora and fauna components and on the natural balances of present ecosystems, during the operating phase of the work under development;

c) assessment of the resilience of potentially impacted ecosystems;

d) identification of interactions with other concerns (noise sources, emission of atmospheric, water, and soil pollutants, changes in water systems, climate change, etcetera.)

e) identification of areas of particular ecological value that are directly impacted by the work under development, whether temporarily or permanently."

Furthermore, the study must clarify interconnection among different ES, for example emphasising to what extent the increase of an ecosystem service can be related to the reduction of another, or how a project can determine, on the basis of adopted project solutions, a potential negative impact for different ES, evidently related.

In the analysis of environmental compatibility of the work and evaluation of the alternatives, it is essential to avoid "double counting", by assigning in whole or in part the same value to two ES that are quantified on the basis of common parameters and indicators.

Analysis and evaluation of the monetary value of ES should be applied to the baseline scenario (ante-operam assessment), taking into account the current condition of ecosystems, and to the different post-operam scenarios (as many as there are alternatives), taking into account possible structural and functional changes in ecosystems during (construction phase) and following (operation) the work.

7.2. Assessment of Alternatives

An EIS must answer the above mentioned questions for each project alternative, with regard to both the construction and operation phase, in order to identify the alternative linked to the lower environmental cost, calculated as the combination of values of the quantities of ES that potentially impacted ecosystems are no longer able to provide.

Since the quantity of ES is expressed as referred to a unit of time (for ex. CO_2 sequestered/year), the time factor plays an important role. The comparison among different alternatives must be carried out by reference to a definite time period, evaluating the ability of ecosystems to partly recover their capacity to provide some ES, also by reason of identified and implemented mitigation measures.

Assessment of alternatives is generally carried out by adopting consolidated methodological approaches, such as for example, multi-criteria analysis, hierarchical analysis, or cost benefit analysis. The approach based on economic estimate of ES complements the cost benefit analysis approach. The analysis in terms of quantity, and the economic value estimate of ES provided by potentially impacted ecosystems, returns values for indicators that can be combined in a cost benefit analysis. In such analysis, the cost is deemed to be the entirety of lost ES, while the benefit is the entirety of conserved, maintained, or improved ES, if the work includes additional conservation, mitigation, or environmental compensation measures, that are well thought-out and with a focus on ecosystems, such as the ones discussed in the next paragraph.

7.3. Support for Choosing Mitigation and Compensation Measures

The NSEP Guidelines request to:

- "identify and describe mitigation measures relating to the construction and operation phase and potential discontinuation;
- describe the criteria chosen at project level for the control of consumption of raw materials, energy, water, soil; for the reduction of interferences caused by the work, such as emissions and waste production; for ensuring that the work is integrated with both landscape and ecosystems [...]
- provide for compensation measures designed to restore balance to the environmental system, in order to compensate residual impacts, in those cases where mitigation efforts cannot fully offset them."

Furthermore, the Guidelines call for mitigation measures to be identified *"also by defining the timeframe and costs of implementation".*

What needs to be emphasised is, firstly, the reference to the need of the project to be integrated in the ecosystem, pointing out again the relevance of an ecosystem analysis that provides answers as to the eligibility of the proposed design solutions.

Additionally, the Guidelines specify that mitigation measures must be defined in terms of timeframe and costs of implementation. Therefore, ES analysis can help answer some questions, such as:

- What is the cost of the expected environmental impact for which mitigation measures are in place?

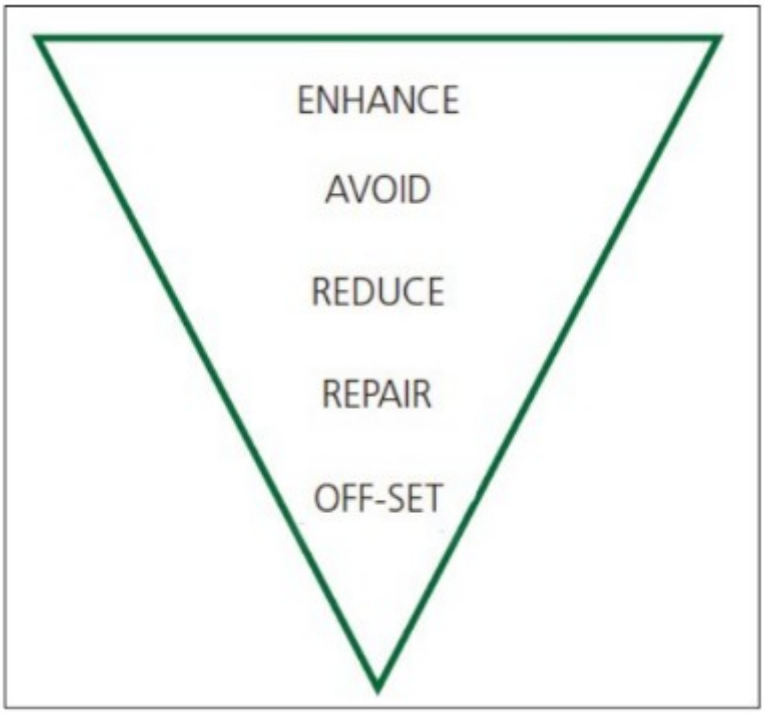
- Is the implementation cost of mitigation measures in line with the cost of the environmental damage that is being mitigated?

The cost benefit analysis, completed with the economic evaluation of ES, can also be used to compare mitigation and/or compensation measures and to evaluate their level of acceptability.

Lastly, it is emphasised how, by saying that compensation measures must be taken into account only if mitigation interventions cannot offset the project's residual impacts, a reference is made to a methodological approach that considers a hierarchy among the possible mitigation and compensation measures. According to this approach, for an EIS that includes analysis and evaluation of ES and of potential impacts of the project on them, measures should be identified for the purpose of (in hierarchical order):

- enhancing ES;
- avoiding negative effects on ES;
- reducing negative effects;
- restoring the capacity of ecosystems to produce ES;
- **compensating negative effects.**

Figure 4 - Hierarchy of mitigation measures (11)



7.4. Methodology for Estimating Economic Value

The role of *Posidonia oceanica* meadows in the coastal marine environment is comparable to the role played by forests in the terrestrial one. These meadows represent the main asset of the coastal waters of the Mediterranean Sea, and play a key biological role in maintaining coastal ecological and geomorphological balances, and the economic activities related to them.

P. oceanica meadows provide a variety of services and functions, especially for coastal marine areas. It is possible to calculate the value of these services with environmental economics approaches, such as the *"user-side"* one, based on the calculation of the quantity of money that people are or would be willing to pay to maintain a given ecosystem service provided by phanerogam meadows; or through its market value; or through biophysical assessment methods such as the "*donor-side*" one, that involves the economic assessment of natural resources by measuring the "emergy".

The following table shows some *"user-side"* approaches.

Table 1 - U*ser-side* approaches applicable to the assessment of *Posidonia oceanica*'s ES

Economic Assessment Approaches and Methods
Mitigation or compensation cost
Conservation cost

Economic Assessment Approaches and Methods
Social cost of Carbon
Avoided cost
Market cost
Willingness to pay
Replacement cost
Hedonic price
Travel cost
Environmental impact assessment
Contingent choice
Willingness to give up
Opportunity cost
Benefits transfer
Delphi method
Revision and comparison of existing studies

Some of the proposed approaches, such as for example, emergy analysis and conservation cost, allow spatially explicit estimates. With these approaches, as a matter of fact, it is possible to get economic estimates for well-defined geographical areas, such as for example, a Posidonia matte. With other approaches it can be difficult to get such estimates, since their methods do not allow for baseline data to be geo-referenced.

Another important factor to consider is time. As a matter of fact, taking into account a hypothetical environmental impact to a *Posidonia oceanica* meadow, the effects on the economic value of its ecosystem services will vary over time, according to the type of project or activity, to any potential environmental mitigation and compensation actions, to natural ecological dynamics of the meadow, and other potential side factors.

The following table shows the categories of ecosystem services of *Posidonia oceanica*, as defined by the IPBES classification, the main environmental indicators to be used for quantifying the above mentioned ES and the possible assessments methods for their economic value.

The following IPBES classification categories were not taken into account:

- **3 (Regulation of air quality), 6 (Regulation of freshwater quantity, location and timing), 10 (Regulation of organisms detrimental to humans),11 (Energy), 13**

(Materials and assistance), as they were not deemed applicable to the *P. oceanica* ecosystem;

- 5 (Regulation of ocean acidification) and 17 (Supporting identities), as a result of indicators and economic assessment methods shared with categories 4 (Climate regulation) and 16 (Physical and psychological experiences) (high risk of "double counting");
- 9 (Regulation of hazards and extreme events), as regards the reduction of capacity of the *P. oceanica* ecosystem of providing such ES, the same negative impact is assigned to category 8 (Formation, protection and decontamination of soils and sediments, specifically related to erosion control and coast protection), namely increase in coastal erosion (high risk of "double counting").

Table 2 - Specific categories concerning the ES of *Posidonia oceanica*

Categories of *P. oceanica* ES to people	Brief description	Main environmental indicators	Economic assessment approaches and methods
1 Habitat creation and maintenance	Development of a three-dimensional environment with ecological conditions supporting proliferation of a high variety of species, including fish species of commercial interest. Sheltered area for egg laying and growth of juveniles.	• Foliar density (n. shoots m^{-2}) • Depth and edge type (higher and lower) of the meadow • Conservation Index (CI) (12) • Substitution Index (SI) (13) • Phase Shift Index (PSI) (13) • Surface of the meadow (ha) • Abundance of associated fauna (e.g. epifauna, vagile fauna, fish fauna) (Individuals·m^{-2}).	• Biophysical assessment (e.g. Emergy analysis) (14,15,16,17,18) • Mitigation or compensation cost • Conservation cost
2 Dispersal of seeds and other propagules	Possibility of colonizing areas more or less distant from the meadow of origin, enabling to recreate favorable conditions to the creation of this ecosystem with all the services it provides.	• Increase of surface over unit of time (year).	• Biophysical assessment (e.g. Emergy analysis)
4 Climate regulation	Positive effects on greenhouse gas emissions (sequestered CO_2) and blue carbon reservoir in the *P. oceanica matte.*	• Net primary production (Stored Carbon) • Oxygen emitted • sequestered CO_2	• Biophysical assessment (e.g. Emergy analysis)Social cost of Carbon. • Measure of avoided cost (e.g. maintenance cost of CO_2 absorption systems). • Market cost
7 Regulation of Coastal water quality	*P. oceanica* leaves, due to their density, cause a decrease in kinetic energy of sediment particles transported by water, supporting seabed sedimentation and enhancing water clarity.	• Turbidity and concentration measurements (e.g.(TSS) Total suspended solids)	• Willingness to pay
8 Erosion control and coast protection	The high vegetable biomass of *P. oceanica* meadows reduces seabed hydrodynamics. Reduction of wave action and currents thus contribute to protect the coast from erosion and to support stabilization of the coastal line. Furthermore, the "banquettes" of dead leaves that form on the shores in autumn help to protect the beaches from erosion, especially during winter storms.	- Quantity of sediment retained in the meadow - Quantity of sediment trapped in the *banquettes* - Reduction of incident energy	• Biophysical assessment (e.g. Emergy analysis) • Measure of avoided cost (e.g. cost of coastal protection systems and beach replenishment activities). • Replacement cost • Hedonic price
12 Food and nourishment source	High vegetable biomass and relatively lower animal biomass. Two types of primary production (PP) at the base of trophic chains on which human nutrition also depends. PP originating from the plant itself and PP owed to the epiphytes of leaves. Part of the PP is consumed within the meadow, while the majority is exported outside, to poorer ecosystems.	• Presence and biomass (Individuals·m^{-2}; $g \cdot m^{-2}$) of associated fauna (e.g. epifauna, vagile fauna, fish fauna) • Foliar Biomass ($mg_{PS} \cdot shoot^{-1}$) • Epiphytes Biomass ($mg_{PS} \cdot shoot^{-1}$)	• Biophysical assessment (e.g. Emergy analysis) • Market value of fish products

MAIN ENVIRONMENTAL INDICATORS OF ECOSYSTEM SERVICE N. 1 "HABITAT CREATION AND MAINTENANCE":

- FOLIAR DENSITY (n. shoots m^2): number of live shoots of *P. oceanica* per unit of surface area (m^2). Provides information about the vitality of the meadow, and effectively detects human impact on the ecosystem (19).

  Method: data is collected by scuba diving at a known depth or at various bathymetric lines following the border of the meadows, usually close to the higher edge, the lower edge, and the middle of the meadow (about 15 m). Shoots are counted within square areas with a surface area of 40 x 40 cm, for a number of times that varies from 6 to 9 (2/3 in each area), in three areas of the meadow (about 10 m of distance apart from one another) (ISPRA protocol). The values are recorded per m^2, averaged and compared with the most recent reference classification (UNEP MAP RAC/SPA 2011) (20).

- DEPTH AND TYPE OF EDGES (HIGHER AND LOWER) OF THE MEADOW: the features of the edges and the changes in their position (depth) over time, provide information in terms of stability, progress or regression of the meadows, linked to water clarity, hydrodynamic regime, sedimentary balance, and direct and indirect human actions along the coast.

  Method: data on depth and observations are collected by scuba diving. Monitoring of the lower edge over time can be carried out by using markers fixed on the seabed ("balise") and in situ pictures, while the higher edge can be monitored with aerial and/or satellite pictures. The depth of the lower edge is evaluated according to the UNEP MAP RAC/SPA (2011) classification, while the type of edge is defined according to Pergeant et al. (1995) (21).

- CONSERVATION INDEX (CI): represents the proportion of live *P. oceanica* compared to the surface of dead *matte* in a specific sector or area of the meadow. It can provide information on stability, progress or regression of the meadows being examined. Changes in CI over time enable to define alterations to the meadow, mainly caused by human impacts, however it must be taken into account that the dead matte can also have natural causes (e.g. hydrodynamic regime).

  Method: data on coverage (%) of the seabed is collected by scuba diving along transepts or sampling stations (for a number of times that is representative of the meadow) located in a random fashion, in line with the sector of the meadow or the depth being examined. Coverage means the average percentage of covered substrate

(from a vertical projection) of the *P. oceanica* meadow compared to the total surface of the examined sector (sand, rock, dead *matte* and live meadow). The conservation index (12) is calculated with the formula CI= L/(L+D), where "L" represents coverage (%) of live *P. oceanica* and "D" coverage (%) of dead *matte*. The value obtained is then compared with the reference classification (13).

- SUBSTITUTION INDEX (SI): represents the proportion of meadow substituted by the other phanerogam common in the Mediterranean, *Cymodocea nosoda*, and/or by the three green algae of the genus *Caulerpa;* the native *Caulerpa prolifera*, and the two alien ones *Caulerpa cylindracea* and *Caulerpa taxifolia*. Changes in the SI over time allow to determine if the substitution is permanent, increasing, or if, over the long term, it can support restoration of the *P. oceanica* meadow of origin.

  Method: coverage (%) data is collected on the "substitute" species of *P. oceanica* by scuba diving along transepts or sampling stations (for a number of times that is representative of the meadow) located in a random fashion, in line with the sector of the meadow or the depth being examined. The substitution index (13) is calculated using the formula SI= S/(S+P), where "S" represents the coverage (%) of the substitute species and "P" the coverage (%) of *P. oceanica*. The value obtained is then compared with the reference classification (13).

- PHASE SHIFT INDEX (PSI): defines and measures the extent of the phase shift in place within the *P. oceanica* ecosystem, providing a concise evaluation of the irreversibility of changes endured by a meadow subject to regression, in regard to dead *matte* areas and to the presence and quantity of substitutes (i.e. *C. nodosa*; *C. cylindracea*; *C. taxifolia*; *C. prolifera*).

  Method: data on coverage (%) of the seabed and on substitute species is collected by scuba diving along transepts or sampling stations (for a number of times that is representative of the meadow) located in a random fashion, in line with the sector of the meadow or the depth being examined. The phase shift index (2) is calculated using the formula PSI = {[D/(P + D) · 1] + [Cn/(P + Cn) · 2] + [Cp/(P + Cp) · 3] + [Ct/(P + Ct) · 4] + [Cr/(P + Cr) · 5]}/6, where "D" represents the coverage (%) of dead *matte*, "P" that of *P. oceanica*, "Cn" that of *C. nodosa*, "Cp" that of *C. prolifera*, "Ct" that of *C. taxifolia* and "Cr" that of *C. cylindracea.*

- SURFACE OF THE MEADOW: The size of the meadow and the changes it undergoes over time provide information in terms of stability, progress or regression of the meadow itself.

Method: the surface of the meadow can be calculated using a map that is the result of various remote sensing techniques (i.e. satellite imagery; aerial pictures; acoustic measurements) that enable to obtain, process and interpret data with the support of on-site inspections (sea truth). Morphological and bathymetric seabed data is entered on a geographic information system (GIS) in order to be analysed and provide all necessary information, including the area (ha) of the meadow.

- ABUNDANCE OF ASSOCIATED FAUNA (e.g. epifauna, vagile fauna, fish fauna) (Individuals·m^{-2}): Defines biodiversity of the *P. oceanica* ecosystem, both in terms of specific richness and biotic interactions.

Method:The ecosystem's complexity does not make it possible to use a single sampling technique. Various techniques are used, depending on the area being examined.The presence and abundance of fish fauna can be measured with the visual census technique along transepts of known length placed parallel to the coast or placed at depth. Usually, this type of sampling is carried out while scuba diving, but the transepts along the coast, especially if in shallow water, can also be carried out time-based while snorkelling. The vagile fauna of the foliar canopy can be sampled by using small fishing nets (22) while for the vagile fauna of the rhizomes, sediments and *matte*, an air-lift suction sampler is used (i.e. air–lift) on a known surface (e.g. a 50 x 50 cm square). To sample the epifauna present on the leaves of *P. oceanica,* a variable number of shoots must be collected (about 9 according to the ISPRA protocol) in order to obtain coverage and/or epiphytic biomass measurements.

ECONOMIC ASSESSMENT APPROACHES AND METHODS FOR ECOSYSTEM SERVICE N.1:

- **BIOPHYSICAL ASSESSMENT - EMERGY ANALYSIS**

A biophysical assessment of the value of a service allows to estimate its relevance with a *donor-side* approach that is not tied to market dynamics or to user preferences, whether expressed directly or indirectly. An emergy analysis assesses the value of an asset or a service in relation to the solar power that was directly or indirectly needed to obtain it; its size is extensive and its unit of measurement is solar emergy joule (sej).

Method: the assessment of the ecologic value of the creation and maintenance of the *Posidonia oceanica* meadow habitat is carried out considering the value of the service as equal to the effort expended by nature to create and maintain the ecosystem. Since emergy accounting (23) takes into account the resources used directly or indirectly to produce a product or to maintain a service, the ecologic value is recorded as the total emergy required for primary production employed to generate the system (capital) and to maintain primary production necessary to support the actual structure of the ecosystem (18, 3, 5). The biophysical assessment of the value of natural capital and of generated

ecosystem functions follows the diagram shown in Picture 7-3 and the formulas in tables 7-2 and 7-3. Conversion in emergy terms and in the equivalent monetary value of natural flows calculated is done by applying appropriate conversion factors (*transformities*), that, updated to 2017, are shown in Table 7-4. Conversion in monetary terms is done by applying the "emergy to money ratio" factor (Table 7-4) that represents the purchasing power of one solar emergy Joule.

Picture 5 - Biophysical and trophic environmental accounting model: flow diagram.

Figura 5 - Modello biofisico e trofico di contabilità ambientale: diagramma di flusso.

Table 3 - Main formulas for calculating nutrients and natural flows that help generate natural capital

Items	Capital formula	Unit
Carbon	B_o_{tot}	g
Nitrogen	$B\_o_{tot} \cdot 7 / 41$	g
Phosphorus	$B\_o_{tot} / 41$	g
Solar radiation	Annual solar radiation per unit of area · (1-albedo) · area · time needed to form a stock	J

Items	Capital formula	Unit
Rain, chemical energy	Annual rainfall · Gibbs free energy of water · water density · area · time needed to form a stock	J
Wind	Air density · drag coeff. · (geostrophic wind speed)^3 · seconds/year · time needed to form a stock	J
Currents	½ · current speed^2 · seawater density · time needed to form a stock	J
Geothermal heat	Area · geothermal flow · time needed to form a stock	J
Tides	½·yearly number of tides · (height of tides)^2 · seawater density · gravity · area · time needed to form a stock	J
Runoff	(Annual precipitation - evaporation - aquifer infiltration) · water density · Gibbs free energy · catchment area · time needed to form a stock	J

Table 4 - Main formulas for calculating nutrients and natural flows that help generate ecosystem functions

Items	Formula funzioni ecosistemiche	Unit
Carbon	C=max(Pa:Pe)	g/year
Nitrogen	C ·7 / 41	g/year
Phosphorus	C / 41	g/year
Solar radiation	Annual solar radiation per unit of area· (1-albedo) · support area	J/year
Rain, chemical energy	Annual rainfall · Gibbs free energy of water · water density · support area	J/year
Wind	Air density · drag coeff. · (geostrophic wind speed)^3 · seconds/year · support area	J/year
Currents	½ · current speed^2 · seawater density · support area	J/year
Geothermal heat	Geothermal flow · support area	J/year
Tides	½·yearly number of tides · (height of tides)^2 · seawater density · gravity · support area	J/year
Runoff	(Annual precipitation - evaporation - aquifer infiltration) · water density · Gibbs free energy · hydrographic basin size	J/year

Table 5 - List of Unit Emergy Values (UEVs) employed to calculate emergy.

INPUT	UEV (seJ/unit)		Reference
C	1.02E+08	seJ/g	Campbell et al., 2014 (50)
N	7.40E+09	seJ/g	Odum, 1996 (23)
P	2.86E+10	seJ/g	Odum, 1996 (23)
Sun	1.00E+00	seJ/J	Odum, 1996 (23)
Rain	2.93E+04	seJ/J	Odum, 1996 (23)
Wind	2.41E+03	seJ/J	Odum, 1996 (23)
Currents	3.80E+04	seJ/J	Odum, 1996 (23)
Geothermal heat	2.00E+04	seJ/J	Brown e Ulgiati, 2010 (51)
Tides	7.20E+04	seJ/J	Brown e Ulgiati, 2010 (51)
Runoff	6.61E+04	seJ/J	Odum, 1996 (23)
Emergy to money ratio	9.60E+11	seJ/€	Pereira et al., 2013 (52)

- **MITIGATION OR COMPENSATION COST**

Assessment methods based on mitigation or compensation costs is a group of techniques based on "exchange" value estimates that, as estimate of the value of an asset, use the cost of adopted measures to maintain supply of ES provided by such asset.

Method: Estimate is carried out by recording the cost of the necessary actions to avoid, mitigate, or restore the loss of services provided by ecosystems. Since costs are estimated on the basis of observable market prices (for example: public projects price lists, costs obtained from market investigations), it is a group of methods that is also accepted in the experimental ecosystem accounting guidelines within the SEEA - system of environmental-economic accounting proposed by the United Nations (24).

- CONSERVATION COST

It is an indirect estimate system of the value of an environmental asset that assumes that the asset's value is at least equal to the cost directly or indirectly incurred for its maintenance and conservation.

Method: the assessment system contingent on conservation cost is based on the estimate of the cost of the area's environmental conservation (including pollution control costs, detailed or diffuse) and cost-opportunity, that is the cost determined by not being able to develop certain activities in the areas of interest.

Conservation costs can be deduced, for example, from specific conservation projects, or from estimates based on the financial statements of management bodies of protected areas, in case the *Posidonia oceanica* meadow being examined falls under their responsibility.

Cost-opportunity, which is harder to quantify, calls for one or more alternative hypotheses for the use of the area of interest, on the basis of which annual economic benefits are estimated. Alternative hypotheses can be formulated, among other things, considering an environmentally similar area in which activities have already been carried out and of which it is possible to know economic and financial benefits.

Table 6 - Strengths and weaknesses of economic assessment approaches and methods for ecosystem service n.1:

	Emergy Analysis	Mitigation or compensation cost	Conservation cost
Strengths	Effective operational tool to provide a concise monetary measure of the capital value, functions and ES. Sound accounting basis for a monetary assessment based on ecological principles and not affected by economic preferences or dynamics	Accepted in the experimental ecosystem accounting guidelines within the system of environmental-economic accounting (SEEA).	Easy enough to determine once basic information is obtained
Weaknesses	Major effort to collect samples and process analysis	In most cases it represents a partial estimate of the value	Totally dependent on the level of protection/conservation applied to the asset Basic information at times deficient and/or difficult to obtain Difficult to assess cost-opportunity
Required human resources	Naturalist and economics skills. High level of training	Naturalist and economics skills.	Naturalist and economics skills.

Required financial resources (*)	High	Limited	Moderate
Required equipment and means	Certified divers, support dive boat, laboratory for lepidochronological and taxonomic analyses		

* Human resources, Estimate of expenditure: High = approx. 25000 €/year; Moderate = approx. 15000 €/year; Limited = approx. 10000 €/year; Low = approx. 5000 €/year

MAIN ENVIRONMENTAL INDICATORS FOR ECOSYSTEM SERVICE N. 2: DISPERSAL OF SEEDS AND OTHER PROPAGULES

- SURFACE INCREASE OVER UNIT OF TIME (YEAR)

Represents expansion of the meadow due to sexual reproduction of the plant, which causes colonisation of areas that are distant from the meadow of origin.

Method: Surface increase over unit of time (year) is measured with a diachronic analysis, that calls for a comparison of maps of the same meadow (or seabed area) at different times, in a GIS environment (25,26). Using vector overlay it is possible to create discordance maps, in which positive discordances show the acquired surface.

ECONOMIC ASSESSMENT APPROACHES AND METHODS FOR ECOSYSTEM SERVICE N.2

- **BIOPHYSICAL ASSESSMENT - EMERGY ANALYSIS**

A biophysical assessment of the value of a service allows to estimate its relevance with a *donor-side* approach that is not tied to market dynamics or to user preferences, whether expressed directly or indirectly. An emergy analysis assesses the value of an asset or a service in relation to the solar power that was directly or indirectly needed to obtain it; its size is extensive and its unit of measurement is solar emergy joule (sej).

Table 7 - Strengths and weaknesses of economic assessment approaches and methods for ecosystem service n.2

	Emergy Analysis
Strengths	Effective operational tool to provide a concise monetary measure of the capital value, functions and ES. Sound accounting basis for a monetary assessment based on ecological principles and not affected by economic preferences or dynamics
Weaknesses	Major effort to collect samples and process analysis
Required human resources	Naturalist and economics skills. High level of training
Required financial resources	High
Required equipment and means	Certified divers, support dive boat, laboratory for lepidochronological and taxonomic analyses

MAIN ENVIRONMENTAL INDICATORS OF ECOSYSTEM SERVICE N. 4: REGULATION OF CLIMATE

- NET PRIMARY PRODUCTION ($gC \cdot m^{-2}\ year^{-1}$): is the quantity of organic matter (or organic carbon) produced during photosynthesis. Net primary production (NPP) therefore indicates a biomass variation (B) per unit of area (m^2) and of time (t). The unit of time generally used is the year.

  Method: primary productivity connected with the biomass stored in the habitat is calculated considering the increase of biomass in rhizomes and the yearly production of leaves, obtained from the lepidochronological analysis.

- EMITTED OXYGEN: is molecular oxygen (O_2) released as waste product of photosynthesis.

  Method: Taking into account a standard photosynthesis reaction, the quantity of oxygen released by the plant is proportional to the NPP according to the stoichiometric ratio 1:2.

- SEQUESTERED CO2: sequestering and storing carbon dioxide is a process that entails geologic carbon sequestration of the latter (in this case) in the *matte* of *Posidonia oceanica*. It is estimated that approximately 30% of the net primary production of *P. oceanica* is stored in the *matte* (i.e. substrate made up of rhizomes, roots, and sediment over which the *P. oceanica* grows) (27). Therefore, it is possible to distinguish a short-term carbon reservoir (in which mineralization takes place between 2 and 6 years after carbon is stored) and a long-term reservoir (in which it takes from several decades to several millennia for mineralization to occur). The percentage of carbon sequestered in the long-term is on average 27 % of the total carbon fixed by plants (28).

  Method: according to what is explained in Mateo e Romero (1997) (29), the subterranean biomass, formed by roots, rhizomes and sheaths of old leaves, undergoes an almost negligible decay, at least in the short and medium term (decades), and it represents the carbon stock provided by the meadow. To evaluate the quantity of organic substance and thus of carbon stored in the sediment, it is assumed that the entire production of rhizomes and roots is stored in the sediment. The biomass of roots and rhizomes is estimated by collecting samples with a core drill (internal diameter of 15 cm), penetrating 20 cm into the sediment (30, 31). The sampled plant is divided in (1) live rhizomes, (2) dead rhizomes (3) live roots, (4) dead roots (32). Carbon stock rate is calculated by multiplying growth rate of live parts times the carbon concentration present in the corresponding dead parts.

ECONOMIC ASSESSMENT APPROACHES AND METHODS FOR ECOSYSTEM SERVICE N.4

- **BIOPHYSICAL ASSESSMENT - EMERGY ANALYSIS**

A biophysical assessment of the value of a service allows to estimate its relevance with a *donor-side* approach that is not tied to market dynamics or to user preferences, whether expressed directly or indirectly. An emergy analysis assesses the value of an asset or a service in relation to the solar power that was directly or indirectly needed to obtain it; its size is extensive and its unit of measurement is solar emergy joule (sej).

Method: refer to ecosystem service n.1

- **SOCIAL COST OF CARBON AND AVOIDED COST**

The economic value of the climate regulation ES can be estimated by multiplying the annual carbon stock (expressed as equivalent tonnes of CO_2 per hectare, that is t CO_2 e x ha^{-1} x $year^{-1}$) times its value (USD/ t CO_2 e or Euro/ t CO_2 e) times the surface expressed in hectares. Annual stock is evaluated using the above-mentioned method.

The economic value can be estimated, in addition to using the emergy approach, using the Social Cost of Carbon (SCC), avoided cost or market price.

In the case of SCC[12] and avoided cost, it is possible to use reference values that result from evaluations with complex models. These values can be extremely variable. For example, for SCC the value can vary between 54 (33) and 805 USD/t CO2 (34), while avoided cost, due to the costs for capture and storage systems can take, according to the IPPC (Intergovernmental Panel on Climate Change) (35) values between 25 and 30 USD/t CO2.

- **MARKET PRICE**

The economic value of the climate regulation ES can be estimated by multiplying the annual carbon stock (expressed as equivalent tonnes of CO_2 per hectare, that is t CO_2 e x ha^{-1} x $year^{-1}$) times its value (USD/ t CO_2 e or Euro/ t CO_2 e) times the surface expressed in hectares.

Annual stock is evaluated using the above-mentioned method.

For the reference value of the price it is possible to use those of the main carbon markets, but it is advisable to use the reference price of the Emission Trading Scheme (ETS), of the European Union.

12 The SCC represents the marginal cost caused by emissions of additional quantities of greenhouse gases, expressed as equivalent CO_2, while the avoided cost represents the total cost

Table 8 - Strengths and weaknesses of economic assessment approaches and methods for ecosystem service n.4

	Emergy Analysis	Social Cost of Carbon	Avoided Cost	Market Price
Strengths	Effective operational tool to provide a concise monetary measure of the capital value, functions and ES. Sound accounting basis for a monetary assessment based on ecological principles and not affected by economic preferences or dynamics	Very easy to apply using the biomass values already obtained from the application of other ES or from bibliographical sources	Very easy to apply using the biomass values already obtained from the application of other ES or from bibliographical sources	Very easy to apply using the biomass values already obtained from the application of other ES or from bibliographical sources For the EU, it represents a reference monetary value that is widely accepted
Weaknesses	Major effort to collect samples and process analysis	Dependent on outside economic and monetary parameters, which are the same for all ecosystems Reference economic and monetary parameters vary greatly	Dependent on outside economic and monetary parameters, which are the same for all ecosystems Reference economic and monetary parameters may vary	Dependent on outside economic and monetary parameters, which are the same for all ecosystems Reference economic and monetary parameters may vary
Required human resources	Naturalist and economics skills. High level of training	Naturalist and economics skills	Naturalist and economics skills	Naturalist and economics skills
Required financial resources	High	Low	Low	Low
Required equipment and means	Certified divers, support dive boat, laboratory for lepidochronological and taxonomic analyses	Spreadsheet and baseline data obtained from other ES or from bibliographical sources	Spreadsheet and baseline data obtained from other ES or from bibliographical sources	Spreadsheet and baseline data obtained from other ES or from bibliographical sources

* Human resources, Estimate of expenditure: High = approx. 25000 €/year; Moderate = approx. 15000 €/year; Limited = approx. 10000 €/year; Low = approx. 5000 €/year

MAIN ENVIRONMENTAL INDICATORS OF ECOSYSTEM SERVICE N. 7: REGULATION OF COASTAL WATER QUALITY

- **TURBIDITY AND CONCENTRATION MEASUREMENT (Total Suspended Solids – TSS): corresponds to the dry weight of suspended particles that are not dissolved in a water sample. It is a parameter commonly used to assess water quality.**

  Method: TSS are determined by filtering an accurately measured volume of water (usually one litre) through a pre-weighted filter, with a specific pore size. After the drying process, the recorded weight gain of the filter is the dry weight of the particles present in the water sample expressed in units calculated from the volume of filtered water (e.g. $mg \cdot l^{-1}$).

ECONOMIC ASSESSMENT APPROACHES AND METHODS FOR ECOSYSTEM SERVICE N.7

- **WILLINGNESS TO PAY**

The value of an environmental asset or an ecosystem service can be calculated according to market laws based on user preferences, for example investigating willingness to pay to take advantage of an asset or willingness to accept a corresponding asset if that asset is no longer available. The value of assets or services is determined on the basis of willingness to pay (WTP) or to accept (WTA) a given amount of income for a change in individual wellbeing. WTP is therefore a theoretical price that represents the value subjectively assigned by a consumer to a given quantity of asset. This value coincides with the market price if it exists and is not distorted. Instead, if the market does not exist (as for environmental assets) or in the case that it is distorted, the WTP represents a useful tool to estimate social benefits resulting from the production of the asset in question.

Method – to assess willingness to pay it is necessary to develop questionnaires to distribute to a statistically relevant and non-stratified portion of stakeholders. The steps to observe are the following:

- identifying users of the asset/service being evaluated
- defining sample size

- defining methods for acquiring information (questionnaires, interviews, open-ended/closed-ended questions, etc.)
- developing questionnaires that must:
  a) detect the level of environmental sensitivity of the person being interviewed, and of knowledge of the asset
  b) present the hypothetical market and ask whether there is willingness to pay
  c) distinguish the person being interviewed, with demographic information
- carrying out statistical analyses that evaluate the validity of answers

Table 9 - Strengths and weaknesses of economic assessment approaches and methods for ecosystem service n.7

	Willingness to Pay
Strengths	Allows to assess non-use values Is widely used in reference literature
Weaknesses	People being interviewed can exhibit "free-riding" behavior inconsistency with rational choice theory (marginal demand curve is not always sloping downward when use of the asset increases) initial information can influence answer on willingness to pay distortions caused by a sense of complacency (satisfaction generated by the personal feeling of having contributed to a good cause)
Required human resources	Economic skills – social skills
Required financial resources	Moderate
Required equipment and means	

MAIN ENVIRONMENTAL INDICATORS OF ECOSYSTEM SERVICE N. 8 "EROSION CONTROL AND COAST PROTECTION":

- **QUANTITY OF SEDIMENT RETAINED IN THE MEADOW: there are exchanges of fine and coarse materials among the submerged part of a beach, the emerged part, and the coastal dunes, on which the coastal dynamic equilibrium depends. The leaves of *P. oceanica* create a deceleration action that supports the sedimentation process in the area taken up by the meadow, as well as the growth of the *matte*, the structured substrate of sediment deposition and interpenetration of rhizomes and roots of marine phanerogams. This protects the seabed from the erosive action of waves and currents (rise in cohesion and in shear strength) (36) (37). It was estimated that the regression of only one meter of meadow can cause the loss of 15 - 18 meters of sandy coastline (38).**

  The indicator, that is measured in g of dry weight per unit of surface (g_{DW}[13] m^{-2} a^{-1}), is calculated using this equation: (Primary deposition inside the meadow – primary deposition outside the meadow) + (Resuspension outside the meadow – resuspension inside the meadow). Its value depends by multiple factors such as density of the *Posidonia o.* meadow, hydrodynamic conditions inside and outside the meadow, granulometry of suspended solids. Experimental observations have shown how meadows can trap fine particles, hindering resuspension of sediment (39), process that explains the considerable quantity of clayey silt content detected in the *matte* (40). The latter are distinguished by a growth rate that can vary significantly from one site to another (0,6 – 10 mm y-1 (41)).

  A study on the *Posidonia oceanica* meadows in the site of Port Lligat Bay in Spain has produced a picture of the chemical and physical characteristics of the *matte*, with the average trapped inorganic sediments of 898.6±26.3 g_{DW} m^{-2} a^{-1}, of which 120.0 ± 6.4 g_{DW} m^{-2} a^{-1} being the clayey silt fraction (<63 µm) (41).

  Method: the quantity of sediment trapped in the meadow can be measured by using plexiglass (PVC) cylinders located at predetermined distances inside and outside the meadow (42)

- **QUANTITY OF TRAPPED SEDIMENT IN THE BANQUETTES**: due to the loss of leaves, that can reach a ponderal index value between 10 - 20 tons per hectare of meadow (43), vegetable fragments are carried towards the emerged part of the beach (about 25%, taking into account that 70% remains in the *intermattes* of the meadow and the remaining 5% is carried away towards the pelagic zone (44)), causing the creation of *banquettes*, that have an active role in holding great quantities of sediment that are trapped among the multiple layers of deposits. The sand content depends on the size of sediments. In beaches with coarse grain size, distinguished by particles that have a diameter greater than 1 mm, the quantity of sand trapped in the *banquettes* is very high, while in beaches

13 DW: Dry Weight

with medium or fine grain sizes, the quantity of trapped sand decreases significantly. The indicator is measured in (**kg m-3**). Studies carried out on coastal areas of Sardinia have shown an average quantity of sediments trapped in the *banquettes* of approximately 60 (40) – 92,8 (45) kg m-3. In fact, removal of a *banquette* will generate impacts both on beach geomorphology and by creating changes in the sediment budget.

Method: Collection of a determined quantity of biomass trapped in the *banquettes* and gathering of the sediments trapped inside, either mechanically or with an air nozzle, letting the biomass collected dry out and the water content decrease. (46).

- **REDUCTION OF INCIDENT ENERGY: Some studies have shown how hydrodynamic forces are reduced between 10% and 75% among *P. oceanica* leaves (39) and by 20% several centimetres over the meadows (47), which results in a reduction of their erosive action (48). Hydrodynamic parameters such as wave period, incident energy flow, a combination of unidirectional and orbital flow, and the ratio between water depth/height of the meadow, as well as density and height of leaves, significantly affect the capacity of the meadow to protect the coast from erosion (49). The meadow plays a role in reducing incident energy in conditions of low-energy and moderate amplitude waves, while during storms its coastline protection action is almost insignificant (50). The indicator, expressed in (Joule m-2), is thus crucial, but there are other parameters that also play a key role.**

  Method: the value of the indicator can be calculated by using hydrodynamic models based on lab experiments (50, 51) or *in situ*, by using tools such as an Acoustic Doppler Velocimeter (ADV) (52).

ECONOMIC ASSESSMENT APPROACHES AND METHODS FOR ECOSYSTEM SERVICE N.8

- BIOPHYSICAL ASSESSMENT (E.G. EMERGY ANALYSIS)

  A biophysical assessment of the value of a service allows to estimate its relevance with a donor-side approach that is not tied to market dynamics or to user preferences, whether expressed directly or indirectly. An emergy analysis assesses the value of an asset or a service in relation to the solar power that was directly or indirectly needed to obtain it; its size is extensive and its unit of measurement is solar emergy joule (sej).

  Method: please refer to ecosystem service n.1

- MEASURE OF AVOIDED COST (e.g. cost of coastal protection systems and beach replenishment)

The measure of the value of the avoided cost is based on quantifying the expenses that would be necessary to take on in order to carry out the same service provided by nature, by using technology applications. Coastal protection can be achieved using hard protection structures

(revetments, breakwaters, seawalls, bulkheads, sea dikes), soft ones (beach nourishment using gravel) or detached (emerged or submerged breakwaters, platform-islands), cross-shore coastal protection methods (groynes, *headlands*), replenishments, sand *by-pass* systems, beach drainage systems, beach restoration, and dune protection (53).

Method: In the case of coastal protection projects with off-shore systems, the assessment must be carried out with the use of fluid dynamics models to determine the types and dimensional and construction characteristics of a barrier that plays the same role.

- **HEDONIC PRICE**

It is an indirect assessment method based on revealed preferences (such as WTP or travel cost) through analysis of surrogate markets, usually the property one. The hedonic price model is also based on the theory of Lancaster (1966) (54), according to which people assign a value to an asset according to the different characteristics it possesses. House prices reflect both structural characteristics, as well as other characteristics (accessibility, closeness to services, etc.) and environmental qualities (geomorphological stability of the area where the houses are located, stability of nearby beaches, etc.) that people believe to be important when they decide to buy a house. This method is used to assess environmental costs associated to pollution and landscape degradation or the benefits associated to closeness to areas of environmental or cultural interest and/or social and commercial services (for ex. shops, schools, hospitals).

Method: the hedonic pricing function is a derivative of the price of houses compared to the environmental variable that is being analysed (in this case presence, coverage, and conservation status of the *P. oceanica* meadow), that represents the value that individuals implicitly assign (revealed preference) to the meadow. The data to collect is the following:

- sale prices and houses location
- structural characteristics of houses: surface, garden size, number of rooms, bathrooms, etc.
- urban area characteristics: presence of services, schools, criminality rate, etc.
- distance from large urban agglomerations and malls, available public transport
- environmental characteristics of the area where the urban settlement is located
- environmental characteristics of the meadow (coverage and conservation status of the meadow)
- morphological stability condition of coastal areas

Table 10 - Strengths and weaknesses of economic assessment approaches and methods for ecosystem service n.8

	Emergy Analysis	Measure of Avoided Cost	Hedonic Price
Strengths	Effective operational tool to provide a concise monetary measure of the capital value, functions and ES. Sound accounting basis for a monetary assessment based on ecological principles and not affected by economic preferences or dynamics	Strong communication impact	Is based on choices actually made by individuals and not estimated or parameterized. Market data used is usually reliable since it comes from different information sources, and it is analyzed using consolidated, standard econometric techniques.
Weaknesses	Major effort to collect samples and process analysis	A reference market on which to base assessments for this ecosystem service does not exist	Is not able to assess the non-use value of the asset. Allows to assess supply of environmental assets and services, but not demand. This method is valid to the extent to which people are informed on the environmental characteristic being examined (asset or service) and aware of its levels. If not, the value will not be reflected by house prices. This method is still giving rise to many econometric challenges, such as the risk of omitting significant variables when building functions, the possible correlation among several variables, the difficulty of identifying the functional form of the equation (results are overly dependent on model specification).
Required human resources	Naturalist and economics skills. High level of training	Economics skills	Economics skills – social skills
Required financial resources ([a])	High	Limited	Moderate / High
Required equipment and means	Certified divers, support dive boat, laboratory for lepidochronological and taxonomic analyses		

* Human resources, Estimate of expenditure: High = approx. 25000 €/year; Moderate = approx. 15000 €/year; Limited = approx. 10000 €/year; Low = approx. 5000 €/year

MAIN ENVIRONMENTAL INDICATORS OF ECOSYSTEM SERVICE N. 12 "FOOD AND FEED":

- PRESENCE AND BIOMASS OF ASSOCIATED FAUNA (e.g. epifauna, vagile fauna, fish fauna) (individuals·m^{-2}; $g \cdot m^{-2}$): Defines the biodiversity of the *P. oceanica* ecosystem both in terms of specific richness and of biotic interactions.

  Method: Due to the complexity of the ecosystem, it is not possible to use a single sampling technique. Different techniques are used depending on which area is being examined. The presence and abundance of fish fauna can be detected by using the visual census technique along transepts of known length placed parallel to the coast or placed at depth. Usually, this type of sampling is carried out while scuba diving, but the transepts along the coast, especially if in shallow water, can also be carried out time-based while snorkelling. The vagile fauna of the foliar canopy can be sampled by using small fishing nets (22) while for the vagile fauna of the rhizomes, sediments and *matte*, an air-lift suction sampler is used (i.e. air–lift) on a known surface (e.g. a 50 x 50 cm square). To sample the epifauna present on the leaves of *P. oceanica,* a variable number of shoots must be collected (about 9 according to the ISPRA protocol) in order to obtain coverage and/or epiphytic biomass measurements.

- FOLIAR BIOMASS: Due to their low digestibility, only certain species of herbivores feed directly on the leaves of *Posidonia oceanica*: the bony fish *Sarpa salpa,* the isopod *Idotea hectica,* and the sea urchin *Paracentrotus lividus.* The foliar biomass can reach very high values, up until 900 g_{PS} m^{-2} and can vary depending on seasonality and depth. Furthermore, the leaves, even when dead, if exported in other ecosystems represent a not negligible food source for detritivore organisms.

  Method: foliar biomass is measured in mg of dry weight (mg_{PS}·$shoot^{-1}$). After taking leaf biometry measurements on the collected shoots (in a number that varies from 10 to 18), preferably in the summer season when they reach their maximum length, epiphytes are removed from each leaf, by delicately scraping them off of both foliar laminae. After cleaning leaves from epiphytes and taking off their base, the leaves are placed in a stove for the time necessary to eliminate any trace of water, then they are weighed.

- EPIPHYTE BIOMASS: Most of the herbivores living in *P. oceanica* meadows feed on the leaves' epiphytes. The structure of the epiphytic community is linked to the various phases

of the vegetative cycle of the plant. The highest coverage of epiphytes on the leaves happens during summer, and it coincides with a slowdown of leaf growth. Epiphytes can also vary depending on human disturbance, for example their biomass seems to increase in the presence of organic pollutants. This is the reason why they are considered early indicators of environmental stress.

Method: Foliar biomass is measured in mg of dry weight (mg_{PS}·$shoot^{-1}$). After taking leaf biometry measurements on the collected shoots (in a number that varies from 10 to 18), preferably in the summer season, when they reach their maximum length, epiphytes are removed from each leaf, by delicately scraping them off of both foliar laminae. Epiphytes are collected and placed in a stove to dry, then they are weighed.

ECONOMIC ASSESSMENT APPROACHES AND METHODS FOR ECOSYSTEM SERVICE N.12

- BIOPHYSICAL ASSESSMENT (E.G. EMERGY ANALYSIS)

A biophysical assessment of the value of a service allows to estimate its relevance with a donor-side approach that is not tied to market dynamics or to user preferences, whether expressed directly or indirectly. An emergy analysis assesses the value of an asset or a service in relation to the solar power that was directly or indirectly needed to obtain it; its size is extensive and its unit of measurement is solar emergy joule (sej).

Method: please refer to ecosystem service n.1

- **MARKET VALUE OF FISH PRODUCTS**

In case of supply of environmental assets for which there is a market and that can be assessed according to their exchange value, the latter can be considered as an estimate of the value of the service provided. In regard to the ecosystem service "food and nourishment source", the value of fish resources marketed by local fishermen can be interpreted as a measure of the value provided by the system under consideration. What is assessed is the value of the fish production owed/linked to the presence of *P. oceanica*, compared to a situation where there are no meadows.

Method - The economic value of fish catches can be inferred by the market prices indicated by fishermen following specific interviews or by using national databases (e.g. Ismea - http://www.ismea.it) and taking into account the data of the market closer to the area of study, or as an alternative, the national market. The information must be contextualised within the market dynamics, which is why it is required to carry out a historical analysis on at least 5 years.

Table 11 - Strengths and weaknesses of economic assessment approaches and methods for ecosystem service n.12

	Emergy Analysis	Market Value
Strengths	Effective operational tool to provide a concise monetary measure of the capital value, functions and ES. Sound accounting basis for a monetary assessment based on ecological principles and not affected by economic preferences or dynamics	Easily accessible and available information. Indication of the effects of ES on the local economy
Weaknesses	Major effort to collect samples and process analysis	Highly dependent on market dynamics that could instead be independent of ecosystem service provision
Required human resources	Naturalist and economics skills. High level of training	Economics skills
Required financial resources *	High	Limited
Required equipment and means	Certified divers, support dive boat, laboratory for lepidochronological and taxonomic analyses	

* Human resources, Estimate of expenditure: High = approx. 25000 €/year; Moderate = approx. 15000 €/year; Limited = approx. 10000 €/year; Low = approx. 5000 €/year

MAIN ENVIRONMENTAL INDICATORS OF ECOSYSTEM SERVICE N. 14 "MEDICINAL, BIOCHEMICAL AND GENERIC RESOURCES":

- **FOLIAR BIOMASS: greater the foliar biomass, greater the content of bioactive substances contained in the leaves of *P. oceanica*.**

  Method: foliar biomass is measured in mg of dry weight (mg_{PS}·$shoot^{-1}$). After taking leaf biometry measurements on the collected shoots (in a number that varies from 10 to 18), preferably in the summer season when they reach their maximum length, epiphytes are removed from each leaf, by delicately scraping them off of both foliar laminae. After cleaning leaves from epiphytes and taking off their base, the leaves are placed in a stove for the time necessary to eliminate any trace of water, then they are weighed.

ECONOMIC ASSESSMENT APPROACHES AND METHODS FOR ECOSYSTEM SERVICE N.14

- BIOPHYSICAL ASSESSMENT (E.G. EMERGY ANALYSIS)

  A biophysical assessment of the value of a service allows to estimate its relevance with a donor-side approach that is not tied to market dynamics or to user preferences, whether expressed directly or indirectly. An emergy analysis assesses the value of an asset or a service in relation to the solar power that was directly or indirectly needed to obtain it; its size is extensive and its unit of measurement is solar emergy joule (sej).

  Method: please refer to ecosystem service n.1

- **MARKET VALUE OF COSMETIC PRODUCTS**

In case of supply of environmental assets for which there is a market and that can be assessed according to their exchange value, the latter can be considered as an estimate of the value of the service provided. In regard to the ecosystem service "cosmetics" the value of cosmetic productions marketed and that use active ingredients derived from *Posidonia oceanica* can be interpreted as a measure of the value provided by the system under consideration.

Method: Even if on the market, the cosmetic products that use active ingredients derived from *P. oceanica* are limited to a few, niche productions. The economic value of cosmetic products can therefore be inferred by the market prices of these productions following specific interviews. The information must be contextualised within the market dynamics, which is why it is required to carry out a historical analysis on at least 5 years.

Table 12 - Strengths and weaknesses of economic assessment approaches and methods for ecosystem service n.14

	Emergy Analysis	Market Value
Strengths	Effective operational tool to provide a concise monetary measure of the capital value, functions and ES. Sound accounting basis for a monetary assessment based on ecological principles and not affected by economic preferences or dynamics	Easily accessible and available information. Indication of the effects of ES on the local economy
Weaknesses	Major effort to collect samples and process analysis	Highly dependent on market dynamics that could instead be independent of ecosystem service provision
Required human resources	Naturalist and economics skills. High level of training	Economics skills
Required financial resources	High	Limited
Required equipment and means	Certified divers, support dive boat, laboratory for lepidochronological and taxonomic analyses	

* Human resources, Estimate of expenditure: High = approx. 25000 €/year; Moderate = approx. 15000 €/year; Limited = approx. 10000 €/year; Low = approx. 5000 €/year

MAIN ENVIRONMENTAL INDICATORS OF ECOSYSTEM SERVICE N. 15 "LEARNING AND INSPIRATION":

- NUMBER OF PARTICIPANTS IN LEARNING AND EDUCATIONAL ACTIVITIES RELATED TO THE MEADOW: the indicator shows the value of a flow of visitors (n. visitors/year) who have paid for environmental learning/education services related to the presence of the meadow and/or for access to visitor centres specialised in the marine environment, and especially in the *Posidonia oceanica* habitat. This does not include snorkelers/divers, who are taken into account for the assessment of ecosystem service n. 16 (in order to avoid double counting).

  Method: collection of presence data through questionnaires used in structures/visitor centres and local environmental associations/cooperatives that provide environmental education services related to the presence of the meadow.

ECONOMIC ASSESSMENT APPROACHES AND METHODS FOR ECOSYSTEM SERVICE N.15

- **EDUCATION SERVICES EXPENSE**

The assessment is based on data that distinguishes the economy of environmental learning/education services at a local level related to the presence of the meadow.

Method: data collection through questionnaires used in structures/visitor centres and local environmental associations/cooperatives about the costs of environmental learning/education services provided and the number of presences. In case of a managed site (for ex. included in a protected area), any investments made by the managing association for environmental education, and especially related to marine habitats, are included in these costs. The value obtained, net of potential investments made by the managing association (if there is one) towards environmental education, shall be a component or underestimate of the travel cost, if the latter is understood as the sum of costs incurred to reach the site and of costs incurred to enjoy the services.

- **WILLINGNESS TO PAY**

The value of an environmental asset or ecosystem service can be calculated according to market laws based on user preferences, for example investigating willingness to pay to take advantage of an asset/service. The value of educational/recreational services can therefore also be determined on the basis of willingness to pay (WTP) of consumers, according to the value subjectively assigned by consumers themselves to these services. This value coincides with the market price if it exists and is not distorted. Instead, if the market does not exist (as

for environmental assets) or in the case that it is distorted, the WTP represents a useful tool to estimate social benefits resulting from the production of the asset in question.

Method: please refer to ecosystem service n.7

- **TRAVEL COST**

There is the assumption that the value assigned by individuals to an asset or service can be assessed by collecting data on the costs incurred to enjoy the asset or service. The costs incurred include the travel costs to reach the site, potential entrance fees to structures or services, and any other on-site expenses. Once the demand curve of the asset or service is drawn, consumer surplus is measured (area under the demand curve) through which it is possible to assess use values (in this case for learning/education purposes) but not other types of values (option or non-use values).

Method: The demand function is defined through costs incurred by individuals (statistical survey). The utility maximisation problem depends on a number of parameters, among which journey cost and times, on-site expenses for educational-recreational services and other assets or services, salary level and perception of the site's environmental quality. It is possible to follow two approaches: zonal or individual. In the first case, different places of origin are identified (interviews given to a sample of visitors through specifically prepared questionnaires and after dividing them according to places of origin arranged in concentric order from the site) and each zone is assigned a monetary cost for each km travelled to the point of arrival. The individual approach instead calls for collecting more detailed information (also by using questionnaires); the demand curve is therefore based on the number of visits paid by each individual, rather than the number of visits per zone (with the zonal approach the demand function is identical within each place of origin). In the survey (individual approach), the following information must be collected:

- place of di residence /starting point
- number of visits to the site during the year or season
- length of journey (in km or in time)
- time of stay at the site
- travel expenses
- income and other socio-economic characteristics
- any different places potentially visited during the same trip
- other reasons related to the trip (besides visiting the site)
- perception of the quality (environmental, recreational) of the site

- which are the (substitute) sites that the visitor could visit instead of the site being examined

Data can be analysed with standard econometric techniques: linear regression can be used to estimate travel cost in relation to the number of visits and other regressors. If a regressor related to perceived environmental (or recreational) quality is included, it will be possible to assess the effect of a change in quality on the consumer surplus.

In the definition of travel cost it is possible to include also the opportunity cost of free-time, although evaluation of this variable is complex and often associated with a significant degree of uncertainty.

- **VALUE OF RESEARCH PROJECTS**

An assessment of the value of the ecosystem service can be carried out based on the sum of funding of projects for the protection of the meadow over a certain period of time.

Method: the value can be derived starting from economic data from local-scale projects (related to the specific *Posidonia oceanica* meadow being examined) and/or (if there is no local-scale) starting from the cost of projects executed on a larger scale, for ex. national/European, for unit of surface of meadows where projects are being carried out (for example reference can be made to the database of the LIFE projects financed by the European Commission – data available online) (55). The average annual value of these projects per unit of surface (€/ha*year) multiplied by the surface of the meadow being examined gives an assessment of the value of the ecosystem service.

Table 13 - Strengths and weaknesses of economic assessment approaches and methods for ecosystem service n.15

	Expenditure for Education Services	Willingness to Pay	Travel Cost	Value of Research Projects
Strengths		Allows to asses non-use values. Is widely used in reference literature.	Reliable conclusions on the behavior of individuals even from a relatively small sample of subjects. Data can be analyzed with consolidated standard econometric	Allows to asses non-use values. Values of research projects can be inferred easily from local databases (managing entity (investments), national databases (state funding) and

	Expenditure for Education Services	Willingness to Pay	Travel Cost	Value of Research Projects
			techniques. Methodological approach widely used in reference literature.	European databases (for ex. the LIFE projects database) Independent from whether or not research projects were conducted in a specific site
Weaknesses		People being interviewed can exhibit "free-riding" behavior. Inconsistency with rational choice theory (marginal demand curve is not always sloping downward when use of the asset increases) Initial information can influence answer on willingness to pay Distortions caused by a sense of complacency (satisfaction generated by the personal feeling of having contributed to a good cause)	Is not able to assess the non-use value of the resource, which usually results in an undervaluation of the assessment of the total economic value of the asset or service. In case that the trip includes multiple destinations a level of uncertainty is introduced when attributing the cost to the site and to the service. Non-applicable for assets with travel cost that is at zero or very low.	Connected to the coverage of *P. oceanica* meadows, but not to their state of conservation. Risk of double counting with other ES if the total sum of the research projects are not known in detail (cost structure for carrying out different actions)
Required human resources	Generic skills	Economic skills – social skills	Economic skills	Generic skills
Required financial resources*	Moderate	Moderate	Moderate	Limited
Required equipment and means				

* Human resources, Estimate of expenditure: High = approx. 25000 €/year; Moderate = approx. 15000 €/year; Limited = approx. 10000 €/year; Low = approx. 5000 €/year

MAIN ENVIRONMENTAL INDICATORS OF ECOSYSTEM SERVICE N. 16 "PHYSICAL AND PSYCHOLOGICAL EXPERIENCES":

- BEACH ATTENDANCE ON THE BEACHES IN FRONT OF *P. OCEANICA* MEADOWS: the indicator shows the value of the flow of beachgoers (n. presences/year) who choose as their destination the beaches in front of *Posidonia oceanica* meadows.

  Method: data is collected through questionnaires given to managers and users of beach resorts and/or users of public beaches, aimed both at calculating the number of presences and at acquiring other useful information (for ex. for assessing willing to pay or travel cost).

- NUMBER OF SNORKELERS/DIVERS: the indicator shows the value of the flow of snorkelers/divers (n. snorkelers/divers/year) that use rental services for dive gear and equipment for underwater activities.

  Method: presence data is collected through questionnaires distributed at centres/structures/associations that organise excursions and rent gear and equipment for underwater activities related to the presence of the meadow, and also given to users, aimed both at calculating the number of presences and at acquiring other useful information (for ex. for assessing willing to pay or travel cost).

  NUMBER OF MOORINGS IN THE MOORING AREAS CLOSE TO THE MEADOWS: the indicator shows the value of the flow of vessels moored during spring and summer (n. moored vessels/year) close to the meadows.

  Method: the indicator can be measured by using aerial photography to find out the number of moored boats, after having defined a reference buffer area around the perimeter of the meadows.

ECONOMIC ASSESSMENT APPROACHES AND METHODS FOR ECOSYSTEM SERVICE N.16

- **WILLINGNESS TO PAY**

The value of an environmental asset or an ecosystem service can be calculated according to market laws based on user preferences, for example investigating willingness to pay to take advantage of an asset/service. The value of recreational services can therefore also be determined on the basis of willingness to pay (WTP) of consumers, according to the value subjectively assigned to these services. This value coincides with the market price if it exists and is not distorted. Instead, if the market does not exist (as for environmental assets/services) or in the case that it is distorted, the WTP represents a useful tool to estimate social benefits resulting from the production of the asset/service in question.

Method: in addition to what has already been mentioned for ecosystem service n.7, it is important to stress the following. For this service, the main reference targets are the users of beaches in front of *P. oceanica* meadows, and the participants to beach activities (e.g. snorkelling and canoe). With regards to snorkelers, it is possible to calculate annual earnings of structures/centres that provide services in the site which is being examined, based on the type of services offered and on user demand for these services, by adding the value of the permits granted annually (56) to the total value of provided services. Individuals are able to choose among a variety of destination sites on the basis of the sites' observable characteristics (Lancaster value theory) (54); the consequence is that it is possible to relate WTP, for example, to the coverage or conservation status of the meadow, to the number of visitors (snorkelers tend to shun crowded places), by using models such as the Multinomial Logit Model and the Latent Class Model (that refer to the same utility function) (57).

- **TRAVEL COST**

There is the assumption that the value assigned by individuals to an asset or service can be assessed by collecting data on the costs incurred to enjoy the asset or service. The costs incurred include the travel costs to reach the site, potential entrance fees to structures or services, and any other on-site expenses. Once the demand curve of the asset or service is drawn, consumer surplus is measured (area under the demand curve) through which it is possible to assess use values (in this case for learning/education purposes) but not other types of values (option or non-use values); the value taken into account is therefore a part of the total travel cost.

Method: please refer to ecosystem service n.15

- **ECONOMIC IMPACT OF TOURIST RECREATIONAL ACTIVITIES**

Assessment of the tourist recreational value of a meadow in terms of the fraction of added value made by accommodation structures and restaurants at the beach site (the geographic location of the structures close to a meadow plays a role in their turnover).

Method: market investigation aimed at calculating earnings of accommodation structures and restaurants based on the costs of provided services and on the number of tourists, through questionnaires given to users in order to collect useful information to assess the importance of the presence of the *P. oceanica* meadow on the decision to visit a specific site (reasons for the trip and for choosing a site, perception of the quality (environmental, recreational) of the site, any potential other sites that users could choose to visit as an alternative, etc).

- **HEDONIC PRICE**

It is an indirect assessment method based on revealed preferences (such as WTP or travel cost) through analysis of surrogate markets, usually the property one. The hedonic price

model is also based on the theory of Lancaster (1966) (54), according to which people assign a value to an asset according to the different characteristics it possesses. House prices reflect both structural characteristics, as well as other characteristics (accessibility, closeness to services, etc.) and environmental qualities (geomorphological stability of the area where the houses are located, stability of nearby beaches, etc.) that people believe to be important when they decide to buy a house. This method is used to assess environmental costs associated to pollution and landscape degradation or the benefits associated to closeness to areas of environmental or cultural interest and/or social and commercial services (for ex. shops, schools, hospitals). It is required to be mindful of the risk of double counting, since this calculation method could also include part of the value generated by other ES.

Method: please refer to ecosystem service n.8

- **CONTINGENT CHOICE**

Sets out to assess the economic value of assets "without a market" through a direct investigation to detect consumer preferences. It is based on the simulation of a hypothetical or contingent market and its goal is to assess willingness to pay (WTP) to improve the level of wellbeing, in other words the willingness to accept (WTA) "giving it up". Of course, the values obtained are "contingent", that is dependent on the simulated market.

Method: data collected with a questionnaire that should describe accurately and as realistically as possible an ideal situation to which a hypothetical market situation is associated. The assessment of the economic value is thus created in relation to hypothetical scenarios. The method can be applied through the following steps:

- defining the hypothetical market
- defining the sample of people to interview
- developing and implementing the *survey* that calls for:
  - initial interviews and/or focus groups whose goal is to understand the issues connected to the asset to evaluate.
  - designing the questionnaire
  - pre-testing the questionnaire
  - carrying out the investigation.
- analysing results (data is analysed with the best-suited statistical techniques for each type of question).

Application of this method is usually complex, long, and expensive; as a consequence, over time, various experts have drafted guidelines for collecting data, defining the sample, describing hypothetical scenarios, using the different elicitation techniques (bidding

game, payment card, *open-ended*, dichotomous choice with a potential *follow up*), defining the payment mechanism, validating questions (to verify that the people being interviewed have understood the scenario), and using repetition in the interview.

Table 14 - Strengths and weaknesses of economic assessment approaches and methods for ecosystem service n.16

	Willingness to Pay	Travel Cost	Economic Impact of Tourist Recreational Activities	Hedonic Price	Contingent Choice
Strengths	Allows to asses non-use values. Is widely used in reference literature.	Reliable conclusions on the behavior of individuals even from a relatively small sample of subjects. Data can be analyzed with consolidated standard econometric techniques. Methodological approach widely used in reference literature.	Studies based on services marketing trends and on the behavior of individuals according to consolidated approaches.	Is based on choices actually made by individuals and not estimated or parameterized. Market data used is usually reliable since it comes from different information sources, and it is analyzed using consolidated, standard econometric techniques.	Allows to asses non-use values, in particular option value and existence value. Can be widely used.

	Willingness to Pay	Travel Cost	Economic Impact of Tourist Recreational Activities	Hedonic Price	Contingent Choice
Weaknesses	People being interviewed can exhibit "free-riding" behavior. Inconsistency with rational choice theory (marginal demand curve is not always sloping downward when use of the asset increases) Initial information can influence answer on willingness to pay Distortions caused by a sense of complacency (satisfaction generated by the personal feeling of having contributed to a good cause)	Is not able to assess the non-use value of the resource, which usually results in an undervaluation of the assessment of the total economic value of the asset or service. In case that the trip includes multiple destinations a level of uncertainty is introduced when attributing the cost to the site and to the service. Non-applicable for assets with travel cost that is at zero or very low.	Is not able to assess the non-use value of the resource. In areas where multiple services are offered, it is possible to introduce a significant level of uncertainty.	Is not able to assess the non-use value of the asset. Allows to assess supply of environmental assets and services, but not demand. This method is valid to the extent to which people are informed on the environmental characteristic being examined (asset or service) and aware of its levels. If not, the value will not be reflected by house prices. This method is still giving rise to many econometric challenges, such as the risk of omitting significant variables when building functions, the possible correlation among several variables, the difficulty of identifying the functional form of the equation (results are overly dependent on model specification).	This method has its limitations in the ways it can be applied (description of hypothetical scenarios, choice of comparison/reference economic values, questionnaire structure, choice of elicitation techniques). Scenarios that are unrealistic can result in the people being interviewed declaring untruthful WTP and WTA values, just as they may be led to underestimate (*free riding* error) or overestimate (*over pledging* error) the value of the asset by following a personal strategy

	Willingness to Pay	Travel Cost	Economic Impact of Tourist Recreational Activities	Hedonic Price	Contingent Choice
Required human resources	Economic skills – social skills	Economic skills	Economic skills	Economic skills – social skills	Economic skills – social skills
Required financial resources	Moderate	Moderate	Moderate	Moderate / high	High
Required equipment and means					

* Human resources, Estimate of expenditure: High = approx. 25000 €/year; Moderate = approx. 15000 €/year; Limited = approx. 10000 €/year; Low = approx. 5000 €/year

MAIN ENVIRONMENTAL INDICATORS OF ECOSYSTEM SERVICE N. 18 "MAINTENANCE OF OPTIONS":

- TREND OVER TIME FOR ALL INDICATORS: The trend of a set of indicators among the above mentioned ones over a significant time period (5/10 years) can provide information on the conservation status of natural heritage, in this case of the *P. oceanica* meadows.

  Method: The values, at time zero, of the indicators taken into account are compared with the values of the same indicators after the significant time period has elapsed. The difference obtained can be interpreted on the basis of reference values to determine if any changes occurred in the *P. oceanica* meadow. To this end, monitoring plans are a useful tool to determine the conservation status of an ecosystem.

ECONOMIC ASSESSMENT APPROACHES AND METHODS FOR ECOSYSTEM SERVICE N.18

- **WILLINGNESS TO PAY**

The value of an environmental asset or ecosystem service can be calculated according to market laws based on user preferences, for example investigating willingness to pay to take advantage of an asset/service. The value of educational/recreational services can therefore also be determined on the basis of willingness to pay (WTP) of consumers, according to the value subjectively assigned by consumers themselves to these services. This value coincides with the market price if it exists and is not distorted. Instead, if the market does not exist (as for environmental assets/services) or in the case that it is distorted, the WTP represents a useful tool to estimate social benefits resulting from the production of the asset/service in question.

Method: please refer to ecosystem service n. 7

- **WILLINGNESS TO GIVE UP ASSETS AND SERVICES PROVIDED BY *P. OCEANICA* MEADOWS**

The value of an environmental asset or an ecosystem service can be calculated according to market laws based on user preferences, for example investigating willingness to accept a corresponding asset if that asset is no longer available. The value of assets or services is determined on the basis of willingness to accept (WTA) a given amount of income for a change in individual wellbeing. WTA is therefore a theoretical price that represents the value subjectively assigned by a consumer to a given quantity of asset. This value coincides with the market price if it exists and is not distorted. Instead, if the market does not exist (as for environmental assets/services) or in the case that it is distorted, the WTA represents a useful tool to estimate social benefits resulting from the production of the asset/service in question.

Method – to assess willingness to accept it is necessary to develop questionnaires to distribute to a statistically relevant and non-stratified portion of stakeholders. The steps to follow are the following:

- identifying users of the asset/service being evaluated
- defining sample size
- defining methods for acquiring information (questionnaires, interviews, open-ended/closed-ended questions, etc.)
- developing questionnaires that must:
  d) detect the level of environmental sensitivity of the person being interviewed, and of knowledge of the asset
  e) present the hypothetical market and ask whether there is willingness to pay
  f) distinguish the person being interviewed, with demographic information
- carrying out statistical analyses that evaluate the validity of answers

- **COST–OPPORTUNITY**

Cost-opportunity is an assessment of the value of an asset based on determining the cost associated with the impossibility of carrying out any given activities in the area of interest. Cost-opportunity calls for one or more alternative hypotheses for the use of the area of interest, on the basis of which annual economic benefits are estimated. Alternative hypotheses can be formulated, among other things, considering an environmentally similar area in which activities have already been carried out and of which it is possible to know economic and financial benefits.

Method: Please refer to ecosystem service n. 1

- **CONTINGENT CHOICE**

Sets out to assess the economic value of assets "without a market" through a direct investigation to detect consumer preferences. It is based on the simulation of a hypothetical or contingent market and its goal is to assess willingness to pay (WTP) to improve the level of wellbeing, in other words the willingness to accept (WTA) "giving it up". Of course, the values obtained are "contingent", that is dependent on the simulated market.

Method: Please refer to ecosystem service n. 16

Table 15 - Strengths and weaknesses of economic assessment approaches and methods for ecosystem service n.18

	Willingness to Pay	Cost-opportunity	Willingness to Give Up	Contingent Choice
Strengths	Allows to asses non-use values. Is widely used in reference literature.	Allows to asses non-use values.	Allows to asses non-use values. Is widely used in reference literature.	Allows to asses non-use values, in particular option value and existence value. Can be widely used.
Weaknesses	People being interviewed can exhibit "free-riding" behavior. Inconsistency with rational choice theory (marginal demand curve is not always sloping downward when use of the asset increases) Initial information can influence answer on willingness to pay Distortions caused by a sense of complacency (satisfaction generated by the personal feeling of having contributed to a good cause)	Distortions due to unrealistic assessments of the value of alternative opportunities taken into account	People being interviewed can exhibit "free-riding" behavior. Inconsistency with rational choice theory (marginal demand curve is not always sloping downward when use of the asset increases) Initial information can influence answer on willingness to pay Distortions caused by a sense of complacency (satisfaction generated by the personal feeling of having contributed to a good cause)	This method has its limitations in the ways it can be applied (description of hypothetical scenarios, choice of comparison/reference economic values, questionnaire structure, choice of elicitation techniques). Scenarios that are unrealistic can result in the people being interviewed declaring untruthful WTP and WTA values, just as they may be led to underestimate (free riding error) or overestimate (over pledging error) the value of the asset by following a personal strategy
Required human resources	Economic skills – social skills	Economic skills – social skills	Economic skills – social skills	Economic skills – social skills

	Willingness to Pay	Cost-opportunity	Willingness to Give Up	Contingent Choice
Required financial resources ([a])	Moderate	Moderate	Moderate	High
Required equipment and means				

* Human resources, Estimate of expenditure: High = approx. 25000 €/year; Moderate = approx. 15000 €/year; Limited = approx. 10000 €/year; Low = approx. 5000 €/year

8. Minimum Content of the Technical Document for Economic Assessment of Environmental Impacts

The economic assessment of environmental impacts presented in this guide can be used to supplement different parts of the EIS, of the EIA procedures, or it can be included in the description and assessment of impacts on the habitat in the case of AA reports and in projects that are not covered under EIA procedures.

Otherwise, it is also possible to produce an additional document to an EIS or AA Report, of which the following is a standard Index:

- Introduction and aim of the document
- Methodological approach
- Territorial framework and description of the work
- Summary of the environmental, territorial, socio-economic contexts of reference
- Description, analysis and assessment of the economic value of ES
- Impacts on ES and on their economic value
- Analysis and comparison among alternatives (ES and their economic value)
- Mitigation and compensation measures for the value lost by ES (potential chapter)
- Summary of results and conclusions
- Bibliography of reference sources
- Attachment: map with location of meadow
- Attachment (potential): map with location of flows and of ES beneficiaries

In both cases it is recommended to use the approaches of analysis that are best-suited to the context and the work, in regard to objectives, available information, potential impacts in terms of magnitude, and factors of space and time and magnitude. In addition, the limitations of these approaches, analyses, economic assessments, and results should be emphasised.

For investigations, the following is recommended:

Minimum data for field investigations

The economic assessment of impacts on *P. oceanica* requires to collect a minimum set of on-site data regarding the health of the meadow, its expansion and the type of associated fish fauna.

To determine how healthy *P. oceanica* meadows are, it is possible to refer to the PREI (58), which is used at the national level by Environmental Protection Agencies to determine the ecological status of surface water bodies. The sampling, as set out by the protocol of the Italian Institute for Environmental Protection and Research, provides for the collection of 18 leaf bundles to be analysed in the lab at a later time, and 9 measurements of foliar density within 40 x 40 cm square areas at a depth of 15 mt. In addition, the depth and the type of lower limit of the meadow must be measured.

The PREI however, does not take into account the landscaping of the meadow, that is its continuity and coverage, which can provide important information about its conservation status. This is why it is recommended to back up the PREI sampling, which is punctual, with coverage data along (at least) one transept at depth that covers the entire surface of the meadow, from the lower limit to the higher limit. (13).

If bionomic maps of the area of interest are not available, the surface of the meadow can be assessed by using *remote sensing* techniques, verified by on-site investigations (sea truth). Therefore, mapping a *P. oceanica* meadow calls for collecting, processing, and interpreting a set of data acquired with different techniques, e.g. satellite imagery, aerial pictures, and acoustic measurements (59).

To carry out a census of fish fauna, on-site detection techniques can be conducted by snorkelling or scuba diving. Among the ones most commonly used is the *visual census* technique along transepts of know length and width (e.g. 25 x 5 m), usually while scuba diving, or time-based transepts while snorkelling (60). This must be carried out for a number of times able to be used to detect the variability of the area being examined.

Minimum set of socio-economic investigations

The socio-economic investigations that are useful in the assessment of the economic value of ecosystem services provided by *P. oceanica* meadows are linked to the methods for an analysis of the costs taken into account. Nevertheless, generally speaking it is possible to identify a standard set of investigations:

- study of the market value of fish products linked to the presence of *Posidonia oceanica*;
- analysis of the value of cosmetic productions marketed and that use active ingredients derived from *P. oceanica.*;
- study of the framework of local tourist and beach economy, aimed at emphasising the value of the tourist and coastal sector and its dependence on the presence of phanerogams;
- acquisition of the Emission Trading Scheme (ETS) carbon reference price.
- investigations using functional questionnaires in order to:

- collect data from local environmental structures/visitor centres and associations/cooperatives regarding the costs for environmental learning/education services provided and the number of presences;
- assess willingness to pay of the users of the coastal area and of the economic activities that are typical of beach tourism;
- understand the reasons that cause users to choose to spend time in a coastal area where *P. oceanica* is present, rather than in another area, and to bear travel costs to reach the place and enjoy the marine coastal habitat;
- assess the value of housing (rent, sale) depending on the services provided by *P. oceanica* (geomorphological stability of the area where housing is located, stability of nearby beaches, water clarity, etc).

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Attachment I - Experiences of Economic Assessment of Environmental Impacts

Texts on general approaches, guides and manuals on economic assessment of environmental impacts are listed below. Scientific articles or other manuscripts on specific cases or projects are not included.

- Asian Development Bank (ADB) (1986), *Economic Evaluation of Environmental Impacts: A Workbook*. Manila: ADB.
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- James, D., Gillespie, R. (2002), *Economic Assessment Draft EIA Guidelines*, Prepared on behalf of Planning NSW
- UNEP (author: Geneletti, D.) (2014), *Integrating Ecosystem Services in Strategic Environmental Assessment: A guide for practitioners*. A report of Proecoserv
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- Kaggwa, R. (National Environmental Management Authority), Masiga, M. (ENR Africa Associates), Bruner A. (Conservation Strategy Fund) (2014), *Guidelines for Conducting Economic Analysis of Environmental Impacts in Uganda,* CFA, NEMA, USAID
- Mburu (editor) et al., s.d., *Economic Valuation and Environmental Assessment. Training Manual*. German Ministry of Education and Research (BMBF) through Subproject E13 of the BIOTA-East Africa Project and accomplished through the cooperation of the Center for Development Research (ZEF) and IUCN - The World Conservation Union-Eastern Africa Regional Office (IUCN-EARO)

- The Health and Environment Linkage Initiative (HELI), s.d., Using Economic Valuation Methods for environment and health assessment, World Health Organization and United Nations Environment Programme
- Vaughan, W. J., Ardila, S. (1993), *Economic Analysis of the Environmental Aspects of Investment Projects*. Working Paper ENP100. Inter-American Development Bank. Productive Sectors and Environment Subdepartment. Environment Protection Division
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Attachment 2 – EIA Case studies with a potential impact on *Posidonia oceanica*

CASE STUDY (n.)	TITLE	PROPOSER
1.a	Trans Adriatic Pipeline – TAP	Trans Adriatic Pipeline AG Italia S.p.A.

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Environmental and Social Impact Assessment and Appropriate Assessment	1805	2012-2014	concluded	positive with limitations

TYPE OF WORK AND DESCRIPTION OF IMPACT

The project concerns the creation of a gas pipeline that will transport gas from the new sources of supply in the region of the Caspian Sea to Western and South-Eastern Europe, through the so-called Southern Gas Corridor. The part of the gas pipeline that falls within the competence of Italy includes a submarine pipeline (offshore section) approximately 45 km. long, an underground gas pipeline (onshore section) approximately 8.2 km. long, a block valve station (BVS) located at the starting point of the onshore section, and a Pipeline Receiving Terminal. Interference with *Posidonia oceanica* and *Cymodocea nodosa* meadows. By drilling a microtunnel, the coastal area of interest with regard to the presence of *Posidonia oceanica* habitats is avoided. Direct impact is limited on the formations of *Cymodocea* at the offshore exit point of the microtunnel. However, sedimentation of the sedimentary material which is resuspended during underwater work, just as the handling of anchors, can have a negative effect on the underwater meadows.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS

Among the various limitations, it is required to design a project for the creation of the microtunnel, to be subject to verifying if it requires an EIA, that implements limitations for the protection of underwater meadows.

ECOSYSTEM SERVICES (ES)

References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
yes	no	none	yes	surface of ecosystems

Assessment of the Impact on ES (yes, no)
no

CASE STUDY (n.)	TITLE	PROPOSER
1.b	Project for building the microtunnel at the landing site of the TAP pipeline in the district of Melendugno, submitted in accordance to requirement A.5) of the Ministerial Decree 0000223 of 11.09.2014 as amended by Ministerial Decree 0000072 of16.04.2015	Trans Adriatic Pipeline AG Italia S.p.A.

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Subject to verifying if it requires an EIA	3559	2017-2018	concluded	disqualification

TYPE OF WORK AND DESCRIPTION OF IMPACT
(rif. Case Study n. 1.a)

MITIGATION / COMPENSATION MEASURES - LIMITATIONS
The project proposes solutions for minimizing impacts, concerning the potential impact of the suspended material as well as that of the anchors

ECOSYSTEM SERVICES (ES)				
References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
yes	no	none	yes	surface of ecosystems
Assessment of the Impact on ES (yes, no)				
no				

CASE STUDY (n.)	TITLE	PROPOSER
2	Technical and functional adaptation to the Port Master Plan of the Porto Torres public port - lengthening of the West seawall and removal of the deep-water pier	North Sardinia Port Authority

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Environmental Impact Assessment and Appropriate Assessment	3523	2016-2018	concluded	positive with limitations

TYPE OF WORK AND DESCRIPTION OF IMPACT
The project calls for the lengthening of the West seawall and the removal of the East pier in order to protect the expanse of water. Direct interference with *Posidonia oceanica* meadows.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS
Transplantation to an adjacent area with similar characteristics (surface ratio 1:1), compensation measure consisting in the placement of anti-trawling devices, and the use of anti-turbidity barriers made up of geo-textile screens, or containment sheets positioned around the construction site in order to contain sediments and, as far as possible, to avoid their dispersion. The following are prescribed 1) a study must be prepared for the exact definition of the areas for transplantation, the ways in which the material removed will be handled must be clarified, as well as the compatibility of the sediment contained in the removed matte with the destination site; 2) a monitoring plan for the meadow and fish resources must be in place (for at least 5 years); 3) mitigation measures in the planning stage against resuspended material causing water turbidity and for moorings of the operational vessels

ECOSYSTEM SERVICES (ES)				
References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
no	no	none	no	surface of ecosystems
Assessment of the Impact on ES (yes, no)				
no				

CASE STUDY (n.)	TITLE	PROPOSER
3	Safeguarding project for the Favignana Port	District of Favignana (TP)

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Environmental Impact Assessment and Appropriate Assessment	2315	2013	suspended	Positive result with limitations(CTVIA Opinion of 15/10/2015), contingent upon the accomplishment of the procedures provided for in Art. 6 of the Dir. 92/43/CEE concerning adopted compensatory measures

TYPE OF WORK AND DESCRIPTION OF IMPACT
Construction of a breakwater made with prefabricated reinforced concrete structures, protected by a barrier of tetrapods. Direct interference with *Posidonia oceanica* meadows.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS
Since it is not possible to proceed with alternatives to the location or structure of the project, it is recommended to resort to compensation measures: 1)extension of the MPA to include non-protected meadow 2) placement of anti-trawling devices; 3) creation of mooring sites; 4) experimental replanting of *Posidonia oceanica*; 5) experimental underwater monitoring; 6) Reinforcing the management of mooring sites.

ECOSYSTEM SERVICES (ES)				
References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
yes	no	none	yes	surface of ecosystems, economic value in Euros of transplanting activities

Assessment of the Impact on ES (yes, no)
no

CASE STUDY (n.)	TITLE	PROPOSER
4	Merchant line with alternating current at 220 kV Italia - Malta. Section included between the Electrical Substation of Ragusa and the further extent of Italian territorial waters	Enemalta Corporation

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Environmental Impact Assessment and Appropriate Assessment	1613	2011-2012	concluded	positive with limitations

TYPE OF WORK AND DESCRIPTION OF IMPACT
Creation of a connection between Malta's electricity transmission network and the Italian one through a terrestrial and submarine cable interconnection, with alternating current at 220 kV. Direct interference with *Posidonia oceanica* and *Cymodocea nodosa* meadows.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS
In areas where *Posidonia oceanica* is present: 1) Laying of submarine cables in the phanerogam meadows without under-grounding, using mooring devices and potential cast iron safeguards; 2) detailed monitoring of the phanerogam meadows; 3) use of operational vessels equipped with high efficiency mooring systems (the ship laying cables will nonetheless not be moored on the meadow); 4) replanting of *Posidonia oceanica* rhizomes(surface ratio. 1:1)

ECOSYSTEM SERVICES (ES)				
References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
yes	no	none	yes	surface of ecosystems
Assessment of the Impact on ES (yes, no)				
no				

CASE STUDY (n.)	TITLE	PROPOSER
5	Pipeline to import gas from Algeria to Italy via Sardinia	GALSI Spa

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Environmental Impact Assessment and Appropriate Assessment	345	2008-2011	concluded (with EIA Decree MD-0000057 that alters the validity of EIA decree DVA-DEC-2011-0000591)	positive with limitations

TYPE OF WORK AND DESCRIPTION OF IMPACT
Pipeline to import gas from Algeria to Italy via Sardinia. Direct interference with *Posidonia oceanica* meadows.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS
Use of low environmental impact *post trenching* and *back filling* techniques (as well as, use of containment sheets to limit sediment dispersion during back filling, covering of the pipeline with sediment containing rhizomes that was previously collected, manuring. Use of suitable mooring techniques. The surface to be replanted must be at least of a 1:13 ratio compared to the surface that will be destroyed during the project's operations at sea, and in any case shall not be less than 6150 mq as planned by the Proposer.

ECOSYSTEM SERVICES (ES)				
References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
no	no	none	no	surface of ecosystems
Assessment of the Impact on ES (yes, no)				
no				

CASE STUDY (n.)	TITLE	PROPOSER
6	Procida Gas Pipeline (NA) - sea area between Lake Fusaro (Bacoli) and the Procida Port Area	Progas Metano

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Environmental Impact Assessment and Appropriate Assessment	848	2010-2012	concluded	positive with limitations

TYPE OF WORK AND DESCRIPTION OF IMPACT

Construction of the offshore pipeline for transport of natural gas to the Procida Island. The submarine pipeline is made up of a stainless steel pipe (with an external coating of extruded polyethylene), which starts from the beach close to the landing site of Bacoli and then continues towards the open sea until it reaches the landing site of Procida in the Port Area (Via della Libertà). The submarine pipeline is completely underground in the two landing sites, that is at a depth of approximately -10 mt, while it rests on the seabed for approximately 5,813 mt, of which 4,567 mt on sand and1,246 on *Posidonia oceanica* matte.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS

1) Maximum width of excavation area 3 mt; 2) excavation material loaded on a barge and removed; 3) during excavation, turbid wastewater pumped and clarified before it is released; 4) pontoon on which the excavator is mounted not moored in the are of the meadow; 5) replanting of Posidonia rhizomes on a surface no less then 108% of the excavated surface; 6) suitable ways to collect root cuttings; 7) monitoring colonization process for at least 10 years

ECOSYSTEM SERVICES (ES)

References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
no	no	none	no	surface of ecosystems

Assessment of the Impact on ES (yes, no)
no

CASE STUDY (n.)	TITLE	PROPOSER
7	Port of Cagliari - Construction of the Ro Ro terminal of the Canale Port - I operational lot	Cagliari Port Authority

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Environmental Impact Assessment and Appropriate Assessment	3390	2016-2018	conclusa	Dismissed - By letter n. 10900 of 7/06/2018, the Sardinia Sea Port Authority, has decided to "withdraw the project submitted for obtaining an assessment of environmental compatibility" and "resubmit the project meeting the new needs which have arisen".

TYPE OF WORK AND DESCRIPTION OF IMPACT
The first operational lot of the new Ro Ro Terminal involves the construction of four docks, the relative boarding areas, and a suitable expanse of water for approaching and mooring maneuvers. The work included in the project does not fall within the boundaries of Posidonia oceanica meadows, which therefore will not be affected by the negative effects of dredging activities that will be carried out adopting all necessary precautions.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS

ECOSYSTEM SERVICES (ES)				
References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
no	no	none	no	none
Assessment of the Impact on ES (yes, no)				
no				

CASE STUDY (n.)	TITLE	PROPOSER
7	Port of Cagliari - Construction of the Ro Ro terminal of the Canale Port - I operational lot	Cagliari Port Authority

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Environmental Impact Assessment and Appropriate Assessment	3390	2016-2018	conclusa	Dismissed - By letter n. 10900 of 7/06/2018, the Sardinia Sea Port Authority, has decided to "withdraw the project submitted for obtaining an assessment of environmental compatibility" and "resubmit the project meeting the new needs which have arisen".

TYPE OF WORK AND DESCRIPTION OF IMPACT
The first operational lot of the new Ro Ro Terminal involves the construction of four docks, the relative boarding areas, and a suitable expanse of water for approaching and mooring maneuvers. The work included in the project does not fall within the boundaries of *Posidonia oceanica* meadows, which therefore will not be affected by the negative effects of dredging activities that will be carried out adopting all necessary precautions.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS
-

ECOSYSTEM SERVICES (ES)				
References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
no	no	none	no	none
Assessment of the Impact on ES (yes, no)				
no				

CASE STUDY (n.)	TITLE	PROPOSER
9	LNG regasification terminal in Brindisi	Brindisi LGN S.p.A.

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Environmental Impact Assessment and Appropriate Assessment	1651	2008-2009	concluded	positive with limitations

TYPE OF WORK AND DESCRIPTION OF IMPACT
The project involves the construction of an LNG Terminal made up of two aboveground complete containment tanks and LNG vaporizers that use seawater, plus a dock for mooring LNG carriers. Impacts on *Posidonia oceanica* meadows are not expected, although a map of the meadow in the areas close to that of the project has not been created

MITIGATION / COMPENSATION MEASURES - LIMITATIONS
A map of *Posidonia oceanica*, both live and dead, present around the area of the project must be used. If an interference occurs, as compensation the proposer shall replant an equal number of plants in an area that shall be identified by the Italian Institute for Environmental Protection and Research (with the relative monitoring exercises and interventions to ensure the plants take root).

ECOSYSTEM SERVICES (ES)				
References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
no	no	none	no	none
Assessment of the Impact on ES (yes, no)				
no				

CASE STUDY (n.)	TITLE	PROPOSER
10	Operational adjustment of the work stipulated in the Development Plan of the Salerno Port: port deepening - project for management of dredged sediments, by using open sea disposal in areas outside the continental shelf	Salerno Port Authority

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Subject to verifying if it requires an EIA and Appropriate Assessment	3486	2016-2017	concluded	positive (excluded from EIA procedure) with limitations

TYPE OF WORK AND DESCRIPTION OF IMPACT
The project involves the open sea disposal in areas outside the continental shelf of the dredged material removed from the Salerno Port. Evaluations made have shown the presence of marine phanerogams only in the coastal area opposite Vietri sul Mare and where the inner breakwater of the port is located, where there is a biocoenosis of Well Sorted Fine Sands (WSFS) with facies and a *Cymodocea nodosa* in very poor condition

MITIGATION / COMPENSATION MEASURES - LIMITATIONS
During dredging activities, floating barriers anchored on the seabed must be used to protect the sensitive *Posidonia oceanica* and *Cymodocea nodosa* ecosystems close to the port

ECOSYSTEM SERVICES (ES)				
References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
no	no	none	no	none
Assessment of the Impact on ES (yes, no)				
no				

CASE STUDY (n.)	TITLE	PROPOSER
11	Project for the construction, at Pentimele in Reggio Calabria, of a docking pier for ferries connecting Reggio Calabria and Messina by sea in both directions, for ground transport of motor vehicles and heavy goods vehicles	Caronte&Tourist S.p.A.

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Environmental Impact Assessment and Appropriate Assessment	3425	2016-2018	CTVIA Opinion delivered, MIBACT Opinion pending	positive with limitations

TYPE OF WORK AND DESCRIPTION OF IMPACT
The project involves the construction of two docking piers for Ro-Ro ferries for transport from the Reggio Calabria Port to the Tremestieri Port in the North landing yard of the Reggio Calabria Port. Inspections and investigations carried out during the planning stage did not show the presence of *Posidonia oceanica* meadows in the landing area, in its vicinity or in the area of interest of the project.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS
Monitoring activities shall be carried out. However, since there are no direct impacts on *Posidonia oceanica* meadows, and no available plants to relocate, it is not considered possible to carry out replanting activities as anticipated by the proposer. It is preferable to use the estimated budget for different protection activities to be performed on existing meadows, for example by using anti-trawling devices, to be agreed with the SIC managing body

ECOSYSTEM SERVICES (ES)				
References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
yes	no	none	yes	none
Assessment of the Impact on ES (yes, no)				
no				

CASE STUDY (n.)	TITLE	PROPOSER
12	Reconfiguration of the South dock of the Santo Stefano Island in the district of La Maddalena - Batteria Punta dello Zucchero	Military Engineers Branch for the Italian Navy in Cagliari

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Environmental Impact Assessment and Appropriate Assessment	3367 (subject to verification) - 3414 (EIA - scoping phase)	2016-2017	Application 3367 dismissed: the proposer intends to initiate EIA procedure - Procedure 3414: Definition EIS contents (Scoping)	-

TYPE OF WORK AND DESCRIPTION OF IMPACT
The project involves expanding the dock head and building a new floating dock not connected to land which will function as a mooring dolphin; furthermore, underwater excavations will be carried out on granite gravel and rock. In addition, part of the floor of the existing dock will be demolished and excavations will be carried out to lower the dock and allow mooring of the"Classe Cavour" naval units. A large meadow of *Posidonia oceanica* on matte-sand grows close to the part of the dock affected by the project, and a direct interference is verified on approximately 195 sq. m.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS
1) moorings of vessels who operate on the meadow must be minimized or substituted or supported by moorings on mooring posts; 2) Transplanting of *Posidonia* rhizomes in a neighboring area not affected by the project, according to ISPRA (Italian Institute for Environmental Protection and Research) guidelines.

ECOSYSTEM SERVICES (ES)				
References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
yes	no	none	yes	Surface of ecosystems

Assessment of the Impact on ES (yes, no)
no

CASE STUDY (n.)	TITLE	PROPOSER
13	Offshore Wind Farm Brindisi	TG Energie Rinnovabili s.r.l.

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Environmental Impact Assessment and Appropriate Assessment	2434	2013	suspended	-

TYPE OF WORK AND DESCRIPTION OF IMPACT

The project involves the construction of a wind energy plant, made up of da 36 wind turbines at sea, and the necessary work for the connection to the NETS. The ducting connecting the wind farm to the existing power line is made up in part by underwater cables and also in part by underground cables. Direct interference with *Posidonia oceanica* meadows and the Coralligenous habitat, due to the setup of the wind turbines and the cables and to large amounts of sand being lifted, which result in the 'suffocation' of meadows.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS

In the areas where *Posidonia* and/or *Cymodocea* are present, marine cables will be usually set down on the bottom, and tied with fixing elements.

ECOSYSTEM SERVICES (ES)

References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
yes	no	none	yes	Surface of ecosystems

Assessment of the Impact on ES (yes, no)
no

CASE STUDY (n.)	TITLE	PROPOSER
14	Mining Site of Realmonte (AG) - Construction of an industrial unit for the production of Potassium Sulfate and Sodium Chloride recrystallized from Kainite	Italkali - Società Italiana Sali Alcalini S.p.A.

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Environmental Impact Assessment	3310 (EIS - scoping phase)	2016	concluded - Definition EIS contents (Scoping)	-

TYPE OF WORK AND DESCRIPTION OF IMPACT
The project involves the construction of a plant for the production of potassium sulfate and sodium chloride by using kainite. The installation on the seabed of the intake pipeline (seawater) and the outfall (salt solution) could directly interfere with *Cymodocea nodosa* meadows, while no interference is expected with *Posidonia oceanica* meadows (which are far away from the area of interest). During the EIS development phase, a more detailed analysis will be carried out.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS
An evaluation of the actual state and density of *Cymodocea nodosa* and *Posidonia oceanica* is required

ECOSYSTEM SERVICES (ES)				
References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
no	no	none	no	none
Assessment of the Impact on ES (yes, no)				
no				

CASE STUDY (n.)	TITLE	PROPOSER
15	LNG Regasification terminal of Rosignano Marittimo (Alteration of existing structure)	EDISON S.p.A.

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Subject to verifying if it requires an EIA and Appropriate Assessment	3225 (procedure Variant: 292)	2016-2017	concluded	positive (excluded from EIA procedure) with limitations

TYPE OF WORK AND DESCRIPTION OF IMPACT

The Decree N. DEC/VIA/1257 of 15 December 2004 gave a positive assessment of environmental compatibility with limitations as regards the project called "Rosignano Project", which entails the creation of an LNG Regasification terminal, the alteration of the existing Solvada pier, the creation of a gas pipeline for the connection to the national gas network, the decommissioning of the ethylene plant with its single containment storage tank and the creation of a new Ethylene Terminal with a double containment tank. For the purposes of adapting the project on the basis of the comments received by local Institutions during the investigation, the Edison SpA company has then prepared a new project called "Rosignano Project Variant", for which in September 2005, an EIA procedure was initiated, and which lead to a favorable outcome of environmental compatibility with limitations (Decree N. 844 of 18 November 2010). The Variant does not provide for any adjustments to the Pier's alteration work.
Lastly, the Edison S.p.A. company undertook a revision to the "Rosignano Project Variant", while the procedure for granting the Single Authorization from the Ministry of Economic Development for the previous variant was ongoing. The area of the facility and the lengthening on pilings of the existing Solvada Pier remain unchanged. Investigations have shown the presence in the area of interest of *Posidonia oceanica* meadows.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS

Replanting and monitoring of *Posidonia* specimen, in a number at least equal to the number of specimen potentially harvested during the work for the lengthening of the pier (ref. DECREE DVA-DEC-2010-0000844 of 18 November 2010)

ECOSYSTEM SERVICES (ES)

References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
no	no	none	no	none

Assessment of the Impact on ES (yes, no)
no

CASE STUDY (n.)	TITLE	PROPOSER
16	Project for the remodulation (landside areas) of the Airport Master Plan for the Palermo International Airport "Falcone Borsellino"	ENAC - Ente Nazionale per l'Aviazione Civile (National Civil Aviation Authority)

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Environmental Impact Assessment and Appropriate Assessment	1951	2012-2015	concluded	positive with limitations

TYPE OF WORK AND DESCRIPTION OF IMPACT
The remodulation of the Airport Master Plan for the Palermo International Airport "Falcone Borsellino" entails work to be carried out on airside infrastructures, landside infrastructures, technology services, networks and systems in order to meet the demands of growing air traffic, security and the standards of service of infrastructures. In particular, it is planned to create submarine pipelines for the geothermal recovery system using seawater. Direct interference with *Posidonia oceanica* meadows.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS
The proposer intends to set up the pipelines and afterwards stabilize them on the seabed using ballast, and considers the use of diffuse discharges or discharge through multiple outlets in order to avoid increasing turbulence and to reduce the impact of discharge at different temperatures on benthic communities and on *Posidonia*. The drafting of an executive project that, "Does not interfere in any way with the *Posidonia oceanica*" and the drafting of a detailed project of the intake and outfall of seawater in order to limit the impact on the environment is required.

ECOSYSTEM SERVICES (ES)				
References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
no	no	none	no	none
Assessment of the Impact on ES (yes, no)				
no				

CASE STUDY (n.)	TITLE	PROPOSER
17	Permit for liquid and gaseus hydrocarbon prospection at sea d4E.P-SA "Nora"	SARAS S.p.A.

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Subject to verifying if it requires an EIA	39	2007-2008	concluded	positive (excluded from EIA procedure) with limitations

TYPE OF WORK AND DESCRIPTION OF IMPACT
Prospection basically entails a detailed seismic survey and its interpretation aimed at detecting structures of mining interest. Investigations will be carried out using a seismic vessel that will keep a cruising speed of approximately 4.5-5 knots. Direct interference with *Posidonia oceanica* meadows.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS
The survey area must be reduced, since search operations can only be carried out between the bathymetric range of 40 e 200 m.

ECOSYSTEM SERVICES (ES)				
References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
yes	no	none	no	none
Assessment of the Impact on ES (yes, no)				
no				

CASE STUDY (n.)	TITLE	PROPOSER
18	Prospecting Permit d148 D.R. C.S.	Apennine Energy Srl - Gr. Consul Oil & gas Ltd

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Environmental Impact Assessment and Appropriate Assessment	2082	2012-2014	dismissed (the Proposer withdrew the EIA application)	-

TYPE OF WORK AND DESCRIPTION OF IMPACT
The project involves the creation of seismic lines, the acquisition of a number of existing seismic lines in the area, and the perforation of an exploratory well depending on the result of the seismic survey. The existence of a number of areas characterized by the presence of *Posidonia oceanica* and *Cymodocea nodosa* in the vicinity of the project area is likely.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS
-

ECOSYSTEM SERVICES (ES)				
References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
no	no	none	no	none
Assessment of the Impact on ES (yes, no)				
no				

CASE STUDY (n.)	TITLE	PROPOSER
19	Prospecting Permit for exploration of liquid and gaseus hydrocarbons at sea called d5E.P.-SA "Eleonora Mare"	SARAS S.p.A.

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Subject to verifying if it requires an EIA	36	2007-2008	concluded	positive (excluded from EIA procedure) with limitations

TYPE OF WORK AND DESCRIPTION OF IMPACT
Prospection basically entails a detailed seismic survey and its interpretation aimed at detecting structures of mining interest. Investigations will be carried out using a seismic vessel that will keep a cruising speed of approximately 4.5-5 knots. Direct interference with *Posidonia oceanica* meadows.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS
The survey area must be reduced, since search operations can only be carried out between the bathymetric range of 40 e 200 m.

ECOSYSTEM SERVICES (ES)				
References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
no	no	none	no	none
Assessment of the Impact on ES (yes, no)				
no				

CASE STUDY (n.)	TITLE	PROPOSER
20	Offshore Wind Farm, Strait of Sicily in the area of Banco di Pantelleria and Banchi Avventura	Four Wind s.r.l.

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Environmental Impact Assessment and Appropriate Assessment	560	2009-2015	concluded	negative

TYPE OF WORK AND DESCRIPTION OF IMPACT

The project involves the construction of a wind energy plant, made up of da 36 wind turbines at sea off the South-Western Sicilian coast and the Island of Pantelleria, of a submarine cable system, and an underground one. The Proposer states that direct investigations have shown no presence of *Posidonia oceanica* meadows along the entire cable route, but the Ministry, from analyzing biocoenosis mapping, found that a number of turbines are close to a patchwork of areas where *Posidonia* is present and, in any case, these same areas are crossed by cables.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS

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ECOSYSTEM SERVICES (ES)

References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
no	no	none	no	none

Assessment of the Impact on ES (yes, no)
no

CASE STUDY (n.)	TITLE	PROPOSER
21	Stable crossing of the Strait of Messina and road and railway connections on the both the Calabrese and Sicilian sides	Stretto di Messina S.p.A.

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Environmental Impact Assessment and Appropriate Assessment	1546	2011-2013	concluded	Environmental compatibility of variants could not be quantified

TYPE OF WORK AND DESCRIPTION OF IMPACT
Project for the creation of a stable road and railway connection between Sicily and the mainland, involving the creation of a crossing and its connections on the Sicilian and Calabrese sides. *Posidonia oceanica* meadows are detected along stretches of both the Sicilian and Calabrese coasts. However, the project does not show any relevant impact on the above-mentioned meadows.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS
-

ECOSYSTEM SERVICES (ES)				
References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
no	no	none	no	none
Assessment of the Impact on ES (yes, no)				
no				

CASE STUDY (n.)	TITLE	PROPOSER
22	Interconnecting Pipeline Greece-Italy (IGI) - Poseidon Project. Italian Section	EDISON S.p.A.

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Environmental Impact Assessment and Appropriate Assessment	283	2006-2010	concluded	positive with limitations

TYPE OF WORK AND DESCRIPTION OF IMPACT

Project for the construction of an interconnection pipeline Greece-Italy (IGI). The landing site section and the section immediately offshore from it, for a length that equals to approximately 750 mt., cut across the Site of Community Importance IT9150011 "Alimini", within which the presence of the priority habitat 1120* *Posidonia oceanica* meadows was observed.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS

The Proposer decided to modify the original project (2006) with regard to the pipeline installation technology for the shore approach section. Instead of the traditional open cut technique, the Horizontal Directional Drilling (HDD) was suggested. The position of anchors and vessels involved in the operations was studied to avoid any direct effects on the meadow. Mitigation measures to minimize the rise in turbidity connected to sediment resuspension and discharge at sea of benthic muds.

ECOSYSTEM SERVICES (ES)

References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
yes	no	none	yes	Surface of ecosystems

Assessment of the Impact on ES (yes, no)
no

CASE STUDY (n.)	TITLE	PROPOSER
23	Project for the submarine pipeline in the stretch of sea between the Fusaro Lake in the Bacoli District (NA) and Punta San Pietro in the Ischia District (NA)	Ischia gas S.r.l.

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Environmental Impact Assessment and Appropriate Assessment	1415	2006-2008	concluded	positive with limitations

TYPE OF WORK AND DESCRIPTION OF IMPACT

Project for the construction of a submarine pipeline, as a part of the natural gas distribution system to supply the Ischia and Procida Islands. The cable-laying corridor of the pipeline (and the location of the two landing sites), restricted by the routes of subsea cables for the transport of electricity at 30,000 V of ENEL, affects a meadow of phanerogams (*Posidonia oceanica, Cymodocea nodosa, Zostera noltii*) for a stretch of approximately 400-500 mt, and a total affected surface of approximately 1,600 sq. m. The proposer decided to use trenching, installation, restoration and/or compensation of the areas of *Posidonia* that have to be removed, having delivered a negative assessment of the applicability of tunneling techniques.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS

Replanting in suitable areas, not within the trenching route, of the phanerogam shoots removed before trenching (the ratio of the surface of meadow destroyed/replanted is 1:1). Dredged material must be loaded on a barge and moved away from the trench in order to avoid damaging the meadow next to the trenching area and reduce water turbidity. The material must be stored in ventilated containers to reduce decay of biotic communities. During trenching work, wastewater, which is turbid due to the trenching work itself, must be removed using air-lift pumps placed next to the trench, and then stored in tanks positioned on the pontoon. To anchor the latter, it is not allowed to use anchors or moorings in the area of the meadow or in its immediate vicinity. Monitoring of the replanted areas is expected for at least 5 years, and for at least 10 years (2 times a year) for the trenching route, for the purposes of observing the potential spontaneous colonization of the adjacent Posidonia.

ECOSYSTEM SERVICES (ES)

References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
yes	no	none	yes	Surface of ecosystems, ecological parameters expressed in numerical values

Assessment of the Impact on ES (yes, no)
no

CASE STUDY (n.)	TITLE	PROPOSER
24	Port Master Plan of the Piombino Port	Piombino Port Authority

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Environmental Impact Assessment	1645	2010-2011	concluded	positive with limitations

TYPE OF WORK AND DESCRIPTION OF IMPACT

The work planned in the Port Master Plan is likely to generate an impact on marine biotic communities within the port area following reduction of solar exposure (caused by peaks in turbidity during the summer provoked by the increase of maritime traffic and direct shading caused by vessels). The presence of *Posidonia oceanica* was detected on the seabed areas outside the area of work (outside the Battery Pier); dead matte as high as two meters covered in sediment and communities of photophilic algae, *Caulerpa racemosa* and *Caulerpa prolifera*, which are signs of degradation of *Posidonia* caused by excessive sedimentation. The seabed areas inside the area of work, facing the sediment tank, appear more degraded both for the presence of the port and industrial waste as well as the outlets of the Cornia River and the Terre Rosse Channel (presence of a sparse meadow of *Cymodocea nodosa* and *Caulerpa prolifera*). Monitoring activities have shown the presence of Posidonia at the entrance of the access channel to the port area.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS

Total transplanting of the *Posidonia oceanica* detected, of the specimen of *Pinna nobilis* potentially affected by dredging, and of about 2,000 root cuttings of *Cymodocea nodosa* in suitable areas adjacent to the port. Ecological and structural monitoring of present biotic communities, covering the entire physiographic unit of the Follonica Gulf, in the ante operam phase, in the construction phase, and for at least 4 additional years. In particular, mapping and census of the density and state of conservation of *Posidonia oceanica* meadows, in order to assess the effects of the phenomena of sediment deposition and seabed erosion. In case of changes to the state of conservation attributable to the new configuration of the Port Master Plan, the threatened Posidonia must be replanted in different areas of the Follonica Gulf, where modified hydrodynamic conditions do not have any effect.

ECOSYSTEM SERVICES (ES)

References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
no	no	none	no	Surface of ecosystems

Assessment of the Impact on ES (yes, no)
no

CASE STUDY (n.)	TITLE	PROPOSER
25	Strategic Projects for the Civitavecchia Port	Civitavecchia Port Authority

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Environmental Impact Assessment	2642	2013-2015	concluded	positive

TYPE OF WORK AND DESCRIPTION OF IMPACT

The project entails the expansion of the Civitavecchia Port through different types of work and, in particular, within the Lot I Strategic Projects, through the construction of a Ferry Basin and a Service Dock, the lengthening of the C. Colombo Breakwater, the construction of the Large Tanker Energy Dock (D.E.G.M. in Italian) and of the new access to the historical Basin: opening to the South.
The above-mentioned work has an effect on the SCI IT6000005 "Seabed areas between Punta S. Agostino and Punta della Mattonara" and IT6000006 "Seabed areas between Punta del Pecoraro and Capo Linaro" both direct and indirect: the projects cause the reduction of the surface of habitats 1120* and 1170, as well as the reduction of the *Pinna nobilis* population at the SCI IT6000005 due to the occupation of its Southern section, while the remaining part of the SCI does not experience effects of fragmentation or direct loss of habitats neither in the short term (during the construction phase) nor in the long term. The planned work will be carried out on the boundary of the SCI IT6000006, that therefore will not experience habitat loss or fragmentation neither in the short term (during the construction phase) nor in the long term.
In any case, interference is expected in the areas adjacent to the areas of work in both SCIs caused by sedimentation and concentration of suspended solids, especially following dredging activities.
Overall, it is estimated that the project will cause a loss of *Posidonia oceanica* meadows measurable between 0.84 and 4.17 ha.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS

Proposable mitigations concern only indirect impacts, since it is in no way possible to mitigate direct ones. Such mitigations must be primarily linked to dredging technologies, aimed at avoiding excessive and persistent water turbidity, as well as the use of experimental movable barriers suitable for limiting the dispersion of suspended material. The timing of work and the marine weather forecast must also be taken into account. Monitoring activities are expected to be intensified, to cover the entire area of interest of the two SCIs IT6000005 and IT6000006, with regard to the two main habitats (1120* and 1170).
With the EIA Decree 6923/2002 and, following, the CIPE Decision n. 103 of 20.12.2004 the compensation measure that was chosen was the removal and subsequent replanting of *Posidonia oceanica* root cuttings, for a total surface that equals to 2 ha; measure which has then been implemented.
At a later time, the European Commission has requested to proceed to a new Appropriate Assessment (AA) concerning the projects "Large Tanker Energy Dock", "Strategic Projects" and "Port Master Plan of Civitavecchia" as well as to proceed with the development of new and more suitable compensation measures, considering the adopted ones "entirely inadequate". The Services appointed by the European Commission have agreed with the National Authorities upon the inclusion of approximately 222 hectares of priority habitat1120* within the national Natura 2000 network, the new boundaries of the SCI IT6000005, and its designation as a Special Area of Conservation, thus providing it with appropriate conservation objectives and measures.
The set up 50 mooring buoys for mooring diving and recreation vessels is also expected, in order to limit the damage causes by anchors, as well as the placement of 100 tetrapods to fight illegal fishing on the meadow.

ECOSYSTEM SERVICES (ES)

References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by*	*Parameters for the Qualitative Assessment of ES*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in*

		the author, TEEB, CICES, other)	*(yes/no)*	*Euros, ecological parameters expressed in numerical values, etc.)*
yes	yes	none	yes	Surface of ecosystems, ecological parameters expressed in numerical values
Assessment of the Impact on ES (yes, no)				
no				

CASE STUDY (n.)	TITLE	PROPOSER
26	Variant of the Port Master Plan (year 2004) of the Civitavecchia Port (RM)	Civitavecchia Port Authority

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Environmental Impact Assessment	273	2005-2010	concluded	positive

TYPE OF WORK AND DESCRIPTION OF IMPACT

The plan presents the construction of the new Commercial Terminal, centrally located in regard to the new configuration of the port. Furthermore, it identifies two areas to be allocated for industrial activities; the first one dedicated to ENEL, the second one to shipbuilding. The planned historic basin will be dedicated to recreational boating. The Mattonara Dock will be home to Port Services. The Terminal dedicated to passengers – cruises – will in part occupy the Cristoforo Colombo Breakwater, in part the extension that will be constructed to replace the Petroli, Albicini and Vespucci Docks. It is estimated that between 4.8 ha and 9.6 ha of *Posidonia O.* meadows, assuming a coverage of15% and 30% respectively, will irretrievably be lost. The same is true for the ones on the mixed seabed in the Southern area, where dredging activities will take place and maritime structures will be built.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS

The main mitigation strategy is to adopt dredging and backfilling techniques that, even in the presence of favorable natural conditions, such as a small dynamic range, thus apt at maintaining pelites and potential pollutants suspended, typically generate small amounts of turbidity.

ECOSYSTEM SERVICES (ES)

References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
no	no	none	no	none

Assessment of the Impact on ES (yes, no)

no

CASE STUDY (n.)	TITLE	PROPOSER
27	Taranto Port - Redevelopment of the Polisettoriale Pier - New Outer Breakwater for the protection of the Port outside the Taranto roadstead - West Section	Port Authority of Taranto

PROCEDURE				
Type	*ID_VIP MATTM*	*Duration*	*State*	*Result*
Environmental Impact Assessment	2714	2014-2015	concluded	positive

TYPE OF WORK AND DESCRIPTION OF IMPACT

Among the 20 June 2012 projects provided for in the "Agreement for the Development of Container Traffic in the Taranto Port and Overcoming the Socio-Economic State of Emergency" is the new Outer Breakwater for the protection of the Polisettoriale Pier, for which "the construction must be programmed in functional lots". The first lot, subject of the Environmental Impact Assessment, has a length of 500 mt. and ensures adequate protection of the Container Terminal Dock of the Polisettoriale Pier. Close to the area of work, near the S. Pietro Island, is located a Posidonia O. meadow., for which the project is expected to have potential negative impacts in the construction phase, due to sediment resuspension.

MITIGATION / COMPENSATION MEASURES - LIMITATIONS

During seabed remediation, 'technical' dredging, the installation of natural and artificial boulders, in order to reduce turbidity, barriers made up of geo-textile screens, or containment sheets to surround the area of work and confine suspended sediments and avoid their dispersion so far as possible, shall be used.

ECOSYSTEM SERVICES (ES)

References (yes/no)	*Use of the term ES (yes/no)*	*Type of ES classification (none, proposed by the author, TEEB, CICES, other)*	*Parameters for the Qualitative Assessment of ES (yes/no)*	*Parameters for the Quantitative Assessment of ES (surface of ecosystems, economic value in Euros, ecological parameters expressed in numerical values, etc.)*
no	no	none	no	none

Valutazione dell'impatto sui SE (sì, no)
no