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JERICO-S3 MILESTONE

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

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→ **Please specify the type of milestone:**

- ❑ Report after a workshop or a meeting (TEMPLATE A)
- ■ Report after a specific action (TEMPLATE B) (test, diagnostic, implementation,…)
- ❑ Document (TEMPLATE B) (guidelines,...)
- ❑ Other (TEMPLATE B) (to specify) …………………….

Diffusion list			
Consortium beneficiaries	Third parties	Associated Partners	Other

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1.Objectives

The aim of JERICO-S3 WP2.4 is to explore potential enhancements of monitoring capacities on the national and regional level through an integrated modelling-monitoring approach. The scope of the study is limited to monitor regional connectivity in Baltic-North Sea (Kattegat and Skagerrak, WP2.4.1) and estuarial-coastal continuum in national waters in 6 partner countries (WP2.4.2), i.e., Denmark (DMI), Finland (FMI), Germany (HEREON), Norway (IMR) and Spain (SOCIB), Netherlands (Deltares). In Milestone 10, the gaps of monitoring capacity in resolving Baltic-North Sea connectivity and multiscale processes in coastal-estuarial continuum have been identified. Therefore in Milestone 11, recommendations for how to filling the gaps should be investigated and given.

2. What has been achieved in Milestone 10?

In milestone 10, the monitoring capacity in estuarial-coastal continuum in each of the 5 countries has been mapped, and a qualitative gap analysis has been made for identify potential gaps in a range of targeted applications, including information services for operational activities, climate change adaptation and ocean health. However, due to the wide range of applications, such a fit-for-purpose gap analysis has not identified kep products needed in each application area, instead, it is mainly based on expert knowledge from the partners. Thus can only be regarded as an ad hoc gap analysis.

3. Implementation process in Milestone 11

The research to reach milestone 11 is two-folded: the first action is to make recommendations based on the monitoring and modelling gaps identified in Milestone 10; the second is to perform a more detailed and robust gap analysis for a given "high impact" sector, and then make recommendations for gap-filling. Due to rapid increasing needs and expansion of offshore wind farms (OWF) in European Seas, we decided to perform a thoroughly observation requirements and gaps analysis for the OWF sector. Based on this gap analysis, recommendations for filling the gaps will be made.

This OWF is an industry involving many different sectors, and featured by high connectivity (Fig. 1). Value chain of OWF industry can be divided into four phases, i.e., development phase (4-6 years), construction phase (2-4 years), operation phase (up to 20 years) and deconstruction phase (Weig, 2017). The topic is very suitable for illustrating typical dynamical interactions between spatial scales and regions as well as the complexity of human activities in coastal regions. During the development phase, marine data are needed for optimal siting, including assessment of environmental conditions and respective impacts on OWF operation. During the following phases, marine forecasts are needed for operation and maintenance of the WOFs. Both oceanic and atmospheric conditions are of relevance. This is even more challenging in icing and high sea waters.

Impacts of OWFs on the environment cover a large spectrum of physical, chemical and ecological system components. With the ongoing growth of the installations, short-term operational aspects (e.g. shadowing of one wind farm by another wind farm) have to be considered as well as long-term impacts on ecological systems.

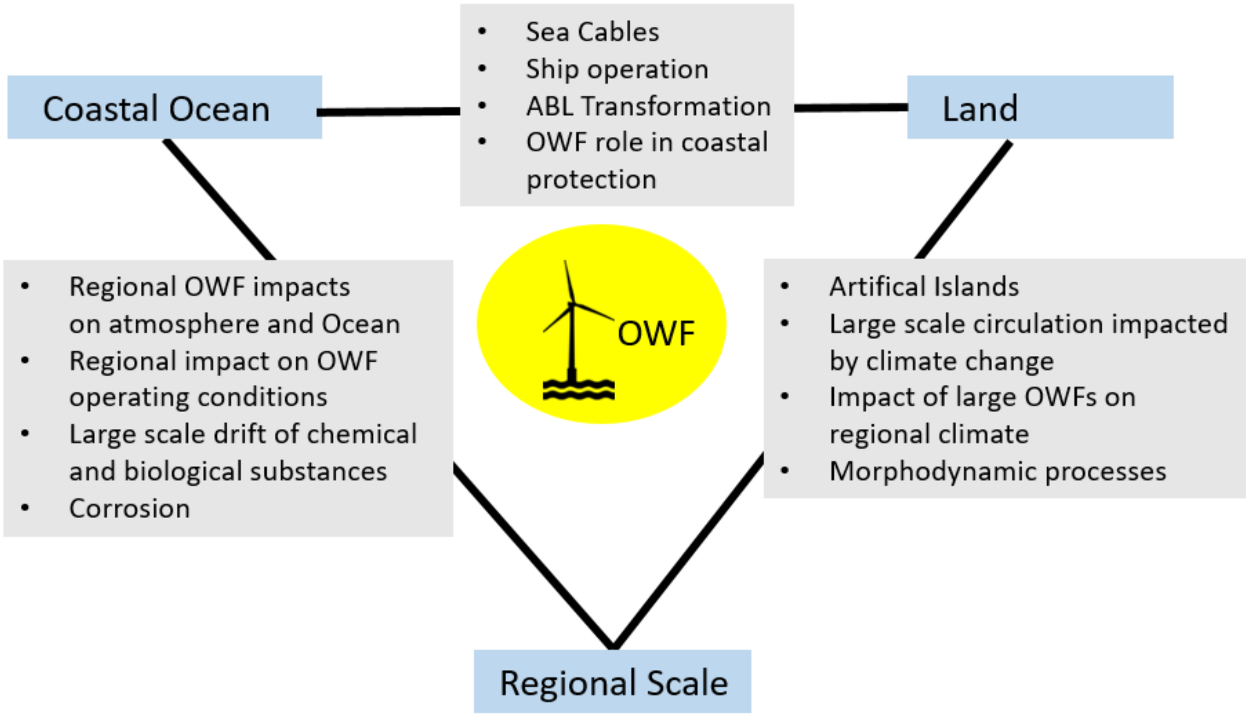

Figure 1. Connectivity relations in the framework of the offshore windfarm sector

The fit-for-purpose gap analysis for OWF sector targets monitoring activities with two kinds of connectivity: land-coast-sea connectivity and ecosystem connectivity. In land-coast-sea connectivity tasks, we consider land-related offshore maintenance, seabed cable protection, non-local physical and geological impacts, i.e., wake/lee effects in atmosphere, sea and shoreline. In ecosystem/process related connectivity tasks, we consider assessment of OWF impacts on habitat change, marine mammals and birds and non-indigenous species (NIS). The issues related to these two kinds of connectives have relatively high socioeconomic impacts.

The fit-for-purpose gap analysis on the OWF industry includes four steps. The first is to define application areas and required key information products in both land-coast-sea connectivity areas including OWF maintenance, submarine cable protection, wake effects in atmosphere and sea, lee effects on shoreline change and marine ecosystem connectivity areas, including OWF impacts on habitat change, mammals and birds and non-indigenous species. The second step is to identify required marine observations, associated with existing or proposed monitoring-modelling solutions. The third step is to map availability of existing in-situ and satellite observations, as well as modelling capacities analyze and to identify the gaps. Finally, recommendations will be made for filling the gaps. The step 2-4 analysis is performed for each of the six application areas. Assessments in different application areas are made for selected national and/or regional cases, e.g., data adequacy for submarine cable protection is assessed for Danish waters.

Meta data of satellite and in-situ observations in European Seas from Copernicus Marine Environment Monitoring Service (CMEMS) and EMODnet are used. National data consist of in-situ observations mainly from operational agencies, environmental monitoring, geological survey and fishery monitoring from Denmark, Finland, Germany, Norway and Spain. For some application areas, research and commercial observations are also used.

Based on the fit-for-purpose gap analysis, recommendations for filling the gaps are made.

4. Major recommendations

4.1 Recommendations on national coastal observing

Denmark: For observation handling and accessibility in operational oceanography, two recommendations can be made. The first is that there should be a centralised national marine data management system to collect and the data from different agenecies and make them available. Currently this is not available although open data can be accessed from DMI and environmental data portal https://vandportalen.dk/. The second is to shorten the delivery time of the non-operational data such as observations from environmental and fishery monitoring.

For filling observations gaps, more frequent hydrochemistry observations are needed data in national monitoring program NOVANA. In inner Danish waters (Kattegat), waves, sediment concentration, sedimentation rate and pCO2 should be monitored. Currently they are few.

There is also a lack of operational modelling capacity for SPM transport, coastal erosion, rapid environment assessment, plastics, water quality. This should be developed. In addition, it is recommended that model-data fusion and hybrid modelling (including ML and AI) should be developed for improve product quality on algae bloom, oxygen depletion and eutrophication assessment. By filling gaps in data management, more data should be available and used for developing new operational modelling capacities and model-data integration including data assimilation.

Finland: It is recommended to have more observations on marine biogeochemistry in national waters, More physical, biological, and chemical observations in the Bothnian Sea and Gulf of Bothnia, especially in the archipelago areas.

For data management, Finland currently lacks a National Oceanographic Data Center. A major gap is that observations from different agencies are not coordinated and harmonized. There is also a need for operational near real time (NRT) delivery of non-operational data.

It is recommended following activities to address the identified gaps in Finish waters:

- Develop new platforms are currently developed for marine observations, especially on land-sea continuum and archipelago areas. These include merging of Gulf of Finland observations carried out by Finland, Estonia and Germany in the framework of JERICO GoF PSS, providing seamless data flows and harmonized data. Some activities are already on-going. In the Archipelago Sea, a local ferry operating on regular route will be equipped with a mobile marine weather station including SST observations. In Bothnian Sea, there are on-going negotiations to equip a regular ship operating between Finland (Vaasa) and Sweden (Umeå) with suitable instrument for e.g. sea ice and SST observations, and potentially with a flow-through system.
- For data management, FINMARI has started a data management group coordinating and planning the marine data issues. In this planning, the focus is on European data bases and existing services. In addition, FMI and SYKE are discussing about the possibility to create a National Oceanographic Data Center node for Finland as a part of national Decade of Oceans- activities.

Germany: The recommendation for German monitoring system is mainly made for offshore wind farm sector, which is included in 5.2.

Netherlands: for OSPAR assessments a wider spatial and temporal coverage is needed for monitoring data of the main eutrophication indicators: dissolved inorganic nitrogen, dissolved inorganic phosphorus and chlorophyll-a. Additionally, observations of oxygen concentrations in deeper water layers and of primary production would be required to enable the use of these as additional eutrophication indicators.

OSPAR member states are aware of the current gaps in monitoring programmes but have not yet identified solutions. In the pilot super site research as part of the North Sea and Channel PSS in Jerico-S3 WP4, we are including additional monitoring data sources, such as Ferrybox data to a database to have a more complete coverage of available monitoring data and better insight in remaining gaps. Also, approaches are tested to make sensor data easier to include in assessments. In the Netherlands we are developing a new Ferrybox trajectory in collaboration with NIVA in Norway, including an auto-sampler to enable a better spatial and temporal coverage of monitoring data.

Norway: Since the coast of Norway is extremely long with a severe number of fjords and rivers, it is impossible to cover the whole coast with in-situ monitoring activities. The Norwegian approach is therefor to identify pilot areas which are aimed to be intensively observed and which can serve as example areas for other regions. Due to the strong aquaculture activity near shore and the oil and gas exploration activity offshore with their related monitoring programs is the Norwegian area within the focal areas named above relatively good covered by the monitoring. Due to the fact that not all areas can be included in that monitoring (see above) a mapping activity is necessary in order to prove the validity to use the pilot observational approach which is then used for the whole coast.

In addition to that there is a lack of current measurements. To intensify the activity in that direction would lead to a better knowledge of the uncertainties within the model simulations. Due to the long coastline there are many actors involved in the observational activities. The coordination between the different actors could be subject of improvement.

The further integration of the different actors within In-situ monitoring, Remote Sensing as well as numerical modeling under the so called Coastwatch approach which forms the Norwegian contribution on the JERICO Research infrastructure is crucial for addressing the fragmentation of the observational efforts.

Spain: in the whole path of the Northern Current is monitored by altimetry but only at scales larger than O (100) km. The details of the circulation are captured by HF radars in specific areas, but most of the NWMed PSS coast is still not covered by the present HF radar systems. These issues should be resolved by an improved monitoring system. For data management, access to the data is not fully centralized yet, platforms are being incorporated into the international databases (Copernicus Marine Service, EmodNet) but some data are still missing there.

It is recommended that i) French moorings should be incorporated into the assimilation system; ii) research should be performed to assimilate the operational glider data in the simulations. Data access and quality control are two main aspects that need to be carefully considered. The impact of the assimilation of Ebro Delta and Toulon HF radar need to be evaluated before a possible implementation in the operational system.

4.2 Recommendations on monitoring in areas with high connectivity

In this part, offshore wind farm sector is investigated, as an example of areas with high connectivity. The gaps of existing observations have been identified for the purpose of OWF siting, operation and impact assessment, and recommendations for filling the gaps are made accordingly. Currently this work is still on-going. However, there are already some recommendations made.

For in-situ monitoring, information about the lower atmospheric boundary layer are missing (e.g. stability) to better understand/predict atmosphere ocean exchange processes (in particular momentum and heat). There should also be more efforts to develop long term measurement strategies to monitor the massive growth of offshore wind farms. This is strongly linked to the error analysis for models available today, because observation needs are not so significant where models are known to perform well.

It is noticed that in-situ measurements used for operational applications are increasingly affected by offshore wind parks. There should be dedicated observation campaigns to analyse conditions before and after wind farm installations. There are too few measurements of the 3D structure of ocean circulation in coastal areas. This is necessary to better monitor possible impacts of offshore wind farm installation with secondary effects on biological processes. There is a need for more observations of primary production, zooplankton and fish abundance. This will be of increasing importance with the expansion of wind farms. For the wake/lee effects, more observations are needed to understand enhanced vertical mixing and consequent turbidity of the water, vertical nutrient flux due to break-up of stratification and change of primary production and carrying capacity by considering a co-consequence of changes in light climate and nutrient availability changes in the farms.

Monitoring activities are needed to understand following potential impacts of OWFs:

- more hard substrate habitat in otherwise sandy areas leading to more filter feeders, such as mussels on the piles
- consequently more grazing pressure on the phytoplankton (lower chlorophyll-a)
- possibly locally more transparency due to higher grazing pressure (which is counter-acted by enhanced sediment resuspension)

In addition, more precise information on river runoffs are desirable, more frequent updates of the bathymetry, in particular in the tidal dominated German Bight, are desirable. This is of interest in the context of offshore wind farms but is also relevant concerning dredging activities in the Elbe River. Furthermore, a realistic bathymetry of the Danish Straits is critical to capture the connectivity between the North Sea and Baltic Sea with sufficient accuracy.