JERICO-S3 DELIVERABLE

Joint European Research Infrastructure for Coastal Observatories

Science, Services, Sustainability

DELIVERABLE #, WP# and full title	JERICO-S3 D9.5 - WP9 - "JERICO Design Report, final version"
5 Key words	Research Infrastructure, Coastal Observations, Service Delivery, Stakeholder Engagement, Sustainability
Lead beneficiary	Ifremer
Lead Author	Alexandre Epinoux
Co-authors	Lucie Cocquempot (Ifremer)
Contributors	Laurent Delauney, Nathaniel Bensoussan (Ifremer)
Final version date/ Submission date (dd.mm.yyyy)	23.09.2024

Nature: **R**

(R = Report, P = Prototype, D = Demonstrator, O = Other)

Dissemination level : **PU**

PU = Public, PP = Restricted to other programme participants (including the Commission Services), RE = Restricted to a group specified by the consortium (including the Commission Services), CO = Confidential, only for members of the consortium (including the Commission Services)

GRANT N°: 871153
PROJECT ACRONYME : JERICO-S3
PROJECT NAME : Joint European Research Infrastructure for Coastal Observatories - Science, services, sustainability
COORDINATOR : Laurent DELAUNEY - Ifremer, France - jerico@ifremer.fr

DOCUMENT TECHNICAL DESCRIPTION

Document ID	JERICO-S3-WP9-D9.5-23.09.2024-V1.2

REVISION HISTORY

Revision	Date	Modification	Author
V0.1	25/07/2024	First draft	Alexandre Epinoux
V0.2	31/07/2024	Consolidation of content	Alexandre Epinoux
V1.0	06/09/2024	Hyper restructuring	Alexandre Epinoux, Lucie Cocquempot
V1.1	12/09/2024	Consolidation of content	Alexandre Epinoux, Lucie Cocquempot
V1.2	23/09/2024	Revision and update of content; delivery version	Alexandre Epinoux, Lucie Cocquempot, Laurent Delauney, Nathaniel Bensoussan

APPROVALS

	Name	Organisation	Date	Visa
Coordinator	Delauney Laurent	Ifremer	25/09/2024	X
WP Leaders	Lucie Cocquempot	Ifremer	23/09/2024	X

Diffusion list

Consortium beneficiaries	Third parties	Associated Partners	other
X	X		

TABLE OF CONTENT

EXECUTIVE SUMMARY

JERICO stands as a unique and comprehensive Research Infrastructure (RI) dedicated to the holistic observation of coastal marine systems, addressing a critical gap in the European landscape. Unlike existing infrastructures which focus on deep ocean or inland and transitional environments, JERICO is designed to specifically meet the needs of coastal marine systems. This initiative leverages a collaborative approach, engaging with other environmental RIs to enhance its service offerings and integrate with broader research efforts.

The foundational support for JERICO has been strengthened significantly, reflecting a robust political and financial backing essential for its upcoming ESFRI Roadmap application. Nine EU Member States have committed their support, with France, Italy, Finland, and Croatia anticipated to provide crucial ministerial backing. This growing alignment underscores the importance of JERICO in addressing regional and global environmental challenges and highlights its critical role in marine and coastal observation efforts.

The development of JERICO is guided by a dynamic Business Plan (developed in JERICO-S3 D9.3), which includes a comprehensive Services Estimation Model (SEM) to ensure financial feasibility and long-term sustainability. The SEM outlines the initial service development phase with 20 services, and anticipates an expansion to 40 services by 2058. It incorporates a detailed financial framework, including projections for personnel, technology, and infrastructure needs. The plan also integrates advanced technologies and a user-centred approach to optimise service delivery and ensure continuous alignment with user needs. Risk management is taken into account in JERICO's strategy, and are categorised into financial, organisational, operational, technical, and scientific, with a methodology that includes risk identification, analysis, and evaluation. This approach ensures that potential negative impacts are addressed effectively and that mitigation strategies are implemented to minimise risk magnitudes.

The work conducted during the JERICO-DS Design Study, further advanced through the JERICO-S3 project, has provided a solid foundation for our stated goal of entering the PREPARATORY PHASE. This includes the extension of scientific leadership, structuring of regional and site-specific tests, and the establishment of user strategies and business cases. The preparation phase, set to continue through 2028, will focus on establishing multidisciplinary observations, proving observation capacities through joint actions, and solidifying collaborations with other RIs and data aggregators. Looking forward, the IMPLEMENTATION phase will involve the preparation of technical expertise centres, the development of virtual facilities, and the upgrading of in situ systems. The formation of a legal entity with approved governance and the consolidation of the funding plan are crucial steps in ensuring JERICO's successful transition into operation. The ongoing engagement of nations and the optimization of resources will foster synergies and enhance the overall effectiveness of JERICO.

Overall, JERICO is well-positioned to advance its objectives through increased political and financial support, a solid business plan, and a comprehensive user engagement strategy. Its commitment to expanding its geographic and operational scope, coupled with a user-centred approach, with strategic collaborations and services catalogue dedicated to

support science and the blue economy, will ensure its role as a pivotal component of Europe's marine research infrastructure.

A. JERICO in a nutshell

1. Coastal ocean main specificities

The specific characteristics of the coastal ocean influence the nature of the main associated scientific/environmental/societal issues. JERICO generates and processes solid observation data to tackle them.

● **Coastal ocean: a heterogeneous interface where a large variety of potential drivers are interacting over a large range of nested spatio-temporal scales**
The coastal ocean is located at the interface between the continent, the open ocean and the atmosphere and is in tight interaction with these adjacent systems. Both its structure and functions are affected by a large variety of fluxes originating from those systems. Interplay between major river discharge and winds creates Regions Of Freshwater Influence (ROFIs), which are largely differing from the surrounding ocean regarding their physics, biogeochemistry and biology, whereas changes in coastal ocean biodiversity and biological productivity are largely cued by climatic processes/oscillations primarily affecting the open ocean. Spatial heterogeneity therefore clearly constitutes a first major characteristic of the coastal ocean. The coastal ocean is also showing strong dynamics over a large range of temporal scales. These include a number of nested components: (1) long term (e.g. in relation with climate change), (2) interannual (e.g., in relation with climatic oscillation), (3) seasonal (in temperate areas), (4) mesoscale related and (5) short term, including episodic events (e.g. in relation with the occurrence of rare/extreme events that constitute key factors in controlling the structuration and the functioning of coastal marine systems).

Due to this heterogeneity, observing, understanding and ultimately predicting changes of coastal marine systems over a large range of spatio-temporal scales constitutes a first key objective for JERICO.

● **Coastal Ocean: a stake area for society and economy**
The coastal ocean is the most productive part of the world ocean and is one of the major sources of food for humans. Biological productivity in coastal waters results from a complex interplay between biological, biogeochemical and physical processes. The coastal ocean is providing a large variety of other ecosystem services including: (1) transportation, (2) availability and access to raw materials and resources for industry, (3) repository and dilution of contaminants, and (4) leisure and cultural resources. The coastal ocean is by far the most economically valuable component of the world ocean and the economic values of the littoral components can be comparable and even higher than the highest ones of continental biomes. The exploitation of these services results in the densification of human coastal populations and the intensification of their activities (although some estimates stated that up to one human being out of 2 lives close to the coast, globally, the percentage may be overestimated but still significant; see Small and Nicholls, 2003; McGranahan, Balk

& Anderson, 2007), which is planned to increase substantially (Merkens et al., 2016). The coastal ocean is therefore the component of the world ocean most affected by anthropogenic disturbances. A second key objective for JERICO is to assess negative anthropogenic impacts in order to enhance the sustainability of the ecosystem services provided by the coastal ocean and to ensure the conservation of a Good Environmental Status (GES) for coastal marine waters. This is far from trivial since anthropogenic impacts are superimposed to those of natural ones.

2. JERICO's Vision, Mission, Value

In JERICO-DS deliverable D1.3, a revision of JERICO's Vision ('why does JERICO exist?'), Mission ('what future does JERICO want to create?') and Values ('what is important for JERICO?') was proposed. At the same time, the Purpose statement was discarded, because of its similarity with the Mission one. The revised and official Vision, Mission and Values statements of JERICO are :

- **JERICO Vision statement:**

"JERICO will be the pan-European integrated gateway to long-term scientific and harmonised observations and related services for coastal marine systems."

- **JERICO Mission statement:**

"The JERICO mission is to enable a sound understanding of the responses of coastal marine systems to natural and anthropogenic stressors. To do so, JERICO adopts a systematic approach to monitor, observe, explore and analyse coastal marine systems in order to reach reliable information of their structure and functioning in the context of global change. JERICO encompasses the whole range of environmental sciences, technologies and data sciences. It achieves observations at global, regional and local scales, through the implementation and the harmonisation of a set of complementary platforms and multidisciplinary observation systems. JERICO enables open-access to state-of-the-art and innovative facilities, resources, FAIR data and fit-for-purpose services, fostering international science collaboration."

- **JERICO Values statement:**

1. "<u>JERICO cares about the marine environment:</u> it contributes to the understanding and monitoring of the changes of coastal marine systems; it provides data-driven information for the protection and the sustainable management of coastal resources.

2. <u>JERICO declines scientific excellence through a regional approach</u>: it identifies scientific marine coastal challenges common to regional sites, gathering all major coastal observing systems throughout Europe; it has a strong scientific community and leadership developed and demonstrated during several previous EU-funded projects.

3. <u>JERICO implements multiplatform and multidisciplinary observation systems</u>: it uses scientifically sound observations of physical, chemical and biological parameters

and innovative biogeochemical observing technologies; it recognizes that scientific excellence in coastal areas can be achieved only through multisystems as these areas are characterised by many high-variable scales, both in time and in space.

4. JERICO seeks for collaboration and co-creation: it interacts with many other environmental RIs to take a holistic approach to the marine environment, from the coastline to the open sea, as a global ecosystem; it listens to its stakeholder and users to include their desiderata in its future development.

5. JERICO removes barriers: it enables open-access to state-of-the-art and innovative facilities, resources, FAIR data and fit-for-purpose services; it encourages transparent policies for the access, recruitment procurement and its governance; it promotes equal opportunities for its members considering gender equality and under-represented communities."

3. JERICO Community

a. Important EU project legacy

JERICO is an essential component of the EU efforts to a better understanding of coastal marine systems. It aims to be the future coastal component of the European Ocean Observing System (EOOS), to play a crucial role in AtlantOS and All Atlantic Ocean Research and Innovation Alliance and to be part of the Global Ocean Observing System (GOOS). The specificities of the coastal ocean had led the EU to invest in a complex endeavour for the coordination and harmonisation of coastal observing capacities in view of enabling multidisciplinary observations over a wide range of spatio-temporal scales. This was, and still is, supported by: (1) three successive 4-year EC funded projects to start constructing pan-European coastal RI involving about 40 partners from 17 EU countries, as well as (2) two concomitant projects (JERICO–S3 & JERICO-DS, the latter having recently ended) dedicated to advance the design phase of sustained JERICO and initiate a preparatory one.

JERICO-FP7 (Infra-IA): **FIRST STEP, Early years development**
2011-2014
Project Description: 27 partners from 17 countries. The JERICO consortium was formed from the existing and unconnected communities that were mainly relying on automated high-frequency observation systems: ferryboxes, gliders and fixed platforms like buoys. It provided a preliminary definition of coastal observation systems that deliver high-frequency in-situ physical and biogeochemical data, in the coastal domain. After this preliminary integration and harmonisation process, the consortium agreed on the need to better include the observation of the biology compartment with an ecosystem approach.

JERICO-NEXT (Infra-IA): **SECOND STEP, Biology and Biochemistry reinforcement**
2015-2019
Project Description: 34 partners from 15 countries. An ecosystem approach was applied according to five main scientific topics: (i) pelagic biodiversity focused on phytoplankton and eutrophication, (ii) benthic biodiversity focused on habitats, (iii) chemical contaminants (mainly organic), (iv) carbon cycle and carbonate system, (v) hydrography and transport

with some applications to operational oceanography and forecasting. The JERICO also integrated new systems: HF radars and coastal cabled observatories. First bricks were also laid to build a sustainable RI by elaborating a cost-business analysis and proposing a first scientific approach complying with the general JERICO mission.

JERICO-S3 (Infra-IA): **THIRD STEP, Regional structuration and interfacing**
2020-2024
Project Description: 39 partners from 17 countries. It is targeting a more science-integrative approach to better observe the coastal ecosystem, raising up the scientific excellence, with consideration of regional and local ecosystems; the preliminary development of an e-infrastructure supporting scientists and users by offering access to dedicated services; progress on the design of the RI and its strategy for sustainability. JERICO-S3 furthers collaborations with other marine RI initiatives to jointly progress on the structuring of the EU marine framework within (CMEMS, EUROARGO, EMSO, ICOS, EMBRC) and outside Europe. This H2020 project started on 1 Feb. 2020. Besides the scientific advancement, these three projects built a general strategy for the establishment of a European Research Infrastructure (JERICO). Further, conceptual and technical progress as well as a part of the Design phase of the RI are currently ongoing through the third I3 program (JERICO-S3).

JERICO-DS (Infra-DEV): **DESIGN Achievement OF THE RI**
2020-2023
Project Description: with a partnership organised according to 14 involved countries, it includes seven national coastal observing RIs thanks to the maturity of the consortium. It aims to both conclude a Design Phase and to initiate some tasks of a Preparatory Phase of the ESFRI process. It will work with a bi-directional approach, i.e. between national RIs and the pan-European dimension, to coordinate national engagements towards legally bound commitments. As a benefit of this long-term effort, since 2011, JERICO has developed a unique position, filling in a major gap in the landscape of European Environment RIs. JERICO has developed the conceptual and practical expertise aiming in providing high-quality coastal observations and services to the marine scientific community at large and to a range of local, regional (thus national) and European end-users. Moreover, several European countries have recently restructured their national effort to better address their coastal priorities into dedicated National Research Infrastructures (NRIs) dedicated to national coastal Observation, which clearly constitute the national basis of JERICO.

However, Europe still lacks an integrated Research Infrastructure addressing the complexity of marine coastal systems and the diversity of scientific/environmental issues and stakeholders within different national frameworks. JERICO clearly aims to fill this critical gap. As a result, it will enable cutting-edge European coastal research to reach a sound understanding of changes and adaptations of marine coastal systems.

b. JERICO advisory bodies

JERICO moves forward in part thanks to the various committees that have been put in place. These committees include:

- **The Scientific, Technical and Advisory Committee**:

The Scientific and Technical Advisory Committee (STAC), currently in place under the JERICO-S3 framework, serves as an international advisory body composed of leading experts and key stakeholders involved in JERICO. This includes representatives from institutions such as the University of Washington (iOOS), IMOS, MERCATOR Ocean International, EMBRC, EMSO, EUROARGO, ONC, as well as Patrick Farcy, one of JERICO's founding figures. For now, the same STAC will continue its role. However, in the future, the members of the STAC will be officially appointed by the Assembly of Members (AoM) and will provide independent, external expert advice on strategic, scientific, and technical matters to both the Executive Committee (ExCo) and the AoM, as necessary. A core function of the STAC will be to promote stronger collaboration with other related RIs and ensure that JERICO's products and services achieve maximum scientific and societal impact.

- **The JERICO User Committee**:

The JERICO User Committee (JUC) was established to offer specific guidance on user needs and requirements concerning JERICO's products and services. This is elaborated in detail in deliverable 9.2, which outlines the User Strategy. Later on, the JUC is expected to take on the additional responsibility of evaluating user satisfaction, providing feedback on the quality and relevance of JERICO's products and services. It will also play a key role in advising the Executive Committee on issues critical to the long-term sustainability and impact of the RI. During JERICO-S3, the JUC concentrated primarily on data management and was composed of four members, representing EMODNet (Dick M.A. Schaap), EOSC-Blue Cloud (Patricia M. Cabrera, Julia Vera Prieto), and Copernicus-INSTAC (Dominique Obaton). In the future, the JUC will be expanded to reflect the diverse spectrum of JERICO's user base, including representatives from the scientific community, environmental managers, and industry. The Terms of Reference (ToR) for the JUC were developed by Ifremer as part of Work Package 9 (WP9).

- **The Nations Committee**:

The Nations Committee of JERICO plays a pivotal role in the governance and long-term sustainability of the RI. It is composed of national representatives from each country involved in JERICO, ensuring that the strategic priorities, financial commitments, and national interests of all participating states are adequately represented. This committee serves as a platform for discussing national contributions to JERICO, including funding allocations, infrastructure development, and alignment with each country's scientific and monitoring agendas. One of the key responsibilities of the Nations Committee is to facilitate coordination between national coastal and marine programs and JERICO's overarching goals. By doing so, it ensures that JERICO is not only a pan-European initiative but also one that addresses the specific needs and priorities of each member nation. Furthermore, the Nations Committee is tasked with securing long-term financial commitments from national governments, which is critical to JERICO's ESFRI application and, should it succeed, JERICO's sustainability as it evolves and expands its services. In addition, the Nations Committee is involved in high-level decision-making processes that shape the future direction of the RI. This includes advising on strategic partnerships, resource allocation, and the development of new services or research areas that can benefit both the scientific community and society at large. By representing the diverse interests of each participating country, the Nations Committee ensures that JERICO remains a truly collaborative and inclusive effort, maximising its impact across Europe's coastal and marine research landscape.

- **The Steering Committee**:

The Steering Committee brings together representatives from each region or site within the JERICO, reflecting the distributed nature of its RI which is organised into regional and local sites spanning multiple countries. These representatives typically have a long history of collaboration in their respective regions, working together to achieve shared scientific or monitoring objectives related to coastal water research. The role of the Steering Committee is central to the governance of JERICO, ensuring that regional and local perspectives are integrated into the overall management of the RI. By doing so, it helps align local initiatives with the broader strategic objectives of the infrastructure. Later on, stakeholder analysis will play a critical role in identifying the most relevant users to be involved in the Steering Committee. They will contribute to the ongoing development and refinement of the RI's strategies, ensuring that the evolving needs of both scientific and non-scientific stakeholders are met. Their participation in regular reviews and governance processes will help maintain a responsive and adaptive approach, to ensure that the RI's activities remain aligned with its mission as well as its user expectations throughout its lifecycle.

c. Place of Users and Stakeholders in JERICO

Within the JERICO framework, **users** refer to the diverse range of individuals, institutions, and organisations that access, utilise, or benefit from the infrastructure's coastal and marine observation data and services. These users include most notably academic researchers, governmental agencies, environmental monitoring bodies, industry professionals, and NGOs engaged in marine conservation and policy-making. Ultimately, JERICO also serves the needs of **stakeholders**, who are entities with a vested interest in the development, operation, and outcomes of the infrastructure. Stakeholders include national governments, institutional representatives, European RIs, marine service providers and data aggregators, funding bodies, policy-makers and key players of Ocean Observing Systems worldwide. Their involvement is pivotal in ensuring the long-term success, relevance, and impact of JERICO on both regional and international levels. Taken together, users' and stakeholders' needs shape the direction of JERICO.

JERICO-S3 WP9 has made significant progress in addressing the various needs of key sectors within the Blue Economy. By leveraging JERICO's extensive mesh of *in-situ* coastal observatories, the initiative could provide crucial high-resolution, real-time data and expertise across multiple domains, including marine renewable energy, coastal management, and aquaculture. For the marine renewable energy sector, JERICO could offer fine-scale environmental data critical for site selection, impact assessment, and operational monitoring, complementing existing platforms like Copernicus and EMODnet. In coastal management, JERICO's data fills gaps in spatial and temporal coverage, supports hazard monitoring, and enhances resilience planning in the face of climate change. For aquaculture, it could facilitate site characterization, environmental monitoring, and real-time data access, aiding in the development of sustainable practices and risk management. Despite some limitations, such as the need for a more detailed and geographically specific user analysis and the development of tailored products, JERICO's ability to provide centralised access, foster data harmonisation, and build capacity underscores its pivotal role in advancing sector-specific strategies and decision-making processes.

An engagement strategy has been elaborated with the JERICO User Community to involve stakeholders into JERICO at the most relevant positions. Main users have been listed (Figure 1), as well as their needs and expectations in terms of Product and Services (P&S), as a first phase. Then we elaborated a methodology to assess their potential representativeness in JERICO according to their profile: needs/expectations versus influence capacity. This is explained in greater detail in JERICO-S3 deliverable D9.1. Then, according to the user and stakeholder profiles we can elaborate on whether they could be in the JERICO User Committee (JUC) and on the type of recommendations and advice we could get. Users and Stakeholders will be involved in the JUC according to their level of Influence (or Power) and Interest towards JERICO. Indeed, on the one hand, the more power (institution position, market position) a user has, the more she/he is able to interfere in the environment of the RI. On the other hand, the higher the user is interested in the scientific achievements of JERICO, the more she/he is likely to be involved in the RI. The ability (Power) and the willingness (Interest) to interfere in the Research Infrastructure are therefore complementary variables upon which we base our engagement actions.

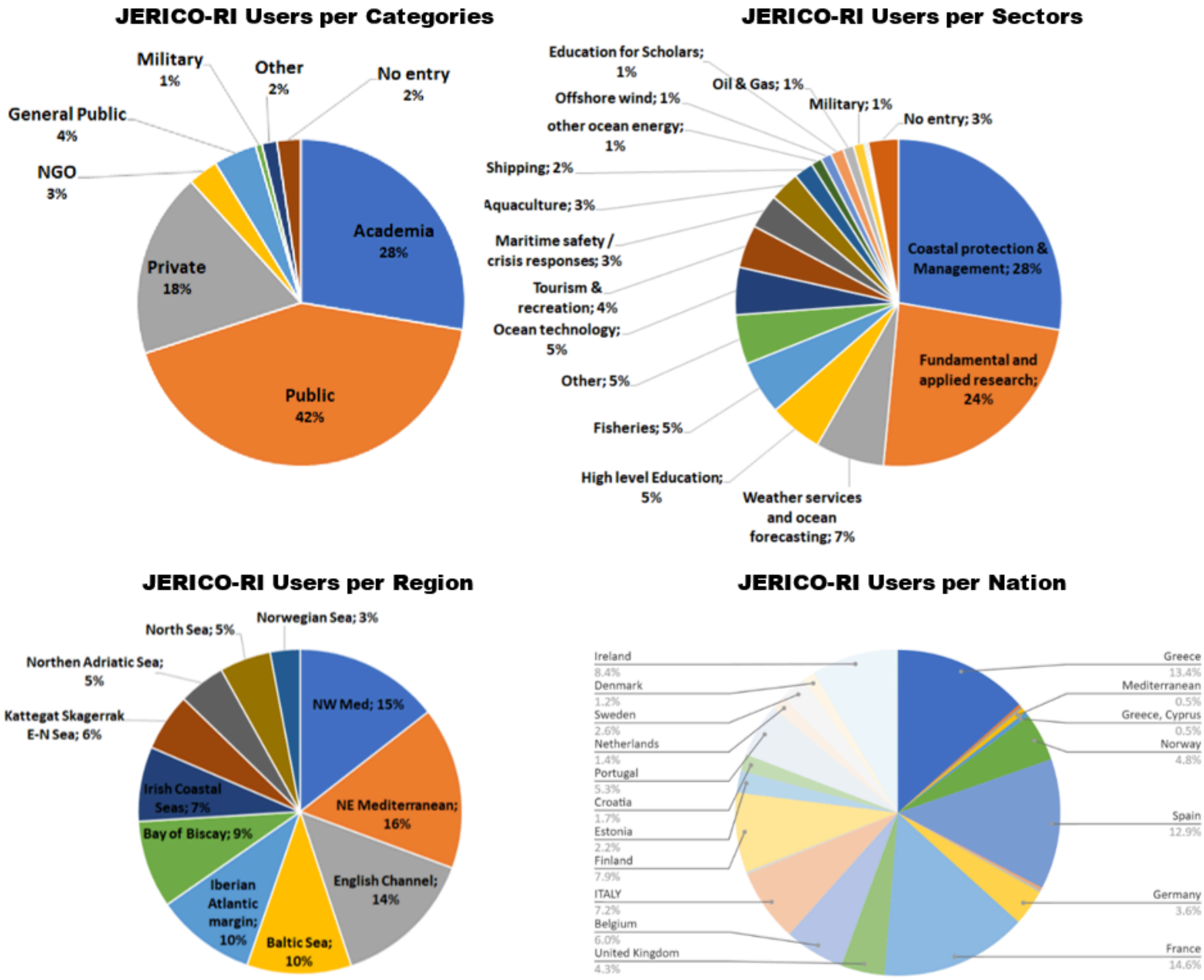


Figure 1: Distribution of JERICO users per categories, sectors, region and countries. Reproduced from JERICO-S3 D9.1.

The Users that we first consider involving in the User Committee of the Infrastructure are the ones with both a high level of power (ability to interfere) and with a high level of Interest (willingness to be involved). Thanks to a quantitative analysis led in the framework of the stakeholder analysis to elaborate the User Strategy, we have been able to allocate each user a Power Score and an Interest Score and rank them according to these variables (see Figure 2). The application of the methodology outcomes on a 4 cells matrix in which users and stakeholders are distributed into 4 categories: "Keep Satisfied" and "Manage Closely" for high power, and "Monitor" and "Keep Informed" for low power as shown in Figure 2.

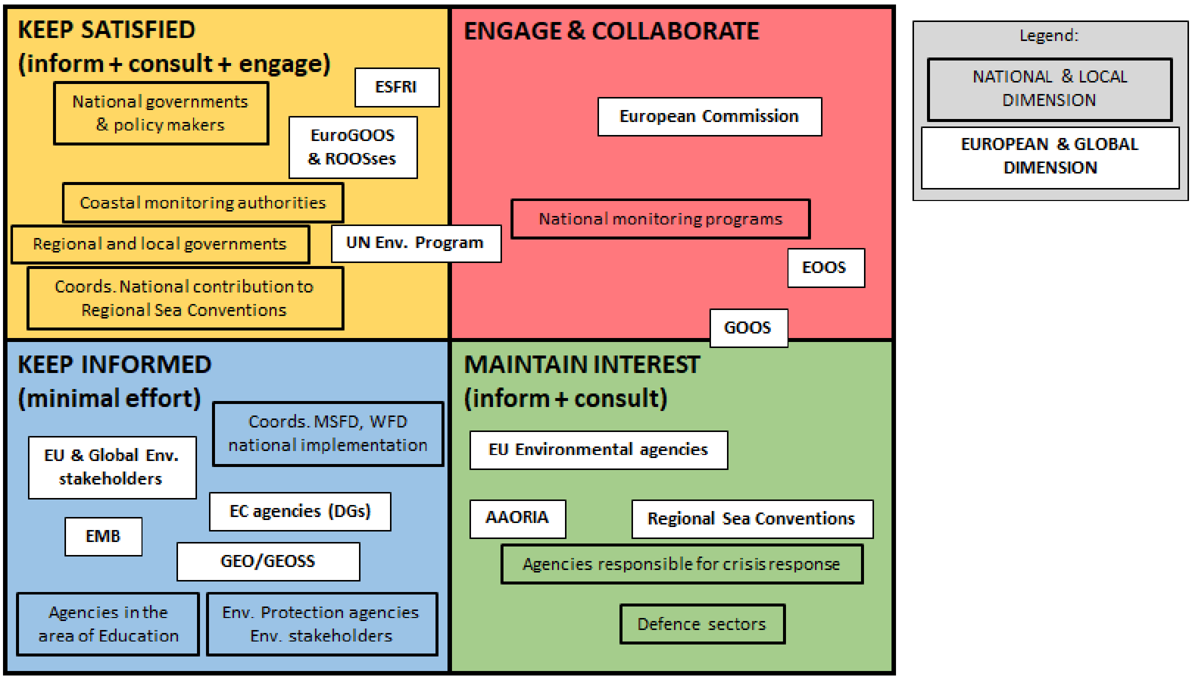


Figure 2: JERICO user classification following a Power vs Interest matrix, indicating the most adapted behaviour towards each currently identified user (reproduced from Figure 3a of D6.2 of JERICO-DS).

Those users belonging to the two other categories will be targeted with specific communication strategies to ensure they are aware of the potential of JERICO. They will also be surveyed to capture their needs. The analysis helps to restrain the amount of Users to be carefully considered, but many Users are filling a high level of Power in this raw analysis.

B. Science & Technology cases

1. Science case

The science case for JERICO lies in its ability to provide comprehensive, high-quality data and advanced observation systems that are essential for addressing the multifaceted challenges of coastal environments. **JERICO's science strategy** is centred on developing and integrating innovative coastal observation technologies and methodologies to monitor and predict changes in the coastal ocean. This leads to a better understanding and management of coastal ecosystems, contributing to sustainable development and the protection of marine resources. JERICO supports EU policies aimed at achieving environmental sustainability and resilience against the growing threats posed by climate change and human activities by bringing together various Research Infrastructures (RIs) and fostering collaboration across Europe. The three **Key Scientific Challenges** (KSCs) are the following:

- **KSC#1:** Assessing changes under the combined influence of global and local drivers.
- **KSC#2:** Assessing the impacts of extreme events.

- **KSC#3:** Unravelling and predicting the impacts of natural and anthropogenic changes.

In addition, 16 **Specific Scientific Challenges** (SSCs) were defined. These challenges align with societal needs and policy requirements, such as climate change adaptation, marine biodiversity conservation, and sustainable resource management.

The last elements of the scientific framework are **Research Axes** (RAs). RAs represent specific projects or activities designed to address the KSC and SSC, such as the development of new monitoring technologies, data integration strategies, and innovative research methodologies.

Within the JERICO scientific framework, KSCs and SSCs are enduring questions tailored to the marine coastal environment and are key components of the science strategy. RAs, however, are more focused on variables and processes that evolve in response to emerging scientific questions driven by societal needs. In this context, KSCs and SSCs contribute to the integrated observations (see JERICO-S3 D1.3).

The need for JERICO is further underscored by the increasing pressures on coastal zones, including sea-level rise, ocean acidification, pollution, and habitat degradation. These areas are often hotspots of biodiversity and economic activity, but they are also some of the most threatened environments globally. JERICO's integrated approach to monitoring and understanding coastal processes at multiple scales — from local to regional and pan-European — enables effective responses to these challenges. It provides critical data that informs environmental policies and management strategies, ensuring that interventions are timely, targeted, and based on the best available science.

To address scientific challenges effectively, the KSCs, SSCs, and RAs consider various scales, recognizing the dynamic and complex nature of ecosystems where ecological processes and human interactions can vary significantly, over short distances. An integrated multi-scale approach is essential for the effective management of these areas, so as to enable responses to local challenges and align efforts with regional and European strategies. This integration is crucial for addressing societal challenges related to the marine and coastal environment in a coordinated, holistic manner. Environmental management interventions, such as oil spill cleanups, habitat restoration, and fishing regulations, require precise and localised data to be effective. Small-scale observations enable targeted interventions in high-risk areas. Coastal zones are disproportionately affected by sea-level rise, ocean acidification, and extreme weather events. A multi-scale approach facilitates monitoring these impacts and adapting policies accordingly, considering local specifics while ensuring broader regional coordination. To fully understand coastal processes, it is paramount to combine detailed local observations (small scale) with broader analyses (regional or pan-European). For instance, regional climate models benefit from precise local data to refine their forecasts and scenarios.

Regions involved in JERICO-S3, including **Integrated Regional Sites (IRSs)** and **Pilot Super Sites (PSSs)** (WP3 and WP4), play a vital role in the integration, harmonisation, and efficient operation of coastal observatories. They contribute significantly to the pan-European effort of monitoring and understanding coastal seas by aligning with the overarching JERICO-S3 science strategy while addressing specific regional challenges. These regions standardise data collection methods, deploy innovative technologies, and engage a diverse range of stakeholders, including researchers and policymakers. Transnational and cross-regional integration is encouraged to extend regional activities to broader areas and jointly identify observational gaps. Furthermore, actions by IRSs and PSSs aim to promote the use of their data and products in collaboration with other RIs, in order to support EU directives, Regional Sea Conventions (RSCs) and European strategies and initiatives:

- JERICO could be instrumental in **the implementation of the marine Strategy Framework Directive (MSFD) and the Water Framework Directive (WFD)** by providing harmonised, high-quality data (*e.g.* concerning marine biodiversity, water quality and marine ecosystems) that could significantly help to assess the environmental status of marine and coastal waters.
- JERICO could **contribute significantly to RSCs** such as the **OSPAR** (North-East Atlantic), the **HELCOM** (Baltic sea) and the **Barcelona** conventions
- JERICO could be well-aligned as well with broader European actions, such as the **European Green Deal** and the **EU Biodiversity Strategy 2030**, by supporting sustainable resource management, marine spatial planning and biodiversity protection. JERICO could also **enhance climate change resilience**, for example by providing data on sea-level and coastal erosion.

More globally, **JERICO would as well contribute significantly to several Sustainable Development Goals (SDGs)**, that are related to environmental sustainability, climate action and the sustainable use of marine resources:

- **SDG 14 (Life below water)**

  JERICO could provide extensive and high-resolution data on marine ecosystems, water quality and biodiversity; such data is vital in order to track progress towards managing and protecting marine habitats. JERICO could also help for the identification and management of Marine Protected Areas (MPAs); thus helping the conservation and restoration of marine ecosystems.

- **SDG 13 (Climate action)**

  JERICO contributes to this SDG by monitoring the impacts of climate change on coastal and marine environments, with the availability of long-term time series on sea-level, ocean warming and acidification and coastal erosion. This could lead to much improved climate adaptation strategies and affiliated mitigation measures.

- **SDG 6 (Clean water and sanitation)**

  Data on water pollutants and contaminants, or eutrophication phenomena, are of great interest for the sustainable management of water. Such data for coastal areas could be provided by JERICO.

- **SDG 9 (Industry, innovation and infrastructure)**

  JERICO also supports SDG 9 by fostering innovation in the field of ocean observation technologies. JERICO enhances the development and deployment of new technologies, which in turn fosters innovation in marine industries and in the Blue Economy, and encourages investments.

- **SDG 11 (Sustainable cities and communities)**

  Data provided by JERICO is relevant for SDG 11 as well, in order to ensure a sustainable urban and coastal development; in particular, the real-time monitoring of sea-level and other coastal hazards (*e.g.* Harmful Algal Blooms) helps cities to better prepare for and mitigate the impacts of natural disasters.

- **SDG 17 (Partnerships for the goals)**

  JERICO contributes to SDG 17 by favouring international collaboration, as a pan-European RI; indeed, JERICO facilitates cooperation between various nations, research institutes and other bodies, around a knowledge-sharing, capacity-building platform. This strengthens the ability of coastal nations to address global environmental challenges.

Integration is the cornerstone of JERICO's overall science strategy, achieved not only regionally but also through technological innovation and experimentation (see JERICO-S3 D1.3). The goal of integration is to observe and understand complex processes occurring at different time and space scales, by combining multiple scales of distributed marine observations into a unified observation system, delivering freely accessible data to end users. This involves implementing an infrastructure comprising platforms and science-based sensor systems that measure physical, chemical, and biological properties and processes in coastal waters, from the boundaries of open ocean to those of the land-sea interfaces.

In JERICO, integration occurs on two levels: 1) the regional level, aimed at connecting disconnected, overlapping, or neighbouring systems and addressing gaps in existing observations, a concept demonstrated to some extent in the IRS/PSS; and 2) at pan-European level, where global harmonisation led by JERICO governance ensures coordinated coastal observations across regions to meet global needs. A central structure to coordinate these regions is essential, as developed in governance strategies.

The contributions of regions to the KSCs and SSCs are diverse (Figure 3). There are differences between IRS and PSS in terms of implementation and maturity. Within the PSS, approaches vary by region, depending on the region's history, scientific objectives, expertise, technological innovations, and connections between countries and existing RIs. In some regions, actions have broad regional representativeness, while in others experimentation is focused on small-scale processes. D1.3 emphasises the importance of interregional and transnational integration, as well as collaboration with other initiatives and programs beyond JERICO.

		Pilote Super Sites					Integrated Regional Sites				
KSC	SSC	North S.	EC	NWM	CS	BS/GF	BOB	NAS	IAM	K/S	Nor S
Assessing changes under the combined influence of global and local drivers	Land-Ocean continuum	✓		✓			✓		✓		✓
	Sea-atmosphere interface										
	Connectivity and transport			✓			✓		✓	✓	
	Biodiversity		✓				✓		✓		
	Primary productivity		✓		✓					✓	
	Ecosystem functionning	✓			✓	✓		✓		✓	
	Carbon budget and CO2 system	✓				✓				✓	
Assessing the impacts of extreme events	Extreme events & impacts on ecosystems			✓	✓	✓	✓	✓			
	Extreme events & coastal hazards						✓		✓		
	Harmful algal blooms		✓			✓				✓	✓
Unravelling and predicting the impacts of natural and anthropogenic changes	Climate change impacts					✓	✓		✓	✓	
	Eutrophication		✓	✓		✓					
	Impact of big cities			✓							
	Litter and plastic			✓			✓	✓	✓	✓	
	Contamination			✓					✓	✓	✓
	Unravalling impacts					✓	✓				✓

Figure 3: List of the 16 Specific Scientific Challenges addressed by the Pilot Super Sites and the Integrated Research Sites as identified during the JERICO-S3 and their further grouping in three Key Scientific Challenges (KSC). North S: North Sea, EC: English Channel, NWM: Northwestern Mediterranean, CS: Cretan Sea, BS/GF: Baltic Sea: Gulf of Finland, BOB: Bay of Biscay, NAS: Northern Adriatic Sea, IAM: Iberian Atlantic Margin, K/S: Kattegat/Skagerrak, Nor S: Norwegian Sea (table from D1.2)

The evolution of thinking around SSCs and RAs, along with increasing societal expectations, has led the JERICO community to consider explicitly addressing the land-sea interface. This includes observing coastal geomorphology, the transport of mineral and organic compounds, the impacts of land-originating discharges (both point-source and diffuse), and extreme coastal events (*e.g.*, heat waves, storm surges, habitat degradation), as well as pelagic-benthic coupling.

Many JERICO partners already address these scientific questions at the national level, with the necessary infrastructure and long-term funding in place. Thus, incorporating these topics within JERICO's scope was seen as a natural progression. Moreover, this inclusion provides a strong scientific foundation for leveraging complementarities between RIs, such as DANUBIUS (river to coast), EMBRC (marine biological resources), EMSO (deep waters), and ICOS (quantification of carbon fluxes), and developing joint research actions and services. The memorandums of collaboration (MoC) established bilaterally with these RIs reflect this complementarity and shared vision (see JERICO-S3 D2.1).

JERICO's science strategy is built on a multi-scale and multidisciplinary approach to understanding the complexity of coastal environments. It is based on the integration of multiple platforms and may be enhanced through collaborations with other established marine RIs within the EU landscape (*e.g.*, EMSO, EMBRC, EURO-ARGO, ICOS, DANUBIUS). Strengthening collaboration and interoperability with these RIs is viewed as crucial for maximising the value and impact of these RIs (including JERICO) on science and society and for supporting EU policies. A mapping of commonalities between RIs (Figure 4) has formed the basis for establishing MoCs with these RIs.

Collaboration field	EMBRC	EMSO	EuroARGO	ICOS	DANUBIUS	eLTER	LifeWatch
Marine Biology	X	X			(X)	X	X
Ecology Research	X				X	X	X
DeepSea Platforms		X	X				
Subsurface Ocean Properties			X	Not yet			
Marine Carbon Cycle			X	X			
River-sea Continuum					X		
Ecosystem structure and functions						X	X
Near shore sites	X	X		X	X	X	
Biodiversity	X	X				X	X
Mesocosms							
Biogeochemistry		X	X	X	X	X	
Data	X	X	X	X	X	X	X
Services	X, access	X	X (data provision)	X	X	?	X (IT services)

Figure 4: Collaboration field proposed in the different MoC with others RIs (from JERICO-S3 D2.1)

In these collaborations, JERICO will offer extensive expertise in coastal and shelf seas, providing access to platforms, FAIR data (Essential Ocean Variables, EOVs, with high-quality control procedures), and in-depth knowledge of coastal processes across different regions (*e.g.*, water mass transport, acidification, phytoplankton distribution).

DANUBIUS has been identified as a high priority. For example, observations conducted by DANUBIUS are crucial for JERICO, as river discharges significantly influence physical, biogeochemical, and biological processes in coastal waters (*e.g.*, organic matter and nutrient fluxes, impacts on salinity and total alkalinity, primary production). Such collaborations will be demonstrated in the HORIZON-CL6-LandSeaLot project (grant #101134575), which seeks to enhance integration and collaboration between communities working at the land-sea interface, including the JERICO and DANUBIUS communities.

Collaborations with EMBRC will focus on developing tools (and/or best practices) for imagery (plankton morphology) and DNA analysis (plankton species) and deploying these tools on JERICO platforms as they reach a high level of maturity and performance (or Technology Readiness Level, TRL, for sensors). In this context, JERICO will provide long-term time series with spatial coverage of oceanic data, benefiting EMBRC in interpreting and understanding plankton distribution in the marine environment (*e.g.*, bio-regions, clustering). Scientific collaborations around environmental issues, such as Harmful Algal Blooms (HAB), invasive species, and conservation/restoration actions, are already envisioned by the two RIs.

Collaborations with EMSO and EURO-ARGO will focus on (1) technological developments of mutual interest (*e.g.*, coastal profilers, cabled observatories, autonomous observing vehicles) and (2) ensuring a seamless observing continuum from the coast to the open ocean and deep ocean. JERICO will contribute observations, expertise, and insights into processes occurring in coastal regions.

For ICOS, there is a need to extend and improve observations of air-sea CO2 fluxes at the land-sea interface and in coastal regions. Since 2015, the JERICO community has been working on observing the carbonate system in coastal waters. Currently, this is done using coastal fixed buoys and Ferrybox systems, but in the future, it could involve autonomous platforms, an area where JERICO has significant expertise (*e.g.*, gliders). Collaboration between ICOS and JERICO experts may accelerate the deployment of tailored solutions to better understand the carbonate system, its variability, and its ecosystem impact in coastal regions. JERICO will provide auxiliary variables necessary for ICOS to adjust and validate carbonate variables, which require enhanced accuracy in coastal waters (*e.g.*, measurements for Total Alkalinity, Total Carbon, and pH), along with access to multiple platforms for deployment.

2. JERICO Technological Roadmap

JERICO-DS WP2 was responsible for defining the technical design of JERICO, drawing on national capacities and visions and working closely with WP1, which focused on the Scientific Strategy. This process involved a Technology Outlook, which served as the foundation for a Technology Gap Analysis. This analysis then facilitated the development of a comprehensive Technology Roadmap, created in close collaboration with WP3, which focused on the future e-infrastructure of JERICO to ensure optimal integration with the physical infrastructure.

The technological design of JERICO began with a detailed survey distributed to national representatives, providing a clear overview of technical capabilities, refined through JERICO-DS deliverable D2.1. The design process addressed four key technical aspects critical to JERICO's operation: Strategy - how to coordinate technology use and align with existing initiatives; Systems - selection and implementation of technologies; Structure - organisation of technical work and technologies to achieve JERICO's goals; and Staff and Skills - required human capacities and competencies. The technological framework established essential components and "core variables," which were initially based on GOOS Essential Ocean Variables (EOVs) and later expanded to include variables necessary for addressing JERICO's specific KSCs. These variables can be observed at least semi-continuously with current sensors and platforms, with the option to introduce new variables that enhance the KSCs and ensure interoperability with existing "core" variables.

In JERICO-DS deliverable D2.2, an assessment of existing technical capacities was conducted using the same questionnaire for national representatives, along with relevant findings from JERICO-S3 and previous JERICO projects. This assessment summarised the current spatial and temporal resolution of JERICO observations and the Technological Readiness Levels (TRL) of observation methods for "core variables" at JERICO sites. The analysis identified key issues, primarily the lack of operational, high TRL sensors and procedures for monitoring biological, chemical, and benthic variables. This gap is largely due to insufficient sustained funding, which depends on national priorities and resources, occasionally supplemented by European research projects. Despite significant support from stakeholders such as the European Environmental Agency and COPERNICUS, which do emphasise the need for high-quality FAIR in-situ data, and especially so for coastal areas, the funding for necessary technical and human resources remains to be increased.

The Technology Roadmap for JERICO was developed through a collaborative approach involving extensive interactions with national representatives via questionnaires and workshops. Detailed in JERICO-DS deliverable D2.3, the roadmap included a list of development proposals and related activities for the four technical aspects identified (Strategy, Systems, Structure, Staff and Skills), which were evaluated and ranked by the national representatives, resulting in a shortlist. The feedback was analysed and balanced with JERICO's resources and the requirements for the upcoming ESFRI application. A final list of Technology Roadmap items was established, comprising 44 activities divided into three phases: "Now" (tasks to be completed before the ESFRI application), "Short" (tasks for JERICO's Preparatory Phase), and "Long" (tasks for JERICO's Implementation Phase). The timelines for Strategy, Structure, and Systems activities are illustrated in Figures 5, 6, and 7. To oversee the implementation of these activities and the execution of the Technology Roadmap, the NC (Nation Committee), associated groups in JERICO-S3, and the ESFRI proposal writing team will maintain close and frequent collaboration.

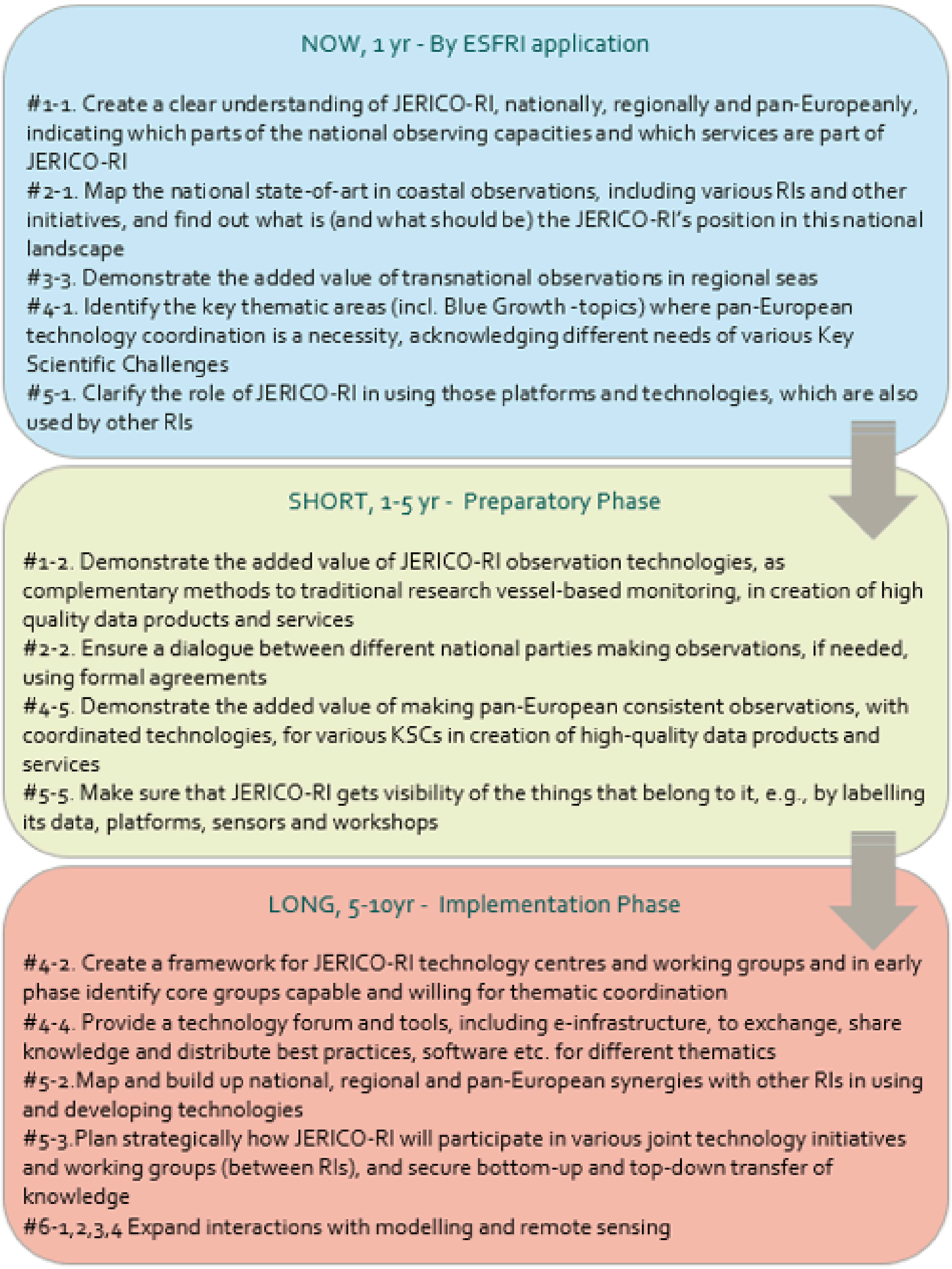


Figure 5: JERICO Technology Roadmap Activities for Strategy Proposals. Reproduced from JERICO-DS D2.3.

NOW, 1 yr - By ESFRI application

#9-1. Make the catalogue of SOPs and Best Practices easily available
#10-1. Perform an in depth analysis of PSS and IRS work done, in terms of transnational technology collaborations
#11-6. Participate in marine industry events for promotion of JERICO-RI technologies and opportunities

SHORT, 1-5 yr - Preparatory Phase

#7-4. Demonstrate, towards stakeholders at nations and regions, the added value of transnational and multiplatform approach, and technology requirements of it
#8-2. Plan, as necessary, the required JERICO-RI technology centres for centralised supporting actions and identify core groups capable and willing for their coordination
#10-4. Build-up transnational demonstrations of technology collaboration, with follow-up documentation of issues faced

LONG, 5-10yr - Implementation Phase

#7-1. Create a mechanism for joint evaluation of emerging coastal challenges and required observing technologies, to steer the future developments in observations
#7-2. Identify national and regional priorities in KSCs and their subsequent needs for developing technologies and observations
#7-3. Recognise pan-European added value, per various KSCs, for joint harmonised observations, and balance these with national and regional observation priorities
#9-5. Reinforce training for methods and use of SOPs and Best Practices
#9-6. Secure seamless integration of technology Best Practices and SOPs with those for data management
#11-4. Promote the JERICO-RI platforms, especially new technologies used, multiplatform approach, and pan-European sites, as key sites for industry in their product development

Figure 6: JERICO Technology Roadmap Activities for Structure Proposals. Reproduced from JERICO-DS D2.3

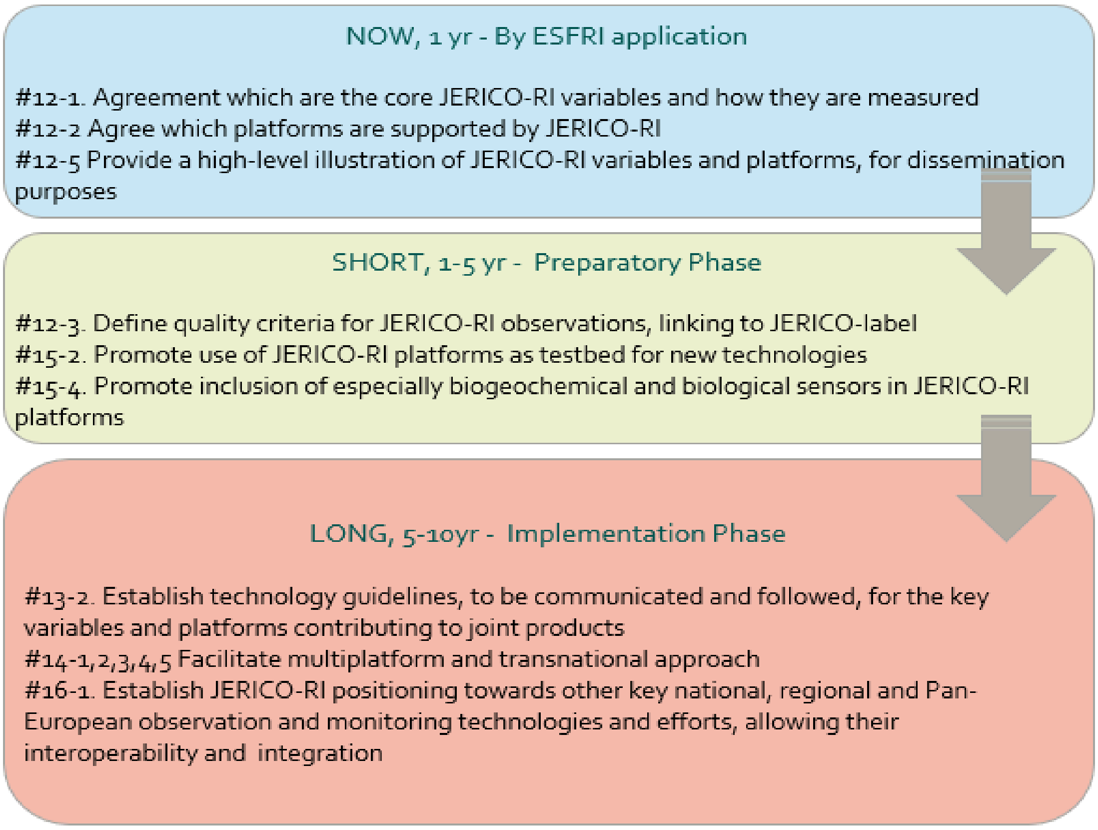


Figure 7: JERICO Technology Roadmap Activities for Systems Proposals. Reproduced from JERICO-DS D2.3.

3. Regional approach of JERICO

The JERICO-S3 project, through WP1, aimed to refine the science strategy established during JERICO-NEXT and develop a forward-looking vision for coastal observation systems, both in terms of technology and methodology. A primary objective was to identify common scientific questions that would underpin the science strategy. The JERICO-S3 project focuses on three main pillars: enhancing societal impact for a broader community of stakeholders; advancing innovative technologies for Coastal Ocean observing and modelling; and interfacing with other Ocean Observing initiatives.

The regional approach of JERICO-S3 is characterised by the establishment of Integrated Regional Sites (IRS) and Pilot Super Sites (PSS) across European coastal regions. At the time of this report, JERICO operates 5 PSSs and 5 IRSs (see Figure 8).

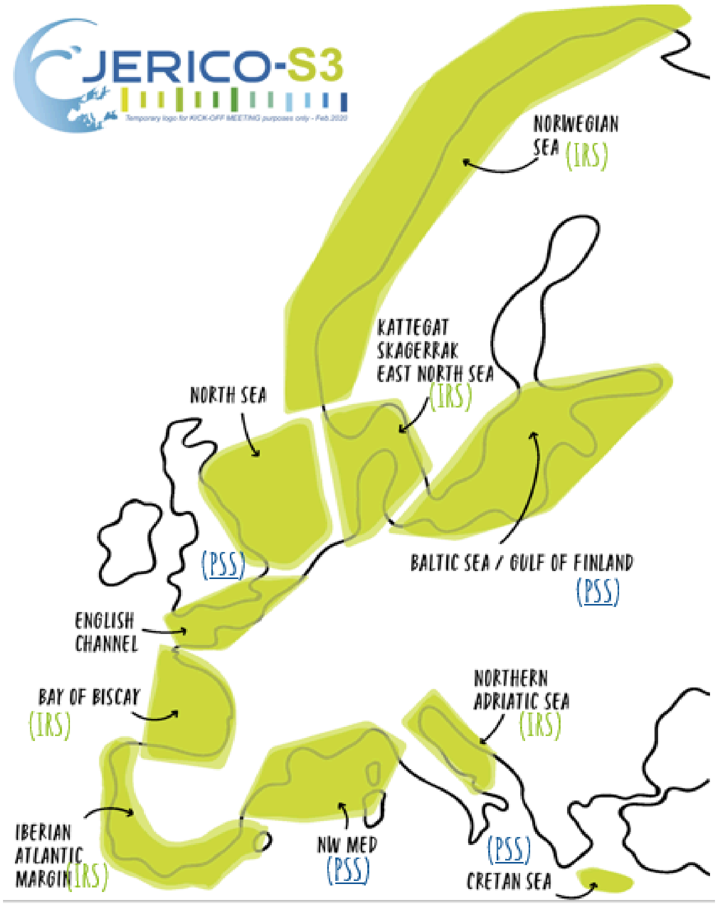


Figure 8: Map showing the geographical locations of the PSSs and IRSs part of JERICO-S3. Reproduced from JERICO-S3 D1.1.

IRSs serve as extensive coastal observatories designed to capture the variability and complexity of regional coastal dynamics. Their role primarily involves networking activities to promote transnational collaboration, including mapping and developing governing structures, organisational strategies, integration approaches, observational strategies, and regional data management and accessibility. IRSs incorporate various observing systems, sensors, and data collection methods to deliver comprehensive insights into physical, chemical, and biological parameters.

In contrast, PSSs are specific sites selected for innovative research efforts, targeting particular societal needs and scientific gaps. These sites are advanced enough to support innovative methodologies, technologies, and modelling approaches, enabling detailed studies of specific coastal processes or phenomena. Together, IRSs and PSSs create a network that provides a multi-scale understanding of coastal environments, ranging from regional dynamics to localised phenomena across Europe.

The first deliverable from JERICO-S3 WP1, D1.1, laid the groundwork for the science strategy by identifying common scientific challenges and outlining spatial patterns for addressing these challenges across the network. This process involved extensive partner consultations to collect regional inputs, resulting in the identification of 40 scientific questions and objectives, which were categorised into 16 SSCs, further organised into the 3 KSCs inherited from the 2021 ESFRI application. This framework is continually updated with a list of RAs, which includes recommendations based on preliminary regional analyses, particularly regarding innovative technologies.

The preliminary analysis highlighted regional differences in maturity levels, showing that both PSSs and IRSs serve as proof of concept for regional integration, transnational governance, and collaboration. To maximise system benefits, the analysis mapped limitations in addressing some SSCs and KSCs, identified structural issues within the RI, and emphasised the need for strong interactions between PSSs and IRSs. This included the necessity for coordinated efforts across work packages and centralised actions to address technological and organisational challenges and large-scale, long-term environmental issues.

JERICO-S3 deliverable D1.2 provided a detailed assessment of which KSCs and SSCs were being addressed by each region. It noted that only a few platforms were equipped to measure biological variables (such as phytoplankton and zooplankton counts and benthic observations), even though these measurements are increasingly vital. Additionally, the challenge of data harmonisation and integration became more significant with the inclusion of satellite observations and modelling tools. Certain RAs were prioritised based on regional challenges and capacities (*e.g.*, phytoplankton observations in the Gulf of Finland, 3D transport models in the Northwestern Mediterranean). While not all regional specificities were adequately addressed due to limitations in mature technologies, integration tools, and regional collaboration infrastructure, common scientific and societal challenges were identified across all regions (*e.g.*, pelagic biogeochemical processes, carbon fluxes and budgets).

Challenges are often dependent on their geographical scale. JERICO-S3 D1.2 identified a key role for JERICO in centralising actions related to KSC#3 ("unravelling the impacts of natural and anthropogenic changes"), as climate change impacts are a concern for the entire European coastal area. This underscores the need for a pan-European vision and strategy to enhance collaboration in data and expertise. This highlights the value of JERICO as a comprehensive Distributed Research Infrastructure (DRI) rather than merely a network addressing regional challenges. Following the recommendations from JERICO-S3 D1.1, the decision was made to eventually eliminate the distinction between PSSs and IRSs, integrating them into common regions.

4. JERICO's Dynamic Framework: Balancing Stability with Adaptability

J ERICO operates within a dynamic framework that integrates long-term scientific objectives with adaptability to emerging needs in coastal marine research and technology. Anchored by KSCs and SSCs, JERICO focuses on advancing our understanding of coastal marine ecosystems, addressing environmental risks, and promoting sustainable marine resource use (see also JERICO-S3 D1.4 for a complete picture of the long-term vision, and D1.5 for an exhaustive assessment of the science strategy). **These objectives align with**

the UN Sustainable Development Goals (SDGs) and European policies (see section B.1).

a. A stable overarching scientific objective

While JERICO embraces adaptability to integrate emerging technologies and address evolving user needs, the stability of its foundational framework is equally crucial. The current set of KSCs and SSCs was defined after a broad consensus was reached, and they form the cornerstone of JERICO's stability, providing a consistent research focus that guides the entire network's efforts.

Key Scientific Challenges (KSCs) represent the broad, overarching issues that JERICO aims to address, such as understanding the impacts of climate change on coastal ecosystems or mitigating environmental risks from pollutants. These challenges are designed to be stable and enduring, reflecting long-term scientific priorities that align with global and European environmental goals, including the UN Sustainable Development Goals (SDGs).

Specific Scientific Challenges (SSCs), on the other hand, are more detailed and focused, addressing particular aspects or processes within the broader KSCs. While SSCs may evolve as new scientific knowledge emerges or as specific research needs change, they are structured to ensure continuity in JERICO's research agenda. This stability ensures that the infrastructure maintains a clear and consistent direction in its scientific endeavours, even as technological and methodological advancements occur.

With this stable set of KSCs and SSCs, JERICO ensures that its research framework remains focused. This stability is essential for achieving long-term scientific goals and delivering consistent outcomes. It provides a reliable basis upon which the infrastructure can build and adapt, integrating new technologies and methodologies without losing sight of its core scientific objectives.

b. An evolutionary approach

On the other hand, to maintain relevance and impact, JERICO's Research Axes (RAs) and Technological Roadmap are designed to be flexible, incorporating new discoveries and technological advancements as they arise.

The technological Roadmap (see section B.2.) is a cornerstone of JERICO's adaptability, and it outlines three phases: "Present," "Short-term," and "Long-term." Developed collaboratively with national representatives, this roadmap identifies current technological needs and highlights gaps in sensor and observation systems, particularly for biological, chemical, and benthic variables. It ensures that JERICO can advance its employed technology to meet emerging research challenges while maintaining interoperability with existing systems. **This approach is crucial for harmonising and integrating coastal observation efforts across Europe.**

By 2040, JERICO anticipates a transformative shift driven by advancements in Internet of Things (IoT), artificial intelligence (AI), automation, and biotechnology. The future coastal observing systems will leverage continuous, high-resolution data streams from an extensive array of interconnected sensors, allowing for precise monitoring of physical, chemical, and biological parameters across spatial and temporal scales. AI-driven predictive models will enhance our ability to foresee and manage environmental changes, while autonomous platforms such as autonomous underwater vehicles (AUVs), drones, and robotics will enable constant data collection in diverse and remote locations. Biotechnology innovations, including environmental DNA (eDNA) analysis and advanced biosensors, will provide unprecedented insights into marine life and ecosystem health.

A relatively high number of platforms from various countries is already included in JERICO, although not all platforms stand at the same technological level. JERICO evaluates the maturity of its observatories using a conceptual framework that includes Technological Readiness Levels (TRLs) and alignment with agreed Best Practices. By classifying observatories into different maturity levels, JERICO identifies areas for improvement and guides less mature sites toward adopting advanced technologies. This classification helps align practices with international standards, such as those set by GOOS, ensuring that the network delivers high-quality data for scientific research and policy support for coastal areas.

JERICO emphasises adaptability also in its User Engagement Strategy, driven by feedback mechanisms and user engagement. The JERICO User Committee (JUC) and the JERICO User Forum (JUF) are instrumental in ensuring the infrastructure meets the evolving needs of its diverse user base, including both scientific and private sector stakeholders. The JUF will facilitate continuous interaction and enable users to provide feedback and engage with JERICO's management team directly. JERICO's approach to user engagement is informed by ISO 9001 international standard for quality management. This includes monitoring user satisfaction through key performance indicators (KPIs) such as the Net Promoter Score, User Effort Score, and User Satisfaction Score. Regular surveys and post-Transnational Access (TA) questionnaires collect detailed feedback, allowing JERICO to refine its various services and ensure they consistently align with user needs. By learning from other successful European RIs, such as Euro-Argo ERIC and EGNOS, JERICO is developing a flexible and scalable User Engagement Plan to adapt to evolving user needs over time.

JERICO's e-infrastructure, particularly JERICO-CORE, ensures seamless integration with other European RIs like Blue-Cloud. A dedicated Access Policy governs the use of physical, remote, and virtual access modalities, adhering to principles of fair, transparent, and non-discriminatory access. This policy aligns with the European Charter of Access for Research Infrastructures, promoting scientific excellence and international cooperation.

c. JERICO's framework summary

JERICO's long-term vision is supported by a flexible framework that balances scientific excellence with practical management of a distributed, multinational Research Infrastructure. The Technological Roadmap, maturity assessments, and the JERICO Label contribute to sustainability, ensuring high-quality, FAIR data and services for the future.

Additionally, JERICO's commitment to user engagement through the JUC, JUF, and robust feedback mechanisms ensures the infrastructure remains relevant and beneficial to both the scientific community and broader society in the longer term.

The dedication of personnel involved in JERICO activities has been very important, as they drive sustained observation efforts and maintain long-term commitment to the infrastructure's goals. This human resource aspect is critical, as it ensures that the technological advancements—integrating IoT, AI, automation, and biotechnology—are effectively applied to real-world challenges. By cultivating a skilled workforce and fostering collaboration among its members, JERICO enhances its capacity to address both long-term coastal environmental research challenges and the immediate needs of its diverse stakeholders, setting the stage for a transformative shift in coastal observation by 2040.

At the same time, JERICO's KSCs and SSCs provide a stable foundation for the infrastructure's long-term scientific focus. These challenges ensure that while the technological and operational aspects of JERICO evolve, its core scientific objectives remain consistent, addressing critical issues such as climate change, ecosystem health, and sustainable marine resource management. This balance between adaptability and stability is key to JERICO's enduring impact.

C. Design of JERICO

JERICO provides a fundamental component of the EU effort in observing and understanding the coastal ocean. JERICO is the natural convergence of a) the actions of several European countries for the structuration of their NRIs (National Research Infrastructures) dedicated to national coastal Observation, and b) three successive EC-funded projects, of which the last two ones have concluded or are to be soon (JERICO-S3 and JERICO-DS).

The Design for the future sustainable pan-European JERICO builds on the scientific case presented in Section B, in terms of KSCs, of SSCs and of RAs (see Figure 3). A key concept that underlies all the JERICO projects and NRIs, is the consideration of the entire data cycle, from sensors to data and to products and services. This concept is applied to multidisciplinary data, implying multiple data life cycles, with the goal of using them jointly to successfully tackle the KSCs and provide extensive services of excellence. The Design strategy is articulated in order to ensure a sound strategy for the JERICO and follows the architectural development of JERICO, as reported in Section B. Here we briefly indicate the main directions that are then expanded in the following subsections.

The first direction (expanded in section C.1.) addresses the core of the JERICO, *i.e.* the design of an harmonised RI in the coastal ocean. Starting from an overview of the extensive present observing system that composes the JERICO, future developments are designed, including enhanced best practice applications for multiparametric sensors to be used in a holistic way, and developments of innovative technologies. Parallel to this direction, and starting from the present regional approach of JERICO, a design of the future site and observation system structuration (section C.2.) is carried out. As a next step, the elaboration of Services for science and society is presented (section C.3.), to be considered together with the plan involving users and stakeholders (see section A.3.b.). Present services are discussed and a roadmap for future ones is presented. Another crucial point in the design of the JERICO is the collaboration with existing harmonised observation initiatives (section C.3.a.). Here, general support statements from other RIs are presented and a collaboration plan is designed. Finally, the design of the JERICO governance is presented (section C.4.).

1. A harmonised European RI for Science & Society in the coastal and littoral area

As described in section B (see also Figure 9), observations for the coastal ocean encompass a great number of platforms and techniques, most of them relying on automated high frequency sensors, including fixed platforms (*e.g.* buoys and moorings), ferryboxes, gliders, coastal cable observatories, and HF radars. The JERICO observing infrastructure includes today all these types of platforms, and is distributed on nearly every European coastal border from the northern Norwegian coast down to the Canary Islands. As a result after the last 11 years of projects, during which the JERICO community structured and coordinated the step by step development of a European Coastal Ocean Observing System (ECOOS), the observation system is Europe wide, multisystem, multiparameter, multidisciplinary, integrative and involves 14 nations.

The JERICO is made of 432 fixed platforms/stations, 7 coastal seabed based observatories, 27 HF Radars, 16 Ferry-box lines, 16 glider transects, 4 referenced coastal profilers, 1 saildrone, 1 surface drifters and 34 regular and long term manual sampling stations (see also Figure 10). It is an impressive coverage, where fixed platforms/stations are prevalent, but also other platforms play an important role. HF radars, for instance, are less numerous but they cover large areas and, being a relatively recent operational technology, are rapidly developing in terms of implementation. Ferry-box lines are mainly situated in Northern Europe even though some transects are maintained also in the Cretan sea. Gliders transects, on the other hand, are mainly located in the Mediterranean Sea. Only a few coastal profilers are mapped, that is not surprising due to their vulnerability in coastal areas. In terms of variables observed, there are 327 water temperature measuring points, 127 for conductivity, 121 for turbidity, 103 for dissolved oxygen, 64 for pH and only 6 for pCO_2. Surface current is measured in 56 locations. Biology is observed in 118 locations by Chl-A fluorescence and in 54 locations as phytoplankton observations. Chemicals are observed in 33 locations only. It appears that when the technology that needs to be used for a variable, such as pCO_2, is not based on optics, thermocouple or resistive electrodes, the number of locations where the variable is addressed is low. Wind speed and direction, air pressure and air temperature are measured in nearly 100 locations as well.

Special equipment items described in section B.2. could be part of the JERICO observing systems as "services". Indeed these special equipment items could be proposed by JERICO to be deployed temporarily, on demand, in specific regions to address specific scientific topics. Transnational Access (TA) mechanisms could be used in order to organise the provision of equipment to scientific teams.

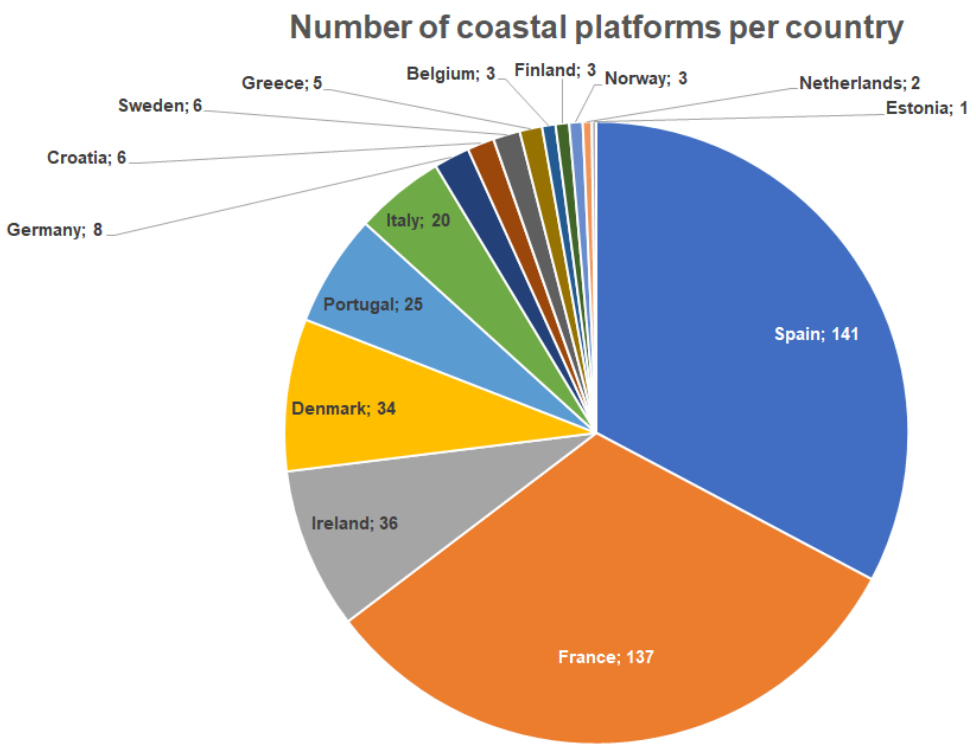


Figure 9: Distribution of fixed point coastal observing platforms in Europe per country.

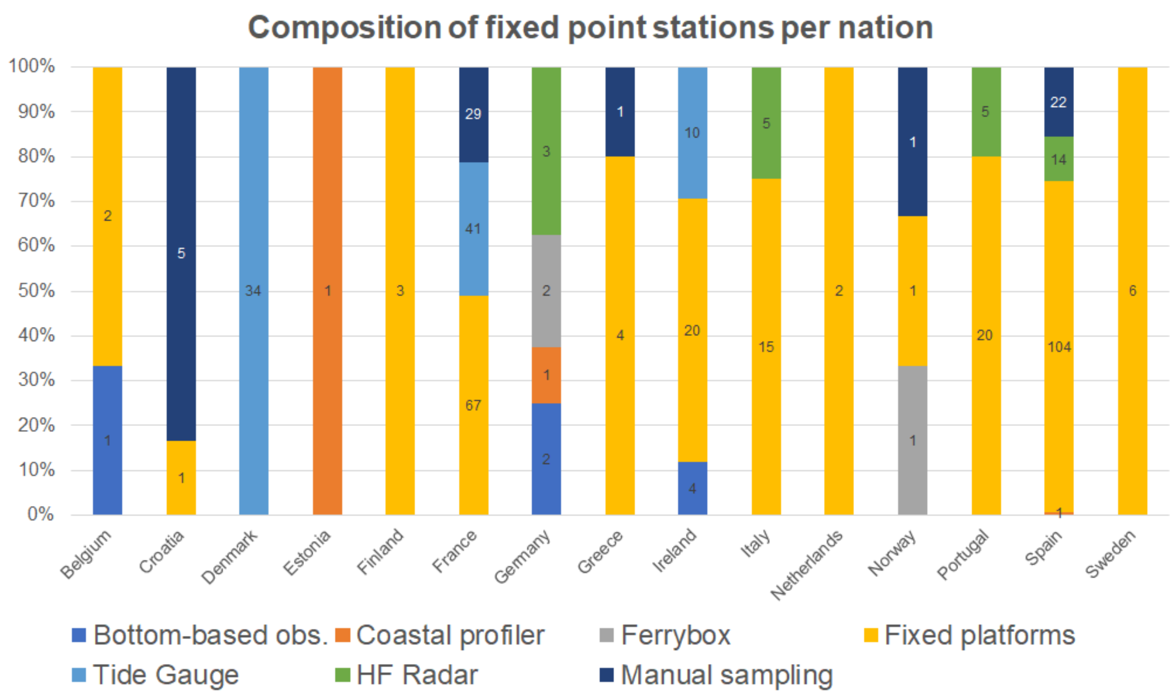


Figure 10: Distribution of fixed point coastal observing platforms in Europe per type of platform.

As a first conclusion, we highlight that JERICO covers the European coastline and is well suited to provide data to meet the various KSCs. JERICO maintains a fair amount of various observing platforms. The use of autonomous profiling systems can be further developed, since given the complexity of coastal waters with respect to the open ocean, at present they are not largely deployed along the European coasts.

Of the various nations involved in JERICO, France and Spain stand out per the number of fixed point coastal observation stations deployed and per the need to cover two significantly different areas: the Atlantic Ocean and the Mediterranean seas. Their observation capacities are succinctly described hereby, as case studies in the framework of JERICO.

French Coastal Observation Systems

France has a robust mesh of research and observation initiatives known as *Service National d'Observation* (National Observation Service, abbreviated by SNO), coordinated under the NRI *Infrastructure de Recherche Littorale et Côtière* (Littoral and Coastal Research Infrastructure, abbreviated by ILICO). ILICO integrates various SNOs, facilitating comprehensive coastal and marine environmental monitoring, each SNO contributing to coastal and marine environmental monitoring. These infrastructures are operated by CNRS, IFREMER, and various French universities and span various geographic locations across France, not including at the moment overseas territories (which are monitored by several SONEL stations and by 2 specific SNOs: Corail & ReefTemps), also covered by observation initiatives. In total, France has 137 fixed-point stations (Figure 9), mostly fixed platforms (Figure 11) focused on physical, chemical or biological (Figure 12) data according to the observation program aims.

- **DYNALIT** focuses on turbidity measurements across major river systems (the Gironde, Loire, Rhône, and Seine), using manual sampling methods.
- **MOOSE** monitors chemical and physical parameters such as Chlorophyll-A (Fluorescence), dissolved oxygen, salinity, water temperature, and currents across various fixed platforms, moorings, gliders, and radar stations. Data collection encompasses both surface currents and deeper water layers.
- **PHYTOBS** focuses on phytoplankton and other biological measurements.
- **SOMLIT** integrates fixed platform observations, covering a wide range of environmental parameters such as salinity, dissolved oxygen, pH, turbidity, and water temperature.
- **SONEL** specialises in sea level monitoring, with fixed platforms located in coastal areas (usually harbours), contributing to long-term sea level data.

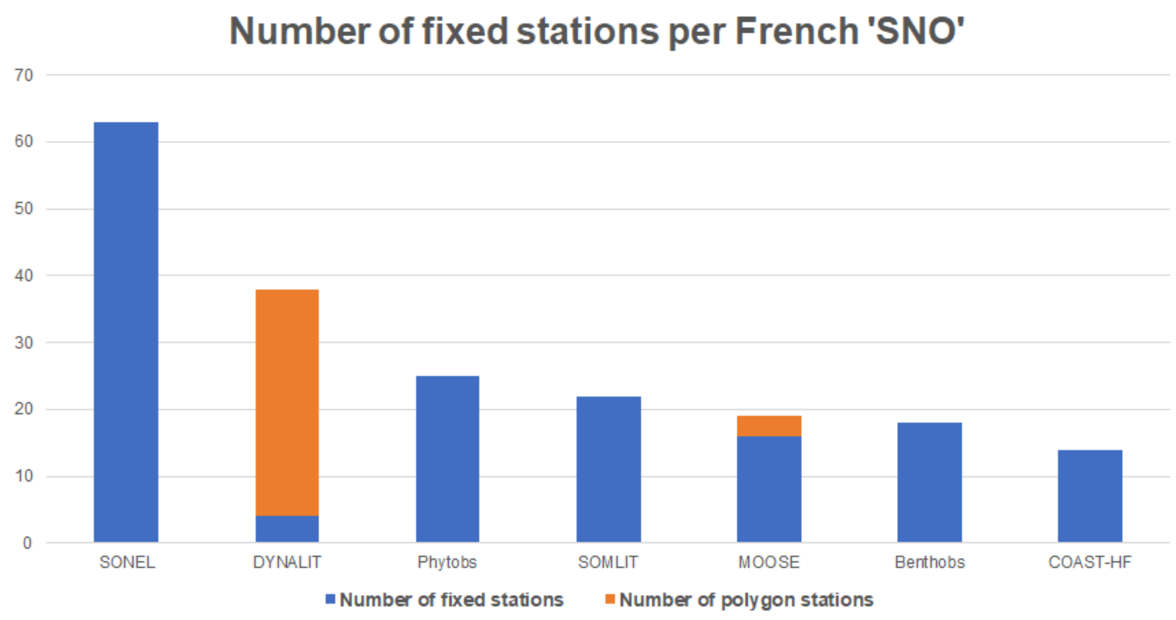


Figure 11: Distribution of fixed point coastal observing platforms in France per coastal observation initiative.

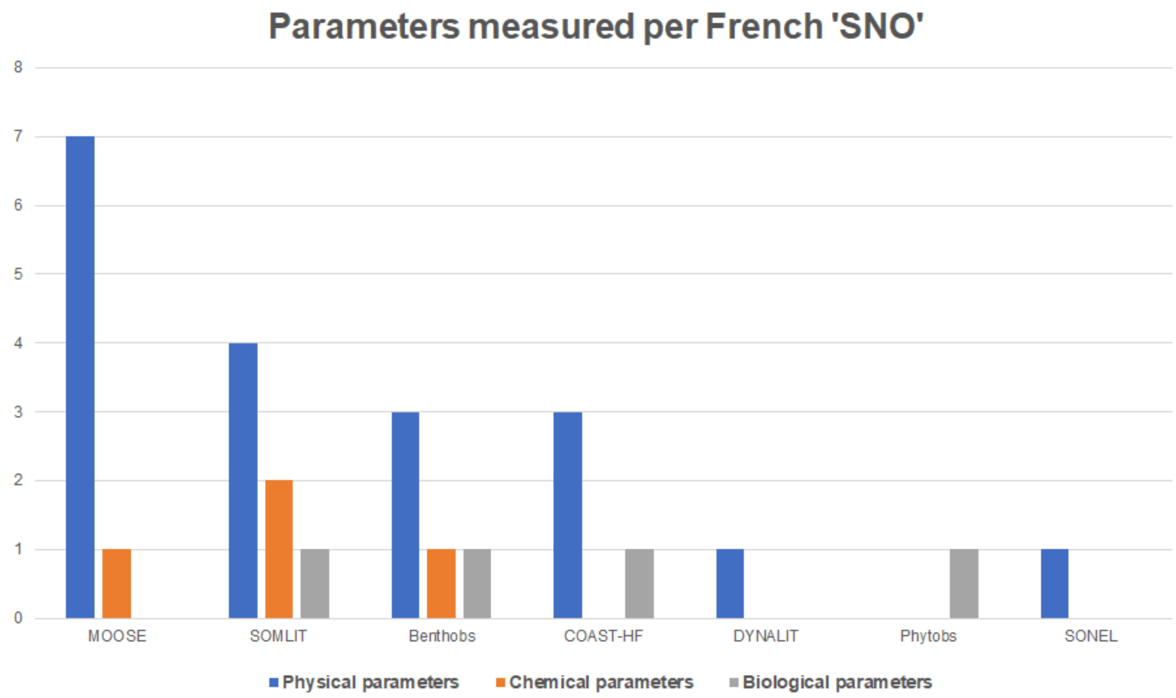


Figure 12: Parameters measured by each French coastal observation initiative.

ILICO and its associated SNOs present a comprehensive effort by France to observe and analyse its coastal and marine environments. Each initiative focuses on specific parameters essential for understanding marine ecosystems and their responses to environmental changes. The French systems will provide JERICO with comprehensive datasets that cover both the high-energy environments of the Atlantic and the more stable, yet equally critical, conditions of the Mediterranean.

Spanish Coastal Observation Systems

Spain has at its disposal various coastal and marine observation points, primarily operated by AZTI and Puerto Del Estado, in the Bay of Biscay, the Iberian Margin, and the NW Mediterranean, focusing on different types of platforms (HF Radar, fixed platforms, manual sampling, see Figure 13) and a variety of observed parameters such as surface and water column currents, air pressure, temperature, salinity, dissolved oxygen, phytoplankton, and biological benthic data.

For AZTI-operated stations in the Bay of Biscay, notable systems include:

- **HF Radar Systems** at Matxitxako and Higer, which track surface currents.
- **Fixed Platforms** like the Donostia buoy and Pasaia and Bilbao stations, observing parameters ranging from air pressure to water temperature, wave patterns, and wind direction.
- **Manual Sampling Points** such as L-A10, L-B10, providing detailed biological data, including benthic organisms, chlorophyll-A fluorescence, dissolved oxygen, salinity, and turbidity.

SOCIB (the Balearic Island Coastal Observing System) is also a significant contributor to coastal observations in Spain, focusing on the Balearic Sea and providing vital data for JERICO's objectives. Their integration of advanced technologies enhances the range and accuracy of collected data.

PDE-operated systems span a broader geographical range, from the Iberian Margin to the NW Mediterranean, with similar platforms and data collection:

- **HF Radar Stations** such as Faro de Cabo Silleiro and Antena Tarifa, tracking surface currents.
- **Fixed Platforms** like buoys near Gran Canaria and Tenerife, which capture a comprehensive set of environmental parameters including currents, waves, and air pressure.
- **Tide Gauges** located at several coastal points like Bilbao and Barcelona, focusing on sea level and wave observations.

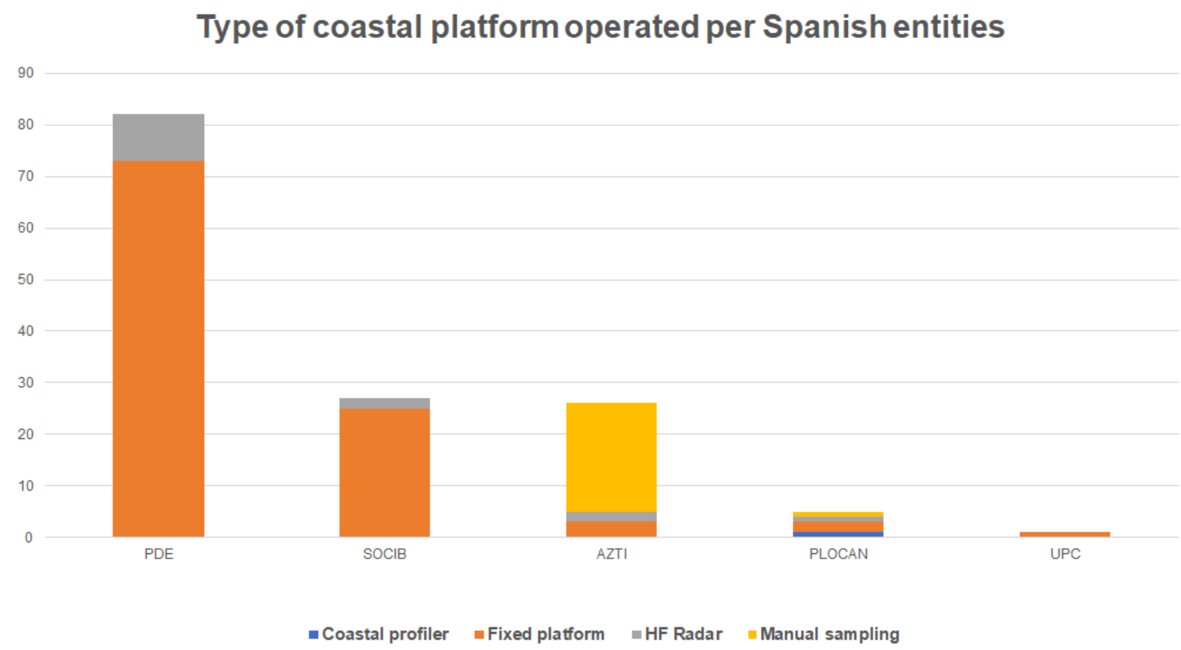


Figure 13: Type of platform used by Spanish coastal observation initiatives.

Spain's systems contribute to JERICO by providing a detailed view of the Mediterranean's environmental pressures and the Atlantic's dynamic conditions. This dual perspective enhances the ability to address diverse challenges and supports more effective regional and international marine management strategies.

2. JERICO observation system: future strategy and design

a. From the application of Best Practices on sensors, to the delivery of processed data

While the JERICO observing system outlined above is certainly impressive, there are still a number of challenges to face. Future steps are envisioned especially in terms of interoperability and integration, in order to guarantee an increasingly more holistic use of measured variables to best tackle science questions and to provide societal Services.

A basic requirement to enable efficient study and monitoring and streamlined services by an observing infrastructure - especially when it has to operate as part of a network - is defining and following Best Practices for managing and running it. This is particularly true in the context of instrumentation and measurement, maintenance, data acquisition, data flow, data integration and data product generation. Acknowledging this fact, the JERICO is used to place a lot of importance on Best Practices. Critical progresses have been made in the last 8 years through the JERICO series of projects, in terms of Best Practices definition and their application for the harmonisation of the observatories, for physics sensors and variables, and then for biogeochemistry and biology observations and their future integration.

As such JERICO already contributed significantly to the UNESCO/IOC "Ocean Best Practices system repository": https://repository.oceanbestpractices.org/handle/11329/362 and https://search.oceanbestpractices.org/search?q=jerico&fields=all. The current operation of systems to be part of JERICO, in the framework of the JERICO-S3 project, is pushing needed technologies towards maturity and readiness for integration in existing coastal observatories for monitoring and better understanding the complexity of the coastal areas. The mesh of systems embedded in JERICO saw its maturity increase with the completion of the JERICO-S3 project. The effort covers all the levels from the sensors and platforms to the data and their delivery as shown by the figure here after. It can be depicted in 3 steps before ending to the Users (Figure 14).

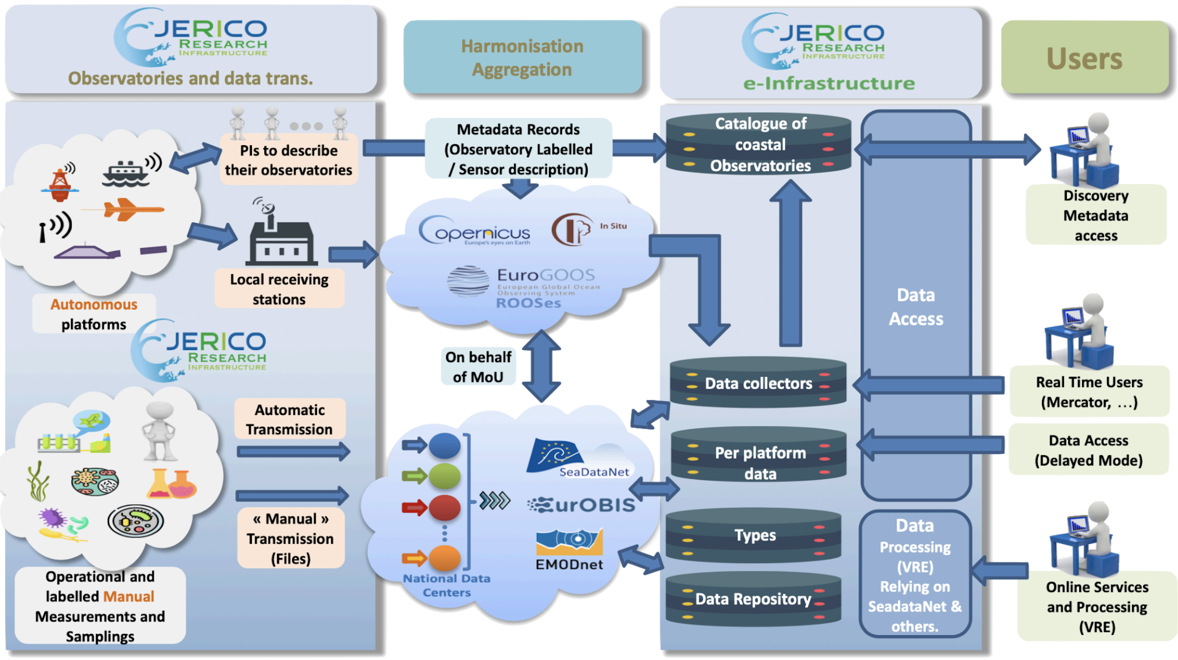


Figure 14: JERICO Data flux from the data sources to the users.

At the level of observatories

Regarding sensors and platforms, the current situation is that Best Practices (BPs) are still at different levels of development depending on the maturity of the observing platform. A dedicated effort is ongoing to achieve the highest "readiness level" on harmonisation in the JERICO with a coordinated and interactive implementation of multiplatform and multidisciplinary sensors. On the one side, previous documentations for mature coastal observing platforms (such as HF Radars, Gliders, Ferryboxes, Fixed Platforms) are harmonised and updated, and toolboxes are developed, such as dynamic technical inventory, collaborative support service, automated outage reporting and links to specific chapter/appendix of the BPs documentation. In parallel, a target effort is made for progressing in the harmonisation of procedures for pilot combined biogeochemical and biological systems. These include biogeochemical sensors on coastal observing platforms (*e.g.*, carbonate system variables, oxygen, nutrients), automated coastal water sampling and preservation of target molecules (barcodes) for DNA based biodiversity lab measurements, biological automated sensors mainly on phytoplankton & zooplankton functional diversity (using flow cytometry and multispectral fluorometer, and/or addressed by in flow and in situ imaging).

From observatories to data aggregators

A similar effort is ongoing to harmonise procedures applied along the data lifecycle including those to qualify the data quality. It also aims at providing tools and standards to stakeholders and Users to enhance the access and use of coastal platforms and data. Best practices from multiplatform perspective are identified, from data acquisition, processing and analysis, storage and preservation to publishing in the EU aggregators such as CMEMS, SeaDataNet, BlueCloud project, and EMODNet. JERICO tools are identified, tested and compiled for QA/QC, data and metadata management, and reformatting to support the data centres in data lifecycle management. JERICO promotes the efficient FAIR data management practices developed during the JERICO projects. The data management plans of JERICO evolved since its initial version in the FP7 project where:

- The Delayed Mode (DM) data flow follows the SeadataNet guidelines and procedures,

- The Near Real Time (NRT) data flow reaches the EMODnet services.

This came out on 3 JERICO-FP7 data management handbooks in 2015 (JERICO-FP7 D5.3 and D5.7, and D5.8 for NRT data) that describe the general JERICO data management structure and policy, and provide partners with practical advice and information on how to manage their DM and NRT data. The documents also contain references and links to the basic and most important online documents needed for implementing established procedures.

Then with JERICO-NEXT, key materials were added:

- A compiled data policy (Gorringe et al. 2017 - JERICO-NEXT D5.1), or recommendation, which states that every data provided to JERICO-NEXT shall be unencumbered, *i.e*. freely accessible at no charge to third parties. It is highly requested that all provided data are adequately documented with sufficient metadata in order to enable interoperability with data aggregators such as EMODnet, SeaDataNet/BlueCloud and CMEMS INSTAC. The JERICO-NEXT Data Policy provides recommendations on ownership, to which data these recommendations are applied, DOI, data citation and the main recommendations on data sharing and dissemination principles.

- Integration of biological data aimed at providing an operational link between JERICO-NEXT and EMODnet Biology, making the data generated by the project findable and increasing its accessibility. Standardisation and integration into the EurOBIS database was applied.

- Significant improvements have been achieved in the framework of the Sea Data Cloud project to develop controlled vocabularies for Flow cytometry (FCM) data.

- EMODnet Biology and OBIS have transitioned to a new data schema that has allowed for the integration of tests FCM datasets in EMODnet Biology, which, together with new developments in the download toolbox, have made JERICO-NEXT data discoverable at the record level in the EMODnet Biology portal.

- Definition of common formats and Quality Control (QC) procedures for HFR data.

- Standardisation of a world-class system for the scientific inter-calibration and correction procedures for glider physical data collection.

The Data Management Plan (DMP) developed in JERICO-S3 D6.1 follows the FAIR principles (Findable, Accessible, Interoperable, and Reusable), ensuring effective data management throughout its lifecycle. By 2040, the need for AI-ready data — high-quality, well-governed, and interoperable datasets — will be crucial for developing effective AI applications and ensuring robust environmental management. JERICO's data management system is designed with a lifecycle security plan to assess and mitigate risks, ensuring data integrity and availability for research and beyond.

The integrated (physics and biogeochemistry) data management approach will ensure that the JERICO output will become available in a structured and streamlined way. Data collected from JERICO will be considered as Open Data. This was included already in the terms and conditions for the JERICO-S3 and JERICO-DS projects. An important objective, regarding the whole life cycle from sensors to data delivery is the definition of Key Performance Indicators (KPIs) for monitoring the operations and data production not only at single platform level but also in terms of integration capabilities within regional coastal observatories.

A virtual infrastructure as a one-stop-shop service

The need for a dedicated e-infrastructure for the JERICO and its associated challenges was first identified during the JERICO-NEXT project. In the work descriptions of both the JERICO-DS and JERICO-S3 projects, the pilot version of JERICO's e-infrastructure was referred to as e-JERICO, before undergoing a rebranding into JERICO-CORE.

The technical design study of JERICO-CORE is detailed in the JERICO-DS deliverable D3.2, which follows the guidelines and recommendations from the 2021 ESFRI Roadmap's Strategic Report (Part 2. Landscape Analysis - Section 1. Data, Computing & Digital Research Infrastructures). Additionally, e-infrastructures from key European initiatives were examined to inform the development of JERICO-CORE.

Figure 15 illustrates the envisioned architecture of JERICO-CORE and the service landscape that it will encompass.

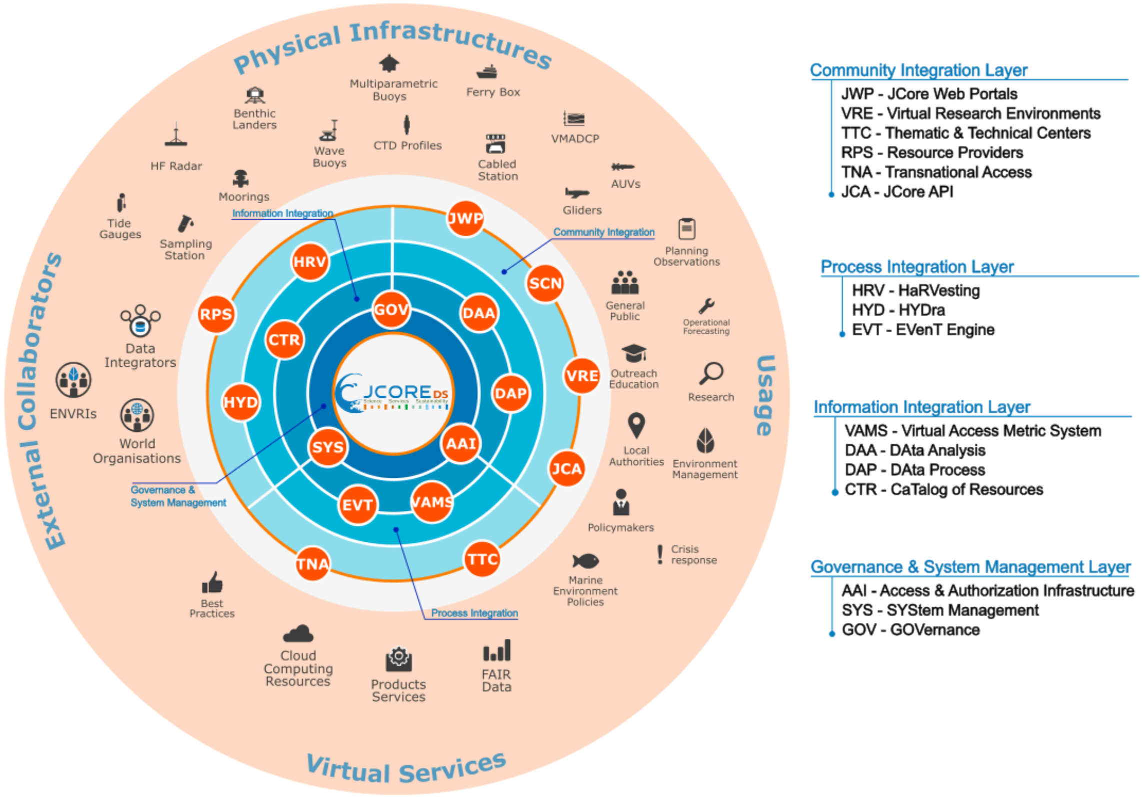


Figure 15: Service architecture landscape view for JERICO-CORE. Reproduced from JERICO-CORE D3.2.

The JERICO-DS deliverable D3.2 also presents a comparative evaluation of major European e-infrastructures, including EGI (European Grid Infrastructure), EOSC (European Open Science Cloud), D4Science, EUDAT, and Blue-Cloud. The assessment focused on technical criteria relevant to the feasibility of JERICO-CORE development on these platforms, without consideration of economic or legal factors. The results identified Blue-Cloud as the most suitable solution for the implementation of JERICO-CORE. Consequently, a new and enhanced conceptual design for JERICO-CORE was established (see Figure 16).

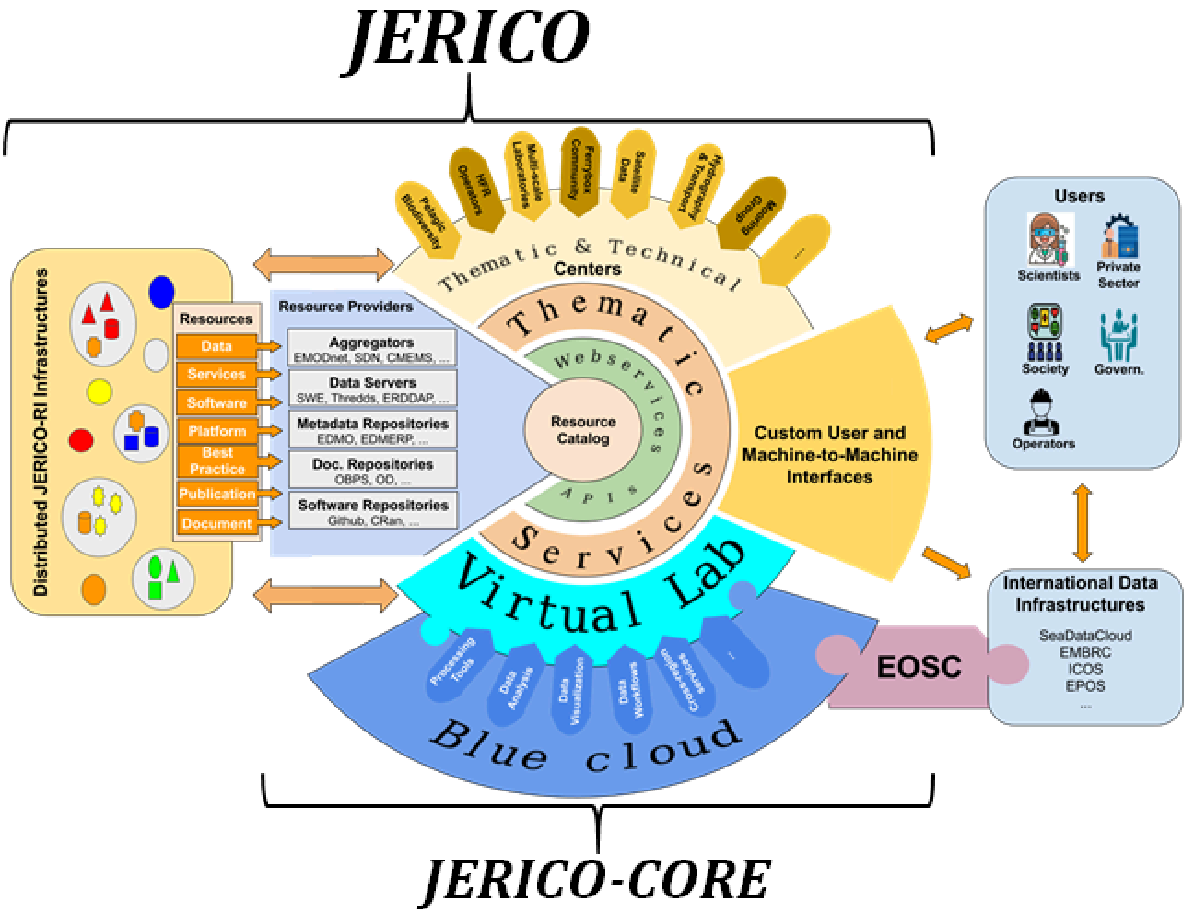


Figure 16: JERICO-CORE final Conceptual Design. Modified from JERICO-CORE D3.2.

The design phase of JERICO-CORE is further elaborated in JERICO-DS deliverable D3.5, which outlines a strategic development plan aligned with the different phases of the ESFRI Roadmap: Design, Implementation, Operation, and Closure. This plan was formulated based on the outcomes of the JERICO-CORE pilot, with the goal of shaping the future JERICO-CORE infrastructure.

b. Developments and technology strategy

In this section, the two specific directions for future investigations are described, namely the: 1) priorities for the JERICO technological strategy and 2) current major developments of JERICO. The priorities include: a) exploring Smart Ocean, bringing Internet in the Ocean; b) integrating Machine Learning and Artificial Intelligence; c) better designing of the observation capabilities for modelling needs; d) developing sensor technology. Major developments comprise: i) improving the Technological Readiness Level (TRL) of the biological observing systems and of its integration with other compartments; and ii) delivering a larger number of observation data suitable for integrated multidisciplinary modelling.

❖ **Priorities for the JERICO technological strategy**

➢ Exploring Smart Ocean, bringing Internet in the Ocean

JERICO sets up smart integrated sensor packages to optimise observations of ecosystem processes of high importance at the European level. JERICO promotes the use of Internet-of-Things and Sensor-Web-Enablement technologies to interconnect sensors (JERICO-S3 involves the 52°North SME within the consortium that is expert in sensors interoperability with *e.g.* Sensor Web Enablement protocols and its implementation on oceanographic observation systems (NeXOS FP7 project), and provides an innovative technological framework for their automated steering and triggering.

➢ Integrating Machine Learning and Artificial Intelligence

The JERICO-S3 project initiated a few pilot studies as a preliminary stage of e-JERICO that are based on a common Virtual Research Environment (VRE), using an AI approach and already existing e-facilities. JERICO capitalises on the VRE development to implement how ML and AI can be integrated in:

➢ the design of the image analysis (*e.g.* images of benthic habitat, pelagic video captures, images of zooplankton and particles abundances);

➢ the optimization process of methodologies that combine, blend and merge collected data and numerical models (data assimilation and AI).

The exponential increase in availability of observations also offers unprecedented potential for new exploitation of ML strategies (*e.g.* Artificial Neural Networks, Bayesian Beliefs Networks). These have been used to study marine ecosystems over the past two decades (Quetglas et al., 2011) but were limited by the fact that they require large amounts of data, while ecosystems are often undersampled in space and time. Expanding the present ability to observe the coastal ocean area will enable advances in the prediction of future ecosystem states and the dynamics of key species via the integration of model predictions, historic data and ML strategies to generate adaptive modelling tools that are sensitive to the complex interactions of evolving marine ecosystems.

➢ Better designing of the observation capabilities for modelling needs

Integration of physics, biology and biochemistry for modelling: particularly compelling examples of the importance of observations to ecosystem model simulations are provided in the recent review on the use of ecosystems models in Europe conducted by the European Marine Board (Heymans et al., 2018). They include ecosystem predictions conducted by the UK MERP program using a multi-model ensemble approach (Spence et al., 2018) that brings together observations, data and modelling to provide a more complete picture of how different ecosystem components (living organisms, abiotic parameters, external pressures) are distributed in space and time, and to develop scenarios reflecting future states of marine food webs and ecosystem services at spatial and temporal scales relevant to management and policy. Another example is the ensemble modelling approach for the Mediterranean Sea, developed by the Italian RITMARE project, which integrates physical, biogeochemical, food web, machine learning and socio-economic evaluation to gain a better understanding of ecosystem functioning in fishery relevant regions, and to identify and evaluate ecosystem based fishery management strategies (Celić et al, 2018). The ensemble approach was also followed in the prediction of eutrophication in a future climate change scenario for the North and Baltic Seas, following the challenge addressed in 2005 by OSPAR to the modelling community.

Combined systems integrating ecosystem models are used to evaluate impacts of invasive species. One example is the study of the impact of invasive snow crabs on the Norwegian and Barents Sea that was modelled by Atlantis, a modelling framework used for marine resource management (Heymans et al, 2018). The situation regarding data assimilation in models referred to earlier, is mirrored when it comes to the automatization of measurements: while physical variables are being routinely measured, the automatization of measurements in the fields of biogeochemistry and especially biology is only just emerging (as emphasised by Guidi et al., 2020), rates and fluxes are comparatively rarely measured, and this lack of data makes ecosystem model parameterization and validation more difficult and therefore reduces model quality. Emerging biological data such as molecular genetics ('-omic' tools *e.g.* eDNA), changes in population size, biodiversity and behaviour, through imaging and optical techniques and hydro-acoustic approaches such as echo sounding, sonar and hydrophones (Benedetti-Cecchi et al., 2018), offer new modelling challenges and opportunities. They are crucial to quantitatively parameterize processes that are key in long term simulations required by climate change studies but are presently not considered in marine ecosystem models (such as evolution, adaptation and plasticity). The improvement in coastal modelling will also have direct benefits for the JERICO development, since validated coastal models are powerful tools for the integration of sparse observations and extrapolation of information to non observed areas. They can contribute to the efficient design and optimization of coastal observing systems for science and operational uses (*e.g.*, Fujii et al., 2019). In addition, emergent ML models can also offer a new way to analyse and synthesise large amounts of data and information in real time, and support the next generation of observing and decision systems.

➢ Developing sensor technology

JERICO future steps in sensor development in the different disciplines are:

→ Biogeochemistry: biogeochemistry coastal monitoring is a large topic and can not be addressed only by JERICO. The JERICO community will support the already driven effort for the improvement and harmonisation of measurements dedicated for the carbonate system (TA, pCO_2, pH) and oxygen. Moreover, contaminants and nutrients are of prime interest for coastal observing systems, JERICO must be part or manage collaborative projects dedicated to improve the TRL of such instruments. Likewise it is now essential to combine the various technologies previously developed, for example the ones concerning benthic monitoring (*i.e.*, sediment imaging) within an Autonomous Coastal Observing Benthic Station to allow for a more holistic monitoring of the sediment-water interface.

→ Biodiversity: biodiversity monitoring needs complex sensor development especially using biosensors based on molecular, microbial and omics technologies and their integration in coastal sensor packages targeting coastal EOV acquisition. Moreover, during the 2018 Alliance for Coastal Technology (ACT, http://www.act-us.info/) workshop on "National coastal ecosystem moorings", imaging systems and genomics have been identified as the two most promising fields for the development of new biological sensors. For phytoplankton imagery the technology is recent and difficult to implement as an autonomous system. Efforts have to be engaged in that direction.

→ Biofouling protection for sensors: In coastal marine environments, biofouling is a major problem for monitoring systems and especially *in-situ* sensors. Every sensing technology is affected by biofouling and then autonomous monitoring devices must be equipped with biofouling protection. Various biofouling protections exist on the market, with pros & cons depending on the situation of the monitoring platform. Sensor development should always take into consideration this difficulty when applied to marine coastal areas. JERICO's expertise in this domain will be of great interest for the companies and the teams involved in sensor developments.

❖ **Current major developments of JERICO**

➢ Improving the Technological Readiness Level (TRL) of the biological observing systems and of its integration with other compartments.

To support the development of complex biodiversity sensors, JERICO community intends to integrate molecular, microbial and omics technology in the design of new coastal sensor packages. Omics technology is changing our understanding of organisms' evolution and adaptation to environmental conditions of the oceans. Omics provide a repository of information that must be integrated into current understanding of the structure and functioning of marine ecosystems. Each omic analysis can generate data with a size that may vary from terabytes to petabytes. These large datasets make the integration of omics technology very challenging also in terms of data cleaning, normalisation, statistical validation, data storage and handling, sharing and data archiving. As for imaging systems, the emphasis has been put on the necessity of developing common standards and new image analysis procedures allowing for the processing of the huge amount of generated information. As well, omics-based biotechnologies are already providing ways of observing important variables that could not be observed *in-situ* to date (including phytoplanktonic biodiversity and contaminants), and *in-situ* imaging methods provide a high temporal and spatial resolution for observing the distribution, abundance, diversity and biomass of phytoplankton and zooplankton. These technologies have been addressed in JERICO-S3 in collaboration with other RIs and initiatives. EMBRC is a key collaborator in that perspective (see section C.3.b.). More generally, to promote and support the needed effort, key members of JERICO are part of the EuroGOOS Technology Plan Working Group (TPWG) which is currently working to create a European marine technology community through the upcoming EOOS Technology Forum to strategically address technological innovation for marine observing systems. As such the strategy for technological developments needed for JERICO is spread beyond the JERICO community and shared with other actors of the marine domain.

➢ Delivering a larger number of observation data suitable for integrated multidisciplinary modelling

In the framework of JERICO-NEXT, the link with the modelling community was enhanced in a dedicated action to assess improvement drawn by the assimilation of JERICO data into some selected models. The models used were for a large majority downscaled from larger scale CMEMS models, adding value through refined resolution and coastal data assimilation, and so playing the role of "intermediate users" with the potential to link CMEMS with coastal end-users and applications. It was also concluded additional modelling developments addressing the physical-biogeochemical coupling would be beneficial to better exploit the whole range of multidisciplinary JERICO observations. As such synergy between both the JERICO and the modelling community has to be kept and even strengthened. The interplay between the JERICO and coastal modelling communities will be further developed and reinforced in two developing frameworks, the CoastPredict program (Predicting the global coastal ocean: toward a more resilient society proposal for a United Nations decade of the ocean programme - https://www.coastpredict.org/) and the "Digital Twin of the Ocean" initiative. Based on the Robinson and Brink (2005) concept of the "global coastal ocean", which calls for a common scientific approach for studying the different coastal areas, the CoastPredict program is aiming to achieve, among others, the following goals:

● Integration of the coastal and open ocean observing and modelling systems;

● Improved, multidisciplinary and extended range predictive capabilities for the coastal zone;

Concerning the specific requirements for modelling in the coastal areas, Robinson and Brink (2005) highlight the need of improved sub-seasonal to seasonal predictions in the coastal zones through a deeper understanding of the multiscale interactions and processes occurring at the coasts, an innovative combination of observing and numerical prediction systems and an appropriate coupling between the meteorological, hydrological and oceanographic compartments at the coasts.

The "Digital Twin of the Ocean" framework is part of the new strategy for the European Green Deal. This framework aims at integrating a wide range of data sources (from physics to ecology through biology, chemistry and geology) in order to transform data into knowledge. It calls, among others, for allowing an assessment of the state of ecosystems, habitats and the impact of human activities (including along coasts) and forecasts of their short and long-term changes. The Digital twin of the Ocean will also contribute to the development of digital interactive high-resolution models of the oceans and seas, as part of the development of a very high precision digital model of the Earth (Destination Earth initiative). The call requests building on existing partnerships (such as EuroGOOS and AtlantOS) and on the integration of existing European and national leading-edge capacities and Marine RIs in ocean observation. Among these RIs, JERICO is explicitly mentioned together with other RIs with which JERICO interfaces, like Bluecloud and EDMONET for data infrastructures, or Copernicus and space data for forecasting and climate services. The idea is to put forth innovative IT technology to bring together research and innovation, infrastructures and communities in support of the European Green Deal and to societal transitions. JERICO will be ideally positioned to leverage synergies with these global and European initiatives as several of its members are involved in them already and/or plan to join. Links to modelling initiatives already exist with a large number of initiatives within and outside of JERICO.

As an example of the interactions JERICO has with the modelling community, efforts for the coastal zone of the Northwest Mediterranean Sea are portrayed here. The Gulf of Lion & the Ligurian Sea can be considered as a case study for an oligotrophic coastal sea surrounded by multiple small rivers plus a major one (Rhône River). The area is impacted by open-sea convection and canyon cascading. Two models, validated using observations, have been implemented for this region with a coupling between hydrology and biogeochemistry/ecosystem models:

Table 1: Models used to estimate different parameters in a coastal area of the NW Mediterranean, within JERICO.

Numerical codes	Symphonie model (see Ulses et al., 2016)	MARS-3D model (see Dufois et al., 2014)
Modules for Physics/transport	MUSTANG particle dynamics (Mikolajczak, 2019)	MUSTANG particle dynamics (Dufois et al., 2014)
Modules for pelagic food web and biogeochemistry modelling	ECO-3M-S (Auger et al., 2011; Kessouri et al., 2017)	ECO3M-MED and ECO3M-MASSILIA-P (Fraysse et al., 2013 ; Alekseenko et al., 2014)
Specific modules for BGC-sediments and PCBs	OMEXDIA-Metamodel-integrated biogeochemical sediment model (Ulses et al., 2016)	PCB (chemistry) (Alekseenko et al., 2018)

For constraining these models, different types of observations - which to a large degree are part of JERICO - were used:

● COAST-HF stations' data: High Frequency from sensors/buoys (SOLEMIO, MESURHO, JULIO, EOL), low frequency from sampling (SOMLIT)

● Satellite data: ocean colour maps and time series (see ACRI-ST A. Mangin), ocean SST maps, turbidity

● Sea campaigns: transects in the Gulf of Lion with towed instruments or station measurements and ship mounted instruments, MOOSE_GE annual sections and MOOSE monthly cruises

● Coastal gliders: Rhône transect, western transect, Ligurian sub-mesoscale transect

In the future, efforts will be undertaken to couple pelagic and benthic modules in the coastal domain under collaboration with modelling communities, to include particle dynamics in the physical-biogeochemical model as a carrier of nutrients and contaminants, to improve spatial scales in order to resolve small scale processes, *e.g.* in freshwater-saltwater gradients near river outlets, and to provide a systematic use of multiple data sources for model constraint.

c. Elaboration of Services for science and society

The access to JERICO services is crucial for the delivering of an excellent JERICO scientific production. As a matter of only fit-for-purpose, services are able to enhance the positive scientific and socio-economic impact of the Infrastructure as it is envisioned in JERICO core mission to:

● Deliver high-quality FAIR data, information, tools and services in support of research and innovation.

● Provide fit-for-purpose innovative services to monitor the complex marine coastal seas and offer open-access to a large set of state-of-the-art technological platforms and facilities, for international science collaboration.

● Hold an expertise for operational data acquisition, delivery and processing.

The work led across the two most recent projects (JERICO-DS and JERICO-S3) helped to preliminarily assess socio-economic impacts of JERICO Services, which can be listed as:

● Support decision making with regards to Protection of marine environment from oil spill accidents, taking into account the future plans for oil drilling activities in the area.

● Secure ecosystem health, ecosystem services and sustainable blue growth.

● Integrated management of commercial fishing.

● Forecast the transport of floating marine litter and plastic pollution, transport of pollutants.

● Support for marine spatial planning and management for renewable energy,

● Support for marine natural resources (biodiversity, HAB, eutrophication and seafood quality).

These socio-economic impacts are in correspondence with the stakeholder analysis performed more recently in JERICO-S3 D9.1 as expressed in section A.3.b. Moreover they confirmed the high importance of JERICO services to support public and academic activities in the three main sectors of (1) Coastal protection and management, (2) Fundamental and applied research and (3) Weather Services and ocean forecasting. A particular attention will thus be paid in addressing the needs of these main users. For instance, our analysis has revealed that those users were quite equally relying on Virtual and on Physical access, thus fostering the need to develop equally both Physical and

Virtual access in a complementary way. Further targeted analysis will be led to precise the needs of these users. One way to ensure that is to involve users and stakeholders in the governance of the RI (cf. sections A.3.b and C.4.) and to elaborate Thematic Expert centres dedicated to main uses. Hereafter is described the current status of service provision and access in JERICO with the current developments, then strategic considerations will follow.

Service provision

Under the coordination of JERICO-S3, JERICO provides service access to a range of resources: systems and facilities as hardware part of the RI, products, IT facilities and knowledge as software. Some are in development and commitment of services from NRIs still need to be discussed. Services of JERICO are organised under four main categories:

1. Systems: observation platforms and stations that are available for scientific teams and industry partners to lead research and experiments. Modalities of physical access vary according to the infrastructure policy:

a. Fixed platforms,

b. Ferryboxes,

c. Gliders

d. Coastal cabled observatories (seabed and water column),

e. Multiplatform systems (combination of single platforms outlined above)

f. Special equipment (*e.g.*: sediment profile viewer, novel instrumentation for microscopy and image analysis).

2. Calibration Facilities under modalities of physical access:

a. Access to metrology laboratories for the calibration of oceanographic sensors

b. Access to laboratories for the purpose of testing and calibrating equipment.

3. IT facilities and data products complement the access to the physical part of the RI:

These include access to products, services or data available from distance via the internet.

a. Sharing of IT facilities and joint services for processing of data acquired through the distributed JERICO nodes and collaboration with other RIs for integrating new solutions for enhancing data management flows and platforms.

b. Data products:

i. Dedicated added value coastal data and products not offered elsewhere. Cover existing gaps of knowledge in coastal ocean state and variability not provided from existing ERIC landscape.

ii. Data products distributed across relevant Pan-European and global marine data infrastructures (EMODnet, SeaDataNet and Blue-Cloud, CMEMS, WOD, GTS).

4. Knowledge resources to different kinds of scientific knowledge produced by JERICO:

a. Educational and training resources that cover the whole JERICO coastal observing ocean value chain, including internal advanced training and educational training (events and materials).

b. Code libraries containing the tools and services used for JERICO data lifecycle management.

c. Best Practices library extended after those created in the framework of JERICO-FP7 and JERICO-NEXT, including procedures and processes to manage the entire data life cycle from the metrology to the data processing.

d. Expert advice sharing, technical and scientific expertise.

e. Bibliographic references produced by JERICO consortium (scientific articles & reports).

Modalities of access

The JEIRCO-CORE pilot intends to be a unique point of access to all JERICO resources: it will open access to both hardware and software parts of the RI according to two modalities of access to its services and infrastructures:

● Virtual Access (VA) to ensure free of charge access to the JERICO e-infrastructure resources.

● Transnational Access (TA) to access the systems of the distributed JERICO.

❖ **Virtual Access (VA)**

The JERICO virtual access service is currently provided under the JERICO-S3 Virtual Access Programme (VA), and it is set to continue after the project's completion (with the exception of the JERICO-CORE pilot, of which only the VRE will remain for prototyping future JERICO Thematic Services or custom services). Under the VA programme, a user can remotely access an infrastructure listed from VA providers via the internet to gain access to a resource that delivers products, services, data or information. Access to all JERICO Resources will be made available through the e-JERICO, as well as through the web pages of the main involved services providers, including data aggregators (EMODnet, SeaDataNet/Blue-Cloud and CMEMS), IOC OBPS-Repository, IODE OTGA, e-libraries (github, etc). This access will be freely available and the ambition is to provide access 24h per day, 365 days per year. Free and open access means unrestricted access at no cost for all interested individuals, whether they are within or outside of the JERICO, but an acceptance of the JERICO data policy will be required. Registration may be required to have access, but no restrictions apply. Access to all JERICO resources will be recorded through web based statistics for all virtual access activities. Access to resources will be possible via the established web links through the JERICO Resources Catalog that will be accessible from the e-JERICO portal. The actual resources will be stored in the original infrastructures that contain them (IOC OBPS-Repository, IODE OTGA, Regional Sites of JERICO, e-libraries, EU marine data infrastructures). The User Analysis summarised in section C.3.b has confirmed the high importance of the Virtual Access mode among the JERICO User community thus improving the relevance of this current action. Nonetheless, four pilot-focused regional/thematic services, from JERICO-S3 data to demonstrate the benefits of the JERICO information life cycle, were developed. The work was done in the areas of physical, biogeochemical and biological oceanography to be examples on "how to" for larger scale creation of products and services. Specific Pilot Data-to-Products Thematic Services (D2PTS) targets included:

1) HF-Radar tailored products: a development of physical oceanography products from HF Radar data to provide gap filled surface current data products, potentially transferable to CMEMS in the future.

2) Estimation of sea water masses types and transport monitoring: exploitation of physical oceanography products from glider data that may be combined with biogeochemistry observations.

3) Biogeochemical state of coastal areas: set to provide regional, combined multiplatform observations products.

4) JERICO-EcoTaxa: distributes coastal plankton monitoring products from ecological imaging sensors.

❖ **Transnational Access (TA)**

Physical access to the observational platforms and access to the calibration facilities is currently provided and funded through the JERICO-S3 Transnational Access Programme (TA). Under the TA programme, access is provided free of charge and includes all the logistical, technological and scientific support, as well as specific training, that is normally provided to external users of the specific infrastructure/installation. Access is provided based on units of access (day, week, 6 months, etc) and access costs are calculated as follows:

● on the basis of unit cost rates per unit of access,

● or actual costs.

Users are required to directly interact with the managers of the infrastructures/installations they wish to use during the preparation of proposals to:

● verify the particulars of access to the infrastructure/installation they wish to use,

● and verify the feasibility of the proposed projects and address practical concerns.

Proposals from potential users are then sent to the JERICO-S3 TA management team. The management team will preliminarily check the proposals for respect of access rules and technical quality and will coordinate the evaluation process. Proposals will then undergo a three-step selection process conducted by a selection panel (SP) of independent international experts. This process involves:

● Validation of each proposal by the interested facility operator (feasibility assessment).

● Evaluation based on scientific excellence, innovation and impacts on the state-of-the-art.

This step will be performed by the SP with the aid of additional experts, if necessary.

● Final assessment and selection by the SP, which will recommend a short-list of proposals eligible for support

❖ **Access Policy**

Based on the existing Virtual Access and Transnational Access programmes, a long-term Access Policy will be developed during the JERICO-DS project. The JERICO Access policy will cover the terms and conditions for end-users to grant the provision of (1) physical access to the JERICO platforms, and (2) open and free access to JERICO digital services, data products and knowledge products without any local, national or regional barrier.

3. Roadmap for the elaboration of future services

The elaboration of services has to be a strategic implementation of efficient fit-for-purpose products. JERICO is, in the domain of coastal observation, answering two major needs that are complementary. On one hand, it wants to address the main scientific challenges relevant to the global and EU integrated landscape of marine and environmental initiatives. JERICO services are envisioned as a pan-European Coastal Ocean Integrated component of this landscape. On the other hand, a particular attention is being paid to the socio-economic impact of the RI (see section D.3.). It aims to deliver scientific achievements to the broad range of socio-economic activities which rely on coastal and marine science among europe. These two drivers are taken into account in the strategy for the elaboration of products and services roadmap, meaning the setting of priorities and targets on the short and long term. Both are the basis on which relies our strategy for services elaboration. Hereafter the two drivers guiding the services elaboration roadmap of the Infrastructure are developed.

a. Enhancing the european scientific strategies for Ocean Observation

The elaboration of services will strongly contribute towards facing the technological bottlenecks and challenges listed in section B.2. on the short, mid and long-term. Review and expansion of JERICO services will be fully aligned with the EU/Global landscape, and with particular synergy with the EuroGOOS, EOOS and GOOS strategies.

❖ **At present:**

● Identify EU priorities for operational oceanography in coastal areas: JERICO-S3 investigated how disruptive innovations, emerging technologies and cross-disciplines endeavours are likely to give appropriate responses to current and long-lasting environmental challenges in Europe, and lead to a paradigm shift in the way marine coastal ocean will be observed in the future and conclusion also fed the JERICO-DS project. The use of Internet-of-Things and web-sensor enablement technologies is being promoted for interconnecting sensors, also providing an innovative technological framework for automated steering and triggering of sensors, based on machine learning data analytics for e-JERICO.

● Foster cooperation and co-production with EU and national initiatives providing tools and means for data lifecycle management (from acquisition to distribution) of coastal ocean observations: a strong focus is being set towards innovation in products and services for Science and Society for delivering high-quality multidisciplinary datasets and services. The consistency of the datasets provided by JERICO is of highest value for science and for further re-use of data for products and downstream services. In accordance, several tools for users and innovations will be developed and implemented to ensure the traceability and visibility of JERICO data to both reduce cost and enhance the provision of new specialised products available in the Virtual Access environment of the e-JERICO (Virtual Research Environment: VRE).

● Better coordinated and sustained in-situ ocean observing: Establishing the end-points for connecting EOOS stakeholders to the JERICO community and maximising the benefit of coastal ocean observing.

○ Pilot e-Infrastructure: The embryonic version of an e-infrastructure, the Pilot e-JERICO, has been developed in JERICO-S3 as a Virtual Access (VA) scalable framework that allows visibility and easier access to JERICO capabilities. It will: (1) create Pilot Data-to-Products Thematic Services (D2PTS) as exemplars for future thematic services and for demonstration and evaluation of Portal effectiveness; (2) provide access to the most important JERICO Resources (Catalogued) and D2PTS; (3) demonstrate benefits of the JERICO information life cycle through four pilot-focused regional/thematic services, bringing the D2PTS to TRL7; (4) strongly engage with COPERNICUS and EMODnet in the elaboration of coastal products for a range of stakeholders by establishing the formal framework of cooperation with

CMEMS, while servicing CMEMS, SeaDataNet/Blue-Cloud and EMODnet in terms of data provision will be further consolidated.

○ Roadmap for operational e-Infrastructure: After the development of the e-JERICO pilot from the resources made available by some partners and maintained for 2 years as a fundamental component, the JERICO-DS project targeted the technical design of the full e-JERICO. The implementation roadmap for JERICO-CORE, as detailed in JERICO-DS deliverable D3.5, outlines the structured development of the infrastructure according to the ESFRI Roadmap. This roadmap encompasses six phases, including a Pilot phase preceding the ESFRI Roadmap. The implementation is designed to follow a strategic plan, which includes broad actions and milestones for each phase: Design, Implementation, Operation, and Closing. The implementation process is divided into five working streams, each with distinct roles and responsibilities throughout the project's lifecycle: Governance, Co-Design & Co-Development, Operation, Interoperability and Service Integration

○ Integration with EU-Global landscape: In addition, JERICO-DS will gather, study and further syntheses the requirements needed for e-JERICO's provision of effective integration with the map of existing relevant marine domain Pan-European Infrastructures (EMODnet, CMEMS, SeaDataNet), as well as with EU and international initiatives and conventions (EuroGOOS, ROOS's, EU HFR Node, EuroARGO, UNESCO-IOC-IODE, SCOR, ICES, OceanGliders, OSPAR, HELCOM, JCOMM, UNEP/MAP), and cross/multi-domain EU infrastructures and initiatives (EPOS, ICOS, EOSC and ENVRI-PLUS).

❖ **On the long-term:**

JERICO will serve as the coastal component of the GOOS 2030 Strategy by supporting the following strategic objectives:

● Deepening engagement and impact:

○ Regular performance evaluation of delivered products and services leveraged on a continuous improvement process within a Quality Management Framework. The JERICO User Committee (JUC) will gather the requirements from users' inputs that will be used for refining the services currently provided by JERICO to further meet their needs.

○ Contribution to the JERICO user strategy (section C.3.b.) that will significantly improve the perception of both the User landscape and the Use of P&S, and hence support decisions related to the further development of P&S (setting priorities, target groups/sectors, etc). The user strategy will be supported by both the JERICO User Committee and the User forum.

● Supporting integration and delivery:

○ Ensure FAIRness in JERICO Services: Improved multi-domain Thematic services to (1) cover specific needs from partners, (2) integrate with the EU landscape (including EOSC, ENVRI community) and among other infrastructures.

● Building for the future:

○ Innovation of services (AI, smart systems connected to platforms).

○ Ensure and expand systematic operational processes for guaranteeing data lifecycle.

The JERICO User Community is very diversified because of its scope, which is to study the coastal marine domain, and because of its integrative nature across disciplines, systems, methods and regions. Therefore, needs and expectations rising from society can be distributed in a large panel, thus necessitating the elaboration of a dedicated strategy for the implementation of useful services. To that matter, a first objective would be to prepare robust and acknowledged services for the main sectors. Then, as the elaboration of services is also meant to gain more and more users, the second objective would be to target yet less represented sectors (*e.g.* Shipping, Aquaculture, Tourism & Recreation, etc.) in addition to the already more represented ones. Our analysis (see section A.3.b.) has shown that the small sectors were characterised by a higher dependence on one specific access type. Indeed, some of them mainly use Virtual Access while some of them mainly use physical access, so-called Transnational Access (TA). Thus, these sectors have to be targeted with specific services and communication plans among Europe, because the small sectors are the ones with the highest potential gain in terms of new users.

Moreover, the JERICO User Strategy will also contribute to engage JERICO towards a sustainable User-Driven Research Infrastructure through the representation of key user sectors in the JERICO User Committee, which will act as the Users representing body in the governance of the Research Infrastructure. This permanent entity will be thoughtfully composed with relevant Users according to the result of the engagement strategy analysis. This committee will also strengthen the interaction between the end-users of the services and JERICO by gathering return on experience and monitoring their demand and needs. It will be involved in governance through its close relation with User oriented bodies (JERICO User Access Unit, Thematic and Technical Expert Centers, see section C.4.). Thanks to this User approach, JERICO will remain a Users-driven Infrastructure over its lifespan and will address, through the right implementation of Products and Services, the key socio economic scope of European society.

b. Develop a scalable and adaptable User Strategy

To ensure that JERICO's Research Infrastructure (RI) effectively meets user needs, it is crucial to develop and implement a comprehensive User Engagement Plan. This plan, detailed in JERICO-S3 D9.2, serves as a strategic framework designed to actively involve end-users in the development, refinement, and ongoing improvement of the infrastructure's products and services (P&S). By fostering meaningful interactions with users, JERICO aims to enhance user experience, maximise the effectiveness of its offerings, and build robust relationships with its diverse user base.

Understanding and Engaging Users

The process begins with a thorough identification of stakeholders, including scientists, industry partners, and other relevant parties. This involves categorising users based on their specific needs, preferences, and interactions with the infrastructure. In the initial stages, as outlined in Deliverable D9.1, JERICO identified key user groups and created "Power vs Interest" matrices (Figures 2) to prioritise engagement efforts and tailor strategies accordingly.

Understanding user needs is a critical aspect of this plan. This involves gathering detailed insights into the requirements, frustrations, and expectations of different user groups through various methods such as surveys, interviews, and focus groups. By capturing a comprehensive view of user needs, JERICO can ensure that its services are designed to address real-world challenges and deliver tangible benefits.

The User Experience (UX) design approach plays a pivotal role in shaping the infrastructure's offerings. UX design focuses on creating meaningful and effective interactions between users and the infrastructure. One of the primary tools used in UX design is the User Journey Map (UJM). A UJM provides a graphical representation of the steps a user takes while interacting with a service, highlighting their experiences, emotions, and pain points at each stage. This approach allows JERICO to visualise the user's perspective and identify areas for improvement.

User personas, another key element of UX design, are detailed profiles representing different types of users. These personas are developed based on extensive research and aim to encapsulate various user characteristics, needs, and behaviours. For JERICO, user personas were defined during the JERICO User Forum (JUF) held in April 2023. This forum brought together JERICO's core team and partners to create personas that represent scientists with diverse backgrounds and levels of expertise. Each persona includes information such as name, age, professional background, geographical location, and specific frustrations and needs encountered in their work.

The Role of the JERICO User Committee (JUC)

The JUC, formally established in July 2023, plays a crucial role in advising on P&S development and user engagement strategies. Initially composed of experts from Blue-Cloud and Copernicus Marine Service In Situ TAC, the JUC includes individuals with extensive experience in relevant fields. The founding members of the JUC are:

- **Patricia Martin-Cabrera (VLIZ/Blue-Cloud)**: With a background in virtual research environments and a deep understanding of the Blue-Cloud landscape, Patricia Martin-Cabrera brings valuable insights into the perspective of scientists using cloud computing platforms.
- **Julia Vera Prieto (Seascape/EMODNET)**: Julia Vera's experience in stakeholder management and engagement within environmental projects will contribute significantly to enhancing user and stakeholder engagement within JERICO.

- **Dick M.A. Schaap (MARIS/Blue-Cloud)**: Dick Schaap's technical expertise and leadership in cloud-computing projects, particularly in the context of Blue-Cloud, will support the JUC in navigating the complexities of digital infrastructure development.
- **Dominique Obaton (ODATIS/Copernicus In-situ TAC)**: Dominique Obaton's extensive experience in data handling and delivery will be instrumental in shaping JERICO's approach to data management and user engagement.

The JUC's primary responsibility is to provide guidance on the development of P&S and ensure that user needs are effectively addressed. The committee will help prioritise actions and foster synergies between JERICO and Blue-Cloud Virtual Labs, thereby creating a cohesive and integrated infrastructure that extends beyond the JERICO-S3 project.

The JERICO User Forum (JUF)

The JUF has been a platform for engaging users and discussing user experience strategies. Initially organised as physical meetings, the JUF will evolve to include a web-based forum to facilitate ongoing communication and feedback collection. The JUF serves as a key communication channel where users can register, provide feedback, ask questions, and engage with JERICO's central management team.

This forum will be open to both scientific and private sector users, providing a structured framework for discussions and promoting collaboration among different user communities. By creating opportunities for knowledge exchange and collaboration, the JUF aims to enhance the scientific and economic impact of JERICO.

Feedback Mechanisms and Quality Management

To continuously improve its services and ensure user satisfaction, JERICO will implement various feedback mechanisms inspired by international standards such as ISO 9001 for Quality Management and ISO 14001 for Environmental Management. These standards will help formalise processes, enhance operational results, and ensure a user-centric approach. The ISO 9001 standard provides a framework for establishing a Quality Management System (QMS) that includes mechanisms for monitoring user satisfaction and addressing issues promptly. Key performance indicators (KPIs) such as the Net Promoter Score, User Effort Score, and User Satisfaction Score will be used to measure user experience and satisfaction. Additionally, metrics related to user engagement, such as active users, session duration, and feature usage, will help assess the effectiveness of JERICO's services and identify areas for improvement.

Feedback will be collected through various channels, including surveys, user stories, and post-Transnational Access (TA) questionnaires. The surveys will gather detailed information on user experiences, needs, and suggestions for improvement. Post-TA questionnaires will focus on specific aspects of the TA experience, including the impact of JERICO's support and funding.

By adopting these feedback mechanisms and quality management practices, JERICO aims to maintain high levels of user satisfaction, attract new users, and ensure the long-term sustainability of the infrastructure. The insights gained from user feedback will guide the ongoing refinement of P&S, helping JERICO to deliver value and meet the evolving needs of its user community.

Inspiration from Other European Projects

JERICO's approach to user engagement and feedback is informed by practices observed in other European projects and RIs. For example, the European Geostationary Navigation Overlay Service (EGNOS) and Euro-Argo ERIC have employed surveys and feedback mechanisms to gauge user satisfaction and gather insights for improvement. The EMBRC ERIC has also utilised user stories to highlight the impact of its services and foster engagement.

By drawing on these examples and integrating best practices, JERICO will develop a robust User Engagement Plan that supports continuous improvement, enhances user experience, and strengthens its position as a leading research infrastructure.

4. Possible governance of JERICO

The governance of JERICO, a Distributed Research Infrastructure (DRI) encompassing extensive coastal observation facilities across Europe, is envisioned to be both comprehensive and adaptable to its evolving needs. At its core, the governance structure will be defined by a layered model integrating strategic oversight, operational management, and advisory functions (see figure 17). The Assembly of Members (AoM), as the principal decision-making body, will be composed of national delegates from each member country. This body will be entrusted with high-level responsibilities, including approving the annual budget, amending the statutes, and electing key positions such as the Director General (DG). The AoM will also play a crucial role in endorsing strategic and financial proposals put forth by the Executive Committee (ExCo).

The ExCo, chaired by the DG, will be pivotal in the daily operation and strategic development of JERICO. It will oversee the implementation of decisions made by the AoM, manage operational aspects, and guide the establishment and dissolution of Service Offices and Expert Centres. The DG, appointed by the AoM for a renewable term, will spearhead the ExCo and manage the Central Management Office (CMO). The CMO, while not part of the formal governance structure, will handle administrative tasks, quality assurance, risk management, and act as a central communication hub for stakeholders.

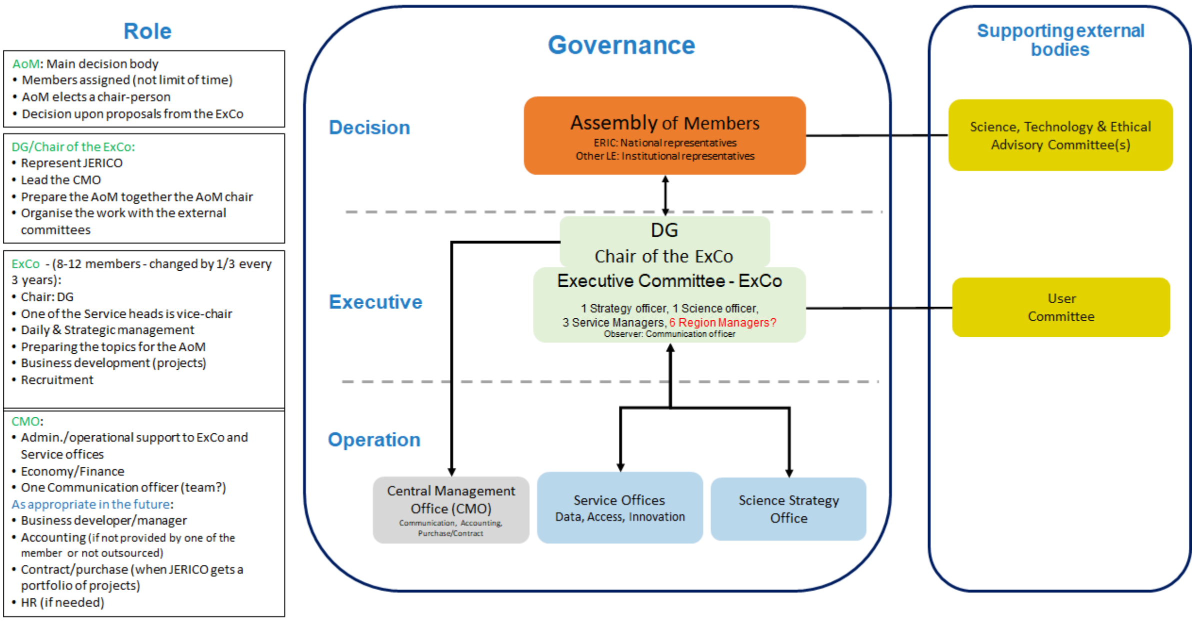


Figure 17: Governance of JERICO, including Decision (in red), Executive (in blue) and Operation (in green) levels. Peripheral bodies supporting the governance and management external advising bodies (in yellow), and CMO (grey).

Service Offices, responsible for delivering JERICO's services, will operate under the ExCo's supervision. These offices will oversee Thematic Expert Centres (TECs), which will focus on specific scientific and technical domains relevant to JERICO's objectives. The relationships between these components and the DRI will be formalised through Service Level Agreements (SLAs), ensuring both operational coherence and the maintenance of each component's legal and administrative independence.

In addition to internal governance, JERICO will benefit from external advisory bodies, such as the Scientific, Technical, and Ethical Advisory Committee (STAC) and the JERICO User Committee (JUC). These bodies will provide independent advice on strategic, scientific, and technical matters, enhancing collaboration and ensuring the sustainability and impact of JERICO's operations. The JERICO User Forum (JUF) will also play a crucial role by facilitating user feedback and maintaining direct communication between users and JERICO's administrative and operational bodies.

As JERICO progresses towards its goal of becoming a key European research infrastructure, various legal models to support its long-term sustainability have been and will be explored. The adoption of an appropriate legal form, potentially an ERIC (European Research Infrastructure Consortium) or a non-profit association, will be essential for JERICO to secure funding, enhance its operational effectiveness, and represent European coastal research interests on the global stage.

This governance framework is designed to ensure that JERICO remains responsive to the needs of its diverse stakeholders, maintains operational efficiency, and effectively supports the advancement of coastal observation and research across Europe.

D. Feasibility of JERICO

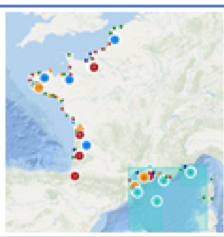
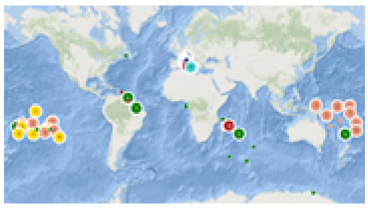
It can not be overstated that the current application capitalises on a robust foundation of Member States' established and recognised NRIs. These dynamic communities of actors have gained official recognition and sustained ressources from their respective nation's political entities. This has prepared the terrain to achieve the ambition of a pan-European Research Infrastructure. The privileged contacts of the nationally recognised entities with national funding agencies and relevant State ministries (or equivalent) provides the strength and unity of voice essential in a rapidly evolving context. These established national RIs are facilitators for other member states with the serious ambition of further developing their national observation systems and integrating JERICO. The feasibility of JERICO is further attested by the favourable development of key performance indicators. Numbers of accessible facilities continue to rise as do Virtual Access capabilities, the breadth and diversity of variables measured, the involvement with the private sector and the production of valuable scientific knowledge. As indicated above, the involvement of Nation-supported entities and infrastructures is projected to rise, riding on the political support secured by JERICO's initial members - there is no question of the added value and necessity of this level of organisation to address national and global issues. The national infrastructures are briefly presented. Despite the multiplicity of drivers (and levels of organisation), the JERICO community shares many common goals, presenting both strong leverage and insurance for JERICO's success.

1. Strong National Research Infrastructures

The establishment of JERICO as a fully integrated European Research Infrastructure on coastal observation relies on the strong scientific achievements of the consortium's European nations. JERICO will also capitalise on well established NRIs on coastal observation and benefit from their long term experience and expertise. The national coastal RIs involved in JERICO are:

- ILICO, France
- CNR-OGS network of observations builds on the RITMARE effort, Italy
- POSEIDON / HIMIOFOTS, Greece
- EIrOOS Irish Ocean Observing Systems, Ireland
- COSYNA, Germany
- FINMARI, Finland
- KKOBS, Marine Component of the Estonian Environmental Observatory, Estonia
- MARINE OBSERVATION SYSTEM, MOS, Sweden
- MONIZEE, Portugal
- ICTS-SOCIB, Spain
- COASTWATCH, Norway
- RBINS+VLIZ+ Meet Net Vlaamse Banken, Belgium
- MWTL + WOT, Netherlands
- Coastal RI Under construction, Croatia.

and are described one by one here after.

France : National Research Infrastructure			
	Infrastructure	ILICO Created in 2016	Expectations from the ESFRI PREPARATORY PHASE:
	Legal Status	Project or (Research Infrastructure)	• To consolidate articulation between Coastal National Research Infrastructure, Jerico partners and other infrastructures at pan- European and national levels, both strategically and scientifically. • To strengthen coastal process understanding thanks to enlarged climatic and anthropic gradients or recorded parameters • To build at the European level a comprehensive view of users and stakeholders and of the products and services they need • To foster technological innovation and exchange of best practices • To complete the European vision of coastal challenges by integrating ultramarine sites and topics
	Coordination	IFREMER-CNRS	
	Accredited by a national roadmap	✓	
	Data management plan	✓	
	Yearly number of publication	Approx 90 p.y.	
Geographical extent:			

Scientific scope:

ILICO remains focused on understanding and observing coastal and nearshore ecosystems in France. Current objectives include:

- **Climate Change**: Expanding efforts to assess long-term changes driven by climate dynamics, including rising sea levels, acidification, and the increasing frequency of extreme weather events, in line with the 2024 IPCC report findings.
- **Local and Global Pressures**: With growing urbanisation and industrial activities along coastlines, ILICO is working on improving methodologies to quantify the combined

impacts of human activities (such as pollution and coastal development) alongside natural evolutionary processes.

- **Resilience and Adaptation**: In light of recent extreme climate events in Europe (e.g., floods and heatwaves), ILICO has reinforced efforts to understand the resilience mechanisms of coastal ecosystems, helping in the formulation of adaptive measures.
- **Optimising Networks**: Technological advancements have been integrated into ILICO's observation networks, including enhanced remote sensing technologies, automated buoys, and AI-based data analysis for real-time monitoring.

Socio-Economic Scope:

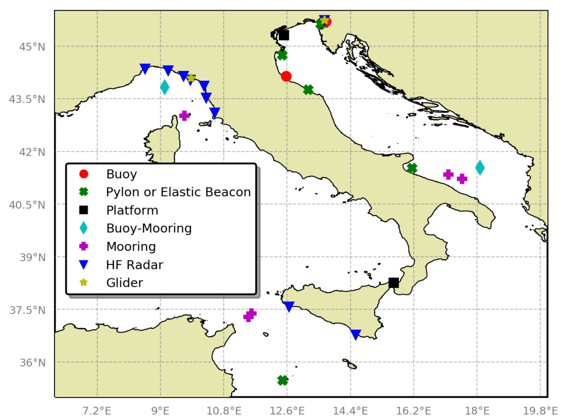
ILICO's engagement with stakeholders has matured by 2024, with an emphasis on:

- **Collaborative Decision-Making**: Continued engagement with policymakers, coastal managers, and environmental groups is aimed at incorporating scientific findings into decision-making for sustainable coastal development.
- **Sustainable and Secure Financing**: ILICO has now expanded its public-private partnerships, ensuring a stable financing model for long-term observational projects.
- **Pooling Resources**: Collaborative projects across French regions have led to cost-efficient shared use of observation platforms and data infrastructures.
- **FAIR Data and Innovation**: ILICO remains committed to the FAIR principles (Findable, Accessible, Interoperable, Reusable) in its digital frameworks, and 2024 has seen an increase in open-access platforms. This strengthens its role in international collaborations and fosters innovation through shared digital resources.

France's Involvement in European RIs: France continues its active participation in multiple European RIs (Eurofleets, EMSO-ERIC, EuroArgo ERIC, SeaDataNet, EuroGOOS, Anaee, EMBRC, eLTER, ACTRIS, AQUACOSM, ARISE, CETAF, DANUBIUS, DISSCO, ELIXIR, EMODNET, EPOS, EUROCHAMP-2020, FixO3, ICOS, LIFEWATCH, IA).

Notable updates include:

- **Eurofleets and EMSO-ERIC**: Stronger integration of marine research efforts across Europe to address global challenges like ocean deoxygenation and the carbon cycle.
- **EMODNET**: Enhanced focus on interoperability with other data networks, contributing to the European Green Deal's marine environmental monitoring targets.
- **LIFEWATCH and EuroGOOS**: France's contribution has expanded towards biodiversity and ecosystem services monitoring, reflecting the EU's commitment to halting biodiversity loss by 2030.

Italy : Network of Observing Systems				
	Infrastructure:	**CNR created in 1923**	**OGS created in 1958**	**Expectations from the ESFRI PREPARATORY PHASE:**
Consiglio Nazionale delle Ricerche	**Legal Status:**	**National Research Center**	**National Research Center**	**The current Italian JERICO configuration includes infrastructures from the two main marine institutes, CNR and OGS. During the Preparatory Phase, a consultation will be open at the national level to consolidate and coordinate a nationally unified system for the monitoring of the coastal ocean.**
	Coordination:	**CNR**		
OGS	**Accredited by a national roadmap:**	✓		
	Data management plan:	✓		
	Yearly number of publication:	**N/A**		
Geographical extent:				

Scientific Scope:

While RITMARE was a major Italian research project focused on the marine environment, ITINERIS has been developed to enhance Italy's marine research capabilities further and integrate them more effectively into European and global research networks. ITINERIS aims to provide comprehensive observational data and support research on coastal and marine environments, with a particular emphasis on integration with other European RIs and addressing contemporary challenges such as climate change and marine ecosystem management.

- **Climate Change**: Monitoring and analysing the impacts of climate change on coastal and shelf waters, including effects on marine biodiversity and ecosystem services.
- **Extreme Events**: Studying the development and consequences of extreme weather events on marine dynamics and ecosystems, and understanding their implications for coastal resilience.
- **Eutrophication and HABs**: Researching the causes and impacts of eutrophication and harmful algal blooms (HABs) on local marine ecosystems, with a focus on mitigation and management strategies.
- **Pollutant Transport**: Enhancing forecasting models for the transport of pollutants and biological agents, improving prediction accuracy for environmental impact assessments.
- **Coastal Ecosystem Dynamics**: Gaining deeper insights into the functioning and interactions of coastal ecosystems, including the physical and biological processes at play.
- **Sea Level Rise and Coastal Change**: Ongoing monitoring of sea level rise and its effects on coastline evolution, contributing to effective coastal management strategies.
- **Operational Oceanography**: Integrating synoptic and multidisciplinary observations to develop advanced forecasting systems and improve overall operational oceanographic capabilities.

Socio-Economic Scope:

ITINERIS supports several national and European projects addressing key socio-economic challenges, including:

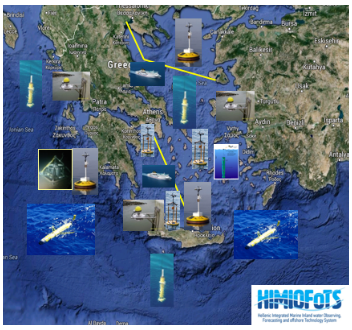
- **Marine Safety**: Enhancing maritime safety through advanced monitoring and early warning systems.
- **Blue Growth**: Promoting sustainable economic growth in marine and maritime sectors, focusing on innovation and job creation.
- **Maritime Spatial Planning (MSP)**: Supporting effective and sustainable use of marine resources through integrated spatial planning approaches.
- **Marine Protected Areas (MPAs)**: Providing scientific data and insights to support the management and conservation of MPAs.
- **Sustainable Fisheries**: Encouraging sustainable fishing practices that balance economic needs with the health of marine ecosystems.

Italy's Involvement in European RIs:

- **EUROFLEETS, FixO3, EMODNET**: Enhancing marine research through improved oceanographic observations, data integration, and monitoring systems.
- **AQUACOSM, EuroGOOS, SEADATANET**: Supporting aquatic ecosystem studies, operational oceanography, and marine data management.
- **EURO-ARGO, EMSO, DANUBIUS**: Advancing deep-sea and coastal monitoring through international collaborations and integrated observational efforts.
- **EMBRC, EPOS, eLTER, ELIXIR**: Strengthening infrastructures for biological and environmental research, including long-term monitoring and data sharing.
- **CETAF, DISSCO, EUROCHAMP-2020**: Enhancing access to scientific collections, data, and atmospheric research.

- **ARISE, ICOS, SIOS, LIFEWATCH, IS-ENES**: Contributing to research on atmospheric and climate systems, Arctic environments, and biodiversity

The JERICO-S3 project is funded by the European Commission's H2020 Framework Programme under grant agreement No. 871153. Project coordinator: Ifremer, France.

Greece : National Research Infrastructure			
	Infrastructure:	POSEIDON / HIMIOFOTS Created in 1997	Expectations from the ESFRI PREPARATORY PHASE:
	Legal Status:	Project towards Legal Entity	• Development of a cabled coastal observatory in the Cretan Sea PSS • Establishment of 2 more glider endurance lines • Development of an ASV component
	Coordination	HCMR	
	Accredited by a national roadmap:	✓	
	Data management plan:	✓	
	Yearly number of publication:	NA	
Geographical extent:			

Scientific Scope:

POSEIDON focuses on the unique marine environment of Greece, characterised by its ultra-oligotrophic conditions, rich biodiversity, and complex coastal systems. Key areas of research include:

- **Regional Specificity**:
  - **Ultra-Oligotrophic Systems**: Monitoring of very low nutrient concentrations and primary productivity, reflecting the characteristic low levels of chlorophyll-a.
  - **Biodiversity Hotspot**: Investigating the high percentage of endemic species unique to the region.
  - **Steep Topography**: Examining the interaction between steep coastal topography and benthic systems, which influences local marine processes.
- **Addressed Issues**:

  - **Intermediate and Deep Layers**: Studying processes occurring in these layers to understand nutrient dynamics and ecosystem health.
  - **Nutrient Stock Variability**: Analysing changes in nutrient levels and their effects on marine life.
  - **Solubility-Biological Pump**: Investigating how solubility and the biological pump influence carbon and nutrient cycling.
  - **Mesopelagic Community Structure**: Researching the structure and dynamics of the mesopelagic zone, which is crucial for understanding marine food webs.
  - **Multiple Stressor Impacts**: Assessing the combined effects of various stressors on ecosystem functioning, including climate change, pollution, and overfishing.

Socio-Economic Scope:

POSEIDON provides valuable data and forecasts that support various socio-economic applications:

- **Strategic Data Forecasts**: Offering critical information on sea conditions to support marine environmental protection and management.
- **Business Development**: Facilitating growth in maritime industries by providing essential data for informed decision-making.
- **Disaster Prevention and Human Safety**: Enhancing early warning systems to prevent disasters and protect human life.
- **Operational Oceanography**: Strengthening Greece's position as a leader in operational oceanography, contributing to global advancements in this field.

Greece's Involvement in European RIs:

- **EMSO (European Multidisciplinary Seafloor and water-column Observatory)**: Contributing to deep-sea and water-column monitoring efforts.
- **EuroArgo**: Engaging in the global Argo network for ocean profiling and data collection.
- **LIFEWATCH**: Supporting biodiversity and ecosystem research through integrated infrastructure.
- **EMBRC (European Marine Biological Resource Centre)**: Focusing on marine biological research and resource access.
- **DANUBIUS**: Collaborating on research related to river-sea systems.
- **ACTRIS**: Participating in atmospheric research, particularly concerning aerosols and trace gases.
- **EPOS (European Plate Observing System)**: Involving geophysical research and observation across Europe.

Ireland: National Research Infrastructure			
	**Infrastructure:**	**EirOOS Irish Ocean Observing System Created in 2018**	**Expectations from the ESFRI PREPARATORY PHASE:**
	Legal Status:	**Project**	**• To ensure that the most up-to-date, world class, pan European coastal and ocean observing research facilities are accessible to Irish researchers and state agencies in support of providing scientific advice to Government.** **• Provide fit-for-purpose ocean observation, impact analysis, projections of future change, and policy support to facilitate Ireland's resilience to a changing climate.** **• Facilitate the potential for a wide range of physical and biogeochemical oceanographic and climate research to offer the Irish research community the opportunity to address key scientific and societal challenges.** **• A Clear roadmap and strategic plan for the services and products to be provided by the RI**
	Coordination	**Marine Institute (MI)**	
	Accredited by a national roadmap:	✓ *(Marine Research and Innovation Strategy)* ✓ *(Harnessing Our Ocean Wealth (HOOW) Integrated Marine Plan for Ireland)*	
	Data management plan:	✓	
	Yearly number of publication:	**10**	
<u>Geographical Extent:</u>			

Scientific Scope:

The EirOOS significantly enhances Ireland's national capacity for monitoring and observing ECV while providing state-of-the-art research platforms for the Irish and international research communities. Its key scientific contributions include:

- **Operational Model Support**: Providing critical data for calibrating and validating operational models, including systems for Harmful Algal Bloom (HAB) warnings, fisheries resource assessments, maritime safety, and search and rescue operations.
- **Research Platforms**: Improving and expanding observational platforms to increase Ireland's participation in Horizon 2020 (H2020) Infrastructures, the European Ocean Observing System (EOOS), and the Copernicus Marine Environment Monitoring Service (CMEMS).
- **Long-Term Climate Data**: Collecting long-term climate data to support climate vulnerability assessments, impact evaluations, and adaptation planning, particularly for the Department of Agriculture, Food, and the Marine.
- **Carbon Cycle Monitoring**: Enhancing carbon cycle observations to support biogeochemical research and foster collaborations with European and international research communities.

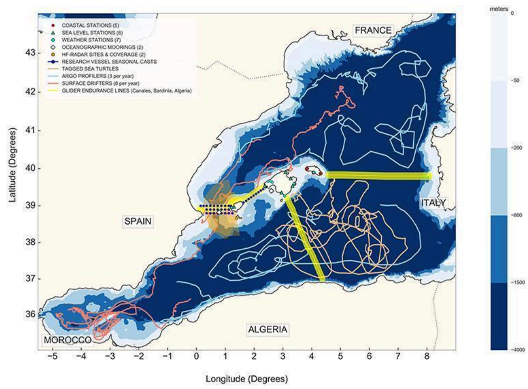
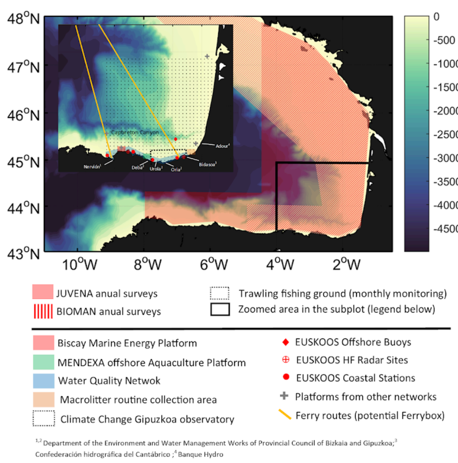
Socio-Economic Scope:

EirOOS addresses several key national and international needs, contributing to:

- **Buoy Network Performance**: Improving the reliability of marine weather parameters through an enhanced buoy network and supporting long-term climate data collection.
- **Water Level and Wave Data**: Upgrading national water level and wave data collection to support coastal and surge flood forecasting.
- **Research Opportunities**: Facilitating new research opportunities and supporting collaborations with industry.
- **Renewable Energy**: Providing high-resolution wave data at ocean energy test sites to promote the development of renewable energy technologies.

Ireland's Involvement in European RIs:

- **EuroFleets+**: Coordinating ocean research fleets for enhanced marine research capabilities.
- **FixO3**: Contributing to fixed-point ocean observation networks.
- **SONET NoE**: Engaging in the Science and Operations of Networks of Environmental Observatories.
- **EuroGOOS**: Supporting the European Global Ocean Observing System.
- **JERICO**: Participating in the Joint European Research Infrastructure Network for Coastal and Shelf Seas.
- **SeaDataNet**: Contributing to the European marine data and information network.
- **Euro-ARGO**: Involved in the Argo program for ocean profiling.
- **EMSO**: Engaging in multidisciplinary seafloor and water-column observations.
- **AtlantOS**: Participating in the Atlantic Ocean Observing System.
- **EPOS**: Contributing to the European Plate Observing System for geophysical research.
- **ELIXIR**: Supporting bioinformatics and molecular data management.
- **ICOS**: Expressed intention to join the Integrated Carbon Observation System.
- **Marinerg-I**: Involved in marine renewable energy research and development.

Spain: NRI & Network of OS					
	3 Infrastructures:	ICTS-SOCIB Created in 2018	EuskOOS	PLOCAN	Expectations from the ESFRI PREPARATORY PHASE:
	Legal Status:	Public Consortium Legal entity	Public regional infrastructure	Public Consortium Legal entity	• Work towards a nationally coordinated system for the monitoring and forecast of the coastal ocean. • Improve and enable access to the existing infrastructures, services and data. • Establish a roadmap for the future integrated observation of the coastal area at national level and contribute to the strategy at European level.
	Coordination	SOCIB	AZTI	PLOCAN	
	Accredited by a national roadmap:	✓	-	✓	
	Data management plan:	✓			
	Yearly number of publication:	25	5		
Geographical Extent:		 			

Scientific Scope:

SOCIB's objectives, driven by international scientific priorities, state of the art technology and by specific interests from the Spanish and Balearic Islands society, are :

- To contribute, address and respond to international scientific, technological and strategic challenges for operational oceanography in the coastal ocean

- To enhance operational oceanography research and technology activities being carried out in the Balearic Islands

- To curate and maintain a world class data repository for legacy support to societally critical long term problems like global/climate change and fishery sustainability.

Through this work SOCIB, is an internationally recognized coastal observing and forecasting system, a reference facility of facilities, contributing to scientific excellence, technology transfer and knowledge dissemination, whilst remaining capable of adapting and responding to society's needs.

As a research and innovation centre AZTI's main activity is focused on its Applied Research projects, New products and services, Scientific advice and Business revitalization and addressed to private companies, scientific organisations, professional associations as well as local, national and international administrations. AZTI provides scientific knowledge on the functioning of coastal systems in order to attain a sustainable management of their goods and services. In addition to research activities, AZTI is responsible for EuskOOS, the Basque coastal operational oceanography coastal observatory. This observatory envisages three purposes:

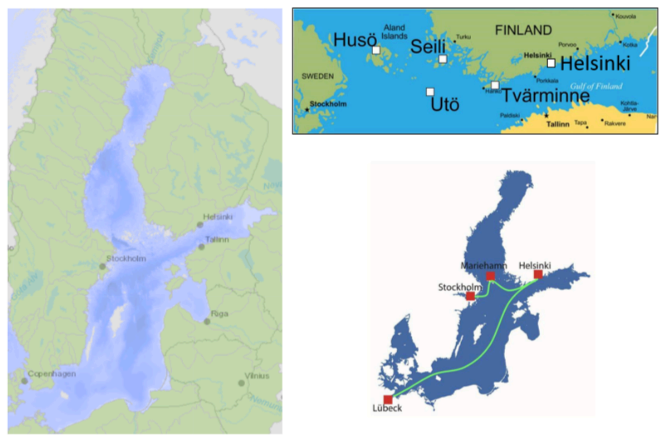
- providing an accurate description of current sea conditions along the Basque coastline;
- offering ongoing forecasts of future sea conditions; and
- supplying ocean-meteorological products to Basque coastal users.

Socio economic Scope*:*

SOCIB is a joint initiative between the Spanish Ministry of Science and Innovation (Ministerio de Ciencia e Innovación) and the Balearic Islands Government (Govern de les Illes Balears). SOCIB activities are science, technology, and society driven; accordingly, SOCIB is designed to respond to international scientific priorities and to the increasing need of society for intensive and quasi real-time monitoring and forecasting of the complex coastal environment, including FAIR data. AZTI (www.azti.es) is a research centre that specialises in the **food and maritime fishing value chain** that carries out strategic and applied research to generate new knowledge. This private foundation is a member of **Basque Research and Technology Alliance (BRTA),** an alliance formed by 4 collaborative research centres and 12 technology centres with the aim of developing advanced technological solutions for the Basque companies. It is accredited as a Sectoral Technology Centre by the Basque Government and as a Technology Centre by the Spanish Ministry of Economy. AZTI develops sustainable products, services and business initiatives aimed at **activating the industrial fabric while recovering and preserving natural resources**.

<u>Spain is involved in the following list of European RI:</u>

JERICO-RI, EuroGOOS, EMSO, EuroFleets, EuroArgo, EPOS

Finland: National Research Infrastructure			
	Infrastructure :	FINMARI Created in 2014	Expectations from the ESFRI PREPARATORY PHASE:
	Legal Status:	Multi-institutional consortium (network of 4 research institutes and 3 universities)	● Further integration of coastal observations ● Clarification of the objectives and responsibilities of RI and partners ● Establishment of roadmap how RI support regional and pan-European scientific and societal topics ● Connection with the adjacent environmental RIs
	Coordination	SYKE	
	Accredited by a national roadmap:	✓	
	Data management plan:	✓	
	Yearly number of publication:	150	
Geographical Extent:			

Scientific Scope:

FINMARI builds a distributed national marine RI with a joint multidisciplinary mission, formulated into a research framework with hierarchical ecosystem diversity levels in foci.

- Capturing the relevant ecosystem variabilities, from physiological and growth scales (minutes to days) to transport and seasonal scales (weeks to months and years),
- Setting rigorous demands for an integrated multi platform RI, both in observation and experimentation.
- Applying state-of-the-art and emerging multidisciplinary measurement techniques for the hierarchical levels of variability.

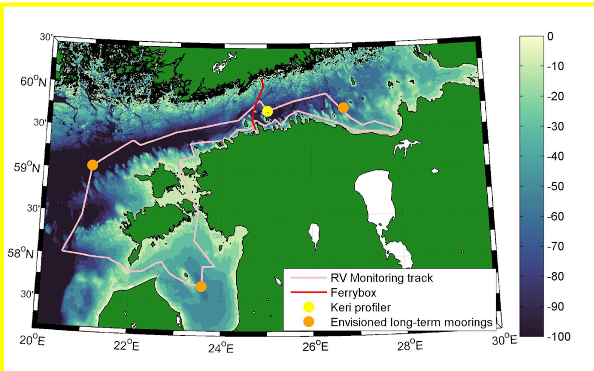
Socio economic Scope:

The FINMARI infrastructure provides

- a natural continuum from basic science to highly applied issues.
- novel measurement techniques allowing for real-time, open access data delivery of the state of the marine environment.
- new services connected to the marine sector by environmental authorities, SME's, and non-profit organisations including the education system.
- synergies and interactions between monitoring and scientific research, hence also providing a solid ground for management of the marine environment.
- direct link from data provision to the decision-making process, also in crosscutting environmental issues.

Finland is also involved in the following list of European RIs:

ACTRIS, ARICE, AQUACOSM, eLTER, EMBRC ERIC (in process), EMODnet, ENVRI-FAIR, EUROGOOS, Eurofleets, Euro-ARGO ERIC, GROOM II, ICOS-ERIC, SeaDataNet

<table>
<tr><th colspan="4">Estonia: Marine component of the Estonian Environmental Observatory</th></tr>
<tr><td></td><td>Infrastructure:</td><td>Marine component of the Estonian Environmental Observatory
Created in 2010</td><td>Expectations from the ESFRI PREPARATORY PHASE:</td></tr>
<tr><td></td><td>Legal Status:</td><td>Project</td><td rowspan="5">• To build a stronger collaboration in observing activities with neighbouring countries.
• To start sustainable continuous measurements in the water column in all three sub-basins of the Estonian marine areas.
• To foster know-how, e.g. best practices exchanges
• To strengthen the understanding of processes and environmental challenges in the coastal sea by utilising pan-European infrastructure.</td></tr>
<tr><td></td><td>Coordination</td><td>TALTECH</td></tr>
<tr><td></td><td>Accredited by a national roadmap:</td><td>✓ - Part of the national RI (Estonian Environmental Observatory)</td></tr>
<tr><td></td><td>Data management plan:</td><td>In progress (draft available)</td></tr>
<tr><td></td><td>Yearly number of publication:</td><td>10</td></tr>
<tr><td colspan="2"><u>Geographical Extent:</u></td><td colspan="2">
</td></tr>
</table>

<u>Scientific Scope:</u>

Main aim of the scientific measurements in the observing system is to make continuous high-resolution measurements sustainable in the eastern Baltic Sea. Vertical and horizontal fluxes of heat, salt, oxygen, chl-a and suspended matter can be estimated from the data. Nutrient samples are regularly taken along the ferrybox line and at Keri station to investigate biogeochemical dynamics, primary production etc.

<u>Socio economic Scope:</u>

The main socio-economic scope of the observing system is on the eutrophication and climate change related effects in the eastern Baltic Sea (Gulf of Finland, Gulf of Riga, Baltic Proper), e.g. deep layer oxygen conditions. The observing system is a basis for the applied research and development tasks on, e.g., green energy, marine pollution, environment protection, tourism, etc.

Estonia is also involved in the following European RI:

EuroFleets, SeaDataNet, EMODnet, Process started to join ICOS (integrated Carbon Observing System) and initiate continuous pCO2 and pH measurements (including marine component)

Sweden: Network of Observing Systems			
	Infrastructure:	**Swedish Marine Observation System MOS Created in 2001**	**Expectations from the ESFRI PREPARATORY PHASE:**
	Legal Status:	**Network**	**● To develop the network at the national level (create connections with other organisations and consolidate existing ones).** **● To add new sensors to existing monitoring platforms and new platforms to the system.** **● To propose a National Research Infrastructure to the Swedish Research Council (Vetenskapsrådet)** **● To enhance the data collection and understanding of the processes in coastal zones.** **● To strengthen collaboration with neighbouring countries**
	Coordination	**SMHI**	
	Accredited by a national roadmap:	**X**	
	Data management plan:	✓	
	Yearly number of publication:		
Geographical Extent:			

Scientific Scope:

Now: The infrastructure investigates the effects of:

- Anthropogenic processes in the Baltic and North Sea regions, i.e. effects of human influence. The expected global warming, the threat of continued eutrophication and the intense economic growth make this region very vulnerable to climate change.
- Long-term observation about climate and environmental change and high frequency observation of short term events (Warnings, oil spills, etc.). Type of measure: Physics/Biology/chemistry. Type of platforms: Buoys, FerryBox, Research Vessels, Sea level stations.

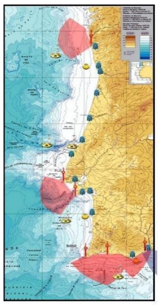
Future Roadmap: integrated system SMHI, Swedish maritime administration, Swedish Marine Universities and Universities of Technology / Novel sensors; e.g. for biodiversity / Harmful algal bloom observation and prediction system with a joint system with neighbouring countries/Long term funding for ERIC.

Socio-economic Scope:

MOS has value-adding links to the Copernicus program, which focuses on making earth observations available for the society. This includes the core services, e.g., freely available operational biogeochemical model products assimilated against observations, and downstream services such as water management, blue growth initiatives, etc., that take advantage of the model products and data.

Sweden is also involved in the following list of European RI: ICOS and ICOS-ERIC, EMBRC, Lifewatch (Sweden is considering becoming partner of ERIC), PRACE, CERN, FAIR, ITER and EUROfusion, BBMRI-ERIC, EATRIS-ERIC, EMBL, ESS, MAX IV laboratory, CESSDA-ERIC, ESS-ERIC, SHARE-ERIC

The JERICO-S3 project is funded by the European Commission's H2020 Framework Programme under grant agreement No. 871153. Project coordinator: Ifremer, France.

Portugal: Network of Observing Systems			
	Infrastructure :	MONIZEE Created in 1960, Major upgrade in 2009	Expectations from the ESFRI PREPARATORY PHASE:
MONIZEE	Legal Status:	Permanent Program	• To consolidate articulation with Jerico partners and other infrastructures at Pan European and national level • To build a comprehensive view of users and stakeholders and of the products and services they need • To complete coverage HF radar and extend capacities by adding gliders to the system • To enlarge and consolidate ability of system to monitor biogeochemical and biological parameters
	Coordination	Instituto Hidrografico (IH)	
	Accredited by a national roadmap:	Not yet, but discussion to be included in the following update. Action program in the national strategy for the sea	
	Data management plan:	Following the data policy of IH	
	Yearly number of publication:	10	
<u>Geographical Extent</u>:			

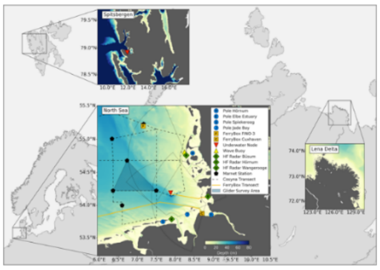
<u>Scientific scope</u>:

MONIZEE is seen as the key monitoring infrastructure for the coastal ocean waters offshore the Portuguese mainland. The infrastructure integrates networks of coastal tidal gauges, wave buoys, multiparametric buoys and HF radar stations and covers the complete shelf and slope waters offshore continental Portugal, from the southern coast (Gulf of Cadiz area) to western coast (up to the border with NW Spain). MONIZEE then provides unique data to support studies of the main physical, chemical, sedimentary and biological conditions affecting this coastal ocean area, namely to characterise the shelf and slope dynamics (with emphasis to coastal upwelling and poleward slope currents), to study biological connectivity and contaminant dispersion over vast regions along the European margin, to infer the impacts of wave conditions on coastal environments and of river outputs on the shelf domain or to understand the interaction between deep ocean circulation and the eastern boundary layer in the North Atlantic. MONIZEE data products are being used by a broad range of national and international members of the scientific community.

Socio-economic scope:

The coastal ocean area offshore the Portuguese mainland is directly exposed to the energetic conditions of the North Atlantic ocean. These conditions affect in different ways the coastal populations whose economy is, in turn, strongly dependent on activities related to the coastal ocean environment. Pressures over this coastal ocean area are related to the intense maritime traffic between Northern Europe, Mediterranean, Africa and American coasts or the presence of large urban concentrations near the coast. The MONIZEE infrastructure was implemented to provide support to different groups of users and stakeholders through a permanent monitoring of the environmental conditions that affect this coastal ocean domain linked to numerical modelling and operational forecasting products. The infrastructure data and derived products are presently being used by national agencies, port authorities, city halls, surfers, fishermen communities, aquacultures, among others. The data collected by the MONIZEE infrastructure is also one of the contributions of Instituto Hidrografico to the national implementation of MSFD as explicitly stated in the law that transcribes this directive to the Portuguese framework

Portugal is also involved in the following list of European RI:
EUROGOOS, SEADATANET, EMSO, EMBRC

Germany: Network of Scientific Observing Systems			
	Infrastructure:	**COSYNA Created in 2010**	**Expectations from the ESFRI PREPARATORY PHASE:**
COSYNA	**Legal Status:**	**Scientific Networking Project**	**• To expand cooperation with JERICO partners to create a truly Pan-European infrastructure • To coordinate observation strategies for certain topics, e.g., carbon cycling, to avoid duplication of efforts and use synergies • Foster and participate in technological development • Provide stakeholders with consistent products**
	Coordination	**HZG**	
	Accredited by a national roadmap:	**X**	
	Data management plan:	**No DMP, but a data policy**	
	Yearly number of publication:	**15 - 20**	
Geographical Extent:			

Scientific scope:

It is COSYNA's mission to develop and operate an integrated observing and modelling system suitable for investigating the environmental state and variability of coastal areas, with a focus on the North Sea and Arctic coastal waters.

The observations comprise a variety of *in situ* techniques as well as remote sensing from shore by radar and from space by satellite. At the centre of the COSYNA observations is a standard package of sensors mounted on stationary and mobile platforms. Key physical, sedimentary, geochemical and biological parameters are observed at high temporal resolution in the water column and the upper and lower boundary layers. Some platforms are equipped with novel sensor systems such as for pelagic imaging of plankton and particles in the water column.

COSYNA's modelling part consists of nested models with different grid sizes for hydrography (salinity, waves, currents), for suspended matter and for biogeochemical and ecosystem processes. By using sophisticated data assimilation procedures, i.e., continuous corrections of the models by observations, the reliability of now-casts and short-term forecasts is improved substantially.

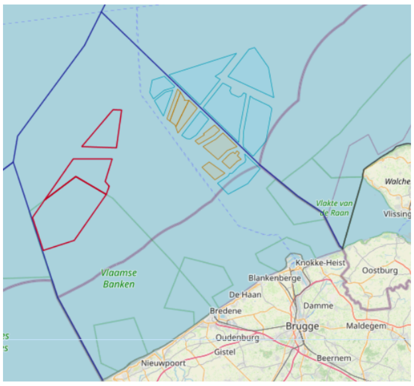
Socio-economic Scope*:*

COSYNA aims to provide data and knowledge tools to help evaluate the role of coastal systems for local and regional scientific questions and to provide scientists a platform for mutual cooperation to help address the grand challenges as defined by the Helmholtz Association. It provides authorities, industry, and the public with tools to plan and manage routine tasks, respond to emergency situations and to evaluate trends. COSYNA specifically develops scientific products and instruments, and provides its infrastructure to the scientific community.

Germany is also involved in the following European RI: Danubius, Euro-Argo, ICOS, EMSO, ACTRIS

Belgium : Networks of Observing Systems					
	3 Infrastructures:	RBINS / OD Nature	MeetNet Vlaamse Banken	VLIZ	Expectations from the ESFRI PREPARATORY PHASE:
	Legal Status:	Federal Scientific Institute (governmental)	Flemish agency	Non-profit association	• To build a stronger collaboration in observing activities at regional and pan-European levels, both strategically and scientifically. • To foster technological innovation and best practices exchanges • To build a comprehensive view of users and stakeholders and of the products and services they need
	Coordination	RBINS	MDK / Vlaamse hydrografie	VLIZ	
	Accredited by a national roadmap:	*Not relevant in Belgium*	*Not relevant in Belgium*	*Not relevant in Belgium*	
	Data management plan:	✓	✓	✓	
	Yearly number of publication:	~10	N.A.	~10	

Geographical Extent:



Scientific Scope:

The Meetnet Vlaamse Banken is a coastal observing system which consists of moored wave buoys and measuring poles at sea and several meteorological stations on shore and tidal stations in the harbours. The measuring poles are fitted with hydro-meteo sensors, to measure waves, tide, currents and other physical parameters. The wave buoys and measuring poles at sea are generally located in the zone up to 30 kilometres off the coast of Belgium. On all of these locations data is continuously measured with different sensors and sent in realtime to a central database in Ostend and also to different platforms to the users of the data.

RBINS/OD Nature marine observing infrastructure includes, among others, RV Belgica, an airplane, fully equipped benthic landers (ADCPs, OBS, C-PODS, CTD, etc), 3 spectral and hyper-spectral radiometer stations and accredited marine chemical and benthic biology laboratories. Data collected at sea are used together with satellite observation and marine ecosystems models in holistic ecosystem studies involving ecology, biology, biodiversity, chemistry, hydrodynamics, geology, sedimentology, eutrophication, and others. RBINS/OD Nature is legally in charge of various environmental monitoring programmes of the Belgian part of the North Sea (WFD, MSFD, impact of human activities at sea, etc) and represents Belgium in several international conventions and organisations.

VLIZ monitors, continuously, monthly or on a regular basis, plural parameters at fixed stations at sea, in the coastal waters and along the beach. These long term data series of both biotic (e.g. phyto- and zooplankton, fish and marine mammals) and abiotic variables contain valuable data that are freely accessible for marine and coastal research in Flanders. VLIZ coastal observing infrastructure includes, among others, RV Simon Stevin, 2 water quality buoys, artificial reef monitoring structures, bottom moored multi purpose tripods and a fleet of unmanned vehicles (ROV, UAV, USV). VLIZ also operates a fish acoustic receiver network, cetacean passive acoustic network and a broadband sound network. VLIZ plays a central role in various scientific networks including eurOBIS, EMODnet and PSMSL/GLOSS.

Socio-economic Scope:

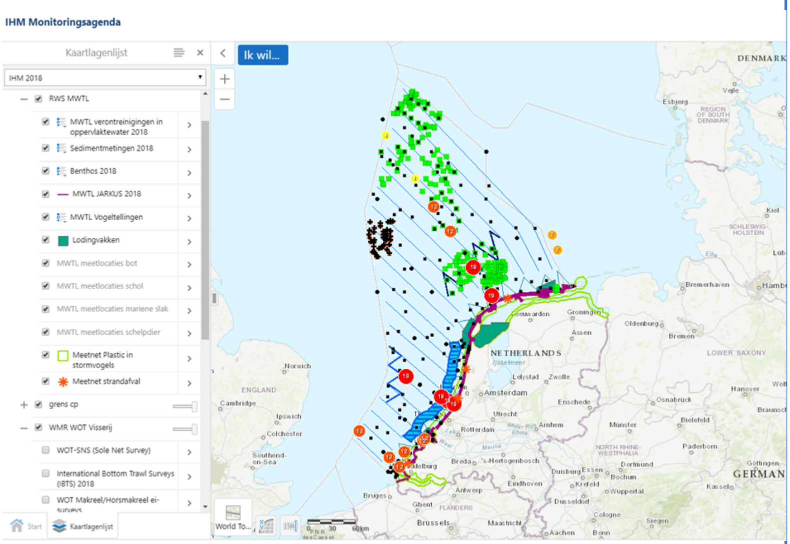
Meetnet Vlaamse Banken delivers services to the maritime sectors. It contributes to the maritime safety of the worldwide largest vessels that must navigate between the shallow Flemish sandbanks to the ports of Zeebrugge and Antwerp. Adopting a FAIR approach, both historical and real time data of the Meetnet Vlaamse banken are made available to anyone.

RBINS marine observing infrastructure is a key-element of the Belgian Federal State to enforce a sustainable management of the North Sea marine ecosystem. It directly contributes the 30+ legal obligations (royal decrees or ministerial decrees) associated to the environmental monitoring, assessments and reporting of human activities at sea such as sand and gravel extraction, dumping of dredged material, wind farms at sea, munition deposit Paardenmarkt, Marine Strategy Framework Directive, Water Framework Directive, Belgian aerial surveillance at sea (Bonn Agreement).

Thanks to its observing system, VLIZ promotes accumulation of marine knowledge and excellence in marine research in Flanders. The target groups for knowledge accumulation are the marine research community as well as educational institutions, the general public, policymakers and the industry. For instance, VLIZ acts as a contact point for the marine research landscape in the Flemish “Blue Cluster”, a partnership between knowledge institutions, government institutions and companies to develop innovative projects that appeal to the economic potential of the North Sea.

Belgium is also involved in the following RIs:

ICOS, Lifewatch, EMBRC, PRACE, EPOS, ELIXIR, ANAEE, ACTRIS, DISSCO, ENVRI-FAIR, EuroGOOS, SeaDataNet, Eurofleets.

<table>
<tr><th colspan="4">Netherlands: National monitoring programme</th></tr>
<tr><td></td><td>Infrastructure :</td><td>MWTL + WOT Monitoring Waterstaatkundige Toestand des Lands + Wageningen Marine Research Created in 1970</td><td>Expectations from the ESFRI PREPARATORY PHASE:</td></tr>
<tr><td></td><td>Legal Status:</td><td>-</td><td rowspan="5">• Optimise international coherence of North Sea monitoring
• Optimise cost efficiency of North Sea monitoring
• Boost innovation in marine monitoring, supporting more science-based marine management</td></tr>
<tr><td></td><td>Coordination</td><td>RWS + WMR</td></tr>
<tr><td></td><td>Accredited by a national roadmap:</td><td>X</td></tr>
<tr><td></td><td>Data management plan:</td><td>✓</td></tr>
<tr><td></td><td>Yearly number of publication:</td><td>Approximately 2</td></tr>
<tr><td colspan="2">Geographical Extent:</td><td colspan="2">
</td></tr>
</table>

Scientific Scope :

The Dutch monitoring is not created for scientific purposes but to support water management. Therefore, the programme is coordinated by RWS as governmental agency responsible for water management of large water bodies, including large rivers, estuaries and the North Sea. Nevertheless the long consistent time series resulting from the monitoring programme have been used in many scientific studies and for model validation. The scientific scope of the programme includes both physical, chemical and biological variables, such as water levels, wave climate, salinity, temperature, turbidity, nutrients, phytoplankton, fish and marine mammals. The monitoring programme is complemented with models (physical, chemical and biological) for all major water bodies for flood forecasting and environmental impact assessments.

For monitoring of higher trophic levels (from zooplankton up to fish and marine mammals) WMR (Wageningen Marine Research) performs the monitoring also in collaboration or as assignment for RWS. They collaborate with KNMI on meteorological and physical marine data by sharing observational platforms at sea. These are now mainly based on oil platforms, but these will be decommissioned soon. Therefore, they work towards using wind farms as alternative monitoring platforms, including more extensive monitoring to also monitor changes in the marine environment due to the wind farms. There is also some international collaboration started on monitoring related to wind farms. A collaboration has started with NIVA on Ferrybox monitoring in the North Sea, implementing a new trajectory that crosses a.o. the Rhine plume along the Dutch coast, where scientific and water management issues are most urgent.

A scientific network for measuring, monitoring and modelling is being created within the Netherlands, including RWS, Deltares, WMR and NIOZ. RWS looks for collaboration with other North Sea countries for coherent and efficient monitoring. This is done through a range of European projects (such as JMP-North Sea and Celtic Sea and JMP-EUNOSAT) and EUROGOOS.

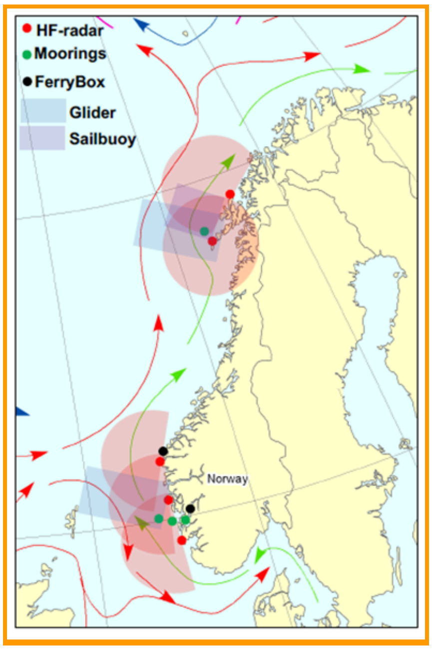
Socio-economic Scope :

The Dutch RI aims to serve the following socio-economic purposes

- To protect the Netherlands against floods (in combination with operational models)
- To support shipping to Dutch harbours
- To provide information for reporting to the EU on the ecological status of marine and coastal waters for the WFD and MSFD
- To provide information for fisheries management through ICES
- To support weather forecasts in collaboration with KNMI (Royal Dutch Meteorology Institute)

Netherland is also involved in the following RI:

EURO-ARGO, ICOS, Aquacosm, EPOS, Danubius, FixO3, EuroGOOS, Seadatanet, Esonet, Lifewatch, Elixer, Actris, Eurofleets, IS-ENES.

Norway: Network of OS/Consortium of Institutes			
	Infrastructure:	**COASTWATCH**	**Expectations from the ESFRI PREPARATORY PHASE:**
	Legal Status:	**Under establishment**	**• Homogenise fragmented coastal research and monitoring capacity within Norway and with JERICO partners • Optimise cost efficiency of the Norwegian waters, • Foster and participate in the development of the JERICO e-Infrastructure • Aiming for a development of a seamless dataflow in Europe**
	Coordination:	**IMR**	
	Accredited by a national roadmap:	**Yes**	
	Data management plan:	***✓ - NMDC (norwegian marine data center) adapted to COASTWATCH***	
	Yearly number of publication:	**Not applicable**	
Geographical Extent:			

<u>Scientific Scope :</u>
Research and development associated with environmental monitoring, climate change, marine pollution, blue growth and ecosystem management greatly benefit from accurate descriptions of the physical, chemical and biological state of the ocean. The strongest currents and overall highest variability are found on the continental shelf and along the shelf break, while the complex geometry of the coastline leads to the creation of small-scale circulation features important for nearshore spreading and dispersion. Hence, the coastal regions and the shelf seas are particularly challenging to resolve in numerical models and

observe in a representative way. However, increasing levels of activities at the interface between fjords and the coastal sea place a clear demand on the accuracy in predictions of e.g. marine ecosystem connectivity and pollutant exchange. Establishing a consistent research infrastructure enabling a coherent approach through combined coastal observations and ocean modelling is therefore imperative to secure a sustainable pursuit of the goals of the Norwegian government and international obligations, such as the UN Sustainable Development Goals (SDGs).

As a consequence, the integrated coastal observing system COASTWATCH with the main partners IMR, NIVA and NORCE provides key sites along the Norwegian coast as a much-needed infrastructure supporting research and knowledge-based management as well as Norway's contribution in the European integrated and multidisciplinary coastal observing system – JERICO. In order to adequately address the complex coupled processes inherent of coastal regions and delivering essential ocean variables, our infrastructure will implement a multiplatform-multi-sensor approach integrating observations from fixed platforms, HF radar systems, coastal gliders, ships of opportunity, surface AUVs and a framework for testing and utilising other observation sources such as satellite-based remote sensing, connected into into Supersites of high societal relevance. This provides Norwegian and international researchers and managers a permanent source of near real-time information of physical, biogeochemical and biological state of coastal and shelf regions, supporting an ecosystem approach for analytical studies of stressors and impacts. Furthermore, the infrastructure represents a hub for easy integration of all observation sources in the area (e.g. salmon farms, national monitoring programs) and a model-based extrapolation beyond the key sites to the entire coast through data assimilation and data-driven machine-learning. We stimulate technology development to better observe the biogeochemical processes and facilitate cross-disciplinary research on coastal processes and assessment of the combined climate change and human impacts.

<u>Socio-economic Scope :</u>

The overall aim for COASTWATCH is to increase knowledge on complex coastal processes, and provide information supporting decision making on coastal management. That is conducted via the provision of research-based advice and building strong links to ministries as well as providing international development cooperation via the directorate for Development Cooperation (NORAD) and the Food and Agriculture Organizations of the United Nations (FAO).

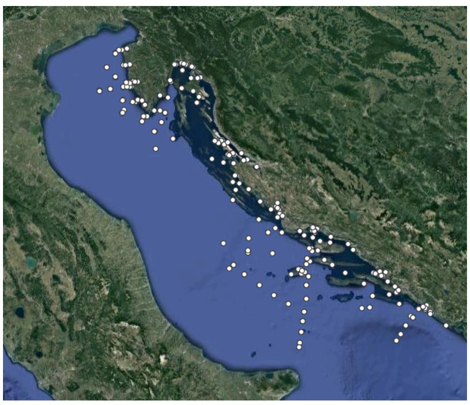
Focal points of the COASTWATCH infrastructure is to serve the following socio-economic fields:

- Aquaculture
- Harmful Algal Blooms
- Land-Coastal-Ocean interactions
- Human Impact
- Sustainable fisheries management
- Integrated Ecosystem Assessment

<u>Norway is also involved in the following list of RI:</u>

EURO-ARGO, ICOS, EMSO (from 2020), AQUACOSM, EuroGOOS, Seadatanet, EMODNET, Eurofleets, EPOS, EMBRC.

Croatia: Network of Observing systems

Infrastructure:	Ruder Boskovic Institute, Center for Marine Research, Rovinj	Institute for Oceanography and fisheries, Split	University of Dubrovnik, Institute for Marine and Coastal Research, Dubrovnik	Expectations from the ESFRI PREPARATORY PHASE:
Legal Status:	Part of Public Institutes/consortium	Part of Public Institutes/consortium	Part of Public Institutes/consortium	• Further development of regional and Pan-European integration • Definition within the national roadmap • Improved integration of national RI • Organisational consolidation • Involvement of further research institutes to complete the observational portfolio for the eastern Adriatic • Improved data flow towards European data repositories with a special focus on data integration and biological datasets
Coordination:	RBI	IOR	UniDU	
Accredited by a national roadmap:	X	X	X	
Data management plan:	✓	✓	✓	
Yearly number of publication:	1299	125	219	
Geographical Extent:				

Scientific Scope:

The Ruđer Bošković Institute employs over 500 scientists in natural sciences, of which more than 130 are dedicated to marine research. Marine research at the RBI covers basic and applied research from biodiversity research over physical, chemical and biological oceanography to marine geology, blue biotechnology and materials sciences. Most of the RBI's marine research is focused on the Adriatic Sea. The RBI is part of the Croatian Reference centre for the Sea and as such in charge of the Croatian monitoring activities under the MSFD.

The Institute of Oceanography and Fisheries is a scientific institution established for the investigation of the sea. The scientific activity conducted encompasses virtually all aspects concerned with sea exploration: physical, chemical, geological, biological and fisheries. In its seventy years of existence, the scientists at the Institute have published over 1700 scientific and professional papers in both domestic and foreign publications.

Both the RBI and IOR together form Croatia's reference centre for the sea that is tasked with the continuous monitoring of the Croatian national waters under the MSFD.

Organised research work in the fields of oceanography and fishery started in Dubrovnik after World War II with the founding of the Fishery Centre in 1946 and with the establishment of the Biological Institute of the Yugoslav Academy of Sciences and Art (JAZU) in 1949. They formed the base for the present scientific research work of the Institute for Marine and Coastal Research of the University of Dubrovnik. The activities of the Institute are basic and concern the research of natural features in the Adriatic Sea and its coastline, particularly research into the structure and processes of ecosystems. The Institute also develops other activities, such as: monitoring living marine and land resources, monitoring sea quality, experimental rearing of plant and animal species with the aim of acquiring fundamental knowledge and studying the various stages of natural processes, maintenance and popularisation of aquarium, maintenance and popularisation of the Botanical Garden on the Lokrum island, formation of scientific and expert collections, as well as the organisation of courses and lectures.

Socio-economic Scope:

The abovementioned marine research infrastructures are committed to long term observations of the Adriatic Sea and to continued research on its marine ecosystems. In this way they produce the basis for Knowledge based sustainable management for Croatia and the Adriatic Sea. The reference centre for the Sea consortium is tasked with the systematic observation of the Croatian waters in the frame of the EUs MSFD. Scientists from the three above mentioned research infrastructures are contributing to all national expert consultancy bodies concerning marine environmental topics.

Socio-economic topics:

- Sustainable management and exploitation of marine resources and marine ecosystems
- Furthering blue biotechnology
- Health and safety of coastal population
- Protection of coastal ecosystems and coastal natural and historical heritage
- Safety at sea

Croatia is also involved in the following list of RI: EUROGOOS, SeaDataNet

2. A European answer to nations concerns

JERICO will be the only Research Infrastructure holistically embracing coastal marine systems. It will therefore fill a crucial gap in the European RI landscape. Existing environmental RIs are either focusing on deep ocean (EuroArgo and EMSO) or on inland and transitional environments (DANUBIUS and eLTER). Regardless of the major importance of the services they provide, none of them are designed to address the specific issue of coastal marine systems. The JERICO community intends to establish collaborative agreements with relevant environmental RIs as expressed in JERICO projects recently accepted for H2020 funding.

As part of the JERICO-DS proposal, we conducted a survey to assess the alignment between the available scientific expertise and the national priorities of each member country within the JERICO-DS consortium. This survey was shaped by the Marine Strategy Framework Directive (MSFD) and reflected the consortium's strong commitment to an ecosystem-based approach. The results highlighted variations across nations in both expertise and priorities, underscoring how these differences could complement one another. In some cases, nations were found to possess high levels of expertise in areas not considered a national priority, suggesting untapped potential that could benefit other countries. Conversely, some nations could address their expertise gaps by drawing on the strengths of others within the consortium, facilitated by JERICO's collaborative framework. Overall, these findings demonstrate the clear value of JERICO in fostering joint progress across nations, allowing them to effectively share knowledge and expertise to advance coastal research and policy efforts.

3. A sound business plan guaranteeing the financial feasibility of JERICO

The financial feasibility of JERICO is fundamentally supported by a robust and dynamic Business Plan that addresses all critical aspects of its lifecycle, ensuring long-term success and sustainability. It is developed in JERICO-S3 deliverable D9.3 "The JERICO Business Plan". The plan integrates a comprehensive Services Estimation Model (SEM) that forecasts and manages the financial requirements associated with the infrastructure's service delivery and development.

a. Detailed Financial Framework and Resource Allocation

The SEM outlines the initial phase of service development, where it anticipates rolling out 20 services. This projection is underpinned by the allocation of resources expressed in Full Time Equivalent (FTE) terms across the five JERICO Service Offices. Each service office is responsible for a specific facet of the service provision, such as data collection, analysis, or user support. The initial deployment phase relies heavily on in-kind contributions from JERICO members, including personnel, equipment, and infrastructure support. These contributions are essential to minimise initial costs and establish a solid foundation for subsequent phases. The financial model incorporates detailed cost estimates for personnel, technology, and infrastructure needs, allowing for precise budgeting as well as financial planning.

b. Growth Trajectory and Scalability

The SEM includes a sensitivity analysis to explore different scenarios of resource availability—worst-case, baseline, and best-case. This analysis is crucial for understanding the impact of varying levels of support on the development and operationalization of services. As JERICO progresses through its lifecycle, the model anticipates an expansion to 40 services by the operational phase (2029-2058), supported by up to 19 JERICO members. The growth trajectory has been carefully mapped out, with projections for increased FTE requirements and additional infrastructure investments. This scalability plan ensures that JERICO can adapt to changing demands and technological advancements, and maintain financial stability.

c. Technological Integration and Innovation

The integration of cutting-edge technologies plays a significant role in enhancing JERICO's value proposition and financial viability. Technologies such as the Plankton Dynamic Sensor Package (PSP), Autonomous Coastal Observing Benthic Station (ACOBS), and Water-Sample Filtering and Preservation Device (WASP) are pivotal in delivering high-resolution, real-time data. These innovations not only improve the quality and accuracy of data collection but also attract users by offering state-of-the-art observational capabilities. The JERICO Coastal Ocean Resource Environment (JERICO-CORE) functions as a central hub, consolidating resources, data, and tools, which enhances the efficiency of service delivery and optimises resource utilisation. The financial model accounts for the costs of acquiring, maintaining, and operating these advanced technologies, ensuring that investments align with the projected benefits and user needs.

d. Service Delivery Processes and Impact Evaluation

The SEM provides a detailed framework for developing, operationalizing, and evaluating services. This framework includes defined service design criteria, operational steps, and methodologies for assessing service impact. The model emphasises continuous monitoring and evaluation to gauge the effectiveness and value of each service. Key performance indicators (KPIs) are established to measure metrics such as data quality, user satisfaction, and operational efficiency. The ongoing impact analysis ensures that services remain relevant and provide substantial benefits to users, which is essential for maintaining user engagement and securing future funding.

e. Strategic Alignment and Policy Integration

The Business Plan aligns with broader strategic goals, including those articulated in the Tenerife Declaration (2023). This alignment emphasises the need for long-term sustainability in RIs, focusing on governance, operations, and service provision. The plan explores innovative funding mechanisms, such as public-private partnerships and collaborative research initiatives, to ensure a diversified and stable financial base.

Additionally, the plan addresses the need for enhanced engagement with smaller EU countries and the fostering of cross-disciplinary synergies, which are vital for building a more balanced and geographically DRI ecosystem.

f. Comprehensive Financial Management

Effective financial management is integral to JERICO's sustainability. The Business Plan outlines strategies for securing diverse funding sources, including national and EU grants, industry partnerships, and membership fees. Detailed budgeting and financial forecasting are employed to track expenditures, manage resources, and ensure that funds are allocated efficiently. The plan also includes mechanisms for financial oversight and accountability, such as regular audits and financial reviews, to maintain transparency and build trust with stakeholders.

g. User-Centred Approach and Value Realisation

A central tenet of the Business Plan is its user-centred approach, which is designed to ensure that JERICO's services are constantly aligned with the needs of its diverse user community. Engagement with users—from scientific researchers to commercial entities—is actively sought to refine service offerings and enhance their relevance. The plan highlights how user feedback is integral to shaping service development and ensuring that the infrastructure remains responsive to evolving needs. This user-driven model not only strengthens JERICO's service portfolio but also supports the business case for transitioning to an independent legal entity, for example under the ERIC framework, which will enhance governance and operational efficiency.

h. Sustainability and Long-Term Viability

The Business Plan places significant emphasis on achieving financial sustainability within a five-year period. This goal is pursued through a combination of infrastructure access fees, expanded data services, and the development of new revenue streams. By focusing on user-driven services and leveraging advanced technologies, JERICO aims to build a sustainable financial model that supports its long-term objectives. The plan outlines strategies for continuous improvement, innovation, and user engagement to maximise the socio-economic benefits of JERICO's offerings and ensure its enduring impact on the European and global research community.

4. Risk Management

Risk assessment identifies hazards and their potential effects and also identifies potential control measures to offset any negative impact on the JERICO. Under the JERICO-DS project there is a specific task to complete a Financial risk assessment and mitigation strategy for the JERICO to ensure that adverse situations are quickly identified and properly managed as the project evolves. The risk management framework developed will document the processes, tools and procedures that will be used to manage and control events with a potential negative impact and provide the RI's risk management plan. This plan will address the roles and responsibilities of the RI head office, risk identification, as well as risk assessment and mitigation plans. The mitigation of the identified risks will be linked to KPIs to ensure that impacts are minimised and mitigation is linked to ongoing performance management actions.

The Risk Management framework categorises the risks under the following headings: Financial, Organisational, Operational, Technical and Scientific. Certain international standards such as International Organization for Standardization (ISO) 31000:2009 and ISO/International Electrotechnical Commission (IEC) 31010:2009 set out principles, guidelines and techniques for risk assessment and management. The methodology outlined below has been used in a risk assessment for combining marine renewables with other blue economy activities via multi-use of spaces and platforms (Williams et al, 2017).

The methodology used to carry out the risk assessment involves three main steps: 1) Risk event identification; 2) Risk analysis and 3) Risk evaluation.

Risk identification is the process of recognising and recording potential risk factors and events that may affect JERICO and the achievement of its objectives. The risk identification process includes identifying causes and sources of the main risks such as events, situations or circumstances that could have a negative impact on JERICO.

The aim of a risk analysis is to measure the impact of a potential event, situation or circumstance as well as developing an estimation of the probability of these hazards actually occurring. Risk analysis involves determining the probability of the event occurring and the magnitude of its impacts. A quantitative risk analysis involves estimating practical values for probability (likelihood) and impact being ranked on a numerical scale ranging from 1 to 5 (a higher rating signifies a higher likelihood or impact of the risk event occurring). These values are then multiplied to create a single numerical value for the overall risk magnitude. The Risk Probability refers to the likelihood or frequency of a risk occurring. Probability rank is ranging from highly unlikely to very likely that an event will occur with 3 intermediate levels (Highly unlikely, Unlikely, Possible, Probable, Likely).

The Risk Impact refers to the consequences of the event occurring and is rated on a scale from 1 to 5 assuming a risk event occurs. A single impact may affect a range of different objectives and stakeholders. The impact rank is 1) Insignificant; 2 Minor; 3) Moderate; 4) Serious; 5) Severe.

The Risk magnitude is calculated by multiplying probability rating by impact rating as shown in the risk matrix below (Figure 18). The risk matrix or map helps to define risk tolerance and identifies risks that need more attention. In this risk matrix:

· Risk magnitude of 4 or less is low risk (green)
· Risk magnitude of 5 to 14 is a moderate risk (yellow)
· Risk magnitude of over 15 is a high risk (red)

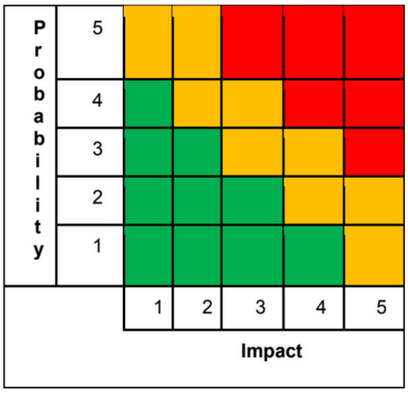


Figure 18: Impact vs Probability risk matrix used in JERICO's risk mitigation strategy.

Risk evaluation examines the extent to which identified risks could affect the ability of JERICO to achieve its objectives. Risk evaluation involves defining control measures and identifying associated monitoring procedures. A risk response strategy is a systematic process in which risks are either accepted or rejected. If a risk is deemed to be above an acceptable level (in this case a high or moderate risk) then mitigating actions should be taken to reduce the risk. Mitigation refers to actions taken, to either decrease impacts of the risk or decrease probability of the risk occurring. Once risk mitigation has been carried out, risk magnitude is then recalculated based on any residual risk.

Risks for the Preparatory Phase:

1) Risks related to Nation involvement or decision: (R1) lack of commitment, delays in their responses (probability 3, impact 5 ->RiskMag 15 High, (R4) lack of engagement on the application of the strategic, operation and data management plans, or the access policy (probability 2, impact 5 -> RiskMag 10 Moderate), (R7) political changes within countries (probability4, impact 2 -> RiskMag 8 Moderate), (R8) discrepancies between Nations (probability 4, impact 3 -> RiskMag 12 Moderate), and (R5) related to insufficient funding (probability 1, impact 5 -> RiskMag 5 Moderate).

Risk-mitigation measures: Direct communication between the consortium and national representatives are facilitated and encouraged through workshops and meetings with the JERICO Nation Committee. Prospective decisions will be submitted to Nation representatives in a timely manner. During the JERICO-DS project, a roadmap for capturing and tracking national commitments to observing Europe's coastal seas will be established. Strong linkages with the emerging Operations Committee of the European Ocean Observing System (EOOS) will be established. In addition, meetings are planned with ministerial representatives of RIs biannually. For funding commitments, detailed frameworks for financial risk mitigation are to be included in the funding plan.

2) Users related risks: (R3) Delays or inconsistencies in the stakeholders commitments about the scientific case, the physical part or the virtual needs (probability 3, impact 5

->RiskMag 15 High), and (R6) lack of interaction with the RI (probability 2, impact 4 -> RiskMag 8 Moderate).

Risk-mitigation measures: JERICO Coordination will organise periodic meetings involving the JERICO User and stakeholder Committee (JERICO-S3 and JERICO-DS). User Strategy design incorporates KPIs to maximise engagement by a broad range of User communities with the RI. Business plans will define a clear, streamlined access policy for users- minimising bureaucracy and red tape.

3) e-JERICO related risks: (R9) Lack of interoperability with other e-infra (probability 2, impact 5 ->RiskMag 10 Moderate), (R11) lack of critical mass of e-JERICO users and activity (probability 3, impact 5 -> RiskMag 15 High).

Risk-mitigation measures: e-Infra interoperability will be facilitated by development of a strategy based on recommendations to adapt FAIR data principles for the EOSC into the implementation phase e-needs. Particular attention will be paid to User strategy by strengthening the co-development of services with other initiatives in the EU landscape and by leveraging User engagement through education, training and the development of capabilities. Mitigation measures for Users-related risks (2) will be identified.

Risks for the Implementation and Operations Phases:
Sustainability of the RI: The EU's economic situation, the political choices and priorities in a difficult context, and the EU and its member states' capacity to maintain and possibly further
develop coastal observing systems are seen as the largest risk in terms of sustainability. The last decade's economic crisis has had a visible impact, with the European south concentrating efforts on sustaining existing systems in contrast with the northern countries where significant investments into new systems have been made. The lack of a national framework for marine issues, e.g. a dedicated ministry, is often a barrier to formulating strategies and funding for ocean observation. This leads to poor uptake of scientific results and transfer of technologies and non-sustainable ocean observing systems.

Risk-mitigation measures: We hope JERICO will raise the awareness of needed changes.

JERICO e-infrastructure considerations

Additionally, a risk assessment and mitigation strategy specific to JERICO-CORE's implementation was developed, considering project planning and the cost of selected components. This proactive approach highlights JERICO's commitment to managing uncertainties related to its e-infrastructure.

5. Support and engagement received

JERICO has established a robust foundation of political and financial support that will significantly strengthen its position for the next ESFRI Roadmap application. Over the years, the initiative has maintained a steady backing, which continues to evolve in line with the ambitions of the project. This support is reflective of the ever-changing political landscape within the EU, and is a crucial asset for JERICO's forthcoming application.

At the political level, nine EU Member States have committed to supporting JERICO's application. These include Croatia, Finland, Greece, Italy, the Netherlands, Norway, Portugal, and Spain, with France playing a leading role in coordinating the effort. This underscores the broad recognition of JERICO's value as a pan-European research infrastructure. The growing alignment of national interests further indicates that the coastal observation capabilities JERICO offers are increasingly seen as essential for addressing regional and global environmental challenges.

Compared to the previous application in 2021, the number of supporting nations for JERICO has increased. Political engagement is not just a formal endorsement but reflects an active recognition of the importance of the RI's activities: sustained marine and coastal observation efforts in response to climate change, biodiversity loss, and other environmental pressures. The political backing from these countries is a clear indication that JERICO is viewed as critical in helping nations meet their scientific objectives.

In Belgium and Estonia, political commitments remain contingent on national political developments depending on elections. Ongoing dialogues with political representatives in these countries suggest that JERICO continues to hold a strategic interest at the policy level.

Financially, JERICO's host country, France, is expected to provide strong ministerial backing, a critical factor for ensuring the infrastructure's sustainability. In addition to France, ministerial commitments are anticipated from Italy, Finland, and Croatia. These commitments are pivotal as they represent a concrete financial endorsement from key coastal nations. Furthermore, the willingness of 13 JERICO member institutions to continue funding their coastal nodes signifies a stable financial underpinning at the institutional level. This continued investment from JERICO's partner organisations demonstrates their long-term commitment to the infrastructure, which is critical for the financial feasibility of JERICO's expansion and development in the next ESFRI phase.

The overall landscape, as depicted in Figure 19, highlights an increase in both political and financial support compared to the 2021 application. This expanded backing is an important development, as it not only shows growing confidence in JERICO's objectives but also reflects a broader understanding of its essential role in Europe's marine research landscape. Such support is vital, as ESFRI evaluations often prioritise projects with widespread and tangible national endorsements.

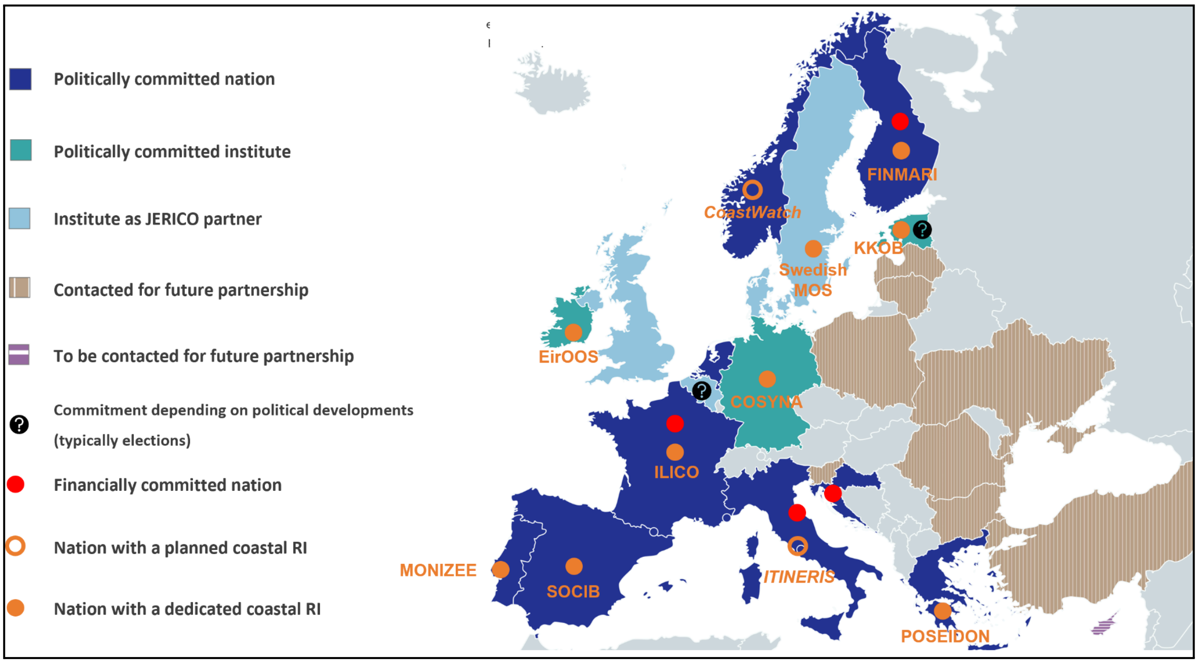


Figure 19- Political commitments for the 2026 ESFRI Roadmap application. Reproduced from JERICO-DS D4.2.

Since the last ESFRI Roadmap application in 2021, JERICO has worked actively to expand its geographic coverage, particularly toward the Black Sea, a region identified in previous recommendations. Contact has been initiated with Romania, Bulgaria, and Turkey to extend JERICO's reach in this area. In Romania, ongoing discussions have led to significant engagement, including participation in key JERICO-S3 activities, indicating increasing familiarity with the infrastructure. In Turkey and Bulgaria, meetings have laid the groundwork for further collaboration, with additional discussions scheduled to deepen involvement. This outreach is a direct response to recommendations from the previous ESFRI application and demonstrates JERICO's capacity to incorporate feedback and proactively enhance its strategic position.

Ukraine has also shown interest in JERICO, with recent discussions resulting in the country's inclusion as an observer in the Nations Committee. This involvement signals Ukraine's emerging role in European marine research despite the current geopolitical challenges, and its observer status could lead to a more formalised role in future iterations of JERICO.

In the Baltic Sea region, three additional countries are being brought into the JERICO network: Poland, Latvia, and Lithuania. Meetings are planned for September 2024 with representatives from each country to discuss their inclusion in the 2025 ESFRI application. These efforts aim to secure a more comprehensive regional presence, which is crucial for ensuring the Baltic Sea is adequately represented within JERICO's research network.

The Mediterranean Sea also presents new opportunities, with Cyprus identified as a potential participant. This region holds strategic importance given its unique oceanographic characteristics and its potential to serve as a hub for Mediterranean coastal observation.

Additionally, Slovenia has been engaged since 2023 in the Adriatic region, where further collaboration is expected to consolidate JERICO's coverage.

In total, JERICO expects to incorporate eight new countries from the Adriatic, Baltic, and Black Sea regions into the 2025 ESFRI Roadmap application, or beyond. This expansion reflects JERICO's commitment to enhance its geographic and operational scope, which will be critical for achieving the level of pan-European integration required. The increased political and financial backing, coupled with the inclusion of these new partners, positions JERICO as a stronger and more inclusive RI.

E. Calendar

Outcomes of JERICO-S3 and JERICO-DS projects include several elements of the DESIGN phase:

- Regional and site structuration in testing phase (until 2026) (JERICO-S3 D1.2, D4.1, D4.2, D4.3, D4.4)
- Socio-economic impact analysed (JERICO-S3 D9.3)
- Users and services identified and user strategy established (JERICO-S3 D9.1 & D9.2)
- e-infrastructure requirements mapped and concept piloted (JERICO-DS D3.2)
- Update of DMP and access policy revised (JERICO-S3 D6.12 & JERICO-DS D3.1)
- Preliminary business plan established (for regional considerations and hardware part) and Business case developed (JERICO-S3 D9.3 & JERICO-DS D4.3)
- Relations with other EU RIs proven (JERICO-S3 D9.6)
- Management structure defined (JERICO-S3 D9.4)
- By the beginning of 2027: proposal for a Preparation Phase.

The PREPARATION phase (2027-2029) has also been partly covered by many outcomes from the JERICO-DS and JERICO-S3 projects:

- KPIs identified and followed (JERICO-S3 D5.3)
- Risk analysis completed (JERICO-S3 D9.3)
- Access and Security policy defined (JERICO-DS D3.1)
- Technical Design including e-needs ready (JERICO-DS D3.2)
- Business plan and funding plan ready (JERICO-S3 D9.3)

Then, the PREPARATION phase is expected to continue as formal PP project (2027-2029) with the following additional outcomes:

- Establishing multidisciplinary observations for cutting edge science and societal needs
- Observation capacities proven through joint actions
- Collaboration with other RIs and initiatives implemented in agreements.
- Collaboration with Data aggregators and CMEMS implemented in agreements.
- Collaboration with EuroGOOS and EOOS implemented in agreements.
- Adoption of Standards agreed and JERICO Label operational.

- Nations agreed to organise the system in Regions and sites.
- Nations commit their systems (hardware and software) in JERICO
- Set up of Expertise centres for the software part (e-JERICO)
- Funding plan consolidated and adopted by nations
- Development of the Legal entity with approved governance
- Formal commitment for funding of the Implementation obtained.

Expected tasks to be led during the IMPLEMENTATION phase (2030-2033):

- Preparation of the Expertise Centers.
- Preparation of the virtual facilities including data hub and data integration.
- Analysis of the sites' observation systems to elaborate plans for technical upgrade of *in-situ* systems.
- Inclusion of JERICO facilities as new entries and roadmap to progress towards maturity.
- Quotations and Detailed costs models.
- Implementation plan defined.
- Scientific, Technology and Ethical advisory committee and User committee fully implemented.
- MoU signed by nations for Implementation Phase.

F. Conclusion

The JERICO stands ready to address a critical gap in the European Research Infrastructure landscape by providing comprehensive, integrated coastal marine observations. As detailed in the ongoing efforts and plans of the JERICO-S3 and JERICO-DS projects, significant progress has been made in both the DESIGN and PREPARATION phases. The projects have laid a strong foundation through enhanced scientific leadership, rigorous regional structuring, and socio-economic impact analyses. The establishment of a user strategy, e-infrastructure requirements, and preliminary business plans further underscores the robust planning of JERICO.

The continued engagement and support from a growing number of EU nations demonstrate an increasing recognition of the value of JERICO. This expanded backing, coupled with a strategic focus on incorporating new countries and regions, highlights JERICO's evolving role in addressing regional and global environmental challenges. The alignment with broader EU and International objectives, including collaboration with other RIs, data aggregators, and key initiatives such as EuroGOOS and EOOS, reinforces JERICO's position as a pivotal player in European marine research.

The business plan plays a central role in JERICO's strategy, providing a detailed framework that outlines financial sustainability, governance structures, and resource allocation. It ensures that the infrastructure is financially viable and adaptable, with clear commitments from participating nations and institutions. This comprehensive plan highlights how regional considerations, in situ systems, and expertise centres will be developed and sustained, offering a robust foundation for long-term operations.

Looking ahead, the PREPARATION and IMPLEMENTATION phases will focus on refining observational capacities, establishing technical and virtual facilities, and securing formal commitments from nations and stakeholders. The transition to a fully operational legal entity and the development of a detailed implementation plan will be crucial for JERICO's successful launch and continued evolution.

In summary, JERICO's strategic approach outlined in this Design Report, combined with its growing support base and well-defined risk management strategies, positions it as a key asset for advancing coastal marine science and addressing critical environmental issues in Europe. The initiative's ongoing efforts to expand its geographic and operational scope will further enhance its impact and ensure its alignment with both national and EU-wide priorities.

G. References

Benedetti-Cecchi, L., Crowe, T., Boehme, L., Boero, F., Christensen, A., Grémare, A., Hernandez, F., Kromkamp, J. C., Nogueira García, E., Petihakis, G., Robidart, J., Sousa Pinto, I. & Zingone, A. (2018) Strengthening Europe's Capability in Biological Ocean Observations. Muñiz Piniella, Á., Kellett, P., Larkin, K., Heymans, J. J. [Eds.] Future Science Brief 3 of the European Marine Board, Ostend, Belgium. 76 pp. ISBN: 9789492043559 ISSN: 2593-5232.

Celić, I., Libralato, S., Scarcella, G., Raicevich, S., Marceta, B., Solidoro, C. (2018), Ecological and economic effects of the landing obligation evaluated using a quantitative ecosystem approach: a Mediterranean case study, ICES J. Marine Sc. 75 (6), 1992-2003, doi: 10.1093/icesjms/fsy069

Fujii, Y., Rémy, E., Zuo, H., Oke, P., Halliwell, G., Gasparin, F., Benkiran, M., Loose, N., Cummings, J., Xie, J., Xue, Y., Masuda, S., Smith, G.C., Balmaseda, M., Germineaud, C., Lea, D.J., Larnicol, G., Bertino, L., Bonaduce, A., Brasseur, P., Donlon, C., Heimbach, P., Kim, Y., Kourafalou, V., Le Traon, P.-Y., Martin, M., Paturi, S., Tranchant, B. and Usui, N. (2019) Observing System Evaluation Based on Ocean Data Assimilation and Prediction Systems: On-Going Challenges and a Future Vision for Designing and Supporting Ocean Observational Networks. Front. Mar. Sci. 6:417.doi:10.3389/fmars.2019.00417.

Guidi, L., Fernandez Guerra, A., Canchaya, C., Curry, E., Foglini, F., Irisson, J.-O., Malde, K., Marshall, C. T., Obst, M., Ribeiro, R. P., Tjiputra, J., Bakker, D. C. E. (2020) Big Data in Marine Science. Alexander, B., Heymans, J. J., Muñiz Piniella, A., Kellett, P., Coopman, J. [Eds.] Future Science Brief 6 of the European Marine Board, Ostend, Belgium. ISSN: 2593-5232.

Heymans, J., Skogen, M., Schrum, C., Solidoro, C. (2018). Future Science Brief Enhancing Europe's Capability in Marine Ecosystem Modelling for Societal Benefit. 10.13140/RG.2.2.16952.60160.

McGranahan, G., Balk, D., & Anderson, B. (2007). The rising tide: assessing the risks of climate change and human settlements in low elevation coastal zones. *Environment and urbanization*, *19*(1), 17-37.

Merkens, J. L., Reimann, L., Hinkel, J., & Vafeidis, A. T. (2016). Gridded population projections for the coastal zone under the Shared Socioeconomic Pathways. *Global and Planetary Change*, *145*, 57-66.

Quetglas, A., Ordines, F., Guijarro, B. (2011). The Use of Artificial Neural Networks (ANNs) in Aquatic Ecology. 10.5772/16092.

Robinson, A.R., and Brink, K.H., The Global Coastal Ocean: Multiscale Interdisciplinary Processes. Harvard University Press, 2005.

Small, C., & Nicholls, R. J. (2003). A global analysis of human settlement in coastal zones. *Journal of coastal research*, 584-599.

Spence, MA, Blanchard, JL, Rossberg, AG, et al. A general framework for combining ecosystem models. Fish and Fisheries. 2018; 19: 1031– 1042. https://doi.org/10.1111/faf.12310.

Williams, H., Masters, I., Pletsas, D., Callaway, R., Blanch, M., Dalton, G., Fuentes-Grünewald, C. (2017). A risk assessment methodology for combining marine renewables with other blue economy activities via multi-use of spaces and platforms, EWTEC conference, Cork, Ireland