JERICO-S3 DELIVERABLE

Joint European Research Infrastructure for Coastal Observatories

Science, Services, Sustainability

DELIVERABLE #, WP# and full title	JERICO-S3 D1.2 - WP1 - Regional approach
5 Key words	Regional specificities, scientific and societal challenges, research infrastructure
Lead beneficiary	CNRS
Lead Author	Laurent Coppola
Co-authors	Antoine Grémare, Anna Rubio, Dominique Durand
Contributors	WP3 leads, WP4 leads
Final version date/ Submission date (dd.mm.yyyy)	21/02/2023 – 13/04/2023

Nature: R

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

Dissemination level : **PU**

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

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

DOCUMENT TECHNICAL DESCRIPTION

Document ID	JERICO-S3-WP1-D1.2-210223-V2.0

REVISION HISTORY

Revision	Date	Modification	Author
V2.0	21.02.2023		L. Coppola
V2.1	31.03.2023	Final review	C. Frangoulis

APPROVALS

	Name	Organisation	Date	Visa
Coordinator	Delauney Laurent	Ifremer	13/04/2023	LD
WP Leaders				

Diffusion list

Consortium beneficiaries	Third parties	Associated Partners	other

TABLE OF CONTENT

[...]

1. EXECUTIVE SUMMARY

One of the main objectives of JERICO-S3 is to bring together European coastal observing Research Infrastructures under one label, in order to address common issues, while allowing the regions to address their local specificities expected by scientists and policy makers. The deliverable D1.2 is reporting on the analysis of how JERICO-RI addresses the regional specificities with the set-up of measurement systems, as well as the common scientific and societal challenges of the different regions involved in the project.

To assess which and how Key Scientific Challenges (KSCs) are currently addressed by each region, a questionnaire was set up for the three identified KSCs and the subsequent Specific Scientific Challenges (SSCs) described in D1.1. The conclusions indicate that currently not all KSCs and SSCs are being addressed at the same level and that connections between regions still need to be improved to provide accurate and relevant products and share knowledge and expertise on technologies and/or data management. This could be explained by the fact that addressing KSC2 ("Assessing the impacts of rare and extreme events") relies heavily on technological advances while tackling KSC3 ("Unravelling and predicting the impacts of natural and anthropogenic changes") requires greater collaboration between institutes and scientists to improve the design, data acquisition, and analysis tools of in-situ observations.

D1.2 also points out that an important and high-value service of the future JERICO-RI should be to centralise KSC3-like actions with a pan-European vision so that regions would collaborate more and share their data and expertise. In addition, a growing requirement is to increase the consideration of societal factors in SSCs through the contributions of scientists, policy makers and managers of the coastal marine environment, in the co-design of the JERICO-RI strategy.

2. INTRODUCTION

JERICO-RI is a European research infrastructure that aims to support the contribution of coastal marine research in addressing a large variety of scientific and societal challenges through the provision of open-access observational data and facilities. The final aim of the regional approach adopted in JERICO-S3 is to create an infrastructure of regional coastal observatories across Europe that covers a wide range of coastal marine environments, from the Baltic to the Mediterranean Sea, and from the Atlantic to the Black Sea. The objective of this regional approach is to enable the collection of comparable, long-term and multi-disciplinary (physical, biogeochemical, biological) data and promote collaboration, alignment and harmonisation among the different regions and countries. Overall, this will enhance our understanding of coastal marine systems, support the development of sustainable coastal management (best) practices, and contribute to the European marine research and innovation landscape.

Within JERICO-S3, experimentation regarding the implementation of this regional approach is achieved through the definition of Pilot Super-Sites (PSS) and Integrated Regional Sites (IRS), which are aiming at demonstrating our current capacities to tackle specific scientific and societal challenges. Beyond this, both PSS and IRS serve as proofs-of-concept for regional integration, transnational governance, and strategic co-design (including collaboration with other RIs). They are aiming at contributing to the optimization of regional observation components that will constitute the backbone of the future JERICO-RI.

In order to evaluate the regional approach through JERICO-S3, the actions proposed in the PSS (WP4) and IRS (WP3) are evaluated to assess (i) how the scientific and societal challenges are currently being addressed, (ii) the current gaps that limit the provision of this information, and (iii) if the collaborations between regions are effective.

This report will contribute to refining the concept of regions as a governance and organisational pillar in JERICO-RI, taking into account regional specificities and the European vision that will be central to the implementation of the future infrastructure.

3. MAIN REPORT

3.1. Identify specific and common science and societal challenges in and across regions

3.1.1. Regional specificities (scientific and societal)

The conceptual design of the future JERICO-RI for coastal areas based on PSS (WP4) and IRS (WP3) must consider the past efforts and ongoing RIs plans and need to be adapted to the specificities of coastal systems. The specific challenges faced by national RIs that need to be considered in planning, relate to the complexity of coastal systems and the great number of scientific issues involved.

The PSS is defined as a coastal marine area that serves as a representative and integrative site for the observation and assessment of key processes and variables related to the coastal ocean and its interactions with the atmosphere, land and human activities. These sites are characterised by on the one hand, their unique physical, biological. biogeochemical, and ecosystemic characteristics, and on the other hand, specific environmental stressors. They were selected based on their scientific and societal relevance, existing infrastructure and data availability. The PSSs provide a proof-of-concept to demonstrate integrated, multi-disciplinary, multi-platform observing capabilities for observing multiple complex and interconnected processes at highly variable time and space scales. The objective of the four PSS defined in JERICO-S3 is to provide long-term, high-resolution and interdisciplinary FAIR observations to support research, innovation and the development of coastal ocean observing systems. The PSSs also aim to improve national, regional and pan-European collaborations for coherent and harmonised observations to meet scientific and societal demands.

In the framework of the JERICO-S3 project, five IRS have been established to promote harmonisation and integration within defined transnational coastal ocean regions (D3.1). Although these regions are not as developed as the PSS in terms of an integrated, cross-platform approach and technology development, the IRS have developed regional strategies based on the JERICO-RI KSC framework and a roadmap has been developed for data interoperability and harmonisation from each region in order to guide future developments and progress (D3.3).

In the following sections, PSSs and IRSs will be considered as JERICO regions with their own specificity and common challenges, taking into account that PSSs are already implemented and operational while IRS are under construction and represent a more conceptual approach.

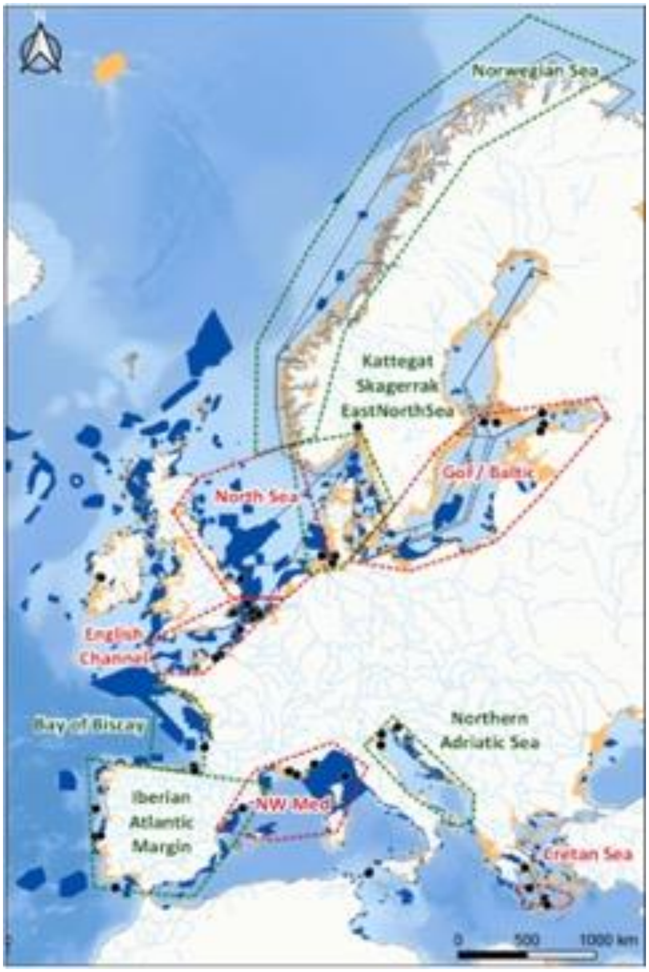

Figure 1: PSS and IRS regions defined in the JERICO-S3 project (red and green respectively)

In JERICO-S3 D1.1, three Key Scientific Challenges (KSC) further divided into 16 Specific Scientific Challenges (SSC) have been defined, based on the synthesis of a global list of regional practical Research Actions (RA). In the following, we will analyse how these different challenges are currently addressed by each region.

Table 1: KSC and SSC currently addressed for each region: North S: North Sea, EC: English Channel, NWM: Northwestern Mediterranean, CS: Cretan Sea, BS/GF: Baltic Sea:Gulf of Finland, BOB: Bay of Biscay, NAS: Northern Adriatic Sea, IAM: Iberian Atlantic Margin, K/S: Kattegat/Skagerrak, Nor S: Norwegian Sea (from D1.1)

		Pilote Super Sites					*Integrated Regional Sites*				
KSCs	**Specific Scientific Challenges**	North S	EC	NWM	CS	BS/GF	BOB	NAS	IAM	K/S	Nor S
Assessing and predicting changes under the combined influence of global and local drivers	Land-Ocean Continuum	■		■			■		■		■
	Sea-atmosphere interface										
	Connectivity and transport			■			■		■	■	
	Biodiversity		■				■		■		
	Primary productivity		■		■					■	
	Ecosystem functioning	■			■	■		■		■	
	Carbon budget and carbonate system	■				■				■	
Assessing the impacts of extreme events	Extreme events:impacts on ecosystems			■	■	■	■	■			
	Extreme events: coastal hazards						■		■		
	Harmful Algal Blooms		■			■				■	■
Unravelling the impacts of natural and anthropogenic changes	Climate change impacts					■	■		■	■	
	Eutrophication		■	■		■					
	Impact of big cities			■							
	Litter and plastic			■			■	■	■	■	
	Contamination			■					■	■	■
	Unravelling impacts					■	■				■

In the D3.1 and D4.1 reports the JERICO-S3 regions have detailed their own regional specificities, as described in the next sections. It should be noted that the KSC/SSC selected to be addressed by PSSs during the 2 year implementation period (actions described in D4.1 and revised in D4.2 & D4.3) partly match those in table 1:

3.1.1.1. NE MEDITERRANEAN SEA/ CRETAN SEA

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

- Land-ocean continuum:
  - Monitor and evaluate the impacts of riverine inputs and the effect of the Black Sea on marine ecosystems
- Connectivity and transport:
  - Seasonal and interannual variability of the surface circulation on the thermohaline circulation
  - Study the contribution of mesoscale activity to the general circulation
- Biodiversity and primary productivity:
  - Study the effects of climate change on marine productivity and biodiversity (warming, acidification, nutrient-oxygen dynamics and extreme atmospheric events)
  - Coupling of intermediate and deep water formation with biogeochemical functioning
- Carbon budget:
  - Region CO_2 source or sink

KSC2 Assessing the impacts of extreme events

- Societal demands: pollution and coastal erosion.

KSC3 Unravelling the impacts of natural and anthropogenic change

- Not addressed

3.1.1.2. NW MEDITERRANEAN

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

- Connectivity and transport:
  - Study the effects of Northern Current (NC) transport: water mass circulation, particles and plankton species, plastics, contaminants
- Land-ocean continuum:
  - Evaluate the impact of major rivers inputs (on ecosystems) in the coastal area (Ebro and Rhône Rivers)
  - Study the shelf water cascading events: dense water formation, organic and contaminants plumes

KSC2 Assessing the impacts of extreme events

- Impacts of rare and extreme events
  - Assess the occurrence of extreme events, like storms (Medicane), flash flooding, and heavy rains

KSC3 Unravelling the impacts of natural and anthropogenic change

- Observations to resolve anthropogenic disturbances:

- Understand Big cities impacts on e.g. eutrophication and contaminants

3.1.1.3. ENGLISH CHANNEL

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

- Biodiversity and primary productivity:
  - Determine the spatial and temporal variability of pressures controlling phytoplankton dynamics (eutrophication, climate change and extreme events)
  - Evaluate the spatio-temporal variability of SPM dynamics
  - Integrate the interactions between organic and inorganic SPM and advance coupled hydrodynamic, sedimentary and ecological models

KSC2 Assessing the impacts of extreme events

- Eutrophication:
  - Use of data in the implementation of the WFD and the MSFD (eutrophication); contribute to the improvement of ecological status assessments

KSC3 Unravelling the impacts of natural and anthropogenic change

- Identify gaps in observations (resolution, variables, procedures)

- 4D assessment of coastal environmental dynamics and anticipate forecasting needs

RI collaborations :

- Facilitate exchange and sharing of knowledge between RIs on the land-sea continuum.

3.1.1.4 NORTH SEA

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

- Carbon budget:
    - Refine the regional carbon budget including terrestrial inputs, coastal carbon cycling, and biological carbon fluxes and identify gaps in observations and interactions on a variety of temporal and spatial scales
- Connectivity and transport:
    - Resolve the impact of small- to large-scale hydrographic structures on ecosystems

KSC2 Assessing the impacts of extreme events

- Impacts of rare and extreme events:
    - The impact of floods and other extreme events such as severe storms on energy and matter budgets, biological productivity and coastal protection
    - Impact of sea level rise on coastal environments, aqua-culture, and coastal protection

KSC3 Unravelling the impacts of natural and anthropogenic change

- Observations to resolve anthropogenic disturbances
    - Impact of offshore-windpark structures on hydrography and biogeochemical processes

See comment aboveRI collaborations :

- Facilitate exchange with other RIs, especially DANUBIUS-RI

3.1.1.5 BALTIC SEA / GULF OF FINLAND

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

- Land-sea continuum:
    - Advance the integration of monitoring at land-sea continuum
- Ecosystem functioning and carbon budget:
    - Clarify the interplay of biological, biogeochemical (carbon fluxes, oxygen depletion), and physical (currents, mixing, weather forcing, water exchange) processes in the region
    - Improve understanding on the functioning of marine ecosystems and biogeochemistry by coupling observations, experimentation and modelling

KSC2 Assessing the impacts of extreme events

- Impacts of rare and extreme events:
    - Assess whether the countermeasures to reduce eutrophication and pollution
    - Resolve how the state of the Baltic Sea is affected by human pressures

KSC3 Unravelling the impacts of natural and anthropogenic change

- Provide improved knowledge framework for sustainable development in the Baltic Sea and the emergence of a blue economy

3.1.1.6 NORTH ADRIATIC SEA

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

- Land-sea continuum & connectivity and transport:
  - Understand the impact of climate change on wind regimes and river discharges and cascading effects on the deep water formation and the general circulation
- Biodiversity:
  - Monitor the biodiversity changes (phosphorus loads, overfishing, anthropogenic modifications and climate change)
- Ecosystem functioning:
  - Understand ecosystem functions along steep ecological gradients.
- Carbon budget & primary productivity:
  - Assess how the horizontal and vertical drivers affect the source and sink of CO_2, particles, nutrients and litter dispersal

KSC2 Assessing the impacts of extreme events

- Impacts of rare and extreme events:
  - Understand the effects of extreme events to minimise coastal risks, to develop an alert network and improve the forecast systems
  - Understand the impact of the sea level rise on the coast and on the delicate lagoon environment characteristic of the northern Adriatic basin

KSC3 Unravelling the impacts of natural and anthropogenic change

  - Coordinate operational oceanography aiming at integrating synoptic and multidisciplinary regional observations, and synergy of in situ infrastructures and remote sensing systems

3.1.1.7 IBERIAN ATLANTIC MARGIN

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

- Land-sea continuum:
  - Improve the present understanding on transboundary processes and connectivity, by bringing insight on the key processes which control along-margin transport and across-margin transport
- Connectivity and transport:
  - Evaluate the biological connectivity within the region and between adjacent regions, through the transport, migration, colonisation and invasion of various organisms.

KSC2 Assessing the impacts of extreme events

- Impacts of rare and extreme events:
  - Study the coastal ocean impacts from remote areas, such as the far impacts of local seasonal upwelling, high turbidity flushing events, vertical mixing and continental dust inputs

    - Evaluate the impacts of extreme weather events and coastal erosion processes on the ecosystems, on coastal ocean conditions and their impacts on coastal communities

KSC3 Unravelling the impacts of natural and anthropogenic change

- Long term observations to resolve climate change impacts:
    - Assess the coastal ocean response and vulnerability to long term variability associated with the North Atlantic atmospheric regimes
- Observations to resolve anthropogenic disturbances
    - Assess the dispersion of chemical contaminants

3.1.1.8 BAY OF BISCAY

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

- Land-sea continuum:
    - Resolve the impact of large rivers on the coastal ocean structure and functioning, and unravelling the effects in relation to climate change.
- Connectivity & transport:
    - Survey the origins and transport of marine litter, plastic pollution and invasive species.
- Ecosystem functioning & biodiversity trends:
    - Study the impact of global change on coastal marine habitats, biodiversity, ecosystem functioning and water quality

KSC2 Assessing the impacts of extreme events

- Impacts of rare and extreme events:
    - Study the impact of climate change (sea level rise and extreme events) on the shore-line (hydro sedimentary transport) to better assess and minimise coastal risks.

KSC3 Unravelling the impacts of natural and anthropogenic change

- Observations to resolve anthropogenic disturbances:
    - Monitor and assess the impact of human activities
- Interoperable and integrated long-term datasets
    - Advance integration of multisource data and circulation model simulations to develop new approaches for surface and subsurface
    - Coastal current retrieval and thereby improve the use of data from coastal observatories to biogeochemical and environmental issues.

3.1.1.9 KATTEGAT/SKAGERRAK

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

- Biodiversity trends and carbon budget:

  - Improve the understanding on the climate change and climate variability effects on carbonate system and spatial-temporal dynamics of phytoplankton and higher trophic levels
  - Carbonate system harmonisation
- Ecosystem biogeochemical processes:
  - Phytoplankton diversity and abundance - Implementing automated imaging in flow
    systems in stationary ocean observatories and in ferrybox systems on research and merchant vessels

KSC2 Assessing the impacts of extreme events

- Impacts of rare and extreme events:
  - Investigate the impact of eutrophication and land-sea interactions on marine ecosystem services, biodiversity
  - Assess the advection of harmful algae, oil, litter and microplastics
  - Advance the monitoring of the biogeography and biodiversity of phytoplankton and zooplankton and develop early detection and warnings of harmful algal blooms

KSC3 Unravelling the impacts of natural and anthropogenic change

- Long term observations to resolve climate change impacts:
  - Combining observations and modelling
  - Higher trophic dynamics: Implementing in-situ imaging and automated object analysis systems in stationary ocean observatories
- Observations to resolve anthropogenic disturbances:
  - Evaluate the dispersal and ecosystem effects of contaminants

3.1.1.10 NORWEGIAN SEA

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

- Land-sea continuum:
  - Land-Coastal-Ocean interactions

KSC2 Assessing the impacts of extreme events

- Impacts of rare and extreme events:
  - Harmful Algal Blooms
  - Aquaculture
  - Sustainable fisheries management

KSC3 Unravelling the impacts of natural and anthropogenic change

  - Observations to resolve anthropogenic disturbances:
  - Human Impact
- Interoperable and integrated long-term datasets
  - Integrated Ecosystem Assessment

3.1.2. Current state of the implementation

Currently in JERICO-S3, the regions that are expected to be implemented with the goal of providing data that meet KSCs and societal needs are the pilot super-sites (PSS). **In the following, we will therefore focus on the different types of implementation in each of the four JERICO-S3 PSS.** The implementation strategy during JERICO-S3 has been described in D4.1 and updated in D4.3. The PSS implementation is summarised below (PSS actions have ended in Nov. 2022).

3.1.2.1. Gulf of Finland (GoF)

The overall scientific aims of GoF were related to understanding how external human pressures affect the state of the sea, how to improve knowledge on key processes and how to advance the observations to meet these goals. Several GoF PSS actions already improved the harmonisation of the observations among partners for various target variables (e.g. phytoplankton, oxygen, carbonate system). Partnership was created to include different competencies and specialisations and subsequently the transfer of knowledge within partnership has been a particularly desirable activity. Transnational harmonisation and sharing datasets are seen as beneficial to all parties and strengthening the joint knowledge base.

Platforms	**Status**	**Variables**
FerryBox (SYKE, FMI, IOW, TALTECH)	operational	T, S, Chla-Fluo, CDOM-Fluo, Turbidity, Phycocyanin-Fluo, Phycoerythrin-Fluo, O_2, pH, CO_2, sampler
Observatory: Utö (FMI, SYKE), Keri (TALTECH)	Mostly operational	Utö: T, S, Chla-Fluo, CDOM-Fluo, Turbidity, Phycocyanin-Fluo, O_2, pH, CO_2,Meteorology, IFCB, Cytosense, FRRF, discrete samples Keri: T, S, Chla-Fluo, Turbidity, Phycocyanin-Fluo, O2, Meteorology
Gliders (FMI, TALTECH)	operational	T, S, Chla-Fluo, CDOM-Fluo,
Argo floats (FMI)	operational	T, S, Chla-Fluo, O_2
Profiling buoys (FMI, SYKE, TALTECH)	operational	T, S, Chla-Fluo, CDOM-Fluo, O_2, Phycocyanin-Fluo,
Wave riders (TALTECH, FMI)	operational	wave height
Research vessels	occasional	Annual program with several cruises & stations in the GoF
Experimental and calibration facilities (SYKE)	as needed	

3.1.2.2. Northwestern Mediterranean Sea (NW Med)

The NW Mediterranean Sea aims to observe and understand the impacts of climate change and anthropogenic pressure on the coastal marine ecosystem, which are already visible due to the dynamics of the North Current and the influence of riverine inputs. The NW Mediterranean Sea system has adopted a multi-platform and multi-disciplinary approach through two permanent observing systems (SOCIB (Spain), ILICO (France)) and several regional networks oriented toward science and society needs.

Platforms	**Status**	**Variables**
Research vessels (ILICO, SOCIB, CNR)	operational (different frequency)	Profiles: T, S, O_2, fluorescence; Bottles: nutrients, carbonate, zooplankton, phytoplankton, genomics
HF radars (CNR, PdE, ILICO, SOCIB)	operational	surface currents
Moorings (ILICO, CNR)	operational	T, S, O_2, currents, particle flux, images
Buoys (ILICO, PdE, UPC, SOCIB)	operational	meteorology, currents, waves, PAR, T, S, O_2, fluorescence, pH, pCO_2
Tide gauges (PdE, SOCIB)	operational	sea level
River stations (ILICO)	operational	Discharge, particles load, nutrients, metals
Seabed (UPC)	operational	T, S, depth, currents, waves, underwater sound, seismometer, video-camera, biodiversity
Gliders (ILICO, SOCIB)for ILICO (MOOSE) the GNF is not operational since July 2021. The endurance lines are operated from MIO and LOV (sub-contractor ALSEAMAR)	operational	T, S, fluorescence, turbidity, O_2, CDOM, BB700 (routinely), particles size, current motion (occasionally)
Numerical models (SOCIB, IFREMER, PdE, CNRS)	Operational, semi-operational	(3D) T, S, currents, waves, sea level

3.1.2.3. North Sea and English Channel (NS/EC)

The overall scientific aims of the English Channel and the North Sea were respectively related to refine the regional carbon budget including terrestrial inputs, coastal carbon cycling, and biological carbon fluxes as well as, to assess regional eutrophication status, phytoplankton biodiversity and productivity, and their modulations. Jointly, this twin PSS is identifying gaps in observations and interactions that hamper regional studies of carbon cycle and eutrophication. These objectives rely on nine actions related to the following main themes: carbon cycling and regional carbon budget, phytoplankton dynamics and biodiversity, as well as eutrophication processes. Whereas some actions aim to improve the harmonisation of the observations among partners for various target variables, others consist in identifying observational gaps and enhancing cross-regional communication as well as interactions with other RIs. Beyond organisational challenges, products resulting from these actions such as optimised monitoring strategy, best practices and numerical tools aim at supporting EU Directives and ecosystem management needs (e.g. MSFD and OSPAR environmental assessment).

Platforms	**Status**	**Variables**
MAREL Carnot station (IFREMER)	operational	T,S, turbidity, Chla, O_2, PAR, nutrients
Buoys: Smile (Ifremer, CNRS), Scenes (IFREMER), Astan (CNRS), Thornton (VLIZ)	operational	T,S, turbidity, Chla, O_2, meteo, (pCO_2, pH), waves, currents
Warp and /WestGabbard (2 x SmartBuoys)	operational	Temperature (water), salinity, fluorescence, oxygen, turbidity, PAR, nutrients, phytoplankton (species abundance)
Benthic Lander MOW1 (RBINS)	operational	T,S, acoustic, turbidity, SPM, turbulence, current, suspended particle size
Ferrybox: Lysbris (Hereon), Magnolia Seaways (Hereon), FunnyGirl (Hereon), Cuxhaven (Hereon), Norrona (NIVA), Connector (NIVA,RWS), Thalassa (CNRS), Endeavour (CEFAS)	operational	T,S,Chla, O_2, turbidity, nutrients, PAR, pH, CDOM, (pCO_2)
Research vessels: Côtes de la Manche (CNRS), Antea (IRD), Sépia II (CNRS), Simon Stevin underway system (VLIZ)	operational	T,S, O_2, turbidity, nutrients, surface pCO_2, surface Chla
COSYNA Helgoland cable observatory (AWI/Hereon)	operational	T,S, turbidity, Chla, O_2, camera
Vertical Profiling Lander Helgoland (AWI/Hereon)	operational	T,S, turbidity, Chla, plankton and particle (imagery), seafloor

3.1.2.4. Cretan Sea (CS)

The CS scientific aims are to study air-sea CO_2 fluxes and pH trends to understand their variability and main regional drivers. This PSS is also seeking for new procedures to improve: (i) primary productivity estimates in oligotrophic waters, and (ii) the assessment of the effects of extreme events on phytoplankton communities. To achieve these goals, the CS uses several tools such as multiplatform observations, mesocosms, modelling, designs new and optimum sampling strategies, evaluates novel technologies, tests/improves estimation algorithms, and revisits best practices. It also uses partnerships at multiple levels: within PSS, with other PSSs, with other environmental RIs, with regional initiatives, as well as with industry and technology-related projects.

Platforms	Status	Variables
Ferrybox PFB	Operational	T, S, Fluo, O_2
Fixed platform: HCB, E1-M3A, MB	Operational	meteo, SST, SSS, (Chla, pH, pCO_2)
Glider PG	Operational	T,S, O_2 every 1m down to 1000m
Argo floats	Operational	T, S (O_2)
Calibration Lab	Operational	T, S, O_2, pH, Fluorescence
Research vessels	Operational	CTD casts: T, S, O_2, Fluo, Turbidity, PAR, Phycoerythrin; Niskin: pH, TC-TA, inorganic nutrients, Chla, bacteria to phytoplankton; Zooplankton net

3.1.2.5 Synthesis of the PSS implementation

Previous tables demonstrated that most of PSS regions operate generic platforms to observe coastal water processes: ferryboxes, fixed moorings/buoys, gliders, research vessels, HF radars. These platforms are used to provide physical and biogeochemical EOVs and only a few are designed for acquiring biological variables (except for chlorophyll-fluorescence), which are essential for answering some RAs. Also, most of the platforms implemented in the PSS do not allow the observation of benthic ecosystems (except in the NS/EC and NW MedSea) which is key for addressing some SSCs and RAs identified as important (e.g. eutrophication or the impact of extreme physical events on contamination transfers).

To tackle various scientific challenges, the integration of the JERICO-RI multiplatforms approach with satellite observations and modelling, was expressed as an important benefit for all PSSs. However, it increased the challenge of merging and harmonising observations, while meeting all demands of coastal ecosystem BGC data. This is presently tackled by specific research calls in Horizon Europe, and JERICO-RI will benefit from such actions in the future. A common view from PSSs facilitated the transfer of knowledge through partnerships between different competencies and specialisations.

Some actions were given more emphasis in certain PSSs than others. NS/EC and CS focused on carbonate system and phytoplankton observations (in 2021). NS/EC focused on eutrophication assessment status as well as processing complex multivariate, multisource and multiscale data sets with machine learning. CS explored new methods to improve primary production estimates in oligotrophic areas. NW Med adopted a coastal multi-platform approach that feeds 3D-transport models, while GoF focused more on phytoplankton observations.

Finally, it can be mentioned that not all regional specificities described for each PPS in §3.1.1, are addressed with the current platforms. For example, in the NW-Med region, the impacts of contaminants on marine ecosystems and resources and those of storms and heat waves on water-mass properties and air-sea exchange fluxes were not addressed. Similarly, the impact of offshore-wind structures on the local hydrography and biogeochemical processes, and the impact of small and large-scale hydrographic structures on ecosystems, were not addressed in the NS/EC. This is likely to result from the lack of:

- Mature and robust technologies to generate useful and accurate dataset
- Platform integration tools and adaptive strategy (e.g. to observe extreme events or to study specific processes): this will require a special and intense observation period activity with multiple platform deployments in a restrictive area (eg. HYMEX program with its special observations period in France to observe deep water formation).
- Scientific expertise: it is the responsibility of the nations and organisations in JERICO-RI to call upon this expertise if the need (SSC) is critical to the region. This difficulty could be due to historical reasons during the set-up and initial phase of the PSS implementation and researchers and stakeholders engagement (top/down directive vs. bottom-up brain-storming).
- Networking and infrastructures collaborations within regions

The outcomes of deliverable D4.4. will update the picture of the full capacity, limitations and lessons learned from the PSS implementation period.

3.1.3. Common scientific and societal challenges

The common JERICO-RI scientific challenges have been identified in D1.1 and presented in Table 1 in this report.

The most common topics in JERICO-S3 regions are the **impacts of land-based discharges** (except for the NE Mediterranean Sea), **connectivity and transport of water masses and materials** is covered by all regions, as well as **pelagic biogeochemical processes and interactions, and carbon fluxes and budgets**. **Long-term observations to resolve climate change impacts** are considered in all regions for temperature, salinity, nutrients and for biogeochemistry datasets.

In the context of societal challenges, all regions aim to advance multidisciplinary observations of the coastal seas, thereby contributing to optimising the pan-European observation of complex environmental challenges, such as marine **contaminants, carbon cycling and biodiversity trends**. The PSS approach is improving the understanding of the functioning of coastal ecosystems. This directly impacts societies, contributing to healthy and productive seas.

Concerning common challenges, the regions agree on the need for more transnational and regional collaboration, which is apparent from scientific collaborations and bilateral collaboration agreements (D3.1). In these regions, they report coastal monitoring programs in the frame of the MSFD at the EU scale.

Finally, it is important to point out that these regional common societal topics, derived from internal expert assessment, are different to those identified by the survey addressed to the National Representatives (NRs), and reported in the deliverable D1.1 of the JERICO-DS project, which are: non-indigenous species, aquaculture, climate change, localised measures/protection from marine litter, riverine inputs, impact/effects of storms and floods.

During the JERICO-S3 project, PSSs were proposed to test and demonstrate the ability of regions to address certain KSCs and SSCs. These PSSs were not intended to address all the regional specificities described above but rather to focus on certain actions that the current observations could address, via a PSS approach, during the course of the years of the project. To assess the relevant SSCs currently addressed by each region, a questionnaire was sent to PSS leaders. For the most relevant SSCs according to the region's leaders, the score is described in Table 2.

Table 2: Results of the questionnaire sent to PSS and IRS regions regarding the most relevant regional challenges (1 = not relevant, 2 = somewhat relevant, 3 = relevant, 4 = very relevant). The total score is indicated in %.

KSC	SSC	PSS-BSGF	PSS-CS	PSS-NWM	PSS-EC/NS	IRS-BOB	IRS-IAM	IRS-NA	IRS-KS	IRS-NorS	Total
Assessing changes under the combined influence of global and local drivers	Land Sea Ocean continuum	4	4	4	4	4	4	4	4	4	100
	Sea-atmosphere interface	3	4	3	3	2		3	3		58
	Connectivity and transport	3	3	4	3	4		3	4		67
	Biodiversity trends	4	4	3	4	3		4	4		72
	Ecosystem biogeochemical processes and interactions	4	4	4	4	3		4	4		75
	Carbon budget and CO2 system	3	4	4	4	3		4	4		72
Assessing the impacts of extreme events	Impacts of rare and extreme events	4	4	4	4	4		4	4		78
	Resolving climate change impacts	4	4	4	3	4		4	4		75
Unravelling and predicting the impacts of natural and anthropogenic changes	Resolving anthropogenic impacts	4	4		4	4		4	4		67
	Disentangling impacts/scales		4		4	4			1		36

The questionnaire addressed to the regions revealed that thematics like **land-sea continuum and impacts of extreme events** are the most **"very relevant"** SSCs for 7 regions (over 9 in total) with a score of 100% and 78%, respectively. Moreover, regions underline that the main societal needs beyond these relevant SSCs are: marine ecosystem health, pollution, impacts of heat waves, water quality (eutrophication), marine living resources, tourism, aquaculture and biodiversity.

The SSC "land-sea-ocean continuum" regroups the impacts of land-derived discharges and exchanges with open ocean area. It includes the RA: nutrients, particles and organic matter, inorganic carbon, litter and contaminants. The "impacts of rare and extreme events" includes: floods, storms/large waves, heat/cold waves, landslides/sudden erosion, tsunamis, volcanic eruptions, harmful algae and jellyfish blooms, accidental pollution, interactions between events.

Overall, it appears that the regions have generally addressed the first KSC more readily than the two others. One reason for this is that the first KSC can be addressed largely on the basis of local currently running *in situ* observations, whereas the other two require greater technological maturity and integration. Addressing KSC2 is highly dependent on technological advances (e.g. high frequency observations, ability to react quickly, adapted forecasting model,...). Tackling KSC3 requires greater collaboration between institutes and scientists to improve the design, acquisition and analysis of field observations. The latter includes the development of appropriate statistical and modelling tools at a higher level of integration than each individual region.

3.2.How are these specificities addressed at present

Table 3: Results of questionnaire sent to PSS and IRS regions regarding the current treatment of SSC (1 = not treated, 2 = poorly treated, 3 = partially treated, 4 = well treated, 5 = fully treated). The total score is shown in %.

KSC	SSC	PSS-BSGF	PSS-CS	PSS-NWM	PSS-EC/NS	IRS-BOB	IRS-IAM	IRS-NA	IRS-KS	IRS-NorS	Total
Assessing changes under the combined influence of global and local drivers	Land Sea Ocean continuum	4	3	3	3	3	2	3	4	2	60
	Sea-atmosphere interface	3	3	3	3	2		2	2		40
	Connectivity and transport	3	3	4	3	3		3	3		49
	Biodiversity trends	3	2	2	3	3		3	3		42
	Ecosystem biogeochemical processes and interactions	2	3	3	3	3		2	3		42
	Carbon budget and CO2 system	3	2	3	3	3		4	4		49
Assessing the impacts of extreme events	Impacts of rare and extreme events	3	2	4	3	4		4	3		51
	Resolving climate change impacts		2	4	3	4		3	3		42
Unravelling and predicting the impacts of natural and anthropogenic changes	Resolving anthropogenic impacts		3		3	3		2	3		31
	Disentangling impacts/scales		4		3	1			1		20

Overall, the **scores are lower** than those from "very relevant" cases (60% and 51% for the land-sea continuum and impacts of extreme events, respectively). This could be due to the lack of expertise, technologies and data accuracy, adapted strategy for the multi-platforms approach, existing tools (e.g. regional models, machine learning) and cooperations between countries, networks/infrastructures and institutes.

At present, the **land-sea continuum** topic is, at least partially, addressed in seven regions, while impacts of extreme events ranged from poorly addressed to well addressed. As expected, PSSs appear to be currently better suited to address these scientific challenges, although disparities appear in the questionnaire results.

For PSS, these specificities are addressed through different platforms ranging from fixed point visits and repeated measurements, to the deployment of autonomous and drifting platforms, enabling sampling at various and fit-for-purpose scale of time and space, and combined with model simulations. Furthermore, several PSSs emphasise the importance of collaborations with other networks and organisations for sharing efforts, expertise and data. For societal needs, the production of MSFD indicators is relevant to provide information to the stakeholders and should be addressed by all PSSs.

For IRS, these specificities are addressed on a more local scale through the individual efforts of single institutes. It is clear that strong collaborations with other nations and networks/RIs will benefit more for better information to science and society.

From the questionnaire (see the link in appendix), it appears that the nature of the societal needs are different for those addressed in the northern regions (Baltic Sea, Kattegat/Skagerrak, North Sea) due to the political stakes of local governments to protect and preserve the marine environment, while the Mediterranean Sea regions mentioned interest on tourism impacts and water quality preservation (the Mediterranean Sea represents 30% of the world's tourism with significant economic resources).

There is certainly a significant difference between regions in dealing with these specificities due to the overarching objectives for deploying a national RI, and the original implementation of the regional network. For regional systems that were intended and implemented by science-purpose only (or academic institutes), accounting for societal issues is limited or underdeveloped, whereas regions that were implemented to respond to operational demands have made progress on these societal challenges and possibly less on science.

Table 4: Results of questionnaire sent to PSS and IRS regions regarding the collaboration between the regions in the defined SSCs

KSC	SSC	PSS-BSGF	PSS-CS	PSS-NWM	PSS-EC/NS	IRS-BOB	IRS-IAM	IRS-NA	IRS-KS	IRS-NorS
Assessing changes under the combined influence of global and local drivers	Land Sea Ocean continuum	KS, NS		BOB	KS, NS	NWM,EC	NWM		NS, GF	NWM
	Sea-atmosphere interface			NA						
	Connectivity and transport	NA, NS	NA, NWM	CS	KS, GF	IAM			NS, GF	
	Biodiversity trends		NA, NWM		NWM				NS, GF	
	Ecosystem biogeochemical processes and interactions		NWM						NS, GF	
	Carbon budget and CO2 system			GF, CS	KS				NS, GF	
Assessing the impacts of extreme events	Impacts of rare and extreme events					IAM, NWM, EC			NS, GF	
	Resolving climate change impacts					IAM, NWM, EC			NS, GF	
Unravelling and predicting the impacts of natural and anthropogenic changes	Resolving anthropogenic impacts					NWM, EC				
	Disentangling impacts/scales									

Regarding the collaborations between regions, it is obvious that the results will be more relevant for the existing and active PSSs and that collaborations will increase during the project time. It appears from the questionnaire that collaborations do exist, especially, but not exclusively, with **neighbouring regions or those that are part of the same oceanic basin**. This concerns essentially the SSCs "transport of water masses" and "land-sea continuum". Other SSCs require collaborations between regions to share expertise, facilities and technologies. Some collaborations are also based on historical consortia, which are nowadays well established through EUROGOOS and regional ROOS (e.g. BOOS, MONGOOS …). In this case, CS and NWM that have good experiences through previous EU projects, ERIC and European organisations have had strong and long-lasting collaborations in decades. For NS/EC, these collaborations are fostered by international commission's involvement (e.g. OSPAR) and EU directives (e.g. MSFD). Finally, these region's collaborations are not only the responsibility of the regions themselves, but also of the programs and projects that have made it possible to build RI-networks and capacity building, including exchanges of students and scientists.

3.3.Requirements, gaps and opportunities

One of the main objectives of JERICO-RI is to bring together several regions under a single label addressing common issues, while keeping the regions capable of responding to their local specificities expected by the scientific community and policy makers. The ultimate goal is to provide data needed for marine research, restoring ocean health, supporting robust indicators of climate change and marine ecosystem status in coastal waters, which are useful for both European nations and EU policy.

In JERICO-S3, ten regions have been defined to monitor and collect data on various physical, chemical, and biological variables in the coastal marine environment. Common products and services developed initially on the bases of a list of SSC are treated at different levels (from well-address to not-addressed) but with high heterogeneity between regions and divergence with respect to knowledge and visions/strategy of nations. In addition, stronger connections between regions are lacking to provide accurate products and share knowledge on technologies and/or data expertise.

In general, we observed that the challenges faced by the regions are different depending on the geographical scale. For example, societal questions are restricted to very local expectations (e.g. toxic algae pollution, oil spills...) whereas the impacts of climate change in general affect a wider coastal area (e.g. hypoxia, eutrophication, acidification...).

The difficulty of building a consistent, harmonised and efficient regional approach in JERICO-S3 is based on the complexity of the interconnected processes relevant in the coastal waters, the heterogeneity of regional implementation status, the long-term engagement of experts (scientists and stakeholders) and different readiness level in terms of data sharing. Such complexity limits the present capability of addressing some SSCs, and in some cases, the gaps in regional inter-connections could induce negative consequences on the ability of the JERICO-RI consortium to efficiently address SSCs.

To fill the gaps mentioned above, the community under the leadership of JERICO-RI, needs to pay close attention to the regional and pan-European scales. But it also requires flexibility and willingness from national and regional stakeholders (e.g. research institutes, ministries) to adopt new sampling strategies, technologies, and data FAIR principles.

A key role that JERICO-RI should play is to centralise KSC3 type actions (see previous discussion) with a pan-European vision and strategy, so that regions collaborate more and share their data and expertise. This would also demonstrate the added value of JERICO-RI over a network of national observatories focused on regional challenges.

Some national structuration, based on top-down, long-term programs and bottom-up proposals, ideally with an interregional, between nations dimension, could "stimulate" the regional approach towards a long-term European coastal observing system. The integration of different regional scientific interests with stakeholders' needs would probably benefit the organisations of activities in JERICO-RI and the provision of high-impact services. This will also need to be accompanied by an efficient European-wide governance, one of the objectives of which will be to provide services that are adopted by nations and regions.

4. OUTREACH, DISSEMINATION AND COMMUNICATION ACTIVITIES

With the objective of updating and deepen the analysis of cross-region research activities and continue the structuration of the JERICO-RI Science strategy as a coastal component of EOOS, WP1 launched a questionnaire addressed to the region leads during the JERICO-WEEK#3 and organised a first follow-on session at the JERICO-DAYS in LISBON. In this questionnaire the relevance (science and societal) of the Science Specific Challenges (SSC) defined in D1.1 for each region was analysed. Then, how each of these SSCs is addressed in the region (by other existing infrastructures or initiatives) and specifically by JERICO-RI, alone or in connection with other regions was reported. Finally, the gaps in terms of datasets or approaches to progress in the addressing of the SSC were also identified.

The proposed approach for this study has been shared and discussed with JERICO partners during the online JERICO-S3 WP1 meeting at the end of 2022. The preliminary results have been discussed with JERICO-DS project partners during an online meeting in 2022.

5. CONCLUSIONS

One of the main goals of JERICO-S3 is to bring several regions together under one label to address common issues, while keeping the regions able to address their local specificities expected by scientists and policy makers. Currently, not all KSCs and SSCs are addressed at the same level and connections between regions are still needed to be improved to provide accurate products and share knowledge on technologies and/or data expertise. In general, we observed that the faced challenges differ between regions depending on the geographic area. Overall, it appears that the regions have generally addressed the first KSC more easily than the other two. One reason for this is that the first KSC can be addressed largely on the basis of current *in situ* observations, whereas the other two require greater technological maturity and integration. KSC2 is highly dependent on technological advances (e.g. high frequency observations, ability to react quickly, adapted forecasting model,...). KSC3 requires greater collaboration between institutes and scientists to improve the design, acquisition and analysis of field observations. The latter includes the development of appropriate statistical and modelling tools at a higher level of integration than each individual region.

The difficulty in building coherent, harmonised, and effective regions in JERICO-S3 is based on the complexity of relevant interconnected processes in coastal waters, heterogeneity of regional implementation status, long-term expert commitment, and data sharing. Due to history, country, and expertise, some regions may meet these expectations but in a limited or fragmented manner (D1.1 of J-S3).

A key role that the future JERICO-RI should play is to centralise KSC3-like actions with a pan-European vision so that regions collaborate more and share their data and expertise. For the future implementation, the distinction between PSS and IRS would no longer be relevant, but rather we should refer to these structures as common regions in JERICO-RI. Finally, this report highlights a number of societal issues that are not being addressed to a great extent in the regions. A future challenge will be to increase the consideration of societal factors in the SSCs in order to design a strategy in JERICO-RI that responds to scientists as well as decision makers and managers of the coastal marine environment.

6. ANNEXES AND REFERENCES

JERICO-S3 D1.1 – WP1 - First analysis of the JERICO-S3 scientific monitoring and regional approaches. Early inputs toward sustainability.

JERICO-S3 D3.1: Initial analysis and summary of region- specific and region-wide monitoring strategies, and regional sustainability plans

JERICO-S3 D4.1. JERICO-S3 Pilot Supersite monitoring strategies

JERICO-DS D1.1 - WP1 - "Preliminary report for long-term scientific plan"

JERICO-DS D.2.1 - WP2 - "Technical and technology outlook for coastal observatories"

The full questionnaire used in D1.2 is available here

https://drive.google.com/drive/folders/1VRRKAeKE__cJaC8tAxpN0v5e8pLOftM3?usp=sharing