



Work package 4: Socio-ecological management framework for MPAs and MSP integration

D4.2: Guideline for the strategic and spatial measures for the nature-inclusive operation of blue



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Grant Agreement number	101060707
Project title	MSP4BIO: IMPROVED SCIENCE-BASED MARITIME SPATIAL PLANNING TO SAFEGUARD AND RESTORE BIODIVERSITY IN A COHERENT EUROPEAN MPA NETWORK
Deliverable title	Guideline for the strategic and spatial measures for the nature-inclusive operation of blue economy sectors – ESE 3
Deliverable number	4.2
Deliverable version	Final
Contractual date of delivery	31 January 2024
Actual date of delivery	31 August 2024
Document status	Final
Document version	2
Online access	Yes
Diffusion	Public
Nature of deliverable	Report
Work Package	4
Partner responsible	University of Cadiz (UCA)
Contributing Partners	CCMS, WWF MED, CNR, s.Pro, UAc, GMU, CORPI, CEREMA, UNANTES, NIMRD
Author(s)	Camila Pegorelli, Silvia Rayo Luego, Javier Garcia Sanabria, Javier Garcia Onetti, Maria de Andres, Ivana Stojanovic
Editor	Margarita Stancheva (CCMS), Mauro Randone (WWF MMI)
Approved by	Ivana Stojanovic, s.Pro
Project Officer	Victoria Beaz Hidalgo
Abstract	As the blue economy continues to expand, the inevitable interactions between various sectors and Marine Protected Areas (MPAs), especially in coastal zones, pose challenges to the delicate balance of critical ecosystems. This report aims to provide a comprehensive set of recommendations tailored for the five primary blue economy sectors addressed in the MSP4BIO project – aquaculture, fisheries,



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Keywords

marine non-living resources, renewable energy, and tourism. These recommendations are strategically crafted to facilitate a sustainable and resilient transition, ensuring the vitality and well-being of the blue environment.

Specifically, the report proposes to assess the sectorial impact of its activities on ecosystem services, recognizing the critical importance of understanding and mitigating potential adverse effects. Additionally, a non-exhaustive list of good management practices is presented for each of the five blue economy sectors. These practices serve as a guide to fostering responsible and sustainable practices that support both economic interests and environmental conservation.

Blue Economy Sectors; Ecosystem Services; Marine Spatial Planning; Marine Protected Area; Sankey Chart

HISTORY OF CHANGES

VERSION	PUBLICATION DATE	CHANGE
1.0	31.01.2023	Initial version.
2.0	31.08.2024	Revised version: modified after comments from the reviewers. The title was updated to explicitly include D4.2 as part of ESE 3. Additionally, Figure 2 was corrected to remove references to ESE 4, and a more accurate depiction from D5.2 was incorporated, with cross-references added for clarity. The text has also been revised to better explain the connections between ESE 2 and ESE 3 within the framework. Furthermore, the section previously titled 'Recommendations for the Use of Deliverables 4.1 and 4.2 in the ESE Framework' has been updated to reflect its new title, 'Incorporating D4.1 (ESE 2) and D4.2 (ESE 3) into the ESE Framework – MSP4BIO Project,' ensuring consistency throughout the document. The observation related to mineral extraction on the sectorial sheet of marine non-living resources now is found in the sector characteristics.



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Acknowledgments

The authors would like to thank all the contributors to the Guideline for the strategic and spatial measures for the nature-inclusive operation of blue economy sectors, who provided important inputs for the finalization of a comprehensive and valuable guideline for Marine Protected Area managers and blue economy stakeholders. Special thanks to: Martina Bocci, Ivana Lukic, Frederick Bruce, Stefano Menegon, Debora Gutierrez, Margarita Stancheva and Mauro Randone.

Our gratitude is extended to the Multi-frame project: Assessment Framework for successful development of viable ocean multi-use systems, which provided insights from its Draft Ocean Multi-Use Toolkit and enriched this guidelines with multi-use good management practices.



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Table of contents

Acknowledgments	4
List of Figures	6
List of Tables	6
Acronyms	7
Executive Summary.....	9
1. Introduction.....	10
2. Methodology	13
3. Results and Discussion.....	21
3.1. Activities by each sector	21
3.2. Pressures and Impacts	22
3.3. Ecosystem services – Multi-criteria analysis	36
3.4. Sectorial Sheets (Good management practices and Sankey Chart)	41
3.4.1. Sankey Charts by sector	41
3.4.2. Good management practices and sectorial sheets	42
3.4.3. Fishery Sectorial Sheet.....	46
3.4.4. Tourism Sectorial Sheet.....	49
3.4.5. Aquaculture Sectorial Sheet	52
3.4.6. Marine non-living resources extraction Sectorial Sheet.....	54
3.4.7. Renewables Sectorial Sheet.....	56
4. Conclusion and recommendations	59
5. Bibliography.....	63
ANNEX I: List of countries that support a ban, moratorium or precautionary pause on deep sea mining.....	67
ANNEX II – Positive and negative impact on ecosystem services by maritime activity.....	68
ANNEX III – Maritime activities pressures on the marine environment and their potential ecosystem service impacted.....	71
ANNEX IV: ESE modules and their integration in the ESE management framework (named as “ESE Model” in the figure).....	89



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



List of Figures

Figure 1: Diagram showing the step-by-step methodology used in this work.	14
Figure 2: The diagram illustrates connection between ESE 2 (4.1. Socioeconomic and governance criteria) and ESE 3 (4.2. Blue economy sector orientations) to the overall ESE Framework of the MSP4BIO Project in the context of Ecosystem Services.	62

List of Tables

Table 1: Sectors by test sites according to MSP4BIO project (www.msp4bio.eu)....	14
Table 2: Pressures and associated impacts according to the MSFD	15
<i>Table 3: Symbology associated with the good practices for their classification.....</i>	18
Table 4: New nomenclature for CICES Group Ecosystem Services	20
<i>Table 5: Selected activities corresponding to each blue economy sector.....</i>	21
<i>Table 6: Fishery: Activities, pressures and impacts on ecosystems for the fisheries sector</i>	23
Table 7: Marine non-living resources: Activities, pressures and impacts on ecosystems for the Marine non-living resources sector	25
Table 8: Renewable energy: Activities, pressures and impacts on ecosystems for the renewable energy sector.....	29
Table 9: Aquaculture: Activities, pressures and impacts on ecosystems for the aquaculture sector	31
Table 10: Tourism: Activities, pressures and impacts on ecosystems for the tourism sector	34
Table 11: Pressure and ecosystem services matrix by sector. Where, the red number is related to the ten most impacted ecosystem services by each sector. And the blue number are those ecosystem services that have a positive impact due to a sector operation	38
<i>Table 12: The Ten Most Impacted Ecosystem Services by Sector and Cumulative Impact. Legend: Abbreviations: CI - Cumulative Impact; F - Fishery; NLMR - Marine non-living resources; R - Renewable; T - Tourism; A - Aquaculture</i>	40



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Acronyms

ACCOBAMS_CCH	Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area - Cetaceans Critical Habitats
ALDFG	Abandoned, lost, or otherwise discarded fishing gear
AZOR	Azores
BlackSeaC	Black Sea Commission
CBD	Convention on Biological Diversity
CICES	Common International Classification of Ecosystem Services
CoP	Community of Practice
EB-MSP	Ecosystem-based Marine Spatial Planning
EBM	Ecosystem-based Management
EBSAs	Ecologically or Biologically Important Marine Areas
EC-CINEA	European Commission - Climate, Infrastructure and Environment Executive Agency
EEA	European Environment Agency
EU	European Union
FAO	Food and Agriculture Organization
FADs	Fish Aggregating Devices
GBRMP	Great Barrier Reef Marine Park
HELCOM	Helsinki Commission for the Marine Environmental Protection of the Baltic Sea
IGO	Intergovernmental Organization
IMMAs	Important Marine Mammal Areas
IMO	International Maritime Organization
IMO - PSSAs	International Maritime Organization - Particularly Sensitive Sea Areas
IOC	Intergovernmental Oceanographic Commission
MPA	Marine Protected Area
MSFD	Marine Strategy Framework Directive
MSP	Maritime Spatial Planning
MSPD	Marine Spatial Planning Directive
NGO	Non-Governmental Organization
NW-Med	North-West - Mediterranean
OECMs	Other Effective Conservation Measures



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
REPCET tool	Real time plotting of cetaceans
SCI	Site of Community Importance
SER	Society for Ecological Restoration
SPA/RAC	Regional Activity Centre for Specially Protected Areas
UCA	University of Cadiz
IUCN	International Union for Conservation of Nature
UK	United Kingdom
UNCLOS	United Nations Convention on the Law of the Sea
UNESCO	United Nations Educational Scientific and Cultural Organization
WCPA	World Commission on Protected Areas
WFD	Water Framework Directive
WWF	World Wide Fund for Nature



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Executive Summary

Focused on the MSP4BIO project's core sectors – aquaculture, fisheries, marine non-living resources extraction, renewable energy, and tourism – this report delineates the impact flow on ecosystem services of sustainable sectoral development. The report emphasizes a non-exhaustive list of effective management practices tailored to each sector aiming at the operationalization of the sector inside or near marine protected areas.

Central to the recommendations is the imperative to mitigate negative impacts, minimize ecological damage, and foster synergies among different sectors, activities and environment. The highlighted practices showcase actions that embody a balanced and sustainable approach to the blue economy. Notably, these strategies consider the unique socio-ecological system of the areas where they are implemented, ensuring a harmonious coexistence between human activities and the conservation of marine ecosystems. These practices serve as a guide to fostering responsible and sustainable practices that support both economic interests and environmental conservation. Moreover, to enhance the accessibility and utility of this report's findings in spatial planning discussions, particularly in the context of Marine Spatial Planning (MSP) and Marine Protected Areas (MPA), a sectorial sheet for each sector was developed. Each sectorial sheet includes crucial information such as essential sector characteristics, a detailed list of sector-specific activities, a Sankey diagram to visualize sectors, pressures, and impacted ES hierarchically, and brief insights into exemplary management practices. The preliminary outcomes of this research will be integrated into the ESE Framework of the MSP4BIO project. More specifically, it supports the other tasks of the MSP4BIO project as Task 4.3. "Participatory development of the integrated trade-offs scenarios"; Task 4.4. "MPAs and MSP Ecological-Socio-Economic integrated management framework".



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



1. Introduction

Numerous initiatives have emerged within the blue economy, aiming to harness the untapped potential of the ocean's resources. Despite these efforts, the lack of effective governance, strategic planning, and a comprehensive understanding of ecosystem impacts has resulted in competition for services and space among various uses and activities. This, in turn, has led to conflicts between users and contributed to the degradation of marine ecosystems.

In addition to supporting traditional and emerging maritime industries such as fisheries, marine non-living resources, renewable energy, tourism, among others, the ocean's ecosystem services play a crucial role in regulating air quality, mitigating the impacts of climate change and have a fundamental role in securing the wellbeing of coastal communities. However, the combined effects of human coastal and maritime activities often result in cumulative impacts on marine ecosystems, a facet that is very often inadequately addressed in the planning and management of these activities.

As Zupan et al. (2018) pointed out, Marine Protected Areas (MPAs) represent the most common approach used to mitigate human impacts on marine ecosystems (Lubchenco and Grorud-Colvert, 2015; Lubchenco et al., 2003) and are being increasingly used worldwide both for conservation and some sectors management (Boonzaier and Pauly, 2015).

The escalating anthropogenic threats pose a significant risk to ocean health, and the increasing congestion of ocean space exacerbates conflicts among various activities inside and outside MPA. Recognizing this challenge and in an attempt to deliver holistic management of uses and activities happening in the marine realm, Marine Spatial Planning (MSP) has emerged as a vital approach to balance economic drivers, preventing activities from exceeding environmentally sustainable thresholds and jeopardizing the ocean's capacity to maintain the ecosystem services it provides.

The relationship between MSP and MPAs is strong but not always explicitly recognized (Trouillet and Jay, 2021). MPAs are one of the tools that can be used to achieve conservation objectives within MSP. The allocation of space within MSP can be used to identify areas that are suitable for protection as MPAs. In this way, MSP can help ensure that MPAs are designated in areas where they will be most effective in achieving conservation objectives. MSP's area designations such as high nature value areas can enhance nature conservation also outside of formal MPAs (Vaughan and Agardy, 2020).

Ocean's benefits reach people through the flow of Ecosystem Services (ES) to cover societal demand in a given area. It is crucial to assess, quantify, and map these flows



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



within marine and coastal social-ecological systems (SES) to underpin the sustainable utilization of ocean resources (Chalkiadakis et al., 2022).

Any human activity that impacts ecosystems has the potential to impact ecosystem services in multiple ways. In addition to impacts on the biophysical production of services, human activities and infrastructure can also undermine the “consumption” of ecosystem services (Mulazzani & Malorgio, 2017). That is, human activity can undermine people’s ability to access or enjoy an ecosystem service, for example, the exclusion zones of wind farms across key fishing areas can impact the viability traditional, recreational and commercial fishing to access the ecosystem service, which is related not only to provision but also cultural types of ecosystem service. The role of impacts to the production versus the consumption of ecosystem services is largely unexplored in the literature (Singh et al., 2020).

Ecosystem Services (ES) are widely utilized by scientists and policymakers to underscore the fundamental role of the environment in sustaining human livelihoods (La Notte et al., 2017). The identification of various ES offers valuable insights for prospective management strategies at regional and local scales (Andrés et al., 2023). A defining characteristic is their status as end products of an ecosystem, maintaining connectivity to the underlying structures and processes (pressures and impacts) while directly contributing to a tangible product or condition of value to human welfare (Potschin & Haines-Young, 2016).

Recognizing the imperative to integrate socio-economic and environmental dimensions within the realms of environmental accounting, mapping, or ES assessment, a need arises for standardization in ES description. Addressing this, the Common International Classification of Ecosystem Services (CICES) was established, drawing upon the groundwork laid by the European Environmental Agency (EEA) in environmental accounting (Haines-Young & Potschin, 2010).

Considering the growth of the blue economy¹ sectors, it is unavoidable that significant interactions will occur with MPAs and other area-based conservation measures, particularly in coastal zones, where most of the activities are concentrated, coinciding with critical ecosystems. This report seeks to offer a non-exhaustive list of key recommendations tailored for the five most relevant blue economy sectors selected to be worked with in the MSP4BIO project – aquaculture, fisheries, marine non-living resources², renewable energy and tourism. These recommendations are designed to

¹ Blue Economy encompasses all sectoral and cross-sectoral economic activities based on or related to the oceans, seas and coasts. (European Commission, 2022).

² Although the Grant Agreement of the MSP4BIO project used the term mineral extraction, this report uses the term marine non-living resources to be in line with the EU Blue Economy Reports (e.g., European Commission, 2023).



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



guide the transition towards a socio-ecological system that is both sustainable and resilient, ensuring the health and vitality of the blue environment.

More specifically:

- i. Present an approach to assess the sectorial impact on the ecosystem services;
- ii. Present a list of good management practices for the five blue economy sectors within MPA;
- iii. Propose an expert multi-criteria analysis to main criteria for uses management in MPAs.

According to the Grant Agreement, this task originally encompassed a fourth objective related to receiving, analyzing, and incorporating the results from the trade-off scenario application in the test sites (Task 4.3). However, it is crucial to note that the deliverable associated with the trade-off scenario has a due date set for March 2024, whereas the current deliverable is expected in January. Consequently, it is impossible to incorporate the results of deliverable 4.3 into this document given the timeline misalignment.



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



2. Methodology

To achieve the objectives of this work, the methodology below described is an adaptation of the of DAPSI(W)R (Driver – Activities – Pressure – Change of State – Impact (on Societal Welfare) – Response) (Elliott et al., 2017), which is the latest conceptual advances of the well-established framework DPSIR (Driver, Pressure, State, Impact, Response) (EEA, 1998), an approach that has long been a valuable problem-structuring framework used to assess the causes, consequences and responses to change in a holistic way of the environment. The DAPSI(W)R(M) framework, as an adaptation of DPSIR, integrates societal welfare (ecosystem services) more explicitly into the analysis, being a better framework to base the development of the present work.

The DAPSI(W)R(M) model is used taken into consideration some adaptations for better fit to the proposal of this work. For example, the initial step involving **Drivers (D)**, that are linked to fundamental human needs, such as the need for sustenance, has been omitted, and the Sectors (Step 1) have been prioritised at the forefront of the model. Since this work falls within a European framework, the Activities (Step 1) chosen from each sector are those that occur in European waters or that have been discussed by its member States (e.g., deep sea mining).

In the model, **Impacts** are defined as effects on human welfare. However, in this methodology, they are connected to the **Pressures** (Step 2) exerted by the activities. The **State of change** of the environment and the Impacts on human welfare are presented here in Step 3 with the identification of potential ES impacted. Finally, the Responses (as Measures) R(M) is presented in this work as **Good Management Practices** (GMP) (Step 5). GMPs are examples of measures implemented inside MPAs, or that could be used in MPA management or EB-MSP. Different from what is proposed by Elliott et al. (2017), GMPs are not directly linked to specific pressures or impacts and does not follow the 10-tenets approach for adaptive management and sustainability (Barnard and Elliott, 2015) but are presented in a more activity-oriented manner based in practices and measures already implemented in different regions.

A step-by-step approach of the methodology is presented in Figure 1.



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

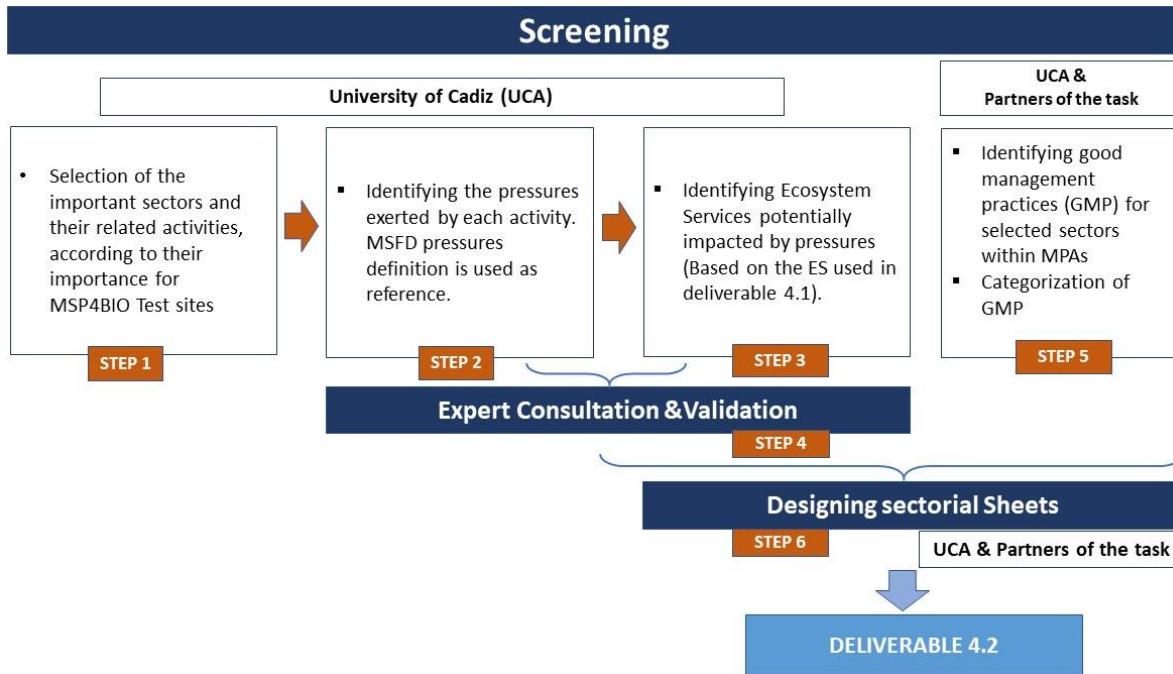


Figure 1: Diagram showing the step-by-step methodology used in this work.

Step 1. Selection of Sectors and related Activities

In the submission phase of the MSP4BIO project, Test Site Leaders were queried about the primary sectors—those deemed most significant—for the testing areas involved in the project. The sectors they identified as most crucial were subsequently selected for 4.2., namely, aquaculture, fisheries, marine non-living resources, renewable energy and tourism. The following steps presented in this report are based on them. Table 1 shows the sectors selected by each test site to put focus on.

Table 1: Sectors by test sites according to MSP4BIO project (www.msp4bio.eu)

Regions	Sectors
NW-MED	Fisheries, aquaculture, tourism and renewable energy
ATLANTIC 1 (Cádiz)	Fisheries, aquaculture and tourism
ATLANTIC 2 (Azores)	Fisheries and tourism
BLACK SEA	Fisheries and tourism
NORTH SEA	Aquaculture, fisheries, marine non-living resources, renewable energy and tourism
BALTIC SEA	Aquaculture, fisheries, marine non-living resources, renewable energy and tourism.

In the specific context of this report's methodology, which is identifying the pressures and impacts on ES related to each sector, it is crucial to identify various activities due to their intricate nature, since inside each sector different activities can lead to diverse ecological pressures and impacts (Elliot et al, 2017).



Step 2. Defining Pressures and Impacts of the Blue Economy Sectors

After defining the sectors and their related activities, a literature review has been carried out to identify their pressures and impacts on the marine and coastal environment.

To ensure consistency in pressure assessment and to address concerns related to data aggregation, facilitating the graphical representation of results, the analysis was framed using the pressures and impacts set up by the MSFD. While the directive does not provide specific definitions for each pressure, it presents eight distinct pressures with illustrative impact examples (Table 2). Using this reference, a categorization of impacts identified in the literature review was performed.

Table 2: Pressures and associated impacts according to the MSFD

Physical loss	Smothering (e.g. by man-made structures, disposal of dredge spoil), Sealing (e.g. by permanent constructions).
Physical damage	Changes in siltation (e.g. by outfalls, increased run-off, dredging/disposal of dredge spoil), abrasion (e.g. impact on the seabed of commercial fishing, boating, anchoring), selective extraction (e.g. exploration and exploitation of living and non-living resources on seabed and subsoil).
Other physical disturbance	Underwater noise (e.g. from shipping, underwater acoustic equipment), marine litter.
Interference with hydrological processes	Significant changes in thermal regime (e.g. by outfalls from power stations), significant changes in salinity regime (e.g. by constructions impeding water movements, water abstraction).
Contamination by hazardous substances	Introduction of synthetic compounds (e.g. priority substances under Directive 2000/60/EC which are relevant for the marine environment such as pesticides, antifoulants, pharmaceuticals, resulting, for example, from losses from diffuse sources, pollution by ships, atmospheric deposition, and biologically active substances), introduction of non-synthetic substances and compounds (e.g. heavy metals, hydrocarbons, resulting, for example, from pollution by ships and oil, gas and mineral exploration and exploitation, atmospheric deposition, riverine inputs), introduction of radio-nuclides.
Systematic and/or intentional release of substances	Introduction of other substances, whether solid, liquid or gas, in marine waters, resulting from their systematic and/or intentional release into the marine environment, as permitted in accordance with other Community legislation and/or international conventions.



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Nutrient and organic matter enrichment	Inputs of fertilisers and other nitrogen and phosphorus-rich substances (e.g. from point and diffuse sources, including agriculture, aquaculture, atmospheric deposition), inputs of organic matter (e.g. sewers, mariculture, riverine inputs).
Biological disturbance	Introduction of microbial pathogens, introduction of non-indigenous species and translocations, selective extraction of species, including incidental non-target catches (e.g. by commercial and recreational fishing).

It is important to mention that the selection criteria for pressures and impacts excluded those not considered as primary impact to the specific activities under assessment. This entailed disregarding external factors, such as oil spills from fishing vessels or environmental impacts generated by the port where the fisheries catch is unloaded, as well as issues related to mass tourism, which lie outside the scope of the primary activity.

Step 3. Identifying Ecosystem Services

In alignment with the MSP4BIO Task 4.1 methodology (Pegorelli et al., 2023), the CICES 5.1 group classification was adopted to characterize the Ecosystem Services (ES) influenced by each activity. Also, the ES of CICES 5.1 group are those related to marine environment. This involved considering pressures specific to activities and establishing a correlation between them and the ES affected. To avoid misinterpretation of the pressures that can be the same for different activities but affect the service in a different way, the following criteria were considered:

- Type of pressure according to MSFD (Step 2);
- Type of impact according to literature review (Step 2);
- Typology of the activity (Step 1).

Step 4 – Expert Consultation

The expert consultation was carried out in both Step 2 and Step 3 to standardize pressures, impacts, ecosystem services to relate sectors-activities-pressures with their interaction with ecosystem services. To do so two approaches were taken.

- **Validation of preliminary results of pressures and activities:** Experts from MSP4BIO project were asked to validate the first findings and categorizations performed related to impact, pressures, activities, and sectors. Impacts not identified in the literature review were added for a more comprehensive result;
- **Multi-criteria analysis** was performed by them to validate and qualify the type of impact on the ecosystem services.
 - The aim is to consider both the negative and positive impacts of activities on ES. However, the current definitions of pressures are biased towards negative ACTIVITY-ECOSYSTEM SERVICE relationships. To counteract this issue, a broader and more neutral tone was used to



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



interpret the Directive's definitions, encompassing possible positive interactions.

- In that matrix, cross-referencing the SECTOR-ACTIVITY-PRESSURE relationship with ECOSYSTEM SERVICES, indicating with a number -1 if it negatively impacts or +1 if it positively impacts. Only significant, direct, and clear interactions were considered:
 - An impact is considered positive if the normal operation of an activity generating that interaction with the environment (pressure) causes the supply of that service to increase. For example, when fishing extracts living resources (biological disturbance), it leads to a decrease in the ecosystem's ability to provide a flow of wild animals for food and other uses. In contrast, the normal activity of aquaculture results in an increase in the flow of the service of cultivated aquatic animals for food.

Step 5. Identifying GMP for each sector/activity

With the aim of formulating a repository of Good Management Practices (GMP) for the blue economy sectors and activities, a comprehensive literature review was undertaken. The selection criteria for primary sources on GMP examples involved technical reports and scientific publications directly relevant to the sectors and activities delineated in STEP 1. The criteria were irrespective of geographical location, emphasizing examples at a global scale. Additionally, preference was given to sources featuring implemented examples with demonstrable positive outcomes, steering clear of theoretical models yet to be put into practice.

To do so, the research considered as scope marine spatial planning and marine protected areas which are the focus of MSP4BIO project. First, a general worldwide search on pressures and impacts of activities has been done. Later, a systematic organization of the acquired information into tables was undertaken. This structure facilitates comprehensibility and ensures ease of incorporation of any subsequent information. Additionally, the collected information underwent thorough revision with test site leaders to identify and incorporate any additional good practices for effective management. This collaborative effort aimed to enhance the comprehensiveness of the table of good management practices by sector.

Categorization of Good Management Practices

To allow a better understanding of the good practices described and, mainly, to be able to select those corresponding to each specific management process, the good practices are classified according to the following criteria (see Table 3 below):

1. Scope of action



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



This indicates whether the good practice is carried out within the framework of an MSP or an MPA process. For this purpose, circles are used to mark those good practices related to the MSP and triangles are used to mark those related to the MPA.

2. Focus of the good practice

This criterion is used to classify good practices according to the main purpose of the good practice. To this end, good practices are classified according to whether they are oriented towards the socio-ecosystem (green), the activities (blue) or the management process itself (purple).

- Towards the socio-ecosystem: good practices where specific reference is made to the conservation or management of the natural ecosystem or any of its elements (i.e. recovery/restoration/conservation measures). It also includes those focused on socio-cultural aspects of the sector.
- Towards the activity: good practices in which specific reference is made to aspects of the activity or sector. These are good practices focused on generating responses to the activity and its pressure. They can be divided into two sub-types:
 - o The good practice is focused on decreasing the activity or its volume.
 - o The good practice is focused on changing the way or the mechanisms in which the activity is carried out.
- Towards the management: good practices that address one of the stages of the sector management process, MSP or MPA.

With these criteria, the good practices presented in the sectorial sheets are accompanied by the symbology outlined in the Table 3:

Table 3: Symbology associated with the good practices for their classification

Focus \ Scope	MSP	MPA
Oriented to the socio-ecosystem	●	▲
Oriented to the development of the activity	○	△
Oriented towards limiting the activity	●	▲



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Oriented to the management process		
------------------------------------	--	--

STEP 6 - Sectorial Sheets

Aiming to make the results of this report more accessible and useful in the discussion of spatial planning and area-based approaches (MSP and MPA), based on an overall overview of potential impacts blue sector (STEP 2) on the marine environment and its ecosystem services (STEP 3) as well as some good management practices (STEP 5) at global level, a sectorial sheet was designed. These concise documents encapsulate fundamental aspects of each sector, encompassing essential characteristics, the associated ecosystem services, a comprehensive list of sector-specific activities, the sector's Sankey diagram (better explained below) accompanied by a brief elucidation and exemplifications of good management practices. This format serves as an efficient and accessible way to communicate key insights and findings for each sector examined in the study. A guideline to use the sectorial sheets are presented in the recommendation section (add the number and hyperlink to the section).

a. Sankey diagram

To visualize categorical data effectively, the 'datavis' diagram, a hybrid form derived from the Sankey diagram initially proposed by Sankey in 1898 (as cited by Schmidt, 2008 (Schmidt, 2008), was employed (Lupton & Allwood 2017). This visualization method organizes dimensions with numerous categories hierarchically, aligning with sectors, pressures, and impacted ES. Taking advantage of these hierarchical structures in visualization proves highly beneficial for end-users, offering a natural means to aggregate and abstract data (Kosara et al., 2006). The implementation of these principles, aimed at enhancing user comprehension, was executed through R Studio to create a straightforward and easily interpretable Sankey graph encapsulating the comprehensive dataset generated in this study.

Considering that 22 Ecosystem Services (CICES group) are being analyzed, and displaying all of them in the same figure would make any interpretation more difficult, some adjustments were considered to facilitate the visualization of the final result, specifically:

- i) Only the 10th lowest-scored Ecosystem Services by sector were considered, in other words, the ecosystem services which are under more pressure by a sector is presented in the final Sankey Chart.
- ii) Ecosystem services nomenclature: a renaming process was implemented when needed, as demonstrated in Table 4. This adjustment aims to enhance



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



comprehensibility for a diverse readership, aligning with the objective for this work to function as a practical tool for the needs of different stakeholders.

Table 4: New nomenclature for CICES Group Ecosystem Services

ES Section	ES Group CICES V5.1	Adapted ES Group nomenclature
Regulation & Maintenance	Lifecycle maintenance, habitat and gene pool protection	Nursery and habitat maintenance
Regulation & Maintenance	Maintenance of physical, chemical, abiotic conditions	Maintenance of physical, chemical, abiotic conditions
Regulation & Maintenance	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Mediation of wastes
Regulation & Maintenance	Water conditions	Water conditions
Regulation & Maintenance	Mediation of nuisances of anthropogenic origin	Mediation of anthropogenic nuisances
Regulation & Maintenance	Regulation of soil quality	Regulation of soil quality
Provisioning	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Wild aquatic animals
Provisioning	Genetic material (from plants, algae or fungi, animals and other organisms)	Genetic material
Provisioning	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Wild aquatic plants/algae
Provisioning	Mineral substances used for nutrition, materials or energy	Mineral substances used for nutrition, materials or energy
Provisioning	Reared aquatic animals for nutrition, materials or energy	Farmed aquatic animals
Cultural	Intellectual and representative interactions with environment (abiotic and natural)	Intellectual and representative interactions with environment
Cultural	Other biotic characteristics that have a non-use value	Environmental conservation for future generations
Cultural	Physical and experiential interactions with the environment (abiotic e.g., caves, Natural e.g. whales)	Physical and experiential interactions with the environment



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



3. Results and Discussion

In the interest of crafting a more concise report and emphasizing the principal findings of this research, the results and discussion will be jointly presented in the following subsections: **3.1. Activities by Each Sector**: this subsection, connected to STEP 1, offers a brief overview of the sectors and activities used in the development of this work; **3.2. Pressures and Impacts**: aligned with STEP 2 and STEP 4 (validation process), this subsection establishes connections among sectors, activities, pressures, and impacts; **3.3. Ecosystem Services - Multi-criteria Analysis**: corresponding to STEP 3 and STEP 4 (multi-criteria analysis process), this subsection delves into the relationship between pressures/impacts and their effects on ecosystem services; and **3.4. Sectorial Sheets - Good Management Practices and Sankey Chart**: Tied to STEP 5 and STEP 6, this subsection showcases sectorial sheets for each sector, synthesizing information, including recommended good management practices and Sankey charts illustrating the socio-ecosystem flow for each sector.

3.1. Activities by each sector

The activities selected for each of the five MSP4BIO sectors to develop the STEP (1,2, 3 and 4) presented on the methodology section are those presented on table 5.

Table 5: Selected activities corresponding to each blue economy sector

Sector	Activities
Fisheries	Trawling, gillnetting, purse seine, longline, pots and traps, trammel net, drift netting, dredges, push and stow
Aquaculture	Aquaculture in coastal or intertidal zones, aquaculture at sea (hatcheries, floating cages, and rafts)
Renewables	Wind farms, tidal ocean energy, wave ocean energy
Extraction of marine non-living resources	Deep-sea mining ³ , dredging, offshore oil and gas
Tourism	Diving, sailing vessels, yacht and motorboats (motor vessels), sport fishing, whale-watching, cruise

³ It is important to highlight this activity rises many concerns among the governments, environmentalist, and researchers due to the lack of knowledge of the impacts it can cause in the marine environment. Many countries have taken measures to stop the development of this activity supporting a ban, moratorium or precautionary pause on deep sea mining (Annex 1).



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



3.2. Pressures and Impacts

The creation of the impact list was guided by a primary focus on the main impact of each activity. Recognizing the inherent variability of secondary impacts based on location (Price et al., 2015), this approach allowed for a nuanced understanding of the diverse ecological consequences associated with each sector.

Having this in mind, the assessment of the main impacts on the marine ecosystem commenced with the activities outlined in Table 5. To thoroughly understand these impacts, a comprehensive literature review was undertaken. This review, conducted with the collaboration of MSP4BIO experts, not only to validate the findings but also to facilitate the categorization of each impact based on the pressures outlined in the MSFD for each respective sector.

These detailed categorizations are systematically presented in sector-specific tables: Tables 6 (Fishery), 7 (Marine non-living resources), 8 (Renewable Energy), 9 (Aquaculture), and 10 (Tourism). Notably, in instances where potential impacts were not initially identified during the literature review, experts adeptly filled these gaps, ensuring a comprehensive overview.

It is crucial to note that the impact analysis of Aquaculture, including the final results and subsequent sectorial analysis (ecosystem services affected and Sankey chart), had to be adapted. Unlike the other sectors, where clear information was available on activities and their impacts on the marine ecosystem, limited materials were available for aquaculture. To address this limitation, a zone approach was taken based on the literature found, dividing the impacts and pressures on Aquaculture into coastal or intertidal zones and Aquaculture at sea (hatcheries, floating cages, and rafts), the final result is presented on Subsection 3.4.5.

When assessing this material and the final results (Sectorial Sheets), it's crucial to consider that although the nature of the pressure is the same across sectors, the environmental impact varies. For instance, in fisheries (Table 6), the impacts of the Biological Disturbance of trawling include changes in species composition, reduction in habitat complexity, habitat destruction by scraping and ploughing, significant reductions in abundance, biomass, species diversity, body size, and productivity caused by overfishing. On the other hand, the Biological Disturbance of Wind Farms leads to collisions as migration barriers for birds and marine mammals, behavioral changes such as displacement from foraging or reproductive areas for fish, birds, and marine mammals, disruption of communication abilities, decreased fish stock from a loss of food sources, and alterations in productivity and composition leading to fishery cessation and displacement and a decrease in biological diversity, among other effects.



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Table 6: Fishery: Activities, pressures and impacts on ecosystems for the fisheries sector

Activities	Pressures	Impacts on ecosystems	Information source
Trawling	Physical damage	Modification of the sediment texture (grain size)	Eigaard, O.R. et al. (2016); McConaughey, R. A. et al. (2020); Jones, J. B. (1992)
		Modification of presence and nature of bedforms	
		Reduction in light levels on sediment and smothered benthos caused by sediment resuspension	
		Habitat destruction by scraping and ploughing	
		Mortality of benthic invertebrates	
		Creation of anaerobic turbid conditions that can lead to the dead of organisms due to vertical redistribution of sediment layers	
	Biological disturbance	Changes in the species composition	
		Reduction in habitat complexity	
		Habitat destruction by scraping and ploughing	
		Significant reductions in abundance, biomass, species diversity, body size and productivity caused by overfishing	
	Other physical disturbance	Underwater noise from both the dredger and the ship	Expert input
Gillnetting	Biological disturbance	Overfishing. Fishing down the food web	Silvano, R. A. et al. (2017); Lyle, J. M., & Tracey, S. R. (2016); Shester, G. G., & Micheli, F. (2011)
		Biodiversity loss caused by by-catch of juvenile commercial fish or endangered species of megafauna (cetaceans, turtles, seals)	
		Increase the conflict and negative interactions between fishers and aquatic predators (sea lions and dolphins) due to small mesh size of gillnet	
		Entanglement of cetaceans, turtles, seals. Injuries and death to non-targeted species	
	Other physical disturbance	Deterioration of the marine environment through ALDFG	
	Physical damage	Bottom-set gillnets, which have weights dragging the bottom	Expert input
Purse seine	Biological	Population loss due to bycatch (turtles, marine	Leroy, B. et al.



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



(with FADs or not)	disturbance	mammals and sharks)	(2013)
	Physical damage	Coral reef habitat destruction	
	Other physical disturbance	Contribution to ocean plastic by derelict FADs	
		Noise from vessels	Expert input
Longline	Biological disturbance	Population loss due to bycatch (marine mammals, turtles and seabirds)	Baker, G. B., & Wise, B. S. (2005)
	Physical damage	Include here bottom longlines, which go with weights and hooks that drag the bottom.	Expert input
	Other physical disturbance	Contribution to ocean plastic by derelict FADs	Expert input
		Noise from vessels	Expert input
Pots and traps	Biological disturbance	Bycatch by ghost fishing	Lively, J. A., & Good, T. P. (2019); Shester, G. G., & Michel, F. (2011)
	Other physical disturbance	Contribution to ocean plastic by derelict FADs	Expert input
		Noise from vessels	Expert input
	Physical damage	The pots are placed on the bottom and when set and retrieved can disturb the surface, break corals or reefs, etc.	Expert input
Trammel net	Biological disturbance	Gradual reduction of the sex ratio over time due to higher contribution of males to trammel net catches at the beginning of the fishing season	Ganias, K. et al. (2021); Baeta, F., Costa, M. J., & Cabral, H. (2009)
		Population loss due to low selectivity (high by-catch)	
	Physical damage	Include here bottom-set trammel nets, which have weights that drag the bottom.	Expert input
	Other physical disturbance	Contribution to ocean plastic by derelict FADs	Expert input
		Noise from vessels	Expert input
	Contamination by hazardous substances	Anti-fouling substances for boats/ships	Expert input
		Possible spills of fuel or motor oil	Expert input
Driftnetting	Biological disturbance	Population loss due to heavy bycatch ("Walls of death" - Banned in the Mediterranean)	Telesetsky, A., & Bratspies, R. (2020); Danalache, T. et al. (2020);



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



			EJF (2007); Johnston, D. M. (1990)
	Other physical disturbance	Contribution to ocean plastic by derelict FADs	Expert input
		Noise from vessels	Expert input
Dredges	Physical damage	Habitat destruction by scraping and plunging	Todd, V. L. et al. (2015); Erftemeijer, P. L. et al. (2012); Erftemeijer, P. L., & Lewis III, R. R. R. (2006)
	Biological disturbance	Risk of population loss of loggerhead, Kemp's ridley, and green sea turtles due to capture or entanglement	
		Risk of population loss of pilot whales and common dolphins due to capture or injuries	
		Risk of population loss (dolphin and porpoises) due to entanglement in the tow lines	
	Other physical disturbance	Underwater noise from both the dredger and the ship	Expert input
	Contamination by hazardous substances	Anti-fouling substances for boats/ships	Expert input
		Possible spills of fuel or motor oil	Expert input
Push and stow net	Biological disturbance	Biodiversity loss and effect nursery production due to bycatch and low selectivity Injuries and death to non-targeted species caused by speed and tow conditions	Briand, C. et al. (2012)

Table 7: Marine non-living resources: Activities, pressures and impacts on ecosystems for the Marine non-living resources sector

Activities	Pressures	Impacts on ecosystems	Information source
Deep-sea mining	Physical damage	Removal of nodules, complete disturbance of seabed and its compaction causing destruction of habitat and associated organisms	Drazen, J. C. et al. (2020); Weaver, P. P. et al. (2018); Sharma, R. (2015)
		Clogging of filter feeding apparatus of benthic organisms due to sediment resuspension	
		Mortality of organisms on the seafloor	



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Dredging	Biological disturbance	Plumes released in the photic zone (down to 200 m) may reduce light penetration and reduce plankton growth or release deep-water nutrients increasing productivity with food chain effects. Plumes released below 200 m depth must be negatively buoyant. Effects on pelagic ecosystems	Expert input
		Depletion of oxygen by bacterial growth on suspended particles	
	Biological disturbance	Smothering of seabed animals. Effects on benthopelagic organisms due to sediment laden plumes near seabed containing particle load	
		Changes on the habitat in terms of the sizes of life that will either be benefited or be impacted negatively - Size and ecosystem function fractionated impact on life	
		Mortality of zooplankton species	
		Effects on meso and bathypelagic fishes and other nekton	
		Impacts on deep-diving marine mammals	
		Effects on fish behaviour	
	Contamination by hazardous substances	Mortality caused by the sediments or trace metals	
		Dissolution of heavy metals within the oxygen-minimum zone	
		Smothering of seabed animals by particulates, especially proximal to the mined area. Toxicity to animals in areas affected by the plume. Effects on benthopelagic fauna	
	Other physical disturbance	Masking effects on marine mammals due to high levels of noise	
	Physical loss	Destruction of seabed habitats	
		Construction of structures or sealing by disposal of dredged material	Expert input
	Biological disturbance	Temporary decrease in water transparency affects phytoplankton, algae and seagrass	Svensson, N. et al. (2022); Manap, N., & Voulvoulis, N.
		Algal blooms and biofouling in turbines caused by turbidity	



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



		Changes in faunal density, number of species and composition at the macrobenthic infaunal level	(2016); Todd, V. L. et al. (2015); Erftemeijer, P. L. et al. (2012); Erftemeijer, P. L., & Lewis III, R. R. R. (2006)
		Habitat degradation	
	Physical damage	Increased oxygenation of bottom sediment changes biodiversity of infauna	
		Burial due to subsequent deposition of material	
		Loss of coral reef habitats due to sediment disturbance	
		Changes in bathymetry - introduction of new habitats	
		Clog membranes of filter-feeding fauna like shellfish due to high level of sediment disturbance	
		Recolonization by opportunistic taxa within disturbed seafloor	
	Other physical disturbance	Noise	
	Contamination by hazardous substances	Sediment toxicity: P, Pb, Zn and Hg increase	
		Resuspension of contaminated sediments increase of nutrient concentration and reduction of dissolved oxygen in the water column affect pelagic fauna	
		Food chain affected by the exposure of contaminants due to sediment resuspension	
	Interference with hydrological processes	Alteration of current velocities and wave conditions affecting the sedimentary regime and causing erosion under seagrass beds	
Offshore oil and gas extraction	Physical loss	Smothering of benthic habitats. Habitat loss	Sommer, B. et al. (2019); Vad, J. et al. (2018); Cordes, E. E. et al. (2016)
		Clogging of feeding and gas exchange structures	
	Physical damage	Direct physical impact at emplacement	
		Provision of hard substratum for colonization by sessile epifauna and associates	
		Increased sedimentation altering natural habitats	
		Mortality and burial of benthic fauna	



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



		Fragmentation of corals	
	Interference with hydrological processes	Direct physical impact at emplacement potentially continuing impact through tidally induced motions	
	Contamination by hazardous substances	Direct toxicity Altered electrochemical environment Changes in nutrient availability Food-web contamination Potential food-chain Trophic amplification Pipelines can corrode and increase toxicity Altered benthic, pelagic and infaunal communities Mortality of corals	
	Other physical disturbance	Potentially continuing impact through tidally induced motions Surface light attract some mobile species and repels others Affect vertical migration of plankton (due to surface light) Localized auditory damage (acoustic energy) Disruption of marine mammal behavior (acoustic energy) Physiological stress to marine mammals (acoustic energy) Invertebrate larval loss (acoustic energy) Disturbance of key bioturbating species in sediments (acoustic energy)	
	Biological disturbance	Altered community structure Decreased species abundance Altered distribution of species due to new artificial	



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



		habitat	
		May increase species connectivity (including invasive species) due to new artificial habitat	
	Physical loss	Structure construction	

Table 8: Renewable energy: Activities, pressures and impacts on ecosystems for the renewable energy sector

Wind farms	Biological disturbance	Collisions: migration barrier for birds and marine mammals	Galparsoro, I. et al. (2022); Lloret, J. et al. (2022); Dannheim, J. et al. (2020); Nazir, M. S. et al. (2020); Draget, E. (2014)
		Behavioral changes: displacement from foraging or reproductive areas for fish, birds and marine mammals	
		Disruption on communication abilities	
		Decreased fish stock from a loss of food sources and alteration in their productivity and composition	
		Fishery cessation and displacement	
		Decreased biological diversity	
		Changes on species composition: effect on the functional traits as productivity, resistance to disturbance and susceptibility to biological invasions	
	Physical loss	Loss of fragile benthic marine and coastal habitats	
		Loss of natural seabed areas	
	Physical damage	Disturbance to sensitive and threatened species (birds, mammals, sea turtles and fish) due to piles, anchors and cables, causing injury or death and changes in habitat	
		Localized erosion: affect larval recruitment, alter sedimentation rates, alter food and oxygen availability, waste removal	
		Decrease or even disappearance of stratification due to local turbulences	



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Ocean energy - Tidal	Other physical disturbance	Sound (noise): There are two different noises: i. during the construction of the wind farm and ii. the noise of the wind turbine working. (i) Temporary hearing loss, tissue damage and imminent death for fish and marine mammals. (ii) Species may abandon areas ranging up to several km from the construction site: affect spawning and juvenile stages of many species	Baker, A. L. et al. (2020); Mendoza, E. et al. (2019); Fox, C. J. et al. (2018); Furness, R. W. et al. (2012); El-Geziry, T. M. et al. (2009)
		Avoidance or attraction to magnetic fields from fish, marine mammals and crustaceans	
	Physical damage	Physical loss: Benthic organisms can be affected through installing a barrage by changes of sedimentation	
		Change of sediment deposition rates affect benthic habitat and it can modify the local water depth if prolonged	
		Changes to tidal regime and sedimentation are predicted to directly and indirectly impact benthopelagic species	
		Physical barriers can interrupt connectivity to small organisms and migratory species	
		Entanglement in mooring lines	
	Other physical disturbance	Altered behaviour in marine mammals (communication and breeding) due to noise	
		Altered behaviour in fish (spawning, distribution) due to noise	
		Exposure to magnetic fields can alter behaviour in fish and crustacea	
	Biological disturbance	Physical injury to seabirds	
		Changes in megafauna occupation patterns, distribution and behaviour	
		Change reproductive and migratory habitats of coastal birds as well as risk of collision	
		Altered reproductive and migratory habits, food availability and nutrient distribution and collision risk in the marine habitat	
		Collision risk: cetaceans, fish and seabirds	
Ocean energy -	Physical damage	Benthic organisms can be affected through installing a barrage by changes of sedimentation	Rahman, A. et al. (2022);



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Wave	Physical loss	Physical loss (due to permanent change of seabed substrate or morphology and to extraction of seabed substrate) - alteration of benthic fauna	Galparsoro, I. et al. (2021); Copping, Andrea E. et al. (2020); Langhamer, O. et al. (2010)
	Other physical disturbance	Alter behaviour in marine mammals (communication and breeding) due to noise	
		Alter behaviour in fish (spawning, distribution) due to noise	
		Exposure to magnetic fields can alter communication systems of species (taxa Chondrostei, Agnathans and Chondrichthyes)	
	Biological disturbance	Migratory birds affected (device creates a barrier in the path the species)	
		Physical injury to seabirds (due to blade strike, collision and entanglement)	
		Changes of species; introduction of new species due to changes in hydromorphology	

Table 9: Aquaculture: Activities, pressures and impacts on ecosystems for the aquaculture sector

Activities	Pressures	Impacts on ecosystems	Information source
Aquaculture in coastal or intertidal zones	Physical loss	Sealing - due to the replacement of an ecosystem with an aquaculture facility	Expert input
	Physical damage	Exploitation of living resources of the seabed and subsoil	Expert input
	Interference with hydrological processes	Hydrological modification for water intake/redirection	Expert input
	Biological disturbance	Selective extraction - much of the feed for aquaculture comes from wild species, thus extracting biomass	Expert input
		Alteration of wild fish stock (competition for food resources in poor ocean productivity times) due to releases on the wild	Bohnes & Laurent (2021); He, P. et al. (2021); Price, C. et al. (2015); Read & Fernandes (2003); Levin,
		Genetic interactions between escaped farmed fish and wild fish	
		Disease transfer by escaped fish or through ingestion of contaminated waste by wild fish	



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



		Effects on the wider ecosystem	P. S. et al. (2001)
		Impacts on benthic communities near cage sites	
		Degradation of local biodiversity	
	Contamination by hazardous substances	Resource depletion caused by the release of anti-bacterial and other chemical used	
	Systematic and/or intentional release of substances	Lower light penetration affecting phytoplankton production	
		Affect photosynthesis of benthic aquatic vegetation (seagrasses)	
		Microlayer of released lipids from fish oil increase the toxicity of some ichthyotoxic algal species	
	Nutrient and organic matter enrichment	Decrease on the quality of water	
		Hypernutrification	
		Accelerate algal growth	
		Produce an undesirable disturbance to the balance of organisms	
		Increased oxygen consumption in deep water	
		Increased production of toxins by certain algae	
		Increased dissolved nitrogen discharge (algae blooms, eutrophication, nutrient enrichment)	
Aquaculture at sea (hatcheries, floating cages and rafts)	Contamination by hazardous substances	Resource depletion caused by the release of anti-bacterial and other chemical used	
	Systematic and/or intentional release of substances	Lower light penetration affecting phytoplankton production	
		Affect photosynthesis of benthic aquatic vegetation (seagrasses)	
		Microlayer of released lipids from fish oil increase the toxicity of some ichthyotoxic algal species	
	Nutrient and organic matter	Increased dissolved nitrogen discharge (algae blooms, eutrophication, nutrient enrichment)	



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Seaweed farming	enrichment	Decreased water quality	
		Hypernutrification	
		Accelerate algal growth	
		Produce an undesirable disturbance to the balance of organisms	
		Increased oxygen consumption in deep water	
		Increased production of toxins by certain algae	
	Biological disturbance	Alteration of wild fish stock (competition for food resources in poor ocean productivity times) due to releases on the wild	
		Genetic interactions between escaped farmed fish and wild fish	
		Disease transfer by escaped fish or through ingestion of contaminated waste by wild fish	
		Effects on the wider ecosystem	
		Impacts on benthic communities near cage sites	
	Physical damage	Degradation of local biodiversity	Expert input
		Habitat damage due to reef installations, bottom anchorages and mollusk facilities	
	Interference with hydrological processes	Obstacle, disturbing currents, swell (although very slightly)	Expert input
	Biological disturbance	Altered genetic composition of local species resulting in loss of natural fitness or altered community composition	Campbell, I. et al. (2019)
		Potential widespread of consequences (disease, parasites and non-native species) for marine communities and ecosystem functioning	
		Large scale changes in local hydrodynamics: reduction in tidal flows at the surface where kelp is suspended could have implications for the benthic and pelagic habitats below	
	Contamination by hazardous substances	Discarded or lost components may contribute to marine pollution such as increasing levels of plastic in marine food webs	



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



		Discarded or lost components may contribute to marine pollution and cause social concerns as the reduction in coastal amenities due drifting debris	
Biological disturbance		Loss of infrastructure can result in the mortality of marine megafauna (marine mammals, marine turtles, sharks, rays and large bony fish) due to entanglement	
		Local nitrogen absorption resulting in phytoplankton community compositional changes	
		Release of reproductive material: 'Crops to wild' gene flow. Potential effects: direct competition with wild populations and hybridization with natural stands	
		Artificial habitat creation	
Other physical disturbance		Creation of noise due to an increase of vessel traffic could create behavioral alterations to affected megafauna	
		Nutrient and organic matter enrichment	
		Positive remedial effects when the quantity and proportion of nutrients removed are equal to those added by anthropogenic activities	

Table 10: Tourism: Activities, pressures and impacts on ecosystems for the tourism sector

Activities	Pressures	Impacts on ecosystems	Information source
Diving	Physical damage	Physical damage to coral reef by clambering over them, by kicking them accidentally with the fins or by stirring up silt that suffocates them	Santander-Botello & Frejomil (2009)
		Damage to benthic organisms like sponges due to air bubble formation during cave diving	
		Physical damage to coral (abrasion and tissue loss) facilitates disease transmission	
	Biological disturbance	Dominance by branching corals that grow faster than massive non-branching corals	
		Algal overgrowth	
		Feeding of large fish by scuba divers reduces local biodiversity (probably reversible over short periods).	
Sailing vessels	Physical damage	Benthic animals, corals and seagrass beds are	Davenport, J.,



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



	Biological disturbance	often damaged by anchoring.	& Davenport, J. L. (2006)
		Introduction of non-indigenous species	
		Transmission of non-indigenous species	
Yacht and motorboats/motor vessels	Physical damage	Benthic animal, corals and seagrass beds are often damaged by anchoring.	Carreño, A., & Lloret, J. (2021)
	Other physical disturbance	Acoustic disturbance of cetaceans particularly during breeding	
	Biological disturbance	Injury or death of cetaceans, seals and turtles as a result of collisions	
		Wake formation altering pelagic and benthic habitats	
		Spread of fouling macroalgae and animals	
Sport fishing	Physical damage	Discarded snagged monofilament fishing lines cause intense damage to rocky habitats and coral reef	Shollenberger, H. et al. (2019); Britton, J. R., & Orsi, M. L. (2012)
	Other physical disturbance	Discarded snagged monofilament fishing lines cause intense damage to rocky habitats and coral reef	
		Entanglement in discarded lines	
		Engine noise and litter	Expert input
Cruise	Physical damage	Cruise ship anchoring is associated with severe long-term damage to coral reef and seagrass meadows	MacNeill & Wozniak (2018); Carić, H. (2011); Brida & Zapata (2010)
		Modifications to the natural and built environment to enable destinations to serve as cruise line destination involve loss of natural habitat, exploitation of local construction	
		Dredging channels for larger vessels causes increased turbidity that is damaging to both corals and seagrass. Dredging can also cause injury and death of filter-feeding animals.	
	Other physical disturbance	Disturbance of wildlife and pressure on endangered species by noise	
	Contamination by hazardous substances	Eco-toxic metal emissions from antifouling coating triggers bioaccumulation of Cu and Zn in mussels and fish	
		Illegal discharge of substances mainly oil and	



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



		other hydrocarbons - Pollution	
		Discharge of garbage and solid waste (plastic, steel cans, paper, cardboard, aluminium) contribute to pollution and habitat loss	
		Nutrient and organic matter enrichment	
		Discharge of wastewater, graywater and sewage contribute to pollution, eutrophication, and habitat loss	
Whale-watching	Biological disturbance	Biological disturbance	Finkler & Higham (2020); Higham, J. E. et al. (2016); Parsons, E. C. M. (2012); Bejder, L. et al. (2006)
		Decrease of abundance of marine mammals	
		Long-term shift in habitat use from an area of high to low vessel traffic (Habitat abandonment)	
		Reduced population fitness due to repeated disturbance: decrease in the amount of time they could spend near their basal metabolic rate (resting) and decrease their basal metabolic rate	
		Decline in size population due to a reduction in calf survival (cetaceans, long-lived and slow to reproduce, prioritize survival over calving)	
		Behavioral changes: surfacing/diving, "active" behaviour (tail slapping and beaching), acoustic, group size or cohesion, swimming speed, swimming direction, altered feeding or resting	
		Chronic levels of stress	
	Other physical disturbance	Cessation of essential behaviours like feeding or resting	
		Boat-related sound can be drowned out or "mask" cetacean vocalizations resulting in animals being unable to communicate	
		Engine size and consequent underwater noise disturb cetaceans (communication, orientation, and predator/prey detection)	

3.3. Ecosystem services – Multi-criteria analysis

A comprehensive examination, involving consultations with domain experts, was conducted. The collaborative efforts of these experts facilitated the identification of pressures, defined as the interactions of humans with the environment through



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



ecosystem services. These interactions were further categorized as positive pressures (+1), indicating favorable impacts, negative pressures (-1) denoting adverse effects, and neutral pressures (0) representing interactions with no discernible positive or negative impact on Ecosystem Services (ES) (ANNEX II). The final results of expert consultation regarding the impact of the blue economy sector on ecosystem services are presented in Table 11. A more detailed analysis by sector, activity, and pressure can be found in Annex I. It is important to note that, although the information in the annex is linked to pressures, the analysis considered the impacts identified by each activity presented in the aforementioned tables (aquaculture, tourism, renewables, fishery, Marine non-living resources).

As previously mentioned, one of the criteria for assessing the impact of activities on ecosystem services was the identification of positive effects. While most results indicate a negative impact on the ecosystem, certain activities within aquaculture, renewables, and tourism have demonstrated positive effects according to expert analyses.

In tourism, both positive impacts are primarily associated with cultural services, particularly in whale-watching, diving, and fishing sports. These activities are more closely linked to well-preserved environments.



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Table 11: Pressure and ecosystem services matrix by sector. Where, the red number is related to the ten most impacted ecosystem services by each sector. And the blue number are those ecosystem services that have a positive impact due to a sector operation

ES Section	ES Group	Fisheries	Aquaculture	Marine non-living resources	Renewables	Tourism	Cumulative impact on each ES
Nursery and habitat maintenance	Regulation & Maintenance	-24	-13	-14	-4	-13	-68
Genetic material	Provisioning	-18	-15	-11	-7	-6	-57
Wild aquatic animals	Provisioning	-17	-12	-15	-4	-9	-57
Wild aquatic plants/algae	Provisioning	-13	-11	-11	-7	-6	-48
Intellectual and representative interactions with environment	Cultural	-21	-7	-5	-2	1	-34
Environmental conservation for future generations	Cultural	-15	-13	-11	1	4	-34
Physical and experiential interactions with the environment	Cultural	-21	-8	0	0	0	-29
Mediation of anthropogenic nuisances	Regulation & Maintenance	-7	-2	-10	-4	-5	-28
Mediation of wastes	Regulation & Maintenance	-14	-8	-1	-2	-2	-27
Regulation of soil quality	Regulation & Maintenance	-6	-9	-6	-6	0	-27
Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance	-1	-1	-10	-6	-8	-26
Pest and disease control	Regulation & Maintenance	-11	-10	-1	0	-2	-24
Water conditions	Regulation & Maintenance	-2	-12	-4	0	-2	-20



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Mineral substances used for nutrition, materials or energy	Provisioning	-2	-8	-6	-2	0	-18
Farmed animals	Provisioning	-7	6	-2	-6	-5	-14
Spiritual, symbolic and other interactions with natural environment	Cultural	-3	-5	0	0	0	-8
Water used for nutrition, materials or energy	Provisioning	0	-4	0	0	0	-4
Atmospheric composition and conditions	Regulation & Maintenance	0	-1	-1	0	-1	-3
Regulation of baseline flows and extreme events	Regulation & Maintenance	-1	4	-3	0	0	0
Non-mineral substances or ecosystem properties used for nutrition, materials or energy	Provisioning	0	0	0	0	0	0
Other mineral or non-mineral substances or ecosystem properties used for nutrition, materials or energy	Provisioning	0	0	0	0	0	0
Other type of regulation and maintenance service by abiotic/biotic processes	Regulation & Maintenance	0	0	0	0	0	0
Cultivated aquatic plants for nutrition, materials or energy	Provisioning	0	1	0	0	0	1



As expected, the extent to which the ecosystem services are affected by different activities in the five blue sectors varies. The ten most impacted ecosystem services by sector and by cumulative impact (sum of all sectors' impact on the ES) are presented in Table 12. It is also possible to identify that the most vulnerable ES to the sectors operations are *nursery and habitat maintenance, wild aquatic animals, genetic material, intellectual and representative interactions with environment, environmental conservation for future generations, physical and experiential interactions with the environment, mediation of anthropogenic nuisances, and mediation of wastes*.

Table 12: *The Ten Most Impacted Ecosystem Services by Sector and Cumulative Impact.* **Legend:** Abbreviations: CI - Cumulative Impact; F - Fishery; NLMR - Marine non-living resources; R - Renewable; T - Tourism; A - Aquaculture

Ecosystem Services	CI	F	NLMR	R	T	A
Nursery and Habitat Maintenance	Yes	Yes	Yes	Yes	Yes	Yes
Wild Aquatic Animals	Yes	Yes	Yes	Yes	Yes	Yes
Genetic Material	Yes	Yes	Yes	Yes	Yes	Yes
Wild Aquatic Plants/Algae	Yes	Yes	Yes	Yes	Yes	Yes
Intellectual and Representative Interactions with Environment	Yes	Yes	Yes	Yes	Yes	Yes
Environmental Conservation for Future Generations	Yes	Yes	Yes	Yes	Yes	Yes
Physical and Experiential Interactions with the Environment	Yes	Yes	Yes	Yes	Yes	Yes
Mediation of Anthropogenic Nuisances	Yes	Yes	Yes	Yes	Yes	Yes
Mediation of Wastes	Yes	Yes	Yes	Yes	Yes	Yes
Regulation of Soil Quality	Yes	Yes	Yes	Yes	No	Yes
Pest and Disease Control	No	Yes	No	No	Yes	Yes
Farmed Animals	No	Yes	No	Yes	Yes	Yes
Maintenance of Physical, Chemical, Abiotic Conditions	No	No	Yes	Yes	Yes	Yes



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Mineral Substances Used for Nutrition, Materials, or Energy	No	No	Yes	Yes	No	Yes
Water Conditions	No	No	No	No	Yes	Yes

3.4. Sectorial Sheets (Good management practices and Sankey Chart)

The results of steps 5 and 6 will be collectively presented in the sectorial sheets for the five sectors: aquaculture, fisheries, marine non-living resources extraction, renewables, and tourism (ANNEX III). These sheets offer a synthesized overview of the impact assessment on the ecosystem analysis, simplifying the complex analyses conducted for the stakeholders and users in particular from the blue economy sectors. The primary purpose is to provide information on the socio-ecological system surrounding the development of the five blue economy sectors. Each sheet provides a general sector overview, highlighting the main ecosystem services the sector relies on, various activities within the sector, a Sankey chart summarizing activities, pressures, and impacts on ecosystem services, and recommended good management practices for enhancing sustainability in the sectors operations.

Some main points found during the elaboration of the Good Management Practices (Step 5) and the Sectorial Sheets, more specifically the Sankey charts (inside STEP 6), are presented in the subsections below.

3.4.1. Sankey Charts by sector

While the Sankey Chart conceals a wealth of information, it serves as an effective visual tool for presenting the intricate outcomes derived from the preceding analysis. It highlights the most affected ecosystem services, along with the associated pressures and activities linked to each of the five sectors analyzed in this report. This visual representation aims to simplify the understanding of complex relationships and outcomes derived from the extensive analysis conducted to build the flow of the activities, pressures, and impacts to the ecosystem services. To streamline the final visualization, it was focused on showcasing the ten most significantly impacted ecosystem services in the charts. This approach enhances the clarity in identifying the origins of impact, associated activities, and the corresponding pressures. In fact, according to Chalkiadakis et al., (2022), understanding, defining and accurately measuring the flows of ecosystem services (ES) is crucial for the sustainable management of social-ecological systems, since it can improve the decision-making process to manage marine ecosystems effectively.



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Based on the Sankey Chart presented on the sectorial sheets subsection below it is possible to identify by sector the primary pressures, the predominant ecosystem services and the type of ecosystem services impacted.

❖ Primary pressures on the ecosystem by sector:

- Fishery: ***Other physical disturbance*** and the ***Biological disturbance***;
- Aquaculture: ***Nutrient and organic matter enrichment, Contamination by hazardous substances and Systematic and/or intentional release of substances***.
- Tourism: ***biological disturbance and physical damage, and other physical disturbance***.
- Renewables: ***physical damage and physical loss***.
- Marine non-living resources: ***physical damage, physical loss and contamination by hazardous substances***.

❖ Ecosystem services and type of ES most impacted:

- Fishery: ***Wild aquatic animals; Nursery and habitat maintenance and Cultural services (Sport, recreation and leisure interaction with the environment, and Intellectual and representative interactions with the environment)*** corresponding mainly to ***Regulation & Maintenance*** and ***Provision*** types of ecosystem services.
- Aquaculture: ***Wild aquatic plants/algae, Wild aquatic animals, and Nursery and habitat maintenance***, corresponding mainly to ***Regulation & Maintenance*** and ***Provision*** types of ecosystem services.
- Tourism: ***Nursery and habitat maintenance, Wild aquatic animals and maintenance of physical, chemical, abiotic conditions***, corresponding mainly to ***Regulation & Maintenance*** and ***Provision***.
- Renewable: ***Wild aquatic plants/algae, regulation of soil, maintenance of physical, chemical, abiotic conditions and Genetic material***, corresponding mainly to ***Regulation & Maintenance*** and ***Provision***.
- Marine non-living resources: ***Wild aquatic plants/algae, Wild aquatic animals, and Nursery and habitat maintenance***, corresponding mainly to ***Regulation & Maintenance*** and ***Provision***

3.4.2. Good management practices and sectorial sheets

The Good Practices obtained have the aim of preserving species, habitats and ecosystems, so most of them can be focused on the socio-ecosystem. However, it can be observed that there are some good practices that focus on minimizing the sector



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



or the specific activity in order to achieve this end, while other good practices do so by adapting the activity itself through more sustainable measures or instruments.

The good practices focused on management are not very abundant in this compilation given the purpose mentioned above. However, some have been included because they are good management practices directly focused on the socio-ecosystem.

It is crucial to highlight that aquaculture serves as a significant alternative to maintaining food security. Certain practices, such as multitrophic aquaculture, are regarded as environmentally friendly and represent good practices for sustaining environmental health while providing food. Some of these activities are also outlined in the context of good management practices, as presented in the Aquaculture Sectorial Sheet.

Furthermore, the identification of Good Management Practices (GMP) for renewable energies presented challenges owing to their innovative nature. Despite these challenges, we systematically documented commendable practices. This methodological approach culminated in the development of a repository delineating exemplary strategies for the effective management and implementation of emerging environmental policies. Notably, these strategies demonstrate a harmonious alignment with the socio-economic and environmental contexts prevalent in the monitored test sites across the five European basins.

In the domain of offshore renewable energy and other sectors, numerous studies have explored the integration of synergy and multi-use strategies. The goal is to optimize marine space utilization and enhance overall efficiency. The subsequent section provides a succinct overview of the benefits and practicalities associated with the implementation of multi-use practices in these contexts.

a. Ocean Multi-Use – Good management Practice

The concept of ocean multi-use originated in Europe two decades ago in response to challenges posed by the growing intensification and diversification of human activities at sea. It involves envisions a holistic and integrated approach to ocean management, where various activities coexist harmoniously, encompassing various combinations of marine uses, such as integrating wind and wave energy technologies, repurposing decommissioned oil and gas platforms, and incorporating fishing-based tourism or aquaculture within offshore wind farms. Multi-use represents a more integrated and efficient approach to marine spatial management, with goals including creating synergies for Blue Growth, fostering collaborations between marine users to reduce conflicts, and alleviating human pressures to benefit biodiversity and local ecosystems Schupp et al., (2019).

Ocean multi-use therefore seeks to optimize the utilization of ocean space by integrating diverse activities such as aquaculture, renewable energy production, shipping, tourism, and conservation efforts. One of the most promising aspects of



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Ocean Multi-Use lies in its potential to serve as a catalyst for marine biodiversity conservation. By strategically planning and managing overlapping activities, it is possible to create synergies that benefit both human development with reduced environmental costs of the ocean. Some well-known examples are described below:

- the **co-location of some types of aquaculture facilities with marine protected areas** can provide a win-win scenario, supporting sustainable seafood production while preserving critical habitats for marine species (Le Gouvello et al., 2017; Mengo et al, 2020).
- **Renewable energy installations (and conservation)**, such as offshore wind farms and wave energy converters, offer another avenue for Ocean Multi-Use. When strategically positioned, these installations can serve as artificial reefs, attracting marine life and enhancing local biodiversity. Balancing these structures with conservation priorities ensures that energy needs are met sustainably, while also providing sanctuaries for marine species (Lukic, 2022).
- The integration of responsible **tourism with conservation efforts** can raise awareness and funding for **marine protection**. Well-managed ecotourism ventures can contribute to local economies while promoting a sense of stewardship for the oceans.

Moreover, Multi-use of Marine Protected Areas can bring additional socio-economic benefits to the region. Examples of business cases and models based on the ocean multi-use principles such as sustainable economic activities in Marine Protected Areas have been studied in different EU and global projects and initiatives, such as in the Horizon Europe Ocean Mission BLUE4ALL project showing variety of examples in the EU and beyond. For the reviewed business cases mostly found in the Mediterranean Sea region, the socio-economic boost is represented through the creation of new jobs and income opportunities for the local community, increased inclusion of women in maritime jobs, a boost in eco-tourism and fishing tourism, and the initiation of small-scale businesses. Some examples can be found below:

- **“The Blue Business Incubator” and “Mediterranean Experience of EcoTourism (MEET)”** are both (eco)tourism-based models, their revenue streams rely on the quality of the marine environment; thus, both are possible to link to blue finance if the business would like to seek financing or investment.
- **“Blue Parks Initiative” and “BLUprint”** are two incubators to support MPAs globally, the first one support locals and provide opportunities to boost eco-tourism through an award; whereas the second supports a broader variety of business activities by providing a guideline to establish sustainable finance models for different business as well as guidance for planning and developing MPAs.
- **Tourism- and fishing-related businesses** are commonly found, but some diversity and innovation among the cases has also been identified. For



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



example, for the cases related to fishing, it varies from production, process, and marketing.

- **Other cases** like the business combination of research (water monitoring and wind power), label for marketing, and carbon and biodiversity credits were also identified. (Lai, T.-Y. et al. (2023). Deliverable D1.3: Review of socio-ecological framework and methodologies (Draft). BLUE4ALL.)

To complement the analysis done in this document good management practices have been provided in the sectorial sheet which included existing multi-use development world-wide, combining nature conservation and marine protection with other uses such as fisheries, tourism and renewable offshore energy.



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



3.4.3. Fishery Sectorial Sheet



General Information: This sectorial sheet is part of a series that includes five sectors central to the MSP4BIO Project: Aquaculture, Fishery, Marine non-living resources extraction, Renewable Energy, and Tourism. The overarching goal of this support material is to provide guidance to managers to better address activities in their marine protected areas (MPAs) following an integrated approach, while also supporting blue economy sectors/industry stakeholders to understand the impacts relevant for sectors operation. To this end, the factsheets provide information on the diverse impacts that activities within each sector may have on Ecosystem Services. Then, Good Management Practices to mitigate these impacts and facilitate the sustainable development of the respective sectors are facilitated. The entire set of sectorial sheets is designed to be a valuable resource for policymakers, aiding in trade-off analysis and addressing user-user and user-environment conflicts. More information can be found here: www.msp4bio.eu

Sector characteristics

Area-based marine conservation
Long-term scientific data series provide compelling evidence that, within numerous Marine Protected Areas (MPAs), diligent conservation efforts have produced noteworthy outcomes, with fishing yields either stabilizing or showing a promising increase. It's important to recognize that fisheries managed with the sole aim of sustaining long-term exploitation may not inherently align with the rigorous ecological standards required for effective nature conservation within an MPA. To thrive within an MPA context, a fishing operation must prioritize nature conservation as its primary objective and implement management practices that are explicitly aligned with this overarching conservation goal.

This document provides an overview of the ecosystem services (ES) upon which the sector relies and those that it influences, as well as the associated pressures. It also highlights instances of successful management practices within the sector operating in MPAs, offering valuable insights for informed decision-making by managers.

Ecosystem Services main dependencies:

- Wild aquatic animals for nutrition
- Lifecycle maintenance, habitat and gene pool protection (i.e. nursery)
- Pest and disease control (i.e. invasive species)

Activities



The Sankey Chart illustrates the flow of pressures (based on the MSFD) from each activity in the environment through Ecosystem Services (Figure 1). The primary pressures on the ecosystem include *Other physical disturbance* and the *Biological disturbance*. These impacts predominantly affect *Wild aquatic animals*; *Nursery and habitat maintenance* and *Cultural services* (*Sport, recreation and leisure interaction with the environment, and Intellectual and representative interactions with the environment*), corresponding mainly to *Regulation & Maintenance* and *Provision* types of ecosystem services. The chart provides a visual representation of the intricate connections between activities, pressures, and their repercussions on specific ecosystem services.

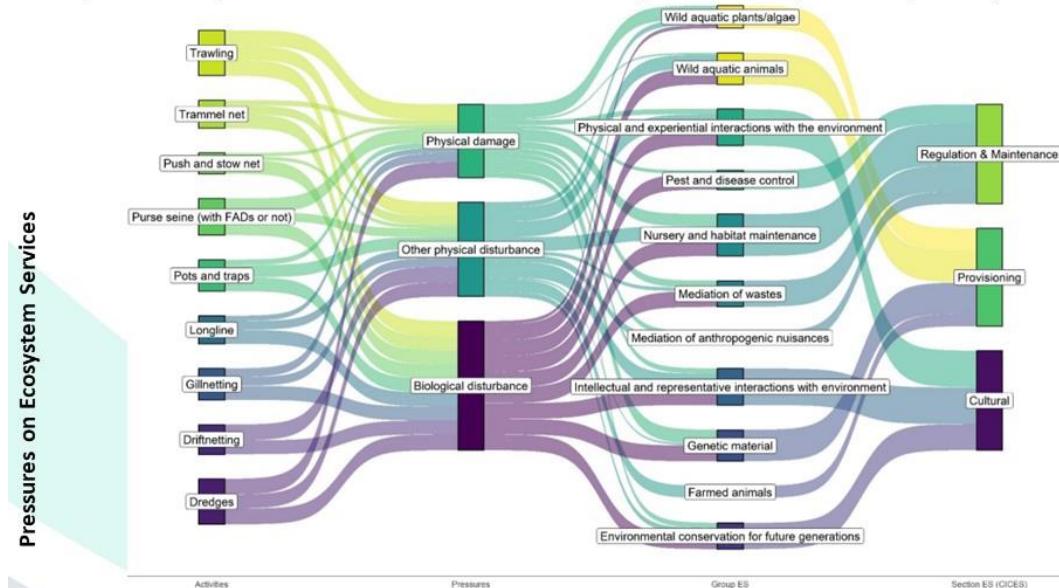


Figure 1: The Sankey Chart of Fishery Sector illustrates the flow of various elements such as 'Activities', 'Pressures', 'Group ES', and 'Section ES (CICES)'. The width of the arrows and boxes is proportional to the quantity of the flow passing through them. This visual representation provides a clear depiction of the distribution and transformation of resources within the system.

In summary, the absence of effective practices in the development of the fishery sector can pose potential risk to crucial ecosystem services (Figure 1). The joint sectoral sheets indicate the direct impact on ecosystem services vital for the sustainability of both Tourism and Fisheries sectors. The implementation of sound practices, as outlined below, is crucial for ensuring the long-term health and resilience of these Blue Economy sectors and the integrity of marine ecosystem. This not only safeguards the environment but also sustains the viability and prosperity of associated industries.



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



FISHERY



This publication was funded by the European Union. Its contents are the sole responsibility of the author(s) and do not necessarily reflect the views of the European Union.

Good management Practices

Table 1 (Part 1) presents a non-exhaustive list of Good Management Practices (GMP) that should be considered during the planning stages of various activities associated with fishery sector. Whenever feasible, the examples provided pertain to areas under either a type of protection or in close proximity to marine protected areas. A brief description of GMP is provided, and for more detailed information, the source can be consulted.

Classification	Good Management Practices	Source
Spatial Approaches/Practices		
	Mapping habitats: for identification of sensitive habitats and fauna, for a more sustainable and rentability of the fishery activity.	Eastern Canada (Scallop fisheries-dredging)
	Vessel mapping updated cartography to enable vessels to avoid areas of VME, proximity alert system. Establishment of benthic protection areas bottom trawling with measures such as: i) individual transferable quotes, and ii) observes and electronic net monitoring system.	Agarba vessels (Spanish fleet - Cod working on Norway EEZ) New Zealand (trawling and dredging)
	For example , a season-long area closure for fishery can be established to safeguard ETP (Endangered, Threatened, Protected) species. For a more effective measure, the area can be adjusted every year, based on data from the previous year. Example: In Canada, snow crab and lobster fishery is not allowed whilst whales are in the area.	Canada snow crab and lobster fishery (long-line; static gear)
Temporal Approaches/Practices		
	Closed areas and closed seasons can be enforced to protect fish at times and locations where they are particularly vulnerable. For example , no fishing is permitted within 500m of any river mouth to protect fish aggregating prior to spawning. In Indonesia, spatial restrictions prohibiting using a net within the sea within 100m of the mouth of a river or stream.	Lake Peipus Perch and Pike-perch Fishery, Estonia Wakatobi National Park, South East Sulawesi, Indonesia
	Changes in permitted activities many times during a single year at predetermined fixed rates (e.g. fishing allowed on public holidays, weekends etc.). For example , in an MPA in Spain, it is not permitted commercial fishing on Saturdays, Sundays, or public holidays. Recreational fishing is allowed only on weekends and two weekdays each week.	Levante de Mallorca - Cala Ratjada Marine Reserve, Spain
	Irregular closures for periodic harvesting on a non-predetermined schedule (closures may be from several months to several years, but opening date not set at point of closure).	Wakatobi National Park, South East Sulawesi, Indonesia
What species or individuals Approaches/Practices		
	Minimum size/weight restrictions. For example , in Fiji, the size limits on fish (defined by national law) through fishing net mesh sizes are defined locally.	Kubulau District Locally Managed Marine Area (LMMA), Bua Province, Fiji (2004)
	Target species restrictions. For example , in New Zealand, ITQ (individual transferable quotes) for all deepwater species.	New Zealand (trawling and dredging)
	"How fishing can occur" Approaches/Practices Once the catches of a relevant volume or number of ETP (Endangered, Threatened, Protected) species or VME (Vulnerable Marine Ecosystems) habitat forming species, the vessel will move a minimum of ?X'NM (safety distance of the ETP and VME) before continuing its activity.	Agarba vessels (Spanish fleet - Cod working on Norway EEZ)
	Use of new devices, such as semi-flexible exclusion grid to reduce bycatch of cetaceans, turtles and elasmobranchio. For example , in Australia, the use of semi-flexible exclusion grid with a bar spacing of 15.5 cm reduced dolphin bycatch trawl fishery by close to 50% and reduced the bycatch of sea turtles, large sharks and rays.	Western Australia (Pilbara) (trawl nets)
	Shift from mobile to static gear can reduce destructive impact.	Evaluation of Marine Protected Area Management Measures Concerning Fishing - UK
	For bird bycatch reduction, Bird-scaring lines or Tori lines can be introduced as a requirement of the license. For example , in South Africa Seabird bycatch reduction methods are now included in license conditions for the deep-sea trawl fishery.	South Africa



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



FISHERY



This publication was funded by the European Union. Its contents are the sole responsibility of the author(s) and do not necessarily reflect the views of the European Union.

Good Management Practices

Table 1 (Part 2) presents a non-exhaustive list of Good Management Practices (GMP) that should be considered during the planning stages of various activities associated with fishery sector. Whenever feasible, the examples provided pertain to areas under either a type of protection or in close proximity to marine protected areas. A brief description of GMP is provided, and for more detailed information, the source can be consulted.

Classification	Good Practice	Source
	"Who is allowed to fish" - Cultural and Community Approaches/Practices	
▲ ▲	Involvement of local communities in participatory management of important habitats for fishery community. <i>For example, In Ecuador and Peru the participatory management fishing communities are responsible for preserving and restoring ecosystems while monitoring the state of the biodiversity flora and fauna and reporting the loss of vegetation or species to the environmental authorities, thus working on implementing restoration actions.</i>	Artisanal, small-scale fisheries and mangrove restoration – Peru & Ecuador Koh Rong Archipelago Marine Fisheries Management Area, Preah Sihanouk Province, Cambodia (2016) Ulithi Atoll and associated islands, Outer Islands of Yap State, Federated States of Micronesia (centuries old)
▲	Cultural ties or residency as criteria for fishing permissions. <i>For example, in the Ulithi Atoll it is needed to have cultural ties or residency to have the permission to fish. In Cambodia, only residents can fish inside the MPA.</i>	Management Program: national Park of Puerto Morelos, Mexico Signilskär-Märket Islands (Finland)
▲ ▲	Fishing activity inside a MPA can require membership of fishing cooperative. <i>For example, in a MPA in Mexico, cooperative members are permitted to commercially fish in one zone where commercial fishing is prohibited for other park users while another zone is directly under concession to the cooperative giving them exclusive commercial fisheries access.</i>	Sihanouk Province, Cambodia (2016) Ulithi Atoll and associated islands, Outer Islands of Yap State, Federated States of Micronesia (centuries old)
▲ ▲	Negotiations between professional and recreational fishers for resource use. MPA fisheries management recognizing local wisdom, traditional knowledge, and customary management of the area. <i>For example, MPAs in eastern Indonesia formally designated period harvest closure zones that are under the management of the local community to decide when to restrict fishing. These zone may have customary fisheries management methods that have been in use for centuries.</i>	Management Program: national Park of Puerto Morelos, Mexico Signilskär-Märket Islands (Finland) Wakatobi National Park, South East Sulawesi, Indonesia
▲	In some areas it is not allowed industrial fishing (the majority of fishing is subsistence fishing). <i>Velondriake, Madagascar Sustainable Approaches/Practices</i>	Velondriake, Madagascar Sustainable Approaches/Practices
▲ ▲	To protect the environment, certain fishing practices, like using trap for catch of lobsters, should limit the time they cover a habitat. <i>For example, leaving traps on top for more than 6 weeks was found to harm seagrass. Therefore, it's recommended to recover traps within a 6-week timeframe, with the optimal soak period not exceeding 4 weeks.</i>	Caribbean (Florida Keys National Marine Sanctuary, USA) (traps)
●	Creation of physical barriers to hinder or impede illegal fishing activities. Example. Artistic sculptures on the seafloor	Artistic sculptures on the seafloor
●	Fishers are required to notify authority in advance of their fishing trip so that the authority can determine if an observer is needed.	USA federal EEZ and State waters of the Bering Sea-Aleutian Islands (pelagic trawling) USA federal EEZ and State waters of the Bering Sea-Aleutian Islands (pelagic trawling)
● ●	Large areas of sensitive habitats are closed to different levels of fishing (e.g. all bottom contact gear; all mobile bottom contact gear; no contact with bottom permitted).	USA federal EEZ and State waters of the Bering Sea-Aleutian Islands (pelagic trawling)
●	Gear marking can be implemented to facilitate an effective tracking of fishing gear and minimize loss of gear therefore reduce entanglements. <i>For example, in Atlantic Canada and Quebec gear marking is required for all non-tended fixed gear fisheries, including lobster and fishery (long-line; static gear) crab.</i>	Canada snow crab and lobster Quebec gear marking is required for all non-tended fixed gear fisheries, including lobster and fishery (long-line; static gear) crab.

Legend

- Triangle: Good practice in MPA // Circle: Good practice for MSP
- ▲ Oriented to the socio-ecosystem
- Oriented towards limiting the activity
- Oriented to the management process



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



3.4.4. Tourism Sectorial Sheet



General Information: This sectorial sheet is part of a series that includes five sectors central to the MSP4BIO Project: Aquaculture, Fishery, Marine non-living resources extraction, Renewable Energy, and Tourism. The overarching goal of this support material is to provide guidance to managers to better address activities in their marine protected areas (MPAs) following an integrated approach, while also supporting blue economy sectors/industry stakeholders to understand the impacts relevant for sectors operation. To this end, the factsheets provide information on the diverse impacts that activities within each sector may have on Ecosystem Services. Then, Good Management Practices to mitigate these impacts and facilitate the sustainable development of the respective sectors are facilitated. The entire set of sectorial sheets is designed to be a valuable resource for policymakers, aiding in trade-off analysis and addressing user-user and user-environment conflicts. More information can be found here: www.msp4bio.eu

Sector characteristics

Area-based marine conservation

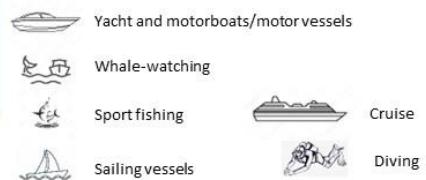
Tourism is a rapidly growing global industry, vital for achieving UN Sustainable Development Goals. However, it brings about social and environmental concerns, particularly in marine protected areas (MPAs). To make this revenue stream successful, proper management is crucial. The potential for significant revenue can lead to pressure on site managers to increase tourist numbers, potentially exceeding the site's capacity. Some MPAs combat this by focusing on high-quality tourism and forming partnerships with eco-friendly tour operators, rather than merely increasing visitor numbers. Sustainable tourism is an ongoing process that requires informed stakeholder participation and strong political leadership to ensure consensus and broad engagement.

This document provides an overview of the ecosystem services (ES) upon which the sector relies and those that it influences, as well as the associated pressures. It also highlights instances of successful management practices within the sector operating in MPAs, offering valuable insights for informed decision-making by managers.

Ecosystem Services main dependencies:

- Intellectual and representative interactions with environment (i.e. for researching, aesthetic experiences)
- Physical and experiential interactions with the environment (i.e. for sport and recreation)
- Spiritual, symbolic and other interactions with natural environment (e.g. national or locale emblem)

Activities



The Sankey Chart illustrates the flow of pressures, based on the MSFD, from each activity in the environment through Ecosystem Services (Figure 1). The primary pressures on the ecosystem include **biological disturbance and physical damage, and other physical disturbance**. These impacts predominantly affect **Nursery and habitat maintenance, Wild aquatic animals and maintenance of physical, chemical, abiotic conditions**, corresponding mainly to **Regulation & Maintenance** and **Provision** types of ecosystem services. The chart provides a visual representation of the intricate connections between activities, pressures, and their repercussions on specific ecosystem services. **IMPORTANT:** The analysis did not take into account the urban expansion needed to support coastal mass tourism which has a strong negative impact on ecosystem services ([Carranza et al., 2020](#)).

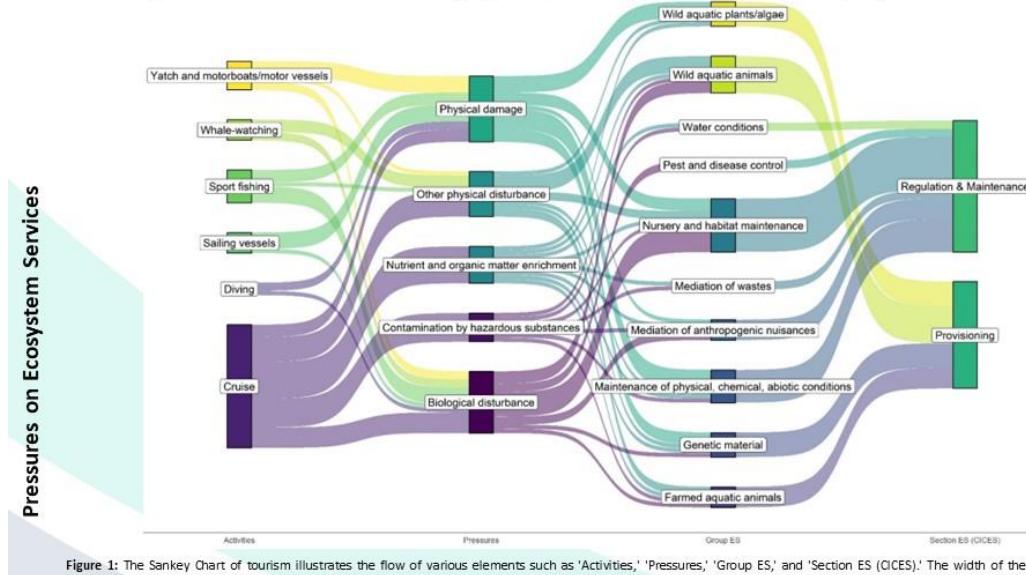


Figure 1: The Sankey Chart of tourism illustrates the flow of various elements such as 'Activities,' 'Pressures,' 'Group ES,' and 'Section ES (ICES). The width of the arrows and boxes is proportional to the quantity of the flow passing through them. This visual representation provides a clear depiction of the distribution and transformation of resources within the system. In summary, the absence of effective practices in the development of the tourism sector can pose potential risk to crucial ecosystem services (Figure 1). The joint sectorial sheets indicate the direct impact on ecosystem services vital for the sustainability of fisheries sectors, for example. The implementation of sound practices, such as ecotourism, as outlined below, is crucial for ensuring the long-term health and resilience of these Blue Economy sectors and the integrity of marine ecosystem. This not only safeguards the environment but also sustains the viability and prosperity of associated industries.



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



TOURISM



Good Management Practices

This publication was funded by the European Union. Its contents are the sole responsibility of the author(s) and do not necessarily reflect the views of the European Union.

Table 1 (part 1) presents a non-exhaustive list of Good Management Practices (GMP) that should be considered during the planning stages of various activities associated with tourism, specifically diving, sailing, sport-fishing, cruises and whale watching. Whenever feasible, the examples provided pertain to areas under either a type of protection or in close proximity to marine protected areas. A brief description of GMP is provided, and for more detailed information, the source can be consulted.

Classification	Good management practices	Source
Dive Tourism Management		
▲	Place mooring buoys to prevent anchor damage to the environment. Example: Coral reef Curacao.	Port-Cross Natural Park, France; Medes Island Archipelago Natural Park, Catalonia, Spain
▲	Regulate diver access through environmental-friendly codes of conduct. Dive masters and instructors to ensure that their clients meet the requirements set out in the code of conduct Encourage customers to purchase a 'dive tag'. Funds generated by the tags can be used in a variety of actions to support conservation. Example, funds can be used for research and monitoring programs.	Curacao, Netherlands Antilles - Private protection from a Dive Center (Easy Divers)
▲	A conservation fee can be charge to support management and conservation programs. For example, private management approach to coral reef conservation in Malaysia.	Sugud Islands Marine Conservation Area (SIMCA) in Sabah, Malaysia
▲	Carrying Capacity - Limit overall yearly dives in the MPA.	Medes Islands Archipelago Natural Park, Catalonia, Spain
▲	Use underwater footage from recreational divers for biodiversity research. Report any dives near protected heritage sites in advance.	Protected shipwreck sites (Belgium)
▲	Restrict diving during specific months and in certain areas.	
Sailing, yacht and motorboats		
▲	Implement speed limits for boats in various zones within the MPA.	Different MPAs in the Mediterranean
▲	Place and management of mooring buoys to prevent anchor damage to the environment.	
●	Promoting awareness among boat owners and captains regarding the significance of effectively managing on-board waste; fostering awareness and conducting inspections at marinas.	
Sport fishing		
▲	Some types of sport fishing can be regulated inside the protected areas to minimize the impact on species under protection. For example, spear-fishing in French protected areas is prohibited. In Italy and Spain amateur line-fishing is also prohibited in the central zone allowed in the rest of MPA sometimes with the need of a permit.	Different MPAs in the Mediterranean
▲	Set minimum catch sizes based on maturity size for vulnerable species.	Protected areas in the growing mediterranean blue economy - PHAROS4MPAs
▲	Promote collaborative systems for reporting and recovering lost fishing gear.	
▲	Establish enhanced protection zones for small-scale fishers.	
▲	Limit the catch weight for authorized recreational fishers.	
Cruise Tourism Environmental Practices:		
●	To reduce emissions, provide onshore power supply (OPS) from renewable energy to connect cruise ship. For example, in Hamburg's Cruise Terminal Altona connects cruise ships to shoreside electricity supplies solely with energy from sustainable sources.	Good practices for sustainable cruise tourism - Altona Port - Germany
●	Design of a sustainable cruise terminal that maximizes the advantages across different stakeholder groups and the city. For example, in the Port of Tallinn, Estonia the sustainable cruise terminal has had a positive environmental and social impact on the city.	Good practices for sustainable cruise tourism - Port of Tallinn, Estonia
●	Operationalization of the processing facilities of waste of cruise ships to recycle and energy production	Good practices for sustainable cruise tourism - Port of Stockholm (Sweden)
●	Environmental Ship Index (ESI) at-berth module that aims to improve transparency and clarity in the way cruise lines and operators provide ports with data on ship emissions at berth.	General
●	Establish permits for vessels entering protected areas like Glacier Bay.	
●	Charge fees and set environmental criteria to cruise line receive concession to enter in a particular area. For example, in the Glacier Bay () the concession is given for cruise lines with highest score in the following criterias i) air pollution reduction measures; ii) water quality measures; and iii) measures to conserve marine mammals.	Glacier Bay (USA/Canada)

Legend: Triangle: Good practice in MPA // Circle: Good practice for MSB
 ●▲ Oriented to the socio-ecosystem ●○ Oriented to the development of the activity
 ●△ Oriented towards limiting the activity ●● Oriented to the management process



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



TOURISM



This publication was funded by the European Union. Its contents are the sole responsibility of the author(s) and do not necessarily reflect the views of the European Union.

Good Management Practices

Table 1 (part 1) presents a non-exhaustive list of Good Management Practices (GMP) that should be considered during the planning stages of various activities associated with tourism, specifically diving, sailing, sport-fishing, cruises and whale watching. Whenever feasible, the examples provided pertain to areas under either a type of protection or in close proximity to marine protected areas. A brief description of GMP is provided, and for more detailed information, the source can be consulted.

Classification	Good management practice	Source
	Whale Watching Guidelines	
	1. General Guidelines Increase public awareness and management plan development. Adopt environmental measures for impact reduction. Use 'umbrella species' to protect ecological communities.	Western Ligurian Sea and Genoa Canyon (Italy)
	2. General guidelines watercrafts Operate to avoid disrupting marine mammals. For example, watercraft speed; distance from the marine mammal (e.g., Caution zones and no-approach zone); number of watercraft in the zone of the marine mammal; engines swift-off.	Wider Caribbean Region (WCR) Vancouver Island North Scotland Wider Caribbean Region (WCR) Vancouver Island North
	Have a Code of Conduct to be followed. For example , i) approach the marine mammal from the side and slightly to the rear of the animal. Avoid approaches from head on or directly from behind; ii) whale flag when their vessel is engaged in whale and dolphin watching to alert other boaters that there are whales nearby and that they should be vigilant; iii) Let the animals be in control of the entire encounter. They should choose how close to approach. If they choose not to interact, or to depart, this should be respected; and iv) when animals are moving in a consistent direction, maintain a steady parallel course. Do not approach from directly behind, and do not cut them off by moving across their path.	Scotland
	3. Underwater Activities and Licensing: Restrict underwater activities and limit swimmers with marine mammals or group of marine mammals. Wider Caribbean Region (WCR) Swimmers should be also accompanied by appropriate trained local guide.	Wider Caribbean Region (WCR) Vancouver Island North
	Licensing and controlling for activities requiring disturbance. For example , research or underwater flash photography and filming sound should not be allowed.	Vancouver Island North

Legend: Triangle: Good practice in MPA // Circle: Good practice for MSP
 Oriented to the socio-ecosystem Oriented to the development of the activity
 Oriented towards limiting the activity Oriented to the management process



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



3.4.5. Aquaculture Sectorial Sheet



General Information: This sectorial sheet is part of a series that includes five sectors central to the MSP4Bio Project: Aquaculture, Fishery, Non-living marine resources extraction, Renewable Energy, and Tourism. The overarching goal of this support material is to provide guidance to managers to better address activities in their marine protected areas (MPAs) following an integrated approach, while also supporting blue economy sectors/industry stakeholders to understand the impacts relevant for sectors operation. To this end, the factsheets provide information on the diverse impacts that activities within each sector may have on Ecosystem Services. Then, Good Management Practices to mitigate these impacts and facilitate the sustainable development of the respective sectors are facilitated. The entire set of sectorial sheets is designed to be a valuable resource for policymakers, aiding in trade-off analysis and addressing user-user and user-environment conflicts. More information can be found here: www.msp4bio.eu

Sector characteristics

Area-based marine conservation: In the EU, aquaculture production holds significant importance for numerous coastal regions. It is crucial that this sector within the EU adheres to the requirements of the Habitats Directive, ensuring alignment with the conservation objectives of Natura 2000 sites and other MPAs. There are multiple compelling examples of sustainable aquaculture development that contribute to environmental preservation and the enhancement of biodiversity. These aquaculture systems can coexist harmoniously with sensitive habitats, providing valuable environmental benefits and services. Within numerous MPAs, aquaculture activities are conducted in a manner fully consistent with the preservation of the natural values of these sites. This demonstrates the potential for aquaculture to serve as a responsible steward of these critical conservation areas.

This document provides an overview of the ecosystem services (ES) upon which the sector relies and those that it influences, as well as the associated pressures. It also highlights instances of successful management practices within the sector operating in MPAs, offering valuable insights for informed decision-making by managers.

Ecosystem Services main dependencies:

- Cultivated aquatic plants and reared aquatic animals for nutrition, materials or energy
- Wild aquatic plants and animals (i.e. for feeding or post-fattening)
- Pest and disease control

Activities

General aquaculture including:

- Shellfish farming
- Shellfish hatcheries and mussel seed fisheries
- Marine finfish farming
- Integrated aquaculture

Pressures on Ecosystem Services

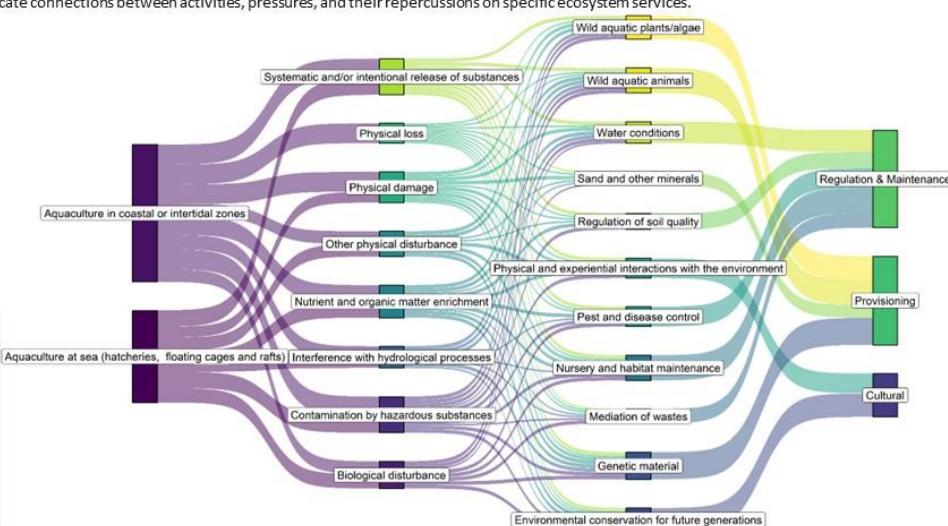


Figure 1: The Sankey Chart of aquaculture illustrates the flow of various elements such as 'Activities,' 'Pressures,' 'Group ES,' and 'Section ES (CICES).' The width of the arrows and boxes is proportional to the quantity of the flow passing through them. This visual representation provides a clear depiction of the distribution and transformation of resources within the system.

In summary, the absence of effective practices in the development of the aquaculture sector can pose potential risk to crucial ecosystem services (Figure 1). The joint sectoral sheets indicate the direct impact on ecosystem services vital for the sustainability of both Aquaculture and Fisheries sectors. The implementation of sound practices, as outlined below, is crucial for ensuring the long-term health and resilience of these Blue Economy sectors and the integrity of marine ecosystem. This not only safeguards the environment but also sustains the viability and prosperity of associated industries.



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



AQUACULTURE



Good management practices

This publication was funded by the European Union. Its contents are the sole responsibility of the authors) and do not necessarily reflect the views of the European Union.

Table 1 presents a non-exhaustive list of Good Management Practices (GMP) that should be considered during the planning stages of various activities associated with aquaculture. Whenever feasible, the examples provided pertain to areas under either a type of protection or in close proximity to marine protected areas. A brief description of GMP is provided, and for more detailed information, the source can be consulted.

Category	Good management practices	Source
1. MPA Buffer Zone Regulations:	<ul style="list-style-type: none"> a. Aquaculture allowed if compliant with organic fish farming regulations. (Madeira - Portugal) 	POGRAMPPS - Network of MPAs of Porto Santo (Madeira)
2. Habitats Regulation Appraisal (HRA):	<ul style="list-style-type: none"> a. Required for projects to ensure no adverse effects on site integrity. 	Scotland's National Marine Plan
4. Regional Collaboration:	<ul style="list-style-type: none"> a. Local knowledge in the development of good practices. <i>Example: Experienced aquaculture farmers in Provence-Alpes-Côte d'Azur (PACA) region collaborate for quality fish production.</i> 	Mayotte, Parc National des Calanques (France)
5. Artisanal Fish Farming Commitments:	<ul style="list-style-type: none"> a. Code of Good Practice: Voluntary guidelines addressing cage design, prophylaxis, and operational practices. b. Development and agreement among artisanal fish farming to follow best practices and the development of the activity. <i>Example: Open sea farming commitment to natural growth, healthy diet, and extreme freshness (no more than 48h from capture to deliver).</i> 	Scotland's National Marine Plan Mayotte, Parc National des Calanques (France)
6. Organic "BIO" Label and Farming Methods:	<ul style="list-style-type: none"> a. Use of a label to certify the environmentally friendly production in terms of the fish comfort and methods utilized. It should lower rearing costs, top-quality water, and organic methods emphasizing low densities and optimal growth. 	Mayotte, Parc National des Calanques (France)
7. Natura 2000 Area Considerations:	<ul style="list-style-type: none"> a. Comprehensive investigations for new fish farms in designated areas, safety zones during nesting times. b. Use specific guidance to prevent impacts on ecosystems within Natura 2000 sites. Reference: "Assessment of plans and projects significantly affecting Natura 2000 sites. Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC" 	Southwest Finland and Satakunta General EU - Habitats Directive
8. Community-Based Contracts:	<ul style="list-style-type: none"> a. Collaborative farming initiatives for marine species that produce little environmental impact, with positive effects on local ecosystems (through reduction of fishing pressure) and on livelihoods resilience through income diversification. <i>Example: Sea cucumbers and seaweed with positive environmental impact.</i> b. Sea Garden Community in Ebeltoft harbor (Denmark). - Collaborative shellfish and seaweed small scale farming for the local community with the aim to restore life to fishing ports and contribute to a cleaner environment. The association includes different types of stakeholders and an active cooperation with other associations, institutions and business 	Velondriake Locally Managed Marine Area, Madagascar Sea Garden Community
9. General Planning Rules based on:	<ul style="list-style-type: none"> a. <i>Habitat Feature Sensitivity Matrices:</i> Risk assessment based on feature-specific matrices and environmental monitoring data. Risk matrices and environmental monitoring data from existing sites quantifying aquaculture x MPA feature interactions; b. <i>Adaptive Risk Management:</i> Informed aquaculture developments in MPAs based on ongoing monitoring and comparison with reference sites inside or outside an MPA. c. <i>Ecosystem Service Tools:</i> Tools to quantify benefits like habitat provisioning, coastal protection, nutrient regulation, and carbon sequestration. 	England MPAs
10. Integrated Multi-Trophic Aquaculture	<ul style="list-style-type: none"> Educational awareness and increase the importance of aquaculture in society Integrated multi-trophic aquaculture to improve efficiency, reduce waste and provide ecosystem services, such as bioremediation 	

Legend: Triangle: Good practice in MPA // Circle: Good practice for MSP
 Oriented to the socio-ecosystem
 Oriented to the development of the activity
 Oriented towards limiting the activity
 Oriented to the management process



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



3.4.6. Marine non-living resources extraction Sectorial Sheet

Marine Non-living Resources

This publication was funded by the European Union. Its contents are the sole responsibility of the authors and do not necessarily reflect the views of the European Union.

General Information: This sectorial sheet is part of a series that includes five sectors central to the MSP4BIO Project: Aquaculture, Fishery, Marine non-living resources extraction, Renewable Energy, and Tourism. The overarching goal of this support material is to provide guidance to managers to better address activities in their marine protected areas (MPAs) following an integrated approach, while also supporting blue economy sectors/industry stakeholders to understand the impacts relevant for sectors operation. To this end, the factsheets provide information on the diverse impacts that activities within each sector may have on Ecosystem Services. Then, Good Management Practices to mitigate these impacts and facilitate the sustainable development of the respective sectors are facilitated. The entire set of sectorial sheets is designed to be a valuable resource for policymakers, aiding in trade-off analysis and addressing user-user and user-environment conflicts. More information can be found here: www.msp4bio.eu

Area-based marine conservation

This document provides an overview of the ecosystem services (ES) upon which the marine non-living resources extraction related sector relies and those that it influences, as well as the associated pressures. It also highlights instances of successful management practices within the sector operating in MPAs, offering valuable insights for informed decision-making by managers. It is important to highlight that among the non-living marine resources related activities, seabed mining represents a significant threat to our oceans. The limited scientific understanding of the deep-sea environment and the technology used hinders our capacity to forecast the environmental consequences of mining activities and to measure the potential for habitat recovery post-disturbance. IUCN strongly advises against any mineral resource exploration and extraction within protected areas categorized as IUCN Protected Areas Management Categories I to IV, advocating for legal prohibitions. Moreover, projects within Category V and VI sites should undergo rigorous Environmental Impact Assessments to ensure comprehensive evaluation of potential impacts.

Ecosystem Services main dependencies:

- Mineral substances used for nutrition, materials or energy (i.e. sand, industrial materials, gas, oil)
- Regulation of soil quality

Activities

- Offshore oil and gas extraction
- Dredging
- Deep-sea mining¹

¹ Deep-sea mining rises many concerns among the governments, environmentalists and researchers due to the lack of knowledge of the impacts it can cause in the marine environment. Many countries have taken measures to stop the development of this activity supporting a ban, moratorium or precautionary pause on deep sea mining, for example, Spain, Portugal, Germany, Ireland, among others.

The Sankey Chart illustrates the flow of pressures (based on the MSFD) from each activity in the environment through Ecosystem Services (Figure 1). The primary pressures on the ecosystem include **physical damage**, **physical loss** and **contamination by hazardous substances**. These impacts predominantly affect **Wild aquatic plants/algae**, **Wild aquatic animals**, and **Nursery and habitat maintenance**, corresponding mainly to **Regulation & Maintenance** and **Provision** types of ecosystem services. The chart provides a visual representation of the intricate connections between activities, pressures, and their repercussions on specific ecosystem services.

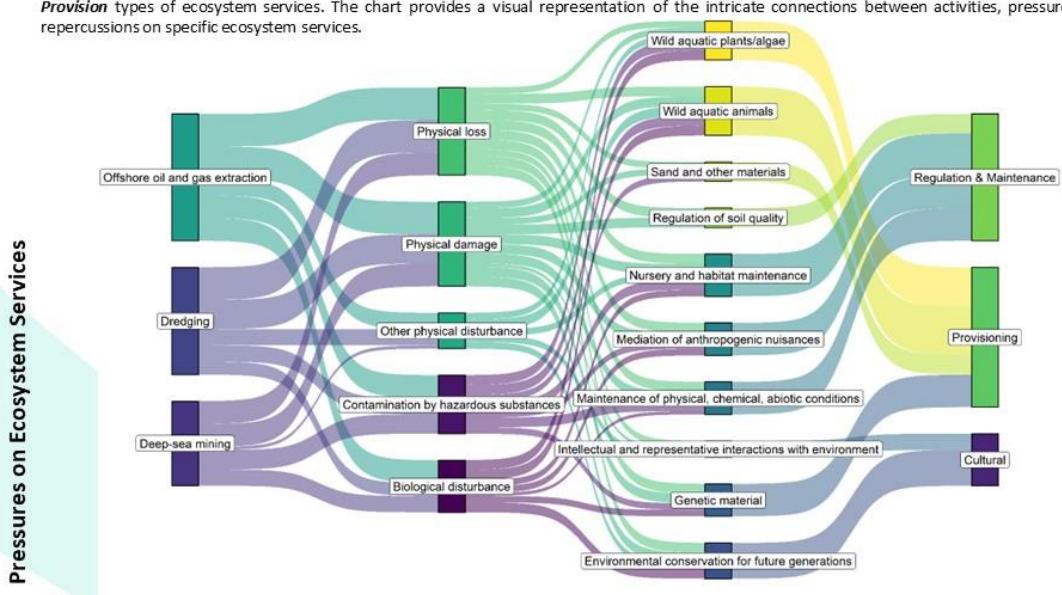


Figure 1: The Sankey Chart of marine non-living resources extraction illustrates the flow of various elements such as 'Activities,' 'Pressures,' 'Group ES,' and 'Section ES (CICES).' The width of the arrows and boxes is proportional to the quantity of the flow passing through them. This visual representation provides a clear depiction of the distribution and transformation of resources within the system.

In summary, the absence of effective practices in the development of the marine non-living resources extraction sector can pose potential risk to crucial ecosystem services (Figure 1). The joint sectorial sheets indicate the direct impact on ecosystem services vital for the sustainability of both Aquaculture and Fisheries sectors. The implementation of sound practices, as outlined below, is crucial for ensuring the long-term health and resilience of these Blue Economy sectors and the integrity of marine ecosystem. This not only safeguards the environment but also sustains the viability and prosperity of associated industries.



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Marine Non-living Resources



This publication was funded by the European Union. Its contents are the sole responsibility of the authors and do not necessarily reflect the views of the European Union.

Good management Practices

Table 1 presents a non-exhaustive list of Good Management Practices (GMP) that should be considered during the planning stages of various activities associated with marine non-living resources extraction, specifically deep-sea mining and dredging. Whenever feasible, the examples provided pertain to areas under either a type of protection or in close proximity to marine protected areas. A brief description of GMP is provided, and for more detailed information, the source can be consulted.

Classification	Good management practices	Examples/Source
	A - Deep-sea Mining:	
●	1. Plan and implement protected areas previous than mineral exploration started. <i>Example: In the abyssal plain of Clarion-Clipperton Zone (CCZ), protected areas must be identified two years previous any mineral exploration throughout the identification of Areas of Particular Environmental Interest (APEIs), later protected from all mining activities.</i>	ISA - Environmental management plan for Clarion-Clipperton Zone
●	2. Code for environmental management of marine mining - model for legally binding legislation on marine mining	General
●	3. Establish temporary reserve area of similar size and character to the one being explored to serve as a possible source for natural repopulation of the mine site. <i>Example: Papua New Guinea mineral extraction.</i>	Papua New Guinea
● ●	4. Use Regional Environmental Management Plans (REMPs) to protect the sea environment.	General
● ●	5. Encourage mining companies to study the environment outside their mining areas.	ISA - Northern Mid-Atlantic Ridge
●	6. A zoning scheme should be developed before any exploitation activities, for example, a core zone of full protection to maintain the sustainability of biological populations; a buffer zone of sufficient size to protect the core zone from indirect effects. <i>For example: In the Clarion-Clipperton Zone (Pacific Ocean) the following measures were taken: i) Establish MPAs at least two years prior to prototype mining; ii) identified 'Areas of Particular Environmental Interest', surrounded by a buffer zone extending 100 km in each direction.</i>	ISA - Northern Mid-Atlantic Ridge Seabed Authority environmental management plan
●	7. Look for ways to reuse, recycle, and design products more sustainably. Circular Economy	General
	B - Dredging:	
●	1. Importance of EMS Data:	
●	a. Quantitative analysis of dredging impact, supporting monitoring process.	
●	b. Voluntary Initiative for Information Sharing: Industry and Crown Estate share aggregate extraction data every six months. Open access on the internet to reduce adverse interactions with other sectors.	Belgium
● ●	2. Annual Reports Using EMS Data:	
● ●	a. Annual summaries guide environmental performance reports, highlighting regional differences in dredging patterns. This analysis support industry to control and manage extraction operations.	
● ●	3. Seabed Mapping and Archaeological Considerations:	United Kingdom
● ●	a. Seabed mapping before dredging to locate wrecks, debris and submerged prehistoric landscapes.	
● ●	b. Restrictions in area archaeological features are encountered. Exclusion zones should be employed.	
● ●	c. Protocols of safe operation: i) stop activities for historical, archaeological, or scientific findings; ii) for new findings (historical, archaeological and or scientific) reporting to competent authorities and adjust Netherlands operation to minimize further impact; iii) establishment of buffer zones around this new findings.	
	4. Environmental aspects:	
●	a. Provide a means for the returning of a species to re-establish in the environment. <i>For example: Re-seeding i.e., Scallop shell seeding for quick species return. Resulting in a return of 70% of species in seven months, which would have required more than five years for natural recolonization.</i>	United Kingdom
●	b. Use of exclusion zones to protect sensitive features.	
	C - Oil and Gas	
● ●	Decommission: Use the oil and gas infrastructure to create artificial reefs. In the Gulf of Mexico, oil and gas operator may choose to work with local government in a Rigs-to-Reef program minimizing decommissioning costs and improving biodiversity.	Oil & Gas Platforms in the Gulf of Mexico, United States

Legend

Triangle: Good practice in MPA // Circle: Good practice for MSP
 ●▲ Oriented to the socio-ecosystem // ●○ Oriented to the development of the activity
 ●△ Oriented towards limiting the activity // ●● Oriented to the management process



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



3.4.7. Renewables Sectorial Sheet



General Information: This sectorial sheet is part of a series that includes five sectors central to the MSP4BIO Project: Aquaculture, Fishery, Marine non-living resources extraction, Renewable Energy, and Tourism. The overarching goal of this support material is to provide guidance to managers to better address activities in their marine protected areas (MPAs) following an integrated approach, while also supporting blue economy sectors/industry stakeholders to understand the impacts relevant for sectors operation. To this end, the factsheets provide information on the diverse impacts that activities within each sector may have on Ecosystem Services. Then, Good Management Practices to mitigate these impacts and facilitate the sustainable development of the respective sectors are facilitated. The entire set of sectorial sheets is designed to be a valuable resource for policymakers, aiding in trade-off analysis and addressing user-user and user-environment conflicts. More information can be found here: www.msp4bio.eu

Sector characteristics

Area-based marine conservation

Climate change poses a significant threat to global marine ecosystems, with rising sea levels and warming oceans jeopardizing the future of marine biodiversity. A profound shift away from fossil fuels towards a zero-carbon energy future is imperative throughout Europe and worldwide. Offshore renewable energy is already being recognized as the protagonist driving this essential change, resulting in a substantial expansion of the sector within the marine realm. Simultaneously, establishing well-managed MPAs is essential to enhance the resilience of European seas to climate change impacts and restore their ecosystems to a healthy state. This approach fosters a Sustainable Blue Economy and ensures the delivery of essential ecosystem services for the maintenance of healthy seas. This document provides an overview of the ecosystem services (ES) upon which the sector relies and those that it influences, as well as the associated pressures. It also brings examples of good practices that minimise negative impacts and maximise possible synergies to ensure a healthy state of the marine ecosystem, offering valuable insights for informed decision-making and a sustainable development of the sector.

Ecosystem Services main dependencies:

- Non-mineral substances or ecosystem properties used for energy (i.e. wind, solar)
- Water used for energy (i.e. tidal power)
- Cultivated aquatic plants for energy (i.e. biomass)

Activities



Ocean energy - Tidal
Wind farms
Ocean energy - Wave

The Sankey Chart illustrates the flow of pressures, based on the MSFD, from each activity in the environment through Ecosystem Services (Figure 1). The primary pressures on the ecosystem include **physical damage** and **physical loss**. These impacts predominantly affect **Wild aquatic plants/algae**, **regulation of soil**, **maintenance of physical, chemical, abiotic conditions** and **Genetic material**, corresponding mainly to **Regulation & Maintenance** and **Provision** types of ecosystem services. The chart provides a visual representation of the intricate connections between activities, pressures, and their repercussions on specific ecosystem services.

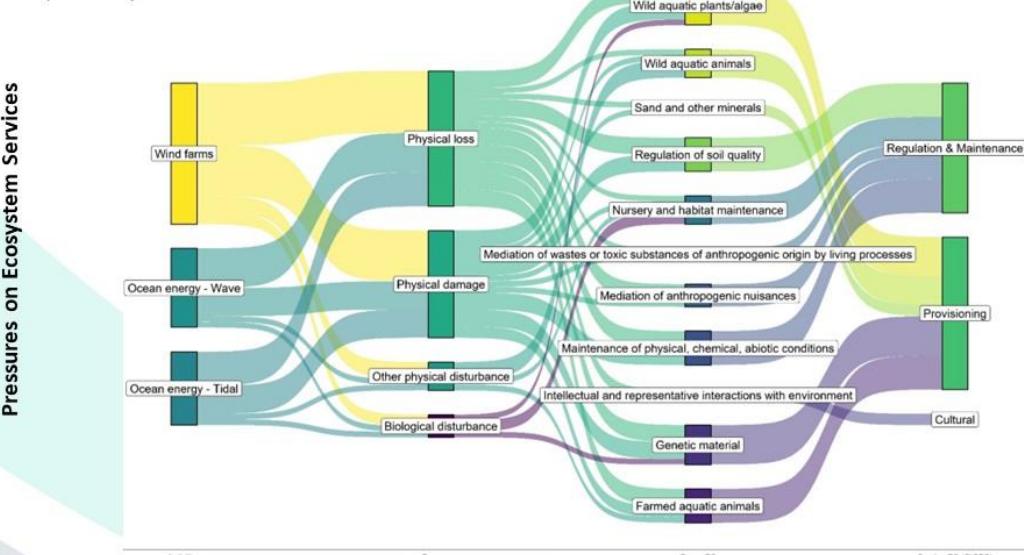


Figure 1: The Sankey Chart of Renewables Energy illustrates the flow of various elements such as 'Activities,' 'Pressures,' 'Group ES,' and 'Section ES (CICES).' The width of the arrows and boxes is proportional to the quantity of the flow passing through them. This visual representation provides a clear depiction of the distribution and transformation of resources within the system.

In summary, the absence of effective practices in the development of the renewable energy sector can pose potential risk to crucial ecosystem services (Figure 1). The joint sectoral sheets indicate the direct impact on ecosystem services vital for the sustainability of both Aquaculture and Fisheries sectors. The implementation of sound practices, like multi-uses, as outlined below, is crucial for ensuring the long-term health and resilience of these Blue Economy sectors and the integrity of marine ecosystem. This not only safeguards the environment but also sustains the viability and prosperity of associated industries.



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



RENEWABLES



This publication was funded by the European Union. Its contents are the sole responsibility of the author(s) and do not necessarily reflect the views of the European Union.

Good Management Practices

Table 1 (part 1) presents a non-exhaustive list of Good Management Practices (GMP) that should be considered during the planning stages of various activities associated with renewable energy, specifically wind farms and ocean energy (tide and wave). Whenever feasible, the examples provided pertain to areas under either a type of protection or in close proximity to marine protected areas. A brief description of GMP is provided, and for more detailed information, the source can be consulted.

Classification	Good Management Practices	Source
Offshore Wind Farms (OWF)		
1. Planning and site selection		
a. Design buffer zones on a case-by-case basis, taking into account the specific technical and ecological characteristics of the protected area.	Mediterranean marine protected areas	
b. Plan and share grid connections between multiples OWFs creating appropriate routes for cable trenches to optimize the use of available infrastructure, minimizing environmental impact.	Mediterranean blue economy Recommendations	
c. Alternative installation methods should be explored to minimize environmental impact. <i>Example: tripod, jacket, gravity foundations or nature-inclusive design approach for infrastructures.</i>	Renewable energy technologies and migratory species: guidelines for sustainable deployment	
d. Sensitivity maps in the MSP process can be used to inform the selection of suitable sites.	Mediterranean blue economy Recommendations	
2. Environmental impact mitigation		
a. Employ techniques that minimize sediment resuspension, and noise during both cable laying and infrastructure construction. <i>Example: horizontal drilling for cable laying and bubble curtains for noise.</i>	Mediterranean blue economy Recommendations	
b. Opt for burying/shielding cables with eco-friendly materials that facilitate habitat regrowth. <i>Example: Concrete.</i>	Canary Islands - Concrete	
c. New solutions to address spills and alternatives for toxic antifouling methods should be explored. <i>Example: Vegetable-based hydraulic fluids for spills and less toxic alternatives for antifouling chemicals.</i>	Mediterranean blue economy Recommendations	
d. Turbine layouts should be planned to avoid barrier effects: placing turbines parallel to migration routes, planning corridors between clusters for safe flight routes, and increase space underneath rotor blades to reduce collision rates for local birds.	Renewable energy technologies and migratory species: guidelines for sustainable deployment	
3. Decommissioning		
a. It should be considered leaving some windfarm infrastructure in place during decommissioning if it has led to the development of a significant ecological community on the hard substrata.	Mitigating biodiversity impacts associated with solar and wind energy	
Multi Use sector-sector and sector-environment		
a. Sector-environment		
Nature enhancement: Well manage, the addition of hard subtract and exclusion of benthic disturbance like bottom trawling give the opportunity for benthic habitat recover. <i>Example: in the Dutch North Sea oyster restoration is been developed in wind farms areas.</i>	Nature enhancement in offshore wind farms, the Netherlands	
Inclusive design: Explore designs for the underwater portions of wind turbines to promote colonization and provide shelter opportunities for marine organisms, while also accommodating aquaculture needs.	Strangford Lough - Northern Ireland	
b. Sector-sector		
Wind-farm and fishery: Define zone areas that is preferred site for large-scale renewable energy projects, at and create conditions to ensure that other activities such as habitat protection, tourism, fisheries, and research are not impeded, but promoted. <i>Example: In Rhode Island, commercial fishing occurs within the wind farm on fair weather days.</i>	Fishing, Offshore Wind Energy & Tourism in the Block Island wind farm, United States	
Wind-farm and aquaculture: Inclusive design combining the development of deep-sea floating wind energy and aquaculture. <i>Example: The European project, Aquawind, aims to achieve a practical demonstration of a multi-use (MU) integrated solution to offshore renewable energy developments, joining an existing marine renewable energy production prototype with an innovative finfish aquaculture solution.</i>	Aquawind Project	
Wind-farm and Tourism: Offshore wind site used for tourism and recreation. Example: In Denmark, the local cooperative that owns and manages the wind farm offers guided tours in collaboration with boat companies, organizing 30 to 40 trips every year.	Middelgrunden offshore wind farm - Copenhagen (Denmark)	

Legend
Triangle: Good practice in MPA // Circle: Good practice for MSP
 Oriented to the socio-ecosystem Oriented to the development of the activity
 Oriented towards limiting the activity Oriented to the management process



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



RENEWABLES



This publication was funded by the European Union. Its contents are the sole responsibility of the authors) and do not necessarily reflect the views of the European Union.

Good Management Practices

Table 1 (part 2) presents a non-exhaustive list of Good Management Practices (GMP) that should be considered during the planning stages of various activities associated with renewable energy, specifically wind farms and ocean energy (tide and wave). Whenever feasible, the examples provided pertain to areas under either a type of protection or in close proximity to marine protected areas. A brief description of GMP is provided, and for more detailed information, the source can be consulted.

Classification	Good Management Practices	Source
Ocean energy (tide and waves)		
1. Planning and site selection		
▲ △	Site selection and review process to avoid major migration corridors and sensitive habitats. <i>Example: set up on-board observers to prevent disturbance to visible migrating marine species (turtles, marine mammals, etc.)</i>	Cape Breton Coastal Region inclusive of the Bras d'Or Lakes Biosphere Region
2. Environmental impact mitigation		
●	a. Installation of noise-deflecting devices during phases will proactively prevent physiological impacts on marine life.	Makah Bay - Pacific North West
●	b. Undersea cables within ocean energy development arrays and landfall connections can be buried to minimize Electric Magnetic Field (EMF) impacts. <i>Example: Faraday cages for EMF elimination around wave energy devices</i>	Renewable energy technologies and migratory species: guidelines for sustainable deployment
●	c. Enhance spill mitigation efforts by adopting vegetable-based hydraulic fluids instead of petroleum-based alternatives.	Renewable energy technologies and migratory species:
●	d. Assessment to determine the compatibility of energy installations with the maintenance or recovery of vulnerable species. <i>Example: optimize conditions for colonization, provide shelter opportunities, and address aquaculture needs within marine environments</i>	Strangford, County Down, Northern Ireland
●	e. Minimizing the use of slack or loose tether and anchor lines during installation and operation activities could prevent entanglement risk to marine species	Pacific North West
3. Long-term biodiversity		
● ●	Long lifespan of structures and possibility for sites to remain in place once decommissioned offer long-term protection once construction is complete.	Strangford, County Down, Northern Ireland
Socio economic (for both)		
1.	Optimize land use for socio-economic benefits	
▲ △	Allocate additional space for various activities to minimize socio-economic impacts associated with implementing energy installations and protected areas.	
2.	Implement effective monitoring practices	
▲	Conduct pre-construction surveys and routine monitoring of installation sites during operation to enhance monitoring and management capabilities.	Compatibility of offshore energy installations with marine protected area
3.	Facilitate stakeholder engagement for sustainability	
▲ △	Create opportunities for stakeholder engagement with developers to enhance sustainability credentials and implement best environmental practices.	

Legend: Triangle: Good practice in MPA // Circle: Good practice for MSP
●▲ Oriented to the socio-ecosystem ●△ Oriented to the development of the activity
●● Oriented towards limiting the activity ●○ Oriented to the management process



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



4. Conclusion and recommendations

This work culminates in a comprehensive guideline for navigating the expansion of blue economy sectors, namely aquaculture, tourism, renewables, fishery, and Marine non-living resources. The emphasis lies in a holistic approach, particularly focusing on their potential impacts on ecosystem services – socio-ecological system flow. By pinpointing primary pressures, the guideline facilitates the identification of targeted actions to minimize their adverse effects. To support better a more sustainable implementation of these sectors, a non- exhaustive list of good practices is provided to guide the transition towards a sustainable and resilient socio-ecological system, ensuring the enduring health and vitality of the blue environment.

In general, the use of ecosystem services flow is essential for the sustainable management of social-ecological systems: this visual representation serves as a powerful aid for conveying nuanced findings, offering a detailed exploration of the impact dynamics within the blue economy sectors. It offers stakeholders and decision-makers a holistic view of the intricate interplay between activities, pressures, and their consequences on key ecosystem services.

The sectorial sheets efficiently encapsulate the outcomes of the analyses for aquaculture, fisheries, Marine non-living resources, renewables, and tourism. By offering concise overviews, these sheets serve as valuable references, shedding light on the intricate interplay of activities, pressures, and impacts on ecosystem services within each sector. The inclusion of Sankey charts and recommended good management practices further enhances their utility in promoting sustainable practices across the diverse domains of the blue economy.

As part of our final remarks and recommendations, a concise guide titled '***On the Use of Sectorial Sheets***' is presented below. This guide, together with the sectorial sheets serve to support discussions related to the marine environment, offering insights and suggestions to address various socio-ecosystem issues. It illustrates the flow of interactions and potential solutions, although it is not site-oriented.

Moreover, considering that this work is a part of the MSP4BIO project, specifically contributing to a broader ecological-socioeconomic (ESE) management framework, the authors offer additional guidance. In '***Incorporating D4.1 (ESE 2) and D4.2 (ESE 3) into the ESE framework – MSP4BIO Project***' the authors provide general insights on how to integrate these results seamlessly into the final framework. This comprehensive guideline aims to enhance the applicability and impact of the research within the larger context of the project, ensuring a cohesive and meaningful contribution to the overall objectives of the MSP4BIO initiative.

a) On the use of sectorial sheets

Firstly, it is essential to have minimal information to apply the sector factsheets correctly. Specifically, it is necessary to understand the objectives of the area to be managed and the activities taking place in it. Additionally, the most important



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



ecosystem services present in this space must be identified. Starting from this information, the following instructions, need to be followed step by step:

- ❖ **Step 1.** Identify in the sector factsheets the activities taking place in a work area for each sector considered.
- ❖ **Step 2.** Observe in the Sankey diagram the potential relationships between activities, the pressures they exert, and the ecosystem services that will be affected.
- ❖ **Step 3.** Contrast the potential impacts on ecosystem services from the activities in the managed area with the established objectives for it.
- ❖ **Step 4.** Get inspired by some of the best management measures to correct existing/potential deviations in a work area based on the objectives to be achieved.

b) Incorporating D4.1 (ESE 2) and D4.2 (ESE 3) into the ESE framework – MSP4BIO Project

Starting from the application of D4.1 (Pegorelli et al., 2023) and D4.2 (present work), methods and results in test sites, the ESE framework is being created by linking test site specificities and their planning / management needs to the “solutions” (criteria, practices, tools) provided by MSP4BIO project. In addition to the ones prepared under D4.1 (ESE2) and D4.2 (ESE3), criteria, practices and tools identified/created under WP3 (ESE 1), as well as those provided under Deliverable 4.3 on trade-off analysis and management (ESE 3) (Gutierrez et al., 2024), are also being incorporated in the ESE framework (see Figure 3 of Matczak et al. (2024) in Annex IV). The ESE framework will answer to test site needs, and, in its final version, it will be available as a general framework for application beyond the project, providing solutions to general and specific planning and management questions and needs, related with MPAs and biodiversity protection in the context of MSP.

This sequential method used for D4.1 and D4.2 enables the grounding of the ESE framework in the real context of each working area, using integrative criteria that consider existing relationships between nature, social and economic fields, thus approaching the area as a socio-ecosystem. It also provides tools and selected best practices to address identified trade-offs, thereby improving the management of the area. This step-by-step methodology will be incorporated in the development of the MSP4BIO ESE framework.

More specifically, the main contributions made by deliverables 4.1 (D4.1) and 4.2 (D4.2) are highlighted:

- In Pegorelli et al. (2023) (ESE 2), the main socio-economic and governance criteria to be considered for managing each test site were identified for different types of spatial management approach (MSP, and different levels of MPA based on IUCN's classification). Additionally, the most important ES related to the prioritized socio-economic criteria in each test site is provided.



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



- In the present work (ESE 3) relates ES impacted to activities that can be carried out by the sectors chosen for each test site. It also includes a selection of best practices available to improve the management of these activities.

The aforementioned contributions are related to the ESE framework in three different ways:

On one hand, socio-economic and governance criteria help establish a specific baseline for each test site from which to begin working. As observed in Pegorelli et al., (2023), socio-economic criteria vary significantly among case studies, reflecting the diverse social, economic, and cultural contexts to which the ESE model must be able to respond.

On the other hand, by establishing existing relationships between socio-economic criteria and ES, ESE 3 facilitated the linking of criteria to activities carried out and the impacts these activities may have on them. Consequently, it highlighted how these activities could affect the achievement of socio-economic criteria identified as priorities (ESE 2).

Finally, the present work provides a collection of best practices available to enhance the sustainability of different activities in the marine environment. This aids managers in achieving better outcomes in addressing trade-offs while also supporting blue economy sectors/industry stakeholders to understand the impacts relevant of sectors' operation, which are addressed through the SeaSketch or similar tool in Task 4.3 (ESE 3) of the Project (Gutierrez et al., 2024). Figure 2 illustrates the connection between ESE 2 and ESE 3 to the final ESE Framework in the context of Ecosystem Services.



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

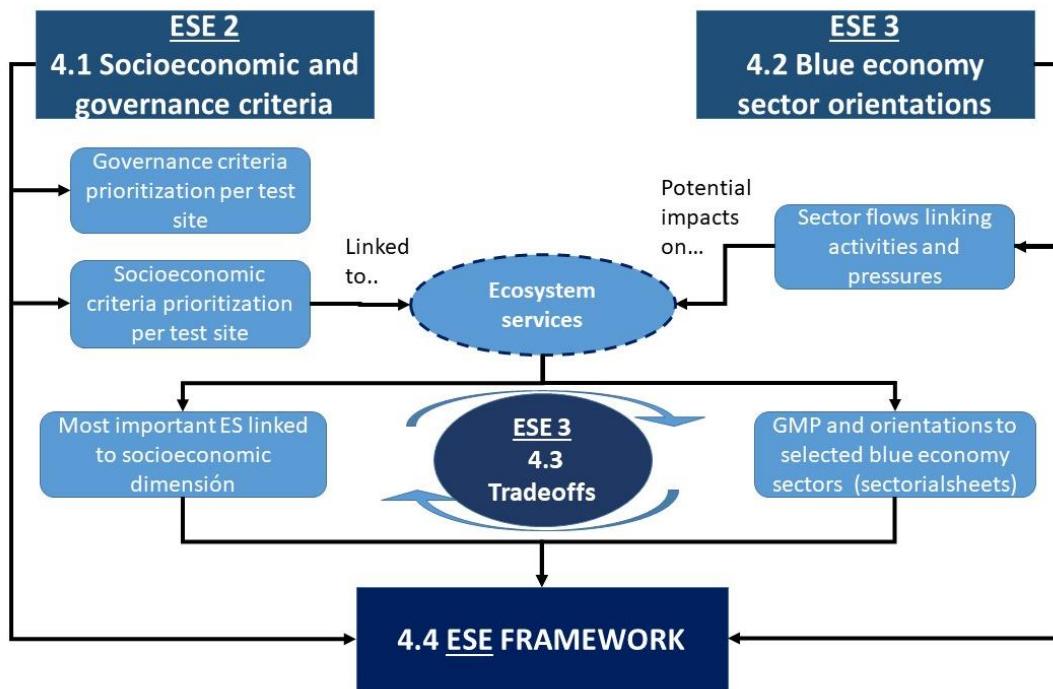


Figure 2: The diagram illustrates connection between ESE 2 (4.1. Socioeconomic and governance criteria) and ESE 3 (4.2. Blue economy sector orientations) to the overall ESE Framework of the MSP4BIO Project in the context of Ecosystem Services.



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



5. Bibliography

de Andrés, M., Muñoz, J. M. B., Onetti, J. G., & Zuniga, L. D. C. (2023). Mapping services for an ecosystem-based management along the Andalusian coastal zone (Spain). *Ocean & Coastal Management*, 231, 106402.

Barnard, S., & Elliott, M. (2015). The 10-tenets of adaptive management and sustainability: An holistic framework for understanding and managing the socio-ecological system. *Environmental science & policy*, 51, 181-191.

Bejder, L., Samuels, A. M. Y., Whitehead, H. A. L., Gales, N., Mann, J., Connor, R., ... & Krützen, M. (2006). Decline in relative abundance of bottlenose dolphins exposed to long-term disturbance. *Conservation Biology*, 20(6), 1791-1798.

Bohnes, F. A., & Laurent, A. (2021). Environmental impacts of existing and future aquaculture production: Comparison of technologies and feed options in Singapore. *Aquaculture*, 532, 736001.

Brida, J. G., & Zapata, S. (2010). Cruise tourism: economic, socio-cultural and environmental impacts. *International Journal of Leisure and Tourism Marketing*, 1(3), 205-226.

Britton, J. R., & Orsi, M. L. (2012). Non-native fish in aquaculture and sport fishing in Brazil: economic benefits versus risks to fish diversity in the upper River Paraná Basin. *Reviews in Fish Biology and Fisheries*, 22, 555-565.

Campbell, I., Macleod, A., Sahlmann, C., Neves, L., Funderud, J., Øverland, M., ... & Stanley, M. (2019). The environmental risks associated with the development of seaweed farming in Europe-prioritizing key knowledge gaps. *Frontiers in Marine Science*, 6, 107.

Carić, H. (2011). Cruising tourism environmental impacts: case study of Dubrovnik, Croatia. *Journal of coastal research*, (61), 104-113.

Carreño, A., & Lloret, J. (2021). Environmental impacts of increasing leisure boating activity in Mediterranean coastal waters. *Ocean & Coastal Management*, 209, 105693.

Copping, Andrea E., & Hemery, Lenaig G. (2020). OES-Environmental 2020 State of the Science Report: Environmental Effects of Marine Renewable Energy Development Around the World. Report for Ocean Energy Systems (OES). United States. <https://doi.org/10.2172/1632878>

Davenport, J., & Davenport, J. L. (2006). The impact of tourism and personal leisure transport on coastal environments: a review. *Estuarine, coastal and shelf science*, 67(1-2), 280-292.

El-Geziry, T. M., Bryden, I. G., & Couch, S. J. (2009). Environmental impact assessment for tidal energy schemes: an exemplar case study of the Strait of Messina. *Journal of Marine Engineering & Technology*, 8(1), 39-48.



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Elliott, M., Burdon, D., Atkins, J. P., Borja, A., Cormier, R., De Jonge, V. N., & Turner, R. K. (2017). "And DPSIR begat DAPSI (W) R (M)!"-a unifying framework for marine environmental management. *Marine Pollution Bulletin*, 118(1-2), 27-40.

European Commission, Directorate-General for Maritime Affairs and Fisheries, Joint Research Centre, Borriello, A., Calvo Santos, A., Ghiani, M. et al., The EU blue economy report 2023, Publications Office of the European Union, 2023, <https://data.europa.eu/doi/10.2771/7151>

Finkler, W., & Higham, J. E. (2020). Stakeholder perspectives on sustainable whale watching: A science communication approach. *Journal of Sustainable Tourism*, 28(4), 535-549.

Fox, C. J., Benjamins, S., Masden, E. A., & Miller, R. (2018). Challenges and opportunities in monitoring the impacts of tidal-stream energy devices on marine vertebrates. *Renewable and Sustainable Energy Reviews*, 81, 1926-1938.

Furness, R. W., Wade, H. M., Robbins, A. M., & Masden, E. A. (2012). Assessing the sensitivity of seabird populations to adverse effects from tidal stream turbines and wave energy devices. *ICES Journal of Marine Science*, 69(8), 1466-1479.

Galparsoro, I., Korta, M., Subirana, I., Borja, Á., Menchaca, I., Solaun, O., ... & Bald, J. (2021). A new framework and tool for ecological risk assessment of wave energy converters projects. *Renewable and Sustainable Energy Reviews*, 151, 111539.

Gutierrez D., Calado H., De Bruyn A., XXX (2023) Trade-offs method for protection and restoration in MSP – ESE3 (Deliverable – D4.3., under the WP4 of MSP4BIO project (GA n° 101060707)).

He, P., Chopin, F., Suuronen, P., Ferro, R.S.T and Lansley, J. 2021. Classification and illustrated definition of fishing gears. FAO Fisheries and Aquaculture Technical Paper No. 672. Rome, FAO.

Higham, J. E., Bejder, L., Allen, S. J., Corkeron, P. J., & Lusseau, D. (2016). Managing whale-watching as a non-lethal consumptive activity. *Journal of sustainable tourism*, 24(1), 73-90.

Kosara, R., Bendix, F., & Hauser, H. (2006). Parallel sets: Interactive exploration and visual analysis of categorical data. *IEEE transactions on visualization and computer graphics*, 12(4), 558-568.

Langhamer, O., Haikonen, K., & Sundberg, J. (2010). Wave power—Sustainable energy or environmentally costly? A review with special emphasis on linear wave energy converters. *Renewable and Sustainable Energy Reviews*, 14(4), 1329-1335.

La Notte, A., D'Amato, D., Mäkinen, H., Paracchini, M. L., Liquete, C., Ego, B., ... & Crossman, N. D. (2017). Ecosystem services classification: A systems ecology perspective of the cascade framework. *Ecological indicators*, 74, 392-402.



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Le Gouvello, R., Hochart, L. E., Laffoley, D., Simard, F., Andrade, C., Angel, D., ... & Marino, G. (2017). Aquaculture and marine protected areas: potential opportunities and synergies. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 27, 138-150.

Levin, P. S., Zabel, R. W., & Williams, J. G. (2001). The road to extinction is paved with good intentions: negative association of fish hatcheries with threatened salmon. *Proceedings of the Royal Society of London. Series B: Biological Sciences*, 268(1472), 1153-1158.

Lukic et al (2023), Draft, Ocean Multi-Use Toolkit, MULTI-FRAME project

Lukic, I. 2022. Ocean Multi-Use Blueprints Collection. Nature enhancement in offshore wind farms, the Netherland.

Lupton, R. C., & Allwood, J. M. (2017). Hybrid Sankey diagrams: Visual analysis of multidimensional data for understanding resource use. *Resources, Conservation and Recycling*, 124, 141-151.

MacNeill, T., & Wozniak, D. (2018). The economic, social, and environmental impacts of cruise tourism. *Tourism Management*, 66, 387-404.

Matczak et al. (2024) *Test Sites Methodology Including the Participation Strategy (Deliverable – D5.2., under the WP5 of MSP4BIO project (GA n° 101060707))*

Mengo, E., Mynott, F., and Muench, A. (2020). Welsh National Marine Plan A review of the potential for co-existence of different sectors in the Welsh Marine Plan Area. REPORT: World Class Science for the Marine and Freshwater Environment, Centre for Environment Fisheries Aquaculture Science.

Mendoza, E., Lithgow, D., Flores, P., Felix, A., Simas, T., & Silva, R. (2019). A framework to evaluate the environmental impact of OCEAN energy devices. *Renewable and Sustainable Energy Reviews*, 112, 440-449.

Mulazzani, L., & Malorgio, G. (2017). Blue growth and ecosystem services. *Marine Policy*, 85, 17-24.

Parsons, E. C. M. (2012). The negative impacts of whale-watching. *Journal of Marine Sciences*, 2012.

Pegorelli C., García-Sanabria J., de Andres M., García-Onetti J., Luengo S. R., (2023) Criteria for the representation of the social and economic dimension of MPAs (Deliverable – D4.1., under the WP4 of MSP4BIO project (GA n° 101060707)).

Potschin, M., & Haines-Young, R. (2016). Defining and measuring ecosystem services. *Routledge handbook of ecosystem services*, 1, 25-44.



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Price, C., Black, K. D., Hargrave, B. T., & Morris Jr, J. A. (2015). Marine cage culture and the environment: effects on water quality and primary production. *Aquaculture environment interactions*, 6(2), 151-174.

Rahman, A., Farrok, O., & Haque, M. M. (2022). Environmental impact of renewable energy source based electrical power plants: Solar, wind, hydroelectric, biomass, geothermal, tidal, ocean, and osmotic. *Renewable and Sustainable Energy Reviews*, 161, 112279.

Read, P., & Fernandes, T. (2003). Management of environmental impacts of marine aquaculture in Europe. *Aquaculture*, 226(1-4), 139-163.

Santander-Botello, L. C., & Frejomil, E. P. (2009). Impacto ambiental del turismo de buceo en arrecifes de coral. *Cuadernos de turismo*, (24), 207-227.

Schupp, M. F., Bocci, M., Depellegrin, D., Kafas, A., Kyriazi, Z., Lukic, I., ... & Buck, B. H. (2019). Toward a common understanding of ocean multi-use. *Frontiers in Marine Science*, 6, 441951.

Singh GG, Eddy IMS, Halpern BS, Neslo R, Satterfield T, Chan KMA (2020) Mapping cumulative impacts to coastal ecosystem services in British Columbia. *PLoS ONE* 15(5): e0220092.

Shollenberger, H., Dressler, E., & Mallinson, D. J. (2019). Invasive Snakehead and Introduced Sport Fish Illustrate an Environmental Health Paradox of Invasive Species and Angler Demand. *Case Studies in the Environment*.

Schmidt, M. (2008). The Sankey diagram in energy and material flow management: part II: methodology and current applications. *Journal of industrial ecology*, 12(2), 173-185.



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



ANNEX I: List of countries that support a ban, moratorium or precautionary pause on deep sea mining.

Table below presents a list of countries that support that support a ban, moratorium or precautionary pause on deep sea mining. In bold, European Union Member States.
(Source: www.savethehighseas.org)

Moratorium Alliance	Palau, Fiji, Samoa and Federated State of Micronesia
Precautionary pause	Chile, Costa Rica, Ecuador, Spain, Germany, Panama, Ireland, Brazil, Finland, Portugal , Vanuatu, Dominican Republic, Sweden and Monaco
Moratorium	New Zealand, Switzerland, Canada, United Kingdom and Mexico
Ban	France



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



ANNEX II – Positive and negative impact on ecosystem services by maritime activity.

The table below presents the classification of impacts on the ecosystem services for by maritime activity. Where positive impact (+1) is indicating favorable impacts, negative (-1) is showing adverse effects, and neutral impacts (0) is representing interactions with no discernible positive or negative impact on Ecosystem Services (ES). For a better visualization, the excel table is accessed here: [Supporting Material](#).



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Sector	Activities	Pressures	Provisioning						Regulation & Maintenance						Cultural			Sum	
			Cultivated aquatic plants for nutrition, materials or energy	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Rared aquatic animals for nutrition, materials or energy	Wild animals (terrestrial and aquatic) used for nutrition, materials or energy	Mineral substances used for nutrition, materials or energy	Water used for nutrition, materials or energy	Maintenance of physical, chemical, abiotic conditions	Lifecycle maintenance, habitat and gene pool protection	Mediation of substances of anthropogenic origin by living processes	Pest and disease control	Regulation of baseline flows and extreme events	Regulation of soil quality	Water conditions	Atmospheric composition and conditions	Other type of regulation and maintenance services by abiotic/biotic processes	Intellectual and representative interactions with environment (abiotic and natural)	Physical and experiential interactions with the other environment (abiotic interactions with natural environment)
Tourism	Diving	Physical damage	0	0	0	0	0	0	-1	-1	0	0	0	0	0	0	0	0	-2
Tourism	Diving	Biological disturbance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tourism	Selling vessels	Physical damage	0	-1	-1	0	0	0	-1	-1	0	0	0	0	0	0	0	0	-4
Tourism	Selling vessels	Biological disturbance	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	-1
Tourism	Yacht and motorboats/motor vessels	Physical damage	0	-1	-1	0	0	0	-1	-1	0	0	0	0	0	0	0	0	-4
Tourism	Yacht and motorboats/motor vessels	Other physical disturbance	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	-1
Tourism	Yacht and motorboats/motor vessels	Biological disturbance	0	0	-1	0	0	0	0	-1	0	0	0	0	0	0	0	0	-2
Tourism	Sport fishing	Physical damage	0	-1	0	0	0	0	-1	0	-1	0	0	0	0	0	0	0	-3
Tourism	Sport fishing	Other physical disturbance	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	-1
Tourism	Sport fishing	Biological disturbance	0	0	0	0	-1	0	0	-1	-1	0	-1	0	0	0	0	0	1
Tourism	Cruise	Physical damage	0	-1	-1	0	0	0	-1	0	0	0	0	0	0	0	-1	0	-4
Tourism	Cruise	Other physical disturbance	0	-1	-1	-1	-1	0	-1	-1	0	0	0	0	0	0	0	0	-6
Tourism	Cruise	Biological disturbance	0	0	0	-1	0	0	-1	0	-1	0	0	0	0	0	0	0	1
Tourism	Cruise	Contamination by hazardous substances	0	0	0	-1	-1	0	0	-1	-1	0	0	0	-1	-1	0	0	-8
Tourism	Cruise	Nutrient and organic matter enrichment	0	-1	-1	-1	-1	0	0	-1	-1	-1	0	0	0	-1	0	0	-8
Tourism	Whale-watching	Other physical disturbance	0	0	-1	-1	0	0	0	-1	0	0	0	0	0	0	0	0	-3
Tourism	Whale-watching	Biological disturbance	0	0	0	0	-1	0	0	0	-1	0	0	0	0	1	1	0	1
Renewables	Wind farms	Physical loss	0	-1	-1	-1	-1	0	-1	-1	-1	-1	0	0	-1	-1	0	0	-11
Renewables	Wind farms	Physical damage	0	-1	-1	-1	-1	0	-1	-1	-1	-1	0	0	-1	0	0	0	-9
Renewables	Wind farms	Other physical disturbance	0	0	-1	-1	0	0	0	-1	0	0	0	0	0	0	0	0	-3
Renewables	Wind farms	Biological disturbance	0	-1	-1	0	1	0	0	0	1	0	0	0	0	0	0	1	1
Renewables	Ocean energy - Tidal	Physical loss	0	-1	-1	-1	0	0	0	-1	0	-1	0	0	0	0	0	0	-6
Renewables	Ocean energy - Tidal	Physical damage	0	-1	-1	-1	0	0	0	-1	0	0	0	-1	0	0	0	0	-5
Renewables	Ocean energy - Tidal	Other physical disturbance	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	-1
Renewables	Ocean energy - Tidal	Biological disturbance	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	-1
Renewables	Ocean energy - Wave	Physical loss	0	-1	-1	-1	0	0	0	-1	0	-1	0	0	-1	0	0	0	-7
Renewables	Ocean energy - Wave	Physical damage	0	-1	-1	-1	0	0	0	-1	0	0	0	-1	0	0	0	0	-5
Renewables	Ocean energy - Wave	Other physical disturbance	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	-1
Renewables	Ocean energy - Wave	Biological disturbance	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	-1
Aquaculture	Aquaculture in coastal or intertidal zones	Physical loss	1	-1	-1	1	-1	1	-1	-1	-1	-1	1	-1	-1	-1	-1	-1	-12
Aquaculture	Aquaculture in coastal or intertidal zones	Physical damage	1	-1	-1	1	-1	0	-1	-1	0	-1	1	-1	-1	-1	0	-1	-9
Aquaculture	Aquaculture in coastal or intertidal zones	Interference with hydrological processes	-1	-1	-1	1	-1	0	-1	-1	0	-1	1	0	-1	0	0	-1	-8
Aquaculture	Aquaculture in coastal or intertidal zones	Contamination by hazardous substances	-1	-1	-1	1	-1	-1	-1	-1	0	-1	0	0	-1	0	0	-1	-12
Aquaculture	Aquaculture in coastal or intertidal zones	Systematic and/or intentional release of substances	-1	-1	-1	1	-1	-1	0	-1	0	-1	0	-1	-1	-1	-1	-1	-13
Aquaculture	Aquaculture in coastal or intertidal zones	Nutrient and organic matter enrichment	1	1	-1	-4	-1	-1	-1	-1	0	-1	0	-1	-1	0	-1	-1	-12
Aquaculture	Aquaculture in coastal or intertidal zones	Biological disturbance	1	-1	-1	1	-1	0	0	-1	-1	0	0	0	0	1	1	1	-3
Aquaculture	Aquaculture areas (hatcheries, floating cages and reefs)	Physical damage	0	-1	-1	0	1	-1	0	-1	0	0	0	-1	0	0	0	0	-5



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Aquaculture	Aquaculture at sea (hatcheries, floating cages and reefs)	Interference with hydrological processes	0	-4	-1	0	-1	0	0	0	0	0	0	0	0	1	0	-1	0	0	0	0	-3
Aquaculture	Aquaculture at sea (hatcheries, floating cages and reefs)	Contamination by hazardous substances	0	-4	-1	1	-1	0	-1	-4	0	0	-4	0	-5	-1	0	-1	-1	-1	0	-1	-10
Aquaculture	Aquaculture at sea (hatcheries, floating cages and reefs)	Systematic and/or intentional release of substances	0	-1	-1	0	0	0	0	0	0	0	0	0	0	-1	-1	0	0	0	0	-5	
Aquaculture	Aquaculture at sea (hatcheries, floating cages and reefs)	Nutrient and organic matter enrichment	0	1	-1	-1	-1	0	-1	-1	0	0	-1	0	-4	-1	0	-1	-1	-1	-1	-11	
Aquaculture	Aquaculture at sea (hatcheries, floating cages and reefs)	Biological disturbance	0	-4	-1	1	-1	0	0	-1	0	-1	0	0	-1	0	0	0	1	0	-1	-6	
Fisheries	Trawling	Physical damage	0	-4	-1	0	0	-1	0	-1	-1	-1	-1	-1	-1	0	0	-1	-1	-1	-1	-14	
Fisheries	Trawling	Other physical disturbance	0	-1	0	-1	-1	0	0	0	-1	0	0	0	0	0	0	-1	-1	-1	-1	-6	
Fisheries	Trawling	Biological disturbance	0	-1	-1	0	-1	0	0	0	-1	0	-1	0	0	0	0	-1	-1	0	-1	-9	
Fisheries	Gillnetting	Physical damage	0	-4	-1	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	-3	
Fisheries	Gillnetting	Other physical disturbance	0	0	0	-1	-1	0	0	0	-1	0	0	0	-1	0	0	-1	-1	0	0	-6	
Fisheries	Gillnetting	Biological disturbance	0	0	-1	0	-1	0	0	0	-1	0	-1	0	0	0	0	-1	-1	0	-1	-8	
Fisheries	Purse seine (with FADs or not)	Physical damage	0	-1	-1	0	0	0	0	-1	-1	-1	0	0	0	0	0	-1	-1	-1	-1	-8	
Fisheries	Purse seine (with FADs or not)	Other physical disturbance	0	0	0	-1	-1	0	0	0	-1	0	0	0	-1	0	0	-1	-1	0	0	-6	
Fisheries	Purse seine (with FADs or not)	Biological disturbance	0	0	-1	0	-1	0	0	0	-1	0	-1	-1	0	0	0	-1	-1	-1	-1	-9	
Fisheries	Longline	Physical damage	0	-4	-1	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	-3	
Fisheries	Longline	Other physical disturbance	0	0	0	-1	-1	0	0	0	-1	0	0	0	0	0	0	-1	-1	0	0	-5	
Fisheries	Longline	Biological disturbance	0	0	-1	0	-1	0	0	0	-1	0	-1	-1	0	0	0	-1	-1	0	-1	-8	
Fisheries	Pots and traps	Physical damage	0	-4	-1	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	-3	
Fisheries	Pots and traps	Other physical disturbance	0	0	0	-1	-1	0	0	0	-1	0	-1	-1	0	0	0	-1	-1	0	0	-6	
Fisheries	Pots and traps	Biological disturbance	0	0	-1	0	-1	0	0	0	-1	0	-1	-1	0	0	0	-1	-1	0	-1	-8	
Fisheries	Trammel net	Physical damage	0	-4	-1	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	-3	
Fisheries	Trammel net	Other physical disturbance	0	0	0	-1	-1	0	0	0	-1	0	0	0	0	0	0	-1	-1	0	0	-5	
Fisheries	Trammel net	Biological disturbance	0	0	0	-1	-1	0	0	0	-1	0	-1	-1	0	0	0	-1	-1	0	-1	-8	
Fisheries	Driftnetting	Other physical disturbance	0	-1	-1	0	-1	0	0	0	-1	-1	-1	-1	0	0	0	-1	-1	-1	-1	-11	
Fisheries	Driftnetting	Biological disturbance	0	0	-1	0	-1	0	0	0	-1	0	-1	-1	0	0	0	-1	-1	0	-1	-6	
Fisheries	Dredging	Physical damage	0	-4	-1	0	0	-1	0	0	-1	-1	-1	-1	0	0	0	-1	-1	0	0	-12	
Fisheries	Dredging	Other physical disturbance	0	-1	0	-1	-1	0	0	0	-1	0	-1	-1	0	0	0	-1	-1	0	0	-5	
Fisheries	Dredging	Biological disturbance	0	-1	-1	0	-1	0	0	0	-1	0	-1	-1	0	0	0	-1	-1	0	0	-9	
Fisheries	Push and stow net	Physical damage	0	-4	-1	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	-2	
Fisheries	Push and stow net	Other physical disturbance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	-1	0	0	-2	
Fisheries	Push and stow net	Biological disturbance	0	-1	0	-1	0	0	0	0	-1	0	-1	-1	0	0	0	-1	-1	0	0	-6	
Mineral Extraction	Deep-sea mining	Physical loss	0	0	-1	0	-1	0	0	-1	-1	-1	0	0	0	-1	0	0	0	0	0	-7	
Mineral Extraction	Deep-sea mining	Physical damage	0	0	-1	0	-1	0	0	-1	-1	-1	0	0	0	-1	0	0	0	0	0	-7	
Mineral Extraction	Deep-sea mining	Contamination by hazardous substances	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	
Mineral Extraction	Deep-sea mining	Biological disturbance	0	-1	0	0	-1	-1	0	-1	-1	0	0	0	0	-1	0	0	0	0	0	-7	
Mineral Extraction	Deep-sea mining	Physical loss	0	-4	-1	0	-1	0	-1	-1	-1	0	0	0	-1	0	0	0	0	0	0	-11	
Mineral Extraction	Dredging	Physical damage	0	-4	-1	0	-1	0	-1	-1	-1	0	0	0	-1	0	0	0	0	0	0	-11	
Mineral Extraction	Dredging	Other physical disturbance	0	-1	0	-1	-1	0	0	-1	-1	0	0	0	-1	0	0	0	0	0	0	-9	
Mineral Extraction	Dredging	Biological disturbance	0	-1	0	-1	-1	0	0	-1	-1	0	0	0	-1	0	0	0	0	0	0	-6	
Mineral Extraction	Offshore oil and gas extraction	Physical loss	0	-4	-1	0	-1	-1	0	-1	-1	-1	0	0	-1	0	0	0	0	0	0	-10	
Mineral Extraction	Offshore oil and gas extraction	Physical damage	0	-4	-1	0	-1	-1	0	-1	-1	-1	0	0	-1	0	0	0	0	0	0	-10	
Mineral Extraction	Offshore oil and gas extraction	Other physical disturbance	0	-1	0	-1	-1	0	0	-1	-1	0	0	0	-1	0	0	0	0	0	0	-7	
Mineral Extraction	Offshore oil and gas extraction	Contamination by hazardous substances	0	-1	0	-1	-1	0	-1	-1	-1	0	0	0	-1	0	0	0	0	0	0	-10	
Mineral Extraction	Offshore oil and gas extraction	Biological disturbance	0	-1	0	-1	-1	0	0	-1	-1	0	0	0	-1	0	0	0	0	0	0	-7	
Sum impact on each ES by			1	-46	-95	-14	-35	-16	-4	-28	-66	-28	-27	-24	0	-28	-20	-3	0	-32	-27	-6	-326



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



ANNEX III – Maritime activities pressures on the marine environment and their potential ecosystem service impacted.

For a better visualization, the excel table is accessed here: [Supporting material](#).

Sector	Activities	Pressures	ES Group	ES Section
Tourism	Diving	Physical damage	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Tourism	Diving	Physical damage	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Tourism	Diving	Biological disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Tourism	Sailing vessels	Physical damage	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Tourism	Sailing vessels	Physical damage	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Tourism	Sailing vessels	Physical damage	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Tourism	Sailing vessels	Physical damage	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Tourism	Sailing vessels	Biological disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Tourism	Yacht and motorboats/motor vessels	Physical damage	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Tourism	Yacht and motorboats/motor vessels	Physical damage	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Tourism	Yacht and motorboats/motor vessels	Physical damage	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Tourism	Yacht and motorboats/motor vessels	Physical damage	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Tourism	Yacht and motorboats/motor vessels	Other physical disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Tourism	Yacht and motorboats/motor vessels	Contamination by hazardous substances	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Tourism	Yacht and motorboats/motor vessels	Contamination by hazardous substances	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Tourism	Yacht and motorboats/motor vessels	Contamination by hazardous substances	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Tourism	Yacht and motorboats/motor vessels	Contamination by hazardous substances	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Tourism	Yacht and motorboats/motor vessels	Contamination by hazardous substances	Water conditions	Regulation & Maintenance
Tourism	Yacht and motorboats/motor vessels	Biological disturbance	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Tourism	Yacht and motorboats/motor vessels	Biological disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Tourism	Sport fishing	Physical damage	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Tourism	Sport fishing	Physical damage	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Tourism	Sport fishing	Physical damage	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Tourism	Sport fishing	Other physical disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Tourism	Sport fishing	Contamination by hazardous substances	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Tourism	Sport fishing	Contamination by hazardous substances	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Tourism	Sport fishing	Contamination by hazardous substances	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Tourism	Sport fishing	Contamination by hazardous substances	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Tourism	Sport fishing	Contamination by hazardous substances	Water conditions	Regulation & Maintenance
Tourism	Sport fishing	Biological disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Tourism	Sport fishing	Biological disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Tourism	Sport fishing	Biological disturbance	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Tourism	Sport fishing	Biological disturbance	Pest and disease control	Regulation & Maintenance
Tourism	Cruise	Physical damage	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Tourism	Cruise	Physical damage	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Tourism	Cruise	Physical damage	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Tourism	Cruise	Physical damage	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural
Tourism	Cruise	Other physical disturbance	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Tourism	Cruise	Other physical disturbance	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Tourism	Cruise	Other physical disturbance	Reared aquatic animals for nutrition, materials or energy	Provisioning
Tourism	Cruise	Other physical disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Tourism	Cruise	Other physical disturbance	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Tourism	Cruise	Other physical disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Tourism	Cruise	Biological disturbance	Reared aquatic animals for nutrition, materials or energy	Provisioning



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Tourism	Cruise	Biological disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Tourism	Cruise	Biological disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Tourism	Cruise	Biological disturbance	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Tourism	Cruise	Biological disturbance	Pest and disease control	Regulation & Maintenance
Tourism	Cruise	Contamination by hazardous substances	Reared aquatic animals for nutrition, materials or energy	Provisioning
Tourism	Cruise	Contamination by hazardous substances	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Tourism	Cruise	Contamination by hazardous substances	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Tourism	Cruise	Contamination by hazardous substances	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Tourism	Cruise	Contamination by hazardous substances	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Tourism	Cruise	Contamination by hazardous substances	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Tourism	Cruise	Contamination by hazardous substances	Water conditions	Regulation & Maintenance
Tourism	Cruise	Contamination by hazardous substances	Atmospheric composition and conditions	Regulation & Maintenance
Tourism	Cruise	Nutrient and organic matter enrichment	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Tourism	Cruise	Nutrient and organic matter enrichment	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Tourism	Cruise	Nutrient and organic matter enrichment	Reared aquatic animals for nutrition, materials or energy	Provisioning
Tourism	Cruise	Nutrient and organic matter enrichment	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Tourism	Cruise	Nutrient and organic matter enrichment	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Tourism	Cruise	Nutrient and organic matter enrichment	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Tourism	Cruise	Nutrient and organic matter enrichment	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Tourism	Cruise	Nutrient and organic matter enrichment	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Tourism	Cruise	Nutrient and organic matter enrichment	Water conditions	Regulation & Maintenance
Tourism	Whale-watching	Other physical disturbance	Reared aquatic animals for nutrition, materials or energy	Provisioning
Tourism	Whale-watching	Other physical disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Tourism	Whale-watching	Other physical disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Tourism	Whale-watching	Contamination by hazardous substances	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Tourism	Whale-watching	Contamination by hazardous substances	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Tourism	Whale-watching	Contamination by hazardous substances	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Tourism	Whale-watching	Contamination by hazardous substances	Water conditions	Regulation & Maintenance
Tourism	Whale-watching	Biological disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Tourism	Whale-watching	Biological disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Renewables	Wind farms	Physical loss	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Renewables	Wind farms	Physical loss	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Renewables	Wind farms	Physical loss	Reared aquatic animals for nutrition, materials or energy	Provisioning
Renewables	Wind farms	Physical loss	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Renewables	Wind farms	Physical loss	Mineral substances used for nutrition, materials or energy	Provisioning
Renewables	Wind farms	Physical loss	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Renewables	Wind farms	Physical loss	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Renewables	Wind farms	Physical loss	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Renewables	Wind farms	Physical loss	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Renewables	Wind farms	Physical loss	Regulation of soil quality	Regulation & Maintenance
Renewables	Wind farms	Physical loss	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Renewables	Wind farms	Physical damage	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Renewables	Wind farms	Physical damage	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Renewables	Wind farms	Physical damage	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Renewables	Wind farms	Physical damage	Mineral substances used for nutrition, materials or energy	Provisioning
Renewables	Wind farms	Physical damage	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Renewables	Wind farms	Physical damage	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Renewables	Wind farms	Physical damage	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Renewables	Wind farms	Physical damage	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Renewables	Wind farms	Physical damage	Regulation of soil quality	Regulation & Maintenance
Renewables	Wind farms	Other physical disturbance	Reared aquatic animals for nutrition, materials or energy	Provisioning
Renewables	Wind farms	Other physical disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Renewables	Wind farms	Other physical disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Renewables	Wind farms	Biological disturbance	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Renewables	Wind farms	Biological disturbance	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Renewables	Ocean energy - Tidal	Physical loss	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Renewables	Ocean energy - Tidal	Physical loss	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Renewables	Ocean energy - Tidal	Physical loss	Reared aquatic animals for nutrition, materials or energy	Provisioning
Renewables	Ocean energy - Tidal	Physical loss	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Renewables	Ocean energy - Tidal	Physical loss	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Renewables	Ocean energy - Tidal	Physical loss	Regulation of soil quality	Regulation & Maintenance
Renewables	Ocean energy - Tidal	Physical damage	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Renewables	Ocean energy - Tidal	Physical damage	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Renewables	Ocean energy - Tidal	Physical damage	Reared aquatic animals for nutrition, materials or energy	Provisioning
Renewables	Ocean energy - Tidal	Physical damage	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Renewables	Ocean energy - Tidal	Physical damage	Regulation of soil quality	Regulation & Maintenance
Renewables	Ocean energy - Tidal	Other physical disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Renewables	Ocean energy - Tidal	Interference with hydrological processes	Water conditions	Regulation & Maintenance
Renewables	Ocean energy - Tidal	Biological disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Renewables	Ocean energy - Wave	Physical loss	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Renewables	Ocean energy - Wave	Physical loss	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Renewables	Ocean energy - Wave	Physical loss	Reared aquatic animals for nutrition, materials or energy	Provisioning
Renewables	Ocean energy - Wave	Physical loss	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Renewables	Ocean energy - Wave	Physical loss	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Renewables	Ocean energy - Wave	Physical loss	Regulation of soil quality	Regulation & Maintenance
Renewables	Ocean energy - Wave	Physical loss	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Renewables	Ocean energy - Wave	Physical damage	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Renewables	Ocean energy - Wave	Physical damage	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Renewables	Ocean energy - Wave	Physical damage	Reared aquatic animals for nutrition, materials or energy	Provisioning
Renewables	Ocean energy - Wave	Physical damage	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Renewables	Ocean energy - Wave	Physical damage	Regulation of soil quality	Regulation & Maintenance
Renewables	Ocean energy - Wave	Other physical disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Renewables	Ocean energy - Wave	Interference with hydrological processes	Water conditions	Regulation & Maintenance
Renewables	Ocean energy - Wave	Biological disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Physical loss	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Physical loss	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Physical loss	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Physical loss	Mineral substances used for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Physical loss	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Physical loss	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Physical loss	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Aquaculture	Aquaculture in coastal or intertidal zones	Physical loss	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Physical loss	Pest and disease control	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Physical loss	Regulation of soil quality	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Physical loss	Water conditions	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Physical loss	Atmospheric composition and conditions	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Physical loss	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Aquaculture	Aquaculture in coastal or intertidal zones	Physical loss	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural
Aquaculture	Aquaculture in coastal or intertidal zones	Physical loss	Spiritual, symbolic and other interactions with natural environment	Cultural
Aquaculture	Aquaculture in coastal or intertidal zones	Physical loss	Other biotic characteristics that have a non-use value	Cultural
Aquaculture	Aquaculture in coastal or intertidal zones	Physical damage	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Physical damage	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Physical damage	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Physical damage	Mineral substances used for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Physical damage	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Physical damage	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Physical damage	Pest and disease control	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Physical damage	Regulation of soil quality	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Physical damage	Water conditions	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Physical damage	Atmospheric composition and conditions	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Physical damage	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Aquaculture	Aquaculture in coastal or intertidal zones	Physical damage	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural
Aquaculture	Aquaculture in coastal or intertidal zones	Physical damage	Spiritual, symbolic and other interactions with natural environment	Cultural
Aquaculture	Aquaculture in coastal or intertidal zones	Physical damage	Other biotic characteristics that have a non-use value	Cultural
Aquaculture	Aquaculture in coastal or intertidal zones	Other physical disturbance	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Other physical disturbance	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Other physical disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Other physical disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Other physical disturbance	Regulation of soil quality	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Other physical disturbance	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Aquaculture	Aquaculture in coastal or intertidal zones	Other physical disturbance	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural
Aquaculture	Aquaculture in coastal or intertidal zones	Other physical disturbance	Spiritual, symbolic and other interactions with natural environment	Cultural
Aquaculture	Aquaculture in coastal or intertidal zones	Other physical disturbance	Other biotic characteristics that have a non-use value	Cultural
Aquaculture	Aquaculture in coastal or intertidal zones	Interference with hydrological processes	Cultivated aquatic plants for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Interference with hydrological processes	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Interference with hydrological processes	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Interference with hydrological processes	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Aquaculture	Aquaculture in coastal or intertidal zones	Interference with hydrological processes	Water used for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Interference with hydrological processes	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Interference with hydrological processes	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Interference with hydrological processes	Pest and disease control	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Interference with hydrological processes	Water conditions	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Interference with hydrological processes	Other biotic characteristics that have a non-use value	Cultural
Aquaculture	Aquaculture in coastal or intertidal zones	Contamination by hazardous substances	Cultivated aquatic plants for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Contamination by hazardous substances	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Contamination by hazardous substances	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Contamination by hazardous substances	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Contamination by hazardous substances	Mineral substances used for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Contamination by hazardous substances	Water used for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Contamination by hazardous substances	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Contamination by hazardous substances	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Contamination by hazardous substances	Pest and disease control	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Contamination by hazardous substances	Regulation of soil quality	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Contamination by hazardous substances	Water conditions	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Contamination by hazardous substances	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural
Aquaculture	Aquaculture in coastal or intertidal zones	Contamination by hazardous substances	Other biotic characteristics that have a non-use value	Cultural
Aquaculture	Aquaculture in coastal or intertidal zones	Systematic and/or intentional release of substances	Cultivated aquatic plants for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Systematic and/or intentional release of substances	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Systematic and/or intentional release of substances	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Systematic and/or intentional release of substances	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Systematic and/or intentional release of substances	Mineral substances used for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Systematic and/or intentional release of substances	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Systematic and/or intentional release of substances	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Systematic and/or intentional release of substances	Pest and disease control	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Systematic and/or intentional release of substances	Regulation of soil quality	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Systematic and/or intentional release of substances	Water conditions	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Systematic and/or intentional release of substances	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Aquaculture	Aquaculture in coastal or intertidal zones	Systematic and/or intentional release of substances	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural
Aquaculture	Aquaculture in coastal or intertidal zones	Systematic and/or intentional release of substances	Spiritual, symbolic and other interactions with natural environment	Cultural
Aquaculture	Aquaculture in coastal or intertidal zones	Systematic and/or intentional release of substances	Other biotic characteristics that have a non-use value	Cultural
Aquaculture	Aquaculture in coastal or intertidal zones	Nutrient and organic matter enrichment	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Nutrient and organic matter enrichment	Reared aquatic animals for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Nutrient and organic matter enrichment	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Aquaculture	Aquaculture in coastal or intertidal zones	Nutrient and organic matter enrichment	Mineral substances used for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Nutrient and organic matter enrichment	Water used for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Nutrient and organic matter enrichment	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Nutrient and organic matter enrichment	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Nutrient and organic matter enrichment	Pest and disease control	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Nutrient and organic matter enrichment	Regulation of soil quality	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Nutrient and organic matter enrichment	Water conditions	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Nutrient and organic matter enrichment	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Aquaculture	Aquaculture in coastal or intertidal zones	Nutrient and organic matter enrichment	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural
Aquaculture	Aquaculture in coastal or intertidal zones	Nutrient and organic matter enrichment	Spiritual, symbolic and other interactions with natural environment	Cultural
Aquaculture	Aquaculture in coastal or intertidal zones	Nutrient and organic matter enrichment	Other biotic characteristics that have a non-use value	Cultural
Aquaculture	Aquaculture in coastal or intertidal zones	Biological disturbance	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Biological disturbance	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Biological disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture in coastal or intertidal zones	Biological disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Biological disturbance	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Biological disturbance	Pest and disease control	Regulation & Maintenance
Aquaculture	Aquaculture in coastal or intertidal zones	Biological disturbance	Other biotic characteristics that have a non-use value	Cultural
Aquaculture	Aquaculture at sea (hatcheries, floating cages and rafts)	Physical damage	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture at sea (hatcheries, floating cages and rafts)	Physical damage	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Aquaculture	Aquaculture at sea (hatcheries, floating cages and rafts)	Physical damage	Mineral substances used for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture at sea (hatcheries, floating cages and rafts)	Physical damage	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Aquaculture	Aquaculture at sea (hatcheries, floating cages and rafts)	Physical damage	Water conditions	Regulation & Maintenance
Aquaculture	Aquaculture at sea (hatcheries, floating cages and rafts)	Physical damage	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural
Aquaculture	Aquaculture at sea (hatcheries, floating cages and rafts)	Other physical disturbance	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture at sea (hatcheries, floating cages and rafts)	Other physical disturbance	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Aquaculture	Aquaculture at sea (hatcheries, floating cages and rafts)	Other physical disturbance	Reared aquatic animals for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture at sea (hatcheries, floating cages and rafts)	Other physical disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture at sea (hatcheries, floating cages and rafts)	Other physical disturbance	Mineral substances used for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture at sea (hatcheries, floating cages and rafts)	Other physical disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Other physical disturbance	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Other physical disturbance	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Other physical disturbance	Spiritual, symbolic and other interactions with natural environment	Cultural
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Other physical disturbance	Other biotic characteristics that have a non-use value	Cultural
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Interference with hydrological processes	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Interference with hydrological processes	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Interference with hydrological processes	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Interference with hydrological processes	Water conditions	Regulation & Maintenance
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Contamination by hazardous substances	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Contamination by hazardous substances	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Contamination by hazardous substances	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Contamination by hazardous substances	Water used for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Contamination by hazardous substances	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Contamination by hazardous substances	Pest and disease control	Regulation & Maintenance
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Contamination by hazardous substances	Regulation of soil quality	Regulation & Maintenance
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Contamination by hazardous substances	Water conditions	Regulation & Maintenance
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Contamination by hazardous substances	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Contamination by hazardous substances	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Contamination by hazardous substances	Other biotic characteristics that have a non-use value	Cultural
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Systematic and/or intentional release of substances	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Systematic and/or intentional release of substances	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Systematic and/or intentional release of substances	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Systematic and/or intentional release of substances	Water used for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Systematic and/or intentional release of substances	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Systematic and/or intentional release of substances	Pest and disease control	Regulation & Maintenance
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Systematic and/or intentional release of substances	Regulation of soil quality	Regulation & Maintenance
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Systematic and/or intentional release of substances	Water conditions	Regulation & Maintenance
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Systematic and/or intentional release of substances	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Systematic and/or intentional release of substances	Physical and experiential interactions with the environment (abiotic e.g., caves. natural: whales)	Cultural
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Systematic and/or intentional release of substances	Other biotic characteristics that have a non-use value	Cultural
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Nutrient and organic matter enrichment	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Nutrient and organic matter enrichment	Reared aquatic animals for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Nutrient and organic matter enrichment	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Nutrient and organic matter enrichment	Water used for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Nutrient and organic matter enrichment	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Nutrient and organic matter enrichment	Pest and disease control	Regulation & Maintenance
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Nutrient and organic matter enrichment	Regulation of soil quality	Regulation & Maintenance
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Nutrient and organic matter enrichment	Water conditions	Regulation & Maintenance
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Nutrient and organic matter enrichment	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Nutrient and organic matter enrichment	Physical and experiential interactions with the environment (abiotic e.g., caves. natural: whales)	Cultural
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Nutrient and organic matter enrichment	Spiritual, symbolic and other interactions with natural environment	Cultural
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Nutrient and organic matter enrichment	Other biotic characteristics that have a non-use value	Cultural
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Biological disturbance	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Biological disturbance	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Biological disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Biological disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Biological disturbance	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Aquaculture	Aquaculture at sea (hatcherries, floating cages and rafts)	Biological disturbance	Pest and disease control	Regulation & Maintenance



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Aquaculture	Aquaculture at sea (hatcheries, floating cages and rafts)	Biological disturbance	Water conditions	Regulation & Maintenance
Aquaculture	Aquaculture at sea (hatcheries, floating cages and rafts)	Biological disturbance	Other biotic characteristics that have a non-use value	Cultural
Fisheries	Trawling	Physical damage	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Trawling	Physical damage	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Fisheries	Trawling	Physical damage	Mineral substances used for nutrition, materials or energy	Provisioning
Fisheries	Trawling	Physical damage	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Fisheries	Trawling	Physical damage	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Trawling	Physical damage	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Fisheries	Trawling	Physical damage	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Fisheries	Trawling	Physical damage	Pest and disease control	Regulation & Maintenance
Fisheries	Trawling	Physical damage	Regulation of baseline flows and extreme events	Regulation & Maintenance
Fisheries	Trawling	Physical damage	Regulation of soil quality	Regulation & Maintenance
Fisheries	Trawling	Physical damage	Water conditions	Regulation & Maintenance
Fisheries	Trawling	Physical damage	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Fisheries	Trawling	Physical damage	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural
Fisheries	Trawling	Physical damage	Other biotic characteristics that have a non-use value	Cultural
Fisheries	Trawling	Other physical disturbance	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Trawling	Other physical disturbance	Rearred aquatic animals for nutrition, materials or energy	Provisioning
Fisheries	Trawling	Other physical disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Trawling	Other physical disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Trawling	Other physical disturbance	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Fisheries	Trawling	Other physical disturbance	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Fisheries	Trawling	Other physical disturbance	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural
Fisheries	Trawling	Other physical disturbance	Other biotic characteristics that have a non-use value	Cultural
Fisheries	Trawling	Contamination by hazardous substances	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Trawling	Contamination by hazardous substances	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Fisheries	Trawling	Contamination by hazardous substances	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Trawling	Contamination by hazardous substances	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Fisheries	Trawling	Contamination by hazardous substances	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Trawling	Contamination by hazardous substances	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Fisheries	Trawling	Contamination by hazardous substances	Water conditions	Regulation & Maintenance
Fisheries	Trawling	Contamination by hazardous substances	Atmospheric composition and conditions	Regulation & Maintenance
Fisheries	Trawling	Biological disturbance	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Trawling	Biological disturbance	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Fisheries	Trawling	Biological disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Trawling	Biological disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Trawling	Biological disturbance	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Fisheries	Trawling	Biological disturbance	Pest and disease control	Regulation & Maintenance
Fisheries	Trawling	Biological disturbance	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Fisheries	Trawling	Biological disturbance	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural
Fisheries	Trawling	Biological disturbance	Other biotic characteristics that have a non-use value	Cultural
Fisheries	Gillnetting	Physical damage	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Gillnetting	Physical damage	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Fisheries	Gillnetting	Physical damage	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Gillnetting	Physical damage	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Gillnetting	Physical damage	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Fisheries	Gillnetting	Other physical disturbance	Rearred aquatic animals for nutrition, materials or energy	Provisioning
Fisheries	Gillnetting	Other physical disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Gillnetting	Other physical disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Gillnetting	Other physical disturbance	Regulation of soil quality	Regulation & Maintenance
Fisheries	Gillnetting	Other physical disturbance	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Fisheries	Gillnetting	Other physical disturbance	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural
Fisheries	Gillnetting	Contamination by hazardous substances	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Fisheries	Gillnetting	Contamination by hazardous substances	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Fisheries	Gillnetting	Contamination by hazardous substances	Water conditions	Regulation & Maintenance
Fisheries	Gillnetting	Contamination by hazardous substances	Atmospheric composition and conditions	Regulation & Maintenance
Fisheries	Gillnetting	Biological disturbance	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Fisheries	Gillnetting	Biological disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Gillnetting	Biological disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Gillnetting	Biological disturbance	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Fisheries	Gillnetting	Biological disturbance	Pest and disease control	Regulation & Maintenance
Fisheries	Gillnetting	Biological disturbance	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Fisheries	Gillnetting	Biological disturbance	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural
Fisheries	Gillnetting	Biological disturbance	Other biotic characteristics that have a non-use value	Cultural
Fisheries	Purse seine (with FADs or not)	Physical damage	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Purse seine (with FADs or not)	Physical damage	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Fisheries	Purse seine (with FADs or not)	Physical damage	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Purse seine (with FADs or not)	Physical damage	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Fisheries	Purse seine (with FADs or not)	Physical damage	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Fisheries	Purse seine (with FADs or not)	Physical damage	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Fisheries	Purse seine (with FADs or not)	Physical damage	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural
Fisheries	Purse seine (with FADs or not)	Physical damage	Spiritual, symbolic and other interactions with natural environment	Cultural
Fisheries	Purse seine (with FADs or not)	Physical damage	Other biotic characteristics that have a non-use value	Cultural
Fisheries	Purse seine (with FADs or not)	Other physical disturbance	Rearred aquatic animals for nutrition, materials or energy	Provisioning
Fisheries	Purse seine (with FADs or not)	Other physical disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Purse seine (with FADs or not)	Other physical disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Purse seine (with FADs or not)	Other physical disturbance	Regulation of soil quality	Regulation & Maintenance
Fisheries	Purse seine (with FADs or not)	Other physical disturbance	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Fisheries	Purse seine (with FADs or not)	Other physical disturbance	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural
Fisheries	Purse seine (with FADs or not)	Contamination by hazardous substances	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Fisheries	Purse seine (with FADs or not)	Contamination by hazardous substances	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Purse seine (with FADs or not)	Contamination by hazardous substances	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Fisheries	Purse seine (with FADs or not)	Contamination by hazardous substances	Water conditions	Regulation & Maintenance



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Fisheries	Purse seine (with FADs or not)	Contamination by hazardous substances	Atmospheric composition and conditions	Regulation & Maintenance
Fisheries	Purse seine (with FADs or not)	Biological disturbance	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Fisheries	Purse seine (with FADs or not)	Biological disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Purse seine (with FADs or not)	Biological disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Purse seine (with FADs or not)	Biological disturbance	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Fisheries	Purse seine (with FADs or not)	Biological disturbance	Pest and disease control	Regulation & Maintenance
Fisheries	Purse seine (with FADs or not)	Biological disturbance	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Fisheries	Purse seine (with FADs or not)	Biological disturbance	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural
Fisheries	Purse seine (with FADs or not)	Biological disturbance	Spiritual, symbolic and other interactions with natural environment	Cultural
Fisheries	Purse seine (with FADs or not)	Biological disturbance	Other biotic characteristics that have a non-use value	Cultural
Fisheries	Longline	Physical damage	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Longline	Physical damage	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Fisheries	Longline	Physical damage	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Longline	Other physical disturbance	Reared aquatic animals for nutrition, materials or energy	Provisioning
Fisheries	Longline	Other physical disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Longline	Other physical disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Longline	Other physical disturbance	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Fisheries	Longline	Other physical disturbance	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural
Fisheries	Longline	Contamination by hazardous substances	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Fisheries	Longline	Contamination by hazardous substances	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Fisheries	Longline	Contamination by hazardous substances	Water conditions	Regulation & Maintenance
Fisheries	Longline	Contamination by hazardous substances	Atmospheric composition and conditions	Regulation & Maintenance
Fisheries	Longline	Contamination by hazardous substances		Regulation & Maintenance
Fisheries	Longline	Biological disturbance	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Fisheries	Longline	Biological disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Longline	Biological disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Longline	Biological disturbance	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Fisheries	Longline	Biological disturbance	Pest and disease control	Regulation & Maintenance
Fisheries	Longline	Biological disturbance	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Fisheries	Longline	Biological disturbance	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural
Fisheries	Longline	Biological disturbance	Other biotic characteristics that have a non-use value	Cultural
Fisheries	Pots and traps	Physical damage	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Pots and traps	Physical damage	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Fisheries	Pots and traps	Physical damage	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Pots and traps	Other physical disturbance	Reared aquatic animals for nutrition, materials or energy	Provisioning
Fisheries	Pots and traps	Other physical disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Pots and traps	Other physical disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Pots and traps	Other physical disturbance	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Fisheries	Pots and traps	Other physical disturbance	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Fisheries	Pots and traps	Other physical disturbance	Regulation of soil quality	Regulation & Maintenance
Fisheries	Pots and traps	Other physical disturbance	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Fisheries	Pots and traps	Other physical disturbance	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Fisheries	Pots and traps	Contamination by hazardous substances	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Fisheries	Pots and traps	Contamination by hazardous substances	Water conditions	Regulation & Maintenance
Fisheries	Pots and traps	Contamination by hazardous substances	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Fisheries	Pots and traps	Contamination by hazardous substances	Atmospheric composition and conditions	Regulation & Maintenance
Fisheries	Pots and traps	Biological disturbance	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Fisheries	Pots and traps	Biological disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Pots and traps	Biological disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Pots and traps	Biological disturbance	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Fisheries	Pots and traps	Biological disturbance	Pest and disease control	Regulation & Maintenance
Fisheries	Pots and traps	Biological disturbance	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Fisheries	Pots and traps	Biological disturbance	Physical and experiential interactions with the environment (abiotic e.g., caves. natural: whales)	Cultural
Fisheries	Pots and traps	Biological disturbance	Other biotic characteristics that have a non-use value	Cultural
Fisheries	Trammel net	Physical damage	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Trammel net	Physical damage	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Fisheries	Trammel net	Physical damage	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Trammel net	Other physical disturbance	Reared aquatic animals for nutrition, materials or energy	Provisioning
Fisheries	Trammel net	Other physical disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Trammel net	Other physical disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Trammel net	Other physical disturbance	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Fisheries	Trammel net	Other physical disturbance	Physical and experiential interactions with the environment (abiotic e.g., caves. natural: whales)	Cultural
Fisheries	Trammel net	Contamination by hazardous substances	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Fisheries	Trammel net	Contamination by hazardous substances	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Fisheries	Trammel net	Contamination by hazardous substances	Water conditions	Regulation & Maintenance
Fisheries	Trammel net	Contamination by hazardous substances	Atmospheric composition and conditions	Regulation & Maintenance
Fisheries	Trammel net	Biological disturbance	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Fisheries	Trammel net	Biological disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Trammel net	Biological disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Trammel net	Biological disturbance	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Fisheries	Trammel net	Biological disturbance	Pest and disease control	Regulation & Maintenance
Fisheries	Trammel net	Biological disturbance	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Fisheries	Trammel net	Biological disturbance	Physical and experiential interactions with the environment (abiotic e.g., caves. natural: whales)	Cultural
Fisheries	Trammel net	Biological disturbance	Other biotic characteristics that have a non-use value	Cultural
Fisheries	Driftnetting	Other physical disturbance	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Driftnetting	Other physical disturbance	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Fisheries	Driftnetting	Other physical disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Driftnetting	Other physical disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Driftnetting	Other physical disturbance	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Fisheries	Driftnetting	Other physical disturbance	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Fisheries	Driftnetting	Other physical disturbance	Regulation of soil quality	Regulation & Maintenance
Fisheries	Driftnetting	Other physical disturbance	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Fisheries	Driftnetting	Other physical disturbance	Physical and experiential interactions with the environment (abiotic e.g., caves. natural: whales)	Cultural
Fisheries	Driftnetting	Other physical disturbance	Spiritual, symbolic and other interactions with natural environment	Cultural
Fisheries	Driftnetting	Other physical disturbance	Other biotic characteristics that have a non-use value	Cultural



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Fisheries	Driftnetting	Contamination by hazardous substances	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Fisheries	Driftnetting	Contamination by hazardous substances	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Driftnetting	Contamination by hazardous substances	Water conditions	Regulation & Maintenance
Fisheries	Driftnetting	Biological disturbance	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Fisheries	Driftnetting	Biological disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Driftnetting	Biological disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Driftnetting	Biological disturbance	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Fisheries	Driftnetting	Biological disturbance	Pest and disease control	Regulation & Maintenance
Fisheries	Driftnetting	Biological disturbance	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Fisheries	Driftnetting	Biological disturbance	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural
Fisheries	Driftnetting	Biological disturbance	Other biotic characteristics that have a non-use value	Cultural
Fisheries	Dredges	Physical damage	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Dredges	Physical damage	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Fisheries	Dredges	Physical damage	Mineral substances used for nutrition, materials or energy	Provisioning
Fisheries	Dredges	Physical damage	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Dredges	Physical damage	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Fisheries	Dredges	Physical damage	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Fisheries	Dredges	Physical damage	Pest and disease control	Regulation & Maintenance
Fisheries	Dredges	Physical damage	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Fisheries	Dredges	Physical damage	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural
Fisheries	Dredges	Physical damage	Other biotic characteristics that have a non-use value	Cultural
Fisheries	Dredges	Other physical disturbance	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Dredges	Other physical disturbance	Rearred aquatic animals for nutrition, materials or energy	Provisioning
Fisheries	Dredges	Other physical disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Dredges	Other physical disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Dredges	Other physical disturbance	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Fisheries	Dredges	Other physical disturbance	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Fisheries	Dredges	Other physical disturbance	Physical and experiential interactions with the environment (abiotic e.g., caves, natural: whales)	Cultural
Fisheries	Dredges	Other physical disturbance	Other biotic characteristics that have a non-use value	Cultural
Fisheries	Dredges	Contamination by hazardous substances	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Dredges	Contamination by hazardous substances	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Fisheries	Dredges	Contamination by hazardous substances	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Dredges	Contamination by hazardous substances	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Fisheries	Dredges	Contamination by hazardous substances	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Dredges	Contamination by hazardous substances	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Fisheries	Dredges	Contamination by hazardous substances	Water conditions	Regulation & Maintenance
Fisheries	Dredges	Contamination by hazardous substances	Atmospheric composition and conditions	Regulation & Maintenance
Fisheries	Dredges	Biological disturbance	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Dredges	Biological disturbance	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Fisheries	Dredges	Biological disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Dredges	Biological disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Dredges	Biological disturbance	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Fisheries	Dredges	Biological disturbance	Pest and disease control	Regulation & Maintenance



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Fisheries	Dredges	Biological disturbance	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Fisheries	Dredges	Biological disturbance	Physical and experiential interactions with the environment (abiotic e.g., caves. natural: whales)	Cultural
Fisheries	Dredges	Biological disturbance	Other biotic characteristics that have a non-use value	Cultural
Fisheries	Push and stow net	Physical damage	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Push and stow net	Physical damage	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Fisheries	Push and stow net	Other physical disturbance	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Fisheries	Push and stow net	Other physical disturbance	Physical and experiential interactions with the environment (abiotic e.g., caves. natural: whales)	Cultural
Fisheries	Push and stow net	Contamination by hazardous substances	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Fisheries	Push and stow net	Contamination by hazardous substances	Water conditions	Regulation & Maintenance
Fisheries	Push and stow net	Contamination by hazardous substances	Atmospheric composition and conditions	Regulation & Maintenance
Fisheries	Push and stow net	Biological disturbance	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Fisheries	Push and stow net	Biological disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Fisheries	Push and stow net	Biological disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Fisheries	Push and stow net	Biological disturbance	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Fisheries	Push and stow net	Biological disturbance	Pest and disease control	Regulation & Maintenance
Fisheries	Push and stow net	Biological disturbance	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Fisheries	Push and stow net	Biological disturbance	Physical and experiential interactions with the environment (abiotic e.g., caves. natural: whales)	Cultural
Fisheries	Push and stow net	Biological disturbance	Other biotic characteristics that have a non-use value	Cultural
Non-living marine resources extraction	Deep-sea mining	Physical loss	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Non-living marine resources extraction	Deep-sea mining	Physical loss	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Deep-sea mining	Physical loss	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Non-living marine resources extraction	Deep-sea mining	Physical loss	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Non-living marine resources extraction	Deep-sea mining	Physical loss	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Non-living marine resources extraction	Deep-sea mining	Physical loss	Regulation of soil quality	Regulation & Maintenance
Non-living marine resources extraction	Deep-sea mining	Physical loss	Other biotic characteristics that have a non-use value	Cultural
Non-living marine resources extraction	Deep-sea mining	Physical damage	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Non-living marine resources extraction	Deep-sea mining	Physical damage	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Deep-sea mining	Physical damage	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Non-living marine resources extraction	Deep-sea mining	Physical damage	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Non-living marine resources extraction	Deep-sea mining	Physical damage	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Non-living marine resources extraction	Deep-sea mining	Physical damage	Regulation of soil quality	Regulation & Maintenance



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Non-living marine resources extraction	Deep-sea mining	Physical damage	Other biotic characteristics that have a non-use value	Cultural
Non-living marine resources extraction	Deep-sea mining	Other physical disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Deep-sea mining	Contamination by hazardous substances	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Deep-sea mining	Contamination by hazardous substances	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Deep-sea mining	Contamination by hazardous substances	Mineral substances used for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Deep-sea mining	Contamination by hazardous substances	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Non-living marine resources extraction	Deep-sea mining	Contamination by hazardous substances	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Non-living marine resources extraction	Deep-sea mining	Contamination by hazardous substances	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Non-living marine resources extraction	Deep-sea mining	Contamination by hazardous substances	Water conditions	Regulation & Maintenance
Non-living marine resources extraction	Deep-sea mining	Biological disturbance	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Deep-sea mining	Biological disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Deep-sea mining	Biological disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Non-living marine resources extraction	Deep-sea mining	Biological disturbance	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Non-living marine resources extraction	Deep-sea mining	Biological disturbance	Other biotic characteristics that have a non-use value	Cultural
Non-living marine resources extraction	Dredging	Physical loss	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Dredging	Physical loss	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Non-living marine resources extraction	Dredging	Physical loss	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Dredging	Physical loss	Mineral substances used for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Dredging	Physical loss	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Non-living marine resources extraction	Dredging	Physical loss	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Non-living marine resources extraction	Dredging	Physical loss	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Non-living marine resources extraction	Dredging	Physical loss	Regulation of baseline flows and extreme events	Regulation & Maintenance
Non-living marine resources extraction	Dredging	Physical loss	Regulation of soil quality	Regulation & Maintenance
Non-living marine resources extraction	Dredging	Physical loss	Intellectual and representative interactions with environment (abiotic and natural)	Cultural



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Non-living marine resources extraction	Dredging	Physical loss	Other biotic characteristics that have a non-use value	Cultural
Non-living marine resources extraction	Dredging	Physical damage	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Dredging	Physical damage	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Non-living marine resources extraction	Dredging	Physical damage	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Dredging	Physical damage	Mineral substances used for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Dredging	Physical damage	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Non-living marine resources extraction	Dredging	Physical damage	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Non-living marine resources extraction	Dredging	Physical damage	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Non-living marine resources extraction	Dredging	Physical damage	Regulation of soil quality	Regulation & Maintenance
Non-living marine resources extraction	Dredging	Physical damage	Other biotic characteristics that have a non-use value	Cultural
Non-living marine resources extraction	Dredging	Other physical disturbance	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Dredging	Other physical disturbance	Rearred aquatic animals for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Dredging	Other physical disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Dredging	Other physical disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Non-living marine resources extraction	Dredging	Other physical disturbance	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Non-living marine resources extraction	Dredging	Other physical disturbance	Other biotic characteristics that have a non-use value	Cultural
Non-living marine resources extraction	Dredging	Contamination by hazardous substances	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Dredging	Contamination by hazardous substances	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Non-living marine resources extraction	Dredging	Contamination by hazardous substances	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Dredging	Contamination by hazardous substances	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Non-living marine resources extraction	Dredging	Contamination by hazardous substances	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Non-living marine resources extraction	Dredging	Contamination by hazardous substances	Mediation of wastes or toxic substances of anthropogenic origin by living processes	Regulation & Maintenance
Non-living marine resources extraction	Dredging	Contamination by hazardous substances	Water conditions	Regulation & Maintenance
Non-living marine resources extraction	Dredging	Contamination by hazardous substances	Atmospheric composition and conditions	Regulation & Maintenance



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Non-living marine resources extraction	Dredging	Biological disturbance	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Dredging	Biological disturbance	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Non-living marine resources extraction	Dredging	Biological disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Dredging	Biological disturbance	Water conditions	Regulation & Maintenance
Non-living marine resources extraction	Dredging	Biological disturbance	Other biotic characteristics that have a non-use value	Cultural
Non-living marine resources extraction	Offshore oil and gas extraction	Physical loss	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Offshore oil and gas extraction	Physical loss	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Non-living marine resources extraction	Offshore oil and gas extraction	Physical loss	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Offshore oil and gas extraction	Physical loss	Mineral substances used for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Offshore oil and gas extraction	Physical loss	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Non-living marine resources extraction	Offshore oil and gas extraction	Physical loss	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Non-living marine resources extraction	Offshore oil and gas extraction	Physical loss	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Non-living marine resources extraction	Offshore oil and gas extraction	Physical loss	Regulation of soil quality	Regulation & Maintenance
Non-living marine resources extraction	Offshore oil and gas extraction	Physical loss	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Non-living marine resources extraction	Offshore oil and gas extraction	Physical loss	Other biotic characteristics that have a non-use value	Cultural
Non-living marine resources extraction	Offshore oil and gas extraction	Physical damage	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Offshore oil and gas extraction	Physical damage	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Non-living marine resources extraction	Offshore oil and gas extraction	Physical damage	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Offshore oil and gas extraction	Physical damage	Mineral substances used for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Offshore oil and gas extraction	Physical damage	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Non-living marine resources extraction	Offshore oil and gas extraction	Physical damage	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Non-living marine resources extraction	Offshore oil and gas extraction	Physical damage	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Non-living marine resources extraction	Offshore oil and gas extraction	Physical damage	Regulation of soil quality	Regulation & Maintenance
Non-living marine resources extraction	Offshore oil and gas extraction	Physical damage	Intellectual and representative interactions with environment (abiotic and natural)	Cultural



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



Non-living marine resources extraction	Offshore oil and gas extraction	Physical damage	Other biotic characteristics that have a non-use value	Cultural
Non-living marine resources extraction	Offshore oil and gas extraction	Other physical disturbance	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Offshore oil and gas extraction	Other physical disturbance	Rearred aquatic animals for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Offshore oil and gas extraction	Other physical disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Offshore oil and gas extraction	Other physical disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Non-living marine resources extraction	Offshore oil and gas extraction	Other physical disturbance	Regulation of baseline flows and extreme events	Regulation & Maintenance
Non-living marine resources extraction	Offshore oil and gas extraction	Other physical disturbance	Intellectual and representative interactions with environment (abiotic and natural)	Cultural
Non-living marine resources extraction	Offshore oil and gas extraction	Other physical disturbance	Other biotic characteristics that have a non-use value	Cultural
Non-living marine resources extraction	Offshore oil and gas extraction	Contamination by hazardous substances	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Offshore oil and gas extraction	Contamination by hazardous substances	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Non-living marine resources extraction	Offshore oil and gas extraction	Contamination by hazardous substances	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Offshore oil and gas extraction	Contamination by hazardous substances	Mineral substances used for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Offshore oil and gas extraction	Contamination by hazardous substances	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Non-living marine resources extraction	Offshore oil and gas extraction	Contamination by hazardous substances	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Non-living marine resources extraction	Offshore oil and gas extraction	Contamination by hazardous substances	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Non-living marine resources extraction	Offshore oil and gas extraction	Contamination by hazardous substances	Pest and disease control	Regulation & Maintenance
Non-living marine resources extraction	Offshore oil and gas extraction	Contamination by hazardous substances	Regulation of baseline flows and extreme events	Regulation & Maintenance
Non-living marine resources extraction	Offshore oil and gas extraction	Contamination by hazardous substances	Water conditions	Regulation & Maintenance
Non-living marine resources extraction	Offshore oil and gas extraction	Biological disturbance	Wild plants (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Offshore oil and gas extraction	Biological disturbance	Genetic material (from plants, algae or fungi, animals and other organisms)	Provisioning
Non-living marine resources extraction	Offshore oil and gas extraction	Biological disturbance	Wild animals (terrestrial and aquatic) for nutrition, materials or energy	Provisioning
Non-living marine resources extraction	Offshore oil and gas extraction	Biological disturbance	Maintenance of physical, chemical, abiotic conditions	Regulation & Maintenance
Non-living marine resources extraction	Offshore oil and gas extraction	Biological disturbance	Lifecycle maintenance, habitat and gene pool protection	Regulation & Maintenance
Non-living marine resources extraction	Offshore oil and gas extraction	Biological disturbance	Mediation of nuisances of anthropogenic origin	Regulation & Maintenance
Non-living marine resources extraction	Offshore oil and gas extraction	Biological disturbance	Other biotic characteristics that have a non-use value	Cultural



This project has received funding from the European Union's Horizon Europe research and innovation programme. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.



ANNEX IV: ESE modules and their integration in the ESE management framework (named as “ESE Model” in the figure). Source: Matczak et al., (2024).

