# JERICO-S3 DELIVERABLE

Joint European Research Infrastructure for Coastal Observatories

**Science, Services, Sustainability**

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# 1. EXECUTIVE SUMMARY

During the JERICO-S3 project, the implementation of integrated observation has focused on the coordination and harmonisation of coastal observatories across various European coastal regions, encompassing different aspects, from regional collaboration and technological innovation to the development of scientific data products and experimentation. The present deliverable summarises and analyses the technical recommendations for such integration based on the real-world experiences coming from the Pilot Super Site (PSS)/Integrated Regional Site (IRS) organisational model that was adopted and enacted for this purpose during the project.

# 2. INTRODUCTION

JERICO-S3 aims to establish a sustainable, pan-European integrated research infrastructure dedicated to observing coastal marine systems. Currently, European-scale environmental observing initiatives mainly focus on open ocean and continental systems, overlooking the highly vulnerable and socio-economically critical coastal zones. The JERICO infrastructure's primary goal is to facilitate a comprehensive understanding of how coastal marine systems respond to natural and human-induced factors, and to address the vital need for coordinated coastal marine observations.

The proposed objective of WP5 of JERICO-S3 was to progress towards the highest "readiness level" of harmonisation of the JERICO Research Infrastructure (RI) by implementing coordinated and interactive best practices across multiple platforms and disciplines among regional operators. In JERICO-S3, a regional approach for integrated observations has been demonstrated through the establishment of Integrated Regional Sites (IRS') and Pilot Super Sites (PSS') across Europe. One aim of this kind of large-scale geographical "clustering" was to integrate major observatories, harmonise data value chains and best practices, and improve exploitation and joint management of multiplatform data to show that regional-scale integration was indeed possible if actively desired and pursued.

This deliverable, D5.7, encapsulates the main messages and some important technical recommendations which emerged from the IRS/PSS experiences in JERICO-S3.

# 3. MAIN REPORT

## *3.1. The objectives of the PSS and IRS*

JERICO-S3 set up Integrated Regional Sites (IRS, WP3) and Pilot Super Sites (PSS, WP4) to demonstrate the capacity of the JERICO RI to realise a multiplatform approach to help answer key challenges concerning Europe's coastal seas while also aligning with the project's overall scientific strategy (WP1) as seamlessly as possible. These "sites" have proved very useful to understand the needs and requirements for integrating, harmonising, and operating coastal observatories efficiently at the national and transnational levels. Eventually, the knowledge gained can be put to good use in actualizing a pan-European vision aimed at monitoring and comprehending Europe's coastal waters and environments. In fact, the IRS/PSS operating model has shown great promise in actively encouraging the standardisation of data collection methods, the tailoring of the use of innovative technologies to regional demands, and the fostering of collaboration among diverse stakeholders, including researchers and policymakers. Additionally, the promotion of transnational and cross-regional integration ensures the expansion of regional activities to broader geographical areas and facilitates the joint identification of observational gaps.

During the project, PSS' provided a number of opportunities to try out different technical integration procedures such as greater operational coordination between major regional observatories, harmonisation of data value chains and best practices and improved exploitation and joint management of multiplatform data (D4.4). Unlike in the case of the PSS', the contributions from the IRS' mainly touched on aspects of data management (D3.3) only.

### *3.1.1. The technical experiences from PSS*

**Integration in technical practices:**
These activities included organising workshops, participating in mesocosm experiments, and exchanging information on practices such as carbonate measurements, data mining, and automated techniques for monitoring phytoplankton diversity. Workshops focused on enhancing data availability for future assessments and evaluating the status of certain best practices, such as river input data collection. Through these exchanges, gaps in practices were identified, leading to the development of joint procedures and the adoption of previously under-utilised practices in certain regions (eg. intercomparison of phytoplankton distribution using fluorometric data). Overall, the efforts facilitated integration and improvement in operational and analytical practices across different marine science communities.

**Integration of data management techniques:**
The integration efforts in data management across PSS, focused on aspects such as harmonisation, quality control (QC) sharing, data flow creation, and publication. Key areas of focus include the carbonate system, river inputs, and phytoplankton data. Efforts related to the carbonate system involved QC sharing, harmonisation, and publication, with some regions creating their first data flows. Collaboration among partners extended to river database identification, comparison, and standardisation, addressing challenges like data gaps and multiple data sources. Integration efforts for phytoplankton data management included improving data availability, harmonising analysis methods, and sharing QC procedures. Specific improvements targeted applications such as ocean colour products calibration and model validation. There is a need for extensive work in quality control, cleaning, and formatting of phytoplankton data, emphasising the abundance of observations in coastal waters beyond what single aggregators like EMODNET provide.

**Integration based on multiplatform and multi-sensors strategy (see D1.3)**
The advantages of using many different platforms is enhancing the ability to cover different space and time scales to understand complex interconnected physical-biogeochemical-biology processes (eg., winter mixing leading to nutrients supply to surface waters which influences the phytoplankton composition and zooplankton grazing and finally impacts the efficiency of organic carbon export). During the PSS experiments, some complex processes have been observed: water mass transport and circulation using HF radars and gliders, $CO_2$ flux using Ferrybox and buoys, Chl*a* bloom using single platforms and satellites. The optimisation of this strategy is discussed in D1.3.
Regarding integration of multiple variables, some PSS' demonstrated their capacity to integrate physical and biogeochemical data to propose improved derived products. For example, the integration of in situ data from gliders with coupled regional models and an artificial neural network approach provided new insight on $CO_2$ air-sea flux in the NW Mediterranean Sea (PSS#4). Multi-platform observations have also been used for better understanding of processes and improved predictions through assimilation techniques (PSS#1).

**Technical integration through RI collaborations:**
All PSS had specific actions on partnership with RIs and regional initiatives. Mesocosms demonstrated the potential of combining controlled experiments based on natural and/or anthropogenic forcings acting in the field (eg., extreme events, $pCO_2$ increase, acidification, …). Smart multi-sensors integration has been used to synchronise and augment the platforms

capacity to collect and provide EOV information (eg. COSTOF). Deployments of Argo floats offer the capacity to get spatial and open sea information on water mass circulation/evolution, nitrate and oxygen content, … . The JERICO-DANUBIUS collaboration was proven to and will be helpful to resolve challenges in harmonisation of river monitoring strategies and data exchange.

**Data and model products**

Data processing and modelling have been well developed and demonstrated in different PSS regions. These have helped to integrate information necessary for the scientific community and EU data aggregators. Combining multi-observation data and neural network predictions contributed to validating model simulations in the NW Mediterranean Sea. A major part of the data management effort involved processing with new numerical methodologies/tools (multi-source and multi-scale) to optimise the processing of high-resolution data sets (eg. buoys, FB), and to fill data gaps and correct some calculations. The processed data were also useful for the calibration/validation of satellite products. Finally, some innovation in technology products concerned sensors and analysis tools especially focused on plankton imagery.

### *3.1.2 Recommandations from IRS*

**Recommendations based on regional data handling and accessibility**

D3.3 focused on data handling and accessibility in the context of the JERICO-S3 data management plan (DMP). It highlighted the importance of these inputs for improving data flows in the later stages of JERICO, particularly for efforts in the move towards ESFRI recognition and other future JERICO-RI endeavours. The analysis suggests the need for further examination of metadata completeness and interoperability. Recommendations include promoting uniformity in data handling and accessibility, especially at the regional level, through coordinated efforts within JERICO-S3. Examples are provided, such as the successful coordination of HF radar data accessibility at the European level, which could be extended to other platforms like FerryBoxes. The text also addresses the challenge of making JERICO-RI data accessible to various stakeholders, including policymakers and industry players, suggesting the need for user-friendly data products. Additionally, all IRS' express a commitment to enhancing data FAIR-ness and integration at regional and trans-regional levels, **emphasising the value of multiplatform data integration**. Finally, the deliverable raises questions about the ideal level of regional data accessibility and proposes common recommendations to guide regional data accessibility and availability efforts across different regions.

## *3.2- Harmonisation in JERICO-S3*

Harmonisation activities will contribute to produce recommendations for integrating new emerging **scientific equipment** or sets of instruments in order to improve the **access to biogeochemical and biological data** (D5.4 Recommendation for Multiplatform implementation of a biogeochemical NRT observatory, D5.6 Best practices document for sampling procedures of biological automatic sensors).

D5.2 of Jerico-S3, whose title is "Technical handbook published within the OBPS Repository of BP for implementing and operating coastal observatories", is a best practices handbook for JERICO's mature platforms management: Mooring, High Frequency (HF) Radar, Ferrybox, Glider. In this context, mature platforms are those that comply with specific criteria from the readiness of requirements, observation elements and data and information products described in [FOO, 2012]. Sensors that can be installed on these platforms are many and can cover many disciplines of ocean observing.

While this document doesn't provide direct recommendation for multiplatform and multisensor integration, it provides fundamental details on a harmonised way to view platform and sensor designs, purposes, deployment procedures, performances, maintenance, Quality Assurance, Quality Control, calibration, data uncertainties, and data management. The analysis of an instrument's advantages, drawbacks, similarities and complementarities that can be subsequently derived represents a useful practical starting point which can significantly facilitate the design of multi-platform and multi-sensor experiments for a more accurate investigation of complex coastal processes.

Moreover, as a further element of harmonisation, D5.2 tries to define and adopt a consistent approach on the challenging task of analysing recommended ocean observing practices (methods), their documentation and the degree to which they are widely and effectively implemented, using a common scale.

For more than ten years, JERICO has been driving the development of optimal practices and meticulously documenting protocols across coastal observation domains. These protocols take many diverse forms, such as standard operating procedures or manuals, each format exhibiting different degrees of recognition and refinement. Occasionally, multiple procedures exist for accomplishing a shared objective, leading to ambiguity in selecting the most suitable approach. On the other hand, creators of practices lack a maturity model that clearly indicates a series of common requirements for a practice to become a best practice. For this objective a new maturity model for methods and their application is presented and discussed. This model is envisioned as a powerful tool that allows both assessment of maturity and further development of (best) practices, in a harmonised way.

**Key Integration Performance Indicators (from D5.3)**

Briefly put, the heart of the JERICO RI (Research Infrastructure) is an interlinked network of functioning coastal observatories incorporating one or more platforms supporting sensors or instruments capturing and making accessible marine environmental data continuously in a more or less regular manner over sustained periods of time. The characteristics of the different observatories, their individual elements and their management practices may (and do) vary, but there is a steady move towards a discrete level of coordinated connectivity and enhanced interoperability favouring more uniform service capabilities, services and products with a distinct JERICO RI "identity". This aspect is particularly conspicuous in the observing and data creation steps where several efforts to try to provide adequate support on issues of data quality and consistency raised by data aggregators and end users are ongoing.

The JERICO-S3 deliverable D.5.3 entitled "Report on the Key Platform Performance Indicators and Key Integration Performance Indicators developed for the JERICO-RI" reported on the development of Key Platform Performance Indicators (KPPIs) and Key Integration Performance Indicators (KIPIs) for assessing the performances of the observing assets of the JERICO-RI, including the level of their integration from the network perspective. As explained in that deliverable, evaluating "performance" implies the prior existence of some kind of system for measuring "performance". Furthermore, it was felt that a similar system should support both an observing asset's operator as well as the JERICO-RI coordination in making informed decisions concerning the development, running, and maintenance of that asset as part of the RI. To this end, an evaluation system composed of two groups of performance indicators was proposed, namely, the KPPIs and KIPIs mentioned in the title of D5.3. The qualities sought in the process of the definition of these indicators were the following:

- simplicity;
- robustness (inferred as the ability to be effective over a wide range of circumstances);
- facility of use;
- operational sustainability.

The main distinction between the KPPIs and the KIPIs is that the former are intended to capture in some way the degree of accomplishment of the tasks set for an asset (platform) by its operator/manager whereas the latter describe the degree to which that asset is integrated in the JERICO "system of systems". The two groups of indicators and their characteristics and proposed metrics are presented in Table 2, below.

**Table 1a.** The JERICO Key Platform Performance Indicators (KPPIs) and Key Integration Performance Indicators (KIPIs): purpose and underlying criteria (from JERICO-S3 D5.3).

| KPPIs | KIPIs |
|---|---|
| ***Intended to capture in some way the degree of accomplishment of the tasks set for a platform by its operator/manager.*** | ***Intended to describe the degree to which a platform is integrated in the JERICO RI "system of systems".*** |
| *Platform Performance is expressed in terms of three criteria:*<br>*1) the ability of the platform to provide the services expected of it (Effectiveness);*<br>*2) the likelihood that the platform will be maintained in working order over an extended period of time, or at least that services will be available to the levels specified throughout its design life (Reliability);*<br>*3) the recurring expenditures for operations and maintenance required throughout the platform's service life (Cost).* | *Platform Integration Performance is expressed in terms of three criteria:*<br>*1) comparability of services offered with respect to the RI's requirements for the same;*<br>*2) level of assimilation of the platform's observations of EOVs/EBVs in the definition of JERICO-RI products/indicators at the regional level;*<br>*3) contribution of the platform's observations of EOVs/EBVs to inter-calibrations/validations improving the quality of JERICO-RI regional products/indicators.* |

**Table 1b.** The JERICO Key Platform Performance Indicators (KPPIs): criteria and proposed metrics (from JERICO-S3 D5.3).

| Criterion | Metrics |
|---|---|
| **Criterion #1**<br>**The ability of the platform to provide the services expected of it (Effectiveness).**<br><br>• *Downtime (number of days)/Time deployed (total number of days/year);*<br>• *Total number of observations or data points handled (one observation or data point is one measurement of a variable at a given time and place) per year;*<br>• *Process conformance to regional SOPs.*<br><br>*For each platform subsystem (variable monitored):*<br>• *Time to final data delivery for Real Time (RT) data;*<br>• *Time to final data delivery for Delayed Mode (DM) data;*<br>• *Number of non-zero Quality Flags delivered / Number of data delivered;*<br>• *Quality process conformance to JERICO-RI BPs.* | *Contribution to European programmes (e.g., the Copernicus Marine Service, EMODnet, EuroGOOS, SDN etc.):*<br>• *Total number of observations delivered to Data Aggregators per year;*<br>• *Total number of users through the Data Aggregators programmes.*<br><br>*Contribution to monitoring programmes, national or otherwise:*<br>• *Total number of observations delivered to monitoring programmes per year;*<br>• *Number of reported variables;*<br>• *Total data delivered per year;*<br>• *Total data delivered per year per variable handled/Total data delivered per year;*<br>• *Total number of users.*<br><br>*Contribution to research activities:*<br>• *Number of citations in peer-reviewed papers per year;*<br>• *Number of research teams (different filiation) having cited data from the observing platform per year.* |
| **Criterion #2**<br>**The likelihood that the platform will be maintained in working order over an extended period of time, or at least that services will be available to the levels specified throughout its design life (Reliability).** | • *Effected number/duration of maintenance stops (n)/Expected (planned) number/duration of maintenance stops (n);*<br>• *Effective uptime (number of days/year)/Expected uptime (number of days/year);*<br>• *Number of outage reports per year/Number of outages;*<br>• *Number of successes in on-site resolution of reported problems/Number of problem reports per year.* |

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| **Criterion #3**<br>**The recurring expenditures for operations and maintenance required throughout the platform's service life (Cost).** | • *Per year operating cost of platform;*<br>• *Percentage of regular funding (e.g., from permanent national programmes or an institute's annual budget) in the per year operating cost of platform;*<br>• *Percentage of intermittent funding (e.g., from projects) in the per year operating cost of platform;*<br>• *Per year maintenance cost of platform;*<br>• *Percentage of regular funding (e.g., from permanent national programmes or an institute's annual budget) in the per year maintenance cost of platform;*<br>• *Percentage of intermittent funding (e.g., from projects) in the per year maintenance cost of platform;*<br>• *Average cost per datum.* |

**Table 1c.** The JERICO Key Integration Performance Indicators (KIPIs): criteria and proposed metrics (from JERICO-S3 D5.3).

| | |
|---|---|
| **Criterion #1**<br>**Comparability of services offered with respect to RI requirements for the same.**<br><br>*For each platform subsystem (variable monitored):*<br>• *Compatibility with the JERICO-RI norm (e.g., the JERICO label requirements) from the standpoint of the technology used (pass/fail/provisory acceptance, subject to review);*<br>• *Compatibility with the JERICO-RI norm from the standpoint of the reference materials used (pass/fail/provisory acceptance, subject to review);*<br>• *Compatibility with the JERICO-RI norm from the standpoint of the calibration methodologies used (pass/fail/provisory acceptance, subject to review);* | • *Level of adherence to available JERICO-RI Best Practices as compiled in JERICO Best Practices documentation (pass/fail/provisory acceptance, subject to review);*<br>• *Level of compliance/compatibility with established target measurement goals for JERICO RI observables (pass/fail/provisory acceptance, subject to review);*<br>• *Level of acceptance of data delivered to international databases (pass/fail/provisory acceptance, subject to review) - e.g., for a specific database, the percentage of data supplied that do not meet the "acceptance criteria" for that database.* |

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| **Criterion #2**<br>**Level of assimilation of the platform's observations of EOVs/EBVs in the definition of JERICO-RI products/indicators at the regional level.** | • *Number of JERICO-RI regional products/indicators resulting from the integration of observations of two or more EOVs/EBVs from the considered platform;*<br>• *Number of JERICO-RI regional products/indicators resulting from the integration of observations of two or more EOVs/EBVs coming from both the considered platform as well as other platforms in the network;*<br>• *Number of JERICO-RI regional products/indicators resulting from the integration of observations of EOVs/EBVs from the considered platform and platforms belonging to other RIs;*<br>• *Number of products/indicators of other RIs integrating observations of at least one EOV/EBV from the considered platform;*<br>• *Geographical coverage of the JERICO-RI regional products/indicators resulting from the integration of the EOV/EBV observations furnished by the considered platform (spatial extension over more than one region).* |

| | |
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| **Criterion #3**<br>**Contribution of the platform's observations of EOVs/EBVs to inter-calibrations/validations improving the quality of JERICO-RI regional products/indicators.** | • *Number of intercalibrations/validations performed employing the observations provided by the considered platform for at least one EOV/EBV;*<br>• *Number of EOVs/EBVs for which the considered platform provides inputs from the standpoint of intercalibrations/validations;*<br>• *Number of intercalibrations/validations enabled by the considered platform's EOV/EBV observations when supported by relevant inputs from other RIs;*<br>• *Number of intercalibrations/validations carried out by other RIs employing the observations provided by the considered platform for at least one EOV/EBV;*<br>• *Geographical extension of the effect of the intercalibrations/validations enabled by the considered platform's EOV/EBV inputs on regional products/indicators (spatial coverage involving more than one region).* |

In the larger sense, the composite system of KPPIs and KIPIs outlined above can be viewed as a "technical" tool serving to support and guide management in making decisions concerning the JERICO RI, its workings and elements, and its value in the context of the constantly evolving European marine observing landscape.

**Recommendation for Multiplatform implementation of a biogeochemical NRT observatory (D5.4)**
This deliverable covers the latest advancements in near real-time sensor observations of biogeochemical EOVs, along with examples of multiplatform observations integrating these EOVs with others. It also provides recommendations for improving near real-time biogeochemical observations, emphasising the importance of **calibration, quality control (QC) procedures, and delayed-mode QC/validation**. Despite the challenges involved, particularly with the third recommendation requiring substantial resources, it is deemed crucial for ensuring **high-quality biogeochemical observations**. The document highlights the significance of such observations in understanding the dynamics of coastal ecosystems, given the interconnection of physical, biological, and chemical processes in marine biogeochemistry.

### *3.3 - Technologies innovations in JERICO-S3*

Some innovative technologies and methodologies have been developed in WP7. with A good example is the cEGIM interoperable instrument module for improving  platform, sensor and data interoperability (T7.2) based on COSTOF2 with a set of generic sensors and assured end-to-end compatibility through the implementation of Sensor Web Enablement (SWE) and Internet of Things (IoT) standards. The module incorporates onboard execution of data processing algorithms with self adaptive behaviour (depending on mission objectives). Sensors/devices handled include those for measuring a series of EOVs (temperature, salinity, oxygen, turbidity, fluorescence) and nitrate concentration (UV-based), registering phytoplankton concentration classes and species, and a camera for capturing zooplankton and particle abundance information (UVP6).

Two others sensor packages have been also tested: 1) an innovative technological solution for high frequency sampling for contaminants and biodiversity - WASP (Water Sample filtering and Preservation device), 2) an autonomous Coastal Observing Benthic Station (ACOBS) - Multi-sensor package comprising a video camera, a sediment microprofiler, a Sediment Profile Imager, and sensors for physical measurements (CTD, turbidity, currents)

A definition and development of data science methodologies for the interpretation and modelling of relevant biological and ecological processes based on the data produced by the innovative sensors experimented have been also demonstrated in JERICO-S3.

In this context, intelligent services have been proposed to : activate/deactivate sensors, change the sensor configuration (e.g. sampling frequency, resolution), send reports and/or raise warnings (T.7.4). Such services could be applied for example for the onset until the end of the phytoplankton bloom period in order to adapt the sampling frequencies of the sensor to a phenomenon under observation.

Finally, the JERICO-Coastal Ocean Resource Environment (JERICO-CORE) has been developed as a technological tool to integrate relevant information for the JERICO-RI. JERICO CORE is the information system that is the foundation for user access to JERICO products and services. It provides access to a broad range of services from data, best practices and documents to access a virtual lab facility to produce advanced products.

In D7.5 four Data-to-Products Thematic Services (D2PTS) have been proposed as demonstrators of JERICO-CORE capabilities: High Frequency Radar (HFR) network with gap-filled surface current products, estimation of sea water mass types and transport monitoring from Gliders, biogeochemical state of coastal areas and JERICO-EcoTaxa with coastal plankton monitoring products from ecological imaging sensors.
Together, these four D2PTS can contribute to a wider understanding of the occurring processes. In particular, the potential contributions of the glider D2PTS and HFR gap-filled surface currents to understanding dynamics in other areas if appropriately positioned remains an open question. The wide possibilities opened up for debate suggests the need for further discussion in future project meetings regarding the broader applicability and potential synergies of these tools across different areas of study.

Major outcomes from technological innovations have been pointed out, and should help to integrate the multi-platforms approach: 1) data processing capabilities of cEGIM should be improved and used in other JERICO-RI regions, 2) data processing capabilities could be extended to ACOBS and WASP, 3) ACOBS and cEGIM could become part of the TNA component of JERICO-RI, 4) AI capabilities should be improved both on the instrumentation side (e.g., Edge Computing) and on the services side (e.g., VRE)

The TA (Trans-National Activities) experimentation projects have mainly enabled trials to be carried out for technological validation and estimates of the performance of sensors and capacity of the sampling instruments (see D1.3 and WP7). Some projects have also helped to deepen understanding of marine ecosystems and to improve monitoring and forecasting capabilities, through the integration of different platforms or the use of integrated sensors on autonomous platforms (eg., gliders) or advanced data loggers (eg. COSTOF). These projects cover processes around water circulation, nutrient dynamics, planktonic responses to extreme events and the impact of environmental factors on marine ecosystems.

As far as technical integration is concerned, it appears that sensor performance (endurance, precision and accuracy) is a key factor to consider. Depending on the question being asked, we need to ensure that we are using the right platforms with the same type of sensors, so that we can cover the right time and space scales and compare the data gathered. In this case, we also need to ensure that the sensors have undergone the correct calibration and maintenance procedures. In most of the best practices concerning platforms and sensors (OBPS), it is often recommended to refer to reference data (in situ measurements) or time series (climatology) in order to be able to adjust the data sets afterwards, as the deployment of platforms and sensors is unfortunately often associated with measurement drifts or outliers. It is also important to follow the recommendations on data processing, for example, by setting up suitable toolboxes. For JERICO platforms, some toolboxes for autonomous platforms are already available (eg., for gliders through the OceanGliders work in Github).

### *3.4- Suggestions to facilitate better technical integration within JERICO*

From the integration experiments in regions, some suggestions for better technical integration within JERICO can be proposed. These concern the management of instruments (eg., calibration history, traceability), consistent and homogenous data processing procedures for EOVs (through ERDDAP), and harmonisation using the most up-to- date best practices.

From the regional analysis, we've identified exemplary platforms and sensors ideally suited for intercalibration and cross-validation purposes (eg., gliders, HF radars, coastal moorings and regular ship visits). These tools have demonstrated efficacy in capturing information on essential variables for understanding coastal processes across varying spatio-temporal scales and geographical regimes. Our recommendations extend beyond regional boundaries, advocating for the adoption of these methods on a pan-European scale. By leveraging these platforms and sensors, we can enhance the consistency and reliability of data collection efforts continent-wide. In this context, there is a need to progress on biological sensors and tools to favour data integration. Collaborative efforts must be undertaken to describe and implement the recommendations in best practices (see D5.6).

Furthermore, our focus on specific coastal processes has led us to pinpoint sensors and platforms that excel in sampling essential variables crucial for process comprehension. These selections are tailored to meet the spatial resolution, sampling time period, and other pertinent requirements dictated by the unique characteristics of each coastal environment. Through meticulous cost/benefit analyses, we've compared different integration strategies, weighing the advantages and drawbacks of low-cost versus high-cost approaches. This evaluation aids decision-makers in selecting the most efficient and economically viable solutions for their monitoring needs.

However, to achieve and sustain the desired level of regional and pan-European integration, several critical elements are still missing. These include the establishment of common calibration laboratories, collaborative procurement of equipment, harmonisation of standard operating procedures, and the facilitation of regular collaborative activities such as workshops. Addressing these gaps will foster greater cohesion and efficiency in data collection and analysis efforts across regions and at the pan-European level. A common procedure for the JERICO regions could be to establish regular inter-comparison of measurements and sensors as established by the ICOS group. It will provide a means to evaluate the performance of sensors, sampling procedures and lab instruments to collect and measure different EOVs accurately .

We have also identified the need for specific data formats and standards for variable uncertainty to ensure interoperability and data consistency. Developing and updating good/best practices are also essential steps toward optimising data quality and enhancing the effectiveness of monitoring initiatives. By addressing these needs comprehensively, we can strengthen regional and pan-European integration efforts, ultimately advancing our understanding of coastal processes and improving decision-making in coastal management.

Sharing and developing Best Practices through the IRS/PSS system within and between regions is also highly recommended to harmonise procedures regarding sensor integration and calibration, platforms deployments and maintenance, and data acquisition, curation and validation. In the long run, such recommendations should extend beyond JERICO to the wider EU marine observing landscape.

# 4.CONCLUSIONS

Technical recommendations from PSS and IRS experiences have been summarised in D5.7. From regional integration experiments, several key suggestions have emerged, focusing on instrument management, consistent data processing, and updating and sharing best practices. Exemplary platforms and sensors, such as gliders and HF radars, have proven effective for intercalibration and cross-validation, essential for understanding coastal processes. Recommendations include expanding the use of these methods in Europe, improving biological sensors, and progressing with data integration. Critical missing elements for effective integration include common calibration labs, collaborative equipment procurement, and harmonised operating procedures. Addressing these gaps, alongside developing specific data formats and standards, will enhance data consistency and quality.

Finally, sharing and developing best practices across regions will be crucial for harmonising procedures and improving coastal management decision-making on a pan-European scale.

# 5. ANNEXES AND REFERENCES

FOO Task Team for the Integrated Framework for Sustained Ocean Observing (2012) A Framework for Ocean Observing (by Lindstrom, E., Gunn, J., Fischer, A., McCurdy, A., & Glover, L. K. et al). Paris, France, UNESCO, 25pp. (IOC Information Document 1284, Rev. 2). DOI: 10.5270/OceanObs09-FOO