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JERICO-RI: THE INTEGRATED COASTAL COMPONENT OF THE EUROPEAN OCEAN OBSERVING SYSTEM

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Abstract

JERICO, the European research infrastructure of coastal observatories (JERICO-RI) is an ocean observing system of systems, designed to provide high-quality data that are supporting knowledge development on the complex and often coupled physical, chemical and biological processes characterizing the coastal waters of Europe. JERICO-RI integrates several observing platform types i.e. fixed buoys, piles, moorings, drifters, Ferrybox, gliders, HF radars, coastal cable observatories and the associated technologies dedicated to the observation and monitoring of the European coastal seas. The RI is to serve both the implementation of European marine policies and the elucidation of contemporary and future key scientific questions. It therefore includes observations of the physical, chemical and biological compartments and aims at a better integration of marine biology with physical and chemical oceanology.

The first phase of the implementation of the JERICO-RI encompassed setting up, integrating and harmonization of existing coastal observing systems around Europe into a system of systems, covering all European coastal waters from the Baltic Sea to the Black Sea, It was performed between 2011 and 2015 in the framework of JERICO-FP7, a 4-year long infrastructure project co-funded by the European Commission, with 27 partners from 17 European countries under the coordination of IFREMER. The second 4-year phase is presently in progress through the H2020 JERICO-NEXT project, which started in 2015 and involves 34 scientific and industrial partners. The main objective of the JERICO-RI consortium is to establish a common strategy towards a sustainable coastal observing system of systems for Europe supporting with data and knowledge innovation and blue growth in Europe.

This paper briefly summarizes the work carried out since 2011 and the present drivers of the JERICO-RI science strategy. It also drafts the strategical elements of the JERICO-RI sustainability.

Keywords: JERICO, JERICO-NEXT, Coastal Observatory, system of systems, harmonization, sustainability, open access, Blue Growth

1. Background and rationale

Threats and pressure to coastal areas are increasing; would it refer to increase in coastal population, degradation of coastal habitats, increased pollution, greater demand for non-living resources (renewable energy), or over-fishing that result in declines in ecosystem health and biodiversity. Consequently one experiences an increase demand of data and *in situ* observations as the backbone for better understanding the changes in the coastal environment and the processes involved. It raised the need for automated and long-autonomy platforms and sensors systems suitable to deliver high quality and comprehensive data. Over the last years, the EU has been contributing to answering this demand by promoting extensive cooperation for the observation of the global ocean, supporting key research infrastructure (RI) projects such as EURO-ARGO (www.euro-argo.eu) and EMSO (www.emso-eu.org), as components of the upcoming European Ocean Observing System (EOOS), with the aim to serve different users of the maritime domain. Indeed, Policy-makers are promoting the exploitation of research-driven marine technologies and data towards innovation, business development and wealth creation in Europe. This is a crucial driver for decision-making for maritime industries and this is giving an explicit framework, in addition to scientific and environmental concerns, for developing a strategy for coastal observation in Europe.

The rationale for improved observations of coastal seas is to provide the data backbone supporting knowledge development for sustainable growth in the coastal zone, as the region of highest economic potential in Europe. Moreover, the coastal component of the European marine observing system is to serve both the implementation of European marine policies and the elucidation of key scientific questions through dedicated observations and ling-term monitoring strategy. The coastal seas are characterised by complex processes depicting high coupling and feedbacks between physical, chemical, geochemical and biological compartments in the water column, at sea-bottom and between pelagic and benthic compartments. Furthermore, coastal seas are under combined pressures of anthropic origins through coast-land interactions (river run-off and diffuse outfalls from land), atmospheric disposals, and long-distance transported chemical and biological compounds. Therefore a coastal observing system must encompass a wide range of measurements, covering different disciplines and environmental compartments, and addressing the interaction between them. Furthermore the system should enable a better understanding of the variability of biological, chemical and physical processes and its causes, would it be natural, anthropogenic or climatic. An appropriate sampling strategy in time and space addressing the heterogeneity of the coastal waters is hence paramount. These requirements lead to the concept of observing system of systems for appropriately addressing the specificities of the coastal ocean. The concept relies on the integration of different observing platforms, different sensors and measurement technologies into a harmonised network that delivers high-quality, consistent and comprehensive datasets describing the coastal environments and the pressure upon them.

Because of development of coastal observatories in Europe has been driven by domestic interests and mainly undertaken through short-term research projects, significant heterogeneity exists concerning technological design of observing systems, measured parameters, practices for maintenance and quality control, as well as quality standards for sensors and data exchange. Therefore main challenges for the coastal research community have been to harmonize the technologies, increase the coherence and the sustainability of these dispersed infrastructures by sharing know-how through dedicated actions and experiments within a shared pan-European framework.

These considerations led 27 leading marine research institutions from 17 European countries to establish the Joint European Research Infrastructure network of Coastal Observatories (referred to as JERICO-RI). The main objective of the JERICO-RI community has been to establish a common approach for a pan-European coastal observing system of systems (marine observatory network).

2. JERICO-FP7: Main achievements

The first phase of the implementation of the JERICO-RI were carried out within the JERICO-FP7 Infrastructure project (2011-2014), co-funded by the European Commission in the 7th Framework Programme. JERICO-FP7 addressed the challenge of observing the complexity and high variability of coastal areas at Pan-European level, in the framework established by European Directives (Water Framework Directive: WFD, Marine Strategy Framework Directive: MSFD) and the marine core service of the European Earth observation programme (Copernicus) by (i) setting up an European Research Infrastructure for coastal observations by **integrated existing systems** in European coastal and shelf seas, (ii) supporting **standardization of methodologies** for the benefit of data quality, data availability and cost efficiency, (iii) promoting the cost-effective **use of the facilities**, (iv) stimulating the **development of new automated systems** for the operational monitoring of the coastal marine environment, with focus on the biochemical compartment.

JERICO-FP7 focused on several observing platforms broadly used around Europe, i.e. **fixed buoys, piles, moorings, ferrybox and gliders**, building upon existing regional networks in Europe, including the European Global Ocean Observation System (EuroGOOS). JERICO-FP7 has contributed to address the challenge of observing the complexity and high variability of coastal areas at Pan-European level.

2.1 JERICO-FP7 Networking Activities

JERICO-FP7 led to the definitions of best practices for the design, implementation, maintenance and distribution of coastal observing systems, as well as the definition of quality standards. The work was supported by ongoing initiatives and projects from "platform" communities, such as the Glider community (GROOM project) and the well-established Ferrybox community. The need for harmonization for Fixed Platforms were considered as stronger since a "fixed platforms" community does not exist per se and a huge variability of technologies is encountered for these types of platform. Standard Operation Procedures (SOP's) were documented and a best practice code was developed. This is reported in JERICO-FP7 best practice reports (www.Jerico-ri.eu) [1], [2], [3], [4]

2.2 JERICO-FP7 Joint Research Activities

Joint research activities were conducted in order to identify new and strategic technologies to be implemented in the next generation of European coastal observatories. Focus was given on the observation of the biochemical compartment, and Observing System Experiments (OSE) / Observing System Simulation Experiments (OSSE) to evaluate the impact of existing data observing networks on coastal forecasting capability through data assimilation. The new technology and methodology developments addressed (i) image and video analysis of the biological compartment, (ii) measurement of the carbonate system (pCO_2, alkalinity and spectrophotometric pH detection) and the quantification of the air-sea CO_2 fluxes, (iii) measurement of nutrients and contaminants.

2.3 JERICO-FP7 Trans National Access activities

Access to JERICO-RI was provided through Trans-National Access to research scientists outside the project consortium. The selection was made following open calls and based on scientific excellence. The objective was to promote the potential of JERICO-RI facilities and platforms when used in synergy. 12 articles presenting significant results of JERICO-FP7 are published in a Special Issue of the "Journal of Marine System", volume 162 [5].

3. JERICO-NEXT: The way forward

The JERICO-FP7 project was the first European wide effort towards the harmonisation and coordination of the major coastal observing platforms including FerryBox, gliders, and coastal fixed platforms. Started in September 2015, the JERICO-NEXT project, involving 34 scientific and industrial partners, builds upon this basis and enlarges the objectives to complementary observing systems including biological observations, with the aim to better understand the specific characteristics of European coastal waters. The overarching objective of JERICO-NEXT is to strengthen and enlarge a solid and transparent European network of coastal observatories and to provide an operational service for the timely, continuous and sustainable delivery of high quality environmental (physical, biogeochemical and biological) data and related to

the coastal environments. By doing so, JERICO-NEXT helps the research community to provide the best possible quality indicators for the MSFD and to promote joint research initiatives and standardization, increasing support to the European industrial sector of coastal instrumentation and monitoring services.

3.1 The JERICO-NEXT vision

JERICO-NEXT has at the heart the statement that **we cannot understand the complexity of the coastal ocean if we do not understand the coupling between physics, biogeochemistry and biology. Reaching such an understanding requires new technological developments allowing for the continuous monitoring of a larger set of parameters. It also clearly requires an a priori definition of the optimal deployment strategy in view of coupling diverse data monitored over very different spatial and temporal scales.**

3.2 Objectives of JERICO-NEXT

Therefore JERICO-NEXT: (1) focuses most its efforts on the assessment of the interactions between physics, biogeochemistry and biology, and (2) is not restricted to pure technological aspects but also includes fundamental scientific considerations within its Networking Activities (NAs). Both aspects are closely associated within JERICO-NEXT Joint Research Activities (JRAs).

One main objective is to provide the researchers with continuous and more reliable coastal data coupling physical and biological information. Furthermore, JERICO-NEXT aims to demonstrate the adequacy of observing technologies and monitoring strategies to provide the information necessary to address a selected set of major environmental issues such as the assessments of: (1) Good Environmental Status as required by the MSFD; and (2) global environmental change impacts on coastal ecosystems. This is addressed through six Joint Research Activity Projects, internal to JERICO-NEXT.

Furthermore, JERICO-NEXT is (i) continuing addressing standardization issues along the value-chain from sensors to data management, and providing access to the RI and data (ii) carrying out joint research activity projects feeding the overall strategy for sustainability of the RI, (iii) preparing for future development of the RI, and (iv) making data available through EMODNET and CMEMS data channels.

Since many environmental issues taking place in the coastal ocean are linked with biological compartments and processes, it is essential not to restrict observed variables to current (candidate) Essential Ocean Variables but to include biological and biogeochemical variables that cannot be acquired in real time or even near real time in view of their relevance regarding the specific environmental issues tackled by each subsystem. The concept of **Essential Coastal Variables** is therefore being consolidated by the JERICO-RI community. It will be introduced in a revised version of the Best

Practices for coastal observatories, and will lead to recommendation on evolutions of EMODNET.

Coastal modelling is a key tool for providing continuity between observations and for providing sound services (e.g. maps and forecasting) to end-users. It is currently much more developed for geophysical than for biogeochemical and even less for biological processes. The complexity of coastal processes points the fact that more *in situ* observations are needed to constrain the models. It is suggested that a future monitoring programme of the European Coastal Ocean should develop a federative action regarding the development and the harmonisation of models (a function, which is currently devoted to IOOS OPerationS division in the US).

The present observing system of systems (JERICO-RI), and its possible evolution, are continuously assessed taking into account the evolution of users' needs, emerging technologies, progress in term of automation and platform integration.

4. Conclusion and perspectives

Maritime and coastal regions are considered as key areas for achieving a substantial economic growth in Europe. This focus uniquely positions the **JERICO-RI** to provide data and knowledge that would enable an environmentally sustainable use of the coastal domain, thereby responding to societal demands.

Dedicated scientific strategies have to be thought through, agreed upon and implemented according to local specificities and broader scientific objectives, in order to strengthen the understanding of the coastal processes, to better inform policy makers as well as to contribute to science, we need sustained comprehensive and consistent data on physical, chemical and biological parameters collected at appropriate time and space scales.

Results from the JERICO-FP7 project and the ongoing analyses within JERICO-NEXT strongly emphasize the fact that the many specificities of coastal processes requires the development of an **integrated network of coastal observatories** that delivers high frequency *in situ* collected physical and/or biogeochemical data, from the sea-shore to the shelf break from a range of platforms, complementing each other for addressing the high spatio-temporal variability inherent to coastal regions.

A major challenge relates to the sustainability of JERICO-RI, both at economical and governance level, and the capability of integrating the latest technology while preserving the scientific value of the data.

Based on these considerations, the JERICO-NEXT community states that the societal needs, the economic potential and the scientific challenges inherent to the European

Coastal Ocean can be properly addressed only by building a strong, specific and coastal-focused observing system of systems, having a dedicated strategy aiming at supporting the sustainable development of European coastal regions. This observing system would provide the coastal component of an emerging European coastal Ocean Observing System (EOOS); the latter possibly providing the ultimate governance structure that would link the different building-blocks of European Ocean observations, being open-ocean research infrastructures (Euro-Argo, EMSO), RIs related to the biological compartment (EMBRC, LifeWatch) and the proposed integrated coastal component, and achieve a European integrated ocean observing system, contribution to GEOSS.

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