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NATURAL CAPITAL ACCOUNTING

PILOT STUDY IN A PROTECTED MARINE AREA IN THE BALEARIC ISLANDS

Project	EU Interreg- MPA Networks
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Authors	Ecoacsa Reserva de Biodiversidad, S. L. Sofía Zerbarini, Julen González Redín, David Álvarez García, Jesús Carrasco Naranjo CentroBalear de Biología Aplicada, S. L. (CBBA) Benjamí Reviriego eftec Ian Dickie, Guillermo García
Text revision	Paz Ferrer Calvo, Ecoacsa Reserva de Biodiversidad, S. L.
INTERREG MPA NETWORKS Leading Partner	MEDPAN
Spanish Project Partner	Fundació Marilles
Director	Aniol Esteban Claret
NCA Pilot action Coordinator	Antoni Font Gelabert

Executive summary

This document details the results of the **pilot study** carried out as part of the MPA Networks Project, funded by the European Regional Development Fund through the Interreg instrument and coordinated by MedPAN, the Mediterranean Network of Marine Protected Areas. The objective of the MPA Networks Project is to contribute to the effective management of marine protected areas of the Mediterranean.

This pilot study pursues the development of a natural capital accounting system applied to a Marine Protected Area (MPA) in the Balearic Islands (Spain) —the **marine reserve of fishing interest *Llevant* de Mallorca-.** The analysis carried out has allowed the identification, quantification and monetization of the natural assets and ecosystem services (SE) of the study area, which allows the development of a natural capital accounting model that can be used to inform those responsible for marine conservation policies in the region in an efficient and robust way .

A. In section 3, a **pre-identification, identification and ranking** of the natural assets and ecosystem services of the study area is conducted, through a process *of bibliographic review of scientific articles, extensive consultations with experts of the project team* and *consultations with local external agents and experts* in different areas of knowledge. As a result,15 different habitat assets (benthic and pelagic) were identified, as well as four different asset groups for species (fauna and flora) and two other independent assets (waters and seascapes). Regarding ecosystem services, of the 90 ecosystem services contained in the CICES list, a total of 30 services were pre-identified and, of these in turn, a total of 18 services were finally selected, which were categorized into nine groups of ecosystem services: two provisioning services ('aquatic animals for nutrition' and 'Posidonia remains'), four regulation services ('Improvement of water quality', 'Protection of Coast Erosion', 'Biodiversity protection' and 'CO_2 Capture') and three cultural ('Active or passive recreational activities', 'Scientific research and education', 'Value of existence, option and legacy').

B. In section 4, **the accounts of the extent and condition of natural assets (*stocks*)** of the study area have been developed, including biophysical information of natural assets. In particular, there are specific details on extension (extension accounts) and condition (condition accounts) of the habitats, as well as the status / condition of the species (biotic asset accounts), based on *cartographic information and bibliographic review*.

C. In section 5, **physical accounts of the ecosystems (flows)** have been developed. The annual flow of ecosystem services provided to society by the study area has been measured in biophysical units. For this purpose, *cartographic information* and *field information* through interviews with local agents and *data from open sources of information* have been used.

D. In section 6, the **monetary accounts of ecosystems (flows)** have been developed. The results show the monetary value of the ecosystem services identified through different valuation methods and economic information specific to the study area. In addition, a specific methodology has been developed and applied that allows assigning a degree or level of (un) certainty to each applied valuation method, in an exercise of transparency and good practice.

E. In section 7, the **maintenance costs** of the study area have been calculated. A protected marine area, in addition to providing benefits to society, has costs derived from the maintenance necessary for the reserve to remain in a favorable state. Through a *bibliographic review*, we have had access to all the budgets associated with the marine areas of the Balearic Islands. Among the maintenance costs identified and applied, are those associated with the Surveillance Service belonging to the Balearic Islands Autonomous Government, an additional surveillance team dependent on the General Secretariat for Maritime Fisheries (SGPM) of the State Government, the Monitoring of Fish Populations at the regional level and the Program of Assistance to Anchoring for recreational boats, to protect posidonia meadows.

F. In section 8, a **Natural Capital Balance Sheet** of the marine protected area *Llevant, has been generated* based on the Balance Sheet *eftec Natural Capital Account Template*. In summary, the following table represents the Balance Sheet of Natural Capital resulting from the analysis carried out, which shows the ecosystem services, their physical and monetary flow, their present value, maintenance costs and, finally, the Total Net Value of Natural Capital in the study area.

Ecosystem services	Physical flow (units / year)		Monetary flow (EUR / year)	Present value (60 years)
2018				
Benefits				
Aquatic animals for nutrition (1.1.6.1)	7,421	Kilograms	129,646	3,400,426
Posidonia remains (1.1.5.1 and 1.1.5.2)	800	Kilograms		-
Improvement of water quality (2.1.1.2 and 2.2.5.2)	3,951	Hectares	211,349	5,543,359
Protection from coastal erosion (2.2.1.1 and 2.2.1.3)	3,951	Hectares	772,547	20,262,735
Maintenance of biodiversity (2.2 .2.3)	19,271	People	447,313	11,732,344
CO_2 capture (2.2.6.1)	3,866	Tons of CO_2	19,331	507,012
Active or passive recreational activities (3.1.1.1, 3.1.1.2., 6.1.1.1)	384,143	Number of users	3,141,440	82,395 .189
Scientific research and education (3.1.2.1, 3.1.2.2, 6.2.1.1)	3	Number of projects	104,892	2,751,150
Gross natural capital assets			**4,826,518**	**126,592,216**
Liabilities				
Maintenance costs			476,137	12,488,344
Net natural capital assets			**4,350,381**	**114,103,872**

G. Section 9 shows a **compilation of aspects to improve, and future recommendations.** Indeed, thanks to this study we are able to know in detail the accounts of the natural capital of a Marine Protected Area in the Balearic Islands. This work can be used as a guide for local and regional decision-making regarding the management of protected marine areas. In parallel, the work carried out has allowed lessons to be learned by overcoming different barriers and limitations. Therefore, certain parts of the study are subject to future work that will allow its expansion and improvement.

Index of contents

Index of acronyms

CAIB: Autonomous Community of the Balearic Islands

CCN: Natural Capital Accounting (spanish acronym)

CICES: Common International Classification of Ecosystem Services

CNCA: Corporate Natural Capital Accounts

CSIC: Spanish Higher Scientific Research Council

EEA: European Environment Agency

ES: Ecosystem Service(s)

GIS: Geographic Information Systems

IEO:Spanish Institute of Oceanography

KIP-INCA:Knowledge Innovation Project on Integrated Systems for Natural Capital and Ecosystem Services Accounting in the EU

MITECO: Ministry for Ecological Transition and Demographic Challenge

MPA: Marine Protected Area

NCA: Natural Capital Accounting

NCAVES: Natural Capital Accounting and Valuation of Ecosystem Services

RMLL:Joint Levante de Mallorca-Cala Rajada Marine Reserve and Marine Reserve *Llevant* de Mallorca.

SCN: System of National Accounts

SE: Ecosystem Service (s) (Spanish acronym)

SEEA: System of Environmental Economic Accounting

SEEA-CF: System of Environmental Economic Accounting-Central Framework

SEEA-EEA:System of Environmental Economics Accounting-Experimental Ecosystem Accounting

SEO: Spanish Ornithological Society

SGPM: General Secretariat for Maritime Fisheries (spain)

UNSD: United Nations Statistics Division

WAVES: Wealth Accounting and the Valuation of Ecosystem Services

MPA Networks Project - EU Interreg

The MPA Networks Project, funded by the European Fund for Regional Development through the Interreg instrument, encompasses 10 organizations belonging to seven countries of the Mediterranean Basin. The project is coordinated by MedPAN, the Mediterranean Network of Marine Protected Areas. Created in 2008, the 63 member organizations and 51 associations from 20 countries belonging to MedPAN have the objective of strengthening marine protected areas in the Mediterranean.

The MPA Networks Project aims to contribute to the effective management of marine protected areas in the Mediterranean, proposing solutions for sustainable financing, for the sustainable management of small-scale fisheries and alsofor the conservation of mobile species.

The actions proposed in the framework of this project focus on strengthening networking, information exchange and analysis of the experiences on the ground in the different marine protected areas under study, with the purpose of designing proposals that improve the effectiveness in their management. The recommendations proposed from this project are aimed at supporting policy improvements at the international, European and national levels.

1. Introduction: marine protected areas and natural capital approach

Marine Protected Areas (MPAs) are areas of sea and coast that are protected and managed due to their ecological importance. MPAs protect marine life while ensuring the livelihood of fishers, stimulating the local economy and offering tourists the opportunity to rekindle their links with nature.

In marine waters, ecosystems and marine resources are under significant pressure. Human activities, as well as the effects of climate change and natural disasters, have a huge impact on marine ecosystems and the so-called blue economy. As a consequence, natural capital, formed by the reserves of natural assets that produce flows of goods and services for society, is being affected.

> **"MPAs provide benefits for the conservation of biodiversity**- they are a refuge for species, they prevent the deterioration of habitats, they allow the development of natural biological communities and they help to revitalize fish populations or degraded environments - **and for the development of local economies,** as they ensure the future of artisanal fishing and favor the development of economic activities for the benefit of local populations. »

The Balearic Islands are no exception. Despite the increase in the coverage of MPAs in the Mediterranean — recognized as an effective management and conservation instrument—, the objective of maintaining Balearic marine biodiversity is far from being fulfilled. Currently, MPAs have shortcomings in the provision of legal instruments and financial resources, which condition the availability of technical and human resources for their complete conservation and protection.

To respond to these economic, technical and management shortcomings, the Spanish Government includes objectives, challenges and budget items to address marine conservation, through the Recovery, Transformation and Resilience Plan (Government of Spain, 2021)..

Specifically, an important investment in the "digitization and knowledge of natural heritage" is expected, which will lead to a substantial improvement in the knowledge regarding species and habitats. Likewise, an investment is expected for "the conservation of terrestrial and marine biodiversity" and "the adaptation of the coast to climate change and implementation of marine strategies and plans for the management of maritime space", among other areas.

One of the main challenges and objectives of this plan is "the protection of the marine environment with the aim of achieving its good environmental status within the framework of the Law for the Protection of the Marine Environment." In parallel, objectives and challenges have been established for those sectors that currently exert a negative impact on the marine environment, such as fishing and tourism. The plan includes measures focused on "promoting sustainability, research, innovation and digitization of the

fishing sector", as well as the objective of "transforming the tourism model towards environmental sustainability".

In general terms, the first step towards sustainable management of marine natural capital is to recognize the value that the blue economy provides in the Balearic Islands. The blue economy is the system that integrates the importance of the seas and oceans, driving innovation and growth for the sustainable development of different sectors of economic activity related to the marine environment. Specifically, it contemplates activities such as fishing, aquaculture and the use of marine environments to generate renewable energy or tourism, among others.

A marine environment in good condition is essential for the Balearic blue economy and for the well-being of its citizens. As a whole, the coastal strip, with its beaches, clean waters and seabed, is the mainstay of many economic activities. Making visible this interdependence between marine waters, social welfare and the local economy, is essential to guarantee a sustainable future.

«**A fifth of the added value generated in the Balearic Islands archipelago is supported by the sea** (Fundación Impulsa, 2020), that is 5 billion euros through a business network of 6,511 companies employing a total workforce of 17.6% —more than a tenth— of the archipelago's business »

This interdependence can be identified, quantified and valued through the so-called natural capital approach. This approach is a new conception to evaluate the relationship of our society with nature, the advantages of which are shown in Figure 1. Among them, the possibility of integrating different elements associated with environmental management together with economic aspects stands out, allowing us to relate economic development with the conservation of natural marine heritage, through a sustainable model framework.

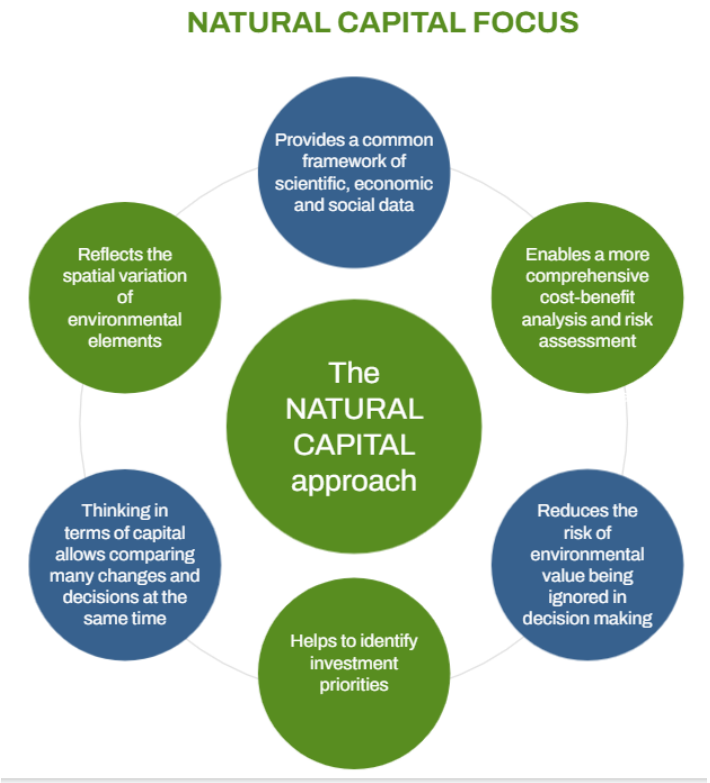


Figure 1. Benefits of the natural capital approach. Source: Own elaboration

As an integral part of this natural capital approach, natural capital accounting encompasses the evaluation of the extent, quality, quantity and value of natural assets and the ecosystem services that flow from them.

Accounting serves as a tool to help public and private actors better understand the interaction between economy and nature, and aims to recognize the contribution of the latter to social well-being. The concept of value is fundamental within accounting, since it implies the best integration of environmental and economic information, which corrects the historical trend of undervaluation and overexploitation of natural capital and ecosystem services, due to their "invisible" condition for the market economy.

> Natural capital accountability is especially relevant for the marine environment. Studies that compare the world's ecosystems' total value show the high relative value of coastal, marine and transition ecosystems, when compared to freshwater and land ecosystems.

Natural capital accounting is a useful instrument for making political and territorial decisions that affect the marine environment. In fact, statistical institutions recognize the importance of valuing ecosystem services and their environmental assets, as well as incorporating them, or at least linking them, to the System of National Accounts (SNA).

The application of natural capital accounting models provides information to decision makers, so that they may more easily consider how investment in environmental assets contributes to broader social objectives, as well as the management, mitigation or restoration actions that are necessary to avoid the deterioration of these assets. Similarly, accounting also helps to better understand how policies can have unwanted effects on the environment and lead to environmental externalities.

Other examples of the benefits of applying the natural capital approach and its accounting in territorial and political management are: the evaluation of "green" or "blue" solutions versus "gray" solutions (artificial engineering); understanding and managing mitigation actions associated with the different uses of the sea; providing solutions to floods and coastal erosion; designating new MPAs; the adoption of a holistic vision of fisheries management, considering not only food supply and the economic performance of the sector, but also the different ecosystem goods and services provided by marine environments.

2. Objectives, accounting framework and study area

2.1 Objectives

The objective of this pilot study is the development of a natural capital accounting system applied to an MPA in the Balearic Islands (Spain) - the Marine Reserve of fishing interest *Llevant* de Mallorca— within the framework of the EU Interreg MPA Networks project. The study contributes to the development of a system that is transferable and replicable for all MPAs in the Mediterranean. Therefore, it is intended to contribute to the effective management of MPAs through a natural capital accounting system that allows an effective management of marine natural capital to be carried out.

This pilot study is used to capture and visualize the links between changes in the marine environment and its economic impact on the Marine reserve. To do this, the identification, quantification and monetization of the natural assets and ecosystem services provided by the marine ecosystems of the study area are carried out, allowing the development of a natural capital accounting model that efficiently and robustly informs those responsible for marine policies in the region.

2.2 Accounting framework

Natural capital accounts allow monitoring of changes in the state of natural capital over time, within a framework comparable to economic accounts (SNA).

> ' **Natural capital accounting** has been defined as 'a tool for measuring changes in the stock and condition of natural capital at a variety of scales and for integrating the value of ecosystem services into accounting and reporting systems'
> (European Commission and European Environment Agency, 2016)

As shown in Figure 2, the natural capital accounting framework includes the evaluation of *stocks*, as well as flows, both in *monetary* and *physical* terms. Non-monetary or physical accounts consider the extent and condition of natural assets, as well as the quantification of ES provisioned by ecosystems. Monetary accounts, on the other hand, consider the economic value of ecosystem services, the cost of maintaining ecosystems and, finally, the balance sheet where the net present value of ecosystems is calculated.

Basically, the central requirement for natural capital accounting is to measure the extent, condition (or status), quantity and value of natural capital assets, including the services and benefits derived from them. According to this, the accounting process aims to answer the following five questions:

I. What assets exist in the study area, what is their extension and in what state are they?
II. What benefits (services) do they provide and in what amount?
III. What is the economic value of these benefits?
IV. How much does it cost to maintain these assets?
V. What is the net present value, taking into account both the costs of maintaining these assets and the benefits they and their services provide?

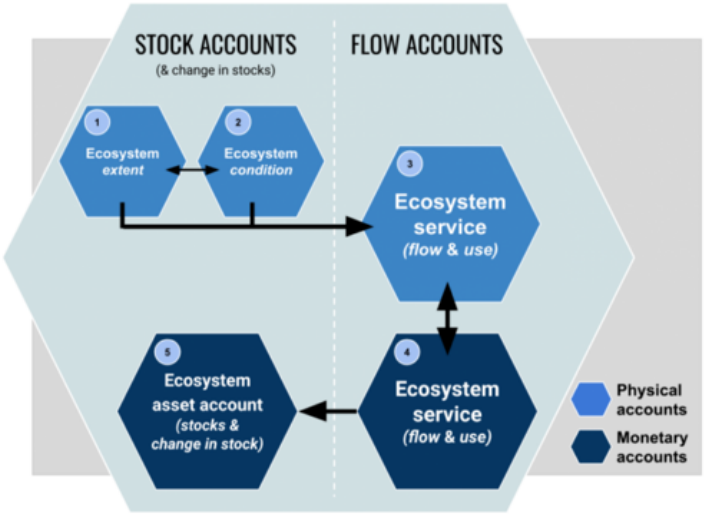


Figure 2.Conceptual diagram of the different accounts that make up the natural capital accounting framework.
Source: United Nations, SEEA EA.

This piece answers the five questions mentioned above in a pilot study carried out in the Marine Reserve *Llevant* of Mallorca, Balearic Islands (Spain). These questions are consistent with all existing natural capital accounting processes and frameworks. At international level and from the perspective of the public sector, there is the SEEA-EEA (System of Environmental Economics Accounting-Experimental Ecosystem Accounting) (United Nations, 2021). This framework follows an accounting structure similar to the System of National Accounts (SNA). Specifically, it has two parts: on the one hand, the Central Framework of the Environmental and Economic Accounting System, which analyzes "individual environmental assets", such as water resources; on the other hand, the Experimental Ecosystem

Accounting (SEEA EEA), which takes the ecosystem perspective and considers how individual environmental assets interact as part of natural processes within a given spatial area.

The various examples of ecosystem accounts using the SEEA EEA framework published to date vary in scope and level of detail (spatial). This reflects differences in budget, technical capacity and data across countries, with notable limitations in developing countries. For example, ecosystem accounts have already been released in multiple countries. Among them, the UK and the Netherlands have published the most comprehensive national accounts to date. At international level, some examples of the application of the framework are included in the NCAVES[1] projects of the United Nations Statistics Division (UNSD), WAVES[2] (World Bank) and KIP-INCA[3](EU). In Spain, Andalusia has compiled ecosystem service accounts and evaluated environmental income within the RECAMAN project (CSIC, 2008-2021).

Despite the fact that the SEEA-EEA framework is standardized at global level, given the examples cited above, its widespread application, whether at the national, sub-national or corporate level is far from the current need in accounting for natural capital. In this sense, there are many voices that demand a regulatory framework that guarantees a wide applicability at multiple scales of natural capital accounting.

A natural capital accounting framework that is based on the same principles of the SEEA-EEA, that has been used more frequently at the subnational and corporate level, is the Corporate Natural Capital Accounts (CNCA). The CNCAs, developed for the UK Natural Capital Committee in 2015 (eftec, RSPB and PwC, 2015), are the most widely used model and are intended to support companies, owners, managers and policy makers in understanding the risks and opportunities associated with the deterioration of natural capital. This framework, which enables organizations to collect information on natural capital in a consistent and comparable format, to help them make informed decisions about natural capital management, has already been tested in numerous pilot cases (e.g., Lafarge Tamarc, National Trust, The Crown State, United Utilities).

Both the SEEA EEA and the CNCA share the same conceptual and methodological basis. Therefore, there are more similarities than differences between the two. Among the differences is the *target group* of each one: while the SEEA-EEA focuses on the public sector and national accounts, the CNCA does so from a corporate and regional point of view. Another main difference is that the CNCA integrates and considers so-called maintenance costs, which refer to the expenses necessary to maintain natural assets and the ecosystem services that they provide.

Taking into account that both frameworks are based on the same basis, the approach proposed to develop the natural capital accounts of this pilot study follows both the framework of the SEEA-EEA and that of the CNCA -the steps to be taken are identical in both cases- including maintenance costs considered by the CNCA.

2.3 Location and context of the study area.

The area is shown in Figure 3. In 2001, the Cala Rajada Fishers' Association submitted a request to create a marine reserve in its fishing area. Contacts were held with the regional and state administrations, after which, finally, in 2007, the *Marine Reserve Llevant de Mallorca* was declared in the more coastal waters under regional jurisdiction[4] and the Marine Reserve Levante de Mallorca-Cala Rajada in waters under state jurisdiction[5]. In this study, the acronym RMLL is used to refer to both areas together.

With the declaration of the RMLL, a total area of 11.000 ha (5,900 ha in inland waters and 5,100 ha in external waters) of diverse sea beds and of great ecological and fishing interest was protected. The main interest of this declaration lies in the importance of the artisanal low impact fisheries that exist in the area.

[1] Natural Capital Accounting and Valuation of Ecosystem Services (NCAVES).
[2] Wealth Accounting and the Valuation of Ecosystem Services (WAVES).
[3]Knowledge Innovation Project on Integrated Systems for Natural Capital and Ecosystem Services Accounting in the EU (KIP-INCA).

[4] Decreto 21/2007, de 23 de marzo, BOIB número 48, del 31 de marzo de 2007.
[5] Orden APA/961/2007, de 3 de abril, BOE número 89 de 13 de abril de 2007

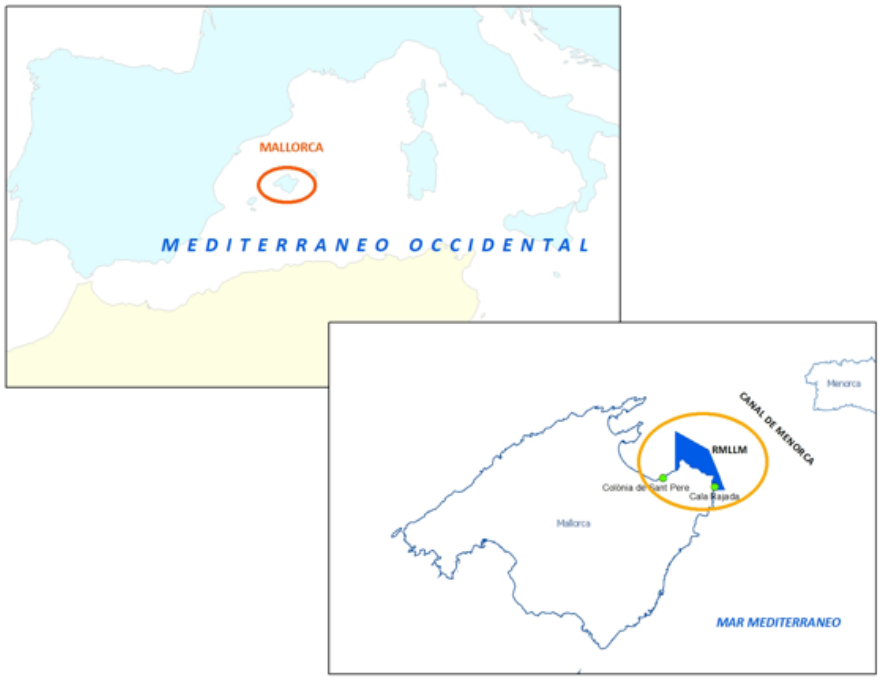


Figure 3. Location map of the Levante de Mallorca-Cala Rajada Marine Reserve (RMLL). Source: own elaboration.

Since its creation in 2007, regulations were introduced for the uses allowed in the MPA, differentiating between the two areas of competence: regional and state. In 2014, the regulations of both administrations were harmonized. The last revision of these regulations dates from 2018.

Within the marine reserve, each administration defined areas with different levels of protection. Thus, within the autonomous part of the marine reserve (see Figure 4, the polygon within yellow and black lines) was declared a **no take area** (see Figure 4, in red), in which only scientific activities can be carried out if they are expressly authorized by the General Secretariat of Fisheries. It prohibits any type of sea fishing, extracting marine flora and fauna, anchoring boats on posidonia and scuba diving.

The rest of the autonomous marine reserve has the qualification of **partial reserve**, in which only authorized and regulated activities are allowed with limitations, including professional maritime fishing of the minor gear modality, recreational maritime fishing from land or boat, flora sampling and marine fauna for scientific or informative purposes, underwater activities, both in apnea and with scuba diving.

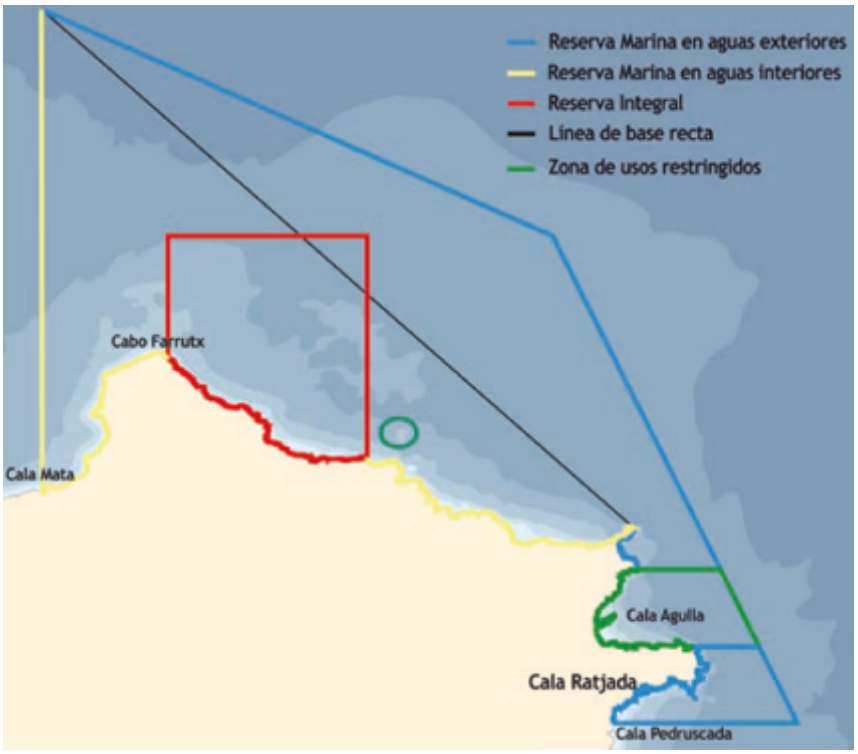


Figure 4. Scope and zoning of the Levante de Mallorca-Cala Rajada Marine Reserve (internal waters, regional jurisdiction and external waters, state jurisdiction). Source: Marine Reserves of Spain-MITECO.

Outside of the integral/no take reserve, professional maritime fishing of minor gear, recreational maritime fishing from a boat, underwater activities of recreation in the scuba diving modality, expressly authorized scientific activities and experimental didactic activities are allowed. Additionally, a restricted-use zone was declared that nowadays has no special regulation. Therefore, in the entire marine reserve the following activities are allowed, without the need for authorization: free navigation, apnea dives and *snorkeling* up to 20 meters from the coast, and recreational sea fishing from land under regulated conditions.

Regulation of the activities allowed for **professional fishing** concerns the size and power of vessels, number of crew, length or number of hooks of the gear, type of nets, times of the year for the different fisheries, days of the week when fishing is permitted, and range of hours of activity. In the case of **recreational fishing**, the authorized gear and modalities are regulated, the number of lines per boat, the number and size of the hooks, the number of specimens caught of certain species, and the business days for the practice of this activity. As for **underwater activities**, authorization must be requested to perform scuba diving and there is a maximum number of dives per day and per year.

In the area declared as RMLL there are other space protection figures partly overlapping with the scope of the marine reserve. This circumstance has generated some confusion for users and citizens, who do not clearly understand the objectives of each one of the existing figures, and confuse rules and regulations, including the name of each one of them. In addition, the regulation of the RMLL itself indicates that the management of certain authorized activities will be subjected to the guidelines or management plans of these other protected areas, in areas where there is an overlap of protection figures. For more information and mapping of these figures of protection, see Annex A

Annex B shows, on the other hand, an analysis of professional fishing in the MPA area.

3. Identification and ranking of natural assets and ecosystem services

The process of identifying natural assets and ecosystem services for the study area has consisted of two consecutive phases:

Firstly, a **pre-identification** of natural assets and ecosystem services through a bibliographic review of scientific articles on cartography, valuations and accounting of the marine environment (see Table 1). At the same time, internal experts from the work team have been consulted.

Secondly, and based on the results obtained in the first phase, the **identification and final validation** of said natural assets and ecosystem services has been carried out through consultation with agents who are external experts in different areas of knowledge. Given the impossibility of conducting face-to-face workshops with external agents[6], telematic meetings have been held with them. Table 1 summarizes all the bibliographic sources, experts and agents consulted:

[6] Due to COVID-19 pandemic restrictions

Table 1. Sources used for the pre-identification and identification of natural assets and ecosystem services. Source: own elaboration

Pre Identification of assets and ecosystem services	
Bibliographic review	**Project's internal experts**
Julia et al. (2019) LIFE + iNDEMARES Project (Menorca Canal Subproject (2009-2013) Direcció General de Recursos Hídrics, Govern de les Illes Balears (2017) Balearic Sea Report (2020) Conselleria d'Agricultura i Pesca. Govern Balear (1992) Campagne et al. (2015) Bujosa Riera (2019) IDEEA Group (2020) Luisetti et al. (2010) Arantza Murillas-Maza (2011)	**Local marine biologist**: Benjamí Reviriego Riudavets **Environmental economist**: Sofia Zerbarini **Environmental Scientist**: Julen González Redín **Forestry Engineer**: David Álvarez García **Forestry Engineer**: Jesús Carrasco Naranjo
Identification of assets and ecosystem services	
NATURAL ASSETS	**ECOSYSTEM SERVICES**
Consultation with external agents	
Head of the Marine Resources Service of the CAIB Species Protection Service of the CAIB Servei d'Informació Territorial de les Illes Balears (SITIBSA) Institut Menorquí d'Estudis Observatori Socioambiental de Menorca Office of the Marine Reserve of Levante de Mallorca-Cala Rajada Environmental Technician Town Hall Capdepera municipality Marine Reserve Monitoring Team (TRAGSATEC-IEO)	Fisheries General Director of the CAIB General Directorate of Emergencies of the CAIB General Secretariat for Scientific Research and Marine Reserves General Secretariat for Fisheries, Ministry of Agriculture, Fisheries and Food Director General Of Sustainable Fishing - General Secretariat of Fisheries, Ministry of Agriculture, Fisheries and Food Directors of hotels in Cala Rajada Directors of diving resorts in Cala Rajada Councilor for Citizen Safety, Fairs and Festivities and the Environment of the City Council of Capdepera Technician of Culture of the Capdepera City Council Capdepera Beaches Exploitation Manager Environmental Technician for Ports de les Illes Balears Charter companies based in the port of Cala Rajada Fishers' *Cofradia* of Cala Rajada

Below, Table 2 shows the list of natural assets identified for the MPA case study. Also, a detailed list of the different species, classified for each of the categories displayed in the "Species" section of Table 2, is shown in Annex C.

Table 2. Natural assets identified in the Marine Reserve *Llevant*. Source: Own elaboration

HABITATS	SPECIES
BENTHIC HABITATS	Species (fauna) with commercial use Species (flora) with commercial use Species with conservation value Species with cultural value
Rocky bottoms with photophilic algae Rocky bottoms dominated by sciaphilic and hemi sciaphilic algae Platform coralligenous dominated by algae or invertebrates Photophilic algae on stone with Posidonia oceanica Fine sands Posidonia oceanica Caulerpa prolifera Cymodocea nodosa Biogenic detrital bottoms with Halopteris filicina Coastal debris Infralittoral and circalittoral detrital bottoms with Vidalia & Eunicella Infralittoral and circalittoral detrital bottoms with dominance of sand and gravel with Spatangus purpureus Semi-dark caves Dark caves	**OTHER ASSETS**
	Marine waters Seascapes
PELAGIC HABITATS	
Pelagic environment	

Regarding the pre-identification of ecosystem services, the Common International Classification of Ecosystem Services (CICES[7]) was used. This methodology, developed by the European Environment Agency (EEA) and which supports the EEAS, currently directed by the United Nations Statistics Division (UNSD), categorizes the ecosystem services offered by different assets. Specifically, CICES offers a standardized and regulated framework that identifies more than *90 ecosystem services* that the natural resources of ecosystems can offer, regardless of where they are located. Under this framework, ESs are classified into different categories: *section, division, group, class, and class type*. In turn, CICES divides ecosystem services into three groups:

- Provisioning: services that nature provides directly to humans, to which a market price is generally applied and that are vital for the survival and well-being of society. These include food, water, wood, and minerals. These types of services are acquired through trade, that is, there is a sale of products.
- Regulation: services provided by nature's ecological processes, which improve and make life possible, also allowing nature to resist or adapt to anthropic pressures. Some examples are climate regulation, the water cycle or erosion control.
- Cultural: services of nature that complement and contribute to human cultural development. They refer to non-material values or benefits that nature provides and that contribute to personal or spiritual enrichment, cognitive development, reflection, enjoyment of nature and the aesthetic pleasures offered by the ecosystems themselves, among others.

During the pre-identification of ecosystem services, out of the 90 ecosystem services contained in the CICES list, **a total of 30 services were pre-identified for the MPA.**

During the second phase (identification and final validation from the first list), out of the 30 pre-identified services, **a total of 18 services were selected: 3 for provisioning, 6 for regulation and 9 for cultural services.** These 18 selected services were grouped into **9 ecosystem service groups: 2 provisioning, 4 regulating and 3 cultural.** This process was carried out due to the similarity between some ecosystem services, which allowed their grouping, and due to the impossibility of obtaining differentiated and specific data for each one of the 18 services selected for the MPA. It was then decided to unite the services of *Biotic Characteristics that allow active interactions (3.1.1.1* and *'passive (3.1.1.2)*, and the *Abiotic Characteristics that allow active and passive interactions (6.1.1.1)* in a single ecosystem service, because the available biophysical and economic data could not be disaggregated for each of these three services separately. Likewise, the characteristics of the three services allowed their grouping into a single ecosystem service group.

Table 3 shows the ecosystem services identified for the study area. The services that show more than one CICES code are several services grouped into one.

[7] Link to Cices https://cices.eu/

	Table 3. Ecosystem services selected for the MPA. Source: Own elaboration		
	CICES Code	**Name Service**	**Definition CICES**
PROVISIONING SERVICES	1.1.6.1	Aquatic animals for nutrition	Wild animals (terrestrial and aquatic) used for nutritional purposes
	1.5.1.1 and 1.5.1.2	Posidonia Remains	Wild plants (terrestrial and aquatic, including fungi, algae) used for nutrition. Fibers and other materials from wild plants for direct use or processing (excluding genetic material)
REGULATION SERVICES	2.1.1.2 and 2.2.5.2	Water quality improvement	Water filtration / sequestration / storage / accumulation by microorganisms, algae, plants and animals; regulation of chemical conditions of salty waters by living processes
	2.2.1.1 and 2.2.1.3	Protection of coastal erosion	Control of erosion ratios; regulation of hydrological cycle and water flow (including flood control and coastal protection)
	2.2.2.3	Maintenance of biodiversity	Maintaining populations in their early stages of life and habitats (including protection of the genetic pool)
	2.2.6.1	CO_2 Capture	Regulation of the chemical composition of the atmosphere and oceans
CULTURAL SERVICES	3.1.1.1, 3.1.1.2 and 6.1.2.1	Active or passive recreational activities	Characteristics of living systems that allow activities that promote health, recovery or enjoyment through active or passive interactions. Abiotic natural features that allow physical experiential active or passive interactions
	3.1.2.1, 3.1.2.2 and 6.2.2.1	Scientific research and education	Characteristics of living systems that allow scientific research, the creation of traditional ecological knowledge, or education and training; natural and abiotic characteristics of nature that allow intellectual interactions
	3.2.2.1, 3.2.2.2 and 6.2.2.1	Existence, option and legacy value	Characteristics of living systems and nature that have an existence, option or legacy value.

The ES identified and shown in Table 3 are described in more detail below:

- **Provisioning**:
  - Aquatic animals for nutritional purposes: fishery resources that are extracted from the reserve.
  - Posidonia remains: the fallen leaves of the plant *Posidonia oceanica* have different uses: for example, they serve as insulation for buildings, as a composting element or as a decontaminating element for sewage water. The use of remains of *Posidonia oceanica* washed ashore depends on the regulations of each country.
- **Regulation:**
  - Improvement of water quality**:** *Posidonia oceanica* meadows and other ecosystems improve water quality thanks to the retention of suspended particles, both living and dead, through their roots and leaves. In this way, these ecosystems act as a filter to improve the quality and transparency of the water.
  - Coastal erosion protection: *Posidonia oceanica* meadows protect the coast from wave erosion by fixing and stabilizing sediments and preventing them from being mobilized by waves, thus eroding the coast. On the other hand, the leaves that separate from the plant in each yearly cycle, end up on the beaches and help dissipate-absorb the energy of the waves, thus protecting the coast from erosion.
  - Maintenance of biodiversity: all marine ecosystems contribute to generate and nurture life. This service has to do with the capacity of ecosystems to sustain populations in their first stages of life.
  - CO_2 Capture: *Posidonia oceanica* and other marine ecosystems play an important role in capturing CO_2 and are considered among the largest carbon sinks in the world.
- **Cultural**:
  - Active and passive recreational activities: active and passive interactions between human beings and biotic and abiotic systems, with the aim of promoting well-being, health or simply the enjoyment of natural environments. Such activities include diving, excursions and boat trips, visiting beaches and the local llampuga fair.
  - Scientific research and education: activities that contribute to human knowledge. This service collects and values the function and quality that habitats have as a source of knowledge and field of transfer of teachings and training in theoretical-practical skills.
  - Existence, option and legacy value: value given by society to some natural assets that shows the interest that people have in conserving them to enjoy them, so that they simply exist or so that they are preserved for future generations.

Next, Tables 4 and 5 show the relationship between the different natural assets and ecosystem services identified for the study area. These tables show the ESs provided by each natural asset, as well as those service-asset interactions prioritized for the subsequent development of the physical and monetary accounts. This **hierarchy (prioritization)** was carried out through consultation processes with experts in the field (see Table 1), who prioritized those ecosystem services with a greater presence in the MPA and for which there are robust and reliable sources of data. Finally, as mentioned above, Appendix C offers the listing of species (asset species) present in the MPA and the categorization according to their value_ commercial, conservation or cultural.

Table 4. Relational matrix of natural assets (ecosystems) and ecosystem services (CICES). An 'X' indicates the ecosystem services provided by each one of the natural assets. Interactions prioritized for evaluation are indicated in green. Source: own elaboration

	NATURAL ASSETS														
	ECOSYSTEMS														
ECOSYSTEM SERVICES	Rocky bottoms with photophilic algae	rocky bottoms dominated by sciaphilic and hemsciaphilic algae	platform coralligenous dominated by algae or invertebrates	photophilic algae on stones with Posidonia oceanica	fine sands	Posidonia oceanica	Caulerpa prolifera	Cymodocea nodosa	detrital biogenic bottoms with Halopteris filicina	Coastal debris	Infralittoral and circalittoral debris bottoms with Vidalia and Eucinella debris	Infralittoral and circalittoral bottoms with dominance of sands and gravels with Spatangus purpureus	Semi-dark caves	Dark caves	Pelagic environment
Aquatic animals for nutrition (1.1.6.1))															
Remains of posidonia (1.5.1.1 and 1.5 .1.2)															
Improvement of water quality (2.1.1.2 and 2.2.5.2)	X	X	X	X	X	X	X	X	X	X	X	X	X		X
Protection of coastal erosion (2.2.1.1 and 2.2.1.3)						X									
Maintenance of biodiversity (2.2.2.3)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
CO_2 capture (2.2.6.1)	X	X	X	X	X	X	X	X	X	X	X	X	X		X
Active or passive recreational activities (3.1.1.1, 3.1.1.2 and 6.1.2.1)	X	X		X	X	X									X
Scientific research and education (3.1.2.1, 3.1.2.2 and 6.2.2.1)				X		X							X	X	
Existence, option and legacy value (3.2.2.1, 3.2.2.2 and 6.2.2.1) *	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

service-asset relationship exists	X
Valuation priority	

Table 5. Relational matrix of natural assets (ecosystems) and ecosystem services (CICES). An 'X' indicates the ecosystem services provided by each one of the natural assets. Interactions prioritized for evaluation are indicated in green. Source: own elaboration

	ASSETS					
	Species				Other Assets	
ECOSYSTEM SERVICES (CICES)	Species (fauna) with commercial use	Species (flora) with commercial use	Species with conservation value	Species with cultural value	Marine waters	Marine landscapes
Aquatic animals for nutrition (1.1.6.1)	x					
Posidonia remains (1.5.1.1 and 1.5.1.2)		x				
Improvement of water quality (2.1.1.2 and 2.2.5.2)						
Protection from coastal erosion (2.2.1.1 and 2.2.1.3)						
Maintenance of biodiversity (2.2.2.3)						
CO_2 capture (2.2.6.1)						
Active or passive recreational activities (3.1.1.1, 3.1.1.2 and 6.1.2.1)	x	x	x	x	x	x
Scientific research and education (3.1.2.1, 3.1.2.2 and 6.2.2.1)	x	x	x	x	x	
Value of existence, option and legacy (3.2.2.1, 3.2.2.2 and 6.2.2.1) *	x	x	x	x	x	

service-asset relationship exists	X
Valuation priority	

4. Accounts of the extension and condition of natural assets (*stocks*)

The physical accounts of the MPA include biophysical information about the environmental characteristics of the assets and ecosystem services. Specifically, the accounts provide the extension (**extension accounts**) and condition (**condition accounts**) of these natural assets.

4.1 Accounts of the extension of the ecosystems

The extension of the selected ecosystems has been determined from cartographic studies, applying Geographic Information Systems (GIS).

The basic cartography used for this determination was provided by the project *Cartography of the marine habitats of the Balearic Islands: Compilation of layers and benthic communities (2019)*, funded by the Marilles Foundation and developed as a collaboration between the Observatori Socioambiental de Menorca (Institut Menorquí d'Estudis) and the Societat d'Història Natural de les Balears. The layers compiled in this project come from different sources and periods[8]. This compilation presented the inconvenience of including some unidentified areas, since the overlap of the different sources was not perfect. To solve this deficiency, a previous cartographic product (1991-1992) was used, known as Charts of sea bottom and Bathymetries of the Balearic Islands, made by the Department of Agriculture and Fisheries of the Balearic Government.

Figure 5 shows the result of the process described above and is the mapping that has served to establish the area occupied by the habitats identified within the MPA, that is, the extent of said habitats.

Table 6 shows the numerical values of the surface (extension) of these habitats, differentiating between the zones managed by the autonomic government and the state government fisheries departments.

[8] (1) Cartografía bionómica bentónica de la reserva marina realizada (Dirección General de Pesca del Govern de les Illes Balears, 2003); (2) Caracterización ecológica de la plataforma continental (50-100m) del canal de Menorca (CSIC e IEO, 2009-2011); (3) Caracterización del ecosistema demersal y bentónico del canal de Menorca y su explotación pesquera (CSIR e IER, 2009-2011); Caracterización ecológica del área marina del canal de Menorca: zonas profundas y semiprofundas (100-400m) (CSIR e IEO, 2009-2011).

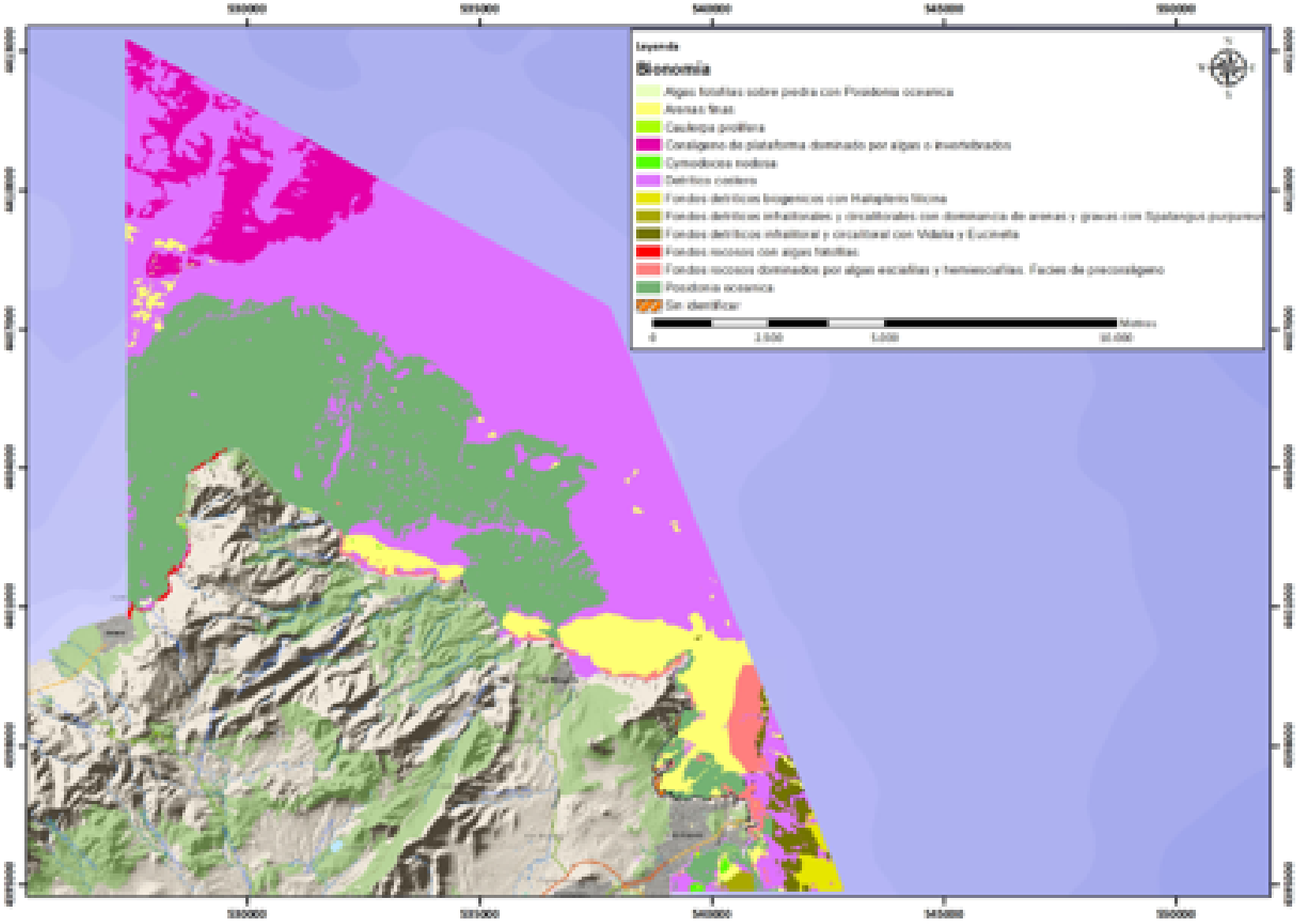


Figure 5. Map of the extension of the ecosystems of the study area. *Source: own elaboration*

Table 6. Extension of the ecosystems of the MPA. (units are Ha for the ecosystems and m^3 for pelagic environment)
Source: own elaboration

Ecosystems	Balearic government zone		Central state zone			TOTAL (m^3)
	No take reserve	Marine reserve	No take reserve	Marine reserve	Restricted use zone	
Rocky bottoms with photophilic algae	0,02	17,63				17,65
Rocky bottoms dominated by sciaphilic and hemiesciaphilic algae. Precoraligenic facies	18,21	31,49		69,78	105,75	225,22
Platform coralligen dominated by algae or invertebrates		453,16		376,94		830,10
Algae on rocky bottom with *Posidonia oceanica*		3,04				3,04
Fine sands	83,42	351,29		247,50	158,48	840,69
Posidonia oceanica	1512,04	2.031,82	4,00	283,75	119,88	3951,47
Caulerpa prolifera		1,00		0,82		1,82
Cymodocea nodosa	0,71			10,33		11,03
Biogenic detritic bottom with *Halopteris filicina*				71,81		71,81
Coastal detritic	287,61	1377,06	98,78	3319,09	86,03	5168,57
Infralittoral and circalittoral with Vidalia and Eunicella				96,89	49,09	145,98
Infralittoral and circalittoral detrital bottom with dominance of sands and gravels with *Spatangus purpureus*				23,13		23,13
TOTAL	**1883,77**	**3764,20**	**102,78**	**4053,32**	**413,48**	**11 290,52**
pelagic environment	**474 745 614,46**	**1 374 614 685,26**	**43 114 275,25**	**2 235 503 742,87**	**192 615 211,87**	**4 320 593 529,71**

Posidonia oceanica meadows, which develop both on rocky and sandy substratum, especially in the western part of the RMLL, are outstanding for their ecological importance and extension. Likewise, the **rocky bottoms**, both photophilous and sciaphilic and coralline, particularly those close to the coast, create a mosaic of habitats of great scenic and fishing interest. The calcareous nature of the coastline and karst processes have originated a large number of cavities and caves, many of them underwater, of which only a few have been explored. Likewise, **Detritic bottoms** in their different variants, with sciaphilic algae (*Halopteris, Peyssonnelia, Vidalia*) or rhodoliths (*Maërl*) also have a very relevant extension.

Some of the existing habitats in the RMLL that are relevant due to their ecological, scientific or functional importance have not been accounted for. On the one hand, there are habitats that have not yet been sufficiently studied and mapped, such as semi-dark caves and dark caves. On the other hand, certain habitats such as the formations of *Neogoniolithon brassica-florida* / *Dendropoma petraeum* in the *mediolittoral* or those of the *upper infralittoral* have a linear distribution on the same coast that does not allow assigning them an occupied area, at least on the scale in which we have worked in this study.

4.2 Ecosystem condition accounts

The conservation status of the different assets has been determined from bibliographic information generated in various research and monitoring projects. Specifically, it is information generated for other purposes that has been used in this study, in the absence of concrete data on the state of the habitats of this MPA. Table 7 shows the numerical values of the qualitative condition of the ecosystems.

Table 7. Condition of the ecosystems of the MPA.
Source: Adapted from Julia *et al*. (2019); LIFE + iNDEMARES Project (Canal de Menorca Subproject (2009-2013); and Direcció General de Recursos Hídrics, Govern de les Illes Balears (2017)

Ecosystems	Condition of the ecosystem
Rocky bottoms with photophilic algae	Favorable
Rocky bottoms dominated by sciaphilic and hemi-sciaphilic algae	Favorable
Platform coralligenous dominated by algae or invertebrate	Unsuitable
Fine sand	Unknown
Posidonia oceanica meadows	Favorable
Caulerpa prolifera	Unknown
Cymodocea nodosa	Unknown
Biogenic detritic bottoms (low algal coverage)	Favorable
Biogenic detritic bottoms with *Halopteris filicina*	Unsuitable
Coastal detritic with spots of *Maërl* and *Vidalia volubilis*	Unknown
Semi-dark caves	Favorable
Dark caves	Favorable
Open sea / pelagic environment	Favorable

Table 7 shows the state / condition of the ecosystems of the MPA. More than 50% of the ecosystems are in a favorable state, with only around 15% in inadequate condition. Specifically, it should be noted that the *Posidonia oceanica*—with a high ecological and socioeconomic importance and with an important extension within the MPA— and the rocky bottoms —important in the most coastal part because they host a mosaic of habitats of great scenic and fishing interest— show a favorable state. On the contrary, detrital bottoms, notable for their great extension, show both a favorable state (in the case of those with low algal coverage) and unfavorable (those with *Halopteris filicina*). As mentioned above, the status of the MPA is relatively favorable and positive.

4.3 Accounts of biotic assets (species)

This section includes the extension and condition accounts related to biotic assets (species). They have been collected jointly in a single account, given that the indicators and data available for species in this MPA do not allow the distinction between extension and condition of species - unlike in the ecosystem accounts, where it has been possible to differentiate between extension and condition. Therefore, this section is presented as an integrated result of condition and extension of species.

Due to the nature and purpose of the RMLL, whose main interest lies in the importance of the area's low impact fisheries and aims to encourage and improve sustainable artisanal fishing, the biotic asset accounts focus only on species of commercial interest, without prejudice of the potential future development of greater knowledge of these assets linked to other benefits. The list of species present in the MPA and their categorization according to the type of value they have — commercial, conservation and cultural value — is included in the Annex C, elaborated after consultation with local experts.

The declaration of the marine reserve meant regulating extractive activities, the objective of which was to recover the stocks of exploited species. The RMLL was created in 2007 and, a year later, the monitoring of fish populations in coastal rocky habitats began in order to obtain an indicator of the recovery of *stocks* of exploited species. Currently, there is a database that includes 5 campaigns carried out in 2008, 2009, 2010, 2016 and 2018 (Morey *et al*., 2018). Likewise, for three locations within the reserve, there is also a set of 2003 data, which can be considered as describing the so-called zero state, prior to the MPA declaration.

Comparison of the results corresponding to 2003 with those obtained in 2018 (both delivered by monitoring the fish populations of coastal rocky habitats in the RMLL), confirm the positive effects of protection, with an increase of the total biomass in three places located within the reserve. Increases are of x1.8, x3.4 and x2.5 (Morey *et al*., 2018).

Specifically, the so-called *reserve effect* is currently manifested in an increase in specific richness - species that had become very rare or had disappeared before the declaration of the MPA are once again present - and in an increase in the abundance and size of individuals, which directly implies an increase in biomass.

Figure 6 shows the biomass (in kg / 250m^2) of all the fish monitoring stations in the reserves of the Balearic Islands, plus two reference stations in other MPAs

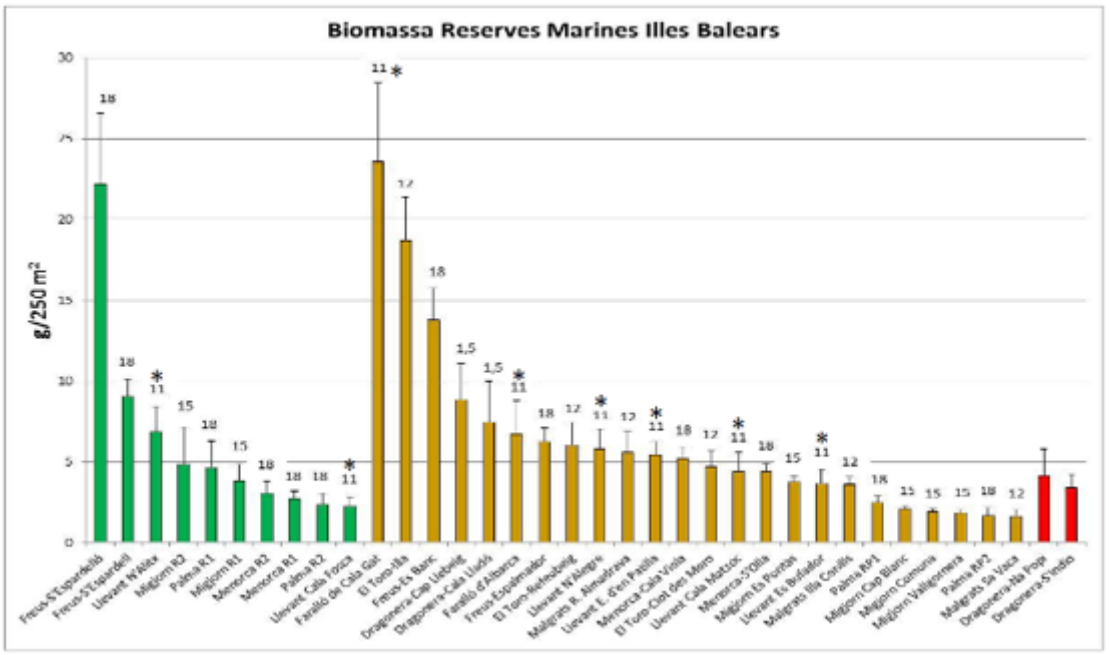


*Figure 6. Biomass from all monitoring stations in the Balearic Islands. Green: no -take reserve; orange: partial reserve; red: out of reserve; asterisk: RMLL stations; number on each column: years from its declaration to 2018.*Source: Morey *et al.* (2018).

5. Physical accounts of ecosystems (flows)

This section measures the annual flow of ecosystem services provided to society by the MPA, that is, the physical amount of benefits that society enjoys from the services provided by natural assets of the analyzed area.

Cartographic information has been used, incorporating field information through interviews with local agents and using data from open information sources. This information varies depending on the service. Thus, production data have been analyzed, in the case of provisioning services; number of visitors or projects, in the case of recreational services, and surface units or population of people, in the case of regulation services. The physical indicators used are closely related to the valuation methods used, as described in section 6: Monetary accounts of ecosystems (flows).

Table 8 summarizes the physical indicators used for each ecosystem service, including their results

Table 8. Physical accounts of the delivery of ecosystem services. Source: own elaboration

ECOSYSTEM SERVICES (CICES)	TYPE OF ECOSYSTEM SERVICE	ANNUAL INDICATOR	VALUE
Aquatic animals for nutrition (1.1.6.1)	Provisioning	Total kilograms of aquatic animals captured	7.421 kilograms
Remains of *Posidonia oceanica* (1.1.5.1; 1.1.5.2)	Provisioning	*Posidonia oceanica* remains, Kilograms used	800 kilograms
Water quality improvement (2.1.1.2; 2.2.5.2)	Regulation	*Posidonia oceanica* meadows area	3.951 ha
Protection of coastal erosion (2.2.1.1; 2.2.1.3)	Regulation	*Posidonia oceanica* meadows area	3.951 ha
Maintenance of biodiversity (2.2.2.3)	Regulation	N / A[9]	N / A
CO_2 Capture (2.2.6.1)	Regulation	CO_2 Tons captured	3.866 tons CO_2
Active or passive recreational activities (3.1.1.1; 3.1.1.2 .; 6.1.1.1)	Cultural	Number of visitors who enjoy recreational activities in the MPA	384.143 visitors
Scientific research and education (3.1.2.1; 3.1.2.2; 6.2.1.1)	Cultural	Number of Organizations carrying out research and education projects in the MPA	3 organizations

[9]Physical accounts for the ecosystem services are not provided but monetary accounts are.

5.1 Provisioning Services

The main Provisioning Services identified in the study area are both measured in total kilograms, and include **aquatic animals for nutrition** captured in the reserve and the **remains of *Posidonia oceanica*** accumulated on the shoreline.

- Aquatic animals for nutrition

This service is provided by the active fauna species with commercial use.

Professional artisanal fishing in the RMLL is managed from a census of vessels authorized to fish in its waters. A total of 47 professional vessels are allowed to fish coming from neighbouring harbours: Cala Rajada base port: 11 vessels; Portocristo base port: 6; Alcúdia base port: 29; Pollença base port: 1. Only 16 of them (34%) have been detected fishing in the area.

According to regulations for professional fishing in the RMLL, vessels authorized to fish inside are obliged to declare their daily catches. fishers must fill in a statement of fishing effort information for each day of fishing carried out, even if no catches are made. The declaration of the catches and the fishing zone, as well as other data, must be sent to the RMLL service, whose surveillance service records also the sightings of fishing activities made from patrolling boats and from land. In the event that, when crossing the declared activity with the record of sightings some inconsistency is found, it is claimed through the corresponding *Cofradía* (fishers' guild).

These activity declaration statements have been the basis for determining the total of catches made in the RMLL. Specifically, 2018 professional fishing catch data has been used, from interviews carried out with the fishers. Table 9 shows the species that have accounted for a percentage of catches greater than 1% of the total:

Table 9. Captured species with a % catch greater than 1%, weight (kg) and proportion (%). Source: own elaboration

Species	Weight	(kg)%
Squid	1478	29.88
Llampuga	557	11.26
Cuttlefish	462	9.34
Rays	442	8.93
Scorpion fish	429	8.67
Spiny lobster	368	7.44
Amberjack	165	3.33
Dentex	120	2 ,43
Red mullet	112	2,26
Little tunny	112	2,26
John Dory	58	1,17
Octopus	56	1,14

Total annual weight (in kilograms) of aquatic animals caught amounts to 4,947. However, it should be mentioned that a correction factor of 1.5 has been applied to this total, with the aim of incorporating those undeclared catches. This correction factor was taken into account after interviewing fishers from the Cofradía de Cala Rajada, who acknowledged that not all the catches made within the marine reserve are

declared and that part of the catches are not marketed through official channels. **The application of this index gives a total catch of 7,421 kilograms**, the final value used in this study (see Table 8).

Early studies (Mallol and Goñi, 2004) show the most important fisheries in the zone, including cuttlefish (*Sepia officinalis*), from January to May; spiny lobster (*Palinurus elephas*), from April to August; red mullet (*Mullus surmuletus*), from July to November; llampuga (*Coryphaena hippurus*), from September to November; squid (*Loligo vulgaris*), all year round; and the longline targeted species, all year round, and especially in the periods of change between the other fisheries. The most important both for their volume of catches and for their economic value are dolphin fish, followed by lobsters and longline targeted species and, to a lesser extent, the fisheries of cuttlefish and red mullet. The high importance of squid fishery in the reserve contrasts with its relatively low importance in the wider Cala Rajada fishing area. This is due to the fact that other fisheries, such as those for lobster or llampuga, develop in a much greater proportion in waters outside the reserve. In the case of lobster - due to the type of seabed - and llampuga - due to the installation of anchored floating objects that act as aggregators - it is mainly authorized outside the reserve and only a small percentage remains inside.

- Remains of *Posidonia oceanica*

This service is provided by the active flora species with commercial use.

The remains of *Posidonia oceanica* have been identified as a capital element in the protection of the coastline in sandy areas. For this reason, its withdrawal and management are subject to regulation in the Autonomous Community of the Balearic Islands (CAIB) since the publication of Decree 25/2018, of July 27, on the conservation of *Posidonia oceanica* in the Balearic Islands (BOIB No. 93, of July 28, 2018). For this reason, since 2018, the local entities that carry out this withdrawal must comply with certain requirements and keep a record of the activity.

After its removal, only traditional uses of these *Posidonia oceanica* remains are allowed, such as for composting and livestock litter, to capture crustaceans when used as bait, or as insulation in construction. However, trade with these remains is not allowed, so only their transfer is contemplated.

In the context of the MPA, only Capdepera City Council removes the *Posidonia* remains on urban beaches or on beaches with services, while natural beaches are outside of this kind of management. Thus, the only beach that matches these criteria is Son Moll Beach. The register of the amount of remains of Posidonia removed from that beach was only available starting in 2020, with a **total weight of 800 kg**, which was the final figure used in this study (see Table 8).

5.2 Regulation Services

The main regulatory services identified are those related to the **improvement of water quality** and **protection from coastal erosion**, followed by **CO_2 capture.**

- Improving water quality and protecting coastal erosion

The water quality improvement service is provided by almost all the benthic marine habitats present in the MPA - except the dark caves -, and also by the water column of the pelagic environment. The coastal erosion protection service is provided by the *Posidonia oceanica* meadows and by the algae communities of the mediolittoral and upper infralittoral. Because only economic data for *Posidonia oceanica meadows* were available to assess these services, the total area of these meadows within the RMLL was used as a biophysical indicator.

The **total area of *Posidonia oceanica meadows*** within the RMLL is **3,951 hectares** (see Table 6). This ecosystem is the main reason for both the improvement of water quality and the protection of coastal erosion. The bibliographic review conducted shows how other authors also use the surface of *Posidonia oceanica* as a biophysical value of water quality services and protection from coastal erosion. For example, in Campagne *et al.* (2015), it is considered that the water purification carried out by the coastal

system is done by the *Posidonia oceanica* meadows. In Mangos *et al*. (2010), the benefit of coastal protection of Mediterranean marine ecosystems is evaluated using the role of *Posidonia oceanica*, which has been scientifically recognized (Hemminga and Duarte, 2000; Koch *et al*., 2009; Boudouresque *et al*., 2012). This evaluation is based on three services derived from *Posidonia oceanica*: the hydrodynamic reduction of the waves (Chen *et al.*, 2007; Pergent *et al.*, 2012), the formation of accumulations of dead leaves on the beach (Mateo *et al*., 2003; Simeone, 2008), and the accumulation of sediments during the formation and consolidation of the wedge-shaped *banquettes* (Gacia *et al*., 1999; De Falco *et al.*, 2000; Koch *et al.*, 2009).

- CO_2 capture

A service provided by all communities dominated by vegetables, whether flowering plants or algae, it is greater in the communities with more productivity. However, although there is considerable knowledge about the balance of matter and energy for various communities of algae and seagrasses, this type of study has hardly been addressed in the Mediterranean, except for the *Posidonia oceanica* meadows.

Posidonia formations have been identified as the largest carbon sink in the Mediterranean marine ecosystem. Therefore, in this study only the capture of CO_2 associated with this ecosystem is analyzed.

Different studies have provided determinations of the carbon assimilation carried out by sea weeds, and figures of up to 750 g C m^{-2} $year^{-1}$ are common (Duarte *et al*., 2005, 2010, 2011), taking into account the different parts of the plant, the epiphytes that grow on it and other inputs such as microphytobenthos and phytoplankton sedimentation. These data have been obtained mainly from metabolic and primary production studies, but it should be noted that they do not actually involve long-term carbon sequestration. These studies are based especially on metabolic issues (inputs of CO_2 in the plant) and organic matter flow, but the outputs (mineralization, herbivory, export) that are processes that release CO_2 are not sufficiently considered.

There is evidence indicating that the true long-term carbon sequestration capacity of *posidonia* meadows is found in the material (sediment and rhizomes) trapped within the mat. Recent studies in the Balearic Islands have quantified the absorption of carbon from the analysis of the upper part of the column of rhizomes, roots and trapped sediments that make up the mat, which is the underground part of the meadow and where most of the carbon accumulates. This compartment is more stable than the one assimilated by the leaves, which are renewed every year, so there is a continuous recycling of the carbon they contain. Mazarrasa *et al*. (2017) proposes an approximation with the figure of 26.66 g C m^{-2} $year^{-1}$, which is equivalent to 97.84 g CO_2 m^{-2} $year^{-1}$.

In this study, this last criterion has been adopted, as it is considered more realistic and better adapted to the conditions of the Balearic archipelago. To quantify the capture of CO_2, the area occupied by *Posidonia oceanica* meadows within the RMLL and the data proposed by Mazarrasa *et al*. (2017) for the capture of CO_2 by these grassland have been used.**The result is 3,866 tons of CO_2** per year (see Table 8).

5.3 Cultural services

The main cultural services identified are **active and passive recreation** and **education and research.**

- Active and passive recreation

The active and passive recreation services are provided by the following habitats: in the benthic environment, by rocky bottoms with photophilic algae, rocky bottoms dominated by sciaphilic and hemiesciaphilicalgae, photophilic algae on stone with *Posidonia oceanica,* fine sands and *Posidonia oceanica*. In addition, it is also supplied by the entire pelagic environment. The service is also provided by all species with commercial, conservation and cultural value, and by landscapes and marine waters. The choice of these habitats responded to the activities that take place within the MPA: diving, excursions, pleasure boats, visits to the beaches and the llampuga fair.

Specifically, as a physical indicator, the number of annual visitors who carried out the activities described during 2018 was considered: 384,143 visitors (see Table 8). In the following Table 10, you can see a detail of the number of visitors by type of activity:

Table 10. Annual visitors (2018 data) to the study area.
Source: Ports de les Illes Balears (2018) and Charter shipping companies operating in the area (2020)

Number of visitors to the Marine Protected Area Llevant	
Number of people who made excursions (2018)	84,437
Number of divers (2018)	706
Number of people who took boat trips (2018)	1,197
Number of people who visited the beaches in the period (Jun-Sep. 2018)	289,803
Total number of people who attended the Llampuga Fair (2017)	8,000
TOTAL	**384,143**

- Education and research

This service is provided by the following habitats: photophilic algae on stone with *Posidonia oceanica*, *Posidonia oceanica*, semi-dark caves and dark caves, since it is in these habitats that most of the education and research activities are carried out. This service is also provided by all species present in the MPA and by marine waters.

For the assessment of this service the *Estudi de la Despesa en Àrees Marines Protegides de les Balears* (2018)[10] was used, where the annual expenses are listed in the MPAs of the Balearic Islands. In particular, in 2018 there were three entities or organizations that carried out research projects in this regard: IEO (Spanish Institute of Oceanography), SEO (Spanish Society of Ornithology) and CSIC (Higher Council for Scientific Research). To put a figure on this ecosystem service, the number of organizations that carry out research and education projects in the MPA was considered; that is, a total of 3 (see Table 8).

6. Ecosystem monetary accounts (flows)

The monetary accounts of the MPA include economic information about the environmental characteristics of ecosystem services. Specifically, they detail the economic value of ES (**monetary accounts of ecosystem services**).

6.1 Economic valuation methodology

Different valuation methods have been used to assign an economic value to the annual flows of ecosystem services in the MPA to feed the monetary accounts of ecosystem services. For this, the method that best suits each ecosystem service and the availability of data in the study area, has been used.The following Table 11 summarizes the method used for each ecosystem service, with a colour for each method that indicates the degree of uncertainty associated with each choice (see Table 12).

[10] Font Gelabert, A. (2018) see Bibliography

Table 11. Methods of economic valuation of ecosystem services used in this study. Source: own elaboration

Ecosystem services (CICES)	Type of ecosystem service	Valuation method
Aquatic animals for nutrition (1.1.6.1)	Provisioning	Market prices
Posidonia remains (1.1.5.1 and 1.1.5.2)	Provisioning	
Improvement of water quality (2.1.1.2 and 2.2.5.2)	Regulation	Transfer of benefits from cost methods
Protection of coastal erosion (2.2.1.1 and 2.2.1.3)	Regulation	Transfer of benefits from cost methods
Maintenance of biodiversity (2.2 .2.3)	Regulation	Transfer of benefits from cost methods
CO_2 Capture (2.2.6.1)	Regulation	Market prices
Active or passive recreational activities (3.1.1.1, 3.1.1.2., 6.1.1.1)	Cultural	Travel budget
Scientific research and education (3.1.2.1, 3.1.2.2, 6.2.1.1)	Cultural	Projects budget

As is well known, the type of valuation method used determines the result likely to be obtained. Whenever possible, **local data specific to the study area have been used**, as they are more robust and have a low level of uncertainty. This was the case for aquatic animals for nutrition, recreational activities, education and research. For the rest of the ecosystem services, it was not possible to use data from the study area and values from other areas and studies were applied. See Annex D for the list of values used.

As an exercise in transparency, a **specific methodology has been developed[11] that allows assigning a level of uncertainty to each applied valuation method**, with the aim of showing the degree of confidence in each of the methods used and, therefore, in the results. The degree of uncertainty assigned to each method (see Table 11) has been calculated from different variables, such as: valuation method, data location (county, local, national, international), application of correction factors, type of data (interviews, official data, estimates, transfer of benefits), sample size and study area, among others. Based on these variables, a score is obtained for the method in question, which is associated with a degree of uncertainty.

[11]See the Methodological guide for the development of models of natural capital accounts in MPAs, the second product of this project.

Table 12. Methodology to estimate the degree of uncertainty of each one of the methods of ecosystem services economic valuation used in this study. Source: own elaboration

Level of uncertainty	
Very high	Score 0-20%
High	Score 20-40%
Moderate	Score 40-60%
Low	Score 60-80%
Very low	Score 80-100%

The colour shown for each of the assessment methods shown in Table 10 indicates the degree of uncertainty of the result obtained from said method with the dataset used.

In Annex D, a detailed description of the different valuation methods used for each of the ecosystem services is included.

6.2 Monetary accounts of ecosystem services

In this section, a monetary measure is assigned to the identified ecosystem services. They are given a monetary value, according to their ability to generate profit or to meet the needs of consumers or beneficiaries of goods, through the valuation methods described in AnnexD.

Table 13 shows the selected ecosystem services, with their indicator and the annual monetary flow of each service.

Table 13. Monetary accounts of the ecosystem services of the MPA. Source: own elaboration

Ecosystem Services (CICES)	Annual indicator	Type of ecosystem service	Monetary value
Aquatic animals for nutrition (1.1.6.1)	Total value of captured aquatic animals	Provisioning	129,646.35 €
Posidonia remains (1.1.5.1 and 1.1.5.2)	Total value of posidonia remains used	Provisioning	-
Water quality improvement (2.1.1.2 and 2.2.5.2)	Value of water treatment	Regulation	211,348.87 €
Coastal Erosion Protection (2.2.1.1 and 2.2.1.3)	Value of coastal erosion control	Regulation	772,547.12 €
Maintenance of Biodiversity (2.2.2.3)	Willingness to pay to conserve biodiversity	Regulation	447 313.21 €
CO_2 Capture (2.2.6.1)	Value of CO_2 captured	Regulation	19,330.60 €
Active or passive recreational activities (3.1.1.1, 3.1.1.2., 6.1.1.1)	Travel budget for visitors who enjoy recreational activities	Cultural	3,141,440.04 €
Scientific research and education (3.1.2.1, 3.1.2.2 , 6.2.1.1)	Total Budget in research and education projects	Cultural	104,891.72 €
			€ 4,826,517.90

SUMMARY OF RESULTS

- *The total monetary value of the ecosystem services of the MPA amounts to **4,826,518 € per year**, which is equivalent to **427.5 € / year / ha.***
- ***67%** are **cultural services**, 30% are regulation services and 3% are provisioning services.*
- *The most valuable ecosystem services are:*
  - ***recreational activities** (3,141,440 euros per year, 65% of the total).*
  - ***protection of coastal erosion** (772,547 euros per year, 16% of the total).*
  - ***biodiversity protection** (447,313 euros per year, 9% of the total).*

6.2.1 Provisioning services

- Aquatic animals for nutrition

This service has been valued by the value of the catches made in 2018, through the market price in the Palma de Mallorca fish market. Specifically, the values have been obtained by crossing the Activity declaration statements — the basis for determining the volume of catches made inside the MPA — and the daily first-sale notes made at the Lonja de Mallorca, located in Palma de Mallorca and managed by the Mallorca Fish Producers Organization (Opmallorcamar). Thus, it has been possible to assign a sale price to each catch made in the RMLL and calculate the economic performance of this activity. **The total value reached 129,646.35 euros.**

Table 14 shows the monetary value of the species that have a value greater than 1% of the total, not including undeclared catches:

Table 14. Species captured according to their value (2018).
Source: Compiled from the data of the fishers in MPA activity declarations combined with prices from first sale notes in the Lonja de Mallorca, managed by Opmallorcamar

SPECIES	SALE	(€)%
Squid	40,916	47.34
Spiny lobster	14,284	16.53
Scorpion fish	8,342	9.65
Cuttlefish	4,813	5.57
Dentex	2,837	3.28
Llampuga - dolphin fish	2,736	3.17
Lemon fish	2,333	2.70
John Dory	1,460	1.69
Red mullet	1,424	1.65
Rays	1,274	1.47

- Remains of *Posidonia oceanica*

It has not been possible to value this service because, due to regulations, it cannot be marketed, so there is no specific market value.

6.2.2 Regulation services

- Water quality improvement

To assess this service, guidance has been sought from the article by Campagne *et al.* (2015), which evaluates the contribution of *Posidonia oceanica* meadows located in the French Sea (Corsica included) to the improvement of water quality.

The quality of seawater depends on the treatment of wastewater that is discharged into the marine environment. Bearing this in mind, this study uses the amount of environmental tax necessary for the conservation of natural resources, as a substitute for the expenses that should be incurred in the event that *Posidonia oceanica* meadows ceased to provide their service of improving water quality. The value shown by this study is 60 euros / hectare for 2014 in France. Said value is adjusted in order to apply it in Spain and in 2018. To do that, the value is adjusted firstly by the Purchasing Power Parity between France and Spain and, secondly, by the difference in inflation between 2014 and 2018. The resulting value is 53.49 euros / ha for 2018 in Spain. This value is applied to the total hectares of *Posidonia oceanica* in the MPA, resulting in **a total value of 211,349 euros.**

- Protection of coastal erosion

For the assessment of this service, the cost incurred by societies when fighting against coastal erosion has been used, that is, the cost of damage avoided. The role of *Posidonia oceanica* meadows in protecting coasts from erosion is scientifically recognized (Hemminga and Duarte, 2000; Cantasano, 2009; Koch *et al*., 2009; Boudouresque *et al*., 2012). Using data from 2001, as well as the cost of damage avoided method, Mangos *et al.*(2010) estimate that the European expenditure against coastal erosion is approximately 160,000 euros per protected kilometer. Campagne *et al.* (2015) shows an annual value of 188 euros / ha in 2014, taking into account an area of 3,300 km that is protected in the Mediterranean. In this study, this value is adjusted considering inflation in 2018, which results in a final value of 195.5 euros / ha. Applying it to the total number of hectares of *Posidonia oceanica* in the MPA, **a total value of 772,547 euros is obtained.**

- Biodiversity conservation

This ecosystem service is one of the most complex when it comes to being valued. The most robust method would be contingent valuation, where surveys are carried out on a sample of people to find out their willingness to pay to conserve biodiversity of the MPA.

Due to the impossibility of carrying out consultations, it has been chosen to apply the benefits transfer method based on other European studies, specifically, the value shown by Halkos *et al.* (2016), where an assessment of different Mediterranean marine areas is carried out in Greece, in the Gulf of Volos and in the islands of Crete and Lesbos. In this study, the method of Choice Experiments is used, which consists of performing surveys for respondents to choose their preferred option from hypothetical, but realistic, options that include environmental attributes. In this case, consumer preferences were quantified for six attributes that represent the good environmental status of the marine ecosystem in the described areas of Greece:

1. the status of the species,
2. the development of the beaches,
3. the zoning of an MPA,
4. the status of *Posidonia oceanica*,
5. species warnings,
6. price to pay.

The payment vehicle proposal was an increase in the water bill for the next few years until 2020, which would be channeled to a Marine and Coastal Ecosystem Management Fund managed by a reliable and independent body.

The main reason for transferring the benefits of this article to this study is based on the fact that both marine spaces occupy very similar ecosystems, and similar ecosystem services are also valued. Specifically, the value taken is 20.77 euros per person. After making the corresponding purchasing power parity adjustments between Greece and Spain, as well as the difference between inflation from 2014 to 2018, a value of 23.21 euros per person in 2018 is reached. This represents the predisposition of the local population to pay to achieve the protection of the biodiversity of the MPA. Considering the local populations of Artà and Capdepera, **a total value for this ecosystem service of 447,313 euros is obtained.**

- CO_2 Capture

To value this ecosystem service, the *blue carbon* price for emission reductions has been used, that is, credits from voluntary markets of marine projects. After consulting experts in this area, a price range between 5-10 euros per ton of absorbed CO_2 has been considered.

Wylie *et al*. (2015) describe some *blue carbon* projects in voluntary markets. For a project in Kenya, the price per ton of CO_2 captured shows a range of USD 6.50 and USD 10.00 for 2013-2014. In this study, a price of 5 euros per ton of CO_2 captured was taken, **reaching a total value of 19,331 euros.**

6.2.3 Cultural services

- Active and passive recreation

This ecosystem service has been valued through the travel budget of the activities carried out in the marine reserve in 2018. The following activities were identifiedwithin the reserve: excursions, diving, pleasure boats, visits tobeaches and the Llampuga fair. All the data are from 2018, except those of the llampuga fair, which are from 2017.

Table 15 details the economic values that were applied to visitors of the MPA:

Table 15. Information for the evaluation of recreational activities.
Source: Own elaboration from multiple public sources (see footnote[12])

Type of information	Value	Indicator
EXCURSIONS		
Average price of excursion	66.67	euros
Percentage of time in MPA during the excursion	25%	
Stay in MPA	7.00	days
Average daily expenditure	159.48	euros
Cost of travel to the island	126.64	euros
Percentage of time spent in the MPA	1.07%	
DIVING		
Average cost of each dive	66.32	euros
Average number of dives per diver	5.00	dives
Stay in MPA	7.00	days
Average daily expenditure	180.00	euros
Cost of travel to the island	124.37	euros
Percentage of time spent in the MPA	35.71%	
BEACHES		
Value of use associated with the enjoyment of a kilometer of beach	0.05	euros / km beach / user
Km of beach in MPA	1.80	km
LLAMPUGA FAIR		
Price of the portion/tapa	2.00	euros
Number of portions	18.586	portions
Percentage of llampugas in the MPA	1.07%	

First, for the **excursions** to the reserve, average prices were estimated. Also, the time of the excursion within the reserve (over the total time of the excursion) was determined. In addition, the average number of days of a typical tourist in Mallorca, the daily expense, the average transfer cost (depending on the origin of the users) were estimated and assigned a percentage based on the time spent in the RMLL. **The total value amounts to 2,531,802 euros.**

For **diving activities,** an average cost of the dive was estimated, the average number of dives per diver in the reserve, the average days of stay for a typical diver, their daily expense, the average cost of transfer,and it was assigned a percentage according to the time spent in the reserve (according to the hours of diving dedicated). It is worth clarifying that the typical diver has a higher average expense in his stay than sun and beach tourists. For this activity, **a total expenditure of 583,158 euros was estimated.**

[12]Source for excursion figures in the reserve: (1) Ports de les Illes Balears (2018); (2) Charter companies operating in the zone (2020)

Sources for diving figures in the reserve: (1) Reserva Marina de interés pesquero de Levante de Mallorca-Cala Rajada, Ministerio de Agricultura, Pesca y Alimentación, Secretaría General de Pesca, Dirección General de Pesca Sostenible (2018); (2) Servei de Recursos Marins, Direcció General de Pesca i Medi Marí, Conselleria d'Agricultura, Pesca i Alimentació, Govern de les Illes Balears (2018); (3)Diving centers operating in the zone (Mero Diving, Dive & Fun Cala Ratjada, Dive & Fun Font de Sa cala, Skualo) (2020).

Sources for MPA beach visitors: (1) Beach lengths: Direcció General d'Emergències i Interior, Conselleria de Presidència, Funció Pública i Igualtat, Govern de les Illes Balears; (2) Bujosa Bestard, A. y Riera Font, A. (2019).

Source for Llampuga fair figures: Ajuntament de Capdepera (2018).

For pleasure boats, economic information could not be obtained, since it was not possible to do the necessary interviews to obtain this information. Only the number of people who take tours in a year is known.

Regarding visits to the beaches, since there was no direct economic information available, the study by Bujosa - Riera (2019) was used, where they calculate a value of € 0.05 per user per kilometer on the island of Mallorca, using the method of travel cost. As it is the same island and the same year, the same value is used for this study without making any adjustments beyond the kilometers of beach associated with the MPA and the number of people in high season. Applying these values, **a total value for beach visits of 26,082 euros was obtained.**

Finally, the **Llampuga Fair** is held every year in Cala Rajada, a port that can be considered the core location of the marine reserve. To assess this celebration, data from 2017 were considered, since in 2018 there were floods in the region that caused the fair to be held on a smaller scale, while in 2019 there was a sharp drop in tourists due to the bankruptcy of Thomas Cook. Although the fair is held in the Port of Cala Rajada, which is part of the reserve, a percentage is assigned based on the number of llampugas that come from the reserve (557 kg) over the total number of llampugas caught by the fishers of that port, both inside and outside the RMLL (51,601 kg), which gives a factor of 1.07%. **The result obtained for the value of this activity is 398 euros**.

Adding all the indicated values, we arrive at **a total value for the ecosystem service of recreation activities of 3,141,440 euros.**

- Education and research

For the service of *education and research,* figures come from the *Estudi of Despesa in Àrees Marines Protegides de les Balears* (2018), which collects the budget of the projects to generate knowledge that were held in *the RMLL.* In 2018, three Institutes carried out research projects in the marine areas of the Balearic Islands: IEO (Spanish Institute of Oceanography), SEO (Spanish Society of Ornithology) and CSIC. From these projects, the proportional part is assigned to the RMLL, reaching **a total value of 104,892 euros.**

- Existence, option and legacy

The service of *existence, option and legacy* has been identified as an important service in the MPA (see Table 2); however, **it has not been included in the physical and monetary accounts of ecosystem services.**

The assessment of this service focuses on those elements of nature (living and abiotic) that are considered to be conserved, enjoyed and used by future generations. This ecosystem service is offered by those habitats that have already been collected or that are likely to be included in protection figures, international, national or regional, or that are of international interest for their conservation. The most appropriate valuation option would have been to use the contingent valuation method, but, given the impossibility of conducting surveys, it was considered appropriate to value this service through the public budgets destined to conserve the MPA that reflect people's willingness to pay to conserve the area. However, since it is considered that these budgets actually reflect the cost necessary to maintain the natural capital of the MPA in an optimal state, the value of the different budgets was included as maintenance costs (see section 7).

6.3 Comparison of results with other valuation and marine accounting studies

Below, Table 16 compares the results obtained in this study with other valuation and accounting studies in marine habitats.

First of all, it should be noted that **this pilot study includes more ecosystem services than any other analysis carried out in the Mediterranean area.**The first column of Table 15 represents the economic values of ecosystem services in relation to the total hectares of the RMLL, while the second column shows the economic values when only the habitats that provide each service in question are considered - that is,

for example, the hectares of *Posidonia oceanica* meadows are considered for the services of improvement of water quality, coastal protection and capture of CO_2

This differentiation between columns is relevant, since the economic results of ecosystem services will be greater the smaller the area by which the total value of the service is divided. That is why the second column shows higher values than the first.

Similarly, in the study by Bujosa - Riera (2019) there is also a difference between considering the entire surface of the study area (first column, 28,290km^2) and only the habitats that provide each ecosystem service (second column) - specifically, the hectares of the Balearic Sea for the service of aquatic animals for nutrition; hectares of seagrass meadows in the Balearic Sea (65,000 ha) for the services of improving water quality, protecting coastal erosion and capturing CO_2; and the consideration of hectares of Balearic beaches (486 ha) for recreational activities.

Table 16. Comparison of values from different studies for the ecosystem services analyzed. Services not rated are indicated with a horizontal line (-). Source: own elaboration

	RMLL pilot study (2021)		**Campagne *et al.* (2015)**		**Bujosa-Riera (2019)**		**Arantza Murillas-Maza (2011)**	**Tuya *et al.* (2014)**	**Girepam Portofino (2020)**	**Conservation of *P. oceanica* meadows in the Mediterranean Andalusian coast (2014)**
	Total area RMLL	**Area by type of habitat**	**Area of Posidonia meadows in French Mediterranean coast**		**Total area of the Balearic Sea**	**Area by type of habitat**	**Exclusive Economic zones in Spain**	**Area of *Cymodocea nodosa* in Gran Canaria**	**Total area Portofino MPA**	**Area of Posidonia meadows in Andalusian Mediterranean**
	(€ / ha / year 2018)	**(€ / ha / year 2018)**	**Min. (€ / ha / year 2014)**	**Max. (€ / ha / year 2014)**	**€ / ha / year 2018)**	**(€ / ha / year 2018)**	**(€ / ha / year 2015)**	**(€ / ha / year 2011)**	**(€ / ha / year 2014-2015 and 2016)**	**(€ / ha / year 2014)**
Aquatic animals for nutrition	11.49	11.49	-	-	7.24	7.24	5.92	961.80	-	10.59
Posidonia remains	-	-	1.50	-	-	-	-	-	-	-
Improvement of water quality	18.74	53.49	60.00	60.00	1.16	50.33	2.81	-	-	22,500.00
Coastal erosion protection	68.49	195.51	188.00	188.00	4 .41	191.76	-	-	-	-
Biodiversity maintenance	39.65	39.65	27.00	35.00	-	-	0.78	-	-	-
CO_2 capture	1.71	4.89	7.70	230.00	1.96	85.32	36.51	-	-	-
Active or passive recreational activities	278.48	278.48	-	-	20.93	121,852.32	-	-	-	20,961.70
Scientific research and education	9.30	9.30	0.33	0, 33	-	-	-	-	-	-
TOTAL	**427.86**	**-**	**284.53**	**513.33**	**35.70**	**-**	**46.02**	**961.80**	**32,703.95**	**43,472.29**

Analyzing the totals of Table 16, the study by Bujosa–Riera (2019) from the Balearic Sea shows values much lower than the rest of the studies, including this one. This is due to the fact that many of the services were calculated on the habitats of *Posidonia oceanica* meadows, which occupy a small area within the Balearic Sea.

Regarding the study by Campagne *et al*. (2015), the analysis is made on the surface of *Posidonia oceanica* meadows in the French Mediterranean, with minimum and maximum values. The total values of all ecosystem services are in line with the values obtained in this pilot study.

In Arantza Murillas-Maza (2011), the values are expressed with respect to the total area of the exclusive economic zones in Spain, including all types of habitats. The difference with this pilot study basically lies in the methodology applied to value ecosystem services: net added value. For example, to value aquatic animals for nutrition, the cost of fisheries is subtracted from market prices, yielding obviously lower values. As with Bujosa-Riera (2019), the values are much lower than those obtained in this pilot study and in Campagne *et al.* (2015).

Regarding Tuya *et al.* (2014), the economic values are calculated with respect to the surface of the habitat of *Cymodocea nodosa* in Gran Canaria. Only the service of aquatic animals for nutrition is valued, by calculating the value of biomass through sampling at different points and valued through market prices. This represents a difference in methodology compared to the pilot study, where the catches made were calculated, and hence the large difference in the values of aquatic animals for nutrition per hectare (961.80 euros / ha / year in Tuya *et al*. (2014) for 11.49 euros / ha / year in this pilot study).

In the Girepam project(2020), in the Portofino MPA, a total value of ecosystem services of 32,703.95 euros / ha / year is obtained. The methodology of this study is different from that of this pilot study, where an evaluation of the pressures exerted on the environment by users of different cultural and provisioning ecosystem services is carried out. The direct burden of recreational and sport fishing activities, beach visits, recreational navigation and artisanal professional fishing is quantified through the damages generated in the habitats of the MPA as a result of their use. In turn, an assessment of the regenerative capacity of these habitats is also carried out.

In the last study considered, on the *Conservation of Posidonia oceanica meadows in the Andalusian Mediterranean* (2014), the values of ecosystem services are calculated with respect to the surface of the *Posidonia oceanica* meadows habitat in the Andalusian Mediterranean.Their results vary completely from the rest of the studies, amounting to a total of 43,472.29 euros / ha / year.

7. Maintenance costs

A marine protected area, in addition to providing benefits to society, also entails costs derived from the maintenance that is necessary for the reserve to remain in a favorable state. In the cited *Estudi de Despesa en Árees Marines Protegides a les Illes Balears* (Font Gelabert 2018), all the budgets associated with the marine areas of the Balearic Islands are listed. From this document, the following maintenance costs are obtained within the RMLL:

Table 17. Maintenance costs. Source: own elaboration

Type of maintenance cost	Total annual budget	Associated Hectares	Euros / ha	Hectares RMLL	Total euros in RMLL
Surveillance via SGPM	350, 000.00 €	5385.00	65.00€	5,385.00	**350, 000.00€**
Autonomous surveillance	471, 401.00€	56, 013.31	8.42€	5,900.00	**49, 653.66 €**
Fish monitoring	123, 932,.00 €	61, 398.31	2.02€	11, 285.00	**22, 778.68€**
Assistance to anchoring	292, 190.00 €	61, 398.31	4.76€	11, 285.00	**53, 704.48€**
TOTAL	**1, 237, 523.00€**	**184 194.93**		**3,.855.00**	**476, 136.82€**

The Autonomous Government Surveillance Service has the objective of enforcing the regulations of marine reserves oriented to improve fisheries. Said service incurs a necessary cost aimed also at conserving, indirectly, the natural capital of the MPA.

Staff must regularly patrol by land and sea, inform users about the characteristics and zoning of the marine reserve, provide periodic information on the status of the reserves and the programs in place for their conservation, and, finally, carry out control and maintenance tasks of the reserve facilities.

As of 2007, the year in which the RMLL was declared, a surveillance team under the General Secretariat of Maritime Fisheries (SGPM) of the State Government was also established to manage the state dependent area. Both teams cooperate and do complementary surveillance work.

After the introduction of marine fishing reserves in 1999, continuous monitoring of the evolution of fish populations has been carried out. The monitoring of fish populations is done in the autonomous fishing reserves and in the state part of the reserves of Dragonera and the RMLL. This is considered a necessary cost to maintain natural capital in good condition.

Finally, the Anchoring Assistance Program is a service provided to sailors with the aim of reducing the impact of anchors on the *Posidonia oceanica* meadows. It serves to advise them on the appropriate places to anchor or to warn them to modify their position, in case they have anchored on *Posidonia*.

The annual maintenance costs in the RMLL amount to 476,136.80 euros, which generate annual benefits for the whole society of 4,826,518 euros.
For every euro invested, ecosystem benefits of 10 euros are generated.

8.Natural Capital

The **Natural Capital Balance Sheet of the RMLL** (see Table 18) has been generated by applying the Balance Sheet '*eftec Natural Capital Account Template'*. First, a matrix of natural assets and ecosystem services has been developed (see section 3), followed by the physical and monetary accounts of each ecosystem service in a separate tab (sections 4.3 and 5.2, respectively), through which a total value of the annual benefits provided by the RMLL of 4,826,518 euros has been obtained.

Once the economic values of the ecosystem services had been obtained (see monetary accounts, section 5), the total value of the natural capital assets was calculated. To do this, future annual benefit flows were projected for each ecosystem service. In this study, a time horizon of 60 years was chosen, since generally the maximum useful life of an intervention is up to 60 years.

As there was no future information on the evolution of ecosystem services, it was decided to project the benefits on a constant basis, that is, no future growth or decline was assumed. On the other hand, all profit flows are considered real flows (as well as the discount rates to be applied), so no inflation was considered either.

To calculate the **present value of the flow of future benefits**, a decreasing real discount rate was used: 3.5% for years 1 to 30, and 3% for years 31 to 60. This rate is the one used in the eftec Natural Capital Account Template and is based on the discount rate of the *Green Book Notes* (HM Treasury and Government Finance Function - 2020), called the Social Rate of Time Preference. The rate has two components: time preference and wealth effect. Time preference is the rate used to value the present with respect to the future, assuming constant per capita consumption. It includes time preference (δ) and catastrophic risk (L). The estimate of time preference in the *Green Book* is 0.5% and catastrophic risk, 1%. Therefore, the estimate of the time preference rate is 1.5%.

The wealth effect reflects the expected growth in per capita consumption over time, and as future consumption is expected to be higher relative to current consumption, this will mean a lower utility and, therefore, a higher rate, calculated as the marginal utility of consumption (**μ**), multiplied by the expected growth rate of future real per capita consumption (**g**). The estimates of **μ** and **g** are at 1 and 2%, which suggests that 2% is a reasonable estimate of the overall wealth effect.

These parameters lead to a rate of 3.5%, a figure that lies within a justifiable range. Estimates of the parameters, and therefore of the Social Rate of Time Preference, have long been, and continue to be, the subject of debate. However, the figure of 3.5% is in the middle of the examples in current literature.

On the other hand, the discount rate was assumed to be decreasing, due to the uncertainty about the future values of its components. This is why, as of year 31, the rate is reduced from 3.5% to 3%. Theoretical and empirical literature has tended to confirm the declining discount rate approach for long-term risk-free discount rates (Arrow et al. 2013, 2014; Gollier and Hammitt 2014; Cropper *et al.* 2014). Behind this assumption is that a prudent planner would want to save more for precautionary reasons. As a result of the persistent growth crises, the future is increasingly uncertain and this precautionary effect increases as the time horizon considered grows. This is reflected in a decreasing time structure of discount rates.

When calculating the present value of future flows using the Social Rate of Time Preference of the *Green Book,* a **Total Gross Value of Natural Capital Assets of 126,592,216 euros is obtained.** If the annual maintenance costs of the marine reserve are considered, a total profit of 4,350,381 euros per year and a **Total Net Value of Natural Capital Assets of 114,103,872 euros is reached.**

Table 18 shows the results of the Natural Capital Balance Sheet developed.

Ecosystem services	Physical flow (units / year)		Monetary flow (EUR / year)	Present value (60 years)
2018				
Benefits				
Aquatic animals for nutrition (1.1.6.1)	7,421	Kilograms	129,646	3,400,426
Posidonia remains (1.1.5.1 and 1.1.5.2)	800	Kilograms		-
Improvement of water quality (2.1.1.2 and 2.2.5.2)	3,951	Hectares	211,349	5,543,359
Protection from coastal erosion (2.2.1.1 and 2.2.1.3)	3,951	Hectares	772,547	20,262,735
Maintenance of biodiversity (2.2 .2.3)	19,271	People	447,313	11,732,344
CO_2 capture (2.2.6.1)	3,866	Tons of CO2	19,331	507,012
Active or passive recreational activities (3.1.1.1, 3.1.1.2., 6.1.1.1)	384,143	Number of users	3,141,440	82,395 .189
Scientific research and education (3.1.2.1, 3.1.2.2, 6.2.1.1)	3	Number of projects	104,892	2,751,150
Gross natural capital assets			**4,826,518**	**126,592,216**
Liabilities				
Maintenance costs			476,137	12,488,344
Net natural capital assets			**4,350,381**	**114,103,872**

SUMMARY OF RESULTS

- *The gross value of the ecosystem services of the Llevant Marine Reserve amounts to **4.826 million euros per year.***
- *The gross value of the natural assets in the RMLL amounts to 126.59 million euros. By substracting its maintenance costs from this value, the value of the **net natural assets is 114.10 million euros.** This value is highly dependent on the discount rate considered.*

Currently, there are discussions that consider the possibility of lowering the discount rate, and even using a discount rate of 0% or negative. The higher rates are related to a greater degradation of natural capital over the years — a decreasing value — or, at least, to greater uncertainty regarding the state and future condition of natural capital. This practice is aligned with the current paradigm based on opting for immediate measures that satisfy short-term objectives, where long-term sustainable practices may have high costs in the distant future. On the contrary, there are rates close to zero, or negative, that give greater importance to long-term conservation and future generations; that is, they take into account distributive impacts and consider that the value of natural capital increases over time.

Annex E shows a small analysis about this discussion, including a sensitivity analysis of the balance sheet of this study with different rates — positive, zero, and negative.

9. Needs, lessons learned and future work

This study allows us to know in detail the natural capital accounts of an MPA in the Balearic Islands. The developed natural capital accounting model offers data not only on the extent, condition, measurement, value and current accounts of natural capital, but also provides a tool that shows the future impact, both physical and economic, of any changes or new scenarios that may take place regarding the management of the marine protected area.

The work carried out allows us to learn certain lessons, thanks to the different barriers and limitations that have been overcome. Likewise, some parts of the study can be reworked, allowing its expansion and improvement. The main lessons learned, barriers and needs for improvement for the RMLL are shown below, in order to better carry out future natural capital accounting and valuation processes:

RELATED WITH DEVELOPMENT OF METHODOLOGIES AND DATA COLLECTION

- Access to robust data on the extraction of marine resources in the RMLL. The best possible collaboration with professional fishers is needed.
- Implementation of the satellite monitoring system (green boxes) in the artisanal professional fleet operating in the RMLL.
- Development of a reliable system to determine the effort and performance of recreational fishing in the RMLL. Data coming from the Diario de Pesca mobile application, launched in 2020 by the General Directorate of Fisheries and Medi Marí of the Balearic Government, may be of great interest.
- Improvement of accessibility to the data regarding uses in the RMLL, once elaborated and conveniently converted into anonymous.
- Elaboration of an *ad hoc* bionomic cartography for the RMLL.
- Studies to determine the status of marine habitats in the RMLL
- Greater care in the recording of removal and management of posidonia remains on the beaches.
- Design and implementation of systems to monitor the populations of commercial species, beyond those of coastal rocky bottom fish.
- Determine methodologies for monitoring the quality of ecosystems in the reserve.

REGARDING ACCOUNTING AND ECONOMIC VALUATION

- Carry out workshops to identify and prioritize ecosystem services with local actors.
- Carry out surveys to determine the cost of travel and to be able to build a demand curve.
- Have access to the data that allow calculating the condition and extent of assets (species and ecosystems) separately.

ORIENTED TO KNOW BETTER THE MARINE RESERVE SOCIAL PERCEPTION

- Analysis of the general population's perception of the performance of the RMLL and other confluent protection figures.

Bibliography

Bibiloni, MA., Uriz, MJ., y Gili, JM. (1989) Sponge communities in three submarine caves of the Balearic Islands (Western Mediterranean): adaptations and faunistic composition. *Marine Ecology* 10 (4): 317-334.

Boudouresque, CF (2010) Structure et fonctionnement des écosystèmes benthiques marins.

Bujosa Bestard, A. y Riera Font, A.(2019) Valoración económica de los servicios ambientales de tres activos representativos del ecosistema marino de Balears. *Study commissioned by Marilles Foundation.*

Cantasano, N. (2009) Management plan for the beach-cast seagrass in Calabria. In: Marine Research at CNR, Chapter: DTA/06-2011. Department of Earth and Environment, National Research Council of Italy: 1173-1182.

Campagne, CS, Salles b, JM., Boissery c, P., y Deter, J. (2015) The seagrass *Posidonia oceanica*: Ecosystem services identification and economic evaluation of goods and benefits. *Marine Pollution Bulletin* 97(1-2): 391-400.

Chen, B., He, G., Yang, J., Zhang, J., Su, M., Qi, J. (2012) Evaluating ecological and economic benefits of a low-carbon industrial park based on millennium ecosystem assessment framework. *The Scientific World Journal* 5:909317.

Conselleria d'Agricultura i Pesca. Govern Balear (1992) Carta Biométrica del mar Balear

Costanza, R., D'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, RV, Paruelo, J., Raskin, RG, Sutton, P., van Den Belt, M. (1997) The value of the world's ecosystem services and natural capital. *Nature* 387: 253-260.

Cropper, Maureen L., Freeman, Mark C., Groom, Ben and Pizer, William A. (2014) Declining discount rates. *American Economic Review: Papers and Proceedings,* 104 (5): 538-543.

CSIC – Consejo Superior de Investigaciones Científicas, Grupo de Economía Ambiental (GEC) (2008-2021) Valoración de la Renta y el Capital de los Montes de Andalucía (RECAMAN). Available at: http://www.recaman.es/content/presentaci%C3%B3n

De Falco, G., Ferrari, S., Cancemi, G., Baroli, M. (2000) Relationship between sediment distribution and *Posidonia oceanica* seagrass.*Geo-Marine Letters* 20(1): 50-57.

Direcció General de Recursos Hídrics, Conselleria de Medi Ambient i Territori, Govern de les Illes Balears (2017) Monitoreo y Evaluación del Estado Ecológico de las masas de agua costeras de la Demarcación Hidrográfica de las Illes Balears utilizando el elemento biológico de calidad *Posidonia oceanica*.

Duarte, CM Kennedy, H. Marbà, N. & Hendriks, I. (2011) Assessing the capacity of seagrass meadows for carbon burial: Current limitations and future strategies». Ocean & Coastal Management, 83: 32-38.

Duarte, CM, Middelburg, JJ, y Caraco, N. (2005) Major role of marine vegetation on the oceanic carbon cycle, Biogeosciences, 2, 1–8.

Duarte, CM, Marbà, N., Gacia, E., Fourqurean, JW, Beggins, J., Barrón, C., Apostolaki, ET (2010) Seagrass community metabolism: assessing the carbon sink capacity of seagrass meadows. Global Biochem. Cy. 24, GB4032.

eftec, RSPB and PwC. (2015) Developing Corporate Natural Capital Accounts. Report for the Natural Capital Committee. Available at:

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/516968/ncc-research-cnca-final-report.pdf

Font Gelabert, A., Pandion Consultoría Ambiental (2018) Estudi de Despesa en Àrees Marines Protegides a les Illes Balears. *Commissioned by Marilles Foundation*.

Gacia, E., Granata, T., Duarte, C. (1999) An approach to measurement of particle flux and sediment retention within seagrass (*Posidonia oceanica*) meadows. *Aquatic Botany* 65(1-4): 255-268.

Gobierno de España (2021) Plan de Recuperación, Transformación y Resiliencia. Available at: https://www.lamoncloa.gob.es/temas/fondos-recuperacion/Documents/30042021-Plan_Recuperacion_%20Transformacion_%20Resiliencia.pdf

Gollier, C. y Hammitt, JK. (2014) The Long-Run Discount Rate Controversy. *Annual Reviews* 6: 273-295.

Groom, By Maddison, D. (2018) New estimates of the elasticity of marginal utility for the UK. *Environmental and Resource Economics* 72: 1155-1182.

Halkos, G. y Galani, G (2016) Assessing willingness to pay for marine and coastal ecosystems: A Case Study in Greece. *MPRA Paper68767, University Library of Munich, Germany*.

Hemminga, M y Duarte, CM (2000) Seagrass Ecology. *Cambridge University Press*.

HM Treasury and Government Finance Function (2020) The green book: appraisal and evaluation in central government.

IDEEA Group (2020) Data assessment report, Ocean accounting pilot for Geographe Marine Park, Institute for the Development of Environmental-Economic Accounting, Victoria, Australia.

Informe Mar Balear (2020). Diversos Autores- Available at: https://informemarbalear.com/images/docs/informe-mar-balear-esp-web.pdf

J. Arrow, K., L. Croppery, M., Gollierz, C., Groom, B., M. Heal, G., G. Newellk, R., D. Nordhaus, W., S. Pindyck, R., A. Pizeryy, W., R. Portneyzz, P., Sterner, T., SJ Tol, R., y L. Weitzman, M. (2014) Should Governments Use a Declining Discount Rate in Project Analysis? *Review of Environmental Economics and Policy* 8(2):145-163.

Julià, M., del Valle, L., Bagur, M., Marsinyach, E., Pons, GX y Carreras, D. (2019) Cartografía de los hábitats marinos de las Islas Baleares: compilación de capas y comunidades bentónicas. Observatorio Socioambiental de Menorca (Institut Menorquí d'Estudis). *Societat d'Història Natural de les Balears. Fundació Marilles.*

Junta de Andalucía (2014) Conservación de praderas de *Posidonia oceanica* en el Mediterráneo Andaluz. *Proyecto LIFE.*Available at: http://www.juntadeandalucia.es/medioambiente/portal_web/web/temas_ambientales/programas_europeos_y_relac_internac/programas_europeos/life/proyectos_ejecucion/LIFE09_posidonia/documentos/AnejoC12.pdf

Kennedy H., Beggins J., Duarte CM, Fourqurean JW, Holmer M., Marba N., Middelburg JJ (2010) Seagrass sediments as a global carbon sink: Isotopic constraints. *Global Biogeochem. Cycles*, 24

Koch, EW, Barbier, EB, Silliman, BR, Reed, DJ, Perillo, GME, Hacker, SD, Granek, EF, Primavera, JH, Muthiga, N., Polasky, S., Halpern, BS, Kennedy, CJ, Kappel, CV, Wolanski, E. (2009) Non-linearity in ecosystem services: temporal and spatial variability in coastal protection. *Frontiers in Ecology and the Environment* 7 (1): 29-37.

Luisetti, T., Turner R., K., Hadley, D., Morse-Jones, S. (2010) Coastal and marine ecosystem services valuation for policy and management, *CSERGE Working Paper EDM, No. 10-04, University of East Anglia.*

Mangos, A , Bassino, J.-P. y Sauzade, D. (2010) Valeur économique des bénéfices soutenables provenant des écosystèmes marins méditerranéens. *Plan Bleu*. Available at: https://planbleu.org/projets/les-ecosystemes-marins-mediterraneens-valeur-economique-des-benefices-soutenables/

Mateo, MA, Sánchez-Lizaso, JL, Romero, J. (2003) *Posidonia oceanica* 'banquettes': A preliminary assessment of the relevance of meadow carbon and nutrients Budget. Estuarine, Coastal and Shelf Science 56(1): 85-90.

Mazarrasa, I., Marbà, N., Garcia- Orellana, J., Masqué, P. y Arias- Ortiz, A. (2017) Effect of environmental factors (wave exposure and depth) and anthropogenic pressure in the C sink capacity of *Posidonia oceanica* meadows. *Limnology and Oceanography* 62 (4), 1436-1450.

Morey, G., Coll, J., Navarro, O. y F. Verger (2018). La reserva marina del Llevant de Mallorca. Seguiment de les poblacions de peixos vulnerables de substrat rocós en el període 2008-2018. *Direcció General de Pesca i Medi Marí-Govern de les Illes Balears – Tragsatec. Novembre de 2018. 74 pàgines.*

Murillas-Maza, A., Virto, J., Gallastegui, MC., González, P., y Fernández-Macho, J. (2011) The value of open ocean ecosystems: A case study for the Spanish exclusive economic zone. *Natural Resources Forum* 35(2):122-133.

Pergent, G., Semroud, R., Djellouli, A., Langar, H. and Duarte, C. (2015) *Posidonia oceanica. The IUCN Red List of Threatened Species* 2015: e.T153534A4516034.

Proyecto LIFE+INDEMARES, Subproyecto Canal de Menorca: Caracterización del Ecosistema demersal y bentónico del canal de Menorca (Islas Baleares) y su explotación pesquera (2009-2013). Available at: https://www.indemares.es/

Sanfélix, M. (1999) Estudio de viabilidad de recuperación de la foca monje (Monachus monachus) en las Islas Baleares. Documents Tècnics de Conservació, IIª época, num.5. *Conselleria de Medi Ambient, Ordenació del Territori i Litoral, Govern de les Illes Balears*

Simeone, S. y De Falco, G. (2013) *Posidonia oceanica* banquette removal: sedimentological, geomorphological and ecological implications. *Proceedings 12th International Coastal Symposium* (Plymouth, England), Journal of Coastal Research, Special Issue No. 65, pp. 1045-1050, ISSN 0749-0208.

Spackman (2016) Appropriate time discounting in the public sector. *Centre for Climate Change Economics and Policy Working Paper No. 207 Grantham Research Institute on Climate Change and the Environment Working Paper No. 182*

Stephen, D., Maguire, P., Zwick, S., William, M., Wildish, J. y Myers, K. (2020). A state of voluntary carbon markets 2020 Second Installment Featuring Core Carbon & Additional Attributes Offset Prices, Volumes and Insights. *Ecosystem Marketplace – Insights Brief.*

Stern, N. (2007) Stern Review on the Economics of Climate Change. *Cambridge University Press*.

The Centre for Social and Economic Research on the Global Environment (CSERGE), Norwich, MS. y Goñi, R. (2004) Seguimiento de las pesquerías (Punto Cero) en el ámbito de la futura Reserva Marina de Cala Rajada (Mallorca). IEO-COB y SGPM/PESCALA I/04-1, 129 pp.

Tuya, F., Haroun, R., Espino, F. (2014). Economic assessment of ecosystem services: Monetary value of seagrass meadows for coastal fisheries. *Ocean & Coastal Management* 96: 181-187.

United Nations – Department of Economic and Social Affairs Statistics Division (2021). System of Environmental-Economic Accounting–Ecosystem Accounting (Final draft). Available at: https://seea.un.org/content/homepage and https://unstats.un.org/unsd/statcom/52nd-session/documents/BG-3f-SEEA-EA_Final_draft-E.pdf

Vázquez-Luis, M. (2016). Inventario de las poblaciones del vermétido Mediterráneo *Dendropoma lebeche* en las costas de baleares. Servei de Protecció d'Espècies, Direcció General d'Espais Naturals i Biodiversitat. Conselleria de Medi Ambient, Agricultura i Pesca, Govern de les Illes Balears. 169 pp.

Wylie, L., E. Sutton-Grier, A., Moore, A. (2015) Keys to successful blue carbon projects: lessons learned from global case studies. *Marine Policy* 65: 76-84.

ANNEXES

Annex A. Other coincident protection figures in the area

The Llevant Peninsula Natural Park was declared in 2001. It includes a terrestrial natural reserve and a marine conservation area. Its surface area was reduced in 2003, to only publicly-owned land. Regulation in the marine conservation area has never been developed.

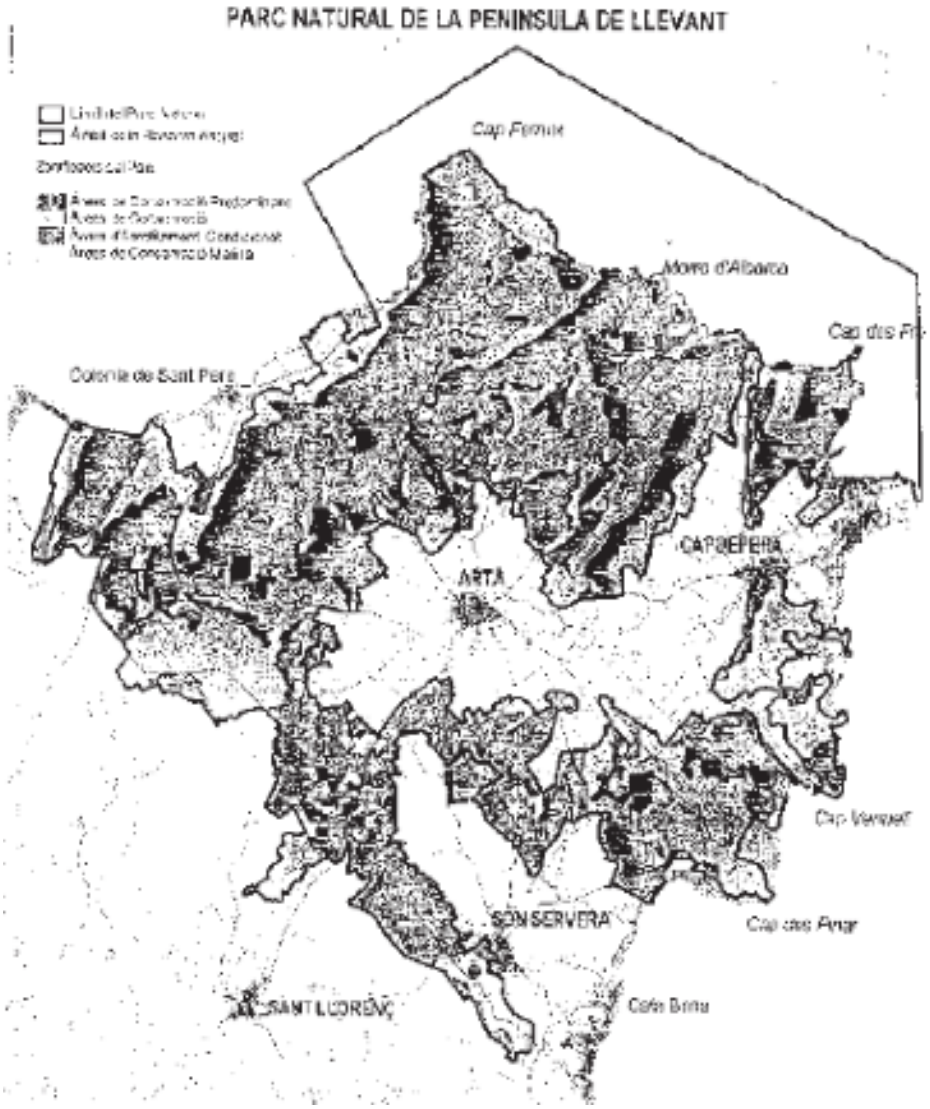


Figure 7. Scope and zoning of the Llevant Peninsula Natural Park in its initial declaration. Source: Decree 127/2001, of November 9th, declaring the Llevant peninsula natural park and the Cap Farrutx and Cap Des Freu nature reserves.

Figure 8. Scope and zoning of the Llevant Peninsula Natural Park after the modification introduced in 2003. Source: Conselleria de Medi Ambient i Territori

In the area of the RMLL), three spaces of the marine Natura 2000 Network that partially overlap have been declared as protected. Two of them are regionally managed: SCI ES5310005 Badies de Pollença i Alcúdia and SCI ES0000227 Muntanyes d'Artà, both designated in 2006.

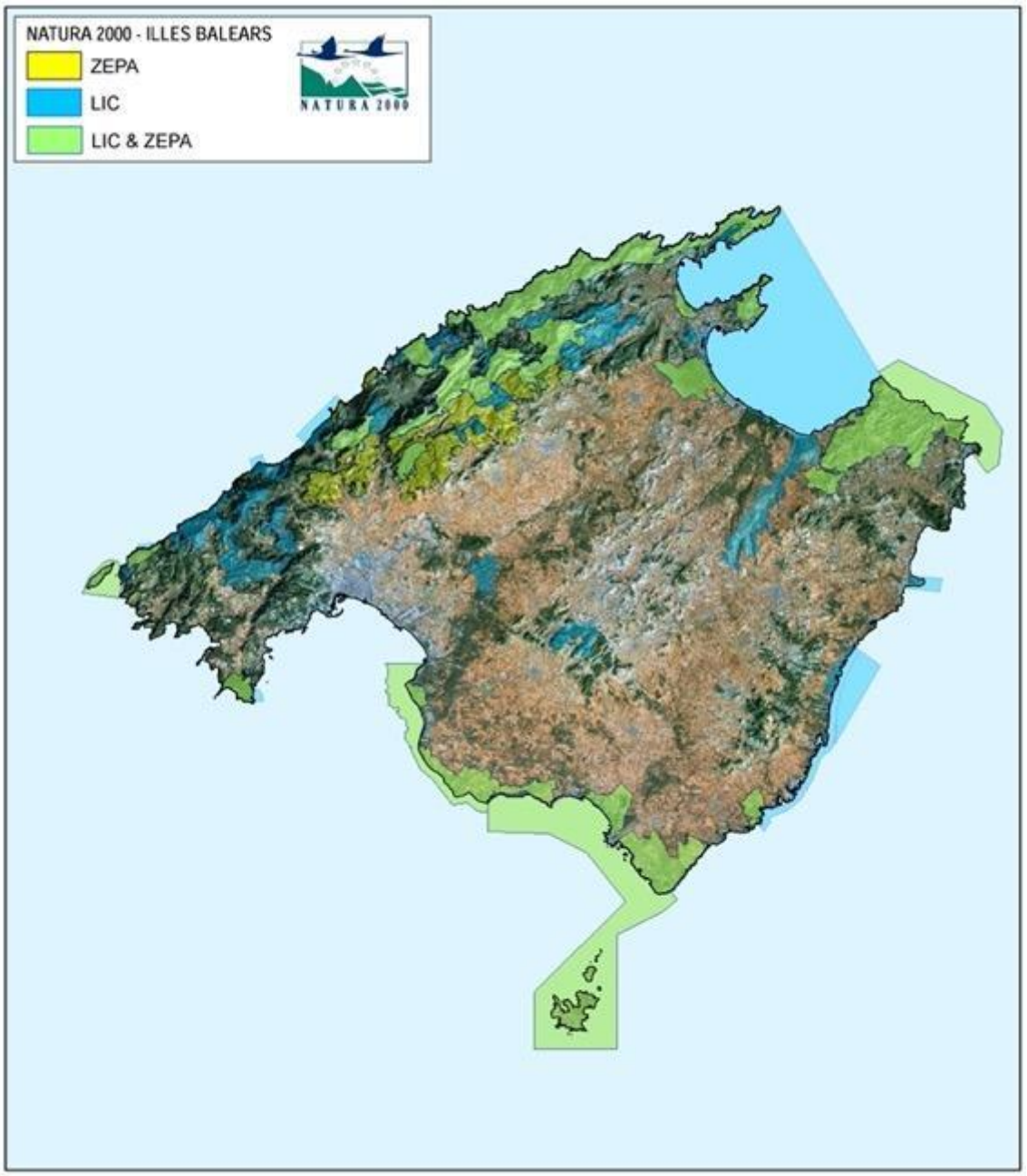


Figure 9. Map of the Natura 2000 areas SCI ES5310005 Badies de Pollença i Alcúdia and SCI ES0000227 Muntanyes d'Artà. Source: Conselleria de Medi Ambient i Territori.

Finally, the marine area of the Menorca Canal was designated by the State Administration as a Site of Community Interest (SCI ESZZ16002 Canal de Menorca) in July 2014.

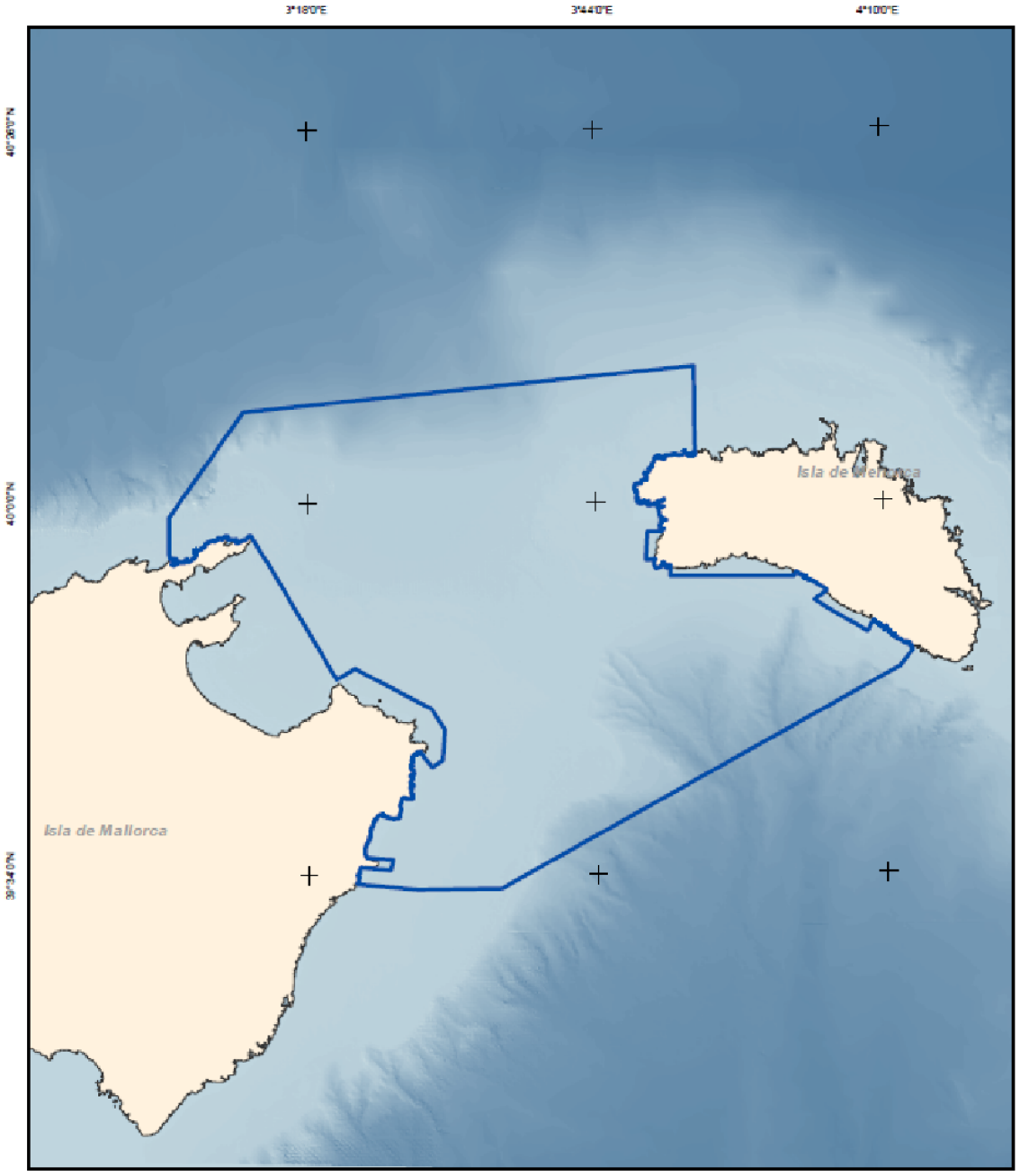


Figure 10. Scope of the SCI ESZZ16002 Canal de Menorca. Source: MITECO.

Annex B. Analysis of professional fishing in the area of the Marine Protected Area (MPA)

The fishing resources of the Balearic Islands have experienced a decline due to overfishing, which has led to losses in all associated sectors. Proof of this is the drastic reduction in the small gear fishing fleet, which 30 years ago was 300% bigger than it is now. However, this decline has not occurred equally on all the Balearic coasts and it is paradigmatic to observe that those fishers *Cofradías* (fishers' guilds) closest to MPAs have experienced a smaller reduction, or have even slightly increased their fleet.

This behavior in the evolution of the different fishing fleets can be explained, at least partially, by the so-called *spillover* effect, which consists of the export of biomass from the interior of the MPAs to border areas open to fishing and, above all, by the phenomenon of larval dispersal from within the MPA, where there is a sufficient number of breeding individuals.

The protection enjoyed by fishery resources in an MPA facilitates their recovery, and this in turn allows the recovery of fishing methods and gear that, being more selective and sustainable, had ceased to be profitable due to resource decline.

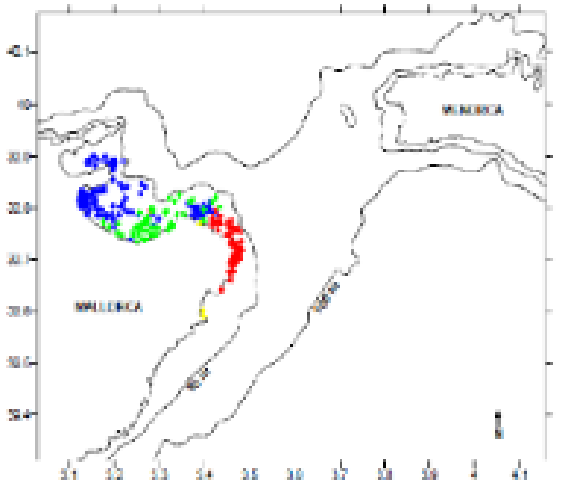
The recovery of exploited stocks and the reintroduction of partly-forgotten gears allow more selective fishing and a reduction of the fishing effort, while obtaining higher quality catches.

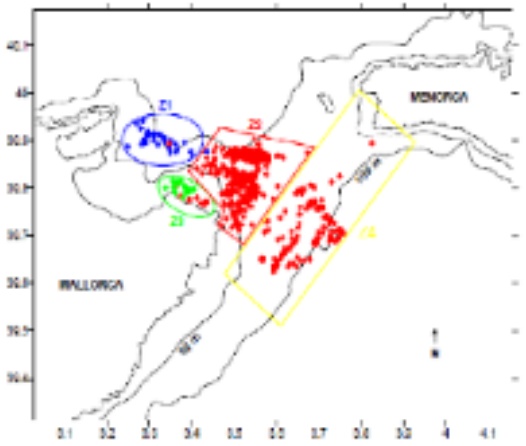
The request for the creation of the RMLL in 2001 was an initiative of the Cala Rajada Fishers' Association. Since its creation in 2007, regulations for professional fishing were introduced, with differences between the two areas of competence, autonomous and State. Subsequently, in 2014, the regulations of both administrations were harmonized and the provisions that have been in force to date were adopted.

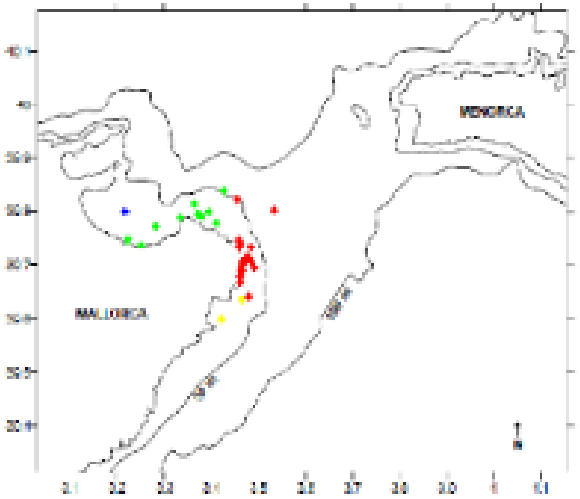
Prior to the declaration in 2007, the General Secretariat for Maritime Fisheries of the Government of Spain signed an agreement with the Spanish Institute of Oceanography (IEO), commissioning a report on the monitoring of fisheries (Zero Point) in the field of the future Marine Reserve of Cala Rajada (Mallorca). Information on fishing for small gears is analyzed from the concept of *métier* (group of fishing operations that result from the combination of fishing gear, target species, geographical fishing area and time of year). This is especially useful for at least two reasons. On the one hand, the catch declaration statements in the RMLL are made daily and it is only allowed to fish with a single gear per day, so the coincidence with the concept of *métier* is complete. Furthermore, the application of the concept of *métier* allows to relate with enough certainty the type of habitat on which each work day takes place.

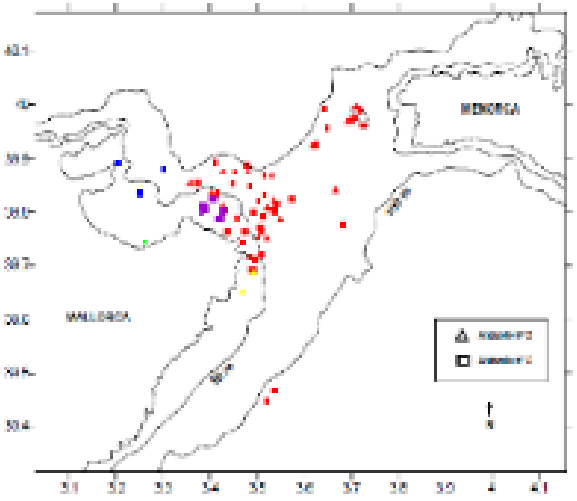
This complete and rigorous study (Mallol and Goñi, 2004) contains an analysis of the small gear fisheries practiced in the area, which serves as a reference to understand the reality of fishing in the RMLL. This activity shows the typical annual rotation of gear and target species that occurs in most artisanal fisheries in the Mediterranean. The information provided in the report is summarized below

Figure 11. Analysis of small gear fisheries in the future RMLL. Source: Mallol and Goñi, 200

Métier	Target Species	Commercial Bycatch	Discarded fish species	Fishing zones
Cuttlefish fishery	*Sepia officinalis*	*Diplodus vulgaris*	*Dactylopterus volitans*	
Jan 20 to April 30		*Mullus surmuletus*	*Dardanus calidus*	
with trammel net		*Octopus vulgaris*	*Dasyatis pastinaca*	
on sand and seagrass		*Sarpa salpa*	*Hexaplex trunculus*	
between 4m and 40m		*Scorpaena porcus*	*Holothuria tubulosa*	
		Scorpaena scrofa	*Torpedo marmorata*	
		Solea vulgaris	Damaged commercial species	
		Uranoscopus scaber		

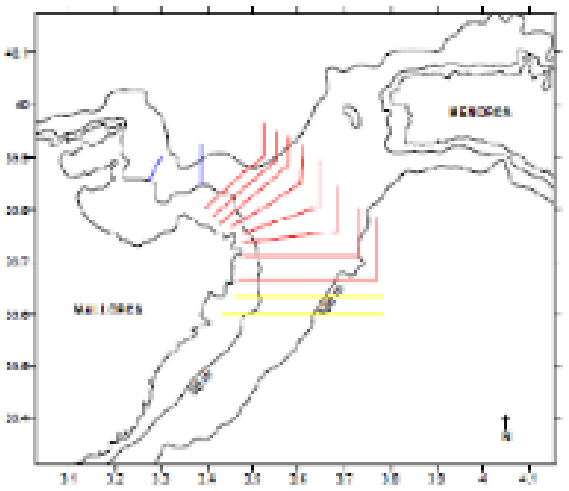
Métier	Target Species	Commercial Bycatch	Discarded fish species	Fishing zones
Spiny lobster fishery	*Palinurus elephas*	*Calappa granulata*	*Dasyatis pastinaca*	
June 1 to August 31		*Lophius piscatorius*	*Echinaster sepositus*	
with lobster trammel		*Phycis phycis*	*Echinus melo*	
coralline gravel or maërl bottom		*Raja* spp.	*Eunicella cavolini*	
between 50m and 90m		*Scorpaena scrofa*	*Holothuria tubulosa*	
		Zeus faber	*Marthasterias glacialis*	
			Ophidiaster ophidianus	
			Spatangus purpureus	
			Sphaerechinus granularis	
			Damaged commercial species	

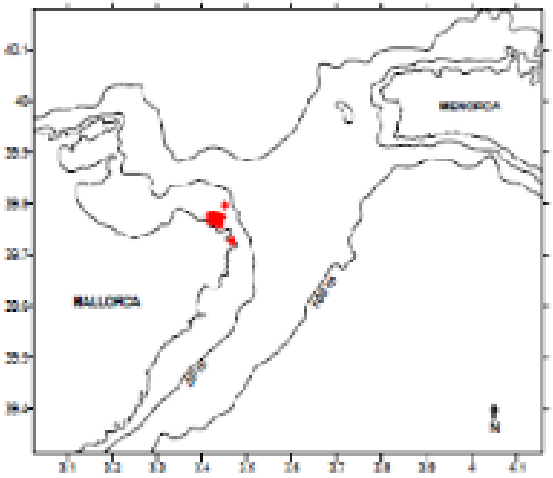
Métier	Target Species	Commercial Bycatch	Discarded fish species	Fishing zones
Mullet fishery	*Mullus surmuletus*	*Dentex dentex*	*Dactylopterus volitans*	
August 15 to December 31		*Diplodus annularis*	*Dardanus arrosor*	
With mullet gillnet		*Diplodus vulgaris*	*Dardanus calidus*	
transition between posidonia and sand		*Labrus merula*	*Echinaster sepositus*	
between 0m and 40m		*Labrus viridis*	*Hexaplex trunculus*	
		Lithognathus mormyrus	*Holothuria tubulosa*	
		Pagellus erythrinus	*Synodus saurus*	
		Sciaena umbra	Damaged commercial species	
		Scorpaena notata		
		Scorpaena porcus		
		Scorpaena scrofa		
		Serranus cabrilla		
		Serranus scriba		
		Spondyliosoma cantharus		
		Symphodus tinca		

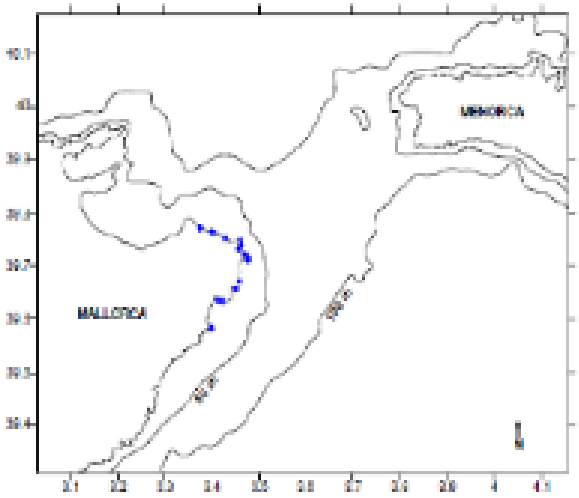
Métier	Target Species	Commercial Bycatch	Discarded fish species	Fishing zones
Longline fishery	*Epinephelus marginatus*	*Scyliorhinus canicula*	*Astropecten aranciacus*	
September 1 to February 29	*Dentex dentex*	*Muraena helena*	*Dardanus arrosor*	
with bottom longline	*Pagrus pagrus*	*Myliobatis aquila*	*Dardanus calidus*	
on rocky bottoms	*Spondyliosoma cantharus*	*Raja* spp.	*Eunicella singularis*	
between 30m and 100m	*Pagellus erythrinus*		*Marthasterias glacialis*	
	Scorpaena scrofa		*Muraena helena*	
			Scyliorhinus canicula	
			Tethyaster subinermis	
Métier	**Target Species**	**Commercial Bycatch**	**Discarded fish species**	**Fishing zones**

"*jonquillo*" fishery	*Aphia minuta mediterranea*	*Sepia officinalis*	*Bothus podas*	
December to March	*Pseudaphia ferreri*	*Loligo vulgaris*	*Chromis chromis*	
Small flying trawling "jonquillera"		*Crystallogobius linearis*	*Coris julis*	
sandy bottoms and seagrass		*Gymnammodytes cicerellus*	*Syngnathus typhle*	
between 20m and 35m			*Dactylopterus volitans*	
			Alloteuthis subulata	
Métier	**Target Species**	**Commercial Bycatch**	**Discarded fish species**	**Fishing zones**

Dolphinfish (*Llampuga*) fishery	*Coryphaena hippurus*	*Naucrates ductor*	*Polyprion americanus*	
August to December		*Seriola dumerili*	*Balistes carolinensis*	
Pelagic purse under floating artifacts ("capcers") with specific gear (“llampuguera”)				



Métier	Target Species	Commercial Bycatch	Discarded fish species	Fishing zones
Squid fishery	*Loligo vulgaris*			
all year round				
jig, with or without artificial light				
Detrital bottoms, fine or coarse gravel				

Métier	Target Species	Commercial Bycatch	Discarded fish species	Fishing zones
Fishery with 'solta' and 'moruna'	*Auxis rochei*	*Dentex dentex*	*Balistes carolinensis*	
gear perpendicular to shore	*Euthynnus alleteratus*	*Epinephelus costae*	*Dactylopterus volitans*	
from May 1 to September 15	*Lichia amia*	*Epinephelus marginatus*		
from October 1 To March 31	*Sarda sarda*	*Mycteroperca rubra*		
rocky coast	*Seriola dumerili*	*Sparus aurata*		
	Trachinotus ovatus	*Sphyraena viridensis*		

Métier	Target Species	Commercial Bycatch	Discarded fish species	Fishing zones
Fishery with Almadrabilla	*Thunnus alalunga*	*Xiphias gladius*		
Midwater drifting floating	*Thunnus albacares*			
February to April	*Thunnus obesus*			
	Thunnus thynnus			

Annex C. Species of interest

After consulting the bibliography available from various sources on biological, fishing and ecological aspects of the RMLL (included in this document), a list of outstanding species has been compiled.

Some species are of significant commercial interest, either because they are the target of fishing or collection by professional or amateur fishers, or because they are species whose observation or contemplation promotes recreational activities that can drive business opportunities. Other species are of interest for conservation, because their populations have been reduced or have disappeared, or because they play a structuring role in habitats, which makes them key to maintaining diversity and ecosystem services. Finally, there is a group of species that can be considered emblematic and that have become part of the culture and collective imagination of local populations and their visitors. Often, more than one of these values may be attributed to a given species

Table 19. Identification of species of fauna and flora in the marine protected area and their categorization based on their commercial, conservation and cultural value. Source: own elaboration

SPECIES	MARKET VALUE	CONSERVATION VALUE	CULTURAL VALUE
Cystoseira spp.		x	
Phymatolithon calcareum		x	
Lithothamnion corallioides		x	
Posidonia oceanica		x	x
Cymodocea nodosa		x	
Vidalia volubilis		x	
Maja crispata		x	
Maja squinado	x	x	
Calappa granulata	x		
Palinurus elephas	x		x
Scyllarides latus	x		x
Sepia officinalis	x		x
Octopus vulgaris	x		
Loligo vulgaris	x		x
Alloteuthis subulata	x		
Pinna nobilis		x	
Pinna rudis		x	
Lithophaga lithophaga		x	
Centrostephanus longispinus		x	
Paramuricea clavata		x	

Eunicella singularis		x	
Corallium rubrum	x	x	x
Dendropoma petraeum		x	
Aphia minuta mediterranea	x	x	x
Apogon imberbis	x		
Auxis rochei	x		
Balistes carolinensis	x		
Bothus podas	x		
Chromis chromis	x		
Coris julis	x		
Coryphaena hippurus	x		x
Crystallogobius linearis	x		
Dactylopterus volitans	x		
Dasyatis parsnip		x	
Dasyatis violacea		x	
Dentex dentex	x		
Diplodus annularis	x		
Diplodus puntazzo	x		
Diplodus vulgaris	x		
Epinephelus marginatus	x		x
Euthynnus alletteratus	x		
Gymnammodytes cicerellus	x		
Labrus bimaculatus	x		
Labrus merula	x		
Labrus viridis	x		
Lichia amia	x		
Lithognathus mormyrus	x		
Lophius piscatorius	x		
Mullus surmuletus	x		
Muraena helena	x		
Mustelus mustelus		x	
Myliobatis aquila		x	
Naucrates ductor	x		
Pagellus erythrinus	x		
Pagrus pagrus	x		
Phycis phycis	x		
Polyprion americanus	x		
Pseudaphia ferreri	x		
Raja asterias	x	x	

Raja brachiura	x	x	
Raja clavata	x	x	
Raja miraletus	x	x	
Raja montagui	x	x	
Raja radula	x	x	
Sarda sarda	x		
Sarpa salpa	x		
Sciaena umbra	x		x
Scorpaena notata	x		
Scorpaena porcus	x		
Scorpaena scrofa	x		
Scyliorhinus canicula	x	x	
Scyliorhinus stellaris	x	x	
Seriola dumerili	x		x
Serranus cabrilla	x		
Serranus scriba	x		
Solea vulgaris	x		
Sphyraena sphyraena	x		
Spicara flexuosa	x		
Spicara smaris	x		
Spondyliosoma cantharus	x		
Symphodus cinereus			
Symphodus doderleini			
Symphodus tinca	x		
Syngnathus typhle		x	
Synodus saurus			
Thunnus alalunga	x		
Thunnus albacares	x		
Thunnus obesus	x		
Thunnus thynnus	x	x	
Torpedo marmorata		x	
Trachinotus ovatus	x		
Trachinus draco	x		
Trachinus radiatus	x		
Trachurus mediterraneus	x		
Uranoscopus scaber	x		
Xiphias gladius	x	x	
Xyrichthys novacula	x		x
Zeus faber	x		

Caretta caretta		*x*	x
Calonectris diomedea		*x*	x
Puffinus puffinus mauretanicus		*x*	x
Tursiops truncatus		*x*	x
Monachus monachus		*x*	x

Annex D. Economic valuation methods used for the different ecosystem services

Market prices

For the service of **aquatic animals for nutrition**, the method used was market price. This estimates the economic value of ecosystem products or services that are bought and sold in commercial markets. It represents the value of an additional unit of that good or service, assuming that the good is sold through a perfectly competitive market. The quantity of aquatic animals for nutrition has been valued through this method, because the price per kilogram of each species is available at the Palma de Mallorca fish market.

This is the most robust method and has the least degree of uncertainty, because it reflects the price that the consumer is willing to pay for the environmental good or service. It is due to the robustness of the method and the regional data obtained that a "low" level of uncertainty was obtained for this assessment. It should be noted, however, that, having detected the existence of undeclared production (see the section "Provisioning services, aquatic animals for nutrition"), and even though a correction has been made in this regard, the *degree of uncertainty "very low"* is not reached for this service.

The service of regulation of the **capture or fixation of CO_2**, for the regulation of the chemical composition of the atmosphere and oceans, has also been valued using the method of market prices, since the capture of carbon dioxide also has a price in the markets and there is the potential to generate a market for carbon rights associated with the management and conservation of *Posidonia oceanica*. A "moderate" level of uncertainty was obtained for this service, as the data for tons of CO_2 capture are based on reference values and not on more robust methods such as field studies.

Travel budget

For **active and passive recreational activities**, the travel budget method was used, which involves the time and money used to make a trip to the MPA, represented by the price of access to the reserve. Therefore, the willingness to pay to visit the MPA can be estimated from the number of visits that people make, incurring various travel costs. This represents an exchange price. At this point, it is worth differentiating the *travel budget method* from the *travel cost method*. While the first represents an exchange value, that is, a value used by users to access the study area, the second represents the consumer surplus, that is, what they are willing to pay to access the area. To calculate the consumer surplus, a demand curve (individual or zonal) must be constructed, which has not been carried out in this study due to insufficient data.

For this reason, the *degree of uncertainty of said method applied to the service in question is "moderate",* since, although data were obtained from the study area, these are estimates that do not allow the construction of a demand curve and calculation of the surplus of the consumer.

Project Budget

Project budgets also represent the exchange rates for different development activities. In this case, they are used to value the ecosystem service of **education and scientific research**, that is, the expenses incurred in knowledge-generation activities in the MPA are counted. This assessment has a *"very low" degree of uncertainty,* as it is based on data specific to the study area.

Benefits Transfer (Cost method, Choice experiments)

The method of transfer of benefits consists in applying values from other studies to the study area, with the necessary adjustments; in our case, this fine-tuning is done using the *unit value transfer.* This method has been used to value the regulation services of **Improvement of water quality, Protection of coastal erosion and Maintenance of biodiversity.**

In the studies from which data have been transferred (see "Accounts of the provision of ecosystem services" for bibliographic references), the cost method is used to value the services of Improvement of

water quality and Protection of coastal erosion. Cost methods - ie. avoided costs, defensive costs, replacement or restocking costs, surrogate costs - are methods that estimate the values of ecosystem services based on the costs of damage avoided by the presence of the service, the costs of maintaining the services, of replacing or repairing them, or of substituting them with other anthropic alternatives. These costs are assumed to provide estimates of the value of ecosystem services.

The *replacement cost* method uses the cost of providing artificial substitutes for an ecosystem or its services as an estimate of the value of the ecosystem or its services. In the case of **Water Quality Improvement,** the studies used deal with the costs that would be involved in improving water quality in the absence of *Posidonia oceanica* meadows that clean the water. In the case of **Coastal Erosion Protection**, the costs incurred for repairing the damage caused by coastal erosion are used as an indication of the service provided by the *Posidonia oceanica* meadows in protecting the coasts from erosion. This represents the method of *cost damages avoided*, as it provides a measure of what will have to be spent in the event of the absence of the service and the occurrence of catastrophe (in this case, erosion). It provides a measure of the damages incurred.

Because these methods are based on the use of costs to estimate profits, it is important to note that they do not provide a technically correct measure of economic value, which is adequately measured by the maximum amount of money or other goods that a person is willing to give up in order to obtaina certain good. With these methods, it is assumed that if people incur in expenses to avoid damage caused by lost ecosystem services, or to repair or replace services, they must be worth at least what people pay.

The valuation of these two regulation services - Water quality improvement and Coastal erosion protection - obtained a "high" degree of uncertainty, since, in the first place, values from another study area were applied to value the services of the MRLL, and, in turn, only one of the habitats present in the reserve was valued.

To assess **the Biodiversity Conservation** service, the study Halkos *et al.* (2016) was used as a reference. This team assesses the willingness of the local population of the Greek islands of Crete, and Lesvos, and the Volos Gulf area to pay for conserving certain attributes of the biodiversity of marine areas, through the method of declared preferences of choice experiments. With this method, surveys are carried out on a specific sample of people and they are asked about their preferences between attributes at different levels, that is, they are presented with different sets of alternatives that contain common attributes of a good, but with different levels, and they are asked to choose the preferred alternative from each set. Each set offers a constant alternative (*status quo*) —that is, the current state in which the good is without changes— and a series of proposed alternatives that require a payment. The choices of the respondents indicate their preferences for the attributes of one alternative over the others, and demonstrate their willingness to exchange one attribute for another. One of the attributes used to describe the alternatives is monetary, and in this way it is possible to estimate the willingness to pay.

The benefit of this tool is that it allows the environmental service to be broken down into its different specific characteristics to analyze the value that society places on each one of them, and thus estimate the satisfaction caused by changes in its attributes.

The valuation method of this service received a *"moderate" degree of uncertainty,* since, although it refers to a very robust method that estimates demand, it relies on the application of another case study.

Annex E. Discount rates

As a sensitivity analysis exercise, that is, to know the impact on the result of the Natural Capital Balance Sheet of any change in the discount rate, another alternative balance sheet is obtained (see next table) considering a discount rate of 3% for years 1 to 30 and 2.57% for years 31 to 60.

Table 20. Natural Capital Balance Sheet with reduced rate. Source: own elaboration.

Ecosystem services	Physical flow (units / year)		Monetary flow (EUR / year)	Present value (60 years)
2018				
Benefits				
Aquatic animals for nutrition (1.1.6.1)	7,421	Kilograms	129,646	3,753,402
Posidonia remains (1.1.5.1 and 1.1.5.2)	800	Kilograms		-
Improvement of water quality (2.1.1.2 and 2.2.5.2)	3,951	Hectares	211,349	6,118,778
Protection from coastal erosion (2.2.1.1 and 2.2.1.3)	3,951	Hectares	772,547	22,366,073
Maintenance of biodiversity (2.2 .2.3)	19,271	People	447,313	12,950,200
CO_2 capture (2.2.6.1)	3,866	Tons of CO2	19,331	559,642
Active or passive recreational activities (3.1.1.1, 3.1.1.2., 6.1.1.1)	384,143	Number of users	3,141,440	90,948,079
Scientific research and education (3.1.2.1, 3.1.2.2, 6.2.1.1)	3	Number of projects	104,892	3,036,728
Gross natural capital assets			**4,826,518**	**139,732,902**
Liabilities				
Maintenance costs			476,137	13,784,675
Net natural capital assets			**4,350,381**	**125,948,227**

The French guidelines, which also follow a Social Rate of Time Preference approach, recommend a rate of 2.5%, compatible with $\delta = 0.5$; $L = 0$, $\mu = 2$ and a growth of 1%. On the other hand, the Stern report (2007) recommends a rate of 2%, following the parameters of $\delta = 0$; $L = 0$, $\mu = 1$, and a growth of 2%. The main differences between the positions of the Stern Report and those of the *Green Book* are that Stern considers zero time preference for ethical reasons (long-term intergenerational fairness), while the *Green Paper* is more concerned with shorter time horizons. Likewise, the Stern report interprets catastrophic risk only as the probability of a social collapse such that there is no society enjoying future well-being, while the *Green Book* interpretation is broader. Finally, a more pessimistic outlook for growth of 1% is found in Groom and Maddison (2018), which shows a Social Rate of Time Preference of 1%.

The following table summarizes the value of net natural capital assets for the different discount rates described:

Table 21. Different values of net natural capital assets for different rates. Source: Own elaboration

	Net natural capital assets
Standard discount rate: 3.5%	114,103,872.33
Reduced discount rate: 3%	125,948,227.28
French discount rate: 2.5%	140,710,653.70
Stern discount rate: 2%	157,926,256.58
Stern discount rate: 1%	203,554,052.94
Without applying discount rate: 0%	261,022,864.79
Negative discount rate: -1%	356,450,166.59