Organisation [CNR (Blue-Cloud 2026)]
Project Charter

Blue-Cloud: Marine Thematic Node

v 2.0

Revision	Reason for and description of change	Editors	Date
1.0	First version	Pasquale Pagano, Sara Pittonet Gaiarin, Dick Schaap	6 March 2025
2.0	Added the Section Marine Node Architecture; minor revisions in other sections	Pasquale Pagano	4 April 2025

1. Project Summary

Blue-Cloud addresses critical gaps within the EOSC ecosystem by providing specialised marine data services, analytical capabilities, and a collaborative environment tailored to ocean research.

Managed via the D4Science e-infrastructure operated by CNR and in collaboration with key research centres driving blue, climate and environmental research, Blue-Cloud contributes to the EOSC ecosystem through:

- **Incubator for New Analytical Workflows**: Blue-Cloud acts as an incubator for new analytical workflows and for generating new marine data products based on quality-controlled FAIR practices. These workflows address Essential Ocean Variables (EOVs) and support the EU Green Deal and UN Agenda 2030. Following the incubator phase that the Blue-Cloud node facilitates, new data products and analytical workflows of proven quality will be included in the offer of the EDITO DTO platform and publishing services.
- **Open Science Interoperability**: Developing a collaborative web-based environment that enables open access to marine data resources and interoperable tools. This involves adopting vocabularies and expressing URIs in outputs to support semantic interoperability.
- **Specialised Computing Capabilities via a Sustainable Technical Infrastructure**: To support innovative marine research, Blue-Cloud provides a Virtual Research Environment (VRE) with Virtual Labs (VLabs), enabling researchers to design, test, and evaluate complex computational analytical flows for various marine data applications. This infrastructure, which offers e-infrastructure services such as computing, storage, analytics, and single sign-on AAI, defines the Marine Node architecture and is aligned with the EOSC Federation Handbook, emphasising core, generic, and federating capabilities to ensure interoperability and effective service delivery.
- **High-Value FAIR Data**: Providing access to multidisciplinary marine data from observations and models. This activity includes connection with EMODnet and CMEMS as recognised European aggregators of in-situ and satellite marine data gathered following the FAIR principles, and collaborative efforts to strengthen FAIRness in data, metadata, and machine services of additional "blue" data infrastructures (BDIs) that can be federated under the aggregators as mentioned above or via other international ones. A Data discovery service facilitating discovery and access to data and data products from Blue Data Infrastructures not yet in EMODnet and CMEMS is included. The overall FAIR data offer is about over 10 million datasets and products from European marine infrastructures.
- **Research Services and derived Cross-Discipline Scientific Use Cases**: Blue-Cloud Virtual Laboratories (VLabs) are embedded in a Virtual Research Environment (VRE) to support researchers in designing, testing, and evaluating innovative computational analytical flows. The VLabs' innovative services, in the form of data products and/or analytical tools, demonstrate the added value of web-based open science as promoted by the European Ocean Science Cloud (EOSC). Current fields of application include Marine and Oceanographic Research, Climate Change Research and Biodiversity and Ecosystem Monitoring.
- **Data harmonisation and data lakes**: Blue-Cloud federates diverse "blue" data infrastructures (BDIs), enhancing the FAIRness of marine data and metadata. Blue-Cloud establishes data subsetting capabilities and deploys data lakes at the Blue-Cloud VRE for data repositories and collections managing and providing access to aggregated and harmonised datasets for Essential Ocean Variables (EOVs) through analytical pipelines or "workbenches".
- **Single Sign-On AAI Integration**: Single Sign-On procedure to align user registration across the Blue-Cloud website, open science platform, and BDIs service. Single Sign-On will also be extended to the EDITO operational services.
- **Supporting Training Programs**: the Blue-Cloud Training Academy guides data providers and ocean observers in utilising marine research infrastructures and data repositories, emphasising FAIR principles for data submissions.
- **Development of an advanced Interoperability Framework:** Blue-Cloud contributes to the development of standards and best practices for data exchange and interoperability, supporting the integration of marine data into the broader EOSC framework. This includes promoting the use of common metadata models and controlled vocabularies

The thematic scope focuses on oceans, EU seas, and coastal and inland waters, while the geographic scope is European, with the possibility to scale up to international data and service repositories (i.e. IODE, ODIS).

2. Value Proposition

- **Main Goal**

Blue-Cloud aims to function as a ***pilot marine thematic node within the European Open Science Cloud (EOSC)***, with the primary goal of serving as an **incubator for quality marine science in support of the European Digital Twin of the Ocean programme** and implementing facilities (namely the EDITO platform). This initiative supports the EOSC federation's mission by enabling open science, fostering collaboration, and ensuring seamless access to FAIR data and services across marine disciplines and borders. This pilot project will allow for assessing with real science cases those specifications and requirements to support the marine and maritime community in the long run through federated open science protocols, services, models and applications.

Blue-Cloud envisions that the EOSC marine node will be the third component of the EDITO operational services EDITO infra and EDITO ModelLab, feeding the EU DTO programme with innovative open science high-quality protocols, services, data products, models and applications generated via collaborative co-creation approaches and FAIR practices, at disposal for further uptake and exploitation by the broader community of implementers of digital twins and benefitting of further sustainability there. After the ramp-up phase, the integration between D4Science and the EDITO catalogue will facilitate mutual access to European researchers to both infrastructures, with seamless access to the open-science services of EOSC and DTO applications available in EDITO, creating a mutually beneficial ecosystem.

- **Key Benefits:**

Blue-Cloud offers **unique capabilities** that differentiate it from other organisations:

- **Specialised scalable Infrastructure:** Powered by the D4Science e-infrastructure, it provides a reliable and scalable foundation for VRE services. With a substantial amount of data currently exchanged, including peaks reaching 10 TB in a single month, the Blue-Cloud platform has the capacity for handling large datasets, a capacity that can be included in the federation offers. Furthermore, the high number of working sessions, averaging 4,500 per month and peaking at over 8,700, underscores the community's active engagement. The revamped VRE underscores Blue-Cloud's commitment to long-term sustainability and EOSC interoperability. Achieving **economies of scale in storage, resources, tech support, and AAI federation** ensures efficiency. The VRE's high availability (99.869% uptime) and TRL 8 status solidify its reliability.
- **Expertise in Marine Data Management**: Blue-Cloud brings together leading European marine research infrastructures and e-infrastructures.
- **Regional Focus:** Blue-Cloud focuses on European seas, coastal, and inland waters, with connections to international data repositories.
- **Engaged Blue-Cloud community**, demonstrating its continuous and significant utilisation of the platform's resources over the past two years. The Blue-Cloud user base comprises 2000+ individuals from a diverse range of stakeholders, including researchers, data managers, data modellers, SMEs, etc.
- **Strong Links to Key European Initiatives:** Blue-Cloud has established links to key European initiatives such as EOSC, EDITO, EMODnet, and Copernicus Marine and Research Infrastructures such as JERICO, ENVRI and more.
- **Strong Partnership**s: Established collaborations with leading e-infrastructures (EGI), cloud providers (Google), and projects (FAIR-EASE, CLIMAREST) demonstrate a proven ability to work effectively within collaborative environments.

Who Benefits

The beneficiaries of Blue-Cloud's contribution to the EOSC Federation include:

- ***Research Institutions and Universities***: Marine researchers, data scientists, and coastal modellers benefit from the platform's capabilities for processing, exploring, and integrating diverse datasets.
- ***Public Sector Bodies***: Environmental managers, policymakers, and national bodies can use the Virtual Labs to build integrated visions of geographical areas of interest and explore different levels of understanding about relevant processes and impacts.
- ***Research User Community***: The broader research community gains access to FAIR marine data, analytical tools, and computing resources, facilitating collaborative research and the adoption of Open Science principles.
- ***Citizens*** and ***Society***: Citizens benefit from increased knowledge and science-based solutions to aquatic challenges.

Blue-Cloud targets a diverse user audience, including researchers, institutions, policymakers, and the private sector. Blue-Cloud enhances its ability to meet user needs within the Federation by

- Providing tailored services, a workspace for data storage and sharing, and VLabs tailored to specific research needs.
- Offering consultancy and support services.
- Establishing the Blue-Cloud Training Academy to guide data providers and ocean observers.
- Engaging users via hackathons and training sessions.

Needs addressed:
Blue-Cloud is responding to the following needs:

- **Open and FAIR data management practice** and EU-wide sharing of research data contributing to restoring healthy oceans, seas, coastal and inland waters
- Need for **infrastructure and analytical resources** in support the interdisciplinary research community involved the Mission Ocean objectives
- **Seamless interactions between EOSC,** operational dataspaces or environments, with reference in particular to the need of a technical interface with the EU DTO platforms

3. Marine Node Architecture

This section details the architecture of the Blue-Cloud Marine Node, outlining its alignment with the EOSC Federation Handbook and its capabilities within the EOSC ecosystem.

3.1. Overview

The Blue-Cloud Marine Node is structured to facilitate the sharing and management of marine data, knowledge, and resources within the EOSC Federation. It serves as an entry point for users to access various services, including data repositories and analytical tools while adhering to EOSC Federation policies. The node is designed to be autonomous in its internal management, provided it complies with the overarching EOSC Federation guidelines.

3.2. Node Core Capabilities

The Blue-Cloud Marine Node implements the following core capabilities, as defined by the EOSC Federation Handbook, to ensure effective operation and service delivery:

- **Resource Catalogue and Registry services:** operates as a centralised repository for scientific products and services, providing users with a powerful tool for resource discovery and integration. Researchers can access the catalogue through the VRE, where they can search for and retrieve detailed descriptions of available resources. The catalogue employs standardised metadata formats and protocols to ensure interoperability and ease of integration with other systems. Users can also publish their methods integrated into CCP, their notebooks developed with JupyterLab, or their R code developed in RStudio, enabling comprehensive and multidisciplinary analyses. This integrated setup streamlines the process of finding, accessing, and sharing scientific resources, making it easier for researchers to conduct their analyses and collaborate with peers within a secure and scalable infrastructure.
- **AAI (Authentication and Authorization Infrastructure):** supports OpenID Connect (OIDC) for authentication and User Managed Authorization (UMA 2) for authorisation flows. It ensures secure access control, allowing administrators to define and enforce access policies per VRE and VLabs based on user roles and permissions. Single sign-on enables user authentication across services.
- **Helpdesk:** provides expert guidance and assistance to users, helping them maximise the potential of the platform's tools and resources. This service is designed to support researchers and organisations in effectively utilising the Marine Node infrastructure capabilities for their specific needs, ensuring that they can achieve their research goals efficiently and effectively.
- **Service Monitoring:** aligns with the IT Service Management standard (FitSM), ensuring that services are delivered consistently and meet agreed-upon quality levels. This involves monitoring service performance, availability, and reliability to identify and address any issues promptly, maintaining a high level of service quality and user satisfaction.
- **Service and Research Product Accounting:** provides a secure and compliant environment for managing accounting data. Users can access the service either through the Marine Node VRE or via a specific

VLab, where they can perform various accounting functions, such as bookkeeping, graphical reporting, and auditing. The platform supports advanced reporting and analytics, allowing users to generate detailed reports and perform in-depth analyses. Robust access controls and encryption measures ensure the security of accounting data. At the same time, GDPR compliance guarantees that all personal data is handled in accordance with the highest standards of data protection. This integrated setup enables managers to manage their VLabs and Community data efficiently and securely, supporting high-quality research within a compliant and reliable infrastructure.

- **Order Management:** operates by allowing users to create and customise their own VLab. Researchers can select the tools and applications they need and configure their VLab to suit their specific requirements. These environments are hosted on the D4Science infrastructure, which provides the necessary computational and storage resources. Users can collaborate within these environments, sharing data and tools seamlessly. The system also integrates with external data sources, enabling comprehensive data analysis. This flexible and scalable approach ensures that researchers have the resources and tools they need to conduct their work efficiently and effectively.
- **Configuration Management System:** Internally manages information on node capabilities, service constraints, dependencies, and service delivery. This is facilitated by the D4Science Service Registry, a shared space for storing information on Node capabilities and service delivery, ensuring consistent service delivery.
- **User Space (Gateway):** provides a centralised platform where researchers can access a wide range of tools (see Node Generic Capabilities) and products specific to the Marine domain (See Node Exchange). Users can log into the gateway and navigate through various open-access services and resources tailored to their needs. The system integrates multiple data sources and computational tools, allowing researchers to perform comprehensive analyses within a single platform. This centralised approach ensures that researchers have easy access to the resources they need, fostering collaboration and enhancing the overall research experience.
- **Application Workflow Management:** Supports the creation and execution of analytical workflows. Blue-Cloud offers Virtual Laboratories (VLabs) within a Virtual Research Environment (VRE) to support researchers in designing, testing, and evaluating innovative computational analytical flows.
- **Resource Provisioning:** Provides the underlying infrastructure for computing, storage, and networking. The Blue-Cloud technical infrastructure offers e-infrastructure services such as computing, storage, analytics and single sign-on AAI.

3.3. Node Generic Capabilities

In addition to the core capabilities, the Blue-Cloud Marine Node offers the following generic capabilities to enhance its functionality and value proposition

- **File Sync & Share (Workspace):** Provides researchers with a secure, centralized location for storing data and resources, simplifying data management and ensuring easy access. Robust security measures protect sensitive data from unauthorized access. To guarantee fault tolerance, low latency, and scalability, data is automatically replicated across multiple storage devices and locations, rather than being stored as a single copy. Moreover, it supports file versioning, history management, accounting, metadata management, and data organization, ensuring that all data is well-documented and easily accessible. A key feature of the Workspace is its automatic connectivity with various tools and applications within the Marine Node infrastructure, such as JupyterLab, RStudio, and the Collaborative Computing Platform (CCP). This enables researchers to seamlessly exploit their stored data within these applications, streamlining data analysis and enhancing the overall research workflow. The service also facilitates collaboration and teamwork by enabling researchers to share data and resources with colleagues, Virtual Lab (VLab) members, or the wider community, supporting joint projects and effective collaboration regardless of geographical location.
- **RStudio**: Provides a comprehensive and integrated development environment for data analysis and statistical computing using the R programming language. It offers tools for coding, debugging, visualisation, and report generation, facilitating reproducible research and enabling users to perform complex statistical analyses and develop custom data processing workflows.
- **JupyterHub**: Offers a multi-user environment for interactive computing, enabling users to work with notebooks, code, and data in a collaborative and flexible manner. It supports various programming languages (including Python, R, and Julia) and is valuable for data exploration, analysis, visualisation, and creating shareable documents that combine code, text, and multimedia.

- **Galaxy**: A web-based platform for accessible, reproducible, and transparent data analyses, empowering users to perform complex computational analyses across various scientific domains. It provides a user-friendly interface for running tools and workflows, managing data, and tracking analysis history, making it suitable for both novice and expert users.
- **CCP Services**: Collaborative Computing Platform (CCP) services delivered by D4Science provide a suite of tools and functionalities to support collaborative research activities. These services include data manipulation, analysis, and sharing capabilities, fostering efficient teamwork and knowledge exchange by providing shared workspaces, communication tools, and data management features.
- **Spatial Data Infrastructure (SDI) Facilities**:
    - ***GeoNetwork*** for the management of spatially referenced resources. It provides powerful metadata editing and search functions as well as an interactive web map viewer and support for OGC standards.
    - ***GeoPortal*** for for managing and accessing geospatial data. It supports the publication, access, and management of GIS projects, enabling users to visualise and analyse spatial data within a collaborative environment. The GeoPortal leverages D4Science's extensive shared storage and computational resources to enhance geospatial research and applications.
    - ***GeoServer*** for sharing geospatial data. It allows users to publish, edit, and share spatial data using open standards, making it an essential tool for geospatial data management and dissemination.
    - **THREDDS Data Server (TDS)** is used to provide metadata and data access for scientific datasets. It supports various remote data access protocols, including OPeNDAP, OGC WMS, and HTTP, making it a versatile tool for researchers and educators to access real-time and archived environmental data.
- **Data Management Facilities**:
    - ***NoSQL Database Management System***s to handle large volumes of unstructured and semi-structured data. Unlike traditional relational databases, NoSQL databases use flexible data models that can adapt to changes in data structures and scale horizontally.
    - ***Relational Database Management Systems*** to manage and organise data in a structured manner using tables. It allows users to create, modify, and query databases efficiently, ensuring data integrity and security.

3.4. Node Exchange Capabilities

In alignment with the EOSC Federation Handbook, the Blue-Cloud Marine Node makes a defined set of its resources—the Node Exchange—available to the wider EOSC Federation. These resources are discoverable and accessible to EOSC Users according to defined access policies and comply with EOSC Federation Policies.

The Blue-Cloud Node Exchange includes:

- ***Generic Capabilities for Federation Use:*** Blue-Cloud offers the capability for EOSC user communities to request customized Virtual Lab (VLab) instances hosted on its infrastructure. These instances can be provisioned with a selection of the Node's Generic Capabilities (e.g., RStudio, JupyterHub, Galaxy, CCP services), enabling external communities to utilize Blue-Cloud's tools and environment for their research. Access is managed via the Node's Order Management core capability.
- ***Community-Specific Capabilities***: The following thematic Virtual Labs (VLabs), representing Research Services and Software tailored to specific marine domains, are offered as part of the Node Exchange:
    - ***VLab1: Integration of Coastal Ocean Observations Along Europe (ICOOE)***: This VLab focuses on integrating and analyzing coastal ocean observation data from various European sources. It provides tools and workflows for data harmonization, visualization, and analysis to support research on coastal dynamics, environmental conditions, and the impact of human activities.
    - ***VLab2: Coastal Currents from Observation***: This VLab provides tools and services to derive and analyze coastal currents from observational data. It supports research on coastal circulation patterns, sediment transport, and the dispersal of pollutants, contributing to a better understanding of coastal processes.
    - ***VLab3: Carbon Plankton Dynamics***: This VLab offers a platform for modeling and analyzing carbon dynamics in relation to plankton activity. It supports research on marine biogeochemical cycles, primary productivity, and the role of plankton in the ocean's carbon sink.
    - ***VLab4: Marine Environmental Indicators***: This VLab provides tools and workflows for calculating and assessing marine environmental indicators. It supports research on the status

of marine ecosystems, the impact of stressors, and the effectiveness of conservation and management efforts.
    - ***VLab5: Global Fisheries Atlas***: This VLab offers a comprehensive platform for accessing, visualizing, and analyzing global fisheries data. It supports research on fisheries management, sustainability, and the impact of fishing on marine ecosystems.
- **Other resources** like specific FAIR Data Sources accessible via the DD&AS to complement the EDITO and EMODnet resources, harmonized EOV datasets, and Training Resources from the Academy.

3.5. Interaction with EOSC Federating Capabilities

The Blue-Cloud Marine Node ensures its professional operation through a Service Management System aligned with FitSM standards and adheres to EOSC cybersecurity policies and best practices. The Node actively participates in the EOSC Federation by integrating with and contributing to the EOSC Federating Capabilities (as defined in Handbook Section 4.3), including:

- ***Metadata and Cataloguing (Federation Resource Catalogue)***: The Blue-Cloud Marine Node commits to making its Node Exchange resources (see Section 4.4) discoverable across the EOSC Federation. This is achieved by:
    - Providing comprehensive metadata for its services and data using standardized EOSC Profile schemas.
    - Mandatory Compliance: Publishing and maintaining the metadata descriptions of its Node Exchange resources in the EOSC Federation Catalogue (Resource Hub - Tier 3 integration).
    - Supporting faceted search and filtering to aid discovery.
- ***AAI (Authentication and Authorization Infrastructure)***: The Blue-Cloud Marine Node integrates with the EOSC AAI Federation to provide secure and seamless access for EOSC users. This involves:
    - Mandatory Compliance: Operating an AAI infrastructure compliant with the AARC Blueprint Architecture.
    - Mandatory Compliance: Enabling user login via federated credentials by participating in eduGAIN as a Service Provider.
    - Implementing role-based access control for its resources.
- ***Interoperability (EOSC Interoperability Framework)***: The Node adheres to the EOSC Interoperability Framework (EOSC IF) to ensure seamless integration. This includes:
    - Using common data formats and metadata standards recommended by EOSC and the marine domain.
    - Employing standard protocols (e.g., OAI-PMH for metadata harvesting, OGC standards for geospatial data) for service access and data exchange.
    - Supporting semantic interoperability through controlled vocabularies and ontologies relevant to the marine domain.
- ***Data Access and Use***: The Node promotes and implements FAIR data principles for its resources. This includes:
    - Striving to make data Findable, Accessible, Interoperable, and Reusable (FAIR).
    - Providing clear information on data licenses and usage restrictions through its catalogue entries and service documentation.
    - Supporting various standard data access mechanisms.
- ***Monitoring and Accounting***: The Node utilizes its core capabilities for Service Monitoring and Accounting and will provide necessary information feeds to the corresponding EOSC Federating Capabilities as required by the Federation policies to ensure transparency and operational awareness. (Refined from Handbook Table 4.3)
- ***Helpdesk***: The Node's Helpdesk will integrate with the EOSC Helpdesk Federation according to defined interoperability guidelines (e.g., ticket redirection or full integration) to provide a streamlined support experience for users accessing Blue-Cloud resources via EOSC.
- ***Order Management***: The Node's Order Management capability, used for requesting resources like VLab instances, will interface with the EOSC Order Management framework to allow EOSC users to request access to Blue-Cloud's Node Exchange resources where applicable.

4. Use Cases

Use Case ID	Use Case Description	Federation Contributions & Value to Users
1	Facilitating Cross-Domain Web-Based Open Science through Virtual Labs (VLabs) - Blue-Cloud as an EOSC Marine Thematic Node VLab Factory	Demonstrates the potential of federated resources; streamlines research workflows and enables collaboration
2	Assessing Transboundary Processes and Connectivity - VLab 1 as a Coastal Ocean Analysis Hub	Blue-Cloud is committed to providing researchers with specialised tools to address critical coastal ocean challenges. VLab 1 serves as a dedicated hub for analysing transboundary processes and connectivity.
3	Carbon Sequestration and Plankton Dynamics- VLab as a Biogeochemical Modeling Platform	Blue-Cloud is committed to advancing our understanding of marine biogeochemical processes. This use case focuses on leveraging Virtual Labs (VLabs) to explore carbon sequestration and plankton dynamics.
4	Eutrophication Assessment - EOV Data Harmonization and Climatology Workbench	Blue-Cloud is committed to providing robust tools for environmental assessment. This use case focuses on developing a workbench for eutrophication assessment through the creation of harmonised Essential Ocean Variable (EOV) data collections.
5	A pilot for EOSC nodes collaboration. Integration and testing of FAIR-EASE components within Blue-Cloud's Virtual Research Environment.	Multi-node end-to-end use case with the CNRS French Node, to demonstrate ongoing federation of specific services with existing nodes
6	Enhancing Marine Research through Collaborative Services: A Synergy Between the Blue-Cloud Marine Thematic Node and the Italian Node	Multi-node end-to-end use case with the Italian National Node, to demonstrate ongoing collaboration for the federated provision of specific infrastructural services at the national level

4.1. Use Case 1: Facilitating Cross-Domain Web-Based Open Science Through Virtual Labs (Vlabs) - Blue-Cloud As An Eosc Marine Thematic Node Vlab Factory

As the EOSC Marine Thematic Node, operating under the Blue-Cloud charter, we are committed to driving the adoption of open science practices within the marine domain. Our core strategy revolves around creating and deploying Virtual Labs (VLabs) as a central component of the European Open Science Cloud (EOSC).

Federation Contributions: Blue-Cloud serves as a **factory** for developing and deploying VLabs, empowering researchers with web-based open science capabilities. These VLabs provide access to data products and analytical tools within a Virtual Research Environment (VRE), effectively serving as real-life demonstrators for Web-based open science. They are designed to be readily available for testing and adoption by research communities across the EOSC federation. As the EOSC Marine Thematic Node, we contribute:

- **VLab Factory**: We establish a robust framework and infrastructure for the streamlined creation and deployment of tailored VLabs, addressing diverse marine research needs.
- **Real-life Demonstrators**: Our VLabs serve as tangible examples of web-based open science, showcasing the added value of the European Ocean Science Cloud (EOSC).
- **FAIR Data Promotion**: By facilitating access to marine in situ and satellite data provided via EMODnet and CMEMS within the EDITO remit, and to other Blue Data providers not yet onboarded into the above-mentioned portals, we ensure adherence to FAIR data principles, enabling seamless exploration of diverse datasets from marine and maritime data infrastructures.
- **Standardised VLab Creation**: We will create a set of best practices and tools for creating VLabs that other communities can reuse.

Value to Users: Researchers can utilise VLabs to manage data storage efficiently, perform advanced data analytics, engage in community management, and share and publish resources. VLabs provides researchers with resources of interest to the marine research and innovation community, which can be leveraged to develop added-value applications for other users further. Each VLab comprises a series of applications for data processing, publishing of data results, managing computation routines, and collaboration services, providing open science-friendly working environments for its users to analyse datasets and regenerate research products.

Blue-Cloud provides access to several virtual laboratories (VLabs), including

- VLab1: Integration of Coastal Ocean Observations Along Europe (ICOOE).
- VLab2: Coastal Currents from Observation.
- VLab3: Carbon Plankton Dynamics.
- VLab4: Marine Environmental Indicators.
- VLab5: Global Fisheries Atlas.
- VLab6: Coastal Water Dynamics VLab.
- VLab7: Marine Omics Observations VLab.
- VLab8: Ecological Restoration VLab.
- VLab9: JERICO Coastal Oceans Resource Environment VLab.

The core of this use case involves providing Virtual Labs (VLabs) that offer data products and analytical tools within the Virtual Research Environment (VRE). These VLabs serve as real-life demonstrators for web-based open science and are available for testing by research communities within the EOSC federation.

The VLabs offer applications for data processing, publishing data results, and managing computation routines. They also provide innovative services in the form of data products and analytical tools, showcasing the added value of web-based open science.

Services Exploited:

- **Virtual Research Environment (VRE)**: The VRE is a central component that provides the VLabs' environment. It offers generic services such as the analytics computing framework, catalogue framework, and storage framework. The VRE facilitates collaboration, data analytics, result publication, and integration with external systems.
- **Data Discovery and Access Service (DD&AS)**: This service allows users to discover and access datasets from various BDIs. It includes features for federated queries and retrieval of multi-disciplinary datasets. The DD&AS is designed to facilitate discovering and retrieving datasets and products from BDIs and interact with the Blue-Cloud VRE.
- **Core Services**: These include authentication, authorisation, and identity management; accounting, monitoring, and metering; and a catalogue of services and products. Core services include secure data management, flexible deployment, efficient software development, and open data publishing.
- **JupyterHub**: Some VLabs, like VLab 1's Thematic Service #3, provide access to JupyterHub, a cloud-based interactive computing environment preconfigured with libraries and packages for running tools.

Key Features:

- **Cross-Domain Integration**: VLabs integrate multidisciplinary data from various sources, such as marine Research Infrastructures like the Joint European Research Infrastructure for Coastal Observatories (JERICO). They combine coastal and open sea data, plankton, hydrodynamics, and fisheries data.
- **Web-Based Open Science**: The VLabs promote web-based open science by providing services in the form of data products and analytical tools.
- **FAIR Data Principles**: Integration with the Blue-Cloud Data Discovery and Access Service ensures adherence to FAIR data principles.
- **Thematic Services**: VLabs are structured around specific thematic services, catering to user interests and research areas. For example, VLab 1 supports coastal ocean users through thematic services addressing transboundary processes, extreme events, and ocean gliders. These services provide tools to work with observations and extract information about connectivity processes.
- **User-Friendly Interface**: The user interface allows users to select geographical areas and periods of interest, guiding them in searching for available datasets.
- **Data Lake Configuration**: A specific data lake configuration, adopting Beacon technology, is co-designed and under development for the WorkBenches to merge and harmonise several data collections for selected EOVs from multiple BDIs.

Unique Selling Characteristics:

- **Real-World Demonstrations**: VLabs demonstrate how cross-domain data can be integrated and used for open science.
- **Federated Approach**: By federating data and e-infrastructures, Blue-Cloud creates a European Open Science Cloud for marine data.
- **Customisation and Flexibility**: VLabs can be tailored to meet the specific needs of individual projects.
- **Focus on Specific Processes**: Thematic Services, such as those in VLab 1, focus specifically on processes like transboundary transport and connectivity.

- **Data Subsetting**: Blue-Cloud equips its infrastructure with subsetting capabilities on the data and metadata managed by selected Blue Data Infrastructures.

Out of Scope:

- Fully harmonising all data from different sources, focusing on essential ocean variables (EOVs) and biodiversity variables (EBVs).
- Harmonising all fisheries datasets worldwide within a single project, focusing instead on specific use cases like tuna fisheries.
- Implementing semantic mapping where terms and codes lack Uniform Resource Identifiers (URIs).

4.2. Use Case 2: Assessing Transboundary Processes and Connectivity - Coastal Ocean Analysis Hub

This VLab supports coastal ocean users with three key thematic services: addressing transboundary processes and connectivity along European margins (focusing on biological connectivity, contaminant spread, and river outflow impacts), analysing extreme events (specifically coastal impacts of major storms), and demonstrating the value of repeated ocean glider sections. It provides researchers with tools for processing, exploring, integrating, and visualising observations and complementary information in coastal ocean areas.

Federation Contributions: Blue-Cloud seamlessly integrates data from diverse sources, including CMEMS, EMODnet (Physics, Bathymetry, Human Activities, and Biology), SOCIB Data Repository, PLOCAN, Instituto Hidrografico, and Puertos del Estado. It allows users to input their data, fostering a collaborative environment and providing tested and ready thematic services that can be used by other communities.

Value to Users: **Researchers** can utilise this VLab to efficiently manage data integration from diverse sources, perform advanced spatial and temporal data analytics, and engage in collaborative research. It also provides researchers with resources of interest to the marine research and innovation community, which can be leveraged to further develop added-value applications for other users. Researchers can

- gain tools for processing, exploring, integrating, and visualising data to understand transboundary processes, extreme events, and ocean glider dynamics;
- develop and share new methodologies and insights, contributing to the advancement of coastal ocean research.

For **Blue Economy Sectors & Crisis Management,** it provides easy access and integrates relevant observations and modelling results to support operational decision-making, such as navigation, coastal protection, and emergency response for risk assessment and mitigation related to extreme events and contaminant spread.

For **Environmental Managers & Policymakers,** it builds integrated visions of geographical areas enabling the exploration of relevant processes for informed decision-making related to coastal management, conservation, and policy development and the evaluation of the impacts of human activities and climate change on coastal ecosystems.

For **Students & General Public**, it enables the exploration of available observations and information about the coastal ocean through interactive visualisations and educational resources, fostering ocean literacy.

Key Features:

- **Data Integration, Analysis, and Visualization**:
  - Seamlessly integrate data from CMEMS, EMODnet, and other sources, enabling cross-disciplinary analysis.
  - Perform advanced spatial and temporal data analysis, including statistical modelling, time series analysis, and geospatial processing.
  - Generate interactive visualisations, maps, and reports to communicate research findings effectively.
  - Access to Jupyter notebooks preconfigured with the needed libraries.
- **Diverse Data Source Access**:
  - Access and integrate data from various marine data providers, including observations, model outputs, and geospatial datasets.
  - Utilise user-provided data to enhance analysis and address specific research questions.
- **Thematic Service Customization**:
  - Tailor thematic services to address specific research needs related to transboundary processes, extreme events, and ocean glider dynamics.
  - Develop and share customised workflows and analytical tools within the VLab environment.

Unique Selling Characteristics:

- **Coastal Ocean Focus**:
  - Provides specialised tools and data tailored to the unique challenges of coastal ocean environments.
  - Offers a comprehensive platform for analysing coastal processes and dynamics.
- **Multi-Data Type Integration**:
  - Combines diverse marine data types, including physical, biological, and chemical data, to provide a holistic understanding of coastal ecosystems.
  - Facilitates the integration of observations and model outputs for improved analysis and prediction.
- **Multi-Stakeholder Support**:
  - Serves a wide range of user groups, including researchers, policymakers, Blue Economy sectors, and the general public.
  - Provides tools and resources tailored to the specific needs of each user group.
  - Enables the regeneration of research products, and the sharing of reproducible workflows.

Out of Scope:

- **Excluded Activities**:
  - Detailed, localised hydrodynamic modelling at the scale of individual harbours or estuaries. The focus is on broader coastal processes.
  - Real-time, operational forecasting for specific maritime activities (e.g., ship routing, oil spill response).
  - Comprehensive, high-resolution bathymetric surveys. The VLab integrates existing bathymetric data, but doesn't conduct new surveys.
  - In-situ, real-time sensor network management or deployment. The VLab uses data from existing sensors, but doesn't control them.
  - Direct management and enforcement of maritime regulations or environmental policies. The VLab provides tools for analysis, but doesn't implement policy.
  - Detailed chemical analysis of contaminant at the molecular level.
  - Direct intervention in crisis management scenarios.
- **Limitations**:
  - The VLab doesn't provide fully automated decision-making tools for crisis management or policy development. It supports analysis, but human interpretation is required.
  - The accuracy of predictions and analyses is limited by the quality and availability of input data from external sources.
  - The VLab's thematic services are focused on pre-defined processes (transboundary, extreme events, gliders), and don't cover all possible coastal ocean phenomena.
  - Specific technical details of individual VLabs and workbenches, focusing instead on the integration and interoperability aspects.

4.3. Use Case 3: Carbon Sequestration and Plankton Dynamics - VLab as a Biogeochemical Modeling Platform

This use case focuses on characterising phytoplankton by linking and integrating biology, biogeochemistry, and physics data from several Blue Data Infrastructures (BDIs). It utilises a dedicated VLab to run a mechanistic model identifying the drivers of phytoplankton abundance and a machine-learning algorithm to calculate carbon sequestration. This VLab provides a platform for advanced biogeochemical modelling and analysis.

Federation Contributions: As the EOSC Marine Thematic Node, we contribute:

- **Data Interoperability**: integrates diverse data types from multiple BDIs, making them interoperable.
- **Modelling Platform**: provides a platform that can be used by other communities to model biogeochemical processes.
- **Real-life Demonstrators**: serves as a tangible example of how integrated data and advanced modelling can be used to address critical marine research questions.

Value to Users: **Researchers** can utilise this laboratory to efficiently integrate diverse biogeochemical data and run complex models; gain insights into the drivers of phytoplankton abundance and carbon sequestration; reproduce data products and analyses by modifying inputs and settings, ensuring transparency and repeatability.

The VLab offers a series of applications for data processing, running mechanistic models, and executing machine-learning algorithms. It showcases the added value of web-based open science in biogeochemical research.

Key Features:

- **Cross-Domain Integration**: Integration of biology, biogeochemistry, and physics data from diverse sources.
- **Modelling and Analysis**: Use of mechanistic models and machine-learning algorithms for analysis.
- **Reproducibility**: Emphasis on reproducibility of results through modifiable inputs and settings.
- **Web-Based Open Science**: The VLab promotes web-based open science by providing services in the form of data products and analytical tools.

Unique Selling Characteristics:

- **Focus on Carbon Sequestration and Plankton Dynamics**: Dedicated to addressing critical biogeochemical processes.
- **Integrated Data Approach**: Combines biology, biogeochemistry, and physics data for holistic analysis.
- **Modelling Platform**: The VLab provides a platform that can be used to run complex models.
- **Real-World Demonstrations**: The VLab acts as a real-world demonstration of how cross-domain data can be integrated and used for open science.

Out of Scope:

- **Excluded Activities**:
  - Detailed analysis of specific plankton species' physiological responses at a cellular level.
  - Direct measurement of carbon fluxes outside the scope of model-derived estimates.
  - Real-time, high-frequency monitoring of carbon sequestration processes.
  - Development of new, fundamental, biogeochemical models. This Vlab will use existing and validated models.
- **Limitations**:
  - The VLab does not provide comprehensive, global-scale modelling of all carbon sequestration processes.
  - The accuracy of carbon sequestration estimates is limited by the availability and quality of input data.
  - The machine learning algorithms will focus on specific, pre-defined sets of parameters, and will not explore all possible variables.

4.4. Use Case 4: Eutrophication Assessment - EOV Data Harmonization and Climatology Workbench

This use case aims to provide workflows for the generation of harmonised and validated EOV data collections for chlorophyll, nutrients, and oxygen, integrating datasets from different Blue-Cloud Data Infrastructures (BDIs). It utilises DIVAnd to produce climatology maps of EOV Eutrophication for the North East Atlantic and European seas, providing a comprehensive assessment of eutrophication status.

Federation Contributions: as the EOSC Marine Thematic Node, we contribute:

- **Data Integration and Harmonization**: The Eutrophication Workbench integrates datasets from WOD, EMODnet-chemistry, and CMEMS.
- **Semantic Interoperability**: The Semantic Analyser (SA) and Beacon are integral to this workbench, ensuring semantic interoperability.
- **Standardised EOV datasets**: The Workbench provides tested and ready EOV datasets that can be used by other communities.

Value to Users. **Environmental Managers & Policymakers** are allowed to check the eutrophication state of an area of interest by changing depth and season on an interactive map. It utilises resulting EOV datasets for EU MSFD Technical Groups, Regional Seas Conventions, EEA & EU directives, UN Ocean Decade Actions, and UN SDG indicators.

For **Biogeochemical Modelers** it provides the merged datasets for more accurate initial and boundary conditions in biogeochemical models.

The workbench offers a series of applications for data processing, EOV data harmonisation, and climatology mapping. It showcases the added value of web-based open science in eutrophication assessment.

Services Exploited:

- Blue-Cloud VRE: The core operational environment.
- Data Discovery and Access Service (DD&AS): For data discovery and retrieval.
- Workbenches: Dedicated workbenches for eutrophication assessment.
- Semantic Analyser: For semantic interoperability.
- Beacon: For data discovery and access.

Key Features:

- **Cross-Domain Integration**: Integration of diverse data sources (WOD, EMODnet-chemistry, CMEMS).
- **Data Harmonization**: Harmonization of data for consistent analysis.
- **EOV Datasets and Climatology Maps**: Generation of valuable datasets and maps.
- **Web-Based Open Science**: The workbench promotes web-based open science by providing services in the form of data products and analytical tools.

Unique Selling Characteristics:

- **Focus on Eutrophication Assessment**: Dedicated to addressing a critical environmental issue.
- **Multi-BDI Data Integration**: Combines data from multiple sources for comprehensive analysis.
- **Valuable Datasets for Stakeholders**: Provides datasets for various policy and research needs.
- **Real-World Demonstrations**: The Workbench acts as a real-world demonstration of how cross-domain data can be integrated and used for open science.

Out of Scope:

- **Excluded Activities**:
  - Detailed, real-time monitoring of eutrophication events.
  - Development of new, fundamental, eutrophication models. This workbench will use existing and validated methods.
  - Direct enforcement of eutrophication-related regulations.
  - Analysis of the causes of eutrophication at the level of specific, local outfalls.
  - Chemical analysis of specific pollutants that contribute to eutrophication.
- **Limitations**:
  - The accuracy of climatology maps is limited by the spatial and temporal resolution of input data.
  - The workbench does not provide real-time, operational forecasting of eutrophication events.

4.5. Multi-node Use Case 5: A pilot for EOSC nodes collaboration. Integration and testing of FAIR-EASE components within Blue-Cloud's Virtual Research Environment.

This use case focuses on integrating and testing components from the FAIR-EASE project, a part of the CNRS DataTerra EOSC node, within the Blue-Cloud Virtual Research Environment (VRE), hosting the Marine Thematic Node. This collaboration is formalised through a Memorandum of Understanding (MOU) signed in November 2024, building on the initial collaboration that began in June 2023. This MOU highlights the shared objectives of Blue-Cloud and FAIR-EASE in promoting FAIR data solutions for research and signifies a crucial step in fostering collaboration across different EOSC nodes.

Federation Contributions: as the EOSC Marine Thematic Node, we contribute:

- **Strategic Inter-Node Collaboration:** This use case serves as an important pilot for the collaboration between the Marine thematic node and the CNRS DataTerra node, showcasing how different EOSC nodes can effectively work together. This collaboration not only demonstrates the practical application of multi-node collaboration within the EOSC framework but also paves the way for future collaborations and interoperability between various EOSC nodes, fostering a more integrated and efficient European Open Science Cloud. By integrating and testing components from the FAIR-EASE project within the Blue-Cloud VRE, this use case enhances the capabilities of the Blue-Cloud VRE and provides valuable tools and resources for researchers studying critical marine environments and processes.
- **Resource Sharing:** Blue-Cloud provides the necessary storage and processing resources within its VRE (powered by D4Science) to host two FAIR-EASE Virtual Lab pilots: the Marine Omics Observations VLab and the Coastal Water Dynamics VLab.

- **Technical Implementation:** The FAIR-EASE VRE is configured and deployed on the Blue-Cloud VRE using a GALAXY VRE environment powered by D4Science, which includes core services for authentication, authorisation, and accounting (AAAI), as well as monitoring.

Key Features:

- **Coastal Water Dynamics VLab Pilot:**
  - Focuses on the Northern Adriatic/Po Estuary, a highly dynamic system influenced by river runoff, meteorology, ocean currents, and marine biogeochemical processes.
  - Addresses scientific and socioeconomic impacts such as biological productivity, carbon cycling, and the transport of materials and substances. By focusing on this highly dynamic system, the pilot project aims to model and analyse the complex interactions between various environmental factors and their impacts on the ecosystem. The outcomes of this pilot will provide valuable insights into the functioning of coastal ecosystems and inform strategies for sustainable management and conservation.
- **Marine Omics Observations VLab**
  - This VLab focuses on the analysis of marine omics data, which involves the study of the genetic material of marine organisms.
  - It aims to provide insights into marine biodiversity, ecosystem functioning, and the impacts of environmental changes. By integrating omics data with other marine data types, researchers can gain a more comprehensive understanding of marine ecosystems. This pilot project will enable researchers to explore the vast amount of omics data and uncover new knowledge about marine life, contributing to a better understanding of marine ecosystems and their responses to environmental changes.

Unique Selling Characteristics:

This use case not only demonstrates the practical application of multi-node collaboration within the EOSC framework but also paves the way for future collaborations and interoperability between various EOSC nodes, fostering a more integrated and efficient European Open Science Cloud. By showcasing the benefits of inter-node collaboration and providing valuable tools and resources for researchers, this use case contributes to the advancement of marine research and the development of a more collaborative and efficient European research ecosystem.

4.6. Multi-node Use Case 6: Enhancing Marine Research through Collaborative Services: A Synergy Between the Blue-Cloud Marine Thematic Node and the Italian Node

This use case explores the synergistic collaboration between the Blue-Cloud Marine Thematic Node and the candidate Italian Node, focusing on how their combined services can enhance marine research. By integrating the specialised marine data services and virtual research environment of Blue-Cloud with the comprehensive national services of the Italian Node, this collaboration aims to provide researchers with enhanced computing power, scalable data storage, collaborative workspaces, integrated services, and unified data discovery. This partnership leverages the strengths of both nodes to create a powerful platform for marine research, fostering innovation and advancing scientific understanding.

Federation Contributions: as the EOSC Marine Thematic Node, we contribute

- **Enhanced Computing Power:** The collaboration will enable more complex and computationally intensive research through shared access to high-performance computing infrastructure.
- **Scalable Data Storage:** Researchers will benefit from shared, scalable storage solutions, facilitating the management of growing data volumes.
- **Collaborative Workspaces:** The integration of interactive notebooks will foster teamwork and knowledge sharing, allowing researchers to collaboratively develop and share code, analyse data, and document findings.
- **Integrated Services:** A rich and diverse catalogue of available services, including data discovery, processing, visualisation, and analysis tools, will streamline research workflows.
- **Unified Data Discovery:** Access to relevant datasets and publications will be simplified through a centralised catalogue, providing a single point of access to a wealth of information.
- **AAI Services:** Uniform access via institutional accounts to the services and products of both nodes, integrated with the EOSC AAI federation.

- **Monitoring and Accounting Services:** Transparent provision of reliable data and usage statistics, integrated with the EOSC EU Node's accounting and monitoring services.
- **Helpdesk Services:** Integrated helpdesk support for all services, aligned with the EOSC Helpdesk services.
- **Training and Support Services:** Comprehensive training and support to implement and utilise open science practices.
- **Cloud and Data Lake Orchestration Services:** Deployment of user-oriented services across heterogeneous cloud resources and creation of dynamic data lake platforms.

Key Features

- **Jointly developed VRE**: The Virtual Research Environment will be jointly developed and customised to meet the specific needs of marine researchers, providing a seamless and integrated platform for their work.
- **Customised services**: The services offered through this collaboration will be tailored to the specific requirements of marine research, ensuring that researchers have access to the tools and resources they need.
- **Jointly organised training programs**: The nodes will organise training programs to ensure that researchers are proficient in using the platform and its services.
- **Jointly organised workshops and hackathons**: The nodes will organise workshops and hackathons to foster collaboration and innovation in marine research.
- **Jointly developed documentation**: The nodes will develop comprehensive documentation for the platform and its services, ensuring that researchers have the information they need to effectively use the platform.

Unique Selling Characteristics

- **Combining National and Thematic Services:** This use case uniquely combines the strengths of a national node and a thematic node, creating a comprehensive platform for marine research.
- **Comprehensive Service Offering:** The wide range of services offered, from computing and storage to training and support, provides a holistic approach to supporting marine research.
- **Enhanced Collaboration and Innovation:** By fostering collaboration and providing access to cutting-edge tools and resources, this use case promotes innovation and advances scientific understanding in marine research.

5. External Dependencies & Key Risks

External Dependencies & Risks	Actions	Deadline
The success of Blue-Cloud heavily relies on the continuous availability and quality of data provided by external Blue Data Infrastructures (BDIs) such as CMEMS, EMODnet, WOD, SOCIB, PLOCAN, Instituto Hidrografico, and Puertos del Estado.	Establish formal agreements (MoUs, service level agreements) with key data providers (e.g. EDITO, EMODnet) outlining data delivery schedules, quality standards, and FAIR principles. Implement automated data quality checks and validation procedures to identify and address data inconsistencies or errors. Establish regular communication channels with data providers to identify and address potential issues proactively.	October 2025
Blue-Cloud's integration into the EOSC ecosystem depends on the stability and interoperability of EOSC core services, including authentication, authorisation, and infrastructure services.	Actively participate in EOSC governance and technical working groups to influence the development of standards and services. Conduct regular testing and validation of Blue-Cloud's interoperability with EOSC core services.	June 2025
The project relies on the ongoing development and maintenance of key technologies such as the D4Science e-infrastructure,	D4Science and Beacon technology providers, respectively CNR and Maris, are both involved in the management of the marine thematic node.	April 2025 (considering April as the starting date)

DIVAnd, JupyterHub, Semantic Analyser, and Beacon.	JupyterHub is a well-known software delivered and maintained, and there is no risk of disruption. SLA will be formalised with the other providers.	
The broad acceptance and use of the Blue-Cloud VLabs and workbenches depends on the active engagement of the marine research community, policymakers, and the Blue Economy sector.	Implement a comprehensive communication and outreach strategy to raise awareness of Blue-Cloud's services and benefits. Establish user feedback mechanisms (e.g., surveys, forums, user groups) to gather input and address user needs. Develop targeted training programs and educational resources for different user groups.	June 2025
Risk of insufficient funding or lack of long-term sustainability for maintaining and expanding Blue-Cloud services beyond the pilot phase.	The EOSC marine node, currently developing as the Blue-Cloud thematic node led by CNR, will be integrated as the third data component of EDITO. CNR, Trust-it, and Maris will be fully associated with EDITO. So the sustainability of the pilot phase is guaranteed by Blue-Cloud, while the long term sustainability by EDITO.	Apr 2026

6. Contributions [Deliverables (Including Documentation)]

ID	Deliverable Name	Deliverable Description	Owner
1	IT Governance documentation Project/Programme Charter Architecture Design Plan and the Architecture Canvas: including hosting, DNS, network IT Security Plan: security model, security architecture and IT security impact assessment Operational Disaster Recovery Plan (including implementation plan) Evaluation of the IT Security Plan: provide input to the IT Security Risk Report Service Interoperability Plan	All the documents, templates and information provided for online tools such as the Architecture Canvas, Global Risk Catalogue, and others that are needed for IT Governance processes, approvals and production launch of the EOSC Node services.	CNR
2	Data protection policies and procedures Risk and Compliance Assessment Plan: Controls for risk, compliance, continuity & recovery + cost-benefit analysis Data Protection Plan and Data Protection Impact Assessment Risk Registry Personal Data Protection Impact Assessment (GDPR) Data Processing Agreement	All documents, templates and information provided for online tools such as the Data Protection Impact Assessment and others that are needed for approvals and production launch of the EOSC services.	MARIS
3	Operational quality plans, service reviews, verification and test session results and defects status and resolution Capacity Plan Operations, Maintenance and Support Plan Incident Reporting Plan (including setup of ticketing system and workflows)	All the operational-related deliverables, including testing, quality assurance management, operations, maintenance, and support, as well as incident handling.	CNR
4	Stakeholder and community engagement strategy Communications Plan Documentation Plan: user/admin manuals and release notes Training Development Plan	All the documents and plans related to stakeholder management address all the profiles described in the previous section.	Trust-IT
5	Production roll-out of service components, including web-service APIs and associated documentation	The actual managed service components of the EOSC Node/onboarded services and API's.	CNR

7. Timing And Milestones

ID	Milestone Description	Target Delivery Date
1.1	Milestone 1.1: Project Kick-off Meeting and Team Alignment ● Establish project governance, roles, and responsibilities. ● Finalise project management plan and communication strategy.	Month 1
1.2	Milestone 1.2: Data Provider Agreement Review and Enhancement ● Review and update existing data provider agreements (MoUs/SLAs) to ensure alignment with project goals and FAIR principles. ● Establish regular communication channels with data providers.	Month 1
2.1	Milestone 2.1 VLab Factory Enhancement and Standardization ● Document and refine the framework for streamlined VLab creation and deployment. ● Develop standardised VLab creation best practices and tools.	Month 2
2.2	Milestone 2.2: VLab Factory User Training and Pilot Program ● Develop and deliver training materials for VLab creation and customisation. ● Start a pilot program for external researchers to create new Vlabs.	Month 2
3.1	Milestone 3.1: Coastal Ocean Analysis Hub Data Integration Optimization ● Optimise data integration pipelines for CMEMS, EMODnet, and other data sources. ● Enhance user data input and integration capabilities.	Month 4
3.2	Milestone 3.2: Thematic Service Enhancement and User Feedback Collection ● Enhance existing thematic services based on user feedback and new research requirements. ● Collect user feedback on the Vlab.	Month 6
4.1	Milestone 4.1: Biogeochemical Model Integration and Validation ● Validate and optimise the mechanistic model and machine-learning algorithm for carbon sequestration. ● Enhance data integration for biology, biogeochemistry, and physics data.	Month 5
4.2	Milestone 4.2: Reproducibility Enhancement and Workflow Sharing ● Release tools and processes for enhancing the reproducibility of model results. ● Release a system for the sharing of workflows.	Month 7
5.1	Milestone 5.1: EOV Data Harmonization and Validation Enhancement ● Enhance data harmonisation pipelines for chlorophyll, nutrients, and oxygen data. ● Implement robust data validation procedures.	Month 9
5.2	Milestone 5.2: Climatology Map Generation and User Interface Optimization ● Optimize DIVAnd-based climatology map generation. ● Enhance the interactive map user interface for improved usability.	Month 10
6.1	Milestone 6.1: Blue-Cloud Training Academy Enhancement and Expansion ● Expand the Blue-Cloud Training Academy with new training materials and programs. ● Conduct training sessions and hackathons for target user groups.	Month 5
6.2	Milestone 6.2: EDITO integration planning. ● Develop a detailed plan for the integration of the Blue-cloud Node infrastructure into the EDITO infrastructure.	Month 6

ID	Milestone Description	Target Delivery Date
7.1	Milestone 7.1: Project Evaluation and Impact Assessment ● Conduct a comprehensive evaluation of the project's achievements and impact. ● Prepare a final report summarising project outcomes and lessons learned.	Month 11

8. CONTACTS

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