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JERICO-S3 D3.2: Report on integration progress within and between IRSs

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Joint European Research Infrastructure network for Coastal Observatory
Science, Services, Sustainability

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APPROVALS

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1. EXECUTIVE SUMMARY

The JERICO-S3 project has established Integrated Regional Sites (IRS) to further develop and integrate regional and pan-European coastal observing efforts. Five IRSs were initiated at the beginning of the project, and an initial analysis (Deliverable 3.1) was made in terms of scientific partners involved, main scientific questions, observational strategies, regional organisation, financial sustainability plans, and plans for future development. This culminated in a road map plan for each IRS in order to progress according to specific requirements of coastal observing in each region as well as specificities in terms of organisation and financial sustainability. This Deliverable presents a mid-project update on the integration progress within each IRS, between IRSs, and in some cases between IRSs and WP4 Pilot Supersites (PSS). Progress is reported in this Deliverable on a region by region basis and include categories related to the roadmap: regional integration activities, interoperability/harmonisation activities, business case activities, and organisation activities. Overall, significant work towards developing IRSs has taken place over the last ~two years, however business case and organisation activities require additional focus.

2. INTRODUCTION

The JERICO-S3 project involves the development of five Integrated Regional Sites (IRS) for coastal ocean areas that are of interest in terms of socioeconomic and ecosystem research importance (Fig. 1). Since borders between nations are human constructs, coastal ocean ecosystems are not constrained by these borders. Therefore, each of the five IRSs involve several JERICO–S3 partner countries focused on accomplishing transnational objectives. The JERICO-S3 IRSs include:

- Northern Adriatic Sea
- Iberian Atlantic Margin
- Bay of Biscay
- Kattegat-Skagerrak-Eastern North Sea
- Norwegian Sea

The initial analysis and report from the IRSs were presented in Deliverable 3.1, which included information related to partners involved, main scientific challenges, observational strategies, regional organisation, financial sustainability plan, and plans for future development. Through this work, a common roadmap plan was developed for each IRS that includes objectives related to: integration, harmonisation, business case, and organisation/structure. This deliverable is a mid-term report on progress achieved within each IRS in relation to the integration objectives, and Deliverable 3.5 will be the final report on integration between and within IRSs.

The following main report section contains a mid-term report from each IRS documenting recent and future activities related to each of the IRSs roadmap plans. This is followed up by a section that highlights integration activities that have occurred and occur between IRSs as well as between IRS and Pilot Supersites (PSS). The "internal" work within IRSs have been noted as being important for developing regional objectives and harmonisation and to make progress towards multi-national cooperation in coastal observing. The "external" work between IRSs and with PSSs have been noted as being crucial since, of course, IRSs and PSSs share common borders as well

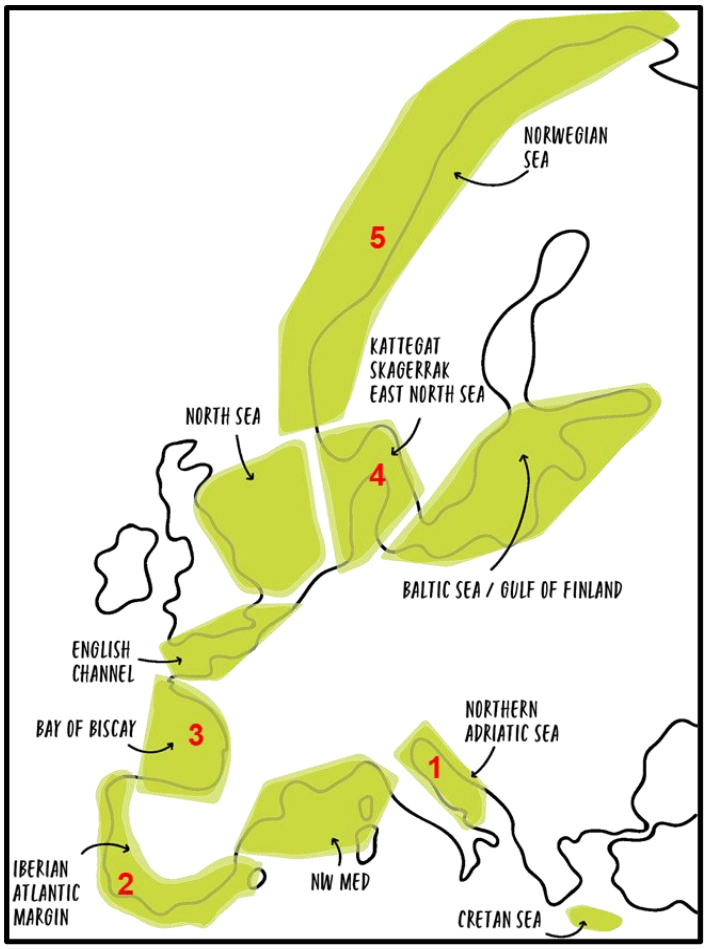

Figure 1. Location and approximate geographic extent of the JERICO-S3 Integrated Regional Sites: 1) Northern Adriatic (NA), 2) Iberian Atlantic Margin (IAM), 3) Bay of Biscay (BoB), 4) Kattegat-Skagerrak Eastern North Sea (KASKEN), and 5) Norwegian Sea (NS). Note that other regions not numbered are the locations of Pilot Supersites covered by WP4.

as common Key Scientific Challenges are present (and therefore foci on certain Essential Ocean Variables; EOVs). Additionally, building a pan-European coastal observing network requires a higher level of coordination in which IRSs and PSSs can observe, adapt, and improve together on a pan-European scale.

3. MAIN REPORT

This chapter of the deliverable is divided into subchapters for integration activities within each of the five IRSs, and a sixth section is included that describes integration between IRSs and

PSSs. Integration activities are presented in four topics that are aligned with the common roadmap plan (Table 16 in D3.1). This includes: 1) Regional integration objectives in relation to institutional involvement, key persons, EU Research Infrastructures and initiatives (especially with relation to activities in WP2); 2) Interoperability/harmonisation objectives in relation to observational efforts, datasets (in relation to guidelines set forth by WP6), activities related to calibration and best practices (in alignment with WP5), and observational strategy (WP1); 3) Business case activities in relation to use cases and building up links with potential users as well as defining and carrying out activities related to long-term financial sustainability (with links to WP9); and 4) Organisational activities in relation to national/regional memorandums of understanding, externally-funded projects, and roadmaps to national/regional coastal observing research infrastructures.

3.1. Northern Adriatic Sea (NA)

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

3.1.1. Regional integration activities

The regional integration activity is developing on topics proposed by the partners involved in this IRS, in particular we are focusing on harmonised observations of regional (deep water) oxygen, a topic not explicitly addressed by the ESFRIs present in the Northern Adriatic and which is a gap to be filled for this area. Contacts will be initiated with other IRS or PSS that have activities on the same topic, especially with GoF-PSS which has a specific action on Harmonised Observations including dissolved oxygen measurements.

The JERICO NA-IRS project affects an area also covered by the DANUBIUS-RI project with the Po Delta and North Adriatic Lagoons Supersite. A collaboration agreement between the two projects has already been discussed at the project coordination level, where it was proposed to elaborate some common key general scientific issues and to consider specific sites of collaboration, for example: the Northern Adriatic. Contacts will then be initiated at the level of a regional research infrastructure to explore the possibility of collaborating on topics of common interest such as best practices/protocols through a joint workshop to be held in the early part of 2023.

A collaboration under the "JIVE" JERICO-S3 TA project on the S1-GB structure off the Po River Delta has been initiated and is being carried out, which aims to study the seawater optical properties and sensor evaluation.

3.1.2. Interoperability/harmonisation activities

With reference to the harmonised observations of regional (deep water) oxygen activity already mentioned above, the activity incorporates the indications of the existing Best Practices from WP5 and documents produced by it, as well as from JERICO, JERICO-NEXT and other initiatives compiled in OBPS Repository. Building on the collected documentation will be followed by a joint workshop for improving and sharing best practices, QA/QC methods and for sharing sensor maintenance best practices. The action will not collect new observational data, but will provide tools for improving data quality and interoperability. All in collaboration with the WP5 tasks most involved on this issue, particularly 5.2 and 5.4.

3.1.3. Business case activities

The NA-IRS consortium is planning for a strengthened collaboration with the Regional Civil Protection agency (stakeholder), through better harmonisation and sharing of data provided by coastal platforms, with particular reference to extreme events.

The observational systems in the NA-IRS provide biogeochemical data that are relevant to environmental monitoring and in particular contribute to the assessment of MSFD descriptors 1, 3, and 5.

A challenging plan for integration with other National Research Infrastructures, expansion of observational capabilities and overcoming the current gaps has been submitted for NA-IRS, in the framework of the Italian component of JERICO-S3, as a contribution to the Recovery Plan. The plan has been approved and started in November 2022.

3.1.4. Organisation activities

The JERICO-RI Northern Adriatic-IRS was present within other meetings organised by projects operating in the same area, with the intention of enhancing the research infrastructure and promoting collaboration with entities not involved in JERICO-S3.

At the suggestion of the JERICO-S3 Coordination, informal contacts were established with the National Institute of Marine Biology of Slovenia to explore their cooperation in the JERICO network with special emphasis on the Northern Adriatic - IRS (Fig. 2). Following these contacts, a virtual meeting was organised on December 17, 2022, with the participation of the following persons: Laurent Delauney (JERICO-S3 coordination), Branko Čermelj (NIB /SLO), Martin Vodopivec (NIB /SLO), Martin Pfannkuchen (IRB/HR), Carolina Cantoni (CNR/IT), Fabio Brunetti (OGS/IT). During this meeting, the coordinator presented the JERICO-S3 project and the benefits of collaboration. An extensive discussion followed, at the end of which the Slovenians expressed great interest and reserved the right to present the potential of cooperation to their colleagues. In view of this expressed interest, the coordination officially invited the Slovenians to participate in the next JERICO General Assembly, which will be held in Rovinj in April 2023.

Figure 2. Virtual meeting on Dec. 17, 2022 to explore collaboration with NA-IRS. Participants: Laurent Delauney (JERICO-S3 coordination), Branko Čermelj (NIB /SLO), Martin Vodopivec (NIB /SLO), Martin Pfannkuchen (IRB/HR), Carolina Cantoni (CNR/IT), Fabio Brunetti (OGS/IT).

3.2. Iberian Atlantic Margin (IAM)

Partners: Instituto Hidrográfico (IH), Portugal; Puertos del Estado (PdE), Spain; The Oceanic Platform of the Canary Islands (PLOCAN), Spain

3.2.1. Regional integration activities

At regional level:

The Iberian Atlantic Margin (IAM) Pilot Study is being developed as a joint contribution to WP7 and WP3 and is allowing a significant interaction between the three partners involved in this IRS. The IAM Pilot Study is bringing together observations collected by IH, PdE and PLOCAN using HF radars, coastal tide gauge stations, gliders, multiparametric buoys and wave buoys. The study focuses on specific time periods that were identified as particularly suitable to demonstrate the added value of a research infrastructure covering a large regional area and operated by multiple partners from different countries that can boost scientific knowledge in the JERICO-RI key scientific questions. The IAM Pilot Study is addressing two main scientific topics, one focussing on Transboundary Processes and Connectivity (which uses datasets collected from January to May 2020) and the second one focussing Extreme Events (which used data collected during two main storm events, in February 2018 and in October 2018). The interest in this Pilot Study motivated, by the end of 2021, the interaction with Blue Cloud and the inclusion of the Pilot Study as part of the JERICO-RI Virtual Lab available in Blue Cloud. During the first semester of 2020 it also led to the preparation of a demonstration action that integrates the Blue Cloud 2026 project recently approved under Horizon Europe.

At national level:

Portugal: A manifestation of interest for inclusion of an expanded MONIZEE infrastructure in the National Roadmap of RIs was submitted by IH in January 2022 to the call launched by the Portuguese Science and Technology Foundation. The MONIZEE infrastructure is presently

operated by IH and contributes to JERICO-RI (and to the IAM IRS) . The manifestation of interest submitted in January 2022 gathered 12 institutions from the Portuguese Mainland and the Azores and Madeira Archipelagos and proposed an extended MONIZEE infrastructure with monitoring capacities and activities developed in the complete Portuguese coastal ocean area (including the insular shelves of Azores and Madeira) and covering the areas of Physical Oceanography, Marine Biology, Marine Chemistry, Marine Geology and Technological Development. A specific articulation with EMSO-PT was proposed as part of this extended MONIZEE infrastructure.

Spain: Collaboration and data exchange between Puertos del Estado and the National Geographic Institute (sea level and GNSS data, for tsunami warning and datum definitions) and the Hydrographic Institute for tidal prediction and definition of a new unique altimetric reference along the Spanish coast. We have MoUs signed with both institutions.

3.2.2. Interoperability/harmonisation activities

- The IAM Pilot Study, as previously stated, is providing a framework to discuss interoperability/harmonisation between IH, PdE and PLOCAN
- A visit of two researchers from IH to PdE was initially planned to be held by the end of September 2022 or in October 2022. This visit aimed to discuss the quality control procedures of tide gauge data that are being used by each one of these two institutions. IH is presently finishing the implementation of a new QC procedure and this visit will be used to discuss this new procedure with the colleagues of PdE. Until the end of 2022 it was not possible, however, to conduct this visit which is now being rescheduled to the first semester of 2023 (precise dates to be discussed with our colleagues from PdE)
- Know-how is being transferred from PLOCAN to IH in the operation of gliders. This work is being developed as part of a cooperation agreement existent between the two institutions. In 2020 and 2021 this work profited from the TNA project GINCAN that IH submitted to the EU Marine Robots project. This framework established the first interactions between the two teams in areas such as glider deployments/recovery, glider preparation for new missions, glider sensor calibration and processing of glider data. This collaborative work is now being extended in 2022/2023 as part of the TNA project CBONDEX submitted by IH and approved as part of the 2nd JERICO-S3 TNA call.
- Further developments can potentially occur as part of possible joint participation of partners in meetings to be held during 2023.

3.2.3. Business case activities

At regional level: No new developments to be mentioned
At national level:
Portugal: the MONIZEE infrastructure is presently contributing to the Portuguese implementation of the MSFD and is also referenced in the National Strategy for the Sea; the infrastructures is also being used in operational support provided to port authorities and maritime authorities and as basic data support for governmental agencies; the process initiated in January 2022 with the submission of a manifestation of interest for inclusion of MONIZEE infrastructure in the National Roadmap, if successful, will open a new funding mechanism with a longer timeframe.

3.2.4. Organisation activities (agreements between partners, MoUs, how to navigate the national funding/RI landscape)

At regional level: No new developments to be mentioned, the three partners are collaborating with existent MoUs or collaborations agreements indicated in Roadmap Table (D3.1).

At national level:
Portugal:The process initiated in January 2022 for inclusion of MONIZEE in the National Roadmap, if successful, will lead to the establishment of a consortium of the 12 Portuguese institutions involved in observation of the Portuguese coastal ocean and insular shelves.
Spain: MoUs signed between Puertos del Estado and the National Geographic Institute and the Hydrographic Institute.

3.3. Bay of Biscay (BoB)

Partners: Ciencia y tecnología marina y alimentaria (AZTI), Spain; Centre national de la recherche scientifique (CNRS), France; French Research Institute for Exploitation of the Sea (IFREMER), France

3.3.1. Regional integration activities

3.3.1.1. Regional integration

In terms of Regional Integration, one of the main needs for the Bay of Biscay IRS (BoB-IRS) was that of identifying all the coastal observation infrastructures not yet involved in JERICO-S3 that potentially would improve the regional observational strategy. To this end, in December 2021, the IRS team organised a meeting with the main actors in the Bay of Biscay (external to JERICO-S3) to work collaboratively in the RI mapping for this region (Fig. 3).

A first objective of the workshop consisted of completing an inventory of present Coastal Ocean Observational efforts achieved in the Coastal Bay of Biscay. A template was shared among potential identified attendants before the meeting. The collected information was synthesised and presented as an introduction to the workshop. This workshop constituted a first key step for the implementation of a coordinated observation scheme in the Bay of Biscay (including our own organisations) in a future dedicated pan-European infrastructure.

Figure 3. Images of the IRS Bay of Biscay workshop held In Irun (Spain) on the 30 Nov 2021 - 1 Dec 2021.

The targeted audience for this workshop were the representatives of organisations identified as major contributors to the observation of the coastal component of the Bay of Biscay. We gathered at least one representative of the following institutions: Bordeaux University, OFB – PNMSA, MNHN, IEO – Centro oceanográfico de Gijón, U Bordeaux OASU, BIMEP, Centre Rivages Pro Tech of SUEZ, PIE UPU /EHU; while the representation of ILICO French infrastructure ensured by G. Charria and that of IBIROOS and KOSTARISK (Cross-Border Laboratory for Coastal Risks Research) by J. Mader.

The workshop was organised in three main sessions. Session I focused on the Synthesis of observational networks & monitoring strategies. Session II provided examples of projects and initiatives for data and networks integration. Session III showcased examples on transboundary initiatives. All sessions consisted in a combination of presentations and discussion sessions, including one session of collaborative work for identifying interests, main problematics, observational, integration and transborder collaboration needs on observations and research related to three proposed domains (Fisheries, Extreme events and Ocean transport and Health). This exercise was a first attempt to work towards one of the objectives of enhanced harmonisation/integration and will be presented in section 3.3.2.

The main conclusions derived from the workshop are summarised in the following. Additional information related to the workshop is presented in Annex 1 (section 5.1).

Main conclusions from the inventory:

- We computed 108 entries to the inventory from French institutions, and 47 for Spanish institutions, with a total of 155 entries. However, there is still important contributions lacking from key actors (e.g., IEO in Spain and SHOM in France), and several Ifremer networks: RECOPESCA, ROME, ECOSCOPA, REMI, Pelagic cruises (PELGAS, EVHOE) and also on the specific issue of genomics data.

- We identified the need to complete the view on who are the users of the data.
- In terms of variables observed, the inventory showed that the observations on Physics are the most common, followed by BGC variables. Only one fourth of the observational efforts are devoted to biology and geology. The interpretation of these results is complex, since it is dependent on how well the contribution of institutions/networks more dedicated to these thematics are represented in the inventory.

3.3.1.2. Connection with adjacent systems

In terms of connection with adjacent systems and communities out of JERICO-S3, we considered the following aspects especially relevant for the BoB-IRS:

- *Increase the connection with adjacent systems (land-sea, open ocean, atmosphere)*. It is worth highlighting the interest of connection with providers of data from continental inputs, since these can be important forcing variables, essential to understand what is happening in the coastal domain.
- *Integrate with existing observing communities (ERICs and others)*. Following with the previous point, the need of connecting with river data providers is identified, and the lack of presence of DANUBIUS-RI in the Bay of Biscay. Other potential interactions with RIs or communities to be developed where identified, like ICOS, Euro-Argo, EMSO.
- Integrate with modelling and satellite observation infrastructures. For modelling a key channel can be EuroGOOS – IBIROOS, to be approached coordination with IRS Iberian Margin and PSS English Channel. For satellites: Copernicus Marine Services, CNES and ESA, were identified as key infrastructures.

As future action in the short mid-term, we identified the need to establish communication with the identified communities and enhance the link with JERICO-S3 WP2 activities. The BoB-IRS actively participated in the IBIROOS annual meeting in 2022. It is worth mentioning that several of the BoB-IRS partners are active actors in IBIROOS and EuroGOOS initiatives (HF radar Task team, Coastal Working group).

In terms of connection with adjacent systems and communities within JERICO-S3, we considered the following aspects especially relevant for the IRS Bay of Biscay:

- Exchange on main science topics and availability of observations in neighbouring areas with adjacent regions: IRS - Atlantic Margin and PSS - English Channel (Both leads were invited to the WS but could not attend).

- The possible collaboration during 2023 in the development of a trans-region activity on slope current monitoring led by IRS - Atlantic Margin has been identified.

3.3.1.3. Interoperability/harmonisation activities (interoperability of systems, observations, data; harmonisation of platform/sensor best practices via WP5)

This section has been built from the outputs of the BoB-IRS workshop (see Section 3.1.1.1). During the workshop a collaborative session using the google online tool "Jamboard" was held for the identification of main problems, observational, integration and transborder collaboration needs related to three proposed specific domains of activity/research: Fisheries, Extreme

events and Ocean transport and Health. This exercise was a first attempt to work towards enhanced harmonisation/integration of Scientific Objectives, observation infrastructures and data flows, and should be extended in the future to other thematics. Tables 1,2 and 3 summarise the outputs for the three thematic.

In a final discussion session, other relevant thematics for the BoB-IRS were identified:

- Contaminants (observation, fluxes)
- MSFD 11 descriptors (not all monitored today but will need to be in the future)
- Marine litter (floating and beached, quantities and characteristics, macro and microplastics)
- Biological connectivity

Future actions require further analyses to plan harmonisation activities in these other thematics. The list of thematics should be left open and updated regularly.

Table 1. Problematics and needs for the enhanced integration/ harmonisation of science and observations in the field of Fisheries

Main problematics
· Use of Space/Marine Spatial Planning · Recruitment and distribution of resources · Lack of tools for fishing effort optimisation · Spatial and temporal scales for integrated analysis of multivariable data are difficult to find – how to connect studies/data obtained at different scales for integration of information · Data access is an issue (few data or data not available, also the difficulty of sampling fishing grounds due to the interaction with Fishing activity)
Main observational needs
· A truly multidisciplinary multiscale approach · Promote collaboration with "Fishing for Data" initiatives · Technological Development for long lasting low cost monitoring *in-situ* systems to increase data availability · Adaptative observational strategy – with continuous monitoring of environmental conditions (multidisciplinary) to solve both spatial and temporal variability in species abundance/distribution in connection with environment
Integration and transborder collaboration needs
· Enhance collaboration on ecosystem surveys in France and Spain, coordinating methods, variables, spatial and temporal sampling schemes)

Table 2. Problematics and needs for the enhanced integration/ harmonisation of science and observations in the field of Extreme events

Main problematics
· Observing short term events and effects in the ecosystem · Differential effects of atmospheric vs. marine heat waves and their synchronicity · Shoreline evolution and flooding events
Main observational needs
· Long term data series, continuous measurement of key parameters and data before, during and after the events · Adaptive sampling to appropriate solve impacts and driving factors · Technological development for improved sampling
Integration and transborder collaboration needs
· Basin scale approach · Expertise sharing, methods, tools · Multidisciplinary for integration of different compartments in the events characterization and their impacts: hydrodynamics and morphological information, human activity, BCG processes

Table 3. Problematics and needs for the enhanced integration/ harmonisation of science and observations in the field of Ocean transport and Health

Main problematics
· Quantification of fluxes and connectivity (Nutrients and environmental contaminants, fate of continental inputs, ecosystem connectivity) · Improving methods for near shore/shelf waters quality assessment in response to the MFSD · Developing scale and continuum approach in boundaries (unravelling the impact of natural vs anthropogenic disturbances on the Ecological Quality status, better knowledge of ocean transport at right scales, need to improve modelling and observations at the limit between coastal and littoral band and between land and littoral)
Main observational needs
· Stronger integration of existing information · More comprehensive multiplatform/multiparametric monitoring programs for some components like nutrients, human activity, rivers inputs, automatic monitoring of marine litter. · Better sampling of hydrography and currents at the shelf and 3D monitoring of transport processes at the right scales and subsurface layers for relate with ecosystem health variables · Updating monitoring programs according to technical innovation technical innovation · Improving modelling capacities (optimise observations to improve model capacities)
Integration and transborder collaboration needs
· Basin scale and approach to coastal transport related to different issues, like connectivity between ecosystems and especially for highly dynamic components (cetacean, seabirds) · Multidisciplinary approach for ecosystem health · Cross-calibration of temporal series, indices /indicators

3.3.2. Business case activities

A first objective related with the Business case of the BoB-IRS consists in characterising the differences in the national structuration and governance of the efforts on coastal observations in the two cross-border countries.

On the Spanish side, the following aspects should be taken into account:

- The main actors performing coastal observations have a strong connection with societal demands, managed both at National and Regional level. This can allow high impacts of the observing initiatives within a coordinated research infrastructure. But sustainability could also suffer from changes in societal priorities driven by political responsibles.
- The mechanism to consolidate the financial sustainability of the infrastructures should involve a high diversity of stakeholders (at national and regional levels at least).
- No national research infrastructure is present in the Bay of Biscay, nor in the western margin of the Iberian peninsula.
- No consolidated coordinated structure involves all the coastal infrastructures. However, the recent national coordination initiative, Spanish Committee for Ocean Observations (CEOO, Comité Español de Observación Oceánica), can highly take advantage from a pan-European coordination at regional level like the ones tackled in the Bay of Biscay or Western Mediterranean in JERICO-S3.

Conversely, on the French side:

- At the national level, the current members of the JERICO consortium are the institutions involved in the ILICO national Research Infrastructure, which is co-led by IFREMER and CNRS-INSU but also includes a large number of Universities. As for the Bay of Biscay, this currently implies the University of Bordeaux and the University of Western Brittany.
- ILICO is composed of several national observation networks, which are each dedicated to a specific scientific field (e.g., biogeochemistry, hydro-sedimentology, planktonology…). These networks conduct long-term observations in relation with academic challenges (e.g., the assessment of long-term effects of global change). A key challenge for ILICO in the near future is to achieve a transition between such a "vertical" approach and the integrated one adopted by the JERICO community.
- When considering current French JERICO members, there is a less urgent need in consolidating the financial sustainability of the French contribution to the Bay of Biscay IRS although one can consider that the obtention of a permanent EU status for JERICO would certainly further contribute to this sustainability.

During the last year, the current members of the BoB-IRS have undertaken an approach to identify key regional actors not currently involved in JERICO-S3. A first meeting was held in Irun with potential scientific partners (see above) and a second one is planned with a second WS with users of the data as additional target audience (in collaboration with WP9). Expected outcomes are as follows:

- Enlargement of the number of JERICO-RI scientific partners
- Identification of external (both private and institutional) partners
- Further identification of the most relevant Specific Scientific Challenges/Research Axes for the Bay of Biscay IRS and of their contributions to meet societal demands
- Establishment of a model of interactions between the JERICO consortium and external partners
- Research of a model for ensuring the long-term sustainability of the observations: (i) structuration of Spanish partners; (ii) integration of potential new scientific JERICO partners

Overall, it is believed that these elements will contribute to reduce current discrepancies between the Spanish and the French components of the BoB-IRS, which certainly constitutes a key point in: (i) optimising the joint tackling of identified key scientific challenges, (ii) enhancing their positive impacts on key societal challenges, and (iii) ensuring the long-term sustainability of the whole system.

3.3.3. Organisation activities

As mentioned in 1.3.2, the logic behind the general organisations (and consequently the funding schemes) are quite different in the Spanish and French components of the Bay of Biscay IRS. When restricting to current JERICO partners, the contributions of French partners to the IRS mostly correspond to the regional components of National Observation Services. The organisation is therefore quite centralised so that the French partners of the BoB-IRS do not hold the authority to engage in Memorandum of Understanding (MoUs) or to define a positioning within the French National funding landscape. Despite the above-mentioned differences, this also largely holds for the current Spanish partners of the IRS. As for the potential enlargement of the partnership, this difficulty is superimposed on the necessities of: (i) ensuring the long-term sustainability of observations newly incorporated in the IRS, and (ii) defining the modalities of the interactions with external observation providers. At that stage, we believe that all these points would highly benefit from a definition of a common target for the organisation scheme of the future JERICO-RI regional components.

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

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 Geesthacht (HZG, now Hereon), Germany; Helmholtz Centre for Polar and Marine Research, the Alfred Wegener Institute (AWI), Germany

3.4.1. Regional integration activities

The acronym KASKEN is used for the area: **KA**ttegat- **SK**agerrak-**E**astern-**N**orth Sea. The Eastern North Sea influences the rest of the KASKEN-IRS area directly through the Jutland current and is influenced by water coming from the Skagerrak from the Baltic current through the Norwegian coastal current. The KASKEN-IRS is also influenced by outflow from the Baltic Sea.

Specific regional scientific topics and objectives of the KASKEN-IRS are drivers of the regional integration activities. They include:

- Investigate the impact of eutrophication and land-sea interactions on marine ecosystem services, biodiversity, and eutrophication.
- Assess the advection of harmful algae, oil, litter and microplastics
- Advance the monitoring of the biogeography and biodiversity of phyto- and zooplankton and develop early detection and warnings of Harmful Algal Blooms
- Improve the understanding on the climate change and climate variability effects on carbonate system and spatial-temporal dynamics of phytoplankton and higher trophic levels
- Evaluate the dispersal and ecosystem effects of contaminants

- Phytoplankton diversity and abundance - Implementing automated imaging in flow systems in stationary ocean observatories and in FerryBox systems on research and merchant vessels
- Further developing combinations of autonomous observations with modelling and remote sensing
- Higher trophic dynamics: Implementing in-situ imaging and automated object analysis systems in stationary ocean observatories (e.g., Underwater observatory North Sea, HZG/AWI)
- Harmonisation between different underway carbonate measuring sensors, especially pCO_2 sensors (in collaboration with North Sea PSS)
- Harmonisation and developing data transfer to the Surface Ocean Carbon Atlas (SOCAT) data base
- Observations at the Baltic Sea-North Sea transition zone

The KASKEN-IRS (SMHI, NIVA, IMR, Hereon, AWI and DMI) has met in virtual and in-person meetings to discuss ongoing and plan future integration activities. The in-person meetings include two workshops on automated plankton observations in Norway and Sweden (October 2021 and August 2022) and a joint IRS/PSS meeting in Geesthacht, Germany (September 2022). Marine monitoring of environmental variables and plankton has been in focus. The observing systems include novel systems on buoys and FerryBox-systems as well as traditional sampling from research vessels. Satellite remote sensing and modelling are other tools used.

3.4.2. Interoperability/harmonisation activities

KASKEN IRS have carried out several activities related to interoperability and harmonisation. This work is presented by category in the following sections:

Plankton

Automated observations of phytoplankton including harmful algae is one focus in KASKEN. Collaboration is ongoing and a workshop is planned for May 2023. A mini workshop was arranged in Solbergstrand, Norway, in October 2021 and a larger international symposium in Fiskebäckskil, Sweden, in August 2022: the GlobalHAB symposium on automated observations of plankton[1] (Fig. 4). There is ongoing collaboration through the European Imaging FlowCytobot (IFCB) user network. SMHI has installed an IFCB on R/V Svea and has carried out sampling in the Skagerrak and the Kattegat. IMR has used the IFCB at Flødevigen Marine Research Station at the Skagerrak coast of Norway and is planning for installing an IFCB at the Coastal observatory Skagerrak - KOS on the island of Torungen. NIVA has been operating an IFCB at the Solbergstrand ocean observatory in the Oslo fjord and used the same instrument during a trial on the FerryBox route Oslo-Kiel where another instrument aimed at investigating plankton, the Cytosense, was operated by RWS (the Netherlands) as part of a transnational activity (TNA). SMHI and NIVA do joint sampling of phytoplankton using the FerryBox on the Oslo-Kiel line and compiled observations and data for a joint presentation at the 10th FerryBox workshop in March 2021. NIVA has developed an automated sampling system for concentrating and preservation of plankton for analysis of eDNA. Sterivex filters are used for concentrating the plankton DNA and a special buffer solution for preservation. DNA

[1] Reported in: Karlson, B., Berdalet, E., Kudela, R.M., 2022. The GlobalHAB mini-symposium on automated plankton observations. Harmful Algae News 71, 1-4.

is extracted in a laboratory on land and sequencing is carried out at sequencing facilities. The aim is to investigate the distribution and diversity of plankton. The KASKEN partners share results on phytoplankton during the yearly Nordic Microalgae meetings.

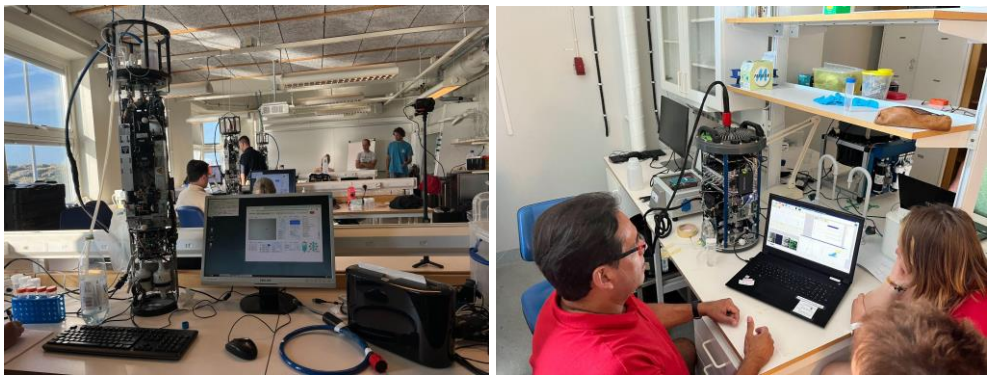

Figure 4. Automated plankton observations, with the IFCB (left) and the CytoSense (right) used during the GlobalHAB symposium in August 2022. The instruments were removed from their waterproof housings during the laboratory work.

During the joint IRS/PSS meeting in Geesthacht, Germany 26-27 September 2022, it was decided that the KASKEN-IRS will arrange a workshop in May 2023, hosted by NIVA in Oslo. The workshop will focus on data harmonization procedures (SOPs) for phytoplankton biomass and carbon (see below), and will include participants from the Norwegian Sea IRS, KASKEN IRS, North Sea PSS and Gulf of Finland PSS. Planning has started by NIVA and invitations will be sent out early 2023 (partners include SMHI, IMR, SYKE, Hereon, more TBD).

Planned themes for the 2023 KASKEN-IRS workshop (Oslo, Norway):

- Phytoplankton biomass

In addition to the work described under the heading "Plankton" above, there is ongoing work on improving chlorophyll estimates based on chlorophyll fluorescence and satellite remote sensing. The effect of non-photochemical quenching on chlorophyll fluorescence is evaluated based on field sampling.

- Carbon system and ocean acidification

Various KASKEN-IRS partners are making pH and pCO_2 observations from FerryBox ships of opportunity (R/V Svea, SMHI; Magnolia Seaways and Lysbris Seaways, Hereon; Color Fantasy, NIVA). This theme will explore instrument calibration and data processing harmonisation.

eDNA - metabarcoding - biodiversity of plankton

SMHI has sampled eDNA for several years during cruises with R/V Svea and R/V Aranda. The resulting data are being worked up. NIVA has developed an automated sampling system for concentrating and preservation of plankton for analysis of eDNA. Sterivex filters are used for concentrating the plankton DNA and a special buffer solution for preservation. DNA is extracted in a laboratory on land and sequencing is carried out at sequencing facilities. The aim is to investigate the distribution and diversity of plankton. Collaboration on standardising methods is ongoing through two projects funded by the Nordic Council of Ministers.

Microplastics

NIVA has developed an automated sampling system for microplastics and evaluated it on the Oslo-Kiel FerryBox route. This monitoring is including in the Norwegian Environment Agency national monitoring of microplastics (MikroNor).

Organic carbon and coastal darkening

Mainly coastal areas are affected by an increase in land runoff of humic substances - termed coastal darkening. Observations of CDOM (Coloured Dissolved Organic Matter) using water sampling and CDOM-analysis in the laboratory as well as automated measurements of CDOM fluorescence is ongoing. A study by NIVA using FerryBox and traditional monitoring stations focusing on organic carbon and coastal darkening has been published (Frigstad et al. 2020[2]) and a new publication acknowledging JERICO-S3 is available (Frigstad et al. 2023[3]).

Carbonate system and carbon fluxes of coastal seas

The long-term dataset (2014-2020) generated by Hereon for the North Sea and KASKEN IRS within the JERICO consortium has been quality controlled and published in the SOCAT database (Macovei et al. 2021[4]). Calculated fluxes for the years 2014-2018 have shown that the KASKEN region is becoming a weaker carbon sink (Macovei et al. 2021), but this has to be verified with further measurements. Recently, a study using recent data from the Magnolia Seaways demonstrated that shorter mesoscale events (on the order of weeks), like the reversal of the general circulation due to wind changes (Macovei et al. 2022[5]), can alter the general air-sea flux trends estimated in Macovei et al. (2021). These works demonstrated that pCO_2 measurements in the KASKEN region can vary significantly within a small area, so the high density of measurements generated from JERICO-S3 partners is necessary to properly estimate carbonate system dynamics in the KASKEN IRS.

Modelling

SMHI has developed a very high-resolution model for part of the Skagerrak coast. Horizontal resolution is 50 m. The model is used e.g., for investigating the dispersion of harmful algae and crab larvae. All KASKEN partners operate ocean models for the area. Models generally have a horizontal resolution of about 1 nm (2 km). The results are used for many different purposes. There is ongoing cooperation through the North West European Shelf Operational Oceanographic System (NOOS).

[2] Frigstad, H., Ø. Kaste, A. Deininger, K. Kvalsund, G. Christensen, R.G.J. Bellerby, K. Sørensen, M. Norli, and A.L. King. 2020. Influence of riverine input on Norwegian coastal system. 2020. Frontiers in Marine Science, doi:10.3389/fmars.2020.00332

[3] Frigstad. H., Andersen, G., Trannum, H.C., McGovern, M., Naustvoll, L.-J., Kaste, Ø., Deininger, A., Hjermann, D.Ø. 2023. Three decades of change in the Skagerrak coastal ecosystem, shaped by eutrophication and coastal darkening. Estuarine, Coastal and Shelf Science, https://doi.org/10.1016/j.ecss.2022.108193

[4] Macovei, V.; Voynova, Y.; Gehrung, M.; Petersen, W.: Ship-of-Opportunity, FerryBox-integrated, membrane-based sensor pCO2, temperature and salinity measurements in the surface North Sea since 2013. In: PANGAEA. 2021. (DOI: /10.1594/PANGAEA.930383)

[5] Macovei, V.; Callies, U.; Calil, P.; Voynova, Y.: Mesoscale Advective and Biological Processes Alter Carbon Uptake Capacity in a Shelf Sea. In: Frontiers in Marine Science. Vol. 9 (2022) 827075. (DOI: /10.3389/fmars.2022.827075)

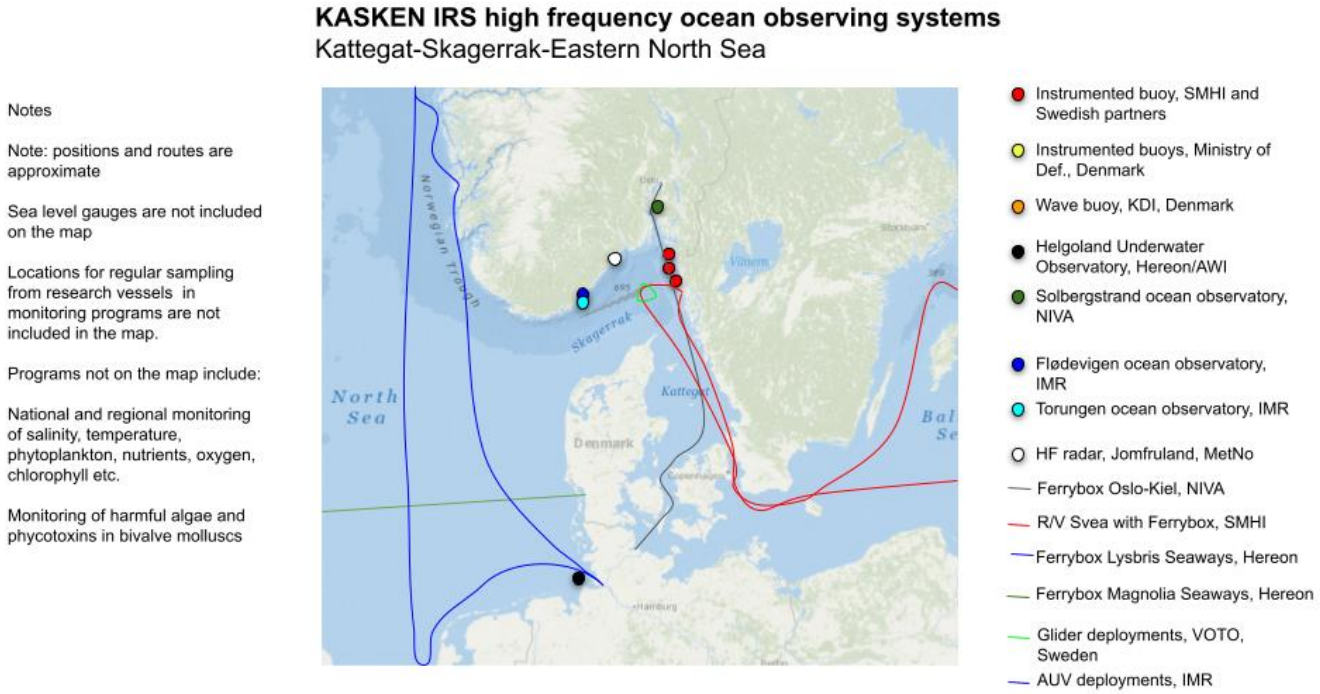

Figure 5. The map indicates the main ocean observation systems in the KASKEN-IRS, see notes to the left of the map for explanations.

An update on the observing platforms in the KASKEN-IRS is provided in Figure 5 and the in the text below:

FerryBox systems

The FerryBox systems are used as sampling platforms for many purposes. Here follows a list of systems in the KASKEN area:

- Color Fantasy, NIVA (Oslo-Kiel)
- R/V Svea, SMHI (Southern and Eastern North Sea, Skagerrak, Kattegat, Öresund, Baltic Proper)
- Tavastland, SMHI (Southern and Eastern North Sea, Skagerrak, Kattegat, Öresund, Baltic Proper and Gulf of Bothnia)
- Lysbris Seaways, Hereon (North Sea, earlier also the Skagerrak)
- Magnolia Seaways, Hereon (North Sea, in 2019 also the Skagerrak)
- SM Connector, RWS and NIVA (installed in March 2022) (Bergen-Odda-Tananger-Immingham-Rotterdam)

Stationary observing systems

The stationary observing systems include buoys and FerryBox systems on land or on islands. Here follows a list of systems in the KASKEN area.

- Väderö buoy, Skagerrak coast, SMHI
- Brofjorden buoy, Skagerrak coast, SMHI
- Koster fjord buoy, Skagerrak coast, SMHI
- Kristineberg Centre, Skagerrak coast, University of Gothenburg

- Solbergstrand ocean observatory, Oslo fjord, NIVA
- Flødevigen ocean observatory, Skagerrak coast, IMR
- Coastal observatory Skagerrak - KOS, Torungen island, IMR
- Helgoland Ocean Observatory, AWI
- COSYNA ocean observatory, Hereon

3.4.3. Business case activities

SMHI arranged a national meeting in May 2022 to discuss needs for marine infrastructure with invited partners such as the Swedish Agency for Marine and Water Management and Research councils. The results of this meeting were discussed during the JERCIO-S3 workshop in Geesthacht, Germany in late September 2022.

In Norway, some parts of the KASKEN observing system are presently funded by the Norwegian Environment Agency on five year cycles. As this is funding coming from a governmental agency, there is no guarantee of renewal. Also in Norway, there are some efforts underway to seek long-term funding for a Norwegian node of JERICO-RI (as described in the Norwegian Sea IRS below) called COASTWATCH.

There are ongoing contacts with the aquaculture industry in Norway, Sweden and Denmark. Contacts with companies operating wind farms in the Kattegat and the Skagerrak are being established.

Some partners in the KASKEN-IRS have, to a smaller degree, institutional support to operate some parts of their coastal observing infrastructure. As institutional funding sources tend to vary depending on the economic well-being of an institute, this funding source is difficult to rely on in the long-term.

3.4.4. Organisation activities

There is ongoing collaboration through UNESCO-IOC Global Ocean Observing System (GOOS). The nations within KASKEN are all part of EuroGOOS. A new activity is the EuroGOOS Biological Observations Working Group (BIOWG) where SMHI, NIVA, Hereon, and DMI participate. There are also discussions about creating and signing multilateral and/or biolateral MoUs. The main aim of MoUs is to create added value for partners. The current situation is:
IMR does not prioritise MoU's, however NIVA and IMR presently have a cooperation agreement that is part of the Norwegian NorSOOP project. A draft MoU has been written between NIVA and Hereon. And an MoU is presently being discussed between SMHI and NIVA.

3.5. Norwegian Sea (NS)

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

3.5.1. Regional integration activities

Norway is developing an integrated coastal service strategy including a wider range of partners in order to fulfil the needs of larger scale activities such as Copernicus and others. An extended group of actors is working on a holistic approach to face the challenges of developing coastal products. This is still ongoing mainly on a national level and the challenge is further the intensive collaboration and the right approach to integrate internationally over the institutes involved in the IRS, because of a lack of common interests in coastal applications. Nevertheless, exchange of experiences is ongoing in the different working groups such as the biological working group of EuroGOOS. Norway is following the so-called COASTWATCH (the Norwegian coastal observing system of systems) approach combining in-situ observations, remote sensing and integration in models for improving system understanding. This approach is already established on the national research infrastructure roadmap and serves as a future Norwegian contribution to JERICO-RI. COASTWATCH has been submitted for funding by the Research Council of Norway (including Norwegian Sea partners IMR, NIVA, and NORCE) in October 2018 and most recently in October 2020. This is described further in the "Business case" section below.

National importance: Norway has great ambitions for the further development of the ocean industries with the goal of the greatest possible overall value creation within a sustainable framework. Coastal waters with adjacent fjords are the most dynamic and productive of all sea areas and sources of renewable and harvestable resources, including considerable diversity in marine industries including aquaculture, fisheries/harvesting, petroleum activities, tourism, transport and leisure. At the same time, there is a political desire for blue growth through increased marine value creation, more safe and healthy seafood for an increasing population and more jobs. This will require more knowledge support for management and value creation that ensures sustainable use of coastal resources. However, a lack of knowledge about coastal ecology and the effects of the various influencing factors is a bottleneck for achieving sustainable growth. COASTWATCH will ensure the integration of existing coastal observation infrastructure with complementary platforms and sensors for the design of socially beneficial operational services and research of high quality and importance.

In terms of cooperation with other research infrastructures, NIVA has begun work with ICOS Norway and ICOS-ERIC to establish a new coastal station of pCO_2 observations along coastal Norway on the same JERICO-RI coastal observing FerryBox platform that operates between Bergen, Norway and Kirkenes, Norway. In this context, NIVA has begun to work closely with the ICOS Ocean Thematic Centre on operation, calibration, and data processing/quality control of surface ocean pCO_2. This also involved participation in a data processing workshop in Paris from 7-9 December 2022 at Sorbonne University. With regards to pCO_2 and carbonate system chemistry, in general, NIVA has also been collaborating with the Cretan Sea PSS on carbonate system observations and carried out an instrument intercomparison experiment across a range of total alkalinity observed in the Aegean Sea region (held at HCMR from 23 May - 10 June 2022). There have also been some discussions with participants in the North Sea-PSS and KASKEN-IRS on carbonate system observations and a workshop is planned that will primarily involve KASKEN-IRS participants, but also some participation from the NS-IRS.

3.5.2. Interoperability/harmonisation activities

In collaboration with the International Oceanographic Data and Information Exchange (IODE) and Institute of Electrical and Electronics Engineers (IEEE), progress was made in the extraction of metrics coming from multiple sources to monitor:
(1) the status of metadata quality content in the Ocean Best Practices System (OBPS) Repository, (2) the access and downloads of documents in the OBPS Repository, and the different ways of (3) community engagement with OBPS. At the same time a web-based Dashboard where those metrics will be grouped and displayed by different KPIs related to OBPS performance is being designed and developed.

In addition, the Norwegian Sea IRS is also collaborating with Balearic Islands Coastal Observing and Forecasting System (SOCIB), IODE and IEEE in the design and development of a proof of concept of a decision tree model to allow users to select, locate and access the appropriate method and/or best practice related to any data lifecycle step involved with any JERICO platform. This decision tree is using both the Best Practices Gap Analysis (JERICO-S3 D6.6) and the Handbook (JERICO-S3 D6.3) as a base for its design. The proof of concept of the decision tree will be deployed in the JERICO CORE and will make use of the CORE API in order to link all those methods and best practices listed in the decision tree with the actual documents that are currently stored in OBPS.

Further integration activities have also been carried out by the NS-IRS. These include cooperation and common participation of IMR, NIVA, and FAMRI in workshops related to biological imaging technologies, and work related to the use and classifier software of the IFCB instrument. NIVA and FAMRI have begun the operation and utilisation of a FerryBox observing system on MS Norrona that operates between Denmark, Faroe Islands, and Iceland. The FerryBox will measure a suite of Essential Ocean Variables as well as collect samples via a refrigerated autosampler for eDNA.

3.5.3. Business case activities

Norway: the COASTWATCH approach develops the holistic coastal approach aiming for an overarching coastal service that is managed to be included in the national Roadmap for infrastructure by the Research Council of Norway. Unfortunately, the proposals sent for funding by the Research Council were not successful. Nevertheless, an extended partnership of dedicated institutes is starting to improve the infrastructure such as HF Radars established by the Norwegian Meteorological institute. Another example is the improvement of the Ships of Opportunity activity mainly driven by the NIVA through the Norwegian Ships of Opportunity Program (NorSOOP) and improving the discrete sampling observations and connecting towards the national monitoring activities mainly driven by the IMR.

3.5.4. Organisation activities

MoUs are established between the main driving operational oceanography institutes in Norway. Preparations are ongoing to include coastal services inside this MoU and extending the partnership. IMR and NIVA are both signatories of a consortium agreement for NorSOOP - the FerryBox based research infrastructure mentioned in the previous section. IMR and NORCE are also working on joint projects together, but no formal cooperation has been noted. NIVA and HAV have signed an MoU for future cooperation. ArcticROOS has formulated a new MoU which is now under the signature process, and Norwegian Sea IRS partners IMR and

NIVA will sign. Apart from this, the establishment of international MoUs is intended but has not progressed until now.

3.6. Integration activities between IRSs and PSSs

Various integration activities have been reported within each IRS section (1.1-1.5). While integration is necessary at the regional level to make progress on "local" issues, scientific challenges, and bringing national research infrastructures (and ministry-backed support), a wider scope of integration is vital for JERICO-S3 to progress on coastal ecosystem challenges at the pan-European level. For example, major climate change impacts such as ocean warming and ocean acidification will not be isolated to one region or another, but will be observed across Europe (and the world) and will impact coastal ecosystems. Integration activities involving IRS+IRS and IRS+PSS, past and future, are listed below:

- Annual JERICO-week meetings have all included "All-Region Workshop" sessions where activities from IRSs and PSSs were presented; 2020 (San Sebastian, Spain), 2021 (virtual - COVID-19), 2022 (Lisbon, Portugal), 2023 (Rovinj, Croatia)
- NA-IRS and Gulf of Finland-PSS (GoF-PSS) have a dissolved oxygen harmonisation activity planned for 2023
- BoB-IRS, IAM-IRS, and English Channel-PSS have a planned workshop to discuss main science topics and availability of observations in 2023
- KASKEN-IRS, NS-IRS, North Sea-PSS, and English Channel-PSS held a joint workshop focused on biological and carbonate system observations (Geesthacht, Germany, 2022)
- The 11th FerryBox workshop, co-sponsored by JERICO-S3, included many participants from all five IRSs (Geesthacht, Germany, 2022)
- IAM-IRS participated in WP6 activities on assessing FAIR data compliance together with GoF-PSS, Cretan Sea-PSS (CS-PSS) and North Sea/English Channel-PSS
- Participants from all IRSs contributed WP5 harmonisation-related deliverables on a Technical handbook for mature observing platforms and multiplatform near real-time biogeochemical observations (2022).
- KASKEN-IRS and NS-IRS participants met to discuss automated phytoplankton observations (2021, 2022)
- KASKEN-IRS, NS-IRS, North Sea-PSS, and GoF-PSS are planning a data harmonisation workshop on phytoplankton and carbon in 2023
- NS-IRS, CS-PSS, and GoF-PSS participated in an experiment at HCMR Crete focused on carbonate chemistry and phytoplankton photophysiology (2022)

4. CONCLUSIONS

Integrated regional sites within JERICO-S3 represent coastal observing partnerships focused on a subset of pan-European coastal seas. This was practical in that neighbouring countries could integrate efforts (reduce duplication), harmonise observation/data handling techniques, and coordinate interaction with users and potential funding sources. The Main Report section of this Deliverable follows up on the status quo of each IRS provided in D3.1 and summarises activities that the IRSs have carried out in the first part of the project. These activities have been categorised based on the roadmap plans developed for each region. Further, the last section of the Main Report includes integration activities between IRSs as well as between IRSs and PSSs - both within the last two years, as well as planned for 2023 thus far. The

JERICO-S3 project design relies on development of integration activities *within* IRSs and *between* IRSs/PSSs in order to address pan-European scientific challenges in the years and decades to come.

In general, IRSs have been carrying out activities related to integration, harmonisation, business case development, and coordination with slight differences in approach and focus. For example, NA-IRS and BoB-IRS have focused efforts towards consolidating coastal observing efforts in their regions including non-JERICO-S3 observations. While IAM-IRS and KASKEN-IRS have focused efforts on topic-based harmonisation and development (e.g., multiplatform observations, carbonate chemistry, etc.). Many IRSs have linked up to existing European environmental RIs including DANUBIUS, ICOS-ERIC, and others. The development of the business cases for the IRSs, however, remain a challenge - national funding and/or plans for funding were mentioned in all IRSs, but regional or multinational funding mechanisms/agreements are not in place and some difficulties lie ahead in terms of coordinating funding from different national ministries and other sources. Finally, the formal organisation of IRSs has also posed challenges (somewhat linked to the business case challenges), and bilateral MoUs represent the extent to which organisations have been formalised.

Further elaboration on how each IRS should be organised and operated is required. In some ways, this is strongly dependent on how business cases develop in each IRS. For example, if common funding was secured by IRS partners to form an integrated coastal observatory, would the following efforts *de facto* result in a formalised organisation? As written in the BoB-IRS section of the Main Report, a focus on "...a definition of a common target for the organisation scheme of the future JERICO-RI regional components" is likely to be instrumental in the development of IRSs during the remainder of the JERICO-S3 project and subsequent efforts.

5. ANNEXES AND REFERENCES

Annex 5.1. Bay of Biscay Workshop report

One of the main outcomes of the workshop was to complete a first map of actors/metadata of observations. The collected info by institutions is provided in Figure A1. The expertise and areas of activity of the people registered to the event are shown in Figure A2. The map of available observations and the number of observations by variable are shown in Figures A3 and A4.

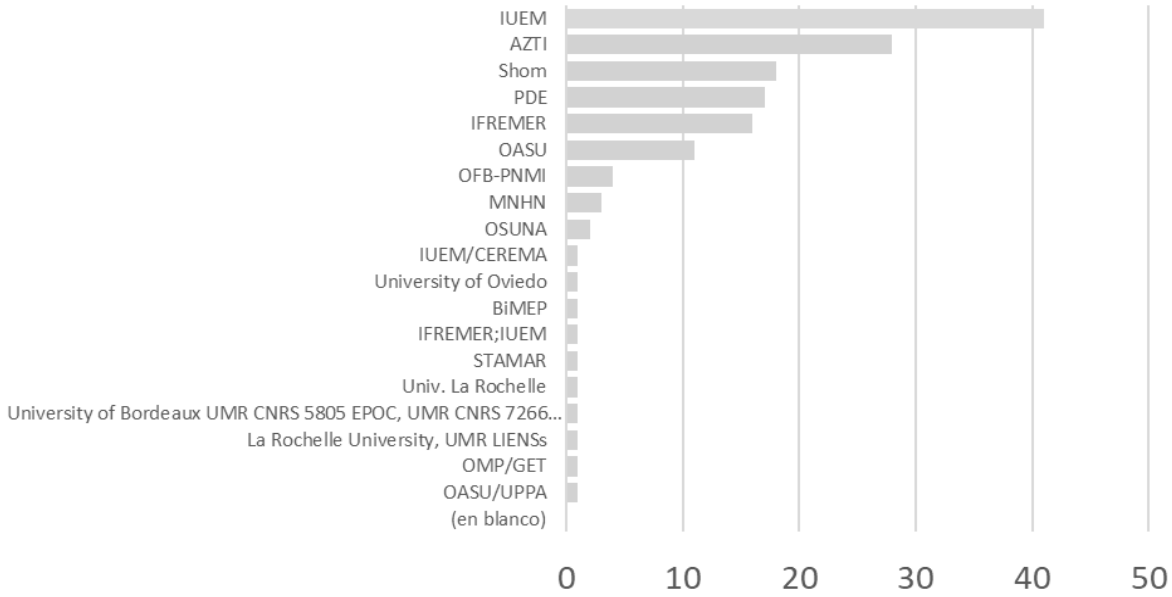

Figure A1. Collected info by Institutions on existing observational infrastructures in the Bay of Biscay.

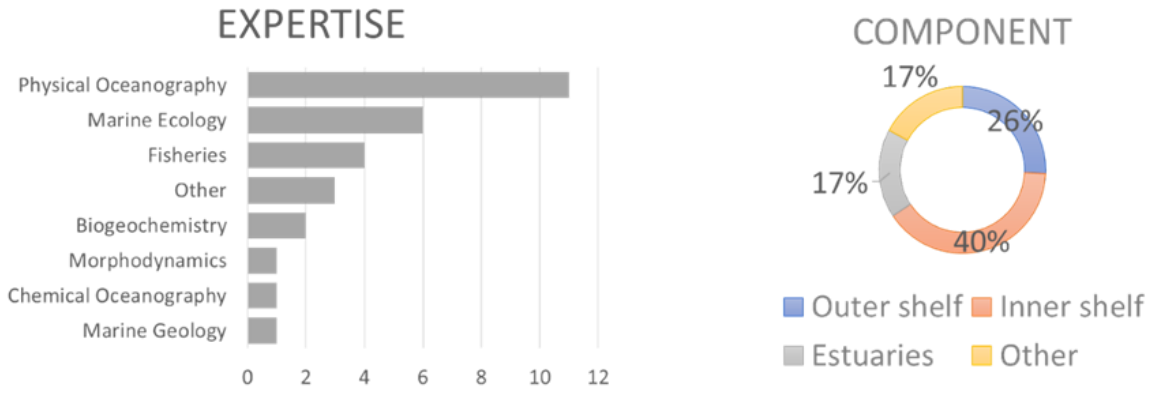

Figure A2. Expertise and area of activity of registered people.

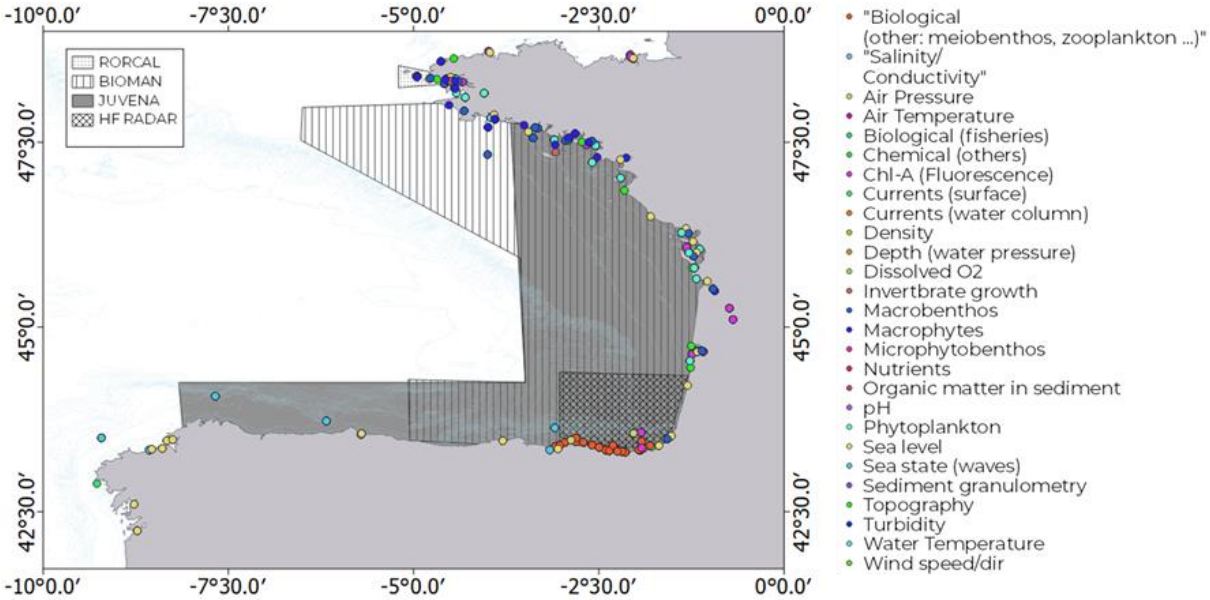

Figure A3. Map of the inventory of observations per variable.

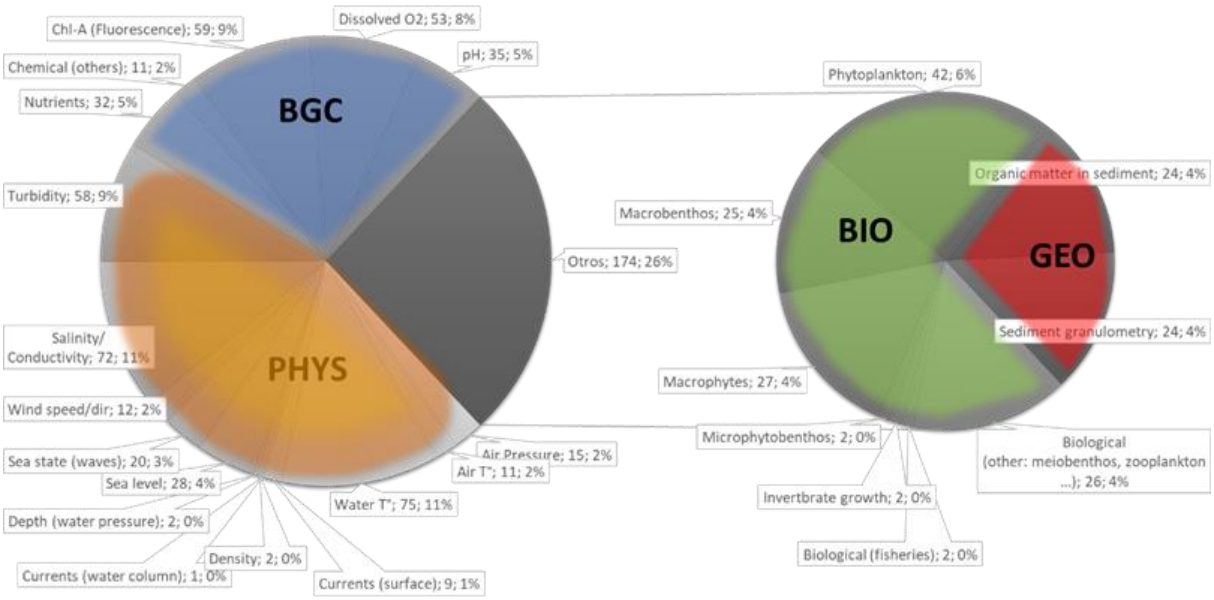

Figure A4. Number of observations per variable, and variable group.