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

# JERICO-S3 DELIVERABLE

Joint European Research Infrastructure for Coastal Observatories
**Science, Services, Sustainability**

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# TABLE OF CONTENT

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# 1.EXECUTIVE SUMMARY

This document gives an overview of the current state, implementation and sustainability of coastal ocean observatories in the integrated regional sites of JERICO-S3. The currently implemented observational infrastructures are established and maintained by such diverse organizations like defense ministeries, port authorities, scientific institutions, ministeries for fisheries and regional governments. All mentioned observational infrastructures respond to KSCs and SSCs of regional and specific importance. However, European, and European-regional strategic documents and regulations resulted in pan-European consolidations for several observations required by e.g the Marine Strategy Framework directive and the respective regional conventions.Sustainability of finances and human resources in almost all cases is established, as permanent positions and maintenance funds are available for the operation and maintenance of the infrastructures mentioned below.

Implementation and organisation is mostly driven by individual organisations or ministries and strategic and technological integration reaches at most national level for some examples, while regional integration remains mostly informal. However, all IRS in their reports agree on the set of KSC and SSC as defined in the course of the JERICO-S3 and JERICO-DS projects to be relevant and exhaustive for their region. This indicates expressed homogeneity in the reasoning behind the observational strategies. Regional conventions under the MSFD as well as regional transborder project apparently have contributed to common observational strategy developments at regional level and to the interoperability of data handling and infrastructure. The overwhelming majority of observations are included in either national monitoring programs or "ROOSes" in the framework of EUROGOOS, which is in line with the JERICO-S3 data handling strategies and significantly contributes to FAIR and sustainable data management. The implementation of the JERICO-RI will ensure the strategic and technological integration of those existing and surely to be extended observational infrastructures at regional and pan-European level, which clearly demonstrates the added benefit of the establishment of the JERICO-RI.

Sustainability of observational strategies, infrastructure and HR is currently mainly achieved at national level. The establishment of the JERICO-RI with its government structure, national commitments and pan-European observational strategies will significantly enhance the sustainability and interoperability at regional and pan-European level beyond the capabilities of a "network of networks" type of structures.

# 2.INTRODUCTION

In the context of this document (Final analysis and summary of region-specific and region-wide monitoring strategies, and regional sustainability plans) the term "monitoring" describes the range of coastal ocean observations the regions intend to maintain to address the JERICO KSCs. Here we summarise regional, observational strategies and elements of their sustainability in the JERICO integrated regional sites (IRS). The document demonstrated the established capacity to ensure coastal observations responding to the full range of identified JERICO-RI KSCs and SSCs. This document summarises the level of sustainability at national, regional and pan-European level for observational strategies, infrastructure and Human resources. The JERICO community throughout the JERICO-S3 project enlarged the range, coverage and spatial resolution of observational infrastructure in coastal European Seas. Observational strategies at national and regional scale were advanced and consolidated to a level, where a JERICO-RI can be established through national commitment.

# 3.MAIN REPORT

## 3.1. Northern Adriatic IRS

**Partners**: Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS), Italy; Consiglio Nazionale delle Ricerche (CNR), Italy; Ruder Boscovic Institute (IRB), Zagreb, Croatia, Center for marine Research (CIM) Croatia.

### Key scientific challenges sustainably addressed

The regional scientific strategies, respective observational strategies and their integration into a pan-European scientific and observational strategy of the JERICO-RI with respect to the identified KSCs are collected and discussed in D1.1 and D1.2. The Northern Adriatic IRS identified the following KSCs, SSCs and Research axes as important for the region:

| Keys Scientific Challenges | Specific Scientific Challenges | Research Axes |
|---|---|---|
| **Assessing changes under the combined influence of global and local drivers** | Land Sea Ocean continuum. Impacts of land-derived discharges and exchanges with open ocean | |
| | Sea-atmosphere interface. Quantification of inputs | Particles<br>Nutrients<br>Contaminants |
| | Connectivity and transport.<br>Pathways of water masses and materials | Water masses (including vertical mixing)<br>nutrients<br>contaminants<br>particles<br>organisms (connectivity) |
| | Biodiversity trends | Phytoplankton<br>Zooplankton<br>Benthos |

| | | |
|---|---|---|
| | Ecosystem biogeochemical processes and interactions | Biophysical interactions<br>Biogeochemical functioning<br>Pelagic<br>Benthic<br>Pelagic/benthic coupling |
| | Carbon budget and carbonate system | Carbon fluxes and budget<br>Carbonate system trends<br>Effects of acidification |
| **Assessing the impacts of extreme events** | Impacts of rare and extreme events | Floods<br>storms/large waves<br>heat/cold waves<br>landslides/sudden erosion<br>tsunamis<br>volcanic eruptions<br>harmful algae / jelly fish blooms<br>accidental pollution<br>Interactions between events |
| | Resolving climate change impacts | Temperature<br>salinity<br>currents<br>sea level rise<br>waves<br>biological productions<br>species distribution ranges (biogeography)<br>nutrients |
| **Unravelling and predicting the impacts of natural and anthropogenic changes** | Resolving anthropogenic impacts | Eutrophication<br>habitat and biodiversity loss<br>contamination<br>coastal engineering<br>use of marine space (including windfarming)<br>use of marine nonliving resources<br>use/cultivation of living resources<br>invasive species<br>maritime traffic<br>(micro) plastics<br>acoustic and electromagnetic noises |
| | Disentangling impacts/scales | Meta analysis<br>coupled modelling |

Table 2 and table 2 in D1.2 detail the perceived level of importance as well as how well the respective SSCs are currently addressed in the regions.

The various observational networks involved in the NA-IRS, allow KSCs to be addressed. Ongoing support from both the JERICO-RI partnership and other funding sources for the integration of these systems will further enhance KSCs response capabilities.

**KSC#1: "Assessing and predicting changes under the combined influence of local drivers"**

Under this KSC, individual SSCs are addressed with different priorities. The "Land Sea Ocean continuum. Impacts of land-derived discharges and exchanges with open ocean" is monitored primarily from observational platforms located near the mouth of the Po River, which is the largest freshwater contributor to the Adriatic Sea. "Biodiversity trends" are studied using Jerico partners' observational platforms distributed along the entire NA-IRS coastline. The same is true for the "Carbon budget and carbonate system", where there are several observational systems partly also supported by the ICOS consortium.

**KSC#2: "Assessing the impacts of rare and extreme events"**

Relative to this KSC, particular attention is devoted to the "Impacts of rare and extreme events where several observational networks adherent to JERICO partners, are able to provide useful information in relation to storm surges, high tides, coastal erosion or river flooding phenomena. Some of these networks are partially supported by regional government agencies responsible for monitoring such phenomena.

Regarding the SSC "Resolving climate change impacts" the data collected by the observational networks adherent to NA-IRS, are used directly by the researchers of the JERICO partners and at the same time made available to the international community through assimilation into the principal oceanographic databases e.g  Copernicus Marine Service and Emodnet.

**KSC#3: "Unravelling the impacts of natural and anthropic changes"**

Regarding the SSCs "Resolving anthropogenic impacts" and "Disentangling impacts/scales," data collected by observational networks afferent to NA-IRS, are made available to the international community through assimilation into principal oceanographic databases e.g., Copernicus or Emodnet. They can also be used directly by stakeholders who request them.

To address the aforementioned KSCs in the region and at regional level the following operational infrastructures are mapped for the IRS-NA:

| Platform/network | Partner | Variables | Sustainability | | |
|---|---|---|---|---|---|
| | | | Financial (Funding source; Medium 3-5 yrs, Long term >5 yrs) | Human resources (short term staff, permanent staff) | Data (institutional, national, regional/european) |

| | | | | | |
|---|---|---|---|---|---|
| GoT (Gulf of Trieste Observing Network)<br><br>4 oceanographic buoys, 3 wave buoys, 2 river stations and 1 HF-Radar system | OGS (IT) | ECV - Atmosphere, Surface: Surface Air Temperature,<br><br>Surface Air Pressure,<br><br>Surface Wind Speed and Direction,<br><br>Humidity<br><br>ECV - Ocean, Physical: Subsurface Temperature<br><br>Subsurface Salinity<br><br>ECV - Ocean, Biogeochemical: Oxygen.<br><br>pH, Fluorescence, Turbidity, Irradiance<br><br>ECV - Ocean, Physical: Sea State, wave height and direction<br><br>ECV - Ocean, Physical: Subsurface | EU projects, Medium Term<br><br>Regional Civil Defense Agency<br><br>Long term | Permanent staff | Near-Real time data sent to OGS-NODC (National Oceanographic Data Center) and then made freely available through an ERDAPP server |

| | | | | | |
|---|---|---|---|---|---|
| | | Current Current Profile<br><br>ECV - Ocean, Physical: Sea Level Regional Sea Level<br><br>ECV - Ocean, Physical: Sea Level Regional Sea Level<br><br>River Current Profile, River Flow Rate, River Level | | | |
| Multiparametric buoys:<br><br>PALOMA | CNR – ISMAR (IT) | ECV - Ocean, Physical: Subsurface Temperature<br><br>ECV - Ocean, Physical: Subsurface Salinity<br><br>ECV - Ocean, Biogeochemical: Oxygen.<br><br>EOV - Ocean Biogeochemistry: pCO2 (inorganic carbon) | EU projects, Medium Term | Permanent staff | Erddap/OPenDAP |

| | | | | | |
|---|---|---|---|---|---|
| | | EOV - physics sea level (pressure) | | | |
| Multiparametric buoys:<br><br>S1GB | CNR – ISMAR (IT) | ECV - Atmosphere, Surface: Surface Air Temperature,<br><br>ECV - Atmosphere, Surface: Surface Air Pressure,<br><br>ECV - Atmosphere, Surface: Surface Wind Speed and Direction,<br><br>Humidity<br><br>ECV - Ocean, Physical: Subsurface Temperature<br><br>ECV - Ocean, Physical: Subsurface Salinity | EU projects, Medium Term | Permanent staff | Erddap/OPenDAP |
| Multiparametric buoys:<br><br>CIM ODASI and CIM ODASII | IRB (HR) | Atmosphere: Wind, air temperature, air pressure, humidity, visibility in air<br><br>Water surface:<br><br>Waves, surface water current, | EU projects, Medium Term<br><br>Croatian Ministery<br><br>Long Term | Permanent staff | National Database for MSFD and institutional database |

| | | | | | |
|---|---|---|---|---|---|
| | | surface temperature, Planktonbiodiversity.<br><br>Watercolumn:<br><br>Chla, phycoerythrin, CDOM, FDOM, transparency, temperature, salinity, pH, CO2, PAR, | | | |

The NA-IRS is a transboundary site that currently involves two countries: Italy and Croatia and several scientific entities that have developed their own observational strategies over the years, to respond to different KSCs.

This apparent heterogeneity arises from the different purposes of the projects and funding that have allowed, over the years, the implementation of the various observational networks constituting NA-IRS.

But if we look at the NA-IRS system in its entirety, as realised through the various JERICO programs and shown in the table above, we will see that it presents itself as a rather homogeneous observational system, providing good spatio-temporal coverage for the variables, that are of interest to the various KSCs reported at the beginning of the paragraph. This rather promising results is also founded in the fact that a good number of projects were aiming at a regional observation capacity with transborder, international collaborations.

The entire NA-IRS observational system is compliant with MSFD and WFD guidelines, while individual subsystems respond according to local needs to national guidelines in terms of search/Rescue, aquaculture, Blue growth, etc.

The table above illustrates the NA-IRS observational system as it is now, but an extensive program of expansion of observational capabilities and monitored variables is currently being implemented for the Italian part, thanks to the Italian PNRR-ITINERIS program, which promotes research infrastructure including the Italian component of JERICO-RI, thanks to funding derived from the Recovery Found. The observational capabilities of the existing sites will be expanded with the implementation of additional instrumentation to acquire both physical and biogeochemical parameters. Simultaneously in Croatia two additional oceanographic multisensor buoys with real time data transfer for the following parameters have been purchased and installed as well as integrated with interoperable systems from the Croatian meteorological service along the entire eastern Adriatic coast. Wind speed, Wind direction, Air temperature, Humidity, Visibility in air, Air pressure, Rainfall intensity, Wave height, Wave direction, Surface water current (speed and direction), Water currents throughout the water column (speed and direction), Chla concentration (1m), Seawater temp, Seawater Salinity. The two buoys installed in the northern Adriatic Sea additionally measure: CO2 pressure (1m), CDOM (watercolumn), FDOM (watercolumn), Phycoerithrin concentration (watercolumn), CHLa concentration (watercolumn), Sea water salinity (watercolumn), Sea water temperature (watercolumn), Sea water transparency (watercolumn), PAR (watercolumn), Seawater pH (watercolumn), Seawater Oxygen concentration (watercolumn).

## Sustainability of the operational coastal observations

**Human resources:** All above mentioned infrastructures are operated and supervised by permanently employed technical and scientific staff. Hence adequate maintenance and quality control is sustainably implemented.

**Financial sustainability:** The operation and maintenance of CIM ODASI and CIM ODASII are operated by the Croatian Consortium "Reference Center for the Sea", which is mandated by the Croatian Ministery for sustainably development and environmental protection to perform national monitoring programs under the MSFD.
Currently, on the Italian side, there is no government program of financial support. Observational systems are supported by the research institutions that have implemented them, through national and European projects and through funding from individual government and regional agencies interested in the data acquired. Nevertheless, monitoring strategies are always defined in accordance with the recommendations of the MSFD and hence sustainably funded as obligatory infrastructure to fulfill memberstates obligations towards te EU.

**Data:** Resulting data from the above mentioned infrastructures CIM ODASI and CIM ODASII are gathered in a national database for MSFD related monitoring data. FAIRness of data and long term storage/data safety is managed.
For the Italian component, as specified in the table, for each observing system that is part of NA-IRS, the data collected are assimilated into the databases of the individual institutes, partly into the National Oceanographic Data Center (NODC), and sent to large oceanographic data aggregators such as Copernicus Marine Service and EMODNET.

## Sustainability at regional level

Current status and update (relative to D3.1) on regional sustainability

At present, at the Italian level, the major contribution is directed to the expansion and modernization of the NA-IRS constituent sites, through the PNRR-ITINERIS project mentioned above. Certainly against this important investment the government will not fail to support the maintenance of the infrastructure once it becomes part of JERICO-RI.

A major contribution to sustainability at regional level in the Northern Adriatic Sea will be the respective national commitments of Croatia and Italy to the JERICO-RI, where Human resources as well as observational infrastructures including maintenance and modernization will be part of the national commitments. These national commitments at JERICO-RI level will ensure the long term perspective of regional strategies developed here. The infrastructures that are currently contributing to and financed by the national monitoring programs under the MSFD framework are at regional level strategically coordinated to some extent by the Barcelona convention, where a regional (Mediterranean wide) strategy for MSFD related monitoring is outlined. Persistence of this convention contributes to the sustainability of the coastal observation framework. Intercalibration efforts for a number of parameters (like e.g. pCO2, ….). A yearly regional conference on observation data and technology will contribute to the sustainability of fit for purpose coastal observations in the region.

## 3.2. Iberian Atlantic Margin IRS

**Partners**: Instituto Hidrografico (IH),Portugal; Puertos del Estado (PdE), Spain; Plataforma Oceanica de Canarias (PLOCAN), Spain.

### Key scientific challenges sustainably addressed

The regional scientific strategies, correspondent observational strategies and how they integration into a pan-European scientific and observational strategy for JERICO-RI, taking in account the identified Key Scientific Challenges (KSCs) are discussed in JERICO-S3 Deliverables D1.1 and D1.2. Table 3.2.1 below provides an updated view of table 2 from D1.2 for the Iberian Atlantic Margin (IAM) IRS, integrating both information that was not available at the time of submission of D1.2 and the developments that occurred during the timeframe of JERICO-S3:

| Keys Scientific Challenges | Specific Scientific Challenges | Research Axes | Priority (text below) |
|---|---|---|---|
| **Assessing changes under the combined influence of** | Land Sea Ocean continuum. Impacts of land-derived discharges and exchanges with open ocean | | 1 |

| | | | |
|---|---|---|---|
| **global and local drivers** | | | |
| | Sea-atmosphere interface.<br>Quantification of inputs | Particles<br>Nutrients<br>Contaminants | 3 |
| | Connectivity and transport.<br>Pathways of water masses and<br>Materials | Water masses (including vertical mixing)<br>nutrients<br>contaminants<br>particles<br>organisms (connectivity) | 1 |
| | Biodiversity trends | Phytoplankton<br>Zooplankton<br>Benthos | 3 |
| | Ecosystem biogeochemical processes and interactions | Biophysical interactions<br>Biogeochemical functioning<br>Pelagic<br>Benthic<br>Pelagic/benthic coupling | 2 |
| | Carbon budget and carbonate system | Carbon fluxes and budget<br>Carbonate system trends<br>Effects of acidification | 3 |
| **Assessing the impacts of extreme events** | Impacts of rare and extreme events | Floods<br>storms/large waves<br>heat/cold waves<br>landslides/sudden erosion<br>tsunamis<br>volcanic eruptions<br>harmful algae / jelly fish blooms<br>accidental pollution<br>Interactions between events | 1 |
| | Resolving climate change impacts | Temperature<br>salinity<br>currents<br>sea level rise<br>waves<br>biological productions<br>species distribution ranges (biogeography)<br>nutrientes | 1 |

| | | | |
|---|---|---|---|
| **Unravelling and predicting the impacts of natural and anthropogenic changes** | Resolving anthropogenic impacts | Eutrophication<br>habitat and biodiversity loss<br>contamination<br>coastal engineering<br>use of marine space (including windfarming)<br>use of marine nonliving resources<br>use/cultivation of living resources<br>invasive species<br>maritime traffic<br>(micro) plastics<br>acoustic and electromagnetic noises | 1 |
| | Disentangling impacts/scales | Meta analysis<br>coupled modelling | 3 |

Table 3.2.1 and table 2 in D1.2 detail the perceived level of importance as well as how well the respective SSCs are currently addressed in the regions.

All the key Specific Scientific Challenges (SSCs) proposed as part of JERICO-RI scientific strategy and introduced in D1.2 have an important expression inside the Iberian Atlantic Margin and are being addressed, with different levels of priority, by the installed observational capacities operated by the IAM IRS partners. Here we discuss the importance of each SSC by grouping them in 3 categories of priority regarding their impacts and how the observation efforts are being directed and the scientific/societal. The relevant research axis are highlighted in bold.

**Highest Priority Specific Scientific Challenges (Priority 1 in table)**

The following SSCs are identified as of highest priority inside the Iberian Atlantic Margin IRS based on the recognition of their relevance for the achievements of key strategic and operational needs in the two countries that contribute to this IRS. In Portugal, the relevance of these SSCs are well expressed, for example, in governmental strategic orientations such as the National Strategy for the Sea 2021-2023 (NSS2021-2023) or the National Strategy for the Adaptation to Climate Changes. These documents introduce key strategic objectives that clearly articulate with the Specific Scientific Challenges indicated below (for example, the first Strategic Objective of the Portuguese NSS2021-2023 is "Fighting Climate Change and Pollution and Restoring the Ecosystems").

***Impact of rare and extreme events***

The Iberian Atlantic Margin IRS extends over geographical area exposed to the high energy manifestations if the North Atlantic Ocean such as **storms and large waves** that directly hit the coastline and coastal ocean environment, leading to severe impacts on the coastal populations and coastal structures, on sectors of economic activity developed offshore or in the ecosystems. The area is also particularly exposed to the impacts of long period (interannual, decadal, multidecadal) variability and trends of the North Atlantic conditions which can promote severe **heat waves** and the passage of **extreme atmospheric events (hurricanes).** The oceanographic conditions prevailing in this area can lead to occasional events of **harmful algae / jelly fish blooms** which constrain fishery activities and negatively impact on the populations health. The IAM covers an area of confluence of influences and a crossroad for main maritime routes, prone to the occurrence of major events of accidental pollution with dramatic consequences for the coastal populations and the coastal ocean environment. The historical register of the earthquake of 1755 and the tsunami that followed, with impacts registered in the global area covered by the IRS, stands as a reminder of the vulnerability of the area to **tsunamis**. These can also be linked to tsunamogenic **landslides/sudden erosion** that can affect the area, particularly the continental slope, which can be triggered by seismic activity, by intensified fluxes of sediments promoted by large submarine canyons or by bottom fluxes, such as sudden releases of methane. In the Archipelagos of Canary (Spain) and Azores (Portugal), the impact of **volcanic eruptions** is a factor to be taken into account.

***Connectivity and transport. Pathways of water masses and materials***

The IAM IRS covers a geographical region where diverse influences converge and important transport mechanisms are generated. Along its western boundary, the area receives direct influences from the North Atlantic circulation, in particular through branches of the Azores Currents that profoundly affect the conditions along the continental slopes of western Iberia and NW Africa (where they force important poleward slope currents), inside the Gulf of Cadiz area (where it interacts with the Mediterranean Water Outflow, see below) or offshore NW Africa and the Canary Archipelago (where it recirculates southwards in the Canary Current and Canary Upwelling Current). The eastern boundary of the IRS comprises the Gibraltar Strait, where key exchanges between the North Atlantic and Mediterranean take place, and the Gulf of Cadiz area (offshore southern Portugal and southwestern Spain), where the complex adjustment of the Mediterranean Water entering in the North Atlantic Basin through the Gibraltar Strait takes place. This adjustment process shapes the long distance influence of the Mediterranean in the Atlantic, either in the form of the salty (and warm) Mediterranean Water veins that flow poleward along the Iberian continental slope or in the form of a more diffuse and Meddy dominated spreading westwards and south. It also seems to control aspects of the deep ocean circulation (e.g. forcing of the Azores Current by the Mediterranean Water Outflow through the beta-plume mechanism). Finally, the IAM IRS position in the mid-latitude sector of the eastern North Atlantic, puts it under the seasonal influence of the eastern limb of the Azores High Pressure System, leading to persistent northerly winds and upwelling conditions developing along the western coasts of Portugal and Spain and along the NW African coast, which together correspond to the northern part of the Canary Upwelling System, one of the most important upwelling systems of the World. These conditions contribute with powerful mechanisms for horizontal (southward and offshore) and vertical (upward) transport affecting these coastal ocean areas.

These complex settings and mechanisms lead to important transboundary transport of **Water masses (**including in the vertical dimension, namely associated with **vertical mixing), nutrients, contaminants, particles** and **organisms**. They promote a long distance connectivity (biological, but also of physical, chemical or sedimentary characteristics) allowing for a long distance spreading of influences and disturbance from sources located in equatorward and/or offshore regions to areas of the European slope further poleward and/or eastward. In these processes, a key role is played by the different submarine canyons and offshore submarine seamounts and banks that are located inside this IRS.

***Land Sea Ocean continuum. Impacts of land-derived discharges and exchanges with open ocean***

The continental part of the IAM IRS is under the influence of important riverine inputs provided from rivers with a European expression such as the Douro river and the Tagus river (along the western coast of Portugal) and the Guadalquivir river (along the Southwestern coast of Spain). The dynamic processes inherent to the shelf/slope environment provide a mechanism for the long range transport of the influences of these inputs crossing the borders and connecting at regional level. The area is also cutted by some of the more important submarine canyon systems of Europe (e.g Nazare Canyon and Lisbon/Setubal canyons along the W coast of Portugal) which not only provide exceptional mechanisms modulating the but also provide a pathway for the interaction between the nearshore environment and the deep ocean offshore. Finally, the IAM IRS comprises the northern branch of the Canary Upwelling System, one of the large upwelling regions of the world. This translates in an important seasonal upwelling with large , recurrent upwelling filaments promoting offshore transport of biological material.

***Resolving climate change impacts***

All the conditions associated with the High Priority SSCs described above are directly impacted by the long term evolution of the conditions prevailing in the North Atlantic and Mediterranean basins, particularly those that reflect multi-year variability (e.g. associated with the North Atlantic Oscillation regimes) or those reflecting the impacts of climate change. For this reason, “Resolving climate change impacts” is also a High Priority SSC in this IRS. This is recognized by different governmental directives (e.g. in Portugal the National Strategy for the Adaptation to Climate Change ) that highlight, in their action lines, aspects such as the promotion of the coastal resilience and the protection of ecosystems, species and habitats, regarding climate change impacts. These include, namely, the impacts on **biological production** and **species distribution ranges** (e.g. installation of exotic **invasive species)** which are affected, for example, by changes in water **temperature**, **salinity**, **currents** and **nutrients**. Or the impacs in coastal areas prone to high risk of **coastal erosion**, **coastal overtopping** or **floods**, promoted as the result of changing **wave regimes** and **sea level rise**. Multi-parametric monitoring systems are recognized as key support decision tools to answer these challenges.

· ***Resolving anthropogenic impacts***

The waters of the IAM IRS show a high diversity in what regards genetics, species, habitats and marine ecosystems, with a great heterogeneity of the seafloor regarding its physiography and geomorphology, which translates in a rich geology and biology. One of the reason why this SSC is considered of Highest Priority in this IRS derives from the recognition that these marine ecosystems are being affected by important anthropogenic pressures that, together with the impacts of climate change (marine heat waves, acidification, hypoxia events), lead to important **habitat and biodiversity loss**.

Important governmental actions and measures are being taken by the two EU countries that contribute to this IRS (Portugal and Spain) to evaluate the status of the marine ecosystems and preserve biodiversity, both as part of their National Strategies for the marine environment or in the framework of national commitments to EU Directives (e.g. Marine Strategy Framework Directive) or Regional Conventions (OSPAR).

The position of the IAM IRS as a crossroad for the major **maritime traffic** routes between Africa and Europe, the Atlantic and the Mediterranean basins, makes it particularly prone to major **contamination** accidents (e.g. oil spills), to the presence of **invasive species** associated with ballast water releases or transport from a remote location and to the general **acoustic and electromagnetic noises** pressures affecting marine species. In recent years an increasing importance is being focused on the monitoring of **(micro) plastics** and **marine litter**.

**High Priority Specific Scientific Challenges (Priority 2 in the table)**

***Sea-atmosphere interface. Quantification of inputs***

The coastal ocean dynamics is, in large measure, driven by atmospheric forcing, either in the form of momentum fluxes (wind stress), of heat fluxes (sensible and latent heat fluxes, radiative input) or of water fluxes (precipitation/evaporation). It is then of paramount importance to understand and quantify the sea-atmosphere interaction. In the IAM IRS, a particular attention is also given to the inputs of nutrients and contaminants that are transported from the continent to the areas offshore. This is of particular importance in the southern part of the IRS where important fluxes are associated with Sahara dust from Sahara desert extending from NW Africa to the coastal ocean areas offshore the Canary Archipelago (Spain), the Madeira Archipelago (Portugal) and the continental areas of South Portugal and Spain.

**Medium Priority Specific Scientific Challenges (Priority 3 in the table)**

***Carbon budget and carbonate system***

***Biodiversity trends***

## Regional Observation Strategy

The operational infrastructure contributing to the IAM-IRS is described in Table 3.2.2. This infrastructure integrates the observing capacities included in the Portuguese MONIZEE infrastructure (operated by Instituto Hidrografico), in the Spanish PORTUS system (operated by Puertos del Estado) and the Spanish PLOCAN infrastructure. Together these capacities provide a comprehensive observation of the regional area that extends from the Alboran Sea to the southwestern, western and northwestern Iberian area and to the Canary Islands archipelago. These capacities are at the core of the national answer to the different Key Scientific Challenges and associated Specific Scientific Challenges described above.

In, particular, focusing on the above mentioned High Priority SSCs, the regional observation strategy comprises the following main aspects:

***Impact of rare and extreme events:*** In Portugal, the monitoring capacities maintained by Instituto Hidrografico are providing support to the administrations of the main ports in the continental area and are feeding the operational Meteorological and Oceanographic Center of the Portuguese Navy, which is part of this institute. In Spain, Puertos del Estado (PdE) is the institution responsible for the coordination and efficiency control of the state-owned Spanish Port System, operating the PORTUS operational oceanographic system, which integrates key components of the national capacities for the monitoring and forecast of waves, currents and storm surges that impact the Spanish coast. PLOCAN installed observing capacities are, among other specific and regional objectives, aimed to assess the coastal ocean response and vulnerability to long term variability associated with the North Atlantic atmospheric regimes, answering to the regions needs for port security, marine traffic safety and oceanographic forecasting

In both countries, the installed observation capacities for in-situ sea level measurements (coastal tide gauges networks operated by partners of this IRS ) contribute to the Eastern North Atlantic and Mediterranean Tsunami early Warning System (ENAMTWS) that was implemented by the United Nations following the big earthquake and tsunami that hit several Asian countries in 2004.

***Connectivity and transport. Pathways of water masses and materials:*** IH (in Portugal) and Puertos del Estado (in Spain) are directly involved in the operational response to crisis at sea, such as oil spills or Search and Rescue (SAR) operations, and coordinated with the national agencies responsible for the mitigation action is response to these crisis. A robust understanding of the main transport mechanisms operating along the Portuguese and Spanish continental shelves and slopes is key to support crisis management, in particular, to feed operational forecast models, and to assess the true regional impacts of these crisis. This was well demonstrated during the Prestige oil spill, for example. The observation networks operated by the IAM IRS partners (table 3.2.2), were shaped taking these aspects in consideration and can be used to provide key information about important transboundary processes such as poleward slope currents or shelf-deep ocean interactions associated with upwelling filaments or submarine canyons. IH and PLOCAN develop a collaboration aimed to maintain a glider section between the W Portuguese coast and

Canary Archipelago, which provides important data about the deep ocean forcing acting on the coastal ocean area of IAM IRS.

**Land Sea Ocean continuum. Impacts of land-derived discharges and exchanges with open ocean:** In the IAM IRS, the observing capacities installed by IH and PdE along the continental coasts of Portugal and Spain provide a broad range of measurements (i.e surface and sub-surface temperature, salinity and currents, among other critical parameters) covering the areas of the coastal ocean affected by the influence of main river outflows (Douro, Tagus, Guadalquivir) and also covering the coastal transition zone between the continental shelf and the deep ocean. Some of the observing platforms are installed in the areas of influence of major submarine canyons, measuring the important exchanges between the coast and the abyssal plain that occur along these canyons, in the form of strong turbidity (flushing) events. In the Canary Archipelago, the observing systems operated by PLOCAN and PdE are of fundamental importance to characterise the insular shelf and how it interacts with the deep ocean circulation impacting the area.

**Resolving climate change impacts:** Inside the IAM IRS, the observation capacities operated by IH (in Portugal) and by PdE and PLOCAN (in Spain) provide some of the longest (several decades) time series of sea surface height at the coast (from tide gauge stations) and of wave conditions and sea surface temperature on continental shelf waters level (from wave and multiparametric buoys). These measurements are proven of fundamental importance to assess the impacts of climate change, such as sea level rise, modifications of the regime of extreme waves associated with major storms, or sea water temperature trends and heat waves . They are also key to assess how the real evolution of the coastal ocean conditions compares with the predicted evolution presented, for example, in the reports of the Intergovernmental Panel on Climate Change (IPCC). During the last two decades, the tide gauges and wave buoys networks that were operated in the areas covered by the IAM IRS were expanded by the integration of new systems such as High Frequency (HF) radars, multiparametric buoys or gliders. The multiplatform character of the capacities installed in the IAM IRS, by allowing to measure several different parameters in a broad area of the coastal ocean environment, is particularly well adapted to track "compound events", in which the joint occurrence of interconnected extremes might exacerbate the coastal impact compared to individual hazards occurring in isolation. The sustainability of these permanent observations will reinforce the capacity to contribute to this topic in the following years.

***Resolving anthropogenic impacts***: The aforementioned science priorities in the IAM IRS are also applicable to the semi-enclosed Mediterranean Sea, where anthropogenic pressures are likely more intense than in any other sea of the world. An increasingly high density of inhabitants (above 470 million) gravitate toward littoral regions for their living needs, which are not only impacted by local human activities but also further altered by massive international tourism, including passenger ferries, cruises, and recreational boating. Apart from the shortage of water resources (tied to the population growth and the intensification of coastal urbanisation, agricultural development, and industrial activities), other interconnected societal challenges in both the AIM IRS and the Mediterranean Sea have been documented and include the following:

Enhanced maritime safety. Efficient ship routing is required to minimize both fuel consumption and the risk of accidental oil spills. Furthermore, search and rescue (SAR) operations constitute a major humanitarian emergency in the Canary Islands and the Strait of Gibraltar, and thereby demand science-based management protocols for a timely response.

Improved ecological decision support systems. The preservation of local marine fauna (seriously jeopardized by intense overfishing), habitat modification, the transfer of alien species, and the ingestion of litter demand tailored tools for informed decision-making. Equally, the monitoring of water quality in the AIM IRS remains a priority, since it is negatively impacted by the discharge of land-based toxic pollutants from local rivers into coastal sea waters  and also by episodic marine pollution episodes.

### Sustainability of the operational coastal observations

The observation infrastructures that contribute to this IRS are operated by institutions of reference, with clear missions to maintain observing capacities in the national coastal ocean areas of the two countries and dedicated personnel to accomplish the required tasks.

In Portugal, IH is a research institute of the Portuguese Navy, recognized as a State Laboratory, and with strategic orientations defined by the Ministry of Defense in articulation with the Ministry of Science and Technology and the Ministry of the Sea, with administrative and financial autonomy. In Spain, PdE is a government agency belonging to the Ministry of Public Works, responsible for implementing the government's port policy, for the coordination and efficiency control of the state-owned Spanish Port System which includes 46 ports managed by 28 Port Authorities. Also in Spain, PLOCAN is a Research Infrastructure (RI) labelled by the ICTS (Unique Scientific and Technological Infrastructure) Spanish National Roadmap, co-funded by the Ministry of Science, Innovation and Universities of the Spanish government and the Canary Islands government and by the European Regional Development Fund (ERDF) under the Operational Programme of the Canary Islands.

**Human resources:**

The observation infrastructures that contribute to this IRS (reported in table 3.2.2) are operated and supervised by permanently employed technical and scientific staff. In Portugal, IH integrates about 30 permanent staff who are directly involved in different tasks related with the maintenance, calibration, quality control, processing and product development for the MONIZEE infrastructure. The articulation of IH inside the Portuguese Navy also provides access to the different vessels (and associated crews) required to operate the offshore systems.

The observational networks operated by PdE encompass deep-waver buoys, coastal buoys, tide-gauges and HF radars. Each network is timely revised through regular and homogeneized maintenance practices, quality control checks in real time, standardization of data access and development of customized visualization tools. These consolidated networks have reached a sound maturation stage thanks to the involvement of 8 permanent staff.

This global scenario allows that inside the IRS adequate maintenance and quality control is sustainably implemented.

**Financial sustainability:**

The MONIZEE infrastructure is a permanent real-time monitoring infrastructure that covers the complete Portuguese coastal ocean area and is operated and maintained by IH. In the Portuguese implementation of the Marine Strategy Framework Directive (MSFD), MONIZEE was identified as contributing with the observations of the Portuguese marine areas to feed the environmental status assessment and monitoring program. It was also indemnified in the National Strategy for the Sea 2030. MONIZEE also feeds the Geo METOC Center operated inside Instituto Hidrografico and that supports the Portuguese Navy in its different missions, particularly during crises at sea (e.g. contamination crisis, search and rescue).

In Spain, PdE is a government agency belonging to the Ministry of Public Works, responsible for implementing the government's port policy, for the coordination and efficiency control of the state-owned Spanish Port System which includes 46 ports managed by 28 Port Authorities. By means of the own-managed operational oceanographic system (**PORTUS**), PdE Physical Environment Area provides to the port system, the society and other stakeholder institutions with met-ocean data (observations, forecasts and derived products) essential for reducing costs, increasing efficiency and sustainability, and ensuring safety in routine port operations, leading to a turnover in 215 of roughly 34 million euros.

PLOCAN is an important infrastructure in the coastal domain, serving as a research and development centre dedicated to studying oceans and marine sustainability. PLOCAN offers, in the Canary Islands, advanced facilities for oceanographic research, testing marine technology, and developing projects related to renewable energies, marine biodiversity, climate change, and aquatic resources. The platform acts as a hub for the scientific community, industry, and governmental institutions, facilitating collaboration and knowledge exchange to address environmental and economic challenges in the marine environment. Additionally, it provides specialised services such as access to oceanographic data, technical advice, and specialised training. With its focus on innovation and sustainability, PLOCAN contributes to advancing marine science and technology, promoting the conservation of coastal ecosystems and responsible development of human activities in the ocean. Its role is significant for understanding and protecting the marine ecosystem, as well as fostering sustainable economic growth in coastal regions. Its observing capacities include fixed and mobile platforms. Long term contributions to JERICO include the observation of physical, biogeochemical data, obtained from different sensing techniques and platforms.

**Data**

The 3 partners that integrated the IAM IRS all promote the dissemination of data, data product and complementary information (such as numerical modelling products and operations forecasts) through their institutional websites. In Portugal, IH provides access to the nar-real time data collected by the MONIZEE infrastructure through the Hidrografico+ portal (https://geomar.hidrografico.pt ). This portal also provides access to operational forecasts of wave conditions in several domains and of circulation in the continental Iberian domain. The Hidrografico+ portal which is the contribution of IH to the Virtual Access mechanism of JERICO-S3. In addition, data from MONIZEE is sent automatically to GTS (via the national focal point, IPMA), to the European HF radar Node, to GLOSS, to ENAMTWS (via the national focal point, IPMA) and to IBIROOS (via the regional focal point, PdE). In addition, IH is one of the two Portuguese institutions (together with IPMA) that is presently conducting the implementation of the National Oceanographic Data Center (NODC-PT).
In Spain, data from PdE observing platforms are integrated in near-time at the PdE PORTUS visualization tool (http://www.puertos.es/en-us/oceanografia/Pages/portus.aspx) , with automatic quality control procedure applied to the main physical variables. The system provides access to near-real time data but also to operational forecasts (waves, sea level and circulation), historical data and derived products and reports. Additionally, the near-real time data are also available in the CMA (Cuadro de Mando Ambiental), https://cma.puertos.es/#/, a service specifically developed for coastal and port activities, as well as through Purtos del Estado mobile applicatin, iMar, freely downloadable from the Spanish Aple App Store and Google Play Store. Data are also accessible through:

- Global Telecommunication System (GTS), for some of the buoys
- Copernicus MArine Environment Monitoring Service In Situ TAC

http://www.marineinsitu.eu/ , https://marine.copernicus.eu/

- EMODnet portal: http://www.emodnet-physics.eu
- GLOSS (Global Sea Level Observing System) data portals (tide gauges)

https://www.psmsl.or/ , http://www.ioc-sealevelmonitoring.or/ , https://www.sonel.org/

- PdE OpenDap: http://opendap.puertos.es/thredds/catalog/html
- NationalTsunami Warning System (Instituto Geográfico Nacional) (tide gauges)

Table 3.2.2 Platforms sustainability and data management

| Platform/network | Partner | Variables | Sustainability | | |
|---|---|---|---|---|---|
| | | | Financial (Funding source; Medium 3-5 yrs, Long term >5 yrs) | Human resources (short term staff, permanent staff) | Data (institutional, national, regional/european) |
| MONIZEE Multiparametric buoys neTwork<br><br>(5 buoys, W and S continental coasts of Portugal) | IH (PT) | EOVs (Physics):<br>Sea State, SST(fondDepth), Subsurface Temperature, Subsurface Currents.<br><br>EOVs (BGCs):<br>Oxygen (1buoy)<br>Particulate Matter (1buoy)<br><br>EOVs (BEs)<br>Phytoplankton<br>(1 buoy)<br><br>EOVs (Others): Ocean Sound (ongoing, 1 buoy)<br><br>ECVs (ATMs, Near-surface): air Pressure, airTemperature, rel. Humidity, Wind speed & direction | Long Term | Permanent staff | Near Real time (Virtual Access JERICO; disseminated to IBIROOS and GTS)<br><br>Delayed Mode |
| MONIZEE Wave buoy network<br><br>(3 buoys, W and S continental coasts of Portugal) | IH (PT) | EOVs (Physics):<br>Sea State, SST (fondDepth) | Long Term | Permanent staff | Near Real time (Virtual Access JERICO; disseminated to IBIROOS and GTS)<br><br>Delayed Mode |
| MONIZEE HF radar network | IH(PT) | EOVs (Physics):<br>Surface Current | Long Term | Permanent Staff | Near Real time (Virtual Access JERICO; disseminated to IBIROOS and European HF radar node)<br><br>Delayed Mode |

| | | | | | |
|---|---|---|---|---|---|
| (6 stations, W and S continental coasts of Portugal) | | | | | |
| MONIZEE Tide Gauge Network<br><br>(12 stations, W and S continental coast of Portugal) | IH (PT) | EOVs (Physics):<br>Sea Surface Height | Long Term | Permanent staff | Near Real time (Virtual Access JERICO; disseminated to IBIROOS and ENAMTW)<br><br>Delayed Mode |
| MONIZEE Gliders<br>(2 units to start operations in 2024) | IH (PT) | TBD | Long Term | Permanent staff | To be defined |
| PORTUS: Multiparametric open waters buoy network<br><br>(17 buoys total , N, NW and S continental coasts of Spain, Canarias) | PdE (ES) | EOVs (Physics): Sea State, SST(fondDepth)SSSalinity Surface Currents<br><br>ECVs (ATMs, Near-surface): air Pressure, airTemperature<br>Wind speed & direction | Long Term | Permanent staff + maintenance contract | NRT (hourly) GTS, Virtual Access JERICO, Copernicus Marine Service<br><br>Delayed Mode: Copernicus MY Wave Product |
| PORTUS: Coastal buoys network<br><br>(total 10 buoys N,NW,S Spain, Canary Archipelago) | PdE (ES) | EOVs (Physics):<br>Sea State,<br>SST(fondDepth)<br>Wave parameters | Long Term | Permanent staff + maintenance contract | NRT (hourly) GTS, Virtual Access JERICO, Copernicus Marine Service<br><br>Delayed Mode: Copernicus MY Wave Product |
| PORTUS:<br>HF radar stations (total 9 global) | PdE (ES) | EOVs (Physics):<br>Surface Current<br>Wave Parameters<br><br>ECVs (ATMs, Near-surface):<br>Wind speed & direction | Long Term | Permanent staff + maintenance contract | NRT ande delayed mode though the EU HF radar Node and the Copernicus Marine Service catalogue. Virtual Access JERICO |

| | | | | | |
|---|---|---|---|---|---|
| PORTUS: REDMAR tide gauge network (39 coastal stations, ports) | PdE (ES) | EOVs (Physics):<br>Sea Surface Height<br>Sea State (port agitation)<br><br>ECVs (ATMs, Near-surface):<br>air Pressure,<br>Wind speed & direction | Long Term | Permanent staff + maintenance contract | RT: Tsunami Warning System, IOC-SLSMF (GLOSS), NRT: Copernicus Marine Service, Virtual Access JERICO<br><br>Delayed Mode: Copernicus MY Sea Level Product, Permanent Service for Mean Sea Level (PSMSL) |
| HFR stations | PLOCAN (ES) | EOVs (Physics): Surface Current | Long term | open-contracts | Near real-time on PORTUS and Copernicus Marine Service |
| Test site ADCP data | PLOCAN (ES) | EOVs (Physics): Subsurface currents | Long term | open-contracts | Institutional |
| Test site BGC sampling data | PLOCAN (ES) | EOVs (Physics, BGC): Water-column discrete sampling ( salinity, temperature,nutrients, O2, pigments) | Long term | open - contracts | Institutional |

## JERICO in the context of regional and national observational and monitoring systems

The previous sections provided detailed information about the national observation capacities installed in the IAM IRS and about the regional articulation of the partners that, in Portugal and Spain, are responsible for these capacities. It was pointed, in those sections, the involvement of these national capacities in different activities/programs that not only inscribe strategic areas defined at national level, but that also respond to national commitments at regional or European level. The contribution of these observation capacities to the national commitments both in the framework of Regional Conventions (OSPAR) or of European Directives, such as the MSFD, the Water Framework Directive (WFD) or the Maritime Spatial Planning Directive (MSPD), can be fulfilled with different levels of involvement, in some cases with the observing infrastructures specifically pointed by the national government as supporting the monitoring programs defined in those commitments.

All the observation capacities integrated in the IAM IRS play a key role during crisis at sea (e.g. SAR operations, oil spills), in the support of the national agencies responsible for the crisis mitigation. This also stems from the national responsibilities of the partners of IAM IRS. The observation capacities are also being used, in the two countries, in the support of many different economic activities such as port authorities and the maritime community, management activities for the litoral and coastal environment, offshore renewable energies, aquacultures and sports (surf, sailing).

### Sustainability at regional level

The regional partners that manage the observation capacities contributing to IAM IRS have already a long history of collaboration. This collaboration is being developed at several different levels, such as:

- The existence of formal agreements between the institutions (in some cases a Frame Arrangement in others a Partners Agreement or a Collaboration Protocol) expressing the identification of common areas of interest and the desire to maintain collaborative actions. These formal mechanism contribute to assure, among others, the sustainability of observations strategies at regional level;
- the joint participation in projects, through which contributions to the financial sustainability of the national infrastructures inscribe in a perspective of regional collaboration;
- the participation in joint action for observation of the regional area, which combine the national observation capacities to provide a regional coverage (e.g. articulation of HF radar stations operated by IH and PdE to provide a continuous coverage of the south coasts of Portugal and Spain; glider section from Portugal to Canary);
- the exchange of know-how and experiences, allowing the development of national capacities in a regionally harmonised perspective.

These are all aspects contributing to the sustainability at regional level, which will certainly be further expanded by the establishment of JERICO-RI.

## 3.3. Bay of Biscay IRS

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

Partners: AZTI Marine Research, Spain; Centre National de la Recherche Scientifique (CNRS), France; French Research Institute for Exploitation of the Sea (IFREMER), France

## Scientific Challenges sustainably addressed

The listing of the main regional scientific objectives and strategies in the Bay of Biscay (BOB) in relation with the JERICO-RI Key and Specific Scientific challenges (KSCs and SSCs) identified in JERICO-S3 D1.1 has been initiated in JERICO-S3 D1.2. **Table 3.3.1** provides an updated status of relevant SSC challenges together with the listing of main tackled Research Axes (RAs).

***Table 3.3.1****: KSCs, SSCs and Research Axes (RAs) relevant to the BOB IRS. Table modified from JERICO-S2 D1.1 (Table IV). Coloured elements are relevant for the Bay of Biscay. Items in red were identified in JERICO-S3 D1.2 (Table 1). Items in orange are also relevant to the BOB.*

| Keys Scientific Challenges | Specific Scientific Challenges | Research Axes |
|---|---|---|
| | | |
| Assessing and predicting changes under the combined influence of global and local drivers | Land Sea Ocean continuum. Impacts of land-derived discharges and exchanges with open ocean | Nutrients, particles and organic matter, inorganic carbon, litter and contaminants |
| | Sea-atmosphere interface. Quantification of inputs | Particles, nutrients, contaminants |
| | Connectivity and transport. Pathways of water masses and materials | Within region, between other coastal regions, between region and open ocean, within region retention dynamics |
| | Biodiversity trends | Phytoplankton, zooplankton, benthos |
| | Ecosystem biogeochemical processes and interactions | Pelagic, benthic, pelagic/benthic coupling |
| | Carbon budget and carbonate system | Carbon fluxes and budget, carbonate system trends, effects of acidification |
| | | |
| Assessing the impacts of extreme events | Impacts of rare and extreme events | Floods, storms/large waves, heat waves, landslides/sudden erosion, harmful algae blooms, accidental pollution |
| | | |
| Unravelling the impacts of natural and anthropogenic changes | Long term observations to resolve climate change impacts | Temperature, salinity, currents, sea level, waves, biological productions, species distribution ranges, nutrients |
| | Observations to resolve anthropogenic disturbances | Eutrophication, habitat and biodiversity loss, contamination, coastal engineering, use of marine space, use of marine non-living resources, use/cultivation of living resources, invasive species, maritime traffic, underwater noise |
| | Interoperable and integrated long term data sets | Biogeochemistry data sets, biodiversity data sets |

The three JERICO-RI KSCs are currently sustainably addressed both inside and outside the JERICO-RI partnership. This is also the case of ten of the twelve identified SSCs and of a large majority of RAs as well.

**KSC#1: "Assessing and predicting changes under the combined influence of local drivers"**

Within this KSC, *"Land Sea Ocean continuum. Impacts of land-derived discharges and exchanges with open ocean"* is a highly relevant SSC mostly due to the fact that BOB is the depository of major Rivers such as the Loire and the Gironde. RAs within this SSC are dealing with: (1) "particles and organic matter", and (2) litter and contaminants". In the first case, this refers to the functioning of submarine prodeltas (e.g. the West Gironde Mud Patch) by continental particles and assessed during French dedicated national/regional research projects. In the second one, this is linked with the offshore impacts of land-derived discharges and issues related with marine litter aggregations at sea and on beaches see the SSC below).

A second highly relevant SSC within KSC#1 is *"Connectivity and transport pathways of water masses and materials"*. This item is relevant at different spatial scales including the within region (e.g. for the analysis of particles and associated organic matter transfers between the Gironde Estuary and the West Gironde Mud Patch) and the between region ones (e.g. for the assessment of the transnational transfer of macro litter).This is currently only partially addressed through specific dedicated actions such as the use of videometry for river litter monitoring, the maintenance of a network of monitoring stations and additional punctual observational efforts.

A third highly relevant SSC within KSC#1 is *"Biodiversity trends"*. At a large spatial scale, this item is relevant in relation with both: (1) major processes such as the latitudinal migration of marine species, and (2) the use of biodiversity as a descriptor of the ecological quality status of large water masses within the framework of European directives such as the Water ramework Directive (WFD) in littoral and transitional waters and the Marine Strategy Framework Directives (MSFD) in waters under national jurisdiction. It is being partially addressed through: (1) e-DNA based solutions, in the framework of AZTI surveys JUVENA and BIOMAN, annual campaigns, and (2) the PHYTOBS and BENTHOBS ILICO research actions (see below).

The SSC "*Ecosystem biogeochemical processes and interactions*" was not initially considered of top priority interest in D1.2. It is nevertheless also clearly relevant for the BOB especially due to the importance and diversity of the physics-biology-biogeochemistry interactions in controlling the functioning of benthic ecosystems. In Spain, it is partially addressed by specific projects dedicated to the integration of data from the euskoos.eus observatory. In France, it mostly rely on data collected within the SOMLIT ILICO research action (see above).

**KSC#2: "Assessing the impacts of rare and extreme events"**

There is a single SSC *"Impacts of rare and extreme events"* within KSC#2. This SSC is clearly highly relevant for BOB. As already mentioned for the Iberian Atlantic Margin (IAM), the BOB is exposed to high energetic events originating from the Atlantic Ocean. This includes winter storms and large waves that induce severe erosion of the coastline endangering littoral populations and economic activities. The BOB is also exposed to periodic climatic oscillations (e.g. the North Atlantic Oscillation), which is largely cuing meteorological conditions including rainfalls. This can result in major floods with significant impacts on River Dominated Ocean Margins (RIOMARs). Moreover, and once again as for IAM, the oceanographic conditions prevailing in the BOB can lead to occasional harmful algae / jellyfish blooms inducing major economic impacts though severe restrictions of aquaculture and fishing activities. Finally, the BOB is also hosting major maritime traffic lines and may thereby suffer for major accidental pollution (e.g. the Erika and Prestige oils spills). In France, this SSC is tackled both through long-term observations achieved within ILICO research actions (e.g. DYNALIT for littoral erosion and COAST-HF) and through dedicated research projects (e.g. on the structuration and the functioning of benthic systems within the West Gironde Mud Patch).

**KSC#3: "Unravelling the impacts of natural and anthropic changes"**

The first SSC within KSC#3 is "*Long term observations to resolve climate changes impacts*". This SSC is clearly highly relevant for BOB, not only for assessing long term changes in Essential Coastal Variables (ECV such as temperature, salinity, nutrients…) but also in providing data sets of independent variables potentially controlling complex biological/biogeochemical processes (e.g. marine species distribution ranges). It is currently tackled through the maintenance of sustainable long-term time series both in Spain and France (see below).

A second SSC within KSC#3 is "*Observations to resolve anthropogenic disturbances*". Here again it is highly relevant for BOB although mostly covering processes taking place at local scales. Potential disturbances sources are clearly diverse. As key examples, one can mention: (1) shellfish cultivation, which can enhance the introduction of potentially invasive species, and (2) in terms of coastal engineering, the development of large wind farming projects (e.g. off Oléron Island for France), which can result in habitat and biodiversity loss through changes in the use of marine space and newly induced disturbances (e.g. marine noise). This SSC is currently mostly tackled through regional or even more local initiatives/projects, which are largely achieved outside the JERICO partnership.

A third SSC within KSC#3 is "*Interoperable and integrated data sets*". This SSC was not identified in D1.2 due to the fact that it is not currently successfully addressed in BOB. It is nevertheless clear that elaborating such data sets through the *a priori* planning of their acquisitions constitute a key element for successfully addressing most above listed SSCs and RAs. The analysis and interpretation of such data sets needs to be addressed centrally through modelling, which would constitute one clear added-value of a future pan-European RI.

## *Regional observation strategy*

The coastal observation and monitoring systems in the Bay of Biscay IRS have several objectives: 1. To assess the ecological/environmental status of the coastal and marine waters to provide the basis towards the implementation of management measures to achieve a good status. It includes the analysis of temporal trends to assess the efficiency of the measures taken. 2. To identify the main anthropogenic pressures and impacts affecting the structure and functioning of marine ecosystems and their provision of goods and services to humans. 3. To provide continuous and near real time observations and tools (e.g. models) for rapid, agile and effective responses to address emergencies (e.g. oil spills, maritime accidents, algal blooms, contamination events…). 4. To provide a long-term series of oceanographic data for assessing trends related to the main anthropogenic factors of global change such as climate change, eutrophication and alien species.

There are significant overlaps in the observation actions required to tackle the above-mentioned challenges. It is indeed clear that the same sets of observations are often relevant for addressing different KSCs, SCs and RAs.

Observations in BOB are currently achieved within different scientific, societal and economics contexts in relation with different (and sometimes event independent) objectives, spatiotemporal scales and sampling strategies. Moreover, BOB marine coastal waters belong to two countries, France and Spain, which have adopted different modalities in implementing marine coastal observations. These points contribute to the complexity of observations currently achieved in coastal BOB although the main international legislation, agreements and conventions regarding coastal and marine waters apply in the same way in both countries and, hence, imply similar observation, monitoring and assessment requirements.

### International perspective

The WFD and the MSFD constitute the main international legislation references for coastal observations. The WFD establishes the obligation of implementing monitoring programmes to assess the ecological status of littoral and transitional water masses based on biological, physico-chemical and hydromorphological elements, as well as procedures to insure the comparability of results at the European level. The MSFD requires Member States to assess the environmental status of marine waters under national jurisdiction according to eleven descriptors and their corresponding criteria and indicators. For both directives, assessments are based on new observations achieved during *ad hoc* cyclical long-term monitoring programmes as well as on data from more sectorial initiatives (e.g. oceanographic long-term programmes, fishing-related surveys, biodiversity regular surveys…). Together, WFD and MSFD have promoted the establishment of quite comprehensive sustained long-term monitoring programmes in coastal BOB that can efficiently contribute to several of the above-mentioned SSCs (e.g. “Biodiversity trends”). The data obtained in these programmes are also used for integrated and/or specific assessments and analysis by diverse institutions (e.g. the European Environment Agency EEA, ICES…).

The European Maritime and Fisheries Fund (EMFF) provides support to the fishing industry and coastal communities to help them adapt to changing conditions in the blue economy sector and become economically resilient and ecologically sustainable. They support data collection programmes for fisheries stock assessment, among other actions in line with the EUMAP regulation. As for the BOB, they are funding AZTI and IEO fishery surveys, and the IFREMER PELGAS and EVOHE surveys in Spanish and French waters, respectively. Interestingly, a large spectrum of variables (e.g. physical, biogeochemical, and biological) are also observed during these surveys. ICES also contributes to the sustainability of observations in BOB as an end user and by providing scientific/methodological recommendations for stock assessment; fisheries management; data collection, analysis and exploitation.

France and Spain are both signatory parties of the OSPAR convention and carry out long term monitoring and assessments in relation with contaminant and hazardous substances, eutrophication, biodiversity, and harmful algae and algal toxins in mollusc aquaculture areas within BOB.

The main actors achieving coastal observatories within BOB are contributing to the Iberia-Biscay-Ireland Operational Oceanographic System (IBIROOS) – a regional node under EuroGOOS. IBIROOS members are sharing strategy, results and resources for improving the impact individual observation systems. The contribution of BoB IRS is connected with: (1) neighbouring regions (i.e., Atlantic Margin and English Channel), (2) the open ocean community, and (3) European actors such as Copernicus Marine Service and Emodnet.

***National perspectives***

The national components of BOB marine coastal observation are quite different in Spain and France.

In Spain observations are mostly achieved within a set individual actions/programs. As for the BOB, AZTI is for example running several observation networks, which are operating in Basque coastal waters only. As for physical variables, AZTI is running and maintaning different platforms such as HF radar and network of fixed moorings in coastal (and estuarine) waters. A highlighted action run by AZTI is the use of videometry for river litter monitoring, AZTI also analyse and exploit the so-obtained data especially through modelling. Associated socioeconomic implications mostly include: (1) water quality (beaches, estuaries, and coastal strip), (2) aquaculture (Harmful Algal Blooms monitoring and control), and coastal or nearshore fisheries.

In France, most long-term marine coastal observations are organised through a federative national research infrastructure named: "Infrastructure de recherche LIttorale et COtière" (ILICO). ILICO provides a national framework coordinated by national research institutes where observations are collected following best practices defined by national and European initiatives. ILICO is federating and coordination 9 different observation national actions operating in different domains ranging from sea level to pelagic and benthic ecosystems. Six of these actions (namely SONEL for sea level ,DYNALIT for hydrosedimentology, COAST HF for high frequency monitoring, SOMLIT for biogeochemistry, PHYTOBS and BENTHOBS for biology) are acquiring long-term time series of observations at between 4 and 25 stations in the BOB. The so-generated data data can be used for tackling some identified relevant SSCs (see above). This is for example the case of the SSC *"Land Sea Ocean continuum. Impacts of land-derived discharges and exchanges with open ocean*". However, most ILICO stations are littoral, which constitutes a drawback for assessing this particular SSC in a highly energetic areas where particle primary deposition areas are disconnected from the coastline. In BOB, specific observation programs (funded internationally, nationally and/or regionally) are therefore aiming at addressing this particular SSC in areas where land-derived discharges are prominent. The JERICO-Next project has for example initiated an observation time series on the West Gironde Mud Patch, which is the proximal deposition area of particles originating from the Gironde River. These observations have then been achieved within several national (e.g. VOG) and regional (e.g. MAGMA) programs, before being recently incorporated in a longer time national project: the PPR RIOMAR. They are currently under a test phase in view of integrating the long-term BENTHOBS ILICO action. This example the potential fruitful interactions between actions of different natures (observation/research) operation on different time scales and funded through different pathways (international/national/regional).

### *Regional and local perspectives*

In both Spain and France, this level mostly corresponds to a set of largely independent actions/initiatives operating over small spatial and temporal scales. They are nevertheless essential in view of tackling some SCCs (i.e., "*Observations to resolve anthropogenic disturbances*"). The coordination of the acquisition of such data, together with their quality assessment and incorporation in common database, thus constitute a key objective for a future EU coastal observation RI operating in the BOB.

### *Sustainability of coastal observations*

#### Financial sustainability

In Spain operation and maintenance of the infrastructures listed in **Table 3.3.2** rely mostly on different departments of the local government (i.e., the Basque Country region), and can be considered long-term. Part of the infrastructures belong to the euskoos.eus observatory established in 2006. Ocean glider observations are, however, based on efforts from AZTI, supported by specific projects with no granted long-term sustainability.

In France, the operation and maintenance of the infrastructures listed in **Table 3.3.2** relies on the French Research Infrastructure ILICO funded by the French research institutes. Observing units are organised in labelled observation actions with a clear long-term commitment in terms of both core fundings and human resources. Complementary resources needed for running operational observing systems at their full capacities are nevertheless provided by specific regional, national and EU projects. These projects are typically short-term (i.e., 3 to 5 years) with no granted long-term sustainability. Although, it should be pointed out that longer (i.e., 10 years) projects have been recently implemented within the framework of the "Programme de Recherche Prioritaire (PPR) Océan et Climat". Two of these projects (FutureObs and RIOMAR) are dedicated to marine coastal observations and are operating in the BOB.

#### *Human resources*

In Spain, all infrastructures mentioned in **Table 3.3.2** are operated and supervised by permanently employed technical and scientific staff. Hence adequate maintenance and quality control is sustainably implemented. Short term staff in longer surveys are sometimes needed to complete the observational strategy. The occasional enrolment of PhD students is possible as well mostly for methodological improvements and the developments of new applications based on collected data.

In France, alll observing systems mentioned in **Table 3.3.2** are operated and supervised by permanently employed technical and scientific staff in involved research institutes (CNRS, Ifremer, French universities). Non-permanent staff can be enrolled for achieving specific complementary short term missions. Master and PhD students can participate in observing actions for research project dedicated missions based on observing recurrent strategy (e.g. analysing added parameters from water samples).

*Data*

In Spain, both data availability and aggregation levels are highly heterogeneous depending on the type of observations. Within the euskoos.eus observatory, data are gathered in an ERDDAP and shared through different channels at the European level both in operational and delayed time mode. For other infrastructures, data FAIRness is still challenging. MSFD, WFD and fisheries related variables are publically available and sent to ICES. Otherwise, channels are not yet well established. In 2022, AZTI started the EBEGI project (https://www.azti.es/en/proyectos/ebegi/) with the aim of ensuring better communication and coordination among the different components of ocean observation in the area and thereby contributing to the development of a common scientific and technological strategy towards the constitution of an optimised observatory. EBEGI includes a specific task for "Publication of FAIR data", which started with development of a database integrating all the metadata of existing measuring systems, measured datasets and activities. Along the same line, the Spanish national glider community has recently (i.e., in December 2023) met to initiate coordination of the glider national infrastructure, with new glider activities recently established in BOB (AZTI and IEO).

In France, all data collected within the above-mentioned international and national perspectives are publically available following FAIRness principles. All data are distributed through data and service centres aiming at ensuring long term backup and data availability (e.g. Coriolis data centre - https://data.coriolis-cotier.org/). This is achieved with the support of a data dedicated national infrastructure: ODATIS (https://www.odatis-ocean.fr/en/). Data can then be more widely distributed through European aggregators such as Copernicus and Emodnet. Therefore, all BOB data generated through ILICO are available in common ASCII or binary formats. This is also the case of data collected within the framework of European Directives. Moreover, there is an obligation to follow the same FAIR principles for all data originating from field campaigns taking place on research vessels of the "Flotte Océanographique Française" RI. The situation is still much less clear for data collected during other local/regional actions.

**Current international, national and regional/local positioning of JERICO-S3 partners**

The current JERICO-S3 partners within BOB are AZTI in Spain and both IFREMER and CNRS in France. They are currently running the infrastructures listed in **Table 3.3.2** to address the KSCs, SSCs and RAs identified as relevant for the BOB (see above).

***Table 3.3.2***. *Description of the operational JERICO-related infrastructures for observations currently achieved in the BOB IRS.*

| Platform/network | Partner | Variables | Sustainability | | |
|---|---|---|---|---|---|
| | | | Financial (Funding source; Medium 3-5 yrs, Long term >5 yrs) | Human resources (short term staff, permanent staff) | Data (institutional, national, regional/european) |
| HF radar | AZTI(ES)<br><br>Ifremer (FR) | Currents (surface) | Medium Term. Sustained on local government funds (Basque Country) program with Directorate of Meteorology and emergency attention of the Basque Government<br><br>[FR] Medium Term. Sustained on institutional Ifremer funds and regional projects | Permanent staff | Near-Real time data sent to euskoos.eus and Copernicus |

| | | | | | |
|---|---|---|---|---|---|
| Slope buoy | AZTI(ES) | Air Pressure, Air T°, Currents (surface), Currents (water column), Salinity/Conductivity, Water T°, Waves, Wind speed/dir | Medium Term. Sustained on local government funds (Basque Country) program with Directorate of Meteorology and emergency attention of the Basque Government | Permanent staff | Near-Real time data sent to euskoos.eus and Copernicus |
| Coastal station | AZTI(ES) | Air Pressure,Air T,Waves,Wind speed/dir,Sea level | Medium Term. Sustained on local government funds (Basque Country) program with Directorate of Meteorology and emergency attention of the Basque Government | Permanent staff | Near-Real time data sent to euskoos.eus and Copernicus |
| Coastal station<br><br>(ILICO/COAST-HF network) | CNRS/Ifremer (FR) | Air Pressure, Air T, Wind speed/dir, T, S, O2, fluo, turbidity, pH | Medium term.<br><br>Partly funded by research institutes (Ifremer, CNRS, French universities) and research national and regional projects | Permanent staff | Near real time data sent to Coriolis and Copernicus |

| | | | | | |
|---|---|---|---|---|---|
| Manual sampling<br><br>(ILICO/Phytobs network) | CNRS/Ifremer (FR) | Phytoplankton | Medium term.<br><br>Partly funded by research institutes (Ifremer, CNRS, French universities) and research national and regional projects | Permanent staff | Data shared through dedicated web portal |
| Manual sampling<br><br>(ILICO/Benthobs network) | CNRS/Ifremer (FR) | Benthic macrofauna | Medium term.<br><br>Partly funded by research institutes (Ifremer, CNRS, French universities) and research national and regional projects | Permanent staff | Data shared through dedicated web portal |
| Manual sampling<br><br>(ILICO/SOMLIT network) | CNRS/Ifremer (FR) | Biogeochemistry, T, S, O2 | Medium term.<br><br>Partly funded by research institutes (Ifremer, CNRS, French universities) and research national and regional projects | Permanent staff | Data shared through dedicated web portal |

| | | | | | |
|---|---|---|---|---|---|
| Coastal station<br><br>(ILICO/SONEL network) | CNRS, Shom | Sea Level | Medium term.<br><br>Partly funded by research institutes (CNRS, Shom) and research national and regional projects | Permanent staff | Near real time sent to Copernicus and tide gauge databases |
| Coastal station and manual sampling<br><br>(ILICO/DYNALIT network) | CNRS | Waves, currents, shoreline, suspended matter, bathymetry/topography | Medium term.<br><br>Partly funded by research institutes (CNRS, Universities) and research national and regional projects | Permanent staff | Data shared through dedicated web portal |
| Manual sampling | AZTI(ES) | Biological<br><br>(benthic), Chl-A (Fluorescence), Dissolved O2, pH, Phytoplankton, Salinity/<br><br>Conductivity,Turbidity ,Water T° | Long term, sampling performed by AZTI under contract of URA – The Basque Water Agency | Permanent staff | Data shared through URA web portal; these data feed mainly WFD and also MFSD requirements |

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

| | | | | | |
|---|---|---|---|---|---|
| Surveys onboard R/V | AZTI(ES) | Biological (fisheries), Biological<br><br>(other), Chl-A (Fluorescence), Temperature, Salinity/<br><br>Conductivity, Density, Depth (water pressure)<br><br>Other data | Long Term. Sustained on european structural funds (EMFAF) and local government funds (Basque Country) program with the Department of Economic Development, Sustainability, and Environment of the Basque Government | Permanent staff / short term staff | Data shared with European countries (North Atlantic region and other regions for specific species with broader distribution) at ICES & information shared with the Basque and Spanish Governments and the Spanish Oceanographic Institute (IEO) for stock assessment and ecosystem management recommendations |
| Gliders | AZTI | Biological (fisheries), Biogeochemical<br><br>(other), Chl-A (Fluorescence), Salinity/<br><br>Conductivity, Dissolved O2, Density, Depth (water pressure) | Short term. AZTI owns the gliders but operation is 100% relying on projects | Permanent staff / short term staff | Data sent to Coriolis |
| Coastal videometry | AZTI(ES) | Sea state, waves, currents (surface), and others (coastline position, nearshore bathymetry, wave overtopping) | Medium-term. A network is today well established but depends of short-term projects/programs.. | Permanent staff / short term staff | Data are available through the network web https://www.kostasystem.com/en/ and are provided to identified end users (in the fields of R&D, coastal risks and management). However, and in spite of their potential for coastal research issues, they are not currently channelled towards regional or European databases or aggregators |

At the national level, AZTI is a key actor in the implementation of both WFD and MSFD descriptors (see above). At the European level, AZTI is currently involved in several EU funded project and is actively participating to international initiatives (e.g., EUROGOOS and IBI-ROOS). AZTI is a key actor in the development of: (1) biological indices (e.g. AZTI Marine Biotic Index and derived indices) to infer ecological water quality, and (2) multimetric indices integrating observations of different sources (i.e., physical, biogeochemical and biological) data.

Within JERICO-S3, CNRS is acting as an umbrella for several universities. This includes the University Bordeaux in the BOB. All three French institutions currently involved in BOB IRS are key players for the implementation of European Directives in BOB, with a significant number of their staff involved under the supervision of the "Office Français de la Biodiversité" (OFB). IFREMER is running three networks in charge of monitoring coastal water (chemical: ROCCH, biological: REPHY and microbiological: REMI) quality in relation with the exploitation of living resources. As mentioned above, IFREMER is also in charge of fishery surveys over the French BOB (see above). ILICO is co-coordinated by IFREMER and CNRS at the French National level. A significant number of IFREMER, CNRS and University staff are strongly involved and are even sometimes the national (co)coordinators of the ILICO actions operating in the BOB (i.e., COAST-HF, PHYTOBS, SOMLIT and SONEL). Some of their staff, not necessarily presently deeply committed to JERICO-S3, are also key players in observations achieved within the WFD and MSFD frameworks. French institutions currently involved in BOB IRS are also connected (e.g., through their participation in ILICO observation actions) with other institutions achieving Observations in coastal BOB but not formally included in the JERICO partnership at present.

Overall, within the current JERICO partnership, there is good ability to tackle RAs and SSCs and at a local level. Sound assessments at wider scales would, however, require developing interactions both within and outside JERICO. At this last level, JERICO BOB current partners could play a key role in setting up and managing such interactions.

## 3.4. Kattegat-Skagerrak-Eastern North Sea IRS (KASKEN)

The acronym KASKEN is used for the area: **KA**ttegat- **SK**agerrak-**E**astern-**N**orth Sea.

Partners: Swedish Meteorological and Hydrological Institute (SMHI), Sweden;, Institute of Marine Research (IMR), Norway; Norwegian Institute for Water Research (NIVA), Norway; Danish Meteorological Institute (DMI), Denmark; Helmholtz-Zentrum Hereon, Germany; Alfred Wegener Institute Helmholtz centre for Polar and Marine Research, (AWI), Germany.

### Key scientific challenges sustainably addressed

The regional scientific strategies, respective observational strategies and their integration into a pan-European scientific and observational strategy of the JERICO-RI with respect to the identified KSCs are collected and discussed in D1.1 and D1.2. The KASKEN IRS identified the following Key Scientific Challenges (KSCs), Specific Scientific Challenges (SSCs) and Research axes as important for the region (see also table 1.):

- Impacts of eutrophication and land-sea interactions on marine ecosystem services, biodiversity, and eutrophication
- Impacts of climate change, e.g.
    - Changed biogeography and biodiversity of phyto- and zooplankton
    - Marine heat waves and cold spells
    - Frequency and effects of storm events
    - Ocean acidification and other effects from changes in carbonate system
- Impacts of of harmful algae on aquaculture, fisheries and tourism
- Impacts of oil spills, other contaminants, litter and microplastics
- Transport of water, nutrients etc. in the Baltic Sea-North Sea transition zone

The United Nations have defined Essential Ocean Variables (EVOs) through the UNESCO Intergovernmental Oceanographic Committee. The EVOs were defined by the Global Ocean Observations System, GOOS. In the KASKEN IRS the EVOs guide part of the observations. Link to the EVOs on the GOOS website:

https://goosocean.org/what-we-do/framework/essential-ocean-variables/

Table 3.4.1 . A summary of scientific challenges and research axes in the Kattegat-Skagerrak-Eastern North Sea

| **Keys Scientific Challenges** | **Specific Scientific Challenges** | **Research Axes** |
|---|---|---|
| **Assessing changes under the combined influence of global and local drivers** | Land Sea Ocean continuum. Impacts of land-derived discharges and exchanges with open ocean<br>Sea-atmosphere interface. Quantification of inputs | Particles<br>Nutrients<br>Contaminants |
| | Connectivity and transport. Pathways of water masses and materials | Water masses (including vertical mixing)<br>nutrients<br>contaminants<br>particles<br>organisms (connectivity) |
| | Biodiversity trends | Phytoplankton<br>Zooplankton<br>Benthic organisms |
| | Ecosystem biogeochemical processes and interactions | Biophysical interactions<br>Biogeochemical functioning<br>Pelagic<br>Benthic<br>Pelagic/benthic coupling |
| | Carbon budget and carbonate system | Carbon fluxes and budget<br>Carbonate system trends<br>Effects of acidification |
| **Assessing the impacts of extreme events** | Impacts of rare and extreme events | Storms/large waves/floods<br>heat/cold waves<br>harmful algae / jellyfish blooms<br>accidental pollution, e.g oil spills |
| **Climate change impacts** | Resolving climate change impacts | Temperature<br>Salinity<br>Ocean acidification - carbonate system<br>Currents<br>Sea level rise<br>Waves<br>Biological production<br>Species distribution ranges (biogeography)<br>Nutrients |

| | | |
|---|---|---|
| **Unravelling and predicting the impacts of natural and anthropogenic changes** | Resolving anthropogenic impacts | Eutrophication<br>habitat and biodiversity loss<br>contamination<br>coastal engineering<br>use of marine space (including windfarming)<br>use of marine nonliving resources<br>use/cultivation of living resources<br>invasive species<br>maritime traffic<br>(micro) plastics<br>acoustic and electromagnetic noises |
| | Disentangling impacts/scales | Meta analysis<br>coupled modelling |

## Strategies for sustaining observations and monitoring in the KASKEN region

The ocean observations in the KASKEN region in general have two different overarching aims: 1: To describe the current situation to be able to help society, e.g. to issue warnings or to help out during emergency situations. The near real time observations are also used for data assimilation in ocean models. 2: to contribute data to long time series to be able to observe trends related to anthropogenic activities such as eutrophication and climate change. The countries in the KASKEN region are all part of the OSPAR convention and carry out long term monitoring in this context. The countries, except for Norway, are also part of the HELCOM convention. HELCOM and OSPAR overlap in the Kattegat. Observations of inorganic nutrients, salinity, temperature, oxygen, phyto- and zooplankton are part of the OSPAR/HELCOM monitoring. This monitoring also contributes to the EU Marine Water Framework Directive and the EU Water Directive. In addition other types of observations are ongoing, they include observations of harmful algae and algal toxins in mussels and oysters in areas where these are harvested as food for humans. A specific monitoring programme on change in the ocean carbonate system, e.g ocean acidification, is coordinated by ICOS (Integrated Carbon Observation System). Additional observations are made in the NOOS framework which at present are focussed on physical variables such as sea level, sea state and currents. Satellite observations contribute to estimates of phytoplankton biomass (ocean colour) and to observations of sea surface temperature. It is not possible to list all observations made here. A summary of the operational JERICO-related infrastructures are listed in table 3.4.2. Observations of the benthic part of the marine ecosystem are not included.

**Human resources:** All systems mentioned in table 2 of infrastructures are operated and supervised by permanently employed technical and scientific staff. Hence adequate maintenance and quality control is sustainably implemented. Short term projects that include PhD students contribute to the development of the systems.

**Financial sustainability:** The operation and maintenance of the infrastructures listed in table 2 are operated by governmental institutes in Sweden, Norway, Denmark and Germany with one exception. The ocean glider based observing system in the Skagerrak is operated by the VoTo foundation with private funding. Observations directly connected to the MSFD, WFD, harmful algae and algal toxins and benthic systems are not listed in the table but these observations also have long term funding. This also applies to observations of sea levels.

**Data:** Resulting data from the infrastructures in table 2 are gathered in national databases in each country. FAIRness of data and long term storage/data safety is managed. Some of the data is distributed to the Copernicus Marine Environmental Service (CMEMS). MSFD and WFD related monitoring data are sent to ICES and EMODnet. Some quality controlled data for carbonate system parameters are sent to the SOCAT dataset.

To ensure that observations are sustainable, each country in the KASKEN IRS is committed to continue operating observing systems, to carry out quality control, to host data and to share data with other countries in the IRS. One needs to keep in mind that the commitment and responsibility is at the national level. The EU does not contribute funding for operating the systems or delivering data to relevant databases. A next step in making the observations sustainable is to write memorandums of understanding (MoUs) between the institutes involved. The process of writing MoUs between JERICO-partners in the KASKEN IRS has started and will continue.

Table 3.4.2. A description of the operational JERICO-related infrastructures for observations in the KASKEN IRS. Note that national and regional monitoring programmes not funded by JERICO are not included.

| **Platform/network** | **Partner** | **Variables** | **Sustainability** | | |
|---|---|---|---|---|---|
| | | | Financial (Funding source; Medium 3-5 yrs, Long term >5 yrs) | Human resources (short term staff, permanent staff) | Data (institutional, national, regional/european) |
| FerryBox Oslo - Kiel | NIVA (NO) | T, S, O, Chla fluo, fDOM, Turbidity, pCO2, pH (occasional phytoplankton diversity, cell abundance and biomass, nutrients) | Medium Term EU projects, Norwegian Environment Agency; internal funding | Permanent staff | Near-Real time data sent to Norwegian Marine Data Center (NMDC) though Arctic Data Center (adc.met.no) |
| Solbergstrand Stationary Ferrybox | NIVA (NO) | T, S, O, Chla fluo, | Medium Term EU projects, Norwegian Environment Agency; | Permanent staff | |

| | | | | | |
|---|---|---|---|---|---|
| FerryBox R/V Svea | SMHI (SE) | T, S, O, Chla fluo, phycocyanin fluo, phycoerythrin fluo, cDOM, Turb, pH, pCO2,, phytoplankton diversity, cell abundance and biomass | Long term > 5 y Swedish governmental funding, Swedish Research council Formas | Permanent staff and PhD student | Near real time data sent to the Swedish Oceanographic Data Centre at SMHI and to CMEMS. Delayed mode data with extended quality control made available yearly. |
| Koster fjord instrumented oceanographic buoy | SMHI (SE) and the University of Gothenburg | T, S, O, Chla fluo, current speed and direction | Long term > 5 y Swedish governmental funding | Permanent staff | |
| Väderöarna instrumented oceanographic buoy | SMHI (SE) | Wave height, direction and period, water temperature | Long term > 5 y Swedish governmental funding | Permanent staff | |
| Brofjorden instrumented oceanographic buoy | SMHI (SE) | Wave height, direction and period, water temperature | Long term > 5 y Swedish governmental funding | Permanent staff | |
| Skagerrak oceanographic gliders observing system | VoTo (SE) and SMHI (SE) | Depth profiles of T, S, Chl a fluo., current speed and direction | Long term > 5 y Voice of the Ocean Foundation (VoTo) | Permanent staff at VoTo and SMHI | Near real time data available at VoTo and at the Swedish Oceanographic Data Centre at SMHI. Delayed mode data with extended quality control made available later. |
| Long term coastal temperature and salinity time series | IMR (NO) | Temperature and salinity | Long term > 5 y Norwegian governmental funding | Permanent staff | |
| Torungen Skagerrak observing system | IMR (NO) | T, S, O, Chla fluo, pCO2, pH, phytoplankton diversity, cell abundance and biomass | Long term > 5 y Norwegian governmental funding | Permanent staff | |
| Flødevigen ocean | IMR (NO) | | Long term > 5 y Norwegian | Permanent staff | |

| | | | | | |
|---|---|---|---|---|---|
| observatory | | | governmental funding | | |
| | IMR (NO) | | | | |
| Helgoland stationary Ferrybox | AWI (Germany) | | | | |
| Underwater Observatory Helgoland | Hereon (Germany) | Zooplankton abundance (Imaging), CTD, O2, Turbidity, pCO2, Chla, PAR, Meteorology | EU and Internal Funds | Senior scientist, EU funded Postdoc, Phd Student | Real-time data sent to Hereon, Data analysis (Image annotation) in near real-time, Subset of data will be linked to Eco-Taxa and EMODnet in the near future |
| Ferrybox at Lysbris Seaways | Hereon (Germany) | Temperature, Salinity, DO, Chla fluorescence, $pCO_2$, pH, Turbidity, cDOM, algal classes | internal and EU funding | Permanent staff (engineers, scientist), externally funded Postdoc | Near real time data reported to COSYNA data portal, and to European FerryBox data portal. Delayed mode quality control are available for some parameters, and is an ongoing activity. |
| Instrumented oceanographic buoys | Denmark | | | | |

## 3.5. Norwegian Sea IRS

Partners: Institute of Marine Research (IMR), Norway; Norwegian Institute for Water Research (NIVA), Norway; NORCE Norwegian Research Centre (NORCE), Norway; Faroe Marine Research Institute (FAMRI), Faroe Islands

**Key scientific challenges sustainably addressed**

The regional scientific strategies, respective observational strategies and their integration into a pan-European scientific and observational strategy of the JERICO-RI with respect to the identified

KSCs are collected and discussed in D1.1 and D1.2. The Norwegian Sea IRS identified the following Key Scientific Challenges (KSCs), Specific Scientific Challenges (SSCs) and Research axes as specifically important for the region. (see also table 1.):

**KSC1 Assessing and predicting changes under the combined influence of global and local drivers:**

- Land-sea continuum:
- Connectivity and transport. Pathways of water masses and materials

**KSC2 Assessing the impacts of extreme events:**

- Impacts of rare and extreme events:
- *Resolving climate change impacts*

**KSC3 Unravelling the impacts of natural and anthropogenic change**

- Observations to resolve anthropogenic disturbances:
- Interoperable and integrated long-term datasets

Table 3.5.1 . A summary of scientific challenges and research axes in the Norwegian Sea

| Keys Scientific Challenges | Specific Scientific Challenges | Research Axes |
|---|---|---|
| **Assessing changes under the combined influence of global and local drivers** | *- Land Sea Ocean continuum. Impacts of land-derived discharges and exchanges with open ocean* | Land-Coastal-Ocean interactions<br>Particles<br>Organic matter<br>Nutrients<br>Litter |

| | | |
|---|---|---|
| | | Contaminants |
| **Assessing the impacts of extreme events** | - *Impacts of rare and extreme events* | Harmful Algal Blooms<br><br>Aquaculture<br><br>Sustainable fisheries management<br><br>Storms/large waves<br>Heat waves<br>Harmful algae blooms<br>Accidental/persistent pollution |
| | - *Resolving climate change impacts* | Temperature<br>Salinity<br>Currents<br><br>Waves<br>Biogeochemistry |
| **Unravelling and predicting the impacts of natural and anthropogenic changes** | - *Resolving anthropogenic impacts* | Eutrophication<br>Habitat and biodiversity loss<br>Contamination<br>(Multi-) Use of marine space (including fishing, Offshore Wind Farms, Oil and Gas exploaration)<br>Use/cultivation of marine living resources<br>Invasive species<br>Maritime traffic<br>(micro) Plastics<br>Acoustic and electromagnetic impact |
| | - *Disentangling impacts/scales* | - Meta analysis<br>- Coupled modelling |

**Strategies for sustaining observations and monitoring in the Norwegian Sea region**

Focal point of the observational efforts in the Norwegian Sea region is to deepen the knowledge of the actual state of the coastal zone and to determine the trends occurring in the Norwegian Sea area. The actual state of the Norwegian Sea is actually impacted quite severely by human activities including aquaculture, oil and gas exploration as well asFisheries and transport/recreational activities. Challenging for the Norwegian Sea territory is that the area is part of two different management approaches. While the Water Framework directive counts for all the near coastal areas, the Marine strategy Framework Directive on the one hand and the Norwegian management plans are to be taken into account for the regions outside the 12 miles zone. Observations of inorganic nutrients, salinity, temperature, oxygen, phyto- and zooplankton are part of those management systems underlying different reporting systems. Because of the heavily ongoing human activities additional types of observations are conducted, including measurement of pollutive substances impacting the food security as well as nutrient observations to determine the impact of aquaculture activities. Carbon system observations in the frame ofICOS as well as monitoring and mapping of the fish stocks in the context of ICES complement the observational efforts undertaken in the Norwegian Sea.

An overview of the operational infrastructures of the JERICO RI contribution towards the observation system is given in table ***

**Human resources:** The systems operational in the JERICO RI activities are handled and maintained by permanently employed technical and scientific staff. The substantial maintenance and operational conduction of measurements is with that sustainably secured. The extension of the system and deeper analyses of the obtained data is nevertheless dependent on short term third party funding and PhD/PostDoc research projects.

**Financial sustainability:** The observational systems are operated and maintained by governmental institutions or institutions partly funded by the government. The government issues annual purpose and mission letters which are providing the main focal objectives to the activities of the governmental institutions. The funding is with that in mind principly only secured year by year, but the purpose and mission letters are stable in terms of ambition of observational activities and the overall sustainability is secured for the actual state. The political status with the war in the Ukraine and the connected energy crisis in Europe limits the funding for observational efforts. The need for decreasing the carbon footprint of human activities is also impacting the observational efforts towards a less research vessel driven observation system, something that is increasing the importance of the Jerico RI observational approach.

**Data:** All data obtained by the JERICO RI infrastructures are collated in national databases. Those databases are securing the FAIRness of the data and long term storage/data safety is ensured. IMR with the Norwegian Marine Data Centre (IMR NMD) secures as well the tight connection with the operational data services such as the Copernicus Marine service as the Coordinator of the Arctic part of the InSitu Thematic Centre of CMEMS. IMR NMD serves as well as Arctic centre in the EModNet activity and as well serving with strong contribution towards the database in ICES securing that all international links are established.

Within 2023 the collaboration between the Norwegian partners of the Norwegian Sea region IMR and NIVA have been formalised by signing a Memorandum of Understanding (MoU). Further formal cooperation is under negotiation.

Table ***. Overview of the JERICO-RI related infrastructure for observational efforts in the Norwegian Sea region Note that national and regional monitoring programmes not funded by JERICO RI are not included.

# 4. CONCLUSIONS

This document contains the reports of 5 Integrated Regional Sites:

1. The northern Adriatic IRS
2. The Iberian Atlantic Margin IRS
3. The Bay of Biscay IRS
4. The Kattegat-Skagerrak-Eastern North Sea IRS (KASKEN)
5. The Norwegian Sea IRS

The reports include information about the respective national and regional strategies for coastal observations as well as information about the respective infrastructure operational at the moment. Furthermore information about the sustainability of infrastructures, observations, observation strategies at national and regional level are discussed.

All IRS aligned their observational strategies with the Key scientific challenges and the Specific scientific challenges as defined by the JERICO community. No additional scientific challenges were reported which indicates a good coverage of the current scientific strategy of the JERICO community. The larger part of all reported operational infrastructures of coastal ocean observation report sustainable financing solutions concerning human resources, maintenance and operation through their involvement in national monitoring programs concerning safety at sea, ecological status or human health. However, sustainability of observational strategies, and financial sustainability at regional level appears to be not yet achieved.
We can conclude that a robust, albeit still wanting in resolution, observational infrastructure for coastal observatories is established and dedicated to the JERICO-RI and the respective scientific challenges. The establishment of the JERICO-RI including formalized commitment of the member states will transition the observational capacity towards a pan-European infrastructure with financial and strategic sustainability at regional and pan-European level. Additionally, existing and operational coastal observation infrastructure will be improved by achieving increased spatial coverage and resolution to adequately respond to societal needs and key scientific challenges.