European Commission

Towards European Integrated Ocean Observation

Expert Group on Marine Research Infrastructures

Final Report

January 2013

Research and Innovation

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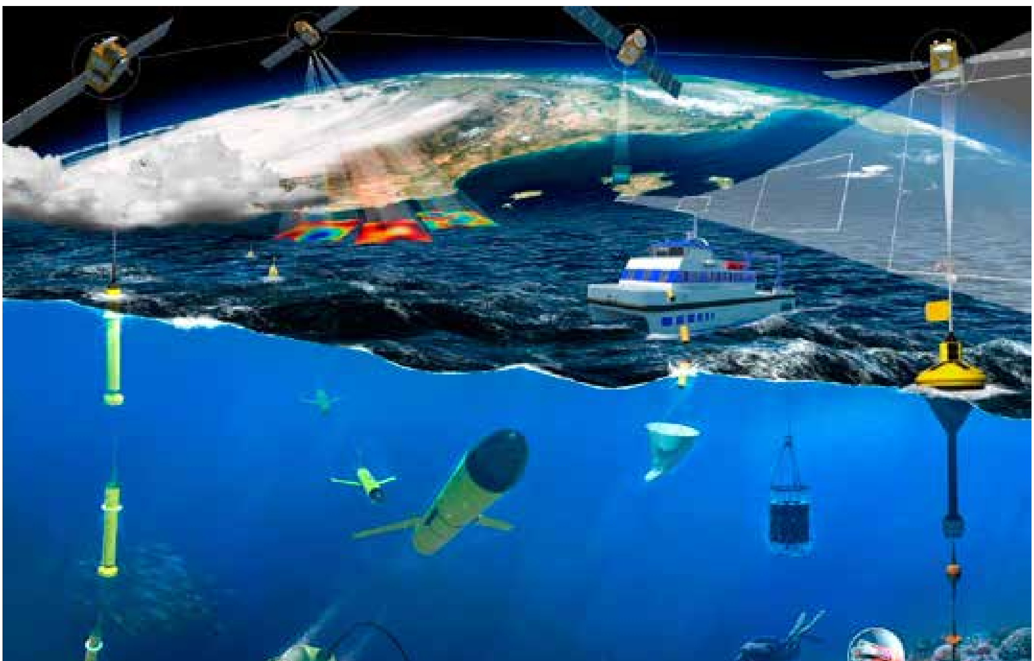

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EU Marine and Maritime Research Strategy

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Cataloguing data can be found at the end of this publication.

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INDEX OF ACRONYMS

AUVs	Autonomous Underwater Vehicles
CDOM	Colored dissolved organic matter
CPMR	Conference of Peripheral and Maritime Regions
CPR	Continuous Plankton Recorder
DCF	Data Collection Framework
DMS	dimethyl sulphide
DNV	Det Norsk Veritas
ECORD	European Consortium for Ocean Research Drilling
EEA	European Environment Agency
EEZ	Exclusive Economic Zone
ELIXIR	ESFRI Infrastructure for Biological Information
EMBRC	European Marine Biological Resource Centre
EMODNet	European Marine Data Observation Network
EMSO	European Multidisciplinary Seafloor Observatory
ERIC	European Research Infrastructure Consortium
ESA	European Sea Agency
ESFRI	European Strategy on Research Infrastructures
EUROBIS	European Ocean Biogeographic Information System
GES	Good Environmental Status
GMES	Global Monitoring for Environment and Security
GOOS	Global Ocean Observing System
GROOM project	Gliders for Research Ocean Observation and Management
HOVs	Human Occupied Vehicles
IOC	Intergovernmental Oceanographic Commission
IMEDEA	Mediterranean Institute for Advanced Studies
IMP	Integrated Maritime Policy

INCC	Joint Nature Conservation Committee
INSPIRE	Infrastructure for Spatial Information in the European Community
JERICO	Joint European Research Infrastructure network for Coastal Observatories
JPI Oceans	Joint Programming Initiative "Healthy and Productive Seas and Oceans"
LIDAR	Light Detection and Ranging
MARS	European Network of Marine Research Institutes and Stations
MCS	Marine Core Services
MMRS	Marine and Marine Research Strategy
MPA	Marine Protected Areas
MRI	Marine Research Infrastructure
MRO	Marine Research Organisations
MSFD	Marine Strategy Framework Directive
NODCs	National Oceanographic Data Centres
ROVs	Remotely Operated Vehicles
SOCIB	Balearic Islands Coastal Observing and Forecasting System
SPM	Self-phase modulation
UNCLOS	United nations Convention on the Law of the Sea
WAMS	World Associations of Marine Stations

EXECUTIVE SUMMARY

From societal needs to ocean observation

With an 89,000 km coastline along two oceans and four seas[1], together with immense overseas territories, Europe can be characterised as a blue continent. These facts leave a strong mark on its citizens, its economy and its climate.

Seas and Oceans provide indeed an essential part of our wealth and well-being. But they are also under huge pressure from human activities and climate change.

Launched in 2007, the EU maritime policy (IMP) pursues the broad objective of an integrated and sustainable development of sea-related activities. The EU Strategy for Marine and Maritime Research (MMRS)[2] was adopted in 2008 to provide a solid science base to the IMP and respond to societal needs such as blue growth, the good environmental status of the seas, the adaptation to climate change and marine / coastal safety.

The MMRS considers the coordinated development of marine research infrastructures at European level in relation to these needs as an essential objective to be pursued by the Commission in cooperation with Member States. Marine Research Infrastructures (MRIs) must also be managed at the European scale because marine challenges do not stop at national borders and synergies can be achieved at European level.

The establishment of the expert group on MRIs, in March 2010, was one of the actions undertaken to pursue the MMRS objective of promoting European marine research infrastructures. The objectives of the expert group were to identify important gaps and needs in European scale MRIs, propose mechanisms to link MRI needs with funding opportunities and advise on governance for European scale MRI.

The Group focused its work on MRIs, which support directly or indirectly the collection and use of marine data, i.e. marine observation infrastructures, because ocean observation is a key enabling area of activity, which underpins all marine and maritime activities. It also decided to take a strategic approach, looking at the "big picture" in terms of governance and identifies big gaps and strategic issues in qualitative terms.

Moving towards European ocean observation capability

The European landscape of MRIs governance initiatives is too complex and fragmented and this is an obstacle to achieving optimal impact of MRIs and responding to increasing societal needs related to our seas.

A number of projects launched to organise European governance for some categories of MRIs, organise networks of marine research organisations, and large integrating initiatives (the Global Monitoring for Environment and Security - GMES, EMODNET), have contributed to reinforce cooperation between organisations managing MRIs. They have also contributed to improve the governance and interoperability at European scale within categories of distributed infrastructures. However the multiplication of governance frameworks for specific categories of MRIs, calls for a strategic framework identifying key societal needs and objectives at

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1 The Atlantic and Arctic Oceans, the Baltic, the North Sea, the Mediterranean and the Black Sea

2 COM(2008) 534 final

European level, and providing for a coordinated development of the different initiatives, MRIs, projects and networks.

The current consultation on marine knowledge launched by the European Commission and the launching of JPI Oceans provide an opportunity to develop a shared vision as well as a strategic framework for ocean observation in Europe. After having analysed contributions from stakeholders, the Commission should propose such a strategic framework ensuring convergence and complementarities between existing infrastructures and initiatives, particularly the marine component of GMES, EMODnet, WISE-marine (the Water Information System for Europe) and the distributed European marine observation infrastructures. EMODnet must be developed as part of this broader European framework for ocean observation.

JPI Oceans could play an important role in implementing such a strategy, by identifying key marine parameters to be measured at European level to respond to societal needs, and the MRIs which should be sustained in a coordinated manner to measure these parameters. Such a process would provide a baseline for a European Ocean Observation capacity and promote convergence between the different European initiatives, MRIs, networks and projects in that area.

Investing in marine research infrastructures – value and funding

MRIs are the means through which we can observe and understand ocean processes. They give access to the knowledge necessary to a sustainable development of sea-related activities, as well as to mitigation of and adaptation to climate change impacts. They are essential to deliver the full contribution of seas and oceans to EU 2020's goal of smart, sustainable and inclusive growth.

MRIs are a large range of different infrastructures, dealing with data collection, data management and data assembling. In order to acquire marine data in an effective way, it is necessary to cover all three stages of the data processing chain, with an optimisation of data flows from data collection till the delivery of services to end-users.

Oceans are broadly under-observed, with spatial, temporal and thematic gaps in marine data collection. There is a need for a sustained effort in data collection, if Europe wants to respond to key societal and scientific ocean related challenges.

It is also crucial to maximise the value we extract from MRIs. This can be achieved by technological progress, by ensuring that MRIs respond to societal needs and by maximising cross-border synergies between MRIs distributed in different countries.

There is value in a coordinated development and utilisation of MRIs at European or regional seas' levels. Sea-related challenges and processes do not stop at maritime borders; they require a concerted approach at the regional, European and even global scales. There are synergies and savings in the coordinated development and utilisation of MRIs at European or regional seas' levels and in ensuring shared and free access to the data they produce.

There will be opportunities to finance marine research infrastructures in the (2014-2020) period with structural funds, as the new structural funds regulations put an even higher focus on research and innovation, with more than 25% of a total amount of ~ € 330 billion to be dedicated to research and innovation-related actions. Efforts will be needed to raise awareness among research organisations of these opportunities and to convey to structural funds managers at regional level the socio-economic value of MRIs. This could be done by using and improving the framework for valuing socio-economic value MRIs attached in annex. Building on the constructive experience undertaken with the European Marine Biological resource Centre (EMBRC), more "brokerage events" should be organised to bridge gaps between marine research institutes involved in European scale MRIs and regional authorities managing structural funds.

Public-private partnerships with industry related to data collection and management infrastructures should be explored, notwithstanding the difficulties of such undertakings. There are mutual benefits to be drawn from such partnerships as all stakeholders could in this way access to more data than they own, which helps them reduce uncertainty and costs. Partnership models should be developed to maximise incentives for marine industries to engage into joint financing of data collection and management infrastructures, taking into account the differences and different interests between well-established marine industries and emerging marine industries. The incoming consultation on "Marine knowledge" should be used to explore the opportunities for public-private partnerships to finance European scale MRIs.

Giving access to marine data at European level

There is a high value in an integrated approach to managing marine data in Europe, based on the principle of "collecting data once and using it as many times as possible".

The SeaDataNet project has developed a common lexicon for marine data across disciplines and applications and an open structure that can, with time, give access to an increasingly bigger number of data centres across sectors and countries, increasingly meeting the standards needed for INSPIRE compliance. As a European platform building upon SeaDataNet, the European Marine Observation Data Network - EMODnet could provide a solid framework for the structured development of a network of distributed data centres using a common lexicon and ensuring broad accessibility for users from scientists to policy makers, as well as user-friendly assembling tools. EMODnet must be developed from the pilot stage to the operational stage, by ensuring that it fits end-users' needs. The pilot sea-basin checkpoints for the Mediterranean and the North Sea currently tested under the integrated maritime policy, can guide the identification of gaps and assessment of future priorities and lessons learned from this exercise could feed into a more permanent process.

Member States are in the process of setting up national processes for a proper stewardship of data that ensures not only safe archiving but also cataloguing using standards and technology allowing retrieval of data through automated processes. These national systems are the foundations of the distributed processes that are being built up at an EU-level. They must ensure that the cost of archiving and managing data is properly budgeted for. They must also seek to ensure that marine data collected with public funds are made available to all potential users, including marine industries that can deliver blue growth and jobs.

A monitoring process to follow and steer the coordinated development of these national marine data management systems could be put in place, in cooperation between the European Commission and JPI Oceans. This could help remove progressively obstacles to access to marine data.

This development of a European framework for marine data management should ensure compatibility with INSPIRE and coherence with the global framework provided by the International Oceanographic Data and Information Exchange (IODE)

Boosting innovation and filling gaps in ocean observation

Ocean observation underpins all marine research and activities and, for this reason, it is of strategic importance. The pace of innovation in ocean observation technologies has been very high in the past two decades and it will continue to be so, both as regards sensors and fixed or mobile platforms that carry them. For this reason, continuous investment in ocean observation research and technologies should be considered as a priority deserving a strategic programming and investments in "Horizon 2020".

In-situ sensing of oceans is much less developed than remote sensing from satellites, done in the framework of GMES. Particular attention should be paid to develop a broad and cost-effective in-situ monitoring of the seas.

In general, for the marine environment, biochemical sensors are less developed than physical sensors. In order to address challenges related to pressures and variations on marine biodiversity, pollution of the marine environment, we need to fill gaps in this area by supporting development and deployment of new biochemical sensors and devices. The potential of new methods and technologies like genomics and marine acoustics to assess (pressures on) biodiversity should be explored. Mainstreaming of genomics into Earth observation should be advanced.

Oceanographic vessels will continue to be an essential component of marine research infrastructures. However, the development of sensors and the increasing use of autonomous and unmanned platforms may change how ships are used. Many oceanographic vessels of the European regional fleet will need to be renewed in the coming years. There is a need for strategic reassessment and coordination at European level of oceanographic vessels as part of a broader assessment and coordination of European marine research infrastructures. JPI Oceans could provide an opportunity to make such an assessment, coordinated with member countries and the European Commission, and building upon the work done by the Eurofleets research project.

The mapping of seabed with topography, geology, habitats and ecosystems is of high value for marine industries, protection of the marine environment and science. There are still important gaps in the mapping of European sea beds, as only a few countries have undertaken this task and the completion of this mapping in a systematic way. A seamless multi-resolution digital seabed map of European waters of the highest resolution possible, covering topography, geology, habitats and ecosystems, to be completed by 2020, would represent a major flagship project with a high societal and scientific value for Europe.

The Mediterranean (in particular its Southern border) and even more the Black sea are generally under-observed seas. Moving towards Good Environmental Status at sub-regional seas' level will necessitate developing strategies for better coverage by marine data infrastructures of these seas, in cooperation with third countries. A coordination of European countries' bilateral scientific cooperation with neighbouring countries in the Mediterranean and the Black Sea could strengthen capacity building in these countries and the ability to tackle common challenges.

I. INTRODUCTION

I. 1. Policy context

With an 89,000 km coastline along two oceans and four seas[3], strongly connected with inland water ways, together with immense overseas territories, Europe can be characterised as a blue continent. These facts leave a strong mark on its citizens, its economy and its climate.

Seas and Oceans provide indeed an essential part of our wealth and well-being. The fast growing global population will increasingly depend on marine food sources. Shipping and coastal tourism are crucial socio-economic activities. Moreover Oceans and seas offer a large unexploited potential from underexplored marine biodiversity, deep sea resources and marine renewable energy. But they are also under huge pressure from human activities and climate change. The growing vulnerability of coastal areas, increasingly crowded coastal waters, the key role of oceans in the climate system and the continuous deterioration of the marine environment all call for a stronger focus on our oceans and seas.

Launched in 2007, the EU maritime policy (IMP) pursues the broad objective of a sustainable and integrated development of sea-related activities, while mitigating and adapting to climate change impacts. From its inception, it was foreseen that the IMP should be informed by a solid science base and the EU Strategy for Marine and Maritime Research (MMRS)[4] was adopted to that effect as its scientific pillar.

The MMRS considers, in particular, the coordinated development of marine research infrastructures at European level, in relation to societal needs identified in the IMP, as an essential objective to be pursued by the Commission, in cooperation with member states[5]. It is indeed necessary to manage marine research infrastructures (MRIs) also at the European scale because marine challenges ignore national borders and synergies can be achieved at European level.

The establishment of the expert group on MRIs, in March 2010, was one of the actions undertaken to pursue the MMRS objective of promoting European marine research infrastructures, including those identified under the European Strategy Forum on Research Infrastructures (ESFRI).

I. 2. Objectives of the expert group

The expert group was set up with the following objectives:

- Identify important gaps and needs in MRIs, in addition to those in the ESFRI list. Attention should be paid to gaps in some EU regional seas;

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3 The Atlantic and Arctic Oceans, the Baltic, the North Sea, the Mediterranean and the Black Sea

4 COM(2008) 534 final

5 Already in 2003, the Academy of Finland published a report on a "European Strategy on Marine Research Infrastructure" (Report 6/03) stating "The co-ordination of existing marine research infrastructures and planning of future infrastructures would be most efficiently planned and executed in the context of a European Marine/Ocean Research Policy, which does not, at the moment, exist."

- On the basis of funding opportunities identified (e.g. under structural funds), propose mechanisms to link MRI needs with funding opportunities;
- Develop a conceptual framework and assessment method for valuing the socio-economic impact of MRI, which can be used to promote investment in marine research infrastructures by member states and maritime regions;
- Advise on governance for EU MRI, in particular with a view to ensure their long term sustainability and maximise synergy in their utilisation.

In particular, it was foreseen that the expert group should produce a report, with key recommendations before winding up its work. Details on the expert group, its meetings and proceedings are provided in **Annex 1**[6].

During the course of the work of the expert group, it appeared necessary to refocus slightly its objectives.

- Firstly, it was decided to focus the work on MRIs, which support directly or indirectly the collection and use of marine data, which can be characterised as marine observation infrastructures. There are two reasons for this focus. On the one hand, marine observation is a key enabling area of activity, which underpins all marine and maritime activities. On the other hand, marine observation infrastructures cover an extremely wide scope and raise very complex challenges, which required the full attention of the group.
- Some important categories of MRIs were therefore left out of the scope of the report. This concerns in particular MRIs used to support the development of marine industries like test sites for marine renewable energy, basins for hydrodynamic tests or infrastructures for aquaculture research, as well as experimental facilities to study environmental and biodiversity variations in (close to) real conditions. All these MRI categories are mentioned in Annex 4, which builds on the mapping of research infrastructures done by the marine European Research Area Network SEASERA. It is important that these other categories of MRIs are subject to further in depth analysis in an adequate framework, with a view to identify critical gaps and needs at European level.
- Secondly, it was decided not to undertake a detailed mapping of MRIs in Europe. Indeed, such work has been done by other initiatives and we refer to them, for more details[7].
- This report takes a more strategic approach targeting public policy officials and stakeholders at European, national and regional levels, who take part in investment decisions regarding MRIs, rather than experts or specialists. After explaining in simple terms what marine observation involves, it looks at the "big picture", in particular in terms of governance and identifies big gaps and strategic issues in qualitative terms. It is hoped that, in this way, it will add value to previous work and enlighten policy makers and non-specialist marine stakeholders on the European landscape of ocean observation infrastructures, its strengths, weaknesses and strategic issues.

6 Presentations made during the meetings of the expert group, as well as the minutes of the meetings are available at the European Commission Maritime Forum website: https://webgate.ec.europa.eu/maritimeforum/category/401

7 Two reports are of particular importance in that context:European environment Agency – GMES in-situ coordination – "Report on in-situ data requirements – August 2011" and "GMES in-situ cost assessment – September 2011" SEASERA Project - D 4.1 Marine Research Infrastructures updated overview, European integration and vision of the future.

II. MARINE RESEARCH INFRASTRUCTURES – DESCRIPTION, NEEDS AND VALUE

II. 1. Marine Research Infrastructures covered in the report

There is not a single definition of RI or of MRI, and there are different ways to categorise them. As mentioned in the introduction, MRIs considered in the framework of the Expert Group are infrastructures which directly or indirectly support the collection, management and use of marine data.

The MRIs can be physical equipment that collects and produces marine data, databases and information systems that give access to these data, as well as supercomputers and models that process these data.

MRIs can collect data in real time or in delayed mode. In real time mode, data is directly acquired by a device equipped with a sensor, then transferred (through submarine cables or satellite or Wi-Fi…) to be used immediately in a data processing system. In delayed mode, a device extracts samples (water, sediments), which are then processed in a laboratory before being analysed with analytical apparatus to produce data. Data collection MRIs therefore comprise therefore both devices equipped with sensors that collect directly marine data and sampling devices / laboratory equipment for data acquisition in delayed mode.

Surface drifter deployment

Data management systems comprise databases and information systems that give access to quality controlled and harmonised data coming from a broad range of measurements, as well as the physical systems that store samples for further analysis in delayed mode.

Data processing systems comprise computing infrastructures and digital models that transform collected data into value added products for end-users.

MRIs can be owned by public or private organisations (marine industries). Different types of ocean and coastal observatories have been established in Europe and internationally in recent years. While this report rather focuses on the landscape of publicly owned and financed MRIs, it also touches upon possible public-private partnerships for shared development of MRIs or for access to the data they produce.

II. 2. Components and description of MRIs

Table 1 provides a detailed description of different categories of marine research infrastructures (mobile platforms, submersible platforms, autonomous and drifting platforms, fixed platforms and systems, in-situ and remote sensors, ICT infrastructures and models, modelling and data management infrastructures), and their roles.

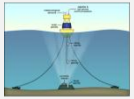
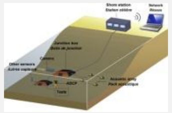
Table 1: Marine research infrastructure categories or components – Description and roles[8]

Infrastructure Categories	Description	Roles
I. MOBILE PLATFORMS		
Research vessels 	A research vessel is a ship designed and equipped to carry out research at sea.	Provide access to the sea as carriers for measuring instruments and sampling equipment for scientific cruises, process study campaigns, event-driven responses, surveys and mapping, and routine monitoring.
Ships of opportunities/Ferry boxes 	The Ships of Opportunity facility utilises a combination of volunteer merchant and, less frequently, research vessels to collect measurements related to physical, chemical and biological oceanography. FerryBoxes combine a set of sensors and biogeochemical analysers that are installed on ships of opportunities.	Repeated measurements for operational oceanography, biodiversity (plankton…), marine pollution (nutrients, chemicals, micro plastics…)

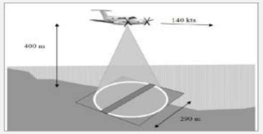
8 The table follows a categorisation made in a report by the US National Research Council "Critical Infrastructure for Ocean Research and Societal Needs in 2030" – ISBN 978-0-309-18603-2

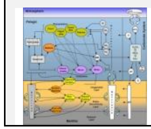
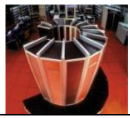
II. SUBMERSIBLE PLATFORMS		
Human Occupied Vehicles (HOVs) 	A vehicle designed to carry people under the surface of the water. Also referred to as a submersible.	Provide water column and seafloor access for process study campaigns, event-driven responses, surveys and mapping as well as routine monitoring, and sampling.
Remotely Operated Vehicles (ROVs) 	A crewless submersible vehicle tethered to a vessel by a cable. It carries a variety of devices (sensors, cameras…).	Provide water column and seafloor access for process study campaigns, event-driven responses, surveys and mapping as well as routine monitoring, and sampling.
Towed Systems 	Systems that have been towed behind ships and boats to perform different types of measurements.	Provide observations and sampling from near surface to just above the seafloor, with use on research vessels or ships of opportunity.

Infrastructure Categories	Description	Roles
III. AUTONOMOUS AND DRIFTING SYSTEMS		
Autonomous Underwater Vehicles (AUVs) and gliders 	Programmable, robotic vehicles that, depending on their design, can drift, drive, or glide through the ocean without real-time control by human operators. Underwater gliders are autonomous vehicles with typical endurance reaching now up to 4-6 months. They move horizontally on wings and profile vertically by controlling buoyancy, from the surface down to more than 1.000 m, monitoring physical, biogeochemical or acoustic data in quasi-real time.	Gliders can operate in coastal and open ocean areas and are ideal for sustained monitoring of key control points. They provide near real time observations (temperature, salinity, velocity, nutrients, optics, fluorometry, acoustics, multi-beam or side-scan sonar) for process study campaigns, event-driven responses, surveys and mapping. Different technological challenges are being addressed to increase endurance at sea, and implement new energy efficient sensors and optimized satellite communications for real time data availability. This would allow the development of emergency response capabilities and/or knowledge based environmental decision-making tools.
Drifters and Floats (e.g. Euro-ARGO) 	Float designed specifically to drift passively with the flow of water. Drifter and float are used interchangeably; historically, however, drifter has applied to instruments on the surface and float to those in the water column.	Provide scalable, adaptable arrays with near real time observations (wind, light, passive radiation, atmospheric pressure, temperature, salinity, chlorophyll fluorescence, dissolved oxygen, nitrate) for routine monitoring and assimilation into forecast models.

IV. FIXED PLATFORMS AND SYSTEMS		
Moorings 	A collection of devices connected to a wire, held up in the water column with various forms of buoyancy and anchored on the sea floor.	Provide surface and water column observations with high spatial and temporal resolution, including persistence at key locations and groundtruth for remote sensing. Provide full integration with mobile autonomous systems.
Cabled Seafloor Observatories (e.g. EMSO) 	Seafloor observatories can have a range of sensors (physical, biochemical, geological, optical, acoustic…) to collect data in a fixed point in the seabed and transfer them through a submarine cable linked directly to a shore station.	Provide continuous real-time power and communication to coastal, deep ocean, and seafloor instruments and networks. Routine interactions with mobile autonomous systems.
V. IN SITU SENSORS		
Physical 	Devices which respond to physical parameters such as temperature, salinity, oxygen, density, currents… and provide a signal that allow measuring them.	Provide measurements essential to physical process studies and baseline dynamical contexts for biogeochemical sensors.

Infrastructures categories	Description	Roles
Chemical  	Devices which respond to chemical parameters such as PH, nutrients, CO2… and provide a signal that allow measuring them.	Provide routine time-series measurements for major and trace elements, carbon species, nutrients, and pollutants in a broad range of environments.
Biological  	Devices which respond to biological parameters such as plankton, chlorophyll … and provide a signal that allow measuring them.	Provide routine measurements with small, inexpensive sensors that replicate current complicated laboratory techniques.
Geophysical 	Devices which respond to geophysical parameters such as sediment thickness, seismic reflections, magnetics, gravity… and provide a signal that allow measuring them.	Provide measurements for understanding solid earth processes of the ocean crust and mitigating geohazards.
VI. MRI REMOTE SENSING		
Satellite 	Satellite remote sensing uses devices embarked in satellites to detect at distance natural radiation (infrared or other) emitted or reflected by the ocean surface (or close to the surface). This is then used to determine related parameters such as temperature, color…	Provide global to regional scale remote observations for sea surface height, temperature, salinity, ocean color, winds, precipitation, ice and radiation.

Airborne 	Airborne remote sensing uses devices embarked in airplanes for the passive characterization of ocean surface (imaging), or active collection using energy emission to detect reflected or backscattered radiation (e.g. Light Detection and Ranging - LIDAR).	Provide low-cost, regional to local-scale remote observations with adaptive and event-driven capabilities. LIDAR is also an effective technology to map coastal areas and seabed in shallow coastal areas.
High Frequency Radar 	High Frequency Radar is based on the analysis of a backscattered radio wave sent on the ocean surface. It measures speed and direction of ocean surface current near the coast (up to 70 kms).	They are part of observational systems for both fundamental research (sustained monitoring for e.g. coastal circulation models) and applied needs (emergency response e.g. for pollution events or preparing search and rescue).
VII. ANALYTICAL DEVICES FOR DELAYED MODE ANALYSIS		
Laboratory equipment for analysis of marine samples 	This comprises all laboratory analytical equipment to perform physical, chemical, biological, geological measurements on extracted samples. It also covers analytical devices for gene sequencing of marine organisms.	Laboratory equipment analysis provides more precise and sensitive measurements than real-time analysis with sensors. In some cases (e.g. gene sequencing), it produces data that cannot (yet) be acquired with in-situ sensors in real time.

Infrastructures categories	Description	Roles
VIII. DATA MANAGEMENT and COMPUTING		
Databases and sample storage systems  	IT systems that store and organize collected marine data (physical, chemical, biological, genomic…), with a view to make them accessible and available for further retrieval and use. "Omics" data management - bioinformatics Physical systems for the organised storage of samples (e.g. geological or biological), with a view to keep them available for further retrieval and use by scientists or stakeholders.	
Numerical models and computational infrastructures  	Super computers that allow running complex models to simulate oceanographic processes.	Simulate oceanographic processes from the open ocean to the coastal scales. Provide transformed and value added information such as analyses and forecasts of different environmental variables.

Marine research infrastructures can also be classified along a data processing chain comprising:

1) data collection using sensors measuring different parameters and equipment for sampling (e.g. biological materials or sediments), and platforms carrying sensors for data acquisition or equipment for sampling;

2) data management infrastructures, for quality control, long term storage and giving access to collected data and derived parameters;

3) data integration and use through information and knowledge infrastructures, including numerical models, adding value to the collected data and generating / distributing data products for specific user applications.

Sensors are at the start of this chain since they make the measurements, which allow data collection. They can be physical (temperature, wave, current, noise…), chemical (Oxygen, Carbon dioxide, nutrients, pollutants…), biological (chlorophyll, plankton, biotoxins, genetic material like DNA or RNA…) or geological (sediments, seismic activity…). Sensors can operate in-situ or remotely (remote imaging from satellites, radars…), depending on the platforms that carry them. They can provide data in real time (data acquired and stored or sent immediately to data centres), or in delayed mode (sampling of seawater followed by analysis in laboratory or delayed transmission of collected data from platform to data centre)[9].

Fixed monitoring device

The Autosub Long Range Autonomous Underwater Vehicle

Sensors are carried by fixed or mobile platforms. The platforms can be submersible (buoys, moorings, drifting platforms, autonomous underwater vehicles, remotely operated vehicles, cabled seabed observatories…), floating (research vessels, ships,...), fixed (offshore platforms, coastal platforms, …) or airborne (satellites and planes). Mobile and fixed platforms can carry several sensors and collect a range of data. The kind of parameters that can be measured by a platform therefore depends on the sensors that are adapted on it. Sometimes this is the result of a choice; for example, a cabled seabed observatory can collect physical, chemical, biological or geo-seismic data depending on the issues it should deal with. But often there are technological limitations (size of sensors, need for electric power…), which prevent scientists from adapting more sensors on a platform. This area is subject to intense research and innovation, and technology evolves quickly in that domain, leading to

9 With the exception of chlorophyll, biological or genetic measurements are generally made in delayed mode however this is evolving quickly with new biosensors being developed.

more sensors being put on platforms and increasing the scope of their measurements. There is a continuous feedback between scientific challenges, technology developments and society needs: technology developments can be driven by science and societal needs but they can also trigger scientific breakthroughs, which in turn become crucial for the sustainable management of ocean and coastal areas.

Collected data are sent to data management centres, where they are stored after quality control and made available for further use. It is important to note the difference and complementarities between physical MRIs used to collect, for instance, data on plankton and a database on plankton. A database with harmonised and quality-controlled data on plankton covering broad geographical areas and long-time series, is in itself a MRI, which facilitates and enables the work of marine researchers. Data storage and management is therefore an important part of the data processing chain, which tends to be overlooked by non-specialists. Not only are data infrastructures increasingly big and expensive but a proper management of data requires harmonisation and common standards, in particular regarding formats for data and metadata[10], quality control methods and flags, and vocabularies, for future retrieval, exchange and use of data. Standardisation of marine data is quite advanced in some areas (physical data), and less advanced for e.g. biological and genomic data. Data management can also include physical storage of samples[11] such as geological cores. The primary objectives of data management centres is thus to ensure that metadata about the data collecting and sampling are completed and that resulting data, both from the direct measurement activities, and from further analyses such as done in laboratories, are managed and stored for wider and further use. As part of this, data centres apply quality control for validation of submitted data before storing and to ensure overall consistency between metadata and data.

The validated data can be used by various users. These include individual researchers that use selected data as input and reference for their scientific analyses. These also include organised communities that combine data and numerical models to generate specific data products that are more fit for purpose of specific user applications than just the basic data. This can take the form, for instance, of a map assessing an environmental status in a marine area, or surface waves, or verification of scientific hypotheses in a research project… etc[12].

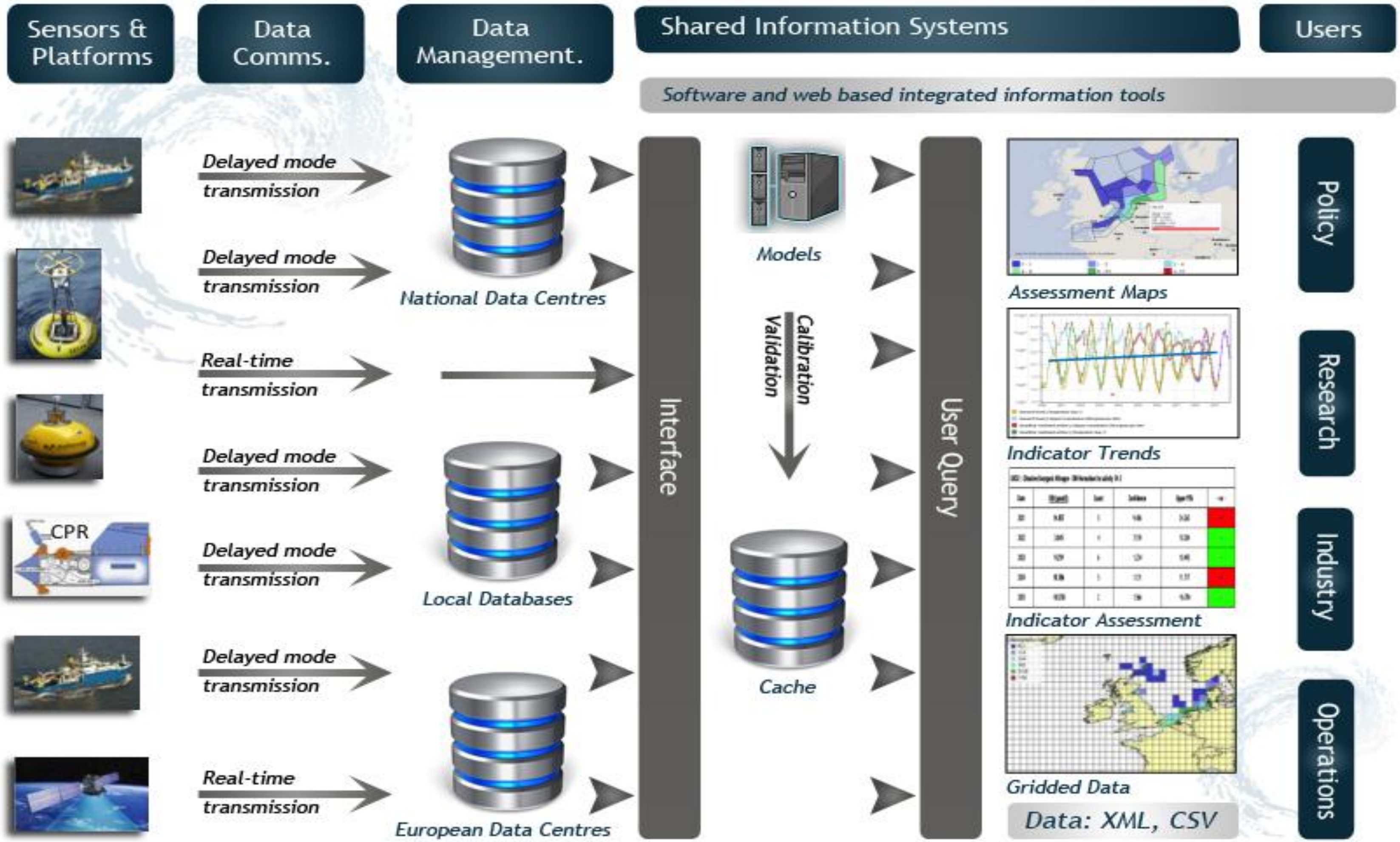
10 Metadata (metacontent) is defined as data providing information about one or more aspects of the data, such as: means of creation of the data, purpose of the data, time and date of creation, creator or author of data, standards used.

11 In the storage of samples, metadata will at first concern the details of the in-situ sample collection, while results of further processing (ex-situ) might become available later on and added to the databases. Managing the complete data processing chain in case of scientific samples is challenging since there might be long time lags between the actual in-situ collection and following ex-situ analyses, involving multiple institutes and researchers. In case of monitoring the data processing chain is more direct because samples are processed on short term by certified laboratories and data results are reported to the monitoring institutes for data storage.

12 A good example of this adding-value chain is the GMES Marine Service (as undertaken by the MyOcean project). It uses real-time data and long timeseries of physical data (climatology data sets) as derived from data collecting systems and data centres, and large mathematical models to produce ocean forecasts, nowcasts and hindcasts on an operational basis. These ocean data products are then used by other adding-value communities (so-called downstream services) to produce regional and coastal data products for specific end-uses (for example to forecast eutrophication in specific coastal areas with fish farms).

Hydrodynamics numerical models are well established and widely used while ecosystem or biogeochemical models are still being developed and require improvements.

The following chart illustrates for example how this data processing chain can work for giving support to the MSFD implementation process for assessing Good Environmental Status.



Sensors & Platforms
Data Comms.
Data Management.
Shared Information Systems
Users
Software and web based integrated information tools
CPR
Delayed mode transmission
Delayed mode transmission
Real-time transmission
Delayed mode transmission
Delayed mode transmission
Delayed mode transmission
Real-time transmission
National Data Centres
Local Databases
European Data Centres
Interface
Models
Calibration Validation
Cache
User Query
Assessment Maps
Indicator Trends
Indicator Assessment
Gridded Data
Data: XML, CSV
Policy
Research
Industry
Operations

II. 3. Marine Research Infrastructures: societal needs and value

Oceans and seas are still largely unknown, particularly the evolution and changes of the coastal ocean and the deep seas. Developing means to observe oceans and their variability[13] is of critical importance for the development of the marine economy, the protection of the marine environment, the prediction of and adaptation to climate change, the safety of marine activities and coastal areas.

It is also of crucial importance to science development, which can be considered as a societal objective in itself.

II. 3.1. Supporting the maritime economy and blue growth

All marine activities depend on a good knowledge of the physical, chemical, biological and / or geological characteristics of the sea and its variability. This is the case for traditional marine activities like fisheries, offshore industry, tourism or shipping, which require knowledge of marine resources as well as an ability to forecast and adapt to changing conditions.

This need is even more pronounced for new activities like aquaculture, marine biotechnology and renewable energy (including offshore wind), which need knowledge of the marine environment and its changes (chemical pollution, bio-toxicity of marine organisms, biodiversity in the environment, seabed characteristics, physical and chemical conditions of the marine environment).

High quality marine research infrastructures support established and new marine / coastal industries by 1) improving knowledge of the marine environment and conditions, 2) giving access to new resources (food, renewable energy, biodiversity…) and 3) decreasing risks of operations. MRIs can also help marine industries better predict and adapt to climate change impacts and risks.

They support spatial optimization of activities in coastal and marine zones, minimizing conflicts of use and taking into account the good functioning of ecosystems. They can also support innovation in marine observation technology, which is in itself a growing industry.

All these benefits of MRIs can be measured in direct and indirect employment and turnover.

13 Variability refers to changes in time and scale of changes taking place in oceans. They can be natural or induced by human activities.

II. 3.2. Understanding and mitigating pressures on the marine environment

The Marine Strategy Framework Directive (MSFD)[14] has set an obligation to define and reach a Good Environmental Status (GES) of all Europe's seas by 2020. The GES must be assessed against a set of descriptors covering a broad range of topics on the marine environment (biodiversity, non-indigenous species, fish stocks, food webs, eutrophication, sea-floor integrity, hydrographical changes, contaminants, litter and underwater noise). This legal obligation creates a considerable need for collection of marine data through marine observations.

Moreover, in order to turn the GES legal concept into a practical reality, there is a need for an integrated approach to future marine observations. In fact, what is required by the MSFD is the knowledge of the combined impact of marine activities on the marine environment, putting ecosystem-based management at the centre of the process. This so-called ecosystem-based approach is essential to ensure that on-going and future marine activities are undertaken in a sustainable way, and it links support of the maritime economy with protection of the marine environment, including the ecosystem services it provides[15]. One way to encapsulate the value of healthy environment in socio-economic terms is to assess the ecosystem services, which can be defined as the non-market benefits we derive from nature. **Annex 5** develops the concept of ecosystem services and gives examples of assessment of their value.

By increasing knowledge of environmental and climate change processes, MRIs allow a better protection of the marine environment and the development of ecosystem services. They help improve public understanding of and inform decision making on key coastal / marine investment decisions. They also help detect and pre-empt harm to human health (e.g. from biotoxins) and improve benefits to human health.

II. 3.3. Understanding ocean-climate interactions

Interactions between oceans and climate take place in two ways.

On the one hand, oceans are an essential regulator of global climate. This happens 1) through large scale ocean currents (called thermohaline circulation) caused by gradients in water salinity and temperature, 2) through Carbon exchanges between the atmosphere and oceans (oceans as Carbon sinks).

On the other hand, the marine environment is heavily and rapidly impacted by climate change (in particular oceans' acidification) while coastal areas are affected by sea level rise and extreme events provoked by global warming. This impact of

14 DIRECTIVE 2008/56/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 June 2008 establishing a framework for community action in the field of marine environmental policy

15 There are other pieces of environmental legislation, which create a need for collection of marine data like the EU Habitats Directive and the Bathing Waters Directive, but the Marine Strategic Framework Directive provides the broadest environmental compliance framework for the marine environment, taking into account all significant pressures, all uses and activities and embracing a range of other policies.

climate change on marine ecosystems and coastal areas also affects marine activities which depend on marine biological organisms (fisheries, aquaculture, biotechnology…) and offshore activities which are sensitive to sea conditions (shipping, harbour infrastructure, coastal protection, offshore energy installations).

There is also a link between marine living organisms, Carbon exchanges and thermohaline circulation since this latter ensures availability of essential nutrients and oxygen to marine organisms, and therefore affects the geographic distributions of marine species.

There is therefore a strong case for investing in marine research / observation infrastructures, which can improve our knowledge of ocean-climate interactions and prediction of the impact of climate change on marine ecosystems and coastal areas.

II. 3.4. Reinforcing marine and coastal safety

With crowded coastal areas, where marine activities compete for limited sea space, it is essential to be able to predict climatic events and develop a response capacity to accidents, accidental pollutions… etc.

Oceanography uses marine research / observation infrastructures and numerical models to predict climatic events, algal blooms, and development of accidental pollutions. In this way, it can improve safety of marine activities and citizens in coastal areas, as well as mitigate impact of accidental pollutions. It can also potentially help optimising shipping operations and other marine activities. It can finally help detect and pre-empt extreme or catastrophic events affecting coastal areas (storms, rogue waves, high tides, tsunamis...).

II. 3.5. Developing scientific knowledge

Scientific knowledge is a societal need in itself, which underpins the development of our societies. Marine scientific knowledge is also obviously a basic need in support of the four societal needs mentioned previously. Understanding the basic oceanographic processes (physical, chemical, biological and geological) both separately and in an integrated way is crucial to support the exploitation of marine resources, ensure their sustainability, understand climate / ocean interactions and improve marine and coastal safety.

High quality marine research infrastructures are essential to pursue scientific research, which can respond to crucial scientific questions (e.g. ocean / climate interactions, ecosystems variability…). They provide employment opportunities for researchers and technicians. They support training of students and future generations of researchers, as well as cooperation with private industries. All these features stimulate innovation in MRIs’ technologies (e.g. sensors and platforms…), which is indispensable to keep scientific excellence.

The need to invest in marine observation and data management infrastructures (and the value of doing it) derives from all the previously described impacts. The more a given infrastructure will contribute to respond to the societal needs identified, the higher will be its value.

II. 4. European governance of MRIs – need and value

There are two reasons for developing European governance of MRIs. One is the geographical scale of marine challenges and the other one is the potential synergies that can be achieved by developing / managing jointly costly MRIs at European level.

<u>Geographical scale of marine challenges</u>

The challenges raised by seas and oceans, whether they are economic, environmental or scientific, are of multiple geographical scales. They are obviously local or national when a country needs to develop marine industries, control pollution or combat sea level rise in a given area. But they are also of a regional / European scale because the marine environment distributes the impact of marine industries, marine pollution or climate change (acidification, ecosystem changes…) to vast areas, entire regional seas and even the global ocean. Similarly the optimal management of marine industries such as fisheries, aquaculture, marine energy, shipping, requires data and planning at regional sea scale, across the maritime borders of states. Finally the understanding of climate change through a better knowledge of ocean / climate interactions is essentially a global challenge, which can only be tackled through a coordinated collection of data at global level.

It can be said that all ocean challenges also have a global scale since we are eventually dealing with a global ocean. However the downscaling of global issues (ocean acidification, sea level rise, alien species…) to a regional / local level is crucial since this is the level that affects stakeholders and determines public authorities' actions.

<u>Synergies at European level</u>

The cost of investing in marine research infrastructures to acquire marine data is substantial. According to a preliminary assessment made by the Joint Programming Initiative "Healthy and Productive Seas and Oceans" (JPI Oceans), the annual research budget dedicated to marine and maritime research in Europe is close to €1.9 billion, out of which 40% are spent on marine research infrastructures.

A recent economic impact assessment in the framework of EMODNet concludes that Europe annually spends €1.4 billion for marine and ocean data collection, of which €0.4 billion for data acquisition by satellites and €1.0 billion by in-situ data collection.

Both these estimates show the importance of ensuring that we maximise value for money from investments in marine research infrastructures, and particularly synergies at European level between member states' investments.

European MRIs might be created by deploying a form of European governance over MRIs of a certain type that are distributed in a number of European countries. Such European governance for selected MRIs might better respond to challenges of regional, European or global scale. It facilitates coordinating national investments in MRIs towards the collection of data needed to respond to European or global scale challenges. It can minimise the costs and maximise the impact of these investments by ensuring maximum convergence and synergies, and avoiding overlaps of costly investments needed to address these challenges.

However a non-coordinated multiplication of European governance structures for MRIs and ocean observation initiatives can also be a source of overlaps and inefficiencies.

Value of making marine data accessible at European scale

Marine research infrastructures are often multi-purpose infrastructures, meaning that the data they produce are relevant for many of the societal issues indicated above. For instance, a seabed observatory can characterise the marine environment, physical changes related to climate change or monitor geo-seismic events. A coastal ocean observatory can monitor the changes related to climate change, invasive species proliferation (e.g. jelly fish) to water quality or beach erosion.

This characteristic of marine research infrastructures shows the importance of giving access to data, with a view to ensure that they are acquired once and used as many times as possible. However in practice, marine organisations (public or private) collect and store marine data but access to these data might be impeded by lack of standardisation of data handling protocols or other legal or administrative obstacles.

Therefore, overarching data management infrastructures with portals that give access to a range of marine data from different sources, based on harmonised standards and data handling protocols, are very relevant to overcome these hurdles.

The impact assessment[16] accompanying the Commission Communication on marine knowledge estimated that a proper integrated approach to managing marine data would save €300 million a year for existing users of marine data. And the value of new innovative products and services derived from better access for entrepreneurs, small businesses and academic institutions could be of the order of €60 to €200 million per year. This is without considering the inevitable future growth in the marine economy and the consequent increased demand for data.

Nor does it take into account a rationalisation of the present marine observation systems that would reduce uncertainty in the behaviour of the sea. Indeed uncertainty is a principal enemy of those responsible for designing offshore structures that can withstand the vagaries of the sea, managing fish stocks, designing marine protected areas or adapting to climate change. For instance it has been estimated that a reduction in uncertainty in future sea-level rise of 25% would save public authorities responsible for coastal management approximately €100 million per year. And since changes in ocean circulation drive the severity or mildness of Europe's seasons, a reduction in marine uncertainty can improve forecasts of energy demand or agriculture production far inland.

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16 European Marine Observation and Data Network Impact Assessment SEC(2010) 998 final Brussels, 8.9.2010

II. 5. Essential marine parameters for societal needs

Marine scientists working in the framework of the Global Ocean Observing System (see later in the document) have defined a list of key user groups for coastal observing systems and the key variables that need to be measured to meet their needs. They are displayed in table 2 thereafter[17].

Geophysical	Sea level and Bathymetry
	Shoreline position
	Temperature and Salinity
	Currents and Surface Waves
	Sediment grain size
Chemical	Sediment organic content
	Dissolved organic nitrogen, phosphorus and silicon
	Dissolved oxygen
Biological	Benthic biomass
	Phytoplankton biomass
	Fecal indicators
Biophysical	Attenuation of solar radiation

This list provides a useful indication of key marine parameters to be collected. It should be considered as a minimal set of key variables, to which other variables can be added (and the corresponding MRIs set up) to respond to precise needs.

For instance the United Kingdom is developing its own Integrated Marine Observing Network and it is defining its own key variables, in relation to key societal needs, in a more detailed way than the GOOS list. This is summarised in table 3 thereafter[18].

17 The material was extracted from An implementation strategy for the coastal module of the Global Ocean Observing System, GOOS Report n. 148; IOC information documents series n.1217; UNESCO 2005.

18 This is work in progress and is shown to illustrate the relation between key variables and societal needs

Table 3: UK-IMON Core Variables identified by partners as essential measurements with for monitoring ecosystem structure and function in UK waters

		Weather & climate	**Marine operations**	**Natural hazards**	**National security**	**Public health**	**Healthy ecosystems**				**Sustained resources**
							Clean & safe	*Healthy & biologica-lly diverse*	*Productive*	*Ocean processes*	
Physical	Salinity	✓	✓	✓	✓	✓				✓	✓
	Temperature	✓	✓		✓	✓				✓	✓
	Bathymetry	✓	✓	✓	✓	✓				✓	✓
	Sea level	✓	✓	✓	✓					✓	✓
	Surface waves	✓	✓	✓	✓	✓				✓	✓
	Surface currents	✓	✓	✓	✓	✓				✓	✓
	Optical properties (e.g. CDOM & SPM)				✓	✓	✓		✓	✓	✓
	Heat flux	✓								✓	✓
	Ocean colour	✓	✓			✓				✓	✓

	Benthic habitats		✓					✓		✓
	Wind speed & direction	✓	✓						✓	
	Surface air temperature	✓	✓						✓	
	Tidal stream flow	✓		✓					✓	✓
Chemical	Contaminants				✓	✓	✓			✓
	Dissolved nutrients					✓	✓			✓
	Dissolved oxygen						✓			✓
	CO2 partial pressure					✓			✓	✓
	pH acidity					✓			✓	✓

		Weather & climate	Marine operations	Natural hazards	National security	Public health	Healthy ecosystems				Sustained resources
							Clean & safe	*Healthy & biologica-lly diverse*	*Productive*	*Ocean processes*	
Biological	Chlorophyll						✓	✓			
	Pathogens				✓	✓		✓			✓
	Phytoplankton species	✓	✓		✓	✓	✓ (Indicator spp.)	✓			✓
	Zooplankton abundance							✓			✓
	Zooplankton species					✓		✓			✓
	Shellfish toxins?					✓	✓				✓
	Incidence of fish kills						✓ (fish kills)	✓	✓		✓
	Fish species							✓	✓		✓

III. THE EUROPEAN LANDSCAPE OF MARINE RESEARCH INFRASTRUCTURES - DESCRIPTION

The European landscape of MRIs is complex, with many initiatives organising the governance of MRIs and data flows at different geographical scales (local, national and European) and at different stages of the data chain (data collection, management, integration and dissemination...).

With the exception of satellite remote sensing infrastructures (usually managed by European agencies), MRIs of European scale are essentially set up by integrating (or creating inter-operability between) similar marine research infrastructures distributed in several member states[19]. Some of these European scale MRIs are already operational, while others are only projects aiming at creating European governance for distributed MRIs.

There are also initiatives integrating several MRIs of European scale to create large observing systems or programmes.

III. 1. The "big picture"

The European landscape of MRIs for in situ observation can be described schematically in 3 levels:

1) A first level of Marine research centres or observatories at national level, which own or manage several MRIs;
2) A second level made of a series of European infrastructure projects, which organise the governance of a given category of MRIs (e.g. drifting floats, seabed observatories, oceanographic vessels, databases of bio-genomic and model organisms, …) across marine research centres and observatories in the EU[20];
3) A third level is made of large European integrated marine observation initiatives, like the Global Monitoring for Environment and Security (GMES), which organise the collection and use of marine data from a range of European scale MRIs (distributed in-situ MRIs and satellite remote sensing).

Marine research centres or observatories contribute therefore with their MRIs to broader initiatives, such as European wide marine research infrastructures or GMES. And they benefit from access to data collected under these large European initiatives.

This shared access at European level to a network of national infrastructures (or to the data they produce), creates considerable added value both in scientific and societal terms. It is one of the main drivers for most European marine research infrastructure projects and initiatives[21].

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19 This characteristic of distributed MRIs of European scale creates sometimes confusion between the MRI itself and a project seeking to organise the European governance of MRIs distributed in member states.

20 These are for example marine MRIs under the European Strategy Forum for Research Infrastructures (ESFRI).

21 Other drivers are savings and bigger impact arising from coordinated investments in MRIs distributed in several countries.

However to maximise this value, obstacles to shared access to data across Europe must be removed. This is the rationale for European scale data management initiatives like SeaDataNet and EMODNet, which together aim for an overarching pan-European infrastructure to give overview of and access to all marine data acquired by monitoring systems and research activities collecting data.

Table 4 on next page describes schematically this landscape.

<table>
<tr><th>Categories of MRIs</th><th>Marine Research Centre 1 – MRC1 in country A</th><th>MRC2 in country B</th><th>…</th><th>MRCn in country X</th><th>…</th><th>MRCp in country Y</th><th>Distributed European Scale MRIs or projects organizing European governance of categories of MRIs</th><th>European data Management Initiatives</th><th>Integrated European Marine Observation Initiatives</th></tr>
<tr><td>Drifting floats</td><td></td><td></td><td></td><td>X</td><td></td><td></td><td>EURO-ARGO</td><td rowspan="6">SeaDataNet
EMODNET
ELIXIR</td><td rowspan="5">GMES</td></tr>
<tr><td>Seabed observatories</td><td>X</td><td></td><td></td><td></td><td></td><td>X</td><td>EMSO[22]</td></tr>
<tr><td>Buoys/ Moorings</td><td>X</td><td></td><td></td><td></td><td></td><td>X</td><td>EURO-SITES (project)</td></tr>
<tr><td>Oceanographic vessels</td><td></td><td>X</td><td></td><td>X</td><td></td><td>X</td><td>EUROFLEETS (project)</td></tr>
<tr><td>Gliders</td><td>X</td><td></td><td></td><td>X</td><td></td><td></td><td>GROOM[23] (project)</td></tr>
<tr><td>…</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>EuroGOOS</td></tr>
</table>

22 European Multidisciplinary Seafloor Observatory

23 Gliders for Research Ocean Observation and Management

Marine biodiversity databases		**X**		**X**			**EUR-OBIS**[24]		
Model organisms/ genetic databases		**X**				**X**	**EMBRC**[25]		**JERICO (Project - Joint European Research Infrastructure network for Coastal Observatories)**
Plankton databases		**X**							
Ferryboxes		**X**		**X**					
Fish captures		**X**					**EU Fisheries Data Collection Framework**		
Satellite Remote Sensing									

24 European Ocean Biogeographic Information System

25 European Marine Biological Resource Centre

III. 2. More detailed Description of the European landscape of MRIs

III. 2.1. The national level

Marine research centres / coastal observatories located at national level are essential building blocks of the European marine observation landscape. Most research centres / coastal observatories are usually interdisciplinary and might have MRIs collecting a range of physical, chemical, biological or geological data[26], which are then processed in models to understand complex oceanographic processes. They therefore usually cover the 3 stages of the data processing chain: 1) data collection, 2) data storage and management and 3) data integration and use.

Despite a growing trend towards interdisciplinary marine research integrating physical and biogeochemical data, marine research centres / observatories might also have a certain focus in their MRIs (e.g. on marine biological and genomic data in relation to research on ecosystems and biodiversity, or on physical / biochemical data in relation to oceanographic forecasts… etc.). One can in particular distinguish coastal observatories with biology / genomics focus from observatories which model oceanographic processes using physical and biogeochemical data.

The nature and number of MRIs managed by marine research centres / observatories will give them a more or less extensive geographical coverage (local / coastal, or regional / open Ocean…). Oceanographic vessels can have a coastal, regional or global range. Fixed platforms (such as moorings, buoys or cabled seabed observatories equipped with a range of sensors) produce frequent measurements in a specific zone, while drifting platforms (like Argo floats or gliders) will cover broad three-dimensional areas.

Some of their MRIs contribute to European scale distributed MRIs (Euro-Argo, EMSO, EURO-SITES, EMBRC) or simply to European networks of MRIs. These European scale MRIs or projects are described in the following chapter. Many of these MRIs are however not integrated at European level. A more precise inventory of MRIs existing at European and national levels has been made by the marine research ERA-Net SEAS-ERA[27].

Besides being the backbone of the European ocean observation capacity, marine research centres and observatories also contribute to innovation in ocean observation, improving the coverage and cost-effectiveness of marine observation at all levels of the data processing chain. They do it often in cooperation with local SMEs.

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26 Marine scientists refer to biological, chemical and geological data as biogeochemical data, whichreflects the integrated approach used to model complex oceanic processes.

27 SEASERA Project - D 4.1 Marine Research Infrastructures updated overview, European integration and vision of the future.

III. 2.2. European scale MRIs

<u>ESFRI</u>

The European Strategy Forum on Research Infrastructures (ESFRI) is a strategic instrument created in 2002 by the European Commission and the Member States to support a coherent and strategy-led approach to policy-making on research infrastructures in Europe and to facilitate multilateral initiatives leading to a better use and development of research infrastructures. In 2004 the Council gave ESFRI a mandate to develop a strategic roadmap for Europe in the field of Research Infrastructures. A first roadmap was produced in 2006 with a list of European scale research infrastructures of vital importance, which was subsequently updated in 2008 and in 2010.

Among 38 infrastructures identified in the last roadmap, 3 are distributed marine research infrastructures (Euro-Argo, EMSO, EMBRC) while 4 others have a substantial marine component (ICOS, LIFEWATCH, ECCSEL, SIOS).

Being the result of a long institutional selection process, ESFRI projects have a high visibility and benefit from Commission support in their preparatory phase. It is expected that Member states should provide financing for their construction and operation. In its 2010 Communication on "Innovation Union", the European Commission set the target that 60% of ESFRI projects should be initiated or constructed by 2015.

As indicated in table 4, Euro-Argo provides European governance for the Argo floats deployed by different European countries / research institutes and it constitutes Europe's contribution to the global Argo program. EMSO provides European governance for a number of seabed observatories (still under development). EMBRC will provide access to model marine organisms and related genomic resources distributed across a network of European marine research stations.

Euro-Argo- Deployment of an autonomous profiling float

Euro-Argo and EMSO are developing a European Governance structure (European Research Infrastructure Consortium-ERIC) to manage the distributed infrastructure. EMBRC is considering a similar development.

<u>Non-ESFRI</u>

Many marine research infrastructures were developed in the framework of research projects, supported either by the Research Framework Programme or by national research programmes.

Most of these projects, like Eurofleets, Euro-Sites or Groom, seek to develop European governance for distributed infrastructures (harmonisation of operational conditions, coordinated management and investments…). Although they must be assessed on their individual merits, they may have potentially similar societal or scientific impact as the ESFRI projects.

Fisheries data collection

As shown in table 2 (core variables for the UK Integrated Marine Observing Network), data on fish capture, species and stocks are essential for the assessment of ecosystems' health and productivity.

Since 2001[28], the EU has funded the collection and dissemination of biological and economic data on EU fisheries by national authorities. Data are collected through a combination of fish landing reports and scientific assessments using research vessels. The primary purpose is to support management of the Common Fisheries Policy although a revision in 2008[29] not only extended the data to the aquaculture and processing sector but widened access for scientific or public awareness purposes. In that Data Collection Framework (DCF), each member state must build databases with collected fisheries data to ensure access and availability of data.

The DCF also includes an obligation to collect data supporting the setting of indicators that give information on the state of marine ecosystems. In that regard, it can support the implementation of the MSFD.

Satellites and remote observation

Satellite and airborne remote sensing are important and cost-effective means to acquire a number of key variables such as sea surface temperature, colour or sea level. These are essential variables used on a daily base by oceanographers to produce the services / products needed by end-users.

Satellites and infrastructures allowing such measurements are generally jointly owned by member states of the European Space Agency (ESA) and managed by European Agencies. Satellites and infrastructures providing remote sensing of ocean surface properties (or close to the surface) are broadly well developed. The main challenge regarding these infrastructures is to sustain their financing as well as the financing of the missions that delivers key data/services for marine scientists and stakeholders.

III. 3. Marine data management infrastructures

III. 3.1. European level

SeaDataNet

The initiative for developing a Pan-European infrastructure for ocean and marine data management started as Sea-Search project under FP5 (2002 - 2005) with a focus on metadata and was continued under FP6 (2006 - 2011) as SeaDataNet with a wider focus including harmonised access to data. It is continued under FP7 (2011 - 2015) as SeaDataNet II with a focus for making the infrastructure more

28 Council Regulation (EC) No 1543/2000

29 Council Regulation (EC) No 199/2008 of 25 February 2008

operationally robust, fully INSPIRE compliant[30], and interoperable with other infrastructures.

SeaDataNet is undertaken by 40 National Oceanographic Data Centres (NODC's), national oceanographic focal points, and ocean satellite data centres, essentially divisions of marine research institutes, from 35 coastal states bordering the European seas. SeaDataNet has focused on establishing common standards and on applying those standards for interconnecting the data centres enabling the provision of integrated online access to comprehensive sets of multi-disciplinary, *in situ* and remote sensing marine data, metadata and products. The SeaDataNet architecture has been designed as a multidisciplinary system from the beginning, which is able to grow by integrating more marine data sets. It is able to support a wide variety of data types and to serve several sector communities. SeaDataNet is also actively sharing its technologies and expertise, spreading its standards and tools to other EU-funded projects, with a view to secure interoperability and achieve cross fertilisation between them. It is also building bridges to other well established infrastructures and initiatives in the marine domain (like EuroGOOS, GMES Marine Services).

EMODnet

The European Marine Data Observation Network (EMODnet) project was launched in 2007 under the EU Integrated Maritime Policy Action Plan. It is meant to be a pan-European infrastructure for access to (and integration of) quality controlled and harmonised marine data. It was further defined in 2010 in the context of the Marine Knowledge Communication[31], in which three objectives have been set for it:

1. To reduce operational costs and delays for those who use marine data;
2. To increase competition and innovation amongst users and re-users of marine data by providing wider access to quality-checked, rapidly available coherent marine data;
3. To reduce uncertainty in knowledge of the oceans and the seas and so providing a sounder basis for managing future changes.

This should help private industry compete in the global economy, meet the challenge of marine industries' sustainability, improve the quality of public decision-making at all levels, and strengthen marine scientific research.

EMODnet builds on SeaDataNet, following the same principles, but extends its scope and seeks to make it permanent. At this stage, EMODnet does only deal with data management. Interconnection with observing systems as well as structural data mining are not tackled for the moment. EMODnet is not primarily aimed at incorporating value added services for end-users. It is conceived as an underlying infrastructure, which will be used as a basis for service providers (such as MYOCEAN or for the "Wise Marine" reporting tool system set up by DG Environment for the MFSD). Overall long term objective is to assemble fragmented and inaccessible

30 The INSPIRE Directive, 2007/2/ EC, established an infrastructure for spatial information in Europe to support Community environmental policies, and policies or activities which may have an impact on the environment. It is based on the infrastructures for spatial information established and operated by the 27 Member States of the European Union. The Directive addresses 34 spatial data themes needed for environmental applications, with key components specified through technical implementing rules.

31 COM(2010) 461 final

marine data into interoperable, contiguous and publicly available data streams for all European seas.

To further the aims set out, the Commission launched preparatory actions. These aim at setting up portals to grant access to certain types of data over a number of maritime basins. 3 year data pilots started in 2009, harvesting from DG Research data on Geology (EuroGeoSurveys consortium), Chemistry (SeaDataNet consortium), Biology (EurOBIS – MARBEF consortium), Hydrography (sub SeaDataNet consortium), Marine Habitats (JNCC consortium) and Physics (Euro-GOOS consortium).

Additional funding is arranged for more data pilots as well as extending and operating existing pilots in 2012-2014. Calls for tender have been launched in 2012 for the following areas: geology, bathymetry, chemistry, human activity, physics, habitats, biology.

The emergence of EMODnet has served as a catalyst for more convergence and cooperation among several data expert communities, further consolidating SeaDataNet's achievements in that respect.

A green paper has just been adopted by the European Commission on "Marine Knowledge 2020, from seabed mapping to ocean forecasting"[32]. With this public consultation, the Commission aims at further shaping a vision for EMODnet, shared with member states and marine stakeholders.

WISE-Marine

WISE-Marine is the extension of the Water Information System for Europe (WISE) to the marine environment. It is managed by the European Environment Agency (EEA) and it is intended to be a comprehensive and shared European data and information management system on the state of the marine environment which supports implementation of the MSFD. It will in particular be used by Member States for the reporting and subsequent dissemination of an initial assessment of marine environmental status, definition of good environmental status, environmental targets, monitoring programmes and measures. It is expected to have links to EMODnet and other infrastructures where data relating to MSFD monitoring and assessments may be held.

Marine Bio-informatics infrastructures

The Marine Bioinformatics Infrastructure must reflect the integration need mentioned above between biological field data (gathered by marine stations/labs), environmental data and "Omics's" data[33] often produced by sequencing techniques and molecular methods. At European level, it is has two poles:

- EMBRC (The European Marine Biology Resource Centre), which provides for integrated data acquisition facilities (diversity analysis, model organisms, genomics). The main existing marine biological laboratories will be integrated within this research infrastructure to provide access to model marine organisms, their ecosystems and genomic resources.

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32 COM(2012) 473 final

33 "Omics" data refers to gene sequencing data in the widest sense.

- ELIXIR is the ESFRI Infrastructure for Biological Information. It should construct and operate a European Infrastructure for Biological Information to support life science research and its translation to medicine and the environment, the bio-industries and society. ELIXIR is organised in domain specific nodes, including one for the marine environmental bioinformatics. It is still in its preparatory phase and the beginning of its construction is planned by the end of 2012.

A more detailed description of this area as well as related challenges and recommendations can be found in the European Science Foundation (ESF-Marine Board) Position Paper 17: Marine Microbial Diversity and its role in Ecosystem Functioning and Environmental Change[34].

III. 3.2. At member states level

Sustaining long time series of data

Data on the marine environment are a valuable asset. And long-term trends can only be distinguished from seasonal changes and decadal-scale natural variation if observations from the past including those collected before the advent of digital storage devices can be compared with those of the present. If these data are lost they are gone forever; the observations cannot be repeated.

Accordingly a number of Member States are in the process of setting up national processes for a proper stewardship of data that ensures not only safe archiving but also cataloguing using standards and technology allowing retrieval of data through automated processes. These national systems are the foundations of the distributed processes that are being built up at an EU-level. The development of National Oceanographic Data Centres (NODCs) is particularly important in that respect.

III. 4. Large integrated Marine data infrastructure initiatives

GMES - MyOcean

GMES (Global Monitoring for Environment Security) is a major end-to-end initiative, from data acquisition (essentially satellite remote sensing at the moment), till the delivery of core services through data assembly and assimilation into forecast numerical models.

MyOcean is a FP7 project from the Space thematic priority to develop the GMES marine component. It ran from March 2009 to March 2012, with a budget of 18 M€ / year (11 M€ / year provided by the EU). The MyOcean2 project ensures a continuation of service provision until the end of 2014, as preparation for the transition to the GMES operational phase post 2014. The rationale of the project is to transform upstream marine data provided by satellites and in-situ measurements (like those provided by EURO-ARGO) into ocean analyses and forecasts released operationally every day for the global ocean and European regional seas. It is part of the 3 "fast track" core services (security, land, marine) to be set-up within GMES.

34 http://www.marineboard.eu/images/publications/Microbial%20Diversity-117.pdf

The Marine Core Service set up by MyOcean is public services with "generic products" (sea level, ocean colour, sea ice, 3-dimensional temperature, salinity and current fields), as opposed to downstream tailored information services, which could be developed on a commercial basis, making use of core services and data. It is therefore geared towards intermediate users / downstream service providers, not end-users.

MyOcean services can potentially be relevant in 4 areas: maritime safety, marine and coastal environment, marine resources, weather / climate / seasonal forecasting.

The vision and overall goal of MyOcean is a cyber-infrastructure with a comprehensive marine monitoring and forecasting capacity (data acquisition, data storage and management, data visualisation). Its key challenges are 1) to produce operationally harmonised and quality controlled ocean analyses and forecasts from the global to the regional seas scales; 2) a stable and well-designed interface with the data collection initiatives e.g. ESFRI marine infrastructures, future MRIs and EMODnet. It presently largely deals with physical parameters and some biogeochemical parameters delivered in real time. It also provides re-analysis data sets. SeaDataNet and MyOcean have established a Memorandum of Understanding, which provides inter alia that MyOcean adopts SeaDataNet standards and makes use of SeaDataNet for quality control, harmonisation, long term archival and access to ocean and marine observational data that are relevant for the scope of MyOcean.

The European environment Agency - EEA is the co-ordinator for the in situ component of GMES (through the FP7 project GISC – GMES In-Situ Coordination). It has set up a partnership agreement with Euro-GOOS (see next paragraph) to ensure that the EEA and Euro-GOOS work together to develop sustainable access to in situ data to meet the requirements of the GMES Marine Service.

Euro-GOOS

Euro-GOOS is an Association of Agencies, founded in 1994, to further the goals of the Global Ocean Observing System (GOOS), and in particular the development of Operational Oceanography in the European Sea areas and adjacent oceans. Today Euro-GOOS has 34 Members in 16 European countries, and a permanently staffed office coordinates its work. Euro-GOOS is established with full recognition of the importance of existing systems in research and operational oceanography in Europe at national and European scales. It provides a coordinated European approach and response to discussions and initiatives at a pan-European level, and to that extent it interacts with the European Commission and other international and intergovernmental entities.

Members of Euro-GOOS are playing a leading role in all ocean monitoring and forecasting projects and initiatives in Europe such as MyOcean, EuroARGO, JERICO[35], EuroSITES etc., especially through commitment of national operational and research infrastructures.

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35 JERICO (Joint European Research Infrastructure network for Coastal Observatories) is an EU-FP7 funded project, which aims at creating a network of coastal ocean observatories and at improving synergies between them as well as creating harmonised procedures for data collection by some of the marine research infrastructures they operate. As part of a broader

IV. ANALYSIS OF THE SITUATION: TRENDS AND GAPS

IV. 1. Societal and policy needs – key parameters – European scale MRIs

Oceano-meteorological buoy at the Bay of Palma

Any analysis of gaps and needs related to European scale MRIs / initiatives should start with societal and policy needs, then determine the key parameters that should be collected to respond to these needs, and finally the MRIs that are needed to collect in the most effective way these parameters. In this way, it would be possible to assess to what extent existing MRIs or initiatives help meet the identified needs.

This report has proposed to categorise the needs at European scale in four main areas:

1) stewardship of the marine environment,

2) understanding ocean / climate interactions to predict and adapt to climate change impacts,

3) supporting the maritime economy,

4) marine safety.

A preliminary analysis of key marine parameters to be measured at European scale has been undertaken and is shown in **Annex 7**. It shows qualitatively how main European scale MRIs fit with the societal needs identified. Areas 3 and 4 have been merged in this table into one big area corresponding to socio-economic needs.

The following are big emerging trends and gaps, in relation to the societal needs identified:

- In-situ MRIs represent the biggest area of gaps and this is where efforts should concentrate. Satellite remote sensing is much more advanced technologically and in geographical coverage and the challenge is to sustain these infrastructures (sentinel missions), which provide the marine core services of GMES;
- Within the scope of in-situ MRIs, biological sensing to characterise ecosystem health and pressures on marine biodiversity are a big gap area. There is a strong trend in marine research centres towards inter-disciplinary research based on integration between physical / biogeochemical and biological (genetic) data and these efforts should be furthered to bridge the gap between marine biology / ecology and oceanography;
- The Marine Strategy Framework Directive (MSFD) will be one of the most important policy drivers for MRIs development at European scale in the coming

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set of European observation initiatives focussing on different ocean areas, JERICO fills the gap existing regarding coastal observation. http://www.jerico-fp7.eu/

decade(s). Besides the pressures on biodiversity that it addresses, attention will need to be paid to new pressures like noise and marine litter.

IV. 2. Governance of European scale MRIs and initiatives

The landscape of European scale MRIs and initiatives is too complex, with the marine component of GMES, EMODnet, marine ESFRI infrastructures evolving as ERICs, projects aiming at creating European governance for other categories of MRIs, networks of marine research institutes like JERICO and MARS[36], and a number of organisations involved in this governance like EURO-GOOS and the EEA… This complexity hinders the development of a coherent European capacity for marine observation.

The current Commission consultation on "Marine Knowledge"[37] provides an opportunity to build a coherent vision for European marine observation, building on EMODNet and the marine component of GMES, as well as on main European scale MRIs. Such a vision should be driven by societal needs at European level, the identification of key parameters and a baseline of European scale MRIs to be sustained, the need to consolidate the existing governance structures, in order to implement this vision and /or ensure convergence between the different governance structures.

IV. 3. Technological developments – gaps and foresight

IV. 3.1. Data collection

Technologies for data collection (sensors, ROVs, AUVs, gliders) have progressed considerably in the past 15 years and will continue to do so in the coming decade(s). This has profound consequences both on the ability to monitor the oceans and on the use of some infrastructures like oceanographic vessels.

Gaps in marine observation capacity can result from 3 challenges:

1) Technological gaps, i.e. technological inability to measure a given parameter, e.g. bio-toxins in real time. This can possibly be overcome by research efforts.

2) Cost effectiveness. A technological solution might exist but is too costly for a broad deployment. This can also be possibly overcome by research to reduce costs (e.g. miniaturisation) as well as by deployment at large scale, which can reduce costs.

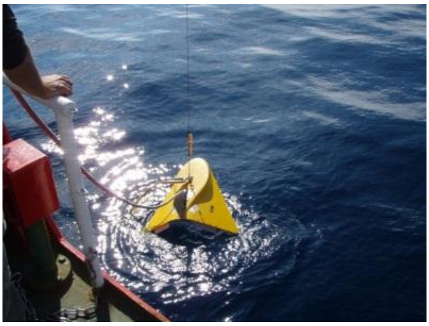
3) Political decision making. The technology might exist at reasonable cost, but policy makers have not made the decision to finance or sustain its deployment. This

36 The MARS network is a foundation gathering Europe's marine research stations. MARS member institutes are world leaders in fundamental marine research and have important research facilities available that allow direct access to the ocean. MARS members are located all over Europe, along the shores of the Atlantic Ocean, the North, Irish, Baltic and Adriatic Seas, and the Black and Mediterranean Seas.

37 COM(2012) 473 final

can be overcome by building a case for the socio-economic value of investing in MRIs.

An analysis of existing technological capabilities for marine data acquisition with a foresight of challenges / developments to come, inspired from the report by the US National Research Council "Critical Infrastructure for Ocean Research and Societal Needs in 2030", is provided in **Annex 3**. It identifies, for each category of MRIs, key existing challenges as well as a foresight of future challenges and developments to come.



Sampling of large water volumes with a tow fish for analysis of organic micropollutants

A detailed gaps and needs analysis regarding the in-situ component of GMES has been undertaken by the GISC project, under the coordination of the European Environment Agency and in cooperation with EURO-GOOS and it provides useful information[38].

The following are most important observations, identified gaps and incoming developments.

In situ / remote sensing

- Sensors are becoming more sensitive and reliable. Although cost of some of these sensors has been considerably reduced, it remains in general an issue as cost reduction can only happen with a broad deployment.
- The development and improvement of new sensors is a crucial and innovative area where Europe has a lot of technological strengths, essentially localised in marine research institutes. The continued development and innovation in sensors' technology requires a consolidation of SMEs that produce them and of the cooperation between these SMEs and marine research institutes (or multidisciplinary teams of marine researchers and engineers).
- There are still big gaps in biochemical sensors, needed to respond to new needs generated in particular by the MSFD. Research and deployment efforts are also needed to fill the gaps regarding the assessment of new pressures like noise and marine litter.
- Remote sensing from satellites or planes is in comparison well developed and cost effective. It allows measurement of parameters like ocean colour sea surface temperature, waves, sea level…. In the current situation, the challenge is to ensure that this capacity is sustained.
- The recent development of marine acoustics e.g. through higher resolution for biomass tracking could make them an increasingly important tool for Marine Ecosystem science and management into the future, in conjunction with other observing technologies.

38 Reference of the EEA – GISC study

Mobile / submersible and fixed platforms / Autonomous and drifting-systems

- The development of AUVs / gliders, with higher autonomy, guidance precision and manoeuvrability has opened and is continuing to open immense new possibilities for ocean exploration and monitoring (physical, biochemical, seabed mapping…).
- These developments, together with progress in in-situ sensors, changes the role of oceanographic vessels, since it is easier to acquire data with in-situ sensors on appropriate platforms (when technologically possible) than through sampling from vessels.
- Oceanographic vessels remain indispensable for big sampling campaigns, deployment of floats, gliders, ROVs, seabed mapping… etc. Consideration should also be given to the integrating and stimulating scientific role that research vessels play by bringing together interdisciplinary and international teams. In that regard, it is important to note that a big part of European regional oceanographic vessels will reach end-of-life in the coming years, which might create an important gap. A careful analysis of the gaps and needs created by this situation, based on the work done by Eurofleets, is necessary.
- Vessels of opportunities have also developed in the past 10 years. Besides the CPR (Continuous Plankton Recorder) programme, which has 80 years long time series, a ferry box programme is now running mainly in Northern Europe. Although such programmes are geographically limited by the fixed transects covered by the vessels, they can provide useful and cheap routine measurements of some physical and bio-chemical parameters. The use of fishing vessels as vessels of opportunities can also open further possibilities.
- Despite a lot of acquisition of bathymetric data, there are still considerable gaps in seabed mapping of European seas. Firstly, a lot of bathymetric data were acquired in a fragmented way (e.g. by the navies) and are not usable / accessible. Secondly, despite the availability of seabed mapping technologies (multibeam echosounders), only a few countries have mobilised the necessary platforms (vessels) and equipment to undertake a complete and systematic mapping of their waters' seabed.

ESFRI / Non-ESFRI marine research infrastructure projects

- Marine ESFRI projects are at different stages of development but most of them are ending their preparation phase. Despite the fact that the Commission has fixed the objective that 60% of the ESFRI projects should be implemented by 2015, there are still uncertainties on the funding of the construction phase and for their sustained financing. The situation is similar for non-ESFRI European scale MRIs like EURO-SITES or Ferry boxes.
- In this situation, it is important to adapt as much as possible the development of European scale MRIs to the EU policy objectives (EU 2020) and societal needs (for instance those identified in Joint Programming Initiatives). This would facilitate financing by member states and / or by regional authorities.
- It is unavoidable that a European process of prioritisation of funding for European MRIs is put in place. This could be made in the framework of JPI Oceans, with the support of competent organisations.

- Interdisciplinary infrastructures like EMBRC, which integrate biological data on marine organisms, environmental data on ecosystems and related genomic resources, have the potential of generating breakthroughs in the assessment of the Good Environmental Status of the seas, particularly as regards pressures on biodiversity. Building on existing genomic techniques (e.g. species identification using marker genes (barcoding), metagenomics to study the biodiversity and function of whole ecosystems, genomic response of species to pressures…), new genomic observatories could develop and pursue the genomic characterisation of ecosystems, as well as modelling of biodiversity dynamics in the framework of Earth Observation systems.

Mobile platforms:The NERC research ship,
the RRS James Cook, in South Georgia

Deep sea glider deployement

IV. 3.2. Data Management

<u>EMODnet and SeaDataNet</u>

The European Commission, in its 2010 Marine Knowledge 2020 Communication[39] recognised the importance of marine knowledge but pointed out that more needs to be done if the EU's 1.5 billion euro / year of public funding in marine data is to contribute towards the Europe 2020 goals. It observed that the data are held by hundreds of different institutions in the EU - hydrographic offices, geological surveys, local authorities, environmental agencies, research institutes, universities. Finding out who holds the data was already a major challenge. Obtaining them can take weeks of negotiation and putting them together to provide a complete picture is even more demanding.

There are two main types of obstacles to the accession to marine data: 1) Lack of harmonised standards and interoperability between different marine data sets on the same parameters, 2) obstacles to accede to existing data for confidentiality or commercial reasons.

As regards harmonisation of standards and interoperability, there has been a considerable progress with SeaDataNet I and II, which has developed standards and protocols for data exchanges, a common lexicon widely shared in the marine scientific community. Similarly the INSPIRE Directive provides a drive for the further harmonisation of marine data.

As regards access to marine data, a distinction should be made between data collected with public funds and data collected by the private sector:

- Despite the European legislation on access and re-use of data, there are still considerable obstacles to the free access to data collected with public funds. This is the case for instance with regard to fisheries data, notwithstanding the fact that the EU contributes half of the funding for their collection. This is also the case for data from research projects where competition for the publishing of results incite researchers to seek to keep data long after they have collected.
- As regards marine data from the private sector, if a private company collects data for its own purposes then, in principle, there is no reason for public authorities to intervene or interfere. However, private companies are already obliged to collect data as part of the impact assessment that is necessary to obtain a licence for certain offshore activities, and once operational, to undertake on-going environmental monitoring. And in many cases they are obliged to handover the data to the licensing authority. Once the licence has been granted, there is no apparent competitive disadvantage in releasing these data to the public domain and, in the case of ongoing monitoring data, there is good reason to have this in the public domain. There is also a case for extending obligations once the licence has been granted. The additional cost of instrumenting offshore platforms to provide continuous information on the state of the sea is small and less than the potential benefit to the whole offshore industry of obtaining better knowledge on the marine environment.

EMODnet builds on SeaDataNet to allow access to and integration of marine data from a progressively larger number of datasets across sectors and countries. But it remains to be seen how EMODnet can overcome obstacles on the access to marine

39 Marine Knowledge 2020: marine data and observation for smart and sustainable growth, 8.9.2010 COM(2010) 461 final

data and create the impetus for a continuously enlarged access to distributed data centres. An analysis of the obstacles on such access and options to surmount them should be made in the framework of the ongoing Commission "Marine knowledge" consultation.

The cost of storing and managing data must also be dealt with. At the moment, marine research organisations, which collect data, are expected to store them and make them available in appropriate format as needed. But they are often not explicitly funded for this service. It is crucial that these costs are budgeted as the proper management of data is indispensable to their further use and to maximise the impact of the investment that their collection represent. The UK Natural Environment Research Council (NERC), for instance, insists that the cost of storing data is budgeted by research organisations. This can be a way to ensure a proper management of collected data although it poses a dilemma for research organisations as the management of marine data can come at the expense of data collection.

The ongoing consultation on marine knowledge launched by the European Commission provides an opportunity to further shape a vision for EMODnet including the necessary convergences with GMES, marine ESFRI infrastructures and WISE-Marine. It should also take into account the necessary linkage with the global framework provided by the International Oceanographic Data and Information Exchange (IODE) and initiatives like the Global Ocean Observing System (GOOS).

WISE-Marine

There are ongoing discussions between the Commission, EEA and member states regarding the relationship between EMODnet and the development of WISE Marine, with a view to streamline access to the data from MSFD implementation and ensure INSPIRE compliance of the data produced. This convergence between EMODnet and WISE Marine is an important part of a coherent vision for the integrated management of marine data in Europe.

Fisheries data

Fisheries data represent an important category of marine scientific data. Besides being necessary to provide fisheries advice under the CFP, they are also needed to assess the status of commercial fish for the MSFD and useful to assess pressures on biodiversity and other descriptors of the MSFD including seafloor integrity and food webs. Whilst fisheries data are collected at national level, fisheries advice and scientific assessments in relation to the CFP and MSFD typically require data from more than one country. The EU Data Collection Framework (DCF) for Fisheries is an important asset for Europe. The recent developments of the regulatory framework for the DCF have the potential of turning it into an effective tool for scientific research, the assessment of fish stocks and impacts on ecosystems. However there are still significant obstacles to that objective, related in particular to the proper setting of national databases for fisheries, the harmonisation of data formats, the free access to data for researchers / environmental managers across the EU and the extension of data collected to cover impacts on related marine ecosystems. These difficulties have been identified within the DCF framework and it is crucial that measures are implemented together with member states to overcome them. Not only would it improve the cost-effectiveness of the DCF investment but it would in addition maximise its use, particularly regarding the monitoring of other biodiversity indicators for the MSFD.

Marine bio-informatics infrastructure

As mentioned in the previous chapter, the mission of ELIXIR (the ESFRI Infrastructure for Biological Information) is to construct and operate a European Infrastructure for Biological Information to support life science research and its translation to medicine and the environment, the bio-industries and society. ELIXIR should act as a long-term data repository for marine biological, environmental and genomic data gathered in particular in the framework of EMBRC. It should provide harmonised standards even between disciplines and ensure interoperability and public access. EMBRC and ELIXIR are cornerstones for the emerging genomic observatories as they would provide the appropriate logistical and data storage / processing for coordinated site-based research with high volumes of sequencing.

The Genomics Standards Consortium (GSC) was created in 2005, with the goal of promoting mechanisms that standardize internationally the description of genomes and the exchange and integration of genomic data. This work is being mainstreamed in marine genomics, internationally and in Europe. In September 2012, the GSC officially launched the international network of Genomic Observatories, which includes an increasing number of marine genomic observatories, among which coastal observatories participating in EMBRC. This development should facilitate the introduction of the standards proposed by the GSC into Marine Genomics and Monitoring.

Legal obstacles for global coverage by MRIs

Many ocean challenges have a global dimension and require data collection across borders. The legal framework for the collection of data is provided by UNCLOS (United Nations Convention on the Law of the Sea). There are still legal obstacles collection of marine data across maritime borders with mobile platforms (like oceanographic vessels or gliders), particularly with third countries in shared seas.

IV. 3.3. Large integrated initiatives

GMES - MyOcean

Currently the GMES Marine Core Services rely on satellite data and in-situ data collected by ARGO and ships of opportunity. In-situ infrastructures provide a small part of the data needed for marine observations and GMES. In the future, coastal data collected at national level will be used by the Marine Core Service.

The Marine Core Service produces analyses for monitoring and forecasts, at surface and at depth, primarily physical oceanographic parameters: physical state (temperature, salinity, currents, sea level, waves) and, when feasible, biogeochemistry (Chlorophyll-a, nutrients, oxygen). GMES-MyOCEAN can contribute to address some of the MSFD needs, as some required indices (upwelling and mixing indices, residence time, temperature and salinity annual mean levels…) are computed by Member States from Marine Core Service products to assess the Good Environmental Status.

The gaps analysis on in-situ marine data conducted by the GISC – EEA project has shown that in-situ data coverage for the Marine Core Service is often inadequate. Existing observation systems do not fully meet the need for assimilation and validation in order to advance the quality of analyses and forecasts. The absence of near real time river runoff data is a serious gap and it will increase when the Marine Core Service moves further into ecological modelling.

The study found that, in order to deliver its services, GMES needs sustained input from (and financing for) EURO-ARGO, EURO-SITES, new and/or improved ferry boxes, gliders, HF radars. The absence of an organisation and coordination at European level of these in-situ infrastructures is also a problem to be addressed in the long term.

If these gaps are addressed, GMES will become the essential system at European level for operational oceanography, responding to needs described before.

Coastal observatories

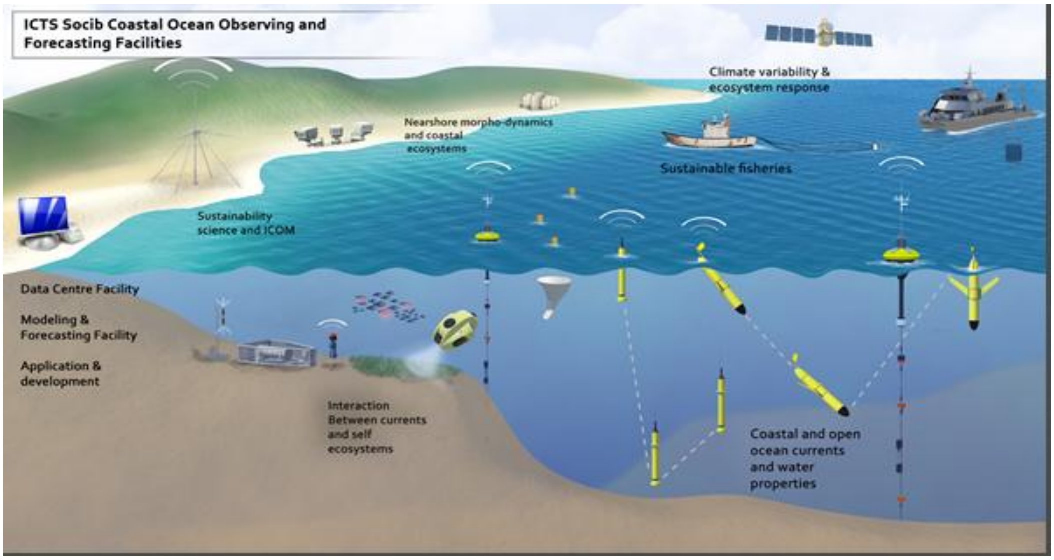
Coastal observatories can have both a local dimension by contributing to addressing local societal issues and a regional sea dimension. They can also contribute to addressing global scientific issues like ocean climate variability.

New needs like those generated by the MSFD will necessitate a stronger focus on MRIs corresponding to high gaps areas (biological data, pressures on biodiversity, contaminants, noise…).

Synergy and integration between coastal observatories is needed:

1. at regional seas' level to better respond to socio-economic and MSFD challenges and improve cost effectiveness of marine observation,
2. at European level to harmonize standards and protocols as well as to exchange good practices. The work undertaken by JERICO will be important in that respect.

SOCIB – an example of coastal observatory with regional dimension



SOCIB (the Balearic Islands Coastal Observing and Forecasting System) is a multiplatform distributed and integrated marine system. It is a facility of facilities, an interesting example that covers all levels of the marine data chain since it is structured with:

- Observation Facilities: New Coastal Research Vessel/HF Radar/Gliders and AUV's/Moorings, tide gauges, ARGO and surface drifters, nearshore beach monitoring and satellite products
- Forecasting Facilities: Ocean currents, Regional Ocean Modeling System (ROMS) and Simulating Waves Nearshore (SWAN) at different spatial scales, forced by Weather Research and Forecasting (WRF) and ecosystem coupling with nutrient-phytoplankton-zooplankton (NPZ)
- Data Centre Facility: Quality control and Web access in open source/Effective data Archiving

SOCIB has developed along 3 key drivers: Science Priorities (scientific excellence), Technology Developments and Strategic Society Needs. Besides addressing key scientific questions on oceans and climate change, coastal ocean processes and ecosystem variability, SOCIB addresses societal issues and provides societal benefits e.g. in the field of:

- Marine and Coastal Environment: Water quality in coastal areas, beach erosion and sediment transport, Integrated Coastal Zone management, pollution management, marine debris, coastal impacts;
- Marine Safety: development of science based decision support tools, search&rescue operations at sea, response to spills and mitigation procedures at sea and at the coast;
- Climate and Seasonal Forecasting: ocean climate variability and indicators, sea level changes and impacts on coastal zone, ecosystem response and variability in the Mediterranean.

Geographical gaps – the Mediterranean and the Black Sea

The Black Sea is generally under-observed as compared to other European seas. There are considerable gaps in MRIs, which hinder the ability to monitor the environment and its variability. There are for instance only two regional-scale oceanographic vessels available and they are both more than 50 years old. It is important to draw the attention of policy makers to this situation, and to highlight the value of investing in MRIs to tackle societal challenges like the GES of the sea and better knowledge of climate change impact on biodiversity hotspots like the Danube delta.

The situation is more nuanced as regards the Mediterranean, with strong observing capabilities in some geographical areas and important gaps in the Southern & Eastern Mediterranean. There are also disparities between EU countries.

Given that challenges like the marine Good environmental Status must be tackled at sub-regional seas level, it is important to develop regional monitoring strategies, which can maximise the impact and value of marine observation infrastructures to be developed.

Capacity building in third countries is an important part of such strategies. A better coordination of bilateral scientific cooperation of member states with third countries could help focus them and maximise their impact towards shared key regional objectives.

IV. 4. Funding MRIs

IV. 4.1. Split of funding roles between EU and member states

In the split of funding responsibilities, the Commission uses EU research funds to support preparatory actions for MRIs of European dimension as well as actions for networking / integration of distributed MRIs at European level. EU funds are also mobilised for GMES and EMODNET, which provides a platform giving access to marine data across Europe.

Member States are supposed to provide funding for MRIs, whether they are localised or distributed, including ESFRI projects. They also provide funding for their marine data management infrastructures (e.g. National Oceanographic Date Centres). They can use EU funds like structural funds to that purpose.

IV. 4.2. Use of structural funds for MRIs

Structural funds are allocated to member states / regions, according to their average income per capita.

The decision to then allocate these funds to programmes / projects is then taken by member states and regions. A study commissioned by the European Commission has shown that many MRIs across Europe have been co-funded by structural funds. There are also unused opportunities for funding MRIs with structural funds. However there are obstacles to such funding too:

- There is often a lack of awareness within scientific organisations of funding opportunities for MRIs within structural funds. There is also unawareness among structural funds managers of the socioeconomic value of some MRIs.

- When they apply for funding of an MRI with structural funds, it is not enough for scientists to build a scientific case for the infrastructure. Structural funds have their own rationale and can only be granted to projects, which can demonstrate socio-economic impact. A serious effort to assess and convey the socio-economic value of the MRI is therefore required, which is not easy for scientists.
- An MRI could receive funding from several sources (EU, member states at central level, regions with structural funds) and it is not easy to coordinate these different sources of funding.
- This is particularly challenging when the MRI that requires funding from structural funds is an ESFRI distributed infrastructure (like EMSO or EMBRC). In that case, the coordinators must reconcile their European planning and scientific rationale with the regional dimension and socio-economic rationale of the structural funds.

A "brokerage event" between EMBRC partners and regional authorities, organised in March 2012 by the European Commission and the Conference of Peripheral Maritime Regions (CPMR) has confirmed both the existence of such difficulties and the financing opportunities when an effort is made to bridge the gap between the two.

These opportunities will be even higher in the (2014-2020) period, as the new structural funds regulations put an even higher focus on research and innovation. More than 25% of a total amount of ~ € 330 billion of structural funds will be dedicated to research and innovation related actions. But efforts will be necessary to overcome the obstacles mentioned previously.

IV. 4.3. Funding from the private sector – possible synergies

Marine industries need marine data. This is the case for established industries like oil and gas industries, shipping and classification companies and high growth industries like offshore wind or aquaculture, which spend considerable amounts of money in environmental impact and risk assessments.

A distinction should however be made between mature industries (e.g. oil & gas and shipping), which have accumulated data and generate high revenues, and new industries, which need data and cash for their growth. The offshore wind industry in particular is expected to invest hundreds of billions of Euros in the coming decades and it is in strong need of marine data to reduce the risks and improve the value of these investments. An initiative triggered by a group of offshore wind related companies seeks to develop an Integrated Seas Information System (ISIS) that could respond to the needs of offshore winds developers, while diminishing the cost of data collection for them.

Overtime, some of the mature industries with offshore activities have constituted important marine databases. For instance, Det Norsk Veritas (DNV) manages four marine databases with important environmental, bathymetric and geological data[40].

40 These are:

The Marine Resource Database: database with environmental resources in coastal and marine areas vulnerable to oil pollution. The database belongs to Oil & Gas Industry and Coastal authorities and is used by Industry and coastal authorities for environmental impact or risk assessments and oil spill response planning.

The possibility to set up databases which would be fed by public and private data and used by public and private stakeholders should be explored. Industry could have an interest in sharing data because it would access to more data than they own, which help reduce uncertainty and costs.

But, from the industry's perspective, databases should focus on usage rather than on thematic data layers. Industries would seek clear definitions of data content and applications linked to the use foreseen. It might therefore be easier for industries to contribute to specialized databases instead of bigger, more generic ones.

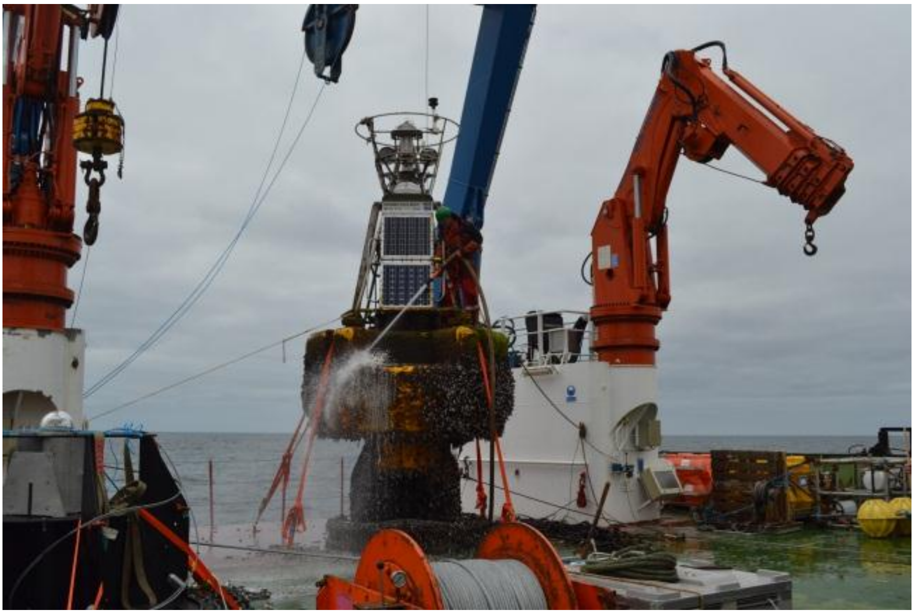
It would also be easier for industries to participate in a public-private partnership on marine data through an association. This would avoid competition for access to data. Finally access to data would be reinforced if the publication rights of data owners were limited in time.

Public-private partnerships in data collection and management represent an interesting option to be pursued in some cases but it is important to keep in mind that they remain challenging and are unlikely to significantly substitute public investments in this area.

The Environmental monitoring Database is a database with environmental seabed monitoring studies carried out at the Norwegian shelf. It belongs to the Oil & Gas Industry and is used by them as well as by the Climate and Pollution Agency, Researchers and for OSPAR reporting.

SEAPOP is a national, long-term monitoring and mapping program for Norwegian seabird populations. It is co-owned Ownership by public authorities (Directorate for nature research, Ministry of Petroleum and Energy), and Oil & Gas industry. It is used by researchers, Industry and Public Authorities for environmental impact and risk assessments, Oil spill response planning.

MAREANO maps depth and topography, sediment composition, biodiversity, habitats and biotopes as well as pollution in the seabed in Norwegian coastal and offshore regions. It is owned by public authorities and used by public authorities, Industry, Researchers for Management plans, environmental impact and risk assessments and research.



Fixed platforms and systems: *Servicing of the Met Office ODAS (Ocean Data Acquisition System) buoy on board the RRS James Cook at the Porcupine Abyssal Plain*

Deployment of a SeaWatch buoy or the POSEIDON network in the Aegean Sea.

V. CONCLUSIONS AND RECOMMENDATIONS

V. 1. Governance

The European landscape of MRIs is too complex and fragmented and this is an obstacle to achieving optimal impact of MRIs and responding to increasing societal needs related to our seas.

The high number of projects launched to organise European governance for some categories of MRIs (ESFRI and non-ESFRI projects), organise networks of marine research organisations (JERICO, MARS…), and large integrating initiatives (GMES, EMODNET), has contributed to reinforce cooperation between organisations managing MRIs. It has also contributed to improve the governance and interoperability at European scale within categories of distributed infrastructures. However the multiplication of governance frameworks for specific categories of MRIs, calls for a strategic framework identifying key societal needs and objectives at European level, and providing for a coordinated development of the different initiatives, MRIs, projects and networks.

The current consultation on marine knowledge launched by the European Commission and the launching of JPI Oceans provide an opportunity to develop a shared vision as well as a strategic framework for ocean observation in Europe. On the basis of comments received by stakeholders, the Commission should propose such a strategic framework ensuring convergence and complementarities between existing infrastructures and initiatives, particularly GMES, EMODnet, WISE-Marine and the distributed European marine observation infrastructures.

JPI Oceans could play an important role in implementing such a strategy, by identifying key marine parameters to be measured at European level to respond to societal needs, and the MRIs which should be sustained in a coordinated manner to measure these parameters. An objective and transparent assessment of the value of the different MRIs and their contribution to addressing societal needs could be organised to that effect. Such a process would provide a baseline for a European Ocean Observation capacity and promote convergence between the different European initiatives, MRIs, networks and projects in that area.

<u>**Recommendations**</u>

1. There is a need to simplify the landscape of MRIs in Europe and create convergence between existing governance structures, MRIs and networks. The definition of a shared vision for European ocean observation and its implementation in the framework of JPI Oceans would be instrumental in that regard.

2. The current Commission consultation on marine knowledge should be used as an opportunity by marine stakeholders, Member States and the European Commission to define a shared vision on European marine observation, putting societal needs at the start and building upon EMODnet, GMES Marine Service, WISE-Marine and the distributed European marine observation infrastructures.

3. JPI Oceans provides a valuable framework to identify key MRIs to be sustained in a coordinated manner at European scale to respond to societal needs. This would provide the baseline for an Integrated European Ocean Observation capacity.

V. 2. Marine research infrastructures – value and funding

Marine research infrastructures (MRIs) are the means through which we can observe and understand oceans processes. They give access to the knowledge necessary to a sustainable development of sea-related activities, as well as to mitigation of and adaptation to climate change impacts. They are essential to deliver the full contribution of seas and oceans to EU 2020's goal of smart, sustainable and inclusive growth.

MRIs are a large range of different infrastructures, dealing with data collection, data management and data assembling. In order to acquire marine data in an effective way, it is necessary to cover all three stages of the data processing chain, with an optimisation of data flows from data collection till the delivery of services to end-users.

MRIs are costly to build and to operate. It is therefore crucial to maximise the value we extract from them, while minimising the cost of building and operating them. This can be achieved by technological progress, by ensuring that MRIs respond to societal needs and by maximising cross-border synergies between MRIs distributed in different countries.

There is value in a coordinated development and utilisation of MRIs at European or regional seas' levels. Sea-related challenges and processes do not stop at maritime borders; they require a concerted approach at the level of regional seas, sometimes even globally. There are synergies and savings in the coordinated development and utilisation of MRIs at European or regional seas' levels and in ensuring shared and free access to the data they produce.

There will be opportunities to finance marine research infrastructures in the (2014-2020) period with structural funds, as the new structural funds regulations put an even higher focus on research and innovation, with more than 25% of a total amount of ~ € 330 billions to be dedicated to research and innovation-related actions. Efforts will be needed to raise awareness of these opportunities among research organisations of the opportunities and to convey to structural funds managers at regional level the socio-economic value of MRIs. This could be done by using and improving the framework for valuing socio-economic value MRIs attached in annex.

Public-private partnerships based on data sharing with industry should be explored, notwithstanding the difficulties of such undertakings. There are mutual benefits to be drawn from such partnerships as all stakeholders could in this way access to more data than they own, which help them reduce uncertainty and costs. Models for developing such partnerships should be developed, to maximise incentives for marine industries to share their data, taking into account the differences and different interests between well-established marine industries and emerging marine industries.

Recommendations

4. Annex 2 of this report provides a useful framework for the assessment of the socio-economic value of European scale MRIs, which could be further elaborated for all categories of research infrastructures with Commission support. This could be used by the marine scientific community to seek funding from structural funds for MRIs. The marine scientific community involved should make an effort to orient European scale MRIs towards societal needs.

5. Other "brokerage events" should be organised to bridge gaps between marine research institutes involved in European scale MRIs and regional authorities managing structural funds, following the event organised on EMBRC by the European Commission and the Conference of Peripheral and Maritime Regions (CPMR).

6. The incoming consultation on "Marine knowledge" should be used to explore the opportunities for public-private partnerships to finance European scale MRIs. Organisations and fora bringing together marine science organisations and maritime industries could be used to explore in more detail such opportunities, identify benefits and obstacles, as well as options to make use of them.

V. 3. Filling gaps in data collection - technological developments

Ocean observation underpins all marine research and activities and, for this reason, it is of strategic importance. The pace of innovation in ocean observation technologies has been very high in the past two decades and it will continue to be so, both as regards sensors and fixed or mobile platforms that carry them. Continuous investment in ocean observation research and technologies should therefore be considered as a priority.

In-situ sensing of oceans is much less developed than remote sensing from satellites, done in the framework of GMES. Particular attention should be paid to develop a broad and cost-effective in-situ monitoring of the seas.

In general, for the marine environment, biochemical sensors are less developed than physical sensors. In order to address challenges related to pressures and variations on marine biodiversity, pollution, we need to fill gaps in this area by supporting development and deployment of new biochemical sensors and devices. The potential of new methods and technologies like genomics and marine acoustics to assess (pressures on) biodiversity should be explored. Mainstreaming of genomics into Earth observation should be advanced.

Oceanographic vessels will continue to be an essential component of marine research infrastructures. However, the development of sensors and the increasing use of autonomous and unmanned platforms may change how ships are used. Many oceanographic vessels of the European regional fleet will need to be renewed in the coming years. There is a need for strategic reassessment and coordination at European level of oceanographic vessels as part of a broader assessment and coordination of European marine research infrastructures. JPI Oceans could provide an opportunity to make such an assessment, coordinated with member countries and the European Commission, and building upon the work done by Eurofleets.

There are still important gaps in the mapping of European sea beds. Only a few countries have undertaken this task and the completion of this mapping in a systematic way. The mapping of seabed with topography, geology, habitats and ecosystems is of high value for marine industries, protection of the marine environment and science. It requires oceanographic vessels equipped with multibeam sonars. With the current capacity available, it would require a few decades to complete the seabed mapping of the entire EEZ of the member states.

The Mediterranean (in particular its Southern border) and even more the Black sea are generally under-observed seas. Moving towards Good Environmental Status at sub-regional seas' level will necessitate developing strategies for better coverage by marine data infrastructures of these seas, in cooperation with third countries. A coordination of European countries’ bilateral scientific cooperation with neighbouring countries in the Mediterranean and the Black Sea could strengthen capacity building in these countries and the ability to tackle common challenges.

Recommendations

7. Europe must keep a strong innovation capacity in marine observation, in order to constantly improve our ability to monitor oceans, while improving cost-effectiveness of such monitoring. A structured long term research effort should be undertaken in the framework of "Horizon 2020" and in cooperation with other EU financing instruments (structural and maritime funds) to support this strategic objective.

8. Attention should be paid to filling gaps in biochemical observation and to emerging technologies that can contribute in particular to the assessment of variations of marine biodiversity in the framework of the MSFD or in relation to climate change.

9. The EU should consider a major initiative to complete a seamless multi-resolution digital seabed map of European waters of the highest resolution possible, covering topography, geology, habitats and ecosystems by 2020. This would represent a major flagship project with a high societal and scientific value for Europe.

V. 4. Data management - moving towards European ocean observation capability

There is a high value in an integrated approach to managing marine data management in Europe, based on the principle of "collecting data once and using it as many times as possible".

SeaDataNet has developed a common lexicon for marine data across disciplines and applications and an open structure that can, with time, give access to an increasingly bigger number of data centres across sectors and countries, increasingly meeting the standards needed for INSPIRE compliance. As a European platform building upon SeaDataNet, EMODNET could provide a solid framework for the structured development of a network of distributed data centres using a common lexicon and ensuring broad accessibility for users from scientists to policy makers, as well as user-friendly assembling tools. EMODnet must be developed from the pilot stage to the operational stage, by ensuring that it fits end-users' needs. It must in particular be developed as part of a European framework for ocean observation, integrating the marine component of GMES, WISE Marine and main European marine research infrastructures. The pilot sea-basin checkpoints for the Mediterranean and the North Sea currently being tested under the integrated maritime policy, offer an opportunity for stakeholders to assess the monitoring in those sea-basins through a structured process. The aim is to guide the identification of gaps and assessment of future priorities and lessons learned from this exercise could feed into a more permanent process.

Member States are in the process of setting up national processes for a proper stewardship of data that ensures not only safe archiving but also cataloguing using standards and technology allowing retrieval of data through automated processes. These national systems are the foundations of the distributed processes that are being built up at an EU-level. They must ensure that the cost of archiving and managing data is properly budgeted for.

A monitoring process to follow and steer the coordinated development of these national marine data management systems could be put in place, in cooperation between the European Commission and JPI Oceans. This could help remove progressively obstacles to access to marine data.

This development of a European framework for marine data management should ensure compatibility with INSPIRE and coherence with the global framework provided by the International Oceanographic Data and Information Exchange (IODE).

Recommendations

10. EMODnet must move to an operational phase, building on SeaDataNet, as part of a wider vision on European ocean observation, including GMES, WISE Marine and main European MRIs.

11. This should be done by ensuring that it takes account end-users' needs i.e. that data made available for use and assembling are fit-for-purpose.

12. A process to monitor the development of national stewardship of marine data should be put in place in cooperation between the European Commission and JPI Oceans, to progressively remove obstacles and enlarge access to existing marine data sets across sectors and countries.

13. The European framework for marine data management should be Inspire-compatible and coherent with the global framework provided by IODE. Further work is needed on standards and protocols, to underpin the development of EMODnet, refining and expanding data management standards, seeking pan-European and global interoperability, and developing new services.

Annexes

ANNEX 1- EXPERT GROUP: LIST OF MEMBERS / INVITED EXPERTS

Characteristics of the group

The expert group was inter-disciplinary, with 18 experts covering physical and biochemical oceanography, marine biology, marine biogeochemistry, socio-economics of marine ecosystems / activities and data management. It was chaired by Rudy Herman, Senior researcher at the Flanders Authority Department of Economy, Science and Innovation.

It also had a broad geographical coverage with experts coming from countries bordering all European regional seas.

On the European Commission side, the organisation of the work of the expert group was provided by Directorate General for ***Research*** and Innovation (Waddah Saab and Gaelle Le Bouler -RTD.H.2). The meetings were attended by officials from RTD.B.3, RTD.E.4, RTD.I.3, the Joint Research Centre – ISPRA, Directorate General for Maritime Affairs, Directorate General for Environment and Fisheries, Directorate General for Enterprises as well as Directorate General for Climate.

Meetings of the expert group

The expert group met 7 times in Brussels and once in Ostend, between 12 March 2010 and 28 March 2012. In addition to presentations made by members of the group themselves, external experts were also invited to make presentations in different areas and participate in different discussions (see list of invited experts in annex I).

Experts	Organisation – field of expertise	Status of participation
1. Rudy Herman (Chairman)	Senior researcher – Flemish Government - Department Economy, Science and Innovation	Member
2. Melanie Austen	Plymouth Marine Laboratory, Socio-economics, ecosystem services	Member
3. Frank Oliver Gloeckner	Max Planck Institute for Marine Microbiology, Microbial Genome Research	Member
4. Hartmut Heinrich	Federal Maritime and Hydrographic Agency – Germany - Euro-ARGO	Member
5. Olivier Lefort	IFREMER - Deputy Manager fleet, Eurofleets	Member
6. Jurgen Mienert	University of Tromsoe, Deep sea observatories, seismic hazards, drilling	Member
7. Kostas Nittis	Hellenic Centre for Marine Research,	Member

	Oceanography, MARCOM, MED-GOOS, Eastern Mediterranean	
8. Paulo Nunes	University of Venice / FEEM, Socio-economic expertise	Member
9. Nicolae Panin	National Institute of marine geology and geo-ecology - Romania, marine geology, sedimentology, coastal zones, Black Sea	Member
10. Damien Périssé	CPMR, responsible for research	Member
11. Nadia Pinardi	University of Bologna, Adriatic-Central Med, Oceanography, MyOcean	Member
12. Slawomir Sagan	Institute of Oceanology – Sopot, Polish Academy of Science, Oceanography, Baltic	Member
13. Dick Schaap	Marine Information Services Netherlands, marine data management, EMODNET expert group	Member
14. Michael Thorndyke	Royal Swedish Academy of Science	Member
15. Joaquin Tintoré	IMEDEA, SEAS-ERA, Jericho (EU network of coastal observatories), Western Mediterranean	Member
16. Phil Weaver	NOCS – Deep sea observatories	Member
17. Pierre Yves Le Traon	IFREMER	Alternate member
18. Svend Otto Remoe	Norway Research Council	Alternate member

Invited experts	Organisation – field of expertise
Georg Hanke	JRC-IES
Nicolas Hoepffner	JRC-IES
Vittorio Barale	JRC-IES
Kathrine Angell-Hansen	JPI Oceans
Carlo Heip	MARBEF coordinator
Nathalie Rousseau	European Ocean Energy Association
Tim Haigh	European Environment Agency
Olaf Banki	University of Amsterdam
Nerijus Blažauskas	Baltic Valley
Anders Carlberg	Maritime Affairs Region Västra Götaland
Franciscus Colijn	Institut für Küstenforschung, Helmholtz Zentrum Geesthacht GmbH
Kate Larkin	National Oceanography Centre, Southampton
David Mills	CEFAS
Asta Raugaliene	Ministry of Interior Klaipėda County Section
Ragnhild Rønneberg	The University Centre in Svalbard - SIOS
Trine Christiansen	European Environment Agency
Wiebke Kooistra	Stazione Zoologica Anton Dohrn - EMBRC
Aengus Parsons	Marine Institute - Ireland
Yvonne Shields	Marine Institute - Ireland
Aurélien Carbonnière	Marine Board
Ana Aguado	Friends of the Supergrid
Jean-François Bourrillet	Ifremer
Slim Gana	Sarost

Niall McDonough	Marine Board
John Shaw	Mainstream Europe
Patrick Camus	IFREMER
Florence Coroner	JPI OCEANS
Geor Demme	DFKI Visualization Center
Alexander Loffler	DFKI Visualization Center
Philipp Slusallek	DFKI Visualization Center
Paul Treguer	Europolemer
Anne Marie Hayes	European Environment Agency

ANNEX 2 - FRAMEWORK FOR VALUATION OF MRIS

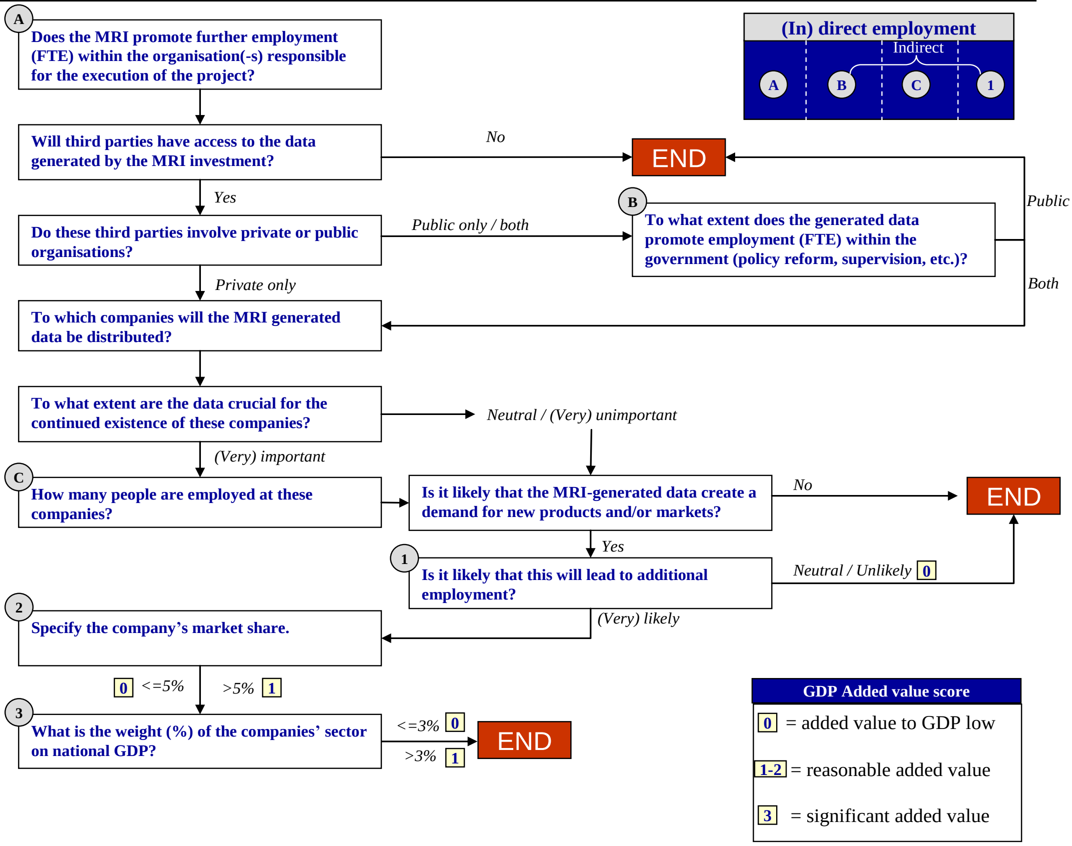
Socio-economic contribution

Within the context of establishing a socio-economic framework for MRI-related project proposals there are four factors that can be impacted by an MRI and stimulated by the objectives of the structural funds (ERDF). They are employment, GDP, education and innovation. The importance of each of these four factors will vary per individual application, depending on the key theme of the operational programme (convergence, development, geographical cooperation). This is illustrated by the fact that the various Member States have reached different levels of development and will therefore have different priorities. Some Members States will for instance prioritise education, whereas others will focus on employment.

Employment & GDP

MRIs can contribute directly and indirectly towards increasing levels of employment. An MRI may for example directly impact employment by creating research positions for science staff. Furthermore, data collected by an MRI may be exploited by other public and private institutions (third-party contacts), creating further employment positions in the companies concerned. In this regard, research on wave characteristics may be of interest to skippers, bathers and even public authorities (the ministry of defence for instance). The potential (commercial) utilisation of the data collected through MRIs can indirectly create employment within both the governmental and the corporate scene. Last not least, utilisation of such data by third parties can create value in terms of GDP. *Figure 5* is an indication on how to measure (in)direct employment and contribution to the GDP.

Figure 1: Measuring MRI impact on employment and contribution to the GDP

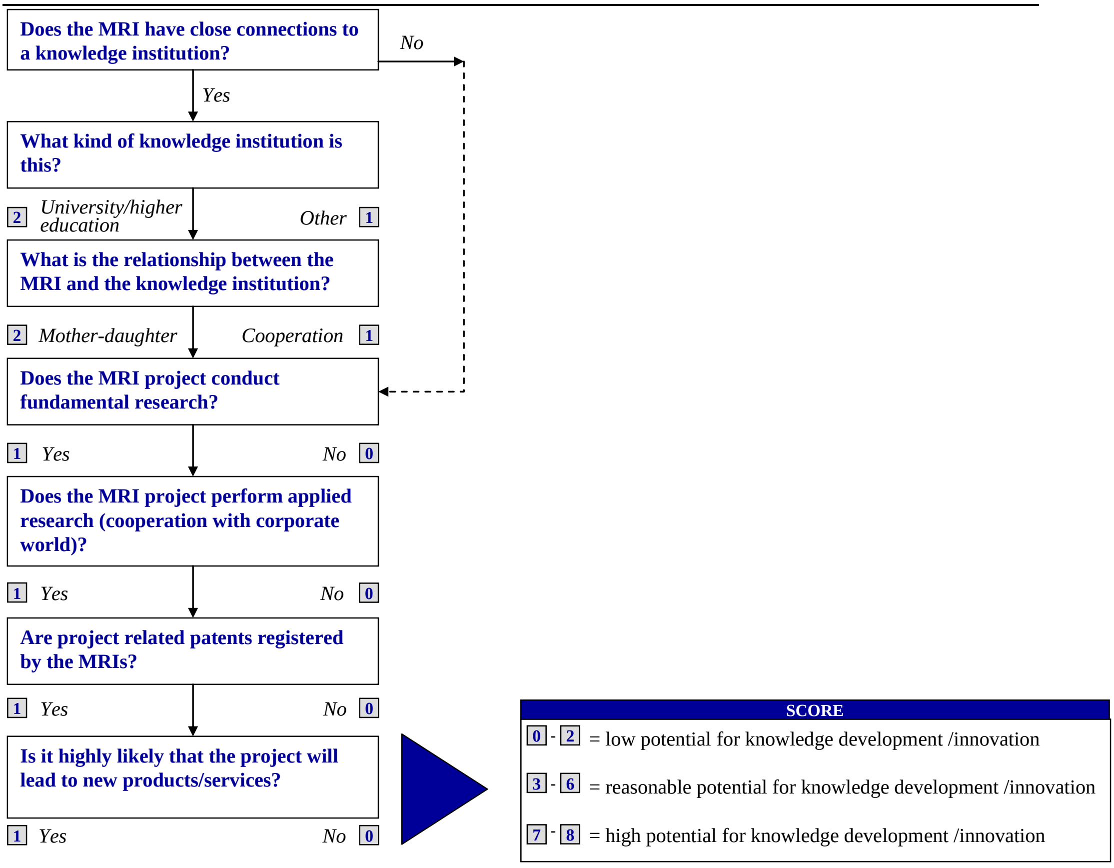


Source: Policy Research Corporation

Science, Education & Innovation

As MROs often conduct fundamental research, they have the additional capacity to enhance knowledge levels within a certain region/Member State. As MROs also tend to have long-standing relationships with universities, or are even organised within a certain department of a university, employees of MROs are often related to such universities or knowledge institutions. As such, MROs contribute directly to the promotion of knowledge (innovation) within their operating environment. An MRO might even register a patent for a certain technology. As patents are often regarded as indicators reflecting innovation strength, an MRO registering a patent is likely to contribute to future innovation. *Figure 6* contains an overview of possibilities for measuring education and innovation.

Figure 2 : Measuring MRI impact on knowledge development and innovation



Source: Policy Research Corporation

Environmental contribution

European Regulations

The MMRS and the MSFD provide a comprehensive framework for measuring the relevance of an MRI to the environment. The MSFD advocates a sound environmental status for all European seas by 2020. To meet this objective, the MSFD has identified different variables (see *Figure 7*) for monitoring the conditions of the seas of Europe. At the time applications are filed they could be assessed by the degree to which they measure, or even attain these variables.

The MMRS consists of various topics (see *Figure 7*) that are considered to be of major significance to the European Union. Again, at the time applications are filed they can be assessed by the degree to which they could contribute towards improving aspects of these topics.

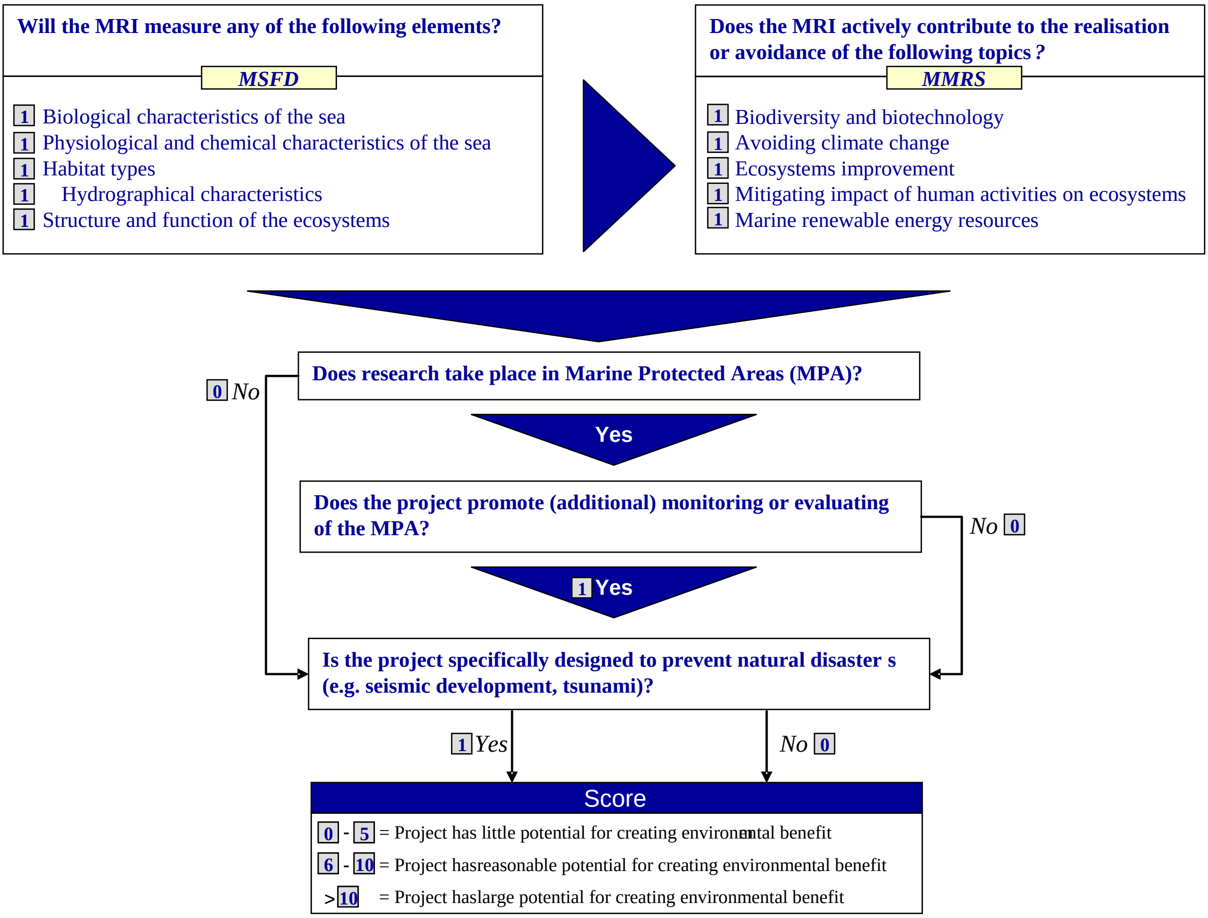
Marine Protected Areas

Marine Protected Areas (MPA) have been established with a view to protecting certain (vulnerable) marine areas. MROs will be more likely to obtain funding if they can demonstrate their contribution to the supervision or protection of an MPA. In similar conditions, projects like these are likely to have a greater impact in an MPA than in a regular marine environment.

Natural disasters

The final variable of the framework provided in *Figure 7* concerns natural disasters (like seismic or tidal waves). As these disasters may have a substantial impact on Member States, indicators of such events will therefore be thoroughly considered. While research activity that is aimed towards preventing such events is partly covered by the topics of the MMRS and the variables of the MSFD, an explicit connection between MRO-research and prevention of natural disasters will probably increase the chances of funding being granted.

Figure 3: Measuring environmental and societal relevance of MRI



Source: Policy Research Corporation

ANNEX 3 - MARINE RESEARCH INFRASTRUCTURE CATEGORIES - CURRENT AND FUTURE TECHNOLOGICAL CHALLENGES [41]

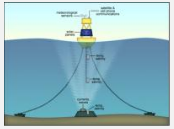
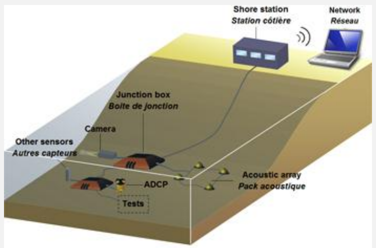
Infrastructure Categories	Ongoing challenges	Future challenges and developments
I. MOBILE PLATFORMS		
Research vessels 	-Fleet planning at European level as part of a marine infrastructure review process, including platform construction, and on board equipment upgrades, with particular attention to the renewal of regional fleet (building on EUROFLEETS' work). -Continued availability of general purpose ships and some special purpose ships for the deployment of complex and heavy equipments. -Flexibility in fleet scheduling, for efficient use, event response, and surge capacity. Further improve the efficiency of the Ocean Facilities Exchange Group (OFEG) for regional vessels.	-Ability to meet increased demand for rapid launch and recovery for diverse arrays of autonomous platforms. -Electric propulsion and alternative power systems to limit fuel consumption.

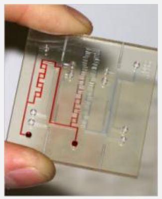
41 The table follows a categorisation made in a report by the US National Research Council "Critical Infrastructure for Ocean Research and Societal Needs in 2030" – ISBN 978-0-309-18603-2

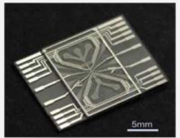
Ships of opportunities 	-Increased use of volunteer observing ships to collect and transmit underway scientific data to national repositories for verification and analysis.	- Develop standardized “container type” sensor packages with small footprint for compatibility and rapid exchange. - Develop methodologies for transect sampling
	II. SUBMERSIBLE PLATFORMS	
Human Occupied Vehicles (HOVs) 	Improved ability to recover water column, seafloor, and sub-seafloor samples.	
Remotely Operated Vehicles (ROVs) 	-Broader ranges of biological, chemical and optical sensors. -More sophisticated sonar systems for bathymetry and water column uses. -Advancements in underwater navigation for more precise and geodetic referenced vehicle locations. -Continued development of hybrid ROVs.	-Continued development of advanced ROV capabilities (e.g., higher power, greater depth ratings, sampling tools, sensors), including ROVs to be deployed from coastal or regional vessels not equipped with DP systems.

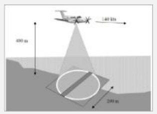
Towed Systems 	Broader ranges of biological, chemical and imaging sensors.	Reconnaissance sampling using high-speed data uplinks that allow for simultaneous video and sample recovery.
III. AUTONOMOUS AND LAGRANGIAN SYSTEMS		
Autonomous Underwater Vehicles (AUVs) and gliders 	-Scalable, multiplatform arrays capable of local, regional, and global-scale observations at broader ranges of spatial and temporal resolution. -Improved battery power for increased mission duration, expanded range, and ability to support more sensors. -Expanded ocean depth capability for a variety of platforms. -AUVs with larger payloads, higher endurance, and ability to work in rough conditions (e.g., high currents, sea states, ice coverage) and at all expected working temperatures. -Improved under ice capability for all autonomous platforms	-Equip platforms with broader suites of multidisciplinary in situ sensors (detailed in section below on in situ sensors). -Autonomous refuelling, at-sea energy harvesting, or other methods for replenishing or self-generating power. - Improvement of piloting algorithms to allow deployment of several AUVs at the same time and have better piloting. -Permanent, large-scale subsurface acoustic positional networks (analogous to GPS) for improved undersea navigation. -Full ocean depth capability for a variety of platforms, including ability to use AUVs in shallow areas with heavy activity, shipwrecks, high turbidity and strong tidal currents.

Drifters and Floats (e.g. Euro-ARGO) 	- Sustain the global array (T & S) for the next decades. -Advancements in underwater navigation for more precise and geodetic referenced vehicle locations. - Evolution of Argo core mission to answer new requirements : • Increased float life time and reliability, reduced costs • Extension to biogeochemical parameters with miniaturized, low cost and reliable sensors • Telecommunication (two way) and increased bandwidth • Extension to deeper depths (below 2000 meters) • Under ice operations (ice detection, acoustic positioning).	-Increased deployment options for autonomous platforms such as volunteer ships or aerial vehicles. -Autonomous refuelling, at-sea energy harvesting, or other methods for self-generating power.

IV. FIXED PLATFORMS AND SYSTEMS		
Moorings 	-Continued, sustained support of centers for deep ocean mooring design, construction and deployment. -Ability for docking mobile autonomous systems (e.g., AUVs, benthic crawlers).	
Cabled Seafloor Observatories (e.g. EMSO) 	-Ability for docking mobile autonomous systems (e.g., AUVs, benthic crawlers).	Multiple data extraction modes (e.g., long range acoustic communication). Autonomous or manual release of automatically collected data capsules and samples.

V. IN SITU SENSORS		
Physical 	-Measurements of the exchange of mass (e.g., gases, aerosols, sea spray, water vapor), momentum, and energy (including heat) across the air-sea interface in a broad variety of conditions (e.g., high wind conditions, severe storms). -Techniques to infer gas exchange under high wind conditions with chemically active (e.g., DMS) and inert (e.g., CO2, Ar) atmospheric gases. -Fully networked and widely accessible data on river outflows, precipitation, and from tide gauges.	- Optical imagery for spatial and temporal observations of ocean surface, estuarine, and riverine processes. - Development of computerized image recognition technology for analysis of large image datasets in relation to pollution (marine litter) and biological assessments (e.g. habitats). - Development of higher resolution Marine acoustics technology for
Chemical  	-Observations of the carbon dioxide system(including pH), major and micronutrients and elemental speciation of key micronutrients (such as iron). -High-resolution analytical tools that enable detailed analysis of oceanic carbon components. -More portable micronutrient analytical systems and speciation analysis for assessing micronutrient speciation and determining its influence on biological activity. -Sensors for identification of chemical pollutants.	Sensor methods for surface micro-layer chemistry. Cheap, easily available sampling systems for testing for chemical pollutants.

Biological  	-Development of methods to obtain organism-specific growth rates and advective, turbulent, and sinking fluxes. -Sensors for identification of plankton biomass and community structure – genetic, imaging, and acoustic. -Sensors for identification of higher trophic levels (e.g., fish, marine mammals) - genetic, imaging, and acoustic. -Sensors for toxin identification (including harmful algal blooms and pathogens).	-Cheap, species survey sampling systems for broad distribution throughout coastal regions. -High throughput genomic, protionomic, metabolamic techniques. -Cheap, small toxin sampling systems for broad distribution throughout coastal regions. -Wide-area benthic sensors for seafloor mapping to provide estimates of benthic community state and function.
Geophysical 	-Seafloor strain measurements (e.g. extensometer), seismic reflection and refraction to detect seismic events in remote areas of the ocean. -Ability to measure bathymetry and processes occurring beneath and at the margins of glaciers, ice shelves, and sea ice including observations at the base of the ice canopy. -Deepwater mapping systems with better sensors (e.g., lower power) and automatic seafloor classification algorithms. -EM sensors that provide proxies for crustal fluids.	-Global-scale, reliable, continuous sensor networks for real-time measurement and warning of seismic, volcanic, or mass wasting events. -Wide-area benthic sensors for seafloor mapping at high resolution, including the ability to penetrate the seafloor.

Genomic Observatories	-Integrate genomic information with environmental, socio-ecological and other biological data. -Mainstream biodiversity –genetic variation– into Earth Observation systems to enable predictive modelling of biodiversity dynamics and resultant impacts on ecosystem services.	-Digital characterization of whole ecosystems, from all-taxa biotic inventories to time-series ’omics studies.
	VI. REMOTE SENSING	
Satellite 	Sustained gravity missions that inform crustal, ocean circulation, and geoid observations.	Geostationary ocean colour and LIDAR remote sensing capability.
Airborne 	-Increased use of unmanned aerial vehicles for campaigns and monitoring. -Ability to remotely measure ocean surface and ice properties beneath cloud cover.	Use of commercial aircraft to collect and transmit ocean surface observations.

Fixed Systems (HF radar) 	-Increased use of electro-optical and infrared instruments for monitoring and long time-series data. -Completion of the land-based HF radar Network. HF radars map surface currents in wide swaths of coastal waters up to 200 km off shore, 24 hours a day, and in all weather conditions. The EEA analysis of in situ needs for the GMES marine core service has identified that an R&D project on HF radars to design and coordinate an array of HF radars in Europe could be a valuable contribution for improving coastal current monitoring and forecasting.	-Extension of broad area surface current arrays (e.g., HF radar, optical imagery) to offshore activities (e.g., offshore platforms, wind farms, volunteer observing ships). -Increased use of tethered aerial platforms. -Increased data gathering capabilities through -expanded use of commercial ocean activities.

ANNEX 4 – MARINE LAND-BASED FACILITIES FOR ENGINEERING AND EXPERIMENTAL FACILITIES FOR BIOLOGY AND ECOSYSTEM STUDIES (DONE BY SEASERA)

The content of this annex is based on the work done by Seas-era, an FP7 ERANET in the field of marine research. It is based on an extract of the draft deliverable 4.1 - Marine Research Infrastructures updated overview, European integration and vision of the future.

In this annex, we selected in particular the parts dedicated to Marine land-based facilities for engineering and experimental facilities for biology and ecosystem studies, which have not been covered by the expert group on Marine Research Infrastructures. The whole finalised deliverable will be available on the dedicated website http://www.seas-era.eu/np4/homepage.html .

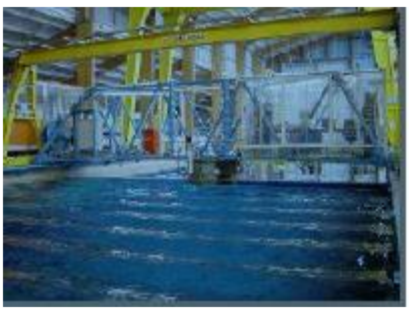
Marine land-based facilities for engineering

A great variety of land-based facilities is necessary for ocean engineering purpose as for the design, the preparation and the qualification of instrumentation and underwater vehicles before their deployment at sea. This includes :

- Deep wave basins, wave flumes
- Water circulation canal,
- Marine instrumentation testing facilities,
- Material behaviour in sea water testing laboratories,
- Marine sensors calibration laboratories
- In-situ testing sites

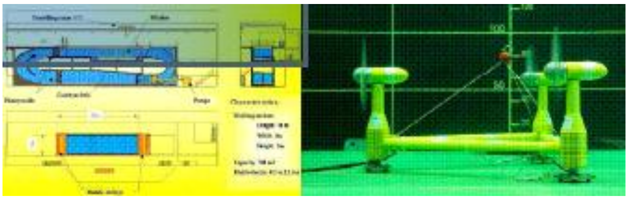
Deep wave basins

Wave basin with a wave energy converter under testing – Submarine view



Water circulation canals

Sketch of a flume and view of a trial in current for a marine energy converter system



Marine instrumentation testing facilities :

- hyperbaric tanks
- shock and vibration generators
- climatic room

1000 bars / 2° C hyperbaric tank

Material behaviour in sea water testing laboratories

100T test bench *Flexural fatigue test on composite in natural sea water*

In situ testing sites

Wave test offshore site *Wave energy converter in test*

A major role in the quality assurance process, for qualification of all the equipment before art sea deployment. And a major role to test at small scale new concepts of offshore platforms and of marine renewable energies devices.

Experimental facilities for biology and ecosystem studies

This type of RI should itself be split into 4 sub-domains due to their specific goals while sharing the same core skills in biology and life resources :

- Marine Genomics facilities
- Aquaculture experimental facilities
- Mesocosm facilities
- Ecosystems and biodiversity observatories

Marine genomics, ecosytems and biodiversity facilities are mostly for observation purpose, while Aquaculture and Mesocosm ones are mostly for experiments purpose.

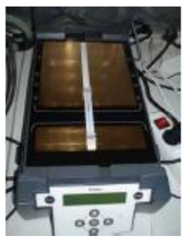
Marine genomics facilities

Marine genomics RIs propose:

- access to analytical platforms : «omics» facilities including bio informatics, animal-borne platforms, microscopy & imaging :
    - genome => sequencing platform
    - transcriptome => microarray
    - proteome => 2D-gel electrophoresis
    - metabolome => GC-MS (Gas Chromatography & Mass Spectrometry)
    - + crystallography, electronic microscope, diffractometer, etc …
- access to marine organisms models and their ecosystems, culture collections and databases => requires the culturing or raising of a variety of micro- and macro-organisms.

Sequencing platform

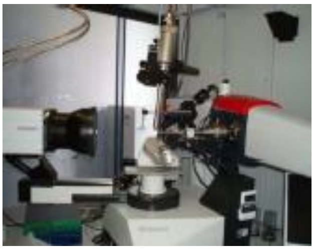
2D gel electrophoresis. The gel is placed between 2 electrodes



Mass spectrometry

Crystallography

Diffractometer



Electronic microscope

These facilities enable:

- exploration of marine biodiversity, , enabled by the knowledge of marine genomes and by novel molecular and imaging technologies => genes and new molecules mining for Health and Biotech
- novel knowledge on basic biological mechanisms and on complex disciplines such as neuroscience and developmental biology => knowledge basis for Fisheries and Aquaculture,
- an in depth knowledge of marine organisms will shed light on the role of these organisms in sustaining earth climate balance and global climate equilibrium.
- to foster integration of marine biology with other biological sciences, e.g., biomedicine.

Direct outputs of the experiments:

- Molecular data
- Interpreted molecular data
- Gene functions
- Functional genomic
- Genome architecture
- Protein structures
- Metabolic pathways
- Molecular markers
- Regulation pathways
- Cellular, physiological, evolutionary, or ecological knowledge)

Projects typology using these facilities:

- Aquaculture,
- Fisheries,
- Resources management,
- Environment
- Blue biotechnology,
- Biodiversity,
- etc…

Aquaculture experimental facilities

Aquaculture experimental facilities include mostly land-based tanks and sea-based cages.

For experiments on :

- Reproduction / genetic
- larval rearing
- fish breeding
- nutrition / feeding
- health / pathology

Research are usually focused on commercial species :

- Sea bass
- Sea bream
- Cod
- Salmon
- Crustacean and Molluscs
- Etc …

Mesocosms facilities

A mesocosm is defined as a medium-scale experimental structure where real-life ecosystems are enclosed to allow manipulation of environmental factors.

Marine mesocosm systems are culture systems for fish larvae with a water volume ranging from 1 to 10,000 m³. In these large enclosures a pelagic ecosystem can be developed, consisting of a multispecies, natural food chain of phytoplankton (diatoms, flagellates, *Nannochloris,...*), zooplankton (tintinnid ciliates, *Synchaeta* and *Brachionus* rotifers, copepods,...) and predators (fish larvae). Intensification of mesocosms is determined by the initial load and by the level of exogenous compounds (fertilizer,...). Environmental conditions of mesocosm systems are fully related to the local climate.

Types of mesocosms : Pold system ; Bag system ; Pond system ; Tank system

http://www.fao.org/DOCREP/003/W3732E/w3732e0u.htm

Ecosystem and biodiversity observatories (new RI project)

A Network of stations committed to use a standardized and cost-effective set of methodologies for joint research on biodiversity, from genes to ecosystem functioning issues.

Tools now exist that allow the analysis of these different levels, going from metagenomics, indicator species and species communities, to habitat mapping and ecosystem modelling.

This observatory system will be used to monitor and assess long-term and large scale changes in aquatic (marine and freshwater) biodiversity and relate them to ecosystem functioning and the pressures and drivers on biodiversity change.

ANNEX 5 - CONCEPT OF ECOSYSTEM SERVICES – EXAMPLES

Ecosystem services are the non-market benefits we derive from nature. It is a useful concept to make the non-market benefits we derive from nature more explicit. Ecosystem services support many local economies. Any decline in their value could impact dozens of thousands of regional jobs.

Our oceans provide many valuable ecosystem services. They regulate the level of carbon dioxide in our atmosphere; recycle essential nutrients; and control pests and diseases. Healthy oceans also provide critical breeding habitat that supports fishing communities and protects our unique biodiversity. Our deep and abiding connections to our oceans, seas and beaches is apparent through sport and recreation; religious and cultural traditions; and inspiration for art, design, education and research. Yet these benefits provided by marine ecosystems are often overlooked because they are economically invisible.

Conceptual diagram illustrating the ecosystem services provided by oceans and the ways in which humans depend on oceans.

Symbols library courtesy of the Integration and Application Network (ian.umces.edu/symbols), University of Maryland Center for Environmental Science.

Conceptual diagram illustrating the ecosystem services provided by oceans and the ways in which humans depend on oceans.
Diagram courtesy of the Integration and Application Network (ian.umces.edu), University of Maryland Center for Environmental Science. Source: Samonte G, Karrer L, Orbach M. 2010. *People and Oceans*. Science and Knowledge Division, Conservation International, Arlington, Virginia, USA.

The following table provides an estimate of Australia's marine ecosystem services made by the Centre for Policy Development. [42]

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42 Stocking Up: Securing our marine economy Laura Eadie and Caroline Hoisington - Centre for Policy Development - September 2011

Table 2: Estimated Ecosystem Services Value from Australia's Marine Estate Ecosystem service Estimated value ($ billions/year)

Ecosystem Services	**Ecosystem service Estimated value ($ billions/year)**
Food (market value of recreational catch)	0.4
Raw materials	0.9
Climate regulation	15.8
Biological control	4.6
Lifecycle maintenance (esp. nursery services)	1.6
Opportunities for recreation (spend by recreational fishers)	1.9
Total	**$ 25.2 billion**

ANNEX 6 - EUROPEAN SCALE MRIS, KEY PARAMETERS AND SOCIETAL NEEDS

Policy / Societal needs e.g.		Key parameters	Existing infrastructures/ initiatives
Environment - MSFD	1. Biodiversity, alien species, fish stocks, food webs, seabed integrity / habitats 2. Eutrophication 3. Hydrographical conditions 4. Contaminants 5. Litter 6. Noise / Energy	• Fish capture • Plankton • Chlorophyll • Nutrients • Benthic habitats • Organic pollutants, biotoxins • Metals	• EU Fish data collection • CPR • Smart buoys • Ferryboxes • Satellite remote sensing
Ocean/Climate interactions	1. Ocean circulation system, ocean / atmosphere interactions 2. Impact of climate change on marine environment 3. Impact of climate change on coastal areas and offshore activities	• Temperature • Salinity • Pressure • CO_2, pH • Oxygen	• Euro-Argo • EMSO • EUROSITES • SIOS • ECORD
Socio-economic needs	1. Marine Energy / Transport… 2. Biological / mineral resources 3. MSP / ICZM 4. Marine safety (hazards) 5. Weather / climate & seasonal forecast	• Bathymetry • Geology • Seismic activity • Wind, wave • Ecosystems • Waves, currents	• EMSO, Euro-Argo • EMBRC • Vessels/multibeam sonars • ECORD • HF radars

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European Commission

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Marine research infrastructures for ocean observation feature highly in the «European Strategy for Marine and Maritime Research» (COM (2008) 534) because they underpin all ocean activities, whether they are scientific or socio-economic. This report summarises the work of the expert group on marine research infrastructures, which met in the framework of the strategy, between 2010 and 2012.
Marine observation infrastructures are essential to support the maritime economy, study the marine environment, ocean / climate interactions and support marine safety. Their socio-economic and environmental value is therefore high as they help address key societal challenges of European scale.
Ocean observation follows a data processing chain involving sensors carried by fixed or mobile platforms for data collection, structured databases for data management and digital models run by super-computers for data products to end-users. The expert group made recommendations on key gaps to be filled, as well as on an improved governance of European scale marine observation infrastructures. The aim of the report is to strengthen Europe's ocean observation capacity, particularly its ability to address key ocean societal challenges and its cost-effectiveness. Its recommendations also aim at creating synergies and convergence within the complex landscape of European ocean observation, paving the way for a European integrated ocean observation capacity.

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