Forget about carbon – let’s go on holiday!

Using tourist values to conserve seagrass meadows

Shrina Kurani

Master Thesis Series in Environmental Studies and Sustainability Science,
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A thesis submitted in partial fulfillment of the requirements of Lund University International Master’s Programme in Environmental Studies and Sustainability Science (30hp/credits)

LUCSUS
Lund University Centre for
Sustainability Studies

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Submitted May 13, 2015

Supervisor: Kimberly Nicholas, LUCSUS, Lund University

Abstract:

Seagrass meadows are a vital part of the marine ecosystem surrounding the island of Mallorca, but human-induced pressures are degrading the seagrass meadows' stock of natural capital. Although researchers are working together with policymakers to implement and improve conservation measures, the current legal framework is not sufficient to protect the meadows from further depletion. Therefore, I use the economic clout of the tourism industry to give weight to tourist preferences, and use tourism to support the valuation of ecosystem services provided by seagrass meadows.

With the support of data from 73 tourist surveys, I first valued tourist benefits from the ecosystem services provided by the marine environment, finding the top five tourist valued benefits from seagrasses were clear ocean water, sandy beaches, natural setting, time with family or friends, and swimming. These five seagrass benefits are also the ones the majority of tourists would not return to Mallorca without, even though the tourist awareness of seagrass meadows existence is less than 11%. I (2) monetized the benefits by projecting the potential losses if the tourists did not return due to the disappearance of the meadows and their corresponding services, calculating up to 6.49 billion EUR per year in losses. As the tourism sector is the largest contributor to the Mallorcan GDP, a strong relationship between tourists and the meadows reinforces the incentive for seagrass conservation. (3) I framed the decline of seagrass meadows with DPSIR to provide a human context in order to identify and develop responses such as raising awareness of the bigger picture for urban sewage and a boaters' code of conduct for unregulated boat anchoring. Based on the lack of ecosystem-based management, this study then (4) demonstrates how free mapping and visualization softwares such as Google Earth and Google SketchUp are an accessible interface to help scientists communicate their findings to policymakers. The economic value of tourism should motivate policymakers to further their understanding of the marine ecosystem and its benefits, and strategically implement activities for its conservation.

Keywords: Ecosystem services, economic valuation, seagrass, science communication

Word count (thesis): 13995

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1 Introduction

Conserving ecosystems is a climate change mitigation double-whammy: we need to mitigate climate change in order to conserve our ecosystems and continue with life as we know it, and we need to conserve our ecosystems in order to help mitigate climate change. In more sophisticated terminology, the relationship is a reinforcing feedback loop. We can either retire into a downward spiral by neglecting both factors, or regain control of our climactic and environmental conditions by supporting both. Although the relationship has been simplified in this context, the connections in fact are on multiple levels and scales. This complexity further entangles human impact, as it demands a full and thorough assessment of response mechanisms; even with legal frameworks enforcing bans on unsustainable local behavior, without global agreements for reducing carbon emissions the ecosystems will still decline at a rapid rate.

In order to design an effective strategy to support both ecosystem conservation and climate change mitigation, we need to better understand the relationship between ecosystems and humans, and that's where ecosystem services comes in. The concept of ecosystem services allows us to operationalize our natural environment, and actually convert it into services and benefits. The concept in itself shines a light on a sampler platter of what nature has to offer, which makes the services more apparent to decision makers (Luisetti, Jackson, & Turner, 2013). The theory is not without its share of ambiguity and controversy, but an advantage to using the ecosystem services framework is its salience, and salience is integral for sustainable development (Cash et al., 2003). The application of ecosystem services helps pertinent stakeholders realize that they are indeed stakeholders, and that an environmental issue goes beyond ecology – it affects society and the economy as well. It attaches conceivable values to the natural world we take for granted, and helps us understand the relationship and define the exchange that occurs continuously.

My thesis explores the ecosystem services provided by seagrass meadows – *Posidonia oceanica* – on the island of Mallorca, Spain, and how tourism can translate the services to economic values. The meadows are an integral part of the greater marine ecosystem, and while serving as an underwater carbon sink, they also perform behind-the-scenes work to maintain the image of Mallorca as an idyllic tourist destination. Seagrases are impacted by both global and local pressures, with scientists projecting a rapid decline (Jordá, Marbá, &

Duarte, 2012). I aim to use the economic significance of Mallorca as a tourist destination to motivate the valuation of the tourist perception of seagrass meadows' ecosystem services, thus backing their conservation. The final and actionable part of my thesis entails recommending responses and the *communication* of both these recommended responses and ecosystem science information in general. Salience is a core aspect of the ecosystem services framework, and I intend to also make it a resounding theme of my thesis. Figure 1 illustrates the key points and actors my thesis focuses on.

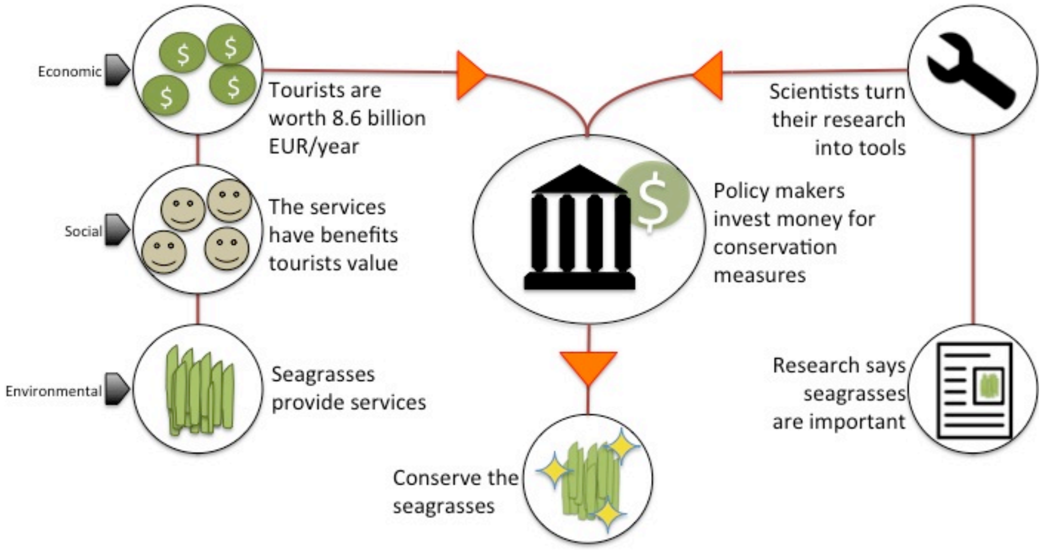


Figure 1: The logic behind my motivation for conserving the seagrasses is illustrated. The left path ties together the environmental, social, and economic systems, respectively with the seagrasses providing ecosystem services, tourist values of the benefits, and tourist worth (Balears, 2014a). The right path supports conservation through research, and making the research available and actionable. The government will be influenced by the path on the left and aided by the path on the right to ultimately conserve the seagrasses. Source: own illustration with icons from the Noun Project: Paper image created by Zach VanDeHey and Tool image by Erin Standley.

In order to weave a red thread from the ecosystem services provided by the marine ecosystem to the holistic communication necessary for its conservation, I focused on the following research questions for the seagrasses of Mallorca:

1) *What are the most important benefits that tourists derive from seagrass ecosystem services?*
2) *What is the economic value of the key tourist benefits?*
3) *How can the best responses to seagrass decline be identified, and what are they?*
4) *How can the complexity of seagrass decline be communicated to policymakers?*

2 Research Approach and Processes

The European Union funded project OPERAs – Operational Potential of Ecosystem Research Applications – aims to establish a link between ecosystem services and practical applications. One of the six work packages that make up the research project is Work Package 2: Practice (WP2). WP2 contains 12 different exemplar case studies all over the European Union, and this thesis is supported by the exemplar based in Mallorca, Spain. The Balearic exemplar of the OPERAs project focuses on marine and coastal ecosystem management for carbon captured and stored by organisms in the sea (OPERAs, 2014).

2.1 Research Approach

As seagrasses are seen as a socio-ecological system (Cullen-Unsworth et al., 2013), I work with both the social and economic system as well as the environmental. My critical realist epistemological cloak is worn in order to broaden environmental issues past the natural sciences and into the social realm in which they are dealt with (Forsyth, 2001). I treat my data as observable inputs to analyze them, but the inputs themselves – values, whether monetary or otherwise – are socially constructed. Hence, a philosophical approach aspiring to discover real statements while simultaneously acknowledging social constructs and human ambiguity is required.

The first half of my research focuses on why the seagrasses are important, while the second half explores how to actually respond to seagrass decline. The critical realist approach allows me to not only describe and observe as I do in the first half, but also to modify and shape "more effective science for environmental policy that is both biophysically more accurate than existing conceptions, and socially more just" (Forsyth, 2001, p. 2) within the second half.

Ultimately, I aim to reform the Promethean discourse of *nature for humans* to one of *sustainable development* (Dryzek, 1997), with the hope that a change in the way we view nature triggers awareness, and promotes conservation. Therefore, scientists promoting sustainability (e.g., conservation) should present their research in a way that so policymakers (within the environmental branch) can turn the knowledge into action.

2.2 Theoretical Foundation

2.2.1 Ecosystem services

The *services* aspect of ecosystem services (ES) translates the natural functions and processes of an ecosystem into services for human well being (Fisher, Turner, & Morling, 2009). The concept of ES gained ground in the 1990s (de Groot, Wilson, & Boumans, 2002), and the Millennium Ecosystem Assessment gave it significantly more weight in the early 2000s. ES enable us to take natural processes and connect them with the human system, to understand how we interact with and benefit from ecosystems. The ecosystem processes include the biological and natural aspects of the systems, such as habitats and chemical processes (Costanza et al., 1997); ES are those that we as humans can benefit from, such as food and carbon sequestration. The ES flow from a stock of natural capital, that is to say the physical composition of the ecosystem (Costanza et al., 1997), which in this case is the stock of seagrass meadows around Mallorca. As is the issue in many interdisciplinary fields, classifying what exactly qualifies as services versus benefits or values is debated upon (de Groot et al., 2002), but the overarching concept of ES allows us to value processes otherwise ignored and unvalued (Costanza et al., 1997), and for conservation sometimes even devalued. This positive valuation helps us incorporate nature into planning and decision-making, as we can also place an economic value on the services provided (Luisetti et al., 2013).

2.2.1.1 *CICES Framework*

The European Environmental Agency (EEA, 2013) further developed the Millennium Ecosystem Assessment's framework for classifying ES (MEA, 2005) with CICES – a Common International Classification of Ecosystem Services. CICES uses the three sections of provisioning, regulation & maintenance, and cultural services, and classes are formed based on the specific outputs and/or processes (EEA, 2013). CICES has been adopted in many projects such as OPERAs (OPERAs, 2014), its sister project OpenNESS (Operationalization of Natural Capital and Ecosystem Services) (Haines-Young & Potschin, 2014), and LINKAGE (LINKing systems, perspectives and disciplines for Active biodiversity GovernancE) (LINKAGE, 2013), and serves as a standard to overcome the obstacle of classification for operationalization. CICES was applied to thematically sort the ES provided by seagrass meadows by the exemplar (N. Marbá & A. Ruiz, personal communication, March 24, 2015).

The three types of ES covered in this thesis are provisioning, regulation and maintenance, and cultural services. The provisioning services are defined as those which provide a material output, or simply put: goods (Barbier et al., 2011). Such goods include raw materials and food, and humans have learned to transform what nature provides into products for our own consumption on a higher level – both systemically and in terms of quantity (de Groot et al., 2002). The regulation and maintenance services are not as associated with goods as with the processes the ecosystem performs, often encompassing the more obvious environmental and ecological functions of the ecosystem. The natural processes that support Earth's systems include nutrient cycling and climate regulation, and without such processes life on earth would not exist as we know it (de Groot et al., 2002). Cultural services, on the other hand, are much more difficult to define and therefore even more subject to ambiguity and undervaluation (Hernández-Morcillo, Plieninger, & Bieling, 2013). Some papers in the early 2000's do not even include the term "cultural ecosystem service", although the services themselves were still individually identified; de Groot et al. (2002) explains cultural, spiritual, and recreational services among a throng of others, and these services were further solidified into a formal framework with the publishing of the Millennium Ecosystem Assessment (MEA, 2005). The cultural enrichment inherent in socio-ecological systems provides benefits to individuals, communities, and the global society as a whole through varying means – from an appreciation of the existence of nature to its recreational value (Plieninger et al., 2015).

2.2.1.2 *Deriving benefits and values from services*

The issue of decreasing stocks in natural capital is an issue for the environmentalist, but is also relevant for the economic and social well being for the people residing on Mallorca. The cascade model (Figure 2) provides a frame to translate the final services from the environmental sphere to the social and economic system (Potschin, Haines-Young, Saarikoski, & Jax, 2014). This model was used to add on the next step to the CICES framework by abstracting the concept to a general level of ecosystem services, and continuing to transcend the environmental border to help understand the impact on the social and economic system.

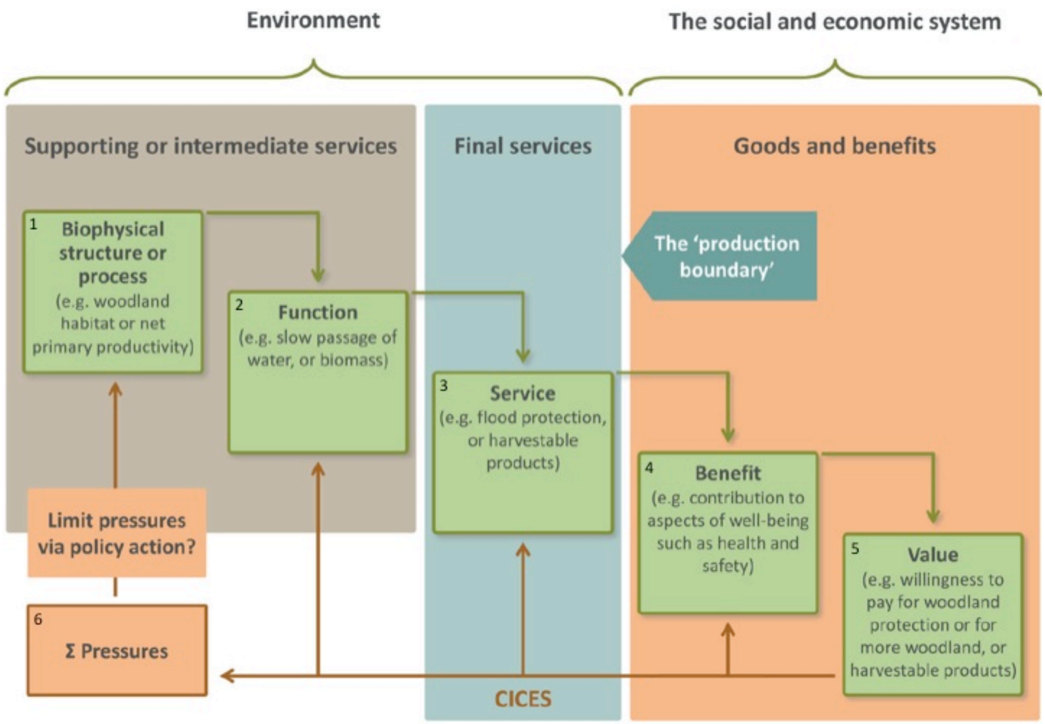


Figure 2: The cascade model incorporates the CICES framework, with the first three elements encased in the environmental system while the last two enter into the social and economic system. The CICES cascade modified from Potschin and Haines-Young (2011) bridges the natural and human systems to further understand the complex relationship. Source: Potschin et al. (2014)

I further modified the model to define and emphasize the links I find important. Firstly, I prefer the term "natural capital" to "biophysical structure or process" as I believe it fits more in the spectrum of economic terminology, considering that the model attempts to convert natural processes to a social and economic context. I also increased the emphasis of the flow from one element to the next, to increase resemblance to a causal loop diagram. I wanted to underscore the services the environment provides as well as the pressures the human system applies back onto the environment, for the purpose of highlighting our position and responsibility to act. While the concepts remain the same, Figure 3 illustrates my understanding of the cascade model, and the conceptual basis of ecosystem services for this thesis.

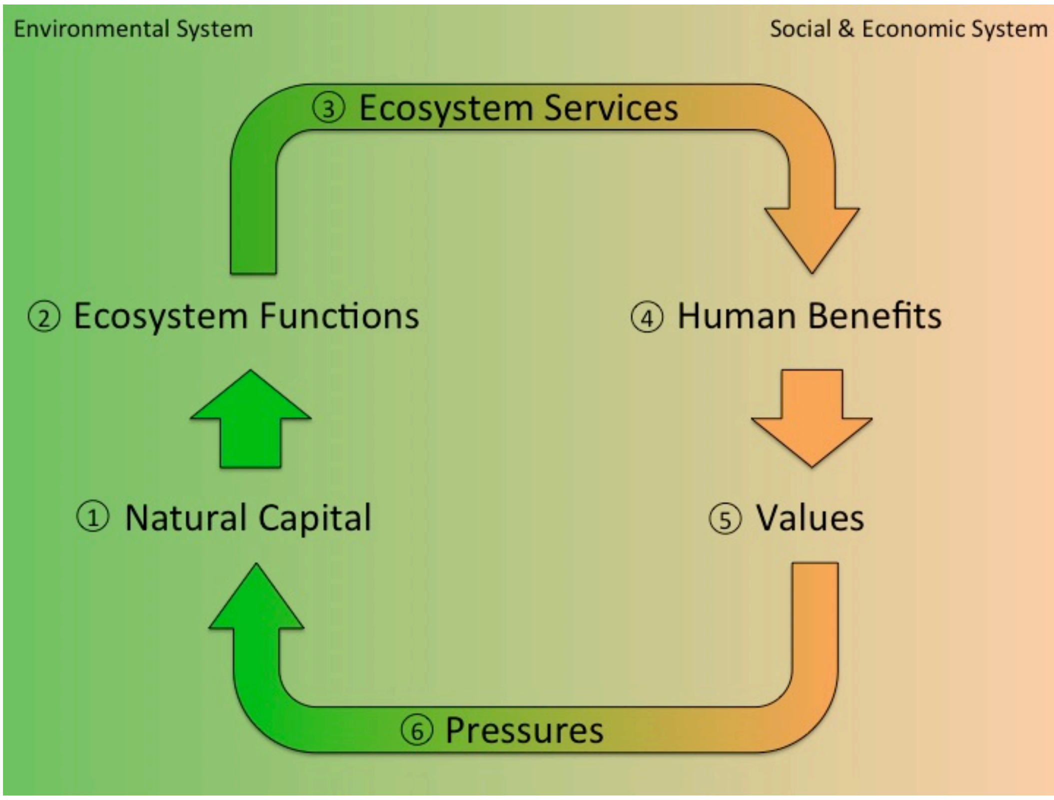


Figure 3: The cascade model, adapted from (Potschin et al., 2014), translates elements in the environmental system to the social and economic system. The environmental system is in green, and the social and economic system in orange. Starting with (1) Natural Capital in the Environmental System, the ecosystem functions are the biophysical processes nature undergoes without human interference. The (2) ecosystem services are what we perceive as nature's services to humans, which can be translated into (3) human benefits. Humans (4) value the Benefits – whether monetarily or socially. The (6) Pressures from the social system are applied back on the Natural Capital. The Ecosystem Services and Pressures are the bridges between the two systems, illustrated by the arrows and the gradient color change.

The final ES are those derived from the ecological processes and functions and put into a human context, as described in the beginning of Section 2.2.1. These services would exist regardless of our classification, but the ES lens helps us understand how we are indeed on the receiving end of a flow of services from nature. The next step from ES flow is how we as humans benefit (Potschin et al., 2014). The benefits can be interpreted as how humans experience and extract use from the environmental services (Haines-Young & Potschin, 2014). Especially for cultural ES, the benefits can be easier to define than the services themselves; recreational activities such as swimming or diving in the ocean are definite benefits, but can be difficult to attribute to a specific service the sea provides.

The issue with deriving benefits from ES lies primarily with the ambiguity in terminology. A review of literature does not provide a clear distinction between the services, benefits, and values that I use in this paper, particularly between the former two and latter two. Cultural

ES in themselves are not clear and distinct, and then taking the next step in derivation only increases the chances of confusion or error. However, this only highlights the need for further exploration of ES and their connection to society. Returning to the next step of the cascade, the term "benefits" is used in plenty, but not consistently in literature. Turner et al. (2003) for example used "benefits" interchangeably with the monetary benefit in a cost-benefit analysis and even with what would otherwise be considered ES, or simply used a transient term without proper explanation. In this thesis, the benefits are the derived use or nonuse experience from the ecosystem service. While this definition is also not precise, it will not be used interchangeably with ecosystem services or economic benefits, unless specified.

2.2.1.3 *Why study tourist values for ecosystem services*

As early as 1974, scientists have been promoting the carbon sequestration power of seagrass to emphasize its significance and promote its conservation, a Scopus search with the string '"seagrass" AND "carbon"' shows. However, when considering the triple bottom line approach that involves the environment, economy, and society (Elkington, 1998), this solution only focuses on the "environmental". In order to incorporate the latter two, an alternative is to consider the values of tourists in relation to ES, thus using economic power to influence the policy.

Seagrasses have been defined as a socio-ecological system due to the dependency of communities on the ecosystem (Cullen-Unsworth et al., 2013), and its contribution to the tourism industry is underscored by this classification. A study conducted by Castaño-Isaza, Newball, Roach, and Lau (2015) in Colombia recognized tourism was recognized as an important industry to the economic well-being of the region, and an indicator of the attractive value of the coastline (Castaño-Isaza et al., 2015).

The tourism population was selected as the focus for data collection to raise the alarm for seagrass conservation, because tourists can be used as a responsive entity for changing ecosystem services. Tourists can be considered transient stakeholders, who actively choose their selected destination, and pay a hefty sum for travel, accommodation, food, and recreation while visiting. Hattam et al. (2015) provides a list of 5 characteristics that define such an indicator for measuring changes in ecosystem services or benefits (Table 1).

Table 1: Tourism's features match the attributes of a strong and suitable data indicator for ecosystem services and benefits. The different attributes and their characteristics (Hattam et al., 2015) align with the qualities of tourism, supporting the tourist population as a sound sampling for data regarding ecosystem services and benefits.

Attribute	Characteristics	Tourism features
Measurability	Availability of data for measurement and quantification	Statistics are publicly available
Sensitivity	Detects change in the ecosystem service over time	Flow of tourists is responsive to the environment (Mihalič, 2000)
Specificity	Responds to changes in management, predictable, low variability	Management affects tourist behavior (Mihalič, 2000)
Scalability	Altering the spatial scale triggers changes in interest	Tourism changes on all spatial levels
Transferability	Research and conclusions are useful for other locations and studies	Data can be compared to other sites

Tourism fits all of the attributes (Hattam et al., 2015) detailed in Table 1, supporting the selection of tourists as the target group for the questionnaire to uncover values for seagrass benefits and services. Once uncovered, these values can be used to better understand the stakeholders' values for ES for a better management of the environment (Jobstvogt, Watson, & Kenter, 2014). However, the issue of monetizing ES for the purpose of market analysis is controversial (Gómez-Baggethun & Ruiz-Pérez, 2011). Especially for cultural ecosystem services, which are often experienced in service and benefit bundles (Raudsepp-Hearne, Peterson, & Bennett, 2010), it becomes even more difficult to monetize the heritage or spiritual value of a landscape (Szücs, Anders, & Bürger-Arndt, 2015). Therefore, tourism can be used as a bundled ecosystem service indicator, and is what my research sets out to explore. Rather than monetizing each individual service, we can make the connection between what tourists benefit from and what they wouldn't return without, providing a complementary bundled monetary value for the tourist experience. If the seagrasses provide even one service that tourists benefit from and wouldn't return without, it is a worthy investment to conserve the seagrasses in order to conserve the tourist experience, and the closely related Mallorcan economy.

The total economic value (TEV) is a sum of use and non-use values, where the use value is defined by an interaction between humans and the environment (Barbier et al., 2011) (Figure 4). The use values are then categorized into direct use, indirect use, and option values; direct use includes recreation and aesthetic benefits, indirect use involves coastal protection and habitats, and option value relates to future opportunities to revisit a site or landscape (Jobstvogt et al., 2014). The non-use values can be broken down into bequest values and existence values, the former being for a value for future generations to experience and the latter the mere knowledge that the ecosystem exists (Jobstvogt et al., 2014).

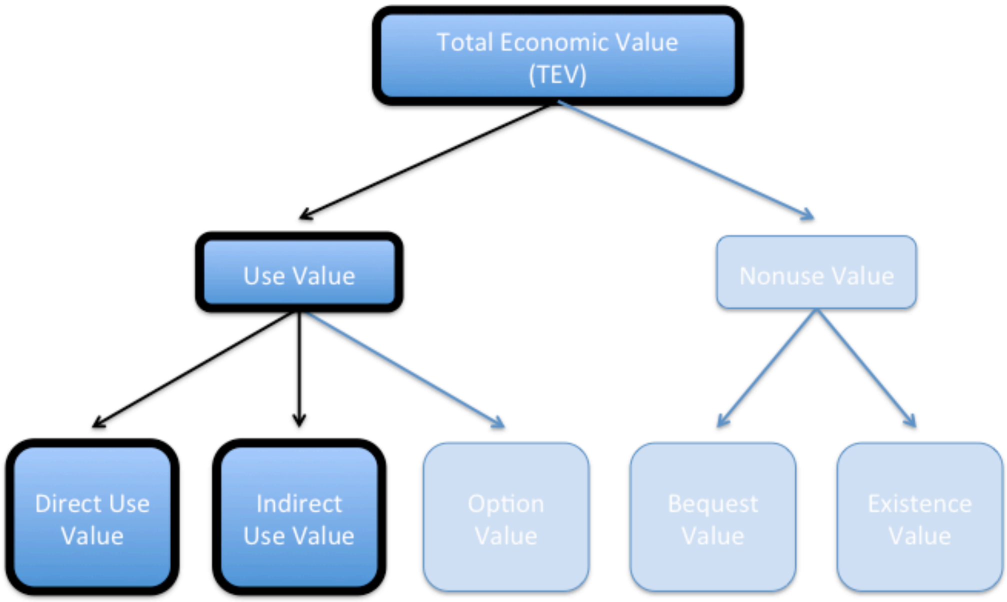


Figure 4: The values that will factor into the Total Economic Value (TEV) are Use values, specifically Direct Use and Indirect Use Values are shown in a bright blue with black border. The other values that can also be considered are in a lighter shade, which include Option Value as a Use Value, and Bequest and Existence Value as a Nonuse Value. Figure adapted from Jobstvogt et al. (2014).

Although use values generate income for the area and people greatly benefit from them, use values are often underestimated since the cost is normally very low or free (Jobstvogt et al., 2014). Therefore, this thesis will focus specifically on the use values the tourists experience while on the island of Mallorca.

3 Case Study: Seagrasses of Mallorca

The island of Mallorca is located off the east coast of Spain in the Mediterranean Sea. It is one of the four major islands in the Balearic Islands, a Spanish archipelago. Surrounding the island of Mallorca is the Mediterranean Sea, which is home to a breadth of marine ecosystems. The marine ecosystem supports the environment for nature, but also for humans: both the humans living and visiting it.

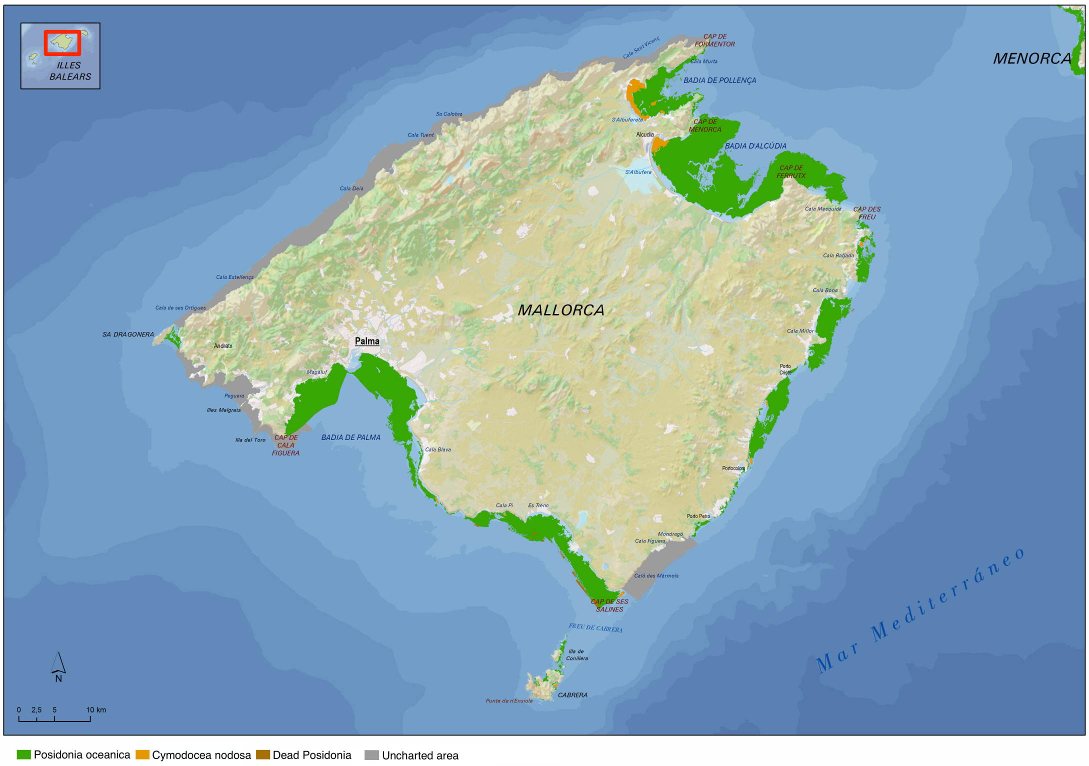


Figure 5: The distribution of seagrass meadows around Mallorca is widespread and prominent. The areas in green represent the seagrasses (N. Marbá & A. Ruiz, personal communication, March 24, 2015).

Seagrass is a critical part of the Mediterranean marine ecosystem (Vassallo et al., 2013). Seagrasses are flowering plants that have adapted over several millennia to live entirely underwater (Bjork, Short, McLeod, & Beer, 2008). Seagrasses are extremely slow growing organisms, with vertical growth ranging between 0.4 to 1.1 cm each year (Milazzo, Badalmenti, Ceccherelli, & Chemello, 2004). Their anatomy includes leaves, rhizomes, stems, leaves, and roots (M&MS, 2004), and alongside salt marshes and mangroves (Barbier et al., 2011), contribute to "biodiversity, biological productivity, nutrient cycling, carbon burial, and sediment stabilization" (Hemminga & Duarte, 2000). While seagrasses are a hub for biodiversity and help maintain the physical ecosystem, they are also the backbone of an underwater solution to the growing issue of excessive carbon: seagrass meadows serve as an expansive, long-term carbon sink (Duarte, Losada, Hendriks, Mazarrasa, & Marba, 2013; Fourqurean et al., 2012; Kennedy et al., 2010; Mateo & Romero, 1992). In the Mediterranean region alone, the meadows store an amount of carbon that is almost as much as the region has emitted since the beginning of the Industrial Revolution (Pergent et al., 2012), with P. oceanica in particular as most capable of capturing CO_2 (Kennedy et al., 2010). As seagrasses are rooted organisms, they have also become synonymous with biological indicators for a healthy ecosystem, as their growth and mortality is sensitive to nutrients, light, and the overall quality of water (Orth et al., 2006).

3.1 Ecosystem Services

The seagrass meadows, as a foundational component of the marine ecosystem, also provide a host of ecosystem services (Duarte et al., 2013). These ecosystem services are categorized by the CICES framework as provisioning, regulation and maintenance, and cultural services (EEA, 2013). The services, outlined below, support the industry and culture of Mallorca.

3.1.1 Provisioning Services

Seagrasses provide provisioning services in terms of nutrition and materials. The nutrition provided comes in the form of marine plants and animals, and manifests as commercial fishing. Juvenile fishes tend to settle in seagrass meadows (Barbier et al., 2011), so the upkeep of commercial fisheries is a prominent ES. Commercial fishing in the Mediterranean accounts for 42% of all employment of the EU catching industry (Morales-Nin, Grau, & Palmer, 2010). The meadows also provide biotic materials such as non-food plant fibers, ornamental resources for souvenirs or furniture, and medicinal uses (Rengasamy, Radjassegarin, & Perumal, 2013).

3.1.2 Regulation and Maintenance Services

Humans benefit from seagrass through its regulation and maintenance services on both a local and global level. Locally, seagrasses regulate flows, the physical environment, and the biotic environment. For flow regulation, both water and mass flows are regulated. Sedimentation (Duffy, 2006) and the attenuation of wave energy (Boudouresque, Guillaume, Pergent, Shili, & Verlaque, 2009) contribute to water flow regulation, whereas erosion protection is enabled by mass flow regulation (Vassallo et al., 2013). Soil qualities in the physical environment are maintained as well through the maintenance of soil fertility and structure (Del Vecchio, Marbà, Acosta, Vignolo, & Traveset, 2013). The biotic environment is supported by seagrasses through lifecycle maintenance and habitat protection, as well as gene pool protection, which maintains nursery populations (Duffy, 2006). On a global level, carbon sequestration and absorption capacities through waste regulation together with atmospheric regulation in the physical environment help regulate climate change (Duarte et al., 2013). These are all services that have been identified as ecological processes humans benefit from, either directly or indirectly by the Balearic exemplar of OPERAs.

3.1.3 Cultural Services

Cultural services are admittedly more difficult to articulate, define, and identify; however, as Mallorca is a tourist destination, the aesthetic appeal of the natural seascape and the recreational value of the seaside activities cannot be denied. The symbolic services include aesthetic and heritage, which are manifested in the cultural seascapes as well as the spiritual aspect (De La Torre-Castro & Rönnbäck, 2004), where the wilderness and naturalness of the area are services both the residents and visitors to Mallorca can appreciate. The experiential services are most visibly obvious through the recreational and community activities that can take place due to the charismatic wildlife and habitats (Cullen-Unsworth et al., 2013), as well as prey for hunting or collecting which drives the booming trend of recreational fishing (Morales-Nin et al., 2010). The OPERAs exemplar has identified the services within the CICES framework for seagrasses (N. Marbá & A. Ruiz, personal communication, June 2, 2015).

3.2 Decreasing stocks in natural capital

Compared to other estuarine and coastal ecosystems such as coral reefs, seagrass suffers from the condition of being relatively uncharismatic and appealing (Orth et al., 2006). While its ecosystem services are even greater in magnitude in comparison (Costanza et al., 1997), seagrass meadows do not generate the same excitement as coral reefs, as illustrated in Figure 6.

Figure 6: The visible differences between seagrass meadows (right) (GuiasIbiza, 2012) and other coastal and estuarine systems (left) include the visually appealing and interactive activities of coral reefs (SeriousShops) that seagrass meadows lack. The meadows are distinctly aesthetically uncharismatic (Orth et al., 2006), a feature that doesn't take into account their otherwise significance in terms of habitats for juvenile fishes or carbon sequestration capabilities.

Although seagrasses are an integral part of the marine environment, 35% of their initial area cover has been lost since 1879 (Waycott et al., 2009). A combination of local and global pressures is contributing to this decrease. While natural fluctuations in seagrass density have occurred in the past, the recent and more rapid changes have been found to be in line with increasing anthropogenic pressures. Alongside climate change (Marbá, Díaz-Almela, &

Duarte, 2014), the decline of seagrasses on a local level can be attributed to excessive nutrient runoff from untreated water (Orth et al., 2006) and unregulated anchoring from recreational tourist boats (Ceccherelli, Campo, & Milazzo, 2007; Milazzo et al., 2004). These pressures are simultaneously deteriorating the conditions necessary for seagrasses to survive as well as directly destroying the meadows.

The relationship between the flow of ES from seagrass meadows to the various beneficiaries is complex, but the critical point is the inverse relationship between the pressures and health of seagrass meadow. Seagrasses, as a stock of natural capital provide a host of services as detailed in Section 3.1: Ecosystem Services, enhancing the tourist experience through characteristics such as fresh seafood and a natural setting for recreational activities. However, pressures increase seagrass mortality. As seagrass recovery can take up to hundreds of years, without properly enforced regulation a business-as-usual scenario would result in an eventual depletion of the stock of seagrass meadows (Ceccherelli et al., 2007). A reduction in seagrass meadows would mean a loss for biodiversity and the services that the seagrasses provide to the Balearic Islands and Mediterranean region as a whole, but also a loss in carbon storage. As the seagrasses currently store an amount equal to the anthropogenic carbon emissions since the industrial revolution, the loss of vegetation increases the risk of releasing this carbon to the atmosphere, as well as losing further sequestration capacities.

3.2.1 Pressures

The pressures most affecting seagrasses are on both a global and local level. Globally, climate change is the largest pressure, with the increasing warming affecting the sensitive habitat seagrasses need to survive. The pressures that have the most destructive impact on the seagrasses of Mallorca are urban sewage and recreational boat anchoring (N. Marbá & A. Ruiz, personal communication, March 24, 2015), and will be elaborated on in Section 5.3.2: Pressures. The distribution of pressures varies throughout the island (Figure 7: The pressures and management characteristics are illustrated in the map. The pressures that will be focused on for this thesis include the moorings and dumping sites), but not to the same extent as the variation throughout the Balearic Islands or the Mediterranean (N. Marbá & A. Ruiz, personal communication, March 24, 2015).

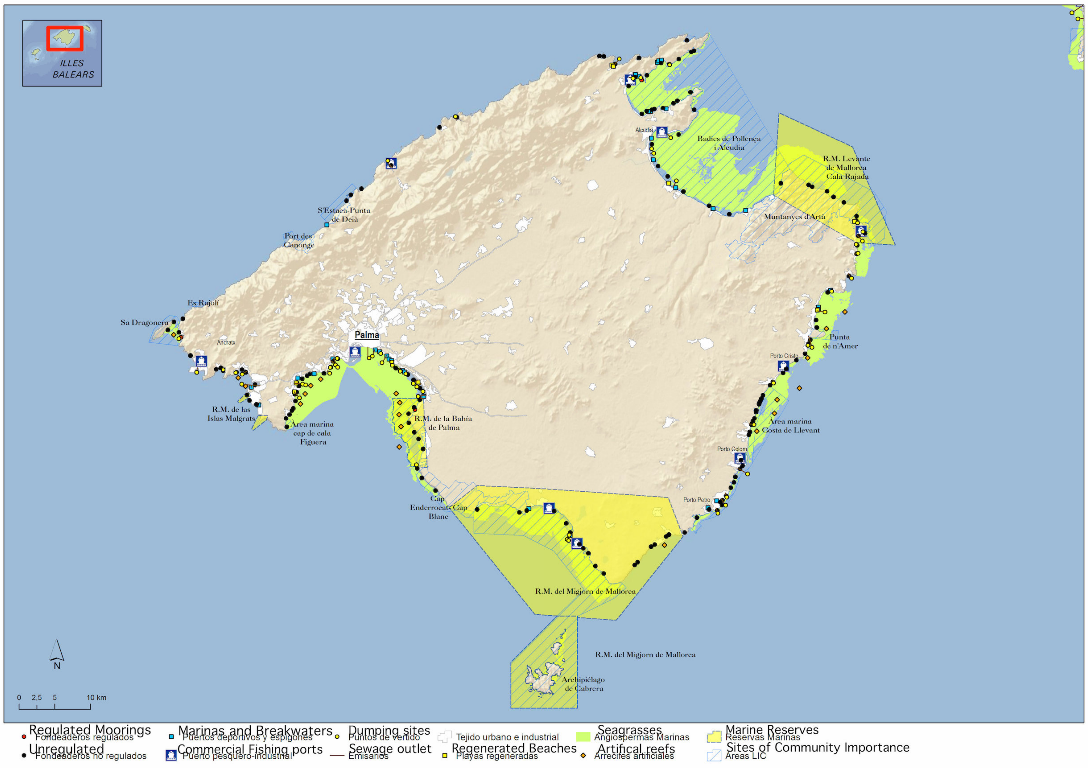


Figure 7: The pressures and management characteristics are illustrated in the map. The pressures that will be focused on for this thesis include the moorings and dumping sites (N. Marbá & A. Ruiz, personal communication, March 24, 2015).

3.3 Legal Framework

Ecosystem-based management, or at least considering ecosystem services in policy is a practice increasingly backed by literature (Daily et al., 2009), and one I promote in this thesis. Unfortunately, the term “ecosystem services” is far from the driving force in decision-making. On a review of marine conservation alone, ecosystem services was the least accounted for compared to other criteria (Leslie, 2005). Specifically in the Balearic Islands, the concept of ecosystem services has not yet been used explicitly in policy (N. Marbá & A. Ruiz, personal communication, March 24, 2015). This absence of ecosystem services in decision-making has a direct impact on the decisions made for ecosystem conservation. If the services and benefits are not adequately valued, then their importance is not visible, and their stake diminished. Therefore, by revealing tourist values and their economic implications, I hope to support ecosystem services’ relevance to policy.

4 Methodology

My overarching research question asks *How can tourist values of benefits from seagrass ecosystem services be used motivate conservation?* The research was conducted as a nonexperimental design, aimed not at causal interactions but the value state of the tourist population on Mallorca. Ultimately, I am determined to make this research applicable. I want to both uncover the importance of seagrass ecosystem services in the eyes of the tourism industry and policymakers, and also breach the communication gap to help them understand it.

My research questions serve two purposes. The first two question focus on the *why* – why are seagrass meadows important to Mallorca? The last two focuses on the *how* – how should we go about conserving them?

4.1 Targeting tourists

The island is a popular tourist destination for Europeans; ranked in the top five most popular tourist destinations (Eurostat, 2012), it is often characterized by its clear water and sandy beaches (Kozak, 2002). The resident population of Mallorca is 864,763 (INE, 2014) while the official bureau of the Balearic Islands counted 9,672,852 tourists to Mallorca just last year (Balears, 2014b). Mallorca's physical environment is one of the primary reasons for travelling there as noted by German and British tourists (Kozak, 2002), which make up over half of the total tourist population (Balears, 2014b). The tourism sector generates almost five times the GDP than the industry in the Balearic Islands, with the over 13 million tourists in 2014 spending an average of 107.96 EUR per tourist per day throughout the islands (Balears, 2014b). As the tourism sector has the largest stake in the economic well being of Mallorca, tourist values and behavior can be extrapolated to be important to the economy and welfare of Mallorca.

4.2 RQ1: Important tourist benefits

A list of seagrass ecosystem services was supplied by the OPERAs exemplar leads. I used this list to derive tourist benefits for each service that had a use value. The derived tourists benefits were used as the basis of a questionnaire administered to tourists in person. The resulting data were used to determine which benefits were most important to tourists.

4.2.1 Deriving Benefits from Services

The benefits tourists receive from the ecosystem services of seagrass meadows were derived in coordination with Kimberly Nicholas from Lund University, and Núria Marbá and Ana Ruiz from IMEDEA, Institut Mediterrani d'Estudis Avançats on Mallorca. With expert ecosystem service knowledge combined with local information, the extent of impact and interaction between the services and tourists shaped the benefits derived from the services.

The benefits were derived and used in the questionnaire for the tourists on Mallorca. Additional tourist benefits were added to the questionnaire at the recommendation of the exemplar leads, to include more indirect benefits that were noted to be benefits derived from a tourist's experience on the island.

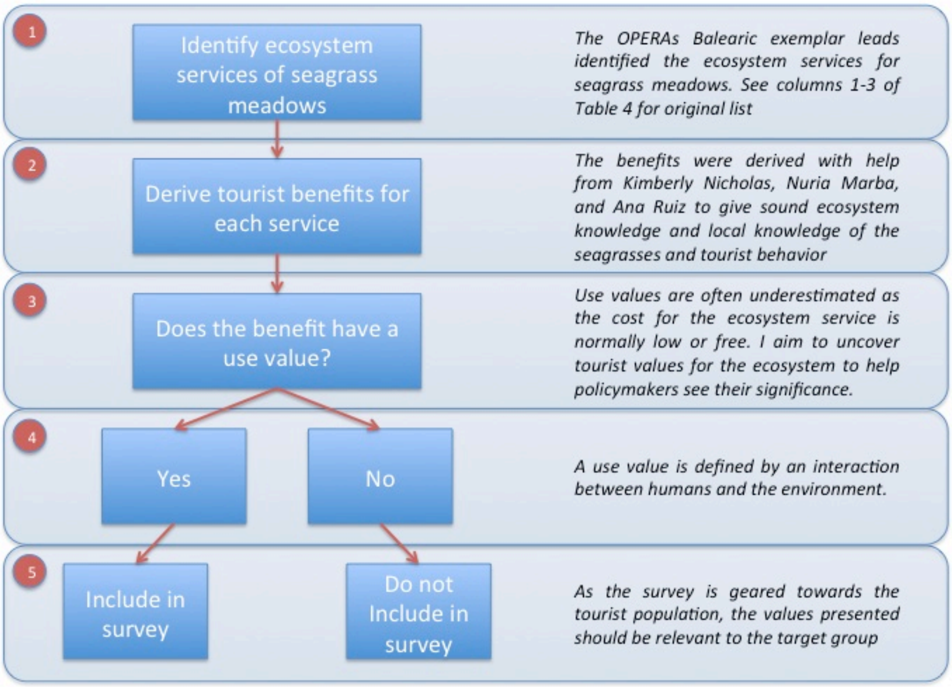


Figure 8: My process from the seagrass ecosystem service to the benefits listed in the survey for tourists to rank involved five steps. The left side of the figure illustrates my process as a flow chart in chronological order while the right side explains how or why the step was taken.

This thesis will focus on the values from a tourist perspective. As the tourists chose to come to Mallorca instead of other destinations, the non-use values, while potentially present, will and can- not be assessed. Within the use values, the option value is also barely investigated, as my approach focuses on the present situation rather than future benefits. The values that will be stressed in this thesis will be the direct use and indirect use values (Figure 4) as they are most relevant to the time the tourists are in Mallorca.

4.2.2 Data Collection

"What are the most important benefits that tourists derive from seagrass ecosystem services?" was investigated through the survey conducted on Mallorca in the summer of 2014. The survey had six sections (Table 2) and was created with Google Forms. Sections #1 and #6 covered demographics to legitimize the survey by comparing the data to official information, #2 the tourists' reasons for coming to Mallorca to validate the derived benefits of RQ1, #3 the importance of tourist benefits on a 5-point Likert scale as the foundation for

RQ1, #4 closed answer sets for the awareness of seagrass meadows and their benefits to support the notion of the invisibility of seagrasses, and #5 if the tourist would return to Mallorca without the benefit to calculate the ratio for RQ2.

I collected data on the island of Mallorca during a span of 15 days in the month of July 2014. I successfully surveyed 73 tourists, of which 65 completed up to and including Section 5 (detailed below in Table 2), 63 completed the entire survey, and with a less than 50% response rate of all potential participants. Most of the surveys were completed at bus stations around Mallorca, as they were the most fruitful locations where tourists were seated and waiting for transportation. The entire survey can be found in Appendix D.

Table 2: The six sections of the survey administered to the 73 tourists on Mallorca. The data were used to identify the most important tourist benefits (RQ1) and to find the economic worth of tourists (RQ2).

Section	Topic	Question Type	Purpose
1	Tourist demographics	Open answer	Legitimize survey by comparing demographics
2	Reasons for coming to Mallorca	Open answer	Align benefits to Section 2 for RQ1
3	Importance of tourist benefits	5 point Likert scale	Main basis for RQ1
4	Awareness of seagrass meadows and benefits	Closed answer, yes/no	Support of seagrass invisibility
5	Returning to Mallorca for each benefit	Closed answer, yes/no for each benefit	Calculate ratio of tourists who wouldn't return for RQ2
6	Cost of visit	Open answer	Legitimize survey by comparing demographics

4.3 RQ2: Economic value of tourist benefits

4.3.1 Economic valuation

The economic impact of tourist values took the information gathered in the survey to answer the question: *"What is the economic value of the key tourist benefits?"* The economic value of the key tourist benefits can be viewed as the losses the island would incur if the tourists did not return. An equation was used to project the potential losses (L) in EUR per year in the future tourism sector if (1) seagrasses no longer existed and were (2) therefore no longer able to provide the ecosystem services that the tourists highly valued. The equation multiplies the ratio of tourists who would not return (R) by the total tourist expenditure per year (E) to calculate the losses in EUR per year (L) from tourists exclusively.

$$L = R \times E$$

Equation 1: The losses (*L*) in EUR per year were calculated with the following variables. *R* represents the ratio of tourists who would not return without the specific benefit and *E* is the total tourist expenditure. The variable *E* is known from data provided by Govern de Illes Baleares at 8.6 billion EUR per year (Balears, 2014a).

4.4 RQ3: Understanding responses to seagrass decline

The DPSIR framework (Figure 9) is broken down into the following sections: Drivers, Pressures, State, Impacts, and Responses. EEA (1999) briefly describes the various elements of DPSIR: drivers can be defined as the larger motivating factors for change, such as population growth; the driving force is transformed pressure on a specific area or region (P = F/A); pressures are the undertakings of society, motivated by the drivers, which affect the state of the environment; this change in state has an impact on the area and could also have larger global consequences, as in the case of climate change.

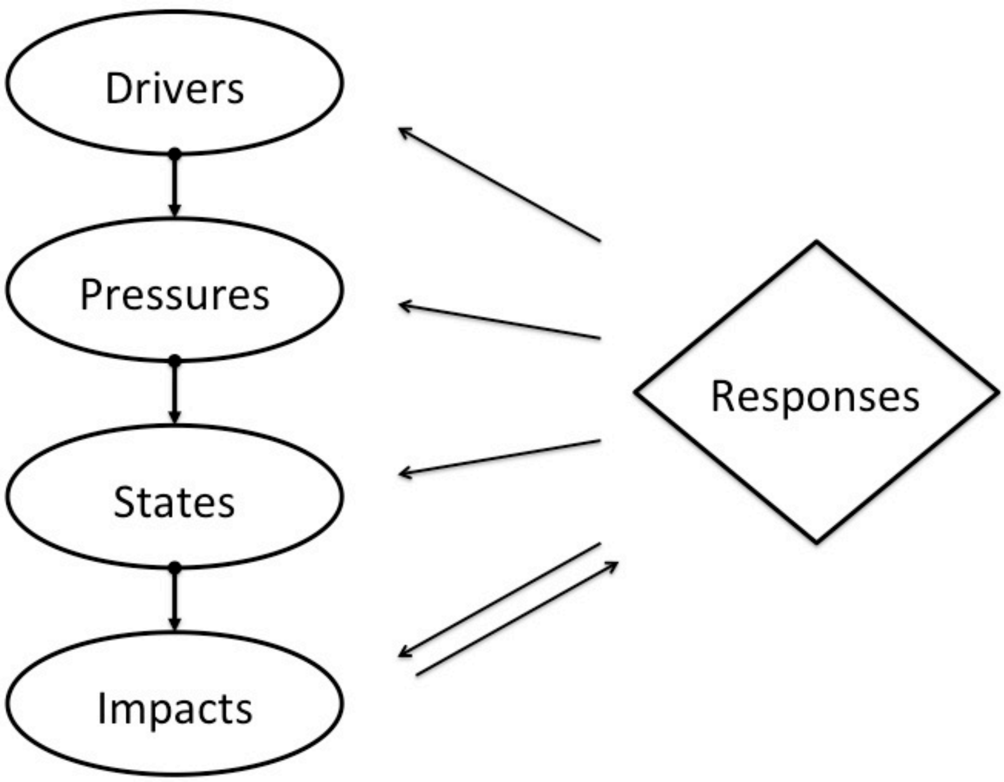


Figure 9: DPSIR framework adapted from (EEA, 1999). The Drivers apply a force, resulting in Pressures, which have resulting States and conditions, ultimately with Impacts on the environmental, social, and economic systems. The responses can and should consider all four of the elements encased in ellipses on the left.

The first step to identify responses is to use an environmental assessment framework to contextualize the case. DPSIR and ecosystem services are both considered frameworks that can help bridge the gap between the environment and society (Le Gentil & Mongruel, 2015), which is something I aim to do in order to make my findings as practical as possible. The DPSIR framework provides a systems-perspective overview, and intrinsically supports ecosystem-based management. DPSIR allows us to break down the problem into manageable, identifiable parts.

I focus on responses to the local pressures to increase relevance to Mallorcan policymakers. The "pressures" element in the DPSIR model is also in the CICES cascade, and is the primary connecting piece to bridge the two models. DPSIR, while a framework for environmental assessment, borders environmental issues (state and impact) with the human context (drivers, pressures, and responses) and focuses more on understanding how the context came to be – the "why". On the other hand, the CICES cascade model describes the relationship between the environment and society.

Literature regarding seagrass often mentions the need to act and respond immediately, whether through advancing scientific knowledge, technological developments, legal frameworks, or societal awareness (or all four) (Marbá, 2009). Borum, Greve, Binzer, and Santos (2004) in "What can be done to prevent seagrass loss" outlines pressures and responses, and of the five highlighted points to combat seagrass loss, only the last point mentions awareness. The remaining four points are regulatory measures that Mallorca is already having problems implementing, or high-cost changes to the systems. It is widely accepted that something needs to be done – but what should actually be done?

The DPSIR framework was used to identify the five elements for the case of seagrass decline around Mallorca. A literature review was conducted to summarize DPSIR in a way that can be communicated easily and concisely to policymakers on Mallorca. Information from the exemplar leads was also used to narrow down the factors for the pressures and responses. The responses were identified in chronological order of the pressures' flows, and then typified into technological improvements, raising awareness, and governmental regulation as Marbá (2009) recommended.

To further assist relevant stakeholders, I further explored and developed the least expensive "no-regrets" measure that is easiest to implement for each relevant local pressure. For illustrating where the urban sewage dumping sites are, I used Google Earth and Google

SketchUp to map the pressures and 3D modeling, respectively. For the response of implementing a code of conduct (COC) I used the Blue Flag COC (Flag) as a basis and compared it to a specific boating COC for seagrasses to find thematic similarities and disparities. I first simplified each point of the Blue Flag COC and then organized the points by theme, starting with the four themes found by Morris (2012) in a review of codes of conducts. Using the Blue Flag COC themes as a guideline, I matched the points from the seagrass specific COC in order to provide more information for developing one in Mallorca.

4.5 RQ4: Communicating the complexity of seagrass decline

Ecosystem service valuation literature lacks salience (Guo & Kildow, 2015), as it does not focus on enhancing the understanding of decision makers to facilitate effective responses. If the literature is not in a state to be used, then due to a lack of scientific understanding on decision making boards, the literature will not be used (Guo & Kildow, 2015).

Many papers have been written about the pressures, states, and impacts, and some even regarding the responses, but the missing link involves how to communicate this information to the people who can put it into action. Therefore, through the aid of open and accessible software, I aim to support decision making through an intuitive awareness interface. As ecosystems exist in a 3D space, Google Earth can be used instead of 2D maps to simulate the distribution of the natural capital in relation to other relevant spatial planning features. In addition to basic GIS layers to show distribution or points, the ecosystem services themselves can be modeled with Google SketchUp to help decision makers understand the services by visualizing how they impact certain target groups. This 3D interface allows policymakers to experience the ecosystem and its services, and benefits, and continue to establish their own values for the benefits.

Table 3: The procedure I followed for modeling and mapping the relevant characteristics for the seagrass ecosystem of Mallorca. The left column provides a general methodology while the right column supplements future users with insight and details for my case specifically.

Step 1. On Google Earth	
1.1 Create or import spatial distribution layers	Existing GIS information regarding distribution of seagrass, protected areas, and internal mapping such as sewage lines and government authority boundaries. As much as information as possible to facilitate both an understanding of the problem and a response

1.2 Placemark relevant characteristics of local pressures	The anchoring points (regulated and unregulated), dumping sites, and any other pressure that requires a response.
Step 2. On SketchUp	
2.1 Geolocate model	After having mapped the relevant aspects to the study (seagrass distribution and pressures), select an area of reasonable size (one that included a sewage pipe and a stretch of the beach). It is important to know what you want to model in Google SketchUp before you Geolocate the model, as it may change the area you select.
2.2 Model ecosystem	Model any aspects of the ecosystem you wish to bring to life. This was limited to the seagrasses for my model.
2.3 Model ecosystem services	The services I modeled were limited to wave attenuation, as the others were difficult to show physically.
2.4 Model benefits (for the target group(s))	Clear ocean water and sandy beaches were modeled. Notice that benefit modeling was limited to the most physically obvious features, and I used words and made diagrams for the rest.
2.5 Model pressures	An anchor in the middle of the seagrasses and the sewage pipe
2.6 Export model to Google Earth	Once the relevant 3D models are placed on the geolocated plane (image from Google Earth), the 3D model can be exported to Google Earth.
Step 3. On Google Earth	
3.1 Create short tour with audio recording in the following order: spatial distribution, ecosystem services, benefits, pressures	The tour following the cascade model, promoting consistency and understanding. First show where the seagrasses are – easy to understand. Then show the ecosystem services and benefits – more abstract and scientific, harder to understand. Lastly show what they should respond to – a call to action.

5 Results

5.1 RQ1: Tourists perception of benefits

5.1.1 Seagrasses provide tourist benefits

A literature verified list of ecosystem services provided by the Balearic Exemplar was used to derive tourist benefits for the services, which had conceivable use values (Table 4). For the provisioning services of commercial fishing and ornamental resources, the benefits of local seafood and natural souvenirs were derived respectively. From the regulation and maintenance services, carbon storage, clear ocean water, coastal protection from storm damage, sandy beaches, marine wildlife habitat, and healthy fish populations were all identified as benefits for tourists. From the cultural services, the benefits included time spent with family, natural setting, inspirational place, unique marine life, swimming & diving, recreational fishing, knowledge of local research, and learning about ocean life.

Table 4: The new column of "tourist benefits" was added on to the existing CICES framework (columns 1-4) from the seagrass cascade model, which derives tourist benefits from ecosystem services.

CICES			**OPERAs**	**Thesis**
CICES Theme	*Service Class*	*Service Group*	*Service Type*	*Tourist Benefit*
Provisioning	Nutrition	Marine plant and animal	Commercial fishing	Fresh, local seafood
	Materials	Biotic materials	Non-food plant fibres Ornamental resources Medicinal resources	Natural Souvenirs
Regulation & Maintenance	Regulation of wastes	Dilution & sequestration	Sequestration & absorption	Carbon Storage
	Flow regulation	Water flow regulation	Sedimentation Attenuation of wave energy	Clear ocean water Coastal protection from storm damage
		Mass flow regulation	Erosion protection	Sandy beaches
	Regulation of physical environment	Atmospheric regulation	Global climate regulation	Carbon storage
		Pedogenesis & soil quality regulation	Maintenance of soil fertility Maintenance of soil structure	
	Regulation of biotic environment	Lifecycle maintenance & habitat protection		Marine wildlife habitat
		Gene pool protection	Maintaining nursery populations	Healthy fish populations
Cultural	Symbolic	Aesthetic, heritage	Seascape character Cultural seascapes	Time spent with family
		Spiritual	Wilderness, naturalness Sacred places or species	Natural setting Inspirational place
	Intellectual & Experiential	Recreation & community activities	Charismatic or iconic wildlife or habitats Prey for hunting or collecting	Unique marine life Swimming/Diving Recreational fishing
		Information & Knowledge	Scientific Educational	Knowledge of local marine research Learning about ocean life

A word cloud (Figure 10) generated to for Section #2 of my survey shows that the most frequent responses to the most important reasons the tourist came to Mallorca are "weather", "sun", and "beach". These results align with the benefits were presented in the survey, and with the results of the closed answer set.

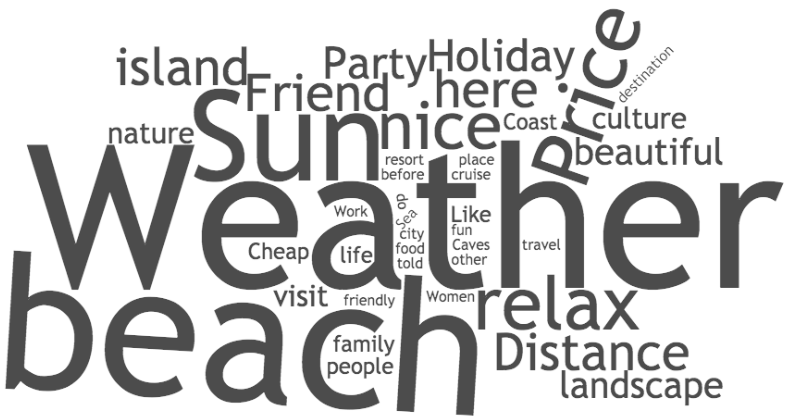


Figure 10: Word Cloud of open answer question regarding tourist reasons for coming to Mallorca, generated by timdream.org/**wordcloud**/

In addition to time spent with loved ones, tourists indicated for Section #3 of my survey that sandy beaches, clear ocean water, swimming, and the natural setting were all very important. Figure 11 illustrates the median importance for each benefit derived in Table 4 for the tourists' stay on Mallorca.

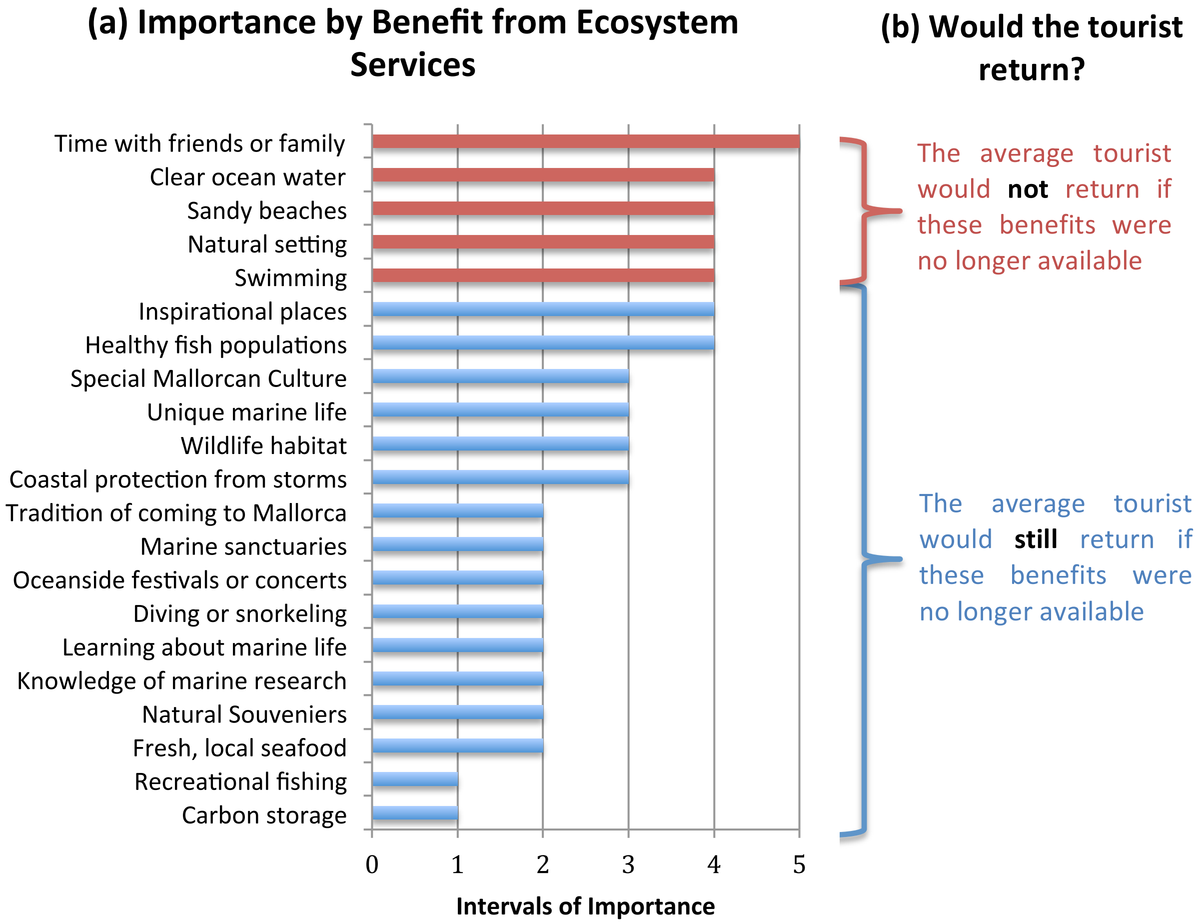


Figure 11: A survey of 73 tourists was analyzed to rank the importance of various seagrass ecosystem benefits. (a) The median tourist importance of each benefit is displayed in descending order where: 1 – Not important, 2 – Slightly important, 3 – Somewhat important, 4 – Very important, and 5 – Extremely important as designated by the Likert scale. (b) The benefits are separated into two color-coded sections: the red bars represent which benefits, if no longer available, would prompt the tourist to NOT return to Mallorca. The blue bars represent the benefits that the tourist would still return to Mallorca without.

Only 5.5% of tourists are aware of the existence of seagrass meadows according to the results of Section #4 of my survey. Figure 12 illustrates how although seagrasses provide a myriad of tourist benefits, tourists are often still unaware of their existence.

Figure 12: Tourists highly value the benefits, but the seagrasses and seagrass services themselves are hidden beneath the surface. Only 5.5% of tourists are aware of the existence of seagrass meadows.

Less than half of the sampled tourist population was willing to return if the top five benefits were no longer available (Figure 13). While Section #6 of the survey found that 94.5% of the tourists would consider returning to Mallorca, of those tourists, most of the level-4 and -5 benefits are also what would deter tourists from returning if the benefits were no longer available.

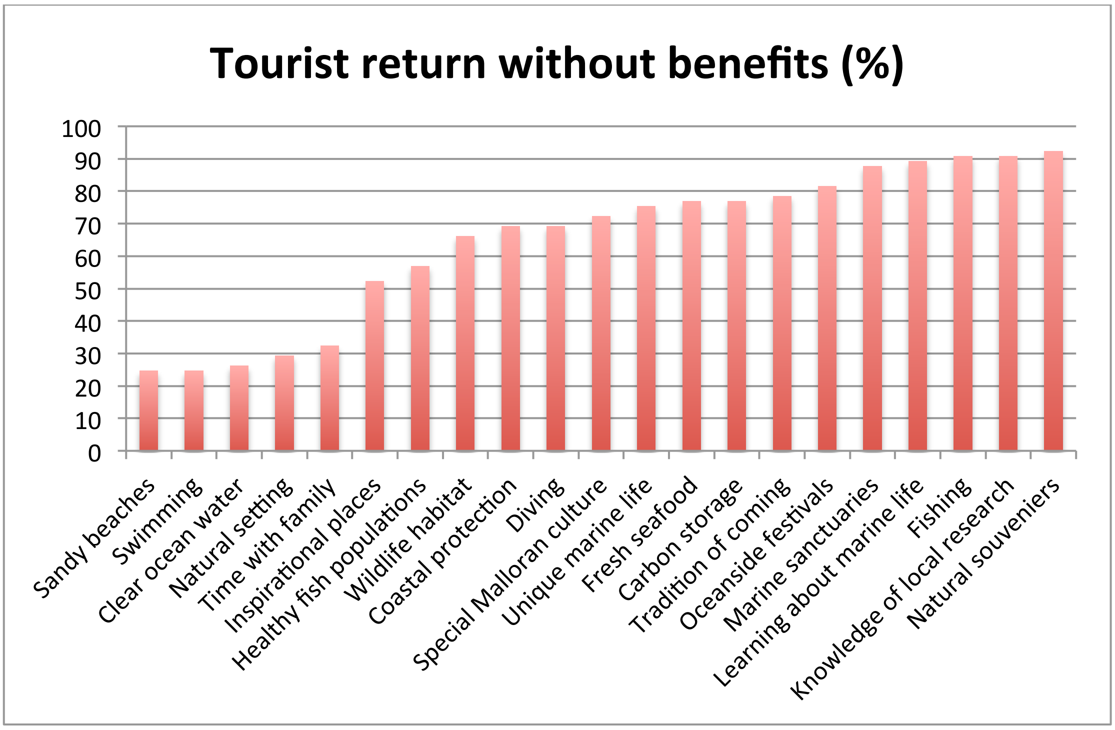


Figure 13: Percentage of tourists who would still return to Mallorca even if the specific benefit no longer existed on the island.

5.2 RQ2: Economic Worth

Up to 6.49 billion EUR per year could be lost if tourists decided not to return without the benefits. The factors that tourists would not return without are sandy beaches, swimming, clear ocean water, natural setting, and time with family or friends (Figure 13), and the projected losses are 6.49, 6.49, 6.35, 6.09, and 5.82 billion EUR/year, respectively.

Table 5: Potential losses in billions of EUR per year are projected from the $L = R \times E$ equation. The variables are: L – losses (EUR), R – ratio of tourist response that would not return without the benefits, and E – total annual tourist expenditure in 2014 (EUR/year).

Factor	Ratio	Expenditure (billion EUR/year)	Losses (billion EUR/year)
Sandy Beaches	0.75	8.6	6.49
Swimming	0.75	8.6	6.49
Clear Ocean Water	0.74	8.6	6.35
Natural Setting	0.71	8.6	6.09
Time with Family	0.68	8.6	5.83

5.3 RQ3: Identifying and exploring responses to seagrass decline

A holistic, focused representation of the elements of seagrass decline was compiled through DPSIR. The drivers provide the underlying motivation and reasoning for the pressures of urban sewage and unregulated anchoring that result in the deterioration of seagrasses, and I hope that the impacts solicit the responses I recommend.

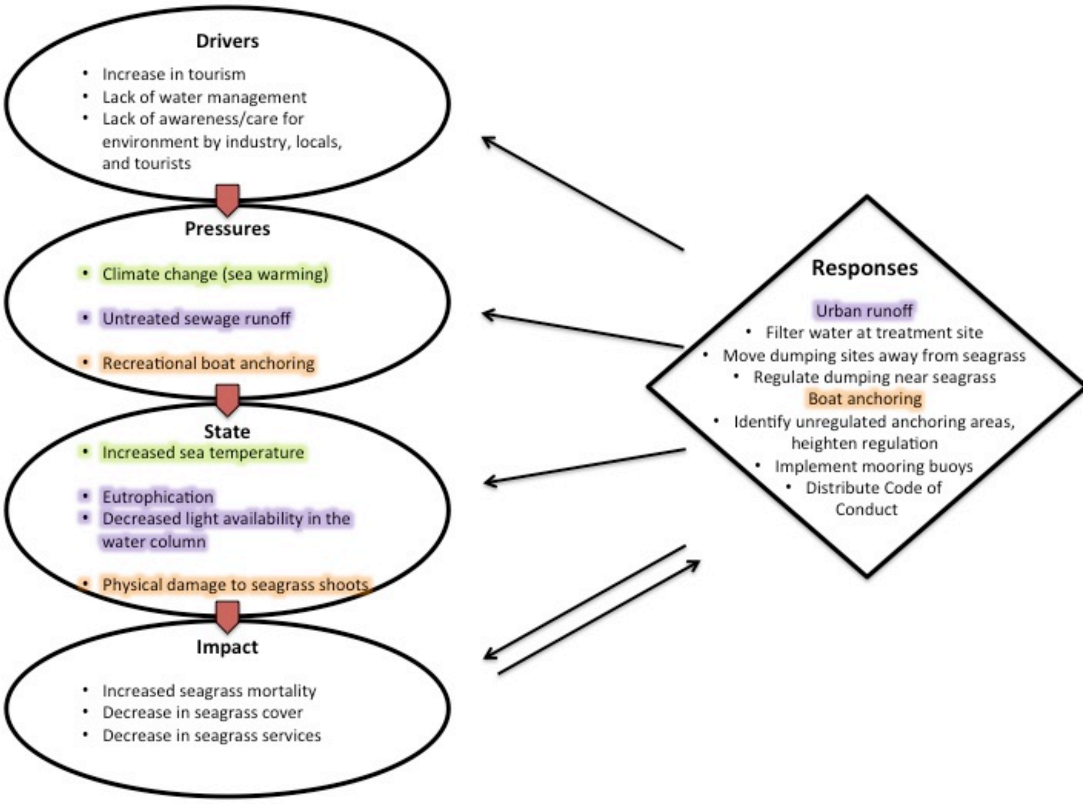


Figure 14: A DPSIR (Drivers, Pressures, State, Impacts, Responses) diagram showing the relationship between each of the different elements of DPSIR, as well as the specifics to the case of seagrasses around Mallorca. The drivers include the forces, often on a higher level, that manifest as pressures on a specific area. The pressures induce a certain state, which in turn have an impact on the target in question. These impacts solicit responses from the human system for mitigation. The color-coding shows the connections between the pressures and the resulting states. The pressures of climate change and sea warming result in increased sea temperature, untreated sewage runoff leads to eutrophication and decreased light availability in the water column, and recreational boat anchoring directly leads to physical damage to seagrass shoots.

5.3.1 Drivers

The drivers for seagrass degradation are on multiple scales and levels. On the highest and most broad level, it is a result of our neoliberal paradigm, which demands profit maximization and continuous growth (Harvey, 2005). This paradigm alongside the paradigm of nature for humans, which takes our environment for granted (Dryzek, 1997), drops a ladder down to the local level of drivers. The general lack of awareness and concern for the environment is coupled with the increase in tourism driven by the economic paradigm, and manifests itself in the form of more drivers on the ground. A lack of the following is the force behind seagrass degradation on a local level: proper water management by the government and treatment facilities (MEDIS, 2005), awareness of industry of their impact on the environment, and awareness of tourists of seagrass ecosystem services and the benefits they receive from them.

5.3.2 Pressures

5.3.2.1 *Climate Change*

As the Mediterranean Sea is a region that is at the top of the list for warming, climate change is impacting the local ecosystems (Burrows et al., 2011). The warming is accelerating the already rapid decline of seagrasses (Díaz-Almela, Marbá, Martínez, Santiago, & Duarte, 2009), and acts as a forceful global pressure in addition to the local pressures listed above. Seagrasses are very vulnerable to sea warming, and the increase in temperature has been documented to increase seagrass mortality (Marbà & Duarte, 2010)

5.3.2.2 *Urban sewage*

In a study on global seagrass decline by Waycott et al. (2009), deteriorating water quality was identified to have the greatest impact on seagrasses, with coastal development activities coming in as a close second. Out of the 77 sites with distinguishable causes for seagrass decline, 35 were from water quality while another 21 were from the coastal development activities (Waycott et al., 2009). The decrease in water quality as a result of increased nutrients and sediments from urban runoff causes an array of deteriorating conditions for seagrasses (Orth et al., 2006). Seagrasses are more vulnerable to the impacts of water quality as they tend to grow in areas that are close to the source of input from land. Seagrass is very sensitive to light input; compared to coral reefs at 0.02% surface irradiation, seagrasses demand a minimum of 11% (Gattuso et al., 2006). While the dumping of nutrients itself inhibits light from passing through the water column, the increase in nutrients also allows a breeding ground for phytoplankton and macroalgae, further reducing surface irradiance(Marbá, 2009). Because of the area where seagrasses tend to grow, they are closer to the inputs of local watersheds and therefore more exposed to nutrient changes, especially in comparison to mangroves and coral reefs. (Orth et al., 2006). There are also higher levels of hydrogen sulfide (H2S) due to the increased levels of nitrogen and phosphorus from the runoff, and as the Mediterranean lacks iron to bind to the molecules, the H2S also increases the mortality of the seagrasses (Marbá, 2009).

Currently, around Palma there 22 recorded dumping sites in the bay (Figure 7), which is also has the densest habitation of seagrass on the southern half of the island. A portion of the bay has been declared a marine reserve, and while there are no dumping sites within this zone, the concentration around the protected area is greater than in other unprotected areas (Figure 7).

5.3.2.3 *Boats anchoring*

The Balearic Islands is a global hub for recreational boating, with almost 300,000 visitors to the Balearic Islands for that purpose in 2009 (Diedrich, Terrados, Arroyo, & Balaguer, 2013). Even though it is only a part of the tourism industry, in 2009 recreational boating still pumped in almost 500 million euros (Diedrich et al., 2013). Mallorca alone has over 14,000 berths, and with the massive influx of visitors during the summer time, the limited space for anchoring is in high demand (Balaguer et al., 2011). With constant space and increasing demand, boat anchoring is still largely unregulated – with the exception of special marine protected areas (Balaguer et al., 2011). Boat anchoring can be done in both sandy and vegetated seabeds, and sandy seabeds are actually preferred by users (Balaguer et al., 2011). However, with the increase in demand, visitors anchor in any space they can, including seagrass beds. Each time the entire process of anchoring is completed (lock-in and retrieval), an average of 34 shoots of seagrass are destroyed (Francour, Ganteaume, & Poulain, 1999)

5.3.3 State

The pressure of climate change and more applicably sea warming results in a state of increased sea temperature (Figure 14). The local pressures that this thesis focuses on also have resulting states. Untreated urban runoff from sewage in particular causes a state of increased eutrophication due to the excess nutrients in the water. The organic matter also further decreases the surface irradiance (availability of light) in the water column. The state culminating from the pressure of recreational boat anchoring is the physical damage the process of anchoring has on meadow shoots.

5.3.4 Impacts

The impacts stemming from the states are unfortunately simple, and morbid. The direct impact is increased seagrass mortality. With rising temperatures, the conditions suitable for seagrass survival are shifted, increasing the mortality rate. Due to the decreasing availability of light due to water turbidity, seagrasses do not have the required amount of surface irradiance, also increasing the mortality rate. Boat anchoring has a direct impact on seagrass mortality, as it destroys shoots during lock-in and retrieval. The increase in seagrass mortality decreases the amount of area the seagrasses cover. Without flourishing meadows, the seagrass services Mallorca is accustomed to cannot be performed, which is estimated to be at 10% of their initial cover. The services that will be impacted include carbon sequestration (which supports with climate change mitigation), wave attenuation and coastal protection from storm damage (which maintains the sandy beaches Mallorca is known for) and sedimentation (which results in the clear ocean water that can be seen around Mallorca).

5.3.5 Responses

Responses were identified for urban sewage and boat anchoring, and are classified under the following three categories: technological improvement, increasing awareness, and governmental regulation (Table 6).

Table 6: The responses to urban sewage and boat anchoring according to the categories of technological improvement, increasing awareness, and governmental regulation. As urban sewage and boat anchoring are the two pressures with the highest impact, responses to these two are developed. The outlined boxes mark the cheapest, no-regrets responses.

RESPONSES (TYPE)	PRESSURES	
	Urban Sewage	**Boat Anchoring**
Technological improvement	Filtration at site	Mooring buoys
Increasing awareness	Contextualize dumping sites	Code of Conduct
Governmental regulation	Protect vulnerable areas with high eutrophication	Protect vulnerable areas with intensive anchoring

5.3.5.1 *Responses to urban sewage:*

The issue of urban sewage can be traced from source to output to identify responses. The sewage is first treated at a water filtration plant – the first logical step is to introduce mechanical filters to further remove organic waste and particles from the water at its source, a relatively cheap and simple retrofit (Borum et al., 2004).

If filtration cannot be done as a proactive measure against nutrient loading, the dumping sites can also be planned away from seagrass beds, such that the increased nutrient output and organic matter does not directly affect the water column and seagrass beds. In order to facilitate more strategic water planning, a suggested method for responding to the issue of urban runoff is providing an interface to policymakers that includes all relevant characteristics for urban water planning such as dumping sites in relation to seagrass meadows. This would enhance their spatial understanding of the distribution of seagrass meadows, allowing them to consider the regional impact different planning components (such as sewage dumping points) can have on the environment. Such an interface could be 3D representations created on Google SketchUp and placed on Google Earth, allowing policymakers to visualize what is otherwise invisible to them while conducting urban planning. By exposing the seagrasses, policymakers may be less likely to place a dumping site close to them. The different layers can be adjusted on Google Earth, showing all plotted characteristics or just the ones relevant to the specific policymakers, such as the water management bureau.

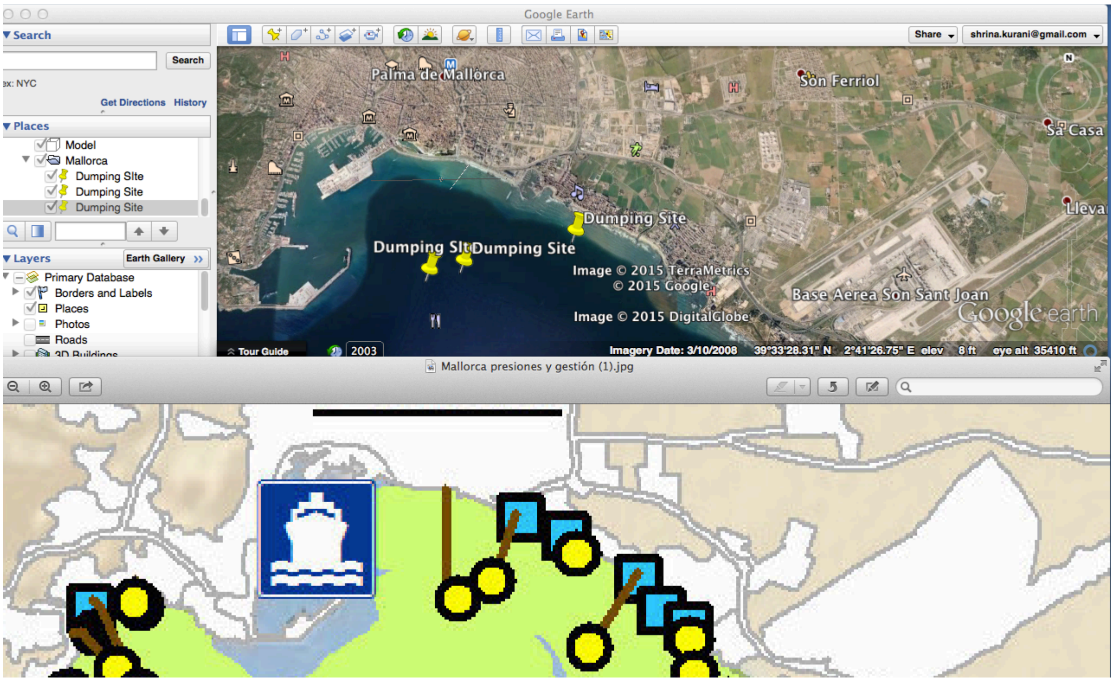


Figure 15: The dumping sites around the Palma Bay were placemarked on Google Earth to improve accessibility. The bottom screen is a map provided by IMEDEA, and the top window is the same map on Google Earth. I recommend the water treatment plants, researchers, and urban planners to all put information on the same medium to allow for better, more aware planning.

As the number of dumping sites in the marine reserves are significantly less (Figure 7), an effective measure could be one (or all) of the following: expand the marine reserves, impose regulation that does not allow dumping sites to be within a certain range of seagrass meadows or that the organic matter to be under a specific concentration before it can be released. This legislation would support the seagrasses from the bottom up – protection would lead to better planning, and hopefully increased filtration.

5.3.5.2 *Responses to boat anchoring:*

The three responses for boat anchoring were developed as mooring buoys, a boaters' COC, and protecting vulnerable areas as a technological improvement, increasing awareness, and governmental regulation, respectively.

Mooring buoys are a technological development that can alleviate the pressure of anchoring on seagrass beds. In a survey taken on the coast of Mallorca, 72% of boat users supported the use of mooring buoys while the majority was even willing to pay for it (Terrados, Diedrich, Arroyo, & Balaguer, 2012). "Overall, 75% of the respondents perceived they would be more likely to use buoys if they were available" (Diedrich et al., 2013). Mooring buoys can help organize the flow of traffic during peak seasons as well as prevent unregulated anchoring from destroying seagrass shoots.

The next step suggested is to increase awareness and responsibility by implementing a COC for boaters, a sentiment Borum et al. (2004) shares. The COC should include helpful guidelines to be environmentally and thus seagrass friendly. Using the BlueFlag Environmental COC for Boats (Flag) as a basis, 6 general themes rose from the COC: behavior regarding waste, environmental considerations beyond the immediate events, sharing and spreading responsibility and awareness, following regulations, respecting the environment, and respecting others (Table 7). The first two are new themes in addition to the review conducted by Morris (2012). By applying these themes to an existing boating COC with special attention to seagrasses, there is an uneven match in operationalizing all of the themes. The themes in the Underwater Volunteer's COC (UVNSW, 2009) also primarily consist of respecting the environment and following regulations, with a small concession of one point to sharing and spreading responsibility and awareness with the promotion of mooring buoys. However, the COC from UVNSW provides clear and precise recommendations for boaters to follow.

Table 7: An alignment of the Blue Flag COC (Flag) and the UVNSW (UVNSW, 2009) COC was performed to see how the general guidelines matched the more specific, operationalized ones. The outlined boxes indicate a strong connection between the Blue Flag points and the related UVSNW points. The colors are according to the Blue Flag theme, and the themes are organized first according to the number of relevant UVSNW points, and then to the number of Blue Flag points. The remaining points of the UVSNW COC that do not fall under a Blue Flag theme

BLUE FLAG THEME	BLUE FLAG POINTS	UVSNW POINTS
Respect Environment	Protect animals and plants	Operate boat in displacement mode in turtle areas to avoid collisions
		Navigate away from/around flocks of roosting or feeding seabirds
	Avoid damaging sea floor	Use designated ramps to prevent erosion and damage to shorelines and vegetation
		Avoid grounding and propeller/keel damage in in areas of seagrass, coral reef and mangrove; minimum 1m clearance between propeller and seabed
	Respect vulnerable areas	Ensure anchor is large enough to avoid dragging and has enough chain
		If possible check out an area before anchoring and avoid lowering onto sensitive habitats such as seagrass or coral
		Anchoring in seagrass areas should be avoided at all costs, but if that is not possible then a soft bag filled with sand is likely to cause minimum damage to seagrass beds
		Use heavy plastic tubing over the anchor chain wherever possible
		Rotate dive sites to avoid over-using a particular site
Follow Regulations	Follow fishing guidelines	If travelling in an estuary reduce the impact of wake by observing speed limits and/or 'no wake' zones
		Be aware of and respect the rules for marine mammal encounters. Relevant legislation attached
		Be aware of 'no anchor' zones
		Be aware of special rules in marine protected areas
Sharing & Spreading Responsibility	Report violation of environmental regulation	Install or lobby for permanent buoyed mooring at dive sites which are experiencing anchor damage
	Encourage others to take care of environment	
Waste	Do not dump toilet water	
	Dispose of toxic waste properly	
	Recycle	
Environmental beyond just immediate behavior	Use environmentally friendly products	
	Do not buy/use objects made from protected species	
Respect others	Avoid fisheries	

		Position boat to center of water channels, correctly trimmed
		Use moorings, if not send a diver to inspect anchor for safe holding and minimal damage
		Motor toward the anchor when hauling in
No Blue Flag theme	No Blue Flag guidelines	Ensure an anchor 'watch' is undertaken

The Blue Flag theme with the most supporting points is Respecting the Environment. Following Regulations and Sharing and Spreading Responsibility both also have connections to the UVNSW COC for the general theme, but there are no direct connections between the Blue Flag points and the UVNSW points. Therefore, I recommend focusing on a COC focusing on the central theme of respecting the environment.

A legal framework to regulating recreational boat anchoring could utilize data from Balaguer et al. (2011). The study developed spatial scenarios to determine areas to focus on which can guide the legal framework such as where to ban it all together, and zones to recommend anchoring on sandy habitats versus vegetated. The information should be accessible, so Google Earth can also be used.

5.4 RQ4: Communicating the responses

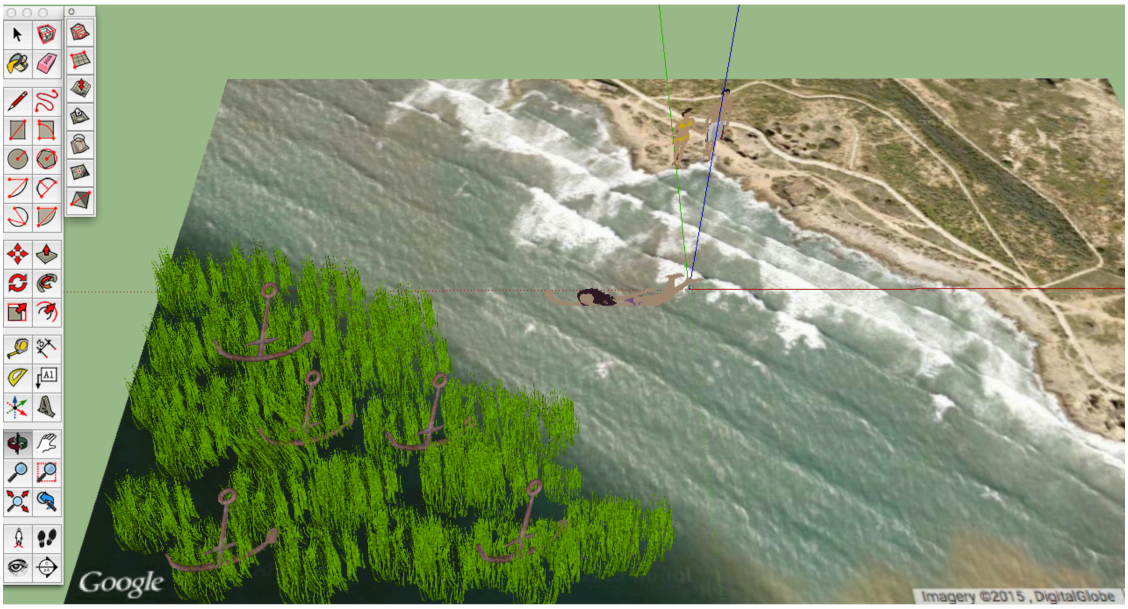
For a more holistic understanding of how the physical ecosystem, the ecosystem services it provides, and human alteration of our environment all intertwine, a comprehensive model containing all characteristics is necessary. As using accessible and easy to use software supports a more general understanding, I used Google SketchUp and Google Earth to model a small portion of the Palma Bay, with the following features: spatial placemarks for seagrass distribution, sewage dumping sites, unregulated anchoring, and imported 3D models from Google SketchUp of the ecosystem services and derived tourist benefits (Figure 15 – 18).

I created a spatial distribution layer of seagrasses in a sample area of Palma and then added the relevant pressures – in this case, unregulated anchoring and dumping sites – on Google Earth (RQ4: Step 1) (Figure 15).

Figure 16: On Google Earth, I added the spatial distribution of the seagrass meadows, shown in green, and represented the dumping sites for urban sewage with the yellow thumbtacks, and unregulated anchoring sites for recreational boats with blue anchors.

I next modeled the pressures of urban sewage and boat anchoring by incorporating a sewage pipe and anchor, respectively, as well as the tourist benefits of time with family and swimming on Google SketchUp (RQ4: Step 2). Clear ocean water, sandy beaches, and a natural setting can all be seen in the geolocated reference plane (Figure 17).

(a)



(b)

Figure 17: On Google SketchUp, a geolocated planar map of a section around Palma was used as the modeling basis. Figure 17(a) shows the sewage pipe headed towards the seagrass meadows, while Figure 17(b) shows the unregulated anchoring in another area of seagrass meadows. Both have 3D models of the seagrass meadows, the relevant pressure for the area, as well as the tourist benefits of the ecosystem services provided by the natural capital stock of seagrass meadows.

After modeling the seagrasses, benefits, and pressures on Google SketchUp, I uploaded them to Google Earth (RQ4: Step 3) (Figure 18). The spatial distribution including sample areas of 3D seagrasses, 3D tourist benefits, and 3D modeled pressures with placemarked points are all available on the same view.

Figure 18: The third step of communicating information with Google Earth and SketchUp involves exporting the models from SketchUp to Earth. The 3D models from Figure 17(a) and (b) were exported to the Google Earth file in Figure 16. In the forefront of the image, the seagrass meadows can be seen in close proximity to the sewage pipes with the dumping sites buried in the meadows, and the unregulated anchoring sites can be seen in the background.

Google Earth can be used to communicate where the seagrasses are in abundance and to designate no-dumping zones and no-anchoring zones. The software can be used to also identify areas that need more personnel for enforcing regulations, or more regulations. The necessary responses can be better understood with the visual, interactive representations.

6 Discussion

The most important benefits for tourists on Mallorca are clear ocean water, sandy beaches, natural setting, time with friends or family, and swimming, and are the benefits tourists would not return to Mallorca without. 5.83 - 6.49 billion EUR could be lost annually, if tourists decided not to come back to Mallorca because the benefits they received from seagrass meadows were no longer available. To conserve the seagrasses, the three-part response for the two top pressures of urban sewage and boat anchoring includes technological improvement, increasing awareness, and governmental regulation. The respective responses for each pressure are as follows: for boat anchoring – mooring buoys, a boaters COC, and no-anchor zones; for urban sewage – mechanical filtration on site, informed planning for dumping sites, and protection of vulnerable areas. In order to better communicate the information, I used Google SketchUp and Google Earth to model the relevant data of natural capital, ecosystem functions, tourist benefits, and pressures.

6.1 Why are seagrass meadows important to Mallorca?

6.1.1 Important tourist benefits

The tourists ranking of benefits was also not exclusive to my survey population: for Australia's Great Barrier Reef (GBR), one study shared the benefit of top tourist importance as clear ocean water (Esparon, Stoeckl, Farr, & Larson, 2015), while fish (variety and abundance), beaches, water clarity, and the natural setting were also within the top six themes for Stoeckl, Farr, and Sakata (2013). However, the other benefits that were ranked highly in my survey for tourists to Mallorca such as time with friends and family were low in the GBR, while in the open answer section of my survey proximity to home was higher on the list but the lowest for tourists to the GBR. These differences reflect a different type of tourist, but also show that there is a consensus in the benefits listed in tourist surveys.

The benefits tourists found important support conservation from a different angle than what is suggested by a pure scientific focus. The Total Economic Value framework is a common method for valuing ecosystems, as seen in other coastal ecosystem valuation studies promoting conservation (Carandang et al., 2013; Ressurreicao & Giacomello, 2013; Subade, 2007). In my study, of the seven benefits ranked with high importance, the top six are direct use benefits. For my survey, of the responses qualifying as "high importance", 7 out of 21 of the benefits occupy over 50% of the responses (Figure 19).

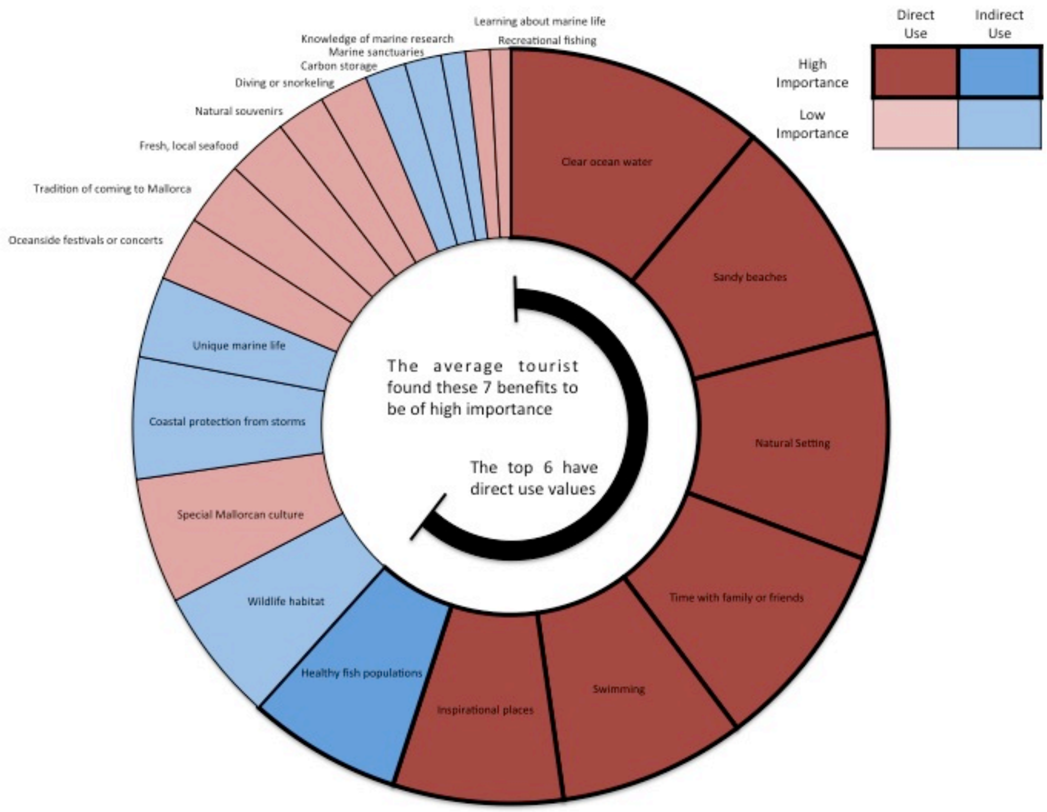


Figure 19: The direct and indirect use values are shown in red and blue, respectively, to illustrate the distribution within the benefits. For each benefit, the ratio of the responses rated with a high importance (Very Important or Extremely Important) was used; the section area of the donut is representative of the benefit's relative ratio. This means that the donut represents the number of responses rating a benefit with high importance, and each section is the relative chunk of high importance responses of all of the high importance responses.

The type of benefits tourists rank as of high importance is relevant when it comes to package we convey the information in for stakeholders. Even though my survey focused on use benefits in general, there was still a heavy predisposition towards the *direct* use benefits specifically. As the valuation should be understood by varying stakeholders such as the governmental body, boaters, and the water treatment plants, it is necessary to focus on a relevant understanding of the value of the seagrass. Ressurreicao and Giacomello (2013) in their study of seamounts in Azores, Portugal to support conservation and sustainable management of the region only focused on monetarily valuing direct use values to "explicitly identify the overlapping interests of multiple users" (Ressurreicao & Giacomello, 2013, p. 215).

6.1.2 Economic worth

The economic valuation of tourists who would not return to Mallorca if the benefits were no longer available has a negative effect on the sustainability of the tourism industry of Mallorca. Considering that a moderately optimistic scenario predicts a deterioration of seagrasses by 2049, it should be in the serious interest of Mallorca to conserve the ecosystem that fuels at least 85% of its GDP, as cited in Hoti, McAleer, and Sanso (2005). However, costs for environmental conservation are more accounted for than the benefits, creating a mismatch in how ecosystem services factor into cost-benefit analyses on a larger level (Thrush et al., 2013). Therefore, especially in areas whose environment is the backbone of the economy, a comprehensive economic valuation is pivotal. Environmental degradation will impact tourism, and which in turn will impact the livelihoods of residents. If governments are aware of the importance of values to the people, they are more willing to spend money and resources consistently for conservation (Subade, 2007).

6.2 How can we champion conservation?

6.2.1 Identification of responses to seagrass decline

The no-regret measures for urban sewage and boat anchoring involve raising awareness of where the dumping sites are in relation to the seagrasses and a COC for boating, respectively. I recommended using mapping software to help stakeholders understand their socio-economic context in relation with the ecological one to adjust the dumping sites, as mapping has been used as a tool for ecological sensitivity analysis in an area with eco-tourism (Hai-ling, Liang-qiang, & yong-peng, 2011). In Australia, a COC was suggested for seagrasses, as it has existed for coral reefs since 1987 (Francour et al., 1999). However, such a COC has yet to be established and promoted in, and in Mallorca, it does not exist at all.

The simplest (in terms of direct impact) pressure of the two is boat anchoring, and the COC could have a more immediate effect than first raising awareness and then changing the dumping sites from piping the sewage in Palma to trucking, for example. By raising awareness for the boaters, a behavioral change could have an immediate and direct effect on anchoring in seagrass meadows. A Boaters' COC is a low-cost measure that supports general environmental awareness while highlighting the importance of seagrasses. It also puts responsibility in the hands of the user by providing ethical guidelines for best practice. In a study where user behavior complied where the COC 100% when dealing with endangered species, the COC was clear and "not open to interpretation" (Smith, Scarpaci, Scarr, & Otway, 2014). The COC for boaters around seagrass areas in Mallorca should also be clear, specific, and actionable. A conduct with well-rounded features of the Blue Flag themes but with specific actions from the UVSNW would be preferable. It is necessary for boaters to understand that it is ultimately both their decision and responsibility to not destroy the meadows. Especially if the boating is done for tourist purposes, the lack of sustainability of the practice means that the tourists may not return in the future if the seagrasses can no longer perform their services, potentially putting them out of business.

The governmental regulation can be assisted with the help of Google Earth. Balaguer et al. (2011) used GIS to map the anchoring around Mallorca, and if the data was uploaded onto Google Earth's online database then policymakers could use it to identify areas to allocate resources (personnel for enforcing restrictions). An accessible map of the dumping sites and sewage pipelines juxtaposed with the seagrass distribution would help urban planners adjust the dumping sites. As there are areas where there are no seagrasses, dumping points can be moved (the sewage could for example be trucked instead of piped).

The technological improvements are again more complicated for urban sewage than the boat anchoring. While mechanical on-site filtration at the water treatment plant is not complicated in itself, it involves larger actors (government regulation, sewage plant cooperation) while the implementation of mooring buoys has been already surveyed to be an acceptable change.

By mitigating all of these individual pressures on a local level, we also mitigate climate change on a global level, and adapt to it. If we increase water treatment, this could lead to a better usage of water on land, which is climate change adaptation since Mallorca has increasing issues with water resources (MEDIS, 2005) due to climate change (Hof & Blazquez-Salom, 2015). From a broader perspective, by implementing seagrass conservation measures we preserve the stored carbon stocks within the sea meadows, ultimately contributing to climate change mitigation on a global level.

6.2.1.1 *A critique of the responses*

Low cost, no-regrets measures can be the first step towards conserving seagrasses. However, as they are often in the 'raising awareness' category, they are also chronologically out of order. If we could tackle the pressure at their root – mechanical on-site filtration for urban sewage and mooring buoys for anchoring – it would be more effective. However, with limited resources in governments, the easiest and cheapest options with limited consequences, namely 3D modeling and mapping urban sewage pathways alongside seagrasses and a code of conduct, are more feasible.

6.2.2 *Communicating the complexity of seagrass decline*

Operationalizing ecosystem services is gaining attention, but the pivotal step of communication has yet to be mastered. Daily et al. (2009) presents a framework for putting ecosystem services into action, of which one piece is the bridge between values and institutions, and how influencing the institutions is a great challenge. A simple search of the document, however, reveals that the word "communication" or any form of it does not appear. In my opinion, this is the missing link. While the assessments and decisions are all important, the communication of information is vital. This is where my thesis goes beyond the normal conclusion of identifying responses to pressures: it proceeds to provide a way to communicate not only the response, but the information the response is founded upon.

Scientists have already conducted research regarding the distribution of meadows (Short, Carruthers, Dennison, & Waycott, 2007), the ecosystem services they provide (Barbier et al., 2011; Duffy, 2006; Vassallo et al., 2013), and the pressures that are affecting them (Borum et al., 2004). However, seagrasses are still invisible, both physically and socially; seagrasses are less covered in media, academia, and society than their fellow coastal ecosystems such as mangroves or coral reefs (Orth et al., 2006). In terms of resources for urban planners, there is not a single seagrass-related map, whether distribution or otherwise, available on Google Earth for the Balearic Islands. Comparatively, forests have their own Google Earth Engine for detecting loss and change (Engine, 2012) as well as a 3D Trees plugin for seeing different species (including mangroves) in cities around the world (Earth). The UNEP Environmental Change Hotspots Map added in 2014 does not list the seagrass meadows in the Balearic Islands, nor does it have a water quality monitoring station. In addition, existing research such as the development of spatial scenarios for anchoring around Mallorca is not open-access; instead, it costs $35.95 to purchase the PDF containing the information that could help focus energies to better regulate anchoring in seagrass meadows (Balaguer et al., 2011).

The necessary responses (identified by RQ3) can be conveyed directly as recommendations, but for a more holistic understanding of the situation, I used Google Earth and Google SketchUp to model the ecosystems, services, benefits, and pressures, following the CICES framework (Figure 20). This allows stakeholders (such as planning officials for dumping sites, the water treatment plants, recreational boaters themselves, and the general environmental planning organizations) to understand the context and make educated decisions.

Researchers and scientists can use Google Earth and 3D modeling as a means to go beyond the traditional academic means of communication, such as papers or posters, and even do more than posting their findings on social media outlets where the results are more accessible.

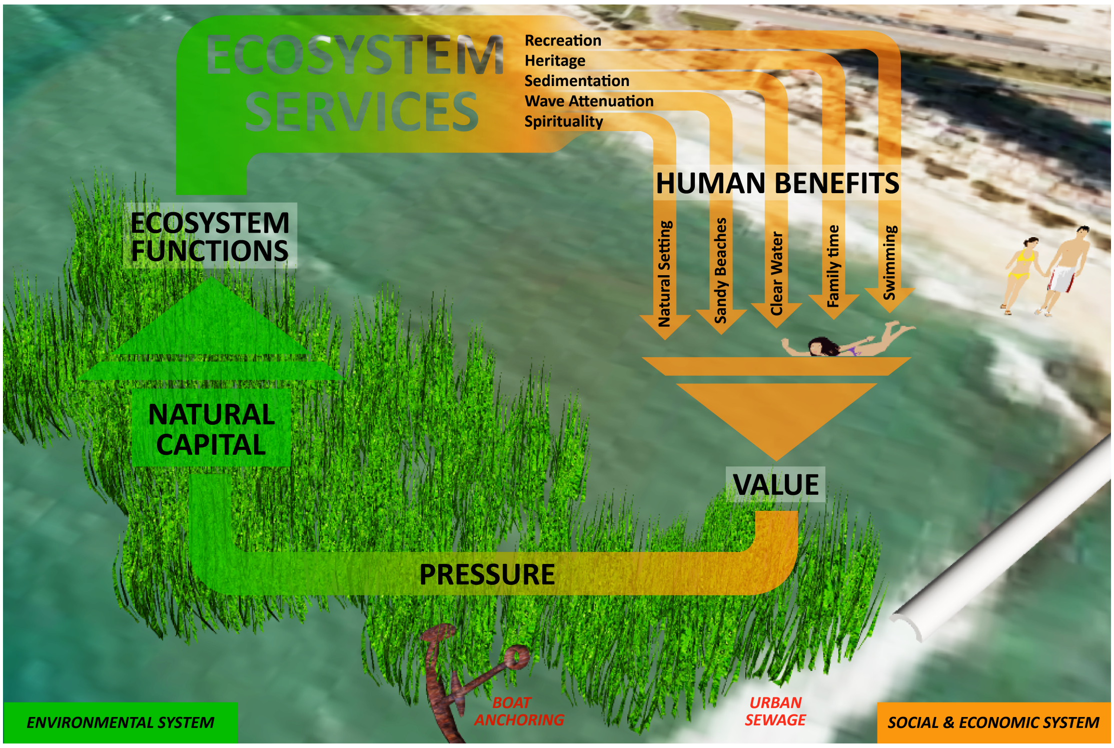


Figure 20: The final Google Earth output following the CICES framework. The natural capital is brought above the surface so it is visible in all its vastness, and the ecosystem service benefits for humans which are highly valued are understood all on the same page. The pressures are also brought to life to help connect activities to their destructive impacts on the natural capital, and the loop continues.

The 3D functionality of Google Earth adds a dynamic component. 2D, static maps have the issue of having to select which features to display at one time, which is a result of limited resolution and only so much space on the map (Hauck et al., 2013). Google Earth is able to turn on and off layers as they are needed, including the functionality to show administrative boundaries to both facilitate regional planning but also zoom out to the larger picture and avoid downstream consequences. The 3D models from SketchUp (or other CAD softwares) can be used where Google Earth is active, and even if it isn't then Google SketchUp can be used to develop the models of ecosystem services and put onto an image of the land taken, either through another GIS software or a simple picture. However, this sort of modeling is not fit for every situation. In particular, when highlighting intangible services Google SketchUp is limited. What it can do, however, is bring to life and thus raise awareness of how the ecosystem around us provides the necessary services for us to enjoy and increase our own wellbeing.

The interface of Google Earth is user-friendly and accessible, characteristics that are necessary to avoid confusion and help law-making stakeholders understand (Cowling et al., 2008). While the case of seagrass decline in Mallorca was used for exemplifying the tool of Google Earth and Google SketchUp, the accessible tools can be used for supporting ecosystem-based management in general. The ecosystem service framework is largely developed from an academic perspective while its use is intended for a more transdisciplinary audience (Thrush et al., 2013). Therefore, we should use tools for communication that reflect the audience and not the creators.

6.3 Data Collection & Economic Calculation Limitations

The impact of the calculations, while still relevant for policy recommendations, should take into account the sample population. The sample size and tourist types are shortcomings in the data. The sample size was 73 individuals, drawn from various sites on the coast of Mallorca, and the main obstacle encountered was finding tourists seated and willing to participate in a survey during their vacation. The bus stations were the most fruitful, creating a bias in the type of tourist surveyed – tourists using public transportation. Therefore, adjustments should be made to the data to include estimations for the sample size and its representativeness of the average tourist profile.

The tourist data gathered from the survey was compared to the official statistics from Balears (2014b) (Table 8). The largest discrepancy (25%) lies in the age group of 15-24, where 35.6% of the individuals I surveyed were in this age group while the group occupies only 10% of the official statistics. A possible explanation for this is that I both approached individuals and conducted the survey in English, and younger tourists were more likely to be more competent in English than their older counterparts. This explanation is supported by the nationality demographics, where the number for English speaking tourists from the UK is very close to that of the official statistics, while the German population is not as represented in my sample.

Table 8: A comparison of my survey demographics to official statistics from Balears (2014b). The age and nationalities are compared to gauge the representativeness of my sample.

Age	Survey Data	Official Statistics
under 6	0%	3.0%
6-14	13.7%	5.2%
15-24	35.6%	10.0%
25-44	37.0%	40.5%
45-64	21.9%	33.8%
over 64	4.10%	7.6%

Nationality	Survey Data	Official Statistics
UK	24.7%	23.8%
Germany	20.5%	32.6%

In an attempt to align the collected data with official statistical data, the average tourist expenditure was calculated. My calculated average tourist expenditure was 136.96 EUR from Section #6 of my survey, which is 24% higher than the official statistic of 110.84 EUR in July of 2014 (Balears, 2014a). However, the primary data must be adjusted due to the fact that the responses to the cost section of the questionnaire were mostly projections; tourists had not yet completed their visit and therefore were projecting their future expenditure for their trips.

6.4 Synthesis

As carbon storage had the lowest importance ranking for tourists who came to Mallorca, will a promotion of seagrass' carbon sequestration capabilities really improve their conservation status? My answer is no. However, tourists are responsive to their destinations, especially for locations like Mallorca. As tourists' economic value is in the billions, a decline in tourism would cripple the economy of Mallorca. It was evident from my observations during the administration of my survey that tourists come to Mallorca not to think, but to relax. The sentiment I gathered was that the tourists did not want to be bothered by questions or learning experiences, observed in my survey when "Learning about ocean life" ranked second to last in terms of importance. Therefore, we should market conservation for its buyers: the public, not the scientific research community. Rather than focusing on the importance of seagrasses for carbon storage, the benefits people receive such as clear water and sandy beaches should instead be emphasized in order to achieve conservation objectives.

These findings can be extrapolated beyond the case of the seagrasses of Mallorca. If there is a significant use value of an ecosystem, the connection between the human benefit and the ecosystem itself should be highlighted and advertised instead of values that humans do not interact with or experience. Google Earth and Google SketchUp can bring the CICES framework to life by incorporating both the environmental and social systems. The CICES framework can be used as a guide to translate functions of the natural, environmental system to the social and economic system, and scientists should formulate their findings in a way that reflects what is important to the actors responsible for making change happen.

7 Conclusion

Currently, the OPERAs exemplar is focusing on quantifying the carbon sequestration of seagrass meadows to conduct a cost-benefit analysis and support conservation measures. While this supports the environmental argument, prominent economic sectors and social impacts should also be taken into account, and may even prove to be a more convincing argument for policymakers. The tourism sector has great economic power in Mallorca, and tourists can thus be seen as transient stakeholders, and their values should be considered when when drafting responses.

This study shows that tourists highly value benefits of seagrasses and would not return if the benefits, such as clear ocean water and sandy beaches, were longer available. The tourist values have a projected economic worth of 5.83 – 6.49 billion EUR per year, and a change in tourist behavior (e.g., not returning to Mallorca) could have a crippling effect on the Mallorcan economy. This paper presents the economic shortcomings of the depleting stock of seagrass meadows, and recommends policymakers to invest in responses to the pressures of urban sewage and boat anchoring. No-regrets responses include raising awareness of the dumping sites and their impact on the seagrass meadows through 3D mapping software and implementing a boater’s code of conduct, respectively. Alongside the responses, I also used Google Earth and Google Sketchup to map and model the elements of the issue of seagrass decline by following the cascade model: the seagrasses themselves as natural capital, the ecosystem services they provide, the benefits humans receive, and the pressures we exert back on the ecosystem.

As I am determined to make my research applicable, I hope a scientist looks through my findings, thinks “oh, what a pretty picture”, and is inspired to communicate their research through a medium that speaks a thousand words without a single one.

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9 Appendix A: Edited tourist response for word cloud

For RQ1, I edited the responses of tourists to align sentiments and have a more powerful visualization. The original response is in the column on the right, while the edited response is in the left column.

Original Response	Edited Response for Word Cloud
Coastal Beaches	Beach
Coastline	Coast
Cheap	Price
Seaside	Coast
Seaside	Coast
Beaches	Beach
Warm weather	Weather
Heat	Weather
Near	Distance
Distance to Germany	Distance
Proximity to Barcelona	Distance
Affordable	Price
Sunshine	Sun
Many beautiful places to visit.	Beautiful place to visit
Relaxing	Relax
Relaxation	Relax
girls	Women
RyanAir	Price
Reasonable flying distance	Distance
Good value for money	Price
Good weather	Weather
hot	Weather
Saw it online, looked cheap	Price
Sun the whole day	Sun
climate	Weather
distance from UK	Distance
Sunny	Sun
Vacation	Holiday
Nice landscape	Landscape
Weather - heat	Weather
cheaper than other islands	Price
White beach	Beach

10 Appendix B: Tourist Data

The data regarding the tourist profile from Balears (2014a)

Number of Tourists	2014 Total		July 2014 Total	
	Balearic	Mallorca	Balearic	Mallorca
TOTAL (1 + 2)	13575260	9672852	2442948	1627509
1. SPAIN	2208022	1090938	374102	146662
2. FOREIGN	11367238	8581914	2068846	1480847
(102) Austria	198210	175530	33859	28552
(110) France	483809	328893	76722	44465
(113) Ireland	125214	100061	25499	19227
(115) Italy	628709	165762	152991	41808
(125) United Kingdom	3385160	2165780	639760	387564
(126) Germany	4142955	3731467	598824	530727
(132) Switzerland	403177	334875	88336	67655
Belgium, Luxembourg and the Netherlands	594523	366144	120408	70117
Nordic countries	798640	758940	207248	196109
Rest of the world	606841	454461	125199	94623

Average daily expenditure (EUR/tourist/day)	2014 Total		July 2014	
	Balearic	Mallorca	Balearic	Mallorca
TOTAL (1 + 2)	107,96	107,69	112.69	110.84
1. SPAIN	94,98	92,82	114.58	110.06
2. FOREIGN	110,33	109,48	112.39	110.91
(125) United Kingdom	105,04	105,95	104.53	99.96
(126) Germany	104,78	104,34	102.47	102.80
Rest of the world	120,33	119,00	124.89	125.38

Total Tourist Expenditure (thousands EUR/year)	2014 Total		July 2014	
	Balearic	Mallorca	Balearic	Mallorca
TOTAL (1 + 2)	12016073	8607415	2240455	1516645
1. SPAIN	1634568	794489	305380	117920
2. FOREIGN	10381505	7812926	1935075	1398725
(125) United Kingdom	2800893	1813894	530076	324282
(126) Germany	3590046	3244956	511450	455327
Rest of the world	3990566	2754076	893549	619117

11 Appendix C: RQ2 Complete numbers for Economic Worth

Factors	Ratio	Expenditure (thousands of EUR/year)	Losses (thousands of EUR/year)
Sandy Beaches	0.753846154	8,607,415	6488666.692
Swimming	0.753846154	8,607,415	6488666.692
Clear Ocean Water	0.738461538	8,607,415	6356244.923
Natural Setting	0.707692308	8,607,415	6091401.385
Time with Family	0.676923077	8,607,415	5826557.846

12 Appendix D: Tourist Survey

Values of Visitors to Mallorca

My name is Shrina Kurani, and I am conducting research as a Master's student from Lund University, Sweden. I am interested in values of visitors to Mallorca as part of a European research project, OPERAs. The survey should take less than 10 minutes.

Your participation is voluntary and your information will be treated confidentially.

For any questions about the survey, please contact me at shrina.kurani@gmail.com

Thank you for your time!

* Required

Demographic Information

1. **What is your age? ***
   (in years)

   ....

2. **What is your gender? ***
   Mark only one oval.

   ◯ Male
   ◯ Female
   ◯ Other / prefer not to state

3. **In what city do you live? ***

   ....

4. **In what country do you live? ***

   ....

5. **What is the highest level of education you have completed?** *
   Mark only one oval.

   - ( ) Primary school
   - ( ) High school/secondary school
   - ( ) Vocational/technical studies
   - ( ) Bachelor's degree
   - ( ) Master's degree
   - ( ) Advanced degree (e.g., MD, PhD, JD)
   - ( ) Other: ______________________

About your stay on Mallorca

6. **Where did you stay on Mallorca?** *
   Check all that apply.

   - [ ] Palma
   - [ ] Magaluf
   - [ ] South West (except Magaluf)
   - [ ] Tramuntana (North West)
   - [ ] North East (Alcudia and Pollença)
   - [ ] Alcudia Bay
   - [ ] East Coast
   - [ ] South East
   - [ ] South
   - [ ] Arenal
   - [ ] Inland
   - [ ] Other coastal region
   - [ ] Other mountainous region

7. **How many nights are you staying on Mallorca?** *

   ____

8. **How many people are you traveling with on Mallorca, including yourself?** *

   ____

9. **Who are you traveling with? ***
   Check all that apply.

   - [ ] Self
   - [ ] Family
   - [ ] Friends
   - [ ] Work colleagues
   - [ ] Tour group
   - [ ] Other: ____________

10. **How many times have you been to Mallorca, including this visit? ***

    ____

In your own words, what are the three most important reasons you come to Mallorca?

11. **Reason 1 ***

    ____

12. **Reason 2 ***

    ____

13. **Reason 3 ***

    ____

Feature rating

In this section, you are asked to rate each of the features in the following table in regards to their importance to you on your visit. The level of importance increases from left to right.

14. **How important are the following features to you on your visit to Mallorca?** *
Mark only one oval per row.

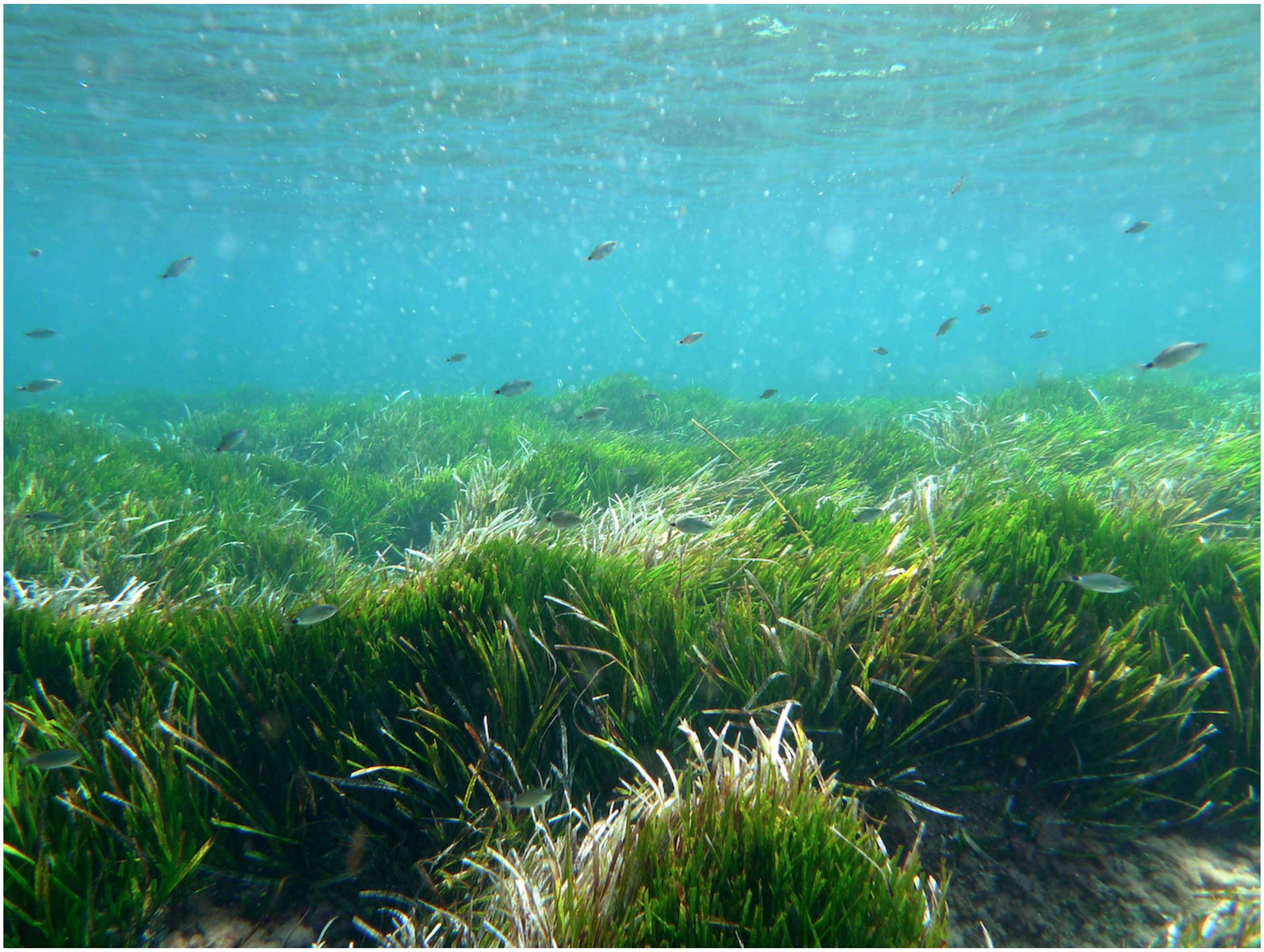
	Not at all important	Slightly important	Somewhat important	Very important	Extremely important
Fresh, local seafood	⬭	⬭	⬭	⬭	⬭
Natural souvenirs from Mallorca	⬭	⬭	⬭	⬭	⬭
Carbon storage	⬭	⬭	⬭	⬭	⬭
Clear ocean water	⬭	⬭	⬭	⬭	⬭
Coastal protection from storm damage	⬭	⬭	⬭	⬭	⬭
Sandy beaches	⬭	⬭	⬭	⬭	⬭
Marine wildlife habitat	⬭	⬭	⬭	⬭	⬭
Healthy fish populations	⬭	⬭	⬭	⬭	⬭
Natural settings	⬭	⬭	⬭	⬭	⬭
Inspirational places	⬭	⬭	⬭	⬭	⬭
Special Mallorcan marine life	⬭	⬭	⬭	⬭	⬭
Recreational fishing	⬭	⬭	⬭	⬭	⬭
Knowledge of local marine research	⬭	⬭	⬭	⬭	⬭
Learning about ocean life	⬭	⬭	⬭	⬭	⬭
Diving or snorkeling	⬭	⬭	⬭	⬭	⬭
Swimming	⬭	⬭	⬭	⬭	⬭
Oceanside festivals or concerts	⬭	⬭	⬭	⬭	⬭
Marine sanctuaries	⬭	⬭	⬭	⬭	⬭
Cultural traditions of coastal Mallorca	⬭	⬭	⬭	⬭	⬭
Spending time with family	⬭	⬭	⬭	⬭	⬭
Tradition of coming to Mallorca	⬭	⬭	⬭	⬭	⬭

About Seagrass Meadows

15. **Are you aware that there are underwater seagrass meadows surrounding Mallorca?** *
Pictures of the seagrass meadows underwater and on the beach are pictured below
Mark only one oval.

⬭ Yes
⬭ No *Skip to question 17.*

Seagrass meadows underwater



Seagrass meadows on beach

Skip to question 17.

16. **Are you aware that the following benefits are provided by seagrass meadows? ***
Mark only one oval per row.

	Yes	No
Fresh, local seafood		
Natural souvenirs from Mallorca		
Carbon storage		
Clear ocean water		
Coastal protection from storm damage		
Sandy beaches		
Marine wildlife habitat		
Healthy fish populations		
Natural settings		
Inspirational places		
Special Mallorcan marine life		
Recreational fishing		
Knowledge of local marine research		
Learning about ocean life		
Diving or snorkeling		
Swimming		
Oceanside festivals or concerts		
Marine sanctuaries		
Cultural traditions of coastal Mallorca		
Spending time with family		
Tradition of coming to Mallorca		

Returning to Mallorca

17. **Would you return to Mallorca? ***
Mark only one oval.

- Yes *Skip to question 23.*
- No *Skip to question 18.*

Travel Costs

18. **What was your roundtrip travel cost to get from your home to Mallorca and back?**
(in Euros, per person)

....

19. **What is the cost for accommodation per night for your stay on Mallorca?**
(in Euros, per night)

....

20. **What is your average daily food expense for your stay on Mallorca?**
(in Euros, per person)

21. **What is your total activity/leisure cost for the entire length of your stay on Mallorca?**
(in Euros, per person)

22. **What is your total cost for water related activities (such as diving, snorkeling, sailing, cruise boat, or on the beach) for the entire length of your stay on Mallorca?**
(in Euros, per person)

Skip to question 24.

23. **For each of the features listed below, would you still return if it were no longer available on Mallorca?**
A "No" answer means you would not return if this feature were no longer available, and a "Yes" answer means you would return even if this feature was no longer available
Mark only one oval per row.

	No	Yes
Fresh, local seafood		
Natural souvenirs from Mallorca		
Carbon storage		
Clear ocean water		
Coastal protection from storm damage		
Sandy beaches		
Marine wildlife habitat		
Healthy fish populations		
Natural setting		
Inspirational place		
Special Mallorcan marine life		
Recreational fishing		
Knowledge of local marine research		
Learning about ocean life		
Diving or snorkeling		
Swimming		
Oceanside festivals or concerts		
Marine sanctuaries		
Cultural traditions of coastal Mallorca		
Spending time with family		
Tradition of coming to Mallorca		

Skip to question 18.

Thank you

Thank you for your time and energy. I greatly appreciate your participation in this research!

24. **Please check the appropriate boxes if you would like to receive a copy of the completed paper and/or be contacted for a follow-up study.**
Check all that apply.

- [ ] I would like to receive a copy of the completed Master's Thesis from Lund University resulting from this research.
- [ ] I can be contacted for a follow-up study in the future.

25. **If you checked either of the above boxes, please provide your email below.**

....

PLEASE BE SURE TO CLICK "SUBMIT" BELOW FOR YOUR ANSWERS TO BE COUNTED IN THIS RESEARCH

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