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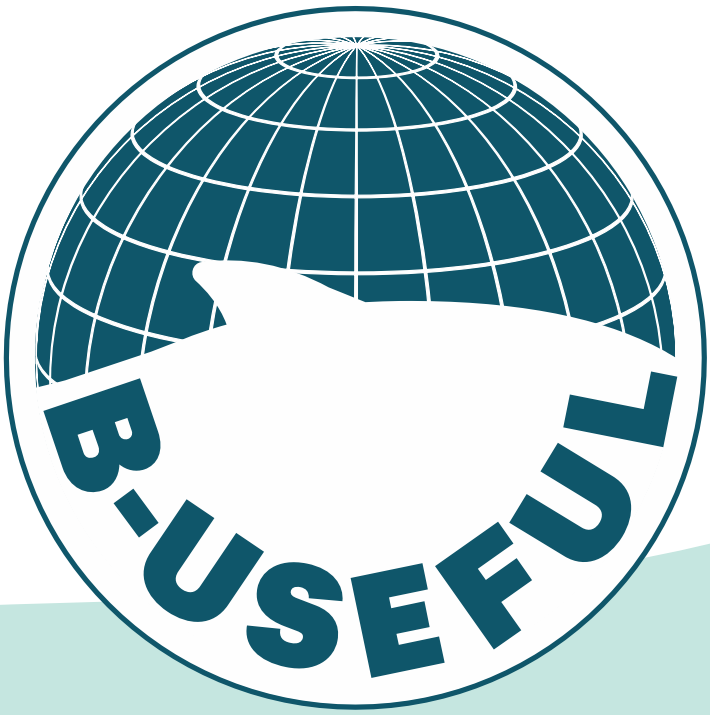

User-oriented Solutions for Improved Monitoring and Management of Biodiversity and Ecosystem services in vulnerable European Seas

Deliverables

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Contents

1. Introduction: purpose and approach

Despite a range of policy and management initiatives, the state of marine biodiversity in European waters has deteriorated in recent decades. Marine biodiversity conservation therefore remains a high priority in Europe.

The goal of the B-USEFUL project[1] is to contribute to achieve policy goals of EU Green Deal and the Biodiversity Strategy 2030 by developing user-oriented tools and solutions to conserve and protect marine biodiversity, effectively building and improving upon existing European data infrastructures and governance frameworks.

Active participation of a broad range of end-users is a prerequisite to ensure relevance and use of the knowledge and tools developed in a project, allowing the active use of the project outcomes in support of biodiversity governance. For this reason, the B-Useful project follows co-creation process that has been designed to support research and innovation in relation to addressing environmental challenges (Mauser et al. 2013).

The governance of marine biodiversity is highly challenging as marine systems are characterized by multiple and overlapping ecological, social, and political boundaries, and are subjected multiple uses and objectives, which often are in tension with each other (Bellanger et al. 2020). In this context, it is purposeful to proceed from an inclusive concept of end-users. In the B-Useful project, end-users therefore include representatives of fisheries, aquaculture, offshore energy, environmental NGOs, advisory councils, scientific organizations, international agencies, government bodies, decision-makers, as well as fisheries and managers of marine environments. Each of these stakeholders have potentially important insights to share about the governance of marine biodiversity, and about what forms of knowledge is particularly important to support marine biodiversity governance. These actors will also directly interact with the data products of B-USEFUL and therefore ensuring that the data produced is shaped by their views of important attributes is crucial.

This report provides an account of research conducted in support of the co-creation process in the B-useful project. The objective of this research is to elicit views from end-users on: a) the performance of marine biodiversity governance, b) what they see as barriers that prevent more effective biodiversity governance, and c) what constitutes relevant and purposeful indicators of marine biodiversity. The research conduct in pursuit of these objectives must take the current policy frameworks on marine biodiversity into account, including European as wells as global policies in support of biodiversity protection. On this basis, the following research questions were established for the purposes of this report:

<u>Policies and their objectives</u>

- What are the main policies for the conservation of marine biodiversity in Europe?
- What are the objectives of these policies?
- Are these objectives being met?

<u>Barriers to achieving policy objectives and solutions to overcome the barriers</u>

- What are the main barriers to achieving the objectives?
- How can the barriers be addressed?

[1] https://b-useful.eu/

Indicators of marine biodiversity

- What characterizes purposeful indicators of marine biodiversity?

A mixed methods approach was followed in order address these questions. The advantage of a mixed methods approach is that it allows for cross-checking and validation of outcomes from the different approaches, while taking the strength and weaknesses of each method into account. The approaches used included: Desk studies, serious gaming, workshops, interviews and a survey. The different methods were not used to address all the research questions but were focused on the research question for which they were considered most suitable. An overview of the methods and research questions is provided in Table 1 below.

Table 1. Overview of guiding research questions and methods.

Guiding research question	**Methods**
• What are the main policies for the conservation of marine biodiversity in Europe? • What are the objectives of these policies? • Are the objectives being met?	Limited policy review Workshops Survey Interviews
• What are the main barriers to achieving the objectives of the main policies for marine biodiversity in Europe?	Limited policy review Limited research review Workshop Surveys Interviews Serious Game
• What characterizes purposeful indicators of marine biodiversity?	Workshop Survey Interviews Serious Game

In the following, the findings of each of these approaches will be presented, followed by an integrative synthesis of the main findings along with a conclusion. The outcomes of this work will support the ongoing development of operational indicators of biodiversity and ecosystem services in the B-Useful project.

2. Results

2.1 Review of policies and research on European marine biodiversity frameworks

2.1.1 Background

This review is based on an analysis of relevant laws and policy to the protection and conservation of marine biodiversity in European waters as well as a limited review of barriers and obstacles to achieve the objectives of the policies for marine biodiversity in Europe. The analysis of barriers and obstacles is based on official EU documents and reports, directly related to the implementation of the policies and laws in question, as well as a limited[2] evaluation of peer-reviewed articles on the same topic.

2.1.2 Main policies and objectives for the conservation of marine biodiversity in Europe

This section analyses the policies and laws deemed relevant for the conservation and protection of marine biodiversity in European seas. Such instruments have been introduced gradually by the EU often in response to the degraded state of habitats and species in the EU.

The main policies and laws relating to the protection and conservation of marine biodiversity in European seas are the following:

- Birds Directive;
- Habitats Directive;
- EU Biodiversity Strategy for 2030;
- Common Fisheries Policy;
- Marine Strategy Framework Directive;
- Marine Spatial Planning Directive;
- Water Framework Directive.[3][4]

[2] The limits of the literature review refer to the thematic scope as well as temporal delimitations: only journal articles that specifically refer to marine biodiversity, ecosystem and environments, published from 2019 to date, were assessed.

[3] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy ("Water Framework Directive").

[4] The present research will not address the Water Framework Directive as it pertains to "the protection of inland surface waters, transitional waters, coastal waters and groundwater," and does not extend to marine waters of European seas.

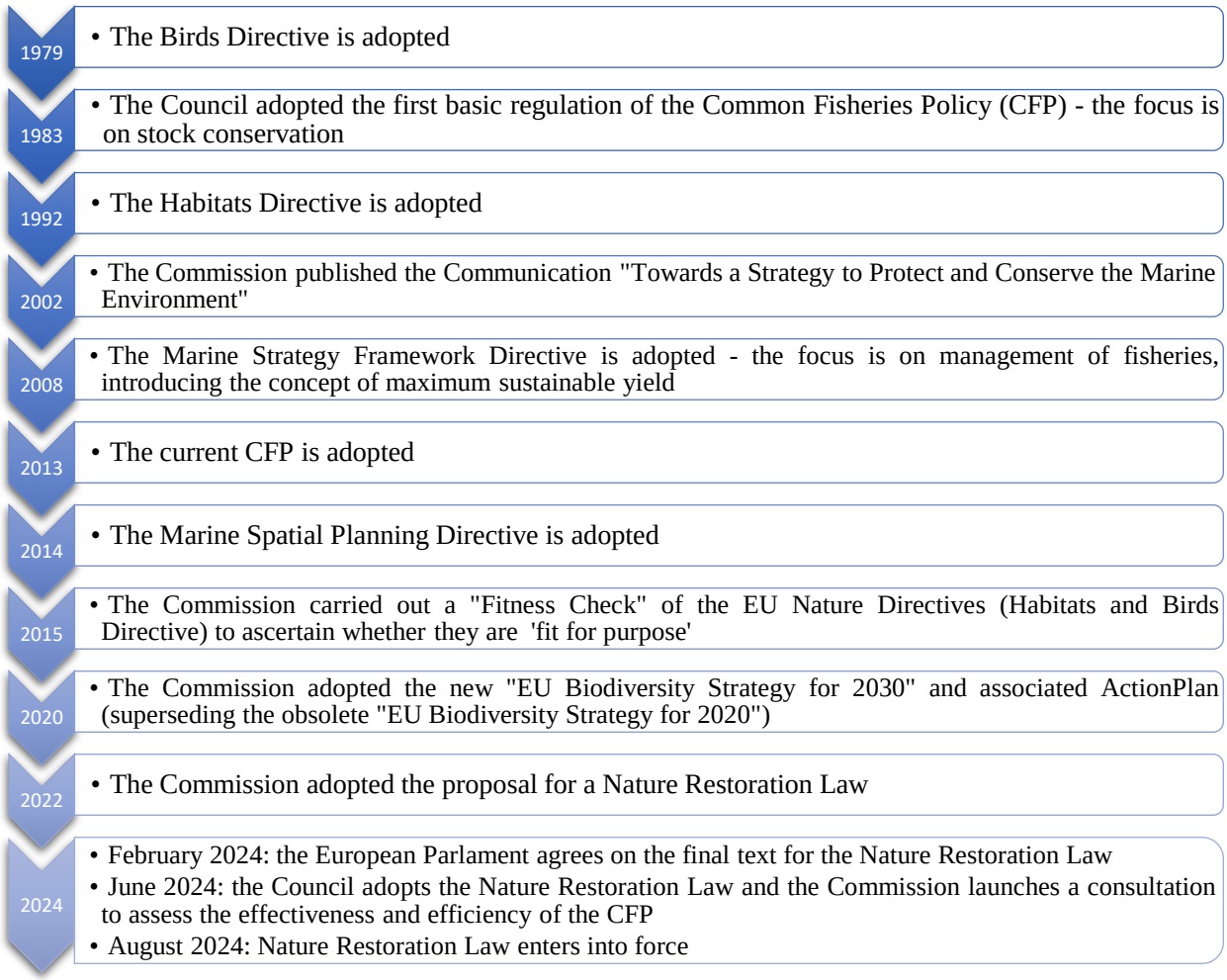

Figure 1. Timeline for European marine biodiversity policy and legislation

An overview of the timeline for European marine biodiversity policy and legislation is provided in Figure 1.

The **Birds Directive**[5] seeks to protect and conserve all naturally occurring wild birds in Member States' territory.[6] In relation to marine biodiversity, the Directive identifies 60 bird species whose conservation necessitates marine site protection as part of the Natura 2000 network[7], a network of protected sites across Europe focused on conserving Europe's most threatened species and habitats.

The aim of the **Habitats Directive**[8] is to protect both natural habitats and species of wild flora and fauna.[9] The concept of favourable conservation status[10] is key to achieve the Directive's goal, as the measures to be taken in accordance with the Directive are centred around the need to maintain or restore such favourable conservation status for flora, fauna and natural habitats.[11] The Directive

[5] Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds ("Birds Directive").
[6] Birds Directive, Article 1.
[7] European Commission, "Managing and Protecting Natura 2000 Sites".
[8] Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild flora and fauna ("Habitats Directive").
[9] Habitats Directive, Article 2(1).
[10] Habitats Directive, Article 1(e), (h)(i).
[11] Habitats Directive, Article 2(2).

does not specifically mention marine biodiversity, however, considering that its definition of natural habitats includes "terrestrial or aquatic areas,"[12] the Directive also applies to marine biodiversity. The focus of the Directive are the habitats and species listed in Annex I and Annex II, respectively, both relevant for the conservation of marine biodiversity, as the Annex I protects habitats in which marine biodiversity resides, while Annex II contains marine species such as fish,[13] invertebrates,[14] molluscs[15] as well as several marine plants species.[16] It further identifies marine habitat types and species that must be designated as Natura 2000 sites.[17] The Habitats Directive together with the Birds Directive are known as the "Nature Directives". Based on the Nature Directives, over 3000 marine sites have been nominated as part of the Natura 2000 sites, amounting to over 9% of the total EU Member States' marine zones.[18]

The **EU Biodiversity Strategy for 2030** ("Strategy" or "2030 Biodiversity Strategy") sets a comprehensive, ambitious long-term plan aimed at protecting nature and reversing the degradation of ecosystems.[19] Its overall objective is to set Europe's biodiversity on the path to recovery by 2030, by setting out new ways to implement existing legislation more effectively, new commitments, measures, targets and governance mechanisms.[20] Adopted in 2020, the Strategy is not legally binding *per se* but aims to create legally binding targets. As an example, the new EU Restoration Law stems directly from it. The 2030 Biodiversity Strategy superseded in 2020 the then obsolete EU Biodiversity Strategy for 2020, whose goals were not achieved.

The **Common Fisheries Policy**[21] ("CFP") aims at managing fish stocks sustainably, reducing overfishing and minimizing the impact of fishing on marine ecosystems, thus it entails the conservation and protection of marine biodiversity. The CFP seeks to achieve its goals through the following tools: setting a total allowable catch and quotas, based on scientific assessment[22] to maintain the fish quota at a maximum sustainable yield,[23] aimed at combating and preventing overfishing; by introducing a landing obligation,[24] to reduce wasteful fishing practice, as well as technical measures (such as gear restrictions, minimum mesh size, closed areas or seasons) to reduce bycatch (the unintentional capture of non-target species); establishing marine protected areas ("MPAs") are also a part of the CFP aimed at safeguarding critical habitats (e.g. spawning grounds or marine reserves), allowing ecosystems to thrive and protecting vulnerable species.

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[12] Habitats Directive, Article 1(b).
[13] Habitats Directive, Annex II, p. 28-29.
[14] Habitats Directive, Annex II, p. 29.
[15] Habitats Directive, Annex II, p. 31.
[16] Habitats Directive, Annex II, p. 31.
[17] European Commission, Environment, "Managing and Protecting Natura 2000 Sites" https://environment.ec.europa.eu/topics/nature-and-biodiversity/natura-2000/managing-and-protecting-natura-2000-sites_en#:~:text=Marine%20Natura%202000%20sites,-Under%20the%20Habitats&text=The%20Birds%20Directive%20lists%20a,EU%20Member%20States'%20marine%20area ("European Commission, "Managing and Protecting Natura 2000 Sites"").
[18] European Commission, "Managing and Protecting Natura 2000 Sites".
[19] European Environment Agency, "EU Biodiversity Strategy for 2030", Policy Document https://www.eea.europa.eu/policy-documents/eu-biodiversity-strategy-for-2030-1.
[20] European Commission, "Questions and Answers: EU Biodiversity Strategy for 2030 – Bringing Nature Back into our Lives" https://ec.europa.eu/commission/presscorner/detail/en/qanda_20_886.
[21] Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulation (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulation (EC) No 2371/2002 and (EC) No 639/2004 and Council Directive 2004/585/EC ("Common Fisheries Policy").
[22] Common Fisheries Policy, Article 6(2).
[23] Common Fisheries Policy, Article 2(2).
[24] Common Fisheries Policy, Article 15.

The **Marine Strategy Framework Directive** (MSFD)[25] was adopted with the aim of achieving "good environmental status" of EU marine waters by 2020.[26] Within this framework, Member States shall take necessary measures to achieve GES, by developing and implementing marine strategies to protect, preserve, and prevent the deterioration of the marine environment[27]. It represents the EU's main tool to protect and conserve the health of its coasts, seas and ocean, directly relevant for the conservation and protection of marine biodiversity.

The **Marine Spatial Planning Directive**[28] (MSPD) seeks to promote the sustainable growth of maritime economies, the sustainable development of marine areas and the sustainable use of marine resource by establishing a framework for maritime spatial planning.[29] This directive too contributes to the protection of marine biodiversity; for instance, ecological corridors may be established as part of marine spatial planning to connect different MPAs to further support conservation measures. Importantly, the MSPD seeks to balance sustainable development of energy sectors at sea with the preservation, protection and improvement of the marine environment.[30]

Policy performance

This section is focused on the performance of the above policies and laws. Such assessment is conducted by indicating each instrument's timeframe and by analysing the fulfilment of their goals within such timeframe. All directives include a deadline by which they are to be transposed into national law which will not be considered for the analysis of their performance centred on protection and conservation of marine biodiversity.

Timeframe

Each legal act and policy has a different temporal horizon. Both **Nature Directives** (Habitats and Birds Directive) do not include any deadline by which their goals are to be achieved as they focus on ongoing long-term conservation of habitats and species. They do, however, contain timeframes withing which their periodical reporting obligations are to be fulfilled. As the name suggests, the deadline to achieve the objectives of the **EU Biodiversity Strategy for 2030** is 2030, in line with the 2030 UN Agenda for Sustainable Development and the Global Biodiversity Framework 30x30. The goal of the **MSFD** to achieve good environmental status ("GES") of EU waters was to be fulfilled by 2020.[31] A objective of the **CFP** of 2013 was to achieve Maximum Sustainable Yield for commercial stocks at the latest by 2020[32] and also to implement the landing obligation for these stocks by 2019.[33] The **MSPD** had an original deadline of 2021, by which the spatial plans were to be established by the Member States.[34]

[25] Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive) ("MSFD Directive").
[26] MSFD Directive, Article 1(1).
[27] MSFD, Article 2.
[28] Directive 2014/89/EU of the European Parliament and of the Council of 23 July 2014 establishing a framework for maritime spatial planning ("Marine Spatial Planning Directive").
[29]Marine Spatial Planning Directive, Article 1(1).
[30] Marine Spatial Planning Directive, Article 5.
[31] Marine Strategy Framework Directive, Article 1(1).
[32] Common Fisheries Policy, Article 2(2).
[33] Common Fisheries Policy, Article 15.
[34] Marine Spatial Planning Directive, Article 15(3).

Achievement of Policies' and Laws' Objectives

To assess whether the above-mentioned policy and legal instruments successfully achieved their objectives within the given timeframe, reference to EU official reports on their implementation is necessary.

The State of Nature reports compile the results from Member States' reporting obligations under the **Nature Directives** and present the most reliable assessment of the Directives' progress in achieving their goals. The first Report[35] covering the period 2007-2012 was published in 2015, the second report[36] covering the period 2013-2018 was published in 2020, while the third one is not yet available as the reporting period runs from 2019 to the end of 2024. Concerning the performance of the **Birds Directive**, the most recent Report indicates that almost half of all waterbirds, including seabirds, have a poor or bad status, showing higher deterioration trends.[37] The assessment of the **Habitats Directive**'s obligations considers terrestrial and marine habitats and species together, making it difficult to discern data only relevant to marine biodiversity; nevertheless, results are also mixed, with three-quarters of habitats assessed having a poor or bad status, and marine mammals representing the category with the highest proportion of unknown assessments.[38] The **EU Biodiversity Strategy** is still ongoing, as the deadline is 2030, as such its implementation cannot be assessed as of yet. The EU Commission published a report[39] on the assessment of the **CFP**'s objectives highlighting positive results as well as areas for improvement; particularly, the goal of reaching MSY by 2020 was not reached in all European seas.[40] In 2020, the Commission also published a report on the implementation of the **MSFD**[41] to assess the achievement of its goal by 2020. Its implementation is ongoing as it is implemented over six-year cycles: the first implementation cycle runs from 2012 to 2017, while the second runs from 2018 to 2023. Despite significant progress, good environmental status was not achieved in all EU water as biodiversity loss was not halted during the first implementation cycle;[42] the Commission is currently assessing all the reports received as part of the second implementation cycle, as such, the most recent assessment of

[35] European Commission, "Report from the Commission to the Council and the European Parliament. The State of Nature in the European Union. Report on the status of and trends for habitat types and species covered by the Birds and Habitats Directives for the 2007-2012 period as required under Article 17 of the Habitats Directive and Article 12 of the Birds Directive" COM (2015) 219 Final (20 May 2015). See https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52015DC0219 ("State of Nature Report for 2007-2012").

[36] European Commission, "Report from the Commission to the European Parliament, the Council and the European Economic and Social Committee. The State of Nature in the European Union. Report on the status of and trends in 2013-2018 of species and habitat types protected by the Birds and Habitats Directives" COM(2020) 635 Final (15 October 2020). See https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0635&qid=1723717400515.

[37] State of Nature Report (2013-2018) p.13, figure 2.1.

[38] State of Nature Report (2013-2018) p.34, figure 3.1.

[39] European Commission, "Communication from the Commission to the European Parliament and the Council. The common fisheries policy today and tomorrow: a Fisheries and Oceans Pact towards sustainable, science-based, innovative and inclusive fisheries management" (21 February 2023) https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52023DC0103 ("Report on the CFP").

[40] Ibid, p.6.

[41] European Commission, "Report from the Commission to the European Parliament and the Council on the Implementation of the Marine Strategy Framework Directive(Directive 2008/56/EC)" (25 June 2020) https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0259.

[42] Ibid, p.16.

the Directive's performance is not yet available.[43] Regarding the **MSPD**, a 2022 report[44] highlighted that progress in establishing maritime spatial plans was mixed:[45] the majority of the EU Member States had marine spatial plans in place, while some still did not.[46]

Additionally, several official reports by EU bodies confirmed a negative assessment of marine biodiversity vis-à-vis the mentioned laws and policy – only the most recent ones and relevant to marine biodiversity are cited herein. For instance, the **EU Court of Audit** Report[47] on the marine environment conducted an in-depth audit of the EU framework to address the main pressures on marine biodiversity and habitats.[48] Despite the adequate design of the framework, EU action has been insufficient to restore seas to a good environmental status.[49] The **European Environment Agency** considered the distribution of MPAs in European seas as skewed towards the coast more than offshore waters,[50] resulting in deep water MPAs being underrepresented in the MPA network; moreover, several sites designated as MPA may be too small to sustain ecosystem resilience.[51]

2.1.3 Main barriers to marine biodiversity conservation in Europe

The following section will present the barriers and obstacles to achieve the objectives of the marine policies and laws aimed at protecting and conserving marine biodiversity in European seas. It is divided in two parts: the first one presents the barriers and obstacles identified from analysing official EU publications, reports and infringement cases, the second part emphasises barriers identified from a literature review.

Obstacles identified by the EU

This section highlights obstacles identified by the EU, through its agencies and bodies, to protect and conserve marine biodiversity in EU waters. The first subsection lists relevant EU reports that describe the barriers and obstacles to achieve policy and legal objectives to protect and conserve marine biodiversity, whereas the second subsection lists relevant infringements procedures.

[43] European Commission, "Environment", Implementation of the Marine Strategy Framework Directive https://environment.ec.europa.eu/topics/marine-environment/implementation-marine-strategy-framework-directive_en

[44] Report from the Commission to the European Parliament and the Council outlining the progress made in implementing Directive 2014/89/EU establishing a framework for maritime spatial planning (2022) COM/2022/185, at <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52022DC0185>.

[45] At the time of writing Estonia, Spain and Bulgaria are yet to establish their final plans, see ibid, para. 4.2, p.6.

[46] European Commission, "European Commission report on implementation of Maritime Spatial Planning Directive: good progress but more work needed" (3 May 2022) https://oceans-and-fisheries.ec.europa.eu/news/european-commission-report-implementation-maritime-spatial-planning-directive-good-progress-more-2022-05-03_en.

[47] European Court of Auditors, "Marine Environment: EU protection is wide but not deep" (2020) Special Report 26/2020, https://www.eca.europa.eu/Lists/ECADocuments/SR20_26/SR_Marine_environment_EN.pdf ("Court of Auditors Report").

[48] Court of Auditors Report, para. 83

[49] Ibid, para. 84.

[50] EEA, "Marine Protected Areas. Designed to conserve Europe's marine life, marine protected areas are a globally recognised tool for managing and enhancing our marine ecosystems" (2019) Briefing No 13/2018, p. 4.

[51] Ibid, p.6.

Official EU Publications and Reports

The EU publications and reports assessed below employ different terms such as "barriers", "threats", "pressures", and "obstacles". For accuracy, the same terminology used in each document will be used.

The **first State of Nature Report** identified **fishing,** particularly for species, **modification of natural conditions**, particularly for habitats, and **pollution** as the most frequently reported threats and pressures for the marine ecosystems.[52] The **second State of Nature Report** (2013-2018) groups together pressures in general for habitats and species, not differentiating the marine from terrestrial ones. Ongoing pressures on protected habitats and species **include changes in land and sea use**, **overexploitation** (e.g. fisheries) and **unsustainable management practices**, compounded by **pollution**, **invasive alien species** and **climate change[53].** It also deemed improvements from the previous report insufficient to achieve the aims of the EU Biodiversity Strategy for 2020, resulting in the adoption of the new EU Biodiversity Strategy for 2030 to address gaps and ensure healthy ecosystems, resilient to climate change and rich in biodiversity.[54]

The **2030 EU Biodiversity Strategy** highlights the following as main drivers of biodiversity loss:[55] **changes in land and sea use, over-exploitation, climate change, pollution, invasive specie**s. This refers to causes of nature's disappearance in general, albeit each is relevant for the context of marine biodiversity too.

The 2023 **CFP** Report notes certain obstacles to the full implementation of the CFP: **fishing activities** continue to adversely affect marine ecosystems,[56] **changes in the state of such ecosystem**s affect short, medium and long-term productivity of fish stocks,[57] **pollution from human activities** at sea and on land also detrimentally impacts marine ecosystems.[58]

The 2020 Report on the **MSFD** implementation[59] highlighted the following as main pressures affecting the marine ecosystems of the EU: **non-indigenous species, fishing, human-induced eutrophication, permanent alteration of hydrographical conditions, contaminants, marine litter, and underwater noise**.[60]

A 2022 report on the implementation of the **MSP Directive**[61] noted several implementation challenges faced by Member States, such as the **application of the ecosystem-based approach, data collection and compilation, coherence of plans** between neighbouring states, m**anaging maritime spaces** to enable both economic activities and policy objectives with environmental protection.[62]

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[52] State of Nature Report for 2007-2012, p. 8.
[53] State of Nature Report for 2013-2018, p. 136.
[54] State of Nature Report for 2013-2018, p. 136.
[55] EU Biodiversity Strategy for 2030, p.2. As the Strategy refers to the IPBES (2019) summary for policymakers, pp.17-19; European Environment Agency (2019) The European environment – state and outlook 2020 at https://www.eea.europa.eu/publications/soer-2020.
[56] CFP Report, p. 5.
[57] Ibid, p.6.
[58] Ibid.
[59] European Commission, "Report from the Commission to the European Parliament and the Council on the implementation of the Marine Strategy Framework Directive (Directive 2008/56/EC)" (25 June 2020) https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0259.
[60] Ibid, pp.17-21.
[61] European Commisison, "Report from the Commission to the European Parliament and the Council outlining the progress made in implementing Directive 2014/89/EU establishing a framework for maritime spatial planning" (3 May 2022) https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022DC0185.
[62] Ibid, para. 4.4, pp. 14-16.

Additionally, the **EU Court of Audit** Report[63] on the marine environment found the following obstacles and pressure to effectively protect marine biodiversity in EU waters: **fishing** as a key pressure;[64] despite the existence of EU laws to protect marine environment, EU "actions have not restored seas to a good environmental status, nor fishing to sustainable levels in all seas;"[65] the l**ack of connected and well managed network of MPAs**;[66] **weak coordination** between the CFP and MSFD;[67] and the fact that the Nature Directives' **lists of threatened species and habitats** do not **incorporate recent scientific knowledge**, criticizing the Commission for not yet updating such lists.[68] It concluded that EU legislations (e.g. Habitats Directive, Birds Directive, CFP, MSFD, MSPD) have not led to the recovery of significant marine ecosystems, biodiversity and habitats.[69]
Lastly, in a 2019 Briefing on MPAs,[70] the **European Environment Agency** (EEA) identified several obstacles to biodiversity protection. In particular, the **distribution of European MPAs towards the coastline, disregarding deep waters,** renders the assessed MPAs not yet ecologically representative,[71] the **small size of MPA**s does not support ecosystem resilience, in turn failing to fully deliver ecosystem services.[72]

Infringement Cases

Infringement decisions brought submitted by the EU Commission are useful to show barriers to effective protection and conservation of marine biodiversity. In 2020, the Commission pursued legal action against Member States[73] for failing to comply with their obligations under EU legislation. In the context of marine environment and biodiversity, three Member States (France, Spain and Sweden) were found to have **failed to take sufficient action to monitor by-catches** of dolphins and porpoise, to **avoid causing significant disturbances** of marine species in conservation areas, **not correctly transposing the Habitats Directive** into national law, and failing to ensure effective controls and inspections of fishing vessels.[74] Another infringement pertains Bulgaria's **failure to comply with its reporting obligations** under the MSFD, resulting in the Commission referring the case to the EU Court of Justice.[75] Further infringement procedures were brought in 2024[76] against Italy[77] for f**ailing to implement measures required by the Habitats Directive to prevent bycatch** of marine and seabird species by fishing vessels, against Denmark, Greece, Malta and Croatia[78] for **failing to submit reports on the updated programmes of measures** as required under the MSFD, and against Sweden for fa**iling to protect marine mammals from fishing vessels' bycatc**h. In 2023,

[63] European Court of Auditors, "Marine Environment: EU protection is wide but not deep" (2020) Special Report 26/2020, https://www.eca.europa.eu/Lists/ECADocuments/SR20_26/SR_Marine_environment_EN.pdf ("Court of Auditors Report").
[64] Court of Auditors Report, para. 83, p. 47.
[65] Court of Auditors Report, para. 84, p. 47.
[66] Court of Auditors Report, para. 85, p. 47.
[67] Court of Auditors Report para. 87, p. 47.
[68] Court of Auditors Report, p. 31.
[69] Court of Auditors Report, pp. 31-
[70] EEA Briefing (2019).
[71] Ibid, p. 4.
[72] Ibid, p. 5.
[73] INFR(2020)4039 of 2 July 2020
See: European Commission, "July Infringements Package: Key Decisions" (2 July 2020) https://ec.europa.eu/commission/presscorner/detail/en/inf_20_1212.
[74] Ibid.
[75] Ibid.
[76] See: European Commission, "February Infringements Package: Key Decisions" (7 February 2024) https://ec.europa.eu/commission/presscorner/detail/en/inf_24_301
[77] INFR(2023)2181.
[78] INFR(2022)2174, INFR(2022)2176, INFR(2022)2181, and INFR(2022)2177.

the Commission called on Portugal[79] to take action to **reduce by-catch of protected cetaceans** by fishing vessels.[80]

2.1.4 Literature review on barriers to biodiversity conservation in the EU

Some obstacles to protect and conserve marine biodiversity identified in a literature review highlight similar recurring themes. Regarding the **implementation of relevant EU law**s, lack of effective, asymmetric or weak implementation has been identified (Fossi et al, 2020; O'Leary et al, 2024; Pröbstl et al, 2023; Hermoso et al, 2022); in the context of MPAs, EU legislation does not require MPAs to be supplied with management plans which makes defining actions needed and identifying authorities in charge more difficult (Muccitelli et al, 2023).

A persistent issue concerned the **absence of effective or limited monitoring**, due to lack of funding and resources (Muccitelli et al, 2023), short term monitoring that fails to provide clear indication of restoration trajectory or success (Danovaro et al, 2021), or general biodiversity monitoring schemes not suited for highly threatened taxa (Hochkirch, 2023).
Other obstacles include **agricultural land-use change**, which threatens marine species such as invertebrates and overexploitation of marine species (Hochkirch, 2023), habitat degradation (e.g. deep-sea mining and fisheries using towed gears with bottom contact) which makes any conservation and restoration effort more challenging (Danovaro et al, 2021), as well as pollution and the pressure it exerts on marine ecosystems (Tonin, 2018), particularly marine litter and plastic pollution (Fossi et al, 2020).

Lack of data renders any assessment of population trend data incomplete, affecting the assessment of species' risk of extinction (Hochkirch, 2023). Knowledge-related barriers to marine biodiversity and habitats protection and how certain issues may impact them are also prevalent (for instance, Fossi et al, 2020, emphasise how the impact of marine litter on marine habitats and species is not fully known). Relatedly, i**nsufficient coverage and protection of deep-sea habitats** results in their under-representation in MPA networks (Muccitelli et al, 2023; Claudet et al, 2021); a reason could be that the management of the deep sea appears too expensive: more funding and high-technology equipment is needed (Danovaro et al, 2021).

Another important obstacle is the **weak political will and lack of action from stakeholder**s: despite the existing evidence of the deteriorating status of marine biodiversity, action is still missing (Hochkirch, 2023). Additionally, the long time-scales required to achieve restoration (Danovaro et al, 2021) do not match short-term political cycles (O'Leary, 2024). Further, the complexity associated with lack of ownership of oceans and logistical challenges of working in a system with many major components raise difficulties for effective marine biodiversity protection (Danovaro et al, 2021). Limited engagement among different stakeholders, lack of collaboration and cooperation between projects and misalignment among organizations, people and processes has also been identified as a barrier to protect and conserve marine biodiversity (O'Leary, 2024).
Several articles specifically focused on MPAs and the failure to achieve their intended purpose. Concerns include: i**nadequate management of MPAs** (Giakoumi et al, 2024), **disconnected administration** in cases where the protected areas fall under different admninistrative boundaries (Podda and Porporato, 2023), i**ncomplete threat monitoring and reporting** resulting in unavailable data (Mazaris et al, 2019), and **lack of strong protection** which may allow for habitat-damaging fishing gears and actions (e.g. bottom trawling) (Predragovic et al, 2024; Perry et al, 2022; Mazaris et al, 2019). Another element often cited in relation to MPAs is the novel threats posed by **climate change**: species' decline in population increase the risk of extinction (Predragovic et al, 2024;

[79] INFR(2020)4038.
[80] See: European Commission, "November Infringements Package: Key Decisions" (16 November 2023).

Kyprioti et al, 2021) and the Natura 2000 network's not accounting for global warming (Mazaris et al, 2019), since MPAs have typically been selected assuming stable climate conditions.
Invasive alien species and their negative impact on marine biodiversity is another common barrier emerged from the literature review (Katsanevakis et al, 2023), causing species shift (Kyprioti et al, 2021) that affect the native biota. Climate change is expected to further exacerbate the issue of invasive alien species.

2.1.5 Recommendations

The EU reports and literature review analysed above reveal certain obstacles to protect biodiversity, but they also offer valuable recommendations and suggestions to address these challenges which are presented in this section separately.

Recommendations from EU official bodies

Recommendations from the **first State of Nature report** (2007-2012) are not considered since they refer to progress in implementing the now outdated EU 2020 Biodiversity Strategy. The **second State of Nature report** (2013-2018), published in 2020, introduced the new EU Biodiversity Strategy for 2030, stressing that the 2030 Strategy is specifically aimed at addressing the gaps from the 2020 Strategy while also focusing on restoration, rather than merely degradation and biodiversity loss.[81] As part of its recommendations, it highlights that additional effort is needed to improve the monitoring capacities within the Member States for the Nature Directives,[82] as well as new indicators and data to evaluate the role of the Natura 2000 network to achieve both the targets of the Nature Directives and the new 2030 Biodiversity Strategy;[83] future reporting should include expected changes in abundancy, distribution, and potential introduction of alien invasive species due to climate change; new standards ought to be set (e.g. for the ecological quality of a new designated area); finally, adequate financial and human resources are needed to achieve the 2030 targets.[84]

The **Biodiversity Strategy for 2030** by its nature sets objectives and provides recommendations to further protect and restore nature in the EU.[85] The recommendations related to marine biodiversity include the establishment of a coherent network of protected areas,[86] designing additional protected and strictly protected areas and setting up ecological corridors to prevent genetic isolation,[87] implementing a new EU Nature Restoration Plan,[88] by strengthening the EU legal framework for nature restoration and restoring the good environmental status of marine ecosystems.[89]

The 2023 **CFP** Report suggests the following elements to strengthen the implementation of the **CFP**: landing obligations, improving knowledge base and strengthening ecosystem-based approach, transparent process of quota allocation, fleet capacity framework, as well as use of EU funding and research opportunities .[90]

[81] State of Nature Report (2013-2018), p. 136.
[82] Ibid, p.136.
[83] Ibid.
[84] Ibid, pp. 136-137.
[85] EU Biodiversity Strategy for 2030, para. 2, pp.3-15.
[86] EU Biodiversity Strategy for 2030, para. 2.1, p.4.
[87] EU Biodiversity Strategy for 2030, para. 2.1, p.5.
[88] EU Biodiversity Strategy for 2030, para. 2.2, p.6.
[89] EU Biodiversity Strategy for 2030, para. 2.2.6, p.11.
[90] Report on the CFP, pp.18-19.

The 2020 Commission Report on the implementation of the **MSFD**[91] contains suggestions for the improvement of the Directive's implementation.[92] Recommendations include adopting a more coherent and ambitious determination of "good environmental status" amongst the Member States,[93] ensuring the effectiveness of measures,[94] streamlining implementation,[95] ensuring greater policy integration,[96] boosting regional cooperation,[97] ensuring data availability and comparability.[98]

The 2022 progress report on the **MSPD**[99] calls Member States to continue to reflect the ambitions of the European Green Deal in their maritime spatial plans as well as include cumulative impacts of anthropogenic pressures in such maritime plans;[100] continued involvement of stakeholders and implementation of monitoring plans is also encouraged.[101]

Additionally, the **European Court of Auditors** offers three recommendations on how to overcome the obstacles and threats it identified in its 2020 report: the Commission alongside its Member States ought to identify the regulatory and administrative changes necessary to protect sensitive species and habitats, enabling faster application of conservation measures under the CFP and MSFD while also incorporating current scientific knowledge to extend protection to more species;[102] the Commission together with relevant Member States should improve protection measures specifically in the Mediterranean, establishing further fishing protected areas in the Mediterranean Sea basin, and continuously report to enable corrective actions;[103] lastly the Commission alongside Member States is urged to identify ways to increase the potential of EU funding to marine conservation objectives.[104] The target implementation date for all three recommendations has passed. However, the EU Court of Auditors (ECA) has prepared a new audit mainly covering the Greater North Sea and Baltic Sea regions. Its findings and recommendations are expected to be published at the beginning of 2025.[105]

The **EEA** 2019 Briefing suggests improving the understanding of marine ecosystem, to better connect MPAs across European seas, improve reporting mechanisms and data flow, measure the degree to which MPAs are achieving their intended purpose,[106] establish larger MPAs beyond coastal waters to include both deeper waters and allow for spillover effect of fish biomass so as to support fishing outside the area whilst protecting biodiversity inside.[107]

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[91] European Commission, "Report from the Commission to the European Parliament and the Council on the implementation of the Marine Strategy Framework Directive (Directive 2008/56/EC)" (25 June 2020) https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0259.
[92] Ibid, para.5, p. 21.
[93] Ibid, para. 5.1, pp. 21-22.
[94] Ibid, para. 5.2, pp. 22-24.
[95] Ibid, para. 5.3, pp. 26-28.
[96] Ibid, para. 5.4, pp. 24-26.
[97] Ibid, para. 5.5, p. 28.
[98] Ibid, para. 5.6, pp. 28-29.
[99] European Commission, "Report from the Commission to the European Parliament and the Council outlining the progress made in implementing Directive 2014/89/EU establishing a framework for maritime spatial planning" (3 May 2022) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52022DC0185.
[100] Ibid, pp. 17-18.
[101] Ibid, p.18.
[102] ECA, Recommendation 1, p. 48.
[103] ECA, Recommendation 2, p. 49.
[104] ECA, Recommendation 3, p. 50.
[105] European Court of Auditors, "Diving into EU Sea Water Quality" (27 June 2024) https://www.eca.europa.eu/en/news/NEWS2024_07_NEWSLETTER_02 .
[106] EEA Briefing (2019), p. 8.
[107] EEA Briefing (2019), p. 5.

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[108] State of Nature Report (2013-2018), p. 136.
[109] Ibid, p.136.
[110] Ibid.
[111] Ibid, pp. 136-137.
[112] EU Biodiversity Strategy for 2030, para. 2, pp.3-15.
[113] EU Biodiversity Strategy for 2030, para. 2.1, p.4.
[114] EU Biodiversity Strategy for 2030, para. 2.1, p.5.
[115] EU Biodiversity Strategy for 2030, para. 2.2, p.6.
[116] EU Biodiversity Strategy for 2030, para. 2.2.6, p.11.
[117] Report on the CFP, pp.18-19.
[118] European Commission, "Report from the Commission to the European Parliament and the Council on the implementation of the Marine Strategy Framework Directive (Directive 2008/56/EC)" (25 June 2020) https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0259.
[119] Ibid, para.5, p. 21.
[120] Ibid, para. 5.1, pp. 21-22.
[121] Ibid, para. 5.2, pp. 22-24.
[122] Ibid, para. 5.3, pp. 26-28.

greater policy integration,[123] boosting regional cooperation,[124] ensuring data availability and comparability.[125]

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The **EEA** 2019 Briefing suggests improving the understanding of marine ecosystem, to better connect MPAs across European seas, improve reporting mechanisms and data flow, measure the degree to which MPAs are achieving their intended purpose,[133] establish larger MPAs beyond coastal waters to include both deeper waters and allow for spillover effect of fish biomass so as to support fishing outside the area whilst protecting biodiversity inside.[134]

Recommendations from the literature review

From the literature review, certain common themes emerged. Above all, the need to strengthen existing instruments and agendas, rather than creating new agendas and instruments, was emphasised (Pröbstl et al, 2023). The inclusion of all relevant stakeholders (Danovaro et al, 2021; Giakoumi et al, 2024, Fossi et al, 2020; O'Leary et al, 2024), from the general public (Hermoso et al, 2022; Tonin, 2018) to fishery, tourism or energy sector (Pröbstl et al, 2023), prioritizing conservation goals (Katsanevakis et al, 2020) was also frequently mentioned. In the context of MPAs, the need to

[123] Ibid, para. 5.4, pp. 24-26.
[124] Ibid, para. 5.5, p. 28.
[125] Ibid, para. 5.6, pp. 28-29.
[126] European Commission, "Report from the Commission to the European Parliament and the Council outlining the progress made in implementing Directive 2014/89/EU establishing a framework for maritime spatial planning" (3 May 2022) https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52022DC0185.
[127] Ibid, pp. 17-18.
[128] Ibid, p.18.
[129] ECA, Recommendation 1, p. 48.
[130] ECA, Recommendation 2, p. 49.
[131] ECA, Recommendation 3, p. 50.
[132] European Court of Auditors, "Diving into EU Sea Water Quality" (27 June 2024) https://www.eca.europa.eu/en/news/NEWS2024_07_NEWSLETTER_02 .
[133] EEA Briefing (2019), p. 8.
[134] EEA Briefing (2019), p. 5.

strengthen cooperation between MPA management authorities and research institutes (Giakoumi et al, 2024) as well as administrative cooperation (Podda and Porporato, 2023) to ensure actual protection in MPAs, rather than mere "paper parks" (Claudet et al, 2021).

Suggested policy recommendations include developing and adopting a more stringent and consistent approach to the implementation of Nature based solutions in the Union to prioritise threatened biodiversity (Riisager-Simonen et al, 2022), adopt environmental contracts (Muccitelli et al, 2023), learning from countries with high biosecurity (Katsanevakis et al, 2023), and developing simplified and accessible concept and policy guidance to provide clarity and consensus (O'Leary et al, 2024).

Implementing a more adaptive management was often mentioned as a recommendation to protect and conserve marine biodiversity, whether in the Natura 2000 framework (Katsanevakis et al, 2020) or as a means to respond to climate change and other dynamic conditions (Predragovic et al, 2024, Hermoso et al, 2022; Kyprioti et al, 2021, Mazaris et al, 2019), such as alien invasive species (Katsanevakis et al, 2023).

A multitude of recommendations related to conservation and effective management arose from the literature review as well. To ensure an ecologically-sound network of protected area, setting cross-border ecological corridors to ensure coherence, connectivity and resilient networks (Hermoso et al, 2022), applying systematic conservation planning principles in marine spatial planning (Katsanevakis et al, 2020), integrating ecological connectivity into MPA planning (Podda and Porporato, 2023), alongside the implementation of systematic conservation planning (Marakntonatou et al, 2021; Miu et al, 2020) were recommended. Other aspects such as using "other effective area-based conservation measures" as promoted by IUCN and Biodiversity Strategy (Hermoso et al, 2022), regional prioritization (Mazaris et al, 2024), simulation modeling on the impact of fisheries (Ovando D et al., 2021), management and prevention of invasive alien species (Katsanevakis et al, 2023) or their incorporation in conservation plans and management actions (Katsanevakis et al, 2020), focus on deep oceans (Danovaro et al, 2021), and the use of novel, restored or deliberately designed artificial marine ecosystems (Riisager-Simonen et al, 2022) represent other mentioned suggestions. Lastly, procuring substantial funding and high-technology equipment is needed, especially in the deep sea (Danovaro et al, 2021), dedicating an adequate share of the MPA annual budged to implement monitoring activities (Giakoumi et al, 2024).

2.1.6 Conclusions from the desk studies

The present desk study aimed at providing an analysis of the current applicable laws and policy related to the protection and conservation of marine biodiversity and their assessment vis-à-vis the fulfilment of their objectives within their respective deadlines. A description of barriers and obstacles to achieve such conservation and protection goals, based on official EU reports and a limited literature review, was offered. From the same documents, recommendations and suggestions to enhance the implementation of such policies and laws was offered. The picture that emerges from the study is one of mixed successes and shortcomings, with key barriers to effectively protecting and conserving marine biodiversity in European seas ranging from institutional to environmental and biological ones. As a response, the EU adopted in 2024 its first **Nature Restoration Law**, whose origins are to be found in the declining state of nature today,[135] further indicative of the limited success of policies and laws analysed in this study to halt, protect and conserve effectively marine biodiversity.

[135] European Council, "Nature Restoration" https://www.consilium.europa.eu/en/policies/nature-restoration/#state.

2.2 Workshops with end-users

Three 3 online workshops were arranged to elicit inputs from end-users on what constitutes relevant and purposeful indicators of marine biodiversity. Two of the workshops had a focus on northern European waters, while the third one focused on the waters of European countries in the Mediterranean. A total of 35 end-users participated in the workshops together with team members of the B-Useful project (Table 2). During the workshop, participants responded to a survey with questions about biodiversity indicators and barriers to achieving biodiversity goals. Outcomes of the survey are presented and analyzed in section 2.3 of this report.

Table 2. Overview of workshops.

Workshop	Date	Attendees	Examples of end-user profiles
GFCM context (1 group)	25.05.2023	19 Attendees. 6 Invited participants and 13 B-USEFUL Team members	MedPan; national research institute; eNGO
Northern European waters (3 sub-groups)	26.05.2023	28 Attendees 17 invited participants and 11 B-USEFUL Team members. 3 sub-groups	Representatives from national administration, OSPAR and HELCOM secretariats, fisheries, wind energy, and seafood
Northern European waters (3 sub-groups)	14.06.2023	20 attendees. 12 invited participants and 8 B-USEFUL Team members 3 sub-groups.	Representatives from national agencies, EFCA, fisheries, eNGO, wind energy
GFCM context (1 group)	15.06.2023	*Not completed due to limited participation*	NGO, GFCM

The following questions discussed in the workshop:

Key questions:

- What characterizes policy relevant and useful indicators of marine biodiversity?
- Do we have and are we using policy relevant and useful indicators of marine biodiversity?
- Do you have preferences regarding indicators?

Additional questions

- What do you see as the most important policies for the conservation of marine biodiversity in Europe?
- What do you see as the main barriers to achieving objectives of these policies?
- Do you have suggestions for the development of policy relevant indicators of marine biodiversity in the B-Useful project?
- Will the proposed Nature Restoration Law require new indicators to be developed and used?

This text provides a synthesis of what was discussed in the workshops in relation to the key questions listed above. The synthesis is as summarized in seven points. These points are presented as general views and compromise key messages from the participating end-users, although they do not necessarily reflect a consensus view.

1) **Take an integrated approach to indicator needs**

End-users recommend taking an integrated approach to indicators and to see biodiversity as a part of an Ecosystem Approach. As biodiversity is a highly complex phenomenon, different and

complementary indicators are needed. Strategic clusters of indicators should be identified regionally and locally. There is a particular need for indicators that take climate change into account. There is also a need for indicators of cumulative impacts from different stresses on the environment. End-user's advice on taking an integrated approach to indicators and to align indicator work with an ecosystem approach ties in with and consolidates a project's approach to build on the established approach of Essential Biodiversity Variables.

2) Desirable indicator characteristics of indicators

The list of desirable features of indicators is long, and end-users are aware that few indicators will perform well in respect to all desirable features**.** The most important features of indicators of marine biodiversity include that they are:

Relevant regarding the objectives in question, e.g. objectives of a considered MPA, or the specific objectives of a biodiversity related policy). In addition, should be relevant for reporting purposes, in the sense that they can support international reporting agreements and reporting periods.

Actionable, such that they inform and support effective management actions.
Responsive, reflecting changes in biodiversity

Harmonizable, in the sense of supporting indicator standardization and harmonization across scales

Feasible, in the sense that it needs be possible to obtain data and assess indicators in terms of cost-effectiveness and organizational capacity.

3) Establish reference levels

It is important to establish reference levels. Ideally, reference levels provide guidance on what constitutes acceptable or desirable states of an indicators. However, it may be difficult to establish reference levels. For instance, it may be difficult to establish reference levels of indicators where there is little information about the biodiversity aspects in question prior to the onset of significant anthropogenic pressures. When no other meaningful reference levels can be established, current levels of biodiversity indicator states can be used as reference levels. This allows changes in indicator levels to be assessed and evaluated.

4) Include representation of uncertainty

Information on uncertainty is important as it helps to establish the relevance and significance of indicator information in planning and decision making. If indicator information is presented without any information about uncertainty, it is unclear how the indicators can actually be used and relied on. End-users highlight the importance of communicating uncertainty in non-technical terms.

5) Include socio-economic information

End-users expressed a demand for information about the economic and social importance of areas considered for marine protection. This would enable decision makers to make informed decisions about trade-offs between conservation and use, which would not be possible based on biodiversity information alone. As a related point, end-users expressed an interest in the development of scenarios that consider socio-economic aspects along with biodiversity development.

6) Active and targeted communication

Biodiversity is a complex phenomenon, and different types of indicators will be needed to represent biodiversity. This makes communication about indicators important. Technically complex indicators can be relevant, but their use requires that particular attention is devoted to how they are communicated to end-users and other stakeholders. Communication strategies should be developed for different target groups.

7) Be aware of barriers to achieving biodiversity goals

End-users identified several barriers that prevent or impair the achievement of policies of key importance for marine biodiversity, such as the EUs 2030 Biodiversity Strategy and the Marine Strategy Framework Directive. These barriers include:

- *Interest conflicts* between perspectives of environmental protection and economic activities in marine areas, and a lack of clear priorities to support decision-making subjected to tradeoffs.
- *Confusion* about marine biodiversity and biodiversity indicators. Much of the confusion stems from that a vast number of used as well as considered indicators exists. Moreover, there has been a tendency to focus on indicators that represent aspects of species diversity and species richness, while indicators of other important biodiversity aspects such as community composition and ecosystem structure and function have received less attention.
- *Institutional fragmentation.* Institutional fragmentation arises for instance when there is insufficient coordination between policies and implementation actions at different scales, e.g. as ranging from the international to the national and local scales. B-Useful team members highlighted an important type of institutional fragmentation, which relates to the availability of data of relevance for assessing biodiversity indicators. In many cases, relevant data exists but it is cumbersome or difficult to gain access to the data from national laboratories. This makes it difficult to assess biodiversity on a regional (e.g. sea-basin) scale.

The above summary of the workshops discussions has been made available to the workshops participants. It is also available in an interactive form at the project website as well as in the form of a factsheet[136].

2.3 Survey

A survey was designed to elicit knowledge and views about what would constitute useful biodiversity indicators, how they might relate to biodiversity policies, and what current barriers are to implementing the objective of those policies. We particularly wanted to understand existing data gaps from the latter objective of this survey, however we ensured to capture broader perceived barriers so as to appraise the relative weight of data gaps in impeding the achievement of European biodiversity policy objectives. The questions used in the survey and the outcomes are accessible here.

The survey was offered to members of a biodiversity data end-user forum constituted under the hospice of the EU Horizon programme project B-USEFUL. The end user forum regroups 115 members provide a balanced representation in terms of gender, scale at which their group operates and sector representation (Figure 2). They represent contributions from eleven countries, including all

[136] https://b-useful.eu/activities/activities/

ICES ecoregions as well as the Mediterranean Sea, and six Advisory Councils. We also have key European data actors (STECF and EMODnet) represented. Industry representatives invited include the Fishing, Wind energy, Food, and Finance sectors.

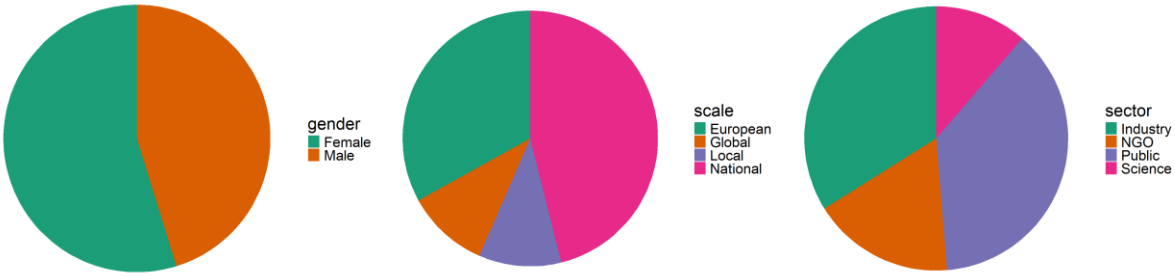

Figure 2. Distribution of the 115 end-user forum members by gender, scale at which their group works, and sector.

End-user forum members were invited to participate in the survey. The goal and objectives of the survey were first presented to them and a clear description of how their information would be used was described (Annex 2). The survey adhered strictly to GDPR. Participants were then asked for their informed consent with the understanding that they could withdraw it at any stage, which would result in their answers, and all metadata associated with it to be removed.

2.3.1 Analyses

Following quality control and summary statistics of participant demographics, we engaged in two sets of analyses for questions related to indicators, policies and barriers. Those questions (Q8, Q13, Q18, and Q25) were on a five-point Likert scale and asked participants to (i) rate agreements (Q8) and European policies (Q13) for their importance for marine biodiversity conservation, (ii) rate importance of potential barriers to achieving biodiversity policy objectives (Q18), (iii) identify the importance of biodiversity indicator characteristics given their usefulness to manage human activities so as to meet biodiversity policy objectives (Q25).

Ordination of question options

To understand whether participants ranked equally the different options for each question, we first estimated the polychoric correlation coefficient between response options given the Likert-scale responses treated as ordinal variables. We then used a factor analysis (maximising the likelihood estimate) to ordinate the variable and assess whether the n-space (n is 5, 6, 13, and 6 respectively for questions 8, 13, 18, and 25) of options for the question can be reduced to a reduced-dimension space where latent factors capture variables (question options) ranked to be of similar importance by participants. The factor analysis used the polychoric correlation coefficient matrix. To decide how many factors should be retained in the reduced space, we compared the distribution of the variance explained by the first p ($p \in [1, n]$) estimated factors to the average amount of variance explained by the same number of factors for 1000 randomised polychoric correlation coefficient matrices. We used the library psych v4.6 in R 4.3 for this ordination process (Revelle, William, 2024).

Clustering of participants by their key characteristics

Once we understand how the options covary, we then can assess whether particular characteristics of the participants might influence how they rank these latent factors. Here we are particularly interested to understand whether diverging views exist among stakeholder types (research

institutions, managers, industry representatives, and NGO representatives). Our challenge is that our samples are unbalanced and therefore, additional characteristics of participants might create confounding effects with our variable of interest (stakeholder type). Given that some of those effects could be non-monotonic, we engaged in a machine learning modelling exercise to understand from the data what are the more important variables that can efficiently classify correctly the rank answers of participants. To do so we used an ordinal forest model to classify the Likert scale rank given by each participant (ordinal response variable with five categories) given the characteristics of each participants collected as metadata during the survey: gender, work experience, time taken to complete the survey, sector and scale at which the participants work (Figure 2), whether the participant directly contributes to achieving policy objectives, and whether the participant works in GFCM ecoregions.

An ordinal forest model (Hornung, 2020), simply extend the principles of random forest to ordinal response variables where decision trees are fitted to classify answers in one of the 5 categories depending on the explanatory variables listed above (Breiman, 2001). A random forest replicates this process many times (here 1000 trees) to provide a robust and testable estimate of the importance of variables in discriminating among the five categories of the response variable. Here we focus on the ranked probability skill score (RPSS), a measure more appropriate for ordinal response variables (Hornung, 2020). This measure is used to train the trees and we use it to rank the importance of the covariates in improving the accuracy and discrimination of the random forest as a permutation variable importance score to contrast the trees with all variables to the trees when one covariate is removed for the tree training. That is in this instance, the more important a covariate is to the classification abilities of the random forest, the larger the variable importance score ($rpss_{error}$) is. If $rpss_{error}$ is negative, it means the classification improves when the variable is removed.

We fitted a model for each option in question sets (30 models in total). For cases where stakeholder type was detected to be an important variable to discriminate rank answers, we then fitted on ordered linear regression to the same response variable to estimate the effect of stakeholder type given the additional variables which were deemed to be of importance in that random forest model. We use ordinalForest in R 4.3 to fit ordinal forest (Hornung, 2020) and for this analysis set, NAs were imputed to be “neutral” responses (8-15% of responses were NAs for those four sets of questions). We used ordinal 2023.12-4.1 in R 4.3 (Christensen, 2023) to fit ordered linear regressions (Greene & Hensher, 2010) (cumulative link model). We used 100 sets of 1000 trees to estimate the scores (RPSS) and constructed the random forest based on the final 5000 trees with a training goal to retrieve the same probability distribution of importance rank.

2.3.2 Results

The survey participation rate was 41.7% (n=48) and representative of the end-user forum (Figure 3). It took participants on average 64.6 minutes (SE=8.52) to complete it.

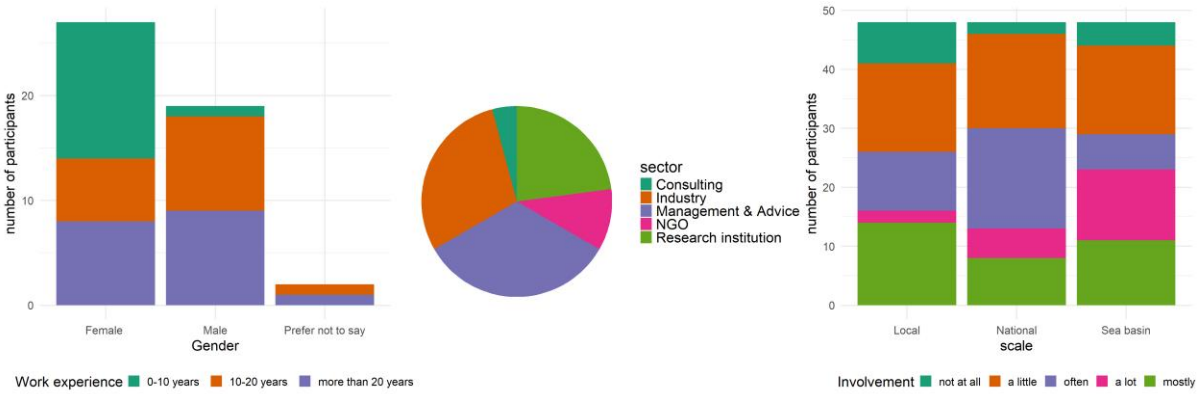

Figure 3. demographics of the 48 survey participants.

On average the 2030 European Biodiversity strategy and the Marine Strategic Framework Directive were deemed the more important European regulations to manage marine biodiversity (Figure 4a). The former was perceived to also be an important international agreement, which can be explained as it underpins the now Nature Restoration Regulation which was still being discussed at the time of the survey. Internationally, the Convention on Biological Diversity (CBD) is deemed more important (Figure 4b) yet the Kunming-Montreal Global Biodiversity Framework, which was adopted by the CBD Convention of Parties was the least ranked (it had the most missing responses). Information at the ecosystem scale was deemed to be more important for biodiversity indicators (Figure 4d), even though status of species population also received high important ranking. The latter being associated with Habitats and Birds Directives obligations. Three barriers emerged as more important to policy objectives implementation. Two of those relate to their very definition (Figure 4c): the lack of obligations, and therefore the lack of clear consequences associated with infringements, and objectives not following a SMART design (specific, measurable, achievable, relevant and time-bound). Biodiversity objectives conflicts with stakeholder interests was also an important barrier. These three barriers create a difficult management landscape. Getting relevant biodiversity indicators was ranked least important in contrast to other barriers.

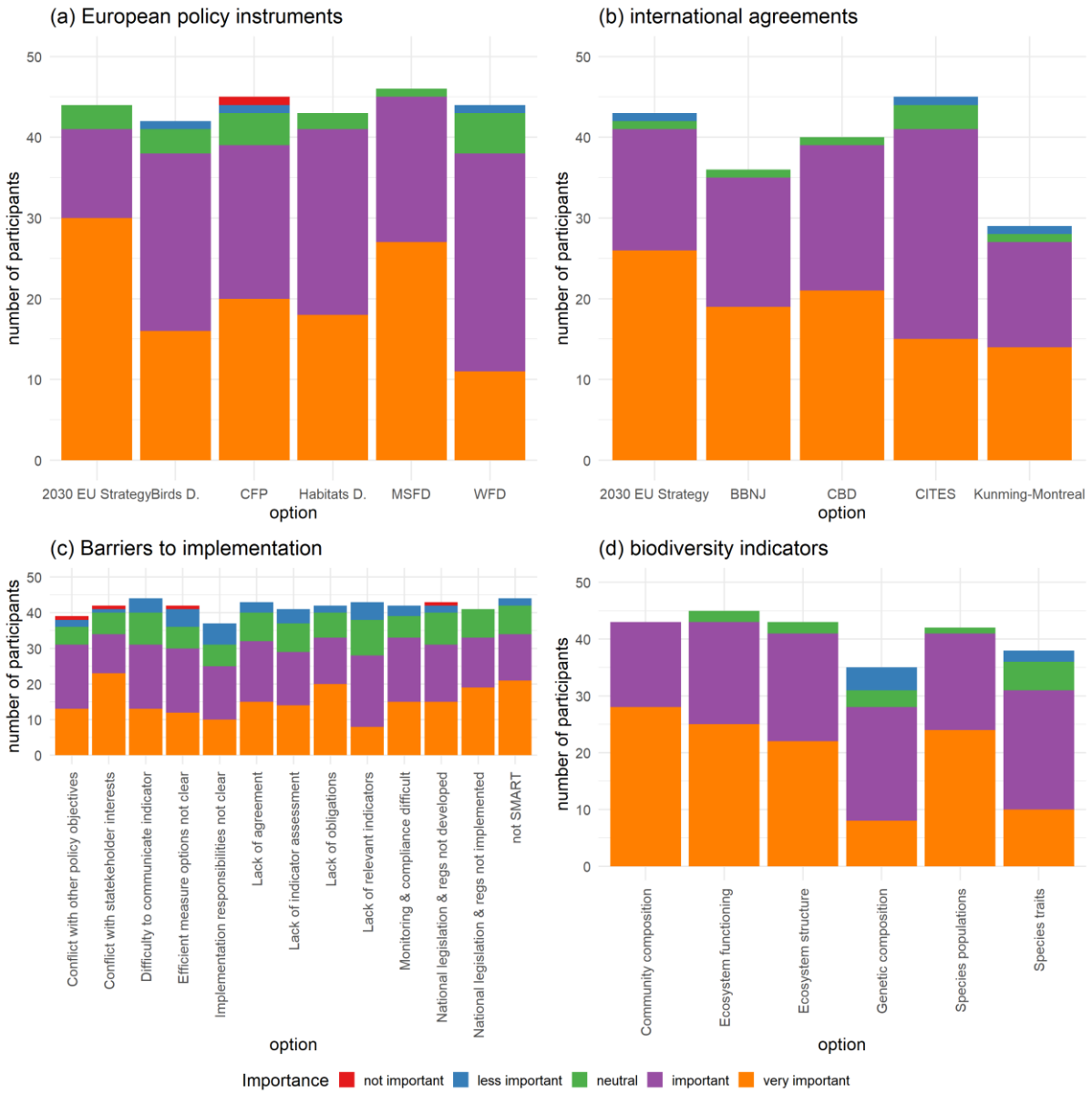

Figure 4. Summary of survey responses for the four questions.

Biodiversity indicators

Three people did not respond to this question set (two from industry and one from management & advice). The set of six options could be reduced to three latent factors (Figure 5) and the weight of each characteristic on these factors, meant we could group them in three categories. We could then interpret the survey summary (Figure 4d) with those groups to show that respondents ranked Ecosystem functioning as a more important feature of biodiversity indicators followed by community composition and species population together. The other indicators were deemed less important.

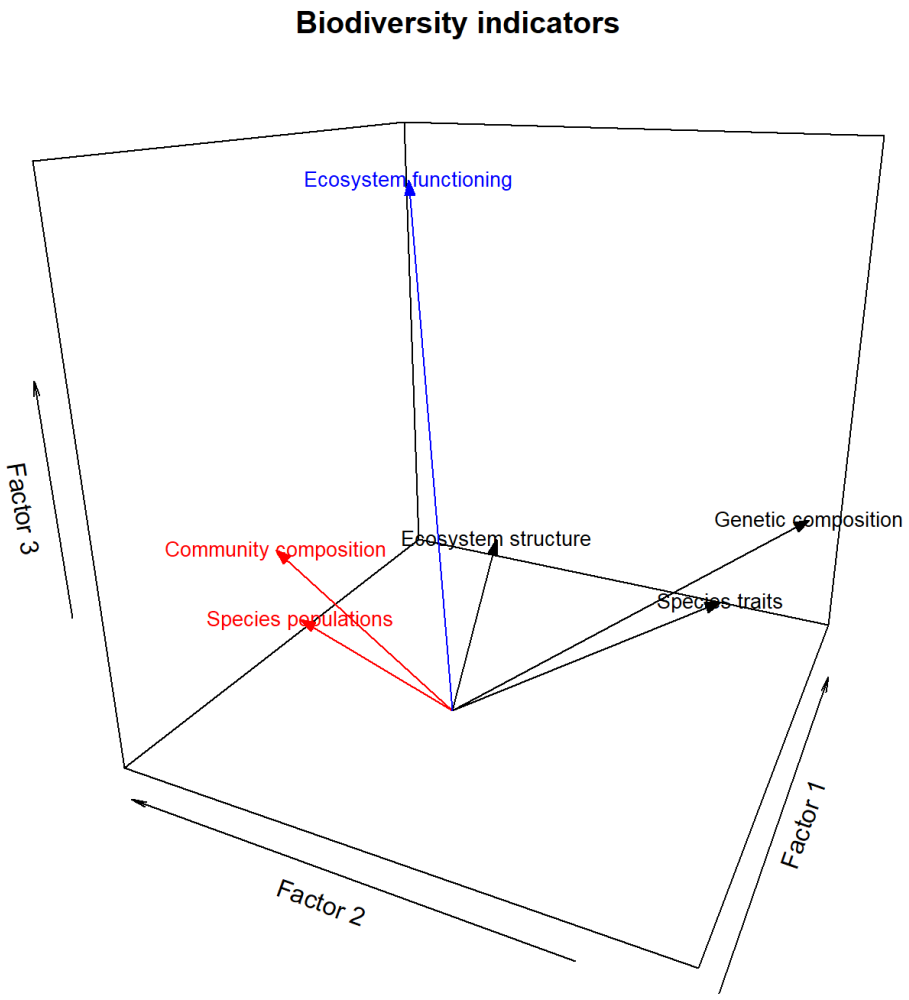

Figure 5. Ordination of responses to the question relating to characteristics of biodiversity indicators. The six-dimensional space can be reduced to three factors and the relation of the indicators to those factors is presented with colour: black characteristics that were commonly ranked similarly and that can be associated to Factor 1, red characteristics that were commonly ranked similarly and that can be associated to Factor 2, blue characteristics that were commonly ranked similarly and that can be associated to Factor 3.

We then assessed whether we could predict the ordinal response level chosen by respondents given their characteristics (stakeholder type, survey completion duration, indicator user, scale of work, gender, work experience, region of focus, and whether they are responsible for policy objectives; see methods) applying random forest to this ordinal regression.

We find that for the six biodiversity indicators, the random forest achieved good prediction accuracy on the data (Table 3). Stakeholder type was not an important variable for genetic composition, species traits, and ecosystem structure, which covers all indicator in first factor of the ordination (Figure 5). It was an important variable for the other indicators and the most important for species populations. There is a consistent importance of gender in all indicators (Table 3). For the indicators where stakeholder was an important variable, we find that “management and advise” stakeholders

were consistently ranking indicators similarly to “industry” stakeholders but that ranking differed from others (Figure 5).

Table 3. Outcome of the ordinal forest for the six biodiversity indicators. Accuracy emerges from both false positive and false negative rate in the confusion matrix contrasting prediction to observations (significance of the accuracy rate in contrast with randomised confusion matrices: *** p<0.0001)

Indicator	*Accuracy*	*Important variables*
Genetic composition	0.81***	Work at local scale > gender
Species populations	0.83***	**Stakeholder** > gender > indicator user > duration
Species traits	0.90***	Duration > gender
Community composition	0.79***	Duration > gender > indicator user > **stakeholder**
Ecosystem functioning	0.90***	Work at local scale > gender > Duration > **stakeholder**
Ecosystem structure	0.90***	Duration>responsible for objectives>work at sea basin scale

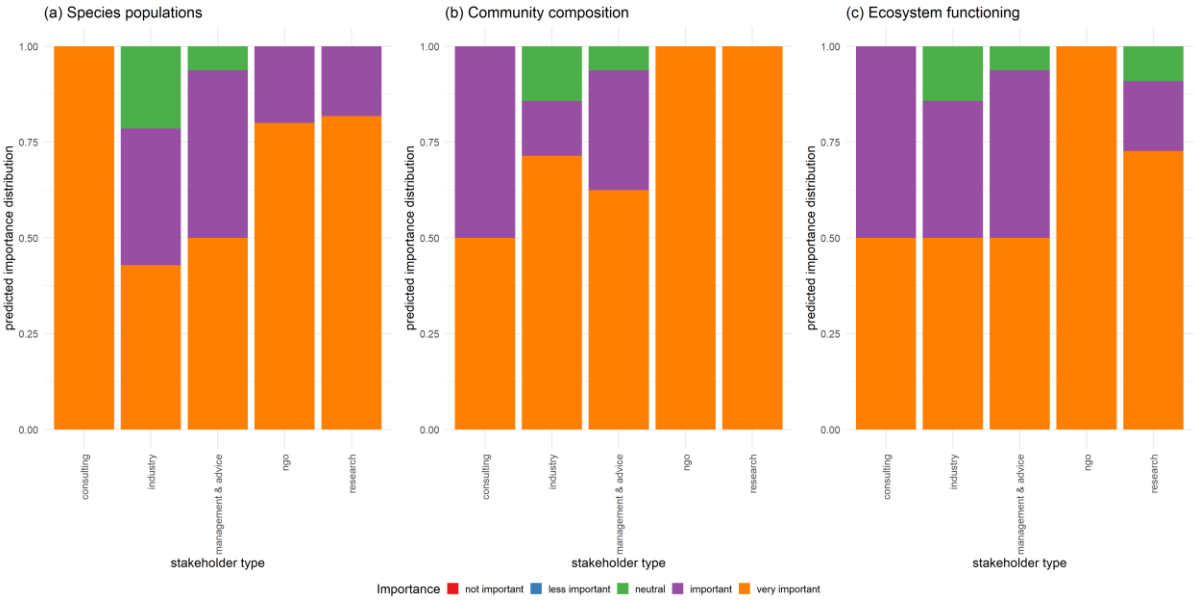

Figure 6. predicted proportional ranking of Species populations, Community composition, an Ecosystem Functioning for the different stakeholder types.

Policy instruments

The set of six options could be reduced to three latent factors (Figure 6) and the weight of each characteristic on these factors, meant we could group them in three categories. We could then interpret the survey summary (Figure 4a) with those groups to show that respondents ranked the 2030 EU biodiversity Strategy as a more important policy instrument followed by MFSD, CFP and WFD.

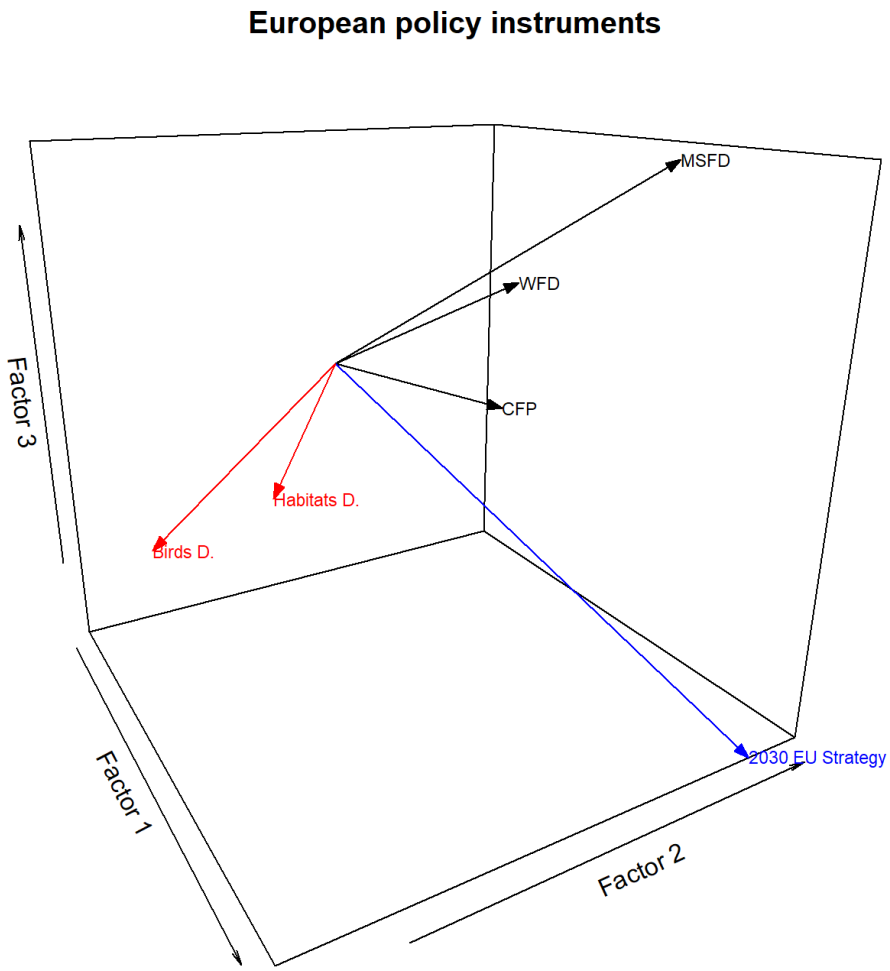

Figure 7. Ordination of responses to the question relating to the importance of European policy instruments. The six-dimensional space can be reduced to three factors and the relation of the indicators to those factors is presented with colour: black instruments that were commonly ranked similarly and that can be associated to Factor 1, red instruments that were commonly ranked similarly and that can be associated to Factor 2, blue instruments that were commonly ranked similarly and that can be associated to Factor 3.

We find that for the 50% of the policy instruments, the random forest did not achieve good prediction accuracy on the data (Table 4). This means that the covariates we considered were not useful to discriminate among the importance rank given by the respondents. Stakeholder type was an important variable for all remaining policy instruments (Table 4). End users differed in their views on the importance of the Habitats and Birds Directive and the CFP (Figure 7). “management & advice” stakeholders tended to rank those instruments somewhat with less importance as “industry” stakeholders did (Figure 7).

Table 4. Outcome of the ordinal forest for the six policy instruments. Accuracy emerges from both false positive and false negative rate in the confusion matrix contrasting prediction to observations (significance of

the accuracy rate in contrast with randomised confusion matrices: ns>0.05,*<0.05,**<0.001,*** p<0.0001). if an ordinal forest model was not accurate, we did not appraise the importance of covariates.

Indicator	*Accuracy*	*Important variables*
MSFD	0.81^{ns}	NA
Habitats Directive	0.88***	Work experience > duration > **stakeholder**
Birds Directive	0.79*	Work experience > duration > **stakeholder** > gender
Water Framework Directive	0.71^{ns}	NA
Common Fisheries Policy	0.90***	Duration > work at sea basin scale > **stakeholder** > responsible for objective
2030 Biodiversity strategy	0.81^{ns}	NA

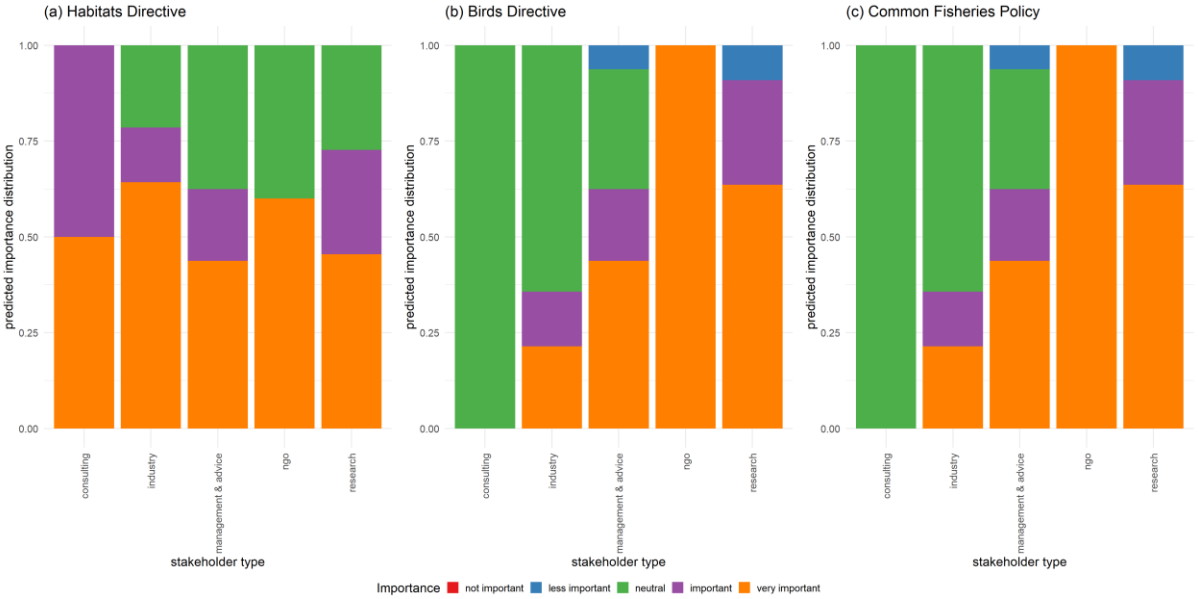

Figure 7. Predicted proportional ranking of Habitats Directive, Birds Directive, and Common Fisheries Policy for the different stakeholder types.

International agreements

The set of five options could be reduced to one latent factor (Figure 8) and the weight of each characteristic on these factors, meant we could group them in three categories. We could then interpret the survey summary (Figure 4b) with those groups to show that respondents ranked the 2030 EU biodiversity Strategy as a more important policy instrument and CITES as the least.

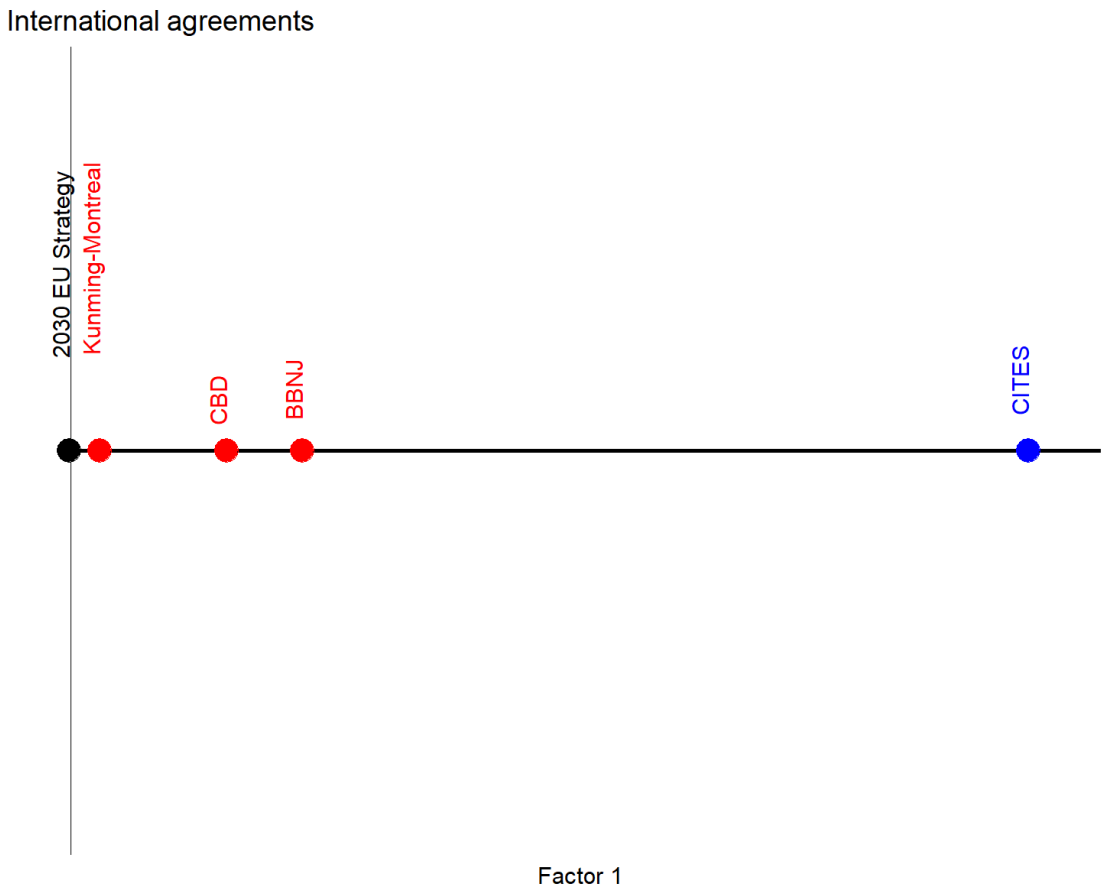

Figure 8. Ordination of responses to the question relating importance of international agreements. The five-dimensional space can be reduced to one factor and the grouping of the indicators along this factor is represented with colours.

Table 5. Outcome of the ordinal forest for the five international agreements. Accuracy emerges from both false positive and false negative rate in the confusion matrix contrasting prediction to observations (significance of the accuracy rate in contrast with randomised confusion matrices: ns>0.05,*<0.05,**<0.001,*** p<0.0001). if an ordinal forest model was not accurate, we did not appraise the importance of covariates.

Indicator	*Accuracy*	*Important variables*
Biodiversity Beyond National Jurisdiction	0.90***	Work experience > **stakeholder**
Kunming-Montreal Agreement	0.85***	Work at sea basin scale > indicator user > work at national scale > work at local scale
CITES	0.79^{ns}	
2030 Biodiversity strategy	0.81^{ns}	
Convention on BioDiversity	0.90***	Duration > indicator user

We find that the random forest did not achieve good prediction accuracy on the data for CITES and the 2030 EU Biodiversity Strategy (Table 5). This means that the covariates we considered were not useful to discriminate among the importance rank given by the respondents. Stakeholder type was an important variable for BBNJ (Table 5) and interestingly the scale at which end users worked was important for the ranking of the Kunming—Montréal agreement. The different end users ranked

BBNJ in varied manner, ranging from less important for industry stakeholders, to most for NGO stakeholders (Figure 9).

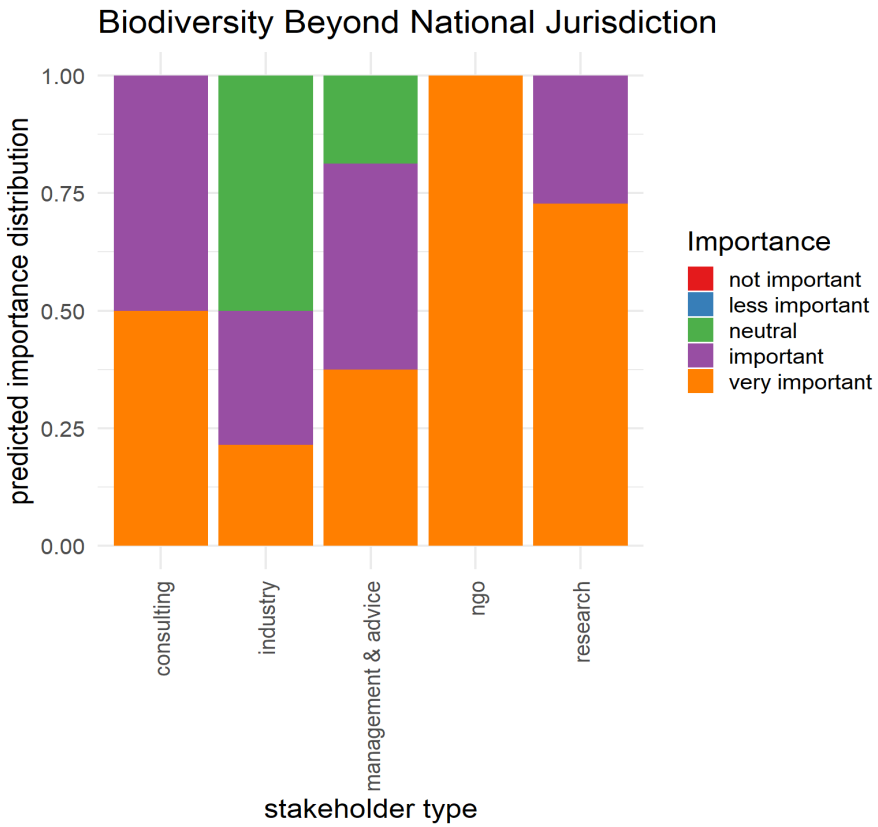

Figure 9. Predicted proportional ranking of BBNJ for the different stakeholder types

Barriers to implementation

The set of 13 options could be reduced to three latent factors (Figure 10) and the weight of each characteristic on these factors, meant we could group them in three categories. We could then interpret the survey summary (Figure 4c) with those groups to show that respondents ranked barriers associated with latent Factor 3 (Figure 10) as more important, this includes objectives being not S.M.A.R.T., a lack of obligations, conflicts between biodiversity objectives and other policy objectives, and conflicts between biodiversity objectives and stakeholder interests. Issues with biodiversity indicator choice, measure, or assessment were not included in this group (Figure 10).

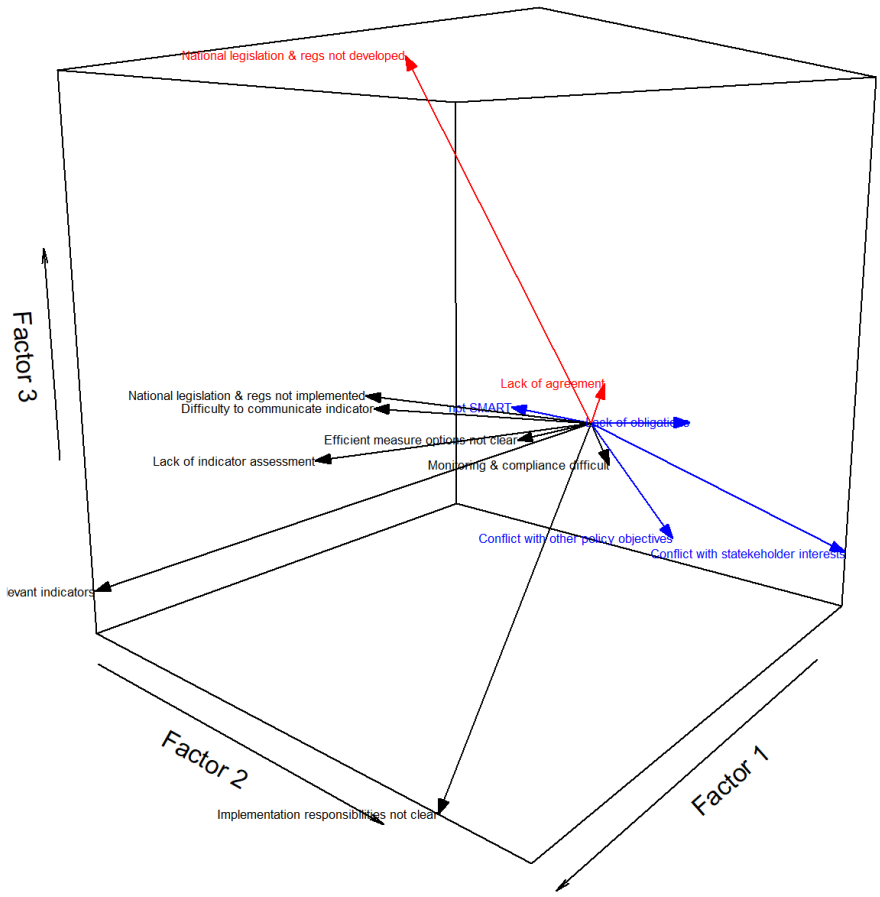

Figure 10. Ordination of responses to the question relating to barriers to policy implementation. The 13-dimensional space can be reduced to three factors and the relation of the indicators to those factors is presented with colour: black barriers that were commonly ranked similarly and that can be associated to Factor 1, red barriers that were commonly ranked similarly and that can be associated to Factor 2, blue barriers that were commonly ranked similarly and that can be associated to Factor 3.

We find that for almost all barriers, the random forest achieved good prediction accuracy on the data (Table 6). Stakeholder type was an important variable (Table 6). Stakeholder is an important variable for three of the 13 barriers considered (Table 6). Importantly, we have little agreement among stakeholders about how important those barriers are; even though most perceive them important to some degree (Figure 11). Yet, the lack of efficient measures (Figure 11c) is seen as less important by stakeholders other than industry and “management & advice” stakeholders.
We see also regional differences emerge in barrier importance ranking (Table 6). That is a difference between end users working in the Mediterranean Sea compared to those working in other regions. The lack of obligations was perceived as more important for Mediterranean end users while they perceived the lack of efficient measures and conflicts between biodiversity objectives and other policy objectives as less important (Figure 12).

Additional information about the survey analysis is provided in Annex 1.

Table 6. Outcome of the ordinal forest for the 13 barriers to implementation considered. Accuracy emerges from both false positive and false negative rate in the confusion matrix contrasting prediction to observations (significance of the accuracy rate in contrast with randomised confusion matrices: ns>0.05,*<0.05,**<0.001,*** p<0.0001). if an ordinal forest model was not accurate, we did not appraise the importance of covariates.

Indicator	*Accuracy*	*Important variables*
Lack of agreement	0.92***	Work at local scale > indicator user > work at sea basin scale > duration
Not SMART	0.81***	Work experience > work at sea basin scale > duration
Lack of obligations	0.85***	**Stakeholder** > work at local scale > work at national scale > *region*
National legislation and regulations not developed	0.92***	Work experience > work at national scale > responsible for objective
National legislation and regulations not implemented	0.98***	**Stakeholder** > duration > work at local scale > responsible for objectives > gender
Lack of relevant indicators	0.75*	Gender
Lack of indicator assessment	0.92***	Gender
Difficulty to communicate indicators	0.85***	Duration > work at sea basin scale > work experience > gender
Implementation responsibilities not clear	0.85***	Duration > work experience > gender
Efficient measure options not clear	0.88***	Duration > *region* > **stakeholder** > gender
Monitoring & compliance difficult	0.94***	Gender > duration > work experience
Conflict with stakeholder interests	0.75^{ns}	NA
Conflict with other policy objectives	0.90***	Duration > *region*

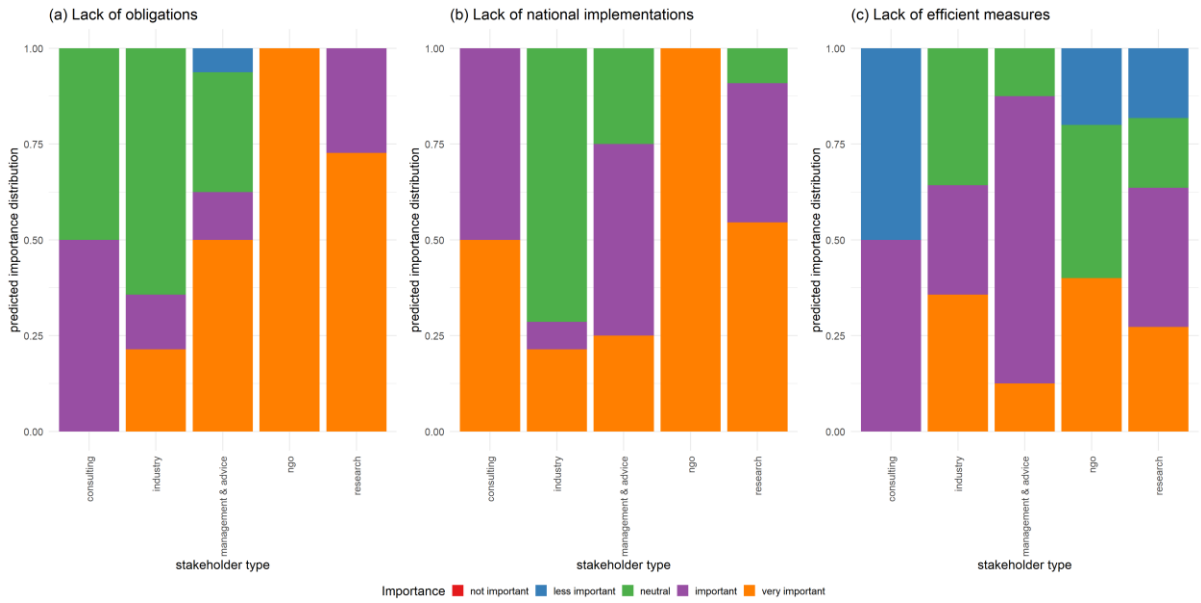

Figure 11. Predicted proportional ranking of lack of obligations, national implementations, and efficient measures as barriers to biodiversity objective implementation for the different stakeholder types.

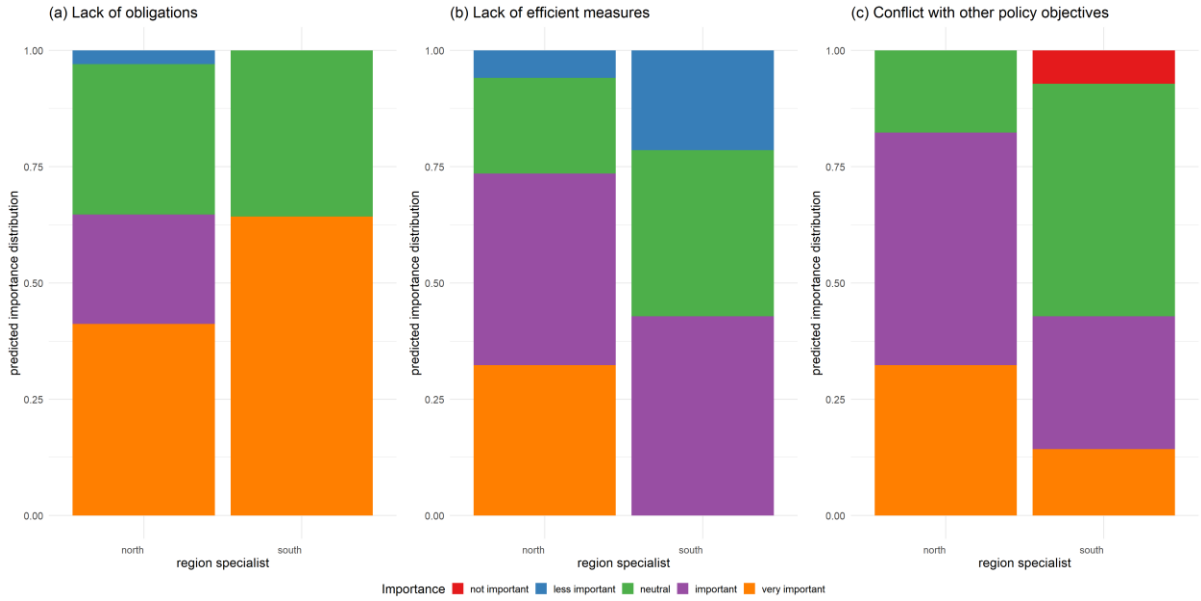

Figure 12. Predicted proportional ranking of lack of obligations, national implementations, and efficient measures as barriers to biodiversity objective implementation for end users from the Mediterranean sea ("south") and others ("north").

2.3.3 Discussion

End users ranked Ecosystem functioning as a more important feature of biodiversity indicators followed by community composition and species population together. However, these were also the indicators for which there was a difference in ranking between stakeholders, with "management & advice" and industry stakeholders ranking them as less important than others did. Although, the difference really emerges between whether those indicators are 'very important' or 'important'. Lack of agreement was more pervasive between stakeholders for the importance of policy instruments and the barriers to implementing biodiversity objectives.

In those barriers, technical aspects of biodiversity indicators (indicator selection, measurement, and assessment) did not emerge as the more important barriers to implementation.

We broadly did not find differences between end users working in the Mediterranean Sea in contrast with those working in other European Seas. It should therefore be possible to employ similar indicators across all European regions and synthesise our understanding of barriers across all regions. However, those differed on their ranking of barriers; particularly lack of obligations and the conflict between biodiversity objectives and other policy objectives as a barrier to implementation (Table 4). For Mediterranean Sea end users conflicts with other policy objectives is less important (Figure 12c) as is the potential lack of efficient measures (Figure 12b).

It is worth noting that a gender difference is prevalent in the importance ranking of biodiversity indicators. In barriers, gender emerges as the only important variable when asked whether we lack relevant biodiversity indicators or their assessment. At the moment, we lack a theoretical foundation to propose mechanisms for those effects. This is an area of research which needs to be expanded to understand its causes and consequences.

2.4 Interviews

Interviews

A total of 9 interviews were conducted with actors that engage professionally with marine biodiversity management in Europe in different ways, especially in terms of development, implementation and monitoring of policies. In addition, written inputs from respondents were obtained in two cases (Table 7). The interviews were semi-structured based on a set of questions developed for the present purposes (Annex 3). The interviews typically lasted about 1 hour. Due to the time constraint of the interviews, not all questions were covered. However, the main topics that the questions were divided into were covered in all interviews.

Table 7. Overview of interviews.

Respondent profile	Code	Interviewer	Output
CEFAS	CEFASa	KNN	Transcript
CEFAS	CEFASb	KNN	Written inputs
DG Environment	DGENV1	KNN	Transcript
DG Environment	DGENV2	KNN	Transcript
DG Mare	DGMARE1	KNN	Transcript
DG Mare	DGMARE2	KNN	Transcript
Energy Company	ENERGY	KNN	Transcript
Environmental NGO, North Sea area	ENGO	KNN	Transcript
Manager, North Sea area	MANAGER_NS	LJ	Written input[137]
Manager, Southwest Europe	MANAGER_SW	TM	Transcript
MEDPAN	MEDPAN	KNN	Transcript

Prior to the interview, an information letter describing the purpose of the study, the discussion topics, and the handling of interview information was sent to the respondents together with a consent form (Annex 4). The Norwegian Agency for Shared Services in Education and Research assessed the approach to be fully compliant with requirements of General Data Protection Regulations. The interviews were audio-recorded and transcribed. The transcripts were slightly edited to improve conciseness and clarity (e.g., removing false starts and word repetitions) and person identifiers were removed. The interviews transcripts and the written inputs resulted in a combined text material of about 70000 words.

Interviews were not included in the methodological toolkit when the task that is reported from here began. The interviews represent an additional research activity to the planned work, which will provide further empirical findings and an opportunity to triangulate findings with the outcomes from the other pursued methods. However, as the work with interviews started later, the formal analysis of the interviews has not been completed at the time of writing[138]. Nevertheless, we have decided to include some provisional findings from the interviews, as it provides interesting and complementary information to the outputs of the other used methods.

[137] In this case, no interview was conducted. Instead, the respondents provided written replies to the questions.

[138] The text material is currently being coded by the first author in N-vivo 14.

3.4.1 What are the main policies for the conservation of marine biodiversity in Europe?

A respondent from DG Environment environmental legislation in support of marine biodiversity as a „package“, which includes: The Water Framework Directive, the Birds Directive, the Habitats Directive, the Marine Strategy Framework Directive, and now also the Nature Restoration Law. The respondent also highlighted the importance of Maritime Spatial Planning Directive. Although there are differences between the scope and instruments of these policies, they are all important components of this package, and they should work as coherent a whole. The CFP is also important for marine biodiversity (DG ENV1). However, DG ENV1 noted, that it is difficult to reconcile the CFP with the environmental legislation, as the CFP includes economic objectives as a well as environmental objectives. In this context, DG ENV1 sees a role for the MSPD in bridging the policies though the member states work with developing maritime spatial plans:

> […] we think that the [MSPD] is the key to integrate environmental objectives and environmental principles into the management of human activities.

The MSFD, the MSPD and the CFP state a commitment to an ecosystem approach. The respondent portrayed an “ecosystem-based maritime spatial planning” as an overarching strategy to reconcile environmental and economic objectives in the marine context. This strategy involves the setting of ecological boundaries for the sustainability of maritime spatial plans. The respondent identified the Commission Decision[139] as a key piece of legislation in this respect, as it requests the identification of thresholds for Good Environmental Status. The respondent also highlighted the important of assessing cumulative impacts of environmental pressures.

What are the objectives of these policies and are the objectives being met?
The respondents generally express the view that the objectives of key policies for marine biodiversity have not been achieved, and that more effective policies and measures are needed. For instance, regarding the MSFD, one respondent observed: “The objective was good environmental status by 2020. That was failed” (DG ENV1).

What are the main barriers to achieving the objectives of the main policies for marine biodiversity in Europe?

One respondent noted that the ongoing evaluation of the MSFD has identified 5 areas of weaknesses:

- The legal framework
- Implementation
- Policy coherence
- Regional cooperation
- Data collection and data flows

Illustrations of problems relating to some of these areas are provided below.

[139] COMMISSION DECISION (EU) 2017/848 of 17 May 2017 laying down criteria and methodological standards on good environmental status of marine waters and specifications and standardised methods for monitoring and assessment, and repealing Decision 2010/477/EU

Legal framework and implementation

Several respondents (including but not limited to DG ENV1 and DG ENV2) observed legal weakness with the MSFD that relate to the national implementation of the European Directives. One respondent expressed the problems as follows:

> So it's very difficult for us to take a member state to court because they haven't achieved good environmental status. It would be impossible for us to do that. It would also not be realistic because good environmental status is complex and long-term objective. The only very strict obligations that we have in the directive in which we've used are the reporting one (DG ENV1).

The respondent explained this challenge further as follows:

> …legislation in the EU apply only to individual member states. It doesn't apply to a collection of member states. It doesn't apply to a whole region. It applies, you can only take one member state to court. You don't take a whole bunch of member states to courts. So we have to find this balance between this wanting to understand and capture the complexity of the marine environment and at the same time being able to force member state to take action through legislative means (DG ENV1)

The respondent noted that this weakness can be addressed through establishing "intermediate targets" and through a strategic shift from a focus on the environmental objectives to be achieved to a focus on specifying requirements in terms of the measures that member states should have in place to protect marine biodiversity, which is something that can be enforced legally. The respondent explained that the Nature Restoration Law will be focusing on measures, and it will thereby support the implementation of the MSFD.

Several respondents noted challenges with national monitoring programs. In part, these challenges relate a lack of capacity in some member state administrations, but they may also relate to a lack of funding.

Data collection and data flows

Several respondents observed challenges with cooperation between members states about marine biodiversity data collection and with sharing. Such cooperation is important to provide for assessment of biodiversity on a regional basis. The cooperation may be limited by states not being willing to share data with other states, but often there are practical challenges to work out, relating to differences in the approaches to data collection.

Other types of barriers to effective marine biodiversity governance

<u>Lack of political will and biodiversity literacy</u>

Several respondents identified a lack of political will as a key barrier to the achievement of objectives of marine biodiversity relevant policies (CEFAS1, DG ENV1, DG ENV2). One respondent linked the lack of political will to a lack of ability to measure the socio-ecological benefits of biodiversity protection. The temporal spatial scales of biodiversity are very challenging, as positive effects of measures taken to protect biodiversity will only be observed in the long term. In turn, this

challenge be associated with the topic of biodiversity literacy, i.e. that the general public and politicians often have a limited understanding of what is involved with marine biodiversity, and why marine biodiversity is important. Several respondents (DG ENV1, CEFAS1) identified biodiversity literacy as an important challenge. As a corollary to this, one respondent expressed the view that limited biodiversity literacy may skew the focus on biodiversity measures towards publicly well-known aspects:

> We still have a very strong focus on certain iconic species and now certain iconic habitats […] as well, especially with the carbon discussion. There's a lot less focus and attention to the more complex interactions. […] I think it's something for us to work on in the coming years [DG ENV).

What characterizes purposeful indicators of marine biodiversity?
All respondents highlighted a need to see biodiversity as an element of an ecosystem approach. One respondent expressed this as follows:

> Without an ecosystem approach, you cannot address biodiversity issues today. And that entails everything, including climate change and fisheries. And everything needs such an ecosystem approach down to maritime spatial planning, because if you don't have that one piece of puzzle, which concerns a part of ecosystem or part of activity, which is linked, […] it's more difficult to achieve biodiversity conservation and restoration (DG ENV1)

The orientation towards an ecosystem approach has two implications for biodiversity indicators in support of biodiversity protection. First, it expresses a need for understanding the value of marine areas for human activities, to arrive at the best possible combinations of area use and area protection. Second, it ties in with, and underlines the need for, research on biodiversity indicators at higher levels of biological organization, including at the levels of communities, food webs and ecosystem functioning.

2.5 Serious game: The iBLUE game

Here we aimed to identify end-user needs and governance barriers to biodiversity protection using state-of-the-art serious games approaches. To this end we have developed an approach with a serious game focused on indicators and marine spatial planning of MSP in which the discussion, dialogue, barriers, needs, dilemmas and trade-offs were actively gathered. In addition, information was retrieved with a pre-survey and post-survey and a triple W interview technique.

2.5.1 Background information data Serious Game iBLUE

The game was played three times, at three levels of managing biodiversity: regional, national and European. In addition, they represented, a Northern country, a southern and the European Union. Overall, the respondents of the survey (n = 21) included NGOs/civil society roles (23%), civil servants (27%), policy makers (10%) (Figure 1). One respondent indicated a dual role as a researcher. Respondents were employed in Belgium (43%), Spain (38%) and the Netherlands (19%).

Most of them had a background in natural sciences, followed by social sciences (Figure 2)

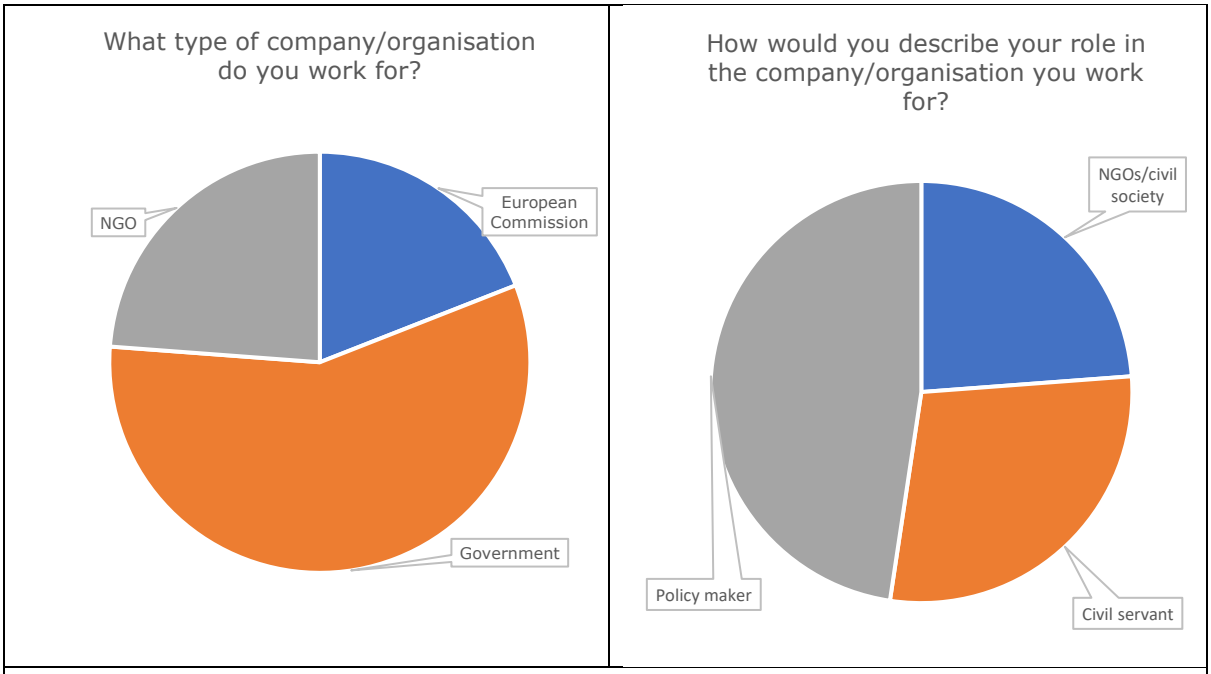

Figure 1 Distribution of the game players in terms of company/organisation and role in the company/organisation

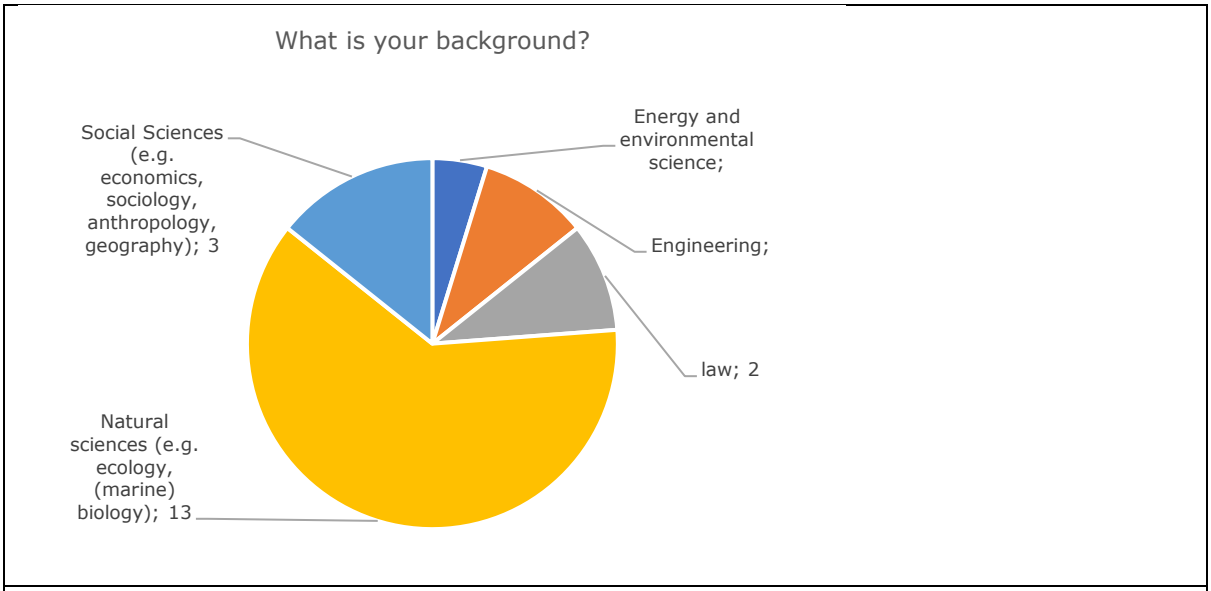

Figure 2 Background of the game players

The mean total years of work experience was 10.5 years, and mean years of work experience in the field of biodiversity (management) was 7.2 years. 18 of the respondents were currently involved in biodiversity (management) directly, while 3 were not. Participants were involved in the topic through several manners.

- Regional actors were mainly involved through roles in participatory governance of MPAs, marine stewardship, and promoting marine governance via civil society. They also noted they coordinate MPAs and lead campaigns, focusing on bridging gaps between science, administration, politics, and society. Their work also includes monitoring and protecting marine areas and species, as well as engaging the community in conservation efforts.
- National actors were mainly engaged in biodiversity management by implementing policy in permits, representing the ministry in various government-financed ecological marine research programs, and being involved in decision-making processes.
- International actors noted they are engaged in biodiversity management through roles such as including Marine Protected Areas (MPAs) in Marine Spatial Planning (MSP), participating in EU decision-making, serving as a project adviser for marine projects under the LIFE programme, and providing policy analysis and advice for decision-making. Additionally, they are involved in policymaking and MSP efforts, highlighting their significant influence in shaping marine and ecological policies.

2.5.2 What are the main barriers to achieving the objectives of the main policies for marine biodiversity in Europe?

Survey results

Pre-survey

Given the limited number of statistical observations, results were lumped across managerial levels and regions. The results of the survey showed that most suggested barriers (based on early workshop and policy analysis) were perceived as barriers (Figure 3). The majority of actors found 'Conflict with objectives of other policies than those that relate to marine biodiversity that prevent implementation of effective measures' as 'very important' barrier. Also deemed either 'very important' or 'important' (together at least 90% of votes) were: Conflict with objectives of other policies than those that relate to marine biodiversity that prevent implementation of effective measures; Conflict with interests of certain stakeholders to prevent implementation effective measures; and National legislation and regulations are not sufficiently/adequately implemented. Lowest rating on importance (most votes for not a huge barrier or not a barrier at all options) were for "Relevancy of policy objectives" (24% total), followed by "Lack of relevant indicators used to measure the status/developments in marine biodiversity" (14%).

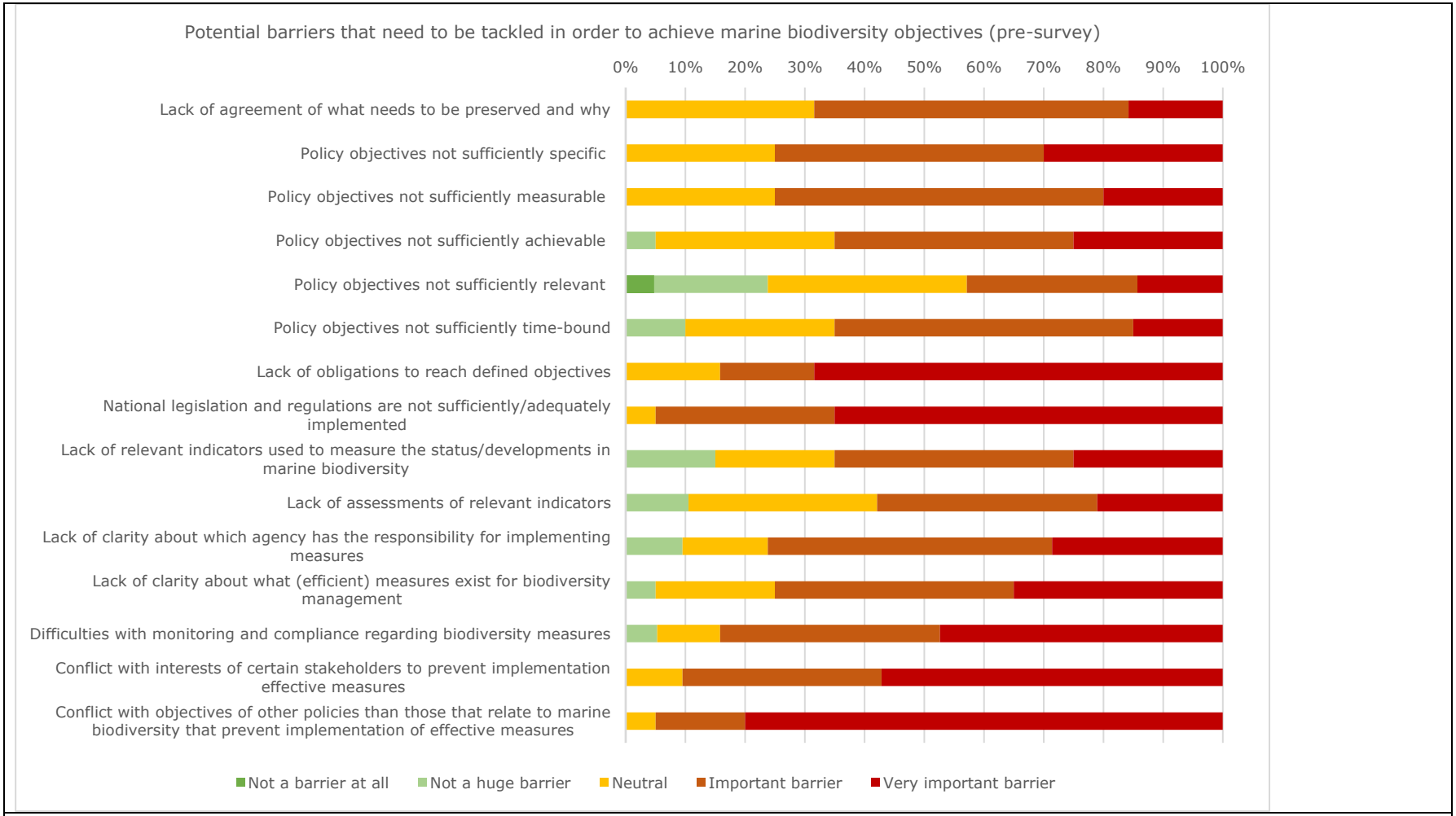

Figure 3 The perceived barriers in achieving marine biodiversity objectives in the pre-survey.

Post survey
After the game, biggest differences in percentages of votes were found for:

- 'Lack of agreement of what needs to be preserved and why' (44% more votes for 'very important barrier')
- 'Conflict with objectives of other policies than those that relate to marine biodiversity that prevent implementation of effective measures' (24% more votes for 'very important barrier')
- 'Lack of assessments of relevant indicators' (23% more votes for 'very important barrier')
- 'Policy objectives not sufficiently relevant' (23% more votes for 'very important barrier')

Open Question results
Apart from the barriers provided in the survey, respondents listed several additional barriers that need to be tackled in order to achieve marine biodiversity objectives:

- Low participatory culture within administration, leading to weak conservation actions due to poor dialogue and weak consensus. Lack of information among involved sectors. Different interpretation of international law and governance.
- Lack of scientific knowledge.
- Difficulties in enforcement of regulations.

Observations during the game
Participants' discussions indicated several barriers or needs in regards to biodiversity management. The most common themes appeared to be scientific barriers and hurdles in regards to policy processes or politics. Furthermore, other users and cultural or social factors also were commonly noticed.

Data availability
Firstly, regarding science-related barriers and needs to effective biodiversity management, a mentioned challenge was the lack of comprehensive data to substantiate management decisions. This relates especially to offshore areas, where data is lacking and decisions are being made based on incomplete or outdated information. To address this, respondents stressed the need for more resources, better data quality, and continuous learning. Using local or indigenous knowledge is mentioned as a valuable addition or alternative when scientific data is lacking, allowing for more informed trade-offs in management decisions. Some examples of these are given in Table 1.

Table 1 Some examples of the items raised in the discussions during playing the game on data availability.
"*There is a lack of awareness and knowledge about the state of conservation and how to manage sites*."
"*More quality information is needed*"
"*It is difficult to make decisions with little information*"
"*Good science leads to good decisions*"
"You can build on indigenous/local knowledge, especially if you don't have the info from monitoring"
"When it comes to knowledge: ignorance is bliss"

Gap between science and policy-making

Another recurring theme is the gap between scientific knowledge and policy-making. Participants noted that policy decisions are often made without making full use of available scientific data, due to a lack of awareness, political considerations or failure to clearly define objectives. Poor alignment between research and legal frameworks appears as a major obstacle. There remains a difficulty of translating scientific data into actionable policy. Participants stressed the importance of creating a clear bridge between research and policy to ensure that ecological boundaries and definitions are understood and applied in the same way in all regions. Furthermore, the relatively slow pace of science related to the faster pace of policy making is also seen as a barrier to effective science-based decision-making. Moreover, decision-makers are often constrained by the lack of qualified administrative staff, making it difficult to implement science-based decisions. Some examples of these are given in Table 2.

Table 2 Some examples of the items raised in the discussions during playing the game on the gap between scientific knowledge and policy-making.
"*It highlights the decoupling of scientific knowledge from legal obligations*."
"Choices are often NOT made on the basis of data"
"Legal boundaries have to be based on scientific knowledge, which is why you cannot make it legally hard. This also makes it difficult to include specific data in permits."
"Lack of qualified technicians in the administration to make informed decisions"
"Sometimes the objective is missing. The results from a research are not appropriate. What is the ultimate goal of what you want to do with the data"
"focusing on extending an MPA has been detrimental to them, because they have focused too much on an area that has turned out to have low biodiversity value"

Cooperation in science

Furthermore, cooperation between countries in regards to science is seen as another essential need. Countries could benefit from sharing knowledge about biodiversity, leveraging learning techniques from other groups and working together to improve conservation outcomes. However, disagreements among scientists on the interpretation of data and limitations in the practical application of research findings can impede progress. Participants highlight the need for projects, like those funded through the Horizon program, to prioritize data gathering and sharing. This would facilitate a more unified approach to understanding and protecting biodiversity. Addressing these issues requires promoting stronger interdisciplinary approaches, integrating both scientific and local knowledge and improving communication between sectors. Some examples of these are given in Table 3.

Table 3 Some examples of the items raised in the discussions during playing the game on Cooperation in science.
"*Countries can profit from biodiversity knowledge from other countries"*
"Then there is also the point that ecologists do not always agree on the data"
"Clear definitions of what ecological boundaries are and implementing this internationally"
"Make a European framework of definitions, this does exist but countries differ in their approach. Interpretation differs. This makes the approach different"

Precautionary approach

Finally, the precautionary principle -often central to decision-making- was mentioned in relation to discussions about when and how protective measures should be taken. Actors are unsure when and how to apply it, with some advocating for immediate action despite incomplete data, while others advocate for avoiding implementing conservation measures without solid evidence. Additional research to obtain more certainty is often expensive and time-consuming. Hence using resources

efficiently and focusing on the best available science is seen as crucial to making well-informed choices, even in the face of uncertainty. Daily practice is that decisions must be made within these constraints of limited data availability and (financial) resources. Some examples of these arguments are given in Table 4.

Table 4 Some examples of the items raised in the discussions during playing the game on the precautionary principle.
"The precautionary principle, where do you apply it? To implement or not to implement?"
"Time and money time pressure is mega. You just can't keep doing research forever"
"We don't know for sure, so we don't do it (all the conservation measures), but it can also be the very reason to install MPAs"

Varying perspectives

Biodiversity management is seen as a 'complex issue'. Participants mention a widespread lack of awareness and knowledge about conservation efforts and the ecological state of marine sites, which hampers decision-making. One of the primary challenges mentioned is the necessity to integrate diverse perspectives and viewpoints. The lack of comprehensive data on marine ecosystems, particularly in offshore areas, exacerbates disagreements and emotional reactions among different actors. This challenge is strengthened by data gaps, which makes making trade-offs more difficult and prone to discussion, as decisions are often made without complete information. Some examples of these are given in Table 5.

Table 5 Some examples of the items raised in the discussions during playing the game on the precautionary principle.
"We talk about the importance of raising awareness, because without raising awareness we cannot take care of the areas"

Co-management of marine environment

A recurring issue is the call for shared management between stakeholders and regions, with particular emphasis on the need for cooperation at EU level and between national governments. Many participants emphasize the importance of joint policies, especially in regions with high biodiversity significance, such as Mallorca. Effective collaboration and learning from various sectors appears as an essential need. A "no border" approach, where countries transcend geopolitical boundaries to manage biodiversity, was brought forward. Some examples of these are given in Table 6.

Table 6 Some examples of the items raised in the discussions during playing the game on the co-management of marine resources.
"*Shared management needed, which is not done now*"
"Effective marine biodiversity management requires collaboration among various stakeholders, including neighbouring countries, to address cross-border ecological issues"

Short-term policy versus long-term needs for conservation

Another occurring theme is the discrepancy between short-term goals and the long-term needs of conservation. Policies often focus on immediate crises rather than ongoing, systemic problems. This leads to a lack of continuity and long-term goals in conservation efforts, with management strategies

subject to changes in political cycles rather than long-term, systematic conservation goals. The complexity of managing both coastal and offshore areas, where data are often limited, adds another layer of difficulty to policy and planning. Some examples of these are given in Table 7.

Table 7 Some examples of the items raised in the discussions during playing the game on the short-term policy versus long-term needs for conservation.
"There is a need for continuity of policies, not depending on the cycle"
"The fuller it gets, the faster the conclusion is made of what to do where"
"*Importance of adaptive indicators, but more important to make decisions*."
"We are living a process of increasing the population and only making a short-term economic profit"

Trade-offs

Logically, actors face challenges in determining where MPAs should be placed to protect biodiversity without negatively impacting other economic activities like fisheries and OWFs. A dominant stance from participants is that the fisheries sector often clashes with environmental objectives, and question whether areas with active fisheries can also support healthy marine ecosystems. Furthermore, actors seem to recognize that a one-size-fits-all solution is unrealistic in the face of such a complex, multifaceted issue. Participants noted that while trade-offs are unavoidable, the more informed decision-makers are, the better their potential outcomes. Emotional reactions during discussions—particularly around the removal of fisheries and MPA placement—indicated the sensitivity of these decisions. An example is given in Table 8.

Table 8 An example of the items raised in the discussions during playing the game on trade-offs.
"*There are many economic interests that take precedence over conservation measures."*

Lack of awareness and connection to the marine environment

According to participants, marine management is hampered by many people failing to comprehend the importance of marine environments compared to land-based ecosystems. This indicates a cultural barrier, namely the disconnection between people and their local environments due to modern lifestyles. Education and awareness-raising are therefore seen as critical, and participants emphasize the need for citizen education. Some examples of these are given in Table 9.

Table 9 Some examples of the items raised in the discussions during playing the game on the short-term policy versus long-term needs for conservation.
"Lack of awareness beyond the emergency of the moment to solve specific problems"
"As populations grow and communities become more globalized, there is less integration into local ecosystems, making it harder to engage people in conservation efforts."

What do actors perceive as main solutions to these barriers?

The results of the survey (Figure 4) indicated that strengthening policy and legal frameworks is a significant priority for improving marine biodiversity management, with a notable call for enhanced funding and resources for management and enforcement activities. The latter suggests the need for better financial support for management measures, such as implementation and enforcement to realize effective marine biodiversity management.

This indicates a recognised need for more robust and efficient regulatory structures to support marine biodiversity efforts.

The emphasis on raising public awareness and fostering behavioural change also stood out (Figure 4), This reflects a recognition of the importance of engaging the public in biodiversity issues and promoting behavioural shifts to support marine conservation.

Other areas, such as 'Adaptive management and monitoring', 'Knowledge and information sharing' and 'Collaboration and stakeholder engagement', received no votes, suggesting that these may not be viewed as immediate priorities.

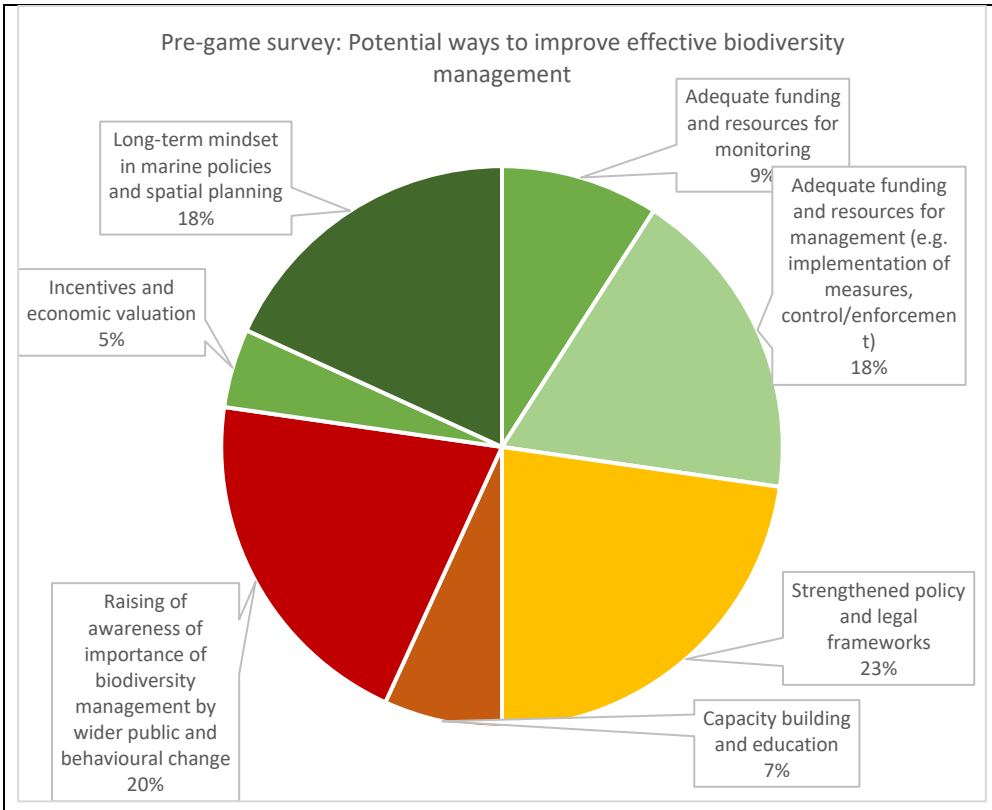

Figure 4 Pre-game survey: Potential ways to improve effective biodiversity management

What do actors see as most valuable characteristics of marine biodiversity indicators?

Among the most important features of indicators voted for in the survey, ‘relevance’ and ‘measurability’ stood out, being rated highly. Science-based indicators also receive considerable attention. Also SMART aspect were found important (Specific, Time bound). The characteristics of ‘comparable across marine basins’, ‘internationally applicable’ and ‘data availability’ were not voted for once (Figure 5).

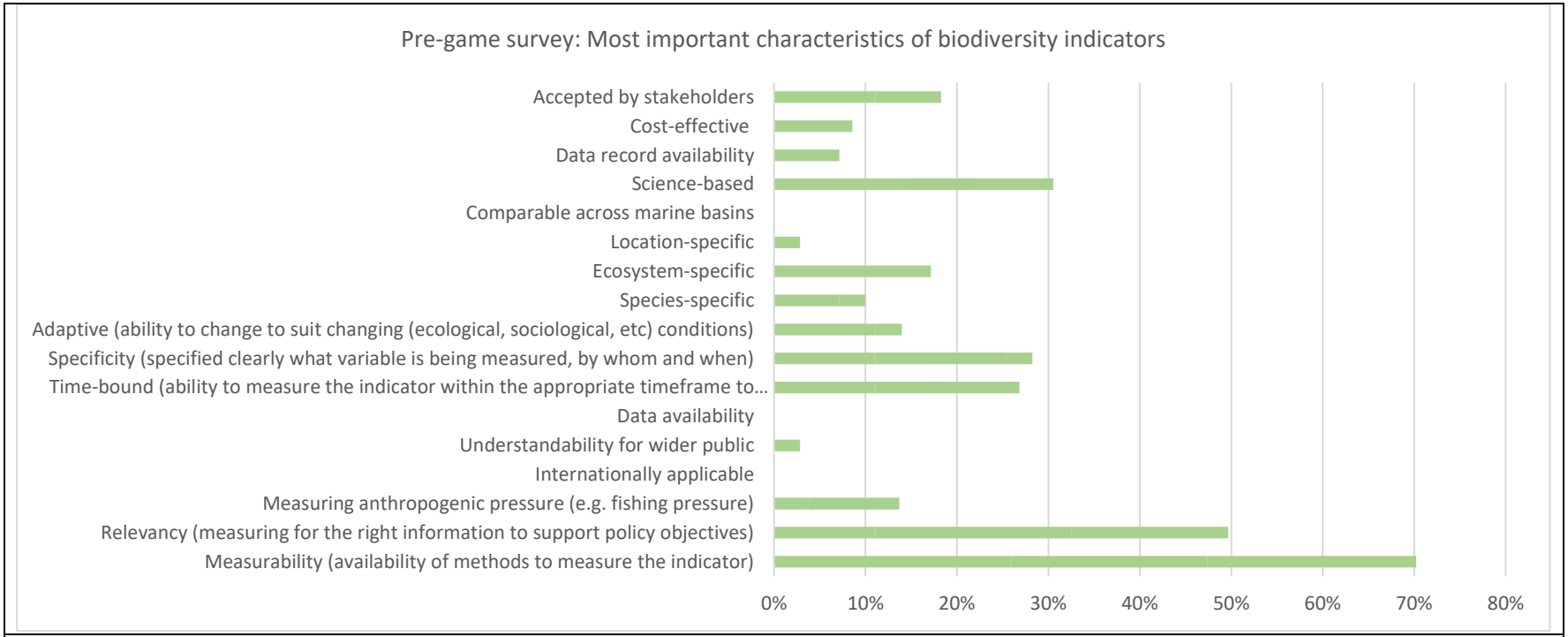

Figure 5 Pre-game survey: Most important characteristics of biodiversity indicators.

Do actors have specific preference for certain indicators? If yes, why?

Motivations for selecting indicators observed during the game were mostly based on ecological/environmental reasoning. Moreover, motivations were also often based on scientific factors, impacts (e.g. pollution) and motivated by other ocean users.

Environmental motivations
The participants' motivations for selecting specific marine biodiversity indicators primarily revolve around the ability of these indicators to provide comprehensive and insightful information about the health and status of ecosystems. They seemed to select indicators that provide multifaceted insights into ecosystem health, biodiversity, and environmental status, balancing between direct biodiversity measures and those that reveal ecosystem processes and impacts.

- Indicators that directly reflect biodiversity (e.g., species richness, community composition) seemed highly valued because they provide an intuitive and broad understanding of ecosystem health.
- Indicators like habitat quality and hotspots of degradation inform on the overall condition of the ecosystem, revealing areas in need of protection or restoration.
- Seen as an obvious and comprehensive indicator, species richness provides detailed information on biodiversity, making it a logical choice for many participants.
- Complementary to species richness, feeding guilds offer insights into ecosystem dynamics and food webs, particularly deemed useful for monitoring MPAs
- Habitat quality provides insights into biodiversity health, especially in degraded habitats that require recovery
- Community composition tracks species populations and their proportions, offering detailed insights into the presence and balance of species.
- Genetic composition was deemed important for understanding population health, particularly in offshore or less-studied areas
- Production in biomass highlights ecosystem productivity and impacts from fishing activities.
- LFI was deemed as useful indicator, as top predators are good indicators of the broader ecosystem's health
- Some participants emphasized underlying processes, such as nutrient flow, over structural aspects like shipwrecks when considering habitat quality.

After the game, participants were also asked what motivated them to select certain indicators. In the survey, a few examples that align with these above observations are:

- *"How closely they were related or could have an effect on biodiversity preservation or improvement"*
- *"Their indication of biodiversity richness"*

Science-based motivation
Participants were also motivated to select marine biodiversity indicators based on a range of scientific motivations, with an emphasis on gathering comprehensive and meaningful data over time. Participants also voiced that they desired to retain indicators over several playing rounds, such as those related to feeding guilds, to provide valuable information over an extended period and compare data across time. This would allow for a deeper understanding of changes and trends in marine biodiversity. This continuity was seen as essential for tracking long-term environmental shifts.

The pollution rate, while easy to monitor, was noted for not providing much insight on its own. However, participants felt that combining it with sensitivity to pollution could offer a more nuanced view of how ecosystems respond to environmental stressors. In this way, they sought to balance the practicality of monitoring with the need for informative, scientifically robust data. In the same

manner, it was noted that species richness alone does not give a complete picture. Feeding guilds, which provide complementary information to species richness, were also considered important because they offer additional insights into how different species interact within ecosystems.

Community-level indicators were generally preferred over species-level ones, as they provide broader information on ecosystem dynamics. In particular, community composition was seen as especially valuable for offering detailed data on species within the ecosystem.

After the game, participants were also asked what motivated them to select certain indicators. In the survey, a few examples that align with these above observations are:

- "*Much information possible, so avoiding indicators that overlap too much*"
- *"A holistic approach and ways that the indicators can be combined"*
- *"How they complemented one another*"
- *"I looked at indicators that seemed to rely on each other. Some knowledge seemed only useful if other knowledge was already at hand (info about a trend is only useful if the original state is known)"*

Other user-based motivations

Participants also selected certain indicators due to concerns about overfishing (deplete fish populations and harm marine ecosystems). It was even deemed essential to monitor fishing in MPAs to protect biodiversity. By tracking fishing effort, participants can better understand the intensity of fishing activities and their effects on marine biodiversity. They also noted that indicator proxies, such as the presence of fishermen, could be used to infer productivity and biodiversity, as areas with more fishing activity are often associated with higher marine life productivity.

Participants highlighted the importance of combining data on the Large Fish Index (LFI) and fishing effort to monitor the impact of fishing in and around MPAs. This approach helps assess the pressure fishing activities place on the environment and determine whether these areas can handle such pressures without biodiversity loss. The inclusion of large fish indicators is particularly valuable for tracking commercial fish species, offering insights into the sustainability of fish populations and guiding fisheries management.

None of the participants provided user-based reasonings when asked for their motivators for indicator selection after the game.

Pollution-based motivations

Multiple times, participants emphasized the need to monitor pollution levels. While pollution is relatively easy to monitor, they noted that it does not provide sufficient insight into the overall health of the ecosystem. It was recommended that it should be combined with indicators of ecosystem sensitivity to pollution. Interestingly, participants also mentioned that pollution indicators are relevant for identifying biodiversity hotspots as these are potentially to be found in areas with lower pollution levels.

None of the participants provided pollution-based reasonings when asked for their motivators for indicator selection after the game.

De-motivations

Participants appeared to become demotivated by several scientific challenges when selecting indicators. Firstly, as aforementioned, it was mentioned that pollution levels were easier to monitor but lacked depth and needed to be combined with sensitivity measurements for better insights. Contrastingly, mammal bycatch was considered difficult to monitor. Also genetic composition was

deemed difficult to monitor, while seen as useful. It was also deemed potentially better suited for future use. Sensitivity to pollution was deemed too new and to be requiring long-term data before becoming truly informative. Interestingly, pollution indicators were often deemed interesting 'at a later stage'. This hinted that this indicator could become potentially interesting once an MPA has been established to monitor its success? Lastly, also uncertainty around current techniques discouraged the use of genetic composition as an indicator.

In the survey, participants were also asked what demotivated them to select certain indicators. The artifact of the game resulted in many responses hinting towards whether an indicator was or was not measuring impact. Most of the other responses, however, also included demotivations related to the uncertainty about the indicators, or unfamiliarity with the indicators. Few examples from the responses:

- *"Failure to understand the meaning"*
- *"That you do not know them"*
- *"To not understand them"*

Furthermore, also few science-based reasonings were provided on why not to select certain indicators:

- *"The status of their development (more innovative ones are possibly less monitored and less robust)"*
- *"Limited data*"

Combining indicators

During the game, the motivations for combining indicators seemed to reflect more practical game-strategies rather than real-life considerations. Three key indicators - habitat structure, community composition and genetic composition - were often chosen because they provide a comprehensive picture of biodiversity. Participants further highlighted the importance of combining information to understand how ecosystems respond to local influences such as pollution. For example, although pollution rate is easy to monitor, it lacks depth and should ideally be paired with sensitivity to pollution for better insight. Also species richness and biomass were mentioned as valuable when applied together.

2.5.3 What are the main policies for the conservation of marine biodiversity in Europe?

In the game, respondents were asked about their awareness of currently policy objectives, frameworks and regulations regarding biodiversity management. The majority of respondents were aware of both marine biodiversity policy regulations (57%) and objectives (48%). A great amount was somewhat aware of regulations (33%) and objectives (43%). Several the respondents expressed uncertainty about policy objectives, while almost half expressed uncertainty about regulations, most being regional actors. Very few respondents indicated they are not aware of current marine biodiversity policy objectives nor regulations.

Secondly, the respondents were asked about how they considered the importance of various directives and policies for marine biodiversity conservation in European waters. The overall results highlight a strong recognition of the importance of these directives and policies for marine biodiversity conservation. All the listed directives and policies are generally considered important for marine biodiversity conservation in European waters, with none being rated as "Not important" or "Not important at all." (Figure 6). The Habitats Directive, Birds Directive, Common Fisheries Policy and the EU Restoration Law all were voted by the majority of respondents as being "Very important." The Marine Strategy Framework Directive, the 2030 Biodiversity Strategy and Water Framework Directive received more mixed results, yet still ranging between “Important” and "Very important."

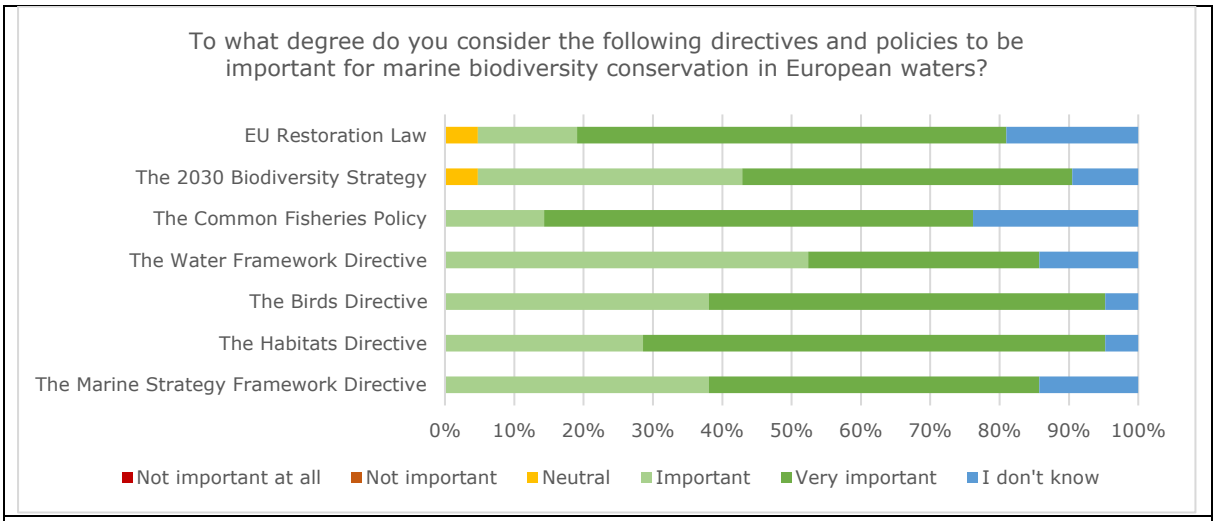

Figure 6 The degree to which directives and policies to be important for marine biodiversity conservation in European waters are considered relevant.

To the question whether respondents found any other policies missing that are important for the conservation of marine biodiversity in European waters, various answers were provided.

Regional:

- Fondo Europeo Marítimo, de Pesca y de Acuicultura (FEMPA)
- Convenio de Barcelona: National lists of threatened species
- Local and Regional Laws, Regulations, and Agreements

International (EU):

- Maritime Spatial Planning Directive
- Invasive Alien Species Regulation
- Common Agriculture Policy
- Research & Innovation Programmes
- Renewable Energy

- Various policies regulating activities at sea and on land

No additional policy frameworks were suggested by the national actors.

2.5.4 Conclusion

What are the main barriers to achieving the objectives of the main policies for marine biodiversity in Europe?
In general area managers and policy makers deem the EU level of regulations as important. It is in the translation of EU policy to the national level and conflict of interest with other stakeholders and policies where large barriers exist. In this sense also more awareness was needed in all participants in the policy cycle on the urgency of protecting biodiversity. In the scientific context a lack of data was very important. Also there a need was defined to make science more applicable to policy information need.

What characterizes purposeful indicators of marine biodiversity?
Among the most important features of indicators voted for in the survey, 'relevance' and 'measurability' stood out, being rated highly in all three scopes of management. Science-based indicators also receive considerable attention. Also other SMART aspect were found important (Specific, Time bound).

What are the main policies for the conservation of marine biodiversity in Europe?
The EU level of regulations was considered important. The main advice was also to establish a stronger link with regional legislation and with other EU regulations that have their domain of influence on other aspects of MSP of the Marine environment. A better translation from EU regulations to national level was advocated.

4. Synthesis: Discussion, conclusion and next steps

4.1 European biodiversity policies, their objectives, and how these are met

The policy review covered a range of police and legislative instruments that serve to conserve marine biodiversity. These include the MSFD, the two Nature Directives, the 2030 Biodiversity strategy, the CFP and the MSFD.

Some of the interviewed policy officers presented these policies as a "package" for marine biodiversity governance. These policy officers do not regard this package as a fully coherent whole, but they noted that each of its elements have been assesses, reviewed and adapted periodically to improve the integration and performance of the policy framework for marine biodiversity in Europe. Importantly, policy officers see the Nature Restoration Law as an important opportunity to address weaknesses with the previous policy and legislative instruments for marine biodiversity.

The survey respondents highlight the 2030 European Biodiversity strategy and the Marine Strategic Framework Directive as particularly important European regulations to manage marine biodiversity. In contrast, interviewed policy officers and most other interviewees do not highlight the 2030 Biodiversity as a particularly important policy for marine biodiversity. Instead, most interviewees emphasized the importance of the MSFD, the Nature Directives, and the recent Nature Restoration Law.

The 2020 report by the Court of Auditors[140] report concluded that EU legislations (e.g. Habitats Directive, Birds Directive, CFP, MSFD, MSPD) have not led to the recovery of significant marine ecosystems, biodiversity and habitats.[141] The interviewed policy officers generally that objectives of biodiversity policies have not been achieved within the defined timelines. Interview respondents generally expressed the view that marine biodiversity in Europe continues to decline and that more effective measures are needed to reverse this trend.

4.2 Barriers to achieving the objectives of the main policies for marine biodiversity in Europe

The survey outcomes reflected disagreement about which barriers to marine biodiversity protection in Europe. However, the survey outcomes also reflect the view that a long list of barriers are relevant.

One important barrier relates to conflicts between objectives of marine biodiversity relevant policies on the one hand, and the interest of stakeholders and the objectives of other policies on the other hand. These conflicts may prevent implementation of effective measures. Most participants in the iBlue game identified this as a 'very important' barrier. The CFP is an example of a policy that includes economic objectives for the fisheries alongside conservation objectives for fish stocks and the marine ecosystems. Interest conflict between fisheries and marine biodiversity objectives were highlighted as important by several interview respondents.

The policy review identifies the national implementation of environmental legislation a main problem. This perception is supported by a range of infringement cases, and by the review of research literature. The perception that member state implementation is a main problem prevalent in several interviews (data not shown). As a related point, the research review identified lack of political will to implement measures to protect marine biodiversity as a key problem. This perception is also prevalent in several interviews (data not shown).

The policy review identified that additional effort is needed to improve the monitoring capacities within the Member States for the Nature Directives and other polices and legislations relevant to marine biodiversity. The policy and research review also identified a need to streamline implementation, support regional cooperation and to enhance the sharing and interoperability of data. These findings were also highlighted in the workshop discussions and in several interviews (data not shown).

Responses to the post game survey reflected that a lack of agreement of what needs to be preserved and why as a particularly important barrier.

4.3 Characteristics of purposeful indicators of marine biodiversity

Important desirable characteristics for marine biodiversity indicators were identified in the the workshop discussions. These characteristics include that the indicators are relevant for assessing policy objectives in question and satisfy reporting purposes, that they inform and support management actions, reflect changes in biodiversity, and are feasible to assess. Similarly, responses to the surveys that were used in relation to the iBlue Game. However, the workshop discussions also reflected awareness that these favourable characteristics may often not be attenable. The workshop

[140] Cf footnote 60.

[141] Court of Auditors Report, pp. 31-

discussions also expressed an interest in representation of uncertainty to accompany estimates of biodiversity indicators, as well as an interest in harmonization and standardization of biodiversity metrics regionally, whenever this is possible. Some of the interviews emphasises the need for further work on indicators and assessments of cumulative impacts of multiple stressors.

The workshop discussions and several interview respondents highlighted the need for further work to define threshold levels for biodiversity indicators, consistent with the 2017 Commission decision on the implementation of the MSFD[142].

Survey responses respondents ranked ecosystem functioning as a more important feature of biodiversity indicators followed by community composition and species population together. This seems to tie in with a one of the key outcomes of the workshops discussions, namely that marine biodiversity governance should be pursued as part of ecosystem approach. Other types of biodiversity indicators were deemed less important by survey respondents. However, the no indicator type was identified as “less important” or “not important” by any type of respondent. This can be taken to suggest a consensus perception that biodiversity is a complex and multifaceted phenomenon, for which a variety and of complementary indicators are needed.

4.4 Conclusion and next steps

Marine biodiversity is a highly complex phenomenon, and effective governance of marine biodiversity governance is highly challenging for a variety of reasons.

A package of policies and legislations have been put in place over the recent decades to provide for the conservation of marine biodiversity in Europe. The performance of the elements of this package are reviewed periodically and adaptations are made. Nevertheless, the objectives of the different policies have not been achieved within the defined timelines. The Nature Restoration law is viewed as an important opportunity to amend weaknesses with previous policies in the context of marine biodiversity.

The common picture that emerges from the different research approaches pursued here is that there is a need for more effective measures to preserve marine biodiversity. Main barriers to effective governance of marine biodiversity include weak national implementation of European directives, and tensions with commercial interest and economic objectives for the use of marine space. However, many other barriers are also regarded important.

Outcomes from the different approaches emphasise a need to pursue biodiversity governance as part of an ecosystem approach, consistent with the commitments made in key policies. In line with this, the outcomes emphasise a need to further develop, define thresholds for, and use indicators of cumulative impacts, foodwebs, and ecosystem functioning.

The outcomes of the research reported here supports the development of indicators, scenarios, and a decision support tool in the B-Useful project. Considerable empirical information has been collected for the purposes of this work. This material will be analyzed further with a view to publish in peer reviewed journals. We currently envisage at least two publications on marine biodiversity governance: One based on the iBlue Game and one based on the key findings emerging from the mixed methods approach.

[142] Cf footnote 139

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Appendices

Annex 1: Supplementary Information for section 2.3

Figure S1. Polychoric correlation coefficient (Cor) matrix estimates for the four sets of questions.

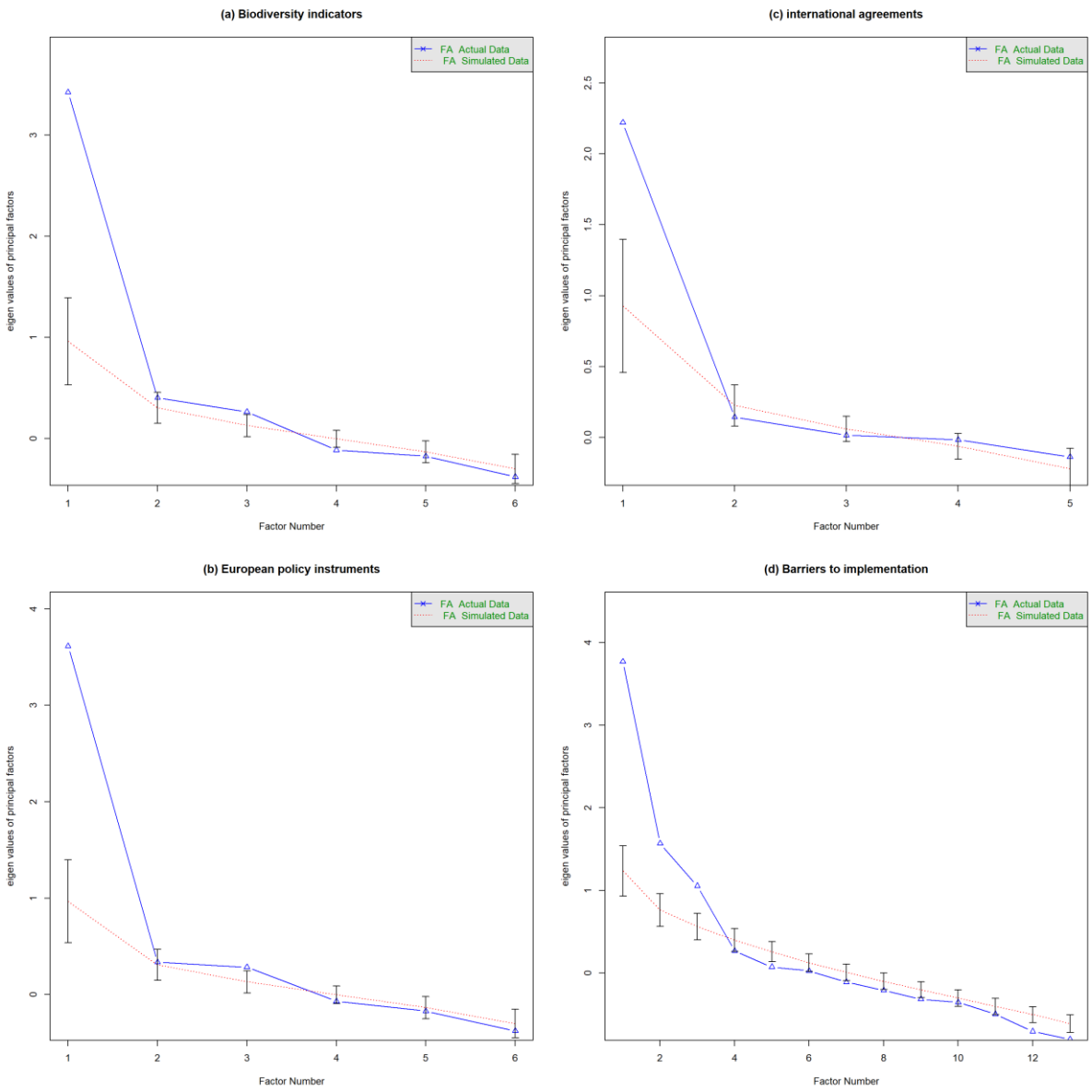

Figure S2. Parallel analysis scree plots to determine the number of latent factors by contrasting variance explained by the real decomposition of the real correlation matrix to 1000 random matrices for the four sets of questions (error bars are min-max). Selected number of latent factors: (a) 3, (b) 1, (c) 3, (d) 3.

Annex 2. Information Letter for the Survey

Thank you for considering participating in our survey. Before you proceed, we kindly ask you to read the following consent declaration.

By participating in this survey, you indicate your voluntary consent to take part in the study and acknowledge that you have understood the conditions under which your responses will be collected, used, and shared.

This survey should take about 20 minutes to complete.

The purpose of this survey is to gather valuable insights and opinions on the information needs and barriers to manage marine biodiversity in European waters. The information collected will be used for research purposes to develop purposeful marine biodiversity indicators that can be used by all.

You have the right to withdraw at any time without providing any reason. Your responses will remain anonymous. Your responses will be aggregated, analysed and presented in a manner that ensures individual identities cannot be discerned. We will take all reasonable measures to ensure the security and protection of your data. Access to the collected information will be limited to the research team responsible for data analysis and reporting.

The results of the survey may be shared in the form of reports, presentations, or publications. These publications will only present data in an aggregated and de-identified manner, ensuring that no individual's responses can be traced back to them. The information you provide will only be used for the purposes described in this consent declaration. Your data will not be shared with any third parties.

Your participation in this survey is entirely voluntary. If you choose to participate, you may withdraw at any time without providing a reason. Should you decide to withdraw, your responses will not be included in the final dataset used for analysis.

If you have any questions or concerns about this survey or the consent declaration, please feel free to contact David Lusseau at davlu@dtu.dk.

By continuing with the survey, you confirm that you have read and understood the information provided in this consent declaration and agree to take part in the survey.

Annex 3: Interview questions

Purpose of the interview

The B-USEFUL[1] project will contribute to achieving the policy goals of the EU's Green Deal and the 2030 Biodiversity Strategy through developing and assessing policy relevant indicators of marine

biodiversity and by developing a decision support tool. Building on existing data, B-USEFUL aims to support decision making processes regarding biodiversity management.

A first step is to this goal to understand what currently drives and shapes biodiversity management in different regions and at different scales. Important questions include: What are the most important policies and regulations for the management of marine biodiversity? Are the goals and objectives of these policies being met? If not, what barriers prevent their achievement? How is biodiversity currently monitored, and are current biodiversity indicators purposeful? What are desirable characteristics of biodiversity indicators? The purpose of the interview is to gather insights on these questions from experts with experience from developing and implementing policies in the context of marine biodiversity in Europe.

Introductory questions

- Can you please shortly describe your background and what you do professionally in relation to marine biodiversity?
- Are you working mainly on an international, regional, national or local level, on the topic of the marine biodiversity?

About marine biodiversity

- Can you please describe to what the concept of “marine biodiversity” means to you?
- What is the importance of biodiversity in your opinion?
- How do you view the state of marine biodiversity in the area where you work?
- In your view, what are the main drivers behind marine biodiversity change at this moment?
- How do you think marine biodiversity will change in the next decade or so?
- How do you see the relationship between biodiversity and an ecosystem approach?

About marine biodiversity policies and management actions

- Can you briefly describe how marine biodiversity is managed in the context of your work?
  - what are the most important policies?
  - What are the most important management actions (taken or not taken)?
  - How do you view the relationship between international, regional and national policies and implementing actions for marine biodiversity? Do these cooperate well?
- Do you feel like current policy and management actions are becoming more effective in reaching the goal protecting marine biodiversity?

Important barriers to achievement of policy objectives for marine biodiversity

In your view, how effective are the management measures in reaching the policy/regulatory objectives at this moment?

- What do you see as the most important barriers to achieving the goals and objectives of these policies?
- Why do you think these barriers exist? For example, financial constraints, lack of importance in national politics, lack of required data...

- What could be done to overcome these barriers?

Nature restoration law

- In your view, will the Nature Restoration Law provide ways to overcome barriers limiting the achievement of the objectives of previous biodiversity policies?

Biodiversity indicators

- What (type of) biodiversity indicators do you think are currently often used to monitor marine biodiversity? In other words, when asked to monitor marine biodiversity, what variables would one commonly measure?
- What do you think are the strengths and weaknesses of these indicators?
- What does a 'relevant and useful' marine biodiversity indicator look like to you? In other words, what characteristics should a marine biodiversity indicator have to sufficiently and effectively support monitoring of biodiversity?
- Can you think of any indicators that you would advise to be used in biodiversity monitoring to better support and create effective biodiversity management?
- What indicators would you recommend for the areas of your interest? Do they differ from the indicators currently being used in the context of your work?
- Are you are you aware of the biodiversity framework named Essential Biodiversity Variables?
- Do you have suggestions for the development of policy relevant indicators of marine biodiversity in the B-USEFUL project?

Any other comments or issues you would like to mention?

[1] https://b-useful.eu/

Annex 4: Information Letter and consent form for interviews

Do you wish to participate in the research project:

B-USEFUL: User-oriented Solutions for improved Monitoring and Management of Biodiversity and Ecosystem Services in vulnerable European Seas

This is an invitation for you to participate in the B-Useful project[1] by way of an interview. In this text, we provide information about the objectives of the particular study in question, and about what participation would imply for you.

Purpose

The B-USEFUL project will contribute to achieving the policy goals of the EU's Green Deal and the 2030 Biodiversity Strategy through developing and assessing policy relevant indicators of marine biodiversity.

A step to this goal to understand what currently drives and shapes biodiversity management in different regions and at different scales. Important questions include: What are the most important policies and regulations for the management of marine biodiversity? Are the goals and objectives of these policies being met? If not, what barriers prevent their achievement? How is biodiversity currently monitored, and are current biodiversity indicators purposeful? What are desirable characteristics of biodiversity indicators? The purpose of the interview is to gather insights on these questions from experts with experience from developing and implementing policies to conserve marine biodiversity in Europe. Together with insights from a survey and several workshops, the insights from the interviews will help the project participants to develop purposeful indicators of marine biodiversisty and to a design policy relevant decision support tool.

Who is responsible for the research project?

The B-Useful project is led by Martin Lindegren (mli@aqua.dtu.dk) from DTU in Denmark. The project task that includes the interviews is led by Kåre Nolde Nielsen (kare.nolde.nielsen@uit.no) from UiT – the Artic University of Norway.

Why do we invite you to participate?

We are inviting you as an expert in marine planning and policy making in relation to marine biodiversity in a European context.

What would it imply for you to participate?

We invite you to an interview. In practice, this will be online meeting which last about one hour (possibly less) and which will take a starting point in the attached questions (B-Useful Interview questions).

For practical reasons, we wish to conduct the interview online as a Teams meeting. We wish to audio-record the session, as this will help is to provide more accurate information than what would be possible by way of notes. The output from the interview will a lightly edited transcript. Person identifiers such as the name of the respondent or statements that the reveal the identity of the person will be edited or deleted to preserve the anonymity of the respondent. The respondent will be offered an opportunity to check, revise or delete any statements. The audio-recoding will be deleted after the respondent has (explicitly or implicitly) approved the transcript. In any case the recording will be deleted before the end of the project (October 2026).

It is voluntary to participate

It is voluntary to participate in the project. If you choose to participate, you can withdraw your consent at any time without stating a reason. All your information that reveals your identity will be deleted. It will not have any negative consequences for you if you do not wish to participate or decide to withdraw later.

Protection of your personal information – how we store and use your information
We will only use the information about you (i.e. the audio-recording) for the purposes described in this information letter. The information will be treated confidentially according to GDPR requirements. Only Kåre Nielsen, David Lusseau and the interviewer will have access to the audio file, and access to the audio file will be restricted with two factor log-in. The transcript will not include names or other person identifiers. We anticipate that the transcript will serve as potential material for a project deliverable and one or more scientific publications. Access to the anonymized transcript will be restricted to participants in the B-USEFUL project.

What happens with my personal information when the project is finalized?
The audio-recoding will be deleted after the respondent has approved the transcript and in any case before the end of the project (October 2026).

Your rights
As long as you can be identified in the data material (audio-recording), you have the right to:

- Know which personal information is registered about you, and receive a copy of the information (i.e., the audio-recoding).
- get personal information about you corrected,
- get personal information about you deleted,
- and submit a complaint to the SIKT (see below) about the treatment of your personal information.

What entitles us to handle personal information about you?
We will handle personal information about you (the audio recording) based on your consent. As requested by UiT – the Arctic University of Norway, SIKT – the Norwegian Agency for Shared Services in Education and Research[2] has judged that the handling of personal information in this project is in accordance with the regulations for personal data protection.

How can I get to know more about this?
If you have questions about the study or wish to make use of your rights, please contact:

Main responsible for interviews: Kåre Nolde Nielsen, UiT – the Arctic University of Norway (kare.nolde.nielsen@uit.no; telephone +47 77644480

Data protection official at UiT: Annikken Steinbakk (personvernombud@uit.no), telephone: +47 77646952).

SIKT: Telephone: +47 73984040

Task responsible Cooperating researchers

Kåre Nolde Nielsen David Lusseau

I have received and understood information about the project “B-USEFUL” and have had the opportunity to ask questions. I consent to:

- ☐ participate in the interview as described above
- ☐ that my personal information (audio-recording of the interview) is stored, at the latest until the end of the project (October 2026)
- ☐ that my information is handled until the end of the project

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(Signed by interview respondent, date)

[1] https://b-useful.eu/
[2] https://sikt.no/en/home