BLUE CONNECT

D2.1 Setting the framework

BIODIVERSITY INDICATORS AND SCIENCE-BASED TOOLS TO SET CONSERVATION OBJECTIVES

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List of Acronyms

ABCM – Area-based Conservation Management

CBD – Convention on Biological Diversity

CLD – Causal Loop Diagram

CMIP – Coupled Model Intercomparison Project

DEB – Dynamic Energy Budget

DS – Demonstration Site(s)

DPSIR – Drivers-Pressures-State change-Impact-Response

EBSA - Ecologically or Biologically Significant Marine Areas

EEZ – Exclusive Economic Zone

EMODnet – European Marine Observation and Data Network

ES – Ecological subject

GBIF – Global Biodiversity Information Facility

GBF – Global Biodiversity Framework

KBA – Key Biodiversity Area

LSWG - Local Stakeholders Working Groups

MPA – Marine Protected Area(s)

MSFD - Marine Strategy Framework Directive

OBIS - Ocean Biodiversity Information System

OECM – Other Effective Area-based Conservation Measures

OS – Operational Steps

SAC – Special Area of Conservation

SDM – System Dynamics Model

Glossary

Ecological connectivity – Degree to which two or more distinct populations, communities, or ecosystems are linked across space through the exchange of genes, individuals, matter, and energy.

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Structural connectivity – A feature of the seascape itself, referring to how physicochemical components and are arranged in the space of the seascape. It is based on aspects such as size, shape, distance, continuity, or similarity, not explicitly considering actual movement, behaviour and other attributes of living organisms.

Functional connectivity – Describes the movement of organisms through the seascape, considering species-specific behaviours, dispersal abilities, and responses to prevailing physicochemical characteristics.

Criteria – Principles used to guide and justify the prioritisation of species, habitats, and areas for conservation and restoration, and the design, management, and assessment of conservation and restoration actions. Some examples are the uniqueness or rarity of species or habitats, their functional role in ecosystems, the importance of specific areas for critical life cycle stages of ecologically or economically significant species, or the overall aggregated biodiversity a given site or region.

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 functioning – Set of processes (ecological and biogeochemical) responsible for the cycle of matter and flow of energy in marine ecosystems, and that collectively define their structure, resilience, and delivery of ecosystem services over time (de Groot et al., 2002).

Ecological subject of interest – Refers to the species, habitats or processes identified as relevant for conservation or restoration based on a detailed process of the prioritisation.

Framework – Structured approach that will guide the development of nature conservation and restoration objectives in the Marine Protected Area cycle and consequently contribute to the outline of conservation/restoration measures to achieve the set goals and targets.

Goals – Achievable desired endpoints. They are strategic, generalised declarations or statements about an expected state of the ecological subjects to be protected or restored, providing a vision of the results to be achieved.

Indicator – Direct measures or proxies of biotic or abiotic components or processes (e.g., species abundance, nutrient and carbon sequestration, or water chemistry parameters) that reflect the health, structure, function, or condition of a species, habitat, or ecosystem and provide a simple and reliable means to operationalize criteria and measure progress toward defined targets. These indicators, which may be quantitative or qualitative, are used to monitor trends, detect changes linked to natural dynamics or interventions, and assess the performance

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of conservation actions or Marine Protected Areas (MPAs) (Gann et al., 2019; OECD, 2023; Schiller et al., 2001).

Irreplaceability – In conservation prioritisation, it refers to the degree to which a site is essential for achieving conservation goals, based on its unique contribution and the lack of suitable alternatives (Kukkala & Moilanen, 2013).

Measures – Actions/strategies implemented to protect, maintain, or restore natural environments, biodiversity, and ecological processes.

Natural regime shift – High-amplitude and low-frequency events that occur over large spatial scales and that are evident in multiple bio-physical attributes over a range of trophic levels (Lees et al., 2006; Levin & Mölmann 2015)

Strict protection – Strictly protected areas are fully and legally protected areas designated to conserve and/or restore the integrity of biodiversity-rich natural areas with their underlying ecological structure and supporting natural environmental processes (European Commission, 2024)

Targets – Specific, measurable, and time-bound benchmarks that operationalize conservation goals. They specify *what* should be achieved, *to what extent*, *where*, and *by when*, thereby providing a concrete basis for tracking progress (operationally implemented through clear indicators) and for guiding actions.

Tool – Means or approach to achieve a solution to a problem.

Vulnerability – In conservation prioritisation, it refers to the degree to which biodiversity features are at risk from threats, defined by the likelihood of exposure, the strength and frequency of the threat (intensity), and the sensitivity of the features to that threat (impact) (Kukkala & Moilanen, 2013).

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Executive summary

This deliverable is the output of the Task 2.1 "Set up of a state-of-the-art integrated framework to set conservation objectives based on ecosystem functioning". The Task 2.1 team conducted a review to identify key conceptual and methodological documents addressing the challenging task of defining conservation and restoration goals and targets. This review serves to establish the foundation and background knowledge for the development of an operational framework that will be further developed as Blue Connect Integrated Framework, throughout the project.

This framework entails two main phases: the scoping phase and the definitions phase. During the scoping phase, information is gathered that will ultimately help to thoroughly understand the system for which conservation goals and targets need to be defined. During the definitions phase, the information that was collected during the scoping phase is converted into actionable goals, operational targets and efficient measures.

The framework was explicitly designed to assist Marine Protected Areas (MPAs) practitioners in clearly defining conservation and restoration goals and setting targets tailored to the specific ecological context of a given marine area. By looking at goals and targets primarily from an ecological perspective, conservation or restoration actions can be more successful in the long term.

1. Background and addressed gaps

Marine Protected Areas (MPAs) are a globally well-established and extensively used area-based measures aimed at protecting and restoring marine ecosystems (Grorud-Colvert et al., 2021). Evidence gathered over the past two decades has shown the manifold benefits of MPAs. The recovery of endangered species and ecologically relevant habitats, the increase in biodiversity across levels of biological organization (from genetic to community level biodiversity), or the spillover effects and enhanced resource availability in adjacent fishing grounds, are only some of the benefits (Barnett & Baskett, 2015; Grorud-Colvert et al., 2021 and citations therein). However, for these benefits to materialize, MPAs must have ecologically sound designs, be effectively implemented, and be adequately managed (UNEP-WCMC & IUCN, 2021; UNESCO et al., 2023). These premises are only achievable if decision-making is strategically and operationally guided by well-defined goals and measurable targets, enabling the development of appropriate measures and providing the needed basis for assessing conservation outcomes and reviewing implemented actions (Kumagai et al., 2022).

MPAs, and area-based conservation and restoration measures at sea more broadly, operate within particularly highly dynamic ecosystems (Jentoft et al., 2011). The marine ecosystems they aim to protect and restore are not isolated and are shaped by (and depend on) processes such as species dispersion and migration, organic matter and nutrient flows, as well as by human

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activities and pressures like coastal development and habitat modification, fishing, shipping, and pollution (Bishop et al., 2017). Crucially, many of these pressures frequently originate beyond the boundaries of the protected area and are not static in space and time. Adding to this ecological and environmental complexity are overlapping rights, interests, and uses, which further complicate the design, implementation and management of conservation and restoration measures in the marine realm. These challenges make it extremely difficult to define meaningful goals and targets without a comprehensive understanding of the system of interest, its spatial interdependencies, and how it has changed, and may continue to change, over time.

New conservation efforts are being pursued globally, implemented through the creation of new or the expansion of existing MPAs, MPAs networks and other effective area-based conservation measures (OECMs) and justified by the strategic goals and targets recently adopted under the Kunming-Montreal Global Biodiversity Framework (GBF) (particularly Target 3, commonly known as the "30×30 target") (CBD, 2022). In Europe, similar efforts are being advanced through the EU Biodiversity Strategy for 2030, which echoes global ambitions by committing to protect 30% of the EU's land and sea by 2030 (European Commission, 2020). While this political momentum and setting strategic goals and targets is vital for fostering international alignment and scaling up conservation efforts to halt biodiversity loss, their effective translation at national and local levels depends on robust, context-specific analysis and implementation actions.

Throughout Europe, conservation and restoration initiatives are often guided by these high-level targets and propelled by the political urgency to comply with international commitments. This urgency frequently comes at the expense of the detailed context-specific analyses and understanding required, risking overlooking the local ecological reality, socio-economic context, existing rights and uses and long-lasting community relationships with the sea. Without a careful translation and adaptation, such an approach may result in ecologically ineffective measures, can undermine local support, and ultimately fail to achieve the intended conservation outcomes.

While global and European agreements and directives set overarching conservation agendas, ambitions, and broad priorities, they often fall short of providing the methodological guidance and practical, science-based tools needed for effective on-the-ground implementation. Strategic frameworks for setting goals and targets in MPA management exist (e.g., IUCN-WCPA, 2008; Jentoft, 2011; The Nature Conservancy, 2007), but they largely remain at the level of defining what should be done rather than providing concrete guidance on how to do it. Thus, actionable frameworks with simplified lexicons that enhance usability and effectively guide MPA practitioners remain largely absent (Burns et al., 2023). Moreover, aspects such as connectivity, vulnerability, and climate change adaptation — though frequently emphasized in the specialized literature — are often overlooked in decision-making processes due to the absence of clear guidance on their consideration and implementation (Beliaeff & Pelletier, 2011). One key action that can help bridge the gap between context-sensitive actions and strategic ambitions and advance conservation commitments is the creation of operational methodologies on how to define and implement measurable goals and targets that are ecologically justified and backed (Magris et al., 2014). Progressively adapting knowledge-based decisions with meaningful context-specific social and biological data can help tackle this existing gap (Magris et al., 2014), supporting the achievement of effective MPA planning in the coming years.

The project Blue Connect ("Strict protection, restoration and co-management of Marine Protected Areas to ensure effective ecosystem conservation and improved connectivity of Blue Corridors"), financed by Horizon Europe (Mission Ocean and Waters), works towards improving scientific knowledge and leading co-creation of science-informed solutions for MPAs. In Blue Connect, the main goal of Work package (WP) 2 in Blue Connect is to develop an ecologically informed operational framework to support the definition of conservation goals and targets for MPAs, from an ecological point of view. WP2 intentionally focuses on the ecological dimension to provide strong foundations for other WPs to effectively integrate socio-economic and governance considerations as the project develops. Effective conservation goals and targets for MPAs need to be grounded in a robust understanding of ecosystem structure, function, and connectivity. Without a clear ecological reference, it is difficult to define realistic, science-based social and management objectives. An operational framework centred on ecological features ensures that these targets are measurable, evidence-based, and directly tied to ecosystem functioning to allow for broader integration.

This deliverable proposes the foundations towards the development of the Blue Connect Integrated Framework through an operational ecologically based framework for the definition of MPAs' conservation and restoration goals and targets, while setting the scene for understanding the knowledge gaps to be addressed in the next steps of the project. The framework is defined as a structured approach that will guide MPA practitioners in setting and refining ecological goals and targets in any phase of the MPA process (Grorud-Colvert et al., 2021) and consequently contribute to the outline of conservation and restoration measures to achieve them.

Furthermore, with the Nature Restoration Law that entered into force in 2024, as part of EU Biodiversity Strategy for 2030, approaching restoration in a systematic and concerted way has become a priority for the European Union. Several actions around restoration have been driven by case study experiences and uncoordinated attempts from regional, national and local initiatives. This deliverable incorporates a restoration perspective with the aim of supporting European countries (and other groups or organisations) in the systematic and ecologically meaningful development of restoration plans.

The operational framework presented here was developed using insights and stakeholder feedback from the Demonstration Sites (DS) as outlined in Deliverable 4.1 “Scoping Analysis”. It also draws on the systematic literature review done of academic literature and grey literature, identified through project partners participating in WP2 and WP3, as described in the methodology section. A global perspective was adopted to incorporate knowledge from diverse contexts. At the same time, a European focus has been maintained through close collaboration with the DS. The resulting framework will be tested and validated in close collaboration with the project Demonstrations Sites in Task 2.4 (“Validation of framework and co-definition of site-specific conservation objectives”).

2. Revision and integration of bibliographic resources

2.1 Search strategy

To identify key conceptual and methodological peer-reviewed papers addressing the definition of conservation and restoration goals as well as targets on which to build the framework, a systematic literature review was conducted based on the PRISMA guidelines (Page et al., 2021). Two preliminary searches were conducted in Web of Science (WoS) to refine the search string and the set of exclusion criteria to be implemented during the screening processes. The final search was performed in both WoS and Scopus engines on the 29th of January 2025 using the following search string:

(marine OR coast* OR sea* OR brackish OR benthic OR demersal OR pelagic OR ocean* OR intertidal OR subtidal OR estuar* OR bay* OR lagoon*) AND (framework* OR method* OR guideline* OR metric* OR plan* OR monitor* OR tool*) AND (objective* OR goal* OR target* OR aim*) AND (conservation OR preservation OR protection OR restoration OR rehabilitation OR rewilding OR recovery) AND (“protected area” OR “protected area network” OR “marine reserve” OR “marine park” OR “marine reserve network” OR “marine park network” OR "marine sanctuar*” OR "protected seascape*" OR "marine conservation area*" OR "special area* of conservation" OR "conservation unit*" OR "area-based conservation" OR "special protection area*" OR "special protection zone*" OR "closed area*" OR "restricted area*" OR "no take zone*" OR "no take zone network*" OR "no take area*" OR "no take area network*" OR "site* of community importance" OR "site* of community interest" OR "site* of special scientific interest" OR "partial protection" OR "temporal protection" OR "permanent protection" OR "fully protected" OR "highly protected" OR "lightly protected" OR "minimally protected" OR “Natura 2000” OR “biosphere reserve”)

This literature search was complemented with relevant reports produced by other Horizon Europe projects (e.g. MSP4BIO, BLUE4ALL, PROTECT BALTIC), which were identified by project

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partners participating in Work Packages (WPs) 2 and 3 of the Blue Connect Project. These reports are cited throughout the document where relevant. In this process, the European Commission portal (cordis.europa.eu) was a valuable resource, helping to identify, access, and download reports and fostering synergies between project products.

Relevant information from the Demonstration Sites of the project was obtained and compiled through the analysis of the data collected under Task 4.1 "Scoping analysis on available baseline conservation data, existing co-management initiatives and local needs". Special attention was given to the sections about: biophysical information, social economic information, legal framework and governance of information and restoration practices. When needed, further information was collected by engaging directly with the DS teams and Local Stakeholders Working Groups (LSWG).

2.2 Screening process

All 4948 articles returned by the systematic search and the 32 project reports identified by Blue Connect partners were screened according to a detailed set of five exclusion criteria (Table 1, Figure 1). Firstly, all documents were assessed at title and abstract level. In this first screening step, 4083 papers were excluded. Secondly, those documents retained at the title and abstract level were screened at full-text level. A total of 564 papers were excluded at full-text level. The screening processes resulted in a final list of 258 relevant articles for information extraction (Figure 1).

Project partners identified 32 potentially relevant reports produced by other projects. From these, 10 documents were excluded during the screening process, leaving 22 documents to extract information from (Figure 1).

Table 1 – Exclusion criteria used for the screening of gathered peer-reviewed papers and reports produced by other projects.

Criteria	Exclude if…
Focus on area-based conservation measures	The document is not focusing on the design, implementation, or management of area-based conservation measures (e.g. MPAs, MPA networks, marine parks, marine reserves, other effective area-based conservation measures, among others).
Realm	The study is not conducted in coastal (land-sea interaction) or marine realms.
Focus of the study	The study is not focused on describing the development of an ecologically focused, science-based conceptual or operational framework, methodology, tool, model, metric, criteria or indicator of relevance for the definition of conservation and restoration goals and targets. Studies only presenting applications of existing approaches were excluded.
Language	The document is not available in English .
Timeframe	The document was not published between 2008 – 2025. This timeframe was chosen because of European countries' involvement in the implementation of the EU Marine Strategy Framework Directive (MSFD), after it was published in 2008.

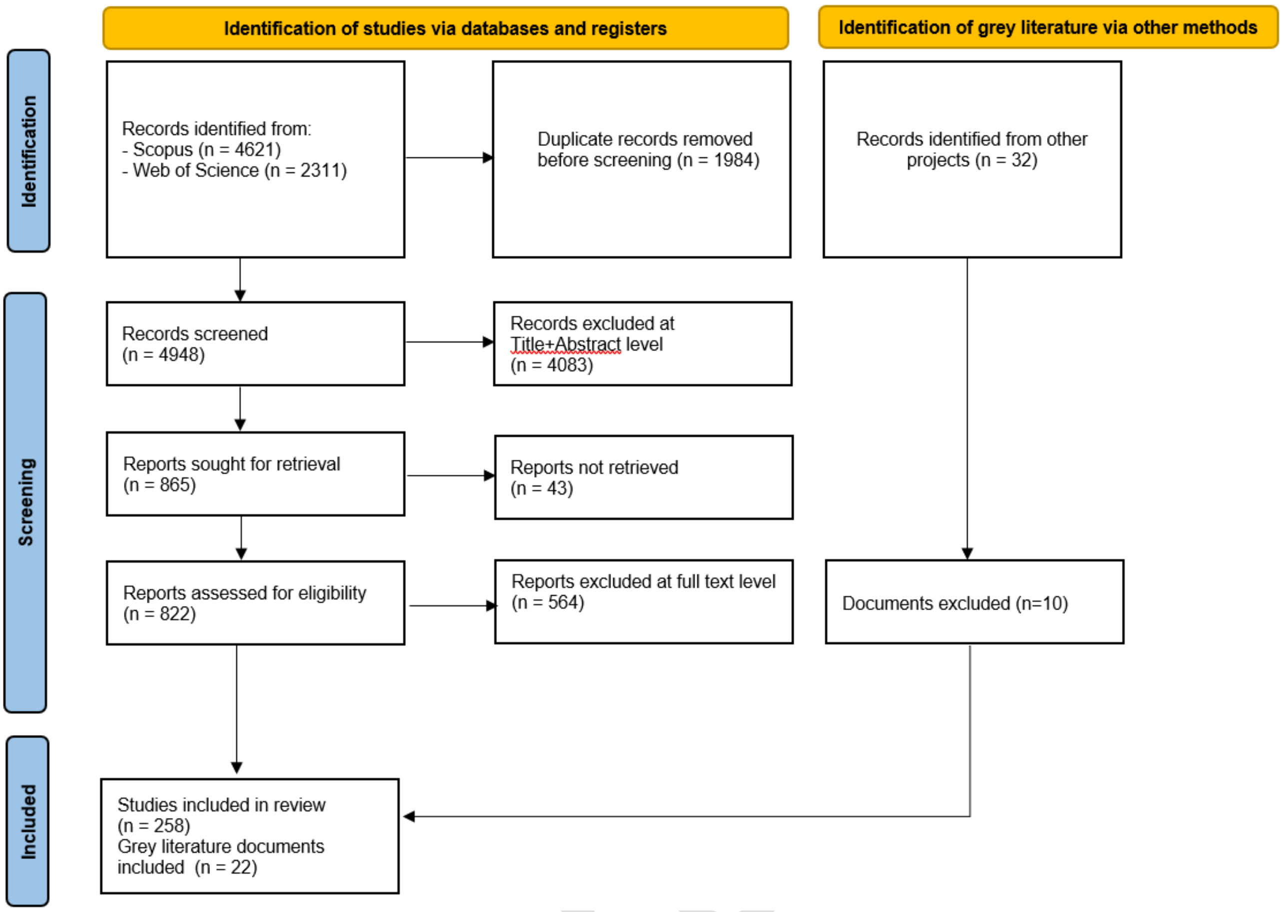

Figure 1 - PRISMA flow diagram summarizing the screening of peer-reviewed articles gathered through searches in Web of Science and Scopus, and project reports identified by Blue Connect partners.

2.3 Data Extraction

The extraction of information from 280 papers and project reports was performed by 15 reviewers from the task 2.1, using a data extraction table designed for this purpose. Reviewers were provided with a protocol (Annex 1) which detailed the extraction fields included in the extraction table and provided detailed guidance on how to perform the extraction. The extraction table was organised in rows corresponding to the documents to be evaluated at the full-text level, and columns corresponding to different fields of information to be extracted (Table 2). Drop-down lists were included in the columns where fixed information was needed to be reported. "Free text" columns were used only in those cases where the reviewers needed to provide clarifications related to the information extracted in other columns or if they needed to summarize specificities of the document described.

Table 2 – Summary of the extraction fields with descriptions and brief instructions included in the extraction table provided to volunteering reviewers for the extraction of information from the gathered peer-reviewed papers and project reports.

Field	***Description and instructions***
Focus of the publication	Briefly describe the main aim of the publication and why it feeds into our work of developing the operational framework.
Geographic focus	Select which geographic range best adapts to the content of the revised document.

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Region/Sea basin	Choose the region/sea basin that the document refers to.
Marine realm	Choose the marine realm on which the document is focusing on and for which its contributions would be more suitable for.
MPA spatial configuration	Choose the type of MPA spatial configuration (i.e., single MPA or network of MPAs, in a national or transnational context) on which the document is focusing on and for which its conceptual or methodological contribution would be more suitable for.
Level of protection	Choose the level of protection that the document focuses on and that best applies to the conceptual or methodological described contribution.
Time frame	Choose the time frame that best adapts to the conservation and/or restoration goals and targets that the conceptual or methodological contributions described in the document might contribute to defined. If selecting "Other" and if it is clearly described please write what is the time scale.
Themes	Categorize the document's contributions according to the overarching conservation/restoration-related themes provided. Choose from the options provided or suggest other relevant ones.
Framework components	Describe the nature of the conceptual or methodological development(s) introduced or described in the paper, using the provided options. Here, our aim is to identify the specific conceptual or methodological contributions the paper offers to inform the construction of our operational framework.
Description	Describe the framework component using explicit information provided by the authors. Feel free to directly copy a sentence or two from the paper.
Definition of goals and targets	Select if the framework component was used/could be used to define goals and/or targets (see glossary for definitions).
Description	Include the goals/targets/objectives that, according to the authors, could be or were assessed using the "framework component". Copy and paste those concrete goals/targets/objectives here.
Ideas for Framework	Note any valuable ideas, concepts, or strategies that could contribute to the design of a framework for defining conservation or restoration goals and targets in MPAs. These could be specific frameworks, components of frameworks, methodologies, key considerations, or approaches that might help structuring or organizing goal-setting.
Contribution to the output	Choose the best option related to how the document contributes to the outline of the operational framework.
Challenges	Highlight challenges of using the approach mentioned in the document.

Building on the information extracted, the Task 2.1 team conducted an in-depth twofold analysis. Firstly, to identify well-established concepts and approaches, currently guiding the planning and management of marine conservation and restoration measures in Europe and globally. Secondly, to pinpoint recent conceptual and methodological advances with the potential to support decision-makers with the challenging task of defining ecologically sound goals and targets.

2.4 Data Synthesis

A two-day in-person workshop was held in Brussels from the 26th to the 27th of May 2025 to support the synthesis of data. During the workshop, the Task 2.1 core team worked on integrating the identified concepts, methods and science-based tools to produce a first blueprint of the Blue Connect Framework, defining its components and drafting methodologies

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for its implementation. An overview of the landscape of available information was generated, to make sure that the gathered peer-reviewed literature was as complete as possible. Some of the reviewed frameworks were not used in this report as they were not deemed relevant by the core team of the task.

The aim was not to replicate existing frameworks, but to extract, synthesize and adapt the most relevant and promising operational elements, that are cited throughout this document, for defining ecologically relevant conservation goals and targets for MPAs and creating missing components based on the results of the review. This led to a draft framework that was discussed on the 18th of June 2025 at the Blue Connect General Assembly in Arendal, Norway.

In this document, the starting point of The Blue Connect Framework is presented. This framework integrates foundational principles for conservation planning and management (IUCN-WCPA, 2008; TNC, 2007), builds on operational goal setting strategies (Jentoft 2011), frameworks for setting criteria, such as EBSA and the MSP4BIO ESE Toolkit (CBD, 2008; Clark et al., 2014; Kotta et al., 2024), and reflects key concepts on ecological connectivity, ecosystem functioning, and climate change vulnerability analysis essential for defining ecological targets and translating them into applicable conservation actions (Alvarez-Romero et al., 2017; Arafeu-Dalmau et al., 2023; Boero et al., 2016; Buenafe et al., 2023; Hilty et al., 2020; Magris et al., 2014).

3. The Blue Connect Framework

3.1 Operational framework for defining ecologically sound goals and targets for conservation and restoration

While internationally agreed goals and targets provide strategic guidance for conservation and restoration efforts across Europe, there is a growing need for operational guidance to implement these high-level ambitions for MPAs. Grounding actions in a deeper, ecologically and environmentally informed understanding of site-specific realities is necessary. The operational framework (Figure 2) introduced in the following sections is designed to address this need by providing a step-by-step approach to support the definition of context-specific, ecologically sound goals and targets. This operational framework can be applied by MPA and MSP (Maritime Spatial Planning) practitioners at different stages of MPAs and MSP implementation processes as a tool to support the MPAs designation and management, through definition, adaptation or refinement of goals and targets for conservation.

The Blue Connect Framework takes into account that the general spatial framework of an MPA is defined by national and regional administrative processes, and contributes to the prioritisation of areas for conservation through focusing on defining conservation and restoration goals and targets within that area, ensuring that it can be applied to both newly proposed and already established areas and support the refinement of their boundaries, when needed. The operational framework builds on prioritisation of ecological subjects for conservation or restoration (Figure 2, S1), alongside the identification of key trends and events of ecological change in an area of interest (Figure2, S2). By placing these elements at the centre of the analysis, the framework proceeds into a holistic understanding of the system of interest (Figure 2, S3), examining the dependencies between prioritised ecological subjects and other ecosystem components, and analysing how both environmental processes and human pressures drive observed and predicted changes in the ecosystem. This is done while also considering spatial interdependencies within and beyond the system's defined boundaries, capturing cross-scale dynamics and effects driven by ecological and anthropogenic processes across seascapes and jurisdictions. The achieved understanding is used to inform the definition of conservation and restoration goals and targets, considering both the initially prioritised ecological subjects and the broader set of ecological components and processes on which they depend. Likewise, the analysis of drivers of change provides essential input for designing measures aimed at preventing, mitigating, or reversing past, ongoing, and potential future ecological changes that may jeopardize conservation and restoration efforts.

To streamline and systematize the implementation processes, the Blue Connect Framework was designed following a user-oriented perspective and as an open platform to accommodate project developments. To do so, the operational framework (Figure 2) was divided into two implementation phases, structured into seven implementation stages, each of them designed to answer key guiding questions, that will prompt a better understanding of the area to be protected, guiding the setting of goals and targets. Some examples of these questions are: "who?" to protect (Figure 2, S1), "what?" is happening (Figure 2, S2) or "how?" the ecosystem works (Figure 2, S3). Recognising that clear approaches to address these questions may not always be readily available or straightforward, each stage of the framework includes a series of operational steps (OS) to methodologically guide users. Each OS helps practitioners navigate recommended methodologies and science-based tools to support implementation. These tools are intended to support data collection, analysis, and decision-making to ensure well-informed and context-specific conservation planning. As the Blue Connect Project progresses, more relevant tools for implementation of this framework are expected to be incorporated into the operational framework.

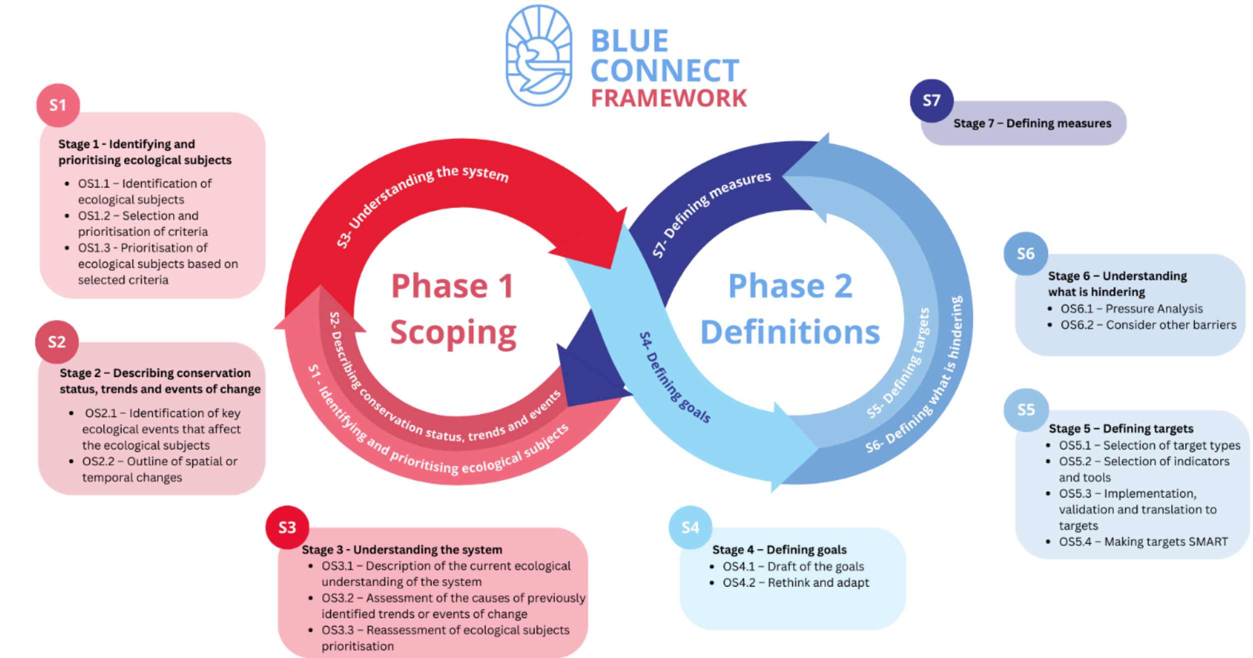

Figure 2 – Schematic representation of the operational framework defining the ecological foundation of the Blue Connect Framework. The framework is structured into two implementation phases, scoping and definitions, each operationalised through a series of ***stages*** *(****S****) and* ***operational steps*** *(****OS****). While the scoping phase is initially intended to precede the definitions phase, the process follows an iterative and temporally adaptable logic. The ecological relevance and validity of the goals, targets, and measures defined during the definitions phase are continuously assessed and refined based on new information integrated through the scoping phase. Please note that S1 and S2, as well as S5 and S6, are implemented simultaneously to inform the subsequent stages jointly. Check Annex 3 for a larger copy of the framework and refer to the glossary for definition of key concepts.*

> It is important to note that, at this stage, the operational framework supports the definition of conservation and restoration goals and targets from an **ecological perspective**. The operational framework presented here will be further developed during the course of the project. It will incorporate further tool developments and applications (from Tasks 2.2, 2.3, 3.1) and lessons learnt from applications at Demonstration Sites (T2.4). The socio-economic perspective and legal or governance barriers are not the scope of this deliverable. These other lenses are investigated in other ongoing project tasks (for example Tasks 3.2 and 3.3.2) that will propose methods to incorporate them into decision support tools (e.g. Governance toolbox of WP3).

3.2 Implementation Phase 1: Scoping

The implementation of the Blue Connect Framework starts with an in-detail scoping phase, which entails the gathering, integration and analysis of ecological information that will ultimately help to thoroughly understand the system for which conservation goals and targets need to be defined.

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Through three stages, this phase guides the practitioners through the journey of understanding the marine ecosystem they need to protect or restore. By identifying and properly justifying **"who"** they are aiming at protecting or restoring (stage 1) and discovering **"what"** is happening in their area of interest (stage 2), they can progressively gain an overarching understanding of **"how"** the (eco)system works and pinpoint the relevant interactions that form that system (stage 3). This proposed sequence is not meant to be rigid or prescriptive, but rather a logical structure that practitioners can adapt to their own context and data realities. The intention is for practitioners to iterate between S1 and S2 as needed. This flexibility is deliberate, since the framework recognises that managers work with diverse ecological contexts, datasets, and management priorities.

Considering the varying realities of knowledge and data availability across Europe, the scoping phase, underlying implementation stages and operational steps were designed to integrate diverse sources of information. Quantitative and qualitative information, gathered through empirical, expert-based, and participatory approaches, are considered essential inputs for the scoping phase. Relying solely on quantitative data, particularly in areas or for ecosystem components where comprehensive research is lacking, risks overlooking valuable information generated through experiential knowledge, such as that held by local communities, practitioners and experts who live or work in close connection with the specific ecological context. Thus, achieving a meaningful understanding of the ecological reality within the area of interest requires the integration of diverse sources of knowledge and data (Hoppit et al., 2025).

3.2.1 Stage 1 - Identifying and prioritising ecological subjects

The identification and prioritisation of ecological subjects relevant for conservation and/or restoration represents the first implementation stage of the scoping phase. The main objective of this stage is to define, justify, and apply a clear set of criteria for determining **"who"** should be protected or restored within the area of interest based on ecological considerations. Thus, stage 1 ultimately provides the ecological foundation for the prioritisation of species, habitats, or ecosystem processes (collectively referred to as ecological subjects) to be at the core of the site-specific conservation and restoration goals, targets, and the corresponding measures to be defined and implemented. The implementation of stage 1 begins with two parallel operational steps: the comprehensive listing and identification of ecological subjects (OS1.1) and the definition and selection of ecologically relevant criteria for prioritisation (OS1.2). These are then integrated in a final operational step (OS1.3), where the listed ecological subjects are prioritised based on their ecological characteristics and the role they play in the ecosystem, considering the selected criteria in OS1.2.

When working towards the refinement or adaptation of goals and targets for marine areas that are already protected, the initially selected goals of protection need to be considered as these might limit the selection of ecological subjects, depending on the size, location and level of protection of the area (e.g., no-take-zone vs. single species protection).

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Operational Step 1.1 – Identification of ecological subjects

The first operational step in identifying **"who"** to target for conservation and/or restoration is the methodologically straightforward yet ecologically critical task of scouting and compiling a comprehensive list of species, habitats, and their ecological roles (i.e., functions) within the area of interest. To effectively support subsequent implementation stages and operational steps, this process must go beyond a generic inventory of pelagic and benthic species or biogenic and non-biogenic habitats. The listing should be constructed relationally, capturing ecological linkages such as trophic dependencies among species, associations with specific habitat types, and individual or group-level contributions to key ecosystem processes (e.g., nutrient recycling, carbon sequestration), while also considering geophysical and chemical processes.

OS1.1 aims to move beyond the "mechanical" imposition of species and habitats predefined in EU legal frameworks (e.g., the Habitats and Birds Directives) as default ecological subjects for conservation. Instead, it promotes a locally meaningful approach, rooted in site-specific knowledge, that ensures both contextual relevance and ecological coherence. To achieve this, OS1.1 is intended to be carried out by local decision-makers or site-level practitioners with the capacity to convene and coordinate expert meetings focused on different biological groups. In this context, "experts" refers not only to academic professionals, such as taxonomists and marine ecologists, but also to individuals with substantial field-based experience, including NGO staff, local naturalists, and practitioners. The process should also include members of the local community with long-standing experience working at sea, such as fishers, divers, and maritime workers, whose site-based knowledge can provide critical insights into species occurrence and their habitats.

The collaborative work of these experts will be complemented by data gathered through local, regional and national monitoring and research programmes. This includes not only openly accessible datasets, but also additional scientific information that may not be publicly available but can be formally shared by experts and institutions within the scope of the action.

The implementation of OS1.1 should proceed in parallel with the definition of selection criteria (OS1.2), so that the listing process can be continuously informed and refined. This allows for a more targeted identification of the information to be collected, e.g., on the ecological roles that species fulfil in the ecosystem in direct relation to the selected functional criteria in OS1.2 (see further details in the following section).

Operational Step 1.2 – Selection and prioritisation of criteria

In parallel to OS1.1, the selection of the criteria for the prioritisation of ecological subjects for conservation and restoration should be performed. These criteria should provide the ecological justification to prioritise those species, habitats, or ecological processes on which conservation and restoration efforts should be focusing on. They should also account for representativity

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and viability, ensuring the inclusion of self-sustaining habitats and processes of sufficient extent to maintain the underlying biological, chemical, geological, and physical oceanographic processes.

While the academic literature increasingly calls for the explicit consideration of the ecological roles (i.e., functions) that species and habitats perform, and the ecosystem processes (i.e., ecosystem functioning) to which they contribute in an effort to mechanistically justify their prioritisation for conservation and restoration (e.g., Kollmann et al., 2016; Miatta et al., 2021), this perspective is still not fully embedded in practice. Although European and international initiatives have begun to explicitly incorporate functional aspects into strategic frameworks (CBD, 2008; Clark et al., 2014; Withouck et al., 2023), this shift has only partially permeated at the national and local levels, where conservation and restoration actions continue to be guided predominantly by structural indicators (Hoppit et al., 2025) relying on species presence, abundance or habitat extent (e.g. species uniqueness, rareness or dominance).

Without disregarding structural criteria, users of the Blue Connect Framework are recommended to pay particular attention to criteria that consider functional aspects when implementing OS1.2. In this direction, the recently developed *Ecological Toolkit* under the Horizon Europe project MSP4BIO introduced a comprehensive set of functional macro-criteria (further detailed in Annex 2) that support the explicit integration of functional aspects into the identification and prioritisation of ecological subjects (Kotta et al., 2024). These macro-criteria are designed to capture how species- and habitat-level traits relate to their vulnerability to both climate- and non-climate-related pressures, their role in supporting essential ecological processes, and their overall contribution to ecosystem-level stability and resilience. They also account for the spatial aggregation of functional diversity and the intensity of ecosystem processes, enabling the identification of functional hotspots, as well as zones that are ecologically critical for the completion of life cycles, such as feeding, breeding, and nursery grounds. Additionally, the toolkit recognises the capacity of certain species, communities, or habitats to enhance ecosystem adaptability, support climate regulation, and mitigate environmental change.

The set of functional macro-criteria introduced by the MSP4BIO *Ecological Toolkit*, along with the methodological guidance provided for their application, provides a solid foundation for the selection of ecologically meaningful criteria during the implementation of OS1.2. This guidance is intended to be applied within the same expert workshops convened for OS1.1, ensuring continuity and coherence between the identification of ecological subjects and the screening of relevant data needed to inform the criteria by which they will be prioritised.

Operational Step 1.3 – Prioritisation of ecological subjects based on selected criteria

After the selection of ecological subjects and criteria, the list of ecological subjects should be prioritised based on their role in the ecosystem and the weighting of selected criteria (Kotta et

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al., 2024, Yamakita et al., 2017). Although not ideally, data availability could also be used to guide selection and prioritisation of ecological subjects (Kotta et al., 2024). This exercise should continue to be steered by an expert-group, which backs transparent and reproducible prioritisation, enables evidence-based and ecologically grounded site-specific decisions (Kotta et al., 2024).

This expert-group can include relevant local experts from scientists, conservationists, environmental technicians, fishers, MSP and land planners, and even nautical agencies and diving schools, if their knowledge base is solid and relevant for providing an ecological perspective on the selection (Batista et al., 2011). Through expert meetings, the group can discuss relevant information about the area to be protected or that is under protection. These discussions should be based on the knowledge the stakeholders have obtained through interacting empirically or scientifically with the ecological subjects of interest. By working together, the experts can decide on the scores to attribute to each ecological subject in relation to the weight of relevant criteria. The group of stakeholders doing this exercise should have, ideally, also been involved in the previous process of listing ecological subjects (OS1.1) and selecting criteria (OS1.2) to allow for consistency and continuity in the process.

In order to make sure that the prioritised criteria resonate with the on the ground reality, they should be selected based on site-specific needs and capacities and the importance they have according to the experts of the area. For example, by engaging appropriate stakeholders with vast experience working, studying or interacting with the ecological subjects of the area as mentioned, one can ensure that the right perspectives are incorporated when prioritising the criteria and that these criteria will go beyond theoretical inputs that can quickly become obsolete.

Information based on experiential and scientific knowledge on known traits, ecological function, or management relevance enriches these prioritisation exercises (Kotta et al., 2024). Qualitative data and narratives ought to be used to inform and justify the inclusion and prioritisation of specific ecological subjects, even when quantitative data is available.

Through the application of a scoring exercise and using a matrix, scores can be assigned to each ecological subject according to the previously selected criteria. This method has been reviewed by Le Berre et al. (2019). Scoring matrices have also been used in the marine environment for ecological climate risk assessment purposes, as for example in the FutureMARES EU project (Garcia et al., 2023).

The scoring of the ecological subjects can be done using a Likert-scale (usually between 1 and 5 or 1 and 7, where 1 can mean the lowest relevance of the ecological subject according to the criterion and 5 or 7 can mean the highest relevance) (Joshi et al., 2015). Criteria can be weighted differently (between 0 and 1) according to the prioritisation that they have been given by the stakeholders in the previous operational step (OS1.2). All the weights of the criteria added should equal one. If some criteria have the same importance they should be given the same weight. Scores can then be summarised for each ecological subject by addition of the multiplication of individual scores for each of the selected criteria.

A demonstration of a template of the scoring matrix is provided in Table 4. In that example, ES2 is the most important ecological subject to focus on based on the selected criteria, followed by ES1 and ES3 (scoring equally), and ES4. C1 is more relevant that C2 or C3 (that have the same weight). Prioritisation between ecological subjects can be further refined in OS2.3 of stage 2 (below) of the framework, with the identified trends and events of change.

Table 3 - Demonstration of scoring matrix for a case with 4 ES and 3 prioritisation criteria. Criteria C1 is judged as more important than C2 and C3 and weighs double in the final sum.

Ecological Subject	Criteria			Score
	C1 (w=0.5)	C2 (w=0.25)	C3 (w=0.25)	
ES1	2	5	1	2.5
ES2	5	1	2	3.25
ES3	2	3	3	2.5
ES4	1	5	1	2

Besides assessing comprehensive data and information on the ecological subject, an expert-group approach allows for a closer look at consistency and compatibility of selected ecological subjects with the preferences of local interest in the process (Al Amin et al., 2020). The strategic use of available knowledge is crucial in ensuring ecological representativity while remaining adaptable to local or data limited contexts (Kotta et al., 2024). This importance is highlighted especially when the compilation of ecological subjects tries to balance compliance with international and EU legal frameworks with ecological validity. This exercise should allow for flexibility to incorporate locally important ecological subjects that may not be otherwise formally designated or protected.

For it to be efficient, the prioritisation and selection of ecological subjects should be done through a bottom-up process that supports the top-down nomination of some potentially relevant ecological subjects (based on national and EU legislation and frameworks (e.g., Habitats and Birds Directives) or MSFD descriptors, for example), and improves it by adding concrete, insightfully context-tailored options. That allows for the building of trust and robustness in the work being developed and will increase the effectiveness and ownership of the process of defining goals and targets for an area

It is recommended that the user reflects upon the prioritisation of ecological subjects throughout stages 2 and 3 as well to see if the chosen criteria and their corresponding scores remain relevant, taking into consideration any newly acquired information. For example, considering current and future human use or climate change scenarios, if a given species is stable and faces no apparent threats, it may not be prioritised unless it holds strategic or legal importance. Conversely, species or habitats recognised as vulnerable (e.g., threatened habitats,

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species of conservation concern) may be prioritised regardless of whether a local decline has yet been documented.

3.2.2 Stage 2 – Describing conservation status, trends and events of change

Due to the dynamic nature of marine ecosystems with their network of interconnected relationships, one must consider the scenarios that threaten the ecological subjects, shifting them far from their baseline or 'pristine' state.

Stage 2 addresses "**what**" has happened, is happening, or might happen in the area of interest and helps provide context for why the need for an MPA has/had arisen in the first place. The necessity for an MPA can stem from negative changes observed in the general ecosystem or in specific ecological subjects. However, it can also reflect the intention to preserve the current state of the ecological subject in the area of interest and protect it from future threats such as climate change. This stage should be carried out in parallel with the previous stage 1. The implementation of stage 2 begins with the identification of key events that affect the ecological subjects (OS2.1) that are then complemented by the outline of specific spatial or temporal changes, when possible (OS2.2). OS2.1 can be implemented simultaneously with OS2.2, depending on the context-specific needs. Here they are separated to provide a step-by-step structure to facilitate the assessment of "**what**" has happened, is happening, or might happen.

Operational Step 2.1 – Identification of key ecological events that affect the ecological subjects

This operational step collects information on any key ecological events affecting or having previously affected either specific ecological subjects or the ecological processes in the region. Such events are natural or human-induced occurrences within an ecosystem. They can range from seasonal changes to less frequent phenomena such as marine heat waves, El Niño, storms, algal blooms, coral mass mortality die-offs, or the introduction of invasive species. Each event, regardless of scale, plays a role in shaping the environment.

The required information can be collected by reviewing literature, media updates, or even interviews based on scientific evidence or observations by local stakeholders. It is useful that this information includes when and where within the region these observations have been made. Past ecological events with a chance of recurring, or events described in nearby/similar ecosystems can also be considered as potential warning signs for the area of interest. In addition to the existing events, a common approach for the practitioners can be to consider climate change-related extreme events that are more likely to occur in their area in the coming decades.

The output of this step should be a narrative description, or a list of past or potential ecological events that have been observed in this or similar areas. Note that this stage is primarily

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observation-driven and does not aim to establish causal explanations for these events. If potential explanations for these events are known, they will be analysed in the next stage (S3).

Operational Step 2.2 - Outline of spatial or temporal changes

Apart from specific events, marine ecosystems can also undergo changes, such as range shifts, regime shifts or migration patterns, over time and/or across space. In this operational step, scientific and empirical information on changes observed in the spatial- or temporal state of the ecological subjects of interest—or the area as a whole—is gathered and integrated statistically or experientially.

This step should produce a narrative explanation of the observed or expected trend based on qualitative and/or quantitative information from the area of interest or a similar region. The information may have varying levels of evidence or detail but should be sufficient to perform or support a time series or trend analysis. An example of such information can be local fishers providing accounts of fish spawning seasons, migration routes, and fishing grounds, which are key to developing MPA boundaries and regulations.

If sufficient records are available, a baseline state of the ecological subjects may be defined here. An example of this application is using the historical data and oyster habitat suitability studies for restoration of oyster beds in the North Sea (Pogoda et al., 2023; Stechele et al., 2023; Thurstan et al., 2024), currently taking place in one of the project's DS. Since the marine environment is in a constant state of change due to natural regime shifts (i.e. abrupt changes that occur over large spatial scales and that are evident) or anthropogenic pressures, it is essential to assess or acknowledge the biases that might be present in the selected baseline state. Some ecosystems may have already passed critical thresholds or tipping points, leading to permanent shifts in ecological balances that may no longer be reversible (Brandl et al., 2024; Sguotti et al., 2022) and to the emergence of a new baseline.

Given that trends represent a statistical concept and can also be derived from experiential information, it is important to associate a level of certainty with the trend either through data analysis or expert knowledge. When knowledge is expanded or reassessed, practitioners should keep in mind that, for example, relatively uncertain trends may "unfairly" impact the outcomes of the analysis of the other stages of the operational framework (e.g. stage 3) when compared to more "certain" trends.

3.2.3 Stage 3 - Understanding the system

Understanding the system to be conserved or restored is crucial in working towards the definition of goals and targets. The system here represents the interaction of the prioritised ecological subjects with the biotic and abiotic factors in the surrounding ecosystem. These factors can be other ecological subjects or environmental variables, such as currents, temperature, or salinity.

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Although the users of this operational framework may have a broad aim to protect a specific marine region in its entirety, it is prudent to work with ecological subjects at the centre of the methodology. Apart from the outcome of direct conservation, having specific ecological subjects to protect can provide a measurable approach, where users can assess the current state and monitor the effects of the restoration or conservation actions, for example, on species abundance or habitat coverage. As such, it is crucial to establish a comprehensive understanding of the system to be conserved or restored, together with pressures that affect it. Compared to the previous stages, this stage is primarily driven by scientific data and reasoning; hence, it can be data-demanding. However, if limited data is available from the area of interest, it should be possible to gain additional information from areas with similar ecological characteristics.

The main aim of this stage is to gain a holistic understanding of interactions within the system of your area of interest, allowing for a comprehensive overview of how trends and events affect the system. A Causal Loop Diagram (CLD) is a useful tool that helps visualise and analyse these interactions. The approach for developing this diagram is adapted from Valdivia Cabrera et al. (2025) and Lin et al. (2020). Here, the CLD analysis is split into two operational steps, where first, the biotic and abiotic interactions with the ecological subjects are considered; second, the interactions with the pressures acting on the system are incorporated. The two operational steps (OS3.1 and OS3.2) are described below, followed by the reassessment of the prioritisation based on the insights gathered here and in previous stages (OS3.3).

Operational Step 3.1 – Description of the current ecological understanding of the system

To start constructing the CLD, one needs to define the extent of the system to be analysed and identify its key ecological subjects (groups of species, functions, habitats, processes) and environmental variables. For instance, in a marine system, a natural process like ocean upwelling can drive changes in nutrient availability, which in turn influences plankton blooms and the broader food web. Drawing on data and insights already collected is essential at this stage, both to make the most of existing knowledge and to identify potential knowledge gaps. Information on the extent of the system and key ecological subjects can be derived from the previous stages 1 and 2. Environmental variables should be selected based on their relevance, impact, and measurability – avoiding unnecessary complexity.

The most critical part is defining the key relationships and feedback loops between the system's ecological subjects and environmental variables. This involves identifying how variables interact—both in direction and intensity—i.e. whether changes in one will amplify (positive feedback) or dampen (negative feedback) changes in another; and which of these feedbacks exert comparatively larger impacts on the system's subjects and variables (Figure 3). For instance, increased nutrient input may lead to algal blooms, which reduce water quality and compromise marine life, potentially triggering other ecological shifts. Understanding these feedbacks is essential for capturing the system's dynamic behaviour, including unintended consequences and points of resilience or fragility.

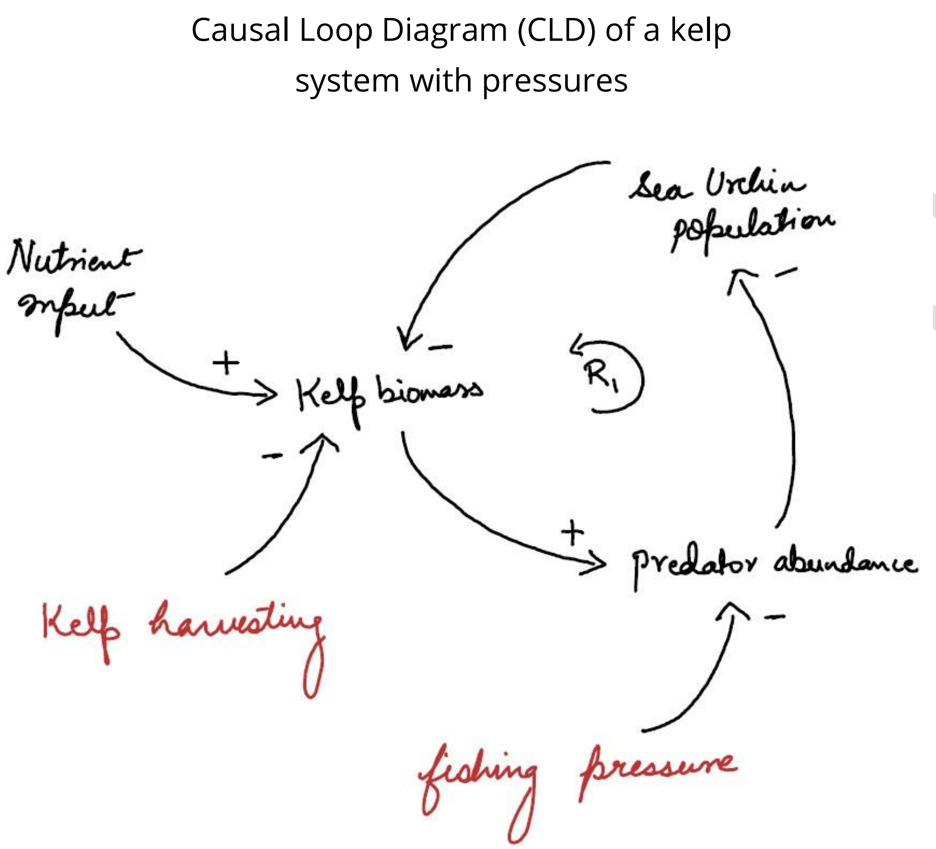

*Figure 3 - **Example of Causal Loop Diagram (CLD):** A simplified kelp system. The feedback is represented by the arrows, with directional (arrow heads) and polarity (pluses or minuses) marks to indicate positive or negative feedback. R1 represents the reinforcing loop. The text in black represents the ecological interactions within the system (OS3.1), while the pressures acting on the system are in red (OS3.2). Note that here nutrient input is driving kelp growth, however, it can become a pressure in case of excess nutrients.*

Operational Step 3.2 – Assessment of the causes of previously identified trends or events of change

The events of change described in the previous stage may directly or indirectly impact one or more of the selected ecological subjects. With the prioritised ecological subject-centric understanding of the system, this operational step analyses the causes behind the ecological events and trends described in S2. These causes can be natural; however, often, human intervention (pressures) is the underlying cause for these alterations. For example, the increasing frequency of extreme events such as marine heat waves is a signal of climate change, attributed to anthropogenic carbon emissions.

A preliminary qualitative assessment of human pressure influence on the prioritised ecological subjects can be done through the DPSIR (Drivers-Pressures-State Change-Impact-Response) framework (Patrício et al., 2016), which provides an overview of the system-pressure-human

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action interaction. Different variants of the DPSIR framework have been adopted across various marine applications (e.g., Al Amin et al., 2020; Ojeda-Martínez et al., 2009; Patrício et al., 2016). However, for this assessment, the DPSIR framework is adapted to gain the ecological understanding of the system by listing:

- Drivers: Broad-scale environmental or anthropogenic factors that primarily affect the ecological subjects (e.g., climate change, seafood demand, tourism, coastal development), originating from within or outside the area of interest.
- Pressures: Natural or anthropogenic stressors on the system (e.g., invasive species, nutrient input, commercial fishing).
- State: Current state of the system. This information is derived from stage 1 and stage 2.
- Impact: Ecological impacts of the listed pressures on a specific ecological subject. These are already described in trends and events of change in stage 2.
- Response: Broad-scale ecological responses observed in the system as a result of these changes and impacts. These are not policy-based, as done in conventional DPSIR approaches, but may rather include shifts in species composition, changes in habitat structure or alterations in trophic dynamics.

Understanding these ecological responses through the DPSIR analogy helps to conduct a pressure assessment and to capture the system's internal feedback mechanisms when possible, resilience thresholds, and potential for recovery or further degradation, thereby informing where and how conservation decisions could be focused.

After the DPSIR analysis, the CLD started in the previous operational step (OS3.1) can be updated to include interaction of ecological subjects with human pressures using the steps provided in the previous operational step (OS3.1) (see the example in Figure 3). The reassessment of the components of the CLD in the presence of human pressures leads to the addition of new processes and feedback loops, offering a more realistic understanding of the current system.

Once a draft CLD is constructed, it should be shared with stakeholders and experts for an exchange of knowledge to refine initial results from this causal analysis exercise. The aim here is not to create an overly detailed map but to refine the diagram to its minimum sufficient state, ensuring that it accurately reflects the core dynamics without removing attention from the main feedback structures. Finally, the CLD should be analysed to identify places where interventions can make the most impact to shift the system in a desired direction. These insights will form the foundation for defining goals and targets in the definitions phase.

For regions with sufficient quantitative data available, a CLD can be translated to a System Dynamics Model (SDM) that allows for specific representations for different component types,

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such as, stocks (quantifiable ES), processes, and variables (Ding, 2021; Lin et al., 2020); hence, providing deeper insights into system functioning.

These operational steps also serve to identify knowledge gaps in the understanding of the system. If system functions or processes cannot be adequately explained or require further scientific validation, an action plan to address these gaps can be developed in Task 2.2 "Connectivity and Blue Corridors" and Task 2.3 "Ecosystem models to support the definition of conservation objectives" of the Blue Connect Project.

Operational Step 3.3 – Reassessment of ecological subjects prioritisation

Based on insights from the initial information collected in stage 1 and stage 2, and system understanding analyses (OS3.1, OS3.2) conducted in stage 3, the prioritisation of ecological subjects may need to be reassessed using the steps outlined in OS1.3 ("Prioritisation of ES based on selected criteria") in stage 1. At any stage of the process, newly uncovered insights may prompt a reassessment of the outcomes of other operational steps. Users may find it necessary to revisit earlier stages to integrate new data, address gaps, or adjust elements of their system understanding – particularly as represented in the causal loop diagram (as described in OS3.1 of stage 3). As previously indicated, this operational framework is designed to be iterative in nature, allowing for continuous refinement as new information becomes available.

This operational framework is structured such that the definitions phase builds directly upon the information collected and prioritised during the scoping phase. Consequently, new insights that emerge during the definitions phase may reveal inconsistencies or gaps in earlier assumptions or prioritisation decisions. In such cases, users should identify which operational step within the scoping phase requires revision and assess how these changes affect subsequent stages and decisions relating to their prioritisation. For instance, one might consider altering either the chosen criteria or their corresponding weights within the matrix, or adding entirely new criteria and shifting the scores accordingly.

In summary, the scoping phase involves compiling all existing information related to the prioritised ecological subjects within the area of interest, including events or trends that have impacted or may impact them. Additionally, the interactions between ecological subjects, as well as the associated human pressures linked with the ecological subjects are examined.

In the definitions phase, goals and targets for the conservation and restoration of the prioritised ecological subjects are established, based on the information collected during the scoping phase.

3.3 Implementation Phase 2: Definitions

The definitions phase aims at translating all the information that was collected during the scoping phase into actionable goals, operational targets and efficient measures. In the definitions phase, all the knowledge about the system to be conserved and the relevant quantitative or qualitative information on the different ecological subjects and their potential interactions will be further detailed to support the definition of goals.

By drafting ecologically informed goals, the process enables the development of operational targets that are evidence-based and context-specific. In conservation, the concepts of goal, aim, objective, and target can have different or overlapping meanings, according to the context in which they are mentioned. For this operational framework, the terms goals and targets are used as two clearly distinct features: Goals are seen as desirable endpoints for an MPA. They are a generalised declaration or statement about an expected state of the ecological subjects to be protected or restored, providing a vision of the results to be achieved (Wood, 2011). These goals guide the scene for the planning and management of the MPA. Thus, making them operational, can be decisive for the effectiveness of the MPA in question. Targets are specific, measurable, and time-bound benchmarks that operationalize conservation goals.

3.3.1 Stage 4 – Defining goals

MPA goals should not be pre-determined and the MPA process should move away from the idea that goals can be overarching and transferable to other areas to adopt (Jentoft et al., 2011). The formulation of operational goals should embrace dynamism and adaptability (Jentoft et al., 2011). Using the goal assessment framework put forward by Jentoft and colleagues (2011) as a basis, the Blue Connect Framework aims to empower decision makers and practitioners to define their goals and targets with the adaptation and flexibility that comes from the exchange of experiences and built knowledge.

Understanding ecological processes is critical to shape and conceptualize relevant goals. However, this understanding does not depend only on quantitative ecological data, and qualitative information is equally relevant for ecologically supporting decision-makers and practitioners in the setting of operational goals (Magris et al., 2014). After the scoping phase, one ideally has a clear picture of the “who” to protect, “what” has happened or might happen, and how the system of interest functions, how changes occur, and how can they be reversed or prevented. Thus, a holistic understanding of the system that is to be protected has been achieved, where the prioritised ecological subjects are dynamically interacting with biotic and abiotic drivers and with natural and human pressures. The implementation of stage 4 consists of two operational steps through which one can draft goals (OS4.1) and refine them (OS4.2).

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Operational Step 4.1 – Draft of the goals

For this operational step, it is important to set aside reality's barriers and challenges and think about the state desired for each of the listed ecological subjects. With the information available to understand the system, one can think about the following questions: what is the vision for the area? and if there were no constraints, where would one set the bar for each ecological subject? Through reflecting without considering any constraints (such as policy in place, capacity or funding) and keeping in mind the learnings from the scoping phase, goals for each of the prioritised ecological subjects should be defined. If there are relevant biotic and abiotic components and processes (including human-related ones) affecting these different ecological subjects, tailored subgoals should be defined for each of them.

Operational Step 4.2 – Rethink and adapt

Goals defined in OS4.1 are not intended to be fixed or immutable. Rather, they should be considered dynamic reference points that should be periodically reassessed. This temporal flexibility is critical, as goals must evolve alongside the systems they aim to protect or restore. Regular updates, informed by continuous monitoring and on-the-ground experience, allow for their progressive adaptation, ensuring they become increasingly tailored to local ecological and management contexts. Maintaining this temporal flexibility is essential for practitioners, as it enables conservation planning to respond to emerging challenges and new insights, rather than locking strategies into outdated expectations or static priorities (Hoppit et al., 2025).

3.3.2 Stage 5 – Defining Targets

Once the goals are defined, setting targets facilitates progress toward achieving them. Targets ensure that conservation and restoration actions are measurable, outcome-focused, and aligned with overarching biodiversity goals, reflecting both the quantity and quality of ecological subjects that are to be maintained, enhanced, or restored (Haldin et al., 2025). In most cases, conservation and restoration targets have already been pre-defined through international or regional agreements or defined during the designation of MPAs that are already established. Within this framework, target setting may involve adapting predefined targets to the specific area under protection and increasing their ambition where feasible.

Target definition is informed by the scoping phase, focusing on the ecological priorities of the protected area. In the definitions phase, the implementation of this stage happens in parallel with the implementation of stage 6 ("Understanding what is hindering"), since defining effective targets requires an understanding of the pressures that could jeopardize their achievement. By understanding these pressures one can ensure that the targets are fit-for-purpose. These stages should therefore be closely coordinated, with their outputs integrated to contribute to the final stage (stage 7) which will ultimately support the definition of measures.

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Stage 5 comprises four operational steps: OS5.1 Selection of target types, OS5.2 Selection of indicators and tools, OS5.3 Implementation, validation and translation to targets and OS5.4 Making targets SMART.

Operational Step 5.1 – Selection of target types

Target setting should ensure a balanced and interconnected approach across the different goals. While each goal may have its own set of associated targets, it is essential to ensure that these targets do not conflict with or undermine each other. Ideally, targets should be coherent, mutually reinforcing, and designed to feed into each other. To support evaluation, operational planning, and tracking of success, it is helpful to first identify the different types of targets and their associated characteristics. These may include, but are not limited to:

- **Representation targets** aim to protect a defined percentage of each habitat or species distribution, ensuring ecological representation across MPAs or within a single MPA (WWF, 2019). They are typically structural and percentage-based, calculated using a combination of *in situ* mapping, species and habitat distribution models, and GIS-based analytical tools. Advanced prioritization and optimization algorithms - such as those used in prioritizR (Hanson et al., 2025), Zonation 5 (Moilanen et al., 2022), or MARXAN (Watts et al., 2021) - support this process.

- **Functionality targets** focus on maintaining the ecological processes and resilience features that allow marine ecosystems to persist and adapt. Rather than only protecting specific habitats or species, functionality targets emphasize the roles and interactions that sustain ecosystem health over time. Setting functionality targets involves identifying key ecological functions present within the area of interest. For example, key benthic marine system functions include: energy and elemental cycling, productivity and food supply, adult immigration/emigration and modification of physical processes (Frid et al., 2008). Functionality targets therefore help ensure that protected areas safeguard not only *what is there* but also *how it works*. This approach underpins long-term ecosystem resilience and sustainability.

- **Connectivity targets** aim to maintain or enhance functional and structural connectivity across the seascape. Within the Blue Connect Framework, connectivity is recognised as a foundational ecological process essential for effectively conserving and restoring prioritised species, habitats, and ecosystem functions. Facilitating ecological connectivity ensures the continuity of key ecological dynamics, such as the movement of individuals, propagules, and genes. This is critical for maintaining population viability, ecosystem functioning, and resilience (Beger et al., 2022; Darnaude et al., 2024).

Regardless of the target type, all targets should be climate-adapted. This includes safeguarding climate refugia identified during the scoping phase and accounting for climate-influenced migration pathways to make targets more effective. As climate change increasingly affects ecosystem and population dynamics, spatial and temporal considerations of the resulting trends of change become essential. Alongside factors such as the potential of resistance, recovery or adaptation of species or areas, these should inform the development of climate-smart conservation targets (Arafeh-Dalmau et al., 2023).

Target types can be further categorized as quantitative or qualitative targets. Quantitative targets are specific and measurable and align with the SMART Framework (see OS5.4). As quantifiable metrics, they are useful for tracking progress and providing clarity but may overlook other factors such as qualitative aspects when used in isolation. Qualitative targets are more subjective and commonly align with descriptive metrics. They can complement quantitative targets, especially when data is limited, to achieve a more holistic focus on the broader goals. Qualitative targets often allow for improved adaptability and flexibility. However, they require careful management and assessment to ensure consistency and impact, as they can be harder to measure and interpret. Evaluation of qualitative targets may include feedback, observations or (structured) assessments (Haldin et al., 2025).

To support implementation and enhance the adaptability, transferability, and long-term relevance of targets, it is important to assess their sustained suitability against plausible sources of variability within the protected area. These sources of variability may include temporal, spatial, and environmental factors (Haldin et al., 2025). Such an assessment helps identify potential risks that could compromise the effectiveness of the defined target. As a practical reference, PROTECT BALTIC Deliverable 6.27 outlines a process for establishing quantitative ecological protection targets in the Baltic Sea (Haldin et al., 2025). It provides guiding principles for target setting and highlights associated risks, offering valuable guidelines for informed decision-making.

Operational Step 5.2 – Selection of indicators and tools

Once the relevant types of targets are identified, this operational step begins with the identification of which indicators (i.e quantitative or qualitative variables that provide a simple and reliable means to measure achievement) should be used for each of the particular target types defined. Each can be useful for more than one conservation goal, and its related target(s). In this context, indicators measure progress towards a target and can relate to a specific information need, such as the conservation status of the ecological subject or the association between one or more variables.

While some indicators can be quantified using basic spatial analysis tools available in standard GIS software, others may require advanced modelling techniques that may often exceed the technical capacity or resources of many decision-makers and practitioners. This underscores the importance of accessible, user-friendly tools and collaborative support mechanisms to bridge the gap between scientific complexity and practical application.

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Based on the ecological subject(s) prioritised in OS1.3 and on the system understanding developed in stage 3, tool selection should balance scientific appropriateness with operational feasibility, ensuring that they are both ecologically relevant and practical for the area of interest. To do so, managers and practitioners should select and implement appropriate science-based tools collaboratively with subject-matter experts. Where local expertise is lacking, international partnerships and lessons from ecologically similar areas can be helpful, enabling the transfer of effective methods and best practices to support context-appropriate decision-making. Collaborations initiated through international research and innovation programmes can provide valuable technical support, foster cross-regional knowledge exchange, and facilitate access to specialised expertise and resources otherwise unavailable locally.

Assessing the availability and quality of data is also key to determine which science-based tools are applicable. A detailed inventory of existing local and national datasets should be compiled, ideally starting already during the scoping phase. If local data is insufficient, open-access European data infrastructure and global platforms such as the Ocean Biodiversity Information System (OBIS), the Global Biodiversity Information Facility (GBIF), the European Marine Observation and Data Network (EMODnet), and Copernicus Marine Service, or Movebank (Kays et al., 2022), among many other, can be used to fill critical information gaps. In doing so, it is important to find the right balance between data availability and the spatial and temporal resolution required by the science-based tools to be implemented in a context-appropriate way, ensuring that the chosen approach remains both feasible and scientifically sound.

If data are insufficient to apply the selected tools, proxies can be identified to fill the data gaps, repeating the tool selection and data assessment process as needed. Once sufficient data is available the selected tools can be applied. To support this operational step, working teams of Tasks 2.2 and 2.3 of Blue Connect will provide structured frameworks with detailed, step-by-step guidance for the selection and application of science-based tools under varying data availability conditions. Task 2.2 will focus on analysing connectivity and assessing both structural and functional connectivity indicators, while Task 2.3 will cover the modelling and spatial mapping of ecosystem functioning. Together, they will deliver practical solutions tailored to context-specific needs and data constraints. These frameworks and their associated toolsets will be progressively refined throughout the project, informed by the evolving needs and implementation experiences of the Demonstration Sites.

Connectivity tools

Given the wide array of available methods for assessing structural and functional connectivity, navigating and selecting appropriate science-based tools can pose a significant challenge, especially for practitioners operating under resource or data constraints. To address this, the connectivity component of the Blue Connect Framework (Task 2.2) introduces a refined classification system, inspired by the work of Keeley et al. (2021), that organises available structural and functional tools into a practical typology. This typology, currently under further development and refinement, aims to help users discern not just what each tool does, but how tools relate to each other in terms of functionality, input requirements, spatial scale, and modelling complexity. By outlining available science-based tools, highlighting their technical and data requirement, identifying potential synergies, and providing step-by-step implementation guidance, the connectivity component of the Blue Connect Framework serves as a navigational aid for making informed, context-sensitive tool choices.

The suite of science-based tools under consideration spans a wide methodological spectrum, including graph theory and network-based models, cost-distance and circuit theory approaches, and more computationally intensive biophysical simulations, among others. These tools are complemented by open-source software solutions, including statistical packages commonly used in connectivity modelling (e.g., R-based packages), which, for example, support the processing of animal tracking data or the generation of species distribution models. These inputs form the ecological and spatial foundation required for robust connectivity assessments, enabling practitioners to quantify, visualize, and prioritise ecological linkages across marine seascapes.

As mentioned before, however, users must evaluate whether the necessary ecological and environmental data are available. This connectivity component of the framework will include detailed guidance for assessing local data readiness, identifying potential data gaps, and accessing supplementary datasets from global and regional repositories. In many cases, connectivity tools are “data hungry,” requiring high-resolution information on habitat configuration, species occurrence, or dispersal traits (Barboza et al., 2025). If data are limited or uneven in quality, the framework will support adaptive strategies, such as downscaling tool complexity, modifying model assumptions (i.e. hypothesis made about the ecosystem and its functioning), or refining the scope of connectivity assessments, ensuring the chosen approach remains feasible and relevant.

Ecosystem functioning tools

The ecosystem functioning component of the Blue Connect framework (under development in Task 2.3) proposes guidance to select appropriate (successions of) tools to assess ecosystem functioning.

Ecosystem functioning tools, used to assess how well ecosystem functions are being performed, can be quantified through ecosystem modelling and have a temporal component as ecosystems are dynamic. When integrated with connectivity tools (e.g. predicting spatial structure of benthic habitats and transport of matter and ecosystem subjects) they are also characterized by a spatial component.

Ecosystem functioning processes depend on and can affect abiotic and biotic conditions in the environment (Marcos et al., 2021). Ecosystem functioning tools therefore rely on data describing these conditions as inputs. These inputs can either come from local data sources (e.g. local monitoring programmes or assessments) or from available, larger-scale, open data sets (as the ones mentioned above or model outputs from the Coupled Model Intercomparison Project (CMIP) for climate change scenarios). Where relevant, modelling tools to simulate local or regional 3D hydrodynamics and biogeochemistry dynamics can also be used. For consistency, it is preferable to align the data sources and tools used to define these environmental conditions with those used to assess connectivity in the area of interest.

Important ecosystem functions to protect include the capacity of habitats for carbon storage and for providing spawning and feeding grounds for fish. To assess potential carbon storage by habitats (e.g. seagrass meadows or seaweed forests), tools varying in complexity and adapted to level of information available (environmental conditions and physiological characteristics of the species or communities at play), can range from simple rate-based approaches (Macreadie et al., 2014) to complex, species- or population- centred models. For example, one could use the Dynamic Energy Budget (DEB) approach.

DEB models can quantify the flow of energy through individual organisms and ecosystems by tracking energy from uptake to utilization for processes like maintenance, growth, and reproduction (Kooijman, 2010). DEB models provide a formal, quantitative framework to explain life history traits and link individual fitness to environmental factors, enabling predictions of organismal and population-level dynamics and the impact of environmental change on marine communities.

Moreover, the potential for ecosystems to provide feeding and spawning grounds for species such as fish can be assessed using 'knowledge-rule'-based habitat suitability tools. Energy flows within ecosystems, from producers to consumers at different trophic levels can be assessed using dynamic, mass-balance food web models (Coll et al., 2024; Dahood et al., 2020). These are relevant if the defined goals require the prediction of dynamics of higher trophic levels (e.g. fish stocks and marine predators) to measure their achievement.

Operational Step 5.3 – Implementation, validation and translation to targets

Once the relevant science-based tools are selected, they can be used to generate ecosystem functioning and connectivity informed outputs. These outputs should then be validated against local observations and expert knowledge.

For example, drawing on comparison from the Baltic Sea Protection Optimization Framework (in preparation under HELCOM and the PROTECT BALTIC project), habitat specific spatial outputs can be initially presented as draft percentages in suggesting a regionally adapted representation type target. Draft percentages in this example are generated with a pre-defined scale, using such as a tool, and which is informed by a weighted scoring matrix rating each habitat across three criteria (inspired by an approach tested in Sweden (SwAM 2021)): current occurrence, conservation status and biological value (Haldin et al., 2025). Draft habitat percentage outputs undergo review by national experts to adjust representation target percentages in accordance to their ecological relevance, ensuring appropriateness to local conditions (Haldin et al., 2025).

Within the Blue Connect Framework, if the validation by experts in this operational step considers the outputs not reliable enough or not sufficiently aligned with local conditions, input data, assumptions (i.e. hypothesis made about the ecosystem and its functioning), or underlying process representation in the tools themselves should be refined (repeating OS5.2), and the outputs re-generated. The validation should then be re-iterated until the tool outputs are judged as ecologically relevant and locally aligned and can be translated into defined targets.

Operational Step 5.4 – Making targets SMART

While the targets are being defined it is crucial to align them with the SMART framework (Table 5). By making targets Specific, Measurable, Achievable, Realistic and Timebound one can make sure that they have the characteristics that allow for the creation of a strategy for the MPA that can be reasonable and achievable through the setting of measures. This operational step can be retaken as needed, according to the knowledge that is acquired during other stages.

Finally, it should be discussed whether the defined SMART targets are sufficient and viable for achieving the defined goals. Any remaining gaps for achieving the goals should be fulfilled with a target, and a plan set in place for incorporating a review cycle of the defined targets.

Table 4 - SMART targets adapted from ICES 2005

Specific	Clearly specify the state to be achieved.
Measurable	Relate to measurable properties of ecosystems, so that indicators can be developed to measure progress.
Achievable	Targets should not conflict. In an effective management framework, it should be possible to achieve all objectives.
Realistic	Targets goals should be implementable using the resources (research, monitoring, and assessment and enforcement tools) available to practitioners.
Time bound	There should be a clearly defined time scale for meeting the targets.

3.3.3 Stage 6 - Understanding what is hindering

During the process of understanding our system (S3) one could already anticipate that there would be different pressures hindering the achievement of the goals and targets being set. Pressure analysis is one of the exercises one can do to understand what could be jeopardizing the achievement of goals better and here an approach to this analysis is suggested, based on the work being developed in Task 3.1 "Pressure analysis" of the project.

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Stage 6 should happen in parallel with stage 5 in order to obtain the best possible information to guide the setting of measures in the stage 7 of the operational framework. In this stage, the operational steps encourage the users to analyse in more details the human pressures affecting their system (OS6.1) and to consider other relevant barriers to conservation (OS6.2)

Operational Step 6.1 - Pressure Analysis

As a first step in this analysis, key human activities and main pressures (e.g. marine traffic, bottom-trawling) that are relevant to the MPAs, or specifically to the selected ecological subjects of those sites, are identified. An expert-based prioritisation should then be made for the activities and pressures. In Blue Connect, this information is coming from discussions with the Demonstration Site teams and LSWG of the different sites.

In case data for human pressures are lacking, as it is often the case, activities can be used as a proxy. Geospatial data of activities and pressures should be collected and processed into distribution maps. By assigning sensitivity scores to the different pressures and activities and overlaying the geospatial data with species or habitat distribution maps, hotspots of potential impact can be identified, and a cumulative impacts assessment can be done. If data becomes available, repeating these steps for future scenarios can provide further insight into the needs to take measures.

The outputs that come out of this analysis should be validated by experts that can provide valuable input for the creation of conservation and restoration measures or the (re)assessment of the feasibility of the targets defined or to be defined. If high-pressure hotspots overlap strongly with prioritised ecological subjects, users may need to adjust the scope, ambition, or timeline of goals and targets, or explicitly link measures to pressure reduction. In this way, pressure analysis directly informs both the realism of conservation targets and the prioritisation of measures in Stage 7.

Operational Step 6.2 - Consider other barriers

Additionally, it is valuable to keep in mind that there are other types of barriers, beyond human pressures, that can influence the outcome of MPAs. Even though this deliverable has a strict ecological perspective, the Blue Connect Project has a broader scope and is also looking into institutional barriers and enablers for defining and implementing effective conservation measures (Task 3.2 “Institutional barriers and enablers for defining and implementing effective conservation measures in European MPAs”) and into understanding how co-definition or co-management can contribute to just and effective MPA management (Task 3.3.2 “Co-defining measures for just and effective MPA management”). Complementing this section of the operational framework with the outputs that will derive from these and other relevant tasks will be beneficial in looking at what is impeding the achievement of the goals and targets in a more holistic way. For practitioners, recognising these additional barriers is not only a descriptive task but also action-oriented process: if institutional, governance, or social obstacles appear likely to block ecological goals, these findings should trigger either the adaptation of targets to what is achievable under current conditions or the parallel identification of enabling measures needed to remove or reduce the barrier.

3.3.4 Stage 7 - Defining Measures

Actions to protect, preserve, or manage natural resources, ecosystems and biodiversity should come in the form of concrete measures to be taken. By deciding what to do and how to do it, conservation goals and targets for an area can be achieved. When defining measures, different barriers and pressures that might be preventing the achievement of the defined goals and targets need to be considered. For example, defining measures to help decrease anthropogenic pressures can increase the persistence of the ecological subjects of interest by decreasing the cumulative pressures affecting them. The process of defining measures can thus serve as an opportunity to (re)apply some of the previously described stages. Thus, stage 7 represents the process of integrating information that was obtained during stage 5 and stage 6. By focusing on the targets defined and on the human pressures and barriers identified, concrete conservation and restoration measures that are tailored to the local context can be defined.

However, drafting strong measures is only part of the challenge - effective implementation of conservation and restoration measures remains a bottleneck. Despite current efforts and attempts to set clear goals and targets (guided also by this operational framework), the implementation of measures often remains slow, due to multifactorial constraints, such as data gaps, limited funding, institutional capacity, and shifting political priorities. Recognizing these challenges, Blue Connect's WP3 and WP5 are working to further develop the process of defining and co-creating robust, context-specific measures. These work packages aim to support the evaluation of measure effectiveness over time and contribute to enabling more efficient and adaptive implementation at local scales.

4. Comparative applications of the framework in two Demonstration Sites

Blue Connect is working towards a systematic approach to marine conservation planning and management. One of the main pillars of project is a holistic framework that considers various elements of biodiversity, ecological functioning, pressures and connectivity, while also leaving space for inputs from stakeholders and local communities. These inputs come from the integration of the Demonstration Sites views into the work of this task, through the compilation of information based on the Task 4.1 Scoping Analysis and, more actively, through the feedback provided during the workshop held at the June 2025 Blue Connect General Assembly and subsequent bilateral meetings.

The varied circumstances of the Demonstration Sites are very relevant to adapt, test and validate the framework throughout the duration of the project. Different perspectives of

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knowledge, amount of information available, different stages in the MPA process and multiple contexts are all to be considered and to be collated in qualitative and quantitative ways.

During the interactive session for Task 2.1 that took place on the 17th of June 2025 in Arendal, the task team presented the first draft of the operational framework and gathered feedback and inputs from the consortium, with a special focus on the Demonstration Sites. During that session, different Demonstration Site representatives discussed how to address the different operational steps of the proposed framework. This allowed participants to raise concerns and provide suggestions on how to make the operational framework more adaptable to and inclusive of the different contexts.

Some of the Demo Sites of the project have been or are already in the process of applying parts of the operational framework in their work. Hence, the process of testing the framework has slowly started and will be further developed under Task 2.4 "Validation of framework and co-definition of site-specific conservation objectives".

Here, a comparative application of the operational framework in the scope of the work of two Demonstration Sites is presented, which contributes to the upcoming project's Milestone 5 (Initial application Blue Connect Integrated Framework to Demo sites to derive preliminary conservation objectives). These examples aim to illustrate how the framework could be applied in the different contexts of the Demonstration Sites.

Here two similar exercises are done: a comparation between the current work in the Macaronesia Demonstration Site and the proposed framework; and a comparation between the previous process of defining conservation goals, targets and measures in the Vlaamse Banken Special Area of Conservation (SAC) and the proposed framework, using a traffic light system to indicate where the process matches the proposed operational framework (**green**: yes; **orange**: partly; **red**: no).

4.1 Macaronesia Demonstration Site

The Macaronesia Demonstration Site spreads across four North Atlantic archipelagos, including the Azores, Madeira, Canary Islands, and Cape Verde. All of these are part of the Temperate Northern Atlantic Marine Ecoregion, except for Cape Verde, which belongs to the Tropical Atlantic Ecoregion.

The LSWG of Macaronesia, together with the DS team, has ongoing work that aligns with the scoping phase of the framework (Figure 2).

Stage 1 – Identification and prioritisation of ecological subjects

From the LSWG, a core team of experts with members from the four archipelagos worked on creating a list of ecological subjects, relevant for the area, through their shared knowledge and expertise. To complement this, the DS team extracted the species data for Macaronesia, available in the platform OBIS from where three gigabytes of species data were downloaded (**OS1.1**). The ecological subjects listed by the experts' group were overlapped with obtained OBIS data as a first step to start thinking about the criteria that will support the prioritisation (**OS1.2**). From the OBIS data, a quick overlap analysis was conducted that showed that 137 of the marine species registered are present in all four archipelagos. From these species, the sperm whale (*Physeter macrocephalus*) was indicated as potential key species for the region as it is found in all four archipelagos and has a high number of occurrences (i.e., registered observation). The sperm whale was also highlighted in the experts' species list as vulnerable and present in all four archipelagos. So far, prioritisation process has not started (**OS1.3**).

Stage 2 - Describing conservation status, trends and events of change

Regarding the description of trends and events of change, the Demonstration Site team identified marine temperature as a relevant event of change for their area. They worked on gathering Sea Surface Temperature (SST) for the Macaronesia region from Copernicus Marine Service (**OS2.1**). With weekly data ranging from 1982 to 2021 they were able to do a trend analysis of the sea surface temperature throughout the years in the region (Figure 4). Preliminary results show that all archipelagos are facing heatwaves and that these events are becoming more frequent with time (**OS2.2**).

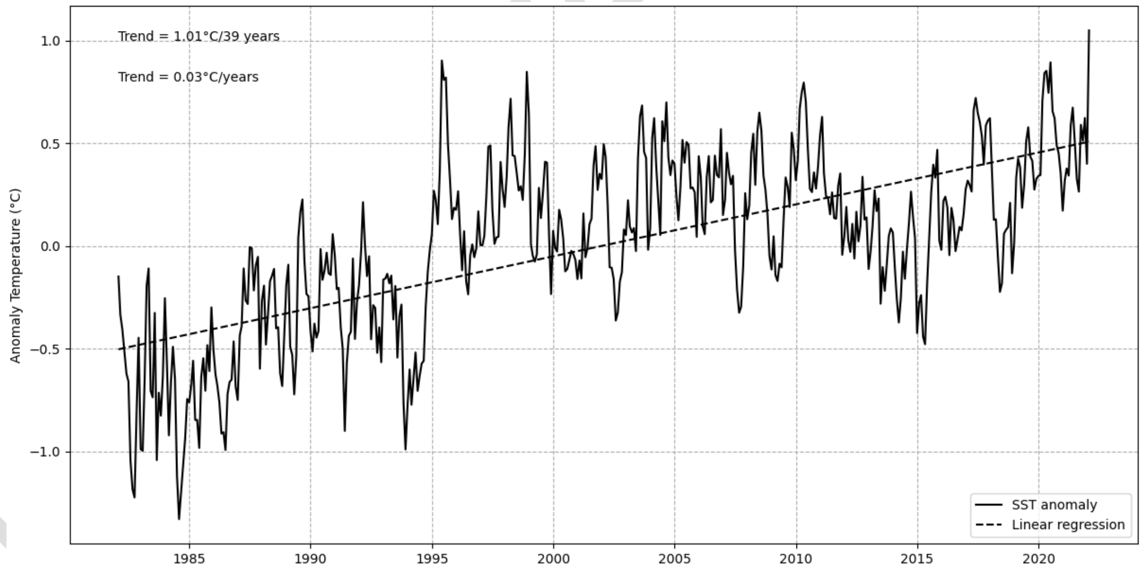

Figure 4 - Trend analysis of SST temperatures in Macaronesia between 1982-2021

These steps will contribute to a better understanding of the system in Stage 3 and assist with the reprioritisation of the list of ecological subjects.

Overall, the scoping phase of the framework is aligning well with the needs of the working being developed in the Macaronesia Demonstration Site.

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4.2 Vlaamse Banken Demonstration Site

The Vlaamse Banken SAC is a 1099.39 km2 size Habitats Directive area and is located in the southwestern part of the Belgian North Sea that includes part of the territorial waters as well as a part of the Belgium EEZ. In addition to 11 species including birds and cetaceans, the Vlaamse Banken SAC is designated for the protection of the "sandbanks permanently covered with seawater" (Habitat type code 1110) and the "Reefs" (Habitat type code 1170).

The Vlaamse Banken SAC represents the culmination of the Belgian MPA designation process which started in 1999 and resulted in the designation of three Special Protection Areas (SPAs) in 2005 in front of the three marine harbours, and the extension of the SAC 'Trapegeer-Stroombank' (designated in 2005) to an area >30% of the Belgian Part of the North Sea surface in 2012 (now renamed to SAC 'Vlaamse Banken') (Pecceu et al., 2016). In 2020 the SAC Vlake van de Raan was designated in the new Marine Spatial Plan (available here).

Implementation Phase 1: Scoping

Stage 1 - Identifying and prioritising ecological subjects

A scoping exercise for potential MPAs was conducted in 2009 focusing on the habitat types listed in Annex I of the Habitats Directive as well as on the species listed in Annex II that are found (or were previously found) in the Belgian Part of the North Sea (Degraer et al., 2009). The criteria for determining "who" should be protected were derived from the EU legislation and (historical) occurrence. This resulted in a comprehensive listing and identification of ecological subjects of interest (as in **OS1.1**). The definition and selection of ecologically relevant criteria for prioritisation included both functional (such as vulnerability or stability) and structural criteria (such as species composition, rarity or distributional range) (as in **OS1.2**). The prioritisation was conducted in a transparent and reproducible way, following the guidance of the Habitats Directive, by an expert group consisting only of scientists and was perceived as top-down by local stakeholders (**OS1.3**).

Stage 2 - Describing conservation status, trends and events of change

As part of the aforementioned scoping exercise historical trends and events were discussed based on the available data (**OS2.1**) and spatial and temporal changes described (**OS2.2**). This exercise initially took place in 2009, so a periodic update is overdue.

Stage 3 - Understanding the system

No systematic description of the current ecological understanding of the system was included as part of the designation process although it was likely influenced by underlying insights into system functioning (**OS3.1**). As part of the preparation for defining conservation objectives and measures a partial assessment of pressures was conducted (Belgische Staat, 2012c) (**OS3.2**). No reassessment of the prioritisation was conducted (**OS3.3**).

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Implementation Phase 2: Definitions

Stage 4 – Defining goals

Conservation goals were defined as part of the management plan for all Natura 2000 MPAs in Belgium, including the Vlaamse Banken SAC (Belgische Staat 2016a). For the most part, these goals aimed at maintaining or moderately improving existing levels of biodiversity within the context of existing pressures. No significant effort was made to consider the ideal state that might be achievable for each of the listed ecological subjects (**OS4.1**). It should be noted that the updated conservation goals (Belgische Staat. 2022) improve on this illustrating the benefit of periodic reassessment of conservation goals and targets (**OS4.2**).

Stage 5 – Defining Targets

The selection of metrics and science-based tools for the setting of targets is still a work in progress with room for improvement. A lot of weight is given to expert judgement but, for example, not enough attention is provided to climate change impacts or connectivity in the area (**OS5.1**). Regarding implementation of tools and translation to relevant decision-making, this is not yet entirely optimised (**OS5.2**). While targets contain some SMART (Specific, Measurable, Achievable, Realistic and Timebound) elements, vague wording means the vast majority of conservation targets do not meet all criteria (**OS5.3**).

Stage 6 - Understanding what is hindering

A pressure analysis is done as part of the periodic revision of the Belgium Maritime Spatial Plan, but not at the level of detail of the MPA itself, except for bottom fishing gears (**OS6.1**), which led to ongoing discussions on the creation of fisheries restriction areas inside the MPA. Consideration of other barriers and co-management processes is not happening yet (**OS6.2**).

Stage 7 - Defining Measures

Currently, measures are defined (Belgische Staat, 2022), though their enforcement and assessment of their effectiveness needs to be improved (**S7**). The negotiation of the implementation of bottom fisheries restriction areas is ongoing, with the MPA practitioners currently in the process of getting a EU Delegated Act.

The operational framework aligns well with existing practice in Belgium but requires significantly more effort to apply in a consistent way. Benefits: improved understanding (system and outcomes) and – hopefully – better sense of ownership and support (currently lacking) and improved estimate of outcomes/effectiveness.

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5. From concept to transferable practice

The initial operational draft of the Blue Connect Integrated Framework presented in this document is divided into two phases: the scoping phase and the definitions phase. The former involves developing a narrative description of the conservation features and their context within the marine areas of interest to define conservation goals. This implies investigating ecological functions and interactions, human pressures, and temporal and spatial dynamics within the system. The latter focuses on a quantitative analysis to set goals and targets based on information gathered during the scoping phase. Challenges of different nature can arise during these processes.

Successful conservation planning depends on the definition of specific goals, translatable into quantifiable and operational milestones (Magris et al., 2014). Percentage-based conservation targets have often been questioned (Wood, 2011). An example is Target 3 proposed by the Convention on Biological Diversity in the Kunming-Montreal GBF:

"Target 3. Ensure and enable that by 2030 at least 30 per cent of terrestrial, inland water, and of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem functions and services, are effectively conserved and managed through ecologically representative, well-connected and equitably governed systems of protected areas (...)." (CBD, 2022).

This target, although valuable in supporting the global movement towards ocean conservation, has been criticised for having vague wording (Dudley et al., 2022). Even previously to this GBF, conservation goals and targets have often lacked clearly defined terminology (Jentoft et al., 2011; Wood, 2011). Common language used in conservation management, such as 'effective', 'ineffective', 'relevant', 'equitable', and 'inequitable', is highly subjective, context-dependent, and poorly defined (Dudley et al., 2022).

MPA goals are often defined *a priori*, ignoring relevant specific features of the ecological and socio-economic contexts of the area (Jentoft et al., 2011). On the contrary, recommendations should be underpinned with ecologically pertinent statements (Magris et al., 2014) to support the creation of appropriate design, management, and operational guidelines applicable to different contexts, which may remain underdeveloped if not well-backed (Allan et al., 2021; Ceccarelli et al., 2021; Fredston-Hermann et al., 2018; Magris et al., 2014).

Well-tailored goals can serve as guidelines for choice and decision-making. The establishment of generic and pre-defined goals can cause a mismatch between the declared goals and those that are operationalised (Jentoft et al., 2011). Vague language use and lack of ecological underpinning are bound to affect the definitions phase of this operational framework, as there is growing interest in aligning marine conservation goals and targets with the SMART framework (Table 4) (ICES, 2005; Wood, 2011).

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Conservation planning is dependent on the establishment of specific goals and targets (Magris et al., 2014). It has traditionally focused on the representation of multiple habitat types within an MPA. However, vulnerability to climate change or other pressures is often overlooked in this process. Prioritising conservation action based on vulnerability and irreplaceability requires historical data or experiential knowledge of the special occurrence of threatened taxa and habitats, which are not always readily available or exhaustive. Furthermore, the intrinsic characteristics of marine habitats can be challenging in this context as they are often not homogeneous and have unclearly defined boundaries. Thus, it is not always easy to identify what needs protection and which is the best course of action to take (Edgar et al., 2008).

Beyond that, prioritising conservation decisions that not only address the representation of the protected features but also their persistence and data availability can lead to bias in ecological subject prioritisation (Yamakita et al., 2017). Planning for persistence entails addressing both connectivity and stochastic events caused by climate change that could render conservation measures suddenly ineffective. There is often a lack of using experiential data on which to base and ecologically justify guidelines to integrate connectivity and climate change effects in marine conservation planning (Ban et al., 2010; Edgar et al., 2008; Magris et al., 2014). Other tools that support prioritisation, such as the methodology for setting Key Biodiversity Areas (KBA) (Dudley et al., 2022), can be useful but need to be further tailored to the marine environment, as they have mainly been applied in a terrestrial context. Moreover, prioritisation of ecological subjects and processes face challenges related to subjectivity and the absence of a standardized, globally consistent methodology. In general, prioritisation outcomes are heavily influenced by the quality and availability of data.

Understanding ecosystem functioning can also be challenging as an ecosystem cannot easily be reduced to its subsystems or simple relationships. System understanding and subsequent accuracy of science-based tools simulating ecosystem functioning processes is heavily reliant on available information and can therefore be extremely variable depending on the study site. However, used methodologies cannot always integrate physicochemical and biological elements in a comprehensive evaluation of the marine environment. Consequently, this may affect human pressure analysis as detailed information of ecosystem's resilience to stressor is rarely available. Stressors are not singular units, in fact, they can interact with each other (Ban et al., 2010). Quantifying the cumulative impact of human activities is fundamental for ecosystem-based management. However, the lack of historical data and data capturing spatial-temporal dynamics such as shifting habitat types and the effects of climate change, means that impact analysis can only offer a snapshot of marine environments at a specific point in time (Ban et al., 2010).

Setting goals and targets based on qualitative criteria can prove to be an added challenge when assessing the effectiveness of conservation measures, as they might not address the uncertainties linked to climate change and ecological connectivity. Planning for feature-specific

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connectivity is challenging as current tools, such as Zonation software, do not include multi-directional connectivity of the marine environment and thus are limited to terrestrial conservation planning (Edgar et al., 2008; Magris et al., 2014). In addition, a recent study by Sequeira et al. (2025) found that migrating marine megafauna—key target species for protection in regions such as Macaronesia and the Scottish MPA Network—spend most of their time within Exclusive Economic Zones (EEZs). These areas present valuable opportunities for targeted conservation measures, but they also significantly overlap with zones of intense human activity, highlighting a critical intersection between ecological importance and anthropogenic threat.

In summary, the process of setting ecological conservation goals and targets in marine environments is inherently complex and requires a structured, context-specific approach. Decisions are shaped by perceived needs and trade-offs, factors that are, once again, largely dependent on the information available (Edgar et al., 2008). The proposed two-phase operational framework highlights the need for a strong ecological foundation, clear and measurable goals and targets.

Several persistent challenges complicate the process, including ambiguous terminology, limited data availability, and the challenge of accounting for complex factors such as connectivity, climate change, and human impacts. Effective conservation planning and implementation needs to go beyond generic targets and integrate ecological relevance, system-specific vulnerabilities, and operational feasibility. Only through a rigorous, adaptive, and ecologically informed approach can conservation goals and targets lead to meaningful and lasting outcomes for marine ecosystems.

6. Conclusion

In summary, the development of this operational framework marks an important milestone in the mission of the Blue Connect Project in enabling MPA practitioners to define context-sensitive, ecologically grounded conservation and restoration goals and targets. By structuring the process into a scoping and a definitions phase, the framework addresses the urgent need for actionable methodologies that account for ecosystem functioning, spatial dynamics, and the realities of overlapping human uses and pressures.

As marine conservation is in a fast-paced phase of strategic expansion under global and European biodiversity commitments, translating high-level targets like the 30×30 goal into effective, on-the-ground action requires frameworks that integrate ecological complexity with local relevance and provide concrete guidance on how to do it. The Blue Connect Framework aims to respond directly to this need, bridging the gap between strategic political ambition and practical implementation. The adoption of the European Ocean Pact, in 2025, which aims to integrate EU relevant ocean policies under one single strategy (European Commission, 2025)

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brings forward key areas of action that are particularly relevant for Blue Connect as it aims to support the protection and restoration of ocean health.

Following international and the EU conservation guidelines and standards, the integrated framework that the Blue Connect project proposes aims to address these gaps by providing a structured approach to setting MPA conservation and restoration goals and targets, grounded in ecosystem functioning. However, the development of this framework also faces a range of challenges when being developed. These include synthesizing highly variable and fragmented ecological information, balancing scientific robustness with practical applicability for Demonstration Sites to assist and collaborate with MPA practitioners and LSWGs, and ensuring that enough flexibility to accommodate diverse ecological and local contexts as well as different stages of definition of goals and targets. Additionally, integrating restoration into the framework requires bridging knowledge gaps, as restoration planning in Europe has often been reactive and uncoordinated. By acknowledging and working through these methodological challenges, the framework sets the foundation for a more coherent and effective approach to marine conservation planning, one that supports both local action and broader policy alignment.

Although, it is recognisable that this operational framework might require a level of time commitment that is not always achievable due to the high amount of work MPA practitioners are often faced with, it is designed to allow for flexibility in addressing the stages that are most applicable to the area in question. MPA practitioners should look at this work as an overarching ecological approach that can and should be adapted to the reality they might have at hands. For example, if a robust baseline ecological data already exists and ecological subjects are well identified users may move directly into prioritisation (OS1.3) or system understanding (Stage 3) without repeating the OS1.1 or stage 2 altogether. Similarly, in partially protected areas where ecological subjects and management goals are already predefined, practitioners may focus, for example, on pressure analysis (stage 6) and the design of measures (stage 7). The framework is also iterative: new insights gained at some stages (e.g., DPSIR analysis in stage 3 or barrier identification in stage 6) may prompt a return to earlier stages to refine ecological subject prioritisation or a jump to later stages to adjust targets or measures. In this way, both the sequence and the set of stages and operational steps can be tailored to local needs and capacities, while still following the same overarching logic.

Looking ahead, continued collaboration, knowledge exchange, and adaptive refinement of the framework will be essential to support countries and communities in designing MPAs that are both effective and resilient, ultimately contributing to the long-term health and connectivity of marine ecosystems across Europe and beyond. Practical insights from Blue Connect Demonstration Sites will ensure that this approach is not only scientifically sound but also adaptable to diverse local and regional settings. Practical insights will support context-specific knowledge on how each stage of the operational framework can be best adapted to the varied characteristics of the Demonstration Sites, reflecting differences including management focus, scale, or jurisdictional context. These insights are valuable in further informing the identification of context-relevant methodological components across the different stages (e.g., relevant categories of criteria for use in the scoping stage, science-based tool selection and subsequent target translation) that are most suitable for the ecological, spatial, and management realities of each site, generating transferable insights to support the identification of approaches best suited to different MPA typologies. This operational framework will be further refined and adapted as the project progresses.

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8. Annexes

Annex 1 - Data screening and extraction protocol

First step

1. Upload your RIS file to Zotero that you can find here: Zotero files for screening. Go to File -> import -> A file (BibTex, RIS, Zotero RDF, etc)
    a. Each file name has the number of articles that is in there and, ordering by alphabetic order the Author's name on Zotero, the first and last author on your group of articles.
2. After opening the file on Zotero, order them by Author's alphabetical order.
3. Apply the **exclusion criteria (**one criteria excludes) to the Title and Abstract of the articles listed in your file.
    a. Not focused on Area-based conservation management (e.g. MPAs,MPA networks, marine parks, marine reserves, OECMS...)
    b. Study not conducted in coastal (land-sea interaction) or marine setting
    c. Study refers to a single application of existing methods, not focusing on describing the development of an ecological focused methodology.
    d. The publication does not describe science-based frameworks, methodologies, tools, metrics, indicators, models, criteria that support ecological definition of conservation or restoration goals or/and targets.
    e. Articles not available in English
    f. Not published between 2008 – present.
4. In your Zotero tag the articles you want to include (or are unsure) in green and the articles you will exclude in red. You can also tag them for Approach and Tag if that makes it easier for when transferring the information to the excel table (see 5)
5. After that, make a copy of the file T2.1_screening_table_4948articles.xlsx, with your name, so you can fill the information
    a. Add your name to the column "Reviewer_title_abs",
    b. Select "include" (if you want to include or are unsure" or exclude (if you want to exclude) on column "title_abstract"
    c. Select the "exclusion criteria" you used to exclude from the dropdown list.
    d. If clear, select an "approach" from the column, you can use the dropdown list, or write a new one.
    e. Add a Tag on the "Tag" column from the dropdown list, you can add other tags or leave it blank if not sure.
6. Be aware that, there might be slight differences between the alphabetic author order in Zotero and the one on the excel sheet, so when you add the information on the excel sheet, make sure that you are on the right row.
7. When you are done, copy your information to the copy the information to the T2.1_screening_table_4948articles.xlsx,

Second Step (after all articles are checked and title and abstract level)

reviews; 3) Overall, read papers that provide recommendations on how to set conservation/restoration goals and targets.

1. Add your name to the "Reviewer_fulltext" - T2.1_screening_table_4948articles.xlsx,
   a. Try to go over articles which **you did not review** at Title+Abstract level.
   b. Make sure you only address articles that are listed as "Included" in column "Title_abstract"
   c. Download an offline copy of the excel and use that work on, copying the information once you are done to the main online excel, so we are not all altering it at the same time.
2. Download and add the article to the folder PDFs_screening_text_level, with the name of the file: ID+Author(s)+Year (e.g. 1_Hansel_etal_2004; 2_Hansel_and_Jones_2008; 3_Hansel_2007)
3. Check exclusion criteria in full text.
4. Decide and fill the "decision_fulltext" column accordingly, selecting Accept, Reject or Unsure from the dropdown list.
   a. Please add to the justification column information on your decision if you feel it is useful.
5. If clear, fill the next columns:
   a. select an "approach" from the column, you can use the dropdown list, or write a new one.
   b. Add a Tag on the "Tag" column from the dropdown list, you can add other tags or leave it blank if not sure. If multiple tags please use ";" to separate them
   c. Select a "Publication type" if clear.
6. After all articles have been checked
   a. Check the "Unsure" articles (that you have not yourself reviewed before) and try to make a decision.
   b. Please have a go at downloading the articles for which the collum "PDF downloaded" says No
7. After all articles are checked at text level, if exclusion criteria don't apply at title and abstract level all included articles should:
   a. Be given an ID number (column I ID_Publication)
   b. Be copied to the folder PDFs, with the updated name of the file: ID+Author(s)+Year (e.g. 1_Hansel_etal_2004; 2_Hansel_and_Jones_2008; 3_Hansel_2007)

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Third Step - extraction

1. All full texts that don't fulfil any of the exclusion criteria should be extracted to the extraction table. If there are still papers that have not been screened, it is good to the screening and extraction at the same time.
2. Ideally one should start with grey literature and then with the literature reviews and systematic reviews and meta-analyses
   a. Grey literature
      i. Add your name to the "Extraction T2.1" column - Grey_literature_deliverables_screening_WP2_WP3.xlsx
      ii. Download the document and add it to PDFs
   b. Systematic literature
      i. Add your name to the "Reviewer name full extraction" - T2.1_screening_table_4948articles.xlsx, Try to go over documents which **you did not screen** when possible.
      ii. The document should be in PDFs_screening_text_level. If it is not, please add it there following Point 2 of the Second Step
3. Then move on to the extraction table. There the information should be filled following the description of the columns.
   a. The first set of columns (grey) are to indicate overall information about the reviewer and publication.
   b. The second set of columns (green) helps set the scene, describe the context and nature of the MPA around which the document revolves.
   c. The third set of columns (orange) are aimed at collecting the information about the knowledge used to define conservation and/or restoration goals and targets of Marine Protected Areas. The knowledge identified in this section should contribute to the outline of the main components of the framework.
   d. The fourth set of columns (blue) encompasses a few other details regarding transferability, benefits and challenges identified in the paper and as space for other comments.
4. After starting the extraction, if on column "Contribution to Framework" if you select "No direct framework contribution, does not provide relevant insights for framework development - stop the extraction" you should stop the extraction and move on to the next document.

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Annex 2 - Functional macro-criteria adapted from MSP4BIO *Ecological Toolkit*

Functional criteria relate to processes and/or traits, at any level of biological organisation, that are relevant and can help infer how an ecological component responds to environmental changes and contributes to ecosystem functioning (e.g., life traits, biological traits, or trophic interactions) (Bongiorni et al., 2023; Diaz & Cabido, 2001; Kotta et al., 2024). Further details on these criteria, adapted from the MSP4BIO Ecological Toolkit, can be found in the following table:

Functional Macro-Criteria	Description
Vulnerability	Assessed through biological traits and species distribution. Biological traits include morphological, physiological, behavioural, and ecological characteristics that influence an organism's performance, survival, reproduction, and role in ecosystem functioning. These traits determine a species' vulnerability to human pressures and climate change.
Stability	Ability to fill diverse niches, assimilate energy (productivity), transfer it within and across ecosystems, and enhance and stabilize ecosystem processes (functioning). Redundancy (e.g., the same function provided by several species with different levels of vulnerability), ecosystem integrity and adaptivity (e.g., the higher the level of functional diversity, the higher the probability of a system to adapt to new conditions) and connectivity are essential to maintain stability.
Functional hot-spots	Habitats/Species that are important for the provision of a discrete ecological function (e.g., carbon storage, photosynthetic production) or areas where key ecological functions are concentrated (e.g., productivity). Presence of key functional species (e.g., apex predators, primary producers, functionally rare species), key functional areas (e.g., carbon sink and source areas) and food web structure (complexity, length, interactions) are key to define these hot-spots.
Climate-smart potential	Habitats and species that offer significant climate benefits, such as contributing to climate mitigation protection and restoration, enhancing ecosystem and community resilience, and facilitating adaptation to climate change. The assessment of climate-smart potential is based on evaluating biodiversity vulnerability to current and future climate change impacts, alongside the analysis of climate velocities.
Life-cycle critical areas	Areas important for the completion of the life cycle of organisms (nursery, feeding, spawning, breeding) and the ecological corridors - links between these areas.

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Annex 33 – Schematic representation of the operational framework at the foundation of the Blue Connect Framework

BLUE CONNECT FRAMEWORK

S1

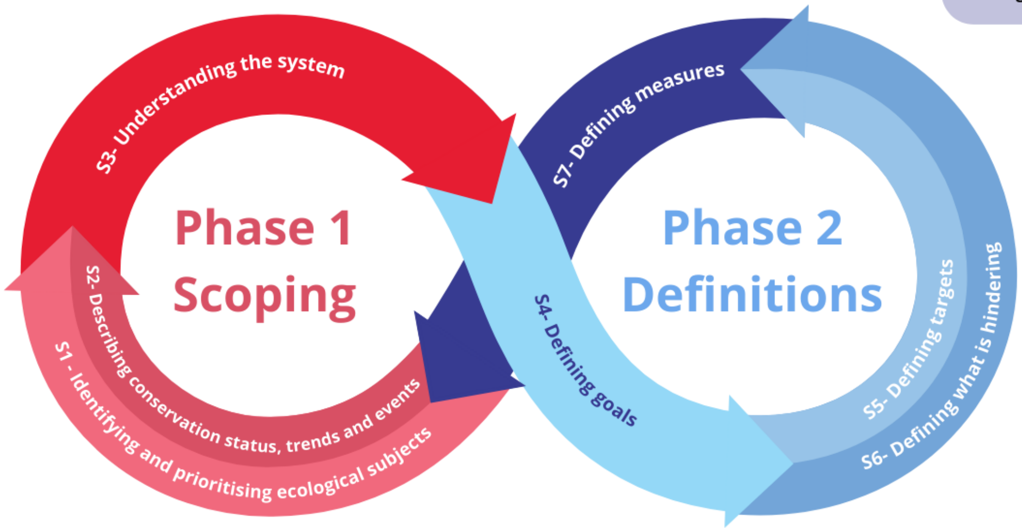
Stage 1 - Identifying and prioritising ecological subjects

- OS1.1 – Identification of ecological subjects
- OS1.2 – Selection and prioritisation of criteria
- OS1.3 - Prioritisation of ecological subjects based on selected criteria

S2

Stage 2 – Describing conservation status, trends and events of change

- OS2.1 – Identification of key ecological events that affect the ecological subjects
- OS2.2 – Outline of spatial or temporal changes



S7

Stage 7 – Defining measures

S6

Stage 6 – Understanding what is hindering

- OS6.1 – Pressure Analysis
- OS6.2 – Consider other barriers

S5

Stage 5 – Defining targets

- OS5.1 – Selection of target types
- OS5.2 – Selection of indicators and tools
- OS5.3 – Implementation, validation and translation to targets
- OS5.4 – Making targets SMART

S3

Stage 3 - Understanding the system

- OS3.1 – Description of the current ecological understanding of the system
- OS3.2 – Assessment of the causes of previously identified trends or events of change
- OS3.3 – Reassessment of ecological subjects prioritisation

S4

Stage 4 – Defining goals

- OS4.1 – Draft of the goals
- OS4.2 – Rethink and adapt

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