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

JERICO-S3 DELIVERABLE

Joint European Research Infrastructure for Coastal Observatories

Science, Services, Sustainability

DELIVERABLE #, WP# and full title	JERICO-S3 D2.2 - WP2 - "Roadmap for cooperation with COPERNICUS and industries"
5 Key words	Roadmap, cooperation, coastal industries
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Final version date/ Submission date (dd.mm.yyyy)	31.07.2023 // 30.07.2024

Nature: **R**

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

Dissemination level : **PU**

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

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

DOCUMENT TECHNICAL DESCRIPTION

Document ID	JERICO-S3-WP2-D2.2-15.07.2024-V1.1

REVISION HISTORY

Revision	Date	Modification	Author
V0.0	15/06/2024	First draft	D. Durand
V1.0	30/06/2024	Consolidation section 2	D. Durand, A. Mangin
V1.1	15/07/2024	Finalisation	D. Durand

APPROVALS

	Name	Organisation	Date	Visa
Coordinator	Delauney Laurent	Ifremer	16/07/2024	X
WP Leaders	Holger Brix	HEREON	16/07/2024	X

Diffusion list

Consortium beneficiaries	Third parties	Associated Partners	other
X	X		

TABLE OF CONTENTS

EXECUTIVE SUMMARY

JERICO have used about 10 years for maturing from a network of institutional or nation research facilities, dedicated mostly to the observation of the physical ocean, into a pan-European research infrastructure, delivering continuous, valuable data, datasets and information about key coastal processes of high relevance to science and society, and developing a range of services to many stakeholders and users in Europe.

In this report we have been focussing of two types of key stakeholders: (1) Copernicus marine service and European space agencies (ESA and EUMetSat), and (2) coastal industries. An analysis of the state of partnerships with JERICO, including success stories has been conducted. Barriers towards improved partnership, and opportunities provided by the European and global context have been identified and will be further exploited beyond the end of the project, and will be used as drivers for the design of specific JERICO services.

The Copernicus marine Service and space agencies have shown a growing need for in-situ observations to develop their own products and services.
The analysis conducted in JERICO-S3 and presented in this report shows that the long-term objectives, which have driven the development of JERICO so far, were the right ones and that the societal and subsequent scientific challenges upon us will greatly benefit the strategy implemented in JERICO. There is strong expectation from CMEMS on JERICO products and services, especially with regards to the implementation of CMEMS´s coastal strategy, but also and not least related to the emergence of the Digital Twins of the Ocean. Specific limitations towards a more efficient partnership have been identified and will be jointly tackled beyond the end of the JERICO-S3 project. Specific services that JERICO could offer to CMEMS and to ESA have been defined, as well as their implementation modality.

Coastal industries encompass many different types of actors, including small and large manufacturers, small and large users of the ocean space, exploiting its physical and/or biological resources, and providers of technical services to those exploiting the coastal ocean.
It is recognised that more and better partnership between a research infrastructure as JERICO and SMEs developing marine technology is required for answering to the policy expectations encompassed into the European green deal and its subsequent components, e.g., energy transition, farm2fork strategy, sustainable blue economy, environmental protection, DTO.
A new partnership framework has been suggested for increasing the interest and feasibility of manufacturers to work closely with research infrastructure for fast-tracking high-impact innovation, addressing greening of activities, the digital ocean and European technological leadership. Increased partnership is also needed with the industry exploiting the coastal ocean, and its supporting providers. The Ocean Enterprise is a powerful initiative in this regard, while establishing a European hub is considered as an appropriate way forward, and will be investigated further, beyond the end of the project.
The fact that more and more industries see the benefit of sharing their own data for creating value and efficiency in bringing solutions to current challenges is seen as a promising context that JERICO intends to exploit as part of its business model.

1 SHORT ABOUT JERICO

JERICO is a European research infrastructure (RI) aiming at providing coastal marine observatories, facilities, expertise and in-situ data for Europe, supporting (1) coastal science, linking land to sea, (2) policy on conservation and restoration of marine waters, and (3) a sustainable blue economy.

JERICO recognises that the coastal ocean is an environment strongly and negatively impacted by anthropic activities and climate change, which requires dedicated measures for ensuring its preservation and conservation. Meanwhile, JERICO also recognises that the planned growth of the blue economy, driven by important societal demands related to energy and food, is inevitable, and will occur for a large part in coastal regions, hence requiring new paradigms for ensuring its environmental, economic and societal sustainability.

In this context, JERICO is a crucial structural element for providing observations, information and new knowledge supporting policymaking on measures aiming at maximising environmental sustainability of European coastal seas and coastlines.

For fulfilling its objectives and maximising its impact for science and society, JERICO is developing and implementing services targeting its three categories of stakeholders (science community, policymakers, private blue sector).

Furthermore, JERICO is elaborating a comprehensive business model and a business plan addressing, among others, the obvious synergies and required collaboration/partnership with coastal industries.

This report summarises progress, achieved during the JERICO-S3 project, on partnerships with (1) the COPERNICUS marine service, as an operational implementer of European marine policies, and (2) coastal industries. It also draws barriers and opportunities that will be jointly addressed between parties for fostering these collaborations and partnerships in the future for the benefit of science and society.

1.1 JERICO services

JERICO services (Figure 1) are structured through five pillars:

- Integrated Observation strategy: JERICO intends to use the tremendous expertise gathered through its community to enable the emerging of augmented observing systems, and to support stakeholders (science community, environmental authorities and coastal industries) in conceptualising, designing and setting-up fit-for-purpose observing systems, following best practices and standards, thereby fulfilling the objectives pursued while contributing to the European and global effort on ocean observation.
- Operation: JERICO aims at providing operational support to "newcomers" on how to deploy, operate and deliver value from observing systems, including data management from metrology to qualification of measured variables.
- Data management & products: JERICO contributes to progress, best practices and adoption of standards related to data management of coastal observations (in partnership with data repositories such as INSTAC, EMODnet, Blue cloud). Furthermore, JERICO intends to deliver user-defined advanced products and information based on its data flow and datasets.

- Access: JERICO is providing access to its observatories and facilities to a broad range of scientific and industrial stakeholders, supporting excellence in science and fast-tracking technological innovations. It also provides virtual access to data/datasets, e-tools for data processing.
- Innovation: JERICO is continuously working on novel technologies, improving the observation of key coastal parameters and coastal processes. It is done within the community and often through partnership with SMEs.

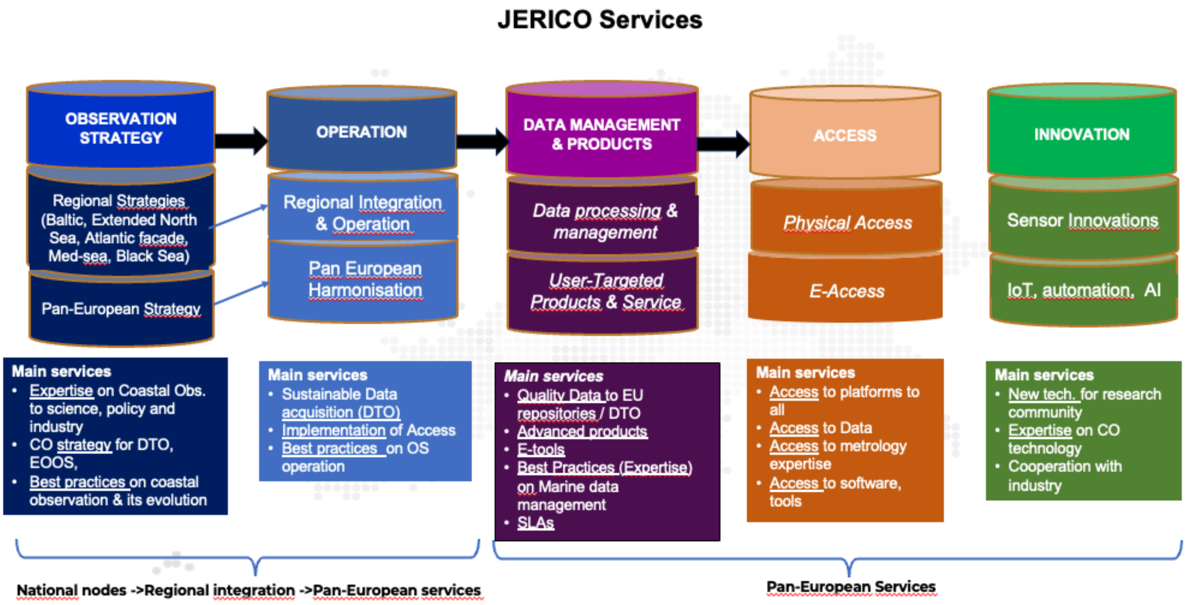

Figure 1 - Definition of JERICO service structures and key foreseen services.

1.2 JERICO Business model

If the observing systems part of the the services will be provided as in-kind contributions from nations, following the expectations from the EU, the provision of services (human resources) and the development/evolution/consolidation of JERICO will have to rely partly on external incomes in form of project generation and commercial service provision.

In addition, some services are expected to be provided free of charge, as for example the contribution of JERICO to Copernicus marine services, which is considered as national in-kind contributions to European strategy.

Furthermore, it is recognised that the marine and maritime industry sector are providers of ocean observations (especially in coastal regions) and should therefore be considered both as users of JERICO services and possibly contributors to the development of more robust and comprehensive services, not least through sharing of data and access to marine platforms and vehicles.

Industry stakeholders also encompass technology developers and providers, which are already key partners for (1) progressing on TRL on innovations from the JERICO community, and (2) co-designing and developing relevant technologies for the scientific community.

Space agencies are also considered as future key users of JERICO services, especially for validation of EO data and development of novel retrieval algorithms.

2 COPERNICUS, ESA AND EUMETSAT

2.1 *ESA/EUMETSAT - Identified needs and requirements for coastal observations*

The purpose of this section is to describe to what extent, JERICO in its present and near future status, can contribute to environmental observation by satellite.

Earth observation by satellite has proven to be an indispensable tool for environmental monitoring and climate evolution studies; however, this is not a standalone technique. Indeed, Earth observation is to be seen as inseparable from in situ measurements. Joint availability of these two sources of information & observation is crucial for:

- The calibration and validation of Earth observation derived products
- The "Mutual" quality control of the stability and potential drift in time of observation systems
- Derivation of algorithms for new parameters derivation from EO

For calibration and validation, the need for in situ "truth" is increasing in order to face the very large number of observations made by the Copernicus program.

In Table 1, the parameters available from JERICO and for which a counterpart exists as derived from Earth Observation (indications on space missions are not exclusive) are summarised. The parameters indicated in italic are not operational today, but experimental algorithms exist and are under tests within specific research projects.

Table 1 – Sentinel-3 derived parameters that are observed operationally by JERICO

Measured by JERICO	Derived from EO
Temperature	Sentinel-3 – SLSTR
Waves	Sentinel-1 – SAR
Sea-Surface Height	Sentinel-3 / Sentinel-6 / SWOT
Turbidity	Sentinel-3 – OLCI / Sentinel-2
Fluorescence (Chl-a)	Sentinel-3 – OLCI
Phytoplankton concentration	Sentinel-3 – OLCI
CDOM	Sentinel-3 – OLCI
pCO2	*Sentinel-3 – OLCI*
DOC	*Sentinel-3 – OLCI*
POC	*Sentinel-3 – OLCI*
PAR	*Sentinel-3 – OLCI*

2.1.1 Support to calibration and validation of satellite observations

a) Fiducial Reference Measurement

For most of the sensors, calibration is generally applied to level 1 EO products (e.g. the basic measurement done by the sensor before any processing to retrieve advanced parameters). The validation is done on level 1 and higher-level products. Both calibration and validation exercises require in-situ measurements that need to be at least as high quality as the satellite data, which necessitates SI-traceability and an uncertainty budget. This is the basis of Fiducial Reference Measurements (FRM) that are: a suite of independent ground measurements that provide the maximum return on investment for a satellite mission by delivering to users the required confidence in data products. This is in the form of independent validation results and satellite measurement uncertainty estimation, over the entire end-to-end duration of a satellite mission. The FRM must: have documented traceability to SI units (via an unbroken chain of calibrations and comparisons); be independent from the satellite retrieval process; be accompanied by a complete estimate of uncertainty, including contributions from all FRM instruments and all data acquisition and processing steps; follow well-defined protocols/community-wide management practices and; be openly available for independent scrutiny. Within this context, the European Space Agency (ESA) funded a series of projects targeting the validation of satellite data products (atmosphere, land, and ocean) and set up the framework, standards, and protocols for future satellite validation efforts.

The Fiducial Reference Measurements for Satellite Ocean Colour (FRM4SOC[1]) project is performed to provide support for evaluating and improving the state of the art in ocean colour radiometry (OCR) through a series of comparisons under the auspices of the Committee on Earth Observation Satellites (CEOS) working group on calibration and validation and in support of the CEOS ocean colour virtual constellation. The objectives of FRM4SOC were to establish and maintain SI-traceable ground-based FRM for satellite OCR with the relevant protocols and uncertainty budgets for an ongoing international reference measurement system supporting the validation of satellite ocean colour.

For altimetry, a similar project has been put in place (FRM4ALT[2]) by ESA with the same objectives of establishing and maintaining FRM stations. In this case, it seems that many stations already exist and that the main objective is to qualify them to become FRM-compliant. The link between the tide gauge network community and the altimetry community is very strong. Common work reaches some strong recommendations towards the networks[3]

For SST, a similar approach has been put in place by EUMETSAT through the project "Towards fiducial Reference measurements of Sea-Surface Temperature by European Drifters" (TRUSTED[4]) The purpose of the TRUSTED project is to set up a service to "provide well-calibrated drifting buoy SST, towards SI-traceable standards, HRSST-FRM", so that it is then possible to "assess and establish the benefit of improved capability of HRSST-2 drifting buoys for satellite SST validation". Further assessment is planned as part of the activities for Copernicus Sentinel-3 SLSTR Validation.

The project incorporates scientific quality control and analysis of the drifting buoy measurements. The project aims to provide measurements from 100–150 drifting buoys with an improved capability (HRSST-2) and assess their quality in coordination with EUMETSAT and the wider international community.

Coordination of the satellite SST community with the Data Buoy Cooperation Panel (DBCP) continues and is a new way of working and, if successful, may extend to other Essential Climate Variables (ECVs). These new measurements are essential, not only for satellite validation activities in order to ensure the quality of the SLSTR SST products for the users,

[1] https://www.mdpi.com/journal/remotesensing/ special issues/2nd ocean color RS
[2] https://earth.esa.int/eogateway/activities/frm4alt
[3] https://eurogoos.eu/download/eurogoos-tgtt-nov2016-report-and-recommendations/?wpdmdl=10740&refresh=62679806e324f1650956294
[4] https://www.eumetsat.int/TRUSTED

but also to contribute to algorithm development, and to lead to further necessary improvements.

b) Copernicus Calibration & Validation Solution

As described above, Fiducial Reference Measurements (FRM) are a suite of independent, fully characterised, and traceable ground measurements that follow the guidelines outlined by the GEO/CEOS Quality Assurance framework for Earth Observation (QA4EO). These FRM provide the maximum Return on Investment (ROI) for a satellite mission by delivering, to users, the required confidence in data products, in the form of independent validation results and satellite measurement uncertainty estimation, over the entire end-to-end duration of a satellite mission. One current objective of the EU is to reduce the complexity of the FMR networks and to improve their efficiency through rationalisation and optimisation of similar measurements (for different parameters) and the creation of "super sites" for calibration & validation. A Horizon Europe Concerted Action called "Copernicus Calibration & Validation Service" (CCVS[5]), led by ACRI-ST, aimed at identifying and describing the present situation of the calibration & validation networks and to propose a roadmap to reach the optimal FMR networks. Generic conclusion is to try at a maximum to qualify existing reliable network to become FRM-compliant, this is the case for altimetry and SST. For Ocean Colour, the ideal sites for Cal/Val activity must include hyperspectral surface reflectance measurements. If azimuth control is not possible then sophisticated filtering has to be added to filter out any possible glint issues. When sensors are not mounted on a fixed structure, tilt sensors with automated filtering are also needed.

Reflectance measurements should be a base for a proper Cal/Val site. In addition, it should be coupled with IOP and concentration measurements. To validate the Copernicus standard products, reflectance measurements are not sufficient. It necessitates pairing reflectance data with measurements of concentration. For clear waters, only CHL measurements can be enough as the others are related to it, although there is hesitation also to this point nowadays. For coastal and inland waters, CHL measurements are best taken simultaneously with CDOM and TSM as they all behave independently from each other and have independent sources. If the concentrations are measured with optical instruments on site, then it would be proper if these are periodically intercompared with laboratory measurements where the procedures and uncertainties are better described. If the concentrations are only measured during field campaigns, then special care must be taken to match these campaigns with satellite overpasses and with clear skies.

In addition to these direct parameters that are used for validation, some auxiliary parameters should be measured, that can help the use of the main ones:

- Wind speed – to estimate the surface roughness
- Water and air temperature – to check if the measurements are within the calibration range
- Aerosol optical thickness – for atmospheric correction evaluations
- Hemisphere photos – for latter data analyses and filtering

To conclude, some components of the JERICO network could be upgraded to become part of the FRM network that would ensure a stable support for mid-term evolution.

2.1.2 Support to Quality Control

[5] https://cordis.europa.eu/project/id/101004242

In situ "truth" is also important to do the continuous & necessary quality control of EO-derived products. This is particularly true for autonomous systems for which calibration with reference target is impossible after launch. Such an exercise is currently done by comparing EO derived data with BGC Argo products when the floats are surfacing. The difficulty is to compare two sources of data, knowing that both can be biassed and/or present drift in the data quality. Although delicate, this exercise is very interesting to detect anomalies if one (or two) of the measurements (Figure 2).

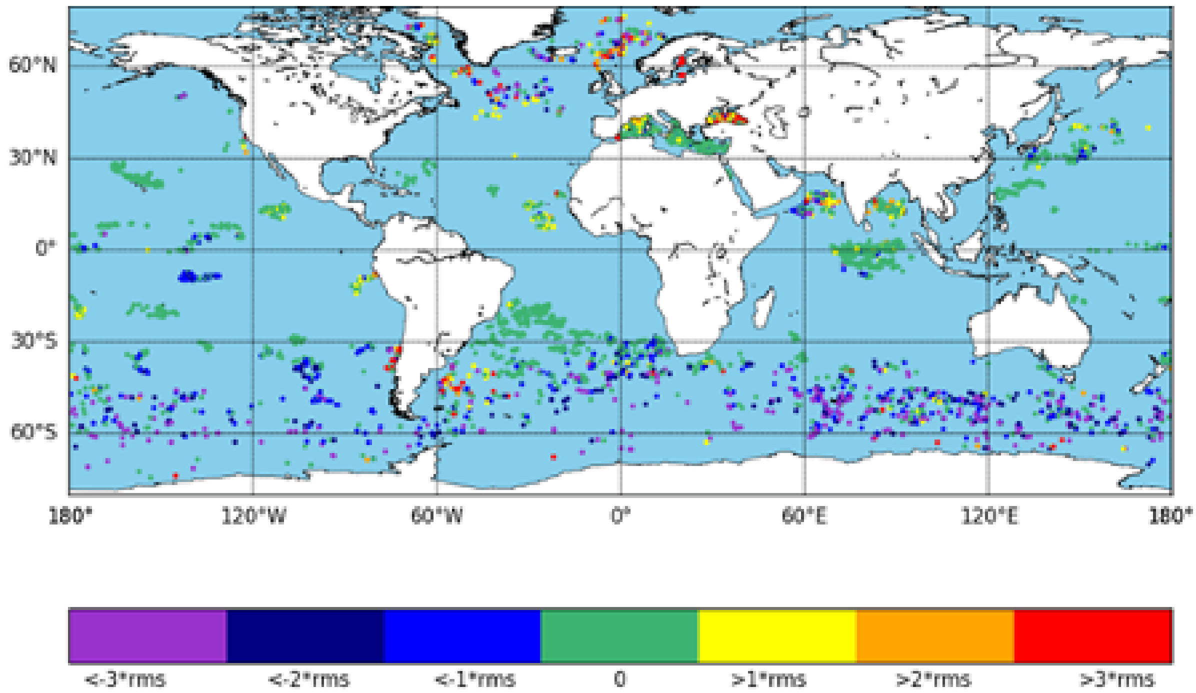

Figure 2 - Comparison between two operational systems to cross check data quality and possible drift of one of the systems. Prerequisite is to compute the "natural" uncertainty of each dataset. If data difference is larger that X times the standard deviation of the acceptable uncertainty, then the data is flagged out (source ACRI-ST – Horizon Europe EuroSea project).

Systematic comparison of some of the data measured by JERICO and the one provided by Earth Observation is one way to bring additional value from in situ observations.

2.1.3 Derivation of novel retrieval algorithms for new parameters

Concerning the derivation of BGC parameters at sea, many scientific projects are conducted to:

1. Improve the existing retrieval techniques (e.g. for surface concentrations of Chlorophyll-a, SPM…),
2. Elaborate new algorithms for new parameters (Phytoplankton Functional Types, Carbon…).

Both objectives rely on availability of numerous in situ data (for training (in case of Machine Learning), fitting (in case of statistical approach), validation and uncertainties assessment). As an example, today, many activities are conducted on carbon cycle, with emphasis on coastal parameters such as pCO2, DOC and POC (which are available from JERICO). Figure 3 is an illustration of an ongoing project by LOG (CO2Coast) with contribution of ACRI-ST and with the support of French ANR. The pCO2 is retrieved with specific neural networks on coastal areas – the dataset which is used to do the ML training is SOCAT (several millions of data).

Specific objectives of the CO2Coast are to:

1. Estimate pCO2 and CO2 fluxes at the sea surface and their uncertainties from remote sensing in coastal waters
2. Analyse temporal evolution of pCO2 and CO2 fluxes over the 25 last years
3. Analyse the estuaries contribution to the CO2 fluxes

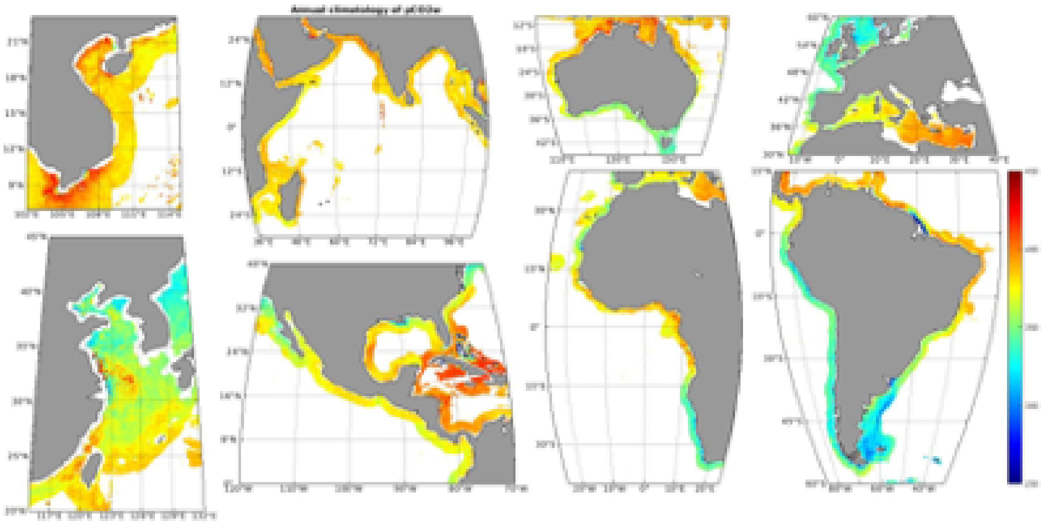

Figure 3 - Estimation of pCO2 from EO – based on a ML training on massive in-situ data.

Several initiatives of algorithm derivation and/or improvement for the retrieval of BGC parameters from EO, require massive in-situ coastal data that can be provided by JERICO. The prerequisite is an estimation of the uncertainty attached to this in-situ data.

2.2 COPERNICUS - Identified needs and requirements for coastal observations

With the aim of progressing on the cooperation between JERICO and the Copernicus Marine Service (CMEMS), a series of meeting have been conducted at different levels and with different part of CMEMS:

- CMEMS management (Pierre Bahurel, CEO and Pierre-Yves Le Traon, Scientific Director – Mercator Ocean International – MOi)
- Head of the Thematic Assembly Centre for in-situ observation (INSTAC) (Dominique Obaton)
- Members of the Ocean Colour Thematic Assembly Centre (OCTAC)
- Participation in the CMEMS requirement workshop (September 14, 2023)

A short conclusion on the main findings, alignments and joint initiatives is provided.

2.2.1 Current context

The Copernicus Marine Environment Monitoring Service (CMEMS) provides regular and systematic information on the state of the physical ocean at global and regional level. There are four main areas of benefits covered by the service: maritime safety, coastal and marine environment, marine resources, and weather seasonal forecasting and climate activities.

CMEMS is based on a production structure covering two layers:

- Processing of space and in-situ observations and delivery of derived products: this is achieved through Thematic Assembly Centres (TACs) organised according to consistent parameters – or sets of parameters. CMEMS include eight TACs mainly handling space observations (Sea Level, Ocean Colour, Sea Surface Temperature, Sea Ice, Winds, Waves, and Multi-Observation Integration), and one TAC dedicated to In-Situ observations (INSTAC).
- Processing of models, for forecasts, hind-cast and reanalyses, fed by products derived from space and in-situ observations (to be provided by the TACs): these tasks are achieved by Monitoring and Forecasting Centres (MFCs), structured according to regional domains (6 European regional seas) and global ocean.

During the last three years, the Copernicus Marine Service has been evolving quickly under several drivers, such as:

- The European Green Deal and subsequent strategies, not least the Digital Twin of the Ocean (DTO) initiative
- The evolution of Mercator Ocean International (coordinator of CMEMS) into an Intergovernmental organisation (IGO). The future IGO envisions to galvanise and coordinate efforts towards the co-development and integration of worldwide ocean prediction activities, serving the objectives of the United Nations Decade of Ocean Science for Sustainable Development (2021-2030).
- The MoU signed between Mercator Ocean and EuroGOOS concerning, among other things, the coordination of access to European in-situ observations.
- The elaboration of a Coastal Strategy by CMEMS to better answer societal demands and needs.

This dynamic context may obviously impact the content of the services that JERICO intends to provide to Copernicus and the DTO.

Pierre-Yves Le Traon has been so nice to provide us with statement paving the way for collaborative work between CMEMS and JERICO, for the best of European policies and ocean strategy:

"Given the tremendous social, economic and biological value of coastal zones, an enhanced monitoring of coastal zone is critical for a wide range of applications (coastal zone management, climate adaptation, coastal modelling, aquaculture, navigation and shipping, marine renewable energy, fisheries, oil spill management, search and rescue, and academia), to respond to various policies (Green Deal, MSFD, WFD, MSP, Flood Directive, ICZM, Bathing Water, Common Fisheries Policy) and for resilience to climate change. The Copernicus Marine Service portfolio has already started to be expanded for the coastal ocean with two main service lines: 1/ coastal zone monitoring through new or improved (e.g. satellite derived bathymetry, high resolution winds, high resolution turbidity) satellite and in-situ observations and 2/ improved coupling between Copernicus Marine global/regional systems and coastal systems operated by member states. Given the essential role of in-situ data for the monitoring of the coastal zone, Copernicus Marine through its in situ Thematic Assembly Centre and in cooperation with EMODnet is working with JERICO to ensure that up to date high quality in-situ data are gathered and made available to the Copernicus Marine user community (more than 70,000 registered users).

MOI thus considers that JERICO through the development and harmonisation of in-situ coastal observations in Europe will provide an essential pillar to the improvement of Copernicus marine service and downstream coastal services and will play a major role in the development of EU DTO capabilities".

2.2.2 INSTAC

Since the early 2000´s, the INSTAC has been developing a data platform for realtime in-situ data, protocols for quality assessment and quality control of data, metadata structures, FAIR principles, and operability capability, serving the objectives of the Copernicus Marine Service.

JERICO partners have been implementing the protocols and standards and delivering their coastal data to the INSTAC since the first JERICO project.

A series of meetings was organised with Dominique Obaton (INSTAC coordinator) to discuss barriers and opportunities for optimal collaboration between CMEMS and JERICO. Besides, Dominique Obaton has been invited to be a member of the current JERICO User Committee (JUC - see Deliverable D9.2).

Data gathered in the INSTAC come from a large span of platforms worldwide, from the open to the coastal ocean. The variables addressed, which cover physics, biogeochemistry and carbonate system, are presented in Table 2.

Table 2 – Main *coastal* variables *presently addressed by CMEMS*[6]

Physics	Biogeochemistry	Carbonate system
○ Temperature ○ Salinity ○ Currents ○ Waves ○ Sea level ○ Meteorology	○ Chlorophyll ○ Oxygen ○ CDOM ○ Nutrients nitrate, phosphate, silicate, ammonium ○ DIC, DOC ○ Turbidity	○ pH ○ pCO2 ○ Alkalinity

CMEMS recognises challenges and gaps to be filled in, as stated in the mapping of service requirements done in 2021[7],: "Consolidation and sustainability of the global and regional in-situ observing systems remain a strong concern. There are critical sustainability gaps and major gaps for biogeochemical observations (carbon, oxygen, nutrients, chl-a)".

A new mapping was conducted in October 2023, acknowledging progress on the BGC parameters, and pointing to the need for CMEMS to start looking into biological data.

[6] See https://doi.org/10.13155/53381 for a detailed list of exhaustive list of parameters
[7] Copernicus Marine Service requirements for the evolution of the Copernicus In Situ Component. MOI, EUROGOOS, CMEMS, V.2, March 2021

a) Barriers:

A number of barriers have been identified through dedicated dialogues.

Barrier #1 - Traceability: A very important factor when delivering data to data repositories (Copernicus, EMODnet, SeaDataNet, Blue cloud in the future) is the traceability of the provider. This is paramount for enabling providers to assess their KPIs, report on the use of their activities and securing sustainable funding for supporting delivering operational services. It is especially important in the context of Copernicus, where in-situ data are expected to be delivered to Europe as an in-kind contribution from Member States (and Associated MS).

The sustainability of services related to data access is therefore pending upon the possibility to gather statistics on usage from data management services, such as INSTAC.

In the context of Europe, the traceability of data provision encompasses four levels:

- The **Observer** (person generally scientist or engineer)
- The **organisation** (research institute, University) employing the Observer and in charge of national observation
- A recognised **national research infrastructure** or observing system, funded by the MS
- A **European RI** (such as JERICO), built upon national contributions, and delivering harmonised data and services for Europe

People in charge at these four levels, need to report on the scientific and socio-economic impact of their activities in order to secure fundings and long-term sustainability.

It means that a data repository, such as the INSTAC, should facilitate access to statistics and periodic reports on amount of data delivered, amount of data consulted/extracted and used, user profile, etc. This is not the case at present, and an effort is to be made to adapt the metadata for ensuring that such services can be provided by data repository in the future.

Obviously, this barrier is not specific to JERICO and may require a consultation among all RIs contributing to the INSTAC in order to find the right model fitting all.

Barrier #2 - Datasets: Most data repositories, including the INSTAC, are addressing data, meaning independent variables/parameters, as their basic structural element.

However, a key JERICO objective is to observe and document complex coastal processes, meaning observing variables/parameters in a non-independent manner in terms of what is **simultaneously** observed and how the parameters are sampled in space and time. JERICO is therefore delivering not only Data, but comprehensive Datasets of high value for supporting understanding of coastal processes, ecosystem functioning and dynamics. This dimension provides a critical added-value for research, but also for the DTO and the capability to design realistic "what if" scenarios, supporting both environmental conservation and sustainable blue economy.

This added-value (of the consistent multi-parameters observation) is presently lost when JERICO data is delivered to data repositories such as the INSTAC or EMODnet. This issue has been discussed both with INSTAC and with the scientific Director of CMEMS, who have both acknowledged the value of holding datasets accessible as such, in the context of the CMEMS strategy concerning coastal services.

Further investigations are going to be jointly conducted addressing how the use of DOI on datasets can help in the process, as well as specific metadata, aiming at facilitating queries at dataset level. The later point could benefit from solving Barrier #1. This will be followed up beyond the end of JERiCO-S3 and as part of the consolidation of the JERICO services for Copernicus.

Barrier #3: In the CMEMS document on INSTAC evolution, mentioned above, a statement is given concerning the role of EUROGOOS and its regional components (ROOSes), mentioning observing platforms that are actually coordinated through JERICO (FerryBox, coastal gliders, and HF radars, and which are considered as "strong priorities for regional CMEMS products". It is worthwhile mentioning here that even if the ROOSes structure and the regionalisation strategy of JERICO can seem close, the regional approach developed in JERICO is science-based and aiming at fostering harmonisation and consistency on data in Europe, while the ROOSes are primarily geographically based. These make the two regional approaches rather different and sometimes inconsistent.

It will be important in the future that these discrepancies, which can be seen as presently suboptimal, would become a strength. It will require that the role of RIs and of EUROGOOS Task teams and working groups would be better defined and that complementarity will be fostered over overlapping.

b) Opportunities:

Variables listed in Table 3 are all variables operationally observed from most JERICO platforms and observing systems (Table 3). They are currently delivered to the INSTAC in realtime or quasi-realtime, as appropriate.

Table 3 - JERICO variables

Physics	Biogeochemistry	Biology and proxies

○ Sea temperature
○ Conductivity/Salinity
○ Currents
○ Waves
○ Sea surface height
○ Underwater noise
○ Eddy Correlation flux
○ Vibration motion (seismometry)
○ Air temperature
○ Atmospheric pressure
○ Relative humidity
○ Wind speed/direction
○ Optics
  ○ Photosynthetically Active Radiation (PAR)
  ○ Water-leaving radiance (Lw)
  ○ Sea surface irradiance (E0)
Water diffuse attenuation (Kd)
	○ Dissolved oxygen
	○ Turbidity
	○ Nitrates
	○ Phosphates
	○ Silicates,
	○ Ammonia
	○ CDOM
	○ Carbonate system (pH, pCO2, Total Alkalinity)
	○ TCO2 (DIC - Dissolved Inorganic Carbon)
	○ DOC (Dissolved Organic Carbon)
	○ TOC (Total Organic Carbon)
	○ POC (Particulate Organic Carbon)
	○ Sediment-water interface (O2 flux, redox imagery, nutrients)
	CO2 in air
		○ Pigment fluorescence (Chlorophyll, Phycocyanin, phycoerythrin)
		○ eDNA
		○ Plankton imagery
		○ taxonomy, abundance
		○ Particle size
		○ Bioturbation

Meanwhile, JERICO has progressed tremendously on a more comprehensive observation of biogeochemistry and biology, trying to make biological parameters operationally accessible.

The datasets operationally gathered by JERICO will have a tremendous impact on the capability of CMEMS to provide new services related to the digital coastal environments (simulation, scenarios, forecasting). We believe that JERICO data/datasets will be paramount in supporting the development of new modelling capability (process, functions, etc.) related to ecosystem functioning and dynamics, which are crucial for consolidating the digital ocean initiative.

Besides, we discussed and agreed on JERICO as a provider of expertise in coastal observation and on technological innovation that could support Copernicus coastal strategy and future services.

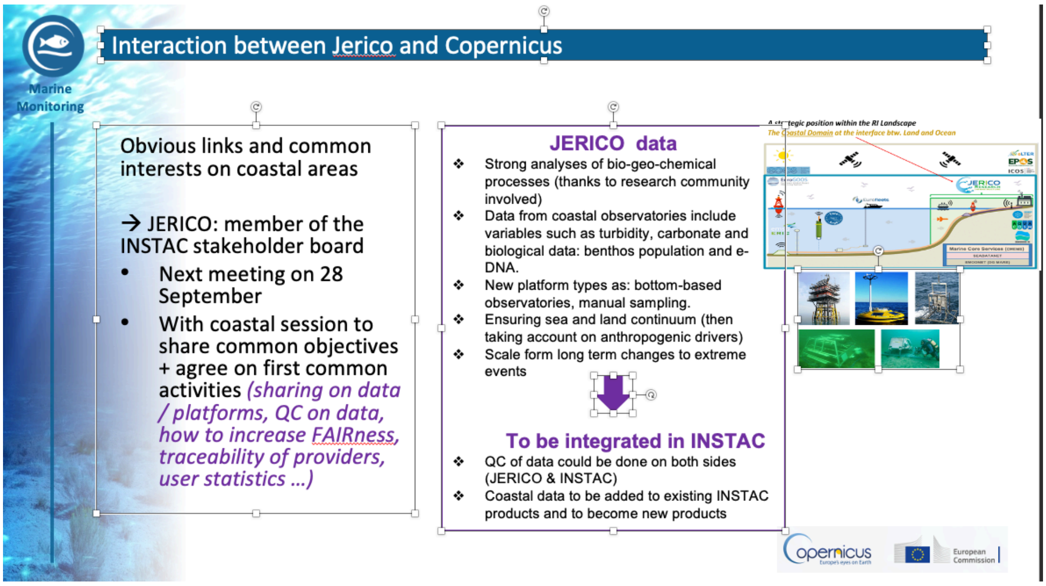

Figure 4 – Interaction between JERICO and Copernicus.

During the last CMEMS requirement consolidation workshop (14-15 September 2023), the need for data to support the effort on the so-called "Green Ocean" (Biogeochemistry) was mentioned as a priority by all MFCs. It was clear that the MFCs were little aware of data/datasets available through JERICO, as they are mostly relying on the INSTAC for in-situ data, which are not yet able to uptake and manage the relevant JERICO data.

A roadmap is to be worked out between JERICO and CMEMS in this regard, as pointed out by INSTAC at the occasion of the 2nd EMODnet-Copernicus Marine Thematic Workshop on coastal issues (September 22, 2023) (Figure 4).

Likewise, the role of High-frequency coastal radar (HF-radars) are considered as crucial for modelling and forecasting of coastal regions (Figure 5), as well as validation and improvement of satellite altimeter estimation of coastal current. The European HF-Radar node is part of the JERICO RI perimeter, with AZTI as coordinator. The future development of the HF-radar network in Europe and its harmonisation, will be developed and implemented as a part of JERICO, and will benefit for the expression of needs and requirements from CMEMS MFCs.

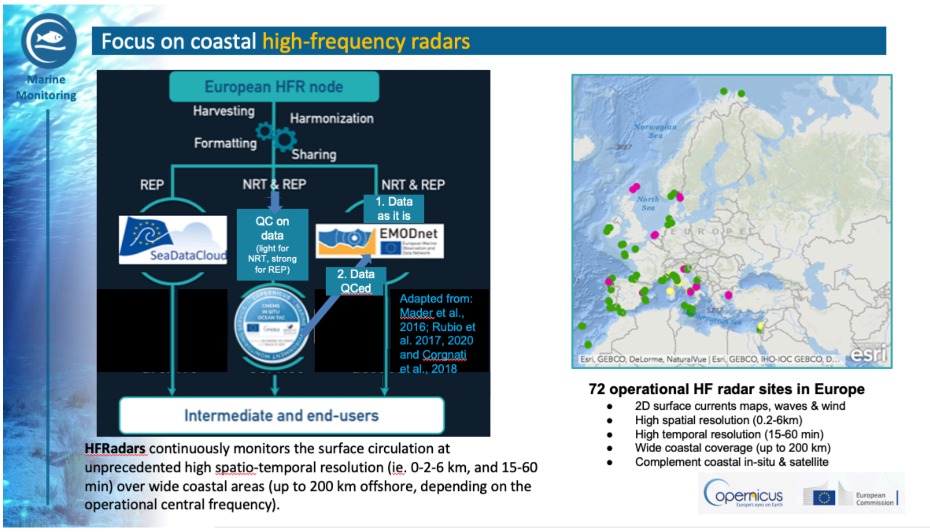

Figure 5 – HF-radar observations within Copernicus.

2.2.3 OCTAC

The Ocean Colour Thematic Assembly Centre (OCTAC) of the Copernicus Marine Service is processing and providing products on a daily and monthly basis, at different scales (global and regional) and different spatial resolutions (100m, 300m, 1 km and 4 km). Thanks to recent missions and improved spatial resolution, products are getting closer to the coastal areas.

As being mainly linked to Bio-Geo-Chemical parameters of the ocean, the OCTAC products are part of CMS dataset called "Green Ocean". Products have been separated into two categories: the **optical** products and the **plankton** products. More specifically these products are:

Plankton:

- Surface concentration of Chlorophyll-a (**Chla**),
- Phytoplankton Functional types and sizes distribution (**PFT/PSD**),
- Primary production (PP)

Optical

- The marine normalised water leaving reflectances **(RRS),**
- The concentration of Coloured Dissolved Organic Matter **(CDOM),**
- The light backscattering coefficient due to particles **(Bbp)** which can be directly linked to the turbidity and concentration of total suspended matter
- The diffuse attenuation coefficient **(Kd)**
- The water transparency under the form of the Secchi Disk Depth **(ZSD)** (Figure 6)

Beyond the processing and the delivery of above Ocean Colour derived products, one of the main missions of OCTAC is to ensure the quality of the products by performing the continuous qualification of data flux (from the source – i.e. space agencies – to the final delivery to users). Products are used for various purposes: science, daily operations, climate studies; all of these topics required a controlled quality and a mastered accuracy of all deliveries. To that purpose two elements are of importance in OCTAC:

- the day-to-day quality control (QC), as well as a kind of "Delayed mode of QC" and
- the validation of products (i.e. the qualification and quantification of uncertainties attached to the products - Figure 7).

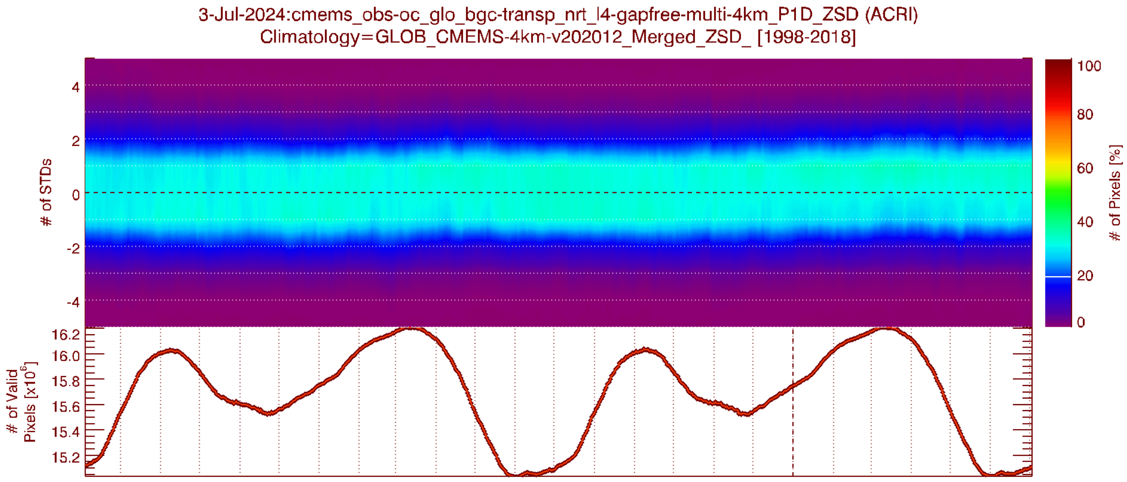

Figure 6 - Illustration of OCTAC product QC (here ZSD) (https://octac.acri.fr/)

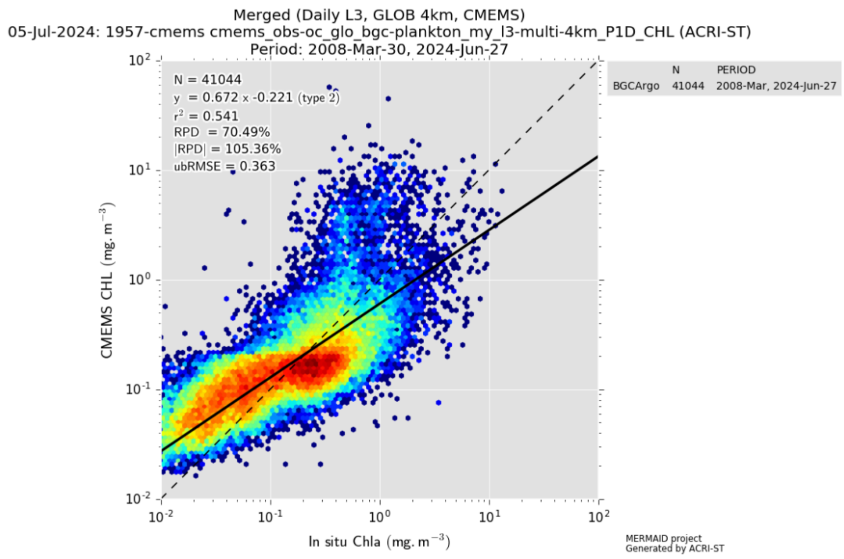

Figure 7 - Illustration of OCTAC product validation (here Chla) (https://octac.acri.fr/)

To serve as reference for these routine tasks of QC and validation of products, OCTAC is continuously looking for new qualified in situ data and the network of observations proposed by JERICO could be a very valuable sources of such data (some – but few – coastal observation network from JERICO are used today by OCTAC). As part of Jerico-S3, a **survey** has been conducted, among JERICO partners, to qualify the compatibility of JERICO measured data with products generated and delivered by OCTAC. The result, synthesised in Annex 1, shows a very good potential for JERICO as a contributor to OCTAC.

As for all activities, **criteria of eligibility for these data to be used for OCTAC** are:

1. strong and reliable documentation of measurements protocol and conditions
2. estimation of quality (necessary requirement) and possibly of quantified uncertainty attached to the product.

On top of these QC and validation tasks, OCTAC is supported by R&D activities that ensure the uptake of the most advanced algorithms for existing or new products. As an example, Primary Production is today subject to many improvements (and therefore evaluation of new algorithms). Another example is the foreseen Entry into Service (EIS) of new products in 2025, namely the concentration of Particulate/Dissolved Organic Carbon (POC and DOC) as well as improved PFT and estimates of pCO2.

As already stated earlier in this report, contributions of JERICO to provide qualified in-situ truth in coastal areas for such parameters (e.g. POC, DOC …) would be very valuable, both for fine tuning of algorithms and for routine operations of qualification.

2.2.4 SST-TAC

As part of FerryBox-based innovations within JERICO, the deployment of deck-mounted sensors for SST was investigated, back in 2005-2010. It showed strong potential for supporting the Cal/Val of satellite SST measurements, which is an issue as bulk surface temperature, generally measured by observing systems, badly correlates with skin surface temperature, measured by satellite.

This investigation was stopped due to lack of funding but could be easily deployed on vessels-of-opportunity and tower-platforms, in the context of JERICO, if fundings from COPERNICUS/ESA for initial investments and operation would become available.

2.3 Relevant JERICO services

As mentioned above, the collaboration framework between Copernicus (including space agencies) and JERICO is manyfold. Through the series of meetings that were carried out as part of JERICO-S3, five sectors have been identified and will be prioritised.

2.3.1 Data access and dedicated measurements

The most obvious service presently provided by JERICO to CMEMS, is the access to pan European harmonised high-frequency coastal observation of the key parameters, following protocols established by the INSTAC.

In the future and as CMEMS progress on the implementation of its Coastal strategy and subsequent services, other parameters from the core JERICO observation portfolio will be available and useful for both hindcast, nowcast and forecast products.

As Artificial Intelligence engine incorporates in the DTO, increasing need for in-situ data will rise. JERICO is already operationally observing many variables and processes, which are not yet used by the modelling community because of the immaturity of ocean modelling especially when biology is concerned. But this data will become a huge asset as the DTO develops and matures. By continuously working to remain on the forefront of coastal observation, JERICO intends to maintain a high relevance for coastal science and coastal management.

JERICO has recommended to implement and deliver specific optical measurements on its platform for supporting Cal/Val and retrieval algorithm development of ocean colour data. Especially, measurement of downwelling irradiance (E0) and water-leaving radiance (Lw) is easily implementable on its FerryBox, surface buoys and tower platforms. Discussions with European space agencies will take place in the context of the project LandSeaLot (See section 2.4).

2.3.2 Observation strategies for Copernicus and the DTO

For accompanying the development of new Copernicus marine products and service in coastal seas, JERICO has proposed to conduct strategic thinking together with CMEMS and EDITO on co-designing the future European coastal observing system, building up on JERICO and complemented (variables to be observed, densification of observations in space and time and sampling strategy, definition of Essential Coastal Processes, etc.) to optimally answering the needs and requirements of CMEMS and the Digital Coast.

The objective will be to propose an ambitious upgrade of JERICO (probably in collaboration with other RIs such as EMBRC and DANUBIUS), as a game changer for the development and implementation of the blue part of the European Green Deal. Obviously, such an initiative will require structural investment way beyond research, but to be proposed as an accompanying measure to the European Investment Bank.

JERICO is developing the capacity to provide harmonised high-quality (Best practices), FAIR, and AI-ready data and datasets over all European coastal regions and self-seas, from the Baltic Sea to the Black Sea, and to deliver these data/datasets to the main European repositories, including Copernicus INSTAC.

JERICO will implement a capacity to elaborate advanced products (statistics, environmental indicators, Multi-platform data visualisation, etc.) under request of specific users. This service can be of interest to CMEMS and the Copernicus Coastal Hub.

2.4 Cooperation model - The LandSeaLot opportunity

Cooperation models based on MoU and/or cooperation agreements with ESA, EUMetSat and Copernicus have been considered, as mentioned in the DoA. It was clarified early in the projects that these two models are not appropriate with these stakeholders, which are used to work with data providers based on Service Level Agreements (SLAs). The latter model has been considered in the service definition (pillar Data management & Products) for future actions when JERICO will enter its implementation phase (ESFRI).

Meanwhile, We have been considering other mechanisms for building partnership with ESA and Copernicus, such collaboration through projects. JERICO seized the great opportunity provided by Horizon Europe under the call HORIZON-CL6-2023-Governance-01, to jointly develop in cooperation with DANUBIUS-RI, the LandSeaLot project, which was kicked off in February 2024.

LandSeaLot (https://Landsealot.eu) aims at defragmenting communities and fostering collaboration for establishing a common observing strategy for optimally observing and studying the land-sea interface. This common strategy is to be elaborated between key stakeholders, contributing to in-situ and satellite observations, and modelling, across rivers, estuaries and coastal sea domains, and addressing key scientific and societal challenges.

In LandSeaLot, ESA and Copernicus services (marine, land monitoring, climate) are directly involved in co-designing the common strategy. It will provide a great opportunity to address the barriers identified above, and to foster and showcase the use of in-situ observations together with satellite data, into joint and new advanced products, serving among other things coastal DTOs.

It is worthwhile mentioning that several JERICO partners are also involved in direct contracting with ESA and CMEMS through the ITT issued by the two organisations, related to the development of new services and ad-hoc products in the context of for ex. the blue economy, nature-based solutions and the support to new satellite missions.

3 COASTAL INDUSTRIES

3.1 A changing context - European green deal and societal transition

Ocean economy encompasses a wide range of sectors, going from the exploitation of living and non-living resources, the renewable energy sector, maritime transport, coastal tourism and leisure and marine manufacturing and construction. Some activities are well established (fisheries, offshore oil and gas, shipping), other are emerging as advancing technologies are opening new frontiers of marine resource development as renewable energy production from wind, wave, salinity gradients, tidal, thermal and biomass sources, marine biotechnology, mining of seabed mineral resources. These new sectors provide new prospects and generate opportunities for economic growth and new jobs.

According to The Ocean Economy in 2030 report, the size of the global ocean economy is going to grow faster than the general economy, with a global gross value added projected to be multiplied by three in 2030 with respect to 2010. The ocean economic sectors with the strongest growth potential include marine aquaculture, fish processing, offshore wind, and shipbuilding.

In recent years, the global community has increasingly recognized the urgent need for concerted action to address the mounting environmental challenges facing our planet's oceans. Many large international initiatives have emerged, each aiming to tackle specific aspects of ocean conservation, restoration and sustainable blue economy. These initiatives represent collaborative efforts involving governments, intergovernmental organisations, non-governmental organisations, academia, and the private sector, with the shared goal of safeguarding the health and resilience of our oceans for future generations, and with demonstrating major progress by 20230.

In Europe the overarching framework is the European Green Deal, which stands as a comprehensive roadmap for the European Union's transition to a sustainable and carbon-neutral economy. Central to this initiative is the recognition of the critical role that oceans play in regulating the Earth's climate, supporting biodiversity, and providing essential ecosystem services. The European Green Deal outlines ambitious targets and policy measures to support the transition towards a more sustainable and renewable energy system and food system, and the fostering of the development of blue economy sectors in a manner that respects ecological boundaries and safeguards marine ecosystems.

Two main targets have been defined related to the energy and food transition: (1) 40 times more energy from the sea, and (2) 6 times more food from the sea by 2030 (take home messages from the UN Ocean summit, Lisbon June 2021). It is expected that a significant part of the measures necessary for implementing these targets will occur in coastal and shelf-seas regions.

In connection to these ambitious objectives of sustainability (economical, environmental and political), the necessity of robust tools for simulating so-called “what if” scenarios has become a keystone for decision-making, especially with regards to the billions of Euros investment to be deployed in support to the marine-based energy transition. This has crystallised into the concept of Digital Twin of the Ocean (DTO).

3.2 The role of industry in coastal observation

In this section, one is addressing the contribution from technology developers, and from marine/maritime large corporations to coastal observations, trying to identify barriers for and opportunities in joining forces. A section is dedicated to data sharing exemplifying what the aquaculture sector in Norway has been achieving by setting up a legal framework and operational tools, for sharing "sensitive" corporate data for the benefit of the entire sector.

3.2.1 Technology manufacturers

Technology developers are key enablers of coastal observation, by providing instrumentations that are the backbones of coastal observing systems.

a) Barriers:

A lot of technological innovations take place in research organisations, developing ad-hoc prototypes for answering specific scientific questions. Sometimes, the design and development are done in collaboration with a private company (often a SME). However, very few of these innovations develop beyond TRL7, into a robust and profitable business. The technology developers (sensors, observation vehicles, etc.) often must focus on rather generic instrumentations, not only used for science but a large range of users from the private sector. It limits drastically the emerging of new technologies, which are required for answering the current societal challenges, even if the maturity of the technology and of the concepts are appropriate.

Presently, the collaborative effort on technology development between the science community and SMEs are mostly done through one-to-one collaboration between one laboratory and one company. There are very few, if not none, initiatives gathering a large scientific community (many research organisations in Europe) and the private sector for developing high-impact technologies with low economical risk for the company.

b) Opportunities

The critical mass of potential scientific customers gathered in a European RI, such as JERICO, may provide a big-enough market prospect for companies to engage on specific development in partnership with the research sector. This opportunity could become even more sustainable if several marine RIs would join forces and set common priorities on technological barriers to be removed, and to implement joint purchase of technology. New partnership models are required to enable seizing such an opportunity. This has been discussed with many SMEs in the context of the JERICO-S3 project, and will be investigated further after the end of JERICO-S3.

Another significant opportunity is related to the new trends introduced in the previous section, bringing stronger demands on data amount and on effective, easy-handling and reliable technologies that can facilitate densifying observations and empowering citizens through citizen science actions. To increase the cost-benefit and sustainability of ocean observing platforms and systems, observers have turned their attention toward technologies that can deliver data from greater coverage at effective cost. The 2024 EOOS Technology Forum was co-organized by EuroGOOS and JERICO, at the occasion of the "Oceanology International" event in London (May 2024). The latter was considered as a great opportunity to bring together for one day, during a workshop, a panel of companies contributing to technological development for oceanographic observation. The event focused on the technologies and systems transforming the ongoing operations of critical marine observing infrastructure and initiatives. The innovation and practical steps needed to expand capabilities in terms of value, return-on-investment and data provision while continuing to preserve functional cost-effectiveness and asset integrity were also discussed. It brought together technology developers, manufacturers and users to exchange knowledge on platforms and sensors of all types, costs and levels of technical sophistication with the goal to enhance accessibility of ocean observations. Key technological issues such as ease of maintenance, evolution and adaptation, ease of deployment and sustainability, were discussed. The event identified and promoted emerging synergies in the technology community to advance the optimisation of ocean observing worldwide.

Four sessions were organised, and their take-home messages are summarised hereafter.

Session 1 - Accessible technology: needs of the ocean observing community

Take home messages:

- There is a strong need to take accessible ocean observing technologies into account at the level of international stakeholders.
- At European level, we have a vision, projects, players and a forum.
- At this stage, it appears that collaborations on sea observation between United States and European Union, which started in bilateral research cooperation (i.e. COPEUS) is now well supported by more global frameworks (i.e. Ocean Decade, GOOS)

Session 2 - Opportunities and challenges for accessible ocean observing

This session overviewed the current challenges confronting the field of accessible ocean observing technology (i.e., sensors and platforms), and highlighted current innovations and successes that are expanding the field and progressing towards an accessible ocean.

Take home messages:

- The cost of the data could be a good metric to define 'accessible' techs.
- To be accessible, most technologies need to be open, both national governments and the private sector have to chip in.
- There is a need to enhance, share and disseminate the innovations regarding accessible technologies. Training aspects and Best Practices sharing should mobilise the community.
- There is a need to offer opportunities to all communities to showcase new ideas and new achievements. Traditional events such as OI should evolve to support the dissemination of such promising practices.
- JERICO and EOOS could be great catalysts of this evolution.

Session 3: Data quality aspects of accessible ocean observing technologies

In this session the panel explored the whole ocean data value chain, covering preparation and calibration, collection and acquisition, data management, transformation to information (product and service development), and advice to society and information decisions.

Take home messages:

- Regarding the data value chain, there are methodological challenges to assess the costs of the calibration step. Initiatives such as MINKE should/will be taken over by Research Infrastructure such as JERICO

- Actions should be taken to strengthen the trust between users and manufacturers on the sensor calibration segment of the data quality.
- We need processes or capacity sharing services to adapt data accuracy to different uses

Session 4: Sustainability aspects of accessible ocean observing technologies

This session addressed three dimensions of sustainability related to ocean observing technology with a specific focus on how these might be affected through a change towards more accessible solutions, namely (i) economical sustainability and viability of ocean observing products; (ii) the environmental sustainability and footprint or the greening of ocean observations; (iii) political and regulatory sustainability related to observations of the ocean.

Take home messages:

- Demand by customers, shareholders and regulation, especially in the growing and maturing Ocean Enterprise, further drives manufacturers towards environmental sustainability of ocean observing technologies (see section 3.2.2 for details).
- Needs for a unified, prevailed and applied methodology to assess the environmental impact of sensors.
- Improving the recoverability, repairability and reusability of platforms and sensors when no longer operational, should be a priority. Given their positions of well-established prescriptors, Research infrastructures should support/initiate/harmonise manufacturers and regulators actions

3.2.2 Corporate users of the ocean space

a) Corporate Environmental and Social Responsibility

At the heart of the sustainable use of the ocean space for the blue economy is the concept of Corporate Environmental and Social Responsibility (CESR) practices. CESR practices are policies and actions taken by companies to ensure their business operations are conducted sustainably, ethically, and with consideration for environmental and social impacts. This has become a keystone of the private sector behaviours and practices when using the ocean space. The development of the EU taxonomy for evaluating greening is reinforcing the need and implementation of CESR practices by the private sector.

In the context of ocean observation, CESR practices encompass the efforts of companies to monitor, protect, and sustainably manage ocean and coastal ecosystems, ensuring that their operations do not harm marine environments and contribute positively to the well-being of coastal communities. Through CESR practices coastal-based companies contribute to ocean observation. Indeed, regular monitoring and transparent reporting of environmental impacts are key aspects of CESR. Advanced ocean observation technologies, such as sensors and remote sensing, collect data on water quality, marine life health, and ecosystem changes. This data informs stakeholders about the company's environmental performance and fosters accountability.

Collaboration with research institutions, non-profits, and government agencies enhances ocean observation efforts. Partnerships allow for sharing data, resources, and expertise, leading to more effective monitoring programs. For example, companies can support research on the impacts of climate change on coastal ecosystems.

Investment made by companies in innovative technologies, such as autonomous underwater vehicles (AUVs), IoT devices, and real-time monitoring systems, improves coastal ocean observation. These technologies provide critical data on ocean conditions, helping to understand and mitigate the impacts of industrial activities on marine environments.

Adherence to environmental regulations is fundamental to CESR. Leading companies often exceed compliance by adopting voluntary initiatives, such as the UN Global Compact and the Sustainable Development Goals (SDGs), which promote higher environmental and social standards.

b) The Ocean Enterprise initiative

The Ocean Enterprise Initiative (OEI) was launched by the Marine Technology Society (MTS) in partnership with NOAA and other key stakeholders in the ocean technology sector. The initiative is designed to foster innovation, promote economic growth, and enhance collaboration among public, private, nonprofit, and academic entities involved in ocean observation and marine technology.

Established in 2023, the OEI aims to advance industry engagement and thought leadership, supporting the development of robust ocean observing systems and sustainable ocean use. A key element of the initiative is the "Dialogues with Industry" program (Figure 8), which started in 2022, involving partners such as NOAA, the Global Ocean Observing System (GOOS), and Kongsberg Discovery[8].

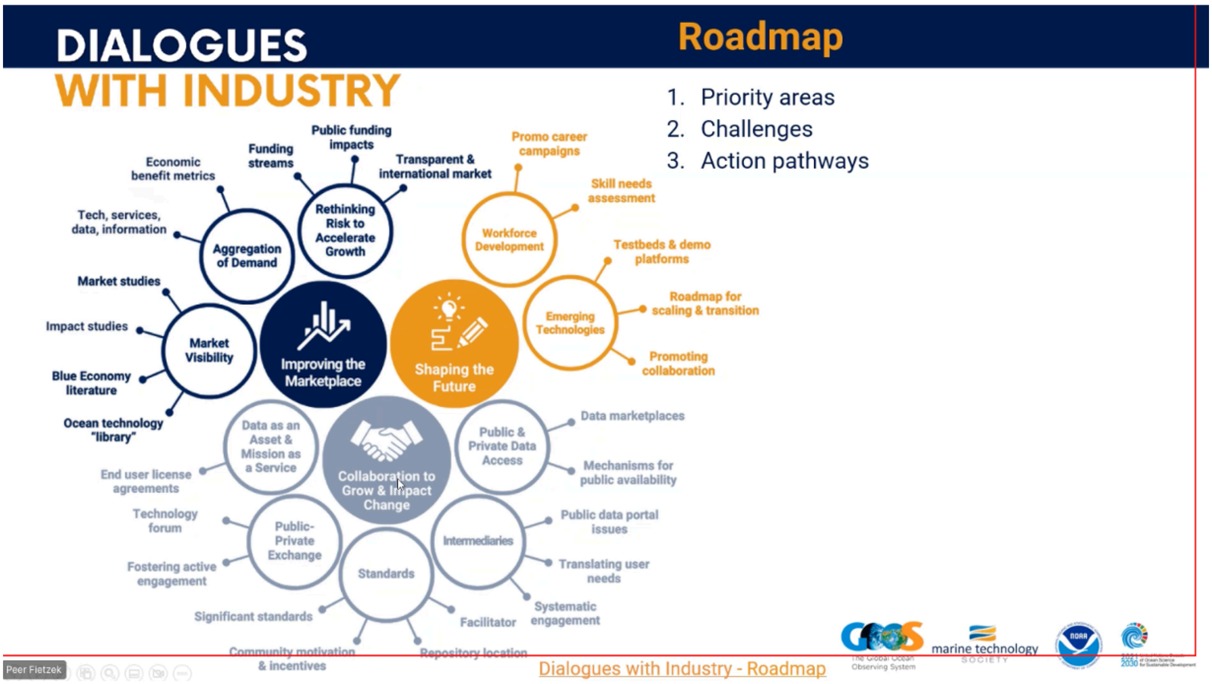

Figure 8 – Dialogues with industry program of the Ocean Enterprise Initiatve.

By leveraging cutting-edge tools such as autonomous underwater vehicles (AUVs), remote sensing technologies, and data analytics, the Ocean Enterprise Initiative seeks to address critical challenges facing our oceans, promote economic growth, and ensure the health and resilience of marine ecosystems.

[8] Kongsberg Discovery is serving the sustainable use of ocean space from the deepest sea to the outer space, and continuously develops solutions and products addressing environmental implications on the ocean ecosystem as well as solving operational challenges.

If the Ocean enterprise is a global initiative, establishing a strong European hub could be an effective manner for organising the collaborative framework, and adapting it to European culture and practices (Figure 9). JERICO has led dialogues with the IOC/UN decade, GOOS and Kongsberg Discovery on the possible co-design what such a European hub could become.

If this initiative is at a very preliminary stage, it holds a great potential for enforcing a breakthrough in partnering between industry and the coastal observation science community.

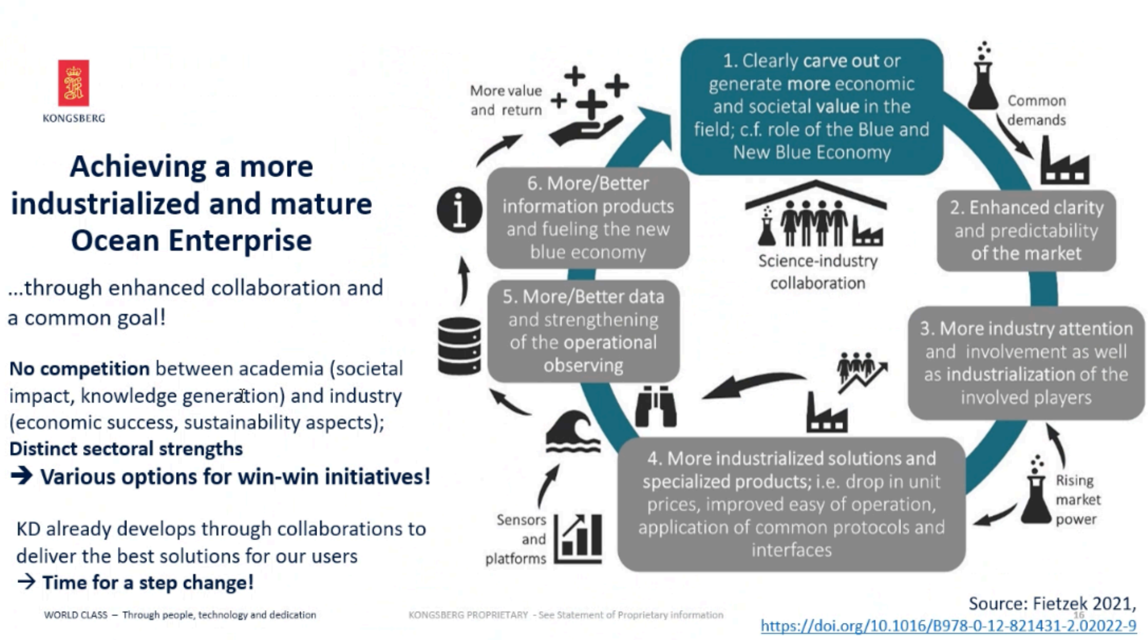

Figure 9 – The Ocean Enterprise initiative as envisioned by Kongsberg Discovery (Peer Fietzek, 2021).

Several JERICO partners are now actively following-up OEI, and we intend to continue collaborating with Kongsberg on designing a European hub, for the beneit of the European Green Deal.

3.2.3 Data sharing with industry - the Norwegian aquaculture sector example

This section summarises the content and outcomes of the Dialogue conducted by JERICO with AQUACLOUD AS (Seafood Innovation Cluster, Norway).

Starting about 7 years ago, The Aquaculture sector of Norway, through their membership into the NCE Seafood Innovation Cluster, established an innovative collaborative framework (Aquacloud) for jointly solving the huge industrial challenge of the salmon lice, affecting fish-farming production. They spent more than two years seeking an appropriate legal framework enabling the removal of main barriers (practice, culture) related to sharing of production and operation data for fish-farms. In partnership with IBM and its AI-platform – Watson – the cluster gathered both production data from the industry, ocean observation from the Norwegian science community and model simulation and forecasting tools.

This is a unique example of an industrial sector sharing data for the benefit of all and joining effort with the scientific sector for better observing and understanding the environment, towards more informed decision-making.

AquaCloud has now developed into a Norwegian industry cooperation, in the form of a limited company, on large, nation-wide, datasets, aiming at facilitating fast learning and situational awareness. The company now receives, amongst other, data on water quality, fish growth, feeding, health and mortality (Figure 10). The latter one is granulated down to number, weight, and categorisation on causes of mortalities, according to a AquaCloud facilitated standard.

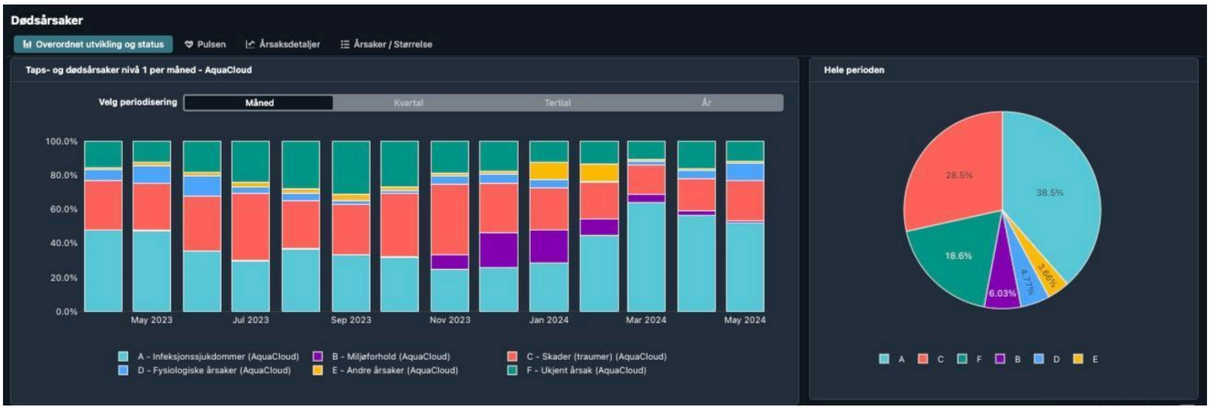

Figure 10 – Main evolution of mortality and its causes (infection, physiological disorder, environmental conditions, injuries, etc.), based on data from 400 Norwegian fish-farms.

The database receives environmental data from some 400 individual sites on a daily basis. The data is temperature (Figure 11), salinity and oxygen. The data has several very important aspects, one being the great north/south axis, another is the west/east axis displaying different ecosystems from oceanic to fjord ecosystems with their different traits.

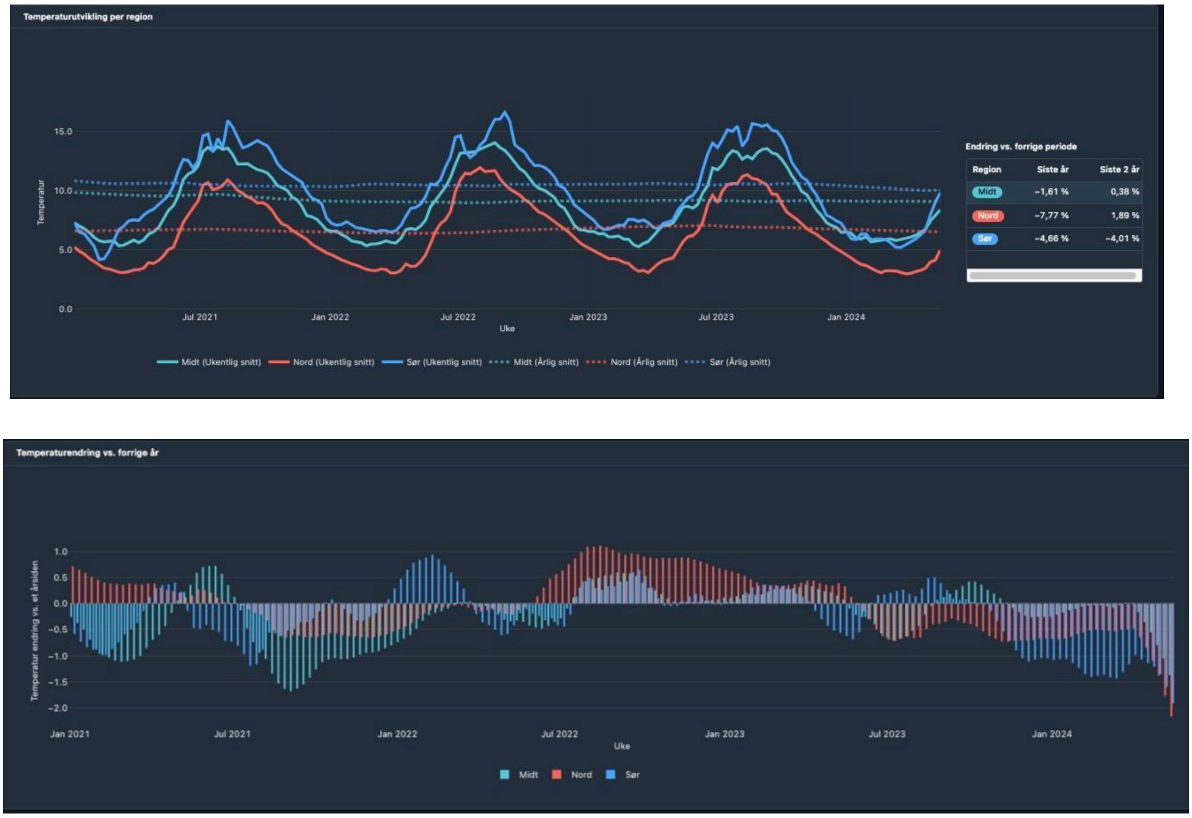

Figure 11 – Temperature data delivered by fish-farmers to Aquacloud, and AI analytics of interannual variability, for Northern Norway (red), mid-Norway (green) and South-Norway (blue).

Another is the time axis, as the data is updated daily and over a number of years. In due time, this data set will have a considerable depth in time, as well as seeing the number of data suppliers increase. This data set makes for granularity of data over large areas, hardly ever seen by other means.

However, the coastal data in Norway, indeed most, if not all, coastal states, is sorely lacking continuous, granular measurements of other variables such as chemical, physical as well as biological parameters.

Bjørgolfur Håvarsson (Innovation manager at the seafood innovation cluster and board member of AQUACLOUD AS) stated the following:

"JERICO would be a good partner in increasing the depth and detail in understanding the oceans, both for use and protection. Without such data, one is surely subject to guessing on how changes in climate and ocean chemistry affects ecosystems and ocean based biological industries such as kelp farming, shellfish farming and finfish farming.

Some of the aspects that are sorely missing are: Oceanographical, chemical and physical aspects such as currents at multiple depths (speed and direction), deep profiles of temperature, oxygen, carbon dioxide, nutritional salts (N, P, Iron, pollution from industries and natural occurring release of carbohydrates/metals, long-term trends in climate, HAB and extreme situations (temperature, oxygen, weather, currents etc).

Combining industrial data (multiple, frequent measurement with huge geographical distribution but with somewhat lower quality than scientific) with high quality, detailed scientifically quality assured data will be a possible game-changer in all aspects of coastal management.

To mention but few, models of coastal currents are gaining ground in understanding how industrial effluents, pathogens etc, spread in the environment. Without quite comprehensive datasets and the understanding of interactions between pathogens and sea water properties will only give the most rudimentary epidemiology, especially in areas of ecological value where industries have a potential to disrupt the ecology.

Such depth and amount of data would become an invaluable resource in supporting European fisheries and aquaculture industries in meeting the challenges the future will inevitably bring. Challenges like ecosystem loss, choice of areas to protect, while allowing European industries to coexist and thrive bound by protected areas and ocean power production, all in the context of environmental changes that will change the same fisheries industries. Furthermore, understanding coastal waters is also the key to understand local climate and changes to local climate that will impact aquaculture."

AquaCloud can be seen as a Norwegian implementation of the OEI concept for the aquaculture sector. JERICO will continue working closely with AQUACLOUD, learning the industry and better understanding the expectations, in developing high-impact services. It is also agreed that the European profile of the seafood innovation cluster, in partnership with JERICO, will be used to foster further collaboration and best practices on coastal aquaculture in Europe.

3.3 JERICO successful stories of cooperation with the industry

In this section, we provide some highlights on success stories of different nature and objectives, but all based upon a partnership between a private company and JERICO.

3.3.1 Cooperation with SMEs through TA service

As part of the JERICO European Infrastructure JERICO-S3 project, French company SEABER accessed the SmartBay Observatory under the JERICO-S3 Transnational Access (TA) funding programme. The main objective of this trial was to showcase the capability and complementarity of the YUCO micro-AUV in providing spatially referenced qualitative salinity data in a real sea coastal environment with waves, currents and tides. SEABER demonstrated the YUCO micro-AUV, a micro Autonomous Underwater Vehicle, which is an unmanned, untethered vehicle that collects oceanographic data in coastal environments. The trial was carried out at the SmartBay Test Facility operated by the Marine Institute, Smartbay is Ireland's national marine scientific research facility, providing national and international researchers with the infrastructure to validate new marine sensors and instruments in real sea conditions.

Alan Berry, Manager of Marine Research Infrastructures at the Marine Institute said, "*The SmartBay Observatory is used to validate new sensor technologies, such as SEABER's innovative and affordable micro AUV system. New marine sensor technologies increase the accessibility and availability of data for organisations monitoring our oceans and in turn contributes globally to our deeper understanding of the oceans.*"

Luc Simon, Global Business Development Manager at SEABER said, "*We were honoured and thrilled to be selected for the JERICO European Infrastructure JERICO-S3 access programme. We were delighted to work with the Marine Institute and SmartBay team to showcase our YUCO micro-AUV system.*"

Details of the SEABER trial of the Yuco platform can be viewed in the following report - https://www.jerico-ri.eu/wp-content/uploads/2022/09/JS3_CALL_1_REF_4031_YUCO-CTD_Final_Project_Report.pdf

The trial was entitled "Validation of an innovative easy-to-use affordable YUCO-CTD micro-AUV platform, embedding an high accuracy and resolution CTD sensor" and it had the following objectives:

- Demonstrate the accessibility, ease-of-use and reliability of this AUV technology to oceanographers such as ocean physicists, who are not necessarily trained in underwater robotics.
- Demonstrate that this micro-AUV technology is able to perform accessible, swift and reliable CTD measurements in challenging coastal environments. - Prove that micro-AUVs embedded with CTD sensors can be used to complement the existing methodologies for CTD measurement.
- Provide a use case to show that more distributed, repeated and scientifically reliable CTD measurements can be made in coastal areas using Yuco-CTD micro-AUV.
- Demonstrate the capability of Yuco-CTD micro-AUV to perform almost vertical profiles with various "sawtooth" navigation modes in coastal waters. - Prove the capability of Yuco-AUV to navigate accurately in unsheltered coastal areas with tidal currents such as those present in Galway Bay thanks to INX © navigation.
- Perform high sampling, high resolution and high accuracy temperature and salinity measurement on the Yuco micro-AUV moving platform based on CTD RBR Argo referenced sensor.
- Demonstrate the autonomy and useability of Yuco-CTD micro-AUV platform combining AUV own performance and low-power CTD. - Analyse variation and

measurement of temperature stratification and correlate Yuco-CTD measurements with data from the SmartBay cabled observatory and glider reference platforms.

Based, in part on the AUV validation trial in Galway bay and the access to the trial's dataset , oceanographers at the Marine Institute began to assess potential applications for micro-AUV platforms to help improve the Institutes monitoring programmes into the future using these relatively low cost platforms.

The Marine Institute now operates a YUCO CTD unit to collect high temporal and spatial resolution Conductivity, Temperature, Depth and environmental measurements in Irish coastal waters (water depths from 0- 200m). A key capability is that the AUV has the capacity to operate unattended for several hours in coastal embayments, periodically exposed to open Atlantic Ocean conditions and provide accurate and precise data. Since receiving training from Seaber on the AUV unit, it has been deployed twice in Galway Bay in 2024 and is now being deployed over the coming weeks in inshore areas in Co. Kerry.

A number of other testing trials and deployments involving SMEs have been carried out across a range of JERICO RI facilities over the duration of the project as part of the Transnational Access Programme and these are described in detail in JERICO-S3 Deliverables D8.2 and D8.3

Figure 12 – Images from the Seaber Yuco Autonomous Underwater Vehicle Trial carried out at Smartbay - a JERICO Research Infrastructure facility in Galway Bay on the west coast of Ireland..

3.3.2 Coastal risk management of storm event in Southeastern Bay of Biscay

The following success story relates to the Key Societal Challenge (KSC) #2 – Assessing impacts of extreme events and is based on tools and services operated by RPT-SUEZ for the Biarritz city, in collaboration with JERICO-EuskOOS Research Infrastructure operated by AZTI.

a) Context of the collaboration

Significant stormy events occurred during the winter 2013-2014 in Southeastern Bay of Biscay producing important damages in coastal cities like San Sebastian or Biarritz. Different early warning systems are in place at national level, but the current space and time scale of the forecasts have been shown as insufficient and local authorities expressed their need for tools at local scale to support effective operational contingency measures and decisions.

RIVAGES PRO TECH of the SUEZ company is a centre of technical and scientific expertise specialised in the management of aquatic environments in response to the needs of local authorities. They develop tools and services for real-time monitoring and forecasting of the nearshore environment for empowered decision making. For example, local authorities in charge of bathing water quality and coastal waters as well as beach users benefit from RIVAGES PRO TECH services. RIVAGES PRO TECH collects data, runs detailed ocean models and provides synthetic indicators for decision making support.

EuskOOS is the operational oceanography system for the Basque coast operated by the metocean agency Euskalmet with the support of the scientific and technological centre AZTI. The EuskOOS Research Infrastructure managed by AZTI includes data services from the different coastal platforms, task forces for deploying observational and modelling tools, advanced expertise on the development of solutions for improving the sustainable management of the coastal area and promoting opportunities in the blue economy.

The collaboration between SUEZ and the EuskOOS-RI has been framed in KOSTARISK, a joint cross-border laboratory for applied research in observation and modelling to support coastal risk management created in 2021. KOSTARISK associates the Wave Interaction and Structure team of the SIAME laboratory, AZTI and RIVAGES PRO TECH of SUEZ. The objective of this laboratory is to bring together researchers from the three organisations in order to implement scientific and technological cooperation in the fields of numerical modelling, physical measurement systems and advanced data analysis, for the development of tools to assist in the management and mitigation of coastal risks.

Figure 13 - Risk levels of the Biarritz early warning system for wave flooding events

b) JERICO-EuskOOS-RI contribution in the service operated by SUEZ

The Donostia buoy is part of the Basque Operational Oceanography System EuskOOS. This fixed platform has been operational since 2007. It is providing NRT data through different products in EuskOOS data centre and in European Data aggregators (EMODnet, Copernicus Marine Service). In this case, RIVAGES PRO TECH is accessing the Donostia Buoy data, first to validate the offshore boundary conditions of their nested forecasting system, then to assimilate the data in the analysis used for correcting the modelling chain (waves at coast and currents).

In addition, EuskOOS-RI provided instrumentation, technicians and divers for acquiring local datasets in the framework of the INTERREG POCTEFA MARLIT project. The datasets obtained from the field work and the exchange on the role of the different components in the impact of wave flooding have allowed RIVAGES PRO TECH to improve and validate the modelling strategy of the early warning system.

Finally, the experts of EuskOOS-RI in coastal videometry supported the installation of the KOSTASystem technology (www.kostasystem.com) able to monitor NRT overtopping in the Biarritz promenade. Those data are contributing both to the forecasting system validation and operational monitoring of the extreme flooding events.

c) Data sharing with industry

The data generated by RIVAGES PRO TECH -SUEZ in the framework of the KOSTARISK R&D projects are shared with the scientific community through the cross-border data exchange platform.

The data generated in the framework of the operational services to the Biarritz city are also shared. For example, the costal videometry data are available online. However, challenges for defining standard and best practices in the management of those data is still a pending issue. EuskOOS-RI plans to work on it in the future.

Moreover, RIVAGES PRO TECH -SUEZ acknowledges the source of data and support coming from EuskOOS-RI or other observational networks. This is the case in the specific interfaces created for their client.

A valuable database gathering environmental factors (forecasted and observed) together with information on measures taken by authorities and damages observed in the coast for the different stormy events is also shared with their scientific partners of KOSTARISK.

d) Lesson learned from this story and recommendation for the future

There is a long tradition of public and private collaboration promoted by local authorities for tackling key issues of coastal management in the cross-border area between South Aquitaine (FR) and Euskadi (SP). This long-term collaborative framework and the corresponding trust established between the private company SUEZ and the Research Infrastructure operated by AZTI is a key element in the successful transfer of knowledge, competence, and solutions.

The role of a technology centre, expert in applied science and transfer to society, is important for ensuring the impact of the Research Infrastructure and the connection with Industry.

Finally, the own internal scientific capacities of the research team of RIVAGES PRO TECH are also contributing to a successful co-design, co-development, and co-validation of the tools.

3.3.3 Coastal Ocean Management and Tourism in the Balearic Islands

Two success stories on collaboration with the industry have been prepared by SOCIB, Spain, with emphasis on lesson-learned that will benefit the consolation of pan-European services by JERICO.

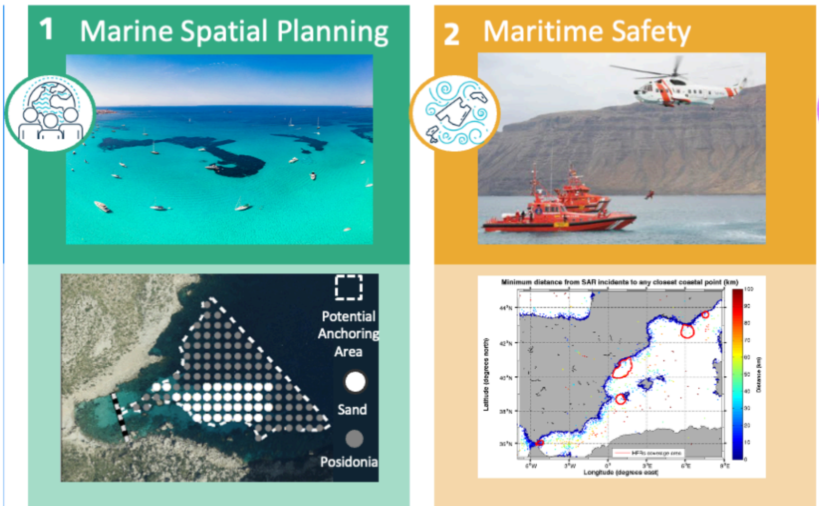

Figure 12 - Overview of the two case studies in support of Coastal and Ocean Sustainable Management & tourism in the Balearic Sea.

a) Case study 1.- Marine Spatial Planning and Recreational Boating Carrying Capacity

Case study 1.- Marine Spatial Planning and Recreational Boating Carrying Capacity	
Why	Knowledge based Conservation of Marine and Coastal Resources is a clear priority in the Balearic Islands that needs to be well balanced with tourism and recreational boating. This sector significantly boosts the Balearic Islands' economy, with over 20,000 moorings, constituting 5% of the Mediterranean total and 17% in Spain, leading to significant impacts on the marine ecosystem.
What	SOCIB conducted detailed spatial analysis to determine nautical carrying capacity, establishing physical limits for anchoring areas (Balaguer *et al*., 2011[9]; Gómez *et al*., 2023)[10].
Collaboration	SOCIB together with the DG for **Harbors of the Balearic Government**, conducted this study in the framework of the General Plan of Ports of the Balearic Islands 2018-2033. Objectives and goals: to estimate the capacity to accommodate recreational boats in the anchorage areas of the Balearic Islands, taking into account different spatial scenarios and anchoring hypotheses that are linked to environmental preservation and user well-being. Stakeholders involved: Ports de les Illes Balears, Aquatica Ingeniería Civil, SL, Regional council of mobility and housing, regional directorate of maritime and air transport.
RI data and services	Use of RI data and services: Geographical information from SA COSTA https://gis.socib.es/sacosta/; Environmental Sensitivity maps of the Coastline. Bathymetry source data: EMODnet, [26]; marine habitat cartography source data: Julià et al. 2018[11] and Julià et al. 2019. Specific RI data or tools employed: Categorization of the coastline, location of beaches, recognition of marine protected areas, delimitation of administration units. RI data supporting project goals: ● High-quality data collection: RI data provides precise, comprehensive datasets crucial for accurate spatial analysis, including environmental data, usage patterns, and spatial distribution. ● Enhanced spatial analysis: Advanced tools within RI allow for precise models representing physical limits and environmental constraints, ensuring reliable capacity estimates. ● Integrated assessments: RI data enables the integration of ecological and economic assessments, balancing environmental preservation with economic benefits. ● Informed decision-making: High-quality data empowers stakeholders to make scientifically sound, socially, and economically viable decisions.

[9] https://doi.org/10.1016/j.ocecoaman.2010.12.002

[10] https://doi.org/10.25704/TPA5-4Y84

[11] http://ide.cime.es/visoride/

	● Facilitated collaboration: RI data provides a common, objective basis for discussions, aiding consensus-building among diverse stakeholders.
Joint utilisation of scientific data and data from public-private sectors	Data shared with the end user: All data from the Spatial analysis of the nautical carrying capacity of anchorage areas in the Balearic Islands have been openly shared with the end-users. All data already published in the scientific paper have been openly shared with the end-user. Data shared by the end user: Number of moorings in the different port facilities managed by the end user.
Lessons learned that can benefit the implementation of JERICO	Challenges identified: ● Balancing economic growth with environmental sustainability: The primary challenge was to find a balance between the economic benefits of recreational boating and the need to preserve marine and coastal ecosystems. ● Determining nautical carrying capacity: Conducting detailed spatial analysis to establish the physical limits for anchoring areas required to predict the capacity for accommodating recreational boats while considering different spatial scenarios and anchoring hypotheses. ● Multi-stakeholder coordination: Effective collaboration among various stakeholders, including Ports de les Illes Balears, Aquatica Ingeniería Civil, SL, the Regional Council of Mobility and Housing, and the Regional Directorate of Maritime and Air Transport, was essential. Aligning their diverse objectives and ensuring their active participation throughout the study was challenging but necessary for comprehensive planning and implementation. Insights into successful strategies: ● Data-driven decision making: Utilising detailed spatial analysis and data-driven methodologies proved to be a cornerstone of the project's success. SOCIB's approach to determining nautical carrying capacity through comprehensive data collection and analysis enabled informed decision-making that balanced environmental and economic considerations effectively. For JERICO, leveraging robust data analytics can enhance the accuracy and reliability of marine spatial planning efforts. ● Collaborative governance: The study's success was heavily reliant on the strong collaboration between SOCIB, the DG for Harbors of the Balearic Government, and other stakeholders. This multi-stakeholder partnership ensured that diverse perspectives were considered, and that there was broad support for the project's goals. JERICO can replicate this by fostering inclusive governance structures that engage all relevant parties, from government agencies to local communities and industry stakeholders. ● Clear objectives and adaptive strategies: Setting clear objectives and maintaining flexibility to adapt to new information or changing conditions was crucial. The study aimed to estimate the capacity for recreational boats while

	linking these estimates to environmental preservation and user well-being. By setting precise goals and being open to adjusting strategies as needed, JERICO can navigate complexities more effectively and achieve long-term sustainability. ● Holistic environmental management: The project's holistic approach, which integrated environmental, social, and economic aspects, ensured a balanced and sustainable outcome. SOCIB's focus on the overall impact on the marine ecosystem, rather than just isolated components, provides a model for comprehensive environmental management. JERICO can benefit from adopting a similarly integrated approach to its projects, ensuring that all facets of the marine environment are considered in planning and implementation. ● Engagement and communication: Continuous engagement and transparent communication with stakeholders were pivotal. Regular updates, consultations, and feedback loops helped to build trust and ensure that the project remained aligned with the stakeholders' needs and expectations. For JERICO, establishing effective communication channels and engaging stakeholders throughout the project lifecycle can enhance collaboration and support. ● Leveraging Technology and Innovation: The use of advanced technologies and innovative approaches in spatial analysis and carrying capacity estimation was key to the project's achievements. Embracing cutting-edge tools and methodologies can provide JERICO with the precision and efficiency needed to manage marine resources effectively and sustainably.
Recommendations to JERICO for future services and collaboration	Suggestions for enhancing data sharing practices: ● Establishing a centralised data repository. ● Standardising data formats and protocols. ● Promoting Open Data Policies. ● Developing Data Sharing Agreements. ● Encouraging continuous data updates and feedback loops. ● Providing training and support. Strategies for maximising the impact and value of RI data and services: ● Enhancing data accessibility and usability. ● Integrating data with decision-making processes. ● Fostering collaboration and knowledge exchange. ● Developing targeted outreach and training programs. ● Encouraging innovation through Open Data and Tools. ● Monitoring and evaluating impact. ● Showcasing success stories and best practices.
Additional material	Paper: Gómez, A.G., Balaguer, P., Fernández-Mora, A., Tintoré, J. 2023. *Mapping the nautical carrying capacity of anchoring areas of the Balearic Islands' coast*, Marine Policy: 155, 105775.

b) Case study 2.- Maritime Safety and Search and Rescue -SAR- Operations (KSC#2)

Case study 2.- Maritime Safety and Search and Rescue -SAR- Operations	
Why	Knowledge based Search and Rescue -SAR- procedures can lead to significant reduction of response times. Over 50% of SAR cases in Spain, especially in summer months, happen within 3 km of the coastline, according to 2019 data from the Spanish National Agency. This trend is also observed in six other Mediterranean countries, emphasising the importance of accurate coastal data for an effective response. SOCIB established a long-lasting and trustable collaboration with the Spanish Maritime Safety and Rescue Society.
What	SOCIB created IBISAR in the frame of **Copernicus Marine Service** User Uptake Program. IBISAR is a service enabling visualisation, comparison, and assessment of ocean current prediction performance in the Iberia-Biscay-Ireland (IBI) regional seas (Révelard et al., 2021[12]; Reyes et al., 2020[13], 2022[14]).
Collaboration	This collaboration has been carried out in the context of a long-standing collaboration between SOCIB and SASEMAR under the umbrella of a general protocol of action between the Maritime Rescue and Safety Society (Jovellanos Integral Maritime Safety Center) and SOCIB.
RI data and services	Use of RI data and services: Observations from drifters and 6 High-frequency radar (HFR) networks available in the Iberian-Biscay-Irish regional seas domain. Most of the HFR networks are national infrastructures contributing to JERICO (https://www.jerico-ri.eu/jerico-ri-catalogue/#/map). Additionally, 8 regional, coastal and local models from the Copernicus Marine Service and other data providers (SOCIB, Puertos del Estado). Specific RI data or tools employed: High-frequency radar networks and surface drifters. RI data supporting project goals: IBISAR evaluates the performance of available models and HF radars by comparing them versus drifter trajectories based on a Lagrangian approach, providing a skill score easily interpretable to end users.
Joint utilisation of scientific data and data from public-private sectors	All data from the IBISAR catalogue have been openly shared with the end-user. SASEMAR has integrated part of these datasets in their operational environmental-data-server and in its viewer GisMAR. On the other hand, SASEMAR has shared data on SAR incidents in the Spanish national territory and drifter data deployed in the framework of their training exercises, available in this portal: https://mmdd.centrojovellanos.es/gis2/
Lessons learned that can benefit	Challenges identified: scarce availability on drifter data in coastal risk-prone areas, difficulties in accessing homogenised metadata in

[12] https://doi.org/10.3389/fmars.2021.630388

[13] https://doi.org/10.1080/1755876X.2020.1785097

[14] https://doi.org/10.5194/os-18-797-2022

the implementation of JERICO	all datasets, need of depth-based drifter classification, lack of NRT operational HFR gap-filled data at pan-European level, lack of time and resources to cover all needs and requirements of the target users, limited number of users from the private sectors, unavailability of easily interpretable assessment metrics, insufficient training activities for end-users, limited downstream long-term user engagement activities. Insights into successful strategies: ● Engage and involve target users from the beginning and along the entire cycle of the service development. ● Support the involvement of the target users under specific collaboration agreements, when possible. ● Gather information about the real needs of the users in their day-to-day duties. More listening to user needs. ● Invite target users to participate in all meetings to follow the service development and to provide feedback. ● Involve target users to collaborate and to participate in the promotional activities of the service. ● Maintain open, smooth and frequent communication with the target users. ● Acknowledge the target users their collaboration and their key role in the provision of feedback on the implementation of the service by promoting their activities and including their institutional logos in all scientific and outreach communications, involving them since the very beginning. ● Involve the private sector, offering them financial and mostly specially interesting non-financial incentives such as specific training sessions, operational access accounts, best practices and expertise exchange, pushing innovation, facilitating them access to existing information on know-how, etc. ● Boost and foster the involvement of Small-Medium Sized Enterprises (SMEs) who provide tailored products and customised services for specific end-users.
Recommendations to JERICO for future services and collaboration	Suggestions for enhancing data sharing practices: ● Integration in European marine data portals of existing complementary historical and real time drifter databases. ● Development of added value products: e.g. gap-filled trajectories for drifters, gap-filled HFR data, HFR short-term predictions. ● Offering benefits for pushing the data to European marine portals, e.g. DOI assignation to datasets, application of benefits granted to those EU projects ingesting data, awarding a distinctive 'data provider label' issued by the data aggregators, establishing mandatory commitments on integrating the data funded with EU public funds. Strategies for maximising the impact and value of RI data and services: ● Inclusion of HFR data uncertainty variables in the data file to unlock their use in data assimilation. ● Use of HFRdata through data assimilation for improving the model predictions in the coastal areas. ● Use of HFR data as a benchmark for model assessment.

	●Increase the number of training sessions for intermediate and end-users, by means of the implementation of different methods including: on-site and online activities (e.g. webinars); in-house training (by request); mentoring schemes ● Enhancing of the promotion and demonstrations of the applicability of the existing downstream services by means of webinars to targeted and potential users to foster the data discovery, usage and potential user's feedback. ● Promotion of further development in the data product market, by increasing the accessibility of the underlying datasets and pushing innovation to a higher level of data integration and processing, demonstrating a clear added value for all parties. ● Support in the generation of critical mass of scientific and technological talent and knowledge needed to support innovative companies. ●Enhance visibility of marine data and information sharing initiatives to private sector by: - best practices exchange in data manipulation tools and expertise for exploiting the available data - promoting free and open initiatives at several international trade fairs - offering diverse types of data formats more commonly used by industry as well as more service oriented approach and adapted skill sets to unlock their re-use for commercial purposes.
Additional material	Use case: IBISAR: One year of supporting emergency response at sea Use case: SASEMAR: effective response needs the most accurate data Use case: IBISAR web service in support to search and rescue operations

3.4 Relevant JERICO services

3.4.1 Observation strategies and operation of observing systems

The JERICO community intends to propose services to the users of the coastal ocean space on the following actions:

- Use of JERICO data/datasets for baseline study and monitoring related to settlements and operation of marine industrial infrastructures, starting with offshore wind parks and aquaculture, including offshore aquaculture (in exposed areas),
- Expertise in setting-up, deploying and operating observation/monitoring systems- helping industries to implement their CESR practices

3.4.2 Access to Observing platforms and sites

As documented by the success of TA actions with SME manufacturers, JERICO intends to increase the range of possibility for SMEs to access its platforms, thereby facilitating testing of technological innovations in various environmental conditions, and progress towards higher TRLs.

It is however obvious that financial incentives, as implemented in TA actions in EC-INFRA projects, are essential, in most of the cases, for enabling SMEs to benefit from provided access.

3.4.3 Access to data and dedicated products

Experiences and success stories, as exemplified above, reinforce our belief that access to JERICO data is paramount for many industries using the coastal ocean space.

Using guidelines like the Dialogues with the industry programme of the OEI will help JERICO raise awareness of its data, products and services. Possibly, partnership with CMEMS and with other RIs may enable providing more comprehensive services and expertise to the industry.

We have been advocating strongly for establishing a joint cross-marine RIs unit, dedicated and specialised in dialoguing with the industry. We expect a European OEI hub to fulfil this need.

A trend seems to happen concerning the willingness of the industry to share observation and data. There is however a long way to go for this trend to become systematic. The example of AQUACLOUD is to be promoted, showing that establishing a legal framework around data sharing may remove or lower existing barriers.

Coastal industries can be interested in advanced products answering their direct needs and interoperable with their systems and practices (ex: risk indices, coastal risk management products, etc.). JERICO will consider these requests on a case by case basis, setting the focus on exploiting the unique expertise of the consortium, and avoiding creating products that can be better provided by others (for ex. Copernicus).

3.4.4 Technology developments

Technological innovation is key for the implementation of a sustainable blue economy. Initiative like the OEI may facilitate or even provide, an appropriate framework for building high-impact ambitious projects for improving drastically coastal observation (including IoT-enabled robotics and automation, access to the biologic compartment, genomics, etc.), for the benefit of industry, policy-making, and specific initiatives such as the DTO.

IN JERICO-S3, several innovations have been developed (cEGIM, PSP, ACOBS, WASP – see deliverable D7.7 and D7.9) and their value for science, demonstrated.

Progressing from prototype to pan European deployment of this novel demonstrated capacity will require partnering with SMEs, within a market prospect that makes the investment interesting for the industrial partner. Planning for joint purchase by as many JERICO partners as possible may reduce the economic risk. Through Memorandum of Collaboration (MoCs) signed between JERICO and sister marine RIs, we intend to facilitate innovations of value for several RIs, and thereby prioritising the objective of partnership with given manufacturers.

Finally, we recommend that a large and ambitious initiative will be conducted between relevant RIs, EuroGOOS and the Copernicus Marine Service, concerning a paradigm shift in observing the land-sea interface, to be submitted to the European Investment Bank as part of the structural investment supporting the Green Deal.

4 Conclusion and perspectives

In this report, we have been focussing on two types of key stakeholders: (1) Copernicus marine service and European space agencies (ESA and EUMetSat), and (2) coastal industries, analysing the state of partnerships, with JERICO, including success stories, barriers towards improved partnership, and opportunities provided by the European and global context.

The Copernicus marine Service and space agencies have shown a growing need for in-situ observations to develop their own products and services.
The analysis conducted in JERICO-S3 and presented in this report shows that the long-term objectives, which have driven the development of JERICO so far, were the right ones and that the societal and subsequent scientific challenges upon us will greatly benefit the strategy implemented in JERICO. There is strong expectation from CMEMS on JERICO products and services, especially with regards to the implementation of CMEMS´s coastal strategy, but also and not least related to the emergence of the Digital Twins of the Ocean. Specific limitations towards a more efficient partnership have been identified and will be jointly tackled beyond the end of the JERICO-S3 project. Specific services that JERICO could offer to CMEMS and to ESA have been defined, as well as their implementation modality.

Coastal industries encompass many different types of actors, including small and large manufacturers, small and large users of the ocean space, exploiting its physical and/or biological resources, and providers of technical services to those exploiting the coastal ocean.
It is recognised that more and better partnership between a research infrastructure as JERICO and SMEs developing marine technology is required for answering to the policy expectations encompassed into the European green deal and its subsequent components, e.g., energy transition, farm2fork strategy, sustainable blue economy, environmental protection, DTO.
A new partnership framework has been suggested for increasing the interest and feasibility of manufacturers to work closely with research infrastructure for fast-tracking high-impact innovation, addressing greening of activities, the digital ocean and European technological leadership. Increased partnership is also needed with the industry exploiting the coastal ocean, and its supporting providers. The Ocean Enterprise is a powerful initiative in this regard, while establishing a European hub is considered as an appropriate way forward, and will be investigated further, beyond the end of the project.
The fact that more and more industries see the benefit of sharing their own data for creating value and efficiency in bringing solutions to current challenges is seen as a promising context that JERICO intends to exploit as part of its business model.

Annex 1 – Result of the survey on JERICO measurements versus OCTAC products

A **survey** has been conducted, among JERICO partners, to assess the compatibility of JERICO measurements and products generated and delivered by OCTAC. The result has been synthetized in Table 4 (1 – 8), which shows a very good potential for JERICO as contributor to OCTAC (each line in the table indicates correspondence between JERICO "offer" and OCTAC needs – the green boxes indicate a present non-use of such data in OCTAC, which illustrates the great potential of JERICO for such outcomes).

Table 4 (1/8) - Available measurements (past/ongoing/future) from JERICO that could benefit to OCTAC (green boxes means that JERICO is not yet used by OCTAC, O/R means Occasional or Regular measurements.

Provider	Parameter/variable	Platform used for the measurements	Sensor used for the measurement			Timeseries (start/end year)	Sampling frequency (space and time)
CNR - paloma	Attenuation of Coloured dissolved organic matter (CDOM)	AAOT oceanographic tower, PALOMA elastic beacon, S1-GB elastic beacon	ECO-Triplet for all 3 platforms	N	R	Will start in May 2023, Will start in May 2023, 2012/ongoing	15 min, 15 min, 60 min
CNRS		Boat	10cm quartz cuvettes into a Shimadzu UV-2450 spectrophotometer	N	O&R	Sea cruises from 2006 in French Guiana, English Channel and Vietnam (for most of the data)	Most of the measurements were collected during a 5-day cruise
HEREON		FerryBoxes (Cuxhaven)	TriOS nanoFlu-CDOM	N	R	since 2020	every 10 Minutes
NIVA		FerryBox	Turner C3/Trios Microflu	N	R	2008-present	1 minute/~300 m
UPC		OBSEA Buoy	Turner designs C3	Y	R	01/08/2022 – present	fixed point sampling. Raw data is measured with bursts of 5 min, with sampling rate of 10 seconds, then the sensor sleeps for 25 min. Averaged data is produced every 30 min.
SYKE		Utö station , FerryBox FINNMAID	fDOM fluorometry and lab analyses from bottles	N	R	approx. 2012 (ferrybox)/2016(Utö onwards)	Utö fixed station, continuous, between Helsinki Travemunde & Helsinki Stockholm, continuous

Table 4 (2/8) - Available measurements (past/ongoing/future) from JERICO that could benefit to OCTAC (green boxes means that JERICO is not yet used by OCTAC, O/R means Occasional or Regular measurements.

Provider	Parameter/variable	Platform used for the measurements	Sensor used for the measurement			Timeseries (start/end year)	Sampling frequency (space and time)
IRB	Backscatter blue profile	Moored buoys network	Seabird Eco Triplet-W	N	R	2023-present	6 hours
IRB	Backscatter red profile	Moored buoys network	Seabird Eco Triplet-W	N	R	2023-present	6 hours
CNRS	Backscattering coefficient @443 nm	Boat	Wetlabs bb-9 or Wetlabs ECO-VSF	N	O&R	Sea cruises from 2006 in French Guiana, English Channel and Vietnam (for most of the data)	Most of the measurements were collected during a 5-day cruise
IRB	CDOM profile	Moored buoys network	Seabird Eco Triplet-W	N	R	2023-present	6 hours
IRB	Chl-a 0,5,10,15,20,25m	Vessel based sampling grid across the northern Adriatic Sea	Laboratory analysis	N	R	1978-present	2 months
IRB	Chlorophyll-a profile	Moored buoys network	Seabird Eco Triplet-W	N	R	2023-present	6 hours
IRB		Vessel based sampling grid across the northern Adriatic Sea	Seabird Eco Triplet-W	N	R	1978-present	2 months
AZTI	Chlorophyll-a surface concentration	Sampling at fixed stations	Fluorescence in CTD	N	R	Since 1995	Seasonal, 16 sampling stations
CNR - paloma		AAOT , PALOMA, S1-GB	ECO-Triplet for all 3 platforms	N	R	Will start in May 2023, Will start in May 2023, 2012/ongoing	15 min, 15 min, 60 min

Table 4 (3/8) - Available measurements (past/ongoing/future) from JERICO that could benefit to OCTAC (green boxes means that JERICO is not yet used by OCTAC, O/R means Occasional or Regular measurements.

Provider	Parameter/variable	Platform used for the measurements	Sensor used for the measurement			Timeseries (start/end year)	Sampling frequency (space and time)
CNRS	Chlorophyll-a surface concentration	Boat	Turner Trilogy fluorometer or Turner 10AU Field Fluorometer	N	O&R	Sea cruises from 2006 in French Guiana, English Channel and Vietnam (for most of the data)	Most of the measurements were collected during a 5-day cruise
FAMRI		Spectrophotometer	Seapoint Fluorometer	N	R	1997 - onwards	1D, 14 days
NIVA		FerryBox	Turner C3/Trios Microflu	N	R	2001-present	1 minute/~300 m
RBINS		RV Belgica	water samples, HPLC	Y	R	2012	6-11 times/year, since 2019 in 3 stations
SYKE		FINNMAID and Silja Serenade FerryBox	in vivo fluorometry and Lab analyses from sample bottles	Y	R	1993 onwards	between Helsinki-Travemunde & Helsinki Stockholm, continuous
SYKE		Utö station	in vivo fluorometry and Lab analyses from sample bottles	N	R	2014 onwards	Utö fixed station, continuous
SYKE		Aranda reserach cruises	Lab analyses from sample bottles	N	R	for ages...	around Baltic
TALTECH		Ferrybox, Keri profiler	Trilux fluorescence sensor (ctg)	Y	R	2020-... (start as part of JERICO-RI)	Ferrybox: 500 m in space, two crossings over the Gulf of Finland a day; Keri profiler: profile every 3-6 h, vertical step of 0.5 m

Table 4 (4/8) - Available measurements (past/ongoing/future) from JERICO that could benefit to OCTAC (green boxes means that JERICO is not yet used by OCTAC, O/R means Occasional or Regular measurements.

Provider	Parameter/variable	Platform used for the measurements	Sensor used for the measurement			Timeseries (start/end year)	Sampling frequency (space and time)
AZTI	Concentration of Suspended Particulate Matter	Sampling at fixed stations	Sampling and lab analysis (filtration and gravimetry)	N	R	Since 1995	Seasonal, 16 sampling stations
CNRS		Boat	Precision scale (and values also controlled using a portable turbidimeter Hach 2100Qis)	N	O&R	No time series. Just sea cruises from 2006 in French Guiana, English Channel and Vietnam (for most of the data)	Most of the measurements were collected during a 5-day cruise
HEREON		Sampling	Lab analysis	N	O	since 2000	4 campaigns a year
NIVA		FerryBox	Turner C3/AML MicroX	N	R		1 minute/~300 m
RBINS		RVBelgica	OBS, Seapoint, water samples	Y	O&R	2004	6-11 times/year, since 2019 in 3 stations
RBINS		benthic lander	OBS, LISST 200, ADP, ADV	N	R	2005	continuous, 1 station
RBINS		buoy	OBS	N	R	2023	continuous, 1 station
SYKE		Utö station	Lab analyses from sample bottles	N	O	random, since 2014	Utö fixed station, continuous
TALTECH		Keri profiler	Trilux turbidity sensor (ctg)	Y	R	2020-... (start as part of JERICO-RI)	Profile every 3-6 h, vertical step of 0.5 m

Table 4 (5/8) - Available measurements (past/ongoing/future) from JERICO that could benefit to OCTAC (green boxes means that JERICO is not yet used by OCTAC, O/R means Occasional or Regular measurements.

Provider	Parameter/variable	Platform used for the measurements	Sensor used for the measurement			Timeseries (start/end year)	Sampling frequency (space and time)
IRB	Light transmission profile	Moored buoys network	Seabird C-Star	N	R	2023-present	6 hours
IRB		Vessel based sampling grid across the northern Adriatic Sea	Seabird C-Star	N	R	1978-present	2 months
IRB	particulate matter 0,5,10,15,20,25m	Vessel based sampling grid across the northern Adriatic Sea	Laboratory analysis	N	R	1978-present	2 months
IRB	pCO2 profile	Moored buoys network	C-sense (Turner design)	N	R	2023-present	6 hours
IRB	Phytoplankton composition 0,5,10,15,20,25m	Vessel based sampling grid across the northern Adriatic Sea	Laboratory analysis	N	R	1978-present	2 months
FAMRI	Primary production	C14 Incubations		N	O	2022-2024	<10km, seasonal
SYKE		Utö station	14-C and FRRF	N	O	random, since 2014	Utö fixed station, continuous
AZTI	Secchi Disk Depth estimates	Sampling at fixed stations	Secchi disk	N	R	Since 1995	Seasonal, 16 sampling stations
CNR - paloma		Small boat, Small boat	Secchi disk, manual for all	N	R O	2008/ongoing 2012/ongoing	monthly, bi-monthly

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Table 4 (6/8) - Available measurements (past/ongoing/future) from JERICO that could benefit to OCTAC (green boxes means that JERICO is not yet used by OCTAC, O/R means Occasional or Regular measurements.

Provider	Parameter/variable	Platform used for the measurements	Sensor used for the measurement			Timeseries (start/end year)	Sampling frequency (space and time)
HEREON	Surface concentrations of Particle Size Distribution -PSD	Sampling	Lab analysis	N	O	since 2013	4 campaigns a year
RBINS		RV Belgica	LISST 200	N	R	2005	6-11 times/year, since 2019 in 3 stations
SYKE		Utö station	IFCB and Cytosense, Lisst occassionally	N	R	2019(IFCB)/2021(CS) onwards	Utö fixed station, continuous
AZTI	Surface concentrations of Phyto functional types (PFT)	Sampling at fixed stations	Sampling and lab analysis (Utermöhl)	N	R	Since 1995	Seasonal, 16 sampling stations
CNR - paloma		only at AAOT oceanographic tower	Flow Cytobot and dicrete samplings using utermohol analysis	N	R	2012/ ongoing, flowcytobot will start may 2023	60 min and monthly
FAMRI		Flowcam 8400		N	R	2022 - onwards	1D, 14 days
NIVA		FerryBox, manual sampling	ISCO refrigerated autosampler; Utermohl and microscopy	N	R	2006-present	variable, approx ~200 km
SYKE		Utö station	IFCB and Cytosense	N	R	2019(IFCB)/2021(CS) onwards	Utö fixed station, continuous
SYKE		Aranda reserach cruises	Lab analyses from sample bottles	N	R	for ages...	around Baltic

Table 4 (7/8) - Available measurements (past/ongoing/future) from JERICO that could benefit to OCTAC (green boxes means that JERICO is not yet used by OCTAC, O/R means Occasional or Regular measurements.

Provider	Parameter/variable	Platform used for the measurements	Sensor used for the measurement			Timeseries (start/end year)	Sampling frequency (space and time)
UPC	turbidity	OBSEA Buoy	B&C electronics SA8065	Y	R	01/08/2022 – present	same as CDOM
CNR - paloma	Vertical attenuation of light (@490nm) Kd490	Small boat, S1-GB elastic beacon	PAR sensor for all	N	R	2008/ongoing, 2012/ongoing	monthly, 60 min
CNRS		Boat	Profiling TriOS RAMSES UV-Vis	N	O&R	No time series. Just sea cruises from 2006 in French Guiana, English Channel and Vietnam (for most of the data)	Most of the measurements were collected during a 5-day cruise
IRB	Visibility (at +3m)	Moored buoys network	CaCS120A	N	R	2023-present	Real time + 10 min integration

Table 4 (8/8) - Available measurements (past/ongoing/future) from JERICO that could benefit to OCTAC (green boxes means that JERICO is not yet used by OCTAC, O/R means Occasional or Regular measurements.

Provider	Parameter/variable	Platform used for the measurements	Sensor used for the measurement			Timeseries (start/end year)	Sampling frequency (space and time)
CNR - paloma	Water leaving reflectances (@400, 412, 443, 490, 510, 560, 620, 665, 674, 681, 709 nm)	only at AAOT oceanographic tower		Y	R		
CNRS		Boat	TriOS RAMSES UV-Vis	N	O&R	No time series. Just sea cruises from 2006 in French Guiana, English Channel and Vietnam (for most of the data)	Most of the measurements were collected during a 5-day cruise
NIVA		FerryBox	RAMSES	N	R	2005-present	1 minute/~300 m
RBINS		AERONET-OC, HYPERNETS	CIMEL, Panthyr, Hypstar,	Y	R	2014 to current	2 stations in Belgian part of North Sea, measurements every 30 minutes
SYKE		Helsinki Lighthouse	AERONET-OC, wavebands may be a bit different from the list...	N	R	2006-2019, cancellation due to covid, continuation discussed	typically from April to October, several times per hour during sunlight hours
SYKE		FINNMAID FerryBox	Spectral measurements, R-Flex, TRIOS RAMSES reflectance setup	N	O	random coverage, maybe fom 2012	between Helsinki-Travemunde, continuous during sunlight hours