The joint European Research Infrastructure Network for Coastal Observatories: Achievements and Strategy for the Future D#1.11

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1 Document description

REFERENCES

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2 Foreword

This document is summarizing a major part of the work performed by the FP7-JERICO consortium, including 27 partner institutions, during 4 years (2011-2015). Its objective is to propose a strategy for the European coastal observation and monitoring. To do so we give an overview of the main achievements of the FP7-JERICO project. From this overview, gaps are analysed to draw some recommendations for the future. Overview, gaps and recommendation are addressed at both Hardware and Software levels of the JERICO Research Infrastructure. The main part of the document is built upon this analysis to outcome a general strategy for the future, giving priorities to be targeted and some possible funding mechanisms, but also upon discussions held in dedicated JERICO strategy workshops. This document was initiated in 2014 by the coordination team but considering the fact that an overview of the entire project and its achievement were needed to feed this strategy deliverable it couldn't ended before the end of FP7-JERICO, April 2015. The preparation of the JERICO-NEXT proposal in summer 2014 to answer an H2020 call for proposals pushed the consortium ahead, fed deep thoughts about this strategy but the intention was to not propose a strategy only bounded by the JERICO-NEXT answer. Authors are conscious that writing JERICO-NEXT is even drawing a bias in the thoughts and they tried to be opened. Nevertheless, comments are always welcome to go farther ahead.

Structure of the document

The Chapter 3 introduces the need of sustained coastal observatories, from different point of view including a short description of the FP7-JERICO project.

In Chapter 4, an analysis of the JERICO coastal observatory Hardware (platforms and sensors) in terms of Status at the end of JERICO, identified gaps and recommendations for further development is provided region by region. The main challenges that remain to be overcome is also summarized.

Chapter 5 is dedicated the JERICO infrastructure Software (calibration, operation, quality assessment, data management) and the progress made through JERICO on harmonization of procedures and definition of best practices.

Chapter 6 provides elements of a strategy towards sustainable and integrated coastal observations for Europe, drawing a roadmap for cost-effective scientific-based consolidation of the present infrastructure while maximizing the potential arising from JERICO in terms of innovation, wealth-creation, and business development.

After reading the chapter 3, for who doesn't know JERICO, any chapter can be read independently.

More details are available in the JERICO final reports and its intermediate reports; all are available on the JERICO web site (www.jerico-FP7.eu) as well as any deliverable. Each chapter will list referring JERICO documents. A small bibliographic list is available at the end of this deliverable.

Acknowledgements:

The JERICO coordination team takes opportunity of this last report to deeply thank any person involved in the FP7-JERICO project, including administrative, technical and scientific staff, considering that so many drops make the ocean. We also acknowledge the European commission for its financial support on the contract agreement #262584, and we are grateful to our Project Officer Agnes Robin, DG Research, for her support and fruitful involvement.

Authorship:

We tried to list involved authors for each chapter, but some of them may have been forgotten due to the size of the network of persons behind the infrastructure. We apologize for that. For any request: jerico@ifremer.fr.

3 Introduction

Authors: **Farcy P (Ifremer), Puillat I. (Ifremer), Mills D. (CEFAS), Durand D. (NIVA & COVARTEC)**

3.1 Need of coastal observations and monitoring

3.1.1 What can be the definition of the coastal area?

Traditionally, we define the coastal area as the part of the seas where the dynamics are impacted by the shallow waters (<200m – Zones 2 to 4 of the figure below) and the presence of the land (mainly the coast basins and the rivers mouths and estuaries), but also by the continent which boundaries are the sea shelves.

Marginal sea is defined as a part of the ocean that is separated from the major ocean basins by topographic features; the Baltic Sea but also the Mediterranean Sea are example of European marginal seas under coastal influence, even if the main part of the Mediterranean Sea is deeper than 200m. They are also regions significantly impacted by fresh water runoff from land.

The main impacting factors in the coastal area (differences from the deep ocean) are:

- the effects of shallow water depth;
- the enhancement of tidal motion;
- the presence of coasts;
- stratification;
- the variations in sea level;
- the terrestrial influences mainly through the rivers and catchment's basins.

3.1.2 The coastal and marginal seas: a complex system to monitor

A couple of decades ago emerged the idea of a major environmental change, at both local and global scales, in the face of the recurrent human increasing activities. Consequently, in the sake of a sustainable humanity development, of the ethic and the ecology, the protection and the monitoring of our environment, for its better protection, have become a major stake. Many scientific and technical tools contributed to improve the environmental knowledge, as helped remote and in-situ observations, and forecast modelling. In-situ environmental sensor systems have been designed to be increasingly sustainable even in a hostile environment such as the ocean. In a similar way, the infrastructures hosting those sensors are now thought and built to be relatively permanent. In marine sciences these considerations gave birth to the **"Observatory" concept: long-term infrastructures dedicated to surface, bottom and/or water column in-situ observations**.

Ocean is known to be a complex system and this complexity is enhanced more specifically in the coastal and marginal seas because of the land and atmosphere forcing, which are acting at higher frequency in space and time. Indeed, the impacting factors mentioned here above generate higher dynamics due to the river inputs (fresh water, nutrients, and contaminants), sea states, boundary currents, wind forcing in the shallow water, etc.

In this context, the coastal observatories are contributing to reach the main research goals by responding to the needs of marine and coastal data in a global change context, i.e. the global change effects on the coastal area, acidification, eutrophication, mesoscale and sub-mesoscale dynamics, shelf/slope and coastal –open ocean exchanges, harmful algal bloom and ecosystem vulnerability.

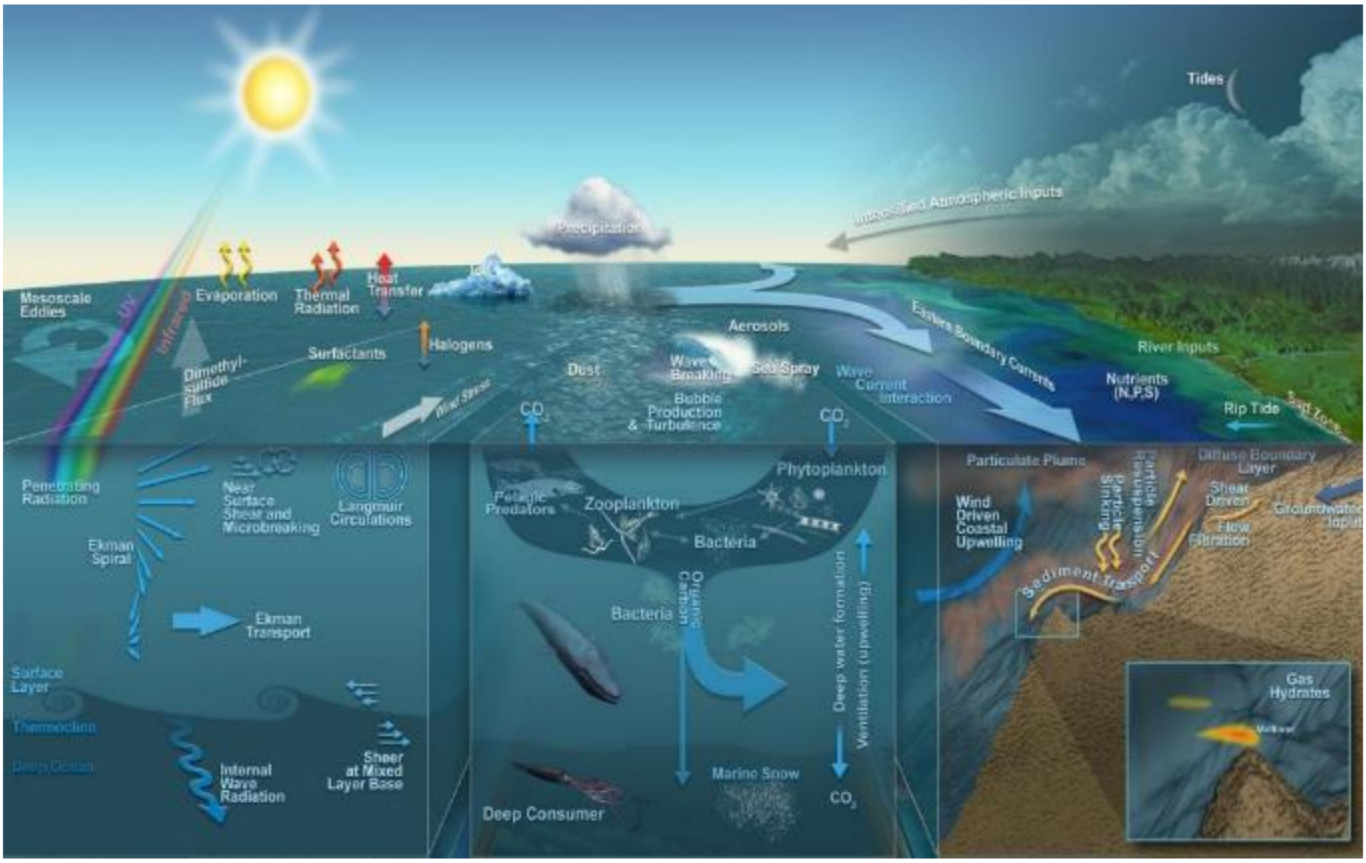

Figure 3.1 The ocean is a complex system due to the diversity of involved processes. [from OOI, Regional Scale Nodes (Delaney, 2008)]

The coastal and marginal seas are characterised by complex physical, chemical and biological processes and by high variability, making these areas more challenging to cost-effectively monitor. With regards to the technology point of view and to the human effort, the monitoring of coastal seas is much more demanding than for deep sea. The coastal parts monitoring needs to measure many parameters coming from multiple observing systems as Lagrangian or Eulerian vectors, ships, fixed stations, radars, satellites.

Nevertheless, most of the European Seas have their own coastal monitoring system, often coordinated regionally, nationally or at a European Level (through EUROGOOS and/or European Research Infrastructure (RI) projects). There is a growing requirement to increase coherence and collaboration in the monitoring and assessment of environmental status of European Seas.

As an example, the actual IBI-ROOS (Irish Sea- Biscay Bay Regional Operational Observing System) is combining 11 kinds of in-situ observing platforms including ferrybox (see table hereafter).

IBI area observatory platforms	Ireland	UK	France	Spain	Portugal	Totals
Fishing vessel based measurements			(60)			(60)
Coastal profilers			(2)			(2)
Ferry Box	1	1	(4)	1		3 (4)
AXBT						
Gliders	1	3	14	3(canaries)		21

Drifting buoys		**20**	**30**			**50**
Fixed buoys (deep water)	**1**	**1**	**5**	**15**		**22**
Fixed buoys (shallow water)	**8**	**8**	**34**	**26**	**6**	**82**
Seabed observatories	**(1)**	**1**	**(2)**			**1 (3)**
Sea level monitoring stations	**20**	**44**	**26**	**39**	**14**	**143**
Radars HF	**1**	**1**	**2**	**1**		**5**

Table 3.1 IBI-ROOS research infrastructure

The sustainability of this system needs to guarantee the sustainability of all the components of the system.

We know that the coastal sea is chronically under sampled, also its monitoring and related investigation is not everywhere considered of high priority. The sustainability of the current observing systems and the development of new ones are not necessary guaranteed.

3.1.3 Society and policy requirements

A coastal observatory network should be:

An integrated system able to provide critical information to support science, marine forecasting, safety, environment and maritime economy" e.g.:

- Research oriented applications (climatic variability, ecosystem functioning),
- Support of maritime transport (forecasts, SAR),
- Fisheries and aquaculture management,
- Environment protection (ecosystem health, oil pollution),
- Coastal zone management (erosion, etc.), MSFD & Water framework directive,
- Support of tourism industry (water quality, yachting),
- Best possible integration with numerical modelling to support continuous information in space and time.

As a consequence, a coastal observatory is dedicated to answer science, society and policy requirements.

Science requirements

The coastal area is impacted by the effects of the global change. An effective observatory network allows us to know what the state of this area is and preferably the historic variability and change. The models are able to forecast how this state will move on in the next days, and produce scenarios for the coming season, year or decades based on climate projections. But, in order to validate the models and the forecasts, it is necessary to know how the coastal ocean is changing and what its variability is: we need to have longest possible time series of ocean data and, of course, sustain the coastal observatories to reach that goal. Moreover, the rationale behind the collection of observations in our coastal seas is a better understanding of both natural and "anthropogenic" variability in biological, chemical and physical. Such data are needed to better inform policy as well as science.

Society requirements

In order to answer society requirements observatories are expected to deliver observations that can sustain the operation of marine forecasting services that bring answers to the questions and expectations of the society in terms of risks and alerts in the coastal seas, ecosystem health, beach erosions, fisheries, biodiversity, oil spill … In this context, the science community has developed the concept of "operational oceanography". This concept is here understood as « being able to support representative data/information of the ocean at the right time, quality and suitable format related to the user's/ societal needs. It is based on very strong links between data providers (observatories) and modelling services; models need more and more data.

A coastal observatory should be a multi-platform distributed and integrated Scientific and Technological Facility, providing streams of oceanographic data and modelling services in support to operational oceanography.

Policy requirements: Marine Policy and European Directives

There are many policy driven requirements for the regular monitoring and assessment of the environmental status of European Seas. These include International treaties (e.g. OSPAR, HELCOM) and several European Directives. A common requirement is to implement an ecosystem approach. To be more explicit there is a requirement for an ecosystem based approach to the management of human activities also referred to as ecosystem based management. Policy requirements are extensive requiring large amounts of data spanning large time and space scales ranging from physics to fish and even sea birds. A new generation of policy drivers such as the Water Framework Directive (WFD) and the European Marine Strategy Framework Directive (MSFD) also require collaborative and regional approaches where the outcome to assessments requires regional agreement between different member states. The MSFD in particular is already taxing both the science and policy communities to devise effective monitoring and assessment strategies in order to achieve Good Environmental Status (GES) by 2020 for European seas. To achieve GES the MSFD requires monitoring and assessment of 11 quantitative descriptors. These are:

1. **Biological diversity** is maintained. The quality and occurrence of habitats and the distribution and abundance of **species** are in line with prevailing physiographic, geographic and climatic conditions.
2. **Non-indigenous species** introduced by human activities are at levels that do not adversely alter the ecosystems.
3. **Populations of commercially exploited fish and shellfish** are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.
4. All elements of the **marine food webs**, to the extent that they are known, occur at **normal abundance and diversity** and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.
5. Human-induced **eutrophication** is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters.
6. **Sea-floor integrity** is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.
7. Permanent alteration of **hydrographical conditions** does not adversely affect marine ecosystems.
8. Concentrations of **contaminants** are at levels not giving rise to pollution effects.
9. **Contaminants in fish and other seafood** for human consumption do not exceed levels established by Community legislation or other relevant standards.
10. Properties and quantities of **marine litter** do not cause harm to the coastal and marine environment.
11. Introduction of **energy, including underwater noise**, is at levels that do not adversely affect the marine environment.

Requirements for monitoring and assessment

Assessment of GES for each descriptor requires application of an assessment method. Typically this requires calculation of an indicator (e.g. over winter concentration of dissolved inorganic nitrogen required for descriptor 5), and an analytical procedure to determine whether the indicator complies with an agreed environmental target. Each indicator requires data and an agreed approach to reporting the outcome for assessment (i.e. maps, graphs, tables). In addition, there is a recognized need for information on prevailing environmental conditions (e.g. time-series of temperature, salinity, turbidity).

Currently, for some descriptors the final choice of indicators and assessment methodology remains unclear. For other descriptors (e.g. eutrophication descriptor 5) the assessment methodology is largely based on an existing framework. An important requirement for the MSFD is move towards a common regional approach to assessment. Where common indicators are agreed, for example, chlorophyll, oxygen and nutrients for descriptor 5 for the North Sea, then further agreement is required on an approach to spatial aggregation of data. Regional scale reporting required by the MSFD requires aggregation within regions at an appropriate ecological scale (e.g. hydrodynamic domains) and does not require assessment within national maritime boundaries. OSPAR has agreed for some common indicators to be adopted by more than one country within a region. OSPAR has also recognised candidate indicators where more work is required to develop the indicator and assessment methodology.

Consequently, regional scale assessments will benefit from regional scale coordination in monitoring and assessment. By operating and regional and pan-European scales JERICO can support regional assessments providing a framework for harmonsing monitoring and facilitating significant increases in efficiency of data collection helping to address the pressing need to 'do more for less' or at least 'more for the same.'

By promoting collaboration, best practice, common standards and the re-use of data, JERICO can also support the need to compare the outcome from environmental assessments between regions and up-scaling to an overall pan-European view of the state of European coastal seas. Furthermore, by evaluating emerging monitoring technologies and determining the 'technology readiness level' JERICO supports the future development of monitoring strategies based on new approaches.

From the previous pages it can be concluded that the marine science community involved in the coastal and marginal seas has… TO RESPOND TO THE 3 KEY DRIVERS:

- The science Priorities
- The strategic Society Needs (policy makers & managers endorsement), MSFD (GES); Energy, Tourism, etc.
- The new necessary Technology Developments (companies, social society endorsement).

Coastal Observatories are particularly well positioned to provide the backbone measurements to answer the above-mentioned needs and drivers but it requires the definition of a JOINT STRATEGY (at international level, in addition to the coordination and Partnership…) between providers of coastal data as well as between Observing and Forecasting Systems.

The common strategy encompasses the following components, elaborated throughout the FP7-JERICO project:

1) Sampling requirements in space and time to address efficiently the needs of both the implementation of the EC Directives and its control, and the operational need of in-situ data from the Copernicus marine services (addressed by WP2 and WP9)
2) Elements of costs and efficiency of observing systems (provided by WP4 and WP10)
3) Standardization, Quality standards (provided jointly by WP3, 4 and 5)
4) Data dissemination (technology, channel, time constraints, …). (provided by WP 5 and 6)
5) Promoting the use of JERICO infrastructure (WP1,WP6, WP7/TOP and WP8)

In the next section, a short description of the FP7-JERICO project is given in order to facilitate the readiness of the rest of the document.

3.2 The JERICO project in a nutshell

3.2.1 Scientific, technological and societal contexts

Coastal observations are important in the marine research because they help understanding marine processes at spatial-temporal scales by direct analysis, by feeding numerical models, and by being assimilated. Moreover acquired data have applications in the domain of coastal engineering such as for instance in the design of a coastal structure, or in the prevention of extreme events (e.g. flooding). As a consequence, around European coastal seas, the number of marine observing systems has quickly increased under the pressure of both monitoring requirements and oceanographic research. Present demands for such systems include reliable, high-quality and comprehensive observations, automated platforms and sensors systems, as well as autonomy over long time periods. In-situ data collected, combined with remote sensing and models output, contribute to detect, understand and forecast the most crucial coastal processes over extensive areas within the various national and regional marine environments.

However significant heterogeneity exists in Europe concerning technological design of observing systems, measured parameters, practices for maintenance and quality control, as well as quality standards for sensors and data exchange. This is because, up to now, the expansion of “coastal observatories” has been driven by domestic interests and mainly undertaken through short-term research projects. Therefore the main challenge for the research community now is to harmonise the technologies, increase the coherence and the sustainability of these dispersed infrastructures by sharing know-how through dedicated actions and experiments and by establishing a roadmap for the future of coastal observatories within a shared pan-European framework. These considerations led 27 institutions to gather in the JERICO project.

3.2.2 Project characteristics and main objective

JERICO (www.FP7-JERICO.eu) is a 4-year long infrastructure project co-funded by the European Commission in the 7th Framework Programme under the grant agreement n° 262584. JERICO is being developed by a consortium of 27 partners from 17 European countries under the coordination of IFREMER (Institut Français de Recherche pour l’Exploitation de la MER), the French national research centre in charge of sustainable management of the sea.

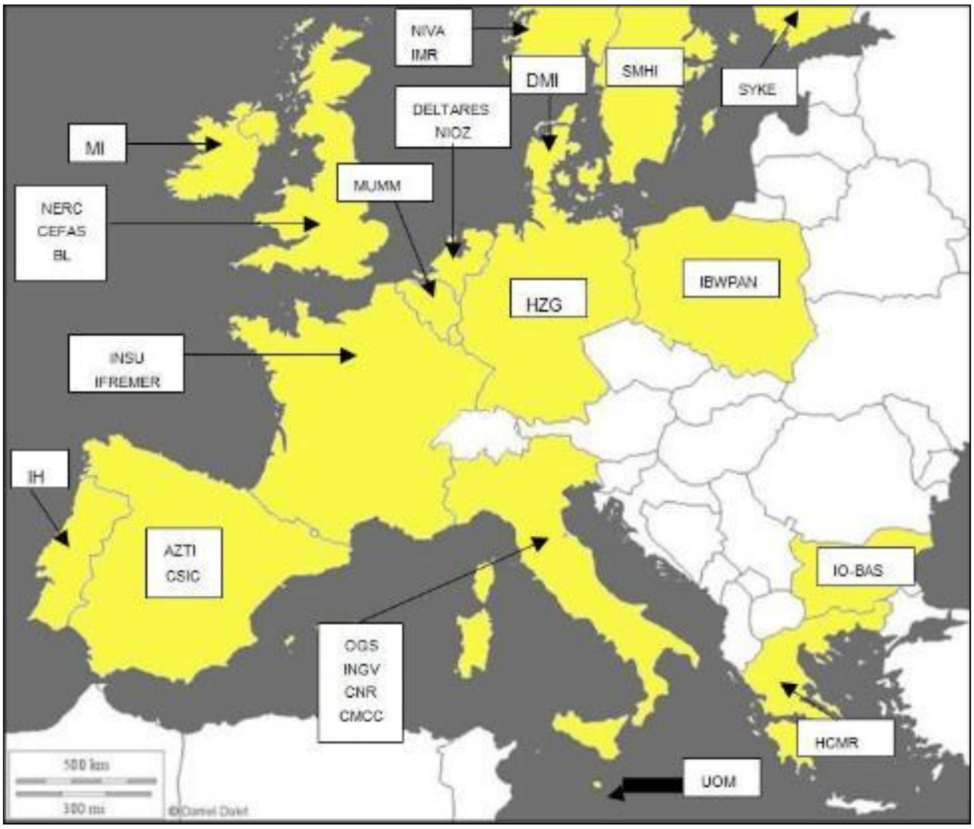

Figure 3.2 Map of institutions involved in the JERICO consortium

The main objective of JERICO (www.FP7-JERICO.eu), which proposes to establish a Pan European approach for a European coastal marine observatory network, is to integrate infrastructures and technologies such as fixed buoys, piles, moorings, drifters, ferryboxes and gliders. JERICO will address 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:

- setting up a European Research Infrastructure for coastal observations based on existing systems in European coastal and shelf seas,
- supporting standardization of methodologies for the benefit of data quality, data availability and cost efficiency,
- promoting the cost-effective use of the facilities,
- stimulating the development of new automated systems for the operational monitoring of the coastal marine environment, with focus on the biochemical compartment.

In order to reach this target JERICO is promoting: (i) networking activities for standardisation issues from the sensors to the data management, (ii) joint research initiatives, (iii) TransNational Access (TNA) to JERICO infrastructures and data access. Networking activities has led to the definitions of best practices for design, implementation, maintenance and distribution of coastal observing systems, as well as the definition of quality standards. Harmonisation and strengthening coastal observation systems within the European Global Ocean Observing System (EuroGOOS) has being sought. Opportunities of Trans-National Access experiments have been carried out in order to promote the potential of JERICO infrastructures used in synergy. New joint researches have been conducted in order to identify new and strategic technologies to be implemented in the next generation European coastal observatories. Focus is given on emerging technologies and on the biochemical compartment.

3.2.3 *Focus and priority areas*

a) JERICO Observing platforms

Coastal observatories dotted along Europe's coastlines deliver a wealth of information on the parameters of the seas. JERICO strives to integrate existing infrastructures and to spearhead the definition of best practices for the design, implementation and maintenance of observing systems and the dissemination of data. It has also initiated research to advance the state of the art, and invited the international scientific community to access key infrastructures. JERICO aims to structure each community related to the three following observation systems:

"Gliders" are small autonomous underwater vehicles. Gliders collect data in the water column, about the temperature, the salinity, the oxygen content, pressure, chlorophyll content and so forth. To find out more about gliders visit the interactive web tool: www.followtheglider.com.

"Fixed platforms" are fixed with respect to their position on or above the seafloor. These platforms host different types of sensors for making measurements related to marine environment and eventually to contaminants. The location of sensors on the seabed or in the water column favours the capability to sense large parts of the ocean which are not detectable from the surface.

"Ferryboxes" are automated instruments packages located on ships of opportunities such as ocean liners and cargo ships. These devices can also be carried by commercial and private boats, and yachts that volunteer to participate in collecting measurements. Measurements are acquired in the upper surface layer.

b) Observations and measurements

The JERICO consortium decided to focus on two sets of parameters. The first set is defined as the core parameters that are operationally observed from the existing JERICO platforms whatever the regional context. It encompasses such parameters as temperature, conductivity/salinity, dissolved oxygen and chlorophyll-a fluorescence. These key parameters provide a general picture of the hydrology, circulation pattern and biochemical properties of the coastal environment.

The second set of parameters considers measurements of high interest for addressing specific scientific questions, but which were not still broadly implemented at the start of the JERICO projects or which had not reached a level of operationallity that made them matured to be broadly implemented. These set of parameters were defined as such: nutrients, carbon budget (pCO2, pH, Alkalinity), current, tide/sea-level, for understanding and predicting tidal cycles, turbidity, coloured dissolved organic matter (CDOM), contaminants, optical properties and sea states.

The JERICO in-situ data can be combined with remote sensing and modelling systems to contribute to detect, understand and forecast the most crucial coastal processes over extensive areas within the various national and regional marine environments.

As part of its drive towards an alignment of practices, JERICO advises coastal observatories to cover the above-mentioned shared list of core parameters. In addition, the JERICO team strongly encourages to address also carbon budget and water quality through the measurement of acidity (pH), partial pressure of carbon dioxide (pCO2) and turbidity. These parameters tie in with environmental monitoring needs as well as with the Water Framework Directive and the Marine Strategy Framework Directive. This list is not exclusive and some other parameters can be monitored as sea-states and currents.

3.2.4 JERICO position in the international display

The ocean, especially the water column, continues to be severely under-sampled in some locations and according to specific scientific objectives or policy requirements. Efforts, such as the integrated ocean observing system (IOOS) and the global ocean observing system (GOOS) and its regional programs, are evolving to provide international coordination. However, gathering the required data in the field can prove costly. Recent efforts have shown great promise in reducing this cost by taking advantage of ships of opportunity (SOOP's) or volunteer observing ships (VOS's) as mobile platforms for environmental data collection. The installed systems can integrate data from water quality and meteorological sensors with GPS information into a data stream that is automatically transferred from ship to shore. The strengths of SOOP program are many: no ship operation costs, no energy restrictions, regular maintenance possible, transects sampled repeatedly and bio-fouling can be better controlled. The potential for data coverage by ferries and cargo ships cruising on the same route on a regular basis is large, especially in coastal regions.

JERICO contributes to the international and global effort on Global Earth Observation System of Systems (GEOSS), and to the marine core service of the European Earth observation programme Copernicus (previously named GMES), by providing coastal data inputs for operational ocean observing and forecasting. JERICO also helps answering to some of the environmental and societal needs in the framework of the European Water Directive and of the Marine Strategy Framework Directive. This project has been conceived in the framework of the Marine ERA-NET (A Marine RTD Infrastructure Strategy for Member States - April 2009). JERICO is clearly a process aiming at bringing together the representative European coastal observatory operators, enhancing their coordination and promoting the cost-effective use of their facilities, in order to support the efficient provision of essential research and monitoring networks. JERICO is also built upon existing infrastructures and regional networks at European scale including the European Global Ocean Observation System (EuroGOOS).

JERICO is designing an infrastructure organisation devoted to the automated in-situ coastal and shelf-sea observations, completing observations from satellites (handled by Copernicus) and from the automated in-situ open ocean systems, such as FixO3 and those developed under the ERIC EURO-ARGO and ESFRI EMSO. The position of JERICO in the maze of EU marine projects and initiatives is illustrated in **Erreur ! Source du renvoi introuvable.**. Data acquisition in the open sea has benefited meteorological and climate change studies in which a limited number of essential variables are monitored, namely temperature and salinity. The coastal component of this global network has been, up to JERICO birth, far less coordinated. It requires datasets comprising many more variables acquired at higher frequencies. The JERICO project has been developed in this perspective to coordinate actions for coastal observatories.

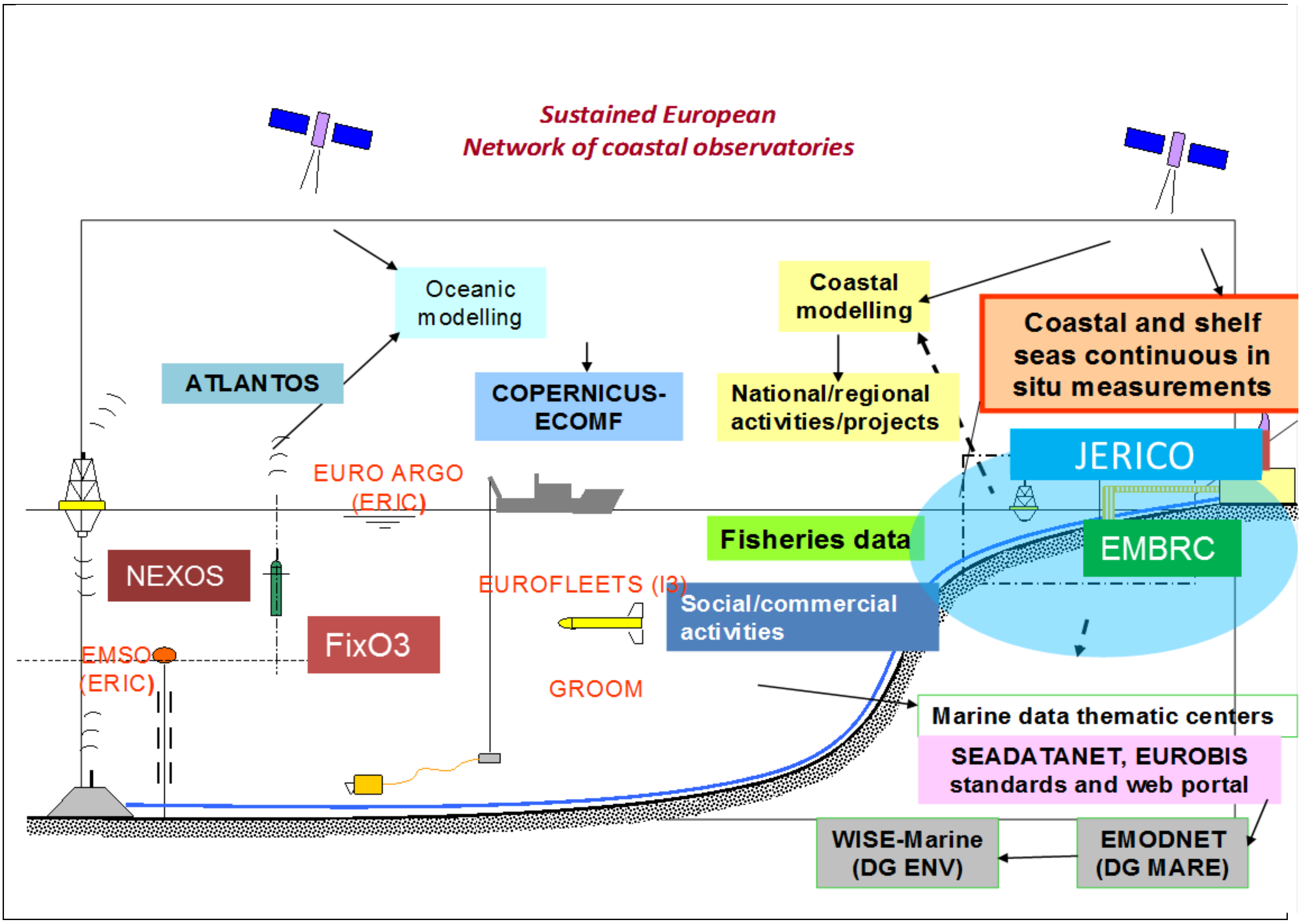

Figure 3.3 Position of JERICO in the map of the EU marine projects and initiatives;

As a consequence, JERICO is an important piece of the global ocean infrastructure that Europe contributes in building, and of the so-called EOOS (European Ocean Observing System, European Marine Board, 2013, “Navigating the Future IV”).

4 The JERICO Infrastructure Hardware

Section 4.1 authors: Morin P. & Kriegger M. (CNRS); Wehde H. (IMR), Puillat I. (Ifremer)
Section 4.2 authors: Nolan G. & Gaughan (MI), Sørensen K. (Niva), Seppala J. (Syke)
Section 4.3 author: Tintore J. (SOCIB-CSIC)

Reference documents:

Del. no.	Deliverable name	WP n°	Lead contractor	To download deliverable
D2.1	Report on existing observation network from all ROOSs	2	IMR	http://www.jerico-fp7.eu/deliverables/d21-jerico-report-on-existing-network
D2.2	Report on recommendations for future research and developments for filling gaps in the areas where observations are unattainable due to lack of best practice or technologies from all ROOSes	2	IMR	http://www.jerico-fp7.eu/deliverables/d22-report-on-existing-calibration-facilities
D2.3	Integrated Pan European Atlas Report on Coastal Observing systems)	2	IMR	http://www.jerico-fp7.eu/deliverables/d23-integrated-pan-european-atlas-report-on-coastal-observing-systems
D2.5	D2.5 Integrated Pan European Atlas Second Report on Coastal Observing systems	2	IMR	http://www.jerico-fp7.eu/deliverables/d2-5-integrated-pan-european-atlas-second-report-on-coastal-observing-systems
10.1	Report on trials and deployments:	10	MI	http://www.jerico-fp7.eu/deliverables/d10-1-report-on-trials-and-deployments
10.2	Set of software:	10	MI	http://www.jerico-fp7.eu/deliverables/d10-2-development-of-set-of-software-for-image-analysis
10.3	Report on data analysis	10	MI	http://www.jerico-fp7.eu/deliverables/d10-3-report-on-data-analysis
10.4	Report on Potential new sensors	10	MI	http://www.jerico-fp7.eu/deliverables/d10-4-report-on-potential-new-sensors-fishing-vessels-and-voluntary-opportunity-ships

10	JERICO WP 10 Workshop Report	10	MI	http://www.jerico-fp7.eu/attachments/article/297/workshop%20WP10%20report%20gnolan%20v3.0.docx
D3.4	Report on New sensor Developments	3	HZG	http://www.jerico-fp7.eu/deliverables/d3-4-report-on-new-sensor-developments

The status of the JERICO infrastructure for each European region involved in EUROGOOS is presented in annex 1 of this document due to the considerable volume of pages needed to review this status. It includes maps of infrastructures and measured parameters. Hereafter, we limited the section 4.1 to an analysis of gaps and recommendations for European ocean observing regions. Then, a summary of the technology and/or methodology developments performed during the FP7-JERICO is given, to identify the gaps and next steps for the coastal technology developments (section 4.2). To conclude the chapter, the European strategy for innovation dedicated to the marine environment monitoring and observation is discussed (section 4.3).

Figure 4.1 Marine research infrastructure (Source : XXXX)

4.1 Observing platforms: gaps and recommendation for the regional to pan-European integration

The objective of this section is to propose a review of gaps and associated recommendations, considering the review of platforms status in each ROOS which is presented in annex 1. For each ROOS a table is synthesizing the status of the existing network for the different platforms and sensors giving an idea of weather the areas are either well observed, not sufficiently observed and areas where observations are missing. This status is not the reflecting the authors' opinion but the answers gathered after dedicated surveys. Indeed, in order to get an overview of the status, gaps and to propose plans for the future, ROOS specifics surveys were sent to ROOS reference persons. Hereafter a synthesis is presented.

A detailed overview of the regional *in-situ* observing system provided by ROOS can be found in Deliverable D2.1"*Report on existing observation network from all ROOSs*".

For all ROOS the key overarching issues that are and will be important for obtaining knowledge about actual state of the environment are displayed in Table 4.1

Table 4.1: A generic summary of areas of benefit, product lines, intermediate and final users (from unknown)

Table 1 A generic summary of areas of benefit, product lines, intermediate and final users

Area of benefit	Products	To intermediate users[a]	Final user
Climate research	Comprehensive and inferred observational data sets reanalysed in state of the art models	Climate research centres	Ocean and climate research; validation of scenarios. Policy-making on climate change
Marine Environmental Protection	State and impact data and associated indicators	EEA, OSPAR, HELCOM, Barcelona, National environmental agencies	DG ENV, Policy makers, general public
Seasonal forecasting and extended weather forecasts	Initial ocean conditions; reanalysis	ECMWF, National Meteorological Services (NMS)	Agriculture, insurance, energy, transport; public safety preparedness; research
Marine safety	High resolution ice/sea state and ocean current forecasts	NMSs, National Oceanographic Agencies, National Marine safety agencies, maritime transport industry	Search and rescue, drifting object management; extreme wave forecast preparation; marine transportation
Fisheries, ecosystems	Physical conditions; re-analysis of past conditions	National marine and fisheries institutes	ICES, DG FISH, National fisheries; research
Shipping and offshore industries	High resolution ice/sea-state and current forecasts for operations: reanalyses for design	Value adding service companies	Operation support, ship routing, structure design criteria, risk assessment; EMSA
Oil Spill management	Temperature, wind, wave and current data	Responsible National marine agencies and European Marine Safety Agency (EMSA)	Affected coastal public authorities and businesses
Civil Security	Temperature, wind, wave and current data	Customs and Excise, Coast Guards	DG TREN, Immigration and drug control agencies, police forces
Marine Environment, Ecosystems	Boundary and initial conditions, data products	National Coastal monitoring and forecasting system	National environmental or marine agencies; National WFD reporting; Coastal management.

4.1.1 BOOS

The BOOS region covers the entire Baltic Sea region. 20 partner institutes cooperate for the provision of operational Oceanography services within the region. The observational system consists mainly of tide gauges and moored buoys/fixed platforms providing real time observations. Ships of Opportunity and Research Vessels are complementing the real time data delivery system. It is obvious that the BOOS real time observational system is mainly based on tide gauges and moored systems/buoys, a consequence of the deep financial crisis in the Baltic within the 1990´s which was followed by a large reduction of vessel based observational efforts. .

a) *Gaps*

The status of existing network for the different platforms and sensors in the BOOS region is synthetized in the

Table 4.2 Status and gaps in the networks and sensors for the different types of platforms in the BOOS region

	Well observed	Not sufficiently observed	Missing	Upcoming in the next 5 years (name of projects, persons involved)
Areas or networks	Ferrybox lines Fixed Platforms	Gliders (only oceanographic campaigns)		
Sensors	Ferrybox (T,S, Turb, Flu Chl) Gliders (T, S, O2, Chl Flu, Turb) Fixed Platforms (Sea Level)	Ferrybox (O2, pCO2, Nutrients, Biological parameters) Fixed Platforms (T, S: Kattegat coastal waters)	Gliders (pCO2, Nutrients, Biological parameters) Fixed Platforms (O2, Chl Flu, Turb, pCO2, Nutrients, Biological Parameters)	

The BOOS region is well observed with numerous Ferrybox lines and fixed platforms and not sufficiently with gliders which are operated, such as in the other regions, only during oceanographic cruises reducing the spatio-temporal coverage of the water column.

To achieve a final configuration of the network, some effort could be put on expanding the network of Ferrybox lines (with lines crossing perpendicularly the existing lines) and on installing new fixed platforms in two areas not sufficiently observed which are the Kattegat and the South Baltic Sea.

As in the other ROOS regions, the recommendation is to develop a routine mode for gliders with implementation of repeated sections in chosen basins of the Baltic Sea to access a better description of the water column.

In terms of parameters, the classical physical, chemical and biological parameters give access to a good description of the BOOS region with Ferrybox lines and effort is being put in implementing in this region recently new validated sensors such as pCO2, nutrients and biological sensors for cyanobacteria and phycocyanins. By contrast, the situation is totally different for the fixed platforms where only the tidal gauge network is sufficiently developed (excepted in Kattegat and South Baltic Sea). A substantial must be put to develop the network of oceanographic multiparametric buoys equipped with the same set of sensors as the existing ferry box to achieve a satisfying spatio-temporal coverage of the BOOS region.

The observing systems should complement existing research vessel based sampling. One reason is to increase spatial and temporal coverage to resolve natural variability. Several biological parameters are under sampled. In the EU Marine Strategy Framework Directive e.g. biodiversity, food webs, invasive species, eutrophication including harmful algal blooms need more data. For phyto- and zooplankton this can be accomplished using e.g. in-situ imaging systems and automated water sampling and subsequent laboratory analyses.

The following remarks are mainly focused on biology. Of course data on currents, stratification etc., are also of importance. Gliders, free drifting profiling devices and HF-radar (for surface currents), are in general missing in the area. HF radar is being evaluated in the Skagerrak at present and may complement in the near future the network of coastal observing systems.

The existing observational system serves the main needs of the actual Marine Forecasting System. However the observational system should be improved in order to reduce the uncertainty of the knowledge obtained. Hereby the BOOS community identifies the following main issues that are subject for improvement of the observational system for the BOOS area within the actual environmental status:

- Ferrybox network – The existing one should be expanded
- Establishment of additionally at least one fixed platform in every basin of the Baltic with near real time measurements in the water column for temperature, salinity, waves, currents, oxygen, nutrients, fluorescence and meteorological parameters
- Near real time current measurements in the Belts and the Sound
- Extension of the water level measurement network especially in the Southern Baltic and Gotland (Visby) region
- Development of a reliable Real time data transmission system from research vessels.

For different reasons data from many stations in the BOOS region are missing due to the fact that many operators/owners do not give access to their data. This leads to a strong recommendation to the station owners in the BOOS region to give a better access to data.

There is a need to improve the in-situ observing system to achieve an appropriate and comprehensive understanding of the functioning of the marine environment and the monitoring of marine and maritime activities to ensure their sustainable development. <u>Key priority in order to implement EU legislations</u> such as the Marine Strategy Framework Directive, the Common Fisheries Policy, as well to improve the ability to monitor the effect of climatic variability the BOOS <u>community has identified the major issues to improve the observational system for the Baltic Sea</u>:

- Stable long-time series multiparameter bottom network for the monitoring of climate variability. For this purpose the long term stability for the variables temperature, salinity and possibly oxygen should be improved
- Improvement of the monitoring system that covers the variability in the biogeochemical variables in order to improve the ability to serve the Baltic Sea Regional Strategy
- Establishment of monitoring capacity to investigate the adaptation of the ecosystem to changed climatic conditions is necessary to fulfill the needs of the marine spatial planning activities ongoing within the BOOS region. That makes it necessary to obtain more detailed basic information for decision making at local as well as at regional scales.

b) *<u>Recommendations for BOOS</u>*

Some specific recommendations could be given depending of the areas:

- ♦ *Kattegat - Skagerrak (eastern North Sea)*

The identified gaps and suggested solutions to overcome the gaps are given:

1. Sampling from research vessels and automated sampling using Ferrybox-systems and fixed platforms should be more coordinated.
2. Water sampling at fixed platforms for quality control of data from automated measurements needs to be further developed.
3. Cabled observatories are few or missing. Using these systems data may be collected from several depths. Cabled observatories provide power and fast data communication, e.g. for automated biological observations.
4. Near surface waters are well investigated. Data from deeper parts of the water column is largely missing.
5. Near real time data on phytoplankton and harmful algal blooms is missing. It is suggested that Imaging Flow Cytometers are evaluated for semi-automated analysis of phytoplankton. Cabled observatories and other fixed platforms should be used. Also Ferrybox-systems are useful platforms for this.
6. Estimates of phytoplankton biomass should be made in a more consistent way compared with today. Use chlorophyll fluorescence collected using Ferrybox-systems and night-time chlorophyll fluorescence from buoys in a consistent way.
7. Near sea floor oxygen data is collected only at a few temporary positions using buoys and bottom mounted systems. The systems should be made permanent.
8. No near real time data on the Jutland current is available. Fixed platforms or Ferrybox systems should be used.
9. Information to fisheries, the aqua culture industry and the public is underdeveloped. A Multilanguage web site with information to the regions should be set up and manned.
10. Data distribution and quality control is underdeveloped.

- *The Baltic Sea*

The identified gaps and suggested solutions to overcome the gaps are given:

1. Near surface waters are well investigated. Data from deeper parts of the water column is largely missing. Bottom mounted systems for measuring inflow of oxygen rich water to the deeper basins should be developed further.
2. Sampling from research vessels and automated sampling using Ferrybox-systems and fixed platforms should be more coordinated.
3. Water sampling at fixed platforms for quality control of data from automated measurements needs to be further developed.
4. Cabled observatories are few or missing. Using these systems data may be collected from several depths. Cabled observatories provide power and fast data communication, e.g. for automated biological observations.
5. Near real time data on phytoplankton and harmful algal blooms is missing. It is suggested that Imaging Flow Cytometers are evaluated for semi-automated analysis of phytoplankton. Cabled observatories and other fixed platforms should be used. Also Ferrybox-systems are useful platforms for this.
6. Estimates of phytoplankton biomass should be made in a more consistent way compared with today. Use chlorophyll fluorescence collected using Ferrybox-systems and night-time chlorophyll fluorescence from buoys in a consistent way.
7. Near sea floor oxygen data is collected only at a few temporary positions using buoys and bottom mounted systems. The systems should be made permanent.
8. No near real time data on the Jutland current is available. Fixed platforms or Ferrybox systems should be used.
9. Information to fisheries, the aquaculture industry and the public is underdeveloped. A Multilanguage web site with information to the regions should be set up and manned.
10. Data distribution and quality control is underdeveloped.

For the BOOS region, in general, the recommendations for developing the coastal observing systems are:

- To expand the network of Ferrybox lines with lines crossing perpendicularly the existing lines in the Baltic Sea.
- To add the dissolved oxygen parameter to the existing four Ferrybox lines not yet equipped with this sensor.
- To harmonize the Ferrybox set of sensors by adding recently validated parameters such as carbon system sensors (pCO2, alkalinity) and in the future additional sensors under development such as nutrients, phycocyanins and cyanobacteria are operated on some of the lines.
- To extend the network of fixed platforms in Kattegat and South Baltic areas to reach a better regular spatial coverage
- To add chemical (dissolved oxygen, pCO_2) and biological parameters (chlorophyll fluorescence,) on existing fixed platforms that are insufficiently instrumented in this region compared to the Ferrybox lines

As for the other European regions the **sustainability of the existing observational system is one of the main challenges** facing the partners within the IBI-ROOS region. Coastal observing system sustainability should be pushed through a better collaboration framework between actors of core and downstream services, aiming to reach a general coherent system in which the levels of founding (Regional, National and European) are clarified and complementary.

4.1.2 NOOS

The NOOS region covers the extended North Sea region and European North West Shelf. NOOS is operated by the 9 bordering countries and 24 partner institutes cooperate for the provision of operational Oceanography services within the region.

The observational system consists of multiplatform real time observing system that is composed mainly by drifters, tide gauges/moorings and Argo observations.

Ships of Opportunity and some Research Vessel activity as well as HF radar systems are complementing the real time data delivery system. Hereby especially the coverage of the *in-situ* observation system, in terms of directs current measurements, is subject for improvement.

Sustainability of the existing observational system is one of the key challenges for the NOOS region.

The marine environment changes throughout the years as a result of both local and external influences. According to focuses processes, and topics some periods are more important to monitor than others. Table 4.3 is providing an overview of periods that are important to cover with monitoring programs to answer some specific issues. In addition there will is a need to improve the sampling strategy, by better choosing the frequency and timing of the monitoring coverage. In other words, there will be periods within the year for the various monitoring elements which are more important than data collection in other periods.

Table 4.3 : Overview over important periods for central issues. Crosses reflect periods where monitoring is recommended. Crosses in parenthesis reflects periods of minor importance for the specific parameter

	J	F	M	A	M	J	J	A	S	O	N	D
Nutrients												
Production basis (abiotic)	x	x	x	x	x			x	x			
Eutrophication	x	x			x	x	x	x				
Longtransport vs. local impact			(x)	x	x	x	x					
Oxygen(bottom water)	x	x					x	x	x	x		
Management plan	x	x		x	x	x	x	x				
Nutrient dynamic	x	x	x	x	x	x		x	x	x		
Acidification (DIC)	x			x				x		x		
Physical oceanography	J	F	M	A	M	J	J	A	S	O	N	D
Transport		x	x	x	x	x	x	x	x	x	(x)	
Ventilation		x	x	x	(x)			x	x	x	(x)	
Mixed layer/ stability		(x)	x	x	x	(x)	(x)	(x)	x	x	x	
Climate effects		x	x	x	x	x	x	x	x	x	x	
Model validation	x	x	x	x	x	x	x	x	x	x	x	X
Phytoplankton	J	F	M	A	M	J	J	A	S	O	N	D
Production basis/ Primary Production		X	x	x	x	x	x	x	x	x		
Biodiversity		(x)	x	x	x	x	x	x	x	(x)		
Climate effects			(x)	x	x	x	x	x	x	x	x	
Eutrophication/environmental status		X	x	x	x	x	x	x	x	x		
Harmful algae/ blooms			x	x	x	x	x	x	x	(x)		
Alien Species			x	x	x	x	x	x	x	x	x	
Management plan		X	x	x	x	x		x	x	x		
Zooplankton	J	F	M	A	M	J	J	A	S	O	N	D
Production basis/Primary production	x		x	x	x	x	x	x	x	(x)		
Biodiversity			x	x	x	x	x	x	x			
Climate effects			x	x	x	x	x	x	x			

a) *Gaps*

The status of existing network for the different platforms and sensors is synthetized in the Table 4.4.

Table 4.4 State of art in the networks and sensors for the different types of platforms in the NOOS region

	Well observed	Not sufficiently observed	Missing	Upcoming in the next 5 years (name of projects, persons involved)
Areas or networks	Ferrybox lines Fixed Platforms	Gliders (only oceanographic campaigns)		
Sensors	Ferrybox (T,S, Turb, Flu Chl) Gliders (T, S, O2, Chl Flu, Turb) Fixed Platforms (Sea Level, T, S)	Ferrybox (O2, pCO2, Nutrients) Fixed Platforms (O2, Chl Flu, Turb)	Ferrybox (Biological parameters) Gliders (pCO2, Nutrients, Biological parameters) Fixed Platforms (pCO2, Nutrients, Biological Parameters)	

For the fixed platforms and Ferrybox lines, the NOOS region is well observed with a sufficiently dense network of existing Ferrybox lines. For gliders, the NOOS region is insufficiently observed with only oceanographic campaigns giving access to an insufficient spatial and temporal coverage.

Concerning the tidal gauge network the NOOS area has reached a satisfying configuration with areas potentially vulnerable to flooding equipped for early warning.

The existing network of fixed platforms gives access to a good description of the physical parameters (temperature, salinity) in the NOOS area. The **main challenge** for the NOOS area will be the same as for the IBI-ROOS region and will be the development of **observations of biogeochemical and biological data which are only marginally provided and lacking in most of the platforms**. An effort must be made to **implement existing platforms with mature sensors** such as dissolved oxygen, fluorometers and turbidimeters. It is recommended to integrate in the future recently validated sensors such as carbon system sensors (pCO_2, alkalinity and pH) nutrients, contaminants and biological sensors (flow cytometer, new biological sensors developed in WP10). Long term high frequency sensor monitoring from fixed stations (moorings, piers), for time series analysis, will have to be preferably implemented near the coast so that regular water samples can be collected for validation and acquisition of additional variables.

The Ferrybox network in the NOOS region is well developed with seven existing lines. It will be recommended to add in the network a North-South line between Amsterdam and Bergen which was previously operated by Norwegian partners (BCCR, Univ. Bergen) to densify the existing network of ferry box lines. In terms of sensors, the existing Ferrybox lines are equipped with the classical validated sensors (T,S, DO, chlorophyll fluorescence and turbidity) but dissolved oxygen sensors are not present for some Ferrybox lines and it is recommended for these lines to complete the set of sensors with Dissolved Oxygen. Some Ferrybox lines are already equipped with pCO2 and nutrient sensors and the experience obtained from the deployment of these sensors will be useful for the implementation of these new validated sensors in other ROOS regions. As for fixed platforms, it is recommended to integrate in the future recently validated sensors such as carbon system sensors (pCO_2, alkalinity and pH) nutrients, contaminants and biological sensors (flow cytometer, new biological sensors developed in WP10).

As for all regions, data from gliders in the NOOS region are obtained during oceanographic cruises. The spatial and temporal coverage are thus limited to specific coastal areas and certain periods. The possibility to operating gliders in a routine mode along repeated sections must be studied. It should be recommended to implement in the NOOS region repeated glider sections with a regular frequency to be determined (monthly, seasonally, yearly) and preferentially along existing Ferrybox lines to complement with data obtained along the water column the surface high frequency data. Gliders will have to be equipped with the classical measured parameters on the European glider fleet and possibly in the future with more recently validated sensors such as pCO_2 and nutrients.

b) *Recommendations for NOOS*

For the NOOS region, the recommendations for developing the coastal observing systems are:

- To expand the Ferrybox network to provide data on a North-South transect in the North Sea (by restarting the previously operated line between 2005 and 2009 from Amsterdam to Bergen with M/S Trans Carrier
- To add the dissolved oxygen parameter to the existing Ferrybox lines not yet equipped with this sensor.
- To harmonize the Ferrybox set of sensors by adding recently validated parameters such as carbon system sensors (pCO2, alkalinity) and in the future additional sensors under development such as nutrients and biological parameters (cyanobacteria, flow cytometer, …)
- To implement in the NOOS region repeated glider sections with a regular frequency to be determined (monthly, seasonally, yearly) and preferentially along existing Ferrybox lines to complement with data obtained along the water column the surface high frequency data.
- To develop observations of biogeochemical and biological data which are only marginally provided and lacking in most of the platforms. An effort must be made to implement existing platforms with mature sensors such as dissolved oxygen, fluorometers and turbidimeters. It is recommended to integrate in the future recently validated sensors such as carbon system sensors (pCO_2, alkalinity and pH) nutrients, contaminants and biological sensors (flow cytometer, new biological sensors developed in WP10).
- To complete the set of observing platforms with HF Radars such as the HF radar recently installed near the mouth of the Rhine river.
- To continue to collect ship-based water samples at some locations for validation and trend analysis
- To develop monitoring platforms giving access to vertical profiles of variables.

As for the other European regions the **sustainability of the existing observational system is one of the main challenges** facing the partners within the IBI-ROOS region. Coastal observing system sustainability should be pushed through a better collaboration framework between actors of core and downstream services, aiming to reach a general coherent system in which the levels of founding (Regional, National and European) are clarified and complementary.

Furthermore NOOS has a strong need for observational data for forecasting models concerning freshwater input from rivers that is still an issue to be improved for the more reliable prediction of the coastal ocean at high resolution in order to serve the public and users with detailed information where the demand is highest. In addition, numerical prediction of ocean bio-geochemistry is a growing activity.

The improvement of the accessing possibilities and making use of freshwater flux and nutrient/contaminant concentration observations are expected.

4.1.3 Arctic-ROOS

The Arctic ROOS region covers the high latitudinal Oceans north of 62 N. A group of 16 partner's institutes collaborate within the Arctic ROOS community providing operational services and scientific data from the observational system. Overall, the Arctic ROOS area is severely under sampled regarding *in-situ* observations. A major part of the observatory is conducted in annual or biannual cruises. In addition to servicing the moorings, the cruises are important for obtaining high resolution hydrography both in the horizontal and vertical. Water samples taken on the cruises are providing stable oxygen isotope ratios and nitrate to phosphate ratios are supplementing the permanently installed instrumentation. In addition, work on the sea ice (ice thicknesses, snow depth, radiative properties) supplements the observations made from the upward looking sonars on the moorings...

The potential changes in the environment make it necessary to evolve the observational system accordingly. Dedicated baseline studies are recommended to get improved knowledge of potential impacts of the expected changes within the Arctic Region.

The changes within the Arctic region are expected to be dramatically.

a) *Gaps*

The status of existing network for the different platforms and sensors is synthetized in the Table 4.5.

Table 4.5: State of art and gaps in the networks and sensors for the different types of platforms in the Arctic ROOS region

	Well observed	Not sufficiently observed	Missing	Upcoming in the next 5 years (name of projects, persons involved)
Areas or networks	Ferrybox lines (Norwegian coastal waters) Fixed Platforms (Norwegian coastal waters)	Ferrybox lines (Norwegian Sea) Gliders (Iceland Sea)	Gliders (Norwegian Sea)	Gliders (University of Bergen, Norway)
Sensors	Ferrybox (T,S, Flu Chl, Turb) Gliders (T, S, O2, Chl Flu, Turb)	Ferrybox (Flu Chl, Turb, Nutrients) Fixed Platforms (Sea Level)	Ferrybox (O2, pCO2, Biological parameters) Gliders (pCO2, Nutrients, Biological parameters) Fixed Platforms (O2, Chl Flu, Turb, pCO2, Nutrients, Biological Parameters)	

The Arctic ROOS region is well observed particularly along the Norwegian coasts with Ferrybox lines and fixed platforms and not sufficiently with gliders which are operated such as in the other regions only during oceanographic cruises reducing the spatio-temporal coverage of the water column. To achieve a better configuration of the network, some effort could be put on expanding the network of Ferrybox lines and on installing new fixed platforms to increase the spatial coverage in the Arctic ROOS region. As in the other ROOS regions, the recommendation is to develop a routine mode for gliders with implementation of repeated sections to access a better description of the water column.

In terms of parameters, the classical physical, chemical and biological parameters give access to a good description of the Norwegian region with Ferrybox lines and effort is being put in implementing in this region recently new validated sensors such as pCO_2. A substantial effort must be put to develop the network of oceanographic multiparametric buoys equipped with the same set of sensors as those existing for ferry boxes to achieve a satisfying spatio-temporal coverage of the Arctic ROOS region.

b) Recommendations for Arctic-ROOS

A long-term monitoring program for the Arctic Ocean should be established in order to observe the changes in the physical and chemical environment and to assess the impact of these changes on the ecosystem.

This program will have to reflect the seasonal fluctuation of sea ice in the area, since access will partly be limited to the summer/autumn period when sea ice coverage is at its minimum.

In order to get an improved knowledge the sampling frequency of the regional surveys should be increased aiming for an at least seasonal coverage.

Focal point of the future monitoring should include:

- Seasonal Oceanography and habitat mapping
- Sympagic community mapping during the regional surveys
- Pelagic community mapping
- Demersal community mapping
- The uncertainties in the impact of the expected changes in the marine environment should be decreased by research efforts that are focusing on the following main topics:
- To estimate vital rates and parameters that are important for the functioning of the present Arctic Ocean ecosystem
- To evaluate the impact of changes in productivity and whether any such changes might result in restructuring of the Arctic marine ecosystem.
- To investigate the interplay between the Arctic Ocean and the shallow shelves.

Evaluate environmental risks of human activities. For the Arctic ROOS region, the recommendations for developing the coastal observing systems are:

- To expand the network of Ferrybox lines using transatlantic merchant vessels.
- To harmonize the Ferrybox set of sensors by adding recently validated parameters such as carbon system sensors (pCO_2, alkalinity) ad in the future additional sensors under development such as nutrients, biological parameters: phycocyanins and cyanobacteria.
- To develop the multiparametric oceanographic fixed platforms network along the Norwegian coast, Svalbard and Iceland: one main challenge identified is the provision of biogeochemical

data (dissolved gases and oxygen, chlorophyll fluorescence, …), lacking on most of the arrays. It should be recommended to add these sensors at least on existing fixed platforms.

- To implement repeated glider sections with a regular frequency to be determined (monthly, seasonally, yearly) and preferentially along existing repeated sections by research vessels and Ferrybox lines

As for the other European regions the **sustainability of the existing observational system is one of the main challenges** facing the partners within the IBI-ROOS region. Coastal observing system sustainability should be pushed through a better collaboration framework between actors of core and downstream services, aiming to reach a general coherent system in which the levels of founding (Regional, National and European) are clarified and complementary.

4.1.4 IBI-ROOS

The IBI-ROOS region extends along the Atlantic front of Europe, covering from the Irish Sea to the most southern Iberian region. 17 partners cooperate for the provision of Operational Oceanography services within the region. The observational system consists of a multiplatform real time observing system currently composed basically of Drifters, Tidal gauges/Moorings, vessels and Argo floats observations. Observations provided by Ferryboxes, Gliders and Fishing vessels as well as HF radar systems are complementing the observational program.

.

a) *Gaps*

The state of art in terms of existing network for the different platforms and sensors give access to information concerning the areas which are either well observed, not sufficiently observed and areas where observations are missing. This information is synthetized in the Table 4.6: State of art and gaps in the networks and sensors for the different types of platforms in the IBI-ROOS region.

For the Fixed Platforms, the IBI-ROOS region is well observed with a dense network of existing platforms.

Concerning the Tidal gauge network the IBI-ROOS area has mostly reached the final configuration. A few areas vulnerable to flooding have been identified to be equipped with tide gauges in order to enable reduction on uncertainties for early warning system. An outstanding issue is the implementation of new transmission technology in parts of the Gauge network to minimize the delay in data transmission. Moreover, for climate purposes, geodynamics laboratories have been proposed to complete key tidal gauge stations as high precision level references.

Concerning the observations of physical parameters (temperature, salinity), the existing network gives access to a good description of the IBI-ROOS region.

Concerning the development of the Moored Buoys network, one main challenge identified for the IBI-ROOS area is also the **provision of biogeochemical data, only marginally provided and lacking on most of the arrays**. New technological solutions for reducing maintenance needs and clear advices on sensors selection are mandatory. The current coastal network is dense but still not homogeneous along the Atlantic coast. A better coordination at IBI-ROOS level for key identified platforms should be pushed.

The application of HF Radars is aimed to be intensified. Networking within the data providers’ community should be pushed. A joint effort to homogenize the acquisition and exploitation procedures of the HF Radar data is needed. This development should contribute to a better characterization of the water surface dynamics and to increase the accuracy of forecasting tools. The addition of high frequency current profilers and T-S chains below offshore buoys on the shelf/slope would contribute to a better observation of the seasonal and interannual variability of hydrodynamics and hydrography. This will allow 4D integration of vertical information with surface data distribution obtained from HF radar and satellite data.

The possibility of operating gliders on a routine mode in the IBI area will be studied. Past experiences from other regions will be transferred. IH (Portugal) is developing collaborative work with colleagues from PLOCAN (Canary Islands) aiming to explore the possibility of operating a glider in the Portuguese waters. The operation of gliders can be articulated with the maintenance missions for the MB, deploy and recover of gliders could profit from the regular occurrence of these missions at sea.

The Ferrybox network in the IBI-ROOS is not sufficiently developed with areas such as the Irish Sea and the West Iberian Peninsula which have no Ferrybox lines. In the North of the region, a line between Scotland and Faeroe Islands would complete the network. Implementation of new Ferrybox lines in these areas will be a priority. A new Ferrybox line between Portugal and Azores which would give access to observations in the coastal Portuguese waters is under study waiting for a potential funding. In terms of sensors, the existing Ferrybox lines are equipped with the classical validated sensors and it is recommended to integrate in the future recently validated sensors such as carbon systems sensors (pCO2, alkalinity, pH), nutrients, contaminants and biological parameters (flow cytometry, new biological sensors).

Table 4.6: State of art and gaps in the networks and sensors for the different types of platforms in the IBI-ROOS region

	Well observed	Not sufficiently observed	Missing	Upcoming in the next 5 years (name of projects, persons involved)
Areas or networks	Fixed platforms	Ferrybox lines Gliders (only oceanographic campaigns)	Ferrybox lines in Irish Sea Ferrybox lines off Western Iberian Peninsula Gliders: better temporal resolution	Ferrybox line between Portugal and Azores (IH Lisbon, S. Almeida) Ferrybox on hydrographic vessels (IH, S. Almeida) Waiting for potential funding Ferrybox between Bilbao and Pasaia (South bay of Biscay) AZTI (J. Mader) Glider operations in Portuguese waters (IH Lisbon, S. Almeida)
Sensors	Fixed Platforms (Sea Level, T, S) Ferrybox (T, S, O2, Chl Flu, Turb) Gliders (T, S, O2, Chl Flu, Turb)	Fixed Platforms (O2, Chl Flu)	Fixed Platforms (pCO2, Nutrients, Biological parameters) Ferrybox (pCO2, Nutrients, Biological parameters) Gliders (pCO2, Nutrients, Biological parameters)	

The application of Ferrybox methodology is still an opportunity for some partner institutes. Moreover in 2012 a large amount of fishing vessels have been equipped within the frame of the RECOPESCA activities. These ships of opportunity should contribute to improve the collaboration within some maritime sectors.

Effort will have still to be put on the Near-real time communication for Oceanographic Research Vessels as providers of key variables (i.e. from CTDs) for data assimilation.

The 4D characterization of shelf/slope hydrodynamics and transport, integrating vertical data (ADCPs and TS chains on fixed platforms) and horizontal data (HF radars and satellite) is a priority in this complex area where different processes are interacting and where the connection between marine core service and coastal downstream services needs to be assessed. This should allow monitoring of:

- Seasonal and inter-annual variability
- Surface and wind-induced circulation
- Mesoscale processes
- River plumes

The main priorities have been crossed with the different drivers:

DEFINING PRIORITIES	Implementing the ecosystem approach	Reducing Europe's carbon footprint	Responding to threats and emergencies	Socially inclusive growth
Geochemical sensors integration (Argo, Fixed platforms, gliders)	X		X	
Coastal circulation pattern monitoring HF Radars network & key moorings	X	X	X	
S&T NRT data from Ferrybox, Fishing vessels, Oceanographic vessels	X		X	X
Tidal gauge network optimization			X	

As for the other European regions the sustainability of the existing observational system is one of the main challenges facing the partners within the IBI-ROOS region. Coastal observing system sustainability should be pushed through a better collaboration framework between actors of core and downstream services, aiming to reach a general coherent system in which the levels of founding (Regional, National and European) are clarified and complementary.

b) <u>Recommendations for IBI-ROOS</u>

For the IBI-ROOS region, the recommendations for developing the coastal observing systems are:

- To expand the spatial coverage by Ferrybox lines in the Irish Sea and off the Western Iberian Peninsula (with a new Ferrybox line between Portugal and Azores)
- To harmonize the Ferrybox set of sensors adding recently validated parameters such as carbon system sensors (pCO2, alkalinity, pH), and in the future additional sensors under development such as nutrients and biological parameter (cyanobacteria, …).
- To implement in the IBI-ROOS region repeated glider sections with a regular frequency to be determined (monthly, seasonally, yearly) and preferentially along existing Ferrybox lines to complement with data obtained along the water column the surface high frequency data.
- To develop the Moored Buoys network: one main challenge identified is the provision of biogeochemical data, only marginally provided and lacking on most of the arrays.
- To complete the set of observing platforms with HF Radars.

As for the other European regions the **sustainability of the existing observational system is one of the main challenges** facing the partners within the IBI-ROOS region. Coastal observing system sustainability should be pushed through a better collaboration framework between actors of core and downstream services, aiming to reach a general coherent system in which the levels of founding (Regional, National and European) are clarified and complementary.

4.1.5 MONGOOS

The MONGOOS region covers the whole Mediterranean Sea. 32 partners collaborate for the provision of operational Oceanography services. The observational system consists of multiplatform real time observing system that is composed by a Ship Of Opportunity Program (SOOP), moored buoys, so-called Mediterranean Multi- sensor Moored Array (M3A), ARGO buoys Gliders and an EMSO multiparametric deep seafloor observation node. These system is complemented by the near coastal national monitoring arrays that are mainly providing wave, surface meteorological parameters, sea level monitoring completed by coastal mooring providing meteorological measurements and physical-chemical-biological data in coastal areas and HF-radars.

One of the major challenges for the MONGOOS region is the sustainability of the established observation system. The ocean observatories established within MONGOOS are at locations that are expected to be the key ocean areas important for the variability in the Mediterranean Sea. Substantial funding has been provided by member states to support the operational costs. However, the long term existence is not assured by the present economic situation.

a) <u>Gaps</u>

The state of art in terms of existing network for the different platforms and sensors give access to information concerning the areas which are either well observed, not sufficiently observed and areas where observations are missing. This information is synthetized in the **Erreur ! Source du renvoi introuvable.**.

The MONGOOS region, some areas are rather well observed with fixed platforms and gliders oceanographic cruises whereas others are insufficiently observed. Concerning **Ferrybox lines**, the recommendation will be first to **harmonize the scientific payload on the existing lines** and second to **expand the Ferrybox lines network** in the future by opening new lines such as Marseille – Tunis which is planned to open in the next two years. Ideally North-South lines (one per sub-basin: west Mediterranean sea, Tyrrhenian sea, Adriatic sea, Ionian sea, Levantine, Aegean sea) and one East-West route (typically Gibraltar-Beirut) with an harmonized set of sensors (T, S, O_2, chlorophyll fluorescence, turbidity) will expand the network.

A major gap in the MONGOOS area is the missing network of multiparametric oceanographic fixed platforms.

Table 4.7: State of art and gaps in the networks and sensors for the different types of platforms in the MONGOOS region

	Well observed	Not sufficiently observed	Missing	Upcoming in the next 5 years (name of projects, persons involved)
Areas or networks	Fixed Platforms (NW Med Sea, Adriatic Sea, Greece) Gliders (NW Med Sea, Cyprus area, South Italy)	Ferrybox lines (4 lines) Gliders (only oceanographic campaigns)	Gliders (outside well described areas) Fixed Platforms (Eastern Med Sea outside Greece)	Ferrybox line Marseille-Tunis (MIO, Marseille, G. Grégori, M. Thyssen, Tunisie)
Sensors	Ferrybox (T,S) Gliders (T, S, O2, Chl Flu, Turb) Fixed Platforms (Sea Level, T, S)	Ferrybox (O2, Chl Flu, Turb) Fixed Platforms (O2, Chl Flu, Turb)	Ferrybox (pCO2, Nutrients, Biological parameters) Gliders (pCO2, Nutrients, Biological parameters) Fixed Platforms (pCO2, Nutrients, Biological Parameters)	

One first gap in the Mediterranean observing system is the lack of information along the African coasts, and MONGOOS recognizes it as one of the main priorities for the future years. The major technological gap regarding the in-situ observational data provision in the MONGOOS, is the lack of biogeochemical data that is available in near real time for the assimilation into the ecosystem forecasting models and/or for the evaluation of the provided forecasts. This needs the evolvement of a biogeochemical observation program that provides near real time data for the whole Sea.

Additionally there is a need to extend respectively upgrade the existing observational system in order to get an improved knowledge of the variability within the Mediterranean Sea. This extension includes:

- the major integration of gliders observations in a coherent vision of the Mediterranean observatories;
- the provision of the minimum number of Argo to assure the minimum requirements of the Med-Argo programme and its extension to Bio-Argo;
- the complete evolution of the SOOP lines in VOS&SOOP in order to have meteorological information in all the basin;
- the provision of a minimum number of XBTs to assure the coverage of all Mediterranean sub/basins;
- The establishment and operation of other EMSO nodes in Mediterranean e.g., Marmara Sea, Hellenic Arc, Ligurian Sea and Gulf of Cadiz

- The harmonisation of the coastal observatories with the large scale observing systems

b) Recommendations for MONGOOS

For the MONGOOS region, the recommendations for developing the coastal observing systems are:

- To expand the existing insufficiently Ferrybox network on the numerous existing ferry lines either in the Western (such as Marseille – Tunis) and Eastern Mediterranean basins
- To add the dissolved oxygen and chlorophyll fluorescence parameters to the existing two Ferrybox lines not yet equipped with this sensor.
- To harmonize the Ferrybox set of sensors by adding recently validated parameters such as carbon system sensors (pCO2, alkalinity) and in the future additional sensors under development such as nutrients, phycocyanins and cyanobacteria are operated on some of the lines to achieve a similar equipment that those existing in the BOOS, NOOS and IBI-ROOS regions.
- To expand the present glider observing network to fully cover the whole Mediterranean Sea to observe accurately shifts in the circulation (EMT, WMT) and ecosystems responses
- To implement in the MONGOOS region repeated glider sections in chosen sub basins with a regular frequency to be determined (monthly, seasonally, yearly) and preferentially along existing Ferrybox lines
- To make a major effort in implementing multi-parametric oceanographic buoys in the Mediterranean Sea with installation of at least one multiparametric oceanographic fixed platform in the major basins and sub basins. Recommendations from OSE and OSSE experiments developed in WP9 will be helpful to determine the sites to instrument in first priority.
- To complete the set of observing platforms with HF Radars and deployment of Argo floats equipped with biogeochemical sensors.

As for the other European regions the **sustainability of the existing observational system is one of the main challenges** facing the partners within the IBI-ROOS region. Coastal observing system sustainability should be pushed through a better collaboration framework between actors of core and downstream services, aiming to reach a general coherent system in which the levels of founding (Regional, National and European) are clarified and complementary

4.1.6 Black Sea GOOS

Within the Black Sea region, the main focus for monitoring the status of the marine environment is laid on collecting data from mainly coastal stations and through scientific cruises. Most of these data are included in databases and are available on the internet. Due to the financial breakdown the amount of observational data available for the Black Sea region decreased dramatically because of the largely reduced number of scientific vessels and cruises. For the monitoring of the marine environment one can define key overarching issues that are relevant for the monitoring of the status of the marine environment today and topics that will be important in the years to come. Table 4.8 provides an overview of these overarching issues for the specific regions covered.

a) Gaps

The state of art in terms of existing network for the different platforms and sensors give access to information concerning the areas which are either well observed, not sufficiently observed and areas where observations are missing. This information is synthetized in the table 4.8.

Table 4.8: State of art and gaps in the networks and sensors for the different types of platforms in the Black Sea region

	Well observed	Not sufficiently observed	Missing	Upcoming in the next 5 years (name of projects, persons involved)
Areas or networks		Fixed Platforms Gliders	Ferrybox lines Gliders	
Sensors	Fixed Platforms (Sea Level)		Ferrybox (All parameters) Gliders (All parameters) Fixed Platforms (All parameters, excepted Sea Level)	
Parameters				

At present, the **Black Sea is the least monitored and scientifically studied system among the European Seas**. Therefore, monitoring and understanding its circulation and thermohaline structure and its control on transport and dispersion of biogeochemical properties are a **strong priority**.

The main challenge for the Black Sea region is the sustainability of the *in situ* observation system. While coastal stations are supported by National Met Offices or Governmental Agencies on a routine basis, most of them do not provide real time data. Additionally, some coastal stations are supported by Research institutes but are very vulnerable because of unsecured availability of national funding.

There is a severe lack of physical and biogeochemical observations in open sea to monitor changes of the basin stratification and seasonal variability of the upper layer. Observations of the ecosystem parameters are carried out regularly only in the coastal zone. Operational monitoring of the coastal zone is very restricted. Additionally, the observational network for the measurement of Sea level is only marginal and not coordinated.

The main issue for improving the Black Sea observational system is to increase the number of available observations. The Observation System Simulation experiments (OSSE) as they are conducted within Workpackage 9 could help identifying the most important positions to cover the main circulation patterns within the Black Sea region.

b) *<u>Recommendations for Black Sea GOOS</u>*

The general goal is to build and maintain Basin scale in-situ observing system, which will consist of coastal, shelf and deep sea components. These observing systems should consist of:

- Coastal observatories: meteorological stations, oceanographic stations, sea level stations; HF radar systems
- Shelf moored or fixed platforms and deep sea observatories;

• Vessels: Research vessels, small vessels, SOOP, VOS, Ferrybox;

• Coordinated basin-scale multi-national surveys by research vessels.

• Autonomous instruments: Argo buoys, Drifters, Gliders

The development of Ferrybox lines in the Black Sea is highly desirable.

The installation of the same costal observatory which will consist of a Weather station, oceanographic station and sea level station in each Black Sea country is reasonable. The resulting network of six observatories will be equipped with the same instruments and connected to In-situ TAC to provide real time data.

Near future aim for the improvement of the observational system is to:

• Install Ferrybox systems equipped with physical and biogeochemical sensors on at least two lines crossing the open Black Sea and establishing an XBT measurement program for these two lines

• Make an important effort to develop a network of multiparametric oceanographic platforms in the Black Sea. Recommendations from OSE and OSSE experiments developed in WP9 will be helpful to determine the sites to instrument in first priority.

• Evolvement of two Glider sections through the Black Sea is highly desirable.

• Establish seasonal multidisciplinary basin-scale surveys covering the whole Black Sea region

• Deploy annually Argo Buoys to monitor the vertical structure of the Black Sea region. These Buoys should be equipped with biogeochemical sensors improving the very large scarcity of biogeochemical measurements and complementary 5 surface drifters should be launched every year to cover upper layer dynamics.

• Install HF radar systems to improve the knowledge of the circulation pattern.

As for the other European regions the **sustainability of the existing observational system is one of the main challenges** facing the partners within the IBI-ROOS region. Coastal observing system sustainability should be pushed through a better collaboration framework between actors of core and downstream services, aiming to reach a general coherent system in which the levels of founding (Regional, National and European) are clarified and complementary.

4.1.7 Synthesis at European Scale: bottlenecks and priorities for the future

At the European scale, the common recommendations for all regions and priorities for the future will be:

- To extend the spatial coverage of Ferrybox lines in the well observed areas and to develop the coverage in insufficiently observed areas such as Black Sea and Eastern Mediterranean Sea.
- To add the dissolved oxygen parameter to the existing Ferrybox lines not yet equipped with this sensor.
- To harmonize the Ferrybox set of sensors by adding recently validated parameters such as carbon system sensors (pCO2, alkalinity) and in the future additional sensors under development such as nutrients, contaminants (bio-sensors, passive sensors, ...) and biological parameters (cyanobacteria, flow cytometer, Fast-repetition rate fluorimetry, .)
- To implement in all ROOS regions repeated glider sections with a regular frequency to be determined (monthly, seasonally, yearly) and preferentially along existing Ferrybox lines to complement with data obtained along the water column the surface high frequency data.

- To develop observations of biogeochemical and biological data on fixed platforms which are mainly tide gauges or platforms equipped with physical sensors (temperature, salinity). A significant effort must be made to implement existing platforms with mature sensors such as dissolved oxygen, fluorometers and turbidimeters. It is recommended to integrate in the future recently validated sensors such as carbon system sensors (pCO_2, alkalinity and pH) nutrients, contaminants and biological sensors (flow cytometer, new biological sensors developed in WP10).
- To these common recommendations, specific priorities to each ROOS region have been given in the above sections.

The main bottlenecks which have been identified are:

- The **sustainability of the existing observational system is one of the main challenges** faced by the partners within any ROOS region. Coastal observing system sustainability should be pushed through a better collaboration framework between actors of core and downstream services, aiming to reach a general coherent system in which the levels of founding (Regional, National and European) are clarified and complementary.
- The **implementation of glider repeated sections** in all the ROOS regions. Glider activity is mainly developed through research programs with a limited spatial and temporal coverage. It will be necessary to promote a better coordination at the European level to select repeated section in key zones of the different ROOS regions,
- The **durability of the Ferrybox lines** or of the ferries affected to repeated lines. During the duration of the project, some lines have been stopped due to change of ferries operating the selected lines or lines which have been stopped by the ferry company. The durability of observations using vessels of opportunity is therefore highly dependent of the maritime companies and can't be easily planned on the long term necessary for observing systems.

4.2 Sensors Integration, new developments and innovation

4.2.1 Status by the end of FP7-JERICO

As part of the JERICO project, there was significant investigation work performed by partners looking at the integration of previously validated sensors for the monitoring of important marine parameters such as alkalinity, nutrients and contaminants using passive and biosensors as well as plankton identification and analysis processes. Research carried out under JERICO has also led to the development of new image analysis techniques to monitor biological compartments and processes. Work carried out under JERICO also resulted in the development of new innovative sensors to monitor DNA/RNA, oil spill detection sensors, and other biological parameters linked with the biodiversity needs.

The work carried out on integration of validated sensors and new sensor development was done under the umbrella of the six principle monitoring tasks identified within the description of work of WP 10 of JERICO (Emerging technologies) and are reported in deliverable D10.1, D10,2, D10.3, D3.4

In addition, a workshop was held on October 16th to 18th 2013 at the Villefranche-sur-mer observatory (France) to outline progress on emerging technologies within the JERICO FP7 project. A particular focus of the workshop was to invite researchers outside the project consortium to:

- Learn of technology developments within JERICO and
- Present results of their own experiments and technology development

A report is available on the JERICO website:

http://www.FP7-JERICO.eu/attachments/article/297/workshop%20WP10%20report%20gnolan%20v3.0.docx

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a) Monitoring of key biological compartments and processes

One of the aims of JERICO was to develop and enhance the use of image analysis techniques to monitor biological compartments and processes that are recorded at high frequency temporal scales and/or over large spatial scales using automated or semi-automated procedures.

Four principal techniques were developed during the JERICO project:

- (i) development on in-situ video images of the sediment interface acquired using ROV or other mobile systems

– (ii) development on in-situ sediment profiler camera system

– (iii) development on video sequences, obtained with fixed platform

– (iv) development dealing with pelagic ecosystems analysis of images obtained with FlowCam, Cytoflow and Zooscan systems.

In order to promote these techniques and to get user feedback it is important that a series of follow on demonstration surveys of the techniques should be organised. The future uptake of the new techniques developed depends on the interaction between users and developers. There is also a need to standardize data formats.

Traditionally taxonomical determination plankton species composition as phyto- and zooplankton has been carried out with optical microscopy. The FlowCam analysis system contains three components: optics, electronics and fluidics. The fluidics system uses a syringe pump to pull the fluid sample through a flow cell perpendicular to the optical path.

The optical system is used to capture images of the plankton particles in the fluid as they pass through the flow cell. Additional optional electronics can also capture two channels of fluorescence information per particle i.e. pigments as chlorophyll or phycocyanin.

Typically, the phytoplankton species/classes determination is done with comparison of spectral signatures and size classes of reference species. Recently also DNA sequencing has been used in phytoplankton identification. With this method the ribosomal DNA is amplified from cDNA and pyro-sequenced. In this method the taxonomical DNA library is needed for comparison.

A lot of effort has been put to analysis of digital images of suspended particles in aquatic systems to reveal abundances, size spectra, and biomass distributions of planktonic organisms and non-living particles. These automated image analysis seems to work better for the open ocean pelagic communities than in the coastal areas, where non-living particles cause lots of noise. Further work is required to develop the identification algorithm to discriminate these non-living particles from the living organisms.

For zooplankton underwater imaging a system has been developed to identify zooplankton species and occurrence with the backscattering characteristics with underwater light propagation. Also the Video Plankton Recorder (VCR) is used for underwater detection of zooplankton. VCR is a coupled video system which is towed through the water column. The observed small organisms are in the approximate size range of 0.2 - 20 mm. for instance copepods.

b) Developments of physico-chemical sensors and implementation on new platforms

Contaminant sensors: bio-sensors, passive ones

New generation of optical nano-biosensors are emerging within several European projects and will in few years be ready for operational use on coastal infrastructures. Developments are ongoing on antibody-based algae-toxin biosensors such as saxitoxin and its derivatives (Dinoflagellate, *Alexandrium*), domoic acid

(*Pseudo nitzschia* sp.) and azaspiracid (*Azadinium spinosum*). Operational technologies for monitoring toxic algae based on the detection of the organisms through miniaturized and autonomous sensor will be an important step forward in the HAB monitoring strategies.

Passive sensors for contaminants such as semipermeable membrane devices (SPMD) and diffusive gradients in thin film (DGT) are today used on fixed platforms and buoys. Moreover, trials have been performed on Ferryboxes. The ambient concentrations are low relative to the sensor detection level, thus a high volume of water needs to be sampled. The development of new analytical methods, like LC-MS/MS, overpassed this issue, allowing to detect very low concentrations of contaminants. This is meaning the possibility to better detect and quantify marine chemical pollution to support the implementation of the MSFD in relationship to descriptor D8 on marine contaminants.

Detection of oil spills using fluorescence sensors are already on the market and next to come is a multi-wavelength sensor giving the possibilities to separate some major oil components with fluorescence signature.

In the next years it will be possible to demonstrate the capacity for monitoring trace levels of hydrophobic substances such as organochlorine pesticides, PAHs and PCBs, and their impact on biological responses using dedicated biosensors. The presence of complex mixtures of chemical pollutants in marine waters represents an emerging global environmental issue.

Optical sensors for algal pigments and other optically active compounds

This research included work on the development and implementation of sensors for the algal pigments on ships:

- Fast-repetition rate fluorometry in autonomous monitoring systems
- *Algal pigments* - Phycoerythrin fluorometry in autonomous monitoring systems

For online measurement of algal pigments, new commercial solutions using several wavelengths or with hyperspectral scanning properties have emerged and tested in various sea areas. Novel instrumental solutions and algorithms to estimate primary production with fluorescence induction techniques have been tested.

Future work should focus on developing better algorithms for data analysis to retrieve taxonomic information. This work involves comparison of optical methods with traditional techniques (microscopy, pigment analysis, 14-C incubation) and with other new techniques (e.g. FlowCam). Integration of instruments for various platforms should be encouraged. When starting to work with new sensors, as soon as possible the user groups should decide on best practices for calibration and instrument maintenance (WP4) to allow collection of coherent data-sets

The state-of-art optical sensors provide information on the abundance of optically active substances. They can be used to track the amount of phytoplankton (Chla fluorescence), total suspended matter (turbidity) and dissolved organic matter (CDOM absorption and fluorescence). The new emerging techniques, which have already been proved during case studies, include novel spectral instruments (absorption, fluorescence, and reflectance) to estimate various optically active substances simultaneously, to discriminate phytoplankton pigment groups or to characterize the quality of dissolved organic matter. New fluorescence induction techniques, when combined with light absorption and light intensity data may provide information on the rate phytoplankton primary production. Along with instrument development, the algorithms to derive end-products from optical signals need to be elaborated.

Besides monitoring, data from new optical sensors is needed for algorithm development and validation of bio-optical models and remote sensing. For the latter, especially new information on backscattering and reflectance at various wavebands needs to be collected in optically complex waters (Case II).

New optical instrumentation is developing quickly. One challenge requiring a special attention from the monitoring community is the intercalibration and comparability of various techniques. Generally accepted guidelines and best practices for instrument calibration, including reference materials need to be agreed. Comparison of instrument outputs, both in terms of optical quantities and derived end-products, is especially challenging for optical devices, as the optical configurations (wavebands, lamps, detectors and filters) affect the data. Successful instrument intercalibration is also the only path forward when combining data from various platforms.

Above water light measurements

Hyperspectral radiometers are used to measure upwelling and downwelling radiance and irradiance from the sea and are used to calculate the marine reflectance. Both radiance and irradiance are important for validation of the ocean colour signal. It is also possible to estimate some biogeochemical parameters (Chl-a) from such measurements and information of the downwelling light available for primary production, and studies of photochemistry (diurnal variation of Chl-a fluorescence) of phytoplankton are important.

Normally a set of 3 hyperspectral measurements is required: downwelling radiance (Ld), upwelling radiance (Lu) and an irradiance (Ed). These sensors can be placed on fixed installations and both hardware and software tools are tested to improve the use of such measurements from a moving platform like passenger ship in combination with the traditional Ferrybox. Together with data from the ship movement (GPS, Gyro), wind and waves, one can calculate the ocean colour signal which is of important for satellite product validation in the Copernicus programs (Sentinels-3 and 2 reflectance).

Carbon system - Alkalinity (pH, pCO2, DO)

The carbon cycling in the coastal waters plays an important role in global carbon cycling and budgets, and to fully quantify the complete carbonate system in seawater it is necessary to establish sensor systems to measure the important variables. Sensors and systems that are close to being ready for validation for operational use are membrane based pCO_2 sensors, spectrophotometric pH and alkalinity (At). And very soon also a carbonate ion ($CO_3{}^{2-}$) sensor will be in operation which will increase the number of carbonate system variables and also the overall accuracy. These parameters are needed to fully constrain the carbonate system in coastal waters due to high variability in salinity, alkalinity, and dissolved organic matter. The carbonate system measurements should be used in combination with parameters characterising the physical parameters (e.g. T, S) as well as the biogeochemical parameters such as Chl-a and oxygen. Continued work with ground-truthing sensors with lab-based discrete sample analysis is needed for further development and validation. The development of new physico-chemical sensors for Carbon measurements using a microfluidic spectrophotometric pH system developed by Rerolle (Rerolle et al. 2013) based on the colorimetric method from Clayton and Byrne using Thymol blue as the pH indicator was also carried out.

c) *Use of emerging Profiling technologies in coastal seas and intercomparison with mature technologies*

A Cytosense bacterial sensor equipped specially for long-term monitoring applications was mounted on the EOL Buoy, close to Villefranche sur Mer. The portable/benchtop flow cytometer CytoSense combines high sensitivity with an extremely wide particle size range (from sub-micron up to 1.5 millimeter diameter). What differentiates the CytoSense from conventional flow cytometers is its size range, its ability to gather flow cytometric data as well as pictures of particles, and the acquisition of multiple data points per particles. This results in a pulse shape of the particle, in which features and internal structure are clearly visible. It therefore allows for better (phyto)plankton species classification and analysis of filamentous algae (up to 4mm length).

The emergence of the capability to deploy a bacterial sensor for long periods will aid greatly in the temporal coverage of bacterial detection in coastal monitoring.

The MAMBO/PAGODE (ARVOR-C) inter-comparison in the Adriatic Sea was set up to find low-cost solutions using instrumented coastal profiling floats could offer a cost effective solution as profiling sensor packages. The system is relatively cheap, more self-contained, requires little maintenance; can transmit data in real-time, and is easy to handle. At their current state-of-the-art, such floats may not pack many sensors presently but it is to be expected that this situation will certainly change in future. Testing the possibility of using a tethered float as a substitute for a profiling buoy is thought to be well worth evaluating.

d) *Ships of opportunity, next generation fishing vessels probes*

A workshop[1] was held in the early part of the JERICO project on using ships of opportunity. An overview of unmanned surface vehicles (USVs) was presented at this workshop to highlight some of the developments that have taken place in that regard. The reader is referred to the workshop presentations for more detailed information. Considerable progress was reported for the Italian Fisheries Operational Oceanographic System (FOOS) where equipping fishing vessels with sensors (eg. temperature, salinity, catch weight and net drum rotations) is becoming a mature and well understood technology. The focus is shifting towards making useful products for fishermen from the data collected from sensors on board fishing vessels.

e) *Ferrybox data quality control algorithm.*

Existing Ferrybox quality control schemes were evaluated and discussed at the Ferrybox workshop in Helsinki (April 2013) with a view to developing new algorithms in the September 2013-2015 period. This task brings together the collective experience of Europe's Ferrybox operator in the development of new algorithms that will be made widely available to FB operators. The algorithms are adapted from the recommendation of the EuroGOOS Data-MEQ group for quality control of real-time in-situ data. The algorithms are applied either directly after measurement (e.g. HZG) or before central storage in a Sismer or Coriolis data center (NIVA) of all Ferrybox data collected under operational oceanography projects like the MyOcean project.

f) *Suspended Particle Measurements (SPM) between satellite Data and seabed measurements*

Existing gaps in Suspended Particle Measurements (SPM) between satellite Data and seabed measurements was addressed by using a sensor buoy. The results established a relationship between surface SPM concentrations, measured *in-situ* (buoy) and remotely (satellite) on one hand, and between the *in-situ* measured SPM concentrations at the surface (buoy) and near the bottom (tripod) on the other hand. With overall conclusion that an optical backscatter sensor instrumented on a surface buoy is a valuable tool towards better understanding SPM dynamics in high-turbidity coastal areas.

4.2.2 JERICO specific gaps in emerging sensing technologies and common gaps across technologies

Some of the gaps identified across the emerging sensing technologies covered under JERICO WP10 include:

i. Technology Readiness Levels (TRL):

- Standardised Technology Readiness assessments of all the JERICO sensor technologies need to be developed completed and evaluated. NOC have done this for a number of biogeochemical sensors in deliverable 10.4 – It is recommended that this should be done for all the other sensors as part of JERICO-NEXT.
- It is recommended that there should be standardized technology evaluations for prototypes and demonstrations to help establish the Technology Readiness Levels (TRL) of the emerging technology

[1] http://www.jerico-fp7.eu/attachments/article/297/workshop%20WP10%20report%20gnolan%20v3.0.docx

- There is a lack of a clear integrated technology roadmap for the future development of the new sensors developed in JERICO. This roadmap needs to be developed for technologies developed in JERICO and for other emerging technologies such as those under development under the 'Oceans of Tomorrow' programme of DG Mare.
- These gaps in technology developments were identified in the Objective 4 of the JERICO-NEXT proposal in and how they will be addressed in the next phase of the project.

ii. Technology demonstrations should be more focused on highlighting the capabilities and potential of pre-commercial or emerging early-stage technologies, building user awareness, and facilitating technology maturation and transition into operational observing. For the majority of potential new sensor trials, the field tests were carried out at only one or perhaps 2 partner sites, this should be increased for more effective evaluations.

iii. There should be a "cost of ownership" assessments for deployment and use of various sensor technologies by JERICO observatories.

iv. An assessment should be undertaken of data transmission technologies for the various sensors – particularly gliders/buoys where power and transmission capabilities are limited and may impact on long term observation.

v. Developing more cost effective parameters and multiuse platforms in JERICO–Next: it is recommended that there should be an evaluation of what were the most cost effective sensors emerging from WP10 and what platforms can be identified as multi-purpose.

a) Specific gaps identified as part of JERICO WP10

For each JERICO sensor types, main gaps are presented here after with reference to deliverables D10.1, D10.2 and D10.4.

Biogeochemical sensors

The Technology Readiness Level of biogeochemical sensors needs to be raised particularly in terms of robustness, and failure prevention. Secondly the long-term drift, and performance degradation of sensor systems with time needs to be i) evaluated and ii) reduced through engineering design and operational methodology.

LED fluorometers for phycobilins and CDOM

- Finding and agreeing the suitable standards for phycobilin fluorometers,
- Evaluation of differences between various optical setups and significance of such differences in optically varying waters,
- Evaluation dynamics of pigment specific phycobilin fluorescence for major phycobilin containing species,
- Evaluation of DOC and absorption specific CDOM fluorescence, and its seasonality, in various sea areas.

Spectral fluorometers

- Lack of accurate calibration of the instrument response using reference solutions
-Quantum correction of spectral output, to get comparable spectral shapes for various instruments,
- Absence of database for different phytoplankton species to be used with fully spectra instruments and with multi-wavelength devices
-Absence of a suite of analytical tools for spectral analysis, including visualization of results.

Sediment Profile Imaging and Video Imaging Technologies - Gaps

The use of the **AviExplore** developed in JERICO, and described in deliverable D10.2, has been so far limited to the development research team and although it has been used within different environments with satisfactory results, the improvement of the existing tool requires tight interactions with other users in this research area and a proactive approach by the developers to promote its use amongst the JERICO consortium and the broader research community.

AviExplore is not an open-source software, it has been designed so that new functionalities can be included and this can be done using extension files (*.dll) written in C++ language - However developing the tool as open source would enhance its appeal to the broader community in the future and accelerate future developments.

b) Strategic Sensing technology developments for MFSD descriptors

Under the Marine Strategy Framework Directive (MSFD), 11 descriptors have been identified as a basis to develop standards on good environmental status of marine waters.

Consideration should be given of the differences in scientific understanding and technology readiness of monitoring programmes for each of the MSFD descriptors. It is widely acknowledged that for some descriptors that the level of scientific knowledge is more developed than for others. Euthrophication, fisheries and contaminants for example are already addressed by other EU legislation and some specifications exists on what GES (Good environmental status) is for these descriptors. For some descriptors such as noise marine litter and biodiversity, much less knowledge exists and they have not been addressed by EU law. The limited knowledge for some descriptors should trigger specific monitoring efforts starting from investigative monitoring that will be built on the state of the art scientific developments such as those highlighted in WP10 of JERICO.

It is important that the developers and users of emerging technologies identified under WP10 of JERICO are aware of and linked to the developments in monitoring strategies and that the technology roadmaps for these technologies can be adapted to align with these programmes requirements at the earliest opportunity to facilitate comparison with existing monitoring technologies and develop a path for implementation of the sensor technology into the relevant monitoring program.

The following areas have been identified as gap parameter areas in terms of the emerging technologies developed and evaluated in JERICO WP10.

Marine litter and plastics detection in coastal areas (MSFD Descriptor 10)

Marine Litter is any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine or coastal environment. It can have damaging ecological and economic effects on the seabed, in the water column and seashore. The relationship between the types and amounts of marine litter in the environment and the degree of harm caused is not at present fully understood. There is a gap in monitoring and detecting marine litter which could start to be addressed by considering what observation platforms and sensors would be best suited for this type of monitoring. The video imaging software developed as part of WP10 has applications in garbage identification but spatial coverage is a significant issue for its application in this space.

Noise monitoring in coastal areas (MSFD Descriptor 11)

Underwater noise is increasing as human activities in the coastal marine environment continue to expand. Noise monitoring capability should be developed in JERICO-NEXT as it was absent from the original project – marine noise has already been identified as a core parameter by the JERICO consortium and identified in the MSFD as a pollutant in the marine environment

In particular, JERICO-NEXT needs to consider the following in relation to acoustic monitoring technology development:

- what platforms are most suitable for noise monitoring?
- what are the most suitable technologies to be used?
- what noise parameters are to be measured?

4.2.3 From ocean research infrastructure to ocean innovation

There is a need for better understanding of the innovation process in oceanography in order to enhance ocean innovation in Europe and bridge the science-policy gap.

The key to success for radical innovation in oceanographic instrumentation needs:

- Visionary leadership
- Close coupling between science, engineering and societal needs
- A coherent investment strategy based on distributed, coordinated resources
- Effective processes for communication, feedback, and contingency planning.
- Incentive to assume responsibility for risky instrumentation development projects without undue career jeopardy.

Work in collaborative, multidisciplinary teams, be tenacious and focused on long term objectives while producing short-term success, and find creative champions among funding agencies and investor organizations are crucial elements of a successful innovation strategy.

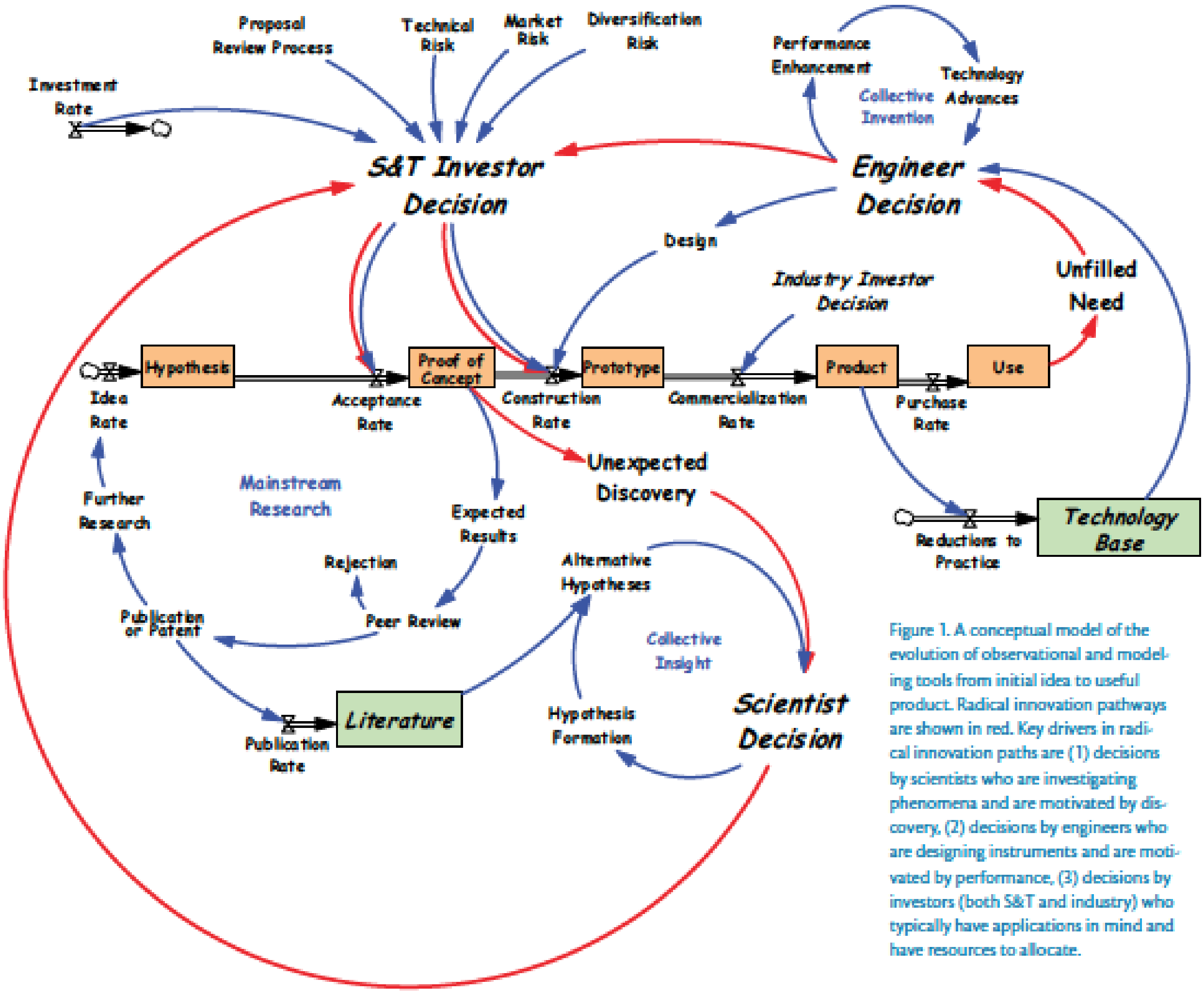

Figure 4.2 "A coherent set of scientists, engineers, and investors that envisioned the scientific goal, understood the technology potential and sustained the funding" (Curtin and Belcher, TOS; 2008).

The challenge for the next 20 years is to understand **how the ocean circulation varies** on monthly, annual to inter-annual and decadal time scales. What is more important is that today, we can monitor this temporal variability at the key spatial scales that characterise global to regional ocean variability and coastal to open ocean exchanges, including the essential meso- and sub-mesoscale eddies that conform the 'ocean weather'. And this is now feasible due to the advent of **new technologies** that are transforming the interplay between humans, oceans and coasts and bring enhanced capabilities for **new science** and new **responses to society needs**.

Therefore, this is a clear example that new **technological innovations** are driving major breakthroughs in science with profound implications on our society, that are already modifying how we understand the variability of the oceans at different scales and by this are also affecting how we are managing the oceans and the coasts, by this contributing to fill the "Science-Policy Gap" (Lubchenco and Sutley, 2010).

These new monitoring technologies are key components of recent ocean observing systems being progressively implemented in many coastal areas of the world oceans as a result of a major paradigm change in ocean observation and data availability (Delaney and Barga, 2009; Tintoré et al., 2013). When different types of these new monitoring technologies are implemented and used together with more traditional platforms, we are then confronted with the new **multi-platform integrated observing** systems –also called ocean observatories or **marine research infrastructures (RI's)**-.

a) Innovation in marine sciences: state of the art

There are numerous **definitions of innovation** and when analysing innovation, in addition to Research and Development (R&D), a wide range of activities such as organisational changes, training, testing, marketing and design among others are considered. Following the Oslo Manual (2010), innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations. Innovation is not limited to technological innovation[2], considering innovation in a wider context, also including organisational and/or commercialisation innovation (e.g. organisational changes, training, testing, marketing and design). In other words, it is now more and more evident that there are many different types of innovation and that there can be very relevant innovation without new knowledge, just combining knowledge that previously existed.

Innovation in oceanography

Technological innovations in oceanography are at the base of new scientific knowledge that has already been applied by society. The oceans are a complex system of direct relevance for human welfare and accordingly it is a system particularly well adapted to the different types of innovation.

Innovation in oceanography is therefore expected to be very active and 3 drivers are clearly identified: basic research, technology development and societal needs. Basic research is needed for example to understand the wide variety of spatial and temporal scales of variability of the ocean circulation and its multidisciplinary effects. At the same time, technology driven activities that imply the development of new sensors and platforms that in turn give rise to new scientific findings and new questions, a well know feedback process between science and technology, are also very frequent. Finally, society driven innovations (beach safety, climate, etc.) are also essential in oceanography. Also important in oceanography and coastal and ocean management is the development of new ways of organizational innovation, including for example new ways of science and knowledge based management of our oceans, coasts and natural resources, a subject that is very close to a new form of knowledge based governance.

The innovation process

It has been analysed historically from different perspectives and models. The Linear Model of innovation (1945) indicates that innovation is the result of different phases: basic research, applied research, technology development, production of a new product (of interest for society, i.e., with customers!). This model prioritises scientific research as the basis of innovation, and plays down the role of later players in the innovation process. This model has been widely used but today it is highly questioned and there are many other more recent models for describing the innovation.

The science–technology bidirectional relation and ocean innovation: Kline and Rosenberg (1986) questioned the linear model, proposed the chain-linked model of innovation and analysed the relation between basic science and technology development. They found that many of the technological advances were not triggered by basic science and that actually, in many cases, technology development had given rise to basic science, for example proposing new instrumentation. In other words, not only they questioned the linear

[2] From OECD definition: technological innovations comprise new products and processes and significant technological changes of products and processes. An innovation has been implemented if it has been introduced on the market (product innovation).

model, they even showed the existence of a reverse flow from technology to basic science. Indeed, as pointed out by Curtin and Belcher (2008), anytime a new instrument appeared, new fundamental scientific findings appeared.

If we focus on specific relatively recent autonomous underwater platforms, Curtin and Belcher (2008) showed that **gliders have been a disruptive innovation** (it is actually the integration of well-developed components; pressure housing, pumps, bladders, sensors, batteries) with an incubation time that was **half of the usual incubation time** in oceanography. They studied the conditions for this and identified 3 key decision centres: scientist, engineer and S&T Investor. They proposed a conceptual model for innovations (considering both observational and modelling tools) from initial idea to products in the market. They concluded indicating that the key to success is the existence of **three decision centres working together (scientists, engineers and Office of Naval Research, ONR, managers) and integrated** towards a common goal for a sustained period of more than 10 years.

The chain-linked innovation model: Kline and Rosenberg (1986) proposed a new model for innovation, the chain-linked model, fundamentally based on complex interactions and the continuous flows of knowledge and cooperation in the different steps of the innovation process. In the chain-linked model, new knowledge is not necessarily the driver for innovation. Instead, the process begins with the identification of an unfilled market need. This drives research and design, then redesign and production, and finally marketing, with complex feedback loops between all the stages. There are also important feedback loops with the organization's and the world's stored base of knowledge, with new basic research conducted or commissioned as necessary, to fill in gaps.

The chain-linked innovation model is certainly closer to the description of innovation in oceanography than the linear model. We have already seen some examples and it is also interesting to note that this approach has been at the base of the new observing activities in the European Seas in the frame of the JERICO and PERSEUS FP7-EU funded projects: i.e., identifying gaps related to both scientific (international well established scientific priorities) and societal needs (e.g., MSFD[3] implementation in European Seas-, establishing upgrades with new sensors and extending coverage, driving new science, etc.). In practice, it is important to realize that from research to applications there are multiple feedbacks and interactive loops.

It is also important to mention here that the EU launched in May 2014 an oceans innovation initiative[4] to help use ocean resources sustainably and drive growth and jobs in Europe. This is an important contribution to Blue Growth actions that will certainly have some impact. However, it is too early to be able to analyse the results from this initiative.

R&D and Innovation

R&D takes on different roles in these models. In the linear model (Bush, 1945) research is seen as the starting point of the process of innovation. In the *chain-linked* model, however, R&D plays the role of problem solver. It may be called upon at any stage in the process to address problem. Firms will draw on their current knowledge base or will get it outside, and if successful, will extend its limits and generate new knowledge and hopefully solve the problem it was called upon to address. The chain-linked model, therefore, defines R&D to be performed by many divergent parties in many areas. R&D is not necessarily done by highly qualified personnel in expensive laboratories. Research, therefore, is adjunct to innovation, not a precondition for it.

Innovation is therefore now a social process, collective and dynamical, carried out by companies or public organisations but with the participation of other units and with an active relationship with other agents or institutions (scientists, industry, and government).

The analysis of the chain-linked innovation model in oceanography points to the importance of the structures that link the different subsystems as shortly expressed hereafter.

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[3] Marine Strategy Framework Directive

[4] http://europa.eu/rapid/press-release_IP-14-536_en.htm

b) Needed structures and tools to enhance Innovation:

Need of structuring mechanisms to enhance interaction and cooperation dedicated to innovation

As expressed in the previous pages, in the interactive innovation process the **interaction and cooperation** between the different actors from different subsystems is essential. At the same level, the existence of a **common goal** is also crucial. The common goals and objectives need to be established.

Research Infrastructures (from now on, RI's) are new key elements in the science-technology-society system. In oceanography, Marine RI's are new structures that provide data products and services in response to international science priorities, enhance technology development and also respond to societal needs. They also have common and **well-defined goals**, **multidisciplinary** approaches and **integration** capabilities together with significant **outreach** activities. It is evident that in the coastal ocean system where JERICO project is acting, the different types of innovation just described are all present, with a significant component arising from R&D. However, **social innovation** is also present in particular through the introduction of new management tools for sound, science and ecosystem based management of the coastal ocean. There are many examples of this in research centres such as IMEDEA (http://imedea.uib-csic.es) and its contributions for more science and ecosystem based Integrated Coastal and Ocean Management (Diedrich et al., 2010).

However, in many cases the interactions do not take place automatically. Therefore, **to enhance the inter-relations and the cooperation between the different subsystems**, we need to establish different mechanisms such as for example instruments to enhance interactions or structural interfaces between the subsystems.

Need of integration and critical mass

The different progresses and advances in oceanography have been related to advances in oceanography instrumentation. And there are two other key concepts we want to bring to the discussion: **integration and critical mass**. Critical mass allows all these activities to be carried out in a well-coordinated and efficient manner. In the case of Research Infrastructures, compared to Research, they have the additional burden of being often very expensive and visible, as well as of needing to outreach and serve researchers well beyond the "owners" and "paymasters" ("the shareholders"). This kind of challenge can be faced only when a critical mass is supporting the RI, and thus when integration has reached a sufficient level. This may open completely different aspects, compared to Research activities, in the expectations of and interactions with both the "shareholders" and the "stakeholders" (i.e. those individuals, communities and institutions which should feel the advantage of the existence and activity of an RI and, therefore, be the "political" base for their existence). JERICO and SOCIB are examples of this.

The different elements already described and discussed associated with ocean innovation are therefore present in RI's and accordingly were analysed in more detail following an interesting review on RI and Innovation from the RAMIRI FP7 project[5].

In conclusion

It is by now clear that the interaction between Research Development and Innovation is a cyclical, mutual-feeding process based on bidirectional reinforcing flows. RIs are a case in which the interlink and bi-directionality from industrial innovation to new instruments (new capabilities for research) and back to development and industry (new products and innovative processes) is particularly clear. Unfortunately, the structure of the EU science and technology system is maybe not always well adapted to these two elements, which appear to be critical for innovation.

Indeed, in Europe, it appears we have the ideas, but we do not have the framework to enforce what we think

[5] Realising and Managing International Research Infrastructures, http://www.ramiri.eu.

has to be done. With H2020, we have advanced significantly; the 3 pillars (Science/Industry/Society) are there, but unfortunately, **they are still disconnected**. We advance in each one of them, one by one, but not integrating them. If we want ocean innovation to progress, **we need to establish structures** that link and integrate to assure efficiency towards a **common goal**. To oil the system, we also need to have a good and clear Strategy: this implies we have good and well-defined objectives and well-defined tasks to achieve them. So, we are doing ok, but not enough!

Actually this is well known in the private sector with companies looking for innovation and open innovation but for this to be really efficient, a well-established common goal has to guide the innovation process. Quoting Steve Jobs "Innovation is saying no to 1.000 things"[6].

Are we ready for these changes? This is certainly an open question in Europe that would need to be raised at the highest political level since different sectors, such as the R&D sector, are involved.

Do we have the framework and right structures to get all the benefits from these changes? ("*to enforce what we think has to be done*[7]").

Is our science system ready to meet the innovation challenge? Including the evaluation of science, which is requesting more and more specialization and a lot of pressure on quick publishing[8], not enough time for discussion, jumping from one topic to another, "salami science", etc. Do we really have the adequate structures to adapt to those changes, the right tools for sound implementation? How do we do that, in an EU context where most of the science funding still comes from the member states?

And we need **partnership** more than coordination…

Finally, we have seen the relevance of Research Infrastructures in driving ocean innovation. The key elements for this being:

- Well defined objectives and common goals well aligned with the strategy
- Science-technology and society driven goals
- Integration
- Critical mass and
- Partnership.

[6] http://www.creativethinkinghub.com/steve-jobs-innovation-is-saying-no-to-1000-things/
[7] Christian Patermann, Rines meeting, 2014, Thessaloniki. http://rines.gr
[8] "Wrong Science", The Economist, October 2013.

5 The JERICO Infrastructure Software

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Reference documents:

Del. no.	Deliverable name	WP n°	Lead contractor	To download deliverable
D1.4	JERICO label definition	WP1	HCMR	http://www.jerico-fp7.eu/deliverables/d14-label-definition
D3.1	Report on current status of Ferrybox	WP3	HZG	http://www.jerico-fp7.eu/deliverables/d31-ferrybox-best-practices
D3.2	Report on current status of glider observatories within Europe	WP3	CSIC	http://www.jerico-fp7.eu/deliverables/d32-report-on-current-status-of-glider-observatories-within-europe
D3.3	Report on the current status of fixed platforms in Europe	WP3	CEFAS	http://www.jerico-fp7.eu/deliverables/d331-report-on-the-current-status-of-fixed-platforms-in-europe
D4.2	Report on Calibration Best Practices	WP4	HZG	http://www.jerico-fp7.eu/deliverables/d4-2-report-on-calibration-best-practices
D4.3	Report on Biofouling Prevention Methods	WP4	CNR	http://www.jerico-fp7.eu/deliverables/d4-3-report-on-biofouling-prevention-methods
D4.4	Report on Best Practice in conducting operations and maintenance	WP4	HCMR	http://www.jerico-fp7.eu/deliverables/d4-4-report-on-biofouling-prevention-methods
D4.5	Running Costs of Coastal Observatories	WP4	HCMR	http://www.jerico-fp7.eu/deliverables/d4-5-running-costs-of-coastal-observatories
D5.6	Delayed mode Data management report V2	WP5	OGS	http://www.jerico-fp7.eu/deliverables/d5-6-delayed-mode-data-management-handbook-v2
D5.8	(Near)Real-time Data management report V2	WP5	OGS	http://www.jerico-fp7.eu/deliverables/d5-8-near-real-time-data-management-handbook-v2
D5.7	Second data management report	WP5	OGS	http://www.jerico-fp7.eu/deliverables/d5-7-second-data-management-report

Europe spends €1.4 billion p.a. for marine data collection: €0.4 billion for satelhttp://www.jerico-fp7.eu/deliverables/d51-dm-data-handbooklite data and €1.0 billion for in-situ observations, respectively. In the case of the latter, the traditional and expensive practice of vessel-based data-gathering is progressively giving way to monitoring via "observatories" - complexes of distributed, autonomous, real-time sensor systems. Burgeoning technology and pressing societal needs will soon make such observatories the backbone of European marine observing activity because of their ability to provide copious quantities of diversified data over large areas at reasonable costs. But to be useful for research and decision-making at a transnational level, all the incoming data have to be comparable and amenable to fitness-for-purpose assessments in relation to specific user-group requirements. This requires measurements to be metrologically sound, and instruments to be working within known specifications at all times despite prolonged deployment in harsh conditions. The only realistic way to achieve these goals is through continuous, responsive, high-quality harmonisation of procedures at diverse levels: from sensors calibrations, deployment procedure, to the data flow until its distribution to the users. In FP7-JERICO, harmonisation is addressed through a dedicated set of recommendation and quality standards, namely the JERICO Label, which is a set of criteria dedicated to guarantee a commonly shared quality level of the delivered data and information.

This chapter summarizes the main achievements of FP7-JERICO towards European harmonization of coastal observatories, remaining bottlenecks and priorities for the future.

5.1 Main achievements towards harmonisation in FP7-JERICO

5.1.1 Harmonisation in conducting operations and maintenance

One of the key objectives in JERICO Networking Activities was the harmonization of operation and maintenance methods, acknowledging the fact that European coastal observatories have been developed according to the national efforts and guided by each country's priorities. This led to observatories with very diverse design and architecture and resulted in the establishment of very different practices for operation and maintenance. Within the limited extend of a project like FP7-JERICO, the priority was given to the most pressing issues like calibration and biofouling, while it is the first time that a Best Practices report on all phases of the system is attempted adopting a platform based approach.

The degree of "harmonization need" depends to a large extent on the observing platform and the previous European efforts. Thus the Glider community, benefiting from the small variability of available products (few types of gliders) and the European funding opportunities (GROOM project) has moved towards harmonization right from the start, describing more and adopting to a lesser degree, common best practices. One step down the scale is the Ferrybox where although the basic concept and architecture behind the installed systems is more or less the same, the existing technology allows certain degrees of freedom and more "custom designs". However, the work done during the FP6 Ferrybox project proved a very good ground on top of which JERICO started building. For these two platforms (gliders and Ferrybox) there are no obvious harmonization gaps in terms operation and maintenance although one has to keep in mind that as technology progresses and new systems are incorporated, harmonization is a never ending issue. In other words, it is a dynamic activity, which the partners must pursue constantly.

As proved the greatest requirements in terms of harmonization were within the Fixed Platforms community where a huge variability is found. Standard Operation Procedures (SOP's) followed by each partner were documented and a best practice code was developed. This is reported in deliverable D4.4. Although some parts in that code inevitably had to be more general, important common issues such as biofouling have been dealt in some detail.

Acknowledging the role of available funds in the design, development and running of coastal observatories, significant effort was invested towards the cost analysis for each platform type, and it is the first time that concise information is available both to the current operators but also to those interested outside the JERICO community. The other pressing issue, aw written above was the biofouling for which a specific deliverable was dedicated (D4.3 Report on Biofouling Prevention Methods). Furthermore, JERICO performed a Biofouling Monitoring Program (BMP) aiming in identifying major organisms responsible for biofouling in different geographical area, as an input to the development and application of more suitable approach to any specific region. Further to the above key issues identified besides those being platform specific are the sensing technologies, the need for qualification and testing and of course the deployment-installation and maintenance of the systems.

5.1.2 Harmonisation of calibration procedures

Calibration, unlike validation, which can be performed with various ways and methods, requires standardised techniques and specialised equipment. This often forces operators of marine observatories to turn to the manufacturers on regular intervals for sensor calibration, increasing total costs and of course time intervals that sensors are unavailable. Although few centres run dedicated calibration laboratories with trained personnel, the overall situation in Europe is characterized by individual and uncoordinated efforts. Moreover, the important issues of standardization and certification are overlooked mainly due to the inherent difficulty of marine observations and the fast evolving technology. On the positive things one has to mention that there is significant experience among European research institutes on calibration methods, which is a valuable asset for future.

JERICO has actively worked towards recording calibration labs, equipment and methods across the network, investing significant efforts in harmonization practices. Indeed, for the first time a large part of the marine community operating calibration labs had the opportunity to come and work together. A series of workshops, common exercises and meetings with the industry proved very valuable. Once the key measured parameters in the coastal ocean were identified, it was decided to have specific workshops/exercises. Thus starting from the Chlorophyll, the second workshop/exercise was devoted to Temperature and Oxygen while an inter-comparison of O2 sensors in-situ and in lab also took place in Villefranche/mer (France). In addition, calibration labs were actively involved in the JERICO TransNational Activity (TNA).

To conclude at the end of the FP7-JERICO project and in order to step forward after the work achieved in FP7-JERICO project and to sustain the activity. The consortium promoted the establishment of a permanent working group for calibration activities. The preliminary strategy plan includes the design of a pan-European calibration grid with two distinct levels; the first will include those labs with the ability to carry primary calibrations on specific parameters; while in the second level there will be labs handling the calibration of one or more parameters at secondary level...

5.1.3 Data management towards European and international standards

A key aspect of an efficient operational observing system is the streamlined processing of real time and delayed mode data, which takes the data from raw to quality assured. Considering the money and effort invested at EU level through numerous projects and initiatives such as SeaDataNet, EuroGOOS Regional Centres, MyOcean and EMODNET, the observation system must ensure that the flow of real-time and delayed mode data will be reliable, accessible and easy to distribute. To do so there are number of key issues which must be considered:

- Data is quality controlled following documented protocols.
- Free and open access according to Aarhus Convention on environmental data as expressed by IOC Data Policy (International Oceanographic Commission of UNESCO).
- Long term archiving (more than 20 years) policy has to be implemented for all types of data, including classified data. Archived datasets should be citable with a mention of the observation system.
- Clear mechanism must be in place to guarantee data authorship traceability.
- Data availability (real time/near real time – delayed mode) compatible with the “observation method” (for example real time is required in operational systems).

- Data frequency is compatible with the "observation purpose" capturing the time scale(s) of the observed phenomena.

To progress towards these objective FP7-JERICO project undertook several actions. Indeed, two handbooks dedicated to near real time data management and Delayed mode data management have been written (deliverables D5.6 and D5.8) in order to guide data and observatories Principal Investigators in the procedure to apply. In addition, deliverable D5.7 reports main guidelines to assess uncertainties.

Data management principles applied in JERICO are also referred in the JERICO Label to be in compliance with the specification of the Group on Earth Observations (GEO) Label. The main goal of the Label is to specify an approach on how to judge the quality of data, based on the completeness of information as to how the data have been acquired, i.e. completeness of metadata description.

5.1.4 The JERICO Label

a) Definition and Objective of the JERICO Label

The ***JERICO Label*** is a set of criteria defined to ensure some standardisation and interoperability, and the quality of data for coastal observatories. The success of the label depends to a large extent in the efficient promotion by the consortium in the wider marine community so it will be internationally recognised and accepted. The JERICO partners introduced the concept of a ***JERICO Label*** in order to:

- acknowledge a consensus on guidelines for best practices in the design, the implementation, the maintenance, the data policy and the valorisation of operational coastal observatories;
- achieve fair recognition of the quality of the managed observatories for the partners and all new comers that comply with this Label;
- help stakeholders becoming aware of the European interest in the development of high quality coastal observatories; and finally
- foster a wider market for the industry in sensor technology and platforms based on the agreed recommendations.

The JERICO Label is described in a dedicated Deliverable D1.4 with important reference to harmonisation dedicated documents listed at the beginning if this chapter.

b) Content of the JERICO Label

To balance between the wide variability within the coastal observational systems dictated by the nature of the coastal environment and the need to set some specific rules, a «fit for purpose» approach has been adopted where each observation system must show that it fulfils a set of requirements emanating from the observational purpose. Thus as a first step a set of three basic criteria are proposed which at a later stage can be particularized and refined to the current needs through an update process discussed further down.

The first criterion is the **Sustainability** of the observatory/platform and although the current economic problems in most European countries make very difficult to plan long ahead, it is important to set a minimum time frame that it will be operational. In particular, the challenge of climate change makes the existence for long time series an advantage.

Operationality is the second obvious criterion as a key aspect of an efficient operational observing system is the streamlined processing of real time and delayed mode data, which takes the data from raw to quality assured. To be considered as operational, the observation system must ensure that the flow of real-time and delayed mode data will be reliable, accessible and easy to distribute.

Finally, the **Observing purpose** is the third criterion, where observatories are classified into two major categories; those that monitor a set of primary or core parameters individually defined by the specific "observational need" and those that also have one or more of secondary or "good to have" parameters.

The above can be summarised in the following ***JERICO Label*** schematic:

Considering the wide variability between the existing observing systems in European waters, apart from the three criteria, the ***JERICO Label*** promotes an extensive list of recommendations, which are the products from several JERICO deliverables and in particular: D 3.1 Report on current status of Ferrybox, D 4.2 Report on Calibration Best Practices, D 4.3 Report on Biofouling Prevention Methods, D 4.4 Report on Best Practice in conducting operations and maintenance, and D 5.6 & D5.8 Data management handbooks… . These reports cover the three major platforms examined during JERICO, Fixed Platforms, Ferry Boxes and Gliders and will be enriched with information on other platforms such as HF Radars, Profilers etc. as this becomes available from JERICO-NEXT.

The recommendations included in the ***JERICO Label*** cover a wide range of issues faced by operators and can be used as a road map towards a European Coastal Observing System. Following the technological advancements, the recommendations need to be updated regularly especially those related to sensor use, such as maintenance, calibration and biofouling:

- Sensing technologies
- Qualification and testing
- Operating Issues
- Deployment-Installation
- Maintenance
- Biofouling
- Metrology-Calibration

Additionally to the above, there are specific recommendations on platform specific issues:

- Fixed platforms – energy storage, connectors, mooring lines, data transmission, choice of materials
- Ferryboxes – connectors, data transmission, choice of materials, flow detection
- Gliders – Energy storage, connectors, data transmission, choice of materials

Of course the ***JERICO Label*** shall not supersede existing legal or safety regulations or requirements and will not define technological solutions but technological specifications and minimum performances considering that technology changes over time and operators must endeavour to adopt innovative instruments.

One of the three levels of the label will be awarded for a three-year period upon request to the JERICO Label Committee. The Label will be updated every three years in order to encompass all possible technological and/or policy changes.

5.2 Strategy towards a better harmonized JERICO RI

5.2.1 A better harmonisation of calibration procedures

One of the most prominent gaps is the lack of a structured calibration lab network both for the JERICO partners and the whole marine community. In other words, the establishment of a permanent working group for calibration activities in FP7-JERICO project is a starting point to structure a calibration lab network. Involved participants recognized the need to set up some common performance evaluation of calibration procedures, for comparison, discussion and consensual agreement on best procedures selection.

In JERICO-NEXT, but not only, the idea of a permanent structured calibration lab network will be pursued following a 2 level approach (task 2.5). The first level will be composed of labs capable of conducting primary reference calibrations for a particular parameter while all those labs operating secondary reference calibrations will be in the second level. The rationale behind this is that, as primary calibrations require expensive, dedicated equipment not widely available, members of the network operating secondary calibration labs will use the parameter specific primary nodes for calibrating their secondary sensors. In other words, the acknowledged primary lab for temperature will host the secondary calibration thermometers used by partners on their labs. One level up (or down), the secondary calibration labs will form a wide spread network of laboratories where partners or any other user will be able to calibrate their operational sensors. These labs will serve both, members of the network, which although run a calibration lab there might be missing some parameter(s), as well as the wider marine community seeking to save both money and time. Furthermore, calibration harmonization efforts will continue for the “problematic” sensors identified in JERICO (optical and carbonate system).

This network will contribute to the European capacity building and will require fostering cooperation between people and groups to promote knowledge exchange and training, nurturing consensus on methodologies and procedures, harmonizing standards of operation, achieving Best Practices, and a rational coordination of resources

In addition to the above, the established in JERICO permanent working group for calibration activities besides the production of a white paper on marine calibration activities and practices in European laboratories (as already decided) will set a roadmap for the future. Obviously it will take advantage from the JERICO-NEXT related activities but also it is important as a group to seek new possibilities for capacity building and cooperation in future calls.

5.2.2 Better harmonisation of operation and maintenance methods

Considering that JERCO FP7 project was the first phase towards a pan-European infrastructure, it was impossible to conclude the harmonization practices only within JERICO and thus important actions are still expected. Indeed, harmonization practices established in FP7-JERICO project should be better shared in order to be continuously upgraded according to technology evolutions, and also to be refined to make them more effective and consistent. In addition, although there are no persisting gaps other than the need to follow the technological improvements, as for gliders and Ferrybox, the idea of a European Coastal Fixed Platform design might be a logical step and the way into the future.

Finally, although Gliders, Ferrybox and Fixed Platforms are key observing platforms in the coastal environment they are by no means the only one. HF Radars, Cabled bottom platforms, coastal profilers and even stand-alone sensors which were not examined during JERICO, have also a significant role in the marine observations and of course must be also included in the European efforts towards harmonization. In the framework of JERICO-NEXT, harmonization activities will focus on HF Radars, Cabled bottom platforms and Coastal profilers which were not included in FP7-JERICO, tailored according to their degree of harmonization “need”. HF Radars are considered less demanding compared to the other two platforms where custom designs are very common.

Moreover, moving forward, the “platform based” harmonization approach in JERICO, will be upgraded to a “network based” approach in an attempt to consolidate the work done and to put in place a mechanism of continuous revision and update of best practices.

The need for automated biogeochemical measurements have pushed the technology towards new sensors (Nutrients, Carbonate system and Optical), capable of being installed either on existing platforms or operated as stand-alone instruments. Effort in JERICO-NEXT will be also directed towards the harmonization of these new sensors and their underlying technologies within the network.

5.2.3 Better harmonization of the coastal data management at European level

The JERICO project proposed a European coastal marine observatory network by integrating different data flow systems that are based on the already existing distributed infrastructures for data collection in regional nodes. The data management scheme that was introduced in the project was based on the two major ongoing European marine data infrastructures that cohabit at European level.

- The first, former MyOcean and now in-situ TAC service of the Copernicus Marine Core Service, deals in priority for operational oceanography needs. That means that effort must be put on near real-time data transmission but not necessary for all parameters (only core parameters are necessary to be transmitted in near real-time). This data system is originally organized with the EuroGOOS ROOSes.
- The second data management infrastructure is maintained by SeaDataNet. The main principle of SeaDataNet is that the data are hosted by the NODCs (National Ocean Data Centres).

These two systems have already started being integrated under the EMODnet Physics in order to provide a unique access point to the full marine data sets, but a specific focus on the data flow from measurements to archiving with standardized and coordinated pan-European methods and quality check criteria has yet to be established. This is particularly relevant for parameters not related to physics. The integration of biological and chemical data in the JERICO RI data management system is a necessary step forward that will expand the overall data capacity but it is very likely to impose difficulties in the designing of a homogeneous data management system. The effective handling of this diverse data set should be realized through the direct linking with EMODnet Biology and EMODnet Chemistry in order the existing standards and methods to be acquired and used.

The first bottleneck could be the difficulty to reassemble datasets in delayed mode, considering that only a subset was transmitted at the beginning of the process The second bottleneck may be the difficulty to link data from a specific project (ie JERICO-NEXT) to a data centre which is no necessary involved in the project. .A third bottleneck is that data providers can be reluctant to deliver and share their data if they haven't got a clear vision on where their data flows. The data management system must provide easy to use tools to provide data originators with facilities to monitor their data

The general strategy for the future data management should comply with the following guidelines:

- The collected oceanographic data should be accessible, freely available, quality-controlled and in agreement with existing standards and conventions
- The data capacity of the European coastal observatory should be increased and the quality of the data provided should be improved. This will allow long-term and sustainable access to high-quality data necessary to understand not only the physics, but also the biological and chemical processes in the coastal zone.
- The direct linking with the major European infrastructures such as the EMODNET and the Copernicus Marine Core Service should be maintained and further upgraded. This will ensure both the proper and effective data dissemination and the data interoperability.
- The observations acquired through different in-situ platforms (mooring, profiling floats, gliders, HF radar, etc.) should follow a standardized data management for their processing and validation.
- Principles and methods regarding the data flow and the quality control procedures that have been already developed through other European and international initiatives should be also taken into consideration.

To reach these general objectives, the following detailed actions is planned to be undertaken in the JERICO follow-up project, so-called JERICO-NEXT.

1) Coastal observation is conducted in Europe by several teams following different objectives: scientific studies to develop knowledge about local or regional processes, coastal monitoring under the framework of environmental policies… It is of high interest to reach a European view of observatories which have been set up, what are the sensors, protocols and methodologies in use.
2) As a consequence, it seems of a very first importance to be able to describe an observing system

(mooring, vessel, …) in a detailed and harmonised manner, and to record these descriptions in a common catalogue. Some developments have been done on SensorML and the next challenge will be to implement these developments to allow the data collector (Principal Investigator) to describe by himself the platforms he is in charge of and to be able to generate harmonized meta-data. The challenge to be taken up is to provide easy to use tools for the PI that enable them to describe their observing system and to also provide them some benefits. Using these tools must not ask additional work to the data providers.

3) In addition, describing the observatories and generating the related meta-data will also facilitate the data ingestion.
4) More and more automatic observatories now transmit measurements in real time via various communication networks, data transmission protocols, compression algorithms, formats. As a consequence, data flows from sea to shore are really heterogeneous and all teams have to implement different software to receive, decode and control observed data. Harmonization in that domain will certainly improve the global efficiency of the systems, using existing standards such as OpenGIS "Sensor Web Enablement".
5) Data control procedures must also be harmonized to reach a standardized level of data quality following the example of what have been done in international deep sea observations programs such as Argo.
6) Roles of the actors (PI's, data centres) to apply these procedures must be clearly defined.
7) Providing easy to use tools for PI to continuously monitor the operational status of the observatories (detection of platforms or sensor anomalies, detection of data transmission losses…) is also a key factor to the global quality of resulting data sets. Monitoring the datasets through the two main data systems will decrease the reticence of the PIs to deliver the data through a system that they may consider as a blind system.
8) In addition, with the real time data flow, more complete and controlled data sets are elaborated in delayed mode after calibration of instruments, download of instrument internal recorders, re-processing of data. These different data flows are very complementary, however they are often managed in different ways

Additional information about the JERICO-NEXT project is given in chapter 6.

5.2.4 The way forward for the JERICO Label

In the framework of the FP7-JERICO project the JERICO label was limited to technological harmonisation issues. It helped to initiate a harmonization target at European scale considering the heterogeneity of the systems. In order to step forward it is necessary to organise the technology harmonization to match with the scientific and societal needs at European scale, and thereby overcome the limitation arising from the fact that an observing network is usually deployed in a local or regional place to answer specific scientific and societal questions that are specific to an area. As a consequence, the main priority for the next steps is to upgrade the JERICO label to make it matching with scientific and policy priorities according to .6 scientific and policy-societal topics (MSFD):

1) Pelagic biodiversity
2) Benthic biodiversity
3) Chemical contaminant occurrence and related biological responses
4) Hydrography and transboundary transport
5) Carbon fluxes and carbonate systems
6) Operational Oceanography

Consequently, the technology part of the JERICO label will be updated: recommendations will be given to fit scientific and policy societal topics. In addition, it will take in account new platforms systems such as HF radars and benthic observatories. This is coordinated in task 1.6 of JERICO-NEXT.

To ensure the sustainability of the label, and considering that this particular effort is in line with complementary efforts in ESONET and FixO3 a possible convergence in the near future with the establishment of a marine research infrastructure Label Committee and a subsequent LABEL must be examined. Moreover, a link with a permanent European group such as EuroGOOS will be also examined

6 Strategy for the future

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Reference documents:

Date.	Report name	WP#	Lead contractor	To download
Oct. 2012	Report after the Strategic workshop #1	1,9	Ifremer	http://www.jerico-ri.eu/download/filebase/jerico_fp7/reports/GA1_BPWOct2012final.pdf
May 2014	Report after the Strategic workshop #2	1,9	Ifremer	http://www.jerico-fp7.eu/attachments/article/302/Strat_WS_report-May2014_V3.pdf
April 2015	Report after the workshop " Strategy towards JERICO-NEXT"	1,9	Ifremer, IRIS	http://www.jerico-fp7.eu/attachments/article/284/Report-Workshop-vFinal-LRdoc.pdf

6.1 The European framework

The ocean environments are experiencing increased pressure e.g. increased pollution, greater demand for non-living resources (renewable energy), over-fishing that result in declines in ecosystem health and biodiversity. The coastal areas are in addition subject to threat connected to increased coastal population and degradation of coastal habitats.

Europe is reacting by promoting a large cooperation for the global ocean by funding major infrastructure projects such as EURO-ARGO and EMSO and proposing a Blue Growth policy. **One of the key objectives is to create a large international cooperation for observing systems in the global ocean, while the idea of a European Ocean Observing System (EOOS) both in open and coastal ocean has been already formulated** (European Marine Board, 2013, "Navigating the Future IV").

To strengthen the understanding of the coastal areas 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. Parts of this integrative approach are the observational systems implemented within the EuroGOOS regional alliances for the European waters. Over the last years several European wide projects have been conducted to integrate the *in-situ* observations towards a system that can serve all the needs from the different users. Based on the EuroGOOS ROOSes these different projects such as MyOcean for mostly real-time data and the SeaDataNet for historical data, are supporting the long-term EMODnet initiative on data gathering and access.

The exploitation of research-driven marine technologies and data for innovation, wealth creation and business development is an increasing demand from policy-makers in Europe. This is a crucial driver for decision-making and this is giving an explicit framework, in addition to scientific and environmental concerns, for developing a strategy for coastal observation in Europe. The JERICO consortium is working in line with this strategy at both the hardware and the software levels, as expressed in the previous pages.

Hereafter we synthesize the main conclusions of FP7-JERICO with regards to strategic issues such as quality of platforms and sensors, data analysis and integration, scientific and policy needs (section 6.2). Then, JERICO's role in the European Ocean Observation System and its economic sustainability is discussed (section 6.3), and the next steps forward are drawn (section 6.4).

6.2 State of the art at the end of FP7-JERICO

A pan European Research Infrastructure of coastal observatories has been implementing with the aim of serving the European research needs, legislation and directives addressing the governance of the coastal zone and providing opportunities for innovation and business development. The Marine Strategy Framework Directive is therefore a driving force in the implementation and further development of JERICO as a network of coastal observing systems.

The JERICO-RI is based on the integration of nationally funded RIs, which therefore firstly address national priorities and aim at answering specific scientific questions of interest. Investment on research infrastructure is a way for the nations to take position in the competitive research market in Europe. It is therefore a non-negligible asset for the nations.

Through JERICO a major effort has been pursued on the integration, harmonization (both hardware, software and quality), accessibility and further development of these national RIs, with the objective of increasing significantly the added-value for Europe in terms of research position, monitoring capability and innovation.

One of the main challenges for JERICO has been to integrate the network of observations and to gather enough knowledge and information in order to enable the recommendation of sensible investments in such a way that it becomes a cost-efficient source of data and information for managing European coastal seas, contributing to:

- the assessment of the environmental status,
- the operational provision of information to stakeholders, and more specifically to models,
- the support to decision-making.

In order to sample the coastal seas, one needs to measure physical, chemical and biological parameters from the surface to the bottom, from the shore to the shelf. Fixed point observatories are needed such as buoy or pile, Lagrangian like observatories as profilers, AUV/gliders, Ferryboxes, ships of opportunity, sailing or fishing vessels, but also data from sea-bottom observatories, coastal radars, and airborne and space-borne vehicles (planes, satellites unmanned air-borne vehicles / drones). Moreover it requires integrating the observations from the different platforms and from different sensors, following sampling strategies that ensure optimal support to research on key scientific and/or societal challenges.

One of the key-issues to be addressed is the trans-boundary dimension of environmental health of the coastal zone. This encompasses trans-boundary pollution, identification, mapping and quantification of pollution sources, transport of harmful chemical and/or biological compounds (e.g. harmful algae, heavy metals, emerging contaminants, invasive species) impacting the environmental status of coastal seas downstream. This implies a sampling strategy suitable for both science and policy requirement is to be set up.

6.2.1 Pan European sampling through regional integration

By the end of FP7-JERICO a number of major coastal observatories in Europe seas, encompassing Ferrybox lines, glider fleets and fixed platforms have been harmonized, integrated and upgraded to a level that secure consistency and quality of the data provided, as defined by JERICO label framework.

The integration of existing observing systems has been pursued following a regional approach supported by the existing ROOS organisation. Status, gaps analysis and recommendations for further development of the regional observing networks have been discussed and consensually agreed with the scientific community representing by the JERICO consortium. This agreement remains to be endorsed by all relevant parties at regional level so that a consistent message coming from the European scientific community can be delivered to national authorities.

A real need for future forecast modelling has been identified: Presently the forecast models are global and have a relatively (but not always satisfactory) high resolution. These models are now nested with more local and coastal models, leading to an increase demand on in-situ data in known format and quality near the coast for evaluation and assimilation. As more parameters are to be acquired, it would be valuable to establish a shared approach in the coastal observatories around Europe. As no single body has leading expertise on all required parameters, sharing expertise based on expert laboratories among the whole European community would be a great asset.

Different applications, such as OSSE simulations, which have performed in FP7-JERICO WP9, reveal the usefulness of Ferrybox measurements not only for monitoring purposes but also for answering key scientific questions and for supporting regional ocean modelling and forecasting services. Due to the large amount of data, a suitable data management has to be established including quality control in both real-time and delayed modes. In FP7-JERICO, two data management handbooks documented the procedures related to the 2 transmission modes. Nevertheless, the quality assessment, that differs from one system to another, has to be especially harmonized and standardized according to international accepted standards in order to make the data comparable and exchangeable. The possibilities to combine different transects and their partial overlap allows a comprehensive overview for a certain area and for a specific parameter. Further, the linkage of such transect data with spatially distributed data from models or satellites can lead to synergistic effects in terms of validation or even improvement of the quality of products in the case of data assimilation. Moreover, data assimilation needs a sufficient spatial coverage which is yet reached only in specific areas.

6.2.2 Value adding through integration of systems

FP7-JERICO was one step forward toward integration between Ferryboxes, gliders and fixed platforms. These platforms are used to run in an automated way mainly, reducing thus the possible parameters to be measured due to technology limitations. Particularly, there is still a particular lack of robust biogeochemical observations in the oceans and especially in the coastal regions with their high biological activities due to the lack of available suitable instruments and platforms. Parameters such as dissolved oxygen, chlorophyll-a, pH, nutrients and turbidity are not collected to the same extent as parameters such as salinity. This situation makes it difficult or even impossible to validate and provide boundary data for ecosystem models, or to understand and be able to parameterize the underlying biological processes better. There are recently a lot of promising technologies under development, or even in a mature stage, for better automated measurements of different biologically relevant parameters. There are ongoing developments by European funded projects such as NEXOS or EnviGuard. Ferrybox systems are an ideal platform to integrate such systems, even if they are in the development stage, since they offer a protected environment and easy access for maintenance. The systems offer the opportunity to collect important data sets at the appropriate temporal and spatial scales across all European sea areas and can contribute to the challenges of the Marine Strategy (MSFD) requiring more biogeochemical data such as eutrophication, algal dynamics including HABs, etc. One example which could be cost effectively investigated by Ferrybox (FB) systems is the impact of coastal areas to climate changes. The budget of climate-relevant gases in shelf seas and estuaries and its contribution to global climate development is still not quite clear, and in particular, the contribution of the shelf seas to the carbon budget is particularly difficult to predict from existing models. There exist mainly only sporadic field campaigns with measurements of pCO2/carbonate, CH4, N2O and halogenated hydrocarbons. Since FBs are only covering surface waters (with the exception of ADCP measurements) the surface water measurements should be complemented by profiling platforms such gliders, AUVs and other profiling instruments. Together remote sensed data can fill the gaps between transects for certain parameters (chl-a, SPM, yellow substances). At least all monitored data need to be integrated (assimilated) by suitable ecosystem models in order to obtain a holistic view of the entire coastal areas.

In summary, the integration of diverse platform types at regional levels increased the scientific value of the observations and the harmonization of national observatories (buoys, fixed platform) that are deployed upstream and downstream from the FB lines.

To reach this target, the JERICO network therefore needs to be reinforced by integrating the biological component, which was not the focus of the FP7-JERICO project. The objective is to contribute in implementing the ecosystem-based management of the Sea and in answering better the gap of knowledge about biodiversity, eutrophication, harmful algae events, and invasive species issue in the coastal seas. The added value of platform integration is coming from synergy and complementarity of the equipment types.

Furthermore, it is paramount to acknowledge the role of coastal modelling (transport, nowcast, forecast) to address specific regional processes is of a tremendous value. JERICO data contribute to this effort (e.g. calibration, assimilation, validation). The role of moving observatories of transboundary nature (Ferrybox, glider, regular transect) have proven of high value for supporting the modelling activity at regional level. Adding-value would be obtained by further harmonizing national observatories (buoys, fixed platform) that are deployed upstream and downstream of the regional transects, in order to ensure the consistency of observations and of data.

6.2.3 Summary of identified priorities by the end of FP7-JERICO

Gaps and bottlenecks have been assessed for both Hardware, (platforms/sensors and the associated technologies, cf. Chap. 4) and Software (procedures, analysis, quality) of the JERICO infrastructure (cf. Chap. 5).

On the technology side, the following challenges have been identified to be prioritized:

- The **sustainability of the existing observational system**, through long-term commitment from the European states
- The consolidation of specific observing systems, such as
  - the implementation of glider repeated sections in all the ROOS regions,
  - the long-term sustainability of Ferrybox lines.

On the software side, JERICO has made major advancements in terms of harmonisation of national observatories, as it is the backbone of the future network. Indeed, by the end of FP7-JERICO, for most of the major coastal observatories in Europe seas, encompassing Ferrybox lines, glider fleets and fixed platforms, harmonization procedures have been discussed and are documented in dedicated reports (e.g. deliverables D4.2, D.4.4)., showing that the integration level that has been reached can secure consistency and quality of the data provided, following the JERICO label framework (deliverable D1.4). Nevertheless, the work has still to be consolidated in the JERICO label, providing guidelines and best practices for the scientific community for optimising the value of the data and its potential for innovation. It must ensure a coordinated approach on data provision in terms of parameters, quality, sampling and distribution.

A better integration of data coming from different kinds of platforms is needed to support modelling/forecasting services. This implies a suitable sampling strategy and harmonized quality control that answer both scientific needs and the modelling technical constrains.

Priorities have to be set upon:

- Establish improved sampling strategy (for scientific, operational and technical issues and policy needs). Resolution requirements for both scientific purpose and operational goals should be the basis for setting up or re-evaluating coastal observing programs. Since resources are limited, sensitivity studies are key- tools to assess an optimal design for coastal observation
- Better harmonise the quality assessment and control. The quality criteria have still to be consolidated in the JERICO label, in order to provide guidelines and best practice for the scientific community for optimising the value of the data and its potential for innovation. It must ensure a coordinated approach on data provision in terms of parameters, quality, sampling and distribution.
- Improve the dialogue between in situ science and modelling science, with a shared approach at European level.
- the gap between maturation of new technologies, which is market and industry driven, and the needs for observations for answering societal and scientific questions is to be addressed.
- The JERICO network is also to be reinforced by integrating the biological component, which was not the focus of the FP7-JERICO project. The objective is to contribute in implement the ecosystem-based management of the Sea and answering better the gap of knowledge about biodiversity, eutrophication, harmful algae events, and invasive species issue in the coastal seas.

The JERICO community emphasizes the complexity of the coastal ocean cannot be understood if we do not understand the coupling between physics, biogeochemistry and biology. Reaching such an understanding clearly requires new technological developments allowing for the continuous monitoring of a larger set of parameter. 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.

6.3 Alliance, Clusters and economical sustainability

6.3.1 A coordinated implementation

If the European Ocean Observing System (EOOS) is implemented, it will be natural that JERICO-RI would develop into the coastal building block of EOOS. It will provide a European web capturing national/regional coastal observatories. The need for pan European activity includes the need for the provision of data to support forecast models. The latter are global in extent but needs to be calibrated and be validated against or parameterized towards high resolution data on the local scale. Likewise, for sound and inter-comparable environmental assessments across Europe there is a necessity to have common practices, common calibrations, common processing, quality control and a common expertise for validation. This is what JERICO is promoting at European level for the coastal ocean.

Incentives are often required to push the research community to harmonise their tools at a European level.
The marine science community, represented by the academia and research institutes needs to provide clear and harmonized recommendations to their respective government in order to maximize the added value for Europe based on national investment on research infrastructure. Mechanisms for optimizing the spreading of these recommendations in member states and the joint assessment of priorities by decision-makers is to be reinforced. Agreement at regional level between countries sharing common environmental challenges and economic opportunities may become a key element of the future European governance on marine RI.

The agreement upon priorities on investment on coastal observatories within a scientific community, such as the JERICO partnership, should influence decisions and priorities when it relates the submission of future national RI proposals. Furthermore, it should strongly influence international funding mechanisms provided by coordinated actions such JPI-Oceans.

The JERICO approach is very close to that of EURO-ARGO and EMSO, which are respectively ERIC and ESFRI infrastructures. As global and coastal models may converge to one overall system, the tendency could be that deep sea and coastal observatories will converge into one integrated infrastructure network too. As a consequence, JERICO intends to share its approach with the FixO3 community for fixed platforms, but also will promote a better cooperation within the Ferrybox and the GROOM/glider communities.

A common approach on the quality and the label definition and management between all the marine research infrastructures under the umbrella of EuroGOOS would be an important step forward.

It is essential that future work supported by the EU rationalises activity across the different EU directorates supporting marine observations. Future structure has to work more closely with the data providers and data users and recognise that a key requirement is data/information products that provide information on the status and changes in ecosystem health.

6.3.2 Economical sustainability

Observing systems are nationally funded, answering to national focus and to specific scientific focus.
This leads to disparity in instruments, parameter measurements, sampling/observation strategies between infrastructures in Europe.
A regional approach may be an efficient manner for raising funds dedicated to common scientific and/or environmental challenges between a limited number of neighbouring countries.
However, if scientific and data collection are coordinated at regional level through e.g. ROOSs, no financial incentives are available through EuroGOOS to support the provision of coastal observations to Europe.
The use of ERA-Net co-fund mechanisms or other gathering of European research councils as non EC-driven initiatives could be potentially used, if neighbouring countries reach agreement on priorities. The main advantages of a regional approach are the following:

- regional focus on the scientific and societal challenges to be addressed
- transboundary issues addressed at the adequate level
- taking advantage of the European region policy
- link to regional funding
- potential from regional structural funds for investing on infrastructure of regional interest (DG Region & MS region)
- value-creation and possibly economic growth shared by neighbouring countries with established tight links.

Possible challenges arising from the regional approach may be about the way to secure the right level of funding and harmonizing the investment levels throughout the European maritime regions (e.g., discrepancies between JERICO-focused regions vs less priority regions). This may require additional political, financial incentives from the EC towards specific regions and EC incentive to coordinate operational regional components at Pan European level.

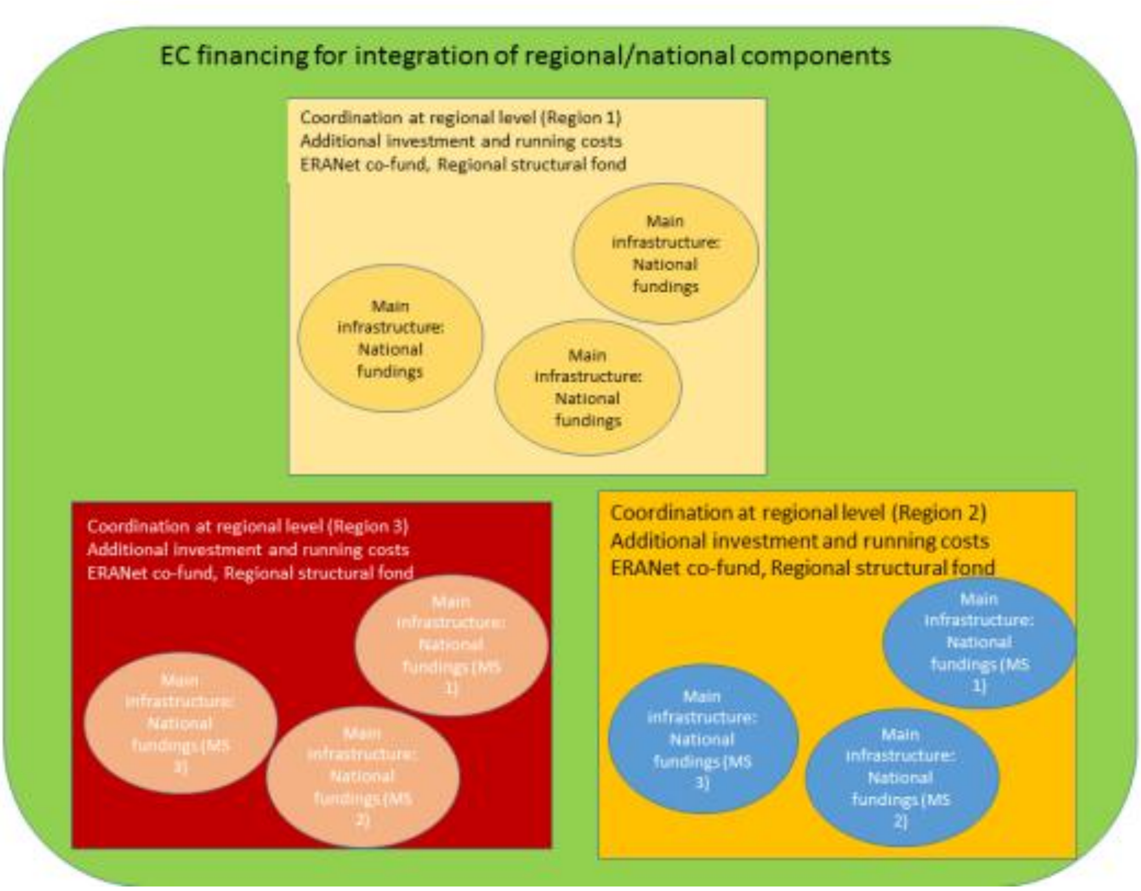

Figure 6.1 Possible integrated financial mechanism from national to EC level

A truly co-funding mechanism between EU and national funding: The individual component activities are thought to be supported by national funding for coastal observatory installation and maintenance. EC funding is further needed to build the network and coordinate these separate national activities, building a common expertise and promoting sustainability of these observatories.
Industry financing can be expected if the RI, or some of its components, become an essential part of the business development. Link is thru improving safety at sea, minimizing environmental impacts of the marine economy, and on supporting industry thru lifecycle of operations, from site selection, build, operation and decommissioning.

Creating and enduring dialogue between data collector, data managers and data users to ensure the availability of measurements, the fit for purpose and data useable for many purposes. It is the only way to ensure value form investment in our observing systems.

To overpass national boundaries, avoiding fragmentation, a regional approach may be an efficient manner for raising funds dedicated to common scientific and/or environmental challenges between a limited number of neighbouring countries.
A truly co-funding mechanism between EU and national funding is needed.

A partnership with industry, not limited to manufacturers of observing systems but including end-users exploiting marine resources, is needed to ensure long-term financing of the running-costs of the infrastructure, the delivery of data, as well as innovation.

6.4 The next step forward: JERICO-NEXT

6.4.1 Objectives of JERICO-NEXT

JERICO-NEXT is the H2020 project that enables to continue the effort engaged during JERICO and to consolidate the coastal observatory network established during the FP7-JERICO project.
JERICO-NEXT contributes towards the implementation of a single (one-stop-shop) European entity for all new marine data, as promoted by the European Commission /initiatives, building upon FP7-JERICO achievements and including physical, chemical and biological data. It will play a pivotal role in the provision of critical coastal information for policy, science and operational uses.
It encompasses:

- *Data acquisition and measurements,* including the infrastructure equipment and software to provide quality controlled and validated data;

- *Data management*, including storage and quality checking; with the objective of better interoperability, data are and will be integrated in the future data management systems, under the umbrella of COPERNICUS and EMODNET. Key partners of JERICO are involved in these activities and ensure the parallel development of the systems;

- *Open access to the infrastructures to research teams and European industries.* JERICO-NEXT will explore new ways to offer services (virtual ecosystem observatory) and make effective and sustainable use of trans-national access possible. Its Forum for Coastal Technology (FCT) already provides a link to industrial partners about requirements and performance of equipment.
- *Integrated e-Infrastructure:* JERICO-NEXT should be of major importance to the EU as it will feed a single Europe wide channel for the provision of all new data that is being collected by shelf and land locked sea monitoring for all marine physical, chemical and biological observation up to the ecosystem level.

  JERICO-NEXT offers unique services to the scientific and industrial communities, opening elements of the infrastructures to users for performing technological tests and experiments. Moreover, as a service to the society and wider public, JERICO-NEXT will help developing tools for supporting rapid and effective decision making.

6.4.2 Main activities designed to address Strategy issues

JERICO-NEXT will work with end-users to identify shortfalls in the data coverage and information services required to better understand coastal dynamics - physical to biological in order to better meet users' needs. The JRA can provide the best solution to go further together for the benefit of all the communities but also for the society. Joint research activities, through partnered research on technology, will lead to the implementation of new technologies designed to cut costs and increase efficiency of sustained marine observatories

a) <u>Strategy item #1: Towards integrated science</u>

The rationale for improved and integrated observations of coastal seas is to gain a better understanding of variability of biological, chemical and physical processes and to attribute measured changes to causes; natural, anthropogenic or climatic. To reach this target, dedicated scientific strategies have to be thought, agreed and implemented according to the local specificities and scientific objectives.

To strengthen this understanding of the coastal areas 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. The FP7-JERICO project provided a clear definition of some coastal observation systems that deliver high frequency in-situ covering physical and/or biogeochemical data, from the sea-shore to the shelf break. This was the first European wide effort towards the harmonisation and coordination of the major coastal observing platforms including ferrybox, gliders, and coastal fixed platforms. JERICO-NEXT will build upon the current JERICO Research Infrastructure and enlarge the objectives to complementary observing systems including biological observations with the aim to better understand the specific characteristics of the coastal areas. JERICO-RI therefore refers to research infrastructure initiated in FP7-JERICO and further developed in JERICO-NEXT.

Building directly on FP7-JERICO, 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 information related to the marine environment in European coastal seas. By doing so, JERICO-NEXT will help the research community to provide the best possible quality indicators for the European Marine Strategy Framework Directive (MSFD) and to promote joint research initiatives and standardization, increasing support to the European industrial sector of coastal instrumentation and monitoring services.

These actions are coordinated in WP1 of JERICO-NEXT.

b) *Strategy item # 2: Long term financial and legal governance structures for the sustainable implementation of JERICO infrastructure*

JERICO-NEXT will establish links with national funding and regional agencies (e.g. JPI Ocean), which are financially supporting observing systems that are parts of the JERICO-RI, to ensure that they know the added value of their contribution. While agencies are typically very aware of the capital investments required for observing systems, in the medium to long term, operational and recurring costs can often be significant in the marine environment. It will make an assessment of both the capital expenditure (CAPEX) and operational expenditure (OPEX) costs for the JERICO-NEXT infrastructure. In terms of a legal framework for the long-term implementation of JERICO-NEXT, an assessment will be conducted for the most commonly used legal forms (ERIC, AISBL) and a recommendation made as to which is the most suitable special purpose vehicle or legal entity for the RI. Finally, a comprehensive cost benefit and value analysis will be undertaken for JERICO-NEXT, outlining both the direct costs and benefits, but also the non-quantifiable costs and benefits associated with coastal marine observing systems. The measurable impact on interested communities of users will be an inherent part of this analysis. Successes recorded through the WP6 (Virtual Access) and WP7 (Trans National Access) will be used as a critical input factor in the cost benefit analysis. This will lead to the definition of a strategy for sustainability of JERICO-RI as a European Research Infrastructure. Different models and options for the sustainability of JERICO-RI through, for example alliances with other I3 and ESFRI infrastructures, and the integration into existing legal entities will be investigated.

The connection with the industrial users and stakeholders through the Forum for Coastal Technology (developed in FP7-JERICO) will be strengthened and made more effective (e.g. focusing on innovative sensors and platforms to improve time and spatial resolutions by clearly defining the needs for observations so that appropriate instruments can be developed that meet those needs (such as accuracy and reliability). We are now ready, in Europe, to create a EURO-ACT (on the quite same model of the US Alliance for Coastal Technology); this will contribute to create a market for European oceanographic instruments and techniques.

c) *Strategy item #3: Towards harmonisation of the existing technologies*

The harmonization of technologies, methodologies and procedures is a vital step in ensuring efficiency and optimal returns from any kind of distributed, heterogeneous, multifaceted, coastal observing infrastructure operating on a transnational level such as the JERICO network. This is because such harmonization leads to an intelligent use of resources across the network, adds to the consistency of its services and products, and helps to provide uniformed access modes and interfaces to users.

To guarantee the harmonization of the network on the long term, JERICO-NEXT will create a Coordination Team (CT). It will handle the overall strategy and supervise its application. Working Groups (WGs), organized from amongst representatives of the involved Partners, will be instituted to advice on specific actions or research areas that are relevant. A separate Calibration Board will be formed to oversee matters relating to calibration and metrological consistency.

WG will carry forward ongoing harmonization attempts within the JERICO network, reviewing accomplishments and revising relevant documentation (principally through the analysis of existing information), in the following three key technology areas: Fixed Platforms, Ferryboxes, and Gliders.

The JERICO network is constantly working to improve its core functionality, which is the ability to provide comprehensive observations of Europe's coastal seas and oceans. This means integrating new, promising observing systems that can expand its spatial reach, such as HF-radar systems and cabled coastal observatories that are particularly attractive technologies from this point of view.

FP7-JERICOThe wider goal is to try and establish a kind of consensus-based "benchmark" for normalizing the operating practices of research infrastructures involved in coastal observing activities that can be freely adopted by any interested party on a purely voluntary basis, provided compliance with the set requirements are met. This will be formalized with the JERICO Label that will be upgraded and enhanced accordingly. This will be coordinated in the WP2 of JERICO-NEXT.

d) *Strategy item #4: Strategy to implement a R&D of technologies and methodologies suitable to long term deployment*

Taking advantage of the strong consortium of partners who are responsible for the majority of coastal observatories in Europe and their substantial experience in observations methods, R&D of technologies and methodologies suitable to long term deployment with particular focus on the biology will be pursued. These efforts will significantly enhance the capability and the quality of measurements in the coastal infrastructures.

In particular, innovative (semi)-automated observation techniques for addressing phytoplankton dynamics at high resolution and in (near) real-time will be investigated focusing on innovative sensors. Three main approaches will be explored and used in combination: image acquisition and analysis (in flow/in-situ imaging); single-cell optical analysis (scanning flow cytometry) and a combination of optical techniques (fluorescence induction, spectrophotometry and spectrofluorometry) for assessing phytoplankton functional groups and photosynthetic activity and physiological status. Biosensors will be investigated as well by using Surface Plasmon Resonance to detect toxins produced by armful algae.

As some established systems have reached maturity in terms of operationality, a key issue is the enhancement of their capabilities. HF Radars are a good example where through innovative and cost-effective methods, new products will be delivered to the scientific community. In addition to the HF Radars the capabilities of coastal profilers will be enhanced through a series of developments and tests focusing in the biological component and the reliability of the systems.

The development of high precision and high frequency reliable sensors for the monitoring of key climate parameters such us the carbonate system in the coastal ocean is of primary importance. Following up the work done in JERICO, developments will be completed while ongoing efforts in related projects will be complemented, providing at the same time operational platforms for testing.

The optimal design of observing networks has been recognized as one of the key issues given the significant constrains associated with labour and costs. Acknowledging this, JERICO invested significant resources on targeted OSEs and OSSEs for the physical parameters and the hydrodynamics. Building on the work done, efforts will be directed towards the development of an advanced OSE/OSSE infrastructure focusing on the high-resolution biochemical transport in coastal areas using well-established standards for optimal configuration of OSSEs.

These activities will be coordinated through the WP3 of JERICO-NEXT

e) *Strategy item #5: Strategy to manage a sustained data and information flow with access to related services*

The JERICO-NEXT data management system will provide procedures and methodologies to enable data collected through the project to comply with the international standards regarding their quality and metadata. Apart from the physical parameters that were the focus of the FP7-JERICO project, additional biological and chemical data are expected to be gathered during JERICO-NEXT. During JERICO-NEXT the data capacity will be expanded, integrating harmonization of biological data, including pelagic and benthic observations for instance as well as tools and services to perform quality controls (tasks 5.2, and 5.5 in JERICO-NEXT WP5). Efficient handling of this diverse data set will require operational links with EMODnet Biology while large-scale relevant efforts such as OBIS and EMBOS will also be considered. Furthermore, the direct links with EMODnet Physics and the Copernicus Marine Core Service will continue to be maintained. JERICO-NEXT will build a platform to register and manage metadata (task 5.3). In addition, the integration of new platform types such as HF radars at European scale rise the need to define harmonized quality control procedures specific for them (task 5.6).

In addition, specific issues regarding the quality of measurements derived from platforms that are widely used in coastal monitoring such as the Ferryboxes and Gliders will also be addressed in two separate tasks (5.5 & 5.7). More generally the working group involved in Data Management work package and associated activities will be sustained beyond JERICO-NEXT project with the Data Management committee managed in JERICO-NEXT WP9.

An objective of JERICO_NEXT is to provide free-of-charge “virtual access” to data and information from in-situ systems such as HF radar, Ferrybox and fixed platforms.

The data and information access will enable scientists to carry out high quality research using data from a variety of coastal observation systems. It will also promote the improvement of existing services and potentially the development of new services. Improvement of existing services may result from feedback from a variety of new users of services provided by the JERICO-NEXT programme. For example, access to in-situ data can improve calibration and validation of numerical models and also provide sea truth data that improves the quality of information derived from remote sensing. New services may result from users developing new data processing tools, systems and algorithms (e.g. development of algorithms for processing data from HF radars) in order to make best use of data derived from JERICO Virtual Services. This WP will provide evidence of the existing client community and their needs for particular scientific services. This information will be of value in order to prioritise and promote the future development of the JERICO network.

In order to build upon activities in WPs, and to gather the consortium around applied activities, 6 so-called Joint Research Activity Projects (JRAPs) will be implemented. They will to put forward the added value of JERICO-NEXT. In that way, most of WPs will be supported by results of JRAPs and reciprocally JRAPs will be fed by WPs conclusions as well. In a more general way the data flow to the European channels such as Copernicus and EMODnet will be tested and applied to JRAPs data. Results will be delivered to the public, the stakeholders and the scientific community. This coordinated in the WP4 of JERICO-NEXT that will help establishing some topical approaches for the scientific strategy and will give inputs to establish the network strategy after JERICO-NEXT.

6.5 Recommendations

At the end of the FP7-JERICO project, the following recommendations can be drafted:

- A multi-platform, multi-scale, multi-purpose approach has to be consolidated
- Integration of observing systems needs to be consolidated due to specificities of marine environment

but also driven by user needs

- Effort to combine operational (monitoring) & research infrastructure is to be pursued
- Similar integrating approaches need to be developed at European scale through improved links/coordination between relevant initiatives: Copernicus (MyOcean-CMEMS), ESFRI (EuroARGO, EMSO), I3 (JERICO, FixO3, GROOM), EMODNET
- System have to be flexible enough to have the potential to be adapted to existing and potential future user needs
- Biological and biogeochemical measurements need to be become a major component of the coastal observing systems
- Major use of platforms of opportunities has to be encouraged
- Forming the underpinning framework for a potential European Ocean Observing System EOOS
- Increase the speed and effectiveness of decision making based on optimised observing system that can rapidly transition data to useable information for multiple purposes
- Create and endure dialogue between the data collectors, data managers and knowledge and evidence providers
- Provide an infrastructure that promotes consistency amongst European regional partners enabling a more collaborative and effective approach to assessing and maintaining the Good Environmental Status of our European seas.
- Include cost-effectiveness as a key component of in the design of systems, in cooperation with system developers and manufacturers. It should ensure a good market penetration towards stakeholders and users with the objective of answering the need for environment monitoring and assessment of the "significant" environmental impacts.
- Involve industry at the beginning of the process (e.g. NEXOS experience) by organizing dedicated meeting focused upon industry types/needs.
- Different industries to be considered: developers & providers versus users & stakeholders… be sure developed products/services are of interest for the latter.
- Need to involve industry in the governance in order to optimize the dialogue and the use of test facilities offered through JERICO_NEXT (TNA).

7 Annex 1: Observing platforms – Status by platform by the end of JERICO-FP7

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7.1 BOOS

Ferrybox: Operational infrastructure

The ferrybox operational infrastructure in the BOOS region is presented Figure A.1. Seven ferryboxes were operational at the beginning of JERICO and six are operational in 2015 (9). The areas covered are the Kattegat – Skagerrak region (with some ferrybox lines in common with the NOOS region) and the Baltic Sea.

Figure A 1: FerryBox routes in BOOS region (active lines in 2014)

The Kattegat – Skagerrak (eastern North Sea) is covered by three FerryBox-lines. Two of these are frequent (Oslo-Kiel and one in the outer Oslo fjord) and one passes through the area at a low frequency. Physical and bio- optical parameters are well covered while biological parameters are only measured at a few localities.

Table A 1 List of vessels equipped with FerryBox systems in BOOS area

Name of platform	Institution	Destination harbours	Start and End of operation	Route
Victoria I	EMI	Tallinn - Mariehamn - Stockholm	2006-Today	Brown
Stena Baltica	IMGW	Gdynia - Karlskrona	2008-2009	See **Erreur ! Source du renvoi ntrouvable.** (red route)
MS Silja Europa	MSI/TUT	Tallinn - Helsinki	1997-Today	Green
MS Color Fantasy	NIVA	Oslo - Kiel	2008-Today	Red
TransPaper	SMHI & SYKE	Kemi-Oulu-(Husum)-Lübeck	2009-Today	Purple
Silja Serenade	SYKE	Helsinki - Stockholm	1998-Today	Light blue
Finnmaid	SYKE	Helsinki-Travemunde, Helsinki-Gdynia	1998[1]-Today	Blue-grey
MS Romantika	LIAE - MSI/TUT	Riga - Stockholm	2013-2013	

[1]1998-2000: vessel was named Finnpartner

The Baltic Sea is covered by approximately six FerryBox-lines. Physical and bio- optical parameters are well covered while biological parameters are only measured at a few localities. The Gdynia – Karlskrona ferrybox line (Fig A2) which has been operated during 2008-2009 has been stopped. This line oriented NW-SE was complementary of the existing lines.

Figure A 2: Stena Baltica route in red (not operational since 2009)

The spatial coverage by ferrybox lines in the BOOS region is good but additional East – West lines such as

Gdynia – Karlskrona crossing the North-South lines will be of interest for completing the spatial coverage of the BOOS region.

Measured parameters

The measured parameters on ferrybox lines in the BOOS region, correspond to the main physical (T, S, Turbidity), chemical (pH, O2) and biological (Chlorophyll Fluorescence) variables (Table 3.10). It should be recommended to add the dissolved oxygen parameter to the four existing ferrybox lines not yet equipped with this sensor. Some recently developed sensors such as nutrients, phycocyanins and cyanobacteria are operated on some of the lines. It is recommended that the experience obtained from the deployment of these new validated sensors must be transmitted to other operators of ferrybox lines of the different ROOS regions through the JERICO partnership.

Table A 2 Measured parameters on FerryBox systems in BOOS region

Name of platform	T	S	pCO2	Trb	Chl-a	pH	CDOM	DO	Nutrients	Irrad.	Rad.	Cyanobact	Phycocyan	Phytoplankton
Victoria I	X	X		X	X		X							
Stena Baltica	X	X		X	X			X						
MS Silja Europa	X	X	X	X	X				X					
MS Color Fantasy	X	X		X	X		X			X	X	X		
TransPaper	X	X	X	X	X	X	X	X					X	
Silja Serenade	X	X		X	X				X				X	X
Finnmaid	X	X		X	X		X		X				X	X
MS Romantika	X	X		X	X			X					X	

Recommendations from D2.2: *“Ferrybox network – The existing Ferrybox network should be expanded”*

Gliders: Operational infrastructure

The gliders operational infrastructure is presented **Erreur ! Source du renvoi introuvable.** A3.

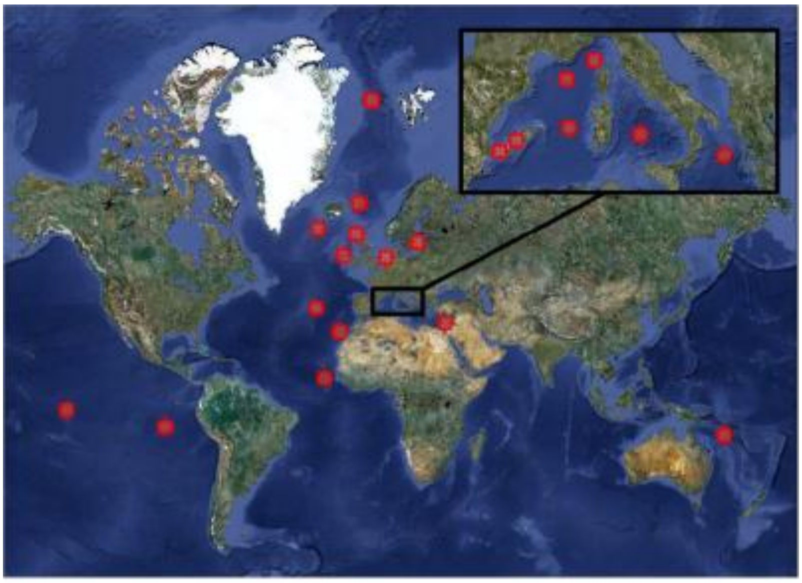


Figure 4.28 - Zones of operation of European glider groups considered in this report. For a matter of simplicity, all those locations included within a 1000 Km wide region, with its epicentre on the most relevant of each group, have been considered part of the same positioning icon (▣)

Figure A 3: Gliders operational infrastructure (Map from D2.1)

As for all regions, data from gliders in the BOOS region are obtained during oceanographic cruises. The spatial and temporal coverage are thus limited to specific coastal areas and certain periods. Data obtained from gliders give access to the description of the water column and are of value to complement data obtained from ferrybox and fixed platforms which describe the surface and/or sub-surface waters. Unfortunately, data obtained from gliders are not covering the same spatio-temporal ranges as for ferrybox lines and fixed platforms.

It should be recommended to implement in the BOOS region repeated glider sections with a regular frequency to be determined (monthly, seasonally, yearly) and preferentially along existing ferrybox lines to complement with data obtained along the water column the surface high frequency data.

The measured parameters on the European glider fleet correspond to the main physical (T, S, Turbidity), chemical (O2) and biological (Chlorophyll Fluorescence) variables.

The most significant sensors in the European sensor arsenal are presented in fig. A5 (Measured parameters from D3.2).

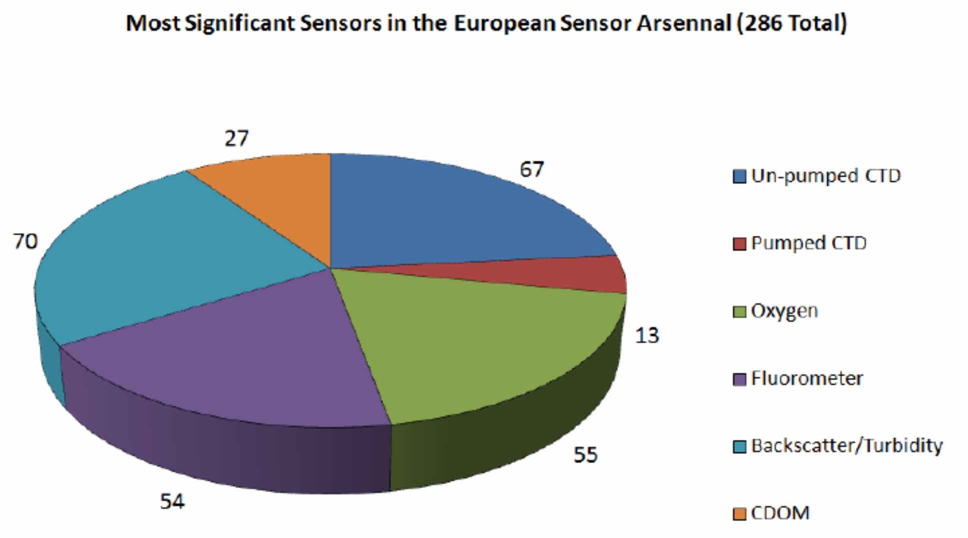


Figure A 4: European sensor arsenal by type of the most common sensors (Source: FP7-JERICO D3.2)

Observing that graph the following evidences emerge:

- **Un-pumped CTD** is the dominant against the pumped glider version by SeaBird. In fact, all the CTDs of the European fleet were done by this leading manufacturer. Since SeaGliders and G1 Slocums (both Coastal and Deep) carry that un-pumped version, the presence of the pumped one is only testimonial at present, although it is expected to grow along with the increase in the number of G2 Slocums (since they typically carry that model on-board) and Sea Gliders with extended payload. The predominant model is cp41p.
- **Dissolved Oxygen Sensors** (Optodes) are also very popular and, at an 85%, provided by Nordic manufacturer AADI. SeaBird also provided a few oxygen sensors to SeaGlider users. AADI models vary between 3830,3835,5013 and 4330
- **Fluorometers, Backscatters/Turbidity and CDOM** are embedded in the same ECO PUCK series device done by Wet Labs. While the first two are generally used, only a half of the users decided to customize their Puck with a CDOM sensor.

Additional but rare sensors existing are presented in fig; A5.

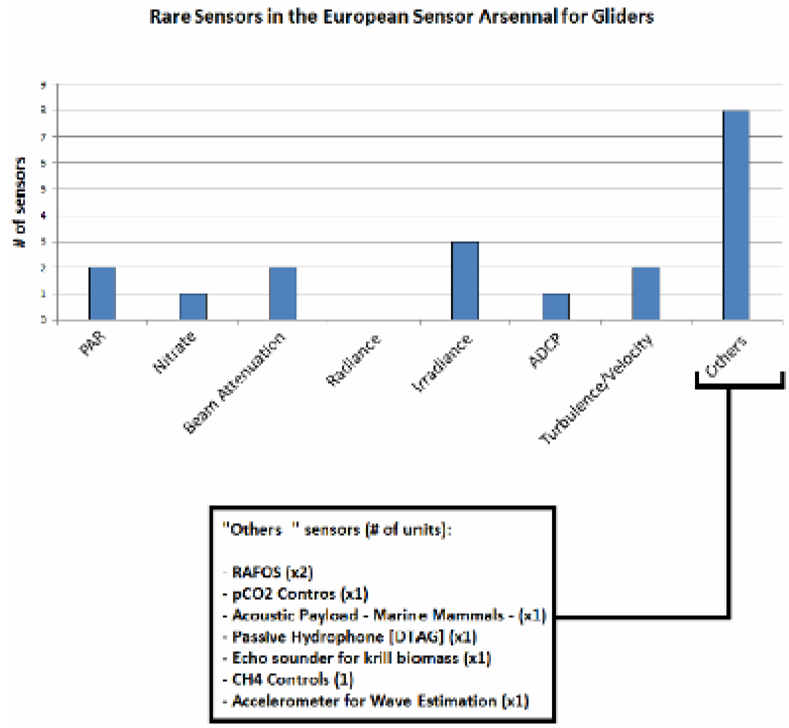


Figure A 5: Rare sensors in the European Sensor Arsennal for Gliders

It should be recommended to add recently validated parameters such as carbon system sensors (pCO2, alkalinity, pH), and in the future additional sensors under development such as nutrients and biological parameter (cyanobacteria, …).

Fixed Platforms: Operational infrastructure

The operational Fixed Platforms infrastructure is presented in fig. A6. The BOOS region is rather well covered with the present fixed platforms infrastructure with a density of fixed platforms less important in the Kattegatt and South Baltic areas. An extension of the network of fixed platforms is needed to reach a better regular spatial coverage in these two areas of the BOOS region.

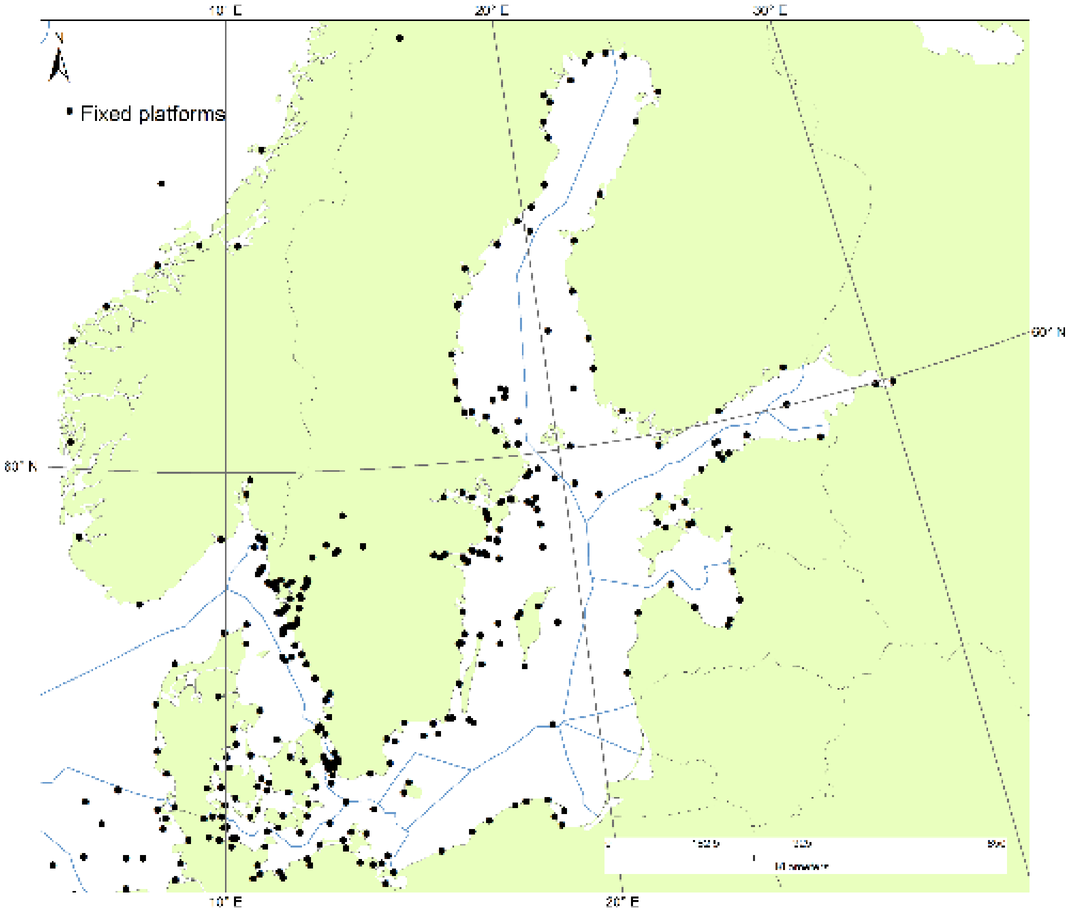
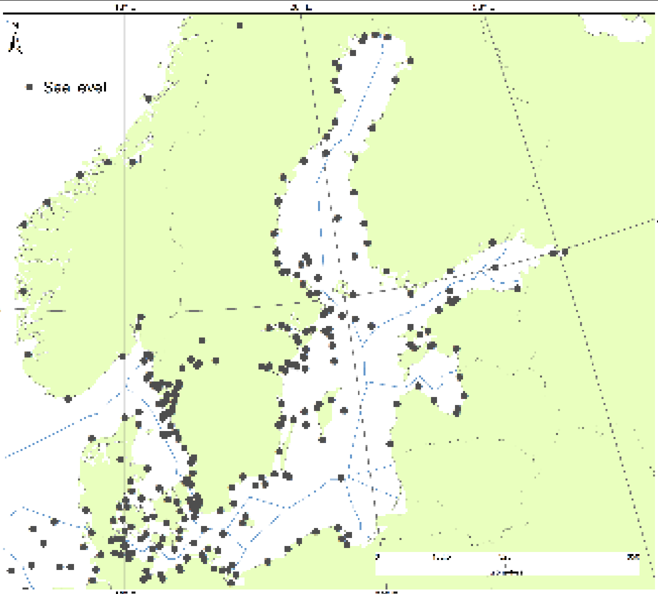


Figure A 6: BOOS - Operational Fixed Platforms infrastructure

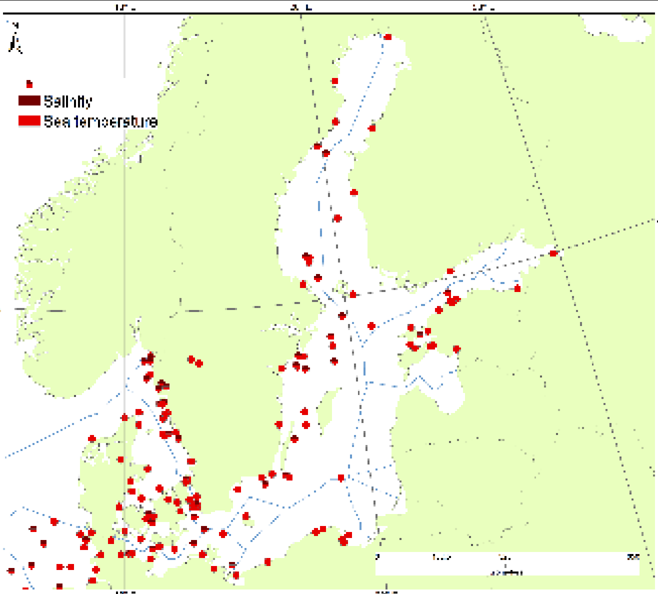
The four maps on figure fig. A7 show the spatial coverage by parameter: Sea level, Sea temperature or salinity, Dissolved gases, Biological parameters (chlorophyll or plankton **Erreur ! Source du renvoi introuvable.**).

In terms of parameters observed, the physical parameters (Sea level, temperature and salinity) are described with a good spatio-temporal coverage excepted in the South Baltic Sea and Kattegat where fixed platforms will have to be implemented to reach a final configuration. Oceanographic buoys are few in the Kattegat - Skagerrak (eastern North Sea) and in the Baltic Sea.

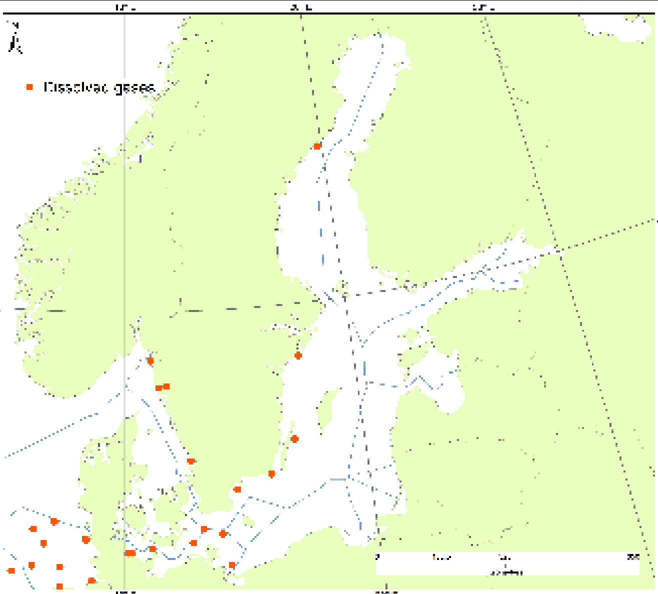
T**he chemical (dissolved gases and oxygen) and biological parameters (chlorophyll fluorescence, biological parameters) are insufficiently described in this region.** It should be recommended to add these sensors at least on existing fixed platforms to obtain a better spatio-temporal coverage for these chemical and biological parameters. Compared to the good spatio-temporal coverage obtained from ferrybox lines a substantial effort must be put in the BOOS region for the instrumentation of multi parameter oceanographic buoys.



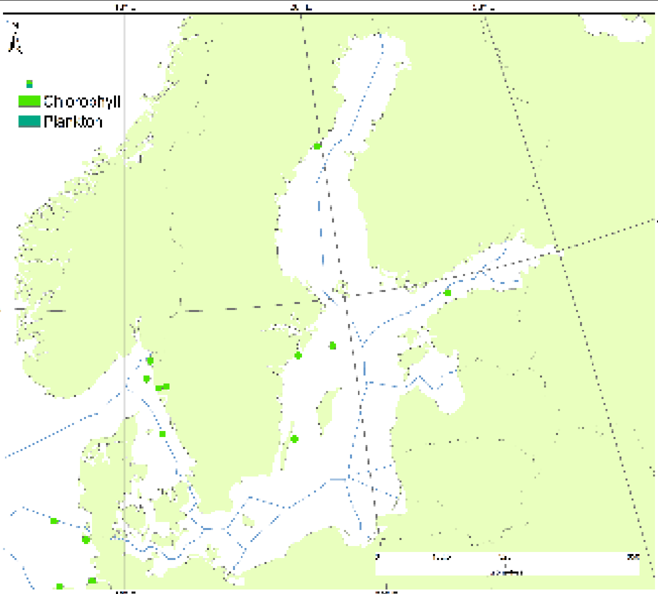
A) BOOS - Fixed Platforms measuring Sea level



B) BOOS - Fixed Platforms measuring Salinity or Sea temperature



c): BOOS - Fixed Platforms measuring Dissolved gases



d) BOOS - Fixed Platforms measuring Chlorophyll or Plankton

Figure A 7

Recommendations from D2.2

- *"Establishment of additionally at least one fixed platform in every basin of the Baltic with near real time measurements in the water column for temperature, salinity, waves, currents, oxygen, nutrients, fluorescence and meteorological parameters*
- *Near real time current measurements in the Belts and the Sound*
- *Extension of the Water level measurement network especially in the Southern Baltic and Gotland (Visby) region"*

7.2 NOOS

Ferrybox: Operational infrastructure

The ferrybox operational infrastructure is presented in fig. A8. Nine ferryboxes were operational at the beginning of JERICO and seven are operational in 2015. Table A 3List of vessels equipped with FerryBox systems in NOOS area. The NOOS area is well covered with ferrybox lines between Belgium, UK, Faeroe Islands, Norway, Sweden, Denmark, Iceland and Germany. It will be recommended that the previously operated line between 2005 and 2009 from Amsterdam to Bergen with M/S Trans Carrier will be restarted in order to provide data on a North-South transect in the North Sea.

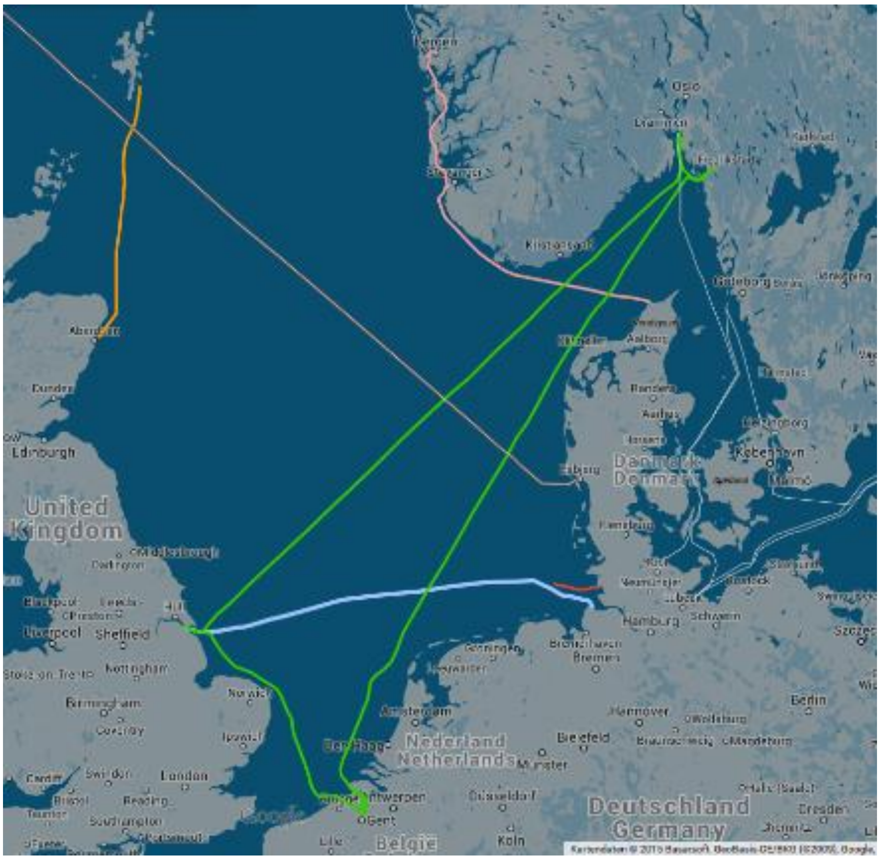


Figure A 8: FerryBox routes in NOOS region (active lines in 2014)

Table A 3List of vessels equipped with FerryBox systems in NOOS area

Name of platform	Institution	Destination harbours	End of operation	Route
M/S Trans Carrier	BCCR, UiB	Amsterdam - Bergen	2005-2009	
Duchess of Scandinavia	HZG	Cuxhaven - Harwich	2002-2005	
TorDania	HZG	Cuxhaven - Immingham	2006-2012	
LysBris	HZG	Moss-Halden-Zeebrugge-Immingham	2007-Today	Green
MS Funny Girl	HZG	Büsum - Helgoland	2008-Today	Red
MS FunnyGirl	HZG	Cuxhaven - Helgoland		
Hafnia Seaways	HZG	Cuxhaven – Immingham	2015-Today	light blue
MS Trollfjord	NIVA	36 locations from Bergen to Kirkenes	2006-Today	
MS Oslofjord	NIVA	Sandefjord - Strømsstad	2015-Today	
KV TOR	IMR	Norwegian West Coast (Bergen)	2011-Today	
MV Hascosay	Marlab	Lerwick - Aberdeen	??	Orange
MS Bergensfjord	NIVA	Hirtshals – Stavanger - Bergen	2008-2013	Pink
MS Norrøna	NIVA/MARLAB/ Univ. Rhode Island	Hirtshals - Torshavn - Seydisfjord	2008-Today	Light brown

Measured parameters

In the NOOS region, the measured parameters on ferrybox lines correspond to the main physical (T, S, Turbidity), chemical (pH, O2) and biological (Chlorophyll Fluorescence) variables (fig. A4**Erreur ! Source du renvoi introuvable.**). It should be recommended to add the dissolved oxygen parameter to the existing ferrybox lines not yet equipped with this sensor.

Table A 4 Measured parameters on FerryBox systems in NOOS region

Name of platform	T	S	pCO2	Trb	Chl-a	pH	CDOM	DO	Nutrients	irradiance	radiance	Wind
M/S Trans Carrier	X	X	X	X	X	?						
Duchess of Scandinavia	X	X		X	X	X		X	X			
TorDania	X	X		X	X	X		X	X			
LysBris	X	X	X	X	X	X		X	X			
MS Funny Girl	X	X		X	X	X		X				
Hafnia Seaways	X	X	X	X	X	X		X				
MS Trollfjord	X	X	X	X	X	X				X	X	X
MS Oslofjord	X	X		X	X				X			

KV TOR	X	X						X				
MV Hascosay	X	X		X	X							
MS Bergensfjord	X	X		X	X				X			
MS Norrøna	X	X										

It should be recommended to add recently validated parameters such as carbon system sensors (pCO2, alkalinity) and in the future additional sensors under development such as nutrients and biological parameters (cyanobacteria, …). High frequency measurements of the carbon parameters will allow to establish more precise carbon budgets in the NOOS area where carbon budgets has been established during classical oceanographic cruises. The recent developments of flow cytometer measurements on ferrybox lines coupled with automatic samplers to validate the species composition by microscopy with on line measurements will be also a recommendation for implementing new sensors in the NOOS area.

Gliders: Operational infrastructure

The gliders operational infrastructure is presented in fig. A9**Erreur ! Source du renvoi introuvable.**.

Figure A 9: Gliders operational infrastructure (Source FP7-JERICO D2.1)

As for all regions, data from gliders in the NOOS region are obtained during oceanographic cruises. The spatial and temporal coverage are thus limited to specific coastal areas and certain periods. Data obtained from gliders give access to the description of the water column and are of value to complement data obtained from ferrybox and fixed platforms which describe the surface and/or sub-surface waters. Unfortunately, data obtained from gliders are not covering the same spatio-temporal ranges as for ferrybox lines and fixed platforms.

It should be recommended to implement in the NOOS region repeated glider sections with a regular frequency to be determined (monthly, seasonally, yearly) and preferentially along existing ferrybox lines to complement with data obtained along the water column the surface high frequency data.

The measured parameters on the European glider fleet correspond to the main physical (T, S, Turbidity), chemical (O2) and biological (Chlorophyll Fluorescence) variables.

The most significant sensors in the European sensor arsenal are presented in fig. A10. (Measured parameters from D3.2).

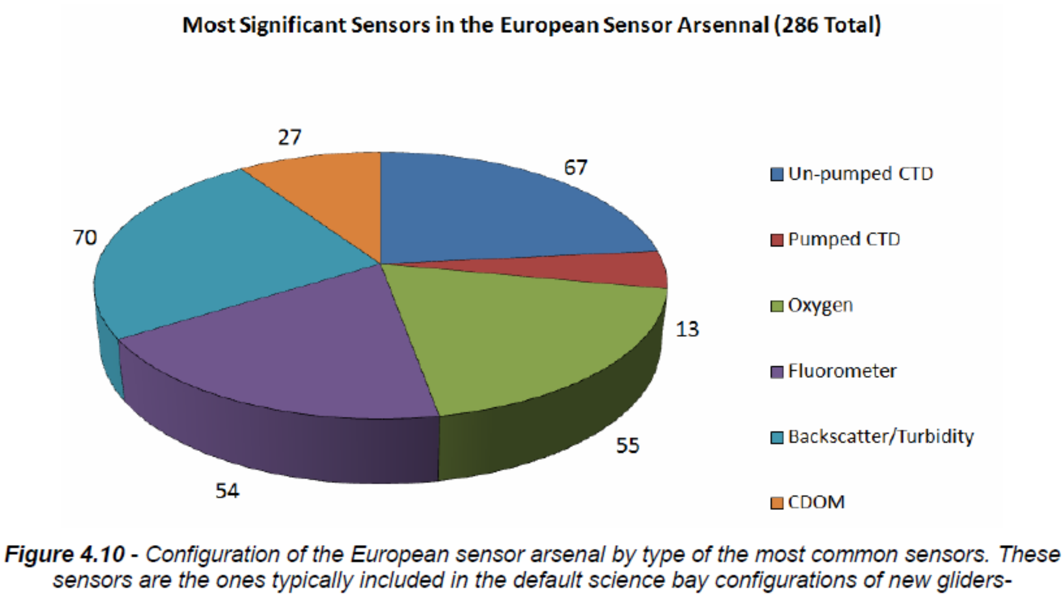


Figure A 10: Measured parameters (Source FP7-JERICO D3.2)

Observing that graph the following evidences emerge:

- **Un-pumped CTD** is the dominant against the pumped glider version by SeaBird. In fact, all the CTDs of the European fleet were done by this leading manufacturer. Since SeaGliders and G1 Slocums (both Coastal and Deep) carry that un-pumped version, the presence of the pumped one is only testimonial at present, although it is expected to grow along with the increase in the number of G2 Slocums (since they typically carry that model on-board) and Sea Gliders with extended payload. The predominant model is cp41p.
- **Dissolved Oxygen Sensors** (Optodes) are also very popular and, at an 85%, provided by Nordic manufacturer AADI. SeaBird also provided a few oxygen sensors to SeaGlider users. AADI models vary between 3830,3835,5013 and 4330
- **Fluorometers, Backscatters/Turbidity and CDOM** are embedded in the same ECO PUCK series device done by Wet Labs. While the first two are generally used, only a half of the users decided to customize their Puck with a CDOM sensor.

Additional but rare sensors existing are presented in fig. A11**Erreur ! Source du renvoi introuvable.**.

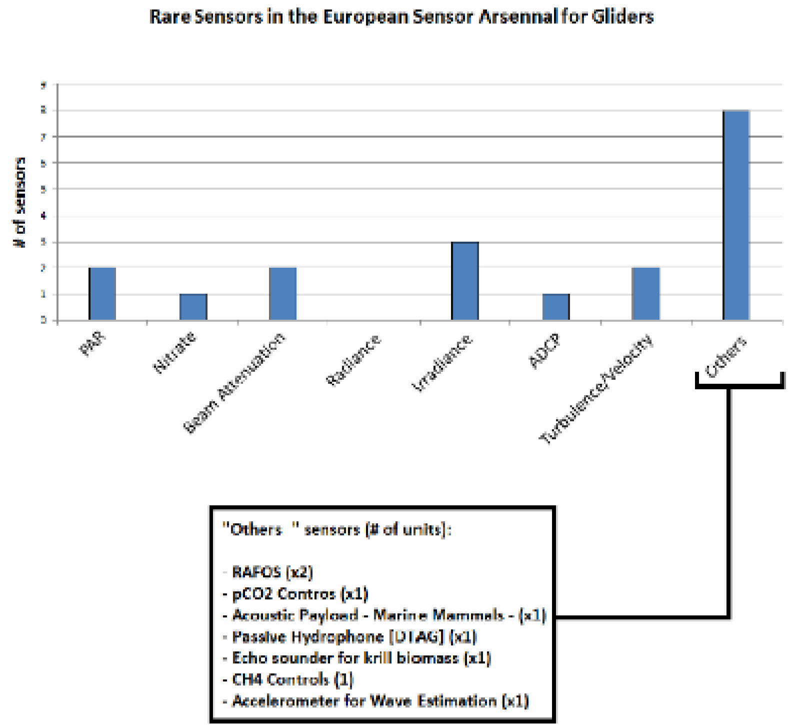


Figure 4.11 - Quantification of the number of not common sensors within the European sensor arsenal -

Figure A 11: Rare sensors in the European Sensor Arsenal for Gliders

It should be recommended to add recently validated parameters such as carbon system sensors (pCO2, alkalinity, pH), and in the future additional sensors under development such as nutrients and biological parameter (cyanobacteria, …).

Fixed platforms: Operational infrastructure

The operational Fixed Platforms infrastructure is presented fig. A12. As IBI-ROOS, the NOOS region is well observed with the present existing infrastructure with a dense network of fixed platforms.

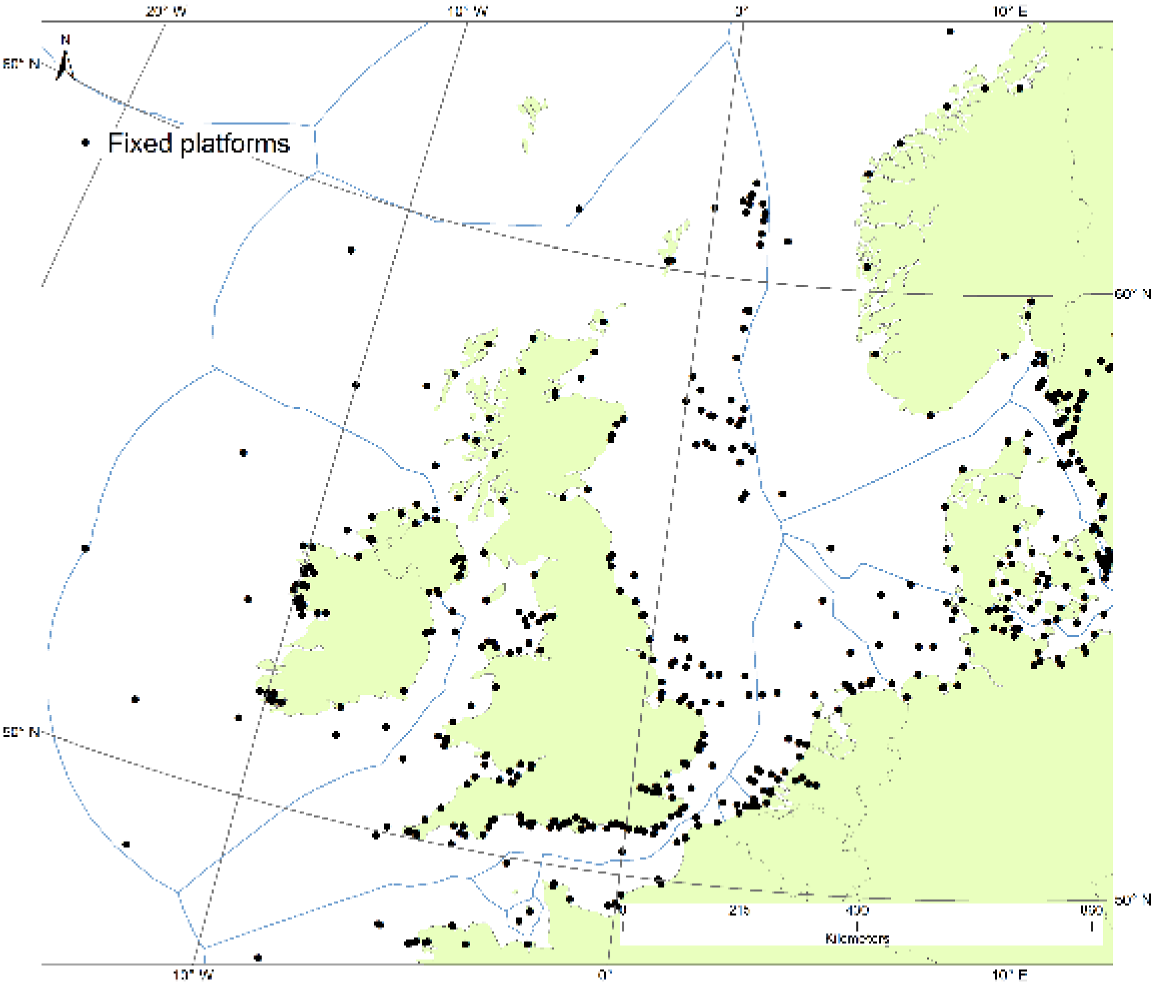


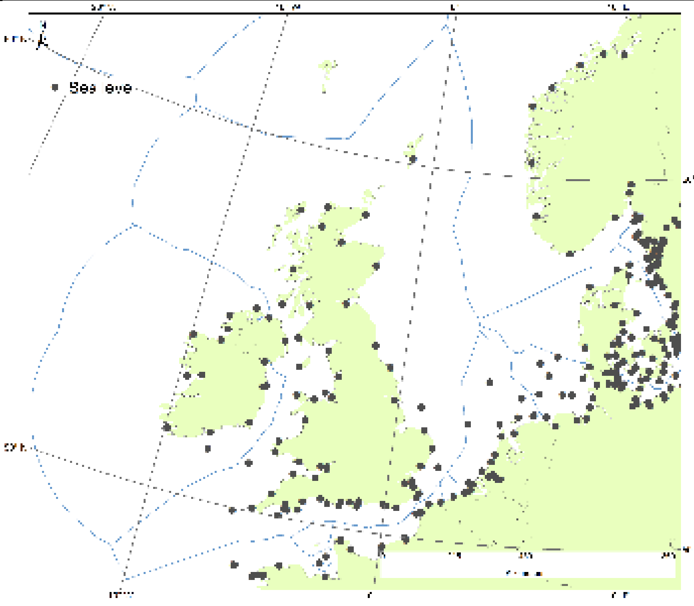
Figure A 12: NOOS - Operational Fixed Platforms infrastructure

The four following maps show the spatial coverage by parameter (Figure A.13):

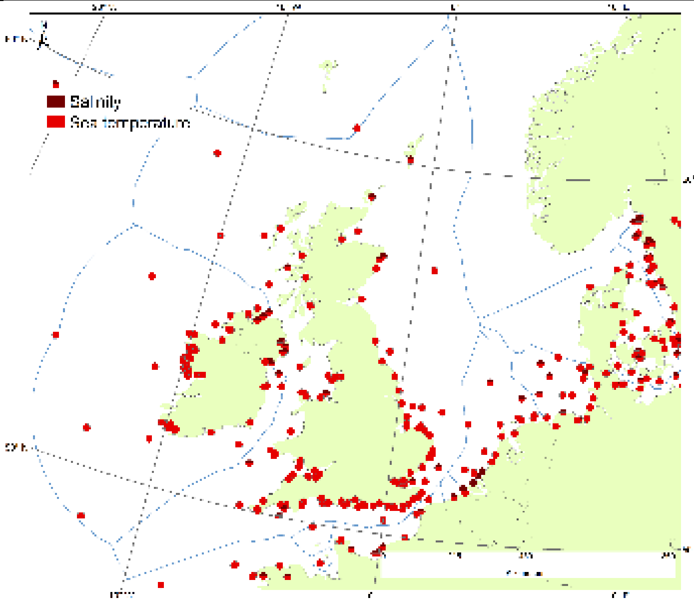
Sea level, Sea temperature or salinity, Dissolved gases, Biological parameters (chlorophyll or plankton).

In terms of parameters observed, the physical parameters (Sea level, temperature and salinity) are described with a good spatio-temporal coverage as for the IBI-ROOS region. The chemical (dissolved gases and oxygen) and biological parameters (chlorophyll fluorescence, biological parameters) are insufficiently described in this region. As for IBI-ROOS, the recommendation will be to add at least these sensors which are already implemented on the other ferrybox and gliders platforms on the existing fixed platforms to obtain a better spatio-temporal coverage for these chemical and biological parameters.

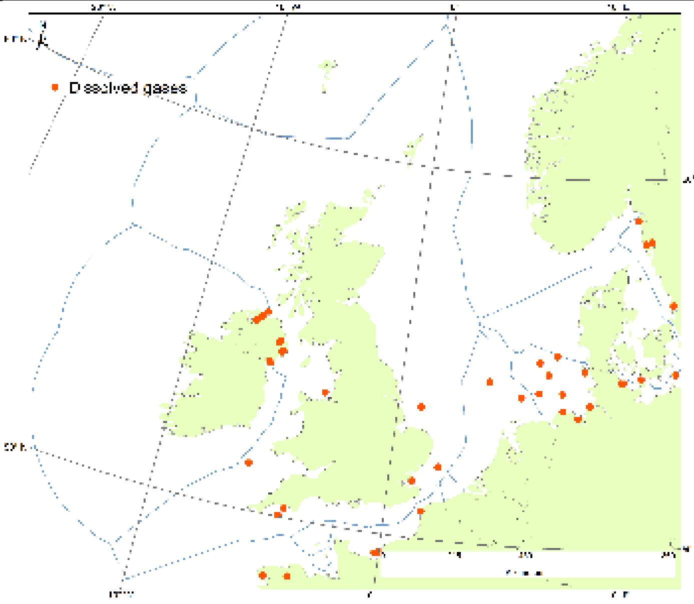
A perennial funding of the measurements is not guaranteed and will be necessary for the detection of extreme events. Due to budget cuts, the only Dutch fixed station (at the Oystergrounds) was stopped. This means there is no detection of oxygen depletion below the pycnocline anymore, except by chance if a monitoring ships happens to take a vertical profile at the time. A perennial funding is an important issue for the implementation of all the types of platforms.



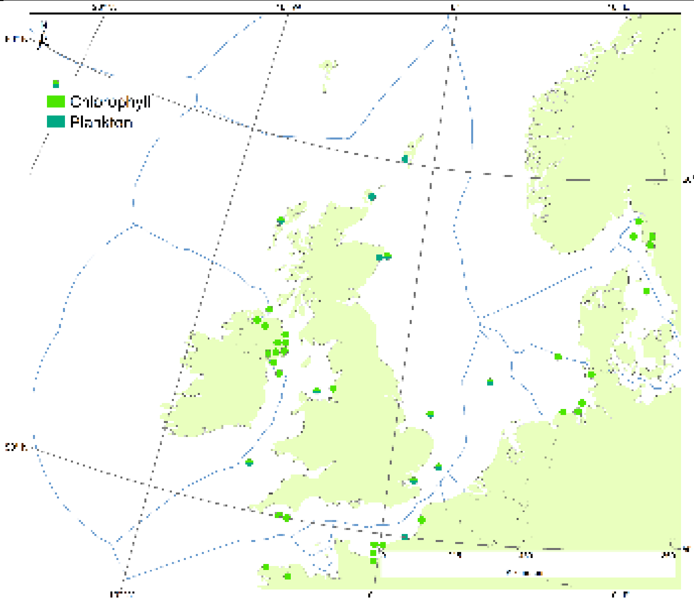
a: NOOS - Fixed Platforms measuring Sea Level



b: NOOS - Fixed Platforms measuring Salinity or Sea temperature



c: NOOS - Fixed Platforms measuring Dissolved gases



d: NOOS - Fixed Platforms measuring Chlorophyll or Plankton

Figure A 13

7.3 Arctic-ROOS

Ferrybox: Operational infrastructure

The ferrybox operational infrastructure in Arctic ROOS region is presented Figure A 14: FerryBox routes in Arctic ROOS region (from 2014) Four ferryboxes are still operational since the beginning of JERICO (

) between Denmark and Iceland, along the Norwegian coasts and between Tromsø and Svalbard.

Figure A 14: FerryBox routes in Arctic ROOS region (from 2014)

Table A 5List of vessels equipped with FerryBox systems in Arctic ROOS area

Name of platform	Institution	Destination harbours	Start and End of operation	Route
MS Norrøna	NIVA/MARLAB	Hirtshals, Torshavn, Seydisfjord	2008-Today	Yellow
MS Norbjorn	NIVA	Tromsø, Bjørnøya, Longyearbyen, Ny Alesund	2008-Today	Red
MS Vesterålen	IMR	Bergen-Kirkenes	2006-Today	Green
MS Trollfjord	NIVA	Bergen-Kirkenes	2006-Today	Green

The Arctic ROOS region is insufficiently described with the existing network of ferrybox lines. Since opportunities to open new lines in this region are few, it will be difficult to increase the spatial coverage of the Arctic ROOS region.

Measured parameters

In the Arctic ROOS region, the measured parameters on ferrybox lines correspond to the main physical (T, S) and biological (Chlorophyll Fluorescence) variables. It should be recommended to add recently validated parameters such as carbon system sensors (pCO2, alkalinity, pH), and in the future additional sensors under development such as nutrients and biological parameter (cyanobacteria, …).

Table A 6 Measured parameters on FerryBox systems in Arctic ROOS region

	T	S	pCO2	Trb	Chl-a	pH	CDOM	DO	Nutrients	irradiance	radiance
MS Norrøna	X	X									
MS Nordbjorn	X	X		X	X				X	X	X
MS Vesterålen	X	X			X						
MS Trollfjord	X	X	X	X	X	X				X	X

Gliders: Operational infrastructure

The real-time data provided in the Arctic ROOS region are presented Figure A.15. These data are obtained from different platforms (gliders, Argo buoys, drifters, research vessels, moorings, icebreakers, ...) with low spatial and temporal resolution. Gliders activity in the Arctic ROOS has developed in the last years.

Figure A 15 Realtime Data provided for the Arctic ROOS region via the EC supported MyOcean project (source: JERICO-FP7 D2.1).

As for all regions, data from gliders in the Arctic ROOS region are obtained during oceanographic cruises. The spatial and temporal coverage are thus limited to specific coastal areas and certain periods. It should be recommended to implement in the Arctic ROOS region repeated glider sections with a regular frequency to be determined (monthly, seasonally, yearly) and preferentially along existing repeated sections by research vessels and ferrybox lines to complement with data obtained along the water column the surface high frequency data.

Fixed platforms: Operational infrastructure

The operational Fixed Platforms infrastructure in the Arctic ROOS is presented figure A.16. The network of fixed platforms is mainly developed along the Norwegian coast and in the Faeroe Islands with a few fixed platforms in Iceland and Svalbard.

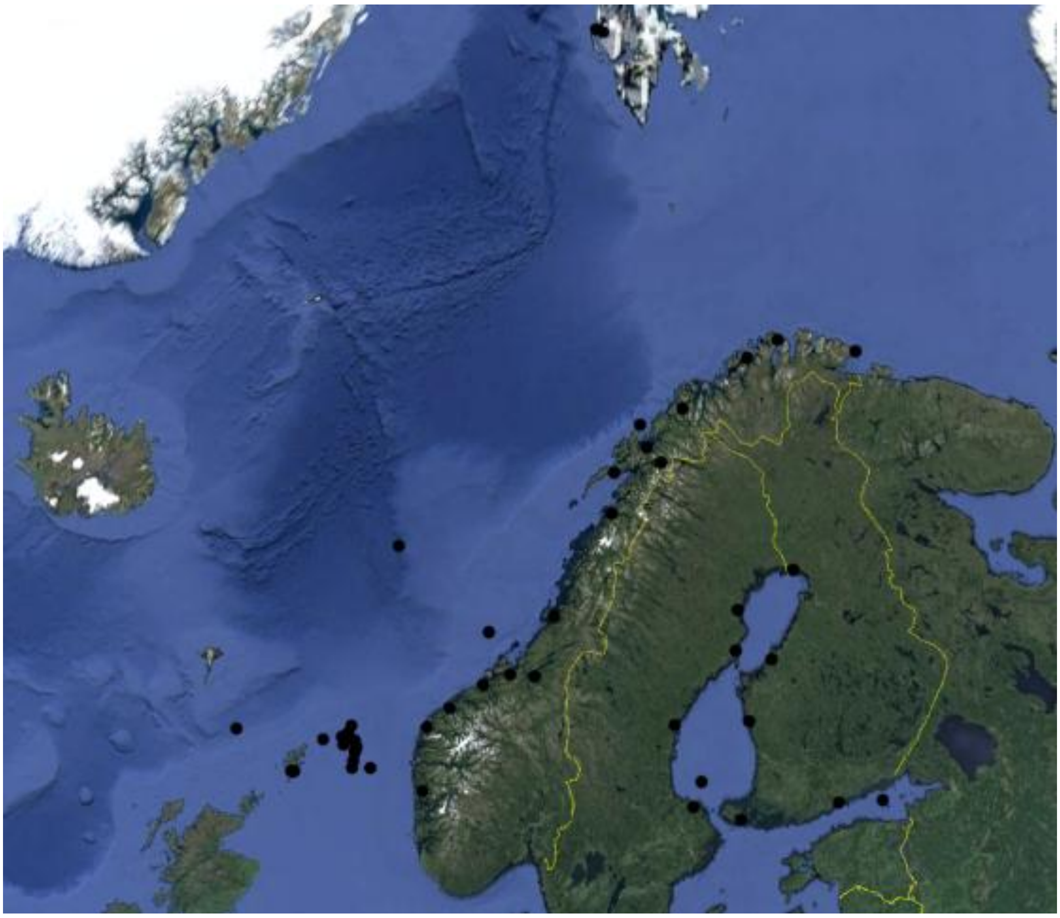


Figure A 16 Artic ROOS - Operational Fixed Platforms infrastructure

The four following maps show the spatial coverage by parameter (Figure A.17):

Sea level, Sea temperature or salinity, Dissolved gases, Biological parameters (chlorophyll or plankton.

In terms of parameters observed, seal level is described with a relatively good spatial coverage along the Norwegian coasts, Svalbard and Iceland (figure 3.50). The other physical parameters (temperature and salinity) are described with an insufficiently spatial coverage: only 5 points along the Norwegian coast.

The chemical (dissolved gases and oxygen) and biological parameters (chlorophyll fluorescence, biological parameters) are insufficiently described in this region. It should be recommended to add these sensors at least on existing fixed platforms to obtain a better spatio-temporal coverage for these chemical and biological parameters.

a) Arctic ROOS – Fixed Platforms measuring Sea level

b) Arctic ROOS – Fixed Platforms measuring Sea temperature or Salinity

c) Arctic ROOS – Fixed Platforms measuring Dissolved Gases

d) Arctic ROOS – Fixed Platforms measuring Chlorophyll or plankton

Figure A 17

7.4 IBI-ROOS

The IBI-ROOS region focuses an important European challenge consisting in developing a Maritime Strategy for the Atlantic Ocean Region (European Commission, Nov. 2011, Communication from the Commission to the European Parliament, the Council, the European economic and social Committee and the Committee of the regions). The challenges and opportunities facing the Atlantic Ocean area can be grouped within five themes. All will contribute to the overriding objective of creating sustainable jobs and growth:

- Implementing the ecosystem approach
- Reducing Europe's carbon footprint
- Sustainable exploitation of the Atlantic seafloor's natural resources
- Responding to threats and emergencies
- Socially inclusive growth

The ecosystem approach is the basis for marine management in both the Common Fisheries Policy and the Marine Strategy Framework Directive.

The Common Fisheries Policy proposes to manage the stocks so as to achieve maximum sustainable yield, whilst preserving goods and services from living aquatic resources for present and future generations. Single species management must make way for multi-species long-term plans that take into account the wider ecosystem.

The International Council for the Exploration of the Sea (ICES) Working Group on Operational Oceanographic products for Fisheries and Environment (WGOOFE) provides an interesting interface between the users of operational oceanographic data products and their providers. A potential mismatch between user requirements and the perception of requirements by the providers has been identified through a questionnaire (Berx et al. 2011).

Temperature, Currents and Salinity were the first variables required, the latter unexpected. The ranking near the top of the list of biophysical products suggests that researchers also need integrated coupled analysis from chemical and biological oceanography. Moreover, researchers in fisheries and environmental science indicate that they need high-quality time series (historic data) that are regularly updated and flexible in terms of spatial and temporal limits and resolutions, more than they need real-time and short-term forecasts.

Another important driver is the Marine Strategy Framework Directive that aims to maintain or restore the correct functioning of marine ecosystems (preservation of biodiversity, correct interactions between species and their habitats, dynamic and productive oceans) whilst ensuring the sustainable use of the sea for future generations. The development of in-situ observing systems should contribute, together with other technologies like remote sensing or numerical models, to monitor the achievement of the Good Environmental Status. Authors have mentioned the technological opportunities in marine observations arisen from marine environmental legislation (Borja, 2011). Currently a Working Group of IBI-ROOS is working on improving the design of new potential OO products for the MSFD accomplishment.

Finally, opportunities from new activities in coastal areas should need this ecosystem approach and thus, drive the development of networks. While continuing research, new technologies and innovative engineering will allow the industry of aquaculture to move further offshore, the sharing of space with other infrastructures, such as wind turbine platforms, is an opportunity. The strategy must therefore promote spatial planning as a tool for implementing the ecosystem approach in the Atlantic Ocean Region.

The second challenge deals with reducing Europe's carbon footprint. Wind turbines are included in EU's Strategic Energy Plan and already moving offshore in order to benefit from stronger winds and reduced landscape impact. The expansion of offshore wind farms in the Atlantic will offer key industrial opportunities for the ports that service them. By 2020, around 20% of the European offshore wind installed capacity could be located in the Atlantic basin.

These offshore wind farms will need coastal operational oceanography products to optimize the management of operations in a very competitive energy market. They will also need contingency plans that include drift forecasts based on a satisfactory surface current pattern characterization. This target skill will also contribute to optimize the routing of maritime transport, another element of the carbon footprint reduction strategy.

The EU needs to be prepared for threats and emergencies in the Atlantic, whether they are caused by accidents, natural disasters or criminal activity. The adoption of important legislative measures on maritime safety has reduced the risk of shipping accidents. However, accidents can still happen and the Atlantic seaboard remains vulnerable to natural events such as the storms which struck the Vendée (France) in 2010. The changing climate added to other human impacts on the sea, means that past behaviour may not be a guide for the future. The trends for extreme events should be considered in the roadmap of the Observing Systems.

The first hours in a crisis are vital. Early warnings require continuous monitoring of the sea and fast transmission of information. To improve the reliability of warning systems and behaviour monitoring and forecasting tools (like for surface transport) are strategic for efficiency of response actions.

The opportunities for growing and creating jobs in the Atlantic coastal area should be built looking for transfer of expertise between the traditional maritime sectors and careers, and the rising ones. Collaboration of maritime sectors in developing the observing system, communication and training on the use of the available data and products, are important to ensure the transfer between generation and sectors of activity, and to achieve a socially inclusive growth.

The evolution of each kind of observing platforms and the development of emerging networks should be driven by the earlier mentioned drivers.

a) *Status by platform by the end of JERICO-FP7*

Ferrybox: Operational infrastructure

The ferrybox operational infrastructure is presented fig. A18**Erreur ! Source du renvoi introuvable.**. Four erryboxes were operational at the beginning of JERICO and only two are operational in 2015 . The areas covered by ferrybox lines are the Western Channel, the Celtic Sea and the Bay of Biscay.

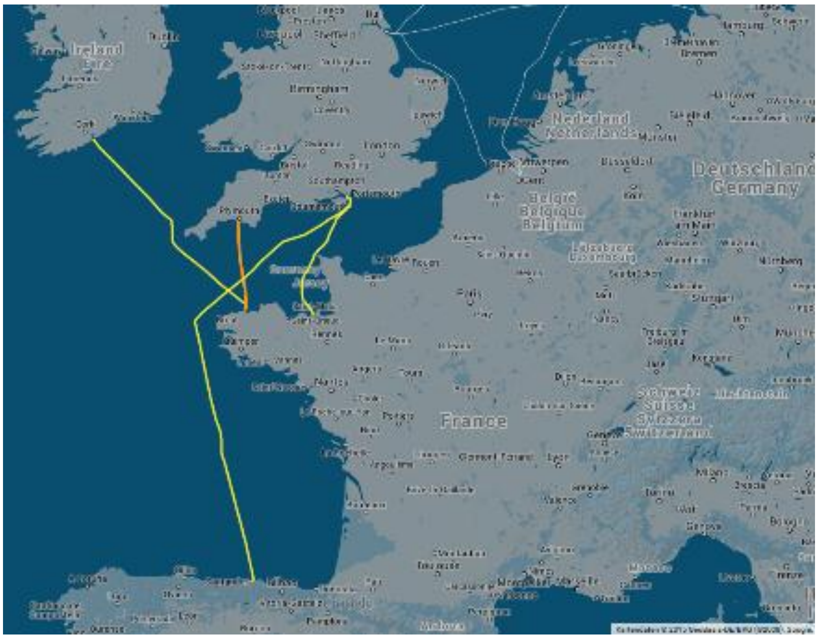


Figure A 18: FerryBox routes in IBI-ROOS region (active lines in 2014)

The **spatial coverage by ferrybox lines is insufficient and lines are missing particularly in the Irish Sea**

and off the Western Iberian Peninsula. To our knowledge, no ferrybox lines are presently being operated in the Portuguese waters, but there have been developments recently, namely through the submission of a project proposal to equip with a ferrybox unit a merchant vessel that operates between the Portuguese mainland and the Azores Archipelago. Also IH has recently assessed the feasibility of installation of ferrybox units on board the hydrographic vessels that are used in the regular maintenance of the MB network. This development is waiting for potential funding mechanism.

In the southern Bay of Biscay some opportunities could be studied in commercial lines from/to Bilbao/Pasaia ports (e.j. Car transport company UECC).

Table A 7: List of vessels equipped with FerryBox systems in IBI-ROOS area

Name of platform	Institution	Destination harbours	Start and end of operation	Route
Lagan Viking	NOCL	Birkenhead- Dublin	2006-2010	See **Erreur ! ource du renvoi introuvable.** (grey route)
Pont-Aven	Ifremer	Portsmouth-Santander-Plymouth-Roscoff-Cork	2011-Today	Yellow
MV Armorique	CNRS-INSU/Ifremer	Plymouth-Roscoff	2010-Today	Orange
Pride of Bilbao	NOCS	Portsmouth-Bilbao	2002-2010	

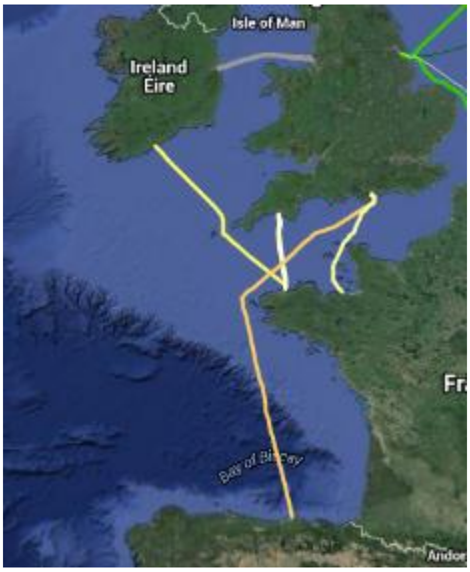


Figure A 19: IBI-ROOS - Lagan Viking route in grey (not operational since 2010)

In the IBI-ROOS region, the measured parameters on ferrybox lines correspond to the main physical (T, S, Turbidity), chemical (O2) and biological (Chlorophyll Fluorescence) variables. It should be **recommended to add recently validated parameters such as carbon system sensors (pCO2, alkalinity, pH), and in the future additional sensors under development such as nutrients and biological parameter**

(cyanobacteria, …).

Recommendations from D2.2

"The application of Ferrybox methodology is still an opportunity for some partner institutes. Moreover, in 2012 a large amount of fishing vessels have been equipped within the frame of the RECOPESCA activities. These ships of opportunity should contribute to improve the collaboration within some maritime sectors."

Table A 8: Measured parameters on FerryBox systems in IBI-ROOS region

Name of platform	T	S	pCO2	Trb	Chl-a	pH	CDOM	DO	Nutrients	irradiance	radiance	Wind
Lagan Viking	X	X		X	X							
Pont-Aven	X	X		X	X		X	X				
MV Armorique	X	X		X	X		X	X				
Pride of Bilbao	X	X	X	X	X			X				

Gliders: Operational infrastructure

The gliders operational infrastructure is presented **Erreur ! Source du renvoi introuvable.** (Map from the D3.2).

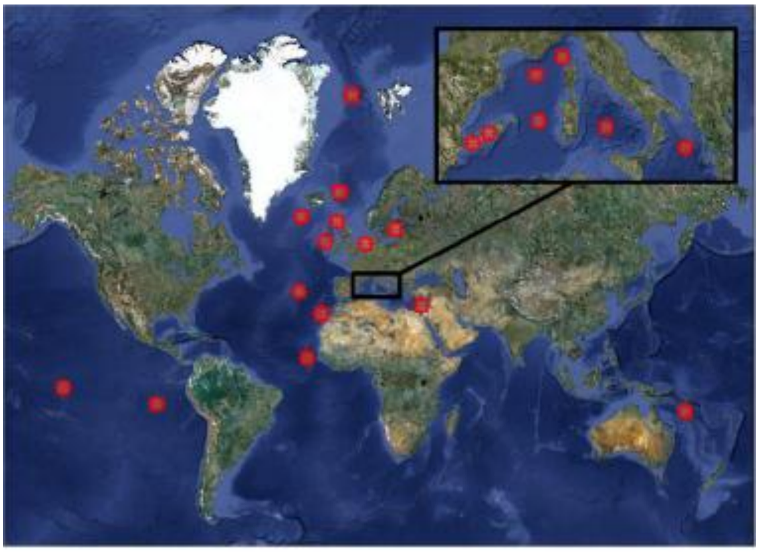


Figure 4.28 - Zones of operation of European glider groups considered in this report. For a matter of simplicity, all those locations included within a 1000 Km wide region, with its epicentre on the most relevant of each group, have been considered part of the same positioning icon ( )

Figure A 20: Gliders operational infrastructure (Map from D3.2)

As for all regions, data from gliders in the IBI-ROOS region are obtained during oceanographic cruises. The spatial and temporal coverage are thus limited to specific coastal areas and certain periods. Data obtained from gliders give access to the description of the water column and are of value to complement data obtained from ferrybox and fixed platforms which describe the surface and/or sub-surface waters. Unfortunately, data obtained from gliders are not covering the same spatio-temporal ranges as for ferrybox lines and fixed platforms.

It should be recommended to implement in the IBI-ROOS region repeated glider sections with a regular frequency to be determined (monthly, seasonally, yearly) and preferentially along existing ferrybox lines to complement with data obtained along the water column the surface high frequency data.

Data along the water column can be also obtained from other sources such as Argo floats and research vessels. An example of real-time data obtained from these different sources is shown in fig. A21**Erreur ! Source du renvoi introuvable.** (Map obtained from D2.1).

The application of Argo buoy methodology is at a mature state and only the inclusion of biogeochemical parameters is recommended to be considered. The positive first experiences with the implementation of Oxygen sensors will encourage these evolutions.

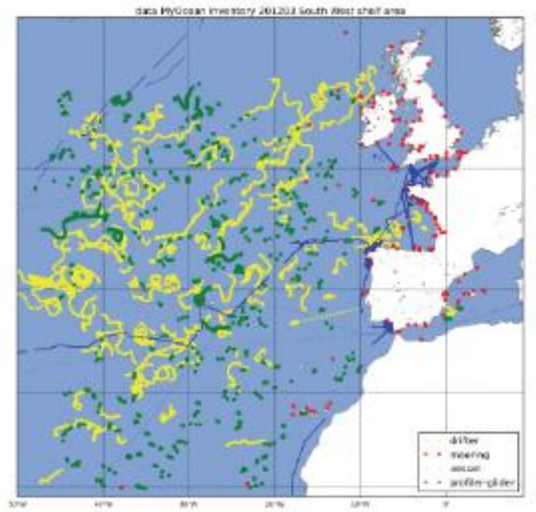


Figure A 21: Real-time data provided for the IBI-ROOS region (Source FP7-JERICO D3.2)

The measured parameters on the European glider fleet correspond to the main physical (T, S, Turbidity), chemical (O2) and biological (Chlorophyll Fluorescence) variables.

The most significant sensors in the European sensor arsenal are presented in fig. A22 (Measured parameters from D3.2).

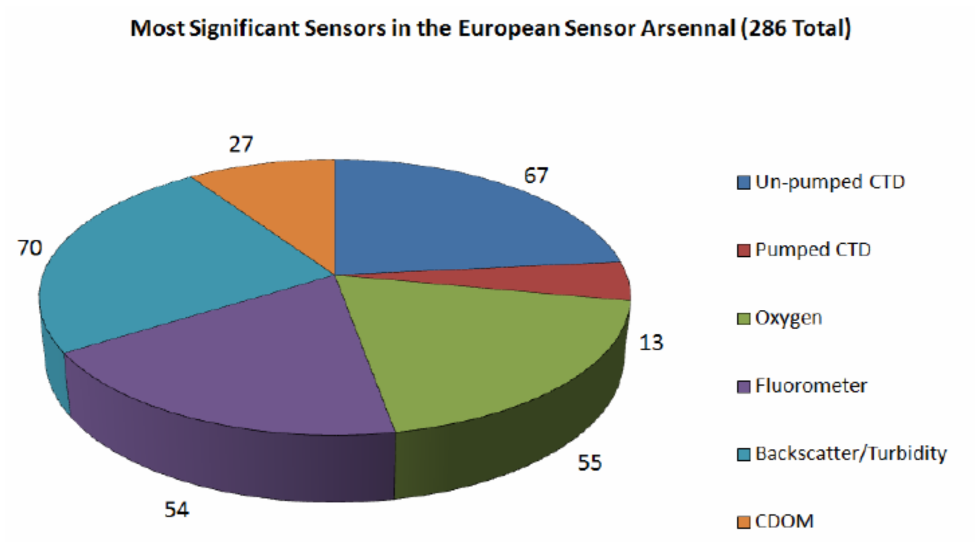


***Figure 4.10** - Configuration of the European sensor arsenal by type of the most common sensors. These sensors are the ones typically included in the default science bay configurations of new gliders-*

Figure A 22: Measured parameters (Source FP7-JERICO D3.2)

Observing that graph the following evidences emerge:

- **Un-pumped CTD** is the dominant against the pumped glider version by SeaBird. In fact, all the CTDs of the European fleet were done by this leading manufacturer. Since SeaGliders and G1 Slocums (both Coastal and Deep) carry that un-pumped version, the presence of the pumped one is only testimonial at present, although it is expected to grow along with the increase in the number of G2 Slocums (since they typically carry that model on-board) and Sea Gliders with extended payload. The predominant model is cp41p.
- **Dissolved Oxygen Sensors** (Optodes) are also very popular and, at an 85%, provided by Nordic manufacturer AADI. SeaBird also provided a few oxygen sensors to SeaGlider users. AADI models vary between 3830, 3835, 5013 and 4330
- **Fluorometers, Backscatters/Turbidity and CDOM** are embedded in the same ECO PUCK series device done by Wet Labs. While the first two are generally used, only a half of the users decided to customize their Puck with a CDOM sensor.

Additional but rare sensors existing are presented in fig. A23.

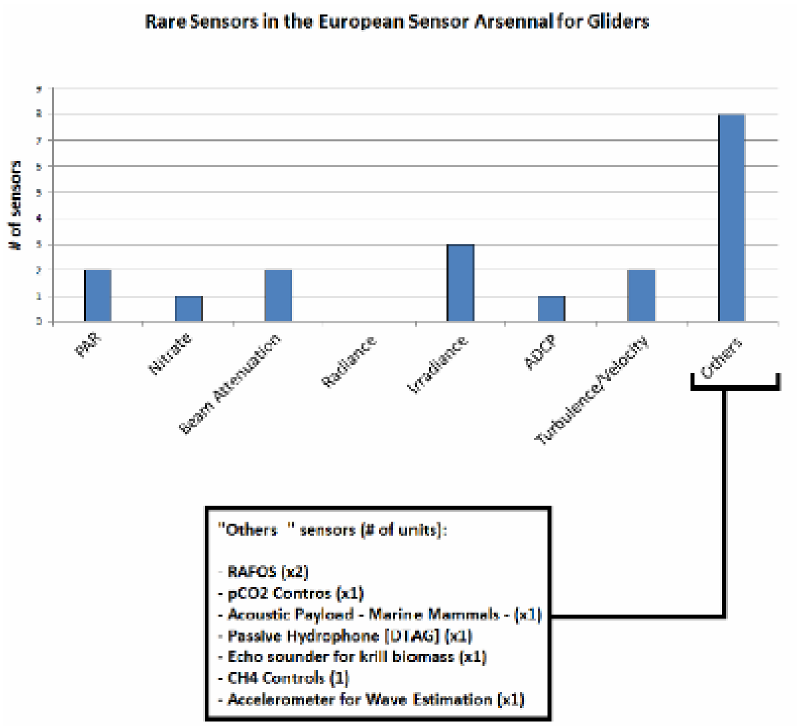


Figure A 23: Rare sensors in the European Sensor Arsennal for Gliders (Source: Jerico-FP7 D3.2)

It should be recommended to add recently validated parameters such as carbon system sensors (pCO2, alkalinity, pH), and in the future additional sensors under development such as nutrients and biological parameter (cyanobacteria, …).

Recommendations from D2.2

"The possibility of operating gliders on a routine mode in the IBI area will be studied. Past experiences from other regions will be transferred."

Fixed Platforms: Operational infrastructure

The operational Fixed Platforms infrastructure is presents in fig.. A 24. The IBI-ROOS region is well observed with the present infrastructure with numerous fixed platforms regularly installed along the IBI-ROOS coastlines.

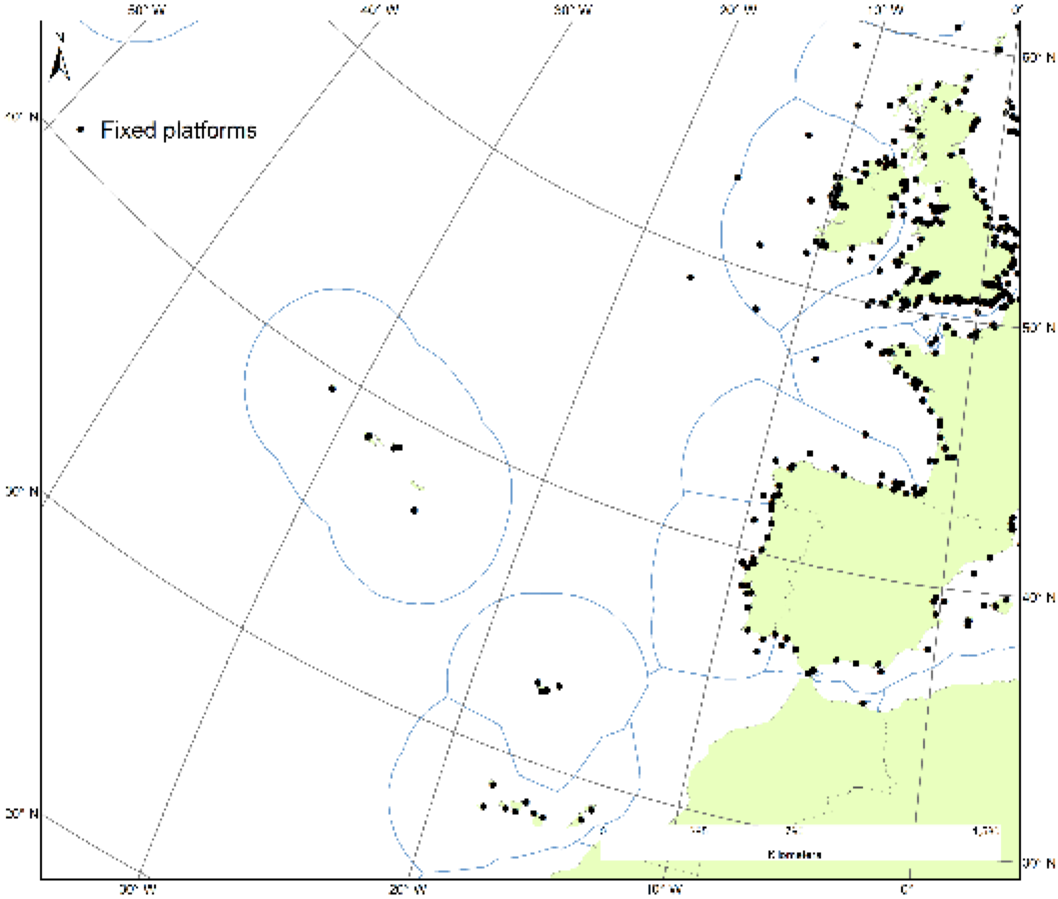
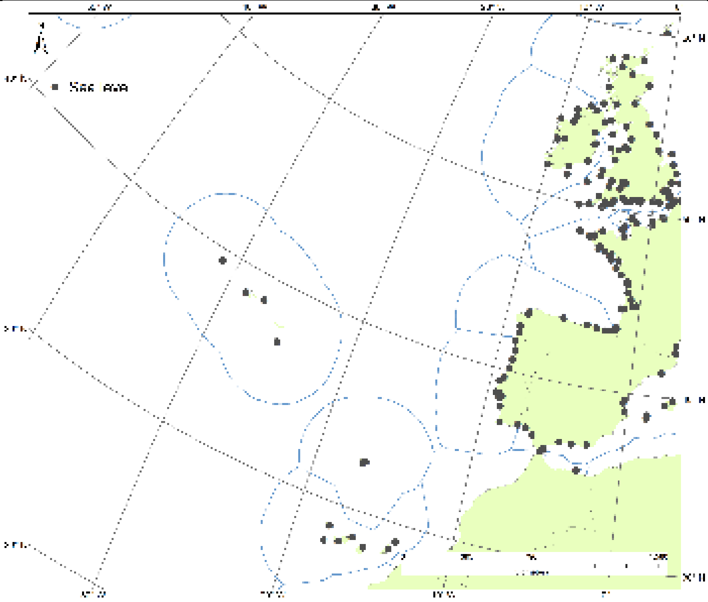
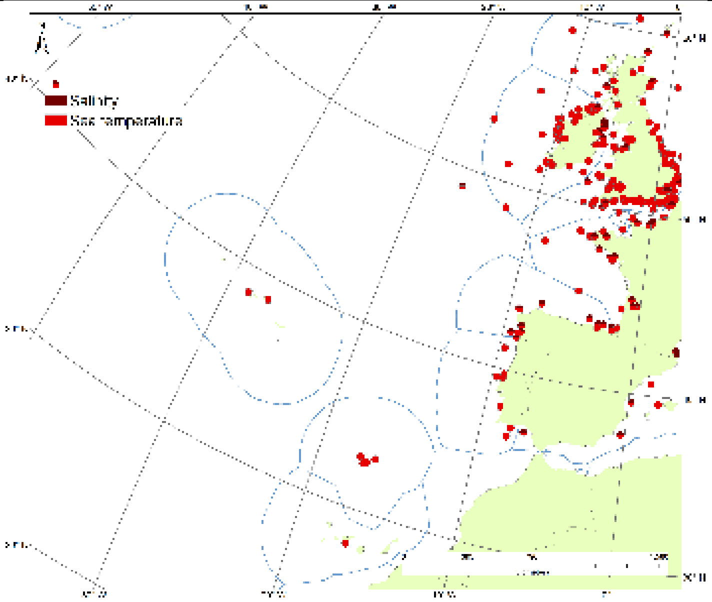


Figure A 24: IBI-ROOS - Operational Fixed Platforms infrastructure

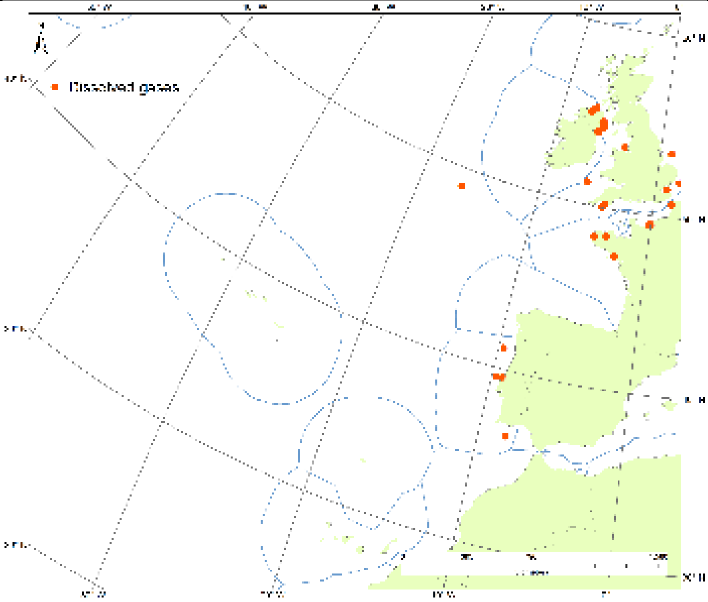
The four following maps show the spatial coverage by parameter (figure A.25:
Sea level, Sea temperature or salinity, Dissolved gases, Biological parameters (chlorophyll or plankton.



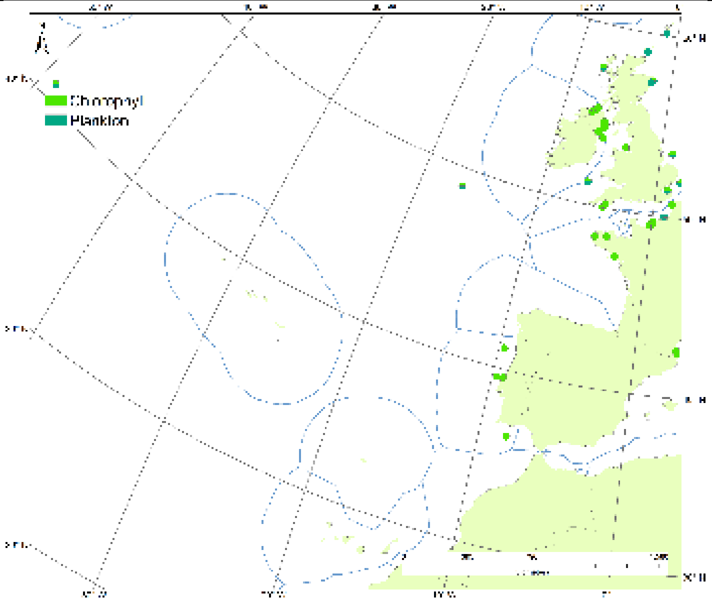
a) : IBI-ROOS - Fixed Platforms measunring Sea Level



b) : IBI-ROOS - Fixed Platforms measuring Salinity or Sea temperature



c) : IBI-ROOS - Fixed Platforms measuring Dissolved gases



d) : IBI-ROOS - Fixed Platforms measuring Chlorophyll or Plankton

Figure A 25

Concerning the development of the Moored Buoys network, one main challenge identified for the IBI-ROOS area is also the provision of biogeochemical data, only marginally provided and lacking on most of the arrays (Recommendations from D2.2). New technological solutions for reducing maintenance needs and clear advices on sensors selection are mandatory. The current coastal network is dense but still not homogeneous along the Atlantic coast. A better coordination at IBI-ROOS level for key identified platforms should be pushed.

Concerning the Tidal gauge network, the IBI-ROOS area has mostly reached the final configuration.

In terms of parameters observed, the physical parameters (Sea level, temperature and salinity) are described with a good spatio-temporal coverage. The chemical (dissolved gases and oxygen) and biological parameters (chlorophyll fluorescence, biological parameters) are insufficiently described in this region. It should be recommended to add at least these sensors which are already implemented on the other ferrybox and gliders platforms on the existing fixed platforms to obtain a better spatio-temporal coverage for these chemical and biological parameters.

7.5 MONGOOS

Ferrybox: Operational infrastructure

The ferrybox operational infrastructure is presented **Erreur ! Source du renvoi introuvable.**. Two ferryboxes were operational at the beginning of JERICO and three are operational in 2015 (fig; A 26**Erreur ! Source du renvoi introuvable.**). The areas covered by ferrybox lines are the northwestern Mediterranean Sea, the Thyrrenean Sea, the southern Adriatic Sea and the Aegean Sea.

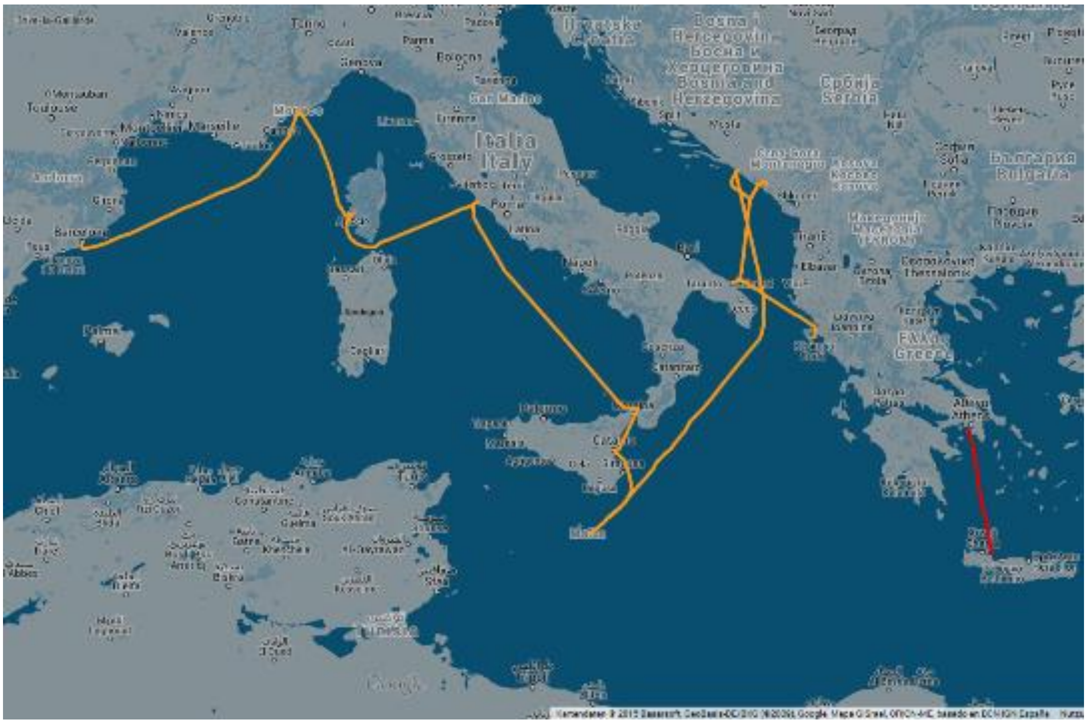


Figure A 26: FerryBox routes in MONGOOS region (from 2014)

The spatial coverage of the MONGOOS region by ferrybox lines is insufficient in general and specially for the Eastern Mediterranean Sea where one line between Pireas and Heraklion is operated. In the Western Mediterranean, the southern part of the basin is also not sufficiently observed. A substantial effort needs to be made in the MONGOOS region to expand the spatial coverage by operating new ferrybox lines on the numerous existing ferry lines either in the Western (between France, Spain, Italy and North Africa or Turkey, ..) and Eastern Mediterranean basins (between Athens and Greek islands, between Italy and Greece, …).

Table A 9 : List of vessels equipped with FerryBox systems in MONGOOS area.

Name of platform	Institution	Destination harbours	Start and End of operation	Route
Olympic Champion	HCMR	Piraeus-Heraklion	2002-Today	Red
Niolon	MIO (HYMEX/CNRS/INSU)	Marseille-Algiers	2012-Today	
Jolly Indaco	MIO (CNRS/INSU)	Genoa -Libyan harbours	2010-2011	
MeinSchiff3	HZG	Several ports in Mediterranean Sea / Canary Islands	2014-Today	Orange

Measured parameters: In the MONGOOS region, the measured parameters on ferrybox lines correspond to the main physical (T, S) for the four existing lines. Only a few chemical (Dissolved Oxygen, pH) and biological (Chlorophyll Fluorescence) variables are observed on two lines.

It should be recommended to increase on the existing lines the number of observed parameters (classical validated parameters) to achieve a similar equipment that those existing in the BOOS, NOOS and IBI-ROOS regions.

It should be recommended in a second step to add recently validated parameters such as carbon system sensors (pCO2, alkalinity, pH), and in the future additional sensors under development such as nutrients and biological parameter (cyanobacteria, …) taking profit of the experience acquired by JERICO partners in the other ROOS regions.

Table A 10: Measured parameters on FerryBox systems in MONGOOS region

Name of platform	T	S	pCO2	Trb	Chl-a	pH	CDOM	DO
Olympic Champion	X	X		X	X	X		X
Niolon	X	X						
Jolly Indaco	X	X						
MeinSchiff3	X	X			X	X		X

Recommendations from D2.2: *"Complete evolution of the SOOP lines in VOS&SOOP in order to have meteorological information in all the basin."*

Gliders: Operational infrastructure

The gliders operational infrastructure is presented in fig. A27 and more precisely for MONGOOS in fig. A28 (Map from EGO web site). The glider activity is well developed in three sectors of the Mediterranean Sea: North-western basin (between South of France, Corsica-Sardinia islands and Spain), in the Ionian Sea South of Italy and in the Eastern Mediterranean (around Cyprus island). This activity corresponds mainly to deployments during oceanographic cruises.

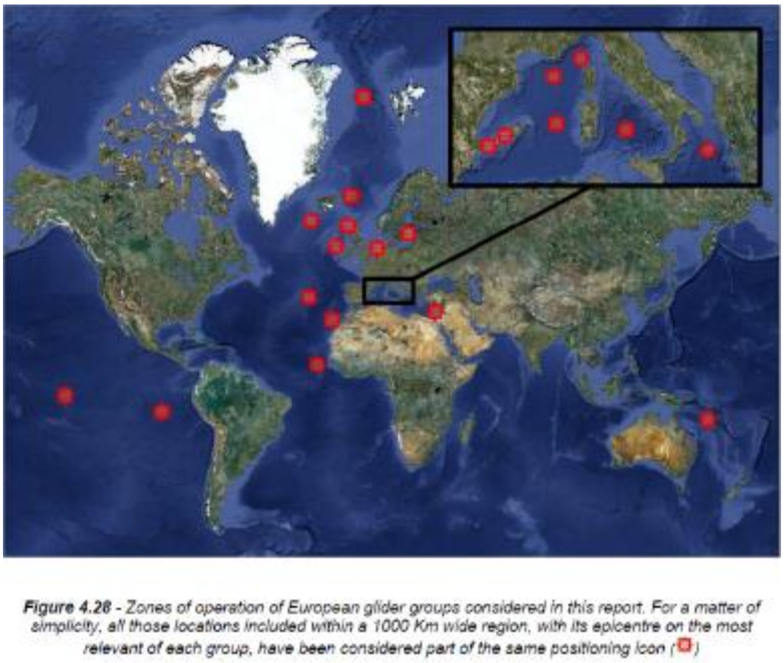


Figure A 27: Gliders operational infrastructure (Source FP7-JERICO D2.1)

Figure A 28: Map from EGO web site – MONGOOS

Figure A 29: map of all glider deployments from September 2004 to December 2012

The above fig. A29 shows the overall spatial coverage of the deployments over the period 2004-2012. This consists of more than 60 000 profiles (max 1000m depth) that can be considered as vertical, considering the dive/ascent slopes (17-26 degrees to the surface) of the gliders that are much steeper than the slopes of the measured oceanic variables.

All gliders collect temperature and salinity 'vertical' profiles as well as the average current over the dives (by comparing GPS fixes at surface and the dead reckoning at depth). Most of the gliders have been equipped with miniaturized biogeochemical sensors. The most frequent are sensors collecting fluorescence chl-a and oxygen concentration sensors, and sensors measuring the water turbidity through optical backscatter at various wavelengths. There are also some deployments with irradiance sensors, beam attenuation sensors and more recently nitrate and noise sensors. The lack of a standardized science bay for biogeochemical applications has led to a rather heterogeneous fleet of Mediterranean gliders in terms of configuration. However, most of the gliders are equipped with oxygen and fluorescence chl-a sensors which would not change a lot if it was restricted to these parameters. For the other parameters there would be more drastic modification. For instance, only 2 deployments of gliders equipped with nitrate sensors have been carried out so far in the Ligurian Sea.

Data along the water column can be also obtained from other sources such as Argo floats and research vessels. An example of real-time data obtained from these different sources is shown **Erreur ! Source du renvoi introuvable.** (Map obtained from D2.1)

The application of Argo buoy methodology is at a mature state and only the inclusion of biogeochemical parameters is recommended to be considered. The positive first experiences with the implementation of Oxygen sensors will encourage these evolutions.

As for all regions, data from gliders in the MONGOOS region are obtained mainly during oceanographic cruises. The spatial and temporal coverage are thus limited to specific areas and certain periods. Data obtained from gliders give access to the description of the water column and are of value to complement data obtained from ferrybox and fixed platforms which describe the surface and/or sub-surface waters.

The present glider observing network should be expanded to fully cover the whole Mediterranean Sea to observe accurately shifts in the circulation (EMT, WMT) and ecosystems responses (as far as basic biogeochemical variables like fluorescence Chl-a/CDOM, turbidity, nitrate and oxygen concentration can characterize them). The key is that a high resolution sampling over long periods of time is necessary.

It should be recommended to implement in the MONGOOS region repeated glider sections in chosen basins with a regular frequency to be determined (monthly, seasonally, yearly) and preferentially along existing ferrybox lines to complement with data obtained along the water column the surface high frequency data.

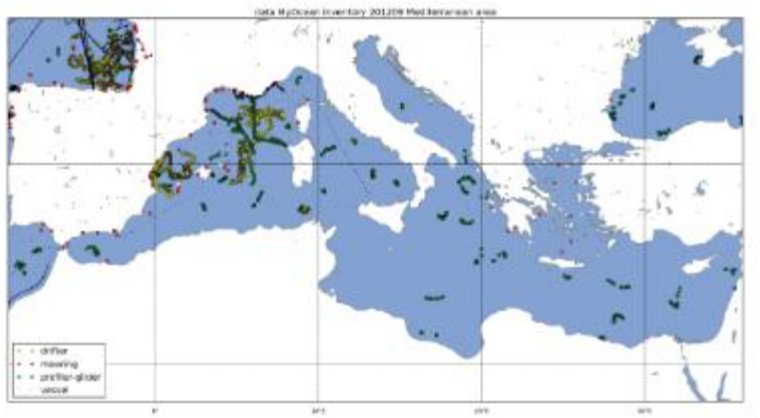


Figure 8.1: Realtime Data provided for the MONGOOS region via the EC supported MyOcean project.

Figure A 30: Map from D2.1

The measured parameters on the European glider fleet correspond to the main physical (T, S, Turbidity), chemical (O2) and biological (Chlorophyll Fluorescence) variables.

The most significant sensors in the European sensor arsenal are presented **Erreur ! Source du renvoi introuvable.** (Measured parameters from D3.2).

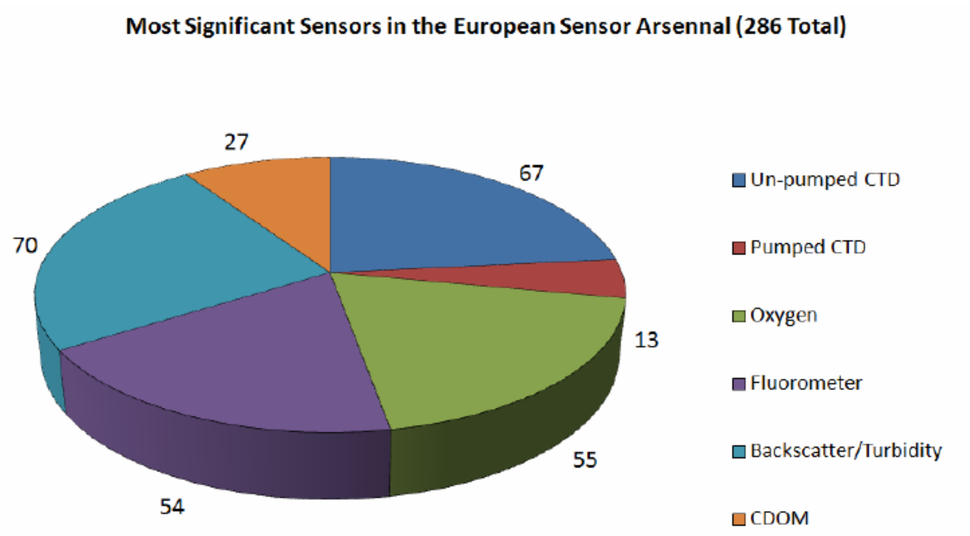


***Figure 4.10** - Configuration of the European sensor arsenal by type of the most common sensors. These sensors are the ones typically included in the default science bay configurations of new gliders-*

Figure A 31: Measured parameters (from D3.2)

Observing that graph the following evidences emerge:

- **Un-pumped CTD** is the dominant against the pumped glider version by SeaBird. In fact, all the CTDs of the European fleet were done by this leading manufacturer. Since SeaGliders and G1 Slocums (both Coastal and Deep) carry that un-pumped version, the presence of the pumped one is only testimonial at present, although it is expected to grow along with the increase in the number of G2 Slocums (since they typically carry that model on-board) and Sea Gliders with extended payload. The predominant model is cp41p.
- **Dissolved Oxygen Sensors** (Optodes) are also very popular and, at an 85%, provided by Nordic manufacturer AADI. SeaBird also provided a few oxygen sensors to SeaGlider users. AADI models vary between 3830,3835,5013 and 4330
- **Fluorometers, Backscatters/Turbidity and CDOM** are embedded in the same ECO PUCK series device done by Wet Labs. While the first two are generally used, only a half of the users decided to customize their Puck with a CDOM sensor.

Additional but rare sensors existing are presented Figure A 32.

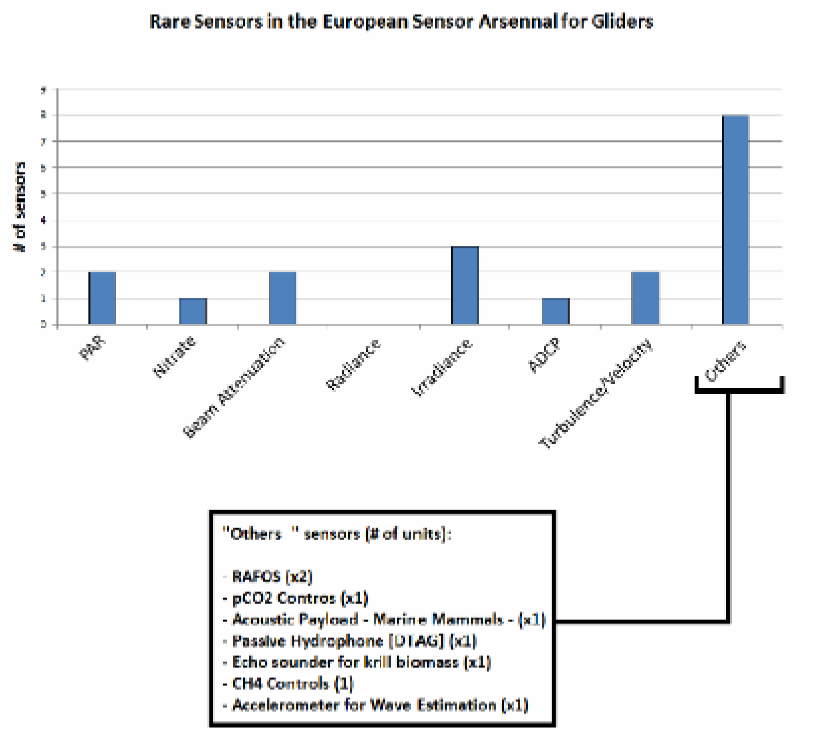


Figure 4.11 - Quantification of the number of not common sensors within the European sensor arsenal -

Figure A 32: Rare sensors in the European Sensor Arsenal for Gliders

It should be recommended to add recently validated parameters such as carbon system sensors (pCO2, alkalinity, pH), and in the future additional sensors under development such as nutrients and biological parameter (cyanobacteria, …).

Recommendations from D2.2

"This is recommended to be complemented by establishment of Glider lines covered by Gliders that are

equipped with sensors for the ecosystem variables.

Extension: the major integration of gliders observations in a coherent vision of Mediterranean observatories."

Fixed Platforms: Operational infrastructure

The operational Fixed Platforms infrastructure is presented Figure A 33. The MONGOOS region is insufficiently observed with very few fixed platforms in Eastern Mediterranean, along the East coasts of the Adriatic Sea and along the African coasts. The Italian, French coasts are rather well instrumented and the fixed platforms network needs to be expanded along the Spanish Mediterranean coast and along the Greek coasts which are less densely instrumented than the French and Italian coasts. It appears clearly that **the network of fixed platforms in the Mediterranean Sea is insufficient to reach a satisfying coverage for the MONGOOS region**.

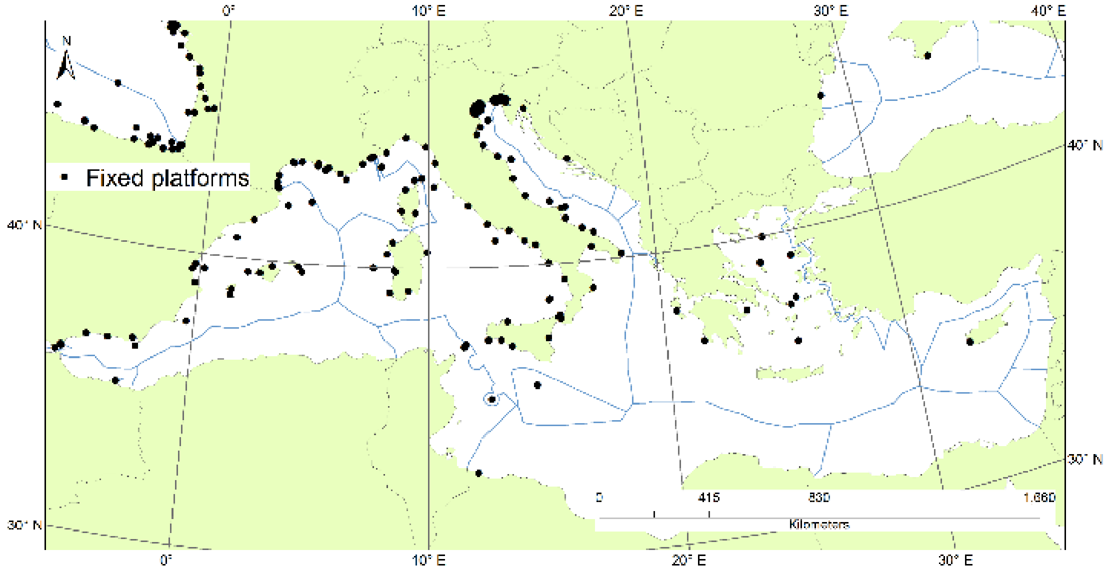
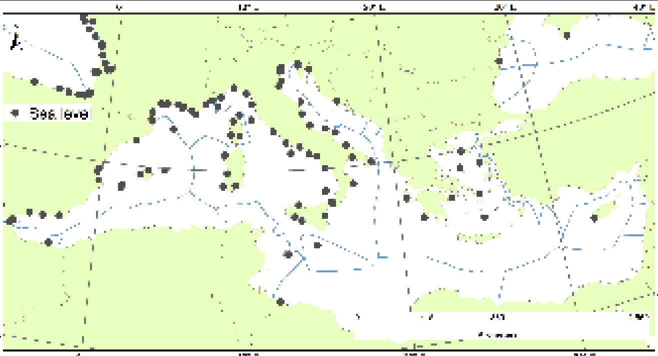


Figure A 33: MONGOOS - Operational Fixed Platforms infrastructure

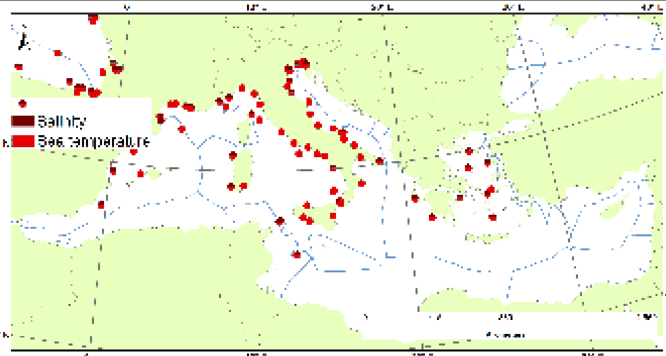
The four following maps show the spatial coverage by parameter (Figure A.37):

Sea level, Sea temperature or salinity, Dissolved gases, Biological parameters (chlorophyll or plankton.

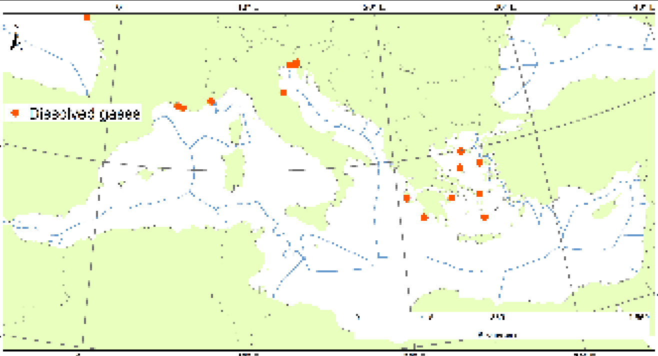
In terms of parameters observed, the existing fixed platforms are mainly equipped with physical parameters sensors (Sea level, temperature and salinity). The Mediterranean Sea is largely under-sampled for these physical parameters and a significant effort will be a major recommendation for the future. Very few fixed platforms are equipped with chemical and biological sensors and data are very sparse and totally insufficient to observe the MONGOOS coastal regions. Even more than for physical parameters, a **major effort in developing multi-parametric oceanographic buoys in the Mediterranean Sea will be a recommendation for the future.** The recommendation will be to install at least multiparametric oceanographic fixed platforms in the major basins. Recommendations from OSE and OSSE experiments developed in WP9 will be helpful to determine the sites to instrument in first priority.



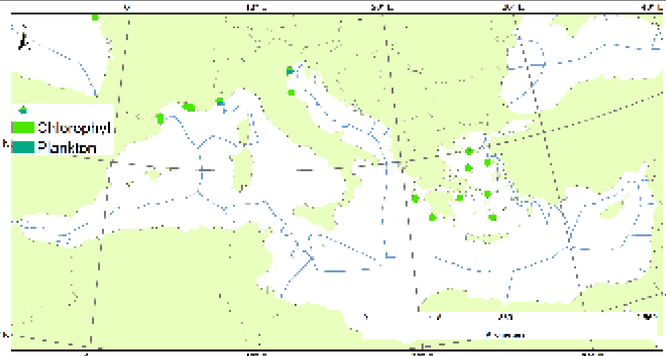
a) MONGOOS - Fixed Platforms measuring Sea Level



b) MONGOOS - Fixed Platforms measuring Salinity or Sea temperature



c) MONGOOS - Fixed Platforms measuring Dissolved gases



d) : MONGOOS - Fixed Platforms measuring Chlorophyll or Plankton

Figure A 34

Recommendations from D2.2: *"One first gap in the Mediterranean observing system is the lack of information along the African coasts, and MONGOOS recognizes it as one of the main priorities for the future years.*

The extension includes:

- *The establishment and operation of other EMSO nodes in Mediterranean e.g., Marmara Sea, Hellenic Arc, Ligurian Sea and Gulf of Cadiz*
- *The harmonisation of the coastal observatories with the large scale observing systems"*

7.6 Black Sea GOOS

Ferrybox: Operational infrastructure

There are no Ferrybox lines in the Black Sea.

Recommendations from D2.2: *"Observing system: Vessels: Research vessels, small vessels, SOOP, VOS, FerryBox;"*

Gliders: Operational infrastructure

The Figure A 35 represents real-time data provided in Black Sea through the MyOcean project. It appears clearly that real time data from different type of platforms are very sparse in the Black Sea and that a major effort to observe this area is needed.

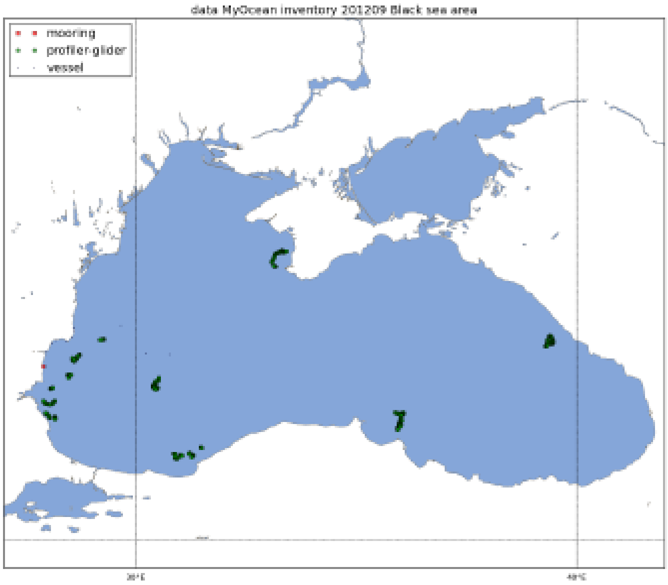


Figure A 35: Real-time data provided for the Black Sea GOOS region via the EC-MyOcean project.

Recommendations from D2.2

"These observing systems should consist of:

- *Autonomous instruments: Argo buoys, Drifters, Gliders*

Evolvement of two Glider sections through the Black Sea is highly desirable."

It should be recommended to **implement in the Black Sea region repeated glider sections** in chosen basins with a regular frequency to be determined (monthly, seasonally, yearly).

Fixed Platforms: Operational infrastructure

The operational Fixed Platforms infrastructure is presented Figure A 36. Only two fixed platforms measuring sea level have been inventoried for the Black Sea. Measurements of other physical parameters (T, S), chemical (Dissolved Oxygen) and biological are totally missing in the Black Sea. As for ferrybox lines, the recommendation will be that the **effort must be in the future the development of a network of multi-parametric oceanographic platforms in the Black Sea**. Recommendations from OSE and OSSE experiments developed in WP9 will be helpful to determine the sites to instrument in first priority.

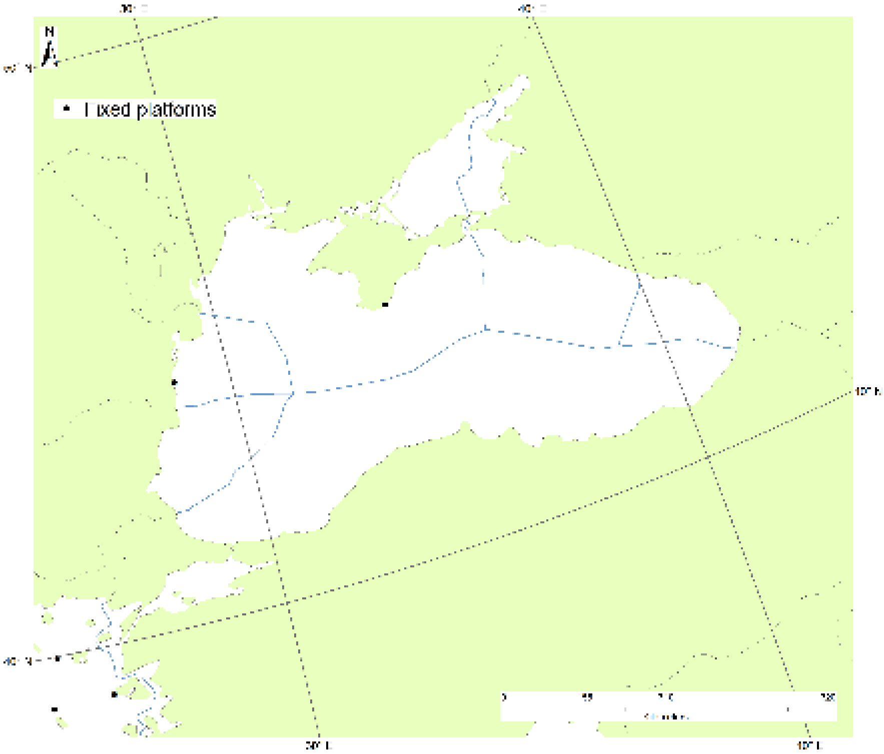


Figure A 36: Black Sea - Operational Fixed Platforms infrastructure

Recommendations from D2.2

"These observing systems should consist of:

- *Coastal observatories: meteorological stations, oceanographic stations, sea level stations; HF radar systems*
- *Shelf moored or fixed platforms and deep sea observatories;*

The installation of the same costal observatory which will consist of a Weather station, oceanographic station and sea level station in each Black Sea country is reasonable. The resulting network of six observatories will be equipped with the same instruments and connected to In-situ TAC to provide real time data."

8 References

Bryden H., C. Robinson, D. Griffiths (2012), Changing currents: a strategy for understanding and predicting the changing ocean circulation. Phil. Trans. R. Soc. A (2012) 370, 5461–5479. doi:10.1098/rsta.2012.0397.

Bush, V. (1945): Science, the endless frontier. A report to the president by Vannevar Bush, director of the office of Scientific Research and Development. Government Printing Office, Washington, July.

Curtin, T. B., Belcher E. O., (2008): Innovation in Oceanographic Instrumentation. Oceanography 21(3):44–53, http://dx.doi.org/10.5670/oceanog.2008.34

Diedrich, A, Tintoré, J and Navinés, F. (2010). Balancing Science and Society through Establishing Indicators for Integrated Coastal Zone Management in the Balearic Islands. Marine Policy 34: 772-781.

Delaney J. R., R. S. Barga: (2009): A 2020 Vision for Ocean Science. pp. 27-38. In “The Fourth Paradigm”. Microsoft Research.

European Marine Board (2013). Navigating the Future IV. Position Paper 20 of the European Marine Board, Ostend, Belgium.
ISBN: 9789082093100

Kline, S.J. and Rosenberg, N. (1986). An Overview of Innovation. In LANDAU, R. and Rosenberg, N. (eds.). The Positive Sum Strategy. Washington/DC, Elsevier.

Le Traon, P. Y., From satellite altimetry to Argo and operational oceanography: three revolutions in oceanography- Ocean Sci., 9, 901–915. www.ocean-sci.net/9/901/2013/. doi:10.5194/os-9-901-2013

Lubchenco J., N. Sutley, (2010), U.S. Policy for Ocean, Coast, and Great Lakes Stewardship. Science, 18 June 2010: 328 (5985), 1485-1486. DOI:10.1126/science.1190041.

Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data (2010). Pages 163. 3rd Edition. ISBN: 9789264013100

Rerolle, V. M. C.; Floquet, C. F. A.; Harris, A. J. K.; Mowlem, M. C.; Bellerby, R. R. G. J.; Achterberg, E. P., (2013) Development of a colorimetric microfluidic pH sensor for autonomous seawater measurements. Anal Chim Acta, 786, 124-131

Tintoré, J., Vizoso, G., Casas, B., Heslop E., Pascual, A., Orfila, A., Ruiz, S., Martínez-Ledesma, M, Torner, M., Cusí, S., Diedrich, A., Balaguer, P., Gómez-Pujol, L., Álvarez-Ellacuría, Gómara S., Sebastian K., Lora, S., Beltrán, J.P., Renault L., Juzà, M., Álvarez, D., March, D., Garau, B., Castilla, Cañellas, T., C., Roque, D., Lizarán I., Pitarch S., Carrasco M.A., Lana, A., Mason E., Escudier R., Conti, D., Sayol, J.M., Barceló, B., Alemany, F., Reglero, P., Massuti, E., Velez-Belchí, P., Ruiz, J., Gómez, M., Álvarez, A., Ansorena L., Manríquez, M., (2013): SOCIB: the Balearic Islands Observing and Forecasting System responding to science, technology and society needs. Mar. Tech. Soc. J., Vol. 47, N. 1. 17 pp. http://doi.org/10.4031/MTSJ.47.1.10

9 Acronyms

ADCP: Acoustic Doppler Current Profiler

EOOS: European Ocean Observing System

EuroGOOS: European part of the Global Ocean Observing System

FB: Ferry Box

ROOS: Regional Ocean Observing System

TNA: Trans National Access