

D2.3 Synthetic overview of the different national actions undertaken to strengthen EGD components in MSP



MEDIGREEN
Mediterranean approach
towards a maritime European
Green Deal in MSP



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List of abbreviations

ABMT	Area-based Management Tool
AUTh	Aristotle University of Thessaloniki
AZA	Allocated Zone for Aquaculture
CBD	Convention on Biological Diversity
CCAA	Autonomous Communities (<i>Comunidades Autónomas</i>)
CCH	Critical Cetacean Habitats
CE	Circular Economy
Cerema	Center for Research and Expertise on Risks, the Environment, Mobility, and Urban Planning (France)
CMEMS	Copernicus Marine Environment Monitoring Service
CNR	National Research Council (Italy)
ComMOD	Companion Modelling
CoP MED	Mediterranean Community of Practice
CORILA	<i>Consorzio per il coordinamento delle ricerche inerenti al sistema lagunare di Venezia</i> (Consortium for coordination of research activities concerning the Venice lagoon system)
DEVOTES	Development of innovative tools for understanding marine biodiversity and assessing good environmental status
DSF	<i>Document Stratégique de Façade</i> (Sea basin Strategic document)
E2E	End-to-end (model)
EBA	Ecosystem-based Approach
EBSA	Ecologically or Biologically Significant Marine Areas
EDITO	European Digital Twin Ocean
EFH	Essential Fish Habitat
EGD	European Green Deal
EMFAF	European Maritime, Fisheries and Aquaculture Fund
EMODNet	European Marine Observation and Data Network
EU	European Union
EUNIS	European Nature Information System
FAO	Food and Agriculture Organization of the United Nations
FAIR	Findable, Accessible, Interoperable and Reusable
FRA	Fisheries Restricted Areas
GFCM	General Fisheries Commission of the Mediterranean
GFW	Global Fishing Watch
HAP	Hierarchical Analytical Processes
IBA	Important Bird Areas
IEO-CSIC	Spanish institute of oceanography (<i>Instituto Español de Oceanografía</i>)
IMMA	Important Marine Mammal Areas
IMTA	Integrated Multi-Trophic Aquaculture
IOC	Intergovernmental Oceanographic Commission
IMO	International Maritime Organisation
IPCC	Intergovernmental Panel on Climate Change
ISRA	Important Shark and Ray Areas
IUAV	Iuav University of Venice
JNCC	Joint Nature Conservation Committee
LMP	Local Management Plan



MAM	Multi-agent model
MASAF	Ministry of Agriculture, Food Sovereignty and Forestry (Italy)
MCA	Multi-criteria analysis
MEDIGREEN	Mediterranean approach towards a maritime European Green Deal in MSP
MHW	Marine Heat Wave
MNHN	<i>Muséum National d'Histoire Naturelle</i> (French National Museum of Natural History)
MITECO	<i>Ministerio para la Transición Ecológica y el Reto Demográfico</i> (Spain)
MPA	Marine Protected Area
MSFD	Marine Strategy Framework Directive
MSP	Maritime Spatial Planning
ODEMM	Options for Delivering Ecosystem-Based Marine Management
OECM	Other Effective area-based Conservation Measure
ORE	Offshore Renewable Energies
OWF	Offshore Wind Farm
PCA	Principal Component Analysis
POAPD	Areas for the Organized Development of Productive Activities
POEM	<i>Planes de Ordenación del Espacio Marítimo</i> (National MSP plans of Spain)
PSSA	Particularly Sensitive Sea Area
PV	Photovoltaic
RCP	Representative Concentration Pathways
RES	Renewable Energy Sector
SECA	Sulphur Emission Control Area
Shom	Service hydrographique et océanographique de la Marine (France)
UfM	Union for the Mediterranean
UNCLOS	United Nations Convention on the Law of the Sea
UNESCO	United Nations Educational, Scientific and Cultural Organization
ZAPAC	<i>Zonas de Alto Potencial para la Acuicultura Marina</i> (High-Potential Areas for Marine Aquaculture)

Introduction

Context and objective of the deliverable

The MEDIGREEN project aims to support the European Green Deal (EGD) transition in the Mediterranean Sea through transnational cooperation in Maritime Spatial Planning (MSP). Four key maritime sectors are explored in particular: fisheries, aquaculture, offshore renewable energy (ORE) and nature protection. The present deliverable D2.3 is part of MEDIGREEN work package 2 “Greening the MED through MSP: sectors at work”, which aims to support EU Member States to advance towards a green and blue transition in the Mediterranean. More specifically, D2.3 is framed into task T2.2 “National actions to strengthen the EGD components of MSP plans”. This task aims to develop actions in MEDIGREEN full partners’ countries (Greece, France, Italy, Spain) to support MSP processes with regards to EGD objectives. Here, EGD objectives refer to (i) climate change mitigation and (ii) adaptation, (iii) sustainable seafood production, (iv) marine biodiversity protection and restoration, (v) blue circular economy, (vi) zero pollution, and (vii) fair and just transition¹.

Methodology

Partners were given the possibility to propose one or several actions to be developed, between October 2025 and March 2026, considering their local and national MSP needs, and their own areas of expertise. An action could cover a specific geographical scale (local, national, regional), and focus on one or several MEDIGREEN sectors. A common template was established in order to report actions in a harmonized way and provide a basis for analysis. Thus, at the beginning of task T2.2, Cerema designed a Factsheet proposal that would serve as a common template to describe each national action (one Factsheet per action). The proposed template was discussed and validated by all partners during an in-presence project workshop (Venice, June 30 - July 2, 2025). It seemed of particular importance to incorporate information about the context and relevance of the actions, their stage of development and conditions for implementation, as well as their potential for larger-scale deployment.

The following **Factsheet structure** was adopted:

- **Part 1. Context and needs** – explaining why the action is relevant and which needs it aims to address;
- **Part 2. Implementation** – describing the current stage of the action’s implementation and their results;
- **Part 3. Transferability, affordability and upscaling** – outlining the scale of the action, the conditions required for its implementation, its technical and financial feasibility,

¹ Based on an EGD nomenclature developed as part of MSP-GREEN project (Bocci M, Cornet A, Arki V, Soffiotti F, Bas A, Brigolin D, Campillos-Llanos M, Campostrini P, Carella F, Cervera-Núñez C, Danenberg A, Frangoudes K, Gee K, Gómez-Ballesteros M, Graner E, Käppeler B, Laroussinie O, Pietilä L, Pohja-Mykrä M, Saarento H, Stanchev H, Stancheva M, Stube M and Ramieri E (2026). Disentangle the skein: a nomenclature framework to assess the contribution of Maritime Spatial Plans to the European Green Deal. *Front. Ocean Sustain.* 4:1751387. <https://10.3389/focsu.2026.1751387>).



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its potential for larger-scale deployment, possible support from regional organizations, and whether it could benefit from cross-border cooperation.

- **Part 4: Short conclusion** - summarizing the action.

A first internal meeting was held online on December 3, 2025, during which partners presented the first part (“Context and needs”) of the national action (s) for which they were responsible. This provided a first overview of the actions, which were at different stages of development. This meeting was also the opportunity to discuss the general timeline of the task and to raise any potential concerns regarding timing or methodology.

Partners were invited to share the final versions of their Factsheet(s) with relevant stakeholders who could benefit from the actions’ results, such as MSP authorities. For instance, all action Factsheets from Greece and Spain were shared with their respective national authorities, and the feedback received was incorporated into the Factsheets.

The task’s final meeting was held online and was divided into two half-day sessions (on March 5 and March 23, 2026). It consisted in the presentation of the 11 national actions, following the common template. This approach aimed to provide a clear overview of the implementation stage of each action, as well as its potential for replication in other contexts and for upscaling at the Mediterranean level, thereby supporting a broader objective of strengthening transboundary coherence in MSP.

Although the final meeting was held exclusively among project partners for practical reasons (language, time constraints), partners were encouraged to exchange with relevant external stakeholders through bilateral discussions. This approach aimed to support the dissemination of results and the integration of feedback to further advance the development of the actions.

Content of the deliverable

This deliverable D2.3 provides a **compilation of the 11 national actions** developed by full partner countries as part of task T2.2. **Table 1** below provides the list of these national actions and associated responsible partners. A total of 11 Factsheets describe each of the actions, using the common template whose structure was presented in the previous sub-section.

Prior to the detailed action factsheets, and following this Introduction, a **Synthesis of the national actions** is provided. This section describes the main characteristics and outcomes of the actions, and a preliminary cross-cutting analysis. An in-depth cross-cutting analysis of these actions will be conducted as part of the next project task (T2.3), which will be led by CORILA.

Table 1. List of the national actions developed as part of task T2.2 and responsible partners.

N.	Responsible partner	Partner country	Title of the action
#1	Shom	France	"Assessing risks in the Mediterranean Sea: Human activities and Marine Heat Waves"
#2	Cerema	France	"Benchmark on the use of modelling approaches to inform MSP"
#3	AUTh	Greece	"Promoting synergies and the multi-use concept in Thermaikos Gulf"
#4	AUTh	Greece	"Exploring the potentials for non-exclusive (mixed) offshore renewable energy zones in Greece"
#5	CORILA, IUAV, CNR	Italy	"Feasibility study on the identification of area-based management tools in the Strait of Sicily"
#6	CORILA, IUAV, CNR	Italy	"Small-scale fisheries in MSP: developing operational guidelines"
#7	CORILA, IUAV, CNR	Italy	"Sustainable aquaculture development through MSP supporting AZA planning in Italian coastal regions (AZA-PLANNING in action)"
#8	IEO(CSIC)	Spain	"Marine Green Infrastructure as nature-based solution for blue carbon storage and sequestration"
#9	IEO(CSIC)	Spain	"Circular economy concept in the framework of MSP plans"
#10	IEO(CSIC)	Spain	"Monitoring aquaculture production in the framework of MSP plans"
#11	IEO(CSIC)	Spain	"Coexistence and multi-use concept in the Spanish MSP plans"



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Synthesis of the national actions

An overview of the actions' characteristics and outcomes and preliminary cross-cutting analysis

General considerations

As part of MEDIGREEN task 2.2, a total of 11 national actions have been developed by full partner countries (Greece, France, Italy, Spain), with the aim to support MSP processes in link with the European Green Deal (EGD) objectives. Partners were given the possibility to propose actions they wished to develop as part of task 2.2, both in terms of topics and scale. Thus, **national actions differ in terms of scales, topics, and approaches, depending on the MSP context and needs in each partner country and the area of expertise of partners' institutions.**

Some actions directly respond to demands from competent MSP authorities, and **contribute to the implementation of specific measures from their countries' national MSP plans.** For example, Action 5 (Italy) (Feasibility study on the implementation of area-based management tools in the Strait of Sicily) contributes to the implementation of the national measure NAZ_MIS|15 (Italian MSP, 2024), which focuses on identifying priority areas for environmental and marine-resource conservation. This is also the case of Action 6 (Italy) on the integration of small-scale fisheries into MSP, which operationalises national MSP Measures 35 and 36 (Italian MSP, 2024); and of Action 7 (Italy) on allocated zones for aquaculture that responds to national measures NAZ_MIS|44² and NAZ_MIS|45³. Besides, some actions also capitalize on other project results (such as MSP4BIODIVERSITY, an Italian national project focusing on marine biodiversity in MSP) ensuring a continuation of action and capitalization of results.

The 11 actions are described through **harmonized structured factsheets** (~20 pages each), detailing the actions' context, implementation stage, and potential for replicability and upscaling. The report of actions through harmonized factsheets is particularly relevant since the actions appear to be very diverse. In addition, this common template facilitates comparison between actions and the understanding of their potential linkages, **which will be particularly useful for conducting the cross-cutting analysis of actions in the next task (T2.3).** Nonetheless, this deliverable provides a synthesis that summarizes main outcomes of the actions.

² NAZ_MIS|44: "Develop, adopt and implement AZA Plans at a regional scale, in line with the PSM Plans and with the support of the AZA Technical Guide (ISPRA /HIPAA)." Responsible for implementation: Regions.

³ NAZ_MIS|45: "Establish a permanent working table aimed at supporting the progressive integration and harmonization between regional AZA plans and PSM in the various maritime areas, strengthening already existing tools, such as the ITAQUA platform." Responsible for implementation: MASAF, ISPRA, Regions.



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Contribution to effective and sound MSP, through a large variety of geographical scales, EGD coverage, methodological approaches and topics addressed by the actions

First, all MEDIGREEN sectors and EGD objectives are addressed through the 11 actions, which contributes to strengthening both sectoral policies and cross-cutting policies. Several actions adopt a multi-sectoral perspective, encompassing MEDIGREEN sectors⁴, thereby supporting solutions fostering synergies in MSP. This is notably the case of Action 6, which supports the proper integration of small-scale fisheries into MSP (Italy); Action 7, which explores aquaculture standardized procedures for MSP (Italy); Action 10, which focuses on monitoring aquaculture in MSP plans (Spain); and Action 4, which focuses on offshore renewable energy (ORE) -while highlighting the need of multi-use approaches within ORE parks (Greece).

These national actions also contribute to an **enhanced consideration of EGD objectives in MSP**, especially those EGDs that are often underrepresented in the MSP plans of the MEDIGREEN countries, such as climate change adaptation (as highlighted by Bocci et al., 2025⁵). For instance, Action 1 (France), which focuses on modelling seascapes to adapt to marine heatwaves, illustrates how ecosystem-based adaptation and climate-smart adaptation can be integrated into MSP in the Mediterranean context. Furthermore, the national actions place strong emphasis on **developing tools capable of addressing multiple EGD objectives simultaneously**. Action 8 (Spain), for example, develops a methodology to identify areas where protection efforts could deliver both climate and biodiversity benefits (e.g., protection of ecosystems and associated elements that can sequester and/or store carbon).

Second, actions differ in terms of geographical scale, with varying implications for MSP:

- Actions focusing on the **local scale** provide very **operational and context-specific examples** that directly support MSP processes. They help identify priority areas for specific or multiple uses (Action 3 in Greece) and for the protection of marine and coastal ecosystems in a context with multiple uses and pressures (Action 5 on spatial nature conservation measures in the Strait of Sicily, and Action 6 on the better integration of small-scale fisheries in MSP in Italy).
- Several actions operate on the **national scale**. These actions are primarily grounded in the analysis of national MSP plans and processes, and **provide valuable insights not only at the national scale but also beyond, given their strong potential for transferability** (as further discussed below). This is the case of Action 4 on exploring ORE potential in Greece; Action 7 on facilitating the allocation of aquaculture zoning procedures for MSP in Italy; and Action 10 on the monitoring of aquaculture in the Spanish MSP plan. This is also the case of Action 2 on modelling approaches for MSP in France, which develops a methodology to identify knowledge gaps in MSP documents and ways to reduce them through modelling. Three out of the four actions developed by IEO-CSIC in Spain contribute to advancing national MSP by addressing the integration of key concepts into the national Spanish MSP plans (POEM), such as

⁴ MEDIGREEN sectors are fisheries, aquaculture, offshore renewable energy, and nature protection.

⁵ Bocci M. et al., 2025. State of play of sector-related EGD components in MSP plans of the EU MED countries. Deliverable D2.1 of MEDIGREEN project. Call EMFAF-2023-PIA-MSP, Grant Agreement number 101182580.

“Marine Green Infrastructure” as nature-based solutions for blue carbon storage and sequestration (Action 8), circular economy (Action 9), and coexistence and multi-use concepts (Action 11).

- One action is developed at the **Mediterranean scale**: Action 1 (developed by the French partner Shom) focuses on physical seascape modelling and identifies marine areas across the Mediterranean Sea that share similar physical characteristics under a changing climate. Results call for the development of **localized-transboundary MSP plans to better adapt to specific** climate-driven phenomena in the future (in particular marine heat waves).

Third, methodological approaches vary greatly among the actions, providing a **large range of concrete examples supporting MSP**. Even though most actions combine several approaches, we can distinguish main ones:

- A couple of actions focus on the use of technical tools to support MSP decision-making, such as **modelling approaches** (Actions 1 and 2). However, while Action 1 directly applies models, Action 2 rather focuses on document analysis in the first place.
- Some actions directly focus on **the identification of priority marine areas** for some specific activities (and how to combine them) or biodiversity protection, using adequate management tools (Actions 3, 4, 5).
- Some actions focus on the development of **methodological guidelines to better support the inclusion of some topics or sectors into MSP**. This is the case of Action 6, which establishes a methodological guideline for improved integration of small-scale fisheries in MSP, supporting a fair and just transition. This is also the case of Action 7, which develops an approach to standardize aquaculture procedures in Italy, to facilitate aquaculture planning and to promote more sustainable and responsible aquaculture practices.
- Quite similarly, Action 10 proposes a framework to **monitor aquaculture** in the Spanish MSP plans (POEM) through the development of an indicator grid tailored to the national MSP and aquaculture context.
- Finally, some actions propose clarification of concepts that are key for MSP. More specifically, in Spain, the POEM was analysed to explore whether core concepts are already being incorporated and could be further strengthened in MSP plans: “Marine Green Infrastructure” (Action 8), “circular economy” (Action 9), “coexistence” and “multi-use” (Action 11). These analyses help **identify pathways to enhance the ambition of MSP plans** by strengthening their coherence with other policies, promoting more efficient and balanced use of marine space, and supporting a fair and just transition. In addition, some actions provide an in-depth analysis of MSP plans; for instance, in terms of data gaps (Actions 2, 8), or integration of core concepts into MSP, which are not always defined or operationalized in existing plans (Actions 8, 9, 11).

In line with the previous paragraph, the work carried out under MEDIGREEN Task 2.2 fosters exchanges among partners on the **concrete impact of MSP plans**, particularly during the final online T2.2 meeting. These discussions raised important questions regarding the role and scope of MSP plans, such as whether they should explicitly define which uses are permitted or restricted within marine areas. The Spanish case provides a useful illustration. The MSP plan (POEM) indicates only the spatial allocation of maritime activities (when already existing) or identify potential areas for future uses, while many practical aspects related to coexistence and multi-use—such as operational rules, technical requirements,

and monitoring obligations—are addressed through sectoral legislation and subsequent authorization procedures. As a result, for example, the plan does not explicitly prohibit the coexistence of other uses within offshore renewable energy (ORE) areas but, in practice, authorities impose navigation restrictions in these zones, effectively limiting or preventing other activities, including maritime transport, fisheries, and aquaculture. This creates ambiguity, as it remains unclear whether these areas are intended to function as exclusive zones or could potentially accommodate multi-use approaches. These aspects should therefore be further clarified in MSP.

In addition, several actions created opportunities to bring stakeholders together to discuss and arbitrate potential uses in specific marine areas. For example, Actions 6 and 7 in Italy involve co-construction of knowledge with a broad range of stakeholders, including regional authorities and national institutions such as the MASAF (Ministry of Agriculture, Food Sovereignty and Forestry), and the Ministry of Infrastructures and Transports, which is the MSP competent authority in Italy. Similarly, under Actions 3 and 4 in Greece, a range of participatory tools such as interviews, workshops and questionnaires with MSP experts, sectoral stakeholders and the general public were conducted. The workshops were particularly valuable to facilitate dialogue for the emergence of synergies and conflicts in a semi-closed gulf in Greece, under Action 3. They allowed to ensure that **local specificities and the perspectives of local professionals were adequately taken into account**. The interviews and questionnaires in Action 4 showed that to ensure social acceptance, the promotion of non-exclusive ORE zones in Greece (and more broadly) is also key. While ORE developments contribute to key EGD objectives, such as climate change mitigation and zero-pollution targets, enabling the coexistence of multiple uses within these areas can amplify these benefits. It can also **support a wider range of non-economic values**, including the preservation of traditional practices, a sense of community belonging, and overall well-being.

Recommendations arising from the actions

Based on the actions' outcomes, recommendations are presented in the concluding sections of the action Factsheets, outlining pathways towards more effective and robust MSP across different scales (for further details, the reader is invited to refer to each Factsheet of this deliverable). These include improvements in various aspects.

From a governance and regulatory perspective, there is notably a need to **develop clearer management frameworks** and distance criteria to support decision-making on non-mixed economic zones in Greece (Action 4), ensuring safety, nature protection and the minimization of ecological and socio-economic impacts. In parallel, more advanced and inclusive consultation processes are required to select areas and sectors that are compatible and can effectively coexist at sea (Action 3). These management frameworks and plans could be developed at different scales. Action 1 could help identifying the right scales for developing some relevant management frameworks to better adapt to climate-driven phenomena (marine heat waves in particular), through the identification of marine areas across the Mediterranean that share similar physical characteristics under a changing climate.

However, it should be emphasized that **effective MSP does not necessarily require the development of new regulatory tools or frameworks**. In particular, Action 5 (focusing on

area-based management tools (ABMTs) in the Strait of Sicily) demonstrates that effective progress can be achieved through the coordinated and strategic use of existing instruments. These include fisheries restricted areas, marine protected areas or strengthened Natura 2000 measures, which can be leveraged to better integrate key features (e.g., vulnerable deep-sea ecosystems, essential fish habitats, ecological corridors) into MSP. Moreover, ABMT can contribute to multiple EGDs and are relatively easy to mobilize, as they combine important ecological gains, high legislative feasibility and acceptable socio-economic applications. A similar rationale applies to actions aimed at clarifying key MSP concepts, such as marine green infrastructure, circular economy concepts, coexistence and multi-use (Actions 8, 9, 11). These actions help identify structural gaps in how these concepts are integrated into existing MSP plans, and show that these gaps can often be addressed by adjusting planning architecture rather than introducing new sectoral-specific regulations.

Some actions also provide **recommendations to improve their national MSP plans**. For instance, Action 10 provides a coherent and implementable list of twelve indicators tailored for the POEM (MSP Spanish plan) monitoring program regarding aquaculture. Besides, Action 11 (exploring the concepts of “co-existence” and “multi-use” at sea) recommends that next cycles of the POEM should include clearer operationalisation of objectives and criteria linked to co-existence or multi-use concepts; for instance, the monitoring system could be strengthened by incorporating multi-use specific metrics such as the number of feasibility studies conducted, authorisations integrating multiple uses, or the spatial extent of areas where co-existence and multi-use is authorised or in testing.

Regarding data and knowledge gaps, some actions highlight important limitations that constraint both the full implementation of the actions and their replicability in other contexts. For instance, Action 8 points out that **a major constraint relates to the availability of marine spatial data**, notably the lack of cartography of potential marine green infrastructure elements in offshore regions. This limits the ability to identify blue carbon-relevant elements in deep or remote marine zones. Addressing such marine data gaps remains a challenge for MSP. In this regard, European data platforms such as EMODnet can play a crucial role in reducing these gaps by providing more accessible and harmonized datasets. In addition, Action 1 highlights that the use of open-source code can further enhance reproducibility and lower implementation barriers. In particular, the European Digital Twin of the Ocean (EDITO), announced under the Ocean Pact, is designed as a distributed and interoperable digital infrastructure that integrates marine data, modelling services and cloud-based computing resources. It is intended to support advanced analysis, simulation and decision-making in the marine domain, thereby strengthening the overall knowledge base for MSP.

Transferability and upscaling

The 11 actions developed under this task T2.2 have been designed to be as feasible, cost-effective and interoperable as possible, in order to support their practical implementation. They provide concrete examples of approaches that can be applied both within their original context and in other environments.

Although most of the national actions are developed and tailored to a specific context, they demonstrate **strong potential for transferability (to other contexts) and upscaling (larger**

scale). This is particularly the case when their methodological approach is not based on country-specific legal constructs, but on more structural components such as guiding principles, strategic objectives, zoning logic, compatibility criteria, and governance arrangements. For instance, all actions focusing on identifying certain components in MSP plans (e.g., knowledge gaps (Action 2), or core MSP concepts (Actions 8, 9 and 11) can be replicated to any structured national MSP framework. They can apply either to an existing MSP plan during its revision cycle, or during the preparation phase of a new MSP plan, based on the analysis of existing coastal and marine policies.

Other actions show potential for transferability and upscaling subject to certain conditions, which differ depending on the type of actions. For instance, the transferability of actions focusing on modelling tools (Actions 1 and 2) involves developing technical skills and a robust dataset. Similarly, the transferability and upscaling of Action 7 (proposing a method for standardizing procedures for the allocation of aquaculture zones (AZA)) depends on the national AZA processes, which vary across countries. As a result, the action's replicability in other countries can be feasible, provided that the administrative context is assessed in advance, in order to prevent unnecessary and time-consuming efforts.

When developing the actions, efforts were made to enable their concrete implementation and transferability. For instance, the methodology for better integrating small-scale fisheries (SSF) into MSP (Action 6) provides a flexible, process-oriented operational framework that systematically integrates SSF into MSP: in regions with limited SSF governance, it can be applied progressively, starting with participatory mapping, stakeholder engagement, and baseline data collection, and gradually expanding to more complex analyses, co-management arrangements, and integrated monitoring systems; in regions with well-established SSF frameworks, the methodology can instead reinforce and harmonize existing practices, aligning local and regional management approaches with national MSP strategies.

Similarly, most actions demonstrate strong potential for upscaling to broader implementation levels, thereby helping to improve data and resource sharing, and strengthen alignment with EU frameworks and policies, ultimately supporting biodiversity protection and restoration and the sustainable use of the sea.

Finally, it should be noted that **the actions developed under this task are at different stages of implementation.** Some will not be completed within the timeframe of this task and are expected to continue beyond the formal MEDIGREEN framework, in line with each country's MSP processes and timelines. Prior to their incorporation into this deliverable D2.3, most of the Factsheets were reviewed by competent MSP authorities. In this regard, sharing the actions with MSP authorities and experts, as well as presenting them directly to decision-makers (as it has been done for some actions), provides a valuable opportunity to support their transition into fully operational measures.



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National action #1: Assessing risks in the Mediterranean Sea: Human activities and Marine Heat Waves (Shom)

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1. Context and needs

The objective of the MEDIGREEN project is to align Maritime Spatial Planning (MSP) initiatives across the Mediterranean sea basin to the ambitions of the European Green Deal (EGD) and thus, the Sustainable Blue Economy development. It focuses on the sustainability of four main human marine activities, namely aquaculture, fisheries, Offshore Renewable Energy (ORE) and nature protection; and uses an intersectoral approach in order to propose solutions for “greening” the MSP.

In this context, on the one hand, it is of major importance to assess current pressures generated by anthropogenic activities in order to map areas under high potential risks of impact on ecosystems. This assessment is the basis for Ecosystem Based Approach (EBA), considered as an important principle of MSP⁶ and following the UN Convention on Biological Diversity (CBD). On the other hand, this assessment has now to be completed with preliminary analyses of climate change effects on marine ecosystems. Indeed, according to the Representative Concentration Pathways 8.5 (RCP) of the Intergovernmental Panel on Climate Change (IPCC), the Mediterranean Sea is expected to experience a Marine Heat Wave (MHW) every year by the end of the 21st century (Daramaraki *et al.*, 2024). These MHW may have major impacts because it is a semi-enclosed basin, subject to intense anthropogenic pressures and highly vulnerable to climate change. The RCP8.5 projection, associated with a very high confidence, concerns an increase in frequency, duration, spatial extent as well as intensity of MHW. This will have impacts on marine organisms, ecosystems, ecosystem services, and thus on anthropogenic activities. It is expected, with high confidence, to push some marine organisms, ecosystems, and thus exploited species in fisheries as well as in aquaculture, beyond the limits of their resilience⁷. One of these impacts is the occurrence of Massive Mortality Events (MME), which were observed in 2003 on coral & sponges (Garrabou *et al.*, 2009), and on exploited mussels (IZS, 2024).

Consequently, in order to comply with the European Directive 2014/89 currently in revision, establishing a framework for MSP, it is now of concern to integrate both current potential risks of impact from anthropogenic activities and to anticipate the effects of climate change, like MHW. Recent studies highlight that integrating climate change into MSP is essential to anticipate ecosystem shifts and support sustainable ocean management, yet remains insufficiently implemented in practice (Frazão Santos *et al.*, 2020; Queirós *et al.*, 2025). In response, international guidance now promotes the development of “climate-smart MSP approaches” (Rekola *et al.*, 2025), integrating adaptation, ecosystem dynamics and sectoral interactions into spatial planning processes (UNESCO-IOC & European Commission, 2025). Such an approach may help better promote a sustainable growth of

⁶ <https://maritime-spatial-planning.ec.europa.eu/faq/ecosystem-based-approach>

⁷ <https://www.ipcc.ch/srocc/chapter/chapter-6/>

economic activities and use of marine resources. This is substantially the EGD main goal, which, for the ocean and seas, includes the protection of biodiversity while ensuring the sustainability of the blue economy and fisheries sectors. It is thus of major importance to integrate effects of global warming in the spatial planning of the Mediterranean maritime space. According to the MEDIGREEN deliverable D2.1⁸, climate change adaptation is not considered but only weakly in a few plans (Greece, Cyprus, Italy and France). To our best knowledge, there is no national plan which considers MHW, despite the fact that they already occurred for a few decades.

This action aims at using existing open-source databases to produce two complementary sets of harmonized spatial information, both at basin scale: (i) potential impact risk maps of anthropogenic pressures on benthic ecosystems; and (ii) maps of physical seascapes, representing oceanographically coherent marine biotopes, during periods of Marine Heat Wave (MHW).

These outputs are designed to inform and support decision-making for adaptive and transboundary MSP (EGD D1.6 Transboundary initiative), allowing the identification of areas sensitive to climate extremes, priority conservation zones, and locations suitable for sustainable development of maritime activities. They are also constructed to support the greening of the Mediterranean Sea basin, and follow the Community of Practice, strengthened by MEDIGREEN WP3, which highlights the importance of considering the basin scale to improve national marine spatial plans.

It is important to note that, to date, data at the scale of the entire Mediterranean Sea remain scarce. However, to provide a relevant assessment of such areas, there is a crucial need for several types of data, i.e., anthropogenic activities locations, marine natural habitats maps and their sensitivities to pressures generated by human activities. These data, ideally, should follow the FAIR principles (Wilkinson *et al.*, 2016): Findable, Accessible, Interoperable and Reusable; and thus, necessitate a coordination between Mediterranean countries. FAIR data are the core for relevant decisions in the context of marine policies, and will be discussed in the implementation chapter of this study (subchapter 'limits').

Nevertheless, this action provides the first spatial information that supports the generation of knowledge for:

- Identifying areas (i) at potential impact risk, (ii) as priorities for conservation, (iii) suitable for sustainable activities
- Considering climate change for marine spatial planning, with a focus on MHW.

Furthermore, it provides information to support the achievement of several European Green Deal objectives, detailed in Table 2.

⁸ Bocci *et al.*, 2025. D2.1. State of play of sector-related EGD components in MSP plans of the EU MED countries. MEDIGREEN project.

Table 2. EGD objectives under which this action was designed

Axis	Sectors impacted	MSP objectives	Green Deal Objectives
Assessment of marine heatwave scenarios on seascapes	Nature protection	Identify structural vulnerabilities, future “dead zones,” and refuge areas to support long-term management within MSP plans.	<p>B3: Anticipation of climate change-related effects</p> <p>B3.1: Identification of climate refugia for marine species and habitats</p> <p>D1.1: Establishment of new or enlargement of strictly marine protected areas (10% target) and definition of strict protection</p> <p>D1.5: Combinations including biodiversity and ecosystem protection</p>
Assessment of human activities pressures & risk maps	Fisheries Aquaculture Nature protection ORE	Identify priority areas for adapting zoning considering human pressures by sector and cumulative potential impact for different habitats.	<p>B2: Protection of climate-sensitive marine and coastal biodiversity, ecosystems, and landscapes</p> <p>D4.5: Multi-use of sea space: combinations including biodiversity and ecosystem protection</p>

The MEDIGREEN project contributes to European maritime policy development, such as the European Ocean Pact⁹ (adopted in 2025) and the European Ocean Act¹⁰ while fully supporting the objectives of the European Green Deal. By producing harmonized datasets, including potential impact risk maps of anthropogenic pressures and maps of marine seascapes sensitive to climate extremes, this action provides evidence-based information to decision-makers. These datasets are made to support MSP decisions in the Mediterranean region to be climate-adaptive, ecologically coherent, and policy-relevant at both national and basin scales.

2. Implementation

To answer the needs for the MSP, in touch with the EGD, it is important to understand and foresee the potential impacts of anthropic activities and the effects of climate change on the Mediterranean Sea at basin scale.

The action was structured in two parts (Fig. 1):

1. An assessment of potential anthropic pressures, and the conception of multiple potential impact risks maps on benthic ecosystems,
2. An estimation of potential effects of Marine Heat Waves on regional seascapes in the Mediterranean Sea.

⁹ [https://www.europarl.europa.eu/RegData/etudes/BRIE/2025/772912/EPRS_BRI\(2025\)772912_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2025/772912/EPRS_BRI(2025)772912_EN.pdf)

¹⁰ <https://www.europarl.europa.eu/legislative-train/carriage/ocean-act/report?sid=10001>

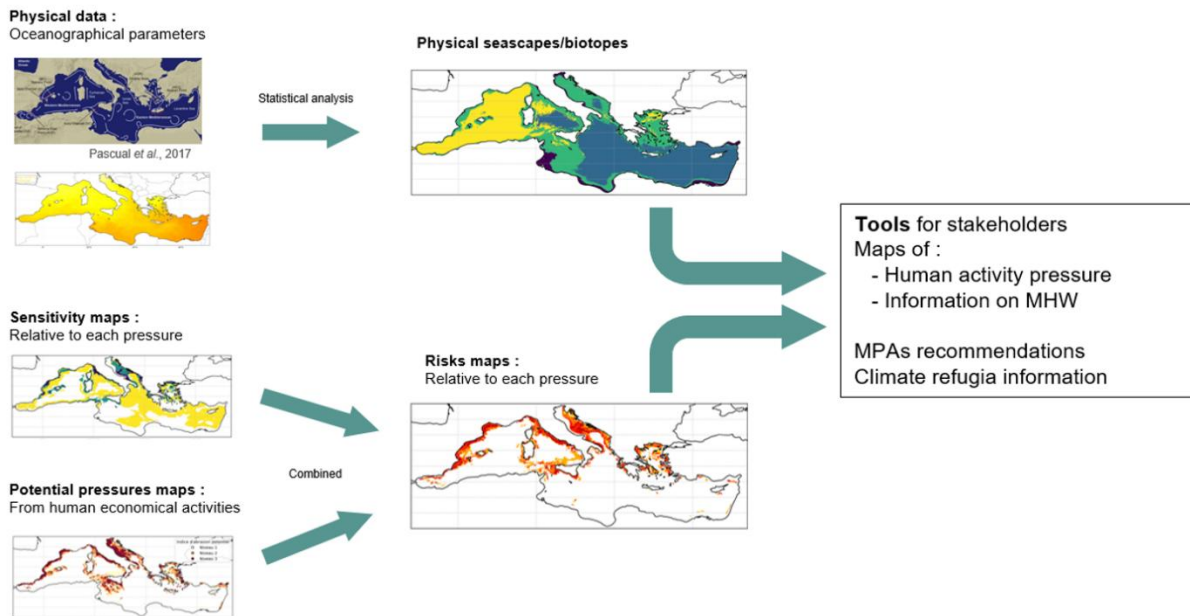


Figure 1: Scheme of the methodology for risks maps and seascapes analysis

2.1. Methodology: conception of potential risks maps

Note: risks are defined as “an exposure to a Hazard, the probability of occurrence of an adverse effect from a phenomenon on a vulnerable target”¹¹. The assessment of potential impact risks maps is the core of the Ecosystem Based Approach recommended for maritime policies.

The analysis of anthropic activities focused on the 4 sectors of the MEDIGREEN project, i.e., ORE, nature protection, fisheries and aquaculture. This study does not include the ORE and the nature protection sectors because ORE were established in the Mediterranean Sea too recently to be taken into account, and nature protection has no adverse impact on ecosystems. Fisheries and aquaculture, which data are available in open access, were under study.

The data for aquaculture were available on the portal EMODnet and corresponded to the presence of either finfish or shellfish farms. Some data from different countries of the Mediterranean Sea were, however, lacking (Table 3). The fisheries dataset was obtained from fisheries activities recorded by the Global Fishing Watch (GFW). It is important to note that only ships larger than 12m are considered by the GFW, thus omitting smaller ships, known to be numerous in the sea, particularly in coastal areas (Table 3). It was decided to focus only on the bottom trawling fishery activity since the potential impact of pelagic trawlers on ecosystems is heavily unknown. Moreover, delimiting a pelagic habitat is still up to debate (Dickey-Collas *et al.*, 2017). The fisheries time was calculated by a machine learning algorithm based on slowing down moments of the ships, and it was decided to exclude spots where less than 100 hours per year of cumulated fisheries were registered. Indeed, these areas probably corresponded to slow traveling routes rather than fishing areas, since they

¹¹ <https://www.ineris.fr/en/risks/how-evaluate-risk/components-risk>

happened on particularly deep oceanic regions, making bottom trawling fishery activity unlikely.

Table 3. Information on data used for the potential impact risks analysis

Variables	Years	Data provider	Data access	Limits
Fisheries	2012 - 2024	Global Fishing Watch	https://globalfishingwatch.org/data-download/	Estimated by machine learning algorithms Does not take into account ships less large than 12m
Aquaculture	2023 (last revised)	EMODnet	https://emodnet.ec.europa.eu/en/human-activities	Information is not available for the whole Mediterranean Sea, mostly the North bank
Habitat localization	2025 (last revised)	EUSeaMap	https://data.europa.eu/data/datasets/02864991-fbf1-43ae-b5e2-4fe4f0569bdc?locale=fr	Confidence in the localization
Habitat sensitivity	2023 (last revised)	MNHN	https://www.patrinat.fr/fr/sensibilite-des-habitats-marins-benthiques-6073	Information is not available for the all benthic habitats

Once anthropogenic activities data were gathered, the second step consisted in linking those activities to pressures they generate. Thus, a matrix linking activity and pressures was created from matrices already validated by ODEMM¹², the JNCC¹³, the MNHN¹⁴ and DEVOTES¹⁵. Then, only pressures for which the sensitivities of Mediterranean benthic habitats were known, were selected. The final matrix is available in table 4. The third step consisted in including benthic habitat sensitivities to selected pressures. The EUNIS typology offers a classification of benthic habitats, and an evaluation of their sensitivities to several pressures was available from the French National Museum of Natural History (Table 3). However, it is important to note that sensitivities were not assessed for all of the benthic habitats of the Mediterranean Sea.

¹²<https://maritime-spatial-planning.ec.europa.eu/projects/options-delivering-ecosystem-based-marine-management>

¹³<https://jncc.gov.uk/resources/97447f16-9f38-49ff-a3af-56d437fd1951>

¹⁴<https://mnhn.hal.science/mnhn-04271772>

¹⁵<https://cordis.europa.eu/project/id/308392/reporting>

Table 4. Matrix linking anthropogenic activities under study to the pressures they generated according to literature

Pressure	Activities	Bottom trawling Fisheries	Aquaculture
Physical abrasion		x	
Change in particle load		x	x
Pollution (synthetic and biological)			x
Structural change (benthic)		x	x

Since the pressure of physical abrasion was only generated by fisheries, three levels of physical abrasions were established, according to the hours of cumulated fisheries in every cell of the grid (1 = weak, 2 = medium, 3 = strong). Fishing effort was not estimated from this dataset.

Because the pressures related to change in particle load and to the structural change of habitats were generated by both fisheries and aquaculture, the analysis only considers a co-occurrence of fisheries and aquaculture (0 = no activity, 1 = presence of one activity, 2 = presence of the two activities). Indeed, it was not possible to estimate the relative contribution of fisheries on the one hand, and of aquaculture on the other hand because, to our best knowledge, there is no comparative study of the intensity of such pressure between the two activities.

Pollutions (synthetic and biological) were considered as generated only by aquaculture, and thus were directly estimated from aquaculture presence data, without levels of intensity (0 = absence, 1 = presence). The three pressures linked with the aquaculture activities (particle load, structural change and pollution) were estimated to have a spatial footprint of 1 km around them (Ottinger *et al.*, 2016), which was considered as taken into account within the grid cell. Finally, to establish a potential impact risks assessment map, the value of each pressure was multiplied by the habitat sensibility value (1 = low, 2 = medium, 3 = high) and then divided by the maximum potential value for each pressure, in order to obtain a risk *ratio* contained between 0 and 1, and to be able to compare potential risks between pressures (Fig. 2). The methodology transformed heterogeneous datasets into standardized pressure indicators and spatial potential impact risk information.

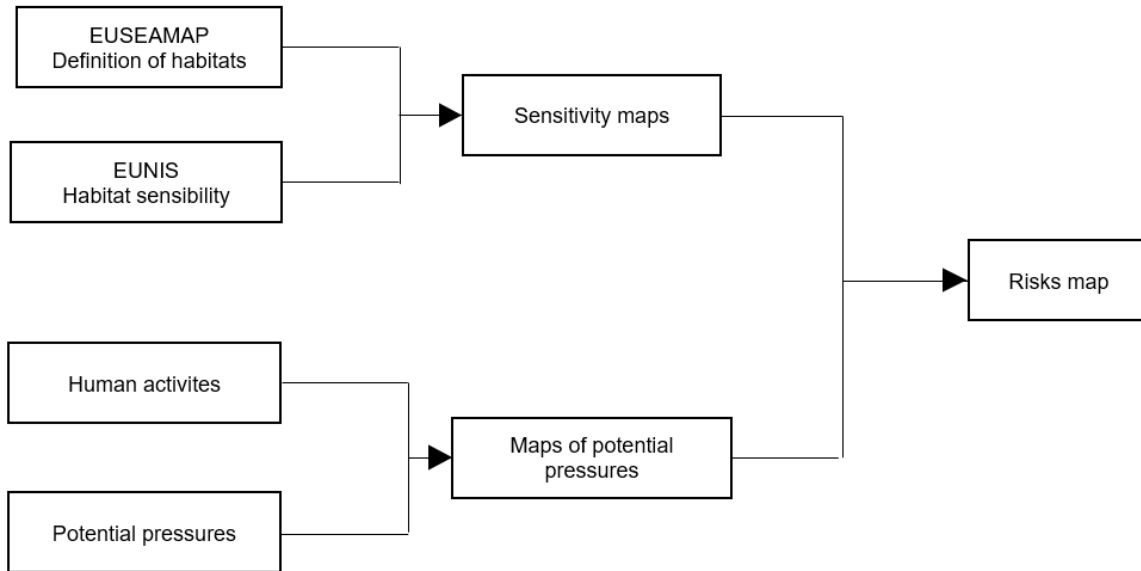


Figure 2: Scheme of the methodology for potential impact risks maps.

2.2. Methodology: Marine HeatWaves (MHW) and seascape analysis

Since there is a growing occurrence of MHW in the Mediterranean Sea, it is important to estimate how they may impact the biotopes (i.e., the physical environment where biological organisms develop) of the Mediterranean Sea. To this end, a preliminary step may be to study the modifications of seascapes (i.e., oceanographically coherent water masses, Tew Käi et al., 2020, Reygondeau et al., 2017) when MHW occurs. In this methodology, oceanographic data were processed into synthetic seascape classifications to generate interpretable spatial information.

The oceanographical dataset covered the years from 2003 to 2025 at a 1-kilometer spatial resolution. The analyses were based on oceanographical open-source data (Sea Surface Temperature, Sea Surface Salinity, bottom temperature, bathymetry and currents) from the CMEMS¹⁶. Chlorophyll was not considered for the analysis. The sedimentology of the Mediterranean Sea was tested as a variable in our analysis, but did not improve results. It was thus discarded.

Several machine learning methods were tested in order to define relevant seascapes. A combination of PCA (Principal Component Analysis) on the selected oceanographical variables, followed by a clustering method (K means), was chosen. These methods were applied on monthly data to establish monthly seascapes. It is important to note that a monthly resolution may cause an overlook of short MHW. However, the choice of a monthly temporal resolution aims to balance ecological relevance, operational usability for marine spatial planning (MSP) and computing time. While finer temporal scales would better capture the duration and intensity of short MHW, they are less compatible with planning and management frameworks, which typically rely on aggregated indicators. Monthly data allow the identification of persistent anomalies while remaining interpretable for policy

¹⁶ <https://marine.copernicus.eu/>

implementation and potential seasonal adjustments of flexible MSP measures. This approach was thus considered as supporting adaptive MSP.

The first step consisted in generating an “initial state”, i.e., a mean map of seascapes from each summer months (June, July and August) of years without intense MHW events (2007, 2008, 2011, 2012, 2014, 2016, 2020 and 2021), according to literature (Daramaraki *et al.*, 2024). Then, the second step compared the initial state seascapes to the ones obtained in summers with intense MHW (2003, 2006, 2009, 2010, 2013, 2015, 2017, 2018, 2019, 2022).

While the initial state was considered as robust since the spatial pattern of seascapes was homogeneous across summer months of all the years without MHW, seascapes configurations during MHW were particularly heterogeneous and did not allow to create a representative MHW-state. It may be hypothesized that this heterogeneity is the consequence of marine heatwaves being random in intensity, duration and localization in the basin.

2.3. Results: human activities & potential impact risks maps

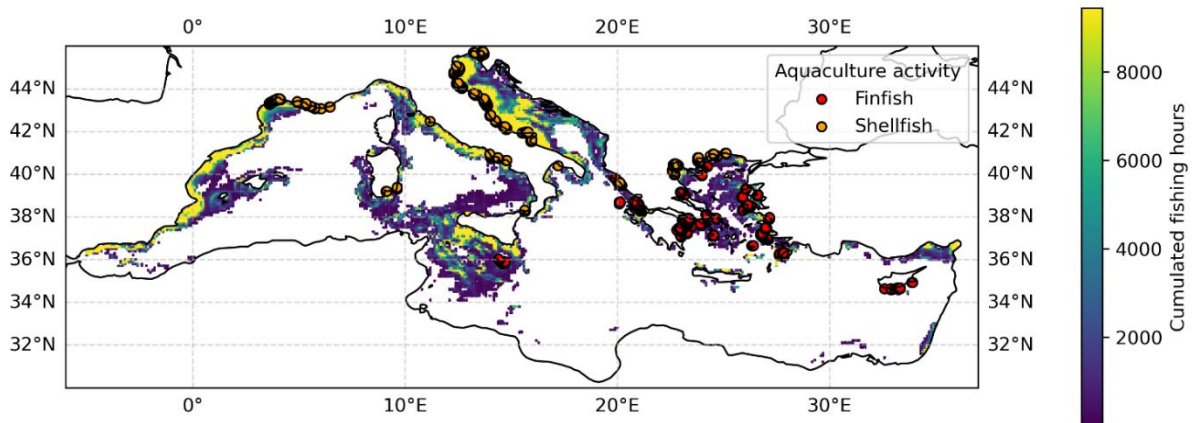


Figure 3: Map of Human activities under study, i.e., fisheries and aquaculture. Red and orange dots represent respectively the finfish and shellfish aquaculture activity. Fishing intensity is measured based on cumulated fishing hours, between 2012 and 2024. Areas without values correspond to areas without fisheries or with less than 100 cumulated hours of fishing per year.

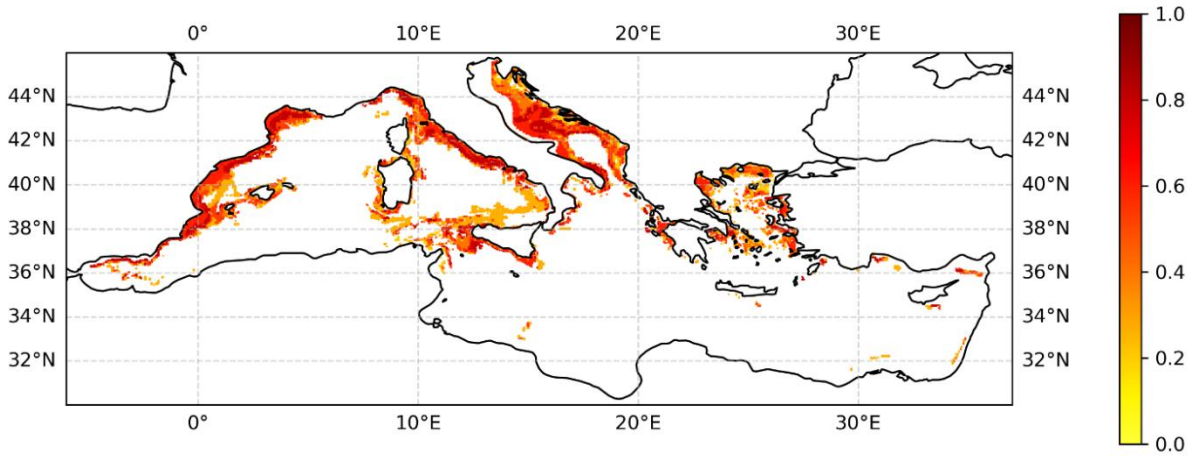


Figure 4: Map of potential abrasion impact risk, based on the crossing between fishing intensity and benthic habitat sensitivity to abrasion. Areas without values correspond to areas without fisheries or with unknown habitat sensitivity.

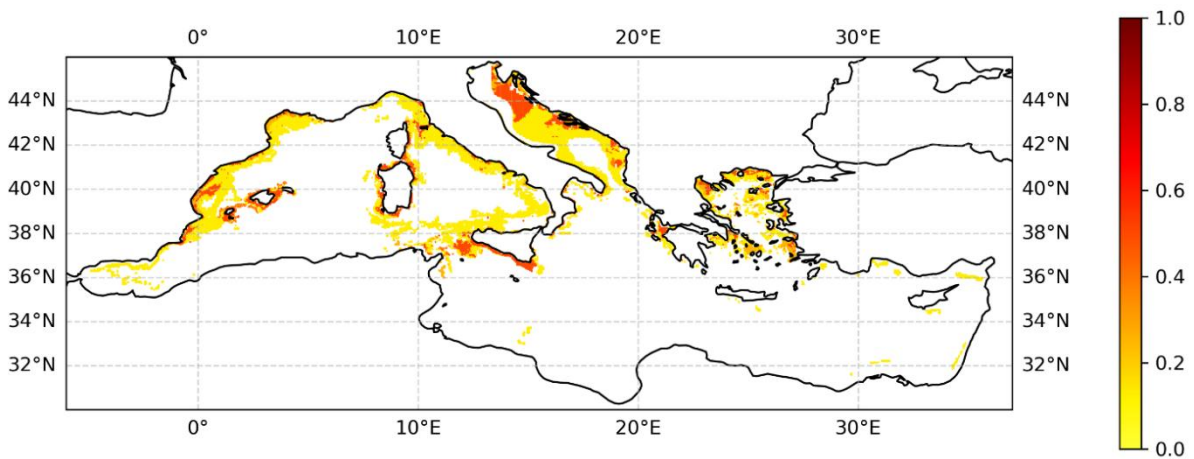


Figure 5: Map of potential impact risk of modifications in particle charge, based on co-occurrence of fishing and aquaculture crossed with benthic habitat sensitivity to change in particle charge. Areas without value correspond to areas without activities or with unknown habitat sensitivity.

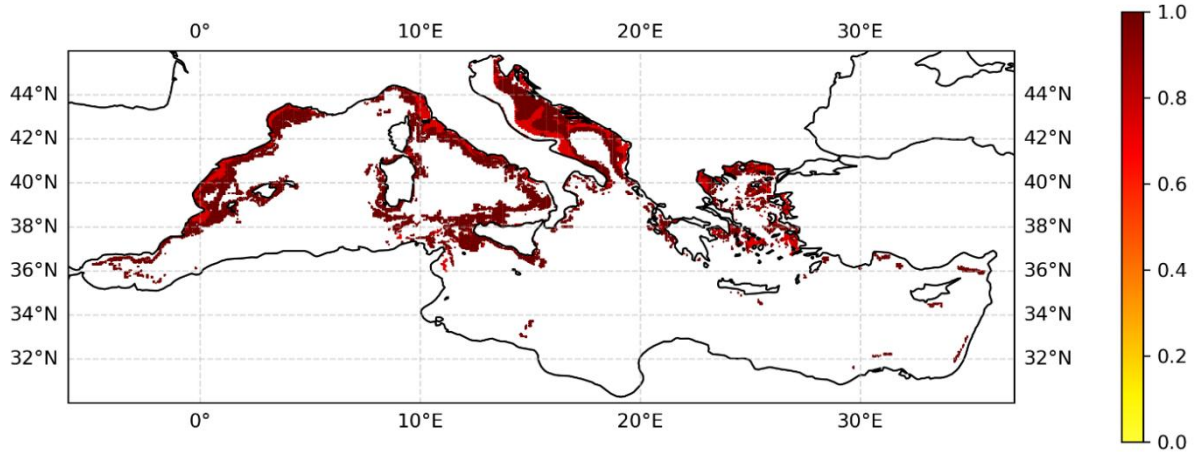


Figure 6: Map of potential impact risk of benthic physical restructuring, based co-occurrence of fishing and aquaculture crossing with benthic habitat sensitivity to benthic physical restructuring. Areas without value correspond to areas without activities or with unknown habitat sensitivity.

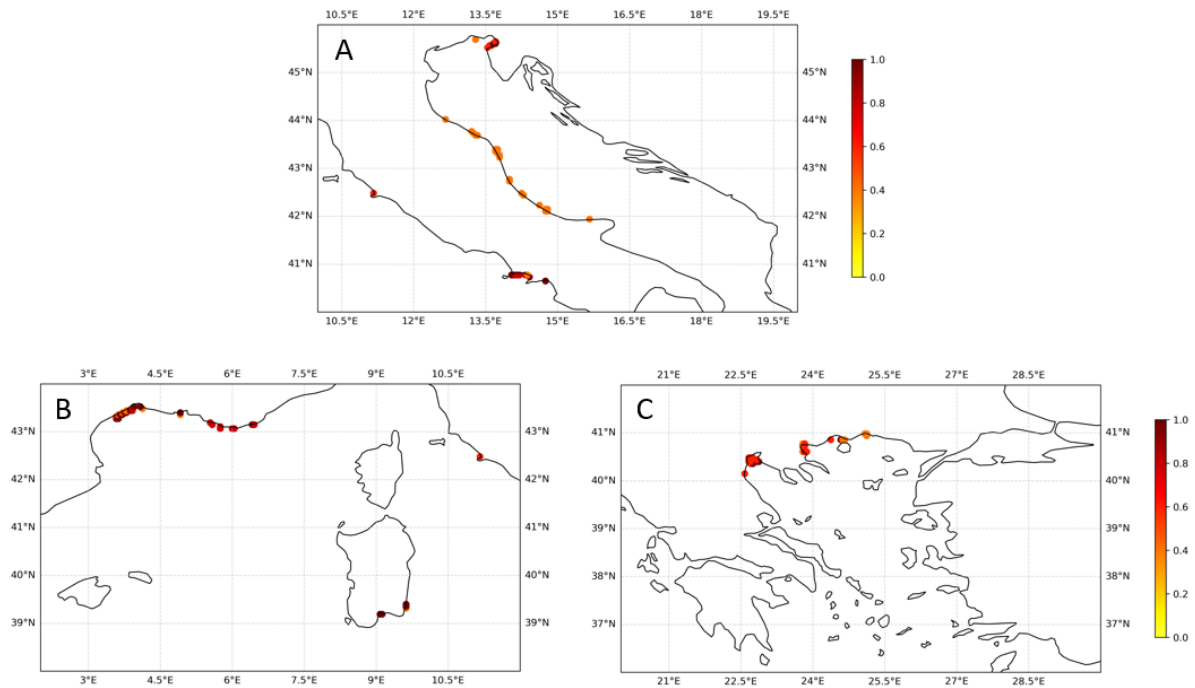


Figure 7: Pollution potential impact risk in the A) Adriatic Sea, B) the Gulf of Lion, and C) the Aegean Sea, calculated by crossing aquaculture presence with the benthic habitats' sensitivities to pollution. Areas without value correspond to areas with unknown habitat sensitivity. These maps are available at larger size in annex A.

According to this assessment, the main potential impact risk on Mediterranean benthic habitat, whether being in intensity or in spatial footprint, was physical restructuring (physical change in the benthic structure). It was expected since habitats are particularly sensitive to restructuring. Abrasion appeared to be an important potential impact risk for benthic habitat, as well as pollution, but with a less important spatial footprint. Particle charge modifications was the only mainly-medium impact risk in the assessment.

2.4. Results: Marine Heat Waves and seascapes analysis

The initial state of physical seascapes showed that 4 different seascapes:

- A coastal seascape showed as dark blue,
- A low bathymetry one showed as green,
- A seascape in the West (yellow),
- A seascape in the East (blue) basin.

This analysis indicated oceanographical differences between the western and the eastern basins of the Mediterranean Sea. The Tyrrhenian Sea showed a mixture of the west and the east seascapes.

During marine heatwaves, the seascapes changed in shapes and spatial configuration. Some MHW episodes showed a chaotic structuration, first by the fact that the western and the eastern basins did not appear as different anymore, and then by the apparition of swirls in many locations, particularly in the western basin and in the South of the Aegean Sea, probably expressing a change in currents or oceanic circulation, rather than temperature only.

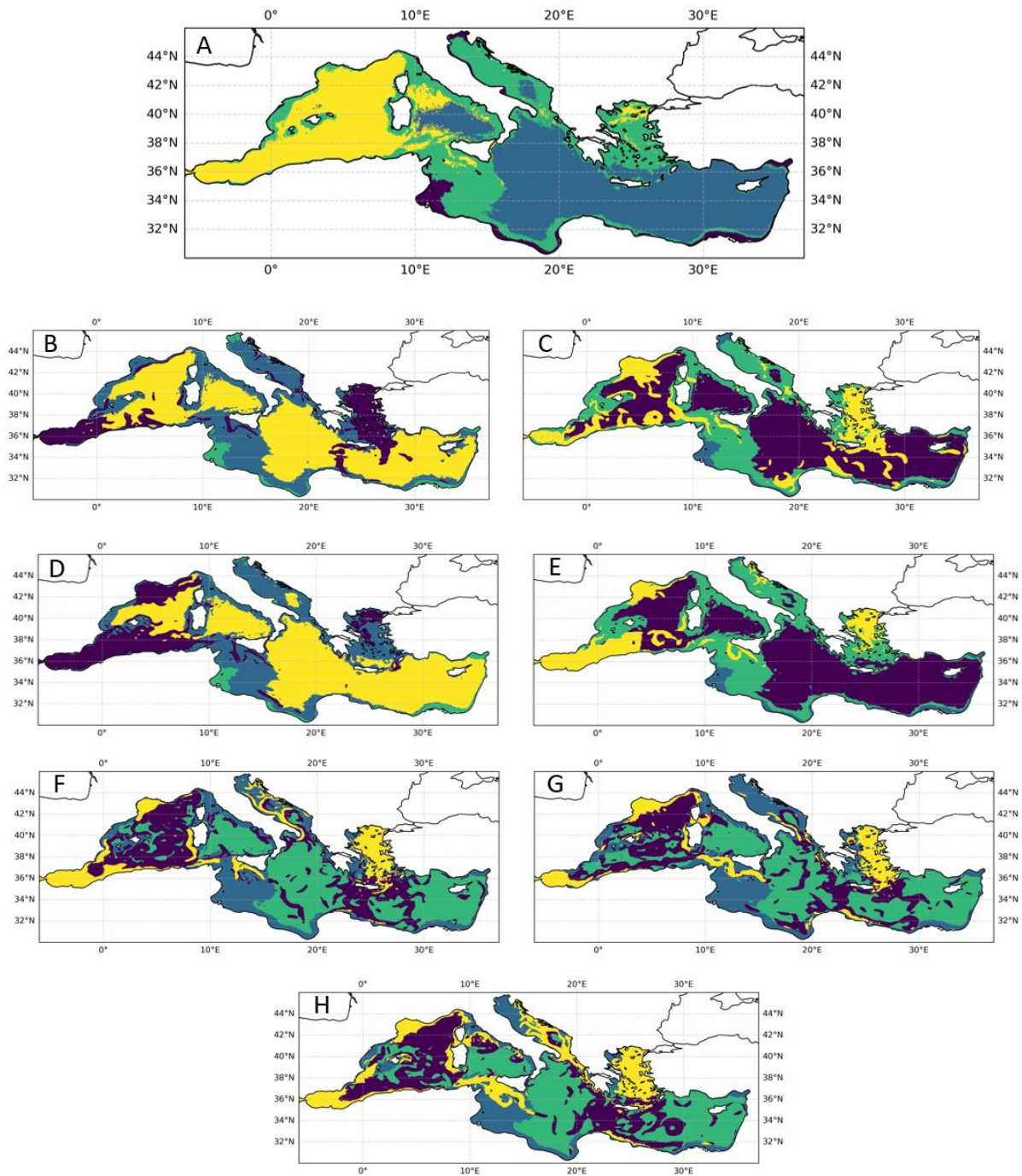


Figure 8: Maps of seascape in the Mediterranean Sea, initial state without MHW and examples during MHW. A) initial state, i.e., mean configuration of seascape during summer months without MHW, B) July 2006, C) July 2015, D) June 2017, E) August 2018, F) August 2022, G) July 2023, H) July 2025. Each colour represents a different seascape. The colours have no meaning other than to differentiate seascape as it is randomly assigned during statistical analyses. These maps are available at larger size in annex A.

2.5. Limits

This study had some limits. Firstly, data for fisheries from ships smaller than 12m from GFW were not available, although they represent a high proportion of the Mediterranean fleet¹⁷. While this limitation was partly mitigated by the focus on trawling activities and benthic impacts, overall fishing pressure may still be underestimated. Pelagic fisheries were not included because of the lack of information on pelagic habitat sensitivities and localizations. Secondly, there was a lack of data regarding benthic habitat sensitivities. As a result, it was not possible to assess potential risk maps for the whole spatial extent of human activities selected for this study. Some of the data did not meet FAIR standards, especially the sensitivity maps.

Thirdly, this study highlighted the potential MHW impact on the oceanography of the sea basin, but there were no similar studies in the literature, to our best knowledge. This implies a lack of information of MHW impact on oceanographical variables, and on seascapes fragmentation on ecosystems. The lack of information regarding the ecological role of exploited species in the Mediterranean Sea may also prevent potential important conclusions for MPAs, biodiversity protection and ecosystems.

Finally, this study did not consider synergies between different pressures. Cumulating pressures between MHW and other anthropogenic pressures (fisheries, increased SST, introduction of alien species...) may imply complex interactions and heavy consequences on the environment.

2.6. Discussion & MSP implication

2.6.1. Human activities, potential impact risks and MPAs

The assessment of risks of potential impacts of anthropogenic activities on marine habitats is essential for Ecosystem Based Management into MSP.

This analysis showed that trawling fisheries and aquaculture may have severe potential impacts risks on the Mediterranean basin, particularly in the coastal regions which are exposed to a high potential cumulative stress from human activities.

According to the available data, the **northern area** showed heavier potential anthropogenic pressures than in the south. The regulation of human activities in this part of the Mediterranean Sea would benefit from a strong implication of European countries in order to decrease pressures on natural habitats and avoid higher potential impacts from cumulative pressures in the near future. This objective of decreasing anthropogenic cumulative pressure on benthic habitats is important for natural conservation and may be achieved by better controlling, monitoring and coordinating human activities within MPAs. Indeed, despite an important MPA network in the northern Mediterranean Sea (Fig. 9), MPA are shown on Figure 9 to be actively protected at 0.04% in the whole basin, and are proved to have an important lack of information regarding their management organization (see <https://medpan.org/en/> for more information). It would be interesting to push the designated MPAs with a management plan (18% of the surface of the sea basin) to add restrictions on human activities in them, in an attempt to reduce potential cumulative pressure on ecosystems.

¹⁷ <https://publications.jrc.ec.europa.eu/repository/handle/JRC144396>

The system of **Mediterranean Marine Protected Areas** in 2020

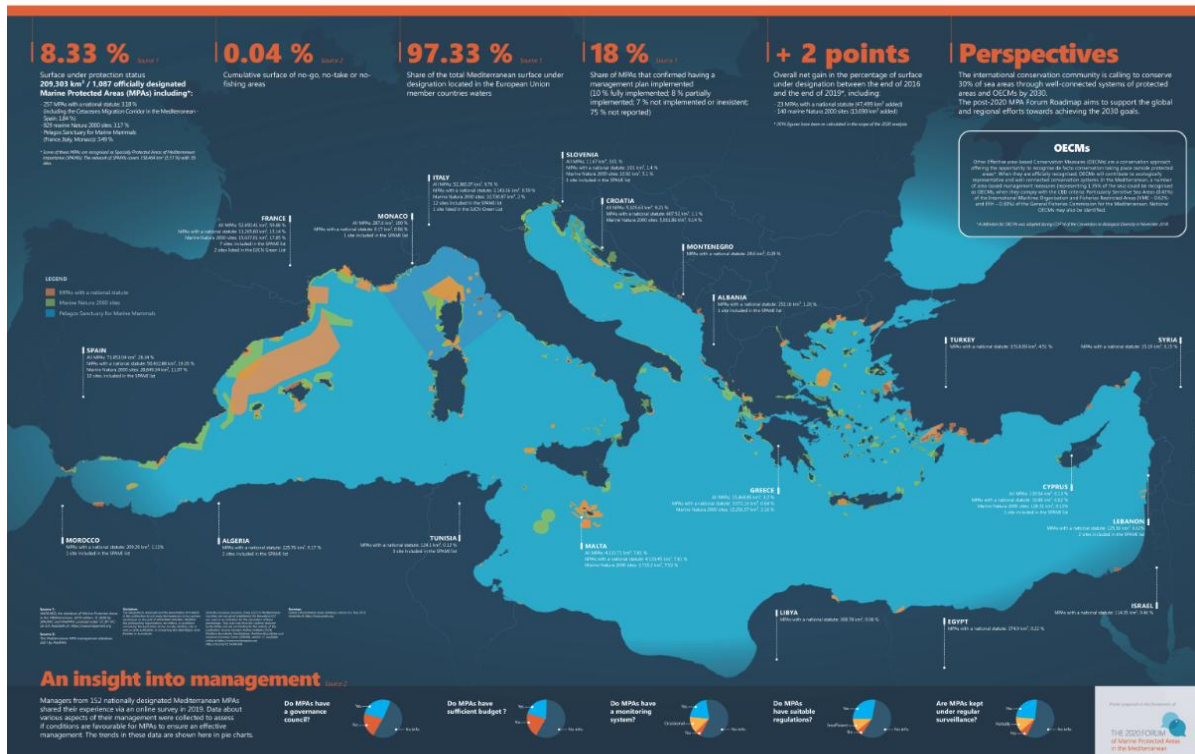


Figure 9: Map of the Mediterranean MPA network (2020)
<https://medpan.org/en/system-mediterranean-mpas-2020#gallery-pid-7294>

The **southern area** of the Mediterranean Sea seemed to have fewer potential risks of potential impact from anthropogenic activities. This is probably due to the lack of open-source data for this area, but also a difference in human activities cannot be excluded. Another consideration to take is the updating temporality of the MPA map: the actual date of 2020. MEDPAN, in charge of providing the status of MPA in the Mediterranean Sea, will publish the status for 2025 in May 2026. From the available data as of today, it may rather be interesting to develop the MPA network along the southern coasts of the Mediterranean Sea as a priority.

2.6.2. Marine Heat Waves

The analysis of seascapes, i.e., biotopes, by comparing an initial state to the modification of the seascapes during MHW, appeared as an interesting preliminary step to consider the effects of climate change for MSP.

MHW vary in duration, intensity, and localisations, and thus have complex and probably unpredictable potential impacts on biotopes. This analysis showed that the perturbations of physical seascapes did not rely only on the increasing temperature of the Mediterranean Sea in the summer, but also on the modification of other oceanographical variables. This was illustrated by the apparition of swirls and patches on months with MHW, which may represent the modifications of the currents and salinity, respectively. In fact, a modification of temperature implies a rise in salinity and a change of the depth of the thermocline (Amaya *et al.*, 2023), which in turn modifies circulation in the water sea column.

In summary, marine heatwaves can potentially impact all the physical components of the ecosystem, but also the chemical and the biological ones, whether directly or indirectly. As a consequence, MHW are probably events of cumulative stress for wildlife by destabilizing their biotopes, and it may be particularly alarming where ecosystems are already confronted with pressure resulting from human activities. It is important to keep in mind that the extent of the impacts of MHW on physical seascapes are still unknown, therefore the conclusions drawn should be interpreted with caution. A better understanding of (i) the consequences of those instabilities on Mediterranean ecosystems; (ii) their cumulation with others direct pressures from human activities and; (iii) the impact of other seasons MHW, should become a priority for years to come.

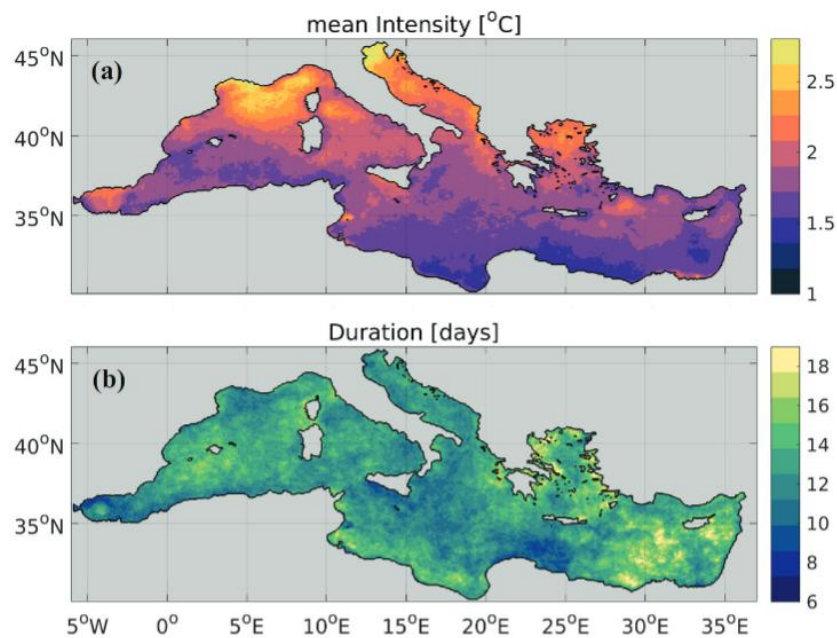


Fig. 3: Mean MHW intensity (a) and duration (b) in the Mediterranean Sea averaged over 1982–2023. MHWs are detected based on the climatology period 1982–2023 by applying the Hobday *et al.* (2016) methodology to the satellite SST dataset: Mediterranean Sea High Resolution L4 Sea Surface Temperature Reprocessed (<https://doi.org/10.48670/moi-00173>).

Figure 10: Mean MHW intensity (a) and duration (b) in the Mediterranean Sea averaged over 1982 and 2023 (Daramaraki *et al.*, 2024)

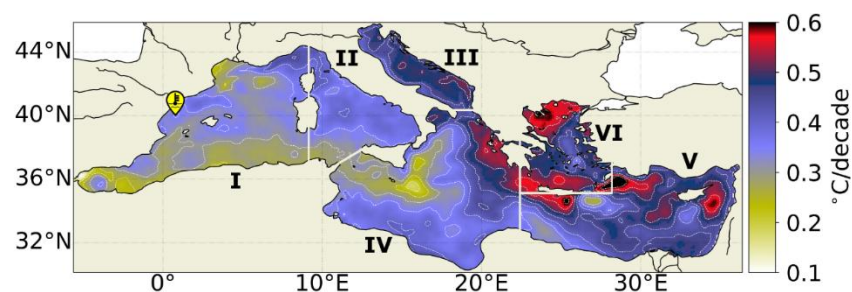


Figure 11: Warming trends of the Mediterranean sea basin, over 1982 to 2021 (Martinez *et al.*, 2023).

As a complement to this analysis, the literature gives several main pieces of information regarding climate change in the Mediterranean Sea.

As seen in the figure 10, the western basin shows more frequent MHW, with the highest intensity and the shortest durations in the basin, while the eastern basin shows the longest duration of MHW. This may be related to the results presented here, first by the different destabilisation patterns between West, where the majority of seascapes were restructured; and East where only the South of the Aegean Sea was modified. Coincidentally, figure 11 shows that the warming of the basin is more important in the East than the West. It may thus be hypothesized that the two areas face different consequences of MHW.

The figure 10 also shows a North-South gradient of the mean intensity of MHW, with the northern part of the basin having the most intense MHW (and Massive Mortality Events according to Daramaraki *et al.*, 2024). Moreover, the northern part of the Mediterranean Sea also seemed to be the area where pressures resulting from anthropogenic activities were the highest. A preliminary cross-analysis suggests that the combination of these two factors may have significant consequences for marine species. Indeed, because the Mediterranean Sea is a semi-enclosed sea, species cannot migrate up to the North in search of colder waters, as MHW events are more intense there. Based on this information, and at this stage of the analysis, it is not possible to robustly identify general climate refugia or dead zones at basin scale. Further development of decision-support tools is required to refine these assessments and support knowledge-based decision-making.

Another potential impact risk resulting from MHW and the warming of the sea is the eutrophication, i.e., bloom of plankton, across the basin (Martínez *et al.*, 2023). This may have long term consequences on the habitats, on the life cycles of living organisms, leading to change in living exploited resources (modifications of fish stocks), and mortality events resulting from harmful algal bloom in aquaculture areas.

The frequency, intensity, duration, and spatial area affected by MHW are rising each year, and are correlated with the warming of the climate according to the IPCC. While preventing MHWs directly remains challenging, their impacts must be anticipated and integrated into Marine Spatial Planning. This reinforces the need to support climate adaptation (B3) and protect climate-sensitive ecosystems (B2), in line with European Green Deal objectives which are currently weakly addressed in the plans.

Key Messages:

- **Human activities** are highly present on the coasts of the Mediterranean Sea, thus causing a high potential impact risks on coastal benthic habitats;
- **Marine Heat Waves** cause a change in the oceanography of the Mediterranean Sea, changing stable summer seascapes to unstable seascapes. The effects of such a change are still unknown, but bring additional information on the consequences of MHW;
- **High potential cumulated impacts** on coastal regions through human activities, climate change and MHW
- Different MSP recommendations depending on the challenges faced regionally;
- **MPA networks**, based on cumulated pressures and climate vulnerability from human activities and MHW/Climate change should be considered. **Valuable information was provided to continue the search for knowledge that will enable the identification of climate refugia or dead zones. Improving the**

management of current MPAs may be key to help face future consequences of cumulative impacts in the Mediterranean Sea;

- **Several lack of data and information**, including (and not limited to) biodiversity and consequences of fisheries from small fishing boats, implications of changing seascapes during MHW, **prevents** further MSP assessments and recommendations.

3. Transferability and upscaling

3.1. Transferability

The action addresses challenges at the Mediterranean basin scale, enabling a transboundary understanding of anthropogenic pressures and Marine Heat Wave (MHW) impacts in line with EGD objectives. It provides relevant inputs to improve national MSP. Its transferability depends on the ability of authorities to use basin-scale information and translate it into operational zoning and sectoral management decisions.

The methodology is transferable to national and sub-national levels, although the ecological relevance of seascape-based biotopes requires further validation at finer scales. Its implementation highlights the need for improved data availability, harmonisation, and governance, as current gaps limit full spatial coverage. It is therefore a key enabling condition for replication.

3.2. Affordability

The methodology relies on open-source data, making it cost-efficient, although data gaps may require complementary datasets (namely fisheries from smaller boats, aquaculture for the whole sea basin, complete dataset of habitat localization and sensitivity of the sea basin). Implementation requires technical skills in spatial analysis and modelling, but resulting maps are directly usable for MSP.

Open-source code will support reproducibility and reduce implementation barriers. It will also be available on GitHub, and the objective is to publish in through the European Digital Twin of the Ocean (EDITO), announced in the Ocean Pact¹⁸. EDITO is conceived as a distributed and interoperable digital infrastructure that integrates marine data, modelling services and cloud-based computing resources to support analysis, simulation and decision-making in the marine domain¹⁹.

3.3. Upscaling

The methodology is re-scalable and replicable in other sea basins, subject to data availability and regional adaptation. It can support regional frameworks such as the Barcelona Convention, the WestMED Initiative, and the Union for the Mediterranean. These results would be interesting to share and discuss in the CoP MED.

¹⁸ [https://www.europarl.europa.eu/RegData/etudes/BRIE/2025/772912/EPRS_BRI\(2025\)772912_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2025/772912/EPRS_BRI(2025)772912_EN.pdf)

¹⁹ <https://edito-infra.eu/european-digital-twin-ocean-introducing-edito-infra/>

Facing climate change, achieving good environmental status while contributing to the Blue Economy in the Mediterranean Sea will be a very complex and challenging task. It will need cooperation, involvement and investment from every country involved under the Barcelona Convention. Its aim is to "reduce pollution in the Mediterranean Sea and protect and improve the marine environment in the area, thereby contributing to its sustainable development". To do so, there is a need for ecosystem-based management on coastal areas, addressing future challenges of anthropogenic activities and climate change in the sea basin. The engagement of scientists and environmental practitioners in the planning process will be key to the successful implementation of marine spatial plans in the Mediterranean Sea. Its implementation benefits from transboundary cooperation, while further work is needed to assess downscaling to national MSP contexts.

4. Conclusion

Main conclusions

This study highlights the high occurrence of potential cumulated risks in the Mediterranean Sea. Firstly, it was shown that there is a high potential impact risk originating from human activities on the coastal regions of the Mediterranean Sea. This originates from the high habitats sensitivities to the different pressures exerted by trawling fisheries and aquaculture. Secondly, summer MHW are not only affecting species, but also the oceanography of the whole Mediterranean sea basin (perturbation in salinity, currents, and vertical circulation). This information suggests that there is a high cumulative impact of pressures affecting the Mediterranean sea basin.

Recommendations

Because there are differences between East and West basins regarding the potential risks (MHW, human activities), it would be interesting to have different localized MSP plans, to better adapt to specific complications in the future.

For the **northern Mediterranean area**, the focus should be to reduce the potential cumulated pressures, especially since it is the area with the most massive mortality events in the sea basin (Daramaraki *et al.*, 2024). Because MHW are tied with climate change, the most accessible reduction of the cumulated pressures is from a better management of the human activities, for example by reducing fisheries that are the most active around the coast, as advised by Potier *et al.*, (2025). It would be a good opportunity to actively regulate activities particularly within the MPAs.

For the **southern Mediterranean area**, the potential apparent difference in human activities with the northern part may be an opportunity to better recommend their implementation and develop a network of MPAs. This could help sustainably develop human activities in this area, and better face climate change challenges in the future.

For the **eastern Mediterranean area**, the prolonged MHW events and the trending of the warming of the sea show that the main challenge for this area will be adaptation and mitigation of climate change.

For the **western Mediterranean area**, the destabilisation of seascapes resulting from MHW may be a sign for a focus in marine sciences to better assess its consequences on ecosystems. Since it is where the warming is the lowest of the whole sea basin, it might be important to prevent future cumulative stress by limiting the potential impact risks of human activities.

It is still important to have a vision at basin scale, and integrate every country in the management decisions, to ensure a sustainable and similar management between areas facing similar challenges, with proper downscaling of measures taken.

Current limitations in data across the Mediterranean basin constrain the development of consistent and transferable MSP analyses. In this context, task 4.4 of MEDIGREEN project will directly address these challenges by aiming to identify data gaps, improve data harmonisation, and support the production of interoperable sectorial basin-scale geospatial layers. Moreover, there is a strong need to develop a shared infrastructure for aggregating and visualising data, information and knowledge at basin scale. This could be achieved either through the development of a maritime basin approach within EMODnet, or through a dedicated regional platform for all Mediterranean stakeholders.

The next step of this study could be to refine the results and work further to:

- Develop a Mediterranean decision tool for MSP, to potentially help define climate refugias and localization of sustainable human activities;
- Expand this analysis to other sea basins, and in particular the Atlantic, considering the AMOC tipping point or the Baltic which is prone to more climate extremes (negative and positive).

Finally, this action reinforces the need to develop and include “climate-smart MSP framework” in the currently under revision MSP Directive. This would ensure the consideration of EBA MSP adaptation to climate-related change, using (i) **dynamic ocean management** - use seasonal data allows for the designation of management areas whose boundaries change in space and time in response to shifts ; (ii) **anticipatory zoning** - *a priori* allocation of areas to particular ocean uses in the future—or to their exclusion—in anticipation of climate change effects ; (ii) **just-in-time spatial planning** - a spatial planning approach that instead of using statutory long-term plans, uses planning laws and rules referring to qualitative relations between different EBA MSP components into an agile MSP governance framework (Frazão Santos *et al.*, 2024 ; Rekola *et al.*, 2025).



Table 5. Summary table of the action's results and recommendations

Axis	Sectors impacted	MSP objectives	EGD Objectives	Results	Recommendations
Assessment of marine heatwave scenarios on seascapes	Nature protection	Identify structural vulnerabilities, information to determine future "dead zones," and refuge areas to support long-term management within MSP plans	<p>B3: Anticipation of climate change-related effects</p> <p>B3.1: Identification of climate refugia for marine species and habitats</p> <p>D1.1: Establishment of new or enlargement of strictly marine protected areas (10% target) and definition of strict protection</p> <p>D1.5: biodiversity and ecosystem protection</p>	<ul style="list-style-type: none"> • Clear differentiation of seascapes under normal conditions (East vs West Mediterranean) • Strong homogenisation and disruption during MHW events • Open-access modelling code (EDITO) 	<ul style="list-style-type: none"> • Strengthen integration of MHW impacts in MSP and sectoral monitoring • Further develop seascape approach to use them as a base for knowledge to: • identify climate refugia and potential dead zones; • adapt and extend MPAs and activity zoning
Assessment of human activities pressures & risk maps	Fisheries Aquaculture Nature protection ORE	Identify priority areas for adapting zoning considering human pressures by sector and cumulative potential impact for different habitat	<p>B2: Protection of climate-sensitive marine and coastal biodiversity, ecosystems, and landscapes</p> <p>D4.5: Multi-use of sea space: combinations including biodiversity and ecosystem protection</p>	<ul style="list-style-type: none"> • Pressure maps for key sectors (trawling, aquaculture) • Basin-scale potential risk maps to anthropogenic pressures • Open-access code (EDITO) 	<ul style="list-style-type: none"> • Address major gaps in sectoral datasets at Mediterranean scale; • Improve harmonisation and interoperability; develop comprehensive basin-scale layers (implemented in MEDIGREEN Task 4.4) • Support evidence-based zoning and pressure mitigation. • Mediterranean data / information platform
Assessment of the effects of marine heatwaves on different ecosystems and implications for sectors	Fisheries Aquaculture Nature protection ORE	Define areas particularly sensitive to thermal extremes that require adaptive and flexible management during extreme events	<p>B2: Protection of climate-sensitive marine and coastal biodiversity, ecosystems, and landscapes</p> <p>B3.2: Identification of areas to be used in the future by specific sectors due to CC</p> <p>D4.5: Multi-use of sea space: combinations including biodiversity and ecosystem protection</p>	<ul style="list-style-type: none"> • First cross analysis of MHW impacts on seascapes and potential impact risk maps due to human pressures • Preliminary identification of MSP implication • Open-access code (EDITO- Model Lab What-if Scenarios) 	<ul style="list-style-type: none"> • Further develop cross-analysis between climate vulnerability and anthropogenic pressures by developing or testing to integrate these results into decision-making process • Support adaptive and flexible MSP • Include MHW in sector monitoring as aquaculture and fisheries • Mediterranean data / information platform



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National action #2: Benchmark on the use of modelling approaches to inform MSP (Cerema)

1. Context and needs

1.1. Maritime spatial planning in the French context

Maritime spatial planning (MSP) uses scientific and geospatial information to organise marine activities, while protecting or restoring marine ecosystems. MSP seeks to reduce conflicts among uses (e.g., fisheries, maritime transport, offshore renewable energy, etc) and to strike a balance between socio-economic needs and ecological priorities, in order to sustain essential ecological services for present and future generations (Guerry et al., 2012).

In France, MSP plans known as Strategic Sea basin documents (*“Documents stratégiques de façade”* - DSF, in French) set out a strategic vision along with socio-economic and environmental objectives, and detail the measures to achieve them. These MSP plans, designed at the sea basin scale, also include “vocation maps” that spatially identify priority zones for activities (e.g., offshore wind development) and for the protection of ecosystems and resources, through strongly protected zones and fisheries restriction areas, for instance. The strategic and operational components of the DSF are updated every 6 years, to respond to changes in the ecosystem status and the evolving socio-economic development priorities. A monitoring programme is incorporated into this process in order to assess to which extent objectives are achieved, and adequately inform the next revision cycle

(<https://www.dirm.mediterranee.developpement-durable.gouv.fr/la-strategie-de-facade-maritime-est-adoptee-a2892.html>).

However, balancing the various and often competing marine uses and conservation priorities remains challenging, in particular in a context where both marine activities and environmental conditions are evolving quickly.

1.2. Modelling approaches in MSP

This work emerged in the context of growing complexity around maritime and coastal management. Modelling approaches can support evidence-based and sound MSP processes. By integrating environmental, economic, social or regulatory data into maps or simulations, models can represent the complexity of ecosystem functioning, and interactions between activities and their impacts on socio-ecological systems (Scheller & Mladenoff, 2007). Models can address knowledge gaps by predicting spatial distribution of marine ecosystems or maritime uses and forecasting their temporal evolution (Fulton et al., 2011; Elith et al., 2009). They make it possible to anticipate impacts and test alternative development scenarios (such as tourism expansion, offshore wind development, or the designation of conservation areas), assessing their socio-ecological impacts, risks and benefits with regards to conservation objectives, sustainable development priorities, and legal requirements. Such tools that therefore support decision-making and management of

complex systems are particularly valuable in the context of MSP revision in France, where the strategic and operational components of the DSF are regularly revised (the updated versions of the strategic components have been adopted in 2025 while the operational components, adopted in 2022, are being revised).

1.3. Overview of the action

1.3.1. Objective

This action, entitled "Benchmark on the use of modelling approaches to inform maritime spatial planning", is developed to respond to this need for decision-support scenarios in MSP. It aims to provide an overview of the different modelling approaches suited to specific needs identified in MSP-related documents. The ultimate goal is to provide insights for the development and revision of MSP-related policies, based on scenario-making approaches where stakeholders would be able to arbitrate together which management options would be the most relevant to implement.

1.3.2. Methodology

The methodological approach of the action is structured around three main steps:

- **Step 1: Identifying knowledge gaps** linked to pressure distribution, ecosystem status, and interactions between human activities and the environment, in coastal and maritime policies. Here, the term "knowledge gaps" refers to elements identified in planning documents and stakeholder reports as being unavailable or missing while being essential for MSP decision-making.
Knowledge gaps are identified through systematic reading of documents, using interpretation when gaps are formulated in an implicit way. Once the knowledge gaps are identified, they are grouped according to a **typology** that enables their categorization and provides a basis for Step 3, which examines which models are suitable for addressing each type of gap.
- **Step 2: Developing an inventory of the existing modelling approaches** that could be mobilized to fill in the knowledge gaps, and **classifying the models** into different types, based on a literature analysis.
- **Step 3: Linking models to the identified knowledge gaps/needs:** step 3 identifies the models best suited to meet the needs identified in the documents analysed, and illustrates these correspondences with **concrete project examples**.
- **Step 4: Developing scenario-making approaches**, in which, based on the testing of models to explore the potential impacts of different management choices, stakeholders would be able to arbitrate together which management options would be best to implement in a given socio-ecological and institutional context. The aim here is to anticipate the impacts of management choices, inform necessary trade-offs, and enhance the coherence, transparency, and effectiveness of decisions for sustainable MSP.

2. Implementation

2.1. Case study of the French Mediterranean sea basin

The methodology described in the previous section 1.3 has been deployed as part of a case study focusing on the French Mediterranean sea basin, carried out by Lemaire and Alloncle (2025) at Cerema. The French Mediterranean is characterized by remarkable but fragile biodiversity, subject to significant pressures linked to the concentration of human activities and intensive maritime use (Fabbri et al., 2025; Coll et al., 2010). The development of new activities, such as offshore wind, adds to these pressures and accentuates the challenges of coexistence between ecosystem protection and economic development, and between different activities (e.g., with fisheries). In this context, supporting the development of sustainable and equitable management approaches, appears essential to organize uses, limit conflicts, and sustainably reconcile biodiversity protection and human activities.

In the case study region, the main MSP document is the **DSF Mediterranean** (“Document stratégique de façade Méditerranée”), which regionally transposes the National Strategy for the Sea and Coast, taking into account the local specificities and the content of existing local policies.

The four MEDIGREEN sectors (fisheries, aquaculture, offshore renewable energy, and nature protection) are covered.

The results of the case study are described in the following section 2.2.

2.2. Results of the case study

2.2.1. Knowledge gaps in MSP documents refer mainly to habitat mapping, population trends, and management scenarios (results of methodological Step 1)

A systematic review of knowledge gaps for the French Mediterranean sea basin was carried out as part of Step 1, in **various key sources**, including:

- the DSF Mediterranean;
- the opinions of the Environmental Authority (particularly the detailed strategic component) which include observations and recommendations on the main environmental and socio-economic issues of the DSF;
- stakeholder contributions (“cahiers d’acteurs”) from the public debate entitled “*La Mer en débat*”, organized between November 2023 and April 2024 by the National Commission of Public Debate. There were 225 “cahiers d’acteurs”. Their purpose is to enable any legal entity (institutions, companies, associations, etc.) to share its points of view and proposals regarding MSP and ORE planning

(<https://www.debatpublic.fr/sites/default/files/2024-06/DSF-Compte-rendu.pdf>).

The **knowledge gaps** identified in the above sources are wide and mainly refer to:

- the **spatial distribution** of species, habitats, and maritime uses (e.g., functional habitat mapping with emphasis on sensitive sites, population dynamics mapping);
- robust **population assessments for fisheries** certification and management measures;



- the **interactions** between human activities and ecosystems (cumulative impacts, use conflicts);
- management scenarios taking into account cumulative effects (multi-use, socio-economic trade-offs);
- a need for **participatory processes** to legitimize choices, and evidence-based decision-making through scenario analyses that integrate ecological, socio-economic, and regulatory dimensions.

Figure 12 below provides a more detailed overview of the knowledge gaps identified in the planning documents examined as part of the case study.

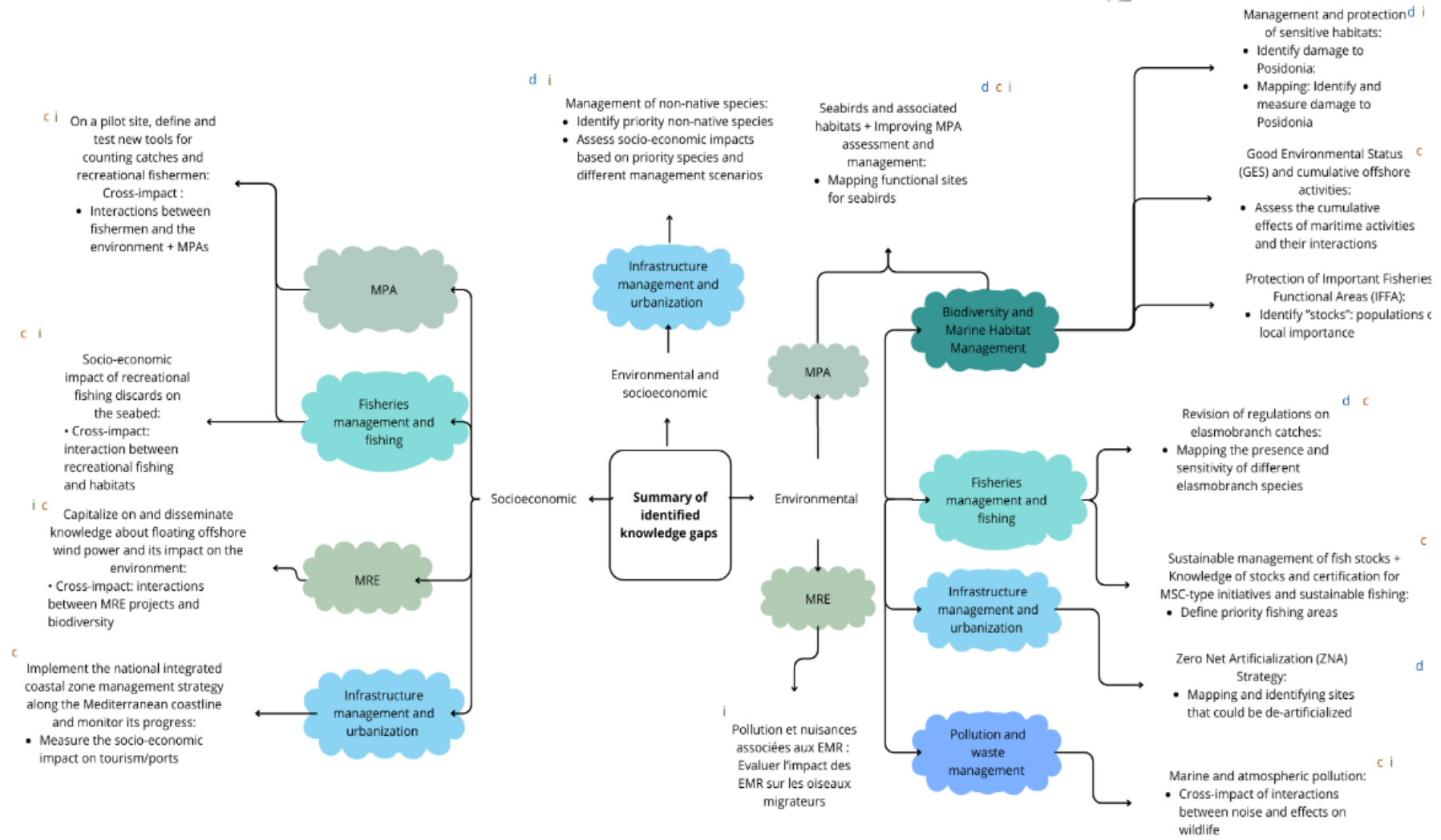


Figure 12: Mind map summarizing the knowledge gaps identified in the planning documents examined as part of the case study. *d*: distribution of issues, *i*: interaction, *c*: cross-analysis /informing decision-making. MRE: marine renewable energy (from Lemaire & Alloncle, 2025).

2.2.2. *The classification of existing modelling approaches as a prerequisite for the analysis (results of methodological Step 2)*

As part of Step 2, the **inventory and classification of modelling approaches** were carried out, based on the **systematic review** of 87 articles (grey and peer-reviewed). In addition to the literature review, **interviews** were conducted with researchers and modelling practitioners from French marine institutes and laboratories in order to refine the classification of modelling approaches, and to gain insight into existing or past projects using models from which MSP could draw inspiration to address knowledge gaps.

The **qualitative models** identified include fuzzy cognitive maps, graphs or network theories.

Quantitative models include:

- deterministic and stochastic models, which predict population evolution based on their internal dynamics (Murray, 2002);
- species distribution models (SDMs), which establish correlations between species occurrences and environmental variables to predict potential geographical distributions (Elith & Leathwick, 2009);
- agent-/individual-based models (ABM/IBM), which simulate the functioning of a whole system considering the behaviour of individuals (human or species) and their relationship (Grimm & Railsback, 2013);
- end-to-end models (E2E), which compile several models to address a complex question, attempting to represent ecosystem components and processes as faithfully as possible (Fulton et al., 2011);

Participatory and **decision-support approaches** are also presented, such as companion modelling, multi-criteria analysis, and hierarchical analytic processes, given their importance in improving environmental management, including in MSP (Gee et al., 2019).

These categories of quantitative models are not meant to be mutually exclusive. Instead, they provide a conceptual framework for considering integrated modelling strategies in MSP, with the purpose of supporting decision-making.

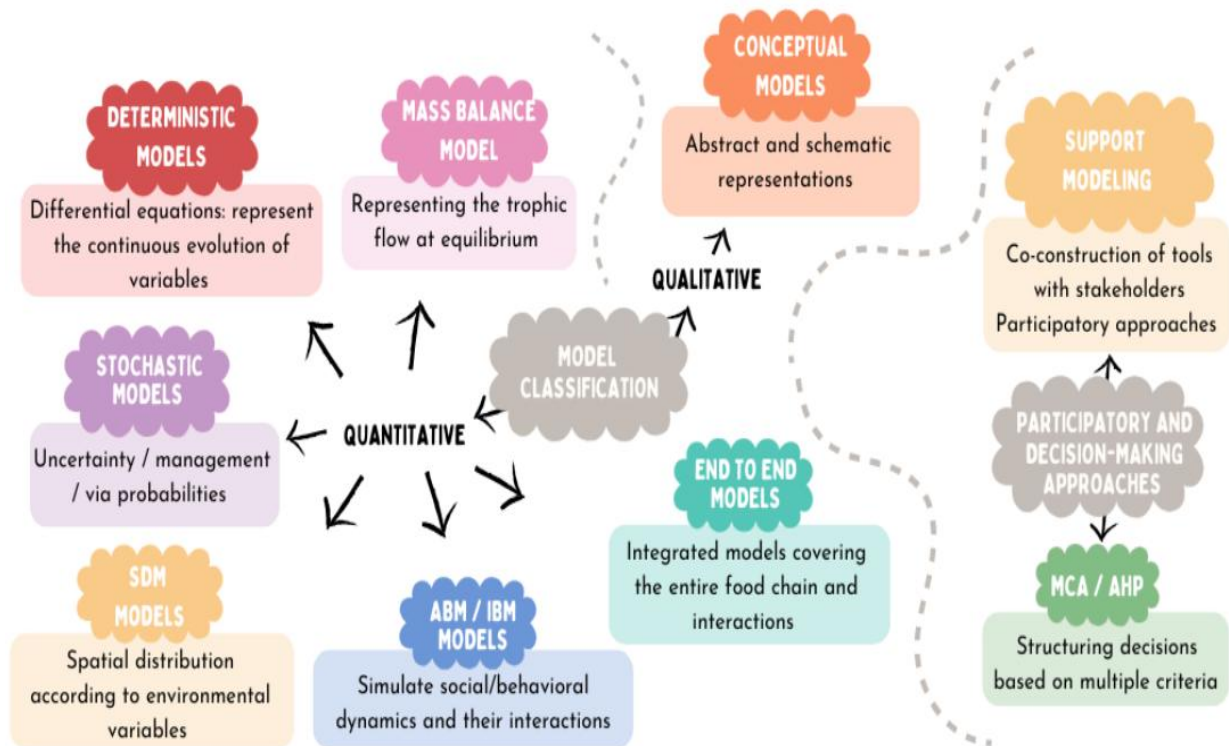


Figure 13: Classification of the different modelling, participatory and decision-making approaches selected for the case study (from Lemaire & Alloncle, 2025).

2.2.3. Model types to address existing knowledge gaps in the French Mediterranean sea basin (results of methodological Step 3)

As part of the case study, a correspondence table was created to align planning needs – derived from shortcomings identified in existing planning documents (during Step 1)– with the model types best suited to address them (Step 2). To do so, the analysis considered both the strengths of each modelling approach (such as spatial depiction, probabilistic assessment, and representation of interacting pressures) and their constraints. Rather than serving as a mere catalogue, this work seeks to organize existing knowledge in a way that supports informed, effective, and context-appropriate use of models in planning activities. The correspondences are summarized in Table 6 below. This table constitutes a summary and is therefore not exhaustive; for complete results see the report of Lemaire & Alloncle (2025).

Table 6. Knowledge gaps highlighted in key MSP documents of the French Mediterranean sea basin and the corresponding modelling approaches suited to address these gaps.

Knowledge gaps	Recommended models	Uses/outputs	Caveats	Examples of existing projects
Habitat mapping (gaps focus in particular on the mapping of functional sites for seabirds and associated habitats, or for getting information on the presence or absence of certain elasmobranch species)	Species distribution models (SDMs) End-to-End models when species interactions are important; Bayesian or stochastic coupling with SDMs.	Spatially explicit maps of habitat suitability and probability of presence, as well as spatial scenarios that explicitly incorporate uncertainty.	Species distribution models on their own do not capture causal ecological mechanisms. Coupling them with Bayesian or deterministic models helps account for uncertainty and ecological interactions.	Within the NESTORE project—a collaboration between France Énergies Marines, Ifremer, and CNRS—cumulative impacts of marine renewable energies are assessed using several models. A key component is an end-to-end modelling approach that couples species distribution modelling with Bayesian inference to produce spatially explicit representations of ecosystem services and human pressures.
Population trends (mainly in the context of the protection of Important Fishery Functional Areas, and fisheries management more generally)	Bayesian or stochastic population models (e.g., SPiCT, JABBA), optionally coupled with SDMs to introduce spatial structure.	Estimates of biomass or abundance, probability distributions, and forecasts of population trends relevant for management and certification purposes.	While Bayesian and stochastic approaches effectively represent uncertainty, they can be computationally demanding. Adding spatial coupling generally requires additional data.	Ecosim project: uses a temporal dynamic model that simulates the response of (eco)systems to pressures (fishing, climate). Ecopath project: the spatialized version of Ecosim.
Management scenarios, cumulative effects, and multi-use	Multi-agent models (MAMs); Multi-Criteria Analysis (MCA) End-to-End (E2E) models; complemented by Hierarchical Analytical Processes (HAP) for structuring decisions. Companion modelling can be used to support	Exploration of alternative management scenarios and socio-ecological outcomes, analysis of emergent behaviour driven by stakeholder actions, assessment of trade-offs, and identification of prioritized options.	ABMs and E2E models are often data- and computation-intensive. MCA and HAP approaches rely on subjective weighting; participatory processes are therefore essential to enhance transparency and legitimacy.	The SAFRAN project, led by CIRED, analyzes the impact of anthropogenic activities (particularly shoreline development) on ecosystem services. LIFE Adapto+ project, led by Conservatoire du Littoral and including Cerema, uses MCA to compare and prioritize

	stakeholder co-construction.			<p>different coastal management options to adapt the coasts to climate change impacts.</p> <p>The ComMod (Companion Modelling) project integrates multi-agent modelling with role-playing approaches to simulate the functioning of socio-ecological systems and to collectively explore the impacts of alternative management options.</p>
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2.3. Implication of the case study's results for MSP

The results of this work can be used to:

- **Provide an operational correspondence table** between MSP needs identified in MSP-related documents or literature and families of models that are suited to address these needs.
- **Support planners and decision-makers** in selecting modelling approaches that are appropriate for the specific knowledge gaps identified in maritime and coastal planning documents, thanks to the correspondence table.
- **Enhance transparency and anticipation in decision-making**, by clarifying the types of outputs each modelling approach can deliver and by explicitly highlighting their limitations, to allow for a more informed interpretation of model results in planning processes.
- **Promote the use of hybrid and combined modelling approaches** (for example, coupling SDMs with Bayesian or deterministic models, or combining ABMs with SDMs) where these can improve realism and better account for uncertainty.
- **Encourage participatory approaches**, including companion modelling or Hierarchical analytical processes, to strengthen legitimacy, integrate local and operational knowledge, and arbitrate trade-offs.
- **Contribute to capacity building and knowledge transfer** by recommending training materials (e.g., posters, summary sheets) that help planners and stakeholders understand model choices, assumptions, and results.

- **Foster stronger collaboration between institutional actors** (such as Cerema) and scientific partners (including Ifremer, CNRS, and others) for the joint development and application of models.
- **Highlight the central role of data**, by identifying needs for improved data collection, data management, and data accessibility to support calibration, validation, and robust model use.
- **Identify priorities for future work and research**, including methodological developments, improved propagation of uncertainty, and clearer documentation and guidelines for applying models in MSP.

2.4. Perspectives of the work

The work carried out as part of this case study focusing on the French Mediterranean sea basin is substantial but preliminary. It included the realisation of methodological Step 1 (identification of knowledge gaps), Step 2 (inventory and classification of modelling approaches suited to address the gaps) and Step 3 (correspondence between gaps and models). It therefore **provides a key basis for future case studies**, which could draw on these first outputs (see section 3.3 for more details). However, Step 4 on the development of scenario-based management approaches has not been developed due to time constraints. **This would be relevant to go further by implementing Step 4, in which**, based on the testing of models highlighting the potential impacts of different management choices, **stakeholders would be able to arbitrate together which management options would be best to implement.**

To sum up, perspectives for this work are:

- To test the modelling approaches that have been identified to address the existing needs/knowledge gaps;
- Then, focus on scenario-making, which are methods used to imagine, build and analyse multiple plausible futures based on key uncertainties, trends, and possible changes in social, economic, environmental or political condition;
- Involve stakeholders in building and configuring the scenario-making approaches. This can be achieved by building on the [ComMod](#) association, whose main goal is to design, analyse, develop, and promote scientific research and its applications in the field of Companion Modelling, including its main methods and tools, i.e., role-playing games, multi-agent modelling, and social simulation.

2.5. Limitations of modelling approaches in maritime spatial planning

While modelling is emerging as a key tool to develop and monitor MSP policies and associated plans, certain caveats should be highlighted. These include notably a lack of available data to feed models, and a lack of expertise of MSP decision-makers in using models. We therefore stress the importance of pursuing data collection and availability through adequate

platforms, and recommend improved training for planning stakeholders to optimize the use of modelling tools in sustainable maritime and coastal management.

3. Transferability and upscaling

3.1. Transferability

The action, tested at the scale of the French Mediterranean sea basin, could easily be replicated in other sea basins in France and in other countries, provided that MSP-related plans are in place.

Indeed, this approach can be applied to any MSP-related plan. The underlying principle remains the same: identify knowledge gaps in a given MSP-related plan, and determine which models can best address those gaps. To support this process, the correspondence table between gaps and models developed in this case study can be used as a practical tool, thanks to the classification of both needs and models according to a relevant typology (see sub-section 2.2). Of course, the models presented here correspond to the specific existing needs of the case study; hence, the list of models is not exhaustive, and other models not presented here may be more appropriate for addressing the needs in different regions or countries.

The approach can be applied either (i) to a finalised MSP plan, as part of a plan update, or (ii) during the development phase of an MSP plan, based on the analysis of existing coastal and marine policies of the area.

3.2. Affordability

The action can be replicated to other contexts, provided that certain conditions are met, particularly in terms of capacity building, knowledge, and technical expertise.

First, the identification of knowledge gaps in plans (methodological Step 1) can sometimes be difficult, as knowledge gaps are not always explicitly mentioned or fully articulated. It is therefore **necessary to have a good understanding of the ecological, socioeconomic, and institutional characteristics of the region** in order to correctly interpret the content of the plan in terms of knowledge gaps and translate them into actual needs.

Second, the effective implementation of Steps 2 and 3 requires specific technical skills. Once a specific model type has been identified to address a given need, there is rarely a “ready-made” model that can be applied directly; **models are generally context-specific and must be adapted or parameterized to a new context**, which requires significant technical modelling skills.

One way to access and strengthen these modelling capabilities is to collaborate with research laboratories that can develop, calibrate and adapt models to national or regional MSP needs. This would also help strengthen the capacity building in MSP regarding modelling approaches.

3.3. Upscaling

3.3.1. Implementation at a larger scale

The approach can be extended to a broader scale, i.e., at the Mediterranean level. This upscaling would require review of the key MSP-related documents in all Mediterranean countries in order to identify common types of knowledge gaps and related needs at the basin scale; as at national or sub-national scales, the next steps would be to determine which models are best suited to addressing the needs. Such an exercise would involve analysing a substantial amount of information from MSP-related documents that may be at different stages of development and implementation, which calls for a coordinated and structured analytical framework.

3.3.2. Endorsement by a regional organisation

Several types of European and Mediterranean organizations and tools/platforms could realistically support the upscaling of the action, both technically and institutionally. These include notably:

- Regional sea and Mediterranean-specific organisations, such as:
 - UNEP/MAP (Mediterranean Action Plan), which constitutes the regional governance framework under the Barcelona Convention, with a strong mandate on ecosystem-based management and MSP-related processes;
 - Plan Bleu, which has expertise in Mediterranean sustainability scenarios, data analysis, and policy support, and could support the analysis of knowledge gaps at Mediterranean scale;
- European MSP and marine knowledge platforms, such as:
 - EMODnet, to enhance marine data harmonisation and accessibility; EMODnet could notably support the precise identification of data and knowledge gaps;
 - European MSP Platform/MSP Assistance Mechanism, with experience in comparative analysis of MSP practices across countries;
- Research structures in the countries;
- Funding mechanisms (e.g., Horizon Europe, Interreg EURO MED) for the funding of the coordination of modelling and scenario analysis and for their practical experience in transnational cooperation and testing of pilot initiatives at the Mediterranean scale.

3.3.3. The action would benefit from transboundary cooperation

Adopting a cross-border approach to MSP is considered essential in maritime areas, since marine species and many maritime activities and pressures transcend jurisdictional boundaries (Jay et al., 2016; Flannery et al., 2015). In our particular case, the upscaling of the action would benefit from transboundary cooperation, for several reasons:

- First, transboundary cooperation would help address knowledge gaps in a more effective way: many knowledge gaps (such as cumulative impacts, ecological connectivity and functioning, or climate impacts) are likely to be shared by the different Mediterranean countries, since marine ecosystems, ecological processes, and human uses are inherently transboundary (Flannery et al., 2015; Katsanevakis et al., 2011). Therefore, these gaps cannot be addressed at the national scale only; addressing them in a long-term and effective way requires transboundary cooperation (Pınarbaşı et al., 2020; Gilliland & Laffoley, 2008);

- In line with the previous point, transboundary cooperation would support the application of models at scales that are ecologically and functionally relevant: many models (e.g., ecosystem-based models, connectivity models, cumulative impact models) are more robust and meaningful at basin scale due to the inherent transboundary aspect of ecosystems' functioning and pressures to resources and ecosystems.
- Transboundary cooperation would also improve consistency across countries' MSP processes (e.g., through harmonization of approaches, identification of common needs, limitation of fragmented or conflicting decisions), in a context where MSP plans across Mediterranean countries are at different stages of development and implementation, and use different methodologies.
- Finally, cross-border cooperation would improve the MSP efficiency more generally, by allowing countries with more advanced MSP processes or modelling capacity to support others, thereby reducing duplication of effort and strengthening regional capacities.

4. Conclusion

This action proposes to support effective MSP processes through the use of modelling approaches, which can be powerful tools to represent the state and dynamics of socio-ecosystems, anticipate potential impacts and trends, and provide management options that ensure the sustainable and equitable use of the sea. The methodology developed here consists in identifying existing knowledge gaps and related needs mentioned in MSP-related documents, then identifying and running models that can adequately address these needs.

The action has been partially implemented for the French Mediterranean sea basin, where environmental and socio-economic stakes are particularly important and complex, due to an exceptional concentration of uses (Fabbri et al., 2025) and the presence of rich marine ecosystems submitted to various anthropogenic pressures and rapid warming of the waters (Coll et al., 2010).

Results of the case study first show a broad range of knowledge gaps identified in key MSP-related documents (including the DSF Mediterranean), notably in relation to habitat mapping, fisheries population trends, cumulative effects, multi-use interactions and management scenarios. An inventory and classification of modelling approaches was developed, leading to a correspondence table linking specific types of knowledge gaps to the models most suited to address them. The analysis outlines key strengths and potential limitations of the models, supported by concrete examples from projects or initiatives where these models have been applied in practice. Limitations to the use of models are also highlighted, reminding that the effectiveness of models depends on a strong understanding of both the issue that is intended to be addressed and of the models that could be used. This, in turns, relies on the availability of relevant data to feed the models -and therefore the need to pursue data collection and usability-, and the ability of MSP stakeholders and practitioners to correctly apply the models and interpret their outputs.

The work carried out as part of this case study lays the foundations for the development of management scenarios in the French Mediterranean. The application of the modelling



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approaches identified in this analysis to meet current regional needs, combined with the participatory development of scenarios involving a wide range of MSP decision-makers and practitioners (including sectoral users such as fishermen), would explore plausible future pathways and provide support for informed decision-making.

The proposed approach has strong potential for transferability and upscaling across other geographic areas, provided that appropriate MSP-related plans are in place. Where MSP plans are not yet fully developed, the analysis may instead draw on existing coastal and marine policy instruments. Scaling up such action would be significantly strengthened through transboundary cooperation, which can facilitate the identification of shared knowledge gaps and enable their more effective resolution through modelling conducted at ecologically and functionally relevant scales. In addition, transboundary cooperation can enhance coherence among national MSP processes by promoting the harmonization of methodologies, the identification of common priorities, and the reduction of fragmented or conflicting decisions. Finally, regional capacities would be reinforced through the pooling of resources, expertise, and data.



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National action #3: Promoting synergies and the multi-use concept in Thermaikos Gulf (ATh)

1. Context and needs

1.1. The multi-use concept serving EGD goals through MSP

Spatial planning and management measures are being implemented in a specific area to balance human activities with ecological protection and sustainability. Typically, the marine space and its resources have been perceived as inexhaustible, however, this perception can no longer be sustained with the constant intensification of human activities in the marine space (Jouffray et al., 2020). The competition for space and resources that the maritime uses have created, are driving the need to regard the sea as a finite and valuable resource that must be planned and managed holistically (Ehler and Douvère, 2009; Reimer et al., 2023).

Marine Spatial Planning (MSP) that was defined by the Directive 2014/89/EU as “a process by which the relevant Member State’s authorities analyse and organise human activities in marine areas to achieve ecological, economic and social objectives” can achieve this balance. With MSP, the traditional sector-by-sector management gives its place to an integrated, ecosystem-based approach that recognises that spatial overlaps among uses can lead to conflicts or synergies, enabling the promotion of multi-use practices to support marine sustainability (Papageorgiou, 2022). The multi-use concept at sea refers to the spatial proximity, overlap or economic exchange between at least two sectors operating in the same marine area (Przedzimirska et al., 2021). While this co-existence can intensify competition and conflict, it can also create reciprocal benefits. In this context, MSP can play a key role in fostering sustainable combinations between sectors (Schupp et al., 2019; Stancheva et al., 2022) and enabling strategic decision making that could transform a potential conflict into synergy (Bocci et al., 2019; Stancheva et al., 2022). For example, systematically planned combinations such as offshore wind energy with aquaculture or tourism with cultural heritage protection can enhance resource and space efficiency while conserving ecological functions (Przedzimirska et al., 2021; Stancheva et al., 2022).

Adopting the multi-use concept – and promoting non-exclusive (mixed) economic zones – is of paramount importance, especially in spatially constrained environments such as marine bays and gulfs, where competition among users is even higher due to the lack in space and resources. These semi-closed marine spaces often combine high ecological value with intense human pressures where traditional segregated zoning approaches are insufficient and multi-use promotion through MSP can optimise spatial allocation and minimize conflict. MSP-wise, the multi-use concept may be implemented when “generic use” zones are established, as well as when “priority zones” of non-exclusive use are introduced.

The multi-use concept, when implemented through MSP, can function as a governance tool that aligns environmental protection, economic development, and social equity in the marine space, thus directly supporting the European Green Deal goals. By enabling co-location of marine uses, it accelerates the transition to a low-carbon maritime economy, by reducing

spatial pressures and infrastructure duplication, actively supporting **climate change mitigation**. It strengthens **climate change adaptation** by enhancing the resilience of marine activities to environmental changes allowing the flexible use of marine space to evolving climate impacts. The reduction of spatial fragmentation of marine uses allows conservation objectives to be embedded within economic activities ensuring that environmental thresholds are respected and **biodiversity protection and ecosystem restoration** is adequately supported. The multi-use concept further supports the **blue circular economy** by encouraging shared infrastructure and cross-sectoral value chains, which reduce resource use, operational costs, and encourages innovation across maritime sectors. At the same time, it contributes to **zero pollution** by supporting coordinated environmental standards in marine uses thus minimizing emissions and marine litter. Finally, the multi-use concept, especially when implemented through MSP, contributes to a **fair and just transition** not only by creating new job opportunities through the economic growth of traditional and new maritime sectors but also by ensuring stakeholder participation in spatial decision-making processes.

1.2. Objective of the action and key MSP facts on the case study

This national action aims at exploring methods on how to promote synergies and non-exclusive (mixed) economic zones in constrained marine areas (like gulfs and bays) and by association how to promote the multi-use concept, which favours EGD goals through MSP. A case study approach was chosen to test these methods. Thermaikos Gulf was chosen for being one of the busiest gulfs in Greece and the largest gulf in the Aegean Sea. Apart from being a constrained marine area (semi-closed bay), Thermaikos is currently regulated under a sector-by-sector planning approach and by national legislation (designating fishing zones etc). Therefore, the need to move from this sectorial approach to a more place based one, while also promoting synergies and zones where users can co-exist, is of great importance.

MSP-wise, Thermaikos is part of the geographical scope of the Maritime Spatial Framework for the North Aegean Sea (ØXE1). This Framework/Plan has been already drafted and is in the process of adoption. In total, four (4) Maritime Spatial Frameworks/Plans will be adopted, equal to the number of marine spatial units designed in Greece. In the draft Maritime Spatial Framework for ØXE1, Thermaikos Gulf is addressed as one of the four development zones of the North Aegean Sea. Within this Development Zone, the planning guidelines have a strategic nature, and – more or less – compile the existing sectoral planning regulations. However, given the conditions and the peculiarities of this area (semi-closed gulf) – it is of paramount importance to move from this sectorial MSP approach to a place-based one, whilst reaching more detailed planning regulations.

2. Implementation

2.1. Methodology

Having as main objective to explore methods on how to advance synergies and non-exclusive economic zones in a semi-closed marine area (Thermaikos Gulf), the steps taken were the following:

■ **STEP 1: Analysis of the existing situation with emphasis on key marine sectors**

This step included analysis and mapping of the key marine sectors in the area, placing emphasis in mapping the environmental conditions and the sensitive marine areas (under protection status or not). This step also included the analysis of land-sea interactions, having in mind that positive interactions may further promote synergies in a marine area.

■ **STEP 2: Local stakeholders mapping**

This step included the creation of an extensive/exhausting listing of all marine stakeholders of the study area, emphasising stakeholders of the key marine sectors. The categories of stakeholders that were included in this list were:

- Marine professionals (with emphasis on the MEDIGREEN sectors)
- Local managing authorities for protected areas
- Central Government authorities located in Thessaloniki and Thermaikos Gulf
- Regional Authority (i.e., Central Macedonia Region)
- Coastal Municipalities surrounding the Gulf
- Marine sector and MSP experts
- NGOs

■ **STEP 3: Consultation with key local stakeholders**

A workshop was organised – simulating a participatory process – to promote interaction and knowledge exchange among the key stakeholders in the area. The participation of local stakeholders was necessary, to promote collaboration and ensure feasible and viable spatial planning solutions.

A combination of interactive tools was used to facilitate engagement and collect stakeholder input:

- **Round tables** (experts and professionals of the sectors were invited to present and then engage in discussions with the participants)

The round tables were held in sessions for each one of the MEDIGREEN sectors.



Photographs 1, 2: Roundtables and discussion

- **Slido** (supporting real-time interaction during the workshop through live polling and question collection, enabling participants to share opinions and priorities)

The Slido questions were in sync with each session for the MEDIGREEN sectors, eventually focusing on the synergies of the activities in Thermaikos Gulf:

Environment

- Select which of the following uses/activities you consider compatible with Marine Protected Areas.
- Rank the following land-based factors based on the degree of impact on Marine Protected Areas.
- Rank the most significant threats facing Greece's marine ecosystems, classifying them from 1 (highest threat) to 7 (lowest threat), based on their degree of impact.

Fisheries

- Select which of the following uses/activities you consider compatible with fisheries.

Aquaculture

- Select which of the following uses/activities you consider compatible with aquaculture.

Offshore Renewable Energy

- Select which of the following uses/activities you consider compatible with ORE.

Thermaikos Gulf

- Do you consider the absence of a Marine Spatial Plan—for regulating existing and/or future uses—in Thermaikos Gulf to be a shortcoming?
- To what extent do you agree with the decision to designate Thermaikos Gulf as a “generic use” marine area?
- To what extent do you agree with the promotion of synergies in the marine environment (i.e., through the creation of non-exclusive zones)?
- Which activities do you consider appropriate to create synergies in Thermaikos Gulf, with the aim of optimizing the area's economic potential?
- Rank the following sectors based on the priority you believe they should have in Thermaikos Gulf

- **MSP serious game** (a gamified simulation exercise to allow stakeholders to explore spatial conflicts, synergies, and potential multi-use solutions within a real-life case scenario)

A map of Thermaikos Gulf was created (size 1.4x2 m) that was used as the base for a board game. The map depicted the current uses and other elements of the Gulf. The participants were divided in groups corresponding to sectors of the area. Supporting their sectors, they were called to propose how they could further develop and/or create synergies with the rest of the marine activities in the Gulf. This was further explained and explored on the actual board game with the placement of pawns (each one depicting marine and coastal elements and uses). The results of the game were used for the proposal for development of potential non-exclusive economic zones in Thermaikos Gulf.



Photographs 4, 5: MSP serious game

Ultimate objective of the workshop was the mapping of local stakeholders' perception:

- regarding the synergies and conflicts that may rise in the study area
- towards the co-use of space and the promotion of non-exclusive economic zones

■ **STEP 4: Drafting of planning and policy recommendations**

The drafting of planning and policy recommendations was an important part of this methodology, for the operationalisation of the outcomes of the analysis and the consultation, and the development of useful planning solutions for the study area and for the MSP process in Greece, under the multi-use approach.

2.2. Analysis of the study area and of the sectoral needs

Thermaikos Gulf, the largest gulf of the Aegean Sea, is located in the north of Greece and is part of the Central Macedonia Region. The metropolis of Thessaloniki - the second largest city of the country, is found in its northern part (Figures 14 and 15). Thessaloniki is a fast-growing international transport and trade hub as its port is a main maritime gateway that connects the Aegean Sea with Europe. From a geomorphological point of view, Thermaikos Gulf forms a distinct coastal system characterised by its shallow bathymetry (maximum depth of 45 meters) and considerable sediment accumulation from the major rivers (Axios, Aliakmonas, Pinios, Loudias and Gallikos) that drain in the gulf. The area is a very sensitive ecosystem that is composed of a system of river estuaries, salt marshes and lagoons. Thermaikos Gulf also hosts a variety of economic activities including fisheries, aquaculture, tourism, port and maritime commerce. In this action, the analysis placed emphasis on the four MEDIGREEN sectors (and not only) and on key interactions created with the land, given that positive interactions may conditionally advance synergies in the area.

2.2.1. Key marine sectors and elements in Thermaikos Gulf

Fisheries

Historically, Thermaikos Gulf has been considered as one of the most important fishing grounds, with a strong presence of professional and recreational fishing activities. The Gulf

also hosts the country's largest fishing fleet. But despite its economic role fish stocks have seen a decline attributed to overfishing and benthic disturbance from bottom trawling (Dimitriadis et al., 2014). Due to the ecological sensitivity of the Gulf a set of spatio-temporal measures has been set by a number of legislative documents (Royal Decree 917/1966 - National Gazette No A-248/27.9.1966 and Presidential Decree 68/2009 - National Gazette No 90/A/12.6.2009).

Aquaculture

Likewise, aquaculture has a very strong presence in the area with around 90% of the total mussel farming production units of the country located in the western part of the Gulf (Famellos, Krestenitis and Georgiadis, 2006; Kalaitzidou et al., 2021). Additionally, 80% of the national production of mussels is produced in Thermaikos Gulf (Thermaikos Gulf Management Authority, 2022). Mussel farming in the area has a long tradition and a high socio-economic importance, providing employment for local residents that can be threatened by environmental challenges such as harmful algal blooms and contaminant accumulation (Kalaitzidou et al., 2021). The framework for the spatial organization of the aquaculture sector operates at the national level and was adopted in 2011 (currently under revision). Under this framework, an Aquaculture Exclusive Zone has been established in the southern Thermaikos Gulf in Pieria Prefecture (Presidential Decree 21-03-19, National Gazette No. 206/Δ/09.05.2019), where aquaculture activities are particularly intensive.

Offshore Renewable Energy (ORE) and energy installations

Currently there is no ORE development in the area. Moreover, the draft National Offshore Wind Parks Development Program (pending consultation), has not included ORE zones in the study area.

In the past, there was interest by energy companies to explore locations within the Gulf for pilot projects regarding floating solar panels, but that motion did not move further. Currently, local discussion has shifted to a project related to the development of a floating LNG platform.

Ecological value and the role of protected areas

The ecological importance of the Gulf is formally recognised by an extensive network of protected areas (Table 7). The most prominent one is the Axios-Loudias-Aliakmonas Delta which was designated as a National Park in 2009 (Joint Ministerial Decision 12966 - National Gazette No 220/ΑΑΠ/14-5-2009). It integrates terrestrial, coastal and marine ecosystems that include the rivers' estuaries, salt marshes and a lagoon. The National Park is included in the Natura 2000 network, with three designated sites, and protected by the Ramsar Convention. In total, within the gulf area there are seven (7) marine and partially marine Natura 2000 sites (Table 7), that incorporate coastal waters, transitional zones, lagoons, and wetlands that support key marine and coastal habitats such as *Posidonia oceanica* seagrass meadows (Androulidakis et al., 2024). Wildlife Refuges (with strict restrictions) are also included in the Natura 2000 network and are regulated by Law 3937/2011. Finally, the Gulf is also home to protected *Posidonia Oceanica* meadows (Joint Ministerial Decision - Gazette No 105/Δ/12-03-2019). Collectively, these protected areas reflect a conservation strategy designed to safeguard the Gulf's coastal and marine biodiversity from the multiple human pressures present at the area.

Table 7. Marine and partially marine Natura 2000 sites in Thermaikos Gulf. Source: Processed by authors

GR1220002	SCI	Delta Axiou – Loudia – Aliakmona – Evriteri periochi – Axioupoli	41,496 ha
GR1220010	SPA	Delta Axiou – Loudia Aliakmona – Alyki Kitrous	28,855 ha
GR1250004	SCI	Alyki Kitrous – Evriteri periochi	1,457 ha
GR1220012	SCI	Limnothalassa Epanomis kai thalassia paraktia zoni	808 ha
GR1270010	SCI	Akrotirio Pyrgos – Ormos Kypsas – Malamo	1,179 ha
GR1270008	SCI	Paliouri – Akrotiri kai Thalassia Zoni	16,161 ha
GR1220005	SCI/SPA	Limnothalassa Angelochoriou	373 ha

Key coastal uses and infrastructure interacting with the Gulf

Coastal tourism is a strong economic driver that is linked to the Gulf's coastal infrastructure and cultural attractions. Except for the area along the National Park, the coastline of Thermaikos Gulf is characterised by intense coastal development, very relevant to tourism facilities.

Port activities and maritime commerce add an important dimension to the Gulf's economy. Especially the international port of Thessaloniki, that is also recorded among the land-based activities (along with the shipyard industry) adding pressure to the marine ecosystem of Thermaikos Gulf.

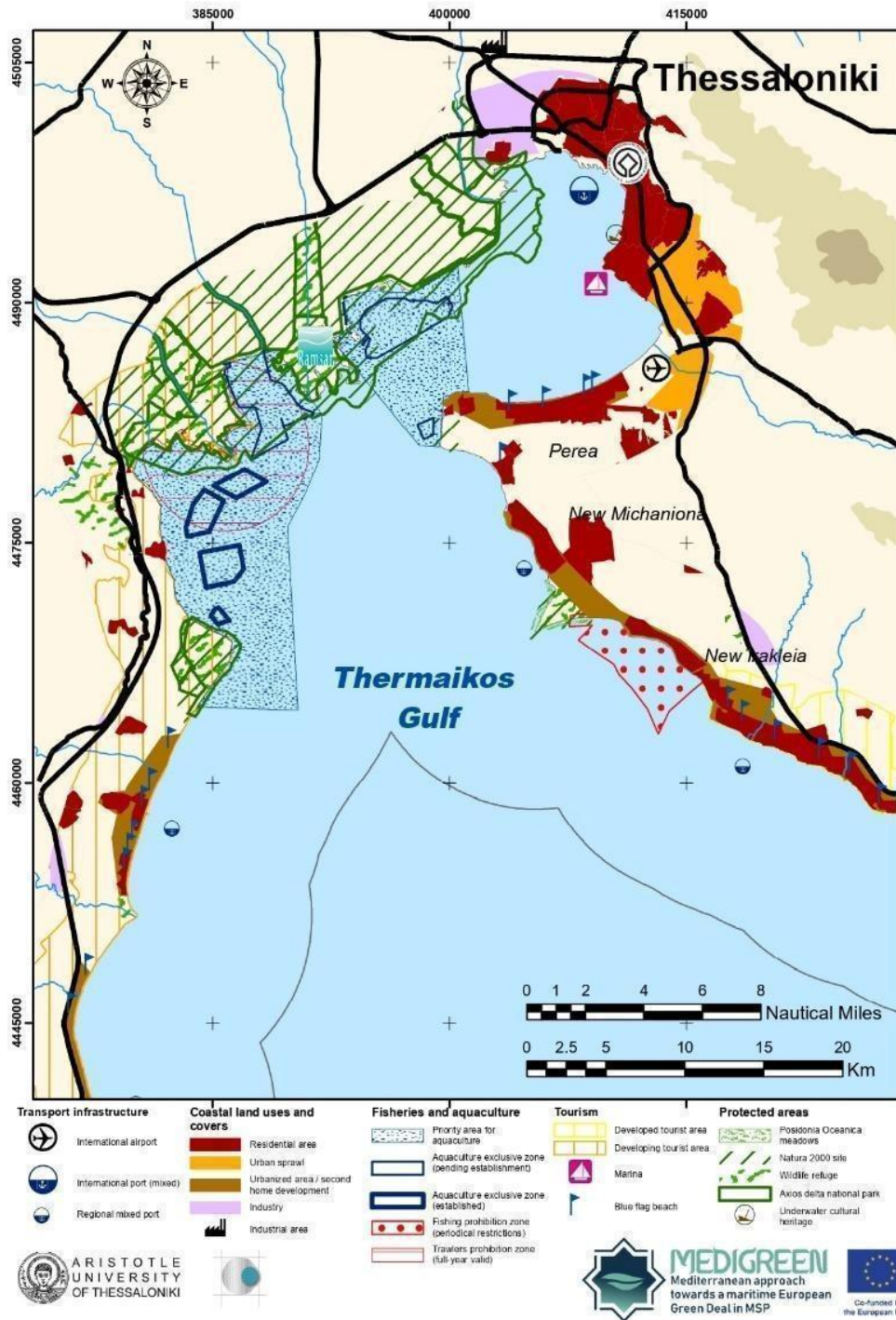


Figure 14: Marine and land-based activities in Thermaikos Gulf

2.2.2. Synthesis of the analysis

The analysis performed illustrated the complex economic and environmental profile of Thermaikos Gulf, where this plethora of human activities must be balanced and spatially organised. It also highlighted the conflicts of existing activities not only with each other but also with the marine environment. These conflicts are presented below as “user-environment conflicts” and “user-user conflicts”.

User-environment conflicts

- Inner Thermaikos Gulf has a much more sensitive ecosystem than the outer parts of the gulf in terms of carrying capacity.
- Fisheries can cause an impact on fish stocks, seabed condition, and produce marine litter (e.g., abandoned nets, ropes, barrels, etc.). There is a need for regulation of the intensity and the fishing methods within protected areas (e.g., Axios National Park and areas with underwater archaeological sites).
- Aquaculture causes pressures to the marine protected areas and the marine environment of the gulf in general (e.g., lost barrels, nets).
- Land uses such as coastal industry, agriculture, excessive tourism development and wastewater from coastal settlements put direct pressure on the marine environment.

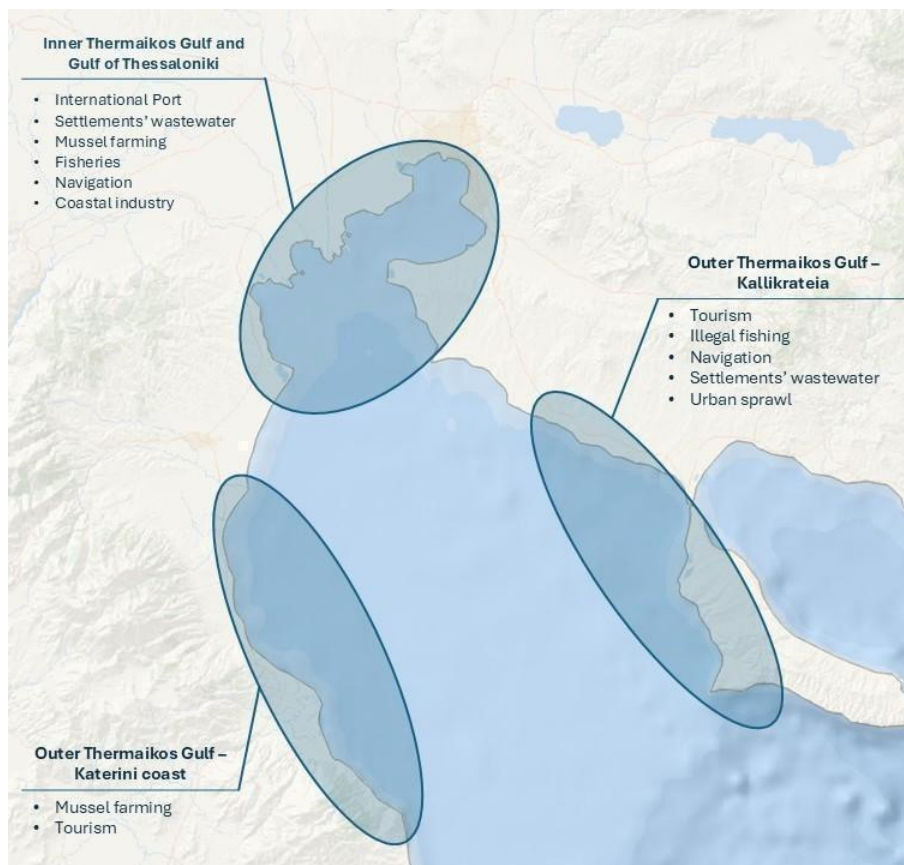


Figure 15: Areas of pressure by human activities in the ecosystem of Thermaikos Gulf.

User-user conflicts

- Fisheries face the following challenges:
 - Conflicts within the sector, in particular coastal commercial fishing has been impacted by intense recreational fishing and the illegal distribution of catches in the market.
 - A high number of existing uses combined with emerging new activities and investments compete for spatial allocation in the Gulf, creating a high risk of shrinking fishing grounds.

- Land-based uses and activities, including coastal overdevelopment, insufficient wastewater treatment, coastal industry, agriculture, and mining.
- Aquaculture development may create spatial interactions or other competition with fisheries.
- Tourism faces multiple pressures from:
 - Land uses such as coastal industry and commercial use of ports
 - Fisheries
 - Aquaculture
- Underwater antiquities are threatened by most of the marine activities.

The conflicts presented show the strong competition and interdependence of the coastal and marine uses not only between them, but also with the environment. Therefore, adopting the multi-use approach in the case of Thermaikos Gulf, is of paramount importance, as a suitable management that respects the scarcity of space.

2.3. Findings of the workshop

The workshop took place in the beginning of March 2026 and was attended by 45 local stakeholders, with representatives coming from almost all the categories that were invited. The results of the workshop are presented below.

2.3.1. Findings for the potential development of non-exclusive economic zones in Thermaikos Gulf

Following the discussions and the interaction among the local stakeholders and especially the professionals in the area, the following synergies were identified in the area:

User – environment synergies

- Marine Protected Areas sustain fish stocks and water quality, benefiting fisheries and aquaculture
- Recreational activities (e.g., sailing, diving and other non-mechanical water sports) are deemed synergistic with marine areas under protection status
- Fisheries – although acknowledged as a stressor of the marine ecosystem – they can conditionally serve protection goals of the marine ecosystem (participation in litter collection campaigns etc).

User-user synergies

- Fisheries have potential for synergies with:
 - aquaculture and more specifically mussel farming
 - alternative tourism such as fish and gastronomic tourism
- Synergies within the aquaculture sector, with the promotion of multi-culture, especially through the promotion of microalgae cultivation with mussel and fish farming.
- Tourism has potential for synergies with:
 - Aquaculture – alternative forms of tourism (such as fish, gastronomic and diving tourism)
 - Culture – protection and promotion of culture sites through coordinated tourism activities.

- Sports and recreational activities – promotion of water and diving to complement tourist and recreational activities.

It should be highlighted that ORE was perceived as a sector of a very low priority in the study area, given its expected impact on the ecosystem of Thermaikos Gulf.

Potential areas for the allocation of non-exclusive economic zones

Following the outcomes of the MSP serious game, three main marine areas were identified in Thermaikos Gulf, where high competition for space among users exists:

- Marine Area A: Inner Thermaikos Gulf and Gulf of Thessaloniki
- Marine Area B: Outer Thermaikos – Katerini coast
- Marine Area C: Outer Thermaikos – Kallikrateia

Marine Area A - Inner Thermaikos Gulf and Gulf of Thessaloniki

This area concentrates the highest number of human activities and simultaneously includes a very sensitive ecosystem under protection. The activities that are developed in the area include commercial coastal fisheries, aquaculture (mussel farming), cultural sites, recreational activities (e.g., sailing), navigation and port facilities. Given the diversity of uses, the zone is not suitable for generic use. Its saturated carrying capacity and high ecological value means that there is very limited, if any, space for new activities.

Suitable to serve as Restricted Zone: In this Area, new uses and the expansion of the existing ones should be avoided, as this will lead to the excess of the carrying capacity of this very sensitive area. Soft marine tourism activities should be endorsed.

Non-exclusive zones could prioritize the aquaculture sector (e.g., mussel cultures sanitation could be developed to support existing facilities and enhance productivity without further increase to spatial pressure).

Marine Area B - Outer Thermaikos Gulf- west coast (Katerini)

In this zone coastal commercial fisheries, culture sites, tourism and recreational activities take place. Given the moderate concentration of uses and the ecological characteristics of the area, there is potential for it to host non-exclusive economic zones, supporting the co-existence of activities.

Suitable to host Priority Use Zones: The sectors prioritised should be aquaculture, fisheries and coastal and marine tourism

Marine Area C - Outer Thermaikos Gulf - east coast (Kallikrateia)

This zone presents a strong cultural heritage profile with numerous sites found in its coasts. Tourism is also very prominent alongside fisheries and other recreational activities (e.g., water sports). The diversity of uses and the opportunities that are presented by the synergies between its existing uses make this area potentially to function as a mixed economic zone.

Suitable to host Priority Use Zones: The sectors prioritised should be fisheries and coastal and marine tourism.

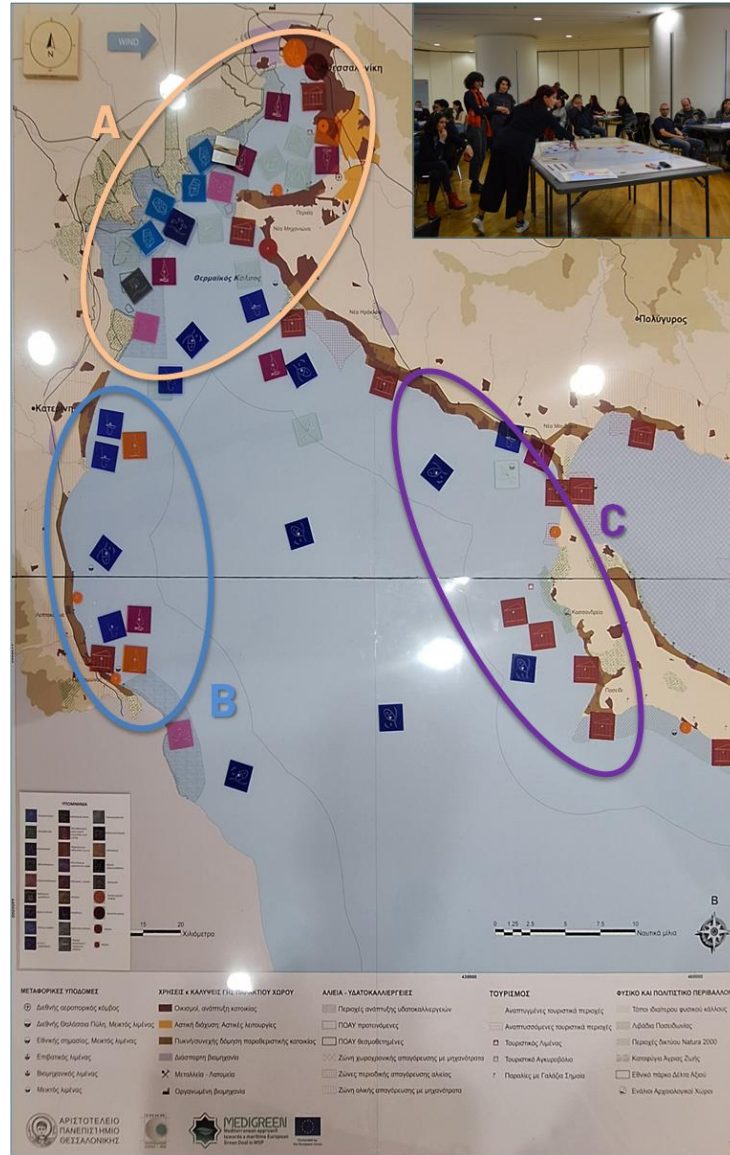


Figure 16: Sectors claiming their territory in Thermaikos Gulf during the MSP serious game of the Workshop

Findings about the stakeholders' participation

The stakeholders that participated in the Workshop (and derived from almost all categories invited), actively participated throughout the workshop, engaging in discussions, contributing ideas and sharing knowledge. In some cases, controversies were observed and tension in the discussion, related to the threats and pressure that marine activities (e.g., fisheries) put on the marine ecosystem of Thermaikos Gulf and its biodiversity.

Some sectors were overrepresented (e.g., trawlers, ecologists), taking more time from other sectors in the conversation. This was expected. However, it is an aspect that should be more carefully considered in the future.

The participants showed particular interest and enthusiasm about the MSP serious game where they collaboratively explored potential synergies and conflicts in the study area. Their high level of involvement reflects their strong interest in the planning of the marine space of Thermaikos Gulf. Their commitment is also underscored by the repeated participation in past workshops regarding MSP in the area demonstrating a strong commitment for an informed and participatory planning.

2.3.2. The contribution of rising synergies in Thermaikos Gulf to the EGD goals

The results presented above regarding the synergies between the sectors and activities developed in Thermaikos Gulf show their potential to contribute to the goals of the European Green Deal (EGD). The rising synergies and the combination of uses identified through this action can support all EGD Goals including Fair and Just transition. The promotion of cooperation between sectors such as fisheries, aquaculture, environmental protection and tourism can enhance ecosystem resilience and support local economic development. Table 8 presents the connections between the identified synergies and the EGD goals.

Table 8. EGD goals and how they are promoted through the rising synergies (and combinations of uses) in the case of Thermaikos Gulf.

Synergy	Climate Change Mitigation	Climate Change Adaptation	Sustainable Food Production	Biodiversity and Ecosystem Protection and Restoration	Blue Circular Economy	Zero Pollution	Fair and Just Transition
Marine protected areas supporting fisheries and aquaculture	✓	✓	✓	✓	✓	✓	✓
	The marine protected network system found in Thermaikos Gulf contributes to the maintenance of healthy habitats, fish stocks and water quality which benefit the fisheries and aquaculture that are developed in those areas under strict regulations. In this way they support biodiversity and ecosystem protection and restoration as well as sustainable seafood production . The regulations that need to be followed inside these areas by fisheries and aquaculture strengthen the capacity of the marine ecosystems to respond to climate-related pressures, supporting climate change adaptation . Climate change mitigation is also supported by the preservation of carbon-sequestration habitats. The long-term productivity of these marine sectors can be promoted by the sustainable use of the ecosystem, supporting the blue circular economy and zero pollution objectives are followed by the reduction of environmental degradation. All the above ensure that the coastal fishing communities can continue to depend on the marine resources of the area long-term in line with the goals of fair and just transition .						
Valuable ecosystems and low-impact recreational activities (sailing, diving, water sports)		✓		✓	✓	✓	✓
	Synergies between environmental protected areas or valuable ecosystems with low-impact recreational activities (such as sailing, diving and water sports) can be fostered with proper management. Activities like these can promote environmentally responsible tourism and increase awareness of marine conservation. In this way, they support biodiversity and ecosystem protection and restoration and contribute to climate change adaptation by promoting the protection of climate-sensitive marine and coastal biodiversity. Simultaneously, low-impact recreational activities encourage responsible use of marine resources in line with the blue circular economy and help maintain water quality contributing to zero pollution . Lastly, this combination of sectors can create job opportunities for the coastal communities of the Gulf, thus supporting fair and just transition .						
Collaboration between fisheries and environmental stakeholders		✓	✓	✓	✓	✓	✓
	A future synergy and sufficient communication between the environmental stakeholders and the ones of fisheries and aquaculture will have a positive effect for both. This dialogue will support the adoption of better fishing practices leading to a sustainable food production , that promote biodiversity and ecosystem protection and restoration and better improve the capacity of fisheries to adapt to changing environmental conditions thus supporting climate change adaptation . Coordinated efforts by both sides can support the efficient and sustainable use of marine						

	<p>resources, promoting the blue circular economy, and help reduce environmental pressures and marine litter in line with zero pollution objectives. Finally, fair and just transition is also supported as fishing communities of Thermaikos Gulf, through this synergy, can ensure that environmental protection measures take into consideration their socio-economic needs.</p>
<p>Fisheries and aquaculture (e.g., fishing with nets and mussel farming)</p>	<p style="text-align: center;">✓ ✓ ✓ ✓ ✓ ✓</p> <p>Interactions between the sectors of fisheries and aquaculture are not very common but can have positive reciprocal effects. It can help reduce pressure on wild fish stocks and allow for a more efficient use of marine space and resources directly supporting biodiversity and ecosystem protection and restoration and sustainable food production. The diversification in the production systems can help increase resilience in climate change related effects, contributing to climate change adaptation, while joint practices improve operational efficiency and reduce environmental footprints, supporting the blue circular economy. Additionally, these interactions reduce waste, helping achieve zero pollution, and strengthen coastal fishing and aquaculture communities of the Gulf by maintaining stable economic opportunities, thus promoting fair and just transition.</p>
<p>Fisheries and aquaculture combined with tourism (fish tourism, gastronomic tourism, diving tourism)</p>	<p style="text-align: center;">✓ ✓ ✓ ✓ ✓ ✓</p> <p>A synergy between tourism and the sectors of fisheries and aquaculture can create additional income for the professionals while raising awareness of marine ecosystems. Alternative tourism linked to fisheries and aquaculture such as tasting experiences or diving visits promote awareness of marine ecosystems supporting biodiversity and ecosystem protection and restoration, while also encouraging environmentally responsible practices within the sectors, in line with zero pollution objectives. Additionally, they support sustainable seafood value chains that help promote a sustainable food production and the blue circular economy. The diversification in traditional activities supports the increase of resilience in both environmental and economic changes directly supporting climate change adaptation and fair and just transition.</p>
<p>Integrated aquaculture multi-culture (microalgae cultivation combined with mussel or fish farming)</p>	<p style="text-align: center;">✓ ✓ ✓ ✓ ✓ ✓</p> <p>The promotion of multi-culture systems, combining microalgae cultivation with mussel or fish farming, can enhance the efficiency and sustainability of the aquaculture sector in Thermaikos Gulf. The inclusion of microalgae provides additional nutritional and ecological benefits, thus promoting biodiversity and ecosystem protection and restoration. Diversified aquaculture systems are more resilient to environmental changes, supporting climate change adaptation, and improving resource efficiency, supporting the blue circular economy. Mussel and microalgae cultivation naturally filter and improve water quality, supporting zero pollution. This leads to better aquaculture practices and promotes a more sustainable seafood production. Lastly, this new combination fosters fair and just transition as it creates new job opportunities and ensures long-term viability of the sector.</p>
<p>Tourism, cultural heritage, recreation and port infrastructure synergies</p>	<p style="text-align: center;">✓ ✓ ✓ ✓ ✓</p> <p>The coordinated development of tourism, cultural heritage promotion, recreational activities (e.g., water sports) and port infrastructure (e.g., marinas) can enhance the sustainable use of the coasts of Thermaikos Gulf. The integration of cultural and natural heritage in tourism can contribute to the promotion of archaeological sites and coastal ecosystems, supporting biodiversity and ecosystem protection and restoration. Port infrastructure when strategically planned within tourism goals can also improve the resilience of coastal development to climate-related pressures, contributing to climate change adaptation. At the same time, multi-use coastal infrastructure (e.g., ports with passenger and industrial use) can support diverse economic activities and a more efficient use of space in line with the blue circular economy. Finally, new employment opportunities will strengthen the local economy of the Gulf, supporting a fair and just transition.</p>

2.4. Recommendations

Based on the outcomes of the workshop and the analysis of the case study area of Thermaikos Gulf the following recommendations have been developed to support the sustainable growth of the sectors under the multi-use concept, having also in mind to serve the EGD goals.

Recommendations for MSP and the Greek legislative framework

- The MSP legislative framework of Greece should provide the possibility for the development of zones promoting the multi-use concept. These zones could be Priority Zones of non-exclusive use.
- Given that the establishment of Priority Use Zones and the decision about which other sectors should be permitted with these zones should be considered on a case-by-case basis, consultation should also involve local stakeholders.

Recommendations for the Maritime Spatial Framework of the North Aegean Sea

- Although the Maritime Spatial Framework for the North Aegean Sea is a regional scale plan, it could also focus and become more detailed in the case of Thermaikos Gulf.
- This more detailed plan (which may serve as a pilot local scale maritime spatial plan), should definitely explore the option of allocating Priority Zones of non-exclusive use, in areas where competition is high.
- Consultation of MSP Frameworks should become more inclusive and involve regional stakeholders as well, with emphasis on the local governments (1st and 2nd tier administration) as well as the decentralised offices, based in the area.

Recommendations for the promotion of Priority Zones of non-exclusive use in Thermaikos

- Further research – and also workshops with local stakeholders – are needed to explore specific matches across sectors, and also possible locations for the establishment of Priority Zones.
- Given that, so far, the only Priority Zones in the area are AZAs (Allocated Zones for Aquaculture), research should start from identifying synergies with other sectors.
- The adoption of Priority Zones calls for consultation involving local professionals and societies (apart from local governments as well as the decentralised offices, based in the area).

As the Maritime Spatial Framework for the North Aegean Sea is currently finalised, the above recommendations could be taken into consideration by the competent authority of MSP in Greece, the Ministry of Environment and Energy. They can also be taken into consideration by the local and regional authorities.

3. Transferability and upscaling

3.1. Transferability

This action focused on the use of the multi-use concept in the Thermaikos Gulf, which is a spatially limited marine area, very typical not only in Greece but also in other countries. By choosing a Gulf, this action also approached MSP from a local perspective, where planning guidelines need to be more detailed, and zoning – and the use of non-exclusive economic zones – can be fully adopted. Both these aspects (planning in limited marine areas, implementing local scale MSP and non-exclusive economic zones) have not been sufficiently explored across the Mediterranean and beyond.

The methodology used for this action can easily be transferred to cases where local-scale MSP needs to be performed (like in Gulf settings). And although this action focused mainly on the potential synergies between the four (4) MEDIGREEN sectors, it can easily be adapted to include a wider range of maritime uses, as appropriate. Finally, the promotion of non-exclusive economic zones is just as important in the case of limited marine areas as in other maritime contexts, which makes this action even easier to transfer.

Overall, this national action demonstrates the value of the multi-use concept in MSP and highlights the importance of participatory approaches. The Thermaikos Gulf case study further demonstrates the importance of evidence-based, locally tailored planning, continuous stakeholder involvement. This action can provide valuable support for future decision-making by competent MSP authorities.

3.2. Affordability

The promotion of mixed (or non-exclusive) economic zones is a task that is mainly achieved at the local level. At this level, the need for detailed data (geospatial or other data) and for meaningful interaction between stakeholders is more acute. Therefore, this action can easily be replicated in other contexts, provided that stakeholders are engaged and data are available.

Mapping stakeholders is crucial to achieve inclusiveness and appropriate representation. Greater participation in local consultation processes will enable meaningful discussions and more effective solutions, minimize feelings of exclusion and maximize potential synergies and cooperation between sectors and uses.

Data availability is also very important, as analysis and mapping of the study area and of the existing sectors is necessary to better understand economic trends and interactions between marine users, as well as between users and the environment. Obtaining data can involve technical and financial costs, unless open access platforms are available.

Once non-exclusive economic zones are established, monitoring is necessary to track and ensure the sustainability of the sectors involved.

3.3. Upscaling

The implementation of the multi-use approach in planning and the establishment of non-exclusive economic zones is an issue that is addressed at the local level. Although, so far,

documents and policies related to MSP refer to the regional and national level, they also include references to the multi-use concept, as they recognize that marine space and resources are not inexhaustible and, therefore, must be planned and managed holistically.

To ensure upscaling of the multi-use concept and of non-exclusive economic zones, future research should focus on identifying synergies and interactions between marine sectors, also taking into account technological developments related to the sectors in search. Uses and synergies developed within non-exclusive economic zones, may also benefit from transboundary cooperation, especially if land-based sectors (e.g., tourism) from different countries are involved.

The use of non-exclusive economic zones should not only regard place-based MSP initiatives, but also sectoral plans and planning.

Ensuring upscaling also involves knowledge transfer (particularly with regard to synergies between sectors). To this end, national, regional, and local authorities and stakeholders should be informed.

4. Conclusion

The importance of the multi-use concept is increasingly recognized, as it offers valuable solutions in the sea, which is no longer considered an inexhaustible space and resource. The multi-use concept is even more important in the case of bays and gulfs, i.e., in marine areas with limited space, where usually users compete for the same space and/or resources.

MSP-wise, the multi-use concept can be applied within:

- Generic use zones
- Priority Zones of non-exclusive use
- Marine Protected Areas

The selection of a spatial planning model involving the use of non-exclusive economic zones in the sea, is a decision that depends on each country's planning policy and planning tradition. Once this has been decided, the creation of non-exclusive economic zones is a decision that must be considered on a case-by-case basis and addressed through MSP initiatives at the local level. So far, local level MSP initiatives – under a place-based approach – have not yet been explored in most Mediterranean countries.

Selecting areas and sectors that are compatible and can coexist (creating synergies) at sea, requires advanced and inclusive consultation processes. Mapping and involving relevant stakeholders in these processes is not easy. Conflicts often arise and negotiations can be difficult. This means that, if necessary, additional efforts must be made to facilitate communication and encourage cross-sectoral cooperation, even at the cross-border level.

The establishment of non-exclusive economic zones is not a task that concerns only place-based MSP initiatives, but also sectoral planning. Therefore, future research should focus on identifying synergies between key maritime sectors, not only with other maritime uses (user – user synergies), but also with land-based activities and with the environment (user – environment synergies).



The integration of the multi-use concept into MSP initiatives is highly important also because it can contribute to the EGD (European Green Deal) goals, by providing solutions for climate change mitigation, climate change adaptation, restoring biodiversity and ecosystems, and a just and fair transition. The use of the multi-use concept may also facilitate blue circular economy solutions and zero pollution initiatives.

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National action #4: Exploring the potentials for non-exclusive (mixed) offshore renewable energy zones in Greece (ATh)

1. Context and needs

1.1. The need for non-exclusive economic zones in MSP

Marine activities have always coexisted in marine areas and have largely developed independently, within exclusive zones. The use of when planning in the marine space (MSP) has been promoted for many years and has been adopted so far by numerous maritime plans worldwide (e.g., Germany, Australia, etc.). In the past, marine zoning was used by single sectors (e.g., fishing zones), as a result of the sectoral planning approach that prevailed in the sea (Papageorgiou et al., 2020). Recently, however, and especially following the adoption of the Marine Spatial Planning Directive (EU MSPD 2014/89), this approach has been challenged by a more place-based approach, which requires consideration of the development and coexistence of all marine activities within marine ecosystems with varying carrying capacities and biodiversity characteristics.

With this in mind, a basic typology that can be implemented in MSP, concern the following types of zones (Beriatos et al., 2015):

- **General-Use Zones:** zones open to the development of marine uses and productive activities in general.
- **Priority-Use Zones (of exclusive or non-exclusive use):** zones in which specific uses or activities are promoted. These zones may be exclusive (i.e., allowing the development of a single use) or non-exclusive (i.e., giving priority to a specific use while permitting a selection of others that are compatible and can coexist in the same area).
- **Restricted-Use Zones:** zones in which strict restrictions apply regarding the development of uses and activities. These zones are typically designated in marine protected areas.
- **Prohibited Zones:** which are excluded from the planning process due to their nature (e.g., military zones, nature reserves) or due to the occurrence of dangerous natural phenomena (rip currents, strong currents, etc.)

Among the aforementioned types of zones, this national initiative focuses on Priority Use Zones and, more specifically, on those of a non-exclusive use, i.e., those that give priority to a marine use or activity without excluding other uses (which must be selected with a view to promoting synergies within the zone). This type of zoning is essential today, as the intensity of maritime activities is higher than in the past and new sectors have been introduced in maritime areas, such as offshore renewable energy, which compete for the same space with other uses (traditional or not).

By their very nature, Priority Use Zones are fully aligned with the multi-use concept, which refers to how two or more activities could share resources in the same marine area or in close proximity (Calado et al., 2019; Depellegrin et al., 2019, citing Zaucha et al., 2016) and, where possible, to develop synergies between these sectors so that both activities benefit (European Commission 2021, Depellegrin et al., 2019).

Priority Zones of a non-exclusive use, can play a significant role in advancing the objectives of the European Green Deal (EGD), such as climate change mitigation, climate change adaptation, restoring biodiversity and ecosystems, as well as a just and fair transition. Applying the multi-use concept can also facilitate solutions for the marine sector's circular economy and zero-pollution initiatives.

Considering the above, the overall objective of this national action is to explore the conditions and challenges of integrating the multi-use concept into Greece's Maritime Spatial Planning (MSP) process. More specifically, to explore the conditions and challenges of introducing ORE Zones (which is a priority sector in Greece) that are not designed to be exclusive, but to co-exist with other uses. With this in mind, a necessary step of this national action is to examine the compatibility of ORE with other sectors, namely those sectors that can coexist with ORE and also to explore potential synergies that may arise with ORE, specifically activities that could benefit from the development of ORE in the case of Greece.

1.2. The marine renewable energy sector in Greece and its integration in MSP

The renewable energy sector (RES) has been a priority in Greece for many years, as the country seeks to meet its energy needs and achieve its strategic goals, which consist of reducing greenhouse gas emissions by 58% by 2030, by 80% by 2040, and achieving climate neutrality (98%) by 2050. Another national goal is to install a total capacity of 12 GW from solar and wind farms, including offshore wind farms (OWFs), by 2030. These national targets are fully aligned with the EU's goals, which are to achieve net-zero greenhouse gas emissions by 2050 and an interim target of reducing emissions by at least 55% by 2030.

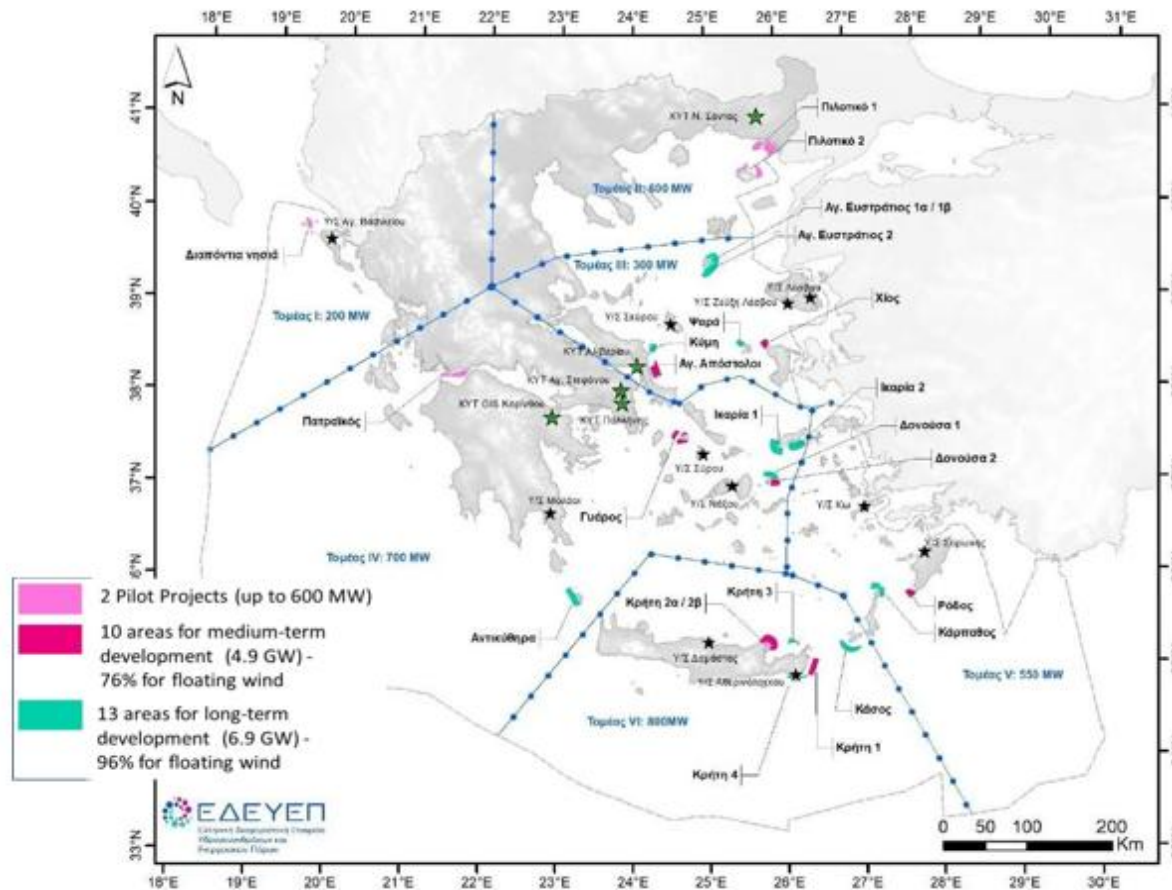
Greece was among the first European countries to adopt a Special Spatial Framework for the Utilization of Renewable Energy Sources, aiming at meeting the goals set by the EU in the 2000s. The geographical scope of this Framework (adopted in 2008) covers the entire country (national level). As a framework of a national range, it provides strategic guidelines, as well as more detailed ones regarding the distances that must be maintained from certain infrastructure, habitats, etc., and guidelines for the protection of the Greek landscape. Given the timing of its adoption (at the outset of the discussion on MSP within the EU), the Framework placed emphasis on the land areas of the country. However, the Framework also made specific reference to the maritime parts of the Greek territory and the uninhabited islands, recognizing the need for additional spatial criteria for allocating ORE, due to carrying capacity and geopolitical challenges.

Nowadays, the RES Special Spatial Framework (adopted in 2008) is undergoing a review. Currently, there is an increasing focus on the country's marine parts, with the aim of meeting European and national targets for renewable energy production. So far, the forms of renewable energy that the country prioritizes in its marine areas (and are regulated through national legislation) are wind and solar energy, due to their high potential in the Greek seas.

Table 9. Key national legislation on ORE

ORE	Law	Title	Status
OWF (Floating and fixed)	4964/2022	“Provisions for the implementation of environmental licensing, setting a framework for the development of Offshore Wind Farms, addressing the energy crisis, environmental protection and other provisions”.	A Plan was elaborated in 2023 selecting 23+2 marine zones for the siting of OWF (see Map 1)
PV (floating)	4951/2022	“Modernization of the licensing process for Renewable Energy Sources - Phase II, Licensing of electricity production and storage, framework for the development of pilot floating offshore photovoltaic stations, and specific provisions for energy and environmental protection”	No plan for floating PVs has been elaborated. No areas have been selected. No installations so far

Between Photovoltaics (PVs) and Offshore Wind Farms (OWFs), Greece places more emphasis on the latter (i.e., OWFs). This becomes evident because, although the revision of the national RES Spatial Framework is underway, a side/parallel Plan/Framework was drafted in 2023 (which is currently under consultation), with the aim of accelerating the siting of OWFs. The selection of the areas (in terms of size and location) was guided by the goal of achieving the installed capacity of OWFs alone, which amounts to 1.9 GW by 2030 and 11.8 GW by 2050, according to the National Energy and Climate Plan.



Map 1: The proposed potential areas for OWF siting in the Greek marine space. Source: National Offshore Wind Farm Development Framework (2023).

The OWF National Framework (“National Offshore Wind Farm Development Plan/Framework”) selected 23 (+2) zones as potential areas for the siting of OWF, four (4) of which are appropriate for fixed-foundation OWFs while the rest are appropriate for floating OWFs. Both the Framework and its SEA are pending new consultation and then adoption. This OWF Plan/Framework makes no reference to the multi-use concept, therefore it is presumed that the zones intended for exclusive use. Furthermore, it remains unclear whether, apart from the areas selected and shown in Map 1, it will be possible to allocate ORE and OWFs in other parts of the Greek marine space, within the framework of the Maritime Spatial Plans of Greece that will be eventually adopted.

Considering the above, and stepping on the multi-use concept, the main objective of this national action is to explore the feasibility and conditions under which ORE installations could be developed in Greece in non-exclusive zones. By extension, this national action also seeks to identify key marine sectors that are compatible with and create synergies with ORE, so that their coexistence in a non-exclusive zone can be successful. Finally, it should be noted that the promotion of ORE and of non-exclusive ORE zones is also critical in advancing the EGD goals, namely, climate change mitigation, climate change adaptation, the restoration of biodiversity and ecosystems, as well as a just and fair transition.

2. Implementation

2.1. Methodological steps

The methodological approach of this national action included:

STEP 1: A review of national legislation on RES and renewable energy, as well as relevant sectoral spatial plans and the ORE zoning used in Greece. This was necessary in order to understand the Greek RES and ORE model and to identify potential ambiguities within it.

STEP 2: A literature review to identify studies and practices regarding potential synergies and conflicts between RES activities and other marine activities. This review also allowed for the identification of European Green Deal (EGD) objectives that can be achieved through RES and ORE and the use of non-exclusive ORE zones.

STEP 3: A survey using a questionnaire targeting the general public in Greece, aimed at clarifying social concerns and the level of acceptance of ORE projects in the country. This step was designed to play a decisive role in identifying actions to minimize concerns and increase social acceptance.

STEP 4: Meeting with the competent Greek authority (held on February 24, 2026) to discuss options for integrating the multi-use concept in MSP and of introducing non-exclusive ORE zones.

STEP 5: Interviews with professionals in the marine sector, particularly those active in the MEDIGREEN sectors. This step took place during the workshop organized on March 5, 2026. The interviews aimed at exploring the views of professionals as regards the feasibility of their coexistence with ORE.

2.2. Spatial conditions of the ORE technologies promoted in Greece

As mentioned earlier, Greece prioritizes OWFs and PVs as the potential technologies to be installed in the open sea.

Technology-wise, two types of OWFs are being promoted as suitable for installation in Greek waters. The first type is fixed OWFs, which are anchored to the seabed using foundations such as gravity, monopile, tripod, and jacket foundations. The second type is floating wind farms, which are mounted on floating support structures. The stability of the floating structures is achieved through buoyancy, and various types of mooring systems are used to stabilize them. Depending on the design of the floating support structure, they are categorized as “barge”, “semi-submersible”, “spar buoy” and “tension leg platform” type devices (HEREMA, 2023).

Fixed-foundation wind farms can be installed at depths of 0–60 meters (this is not feasible at greater depths), while floating wind farms can be installed at depths of up to 1,000 meters. However, depths of up to 500 meters are more preferable and feasible (HEREMA, 2023).

As for photovoltaics, only the development of pilot floating PVs are being promoted in Greece. The floating support structures are similar to those mentioned in relation to OWFs.

The construction of ORE projects, regardless of technology, also involve other marine activities that at that phase work synergistically and the most important ones are cable construction and dredging from the aspect of seabed preparation to host the OWF and PV foundations.

Regarding other requirements, both offshore energy projects, such as OWFs and floating PVs, require the development of supporting infrastructure for the generation and transmission of electricity to the network. This includes the construction of offshore electrical interconnection and transmission infrastructure. Such infrastructure includes inter-array cables, offshore substations, export cables, onshore substations, and potential energy storage facilities. Last, and regardless of the technology used, ORE constructions also require an onshore connection, through existing ports that facilitate storage and also serve personnel transfer.

2.3. Seeking compatibilities and synergies of ORE with other sectors and uses

Compatibility between marine activities refers to when two or more marine activities can take place in the same area or areas in proximity with or without conditions. Synergy means that not only those activities can take place in the same area or areas in proximity, but also that those activities work together and / or interact in a way that all users are benefited (MUSES, c.2026).

Historically, the first temps to explore compatibilities and conflicts between marine uses in general, date back in the 2000s, commencing with the work of Ehler and Douvere published by UNESCO (Ehler & Douvere, 2009) and even though the first offshore wind farm was constructed back in 1991 in Denmark, the larger OWF projects started being constructed after 2010 globally and in European level (TGS4C, c.2026). Since 2010, following licensing and construction of different projects, coexistence and compatibility possibilities between marine activities in general, and specifically between OWF and other marine activities, have

started being understood better through reporting and monitoring of the OWF operation. In 2021, the European Union published a guidance on “Best Practice Guidance in Multi-Use Issues and Licensing Procedures” (European Commission, 2021) and in 2018, a guidance on how specific conflicts between marine activities could potentially be addressed (European Commission, 2018). In the MSP Platform website, a matrix is available on coexistence and synergies, where applicable, between specific marine activities.

Many studies have been elaborated regarding MSP and pilot ORE projects (mostly OWFs and less on floating PVs) have been constructed in marine space, so there is more detailed knowledge on compatibility and synergies even though practically the knowledge is still limited. Also, different countries, according to their national legislation, implement various conditions and manage marine activities to be more compatible.

Compatibilities and Synergies with OWFs

Regarding compatibility and synergies of **OWFs with aquaculture**, they are considered feasible due to the potential sharing in infrastructure (Demmer et al, 2022). A recent study in Spain showed that there are significant economic and technical benefits between the two industries but they face legal and administrative constraints because competencies for the ORE sector belong to the central government while for aquaculture to the regional ones. The highest benefits are met during the construction period (common infrastructure, personnel transfer and operation of an aquaculture unit from RES) (Weiss et al., 2025). During the operation phase, aquaculture could benefit from operating in vicinity to OWF by using its energy supply - since aquaculture relies on diesel for operating and monitoring facilities so far. Also, piled OWF work as artificial reefs and support stock enhancement which supports the development of aquaculture in the area (Liu & Heo, 2026). Despite all the recorded synergies until today, in reality and during the operation period of ORE synergies present difficulties (Weiss et al., 2025, Liu & Heo, 2026). In general, though, the coexistence of ORE and aquaculture show great potential but the practices are limited and in pilot stage.

Although **OWF sector and oil and gas extraction** is not considered generally compatible, there are examples that show this can be conditionally achieved and present important synergies; however, safety distances should be in place. The example of Hywind Tampen in Norway, in which multiple windfarms have been in place to generate electricity and support the operation of five (5) oil platforms show that the two activities can coexist and synergies can be developed (personnel transfer, maintenance, etc)(Equinor, c.2026).

Conditional Compatibilities with OWFs

Synergies between **fisheries and OWFs** seem more complicated while coexistence is being implemented in practice in different countries. The dangers that OWF poses on fisheries is related to stock and survivability of species due to impacts such as underwater noise and vibration or electromagnetic fields. However, there are cases in northern Europe (eg UK, the Netherlands) that fixed-foundation OWF and fisheries coexist and work at the same area under careful planning and management while coexistence and synergies between floating OWFs and fisheries is limited (Wawrzynkowski et al, 2026). In the cases of northern Europe, even though coexistence is permitted, the activities lack synergies (Bonsu et al, 2024).

OWFs and maritime transport are not considered compatible and they cannot be combined, due to safety reasons. Depending on the intensity of use of the navigation routes, ORE

installations and zones must keep safety distances, to avoid collisions and accidents (European MS Platform, c.2026b). However, maritime transportation to facilitate the OWF construction and operation is necessary and specific navigation safety rules are usually in place for that purpose.

Moreover, **OWFs and marine tourism** seem incompatible, new opportunities and forms of tourism are developing for recreational and educational purposes. Despite the impacts of ORE on landscape and obstruction of sailing routes, an allowance of recreational sailing boats within the area of OWF, in safe distances though, could offer opportunities to this type of leisure activity. In line with the multi-use concept, countries that will allow sailing boats within ORE zones should design safe sailing routes in proximity early in the process or during the design of non-exclusive ORE zones (European MS Platform, c.2026c). Synergistic operation though seems unachievable due to the nature of both those activities.

Cable installations can be combined with ORE, provided that construction rules are in force. Because the ORE technologies (windfarms or solar panels) need to be connected with the shore, cables are components of ORE development, those two sectors could work synergistically on occasions during construction and operation phase of the project (personnel transfer, same ships for maintenance works etc). However, regarding pipelines or cables that are not components of the ORE development, this seems difficult due to safety and security concerns (European MS Platform, c.2026a).

Dredging is part of ORE projects development since this activity prepares the seabed for the foundations (fixed-foundation WF) and opens cable canals. However, **aggregates dredging** is incompatible close to ORE because it can affect the stability and integrity of OWF infrastructure. It could be conditionally compatible through careful planning, management and coordination (Marine Management Organisation, 2026a).

The synergies between ORE and cables or dredging apply to all technologies promoted for offshore energy production, namely for OWFs and PVs due to the offshore nature.

Incompatibilities with OWFs

Even though **OWFs** and **Marine Protected Areas (MPAs)** seem not to be able to coexist because of the ecological risks, recent research highlights potential synergies related to biodiversity protection and ecosystem restoration mostly on fixed foundation technologies. These for example can occur since the foundations in long-term could potentially benefit the biodiversity locally (e.g., acting as artificial reefs) (Demmer et al, 2022). Despite these synergies, the relationship remains controversial due to noise, vibration, chemical pollution, EMFs, bird collision or marine mammal entanglements risks and sediment disruption (Lloret, 2025).

OWFs are also incompatible with **cultural heritage** protected areas and areas used by the **military**.

Knowledge on floating PVs

Specifically for floating PVs, literature around synergies of floating PVs with other activities is still limited however, it seems that they could work synergistically with other forms of RE on a multi-use platform such as hydropower and OWF (Amer et al, 2023; Rusu 2023). The synergies in operation and construction are similar to those applying to OWF.

In conclusion, according to current knowledge and pilot projects that have been constructed so far (e.g., ORE and aquaculture projects in the North Sea or Spain, boat tourism in OWF areas, seaweed and mussels' cultivation on piled OWF, Hywind Tampen), ORE could work synergistically with aquaculture and oil and gas extraction. Activities such as fisheries, waste disposal, water abstraction, tourism and recreation, navigation, and dredging could coexist conditionally with specific forms of ORE; however, safety and spatial conditions are necessary. Regarding marine protected areas, ORE presents generally more important impacts than opportunities so they are considered incompatible. Cultural protected areas and military areas are also incompatible with ORE.

2.4. Social concerns and acceptability of ORE in Greece

As with any development in space, ORE may also raise social concerns regarding environmental impacts or the displacement of other activities. In the case of Greece, the ORE sector is still in its infancy, meaning that no projects have yet been implemented (not even at the pilot level), leading, consequently, to greater scepticism.

The questionnaire survey conducted as part of this national action aimed to investigate the intensity and characteristics of this scepticism toward ORE installations in Greece. This survey was deemed necessary to contribute to the drafting of policy recommendations for increasing social acceptance of ORE in Greece, taking into account the medium and long-term plans established at the national level for OWFs (Map 1) and floating PVs.

The survey was conducted in February and early March 2026. The questionnaire was available online, and various channels were used to reach the broader public in Greece (social media, associations related to the maritime sectors, personal contacts, etc.). More than 300 responses were collected, the vast majority of which (>75%) were residents in coastal and/or insular areas of Greece, living there on a permanent or a periodic basis.

Regarding the level of information, only 13% considered themselves sufficiently informed on ORE installations and topics, while an additional 23% considered themselves somewhat informed. This means that the vast majority of the selected opinions (64%) came from participants who reported a low level of knowledge and awareness regarding ORE.

Survey Results

The vast majority of the general public in Greece strongly agrees that the use of RES will contribute significantly to:

- the national economy
- the creation of new jobs
- to energy stability and energy self-sufficiency
- to mitigating the effects of climate change
- to the sustainable management of resources

In contrast, the general public was not particularly convinced of the contribution of renewable energy to the local economy and development.

With regard to the coexistence of ORE with other maritime sectors, the general public in Greece perceives very limited synergies and compatibility with other sectors (Figure 17),

particularly with fisheries, marine tourism, and shipping. Overall, they believe that ORE hinders other maritime activities and cannot coexist with them. Furthermore, they consider that ORE is a sector that strongly affects in a negative way the maritime tradition and cultural identity of coastal and island regions.

Respondents agreed (partly to strongly) that ORE disrupts fishing grounds (56% of all responses). Next, they agreed (partly too strongly) that renewable energy hinders marine tourism (53% of all responses regarded boat tourism and 54% of all responses regarded other forms of marine tourism, such as diving) and finally, that ORE hinders navigation (51% of all responses).

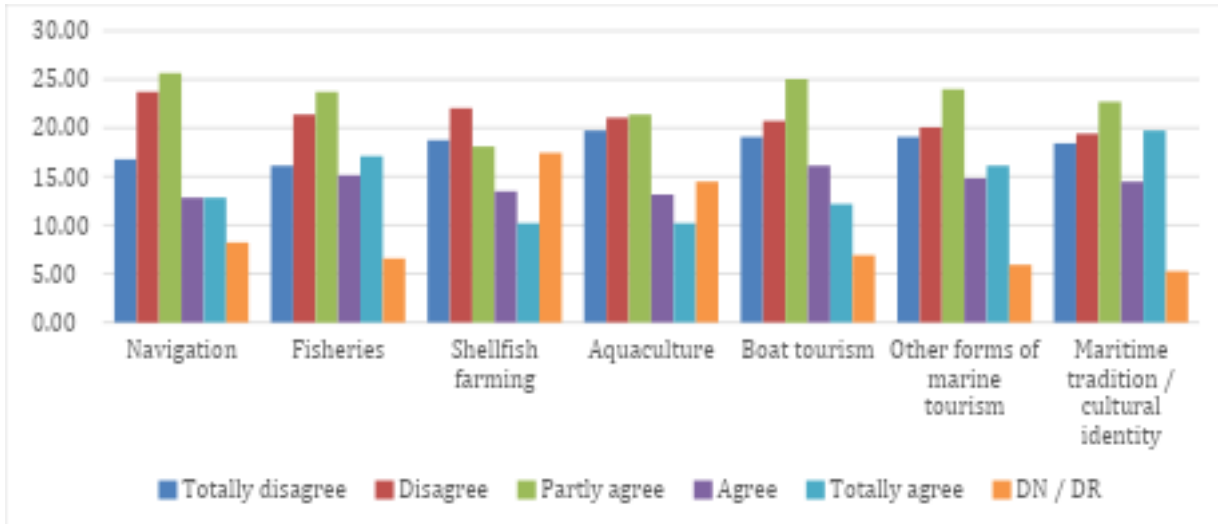


Figure 17: Perception of the general public on compatibilities with ORE

Although the survey used different questions per ORE type, the overall perception is that the environmental impacts do not differ between fixed-foundation and floating OWF or even in the case of floating PVs (Figures 18, 19 and 20).

In particular, in both types of windfarms (fixed and floating), respondents considered landscape as the factor highly impacted (for both fixed and floating 50% of the total responses voted that the landscape will be highly impacted or very highly impacted), followed by birdlife (for fixed technologies 44% voted that the birdlife will be highly impacted or very highly impacted and for floating this percentage was 43%) and then fish fauna (for fixed technologies 41% voted that the fish fauna will be highly impacted or very highly impacted and for floating this percentage was 43%) (Figures 18 and 19).

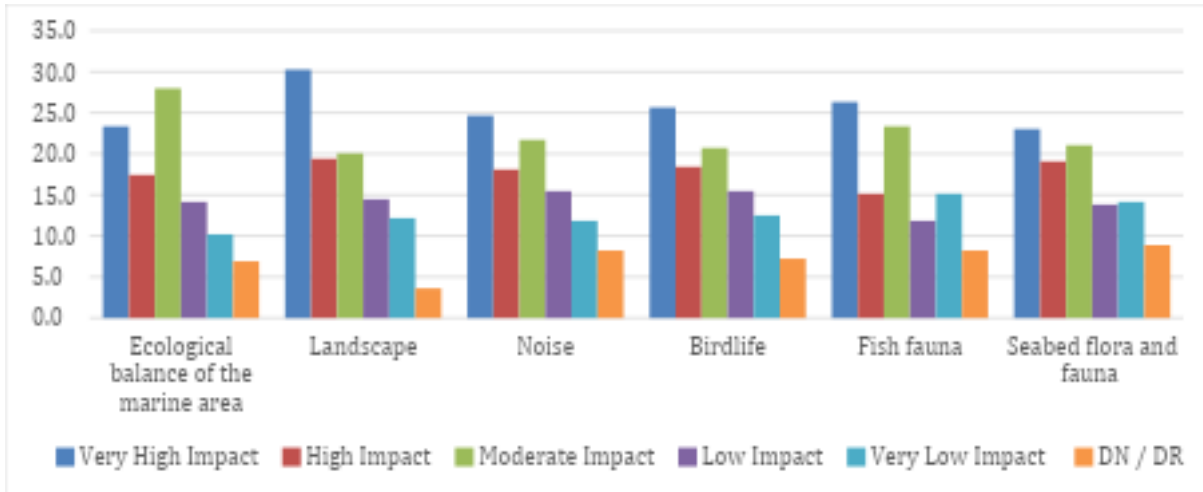


Figure 18: Impact of fixed-foundation WF on environmental factors

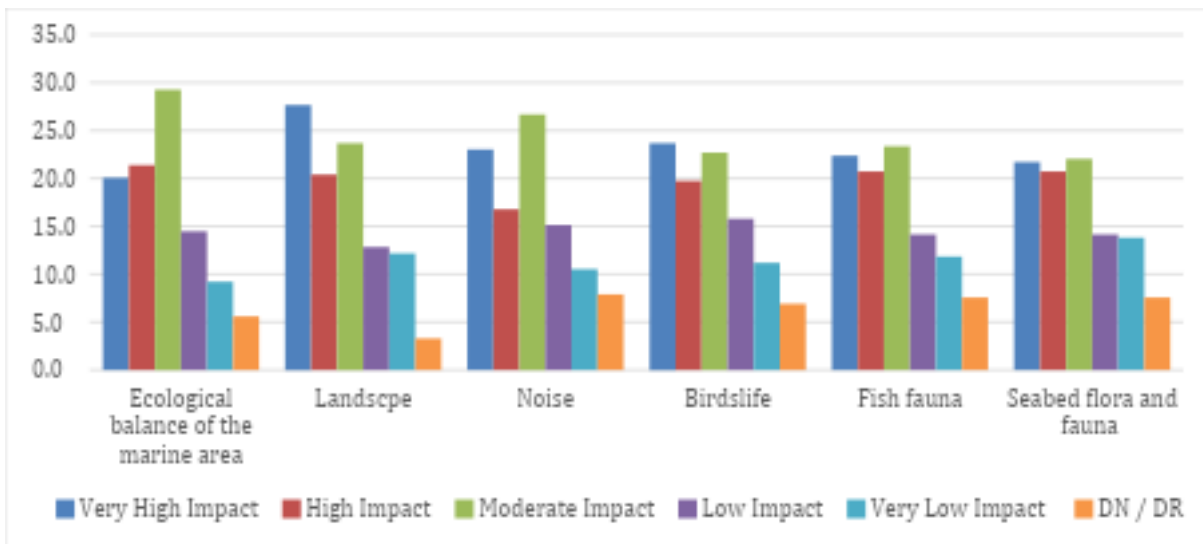


Figure 19: Impacts of floating WF on environmental factors

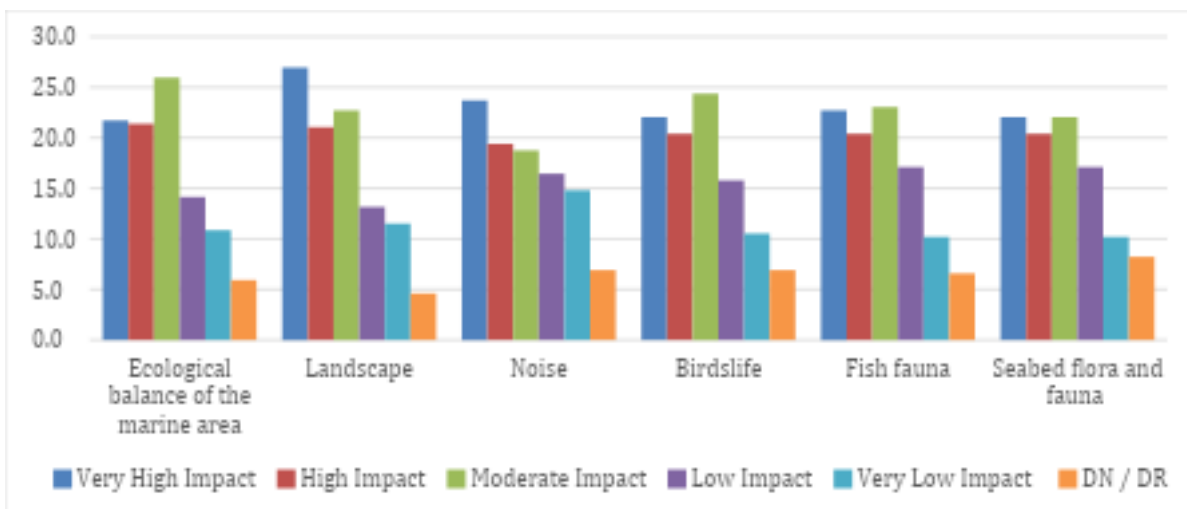


Figure 20: Impacts of floating PVs on environmental factors

The answers were almost the same in the case of floating solar panels (Figure 21). Specifically, respondents considered landscape as the factor highly impacted (48% responded that landscape will be highly impacted or very highly impacted), followed by noise (43%) and fish fauna (43%).

To confirm the results obtained by this survey, a last but very important question was included in the Questionnaire. It regarded the tolerance of the general public towards new developments of ORE installations in the area they live or work. The results revealed a very low tolerance, i.e.: **31% of respondents declared a strong disagreement, 20% declared normal disagreement**, and 18% said they somewhat agree. Only 14% responded that they agree, 10% that they strongly agree while 7% of the respondents did not want to express their opinion. (DN/DR).

Overall, some key conclusions coming from the survey (that need to be considered in the drafting of policy recommendations towards raising social acceptance of ORE) are the following:

- The **social acceptance** of the ORE sector is still very low in Greece, also because no installations exist and therefore there is no experience. This is also confirmed by the **low tolerance recorded towards ORE** projects in the areas where they live.
- Respondents believe that **ORE has a lot to offer**, but they are very concerned about the **environmental impacts** and the **benefits of local communities**.
- Their main environmental concerns relate to the **landscape** (visual and acoustic), which is reasonable because it is easily noticeable. They believe there is an impact on **birdlife** due to the movement of blades (wind turbines) and fish fauna.
- Knowledge and information on the ORE (and RES) sector is missing.

2.5. Main recommendations

Taking all of the above into account, the following are some recommendations for incorporating the multi-use concept of into Maritime Spatial Planning (MSP) and for promoting non-exclusive offshore renewable energy zones in Greece:

Recommendations towards integrating the multi-use concept in MSP

Greek legislation on MSP (Law 4546 of 2018, as amended by Law 4759 of 2020) clearly defines the need to incorporate the multi-use concept and the shift from a sectoral planning approach to a more place-based one. However, no reference is made to any tool or specific method that would ensure this shifting and integration.

In the planning tradition of Greece, the multi-use concept has been long been facilitated with the use of Priority-Use Zones, and especially through a particular Zone called “Areas for the Organized Development of Productive Activities” (under the acronym POAPD/ΠΟΑΠΔ). This type of Zone – which applies to both rural and the peri-urban areas – was originally introduced in 1986 (by Law 1650, art. 18) and was amended in 1999 by Law 2742. According to the definition provided in art. 10 of Law 2742, POAPD (ΠΟΑΠΔ) may be designated land or maritime areas suitable for the development of economic activities in the primary, secondary, or tertiary sectors, as well as activities or initiatives that function as pilot projects. POAPDs (ΠΟΑΠΔs) may be distinguished in: a. Single-use or exclusive-use zones (which allow for the allocation/development of a single sector or activity), and b. non-

exclusive-use zones (in this case, a sector or use is designated as having priority, and then other uses are defined that could co-exist).

In light of the above, the concept of POAPD zoning should also be applied to MSP. So far, it has been used only in the context of aquaculture. Indeed, the existing sectoral spatial planning framework (under review) gives priority to the development of aquaculture farms within POAPDs, which, however, have exclusive/single use (i.e., aquaculture).

In conclusion, MSP legislation in Greece should adapt to include Priority Use Zones and provide further details regarding their use.

Recommendations for adopting non-exclusive ORE zones

Regarding ORE, a National Spatial Planning Framework has been drafted in Greece, allocating zones for the development of OWFs (see Map 1). The zones promoted within this Framework (which is pending consultation and adoption) makes no reference to the coexistence of OWFs with other uses, therefore it is assumed that these zones will be designated for the exclusive use of OWFs. Furthermore, the Framework in question does not clearly specify what will happen outside the designated OWF zones, namely whether ORE development will be permitted in other marine areas of Greece or whether it will be excluded from all other Greek marine territories. This clarification is very important, as it affects the scope that will remain within the four (4) Marine Spatial Plans/Frameworks for addressing OWFs and the ORE.

In addition to OWFs, floating PVs are also being promoted in Greece (under Law 4951 of 2022). This law sets the procedure only for pilot projects involving floating offshore photovoltaic systems. However, a Spatial Plan/Framework has not yet been developed to establish spatial criteria for the distribution of offshore PV installations and to promote their coexistence with other uses.

Following an analysis of the synergies between marine activities and ORE, those activities that could operate synergistically are aquaculture and oil and gas extraction. Activities such as fishing, water desalination, tourism and recreation, shipping, as well as dredging could coexist under certain conditions, and with specific forms of ORE; however, safety and spatial planning conditions must be ensured during all three phases of ORE projects (construction, operation, and decommissioning). With regard to MPAs, although ORE installations could offer opportunities for new ecosystems, their environmental impacts are significantly greater than the opportunities.

To summarize the above, it is essential that all forms of ORE be spatially planned in Greece based on the multi-use concept. This implies that future research will focus on compatibility and synergies of RES with other sectors. This research must also define the terms of spatial-temporal management and the criteria for the coexistence of RES with other land uses. All of this information is also critical in view of the revision of the National Sectoral Framework for RES (which covers the country's land and marine areas).

Recommendations to raise the social acceptance of ORE in Greece

ORE is not a sector that receives great acceptance by the general public in Greece (as confirmed by the results of the survey presented in section 2.4). Therefore, increasing social

acceptance of ORE is a necessary task, given that the Greek government is in the process of developing more than twenty (20) OWF zones to host facilities that will reach a capacity of 4.9 GW by 2030 and 6.9 GW by 2050. With this in mind, the key recommendations for increasing public acceptance of ORE in Greece are:

- Improving public information and communication regarding the contribution of ORE to the EGD objectives, the compatibilities and synergies that could be developed between ORE and other uses, as well as the environmental impacts of ORE (particularly on the landscape, noise, fish fauna, seabed habitats, and birdlife), depending on the technologies used. This information could be provided through the organization of events and campaigns, as well as through the use of brochures or other material.
- Improving consultation with local communities and professionals in the maritime sector in areas where ORE projects will be allocated. This also entails providing compensation to professionals in the maritime or coastal sectors and to local communities that may be affected by ORE projects. Through these consultations, it will also be possible to identify synergies between the ORE sector and other local professionals.
- Encouraging ORE investors to adopt greener practices and to also highlight the non-economic values associated with developments in the ORE sector (e.g., educational, ecological, etc.).

3. Transferability and upscaling

3.1. Transferability

This national action examined the possibilities and conditions for incorporating the multi-use concept into the MSP process, as well as the possibilities and conditions towards designating non-exclusive ORE zones.

The findings and recommendations regarding the integration of the multi-use concept into the MSP process could easily be transferred to other countries. The adoption of non-exclusive “priority zones” could easily be considered in other contexts and/or countries, particularly following a careful review of the legislative framework.

As for the compatibility and synergies identified with the ORE sector, these could also be useful in other countries that are in the process of developing non-exclusive ORE zones. Furthermore, the methodology used to identify compatibility and synergies (the literature review, the interviews, etc.) can also be applied to other uses and sectors.

Another aspect of this national action that could easily be replicated is the questionnaire-based survey. Mapping social concerns is of paramount importance when planning large-scale ORE projects that are unfamiliar to the local context and tradition. The findings of such a survey can lead to the identification of targeted actions to increase social acceptance.

3.2. Affordability

Compatibilities and synergies related to ORE have not yet been sufficiently explored. Apart from the existing literature that is still limited on this topic, it is important to obtain more

information from practice (not only theory). However, the established ORE developments are still very few. Therefore, selecting the uses that will coexist within ORE zones is not an easy task, requiring experimentation.

The promotion and establishment of non-exclusive ORE zones is better to be addressed at the local level. At this level, the need for detailed data (geospatial or other data) and for meaningful interaction between stakeholders is more acute. Stakeholders' engagement and data availability may be a challenging task.

Mapping stakeholders is a crucial step towards achieving inclusiveness and meaningful participation that will ultimately lead to more effective planning solutions towards facilitating sectors to co-exist. Delivering inclusive consultations is a challenging task, calling for long term commitment and preparation.

The establishment of non-exclusive ORE zones also requires a high level of horizontal and vertical coordination and data sharing between competent authorities of different levels (national, regional and local) and of other institutions. Data availability is very important to analyse and map the existing sectors and the interactions with the marine ecosystems, the land and the local communities. Obtaining data may include technical and financial costs.

Once non-exclusive ORE zones are established, monitoring is necessary to track and ensure the sustainability of the sectors that will be allowed to co-exist.

Overall, the action may involve costs the relevant database; personnel costs to establish the necessary procedures for coordination between authorities and institutions and platforms development for data-sharing between them and finally, once the non-exclusive zones are established, costs regarding data obtaining at local level and monitoring them throughout the lifecycle of the OWF.

3.3. Upscaling

This action could be of use on a larger scale and in various ways. In policy and documentation level, this national action can offer information for methods and recommendations towards achieving synergies among marine activities, raising social acceptance of ORE and information on the benefits of promoting "Priority Zones" under the multi-use concept.

The concept of multi-use in planning is already integrated in international policy documents and national legislation related to MSP, as these documents recognize that the marine space and resources are not inexhaustible and that marine uses need to co-exist.

Although the designation of non-exclusive economic zones is a task relevant to local scale MSP initiatives, these types of zones could also facilitate cross-border cooperation at the Mediterranean level. This is because the synergies arising from the coexistence and the multi-use of the marine space may exceed national boundaries. For example, fishing grounds, shipping routes and ports (supporting ORE activities) often have a transboundary nature and may concern neighbouring countries sharing the same sea.

In the case of ORE zones, transboundary cooperation can be two-fold: a. by allowing cross-border users to co-exist with an ORE development and b. by developing ORE zones in cross-



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border areas. In both cases, consultation with the local societies affected by the ORE projects is very important.

4. Conclusion

This national action focused on the integration of the multi-use concept in MSP, which refers to how two or more activities could share resources and space to benefit all users and if possible, synergies to be developed between those sectors. This concept, although integrated in international policy documents and in national legislation, methods and tools towards its integration in MSP is basically missing. A basic observation of this national action is that “Priority Use Zones”, and more specifically on non-exclusive use (that prioritise a use or activity, while allowing other uses to co-exist) can serve the multi-use concept, promote synergies among sectors and also advance the EGD goals.

Having a further focus on ORE, this national action explored the potentials and conditions for the coexistence of ORE with other uses. In other words, this national action explored ways towards introducing non-exclusive ORE zones. And although existing literature refers to synergies between ORE (and mainly OWFs) and other marine activities, detailed references and practical examples are still limited. At a first glance, coexistence and synergies of ORE seem possible with aquaculture and other ORE installations and energy networks/cables. ORE may conditionally coexist with fisheries, waste disposal, water desalination, tourism and recreation, navigation and dredging following safety and spatial conditions. Last, ORE developments are incompatible with nature and culture protection sites and areas reserved for military use.

Greek legislation on ORE developments has been in place for long-time. However, this legislation and policy documents should be revised to promote non-exclusive ORE zones. The decision on the uses that will be selected to coexist with ORE, it is important to be taken on a case-by-case basis, to ensure consideration of the local specificities and of the local professionals. To facilitate this decision, management and distance criteria should be developed, ensuring safety, environmental protection and minimizing ecological and socio-economic impacts.

The promotion of non-exclusive ORE zones in Greece (and elsewhere) is also very important for another major reason, which is the limited social acceptance of the general public. ORE developments may serve important EGD goals (e.g., climate change mitigation, zero pollution initiatives). However, when allowing other uses to coexist within ORE zones, the EGD goals served may get magnified, and more non-economic values may be promoted.

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National action #5: Feasibility study on the identification of ABMTs in the Strait of Sicily (CORILA, IUAV, CNR)

1. Context and needs

1.1. The Italian Maritime Spatial Plans

In September 2024, Italy adopted its Maritime Spatial Plans (MSP) through the Ministerial Decree No. 237, thereby completing the national transposition and implementation pathway of Directive 2014/89/EU on maritime spatial planning (European Commission, 2024a; Gazzetta Ufficiale, 2024). The Italian MSP framework is organised around three maritime areas (Adriatic, Ionian and Central Mediterranean, and Tyrrhenian and Western Mediterranean), further articulated into sub-areas and nested Planning Units (UPs), enabling a multi-scalar approach to decision-making and spatial management (Ramieri et al., 2024).

The implementation phase of the MSP plans requires the operationalisation of priority measures, including those intended to ensure coherence between MSP objectives and key EU and international policy commitments. In this context, the MSP provisions foresee the establishment of an **inter-policy technical table named “MSP – MSFD – Biodiversity Strategy 2030 (Protected Areas and Restoration) – Fisheries Policies”**, connected to the activities of the MSP Technical Committee and oriented to the elaboration of concrete, technically sound proposals to enhance the integration of MSP with biodiversity conservation and sustainable management of fishery resources (Italian MSP, 2024).

The present feasibility study (MEDIGREEN project, Italian national action) is developed in this implementation setting. The scientific team of CORILA-IUAV-CNR (MEDIGREEN partners) supported the MSP Competent authority in the preparation of the national plans. The same institutions now support the MSP Competent authority in the implementation of plans, including the priority measures, by producing evidence-based inputs and spatially explicit proposals that can be discussed within the technical tables and translated into operational planning and management decisions.

1.2. Objective of this study

This study contributes to the implementation of the **national measure NAZ_MIS15** (Italian MSP, 2024), which focuses on **identifying priority areas for environmental and marine-resource conservation**, aligned with the Marine Strategy Framework Directive (MSFD) Programme of Measures (PoM 2021 Update), Natura 2000 and the EU Biodiversity Strategy 2030 (Italian MSP, 2024). The full recital of the measure is reported in the footnote²⁰.

²⁰ To establish a technical working group entitled “MSP – MSFD – Biodiversity Strategy 2030 (Protected Areas and Restoration) – Fisheries Policies”, linked to the activities of the Technical Committee for Maritime Spatial Planning (MSP), aimed at:

2.1 Identifying priority areas for environmental conservation and/or marine resource conservation, for the purpose of expanding the national network of Marine Protected Areas (MPAs) and/or Natura 2000 sites, as well as for assessing the potential of Other Effective area-based Conservation Measures (OECMs) to achieve environmental protection objectives, in line with the provisions and instruments established under the MSFD Directive (with particular reference to Measure 1 of Descriptor 1 of the updated MSFD Programme of Measures, 20/12/2021), the Natura 2000 framework, and the Biodiversity Strategy 2030.

The EU Biodiversity Strategy 2030 sets the objective of protecting at least 30% of EU seas by 2030, including at least 10% under strict protection (European Commission, 2020). Meeting these targets in highly used and ecologically valuable regions requires robust identification of conservation priorities and the appropriate deployment of Area-Based Management Tools (ABMTs), including Marine Protected Areas (MPAs) and Other Effective Area-Based Conservation Measures (OECMs).

The **Strait of Sicily** is considered in this study as a strategic test case for this approach: it combines exceptional ecological value and connectivity with intensive and competing maritime uses, creating both a high need and a high potential for ABMT-based solutions to support ecosystem-based MSP.

This feasibility study aims to support the implementation of the national measure NAZ_MIS15 and the activities of the MSP – MSFD – Biodiversity Strategy 2030 – Fisheries Policies technical table by (i) assessing the full range of ABMTs available under international, European, regional and national frameworks; (ii) analysing opportunities and constraints for their application in the Strait of Sicily; and (iii) translating findings into a shortlist of implementable options, consistent with MSP planning provisions and sectors developments (Italian MSP, 2024). A specific added value is the comparative consideration of both MPAs and OECMs, in view of the EU Biodiversity Strategy targets and the practical need to deploy effective measures across different jurisdictional spaces and governance regimes.

1.3. The Strait of Sicily

The geographic focus of this study is the Strait of Sicily, as considered within the Italian MSP Plan for the Ionian and Central Mediterranean maritime area. The scope of the study includes three MSP sub-areas: IMC/1, IMC/5 and IMC/6 (Figure 21), located in the Strait of Sicily and covering territorial waters, as well as offshore waters up to the median line (Italian MSP, 2024). This spatial framing is particularly relevant for the analysis of ABMT feasibility, as it spans coastal and offshore environments where different legal bases and competent authorities apply (e.g., conservation under Natura 2000 and MPAs in territorial waters; fisheries spatial measures and sectoral rules in territorial and offshore areas).

The Strait of Sicily is also a transition zone between the western and eastern Mediterranean basins, where oceanographic dynamics, including the exchange of Atlantic and Levantine waters, support high biological productivity and species movements, making the area a key node for ecological connectivity and cumulative-impact management (FAO, 2019; Sabatella et al., 2024).

The Strait of Sicily is recognised as one of the most ecologically important areas in the Mediterranean, characterised by high morphological diversity, including continental shelves, offshore banks, seamounts, slopes, canyons, and deep basins, as well as complex circulation patterns that sustain biodiversity and ecosystem productivity (UNEP/MAP-SPA/RAC, 2020; FAO, 2022). In this area, rich benthic and pelagic habitats coexist, including extensive *Posidonia oceanica* meadows, maerl and rhodolith beds on offshore banks, and deep-sea coral assemblages, which contribute to the structural complexity and ecological functioning of the marine ecosystem (Consoli et al., 2021; Maggio et al., 2022). These habitats underpin

2.2 Initiating studies and assessments on ecosystem functions and the ecosystem services derived from them, aimed at defining a coherent and connected network of protected areas; initiating studies and connectivity assessments aimed at identifying the relevant ecological connectivity corridors.

key ecological functions, including spawning, nursery, and feeding grounds for species of conservation and commercial importance, thereby supporting fisheries productivity and maintaining ecosystem resilience (FAO, 2019; Pastor et al., 2023). The Strait of Sicily hosts some Vulnerable Marine Ecosystems (VMEs)²¹ such as cold-water coral reefs, coral gardens, bamboo coral forests, sea-pen fields, sponge grounds, and maërl beds, mainly located around Adventure Bank, Graham Bank, the Malta Plateau, and deep slopes south of Sicily (Lauria et al. 2017; FAO/GFCM, 2009). These areas are also recognized as Essential Fish Habitats (EFH), mainly associated with muddy shelf and slope habitats that host nursery areas for hake and shrimp, plus rocky banks that support spawning grounds for demersal fish. Namely, the Adventure Bank is a major nursery ground for European hake, hosts shrimp nursery areas and represents a high biodiversity demersal habitat. The Malta Plateau is an important area for deep-water rose shrimp: it hosts slope ecosystems with recruitment areas. The Graham Bank is a rocky habitat hosting spawning areas for several demersal species (Garofalo et al., 2011; Fiorentino et al., 2013; MEDITS Programme, International bottom trawl survey database (since 1994), coordinated by the General Fisheries Commission for the Mediterranean; Colloca et al., 2015).

The Strait of Sicily represents one of the most ecologically significant regions of the central Mediterranean for marine megafauna, including cetaceans, marine turtles, sharks, and large pelagic fishes (Colloca et al., 2017; Mannocci et al., 2017). Acting as a biogeographic gateway between the western and eastern Mediterranean, the Strait plays an important role in facilitating ecological connectivity and migration between the two basins. Several cetacean species have been recorded in the area, including the Sperm whale, Fin whale, Striped dolphin, Common bottlenose dolphin, and Risso's dolphin. The Strait serves both as a feeding area and a transit route for these species. Deep-diving cetaceans such as sperm whales are mainly associated with offshore and slope habitats, whereas dolphins are more frequently observed on continental shelf areas where pelagic fish are abundant (Mannocci et al., 2017). Marine turtles are also an important component of megafauna in the region. The Loggerhead Sea turtle is widely distributed in the central Mediterranean and regularly recorded in the Strait of Sicily. Juvenile and sub-adult turtles often forage in the area, while adults transit through the Strait during seasonal migrations between nesting sites in the eastern Mediterranean and feeding grounds in the western basin (Casale and Margaritoulis, 2010). Large pelagic predators also occur in the region, including the Blue shark, Shortfin mako shark, and occasionally the Great white shark. These highly mobile species use the central Mediterranean as part of wider migratory pathways and feeding habitats. Similarly, the Atlantic bluefin tuna passes through the Strait during seasonal migrations between Atlantic feeding areas and Mediterranean spawning grounds (Block et al., 2005).

The ecological importance of the area is corroborated by scientific and policy processes recognising the Sicily Strait and associated banks as meeting criteria for Ecologically or Biologically Significant Marine Areas (EBSAs) under the CBD framework (UNEP/CBD, 2014). Peer-reviewed studies further document biodiversity hotspots on key banks (e.g., Graham, Nereo and Pantelleria Vecchia) within the broader Sicily Strait EBSA context (Altobelli et al., 2017), and describe habitats and species of conservation interest linked to regional protected-area processes (Consoli et al., 2021).

²¹ VMEs are defined as marine habitats that are particularly sensitive to disturbance due to their structural complexity, the presence of fragile or slow-growing species, and their limited capacity to recover from impacts, especially those caused by bottom-contact fishing activities. The concept was formally introduced by the Food and Agriculture Organization in the International Guidelines for the Management of Deep-sea Fisheries in the High Seas (2009) and is applied in the Mediterranean through management measures adopted by the General Fisheries Commission for the Mediterranean.

In addition to biodiversity values, the Strait of Sicily provides a broad portfolio of ecosystem services (ES), described in the results from the MSP4BIODIVERSITY national projects according to CICES v5.1 classification (Barbanti, 2023). Provisioning services include fisheries production and aquaculture-related outputs. Regulating and maintenance services include climate and atmospheric regulation (e.g., CO₂ removal and climate regulation), nutrient cycling and water-quality regulation, and lifecycle maintenance through habitat provision. Cultural services are particularly significant in the study area and include recreation and nature-based wellbeing, research and education, and values associated with landscape and underwater cultural heritage. These services reinforce the socio-economic rationale for conservation and provide an explicit bridge between biodiversity objectives and MSP sectoral priorities.

1.4. Maritime uses and pressures

The Strait of Sicily is among the most intensively used sea areas in the Mediterranean. Major use sectors include fisheries, maritime transport, energy (including hydrocarbon infrastructure and emerging renewables), tourism and recreation, and landscape/cultural heritage values.

Fisheries are a key traditional and economic sector, with both industrial and small-scale fleets operating in the region and relying on the productivity of demersal and pelagic systems. At the same time, fishing pressure—particularly from bottom-contact gears—can affect vulnerable benthic habitats and nursery areas. In the Strait of Sicily, fisheries management already includes spatial measures such as GFCM Fisheries Restricted Areas (FRAs), established to protect vulnerable marine ecosystems and sensitive habitats (FAO GFCM).

Maritime transport constitutes a major driver of cumulative pressure, given the strategic role of the Strait of Sicily as an east-west corridor in the Mediterranean. Associated pressures include risks of accidental pollution, chronic discharges, underwater noise, and collision risks for protected species. O&G energy infrastructure (pipelines and offshore installations) and the potential expansion of offshore renewable energy further increase spatial competition and the need for integrated planning solutions.

Tourism and recreational uses—particularly along the coast and around island systems—generate additional pressures on coastal habitats and water quality, while also benefiting directly from cultural ecosystem services linked to nature and heritage values (Barbanti, 2023).

Beside its important economic uses, the Strait of Sicily is also characterized by a high concentration of areas dedicated to nature conservation and cultural heritage protection. Several marine and coastal protected areas are established along its shores, including Marine Protected Areas and Natura 2000 sites designated under the Habitats Directive and the Birds Directive. In addition to ecological protection, the area hosts numerous coastal landscapes of high natural and cultural value, many of which are subject to national or regional landscape protection regimes. The Strait of Sicily is also notable for its rich underwater cultural heritage, reflecting millennia of maritime activity and trade across the central Mediterranean. Archaeological remains such as ancient shipwrecks, submerged structures, and historical artefacts constitute an important component of the marine environment and are increasingly recognised as elements requiring protection and management under international frameworks such as the UNESCO Convention on the Protection of the Underwater Cultural Heritage.

The Italian part of the Strait of Sicily is included in the MSP plan for the Central Mediterranean and Ionian Sea. This plan considers the Italian territorial waters and the offshore waters up to the midline. The Strait of Sicily is considered in the MSP plan with three different subareas: ICM/1, Territorial waters of Southern Sicily; ICM/5 Territorial waters of Pantelleria and Pelagie Islands; and ICM/6 Continental platform of Southern Sicily (Figure 22). As a whole, the MSP provisions for these areas emphasise the need to reconcile environmental protection with the sustainable development of maritime uses. This is represented by the zoning provisions identified for the three sub-areas (Figure 23). In ICM/1, the plan recognises high ecological value and the need to safeguard key habitats and species while ensuring compatibility with fisheries, ports, tourism and other activities. In ICM/5 the plan encourages an integrated management approach that strengthens conservation measures, supports local economies linked to nature-based activities, and safeguards the natural and cultural heritage associated with these islands, avoiding pressures that could determine threats to marine biodiversity and habitats. In ICM/6, the MSP addresses a context characterised by intensive uses (fisheries, shipping corridors, energy infrastructure) and explicitly calls for strengthening the protected-area and conservation framework, including coherent networks of protected/managed areas and measures to reduce pressures on biodiversity (Italian MSP, 2024).

Across all three subareas, the MSP planning logic aligns with an ecosystem-based approach and stresses the importance of evidence-based zoning and measures, supported by monitoring and adaptive governance. This provides a direct policy entry point for ABMTs as implementable spatial instruments, particularly when they can be designed to reduce cumulative impacts while maintaining the viability of key economic sectors.

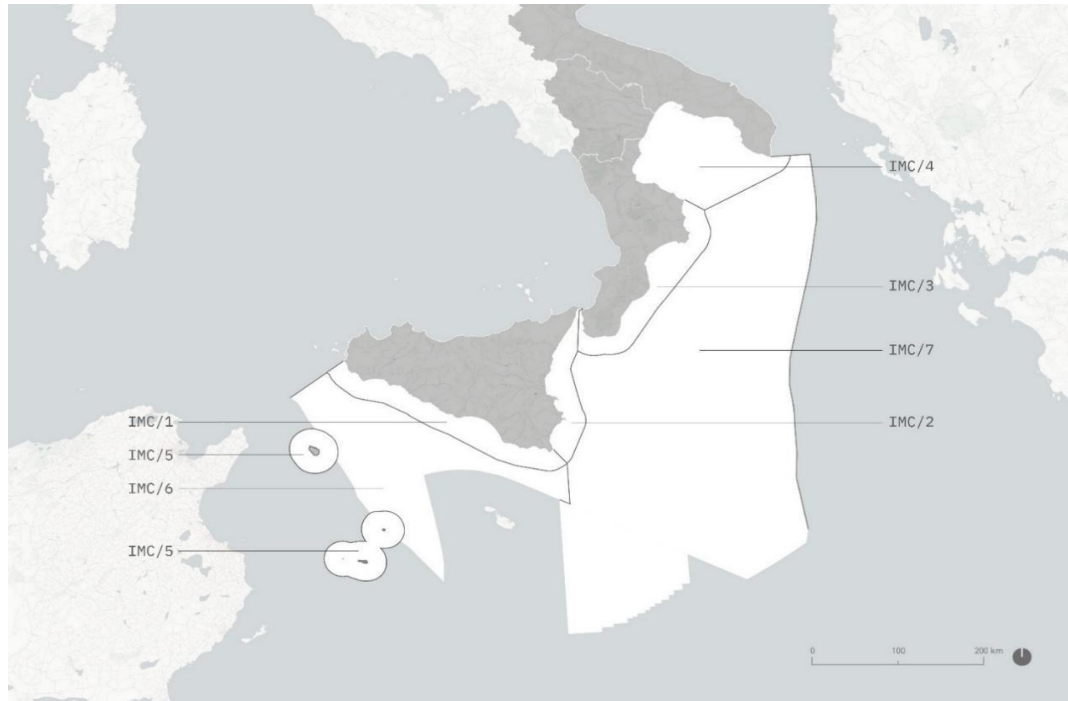


Figure 21. Geographical scope of the Italian MSP plan for the Central Mediterranean and the Ionian Sea. Identification of subareas. The subareas corresponding to the Italian part of the Strait of Sicily are ICM/1, ICM/5 and ICM/6. Source: Italia MSP (2024).

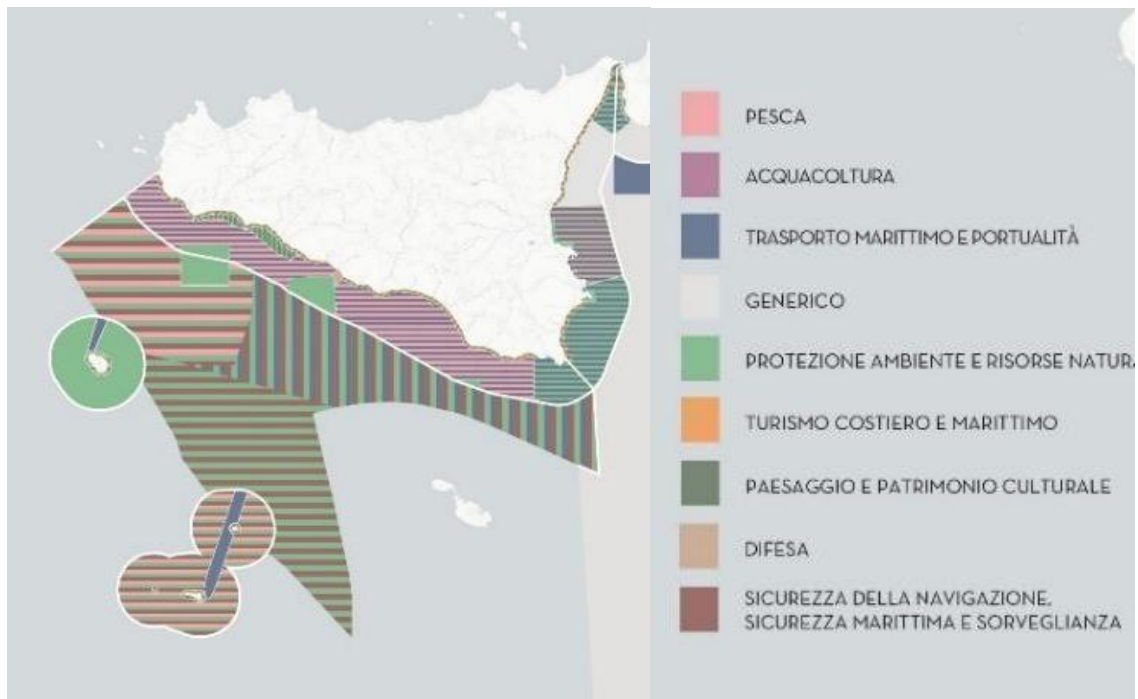


Figure 22: Planning Units (PUs) of the Strait of Sicily as identified in the Italian MSP plan for the Central Mediterranean and the Ionian Sea, and their vocation. The light green colour represents the PUs where nature conservation is identified among the priority uses. The dark green colour represents the PUs where landscape and underwater cultural heritage is identified among the priority uses. Source: Italia MSP (2024).

1.5. Area-Based Management Tools (ABMTs)

In the context of marine governance and maritime spatial planning, Area-Based Management Tools (ABMTs) are spatial management instruments that establish a system of rights, restrictions, and management responsibilities within clearly defined geographic areas to regulate human activities and achieve specific ecological, conservation, resource management, or socio-economic objectives. They operate under the authority of designated competent bodies and can provide varying levels of protection depending on their legal basis and management objectives (UNGA, 2007; Prior, Chircop and Roberts, 2010; Gissi et al., 2022). ABMTs constitute a core operational mechanism for implementing ecosystem-based management, enabling spatially explicit regulation of maritime activities to ensure the conservation of biodiversity, ecosystem services, and sustainable use of marine resources (Ehler and Douvere, 2009; European Parliament and Council, 2014).

ABMTs encompass a wide range of spatial management measures established under international, regional, European, and national legal frameworks. These **include Marine Protected Areas (MPAs), Other Effective area-based Conservation Measures (OECMs)**, fisheries spatial closures, maritime safety routing measures, and spatial measures aimed at protecting cultural heritage or vulnerable marine ecosystems (FAO, 2011; UNEP-WCMC, IUCN and NGS, 2018).

Marine Protected Areas (MPAs) represent the primary spatial instrument for marine biodiversity conservation. The International Union for Conservation of Nature (IUCN) defines an MPA as “a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values” (IUCN-WCPA, 2008). MPAs are widely

recognised as fundamental tools for protecting marine biodiversity, maintaining ecosystem services, and enhancing ecosystem resilience, and they form the backbone of spatial conservation strategies at global and regional levels (Vilas et al., 2020; UNEP-WCMC, IUCN and NGS, 2018).

In the Italian legal framework, MPAs are managed through a zoning system that regulates human activities according to different levels of protection. This system typically distinguishes three categories: Zone A, Zone B, and Zone C. Zone A represents the integral reserve, where the highest level of protection is applied and human activities are generally prohibited, with access allowed only for scientific research and surveillance. These areas are therefore usually considered no-take zones, ensuring full protection of habitats and species. Such areas have generally a limited extension. Zone B corresponds to a general reserve, where certain regulated activities may be permitted, such as small-scale fishing, guided tourism, or navigation under strict conditions. Zone C is a partial reserve, where a broader range of activities may occur but still subject to management rules aimed at minimizing environmental impacts. Through this graduated zoning approach, Italian MPAs seek to balance strict conservation objectives with sustainable local uses of marine resources.

In Europe, MPAs include a range of spatial designations, such as Natura 2000 sites established under the Habitats Directive (92/43/EEC) and the Birds Directive (2009/147/EC), Ramsar sites designated under the Ramsar Convention, UNESCO Biosphere Reserves, and nationally designated marine protected areas.

Complementing MPAs, Other Effective area-based Conservation Measures (OECMs) represent an additional category of AMBTs. The Convention on Biological Diversity defines **OECMs as “geographically defined areas other than Protected Areas, which are governed and managed in ways that achieve positive and sustained long-term outcomes for the *in situ* conservation of biodiversity, with associated ecosystem functions and services and, where applicable, cultural, spiritual, socio-economic and other locally relevant values”** (CBD, 2018). OECMs play an important role in **expanding spatial conservation coverage beyond formally designated protected areas**, particularly in areas where **biodiversity conservation may be achieved through sectoral management measures**.

The involvement of maritime sectors in environmental management is therefore key for OECMs identification and management. Despite the fact that the Mediterranean Sea does not currently have any formally recognized OECMs, the Post-2020 Regional Strategy for marine and coastal protected areas and other effective area-based conservation measures in the Mediterranean (UNEP/MAP-SPA/RAC, 2021) recognizes OECMs as an essential tool to help Contracting Parties under the Barcelona Convention to achieve the regional targets for biodiversity conservation. A non-exhaustive list of the types of areas that could be potential OECMs in the Mediterranean can include:

- Fisheries Restricted Areas (FRAs), in particular those that host critical species, and those that are permanently restricted so as to enhance the long-term conservation outcomes.
- Marine or coastal military closure areas, as some are often no go-areas and can have good conservation outcomes.
- Archaeological and cultural heritage (sunken ships, archaeological shipwrecks, underwater ancient remains, cities, etc.).
- Areas managed for navigation purposes such as IMO Particularly Sensitive Sea Areas (PSSA).

Taken together, AMBTs represent a comprehensive and flexible spatial management toolbox that enables policymakers and maritime spatial planners to implement ecosystem-based

management, conserve marine biodiversity, protect ecosystem services, and ensure the sustainable use of marine resources across different maritime sectors and governance levels.

2. Implementation

Despite the presence in the area of protection and management measures, the Strait of Sicily remains exposed to cumulative pressures that can undermine biodiversity values and the ecosystem services on which local economies depend. The MSP itself recognises the need to strengthen spatial conservation measures and contribute to EU biodiversity targets, including the 30% protected and 10% strictly protected targets by 2030 (European Commission, 2020; Italian MSP, 2024).

ABMTs offer a practical pathway to address these needs, as they enable spatially explicit regulation of pressures, protection of key habitats and ecological processes (e.g., nurseries, migration corridors), and the coordination of multi-sector activities. Importantly, ABMTs can be shaped not only as classic protected areas (MPAs, Natura 2000) but also as sectoral or multi-sector tools (e.g., fisheries closures, routing measures, OECMs), which may be particularly relevant in offshore planning units where governance and enforcement conditions differ from coastal settings.

The implementation of the feasibility study was based on the following methodological steps. The results of the steps are briefly presented in the following paragraphs.

Step 1 - Data collection. A collection of data on the marine environment, the economic sectors operating in the area, and the ABMTs in place was made available, capitalising on the results of the MSP4BIODIVERSITY project²². This project aimed at developing a methodological framework, based on co-constructed scenarios, and modelling tools to support biodiversity mainstreaming into MSP. The project focused on three pilot areas, one being the Strait of Sicily (see paragraph 2.1).

Step 2 - Review of ABMTs. A review of ABMT typologies and legal bases potentially relevant to the Strait of Sicily (international, EU, regional and national) was prepared, including an analysis of the objectives of each ABMT type, typical contexts of application, including governance requirements and jurisdictional constraints (see 2.2). An overview of ABMTs already present in the Strait of Sicily is also provided (see paragraph 2.3).

Step 3 - Identification of possible new ABMTs. Comparing the ABMTs in place and main environmental issues in the study area (gap analysis), typology and locations of possible new ABMTs were identified, to contribute to the objective of the measure NAZ_MIS15 (Italian MSP, 2024), having the purpose of expanding the national network of Marine Protected Areas (MPAs) and/or Natura 2000 sites, as well as for assessing the potential of Other Effective area-based Conservation Measures (OECMs). This step was also supported by the findings of the MSP4BIODIVERSITY project, which provided a relevant scientific knowledge base on the

²² Project funded by the European Union – NextGenerationEU – National Recovery and Resilience Plan (PNRR) – Mission 4 “Education and Research”, Component 2 “From Research to Business”, Investment 1.4 – Call No. 3138 of 16 December 2021, as amended by Ministerial Decree No. 3175 of 18 December 2021 of the Ministry of University and Research (MUR); Award Number: Project Code CN_00000033; Funding granted by Ministerial Decree (MUR) No. 1034 of 17 June 2022; CUP D33C22000960007; Project title: “National Biodiversity Future Center – NBFC”.

most ecologically valuable, still unprotected or under protected areas, also based on stakeholder inputs. A list of possible new ABMTs is provided (see paragraph 2.4).

Step 4 - Feasibility analysis. Each new proposed ABMT was assessed for its ecological value, the complexity and length of the designation process, and the socio-economic dimension. Based on the results of this analysis, a prioritization of the new proposed ABMTs was provided.

Step 5 - Feeding the MSP process. The outputs of this study are designed to be usable by the MSP – MSFD – Biodiversity Strategy 2030 – Fisheries Policies technical working group, thus supporting the development of detailed, spatially explicit proposals aimed at strengthening biodiversity conservation and ecosystem service provision, while ensuring compatibility with existing maritime uses. The Italian MEDIGREEN project partners have already informed the Italian competent MSP authority of their availability to present the results of this study to the relevant technical working group. The working group has not yet been convened. The presentation of results and the collection of feedback will therefore take place at the first available opportunity, hopefully during the implementation period of the MEDIGREEN project.

2.1. Base of data

The following data have been collected in a GIS project:

- Benthic habitats: Posidonia meadow, Maerl and rhodolites, Deep-sea corals, Hard bottom
- species: Red and white corals thanatocenosis, *Pinna nobilis*.
- Protected areas, including those for the protection of Underwater Cultural Heritage, Attention areas, and Other area-based management measures and limitations to sea uses.
- Fishing effort and aquaculture sites
- Maritime traffic Intensity and ports
- Oil and Gas search and exploitation areas
- Coastal municipalities relevant for tourism

Additional information has been collected on the presence and distribution of fish species of commercial interest (big pelagics, small pelagics demersal species including those of commercial interest: e.g., Deep-water rose shrimp, deep-water red shrimps, Norway lobster, squids); sea turtles, marine bird species.

2.2. Inventory of ABMTs

Area-Based Management Tools (ABMTs) represent a comprehensive set of spatial governance instruments that regulate human activities within defined marine areas to achieve specific environmental, resource management, safety, or cultural objectives. Their legal basis derives from international law, particularly the United Nations Convention on the Law of the Sea (UNCLOS), as well as global environmental agreements, regional conventions, and European Union legislation. ABMTs constitute key operational tools for implementing ecosystem-based management and maritime spatial planning, enabling the spatial integration of environmental protection and socio-economic activities. A review of existing ABMTs has been prepared and is summarized in the table reported in **Annex B**. A narrative description is given in the following paragraphs.

2.2.1. Maritime pollution control and navigational safety

One fundamental legal framework for ABMTs addressing marine pollution is UNCLOS Article 211(6), which allows coastal States to establish **special areas** within their Exclusive Economic Zones where stricter pollution control measures apply. These provisions are implemented through the International Maritime Organization (IMO), particularly under the MARPOL Convention (1973/78). Under MARPOL Annex I and Annex V, the Mediterranean Sea, including the Strait of Sicily, has been designated as a Special Area, reflecting its ecological vulnerability and the intensity of maritime traffic. These designations impose stricter regulations on the discharge of oil and garbage from ships, contributing to the protection of marine ecosystems.

Further strengthening this framework, the Mediterranean Sea has been designated as a Sulphur **Emission Control Area (SECA)** under MARPOL Annex VI, which entered into force in 2025. This designation limits sulphur emissions from ships operating in the region and represents a major ABMT addressing atmospheric pollution and its impacts on marine and coastal ecosystems. In parallel, Mediterranean coastal states are currently examining the possible designation of the entire Mediterranean as a Nitrogen Oxides Emission Control Area (NECA), although such a measure has not yet been formally adopted.

Navigational safety ABMTs are also implemented under the International Convention for the Safety of Life at Sea (SOLAS, 1974) and related IMO routing measures. These include **Traffic Separation Schemes (TSSs)** and **Areas To Be Avoided (ATBAs)**, which regulate vessel traffic to reduce collision risks and protect environmentally sensitive areas.

2.2.2. Fisheries management

Fisheries-related ABMTs represent a critical component of spatial management in the Strait of Sicily, where fisheries constitute one of the main maritime uses and economic activities. At the regional level, **Fisheries Restricted Areas (FRAs)** have been established by the General Fisheries Commission for the Mediterranean (GFCM) under its regulatory framework. These areas prohibit or restrict fishing activities to protect vulnerable marine ecosystems, spawning grounds, and nursery areas. In the Strait of Sicily, several FRAs have been established so far, including areas protecting deep-sea habitats and vulnerable ecosystems. These measures contribute to ecosystem conservation and fisheries sustainability.

At the European level, the Common Fisheries Policy (Regulation (EU) No. 1380/2013) provides the legal basis for the designation of **fish stock recovery areas** under Article 8 and other spatial conservation measures under Article 7 and Regulation (EU) 2019/1241 on technical measures. These spatial measures restrict fishing activities in biologically sensitive areas to protect marine ecosystems and support sustainable fisheries management.

2.2.3. Marine biodiversity conservation

Marine biodiversity conservation ABMTs constitute a central component of the spatial management framework in the Strait of Sicily. **Marine Protected Areas (MPAs)**, established under national legislation (Italian Law No. 394/1991), the Convention on Biological Diversity, and European Union legislation, represent the primary spatial conservation instrument. These areas contribute to protecting marine habitats and species and maintaining ecosystem services. In addition, **marine Natura 2000 sites** established under the Habitats Directive (92/43/EEC) and the Birds Directive (2009/147/EC) constitute legally binding conservation ABMTs. At the regional level, the Strait of Sicily falls within the scope of the



Barcelona Convention, which provides the legal framework for the designation of **Specially Protected Areas of Mediterranean Importance (SPAMI)**. These areas contribute to regional biodiversity conservation and ecosystem-based management.

Besides the ABMTs which are ultimately legal instruments, some other types of areas can be identified, as a result of a scientific process and in scientific contexts, as areas of relevance for some biological or ecological characteristics. It is the case of the Ecologically or Biologically Significant Marine Area (EBSAs) under the Convention on Biological Diversity. This designation reflects the area's exceptional ecological importance, biodiversity, and ecological connectivity. Other areas of this type are the Important Marine Mammal Areas (IMMAs) and the Important Shark and Ray Areas (IRSAs), highlighting its importance for marine megafauna conservation. These **scientifically identified areas** provide critical information supporting conservation planning and the potential establishment of legally binding ABMTs.

2.2.4. Cultural heritage protection

The UNESCO World Heritage Convention (1972) and the UNESCO Convention on the Protection of the Underwater Cultural Heritage (2001) provide the international legal framework for protecting **underwater cultural heritage**. These conventions allow for the designation of protected areas where activities that may damage cultural heritage are regulated or prohibited. At the national level, underwater cultural heritage is protected under Italian legislation and integrated into MSP.

2.3. ABMTs present in the Strait of Sicily

A wide range of ABMTs has already been implemented in the Strait of Sicily under international, European, regional, and national legal frameworks, including MARPOL Special Area designation and SECA Mediterranean, Fisheries Restricted Areas established by GFCM, Natura 2000 marine sites, and Marine Protected Areas. They are listed in Table 10.

Table 10. ABMT in place in the Strait of Sicily: Protected areas, Attention areas and Other Area-Based measures and limitations to sea uses.

ABMT category	ABMT type	Name/Object	Legislative context
Marine and coastal biodiversity conservation	MPA	Isole Pelagie	Framework law 6 December 1991, n. 394
	Marine Natura 2000	Several, mainly related to sea turtle nesting sites and Posidonia meadows	Habitats Directive (92/43/EEC) Birds Directive (2009/147/EC) And their national implementation Decrees
	Coastal Natura 2000 + National Parks	Several, plus the Pantelleria National Park	Habitats Directive (92/43/EEC) Birds Directive (2009/147/EC) And their national implementation Decrees
Fisheries management	Fishery Restricted Areas	– FRAs "East of the Adventure Bank" – FRAs "West of the Gela Basin" – FRAs "East of the Bank of Malta".	Individual GFCM recommendations: – GFCM/35/2011/7 – East of Adventure Bank FRA – GFCM/35/2011/6 – West of Gela Basin FRA – GFCM/35/2011/5 – East of Malta Bank FRA
	Trawling ban	Trawling ban 3 nm from coast or 50 m depth	EU Reg. 1967/2006 + DPR 1639/1968
	Trawling ban	Trawling ban in the >1000m deep areas	GFCM Recommendation GFCM/29/2005/1
Marine pollution control and navigation safety	Special area	Entire Mediterranean (including the Strait of Sicily)	MARPOL Annex 1 and V
	SECA	Entire Mediterranean (including the Strait of Sicily)	MARPOL Annex VI

The Italian sector of the Strait of Sicily—including Sicilian territorial waters and offshore waters up to the median line—overlaps with several internationally recognised **biodiversity priority areas** identified through different scientific frameworks. Although these designations are generally non-regulatory, they provide robust scientific evidence supporting conservation priorities and are increasingly considered in marine spatial planning and ecosystem-based management (Figure 23).

Ecologically or Biologically Significant Areas (EBSAs). A large portion of the central Mediterranean, including the Sicilian Channel / Strait of Sicily, has been identified as an EBSA under the Convention on Biological Diversity EBSA process. This EBSA extends across the central part of the Strait between southern Sicily and the Tunisian and Maltese shelves and includes important bathymetric features such as the Adventure Bank, Malta Plateau and the



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Pantelleria basin system. The EBSA designation reflects the area's high biodiversity, the presence of vulnerable habitats (including deep coral communities and seamount ecosystems), and its ecological role as a migration and connectivity corridor between the western and eastern Mediterranean basins.

Important Marine Mammal Areas (IMMAs). The central Strait of Sicily also overlaps with a IMMA identified by the IUCN Marine Mammal Protected Areas Task Force. The Lampedusa IMMA, located around the Pelagie Islands (Lampedusa and Linosa) extends southwards toward the Tunisian shelf. This IMMA (about 17,500 km²) was identified due to the regular presence of fin whales and bottlenose dolphins, with evidence that the waters around Lampedusa function as a seasonal feeding area for fin whales and a core habitat for resident bottlenose dolphin populations.

Important Shark and Ray Areas (ISRAs). Within the central Mediterranean, several Important Shark and Ray Areas (ISRAs) have been proposed or identified in the Sicilian Channel-Malta Plateau region, reflecting the importance of the area for threatened elasmobranch species. These ISRAs are generally associated with offshore banks and slope habitats, including areas around the Adventure Bank and Malta Bank, where nursery grounds and aggregation areas for several shark and ray species have been reported in scientific literature.

Critical Cetacean Habitats (CCH). In the Strait of Sicily, two CCHs are identified. The offshore waters between southern Sicily, Malta and Tunisia, including the Malta Plateau and the central channel, are considered key areas supporting cetacean feeding and movement patterns across the Mediterranean basin and recognized as CCH (The Strait of Sicily for fin whales and common, bottlenose and striped dolphins). The second one corresponds to the marine area in the Eastern Maltese Sea, surrounding the island of Malta and south-eastern Sicily

Important Bird Areas (IBAs). An offshore IBAs - identified by BirdLife International - occurs in the Sicilian Channel between southern Sicily, Malta and Tunisia, where productive waters provide key foraging areas for pelagic seabirds such as Scopoli's shearwater, Yelkouan shearwater and Mediterranean storm petrel. The area is considered particularly significant because it supports a substantial proportion of the global populations of some Mediterranean endemic seabird species.

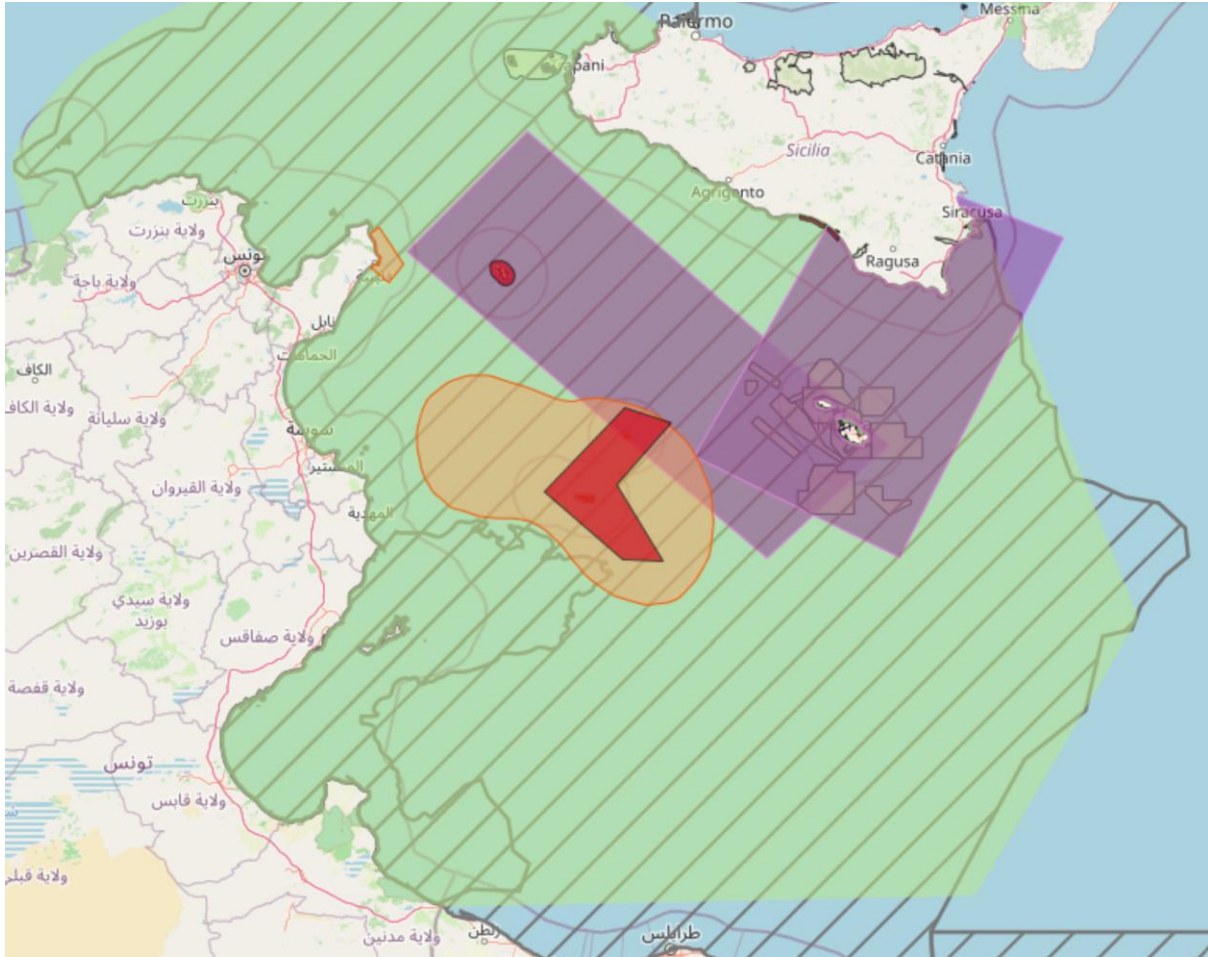


Figure 23. Biodiversity priority areas in the Strait of Sicily.

2.4. New proposed ABMTs for the Strait of Sicily

Despite these measures, several biodiversity hotspots remain without formal legal protection: offshore banks, seamounts, and deep-sea habitats that host vulnerable marine ecosystems, including cold-water coral assemblages and rhodolith beds (Bo et al., 2015; Maggio et al., 2022). Furthermore, the current spatial coverage of legally protected marine areas remains insufficient to meet the targets established under the EU Biodiversity Strategy for 2030, which calls for the protection of at least 30% of marine areas, including one-third under strict protection (European Commission, 2020). It should be noted, however, that these targets are assessed at national scale; therefore, a specific marine sub-region may remain below the quantitative threshold if compensated by higher protection levels in other areas of the national marine space. Nevertheless, considering the ecological importance of the Strait of Sicily – characterized by high habitat diversity, key ecological connectivity functions, and the presence of vulnerable marine ecosystems – the area should reasonably receive particular attention within national conservation strategies. Functional gaps remain in the protection of offshore banks (e.g., Graham, Pantelleria, and Avventura banks) and deep-sea ecosystems, and ecological corridors supporting migratory species (UNEP/MAP-SPA/RAC, 2020; FAO, 2019). In addition, although fisheries spatial measures contribute to ecosystem protection, integration between fisheries management measures and broader biodiversity conservation objectives remains incomplete, highlighting the need for more comprehensive spatial management approaches (Colloca et al., 2017).

In addition, high cumulative pressures from multiple maritime sectors, including fisheries, maritime transport, offshore energy infrastructure, and tourism are documented for the area. The Strait represents one of the main shipping corridors in the Mediterranean, with increasing risks of pollution, underwater noise, and ship strikes affecting marine megafauna (UNEP/MAP, 2020; European Commission, 2021).

Based on considerations on the ecological data available, several proposed new ABMTs are identified in Table 11. The proposed ABMTs have been discussed with stakeholders in the framework of the MSP4BIODIVERSITY project which organized two in-person workshops in November 2024 and June 2025 respectively. During the workshops, alternative spatial planning scenarios (what-if scenarios) for the Strait of Sicily were discussed, together with their environmental and socio-economic effects. In such a context, the ABMTs illustrated in Table 11 were also considered. The scope of the present study is to capitalize on the results from that project to move forward with a feasibility evaluation, in order to provide a comprehensive and structured basis for discussion for the inter-policy technical table "MSP – MSFD – Biodiversity Strategy 2030 – Fisheries Policies on the national measure NAZ_MIS15.

The proposal considers some candidate sites for new MPAs already included in the national list (candidate areas = aree di esperimento) This is the case of the offshore banks such as the Graham, Pantelleria, and Avventura banks, which represent biodiversity hotspots and essential habitats for benthic communities, fish spawning, and marine megafauna. Similarly, the proposed designation of a new Marine Protected Area around Pantelleria Island would protect ecologically important coastal and offshore habitats, including extensive *Posidonia oceanica* meadows, volcanic substrates, and pelagic habitats. The Pantelleria area also plays a key role as a stepping-stone habitat connecting coastal and offshore ecosystems, further enhancing ecological connectivity.

Fisheries-related ABMT proposals represent another key component of the proposed spatial management framework. The proposed designation of new FRAs to protect Essential Fish Habitats (EFH), particularly in offshore areas such as Planning Unit IMC/6, would protect critical nursery and spawning areas for commercially important species, including European hake (*Merluccius merluccius*) and deep-water rose shrimp (*Parapenaeus longirostris*). These measures would contribute significantly to ecosystem-based fisheries management and support the long-term sustainability of fisheries resources in the region (FAO, 2019; Colloca et al., 2015).

The proposed designation of additional FRAs to protect vulnerable marine ecosystems, including deep-sea *Isidella elongata* coral habitats, would address one of the most significant conservation gaps in the Strait of Sicily. These habitats are highly vulnerable to bottom trawling and represent important biodiversity hotspots supporting diverse benthic communities (Bo et al., 2015). Similarly, the proposed enlargement of existing trawling restrictions to depths of 800 meters would significantly enhance protection of deep-sea ecosystems, which are currently underrepresented in existing ABMT frameworks.

In addition to FRAs, three extensions of trawling bans are proposed: in coastal areas, from 3nm to 6 nm, on a seasonal base; in SCIs/SACs designed for the protection of benthic species or habitats (according to Biodiversity Strategy 2030 – Action Plan: Protecting and restoring marine ecosystems for sustainable and resilient fisheries. COM(2023)102 final, 21 February 2023); below 800m depth to reinforce the ban actually in place under GFCM below 1000m depth.

Maritime traffic management measures also represent a strategic opportunity to reduce cumulative environmental pressures. The proposed designation of a Particularly Sensitive



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Sea Area (PSSA) in the Strait of Sicily, including areas identified as Critical Cetacean Habitat (CCH), would allow the implementation of associated protective measures, including ship speed reduction and routing measures. These measures would significantly reduce ship strike risks, underwater noise, and pollution impacts on marine mammals, particularly sperm whales (*Physeter macrocephalus*) and fin whales (*Balaenoptera physalus*), for which the Strait of Sicily represents an important migration corridor (Notarbartolo di Sciara et al., 2016).

Finally, the proposed designation of a transboundary UNESCO Biosphere Reserve under the Man and Biosphere (MAB) Programme, including Pantelleria, the Pelagie Islands, and adjacent waters, represents an important governance and conservation opportunity. Such designation would promote integrated ecosystem management, strengthen international cooperation between Italy, Malta, and Tunisia, and support sustainable development while maintaining ecosystem integrity.

Table 11. Proposed new ABTMs to be implemented in the Strait of Sicily.

N.	ABMT category	ABMT type	Objective(s)	Subarea(s)	Planning Unit(s)
1	Marine pollution control and navigation safety	New PSSA designation	Reduce pressures and impacts from intense maritime traffic related to pollution and noise emissions, and collisions with marine megafauna. Speed reduction measures are proposed in a core area included in the PSSA, corresponding to the Italian side of the CCH located between Italy and Malta	IMC/1, IMC/6	IMC/1_03 P(tm, n), IMC/1_05 P(n), IMC/1_06 P(N), IMC/1_08 P(n), IMC/1_09 P(tm, p), IMC/1_10 P(tm, n), IMC/6_01 P(n,p, s), IMC/6_02 P(tm, s, n)
2	Fisheries management	New FRA designation	Protect one Essential Fish Habitat (EFH)	IMC/6	IMC/6_01 P(n, pm s)
3		New FRA establishment	Protect elasmobranches	IMC/6	IMC/6_01 P(n, p, s), IMC/6_02 P(tm, s, n), IMC/6_03 P(n, s)
4		New FRA designation	Protect one Vulnerable Marine Ecosystem (Isidella)	IMC/6	IMC/6_03 P(n, s)
5		Trawling ban extended from 3 to 6nm from the coast (seasonally)	Protection of benthic habitats	IMC/1, IMC/5.	IMC/1_03, IMC/1_09, IMC/1_10, IMC/5_04, IMC/5_05, IMC/5_06, IMC/5_07, IMC/5_08
		Trawling ban extended to -800m	Protection of VME	IMC/5, IMC/6	IMC/5_02 P(ppc, t, n), IMC/5_07 P(tm), IMC/6_03 P(n, s)
		Trawling ban in the N2K areas protecting benthic habitats and species	Protection of benthic habitats and species	IMC/1, IMC/5	IMC/1_01 P(t, ppc, n), IMC/1_04 P(n, ppc), IMC/1_02 (t, ppc, n)
6	Marine biodiversity conservation	1 New MPA designation	As per the Italian proposed MPAs list (Isola Pantelleria)	IMC/5	IMC/5_01 P(ppc, t, n), IMC/5_05 P(t, n), IMC/5_06 P(tm)
7		2 New MPA designation	As per the Italian proposed MPAs list (Banchi di Graham, Pantelleria e Avventura)	IMC/6	IMC/6_01 P(n, p, s)
8		Existing MPA measures strengthening	Zones A and Zone B of MPAs in this area to be changed into rigorous protection	IMC/5	IMC/5_02, IMC/5_08 P(n,p, s)
9					
10	Cultural heritage protection	New MAB UNESCO designation	Protect the transboundary area between Italy (Capo Passero) and Tunisia (Kerkennah, Gulf of Gebes), including Pantelleria, Pelagie Islands and Malta	IMC/1, IMC/5, IMC/6	Several PUs

Existing and new proposed ABTMs are illustrated in the following figures.

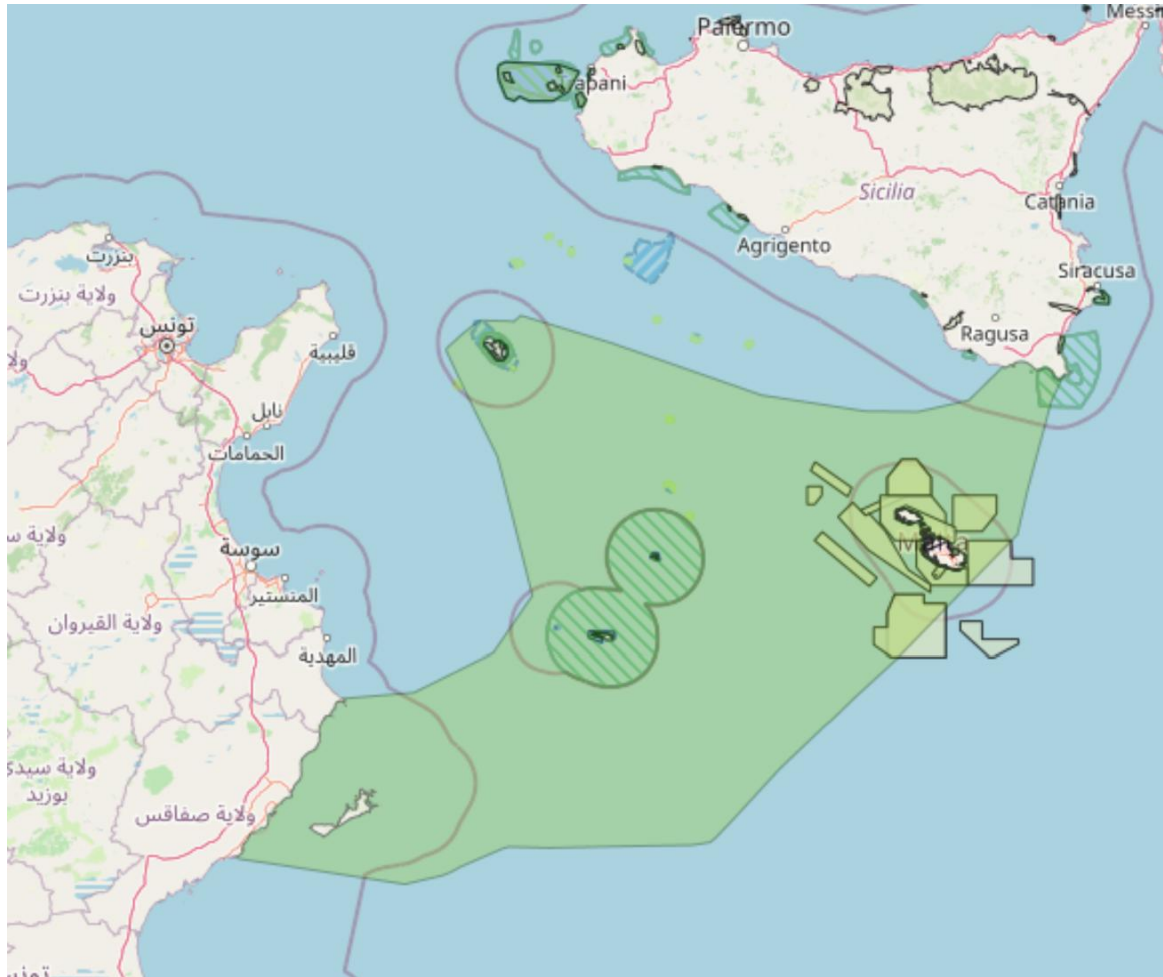


Figure 24. Existing and proposed new MPAs. Existing MPAs (dark green grid), new MPAs (light blue grid), existing Natura 2000 (light green grid), new proposed MAB UNESCO Biosphere Reserve (very light green).
Data source: MSP4BIODIVERSITY project.

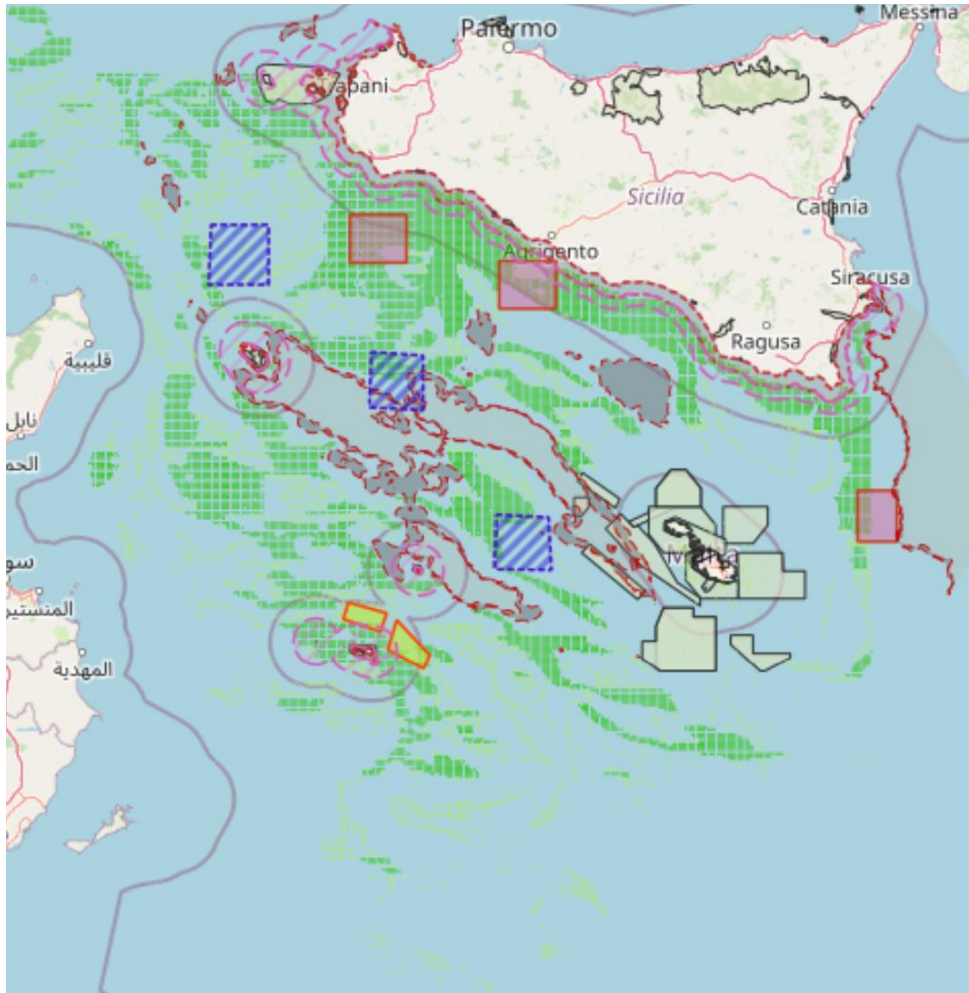


Figure 25. Existing and proposed new fisheries management spatial measures. Areas where trawling is forbidden (within 3nm from the coast and below 50m depth)(light pink), areas where trawling is already forbidden (>1000m deep)(red dashed line), new proposed areas where trawling should be forbidden (>800m deep)(pink dashed line), existing FRAs (red grid), proposed new FRAs (violet grid), proposed new areas for trawling ban – nursery areas (light green). Data source: MSP4BIODIVERSITY project datasets.

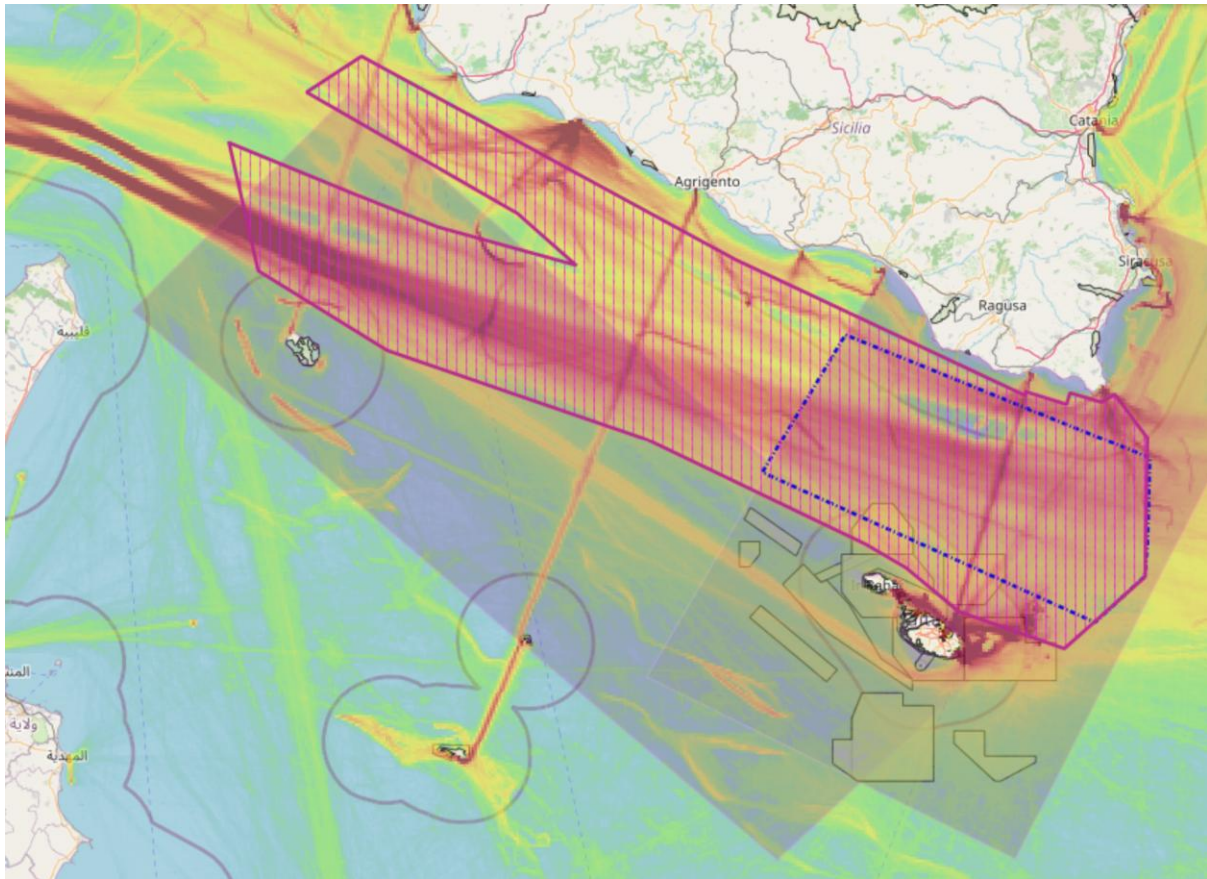


Figure 26. Proposed new PSSA (red line) and the area with speed reduction (blue dashed line) corresponding to the CCH identified between Italy and Malta, CCHs in the area (light violet). Maritime traffic density (total) is also represented. Data source: MSP4BIODIVERSITY project; EMODNET (vessel traffic data 2024).

2.5. Feasibility assessment of candidate ABMTs

The feasibility of the candidate ABMTs is assessed through an expert-based approach, by considering three key dimensions: a qualitative evaluation of the ecological gain brought by the designation, some considerations regarding the legislative and procedural feasibility, and some considerations on the socio-economic acceptability. These dimensions reflect the core criteria for ABMT implementation within the MSP framework, ensuring that proposed measures contribute effectively to biodiversity conservation while remaining legally feasible and socially and economically sustainable.

The ecological gain assessment considers the conservation value of the areas concerned, including their importance for biodiversity, habitat protection, ecological connectivity, and ecosystem functioning. Particular attention has been given to offshore banks, deep-sea habitats, and fisheries essential habitats, which are currently underrepresented in existing protection frameworks but play a critical role in maintaining ecosystem integrity and fisheries productivity.

The legislative and procedural feasibility assessment evaluates the legal pathways available for the establishment or strengthening of each ABMT, taking into account the applicable legal frameworks, institutional responsibilities, and procedural requirements. This includes international mechanisms such as IMO PSSA designation, regional mechanisms such as FRAs under the GFCM, and national conservation measures such as MPAs and Natura 2000



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sites. The complexity and expected duration of designation processes vary depending on the ABMT type, the number of stakeholders involved, and the level of international coordination required.

The socio-economic acceptability assessment considers the potential impacts of proposed ABMTs on maritime sectors, including fisheries, maritime transport, tourism, and regional economic activities. While some measures may impose restrictions on specific activities, particularly industrial fisheries or maritime transport, many ABMTs also provide long-term socio-economic benefits, including improved fisheries sustainability, enhanced ecosystem resilience, and opportunities for sustainable tourism and international recognition. More robust considerations will be available from modelling and assessment activities still ongoing in the framework of the MSP4BODIVERSITY project. The results will further support the discussion this feasibility study aims to inform at the national MSP level.

Overall, the feasibility assessment demonstrates that several proposed ABMTs offer substantial ecological benefits while remaining legally feasible and socio-economically acceptable, particularly those targeting offshore vulnerable marine ecosystems, essential fish habitats, and biodiversity hotspots. Measures such as FRAs, offshore MPAs, and strengthened Natura 2000 protection represent particularly promising opportunities for improving the coherence and effectiveness of the ABMT network in the Strait of Sicily.

More complex measures, such as the designation of a PSSA or transboundary UNESCO Biosphere Reserves, may require longer-term international coordination but offer significant strategic benefits for ecosystem protection and sustainable maritime governance.

The results of this feasibility assessment provide a scientific and policy basis for the prioritization and progressive implementation of new or strengthened ABMTs in the Strait of Sicily, contributing to the achievement of national MSP objectives and European and international biodiversity conservation targets, including the EU Biodiversity Strategy for 2030.



Table 12. General characteristics of ABMTs

ABMT type	Area / Objective	Ecological gain	Legislative and procedural feasibility	Socio-economic acceptability
New PSSA designation (IMO)	PSSA + speed reduction area between Italy and Malta	Very high ecological gain. The Sicily Strait is a major migration corridor for sperm whales, fin whales, and pelagic megafauna, and an area of intense shipping. Establishment of a PSSA and particularly speed reduction would significantly reduce ship strikes, underwater noise, and chronic pollution. It would also improve ecological connectivity between the western and eastern Mediterranean basins.	Medium-low feasibility (long-term process). Requires submission to IMO by Italy (possibly jointly with Malta), scientific justification, risk assessment, and stakeholder consultation (shipping industry, ports, defence, fisheries). Typically, 3–6 years. A strong scientific basis already exists (IMMA, CCH).	Medium acceptability. Some economic impact as speed reduction mainly affects transit efficiency rather than excluding navigation. The shipping sector may resist due to increased transit time, but benefits include reduced accident risk and improved environmental compliance. Minimal direct impact on fisheries or local communities.
New FRA designation – Essential Fish Habitat (EFH)	FRA for EFH protection	Very high ecological gain. Protects nursery grounds of key commercial species (e.g., hake, deep-water shrimp), improving recruitment and long-term fisheries sustainability. Strong positive effects on ecosystem functioning and fisheries productivity.	High feasibility (medium timeframe). Established through GFCM scientific and regulatory process. Requires proposal by national authority and approval by GFCM Scientific Advisory Committee. Well-established procedure, typically 2–4 years.	Medium acceptability. Short-term impacts on trawl fisheries, but long-term benefits for fisheries productivity and stock recovery. Offshore location reduces impact on small-scale coastal fisheries. Likely acceptable with proper stakeholder engagement, agreement for co-management, mapping and preservation (for fisheries) of shipping grounds, and compensation measures.
New FRA designation – Elasmobranch protection	FRA for elasmobranch habitats	Very high ecological gain. The Strait of Sicily hosts Important Shark and Ray Areas (ISRAs) and critical habitats for threatened species. Protection would address major conservation gaps for highly vulnerable taxa.	Medium feasibility. Same GFCM process as above. Requires strong scientific evidence but aligns with international conservation priorities (IUCN, GFCM).	Medium-high acceptability. Limited economic impact as elasmobranchs are mostly bycatch species. Some constraints on fishing gear, but relatively low socio-economic disruption compared to broad fisheries closures. Likely acceptable with proper stakeholder engagement, agreement for co-management, mapping and preservation (for fisheries) of shipping grounds, and compensation measures.
New FRA designation – Isidella VME protection	FRA for Deep-sea Isidella coral habitats	Very high ecological gain. <i>Isidella elongata</i> forests are vulnerable marine ecosystems (VMEs) highly sensitive to trawling. Protection would preserve biodiversity hotspots and deep-sea ecosystem integrity.	High feasibility. A strong legal and scientific framework already exists under GFCM and FAO VME protection guidelines. Precedents exist in Mediterranean FRAs.	Medium acceptability. Short-term impacts on trawl fisheries, but long-term benefits for fisheries productivity and stock recovery. Likely acceptable with proper stakeholder engagement, agreement for co-management, mapping and preservation (for fisheries) of shipping grounds, and compensation measures.

ABMT type	Area / Objective	Ecological gain	Legislative and procedural feasibility	Socio-economic acceptability
FRA enlargement – trawling ban extended to - 800 m	Deep-sea ecosystem protection	High ecological gain. Extends protection to deep-sea VMEs and enhances resilience of ecosystems vulnerable to trawling disturbance. Despite fishing effort in these areas seems to be limited, the measure would already improve ecosystem integrity and biodiversity conservation, and might become even more relevant in the future if a shifting of effort in these areas will be observed due to increased limitations in coastal ones.	High feasibility. Extension of existing measures is easier than creating new designation. Supported by GFCM deep-sea conservation commitments.	Medium acceptability. Limitations to fishing activities are always difficult to receive. However, limited economic impact is expected due to the limitation of the spatial scope of the measure.
New MPA designation – Pantelleria Island	Coastal and offshore biodiversity protection	Very high ecological gain. Pantelleria hosts seagrass meadows, volcanic habitats, and biodiversity hotspots. MPA designation would protect key habitats and enhance ecological connectivity.	Medium feasibility. National designation under Italian Law 394/1991 requires ministerial decree, consultation with Regione Siciliana, municipalities, and stakeholders. Typically, 3-5 years. Already included in the national candidate MPA list.	Medium acceptability. Potential constraints on fishing and development, but strong potential benefits for sustainable tourism and local economic development. Generally positive local perception if well managed.
New MPA designation – Banchi Graham	Offshore banks protection	Very high ecological gain. Offshore banks are biodiversity hotspots and stepping-stone habitats. Protection enhances connectivity and protects vulnerable benthic communities.	Medium feasibility. National designation is possible but offshore location requires coordination with fisheries authorities and national ministries.	High acceptability. Limited direct economic conflict due to limited exploitation, the proximity of an already existing FRA and the evidence of a limited fishing pressure at present. Benefits can be derived from co-management scheme with small-scale fisheries
Strengthening existing MPAs (Zone A and B expansion)	Increase strict protection levels	Very high ecological gain. Increased protection enhances effectiveness of existing MPAs, improving biodiversity conservation and ecosystem resilience.	High feasibility. Amendment of existing management plans is easier than new designation. Managed at national level.	Medium acceptability. Some local resistance possible from fisheries and tourism sectors but generally manageable.
Strengthening Natura 2000 protection (ban trawling)	Protect benthic habitats	Very high ecological gain. Direct protection of vulnerable benthic habitats and species already identified as conservation priorities.	Very high feasibility. Already supported by Habitats Directive legal framework and CFP Article 11.	Medium acceptability. Impacts trawl fisheries but improves ecosystem health and long-term fisheries sustainability.
New UNESCO MAB designation – transboundary area	Pantelleria, Pelagie, Malta, Tunisia	High ecological gain. Promotes integrated conservation and sustainable development across large ecological regions. Enhances ecosystem connectivity and international cooperation.	Medium feasibility. Requires multi-state coordination and UNESCO nomination process. Politically feasible but administratively complex.	Very high acceptability. Mostly governance and recognition tools. Limited regulatory restrictions. Strong tourism and international visibility benefits.

2.6. Prioritization of candidate ABMTs for implementation in the Strait of Sicily

Based on the feasibility assessment presented above, the proposed ABMTs can be prioritized. This prioritization supports a phased implementation approach aligned with the objectives of the Italian Maritime Spatial Plan and the EU Biodiversity Strategy for 2030.

High priority measures: immediate opportunities for implementation.

The designation of new FRAs to protect Essential Fish Habitats and vulnerable marine ecosystems, including *Isidella elongata* coral habitats, represents the highest priority category. These measures offer substantial ecological benefits by protecting critical nursery grounds, spawning areas, and vulnerable benthic habitats, while remaining highly feasible under the existing legal framework of the GFCM. The proposed enlargement of existing trawling restrictions to depths of 800 meters similarly represents a highly effective and feasible measure to strengthen the protection of deep-sea ecosystems.

The strengthening of conservation measures within existing Natura 2000 sites, particularly through the prohibition of bottom trawling and other destructive fishing practices, also represents a high-priority opportunity. These measures can be implemented within existing legal frameworks under the Habitats Directive and Common Fisheries Policy, and would significantly enhance the effectiveness of existing protected areas in achieving their conservation objectives.

The designation of new MPAs on offshore banks, including the Graham, Pantelleria, and Avventura banks, represents another high-priority measure. These offshore biodiversity hotspots play a key role in supporting marine biodiversity, ecological connectivity, and fisheries productivity, and their protection would significantly improve the ecological coherence of the ABMT network in the Strait of Sicily.

Strategic priority measures: high ecological value requiring longer-term implementation.

The designation of a new MPA around Pantelleria Island represents a strategic priority measure, offering significant ecological benefits while supporting sustainable tourism and ecosystem-based local development. However, its implementation requires national designation procedures and stakeholder consultation, resulting in longer implementation timelines.

Similarly, the proposed designation of a PSSA in the Strait of Sicily represents a strategic measure with substantial ecological benefits, particularly for marine mammal conservation and mitigation of maritime traffic impacts. However, this process requires international coordination and approval by the International Maritime Organization, and therefore represents a medium- to long-term implementation objective.

Enabling and supporting measures: strengthening governance and international cooperation.

The proposed designation of a transboundary UNESCO Biosphere Reserve, including Pantelleria, the Pelagie Islands, and adjacent marine areas, represents an important enabling measure to strengthen integrated ecosystem management and international cooperation. While this designation may not immediately impose legally binding restrictions on maritime activities, it provides a valuable governance framework supporting ecosystem-based management, scientific research, and sustainable development.

2.7. Feeding the MSP process

The results of this feasibility study will be presented to the Competent Authority for MSP and at the inter-policy technical table “MSP – MSFD – Biodiversity Strategy 2030 (Protected Areas and Restoration) – Fisheries Policies. Exchanges in this direction have been already undertaken and the meetings are scheduled within the agenda of implementation of the priority actions identified by the Italian MSP plan.

2.8. Results in light of EGD objectives

The results of the feasibility study strongly and practically support the realization of MSP-related objectives and the implementation of MSP measures directly in line with the objectives of the European Green Deal. The AMBTs identified all directly target the topic of Biodiversity and ecosystem protection and restoration, one of the six EGD topics considered by the MEDIGREEN project. The feasibility, analysis and prioritization results provide tangible elements for the Italian national technical table named “MSP – MSFD – Biodiversity Strategy 2030 (Protected Areas and Restoration) – Fisheries Policies, established in the framework of the Implementation of the Italian MSP process. The results of this study concretely address the national measure NAZ_MIS15, aiming to identify priority areas for environmental and marine-resource conservation, aligned with the MSFD Programme of Measures, Natura 2000 and the EU Biodiversity Strategy 2030 in the Italian MSP domain.

3. Transferability and upscaling

3.1. Transferability

The proposed action is transferable to other Mediterranean marine areas where high ecological value must be preserved within a context of multiple and interacting pressures. Many sub-regions of the Mediterranean Sea share characteristics similar to the Strait of Sicily: biodiversity hotspots, ecological connectivity corridors, intense fisheries activity, major maritime traffic routes, and emerging offshore energy developments. In such contexts, ABMTs represent flexible and adaptable instruments capable of addressing complex spatial conflicts while strengthening environmental protection.

ABMTs can be applied individually or in combination, depending on ecological priorities and governance needs. Their modular nature allows them to operate at multiple spatial scales – from local coastal zones to national waters and regional sea-basin levels. While ABMTs are often most effectively implemented at national scale, they are equally suitable for sub-national areas that are sufficiently extensive and ecologically complex to benefit from the coordinated application of multiple spatial tools. The Strait of Sicily represents such a case: a sub-national yet strategically significant area where the integration of FRAs, Natura 2000 strengthening measures, offshore MPAs, and maritime traffic management instruments provides a coherent and scalable management framework.

The enabling conditions for transferability rely primarily on a strong science-based approach. Robust ecological data, spatial pressure analysis, possibly, well-documented ecosystem-service assessments, and transparent stakeholder consultation processes are essential for successful replication. Political commitment is equally important and may need to operate at different governance levels depending on the type of measure. For example,

IMO-based instruments such as a PSSA require national-level political engagement, whereas strengthening Natura 2000 management or fisheries measures may be initiated through sectoral authorities with regional involvement.

From a legal perspective, transferability is facilitated by the fact that the legislative frameworks supporting these measures are already established at international and European levels. Instruments deriving from UNCLOS, the Convention on Biological Diversity, the Barcelona Convention, the Common Fisheries Policy, the Marine Strategy Framework Directive, and the Maritime Spatial Planning Directive have been transposed into national legislation in EU Member States. Therefore, implementation does not require the creation of new legal instruments but rather the coordinated use of existing ones. Where a country is not a party to certain conventions or is not aligned with a given framework, implementation may become more complex, as legal harmonization and institutional capacity-building would first be required.

As with all initiatives aimed at nature conservation, some ABMTs – particularly MPAs, Natura 2000 sites, FRAs areas, and the strengthening or enlargement of existing measures – require meaningful engagement with local communities and stakeholders. Fisheries operators, maritime transport actors, local administrations, and tourism stakeholders must be involved through science-based dialogue. Demonstrating the added value of protection measures is crucial, including evidence of spill over effects supporting fisheries productivity, maintenance of ecosystem assets that underpin sustainable tourism, and broader well-being benefits for local populations.

In this regard, the ecosystem services approach provides an effective framework for communication and consensus-building. By highlighting both monetary and non-monetary values of ecosystem protection – such as food provision, climate regulation, cultural identity, and risk reduction – it allows conservation measures to be framed not as constraints, but as long-term investments in natural capital and regional resilience.

For these reasons, the methodology and ABMT portfolio developed in the Strait of Sicily can be considered transferable across the Mediterranean basin, particularly in areas where ecological value and cumulative pressures intersect and where ecosystem-based maritime governance is being progressively strengthened.

3.2. Affordability

Affordability represents a critical dimension in the implementation of ABMTs, particularly in complex and data-intensive marine regions such as the Strait of Sicily. The establishment, strengthening, or enlargement of spatial protection measures relies fundamentally on the availability of robust scientific knowledge, which requires significant time, financial resources, and specialized expertise.

High-level scientific skills are necessary to document the status and dynamics of marine habitats, species, fish stocks, and underwater cultural heritage. Comprehensive ecological baselines must be supported by long-term monitoring data, including information on conservation status, population trends, fisheries catch, habitat condition, patterns of occurrence of pressures such as biomass extraction, pollution emissions, ship collisions or seabed disturbance. The availability, harmonization, and integration of these datasets into interoperable GIS platforms are essential to support spatial analysis and informed decision-making.

This requirement becomes particularly demanding in offshore and deep-sea environments, where ecological knowledge remains limited, and data acquisition is technically complex and costly. Offshore banks, deep-sea ecosystems (e.g., coral assemblages), knowledge about mobile species require advanced survey techniques (e.g., multibeam mapping, ROV exploration, acoustic monitoring), which significantly increase financial and logistical demands. Despite these challenges, a robust scientific knowledge base is indispensable for ensuring the credibility, legitimacy, and effectiveness of ABMT proposals.

The involvement of scientific institutions is therefore essential. Universities, marine research institutes, and specialized agencies provide the expertise required to generate, interpret, and validate data. However, scientific knowledge must also be translated into operational information that is functional for policy processes. Technical findings need to be synthesized into spatially explicit, decision-support formats that are accessible to public administrations and stakeholders. In this regard, uncertainty and data gaps must be transparently acknowledged and managed through precautionary and adaptive management approaches, ensuring that decision-making remains evidence-based while not being paralysed by incomplete knowledge.

Affordability also depends on administrative capacity. Effective implementation of ABMTs requires a strong command of international, European, national, and, where relevant, regional (sub-national) legislative frameworks. Public administrations must possess the technical know-how to initiate, coordinate, and follow procedural steps for designation processes under instruments such as the Common Fisheries Policy, the Habitats Directive, the Barcelona Convention, or the IMO framework. This includes drafting proposals, conducting consultations, preparing technical documentation, and ensuring inter-institutional coordination.

Human resources, institutional stability, and financial allocations are therefore decisive factors. Even when legal frameworks are already in place, insufficient administrative capacity may delay or weaken implementation.

It is of outmost importance that ABMTs, once established, are effectively managed according to a clear and verifiable management plan. This aspect is crucial not to leave the measures unimplemented. Availability of funds to ensure adequate human resources, clear surveillance and control schemes, are indispensable. Effective monitoring, control and enforcement mechanisms should ensure that violations of ABMT management plans are detected and sanctioned.

Finally, stakeholder engagement represents an additional affordability component. Depending on the type of measure – for example, MAPs, FRAs, Natura 2000 strengthening, or maritime routing measures – different stakeholder groups must be consulted and involved. These may include fisheries operators, port authorities, shipping companies, tourism actors, local communities, environmental NGOs, and research bodies. Meaningful engagement requires time, facilitation skills, and financial resources. Capacity to manage dialogue, address conflicts, and integrate stakeholder input into final decisions is essential for the legitimacy and long-term effectiveness of ABMTs.

3.3. Upscaling

The proposed action is well-suited for upscaling beyond the Strait of Sicily and can serve as a model for coordinated marine conservation across the Mediterranean basin. Ideally, its application across maritime borders would allow for a harmonized, integrated, and ecosystem-based approach to marine protection at regional scale. At sub-regional and

cross-border levels, upscaling would significantly enhance effectiveness. The Strait of Sicily itself is a transboundary ecological system connecting Italian, Maltese, and Tunisian waters. Ecological processes, migratory species, fish stocks, maritime traffic corridors, and environmental pressures do not follow administrative boundaries. Therefore, the coordinated application of ABMTs across maritime borders would allow for a more coherent implementation of the ecosystem-based approach.

A first key driver for upscaling is data sharing and scientific cooperation. The development of ABMTs requires extensive ecological, fisheries, oceanographic, and socio-economic data, which are costly and time-consuming to generate. Cross-border data sharing, harmonized monitoring protocols, and interoperable GIS systems would significantly reduce duplication of effort and costs, while increasing the scientific robustness of decision-making. Joint scientific assessments would also allow for consistent ecological baselines and more coherent conservation targets at sub-regional scale.

A second critical element is the adoption of a true ecosystem-based approach. Marine ecosystems, species distributions, and the pressures affecting them – including fishing, maritime transport, pollution, and climate change – operate across jurisdictional boundaries. Transboundary conservation measures would therefore better reflect ecological reality, ensuring protection of migratory corridors, shared fish stocks, and connected habitats. This approach would strengthen the ecological coherence of ABMT networks and reduce fragmentation of protection regimes.

Upscaling would also facilitate the achievement of conservation objectives under international and European policy frameworks, including, e.g., the Convention on Biological Diversity and the EU Biodiversity Strategy for 2030. A coordinated regional or sub-regional application of ABMTs would improve progress toward quantitative targets (e.g., 30% marine protection), strengthen monitoring and reporting consistency, and enhance policy coherence across governance levels.

The process of upscaling would benefit substantially from the support of regional organizations and macro-regional initiatives. In the Mediterranean context, the Barcelona Convention and its SPA/BD Protocol provide an existing legal and institutional framework for regional cooperation. Similarly, initiatives such as WestMED and EUSAIR (EU Strategy for the Adriatic-Ionian Region) offer governance platforms that can facilitate transboundary dialogue, funding coordination, and strategic alignment. The availability of common guidelines, shared technical standards, and dedicated funding mechanisms for cross-border and transnational projects would significantly increase the feasibility of scaling up.

However, upscaling also implies increased complexity. Involving multiple countries introduces legal, administrative, and political challenges. Not all Mediterranean countries share identical legal obligations or levels of integration within international frameworks. Effective upscaling would therefore need to rely on policy instruments that are mutually recognized, legally compatible, and incorporated into national legislation across participating states. In some cases, legal harmonization or institutional strengthening may be required before full implementation can occur. Stakeholder engagement, too, becomes more demanding at the transboundary scale. Consultation processes would involve a broader range of actors, including multiple national administrations, fisheries sectors operating in shared waters, maritime transport authorities, regional development bodies, and civil society organizations. This increases procedural costs and coordination requirements.

Nevertheless, the ecological benefits of coordinated ABMT implementation at a regional scale are substantial. Improved protection of shared ecosystems, enhanced resilience of fish stocks, reduction of cumulative pressures, and strengthened ecological connectivity would translate into long-term socio-economic benefits. These include increased fisheries sustainability, reduced environmental risk, enhanced ecosystem services (such as climate regulation and coastal protection), and stronger foundations for sustainable maritime economic activities.

In conclusion, while upscaling introduces governance and coordination challenges, the ecological and socio-economic returns justify the effort. A phased approach – beginning with sub-regional cooperation (e.g., Italy-Malta-Tunisia) and progressively integrating wider Mediterranean coordination – represents a realistic pathway toward strengthening ecosystem-based maritime governance across the basin.

4. Conclusion

This feasibility study demonstrates that the Strait of Sicily represents a strategic and operationally mature test case for the implementation of ABMTs within the framework of the Italian Maritime Spatial Plans and in direct support of national measure NAZ_MIS15. The study confirms that the MSP implementation phase provides a concrete institutional entry point – notably through the “MSP – MSFD – Biodiversity Strategy 2030 – Fisheries Policies” technical table – for translating scientific analysis into spatially explicit conservation proposals.

The Strait of Sicily combines exceptionally high ecological value with intense and cumulative maritime pressures. While a diversified portfolio of ABMTs is already in place – including MARPOL Special Area and SECA designations, GFCM Fisheries Restricted Areas, Natura 2000 sites, and national MPAs – significant ecological and functional gaps persist. Offshore banks, vulnerable deep-sea ecosystems, essential fish habitats, and ecological connectivity corridors remain underrepresented within the existing protection framework. Moreover, the current spatial coverage is insufficient to meet the quantitative and qualitative targets of the EU Biodiversity Strategy for 2030.

The study demonstrates that the ABMT toolbox available under international, European, regional, and national legal frameworks would significantly help to address these gaps without requiring new legislative instruments. Instead, effective progress depends on the coordinated and strategic use of existing mechanisms – including FRAs, MPAs, strengthened Natura 2000 measures, and maritime routing instruments such as PSSA designation. The feasibility assessment confirms that several measures – particularly new FRAs protecting essential fish habitats and vulnerable marine ecosystems, strengthening of Natura 2000 management, and the protection of offshore biodiversity hotspots – offer high ecological gain combined with strong legislative feasibility and acceptable socio-economic implications.

More complex measures, such as a PSSA or a transboundary UNESCO Biosphere Reserve, require longer timeframes and enhanced international coordination but provide significant strategic benefits in terms of ecosystem connectivity, megafauna protection, and governance integration.

From a broader Mediterranean perspective, the methodology and results of this study are transferable and scalable. The Strait of Sicily exemplifies a sub-national yet ecologically



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complex maritime region where modular and complementary ABMTs can be applied in combination to reconcile biodiversity conservation with fisheries, shipping, energy, and tourism. Upscaling – particularly through cross-border cooperation between Italy, Malta, and Tunisia – would enhance ecological coherence, improve data sharing, and strengthen progress toward regional biodiversity targets under the CBD and EU frameworks.

Affordability considerations highlight the central importance of scientific capacity, data integration, administrative competence, and stakeholder engagement. While the development and justification of ABMTs require substantial scientific and institutional investment – especially in offshore and deep-sea contexts – these costs must be viewed as investments in natural capital, ecosystem resilience, and long-term socio-economic stability.

In conclusion, the Strait of Sicily possesses both the ecological urgency and the institutional readiness to serve as a flagship case for ecosystem-based maritime governance in the Mediterranean. The proposed portfolio of ABMTs provides a coherent, feasible, and strategically aligned pathway to strengthen marine biodiversity protection, enhance ecosystem services, and contribute concretely to the objectives of the European Green Deal and the EU Biodiversity Strategy for 2030.

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National action #6: Small-Scale Fisheries in Maritime Spatial Planning: Developing Operational Guidelines (CORILA, IUAV, CNR)

1. Context and needs

1.1. SSF within the current Italian MSP framework

As defined by FAO (2001), Small-Scale Fisheries (SSF) are fundamentally characterised by their social, economic, and cultural integration within coastal communities. Beyond technical features such as vessel size and gear type, SSF typically involve labour-intensive operations using relatively small amounts of capital, reliance on local and traditional ecological knowledge, strong household and kinship-based organisation, and often occupational pluralism where fishing is combined with other livelihood activities (GFCM, 2023; Monnier et al., 2020).

In the Italian context, SSF encompasses artisanal fishing activities using vessels under 12 meters with passive gear, operating in coastal waters through multi-species targeting based on seasonal patterns and traditional practices. Italian SSF demonstrate strong embeddedness in local communities, close ties to local markets, and limited mobility and capacity to relocate when local resources decline, making them particularly vulnerable to spatial displacement and sensitive to planning decisions.

This national action is positioned within the implementation phase of Italy's Maritime Spatial Plans, officially approved in September 2024 (Ministerial Decree No. 237), covering three maritime areas: the Adriatic, the Ionian-Central Mediterranean, and the Tyrrhenian-Western Mediterranean. The Italian MSP framework identifies SSF as a priority sector requiring enhanced spatial management and better integration with other marine uses and conservation objectives.

Specifically, this action operationalises National Measures n°35 and n°36 of the Italian Maritime Spatial Plans, which call for:

- Measure 35: promotes agreements and co-management platforms between small-scale fishers and entities responsible for managing coastal and marine protected areas (Marine Protected Areas, Natura 2000 sites, national or regional parks with coastal and marine areas, etc.), to enhance the role of such areas in sustainable development and in recognising the quality, including environmental quality, of products and services offered by artisanal small-scale fisheries.
- Measure 36: calls for the development of local plans for small-scale fisheries containing spatial provisions and measures, based on the best available knowledge on fishing areas, and involving coastal communities and artisanal fishers.

Together, these measures establish the policy framework for:

- Enhanced coordination and co-management between SSF and marine protected areas.

- The development of spatial provisions specifically dedicated to small-scale fisheries.
- Participatory governance mechanisms that actively involve SSF stakeholders and coastal communities in planning processes.
- Integration of local and traditional knowledge into spatial management decisions.

Despite the strategic recognition of SSF in the MSP, a significant implementation gap exists between policy objectives and on-the-ground application. The transition from planning to implementation requires concrete operational methodologies that can guide regional and local authorities in effectively integrating SSF into spatial management frameworks while fostering synergies with existing conservation regimes, particularly Natura 2000 sites and Marine Protected Areas (MPAs).

1.2. From needs to the overall objective of the action

The action responds to three interconnected needs that have emerged as critical barriers to effective SSF integration in Italian maritime spatial plans.

First, spatial under-representation and designation gaps persist as small-scale fisheries remain largely invisible in formal spatial designations despite their socio-economic importance and extensive use of coastal waters. Unlike commercial fishing with clearly defined spatial footprints, SSF activities are often poorly documented, seasonally variable, and based on traditional knowledge. This leads to inadequate consideration of SSF spatial requirements in marine use zoning, potential conflicts with expanding marine protected areas and other conservation measures, limited recognition of traditional fishing grounds and practices in spatial planning decisions, and the risk of displacement of SSF communities from historically used areas.

Second, fragmented coordination with nature protection regimes prevents the realisation of potential synergies despite the shared interests of SSF and nature conservation in healthy marine ecosystems and sustainable resource use. Natura 2000 sites, MPAs, and Other Effective area-based Conservation Measures (OECMs) are managed through separate regulatory frameworks with limited coordination with fisheries management. Management plans for protected areas frequently lack adequate consideration of small-scale fishing activities and their potential compatibility with conservation objectives. In contrast, fisheries management measures rarely capitalise on the ecological benefits provided by marine protection. The absence of integrated spatial frameworks that simultaneously address conservation goals and SSF sustainability further compounds this fragmentation.

Third, limited and ineffective stakeholder engagement continues despite policy commitments to participatory governance, with SSF communities remaining marginalised in MSP processes. Insufficient mechanisms exist for meaningful participation of SSF representatives in spatial planning decisions, and limited capacity among SSF stakeholders hampers their ability to engage effectively in technical planning processes. The lack of co-design approaches that integrate local ecological knowledge and fishing practices into spatial management, combined with inadequate platforms for dialogue between SSF communities, conservation authorities, and MSP implementers, perpetuates this marginalisation.

The core challenge is translating policy into practice. This challenge is compounded by a fundamental data deficit: comprehensive spatial data on SSF activities, traditional fishing grounds, seasonal patterns, and gear-specific practices are largely absent or fragmented across different administrative levels and institutions. Without this foundational knowledge, current approaches lack systematic frameworks for mapping and characterising SSF spatial patterns and dynamics, clear criteria for identifying synergies and managing trade-offs between SSF and conservation, procedural guidance for participatory co-design processes, and monitoring frameworks for adaptive management. The absence of standardised data collection protocols and shared information systems between fisheries authorities, conservation managers, and MSP implementers further exacerbates this gap, making evidence-based decision-making nearly impossible.

In response, the **overall objective of the action** is to develop a replicable operational methodology for integrating SSF within MSP implementation at the regional/sub-area scale. This methodology embeds SSF directly into spatial planning processes, addressing all three barriers simultaneously: it makes SSF spatially visible through systematic data collection and mapping, creates coordination mechanisms between fisheries and conservation governance, and establishes participatory frameworks for stakeholder engagement. By providing regional and local authorities with concrete tools to operationalise Measures 35 and 36, the methodology bridges national policy and local implementation while remaining flexible enough to adapt to diverse ecological, social, and institutional contexts across Italy's marine regions.

1.3. SSF and Interacting Marine Sectors

Beyond SSF as the primary focus, the action necessarily engages with several secondary sectors and uses that interact with and influence small-scale fishing activities. Nature conservation and marine protection constitute a critical secondary sector, including management authorities for Natura 2000 sites, Marine Protected Areas, and emerging Other Effective Conservation Measures (OECMs). The relationship between SSF and these conservation regimes forms a core element of the methodology, as both share coastal spaces and potentially complementary objectives.

Commercial fishing activities, including trawling and larger-scale operations, represent another key sector given their spatial overlap with SSF grounds and potential resource competition, which can create displacement pressures on artisanal fishing communities. Similarly, recreational fishing has grown substantially in coastal areas, often targeting the same species and utilising the same spaces as SSF, creating both competition for resources and potential conflicts over access rights that must be addressed within spatial planning frameworks.

Coastal tourism and recreation present both opportunities and challenges for SSF integration, particularly where spatial overlaps exist and where potential synergies between fishing heritage, local seafood systems, and tourism experiences can be developed.

Finally, marine renewable energy and aquaculture emerge as sectors that increasingly compete for or share coastal space with SSF, requiring careful spatial allocation and potential co-use arrangements. The methodology developed by this action emphasises multi-sectoral coordination, recognising that effective SSF integration requires



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understanding and managing the complex web of interactions across all these sectors within MSP implementation.

1.4. Contribution to European Green Deal Topics

The action contributes primarily to two interconnected topics within the European Green Deal maritime dimension: Sustainable Sea-Food Production and Biodiversity and Ecosystem Protection and Restoration.

Under *Sustainable Sea-Food Production (C)*, the action directly advances *Sustainable fisheries (C.1)* by developing spatial and governance frameworks that support the ecological sustainability of SSF while maintaining their socio-economic viability. The methodology addresses area and time-based management measures that align fishing practices with ecosystem carrying capacity and seasonal ecological dynamics. The action also contributes to *Governance-related measures (C.5)* by establishing participatory co-design processes that enhance stakeholder involvement, improve coordination between authorities, and create adaptive management frameworks. The action recognises that sustainable fisheries require effective governance arrangements that engage fishing communities as active partners in management, not merely technical measures.

Under *Biodiversity and Ecosystem Protection and Restoration (D)*, the action significantly contributes to the establishment of new or enlargement of Natura 2000 and OECMs (D.1.2) by developing methodologies that enhance the effectiveness of existing protected areas and facilitate the designation of new conservation measures that explicitly integrate SSF considerations. The action explores how SSF spatial management can contribute to conservation objectives and how protected areas can be designed to accommodate compatible fishing practices. The methodology also promotes *Ecological connectivity (D.1.4)* through spatial configurations that enhance connectivity between protected areas, recognising that mobile fish species and ecosystem processes require network-based protection approaches and that SSF management can both support and benefit from this connectivity. Finally, the action strengthens *Governance-related measures (D.4)* by creating coordination mechanisms between conservation authorities and fisheries management and establishing platforms for integrated decision-making that simultaneously addresses conservation and sustainable use objectives.

2. Implementation

The action develops a systematic operational guideline for integrating Small-Scale Fisheries within MSP implementation at the regional level (coastal sub-area²³). This methodology is designed to be embedded directly within MSP processes while remaining flexible enough to accommodate diverse ecological, social, and institutional contexts across Italy's maritime areas.

²³ Coastal sub-areas refer to the spatial subdivisions established within Italy's three maritime areas to improve the MSP planning process and enhance coordination among involved actors. The three maritime areas have been divided into 18 coastal sub-areas and 9 offshore sub-areas. In the case of coastal sub-areas, regional administrative boundaries extend up to 12 nautical miles, providing Regions with the possibility to determine their own planning framework within their respective sub-areas.

Within the national MSP implementation process, dedicated technical working groups (“tavoli tecnici”) are foreseen to address specific thematic priorities. One of these tables focuses explicitly on the synergies between fisheries, nature protection, and MSP. This institutional setting represents the most appropriate forum for presenting and discussing the proposed action in an integrated manner, as it directly addresses the interface between small-scale fisheries, conservation measures (including MPAs and Natura 2000), and spatial planning provisions.

The convening of these technical tables falls under the responsibility of the MIT, which oversees MSP implementation at the national level. While other thematic tables are currently active, the one dedicated to fisheries–nature–MSP synergies (most relevant to this action) has not yet been activated, and its timeline remains uncertain.

As proponents of this action, we cannot independently convene such a forum; however, we formally commit to presenting the methodology within that framework as soon as the relevant table is activated. In this sense, with reference to the question “Has the action been implemented?”, the methodology has not yet been formally implemented through the national MSP technical governance structures, but a clear pathway for institutional presentation and integration has been identified and is dependent on the activation of the appropriate technical working table.

2.1. Pillars

The methodology is structured around four interconnected pillars that address the barriers identified in Section 1.2:

Pillar 1: Spatial Characterisation and Data Integration

Addressing the fundamental data deficit in SSF spatial information, this pillar develops systematic frameworks for:

- Participatory mapping of SSF spatial patterns: Combining Volunteered Geographic Information (VGI) from fishing communities with official data sources (VMS where available) and scientific survey data. The methodology employs participatory GIS techniques adapted from recent Mediterranean experiences (Carrà et al., 2017), enabling fishers to directly contribute their knowledge of traditional fishing grounds, seasonal patterns, and gear-specific practices.
- Multi-temporal spatial analysis: Recognising the high spatial and temporal variability characteristic of SSF (Raicevich et al., 2020), the methodology incorporates seasonal mapping protocols capturing monthly and annual variations in fishing effort distribution, species targeting, and gear deployment patterns.
- Conflict and synergy mapping: Systematic identification of spatial overlaps and interactions between SSF and other marine uses (commercial fishing, recreational fishing, marine protected areas, tourism, aquaculture, renewable energy), distinguishing between competitive interactions requiring spatial allocation decisions and potential synergies enabling co-use arrangements (Grati et al., 2022).

Pillar 2: Co-Management Platform Development

Operationalising MSP Measure 35's call for co-management platforms between SSF and protected area authorities, this pillar establishes:

- Multi-stakeholder governance structures: Building on Sicily's Local Management Plan (LMP) experience (Carrà et al., 2017), the methodology adapts participatory

governance models to MSP implementation contexts. Governance platforms include representatives from SSF cooperatives/organisations, MPA/Natura 2000 management authorities, regional MSP implementation bodies, scientific institutions, and other relevant marine use sectors.

- Structured dialogue protocols: Establishing regular technical meetings, annual strategy reviews, and conflict resolution mechanisms that enable systematic communication between SSF communities and conservation/planning authorities. The methodology draws on the GFCM Regional Plan of Action for SSF principles (GFCM, 2023), emphasising meaningful participation beyond token consultation.
- Joint decision-making frameworks: Procedures for collaborative development of spatial provisions, management measures, and monitoring protocols, ensuring SSF considerations are incorporated throughout the MSP planning cycle rather than as afterthoughts.

Pillar 3: Local Spatial Planning Integration

Operationalising MSP Measure 36's call for local plans containing spatial provisions, this pillar develops:

- Sub-area planning protocols: The methodology operates at the sub-area level. This scalar approach recognises that effective SSF management requires finer spatial resolution than basin-wide MSP frameworks typically provide.
- Spatial provision typologies: The methodology distinguishes between different types of protected areas and develops tailored integration pathways for each. *For areas without existing management plans (e.g., Natura 2000 sites lacking specific regulations):* Integration pathways that simultaneously develop conservation management frameworks and SSF spatial provisions, ensuring SSF is embedded from the outset rather than accommodated post-hoc. This includes identifying SSF practices compatible with conservation objectives, establishing access rights and effort controls, and developing monitoring systems. *For Marine Protected Areas with existing management plans:* Synergy identification and coordination enhancement approaches that review existing MPA zonation and regulations, assess compatibility with SSF activities, identify opportunities for adaptive co-management, and establish formal coordination mechanisms between MPA authorities and SSF organisations.
- Spatial measure portfolio: A catalogue of spatial management options adapted to SSF contexts, including: preferential access zones for SSF within coastal bands (leveraging CFP provisions for 12nm coastal access); seasonal area closures coordinated with ecological cycles and SSF practices; gear-specific spatial allocations that separate conflicting fishing methods; buffer zones around sensitive habitats with SSF-compatible regulations; and collaborative surveillance arrangements where SSF communities participate in monitoring and enforcement.

Pillar 4: Monitoring and Adaptive Management

Recognising that effective integration requires ongoing assessment and adjustment, this pillar establishes:

- Indicator frameworks: Building on Sicilian LMP monitoring experience (Carrà et al., 2017), the methodology employs biological indicators (CPUE by gear and species, size composition of catches), technical indicators (fishing effort distribution, gear selectivity), economic indicators (value per vessel, income stability), and social indicators (employment, stakeholder satisfaction, conflict incidence) to track outcomes across sustainability domains.

- Participatory monitoring systems: Engaging SSF communities directly in data collection through simplified reporting protocols, mobile applications for effort and catch recording, and fisher-led ecological observations that contribute to both stock assessment and adaptive management (European Commission, 2023).
- Adaptive management cycles: Annual review processes that assess indicator performance against baseline and reference points, identify emerging issues or opportunities, and enable timely adjustments to spatial provisions and management measures. These indicators will be embedded and aligned within the monitoring program provided by the national maritime spatial plans. This iterative approach ensures the methodology remains responsive to changing ecological, social, and economic conditions.

2.2. Methodological Application Process

The methodology is applied through a sequential but yet context-sensitive process, structured to account for differences in regional governance maturity and data availability. While the four methodological pillars remain constant, their operationalisation varies depending on the institutional maturity and data availability of the target region, allowing SSF-related knowledge and governance mechanisms to be progressively integrated into the analytical, interaction, strategic, and spatial planning stages of MSP.

The integration of results occurs at the MSP sub-area scale, ensuring alignment with the formal national maritime spatial plans.

2.2.1. Institutional Responsibilities

At the national level, the Ministry of Infrastructure and Transport (coordinating MSP implementation) and the Ministry of Agriculture, Food Sovereignty and Forestry (responsible for fisheries management) provide strategic oversight, ensure consistency across sub-areas, and validate regional spatial provisions for integration into national MSP frameworks. At the regional level, Regional Administrations exercise planning competence within 12 nautical mile coastal sub-areas, leading stakeholder engagement, coordinating co-management platform establishment, and formally adopting spatial provisions within regional maritime spatial plans. Regional fisheries departments serve as primary liaisons with SSF communities and existing governance structures such as consortia and producer organisations.

SSF organisations, including cooperatives, consortia (CO.GE.PA), and producer organisations, represent fishing communities in governance platforms, contribute local and traditional ecological knowledge, participate in participatory mapping and monitoring, and support communication with broader SSF communities. MPA and Natura 2000 managing authorities provide conservation expertise, contribute ecological data, participate in compatibility assessments, and ensure coordination between spatial provisions and conservation management plans.

Non-governmental organisations (NGOs) play multifaceted roles, including advocacy for SSF rights and sustainable practices, technical support for capacity building and participatory processes, facilitation of multi-stakeholder dialogue and conflict mediation, independent monitoring and civil society oversight of implementation, and connection to international networks and best practices. Environmental NGOs contribute conservation expertise and support compatibility assessments between SSF and biodiversity objectives, while

fisheries-focused NGOs provide technical assistance to SSF communities and advocate for their inclusion in decision-making processes. NGOs also serve as bridges between local communities and institutional actors, often facilitating communication and trust-building in contexts where historical tensions exist between fishers and authorities.

2.2.2. Operational steps

Step 0: Regional Governance and Data Screening

(Aligned with MSP phase 1 process: *Current status and future trends*)

A preliminary screening assesses the institutional and data readiness of the region.

This phase includes:

- Assessment of the existence of regional SSF instruments (e.g., Local Management Plans, regional fisheries action plans, co-management structures);
- Mapping of institutional responsibilities across fisheries, MSP, Natura 2000, and MPAs;
- Identification of available datasets and common repository/gathering data platform²⁴ (VMS, logbooks, landing declarations, scientific surveys, participatory data, observatories);
- Evaluation of stakeholder representation structures and organisational capacity within SSF communities;
- Identification of existing spatial measures affecting SSF (including MPA management provisions).

The screening phase determines the operational entry point of the methodology, distinguishing between:

- Regions with structured SSF governance frameworks, where the methodology builds upon and integrates existing instruments;
- Regions with limited or fragmented frameworks, where the methodology supports institutionalisation and formal recognition of SSF within MSP.

Step 1: SSF Baseline Assessment

(Aligned with MSP phase 1: *Current status and future trends*)

Building on the screening results, this stage consolidates available knowledge and activates stakeholder engagement.

Activities include:

- Scoping of SSF activities, spatial patterns, and socio-economic characteristics within the target sub-area;

²⁴ The choice of a **common repository and data-gathering platform** is a critical and often underestimated decision (MSC, 2024). Rather than developing new, context-specific or project-dedicated platforms, it is strongly recommended to build upon and integrate with existing tools and infrastructures, in order to ensure interoperability, and scalability of data from the regional to the national and EU level. A notable best practice in this regard is **DatAlboran**, a software tool and associated database developed in 2022 through a collaborative initiative led by Motril's Fisheries Producer Organisation (FPO) and the NGO SoldeCocos in the North Alboran Sea (Spain). DatAlboran was specifically designed to address information gaps on fisheries' environmental impacts and stock status by integrating data collected through a participatory process involving fishers, scientists, NGOs, and national and regional administrations. Its scope encompasses stock assessments, bycatch and discard characterisation, as well as monitoring of endangered, threatened and protected (ETP) species and sensitive habitats. What makes DatAlboran particularly relevant as a model is not only its multi-actor, co-designed nature, but also its ambition to serve as a shared and interoperable infrastructure (MSC, 2024). This approach reflects a broader principle that should guide MSP and fisheries data governance: the platform undermines data comparability and supports the aggregation of information at the scale required for EU-level reporting obligations.

- Compilation and harmonisation of existing datasets;
- Identification and mapping of relevant stakeholders across fisheries, conservation, planning authorities, and other marine use sectors;
- Establishment (or consolidation) of a core working group representing key stakeholder categories;
- Preliminary mapping of spatial conflicts and synergies requiring MSP attention.

In regions with existing SSF plans, this step focuses on consolidating and updating information; in regions without structured frameworks, it includes trust-building and capacity development activities.

Step 2: Interaction Analysis

(Aligned with MSP Phase 2: Use-Use and Use-Environment interactions)

This step operationalises Pillar 1. Building upon the analytical baseline, this phase integrates SSF within MSP conflict and synergy analyses.

Activities include:

- Spatial analysis of interactions between SSF activities, protected areas (MPAs and Natura 2000), and competing maritime uses;
- Identification of potential synergies with conservation measures and spatial incompatibilities requiring planning intervention.
- Participatory spatial mapping documenting traditional fishing grounds, seasonal patterns, and local ecological practice;
- Integration of participatory data with official monitoring systems and scientific information;

Outputs from this stage directly feed into the MSP interaction analysis between maritime uses and environmental components.

Step 3: Co-Management Framework Design and Institutional Alignment

(Aligned with MSP Phases 3 and 4. Strategic planning of subareas with specific reference to OS_P103, Promotion, development and spatial management of sustainable small-scale coastal fisheries)

This step operationalises Pillar 2 by linking the SSF integration pathway to the strategic objectives defined within the Maritime Spatial Plans, particularly OS_P103, which promotes the sustainable development and spatial recognition of small-scale coastal fisheries as an economically, socially, and territorially embedded activity. Within this strategic framing, MSP is expected to support the long-term viability of SSF communities through the identification, where appropriate, of marine areas dedicated to sustainable fishing practices, while fostering technological innovation, knowledge integration, and cross-sectoral synergies with related value chains such as tourism, local food systems, and processing industries.

Activities include:

- Formalisation or adaptation of a multi-stakeholder governance platform (Grat et al., 2022);
- Definition of mandate, membership criteria, and decision-making procedures;
- Establishment of coordination mechanisms between SSF organisations, MPA/Natura 2000 authorities, and MSP regional bodies;
- Creation of thematic working groups addressing access rules, compatible practices, monitoring protocols, and conflict resolution;
- Capacity-building initiatives to ensure effective SSF participation in technical planning processes.

In regions with existing SSF governance structures, this step focuses on institutional alignment and vertical integration with MSP authorities.

In regions without such structures, it represents the establishment of new co-management mechanisms.

Step 4: Development and Integration of Spatial Provisions within MSP

(Aligned with MSP Phases 3 and 4. Strategic planning of subareas with specific reference to OS_P|03, Promotion, development and spatial management of sustainable small-scale coastal fisheries)

This step operationalises Pillar 3 and represents the core integration moment between SSF governance and MSP implementation.

At the sub-area scale defined by the national maritime spatial plans framework, spatial evidence and governance agreements are translated into formal planning provisions.

Activities include:

- Promoting local spatial planning provisions integrating SSF within the MSP framework;
- Scenario analysis of alternative spatial configurations;
- Negotiation and consensus-building around spatial allocations, preferential access zones, seasonal closures, buffer zones, and compatible-use regulations;
- Technical refinement of spatial measures to ensure legal clarity and enforceability.

The outputs of this stage are incorporated into the national maritime spatial plans sub-area strategy, either through:

- Identification of sub-area-specific MSP objectives related to the spatial sustainability and continuity of SSF activities;
- Integration into planning units;
- Inclusion of regulatory or strategic provisions;
- Formal recognition of co-management arrangements;
- Alignment with existing protected area management plans;
- Definition of regionally tailored MSP measures supporting SSF access, compatibility of uses, and ecosystem-based management practices.

This approach ensures that locally developed SSF provisions are embedded within the formal MSP architecture. Moreover, it provides dual functionality: in regions where SSF activities are limited or absent, the MSP process serves as a tool for promotion by defining specific objectives and measures to support potential SSF development; in regions where SSF is already present, the methodology reinforces existing frameworks, integrating SSF considerations into planning units and spatial/regulatory provisions.

Step 5: Implementation, Monitoring, and Adaptive Feedback

(Aligned with MSP Phase 5. Monitoring program and Phase 6. Implementation)

The final step operationalises Pillar 4 and ensures the long-term integration of small-scale fisheries (SSF) into the MSP framework. Activities include:

- Formal adoption of spatial provisions through regional or national procedures.
- Communication and outreach to broader stakeholder communities, ensuring awareness and engagement of SSF actors.
- Deployment of monitoring systems using biological, technical, economic, and social indicators, with particular attention to metrics relevant for SSF. These include social and economic indicators such as employment levels, income stability, and

diversification opportunities; technical and operational indicators such as fleet activity, gear use, bycatch rates, and energy efficiency; and environmental indicators, including seabed impact and interactions with protected habitats. This comprehensive approach allows for continuous assessment of SSF sustainability, supports adaptive management, and strengthens the integration of SSF data into the MSP plans monitoring framework, building upon and complementing existing national indicators.

- Annual adaptive review cycles that evaluate indicator performance, identify emerging issues or opportunities, and enable timely refinement of spatial provisions and management measures.

Monitoring results feedback both into regional governance processes and the national maritime spatial plans review cycles, reinforcing the adaptive and iterative nature of MSP while ensuring that SSF considerations remain embedded in strategic and operational planning.

2.3. Implementation timeline

The methodology follows an indicative timeline balancing thoroughness with implementation urgency:

Step	Duration	Key Milestone
Step 0	3-6 months	Governance/data screening complete; entry point determined
Step 1	6-9 months (overlap with Step 2 from month 4)	Baseline assessment finalised; working group established
Step 2	9-15 months	Spatial characterisation complete; interaction analysis integrated into MSP
Step 3	12-18 months (overlap with Step 2 from month 10)	Co-management platform operational; coordination mechanisms established
Step 4	18-30 months	Spatial provisions formally adopted and integrated into MSP sub-area plans
Step 5	From month 24	First annual monitoring cycle complete; adaptive management operational

Total duration: 24-36 months for full implementation, followed by continuous adaptive management cycles. The timeline accommodates regional variation, with data-rich regions potentially accelerating early phases while regions building governance capacity from scratch may require an extended Step 3 duration.

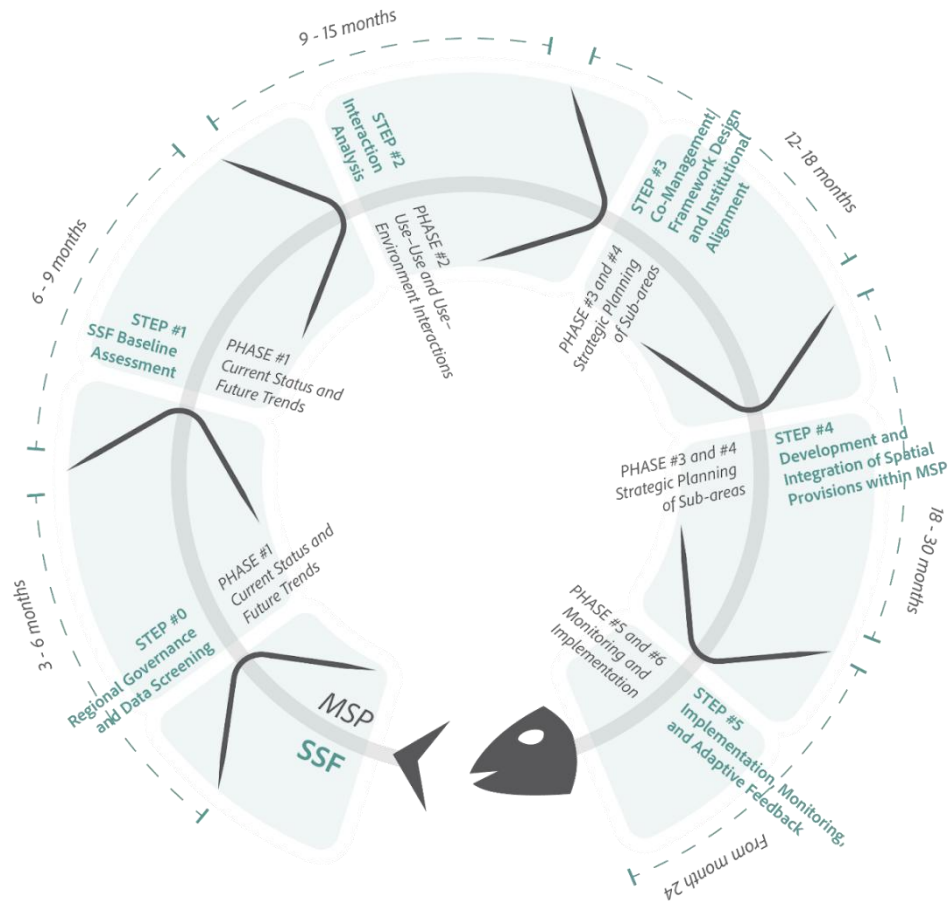


Figure 27. SSF methodology steps and the corresponding MSP phases.

3. Transferability and upscaling

3.1. Transferability

The guidelines for integrating SSF into MSP processes address a governance challenge that operates across multiple scales. While operationalised at the coastal sub-area level, the methodology responds to issues ranging from highly localised spatial conflicts to national strategic planning frameworks, with potential relevance at the Mediterranean and broader EU levels.



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At the local scale, SSF is deeply place-based. Fishing grounds are fine-grained, seasonally variable, and gear-specific, often closely tied to community identity and livelihoods. Conflicts emerge where SSF overlaps with other maritime uses such as marine protected areas (MPAs), Natura 2000 sites, tourism, aquaculture, offshore energy, and other fisheries segments. Effective integration, therefore, requires participatory mapping, spatial knowledge and harmonisation, and dedicated governance mechanisms.

At the national level, maritime spatial plans frequently include strategic objectives for sustainable fisheries but lack operational pathways to translate them into sub-area-specific spatial provisions. The methodology addresses this gap by embedding SSF considerations throughout the MSP cycle: baseline assessment, interaction analysis, definition of strategic objectives, sub-area planning, and monitoring—phases that are both commonly found in strategic planning processes and integral to MSP implementation frameworks.

In this sense, the methodology is relevant for other coastal regions and national contexts with similar conditions: predominantly small-scale fleets, limited spatial data, overlapping conservation frameworks, and evolving co-management practices. Accordingly, it can be adapted to regions operating under comparable institutional and policy frameworks.

Transferability depends on enabling conditions, including a functioning MSP framework with clearly defined sub-area scales and assigned responsibilities, and institutional willingness to integrate SSF into multi-stakeholder planning processes. Even in regions with limited SSF governance, minimal coordination between fisheries authorities and MSP bodies allows the methodology to be applied progressively.

Importantly, the methodology is process-oriented and does not prescribe fixed spatial solutions but defines a structured sequence of actions (screening, baseline assessment, interaction analysis, co-management platform development, spatial provision integration, and adaptive monitoring) that can be calibrated to institutional maturity and local conditions. This modularity enables application in diverse ecological, social, and governance contexts, including data-poor areas or regions with emerging SSF structures.

A core strength of the methodology is its dual functionality. In regions where SSF is limited, MSP can act as a strategic promotion tool, defining sub-area-specific objectives and measures to support sustainable development and community revitalisation. Where SSF governance structures are already established, the methodology strengthens and harmonises these frameworks with MSP strategic and spatial provisions as well as monitoring programmes, ensuring vertical coherence and regulatory integration. By directly incorporating SSF into the planning cycle and linking spatial allocations with adaptive monitoring, the approach secures durable integration without duplicating existing processes.

This combination of scalability, modularity, and procedural alignment underpins its transferability, making it applicable across Italy's coastal sub-areas and in other Mediterranean or EU regions where small-scale fisheries coexist with conservation objectives and competing maritime uses under formal MSP frameworks.

3.2. Affordability

Knowledge and Data Requirements

A key barrier to integrating SSF into MSP is the critical knowledge gap on spatial, ecological, socio-economic, and institutional aspects of small-scale fisheries. The proposed guidelines directly address this by generating and consolidating essential data. Core information includes SSF activity patterns (locations, seasonal variations, gear use), fleet composition, catch volumes, and interactions with other maritime uses such as MPAs, Natura 2000 sites, tourism, aquaculture, and offshore energy. Complementary ecological data on seabed habitats and species distributions support conflict and synergy analyses. Where historical datasets are limited, participatory approaches (such as voluntary geographic information (VGI) and fisher-led mapping) enable incremental knowledge building while fostering stakeholder trust. Socio-economic data on employment, income stability, diversification, and community structures are also critical for defining realistic objectives and assessing outcomes. By explicitly targeting these knowledge gaps, the methodology ensures SSF considerations are evidence-based and effectively embedded within the MSP cycle.

Technical Skill Requirements

Implementing the methodology requires moderate technical expertise across several domains. Spatial analysis skills, including GIS proficiency and management of multi-temporal and multi-source datasets, are needed to produce reliable interaction maps. Knowledge of ecological dynamics and fisheries science is essential for interpreting environmental indicators and evaluating sustainable access measures. Governance and stakeholder engagement skills are critical to establishing multi-stakeholder co-management platforms, facilitating structured dialogue, and negotiating spatial provisions. The methodology is modular: it can operate at a basic level with simplified participatory mapping and analysis, while advanced applications integrate complex ecological models, socio-economic assessments, and detailed monitoring systems.

Financial Considerations

Costs can be moderate if the methodology leverages existing institutional capacities, networks, and monitoring infrastructures. Main cost components include:

- Stakeholder engagement and facilitation, encompassing workshops, technical meetings, capacity-building, and participatory mapping.
- Spatial data management, including development of databases, data flow and GIS platforms.
- Monitoring and evaluation systems for biological, technical, economic, and social indicators.
- Specialised scientific support for ecological assessments and alignment with MSP implementation.

Financial burdens can be reduced by using existing governance networks, such as cooperatives, consortia, and producer organisations, and by integrating monitoring with ongoing national or regional programmes, including PGSM initiatives. Additional support can rely on European funding sources, such as the European Maritime, Fisheries and Aquaculture Fund (EMFAF), covering participatory processes, co-management development, and monitoring systems.



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Adaptability to Resources

A key strength of the methodology is its scalability relative to available resources. In well-resourced regions, implementation can include high-resolution spatial analysis, extensive ecological monitoring, and multi-year adaptive cycles. In resource-limited contexts, a lighter approach can prioritise participatory mapping, essential co-management platform establishment, and basic monitoring of socio-economic indicators, gradually expanding as capacity grows.

3.3. Upscaling

The operational guidelines are designed to scale beyond the regional scale. Its principles, processes, and tools can be applied across larger geographic scales and multi-regional contexts, supporting coordinated planning within national waters and across transboundary maritime areas.

The methodology could inform basin-level MSP strategies by aggregating sub-area data, identifying systemic patterns of SSF activity, and highlighting cross-cutting spatial conflicts or synergies. For instance, the spatial interaction mapping and co-management frameworks developed at the sub-area level should feed into national strategies, supporting coordinated planning across multiple coastal regions and enabling harmonised approaches.

Regional and international institutional frameworks offer additional pathways for upscaling. Organisations such as the IOC, UNESCO MSP Global, Barcelona Convention, the WestMed Initiative, or the Union for the Mediterranean (UfM) could endorse or support the methodology by integrating its principles into regional guidelines or capacity-building programs. Such endorsement would not only increase visibility but also promote convergence in SSF governance practices across Mediterranean countries (EU-Extra EU), facilitating knowledge exchange and the harmonisation of spatial management measures. Participation in regional initiatives could also enhance access to technical expertise, shared datasets, and funding opportunities, further enabling large-scale implementation.

Cross-border and transboundary cooperation represents another dimension of upscaling potential. Many small-scale fleets operate in contiguous national waters or shared ecological systems, such as straits, estuaries, or migratory species habitats. Coordinated application of the methodology could support the alignment of spatial provisions, monitoring protocols, and co-management platforms across borders, reducing conflicts, improving ecosystem-based management, and fostering socio-economic resilience for SSF communities. Importantly, the methodology's modularity and process-oriented design pave the way to integrate locally driven initiatives into broader regional frameworks without requiring uniform site-specific solutions.

4. Conclusion

This action has developed a systematic methodology to integrate Small-Scale Fisheries (SSF) into Maritime Spatial Planning (MSP) at regional and sub-area levels. It directly addresses three key barriers: spatial under-representation, fragmented coordination with conservation frameworks, and limited stakeholder engagement. By operationalising national MSP Measures 35 and 36, the methodology provides a practical bridge between



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policy objectives and on-the-ground implementation while remaining flexible across diverse ecological, social, and institutional contexts.

The methodology follows a sequential, context-sensitive process comprising five operational steps: regional governance and data screening, SSF baseline assessment, interaction analysis, co-management framework design, and development and integration of spatial provisions within MSP. Each step corresponds to one or more of the methodology's four pillars—spatial characterisation and data integration, co-management platform development, local spatial planning integration, and monitoring with adaptive management—ensuring that SSF activities are made visible, interactions with other maritime uses are analysed, governance platforms are operational, and spatial provisions are embedded within formal planning instruments. This structure enables a systematic, evidence-based approach that accommodates both well-documented and data-limited contexts, ensuring adaptive management and iterative learning throughout the MSP cycle.

A central strength of the methodology is its modularity and scalability. In regions with limited SSF governance, it can be applied progressively, focusing initially on participatory mapping, stakeholder engagement, and baseline data collection, while gradually expanding to more complex analyses, co-management arrangements, and integrated monitoring systems. In regions with established SSF frameworks, the methodology reinforces and harmonises existing practices, aligning local and regional management with national MSP strategies. Beyond the regional scale, it can be adapted to basin-level, cross-border, and transboundary contexts, supporting harmonised spatial provisions, monitoring protocols, and co-management platforms across multiple countries and institutional arrangements.

Financial and technical requirements are moderate and adaptable. By leveraging existing governance networks, institutional monitoring infrastructures, and European funding mechanisms such as the European Maritime, Fisheries and Aquaculture Fund (EMFAF), the methodology can be implemented efficiently without duplicating efforts. Technical expertise in spatial analysis, ecological assessment, and stakeholder facilitation is required, but the approach is designed to accommodate varying levels of capacity and resources.

In summary, the methodology provides a replicable, process-oriented operational framework that systematically integrates SSF into MSP. It strengthens the ecological, social, and economic resilience of small-scale fisheries, promotes coordination with conservation and other maritime sectors, and ensures that spatial planning decisions are participatory, adaptive, and evidence-based. Its modular and scalable design makes it a robust tool for advancing integrated maritime governance, capable of supporting sustainable fisheries and informed spatial management in Italy and beyond.



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National action #7: Sustainable aquaculture development through MSP supporting AZA planning in Italian coastal regions (AZA-PLANNING in action) (IUAV)

1. Context and needs

Italian Maritime Spatial Planning (MSP) plans were formally approved in 2024 through Decree n. 237 of 25 September 2024. These plans represent an important step in the implementation of a coordinated framework for the sustainable use of marine space and resources. Among the various maritime sectors considered within the MSP process, aquaculture has been recognized as a strategic activity with significant potential for economic development and food production. The MSP plans therefore include specific considerations and indications related to the aquaculture sector. In particular, they provide **strategic guidance** by **identifying planning units where aquaculture may have priority**, and where the activity could be developed in a sustainable way. An example of Italian Adriatic MSP plans provisions is shown in figure 28. In addition to the spatial identification of suitable areas, the MSP plans also define a number of measures intended to facilitate the orderly development of the sector and to ensure that aquaculture activities are compatible with other maritime uses and with environmental protection objectives. One of the most relevant measures included in the MSP plans concerns the definition, adoption, and implementation of Allocated Zones for Aquaculture (AZA) plans. This measure is identified as **NAZ_MIS/44** and focuses on **“Developing, adopting, and implementing AZA plans at the regional scale, and aligning them with MSP plans”**.

The concept of AZA originates from the international framework developed by the Food and Agriculture Organization of the United Nations (FAO) and, in particular, from the work of the General Fisheries Commission for the Mediterranean (GFCM). AZA plans are sectorial plans for aquaculture, responding to the provisions of the GFCM Resolution GFCM/36/2012/1 on allocated zones for aquaculture, which encourages Mediterranean countries to identify and manage areas specifically designated for aquaculture development. The objective of this approach is to promote the sustainable growth of aquaculture by ensuring that farming activities are located in areas where environmental, social, and economic conditions are appropriate.

At present, **technical guidelines for the selection and identification of AZAs** have been developed and made available by the GFCM (Macias et al., 2019; Fourdain et al., 2024) as well as by the Italian National Institute for Environmental Protection and Research (ISPRA) (Marino et al., 2020). These guidelines provide scientific and technical support for identifying suitable areas, considering factors such as environmental conditions, carrying capacity, potential interactions with other maritime uses, and the need to safeguard marine ecosystems. However, despite the availability of these guidelines, **there is still a significant lack of harmonization in the administrative procedures** currently adopted by the various Italian coastal regions to define and implement AZA plans. Differences exist in several aspects of the process, including the possibility to use existing monitoring data for characterizing the environment, the methodologies used for site selection, the criteria applied for evaluating environmental suitability, and the institutional procedures followed

for the formal adoption of the plans. It is worth noting here that some of these aspects have been defined in the National Guidelines produced by Ispra, but show differences in application.

Another aspect where significant variability exists concerns the type of output expected from the AZA planning process. In some cases, the process results primarily in the production of suitability maps that identify areas potentially appropriate for aquaculture development. In other cases, however, the expected output is a proper planning document, that includes detailed zoning, management measures, and operational rules to support the management of aquaculture activities within the designated areas. **The lack of a standardized approach to define the content and structure of AZA plans makes it more difficult to ensure consistency across regions and may create uncertainty for both public administrations and aquaculture operators.**

Further uncertainties concern the need of a **Strategic Environmental Assessment (SEA) phase** as part of the AZA planning process. While in some regions the SEA procedure is necessary, due to the potential environmental implications of spatial planning decisions (e.g., fish farms above a certain surface require EIA), in other regions its application remains unclear or has not been fully defined. This lack of clarity can lead to different interpretations and practices, further contributing to the overall lack of harmonization at the national level.

In addition to these procedural issues, there is also limited clarity at the national level regarding the administrative authorization process that will follow the designation of AZAs. For example, it is not yet fully defined whether the designation of an AZA will lead to an automatic approval of requests for concessions within the designated area, or whether individual proposals for aquaculture installations will still need to undergo a separate siting assessment and authorization procedure. The absence of a clearly defined framework for these administrative steps may create uncertainty for investors and operators interested in developing aquaculture activities. The situation is further complicated by the fact that, in some Italian regions, the authority responsible for granting concessions for marine aquaculture lies with municipalities rather than with regional administrations. This additional layer of governance can introduce further variability in procedures and decision-making processes, potentially slowing down the development of the sector or creating inconsistencies in the application of rules across different territories.

In such a complex institutional and regulatory context, there is a clear need to provide a coherent and transparent framework that can guide both public administrations and aquaculture operators. In order to effectively support the sustainable growth of the sector, it is therefore necessary to develop procedural guidance at the national level. Such guidance should aim to ensure a sufficient degree of harmonization in the procedural steps that regional authorities are expected to follow when designating AZAs, as well as in the type of outputs and planning documents produced. **Establishing a shared framework would help reduce uncertainty, facilitate coordination among institutions, and create more predictable conditions for investment in aquaculture.**

Within this broader context, the present national action aims to foster the development, adoption, and implementation of AZA plans across the country. More specifically, **the action seeks to standardize the nature of the procedures to be followed and to provide regional administrations with clear and detailed information on the legal and regulatory framework governing the preparation and approval of AZA plans. By clarifying roles,**

responsibilities, and procedural steps, the action intends to support a more efficient and consistent implementation of AZA planning at the regional level.

Although this initiative is primarily designed to support the sustainable development of the aquaculture sector, **it is also closely aligned with broader international principles** and policy frameworks. In particular, the approach is consistent with the Ecosystem Approach to Aquaculture (Soto et al., 2008), which emphasizes the need to integrate aquaculture development within the wider ecosystem and to consider its interactions with environmental processes and other human activities (Convention on Biological Diversity and its principles - UNEP/CBD, 1998). Similarly, the initiative reflects the principles promoted by international policy documents such as the Shanghai Declaration (2021), which encourages sustainable and responsible aquaculture development.

Importantly, AZA planning does not focus exclusively on the aquaculture sector itself but also takes into account the **interactions between aquaculture and other maritime activities as well as with the marine environment**. For example, the presence of aquaculture installations may interact with sectors such as fisheries, tourism, maritime transport, and energy production. By identifying suitable locations and defining clear management rules, AZA plans can help reduce potential conflicts among different uses of marine space and promote more effective coexistence among sectors.

For this reason, the implementation of AZA plans is expected to have positive impacts not only on aquaculture but also on **other maritime sectors** operating in the same areas. For instance, a well-planned spatial allocation of aquaculture activities can help improve compatibility with traditional fisheries by reducing spatial conflicts and ensuring that fishing grounds are not unnecessarily affected. Similarly, clear spatial planning can facilitate the coexistence of aquaculture with tourism and recreational activities, potentially creating opportunities for new forms of economic integration, such as aquaculture-related tourism or educational activities.

Another important opportunity relates to the **potential development of co-use solutions**, where aquaculture is integrated with other offshore activities. For example, aquaculture installations could potentially be combined with offshore renewable energy production systems, creating multifunctional marine spaces that maximize the efficient use of available areas while reducing environmental pressures. Such approaches are increasingly being explored in different parts of the world and could represent an innovative pathway for the future development of the sector.

In addition, AZA planning can support a more informed and environmentally responsible siting of aquaculture farms. By analysing the environmental characteristics of different marine areas, including their **assimilative capacity and ecological sensitivity**, planners can identify locations where aquaculture activities are less likely to cause negative environmental impacts. This process can also contribute to the definition of appropriate principles for **environmental monitoring programs** associated with aquaculture sites, providing practical tools for managing the interactions between aquaculture production and the surrounding marine environment.

Finally, AZA plans can contribute to promoting the **diversification of aquaculture production systems**. By identifying suitable areas for different types of farming activities, the plans can support the **transition towards more sustainable practices** and encourage



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innovation within the sector. In particular, AZA planning can facilitate the expansion of the farming of **Low Trophic Level species**, which generally have lower environmental impacts and can contribute to more efficient food production systems. At the same time, it can support the further development of **polyculture systems and integrated multi-trophic aquaculture (IMTA)**, where different species are farmed together in ways that enhance ecological balance and resource efficiency.

Overall, the development, adoption, and implementation of AZA plans represents a key instrument for guiding the sustainable growth of aquaculture in Italy, while ensuring that this development remains compatible with environmental protection objectives and with the needs of other maritime sectors.

The present action covers the following EGD topics and sub-topics (classification based on Bocci et al., 2025):

Topic: Climate change mitigation. Subtopic: Initiatives towards emission reduction in other sectors considered by the Plan(s) (e.g., fishing boats).

Topic: Climate change adaptation. Subtopic: Identification of areas to be used in future by specific sectors, due to climate change.

Topic: Sustainable Sea-food production. Subtopics: Development of marine aquaculture installations; Development of organic marine aquaculture, IMTA, low-trophic aquaculture; Multi-use of the sea space: combinations including marine aquaculture; Development of marine algae production; Multi-use of the sea space: combination including algae production

Topic: Biodiversity and ecosystem protection and restoration; Subtopic: Multi-use of the sea space: combination including biodiversity and ecosystem protection

Topic: Blue Circular Economy. Subtopics: Repairing and end-of-life recycling of fishing and aquaculture gears

Topic: Zero pollution. Subtopic: Measures related to fisheries and aquaculture.

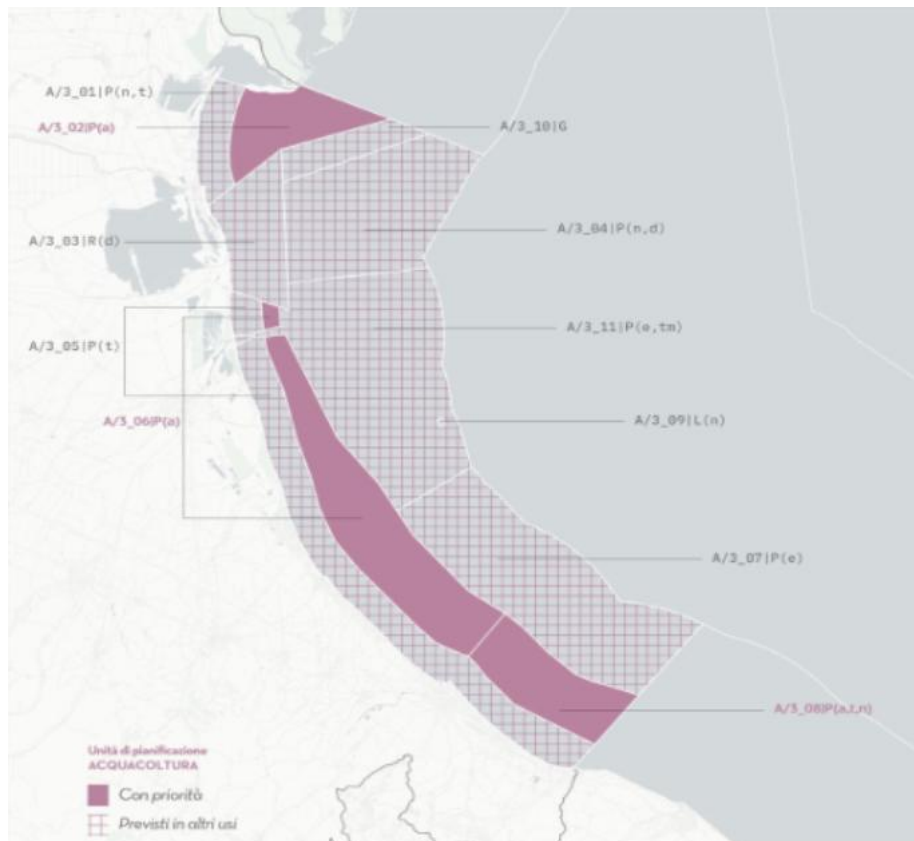


Figure 28. Planning Units in which aquaculture is defined as a Priority (purple) within the territorial waters of Emilia-Romagna region (in all the remaining planning units aquaculture is present within the list of "other uses").

2. Implementation

The present AZA PLANNING action accounts for three main steps, and was designed to be implemented by a technical group of national experts on aquaculture, supported by legal experts and national MSP practitioners. The three main work tasks include:

1. Preparing a procedural guidance for the coastal regions in charge of AZA identification, including expected outputs of the process (technical and administrative acts), their expected contents, as well as examples of good practices from available experiences of process of AZA designation at national level. The guidance will also consider the phase of AZA implementation and particularly the administrative and authorization procedures for assigning the aquafarm concessions.
2. The procedural guidance will be developed in collaboration with the coastal regions, through the existing ITAQUA national platform for aquaculture, which is already established, and was designed to represent an open technical channel of discussion of aquaculture, between the Ministerial central offices and the regional offices.
3. The co-construction process will involve the Ministry of Agriculture, Food Sovereignty and Forestry (MASAF), responsible for aquaculture, and the MSP



competent authority, Ministry of Infrastructures and Transport (MIT)(see Ramieri et al., 2024);

Task 1 above was started by making a comparison among the ongoing processes of suitability analysis, AZA selection and, where available, of AZA plan development for the different coastal regions. This will focus on:

- definition of the legal framework, the governance asset and administrative procedures, including the necessary deliberations/resolutions by the region across the whole process of AZA designation and their required contents;
- expected outputs of the process in terms of documentation to be prepared (what kind of documentation is necessary for AZA designation), aspects related to funding of the activities and the relative costs expected, aiming at provide useful estimations about the financial resources required for the different steps of the process (e.g., data acquisition, suitability analysis, zoning, plan definition, participation, permitting procedure);
- integration with environmental permitting procedures in order to provide clear indications about the eventual need and the expected contents of the SEA (Strategic Environmental Assessment) and AA (Appropriate Assessment) studies for AZA plans (considering the different aquaculture typologies)
- implementation procedures clarifying the administrative process of examination of concession requests, information and evidence to be provided by the proponent, guidelines for the designation process.

Task 2 involves the co-construction of the document with the regions. The tool used to perform this step will be the Itaqua platform, which is gathering all the regions, MASAF, CREA (National Research Institute in Agriculture and Rural Economy), and ISPRA. This includes a consultation step with the regions, aimed at mapping the different situations in terms of instruments already adopted for AZA management (e.g., suitability/vocational maps, zoning maps, proper plans including the completion of a SEA procedure). Within this phase regions will also highlight current procedural problems experienced and share examples of good practices adopted for their solution. As a second step, the governance situation of the different regions is mapped, by identifying regional offices responsible for the AZA planning process, and other regional offices and public bodies responsible for collecting information relevant in the AZA process. This latter step is pivotal for avoiding bottlenecks caused by missing information.

Task 3 will be performed through iterative reviews of the document produced by the technical group of experts from the MASAF. This review will also include a contribution from the MSP competent authority, in order to maximize the impact of the action on the two following MSP national measures, which are dealing with AZA planning implementation:

NAZ_MIS|44. "Develop, adopt and implement AZA Plans at a regional scale, in line with the PSM Plans and with the support of the AZA Technical Guide (ISPRA /HIPAA)." Responsible for implementation: Regions.

NAZ_MIS|45. "Establish a permanent working table aimed at supporting the progressive integration and harmonization between regional AZA plans and PSM in the various maritime

areas, strengthening already existing tools, such as the ITAQUA platform.” Responsible for implementation: MASAF, ISPRA, Regions.

At present stage, the work for implementation of the present AZA PLANNING action involved the **initiation of points 1 and 2 above**. This was carried out through informal exchanges among Italian national researchers and other experts involved in AZA planning, during fall 2025. Subsequently on February 18 2026, a workshop was carried out during the Italian Aquaculture fair “Aquafarm” held in Pordenone. The event was promoted by the Emilia Romagna Region and organized by University luav of Venice. During this event, important information regarding points 1 and 2 above were shared, allowing to compare different regional approaches to AZA identification and planning. Further details on this event are reported in the textbox 1 below. Current steps deal with the completion of point 1, with the production of a draft structure of the document informing AZA planning procedure, and the organization of a new meeting involving the regions and the Itaquua platform for the month of November 2026. A technical meeting in preparation to this event will be tentatively carried out among the technical group of experts for AZA, during the Aquaculture Europe conference, which will take place in Lubiana in September 2026.

Overall, it will be possible to measure the impact of this AZA PLANNING action in terms of AZA planning processes activated within a period of 3 years from the completion of the action. Another possible indicator concerns the number of AZA plans adopted with SEA completed. This second assessment might consider a wider temporal scale (proposed 5 years), in order to take into consideration possible delays during the SEA implementation. Table 13 below resumes a set of possible impact indicators, which were identified on the basis of the Italian MSP plans, and the national strategic plan for aquaculture development (PNSA 21-27).

Overall, this action will contribute to the achievement of EGD objectives. In fact, the provisions of well-structured and innovative AZA plans will impact on:

- Promoting emission reduction through rational allocation of the maritime space to aquaculture activities (distance from the harbours is one of the key control variables of emissions). Related objective: Climate change mitigation.
- Identifying suitable climate refugia for aquaculture (e.g., shellfish cultivated in areas exposed to prolonged heat-waves can be temporarily translocated in areas less suitable in terms of seston (food) availability, but characterized by lower temperatures). Related objective: Climate change adaptation.
- Defining site suitability with respect to different types of aquaculture (fish, shellfish, macroalgae), and taking into consideration species diversification can help promote growth and resilience, and increase the potential of integration with other sectors. Related objective: sustainable seafood production.
- Mapping existing conservation areas, corridors within the suitability analysis, and undergoing the appropriate assessment procedure of the plan will help integrating with Natura 2000 network, and other conservation/restoration elements in the area. Related objective: Biodiversity and ecosystem protection and restoration
- Considering land-sea interactions in terms of value chain and land-based infrastructures needed by aquaculture can be performed from a life cycle assessment perspective (end-of-life and recycling of the gears). Related objective: Blue Circular Economy.

- Plans can support the development of the Environmental Monitoring Program, decreasing pressures from the sector on the marine environment. Topic: Zero pollution.

Table 13. Tentative (non-exhaustive) list of MSP-AZA related impact indicators.

MSP-plan related aquaculture indicator	EGD goal associated
New areas used as aquaculture sites	Sustainable seafood production
Change in the volume of aquaculture production	Sustainable seafood production
No. of projects regarding the definition of AZAs in accordance with the GFCM guidelines and the new national guidelines	Sustainable seafood production
No. of projects on reducing the impact of aquaculture on the environment (eco-management and audit systems, environmental services linked to organic aquaculture)	Zero pollution Biodiversity and ecosystem protection and restoration
No. of projects on increasing the potential of aquaculture sites and measures for public and animal health	Climate change adaptation
No. of circular economy projects in aquaculture and quantification and accounting of environmental services offered by the sector (for example, through LCA approaches)	Blue circular economy

Box 1. Contents of the workshop organized in the framework of steps 1 and 2 of this action.

AZA Planning and Aquaculture Resilience

Date and place: 18 February 2026, 11:30–13:30 at Aquafarm 2026 (meeting room, Pordenone Fair)

This event is part of the conference program of Aquafarm 2026 and focuses on the designation of Allocated Zones for Aquaculture (AZA). This sectoral planning process, currently being carried out at the regional level in Italy, is based on the assessment of site suitability and on the evaluation of the conditions for coexistence with other uses of marine space. The identification of AZAs follows a participatory process and is designed to integrate with the multi-sector planning framework established by the national Maritime Spatial Planning (MSP) plans.

The process relies on the best available scientific knowledge and makes use of several analytical and technical tools, including Geographic Information Systems (GIS), spatial information produced by operational oceanography, and sustainability assessments developed through models and systemic indicators. The identification of AZAs is aimed at supporting the sustainable development of the aquaculture sector, while also considering the future resilience of production systems under changing climatic conditions. In addition, AZA planning takes into account land–sea interactions, adopting an integrated perspective that considers the development of the entire aquaculture value chain.

The event will consist of two consecutive sessions:

Short presentations will be delivered by researchers and professionals with specific experience in site selection and sustainability assessment for aquaculture. These contributions will review the practices currently used in AZA identification processes, with the aim of stimulating discussion and identifying both strengths and current challenges.

This will be followed by a roundtable discussion involving representatives from the aquaculture production sector and the Itaquua platform, which coordinates activities among Italian regions. The discussion will focus on the role of AZAs in supporting the resilience of the aquaculture sector.

Program:

Welcome and introduction
Emilia-Romagna Region and Iuav University of Venice

Tommaso Petoichi (ISPRA)
AZA Technical Guidelines and Copernicus data: applications to case studies.

Erika Porporato (IMC Oristano)
The Sardinia AZA Plan: a shared pathway for the sustainable development of aquaculture.

Riccardo Napolitano (CREA)
Shellfish farming and climate change: LCA as a tool for evaluating adaptation scenarios.

Stefano Kutin (Autonomous Region of Friuli Venezia Giulia)
AZAs in Friuli Venezia Giulia: current status and future perspectives.

Antonio Gottardo (Legacoop Veneto)
The AZALEA project: identification of AZAs in the Veneto Region.

Daniele Brigolin (Iuav University of Venice)
Models and operational data in participatory processes: examples from the work on the Emilia-Romagna AZA plan.

Following the presentations, roundtable discussion:

The role of AZAs in strengthening production resilience: challenges and opportunities.
Participants will include representatives from API, AMA, ITAQUA, and the speakers.

Organized by:
Iuav University of Venice and the Emilia-Romagna Region

Contact:
Daniele Brigolin – dbrigolin@iuav.it

3. Transferability and upscaling

3.1. Transferability

This action addresses a challenge at the level of Italian regions (**NUTS2 territorial level**). In terms of **enabling conditions**, the implementation of this action requires the possibility of engaging in the process of all the regional offices responsible for AZA planning (including the offices/agencies which are responsible for the collection and management of the relevant environmental information). There is a **limited risk** of not succeeding in this step, since there is a mandate of the **Itaqua national platform** from the central level (MASAF) for **coordinating the regions**. An adequate management of tasks 2 and 3 of the project, involving stakeholder engagement and coordination will be of pivotal importance. Differences in the **administrative procedures** among the regions (e.g., autonomous regions which are in Italy regions with a special statute) may also impact the process.

3.2. Affordability

Knowledge/skills are required in the framework of AZA planning, administrative law, and MSP. In particular, with respect to AZA planning a group of experts from different institutions in Italy has already been set up on the occasion of the first meeting described above. This group can definitely be integrated, with the inclusion of new experts in specific areas (e.g., algae aquaculture). Experts in administrative law, with experience in MSP are available within the luav University staff, and will be involved in the development of the next steps of the action. In terms of MSP expertise, the team focused mainly on the definition and spatialization of measures promoting the integration between aquaculture, MSP, and green deal, which were described in depth in the previous part of this document. A second relevant aspect, which will be supported by MSP experts, is the design of an adequate set of indicators for monitoring the performance.

Completion of the process described in this action, and mainly of tasks 2 and 3 involve a participatory effort which can benefit from the presence of specific expertise in stakeholder engagement. This step will also require a substantial effort in terms of secretariat activities (exchanging emails and ensuring that stakeholders adhering to the process are adequately supported in terms of help, and outcomes from the meetings are timely provided). An adequate **financial support** will therefore be necessary to organize the co-creation meetings and perform the desk work described above. The expected duration of this step is approximately 1 year, considering its iterative nature and the fact that task 3 is performed at a central level, and involves a lower number of stakeholders, but task 2 requires the engagement of multiple Italian regions, with some phases of the work which will necessarily overlap in terms of time.

3.3. Upscaling

In principle, this action is of interest for **all the Mediterranean countries under the GFCM** – transfer must take into account local governance context. Upscaling needs and constraints can be evaluated through exchanges with Mediterranean countries at GFCM level, aimed at mapping current administrative and procedural constraints experienced in the implementation of AZA resolution GFCM/36/2012/1.



Figure 29. Participatory mapping exercise carried out in the framework of stakeholder consultation for the definition of AZA plan in Emilia-Romagna region.

4. Conclusion

The action described focuses on AZA plans (plans of Allocated Zones for Aquaculture). The work was designed to provide regional administrations with clear and detailed information on the legal and regulatory framework defining the preparation and approval of AZA plans. In terms of EGD, AZA plans approvals have the possibility of contributing to multiple goals and sub-goals, namely:

- Climate change mitigation
- Climate change adaptation
- Sustainable Sea-food production
- Biodiversity and ecosystem protection and restoration
- Blue Circular Economy
- Zero pollution.

Furthermore, the approval and implementation of the AZA plans will impact on the development of the following MSP national measures:

NAZ_MIS|44. "Develop, adopt and implement AZA Plans at a regional scale, in line with the PSM Plans and with the support of the AZA Technical Guide (ISPRA /HIPAA)." Responsible for implementation: Regions.

NAZ_MIS|45. "Establish a permanent working table aimed at supporting the progressive integration and harmonization between regional AZA plans and PSM in the various maritime areas, strengthening already existing tools, such as the ITAQUA platform." Responsible for implementation: MASAF, ISPRA, Regions.

In extreme synthesis, the action **integrates three main tasks:**



1. distilling knowledge from existing processes (reviewing technical and administrative acts and gathering examples of good practices from available experiences of process of AZA designation at national level). Administrative and authorization procedures within the implementation step will also be considered in the analysis;
2. co-construction involving the regions, through the mediation of the Itaquá platform;
3. co-construction at the national level, involving MASAF (Ministry of Agriculture, Food Sovereignty and Forestry), and the MSP competent authority (Ministry of Infrastructures and Transports).

At the current stage, implementation concerned mainly tasks 1. Additional resources will be required to implement tasks 2 and 3, and mainly to sustain the participatory process within these tasks. **Transferability** and **upscaling** of this action are possible, but they will require a careful a-priori evaluation of the **administrative context**, in order to prevent time consuming efforts.



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National action #8: Marine Green Infrastructure as Nature-Based Solution for blue carbon storage and sequestration (IEO-CSIC)

1. Context and needs

According to the European Commission Communication on Green Infrastructure (GI) – Enhancing Europe’s Natural Capital (2013), **green infrastructure** is defined as “a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, GI is present in rural and urban settings”. This communication requires countries to develop a strategy on green infrastructure at the national level. However, prior to the drafting of this communication, the concept of green infrastructure had been much more studied in urban or agricultural contexts, through connectivity in green areas or through the connection of trees and shrubs, respectively. In contrast, the concept of GI in the marine environment—its study and application—remains largely unknown.

In Spain, following the EC communication, GI was integrated into Law 42/2007, of December 13, on Natural Heritage and Biodiversity, which called for the development of the National Strategy on Green Infrastructure and Ecological Connectivity and Restoration. This Strategy was approved in 2021, encouraging autonomous communities (subnational governments) to develop their own regional strategies. However, for the marine environment, which falls under state jurisdiction, GI was decided to be integrated into the Maritime Spatial Planning (MSP) process as one of the activities and uses whose spatial distribution should be included in the Maritime Spatial Plans (POEM, by its Spanish acronym). Therefore, during the drafting of the first-cycle of the POEM, an initial identification was made of the potential elements that could constitute GI in each marine demarcation, based on a tentative list of elements included in the **National Strategy on Green Infrastructure and Ecological Connectivity and Restoration**. These elements vary in nature, such as species and habitat distribution areas, environmentally significant zones within the public maritime-terrestrial domain, or geological features like submarine canyons, among others, including some elements that by their nature can have the function of storing and/or sequestering carbon. The identified elements were added as an annex to the diagnostic document for each marine demarcation in the POEM, through descriptive factsheets for each element containing information on its definition, a map of its spatial distribution, its preliminary relationship with ecosystem services, connectivity, and its importance in the MSP context. Additionally, the first-cycle of the POEM first-cycle included a measure to be implemented **OEM3: “Definition and incorporation into the POEM of the set of elements that constitute marine green infrastructure”**.

The POEM is in the process of implementing their measures and undergoing the review of its first cycle. In the context of Marine Green Infrastructure (MGI), work is underway to implement the OEM3 measure mentioned above. This measure, in addition to building on the list of potential elements already identified in the POEM for each marine demarcation, is based on a case study developed in the canary marine demarcation in the framework of the **MSP-OR project**: “Integrating Green Infrastructure in MSP. A methodology for outermost

regions". During this case study, a methodology was developed and validated to test the GI concept through the analysis of ecosystem services and criteria of high ecological value (based on EBSA criteria), assessing the contribution of each identified MGI element to biodiversity and connectivity.

During the implementation of the OEM3 measure, this **methodology** has been adapted to be used in the five marine demarcations of Spain through:

- i. Updating the lists of MGI elements for each marine demarcation;
- ii. Updating the spatial data of MGI elements;
- iii. Conducting a bibliographic analysis related to GI, ecosystem services, and ecological criteria;
- iv. Developing a new assessment and a matrix-table of ecosystem services and high ecological value criteria based on EBSA criteria; and
- v. Consulting experts through a questionnaire and a participatory workshop.

Work of measure OEM3 is still ongoing by the time this action is being developed.

Related to the **national action**, many of these elements identified for the MGI in Spain are **features that capture and/or store carbon**. Identifying and spatializing these areas is key, not only in the context of MSP, but also in terms of the role that these elements can play in mitigating the possible effects of climate change, regulating the carbon cycle in the marine environment, and ensuring their long-term protection.

Therefore, analyzing and mapping these elements can help identify important areas for blue carbon in the marine environment, which can be integrated into spatial zoning distribution within the MSP context for various purposes—from areas important for biodiversity, to the designation of specific blue carbon zones. In the review of the first cycle of the POEM, the inclusion of areas that are susceptible to capturing and storing CO₂, have been considered either as a new zoning category for areas with blue carbon potential or by integrating them into the High Potential Areas for Biodiversity conservation.

The **analysis** carried out in this national action aims to evaluate how, through the use of the marine green infrastructure as a tool, and based on the potential MGI elements in the Spanish Mediterranean marine demarcations, the aim is to **identify and map** those MGI elements that have the potential to capture and store CO₂.

Regarding the **elements of the EGD** to which this action relates, it addresses the following:

A. Climate change mitigation

A.4 Blue carbon sinks

- A.4.1 Preserving and restoring coastal vegetation systems as tidal marshes and seagrasses accumulating "blue carbon"

A.5. Knowledge-related measures

B. Climate change adaptation

B.1 Green Infrastructures to enhance coastal resilience

B.1.1 Green Infrastructures: Creation and maintenance of Nature-based solutions

B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes

- B.2.1 Identification of spatial and non-spatial measures addressing the impacts from climate change

B.3 Anticipation of climate change-related effects

B.3.1 Identification of climate refugia for marine species and habitats

B.4 Knowledge-related measures

- D. Biodiversity and ecosystem protection and restoration
 - D.1 A coherent network of marine protected areas
 - D.1.3 Identification of ecological “blue” corridors
 - D.1.4 Elements that improve marine connectivity (i.e., submarine canyons, artificial reefs, etc.)
 - D.1.5 Multi-use of the sea space: combination including biodiversity and ecosystem protection
 - D.3 Knowledge-related measures
 - D.4 Governance-related measures

2. Implementation

2.1. Description of the action implemented

This national action is based on the work previously described, that is being carried out for measure OEM3 of the Spanish MSP plan, adding the analysis of blue carbon within this concept of GI, as an added value as many of the elements that conform MGI can have this important function of carbon storage and/or sequestration. In Spain, the marine environment is subdivided into five marine demarcations. The scope of this work has been developed in the two Mediterranean marine demarcations: (1) the Levantine-Balearic marine demarcation and (2) the Strait and Alboran marine demarcation (Figure 30).

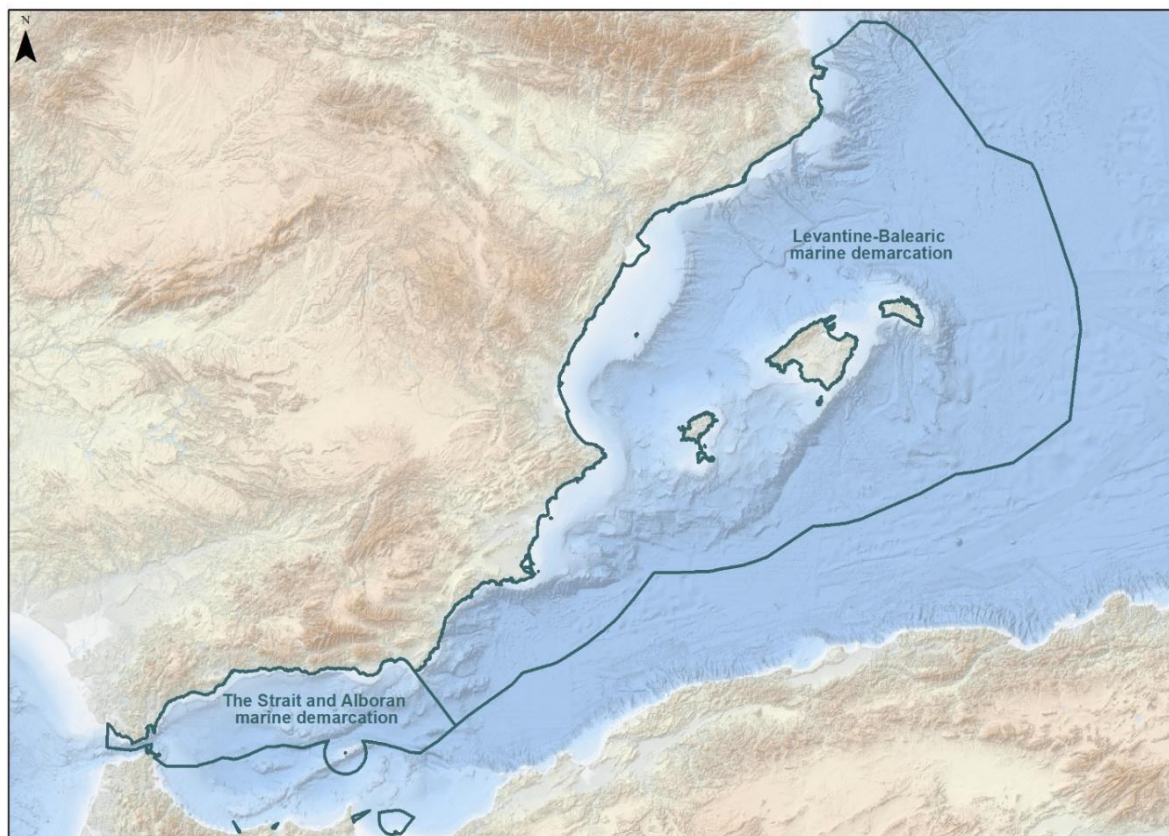


Figure 30 – Scope of the National Action. Source: Own elaboration.



The **set of elements that conform the MGI** for each marine demarcation has been updated since the POEM was approved in 2023. This list is based on (i) a tentative list of potential elements that are included in the National Strategy on Green Infrastructure and Ecological Connectivity and Restoration, (ii) the results obtained from different expert consultations and workshops carried out during 2024 and 2025, and (iii) the spatial data available for each MGI element. The following table shows the MGI elements updated at the end of 2025, including a short description explaining why it has been considered as an element of the MGI.

Table 14 – List of the elements of Marine Green Infrastructure considered. Source: Own elaboration.

LIST OF MARINE GREEN INFRASTRUCTURE ELEMENTS		
MGI ID	MGI element	Description
01 High connectivity corridors between habitat types of community interest		
101	Habitat 1110: Sandbanks which are slightly covered by sea water all the time	Marine Habitats of Community Interest (HCI) are considered part of the MGI due to their status as habitats threatened with disappearance from their spatial distribution area; they have a reduced natural distribution area due to their regression or are a representative example of characteristics typical of one or more biogeographical regions. These habitats, by their very nature, provide numerous ecosystem services, generate connectivity and contribute to biodiversity conservation (due to their priority importance under protection regimes). The spatial distribution of some of these habitats is included within the delimitation of Marine Protected Areas (MPAs), mainly in the Natura 2000 Network as they are HCIs, but they may also be distributed in other types of MPAs under other protection tools.
102	Habitat 1120: Posidonia beds (<i>Posidonia oceanica</i>)	
103	Habitat 1170: Reefs	
104	Habitat 1180: Submarine structures made by leaking gases	
02 Areas with environmental management of public domain		
201	Public Maritime-Terrestrial Domain	These two elements have been considered as they are located on the boundary between the terrestrial and marine environments, adding value to land-sea interactions given the ecosystem processes that occur at this interface, which is an area with a very significant exchange of matter, energy, nutrients and sediments. Furthermore, the value of ecosystem services, as well as the connectivity between both areas, is very important. In addition to protecting biodiversity, it plays a very important role in mitigating climate change.
202	Areas of significant potential flood risk (ARPSIs)	
03 Elements of the marine environment		
301	Submarine banks, seamounts or	These geomorphological elements have been considered because they play a very important role in conservation (numerous habitats/species reside in this type of geological element, therefore, they are areas that harbour high biodiversity) and connectivity (they are elements that are important for the migration, recruitment or feeding of many species, they are areas with high primary productivity, etc.). In some cases, the species/habitats found in this type of element are very unique, making them unique enclaves.
302	Submarine canyons and channels	
303	Submarine ridges and escarpments	
304	Diapire	
305	Underwater gas emissions	
306	Continental shelf (certain neritic zones)	
307	Continental slope areas	
04 Other important areas for biodiversity conservation and ecosystem service provision		
401	Distribution areas of wild species under special protection and endangered species, and critical areas designated in recovery plans	This element corresponds to areas identified as critical for a species in its corresponding Conservation or Recovery Plan. Therefore, the need to spatially incorporate the location contributes to the protection of the species, which may help to improve its distribution, reducing the degradation, loss or fragmentation of its habitat.
402	Areas identified as ecologically vulnerable and at ecological risk along the coast	This element has been considered as it is located on the boundary between the terrestrial and marine environments, adding value to land-sea interactions given the ecosystem processes that occur at this interface, which is an area with a very significant exchange of matter, energy, nutrients and sediments. Furthermore, the value of ecosystem services, as well as the connectivity between both areas, is very important. In addition to protecting biodiversity, it plays a very important role in mitigating climate change.
05 Other important areas for connectivity		
501	Migration routes and dispersal areas (birds, cetaceans, marine areas of dispersal for larvae and juveniles)	This element has been considered because scientific knowledge has identified certain areas that are important for certain species, such as some migratory corridors. The spatial distribution of species corresponding to the report in Article 17 and Article 12 of the Habitats and Birds Directives, respectively, is included as an element. The spatial location of this distribution helps to identify areas that are important for biodiversity conservation, connectivity and restoration, due to their priority importance under the protection regime. The spatial distribution of some of these species is included within the delimitation of Marine Protected Areas (MPAs), mainly from the Natura 2000 Network, but they may also be distributed in other types of MPAs under other protection tools.
50101	<i>Caretta caretta</i>	
50102	<i>Chelonia mydas</i>	
50103	<i>Demochelys coriacea</i>	
50106	<i>Balaenoptera acutorostrata</i>	
50108	<i>Balaenoptera physalus</i>	
50109	<i>Delphinus delphis</i>	
50111	<i>Globicephala melas</i>	
50112	<i>Grampus griseus</i>	
50114	<i>Megaptera novaeangliae</i>	
50117	<i>Orcinus orca</i>	
50119	<i>Physeter macrocephalus</i>	
50121	<i>Stenella coeruleoalba</i>	
50124	<i>Tursiops truncatus</i>	
50126	<i>Ziphius cavirostris</i>	
50127	<i>Calonectris borealis</i>	
50128	<i>Calonectris diomedea s. str.</i>	
50129	<i>Chlidonias hybrida</i>	
50130	<i>Chlidonias niger</i>	
50132	<i>Hydrobates pelagicus</i>	
50133	<i>Larus audouinii (ichthyaetus audouinii)</i>	
50134	<i>Larus fuscus</i>	
50135	<i>Larus genei (Chroicocephalus genei)</i>	
50137	<i>Larus melanocephalus (ichthyaetus melanocephalus)</i>	
50138	<i>Larus michahellis</i>	
50139	<i>Larus ridibundus (Chroicocephalus ridibundus)</i>	
50142	<i>Phalacrocorax aristotelis aristotelis (Gulosus)</i>	
50143	<i>Phalacrocorax aristotelis desmarestii (Gulosus)</i>	
50145	<i>Puffinus mauretanicus</i>	
50148	<i>Sterna hirundo</i>	
50149	<i>Sternula albifrons</i>	
50150	<i>Thalasseus sandwicensis</i>	
50152	<i>Corallium rubrum</i>	
50153	<i>Lithothamnium coralloides</i>	
50154	<i>Patella ferruginea</i>	
50155	<i>Phymatholithon calcareum</i>	
50156	<i>Pinna nobilis</i>	
502	Artificial reefs	This element of the MGI has been considered because artificial reefs directly influence the increase in biomass and biodiversity of the ecosystem, and therefore provide numerous ecosystem services. In addition, they are areas of high connectivity for many species, as well as breeding and refuge areas. They also act against erosion and provide protection against climate change.
06 Protection of wetlands		
601	Sensitive areas for urban water treatment	This element has been considered because it is located at the boundary between land and sea, adding value to land-sea interactions and the ecosystem processes that occur at this interface, which is an area with a very significant exchange of matter, energy, nutrients and sediments. In addition, the value of ecosystem services, as well as the connectivity between the two areas, is very important. It is worth highlighting the important role they play in mitigating climate change.

It should be noted that not all elements appear uniformly in both marine demarcations, either because the element is not represented in the marine demarcation, or because no spatial data available has been found to represent it spatially. The following list indicates the MGI elements represented in each demarcation.

Table 15 – List of the elements of Marine Green Infrastructure considered in the Mediterranean marine demarcations. Source: Own elaboration.

Levantine-Balearic marine demarcation		The Strait and Alboran marine demarcation	
MGI ID	MGI element	ID /VM	MGI element
01 High connectivity corridors between habitat types of community interest		01 High connectivity corridors between habitat types of community interest	
101	Habitat 1110: Sandbanks which are slightly covered by sea water all the time	10301	Habitat 1110: Sandbanks which are slightly covered by sea water all the time
102	Habitat 1120: Posidonia beds (<i>Posidonia oceanica</i>)	10302	Habitat 1120: Posidonia beds (<i>Posidonia oceanica</i>)
103	Habitat 1170: Reefs	10303	Habitat 1170: Reefs
104	Habitat 1180: Submarine structures made by leaking gases	10304	Habitat 1180: Submarine structures made by leaking gases
02 Areas with environmental management of public domain		02 Areas with environmental management of public domain	
201	Public Maritime-Terrestrial Domain	201	Public Maritime-Terrestrial Domain
202	Areas of significant potential flood risk (ARPSIs)	202	Areas of significant potential flood risk (ARPSIs)
03 Elements of the marine environment		03 Elements of the marine environment	
301	Submarine banks, seamounts or elevations	301	Submarine banks, seamounts or elevations
302	Submarine canyons and channels	302	Submarine canyons and channels
303	Submarine ridges and escarpments	303	Submarine ridges and escarpments
304	Diapyre		
305	Underwater gas emissions	305	Emanaciones gaseosas submarinas
306	Continental shelf (certain neritic zones)	306	Continental shelf (certain neritic zones)
307	Continental slope areas	307	Continental slope areas
04 Other important areas for biodiversity conservation and ecosystem service provision		04 Other important areas for biodiversity conservation and ecosystem service provision	
401		401	Distribution areas of wild species under special protection and endangered species, and critical areas designated in recovery plans
402	Areas identified as ecologically vulnerable and at ecological risk along the coast	402	Areas identified as ecologically vulnerable and at ecological risk along the coast
05 Other important areas for connectivity		05 Other important areas for connectivity	
501	Migration routes and dispersal areas (birds, cetaceans, marine areas of dispersal for larvae and juveniles)	501	Migration routes and dispersal areas (birds, cetaceans, marine areas of dispersal for larvae and juveniles)
50101	<i>Caretta caretta</i>	50101	<i>Caretta caretta</i>
50102	<i>Chelonia mydas</i>	50102	<i>Chelonia mydas</i>
50103	<i>Dermochelys coriacea</i>	50103	<i>Dermochelys coriacea</i>
50106	<i>Balaenoptera acutorostrata</i>	50106	<i>Balaenoptera acutorostrata</i>
50108	<i>Balaenoptera physalus</i>	50108	<i>Balaenoptera physalus</i>
50109	<i>Delphinus delphis</i>	50109	<i>Delphinus delphis</i>
50111	<i>Globicephala melas</i>	50111	<i>Globicephala melas</i>
50112	<i>Grampus griseus</i>	50112	<i>Grampus griseus</i>
50114	<i>Megaptera novaeangliae</i>	50114	<i>Megaptera novaeangliae</i>
50117	<i>Orcinus orca</i>	50117	<i>Orcinus orca</i>
50119	<i>Physeter macrocephalus</i>	50119	<i>Physeter macrocephalus</i>
50121	<i>Stenella coeruleoalba</i>	50121	<i>Stenella coeruleoalba</i>
50124	<i>Tursiops truncatus</i>	50124	<i>Tursiops truncatus</i>
50125	<i>Ziphius cavirostris</i>	50125	<i>Ziphius cavirostris</i>
50127	<i>Calonectris borealis</i>	50127	<i>Calonectris borealis</i>
50128	<i>Calonectris diomedea s. str.</i>	50128	<i>Calonectris diomedea s. str.</i>
50129	<i>Chlidonias hybrida</i>		
50130	<i>Chlidonias niger</i>	50130	<i>Chlidonias niger</i>
50132	<i>Hydrobates pelagicus</i>		
50133	<i>Larus audouinii (Ichthyophaga audouinii)</i>	50133	<i>Larus audouinii (Ichthyophaga audouinii)</i>
50134	<i>Larus fuscus</i>		
50135	<i>Larus genei (Chroicocephalus genei)</i>	50135	<i>Larus genei (Chroicocephalus genei)</i>
50137	<i>Larus melanocephalus (Ichthyophaga melanocephalus)</i>	50137	<i>Larus melanocephalus (Ichthyophaga melanocephalus)</i>
50138	<i>Larus michahellis</i>	50138	<i>Larus michahellis</i>
50139	<i>Larus ridibundus (Chroicocephalus ridibundus)</i>	50139	<i>Larus ridibundus (Chroicocephalus ridibundus)</i>
50142	<i>Phalacrocorax aristotelis aristotelis (Cullosus)</i>		
50143	<i>Phalacrocorax aristotelis desmarestii (Cullosus)</i>		
50145	<i>Puffinus mauretanicus</i>		
50148	<i>Sterna hirsundo</i>	50148	<i>Sterna hirsundo</i>
50149	<i>Sternula albifrons</i>	50149	<i>Sternula albifrons</i>
50150	<i>Thalasseus sandwicensis</i>	50150	<i>Thalasseus sandwicensis</i>
50152	<i>Corallium rubrum</i>	50152	<i>Corallium rubrum</i>
50153	<i>Lithothamnium coralloides</i>	50153	<i>Lithothamnium coralloides</i>
50154	<i>Patella ferruginea</i>	50154	<i>Patella ferruginea</i>
50155	<i>Phymatholithon calcareum</i>	50155	<i>Phymatholithon calcareum</i>
50156	<i>Pinna nobilis</i>		
502	Artificial reefs	502	Artificial reefs
06 Protection of wetlands		06 Protection of wetlands	
601	Sensitive areas for urban water treatment	601	Sensitive areas for urban water treatment

2.2. Methodology

Based on the work conducted in the framework of OEM3 measure of the MSP plan, which contains the list and spatial data of the MGI elements, this national action has been implemented in order to identify those MGI elements that store and/or capture carbon, applying the following methodology:

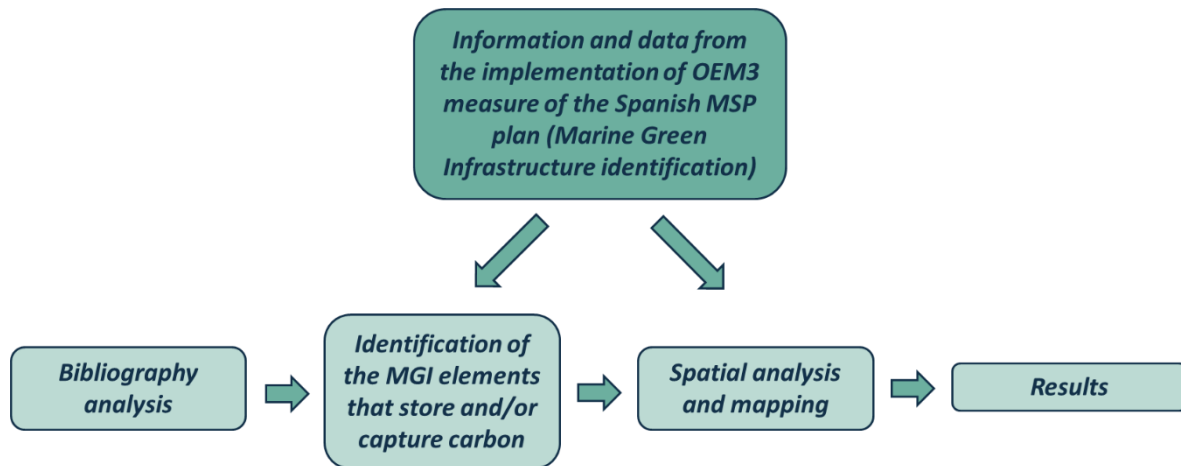


Figure 31 – Methodology of the National Action. Source: Own elaboration.

These steps are explained below.

A. Bibliography analysis

The first step was to conduct a bibliographic analysis to assess which MGI elements on the list for each marine demarcation can play the role of carbon sequestering, storing, or both.

To this end, a bibliographic search was carried out of various documents, mainly scientific articles, but also other items of interest such as guides and policy briefs from different institutions. Although the analysis has been straightforward for some elements, whose role in carbon sequestration and/or capture is widely recognised (i.e., habitats 1110 and 1120), it has been more difficult to find extensive information on other elements, such as certain geological elements.

B. Evaluation of the elements of the MGI based on the bibliographic analysis

Once the bibliographic analysis was completed, an assessment of the MGI elements was carried out for each marine demarcation, based on their carbon sequestration and/or storage function. To this end, a matrix-table was created incorporating this information, and, in order to quantify the analysis developed to a deeper degree, and based on the bibliography, each MGI element was assigned a value on a scale of 0 to 2:

Carbon storage:

- 0: Does not store carbon
- 1: Partially stores carbon
- 2: Highly stores carbon



Carbon sequestration:

- 0: Does not captures carbon
- 1: Partially captures carbon
- 2: Highly captures carbon

Where 0 represents those elements that do not play any role related to carbon capture and/or storage; 1 represents elements that are considered to perform any of these functions partially, given that in the bibliography has not been able to conclude that the function is very high or that there is insufficient literature to corroborate this; and 2 represents elements for which there is extensive literature indicating that this type of element performs any of the functions.

Tables 16 and 17 are the two matrix-tables generated related to MGI elements that play the role of capture and/or storage carbon for each Mediterranean marine demarcation.

Table 16 – Matrix-table of MGI elements of the Strait and Alboran marine demarcation that store and/or capture carbon. Source: Own elaboration.

MGI ID	The Strait and Alboran marine demarcation MGI element	Blue Carbon	
		Storage	Sequestration
101	Habitat 1110: Sandbanks which are slightly covered by sea water all the time	2	2
102	Habitat 1120: Posidonia beds (<i>Posidonium oceanicae</i>)	2	2
103	Habitat 1170: Reefs	2	1
104	Habitat 1180: Submarine structures made by leaking gases	0	0
201	Public Maritime-Terrestrial Domain	2	2
202	Areas of significant potential flood risk (ARPSIs)	2	2
301	Submarine banks, seamounts or elevations	0	0
302	Submarine canyons and channels	2	0
303	Submarine ridges and escarpments	0	0
305	Emanaciones gaseosas submarinas	0	0
306	Continental shelf (certain neritic zones)	1	0
307	Continental slope areas	1	0
401	Distribution areas of wild species under special protection and endangered species, and critical areas designated in recovery plans	0	1
402	Areas identified as ecologically vulnerable and at ecological risk along the coast	1	1
501	Migration routes and dispersal areas (birds, cetaceans, marine areas of dispersal for larvae and juveniles)	0	1
50101	<i>Caretta caretta</i>	0	0
50102	<i>Chelonia mydas</i>	0	0
50103	<i>Dermochelys coriacea</i>	0	0
50106	<i>Balaenoptera acutorostrata</i>	0	1
50108	<i>Balaenoptera physalus</i>	0	1
50109	<i>Delphinus delphis</i>	0	0
50111	<i>Globicephala melas</i>	0	0
50112	<i>Grampus griseus</i>	0	0
50114	<i>Megaptera novaeangliae</i>	0	1
50117	<i>Orcinus orca</i>	0	0
50119	<i>Physeter macrocephalus</i>	0	1
50121	<i>Stenella coeruleoalba</i>	0	0
50124	<i>Tursiops truncatus</i>	0	0
50125	<i>Ziphius cavirostris</i>	0	0
50127	<i>Calonectris borealis</i>	0	0
50128	<i>Calonectris diomedea s. str.</i>	0	0
50130	<i>Chlidonias niger</i>	0	0
50133	<i>Larus audouinii (Ichthyiaetus audouinii)</i>	0	0
50135	<i>Larus genei (Chroicocephalus genei)</i>	0	0
50137	<i>Larus melanocephalus (Ichthyiaetus melanocephalus)</i>	0	0
50138	<i>Larus michahellis</i>	0	0
50139	<i>Larus ridibundus (Chroicocephalus ridibundus)</i>	0	0
50148	<i>Stema hirundo</i>	0	0
50149	<i>Stemula albifrons</i>	0	0
50150	<i>Thalasseus sandvicensis</i>	0	0
50152	<i>Corallium rubrum</i>	2	1
50153	<i>Lithothamnium coralloides</i>	2	0
50154	<i>Patella ferruginea</i>	0	0
50155	<i>Phymatholithon calcareum</i>	2	0
502	Artificial reefs	1	1
601	Sensitive areas for urban water treatment	1	1

0	Does not store carbon	Does not capture carbon
1	Partially stores carbon	Partially capture carbon
2	Highly stores carbon	Highly capture carbon

Table 17 – Matrix-table of MGI elements of the Levantine-Balearic marine demarcation that store and/or capture carbon. Source: Own elaboration.

MGI ID	Levantine-Balearic marine demarcation MGI element	Blue Carbon	
		Storage	Sequestration
101	Habitat 1110: Sandbanks which are slightly covered by sea water all the time	2	2
102	Habitat 1120: Posidonia beds (<i>Posidonia oceanica</i>)	2	2
103	Habitat 1170: Reefs	2	1
104	Habitat 1180: Submarine structures made by leaking gases	0	0
201	Public Maritime-Terrestrial Domain	2	2
202	Areas of significant potential flood risk (ARPSIs)	2	2
301	Submarine banks, seamounts or elevations	0	0
302	Submarine canyons and channels	1	0
303	Submarine ridges and escarpments	0	0
304	Diapryo	0	0
305	Emanaciones gaseosas submarinas	0	0
306	Continental shelf (certain neritic zones)	1	0
307	Continental slope areas	1	0
402	Areas identified as ecologically vulnerable and at ecological risk along the coast	0	1
501	Migration routes and dispersal areas (birds, cetaceans, marine areas of dispersal for larvae and juveniles)	0	1
50101	<i>Caretta caretta</i>	0	0
50102	<i>Chelonia mydas</i>	0	0
50103	<i>Dermochelys coriacea</i>	0	0
50106	<i>Balaenoptera acutorostrata</i>	0	1
50108	<i>Balaenoptera physalus</i>	0	1
50109	<i>Delphinus delphis</i>	0	0
50111	<i>Globicephala melas</i>	0	0
50112	<i>Grampus griseus</i>	0	0
50114	<i>Megaptera novaeangliae</i>	0	1
50119	<i>Physeter macrocephalus</i>	0	1
50121	<i>Stenella coeruleoalba</i>	0	0
50124	<i>Tursiops truncatus</i>	0	0
50125	<i>Ziphius cavirostris</i>	0	0
50127	<i>Calonectris borealis</i>	0	0
50128	<i>Calonectris diomedea s. str.</i>	0	0
50129	<i>Chlidonias hybrida</i>	0	0
50130	<i>Chlidonias niger</i>	0	0
50132	<i>Hydrobates pelagicus</i>	0	0
50133	<i>Larus audouinii (Ichthyaeetus audouinii)</i>	0	0
50134	<i>Larus fuscus</i>	0	0
50135	<i>Larus genei (Chroicocephalus genei)</i>	0	0
50137	<i>Larus melanocephalus (Ichthyaeetus melanocephalus)</i>	0	0
50138	<i>Larus michahellis</i>	0	0
50139	<i>Larus ridibundus (Chroicocephalus ridibundus)</i>	0	0
50142	<i>Phalacrocorax aristotelis aristotelis (Gulosus)</i>	0	0
50143	<i>Phalacrocorax aristotelis desmarestii (Gulosus)</i>	0	0
50145	<i>Puffinus mauretanicus</i>	0	0
50148	<i>Sterna hirundo</i>	0	0
50149	<i>Sternula albifrons</i>	0	0
50152	<i>Corallium rubrum</i>	2	1
50153	<i>Lithothamnium coralloides</i>	2	0
50154	<i>Patella ferruginea</i>	0	0
50155	<i>Phymatholithon calcareum</i>	2	0
50156	<i>Pinna nobilis</i>	2	0
502	Artificial reefs	1	1
601	Sensitive areas for urban water treatment	1	1

0	Does not store carbon	Does not capture carbon
1	Partially stores carbon	Partially capture carbon
2	Highly stores carbon	Highly capture carbon

C. Spatial analysis

After the elaboration of these matrix-tables and their valuations, this information has been used to conduct the spatial analysis for each marine demarcation. The following information was used to develop the spatial analysis:

- Based on the matrix-tables created in the previous step. Elements with a value of 0 for both functions were discarded to simplify the computation process.
- The cartography of these MGI elements was used. For some MGI elements, the cartography was adapted taking into consideration information from the bibliography research. For example, for some geographical elements (i.e., the continental shelf or slope), only areas with a muddy and very fine sand substrate have been considered, as this type of substrate stores carbon, discarding those parts of the element that are composed of other types of substrates.
- The spatial analysis was performed using a grid with 1 km sides.

The spatial analysis was performed using ArcGIS Pro software.

D. Evaluation of the results of the spatial analysis

The results show the spatial distribution in which marine green infrastructure fulfils any function of carbon sequestration and/or storage in each grid cell. According to the assessment carried out in the previous point, each grid cell may have different values as a result, depending on the number of green infrastructure elements that appear in that grid cell, as well as the sum of the valuation according to the function each element can perform.

Three types of maps have been produced for each marine demarcation:

- Spatial distribution of total value of MGI elements that play the role of carbon sequestration;
- Spatial distribution of total value of MGI elements that play the role of carbon storage;
- Spatial distribution of total value of MGI elements that play the role of carbon storage and sequestration.

2.3. Results

The literature review provided a deeper understanding of the elements considered within the marine green infrastructure, showing how they can play an additional role to carbon capture and/or sequestration. Both demarcations are represented by 46 (Strait and Alboran marine demarcation) and 51 (Levantine-Balearic marine demarcation) MGI elements. In this regard, the bibliography review itself filters and decreases this number by demarcation, given that there are many elements, especially pelagic species distribution, that do not perform either of these two functions. The bibliographic analysis developed made possible to identify which elements of the MGI perform only one of the functions, either carbon sequestration or capture; but it has also been possible to identify those that perform both functions, as is the case with phanerogams, which, in addition to sequestering carbon through their own photosynthesis process, can also store it in their roots. Figure 32 shows the type of carbon function that has been identified in MGI elements.

Type of carbon function by each MGI element

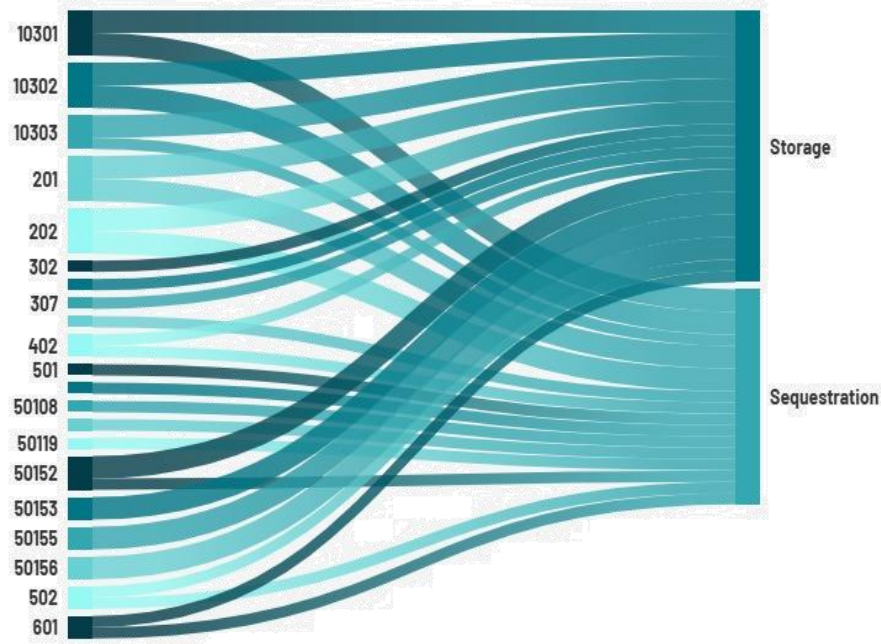


Figure 32- Type of carbon function performed by each MGI element based on the bibliography research. Source: Own elaboration.

As mentioned in the introduction, in addition to emphasizing these functions through elements that have been extensively studied, such as seagrass beds (represented by elements 1110 and 1120) or maerl beds (represented by element 1110), it has been of great interest to find bibliographic information on other elements in which this function is less studied, but which perform one of the functions. For example, the role of some geological elements such as the continental shelf and slope, which, if composed of a muddy or very fine sand substrate, have a carbon storage capacity. Other elements related to species distribution, such as whale species in particular or areas known for their feeding habits, have highlighted the potential contribution of these species to carbon capture. They can also play a significant role in the carbon cycle itself and contribute to carbon storage after the end of their life cycle, serving as an important source of carbon through their skeletons when it is accumulated in the substrate.

This information has been integrated in a final matrix-table for each marine demarcation. By marine demarcation, the elements of the MGI that perform one or both functions can be seen in tables 18 and 19. In both demarcations, the total number of elements decreased to 20.

Table 18 – Final matrix-table of the elements of the MGI of the Strait and Alboran marine demarcation that store and/or capture carbon. Source: Own elaboration.

MGI ID	The Strait and Alboran marine demarcation MGI element	Blue Carbon	
		Storage	Sequestration
101	Habitat 1110: Sandbanks which are slightly covered by sea water all the time	x	x
102	Habitat 1120: Posidonia beds (<i>Posidonia oceanica</i>)	x	x
103	Habitat 1170: Reefs	x	x
201	Public Maritime-Terrestrial Domain	x	x
202	Areas of significant potential flood risk (ARPSIs)	x	x
302	Submarine canyons and channels	x	x
306	Continental shelf (certain neritic zones)	x	x
307	Continental slope areas	x	x
401	Distribution areas of wild species under special protection and endangered species, and critical areas designated in recovery plans		x
402	Areas identified as ecologically vulnerable and at ecological risk along the coast	x	x
501	Migration routes and dispersal areas (birds, cetaceans, marine areas of dispersal for larvae and juveniles)		x
50106	<i>Balaenoptera acutorostrata</i>		x
50108	<i>Balaenoptera physalus</i>		x
50114	<i>Megaptera novaeangliae</i>		x
50119	<i>Physeter macrocephalus</i>		x
50152	<i>Corallium rubrum</i>	x	x
50153	<i>Lithothamnium coralloides</i>	x	x
50155	<i>Phymatholithon calcareum</i>	x	x
		x	x
502	Artificial reefs	x	x
601	Sensitive areas for urban water treatment	x	x

0	Does not store carbon	Does not capture carbon
1	Partially stores carbon	Partially capture carbon
2	Highly stores carbon	Highly capture carbon

The spatial data related to these MGI elements was prepared before the development of the spatial analysis. For this reason, some of the layers, especially geological elements (Submarine canyons and channels (302); Continental shelf (306) and slope (307)), were clipped according to the type of substrate that facilitates carbon storage, using only the substrate of muddy or very fine sand. In the case of coastal elements, such as certain areas of the Public Maritime-Terrestrial Domain (201), Areas of Significant Potential Flood Risk (202) or Sensitive Areas for Urban Water Treatment (601), layers were also clipped to use only the areas that had a spatial overlapping with coastal elements that perform the function of sequestration and/or carbon storage, such as wetlands or dunes. To this end, a cartographic search was carried out to identify wetland areas or the distribution of Coastal Habitats of Community Interest (based on Habitats Directive reporting) that spatially represented any of these criteria. Once the spatial data was obtained, the layers of the MGI elements that spatially overlapped with any of this information were cut to use only the information relating to those areas that perform any of these carbon functions.

Table 19 – Final matrix-table of the elements of the MGI of the Levantine-Balearic marine demarcation that store and/or capture carbon. Source: Own elaboration.

Levantine-Balearic marine demarcation		Blue Carbon	
MGI ID	MGI element	Storage	Sequestration
101	Habitat 1110: Sandbanks which are slightly covered by sea water all the time	x	x
102	Habitat 1120: Posidonia beds (<i>Posidonium oceanicae</i>)	x	x
103	Habitat 1170: Reefs	x	x
201	Public Maritime-Terrestrial Domain	x	x
202	Areas of significant potential flood risk (ARPSIs)	x	x
302	Submarine canyons and channels	x	x
306	Continental shelf (certain neritic zones)	x	x
307	Continental slope areas	x	x
			x
402	Areas identified as ecologically vulnerable and at ecological risk along the coast	x	x
501	Migration routes and dispersal areas (birds, cetaceans, marine areas of dispersal for larvae and juveniles)		x
50106	<i>Balaenoptera acutorostrata</i>		x
50108	<i>Balaenoptera physalus</i>		x
50114	<i>Megaptera novaeangliae</i>		x
50119	<i>Physeter macrocephalus</i>		x
50152	<i>Corallium rubrum</i>	x	x
50153	<i>Lithothamnium coralloides</i>	x	x
50155	<i>Phymatholithon calcareum</i>	x	x
50156	<i>Pinna nobilis</i>	x	x
502	Artificial reefs	x	x
601	Sensitive areas for urban water treatment	x	x

0	Does not store carbon	Does not capture carbon
1	Partially stores carbon	Partially capture carbon
2	Highly stores carbon	Highly capture carbon

The spatial analysis was developed to identify those areas that, based on the elements of the MGI and their valuation on the carbon function. For this purpose, using the information from the matrix-tables and the adapted cartography, a spatial analysis was carried out using a 1 km grid. As a result, for each cell of the analysis grid, an output value is obtained corresponding to the sum of the average value of the carbon function that each of the MGI elements can fulfil. Based on the resulting output, a spatial representation was produced for each marine demarcation, identifying those areas with higher or lower values for the carbon functions. Three types of maps were generated as represented in figures 33 to 38.



The Strait and Alboran marine demarcation:

- Map of carbon sequestration areas based on MGI elements:

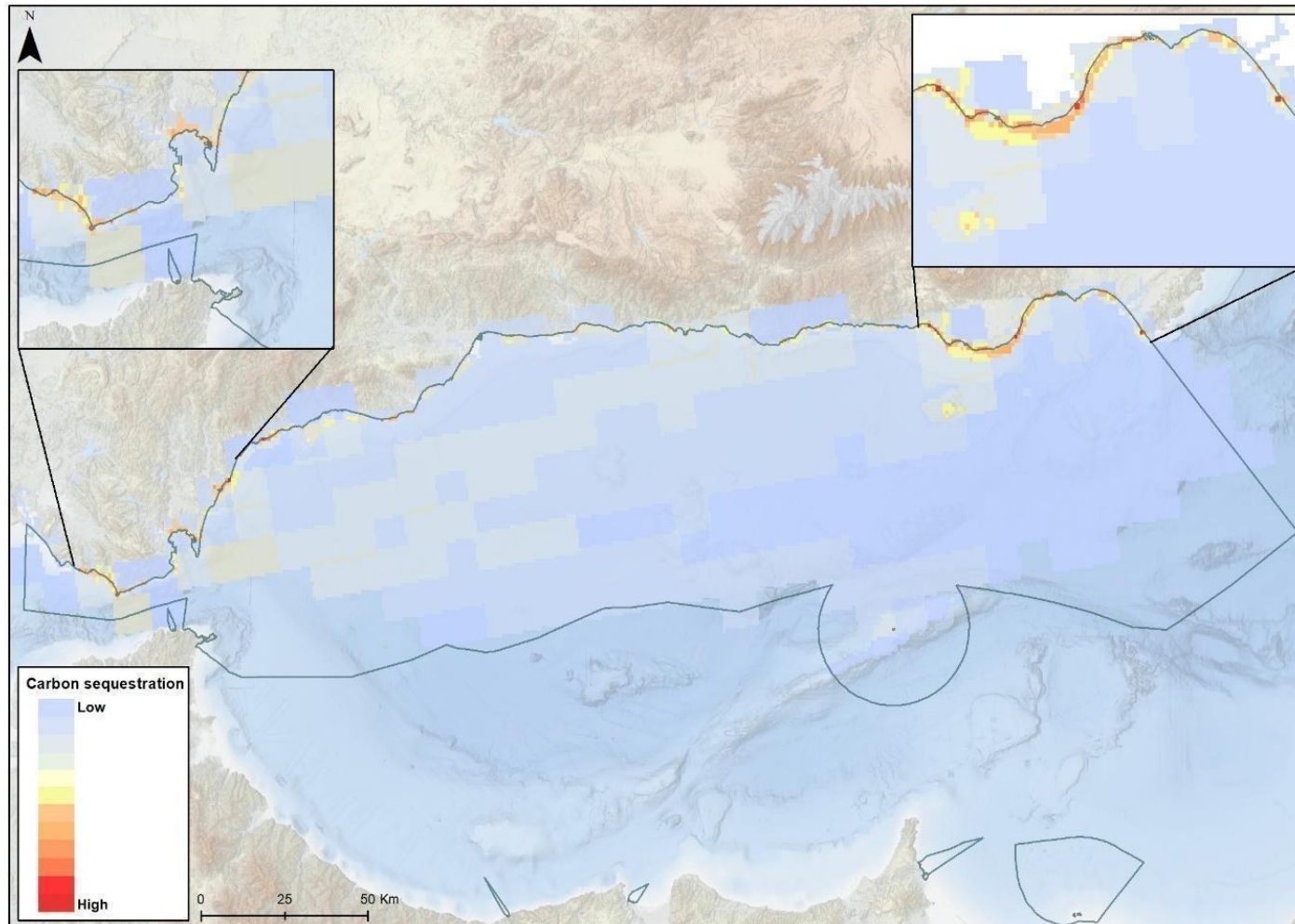


Figure 33 - Carbon sequestration based on MGI concept in the Strait and Alboran marine demarcation. Source: Own elaboration.

- Map of carbon storage areas based on MGI elements:

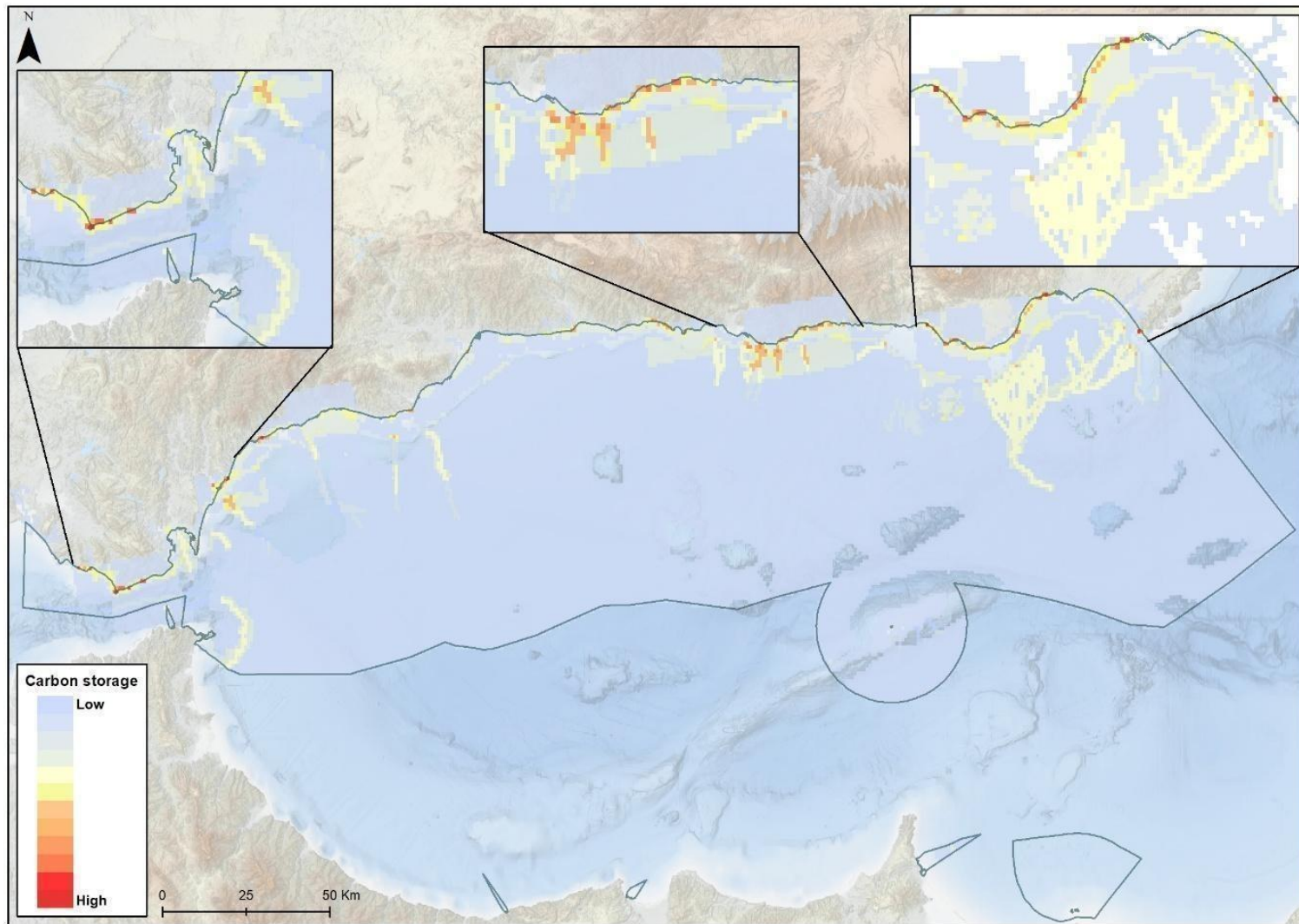


Figure 34 - Carbon storage based on MGI concept in the Strait and Alboran marine demarcation. Source: Own elaboration.

- Map of carbon sequestration and storage areas on MGI elements:

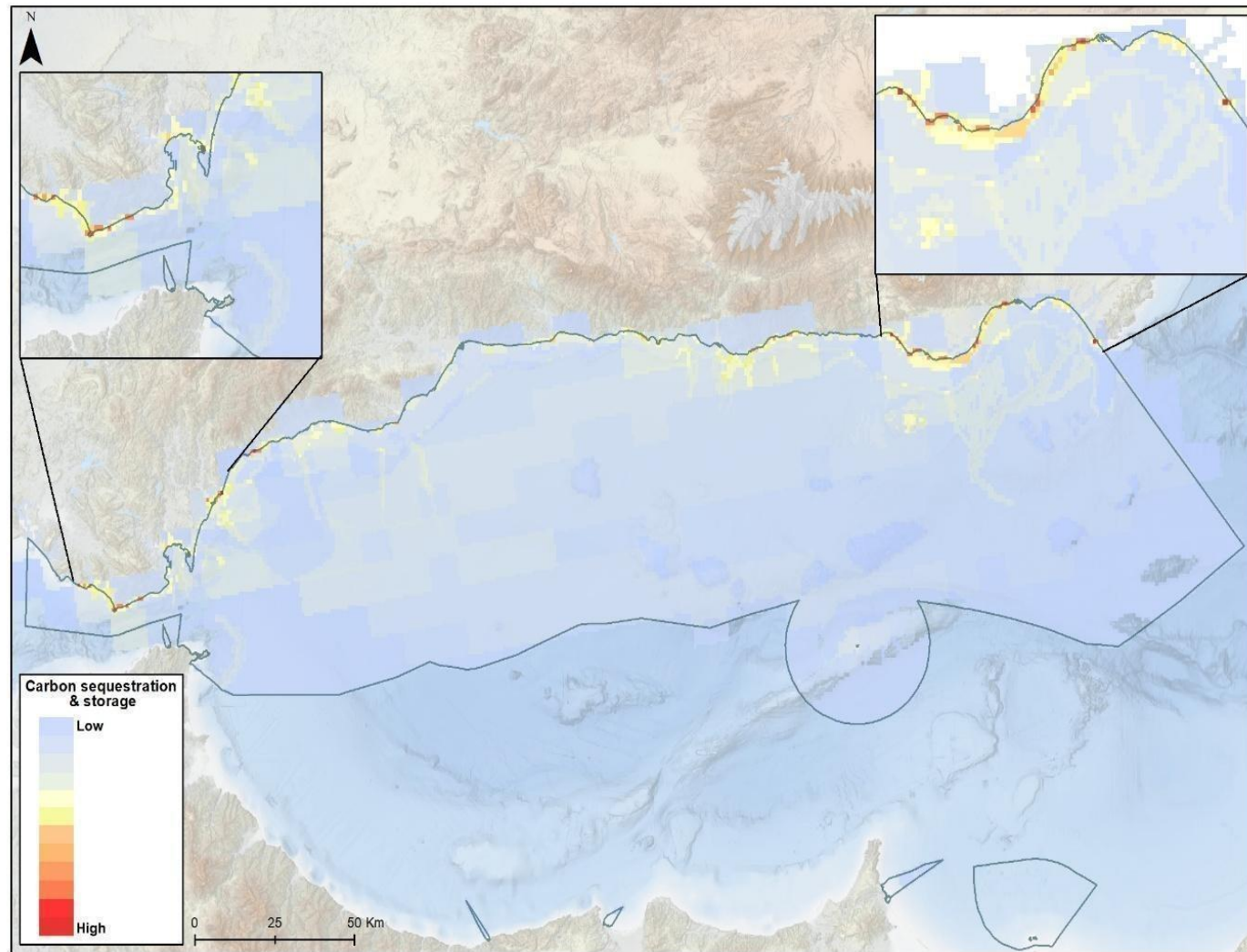


Figure 35 – Carbon sequestration and storage based on MGI concept in the Strait and Alboran marine demarcation. Source: Own elaboration.



The Levantine-Balearic marine demarcation:

- Map of carbon sequestration areas based on MGI elements:

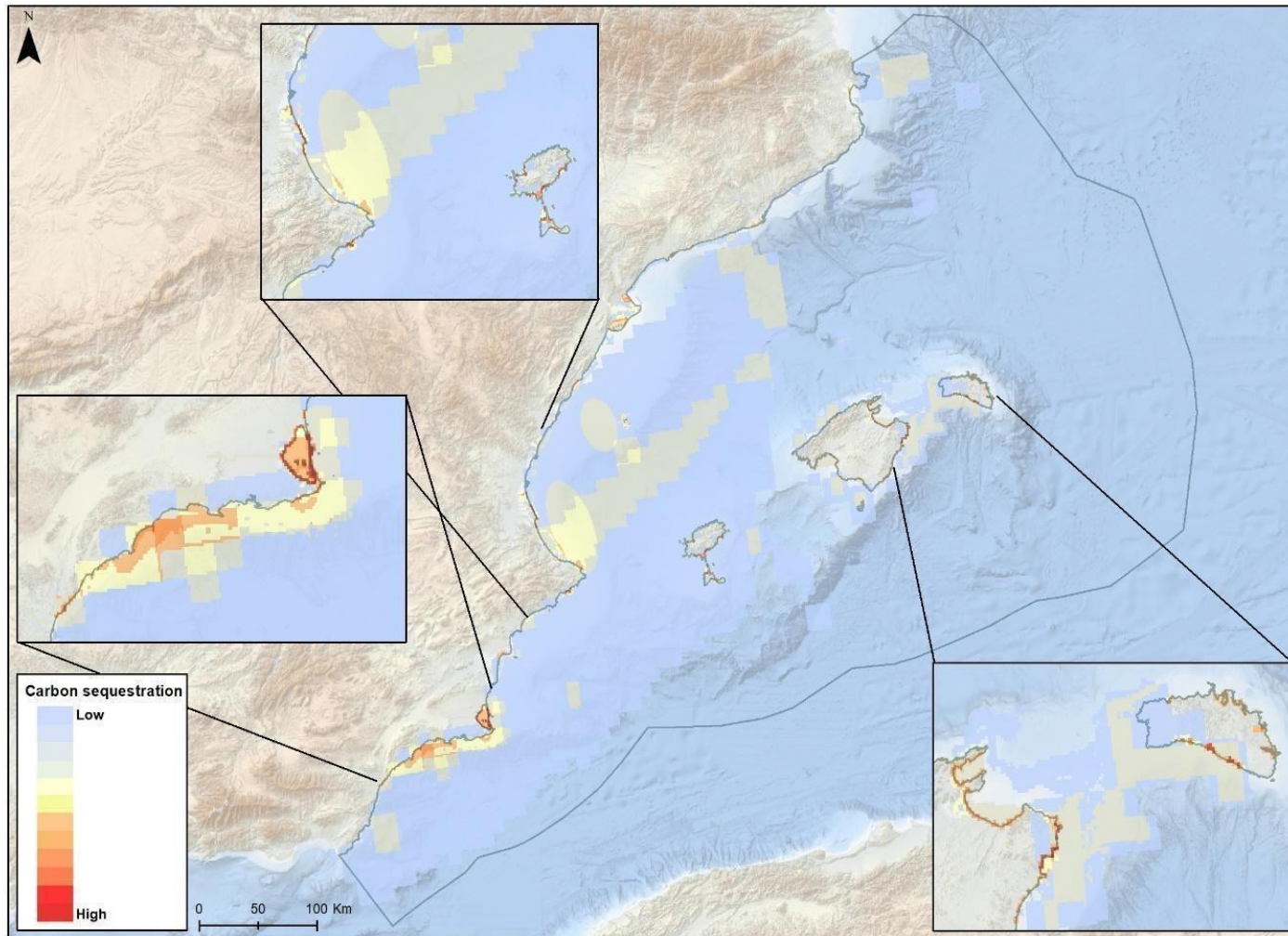


Figure 36 - Carbon sequestration based on the MGI concept in the Levantine-Balearic marine demarcation. Source: Own elaboration.



- Map of carbon storage areas based on MGI elements:

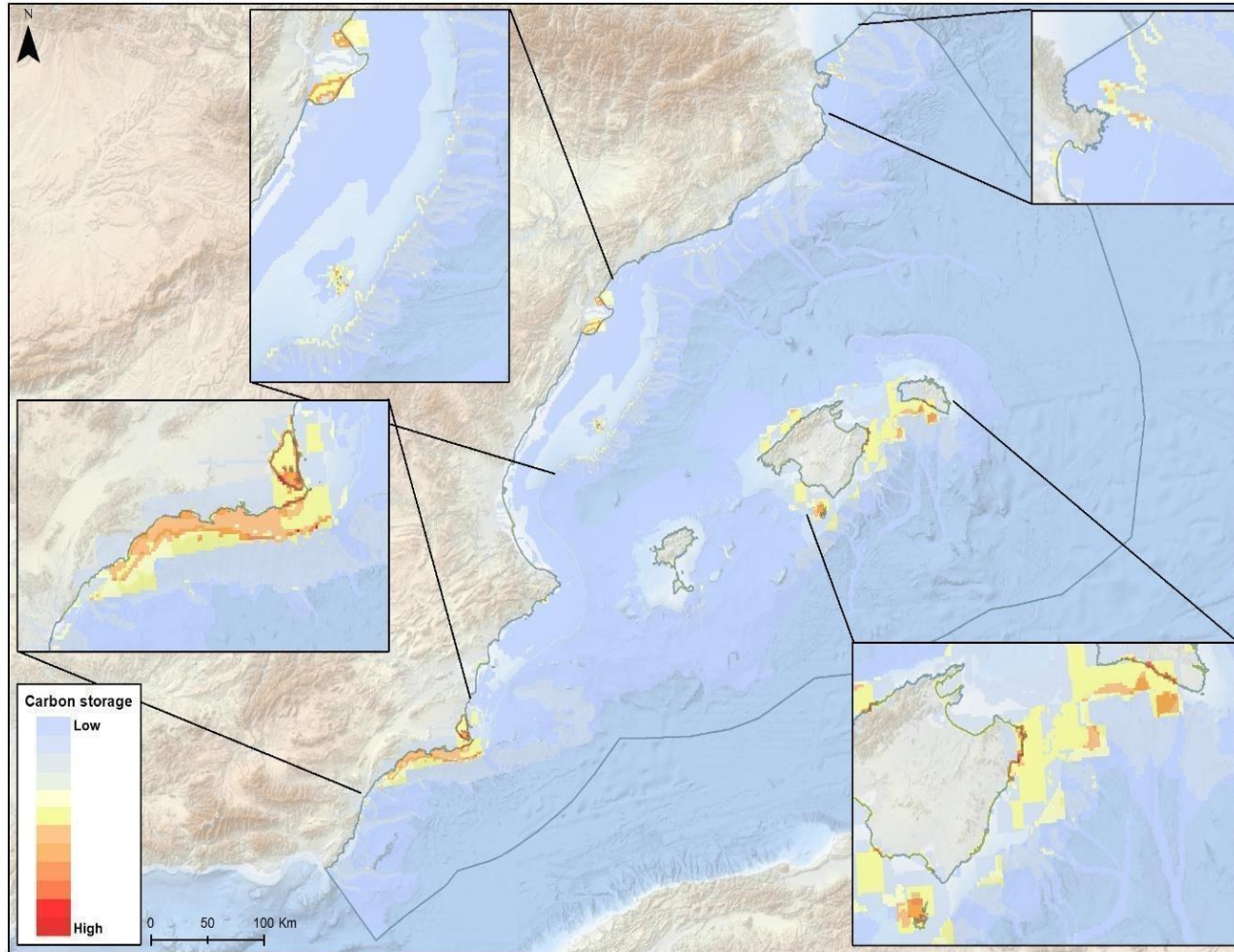


Figure 37 – Carbon storage based on the MGI concept in the Levantine-Balearic marine demarcation. Source: Own elaboration.

- Map of carbon sequestration and storage areas on MGI elements:

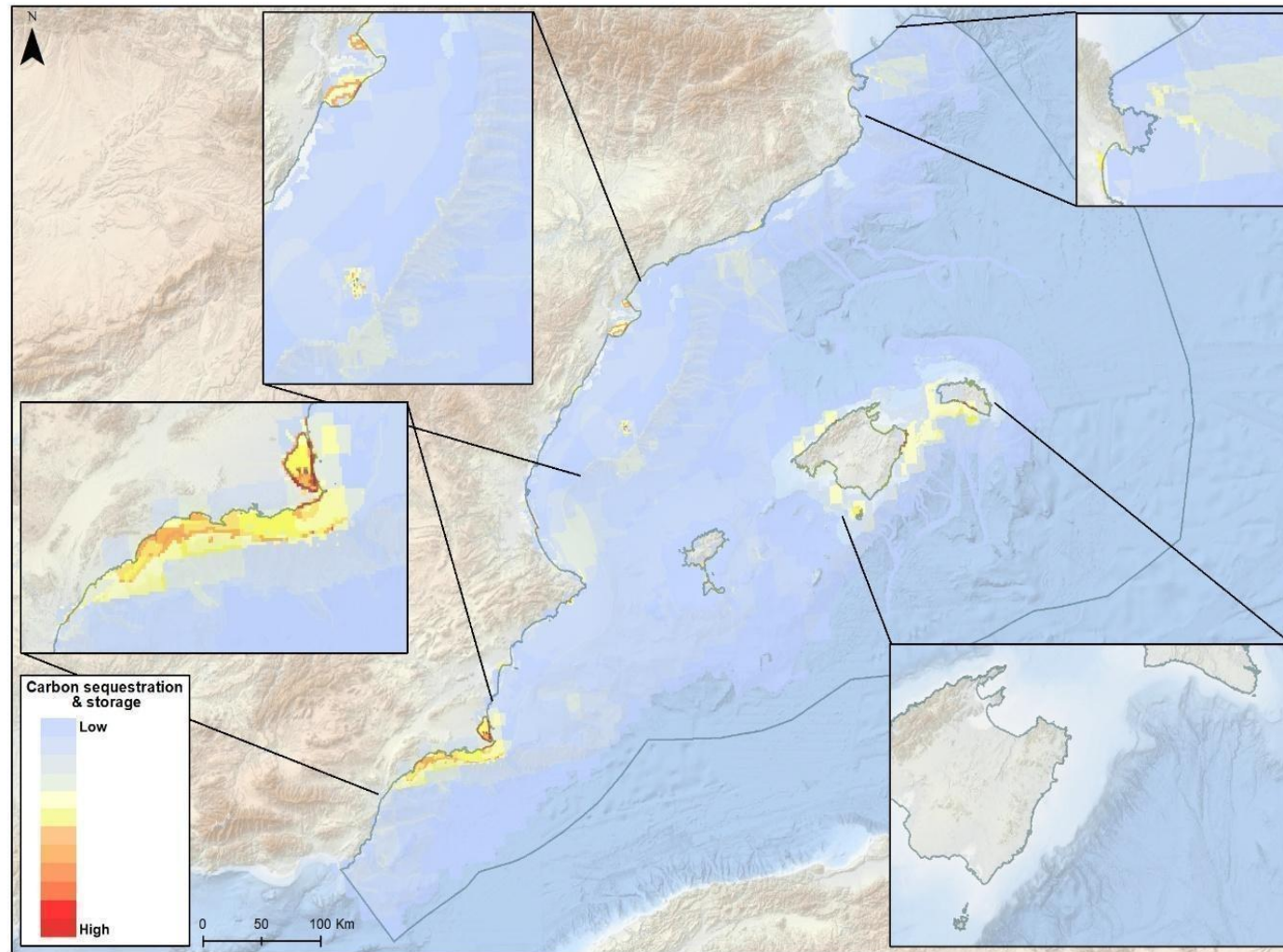


Figure 38 – Carbon sequestration and storage based on the MGI concept in the Levantine-Balearic marine demarcation. Source: Own elaboration.

For both marine demarcations, the results obtained are consistent in terms of the areas identified specifically for their proximity to the coast, given that many of the elements that perform any of the functions are located at the land-sea interface or very close to the coast. Furthermore, for both marine areas, the highest values correspond to the carbon storage function, which is also coherent with the nature of MGI elements that perform this function.

Analysing each of the carbon functions independently, on the one hand, it can be seen that those areas where **carbon sequestration** by elements identified by the MGI occurs are located near the coast. In this sense, they mostly correspond to Habitats of Community Interest, mainly the elements "Habitat 1110: Sandbanks which are slightly covered by sea water all the time" (101) and "Habitat 1120: Posidonia beds (*Posidonium oceanicae*)" (102), but also to those coastal areas which, although they are elements identified in "Areas with environmental management of public domain" more related to elements of management, where some areas can overlap with other Habitats of Community interest on the coast such as Habitat 1150 (Coastal lagoons) or Habitat 1160 (Large shallow inlets and bays). This is very clearly shown in the Strait and Alboran marine demarcation, in the surroundings of Cabo de Gata in Almería, and in the Levantine-Balearic marine demarcation, in the Mar Menor area. Any of these elements are very characteristic in both demarcations, despite being very sensitive to the effects of climate change, they play a crucial role in carbon sequestration at the land-sea interface. On the other hand, and being more predominant in the Levantine-Balearic marine demarcation, the interesting role played by some species of marine mammals in carbon sequestration stands out. In this regard, areas where these species are known to use the space have been identified, especially fin whales, for example in the area of Cabo de la Nao, where carbon sequestration values have been reflected in the results of spatial analysis.

On the other hand, in relation to the **carbon storage** function, as mentioned above, in general, the grid values are higher for areas identified for sequestration. In this regard, the role played by geological elements is noteworthy. Additionally, if they also conform of mud or very fine sand substrate, they play a role in carbon storage, especially in some areas with MGI elements such as the "Continental shelf (certain neritic zones)" (306) and "Continental slope" (307). In addition, other elements such as "Submarine canyons and channels" (303), which added to performing this storage function, can have a very interesting function of transferring carbon from continental shelf areas to deeper areas, which perform a very important function from the point of view of maintaining the carbon cycle, highlighting the importance of connectivity through this type of MGI element. This situation is shown in areas between the coast of Málaga and Granada, as well in Almería coast in the surroundings of Cabo de Gata, all in the Strait and Alboran marine demarcation. And in the case of the Levantine-Balearic marine demarcation, it can be seen in the Balearic Islands, especially in the south of Menorca and the east of Mallorca, seen a spatial connectivity between the MGI elements. And as well in the area of Tiñoso canyon y Seco de Palos located in the south-east of Murcia Region.

Finally, results also highlighted the important role that some elements play for **both functions at the same time (sequestration and storage)**, which are mainly located near the coast, this is the case of MGI elements such as Habitat 1110 (101), Habitat 1120 (102), areas of the Public Maritime-Terrestrial Domain (201) or Areas of significant potential flood risk (202). These elements play a very important role as nature-based solutions at the land-sea interface, having a key function in climate change mitigation, i.e., erosion control, but also being areas identified for climate refugia or elements that can improve connectivity (especially between land and sea).



In relation to the **EGD elements addressed** by this national action, a correlation has been established between the functions of each MGI element involved in carbon sequestration and/or capture and the EGD elements. For this, a table has been elaborated.

Table 20 – Table correlating MGI elements that sequester and/or store carbon and the elements of the EGD. Source: Own elaboration.

Levantine-Balearic marine demarcation		The Strait and Alboran marine demarcation		Blue Carbon - EGD objectives	
MGI ID	MGI element	MGI ID	MGI element	Storage	Sequestration
101	Habitat 1110: Sandbanks which are slightly covered by sea water all the time	10301	Habitat 1110: Sandbanks which are slightly covered by sea water all the time	A.4 Blue carbon sinks A.5. Knowledge-related measures B.1 Green Infrastructures to enhance coastal resilience B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.1 A coherent network of marine protected areas D.3 Knowledge-related measures	B.1 Green Infrastructures to enhance coastal resilience B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.1 A coherent network of marine protected areas D.3 Knowledge-related measures
102	Habitat 1120: Posidonia beds (Posidonion oceanicae)	10302	Habitat 1120: Posidonia beds (Posidonion oceanicae)	A.4 Blue carbon sinks A.5. Knowledge-related measures B.1 Green Infrastructures to enhance coastal resilience B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.1 A coherent network of marine protected areas D.3 Knowledge-related measures	B.1 Green Infrastructures to enhance coastal resilience B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.1 A coherent network of marine protected areas D.3 Knowledge-related measures
103	Habitat 1170: Reefs	10303	Habitat 1170: Reefs	A.4 Blue carbon sinks A.5. Knowledge-related measures B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.1 A coherent network of marine protected areas D.3 Knowledge-related measures	B.1 Green Infrastructures to enhance coastal resilience B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.1 A coherent network of marine protected areas D.3 Knowledge-related measures
201	Public Maritime-Terrestrial Domain	201	Public Maritime-Terrestrial Domain	A.4 Blue carbon sinks A.5. Knowledge-related measures B.1 Green Infrastructures to enhance coastal resilience B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures	B.1 Green Infrastructures to enhance coastal resilience B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.3 Knowledge-related measures D.4 Governance-related measures



				D.3 Knowledge-related measures D.4 Governance-related measures	
202	Areas of significant potential flood risk (ARPSIs)	202	Areas of significant potential flood risk (ARPSIs)	A.4 Blue carbon sinks A.5. Knowledge-related measures B.1 Green Infrastructures to enhance coastal resilience B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.3 Knowledge-related measures D.4 Governance-related measures	B.1 Green Infrastructures to enhance coastal resilience B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.3 Knowledge-related measures D.4 Governance-related measures
302	Submarine canyons and channels	302	Submarine canyons and channels	A.4 Blue carbon sinks A.5. Knowledge-related measures B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.1 A coherent network of marine protected areas D.3 Knowledge-related measures	x
306	Continental shelf (certain neritic zones)	306	Continental shelf (certain neritic zones)	A.4 Blue carbon sinks A.5. Knowledge-related measures B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.1 A coherent network of marine protected areas D.3 Knowledge-related measures	x
307	Continental slope areas	307	Continental slope areas	A.4 Blue carbon sinks A.5. Knowledge-related measures B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.1 A coherent network of marine protected areas D.3 Knowledge-related measures	x
		401	Distribution areas of wild species under special protection and endangered species, and critical areas designated in recovery plans		B.1 Green Infrastructures to enhance coastal resilience B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related



					effects B.4 Knowledge-related measures D.3 Knowledge-related measures D.4 Governance-related measures
402	Areas identified as ecologically vulnerable and at ecological risk along the coast	402	Areas identified as ecologically vulnerable and at ecological risk along the coast	A.4 Blue carbon sinks A.5. Knowledge-related measures B.1 Green Infrastructures to enhance coastal resilience B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.3 Knowledge-related measures D.4 Governance-related measures	B.1 Green Infrastructures to enhance coastal resilience B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.3 Knowledge-related measures D.4 Governance-related measures
501	Migration routes and dispersal areas (birds, cetaceans, marine areas of dispersal for larvae and juveniles)	501	Migration routes and dispersal areas (birds, cetaceans, marine areas of dispersal for larvae and juveniles)		B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.1 A coherent network of marine protected areas D.3 Knowledge-related measures
50106	<i>Balaenoptera acutorostrata</i>	50106	<i>Balaenoptera acutorostrata</i>		B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.1 A coherent network of marine protected areas D.3 Knowledge-related measures
50108	<i>Balaenoptera physalus</i>	50108	<i>Balaenoptera physalus</i>		B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.1 A coherent network of marine protected areas D.3 Knowledge-related measures
50114	<i>Megaptera novaeangliae</i>	50114	<i>Megaptera novaeangliae</i>		B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.1 A coherent network of marine protected areas D.3 Knowledge-related measures

50119	<i>Physeter macrocephalus</i>	50119	<i>Physeter macrocephalus</i>		B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.1 A coherent network of marine protected areas D.3 Knowledge-related measures
50152	<i>Corallium rubrum</i>	50152	<i>Corallium rubrum</i>	A.4 Blue carbon sinks A.5. Knowledge-related measures B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.1 A coherent network of marine protected areas D.3 Knowledge-related measures	B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.1 A coherent network of marine protected areas D.3 Knowledge-related measures
50153	<i>Lithothamnium coralloides</i>	50153	<i>Lithothamnium coralloides</i>	A.4 Blue carbon sinks A.5. Knowledge-related measures B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.1 A coherent network of marine protected areas D.3 Knowledge-related measures	x
50155	<i>Phymatholithon calcareum</i>	50155	<i>Phymatholithon calcareum</i>	A.4 Blue carbon sinks A.5. Knowledge-related measures B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.1 A coherent network of marine protected areas D.3 Knowledge-related measures	x
50156	<i>Pinna nobilis</i>			A.4 Blue carbon sinks A.5. Knowledge-related measures B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.1 A coherent network of marine protected areas D.3 Knowledge-related measures	x



502	Artificial reefs	502	Artificial reefs	<ul style="list-style-type: none"> A.4 Blue carbon sinks A.5. Knowledge-related measures B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.1 A coherent network of marine protected areas D.3 Knowledge-related measures D.4 Governance-related measures 	<ul style="list-style-type: none"> B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes B.3 Anticipation of climate change-related effects B.4 Knowledge-related measures D.1 A coherent network of marine protected areas D.3 Knowledge-related measures D.4 Governance-related measures
	601		Sensitive areas for urban water treatment	601	Sensitive areas for urban water treatment

0	Does not store carbon	Does not capture carbon
1	Partially stores carbon	Partially capture carbon
2	Highly stores carbon	Highly capture carbon

This correlation identifies that the EGD elements most related to **climate change adaptation**, (especially B.2 Protection of climate-sensitive marine and coastal biodiversity and ecosystems, and landscapes; B.3 Anticipation of climate change-related effects; and B.4 Knowledge-related measures), are the most closely identified with the MGI elements that are related to carbon storage and/or sequestration. This is followed by the MGI element on D.3 Knowledge-related measures relating to biodiversity and the protection of such elements.

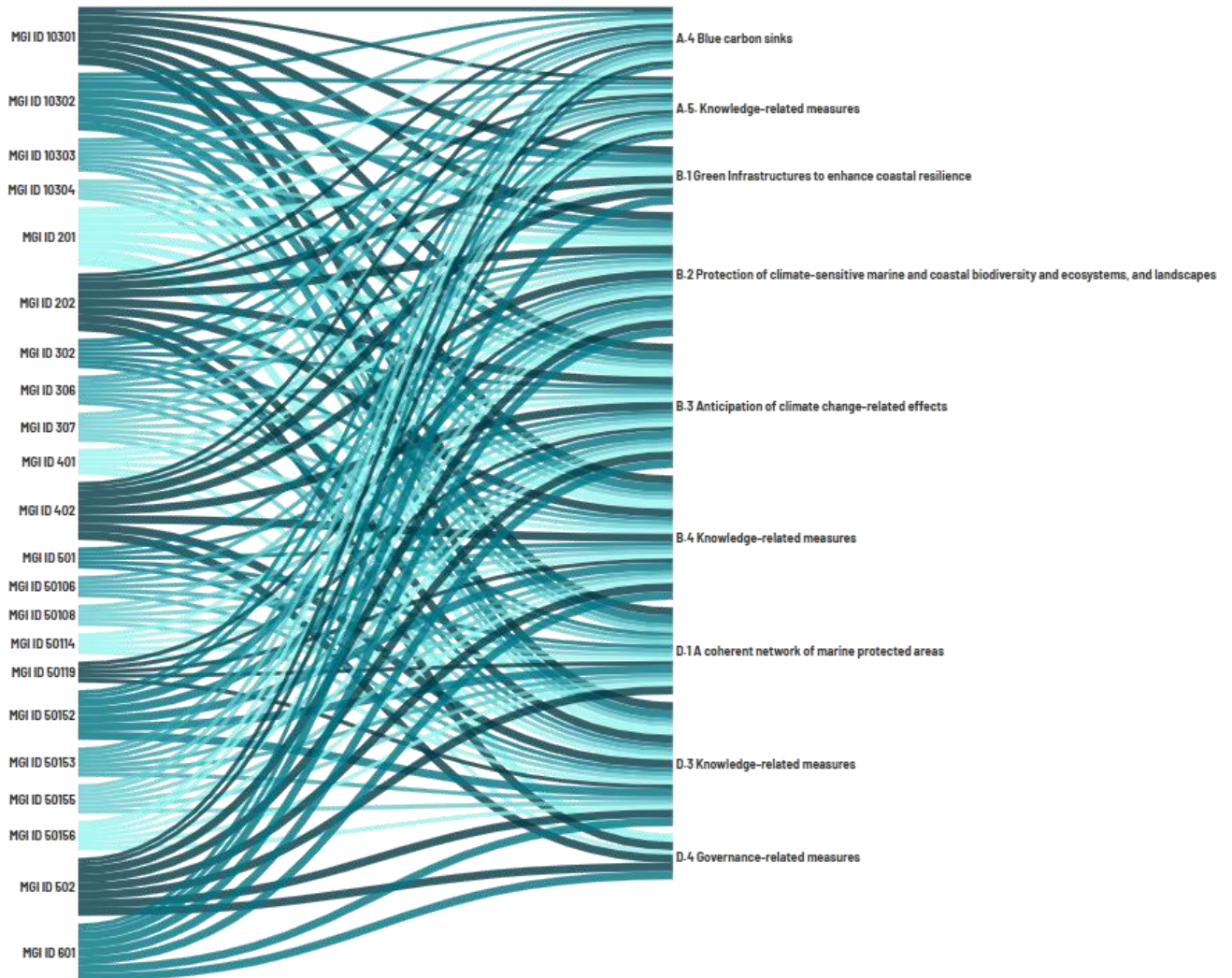


Figure 39 – Correlation between MGI elements that sequester and/or store carbon and EGD elements.
Source: Own elaboration.

Once the most important elements of the EGD have been identified—particularly those related to climate change adaptation—and once the areas relevant for carbon sequestration and/or storage have been spatialised, it becomes evident that the use of GI as a tool significantly enhances the identification of elements performing these functions. It also contributes to identifying areas that are especially important for climate change adaptation, as well as for climate change mitigation and biodiversity conservation.

In this sense, GI can be used as a valuable decision-support tool within MSP processes. For example, it can provide information for zoning related to climate change considerations or the designation of areas for biodiversity conservation.



3. Transferability and upscaling

3.1. Transferability

The methodology for identifying marine green infrastructure elements that potentially capture and/or sequester carbon is simple and easily applicable to other areas of the Mediterranean or different scales. This national action has been carried out at the marine demarcation level according to the scope of application of MSP in Spain. In this regard, during the current review of the Maritime Spatial Plans in Spain, the results obtained in this study are enabling the assessment of the creation of a specific High Potential Area for Blue Carbon Sequestration, thereby reinforcing the integration of climate change mitigation and adaptation into maritime spatial planning in Spain.

The methodology could be transferred to other areas or scales, provided that the spatial data used for the analysis allow for this. Therefore, the main limitation is the availability of spatial data relating to the distribution of marine green infrastructure elements.

3.2. Affordability

For the national action developed, it is essential to have knowledge on several issues:

- On the one hand, identifying the elements that make up the MGI requires describing their characteristics, detailing the functions they perform, and analysing the ecosystem services they provide, as well as their ecological value and degree of connectivity. This information makes it possible to assess their contribution in the context of blue carbon, particularly regarding their capacity for carbon storage, sequestration, and long-term ecological resilience. To this end, it is necessary to conduct a bibliographic review of these elements in order to deepen their understanding and determine more precisely which of them should be used as part of the MGI.
- On the other hand, it is necessary to have a good understanding of how to handle this information at the cartographic level. In other words, it is necessary to have (i) proper spatial data management skills, (ii) knowledge of how to perform spatial analysis using GIS tools, and (iii) *know how* to interpret the results obtained so that there is consistency between the identification of MGI elements and the results obtained in a spatial analysis.

3.3. Upscaling

As mentioned in the Transferability section, the methodology implemented in this national action can be scaled up to broader scales, depending on the availability and the quality of the spatial data.

However, it should be highlighted that the use of MGI as a tool for identifying blue carbon ecosystems helps not only to assess the sequestration and storage process at the national level, but also at the cross-border level. For this, a collaboration between countries is therefore key to achieving accurate identification and assessment of blue carbon in the marine environment.



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4. Conclusion

The use of Marine Green Infrastructure (MGI) as a tool makes it possible not only to identify areas that play an important role in maintaining biodiversity and connectivity, but also to support the identification of elements that, by their very nature, perform additional functions linked to climate change mitigation and adaptation. In the context of blue carbon, this approach facilitates the detection of areas relevant for carbon sequestration and/or long-term storage. It is important to highlight that this methodology goes beyond classical blue-carbon habitats—such as seagrass meadows or saltmarshes—by incorporating other elements, such as geological formations or specific coastal zones, which may also contribute to carbon-related processes.

The identification of these areas can contribute to the establishment of specific zoning categories related to climate change or can be integrated into biodiversity zoning already established. In this way, the objectives of preservation, protection, and environmental enhancement can explicitly incorporate climate-change-related considerations, such as the identification of areas with high potential for blue carbon.

However, several limitations must be acknowledged. A major constraint arises from the availability of marine spatial data. Much of the existing cartography is concentrated in coastal areas, either because these MGI elements are naturally located nearshore or because data collection efforts have been historically focused in these accessible environments. In contrast, offshore regions often remain poorly mapped, with substantial knowledge gaps regarding the presence, distribution, and ecological role of potential MGI elements. This lack of information restricts the full integration of offshore elements into MGI analyses and may limit the capacity to identify blue carbon-relevant features in deeper or more remote marine zones.

In any case, the methodology presented in this national action can serve as a starting point for the use of a specialised tool within the context of Green Infrastructure concept and its use in the context of MSP. This approach can be applied at different spatial scales, ranging from detailed case studies at the sub-regional level to broader regional assessments that incorporate a cross-border perspective.



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National action #9: Circular economy concept in the framework of MSP plans (IEO-CSIC)

1. Context and needs

The overarching aim of Maritime Spatial Planning (MSP) is to enable the sustainable development of maritime activities while protecting the environment. However, the spatial focus of MSP processes tends to emphasise zoning and coexistence between uses, often overlooking cross-cutting sustainability aspects such as the circular economy.

Among the six European Green Deal (EGD) priorities assessed by MEDIGREEN through the Deliverable 2.1 *State of Play* report, the Blue Circular Economy emerges as the least developed dimension across Mediterranean national MSP plans, including Spain's *Planes de Ordenación del Espacio Marítimo* (POEM).

In the maritime context, the circular economy refers to the application of sustainability principles aimed at reducing primary resource consumption, extending the lifespan of materials and infrastructure, and minimising waste through reuse, repair, recycling and recovery processes. Despite its relevance for sectors such as fisheries, aquaculture, ports and maritime transport, these principles are not structurally integrated into current MSP frameworks.

In Spain, references to circularity remain scarce and largely confined to sector-specific measures—such as port waste management, recovery of derelict fishing gear, or handling of end-of-life vessels. These actions are typically regulated through sectoral or environmental legislation and are not embedded within the strategic or spatial planning logic of the POEM.

Although the MSP Directive (2014/89/EU) does not explicitly refer to the circular economy, the evolving EU policy landscape—particularly within the framework of the emerging Ocean Pact—has begun to incorporate related concepts such as resource efficiency, waste prevention and sustainable maritime value chains. However, these principles remain indirectly framed and have not yet been translated into operational planning criteria or spatial tools capable of embedding circular economy considerations within national MSP processes.

In the case of the POEM, the concept of the circular economy is included in the guiding principles but remains largely non-operationalised. No specific objectives, zoning criteria, or monitoring indicators are currently in place. Some scattered measures in the port and maritime transport sectors, such as port reception facilities, waste collection and segregation, and efforts to reduce illegal dumping, can be considered proxies. However, these references remain fragmented and are not embedded within a coherent spatial strategy for circularity. The concept is also indirectly reflected in governance measure 6 (OEM6), “Development of a national blue economy strategy”, which foresees alignment with national objectives in energy and climate change, including just transition, as well as biodiversity, circular economy and sustainable resource management, with particular emphasis on the application of the ecosystem approach. Nonetheless, this reference remains strategic and indirect, without translating into concrete spatial or operational provisions within the POEM.

In the new planning cycle, alignment has been further strengthened by the introduction of a horizontal, multi-sectoral objective (H.17) To investigate the possibilities for integrating the circular economy into maritime spatial planning schemes. While this represents a positive step towards more integrated planning, further development would be needed to translate circular economy principles into more concrete spatial, regulatory and monitoring provisions within MSP.

Although the blue circular economy may initially appear to fall beyond the traditional scope of MSP, existing national examples and the innovative practices explored by MSP-GREEN²⁵ partners demonstrate that MSP can play a meaningful role in advancing this dimension of the EGD. The absence of explicit operational integration within current MSP frameworks should therefore not be interpreted as a structural limitation of MSP, but rather as an opportunity for further development. Continued exploration of the relationship between MSP and the blue circular economy is both necessary and timely.

This National Action aims to explore how the concept of circular economy can be meaningfully integrated into the MSP framework in Spain. It will analyse the POEM across different planning layers, from guiding principles and objectives to zoning logic, compatibility criteria, sectoral measures, and monitoring frameworks. The goal is twofold:

- First, to identify where and how circular economy principles can be explicitly addressed in future POEM cycles. Although the POEM are currently undergoing revision, this work analyses the first cycle in order to extract lessons learned, identify entry points and provide concrete recommendations that can feed directly into the forthcoming planning updates.
- Second, to assess which existing elements of the plan can act as “facilitators” for the implementation of circular economy practices, even if not labelled as such.

In line with the MEDIGREEN methodology, the action will also consider interactions with key economic sectors, such as fisheries and aquaculture, where some circular economy initiatives are already emerging. Furthermore, given the relevance of ports and maritime transport in enabling circularity (e.g., through logistics, waste handling, and industrial symbiosis), these sectors will also be included in the assessment.

The EGD topics addressed through this action will primarily be:

E – Blue circular economy

E.1 – Circular design

E.1.1 – Circular design of boats and ships and their components

E.1.2 – Circular design of fishing and aquaculture gears

E.2 – Waste prevention

E.2.1 – Upgrade, strengthening of waste collection systems in ports

E.2.2 – Upgrade, strengthening of waste collection systems in coastal touristic sites

²⁵ The [MSP-GREEN project](#), funded by the European Maritime, Fisheries and Aquaculture Fund (EMFF), aimed to align the Maritime Spatial Plans of EU Member States with the ambitions of the European Green Deal. It was implemented between 1 November 2022 and 31 October 2024.



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E.2.3 – Collecting, transshipping and disposing of waste from ships and other port industries

E.3 – Re-use, repair, upgrade, recycle

E.3.1 – Development of vessel repairing, refitting, and dismantling services in ports

E.3.2 – Development of boat repairing, refitting, and dismantling services in yards and marinas

E.3.3 – Repairing and end-of-life recycling of fishing and aquaculture gears

E.4 – Knowledge-related measures

E.5 – Governance-related measures

2. Implementation

This section outlines the methodological approach adopted to identify where and how circular economy principles can be explicitly integrated into the upcoming revision of the Spanish Maritime Spatial Plans (POEM). The National Action applies a structured, desk-based analytical framework built on the architecture of the current plans, the findings of the MEDIGREEN State of Play, and relevant experiences from other regional MSP contexts.

The methodology combines a gap analysis of existing provisions with an opportunity mapping exercise aligned with EGD priorities.

The first step examines the main components of the POEM, guiding principles, objectives, spatial zoning, coexistence criteria, sectoral and cross-sectoral measures, and monitoring frameworks, to assess the extent to which circular economy considerations are currently incorporated.

In parallel, the analysis reviews existing references to circular economy or related sustainability concepts that could be incorporated into MSP. Potential entry points for integrating circular economy principles are identified based on established frameworks (e.g., waste prevention, resource efficiency, reuse, circular design, industrial symbiosis), cross-referenced with examples and findings from the MSP-GREEN and MEDIGREEN projects and other national MSP practices.

Special attention is given to sectors most relevant for circular economy integration—such as ports, maritime transport, fisheries, and aquaculture—while also considering horizontal enablers that could strengthen circularity across the entire MSP framework.

This analytical process will yield a targeted set of recommendations to inform revisions to the POEM and to provide a transferable approach.

2.1. Consideration of Circular Economy in the Spanish Maritime Spatial Plans

2.1.1. Insights from the diagnostic analysis of the Levantine–Balearic and Gibraltar Straig and and Alboran Marine Demarcations

The analysis of the “*Diagnosis of maritime sectors: current situation and future or potential development*” for the Levantine–Balearic Marine Demarcation indicates that circular-economy considerations are primarily focused on two areas: waste management (particularly plastics and marine litter) and the sustainable development of the aquaculture sector. The document refers to the Spanish Circular Economy Strategy (2020), identified as a key instrument for reducing waste generation and maximising the value of unavoidable waste streams. The document clarifies that the POEM does not explicitly address waste quantification, as this is already covered in the Marine Strategies (as one of their descriptors, marine litter) and the Spanish Circular Economy Strategy.

In the Gibraltar Strait and Alboran Marine Demarcation, circular-economy considerations are similarly addressed primarily through waste management policies and aquaculture sustainability strategies. The diagnostic phase explicitly refers to the Spanish Circular Economy Strategy and EU plastics policies, while clarifying that the POEM does not directly regulate waste streams, as these are covered by Marine Strategies and sectoral legislation. However, given the high concentration of port infrastructure, maritime traffic corridors, and industrial activities within this demarcation, significant untapped potential exists to strengthen circular-economy integration through enhanced land–sea coordination, reverse logistics systems, and industrial symbiosis approaches within the MSP framework.

2.1.2. Circular economy as a guiding principle of the Spanish Maritime Spatial Plans

Within Block II, dedicated to guiding principles and planning objectives, the circular economy is identified as one of the pillars guiding the overall process of MSP and its implementation. It is included in a broader set of principles aimed at supporting the ecological transition towards a low-carbon, resource-efficient economy. **In this context, the circular economy is framed as a high-level orientation rather than as an operational planning concept.**

2.1.3. Circular economy within sectors, specifically tourism

During the POEM design phase, a set of existing objectives for the activities, uses, and interests of the maritime economic sectors, established by the regional governments within their respective jurisdictions, was recognised. Among these, in the case of the Balearic Islands (Levantine–Balearic Demarcation), the circular economy is explicitly identified as an environmental objective for the tourism sector. The need to transform the current tourism development model is emphasised, with particular attention to maritime tourism (cruises) and cruise activities, promoting them in accordance with the principles of the circular economy, environmental protection, and the use of clean energy sources.

2.1.4. Indirect references to circular economy-related practices

Although the exact term “*circular economy*” is not systematically used throughout the POEM, several references to practices that are core elements of the circular economy can be identified in different sectors:

- Aquaculture: Environmental objectives include strengthening the minimisation, valorisation, and reuse of waste generated by aquaculture activities.
- Port activities: The plans consider existing objectives regarding waste prevention and ensure proper waste management, favouring reuse and recycling within port areas.
- Dredging material: The POEM prioritises the productive use of dredged material (e.g., beach nourishment) over disposal, in accordance with environmental acceptability criteria.

As highlighted in Deliverable D2.1, circular economy principles remain largely absent from the operational dimension of the Spanish plans, particularly in terms of spatial criteria and implementation mechanisms. There is no explicit or systematic integration of reuse, recycling, or waste minimisation strategies in the marine context, nor are these principles translated into concrete measures.

Starting from the current situation in Spain, where circular economy considerations are only partially integrated into MSP, and understanding the circular economy as a sustainability approach that reduces primary resource use and waste while extending material lifecycles (European Commission, 2020), this National Action is based on the premise that MSP provides a strategic opportunity to operationalise circular principles across maritime sectors.

2.2. Assessment of Circular Economy concepts and their applicability to MSP

The circular economy (CE) is widely understood as an economic system aimed at minimising resource inputs and waste generation by closing, slowing and narrowing material and energy loops (Geissdoerfer et al., 2020). In the maritime context, this translates into reducing primary resource consumption, extending the lifespan of infrastructure and assets, and promoting reuse, repair and recovery across blue economy sectors.

This understanding of CE can be applied to each blue economy sector, whose processes span the entire product lifecycle—from design to end-of-life. However, translating these lifecycle-based principles into spatial planning frameworks remains challenging.

Although academic literature directly linking MSP and the circular economy remains limited, a growing body of sector-specific research and pilot initiatives has explored the application of circular economy principles across individual maritime sectors. For example, Integrated Multi-Trophic Aquaculture systems seek to close nutrient loops through spatially coordinated multi-species production; fishing-gear recovery schemes aim to reintegrate materials into secondary value chains; and initiatives promoting the reuse of dredged materials in ports illustrate how marine-derived materials can be redirected into terrestrial uses. In this context, **MSP can contribute to operationalising circular economy principles by spatially enabling such practices – for instance, by identifying suitable areas or establishing compatibility criteria that facilitate the development of IMTA systems in specific locations.**

The specialised literature further highlights that maritime circularity requires the development of closed-loop supply chains (CLSCs) and recovery hubs capable of collecting, sorting and directing components towards remanufacturing, repair or recycling processes. While such infrastructures are often associated with port or industrial policy domains – and therefore fall outside the direct competences of Spanish MSP – spatial planning can nevertheless play a facilitating role by identifying suitable areas, promoting land-sea

coordination, and ensuring compatibility between circular-economy infrastructure and other maritime uses.

While these approaches demonstrate clear sectoral applicability across maritime transport, port activities, maritime tourism, fisheries and aquaculture, the specific role of MSP in spatially enabling and coordinating these circular chains remains insufficiently developed.

To date, circular economy implementation has been closely associated with coastal management and the land-sea interface, particularly in ports conceived as nodes for remanufacturing and recycling. One illustrative case at the European level is a key initiative developed within the MSP-GREEN project, the action “A case of Blue Circular Economy in MSP – supporting ports in reusing dredged materials on land”, which provides a concrete example of how circular economy principles can be operationalised through MSP. This fact sheet presents a national action implemented in France, focusing on the circular management of dredged materials generated by port activities. Dredging is a recurrent and essential activity to ensure navigational safety and to enable ports to accommodate larger vessels. In France alone, this activity generates up to 25 million tonnes of dry sediment per year. For economic and logistical reasons, most dredged sediments are disposed of at sea through re-immersion in the marine environment. However, where sediments are clean (e.g., sand, gravel or rock fragments), their reuse on land may provide greater environmental and economic benefits than marine disposal. From a circular economy perspective, these materials can be considered secondary raw materials capable of feeding other value chains, such as coastal protection, construction, land restoration or infrastructure development. This example illustrates how MSP can play a strategic enabling role. While MSP does not directly regulate terrestrial land use, it can influence spatial allocation, compatibility criteria and planning conditions in ways that facilitate circular flows between sea-based and land-based activities. Rather than planning activities in isolation, MSP can support clustering or proximity of activities that exchange materials, energy or water, thereby fostering industrial symbiosis and reducing transport, disposal and environmental impacts.

Another concept that can be introduced, in addition to coexistence, is the explicit multi-use approach as a circular lever. The multi-use approach to marine infrastructure (e.g. wind + aquaculture, wind + algae, tidal + algae) is generally conceived as a solution to optimise space, but it can also support material and energy synergies designed from the outset within multifunctional areas. An illustrative example is the H2OCEAN project, which developed a wind-wave open-sea platform equipped for hydrogen generation supporting multiple energy users. In this sense, MSP could incorporate zoning criteria focused on multi-use configurations that optimise space and resource flows.

Considering these approaches and in line with the MSP-GREEN project's findings, MSP must work closely with terrestrial spatial planning to support circular-economy activities. In accordance with the MSP Directive (2014/89/EU), which explicitly requires consideration of land-sea interactions (LSI), this implies improving the understanding of value chains across the land-sea interface and analysing material flows such as:

- The use of biological by-products from the sea;
- The valorisation of waste from seafood production;
- The reuse of dredged materials;
- The recovery and reuse of ghost nets;
- The repair and refitting of vessels.

In this regard, although the circular economy is well developed at sectoral and operational levels, its spatialisation within MSP remains limited.

These identified gaps provide the foundation for the following set of strategic recommendations.

2.3. Recommendations for strengthening Circular Economy integration in MSP

Based on the preceding analysis, MSP can act as a strategic enabling framework for the structural integration of circular economy principles. In particular, it is well-positioned to address circular economy principles at the strategic intent stage, when decisions are still being shaped, and impacts can be influenced from the outset. **Acting at this early design phase enables informed decision-making that anticipates and reduces environmental impacts before sectoral developments take place.**

Incorporating circularity considerations at the planning stage—rather than solely at project or sectoral level—MSP has the potential to enhance resource efficiency, reduce waste streams, support multi-use solutions and foster synergies between maritime activities. **In this sense, planning becomes a framework for informed intent, integrating sustainability and circularity into the strategic distribution of maritime activities.**

Building on the structure of the POEM, recommendations to strengthen the integration of circular economy principles can be articulated at different levels of its planning architecture, within the strategic and spatial remit of MSP: guiding principles, objectives, coexistence criteria, zoning provisions and measures. While the POEM follows this formal structure, this National Action adopts an analytical lens that translates these components into functional entry points. Accordingly, the recommendations are organised under the following thematic dimensions:

-Guiding principles: At the highest strategic level, MSP should explicitly recognise the circular economy as a cross-cutting principle guiding spatial allocation and sectoral development.

MSP should not be limited to representing uses at sea, but should function as a strategic tool to enable circular flows between marine and terrestrial activities. This implies promoting spatial configurations that reduce distances, favour functional proximity, and facilitate the closure of material loops across the land–sea interface.

Where appropriate, MSP should prepare the ground for sound authorisation decisions by defining sector-specific measures that embed circular economy considerations from the outset.

- Regulatory alignment and policy coherence: At the regulatory level, MSP should identify and strengthen synergies with existing sectoral policies, integrating relevant recommendations, objectives and constraints into spatial planning provisions. This includes ensuring coherence with port regulations, fisheries and aquaculture policies, waste and circular-economy strategies, and coastal and land-use planning instruments.

In the Spanish context, this also entails alignment with measures such as OEM6 (“Development of a national blue economy strategy”), which explicitly refers to circular economy, biodiversity and sustainable resource management. MSP can play a key role in ensuring that such strategic orientations are effectively translated into spatially relevant provisions and planning criteria.

While MSP does not establish fiscal instruments directly, it should provide the strategic and spatial framework that facilitates the implementation of complementary economic tools—such as fiscal incentives—by other competent authorities.

- Zoning and compatibility criteria: Zoning provisions offer an opportunity to spatially embed circular economy principles, particularly in areas characterised by strong land–sea interactions. In coastal and port-adjacent zones, MSP could identify areas where circular-economy functions require coordination with terrestrial planning instruments. The POEM could establish spatial and compatibility criteria to recognise and accommodate circular-economy functions (such as the reception of end-of-life maritime equipment, material recovery, and reverse logistics systems connected to maritime supply chains), particularly where land–sea interactions are relevant. Compatibility criteria within zoning decisions could help competent authorities in facilitating the authorisation of activities that integrate circular-economy mechanisms. For example:

- Where aquaculture priority areas are designated, compatibility or prioritisation criteria could recognise operators implementing circular production systems (e.g., waste valorisation, nutrient recirculation, integrated multi-trophic systems).
- In fisheries, mechanisms could be put in place to encourage the recovery of ghost gear and its integration into recycling chains.

Authorisation processes could explicitly consider whether proposed activities contribute to closing material loops within the planning area.

Providing clear circular-economy criteria would support competent authorities in incorporating circularity considerations into licensing and permitting decisions.

- Socio-economic and governance dimension: The integration of circular economy principles into MSP should include a socio-economic assessment of their impacts, with a view to ensuring a fair and just transition for coastal communities. Particular attention should be paid to small-scale fisheries and coastal small and medium-sized enterprises (SMEs), given their vulnerability and central role in local economies. The purpose is not to position small-scale fisheries or coastal SMEs as circular-economy actors per se, but rather to ensure that the structural changes associated with circularity, such as new value chains, spatial reallocations, or technological and logistical requirements, do not exacerbate existing vulnerabilities and instead contribute to more resilient and inclusive coastal economies.

The operational implications of these socio-economic assessments should be reflected across all stages of the MSP process—from stakeholder engagement to spatial allocation and monitoring—so that socio-economic evidence effectively informs spatial prioritisation decisions.

Strengthening the integration of the circular economy into MSP does not require the creation of new sectoral instruments, but rather a strategic refinement of existing planning architectures. Currently, establishing blue circular economy criteria that allow for weighting planning within zoning processes would likely be the most realistic approach. Furthermore, by integrating circular principles into guiding frameworks, zoning logic, compatibility criteria, and governance mechanisms, MSP can reinforce its contribution to the EGD, without exceeding its institutional scope.

3. Transferability and upscaling

3.1. Transferability

The challenge addressed by this National Action operates across multiple scales. At the national level, it concerns the structural integration of circular economy principles within MSP frameworks, specifically in the context of the POEM. However, as highlighted in the MEDIGREEN State of Play, the limited operationalisation of the circular economy within MSP is not unique to Spain but represents a broader pattern across Mediterranean countries.

Furthermore, many of the dynamics linked to the circular economy—material flows, port logistics, fisheries supply chains, maritime transport routes, and environmental pressures—transcend the jurisdictional boundaries of MSP. The issue, therefore, has both a national planning dimension and a basin-scale relevance, particularly in semi-enclosed seas such as the Mediterranean, where ecological and economic interdependencies are strong.

Consequently, this National Action addresses a systemic and multi-level challenge situated between national spatial planning processes and transboundary maritime dynamics.

The approach developed under this National Action is inherently transferable, as it does not rely on Spain-specific legal constructs but rather on structural components: guiding principles, strategic objectives, zoning logic, compatibility criteria, and governance arrangements.

The underlying logic remains consistent across contexts: identify structural gaps in the integration of circular economy principles into existing MSP plans, and determine how these gaps can be addressed through adjustments to the planning architecture rather than new sectoral regulation.

Therefore, the methodology can be applied to any structured national MSP framework: to an existing MSP plan during its revision cycle, or during the preparation phase of a new MSP plan, based on the analysis of national coastal and marine policies.

Although specific entry points may vary depending on national maritime sectors and administrative systems, the core logic remains replicable:

- Examine how circular economy considerations are currently reflected (explicitly or implicitly) within an MSP plan;
- Identifying where circular economy principles are implicitly present but not operationalised;
- Mapping spatial opportunities for circular material flows, particularly at the land–sea interface;
- Embedding circularity considerations into zoning and compatibility criteria;
- Strengthening cross-sectoral coordination mechanisms.

Access to relevant spatial and sectoral data, as well as analytical capacity to identify circular entry points in planning documents, would also be important. However, effective coordination among maritime planning authorities, land-based planning bodies, port administrations, sectoral bodies, and environmental authorities is paramount. Since the integration of the circular economy often lies at the interface of multiple policy areas, intersectoral dialogue mechanisms are essential.

3.2. Affordability

This National Action is primarily analytical and strategic, and does not require significant financial investment or infrastructure development. Its implementation relies on institutional coordination, stakeholder engagement and adjustments within existing planning frameworks. Affordability is ensured by building on established MSP cycles and governance processes rather than creating new regulatory or administrative structures.

However, certain enabling conditions are necessary.

First, identifying integration gaps requires a solid understanding of the ecological, socio-economic, and governance context of the maritime demarcation or planning area. Circular economy considerations are often implicitly embedded within sectoral measures, and their interpretation demands analytical capacity and cross-sectoral knowledge.

Second, effective integration depends on coordination among maritime planning authorities, as is already established within the existing MSP process, as well as with terrestrial planning bodies, given the relevance of the blue circular economy at the land–sea interface. This coordination also extends to port authorities, waste management agencies and other sectoral administrations. The principal resource requirement is therefore institutional coordination rather than capital expenditure.

Overall, costs are limited to analytical work, inter-administrative coordination and potential stakeholder engagement activities, making the action affordable within existing MSP governance structures.

3.3. Upscaling

The approach developed under this National Action can be implemented at a larger scale, particularly at the Mediterranean basin level and potentially within broader EU MSP discussions.

At the Mediterranean scale, upscaling would involve applying the same structured analytical framework—based on gap analysis, opportunity mapping and review of planning architecture—to MSP-related documents across countries. Currently, the inclusion of the blue circular economy in the MSP plans of some countries participating in the MEDIGREEN project is reflected in the State of Play, highlighting the limited operationalisation of circular economy principles across Mediterranean MSP processes.

Cross-border cooperation would enhance the effectiveness of upscaling. Circular economy dynamics—such as material flows, maritime transport routes, fisheries supply chains, and port logistics networks—are inherently transboundary. Although this already involves different scales, the cross-border approach is already being considered in planning, so including the concept of a circular economy in spatial planning would improve the implementation of some of the initiatives mentioned, and would also improve coherence between national plans, reduce fragmentation of approaches, and support cumulative progress toward EGD objectives.

Moreover, transboundary cooperation would allow countries with more advanced circular integration practices within MSP to support others, fostering convergence, avoiding duplication of effort and strengthening regional capacity for systemic blue circular transition.

In this context, macro-regional governance frameworks such as the WestMED Initiative could provide a suitable platform for advancing circular-economy integration within MSP processes. Through its focus on sustainable blue economy development, innovation, and regional cooperation, WestMED offers an institutional space where circularity principles could be further aligned with maritime spatial planning practices across the Western Mediterranean basin.

4. Conclusion

Although academic literature directly linking MSP and the circular economy remains limited, a considerable body of sectoral research and practical initiatives has addressed circular economy principles in fisheries, aquaculture, ports and maritime transport; however, these efforts have largely remained operational and sector-driven rather than spatially embedded within MSP frameworks. This National Action demonstrates that the challenge does not lie in the absence of circular-economy practices, but in their limited spatialisation and operational integration within existing MSP frameworks.

The analysis of the Spanish POEM confirms that circular economy considerations are currently present primarily as guiding principles and sectoral references, without being embedded in zoning logic, compatibility criteria, operational objectives, or governance mechanisms. As identified in the MEDIGREEN State of Play, this situation is not unique to Spain but reflects a broader Mediterranean pattern in which the Blue Circular Economy remains the least operationalised of the EGD topics within MSP processes.

By applying a structured methodology based on gap analysis and opportunity mapping aligned with EGD priorities, this National Action demonstrates that MSP can serve as a strategic enabling framework for circular economy integration. Rather than creating new sectoral instruments, MSP can embed circularity within its existing planning architecture—through guiding principles, regulatory coherence, operational objectives, zoning provisions and governance arrangements—while remaining within its institutional remit.

Particular relevance arises at the land-sea interface, where material flows, port logistics, fisheries supply chains and opportunities for industrial symbiosis converge. In line with the mandate of the Directive 2014/89/EU to take land-sea interactions (LSI) into account, MSP should explicitly address these interdependencies by promoting spatial coherence between maritime and terrestrial planning frameworks. In this context, MSP can facilitate spatial configurations that shorten material loops, promote proximity-based synergies and strengthen the resilience and strategic autonomy of coastal economies.

Strengthening the integration of circular economy principles within MSP is therefore not a question of expanding competences, but of refining planning design. By operationalising circularity within the spatial logic of maritime plans, MSP can reinforce its contribution to the EGD and support a systemic transition toward a more resource-efficient and resilient blue economy.

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National action #10: Monitoring aquaculture production in the framework of MSP plans (IEO-CSIC)

1. Context and needs

1.1. Purpose and scope

This national action focuses on marine aquaculture, one of the blue-economy sectors with the strongest growth potential in the Mediterranean region. **The action seeks to define an interoperable, sector-specific indicator system** that enables consistent assessment and comparison across Spanish marine demarcations in the context of the Spanish Maritime Spatial Plans (POEM – Planes de Ordenación del Espacio Marítimo), and measures its progress towards the European Green Deal (EGD) objectives.

This fit-for-purpose set of indicators is conceived as a **proposal to be integrated into the aquaculture monitoring programme of future MSP cycles**. It has been designed to:

- **assess the performance of marine aquaculture in MSP terms** (spatial allocation, coexistence, safeguards and long-term planning);
- capture **economic, social and environmental dimensions** relevant to MSP;
- are **limited in number** yet **informative, measurable, achievable, relevant and time-bound** (qualitative and quantitative);
- are **interoperable** and applicable at the national scale; and
- enable assessment of the **sector's contribution to the European Green Deal (EGD)**.

This work will be anchored in the aquaculture objectives approved in the first cycle of the POEM, namely:

A.1 Develop a **spatial plan for aquaculture from a medium- and long-term** perspective, compatible with **environmental conservation, technological progress and climate resilience/adaptation**.

A.2 **Strengthen competitiveness and support job creation** by facilitating access to **suitable areas** and promoting **best practices** in the **location, size and management** of facilities.

1.2. Why indicators matter

KEY CONCEPT

An **indicator** is a **quantitative or qualitative variable** that **offers a measurable representation of progress or proximity to a given goal**.

Effective indicators support **objective measurement, trend evaluation and decision-making**, by providing actionable evidence to monitor performance, detect deviations, improve efficiency and assess whether outcomes align with targets.

A well-designed set of indicators would offer a clear picture of how the aquaculture sector is evolving in relation to MSP measures, its progress towards the EGD objectives, and where adjustments may be required.

In the MSP context, the use of indicators is essential to understand how plans drive change, track progress against anticipated needs and address emerging or unforeseen needs (cf. Zuercher et al., 2022).

1.3. Governance landscape in Spanish marine aquaculture

Marine aquaculture is coordinated nationally in Spain, while management and licensing competences rest in general with regional administrations. The General Subdirectorate of Aquaculture, Fisheries Marketing and Structural Actions (Ministry of Agriculture, Fisheries and Food - MAPA) sets overall guidelines and basic regulations, and most coastal regions have developed their own aquaculture strategies tailored to local conditions. JACUMAR, the National Advisory Board for Marine Crops, a Spanish collegiate body dependent on the MAPA, is the one that coordinates aquaculture between the State and the Autonomous Communities.

Maritime Spatial Planning (MSP) is conceived as a tool to support the sustainable development of maritime sectors, manage conflicts and synergies among uses, and ensure nature protection. However, in practice, the first POEM cycle (adopted in 2023 and currently under review) articulated objectives and measures that were largely strategic, providing insufficient granularity to steer the sustainable development of marine aquaculture. Moreover, MSP does not always provide the specific instruments or authority needed to manage certain operational aspects.

1.4. POEM

The first cycle of the POEM was approved in 2023. Among other elements, it **designates High-Potential Areas for Marine Aquaculture** (ZAPAC-Zonas de Alto Potencial para la Acuicultura Marina) across Spain's five marine demarcations, two of which lie in the Mediterranean (Levantine-Balearic; the Strait and Alboran). The ZAPACs are mapped and accompanied by use regulations, criteria to manage interactions with other activities and measures to be implemented in the coming years, with the dual aim of safeguarding current allocations and accommodating future expansion needs. Regional governments were consulted to reflect regional priorities and to align ZAPAC zoning with existing sectoral planning tools and economic, social and environmental objectives.

The areas identified as ZAPAC include different categories:

- Potential areas
- Conditional potential areas
- Preferred areas
- Conditional preferred areas
- Areas of interest declared by the different Autonomous Communities (CCAA-Comunidades Autónomas):
 - Aquaculture Interest Areas (ZIA-Zonas de Interés para la Acuicultura))
 - Areas of interest for marine aquaculture (ZICM-Zonas de Interés para los Cultivos Marinos)

As with any planning instrument, the POEM requires periodic monitoring to assess effectiveness and support adaptive management. Although the POEM includes an indicative list of seven indicators to monitor aquaculture performance, a final indicator set has not been approved.

1.5. Alignment with EGD priorities

Regarding **EGD elements**, this national action might address:

. Climate change mitigation

A.2 Clean energy transition in maritime sectors

A.2.3 Initiatives towards emission reduction in other sectors considered by the Plan(s) (e.g., fishing boats)

B. Climate change adaptation

B.2.1 Identification of spatial and non-spatial measures with the aim of addressing the impacts from climate change

B.3 Anticipation of climate change-related effects

B.3.2 Identification of areas to be used in future by specific sectors, due to climate change (e.g., fisheries, aquaculture, maritime routes, etc.)

C. Sustainable sea-food production

C.2 Sustainable aquaculture and shellfish production

C.2.1 Development of marine aquaculture installations

C.2.2 Development of organic marine aquaculture, IMTA, low-trophic aquaculture

C.2.3 Introduction of energy savings in marine aquaculture. Including autonomous systems

C.2.4 Multi-use of the sea space: combinations including marine aquaculture

C.3 Sustainable algae production

C.3.1 Development of marine algae production

C.3.2 Multi-use of the sea space: combination including algae production

C.5 Governance-related measures

D. Biodiversity and ecosystem protection and restoration

D.1.5 Multi-use of the sea space: combination including biodiversity and ecosystem protection

E. Blue Circular Economy

E.1 Circular design

E.1.2 Circular design of fishing and aquaculture gears

E.2 Waste prevention

E.3 Re-use, repair, upgrade, recycle

F. Zero Pollution

F.1 Pollution prevention

F.1.3 Measures related to fisheries and aquaculture

E.2 Pollution remediation

G. Fair & Just Transition

- G.1 Stakeholder participation
- G.2 Representativeness of diversity of stakeholders at different levels
- G.3 Public access to data and plans

2. Implementation

This national action proposes a practical set of tailored-made indicators to support the monitoring of marine aquaculture within the POEM and to enable the assessment of the sector's alignment with the EGD objectives. Although the POEM is already in force, its monitoring programme has not yet been launched. **This action is therefore conceived as a proposal to be integrated into the aquaculture monitoring programme in future MSP cycles.**

2.1. Methodology

The methodology includes five components, along with indicator requirements and provisions for future expansion:

(i) Indicator screening

- Build a list from literature, MSP practice, POEM provisions, sectoral sources (national/regional registers, economic statistics, producer associations, research outputs), MEDIGREEN task 2.1.2.
- Screen by: MSP relevance, parsimony, data feasibility, EGD relevance, and possible transferability).

(ii) Indicator fiches (metadata sheets)

For each shortlisted indicator, define: code, name, MSP link, EGD link, units/formula, geographic scale (ZAPAC/demarcation/national, regional), update frequency (annual, multi-annual, etc.), data source/s, attribution test.

The indicator fiches may be even more complete, by including additional information, such as: baseline value, target/threshold, time-scale/time-bound (implementation horizon), limitations (if any), etc.

(iii) MSP attribution strategy

KEY CONCEPT

The concept of **attribution** refers to the **degree to which an observed change** (ecological, socioeconomic, governance-related, etc.) **can be directly linked to, explained by, or assigned to the actions and measures implemented through the MSP process.**

The attribution strategy outlines **how observed changes in the indicators will be linked to the implementation of the POEM rather than to external factors.**

To do this, the analysis combines temporal, spatial, and contextual comparisons with qualitative validation.

a. Temporal contrast (before/after POEM adoption).

Changes in each indicator will be examined relative to the introduction of the POEM, comparing conditions prior to 2023 with those observed afterwards. This allows the identification of temporal discontinuities potentially attributable to MSP.

b. Spatial contrast (areas with/without MSP intervention).

Where applicable, areas subject to explicit MSP measures—such as ZAPAC or other designated suitable zones—will be compared to similar areas not subject to the same planning provisions. This “with/without” structure supports the isolation of MSP-related effects.

c. Contextual controls

To avoid attributing changes to MSP that are driven by external dynamics, a set of contextual variables will be incorporated into the analysis. These include price indices for key inputs (e.g., feed, energy), climate-related anomalies (Sea Surface Temperature (SST), marine heatwaves, harmful algal bloom (HAB) events, disease outbreaks, and major policy shifts.

d. Validation.

To ensure that the analysis is robust and that observed changes can be credibly linked to MSP implementation, the results should be validated.

This qualitative validation integrates three independent sources of evidence:

d.1 Expert consultation with technical and policy experts to verify whether the observed trends are reasonable based on the sector knowledge and implementation dynamics.

d.2. Operator surveys: insights from users and operators to check whether the statistical patterns match what they see in practice.

d.3. Permitting file review: revision of administrative records concerning licensing, applications, renewals and permit modifications to detect any procedural or operational changes that may be linked to MSP implementation. Ex: Since the POEM are in force, the authorization times have sped up/slowed down.

(iv) Data standards

Defining the data formats and documentation standards to ensure that all indicator data remain interoperable and reproducible over time. This could be applied by standard templates and validation rules, to guarantee data quality, consistency and common formatting.

(v) Pilot Studies & Methodological Refinement

Testing the indicator system in real conditions (e.g., in two marine demarcations), refining it with relevant stakeholders (regional and national administrations, scientific bodies, sectoral actors, etc.), and consolidating it into national guidance aligned with POEM monitoring.

- Indicator requirements and extensibility -

To verify the shortlist is robust, implementable and extensible, each indicator must meet the following requirements:

- **Relevance to MSP decisions:** Directly linked to spatial allocation (ZAPAC), coexistence/multi-use, protection and safeguard zoning, carrying capacity and spatial pressure, conflicts between uses, etc.
- **EGD linkage:** Clear mapping to at least one EGD dimension (mitigation/adaptation, biodiversity, circularity/zero pollution, just transition).
- **Policy interpretability:** Provides actionable evidence for POEM adaptive management (2027 review), regional zoning guidance, or permitting practice.
- **Parsimony and feasibility:** Data demands are proportionate; formulas are simple; calculations are replicable.
- **Attribution readiness:** Includes a feasible control (before/after; with/without).

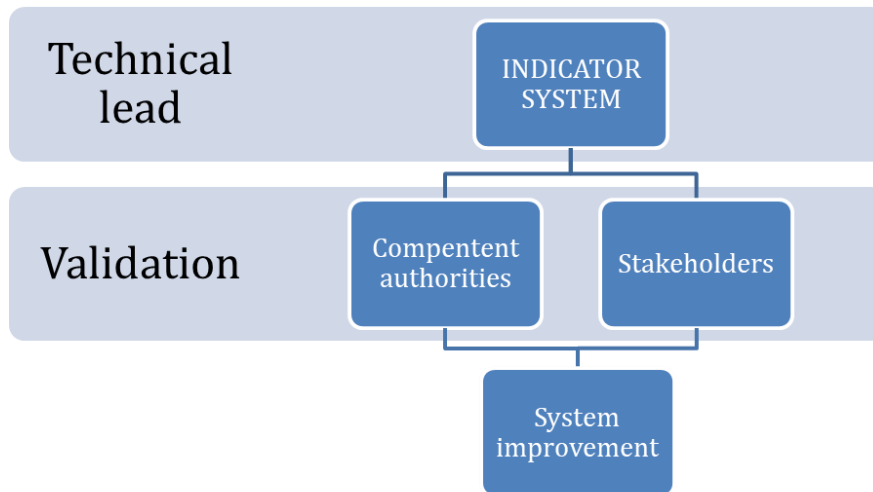
- **Transferability:** Definitions and calculations are replicable in all marine demarcations and other Mediterranean countries (EU/non-EU) with minimal adaptation, or even beyond.

The methodological steps described above were completed for the conceptual and operational design of the indicator framework (steps i to iii). Due to time and resources constraints, the work focused on developing indicator definitions, formulas, indicators' structure, and attribution logic. No piloting, data population or field computation was undertaken. These activities are proposed for the subsequent implementation phase of the POEM monitoring programme, when regional data flows, operational workflows and stakeholder engagement mechanisms can be activated.

2.2. Governance and stakeholder engagement

The governance framework is designed to ensure that the **indicator system can be validated** (additionally to the MSP-attribution strategy validation) **and** continuously **refined** through engagement with the most relevant stakeholders. This will enable alignment with major public policies, the integration of best available practices and technologies, and a fair and just transition, with stakeholder feedback progressively improving the system. Given the limited time and resources available, the indicator system has not yet been validated through expert or stakeholder review. Such validation, together with the governance arrangements outlined below, is proposed for the implementation phase and will provide the continuous feedback loop required to further strengthen and update the system.

- **Technical work:** Specific institution/company responsible for the methodological development, indicator fiches and piloting activities. and QA/QC procedures.
- **Validation:**
 1. Competent authorities (CA)
 - National level
 - Directorate-General for Fisheries and Aquaculture Management (Ministry of Agriculture, Fisheries and Food (MAPA)
 - Directorate-General for the Coast and the SEA (Ministry for the Ecological Transition and the Demographic Challenge (MITERD): MSP CA
 - Regional level
 - Regional administration bodies responsible for aquaculture and other sea-related uses potentially affected by this aquaculture activity, including environmental protection.
 2. Sectoral actors
 - Producer organizations and aquaculture operators
 - Research & technology centres
 - Other sectoral actors: tourism operators; ORE developers (multi-use);
 - NGOs,
 - Etc.



2.3. Results

Expected outputs of the action:

- **Indicator framework** linking MSP measures (ZAPAC zoning, coexistence rules, multi-use) to EGD outcomes (mitigation/adaptation, biodiversity, circularity/zero pollution, just transition).
- **Operational guidance for POEM objectives** (see them above, in pg 3) A.1 (long-term, climate-resilient spatial planning compatible with environmental protection and technology progress) and A.2 (competitiveness, access to suitable areas, best practices).
- **Information base** to support the 2027 POEM review, with indicators structured to allow consistent comparison across demarcations and through future cycles, including cross-border comparability.
- **Administrative simplification** via standardised templates and a parsimonious indicator set.

Link with national/subnational MSP implementation

- At **national level**, the framework may help activate the POEM monitoring programme: indicator catalogue, metadata, formulas, protocols for annual reporting, etc.
- At **subnational level** (demarcations, CCAA), indicators will support: refinement of ZAPAC boundaries/capacity, permitting guidance (location/design/scale), and multi-use feasibility.

2.4. Proposed indicator shortlist

The table below presents the 12 aquaculture MSP-related indicators. For each one, the following information is proposed to be completed:

- MSP link (why it matters)
- EGD link
- Units / Formula (summary)



- Scale
- Frequency
- Primary sources
- Attribution test (summary)

The EGD objectives to which indicator- linkages will be established are the following:

- a. Climate change mitigation
- b. Climate change adaptation
- c. Sustainable seafood production
- d. Biodiversity and ecosystem protection and restoration
- e. Blue Circular Economy
- f. Zero pollution
- g. Fair & Just transition



Code	Indicator	MSP link	EGD link	Units / Formula	Scale	Freq.	Primary sources	Attribution test (summary)
A1	Proportion of aquaculture licensed area located within ZAPAC	Effectiveness of POEM spatial allocation	b, d	(%) Total licensed area within ZAPAC/ Total licensed area)	ZAPAC/ Demarcation/National	Annual	POEM GIS (InfoMAR), Acuivisor (Aquaculture GIS - MAPA);	Since ZAPAC did not exist before the POEM, attribution is assessed using new concessions (post-2023). The test compares: (i) the probability that new licences are located within ZAPAC versus non-ZAPAC areas; (ii) The spatial distribution of concessions prior to the POEM is used as a proxy baseline for understanding pre-existing siting preferences, allowing comparison with post-2023 licensing patterns to identify whether the POEM is influencing location choices.
A2	Density of aquaculture installations within ZAPAC relative to capacity guidelines	Ensures that development within ZAPAC respects POEM-related carrying capacity limits and avoids over-concentration	d, f	Ratio (installed units/ recommended capacity)	ZAPAC Demarcation/National	Annual	POEM layers; ACUIVISOR ; aquaculture carrying capacity plans ²⁶	Attribution assessed by (i) comparing post-2023 density patterns in ZAPAC vs. non-ZAPAC areas; (ii) deviation from historical density patterns in environmentally similar areas (pseudo-baseline);

²⁶ Carrying capacity models for marine aquaculture have been developed by several projects, research papers, and could be used to feed this indicator. Two examples are:

<https://www.programapleamar.es/proyectos/maccam-modelos-innovadores-aplicados-de-capacidad-de-carga-de-la-acuicultura-marina>

Romero, F., Sanchez-Jerez, P., Martínez, G., Hernandez-Contreras, A., Fernandez-Gonzalez, V., Agraso, M. M., & Toledo-Guedes, K. (2023, February). A proxy for carrying capacity of Mediterranean aquaculture.

A3	Coexistence index with other uses (shipping, ORE, MPAs)	Spatial conflicts/synergies	b, e, g	Composite index combining reported conflicts for spatial overlap with other uses and weighted compatibility/mitigation factors, normalised to a 0-1 scale	Demarcation	Annual	POEM GIS (InfoMAR); regional data	Attribution assessed by: (i) comparing coexistence scores for new or expanding sites inside ZAPAC vs. non-ZAPAC areas (post-2023); (ii) deviations from historical pre-POEM coexistence patterns (pseudo-baseline), if any.
A4	Permitting lead time for new sites	Process efficiency linked to MSP guidance	g	Median days from application to license	Regional/National	Semi-annual/Annual	Regional authorities ;	(i) comparison of lead times for applications within ZAPAC vs. outside ZAPAC; (ii) temporal shift post-POEM;
A5	Production share from low-trophic/IMTA systems²⁷	MSP can prioritise suitable areas	a, c, e	(%) production from low trophic or IMTA systems/total aq. production	Demarcation/National	Annual	Producer stats; surveys; regional registries.	(i) comparing the new post-2023 licences adopting low-trophic/IMTA systems inside ZAPAC versus non-ZAPAC areas; (ii) checking if ZAPAC areas are naturally more suitable for low-trophic/IMTA, so differences are not mistaken for POEM effects.
A6	Energy efficiency of aquaculture production	Site location defined through the POEM—particularly ZAPAC—affects farm exposure, distance to ports and operational conditions, all of which influence energy use. This	a	kWh used per tonne of live weight	Facility (aggregated)/Demarcation	Annual	Operator reports; audits; regional registries	(i) comparing the energy consumption of new post-2023 installations located inside ZAPAC versus outside; (ii) comparing ZAPAC and non-ZAPAC sites with matched-pairs analysis controlling for species, scale, distance to port and technology to ensure differences in energy use are not due to these factors;

²⁷ IMTA systems refers to Integrated Multi-Trophic Aquaculture.

		indicator tracks whether MSP-guided siting supports more energy-efficient aquaculture operations						
A7	Adoption of multi-use configurations (e.g., ORE-AQ, nautical tourism, R&D&I, ecological restoration, etc.)	Tracks MSP coexistence objective	a, e	n ^o sites or % ORE/aq facilities co-located	Demarcation/National	Annual	Licensing data; project registry; regional authorities	Attribution is assessed by analysing whether new multi-use projects emerge more frequently inside ZAPAC than outside after the adoption of the POEM. The test compares: (i) the uptake of multi-use configurations in new post-2023 licences located in ZAPAC versus non-ZAPAC areas; and (ii) whether multi-use grows faster within ZAPAC than in comparable areas outside.
A8	Compliance with environmental buffers/exclusion zones	The POEM defines spatial safeguards to integrate buffers established by other regulations. A8 measures whether sites comply with these defined rules	d, f	% sites compliant; n ^o non-compliances	ZAPAC/Demarcation	Annual	MITECO; MAPA; Inspections; monitoring; GIS; regional authorities registries	Attribution is assessed by comparing: (i) whether new post-2023 aquaculture licences located inside ZAPAC show higher compliance with environmental regulations regarding buffer areas than those located outside; and (ii) whether compliance improves more rapidly within ZAPAC than in comparable non-ZAPAC areas, using a difference-in-differences approach that controls for environmental sensitivity and regional regulatory conditions.
A9	Coverage of waste and gear circularity plans	MSP could include criteria for promoting licensing in ZAPAC to circularity requirements	e, f	% sites with an approved circularity plan; % gear recovered/recycled	Demarcation/National	Annual	Operators; port reception facilities; regional authorities	Attribution is assessed by comparing: (i) the uptake of circularity plans in new post-2023 aquaculture licences located inside ZAPAC versus outside; and (ii) whether adoption increases faster within ZAPAC than in comparable non-ZAPAC areas.

A10	Incident rate related to environmental events	Spatial planning can reduce exposure/risk	b, d	Incidents per 100 sites (algal blooms (HABs), storm-related damage, escapes, etc.)	Demarcation/National	Annual	Regional authorities ; National authorities ; operator reports; environmental monitoring datasets	Attribution is assessed by comparing: (i) incident rates for new post-2023 sites located inside ZAPAC versus those outside; and (ii) whether incident rates decrease (or increase less) within ZAPAC than in comparable non-ZAPAC areas, adjusted for climatic and oceanographic conditions (e.g., storm intensity, HAB frequency).
A11	Stakeholder participation breadth in MSP-aquaculture processes	The POEM requires inclusive engagement for spatial decision-making; A11 tracks whether MSP implementation broadens stakeholder participation.	g	N ^o stakeholder groups represented/sessions held	Demarcation/National	Annual	Meeting records; consultation reports; regional authorities ; national MSP authority	Attribution is assessed by comparing (i) participation levels in post-2023 processes directly linked to MSP implementation (e.g., ZAPAC discussions, spatial siting and coexistence meetings) versus participation in non-MSP processes; and (ii) whether participation expands more in MSP-related processes than in non-MSP processes over the same period, that controls for regional engagement practices.
A12	Added value and employment in ZAPAC-located production	Measures economic performance of MSP spatial allocation; tests whether ZAPAC designation supports competitive aquaculture	c, g	€ GVA per tonne; total employment (Full time equivalent, FTE) in ZAPAC vs. non-ZAPAC; ratio of GVA_ZAPAC/GVA_total	ZAPAC/Demarcation/National	Annual	MAPA production data; operator surveys; regional registries	Attribution is assessed by comparing: (i) post-2023 growth in GVA and employment for sites located inside ZAPAC versus those outside; and (ii) whether economic performance increases more rapidly within ZAPAC controlling for species mix, technology and market conditions.

3. Transferability and upscaling

3.1. Transferability

The indicator framework developed under this national action has been intentionally designed for **high transferability** across the five Spanish marine demarcations, but could be used beyond, across Mediterranean countries (EU and non-EU) that operate under similar MSP or other maritime planning principles. Its structure, definitions and computation methods are not tied to Spain's administrative system, making it a versatile, portable monitoring tool.

If the set of indicators is used beyond the UE, a “difference in differences approach” could be used to compare the evolution of indicators across areas with different levels of spatial planning exposure, while statistically controlling for confounding factors such as market cycles, technological uptake, or major regulatory changes. This method tells us whether regions more exposed to MSP changed more than less exposed regions, after accounting for factors that affect all regions equally.

(i) Functional definitions

Indicators are defined around MSP functions (zoning, coexistence, environmental safeguards, multi-use, regulatory efficiency) rather than Spanish-specific categories. Although the POEM defines ZAPAC, other countries typically have equivalent designations (e.g., “suitable aquaculture areas”, “allocations zones”). Substitution of these areas is straightforward.

(ii) Compatibility with regional data infrastructures

Most indicators can be produced using datasets commonly available across Mediterranean administrations (some of them at least within the UE): licensing registries, port/logistics data, habitat layers, MPAs, bathymetry, and traffic densities. In contexts with limited data availability, simplified or proxy versions can be designed.

(iii) Alignment with regional priorities

The topics embedded in the indicator set—climate adaptation, coexistence across sectors (notably aquaculture–ORE), biodiversity protection, circularity and fair & just transition—are priorities shared across Mediterranean coastal states (EGD goals). This increases the relevance and usability of the indicator framework beyond national borders.

Transfer pathways

The framework may be transferred through:

- bilateral exchanges with competent authorities;
- publication of open templates;
- integration into national MSP or aquaculture capacity-building actions;
- adaptation by regional initiatives (e.g., GFCM ecosystem-based aquaculture, UNEP/MAP ICZM frameworks).



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3.2. Affordability

The **indicator set is intentionally parsimonious** (12 indicators) and designed to minimise administrative and technical burden while ensuring policy relevance. The set does not require monitoring or administrative processes beyond the transmission of information from one administration to another, acknowledging that this might be already challenging, given the complexity of inter-administrative communication/data-transmission in some cases.

Cost-efficiency is achieved through:

(i) Use of existing datasets

Most indicators rely on data already collected by regional administrations or national agencies (licences, production statistics, environmental monitoring, maritime uses). No new monitoring campaigns are required (a priori).

(ii) Standard geospatial operations

Spatial analysis (overlaps, buffers, distances, classifications) can be performed with standard GIS software (QGIS, ArcGIS). This avoids the need for specialised modelling or costly analytical tools. Additionally, R software could be used for statistical analysis if needed (free software).

(iii) Integration into existing workflows

Regional authorities already manage licensing, inspections and environmental assessments. The indicators draw from these processes, avoiding parallel systems.

Estimated workload

Initial setup (data acquisition, templates, harmonisation) requires a one-off investment. Annual computation can be integrated into routine reporting with limited additional effort. Attribution analyses require some analytical capacity but could be decentralised (e.g., specific agency or institution)

Overall, the action is **affordable**, especially as most costs come from coordination and data harmonisation, not new monitoring.

3.3. Upscaling

Upscaling refers to expanding the indicator framework beyond this national action focused on the two Spanish Mediterranean Marine Demarcations to support regional, national and Mediterranean-wide MSP monitoring.

Upscaling opportunities:

(i) National level

The indicator set can form the core of the POEM monitoring programme for aquaculture. Its modular design allows integration with indicators for other sectors (fisheries, ORE, nature protection), enabling a standardised national MSP dashboard for the five Spanish marine demarcations.

The framework could be upscaled by redesigning its structure to assess the performance of these sectors using the same modular and spatial-planning-based methodology.

(ii) Mediterranean regional level

Definitions and computational logic are compatible with European datasets (EMODnet, Copernicus, MAPAMED) and would enable cross-country comparison. For non-EU countries, data availability should be verified, but upscaling the methodology may be interesting to advancing coherence between EU and non-EU countries in the Mediterranean, especially on zoning, coexistence and climate adaptation.

(iii) Integration with sectoral reporting

Indicators can be aligned with the GFCM Strategy for Sustainable Aquaculture, the EU Algae Initiative, and the FAO Blue Transformation Monitoring System, etc. This creates synergies and avoids duplication.

Requirements for upscaling

Upscaling requires: (a) stable governance (POEM monitoring unit); (b) sustained data-sharing agreements with CCAA (Autonomous communities, *Comunidades Autónomas* in Spanish); (c) a harmonised geodatabase; and (d) periodic methodological reviews (every 3–5 years). These conditions can be met with existing institutional structures.

4. Conclusion

This national action delivers a **coherent, implementable and policy-relevant framework to monitor aquaculture** within the Spanish MSP plans (POEM). It advances significantly beyond previous tasks by providing a concise, **attribution-ready indicator shortlist**, grounded in spatial planning logic and directly linked to European Green Deal objectives.

Overall, the proposed set of twelve indicators **capture core MSP dimensions**—in particular zoning alignment, coexistence, environmental safeguards, circularity, multi-use potential, administrative performance and socio-economic outcomes. The framework has been designed to be **technically feasible, affordable, and interoperable** within Spanish marine demarcations.

A **key strength** of this framework is that it **relies entirely on existing data sources**. No new data-collection is required (*a priori*); the main challenge lies in bringing together information held by different administrations/platforms/research centres and ensuring a consistent structure across demarcations. This makes the system feasible to implement, even if some coordination efforts will be needed.



The **attribution test is an essential component**, as it helps distinguish changes linked to MSP implementation from those driven by unrelated factors. While this adds a certain level of **technical complexity**, the methods proposed remain proportionate and manageable within the broader monitoring effort.

Expert validation will be critical to ensure the robustness and credibility of the results, and to ensure the progressive optimisation of the indicator system. Equally important is establishing a **clear and regular monitoring frequency**, so future POEM cycles can build on a stable dataset and track progress in a comparable way.

Although the national action is designed for Spain and tailored to the POEM framework, the approach is transferable and could be adapted for use in other MSP contexts facing similar monitoring needs.

By establishing clear metadata, formulas, and attribution strategies, the action supports evidence-based adaptive management for the POEM. The approach strengthens transparency, cross-sector dialogue, and the integration of sustainability principles into spatial decision-making. The outputs lay a robust **foundation for activating the POEM monitoring programme** and enabling future extensions into climate resilience, innovation, and restorative aquaculture.



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National action #11: Coexistence and multi-use concept in the Spanish MSP plans (IEO-CSIC)

1. Context and needs

Maritime Spatial Planning (MSP) is defined as a tool to promote the sustainable development of maritime activities. While coexistence is not explicitly mentioned in this definition^{28 29}, the increasing competition for marine space suggests that MSP should also foster coexistence among activities, moving beyond a reactive approach focused solely on conflict resolution. *Coexistence* refers to situations in which different activities can operate in the same area—sometimes even at the same time—without negatively affecting each other's performance, and without requiring specific management measures. In practice, however, only a limited number of activities are naturally compatible in shared space unless certain conditions are met (for example, recreational diving within a Marine Protected Area when conducted under specific rules). The purpose of MSP, as an integrated planning and management process, shall be to establish the “rules” that may enable two or more activities to be compatible when sharing space, or, when this is not possible, to allocate them to different areas.

Moving from passive coexistence to multi-use or co-location represents a higher level of integration between maritime activities. While coexistence simply requires that activities do not interfere with one another, multi-use implies that they actively benefit from sharing the same space, infrastructure or operational framework. Over the past years, multi-use has been widely explored in research as a potential solution to challenges related to spatial conflict, competing policy objectives and the efficient use of marine space (e.g., MSP-GREEN³⁰). However, despite its conceptual appeal, the practical implementation of multi-use remains limited, as technical, legal and economic feasibility have yet to be fully demonstrated. Even so, multi-use offers a more ambitious approach³¹ to integration and should be actively pursued where possible, as it can significantly increase spatial efficiency³² and enhance the combined value of different activities at sea³³.

Although coexistence and multi-use are conceptually different, this assessment addresses both, recognising their complementary nature and the ways in which coexistence can serve as a foundation for future multi-use approaches.

²⁸ Intergovernmental Oceanographic Commission of UNESCO (2023). Marine Spatial Planning – IOC-UNESCO.

²⁹ Directive 2014/89/EU of the European Parliament and of the Council of 23 July 2014 establishing a framework for maritime spatial planning. Official Journal of the European Union, L 257, 28.8.2014, pp. 135–145.

³⁰ Ramieri, E., Bocci, M., Gee, K., Capurso, G., et al., 2024. Recommendations on how to strengthen the integration of EGD maritime components into MSP. MSP-GREEN project.

³¹ European MSP Platform. (2024). Co-existence and multi-use of activities. European Commission. <https://maritime-spatial-planning.ec.europa.eu/msp-resources/co-existence-and-multi-use-activities>.

³² Kyvelou, S.S.I., & Ierapetritis, D.G. (2021). Fostering Spatial Efficiency in the Marine Space, in a Socially Sustainable Way: Lessons Learnt From a Soft Multi-Use Assessment in the Mediterranean. *Frontiers in Marine Science*, 8, 613721. <https://doi.org/10.3389/fmars.2021.613721>.

³³ Bocci, M., Sangiuliano, S.J., Sarretta, A., Ansong, J.O., Buchanan, B., Kafas, A., et al. (2019). Multi-use of the sea: A wide array of opportunities from site-specific cases across Europe. *PLOS ONE*, 14(4), e0215010. <https://doi.org/10.1371/journal.pone.0215010>.

While the MSPD mentions that MSP should encourage multi-purpose uses in its preamble, it does not mention it in any of the articles of the Directive. On the other hand, the term “coexistence” is mentioned twice, once in the preamble and another one in article 5 that regulates the objectives of MSP, but no more criteria on how this coexistence should be pursued are included.

This national action seeks to analyse **how the Spanish MSP plan** (*Planes de Ordenación del Espacio Marítimo, POEM* – by its initials in Spanish) has **approached the coexistence and multi-use concepts in its different elements** (guiding principles, objectives, zoning & coexistence criteria, measures and monitoring). The aim of the analysis is not only to identify where these concepts have been taken into account directly but also what other related “facilitators” the plan have already incorporated that could make the implementation of these concepts easier. Recommendations are made in order to improve the applicability of these concepts in the next cycle of the POEMs, in some cases based on cases from other countries. It is also important to consider that the POEM, by its current nature, does not have the authority to establish binding requirements or to create the administrative procedures necessary for coexistence or multi-use to become fully operational; it can only establish planning criteria. The level of operational detail and granularity needed to implement these concepts must therefore be provided by other instruments—such as sectoral regulations, subsequent plans, authorisation frameworks or governance processes.

NOTE: The first cycle of the POEM is being reviewed at the time this study is conducted. The analysis has been performed for the first cycle of the POEM³⁴. However, a preliminary analysis has also been conducted for the proposed guiding principles and objectives of the second cycle of the POEM, which were presented for public consultation in the context of the Strategic Environmental Assessment in December, 2025³⁵.

In terms of sectors, this national action, by its nature, quite transversal, addresses all MEDIGREEN sectors: Fisheries & ORE regarding coexistence and multi-use, Nature protection & ORE regarding coexistence; Aquaculture & ORE regarding multi-use.

Regarding EGD elements, this national action relates to:

A. Climate change mitigation

- A.1.4 Multi-use of the sea space: combination including energy installations
- A.6 Governance-related measures

C. Sustainable sea-food production

- C.1.6 Multi-use of the sea space: combination including fisheries
- C.2.4 multi-use of the sea space: combinations including marine aquaculture
- C.5 Governance-related measures

D. Biodiversity and ecosystem protection and restoration

- D.1.5 Multi-use of the sea space: combination including biodiversity and ecosystem protection
- D.4 Governance-related measures

³⁴ <https://www.miteco.gob.es/es/costas/temas/proteccion-medio-marino/ordenacion-del-espacio-maritimo.html>

³⁵ <https://sede.miteco.gob.es/portal/site/seMITECO/navSabiaPlanes>

2. Implementation

2.1. Methodology

The methodology to assess the inclusion of the coexistence and multiuse concepts in the POEM followed a systematic review of the plan itself, with the aim not only to identify where these concepts have been taken into account directly, but also what other related “facilitators” the plan already has that could ease their implementation.

There are different elements in the POEM that operationalize the inclusion of specific concepts in the planning process. In this assessment the following elements of the plan have been analyzed:

Guiding principles. Overarching objectives that shape the entire MSP process, ensuring that decisions are grounded in sustainable development, an Ecosystem Based Approach (EBA), effective governance, participation and environmental protection, while prioritizing the public interest and the best available scientific knowledge.

Objectives

- **General planning objective.** The overarching purpose of the POEM.
- **Objectives of general interest.** These are priority objectives linked to essential public needs, such as environmental protection, climate change adaptation and mitigation, maritime safety, national defense, water quality and supply, scientific research and innovation, and the safeguarding of underwater cultural heritage.
- **Horizontal multi-sector planning objectives.** These objectives apply across all marine sectors and activities, aiming to reduce conflicts, facilitate coexistence, improve administrative coordination, integrate land-sea interactions and ensure that human activities do not compromise the good environmental status or the objectives of general interest.
- **Sector-specific planning objectives.** These are tailored goals for each maritime sector - such as fishing, aquaculture, energy, navigation, ports or tourism - designed to support their sustainable development, enhance competitiveness and innovation, and guarantee their compatibility with marine conservation.

Zoning

- **Priority Use Areas.** These are areas of the marine space where a specific public-interest use must be safeguarded above others, such as biodiversity conservation, navigation safety, national defense, extraction of sand for coastal protection, cultural heritage protection, or research and innovation, applying specific rules to ensure that priority use is not compromised.
- **High Potential Areas.** These are areas identified as especially suitable for the future development of certain economic activities—such as offshore wind, aquaculture, port activity, or research—based on environmental and technical criteria, and supported by dedicated planning provisions.

Coexistence criteria & zoning criteria. Rules that determine how different activities may coexist within the marine space, ensuring compatibility by minimizing environmental impacts, resolving spatial overlaps on a case-by-case basis, prioritizing general-interest objectives, and safeguarding protected areas and ecosystem integrity. The POEM includes general criteria and also criteria specific for each zoning element.

Measures. Concrete actions to be implemented during the plan’s lifetime—such as spatial pressure analyses, socio-economic forecasting, technical working groups, or improved marine data systems—intended to strengthen marine planning regarding specific identified gaps.

Monitoring. The system used to assess the implementation and effectiveness of the POEM. The plan itself included a preliminary set of indicators although the monitoring programme had not been established by the time this assessment was conducted.

2.2. Assessment

The assessment was carried out based on a textual analysis of the first cycle of the POEM for each of these elements. Their relation to the concept of multi-use or coexistence has been justified. This way, “entry points” or “facilitators” are identified in the POEM, as opportunities through which it would be relevant to integrate the multi-use concept or to reinforce coexistence elements. Furthermore, the recent *Expert Study on Ocean Multi-Use in the German EEZ* (s.Pro/BSH, 2025)³⁶ has been taken into account to validate recommendations made towards lessons learnt from other countries.

2.2.1. Coexistence and multi-use in the guiding principles of the POEM

Within the guiding principles of the first-cycle of the POEM, neither coexistence nor multi-use is explicitly mentioned. However, many of the principles—such as improving the competitiveness of the maritime economy^{37 38}, promoting a green transition and circular economy³⁹, ensuring efficient use of space, and minimising impacts—are conceptually aligned with the logic of coexistence and multi-use. Multi-use directly supports these principles by reducing spatial and material consumption, avoiding duplicated infrastructure and contributing to resource-efficient development.

A significant evolution appears in the new guiding principles proposed for the second cycle of the POEM - presented for public consultation in December 2025 - which now include an explicit reference to the **“promotion of coexistence and synergies between sectors, including multi-purpose or multiple use of space.”** This marks an important shift: multi-use is no longer only implicitly aligned with the guiding principles, but recognized as a deliberate

³⁶ Schultz-Zehden, A., Drews- von Ruckteschell, F., Dittmer, P., Smolka, U., Staufenberger, T., Strothotte E., Schatz, V. (2025). Expert Study on Ocean Multi-use in the German Exclusive Economic Zone (EEZ) of the North and Baltic Sea. Summary Report.

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³⁹ Guyot-Téphany, J., Trouillet, B., Diederichsen, S., Juell-Skielse, E., Thomas, J-B. E., McCann, J., Rebours, C., Scherer, M., Freeman, P., Gröndahl, F., Walsh, J. P., & Lukic, I. (2024). Two decades of research on ocean multi-use: achievements, challenges and the need for transdisciplinarity. *npj Ocean Sustainability*, 3(8). <https://doi.org/10.1038/s44183-024-00043-z>

planning ambition. This explicit inclusion strengthens the policy foundation for multi-use and directly responds to some of the limitations identified in the first cycle.

Beyond this explicit mention, the updated guiding principles introduce wider strategic directions—such as those related to economic diversification, governance improvements, food and energy security, and adaptive management—that also reinforce the enabling environment for coexistence and multi-use. Although these principles do not reference multi-use directly, they support many of the conditions necessary for its future implementation: better administrative coordination, more robust cross-sectoral engagement and a more flexible, iterative approach to planning.

Together, the guiding principles of both cycles show a **trajectory of increasing alignment with coexistence and multi-use**. The first-cycle principles provide a conceptually compatible foundation, while the proposed guiding principles of the second-cycle strengthen and clarify the direction of travel, positioning multi-use more centrally within Spain's evolving MSP framework.

2.2.2. Coexistence and multi-use in the objectives of the POEM

The analysis of the POEM's objectives shows that several of them may serve as **entry points** for integrating multi-use, while others could **benefit directly from** its implementation. The POEM establishes four groups of objectives—the general planning objective, objectives of general interest, horizontal multisectoral objectives and sector-specific objectives—each of which relates to coexistence and multi-use in different ways.

In the first cycle, the general planning objective already provides a broad foundation by promoting a sustainable and balanced use of the marine space. Although not explicitly linked to coexistence or multi-use, it supports the idea that activities should be developed in a compatible manner and in coherence with marine strategies and sectoral plans. Among the objectives of general interest, the one **most strongly connected to multi-use is the aim of promoting scientific research, development and innovation—particularly in relation to marine renewable energies**. This objective implicitly opens space for testing integrated configurations, exploring synergies among sectors, and using innovation as a platform to advance coexistence and multi-use solutions.

The horizontal multisectoral objectives of the first cycle offer even more direct alignment. These objectives include reducing conflicts, **facilitating coexistence, identifying synergies** and improving administrative coordination. While they are not explicitly framed in terms of multi-use, they set out the **enabling pre-conditions** that are essential for its future implementation: **improved cross-sectoral dialogue, better coordination between competent authorities, and increased predictability in authorisation procedures**. These objectives therefore create a supportive policy environment for multi-use, even if they stop short of articulating concrete pathways for achieving it.

By contrast, sector-specific objectives tend to focus on ensuring that each activity is protected from interference by others. **This defensive orientation limits their capacity to actively promote coexistence or integrated uses**, even though these sectors—such as offshore renewable energy, aquaculture, fishing or tourism—could significantly benefit from compatibility-based approaches. In future cycles, sector-specific objectives could evolve **toward explicitly recognising opportunities for coexistence and multi-use** (for example,

renewable energy co-located with certain types of aquaculture or research activities), thereby complementing the more strategic aims expressed in the general and horizontal objectives.

The updated objectives proposed for the **second cycle of the POEM** reinforce this evolving trajectory. Most notably, they introduce an explicit objective to **“facilitate and promote the coexistence of uses and activities, including the promotion of multiple uses of maritime space.”** This represents a significant shift from the first cycle, where multi-use was only indirectly aligned with certain objectives. The new objective elevates coexistence and multi-use from a conceptual alignment to a clear planning ambition, providing a firmer strategic basis for operationalising these approaches in the next cycle of the POEM.

Other updated objectives—such as those aimed at improving scientific knowledge (including ecosystem carrying capacity), strengthening governance, and supporting key sectors such as fisheries and aquaculture—also help reinforce the enabling environment for coexistence and multi-use. While these objectives do not mention multi-use directly, they address several constraints identified in the first cycle, such as gaps in technical knowledge, the need for clearer prioritisation between uses, and the importance of reducing impacts on environmentally and socio-economically sensitive sectors.

Overall, the **first-cycle objectives provide several conceptual openings for coexistence and multi-use, but tend to lack explicit operational direction.** The updated second-cycle objectives build on this foundation by making the promotion of coexistence and multi-use explicit and by reinforcing the supporting conditions—scientific evidence, governance, sectoral sustainability and spatial prioritisation—necessary to make these concepts more feasible in practice. Together, they mark a gradual but meaningful shift towards a more integration-oriented approach in Spain’s maritime spatial planning framework.

2.2.3. Coexistence and multi-use in the planning criteria

The POEM establishes a set of criteria intended to ensure the sustainable coexistence of uses and activities in the marine space. However, these criteria are predominantly oriented towards **environmental protection** and the **assessment and minimisation of impacts**, rather than towards actively promoting coexistence or enabling multi-use. The criteria are largely derived from pre-existing environmental legislation—such as Natura 2000 assessments, Environmental Impact Assessment (EIA) requirements, and compatibility reports under the Marine Strategy Framework Directive—and therefore focus mainly on establishing conditions or restrictions to avoid harm to sensitive habitats, species or protected areas.

These criteria also promote the conservation of the marine environment beyond what is required by EIA regulation and reiterate the principles of **minimum occupation** and **minimum impact** as prerequisites for authorising activities. Although these principles are consistent with multi-use—since multi-use can reduce overall spatial and material footprint—**the POEM does not operationalise how to determine minimum occupation for each activity nor how such assessments could support multi-use arrangements.** The absence of quantified or activity-specific thresholds limits the practical value of these criteria for promoting shared spatial solutions.

The POEM also prioritises the development of each activity within the areas assigned to it through zoning, which is logical from a planning perspective but does not automatically promote coexistence. **Unless zoning is explicitly designed to consider co-location** (e.g., multi-purpose areas or areas designated for testing and/or developing multi-use), **zoning**

alone may reinforce sectoral separation rather than integration. The requirement to assess the socioeconomic impacts of proposed activities on existing or future uses provides useful decision-support information, but it does not explicitly encourage coexistence or multi-use. It may, however, help authorities identify situations where coexistence is desirable or where multi-use could be justified on socioeconomic grounds.

Regarding sector-specific coexistence criteria, the POEM again focuses on preventing or minimising impacts on the marine environment, often by referring to existing regulatory frameworks. For example, *unregulated anchoring must avoid seagrass meadows and underwater cultural heritage*, which could be interpreted as a basic coexistence rule between recreational boating and these sensitive features. The plan in fact foresees a specific measure (see section 2.2.6.) to elaborate a management plan for recreational boating mooring. However, the plan does not yet specify mechanisms for implementing such coexistence (e.g., through ecological mooring systems or managed anchoring zones), leaving practical application to the approval of such a plan. Similarly, criteria for R&D&I areas allow installations outside designated polygons, which could be advantageous for testing multi-use solutions, but this potential is not explicitly articulated.

Sectoral criteria sometimes hint at coexistence—for instance, by requiring *activities to minimise interference with permanent fishing ban areas*, or by *encouraging measures to reduce vessel-cetacean collisions*. However, these provisions do not define the conditions for functional coexistence; instead, their practical implementation has been delegated to specific working groups tasked with operationalising the criteria. In other cases, the criteria aim only to avoid undermining the objectives of protected areas or regulated zones, rather than adapting activities to ensure compatibility. **True coexistence would require activities to be designed or managed in ways that safeguard the purpose of the areas they overlap with, something that currently depends largely on other regulatory instruments rather than on the POEM itself.**

2.2.4. Coexistence and multi-use in the integration of Land-Sea Interactions

The POEM's criteria for Land-Sea Interactions (LSI) focus on ensuring coherence between marine activities and coastal policies, mainly to prevent cross-domain impacts rather than to actively promote coexistence or multi-use. Most criteria address situations where land-based activities—such as desalination, wastewater discharges, or coastal infrastructure—may affect marine uses that depend on good water quality or stable coastal dynamics (e.g., aquaculture, navigation). This helps avoid conflicts and supports basic coexistence but does not yet create operational pathways for multi-use.

Similarly, the POEM requires that offshore activities consider their impacts on coastal socio-economic uses, landscapes, and cultural or recreational values, again emphasizing conflict avoidance rather than integration. These criteria help identify compatibility issues but do not explore synergies, shared-infrastructure opportunities, or potential circular-economy approaches that could arise from better coordination between land-based and marine activities.

2.2.5. Coexistence and multi-use in the zoning of the POEM

Zoning is one of the most influential elements of the POEM in shaping how marine activities can coexist or, alternatively, how they are kept separate. The plan organises marine space

through Priority Use Areas (ZUP, Zonas de Uso Prioritario) and High Potential Areas (ZAP, Zonas de Alto Potencial), each accompanied by criteria that define acceptable uses, restrictions, and conditions for coexistence. While zoning provides the structural basis for coordinating multiple activities, its current formulation is **still sectorial and although it is not based on exclusivity, it leaves limited room for proactive coexistence or multi-use arrangements.**

In the Priority Use Areas, the criteria focus mainly on safeguarding the primary function of each zone. For biodiversity conservation areas, the POEM requires avoiding activities that could compromise ecological values, such as the installation of offshore wind farms in critical seabird habitats or in locations with habitats of community interest. Similarly, in priority areas for the extraction of sand deposits for coastal protection, the criteria aim to prevent disturbances from other activities and minimise impacts on fisheries and aquaculture. Priority areas for underwater cultural heritage are governed by strict avoidance measures: unregulated anchoring must be prevented, and infrastructure installations are generally incompatible with the protection mandate. These provisions effectively secure the priority use of these areas but do so by limiting the opportunity for coexistence rather than by guiding activities toward compatible forms of interaction. In essence, Priority Use Areas reinforce a hierarchical approach to zoning, where primary uses dominate and coexistence is considered only under certain conditions.

A notable exception is the **Priority Use Areas for Research, Development and Innovation (R&D&I)**. Here, the POEM explicitly states that testing of **marine renewable technologies may be combined with research activities from other sectors**—such as aquaculture or environmental monitoring—making this the clearest example in the zoning framework where multi-use is directly encouraged. Importantly, the fact that this support is limited to experimental or pilot settings does not stem solely from the plan's design, but rather reflects today's technological and commercial reality, where fully operational, large-scale multi-use solutions have not yet been implemented in practice. In this context, R&D&I areas act as appropriate and realistic entry points for multi-use development, serving as incubators for integrated solutions until commercial-scale multi-use becomes technically viable and economically established.

In the **High Potential Areas**, the zoning logic is different: these areas identify locations especially suitable for the development of specific activities, such as offshore wind, aquaculture, port expansion or R&D&I. The criteria in these areas concentrate on environmental safeguards—such as avoiding impacts on habitats of community interest or reducing risks to seabirds—as well as operational considerations like ensuring safe navigation or avoiding interference with defence activities. Although High Potential Areas establish spatial preferences, they by default do not impose exclusivity. In many cases, activities could still develop outside these areas, and the zoning does not automatically rule out shared or overlapping uses. **This lack of exclusivity provides a latent opportunity for coexistence, but the plan does not explicitly articulate how such coexistence should be managed.**

Some criteria within High Potential Areas, particularly for offshore wind energy, move closer to operational coexistence. For example, developers are required to analyse compatible fishing gears, facilitate vessel transit, and ensure that wind farm layouts maintain adequate permeability parallel to the coast, especially for artisanal fleet operations. However, these provisions still depend heavily on project-level processes (EIA, MSFD compatibility reports,

technical studies) rather than being directly enforced through zoning. This underscores the fact that **coexistence in the POEM relies more on downstream authorisation mechanisms than on proactive spatial design.**

At the same time, High Potential Areas include criteria instructing activities to minimise impacts on other uses, such as avoiding disruption to shell fishing areas during port expansion or ensuring that aquaculture developments do not interfere with national defence or cultural heritage protection. These provisions contribute to a basic level of coexistence but remain largely mitigative rather than integrative. They **prevent conflicts but do not promote synergies or shared spatial solutions.**

2.2.6. Coexistence and multi-use in the measures of the POEM

The POEM includes several measures that, while not explicitly designed to promote coexistence or multi-use, can serve as important entry points for developing these concepts in future cycles. Many of these measures strengthen knowledge, governance, conflict management and testing capacities—key prerequisites for enabling multi-use under current technological and regulatory conditions.

One significant measure is the plan's commitment to develop a **prospective analysis and socio-economic characterisation of the different sectors of the Spanish blue economy.** This analysis could help identify leverage points for multi-use by revealing compatible sectoral combinations, shared infrastructure needs, and potential efficiency gains. To fully harness this opportunity, **the study should explicitly incorporate an economic feasibility assessment of multi-use, evaluating whether specific co-location configurations could be viable in practice and under what conditions.**

Some measures focus on conflict management, normally by avoiding spatial overlap between uses or with sensitive biodiversity elements—for example, through the development of recreational boat mooring management plans. This measure tries to find solutions to compatibilize recreational boat mooring with the preservation of seabed habitats and the underwater cultural heritage, **aiming at reducing impacts while enabling continued activity, such as with ecological moorings.**

Measures related to governance also offer opportunities for strengthening multi-use. The POEM provides for the creation of working groups to address management challenges at the appropriate scale. **Establishing a dedicated multi-use working group, involving authorities responsible for different parts of the permitting system as well as R&D&I platforms and interested sectors, would create a structured forum to analyse feasibility, coordinate regulatory requirements, and facilitate joint solutions.**

Some measures relate more directly to the concept of multi-use, such as the identification of potential new areas for R&D&I. However, the plan does not explicitly require these areas to support multi-use initiatives. This measure could be strengthened by adding **criteria to prioritise testing of compatibility, multi-use configurations, and studies on impacts and carrying capacity,** thereby positioning R&D&I areas as realistic incubators for future integrated uses.

Sector-specific measures could also indirectly support multi-use. The Sustainable Aquaculture Development Strategy (2021–2030) encourages the identification of new

aquaculture sites, including offshore locations. In the cases these sites overlap with offshore wind areas, the POEM could require joint feasibility studies to analyse potential coexistence or multi-use opportunities. In this way, sectoral expansion planning could become a natural driver of integration rather than parallel development.

Finally, several measures could act as precursors for more operational guidance. The POEM includes the analysis of the potential effects of offshore wind farms on marine ecosystems, which may offer insights into how to better align wind energy with biodiversity protection goals. Building on this measure, a **guideline on low-impact technologies adapted to specific ecosystems could be developed, helping identify which designs and technical solutions might enable coexistence.**

2.2.7. Coexistence and multi-use in the monitoring of the POEM

NOTE: At the time of this assessment, the monitoring programme of the POEM has not yet been developed; however, the plan was approved with a set of preliminary indicators that offer initial insights into how its performance could be tracked. While these indicators are not explicitly designed to measure multi-use performance, several of them provide a foundation on which a more robust monitoring framework could be built.

A first set of relevant indicators relates to R&D&I activities, including the area occupied by R&D&I projects, the number of projects developed within designated R&D&I zones, and—crucially—an indicator designed to track **“new authorised uses involving multiple uses or multiple platforms.”** This is one of the few monitoring elements in the POEM that directly acknowledges the possibility of multi-use. A similar indicator exists for the hydrocarbons sector, assessing whether uses are authorised on existing platforms as a way for them to become multi-platforms.

Another indicator refers to **“new authorised uses that interact with other uses or activities and may be considered synergies.”** This indicator is broader than multi-use and better aligned with coexistence, as it reflects situations where more than one activity operates compatibly or where cross-sectoral benefits arise. However, its utility will depend heavily on how “synergy” is defined and operationalised. Without clear criteria—e.g., shared infrastructure, spatial co-presence, coordinated management or reduced footprint—it risks capturing only loosely related interactions. Strengthening the definition of synergy would help differentiate between coexistence and true multi-use.

Additional indicators focus on governance and stakeholder engagement, such as the number of participatory events or ad-hoc meetings with stakeholders. Although these indicators currently measure progress toward governance objectives rather than integration outcomes, they could be adapted to **evaluate whether multi-use is being actively discussed, whether specific multi-use proposals have been reviewed, and whether stakeholders perceive multi-use as feasible and desirable.** In this sense, governance-related indicators could become useful proxies for monitoring the enabling conditions for multi-use.

Despite these promising elements, the preliminary monitoring framework still presents important gaps for assessing coexistence and multi-use. It does not include indicators on spatial overlap between sectors, levels of compatibility or conflict, environmental performance of co-located activities, or socio-economic benefits derived from integrated

uses. Without such indicators, it will be difficult to evaluate whether coexistence or multi-use are progressing beyond isolated project-level experiences.

Looking ahead, the monitoring system could be strengthened by incorporating multi-use-specific metrics, such as the **number of feasibility studies conducted, authorisations integrating multiple uses, or the spatial extent of areas where coexistence or multi-use is authorised or in testing. Including indicators on environmental and socio-economic outcomes of co-located activities would also help assess whether multi-use contributes to the POEM's broader objectives.**

3. Transferability and upscaling

3.1. Transferability

The challenge addressed in this national action – the integration of coexistence and multi-use into MSP – is relevant across multiple spatial scales. At the local scale, coexistence issues arise where concrete interactions between uses occur (e.g., mooring of recreational vessels and seagrass habitats). These interactions require detailed, place-based assessments and are strongly influenced by local ecological and socio-economic conditions. At the sub-national and national scale, coexistence relates to broader questions of spatial allocation, coordination across sectors, and alignment with national strategies (e.g., offshore wind, aquaculture, biodiversity protection). The POEM addresses these challenges through zoning (Priority Use Areas, High Potential Areas) criteria and measures, which apply uniformly across all Spanish marine demarcations. Finally, at the basin scale, the principles underpinning coexistence and multi-use – such as minimising conflict, protecting ecological values or ensuring efficient spatial use – are consistent with EU-wide MSP approaches and regional sea-basin initiatives. Thus, the issues analysed in this national action are highly transferable, as coexistence and multi-use are systemic challenges faced by all Mediterranean countries.

The enabling conditions for implementing coexistence and multi-use emerge clearly from the POEM assessment. From a governance perspective, successful transfer requires mechanisms for coordination among competent authorities, given that many coexistence decisions rely on downstream authorisation processes beyond the direct competence of MSP. The POEM's proposed working groups represent an enabling structure that could be adapted by other countries to discuss feasibility, compatibility, legal requirements and cross-sectoral impacts. Strengthened stakeholder engagement is another essential condition for transferability, as coexistence is shaped by sector perceptions, operational constraints and willingness to cooperate.

Finally, context-related enablers include the availability of R&D&I platforms (prominent in the Spanish case), the presence of data systems such as INFOMAR, and the capacity to conduct socio-economic and environmental analyses. These elements demonstrate that transferability depends not only on MSP design but also on the knowledge base, technical capacity and institutional maturity that support implementation.

3.2. Affordability

The affordability of this national action—an assessment of how MSP integrates coexistence and multi-use—might be moderate for Mediterranean countries. Since the assessment relies mainly on desktop document review, planning interpretation and qualitative analysis, the knowledge and resource requirements are modest. Countries primarily need access to their marine planning instruments (MSP plans, sectoral strategies, zoning documents and relevant legislation) and a multidisciplinary team with analytical, policy and MSP-related skills. No engineering, field surveys or advanced modelling techniques are required, making the approach accessible to both EU and non-EU Mediterranean countries, regardless of their institutional maturity in MSP. Financially, the action demands mainly staff time, limited coordination efforts and expert consultation, which can often be integrated into ongoing planning and governance activities.

Affordability for Spain to implement the recommendations

Having in mind the strategic character of the POEM, and the fact that its provisions are ultimately implemented through downstream authorisation processes often governed by different authorities, the implementation of the recommendations proposed in this assessment will require a **high level of horizontal and vertical coordination**, as well as a **structured and continuous flow of data** between competent administrations. These governance-related requirements represent the main cost drivers for Spain. They do not necessarily imply high financial expenditure, but they require institutional commitment, dedicated coordination mechanisms and improved interoperability across sectoral systems.

Many of the recommended actions—such as incorporating multi-use feasibility into prospective studies, reinforcing working groups, or improving compatibility criteria—are **primarily organisational and procedural**, rather than infrastructure-intensive. As such, their affordability is relatively moderate: they can be undertaken within existing administrative structures, provided that responsibilities are clearly assigned and that coordination processes are strengthened. Enhancing data flows for coexistence and multi-use (e.g., environmental, socio-economic, spatial compatibility information) may require investment in data harmonisation and integration systems, but these costs remain moderate compared to other MSP-related investments and could benefit from ongoing national marine data initiatives.

More advanced recommendations—such as establishing pilot multi-use or multipurpose zones, developing compatibility assessment methodologies, or improving monitoring frameworks for coexistence—carry higher technical and analytical requirements. These actions mainly require targeted studies, stakeholder engagement processes and improved monitoring protocols. However, the biggest challenge is again organisational cohesion: ensuring that sectoral authorities, regional administrations and national bodies collaborate effectively and sustain long-term coordination. In this sense, the affordability of implementing recommendations in Spain is less constrained by financial cost and more by governance capacity and inter-institutional alignment.

Overall, Spain is well positioned to implement the proposed recommendations at a reasonable cost. Many of the enabling structures—R&D&I areas, working groups, data platforms, and cross-sectoral coordination mechanisms—already exist or are being reinforced within the POEM revision process. With focused effort on improving

coordination, data integration and multilevel governance, the implementation of these recommendations is considered affordable and feasible within the current Spanish MSP framework.

3.3. Upscaling

The action—an assessment of how national MSP documents integrate the concepts of coexistence and multi-use—could readily be implemented at a larger scale. Because the methodology relies primarily on document analysis, interpretation of objectives, zoning, criteria and measures, and identification of “entry points” or “facilitators,” it can be applied to any MSP plan or, to supranational strategies and action plans. The approach is therefore scalable to the basin level, helping identify common gaps or opportunities across the Mediterranean.

Developing such an assessment at the sea basin level would help better understand how MSP or sectoral systems across the region are addressing these principles, and where progress or harmonisation is needed.

Finally, the action would benefit significantly from cross-border or transboundary cooperation. Coexistence and multi-use challenges do not stop at national boundaries: fishing grounds, ecological corridors, shipping routes, offshore energy areas and cultural landscapes often extend across borders. Conducting parallel assessments between neighbouring countries would allow the identification of shared pressures, mutual incompatibilities, or opportunities for joint multi-use pilots. It would also support alignment in governance approaches, permitting processes and data interpretation—particularly important in the Mediterranean, where sea-basin integration is still developing. Cross-border cooperation would therefore enhance both the robustness of the assessment and its potential to inform coordinated regional action.

4. Conclusion

This assessment shows that the **first cycle of the POEM includes several elements relevant to coexistence and multi-use, but their operationalisation remains limited.** While the plan incorporates principles that align with these concepts—such as efficient use of space, minimum impact, competitiveness and circular economy—these remain conceptual and require clearer translation into operational guidance. The **new guiding principles proposed for the second cycle represent an important evolution:** they include, for the first time, an explicit reference to **“the promotion of coexistence and synergy between sectors, including multi-purpose or multiple use of space.”** This directly strengthens the policy foundation for multi-use. Additional principles related to governance improvements, economic diversification, food and energy security, and adaptive management further strengthen the enabling environment by addressing gaps observed in the first-cycle framework.

The analysis of the first-cycle objectives reveals uneven potential for integration. General and general-interest objectives support coexistence indirectly through sustainability and research ambitions, while horizontal multisectoral objectives—such as those related to reducing conflicts, improving coordination and identifying synergies—offer clearer

opportunities for coexistence and, indirectly, for multi-use. However, sector-specific objectives remain largely defensive, focusing on avoiding interference rather than promoting compatibility or shared-space solutions. This limits their ability to drive coexistence or support multi-use across sectors that could benefit from integrated approaches.

The updated objectives proposed for the second cycle of the POEM demonstrate a clear evolution in strategic ambition. Most notably, the **new objective to “facilitate and promote the coexistence of uses and activities, including the promotion of multiple uses of maritime space”** represents a significant shift, providing explicit policy backing for multi-use that was absent in the first cycle. Other updated objectives—particularly those linked to improved scientific knowledge, carrying capacity, governance enhancements, and supporting key sectors such as fisheries and aquaculture—reinforce the enabling conditions necessary to make coexistence and multi-use more feasible. Their inclusion reflects the **POEM’s adaptive nature: as a tool with a cyclical review mechanism, each planning cycle builds upon and learns from the previous one**, progressively integrating new knowledge, emerging sectoral needs and improved planning practices.

Planning criteria and zoning further illustrate the patterns of the first cycle. Criteria focus largely on environmental protection and impact mitigation, lacking operational tools such as compatibility thresholds or minimum-occupation benchmarks. Priority Use Areas safeguard a dominant use, while High Potential Areas guide sector-specific development but do not explicitly promote coexistence or multi-use. Only **R&D&I Priority Use Areas explicitly support the testing of integrated configurations**. Measures and monitoring provisions provide partial support, but they do not yet contain explicit actions or indicators necessary to operationalise or track coexistence and multi-use.

A fundamental constraint is that the POEM regulates only the spatial dimension of maritime activities, leaving many practical aspects of coexistence and multi-use—such as operational rules, technical requirements and monitoring obligations—to sectoral legislation and downstream authorisation procedures. Moreover, the POEM binds administrations, not users, limiting its capacity to directly influence activity behaviour in shared spaces.

For the next cycles of the POEM, progress would require clearer operationalisation of objectives and criteria, designation of multipurpose or multi-use-ready areas, improved governance and coordination mechanisms, and a monitoring framework capable of assessing coexistence and multi-use.

Many of these challenges are reflected in the findings of the *Expert Study on Ocean Multi-Use in the German EEZ* (s.Pro/BSH, 2025), which proposes recommendations that align closely with aspects already present in the POEM. The German study emphasises early integration of multi-use into planning processes—consistent with POEM’s updated guiding principles and horizontal objectives on coordination—and highlights the usefulness of demonstration areas, a concept that mirrors the potential role of POEM’s R&D&I Priority Use and High Potential Areas as testing grounds for integrated solutions. It also stresses the importance of robust governance mechanisms, improved environmental and technical data and operational coordination—elements that resonate with POEM’s existing measures and coexistence criteria. This convergence suggests that Spain already possesses partial structural components aligned with international best practice, which could be reinforced in the next planning cycle.



Overall, the POEM provides a solid conceptual basis for coexistence and emerging opportunities for multi-use. However, meaningful progress will depend on more explicit operationalisation, strengthened zoning and planning criteria and enhanced governance coordination. Incorporating lessons from recent multi-use studies—together with the advances introduced in the updated guiding principles and objectives—can support Spain’s transition from a reactive coexistence approach towards a proactive, feasible and technically grounded multi-use framework in the next cycles of its maritime spatial plans.

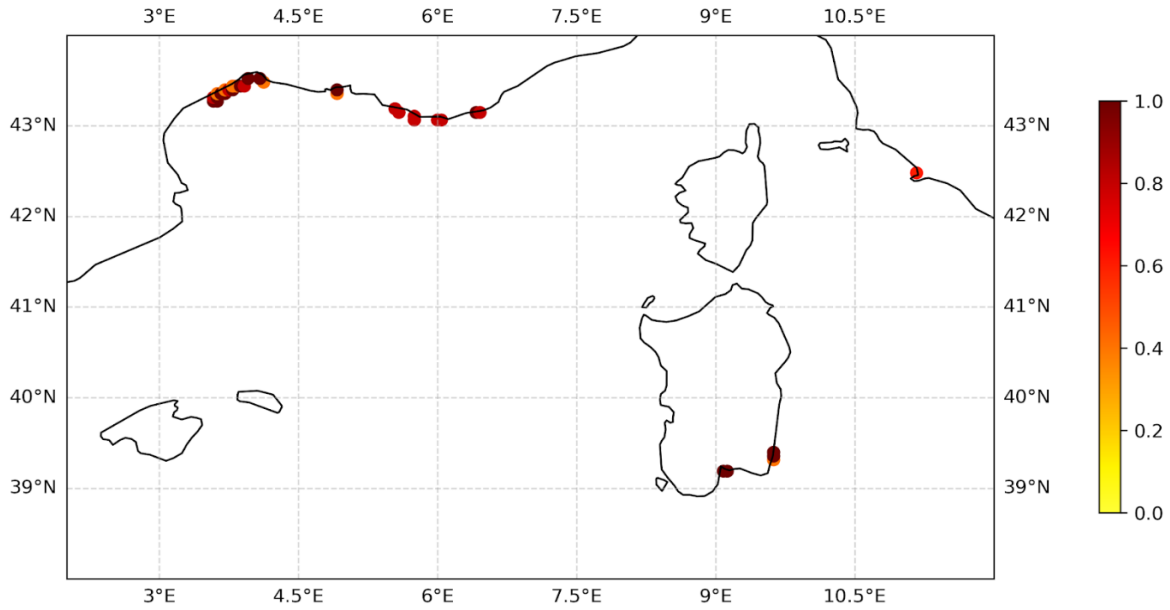


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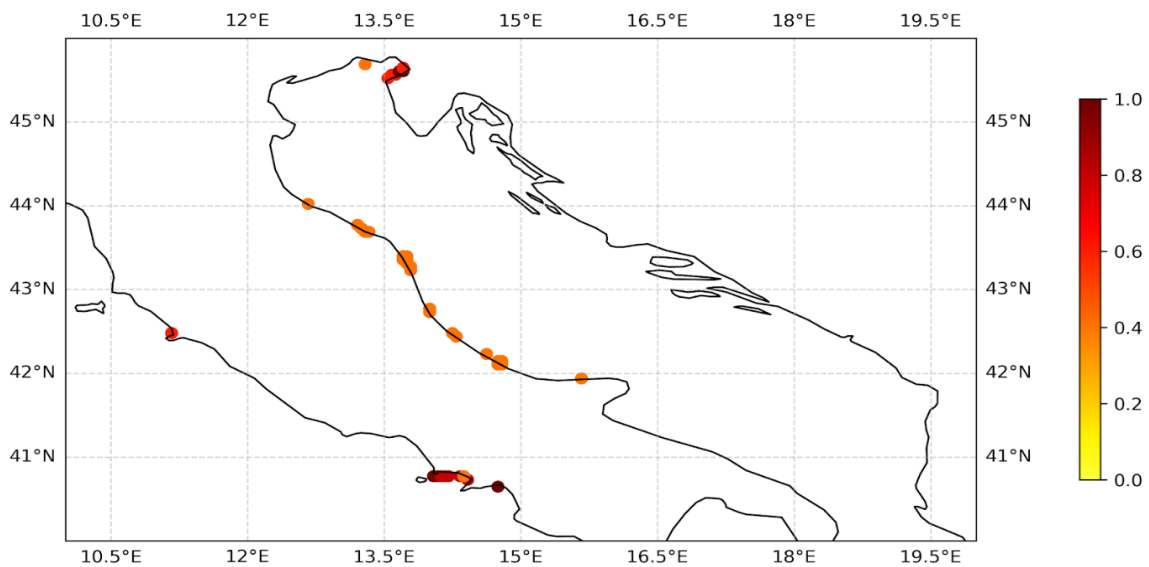


Annexes

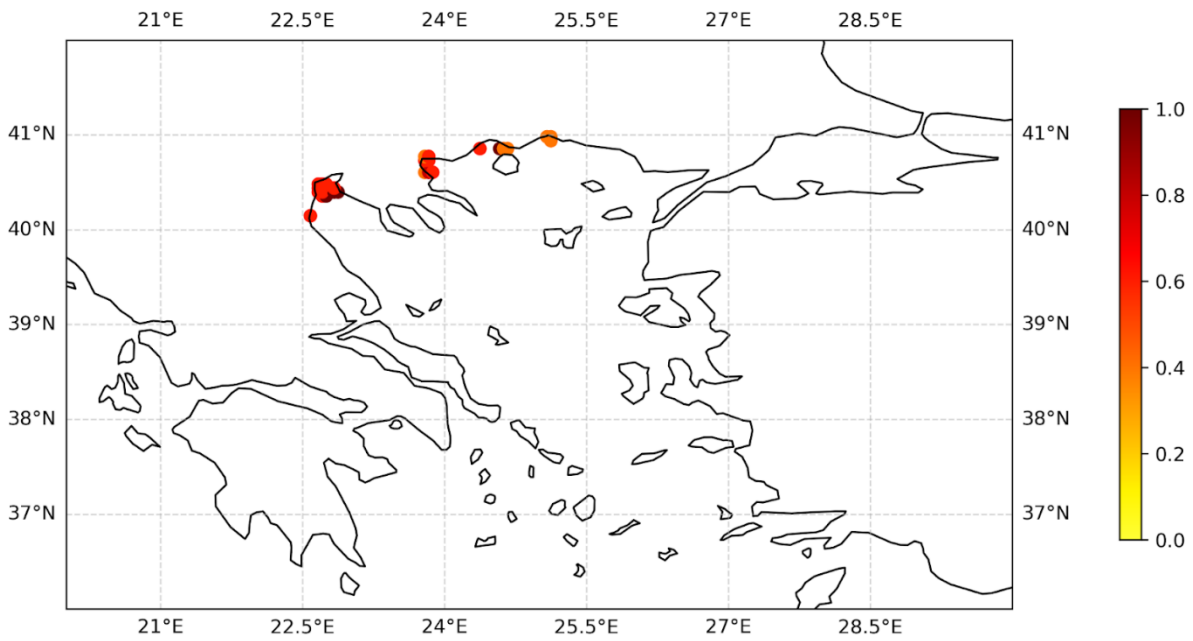
Annex A (National Action #1)



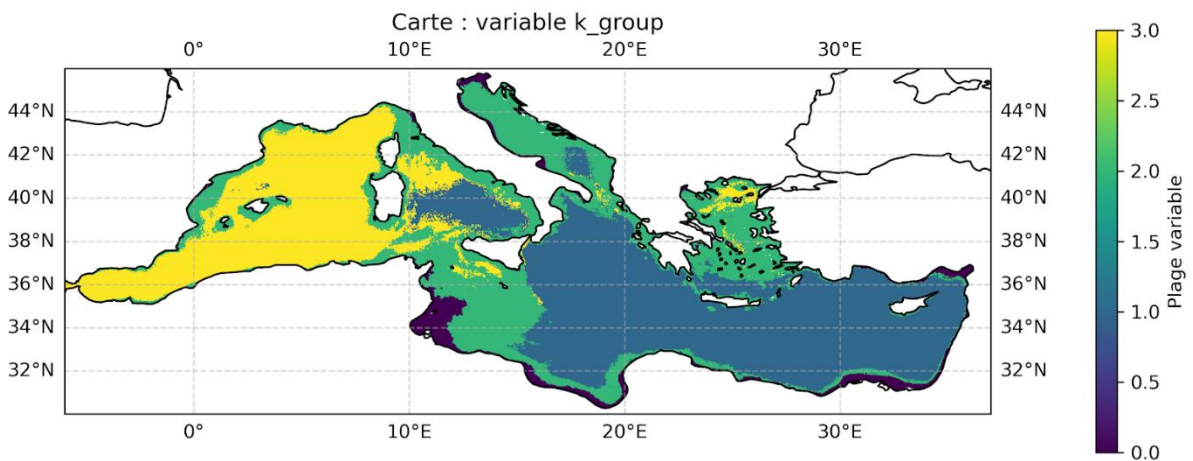
Pollution potential impact risk in the Gulf of Lion, calculated by crossing aquaculture presence with the benthic habitat's sensitivities to pollution. Areas without value correspond to areas with unknown habitat sensitivity.



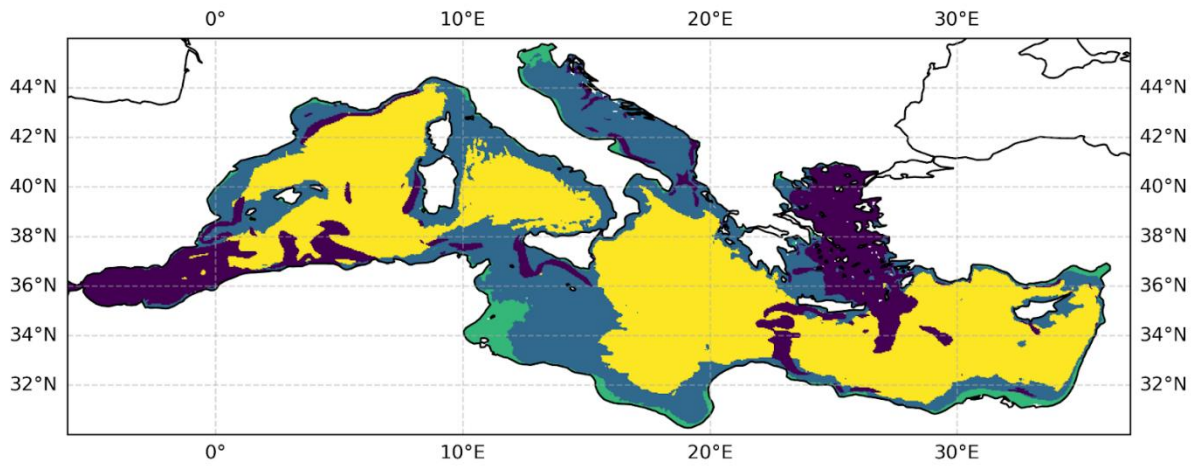
Pollution potential impact risk in the Adriatic Sea, calculated by crossing aquaculture presence with the benthic habitat's sensitivities to pollution. Areas without value correspond to areas with unknown habitat sensitivity.



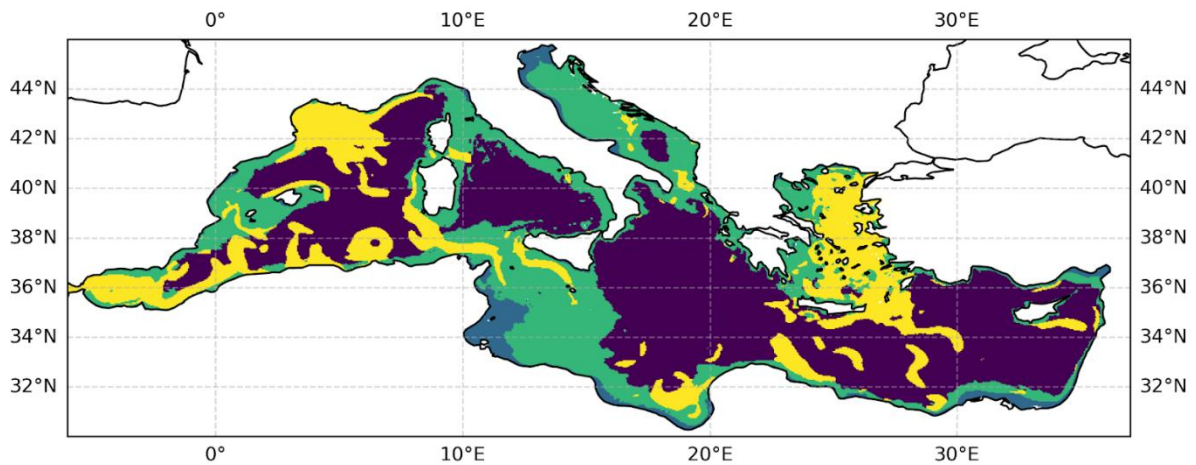
Pollution potential impact risk in the Adriatic Sea, calculated by crossing aquaculture presence with the benthic habitat's sensitivities to pollution. Areas without value correspond to areas with unknown habitat sensitivity.



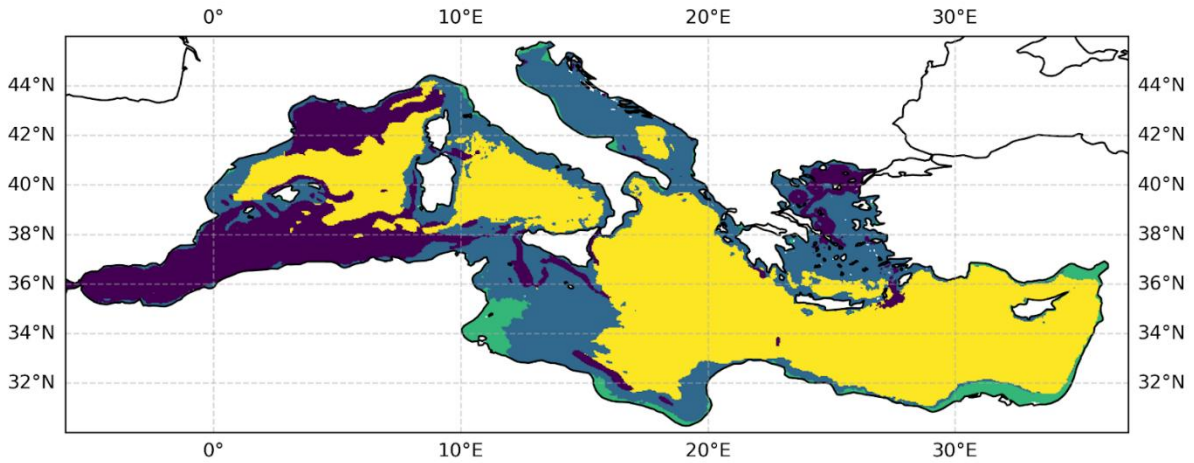
Map of an initial state seascape in the Mediterranean Sea i.e., mean configuration of seascapes during summer months calculated on years without intense MHW (2007, 2008, 2011, 2012, 2014, 2016, 2020 and 2021.). Each colour represents a different seascape. The colours have no meaning other than to differentiate seascapes as it is randomly assigned during statistical analyses.



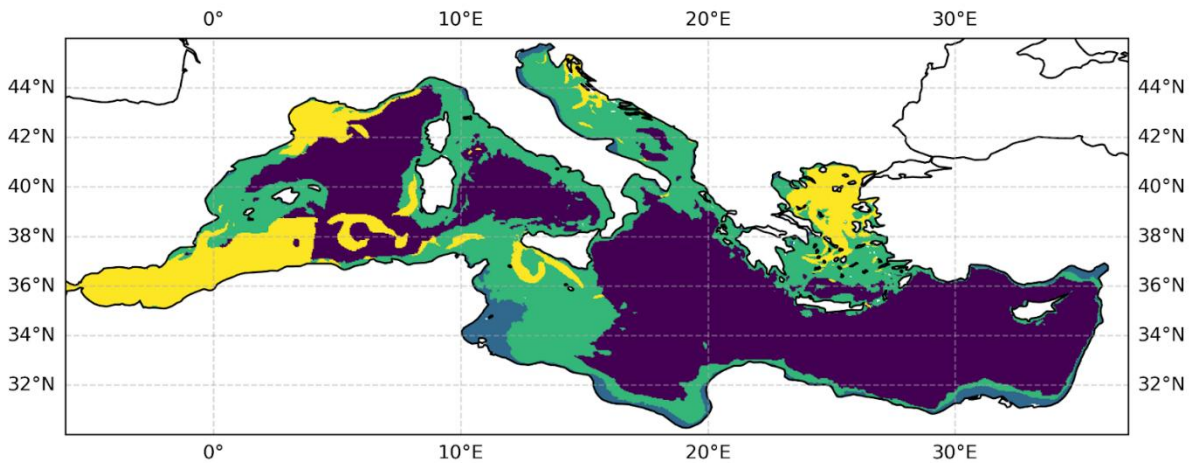
Map of seascapes in the Mediterranean Sea during MHW (July 2006). Each colour represents a different seascape. The colours have no meaning other than to differentiate seascapes as it is randomly assigned during statistical analyses.



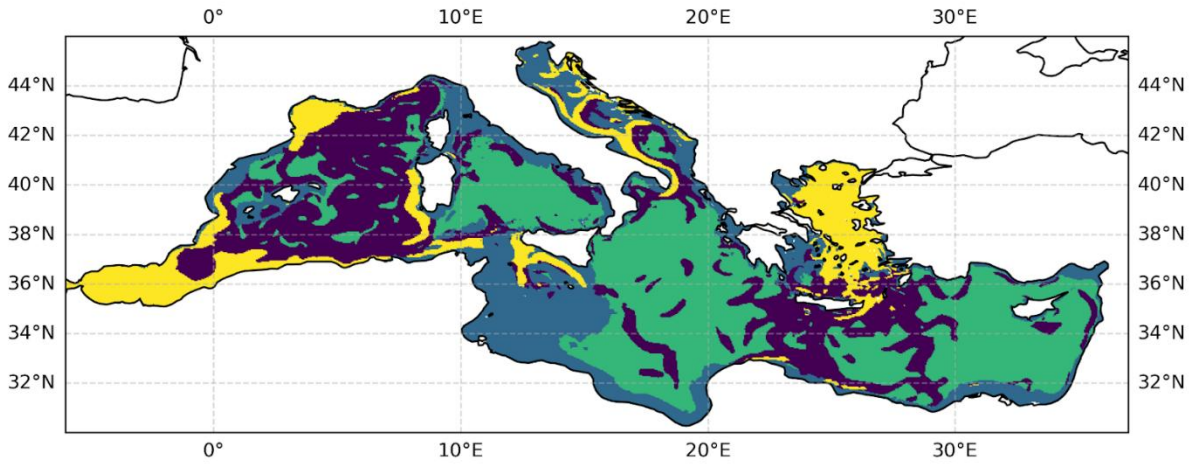
Map of seascapes in the Mediterranean Sea during MHW (July 2015). Each colour represents a different seascape. The colours have no meaning other than to differentiate seascapes as it is randomly assigned during statistical analyses.



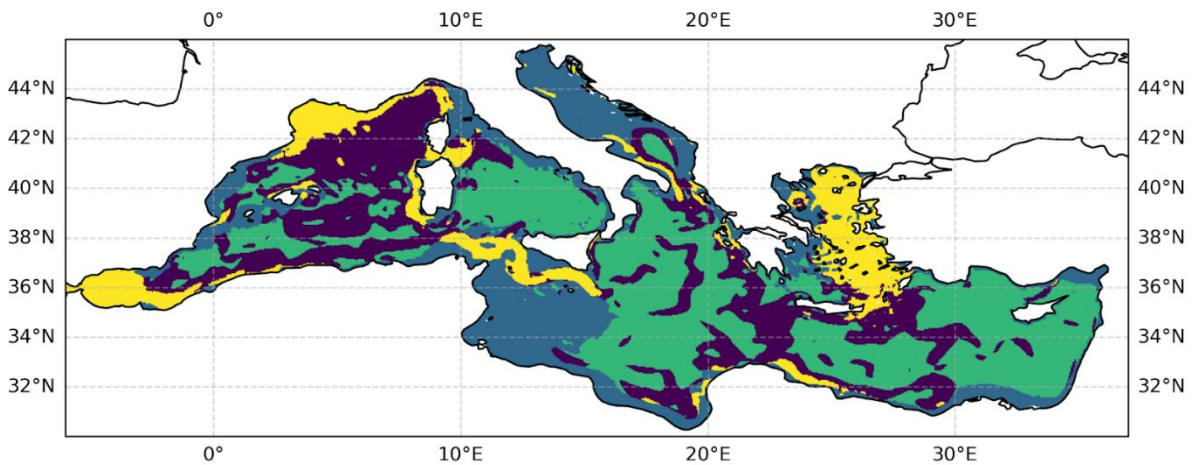
Map of seascapes in the Mediterranean Sea during MHW (June 2017). Each colour represents a different seascape. The colours have no meaning other than to differentiate seascapes as it is randomly assigned during statistical analyses.



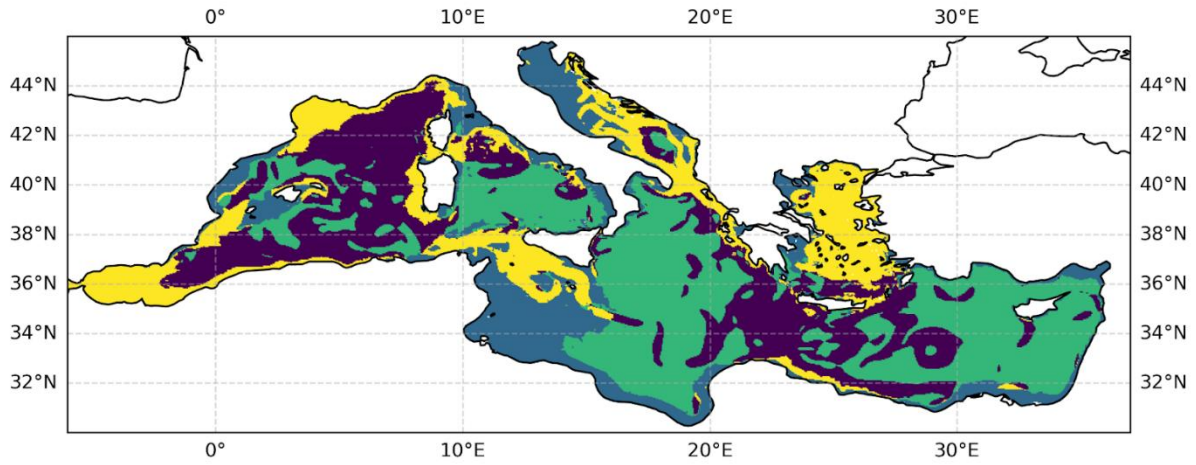
Map of seascapes in the Mediterranean Sea during MHW (August 2018). Each colour represents a different seascape. The colours have no meaning other than to differentiate seascapes as it is randomly assigned during statistical analyses.



Map of seascapes in the Mediterranean Sea during MHW (August 2022). Each colour represents a different seascape. The colours have no meaning other than to differentiate seascapes as it is randomly assigned during statistical analyses.



Map of seascapes in the Mediterranean Sea during (July 2023). Each colour represents a different seascape. The colours have no meaning other than to differentiate seascapes as it is randomly assigned during statistical analyses.



Map of seascapes in the Mediterranean Sea during (July 2023). Each colour represents a different seascape. The colours have no meaning other than to differentiate seascapes as it is randomly assigned during statistical analyses.

Annex B (National Action #5)

Review of existing area-based management tools (ABMTs)

No.	Name	Legal source	Year of entry into force	Objective	Description	Marine domain	Maritime jurisdictional area	How to propose designation	Authority to claim designation	Examples
1	Clearly defined areas	UNCLOS art. 211.6	1994	Prevention, reduction and control of pollution from vessels	Clearly defined areas refer to specific and geographically delimited maritime zones within a State's EEZ where, due to recognized oceanographic and ecological conditions as well as the particular character of vessel traffic, internationally agreed special mandatory measures are required to prevent, reduce, and control pollution from ships. They represent an early legal foundation for what are now understood as area-based management tools (ABMTs) in maritime environmental governance.	Water column surface	The legal basis for adopting special mandatory pollution-control measures under Art. 211(6) applies only within a coastal State's EEZ.	Guidance and assessment standards are developed within MARPOL Annex VI. Proposals must be supported by robust scientific evidence demonstrating special oceanographic and ecological conditions, significant or hazardous shipping traffic, heightened environmental vulnerability, and a clear need for stricter measures than global standards.	A coastal State may propose the designation of a clearly defined area within its EEZ, but the adoption of special mandatory measures requires submission of a scientifically justified proposal to the International Maritime Organization, which evaluates and approves the measure through its competent bodies before it can enter into force.	There are no widely cited maritime zones formally titled "Clearly Defined Areas" – but several IMO-designated areas are considered functional applications of Article 211(6). Examples are Emission Control Areas, (ECAs), MARPOL Special Areas, IMO Particularly Sensitive Sea Areas (PSSAs).
2	Special Areas	Marine Pollution Convention 1973/78 (MARPOL 773/78, as amended)	Annex I (persistent oil) and Annex II (HNS): 1983; Annex IV (sewage): 2003; Annex V	Prevention of pollution from shipping	2.1. MARPOL 73/78, in Annexes I, II and V, defines certain sea areas as Special Areas in relation to the type of pollution covered by each Annex. A Special Area is defined as "a sea area where for recognized technical reasons in relation to its	Water column surface	Territorial Sea, EEZ, high seas. Regional seas plus Antarctica. A Special Area may encompass the maritime zones of several States, or even an entire enclosed or semi-enclosed area.	Guidelines for the designation of Special Areas under MARPOL 73/78 adopted by resolution A.927(22). Resolution A.982(24) revokes annex 2 of resolution A.927(22) Special Area designation should be	Treaty parties (coastal states on demand) within IMO (MEPC). About the procedures for the designation of a special area (3): 3.1 A proposal to designate a given sea area as a Special Area should be submitted to the Marine Environment	Under MARPOL Annex I, several sea areas have been designated as Special Areas where stricter rules apply to the discharge of oil due to their ecological sensitivity and traffic intensity. These include the Baltic Sea, Mediterranean Sea, Black Sea, Persian Gulf, Red Sea, Gulf of Aden, the North Sea

			(garbage): 1988		oceanographic and ecological conditions and to the particular character of its traffic, the adoption of special mandatory methods for the prevention of sea pollution by oil, noxious liquid substances, or garbage, as applicable, is required." Under the Convention, Special Areas are provided with a higher level of protection than other areas of the sea. 2.2			made on the basis of the criteria and characteristics listed in paragraphs 2.3 to 2.6 to avoid the proliferation of such areas.	Protection Committee (MEPC) for its consideration in accordance with the rules adopted by the IMO for submission of papers. 3.2 A proposal to designate a sea area as a Special Area should contain: 1) a draft amendment to MARPOL 73/78 as the formal basis for the designation; and 2) a background document setting forth all the relevant information to explain the need for the designation.	and North-West European Waters, the Oman area of the Arabian Sea, Southern South-African waters, and Antarctic waters. Similarly, under MARPOL Annex V, enhanced restrictions on garbage discharges apply in designated Special Areas such as the Baltic Sea, Black Sea, Mediterranean Sea, Persian Gulf, Red Sea, Wider Caribbean Region (including the Gulf of Mexico), the North Sea, and Antarctic waters, reflecting their heightened vulnerability to marine litter pollution.
3	Emission Control Areas (ECAs)	International Convention for the Prevention of Pollution from Ships MARPOL 73/78, Annex VI (SECA)	2005	Control of air pollution from ships: low air emission zones for Sox, NOx and particles	Emission Control Areas (ECAs) are geographically defined sea areas where stricter controls apply to air emissions from ships than the global standards established under MARPOL Annex VI, adopted by the International Maritime Organization (IMO). ECAs may address sulphur oxides (SECA), nitrogen oxides (NECA), or both, requiring ships operating within these zones to comply with enhanced fuel quality standards or engine emission limits. SECAs limit the sulphur content of fuel oil (currently 0.10%), while NECAs impose stricter Tier III NOx standards for new	Air, water column surface	Regional seas plus Antarctica plus coastal waters plus port areas (internal waters)	The establishment of an ECA requires a scientifically supported proposal in accordance with the criteria and procedures set out in MARPOL Annex VI and related IMO guidelines, demonstrating environmental vulnerability, shipping density, risk assessment, and the need for stricter measures than global standards.	A coastal State or group of States submits the proposal to the International Maritime Organization (IMO), which evaluates it through its technical bodies (notably the Marine Environment Protection Committee) before adoption and entry into force.	Examples of ECAs include the Baltic Sea and North Sea (SECA and NECA), the North American ECA, and the Mediterranean Sea SECA (entered into force in 2025).

					engines installed on vessels operating in the area. These zones function as area-based management tools aimed at reducing air pollution, protecting marine ecosystems, and safeguarding coastal populations.					
4	Areas To Be Avoided (ATBAs)	Established under the International Convention for the Safety of Life at Sea (SOLAS 74), specifically Chapter V (Safety of Navigation). Governed by the IMO's General Provisions on Ships' Routeing (as amended).	1980 (initially SOLAS V/8)	Maritime safety, marine conservation, emergency preparedness and response	Area To Be Avoided (ATBA) is a routing measure adopted to enhance maritime safety and environmental protection by designating a clearly defined sea area that ships, or certain classes of ships, should avoid navigating. Such areas are typically established where navigation poses particular risks due to hazards, environmental sensitivity, high traffic density, or the presence of vulnerable coastal or marine ecosystems.	Water column surface	In the territorial sea, the coastal State has sovereignty (subject to innocent passage). Routing measures are commonly proposed by the coastal State and adopted by the IMO. Ships exercising innocent passage are generally required to respect IMO-adopted routing systems. Territorial sea is a very common location for TSS and ATBAs, particularly near ports, narrow straits, and environmentally sensitive coasts. In the EEZ, the coastal State does not have full sovereignty but may propose routing measures for safety and environmental protection. Once adopted by the IMO, they become internationally recognized and	The designation of an ATBA is guided by the IMO's General Provisions on Ships' Routeing, which require a detailed technical justification including navigational risk assessment, hydrographic conditions, traffic analysis, and environmental considerations, ensuring that the measure improves safety without unnecessarily restricting freedom of navigation. Details can be found in the IMO Resolution A.572(14) "General Provisions on Ships' Routeing" (1985), as amended	IMO MSC: In November 1997, the IMO Assembly adopted resolution A.858(20) by which it delegated to MSC the function of adopting traffic separation schemes, and routeing measures other than traffic separation schemes, including the designation and substitution of archipelagic sea lanes. So, a coastal State, or group of States, submits a proposal to the International Maritime Organization (IMO), which reviews it through its Maritime Safety Committee before formal adoption and international implementation.	Examples of Areas To Be Avoided include routing measures around the Great Barrier Reef (Australia), the Galápagos Archipelago (Ecuador), and certain sensitive areas in the English Channel and off the coast of Florida, where navigation is restricted to reduce risks to shipping safety and fragile marine environments. In the Mediterranean, in the Bocche di Bonifacio area, IMO adopted an Area To Be Avoided applicable to certain categories of ships, particularly those carrying dangerous goods.

							binding under SOLAS. Routing measures in areas beyond national jurisdiction must be adopted exclusively through the IMO. No single State can unilaterally impose them, but States may jointly propose them. Dover Strait TSS extends partly into areas beyond strict territorial seas. Several Atlantic and Pacific routing systems apply in international waters.			
5	Traffic Separation Schemes (TSSs)	Established under the International Convention for the Safety of Life at Sea (SOLAS 74), specifically Chapter V (Safety of Navigation). Governed by the IMO's General Provisions on Ships' Routing (as amended).	1980 (initially SOLAS V/8)	The primary objective of a TSS is to enhance maritime safety by organizing vessel traffic into clearly defined lanes according to direction of travel, thereby reducing the risk of collision, grounding, and navigational congestion in busy or hazardous waters. TSS may also contribute indirectly to environmental	A Traffic Separation Scheme is a routing measure that divides opposing streams of vessel traffic into separate lanes, typically separated by a buffer zone or separation line. Ships are required to follow the appropriate lane corresponding to their direction of navigation, unless specific exceptions apply.			The designation of a TSS must follow the IMO's General Provisions on Ships' Routing, requiring a comprehensive navigational risk assessment, hydrographic analysis, traffic density evaluation (often AIS-based), consultation with affected States, and demonstration that the measure will improve safety without creating disproportionate constraints on navigation. Environmental sensitivity may also be considered where relevant.	A coastal State or group of States submits a detailed proposal to the IMO, which reviews it through the Maritime Safety Committee before formal adoption and international implementation.	Major examples include the Dover Strait TSS (one of the busiest in the world), the Strait of Gibraltar TSS, the Bosphorus Strait routing system, and several Mediterranean schemes such as those in the Strait of Bonifacio and approaches to major ports including Genoa and Barcelona.

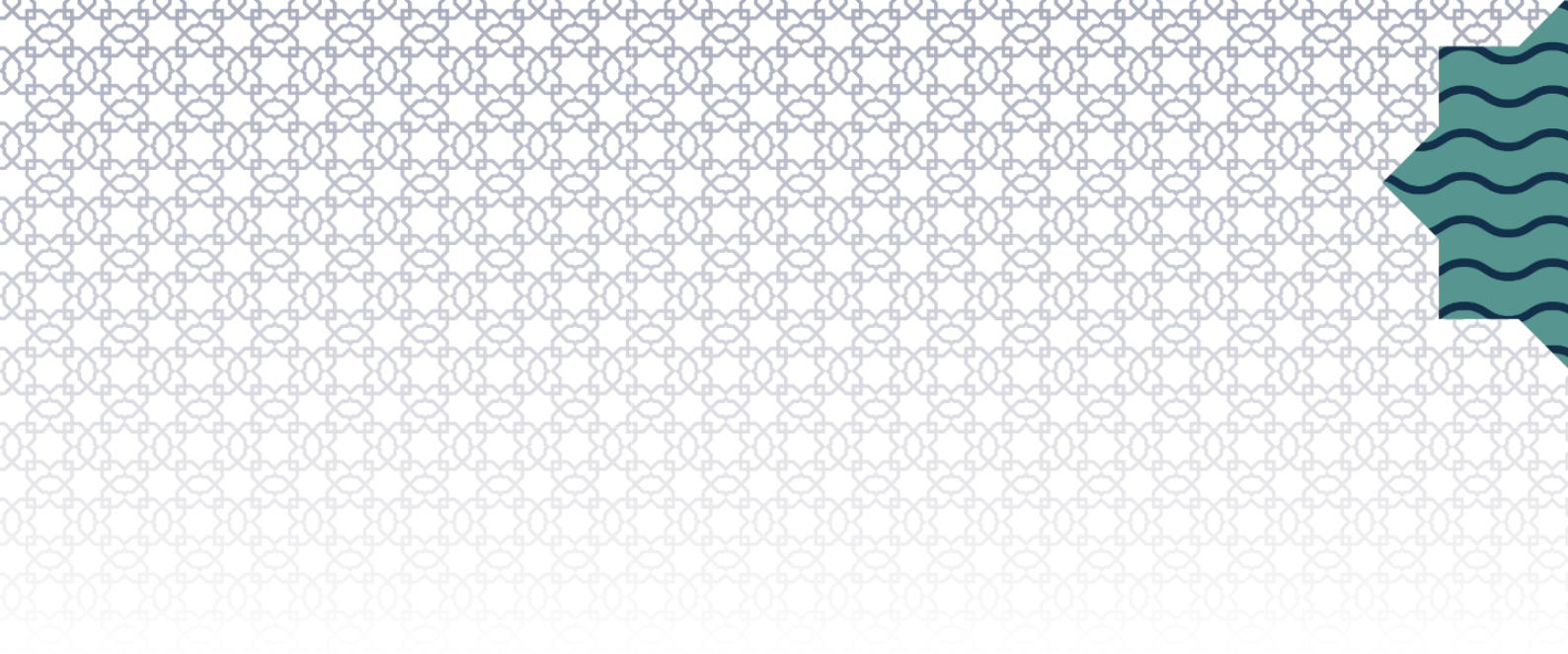
				protection by lowering the probability of maritime accidents.						
6	Fishery Restricted Areas (FRAs)	General Fisheries Commission for the Mediterranean (GFCM) a Regional Fisheries Management Organization operating within the framework of the Food and Agriculture Organization (FAO). Their legal basis derives from the GFCM Agreement and binding recommendations adopted by the Commission pursuant to international law, including the United Nations Convention on the Law of the Sea (UNCLOS) and the FAO Code of Conduct for Responsible Fisheries.	1952 (Council); 2004 (Commission)	The objective of FRAs is to ensure the long-term sustainability of marine living resources by protecting vulnerable ecosystems, essential fish habitats such as spawning and nursery grounds, and overexploited stocks through spatially defined fisheries management restrictions.	A Fisheries Restricted Area is a geographically defined marine zone where specific fishing activities are prohibited, restricted, or regulated, particularly bottom trawling and other gear with significant ecological impact. These areas function as spatial management tools to support stock recovery and ecosystem conservation.	Water column surface and seabed	Territorial sea, continental shelf, EEZ, high seas	The designation of FRAs is based on scientific advice provided by the GFCM Scientific Advisory Committee on Fisheries (SAC), which evaluates ecological vulnerability, the presence of essential fish habitats or vulnerable marine ecosystems (VMEs), fishing pressure, and conservation priorities. Proposals must be supported by spatial data, fisheries impact assessments, and ecological justification, ensuring consistency with ecosystem-based fisheries management principles.	Proposals for Fisheries Restricted Areas are submitted by one or more GFCM Member States and are reviewed and adopted by the General Fisheries Commission for the Mediterranean through binding recommendations. Measures are decided by the Parties which make up the Commission. The Commission has the authority to adopt binding recommendations.	In the Mediterranean and the Black Sea, 1 760 000 km ² of sea habitats are protected by ten FRAs established by the GFCM. This includes one large deep-water FRA (1 730 000 km ²) in which the use of towed dredges and trawl nets in all waters deeper than 1000 metres is banned to protect deep-sea benthic habitats. In addition, examples of GFCM Fisheries Restricted Areas include: - Lophelia Reef FRA (Santa Maria di Leuca, Italy) - established to protect deep-sea coral ecosystems - Strait of Sicily FRA - protecting spawning and nursery grounds of key commercial species - Jabuka/Pomo Pit FRA (Adriatic Sea) - protecting important demersal fish habitats - Gulf of Lion FRA (France) - protecting vulnerable benthic ecosystems



7	Fish Stock Recovery Areas (Biologically Sensitive Areas)	Common Fishery Policy (European waters) Regulation (EU) No. 1380/2013, Art. 8; Recital 22	Last update 2013	The objective of these areas is to protect spawning grounds, nursery areas, and biologically sensitive habitats to support stock recovery and ecosystem conservation	Spatially defined areas where fishing activities may be restricted or prohibited permanently or seasonally to protect vulnerable life stages and habitats	Water column surface and seabed	Primarily EU waters (territorial sea and EEZ of Member States); may also apply to EU vessels beyond EU waters under CFP competence	Designation is based on scientific evidence demonstrating the presence of spawning grounds, nursery areas, or biologically sensitive habitats, supported by advice from scientific bodies such as STECF, and adopted through regional cooperation and CFP procedures.	EU Member States identify candidate areas and submit joint recommendations; the European Commission proposes and adopts measures via delegated or implementing acts, or through multiannual plans	Western Mediterranean nursery areas identified under Regulation (EU) 2019/1022; protection zones for hake (<i>Merluccius merluccius</i>) and deep-water rose shrimp (<i>Parapenaeus longirostris</i>) in Spanish, French, and Italian waters

8	Spatial and Temporal Closures under Technical Measures	Common Fishery Policy (European waters) Regulation (EU) No. 1380/2013, Art. 7; Regulation (EU) 2019/1241 (Technical Measures Regulation)	Last update 2013	The objective of these areas is to protect juveniles, spawning aggregations, endangered species, and marine ecosystems; reduce unwanted catches and ecosystem damage	Defined areas where fishing is restricted or prohibited based on gear type, season, species, or ecosystem protection needs	Water column surface and seabed	EU waters (territorial sea and EEZ); applies to EU vessels globally where CFP rules apply	Establishment relies on scientific and technical evidence identifying vulnerable species, juvenile concentrations, spawning aggregations, or ecosystem risks, ensuring proportional and effective conservation measures.	Member States submit joint recommendations supported by scientific evidence; Commission adopts measures via delegated acts or technical regulations	Seasonal closures protecting demersal species nurseries in the Strait of Sicily, Tyrrhenian Sea, and Gulf of Lion
9	Fisheries Conservation Measures Supporting Natura 2000 Marine Sites	Common Fishery Policy (European waters) Regulation (EU) No. 1380/2013, Art. 11; Habitats Directive 92/43/EEC; Birds Directive 2009/147/EC	Last update 2013	The objective of these areas is to ensure fisheries activities do not compromise conservation objectives of protected habitats and species	Fisheries restrictions applied within Natura 2000 marine sites, including gear bans, spatial closures, and access limitations	Water column surface and seabed	Territorial sea and EEZ of Member States; applicable to EU and non-EU vessels where relevant	Measures must be based on conservation objectives defined under EU environmental legislation and supported by scientific assessment demonstrating that fisheries activities may adversely affect protected habitats or species.	Coastal Member States propose fisheries restrictions necessary to meet conservation obligations; Commission adopts binding measures	Fisheries restrictions in Natura 2000 sites such as the Strait of Sicily cold-water coral areas, Adriatic reef habitats, and Spanish Mediterranean seagrass (<i>Posidonia oceanica</i>) protected areas
10	Emergency Closure Areas	Common Fishery Policy (European waters) Regulation (EU) No. 1380/2013, Arts. 12-13	Last update 2013	The objective of these areas is to provide rapid protection where fish stocks or marine ecosystems face serious and immediate threats	Temporary closures restricting fishing activities to prevent stock collapse or protect ecosystems	Water column surface and seabed	EU Mediterranean waters, primarily the territorial sea and EEZ	Emergency closures require scientific evidence indicating a serious and immediate threat to marine biological resources or ecosystems, justifying urgent spatial restrictions to prevent significant harm.	The European Commission or Member States adopt emergency closures based on scientific evidence	Emergency closures protecting Mediterranean swordfish (<i>Xiphias gladius</i>) juvenile concentrations and vulnerable demersal stocks

11	Spatial Measures within Multiannual Plans (MAPs)	Common Fishery Policy (European waters) Regulation (EU) No. 1380/2013, Art. 9; Regulation (EU) 2019/1022 (Western Mediterranean MAP)	2013, 2019	The objective of these measures is to ensure sustainable exploitation of fisheries resources through long-term ecosystem-based spatial management	Spatial restrictions and closures, integrated into regional fisheries management plans targeting key stocks and ecosystems	Water column surface and seabed	Western Mediterranean Sea (Spain, France, Italy EEZ and territorial waters)	Spatial measures are developed based on scientific advice evaluating stock status, ecosystem interactions, and fisheries impacts, ensuring long-term sustainability under ecosystem-based fisheries management.	Commission proposes MAP; adopted by European Parliament and Council; spatial measures implemented via technical regulations	Western Mediterranean Multiannual Plan protection areas for hake, red mullet, and Norway lobster nurseries
12	Real-Time Closures and Adaptive Spatial Protection Measures	Common Fishery Policy (European waters) Regulation (EU) 2019/1241; CFP regionalisation (Art. 18 Reg. 1380/2013)	2013, 2019	The objective of these areas is to protect juvenile fish concentrations and vulnerable marine ecosystems through adaptive management	Temporary or dynamic closures triggered by scientific monitoring or fisheries data	Water column surface and seabed	EU Mediterranean waters under Member State jurisdiction	These closures are triggered by monitoring data and scientific analysis identifying real-time risks to juvenile fish, vulnerable species, or sensitive habitats, allowing adaptive and precautionary management.	Member States implement closures based on scientific monitoring; the Commission may formalise through delegated acts	Temporary closures in Italian, Spanish, and French Mediterranean waters protecting juvenile demersal fish populations



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