Marine Ecosystem Services in Europe

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The concept of ecosystem services (ES) refers to the multiple benefits humans gain from maintaining ecosystem health and functions. This notion has theoretical and practical implications because it frames scientific findings into economic terms to raise awareness of the value of functional ecosystems. It follows that environmental management that incorporates the ecosystem service approach is economically efficient and sustainable. The ES approach is particularly useful for coastal and marine ecosystems because they traditionally lack spatial planning and protective regulation. Moreover, the concept of ecosystem services emphasizes the ocean's function as a climate regulator, and its crucial role for mitigation and adaptation to climate change. Regional implementation of integrated management already exists in the European Union. The next step now is to apply the ES approach to other, threatened regions such as the Mediterranean in order to ensure ecosystem resilience and service provision.

INTRODUCTION

The term "ecosystem services" emerged in the 1970s to raise public awareness of biodiversity conservation. It is a utilitarian concept which frames ecosystem functions as goods and services for the human population. The Convention on Biological Diversity (1992) defines ecosystems as "*a dynamic complex of plant, animal, and micro-organism communities and the non-living environment, interacting as a functional unit*". Ecosystems are therefore composed of animals, plants, minerals and humans living together in a shared space. Interactions within the ecosystem can produce various important services for human societies. These services can be linked to the exploitation of natural resources (*e.g.* timber, fish), the regulation of the environment (*e.g.* water quality, pollination), and cultural services (*e.g.* recreation, natural patrimony). However, many human lifestyles create significant pressures on their ecosystems' natural capital (*i.e.* resources) and functions. As a result, human activities such as overfishing, oil drilling, waste disposal and shipping impact ecosystems' ability to provide services both directly and indirectly (Costanza *et al.*, 2014). The concept of ES has been developed to assess how man-made pressures affect ecosystem health and service provision.

The ES approach aims at evaluating these strains by integrating ecology and economics. It identifies ecological functions and translates them into economic units. As an ecosystem functions using its natural resources, it produces goods and services that increase human wellbeing (Van den Belt *et al.*, 2016). For instance, one coastal ecosystem has a set amount of natural capital in the form of mangroves. Mangroves serve as habitat for fish, especially nurseries for juveniles (Chumra *et al.*, 2003). By protecting juvenile fish, mangroves maintain and even increase the quantity of available fish in local fisheries (Aburto-Oropeza *et al.*, 2008). Hence this ecosystem provides a valuable service, *i.e.* supplying food and livelihoods. The same territory often provides additional services. Mangroves are among the most biochemically active natural systems in the world, and are consequently important carbon sinks (Chumra *et al.*, 2003; Barbier *et al.*, 2011). Moreover, mangroves' intricate root systems mitigate coastal erosion (Wolanski, 2007). Therefore the concept of

ecosystem services examines how people depend on ecosystems, what benefits ecosystems provide in a utilitarian sense, and how to better manage and protect ecosystems for the benefit of both nature and people.

AN ANTHROPOCENTRIC CONCEPT

The concept of ES is essentially human-centered. Ecosystem functions are only considered to be services if they improve the life of humans. There have been several attempts to classify the different kinds of services ecosystems supply. One common typology is the Millennium Ecosystem Assessment (Millenium Ecosystem Assessment, 2005). This framework divides ES into four groups. Other categorizations such as The Economics of Ecosystems and Biodiversity (TEEB, 2010) use similar groupings. Typologies commonly find that coastal and marine ecosystems provide:

- Provisioning services: fisheries, bioprospecting, building materials;
- Supporting services: life-cycle maintenance for both fauna and flora, primary and secondary production, nutrient cycling;
- Regulating services: carbon sequestration and storage, erosion prevention, waste-water treatment, moderation of extreme events;
- Cultural services: touristic, recreational, aesthetic and spiritual benefits.

The ocean – from the coast down to the deep sea – covers the majority of the planet and provides a host of services, both extractive and non-extractive, to society. In many cases, non-extractive benefits are not considered during the decision-making process although they may be significant (*e.g.* the ocean absorbs approximately one third of emitted carbon dioxide (IPCC, 2014)). Marine ES are generally taken for granted. Fish are expected to live in the sea, boats to be navigating on it, and tourists to freely walk on the beach. Because these services are considered a given, they are rarely accounted for when making planning or investment decisions. The ES approach aims to highlight the hidden benefits humans gain from their ecosystem, for instance by giving services a monetary value (TEEB, 2010). It is difficult to value the flow of coastal and marine ecosystem services and goods because the same ecosystem can have a local, regional, or global impact, and gathering

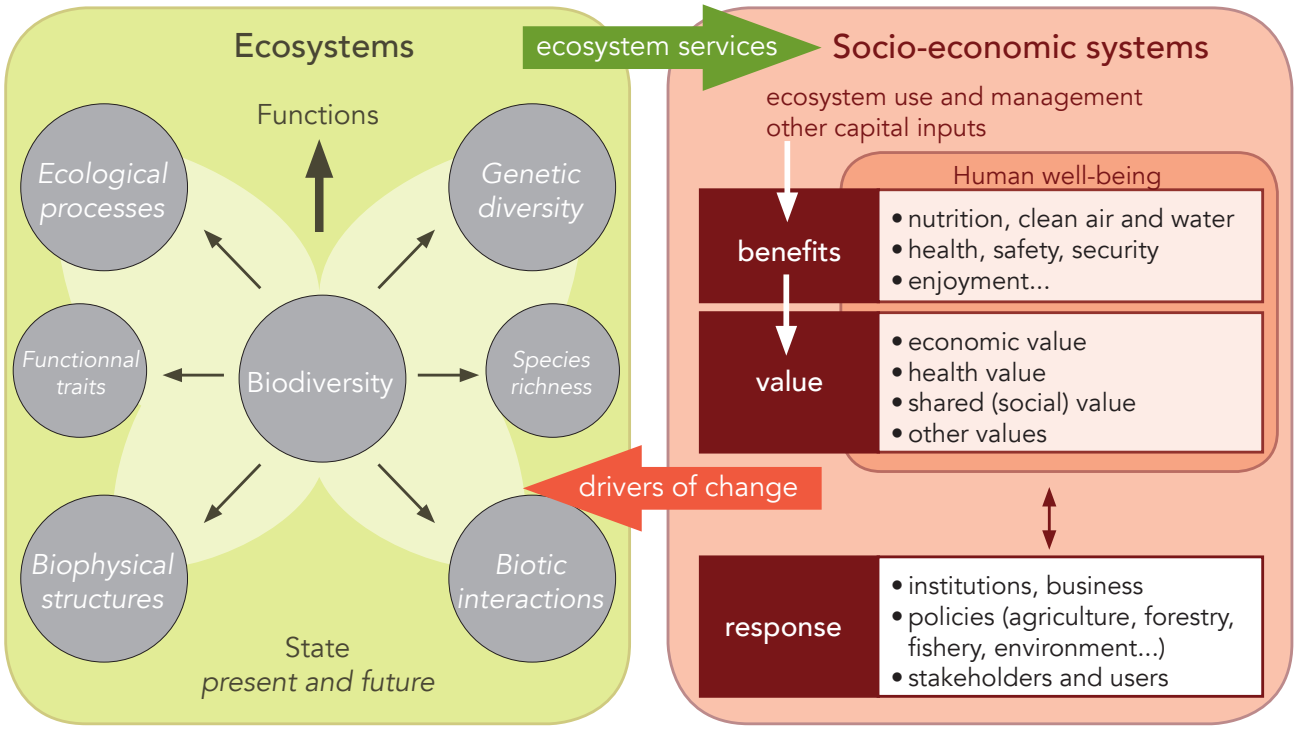

Fig.1 – Conceptual framework for EU wide ecosystem assessments. © biodiversity.europa.eu/maes.

sufficiently precise data is tedious (Pendleton, 2016). Nevertheless, extensive studies conclude that the global value of marine and coastal ecosystem services amounted to 20.9 trillion US dollars in 2011 (Costanza *et al.*, 2014). In spite of great biodiversity loss, *e.g.* the deterioration of coral reefs, ecosystem services are more greatly valued today than twenty years ago thanks to greater research in the field.

MARINE ECOSYSTEM SERVICES AND CLIMATE CHANGE

More data has shown that several ecosystem services are directly related to climate change policy, either for mitigation or adaptation. First and foremost, several coastal and marine ecosystems are important for carbon sequestration. The potential of coastal ecosystems such as mangroves seagrasses and marshes, to store and retain carbon is non-negligible. The destruction of these ecosystems is estimated to cost $USD 6-42 billion annually in economic damages (Pendleton *et al.*, 2012). Current projects are attempting to assess if these ecosystems may be covered by REDD+ (Reducing Emissions from Deforestation and Forest Degradation) mechanisms in the future (Herr *et al.*).

In terms of adaptation, coastal and marine ecosystems sustain the livelihoods of millions of people worldwide through fisheries and tourism (Allison *et al.*, 2016). Mangroves and coral reefs provide coastal protection to nearby coastal towns and cities, an increasingly important service due to sea-level rise and the change in cyclone patterns (Das and Vincent 2009; Gedan *et al.*, 2010; Pramova *et al.*, 2012). Seagrasses and oyster beds may also provide coastal protection (Swann, 2008).

It is possible that the adverse effects of climate change (*i.e.* increasing sea temperature, ocean acidification, deoxygenation, sea-level rise, extreme weather events) will modify or impair the provision of coastal and marine ecosystem goods and services in the future (Craft *et al.*, 2009). Assessing current provisions of ecosystem services from coastal and marine ecosystems is therefore important to understand future trade-offs and opportunities to tackle global issues such as climate change.

MANAGING ECOSYSTEM SERVICES IN A MARINE ENVIRONMENT

The concept of ecosystem services originated from terrestrial systems and has since been applied to the coastal and marine realm, without taking into account the marine environment's unique challenges. The ocean has more fluid boundaries relative to terrestrial systems, which makes it difficult to map the flow of services without more scientific data (Jobstvogt *et al.*, 2014). Marine spatial planning is therefore less developed and has now only emerged recently as a mainstream political issue. The ocean is also tightly linked to the atmosphere (and sometimes land), which can change its chemistry and mixing (Screen and Francis, 2016). These complex and interconnected relationships can make it difficult to effectively manage coastal and marine systems and may require innovative strategies to address.

Moreover, implementing regulation is often complicated by questions of jurisdictions. States have jurisdiction over their Exclusive Economic Zone (EEZ), which is usually limited to 200 nautical miles from the coastline or may at the maximum extend to the end of the continental shelf. This breakdown means that a considerable part of the ocean is not subject to State regulation. To effectively protect marine ecosystems, the United Nations Convention on the Law of the Sea (UNCLOS, 1982) defines the rights and responsibilities that members have to the global ocean. The agreement also established other governing bodies, such as the International Seabed Authority (ISA) which governs the international seafloor and its resources. But the question of managing areas beyond national jurisdictions such as the water column and the seabed still remains. Collaborative action among States is often the only way to create a legal framework for protecting ecosystems.

Human societies have every reason to adopt a protective and sustainable development approach to their coastal and marine ecosystems. Although the translation between ecological processes and ecosystem services is still unclear in many cases,

biodiversity is often at the core of service provision (Palumbi *et al.* 2008, Cardinale *et al.*, 2012) as well as resilience and the ability to recover from impacts (Worm *et al.*, 2006; Lindegren *et al.*, 2016). Healthy ecosystems can provide greater benefits (both monetary and non-monetary) relative to disturbed or degraded ones. Integrating the concept of ecosystem services into existing management tools, such as marine spatial planning and ecosystem-based management, becomes increasingly important as the human footprint on the ocean continues to grow (Böhnke-Henrichs *et al.*, 2013). The deep sea in particular is becoming more and more affected by human activity (Le and Sato, 2016; Ramirez-Llodra *et al.*, 2011). Fishing for instance increasingly impacts deep-sea ecosystems as fisheries are moving deeper into the water column due to warming waters. Fossil fuel companies too are showing greater interest in deep-sea mineral and oil resources, as submerged deposits are gradually running out.

A USEFUL TOOL FOR SUSTAINABLE MANAGEMENT OF MARINE AND COASTAL ECOSYSTEMS

Current programs to assess marine and coastal ecosystem services are already in place internationally, at the global, national and local scales. These assessments serve three purposes: first to systematically assess the benefits in terms of goods and services that the ocean or specific ocean and coastal ecosystems provide; to gather information to improve management and marine planning, and lastly to communicate the value of the ocean. Systematic assessments, like the French national project "Évaluation Française des Écosystèmes et Services Écosystémiques", identify trade-offs and opportunities to better manage biodiversity (EFESE, 2016). Other types of ES assessments can be used to improve marine planning and management at more local scales. The VALMER project for example attempted to assess ecosystem services in the

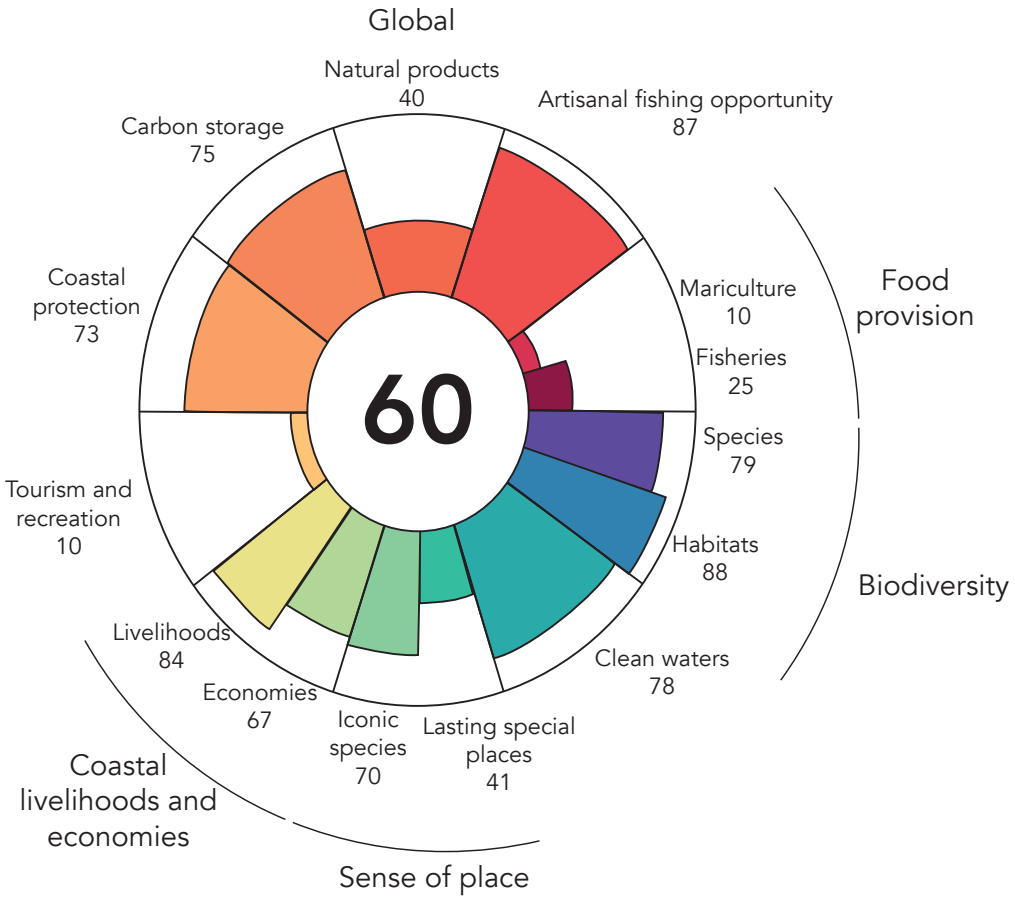

Fig.2 – Indicators of the OHI Index. © Halpern *et al.*, 2012 With permission.

English Channel to inform management and planning (VALMER, 2016). Ecosystem services assessments can also be used for communication purposes on the role of coastal and marine environments. One often cited example is the value of sharks in Palau, that is estimated at $1.9 million when alive, 16.6 times more than the value of shark fin. In addition, a recent comprehensive study by WWF (Ocean Wealth Report, 2015) aims at advertising the tremendous value of the marine environment. But these evaluations are often conducted during State-specific assessments, which makes it difficult to compare the results with foreign assessments and agree on the state of biodiversity in transnational ecosystems.

Since 2012, a new indicator has been developed to remediate this situation. The Ocean Health Index (OHI) compiles data from all over the world and assesses the health of States' sea waters within their Exclusive Economic Zone (Halpern *et al.*, 2012). The OHI rates countries based on a variety of indicators to identify key points of pressure, improvement and strength. This innovative index is a standardized and transparent measure which incorporates competing public goals (exploitative and preservationist uses of ocean resources). It is meant "*to be used by scientists, managers, policy makers and the public*" to evaluate and communicate about results of integrated management policies (Halpern *et al.*, 2012). The OHI could be particularly useful to promote collaboration between States and assess trends in marine ecosystem health globally, as well as inform decison makers at the national level.

INTEGRATING THE CONCEPT OF ECOSYSTEM SERVICES INTO POLICYMAKING AND POLICY DESIGN: THE EUROPEAN UNION'S COLLABORATIVE APPROACH

Integrated policies, which take into account the ecosystem service approach, are already being put into practice within the European Union (EU). Since June 17, 2008, all EU Member States must abide by the Marine Strategy Framework Directive (MSFD 2008/56/CE), which commits in its article 1.3 to applying an ecosystem-based approach to enable the "*sustainable use of marine goods and services*" (Europa, 2016). The directive aims at achieving Good Environmental Status (GSE) for all marine waters by 2020. GSE is assessed using 11 qualitative criteria, which evaluate an ecosystem's ability to function properly and sustainably (MEEM, 2013). The MSFD follows the ecosystem service approach thanks to integrated management: marine ecosystems are protected with the aim of safeguarding ecological functions. In France for instance, maritime zones are divided in many subregions, which reflect large ecosystems and administrative boundaries. Each subregion elaborates and implements a Marine Environment Action Plan (MEAP) (Ministère de l'Ecologie, 2011). Every stakeholder – elected officials, scientists, and fishermen among others – is invited to conciliation meetings, and public consultations are organized to analyze the situation in terms of physical, biological, economic, and social characteristics, as well as man-made pressures on the environment and policy objectives (Direction Interrégionale de la Mer, 2015). At the EU level, there are several working groups in charge of coordinating national policies to ensure that all EU waters are equally protected throughout the European Union. Moreover, the ES approach of the directive aims at making neighboring States collaborate and take action together to protect common ecosystems in an attempt to ensure that they will work properly and provide us with services.

A SUCCESSFUL EXAMPLE OF INTEGRATED MANAGEMENT IN THE MEDITERRANEAN: POSIDONIA MEADOWS

Posidonia meadows (*posidonia oceanica*) are underwater flowering plants, which grow slowly – 1 m in 100 years-on the Mediterranean coasts (Boudouresque *et al.*, 2010). They are endemic to the Mediterranean Sea and play an essential role in marine biodiversity. Up to 50 endemic species, *i.e.* species that can only grow in a certain habitat, dwell there (Campagne *et al.*, 2015). These meadows have various ecological functions: they

constitute an important food source for species like urchins or wrasses; many fish come there to reproduce and to establish nurseries for their offspring, giving them a protected place to develop into adult fish. Moreover, thanks to their rhizomes and roots, posidonia meadows hold sediments on friable soil, thus effectively protecting the coastline against erosion caused by weather events, such as storms. Similarly, dead posidonia leaves help protect beaches by preventing currents and winds from taking sand away during storms. Furthermore, seagrass meadows are recreational hotspots for human activities such as snorkeling and diving, while also supporting traditional fishing, and mitigating climate change by sequestering carbon.

However, posidonia meadows are vulnerable to high human disturbance: boat anchors wrench them out, coastal urbanization, greater infrastructure – ports, levees – all destroy these habitats (Telesca *et al.*, 2015). Fewer Posidiona plants means less protection against erosion, both along the coastline and on the beach (Vassalolo *et al.*, 2013). Moreover, habitat destruction and deterioration has adverse impacts on marine species housed by the seagrass beds, which leads to biodiversity loss as species leave or disappear. This in turn results in less fish in the area, so fishermen suffer, along with recreational activities that lose their attractiveness.

CONCLUSION

The concept of ecosystem services is an anthropocentric notion, which aims at highlighting the benefits humans receive from living in fully functioning ecosystems. Economic valuation of such services becomes the yardstick for all stakeholders to collaboratively decide on the best policies to protect and sustainably use multiple ecosystems. The ecosystem service approach is particularly useful to manage coastal and marine ecosystems, which are tremendously valuable, especially with regards to climate change. The concept is needed to promote integrated management of natural resources. As ecosystems know no borders, the notion of ecosystem services is helpful for States to collaborate on protecting and using common resources sustainably in order to keep benefiting from ecosystems. Because a damaged ecosystem will produce less services, the total costs associated with non-integrated management will be higher than with using the ecosystem service approach. Therefore, taking advantage of the ecosystem service approach is ecologically and economically smart, as it substantially saves money while encouraging sustainable management and the reaping of greater coastal and marine ecosystem benefits in the long term.

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