BLUE CONNECT

D5.1 Best practices in MPA monitoring and assessment

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1. Acronyms

For acronyms referring to Protected Area Management Effectiveness tools, see Table 2.

BACI	Before-After-Control-Impact
CBD	Convention on Biological Diversity
EU	European Union
EBDM	Evidence-Based Decision Making
EBV	Essential Biodiversity Variables
HELCOM	Helsinki Convention
IUCN	International Union for Conservation of Nature
MEE	Monitoring, Evaluation, and Effectiveness Cycle
PAME	Protected Area Management Effectiveness
MP	Management Plan
MPA	Marine Protected Area
NIS	Non-Indigenous Species
NMDS	Non-Metric Multidimensional Scaling
NOAA	National Oceanic and Atmospheric Administration
OECMs	Other Effective Conservation Measures
OSPAR	Oslo-Paris Convention
SMART	Specific – Measurable – Action-oriented – Realistic – Time-bound conservation objectives
SPAMI	Specially Protected Areas of Mediterranean Importance
WCPA	IUCN World Commission on Protected Areas
WP	Work Package

2. Glossary

Adaptive management. A systematic process of continually improving management policies and practices by learning from the outcomes of existing programmes using the best available information and incorporating monitoring and evaluation systems to systematically test the effectiveness of management methods and refine them over time (IUCN-WCPA, 2008).

Biodiversity monitoring. The process of regular data collection and analysis that is then used by managers to determine whether biodiversity objectives are being met (Dalton et al., 2024).

Cultural value. Objects, seascapes, practices and histories valued as part of cultural heritage, identity, spirituality, tradition or livelihoods associated with an MPA. (Balvanera et al., 2022; Roszko, 2021)

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Demonstration Site. BLUE CONNECT Demonstration Sites are planned, committed, newly designated or actively implemented MPAs where tools created by the project are tested and validated in line with their needs and potentials but also serve as advisory sites providing best practices, tools and frameworks for (co)-management and co-ownership.

Ecological safeguards. Deployed strategies to mitigate the unintended consequences of management actions (e.g. when removing NIS species).

Evaluator. In the context of the present work, this refers to the individual responsible for analysing Protected Area Management Effectiveness (PAME) evaluation frameworks and methodologies. The evaluator assesses their application in relation to MPA planning, operations, governance, and outcomes, as well as the practical implementation and use of the evaluation tools themselves.

Goals. Achievable desired endpoints. They are a generalised declaration or statement about an expected state of the ecological subjects to be protected or restored in the MPA, providing a vision of the results to be achieved.

Governance. Relating to seven principles of legitimacy, transparency, accountability, inclusiveness, fairness, connectivity and resilience that enable positive management outcomes (Lockwood, 2010).

Indicators are quantitative or qualitative variables that provide a simple and reliable means to measure achievement, reflect changes connected to an intervention, or help assess the performance of a MPA site or process over time (European Environment Agency, 2014; OECD, 2023)

Major conservation values. Conservation features/values, habitats/species/ecosystem for which the MPA been designated.

Management performance. Refers to the quality and effectiveness of actions taken to implement and operate an MPA. This includes planning, staffing, enforcement, stakeholder engagement, and resource allocation. It focuses on how well management inputs and processes are executed, regardless of whether conservation goals have yet been achieved (Leverington et al., 2010a).

Management outcomes. Refers to the actual results or impacts of MPA management in terms of achieving its stated ecological, social, and governance objectives. This includes changes in biodiversity, ecosystem health, stakeholder well-being, and compliance. Outcomes reflect whether management actions are producing the intended effects.

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Means of verification. Mechanisms in place that make the MEE scores transparent for others (e.g. background data needs to be disclosed, evaluation discussed with stakeholders etc.)

Marine Protected area (MPA). A clearly defined geographical coastal and marine space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values. Adapted from (Stolton et al., 2013)

MPA Monitoring Framework or MPA Monitoring System. Structured system that outlines how performance will be tracked over time. It specifies what indicators will be used, data sources, frequency of data collection, roles and responsibilities, and how the information will be used to inform management decisions (UNEP-WCMC & IUCN-WCPA, 2021)**.**

MPA objective. A formal statement detailing a desired intermediate result that contributes directly to achieving the broader conservation goals of the MPA. An objective may target, for example, the reduction of a critical threat (e.g., illegal fishing) or the improvement of key ecological or social conditions (OECD, 2023)

Monitoring, Evaluation, and Effectiveness (MEE) cycle. Structured, iterative process used to assess how well a Marine Protected Area is managed and whether it is achieving its intended ecological, social, and governance objectives. It involves monitoring, evaluation and effectiveness assessment of results (Pomeroy et al., 2005).

Monitoring Programme. Operational plan for conducting regular, systematic observations or measurements to gather data over time. It focuses on implementing the monitoring framework through specific protocols, tools, and schedules. It helps to evaluate performance as part of a key components of management plans (Hockings et al., 2006).

MPA stages of establishment. Describes the progression of a Marine Protected Area from initial proposal to full, active management. These stages help assess the status, level of protection, and likely conservation outcomes of an MPA (Grorud-Colvert et al., 2021).

MPA network. Defined as a collection of individual MPAs or reserves operating cooperatively and synergistically, at various spatial scales, and with a range of protection levels that are designed to meet objectives that a single reserve cannot achieve (IUCN-WCPA, 2008).

Pressures/Threats. Factors (potentially) impacting the conservation values of the site negatively (e.g. contamination, underwater noise). Here it can include human impacts as well as regularly occurring natural threats (e.g. storms), if relevant for the MPA.

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Protected Area Management Effectiveness (PAME). Assessment of biodiversity, social, cultural and economic outcomes as a result of protected area management. This evaluation also includes understanding the context of management, planning, inputs, processes, outputs and outcomes (Hockings et al., 2015).

Protected Area Management Effectiveness (PAME) Tool. Structured method or framework used to assess how well protected areas are being managed, primarily focusing on planning, implementation, inputs, processes, outputs, outcomes, and enabling conditions. These tools help evaluate the adequacy and effectiveness of management systems and practices in achieving conservation objectives (Hockings et al., 2006).

Theory of Change. A logical and testable pathway connecting conservation actions to results, typically through a chain of intermediate outcomes and assumptions. It identifies conservation targets, threats, strategies, objectives, and the expected changes in ecological or social systems, visualized through results chains or a conceptual model (Conservation Measures Partnership, 2025).

Voluntary compliance. Non regulatory measures developed to facilitate stakeholders' acceptance of MPA zoning and management arrangements.

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3. Introduction

The importance of Protected Areas (PAs) and their effectiveness are central to both European Union (EU) and international conservation policy. This is reflected in the Convention on Biological Diversity (CBD) Kunming-Montreal Biodiversity Framework, which aims to ensure that by 2030, at least 30% of terrestrial, inland water, coastal, and marine areas are effectively conserved and managed. The EU Biodiversity Strategy for 2030 further defines several major targets in which PAs play a central role: protecting 30% of the EU's land and sea surface (through new designations, completing the Natura 2000 network and recognising existing national/regional designations), strictly protecting 10% of EU land and sea. In addition, the strategy calls for the effective management of all protected areas by 2030, including the definition of clear conservation objectives and measures, and the implementation of appropriate monitoring (European Commission, 2020a). Achieving these ambitious targets depends on establishing ecologically representative, well-connected, and equitably governed and managed systems of PAs and effective conservation measures.

One of the persistent challenges for Marine Protected Areas (MPAs) in Europe is enhancing their actual effectiveness (Aminian-Biquet et al., 2025; European Environment Agency, 2020), moving beyond nominal protection to ensure they deliver tangible conservation outcomes and socio-ecological benefits. The European Environment Agency concludes in its reporting on management effectiveness of EU's Natura 2000 network that management effectiveness standards are insufficiently known and understood among practitioners. Moreover, it indicates that less than 8% of the recorded PAs in the EU have undergone assessments (European Environment Agency, 2020).

Improving the design, implementation, and enforcement of conservation measures becomes essential to ensure that MPAs contribute meaningfully to ecosystem resilience, biodiversity recovery, and the sustainable use of marine resources. This requires moving beyond formal designation to focus on how effectively MPAs are managed and whether they achieve their conservation and restoration goals under current and future pressures, including those linked to climate change. Equally important is ensuring that these outcomes can also deliver tangible benefits to local communities (Schmidt et al., 2022; Simard et al., 2016).

To support this needed transformation and ensure the effective conservation of marine areas, clear and comprehensive methodological frameworks, along with structured processes and criteria must be defined to guide managers and stakeholders in establishing and improving MPA monitoring and assessment of conservation outcomes.

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This includes guidance on prioritising best practices in monitoring and evaluating conservation and restoration efforts as well as assessing management effectiveness (Dalton et al., 2024). Central to this approach is the implementation of robust monitoring schemes that incorporate relevant evaluation systems to regularly measure ecological performance, including climate change-related ecosystem service provision. Additionally, these monitoring frameworks should address both ecological and social dimensions of MPA performance, enabling adaptive management, supporting evidence-based decision-making, and promoting transparency and accountability in conservation efforts.

As part of this objective, the present work supports this needed transformation to improve MPA monitoring and assessment by presenting "**best practices in MPA monitoring and assessment"** that support adaptive management. This involves identifying and evaluating the most relevant tools and key factors influencing MPA effectiveness, including governance, spatial design, and external pressures. This initial analysis is critical for selecting the most suitable approaches to be applied and tested in MPAs at different stages of establishment (Demonstration Sites), ultimately forming the foundation for a robust, scalable system for evaluation and learning. Particular emphasis is placed on the tool designed primarily for designated Natura 2000 areas (the EU PAME tool), which focuses on effectiveness in relation to the legislation and reporting requirements of the Natura 2000 network.

Complementary to this review focused on tools and frameworks for MPA assessment, a comparative review of selected monitoring frameworks was conducted to inform the design of effective monitoring systems. This analysis compiled best practices and provide practical guidance for designing monitoring systems capable of supporting adaptive management and evidence-based decision-making in MPAs.

Management Effectiveness Evaluation

To support the implementation of effective MPA management, ***Protected Area Management Effectiveness Evaluation*** **(PAME)** provides a systematic approach to assess the success of PAs in safeguarding their values and achieving their goals. In 2000, the International Union for Conservation of Nature (IUCN) proposed a six-step ***Cycle for Management Effectiveness Evaluation*** **(MEE)** in Protected Areas (Hockings et al., 2000). This framework defines the management cycle through six key elements: context, planning, inputs, processes, outputs, and outcomes (Figure 1). Updated in 2006, this framework serves as the foundation for PAME in many PAs worldwide (Hockings et al., 2006). According to this framework, management effectiveness evaluation involves "*reviewing the results of actions taken and assessing whether these actions are producing the desired outcomes*".

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In general, *Management Effectiveness Evaluation* in a Protected Area aims to:

- Facilitate the improvement of management actions by identifying what works, what does not, and why.
- Communicate progress on conservation objectives and promote accountability.
- Provide transparency, enabling stakeholders to see how well their needs have been addressed.
- Determine and award a level of effectiveness (e.g. Blue Parks Award Scheme, IUCN Green List label).

Figure 1 ***Protected Area Management, Evaluation Effectiveness (MEE) Cycle.*** *Adapted from Hockings et al (2006). To conduct successful evaluations, MPA management teams must develop consistent records of management actions and data (Pomeroy et al., 2005) to track progress toward MPA commitments and make any necessary adjustments.*

Originally, tools developed for management effectiveness evaluation (PAME tools) used to focus on the three main components of assessment: a) design issues related to PAs (including individual sites and networks of sites); b) the appropriateness of management systems and processes; and c) the delivery of conservation objectives. More recently, the

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governance dimension—assessing the quality and robustness of governance structures within Protected Areas— has emerged as a critical factor in shaping conservation outcomes and aligning these areas with broader conservation planning goals (e.g. Eklund and Cabeza, 2017; IUCN Green List of PAs).

Protected Area effectiveness is inherently multifactorial and highly context dependent. Evaluations must consider the specific context of each PA, including its stage of establishment, level of protection, ability to achieve long-term biodiversity conservation objectives, and sociological outcomes when those are included in conservation goals (Gatiso et al., 2022; Stolton et al., 2020; WWF and IUCN WCPA, 2023).

Effective management can drive conservation outcomes through two primary mechanisms: (1) reducing threats through resilient, comprehensive, and consistently effective management practices, and (2) enhancing resilience through strategic location and design, as well as targeted restoration actions. These mechanisms determine the capacity of PAs—individually and collectively—to protect genetic, species, and ecosystem diversity over the long term. Moreover, PA effectiveness depends on both internal and external factors. Internal factors include elements within the MPA management remit, such as governance, monitoring, and enforcement. These elements can be assessed by the PAME process. External factors, however, often lie beyond the control of MPA managers and include external threats, ecological connectivity, climate change vulnerability, and legal or political influences. PAME can address how well PA management considers such factors to increase the likelihood of reaching conservation goals even under adverse external influences.

Building on these factors and mechanisms along with the extensive guidelines and literature on the subject, the pathway from effective management to achieving desired conservation and social outcomes in Protected Areas, including MPAs, starts with the following foundational components that underpin the management process: **good governance, sound design and planning, effective operational management, and enabling conditions** (WCPA IUCN Green List of PA; Bennett and Dearden, 2014; Grorud-Colvert et al., 2021). Good governance and sound design establish the necessary institutional, legal, and spatial frameworks, while enabling conditions such as socio-political support, legal clarity, financial resources, and institutional capacity, facilitate effective implementation. These components guide operational management actions and are reinforced by **monitoring,** which provides critical feedback for **refining strategies and ensuring accountability**. Together, they support the implementation of conservation measures through an adaptive cycle of evaluation and learning.

However, MPA conservation planning and evaluation must also **be designed to prepare for deep uncertainty**, particularly in relation to the amount of greenhouse gases (GHG) the world will emit, the pace and nature of **climate change**, and its impacts on coastal

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and marine species, ecosystems, affected communities, and the complex interactions that will occur between traditional threats and climate-driven pressures. Moreover, the effectiveness of conservation strategies in such uncertain futures remains difficult to predict. This uncertainty reinforces the critical need for adaptive, forward-looking management that not only responds to the current pressures but that is also equipped to evolve in the face of unpredictable environmental and socio-political change.

The implementation of PAME tools and of monitoring frameworks can support the evaluation of how thoroughly PA managers consider relevant these factors and foundational components to support the achievement of conservation goals (Figure).

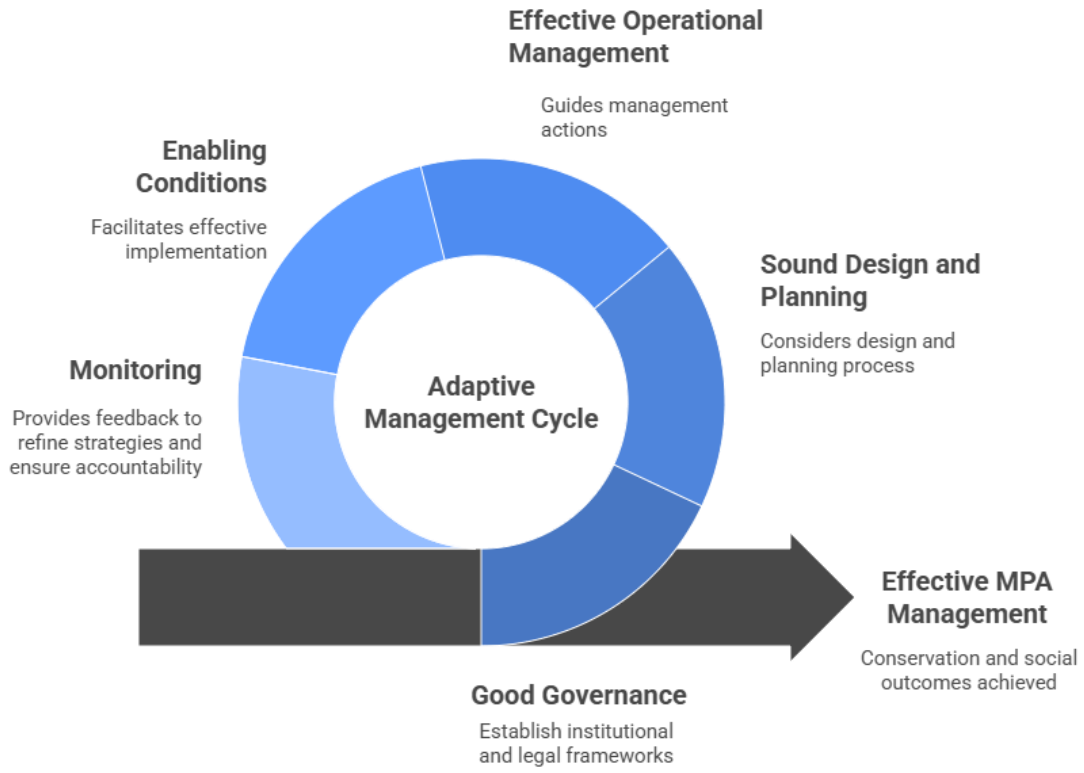

Figure 2 ***Core components of effective management processes to achieve desired conservation and social outcomes within an MPA****. Author's own elaboration.*

3.1. Frameworks and tools for Management Effectiveness Evaluations (PAME tools)

Since the introduction of the first framework, numerous tools and guidelines have been developed globally to implement management effectiveness evaluations (PAME) in Protected Areas, including MPAs. These include tools such as METT, RAPPAM, PAME, MaPAF, and Scorecard approaches (Table 2), and a variety of qualitative and quantitative tools, including opinion-based methods. Considering this wide range of options as well

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as variety of PAs, it remains challenging to define a single “best” approach for evaluating MPA management effectiveness.

In line with the objective of identifying and promoting best practices in MPA assessment, there is a need to develop a comprehensive framework that defines clear workflows and processes for selecting and applying best practices from the most appropriate tools. Such a framework should enable managers and stakeholders to make informed decisions, ensure methodological consistency, and strengthen the evaluation of MPA management effectiveness across different contexts.

These tools should incorporate well-defined criteria and effectiveness indicators to enable the measurement of conservation outcomes (Gaston et al., 2008; Pajaro et al., 2010; Pomeroy et al., 2005). Indicators may be assessed directly or compared against reference target values to enhance the interpretation of results (Rodríguez-Rodríguez and Martínez-Vega, 2022). The tools should aim to demonstrate how well MPA management performs relative to its objectives (Pajaro et al., 2010) and typically encompass biophysical, governance, and socioeconomic components, providing a comprehensive view of management effectiveness. Ultimately, the accuracy and reliability of these evaluations depend on robust baselines and extensive monitoring data, which are still lacking in many Protected Areas.

While some of the assessment tools have been used in multiple sites (e.g. METT), the overall uptake of PAME tools by MPAs remains limited. Improving the MEE cycle and its outcomes requires clearer guidance on when and how to use specific PAME tools, as well as on the most appropriate approaches for different contexts. The analysis presented here aims to provide such guidance by defining a set of criteria for assessing management effectiveness and applying them to evaluate existing MPA monitoring and evaluation tools. The initial set of criteria used in this work was inspired by the topics and parameters commonly applied in established PAME tools, such as METT, RAPPAM, MaPAF, and Scorecard approaches. These criteria were selected to provide a structured basis for assessing management effectiveness across multiple dimensions and to ensure compatibility with widely recognised evaluation practices. Special consideration was also given to those criteria taken by the assessment tool developed for the European Commission DG Env in 2022 for marine Natura 2000 sites. This tool (in the following: EUN2000 tool) is still being further developed but once it is finalised, it should serve as one of the main evaluation tools for different sites in Europe.

3.2. Monitoring in the Management Effectiveness Cycle

A central element to effective MPA management is monitoring. Targeted monitoring of the achievement of the MPA’s conservation objectives, management performance and impact enables the adaptive alignment of management activities with objectives.

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The design and implementation of monitoring at an MPA must be carefully tailored to the specific ecological and socio-economic context of each site as well as its maturity (stage of establishment) (Figure 3) and level of protection. Effective monitoring begins with clearly defined objectives and indicators that reflect both ecological targets and management priorities. This requires the identification of key attributes to be monitored (e.g. habitat condition, pressure impacts) and the selection of appropriate methods , as well as the spatial and temporal resolution of data collection (Dalton et al., 2024; Nature United, 2023).

Figure 3 ***MPA Stages of establishment (Proposed/Committed, Designated, Implemented and Actively Managed)****. Adapted from Grorud-Colvert et al. (2021)*

Implementation does not only involve data gathering, but also the establishment of protocols, data processing and interpretation, as well as definition of roles and responsibilities among involved stakeholders. This definition can include engaging local communities and stakeholders in the monitoring process, which in turn can enhance both data relevance and stakeholder ownership.

Ultimately, well-designed and effective monitoring will provide results that are essential for applying an adaptive management approach in the MPA, allowing managers to evaluate performance and adjust responses on time to changing conditions. It will also help to improve accountability and strengthen the overall impact of conservation actions.

To support the design of effective monitoring systems within MPAs, a comparative overview of selected monitoring frameworks was conducted. This analysis of frameworks sought to collect best practices and support the design of effective monitoring systems within an MPA.

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4. Methodology

The identification of best practices in selecting MPA evaluation tools was organised into four main steps (Figure 4). First, a comprehensive screening of PAME tools was conducted and the list of tools to analyse was narrowed down based on the defined selection criteria. Second, a Tool Evaluation Matrix was developed and used to systematically compare the tools. Third, the relative importance of different criteria for tool selection based on the stage of MPA establishment was discussed during a participatory workshop. Finally, the resulting recommendations were summarised as a guidance on the most relevant MPA effectiveness assessment systems to be applied in the Demonstration Sites.

This analysis was complemented by a comparative overview of selected monitoring frameworks. This aimed to describe and evaluate each framework based on its relevance to adaptive management, drawing attention to critical aspects such as the existence of clear criteria for selecting monitoring indicators, the use of baselines and thresholds, the capacity to address threats and pressures, and the ability to assess conservation outcomes, including restoration efforts. Additionally, the analysis considered whether each framework is embedded within the broader Management Effectiveness Evaluation cycle (Figure 1) and whether it incorporates considerations of cost-effectiveness.

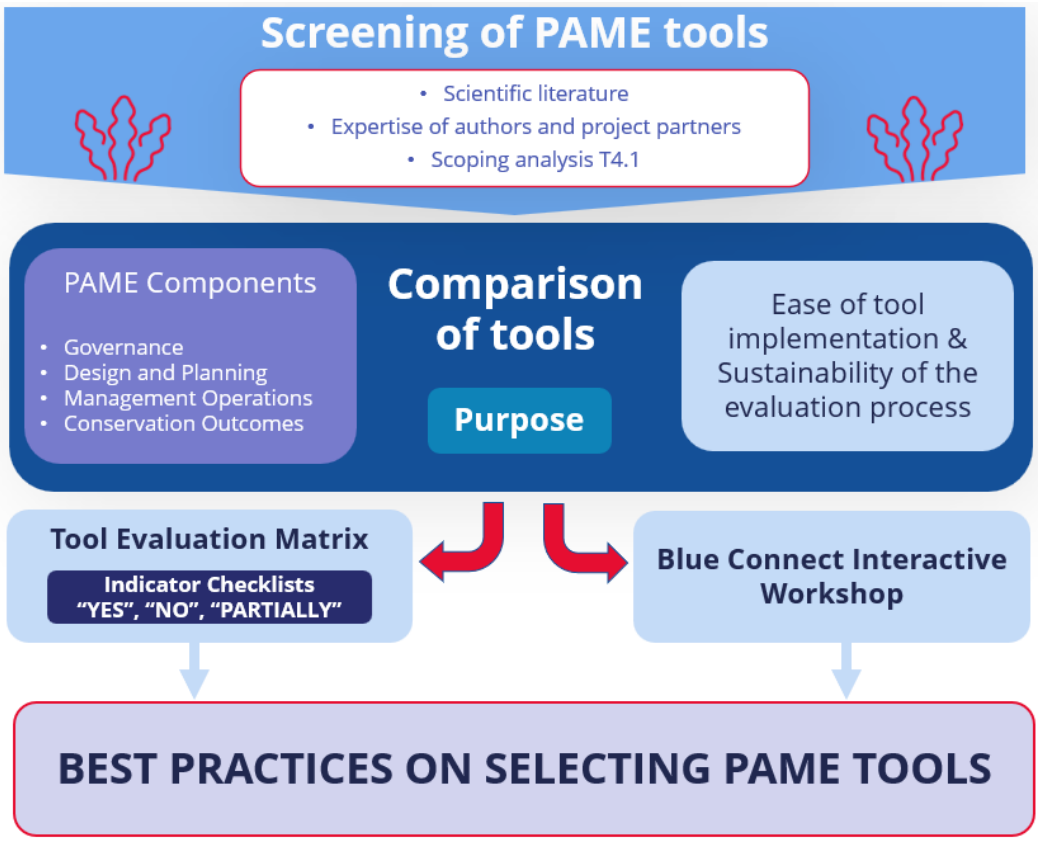

Figure 4 ***Methodology used to develop the Deliverable****. Please see main text for details.*

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4.1. Screening of PAME tools

PAME tools were defined as a collection of criteria, questions and indicators, that can readily be applied to assess management effectiveness of a marine and terrestrial protected area throughout its lifecycle. Thus, frameworks that broadly describe management effectiveness as part of the MPA management process or geoportals solely displaying data related to effectiveness were not included in the analysis as PAME tools, although they can support the PAME implementation process when available. Statistical methods, such as Before-After-Control-Impact (BACI) analysis, that can be used to calculate single indicators of effectiveness are not discussed as tools either. Instead, they are considered in chapter **Error! Reference source not found.** "Frameworks for M onitoring MPAs".

The management effectiveness evaluation tools to be assessed were compiled based on the expertise of the authors as well as a comprehensive literature review. One key reference was the final report of the project "Management effectiveness of marine Natura 2000 sites and other EU marine protected areas"[1], financed by the European Commission DG Env to develop the EUN2000 tool. The report included a review of PAME tools up to the beginning of 2021 and identified 156 relevant references, mostly produced by conservation practitioners. These were scanned for PAME tools for the current analysis. To be able to identify tools published after 2020, a Scopus search was also conducted on 07/05/2025 using the search string "((“management effectiveness”) AND (“protected area”) AND (evaluation OR assessment))". This search returned 86 results, of which 10 references introduced additional PAME tools. Besides the identification of tools, the search results were also used to identify recent global and regional guidelines and tools produced by conservation practitioners that could be applicable on EU MPAs.

Additionally, the scoping analysis carried out by the Blue Connect project, which aimed to collect best practices in monitoring and evaluation from Demonstration Sites, was considered (Task 4.1. Baeckelandt et al., 2025). The Demonstration Site teams suggested four PAME tools (“Guide for the quick evaluation of management in Mediterranean MPAs”, “Marine Mammal Management Self-Assessment Tool”, “Canary Islands Geographical Information System” and “Geoportal SIGMAR”). Of these, the last two were excluded as they are geoportals, and therefore did not correspond to the definition of PAME tools applied here.

The list of identified PAME tools was further narrowed down to exclude tools specifically developed for regions outside Europe (e.g. the Site Consolidation Scorecard used in the Americas- The Nature Conservancy and U.S. Agency for International Development,

[1] Final report available at: https://circabc.europa.eu/ui/group/00564ca7-9d16-4b81-bac5-b35fcb84aa33/library/0d81306a-2f30-4062-81a1-bfeebb01f152?p=1&n=10&sort=modified_ASC

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2003), taxon-specific tools (e.g. Birdlife IBA - BirdLife International, 2006; Marine Mammal Management Self-Assessment Tool[2]-) and tools that were not freely accessible or that were only published in one scientific article but not tested in protected areas.

4.2. Comparison of PAME tools using a Tool Evaluation Matrix

A Tool Evaluation Matrix was developed to systematically compare PAME tools based on their purpose, the aspects of management effectiveness they consider and on the PAME implementation process itself. Criteria to evaluate each tool was developed by the UMA team and subsequently revised by task partners. The Excel file containing the Evaluation Matrix also included a sheet on acronyms and a Glossary to aid consistent evaluations and standardized terminology.

The first four questions of the Matrix aimed to **capture the purpose of the tool**. These were all commonly stated goals of PAME tool applications: 1) facilitate the improvement of management actions, 2) communicate progress on conservation objectives, 3) provide transparency, enabling stakeholders to see how well their needs have been addressed, and 4) determine and award a level of effectiveness (in form of a certification or label). During the evaluation process of the different PAME tools, the evaluator had to assess for each of these four purposes if the given tool aims to fulfil them and write down their answer ("Yes", "No" or "Partially") as well as any comments justifying the assessment. Here the goal was not to assess how suitable the tools are for achieving their purposes, but to assess what their stated purpose was.

The second section of the Tool Evaluation Matrix was developed building on management effectiveness criteria included within the tools. This section included a number of criteria **on four components of management effectiveness**, which correspond to the components assessed by the IUCN Green List Standard and previous global assessment standards (Governance, MPA Design and Planning, Effective Management Operations and Conservation Outcomes). All criteria comprising the EUN2000 tool were included as well.

Criteria included in the Matrix are conceptual components of management effectiveness (for example, "Processes Enabling Governance Vitality" under the Governance component). For each criterion, a checklist of one to twelve concrete indicators was included (Figure 5). The indicators were measurements or evidence that can be used by MPAs to monitor their progress on the given criteria (for example, "Programme for review and updating of management plans (MPs)").

[2] https://marine-mammals.info/self-assessment-tool

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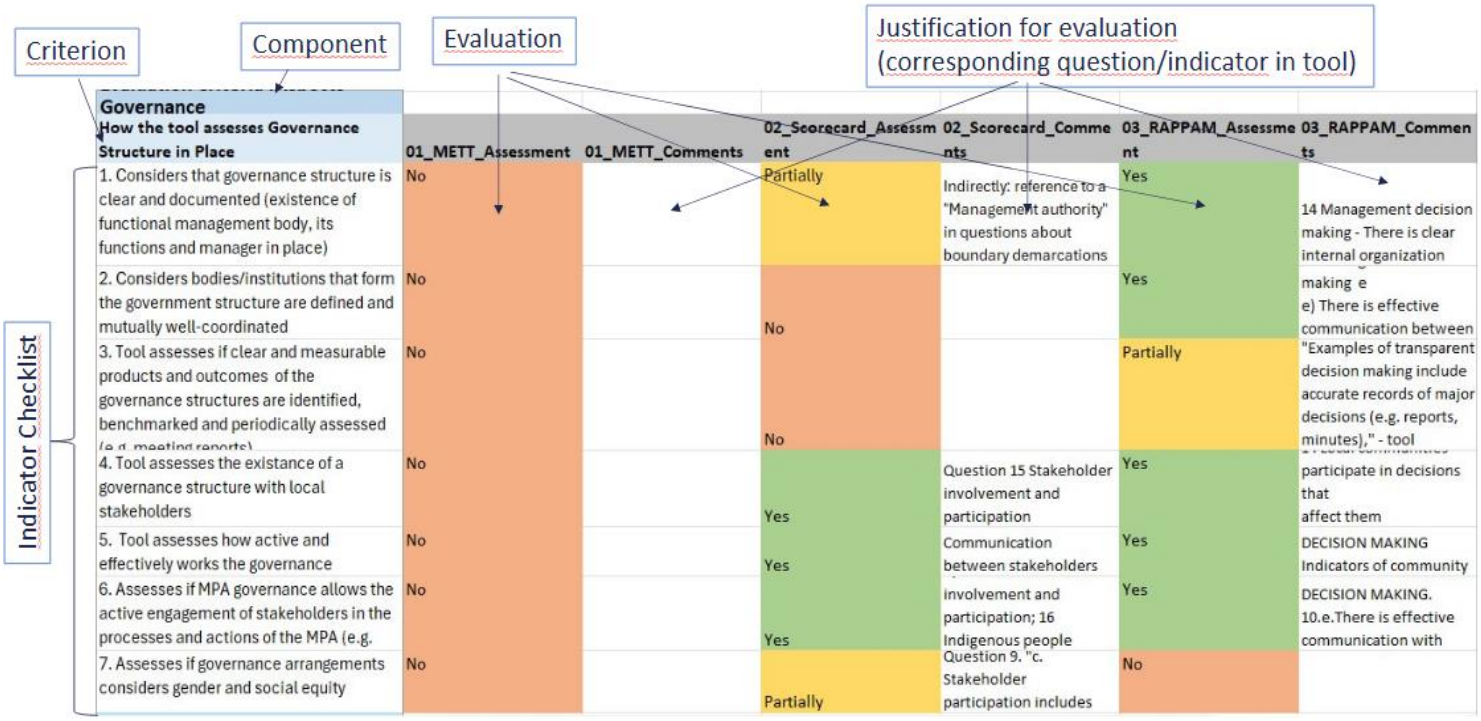
For each indicator of the checklist, evaluators had to decide if the tool they were reviewing considered them. For example, they had to judge if the indicator "Assesses if a programme for review and updating of management plans (MPs) is included" holds for the tool they were reviewing. The EoH tool assesses if "the management plan for the property is reviewed on a regular basis". In such case, the evaluator recorded a "Yes". If the indicator was only considered by the tool to some degree, they noted "Partially" (like for the Blue Park Awards, which considers if the MP has been updated within the last 15 years, but not necessarily if there is a regular process of updates). The evaluator recorded "No" if the indicator was not considered by the tool at all. In the "Comments" column evaluators were asked to record the corresponding question or indicator in the tool if they had answered "Yes" or "Partially" (Figure 5). If they had answered "Partially", they were also asked to explain why the criteria was only partially satisfied by the tool. The column could be used to add any other comment or clarification on the tool assessment. For a few questions, other answer options rather than "Yes", "No" or "Partially" were provided. For example, for the indicator "Considers if the MPA has established an inventory of conservation features/objectives (CO) and associated ecosystem services and cultural values" the answer options were "Both conservation features and ecosystem services", "Only conservation features/objectives", "Only ecosystem services/cultural values" and "No". A full list of criteria and indicators, as well as answer options are included in Table A 1 in Annex 1.



Governance How the tool assesses Governance Structure in Place	01_METT_Assessment	01_METT_Comments	02_Scorecard_Assessment	02_Scorecard_Comments	03_RAPPAM_Assessment	03_RAPPAM_Comments
1. Considers that governance structure is clear and documented (existence of functional management body, its functions and manager in place)	No		Partially	Indirectly: reference to a "Management authority" in questions about boundary demarcations	Yes	14 Management decision making - There is clear internal organization
2. Considers bodies/institutions that form the government structure are defined and mutually well-coordinated	No		No		Yes	making e e) There is effective communication between
3. Tool assesses if clear and measurable products and outcomes of the governance structures are identified, benchmarked and periodically assessed (e.g. meeting reports)	No		No		Partially	"Examples of transparent decision making include accurate records of major decisions (e.g. reports, minutes)," - tool
4. Tool assesses the existance of a governance structure with local stakeholders	No		Yes	Question 15 Stakeholder involvement and participation	Yes	participate in decisions that affect them
5. Tool assesses how active and effectively works the governance	No		Yes	Communication between stakeholders	Yes	DECISION MAKING Indicators of community
6. Assesses if MPA governance allows the active engagement of stakeholders in the processes and actions of the MPA (e.g.	No		Yes	involvement and participation; 16 Indigenous people	Yes	DECISION MAKING. 10.e.There is effective communication with
7. Assesses if governance arrangements considers gender and social equity	No		Partially	Question 9. "c. Stakeholder participation includes	No	

Figure 5 ***Screenshot of the top rows of the second part of the Tool evaluation Matrix****. It shows the indicator checklist for the first criterion under the Governance component (first column), as well as assessments results and*

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related comments for the METT, Scorecard and RAPPAM tools. The results shown are from the consolidated matrix (see main text).

Finally, in the third section, additional criteria were included on **the ease of tool implementation and sustainability of the evaluation process** (Table 1)**.** These were developed to be able to guide managers in tool selection not just based on the relevance of tools for their purposes but also based on the resources they have available to conduct the MEE process, as well as other factors they need to consider, e.g. reporting requirements or stakeholder involvement.

Table 1 Criteria related to first-time tool implementation and sustainability of the MEE process. See main text for details on calculating the "ease of implementation score".

Criteria	Answer options
Criteria used to calculate the "ease of implementation score" (score values are indicated in brackets)	
Time for implementation	Less than 3 days (0), 3-14 days (1), 14-30 days (2), More than 30 days (3)
Financial need to apply the tool (assessors' opinion)	Low (1), Medium (2), High (3)
Level of experience required to use the tool	No experience (0), Little experience (1), Experienced (2), Very experienced (3)
Ease of scoring of the indicators/criteria	Yes, simple rating system for all indicators, according to the interpretation given (e.g. colour coding, numbering) (1); Partly, only some indicators are scored in a simple rating system (2); No (3)
Includes a Glossary and Manual	Yes (1), No (3)
Includes a Glossary and Guide for Development	Yes (1), No (3)
Criteria related to MEE context	
Type of assessment	Self-assessment tool, Automatic tool, Independent assessment tool
Scale of assessment: Developed for a network/regional context OR applicable to site-level assessment and regional-level assessment	Network/regional, Both site-level and network-level
Input from local stakeholders possible/needed	Yes, No, Not specified
Developed only for a specific region/countries	Universal/ *Name region*
Aligned with national, regional and EU (MSFD) frameworks & reporting obligations	Natura 2000, National MPA reporting, Regional Convention reporting, CBD reporting, Not specified
Other criteria	
Data/information needed	It is based on expert opinion, Requires evidence-based information, It is automatically filled from different databases, Mixed expert opinion and evidence
Tool includes (local) indicators and means of verification	Required, Not required

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Available in language	*List languages*
It allows free text to explain successes and challenges	Yes/No
How it considers overlapping designations	It considers same MEE for overlapping designations, It considers different MEE for overlapping designations Not specified
Considers stage of MPA establishment (Designated, Implemented, Active Managed)	Yes, No, Not specified
Results of tool give a snapshot of the MPA progress	Yes, No

Assessment of PAME tools

This work involved first to conduct a pilot test of the Tool Evaluation Matrix. Each task participant (Evaluator) evaluated one randomly assigned tool, to ensure that participants understood the task and the Matrix as well as to identify potential sources of confusion.

Feedback from participants was used to refine the Matrix, and clarifications were given to all when needed. After this first test round, tools were distributed among evaluators randomly. Answers were recorded in individual spreadsheets. All tools were reviewed by one to three experts including UMA. Spreadsheets containing individual responses were consolidated into one Excel table by UMA to enable a consistent analysis of tools. All responses and comments were reviewed.

If different evaluators assessed the same indicator on the same tool differently (e.g. one gave a "Yes" and another "Partially"), then the case was individually analysed, and a final decision was made accordingly by UMA. Evaluation of tools by multiple evaluators decreased the risk of overlooking aspects assessed by the tools, despite diverse terminologies. A consolidation of answers enabled a consistent assessment across all tools, reducing variation linked to individual experts.

The consolidated matrix was used to compare tools based on all criteria described above. Tools were reviewed in detail and compared based on their characteristics using qualitatively and quantitative methods. It was also assessed the extent to which each tool consider the need for adequate and sustainable financial resources to support ongoing implementation. Moreover, it was examined how tools facilitate the establishment and development of monitoring programmes, promote the generation and use of evidence, and support a learning-oriented management process that enables continuous improvement. Special focus was given to comparing the tools in how they consider MPA management effectiveness under uncertainty (e.g. climate effects) with particular attention to how they address ecological and social vulnerability, and the preparedness

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of management systems to respond to future challenges. In addition, the EUN2000 PAME tool was analysed in greater detail, as this has being proposed as the main PAME tool applicable across Natura 2000 sites EU in the future.

Following this, a non-metric multidimensional scaling analysis (NMDS) was applied to visualise the similarities and dissimilarities between the different assessment tools based on the full matrix. This analytical method was chosen as it is suitable for qualitative data. The dissimilarity matrix was constructed using Gower distance (a measure of dissimilarity) based on the answers in the matrix (Maechler et al., 2023). Answers were treated either as categorical ("Self-assessment tool", "Independent assessment tool" and "Automated assessment tool"; all questions in Table 1 except the time for implementation, financial need, level of experience and ease of scoring) or ordinal (e.g. "No", "Partially", "Yes"; all other questions of the matrix). Tools were clustered into groups using Partitioning Around Medoids Clustering, usable for distances based on non-quantitative data (Figure 7).

Further, a visualization of the checklist results was created to be able to compare the tools specifically on how they consider the four main MEE components. As these indicator checklists contained 81 elements, it was necessary to condense the information to be able to visually compare tool similarities. For this aim, "Yes", "No" and "Partially" answers were coded as 1, 0 and 0.5, respectively. Scoring for other answers options followed the same logic, and scores are noted in Table A 1 of the Annex. For each criterion, these values were summed and divided by the theoretical maximum value (i.e., the value if the answer is "Yes" for all the elements of the checklist), resulting in a score 0-1 for all the criteria. These quantitative Criteria Scores were then visualised on a colour scale to efficiently overview tool similarities and identify patterns (Figure 8).

To calculate an Ease of Implementation Score, answers related to ease of implementation criteria were also transformed into scores (Table 1). Scores on individual criteria were summed to get the Ease of Implementation Score of each tool, where lower values meant that less resources were required for implementation. Ease of Implementation Scores were contrasted with averaged Criteria Scores for each component, to assess the trade-off on the depth of information provided by the PAME to the resources needed for the implementation of the process (Figure 9). Analysis and visualisations were performed using R (R Core Team, 2021).

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4.3. Participatory workshop on best practices in MPA evaluations and monitoring indicators

During the General Assembly of Blue Connect (17-18 June 2025, in person & online), UMA led an interactive session where participants discussed the importance of the different criteria for management effectiveness evaluation and those potential monitoring requirements for some of the criteria (Figure 6). The discussion was structured in three groups, based on MPA Stage of establishment (Designated, Implemented, Actively Managed). Participants assigned themselves to one of the groups based on their experience and relation with the Demonstration sites. There was also an online discussion group on Designated MPAs. Integrating insights from the interactive workshop on PAME helped to fine tune results and assess an approach to selecting PAME tools for site MPA management effectiveness assessment.

Figure 6 ***Interactive section on MEE at the Blue Connect General Assembly****, 18 June 2025.*

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4.4. Selecting best practices in MPA management monitoring frameworks

Finally, the study assessed selected monitoring frameworks to determine their suitability for supporting the PAME process and demonstrating biodiversity outcomes. This comparative analysis provides insights to inform the design of effective monitoring systems within MPAs. This analysis aimed to evaluate the relevance of different frameworks to adaptive management by assessing key features, such as:

- The existence of clear criteria for selecting monitoring indicators;
- The inclusion and application of baseline conditions and thresholds;
- The capacity to address both internal and external threats and pressures;
- The ability to assess ecological and socio-economic conservation outcomes, including restoration efforts.

Furthermore, the review considered the degree to which each framework is embedded within the broader Monitoring, Evaluation, and Effectiveness (MEE) cycle. Special attention was also given to whether frameworks promote stakeholder co-design and engagement, and whether they incorporate cost-effectiveness as a principle for implementation.

The selected frameworks include both global and EU-level systems that offer structured indicator sets, emphasize condition-based monitoring, and support evaluation of pressures and responses in PAs. This comparative overview was used to inform the identification of best practices and guide the selection of the most suitable frameworks for developing robust, scalable monitoring strategies for application in the Demonstration Sites.

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5. Main outcomes

5.1. Selected PAME tools

The PAME tools screening procedure resulted in a final list that contained 21 tools (Table 2). The selected tools included those that were developed for global use for any type of PA (e.g. METT, RAPPAM) and others that were developed specifically for (M)PAs within certain regions (e.g. CPAMETT, MEDPAME, OSPAR). The compilation includes also tools that were developed by a specific study to investigate a set of PAs and not for general applicability (FIPAME, Headline). Most tools are presented in the form of questionnaires, downloadable Excel tables or browser applications. However, two tools are computer programs hosted by individual institutions and not readily available for general use (MaPaF, ProtectBaltic). Two tools (EUN2000 and ProtectBaltic) are currently under development.

The selection included a diverse set of tools in the study to provide insights into different perspectives on how management effectiveness can be assessed across regions, as well as the various ways of measuring and evaluating it.

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Table 2 List of tools included in the analysis.

Name and reference	Abbreviation	Description
Blue Park Standard (Marine Conservation Institute, 2022)	BlueAwards	The fulfilment of Blue Park Award Criteria by an MPA is assessed by a scientific committee. If the MPA fulfils the criteria it receives the Blue Park Award and becomes part of the Blue Park network.
Biosphere Reserve Effectiveness of Management index (Matar and Anthony, 2022)	BreMi	Developed for managers of UNESCO Biosphere Reserves. Consists of a number of indicators of reserve performance that are rated on a scale 0-10. Useful both for a site-level analysis as well as for comparisons between PAs.
Carpathian Countries Protected Areas Management Effectiveness Tracking Tool (WWF International Danube Carpathian Programme, 2012)	CPAMETT	Originally an online tool dedicated to the evaluation of PAs in the Carpathian ecoregion by their management teams, based on the METT tool. Currently only the pdf documentation seems to be available.
Enhancing Our Heritage Toolkit 2.0 (UNESCO/ICCROM/ICOMOS/IUCN, 2023)	EoH	Assessment methodology to support participatory evaluations of UNESCO World Heritage Sites but can be used for any PA. It includes a guidance for gathering information, a number of worksheets and reflection questions. It has a strong focus on cultural values.
EU Marine Natura 2000 tool[3]	EUN2000	User-friendly Excel tool to support reporting on conservation outcomes on natural values, mainly for EU Natura 2000 sites and network but also for other PAs. Under development.
Guide for quick evaluation of management in Mediterranean MPAs (Tempesta and Otero, 2013)	MEDPAME	Developed by WWF and IUCN and published by the MedPAN. Mainly aimed at Mediterranean MPA managers. Comprises 18 priority and secondary indicators, which can be scored by the evaluation team based on a set of questions. Also provides guidance on monitoring to be able to assess the indicators.
Headline Indicators (Leverington et al., 2010b)	Headline	A tool to assimilate the results of other PAME across the network. Diverse information is condensed into a relatively few indicators highlighting main aspects of

[3] https://circabc.europa.eu/ui/group/00564ca7-9d16-4b81-bac5-b35fcb84aa33/library/0d81306a-2f30-4062-81a1-bfeebb01f152?p=1&n=10&sort=modified_ASC

		management effectiveness. Introduced as part of a Global Study of management Effectiveness, initiated by WCPA.
How Is Your MPA doing? (Pomeroy et al., 2005)	Pomeroy	A framework and tool at the same time, explaining the different steps of an MEE and how to plan each, giving a lot of flexibility in the assessment. Provides a list of objectives and indicators, and the evaluator chooses what will be used. Published by IUCN, WWF and NOAA.
Integrated Management Effectiveness Tool v 2.13 (Bialowolski et al., 2023)	IMET	Computer application with a built-in statistical and visualization system, by IUCN. Focuses on providing a detailed analysis, finding and improving critical issues in management. The assessment in conducted by a team including PA staff, local stakeholders and national services and is facilitated by at least one IMET coach.
IUCN Green List Standard[4]	GreenList	Describes 17 criteria, accompanied by 50 indicators. Candidate sites for listing prepare a dossier addressing all criteria, which is evaluated by an Expert Assessment Group.
Management Effectiveness Assessment tool by the Protect Baltic project	ProtectBaltic	Automatic tool under development to evaluate the network of MPAs in the HELCOM region based on information extracted from databases. The version of the tool assessed is not publicly available. A publicly accessible description of the method is available under HELCOM (2021)
Management Effectiveness of Protected & Conserved Areas Indicator (JNCC, 2024)	MEPCA	MEPCA is a complementary indicator in the monitoring framework of Kunming-Montreal Global Biodiversity Framework (GBF). Can translate scores from existing assessments based on other tools like METT into a more condensed evaluation.
Management Effectiveness Tracking Tool (Stolton et al., 2020)	METT	Excel tool of multiple-choice questions used to calculate an MEE score, with free-text sections to provide evidence and justification. The most widespread MEE tool for all types of PAs as PAs receiving funding from the World Bank are required to use it for reporting.
Marine Protected Area Protection Assessment Framework (Rodríguez-Rodríguez et al., 2016)	MaPaF	Automatic tool to evaluate the effectiveness of the Mediterranean MPA network based on information extracted from existing databases. It comprises 5 indicators that are integrated into one super-index.

[4] https://iucngreenlist.org/standard/components-criteria/

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MPA Resilience Self-Assessment Tool v.1.[5]	RSAT	Online self-assessment tool with a focus on managing MPAs for climate change preparedness and adaptation of PAs, mostly consisting of multiple-choice questions.
Rapid Assessment and Prioritization of Protected Area Management (Ervin, 2003)	RAPPAM	A global, well-known tool by WWF for all types of PAs with a scoring system based on a multiple-choice questionnaire. The tool is intended to be filled out in one or several workshops. Useful both for a site-level analysis as well as for comparisons between PAs.
Rapid Ramsar Management Effectiveness Evaluation Tool (Munguía and Heinen, 2021)	RMEET	Reporting framework proposed as a part of the Ramsar Conventions information-gathering protocols to facilitate system-wide comparisons of Ramsar sites. Comprises 4 sections, each containing 3-4 questions.
Score Card to Assess Progress in Achieving Management Effectiveness Goals for Marine Protected Areas (Staub and Hatziolos, 2004)	Scorecard	A scorecard based on the METT intended to be filled by managers and stakeholders together to identify successes and areas for improvement. It is also used for reporting on the performance of World Bank investments in MPAs to its shareholders and other partners, such as the Global Environment Facility.
Self-assessment scorecard for OSPAR MPAs (OSPAR, 2007)	OSPAR	Designed as a quick self-assessment tool of OSPAR MPAs by managers, ideally with validation from stakeholders. Comprises a series of questions that are scored between 0 and 3.
Format for the periodic review of Specially Protected Areas of Mediterranean Importance (UNEP/MED, 2023)	SPAMI tool	A questionnaire used for periodic review of designated SPAMIs under the Barcelona Convention, evaluated by a Technical Advisory Commission. The assessment reviews conservation status and management progress of the area to evaluate if the SPAMI status can be renewed.
System-level evaluation of protected area management effectiveness for Parks & Wildlife Finland (PAME) (Stolton et al., 2024)	FIPAME	Network-level questionnaire (open-ended) to evaluate the Finnish Network of PAs, building on results from the first evaluation report (2005). The assessment was conducted by Parks & Wildlife Finland, that operates the PAs.

[5] https://www.coastal-resilience.online/access-to-coastal-resilience-assessment-tool.php

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5.2. Comparison of PAME tools

Outcomes of the tool review process guided by the Tool Evaluation Matrix

The co-author team systematically collected information about the tools using the criteria in the Tool Evaluation Matrix (chapter 4.2) related to tool purpose, consideration of management effectiveness components, first-time implementation and sustainability of the PAME process. The resulting matrix was analysed using NMDS and clustering analysis to gain first insights into which tools are most similar to each other (Figure 7). From this analysis it was observed:

1) a group containing only tools with a focus on network-level assessments (Headline indicators, MEPCA, MaPaF, ProtectBaltic tool, RMEET (Ramsar);

2) a group containing some self-assessment tools (Scorecard, MEDPAME, BreMi, CPAMETT) that are suitable for sites and networks;

3) a group with two tools with the purpose of obtaining or maintaining a certification (BlueAwards and SPAMI tool) and other tools that are suitable for sites and networks (METT, EUN2000, RAPPAM);

3) a group containing comprehensive tools, one network assessment tool (FIPAME), one site self-assessment tool (OSPAR), three tools where providing transparency was a strong focus of MEE (IMET, EoH, Pomeroy) and the GreenList certification tool; and

4) the RSAT tool as an own group, as the most distant from the other tools, explained by its unique focus on managing MPAs for climate change effectiveness.

These results highlighted that the most important criteria distinguishing tools were those criteria related to purpose (providing transparency and achieving certification) and the scale of assessment (Table 1). In addition, to what extent the tools considered the different MEE components played a role, as tools containing only a few questions like MaPaF were placed opposite from very comprehensive tools like the GreenList and EoH by the NMDS procedure.

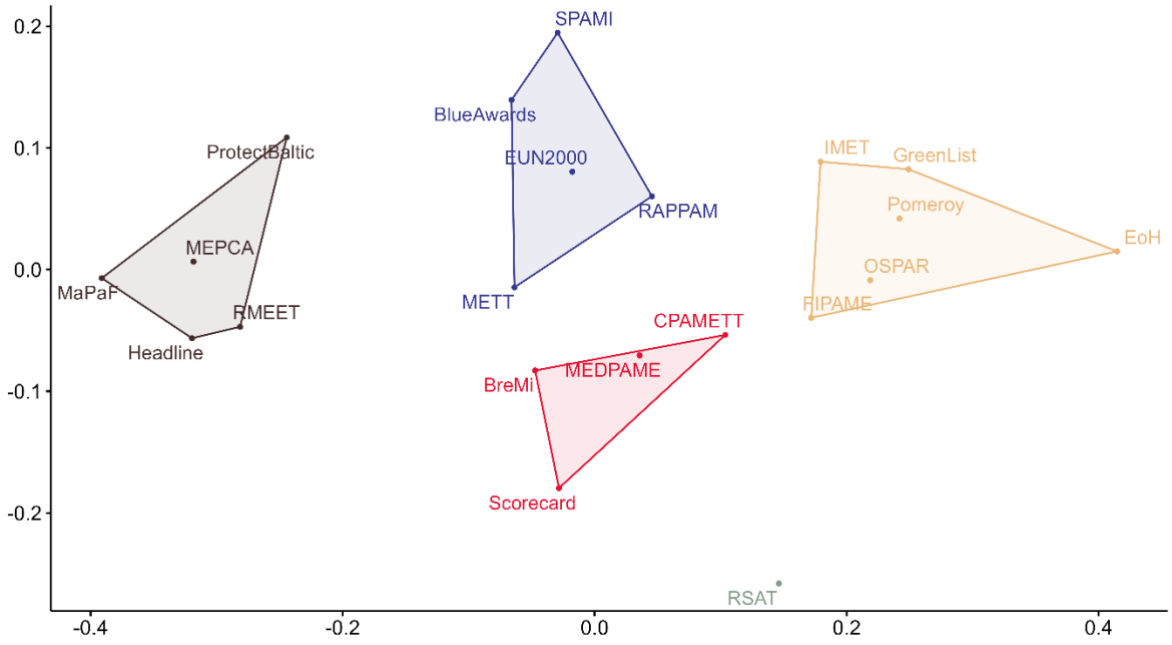

Figure 7 ***NMDS visualization of tool similarity****. PAME tools which are placed closer to each other are more similar. Note: The axes in NMDS do not have an interpretable meaning and represent the stress level of similarity or dissimilarity of the grouping. Grouping of tools (colour) is based on Partitioning Around Medoids.*

The few criteria that best reflect tool similarity based on the NMDS likely also capture the primary considerations of managers when selecting tools, and taking these into account already substantially narrows the list of potentially applicable options. Accordingly, the tools were grouped based on the results of the Tool Evaluation Matrix in relation to these criteria (Table 3), and comparisons were subsequently focused within these groups for further analysis.

Table 3 Grouping of tools based on selected criteria. Each tool is included in only one group. When grouping tools, purpose was considered with priority over assessment scale. Grouping is based on answers in the consolidated Tool Evaluation Matrix. "Evaluating MPA resilience to emerging threats" was not a purpose originally included in the Tool Evaluation Matrix, and is added here as the RSAT tool emerged as an own group in the NMDS analysis (Figure 7)

Grouping criteria	Group	MEE tools
Purpose	Provide transparency	EoH, IMET, RAPPAM, Pomeroy
	Certification	BlueAwards, GreenList, SPAMI
	Evaluate MPA resilience to emerging threats (e.g. climate change)	RSAT
Assessment scale	Both site-level and network-level assessment	BreMi, CPAMETT, EUNatura2000, MEDPAME, METT, OSPAR, Pomeroy, Scorecard
	Network/regional assessment	FIPAME, Headline, MaPaF, MEPCA, ProtectBaltic, RMEET

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To analyse the comprehensiveness of tools in terms of the four MEE components (Figure 4) in greater detail, a visualization of the Criteria Scores for each tool was created (Figure 8). From the group of tools that aim to enable transparency (Table 3), EoH and IMET are more detailed while RAPPAM and the Scorecard consider less criteria. From the group of tools usable for certification purpose the most detailed is the GreenList. From the tools that can be used both for site-and network-level assessments, the Pomeroy and OSPAR tools assess the largest number of criteria. All tools from this group cover at least half of the criteria under each component at intermediate-to high level (Scores 0.4-1). In contrast, tools for network-level assessments only consider a few criteria, except for the FIPAME which has a different approach from the other ones. Other tools gather data on PAs at a site level, then integrate these into a network-level assessment. The FIPAME questionnaire contains questions at the network level (e.g., “Is there effective public participation in protected area management in Finland?”).

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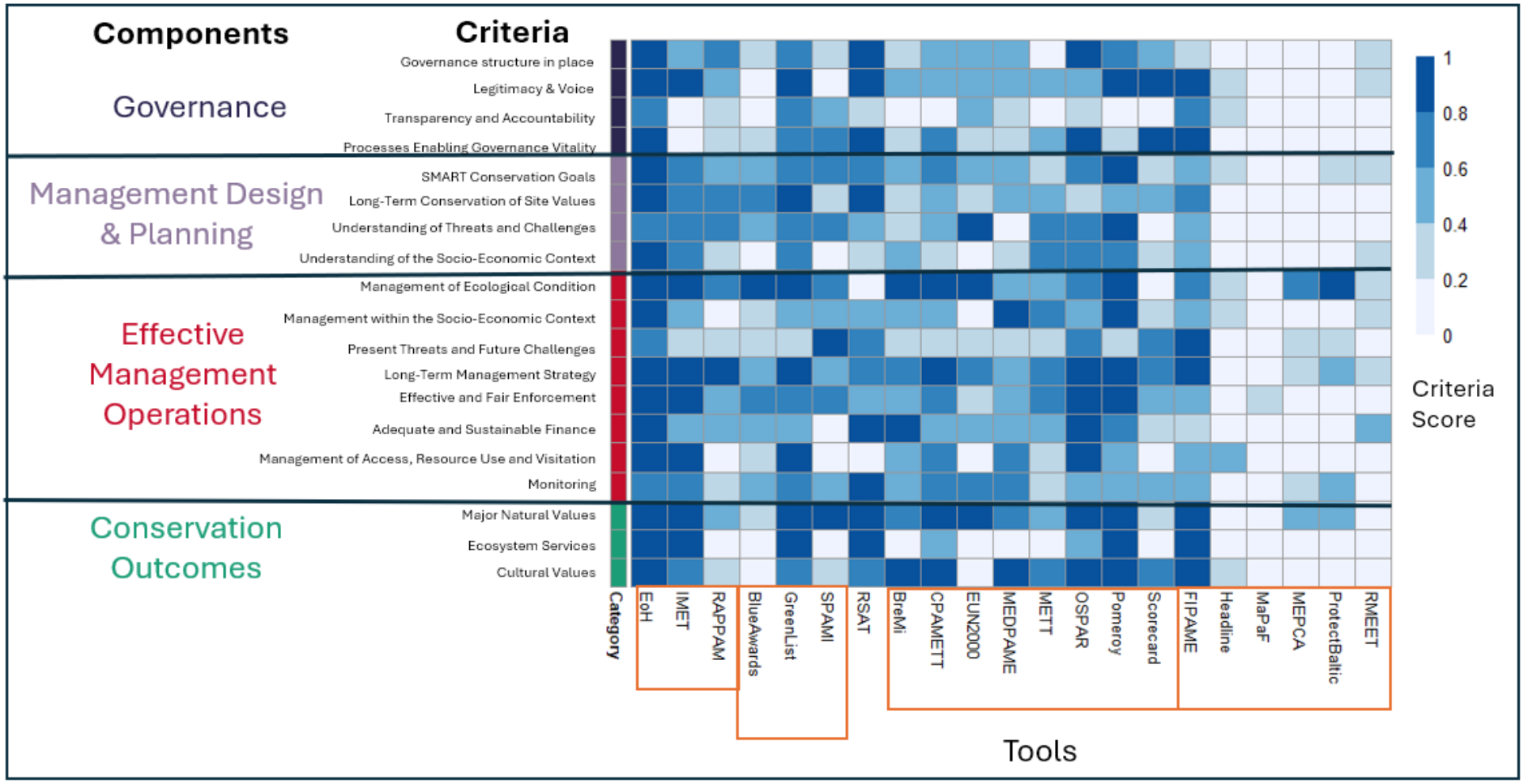

Figure 8 ***Criteria Scores for all criteria within the four MEE components (rows) for all evaluated tools (columns).*** *The orange brackets around tools indicate their grouping according to Table 3.*

Governance Criteria

Common criteria considered under the governance component by different PAME tools include the evaluation of the existence of a functional governance structure in place, participatory approaches to governance and the assessment of processes enabling adaptive management (e.g. a regular review and update of management plans). Only a few tools (EoH, FIPAME and the GreenList) explicitly assess MPA transparency such as public availability of governance-related documents and monitoring information, and the existence of an MPA process for dispute resolution.

Management Design and Planning Criteria

Different criteria of management design and planning related to natural site values, socio-economic context, threats and challenges and long-term planning are considered to a similar extent across the tools. The existence of a legal designation and management plan is assessed by all tools. However, fewer tools assess the existence of specific and clearly measurable conservation objectives in the management plans (e.g. MEDPAME, BlueAwards). Tools such as RAPPAM, IMET, OSPAR, EUN2000, and EoH especially stand out in this regard as they not only assess specific and measurable goals but also the steps of timeframes to achieve them.

RAPPAM emphasizes clearly defined goals linked to biodiversity values and systematic steps to achieve them. IMET focuses on SMART (Specific, Measurable, Achievable, Relevant, Time-bound) goals within a structured workplan. OSPAR evaluates whether conservation objectives have been developed and agreed upon, specifying favourable conservation status and associated timeframes. EUN2000 provides a detailed framework for defining the condition of habitats and species, including relevant attributes, target values, and timescales aligned with ecological requirements. The EoH tool adds depth by assessing the overall adequacy of the planning framework itself.

Most tools also assess if the MPA planning has considered human activities and threats. However, only the Pomeroy and the EUN2000 tool consider criteria related to evaluate if the MPA assess cumulative effects of pressures while most tools focus only on the pressures inside the MPA, not evaluating if the MPA planning considered the effects of external factors on conservation objectives.

Effective Management Operations Criteria

The focus of most tools is evaluating if management measures are proposed and being implemented, including the enforcement of regulations. Most tools also evaluate if measures effectively reduce pressures. Considering financial available resources, all tools evaluate if financial constrains are threatening the achievement of management

objectives, except for the automated tools (MaPaF, ProtectBaltic) and the high-level reporting tools (Headline, MEPCA).

In terms of monitoring, most tools asses if monitoring programs both on pressures and on the condition of major site values exist at MPA sites. However, they only assess the existence of such programs and not their adequacy. Exceptions are the SPAMI, EoH and OSPAR tools that include an assessment of the adequacy of the monitoring program and its implementation. The Pomeroy tool provides guidance on establishing an adequate monitoring program that includes potential indicators to be monitored, necessary requirements and methods for the interpretation of the results. It also includes references to survey techniques. However, as the tool was published two decades ago, these may be partly outdated. The MEDPAME tool developed for the Mediterranean also provides indicators to monitor focal species and habitats and specific pressures (fishing effort, invasive alien species and climate change impacts). In contrast, the global tool under the Green List requires targeted monitoring to be conducted against defined performance measures related to site objectives. The FIPAME assesses if monitoring fulfils reporting obligations under European Directives and International Conventions.

In contrast, visitor management is only considered in detail (at least 5 "Yes" in the indicator checklist) by the IMET, MEDPAME, CPAMETT, OSPAR, EoH and GreenList tools. Similarly, the existence of a management plan for resource users (e.g. fisheries management plan) is considered by the METT, Pomeroy, MEDPAME, SPAMI, OSPAR, and EoH tools.

Conservation Outcomes Criteria

The Tool Evaluation Matrix assessed the extent to which different tools evaluate conservation outcomes, focusing on three key dimensions: natural values, social and cultural values, and ecosystem service values. Among these, the conservation of natural values is the most consistently addressed, with almost all tools including it as a central criterion. In contrast, the conservation of social and cultural values is considered by just over half of the tools, and ecosystem service values are the least frequently addressed.

The detailed assessment of natural values varies across tools, both in terms of the depth of evaluation and the approaches applied. The indicators that the tools use to assess conservation of natural values are listed in Table 4.

For example, METT includes general assessments of species, habitats, and other natural values, while RSAT provides a more in-depth analysis by examining the status and evolution of key species, populations, and ecological processes, including interdependencies within and between ecosystems. Similarly, MEDPAME assesses the conservation condition of focal habitats and the abundance and population structure of focal species.

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Some tools focus on maintaining current ecological conditions. SPAMI tool, for instance, emphasizes the maintenance of species and habitat status with no significant changes in ecosystem functioning. This PAME assessment tool associated to SPAMI sites (Specially Protected Areas of Mediterranean Importance) under the Barcelona Convention has a narrower focus, as it is specifically developed to support the needs of SPAMI-designated sites. Its primary function is to assist these sites in identifying management gaps and areas for improvement, in alignment with the legal obligations and conservation objectives set by the Protocol concerning Specially Protected Areas and Biological Diversity (SPA/BD Protocol).

OSPAR evaluates whether the condition of features of interest has improved, and CPAMETT monitors the conservation status of key indicator species. EoH (Enhancing our Heritage) offers one of the most comprehensive approaches, assessing not only the status and trends of attributes related to Outstanding Universal Value and other important values, but also the adequacy of the monitoring systems and the use of findings to inform and improve management.

Other tools such as BreMi focus on tracking the condition and trends of biodiversity values over time, while ProtectBaltic evaluates the status of defined conservation features. IMET makes a clear distinction between short-term, management-level conservation outputs and long-term outcomes related to key ecological values, evaluating both dimensions separately.

Some tools assess whether management objectives related to conservation have been achieved. Scorecard asks whether management objectives have been met, although these objectives are not necessarily conservation-specific. In contrast, MEPCA and FIPAME focus explicitly on conservation objectives and outcomes. EUN2000 includes an assessment of whether conservation objectives are on track to be achieved within an appropriate timescale, making it especially inclusive for recently established MPAs. Pomeroy focuses on whether populations of target species for use remain within desired reference points, while BlueAwards requires a monitoring program to be in place, but does not directly evaluate progress toward conservation targets, and only confirms the current existence of biodiversity values.

Despite the broad coverage, a few tools do not explicitly assess conservation outcomes. These include RAPPAM, Headline Indicators, MaPaF, and RMEET, which either lack a direct outcomes focus or limit their assessments to management inputs and processes.

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Table 4 Assessment of the conservation status of natural values by different PAME tools.

Evaluates change in conservation status	Assessment of the status of species/habitats (biodiversity values) of importance (METT, RSAT, SPAMI, OSPAR, CPAMETT, BreMi, EoH, IMET)
	Focal species abundance and population structure, focal habitats' conservation condition (MEDPAME)
Evaluates if site objectives have been achieved	Management objectives (Scorecard)
	Conservation objectives (MEPCA, ProtectBaltic)
	Assesses achievement of conservation objectives or if they are on track to be achieved (EUN2000)
	Assesses achievement of short-term objectives (outputs) and long-term objectives separately (Scorecard, IMET, FIPAME, Headline, EoH, BreMi, GreenList)
	Evaluates status of value/populations against a reference threshold (Pomeroy, GreenList)

Other elements to consider when selecting a PAME tool

Tools applicable at the site and network level are the ones that MPA managers may use for a self-assessment. During the interactive workshop at the Blue Connect assembly meeting, participants discussed which elements could be the most important to enable managers to choose among self-assessment tools. All discussion groups considered **human and financial resources available** for the assessment (including collecting the necessary information) as the most important selection criterion in choosing an PAME tool, besides the **relevance of the evaluation outcomes for management**. Two Demonstration sites (L'Albera and the Scottish MPA Network) shared that on their sites, local communities (such as NGOs and fishers) are more involved in monitoring and supervising the area than administrative bodies, as no active MPA management bodies are in place. In these situations, it is essential to use a tool that allows these communities to be involved in initial and subsequent evaluations. In this regard, participants emphasized the importance of ensuring that the tool is **sufficiently flexible to be adapted to different stakeholders** (e.g., allowing questions to be communicated in non-specialist language and enabling easy visualization of results), even in transboundary management contexts involving diverse actors. To facilitate selection among self-assessment tools, the study analysed their comprehensiveness across management effectiveness components in relation to their Ease of Implementation Score, highlighting those designed for participatory application with stakeholders (Figure 9).

The tools that are the most comprehensive on most components (EoH and Pomeroy) also require more resources to implement. The IMET requires less effort to implement and

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has still high scores on all components except the governance one. All three tools (EoH, Pomeroy and IMET) should be implemented as part of a participatory process. The OSPAR tool, which is to be made by managers and validated by stakeholders, has high Mean Criteria Scores on all components while being easy to implement at the same time. The Scorecard tool also requires low effort to implement and assesses governance aspects in detail, but is more concise on other management effectiveness components.

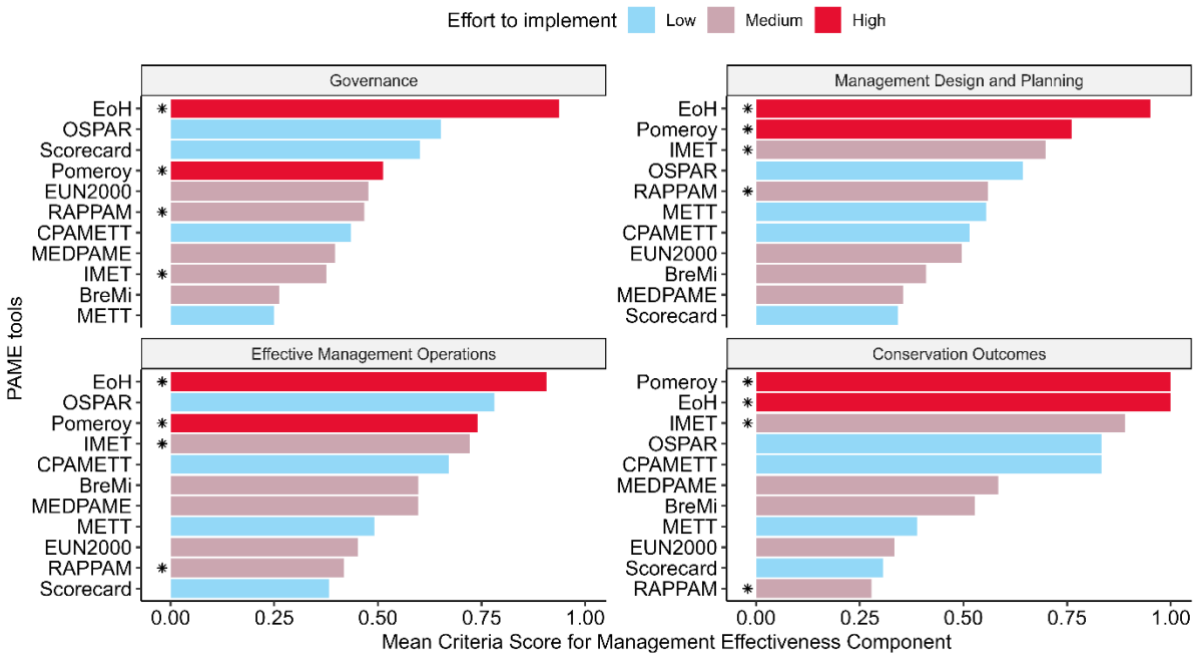

Figure 9 ***Mean Criteria Scores within a given management effectiveness component (panels) of PAME tools that can be used both for site-level and network-level assessment****. Larger values indicate that the tool considers a larger number of indicators for the criteria within the given component. Colors correspond to the Ease of Imnplementation score, from blue to red representing increasing efforts required for implementation (according to criteria in Table 1). Tools with the purpose of transparency, that are always implemented in a participatory process, are marked with an asterisk.*

Individual MPAs may have specific criteria that are important for their management context, which may change the ranking of the tools above. For example, some participants suggested that for their sites it is important to consider if the evaluation tool assesses the regulation of activities through different legal frameworks. This was the case for the Scottish MPAs where uses and potential pressures are controlled by frameworks that are not specific to the MPAs (national fisheries legislation, MSC certification, etc). Another aspect highlighted was the importance to assess if the MPA understands if the changes to the conservation objectives are clearly related to the changes in pressures inside the MPA, or due to other external factors (especially in highly mobile species). It was also mentioned that the tools should assess if MPAs took steps to protect species with urgent protection needs.

There were different viewpoints about **scores versus free-text** answers in the MEE tools. Total scores are more easily communicated while disaggregated scores can help

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management bodies to make decisions based on results. However, deciding a score may be difficult, and the free text answers provided by some tools allow a more informative approach that could also support improve management.

On one hand, for recent Designated MPAs it was considered less important that the PAME tools support in **fulfilling reporting needs** than its role in supporting adaptive management. On the other hand, for Actively Managed MPAs the fulfilment of reporting needs was considered highly important. Also, the existence of a **guidance on how to use the tools results** was important so that next steps to improve MPA management could be better prioritized.

Managing under uncertainty - climate change, connectivity and ecological restoration in PAME

The importance of managing PAs with climate change in mind has been recognised more than a decade ago (Ervin, 2011). Since then, there is accumulating evidence demonstrating that conservation efforts in MPAs can be counteracted by climate change (Bates et al., 2019). Additionally, climate uncertainty can also increase socio-economic tensions in the marine space (Schmidt et al., 2022). In the face of this uncertainty, MPAs should incorporate climate change scenarios, vulnerabilities and impacts in the planning phase, in setting up their monitoring plans and creating action plans to mitigate climate impacts (Cannizzo et al., 2025; Garrabou et al., 2019; Otero et al., 2013). A PAME process can help to evaluate how far the MPAs have come in such efforts, if a PAME tool is used that incorporates corresponding indicators.

Climate change results in shifting species ranges (Poloczanska et al., 2013). Sites may function as refugia from climate extremes depending on their oceanographic characteristics (Burrows et al., 2019). Marine communities have a higher chance to persist when movements of individuals among sites are not hindered (Pinsky et al., 2020). Ensuring functional connectivity between MPAs supports species migration, genetic exchange, and ecosystem recovery, all of which are essential for long-term adaptation to changing ocean conditions. Thus, incorporating spatial and temporal ecological context into MPA planning is key to avoid insufficient connectivity between PAs (Arafeh-Dalmau et al., 2021). All tools that can be used at the site level, except for the MEDPAME and the SPAMI tool, assess if the MPA planning **considered connectivity needs of their major natural conservation value objectives (**RSAT, METT, CPAMETT, IMET, Scorecard, Pomeroy, RAPPAM, OSPAR, EoH, GreenList, BlueAwards). The BreMi tool only evaluates this aspect to a limited extent, via considering if MPA size is sufficient to reach conservation objectives. From the network-level tools, only the FIPAME assesses if the PAs are integrated into an ecological network. Using such PAME tools will help the assessment and needed improvement of connectivity between MPAs in Europe (Assis et al., 2021).

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Around half of the tools at the site level (RSAT, METT, IMET, MEDPAME, EoH, GreenList, BlueAwards) and FIPAME also allow the evaluation of **ecological vulnerability to climate change** in the MPAs and assess if this is incorporated in the management plans. On the other hand, **social vulnerability to climate change** is only considered by the METT (vulnerability of "human systems") and EoH (vulnerability of the cultural heritage value of the site). This aspect is assessed partially by the IMET (vulnerability of ecosystem services) and FIPAME ("other values" of the sites). The RAPPAM, CPAMETT and EUN2000 ask the assessor or assessor team to list climate change impacts among other pressures and threats to the site, but do not evaluate if the MPA is designed or is already consciously managed to adapt to climate change. Considering **climate change scenarios** into MPA planning is also a useful tool to incorporate future species distributions, connectivity needs and species vulnerabilities into MPA site selection (Ervin, 2011). However, only three tools explicitly mention the incorporation of climate scenario projections into MPA planning (RSAT, EoH, GreenList).

Active restoration and direct management of the ecological status instead of passive protection have come into focus recently as actions contributing to climate change mitigation and adaptation (Manea et al., 2023). Such actions **may have unintended negative consequences** (Velle et al., 2025), and MPAs should plan to avoid these. The RSAT tool has a criterion to address this in its evaluation by looking at "Decision-making mechanisms and protocols to ensure that restoration initiatives cannot create new negative impacts affecting the surrounding environment". The FIPAME and the SPAMI tools address the existence of monitoring of the impacts of management actions in the MPA in general, and the existence of feedback mechanisms to adjust these actions in case of failures. Unintended consequences of management actions may be monitored in MPAs as part of an adaptive management cycle, but our analysis shows that most current PAME tools do not assess the existence of concrete feedback mechanisms from management actions to consequences to the adaptation of actions. As active management becomes more prominent, this aspect may receive more attention in future PAME tools and assessments.

5.3. Specific features of the EUN2000 PAME tool

This tool is being developed **mainly for designated Natura 2000 areas** for the conservation of natural values (habitats and/or species) and, therefore, focuses on that aspect of effectiveness and on the legislation and reporting needs of the Natura 2000 network. This means that most of its questions and criteria address the achievement of conservation objectives (on species/habitats) under the Habitats or Birds Directive. The tool has less emphasis on procedural management and does not consider socio-economic context or outcomes or ecosystem services. Nevertheless, it assesses stakeholder engagement in MPA management in detail. The tool is mainly meant for

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managers to evaluate the ecological status of the MPA they are managing and the work carried out.

Compared to other tools, on the **governance** aspect, the tool has a unique feature. It asks assessors to explicitly evaluate the stakeholders' engagement in all aspects of MPA management (e.g. natural conservation objectives, Pressures, Measures etc.), not just on specific aspects or in general. However, it does not evaluate if stakeholder mapping has been done to ensure equity and broad stakeholder representation. Stakeholder mapping is not assessed by most tools and is only evaluated by the tools with a focus on participatory assessments (IMET, EoH), the comprehensive GreenList Standard and the Pomeroy tool. Also, the EUN2000 tool does not assess indicators related to the documentation of management (e.g. documentation of governance structure, meeting reports).

In terms of **MPA design and planning**, the EUN2000 tool is one of the most detailed PAME tools on the identification of SMART conservation objectives and the understanding of threats and challenges. It is unique in that it considers cumulative impacts of pressures, the confidence level of impacts and the impact from pressures inside and outside the MPA separately in management planning. However, the tools focus is on current pressures and not on future challenges, shown by the lower score achieved on the criterion "How the Tool Assess Design for Long-Term Conservation of Major Site Values". Also, the tool does not consider the incorporation of the social and economic context into planning, neither planning of alternative income generating activities and social vulnerability to climate change. This contrasts with most other tools, which consider this aspect at least to some extent, except the automated tools (MaPaF and ProtectBaltic) and the MEPCA, created for CBD reporting. Moreover, the EUN2000 tool does not assess the incorporation of connectivity into planning. The rationale behind that may be that it is assumed that the Natura 2000 network is designed to be well connected and, thus, this does not need to be evaluated at the site level.

The tool does offer an in-depth analysis of results from **management operations**. Its strength is that it asks the assessor to explicitly link measures to conservation objectives and pressures and evaluate their implementation status. An important feature is that it considers taking measures outside of the MPA, not only within. It does not assess actions related to enhancing community benefits of the site, or preparedness to future challenges (like climate change), reflecting the findings above with respect to the Management Planning component. Compared to other self-assessment tools, there is less emphasis and no detailed evaluation of the processes and resources supporting the enforcement of laws and regulations and of the MPA communication strategy. Solely the implementation status of the respective actions would be evaluated if they are included in the management plan and are specifically related to conservation objectives. Thus, the

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tool strikes a balance between keeping the evaluation time short but remaining comprehensive in terms of measures supporting conservation outcomes.

The only type of **conservation outcome** the tool evaluates are conservation values. The evaluation of conservation outcomes is extensive. Information needs to be provided on the confidence level in species/habitat status, and changes in status is linked to management measures. In addition, reasons for limited progress are evaluated. During this evaluation, presumed? deficiencies in, for example, enforcement or communication are analysed, although with only a limited number of explicit questions. The tool does not consider outcomes in terms of ecosystem services or social or cultural values, in contrast to all other self-assessment tools.

Interestingly, this is the only tool which explicitly considers a different MEE for **overlapping PA designations**, probably due to its focus on evaluating legally defined conservation objectives, that may differ based on different legal designations at the same site. In terms of ease of implementation, the EUN2000 is a straightforward Excel tool. However, it requires comprehensive monitoring information on species/habitats and pressures to be informative, as these are the main aspects that it evaluates. During its testing phase with a project, an assessment to 74 sites was conducted, covering all the European regional seas[6]. Users reported an evaluation time of 4 hours to one day per site. However, one of the tool developers indicated that the short evaluation time was due to lack of data at most of the sites, and, if data would be available, then for a first assessment it could take up to 3-4 days to compile all the information, depending on MPA complexity (pers. comm., M. Parga, SUBMON).

The tool includes a very detailed help form and creates automated charts on assessment outcomes, which ease communication. It is implemented in Microsoft Excel, which is a proprietary software. This does not follow the EU commitments on using open-source tools (European Commission, 2020b). However, the final digital tool implementation is still ongoing.

[6] Final report available at: https://circabc.europa.eu/ui/group/00564ca7-9d16-4b81-bac5-b35fcb84aa33/library/0d81306a-2f30-4062-81a1-bfeebb01f152?p=1&n=10&sort=modified_ASC

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5.4. Frameworks for Monitoring MPAs

Global Frameworks

A wide range of monitoring frameworks have been developed to support the design and implementation of biodiversity monitoring systems in MPAs, each with varying levels of integration into the full Monitoring, Evaluation, and Effectiveness cycle (MEE) (Table 5). The recent framework by IUCN WCPA for monitoring biodiversity in protected areas and other effective area-based conservation measures follows four key phases: preparatory, conceptual, implementation, and re-evaluation (Dalton et al., 2024). The preparatory phase defines the monitoring's purpose based on management goals, stakeholder needs, existing legal obligations, and site-specific conditions, identification of priority questions and potential knowledge gaps. In the conceptual phase, the programme's framework is shaped using guiding questions—why, what, where, when, who, and with what resources—to clarify objectives, select indicators, and determine methods. The implementation phase focuses on fieldwork and analysing results to inform adaptive management and PAME reporting. Finally, the re-evaluation phase assesses the programme's effectiveness, informs adjustments, and supports knowledge sharing across sites and networks, ensuring continued relevance and improvement. This framework uses an indicator selection guided by the Essential Biodiversity Variables (EBVs), based on the importance of the species or habitat in meeting site objectives, the complexity of their management, and the availability of human and financial resources. Although it does not directly assess threats, it can identify them indirectly by correlating long-term changes in the state of sensitive indicators. While the framework aligns with the PAME cycle, its scope remains relatively narrow on indicator criteria selection, serving primarily as an indicator-based approach mostly for species conservation goals with less importance on ecosystem services and socio-cultural benefits.

A complementary and widely adopted framework comes from Conservation Measures Partnership with its latest update on Global Effective Management Framework and Conservation (Open) Standards (2025), which provides structured guidance for developing a formal monitoring, evaluation, and learning plan. Central to this approach is the use of focal values (Key ecological attributes as ecosystems and species targets, ecological process) as key components of biodiversity that represent the overall integrity of the system being managed. Indicators are developed per conservation objective and must meet specific criteria: they should be measurable, precise, consistent, and sensitive, and directly linked to the situation model or theory of change, reflecting key factors, assumptions, and expected results. The framework prioritizes structured indicator development aligned with clearly defined management objectives and incorporates both threat reduction and biophysical outcomes, ensuring full integration into the MEE cycle.

The Open Standards framework is currently evolving to support a full adaptive management and learning cycle within the protected area MEE process.

Other frameworks, such as those developed by Nature United (2023) and Cardoso-Andrade et al. (2022), propose participatory and expert-based approaches to selecting performance indicators, with clear emphasis on linking monitoring to management triggers, cascading outcomes, and cost-effectiveness. National or site-specific frameworks (e.g., Caselle et al., 2022; Jiao et al., 2022; Mezquida et al., 2005) present practical guidance for indicator development and baseline setting, though often lack fully developed MEE integration. The marine Natura 2000 framework in the EU relies on standardized reporting formats[7] and predefined indicators, offering less flexibility to tailor monitoring design, but includes basic provisions for tracking pressures and conservation status.

The BRIM framework, originally developed for terrestrial Biosphere Reserves (Biosphere Reserve Integrated Monitoring, 2001), provides a structured approach to ecosystem monitoring. It recommends a core set of variables, including both biodiversity indicators and abiotic ecosystem characteristics, to be monitored over time as essential measures of environmental change. This toolbox is designed to detect trends and shifts in ecosystem conditions, offering a scientific foundation for informed management decisions. BRIM places strong emphasis on clearly defining the goals of the monitoring process and encourages a distinction between driving forces, indicators, and policy responses. It also promotes the creation of an open, participatory environment that fosters learning, knowledge exchange, and constructive dialogue. Crucially, the framework highlights that setting monitoring goals should be a collaborative process involving all relevant stakeholders.

Monitoring frameworks for restoration outcomes like the “International principles and standards for the practice of ecological restoration” (Gann et al. 2019) emphasize ecosystem attribute recovery and provide practical tools (e.g., the ecological recovery wheel), though they focus less on long-term conservation outcomes. The broad categories developed on these restoration standards to assist practitioners with evaluating the degree to which biotic and abiotic properties and functions of an ecosystem is recovering include absence of threats, physical conditions, species composition, structural diversity, ecosystem function, and external exchanges. Further to this broad framework, to determine the extent that restoration interventions are having an effect, monitoring data must be collected before and after treatment/management actions on both control and treated/managed sites (Before-After-Control-Impact or BACI experimental design) (Stewart-Oaten et al., 1986; Underwood, 1992). Based on BACI

[7]https://cdr.eionet.europa.eu/help/habitats_art17/Reporting2025/Art.17%20report%20format%202019-2024.pdf/

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design, Hayes et al. (2019) proposed that a monitoring framework should be grounded in the Evidence-Based Decision Making (EBDM) paradigm. Within this approach, monitoring activities are shaped by questions that aim to improve understanding of values (e.g. describe the status of ecosystems or socio-economic conditions) and pressures (e.g., through baseline surveys), identify trends or patterns in the data (e.g., correlations between habitat and species abundance), and ultimately establish causal links between management actions and observed changes in ecological or social conditions. For example, "Did the enforcement of a no-take zone cause the increase in demersal fish populations?". This structured approach incorporates these new elements to inform that monitoring goes beyond data collection to support targeted, effective conservation decisions.

Across the different monitoring frameworks, common strengths include attention to baseline definition, indicator selection criteria, and links to management objectives (Table 5). Less consistently, these frameworks address the integration of monitoring into a continuous MEE cycle and comprehensive cost-effectiveness assessments, though some frameworks do consider these elements during indicator selection or monitoring design. Overall, while the level of maturity and comprehensiveness varies, the most robust frameworks (e.g. Global Effective Framework from Open Standards) are those that embed monitoring into adaptive management, align with site objectives, and allow for participatory or expert-driven indicator development.

Monitoring Climate Impacts

Monitoring is key to detect climate change–induced spatio-temporal shifts and separate them from the effects of other pressures, management actions and natural variability. The Open Standards for the Practice of Conservation (Conservation Measures Partnership, 2025) suggest using dedicated monitoring techniques and specific indicators (e.g. marine heatwave intensity) to understand climate impacts and capture climate variability. On the other hand, the report on Best Practices for MPA Network Monitoring encourages using the same indicators that are used for general MPA effectiveness also to measure climate effects (e.g. species distributions and behaviour), but adjust sampling and analytical approaches to focus on vulnerable species and ecosystems and areas under greatest climate risk (Nature United, 2023).

Only few management effectiveness assessment tools explicitly consider if the MPA has a **monitoring for climate impacts** (PAME tools: RSAT, MEDPAME, IMET) although more PAME tools might evaluate this as part of the assessment of general threat monitoring. An important function of monitoring is that it should provide early warning signs of tipping points to trigger preventive actions when possible. Such actions may include modifying management strategies and reconsider conservation objectives (Conservation Measures Partnership, 2025). Thus, monitoring information can leverage early warning

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action plans, which are key elements assessed for climate change readiness in PA effectiveness as considered by the PAME tools of RSAT, MEDPAME, and partially by the EoH, evaluating the existence of a "climate change mitigation and adaptation strategy".

Monitoring based on MPA Establishment Stage

Results from workshop discussions further underscored that an effective MPA monitoring framework must be tailored to the specific context and maturity of each MPA, as well as to the PAME criteria (planning and design, governance, operational management, and outcomes). Participants highlighted **the importance of acknowledging the stages of MPA establishment (Committed, Designated, Implemented, and Actively Managed),** since each stage presents distinct monitoring needs, capacities, and priorities (Grorud-Colvert et al., 2021).

For MPAs in the early Committed or Recently Designated stages, participants stressed that monitoring design plays a foundational role. The focus should be on establishing baseline ecological and socio-economic conditions, mapping key pressures, and identifying stakeholder groups. Early integration of monitoring ensures that data gaps are addressed from the outset and that future management actions are built on solid, context-specific evidence. Relevant PAME indicators may include for example whether the MPA has analysed and mapped participation in professional and recreational fishing, identified key stakeholder groups, and assessed community dynamics. This stage may also assess whether zoning and fisheries exclusion plans consider specific local communities, and whether the tourism sector linked to the MPA has been mapped, data collected and analyzed.

For Newly Implemented MPAs, discussions emphasized that monitoring should track the effectiveness of initial management actions and establish operational benchmarks. Key indicators may include enforcement effort (e.g., patrols, fines), infrastructure deployment (e.g., buoys, signposts), visitor use, and community engagement. Participants also noted that monitoring at this stage provides early feedback on performance, including restoration actions if applicable, and should be clearly linked to adaptive management triggers while defining scheduling, methods, and data responsibilities.

For Actively Managed MPAs (typically established for more than five years), participants agreed that monitoring design should emphasize outcome-oriented indicators that evaluate ecological, social, and governance impacts. Indicators should address natural values (e.g., extent and integrity of key habitats, population trends of indicator species), ecosystem service delivery (often using expert-based or participatory assessments), and cultural values (e.g., perception and use of the MPA by local communities). Monitoring at this stage was seen as critical for demonstrating long-term impact, justifying

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management actions and investments, and ensuring that indicator sets are regularly reviewed to reflect evolving conservation and community priorities.

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Table 5 Comparison of biodiversity monitoring frameworks relevant to Protected Areas (PAs) and Other Effective area-based Conservation Measures (OECMs). The table summarizes key features across frameworks and key elements within them, such as indicator selection, use of baselines and thresholds, threat assessment, conservation outcomes, integration into the MEE cycle, and cost-effectiveness.

Name	Description	Selection criteria for monitoring indicators	Considers baselines and thresholds	Addresses threats and pressures	Assesses outcomes of conservation (incl. restoration)	Embedded into whole MEE cycle	Considers cost-effectiveness
A framework for monitoring biodiversity in PAs and OECMs (Dalton et al., 2024)	Decision-making framework for managers to develop biodiversity monitoring programmes	It defines indicators through the EBV. Selection is based on importance of the species or habitat to meet site management objectives, how challenging the species or habitat is to manage and (human and financial) resources.	Considered	Limited, it only identifies threats in long-term datasets through correlating changes in the state of a sensitive biodiversity indicator	Included as EBV	It relates to PAME process	Initial costs of monitoring are evaluated against the value of knowledge after several monitoring cycles
Open Standards for the Practice of Conservation (Conservation Measures Partnership, 2025)	Includes how to develop a formal monitoring, evaluation, and learning plan.	It uses focal values to represent key aspects of the overall system. Indicator & criteria are measurable, precise, consistent, and sensitive and should be tied to key factors, results, or assumptions in the situation model or theory of change	Encourages to measure baselines within the first few months of project start. Indicator thresholds should be established for selected indicators to trigger actions.	Assesses threat reduction as outcome	Includes biophysical results and biodiversity values	Into an Adapted Management Cycle that can be incorporated in MEE	In choice of methods & in focusing data collection on critical needs.
International principles and standards for the practice of ecological restoration	Framework to guide restoration projects toward achieving intended goals including a guide for practitioners in	Focus on BACI experimental design with criteria on measurable objectives, aligned layouts and schedules, and clear action triggers. Where relevant, controls and replication can	Once indicators are determined, baseline data are collected and milestones determined to see	Threats from adjacent areas managed or mitigated. Includes detecting type and degree of	Focus on restoration actions not on conservation objectives	Ecological recovery wheel is a tool for conveying progress of ecosystem recovery; from	Cost of restoration actions in general but not cost-effectiveness of monitoring.

(Gann et al., 2019)	planning, implementation, and monitoring activities.	support indicator selection and evaluation.	whether the rate of progress is on track.	drivers and threats that have caused degradation on the site and ways to eliminate, mitigate, or adapt to them.		planning and design to reporting and maintaining ecological restoration projects	
Best Practices and Procedures for Operationalizing MPA Network Monitoring **(Nature United, 2023)**	Synthesis of global insights and recommendations for developing and implementing monitoring in MPA networks.	Link to management objectives (preferably more than one). Create complementary suites of indicators. Indicator selection in a systematic, transparent and participatory process.	Dedicated chapter on baseline monitoring. Recommends defining management benchmarks (unacceptable state of a monitored indicator) that trigger management action.	Human activity pressures are listed as potential indicator class to be monitored	Assessment of MPA impacts via an indicator chain for assessing the cascading effects of a management action on ecological indicators, ecosystem services and social values.	Monitoring is part of a cycle where it is developed based on management goals, feeds data into network-level MEE, which results in a revision of goals.	In the indicator selection process and when creating monitoring partnerships
Setting Performance Indicators for Coastal Marine Protected Areas: An Expert-Based Methodology (Cardoso-Andrade et al., 2022)	Expert-based methodology to co-define a list of multidisciplinary MPA performance indicators; not a monitoring framework in itself	Link to MPA goals, expert-based selection based on criteria.	It includes criteria for relevance, reliability, effectiveness, baseline situation, comprehensiveness and uniqueness	Not included	Includes how define a short list of performance indicators for performance assessment	Focus is on indicator performance criteria and the scoring methods to guide the design of a future monitoring program; not on MEE context	It assesses specific costs as criteria for selection of survey methods
Establishing an ecological	A framework on monitoring key	Direct link to management objectives, monitoring key	Not included	Only as part of a supply-demand	Achievement of	Suggest evaluating	Not included

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monitoring system for national parks in China: A theoretical framework (Jiao et al., 2022)	conservation objectives as well as ecosystem services including the choice of monitoring techniques, indicators and data management.	ecological processes over various spatio-temporal scales		analysis of ecosystem services (i.e. only overexploitation)	management objectives.	performance at national, municipal and PA level.	
California's MPA Monitoring Program (Caselle et al., 2022)	MPA Monitoring Program Framework to inform adaptive management	No explained. Direct link to Methods and Analytical Approaches for ecological performance	It has a phase 1 to establish baseline and phase 2 for long term	Assesses human engagement	Assesses changing conditions and the performance of the MPA network to inform adaptive management decisions.	Organized into 3 core components for efficient implementation and useful results: Science, Communication, and Evaluation	Not included.
Biosphere Reserve Integrated Monitoring approach BRIM (Biosphere Reserve Integrated Monitoring 2001)	Methodological guide aimed at facilitating implementation of monitoring activities of abiotic ecosystem components and processes in biosphere reserves	Selection based on participatory approach process; relevant to objectives, availability, sensitive, consistent and agreed by stakeholders.	Initially it was developed as a terrestrial framework. Baselines on abiotic conditions and biodiversity but unclear on how to set them.	Includes indicators to measure economic and social dimension	Focus on Biosphere Reserve values, including natural and social.	Includes elements on management performance assessment	Not included
A framework for designing ecological monitoring	Methodological process to design a monitoring plan. Specifies three	First: link to management objectives & key ecological processes. Second, sensitivity, known	Baseline is defined as the acceptable natural range of variation (so	Threat Reduction Assessment (TRA) approach	It is not a focus, but monitoring should be	Focuses on how to develop a management plan to monitor	Cost is considered in indicator selection and

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programs for Pas: A Case Study of the Galachos del Ebro Nature Reserve (Spain) (Mezquida et al., 2005)	potential levels of monitoring of increasing complexity.	responses to perturbation, non-excessive variability, ease of interpretation, cost and sampling effort.	threshold implied, outside the baseline is a problem).		linked to management objectives so it implies assessment of the achievement of those objectives.	ecological state, not on its use for MEE)	level (I-III) of monitoring program
(Marine) Natura 2000 sites Monitoring Framework[8]	Monitoring, assessment and reporting of conservation status.	Indicators are specified in the reporting format, no selection by the managers.	Depending on the indicator, the previous reporting period is considered as a baseline, or a rolling 12/24-year window	Requires listing of pressures (including past and future), impact and sources, but does not provide any guidance on how to monitor besides a code-list of potential pressures.	Change and reasons for change in conservation status and conservation status trend	Not yet, but the EUN2000 tool is being developed for this purpose.	Not included.

[8] Reference Portal for reporting under Article 17 of the Habitat Directive https://cdr.eionet.europa.eu/help/habitats_art17

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6. Conclusions and recommendations

6.1. PAME tool selection and best practices for site-level MPA management assessment

Considerations on "Purpose", "Depth" and "Outcomes of Assessments"

Protected Area Management Effectiveness (PAME) evaluations can be carried out at various spatial scales, and the appropriate choice of tools depends on the scale and on the purpose of the assessment. At the level of a single MPA, PAME evaluations primarily support the improvement of management actions and, in some cases, enhance transparency and accountability toward stakeholders.

When selecting a suitable PAME tool, managers must carefully weigh trade-offs between **the depth and detail of the assessment**, the **resources required** to implement it, and the **usefulness of the evaluation outcomes**. A more detailed tool often provides a comprehensive and nuanced view of management effectiveness, covering governance, design, processes, and outcomes. However, it can also demand significant time, expertise, and financial investment. By contrast, more concise self-assessment scorecards can provide a practical overview of strengths and weaknesses with relatively low effort. . This should help create potential actions by tracking progress across the management processes, intermediate results, and ultimate ecological and social impacts.

Among the more detailed frameworks, the **Pomeroy tool**, **Enhancing Our Heritage (EoH)**, and the **Integrated Management Effectiveness Tool (IMET)** are often referenced. Each differs in emphasis and ease of application: Pomeroy provides full guidance on monitoring and evaluation but requires significant adaptation effort; EoH offers ready-to-use worksheets but was originally designed for cultural World Heritage sites; and IMET, while somewhat less comprehensive, is more user-friendly with built-in visualization support.

For many MPAs, particularly in regional or network contexts, more **practical and balanced tools** such as **the OSPAR MPA Scorecard or CPAMETT may** be the most suitable options. These provide structured multiple-choice questionnaires that allow consistent scoring, quick comparisons, and identification of weakness or priority areas for improvement, while still covering the key elements of management effectiveness.

It should be noted, however, that the analysis made here assigned equal weight to each management effectiveness criterion. In practice, MPA managers or stakeholders may prioritise certain elements of effectiveness over others (e.g. focusing on current challenges vs. long-term planning or incorporating socio-economic aspects). Applying different weights to reflect these priorities would likely alter the relative ranking of tools.

An essential element in evaluating management effectiveness is also to consider **the assessment of conservation outcomes,** thus is, the actual ecological and social impacts, including cultural benefits, of management efforts. To be able to evaluate conservation outcomes, first it is key to define SMART conservation objectives in the management plan, as assessed by the IMET, the Rapid Assessment and Prioritization of Protected Area Management (RAPPAM), the EU Marine Natura 2000 (EUN2000) and the OSPAR tools. The same tools also provide separate scores for the outcomes on individual conservation objectives, allowing more adaptive management as managers can have a more nuanced impression of MPA progress. Tools that evaluate progress on short-term outputs as well as long-term objectives, like the IMET, especially foster adaptive management by aiding MPAs to formulate long-term strategies as well as action plans that serve these strategies.

Considerations on the role of Stakeholder Engagement

Stakeholder involvement is another key factor when selecting a PAME tool. For evaluations focused on improving local management, it is essential to at least consult stakeholders to validate the findings. This is the recommended approach from tools such as the Guide for Quick Evaluation of Management in Mediterranean MPAs (MEDPAME), OSPAR, and CPAMETT. Tools like Pomeroy, EoH, and IMET go further, providing structured guidance on stakeholder mapping and engagement of stakeholders in every phase of the assessment process. The RAPPAM tool also encourages participatory implementation through stakeholder workshops, but it lacks specific guidance on stakeholder identification and ensuring equitable representation.

Considerations on addressing Climate Change and Risk

Given that all MPAs should account for climate change and future uncertainties in their management strategies, selecting tools that incorporate these dimensions is essential. The MPA Resilience Self-Assessment Tool (RSAT) is specifically designed to evaluate resilience to climate-related and other future challenges. Among broader PAME tools, the EoH and MEDPAME stand out for their detailed treatment of risk management and climate change mitigation, making them especially relevant in today's context of accelerating environmental change.

Considerations on the Implementation of Management Effectiveness Assessments at Different Stages of MPA Establishment

In the case of *Designated MPAs* where no management is yet in place, PAME cannot currently be implemented. However, referencing the criteria of different PAME tools during this phase can guide the transition from designation to effective implementation.

For *Newly Implemented MPAs,* PAME is particularly useful for defining which effectiveness criteria will be monitored and for developing monitoring plans accordingly. The Pomeroy

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tool is especially relevant in this context, as it provides both effectiveness criteria and practical guidance on monitoring (see next chapter for further discussion on monitoring).

Actively managed MPAs that meet high standards of conservation effectiveness could use PAME assessments to pursue recognition through a certification and showcase their achievements. For instance, the Blue Park Award recognizes MPAs that contribute to a global network of highly effective marine protected areas. Thus, beyond demonstrating effective management, ecosystem representation and uniqueness, MPA size, age and connectivity are important considerations for an MPA to meet the Blue Park Standard. On the other hand, any PA regardless of characteristics such as size or age can commit to the IUCN Green List Programme and work towards certification using the IUCN Green List Standard Criteria. However, while the Green List Standard is designed to be globally applicable, regional or national adaptation is a critical element of its implementation (e.g. customize indicators, alignment with procedures from PA frameworks, etc). As a preparatory step, the IMET tool can be used to support sites aiming to join the IUCN Green List, as it covers most of the indicators of the Green List (Bialowolski et al., 2023).

Building on all these considerations, the following figure (Figure 10) summarizes the main criteria that can guide the selection of a PAME tool at the level of an individual MPA.

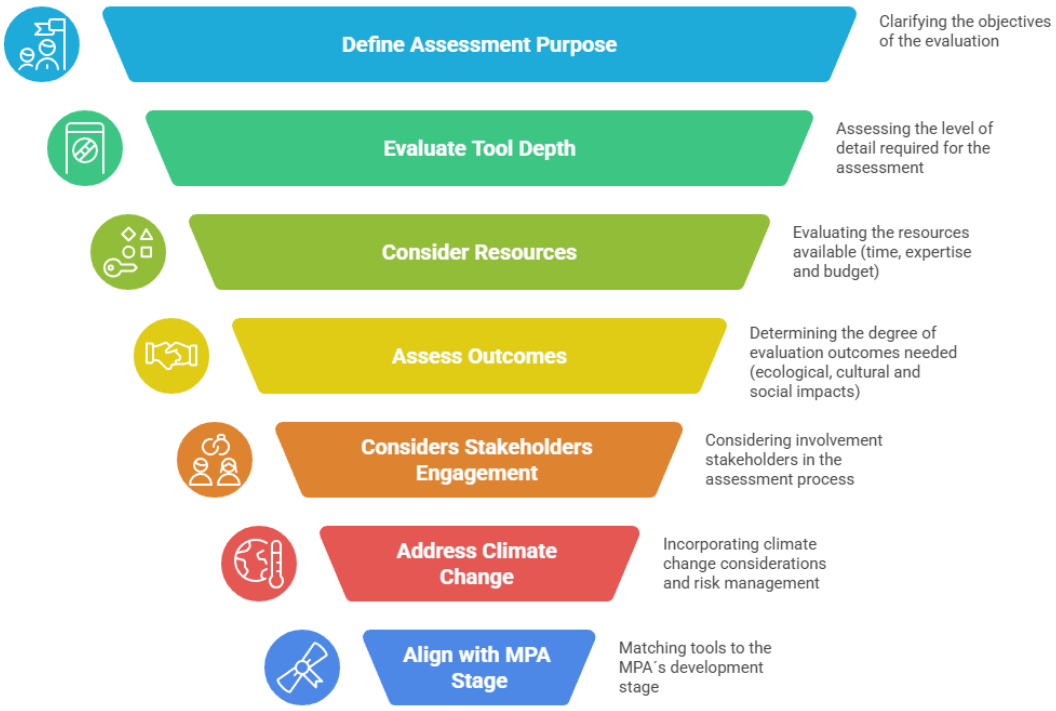

Figure 10. ***Criteria elements for selecting a Protected Area Management Effectiveness (PAME) tool for individual MPAs.***

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6.2. PAME tool selection for measuring success in managing MPA Networks

Beyond improving management at the site level, PAME can also provide insights at the regional scale by offering a broader understanding of the effectiveness of MPA networks and where management support may be needed. Some tools are particularly well-suited for use in specific regions or types of PAs due to their alignment with regional priorities and management contexts as well as their straightforward scoring systems.

For example, the OSPAR, EUN2000, CPAMETT, and MEDPAME tools are designed with region-specific criteria that reflect tailored management effectiveness criteria, legal frameworks, and regional context. This enhances relevance compared to more globally oriented tools such as RAPPAM or IMET. The same is true for the Biosphere Reserve Effectiveness of Management index (BreMi), supporting assessments across UNESCO Biosphere Reserves, aligning with the program's management objectives and evaluation needs.

Tools such as Pomeroy and Enhancing Our Heritage (EoH) offer greater flexibility through free-text responses and adaptable indicator selection. This flexibility supports detailed, context-specific assessments and encourages tailored approaches to evaluating management effectiveness at site level. However, this flexibility also results in reduced standardization, making it difficult to aggregate results across multiple sites or regions in a consistent way. Some tools, like FIPAME, RMEET, and MaPaF, are designed specifically for network-level assessments by focusing on Finnish protected areas, Ramsar sites, and Mediterranean MPAs, respectively. This is also the case for the ProtectBaltic tool in its current form, although future versions are expected to include more detailed site-level assessment components.

The figure below (Figure 11) summarizes how different tools can be selected depending on whether the assessment focuses on individual MPAs or on broader networks, illustrating the distinction between site-level, flexible approaches and more standardized, region-specific frameworks.

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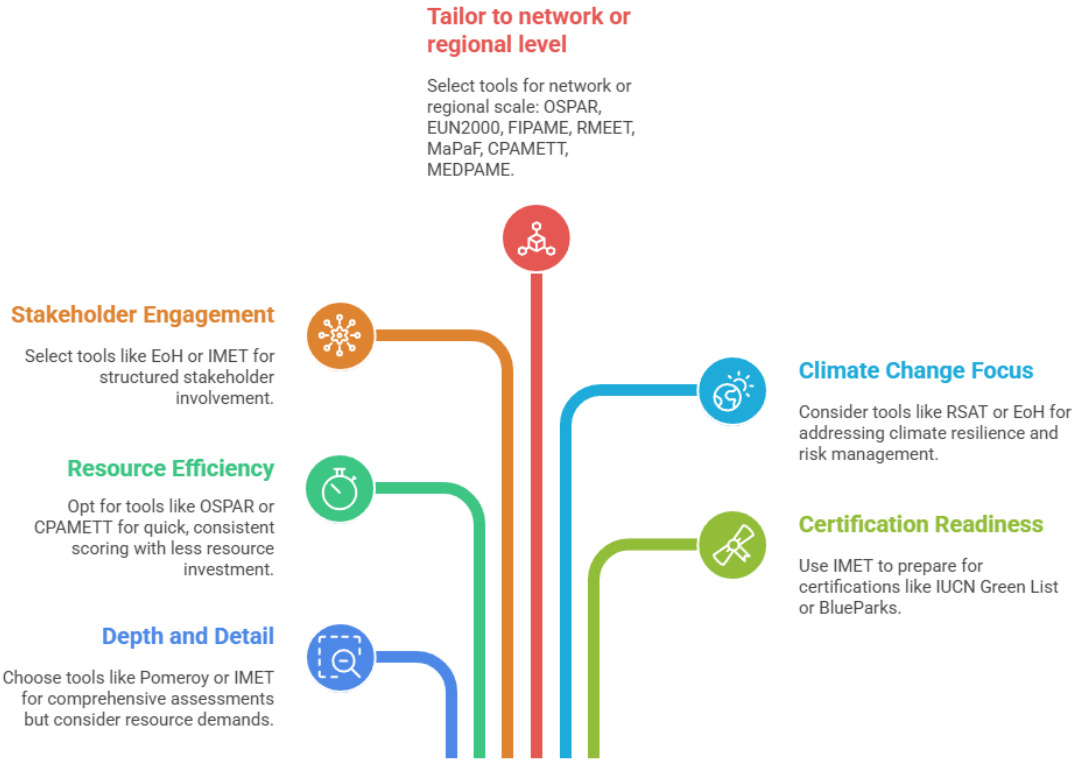

Figure 11. ***Selection of PAME tools for site-level and network-level assessments.***

6.3. The EUN2000 Tool: Focus and Limitations

A detailed analysis of the EUN2000 tool was made, as it is intended to serve as the primary PAME tool at the EU level for assessing Natura 2000 sites. In its current form, the tool effectively supports the collection of comparable information on management effectiveness across marine Natura 2000 sites and helps identify key management deficiencies to address those conservation objectives focused by the Habitats or Birds Directive. Although pilot testing during the tool's development highlighted that many sites[9] currently lack sufficient data for a comprehensive PAME, its structured approach provides clear guidance on where to focus future monitoring efforts to address these knowledge gaps.

However, the EUN2000 tool is not well-suited for MPAs that aim to protect social benefits and cultural values or require integration of socio-economic considerations. For such sites, tools like RAPPAM or METT may be more appropriate. These were the most similar tools to the EUN2000 based on our analysis (Figure 7) and include the assessment of the socio-economic dimension within all components of the management. RAPPAM evaluates the management plan and the MPA monitoring programs in less detail than

[9] Final report: https://circabc.europa.eu/ui/group/00564ca7-9d16-4b81-bac5-b35fcb84aa33/library/0d81306a-2f30-4062-81a1-bfeebb01f152?p=1&n=10&sort=modified_ASC

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the EUN2000, but places more emphasis on the enforcement of regulations and visitor management. While otherwise it is generally very similar to the EUN2000 tool in the criteria considered, the evaluation process is simpler by rating criteria on a yes-mostly yes- mostly no-no scale, with limited space provided for explanation. The EUN2000 tool contains a more sophisticated scoring system and integrated dashboard for the overview and analysis of the results. This is true for the METT as well, which contains an even larger number of digital worksheets that are assessed and scored. Yet, the METT only considers a few criteria related to governance and does not evaluate the content of the management plans, making it less suitable than the other tools to discover deficiencies in these aspects and operationalise management actions.

6.4. Recommendations on best practices for monitoring frameworks in MPAs

Monitoring frameworks for MPAs are most effective when they are embedded within a structured and adaptive conservation planning process. Thus, monitoring should not be seen as an isolated task, but rather as a core component of the Management Effectiveness Evaluation (MEE) cycle, which includes stages of design, implementation, monitoring, evaluation, learning, and adaptation (Figure 12).

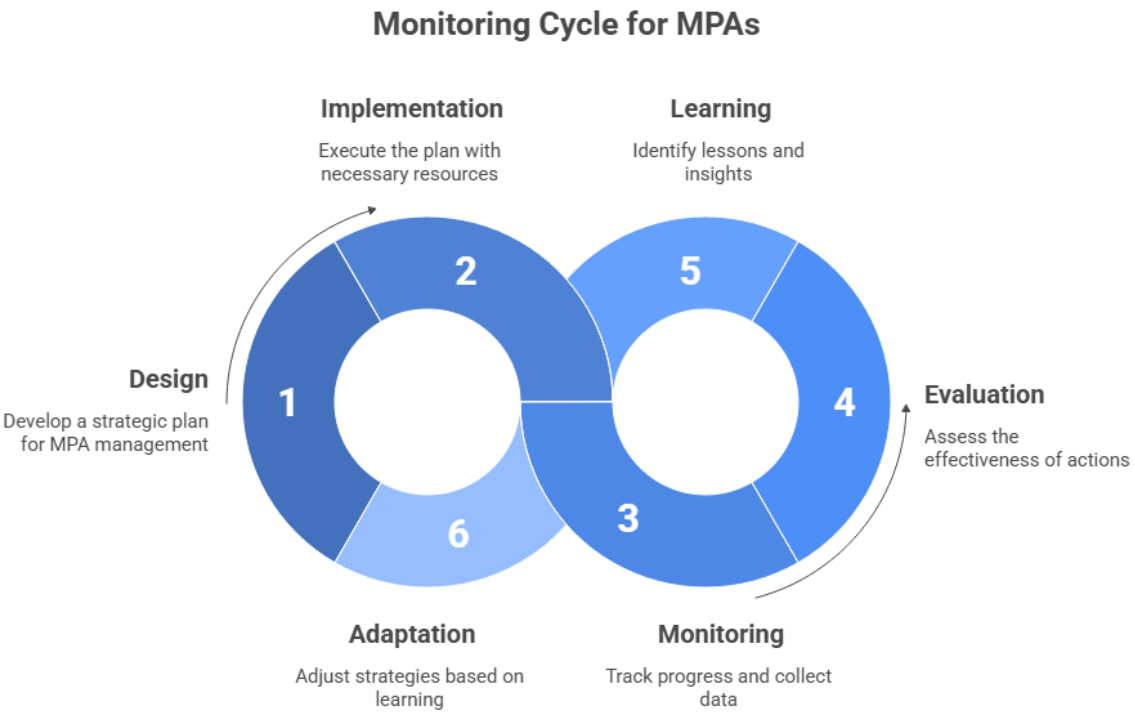

Figure 12 ***MPA Monitoring Framework Process****.*

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The previous analysis reveals that MPA monitoring frameworks can be positioned along a continuum from reactive to proactive (Figure 13). At the reactive end are evaluation-driven frameworks, which emphasize retrospective performance assessment and accountability (e.g. frameworks based on BACI approach, Cardoso-Andrade et al., 2022). Management cycle-integrated frameworks go a step further by embedding monitoring into ongoing adaptive management processes, allowing for learning and strategic adjustments (e.g. IUCN WCPA framework for monitoring biodiversity in PAs and OECMs). The most proactive frameworks are those grounded in a Theory of Change, which use conceptual models from the outset to align monitoring activities with desired ecological and social outcomes (e.g. Global Effective Management framework and Conservation Open Standards for the Practice of Conservation; Nature United, 2023).

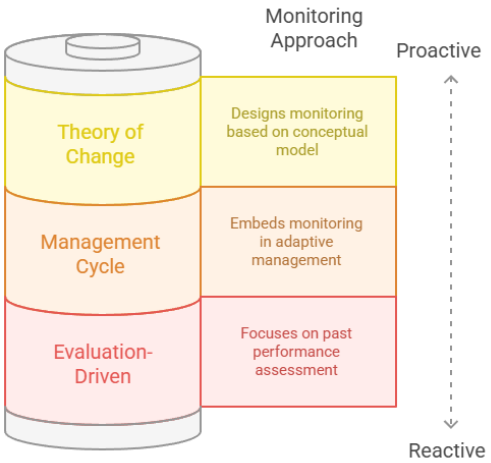

Figure 13 ***MPA monitoring approaches range from reactive to proactive.***

Rather than viewing these levels as mutually exclusive, the analysis (Table 5) shows that they represent complementary components of an effective MPA monitoring system. Evaluation-driven approaches offer important baseline and accountability functions; management-integrated approaches support adaptive action; and Theory of Change-based frameworks enhance strategic coherence and learning. All these elements play a role across the MPA implementation process.

Establishing a Theory of Change is an important step for Designated MPAs. Newly Implemented MPAs can use evaluation-driven approaches to set up adequate monitoring frameworks for baselines and outcomes. As MPAs become more mature, monitoring can be iteratively refined based on local experience and rely more on management-integrated monitoring frameworks to support adaptive action. Thus, the most effective MPA monitoring systems combine these approaches to ensure that monitoring is outcome oriented and move from compliance-based reporting to supporting learning and adaptive management.

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Several other aspects are also important to consider in the development of a monitoring framework as part of the management effectiveness cycle of a MPA. Monitoring frameworks must also be built on principles of co-design and co-implementation, ensuring that monitoring plans are developed with the active participation of key stakeholders, including local communities.

During the design of monitoring plans, additional considerations should also be taken on the use of new technologies and artificial intelligence to enhance MPA monitoring capacity. High-resolution satellite imagery and unmanned aerial or underwater vehicles can support more frequent, cost-effective observations of ecosystems and human activities that are often missing in traditional monitoring (Dinkel et al., 2025; Schofield et al., 2019). In parallel, artificial intelligence tools such as computer vision and deep learning algorithms can automate the identification of marine life in images and streamline the analysis of biological, oceanographic, and socio-economic data (Boulent et al., 2023; Clarke et al., 2021).

To be meaningful, these frameworks should also incorporate the monitoring of pressures, both within and beyond MPA boundaries, including land-sea interactions, cumulative impacts, and global pressures such as climate change. This information is essential for understanding the real drivers of change in the MPAs and for designing adaptive management strategies.

From the comparison of key features across frameworks, and the critical elements embedded within them, a set of core principles can be drawn up that could guide the design and implementation of MPA monitoring systems. These frameworks emphasize on:

- Strategic planning grounded in clear (SMART) objectives and theories of change,
- Inclusivity and co-design, ensuring stakeholder relevance and legitimacy,
- Resilience thinking, by addressing both ecological and social vulnerabilities, and
- Continual learning, enabling managers to respond effectively to change and uncertainty.

In addition, several best practices can be drawn from the analysis of different monitoring frameworks (Figure 14). These are proposed here to support the development and implementation of MPA monitoring systems at the Demonstration sites. The aim is to foster adaptive management, improve conservation and restoration outcomes, and ensure feasibility across diverse MPA contexts. These best practices include:

- **Design monitoring based on a clear theory of change:** In line with the Open Standards for the Practice of Conservation, best practice involves developing a

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conceptual model of the MPA system that identifies conservation targets, threats, and expected outcomes. This approach ensures that monitoring focuses on key assumptions and management hypotheses.

- **Integrate monitoring into the full management cycle (MEE):** Monitoring efforts should be made across all stages, from planning to implementation and adaptation, to enable response-action mechanisms and continuous learning (e.g. as outlined in the IUCN WCPA framework)
- **Establish clear, measurable objectives and indicators:** By using SMART objectives and choosing indicators that address both outcomes (e.g., on conservation such as species status) and processes (e.g., compliance, governance). Frameworks such as the Open Standards and the approach proposed by Cardoso-Andrade et al., (2022) offer good guidance in this area.
- **Ensure sustainable financing, cost-effectiveness and institutional support:** Some frameworks consider a key element of success to build monitoring into long-term budgets, capacity building and staff plans (human resources), and institutional mandates.
- **Integrate monitoring for restoration outcomes:** Where restoration is a management goal, MPA monitoring should include indicators for ecosystem recovery such as species recolonization, habitat regeneration, and ecological function, especially where restoration is a management goal (e.g., as in the "International principles and standards for the practice of ecological restoration" Gann et al., 2019)
- **Address ecological and social vulnerabilities:** Effective monitoring should include tracking ecological climate driven stressors (e.g., coral mass mortality events) and social dynamics (e.g., dependence on fisheries resources) to assess resilience and inform risk management (Nature United, 2023).
- **Assess threat reduction:** This includes evaluating the extent to which key pressures have been reduced through management interventions, following approaches such as that proposed by Mezquida et al., (2005).
- **Link monitoring to evaluation and performance reporting:** Monitoring data should feed directly into PAME assessments and outcome-based evaluations by using reference conditions, thresholds, and clearly defined baselines (e.g., as in the Open Standards by the Conservation Measures Partnership, 2025, and the WCPA monitoring framework by Dalton et al., 2024).

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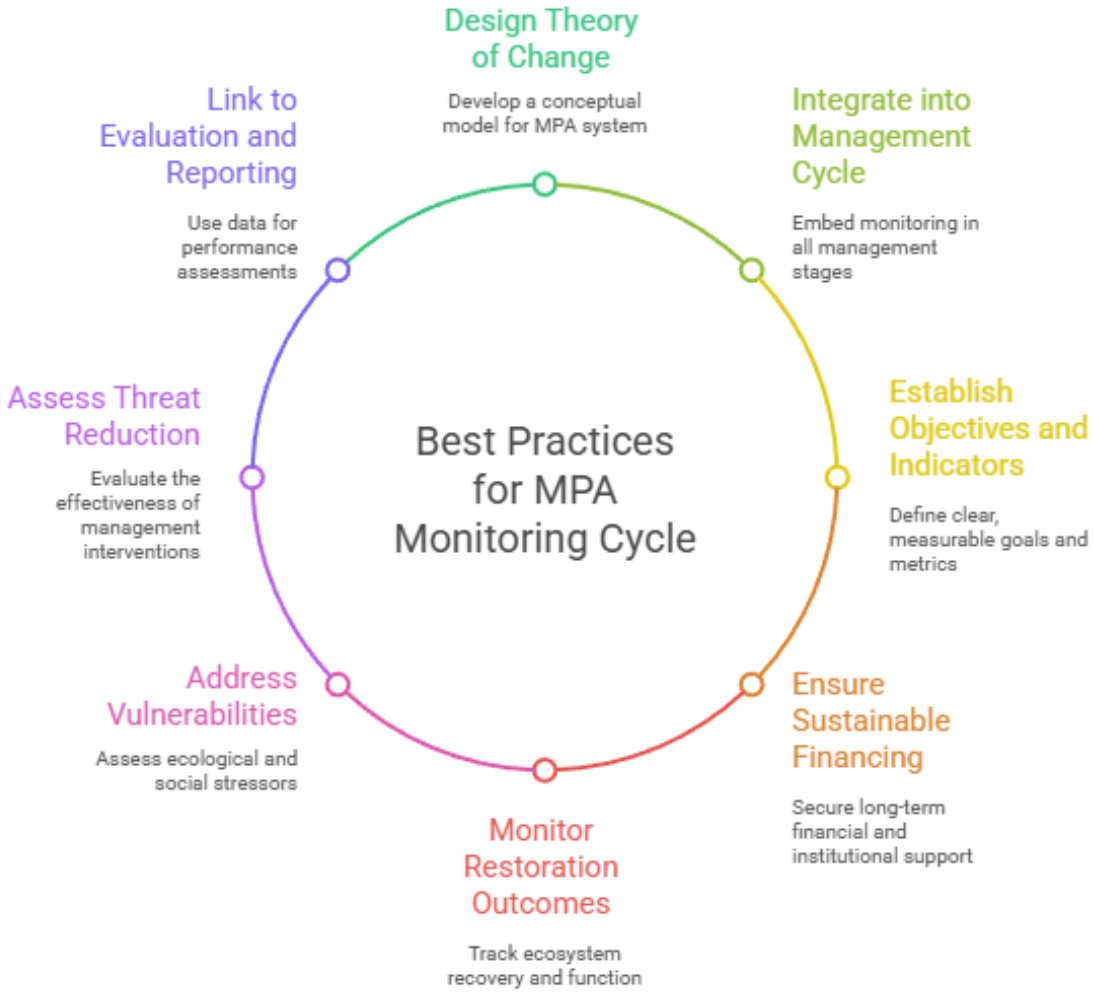

Figure 14 **Best practice elements from MPA Monitoring Frameworks**. Own elaboration.

6.5. Summary

In conclusion, most PAME tools demonstrate strong capacity to track aspects of governance and management design, as well as to assess management effectiveness in terms of processes and actions implemented. While some tools promote or require the setting of SMART objectives, this is not a consistent feature across all. More critically, there remains a significant gap in the ability of most tools to track actual outcomes, such as improvements in ecological condition, reduced threats, or enhanced social and cultural benefits. Measuring these outcomes via quantitative and qualitative indicators are essential to determine whether management actions are truly delivering conservation impact.

To improve their relevance and effectiveness, PAME tools must strike a better balance between feasibility, usefulness, and credibility, ensuring they are practical for managers

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while still providing robust, outcome-oriented insights. To enhance both the credibility and usability of PAME tools, a well-designed scoring system is essential. Scoring facilitates a clearer understanding of progress at different levels from strategic planning and governance to operational actions and achieved outcomes. When well structured, it can help managers and stakeholders quickly identify strengths, gaps, and areas requiring improvement. Importantly, such systems should be grounded in a comprehensive set of indicators that capture not only management processes (e.g. development of regulations) but also results (e.g. implementation of activities) and impacts (e.g. threat reduction, species recovery).

Based on our analysis, the final selection of the PAME tools for demonstration MPA sites will be guided by the specific management context, conservation objectives, available resources at each site, and the criteria outlined in this document. Within the Blue Connect Project, the selection of two Demonstration Sites which are Actively managed MPAs will provide the most suitable setting for applying full assessments with PAME tools, as they already have established management frameworks, implementation experience, relevant data, and stakeholder engagement mechanisms in place. Stakeholder consultation at site level will be essential to ensure that the selected tool is practical, relevant, and supported by those involved in or impacted by its application. The application of PAME tools to assess effectiveness at Demonstration Sites will aim to support the adaptation of management and monitoring practices, inform decision-making, and strengthen local capacity for ongoing evaluations of effectiveness.

Monitoring systems at the Demonstration sites will incorporate best practices while also piloting innovative approaches to enhance adaptability, relevance, and effectiveness. Monitoring efforts will be tailored to each site's ecological and social context with active stakeholder consultation. Emphasis will be placed on integrating monitoring within the full management cycle, using clear objectives and indicators, and applying strategic frameworks such as the Open Standards. The application of these monitoring best practices will aim to support adaptive management, strengthen alignment with conservation goals, and build long-term capacity for outcome-oriented evaluations.

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7. Annex 1

Table A 1 Checklist of criteria assessed on the four components of management effectiveness (Governance, Management Design and Planning, Effective Management Operations and Conservation Outcomes). For answer possibilities other than Yes, No, Partially, it was also included the score values that were used to calculate the Criteria Score. For the former, the values of 1, 0 and 0.5 were used, respectively.

Evaluation Criteria (Aspects considered by the tool)	
Governance	
How the tool assesses Governance Structure in Place	**Answer possibilities**
1. Considers that governance structure is clear and documented (existence of functional management body, its functions and manager in place)	Yes/No/Partially
2. Considers bodies/institutions that form the government structure are defined and mutually well-coordinated	Yes/No/Partially
3. Tool assesses if clear and measurable products and outcomes of the governance structures are identified, benchmarked and periodically assessed (e.g. meeting reports)	Yes/No/Partially
4. Tool assesses the existance of a governance structure with local stakeholders	Yes/No/Partially
5. Tool assesses how active and effectively works the governance structure with stakeholders (e.g. assesses frequency of meetings or other means)	Yes/No/Partially
6. Assesses if MPA governance allows the active engagement of stakeholders in the processes and actions of the MPA (e.g. stakeholder support implementation on monitoring, pressure reduction, conservation measures)	Yes/No/Partially
7. Assesses if governance arrangements considers gender and social equity	Yes/No/Partially
How the Tool assesses Legitimacy and Voice	
1. Assesses if stakeholders are brought together across scales (e.g. different stakeholders at different spatial scale of MPA) in the decision-making process of the MPA.	Yes/No/Partially
2. Indicates the establishment of a participatory approach to management planning	Yes/No/Partially
How the Tool Measures Transparency and Accountability	
1. Assesses if governance structure and management documents are publically available	Yes/No/Partially
2. Assesses if results from meetings are publically available	Yes/No/Partially
3. Assesses the existence of an MPA process to identify, hear and resolve complaints, disputes or grievances related to the governance or management	Yes/No/Partially
4. Tool considers accesability to the results of monitoring information	Yes/No/Partially

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How the Tool assesses Processes Enabling Governance Vitality and Capacity to Respond Adaptively	
1. Assesses if there is flexibility to deal with unexpected events (e.g. disaster, new developments)	Yes/No/Partially
2. Assesses if a programme for review and updating of management plans is included	Yes/No/Partially
3. Considers if a strategic vision of the governance system in the MPA is regularly updated.	Yes/No/Partially

Management Design and Planning

How the Tool identify SMART Conservation Goals and Measures of Major Site Values	
1. Assesses existence of a legally binding document (MPA designation with conservation objectives)	Yes/No/Partially
2. Assess whether a protected area coordination mechanism and corresponding legal framework exist at the national level	Yes/No/Partially
3. Considers if the MPA has established an inventory of conservation features/objectives (CO) and associated ecosystem services and cultural values	No (0) Only conservation features/objectives (0.5) Only ecosystem services/cultural valus (0.5) Both conservation features and ecosystem services (1)
4. Assesses if specific site-specific CO exist for the /species/habitats/ecosystems for which the MPA has been set in the designation process	Yes/No/Partially
5. Assesses if MPA MP define the degree of conservation/condition of the species/habitats/ecosystems to be achieved and/or maintained within the MPA, the relevant attributes and their target values (measurable targets) in accordance with their ecological requirements	Yes/No/Partially
6. Assesses the existence of a management plan (MP) with SMART conservation goals	Yes/No/Partially
7. The tool assesses compliance with legally established deadlines for drafting or updating planning documents	Yes/No/Partially
8. Assesses if the MP identifies responsible authorities for each specific measure and determines steps for the implementation of each measure	Yes/No/Partially
9. Assess if management plan has an associated budget for implementation	Yes/No/Partially
10. Assess the human resources (personnel and capacities) required by the management body in the Management Plan.	Yes/No/Partially
11. Assess the material (equipment, infrastructure) required by the management body in the Management Plan.	Yes/No/Partially
12. Assesses if the MPA has science-based indicators that are clearly defined to assess MPA management effectiveness	Yes/No/Partially

How the Tool Assess Design for Long-Term Conservation of Major Site Values

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1. Considers the existence of a current management plan (MP) or equivalent that is used to guide management priorities and activities	Yes/No/Partially
2. Considers the MP is based on a clearly defined strategic vision and defined objectives	Yes/No/Partially
3. Evaluates if site considered connectivity needs of major CO (within the MPA) (e.g. large enough and sufficiently connected to other habitats or ecosystems, viable populations, species life cycle)	Yes/No/Partially
4. Evaluates if ecological vulnerability to climate change in the MPA (climate risk, range shifts) was considered and incorporated in the MP	Yes/No/Partially
5. Evaluates if MPA site considers climate change scenarios (climate simulations) into design and planning	Yes/No/Partially
How the Tool value the Understanding of Threats and Challenges	
1. Assesses if MPA planning includes list of human activities (proxies for pressures/threats at MPA level)	Yes/No/Partially
2. Assesses if MPA planning includes pressures and threats (incl. extraction of species)	Yes/No/Partially
3. Assesses if deficiencies are identified and if causes of deficiencies are analysed– impacts of activities	Yes/No/Partially
4. Assesses if main impacts on Conservation Objectives are identified inside and outside the MPA and if their impact have been assessed	Yes/No/Partially
5. Considers the assessment of cumulative effects of pressures in MPA	Yes/No/Partially
How the Tool value the Understanding of the Social and Economic Context	
1. Assesses if social and economic context of the site has been incorporated into the management plan	Yes/No/Partially
1. Assesses if alternative Livelihoods and/or Income Generating Activities are included in design and MPA planning (and considers the non-applicability for MPAs of Category Ia and Ib)	Yes/No/Partially
3. Assesses if social vulnerability to climate change in the MPA was considered and incorporated in the MP	Yes/No/Partially
Effective Management Operations	
How the tool considers Management of Ecological and Physico-chemical Condition	
1. Assesses if the MPA identified and established strategies and actions to achieve the conservation objectives of the MPA	No (0) Only the identification of strategies and actions is assessed (0.5) Both (1)
2. Assesses if conservation measures are proposed, established and/or actually implemented (depending on MPA stage)	Yes/No/Partially
3. Assess if conservation measures are detailed and/or quantifiable?	Yes/No/Partially
How the tool considers Management within the Social and Economic Context of the Site	

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1. Considers if MPA has developed actions to enhance the social and economic benefit of the site to local communities (if applicable depending on MPA type)	Yes/No/Partially
2. Considers if the MPA has a management plan for resource users, e.g. a fisheries management plan (if applicable)	Yes/No/Partially
How the tool considers Management of Present Threats and Preparedness to Future Challenges	
1. Assesses if MPA conservation measures effectively address known pressures and threats to the protected habitats/species/ecosystems	Yes/No/Partially
2. Assess if MPA develops measures to anticipate future challenges (e.g. disease outbreak of CO)	Yes/No/Partially
3. Evaluates the existence of ecological safeguards against unintended consequences of management actions (e.g. active restoration)	Yes/No/Partially
How the tool considers Development and Implementation of a Long-Term Management Strategy	
1. Assesses if MPA long-term objectives are developed in a written management plan	Yes/No/Partially
2. Evaluates if all the MP measures are implemented and evaluates progress towards targets of all protected features	Yes/No/Partially
3. Considers if MPA has adequate numbers of appropriately trained staff, led by an effective management team, to implement all aspects of its management plan in the long term	Yes/No/Partially
4. Assesses if financial constraints are not threatening the capacity of management to achieve the site's objectives	Yes/No/Partially
5. Assesses if MPA can demonstrate that management activities and policies, and/or legislation and regulations are being implemented and are consistent with the management plan	Yes/No/Partially
6. Assesses if MPA management body benefit from and take into account scientific inputs (e.g. from projects) to support the decision-making	Yes/No/Partially
7. Assesses if MPA plan is regularly reviewed and updated at the end of its stipulated period of validity	Yes/No/Partially
How the tool considers Effectively and Fair Enforcement of Laws and Regulations	
1. Tools considers if the MPA's boundaries, its zoning and associated regulations made known for the users (buoys, maps, information boards, markers...)	Yes/No/Partially
2. Considers if there are appropriate regulations in place to control uses and activities	Yes/No/Partially
3. Considers if MPA has a system in place to enforce regulations (ie. zoning, restricted fishing gears, activity forbidden)	Yes/No/Partially
4. Considers if MPA has regular surveillance and violation detection measures as well if sanctions can be made	Yes/No/Partially
5. Considers promotion of good practices and the establishment of voluntary compliance for MPA users	Yes/No/Partially

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How the tool considers Adequate and Sustainable Finance	
1. Assesses if the MPA has a business plan	Yes/No/Partially
2. Assesses if there is sufficient current budget in MPA and if the budget is secured long-term	No (0) Only assesses current budget (0.5) Assesses both current and long-term budget (1)
How the tool considers Management of Access, Resource Use and Visitation	
1. Tool assesses if the MPA has a communication strategy for different stakeholders and goals	No (0) Only assesses strategy for different stakeholders (0.5) Only assesses strategy for different goals (0.5) Both (1)
2. Tool assesses if visitors are allowed and if access is managed to minimise harm to the major site value	No (0) Only assesses if visitors allowed but not access management (0.5) Yes (1)
3. Tool assesses type/nature and level of permitted access for visitors are clearly described and are compatible with CO	Yes/No/Partially
4. Tool assesses if MPA evaluates carrying capacity of visitors and users (if applicable depending on MPA type)	Yes/No/Partially
5. Tool assesses if MPA promotes sustainable or responsible tourism initiatives	Yes/No/Partially
6. Tool assesses if MPA has specific regulations for activities	Yes/No/Partially
How the tool considers Established monitoring, decision from monitoring observations and learning processes	
1. Tool considers if the MPA has a regular and systematic monitoring of the types and level of pressures/threats	Yes/No/Partially
2. Tool considers if the MPA has a monitoring for climate impacts	Yes/No/Partially
3. Tool considers if the MPA has early warning and action plans for climate change and extreme events (e.g. Disease outbreak)	Yes/No/Partially
4. Tool considers if the MPA has regular and systematic monitoring of the condition of the habitats/species/ecosystems (major values)	Yes/No/Partially
5. Tool considers if the MPA includes regular monitoring of the achievement of conservation objectives and goals (success)	Yes/No/Partially
6. Tool considers if the MPA specifies the specific threshold levels in relation to each set of performance measures that relate to conservation objectives	Yes/No/Partially
Conservation Outcomes	
How the tool considers Demonstrative Conservation of Major Natural Values	

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1. Considers if the MPA achieved favourable conservation status of each habitats/species/ecosystem (CO) for which the MPA been designated (e.g. improved/remained stable/deteriorated, favorable,...)	Yes/No/Partially
2. Considers external factors affecting the conservation status of the CO for which the MPA has been designated	Yes/No/Partially
How the tool considers Demonstrative Conservation of Ecosystem Services	
1. Considers if the MPA maintains and provides its major ecosystem service values (e.g. improved/remained stable/deteriorated, favorable,...)	Yes/No/Partially
How the tool considers Demonstrative Conservation of Cultural Values	
1. Considers if MPA conserve cultural values (e.g. improved/remained stable/deteriorated, favorable,...)	Yes/No/Partially
2. Tool assesses the degree of development of environmental and awareness programmes in the MPA	Yes/No/Partially
3. Considers the degree of perceptions by users (Visitors, Locals)	Yes/No/Partially

8. References

Aminian-Biquet, J., Sletten, J., Vincent, T., Pieraccini, M., Queffelec, B., Laznya, A., Vaidianu, N., Claudet, J., Young, J., Horta e Costa, B., 2025. Major data gaps and recommendations in monitoring regulations of activities in EU marine protected areas. Npj Ocean Sustain. 4, 3. https://doi.org/10.1038/s44183-025-00104-x

Arafeh-Dalmau, N., Brito-Morales, I., Schoeman, D.S., Possingham, H.P., Klein, C.J., Richardson, A.J., 2021. Incorporating climate velocity into the design of climate-smart networks of marine protected areas. Methods Ecol. Evol. 12, 1969–1983. https://doi.org/10.1111/2041-210X.13675

Assis, J., Fragkopoulou, E., Serrão, E.A., Horta e Costa, B., Gandra, M., Abecasis, D., 2021. Weak biodiversity connectivity in the European network of no-take marine protected areas. Sci. Total Environ. 773, 145664. https://doi.org/10.1016/j.scitotenv.2021.145664

Baeckelandt, M., De Raedemaecker, F., Withouck, I., Whatley, L., Debusschere, E., Trabulo, R., Kvanneid, A.J., Friedrich, L., Otero Villanueva, M.D.M., Bauer, B., Fabres, J., Jacob, M., Barboza Gonzalez, F.R., Vilmin, L., Barbanti, A., Randone, M., Stancheva, M., Stanchev, H., Guitierrez, D., Santos, N., de Ramos, B., Shucksmith, R., Hague, E., Dalmau Elorza, A., de Juan Carbonell, C., Eggermont, M., Kostovska, D., Pavlova, D., Uzunov, S., Zanella, A., Macedo, T., Garcia Varas, J.L., Esparza, O., Spinu, A., Sáez, J., 2025. Scoping and shortfall analysis on baseline data and practices to support achieving efficient MPA conservation and management (Deliverable – D4.1 under WP4). BLUE CONNECT project (GA n° 1011656759).

This project has received funding from the European Union's HORIZON Innovation Actions under Grant Agreement No 1011656759

Balvanera, P., Pascual, U., Christie, M., Baptiste, B., González-Jiménez, D. (Eds.), 2022. Methodological Assessment Report on the Diverse Values and Valuation of Nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. IPBES secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.6522522

Bates, A.E., Cooke, R.S.C., Duncan, M.I., Edgar, G.J., Bruno, J.F., Benedetti-Cecchi, L., Côté, I.M., Lefcheck, J.S., Costello, M.J., Barrett, N., Bird, T.J., Fenberg, P.B., Stuart-Smith, R.D., 2019. Climate resilience in marine protected areas and the 'Protection Paradox' [WWW Document]. Biol. Conserv. https://doi.org/10.1016/j.biocon.2019.05.005

Bennett, N.J., Dearden, P., 2014. From measuring outcomes to providing inputs: Governance, management, and local development for more effective marine protected areas. Mar. Policy 50, 96–110. https://doi.org/10.1016/j.marpol.2014.05.005

Bialowolski, P., Rakotobe, D., Marelli, A., Roggeri, P., Paolini, C., 2023. Use of the IMET tool in the evaluation of protected area management effectiveness in Central Africa. J. Environ. Manage. 326. https://doi.org/10.1016/j.jenvman.2022.116680

BirdLife International, 2006. Monitoring Important Bird Areas: a global framework, 1.2. ed. Cambridge, UK. BirdLife International.

Boulent, J., Charry, B., Kennedy, M.M., Tissier, E., Fan, R., Marcoux, M., Watt, C.A., Gagné-Turcotte, A., 2023. Scaling whale monitoring using deep learning: A human-in-the-loop solution for analyzing aerial datasets. Front. Mar. Sci. 10. https://doi.org/10.3389/fmars.2023.1099479

BRIM (Biosphere Reserve Integrated Monitoring), 2001. Report of the Special Meeting on Biosphrere Reserves Integrated Monitoring Office of the Global Terrestrial Observing System (GTOS), Food and Agriculture Organization of the United Nations (FAO) from Rome, Italy, 4–6 September 2001.

Burrows, M.T., Bates, A.E., Costello, M.J., Edwards, M., Edgar, G.J., Fox, C.J., Halpern, B.S., Hiddink, J.G., Pinsky, M.L., Batt, R.D., García Molinos, J., Payne, B.L., Schoeman, D.S., Stuart-Smith, R.D., Poloczanska, E.S., 2019. Ocean community warming responses explained by thermal affinities and temperature gradients. Nat. Clim. Change 9, 959–963. https://doi.org/10.1038/s41558-019-0631-5

Cannizzo, Z.J., Hunter, K.L., Hutto, S., Selgrath, J.C., Wenzel, L., 2025. Future-proofing the global system of marine protected areas: Integrating climate change into planning and management. Mar. Policy 171, 106420. https://doi.org/10.1016/j.marpol.2024.106420

Cardoso-Andrade, M., Queiroga, H., Rangel, M., Sousa, I., Belackova, A., Bentes, L., Oliveira, F., Monteiro, P., Sales Henriques, N., Afonso, C.M.L., Silva, A.F., Quintella, B.R., Costa, J.L., Pais, M.P., Henriques, S., Batista, M.I., Franco, G.,

This project has received funding from the European Union's HORIZON Innovation Actions under Grant Agreement No 1011656759

Gonçalves, E.J., Henriques, M., Leonardo, T., Coelho, P., Comas-González, R., Fernández, L.P., Quiles-Pons, C., Costa, A., Espírito-Santo, C., Castro, J.J., Arenas, F., Ramos, S., Ferreira, V., Gonçalves, J.M.S., Horta e Costa, B., 2022. Setting Performance Indicators for Coastal Marine Protected Areas: An Expert-Based Methodology. Front. Mar. Sci. 9. https://doi.org/10.3389/fmars.2022.848039

Caselle, J.E., Nickols, K.J., Smith, J.G., Lopazanski, C., Brun, J., Free, C., Anderson, C., Carr, M., Claudet, J., Dugan, J., Eurich, J., Francis, T., Gill, D., Hamilton, S., Kaschner, K., Mouillot, D., Raimondi, P., Starr, R., Ziegler, S., 2022. A synthesis of ecological and social outcomes from the California MPA network (NCEAS working group final report). Calif. Ocean Prot. Counc. Data Repos. https://doi.org/doi:10.25494/P6430V

Clarke, P.J., Cubaynes, H.C., Stockin, K.A., Olavarría, C., de Vos, A., Fretwell, P.T., Jackson, J.A., 2021. Cetacean Strandings From Space: Challenges and Opportunities of Very High Resolution Satellites for the Remote Monitoring of Cetacean Mass Strandings. Front. Mar. Sci. 8. https://doi.org/10.3389/fmars.2021.650735

Conservation Measures Partnership, 2025. Open Standards for the Practice of Conservation v. 5.0.

Dalton, D., Berger, V., Kirchmeir, H., Adams, V., Botha, J., Halloy, S., Hart, R., Švara, V., Torres Ribeiro, K., Chaudhary, S., Jungmeier, M., 2024. A framework for monitoring biodiversity in protected areas and other effective area-based conservation measures, IUCN WCPA Technical Report Series. IUCN, Gland, Switzerland.

Dinkel, T.M., Girard, A., Bär, T., Dähne, M., Craul, A.-K., Cosentino, M., Meyer-Klaeden, O., Dahlke, F., von Dorrien, C., 2025. Performance of theodolites versus drones in land-based studies of marine mammals. Sci. Rep. 15, 1–16. https://doi.org/10.1038/s41598-025-06978-8

Eklund, J., Cabeza, M., 2017. Quality of governance and effectiveness of protected areas: crucial concepts for conservation planning. Ann. N. Y. Acad. Sci. 1399, 27–41. https://doi.org/10.1111/nyas.13284

Ervin, J., 2011. Integrating protected areas into climate planning. Biodiversity 12, 2–10. https://doi.org/10.1080/14888386.2011.564850

Ervin, J., 2003. WWF Rapid Assessment and Prioritization of Protected Area Management (RAPPAM) Methodology. WWF, Gland, Switzerland.

European Commission, 2020a. EU Biodiversity Strategy for 2030 – Bringing nature back into our lives.

European Commission, 2020b. Open Source Software Strategy 2020 – 2023: Think Open (Policy Document). European Commission.

European Environment Agency, 2020. Management effectiveness in the EU's Natura 2000 network of protected areas. European Environment Agency.

European Environment Agency, 2014. Environmental Indicator Report 2014.

This project has received funding from the European Union's HORIZON Innovation Actions under Grant Agreement No 1011656759

Gann, G.D., McDonald, T., Walder, B., Aronson, J., Nelson, C.R., Jonson, J., Hallett, J.G., Eisenberg, C., Guariguata, M.R., Liu, J., Hua, F., Echeverría, C., Gonzales, E., Shaw, N., Decleer, K., Dixon, K.W., 2019. International principles and standards for the practice of ecological restoration. Second edition. Restor. Ecol. 27, S1–S46. https://doi.org/10.1111/rec.13035

Garrabou, J., Azzurro, E., Bensoussan, N., Sbragaglia, V., Otero, M., 2019. MPA-Adapt Project. Joint Governance Plan: Developing Adaptation Plans to Face Climate Change Impacts in Mediterranean Marine Protected Areas (Project Deliverable). MPA-Adapt Project.

Gaston, K.J., Jackson, S.F., Nagy, A., Cantú-Salazar, L., Johnson, M., 2008. Protected areas in Europe: principle and practice. Ann. N. Y. Acad. Sci. 1134, 97–119. https://doi.org/10.1196/annals.1439.006

Gatiso, T.T., Kulik, L., Bachmann, M., Bonn, A., Bösch, L., Eirdosh, D., Freytag, A., Hanisch, S., Heurich, M., Sop, T., Wesche, K., Winter, M., Kühl, H.S., 2022. Effectiveness of protected areas influenced by socio-economic context. Nat. Sustain. 5, 861–868. https://doi.org/10.1038/s41893-022-00932-6

Grorud-Colvert, K., Sullivan-Stack, J., Roberts, C., Constant, V., Horta e Costa, B., Pike, E.P., Kingston, N., Laffoley, D., Sala, E., Claudet, J., Friedlander, A.M., Gill, D.A., Lester, S.E., Day, J.C., Gonçalves, E.J., Ahmadia, G.N., Rand, M., Villagomez, A., Ban, N.C., Gurney, G.G., Spalding, A.K., Bennett, N.J., Briggs, J., Morgan, L.E., Moffitt, R., Deguignet, M., Pikitch, E.K., Darling, E.S., Jessen, S., Hameed, S.O., Di Carlo, G., Guidetti, P., Harris, J.M., Torre, J., Kizilkaya, Z., Agardy, T., Cury, P., Shah, N.J., Sack, K., Cao, L., Fernandez, M., Lubchenco, J., 2021. The MPA Guide: A framework to achieve global goals for the ocean. Science 373, eabf0861. https://doi.org/10.1126/science.abf0861

Hayes, K.R., Hosack, G.R., Lawrence, E., Hedge, P., Barrett, N.S., Przeslawski, R., Caley, M.J., Foster, S.D., 2019. Designing Monitoring Programs for Marine Protected Areas Within an Evidence Based Decision Making Paradigm. Front. Mar. Sci. 6. https://doi.org/10.3389/fmars.2019.00746

HELCOM, 2021. Methodology, test case and recommendations for assessing the management effectiveness of the Baltic Sea Marine Protected Area (MPA) network. HELCOM ACTION (2021).

Hockings, M., Leverington, F., Cook, C., 2015. Protected Area Management Effectiveness, in: G. L. Worboys, M. Lockwood, A. Kothari, S. Feary & I. Pulsford (Eds.),Protected Area Governance and Management. Canberra: ANU Press., pp. 889–928. https://doi.org/10.22459/PAGM.04.2015.28

Hockings, M., Stolton, S., Dudley, N., 2000. Evaluating Effectiveness: A Framework for Assessing the Management of Protected Areas., Best Practice Protected Area Guidelines Series. IUCN, Gland, Switzerland and Cambridge, UK.

This project has received funding from the European Union's HORIZON Innovation Actions under Grant Agreement No 1011656759

Hockings, M., Stolton, S., Leverington, F., Dudley, N., Courrau, J., 2006. Evaluating Effectiveness: A framework for assessing management effectiveness of protected areas., 2nd ed.

IUCN-WCPA, 2008. Establishing Marine Protected Area Networks—Making It Happen. IUCN World Commission on Protected Areas, National Oceanic and Atmospheric Administration and The Nature Conservancy, Washington, D.C.

Jiao, W., Liu, X., He, S., 2022. Establishing an ecological monitoring system for national parks in China: A theoretical framework. Ecol. Indic. 143, 109414. https://doi.org/10.1016/j.ecolind.2022.109414

JNCC, 2024. A guide to using the Management Effectiveness of Protected and Conserved Areas (MEPCA) Indicator.

Leverington, F., Costa, K.L., Pavese, H., Lisle, A., Hockings, M., 2010a. A Global Analysis of Protected Area Management Effectiveness. Environ. Manage. 46, 685–698. https://doi.org/10.1007/s00267-010-9564-5

Leverington, F., Lemos Costa, K., Courrau, J., Pavese, H., Nolte, C., Marr, M., Coad, L., Burgess, N., Bomhard, B., Hockings, M., 2010b. Management effectiveness evaluation in protected areas – a global study. Second edition 2010. The University of Queensland, Brisbane, Australia.

Lockwood, M., 2010. Good governance for terrestrial protected areas: A framework, principles and performance outcomes. J. Environ. Manage. 91, 754–766. https://doi.org/10.1016/j.jenvman.2009.10.005

Manea, E., Agardy, T., Bongiorni, L., 2023. Link marine restoration to marine spatial planning through ecosystem-based management to maximize ocean regeneration. Aquat. Conserv. Mar. Freshw. Ecosyst. 33, 1387–1399. https://doi.org/10.1002/aqc.3999

Marine Conservation Institute, 2022. Blue Park Criteria: 2022. Seattle, WA.

Matar, D.A., Anthony, B.P., 2022. BREMi—A New Tool for the Evaluation of UNESCO Biosphere Reserve Management Effectiveness: Case-study in the Arab Man and Biosphere (ArabMAB) Regional Network. Environ. Manage. 70, 730–745. https://doi.org/10.1007/s00267-022-01711-x

Mezquida, J.A.A., De Fernández, J.V.L., Yangüas, Miguel.A.M., 2005. A Framework for Designing Ecological Monitoring Programs for Protected Areas: A Case Study of the Galachos del Ebro Nature Reserve (Spain). Environ. Manage. 35, 20–33. https://doi.org/10.1007/s00267-003-0051-0

Munguía, S.M., Heinen, J.T., 2021. Assessing Protected Area Management Effectiveness: the Need for a Wetland-Specific Evaluation Tool. Environ. Manage. 68, 773–784. https://doi.org/10.1007/s00267-021-01527-1

Nature United, 2023. Best Practices and Procedures for Operationalizing Marine Protected Area Network Monitoring: Synthesis of Global Insights and Recommendations for British Columbia's Northern Shelf Bioregion. Report prepared by ReConnect Consulting and ESSA Technologies.

This project has received funding from the European Union's HORIZON Innovation Actions under Grant Agreement No 1011656759

OECD, 2023. Glossary of Key Terms in Evaluation and Results-Based Management for Sustainable Development (Second Edition). OECD Publishing, Paris.

OSPAR, 2007. Guidance to assess the effectiveness of management of OSPAR MPAs: a self-assessment scorecard.

Otero, M., Garrabou, J., Vargas, M., 2013. Mediterranean Marine Protected Areas and Climate Change: A Guide to Regional Monitoring and Adaptation Opportunities. IUCN, Malaga, Spain.

Pajaro, M.G., Mulrennan, M.E., Alder, J., Vincent, A.C.J., 2010. Developing MPA Effectiveness Indicators: Comparison Within and Across Stakeholder Groups and Communities. Coast. Manag. 38, 122–143. https://doi.org/10.1080/08920751003633094

Pinsky, M.L., Selden, R.L., Kitchel, Z.J., 2020. Climate-Driven Shifts in Marine Species Ranges: Scaling from Organisms to Communities. Annu. Rev. Mar. Sci. 12, 153–179. https://doi.org/10.1146/annurev-marine-010419-010916

Poloczanska, E.S., Brown, C.J., Sydeman, W.J., Kiessling, W., Schoeman, D.S., Moore, P.J., Brander, K., Bruno, J.F., Buckley, L.B., Burrows, M.T., Duarte, C.M., Halpern, B.S., Holding, J., Kappel, C.V., O'Connor, M.I., Pandolfi, J.M., Parmesan, C., Schwing, F., Thompson, S.A., Richardson, A.J., 2013. Global imprint of climate change on marine life. Nat. Clim. Change 3, 919–925. https://doi.org/10.1038/nclimate1958

Pomeroy, R.S., Watson, L.M., Parks, J.E., Cid, G.A., 2005. How is your MPA doing? A methodology for evaluating the management effectiveness of marine protected areas. Ocean Coast. Manag. 48, 485–502. https://doi.org/10.1016/j.ocecoaman.2005.05.004

R Core Team, 2021. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria.

Rodríguez-Rodríguez, D., Martínez-Vega, J., 2022. Effectiveness of Protected Areas in Conserving Biodiversity: A Worldwide Review, Strategies for Sustainability. Springer International Publishing, Cham. https://doi.org/10.1007/978-3-030-94297-7

Rodríguez-Rodríguez, D., Rodríguez, J., Abdul Malak, D., 2016. Development and testing of a new framework for rapidly assessing legal and managerial protection afforded by marine protected areas: Mediterranean Sea case study. J. Environ. Manage. 167, 29–37. https://doi.org/10.1016/j.jenvman.2015.11.016

Roszko, E., 2021. Maritime Anthropology, in: Pedersen, L., Cliggett, L. (Eds.), The SAGE Handbook of Cultural Anthropology. SAGE, London, pp. 297–316.

Schmidt, D.N., Pieraccini, M., Evans, L., 2022. Marine protected areas in the context of climate change: key challenges for coastal social-ecological systems. Philos. Trans. R. Soc. B Biol. Sci. 377, 20210131. https://doi.org/10.1098/rstb.2021.0131

This project has received funding from the European Union's HORIZON Innovation Actions under Grant Agreement No 1011656759

Schofield, G., Esteban, N., Katselidis, K.A., Hays, G.C., 2019. Drones for research on sea turtles and other marine vertebrates – A review. Biol. Conserv. 238, 108214. https://doi.org/10.1016/j.biocon.2019.108214

Simard, F., Laffoley, D., Baxter, J.M. (Eds.), 2016. Marine Protected Areas and Climate Change: Adaptation and Mitigation Synergies, Opportunities and Challenges. International Union for Conservation of Nature (IUCN).

Stewart-Oaten, A., Murdoch, W.W., Parker, K.R., 1986. Environmental Impact Assessment: "Pseudoreplication" in Time? Ecology 67, 929–940. https://doi.org/10.2307/1939815

Stolton, S., Ahlroth, P., Auvinen, A.-P., Dehmel, N., Dudley, N., Hosek, M., Lahti, K., Leung, Y.-F., 2024. Management Effectiveness Evaluation of Finland's Protected Areas 2023, Metsähallituksen luonnonsuojelujulkaisuja. Metsähallitus, Vantaa.

Stolton, S., Hockins, M., Dudley, N., 2020. Management effectiveness tracking tool. Reporting progress at protected area sites: fourth edition. Excel workbook and guidance; 2020.

Stolton, S., Shadie, P., Dudley, N., 2013. Guidelines for applying protected area management categories including IUCN WCPA best practice guidance on recognising protected areas and assigning management categories and governance types. IUCN.

Tempesta, M., Otero, M.D.M., 2013. Guide for quick evaluation of management in Mediterranean MPAs.

The Nature Conservancy, U.S. Agency for International Development, 2003. Measuring Success: The Parks in Peril Consolidation Scorecard Manual. Arlington, VA: The Nature Conservancy and U.S. Agency for International Development.

Underwood, A.J., 1992. Beyond BACI: the detection of environmental impacts on populations in the real, but variable, world. J. Exp. Mar. Biol. Ecol. 161, 145–178. https://doi.org/10.1016/0022-0981(92)90094-Q

UNEP/MED, 2023. Decision IG.26/5 - Specially Protected Areas (SPAs), Specially Protected Areas of Mediterranean Importance (SPAMIs) and Ecosystem Restoration.

UNEP-WCMC & IUCN-WCPA, 2021. Guidelines for Marine Protected Areas Monitoring and Evaluation. UNEP World Conservation Monitoring Centre and IUCN World Commission on Protected Areas. Cambridge, UK: UN Environment Programme.

UNESCO/ICCROM/ICOMOS/IUCN, 2023. Enhancing Our Heritage Toolkit 2.0: Assessing Management Effectiveness of World Heritage Properties and Other Heritage Places. UNESCO, Paris.

Velle, G., Thorstad, E.B., Garseth, Å.H., Gjøen, T., Lo, H., Mo, T.A., Malmstrøm, M., 2025. Balancing the restoration of a native fish and the risks of hitchhiking

This project has received funding from the European Union's HORIZON Innovation Actions under Grant Agreement No 1011656759

invasive species. Manag. Biol. Invasions. https://doi.org/10.3391/mbi.2025.16.1.15

WWF International Danube Carpathian Programme, 2012. Tracking Progress in Managing Protected Areas in the Carpathian Countries. Vienna, Austria.

WWF, IUCN WCPA, 2023. A Guide to Inclusive, Equitable and Effective Implementation of Target 3 of the Kunming-Montreal Global Biodiversity Framework: Version 1.

This project has received funding from the European Union's HORIZON Innovation Actions under Grant Agreement No 1011656759