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HORIZON-MISS-2021-OCEAN-02-01- Blueprint demonstration for co-created effective, efficient and resilient networks of MPAs climate resilience

Deliverable D2.3 - *Identification and valuation of benefits from marine ecosystem services*

WP2 – Science-based tools for socio-economic and governance solutions

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Acronyms

ES: Ecosystem services
ESV: Ecosystem services valuation
IS: Information site
LL: Living lab
MPA: Marine Protected Area
OECM: Other Effective Conservation Measures
SEG: Stakeholder Engagement Group
WP: Work Package

Glossary

Co-creation in the context of Blue4all is a collaborative process where project partners and multiple stakeholders together create the design and implementation of science-based tools for effective marine protection that Marine Protected Areas (MPAs) and Other Effective Area-Based Conservation Measures (OECMs) can apply in context-specific manner.

Information sites (ISs) are sites that offer a representative view on the challenges and tools of the wide diversity of MPAs and networks of MPAs in Europe.

Living labs (LLs) are sites with which Blue4all will involve in a co-creation process with the end goal of producing a Blueprint Platform for effective, efficient and resilient MPAs. These sites have a clearly defined geographical scope, are recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values.

Stakeholder Engagement Groups (SEGs) are in situ co-creation bodies Blue4all will establish in each Living lab. SEG members are invited based on a stakeholder analysis, and they represent the primary stakeholder groups in their Living lab (e.g., national and/or local authorities, community leaders, and representatives of the civil sector and other key sectoral and interest groups such as scientists). SEGs meet regularly and take part in tool co-creation, testing and validation.

Blueprint Platform is a a web-based platform that will provide a comprehensive and adaptive toolkit in a user-friendly manner to end-users to support enhancing MPAs' efficiency, effectiveness and resilience.

Ecosystem services are the direct and indirect benefits that ecosystems provide and on which humans depend. They can generally be categorised into four types: provisioning (e.g., food), cultural (e.g., tourism), regulating (e.g., flood protection), and supporting services (e.g., habitat provision).

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Executive Summary

Deliverable D2.3 contributes to the Blue4all project's overarching goal of developing science-based, co-created tools to enhance the effectiveness, efficiency, and resilience of Marine Protected Areas (MPAs) and MPA networks. Specifically, this deliverable addresses all activities within T2.3 of the project: identification and valuation of benefits derived from marine ecosystem services, recognising that socio-economic evidence is valuable for informed decision-making, stakeholder acceptance, and the long-term sustainability of marine conservation efforts.

The objectives of this report are threefold:

1. **To identify existing tools and scientific methods** that can be used to assess the monetary and non-monetary values of ecosystem services relevant to MPAs and OECMs.
2. **To develop a structured framework** that guides MPA managers and decision-makers in selecting and applying these tools according to their context, data availability, stakeholder needs, and management objectives.
3. **To prepare the foundation for practical implementation** of this framework through integration into the Blue4all Blueprint Platform, where it will take the form of step-by-step guidance and a decision-support decision-tree.

To deliver on these objectives, the report follows a structured process:

- It begins by outlining the relevance of ecosystem service valuation within the broader ecological and governance context of marine protection.
- It then compiles a comprehensive longlist of tools and methods, incorporating both monetary and non-monetary approaches.
- A systematic screening and shortlisting approach is applied to evaluate these tools according to their usability (including strengths and weaknesses), resource requirements, data needs, and applicability to marine settings.
- The shortlisted tools are further assessed in depth to inform the development of step-by-step methodological guidance which will be showcased on the Blueprint Platform.
- Finally, the report describes the framework that supports MPA managers in choosing the right valuation approach depending on management objectives, ecosystem characteristics, and stakeholder priorities. The components of this framework result from all activities executed within T2.3 and it is further integrated into the Blueprint Platform through a decision-tree and step-by-step (methodological) guidance on tool implementation.

The framework developed within this deliverable is not a singular valuation tool, but a structured process that integrates existing valuation methods into a practical, decision-oriented format. It is designed to support different governance contexts, including individual MPAs, MPA networks, and OECMs, and to connect socio-economic valuation with future tasks on financing mechanisms.

In doing so, the deliverable ensures that socio-economic valuation becomes a functional and accessible component of marine management—helping to articulate the benefits of ecosystem services in ways that support decision-making, enhance stakeholder engagement, and increase the long-term resilience of marine protected areas.

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1 Introduction

The aim of the Blue4all project is to align top-down regulatory demands about European marine protected areas (MPAs) and MPA networks with operational realities (MPA management) and bottom-up societal expectations as a guarantee for achieving effective, efficient, and resilient MPAs and networks of MPAs. An important part of this work is co-creation of robust and replicable social, governance, ecological and environmental tools to meet conservation and/or restoration objectives in socially sustainable and acceptable ways. In the project, these science-based tools have been tested in Living Labs (LLs), i.e. locations where (networks of) MPAs are in the process of establishment and/or management, and where such tools can be fed into the ongoing MPA process.

This report results from the work conducted within T2.3 (Tools for valuating benefits from ecosystem services; hereafter T2.3) of the Blue4all project. Within work package 2 (WP 2: Science-based tools for socio-economic and governance solutions), T2.3 specifically looks at the potential of (existing) tools to identify and value the benefits from marine ecosystem services with the aim of improving such tools (Plan of Actions: O2.3; see also D2.1 (Varjopuro et al., 2023)[1]). The tools addressed by T2.3 facilitate generating socio-economic valuation of marine ecosystem services. This implies the attempt to reveal and objectify how nature contributes to human wellbeing. This differs from the financial tools that are explored in D2.4, in which funding sources and business models are researched. Importantly, the economic valuation tools developed in T2.3 serve a bridging function between the stakeholder and governance insights generated in D2.2 and the funding and financing mechanisms examined in D2.4. By quantifying ecosystem services (thus leveraging from information generated by WP3) in socio-economic terms, these tools enable governance outcomes to be translated into actionable financial strategies, thereby supporting decision-making and the mobilisation of investment in marine conservation and sustainable use. The assessment of tools was conducted in distinct phases: tools identification, initial tools screening and shortlisting, in-depth tools assessment, and tools testing and validation in the Blue4All LLs. Throughout the distinct phases of this task, the Blue4all approach of bottom-up and co-creation was carefully adhered to. Finally, the task contributes to developing step-by-step guidelines for a subset of tools to be improved. While these step-by-step guidelines, accompanied with a decision-tree to guide users towards the "right" valuation tool, are subject to the output generated for integration onto the Blueprint Platform, and thus out of scope for this deliverable report, they are an integral and valuable result of T2.3. The process of how we got to these tool improvements will be described in this report.

In this report, the results from T2.3 are structured according to the aforementioned distinct phases. First, in this introductory first chapter, we describe the (scientific) scope and motivation to the activities executed within T2.3. This includes addressing how and why tools to value ecosystem services could contribute to more effective, efficient, and resilient MPAs. In Chapter 2 we expand on the process of identifying tools and developing a systematic way of initial tools screening and later, the in-depth assessment. We describe the process of how we started from a longlist of tools (based on D1.3) and evolved to the final list of potential *promising tools* for tools testing. To systematically objectify this potential, we describe the process of an intermediate in-depth assessment of the potentially promising tools. This last step led to the final shortlist of tools that were subjected to the tools testing and validation phase. Chapter 2 outlines the methodology used to identify relevant tools and establish a systematic approach for both the initial screening and subsequent in-depth assessment. The process began with a longlist of tools and was progressively refined to determine the most promising tools for testing and validation (Chapter 3). To ensure an objective and transparent selection process, an intermediate in-depth assessment (Chapter 4) was conducted, evaluating the potential of each shortlisted tool against predefined criteria. This assessment resulted in the final list of tools that proceeded to the testing and validation phase, thus actual application in the Blue4All LLs, as determined in collaboration with WP2, WP3 and WP4.

In Chapter 5, the tools' testing and validation phase is described in detail. More specifically, we demonstrate the testing and validation of tools in each of the three chosen Blue4all LLs: MPA Vlaamse Banken (BE), French Natura 2000 Network MPA (FR), and Danish Wadden Sea MPA (DK). The implementation of the tools provided evidence from practical experience, in which the process (meaning requirements, preconditions, assumptions, ease of use, etc.) was equally important to the results in terms of ecosystem services values. Additionally, we

[1] Varjopuro R., Raatikainen K.J., Van Schoubroeck S., Compernolle T., Van Oijstaeijen W., Mata Lara M., Stojanovic I., Toonen H. (2023) Enablers for socio-economic transition processes towards effective, efficient and resilient networks of MPAs. Deliverable – D2.1 under the WP2 of the Blue4all project (GA n° 101094014).

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integrated how the respective results from the tools' testing and validation were received by MPA managers / SEG members.

In Chapter 6 we set out the framework for identifying and valuing ecosystem services. We describe the different components and how they were shaped throughout the process of T2.3. We further clarify how the integrative and synthetic nature of this task will contribute to the Blueprint Platform.

Chapter 7 summarizes and links the insights acquired throughout the different phases of T2.3. We conclude with coupling back to the task objectives and provide general recommendations on socio-economic valuation tools for marine ecosystem services. It further expands on how these builds into a framework for identifying ecosystem services and assessing monetary and non-monetary values. This framework, existing of step-by-step tool guides and a decision-tree will be the basis for the integration of D2.3 into the Blueprint platform.

1.1 Context of socio-economic valuation in MPAs

Our oceans and seas provide a wide array of ecosystem services. To safeguard the capacity of these marine bodies to generate such benefits and protect biodiversity, MPAs have been (and are being) established. As defined in Target 3 of the Kunming-Montreal Global Biodiversity Framework and the EU Mission "Restore our Oceans and Waters by 2030", 30% of our oceans must be protected through networks of MPAs and other effective conservation measures (OECMs) to maintain healthy and functioning ecosystems. The UN High Seas treaty (the agreement on Biodiversity Beyond National Jurisdiction – safeguarding biodiversity at high seas[2]) further cleared the ratification threshold in the summer of '25, meaning it enters into force in January 2026. While designating areas as MPAs and OECMs limits human's direct (and usually unsustainable) use of certain marine areas, protection ensures long-term well-being of both marine life and human populations that depend on the ocean. Mapping and valuing (cultural) ecosystem services can be pivotal for understanding stakeholders' perceptions of marine protection and the factors that influence acceptance and ownership. Ecosystem services are defined by the European Commission as those services or benefits that ecosystems provide and on which humans depend[3]. Moreover, such insights support informed decision-making and inclusive management decisions. Interdisciplinary socio-economic research thus serves as a bridging mechanism, connecting ecological importance to effective, efficient and resilient MPA implementation and uptake. The ecosystem services valuation reasoning adopted in this deliverable follows the framework of the ecosystem service cascade model. As depicted in Figure 1, we establish how biophysical structures or processes entail certain ecosystem functions, which lead to ecosystem services that create benefits to humans. From these benefits, humans derive value, which can be economic, but also social, moral, aesthetic, or others. Through establishing how ecosystem services led to benefits and making those benefits more tangible into values, we aim to make explicit the (societal) value that is derived from the ecosystem and its structures and functions.

[2] https://news.un.org/en/story/2025/09/1165901
[3] https://eur-lex.europa.eu/EN/legal-content/glossary/ecosystem-services.html

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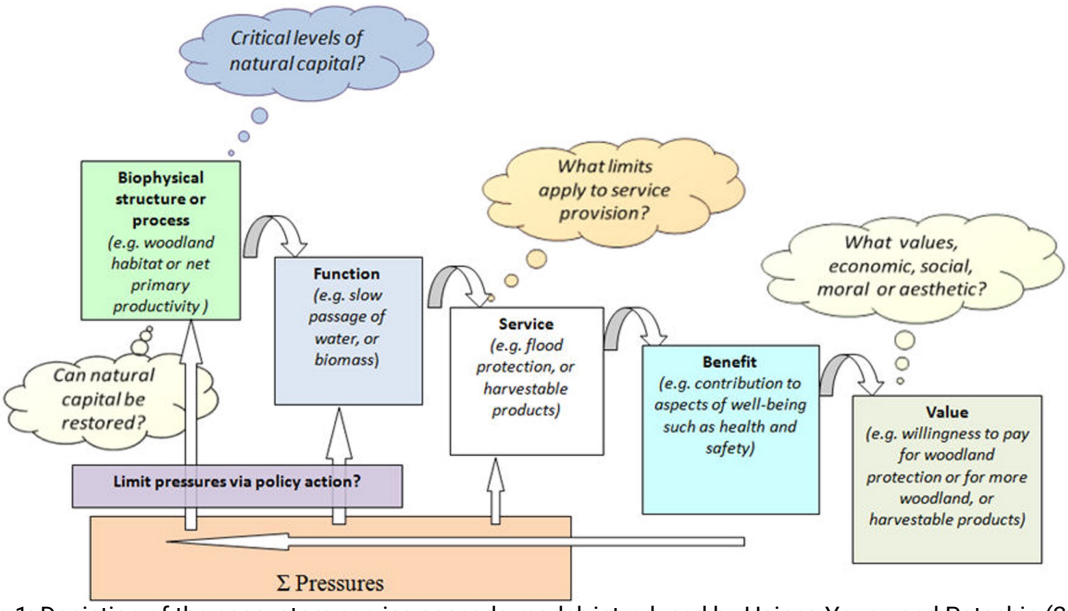

Figure 1: Depiction of the ecosystem service cascade model, introduced by Haines-Young and Potschin (2011)[4]

1.2 Needs of Blue4all MPAs

In D4.1 (part of WP4, T4.1), the context of the Blue4all LLs and information sites (IS) was established. The baseline assessment defines the playing field for the research approach adopted in T2.3. It was determined that LLs are involved in the development of tools from the start to the final validation as collaborators; the intent was to address specific needs apparent at the LLs during tools testing and validation. This approach ensures coherence with the general workflow of T2.3 described in D2.1, particularly in the stakeholder engagement phase, where LL managers and decision makers are key contributors to defining valuation needs and supporting the selection and development of suitable valuation tools

Needs that can be addressed through socio-economic and ecosystem services valuation were identified in the needs assessment (D4.2). From this exercise, LLs to test and validate ecosystem service valuation tools were identified. The section below copies in the relevant needs that were established by those LLs related to ecosystem service valuation in the needs assessment (D4.2).

a) Danish Wadden Sea MPA

"Also, the participants of the online workshop agreed that a better understanding and **mapping of ecosystem services would create more value in marine protected areas and** their surrounding areas. They emphasized the importance of **understanding how ecosystems serve society**. They also discussed the challenge of assigning a monetary value to ecosystem services. They acknowledged that while this is a complex task, it is beneficial to be able to **express the value of ecosystem services in economic terms**, as this is the language commonly used in decision-making processes."

"The participants further discussed the need for a more holistic approach to nature transformation and conservation. This involves considering not only the greatest economic values but also **the interests of all people who use and are affected by nature**. In addition, the importance **of involving all stakeholders in decision-making processes** concerning ecosystem services was highlighted. This ensures that decisions are not only based on economic values but also consider the interests of all people affected by these decisions."

"To address these issues (cfr. "the economic challenges, particularly the lack of funding for projects and research in the area, affecting all parties and hindering Denmark's equal participation in the trilateral Wadden Sea Cooperation"), participants proposed a holistic socioeconomic model that includes the value of nature, **aiding in decision-making processes and demonstrating the need for funds** in political processes."

[4] Potschin, M. B., & Haines-Young, R. H. (2011). Ecosystem services: Exploring a geographical perspective. *Progress in Physical Geography: Earth and Environment*, 35(5), 575-594. doi:10.1177/0309133311423172

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"The workshop participants of the additional online workshop also touched on the topic of funding and the potential use of **putting a monetary value on ecosystem services, which could be beneficial for decision-making**."

"Participants expressed the need for tools, based on existing biogeophysical data, to assess and monetize ecosystem services, aiding in ocean planning and political decision-making, such as evaluating the **economic impact of potential projects like wind farms on species, coastal protection, and tourism**. "

"Communication Gap: Need for **better communication** of the concept (ecosystem services) in politics."

"Difficulty in Valuing 'Soft Values': Challenge in assigning a **monetary value to 'soft values'** that don't inherently have a price. "

"Complexity of **Mapping and Assessment**: The process is complex, though demand is rising. "

b) Vlaamse Banken MPA

"The concept of ecosystem services is relatively well known and is important in **communicating with stakeholders**. The main challenge here is that it remains a relatively intangible concept – lacking concrete links between e.g. specific measures taken for certain species and how this leads to an increase in ecosystem services. Making these links more explicit and adapted to the local context (by e.g., producing factsheets) could improve communication."

"**Overcoming resistance to change**; dealing with stakeholders who plainly refuse any change (and see the current situation as part of their cultural identity)"

c) French Natura 2000 MPA

"During this discussion, the most relevant and priority need emerged as the necessity **to raise awareness and foster acceptance of the Living Lab**, MPAs, and their ecological aspects among socio-economic actors."

"The SEG agrees that leveraging ecosystem services can **enhance the effective management of MPAs**. They recognize that ecosystem services can aid in **gaining acceptance** of the MPA, **achieving its goals, and implementing conservation measures.** However, the SEG emphasizes several important considerations:

- Due to the testing phase, lack of experience, and limited funding, it may not be feasible to conduct Research and Development on ecosystem services.
- SEG are much interested about concrete example of use ecosystem service for acceptability in MPAs.
- The SEG is wary of relying on monetary valuation of ecosystem services, citing insufficient knowledge about marine ecosystem services and potential risks.
- Ecosystem services assessments must account for the diversity of activities and cumulative impacts within the MPA.
- There is a need to be cautious about how ecosystem services are utilized by certain actors, as they may use them to promote specific activities rather than the MPA itself."

1.3 Collaboration in T2.3

The collaboration within T2.3 was structured to actively support integration across work packages, recognising that effective tool development requires interdisciplinary input. During the T2.3 conceptualisation phase—the first two years of the Blue4All project—dedicated quarterly T2.3 meetings were organised to bring together contributors from WP2, WP3, and WP4. These meetings served not only to coordinate activities but to jointly shape the approach to tool identification, selection, and assessment, ensuring that the process reflected ecological, social, and economic perspectives.

Involving collaborators from WP3 and WP4 at this early stage allowed for a more coherent methodology and a shared understanding of the intended applications of the tools. This collaborative approach helped align the assessment criteria with the needs of different stakeholders and ensured that diverse expertise was reflected in the evaluation process.

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Furthermore, for several case studies, close collaboration between WP2, WP3, and WP4 was essential to ensure the correct and context-specific application of economic valuation tools. This interdisciplinary coordination was necessary to meet the requirements of the respective stakeholder engagement groups and to ensure that the tools selected were both scientifically robust and practically relevant.

2 Tools identification

The first step of T2.3 existed in identifying existing tools to contribute to ecosystem service valuation. Leveraging the information gathered in WP1, specifically D1.3, this assessment started with a longlist of potential tools related to mapping and valuing ecosystem services. During the review of toolkits (including software, websites, etc.), we realized that applicability is often hampered for several reasons (outlined in section 3.2) and therefore decided to incorporate valuation methods in the review as well.

In this document, and in line with the WPs glossary defined in D2.1 (section 2.2), a tool can be a toolkit or a method. A toolkit is defined as something an MPA manager can use to help value and understand the benefits that nature provides to humans in MPAs. This can be a software program, an app, a guidebook, a spreadsheet, etc. A method is defined as a scientific approach or technique behind a tool. It can be considered as a 'recipe' that explains how to collect and analyse data to value and understand the benefits that nature provides to humans in MPAs. Examples are stated preference methodologies, carbon footprint analysis, etc.

The purpose of this review is to capture if and how a certain tool or method can be applied by an MPA manager for a certain valuation need. This assessment is based on literature, consisting of user manuals, case studies, academic literature, and grey literature. Finally, this assessment will help to identify the *most promising tools*, which will afterwards be subjected to testing and eventually validation in one of the LLs of the Blue4all project.

2.1 Tools availability

In D1.3, an overview of monetary and non-monetary ecosystem service valuation methods and toolkits that can support MPAs and OECMs was provided. Beyond that initial set of tools, an extended literature review—primarily through cross-references—was carried out to compile the most comprehensive list possible. At the outset of T2.3, the scope of "tools" was initially limited to toolkits. Toolkits were interpreted as practical and ready-to-use resources (software, models, spreadsheets, …) that facilitate ecosystem service valuation. However, as will be detailed later (in Chapter 0), the initial tools screening yielded too few options when limiting to toolkits; therefore, valuation methods were subsequently included in the longlist of options. The full list of tools addressed within this task can be seen in
Table *1*.

Table 1: Full list of toolkits and methods considered within T2.3

N°	Reviewed toolkits
1	ARIES
2	Atlantis
3	BVMtool (LifeWatch)
4	Coastal Capital Valuation Tool
5	Ecopath EcoSim (EwE)
6	Envision
7	InVEST Coastal Blue Carbon
8	InVEST Coastal Vulnerability
9	InVEST Habitat Quality
10	InVEST Visitation: tourism and recreation
11	InVitro
12	Madrona
13	MARine Ecological Emulator (MAREE)
14	MARXAN

N°	Reviewed methods
1	Contingent valuation
2	Choice experiments
3	Travel cost method
4	Hedonic pricing
5	Replacement cost method
6	Damage cost method
7	Production function method
8	Direct market valuation method
9	Benefit transfer
10	Biophysical modelling and mapping
11	Assessments using rating and ranking questions
12	Qualitative methods
13	Participatory (cultural) mapping
14	Community voice method

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15	Mimes
16	MSP Challenge 2050
17	Mytilus
18	PlanWise4Blue
19	Rios
20	SEANERGY and Baltic Explorer (combo)
21	SeaSketch
22	SERVEs
23	SolVES
24	Symphony
25	Tools4MSP Geoplatform
26	Vista
27	Zonation 5

15	Q-method
16	Multi-criteria decision analysis (MCDA)

2.2 Graphic overview of the tool selection procedure

After identifying the longlist of available tools, and in accordance with D2.1, the process of tool selection was developed. The objective of the tool selection procedure lay in evaluating the longlist of tools to define those "most suitable" or "most promising" tools that align with stakeholder groups' needs. This process of analysing and comparing all tools on their appropriateness within the context of ecosystem service valuation (ESV), exists of several steps, graphically depicted in Figure 2. In Chapter 3, the method of reducing the longlist of available tools to a shortlist of most promising tools is described in detail.

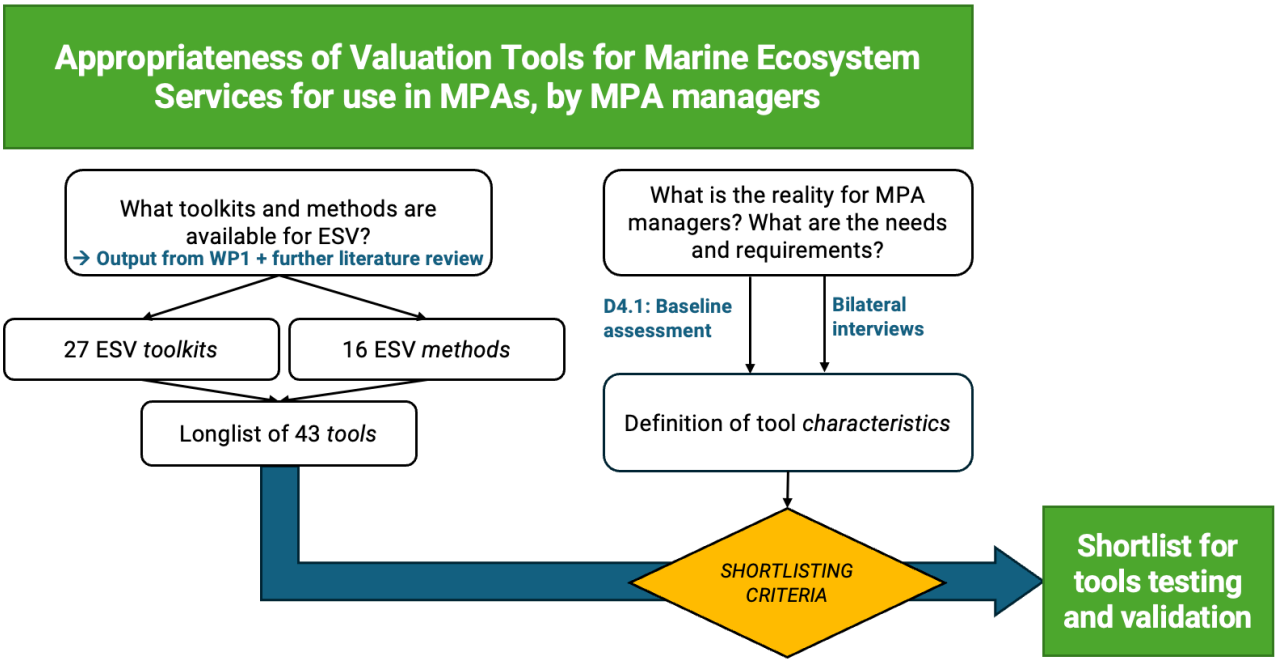

Figure 2: Schematic overview of tool selection procedure (initial tools screening and shortlisting)

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3 Initial tools screening and shortlisting

3.1 Tool characteristics

In Task T2.3, we built upon the findings of WP1 and WP4 to evaluate the relevance and applicability of the identified tools within the specific management contexts of MPAs and OECMs. Contextual "realities" were defined using insights from the baseline assessment in Deliverable D4.1, complemented by bilateral interviews with experts and MPA managers from the Blue4All LLs. This allows to identify those tools that align with the stakeholder groups' needs, as outlined in D2.1.

Subsequently, key tool characteristics were identified that influence their usability for integrating ecosystem service valuation into the resilient, effective, and efficient management of MPAs. In this context, the assessment focuses on tool appropriateness, as introduced in Deliverable D2.1. The basis for the tool characteristics results from previous experience with reviewing ecosystem service valuation tools (Van Oijstaeijen et al., 2020[5]), adjusted for the contextual specificity that MPA management entails. These list characteristics was therefore compiled by taking the perspective of the primary end-users: MPA managers and staff working at MPA management offices. They serve as descriptors that determine the practical applicability of the tools. This screening provides a detailed description of each tool's functionality, operational requirements, and contextual suitability. These characteristics offer granular insights into aspects such as the tool's purpose, data needs, user expertise, and implementation process. The full list of characteristics is provided in Table 2.

Four criteria were then utilized to conclude the screening exercise with a shortlist of most promising tools. While the four criteria were not explicitly included as standalone characteristics, they were distilled from the analysis of these characteristics as the most critical factors influencing tool applicability in MPA and OECM settings. In other words, the characteristics served as the analytical foundation from which the criteria were derived. The criteria that are used for the shortlisting are:

- **Ecosystem service valuation** is derived from characteristics that indicate whether and how the tool incorporates ecosystem services as a core component of its methodology.
- **Time requirements** emerge from the time investment needed to go through an entire tool application process.
- **Expertise requirements** reflect the technical complexity of the tool, the need for specialist knowledge, and the degree of support or guidance available.
- **Data requirements** result from the specificity or accessibility of data needed for meaningful application.

By synthesising these characteristics into four overarching criteria, the assessment framework translates descriptive information into a practical traffic light scheme, colour coding in green, yellow, and red. This enables the identification of those tools that are not only relevant in principle, but also feasible and appropriate for implementation by MPA managers under real-world constraints.

[5] Van Oijstaeijen, W., Van Passel, S., & Cools, J. (2020). Urban green infrastructure: A review on valuation toolkits from an urban planning perspective. *Journal of environmental management, 267*, 110603. doi:https://doi.org/10.1016/j.jenvman.2020.110603

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Table 2: Overview of tool characteristics, compiled for every tool in the initial tools screening

N°	Tool characteristic
1	Geographical focus
2	Regularly updated?
3	Open source? (publicly available)
4	Focus on marine? Or broader focus including land-based / river basins / wetland areas / etc.
5	Type of tool (Web-based interface, Excel, PDF guidebook, Method, …)
6	Is the tool calculating, descriptive, or both?
7	What is/can be assessed? (e.g., what does the tool say they assess?)
8	Which ecosystem services included?
9	Monetary valuation/facilitates getting monetary values?
10	Which valuation methods are applied in the tool?
11	Transferability (i.e., how spatially explicit is the tool, can it be utilized elsewhere?)
13	What do the results look like?
14	Where to find the tool? (URL, ..?)
15	Examples of tool applications (case studies, good/best practices)

3.2 Results and takeaways

After the initial tool screening, it became apparent that, compared to terrestrial and urban ecosystems, fewer dedicated and widely applicable toolkits are available for the valuation of marine ecosystem services. This disparity likely reflects a combination of historical, methodological, and institutional factors. Ecosystem service valuation frameworks were initially developed with terrestrial and urban planning contexts in mind, where ecosystem boundaries are more clearly defined, data availability is higher, and decision-making processes are more centralized. In contrast, marine ecosystems are characterized by fluid spatial boundaries, complex and less observable ecological processes and causal relations, and significant data limitations, particularly offshore. Many marine ecosystem services are also non-marketed, indirect, or global in nature, making them more difficult to quantify and integrate into standardized valuation tools. Most of the toolkits that were identified in D1.3 and the complementary literature review are designed to guide processes that either focus on spatial mapping (of ecosystem services) or contribute to zoning and marine spatial planning.

Further, in screening the longlist of toolkits, it was established that many existing toolkits originate from research projects. Often, this leads to the observation that they have not been maintained, the software may be outdated, and/or there is no longer a point of contact for these toolkits. As the tools that feature on the Blueprint platform should be usable and up to date, we excluded such toolkits from the longlist.

Next, applying the shortlisting criteria helped in the identification of “most promising” tools. The first hard exclusion criterion was the level of complexity of a toolkit. It was observed that some tools – although extensively supported scientifically – do not respond to the needs identified by the Blue4All LLs, and the objectives of tools that were defined (cfr. usable, versatile, efficient, and effective). Since the primary objective is to discern tools that can be used by MPA management, toolkits that are very resource-demanding were excluded. Such toolkits would be (either) too time intensive, data intensive, or expertise intensive. Which tools were excluded and for what reason becomes visible in Table 3

While ecosystem service valuation tools were scarce, we found that tools that include the subset of cultural ecosystem services were even scarcer. The needs assessment, however, showed that the Blue4all LLs express an interest into people’s recreational, emotional, or spiritual appreciation of MPAs. To accommodate for this gap, it was decided to consider scientific valuation method’s potential to be used in MPA management. The longlist of methods originates from D1.3, complementary literature review within T2.3 and Van Schoubroeck et al. (2024)[6].

[6] Van Schoubroeck et al. (2024). Valuation of ecosystem services in marine protected areas: A comprehensive review of methods and needed developments. *Ecosystem Services*, 70, 101678.https://doi.org/10.1016/j.ecoser.2024.101678

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Based on these considerations, a traffic light assessment was developed to facilitate the shortlisting of tools, as presented in Table 3. This assessment applied a traffic light scoring system to four key criteria derived from the screening process: (1) suitability for ecosystem service valuation, (2) time requirements, (3) data requirements, and (4) expertise requirements. Each toolkit or method was evaluated against these criteria using the insights obtained from the detailed tool characteristics assessment.

The shortlisting process followed a stepwise exclusion approach. First, tools that received a red score for ecosystem service valuation—indicating they are not fit for this purpose—were excluded from further consideration. For tools rated green or yellow on this primary criterion, the remaining criteria were then evaluated. Finally, tools that received red scores across all three remaining domains (data, time, and expertise requirements) were deemed unsuitable for practical application in the context of Task T2.3 and were removed from the shortlist.

Toolkit name	1[a]	2[b]	3[c]	4[d]	Method name	1[a]	2[b]	3[c]	4[d]
PlanWise4Blue					Contingent valuation				
MSP Challenge 2050					Choice experiments				
Tools4MSP Geoplatform					Travel cost method				
SeaSketch					Hedonic pricing				
Atlantis					Replacement cost method				
Zonation 5					Damage cost method				
Ecopath EcoSim (EwE)					Production function method				
MARXAN					Direct market valuation method				
INVEST Coastal Blue Carbon					Benefit transfer				
INVEST Coastal Vulnerability					Biophysical modelling and mapping				
InVEST Habitat Quality					Assessments using ratings and rankings				
ARIES					Qualitative methods				
Coastal Capital Valuation Tool		*	*		Participatory (cultural) mapping				
Envision					Community voice method				
Rios					Q-method				
SolVES					Multi-criteria decision analysis (MCDA)				
Vista									
InVEST visitation: tourism and recreation									
Symphony	Not accessible								
Mytilus	Not accessible								
MARine Ecological Emulator (MAREE)	Not accessible								
SEANERGY and Baltic Explorer	Not accessible								
BVMtool, also called LifeWatch	Not accessible								
InVitro	Outdated**								
Madrona	Outdated***								
Mimes	Not accessible								
SERVEs	Not accessible								

[a] Suitability for ESV, [b] time requirement, [c] data requirement, and [d] expertise requirement.
* Not applicable, it is not a calculating tool but a guiding document for a wide range of different methods, so no singular data or expertise requirement.; ** Last version dates to 2008, *** Last version dates to 2013

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Table 3: Traffic light assessment of toolkits and methods based on suitability for ecosystem service valuation and practical implementation factors (data, time, and expertise requirements). Tools were evaluated using a color-coded scoring system, where **green** indicates high suitability or low requirement, **yellow** indicates moderate suitability or manageable requirement, and **red** indicates low suitability or prohibitive requirement. Tools receiving a red score for ecosystem service valuation were excluded, and those receiving red scores across all remaining criteria were not shortlisted.

Following aforementioned logic, toolkits that will be subjected to in-depth assessment are**: PlanWise4Blue, Zonation5, EcoPath Ecosim, InVEST, ARIES, Coastal Capital Valuation Tool, and SolVES**. Similarly, for the methods, the following methods are withheld: **contingent valuation, replacement cost method, damage cost method, production function method, benefit transfer, assessments using ratings and rankings, qualitative methods, participatory (cultural) mapping, and multi-criteria decision analysis.** Apart from being scrutinized further in the in-depth assessment, this also implicates that these tools will be featured on the Blueprint platform as an outcome of T2.3.

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4 In-depth tools assessment

The shortlist of tools identified in the previous steps underwent a detailed review to determine their potential applications, strengths, limitations, required resources, and the specific research questions they can address. This in-depth assessment aimed to establish a case study protocol for tools that receive a positive evaluation, providing clear guidelines for their use in testing and validation. Each assessment followed a standardized structure, including: a general description of the tool, a step-by-step guide for its application, and a summary of its advantages and limitations. The exercise was carried out by all T2.3 collaborators using a template developed by the University of Antwerp (see Appendix 1: In-depth assessment of the "most promising tools"). During dedicated T2.3 meetings, we distributed the shortlisted tools across task participants, often based on previous experience with a tool. The process of in-depth tools assessment was executed in May-June '24, and concluded their advantage and limitation by August '24. Contributors to these assessments are: Tin-Yu Lai (Syke), Annaïk Van Gerven (RBINS), Martha Stevens (VLIZ), Soukaina Anougmar (UAntwerp), Sophie Van Schoubroeck (UAntwerp), Wito Van Oijstaeijen (UAntwerp), Venla Ala-Harja (HELCOM), Francisco R. Barboza (UTartu), Loïs Watt (HELCOM), Kaisa J. Raatikainen (Syke).

The following sections present the conclusions of each tool's in-depth assessment..

4.1 Invest models

4.1.1 Coastal Blue Carbon[7]

The Coastal Blue Carbon model within the InVEST suite is designed **to estimate carbon sequestration and storage in coastal ecosystems.** It shares its interface and underlying logic with the terrestrial carbon model, which benefits users already familiar with that system

Advantages	Limitations
The tool is supported by a clear user manual and virtual training materials, making it relatively accessible. Although the video tutorials do not cover the coastal model specifically, the similarities with the terrestrial model help bridge this gap. The interface is intuitive, allowing users to run the model with minimal technical barriers.	The model's effectiveness depends on the availability of local ecological and spatial data. Preparing these datasets requires both GIS capabilities and ecological expertise, necessitating collaboration with scientific partners. Additionally, the model applies a simplified accounting approach that does not capture the complexity of carbon dynamics in coastal and marine systems. (e.g., it assumes linear increases in carbon stock as habitats mature, which may not reflect real-world variability). Furthermore, it does not account for net carbon sequestration, which is the amount of carbon buried and preserved for > 100 years in coastal and marine ecosystems.

[7] http://releases.naturalcapitalproject.org/invest-userguide/latest/en/coastal_blue_carbon.html#

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4.1.2 Tourism and recreation[8]

This tool – also part of the InVEST models - **estimates visitation rates** to marine protected areas **based on the presence of natural features**, thereby supporting both conservation planning and ecosystem service valuation.

Advantages	Limitations
One of its key strengths lies in its ability to link ecological features with human use patterns, offering a compelling rationale for protecting high-value areas. It also provides an indirect means of estimating the monetary value of natural features, which can be useful for policy and management decisions. The tool is open-source and relatively straightforward to apply for users with some technical background.	Nonetheless, it requires a moderate level of GIS proficiency and familiarity with spatial modeling. Data collection and formatting can be time-consuming, and some adaptation may be needed to ensure compatibility with the model's requirements. A notable limitation is its reliance on geotagged images from Flickr, a platform that may not provide sufficient data coverage in all regions. Apart from data coverage, GDPR restrictions complicate the use of data from platforms like these.

4.2 ARIES[9]

ARIES (Artificial Intelligence for Environment & Sustainability) is a web-based platform that enables users **to model ecosystem services across a wide range of physical, social, and economic contexts**. It provides access to a library of models and spatial datasets, ranging from global to local scales.

Advantages	Limitations
The platform is designed to accommodate users with varying levels of expertise. Beginners can rely on pre-configured models and datasets, while advanced users have the flexibility to integrate their own data and customize model components. ARIES supports collaborative workflows and promotes the reuse of models, contributing to improved knowledge management and sustainability assessments.	Validating model outputs can be difficult due to the inherent complexity of ecological systems. The platform depends on the availability of high-quality data, which may be lacking. While efforts have been made to streamline the user experience, the system can still be complex for those unfamiliar with ecosystem modeling. ARIES requires significant computational resources and extensive spatial datasets. Lastly and most importantly, ARIES is not accessible to the public yet (as of Oct 2024).

[8] http://releases.naturalcapitalproject.org/invest-userguide/latest/en/recreation.html
[9] https://aries.integratedmodelling.org

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4.3 SolVES[10]

SolVES (Social Values for Ecosystem Services) is a tool **developed to assess and map non-material values associated with ecosystems**, particularly cultural ecosystem services. SolVES constitutes of a methodology and QGIS extension, facilitating the integration of spatial layers into participatory mapping (or public participation GIS (PPGIS)).

Advantages	Limitations
Its main advantage is its focus on social values, which are often overlooked in traditional valuation approaches. The tool is scalable and offers a comprehensive framework for capturing a wide range of cultural values. It is supported by a detailed user manual, which helps users navigate its interface and configuration.	However, the tool requires the collection of survey data, which can be time-consuming and resource-intensive. It also operates within a Windows environment and requires QGIS, which may pose compatibility issues for some users. Although the interface is well-documented, it still demands a learning period, especially for those unfamiliar with GIS-based tools.

4.4 Zonation 5[11]

Zonation is a **spatial prioritization tool specifically developed to support conservation-oriented spatial planning (including land and marine use planning)**. It is not intended for species distribution modeling, ecosystem service valuation, or general-purpose GIS tasks. Instead, it helps identify areas of high conservation value based on ecological data and user-defined priorities.

Advantages	Limitations
One of the tool's main strengths is its ability to produce spatially explicit outputs that support evidence-based decision-making. Once the input data are prepared, running the model is relatively straightforward, and the software is well-documented. Zonation is particularly effective in scenarios where conservation planning must be integrated into broader land-use strategies.	However, the quality of the results is highly dependent on the quality and resolution of the input data. Preparing these data requires significant time and expertise in GIS. Moreover, stakeholder engagement is essential throughout the process, from model development to validation and implementation. While the tool itself is accessible, the broader process of using Zonation effectively can be resource-intensive and requires careful planning. The tool is not intended for ES valuation.

[10] https://www.usgs.gov/centers/geosciences-and-environmental-change-science-center/science/social-values-ecosystem
[11] https://zonationteam.github.io/Zonation5/

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4.5 EcoPath Ecosim (EwE)[12]

EcoPath with EcoSim is a widely used modeling suite for ecosystem-based fisheries management and ecological modeling. It allows users to **construct mass-balance models of marine ecosystems and simulate the effects of different management scenarios.**

Advantages	Limitations
The tool is highly versatile and has been applied in a wide range of ecological and spatial contexts. A large number of EwE models already exist globally, which can be adapted to new case studies. The software is open access and supported by extensive documentation and a strong user community.	Despite these advantages, developing a new EwE model requires substantial data on species interactions, biomass, and fisheries. Acquiring and processing these data can be time-consuming. Additionally, while the software is well-supported, it still requires a significant investment of time to understand its structure and functionality, particularly for new users. Restricted to fisheries management and ecological modeling, not ES valuation (besides fish production).

4.6 Coastal Capital Valuation Tool[13]

The Coastal Capital Valuation Tool is best described as a **methodological guide rather than a standalone valuation tool.** It provides a structured approach to conducting ecosystem service valuation in coastal contexts, outlining best practices and key steps.

Advantages	Limitations
Its main value lies in its role as a reference framework for practitioners seeking to design and implement valuation studies.	However, it does not include computational components or data processing capabilities. As such, it cannot be applied directly to a case study without being paired with another valuation method or tool.

[12] https://ecopath.org
[13] https://www.wri.org/research/coastal-capital-ecosystem-valuation-decision-making-caribbean

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4.7 PlanWise4Blue[14]

PlanWise4Blue is a **web-based decision-support tool developed to assess the cumulative effects of human pressures on marine ecosystems**. It is currently tailored to the Baltic Sea region but is being expanded to other European sea basins through ongoing research projects.

Advantages

The tool's key strength is its reliance on the best available scientific evidence, using expert knowledge only when empirical data are lacking. It is web-based, requiring no installation, and provides real-time results through a high-performance computing infrastructure. The interface is intuitive, and users are guided through the process via a series of informative tabs. No coding or advanced ecological knowledge is required, making the tool accessible to a broad audience. The outputs include customizable maps that can be directly used in policy and planning.

Limitations

The main limitation is its current geographic scope, which is restricted to the Baltic Sea. Additionally, users cannot upload their own data, a design choice intended to maintain data quality and consistency. However, future updates aim to introduce more flexibility in this regard.

4.8 Contingent valuation Method (CVM)[15]

The Contingent Valuation Method is a **survey-based approach used to estimate individuals' willingness to pay for non-marketed goods (like ecosystem services)**, such as biodiversity, clean air, or recreational opportunities.

Advantages

CVM is relatively easy to implement and analyze, and it can be applied to a wide range of goods and services (including to assess non-use values). It is also cost-effective compared to more data-intensive valuation methods.

Limitations

The method is often criticized for the presence of "protest zeros"—responses in which individuals refuse to assign a monetary value for ideological or fairness-related reasons. These responses can distort the results if not properly identified and excluded. To address this issue, surveys typically include follow-up questions to determine the reasons behind zero bids. Despite these efforts, distinguishing between true zero valuations and protest responses remains a challenge. Moreover, the method's reliance on hypothetical scenarios introduces a degree of uncertainty, as respondents may not behave in real life as they claim in surveys.

[14] https://ese.tools4msp.eu/elements/operational_approaches/operational_approach8.html
[15] E.g., Carson, R. T., & Hanemann, W. M. (2005). Contingent valuation. *Handbook of environmental economics*, *2*, 821-936.

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4.9 Benefit transfer[16]

The benefit transfer method estimates the value of ecosystem services by **applying results from existing valuation studies to new policy or project contexts**. It is particularly useful when time or resources do not allow for primary data collection.

Advantages

This approach is both cost-effective and time-efficient, as it avoids the need for new fieldwork or surveys. It is also broadly applicable across different types of ecosystem services and geographic contexts, provided that relevant studies are available.

Limitations

However, the accuracy of benefit transfer depends heavily on the similarity between the original study site and the new application site (implying the requirement that there are existing, comparable studies at hand). If the ecological, social, or economic contexts differ significantly, the transferred values may not be reliable. Moreover, the method relies on the quality and transparency of the original studies, which can vary widely.

4.10 Replacement cost and substitute cost method[17]

These methods estimate the value of ecosystem services **based on the cost of replacing them with man-made alternatives or substitutes**. They are grounded in actual market prices, which can make them more tangible and defensible in policy discussions.

Advantages

One of the main advantages of these approaches is their practicality, especially in cases where ecological data are limited. They are particularly useful for estimating indirect use values, such as the cost of replacing natural flood protection with engineered infrastructure.

Limitations

Nonetheless, these methods are only applicable when a clear substitute exists, which is often not the case for many marine and coastal ecosystem services. Additionally, they may underestimate the value of natural features by only considering physical indicators of benefits, without accounting for broader ecological or cultural values (so called co-benefits). These methods are best used as part of a broader valuation strategy rather than as standalone tools.

[16] Johnston, R. J., Rolfe, J., Rosenberger, R. S., & Brouwer, R. (2015). Introduction to benefit transfer methods. In *Benefit transfer of environmental and resource values: a guide for researchers and practitioners* (pp. 19-59). Dordrecht: Springer Netherlands.

[17] E.g., Jackson, S., Finn, M., & Scheepers, K. (2014). The use of replacement cost method to assess and manage the impacts of water resource development on Australian indigenous customary economies. *Journal of Environmental Management*, *135*, 100-109., Brown, T. C. (2017). Substitution methods. In *A Primer on Nonmarket Valuation* (pp. 347-390). Dordrecht: Springer Netherlands.

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4.11 Damage cost method[18]

This valuation method assesses the economic benefits of ecosystem services **by estimating the costs that would be incurred in their absence**. Its application is mostly in regulating ecosystem services (e.g., coastal protection through mangrove forests).

Advantages	Limitations
It is theoretically applicable to a wide range of ecosystem services and spatial scales. In principle, any actor with access to adequate biophysical, ecological, and economic data can implement these assessments. No specialized software is required, which increases their accessibility.	However, the practical application of these methods is often limited by data availability. Reliable implementation requires detailed knowledge of both ecological processes and market dynamics. As such, these methods are typically used in academic research settings rather than by local managers or practitioners. Furthermore, there are still relatively few documented case studies demonstrating their use in marine contexts.

4.12 Production function method[19]

This is an economic valuation approach that **estimates the contribution of ecosystem services to the production of market goods** by linking ecological functions directly to economic outputs. It quantifies how changes in ecosystem condition affect productivity, allowing the **value of ecosystem services to be inferred through their impact on measurable economic performance**.

Advantages	Limitations
A clear, quantifiable link between ecosystem services and economic outputs, making it useful for policy and resource management decisions. It is grounded in observable data, which can enhance the credibility and transparency of the valuation results.	It requires detailed biophysical and economic data, which may be costly or difficult to obtain, especially for complex ecosystems. It may also oversimplify ecological processes and does not assess services that do not directly contribute to market production. Next, in the marine environment, we notice that causal links in ecosystem processes and functioning are less tangible and researched, leading to a very limited number of examples of applications in this space.

[18] https://www.ecosystemvaluation.org/cost_avoided.htm
[19] E.g., E.B. Barbier, Valuing ecosystem services as productive inputs, *Economic Policy*, Volume 22, Issue 49, 1 January 2007, Pages 178-229, https://doi.org/10.1111/j.1468-0327.2007.00174.x

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4.13 Assessments using rating and ranking[20]

Rating and ranking methods are simple tools used to **prioritize ecosystem services or management options based on stakeholder preferences.** They are often employed in participatory settings to capture local knowledge and values.

Advantages

These methods are easy to administer and interpret, making them suitable for a wide range of contexts. They can be particularly useful in early stages of decision-making, where a quick overview of stakeholder priorities is needed.

Limitations

Rating and ranking also have notable limitations. The choice of rating scale can influence results, and there is a risk of bias in how respondents use the scale. Ranking exercises, while useful, force respondents to differentiate between options even when they may consider them equally important. Additionally, these methods do not provide monetary valuations and may require significant time and resources to administer surveys effectively.

4.14 Qualitative methods[21]

Qualitative methods, such as semi-structured interviews, are **widely used to explore how people perceive and value their environment**. They are particularly effective for assessing cultural ecosystem services, which are often difficult to quantify.

Advantages

Interviews can reveal deep insights into local values, traditions, and perceptions that influence how communities relate to natural areas. This information is especially relevant for MPA planning, where social acceptance and cultural significance play a critical role in the success of conservation measures. Further, qualitative methods like focus groups or workshops can facilitate stakeholder engagement and participation

Limitations

The main limitations of qualitative methods are their time intensity and limited scalability. Conducting, transcribing, and analyzing interviews requires significant effort. Moreover, the findings are typically context-specific and may not be generalizable beyond the study area.

[20] E.g., Louviere, J.J., Flynn, T.N. & Marley, A.A.J. (2015). *Best-worst scaling: Theory, methods and applications*. Cambridge University Press.
[21] E.g., Lim, W.M. (2024). What is Qualitative Research? An overview of Guidelines. *Australasian Marketing Journal*, 33(2), 199-229. https://doi.org/10/1177/14413582241264619

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4.15 Participatory (cultural) mapping[22]

Participatory mapping involves **engaging local communities in identifying and spatially representing the values they associate with specific places**. This method is particularly effective for capturing non-market and intangible values, such as cultural identity, heritage, and sense of place.

Advantages

One of the key strengths of this approach is that it fosters community involvement and ownership, which can enhance the legitimacy and effectiveness of conservation initiatives. It also integrates local and traditional knowledge, which is often overlooked in more technical assessments. Additionally, PPGIS is very flexible in implementation; It can be done online, as a web-based spatial survey; or it can be done by placing physical markers on a paper map.

Limitations

Participatory mapping may lack the quantitative rigor of other methods. The results are highly context-dependent and may not be transferable to other settings. There is also a risk of bias if the process does not ensure balanced stakeholder representation. Skilled facilitation and trust-building are essential for successful implementation.

4.16 Multi-criteria decision analysis (MCDA)[23]

MCDA is a structured approach for **evaluating complex decisions involving multiple, often conflicting, criteria.** It is particularly well-suited for assessing trade-offs among ecosystem services and integrating diverse stakeholder perspectives.

Advantages

The method allows for the inclusion of both qualitative and quantitative data and can be adapted to a wide range of decision-making contexts. It promotes transparency and provides a clear rationale for how decisions are made, which is valuable in participatory planning processes.

Limitations

Despite its strengths, MCDA can be resource-intensive. The design of criteria and indicators must be carefully tailored to each decision context, and the process often requires substantial data collection and stakeholder engagement. Subjective weighting of criteria can introduce bias, and the overall effectiveness of the method depends on the quality of facilitation and the level of stakeholder understanding.

[22] E.g., Fagerholm, N., Raymond, C. M., Olafsson, A. S., Brown, G., Rinne, T., Hasanzadeh, K., … Kyttä, M. (2021). A methodological framework for analysis of participatory mapping data in research, planning, and management. *International Journal of Geographical Information Science*, *35*(9), 1848–1875. https://doi.org/10.1080/13658816.2020.1869747

[23] E.g.,Triantaphyllou, E. (2000). Multi-Criteria Decision Making Methods. In: Multi-criteria Decision Making Methods: A Comparative Study. Applied Optimization, vol 44. Springer, Boston, MA. https://doi.org/10.1007/978-1-4757-3157-6_2

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4.17 Conclusions

In this chapter, we presented the procedure and outcome of selecting tools that will be used for tools testing and validation in the Blue4all LLs, which was guided by considerations of usability, contextual relevance, and added value for marine protected area management. The combination of tools' capacities and field of application, with the context of the LLs and IS (D4.1 and D4.2), led to the matchmaking exercise to develop case studies (in coordination with WP3 and WP4). Not all methods reviewed were equally suitable for further application. Some approaches, such as multi-criteria decision analysis, were found to be too resource intensive for routine application by MPA managers, while others, like production function models, were considered overly complex for the type of case work envisaged. Likewise, cost-based methods (damage, replacement, and avoided cost) did not align with the available Blue4all LLs and their needs, making it difficult to demonstrate their practical value. ARIES, although promising, is still under development and therefore not yet fit for use in this context.

Reviewed toolkits	Reviewed methods
ARIES	**Contingent valuation**
Coastal Capital Valuation Tool	Replacement cost method
Ecopath EcoSim (EwE)	Damage cost method
InVEST Coastal Blue Carbon	Production function method
InVEST Visitation: tourism and recreation	**Benefit transfer**
PlanWise4Blue	**Assessments using rating and ranking questions**
SolVES	**Qualitative methods**
Zonation 5	**Participatory (cultural) mapping**
Atlantis	Choice experiments
BVMtool (LifeWatch)	Travel cost method
Envision	Hedonic pricing
InVEST Coastal Vulnerability	Biophysical modelling and mapping
InVEST Habitat Quality	Community voice method
InVitro	Q-method
Madrona	
MARine Ecological Emulator (MAREE)	
MARXAN	
Mimes	
MSP Challenge 2050	
Mytilus	
Rios	
SEANERGY and Baltic Explorer (combo)	
SeaSketch	
SERVEs	
Symphony	
Tools4MSP Geoplatform	
Vista	

Table 4: Oversight of tools assessed in T2.3, all tools above the double line marker are featured on the Blueprint Platform, all tools below the blue double line marker have been dropped. The tools in bold are further explored in the testing and validation stage, showcased in Chapter 5.

Other tools were considered more closely in relation to existing needs and overlaps. Participatory (cultural) mapping, for example, showed significant conceptual and methodological overlap SolVES. Since SolVES offers a more consolidated and operational approach, it was selected as the preferred option. In contrast, InVEST has been retained despite certain limitations, notably the reliance of its tourism and recreation module on Flickr data, which is not relevant everywhere. The value of InVEST lies in its ability to provide a clear framework for structuring reasoning and exploring management trade-offs, making it a useful addition for decision support even if some modules are less applicable locally.

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Despite the methodological or operational challenges that the previous tools bring with, it was decided that all tools presented in this chapter, will be featured on the Blueprint Platform as part of the T2.3 framework that is integrated into the Blueprint Platform using a decision-tree. Based on the MPA needs presented in Chapter 1, and the usability and readiness of tools demonstrated in this chapter, we identified tools for testing and validation in the Blue4all LLs. The idea here was to identify ways to improve the valuation methods, in accordance with the task objectives formulated in D2.1. This presents the main contribution of the framework of T2.3: a flow in which users with interest in economic valuation of ecosystem services identify the appropriate tool (given their need), and the step-by-step guidance to use this tool. While the backbone of appropriate tool identification and application are laid through the in-depth assessments discussed in this chapter, Chapter 5 contributes to proposing tool improvements to a selection of tools. After all, there is more potential to improve the methods, than the toolkits, as those are often not open source.

This selection exists of: SolVES, Benefit transfer, Contingent valuation, ranking and rating, qualitative methods, and best-worst scaling – which can be seen as a special type of rating and ranking (marked in bold in Table 4). We subject these tools to actual cases co-created within the Blue4all LLs. They are intended to support MPA managers not by overwhelming them with technical complexity, but by offering clear, context-sensitive approaches that can inform decision-making and highlight the social, ecological, and economic dimensions of marine conservation. This targeted selection increases the likelihood that the tools will be taken up in practice and ultimately contribute to more effective and adaptive MPA management.

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5 Testing and validation of tools in Blue4all living labs

After theoretically assessing and testing the tools, the selected tools are subjected to real-life and needs-oriented questions within the Blue4all LLs. To validate the potential of using these shortlisted tools, high-level needs were identified through the D4.2 needs assessment. The identification of LLs to collaborate with is based on overlaps between the application potential of respective tools and the questions raised by LLs.

To test and validate the tools under real-life conditions, small research projects were conducted within several LLs. In the light of these, we worked together with the respective LL contact points (and if possible, with the MPA management). This led to research designs that aimed at responding to one or more needs identified by the SEG and described in Chapter **Error! Reference source not found.**. In this report we focus on the application of each tool, the benefits and shortcomings that arose through the research projects, rather than the outcomes of the projects.

For each tool, we follow this structure: context, research question(s), method description (including data collection and analysis), results, and final tool assessment, based on lessons learned during the implementation of the case study. For describing the final tool results, four main indicators were selected: usability, support for stakeholder dialogue, validity of the results, and proposed improvements to the tool. These first three indicators capture the practical, social, and scientific dimensions needed for effective decision-making in MPAs. Usability ensures that the tool can be applied in real-world contexts (and by the target audience), support for stakeholder dialogue promotes legitimacy and collaboration (and is one of the key needs with the LLs), and validity of results guarantees that outcomes are credible and policy relevant. Together, they ensure that a socio-economic valuation tool is not only technically sound but also accepted and actionable. Through the last indicator we underline how we can improve the tool or improve the implementation potential of the tool. Based on lessons learned during the testing and validation, we formulated tangible ways on how to improve tools or their implementation potential for the integration onto the Blueprint Platform, as a key element of the framework proposed by T2.3.

5.1 Danish Wadden Sea MPA

CONTEXT.
The total area of the entire Wadden Sea measures approximately 22,000 km². This vast intertidal coastal zone is located in the north-western part of Europe, stretching up to the southern North Sea. The Netherlands, Germany, and Denmark share parts of this area, which makes the Wadden Sea a shared marine coastal landscape[24].

This study focuses on the northern Wadden Sea, specifically the northern part of the Danish Wadden Sea, where intensive human activities take place, including the expansion of Esbjerg Harbour, tourism, and the dredging of shipping lanes. The Danish Wadden Sea is located in the lower eastern part of the North Sea along Denmark's west coast. [25]. The area is a conservation area, designated as a Nature and Wildlife Reserve and National Park under Danish legislation (D1.1). It is also part of the Trilateral Wadden Sea UNESCO World Heritage Site[26]..

The Danish Wadden Sea, like the entire Wadden Sea area, matters internationally for its outstanding biodiversity value, connected to its marshes and tidal flats. The area is highly dynamic as it changes constantly with the inflowing and outflowing water across vast intertidal mudflats. Intertidal flats support the production of microphytobenthos, and an enormous number of worms, snails, mussels, and crustaceans and the geomorphological conditions favour the development of salt marshes and seagrass beds. Because of this productivity, it is also very important for millions of migratory birds that use the Danish Wadden Sea as a staging area every spring and fall. Furthermore, the area is significant as a bird breeding ground[27].

In addition, the Danish Wadden Sea has a distinctive cultural history shaped by centuries of living with and against the sea. Local communities have long depended on coastal protection and dikes as well as on the surrounding marsh and tidal landscapes for livelihoods and settlement[28]. This history is also visible in the

[24] Schroor et al. (2017). https://qsr.waddensea-worldheritage.org/index.php/reports/landscape-and-culture
[25] Goldberg and Jacobsen (2024). Nationalpark Vadehavet - Miljørapport for forslag til nationalparkplan2025-2030.
[26] Hansen, J.L. (2024). Guide – Nationalpark Vadehavet.
[27] https://www.mitvadehav.dk/opgave/vadehavet-som-verdensarv-nationalpark-og-verdensarv
[28] https://kyst.dk/english/the-wadden-sea-dikes

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region's characteristic building traditions—such as well-preserved village environments, marsh farms, and historic half-timbered and gabled houses—which reflect how people adapted to a dynamic coastal environment[29].

Today, the area is widely valued for cultural ecosystem services and nature-based recreation, including guided mudflat walks, hiking and cycling routes, wildlife experiences such as seal and birdwatching, and seasonal phenomena like the starling murmuration known as "Black Sun", its importance for the 12-15 million migratory birds that pass by annually, as well as guided oyster tours[30]. Tourism is therefore a key human pressure and value driver: across the Wadden Sea World Heritage Destination, the Danish regions recorded about 7.9 million overnight stays in 2019, and an estimated 3.5 million day visits[31].

RESEARCH QUESTION(S).
What values do people assign to the northern part of the Danish Wadden Sea, and how are these values linked to specific places?

5.1.1 Tool: SolVES / Participatory mapping

METHOD.
To capture place-based social values and cultural ecosystem services, Public Participation in Geographic Information Systems (PPGIS) was applied. This approach integrates geographic information systems with participatory methods, allowing respondents to spatially express their values and perceptions. PPGIS is increasingly recognised for its ability to incorporate local knowledge into environmental planning, particularly in relation to cultural services, where engaging the actual beneficiaries is essential for valid outcomes[32]. An existing tool which applies PPGIS is SolVES[33]. However, using the SolVES software proved unsuccessful due to persistent running issues, and after consultation with the software developers and other users it was concluded that, given its complexity, the tool would not be practical for MPA managers; therefore, hotspots were instead created in QGIS by uploading the CSV files with the point coordinates, without relying on the SolVES add-in.

The survey to collect the PPGIS data was designed in Qualtrics and consisted of two parts. First, participants (both tourists and locals) were asked to weigh a predefined set of social values associated with the marine environment (a maximum of 5 different values per participant). Following this, they were invited to identify specific locations on a digital map in Qualtrics where they experienced or associated these values, effectively linking social preferences to geographic space.
Data was collected in person using tablets in April 2025 on Fanø Island (Denmark). A total of 240 responses were recorded, of which 226 included complete mapping exercises.

RESULTS.
Data was collected for the following 14 values: aesthetic value, therapeutic value, recreation value, biological diversity value, future value, life sustaining value, birds' diversity value, historic value, cultural value, economic value, intrinsic value, learning/scientific value, spiritual value, subsistence value. The results show that aesthetic value and therapeutic value ranked the highest (an average of 12% weight each), indicating that people strongly associate landscapes with beauty, relaxation, and emotional well-being. Recreation value and biological diversity value followed closely (10% each), reflecting the importance of outdoor activities and the appreciation of nature's richness. By contrast, values such as economic (6%), intrinsic (5%), learning/scientific (3%), spiritual (2%), and subsistence (1%) were less frequently emphasised.

For each type of value, heat maps can be generated to illustrate why different areas in the region are considered important. An example is shown in Figure 3. It highlights that aesthetic value and bird diversity value often overlap, particularly on the island of Fanø. Bird diversity is especially recognised along the peninsula, while aesthetic value is notably concentrated around landmarks such as the lighthouse at

[29] https://eng.nationalparkvadehavet.dk/experience-the-wadden-sea/wadden-sea-culture/the-building-culture-in-the-wadden-sea-area
[30] https://eng.nationalparkvadehavet.dk/experience-the-wadden-sea
[31] https://qsr.waddensea-worldheritage.org/reports/tourism
[32] Brown, G., & Fagerholm, N. (2015). Empirical PPGIS/PGIS mapping of ecosystem services: A review and evaluation. *Ecosystem services*, *13*, 119-133.
[33] https://www.usgs.gov/centers/geosciences-and-environmental-change-science-center/science/social-values-ecosystem

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Blåvandshuk Fyr and the Men at Sea statue in West of Esbjerg. A similar type of analysis can be carried out for all other values.

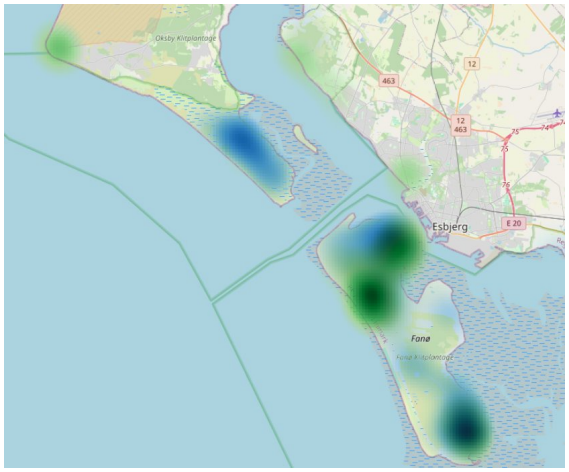

Figure 3. Example heat map comparison between "aesthetic" in green and "birds' diversity" in blue.

In addition, the demographic information can be used to compare different subgroups. For example, Figure 4 compares locals (in red) and non-locals (in green) (categorization based on a self-assessment question) in terms of their valuation of "aesthetic." The results show that locals' values are more widely distributed, whereas non-locals tend to focus on specific areas.

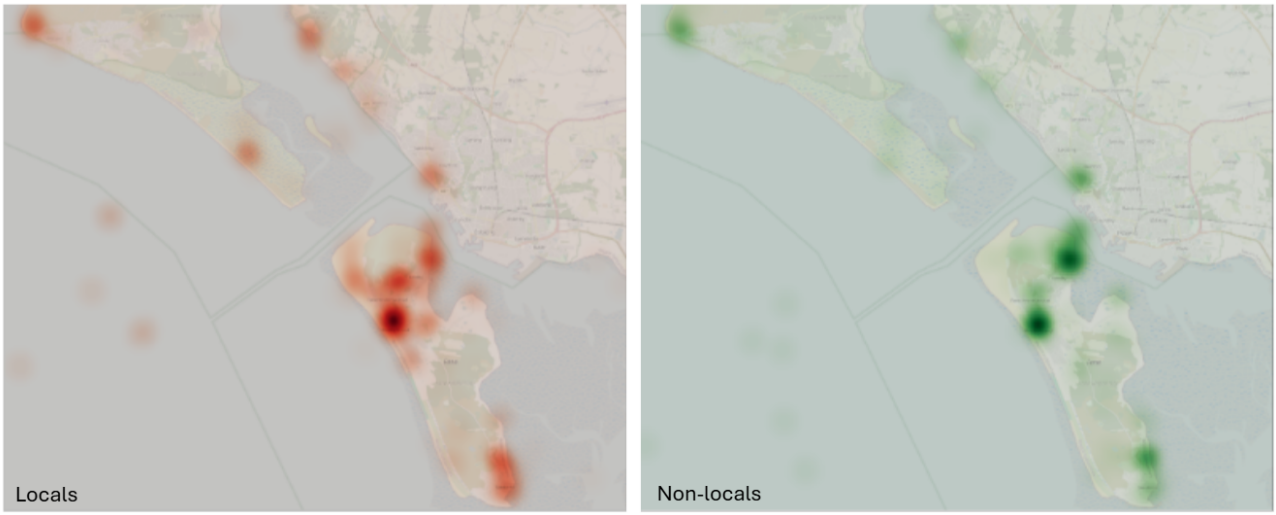

Figure 4. Example heat map comparison between locals (red) and non-locals on "aesthetic" value (green).

Finally, the value maps collected through participatory mapping can also be compared with existing environmental layers. This allows for various spatial analyses to be conducted in order to explore potential spatial associations between perceived values and ecological or landscape characteristics. For instance, Brown 2013[34] applied analytical techniques such as descriptive frequencies and crosstabs, proportional analysis, and diversity analysis (using the Shannon Diversity Index). However, these types of analyses require additional expertise and time, which may make them less practical or appealing for MPA managers. Nevertheless, it can already be insightful to simply overlay and visually compare the different layers, as this can reveal apparent patterns or contrasts without the need for complex analyses.

TOOL ASSESSMENT.

- **Usability**: Participatory mapping is relatively user-friendly for MPA managers, particularly when implemented with basic GIS tools such as QGIS. While the SolVES add-in was originally considered, it proved too difficult to use in practice: the software is hard to access, requires extensive time and

[34] Brown, G. (2013). The relationship between social values for ecosystem services and global land cover: An empirical analysis. *Ecosystem Services*, 5, 58-68. http://dx.doi.org/10.1016/j.ecoser.2013.06.004

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effort to set up, and demands a high level of technical expertise. Instead, hotspots were created directly in QGIS by uploading CSV files with point coordinates, which provided a more accessible and practical approach. Overall, the usability depends on managers' familiarity with GIS, but once data is collected, visualisation is straightforward and intuitive.

- **Support for stakeholder dialogue**: The participatory mapping outcomes were highly appreciated by SEG members, as these maps make tangible links between natural and ecological features and human perceptions. The visual results help initiate discussions around which places are most valued, why these areas matter, and how management can address or protect them. Maps are a powerful communication tool, allowing stakeholders to see their own inputs represented spatially and to compare perspectives across groups. This enhances dialogue and creates a shared understanding of conservation priorities. One perceived limitation of this method arose during the SEG validation meeting October 1st, 2025; it was mentioned that the replicability relieson the requirement of new rounds of data collection. In fact, this is a general limitation of participatory data – which contrasts with the results presented by WP3 during the SEG meeting – that results are very context dependent, and exercises cannot be replicated at minimal effort.
- **Validity of the results**: The validity of participatory mapping depends largely on the quality of the data collected. When carefully facilitated, the method produces robust spatial insights that reveal hotspots of cultural, ecological, and recreational importance. However, technical challenges—such as the limitations of SolVES—may restrict advanced data analysis.
- **Proposed ways to improve tool and implementation**: The SolVES software was not functional. The shift to PPGIS resulted in hybrid solutions between the two tools, which involve a step-by-step guide for MPA managers to create heatmaps from survey data. To collect these survey data, predefined templates are composed.

5.2 MPA Vlaamse Banken

CONTEXT.
The MPA Vlaamse Banken is located in the southwest of the Belgian part of the North Sea (BPNS). The BPNS is an area characterised by intense spatial use, including fisheries, shipping, and offshore energy. This spatial squeeze can lead to stakeholder conflict. The area's ecological features, such as gravel beds that once hosted oyster reefs, are threatened by bottom-disturbing activities. To protect these habitats, the MPA Vlaamse Banken was established as part of the wider Natura 2000 network. However, it currently lacks a formal management plan, and governance is fragmented, split between Flemish, federal, and European authorities (D1.1). Moreover, stakeholder engagement remains limited, leaving the MPA at risk of becoming a 'paper park'. The specific site of oyster reef restoration, the Hinder Banks, is an important fishing area, home to species like common sole (Solea solea) (Solea solea).. The European flat oyster (*Ostrea edulis*) used to thrive here but had nearly vanished by the mid-20th century due to overfishing and disease. The oysters are ecosystem engineers, creating complex 3D habitats that support a wide range of marine life, offering numerous ecosystem services. A comprehensive master thesis, authored by Rosemarie Latte, describing the research activities for this case study can be requested on the University of Antwerp repository: https://anet.be/record/uantwerpen/opacuantwerpen/c:lvd:15807578.

RESEARCH QUESTION(S).
How can ecosystem services associated with the restoration of *Ostrea edulis* (European Flat Oyster) reefs in the Belgian part of the North Sea be identified and valued?

5.2.1 Tool: qualitative methods - interviews

METHOD.
The first part of the research focuses on identifying the ecosystem services provided by *Ostrea edulis* reefs. While a wide range of ecosystem services can be attributed to oyster reefs, MPA managers may lack the time or resources to conduct a full economic valuation of all of them. To address this, semi-structured interviews were conducted with selected experts to help determine which services are most relevant for the MPA Vlaamse Banken. These experts were chosen for their specific expertise in one or more of the following areas: oyster reef ecology, the execution of oyster restoration projects, knowledge of the research site of the Vlaamse

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Banken, or the Belgian fisheries sector. A total of 7 experts were available for an interview, led by master thesis student Rosemarie Latte.

Questions were prepared after reviewing scientific papers and relevant grey literature identified by the MPA management of the MPA Vlaamse Banken. Every expert was asked these same open-ended questions. The first question, "Which ecosystem services would the reintroduced oyster banks in the BPNS provide?", directly relates to the research question of identifying ecosystem services. The remaining questions focused on stakeholder engagement and the characteristics of the Vlaamse Banken, to enhance understanding of the research site. Given the variety in expertise of each respondent and the exploratory nature of the questions, the interviews were conducted in a semi-structured format. This leaves room for reciprocity, flexibility and improvised follow-up questions. This allowed the respondent to give a fuller picture of their view on ES provided by oyster bank restoration.
Once the interviews were completed, full transcripts were created to capture everything that was said. Following transcription, open coding was used to analyse the content and identify references to specific ecosystem services. Open coding involves identifying key concepts and themes mentioned by participants, allowing the researcher to break the transcript into smaller, more interpretable segments. In this study, the codes corresponded to ecosystem services provided by oyster reef restoration[35].

RESULTS.
In this case study, we identified eight ES provided by restored oyster reefs in the Vlaamse Banken. biodiversity, commercial fish production, denitrification, commercial oyster production, existence value, tourism, water quality, and carbon sequestration. However, carbon sequestration was highly contested, and most experts argued that recent research does not support its classification as an ecosystem service of oyster reefs. Based on insights from the interviews and existing literature, three ES were selected for further economic valuation (see 0): biodiversity, commercial fish production and denitrification.

TOOL ASSESSMENT.

- **Usability**: The usability of interviews is generally good, particularly in terms of accessibility for both managers and stakeholders. However, the method is time intensive. It requires careful planning, skilled facilitation during interviews, and substantial time for data processing and analysis. Despite these demands, the method is adaptable and can be tailored to suit different stakeholder groups and management contexts.
- **Support for stakeholder dialogue**: Qualitative interviews perform strongly in supporting stakeholder dialogue. They offer a direct and flexible way to engage with a diverse range of stakeholders, allowing for open-ended responses and in-depth discussion. This method not only captures rich, context-specific insights but also fosters mutual understanding, making it a valuable tool for participatory processes in MPA management.
- **Validity of the results**: The validity of interview results depends on several factors, including the quality of the questions, the interviewer's neutrality, expertise, skills, and the representativeness of the participants. When conducted well, interviews can yield highly relevant and reliable information. However, if sampling is biased or analysis lacks rigour, the findings may not accurately reflect all stakeholders' opinions.
- **Proposed ways to improve tool and implementation:** standardized procedures on how to conduct interviews in a time-efficient and more scientific way. Existing of the different steps of setting up interviews: defining objectives, identifying interviewees, create interview guide, (potentially) obtain ethical approval, conduct the interview, data management, reflection and debrief. While these are not innovative guidelines in itself, they provide the handles to conducting interviews in a systematic manner.

[35] Corbin, J., & Strauss, A. (2014). *Basics of qualitative research: Techniques and procedures for developing grounded theory*. Sage publications.

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5.2.2 Tool: Benefit transfer method

METHOD.
The economic valuation was conducted using benefit transfer, a method that transfers economic values from existing primary valuation studies to the context of the research site. To make the benefit transfer both practical and adaptable, all relevant data and calculations were compiled in an Excel workbook.

The benefit transfer process typically consists of four steps:

1. The first step is to identify and review existing primary valuation studies. These studies estimate the value of ecosystem services by accounting for both use and non-use values.
2. The second step involves assessing the transferability of the values from the primary studies to the specific context of the oyster reefs in the Vlaamse Banken. This assessment depends on how well the temporal, spatial, and methodological aspects of the original studies align with the current site.
3. The third step involves extracting the monetary values or value functions from the selected studies and standardising the results. These functions typically rely on explanatory variables, such as ecological attributes of the ecosystem and the socio-economic characteristics of the study population. For this case study, the most critical variables for determining the transferability, particularly for the ES of denitrification, were the depth of the research site, the distance to shore, and the oyster species studied.
4. The final step of the benefit transfer consists of adjusting the value functions to match the specific characteristics of the Vlaamse Banken. This includes incorporating all relevant ecological and socio-economic features of the area. In this study, this was done by standardising the results from the primary valuation studies to units and assumptions that best suited the Belgian context. After this standardisation, the monetary values were scaled using site-specific factors, such as the surface area of the oyster reef or the projected increase in biomass due to restoration efforts.

For each ecosystem service, a specific formula was used for economic valuation:

- Biodiversity (€): Biodiversity value (€/m^2) x Surface area (oyster banks) (m^2).
- Commercial fish production (€/year): Sum of Commercial value (€/kg) x Increased biomass (kg/year) for each of the fish species attracted or supported by the restoration of the oyster reefs in the MPA Vlaamse Banken.
- Denitrification (€/year): Average rate of denitrification (µmol N2–N m^2 h^1) x Nitrogen removal value (€/µmol) x Surface area (m^2) x 8760 hours[36].

RESULTS.
The research site, located about 35 kilometres offshore and around 30 metres deep, differs significantly from the study sites in most existing oyster reef research, especially regarding the ES of denitrification. Many of the studies on denitrification are based on nearshore or shallow environments, and some even focus on intertidal reefs that are not always submerged by water. No studies were found on the value of ES provided by *Ostrea edulis* in an offshore, deep research site. This mismatch, not only for the studies on denitrification but for other ES as well, made it particularly difficult to find sufficiently comparable primary valuation studies. Defining "key case characteristics" is therefore essential to obtain meaningful results through a benefit transfer application. As a result, the decision on whether and how to use the available values becomes especially important. Since the primary study sites differ considerably from the research site, the outcomes of the benefit transfer need to be interpreted with care. Still, the approach was carried out using the best available data, with the understanding that better data may become available in the future.

Using a projected restoration surface of 100 km², the annual estimated value of enhanced biodiversity was €2.78 billion, while denitrification was valued at €107 million annually. For enhanced commercial fish production, the analysis used a hypothetical biomass increase of 1,000 kilograms for each of seven potentially attracted species, resulting in a total annual value of €46,825.

TOOL ASSESSMENT.

[36] The multiplication by 8,760 converts the hourly rate into an annual estimate.

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- **Usability:** Benefit transfer offers high usability for MPA managers, particularly due to its relatively low technical demands. The method allows users to obtain estimated economic values for ecosystem services without requiring expertise in economic valuation techniques. When presented clearly, benefit transfer outputs can be easily interpreted and applied in management contexts. This makes the method suitable for time-constrained decision-making processes and accessible to practitioners with limited technical backgrounds. Its simplicity supports its potential for integration into standard planning and reporting workflows.
- **Support for stakeholder dialogue**: The tool has the potential to support stakeholder dialogue by translating ecosystem service benefits into monetary values that are easier for non-experts to grasp. This can help reframe MPAs not as restrictive zones, but as areas that deliver tangible benefits—such as improved fish stocks or recreational value—thereby increasing public understanding and support. While the tool was not directly tested with stakeholders in this study, its clarity and communicability suggest it could be a useful resource in participatory settings. Moreover, the exercise – although challenging in this case – contributed to revealing links between intervention and ecosystem services, as was confirmed by the SEG. In that respect, the process of setting up a benefit transfer study can contribute as well.
- **Validity of the results**: The primary limitation of benefit transfer lies in the availability and applicability of source data. This can reduce the accuracy and reliability of the transferred values, limiting the tool's validity. When transferability is limited, the economic estimates produced should be seen as broadly indicative rather than precise. Nevertheless, with access to more context-relevant and methodologically robust primary studies, the validity of benefit transfer outcomes could improve substantially. In the case of MPA Vlaamse Banken, the results of the benefit transfer – especially the quantitative outcome – should be taken with caution. Due to the limited number of comparable studies, the results are merely hypothetical.
- **Proposed ways to improve tool and implementation**: In the application of the tool, we found that emphasizing the limitations and assumptions that underlie this method is essential. In the step-by-step, we therefore demonstrate how to use benefit transfers appropriately (and how to interpret results), and especially address the added value of complementing the benefit transfer method with qualitative approaches – like interviews or focus group discussions.

5.3 French Natura 2000 MPA

CONTEXT.
The Littoral Seino-Marin Marine Protected Area is located along the northern coast of France in the Normandy region, specifically in the Seine-Maritime Department (D1.1). The site, designated as a Special Protection Area (SPA) under the EU Birds Directive, covers a total surface area of 180,050 hectares. Four primary habitat types characterize the MPA: chalk cliffs and its associated coastal grasslands, pebble beaches at the cliff base, intertidal zones, and the sea, which reaches a maximum of depth in the area at 33 meters. There are many activities available on site or nearby, such as commercial and recreational fishing, maritime transport, port activities, offshore and onshore wind power, diving, hiking, water sports, aerial and land-based activities, etc. All these activities can generate waste, pollution, noise and light pollution, or even disturbance or alteration of habitats. Given the configuration of the cliffs and coastline, there is little artificial development along the coast. Normandy represents the second most important fishing region in France after Brittany, resulting in substantial commercial fishing activity within the MPA. Recreational activities both at sea (sailing, surfing, diving, pleasure boats) and on land (hiking, beach activities) contribute to noise pollution and waste accumulation, affecting local ecosystems and bird populations. Tourism has increased significantly in recent years in Normandy. In 2023, Seine-Maritime alone, the French department in which the MPA Littoral Seino-Marin is located, set a record with 22.5 million overnight stays, including 10.4 million by foreign tourists. Tourism is or could be – apart from an important source of income for locals – a threat to the ecosystem, which requires policy design aimed at sustainable management.

For the Natura 2000 MPA, an additional and insightful resource resulting from the research conducted within T2.3 was drafted up to endorse communication between the contact point from OFB, and the SEG. It was written as a response to the expressed needs from the contact point, and from dialogue between WP2 and WP4. This report provides detailed results and elaborates on the strengths and challenges faced during the

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process of tools testing and validation. The tools' testing report can be found in Appendix 8.2 (at the end of this document) and was used during the SEG validation meeting organised by OFB.

RESEARCH QUESTION(S).
The study objective is: (1) How do tourists prioritise ecosystem services and recreational activities within the MPA, and what is their willingness to contribute to conservation when access or quality is limited? (2) How do shellfish farmers perceive and prioritize the benefits and limitations of the MPA in relation to their professional activities?

To respond to the first research question, one survey was designed, that covered the three tools that are highlighted in 5.3.1, 5.3.2, and 5.3.3.

5.3.1 Tool: rating and ranking assessment - Best-worst scaling

METHOD.
Best-Worst Scaling (BWS) was used to assess the relative importance of 13 ecosystem services, which were identified by OFB. The Case 1 BWS ('object case') was employed, whereby respondents were repeatedly presented with sets of objects and asked to select the one they considered 'best' and another they considered 'worst'. A critical element in designing a BWS test is the construction of an experimental design that determines the distribution of items across choice sets. The experimental design relies on a Balanced Incomplete Block Design (BIBD) in most studies, which ensures statistical rigour and fairness in item presentation[37]. In this case study, the BIBD consisted of 13 distinct choice sets, each containing four items. The order of choice sets presentation was randomized to prevent positioning bias. For each choice set presented in the survey, respondents were asked: "Which of the following ecosystem services in the Littoral Seino-Marin MPA is the most valuable to you and which is the least valuable to you?".

The survey was designed as an online survey in Qualtrics software. Data was collected via on-site surveying on tablets in April 2025, resulting in 226 respondents. After cleaning the data, 208 respondents remained.

The BWS data were analysed using both counting and modelling approaches. This dual approach provides complementary insights; the counting method offers intuitive descriptive results, while the conditional logit modelling approach allows for a more detailed and statistically grounded analysis of preferences.

RESULTS.
Tourists demonstrated a strong preference for regulating and supporting ecosystem services. The most valued services were safeguarding biodiversity and ecological balance, coastal protection, and protection of natural habitats. In contrast, provisioning and cultural services, such as seafood harvesting and artistic heritage, were valued less. These preferences indicate that even short-term visitors of the MPA intuitively recognise the ecological functions underpinning their recreational experiences.

TOOL ASSESSMENT.
- **Usability**: BWS scores well on usability, offering a simple and accessible design that requires minimal technical training. Its outputs—clear rankings and preference shares—are intuitive and directly usable by MPA managers for decision-making. However, the method requires data collection through an online or in-person survey, which involves some time investment. Additionally, we also attempted a BWS experiment with shellfish farmers on acceptability of the MPA. The complexity of reaching these stakeholders and obtaining responses through survey methods made the method not usable to respond to this SEG identified need.
- **Support for stakeholder dialogue:** BWS effectively captures and communicates stakeholder priorities, supporting more targeted outreach and engagement. This is under the precondition that stakeholders are reachable and not overburdened with other surveys.
- **Validity of the results:** Regarding validity, the method offers robust insights into stakeholder preferences, especially when supported by statistical models such as the conditional logit. However, care is needed in survey design to avoid fatigue with respondents and ensure clarity in terms of the

[37] Louviere, J.J., Flynn, T.N. & Marley, A.A.J. (2015). *Best-worst scaling: Theory, methods and applications*. Cambridge University Press.

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repeated nature of the exercise. Additionally, there's the risk of confusion through the repetitive nature of the choice tasks, which needs to be remediated in the survey. While the basic counting method provides reliable rankings, more advanced analysis (e.g., latent class analysis) can enhance the depth of insights, though it may require additional statistical expertise for interpretation.

- **Proposed ways to improve tool and implementation:** As BWS is not really accessible to non-academics, the step-by-step guideline that will feature on the Blueprint platform focuses on facilitating the preparation of an experiment, the surveying itself, but also executing and interpreting the analyses. This involves the provision of standardized R scripts.

5.3.2 Rating and ranking

METHOD.
Order Ranking was used to evaluate preferences for nine types of recreational activities in the MPA. This method involves presenting respondents with a predefined list of options and asking them to assign a unique position to each item, thus producing ordinal data that reflects relative preferences rather than absolute values.

The survey was designed as an online survey in Qualtrics software. Data was collected via on-site surveying on tablets in April 2025, resulting in 226 respondents. After cleaning the data, 212 respondents remained.

Given the ordinal nature of the ranking data and the within-subjects design (each respondent provided a complete ranking of all nine activities), the Friedman test was employed to detect overall differences in rankings across recreational activities, using the R package *stats*[38]. Upon obtaining a significant result from the Friedman test, the Nemenyi post-hoc test was conducted to identify specific pairs of recreational activities with statistically significant differences in median ranks, using R package *PMCMRplus*[39]. The Nemenyi test is appropriate for pairwise comparisons following a significant Friedman test, as it controls for Type I error (probability of incorrectly rejecting a true null hypothesis) across multiple comparisons[40]. The combination of the Friedman test and the Nemenyi post-hoc test has been applied in various research contexts involving ranked data, demonstrating their applicability in assessing differences across multiple related recreational activities.

RESULTS.
Hiking was ranked as the most important recreational activity in the MPA by more than half of the tourists. This was followed by beach activities and water activities, with motorised water activities being ranked last by 60% of respondents. Indicating an overall preference for nature-based, low-impact recreational activities in the MPA.

TOOL ASSESSMENT.

- **Usability:** Ranking is a straightforward and widely used method for preference elicitation, making it highly accessible for MPA managers. It involves minimal training for both respondents and administrators, as participants simply order a predefined set of items based on perceived importance. The method is quick to implement, easy to understand, and produces clear, ordinal results without requiring advanced statistical analysis. This makes it a practical tool for integration into broader stakeholder surveys, especially when time or technical resources are limited.
- **Support for stakeholder dialogue:** The ranking method effectively supports stakeholder engagement by encouraging respondents to reflect on and express their relative preferences among a list of items. These insights can be used by MPA managers to better understand public priorities, align

[38] Friedman, M. (1937). *The use of ranks to avoid the assumption of normality implicit in the analysis of variance.* Journal of the American Statistical Association, 32(200), 675–701. https://doi.org/10.1080/01621459.1937.10503522, and R Core Team. (2024). *stats: The R stats package* [Computer software]. R Foundation for Statistical Computing. https://www.R-project.org/

[39] Nemenyi, P. (1963). *Distribution-free multiple comparisons.* Unpublished doctoral dissertation, Princeton University. and Pohlert, T. (2024). *PMCMRplus: Calculate pairwise multiple comparisons of mean rank sums extended* [Computer software]. https://CRAN.R-project.org/package=PMCMRplus

[40] Neyman, J., & Pearson, E. S. (1933). *On the problem of the most efficient tests of statistical hypotheses.* Philosophical Transactions of the Royal Society of London. Series A, 231, 289–337.

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development strategies with visitor interests, and open conversations about how different user needs can be balanced within conservation planning. Although the method does not capture the intensity of preferences or underlying motivations, it can serve as a useful entry point for dialogue on trade-offs and stakeholder priorities.

- **Validity of the results:** Ranking forces respondents to make explicit trade-offs between options, reducing issues common to rating scales such as scale-use heterogeneity or ceiling effects. Scale-use heterogeneity refers to differences in how respondents use rating scales (e.g. some consistently give higher or lower scores), while ceiling effects occur when many responses cluster at the top of the scale, limiting discrimination between options[41]. This improves the clarity and comparability of preference data. However, because ranking only captures relative preferences, it does not provide information on the magnitude of differences between ranked items or absolute valuation. In addition, interpretation may be influenced by the composition of the item list—if irrelevant or inaccessible items are included, they may distort results or frustrate respondents. Careful selection and framing of items are essential to ensure meaningful and valid responses. Next, the outcome of the rating and ranking exercise are influenced by the type of tourism that dominates at the moment of data collection. In April, this meant that tourists seeking active outdoors activities were more dominant compared to those seeking a relaxing beach holidays. Therefore, a longer data collection period, or repetitive data collection phases would contribute in obtaining a thorough understanding of tourists' preferences in the area.
- **Proposed ways to improve tool and implementation:** Similar to the BWS, the improvements made for the integration onto the Blueprint platform involve the provision of R scripts to analyse and statistically test the power of results. Further, limitations of the use of survey data, and how to minimize their impact are also part of the step-by-step guideline.

5.3.3 Tool: Contingent valuation

METHOD. Contingent Valuation Method (CVM) was used to measure tourists' willingness to contribute financially or through volunteer time to support marine conservation initiatives. CVM is a widely used stated preference technique for assigning economic value to quasi-public (partially non-rival and partially excludable) or pure public goods (non-rival and non-excludable). It is a direct valuation method in which respondents are first presented with a hypothetical yet realistic market situation and then asked how much they would be willing to pay (WTP) for the specific environmental services described in the scenario. The method can also assess respondents' willingness to accept (WTA) compensation or their willingness to contribute (WTC) in non-monetary terms[42]. Within the survey, the WTP and WTC questions were formulated as open-ended questions, allowing respondents to enter any monetary amount or number of hours they wished to contribute. A total of seven different scenarios were shown to the respondents, all reflecting different environmental challenges.

The survey was designed as an online survey in Qualtrics software. Data was collected via on-site surveying on tablets in April 2025, resulting in 226 respondents. After cleaning the data, between 203 and 210 respondents remained, depending on the respective scenario (see Table 5).

[41] Krosnick, J. A., & Fabrigar, L. R. (1997). *Designing rating scales for effective measurement in surveys.* In L. Lyberg et al. (Eds.), Survey measurement and process quality (pp. 141–164). Wiley.

[42] Carson, R. T., & Hanemann, W. M. (2005). Contingent valuation. *Handbook of environmental economics*, *2*, 821-936.

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Hypothetical scenario	Number of respondents	Brief description
Water quality	207	This scenario examines support for community-led clean-ups and waste-reduction measures to improve water quality affected by tourism in the MPA.
Wildlife protection	208	This scenario assesses tourists' willingness to accept seasonal access restrictions to protect sensitive bird habitats in the MPA.
Quiet zones	210	This scenario evaluates support for designated quiet zones and alternative routes to reduce underwater noise from recreational activities.
Hiking trails	206	This scenario explores support for trail restoration and erosion control measures that may temporarily limit access to preserve coastal landscapes.
Recreational fishing	206	This scenario examines acceptance of seasonal fishing restrictions and habitat restoration to ensure the long-term sustainability of recreational fishing.
Marine education	205	This scenario tests willingness to support visitor education initiatives that increase awareness of marine conservation and responsible behaviour.
Heritage	203	This scenario assesses the value tourists place on protecting cultural and artistic heritage associated with the MPA alongside its natural features.

Table 5: Number of respondents for every hypothetical scenario in the contingent valuation exercise

To analyse the determinants of individuals' stated willingness to contribute (either through monetary donations or volunteering time), a logistic regression model was employed for each contingent valuation scenario (seven scenarios in total). The dependent variable was binary, indicating whether the respondent was willing to contribute (1) or not (0) to the conservation measures in the scenario under consideration. No distinction was made between WTP and WTC in the modelling process, allowing for a combined examination of the overall willingness to contribute, regardless of the type of contribution. Model coefficients were estimated using the maximum likelihood estimation (MLE) method. The model was implemented in R (R Core Team, 2023) using the glm() function with the binomial family and logit link.

RESULTS.
The contingent valuation exercise reveals clear differences in tourists' willingness to contribute across conservation scenarios, driven primarily by participation rates rather than contribution intensity. Scenarios related to wildlife protection, water quality, and hiking trail restoration attract the broadest support, with approximately 27–30% of respondents indicating a willingness to contribute financially, through volunteer time, or both. In contrast, recreational fishing consistently receives the lowest level of engagement, with only 14.1% of respondents willing to contribute, alongside the lowest monetary and time commitments among contributors. Other scenarios, including quiet zones, marine education, and cultural heritage, show moderate but non-negligible participation, indicating selective rather than widespread support.

Among respondents willing to contribute, monetary and time contributions are relatively stable across scenarios, with mean annual willingness to pay generally clustering between €55 and €60 and median values ranging from €25 to €50. Mean time contributions similarly range between approximately 25 and 34 hours per year. These patterns suggest that differences between scenarios are not driven by substantially higher valuations among supporters, but by whether respondents choose to engage at all. This finding is reinforced by the participation–intensity decomposition and engagement indices, which show that scenarios with lower participation can still generate relatively high overall engagement due to strong contribution intensity among a smaller group of committed respondents.

The analysis of zero responses further indicates that non-participation should not be interpreted as rejection of conservation goals. Across all scenarios, the most frequently cited reason for not contributing is the belief that conservation measures are the responsibility of government authorities, followed by financial and time constraints. Only a small proportion of respondents report that they do not consider the initiatives important, except in the case of recreational fishing, where lower perceived importance plays a more notable role. This suggests that most scenarios enjoy broad normative support, even when individual willingness or capacity to contribute is limited.

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Overall, the results show that the contingent valuation exercise is most informative for identifying relative patterns of engagement and support rather than producing precise monetary valuations of ecosystem services. Differences across scenarios reflect variation in perceived responsibility, feasibility, and relevance, rather than fundamentally different valuations of the underlying ecosystem services. Consequently, the estimated willingness-to-pay and willingness-to-contribute figures should be interpreted with caution and primarily as indicative measures of stakeholder engagement rather than definitive welfare estimates.

Despite this intrinsic value placed on ecosystem health, awareness of the MPA's designation and conservation goals was low: only 20% of tourists knew they were in a protected area, and just 7% were aware of any specific regulations.

TOOL ASSESSMENT.

- **Usability:** CVM is moderately user-friendly for MPA managers, especially when implemented with a simplified, single-scenario approach. This reduces respondent fatigue, simplifies data analysis, and makes the tool more practical for real-world applications. Willingness to pay is the most straightforward component to apply, particularly when ecosystem services are directly experienced by tourists. Willingness to contribute time is useful where financial contributions are not feasible. However, more complex designs involving multiple scenarios or advanced analysis can be challenging to interpret without support from researchers. For effective use in practice, CVM requires careful scenario design and a basic understanding of survey development and result interpretation.
- **Support for stakeholder dialogue:** CVM offers value in facilitating dialogue between MPA managers and stakeholders by making explicit what types of ecosystem services visitors value and how they are willing to support them. It helps managers tailor communication and outreach strategies around services that stakeholders prioritise. Including both WTP and WTC in the tool allows for a broader and more inclusive view of stakeholder capacities and preferences. The results can also inform discussions about volunteer programs or community-based initiatives, especially when monetary contributions are unlikely. That said, the depth of dialogue depends on how well the survey scenarios reflect real conservation issues that stakeholders understand and care about.
- **Validity of the results:** The validity of CVM outcomes is closely linked to the quality and realism of the hypothetical scenarios used in the survey. Scenarios must be context-specific, easy to understand, and relatable for tourists to avoid hypothetical bias or confusion. When well-designed, the tool yields meaningful and reliable estimates of stakeholder preferences and contributions. Enhancements such as visual aids or income-related questions can improve response accuracy and explanatory power. However, complex or poorly framed scenarios can reduce data quality and distort conclusions, limiting the usefulness of the results for informing management decisions. Next, similar to other survey-based valuation methods, survey design and survey implementation are essential to safeguard valid results.
- **Proposed ways to improve tool and implementation:** The testing identified the preparation of the CV experiment as most critical towards obtaining valuable results. We therefore focus on standardizing and facilitating the process of conceptualizing a CV experiment in the step-by-step guideline. Another improvement to the tool, which makes it more accessible to non-academics is the provision of R scripts to facilitate the analysis. However, we also emphasize the careful application. Noticeably, interpreting and communicating CVM results can be difficult, and it can sometimes contain sensitive information. We therefore urge for the integration of a research approach which also integrates qualitative methods, if applying the contingent valuation method.

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6 Framework for identifying and valuing ecosystem services benefits

All activities conducted within Task T2.3 contributed to the development of a framework for identifying ecosystem service benefits and assessing their monetary and non-monetary values in MPAs. While the framework was applied implicitly throughout this deliverable, this section makes it explicit by outlining its structure and use.

The framework follows a stepwise approach that guides users from stakeholder engagement and problem definition to tool selection, application, interpretation, and decision support. Stakeholder engagement is central throughout, ensuring alignment between valuation tools (D2.2), management needs, and implementation potential. Valuation results can subsequently support communication and inform discussions on funding and financing mechanisms, in line with Deliverable D2.4. Operationalised through the Blueprint Platform, the framework provides a structured socio-economic perspective to support effective MPA management and conservation outcomes.

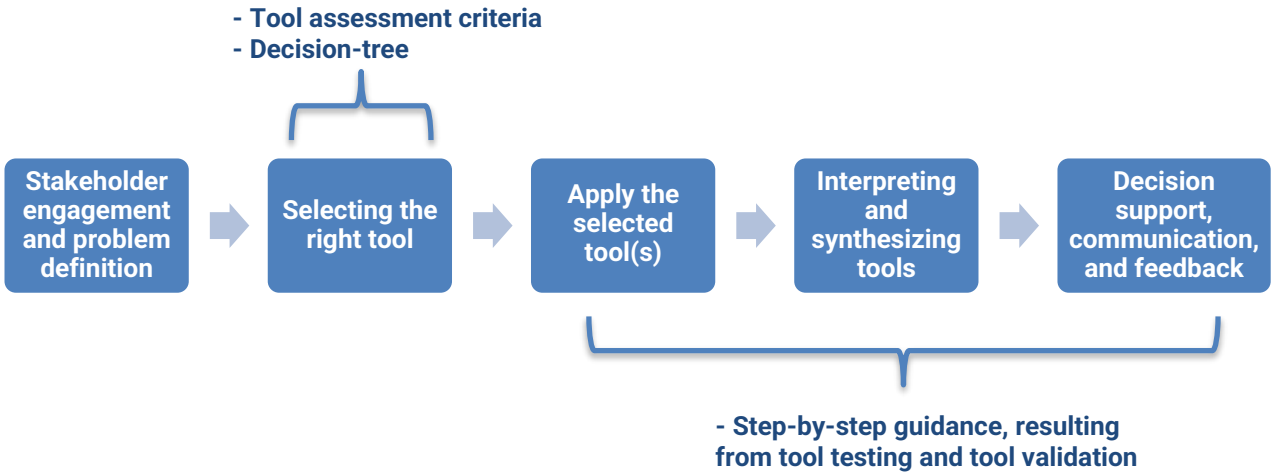

Figure 5: Stepwise framework guiding ecosystem service valuation in MPAs from stakeholder engagement to decision support, tangible resources resulting from T2.3 next to the accolades.

6.1 Stakeholder engagement and problem definition

The first step focuses on structured engagement with MPA managers, decision-makers, and other key actors to clarify the purpose of ecosystem service valuation. This ensures that valuation addresses concrete management questions and builds on insights from the Blue4All Living Labs. Discussions identify which decisions valuation should support—such as prioritisation, communication, or funding—while also clarifying stakeholder expectations and constraints. This step anchors the framework in real-world governance contexts and provides the basis for subsequent tool selection.

6.2 Selecting the right tool

Building on Part 1, the second step focuses on selecting appropriate valuation tools for the identified purpose. Recognising that no single tool fits all contexts, T2.3 defined a set of assessment criteria to support systematic and transparent tool selection. These criteria consider ecosystem service type, desired outputs, stakeholder involvement, and practical constraints.

Tool selection is guided through a decision-tree on the Blueprint Platform, which can also be applied to assess new valuation tools as they emerge. The framework distinguishes between different tool families, including qualitative, preference-based, and cost- or benefit-based approaches, while treating integrated methods such

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as multi-criteria decision analysis as optional extensions. This criteria-based approach ensures purpose-driven, adaptable, and consistent tool selection.

6.3 Applying the selected tool(s)

The third step focuses on the practical application of the selected tool(s), following guidance provided through the Blueprint Platform. Users define the scope of the valuation exercise and conduct data collection and analysis in line with the chosen method(s). Assumptions, limitations, and uncertainties are documented to support transparent interpretation. This step reflects the empirical testing undertaken in T2.3 and allows adaptation to local MPA contexts.

6.4 Interpreting and synthesising results

The fourth step supports the interpretation and synthesis of valuation results, particularly when multiple tools are used. Rather than aggregating outcomes into a single metric, results are compared to identify complementarities, trade-offs, and patterns across ecosystem services and stakeholder perspectives. Interpretation is guided by the management objectives defined in Part 1, ensuring decision relevance and supporting integrated understanding.

6.5 Decision support, communication, and feedback

The final step translates valuation outcomes into decision support and communication. Results are presented in formats suited to different audiences, supporting management discussions, stakeholder dialogue, and strategic planning. This step also includes a feedback mechanism to reflect on the usefulness of tools and results, enabling iterative learning and improvement. Through this step, the framework connects valuation to implementation, supporting informed decision-making and long-term ecosystem service delivery.

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7 Conclusion

This deliverable set out to assess how socio-economic valuation tools can support effective, efficient, and resilient MPA and MPA networks by making explicit the benefits derived from ecosystem services. Across the phases of Task T2.3, a structured and iterative process was followed—from identification and screening of available tools to in-depth assessment, and finally to real-world testing and validation in Blue4All LLs. This process has resulted in the development of a practical framework that enables MPA managers and decision-makers to select and apply existing scientific methods in ways that are context-sensitive, stakeholder-oriented, and aligned with ecological, social, and policy objectives.

The report began by establishing the role of ecosystem service valuation in marine governance. MPAs are no longer justified solely through biodiversity outcomes; they must also demonstrate social relevance, economic contribution, and stakeholder acceptance. Chapter 1 therefore established the conceptual basis for socio-economic valuation as a bridge between ecological evidence (WP3), stakeholder perspectives (D2.2 and D4.2), and financial mechanisms for implementation (D2.4). It also clarified the scope: rather than focusing exclusively on monetary valuation, the task included non-monetary and participatory tools capable of capturing cultural and relational values that are critical for social legitimacy and long-term success of MPAs.

Chapter 2 presented the identification of tools and methods. It became evident that existing marine valuation toolkits are limited in number, often outdated, or tailored to research contexts rather than management realities. This gap necessitated the inclusion of scientific valuation methods alongside toolkits. The resulting longlist represented the first step in constructing what would become the framework: a structured approach to filter, adapt, and translate scientific tools into practical applications.

In Chapter 3, the initial screening and shortlisting refined the longlist through criteria that reflect the operational realities of MPAs. Tools were assessed based on their suitability for ecosystem service valuation, as well as their data, time, and expertise requirements. The analysis demonstrated that while many methods are theoretically powerful, few are readily applicable without adaptation. A critical finding was the reliance of nearly all methods and tools—especially those focused on cultural and participatory valuation—on primary data collection and stakeholder consultation. As a result, low-effort replication is limited, especially in contexts where management capacity is constrained. Additionally, while some resource-efficient economic methods such as avoided cost or replacement cost could be applied in select cases, their applicability is restricted to a very narrow set of ecosystem services. The main takeaway from this chapter is the shortlist of tools to be adopted in the framework that will be integrated into the Blueprint Platform.

The framework featured in this deliverable, will be integrated on the Blueprint Platform through a decision tree or flow to guide users in the direction of the right tool for a certain ecosystem service valuation purpose, and step-by-step guidance to use the shortlisted tools (like scientific methods). In that respect, the work executed within T2.3 contributes to MPA's capacities to demonstrate the added value (whether in monetary terms or not) that different stakeholder groups obtain from the ecosystem functioning, adhering to the ecosystem cascade model presented in Chapter 1. While "economic tools" could be interpreted as revenue generating mechanisms from the initial terms of action, this was not the objective of T2.3. The objective was rather to facilitate and mainstream revealing socio-economic value that results from the healthy functioning of an ecosystem, in this case, marine ecosystems. T2.3 therefore more indirectly contributes to maximizing ES delivery, by informing policy makers on different stakeholders' perspectives, thus providing the handles to balance different priorities.

Chapter 4 built on the initial screening and shortlisting by conducting in-depth assessments of shortlisted tools. This phase marked the conceptualization of the framework itself. In this chapter, all T2.3 contributors shared knowledge and expertise through the in-depth tool assessments. The assessments lay the foundation for identifying which tools would be ready for application in the identified Blue4all LLs: Danish Wadden Sea MPA, Vlaamse Banken MPA, and French Natura 2000 MPA. The framework developed under T2.3 should therefore be understood as a structured decision-support process, composed of step-by-step guidance for each tool and a decision-tree to match MPA needs with suitable scientific methods. It is not a new tool, but a navigation mechanism that operationalizes existing methods for use by non-experts in real management contexts.

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Chapter 5 demonstrated how the selected tools perform under real-life conditions in the Blue4All LLs. Across all three cases, tools were evaluated not only on scientific validity, but on usability and stakeholder relevance. The findings show that participatory and qualitative methods—such as interviews, best-worst scaling, benefit transfer, and PPGIS—can be valuable for capturing cultural ecosystem services and facilitating stakeholder dialogue. These tools generated valuable spatial and social insights that were appreciated by SEG members, especially when presented through visual outputs such as heat maps or value rankings. However, these methods also revealed limitations: they require intensive stakeholder engagement, cannot be easily replicated without new data collection, and rely on careful facilitation to avoid bias. In contrast, tools that aim to quantify monetary values, such as contingent valuation and benefit transfer, were found to be more resource-efficient, but their credibility depends on the availability of comparable studies and stakeholder acceptance of monetary framing. The main contribution described in this chapter with respect to the framework, are the improvements to proposed to existing tools and especially their implementation resulting from their testing and validation.

A key observation emerging from the testing phase is that causal relationships between ecological processes and socio-economic benefits are often complex and context specific. This complexity limits the applicability of many tools at larger scales, such as MPA networks. Applying valuation tools in a network context requires disaggregation into site-level assessments (as also suggested in D4.2) and subsequent aggregation through ecological connectivity or stakeholder representativeness. This presents additional challenges for stakeholder engagement, as the distance between decision-makers and site users increases. The first step of disaggregation, therefore, should safeguard the establishment of a key stakeholder group to facilitate the design and validation of economic valuation exercises. Similarly, when considering OECMs, the tools are theoretically applicable, but they may require further adaptation to account for different governance models, land-sea interfaces, or non-formal conservation objectives.

Overall, the main limitation identified across all tools—whether methods or toolkits—is that none provide a universal solution. Instead, they require contextual tailoring, stakeholder engagement, and data interpretation. Yet this limitation is also the source of their value. The results demonstrate that valuation is not merely a technical exercise to produce figures, but a social process that enhances legitimacy, builds understanding of ecosystem benefits, and aligns management with user expectations. This confirms the central premise of T2.3: that socio-economic valuation tools contribute to maximizing ecosystem service delivery not only by quantifying benefits, but by enabling dialogue, informing adaptive governance, and strengthening the link between ecological outcomes and social well-being.

The framework developed in this deliverable therefore provides a practical pathway for applying valuation methods in MPAs, OECMs, and—importantly—MPA networks. It equips managers with step-by-step guidance on tool selection and use, grounded in scientific methods while adapted for real-world governance contexts. As such, the framework forms the basis for integration into the Blueprint Platform, where it will be operationalized through a decision-tree, step-by-step tool guides, and examples from Chapter 5.

Although the proposal and Deliverable D2.1 refer to the ambition of standardising, comparing, weighing, and interrelating ecosystem service values in an integrated and synthetic way (e.g. through multi-criteria decision analysis), this deliverable does not implement a single, fully integrated valuation framework. Instead, it focuses on the identification, testing, and validation of individual valuation tools and methods in concrete MPA contexts. This reflects both the practical constraints identified in the Living Labs and the limited data, time, and expertise typically available to MPA managers. Integrated approaches such as MCDA were reviewed but found to be resource-intensive and less suited for routine application at this stage. Integration is therefore addressed at the framework level, by clarifying how different tools can be selected and combined depending on management objectives. This approach is intended to support future integration within the Blueprint Platform, where multiple valuation outputs can be brought together in a structured decision-support process rather than aggregated into a single metric.

In conclusion, this deliverable demonstrates that despite limitations in tool applicability, data requirements, and replication potential, socio-economic valuation remains a critical enabler of MPA effectiveness. The framework developed under T2.3 helps ensure that valuation is not an isolated assessment activity, but an integral part of strategic planning, stakeholder engagement, and financial mobilisation. By linking ecosystem service identification to both monetary and non-monetary values, and by translating complex scientific methods into actionable steps, this work contributes directly to maximizing the delivery of marine ecosystem services and strengthening the resilience and legitimacy of MPAs and their networks—ultimately supporting the overarching objectives of the Blue4All project.

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The framework which will feature on the Blueprint Platform will exist of a Step-by-step guidance to use scientific methods, and a decision tree or flow to guide users in the direction of the right tool for a certain ecosystem service valuation purpose. In that respect, the work executed within T2.3 contributes to MPA's capacities to demonstrate the added value (whether in monetary terms or not) that different stakeholder groups obtain from the ecosystem functioning, adhering to the ecosystem cascade model presented in Chapter 1. While "economic tools" could be interpreted as revenue generating mechanisms from the initial terms of action, this was not the objective of T2.3. The objective was rather to facilitate and mainstream revealing socio-economic value that results from the healthy functioning of an ecosystem, in this case, marine ecosystems. T2.3 therefore more indirectly contributes to maximizing ES delivery, by informing policy makers on different stakeholders' perspectives, thus providing the handles to balance different priorities.

General to all tools – whether methods or toolkits – tested in T2.3, participatory methods require data collection and stakeholder consultation. Low effort replication is therefore very limited. Some of the methods that have not been tested because there was no case study (in consultation with D4.4) suited in terms of ecosystem services provided. Such as avoided cost method, replacement cost method or substitution cost method - they could be very resource efficient valuation methods, but only for a very limited number of ecosystem services, and thus very limited number of cases.

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8 Appendix

8.1 Appendix 1: In-depth assessment of the "most promising tools"

1. Context of the assessment

Within WP2, the potential of science-based tools for socio-economic and governance solutions is explored. As a part of this, in **task T2.3 we specifically look at the potential of (existing) tools to identify and value the benefits from marine ecosystem services**. For this, a review of tools was conducted. Leveraging the information gathered in WP1, specifically T1.3, this exercise started with a longlist of potential tools related to mapping and valuing ecosystem services (Tool evaluation.xlsx). During the review of toolkits (including software, websites, etc.), we realized that applicability is often hampered for several reasons, and therefore decided to incorporate valuation methods in this review as well. The longlist was reduced to the current shortlist of following toolkits and methods:
Toolkits: *INVEST models, ARIES, SolVES, Zonation5, Ecopath EcoSim (EwE), Coastal Capital Valuation Tool, PlanWise4Blue*
Methods: *Contingent valuation, Replacement cost method, Damage cost method, Production function method, Direct market valuation method, Benefit transfer, Assessments using rating and ranking questions, Qualitative methods.*

In what follows, a **tool can be a toolkit or a method**. A toolkit is defined as something an MPA manager can use to help value and understand the benefits that nature provides to humans in MPAs. This can be a software program, an app, a guidebook, a spreadsheet, etc. A method is defined as a scientific approach or technique behind a tool. It can be considered as a 'recipe' that explains how to collect and analyze data to value and understand the benefits that nature provides to humans in MPAs. Examples are stated preference methodologies, carbon footprint analysis, etc.

The **purpose of this assessment** is to further deepen our understanding of tools and evaluate how we can set up a valuation protocol for the tools testing. With valuation protocol, we mean clear guidelines and oversight on actual tool application on a concrete research question within an MPA. The workload, time requirement, and prerequisites will be different from tool to tool, which is important to know before further formalizing the tools testing process.
This template is destined to **standardize this exercise**, and we invite the tool reviewers to be as **thorough (yet concise) as possible in their evaluation**.

Thank you very much for taking part in this process!

Assessor: *[Name]*
Tool assessed: *[Tool name]*

General description
[Here, you add a general description of the tool/method, including the purpose of the tool, developer, scale (geographical) and scope (type of ecosystem services), users, data requirements, and technical requirements (e.g. install software).]

Step-by-step guide
[Here, you'll find a detailed outline of the necessary steps to take from start to finish, guiding you from formulating the research question to obtaining and interpreting the results.]

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Example case study

[This section presents an example of an application, demonstrating the use of the tool in a real-world scenario (preferably in a marine context), including potential research questions. The case study can be drawn from a report, video, or scientific literature]

Advantages and limitations

[An important element to keep in mind, is to approach the exercise from an MPA manager's point-of-view, so *advantages and limitations of the tools e.g., regarding data requirements, easy-to-use, scope, etc.]*

Additional remarks

[Optional: Provide additional information, remarks, feedback, etc.]

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8.2 French Natura 2000 MPA tools testing report

HORIZON-MISS-2021-OCEAN-02-01- Blueprint demonstration for co-created effective, efficient and resilient networks of MPAsclimate resilience

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1 Introduction

This report results from the research conducted within task T2.3 of the Blue4all project. Within work package 2 (WP 2) of Blue4All, the potential of science-based tools for socio-economic and governance solutions is explored. As a part of this, in task T2.3, we specifically look at the potential of (existing) tools to identify and value the benefits from marine ecosystem services. Within this task, the assessment of tools was conducted in several distinct phases: tools identification, tools review, tools testing, and finally, tools validation. Throughout the distinct phases of this task, the Blue4all ambition of bottom-up and co-creation was carefully adhered to. In this summary report, the results from a case study in the French living lab are presented. The research was led by University of Antwerp MSc student Joke Seghers, under the supervision of dr. Soukaina Anougmar, dr. Sophie Van Schoubroeck, and dr. Wito Van Oijstaeijen. From beginning to end, this research was executed in close collaboration with OFB's Blue4all project officer Maëlla Sicard.

1.1 Context of socio-economic valuation in MPAs

Our oceans and seas provide a wide array of ecosystem services. To safeguard the capacity of these marine bodies to generate such benefits and protect biodiversity, MPAs have been (and are being) established. As defined in Target 3 of the Kunming-Montreal Global Biodiversity Framework and the EU Mission "Restore our Oceans and Waters by 2030", 30% of our oceans must be protected through networks of MPAs and other effective conservation measures (OECMs) to maintain healthy and functioning ecosystems. While designating areas as MPAs and OECMs limits human's direct (and unsustainable) use of certain marine areas, protection ensures long-term well-being of both marine life and human populations that depend on the ocean. To clearly understand different stakeholders' opinions and perceptions on marine protection, as well as barriers and levers to acceptance and ownership, mapping and valuing (cultural) ecosystem services can be pivotal. Moreover, such insights support informed decision-making and inclusive management decisions. Interdisciplinary socio-economic research thus serves as a bridging mechanism, connecting ecological importance to effective, efficient and resilient MPA implementation and uptake.

1.2 Needs of the French Natura 2000 MPA

In a previous project task (part of WP1, T1.4), the context of the Blue4all living labs (LLs) and information sites was established. The baseline assessment defines the playing field for the research approach adopted in T2.3. It was determined that LLs are involved in the development of tools from the start to the final validation as collaborators; the intent was to address specific needs apparent at the LLs during tools testing and validation. Needs that can be addressed through socio-economic and ecosystem services valuation were identified in the needs assessment (part of WP4, D4.2). From this exercise, LLs to test and validate ecosystem service valuation tools were identified. The French Nature 2000 MPA was one of them. An oversight of the French Natura 2000 MPA is provided below.

"During this discussion, the most relevant and priority need emerged as the necessity **to raise awareness and foster acceptance of the Living Lab**, MPAs, and their ecological aspects among socio-economic actors."
"The SEG agrees that leveraging ecosystem services can **enhance the effective management of MPAs**. They recognize that ecosystem services can aid in **gaining acceptance** of the MPA, **achieving its goals, and implementing conservation measures.** However, the SEG emphasizes several important considerations:

- Due to the testing phase, lack of experience, and limited funding, it may not be feasible to conduct Research and Development on ecosystem services.
- SEG are much interested about concrete example of use ecosystem service for acceptability in MPAs.
- The SEG is wary of relying on monetary valuation of ecosystem services, citing insufficient knowledge about marine ecosystem services and potential risks.
- Ecosystem services assessments must account for the diversity of activities and cumulative impacts within the MPA.
- There is a need to be cautious about how ecosystem services are utilized by certain actors, as they may use them to promote specific activities rather than the MPA itself."

2 Tools tested in the French MPA

After initial discussions with the Blue4All contact point, appropriate tools to bridge the needs of the MPA and ecosystem services valuation were selected. Based on the context drawn, we chose for contingent valuation method and rating/ranking assessments to be applied in the French MPA. Both are explained below.

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2.1 Assessments using rating and ranking (includes BWS)

Rating and ranking methods are simple tools used to prioritize ecosystem services or management options based on stakeholder preferences. They are often employed in participatory settings to capture local knowledge and values.

Advantages

These methods are easy to administer and interpret, making them suitable for a wide range of contexts. They can be particularly useful in early stages of decision-making, where a quick overview of stakeholder priorities is needed.

Limitations

However, they also have notable limitations. The choice of rating scale can influence results, and there is a risk of bias in how respondents use the scale. Ranking exercises, while useful, force respondents to differentiate between options even when they may consider them equally important. Additionally, these methods do not provide monetary valuations and may require significant time and resources to administer surveys effectively.

2.2 Contingent valuation

The Contingent Valuation Method is a survey-based approach used to estimate individuals' willingness to pay for non-market ecosystem services, such as biodiversity, clean air, or recreational opportunities.

Advantages

CVM is relatively easy to implement and analyze, and it can be applied to a wide range of goods and services. It is also cost-effective compared to more data-intensive valuation methods.

Limitations

To address this issue, surveys typically include follow-up questions to determine the reasons behind zero bids. Despite these efforts, distinguishing between true zero valuations and protest responses remains a challenge. Moreover, the method's reliance on hypothetical scenarios introduces a degree of uncertainty, as respondents may not behave in real life as they claim in surveys.

However, the method is often criticized for the presence of "protest zeros"—responses in which individuals refuse to assign a monetary value for ideological or fairness-related reasons. These responses can distort the results if not properly identified and excluded.

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3 Testing of tools in the French MPA

After theoretically assessing and testing the tools, they are subjected to real-life and needs-oriented questions within the Blue4all LLs. To validate the potential of using the tools, high-level needs were identified through the T4.2 needs assessment. The identification of LLs to collaborate with is based on overlaps between the application potential of respective tools and the questions raised by LLs.

To test and validate the tools under real-life conditions, small research projects were conducted within several LLs. This report focuses on the use of each tool rather than the outcomes of the projects. For each tool, we follow this structure: background of the tool and its application, results and interpretation, 4.3.3 Evaluation of tool results and reflection on responding needs outlined in the introduction, and final tool assessment, based on lessons learned during the implementation of the case study. For the final tool assessment, three criteria were selected: usability, support for stakeholder dialogue, and validity of the results.

3.1 French Natura 2000 MPA

CONTEXT. Tool testing in the French Natura 2000 MPA did not take place in the entire network, but focused on the Littoral Seino-Marin MPA. The Littoral Seino-Marin Marine Protected Area is located along the northern coast of France in the Normandy region, specifically in the Seine-Maritime Department. The site, designated as a Special Protection Area (SPA) under the EU Birds Directive, covers a total surface area of 180,050 hectares. Four primary habitat types characterize the MPA: chalk cliffs and its associated coastal grasslands, pebble beaches at the cliff base, intertidal zones, and the sea, which reaches a maximum of depth in the area at 33 meters. Development and infrastructure do not significantly affect the vulnerability of the terrestrial part of the MPA site, as the configuration of the site with cliffs and coasts does not allow for human infrastructure. However, human activities such as tourism, marine traffic, fishing, and wind farms put significant pressure on the ecosystem, especially for nesting and migratory birds. Normandy represents the second most important fishing region in France after Brittany, resulting in substantial commercial fishing activity within the MPA. Recreational activities both at sea (sailing, surfing, diving, pleasure boats) and on land (hiking, beach activities) contribute to noise pollution and waste accumulation, affecting local ecosystems and bird populations. Tourism has increased significantly in recent years in Normandy. In 2023, Seine-Maritime alone, the French department in which the MPA Littoral Seino-Marin is located, set a new record with 22.5 million overnight stays, including 10.4 million by foreign tourists.

RESEARCH QUESTION(S). The study objective is: (1) How do tourists prioritise ecosystem services and recreational activities within the MPA, and what is their willingness to contribute to conservation when access or quality is limited? (2) How do shellfish farmers perceive and prioritize the benefits and limitations of the MPA in relation to their professional activities?

4 Testing of tools in the French Natura 2000 MPA

4.1 Purpose of the study

Besides testing the tools to assess their applicability in a real-life context, two main research questions were defined in dialogue with Maëlla Sicard from OFB:

(1) How do tourists prioritise ecosystem services and recreational activities within the MPA, and what is their willingness to contribute to conservation when access or quality is limited?
(2) How do shellfish farmers perceive and prioritize the ecosystem services, benefits, and limitations of the Littoral Seino-Marin Marine Protected Area in relation to shellfish farming activities?

Next, engaging stakeholders—tourists for research question (1) and shellfish farmers for research question (2)—helps foster dialogue, increase awareness of the MPA, and share existing knowledge.

In parts 4.2 to 4.5 the research surrounding the first research question is described and discussed. In part 4.6 the research surrounding the second research question is addressed.

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4.2 Data collection in MPA Littoral Seino-Marin

Primary data were collected on-site at the MPA from April 7–10, 2025, using a self-administered questionnaire. The survey was distributed by researchers from the University of Antwerp and OFB staff at tourist offices and key locations in Étretat, Saint-Valery-en-Caux, and Veules-les-Roses. A convenience sampling approach targeted visitors present during the collection period. Participants completed the survey on provided tablets or their own devices, with QR codes on posters and flyers enabling later participation. Informational materials about the MPA and its bird populations were also distributed. Follow-up flyer distribution extended participation in mid- to late April, and the survey remained online until the end of May.

The survey was available in French, English, and Dutch, and respondents received a brief introduction to its objectives. Participation was voluntary, anonymous, and confidential, adhering to standard ethical practices. No personal identifiers were collected, and data were analyzed in aggregate. A total of 283 individuals started the survey, of which 226 completed at least the introductory sections. Due to the survey's length, the number of respondents completing the three main sections—Best-Worst Scaling, ranking exercises, and the contingent valuation method—gradually decreased. Consequently, participation varied across these tools. Specific participant numbers and reasons for exclusions are detailed in the respective tool descriptions later in this report.

4.2.1 Respondents' characteristics

4.2.1.1 Origin

The respondents to the survey mainly originated from mainland France, particularly the Northwestern part of France, as can be seen in Figure 6. Besides French respondents, there were also tourists from Belgium (24), Germany (7), the Netherlands (5), United Kingdom (3), USA (3), Ukraine (3), Hungary (2), Italy (2), and one respondent each from Sweden, Mexico, UAE, Thailand, and Andorra. One person prefered to not disclose their country.

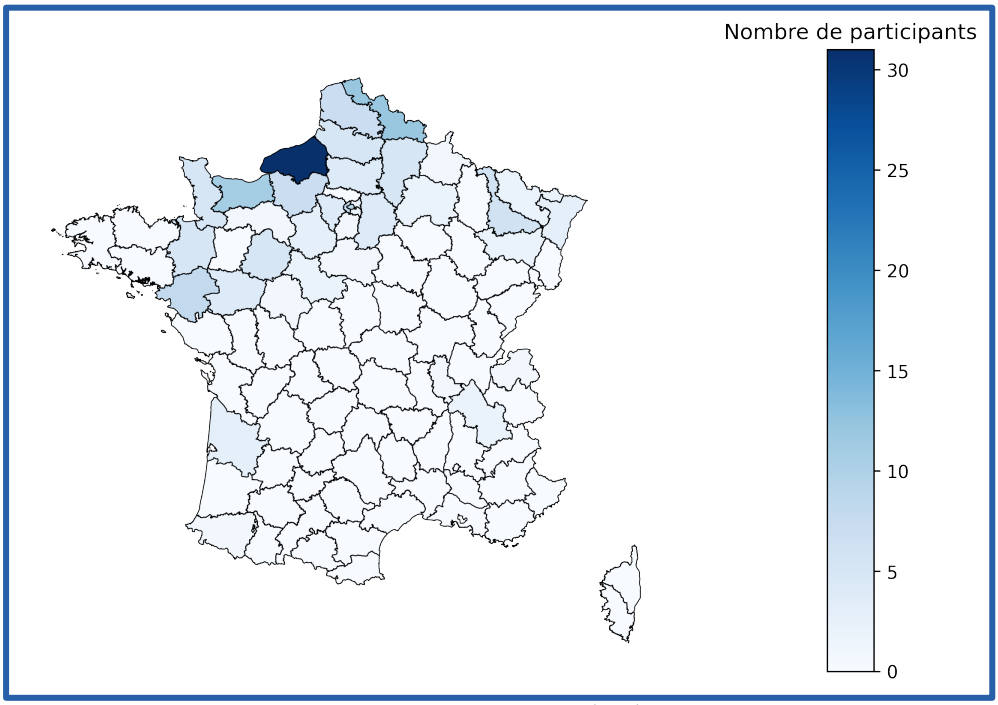

Figure 6: Distribution of French respondents (171) by departmental code

4.2.1.2 Age

Figure 7 shows the distribution of respondents across age groups. Nearly half of the sample falls between 25 and 44 years old. This relatively young demographic can likely be attributed to the timing of data collection. Since data were gathered during the Easter holidays, many young families with children were visiting the area. We assume that older tourists, being less constrained by school holiday periods, tend to avoid the crowds during such times. Notably, four minors participated in the survey. Although they were always accompanied by an adult, their responses were removed from the dataset and not used for the analysis of the tested tools, as the survey did not have ethical approval to include minors.

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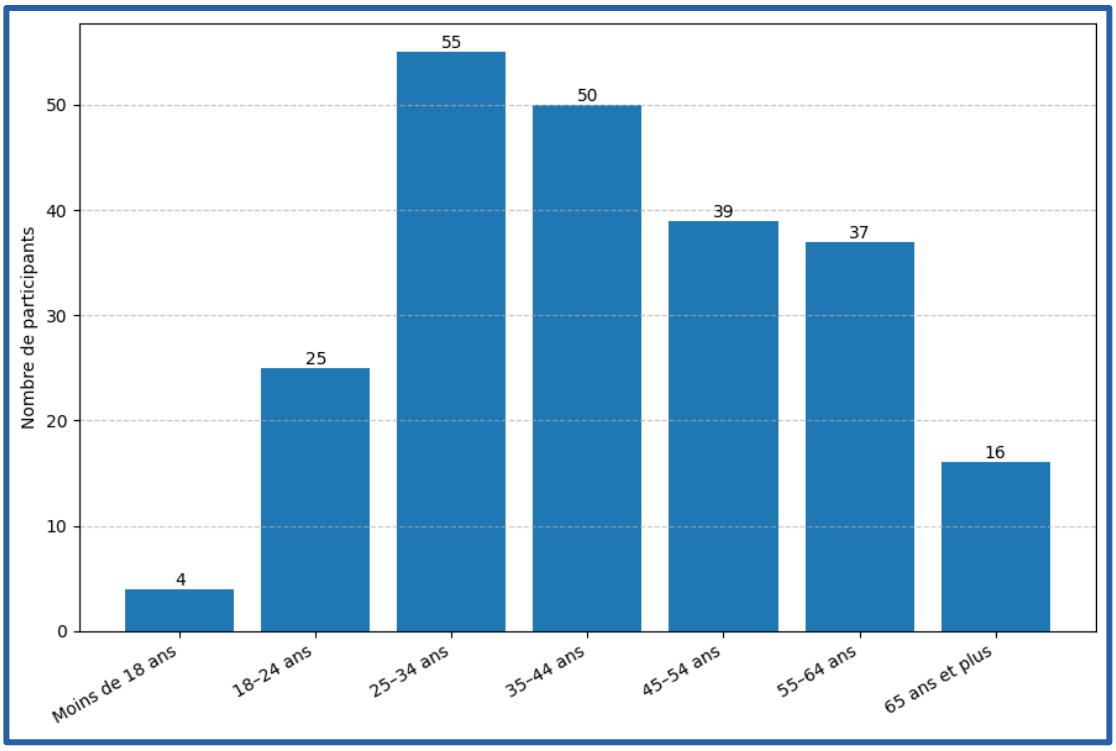

Figure 7: Répartition des participants par tranche d'âge

4.2.1.3 Purpose of visit

Firstly, we asked respondents if they had visited the area (MPA Littoral Seino-Marin) before. 72 respondents (32%) indicated that they had done so, 141 respondents (62%) had not visited the area before, and 13 respondents (6%) were not sure.

The purpose of a visit appears to be strongly shaped by the season in which the data were collected. Many visitors—likely enticed by the pleasant weather—spend their time in the area primarily to relax and unwind, representing roughly half of our sample. The other half, however, comes with clearer intentions. Some are drawn to cultural experiences, while others seek to engage with the natural environment. These activities vary in intensity, from active pursuits such as hiking or guided tours to more leisurely forms of enjoyment, like observing wildlife and exploring natural features. In support of the latter, we distributed informational flyers about the bird species found in the MPA, which were frequently met with enthusiasm and appreciation by respondents. We believe—and informal discussions with local tourism offices support this—that spring attracts a higher number of nature-oriented, outdoor-loving, and environmentally conscious visitors to the coastal areas surrounding the MPA.

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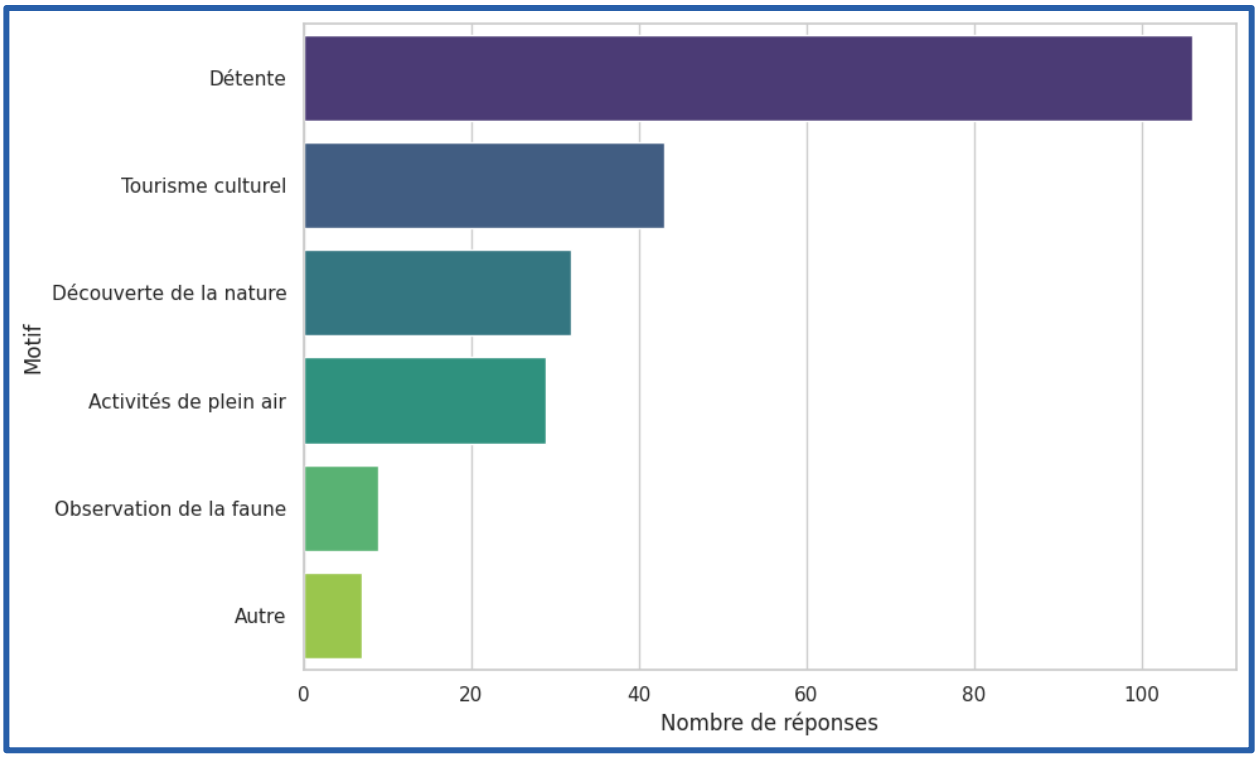

Figure 8: Bar chart describing the purpose of the visit of the survey's respondents

4.2.1.4 *The marine protected area and awareness about it*

The survey served a dual purpose: it sought to **uncover how much people knew** about the marine protected area, while **also giving participants an opportunity to learn more**. As they responded to the questions, visitors discovered the existence of the MPA, explored some of its key conservation goals, and gained insight into the valuable ecosystem services it provides. Perhaps most importantly, **the survey encouraged reflection on the delicate balance between human activities and the protection of these natural environments**, leaving participants with a deeper appreciation of their role in safeguarding the coast. In the text boxes, some information that was shared with respondents is depicted.

"The **Littoral Seino-Marin Marine Protected Area (MPA)** is a specially designated zone along the Normandy coast, established primarily to safeguard large populations of migratory seabirds. This MPA protects these birds by preserving essential habitats such as cliffs, which serve as nesting sites, and coastal areas that provide a lot of food sources."

For tourists, MPAs offer recreational experiences, from coastal walks to wildlife observation and water sports. However, balancing conservation with tourism can sometimes lead to trade-offs, such as restricted access to certain areas or guidelines to minimize environmental impact.

Your feedback will help us understand the **balance between conservation and recreation** in the Littoral Seino-Marin MPA, highlighting which aspects matter most to visitors like you."

"By **making recommendations** for activities such as fishing, boating, and tourism, the **MPA permits sustainable use while maintaining ecosystem services**. An ecosystem service is a benefit that people gain from nature and the living organisms within it. These services help improve our quality of life by providing resources, regulating natural processes, and offering cultural or recreational benefits. In marine environments, these services include important functions like keeping water clean, supporting fisheries, and protecting coastlines."

"This approach from the MPA ensures that both the **natural environment and visitor experiences are preserved for future generations**."

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The survey also assessed respondents' awareness of both the existence of the MPA and the conservation measures in place. The results indicate that many tourists—even those identified as more environmentally conscious—are unaware of the MPA's existence or its associated conservation measures.

Two key insights emerge. First, there is a **general lack of awareness regarding the area's protected status** as an MPA. Second, a notable gap exists between those who know the MPA exists and those who are aware of the specific conservation measures it implements, meaning that a **considerable amount of people know that there is an MPA, yet are not aware what it's purpose is**. This highlights a significant challenge in effectively communicating the MPA's objectives and the conservation impact it seeks to achieve.

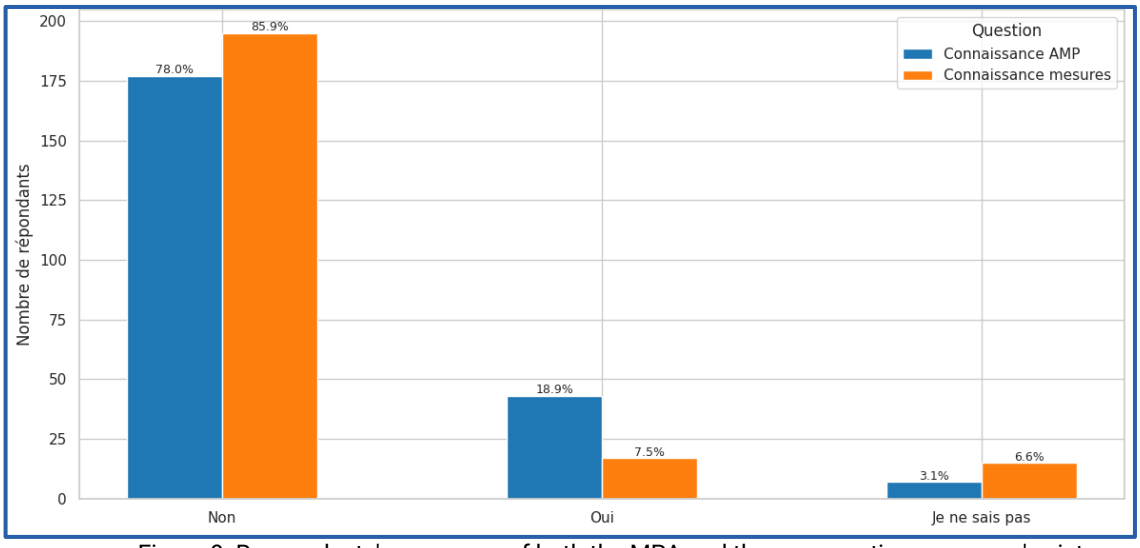

Figure 9: Respondents' awareness of both the MPA and the conservation measures' existence

Finally, in the last question of the survey, respondents were asked how they would like to be kept informed about the presence, role, and objectives of the MPA. Since some respondents dropped out before reaching this question, we have 279 total mentions from 197 respondents. **Respondents were allowed to choose multiple options**.

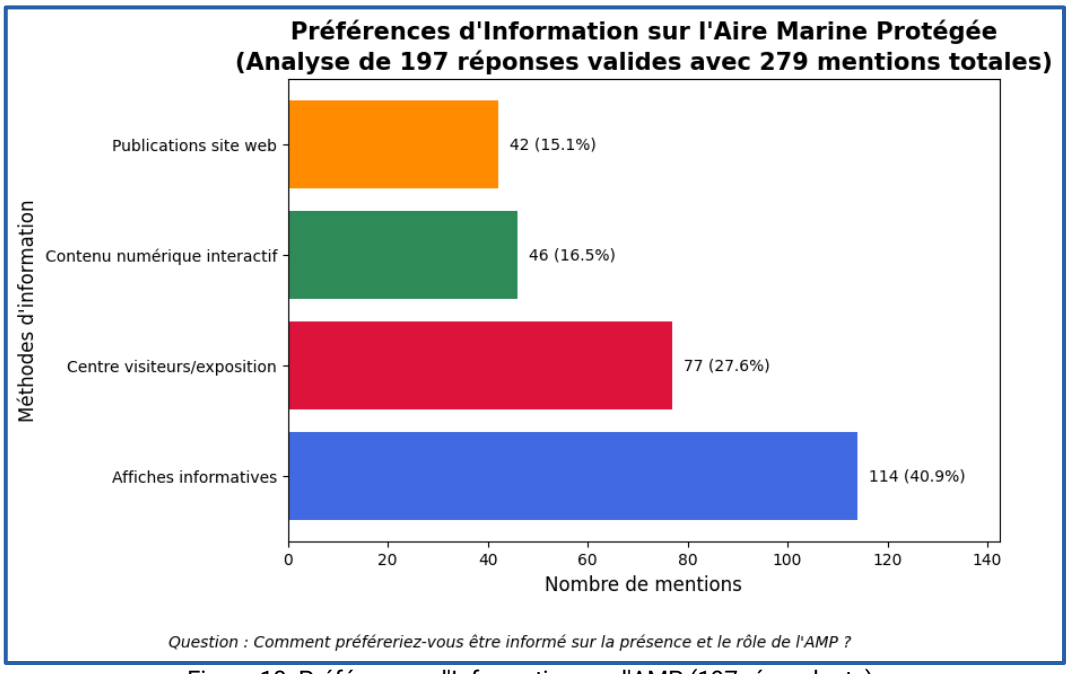

Figure 10: Préférences d'Information sur l'AMP (197 répondants)

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4.3 Tool n° 1: Best-Worst Scaling

4.3.1 Background of the tool and its application

Best-Worst Scaling (BWS) was used to assess the relative importance of 13 ecosystem services. More specifically, the Case 1 BWS ('object case') was employed, whereby respondents were repeatedly presented with sets of objects and asked to select the one they considered 'best' (or 'most important') and another they considered 'worst' (or 'least important'). A critical element in designing a BWS test is the construction of an experimental design that determines the distribution of items across choice sets. The experimental design relies on a Balanced Incomplete Block Design (BIBD) in most studies, which ensures statistical rigour and fairness in item presentation. In this case study, the BIBD consisted of 13 distinct choice sets, each containing four items or 'objects'. Choice sets were shown in random order to minimize potential positioning bias. For the experimental design, as well as the choice of objects (in this case: ecosystem services), there was constant dialogue between the researchers and Maëlla Sicard from OFB. For each choice set presented in the survey, respondents were asked: **"Which of the following ecosystem services in the Littoral Seino-Marin MPA is the most valuable to you and which is the least valuable to you?"**. An example of a choice task is shown in Figure 11; every respondent received 13 of these.

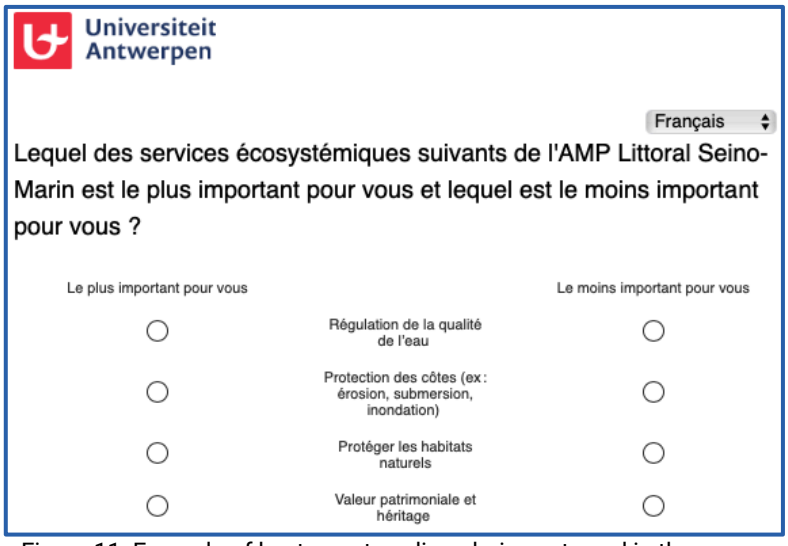

Figure 11: Example of best-worst scaling choice set used in the survey

Objective: *Which ecosystem services do tourists value most and least in the Littoral Seino-Marin MPA, and how do they prioritize their relative importance?*

Number of respondents for BWS analysis: Four respondents were removed because they were under 18. Some respondents displayed inconsistent behavior, selecting the same ecosystem service as both "best" and "worst" across multiple choice tasks. This is a common occurrence in BWS studies due to the repetitive nature of the task. Each instance of such inconsistency was counted as a "strike." Respondents with more than three strikes were excluded from the analysis, as their responses were deemed unreliable. As a result, 14 respondents were excluded due to excessive inconsistencies, leaving 208 respondents for the final BWS analysis.

Two analytical approaches were used:

1. **Counting Analysis** – This straightforward method calculates how many times each service was chosen as "most valuable" or "least valuable" and computes the difference. It provides a simple, descriptive ranking of perceived importance.
2. **Conditional Logit Model** – This statistical model estimates the **relative utility of each service** while accounting for repeated choices by the same individual. It allows us to quantify how much more or less likely a visitor is to select a service as most important compared to the reference service.

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4.3.2 Results and interpretation

The conditional logit model is highly significant, with a **likelihood ratio test** far exceeding the critical value (p < 2e-16). The **concordance statistic** of 0.823 indicates that the model correctly predicts the majority of observed choices, confirming that the estimated preferences are robust and reliable.

Type of analysis	COUNTING ANALYSIS			CONDITIONAL LOGIT		
	B	W	B-W	Coefficient	Std. Error	Share of preferences (in %)
Local seafood	117	279	-162	Ref.	Ref.	2.31
Resources extracted for industry and medical pu rposes (e.g., sand, fish oil)	73	397	-324	-0.550	0.080***	1.33
Water quality regulation (e.g., clean water and c hemical pollution regulation)	237	57	180	1.246	0.086***	8.05
Coastal protection (e.g., from erosion, flooding)	403	35	368	1.898	0.090***	15.43
Climate regulation (e.g., sea breeze effect)	193	87	106	1.030	0.086***	6.48
Safeguarding biodiversity and ecological balanc e	574	9	565	2.636	0.097***	32.30
Protecting natural habitats	397	20	377	1.912	0.090***	15.66
Breeding and nursery area	245	54	191	1.325	0.086***	8.71
Aesthetic value	34	437	-403	-0.813	0.081***	1.03
Support for recreational activities	23	507	-484	-1.065	0.085***	0.80
Opportunity for scientific research and educatio n	138	161	-23	0.393	0.078***	3.43
Heritage and legacy value	184	321	-137	0.192	0.079*	2.80
Mental health and wellbeing	79	333	-254	-0.322	0.080***	1.68

*** p < 0.001, ** p < 0.01, * p < 0.05

Table 6: Results of the best-worst scaling experiment, both the counting analysis and a conditional logit model, with n = 208

The **counting analysis** showed which services were consistently chosen as most versus least important, giving an intuitive ranking. High positive B-W scores indicated strong perceived value, while negative scores indicated services often considered less important.

The **conditional logit coefficients** quantify the strength of these preferences. For instance, services like **biodiversity conservation** and **protection of natural habitats** had very large positive coefficients and high odds ratios, signaling that visitors strongly prioritize these aspects. Conversely, provisioning services such as **local seafood** or **resources for industry** had lower or negative coefficients, indicating they are less influential in tourists' preferences and decision-making.

The **share of preferences** (displayed in the last column of Table 6 and depicted in **Error! Reference source not found.**, derived from the model, translates these coefficients into an intuitive percentage scale, showing the proportion of overall preference each service captures. This makes the results accessible even to non-technical audiences.

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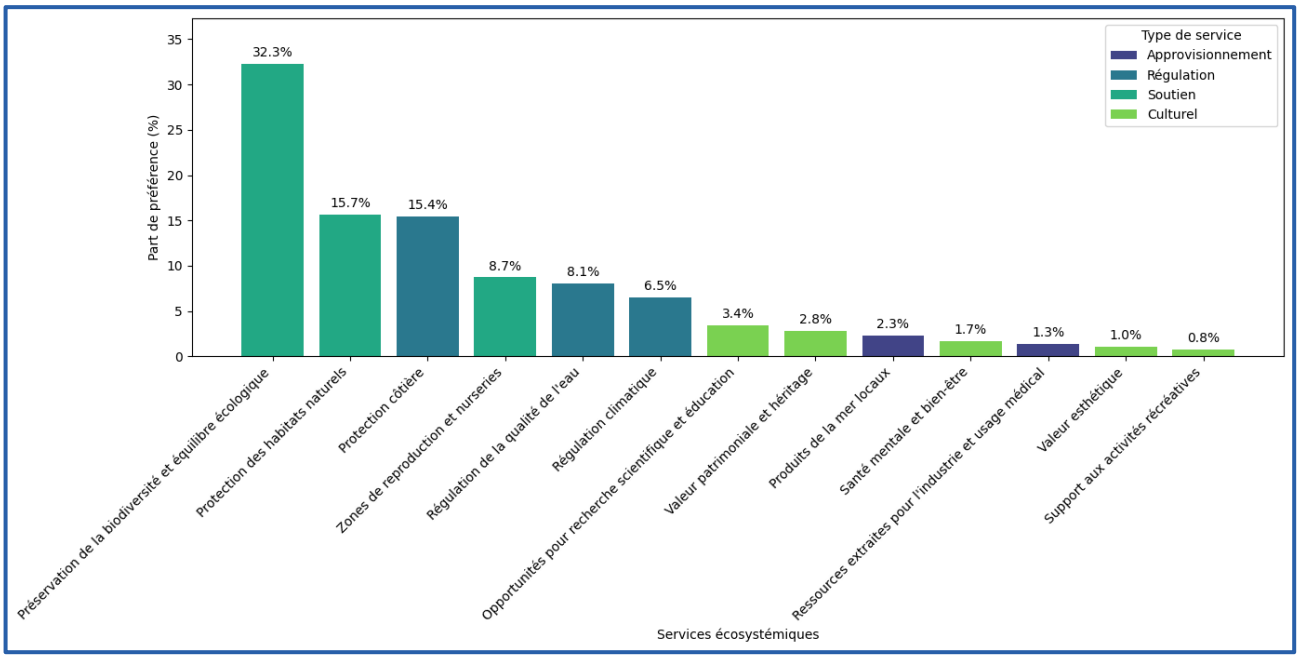

Figure 12: Part de préférence des services écosystémiques selon l'analyse BWS

When examining preferences through the lens of **ecosystem service categories**:

- **Supporting services** (e.g., biodiversity maintenance, habitat protection, breeding grounds) were the most valued, representing over half of total preference. This highlights that visitors understand the importance of ecological integrity for the overall health of the MPA.
- **Regulating services** (e.g., water quality, coastal protection, climate regulation) were also highly appreciated, reinforcing the value placed on ecosystem functions that maintain environmental stability.
- **Cultural services** (e.g., education, heritage, mental well-being) received moderate attention. Visitors value knowledge and recreational aspects but less so than the ecological or regulating services.
- **Provisioning services** (e.g., local seafood, industrial resources) were least prioritized, suggesting that visitors are more motivated by conservation and ecosystem health than by direct resource use.

4.3.3 Evaluation of tool results and reflection on responding needs outlined in the introduction

The Best-Worst Scaling analysis shows that visitors strongly prioritize **supporting and regulating services**—especially biodiversity, habitat protection, and coastal regulation—while provisioning and recreational services are less valued. This provides clear guidance for communication and management: highlighting ecological functions will resonate most with stakeholders and visitors, supporting acceptance of the Living Lab and MPA objectives.

The **conditional logit model** confirms these preferences statistically, with high significance and predictive accuracy. Preference shares translate the coefficients into intuitive percentages, making it easy to communicate which services matter most. The counting analysis complements this by showing which services are consistently chosen as “most” or “least” important. Together, these methods provide both robust evidence and an accessible ranking of ecosystem services.

For SEG priorities: the results can guide **awareness-raising and engagement** by focusing on high-preference services. Concrete, low-cost actions—such as signage, educational panels, citizen monitoring, or guided Living Lab tours—can demonstrate ecological benefits in ways that stakeholders understand and value. Using ecosystem service framing in this way avoids reliance on monetary valuation, aligns with public preferences, and helps ensure that communications support MPA goals rather than narrow interests. Moreover, this can contribute to the gap identified when discussing respondents’ characteristics: their unawareness of the existence of the MPA on the one hand, and the second: the significant of MPA designation in terms of

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conservation objectives. As found in the BWS, (spring) tourists' appreciation highly correlates with the conservation objectives of the MPA – therefore – targeted communicative actions could enhance public support, and thus acceptance and ownership with tourists (and likely also with locals), leading to more effective management of the MPA.

In sum, the BWS results provide actionable insights: focus on ecological and regulating services, communicate their benefits clearly, and design small, visible pilot actions to build awareness, acceptance, and long-term engagement with the MPA.

4.3.4 Tool assessment

- **Usability**: BWS scores well on usability, offering a simple and accessible design that requires minimal technical training. Its outputs—clear rankings and preference shares—are intuitive and directly usable by MPA managers for decision-making. However, the method requires data collection through an online or in-person survey, which involves some time investment.
- **Support for stakeholder dialogue:** BWS effectively captures and communicates stakeholder priorities, supporting more targeted outreach and engagement.
- **Validity of the results:** Regarding validity, the method offers robust insights into stakeholder preferences, especially when supported by statistical models such as the conditional logit. However, care is needed in survey design to avoid fatigue with respondents and ensure clarity in terms of the repeated nature of the exercise. While the basic counting method provides reliable rankings, more advanced analysis (e.g., latent class analysis) can enhance the depth of insights, though it may require additional statistical expertise for interpretation.
- **Implications of sampling:** The results reflect the preferences of tourists visiting the area in April 2025 and should not be assumed to represent all visitors year-round. Participation in surveys is voluntary, introducing potential selection bias. Nevertheless, the exercise provides valuable insights into how tourists value and prioritize the ecosystem services of the MPA, offering guidance for targeted actions that address the SEG's identified needs.

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4.4 Tool n°2: Rating and ranking

4.4.1 Background of the tool and its application

Order Ranking was used to evaluate preferences for nine types of recreational activities in the MPA. This method involves presenting respondents with a predefined list of options and asking them to assign a unique position to each item, thus producing ordinal data that reflects relative preferences rather than absolute values. Given the ordinal nature of the ranking data and the within-subjects design (each respondent provided a complete ranking of all nine activities), the Friedman test was employed to detect overall differences in rankings across recreational activities. Upon obtaining a significant result from the Friedman test, the Nemenyi post-hoc test was conducted to identify specific pairs of recreational activities with statistically significant differences in median ranks. The Nemenyi test is appropriate for pairwise comparisons following a significant Friedman test, as it controls for Type I error across multiple comparisons. The combination of the Friedman test and the Nemenyi post-hoc test has been applied in various research contexts involving ranked data, demonstrating their applicability in assessing differences across multiple related recreational activities. In the survey, respondents were asked: "**Please rank the following recreational activities in the MPA from most to least important to you (1 = most important, 9 = least important).**"

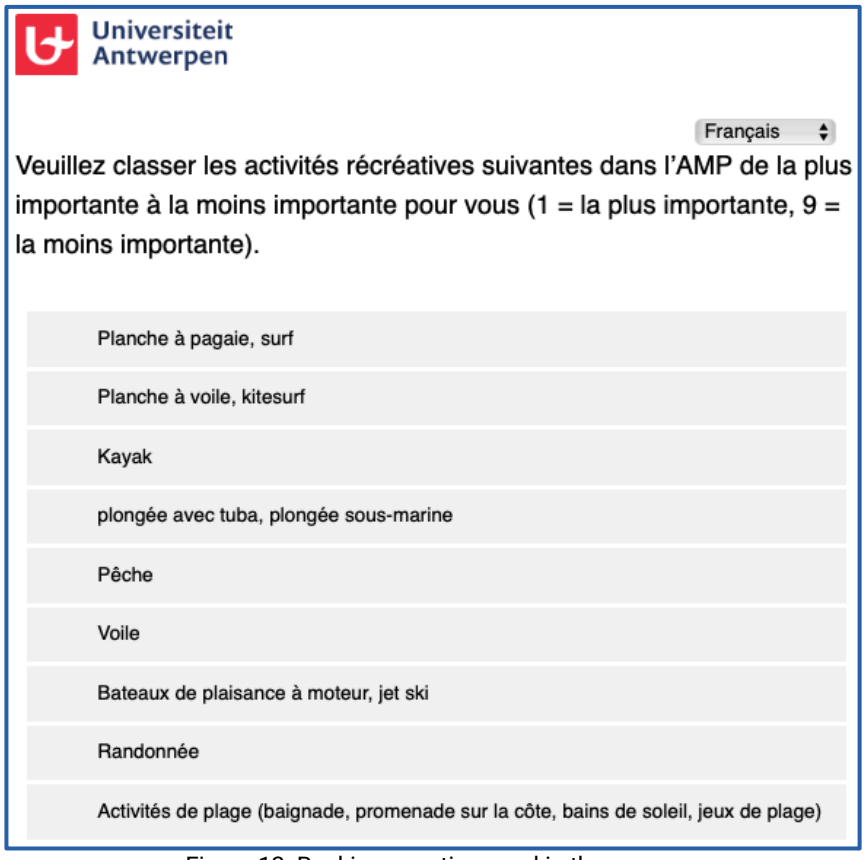

Figure 13: Ranking question used in the survey

Objective: *How do tourists rank the recreational activities available in the Littoral Seino-Marin MPA in terms of personal value and enjoyment?*

Number of respondents for rating and ranking: The full dataset included 226 respondents. After excluding minors, 222 participants remained. Respondents who failed the BWS consistency tests were retained for the ranking question analysis. Of these 222 participants, four did not complete the ranking question and were therefore excluded. An additional six respondents were removed because they left the ranking order unchanged from its initial presentation, indicating a lack of engagement with the task. Eventually, this led to a final sample of 212 respondents for the analysis of the ranking exercise.

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4.4.2 Results and interpretation

Activity	Mean rank	Median rank
Hiking	2.240566	1
Beach Activities	3.094340	2
Snorkelling/Scuba	4.669811	5
Paddleboarding/Surfing	4.957547	5
Kayaking	5.084906	5
Sailing	5.485849	6
Windsurf/Kitesurf	5.702830	6
Fishing	5.976415	7
Motorboats/JetSki	7.787736	9

Table 7: Results from ranking exercise, including mean and median rank per recreational activity

The Friedman test revealed a statistically significant difference in rankings across the nine activities (Chi-Square = 588.48; Df = 8; p-value < 2.2e-16), indicating that respondents did not rank all activities equally and that some activities were consistently preferred over others.

The rankings indicate that **Hiking** is considered the most important activity, with the lowest mean rank of 2.24 and a median of 1, showing strong consensus among respondents. **Beach Activities** follow closely, with a mean rank of 3.09 and a median of 2, indicating they are also highly valued. Activities such as **Snorkelling/Scuba**, **Paddleboarding/Surfing**, and **Kayaking** fall in the middle range, with mean ranks between 4.67 and 5.08 and median ranks around 5. This suggests moderate importance, with some variation in how participants perceive them. **Sailing** and **Windsurf/Kitesurf** are ranked slightly lower, with mean ranks of 5.49 and 5.70, respectively, and median ranks of 6, reflecting less importance relative to the top activities. **Fishing** is lower still, with a mean rank of 5.98 and a median of 7. Finally, **Motorboats/JetSki** is considered the least important, with a mean rank of 7.79 and a median of 9, indicating that respondents generally assign it low priority or value.

To visualize the rank distribution, a heatmap (see Table 8) was created, displaying the percentage of respondents who assigned each activity to each rank position, from highest (first) to lowest (ninth) in perceived value. “Hiking” was most frequently placed in the top ranks, with 55% of respondents ranking it as their first choice and 76% placing it in their top two. “Beach Activities” also scored strongly in the top three ranks, while “Motorized Pleasure Boats” was placed last by 61% of respondents, confirming its low preference.

	1	2	3	4	5	6	7	8	9
Hiking	55.19%	21.23%	7.55%	2.36%	2.83%	2.36%	2.36%	5.66%	0.47%
Beach activities	26.42%	35.38%	12.26%	6.60%	2.36%	1.42%	3.30%	4.72%	7.55%
Fishing	6.60%	6.60%	10.85%	8.96%	4.72%	6.60%	14.62%	25.47%	15.57%
Paddleboarding	3.77%	6.13%	12.74%	19.34%	19.34%	16.51%	13.21%	4.72%	4.25%
Snorkelling, diving	3.30%	13.21%	20.28%	12.26%	15.09%	13.21%	10.85%	9.43%	2.36%
Sailing	1.89%	5.66%	10.38%	12.74%	15.57%	18.87%	20.28%	11.32%	3.30%
Kayaking	0.94%	5.66%	14.15%	21.70%	16.51%	16.51%	13.21%	8.96%	2.36%
Windsurf, kitesurf	0.94%	2.83%	8.49%	13.21%	18.87%	20.28%	16.98%	15.09%	3.30%
Motor pleasure boats	0.94%	3.30%	3.30%	2.83%	4.72%	4.25%	5.19%	14.62%	60.85%

Table 8: Heat map depicting percentages of respondents and their rank assignment

To explore these differences statistically, a Nemenyi post-hoc pairwise test was conducted (see Appendix 6.1). This test utilizes the ‘Critical Difference’, which was established at 0.825. This implies that if the difference in mean rank between two objects is larger than 0.825, these differences are assumed significant.

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This statistically confirms a clear preference for activities like Hiking and Beach Activities, significantly less interest in water-based and adventure activities, and low importance for Motorboats/JetSki and Fishing.

Lastly, to research differences in ranking behaviour amongst respondents' characteristics, as outlined in 4.2.1, ordinal logistic regressions were ran for every recreational activity. In this way, we get an insight into how different people rank the activities differently. Since only very limited respondent characteristics were collected, these results should be very carefully interpreted. The full table can be found in Appendix 6.2, accompanied with a guide on how to read the table in Appendix 6.3. Here we list three main insights from the ordered logistic regression (be careful – causation does not imply causality):

1. French tourists rank 'hiking' significantly lower than non-French tourists.
2. Respondents that are aware of the existence of an MPA in the area, value snorkelling and scuba diving higher.
3. The higher the age group, the lower 'beach activities' is ranked, and the higher 'fishing' is ranked.

4.4.3 Evaluation of tool results and reflection on responding needs outlined in introduction

Understanding recreational activities is crucial because they exert **varying levels of pressure on the ecosystem**, with some activities posing greater risks than others. Identifying which recreational activities visitors value most is therefore essential for **developing protection measures for the MPA that are both ecologically sound and acceptable to stakeholders**. This insight can also help anticipate which regulations might face strong opposition, enabling managers to plan communication and mediation strategies proactively.

The order ranking exercise, supported by the Friedman and Nemenyi tests, provided a clear and interpretable picture of visitors' recreational preferences in the Littoral Seino-Marin MPA. The findings show a strong consensus around certain activities: **hiking and beach activities were consistently ranked highest**, while **motorized pleasure boating and fishing were most often placed at the bottom of the rankings**. Activities such as snorkelling and diving, paddleboarding, kayaking, and sailing occupied intermediate positions, reflecting a diversity of visitor interests rather than a dominant preference for one type of recreation. The heat map reinforced these trends, with over half of respondents placing hiking first and more than 60% ranking motorized boating last, suggesting a general orientation towards low-impact, nature-based recreation over mechanized or extractive activities. This finding is important, and is probably also a result of the type of tourists that visit the area in April. We suggest it is a worthwile exercise to **complement these with tourism surveys in summer**.

This method demonstrated several advantages. The ranking task was easy for respondents to understand, leading to high engagement and very few unusable responses. Because it focused on relative preferences rather than monetary valuation, it avoided many of the challenges raised by SEG members, such as the risks of oversimplifying ecosystem services or introducing contentious economic metrics. The Friedman and Nemenyi tests added statistical rigour, allowing meaningful distinctions between activities to be identified. Taken together, this provides managers with a clear, accessible view of visitor priorities without requiring resource-intensive or complex valuation studies.

The exploratory **regression analyses** add further nuance but should be **interpreted with caution**, as they are based on a limited set of demographic variables and cannot infer causation. For instance, respondents aware of the MPA tended to place a higher value on snorkelling and diving, suggesting that awareness and knowledge of the MPA may influence perceptions of marine recreation. However, this should not be seen as a reason to encourage these activities, given their potential ecological footprint; rather, it highlights the role of awareness-raising in fostering appreciation and stewardship. Similarly, age-based differences, such as older respondents valuing fishing more and beach activities less, underline the need for targeted engagement strategies for different visitor groups.

From the perspective of the SEG's stated priorities, this tool offers strong alignment. It provides a concrete, non-monetary way to integrate ecosystem service perspectives into decision-making, avoiding over-reliance on monetary valuation while still producing actionable insights. The findings demonstrate that many visitors already place high value on low-impact recreation, suggesting opportunities for MPA managers to support sustainable tourism in a way that reinforces conservation goals. By capturing diversity in recreational

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preferences, the tool also supports SEG's emphasis on recognising cumulative impacts and managing multiple activities simultaneously, rather than in isolation.

However, some **limitations** are important to acknowledge. The rankings reflect relative preferences, not absolute measures of value or environmental impact, and therefore should not be used in isolation to justify regulatory or infrastructure decisions. Integration with ecological assessments and stakeholder dialogue is essential to ensure balanced management responses. Expanding the survey to collect richer demographic and behavioural information would also strengthen future analyses, offering deeper insights into visitor segments and trends over time (or seasonal differences).

Looking forward, this tool could play an important role in **adaptive management** within the Living Lab framework. Its simplicity, low cost, and repeatability make it well-suited for longitudinal monitoring, allowing managers to **track changes in visitor preferences over time and assess the effectiveness of awareness campaigns or management interventions**. The ranking heat map and other visual outputs are also valuable communication tools, enabling managers to share findings with local stakeholders, tourism operators, and decision-makers in a clear and accessible way. In combination with ecological monitoring, this approach can provide a strong evidence base to prioritise low-impact activities, support targeted engagement strategies, and ensure that tourism development remains aligned with the MPA's overarching goal of conservation and stakeholder acceptance.

4.4.4 Tool assessment

Usability: The order ranking method proved to be a practical and accessible tool for assessing visitor preferences in the Littoral Seino-Marin MPA. Its simplicity is one of its primary strengths: respondents only needed to place activities in order of perceived importance, which required minimal instruction and little time to complete. For administrators, implementation was straightforward and analysis of the resulting ordinal data was manageable, even without advanced technical expertise. This makes ranking a particularly suitable option for MPAs working with limited time, staff, or technical resources, and it can be easily integrated into broader surveys or consultation processes.

Support for stakeholder dialogue: Beyond data collection, the tool offers strong potential to support stakeholder dialogue. By requiring respondents to explicitly compare recreational activities, it helps reveal not only their priorities but also the trade-offs they perceive between different forms of recreation. Such findings can be a valuable starting point for conversations with visitors, local communities, and tourism operators about how to reconcile recreation with ecological objectives. While the method does not uncover the intensity of preferences or the motivations behind them, it provides a neutral, accessible entry point for engagement and can guide more in-depth qualitative discussions.

Validity: In terms of validity, ranking avoids several pitfalls associated with rating scales, such as scale interpretation differences and clustering of responses at one end of the scale. The forced-choice structure improves comparability by requiring respondents to consider all options relative to one another. However, results should be interpreted with caution: ranking data only indicate relative preferences and provide no information on the magnitude of differences between items. The composition and relevance of the list of activities also directly influence outcomes, as including irrelevant or unfamiliar items may skew results or disengage respondents. Careful design of survey content is therefore essential to ensure the validity and usefulness of the findings.

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4.5 Tool n°3: contingent valuation method

4.5.1 Background of the tool and its application

Contingent Valuation (CVM) was used to measure tourists' willingness to contribute financially or through volunteer time to support marine conservation initiatives. CVM is a widely used stated preference technique for assigning economic value to quasi-public or pure public goods. It is a direct valuation method in which respondents are first presented with a hypothetical yet realistic market situation and then asked how much they would be willing to pay (WTP) for the specific environmental services described in the scenario. The method can also assess respondents' willingness to accept (WTA) compensation or their willingness to contribute (WTC) in non-monetary terms. Within the survey, the WTP and WTC questions were formulated as open-ended questions, allowing respondents to enter any monetary amount or number of hours they wished to contribute. A total of seven different hypothetical scenarios were shown to the respondents, all reflecting different environmental challenges. The hypothetical scenarios were designed and a selection was made in collaboration with Maëlla Sicard from OFB. To emphasize the hypothetical nature of the exercise, respondents were shown the message depicted in Figure 14.

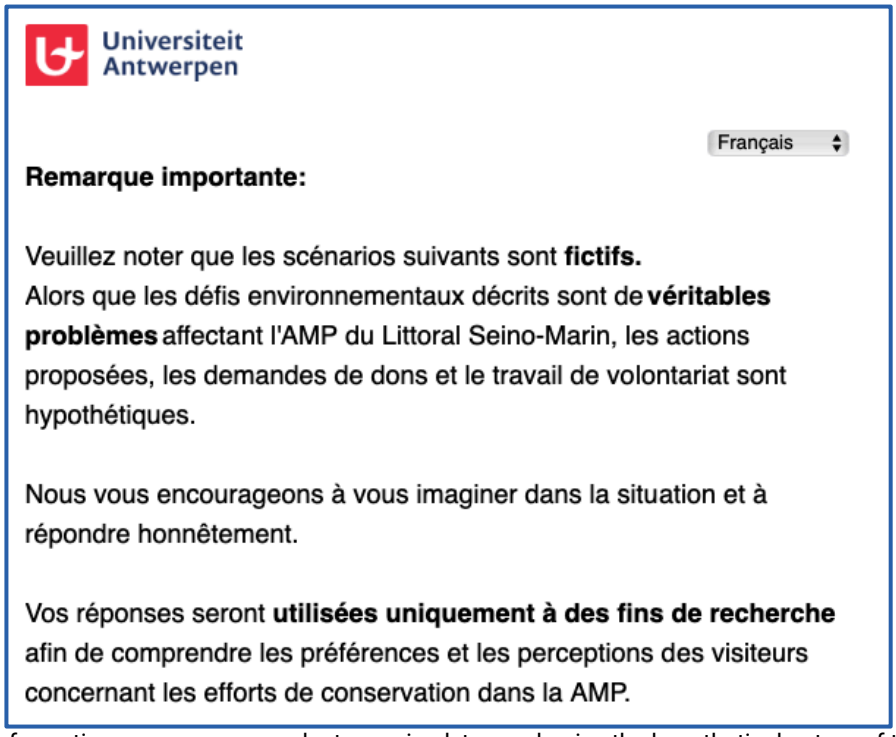

Figure 14: Informative message respondents received to emphasize the hypothetical nature of the exercise

Each scenario reflects a contribution to delivery of a certain ecosystem service. The following scenarios were defined: water quality, wildlife protection, quiet zones (referring to limiting motorized boating that affect the marine ecosystem), restoration of hiking trails, sustainable recreational fishing, visitor eductation and engagement, and cultural and artistic heritage. The order of appearance of these scenarios was randomized. An example of a contingent valuation scenario is depicted in Figure 15. An oversight of all scenarios can be found in Appendix 6.4.

In this research, the primary research interest was to identify whether tourists are willing to contribute to conservation efforts within the MPA to preserve ecosystem services and recreational benefits, rather than focusing on the differences in WTP amounts across scenarios. For the same reason, the option to contribute in volunteering hours was also offered to the respondents, ensuring full capturing of willingness to contribute. A secondary aim of the research was to estimate the mean WTP and WTCP for each individual scenario, in order to inform MPA managers about the average level of support tourists are willing to provide for specific conservation efforts. The intention was not to statistically test differences in WTP between scenarios, but rather to provide practical, scenario-specific insights into tourist contributions.

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Figure 15: Example of choice task in the contingent valuation experiment

Objective: To what extent are tourists willing to contribute financially or through volunteer time to address limitations in access or quality of ecosystem services and recreational benefits in the MPA?

Number of respondents for the contingent valuation analysis: The full dataset included 226 respondents. After excluding minors, 222 participants remained. Respondents who failed the BWS consistency tests or did not alter the ranking in the ranking exercise were retained for the contingent valuation analysis. Of these 222 participants, four dropped out during the ranking exercise. Drop-out during the contingent valuation scenarios meant that every scenario has a different number of valid responses. An oversight is provided in Table 9. Additionally, one respondent was deleted because they answered an unrealistic "€1000 and "1000h" in every scenario.

Hypothetical scenario	Number of respondents
Water quality	207
Wildlife protection	208
Quiet zones	210
Hiking trails	206
Recreational fishing	206
Marine education	205
Heritage	204

Table 9: Number of respondents for every hypothetical scenario

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4.5.2 Results and interpretation

Descriptive results of the contingent valuation experiment are displayed in Table 10. In the first column is the percentage of the sample that responded to be either willing to pay, willing to contribute, or willing to both pay and contribute for a certain hypothetical scenario.

	WTP/WTC (% of sample)	WTP	WTC	Both
Water quality	57 (27.5)	41	11	5
Wildlife protection	63 (30.1)	35	19	7
Quiet zones	42 (19.9)	23	16	0
Hiking trails	59 (28.5)	41	16	2
Recreational fishing	29 (14)	19	8	2
Marine education	43 (20.9)	27	13	2
Heritage	38 (18.5)	24	14	0

Table 10: Descriptive statistics of the sample's WTP and WTC

The participation rates in the first column of Table 10 indicate that the wildlife protection, water quality, and hiking trail scenarios receive markedly higher support than the others. This is consistent with the BWS exercise, where tourists showed a clear preference for supporting and regulating ecosystem services, and with the ranking exercise, which emphasized the importance of hiking for visitors. However, the large number of zero responses makes analysis of the WTP and WTC data particularly difficult, especially in combination with the complex, multiple scenario-setup. Results across scenarios cannot be compared in a statistical meaningful way because of this. As a result, we present only summary tables for each scenario, as model outputs do not reveal any significant effects of the predictors.

Scenario 1

Measure	**Water quality**	**Reasons for not contributing**	
Sample Size	208.00	**I believe it is the government's responsibility to address this issue.**	56
Participation Rate (%)	27.40	**I do not have the financial resources to contribute.**	49
Mean WTP (€)	60.62	**I do not have the time to volunteer.**	28
Median WTP (€)	40.00	**Other**	12
Mean WTC (Hours)	25.00	**I do not consider this initiative important.**	3
Median WTC (Hours)	15.0	**Not specified**	3
		TOTAL NOT WILLING TO CONTRIBUTE	151

Table 11: Summary table of scenario 1: water quality

Scenario 2

Measure	**Wildlife protection**	**Reasons for not contributing**	
Sample Size	208.00	**I believe it is the government's responsibility to address this issue.**	52
Participation Rate (%)	30.10	**I do not have the financial resources to contribute.**	45

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Measure	Wildlife protection	Reasons for not contributing	
Mean WTP (€)	59.78	**I do not have the time to volunteer.**	32
Median WTP (€)	30.00	**Other**	11
Mean WTC (Hours)	37.60	**I do not consider this initiative important.**	5
Median WTC (Hours)	10.00	TOTAL NOT WILLING TO CONTRIBUTE	145

Table 12: Summary table of scenario 2: wildlife protection

Scenario 3

Measure	Quiet zones	Reasons for not contributing	
Sample Size	210.00	**I believe it is the government's responsibility to address this issue.**	68
Participation Rate (%)	19.90	**I do not have the financial resources to contribute.**	50
Mean WTP (€)	57.81	**I do not have the time to volunteer.**	30
Median WTP (€)	50.00	**Other**	14
Mean WTC (Hours)	51.40	**I do not consider this initiative important.**	6
Median WTC (Hours)	20.00	TOTAL NOT WILLING TO CONTRIBUTE	168

Table 13: Summary table of scenario 3: quiet zones

Scenario 4

Measure	Hiking trails	Reasons for not contributing	
Sample Size	206.00	**I believe it is the government's responsibility to address this issue.**	46
Participation Rate (%)	28.50	**I do not have the financial resources to contribute.**	53
Mean WTP (€)	55.83	**I do not have the time to volunteer.**	29
Median WTP (€)	27.50	**Other**	11
Mean WTC (Hours)	29.21	**I do not consider this initiative important.**	7
Median WTC (Hours)	16.00	**Not specified**	1
		TOTAL NOT WILLING TO CONTRIBUTE	146

Table 14: Summary table of scenario 4: hiking trails

Scenario 5

Measure	Recreational fishing	Reasons for not contributing	
Sample Size	206.00	**I believe it is the government's responsibility to address this issue.**	56
Participation Rate (%)	14.00	**I do not have the financial resources to contribute.**	50
Mean WTP (€)	33.00	**I do not have the time to volunteer.**	24

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Measure	Recreational fishing	Reasons for not contributing	
Median WTP (€)	25.00	**Other**	22
Mean WTC (Hours)	27.60	**I do not consider this initiative important.**	25
Median WTC (Hours)	13.00	TOTAL NOT WILLING TO CONTRIBUTE	177

Table 15: Summary table of scenario 5: recreational fishing

Scenario 6

Measure	Marine education	Reasons for not contributing	
Sample Size	205.00	**I believe it is the government's responsibility to address this issue.**	59
Participation Rate (%)	20.90	**I do not have the financial resources to contribute.**	49
Mean WTP (€)	50.67	**I do not have the time to volunteer.**	32
Median WTP (€)	25.00	**Other**	13
Mean WTC (Hours)	30.28	**I do not consider this initiative important.**	9
Median WTC (Hours)	20.00	TOTAL NOT WILLING TO CONTRIBUTE	162

Table 16: Summary table of scenario 6: marine education

Scenario 7

Measure	Heritage	Reasons for not contributing	
Sample Size	204.00	**I believe it is the government's responsibility to address this issue.**	61
Participation Rate (%)	18.50	**I do not have the financial resources to contribute.**	59
Mean WTP (€)	59.29	**I do not have the time to volunteer.**	23
Median WTP (€)	50.00	**Other**	13
Mean WTC (Hours)	33.92	**I do not consider this initiative important.**	10
Median WTC (Hours)	16.00	TOTAL NOT WILLING TO CONTRIBUTE	166

Table 17: Summary table of scenario 7: heritage

Although participation rates differ, the amounts people are willing to pay or the time they are willing to volunteer are relatively consistent. Median willingness to pay across scenarios ranges from €25 to €50, with mean contributions slightly higher due to a few large offers. Time contributions show a similar pattern: median values range from 10 to 20 hours, though some respondents are willing to contribute far more. This skew is most evident in the quiet zones scenario, which has relatively low participation but a high mean willingness to contribute time.

Across all scenarios, **the most common reason for not contributing is the belief that environmental protection is the government's responsibility**, followed closely by financial constraints and lack of time. This highlights that while a subset of tourists is willing to make substantial contributions, a majority expect these initiatives to be publicly funded rather than relying on individual payments or volunteering. Only a small proportion of respondents explicitly state that they do not consider these initiatives important, suggesting that low participation is **not necessarily due to a lack of interest.**

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The data do reveal **priorities**: measures focused on preserving natural habitats, water quality, and hiking infrastructure resonate more strongly with visitors than those related to fishing, marine education, or cultural heritage. However, the large number of zero responses, low participation rates, and limited demographic data make statistical modeling unreliable (see , so this interpretation is based on descriptive patterns rather than statistical tests or predictive modeling.

4.5.3 Evaluation of tool results and reflection on responding needs outlined in introduction

The results of the contingent valuation exercise provide useful insight into visitors' preferences and priorities, but they also highlight several challenges that limit their usefulness as a decision-making tool for the MPA's current needs. Participation rates show that measures such as wildlife protection, water quality improvements, and hiking trail maintenance resonate most strongly with visitors, while recreational fishing, marine education, and heritage initiatives attract far less engagement. This indicates that visitors care deeply about ecosystem services tied to biodiversity and recreation, which aligns with the SEG's view that ecosystem services can be leveraged to build acceptance for MPAs. However, the data also show that many respondents are unwilling or unable to contribute financially or through volunteering, often expressing that they view conservation as a government responsibility. This confirms the SEG's caution around over-relying on monetary valuation for decision-making.

From a technical perspective, the contingent valuation approach used here has clear limitations that make it less effective for answering the MPA's priority questions. The study design used an open-ended or payment card format, rather than the standard dichotomous choice method typically used in contingent valuation studies, meaning that responses do not lend themselves well to maximum likelihood estimation or robust willingness-to-pay modeling. On top of this, the survey asked for both monetary contributions and time commitments, which are measured in fundamentally different units and require different modeling approaches. The large number of zero responses compounds these issues, creating a statistical "corner solution" problem that makes it difficult to analyze predictors of willingness to contribute. Attempts to model multiple scenarios at once proved uninformative, leaving us reliant on simple descriptive summaries rather than deeper inferential insights.

Taken together, these factors suggest that while the exercise illustrates which initiatives resonate with visitors, it does not provide a reliable monetary valuation of ecosystem services or precise guidance on resource allocation. This outcome reflects the SEG's concerns about monetary valuation and points to a need for simpler, more narrative-driven methods to engage stakeholders rather than relying solely on economic modeling. The findings could be more valuable as a communication tool, showing that visitors strongly support biodiversity protection and recreational opportunities, rather than as a strict valuation exercise. In light of the MPA's current testing phase, limited funding, and emphasis on raising awareness, this type of evidence may still serve an important role in building stakeholder understanding and acceptance, even if it cannot yet support advanced economic decision-making.

4.5.4 Tool assessment

Usability: CVM is moderately user-friendly for MPA managers, especially when implemented with a simplified, single-scenario approach. This reduces respondent fatigue, simplifies data analysis, and makes the tool more practical for real-world applications. Willingness to pay (WTP) is the most straightforward component to apply, particularly when ecosystem services are directly experienced by tourists. Willingness to contribute time (WTC) is useful where financial contributions are not feasible. However, more complex designs involving multiple scenarios or advanced analysis can be challenging to interpret without support from researchers. For effective use in practice, CVM requires careful scenario design and a basic understanding of survey development and result interpretation.

Support for stakeholder dialogue: CVM offers value in facilitating dialogue between MPA managers and stakeholders by making explicit what types of ecosystem services visitors value and how they are willing to support them. It helps managers tailor communication and outreach strategies around services that stakeholders prioritise. Including both WTP and WTC in the tool allows for a broader and more inclusive view of stakeholder capacities and preferences. The results can also inform discussions about volunteer programs

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or community-based initiatives, especially when monetary contributions are unlikely. That said, the depth of dialogue depends on how well the survey scenarios reflect real conservation issues that stakeholders understand and care about.

Validity of the results: The validity of CVM outcomes is closely linked to the quality and realism of the hypothetical scenarios used in the survey. Scenarios must be context-specific, easy to understand, and relatable for tourists to avoid hypothetical bias or confusion. When well-designed, the tool yields meaningful and reliable estimates of stakeholder preferences and contributions. Enhancements such as visual aids or income-related questions can improve response accuracy and explanatory power. However, complex or poorly framed scenarios can reduce data quality and distort conclusions, limiting the usefulness of the results for informing management decisions.

4.6 Tool n°4: Survey with shellfish farmers

4.6.1 Purpose of the study

Research question: How do shellfish farmers perceive and prioritize the ecosystem services, benefits, and limitations of the Littoral Seino-Marin Marine Protected Area in relation to shellfish farming activities?

The survey targeting shellfish farmers in Normandy was designed to explore their perceptions of MPAs and their influence on oyster farming. Focusing exclusively on a Best–Worst Scaling exercise, the survey included thirteen carefully developed (in collaboration with OFB) statements addressing environmental, economic, social, and governance dimensions of MPA management, with a deliberate emphasis on terms and examples familiar to local farmers. The study area was expanded beyond the Littoral Seino-Marin MPA, where shellfish farming activity is limited, to include Baie des Veys and Tatihou–Saint-Vaast-la-Hougue MPAs, bringing the total target group to around one hundred shellfish farmers. To comply with privacy regulations, the survey was distributed through the regional representative of shellfish farmers via email and remained open throughout April, with two reminder emails sent during this period to encourage participation. An overview of all statements taken up in the BWS experiment can be found in Appendix 6.5.

4.6.2 Data collection

Data collection for this survey was carried out in close collaboration with the regional representative of shellfish farmers in Normandy, who played a key role in reaching the professional community. The survey, hosted on Qualtrics, was distributed via email to nearly all active shellfish farmers across three MPAs : Littoral Seino-Marin, Baie des Veys, and Tatihou–Saint-Vaast-la-Hougue. This approach ensured both wide coverage and full compliance with privacy regulations, while relying on trusted communication channels through the farmers' representative. With an estimated target group of around one hundred farmers, the survey remained open throughout April, and reminder emails were sent after the first and third weeks to encourage participation. Despite these efforts, only two full responses were collected, alongside four partial responses, which limited the possibility of conducting a formal analysis.

To gain a deeper understanding of this outcome, a constructive follow-up discussion was held in May with the regional representative of shellfish farmers and Maëlla Sicard from OFB. This conversation provided valuable insights into the realities and priorities of the farming community, including the many competing demands on their time and attention. While the online survey format itself was not seen as a barrier, its academic framing and research focus may not have resonated strongly with farmers' day-to-day concerns. **Importantly, no negative feedback or objections were raised about the survey**, which suggests that the low response rate reflected a lack of perceived urgency or direct relevance rather than resistance to participation. The discussion also emphasized the complexity of creating scenarios that are both meaningful and respectful of farmers' experiences, particularly when addressing sensitive topics such as regulatory challenges or environmental responsibilities.

These experiences highlight the **importance of building engagement strategies that extend beyond digital surveys,** particularly when working with highly specialized and time-pressured sectors. The collaborative approach taken here—through close involvement of the farmers' representative and careful survey design—laid an important foundation for future engagement. Moving forward, complementing surveys with in-person discussions, workshops, or participatory forums could help strengthen relationships, build trust, and ensure that research efforts are closely aligned with farmers' perspectives and practical realities. This process

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reflects a commitment to fostering a constructive dialogue between researchers, policymakers, MPA management and shellfish farmers to support shared goals for sustainable MPA management.

4.6.3 Evaluation of tool results and reflection on responding needs outlined in introduction

The shellfish farmers' survey, which relied exclusively on a BWS methodology, provided an innovative and structured way to explore perceptions of ecosystem services, regulatory frameworks, and the socio-economic implications of MPAs. By framing statements in a positive and context-sensitive manner and using a Balanced Incomplete Block Design, the survey was carefully designed to capture nuanced priorities among shellfish farmers without leading respondents toward specific opinions. The collaborative development of the statements, informed by literature, field visits, and input from both OFB and the regional shellfish farmers' representative, ensured that the content was directly relevant to the lived realities of oyster farming in Normandy. However, the very low participation rate limited the tool's ability to produce representative findings. While this limitation constrained the analytical value of the survey, it provided an important learning opportunity for understanding stakeholder engagement challenges in this sector.

The findings from this exercise align closely with concerns raised by the SEG. Both the SEG's reflections and the survey experience highlight the importance of raising awareness, fostering acceptance, and providing concrete, relatable examples of ecosystem services in action. The SEG emphasized caution in over-reliance on monetary valuation tools, citing limited knowledge of marine ecosystem services and potential risks in how these valuations might be used by certain actors. The difficulties encountered in this survey reinforce those points: **a purely survey-based valuation tool, particularly one designed for an audience already facing high regulatory and operational pressures, may struggle to resonate without clear, tangible links to daily experiences and practical benefits.** Farmers' low engagement signals a need to prioritize participatory approaches that go beyond abstract valuation exercises and build trust through dialogue, transparency, and visible outcomes.

This reflection also suggests that the current stage of MPA management and Living Lab development is better suited **to tools that emphasize co-learning and communication** rather than sophisticated economic modeling. Given limited resources and experience with ecosystem service assessments, early-stage efforts may be more impactful if focused on qualitative engagement, storytelling, and locally grounded demonstrations of ecosystem service benefits. Future research tools should therefore be co-designed with stakeholders not only in terms of content but also in format, to ensure they are accessible, respectful of time constraints, and clearly aligned with farmers' priorities. By approaching ecosystem service discussions in a practical and context-driven manner, research initiatives can better contribute to the SEG's call for stronger awareness, acceptance, and trust-building among socio-economic actors in MPAs.

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5 General conclusions

This research aimed to explore the relevance and usability of various socio-economic valuation tools within the Littoral Seino-Marin Marine Protected Area. Rather than focusing on concrete numerical outputs, the key insights lie in the process itself: how such tools can help foster engagement, raise awareness, and support inclusive management practices in MPAs. Furthermore, this process was part of a master dissertation, with most of the research and analyses conducted by MSc. Joke Seghers.

A central lesson from this case study is that the effectiveness of participatory research methods is highly dependent on both place and timing. The interests, priorities, and willingness of stakeholders to engage can vary greatly depending on the season, the socio-economic context, and ongoing local events. For instance, survey responses collected during the Easter holidays reflect the specific visitor profile at that time—likely not representative of the entire year. Similarly, the low engagement from the shellfish farming community shows that even well-designed tools may fall short if the timing, framing, or perceived relevance do not align with the daily realities of the stakeholders involved.

The tools tested here—Best-Worst Scaling, order ranking, and contingent valuation—provided important learning opportunities. Not only did they allow researchers to gather valuable insights about stakeholder preferences, they also served as instruments to raise awareness among participants, stimulate dialogue, and create space for reflection about the MPA's ecological role. However, each tool also has clear limitations when applied in real-world settings, particularly in MPAs that are still in an early phase of stakeholder engagement or that have limited staff and funding. Importantly, some tools, like contingent valuation, require cautious interpretation, especially where monetary values are difficult to estimate or controversial to discuss.

For MPA managers, the practical implication is not to focus on achieving perfect valuation results, but rather to see these tools as part of a broader process of inclusive and adaptive management. They can serve as conversation starters, as ways to communicate ecological priorities in locally meaningful terms, or as monitoring tools to track shifting attitudes over time. In that sense, their value lies more in their function as a bridge—between science and practice, between ecological goals and stakeholder needs—than in the precision of their outcomes.

Finally, participatory methods like the ones tested in this study must be carefully adapted to the local capacity and context of each MPA. Generic recommendations or overly complex tools are unlikely to succeed if they do not match the MPA's current priorities, available resources, and readiness to engage. Future use of such tools should always begin with a clear understanding of these local parameters, and evolve through a collaborative, step-by-step approach that builds trust and relevance over time.

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6 Appendix

6.1 Pairwise post-hoc comparisons (Nemenyi)

	Paddleboarding.Surfing	Windsurf.Kitesurf	Kayaking	Snorkelling.Scuba	Fishing	Sailing	Motorboats.JetSki	Hiking
Windsurf.Kitesurf	0.1147	-	-	-	-	-	-	-
Kayaking	0.9999	0.3280	-	-	-	-	-	-
Snorkelling.Scuba	0.9769	0.0033	0.8262	-	-	-	-	-
Fishing	0.0041	0.9832	0.0228	3.2e-05	-	-	-	-
Sailing	0.5531	0.9964	0.8526	0.0553	0.6524	-	-	-
Motorboats.JetSki	8.7e-14	3.0e-13	8.5e-14	< 2e-16	3.5e-10	7.6e-14	-	-
Hiking	7.8e-14	< 2e-16	8.5e-14	1.1e-13	< 2e-16	< 2e-16	< 2e-16	-
Beach.Activities	8.9e-11	9.3e-14	2.7e-12	1.1e-07	8.6e-14	6.1e-14	< 2e-16	0.0360

6.2 Ordinal logistic regression table

	Activity	Variable	Coefficient	SE	p_value	Odds_Ratio
Paddleboarding/Surfing.Age_Group25-34	Paddleboarding/Surfing	Age_Group25-34	-1.118	0.444	0.012	0.327
Paddleboarding/Surfing.Age_Group35-44	Paddleboarding/Surfing	Age_Group35-44	-0.541	0.442	0.221	0.582
Paddleboarding/Surfing.Age_Group45-54	Paddleboarding/Surfing	Age_Group45-54	-0.183	0.461	0.691	0.833
Paddleboarding/Surfing.Age_Group55-64	Paddleboarding/Surfing	Age_Group55-64	0.020	0.481	0.967	1.020
Paddleboarding/Surfing.Age_Group65+	Paddleboarding/Surfing	Age_Group65+	-0.136	0.577	0.813	0.873
Paddleboarding/Surfing.France	Paddleboarding/Surfing	France	-0.039	0.282	0.891	0.962
Paddleboarding/Surfing.Awareness	Paddleboarding/Surfing	Awareness	-0.768	0.315	0.015	0.464
Paddleboarding/Surfing.1|2	Paddleboarding/Surfing	1|2	-3.994	0.558	0.000	0.018
Paddleboarding/Surfing.2|3	Paddleboarding/Surfing	2|3	-2.927	0.481	0.000	0.054
Paddleboarding/Surfing.3|4	Paddleboarding/Surfing	3|4	-1.903	0.446	0.000	0.149
Paddleboarding/Surfing.4|5	Paddleboarding/Surfing	4|5	-0.954	0.432	0.027	0.385
Paddleboarding/Surfing.5|6	Paddleboarding/Surfing	5|6	-0.134	0.431	0.755	0.874
Paddleboarding/Surfing.6|7	Paddleboarding/Surfing	6|7	0.696	0.437	0.111	2.005
Paddleboarding/Surfing.7|8	Paddleboarding/Surfing	7|8	1.792	0.465	0.000	6.001
Paddleboarding/Surfing.8|9	Paddleboarding/Surfing	8|9	2.603	0.521	0.000	13.504
Fishing.Age_Group25-34	Fishing	Age_Group25-34	-0.614	0.437	0.160	0.541
Fishing.Age_Group35-44	Fishing	Age_Group35-44	-0.413	0.448	0.357	0.662
Fishing.Age_Group45-54	Fishing	Age_Group45-54	-1.356	0.470	0.004	0.258
Fishing.Age_Group55-64	Fishing	Age_Group55-64	-1.859	0.478	0.000	0.156
Fishing.Age_Group65+	Fishing	Age_Group65+	-1.884	0.562	0.001	0.152
Fishing.France	Fishing	France	-0.550	0.284	0.053	0.577
Fishing.Awareness	Fishing	Awareness	0.041	0.314	0.896	1.042
Fishing.1|2	Fishing	1|2	-4.203	0.520	0.000	0.015
Fishing.2|3	Fishing	2|3	-3.398	0.480	0.000	0.033
Fishing.3|4	Fishing	3|4	-2.609	0.456	0.000	0.074
Fishing.4|5	Fishing	4|5	-2.128	0.447	0.000	0.119
Fishing.5|6	Fishing	5|6	-1.903	0.444	0.000	0.149
Fishing.6|7	Fishing	6|7	-1.603	0.439	0.000	0.201

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Fishing.7|8	Fishing	7|8	-0.941	0.430	0.029	0.390
Fishing.8|9	Fishing	8|9	0.515	0.429	0.230	1.674
Hiking.Age_Group25-34	Hiking	Age_Group25-34	0.140	0.456	0.759	1.150
Hiking.Age_Group35-44	Hiking	Age_Group35-44	-0.763	0.474	0.107	0.466
Hiking.Age_Group45-54	Hiking	Age_Group45-54	-0.442	0.488	0.366	0.643
Hiking.Age_Group55-64	Hiking	Age_Group55-64	-1.293	0.533	0.015	0.274
Hiking.Age_Group65+	Hiking	Age_Group65+	-0.633	0.638	0.321	0.531
Hiking.France	Hiking	France	0.765	0.334	0.022	2.149
Hiking.Awareness	Hiking	Awareness	0.467	0.353	0.186	1.595
Hiking.1|2	Hiking	1|2	0.413	0.463	0.373	1.511
Hiking.2|3	Hiking	2|3	1.429	0.471	0.002	4.174
Hiking.3|4	Hiking	3|4	1.929	0.478	0.000	6.881
Hiking.4|5	Hiking	4|5	2.126	0.482	0.000	8.382
Hiking.5|6	Hiking	5|6	2.406	0.489	0.000	11.088
Hiking.6|7	Hiking	6|7	2.691	0.503	0.000	14.753
Hiking.7|8	Hiking	7|8	3.054	0.526	0.000	21.207
Hiking.8|9	Hiking	8|9	5.701	1.098	0.000	299.033
Kayaking.Age_Group25-34	Kayaking	Age_Group25-34	-0.010	0.434	0.981	0.990
Kayaking.Age_Group35-44	Kayaking	Age_Group35-44	-0.268	0.448	0.550	0.765
Kayaking.Age_Group45-54	Kayaking	Age_Group45-54	-0.070	0.464	0.880	0.932
Kayaking.Age_Group55-64	Kayaking	Age_Group55-64	0.376	0.460	0.413	1.456
Kayaking.Age_Group65+	Kayaking	Age_Group65+	-0.796	0.582	0.171	0.451
Kayaking.France	Kayaking	France	0.340	0.286	0.234	1.405
Kayaking.Awareness	Kayaking	Awareness	-0.462	0.318	0.146	0.630
Kayaking.1|2	Kayaking	1|2	-4.627	0.817	0.000	0.010
Kayaking.2|3	Kayaking	2|3	-2.621	0.488	0.000	0.073
Kayaking.3|4	Kayaking	3|4	-1.280	0.438	0.004	0.278
Kayaking.4|5	Kayaking	4|5	-0.202	0.429	0.637	0.817
Kayaking.5|6	Kayaking	5|6	0.483	0.428	0.258	1.622
Kayaking.6|7	Kayaking	6|7	1.266	0.436	0.004	3.545
Kayaking.7|8	Kayaking	7|8	2.217	0.462	0.000	9.183
Kayaking.8|9	Kayaking	8|9	3.889	0.610	0.000	48.844
Snorkelling/Scuba.Age_Group25-34	Snorkelling/Scuba	Age_Group25-34	0.307	0.439	0.484	1.360
Snorkelling/Scuba.Age_Group35-44	Snorkelling/Scuba	Age_Group35-44	0.528	0.434	0.223	1.696
Snorkelling/Scuba.Age_Group45-54	Snorkelling/Scuba	Age_Group45-54	0.454	0.464	0.327	1.575
Snorkelling/Scuba.Age_Group55-64	Snorkelling/Scuba	Age_Group55-64	0.754	0.474	0.111	2.126
Snorkelling/Scuba.Age_Group65+	Snorkelling/Scuba	Age_Group65+	1.083	0.553	0.050	2.953
Snorkelling/Scuba.France	Snorkelling/Scuba	France	0.045	0.283	0.874	1.046
Snorkelling/Scuba.Awareness	Snorkelling/Scuba	Awareness	-0.645	0.322	0.045	0.525
Snorkelling/Scuba.1|2	Snorkelling/Scuba	1|2	-3.043	0.548	0.000	0.048
Snorkelling/Scuba.2|3	Snorkelling/Scuba	2|3	-1.266	0.431	0.003	0.282

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Snorkelling/Scuba.3|4	Snorkelling/Scuba	3|4	-0.161	0.419	0.701	0.851
Snorkelling/Scuba.4|5	Snorkelling/Scuba	4|5	0.354	0.422	0.401	1.425
Snorkelling/Scuba.5|6	Snorkelling/Scuba	5|6	0.986	0.427	0.021	2.679
Snorkelling/Scuba.6|7	Snorkelling/Scuba	6|7	1.646	0.436	0.000	5.184
Snorkelling/Scuba.7|8	Snorkelling/Scuba	7|8	2.443	0.459	0.000	11.504
Snorkelling/Scuba.8|9	Snorkelling/Scuba	8|9	4.168	0.611	0.000	64.593
Beach Activities.Age_Group25-34	Beach Activities	Age_Group25-34	0.458	0.444	0.302	1.581
Beach Activities.Age_Group35-44	Beach Activities	Age_Group35-44	0.815	0.451	0.071	2.258
Beach Activities.Age_Group45-54	Beach Activities	Age_Group45-54	0.753	0.491	0.125	2.124
Beach Activities.Age_Group55-64	Beach Activities	Age_Group55-64	1.400	0.476	0.003	4.055
Beach Activities.Age_Group65+	Beach Activities	Age_Group65+	1.297	0.580	0.025	3.659
Beach Activities.France	Beach Activities	France	-0.183	0.288	0.525	0.833
Beach Activities.Awareness	Beach Activities	Awareness	0.522	0.332	0.116	1.685
Beach Activities.1|2	Beach Activities	1|2	-0.353	0.424	0.405	0.702
Beach Activities.2|3	Beach Activities	2|3	1.236	0.435	0.004	3.443
Beach Activities.3|4	Beach Activities	3|4	1.825	0.444	0.000	6.201
Beach Activities.4|5	Beach Activities	4|5	2.212	0.450	0.000	9.138
Beach Activities.5|6	Beach Activities	5|6	2.374	0.454	0.000	10.739
Beach Activities.6|7	Beach Activities	6|7	2.479	0.457	0.000	11.933
Beach Activities.7|8	Beach Activities	7|8	2.764	0.467	0.000	15.859
Beach Activities.8|9	Beach Activities	8|9	3.316	0.494	0.000	27.550
Motorboats/JetSki.Age_Group25-34	Motorboats/JetSki	Age_Group25-34	0.670	0.469	0.153	1.953
Motorboats/JetSki.Age_Group35-44	Motorboats/JetSki	Age_Group35-44	0.176	0.471	0.709	1.192
Motorboats/JetSki.Age_Group45-54	Motorboats/JetSki	Age_Group45-54	0.335	0.510	0.512	1.398
Motorboats/JetSki.Age_Group55-64	Motorboats/JetSki	Age_Group55-64	0.819	0.526	0.120	2.267
Motorboats/JetSki.Age_Group65+	Motorboats/JetSki	Age_Group65+	1.059	0.693	0.127	2.884
Motorboats/JetSki.France	Motorboats/JetSki	France	0.725	0.312	0.020	2.065
Motorboats/JetSki.Awareness	Motorboats/JetSki	Awareness	-0.131	0.359	0.716	0.877
Motorboats/JetSki.1|2	Motorboats/JetSki	1|2	-3.760	0.817	0.000	0.023
Motorboats/JetSki.2|3	Motorboats/JetSki	2|3	-2.212	0.530	0.000	0.109
Motorboats/JetSki.3|4	Motorboats/JetSki	3|4	-1.590	0.485	0.001	0.204
Motorboats/JetSki.4|5	Motorboats/JetSki	4|5	-1.233	0.469	0.009	0.291
Motorboats/JetSki.5|6	Motorboats/JetSki	5|6	-0.796	0.456	0.081	0.451
Motorboats/JetSki.6|7	Motorboats/JetSki	6|7	-0.487	0.452	0.281	0.614
Motorboats/JetSki.7|8	Motorboats/JetSki	7|8	-0.168	0.450	0.709	0.846
Motorboats/JetSki.8|9	Motorboats/JetSki	8|9	0.545	0.451	0.227	1.725
Windsurf/Kitesurf.Age_Group25-34	Windsurf/Kitesurf	Age_Group25-34	-0.641	0.457	0.161	0.527
Windsurf/Kitesurf.Age_Group35-44	Windsurf/Kitesurf	Age_Group35-44	-0.378	0.463	0.414	0.685
Windsurf/Kitesurf.Age_Group45-54	Windsurf/Kitesurf	Age_Group45-54	0.676	0.484	0.162	1.966
Windsurf/Kitesurf.Age_Group55-64	Windsurf/Kitesurf	Age_Group55-64	-0.353	0.487	0.469	0.703
Windsurf/Kitesurf.Age_Group65+	Windsurf/Kitesurf	Age_Group65+	-0.218	0.605	0.719	0.804
Windsurf/Kitesurf.France	Windsurf/Kitesurf	France	-0.140	0.291	0.630	0.869

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Windsurf/Kitesurf.Awareness	Windsurf/Kitesurf	Awareness	-0.377	0.321	0.241	0.686
Windsurf/Kitesurf.1|2	Windsurf/Kitesurf	1|2	-5.126	0.827	0.000	0.006
Windsurf/Kitesurf.2|3	Windsurf/Kitesurf	2|3	-3.708	0.557	0.000	0.025
Windsurf/Kitesurf.3|4	Windsurf/Kitesurf	3|4	-2.430	0.474	0.000	0.088
Windsurf/Kitesurf.4|5	Windsurf/Kitesurf	4|5	-1.513	0.452	0.001	0.220
Windsurf/Kitesurf.5|6	Windsurf/Kitesurf	5|6	-0.619	0.445	0.164	0.538
Windsurf/Kitesurf.6|7	Windsurf/Kitesurf	6|7	0.266	0.444	0.549	1.305
Windsurf/Kitesurf.7|8	Windsurf/Kitesurf	7|8	1.195	0.453	0.008	3.303
Windsurf/Kitesurf.8|9	Windsurf/Kitesurf	8|9	3.107	0.564	0.000	22.363
Sailing.Age_Group25-34	Sailing	Age_Group25-34	0.836	0.442	0.059	2.308
Sailing.Age_Group35-44	Sailing	Age_Group35-44	1.145	0.448	0.011	3.144
Sailing.Age_Group45-54	Sailing	Age_Group45-54	0.009	0.469	0.985	1.009
Sailing.Age_Group55-64	Sailing	Age_Group55-64	0.409	0.471	0.385	1.505
Sailing.Age_Group65+	Sailing	Age_Group65+	0.619	0.591	0.296	1.856
Sailing.France	Sailing	France	-0.619	0.290	0.033	0.539
Sailing.Awareness	Sailing	Awareness	0.675	0.323	0.036	1.965
Sailing.1|2	Sailing	1|2	-3.855	0.647	0.000	0.021
Sailing.2|3	Sailing	2|3	-2.394	0.480	0.000	0.091
Sailing.3|4	Sailing	3|4	-1.379	0.441	0.002	0.252
Sailing.4|5	Sailing	4|5	-0.632	0.433	0.145	0.532
Sailing.5|6	Sailing	5|6	0.085	0.432	0.844	1.088
Sailing.6|7	Sailing	6|7	0.915	0.436	0.036	2.496
Sailing.7|8	Sailing	7|8	2.127	0.458	0.000	8.391
Sailing.8|9	Sailing	8|9	3.790	0.565	0.000	44.248

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6.3 Guide to read ordered logistic regression table

What Each Column Means:
Activity & Variable: What activity and which predictor we're looking at
Coefficient: The "raw" effect size (positive = worse ranking, negative = better ranking)
Odds Ratio: The "user-friendly" effect size (easier to interpret)
p_value: Is this result statistically significant? (Look for values < 0.05)

Step-by-Step Reading Guide:

- **Step 1: Find a Row You Care About**

Let's say you want to know about age and fishing. Look for rows like: Fishing.Age_Group55-64

- **Step 2: Check if it's Significant**

Look at the **p_value** column. Is it less than 0.05?

- If YES → This is a real effect worth paying attention to
- If NO → This could just be random noise, ignore it
- **Step 3: Interpret the Odds Ratio**

This is the easiest number to understand:
If Odds Ratio is…
… Much less than 1 (like 0.16) = This group **REALLY PREFERS** this activity
… Close to 1 (like 0.85 or 1.15) = This group has **SIMILAR PREFERENCES** to others
… **Much more than 1** (like 3.14) = This group **REALLY DISLIKES** this activity

- **Step 4: Put it in Plain English**

Example: Fishing.Age_Group55-64 has Odds Ratio = 0.16, p = 0.0001

- **Translation**: "People aged 55-64 are **much more likely** to give fishing **better rankings** than other age groups. This is statistically significant."

Another Example: Hiking.France has Odds Ratio = 2.15, p = 0.022

- **Translation**: "French people are **much more likely** to give hiking **worse rankings** compared to non-French people. This is statistically significant."
- **Quick Reference:**

Odds Ratio < 0.5 = Strong preference FOR the activity
Odds Ratio 0.5-1.0 = Mild preference FOR the activity
Odds Ratio 1.0-2.0 = Mild preference AGAINST the activity
Odds Ratio > 2.0 = Strong preference AGAINST the activity

- **What to Ignore:**
- Rows with p_value > 0.05 (not significant)
- The "1|2", "2|3" etc. rows (these are technical cutoff points)
- The exact coefficient numbers (stick to Odds Ratios)

Bottom Line: Look for small p-values (< 0.05), then check if the Odds Ratio is much bigger or smaller than 1.0!

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6.4 Overview of all scenarios for contingent valuation

Scenario 1: Restoring water quality in the MPA
This scenario was included to address one of the most immediate impacts of tourism on MPAs. As water quality directly affects both biodiversity conservation goals and recreational activities that tourists value, it is an important concern for MPA management. Research has indicated that tourism-related waste significantly impacts coastal water quality through plastic pollution, wastewater discharge, and chemical contaminants like sunscreen (Pásková et al., 2024; Ecolmar, n.d.). The proposed solution in the scenario of community-led clean-ups and waste reduction initiatives represents a realistic intervention that could be implemented with tourist support.

Scenario 2: Wildlife protection
This scenario was made based on the specific designation of the Littoral Seino-Marin as an MPA under the Bird Directive protection status from Natura 2000 (OFB, 2020). Wildlife protection represents a core conservation objective for the Littoral Seino-Marin MPA, and this scenario presents tourists with a direct trade-off between unrestricted access and wildlife conservation. The proposed seasonal access restrictions, to sensitive areas for birds, mirror actual management approaches used in protected areas worldwide, providing realistic context for the contingent valuation exercise (Stephenson, 2023; Mutanga et al., 2015)

Scenario 3: Quiet zones
This scenario was developed based on research on underwater noise pollution from motorized water activities and its impacts on marine wildlife, recently recognized by the European Commission's implementation of the first-ever EU-wide limits on underwater noise (European Commission, 2022; Ellis, 2024). This pressure was recognised by OFB for the Littoral Seino-Marin as well. The scenario introduces quiet zones and alternative routes to mitigate this pressure, balancing ecological health with recreational use.

Scenario 4: Restoration of hiking trails
This scenario addresses the critical issue of coastal erosion accelerated by tourism pressure, specifically focusing on hiking trails, a key recreational asset in the Littoral Seino-Marin MPA. Research indicates that coastal tourism significantly contributes to erosion through trampling, vegetation damage, and the creation of unauthorized paths, with the famous chalk cliffs of Étretat, in this study area, being particularly vulnerable to this pressure (Le Singulier, 2024; Silvestri, 2018). In discussions with OFB, trail degradation was identified as a growing concern affecting both visitor safety and the long-term sustainability of tourism in the area. This scenario assesses support for erosion control and trail management efforts that may temporarily limit access but ultimately preserve the scenic and safe hiking environment.

Scenario 5: Sustainable Recreational Fishing
Recreational fishing represents both a popular tourist activity and a potential threat to marine biodiversity when unregulated or excessive. This scenario was included to address the specific challenge of balancing sustainable use with conservation in an MPA that permits certain fishing activities (Costello, 2024; MBPKP, n.d.). It explores public support for seasonal restrictions and habitat restoration measures. It also explores tourists' understanding of the connection between their activities and long-term resource availability, which is central to sustainable tourism development in MPAs.

Scenario 6: Visitor education and engagement
This scenario addresses the role of environmental education in effective MPA management, included based on research indicating that visitor awareness significantly influences behaviour and support for conservation initiatives (Liu et al., 2024; Han et al., 2011). During conversations with OFB, the importance of visitor education, starting with awareness, was confirmed. This scenario tests willingness to support initiatives that promote awareness on marine conservation among tourism through for example interactive exhibits on-site.

Scenario 7: Cultural and artistic heritage
This scenario was developed to capture the cultural ecosystem services dimension of the Littoral Seino-Marin MPA. It highlighted that Étretat's appeal extends beyond its natural features to also its rich cultural and artistic heritage, shaped by artists like Monet and writers like Maurice Leblanc (Le Havre-Étretat Tourism, n.d.). The pressures of tourism threaten these historic structures and heritage as well. By including this dimension of cultural ES, the survey provides a more comprehensive understanding of tourists' valuation of the full range of benefits derived from the MPA.

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6.5 Overview of all BWS statements in the shellfish survey

1. "MPA regulations do not significantly increase the financial burden on oyster farmers."

This statement was included based on research on the regulatory costs experienced by shellfish farmers. A study of Pacific coast operations found that most of these costs were indirect, including staff time dedicated to compliance, legal fees, and required adjustments to equipment or management practices (van Senten et al., 2020). Field visits to the Littoral Seino-Marin MPA revealed similar concerns from the shellfish farmers in the MPA about complying to waste management practices from the MPA management.

2. "Oyster farmers should be more involved in the MPA policy-making process."

Conversations with OFB revealed a very limited participation from shellfish farmers in MPA governance despite their designated role as co-managers. Literature on collaborative governance in MPA management suggests that active participation improves compliance and reduces conflict (Schéré, 2023). The statement aims to assess farmers' desire for greater involvement in decision-making processes that affect their operations.

3. "The MPA provides sufficient incentives (financial, technical or R&D) for the adoption of environmentally friendly oyster farming practices."

Research has revealed that high startup costs form a barrier for implementation of environmentally friendly and sustainable aquaculture practices. This barrier is more significant for small-scale farmers or ones with limited resources, who might need more support and incentives for the transition to sustainable practices (Food Forward NDCs, 2024). This statement was included to evaluate whether shellfish farmers perceive these existing incentives as adequate motivation for adopting sustainable practices within the MPA context.

4. "Conservation efforts in the MPA sufficiently support marine ecosystem functions (e.g. algae and aquatic meadows improve water quality) that benefit oyster farming."

The MPA management plan for Baie des Veys MPA, one of the additionally included MPAs to the study area for this survey, emphasizes that sustaining shellfish farming relies heavily on the health of surrounding watersheds, especially in the inland marsh areas (Marais du Cotentin et du Bessin - Baie des Veys, 2010) The statement aims to assess whether farmers recognize the effect of conservation efforts in the MPA to improve ecosystem functions and farming production conditions.

5. "Waste management in the MPA should be a priority for oyster farmers."

Field observations during the Littoral Seino-Marin MPA site visits revealed issues with plastic waste linked to harvesting practices, which involve plastic-based installations. These plastic materials often end up on beaches or in the sea. Addressing this issue with shellfish farmers proved sensitive, as these methods are standard practice and there is resistance to changing them. This survey item was included to assess farmers' current perspectives on integrating waste management into their operations.

6. "Conservation efforts in the MPA have an impact on predatory species that can threaten oyster farming (e.g., periwinkles, starfish)."

This statement was included following consultations with the shellfish farmers' representative from the Normandy region, who highlighted increased spider crab predation on shellfish as a significant concern. Research from Italy has shown that MPAs' biodiversity protection goals can sometimes conflict with farmers' need for predator control (Tudini & Forgione, 2024). By including this statement, the survey aims to explore whether farmers view conservation measures as potentially increasing predation problems by limiting the ability to manage predator populations.

7. "The increase in the number of visitors to the MPA does not have a negative impact on oyster farming activities (e.g., pollution of water quality, theft of shellfish)."

Research on interactions between aquaculture and tourism identified potential conflicts between these sectors (European MSP Platform, n.d.). An interview with the shellfish farmer representative revealed concerns about visitor impacts on water quality and security of shellfish stocks. This statement was included to evaluate whether farmers perceive tourism promotion aspects of MPAs as compatible with their operations.

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8. " The presence of the MPA is a commercial advantage for oyster products. "

Literature on public perception of shellfish farming in the US indicated potential marketing advantages when their production is seen as environmentally responsible. It suggested that positive environmental associations can strengthen consumer confidence and market position. This statement was designed to assess whether farmers recognize potential branding benefits from operating within an environmentally protected area (Hudson, 2016).

9. "MPA regulations do not create administrative complexity for oyster farmers (e.g., Natura 2000 impact assessment, access to public maritime domain, decree establishing oyster farming concession or its extension)."

This statement was based on the regulatory framework outlined in TOME 2 of the Littoral Seino-Marin MPA management plan, including the prefectural decree of April 24, 2017 (OFB, 2020). This document establishes a structure plan for marine farming operations in the Seine-Maritime region. The statement 39 is intended to assess how oyster farmers perceive the complexity of operating within MPAs, particularly in relation to regulatory compliance.

10. " Restrictions on access to MPAs do not cause major logistical problems for oyster farmers (e.g. avoiding sensitive areas with tractors). "

This statement was developed based on regulatory guidelines outlined in the management plans for the MPA Tatihou – Saint-Vaast-la-Hougue (2008). These include spatial restrictions such as limited vehicle access, constraints on farming equipment, and operational movement regulations to protect sensitive habitats. The purpose of this statement is to assess how shellfish farmers perceive the impact of these spatial and operational constraints on their day-to-day farming activities within the MPA.

11. "The MPA has an effect on water quality and improves oyster farming conditions."

This statement was informed by research and regulatory monitoring programs in France which underscores the essential role of water quality in sustaining shellfish farming. Contamination can directly impact shellfish health and lead to significant financial losses; this issue was highlighted by the shellfish farmers representative too (OFB, n.d.). The statement aims to assess whether farmers believe that the MPA contributes positively to water quality improvements that support their operations.

12. "It is necessary to invest in sustainable oyster farming technologies for future competitiveness."

This statement was informed by industry literature highlighting technological innovation in shellfish farming, which demonstrate how the sector is evolving to address regulatory and environmental demands through advanced solutions. It suggests that investing in such technologies may enable farmers to better comply with environmental standards while remaining competitive in the market (Mer et Marine, 2025). The statement was included to explore whether farmers view technological innovation as a effective way to move forward.

13. "The MPA can positively influence the public perception of oyster farming (e.g., tourists)."

Research from the US shows that while public knowledge of shellfish farming is limited, perception tend to be positive when the industry is viewed as environmentally sustainable (Hudson, 2016). This statement was included to assess whether farmers see the MPA as a potential asset for enhancing their reputation, especially through increased awareness and support from tourists and the broader public. Positive public perception can boost market demand by highlighting shellfish as a clean, sustainable, locally produced product with cultural value (Hudson, 2016).

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7 Additional information

Statistical modelling was explored for the contingent valuation results as well. The below R output displays the results of a logit model to reveal the dynamics underlying the decision to either contribute (in any way) or not contribute. As can be seen, the predictive power of this model is very poor. Two factors support this observation;

- All Pr(>|z|) (p-values) > 0.05 (except two near 0.06–0.07). That means none of the predictors are statistically significant → no variable explains the variation in "willingness to contribute."
- If we compare the null deviance with the residuel deviance, we notice a very limited "improvement", especially given the number of predictors (8). This means that adding our predictors barely improves the model fit.

Therefore, there is no additional insight to be gained from running models on the CV data.

```
> # Logit model for willingness to participate
> participation_model <- glm(Willing ~ France + MPA_Aware + Visited + Age_Group,
+                            data = cv_data_sc1,
+                            family = binomial(link = "logit"))
>
> cat("=== PARTICIPATION MODEL (LOGIT) ===\n")
=== PARTICIPATION MODEL (LOGIT) ===
> summary(participation_model)

Call:
glm(formula = Willing ~ France + MPA_Aware + Visited + Age_Group,
    family = binomial(link = "logit"), data = cv_data_sc1)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-1.0936  -0.8034  -0.6975   1.2951   1.8865

Coefficients:
              Estimate Std. Error z value Pr(>|z|)
(Intercept)    -0.34420    0.51843  -0.664   0.5067
France         -0.04428    0.36457  -0.121   0.9033
MPA_Aware       0.50572    0.39756   1.272   0.2034
Visited         0.18815    0.34243   0.549   0.5827
Age_Group25-34 -0.97653    0.53550  -1.824   0.0682 .
Age_Group35-44 -0.57685    0.53108  -1.086   0.2774
Age_Group45-54 -1.08933    0.59178  -1.841   0.0657 .
Age_Group55-64 -0.81852    0.58337  -1.403   0.1606
Age_Group65+   -1.20608    0.78150  -1.543   0.1228
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 243.65  on 206  degrees of freedom
Residual deviance: 237.31  on 198  degrees of freedom
  (1 observation deleted due to missingness)
AIC: 255.31
```


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