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COLUMBUS
KNOWLEDGE TRANSFER FOR BLUE GROWTH

Acronym: COLUMBUS

Title: Monitoring, Managing and Transferring Marine and Maritime Knowledge for Sustainable Blue Growth

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Portals and Repositories and their role in Knowledge Transfer to support Blue Growth

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EXECUTIVE SUMMARY

The overarching objective of the COLUMBUS project is to transfer unexploited knowledge which has been generated by EU funded science and technology research to actors with the potential to capitalise on the knowledge and bring about measurable value creation; specifically, through contributing to the growth of the marine and maritime economy and/or the implementation of the Marine Strategy Framework Directive (MSFD).

Marine knowledge is generated, to a large extent, through monitoring and observation of our seas and oceans. Marine monitoring and observation activities generate raw data, this data can be assembled and contextualised, creating data products and information that ultimately contribute to our knowledge of the marine environment and the extent and impact of human activities therein. However, data generated via marine observation and monitoring activities can only be used in the creation and application of marine knowledge if it can be found, accessed and used.

In spite of EU initiatives such as EMODnet, Copernicus and Data Collection Framework (DCF) for Fisheries to deliver seamless layers of marine data across national boundaries, there are still shortcomings with the availability and accessibility of EU marine data and gaps remain. Data collections have been largely put in place for specific and/or national purposes. There is still an approximate overview on a sea-basin scale of gaps and duplications and there is no overall view of what the priorities are for further data collection or assembly. Thus the EMODnet Checkpoint initiative will begin to link all existing monitoring data at the level of the Sea Basin and assess them in order to define their future improvements.

Sustained funding is an essential pre-requisite to maintain the existing observing platform network at the national level to secure appropriate data collection and data sharing. There are, however, many issues impeding the wider sharing and uptake of already collected data. These include issues around, open-access data, interoperability, data quality and metadata, scale and resolution, harmonisation and ease of use and user friendliness of data sharing facilities.

Some of the underlying problems include the lack of resources and long-term support for data management and sharing; the lack of knowledge and capacity of the data originator or data holder to manage and serve the data even if he/she would be willing to do so; and the lack of willingness to share data due to conflicting interest between providers and users of data.

This report focuses primarily on marine data portals and repositories as important providers of knowledge in the form of data, metadata and derived data-products. In addition, these data and information systems are also important users of knowledge outputs from research projects. As such, they have a unique position and role to play by fostering direct transfer of data or products from repositories to intermediate and end-users and also by taking up outputs from monitoring activities and projects into data repositories to fill data gaps or to contribute to better architecture, services or data products.

There are numerous local, national and regional marine data repositories, together with over-arching European portals and repositories including; EMODnet, COPERNICUS Marine Environment and Monitoring Service(CMEMS), SeaDataNet, PANGAEA and the European Atlas of the Sea. Screening of these over-arching portals indicates that they contain a wealth of resources with potential to address many of the gaps and needs identified by the different COLUMBUS competence node areas.

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Currently however, the visibility of marine data repositories/portals and the vast resources and tools they offer does not extend well beyond the marine research and wider earth observation community. Whilst these communities are important users of marine observations and data, many potential users from other fora and sectors are not aware of the wealth of freely available data that could reduce their costs or help them develop innovative products. These users may also lie beyond the marine and maritime community. Data repository and portal managers need to consider how to reach beyond their current network – raising awareness of their data and products in fora other than the marine monitoring and observation community.

Considering the complexity of the current marine data landscape, existing initiatives and data systems at national, regional and European level need to better align their systems, and if necessary, merge. The remaining systems should better communicate what they do and do not provide, as well as what they are intended for, to allow users to consider how data layers or products can be applied and to assess which tools are best fit for their purpose.

A major cultural change is required to promote the wider sharing of data in support of Blue Growth amongst those involved in collecting, processing, managing, storing and sharing data. Promotional campaigns and clear signals from all policy levels as well as from all major user/provider communities are required to ensure this shift in attitude to take effect. Others incentives to support data-sharing include; the wider use of data-citation indices, acknowledgement of data sources, tools and resources to support data-management, wider training in data-management and user friendly portals and repositories.

Project limited data repositories or information systems cannot and will not be relied upon by users nor by data holders wishing to share their data. In addition, there is a lack of clear guidelines and obligations for funding recipients to openly share their data in an efficient and useful way to allow interoperable data sharing. There is a need to increase sustainability in marine data information systems funding. Funding bodies should put in place mandatory open-access data policies, but also provide necessary guidance on how data generators should manage and make available their data.

Marine data repositories and portals are often developed bottom up to be fit for purpose, with the intended purpose defined by the developer and not the user. Hence, there is a need to move towards systems which that are fit for actual use and often these are multiple. Direct user interactions are necessary to be able to identify the required parameters and data layers, scale, resolution and tools required by various users. End-user needs should be considered in all stages of development.

The screening of major European marine data repositories and portals has highlighted that there is still a huge gap between the knowledge that can be derived from available European data resources and actual uptake by users. It has also exposed a wide range of underexploited data resources. These resources merit further investigation in the context of COLUMBUS knowledge transfer activities in order to promote the uptake of marine data and data-products by users, resulting in tangible contributions to Blue Growth and marine environmental management.

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1 INTRODUCTION

The overarching objective of the COLUMBUS project is to transfer unexploited knowledge which has been generated by EU funded science and technology research to actors with the potential to capitalise on the knowledge and bring about measurable value creation; specifically, through contributing to the growth of the marine and maritime economy and/or the implementation of the Marine Strategy Framework Directive (MSFD)[1].

Work Package 3 of COLUMBUS was largely focused on prioritising the key knowledge gaps, challenges or bottlenecks relevant to sustainable Blue Growth and the implementation of the MSFD. COLUMBUS Work Package 4 is concerned with knowledge supply; the identification and collection of knowledge outputs with the potential to address the knowledge gaps, bottlenecks and challenges identified in Work Package 3.

Whilst the main focus of Work Package 4 is to collect knowledge outputs from research projects (Task 4.1), this report resulting from Task 4.2 focuses on data portals and repositories as sources of knowledge in the form of data, metadata and derived data-products. This is important because there is still a huge gap between the available knowledge that can be derived from European data resources and actual uptake by users resulting in tangible contributions to Blue Growth, marine environmental management and knowledge-based policy making.

2 AIMS AND SPECIFIC OBJECTIVES

This report starts from the observation that European marine data portals and repositories constitute a critical source of data resources, information and knowledge which is currently largely unknown and underexploited (see Chapter 4) by a wide range of Blue Growth actors.

The overarching aim of this activity and resulting report is therefore to increase the visibility of European marine data portals and contribute to the identification of actions and resources that could be taken forward for knowledge transfer in support of Blue Growth sectors.

To achieve this aim, the following specific objectives were formulated:

- Demonstrate the potential of marine data repositories and portals as a source of marine knowledge necessary to underpin Blue Growth (see Chapter 4)
- Identify major bottlenecks slowing down the uptake and impact of existing marine data resources by intermediary (e.g. ocean service providers) and end users (e.g. oil and gas sectors, shipping industry) (see Section 4.2)
- Identify specific needs or gaps in knowledge which require marine observations, data and associated tools (see Chapter 5)
- Identify data, data-products and other relevant information resources and tools with potential to address some of the priority gaps and needs of users (see Chapter 6)

[1] 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 (Marine Strategy Framework Directive) DIRECTIVE 2008/56/EC http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:164:0019:0040:EN:PDF

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- Make recommendations to remove barriers and strengthen the transfer of marine data and knowledge resources to key Blue Growth actors. (see Section 7.2)
- Formulate suggestions for specific knowledge transfer activities that could be considered for further action within the framework of the COLUMBUS project (see Section 7.3)

3 APPROACH

To achieve the above objectives, the core of the work leading to this report involved a systematic screening of the main European marine data repositories to identify data, data-products and other relevant information which may have potential to meet the needs of the main COLUMBUS user groups (industry, policy, science, and society). This screening was underpinned by a dual approach to first identify end-user needs and secondly to identify relevant repositories and associated resources able to address some of the identified needs and gaps.

When considering the position of data portals and repositories, there are two important components for knowledge generation and transfer as is illustrated by Figure 1. Firstly, data, products, or other resources can be transferred from portals and repositories to users. Secondly, filling critical gaps in these repositories by transferring data, knowledge and technology resources from projects and other monitoring and observing activities which would allow them to provide better services and products for users can indirectly impact positively on Blue Growth. For this reason, this report considers both options to efficiently utilise data portals and repositories: to fill gaps in existing portals and repositories as well as to identify resources (data, data-products, services) for transfer from repositories to users.

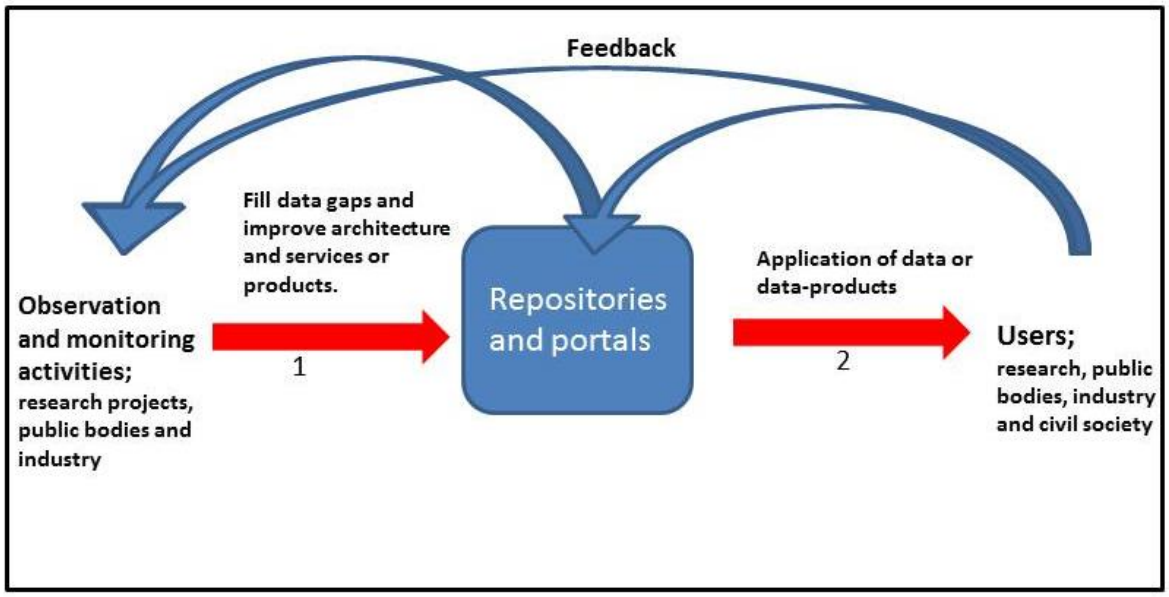

Figure 1 Schematic showing the role of data repositories and portals in knowledge transfer. Two routes of knowledge transfer are shown, where the repositories/portals are both users and providers of data and information products.

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4 MARINE DATA REPOSITORIES AND PORTALS AS A SOURCE OF KNOWLEDGE

4.1 Marine Data, Marine Knowledge and Blue Growth

A recent report on the State of Europe's Seas by the European Environment Agency highlighted the systematic lack of data on the marine environment as being a major obstacle to achieving the EU's Blue Growth objectives, which aspire to greater and sustainable use of the seas' potential. (EEA Report 2/2015)

Data about the marine environment and the impact of human marine and maritime activities is generated to a large extent by Member State funded coastal and ocean observation activities. Currently, Europe's ocean observing infrastructure capability is relatively advanced but fragmented. It includes research vessels, observing and monitoring infrastructures including networks of space-based, airborne and in situ platforms and sensors, marine stations and data management facilities. Until recently, the collection, storage and accessibility of marine observations data has proceeded in an uncoordinated and ad-hoc fashion. Marine observation data is generated and collected by a myriad of organisations - at local, national and regional level - and for a variety of reasons. Marine data can be generated as a result of marine environmental monitoring obligations, the activities of maritime industries, reporting obligations of public bodies responsible for managing activities at sea, and the scientific research community. Increasingly data are also being generated by citizen science activities.

As a result, there is a large degree of variability in spatial and temporal data coverage and many gaps exist. The Marine Knowledge 2020 strategy[2] of the European Commission recognises the potential of Europe's wealth of marine observations to facilitate the growth of a sustainable marine and maritime 'blue economy' and ''to contribute towards meeting Europe's 2020 targets on employment, innovation, education, social inclusion and climate change." The crucial role of data in generating marine knowledge is highlighted in the marine knowledge communication as follows; "The creation of marine knowledge begins with observation of the sea and oceans. Data from these observations are assembled, then analysed to create information[3] in the form of data products such as GIS maps, time-series models and ultimately knowledge on the state or our seas and oceans, their variability and vulnerability. Subsequently the knowledge can be applied to deliver smart sustainable growth, to assess the current health of the marine ecosystem and make predictions for the future or to protect coastal communities." (Figure 2).

[2] Marine Knowledge 2020: Marine data and observation for smart and sustainable growth, 8.9.2010 COM(2010) 461 http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52010DC0461

[3] For a review of the terms 'data,' 'information' and 'knowledge' see Zins 2004.

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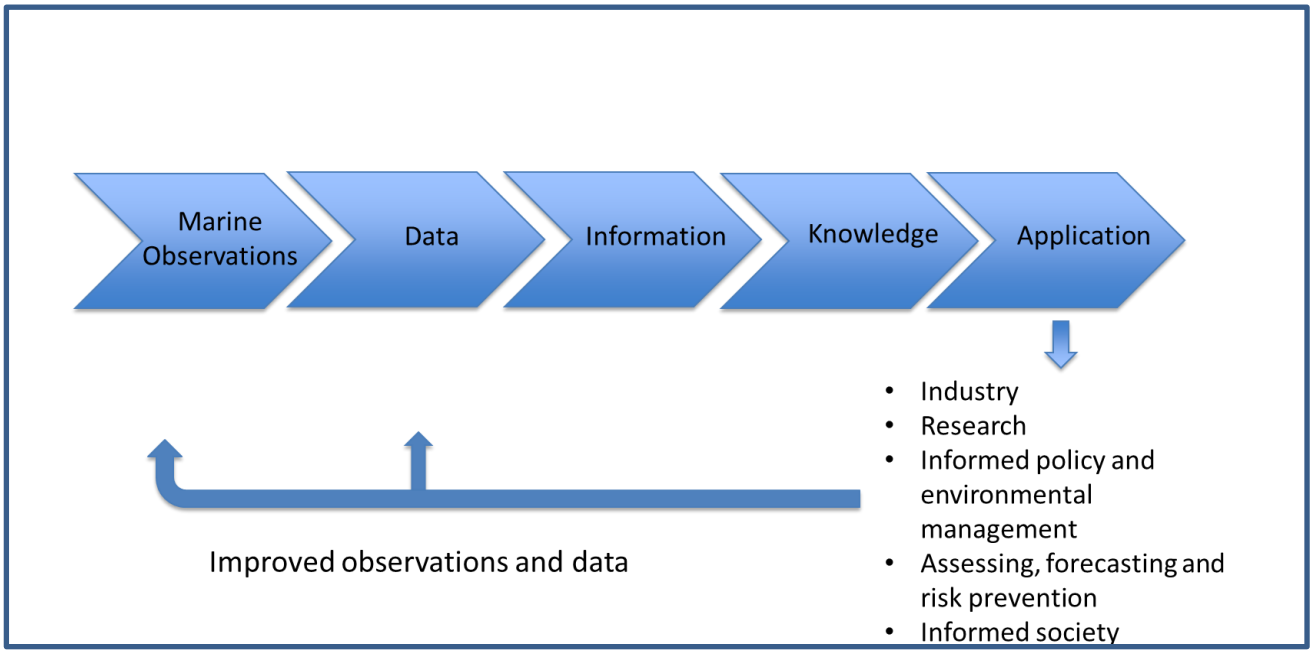
Figure 2. Simplified overview of the marine knowledge value chain illustrating the processes from observation to creation and application of marine knowledge



However, data generated via marine observation and monitoring activities can only be used in the creation and application of marine knowledge if it can be found, accessed and used. Data are often collected for a particular purpose but may have applications beyond the purpose for which they were taken. Effective data management, incorporating the assembly, storage, registration, dissemination and long-term archiving of quality-controlled data, according to agreed standards, maximises the potential uses of the data. This will be discussed further in Section 1.2 below.

It has been estimated that an effective integrated, pan-European marine data infrastructure, making high quality marine data held by public bodies in the EU widely available - based on the principle of "collecting data once and using it as many times as possible," - would save at least one billion Euros per year[4], as well as opening up new opportunities for innovation and growth, facilitating implementation of the Marine Strategy Framework Directive, the Marine Spatial Planning Directive[5] and maritime surveillance activities. It would also help the public and private sectors manage risks and uncertainties connected with the sea. Initiatives such as the European Marine Observation and

[4] Marine Knowledge 2020 Roadmap Innovation in the Blue Economy realising the potential of our seas and oceans for jobs and growth /* SWD/2014/0149 final */ http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=SWD:2014:149:FIN

[5] Directive 2014/89/EU of the European Parliament and of the Council of 23 July 2014 establishing a framework for maritime spatial planning http://eur-lex.europa.eu/eli/dir/2014/89/oj

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Data Network[6] (EMODnet) have made strides towards integration with other EU initiatives - namely the Copernicus Marine Environmental Monitoring Service[7] (CMEMS) and WISE-Marine[8] - using common standards (such as INSPIRE[9]) and in compliance with the principles of the Shared Environmental Information System (SEIS).

Towards an integrated, end-to-end European Ocean Observing System

The EC Marine Knowledge strategy focuses primarily on data and downstream services and less on coordinating the observing tools, technologies and infrastructures that are used to collect marine environmental data. The development, operation and management of observing infrastructures are largely carried out at Member State level in the EU. For this reason, there have been calls to coordinate all components of the observing system in a 'European Ocean Observing System (EOOS),' an inclusive, integrated and sustained Pan-European framework connecting the currently unrelated components. Currently EuroGOOS and the European Marine Board are working together to promote EOOS as a strategic Pan-European framework for advancing Europe's ocean observing capacity. Key components of this framework include standardisation and open-data exchange.

"A truly integrated EOOS would empower European nations to take control of assessing marine environmental status, predicting future scenarios and making informed decisions about ocean governance that balances economic growth with environmental protection…and would ultimately lead to new opportunities in many marine and maritime sectors." It would also "progress Europe's position as a worldwide science and technology leader and further establish Europe's contribution to global initiatives such as the Global Earth Observation System of Systems (GEOSS), through initiatives such as EuroGOOS and Copernicus, the European Programme for the establishment of a European capacity for Earth Observation.." (EMB 2013)

So whilst there is increasing momentum towards unlocking the potential of marine observations, there are currently many impediments inhibiting maximal use of the wealth of European marine observation data.

Europe's current observing capacity, designed mainly for monitoring and understanding the marine environment, must now be developed with user needs in mind, for marine and maritime management and policy development, but also addressing the needs of industry and broader society. These needs will vary on a sectoral and regional basis and in response to as yet unforeseen events. Some of the main challenges in relation to European marine monitoring and observation data are considered below.

[6] The European Marine Observation and Data Network (EMODnet) is a long term marine data initiative from the European Commission Directorate-General for Maritime Affairs and Fisheries (DG MARE) underpinning its Marine Knowledge 2020 strategy. http://www.emodnet.eu/

[7] http://www.copernicus.eu/main/marine-monitoring

[8] http://water.europa.eu/

[9] Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE), to support Community environmental policies, and policies or activities which may have an impact on the environment.

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4.2 Known Marine Data Bottlenecks to Blue Growth

4.2.1 Main Issues

Before data can be used in the creation and application of marine knowledge, there are a number of conditions and criteria that need to be fulfilled (see summary Box 1). First, collected data must be properly processed, stored in appropriate databases and made **discoverable**. For data to be discoverable, the data or the metadata must be made available via an **open data** repository or data portal. Most repositories provide access to data stored in a database at the same location, whereas data portals are often aggregators, gathering data or metadata records from a number of repositories so the data are stored elsewhere. Repositories can be at the level of an institution, or at national, regional, Pan-European or international level. Repositories can maintain, preserve, disseminate and add value to data.

Repositories and portals play an important role in making data discoverable by publishing **metadata** (i.e. data descriptions about the data they hold) and providing search tools. Metadata summarises the basic information about the data: the who, what, when, where and how, of the collected data. Metadata allows the data to be found and subsequently retrieved, either manually via a user-interface with search tools or by a machine/computer via machine to machine communications.

However, there are many issues that complicate the process. Data are collected in many ways and often for a particular purpose, which can result in different standards and vocabularies being used to describe, for example, the same geological substrate in different countries. The use of **agreed common vocabularies** and **standards** supports data discovery and **interoperability**.

In relation to marine data, the successive SeaDataNet projects (Section 6.5) funded under the Seventh Framework Programme (FP7) made significant progress towards the development of controlled vocabularies and standards and have made an important contribution to European marine data management. The Ocean Data Interoperability Platform[10] (ODIP), funded through the EC's FP7 and Horizon 2020 research programmes have contributed to the application of results of EU projects on marine data management to the broader international community.

Summary Box 1. From marine data to marine knowledge for Blue Growth: key enablers and remaining bottlenecks

Some of the main aspects that need to be fulfilled to ensure the efficient generation and application of marine knowledge from data in support of Blue Growth include:

- **Openness**: data needs to openly accessible and free of restrictions of use.
- **Harmonisation**: data needs to be stored using agreed standards and common vocabularies

[10] The Ocean Data Interoperability Platform (ODIP) contributes to the removal of barriers hindering the effective sharing of data across scientific domains and international boundaries http://www.odip.org/

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and made available in formats which allows them to be used and easily combined with other datasets easily.

- **Scale and resolution**: data needs to be fit for purpose and should be available at the appropriate aggregation level, scale and resolution for them to be useful.
- **Data quality and metadata**: data needs to be of the highest quality possible and at least be accompanied by the necessary information about the origin and quality of the dataset to allow users to make judgement as to whether it can be used for the intended purpose
- **Interoperability**: data should be easy to combine with data drawn from other systems/sources and in a way that satisfies the growing demand for exchange via machine to machine communication.
- **Easy and user friendly**: data needs to be discoverable and downloadable in an easy way taking into account the desires of various potential users. search and retrieval tools need to be intuitive and provide shortest routes to actual data discovery and retrieval functions with clear descriptions on how to use the provided services.

Aside from the aspects mentioned in Box 1, other important factors are also currently reducing the optimal re-use of data resources to generate marine knowledge for growth. These include

(i) the **lack of visibility** of the data and information systems and associated tools and resources;

(ii) the **complexity of the marine data landscape** and different data flows;

(iii) the **complexity of the data repositories and portals themselves.**

Data portals and repositories are still largely unknown and underexploited by a vast range of Blue Growth actors who rely on marine knowledge during all stages of their activities from planning to operation. Significant efforts are still required to **better explain the benefits of using already existing data resources and increase their visibility**. This is not an easy task in view of the high number of entities involved in the collection, processing and serving of marine data that is often extremely confusing even for those involved in the initiatives. In addition, marine data portals are often highly specialised and difficult to use requiring a lot expertise that is to some extent linked to the **inherent complexity of the data and metadata** itself. While portals and systems can do a lot to become more user friendly, there will always be a **need to provide user support and training**.

Some of the **underlying problems** include the **lack of resources and long-term funding** for data management and sharing; the **lack of knowledge and capacity** of the data originator or data holder to manage and serve the data even if he/she would be willing to do so; and the **lack of willingness to share data** due to conflicting interest between providers and users of data. However, it should be noted that the main underlying problem is the sustainability of the observing platforms themselves i.e. a lack of committed resources to keep the existing platform network maintained at the national level.

In what follows, we focus on current issues related to data sharing and data openness as a major barrier to Blue Growth.

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4.2.2 *Open Access and Data Restrictions*

4.2.2.1 Towards open access

In recent years there has been a broad international movement towards open access to data. The Berlin declaration on "Open Access to Knowledge in the Sciences and Humanities" recognised the potential of research data as a source of knowledge[11]. In 2007, the OECD (Organisation for Economic Co-Operation and Development) published principles and guidelines for open access to research data from public funding[12]. These principles and guidelines were intended to apply to data gathered using public funds for the purpose of producing public knowledge. In 2013, the EC issued a communication[13] demanding that Member States put policies in place to ensure that publicly funded research data be made 'publicly accessible, usable and reusable through digital e-infrastructures.'

More recently, the growing importance of open (research) data was emphasised in the Draft Council conclusions on 'open, data-intensive and networked research as a driver for faster and wider innovation[14].' An Open Research Data Pilot[15] was launched in Horizon 2020 with a view to improving and maximising access to and reuse of research data generated by projects. The scope of the pilot covers only certain areas of the work programme for 2016 – 2017. It also includes a number of common open-access caveats, allowing projects to opt out at any stage for reasons including; potential commercially exploitable results, security issues or rules on personal data protection.

It is important however to emphasise that open and free access does not necessarily mean 'easy' access. And open, free and easy access does not necessarily mean that the data are useful (e.g. in terms of parameters, scale and resolution, quality, etc.) or immediately useable (e.g. not in a useable format or not accessible in a way which allows combination with other data sets) for a given purpose.

4.2.2.2 Data access restrictions

In 2016, a growing number of national, regional and European marine data and information systems are based on the Open Access principle in line with an accelerating trend towards provision of access via machine to machine communication which requires openness and interoperability between data and systems. However, in reality there are considerable challenges in achieving open, free and easy access. These challenges are largely derived from the differing needs and concerns of data holders on the one hand, who may wish to put in place restrictions to open and free access to their data, and those of data users who want fast, easy and free access to the data on the other hand. In addition,

[11] Berlin Declaration (2003) Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities. Available: http://openaccess.mpg.de/Berlin-Declaration

[12] OECD Principles and Guidelines for access to research data from public funding - ©OECD 2007. Available: http://www.oecd.org/science/sci-tech/38500813.pdf

[13] Recommendation C(2012) 4890 final to Member States on Access to and preservation of scientific information. Available: https://ec.europa.eu/research/science-society/document_library/pdf_06/recommendation-access-and-preservation-scientific-information_en.pdf

[14] Draft Council conclusions on open, data intensive and networked research as a driver for faster and wider innovation http://data.consilium.europa.eu/doc/document/ST-8970-2015-INIT/en/pdf

[15] Guidelines on Open Access to Scientific Publications and Research Data in Horizon 2020 http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/oa_pilot/h2020-hi-oa-pilot-guide_en.pdf

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data providers have a need to collect information about who and why the data is being used and this may also restrict easy access.

There are many different reasons why data originators are not keen on sharing data, including for reasons of national security, commercial sensitivity, privacy or lack of resources and/or know-how. Often data restrictions are linked to the kind of organisation or individual and intended purpose of the collected data. Each of the four COLUMBUS end-user groups (science, policy, industry and society) are also providers of observation and marine data and each face specific challenges in relation to data-sharing.

Scientists and scientific organisations generate significant amounts of marine data but are primarily interested in publishing research results in scientific papers rather than disclosing their underlying data. Depending on the policy of the institution or funding body[16], the data may or may not be made publicly available. Data sharing policies often include some of the following elements:

- Data management plans: where researchers may be required to submit a data management plan with their funding proposals.
- Quality and standards: researchers may be required to adhere to international standards that will ensure the data is accessible by others.
- Metadata: researchers may be required to generate data documentation and metadata to accompany the data so that the data is discoverable and understandable to others.
- Method and timing of data sharing: researchers may be required to make a statement as to how and when they will share the arising research data.
- Data preservation: researchers may be required to deposit their data in a long-term repository, where available, to ensure the preservation of their data beyond the life-time of the project.

Significant amounts of marine data are generated by **public bodies in support of policy development and implementation**. Increasingly public bodies are making data available but large amounts remain hidden. In some cases, data are not made available because underlying licenses required to carry out the survey prevents the release of data even if providers would be willing to share it. In other cases, data are not shared for reasons of security and/or personal data protection issues, or because data generators may be hesitant to share data to avoid users having an opinion or making "wrong" conclusions based on their data (mostly in the case of environmental monitoring and reporting).

Maritime industry produces lots of useful data but sharing is not a common practice. In some cases, the data can be considered to be of strategic interest, providing the company who has collected the data with a competitive advantage. In other instances, the data may no longer be of strategic

[16] Special clause 29 to the FP7 model grant agreement required that projects "protocols and plans for data collection and storage are in line with the Data Policy of the European Union" and also that projects make available data of use for "the purpose of developing, implementing and monitoring environmental policies." The rules under Horizon 2020 go further, with clause 29.3 'Open access to research data' requiring beneficiaries to make available in a suitable repository all data, metadata and other relevant information used to validate their research results. Again, beneficiaries are required to "give access to their results — on a royalty-free basis — to EU institutions, bodies, offices or agencies, for developing, implementing or monitoring EU policies or programmes," (Clause 31.5).

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advantage to the company who collected the data but because the data has often been acquired at a cost, making it freely available to other industrial actors, might be seen as reducing costs for competitors. The data collected by industry are sometimes a by-product of their work or gathered as part of a preliminary baseline screening for environmental impact assessments. As such any subsequent data management or dissemination is not a priority for industry and they often do not allocate resources to it.

An informed (marine-literate) society contributes to better governance and protection of the marine environment. A wide range of **civil society organisations** actively use but also collect marine data, either directly or via participation in projects, to support their work ranging from environmental advocacy to capacity building and protecting interests of sensitive communities and populations. Growingly, citizen science initiatives generate marine data (e.g. Marine LitterWatch [17], jellywatch.org[18], FP7 MicroB3 project's Ocean Sampling Day[19]). While there may be issues in terms of quality and methodology, citizen science projects have the capacity to provide a large amount of long-term spatial data at relatively low costs that is often not available via other means. Generally, civil society organisations are keen on making their data publicly available but often lack the financial or human capacity to do so in an efficient way.

4.2.2.3 Possible solutions and way forward

While there may be justified reasons why some data holders have concerns about making data freely available there are few legitimate reasons for keeping data hidden after a certain period of time. A balance can and should be found between the needs of users and interests of data holders. In some instances, issues with regard to exploitation for commercial reasons or even for further research can be overcome by putting a moratorium on the data, a defined period of time to allow the data-collectors to exploit fully the data, after which time it must be made freely available.

Even initiatives like EMODnet that aim to make data freely available are sometimes faced with restrictions applied to the data by the data owner. However, making data sets discoverable even if restrictions apply to their use, can prevent unnecessary duplication of effort and resources. It also flags the existence of the data-set to potential users who can contact the data-owner to establish its availability for re-use.

The following are some ways forward that could be considered to promote wider sharing of data in support of Blue Growth.

- **Culture change**: Marine data sharing in Europe needs to move from concept to practice and there is still a long way to go to achieve this. It would require a major cultural change in those involved in collecting, processing, managing, storing and sharing data. Promotional campaigns and clear signals from all policy levels as well as from all major user/provider communities are required to ensure this shift in attitude takes effect.

[17] http://www.eea.europa.eu/themes/coast_sea/marine-litterwatch

[18] http://www.jellywatch.org/

[19] https://www.microb3.eu/osd

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- **Leverage data against funding**: in cases of public funding, open-access should be mandatory, as is the case in many countries around the world such as the USA. The European Commission should consider taking a stronger stand to make it obligatory that any data collected with public funds must be made freely available except in exceptional circumstances. One incentive which the European Commission could consider would be to consider reducing or removing the opportunity for future funding if data from current projects are not made available in a timely manner. This would involve allocating resources to data management and the development of data management plans from the onset of research projects.
- **Data citation and research performance**: data providers from research could be strongly encouraged to deposit generated data into a repository when data are clearly identifiable via a Digital Object Identifier (DOI) and through establishing a widely implemented data citation index. As well as facilitating traceability of data, data citation allows the impact of data to be tracked and acknowledges data sources.
- **Leverage data against licenses or permits**: many offshore operators need to collect data and assess environmental impact of their activities, either prior to the activity to obtain a license or during the activity to maintain it. These data should be made available in an easy to use format for others to re-use.
- **Acknowledging data holders**: making data sharing obligatory is not enough. There is a need for a more positive message to encourage providers to share their data with clear indication of the benefits including a system of proper crediting and acknowledgement to increase the visibility of the data holders. In some cases, data providers and sharing systems could set up formal agreements or Memorandum of Understanding which may be useful for data holders to justify their efforts towards their own funders.
- **Providing services and tools for data holders**: data holders should receive better guidance and support if they are willing to share data but lack the technical or financial resources to do so. In some cases, data holders could receive specific services for data access and data management for free in return for their data.
- **Long term funding**: there is a need for long-term sustained funding for thematic and regional data repositories to provide security and confidence for data holders willing to provide their data.

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5 MARINE DATA AND INFORMATION NEEDS

5.1 Establishing Data and Information Needs

The COLUMBUS project identifies 'Blue Growth' and marine legislation such as the implementation of the MSFD as priority areas. Blue Growth[20] is the long term strategy of the European Commission to support sustainable growth in the marine and maritime sectors based on the potential of Europe's seas and oceans to deliver innovation and growth and contribute to achieving the goals of the Europe 2020 strategy for smart, sustainable and inclusive growth. **Sustainable Blue Growth is intrinsically linked with, and dependent on, the implementation of the Marine Strategy Framework Directive.**

The Blue Growth communication of the EC recognises five high potential growth sectors, namely; aquaculture, coastal tourism, marine biotechnology, ocean energy and seabed mining. In addition to these priority areas, the more traditional maritime sectors remain very important to, and all of them rely heavily on, timely access to high quality data and observations for their planning and operations.

To be able to organise knowledge transfer activities, the COLUMBUS project is structured into nine over-arching themes or focal areas called the COLUMBUS Competence Nodes, which collectively encompass all the Blue Growth sectors, in particular the five target areas, and represent the main marine and maritime sectors and actors in Europe. These COLUMBUS Competence Nodes and a description of the subsectors and thematic areas within the scope of each node is provided below (Table 1).

Table 1. COLUMBUS Competence Nodes covering all Blue Growth sectors

• COLUMBUS Competence Nodes	Subsector/Subtheme
• Fisheries	• Fisheries Management
	• Gear/Technology
	• Stock assessment
	• Seafood value chain
• Aquaculture	• Biofouling
	• Breeding and Husbandry
	• Quality
	• Health and Welfare
	• Sustainable aquaculture
	• Production
	• Supply sector and full value chain

[20] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Blue Growth opportunities for marine and maritime sustainable growth /* COM/2012/0494 final */ http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:52012DC0494

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• Monitoring & Observation	• Marine data and information acquisition, storage and access systems
	• Monitoring and observation technology and systems (e.g. sensors, biosensors, bioinformatics, seabed mapping, Ocean observing systems, etc.)
• Marine Biological Resources	• Biomass
	• Biocompounds for applications in e.g. Aquaculture, food, feed, biomaterial, biotechnology
	• Marine genomics
	• Blue biotech
	• Marine ecosystem
• Maritime Transport & Logistics	• Shipbuilding
	• Shipping and operations
	• Maritime logistics infrastructures
	• Operations and Port operations (incl. safety & security, surveillance)
	• Marine engineering value chains
• Marine Physical Resources	• Marine & offshore renewable energy
	• Offshore oil & gas
	• Marine aggregates
	• Deep Sea mining
• Maritime Tourism	• Cruise and Cruise supply chains
	• Leisure marine activities
	• Marine infrastructures
	• Leisure boat-building
	• Marine engineering value chains
	• Coastal tourism
• Marine Governance & Management	• Coastal & ocean governance and management
	• Finance modelling & prediction
	• Socio-economics
	• Environmental impact assessment
	• Water resource management
	• Marine spatial planning
• Marine Environment & Futures	• Oceanography
	• Biodiversity
	• Climate change and effects on marine environment
	• Ecosystem services

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To ensure that this report is relevant to the objectives of the COLUMBUS project and to capitalise on the partners' expertise, data relevant knowledge gaps and/or challenges were identified for each of the nine COLUMBUS Competence Nodes.

In order to carry-out COLUMBUS Task 3.1[21] and feed into the deliverable 'Knowledge Gaps and Needs in Different Focus Areas,' node lead partners were tasked with developing profiles identifying specific challenges inhibiting progress in the sectors encompassed by the overarching COLUMBUS Competence Nodes. These profiles were analysed by Partner 16 (Seascape) to identify gaps and bottlenecks that could be addressed by improved access and application of monitoring and observation data and knowledge.

In addition, a questionnaire (Annex 2) was sent directly to each partner responsible for a COLUMBUS Competence Node as well as to all other partners in COLUMBUS to try and obtain more specific first-hand information about bottlenecks in relation to finding, using and sharing of data in their own marine and maritime sectors. This information was supplemented by further desk-top research by Partner 16 and interviews with key stakeholders.

The results are listed for each COLUMBUS Competence Node in Section 5.3. Due to the broad description of some of the Competence Nodes, there is some redundancy amongst the data needs identified with certain gaps/bottlenecks identified for more than one subsector. Also in many cases the data gaps or bottlenecks refer to an absence of data due to a need for enhanced monitoring and observation. It should be noted that this is a non-exhaustive list of gaps and bottlenecks.

5.2 Data and Information Needs of Main User Communities

There are roughly four major categories of professional users of marine data and data products and services, each looking for data for different purposes and therefore reflect different requirements both in the types, scale and quality of data.

Currently the **scientific community** is probably the largest group of users and generators of marine data. Data provenance is perhaps a bit less important for this community compared with others (e.g. public authorities). Given their contribution to the development of the infrastructure, services and content of some of the main data repositories and portals, this community is relatively well informed about what is available, where and how to obtain it. This is particularly the case for data from other scientists and that of public bodies, but perhaps less the case for data from companies.

Public bodies rely on data for a wide range of purposes from policy preparation up to implementation of legal requirements, e.g. in the framework of international, regional or national monitoring and environmental reporting obligations. In particular, the latter activities have high demands in terms of data collection methodologies, Quality Control and Assurance (QA/QC) and metadata. Nevertheless, these organisations still have a lot of scope to both share their data and use existing tools and external resources much better.

[21] Task 3.1 'Establish an overview of the key challenges, bottlenecks, gaps and needs related to Blue Growth including MSFD Implementation and the revised Common Fisheries Policy by reviewing the latest work carried out by other strategic initiatives. Associated Deliverable 3.1 'Report on knowledge gaps and needs in different focus areas.'

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The **private sector** is not only an important end-user of marine data, information and knowledge, but also critical to ensure uptake as an intermediary data user. It is expected that most impact will be generated by focusing on transfer to these intermediaries who can then generate added value products and services for other users[22][23]. These intermediary companies need to be better informed about what is publicly available for them to contribute to Blue Growth.

Finally, civil society is also an important user of marine data resources but often forgotten. These NGO's and related actors do not always have the necessary in house expertise to find, retrieve and translate the data resources into knowledge products so they need to be better informed about what is publicly available and receive tools and training to be able to use these resources.

5.3 Data and Information Needs for Blue Growth Areas

The following section lists some of the identified data and information needs together with some of the gaps in observing capacity that contribute to these needs. These are listed per COLUMBUS Competence Node area.

5.3.1 *Overarching Data and Information Needs Identified by the COLUMBUS Marine Monitoring and Observing Competence Node*

For the monitoring and observation node, the data and information needs are divided into 'scientific and technical', 'governance and funding' and 'societal.' These were compiled from a range of strategic documents (ABP 2015, EMB 2013, EC 2013, EEA 2015, UNESCO 2012, IOC/INF-1284 – see References) and also from communication with key stakeholders in the field of marine observation and monitoring.

Scientific and Technical Needs:

- There are spatial, temporal and thematic gaps in marine data collection. There is a need for a sustained effort in data collection;
- *In-situ* sensing of oceans is much less developed than remote sensing from satellites;
- There is a need to incorporate both coastal and open ocean observations;
- There is a need for high precision and accurate biogeochemical sensors to contribute to an operational Global Ocean Observing System;
- New methods and technologies such as genomics and marine acoustics should be explored;
- There are gaps in the knowledge base on the condition of marine ecosystems and marine biodiversity and this is hampering progress towards MSFD implementation;
- There is a need to improve knowledge and methods for dealing with data-poor and data-deficient species given the impacts fisheries and aquaculture may be having on species which are not or cannot currently be assessed;

[22] 'Consolidating the Foundations and Building the Future. First EMODnet Open Conference: Summary Report (May 2016) http://www.emodnet.eu/conference;

[23] FixO^3 Deliverable 5.2 2014 http://www.fixo3.eu/download/Deliverables/D5.2%20140826_FixO3_-%20FINAL.pdf

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- There are still important gaps in the mapping of European sea beds;
- Statistical data assimilation and predictive modelling as means of identifying gaps in the current observing system are under-utilised;
- There is a need for advanced technology in automated underwater vehicles (AUVs) to facilitate high resolution seabed mapping in remote areas;
- Whilst AUVs and drones have potential as observation platforms, their use for these purposes presents challenges in terms of security, particularly if used close to trans-jurisdictional boundaries;
- There is a need for improved cross-sector research in the development of sensors, platforms etc. to ensure marine science benefits from innovative technological developments in other areas;
- There is a need to consider how to provide wider access to observatory infrastructures, particularly to those countries lacking marine research infrastructures;
- There is a need to consider how to integrate and harmonise the current technological, procedural and e-infrastructure processes for better integration of European observation and monitoring platforms;
- Oceans observing platforms can be extended to include novel and/or indirect observation platforms such as vessels of opportunity and divers. Use of the latter could also contribute to citizen science and ocean literacy initiatives;
- There is a gap between industry and science in ocean observation and monitoring. An improved industry/science interface would guide scientific research towards greater societal relevance and focus knowledge creation on areas where new technologies and products are most needed;
- There is a need for mechanisms to establish if the present observation infrastructure is the most effective possible - such as via the EMODnet sea basin check-points;
- Challenges common to Big Data include; how to identify the right data, lack of expertise to implement big data applications, synchronisation across data sources, data accessibility and integration, ownership issues, security concerns with regard to data protection and a rapidly changing technology landscape.
- In relation to marine data (and building on initiatives such as EMODnet) there is a need to:
    - Provide wider access to quality-assured, standardised and harmonised marine data, products and metadata which are interoperable and free of restrictions on use – for both for public and private users;
    - Collect data once and use it many times;
    - Develop standards across disciplines as well as within them;
    - Process and validate data at different levels - at national, sea-basin and European level;

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- Build on existing efforts where data communities have already organised themselves;
- Develop a decision-making process for priorities that is user-driven so that available data are fit-for-purpose;
- Accompany data with statements on ownership, accuracy and precision;
- Recognise that marine data is a public good and discourage cost-recovery pricing from public bodies.

Governance and Funding Needs:

- Some data is not freely available to industry;
- Data generated by/for industry may not be freely available to other potential users;
- There is a need to consider how to foster an open-access data policy amongst researchers possibly via incentives such as Digital Objective Identifiers and a data citation index linked to performance indicators. Funding agencies and institutions need to make open access data a supported and mandatory requirement of publicly funded research;
- There is a need to contribute to a more informed civil society to result in better ocean governance and greater transparency bearing in mind stakeholders such as local communities often don't have access to the resources which science and industry have;
- The European landscape of marine research infrastructures governance initiatives is too complex and fragmented and this is an obstacle to achieving optimal impact of marine research infrastructures;
- Considering oceanographic research vessels as an important component of marine research infrastructures, initiatives such as EuroFleets[24] and Ocean Facilities Exchange Group[25] have made some progress towards the coordination of these at European level, however this could be further improved to maximise their potential;
- The multiplication of governance frameworks for specific categories of marine research infrastructures calls for a strategic framework identifying key societal needs and objectives at European level, and providing for a coordinated development of the different initiatives, marine research infrastructures, projects and networks ;
- Marine challenges do not stop at national borders and synergies can and must be achieved at European level. Member States must ensure that the cost of archiving and managing data is properly budgeted for;

[24] Eurofleets (1 and 2) are research infrastructures projects under the 7th Framework Programme of the European Commission aiming at consolidating the construction of a pan-European distributed research fleet infrastructure with common strategic vision and coordinated access to European marine research vessels and equipment. http://www.eurofleets.eu/np4/home.html

[25] OFEG represents Europe's leading oceanographic research organisations and provides a forum to consider barter exchange and co-operation opportunities for the Global and Ocean Class research fleet. http://www.ofeg.org/

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- There is a need for sustainable financing at an EU level so as to extract maximum value from the efforts of individual Member States;
- There is a need for investment in R&D for the continued innovation in infrastructure, in particular funding for ocean sensors, platforms and cross-sector research.

Societal

- There is a need for greater cross-sectoral understanding of the complex interactions of the ocean with most other branches of science, as well as the major influence of the ocean in issues of societal importance;
- There is a need for greater awareness raising and promotion of initiatives such as EMODnet, amongst all potential end-users – not just those in the marine and maritime communities – to highlight the wealth of available marine data with potential for application in numerous areas;
- Valuable marine knowledge (data and information) generated by academic institutions, projects or industrial stakeholders can remain hidden. There is a need for raising awareness amongst marine data generators of the benefits to utilising data repositories for safeguarding, adding value and maximising the potential of their knowledge;
- End-users needs must be considered to establish if the present observation infrastructure is fit-for-purpose.

5.3.2 *Marine Governance and Management*

For the purposes of this report and given the focus of the work of the COLUMBUS marine governance and management Competence Node, the following section focuses on two main areas: implementation of the Marine Strategy Framework Directive (MSFD) and the Marine Spatial Planning Directive (MSPD).

5.3.2.1 Marine Strategy Framework Directive (MSFD) implementation

There is a lack of data, in particular, in relation to the following areas:

- Biodiversity Assessments;
- Parameters describing the characteristics of the size spectrum of the benthic community;
- Non-indigenous species;
- Descriptor 10 Marine litter;
- Descriptor 11 Underwater noise/energy.

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The STAGES project workshop[26] was identified as being relevant in the context of this Competence Node. Subsequent analyses of the workshop report identified the following challenges for implementation of MSFD specific to data needs:

- Lack of long-term data series on biodiversity;
- Lack of data concerning off-shore biodiversity (what data is available is limited to coastal waters and is disparate);
- Need for integrative methods enabling valorisation of incomplete and heterogeneous monitoring data (biodiversity);
- New indicators based on genomic data (biodiversity);
- Technological developments and miniaturisation of sensors to increase data collection;
- Need for new devices for monitoring and transmission of data from the deep-sea;
- Develop marine ecotoxicology data including for emerging contaminants;
- Need for data on source of energy and noise perturbation and also on baseline ambient noise;
- Lack of coherence of data on marine litter, particularly in off-shore areas –need for opportunistic monitoring;
- Lack of data on some stocks of commercially exploited fish and shellfish;
- Data on by-catch not available or limited;
- Lack of data on hydrographical conditions.

5.3.2.2 Maritime Spatial Planning Directive (MSPD) implementation

The development and implementation of Maritime Spatial Planning (MSP) requires the availability of, and access to, sound information on the marine environment, and on current and possible future maritime human activities. MSP planners need information on their chosen area and its surroundings in order to assess its current state and trends, but also to assess potential conflicts and the cumulative environmental impacts of human activities, following an ecosystem based approach. The availability of high quality, interoperable spatial data has been recognised as a key requirement for successful MSP. However, planners rarely require data as such, but the information contained in the data, implying a significant difference between raw data and processed data. Physical, environmental, economic, social, cultural and also political parameters are likely to come into play in the context of using “best available data”, but the available data (whether raw or interpreted) may not always provide the necessary information for MSP.

[26] http://www.stagesproject.eu/images/STAGES/Monitoring_workshop/STAGES_Monitoring%20WorkshopReport_v4_13.01.2015.pdf

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On the basis of the numerous MSP projects (e.g. BaltSeaPlan[27], PartiSEApate[28]) and the Member States Expert Group on MSP itself, the recent scoping paper "Technical Study: Evaluation of data and knowledge gaps to implement MSP[29]" highlighted a number of common issues regarding data and the implementation of the MSP Directive. Some of the following are generic issues related to data access and have been explained earlier in this report:

- **Awareness and suitability of existing data resources**: Numerous national and transnational data sources and providers exist that could provide important input to MSP. These, however, are often widely dispersed, not always known to planners, and not always suited to the specific needs of MSP.
- **Lack of data:** As outlined earlier, many important data gaps exist in Europe's current observation and monitoring system, particularly in offshore regions and regions where fewer human activities take place. There is also a lack of socio-economic data and information.
- **Data quality:** Whilst data may be available, they may not be of sufficient quality for planning purposes and therefore cannot be used.
- **Data availability and ownership:** In many cases data sets exist but remain unavailable to the public for reasons discussed earlier. These situations may impair the validity and accuracy of the plan or result in extra costs if data have to be collected again.
- **Importance of metadata**: Information about the data is often incomplete or non-existent, which limits the possible use of the data and its interoperability.
- **Relevance of data** (related to the quality of data): Much of the existing data has been collected and analysed with individual marine applications in mind, but not necessarily with a view to combining different data for an MSP process. Therefore, the available data, its quality and its analysis need to be assessed for its relevance to the MSP process under consideration.
- **Scope:** Depending on the origin of the collection programme, data collections may be defined within political or administrative borders instead of ecosystem borders, thus limiting the applicability of an ecosystem-based approach. Since environmental processes and human activities extend beyond national borders, this should be taken into account when considering the scope of data collection.
- **Interoperability:** Data and information must be exchangeable between different actors at the local, regional, national and supranational level. The ability to analyse cross-border

[27] http://www.baltseaplan.eu/

[28] http://www.partiseapate.eu/

[29] Assistance Mechanism for the implementation of maritime spatial planning Technical Study: 'Evaluation of data and knowledge gaps to implement MSP' **Scoping Paper** Client: European Commission Directorate-General for Maritime Affairs and Fisheries Service Contract EASME/EMFF/2014/1.3.1.7/SI2.721508 - Call MARE/2014/23 s.Pro & Ecorys

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activities and impacts, while reducing data duplication, relies on the possibility to exchange and use certain data of the neighbouring countries or regional organisations. Interoperability in relation to monitoring programmes for MSFD must be ensured. Close collaboration with MSFD data collection increases cost-effectiveness of monitoring and data collection.

5.3.3 *Fisheries*

Some of the issues in relation to fisheries where there is a need for better access to data are the following:

- Need for seabed mapping to improve the knowledge of where to fish for which species. There is a need for stakeholder feedback to support the design of data collection/sharing;
- There is a need for improved stock assessment methods;
- Data on invasive species could help establish their potential as new commercial fisheries;
- Identification (need for data) of under-utilised fish resources – mesopelagic species;
- Difficulty in obtaining commercial fisheries data due to personal data protection concerns i.e. identifying individual vessels from VMS data;
- Commercially sensitive data i.e. Fisheries logbook catch information.

5.3.4 *Aquaculture*

Some of the gaps and challenges identified in the aquaculture node where improved access to data is required are the following:

- Spatial planning- need to adapt existing and develop new management tools and measures used for environmental monitoring and optimal siting of aquaculture farms, including a need for hydrographic data and geological data to understand the structure and quality of the seabed for installation purposes;
- Chemical data to ensure suitable quality and pH of the water column for fish production;
- Historical and real-time meteorological data to predict waves and currents for optimal design and siting of sea cages;
- Evaluate the assimilative capabilities per volume and area of sea floor of coastal ecosystems and the critical loading rates of biogenic wastes for main water types;
- Establish integrative management tools which consider assimilation capabilities, hydrodynamic energy and presence of sensitive habitats as a tool for siting, spatial planning and ecosystem based management of aquaculture;
- Understand the fate and cumulative effects of persistent agents used in aquaculture and minimising their impact on the environment;
- Provide and make available unbiased information on the interaction of aquaculture and the environment;

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- There is a lack of consistent and up-to-date data on mariculture sites. This is required for maritime spatial planning, particularly by cross border maritime spatial planners.

5.3.5 *Marine Biological Resources*

The following issues were identified where improved data collection or better access to data were required:

- There is a need for data for estimating maximum sustainable yield – species distribution and abundance;
- Combined platforms for observation and biodiversity assessment – via genomic sensors;
- Lack of data for marine organisms in general compared to medical and agronomic sector although this is increasing currently;
- There is often a lack of geographical location data (GPS coordinates) for sequence data (barcoding data);
- There is a significant lack of data on benthic communities making generation of seabed habitat maps difficult;
- There is a need for environmental data to be linked with genetic data to facilitate traceability of genetic resources under the Nagoya Protocol.

5.3.6 *Marine Environment and Futures*

This Node identified 'challenges' as being activities that contributed to damage to the marine environment. These were listed as:

- Marine litter;
- Deep-sea mining (see 3.1.6);
- Ocean acidification.

Relevant to these areas, the following knowledge gaps were identified to which improved access to monitoring and observation data/knowledge could contribute:

- Information on the state of the environment through advanced observing systems;
- Assessments of risks, impacts and vulnerabilities, through regional and decadal analysis and prediction;
- Enhanced environmental information services for users;
- There is a need for more synoptic data of climate relevant variables with sufficient temporal and spatial resolution. These data are required e.g. for data assimilation exercises in climate modelling and reliable predictions as a basis for governmental regulations and political decision making;
- There is a lack of reliable data on concentrations of microplastics and the composition of polymers within the marine environment;
- Currently available data on microplastics is heterogeneous in quality and resolution.

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5.3.7 *Marine Physical Resources*

Within this node two distinct sectors were explored:

- Marine and offshore renewable energy sector;
- Deep-sea mining sector.

Relevant to both sectors, the need for improved sharing of monitoring and observation knowledge was highlighted. The commercial and competitive nature of industry has historically not supported the sharing of knowledge and data, thus research in this area is fragmented and the potential of research activities to contribute to growth in the sectors is reduced.

Data on submarine pipelines are not easily available and/or not accurate. This information has potential for many users, particularly in relation to marine spatial planning. This data however is usually the property of a commercial party and is not easy to obtain for dissemination via a public portal.

There is a need for marine monitoring and observation data to contribute to each distinct sector as follows:

5.3.7.1 Marine Renewable Energy:

- Understanding marine renewable energy pressures on the ocean – including regional baseline;
- Development of models for environmental impacts of marine renewable energy technologies;
- Quantifying the resource characteristics in leased sites within an appropriate timescale;
- Develop a standardised method for ocean energy site characterisation and project planning;
- Installation and protection of cables for offshore wind-farms requires data on underwater topography and seabed soil type as well as predictions on how these will change with time.

5.3.7.2 Deep Sea Mining:

- Lack of knowledge regarding whereabouts of deposits (e.g. oil, gas, aggregates);
- Investigation of environmental impacts – baseline data is necessary;
- Data/outputs from ongoing exploration efforts should feed into better maps of sea-bed ecosystems;
- There is an urgent need for environmental baseline data to be shared in order to establish regional environmental management plans;
- Monitoring results of first extraction projects should be widely shared.

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5.3.8 *Maritime Transport and Logistics*

Maritime transport and logistics is heavily reliant on adequate and accurate data. The following were identified as issues in relation to data availability:

- More hydrographic data provided by private operators will supplement the work of national hydrographic offices and would positively benefit safety of navigation;
- Access to reliable data for rapid response to hazard mitigation (e.g. oil spills);
- AIS data are not freely available;
- Safety of navigation in Arctic areas;
- Need for more data on human activities in and around ports and harbours.

5.3.9 *Maritime Tourism*

The following issues were identified in relation to a need for improved access to data:

- The need to ensure high quality coastal and recreational bathing water quality;
- Affordable and reliable real-time water quality measurement sampling tools with sufficient temporal and spatial concentrations;
- Reliable water quality models of catchments and the near-shore zone;
- Real time public information tools;
- Tracking and quantification of microbial sources;
- Lack of information on marine areas for eco-tourists (e.g. divers) highlighting interesting coastal or underwater features;
- Protection against coastal erosion requires assimilation of data on historical meteorological events that contributed to significant erosion. Such data includes water current and wind flows, water temperature and the bathymetry of coastal areas;
- Underwater features, such as archaeological remains.

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6 Resources from Marine Data and Information Systems

Having identified some of the main issues and needs in relation to marine data in support of Blue Growth, the following section will consider some of the resources currently available which may have potential to address some of the needs outlined above.

6.1 Screening of Public Portals to Identify Relevant Marine Data Resources

The compilation of an initial list of repositories with potentially relevant marine data and information was carried out in two steps.

1. First, Partner 16 carried out initial desk-top research to identify the main Pan-European and regional (sea-basin) repositories and to develop an initial list of marine data repositories from a selected number of EU Member States as an example[30].
2. Secondly, to validate and supplement the list of repositories, Partner 16 solicited input from COLUMBUS partners via an email survey in which they were also asked to provide information regarding the use of repositories within their respective communities via a questionnaire. The resulting overview of data repositories can be found in Annex 1.

The breadth and complexity of the marine monitoring and observation landscape and the scope of the COLUMBUS Competence Nodes is such that a detailed analysis of all potentially relevant portals and repositories would not be possible within the time-scale of this task. For this reason, this report provides a more in-depth analyses of a limited number of overarching portals and information systems in Chapter 6. These portals and data systems were chosen for a more in-depth screening based on a range of criteria as follows: multidisciplinary in thematic coverage, broad geographic scope, free access to data, quality controlled and clear metadata. At least one portal targeting each of the COLUMBUS end-user groups (science, policy, industry and society) was chosen.

The selected marine data systems and portals are:

- The seven thematic data portals of the European Marine Observation and Data Network (EMODnet) - www.emodnet.eu
- COPERNICUS Marine and Environmental Monitoring Service (CMEMS) - http://marine.copernicus.eu
- SeaDataNet - http://www.seadatanet.org
- Data Portal of the Intergovernmental Council for the Exploration of the Sea (ICES) - http://ecosystemdata.ices.dk
- PANGAEA® - https://www.pangaea.de
- European Atlas of the Sea - http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/

[30] It was not possible within the timeframe of this task to develop an exhaustive list of all relevant marine data systems and resources in all EU Member States. However, to gain a better understanding of how difficult it would be obtain information about repositories at Member State level, an initial list of data repositories was compiled for a selection of countries with inputs from contacts in these countries.

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Since each of the portals are themselves an inventory of data, meta-data and products, this report focuses on establishing the potential of the relevant repositories to address the end-user needs identified in D3.1 'Report on knowledge gaps and needs in different focus areas' and also on data needs or challenges highlighted in the respective COLUMBUS Competence Node profiles, but without excluding other options to transfer knowledge in support of Blue Growth. This was carried out in a step-wise process.

1. High level screening of the repositories to obtain an overview of the content. This information was gathered from examining the portals, reading annual reports and relevant papers and recorded in a summary table. (Template 1 Annex 2)
2. Mapping of the data and information in the portal against the Competence Node gaps and bottlenecks. This was carried out by reviewing the information obtained in Step 1 against specific gaps/bottlenecks listed in Section 5.3 and recorded in a summary table (Template 2, Annex 2)
3. Identification of valuable data layers and data-products with potential for application and/or transfer within the COLUMBUS Monitoring and Observation Competence Node. This information was obtained, where possible by interviews with portal coordinators according to the questionnaire in Annex 2.

Because of its multidisciplinary nature and the fact that some of the thematic EMODnet portals are overarching portals providing access to underlying portals, the greatest focus was on EMODnet as outlined below.

6.2 The European Marine Observation and Data Network (EMODnet)

The primary focus in terms of the identification of interesting opportunities for knowledge transfer from European data repositories and portals is on EMODnet as the key European Marine Observation and Data network for the following reasons:

- **Overarching**: As an aggregator of marine data, EMODnet makes available data and information which is held at national or regional level in many different repositories;
- **Multidisciplinary**: EMODnet is unique in providing access to marine observation data from a broad range of thematic areas;
- **Maturity level**: The end-user base for EMODnet is not yet fully established. This allows COLUMBUS to add greater value by screening for under-utilised data and information in EMODnet with potential for transfer to end-users.

The European Marine Observation and Data Network (EMODnet) is a long term initiative launched by the European Commission's Directorate-General for Maritime and Fisheries (DG MARE) and a key implementation mechanism of its Marine Knowledge 2020 strategy. EMODnet is a network of approximately **160 organisations working together to observe the sea, process the data according to international standards and make that information freely available as interoperable data layers and data products.** EMODnet provides access to European marine data across seven thematic areas:

- Bathymetry;

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- Geology;
- Seabed habitats;
- Chemistry;
- Biology;
- Physics;
- Human activities.

For each of these themes, EMODnet has created a gateway (portal) to a range of data archives managed by local, national, regional and international organisations. Through these gateways, users have access to standardised observations, data quality indicators and processed data products, digital terrain models or sediment maps. EMODnet builds on work already done.

EMODnet is developing through a step-wise approach and is currently moving into its third and final development phase towards the development of multi-resolution sea basin map by 2020. EMODnet is also working towards encouraging other marine knowledge providers to share their data, including those from research, public monitoring bodies and the private sector, in order to create a common platform for access to marine data. The Marine Knowledge 2020 roadmap recognised the need to **streamline the data ingestion process**. To this end, a tender has recently been launched by EASME (Executive Agency for Small and Medium-sized Enterprises) to provide a new process for data ingestion or capture which shall **provide a service for those public and private entities, who wish to share their data but have not yet been able to do so**. The service will support these organisations in depositing their data for safekeeping and subsequent dissemination in a suitable repository such as EMODnet.

User requirements are a key priority for EMODnet development. In order to fully address these, a series of **sea basin checkpoints** have been initiated. These mechanisms are checking how **fit for purpose** the **present observation system at the sea basin level** is, and whether it meets the needs of public or private users. In doing so, the checkpoints will identify data **gaps and duplications**. The first checkpoints were established in the **Mediterranean** and **North Sea** in 2013, and subsequently, sea basin checkpoints for the **Arctic**, **Baltic**, **Atlantic** and **Black Sea** were established in late 2015.

The multidisciplinary nature of data made available via EMODnet is a unique feature of EMODnet. The central portal is developing a query tool which will allow the user to search within a specified geographical area of interest and simultaneously access data layers from the different EMODnet thematic portals e.g. combining biological data layers with seabed habitat maps.

Because of **the multidisciplinary nature of EMODnet** the following section considers each of its thematic portals separately[31]. A general overview of each portal is provided along with a summary of data and information in the portal with the potential to address the gaps/bottlenecks identified in the COLUMBUS Competence Nodes.

[31] EMODnet coastal mapping portal was launched at the end of December 2015, for this reason it has not been included in the current analyses.

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6.2.1 *EMODnet Biology Portal*

The EMODnet Biology **Portal provides open access to data** on the **temporal and spatial distribution of marine species and marine species traits** from several species groups in all European seas**.** EMODnet Biology is built on two main information systems: The World Register of Marine Species[32] (WoRMS) as the taxonomic backbone and the European component of the Ocean Biogeographic Information System[33] (OBIS) to integrate and standardise the marine biodiversity observation data. EMODnet biology makes available raw observation data, metadata and data products of surveys in the water column and on the sea bed from phytoplankton, zooplankton, angiosperms, macroalgae, benthos, birds, mammals, reptiles and fish occurring in European marine waters. It also provides data products indicating trends in abundance of selected species, including a range of indicator species. EMODnet Biology has resulted in a wealth of publicly available biodiversity data. There now exists a mature European biodiversity network connecting 159 institutes sharing biodiversity data using common standards and data formats and making available 673 data collections. Despite these efforts there remain significant gaps in data availability. To address this, EMODnet Biology actively promote an open-access culture. They provide support to data holders wishing to share their data and provide them with a Digital Object Identifier (DOI). The team have also made significant efforts to digitalise archival data collections.

Table 2 EMODnet Biology Overview

EMODnet Biology	
Full Name and website	European Marine Observation and Data Network Biology Portal http://www.emodnet-biology.eu/
Description	The EMODnet biology data portal provides free access to data on temporal and spatial distribution of marine species and species traits from all European regional seas. EMODnet Biology is built upon the World Register of Marine Species [34] and the European Ocean Biogeographic Information System.
Types of data	Biological data from surveys in the water column and on the sea bed for species of phytoplankton, zooplankton, angiosperms, macro-algae, benthos, birds, mammals, reptiles and fish occurring in European marine waters including species attributes, sampling methods and biological indicators
Types of products	Biological data products, indicating the temporal and spatial trends in

[32] The aim of a World Register of Marine Species (WoRMS) is to provide an authoritative and comprehensive list of names of marine organisms, including information on synonymy. http://www.marinespecies.org/

[33] The European Ocean Biogeographic Information System – EurOBIS – is an online marine biogeographic database compiling data on all living marine creatures. http://www.eurobis.org/

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	abundance of marine life. Decadal patterns in species distribution and abundance.
Services	Search, selection, mapping and download
Geographic Scope	All European Seas
Timeline	EMODnet Biology was initiated in EMODnet Phase I (2009-2013). During the current Phase II (2013-2016) EMODnet Biology is moving towards a fully operational service.
Operational Structure	The EMODnet biology portal is developed and maintained by a consortium of 21 government agencies and research institutes with national and international expertise in marine biological data monitoring and data management. It is led and coordinated by Flanders Marine Institute (VLIZ) http://www.emodnet-biology.eu/partners
Contacts	http://www.emodnet-biology.eu/contact, info@emodnet.eu

6.2.1.1 EMODnet Biology – Users and applications

The main user group for EMODnet Biology to date has been the scientific community. Its relevance for supporting legislative frameworks is being developed, as outlined in the EMODnet Biology annual report, "We identify and focus on biological data types, species, species attributes, sampling methods and biological indicators to support the variety of legislations, and create biological data products, indicating the temporal and spatial trends in abundance of marine life to support environmental legislations including the Marine Strategy Framework Directive." Specifically, an EU-wide assessment of species and communities identified as indicators for descriptors 1, 2, 3, 4 and 6 of the Marine Strategy Framework Directive was performed. As a result, it is now possible to search the EMODnet Biology Data Portal for the relevant species and observations using the "species importance to society" selection. EMODnet Biology has also developed Operational Oceanographic Products and Services in the form of zooplankton data products to facilitate ICES' Ecosystem Overviews which describe the trends in pressures and state of regional ecosystems.

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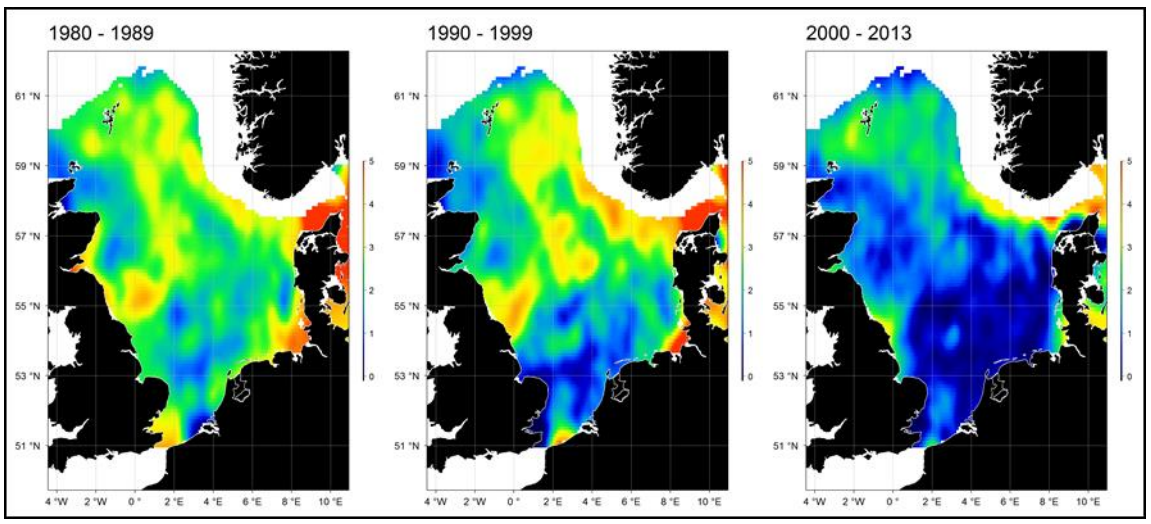

Figure 3. EMODnet Biology data product showing decadal gridded Cod (Gadus morhua) abundance illustrating the dramatic decline in the cod stock in the North Sea. http://www.emodnet-biology.eu/data-products?album=4551&pic=102229

6.2.1.2 EMODnet Biology: Opportunities for Knowledge Transfer

There is an opportunity to promote further the products being developed by EMODnet biology in the context of MSFD but also in a wider context. EMODnet Biology produce over 60 data products indicating the abundance of different marine species. Amongst these products, some provide evidence of the negative effects of human activities on the marine environment, for example. These and their potential application need to be promoted to potential users.

The implementation of the Nagoya Protocol on access to genetic resources and benefit sharing (ABS) will bring with it new responsibilities for users of genetic resources. In particular, users (e.g. scientists, researchers) will need to be able to demonstrate that any genetic resource they are using in the EU has been accessed and is being used in accordance with the national ABS measures in place in the country from which the sample originated. This implies a need for traceability on all genetic resources. The MicroB3 project developed the 'M2B3 reporting standard' (Ten Hoppen *et al*., 2015) which describes minimal mandatory and recommended contextual data that should accompany a marine microbial sample. EMODnet partners contributed to the development of this standard. Opportunities exist to extrapolate these minimal contextual data which should be collected with all biological samples, regardless of the purpose for which they were taken (basic or applied research). This is an interesting and timely opportunity, particularly in light of discussions at the UN General Assembly regarding a new implementing agreement to the UNCLOS for the protection and conservation of biological diversity from areas beyond national jurisdiction. These discussions are considering a package of issues, one of which is access and benefit-sharing of marine genetic resources. There is an opportunity to influence these discussions to support the freedom of marine scientific research and the development of tools such as those described would provide useful concrete means of supporting traceability of marine genetic resources without contributing a heavy administrative burden on scientists.

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Table 3 A non-exhaustive list of EMODnet Biology data and products relevant to COLUMBUS Competence Nodes and relevant gaps or challenges identified in section 5.3

COLUMBUS Competence Nodes		Details of information in EMODnet Biology portal with potential to address gaps and challenges identified in 3.1
COLUMBUS Competence Node	Marine Governance and Management	Data on invasive species MSFD implementation as outlined below
	Fisheries	Benthic survey data
	Aquaculture	Biodiversity data relevant to siting of cages to ensure no damage to stocks and biodiversity
	Marine biological resources (biotechnology)	Information on species distribution and abundance, including microorganisms. EMODnet biology have been involved in the development of standards to be applied to oceanographic biodiversity sampling which could support traceability of genetic resources under the Nagoya Protocol
	Marine Environment and Futures	Data products (time series) can contribute to describing trends in pressures and state of regional ecosystems
	Marine Physical Resources	Data for development of baseline environmental impact assessments for both deep-sea mining and marine renewable energy activities.
	Maritime transport and logistics	N/A
	Maritime Tourism	Identification of species distribution for recreational fisheries and ecotourism
Marine Strategy Framework Directive Descriptor	1, 2, 3, 4	The data portal allows the user to select for the 'status' of species for conservation purposes (IUCN, CITES), whether they are introduced or invasive, of fishery or aquaculture interest (FAO), harmful, or used as an ecological indicator (MSFD). Data can be visualised in map format and administrative boundary layers can be added including; exclusive economic zones (EEZ), ICES eco-regions and IHO Sea Areas
Marine Spatial Planning Directive		Portal contains data relevant to Article 8(2)[35] - Aquaculture areas, Fishery areas

[35] 2. In doing so and in accordance with Article 2(3), Member States shall take into consideration relevant interactions of activities and uses. Without prejudice to Member States' competences, possible activities and uses and interests may include: aquaculture areas, fishing areas, installations and infrastructures for the exploration, exploitation and extraction of oil, of gas and other energy resources, of minerals and aggregates, and for the production of energy from renewable sources, maritime transport routes and traffic flows, military training areas, nature and species conservation sites and protected areas, raw material extraction areas, scientific research, submarine cable and pipeline routes, tourism, underwater cultural heritage.

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6.2.2 *EMODnet Chemistry Portal*

EMODnet Chemistry is the largest thematic consortium of the EMODnet network with 46 institutes working together to collect, standardise and make available information and products for groups of chemical variables covering all European sea-basins. EMODnet Chemistry provides access to marine chemistry data sets and data products related to eutrophication and marine contaminants, based upon inputs gathered and collated from national monitoring efforts and research activities in all European coastal states. Data harvesting and products generation are organised at regional level and the majority of the data is available via open-access.

Table 4 EMODnet Chemistry Overview

EMODnet Chemistry	
Full Name	European Marine Observation and Data Network Chemistry Portal
Description	The portal will give access to marine chemistry data sets and data products specifically implemented to support the Marine Strategy Framework Directive for the five EMODnet regions (Baltic Sea, North Sea area, Atlantic Sea area, Black Sea and Mediterranean Sea) which will be made available following INSPIRE and OGC standards.
Types of data	EMODnet Chemistry provides data on the following; • pesticides & biocides • antifoulants • heavy metals • hydrocarbons • radionuclides • fertilisers • acidity • dissolved gasses • plastics • Chlorophyll • Silicates • organic matter.
Types of data-products	Spatial data products made available as integrated maps for easy viewing of geographic distribution of specific parameters. Time series data visualised as dynamic plots which can be customised in order to display vertical profiles of chemical properties in time- or depth-ranges selected by the user. Spatial interpolated data products are provided as 10-year running averages to allow rapid

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	visualisation of temporal trends;
Services	Search functions to search for, visualise and download data sets and data-products. Quick 'search for chemicals by region' function, allows sea basin level search for chemical data and visualisation of all data points for that region on a map.
Geographic Scope	All European Seas
Timeline	EMODnet Chemistry was initiated in EMODnet Phase I (2009-2013). During the current phase EMODnet Chemistry is moving towards a fully operational service.
Operational Structure	The EMODnet Chemistry portal is developed and maintained by a network of 46 European institutes from 29 coastal countries, comprising 32 partners and 14 sub-contractors. Partners include National Oceanographic Data Centers (NODCs), monitoring agencies responsible for national monitoring programs for nutrients and hazardous substances and research institutes acquiring data on nutrients and contaminants in the marine environment. EMODnet Chemistry is **coordinated** by OGS (Instituto Nazionale di Oceanografia e di Geofisica Sperimentale), Division of Oceanography http://www.emodnet-chemistry.eu/partners.html

6.2.2.1 EMODnet Chemistry – Users and applications

EMODnet Chemistry's main objective is to provide fit-for-purpose data for MSFD implementation. This is being achieved by maintaining a regular and open dialogue with MSFD actors such as the Regional Sea Conventions and by optimising EMODnet Chemistry services and products for specific MSFD indicators. A problem with advancing the dialogues between data repository actors and MSFD actors has been trying to establish at what level within the relevant organisations the dialogue should be taking place. High-level dialogue is useful in the first instance and to maintain overview of the process, however it has become increasingly necessary for dialogue to take place at the relevant technical levels. For this to happen, there is a need to identify the appropriate actors at member state level, in the Regional Sea Conventions and in the EMODnet community.

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Table 5 A non-exhaustive list of EMODnet Chemistry data and products relevant to COLUMBUS Competence Nodes and relevant gaps or challenges identified in Section 5.3

COLUMBUS Competence Nodes		Details of information in EMODnet Chemistry portal with potential to address gaps and challenges identified in 3.1
COLUMBUS Competence Node	Marine Governance and Management	MSFD as outlined below
	Fisheries	Information on pollutants to assess status of fishing areas
	Aquaculture	Data on chemical contaminants to contribute to appropriate siting of aquaculture farms.
	Marine biological resources	Information on chemical contaminants relevant to culturing of biological resources
	Marine Environment and Futures	Data parameters with relevance to climate change (partial pressure of oxygen and carbon dioxide) and eutrophication (chlorophyll)
	Marine Physical Resources	N/A
	Maritime transport and logistics	N/A
	Maritime Tourism	Information on contaminants in touristic marine areas
Marine Strategy Framework Directive Descriptor	5, 8, 9	Data layers to support main actors in MSFD reporting specifically towards D5, eutrophication, D8 concentration of contaminants and D9 contaminants in seafood.
Marine Spatial Planning Directive		Information relevant to Article 10[36]

[36] Article 10 Data use and sharing

1. Member States shall organise the use of the best available data, and decide how to organise the sharing of information, necessary for maritime spatial plans.

2. The data referred to in paragraph 1 may include, inter alia:(a)environmental, social and economic data collected in accordance with Union legislation pertaining to the activities referred to in Article 8; (b) marine physical data about marine waters.

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6.2.2.2 EMODnet Chemistry – Opportunities for Knowledge Transfer

Data, maps and indices on chemical pollutants and nutrients in European seas and coastal areas could be used more in the framework of the Marine Strategy Framework Directive or other marine environmental management and protection activities. In this context, COLUMBUS could consider looking at one of the Regional Sea Conventions such as OSPAR and their assessment process by focusing on a specific indicators or parameter to shed light on how different countries in Europe are handling their data collection, storage, assessment and reporting responsibilities with the aim of streamlining and organising these data flows more efficiently.

6.2.3 *EMODnet Bathymetry Portal*

EMODnet Bathymetry portal collects and provides access to bathymetric survey data and a derived product; a harmonised medium resolution bathymetry Digital Terrain Model (DTM) of all sea basins in European waters. The DTM can be browsed and downloaded via the portal. The portal provides access by discovery and a shopping process to all the underlying and assembled bathymetric survey data sets, in a uniform way. These survey data sets originate from hydrographic and research organisations in Europe and are used as input for generating the EMODnet DTM product. Access to the survey data sets is both open and restricted, according to the data owner's policy. Agreed standards and common vocabularies have been adopted for data, data products and metadata formats. The portal follows INSPIRE and OGC standards for providing discovery, viewing, downloading and wider interoperability services. EMODnet Bathymetry is moving towards high resolution DTMs and some coastal areas are already available at high resolution. Data gaps remain however and more data (bathymetric survey data) would improve the model and its use.

Figure 4. EMODnet Bathymetry high resolution DTM of Tyrrhenian Sea near Sicily – Italy and South Italy

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In the context of this report it is important to note that the EMODnet Bathymetry portal has been built using the SeaDataNet[37] (FP7) Common Data Index (CDI) infrastructure with its network of distributed data centres, which has been adopted and adapted to provide an integrated and harmonised overview and access to the survey data sets that were gathered by the project. The CDI metadata files describe bathymetric survey measurements, following the ISO19115 – 19139 metadata standards, and are supported by SeaDataNet controlled vocabularies. The SeaDataNet Sextant[38] catalogue service has also been adapted as a discovery service for providing details about composite DTM's that are provided by some data centres instead of basic survey data sets. The SeaDataNet II project (FP7) continued the work of SeaDataNet.

Table 6 EMODnet Bathymetry Overview

EMODnet Bathymetry	
Full Name and website	European Marine Observation and Data Network Bathymetry Portal http://www.emodnet-hydrography.eu/
Description	EMODnet bathymetry portal provides access to data and data products on the topography of the seabed, as depth from the sea surface to the seafloor.
Types of data	Provides access to bathymetric survey data sets (open and restricted) for all sea basins in Europe. Also makes available data layers on shipwrecks and underwater features.
Types of products	Provides access to a harmonised medium resolution bathymetry Digital Terrain Model of all sea basins in Europe.
Services	Bathymetry offers discovery, viewing and downloading services for individual and combined survey data layers and Digital Terrain Models as well as information about the underlying data sets used to compile the DTM.
Geographic Scope	All European sea basins.
Timeline	Building on the EMODnet Bathymetry portal developed during Phase I (2009-2013), EMODnet Bathymetry is currently in the 2nd Phase of development (2013 – 2016) and is enhancing and expanding existing services

[37] SeaDataNet, is the pan-European infrastructure for ocean & marine data management sponsored within FP7 (grant agreement 283607, 1/10/2011-30/9/2015) connecting at present more than 100 national oceanographic data centres and marine data centres from 35 countries riparian to all European seas.

[38] Sextant, catalogue service used to provide details about Composite DTM data sets. It allows to discover any Composite DTM's asailable and used for the EMODnet DTM instead of bathymetry survey data sets. The location is given by a Lat-Lon box in a map and descriptions are given of each Composite DTM with information for what, when, how, and who.

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	to move, together with the six other EMODnet sub-portals, towards an operational service with full coverage of all European sea-basins.
Operational Structure	The EMODnet Bathymetry portal is developed and maintained by a consortium of 24 European partners; these comprise members of the SeaDataNet consortium together with marine research institutes, the hydrographic survey community, and industry. EMODnet Bathymetry is coordinated by Marine Information Service MARIS, Netherlands.
Contacts	Via http://www.emodnet-bathymetry.eu/

6.2.3.1 EMODnet Bathymetry – Uses and applications

EMODnet Bathymetry is one of the most recognised of the EMODnet portals, with its DTM product currently the best of its kind. GEBCO[39], the world leader in the development of bathymetric survey data sets currently uses EMODnet Bathymetry's DTM in its global digital bathymetry product. Marine service providers are using EMODnet bathymetry DTMs to support their commercial marine data products and provide a full coverage surface to fill gaps found in commercial bathymetry data. EMODnet Bathymetry also provides bathymetric data for the generation of modelled seabed habitat maps.

Table 7 A non-exhaustive list of EMODnet Bathymetry data and products relevant to COLUMBUS Competence Nodes and relevant gaps or challenges identified in Section 5.3

COLUMBUS Competence Nodes		Details of information in EMODnet Bathymetry Portal with potential to address identified gaps and challenges
COLUMBUS Competence Node	Marine Governance and Management	See MSFD and MSP below
	Fisheries	Seabed maps to contribute to improved knowledge of where to fish for which species.
	Aquaculture	Provides bathymetric information for optimal siting of aquaculture farms.
	Marine biological resources	Information on seabed topography for identification of underwater features relevant to sampling of microbes from extreme environments.
	Marine Environment and Futures	Provides a bathymetric background layer for numerous informative maps of marine environmental features.

[39] http://www.gebco.net/

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	Marine Physical Resources	Hydrographic data relevant to ocean energy site characterisation and development of suitable mooring systems.
	Maritime transport and logistics	Navigational information.
	Maritime Tourism	Provides a layer on underwater features and wrecks which are of interest to recreational divers and fishermen.
Marine Strategy Framework Directive Descriptor (Annex 1)		Information relevant to D6, Seafloor integrity and D7 hydrographical conditions.
Marine Spatial Planning Directive		Article 6e & Article 10[40]

6.2.3.2 EMODnet Bathymetry: Opportunities for Transfer

EMODnet bathymetry DTM has numerous applications as a background layer for products developed by marine service providers. Discussions with service providers at Oceanology International 2016 identified an interest by some service providers in accessing the data layers on ship wrecks and underwater features. These are of interest for the production of e-charts for local fishermen and recreational divers. In terms of transfer of data to EMODnet bathymetry, more bathymetric survey datasets are required.

6.2.4 *EMODnet Human Activities Portal*

EMODnet Human Activities is the most recent addition to the series of EMODnet thematic portals. It aims to map the spatial extent and intensity of a wide array of marine and maritime activities in EU waters and to become the main entry point for spatial data on these activities in Europe.

EMODnet Human Activities does not collect new data but assembles, harmonises and makes available the wealth of data on human activities in Europe that already exists but which is difficult and laborious to access. The main advantage is that information on many and various human activities in European waters is available at the same time, in the same place and in an interoperable format. This significantly reduces the time taken for an operator to obtain the information they need.

The information provided through the portal is collated from a variety of sources, harmonised and made interoperable. Data are free and free of any restrictions on use, to maximise their use by a multitude of stakeholders (policy makers, researchers, students, spatial planners, etc.). Besides

[40] Article 6 Minimal requirements for maritime spatial planning (e) organise the best use of available data in accordance with Article 10

Article 10 Data use and sharing

1. Member States shall organise the use of the best available data, and decide how to organise the sharing of information, necessary for maritime spatial plans.

2. The data referred to in paragraph 1 may include, inter alia:

(a)environmental, social and economic data collected in accordance with Union legislation pertaining to the activities referred to in Article 8; (b) marine physical data about marine waters.

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making available data for download, the portal also features an interactive map, through which users can have a quick and user-friendly overview of where activities are taking place.

Table 8 EMODnet Human Activities Overview

EMODnet Human Activities Overview	
Full Name and website	European Marine Observation and Data Network, Human Activities Portal. http://www.emodnet.eu/human-activities
Description	EMODnet Human Activities makes available information on the geographical position, spatial extent and attributes of a wide array of marine and maritime human activities throughout Europe.
Types of data	Aggregate extraction, Dredging, Fish catches, Hydrocarbon extraction, Major ports, Mariculture sites, Ocean energy facilities, Telecommunication cables, Protected areas, Waste disposal (solids, including dredge material, dumped munitions, marine constructions), Wind farms, Other forms of area management/designation, Status of bathing waters, Offshore Installations, Hydrocarbon licenses and bidding blocks.
Types of products	Particular attention is given to providing, when possible, historical time series to indicate the temporal variation of activities such as fishing and port traffic. Time when data was provided together with attributes to indicate the intensity of each activity will also be included.
Services	The portal allows users to view, query and download data and metadata from public and private sources – from throughout Europe - via a single entry portal, providing access to data that has been harmonised into interoperable formats including agreed standards, common baselines or reference conditions and assessments of their accuracy and precision.
Geographic Scope	All European Sea Basins.
Timeline	Human Activities is a relatively recent EMODnet activity, initiated in 2013 and this phase of its development will run until 2016 at which point a new tender will be released.
Operational Structure	EMODnet Human Activities is a relatively small consortium of 8 partners and is coordinated by COGEA, Italy http://www.cogeaspa.it/.
Contacts	http://www.emodnet-humanactivities.eu/support.php#contact apititto@cogea.it.

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6.2.4.1 EMODnet Human Activities: Users and Applications

Unlike the other EMODnet portals, Human Activities is cross-cutting in terms of thematic areas and as such has potential applications for diverse stakeholders. With the implementation of the marine spatial planning directive, planners are increasingly a key user group. As the portal becomes fully operation it will contribute to better informed, evidence-based decision making, and reduce the indirect costs related to retrieving data currently scattered across multiple sources. For example, before the Human Activities portal was operational, in order to obtain information on oil and gas boreholes in Europe a user would have to survey at least 19 sources to find this information. This process is extremely time consuming; considering different languages, different units of measurements, different projections, different formats, etc. Human Activities now provides this information as a single harmonised layer, in addition to information on licences and platforms.

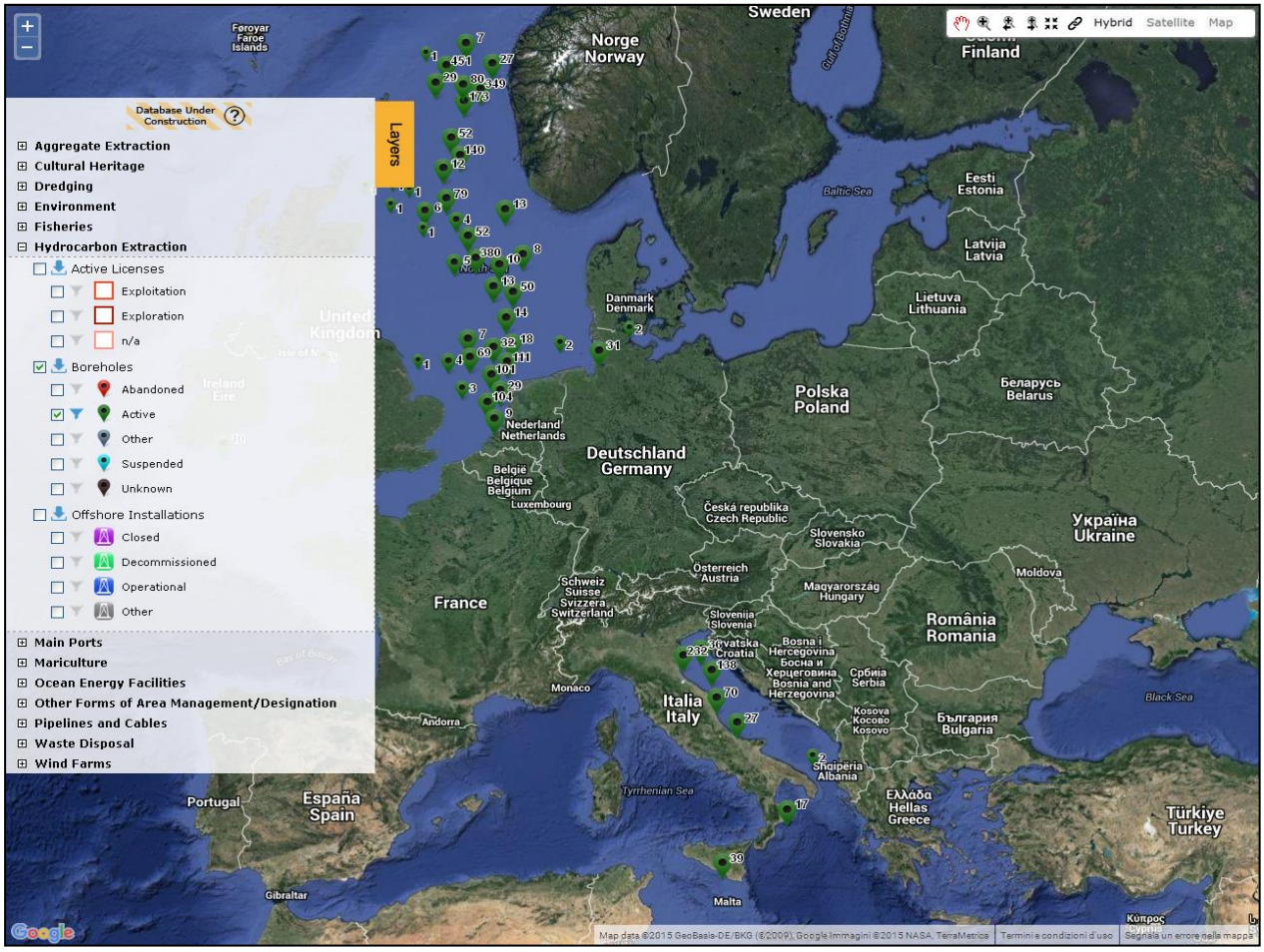

Figure 5. Screenshot from EMODnet Human Activities portal indicating active bore holes for hydrocarbon extraction and showing other available data- layers in the legend.

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6.2.4.2 EMODnet Human Activities: Opportunities for Transfer

There are many opportunities for transfer both to and from the Human Activities portal. Layers with high potential for application include vessel density traffic maps that require AIS data and information on offshore mariculture sites. The former information is either difficult to obtain from public source or available from other sources but at a prohibitive cost. In addition, a key principle of EMODnet (Human Activities) is not to pay for data as this cost would eventually have to be transferred on to users. The data on mariculture sites is required, in particular by spatial planners. However, data on these sites is difficult to obtain, as it has to be acquired on a country-by-country basis but often countries do not have a single national source for this information and as such it can be very time-consuming and challenging to collate. Previously human activities obtained data from the FP7 'EuroShell project[41], which developed a map based viewer making available data on shellfish production sites. This site has not been maintained since the project ended. The Horizon 2020 project BlueBridge[42] may prove interesting as a source of new data.

As a result of interaction between Seascape and Bord Iascaigh Mhara (BIM)[43], at the COLUMBUS partner meeting in March 2016, BIM provided data on Ireland's mariculture sites directly to Human Activities who were able to update their information. At Oceanology International 2016 there was interest by several companies in obtaining data from human activities. One in particular wishes to follow-up, as the portal develops, to obtain information for provision to ports and harbours on the activities happening in and around them. Commercial data on pipelines and cables is difficult to access. Seascape along with their Competence Node partner VLIZ have been engaging with industry actors to explore some of the issues around open-access data sharing by industry. This will be continued throughout the COLUMBUS project. The human activities layer on cultural heritage is of interest for maritime tourism. It may be interesting to explore the data made available via the SplashCos[44] project on submerged archaeology for inclusion in this portal.

[41] http://www.euroshell-net.eu/Project/Approach

[42] The horizon2020 project BlueBridge which is BlueBRIDGE - Building Research environments fostering innovation, decision making, governance and education - is a European project aimed at providing innovative data services to scientists, researchers and data managers to address key challenges related to sustainable growth in the marine and maritime sectors http://www.bluebridge-vres.eu/about-bluebridge

[43] Bord Iascaigh Mhara is the coordinator of the COLUMBUS project, www.bim.ie

[44] SPLASHCOS, a research network (2009–2013) funded by the European Union's COST scheme (Cooperation in Science and Technology) to coordinate and promote research on the underwater landscapes and archaeology of the continental shelf drowned by the sea level rise at the end of the Last Glacial.

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Table 9 A non-exhaustive list of EMODnet Human Activities data and products relevant to COLUMBUS Competence Nodes and relevant gaps or challenges identified in Section 5.3

COLUMBUS Competence Nodes		Details of relevant data, meta-data, information, data products or portal services with potential to address identified gaps and challenges
COLUMBUS Competence Node	Marine Governance and Management	See MSFD and MSP below.
	Fisheries	Fisheries zones and catches by FAO statistical area, mariculture data on finfish production site.
	Aquaculture	Information on renewable energy installations, cultural heritage sites, major ports, aggregate extraction, telecommunication cables, waste disposal, wind farms and off shore installations relevant for optimal siting of aquaculture cages. Information on mariculture sites.
	Marine biological resources	N/A
	Marine Environment and Futures	Developing information on temporal variation and intensity indices of a series of geographically defined human activities
	Marine Physical Resources	Information on existing and previous installations to contribute to site characterisation and project planning
	Maritime transport and logistics	Information for port authorities on relevant activities happening in and around ports
	Maritime Tourism	Data layers on bathing water quality Data layer on cultural heritage
Marine Strategy Framework Directive **Descriptor (Annex 1)**		Specifically, D11 Introduction of energy, however provides information on the spatial extent of human activities which are relevant to all descriptors.
Marine Spatial Planning Directive		Human Activities portal uniquely makes available information on a range of marine and maritime human activities throughout all European sea-basins. Previously this information tended to be available on a per country, regional or sector-by-sector basis.

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6.2.5 *EMODnet Geology Portal*

EMODnet Geology portal provides harmonised data on seabed substrate and bedrock geology, including information on coastal behaviour, aggregate deposits and geological events such as earthquakes, landslides and volcanoes. EMODnet Geology encompasses 36 organisations from 30 countries and consists of the geological survey organisations of all of the maritime countries of the European Union. This partnership ensures that data from all of the European regional seas (including the entire Baltic, Greater North Sea, Celtic Seas, Bay of Biscay and the Iberian Coast, Macaronesia and the Adriatic Sea) are provided to the project. The inclusion of organisations from Iceland, Norway and Russia, expands information access to the North Atlantic Ocean and to the margins of the Arctic (Barents Sea and White Sea). EMODnet geology is built on information primarily held by the project partners, but connects to other owners of information using Web Map Services (WMS)and in doing so ensures that information that is held elsewhere is not duplicated.

A characteristic of EMODnet-Geology is that the main focus is on harmonised interpreted map information rather than the underlying data. However, the web delivery system is designed to be able to access data catalogues of information held by each partner organisation and therefore more detailed information (maps and data) can potentially be accessed at national level.

EMODnet Geology provides some multi-resolution maps, but to ensure a harmonised, continuous map with no gaps, they also provide a broad scale map at lower resolution.

Table 10 EMODnet Geology Overview

EMODnet Geology	
Full Name and website	European Marine Observation and Data Network, Geology Portal
Description	EMODnet Geology portal provides harmonised data on seabed substrate and bedrock geology, including information on coastal behaviour.
Types of data	• Seabed substrate • Sediment accumulation rate • Sea-floor (bedrock) lithology • Sea-floor (bedrock) stratigraphy • Coastal behaviour • Mineral occurrences (e.g. oil and gas, aggregates, metallic minerals) • Geological events and probabilities (e.g. earthquakes, submarine landslides, volcanic centres)
Types of products	Harmonised, interpreted map information assembling the above data.
Services	Search, download and visualisation services.

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Geographic Scope	All European regional sea basins (including the entire Baltic, Greater North Sea, Celtic Seas, Bay of Biscay and the Iberian Coast, Macaronesia and the Adriatic Sea) and extending to the North Atlantic Ocean and the Arctic margins (Barents and White Sea).
Timeline	The current EMODnet-Geology Project started in October 2013 and will run for 3 years, ending in October 2016 at which point the tender will be reissued.
Operational Structure	EMODnet Geology encompasses 36 organisations from 30 countries and consists of the geological survey organisations of all of the maritime countries of the European Union.
Contacts	http://www.emodnet-geology.eu/emodnet/srv/eng/contact

6.2.5.1 EMODnet Geology: Users and Applications

EMODnet Geology products are of interest to a range of users in government, commercial sectors and research organisations. One example of application was where EMODnet Geology provided seabed substrate data to planners for the development of the regional plan for the trade- and sea area of the Gulf of Finland. Information on coastal change is obviously of considerable interest to coastal managers, particular in vulnerable coastal areas. Commercial operators have expressed an interest in the mineral data available via EMODnet Geology.

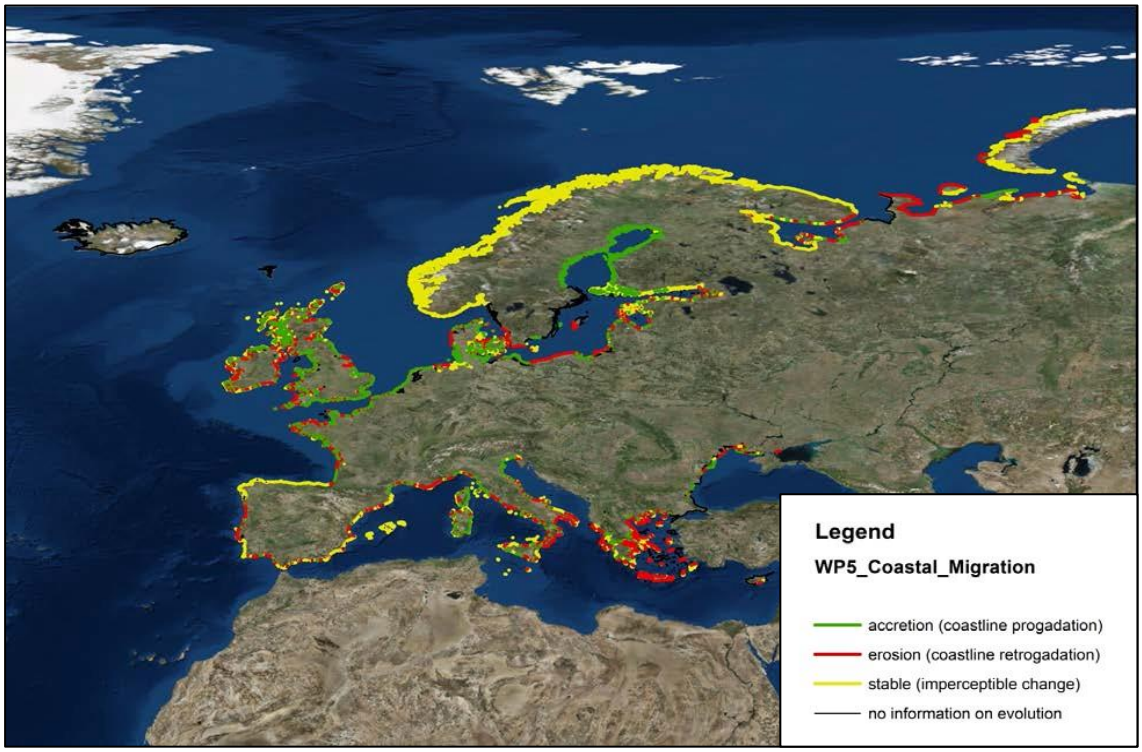

Figure 6. EMODnet Geology map showing coastal change

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6.2.5.2 EMODnet Geology: Opportunities for Transfer

There is a need for more data on coastal behaviour. This information is difficult to obtain and assemble, yet information on coastal resilience and vulnerability are of considerable socio-economic interest in relation to sea-level rise and coastal protection. Further there is a need to evaluate the natural capital of the coasts and for coastal case studies or projects that brings together all of the above elements, as well as economists, coastal engineers and coastal managers. An interesting project with potential to contribute to data needs on coastal change is HisGISkust http://www.vliz.be/hisgiskust/en. This project has digitalised and georeferenced historical coastal maps allowing visualisation of coastal change in Flanders. Furthermore, detailed metadata about the geometric accuracy is provided. This may provide another opportunity for knowledge transfer by exporting this experience to other countries and regions.

Table 11 A non-exhaustive list of EMODnet Geology data and products relevant to COLUMBUS Competence Nodes and relevant gaps or challenges identified in Section 5.3

COLUMBUS Competence Nodes		Details of relevant data, meta-data, information, data products or portal services with potential to address identified gaps and challenges
COLUMBUS Competence Node	Marine Governance and Management	See below
	Fisheries	Contributes information to produce better seabed habitat maps to improve knowledge of where to fish for which species.
	Aquaculture	Provides geological data for appropriate siting of farms Information on seabed substrate data could contribute information on the cumulative effects of persistent agents.
	Marine biological resources	Information on seabed substrate and seafloor geology and submarine geological events contributing to the identification of interesting areas for sampling of extremophiles.
	Marine Environment and Futures	Information on geological events and probabilities contributing to assessments of risks, impacts and vulnerabilities.
	Marine Physical Resources	Information on seabed substrate for baseline information Information on the resource characteristics of a site. Information on seabed soil type relevant to cable installation and protection Maps for 9 different mineral types including aggregates, hydrocarbons, gas hydrates, marine placers, phosphorite, evaporate, polymetallic sulphides, polymetallic nodules and cobalt-rich iron-manganese crusts.

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	Maritime transport and logistics	Information on seabed substrate and bedrock geology relevant to the development of port and harbour infrastructure
	Maritime Tourism	Information on coastal behaviour (erosion and accretion) as well as information on probabilities of geological events e.g. tsunamis their origin and coastal areas affected.
Marine Strategy Framework Directive Descriptor (Annex 1)	6, 7, 8, 9	Information contributing to descriptors 6 (seafloor integrity), 7 (alteration of hydrographical conditions), 8 (concentration of contaminants).
Marine Spatial Planning Directive		Information on seabed substrate to support effective planning of the use of the seafloor.

6.2.6 *EMODnet Seabed Habitats Portal*

Seabed habitats define the environmental conditions at particular points on the seafloor. There is an extensive hierarchy of habitat types, ranging from basic descriptions (high level classifications) such as 'sandy beach' or 'Littoral rock and other hard substrata' through to very detailed descriptions (low level classifications). Areas of similar habitat are shown in the same colour on habitat maps. The habitat type at a given location will depend on the depth of the sea above it, the rocks underlying it, the currents flowing over it and a multitude of other factors. Sometimes these factors combine to produce unique conditions, such as those under which cold water corals grow on the seabed in the North Sea.

The main objective of the EMODnet Seabed Habitats portal is to provide access to seabed habitat maps in an interoperable way. Much of the seabed lacks detailed habitat maps and this posed a significant challenge to the portal. Habitat maps from surveys are very costly and time consuming to produce. A more time- and cost-efficient way to meet the need for a full coverage habitat map is to use low resolution maps and models to 'predict' seafloor habitat types. The EMODnet Seabed Habitats Portal consortium embarked on making Pan-European broad scale maps, based on the EU Nature Information system (EUNIS) – which contains descriptions of seabed habitats. These maps of expected seabed-habitat types are generated by combining information provided by EMODnet Bathymetry (depth) and Geology (bedrock geology and seabed substrate data) portals, as well as using various physical parameters such as light attenuation at seabed. Much of this work was achieved during the INTERREG MESH[45], MESH Atlantic[46] and BALANCE[47] projects. In addition,

[45] The MESH Project (2004 to 2008) was made up of a consortium of twelve partners from five European countries led by the UK's Joint Nature Conservation Committee (JNCC), with financial support from the EC's INTERREG IIIB NWE Programme. http://www.emodnet-seabedhabitats.eu/default.aspx?page=2003

[46] MESH Atlantic (2010 – 2012) was funded by the Atlantic Area Transnational Programme (http://atlanticarea.inescporto.pt)/. The output seabed habitat maps aim to set up an efficient spatial planning tool to support better management of marine resources in the Atlantic Area.

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EMODnet Seabed Habitats collates and makes available seabed habitat maps from various sources, through the EMODnet Seabed Habitats interactive map.

Table 12 EMODnet Seabed Habitats Overview

EMODnet Seabed Habitats	
Full Name and website	European Marine Observation and Monitoring Seabed Habitats Portal http://www.emodnet-seabedhabitats.eu/
Description	Seabed Habitats portal provides access to sea-bed habitat maps in an interoperable way. Maps are based on the EU Nature Information system (EUNIS) - a descriptor of seabed habitats. Seabed habitats define the environmental conditions at particular points at the bottom of the sea.
Types of data	• Seabed Habitats portal builds on the following data layers • Depth (Bathymetry portal) • Seabed substrate (Geology Portal) • Energy at seabed (waves & current) • Salinity • Temperature • Light at seabed • Oxygen at seabed
Types of products	The EMODnet Seabed Habitat interactive mapping portal displays and gives access to broad scale predictive habitat maps and seabed habitat maps from surveys for Europe's marine waters.
Services	The portal allows the viewing, querying and downloading of seabed habitat maps for European marine waters. The interactive map works in conjunction with a metadata catalogue, which is maintained by the International Council for the Exploration of the Seas. Underlying data layers can also be downloaded.

[47] The BALANCE (Baltic Sea Management – Nature Conservation and Sustainable Development of the Ecosystem through Spatial Planning) 2005 – 2007 project is an INTERREG III B co-funded project aimed towards development of informed marine management tools for the Baltic Sea based on spatial planning and cross-sectoral and transnational co-opera http://www.balance-eu.org/

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Geographic Scope	All European regional sea-basins
Timeline	In the first phase of the EMODnet Seabed Habitats project (2009-2012) over two million square kilometres of European seabed were mapped using levels 3 and 4 of the EUNIS (European Nature Information System) classification system. In the current phase 2 of the project (2013-2016), the coverage of the maps is being extended to all European seas and the existing maps are being improved.
Operational Structure	A consortia of nine partners from nine countries are working together to deliver EMODnet Seabed Habitats Phase 2, under the leadership of French research institute Ifremer.
Contacts	info@emodnet-seabedhabitats.eu

6.2.6.1 EMODnet Seabed Habitats: Users and Applications

EMODnet Seabed Habitat maps serve many purposes including the design of ecologically coherent Marine Protected Area (MPA) networks, species distribution modelling, establishing monitoring programmes for seabed habitats and informing maritime spatial planning (MSP). They are also important for Member States to fulfil their legal obligations under the Marine Strategy Framework Directive (MSFD), where full coverage of seabed predominant habitats of all European seas is required.

Table 13 A non-exhaustive list of EMODnet Seabed Habitats data and products relevant to COLUMBUS Competence Nodes and relevant gaps or challenges identified in Section 5.3

COLUMBUS Competence Nodes		Details of relevant data, meta-data, information, data products or portal services with potential to address identified gaps and challenges
COLUMBUS Competence Node	Marine Governance and Management	Contribute to the design of ecologically coherent Marine Protected Area(s) (MPA)
	Fisheries	The portal is extending coverage to all European sea basins which will provide more information on where to fish for which species.
	Aquaculture	Contributes crucial information on seabed habitat type to inform spatial planning/siting of aquaculture farms
	Marine biological resources	Seabed habitat maps provide an indication of the types of flora and fauna that may be found in a particular area.

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	Marine Environment and Futures	Contributes information to the design of ecologically coherent Marine Protected Area (MPA) networks Information for species distribution modelling for assessments of risks, impacts and vulnerabilities.
	Marine Physical Resources	Information contributing to baseline data for environmental impact assessments.
	Maritime transport and logistics	Baseline data for environmental impact assessments in developments of ports and harbours. Maritime safety.
	Maritime Tourism	Seabed habitat maps indicating for example unique conditions such as those under which cold water corals grow on the seabed in the North Sea, of interest to divers. Seabed habitat maps can be useful to recreational fishermen.
Marine Strategy Framework Directive Descriptor (Annex 1)		Demonstrates how the MSFD Annex III requirements can be used in characterising the marine environment.
Maritime Spatial Planning Directive		Baseline information for effective maritime spatial planning

6.2.6.2 EMODnet Seabed Habitats: Opportunities for Transfer

As outlined, there are many potential applications for the EU Seabed Habitat maps. There is also the opportunity to ensure that benthic survey maps from projects are made available to the portal. This would contribute to better habitat maps and also ensure that these costly and valuable products are stored and made available to stakeholders. It was noted at an EMODnet:MSFD coordination meeting (Brussels, December 2016) that some projects with potentially interesting benthic habitat survey maps, which could support MSFD reporting had no long term storage facility for their maps, other than at institutional level.

6.2.7 *EMODnet Physics Portal*

EMODnet Physics provides a one stop continuous access point to near real-time and historical data on the physical conditions of seas and oceans, including salinity, temperature, waves, currents, sea-level, light attenuation and additional parameters (Table 14). EMODnet Physics is built in cooperation and coordination with EuroGOOS and the five Regional Operational Oceanographic Systems (ROOS)[48], Copernicus Marine Environment Monitoring Service (CMEMS)[49] and SeaDataNet[50]. The EMODnet physics portal is fully integrated with, and complementary to CMEMS. Specifically, access

[48] http://eurogoos.eu/regional-operational-oceanographic-systems/

[49] http://marine.copernicus.eu/

[50] http://www.seadatanet.org/

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to the near real-time data stream is supported by the EuroGOOS - ROOS and the CMEMS in-situ Thematic Assembly Centre (TAC) system, whilst metadata discovery to the archived data is organised through the SeaDataNet network and the network of National Oceanographic Data Centres (NODC). The Coriolis infrastructure[51] of IFREMER also plays an important role for providing access to supplementary data from, amongst others, Argo floats (EuroArgo[52]).

Table 14 EMODnet Physics Portal Overview

EMODnet Physics	
Full Name and website	European Marine Observation and Data Network Physics Portal http://www.emodnet-physics.eu/
Description	EMODnet Physics provides a one stop access point to near real time and historical data on physical conditions of seas and oceans.
Types of data	EMODnet Physics provide data for the following parameters • Water Temperature • Waves • Winds • Sea Level • Water Salinity/Conductivity/Density • Currents • Light Attenuation/Absorption/Fluorescence/Back Scattering • Atmosphere • Chemical Parameters
Types of products	• sea level trends • ice coverage • wind data product • high frequency (HF) radar product (sea surface current speed and direction)
Services	Dynamic map facility for searching, visualising and downloading data,

[51] http://www.coriolis.eu.org/

[52] http://www.euro-argo.eu/

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	metadata and products.
Geographic Scope	All European Sea Basins and beyond
Timeline	EMODnet Physics is currently in the second phase of its development (2013 – 2016) and builds on the EMODnet Physics portal developed during EMODnet Phase I (2009-2013).
Operational Structure	EMODnet Physics is founded on three pillars of the European oceanographic landscape; the EuroGOOS-ROOSs (Regional Operational Oceanographic Systems), the Copernicus Marine Environment Monitoring Service (CMEMS) and the SeaDataNet network of National Oceanographic Data Centres (NODCs). It is organised by a core consortium of five partners and is led by ETT (http://ettsolutions.com/)
Contacts	contacts@emodnet-physics.eu

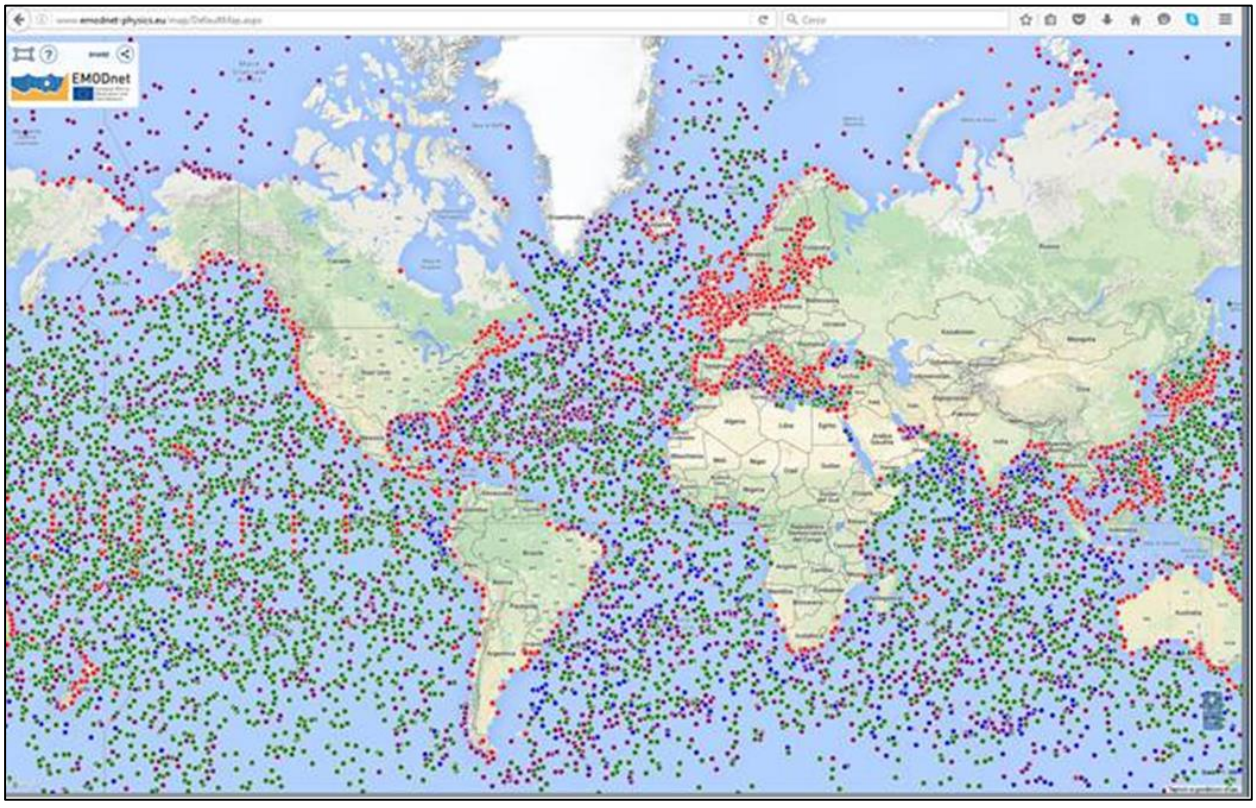

Figure 7 EMODnet Physics map showing 11100 oceanographic monitoring platforms connected and available from the EMODnet Physics portal

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6.2.7.1 EMODnet Physics: Users and Applications

EMODnet physics is one of the most widely used EMODnet data portals. Wave data and wave products are one of the most required data sets. EMODnet Physic provides access to about 270 platforms delivering wave data. Users are interested in both in situ products and high resolution wave data products. These have a multitude of applications in support of coastal or offshore engineering, mariculture or other marine operations such as ship loading and coastal management. Increasingly wave data is of interest to recreational users of the sea. In general terms met-ocean information helps understand and predict a particular situation; whether it is pollution e.g. oil spill, missing persons at sea or other emergency. The European Maritime Safety Agency feed real-time oceanographic measurements from EMODnet into their in-house marine information system allowing them to respond quickly in the case of an emergency.

Table 15 A non-exhaustive list of EMODnet Physics data and products relevant to COLUMBUS Competence Nodes and relevant gaps or challenges identified in Section 5.3

COLUMBUS Competence Nodes		Details of relevant data, meta-data, information, data products or portal services with potential to address identified gaps and challenges
COLUMBUS Node	Marine Governance and Management	See MSFD below and MSPD
	Fisheries	Near-real time and historical information on physical ocean conditions relevant to fisheries management.
	Aquaculture	Provides historical and near-real time data for prediction of waves and currents to support optimal siting of sea cages and development of integrative management tools. Data on waves and currents can provide information on the fate of cumulative and persistent agents used in aquaculture on the marine environment.
	Marine biological resources	Information relevant to sampling and cultivation of marine biological resources.
	Marine Environment and Futures	Historical and near real-time data which can contribute to assessments of risks, impacts and vulnerabilities through regional and decadal analyses.
	Marine Physical Resources	Data and information which can contribute to ocean energy site characterisation and project planning. Data and information which can contribute to quantification of resource characteristics in leased sites within an appropriate timescale.
	Maritime transport and logistics	Provides reliable data which can contribute to rapid response mitigation of oil spills.

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	Maritime Tourism	Data and information which can facilitate tracking of microbial particles. Data and information on historical meteorological events which contributed to coastal erosion. Such information can be used to improve coastal defence/protection measures.
Marine Strategy Framework Directive		Information relevant to descriptors 7 (alteration of hydrographical conditions) and 11 (introduction of energy)
Marine Spatial Planning Directive		Fundamental information on the physical conditions of marine areas to support effective marine spatial planning in line with Article 10[53] of the MSPD.

6.2.7.2 EMODnet Physics: Opportunities for Transfer

EMODnet Physics portal has developed wind and wave products with numerous potential applications. These have not been sufficiently publicised amongst potential users and need to be made more visible, with additional contextual information. There is growing interest in HF radar data, due to it has many potential applications. These data can contribute to search-and-rescue operations and tracking of oil spills as well to help ships navigating into ports and support commercial and recreational users of the sea plan their activities. There may be opportunity to extend these applications to other areas. There is a need to target intermediary service providers and highlight the free access to these data and products and their potential applications.

Figure 8 EMODnet Physics wind data product

[53] Article 10 Data use and sharing

1. Member States shall organise the use of the best available data, and decide how to organise the sharing of information, necessary for maritime spatial plans.

2. The data referred to in paragraph 1 may include, inter alia: (a)environmental, social and economic data collected in accordance with Union legislation pertaining to the activities referred to in Article 8; (b) marine physical data about marine waters.

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6.2.8 *The EMODnet Sea Basin Checkpoints*

EMODnet Sea Basin Checkpoints assess the quality of the current observation monitoring data at the level of the regional sea-basins. By testing the data against specific end-user challenges, the checkpoints will demonstrate how well the current monitoring systems provide data to meet the needs of users. In doing so, data gaps and duplications, as well as significant bottlenecks will be highlighted.

The concept of EMODnet Sea-Basin Checkpoints was introduced within the Green Paper 'Marine Knowledge 2020: from seabed mapping to ocean forecasting.[54] In spite of EU initiatives such as EMODnet, Copernicus and Data Collection Framework (DCF) for Fisheries to deliver seamless layers of marine data across national boundaries, there are still shortcomings with the availability and accessibility of EU marine data. Data collections have been largely put in place for specific and/or national purposes. There is still an approximate overview on a sea-basin scale of gaps and duplications and there is no overall view of what the priorities are for further data collection or assembly. Thus the EMODnet Checkpoint initiative will begin to link all existing monitoring data at the level of the Sea Basin and assess them in order to define their future improvements.

Six sea basin checkpoints[55] are in operation. The first two checkpoints were initiated in the Mediterranean Sea and the North Sea in 2013; with checkpoints for the Arctic, Atlantic, Baltic and Black Sea being launched in 2015.

All checkpoints are addressing some or all of the following challenges which are relevant to the protection and preservation of the marine environment and its resources, the impacts of climate change and anthropogenic activities and to support the activities of maritime actors.

Each of the checkpoints is addressing some or all of the challenges listed below:

- **Windfarm siting:** The objective of this challenge is to find economically viable areas for off-shore wind energy development with minimal impact on both the ecosystem and other human activities.
- **Marine Protected Areas (MPAs):** In this challenge, the network of MPAs in the regional sea basin is analysed and classified, providing information on their coherence and vulnerability to climate change.
- **Oil Platforms leak:** The adequacy of data available for making predictions on the trajectory and impacts of a simulated oil spill will be tested in this challenge.
- **Climate Change:** This challenge evaluates available data on past climate change, focusing on a range of sea basin parameters.

[54] Green Paper Marine Knowledge 2020 from seabed mapping to ocean forecasting COM(2012) 473 final.http://ec.europa.eu/maritimeaffairs/documentation/publications/documents/marine-knowledge-2020-green-paper_en.pdf

[55] All sea basin checkpoint portals can be accessed via http://www.emodnet.eu/

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- **Coastal protection:** The objective of this challenge is to identify the data adequacy for establishing time series of long-term sea level variation and sediment balance per coastal stretch for the relevant sea basin.
- **Fisheries management:** This challenge aims to compile vital fisheries data to support region wide management.
- **Fisheries impact:** The availability, accessibility and quality of data relevant for assessing the impact of the most common fisheries in the sea basin will be tested in this challenge.
- **Eutrophication:** This challenge aims to evaluate the existing sea-basin biogeochemical monitoring network in regard to eutrophication assessment.
- **River inputs:** The objective of this challenge is to create time series of river related parameters: water and sediment discharge, temperature, total nitrogen, phosphates and migration of anadromous species.
- **Bathymetry:** Existing and available sources of bathymetric data for the particular sea basin will be will be investigated and explored in this challenge.
- **Alien species:** This challenge will analyse and summarise existing observation data on alien species and assess their ecosystem and economic impacts.

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6.3 Copernicus Marine Environment and Monitoring Service (CMEMS)

COPERNICUS, previously 'Global Monitoring for Environment and Security' (GMES), is the European Programme for the establishment of a European capacity for Earth Observation and Monitoring. It encompasses three components:

1. **The space component of COPERNICUS** includes the Sentinel satellites of the European Space Agency, which are currently being developed for the specific needs of the Copernicus programme and also 'the Contributing Missions,' which are operated by national, European or international organisations and which already provide a wealth of data for Copernicus services.
2. **The *in-situ* component of COPERNICUS** comprises monitoring networks e.g. ground based weather stations, ocean buoys and air quality monitoring. These *in-situ* networks are managed by Member States and international bodies and make data available to the COPERNICUS services by agreement.
3. **The Copernicus Service component** addresses six main thematic areas; land monitoring, emergency management, **marine monitoring**, atmospheric monitoring, security and climate change. Some of the service areas are already operational whilst others are still in a pre-operational or development mode.

The **COPERNICUS marine environment and monitoring service (CMEMS)** was initiated and developed via the series of MyOcean[56] projects. The objective of these projects was to define and establish an integrated Pan-European capacity for ocean monitoring and forecasting and led to the demonstration phase of the Copernicus Marine Environment Monitoring Service. The MyOcean consortia were coordinated for 6 years by Mercator Ocean[57]. In 2014, the EC and Mercator Ocean signed an agreement for the latter to implement and manage the Copernicus Marine Environment Monitoring Service.

CMEMS has been operational from early May 2015. It provides open and free access to qualified, regular scientific information on the physical and biogeochemical state of all the Earth's oceans, at and below the surface. CMEMS does not operate in situ observing systems but collects observations from data providers, mainly from EuroGOOS and ROOS members and Joint Technical Commission for Oceanography and Marine Meteorology[58] (JCOMM) networks (Observations Programme Area). CMEMS also collaborates with SeaDataNet and EMODnet physics to improve the service for historical/reprocessed data and to involve new partners.

The catalogue of the service's ocean products encompasses products derived from satellite and in situ observation, forecasts and analysis in real time, and time series stretching several tens of years

[56] ; My Ocean (2009-2012), MyOcean2 (2012-2014) and MyOcean follow-on (October 2014- March 2015), respectively funded by the EU's FP7 and HORIZON 2020 research and innovation funding programmes

[57] Mercator Ocean is the French centre for analysis and forecasting of the global ocean.

[58] http://www.jcomm.info/index.php?option=com_content&view=article&id=150&Itemid=97

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into the past (re-analysis).The service is intended for many uses, whether commercial or scientific in nature, for public service missions or simply for citizens wishing to know more about the state of their oceans.

Table 16. CMEMS Portal Overview

CMEMS	
Full Name and website	COPERNICUS marine environment and monitoring service (CMEMS) http://marine.copernicus.eu/
Description	The CMEMS provides regular and systematic core reference information on the state of the physical oceans and regional seas. The observations and forecasts produced by the service support all marine applications.
Types of data	CMEMS provides access to data on the following parameters: • Ocean Temperature • Ocean Salinity • Ocean Currents • Sea Ice • Sea Level • Winds • Ocean Optics • Ocean Chemistry • Ocean Biology • Ocean Chlorophyll
Types of products	CMEMS makes available four main types of data products combining the parameters above • Forecast (Model Outputs) • Near Real Time Products (Model Outputs and Observations) • Multi Year Products (Hindcast and Re-analysis of Model Outputs, Reprocessing of Observations) • Time Invariant Products (Observations), In Situ measurements (from Argo buoys, gliders, Ferryboxes etc.) and Space measurements (from space borne sensors)
Services	CMEMS provides catalogue products discovery, viewing and information service. Registered users can download products. A service desk, user registration, validation statistics, online tutorials, collaborative forums and updates on services and products are also provided.
Geographic	CMEMS products cover the following areas

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Scope	• Global Ocean • Arctic Ocean • Baltic Sea • Atlantic North West Shelf Seas • Iberia Biscay Ireland Regional Seas • Mediterranean Sea • Black Sea
Timeline	CMEMS entered its operational phase in 2015 following the MyOcean demonstration phase (2009 – 2015).
Operational Structure	Copernicus Marine Service is provided by Mercator Ocean and funded by the European Union.
Contacts	http://marine.copernicus.eu/web/21-contact-us.php

6.3.1.1 CMEMS user engagement

CMEMS, via Mercator Ocean and partners, are actively working to enlarge their intermediate users' community. The target is to develop success stories in the four CMEMS areas of benefit ('maritime safety,' 'marine resources,' 'coastal and marine environment' and 'weather, seasonal forecasting and climate') to demonstrate to potential users how the products can be used. This will be accompanied by providing different additional tools (other data formats, interactive visualisations) to ease the products accessibility by non-scientific users. CMEMS is monitoring, on a daily basis, user behaviour, requests and feedback to ensure the service evolves to address user needs. In so doing, CMEMS expect to increase its user database and indirectly increase the number of end users and applications for CMEMS products.

Table 17. A non-exhaustive list of CMEMS data and products relevant to COLUMBUS Competence Node gaps and challenges

COLUMBUS Competence Nodes		Details of relevant data, meta-data, information, data products or portal services with potential to address identified gaps and challenges
COLUMBUS Node	Marine Governance and Management	See below MSFD and MSP.
	Fisheries	Physical oceanographic data products (wave, current, temperature, salinity) to support fisheries management.
	Aquaculture	Ocean current data products for optimal siting of sea cages.

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	Marine biological resources	N/A
	Marine Environment and Futures	Information on sea surface temperature, one of the primary physical impacts of climate change.
	Marine Physical Resources	Information on wind, wave and currents for selecting locations for offshore renewable energy structures.
	Maritime transport and logistics	Sea ice data product to support safer navigation in Arctic waters
	Maritime Tourism	Information on sea level rise to contribute to the prediction of coastal erosion**.**
Marine Strategy Framework Directive Descriptor (Annex 1)		Information on physical and marine biogeochemical components contributing to descriptors 5 (eutrophication), 7 (hydrographical conditions) and 8 (concentration of contaminants).
Marine Spatial Planning Directive		Fundamental information on the physical conditions of marine areas to support effective marine spatial planning in line with Article 10 of the MSPD.

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6.4 International Council for the Exploration of the Sea (ICES)

ICES is an intergovernmental organisation whose main objective is to increase the scientific knowledge of the marine environment and its living resources and to use this knowledge to provide unbiased, non-political advice to competent authorities. Through its work, ICES provides best available scientific knowledge and advice in the North Atlantic and adjacent area.[59]

ICES has a well-established Data Centre, which manages a number of large dataset collections related to the marine environment. Generally, ICES obtains data directly from its member countries by direct reporting. In specific cases ICES use metadata/data portals i.e. WORMS, SeaDataNet and more recently is exploring agreements to deliver operational oceanographic products from major data portals i.e. EMODnet Biology and Copernicus. The majority of data originates from institutes and national and international initiatives (surveys, projects) and the data centre currently hosts over 300 million recorded measurements spanning over 127 years. Supporting its wide user bases to make the best use of its data resources, the ICES data centre provides user friendly search, access and visualisation services to map resources and a range of tools.

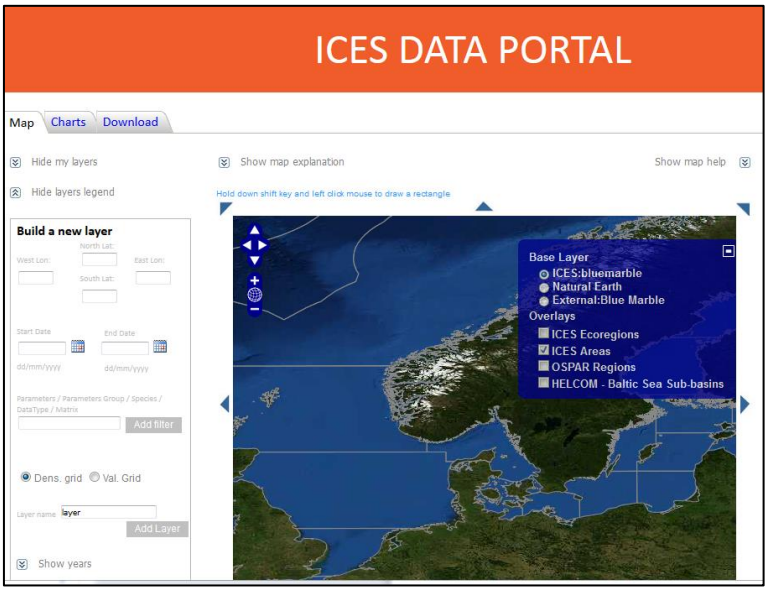

Figure 9. Screenshot of ICES data portal showing web map data query service

Dataset collections are organised around specific thematic data portals as well as being made available via an overarching data warehouse. The current dataset portals provided by ICES are:

- **Contaminants, biological effects, and biological community data** are made available via the DOME web portal (Database on Oceanography and Marine Ecosystems). http://ices.dk/marine-data/data-portals/Pages/DOME.aspx

[59] ICES are also a partner in the COLUMBUS project and work towards knowledge transfer in general, including for data

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- **Eggs and Larvae database** makes available data collected by ichthyoplankton surveys for use by ICES and the wider marine community. http://ices.dk/marine-data/data-portals/Pages/Eggs-and-larvae.aspx
- **Fish Trawl Survey** datasets collected in connection with the Data Collection Framework (EU-DCF) are managed under the DATRAS portal. http://ices.dk/marine-data/data-portals/Pages/DATRAS.aspx
- **Fish predation** is the focus of the fish stomach data portal. http://ices.dk/marine-data/data-portals/Pages/Fish-stomach.aspx
- **Historical plankton** is an 'historical' dataset collection, where the dataset is considered complete and there are no immediate plans to update it. http://ices.dk/marine-data/dataset-collections/Pages/Plankton.aspx
- **Oceanographic data** which includes temperature, salinity, oxygen, chlorophyll a, and nutrients measurements are made available through the OCEAN web applications. http://www.ices.dk/marine-data/data-portals/Pages/ocean.aspx
- **Impulsive underwater noise** collates data on licensed events such as pile driving, controlled explosions from naval operations across the OSPAR and HELCOM areas. http://ices.dk/marine-data/data-portals/Pages/underwater-noise.aspx
- **Vulnerable Marine Ecosystems** hosts data on deep-water VMEs in the North Atlantic biological community; contaminants and biological effects; eggs and larvae; fish predation (stomach contents); fish trawl survey; historical plankton; ocean physics and chemistry. http://ices.dk/marine-data/data-portals/Pages/vulnerable-marine-ecosystems.aspx

Other datasets include; cruise summary reports, projects datasets and sampling station locations and information (station dictionary).

Table 18 Overview of ICES

ICES Data Centre	
Full Name and website	The International Council for the Exploration of the Sea (ICES) data centre http://www.ices.dk/marine-data/Pages/default.aspx
Description	The ICES Data Centre provides marine data services to ICES member countries, expert groups, world data centres, regional seas conventions (HELCOM and OSPAR), the European Environment Agency (EEA), Eurostat, and various other European projects and biodiversity portals.
Types of data	Datasets are organized around specific thematic portals. • Biological community • Contaminants and biological effects • Eggs and Larvae • Fish predation (stomach contents)

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	• Fish trawl survey • ICES Historical Plankton • Oceanographic • Marine underwater noise • Vulnerable marine ecosystems
Types of products	ICES manage a number of maps related to the North-East Atlantic, for the planning of data collection and the visualisation of data. ICES also work closely with the regional sea conventions to offer a selection of their map products through the ICES spatial facility.
Services	Viewing, browsing and downloading data and data products. Web map visualisation services, web services and query tools.
Geographic Scope	The majority of data covers the Northeast Atlantic, Baltic Sea, Greenland Sea, and Norwegian Sea.
Timeline	The International Council for the Exploration of the Sea (ICES) was established in 1902 by exchange of letters between participating countries. In 1964, through an agreed Convention, ICES received a legal foundation and full international status.
Operational Structure	The Council is the principle decision making body of ICES, it comprises the ICES President and two delegates appointed by each of the 20 member countries. The work of the Council is carried out through the Advisory Committee, Science Committee, Data and Information Group, and Secretariat.
Contacts	nfo@ices.dk

Table 19. A non-exhaustive list of ICES data and products relevant to COLUMBUS competence node gaps and challenges

COLUMBUS Competence Nodes		Details of relevant data, meta-data, information, data products or portal services with potential to address identified gaps and challenges
COLUMBUS Competence Node	Marine Governance and Management	See MSFD and MSP below.
	Fisheries	The data from DATRAS (the Database of Trawl Surveys) are used for stock assessments and fish community studies by the ICES community and public users. http://ices.dk/marine-data/data-portals/Pages/DATRAS.aspx
	Aquaculture	Data on chemical contaminants and oceanographic data relevant to the appropriate siting of sea farms.

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	Marine biological resources	Data for stock assessments with potential to contribute to estimation of maximum sustainable yield.
	Marine Environment and Futures	Portal recently launched by ICES visualises all known vulnerable marine ecosystem (VME) data in the North Atlantic. http://ices.dk/marine-data/data-portals/Pages/vulnerable-marine-ecosystems.aspx
	Marine Physical Resources	Data for baseline environmental impact assessments and oceanographic data.
	Maritime transport and logistics	N/A
	Maritime Tourism	N/A
Marine Strategy Framework Directive Descriptor (Annex 1)		ICES data portal has data and information of particular relevance to MSFD implementation. A large portion of the data held are monitoring data. One of the few data portals providing access to data on underwater noise (D11).
Marine Spatial Planning Directive		Information for effective marine spatial planning in line with Article 10 of the MSPD.

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6.5 SeaDataNet

SeaDataNet is a Pan-European infrastructure for managing, indexing and providing access to ocean and marine data sets and data products, acquired from research cruises and other observational activities in European marine waters and global oceans.

The SeaDataNet infrastructure was developed during the Sea-Search project (2002 - 2005) funded under Framework Programme 5 and continued in Framework Programme 6 (2006 - 2011) as SeaDataNet and in Framework Programme 7 (2011 - 2015) as SeaDataNet II. Although currently not funded as a project, the SeaDataNet infrastructure is maintained by the consortium.

SeaDataNet is currently one of the EU's largest marine data infrastructures and represents a model for other platforms dealing with marine data management. In addition to making available data and data products, the successive SeaDataNet projects have made a very significant contribution to European marine data management. The developed standards, tools and services for data and metadata, the controlled vocabularies and the data quality control guidance documents and software have been adopted and adapted in many different EU data management projects.

The SeaDataNet projects were undertaken by the National Oceanographic Data Centres (NODCs), and marine information services of major research institutes, from 35 coastal states bordering the European seas. The consortia also include experts in information technology, data publishing, and modelling, as well as international organisations, namely IOC, ICES, and EU-JRC in its network. SeaDataNet has been working closely together with other European RTD projects and initiatives such as EMODnet (European Marine Observation and Data Network) in the capacity of providing standards, services, data centres and infrastructure for managing marine and oceanographic data, and for providing experience and expertise for joint development of new standards and services.

Table 20 SeaDataNet Portal Overview

SeaDataNet	
Full Name and website	http://www.seadatanet.org/
Description	SeaDataNet is a Pan-European infrastructure for ocean and marine data management derived from in situ observations of the seas and oceans.
Types of data	SeaDataNet provides an integrated and harmonised overview and access to the a wider range of data resources linked via the infrastructure. SeaDataNet also manages and ensures the maintaining of the on-line metadata discovery system that allows access to the following resources: • EDMED (European Directory of Marine Environmental Data) for large data sets, • EDMERP (European Directory of Marine Environmental

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	Research Projects) • EDMO (European Directory of Marine Organisations) • CSR (Cruise Summary Reports) • EDIOS (European Directory of Oceanographic Observing Systems) • Common Data Index (CDI)
Types of products	Regional aggregated data sets of all the temperature and salinity measurements contained within SeaDataNet database. The aggregated datasets have been prepared and quality checked using the Ocean Data View (ODV) software.
Services	SeaDataNet offers a Common Vocabularies Web Service which covers a wide range of ocean and marine disciplines that together with EDMO directory interconnect the metadata directories and makes the different metadata catalogues coherent.
Geographic Scope	European seas and global oceans.
Timeline	The SeaDataNet infrastructure was developed during the Sea-Search project (2002 - 2005) funded under Framework Programme 5 and continued in Framework Programme 6 (2006 - 2011) as SeaDataNet and in Framework Programme 7 (2011 - 2015) as SeaDataNet II. Although no longer funded as a project the SeaDataNet infrastructure is currently maintained by the consortium.
Operational Structure	SeaDataNet is a consortium of the National Oceanographic Data Centres (NODCs), and marine information services of major research institutes, from 31 coastal states bordering the European seas. The network includes expert modelling centres and the international organisations IOC, ICES and EU-JRC.
Contact	sdn-userdesk@seadatanet.org

The diversity of data within SeaDataNet portal makes it relevance to all COLUMBUS Competence Node areas.

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6.6 PANGAEA

PANGAEA Data Publisher for Earth and Environmental Science, is an information system which operates as an **open access repository for long-term archiving, publishing and distributing georeferenced data from earth science research fields**. **Aimed at the scientific research community**, PANGAEA is open to any project or individual scientist for archiving and publishing data relevant to earth systems science. As a result of this the data types in PANAGAE are very diverse.

Currently data from 229 projects are listed in PANGAEA, of which 66 are European, 66 international and the remainder national projects. Data providers agree that all data are provided under a creative commons license and are assigned a Digital Object Identifier (DOI) so that each data-set can be identified, shared, published and cited. Data are archived as supplements to publications or as citable data collections. Citations are available through the portal of the German National Library of Science and Technology.

PANGAEA offers **many benefits to data providers** beyond long term storage of data, including open access to data in several widely machine readable forms. The creative commons attribution license means that authors are referenced if the data are re-used. Minimum formatting is required by the submitting party, although they are responsible for the scientific quality of the data. PANGAEA offer quality assurance on the technical quality of the data and metadata such as citation, references, geo-location and standard vocabularies. Data providers may also submit data under moratorium whilst a project is still ongoing. Published data are fully citable and can be cross referenced with journal articles. PANGAEA can be used free of charge.

For data users PANGAEA provides access to a diverse array of data in the fields of earth and life sciences. In most cases the data are freely available and can be used according to the terms of the license mentioned on the data set description. In some instances, the data sets are password protected under moratorium, as mentioned above, to allow completion of project work and publishing papers.

PANGAEA was initiated in 1993 and funded by the German Ministry of Research from 1994 -1997 to initially provide data management services at national level. Its role was later expanded to include European and International projects. The system is hosted by the Alfred Wegener Institute, Helmholtz Center for Polar and Marine Research and the Center for Marine Environmental Sciences (MARUM), University of Bremen, Germany and is supported with research funding from the EC (research funding), Federal Ministry of Education and Research (BMBF), Deutsche Forschungsgemeinschaft (DFG) and the International Ocean Discovery Program[60] (IODP), formerly the Integrated Ocean Drilling Program (IODP, 2003-2013).

Due to the heterogeneous nature of the data submitted to PANGAEA it is not possible to screen for information relevant to the COLUMBUS Competence Node areas or specific gaps or challenges. It is reasonable to say that there would be information relevant to all aspects of the Competence Node areas. In relation to the COLUMBUS work on knowledge transfer PANGAE provides an extremely important repository for the long term archival and availability of data generated from research

[60] http://www.iodp.org/

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project which may otherwise be lost. This is in line with the first route of knowledge transfer in relation to repositories outlined in Figure 1.

Table 21 PANGAEA Data Publisher for Earth and Environmental Science at a glance

PANGAEA	
Website	https://www.pangaea.de/
Description	PANGAEA is an open access repository for long-term archiving, publishing and distributing georeferenced data from earth and life science research fields.
Types of data	PANGAEA makes available heterogeneous data sets in the broad area of earth and life science research.
Types of products	n/a
Services	• Long term preservation of data. PANGAEA is member of the World Data System (WDS) of the International Council for Science (ICSU). • Quality assurance on metadata, such as citation, references, geo-location, and standard parameter vocabularies. • Reliable identification and access with a DOI name for each data supplement. • Pre-publication, password protected access to data supplements for journal editors in support to the peer-review process. • Open access to data in several widely accepted machine-readable formats. • Creative Commons Attribution license which requires that author(s) are referenced if the data are reused. • Freeware software tools for the visualisation, exploration and interpretation of scientific data. • PANGAEA offers advanced search tools and browser plugins
Geographic Scope	Global
Timeline	PANGAEA has been operational since 1993. The system guarantees long-term availability of its content through a commitment of the operating institutions.
Operational Structure	The system is hosted by the Alfred Wegener Institute, (AWI), Germany and the Center for Marine Environmental Sciences (MARUM), University of Bremen, Germany and is supported with research funding from the following organisations; EC, Federal Ministry of Education and Research (BMBF), Deutsche Forschungsgemeinschaft (DFG) and the International Ocean Discovery Program (IODP).
Contact	https://www.pangaea.de/contact/

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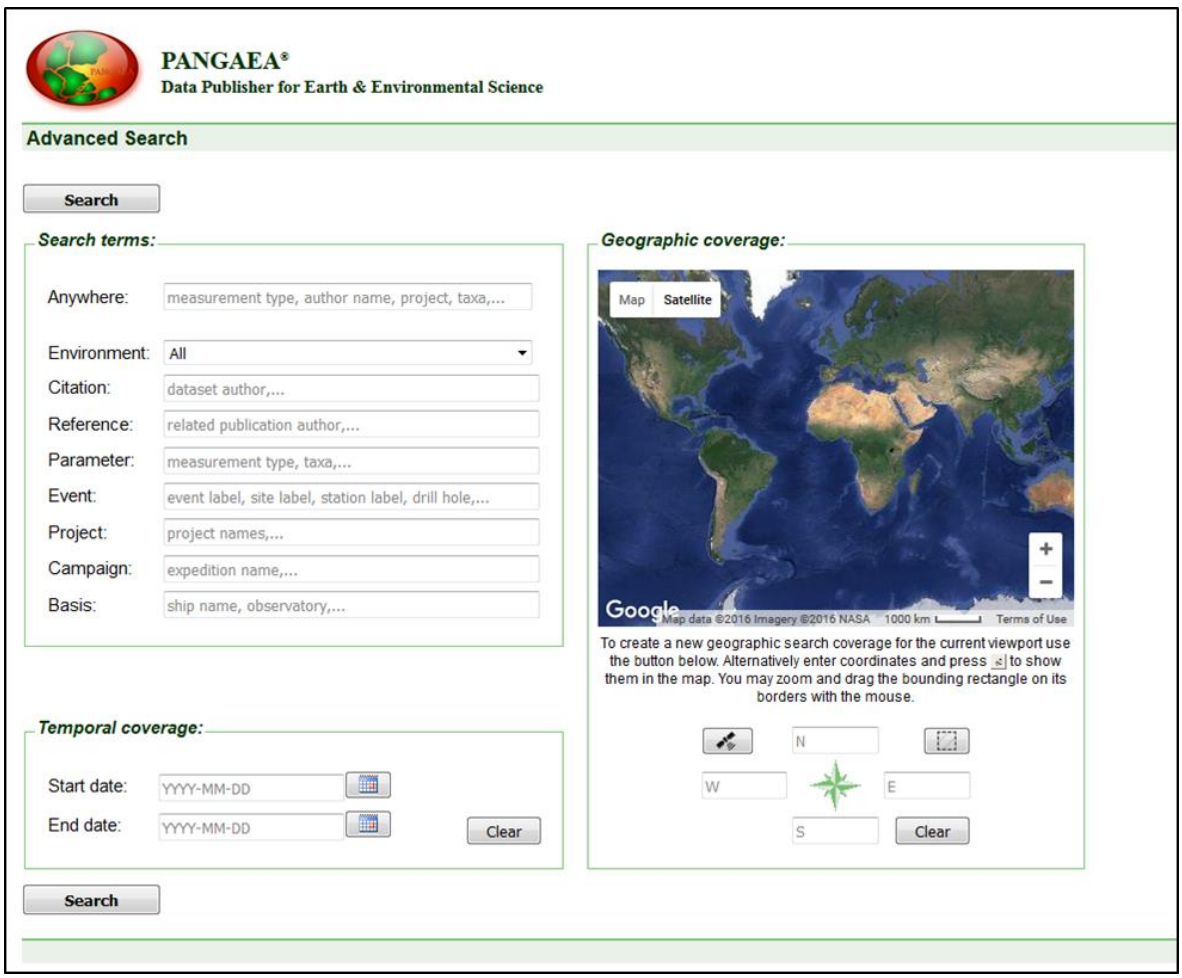

Figure 10. The advance search options available via the PANGAEA open access repository. Project acronyms can be used as a search term

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6.7 European Atlas of the Seas

The European Atlas of the Seas is a freely available, web-based, interactive information system delivering collections of maps derived from data on natural and socio-economic features in the marine and coastal regions of Europe. **Aimed at the general public**, it is also relevant to certain professionals (Barale V. *et al* 2014) and is available in French, German and English. It includes a collection of maps and associated fact sheets based on data originating primarily from the EC and its agencies but also from other sources, including the European Marine Observation and Data Network (EMODnet).

In the context of the implementation of the Integrated Maritime Policy (IMP), the Atlas was initially devised as a public outreach tool to communicate relevant marine and maritime information about the coasts and seas within and around Europe. As such the thematic map layers are classified under eight main categories to represent the main themes relevant for IMP as follows: geography, nature, tourism, security and safety, people and employment, transport and energy, governance and European policies and fisheries and aquaculture.

The Atlas is provided by the European Commission, Directorate-General for Maritime Affairs and Fisheries (DG MARE) who carried out the conceptual work on the Atlas in 2008 and developed early versions of the infrastructure. Development of the third version of the Atlas was assigned to the EC Joint Research Centre, through an agreement with DG MARE, with the aim to further develop the tool and provide access to new services and features.

Table 22. European Atlas of the Seas: At a glance

European Atlas of the Seas	
Full Name and website	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas
Description	The European Atlas of the Seas is an interactive web atlas of marine and maritime information for the coasts and seas within and around Europe.
Types of data	Data layers in the following thematic areas: • Geography – sea basins, bathymetry, coast lines, hydrography, drainage basins; • Nature- sea surface temperature, wind, waves, tides, sea level change, coastal Geology, coastal erosion, marine biology and ecology, protected areas; • Tourism – coastal infrastructures (e.g. accommodation, museums, aquariums) and world heritage sites; • Security and safety – incidents at sea, pollution response vessels and coastal defence works; • People and employment – demographic and economic statistics for coastal regions (GDP, population density, age profiles, employment and unemployment by sector;

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	• Transport and energy – shipping, off shore windfarms, electricity and gas submarine networks; • Governance and European policies – marine conventions, regional advisory councils; • Fisheries and aquaculture, fish stocks, zones, quotas and catches, production, processing facilities; Accompanying metadata reveals the data source from where data can be downloaded
Types of products	GIS Maps
Services	Map viewer and a suite of basic instruments for map analysis and data combination for generation of maps.
Geographic Scope	All European marginal and enclosed seas, as well as the EU Outermost regions.
Timeline	First prototype was published in 2010. Following a public consultation Version 1 of the Atlas was published in 2011. Version 3 is currently available and regular improvements and updates are ongoing.
Operational Structure	Developed and led by the EC's Directorate-General for Maritime Affairs and Fisheries. The Atlas is now executed by the Joint Research Centre, Institute for Environment and Sustainability (IES), units DERD and Water resources.
Contact	MARE-ATLAS@ec.europa.eu

The latest version of the European Atlas aims to exploit available marine and maritime data for two main purposes.

1. to provide the general public with a quick but detailed and authoritative source of maps and statistical information about Europe's seas and coasts, and
2. to provide scientific support to non-specialist professionals in educational organisations, non-governmental bodies, international bodies or policy-orientated professionals in the public or private sector, or those responsible for the planning and/or execution of projects and programs with relevance to European marine and maritime sectors.

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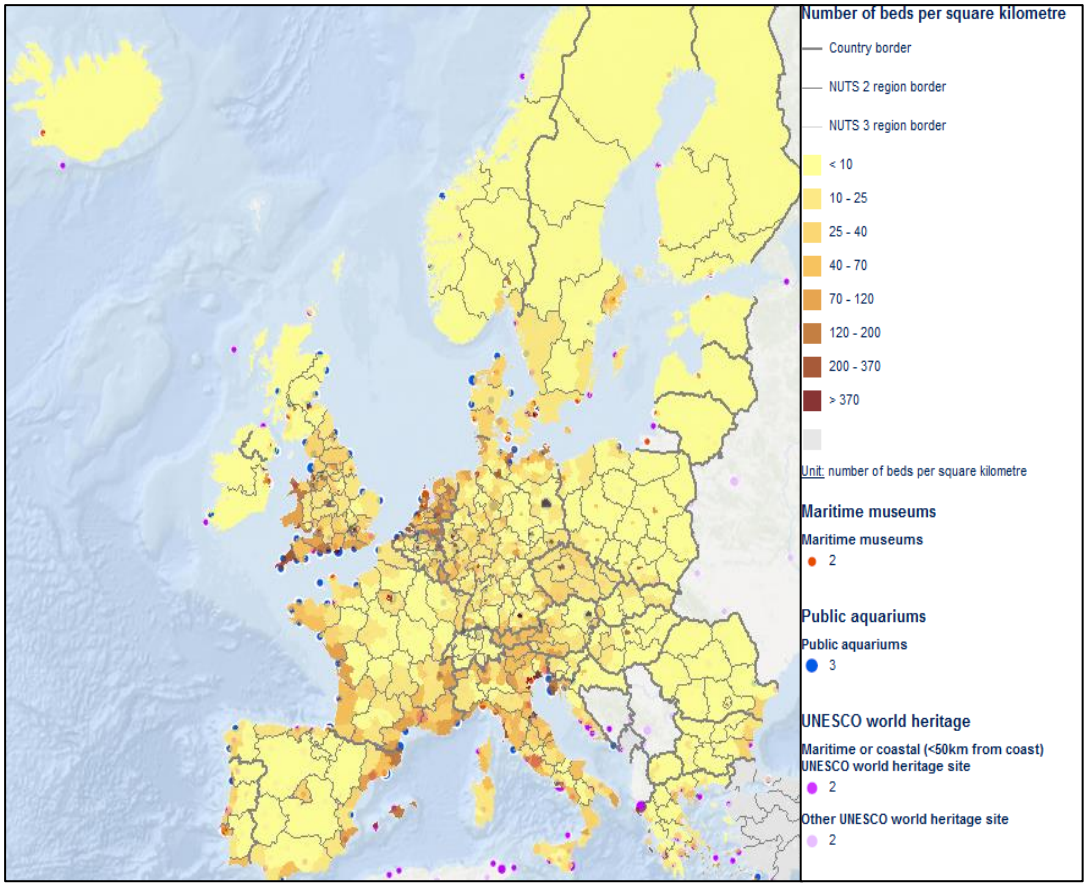

Figure 11. An example of a map generated by European Atlas of the Seas displaying information on marine tourism

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7 DISCUSSION AND CONCLUSIONS

7.1 Summary of Main Achievements and Findings

This report focuses primarily on marine data portals and repositories as important providers of knowledge in the form of data, metadata and derived data-products. In addition, these data and information systems are also important users of knowledge outputs from research projects. As such, they have a unique position and role to play by:

(i) fostering direct transfer of data or products from repositories to intermediate and end-users; and

(ii) taking up outputs from monitoring activities and projects to data repositories (users in this scenario) to fill data gaps or to contribute to better architecture, services or data products.

Successive European marine research projects such as the SeaDataNet, SeaDataNet II, the series of MyOcean projects, Jerico, ODIP and numerous others have contributed significantly to the development of the current European marine data and information sharing landscape. As a result of huge efforts over the last decades, there is a wealth of marine observations and data with a wide range of potential applications currently available via various marine data repositories and portals in Europe.

Despite their potential, this report highlights that there is still a **huge gap between the knowledge that can be derived** from available European data resources **and actual uptake by users** resulting in tangible contributions to Blue Growth, marine environmental management and knowledge-based policy making.

As one of the first steps, Chapter 5 identified specific needs and gaps in knowledge in key Blue Growth areas requiring marine observations, data and associated tools. However, these are largely based on strategic documents which provide indications of data needs and gaps but are often very generic and not always useful as a basis for activities to connect resources with actual needs of knowledge by users. In order to identify specific resources amenable for transfer as outlined in this report, significant added value was experienced from direct one-on-one interactions with intermediary and end-users. Hence, strategic and policy documents are mostly useful for initial orientation and to obtain some level of guidance about potential priorities, but need to be followed up with direct user interactions to be able to specifically identify potential knowledge transfer activities.

Chapter 6 provides summary overviews and insights into some of the key marine data portals and repositories in Europe, identifying resources and tools with potential to address some of the priority gaps and needs of users. Interviews with managers of the EMODnet data portals have shown that **together these constitute a wealth of data, services, information and knowledge**, which are **currently still largely unknown and underexploited** by a wide range of Blue Growth actors. The overviews of the main data repositories and portals help to explain to users and stakeholders the individual roles, particular areas of focus and/or target users of such systems by showcasing examples of existing usage as well as possible areas of new potential uptake and application. This is

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an important activity to raise the visibility of European marine data portals and clear the path for knowledge transfer activities in support of Blue Growth sectors.

7.2 Recommendations to Address Existing Barriers

The work leading to this report also contributed to the identification of major bottlenecks which slow down the uptake (and impact) of existing marine data resources by Blue Growth actors. It is clear that data generated via marine observation and monitoring activities can only be used in the creation and application of marine knowledge if it can be easily found, retrieved and used. While effective data management (including assembly, use of agreed standards, quality control, storage and long-term archiving) maximises the potential uses of the data, this is not enough on its own. To effectively transfer currently existing data resources into knowledge and ensure its meaningful application, several bottlenecks need to be addressed. This report has highlighted a number of important issues that are summarised below with recommendations to overcome some of the existing barriers and strengthen the transfer of marine data and knowledge resources to key Blue Growth actors.

7.2.1 *Restrictions to Open Sharing of Data:*

While there is a growing understanding that open data approaches provide important returns on public investment with benefits for society as a whole, Chapter 4 of this report indicates that there are still a lot of challenges to overcome. There are many reasons why data holders may be hesitant to share their data, but there are few legitimate grounds to keep data hidden after a certain period of time, provided certain measures are in place to ensure ownership, visibility and protect privacy of data providers if relevant.

- There is a need for promotion and communication efforts to change the attitude and culture of data collectors and holders, but this can only happen if the appropriate support mechanisms (e.g. funding models) and tools are in place. To facilitate open sharing of data, appropriate standards, common vocabularies as well as suitable storage and exchange formats to ensure interoperability between data sources must be considered. Data sharing is not always a priority for the data collector and so incentives must be considered to encourage this activity. These will need to be tailored to the data-collector, for example; for researchers - DOI and citation index linked to data, for industry - appropriate models of data-sharing are required with, for example, defined moratoria after which time strategic data can be made open access.

7.2.2 *Lack of Visibility of Marine Data Repositories and Resources Beyond the Specialist Earth Observation Community:*

Currently, the visibility of marine data repositories/portals and the vast resources and tools they offer does not extend well beyond the marine research and wider earth observation community. Whilst these communities are important users of marine observations and data, many other potential users from other fora and sectors are not aware of the wealth of freely available data that could reduce their costs or help them develop innovative products. Examples include the coastal tourism industry and e-chart service providers. Also, in some instances these users may not be from specifically marine or maritime sectors e.g. from ICT industry or App-developers and therefore even

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less familiar and perhaps not always immediately aware of the opportunities that may exist for added value creation.

- In order to facilitate knowledge transfer from data repositories, during and beyond the COLUMBUS project, there is a need to increase the visibility of existing marine data repositories and portals and their potential applications to a wider number and range of potential users.
- Communication and knowledge transfer activities should initially focus on the growing number of SMEs acting as intermediate users – i.e. providers of added value services and products (based on publicly available data resources) for other (end)users - as these are likely to benefit most and which may generate the highest return on investment in terms of creating Blue Growth.
- Data repository/portal managers and funders need to consider how to reach beyond their current network – awareness raising of their data and products in fora other than the marine monitoring and observation community.

7.2.3 *Complexity of the Data Interrogation Tools and Systems:*

Feedback from marine and maritime stakeholder who need marine data and information for their activities suggests that the data portals and repositories are often too complicated to use without proper guidance. To fully exploit the resources of a repository, there is a need for greater support and training in data interrogation techniques for users of repositories.

- Data repositories and portals need to provide better online tutorials and help desk services, and provide regular cross-disciplinary training and workshops in data interrogation techniques for students and interested stakeholders to fully exploit the available resources.
- Focus should be on developing a contingent of experts able to transform marine data resources into useful products and services and ultimately knowledge to support various actors in maritime activities, marine management and policy.
- There is a need to provide simple user-interfaces to allow for viewing, downloading and also explaining the potential applications of data products, with context. Increasing the use of data repositories and portals will provide an additional transfer route to multiply the uptake and impact of research project outputs which are often at the basis of these systems, both in terms of architecture and in terms of data resources.

7.2.4 *Complexity of the Marine Data Landscape:*

There are currently a wide range of marine data and information systems running, or in development, offering a wide range of services, access to data and delivery of processed information and products. It is often confusing, both to external users of these systems as well as for those involved, how these systems are developing and how they relate to each other. This report considers the most significant European marine data repositories and portals and explains their individual roles, particular areas of focus and/or target users. From this assessment, it becomes clear that there is a need for stronger alignment and collaboration between the various systems and joint communication of the complementarities towards users.

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- Existing marine data initiatives and data systems at national, regional and European level need to better align their systems, and if necessary, merge. The remaining systems should better communicate what they do and do not provide, as well as what they are intended for, to allow users to consider how data layers or products can be applied and to assess which tools are best fit for their purpose.

7.2.5 *Funding Issues:*

There is a lack of sustained long term funding for many marine observation activities and associated data infrastructures. Project limited data repositories or information systems cannot and will not be relied upon by users nor by data holders wishing to share their data. In addition, there is a lack of clear guidelines and obligations for funding recipients to openly share their data in an efficient and useful way to allow interoperable data sharing.

- There is a need to increase sustainability in marine data information systems funding.
- Funding bodies should put in place mandatory open-access data policies, but also provide necessary guidance on how data generators should manage and make available their data.

7.2.6 *Insufficient User Engagement and Stakeholder Interaction:*

Marine data repositories and portals are often developed bottom up to be fit for purpose, with the intended purpose defined by the developer and not the user. Hence, there is a need to move towards systems that are fit for actual use. Hence, direct user interactions are necessary to be able to identify the required parameters and data layers, scale, resolution and tools required by various users.

- End-user needs should be considered in all stages of development.

7.3 Next Steps: Avenues for Further Work in the Columbus Project and Beyond

The screening of major European marine data repositories and portals (Chapter 6) has exposed a wide range of underexploited data resources which merit further investigation to develop and implement specific knowledge transfer pathways towards users in a selection of case studies. For example, data, products and maps on physical conditions, biodiversity or cultural heritage features such as wrecks in European waters could be the basis of added value products and services for the tourism and leisure sector. Data, maps and indices on chemical pollutants and nutrients in European seas and coastal areas, as well as seabed habitat information could be used more in the framework of the Marine Strategy Framework Directive or other marine environmental management and protection activities. In this context, COLUMBUS could consider looking at one of the Regional Sea Conventions such as OSPAR and their assessment process by focusing on a specific indicator or parameter to shed light on how different countries in Europe are handling their data collection, storage, assessment and reporting responsibilities. Another area that would benefit from further exploration involves the EMODnet Human Activities portal which is relatively new but caters for the high demand for data and information on socio-economic aspects and human use of the marine and coastal space.

Initial assessment and prioritisation of opportunities for transfer can be done within the COLUMBUS Competence Node on Monitoring and Observation, but some high potential activities may be

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transferred to other Competence Nodes at a later stage if this is deemed more appropriate. Ultimately, a number of opportunities may be beyond the scope of COLUMBUS but could be taken forward at a later stage or in other initiatives.

Specific follow up activities could include:

- Investigate options to promote a culture of freely sharing marine data by data holders as well as by funders of data generators. This may entail options for new funding models and requirements such as the developments of guidelines and requirements for recipients of public funds;
- Explore innovative ways to attract new users and develop new applications from what is already available;
- Establish contact and collaboration with a selection of SME's to better understand how to reach and serve this growing community of intermediary data product and service providers;
- Establish contact and collaboration with one or two large companies operating offshore, e.g. from dredging industry, to explore ways of transferring data resources both towards them and attempt to feed data collected by them to public data repositories.
- Develop communication materials focusing on user interests such as fact-sheets elaborating 'What can marine observation and data products and services do for your work/business?' targeted at the four main target audiences: industry, science, society and policy; leaflets tailored for specific Blue Growth sectors, listing most relevant products and services available; or pamphlets (e.g. two-sided information sheet) per EMODnet portal with an overview of what is available (data and products) to hand out at business events.
- Compose dedicated presentations on European marine data tools and resources at business conventions and meetings;
- Consider organisation of workshops/training activities to assist specific user communities to make better use of the available data and information tools and resources;
- Several data gaps have been identified that could be addressed to some extent by outputs of ongoing or completed research projects, these include a lack of data on mariculture sites, a need for more information on underwater archaeological sites, a need for improved data in relation to coastal change and coastal management and a need for benthic survey data. Relevant projects have been identified and these will be investigated further by the COLUMBUS monitoring and observation Competence Node as part of their knowledge transfer activities during the remainder of the project (finish February 2018).

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ABBREVIATIONS AND ACRONYMS

CMEMS	Copernicus Marine Environment and Monitoring System
DG MARE	European Commission Directorate-General of Maritime Affairs and Fisheries
DTM	Digital Terrain Model
EMODnet	European Marine Observation and Data Network
EMSA	European Maritime Safety Agency
EuroGOOS	European component of the Global Ocean Observing System (GOOS)
GIS	Geographic Information Service
HF radar	High Frequency Radar
ICES	International Council for the Exploration of the Sea
INSPIRE	Infrastructure for Spatial Information in the European Community
IODE	International Oceanographic Data Exchange System of UNESCO's Intergovernmental Oceanographic Commission (IOC)
MSFD	Marine Strategy Framework Directive
MSPD	Marine Spatial Planning Directive
NODC	National Oceanographic Data Centre defined within the International Oceanographic Data Exchange (IODE) System of the UNESCO Intergovernmental Oceanographic Commission (IOC)
OGC	Open Geospatial Consortium
ODP	Ocean Data Portal
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic (also known as Oslo Paris Convention)
QA/QC	Quality Assurance/Quality Control
UNESCO	United Nations Educational, Scientific and Cultural Organisation
WFS	Web Feature Service
WMS	Web Map Service

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GLOSSARY OF TERMS

Accuracy

The degree to which a measured value (either spatial resolution/precision or attribute) conforms to a true or accepted value. Accuracy is a measure of correctness. It is distinguished from precision, which measures exactness.

Attribution licence

A licence that requires that the original source of the licensed material is cited (attributed).

Bathymetry

Bathymetry is the study of underwater depth, leading to topographic maps of the ocean floor. A bathymetric map or chart usually shows seabed relief or terrain as contour lines or false colour composite images, using a colour ramp (shades of different colours) to indicate different depths.

Big data

A loose term, not formally defined, for high-volume, high-velocity and high-variety information assets that demand cost-effective, innovative forms of information processing, that can give enhanced insight and decision making.

Common Data Index (CDI)

Provides a highly detailed description of the data, answering to the questions: where, when, how and who collected the data, and how to get them. One CDI describes a data series which can be a vertical profile on a fixed location, a time series or a trajectory data set.

Creative Commons

A non-profit US organisation that enables the sharing and use of creativity and knowledge through free legal tools.

Data

Data are the basic individual items of numeric or other information, garnered through observation; but in themselves are devoid of information.

Data Repository

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A repository is a central place in which an aggregation of data is kept and maintained in an organised way, usually in computer storage. A repository may be just the aggregation of data itself into some accessible place of storage or it may also imply some ability to selectively extract data.

DTM - Digital Terrain Models

A digital terrain model (DTM) is (generally) a filtered version of a Digital Elevation Model (DEM) to remove all the features on/above the surface (buildings, forests etc.). The DTM provides a so-called bare-earth model, devoid of landscape features. See DEM - Digital Elevation Models.

Georeference

Description of a location relative to the Earth.

Geospatial

Referring to location relative to the Earth's surface. "Geospatial" is more precise in many GI contexts than "geographic," because geospatial information is often used in ways that do not involve a graphic representation, or map, of the information.

Geospatial data

Location properties related to any terrestrial feature or phenomena. Location properties may include any information about the location or area of, and relationships among, and descriptive information about geographic features and phenomena. This includes remotely sensed data, vector map data, addresses, coordinates, etc.

Geographical Information System (GIS)

A geographical information system (GIS) can be seen as a system of hardware, software and procedures designed to support the capture, management, manipulation, analysis, modelling and display of spatially referenced data.

GIS Database

A GIS database includes data about the position and the attributes of geographical features that have been coded as points, lines, areas, pixels or grid cells.

Information

Information can be defined as data that have been given meaning through some form of interpretation and/or analysis that when presented in context represents added value, message or meaning.

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Interoperability

The ability of two or more systems, or components to exchange information, and to use the information that has been exchanged. It is commonly used to describe the sharing of data on the internet where a mapping website will draw data from another website to give context to its data; for example, a website may draw a coastal outline from a central repository rather than try to maintain its own copy.

Interpretation

The process of giving data meaning through directed analysis and reasoned explanation.

Layers

The visual representation of a geographic dataset in any digital map environment. Conceptually, a layer is a slice or stratum of the geographic reality in a particular area, and is more or less equivalent to a legend item on a paper map. On a road map, for example, roads, national parks, political boundaries, and rivers might be considered different layers.

In ESRI™ ArcGIS, a layer is a reference to a data source, such as a shapefile, coverage, geodatabase feature class, or raster, that defines how the data should be symbolised on a map.

Maps

A simplified depiction of a space, a navigational aid which highlights relations between objects within that space. A graphic representation of a parameter that can be used to derive information for a specific area.

Metadata

Metadata is data that describes other data. Meta is a prefix that in most information technology usages means "an underlying definition or description." Metadata summarises basic information about data, which can make finding and working with particular instances of data easier. Typically, metadata will answer the 'who? what? where? and when? questions' for a dataset.

Metadata element

One of the pieces of information recorded in a metadata record. For example, the title of a data set is a metadata element.

Metadata standard

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A set of metadata elements that are needed to describe a particular type of data. Metadata standards are usually defined by official standards organisations, but they can also be defined by an organisation or project for a specific purpose: the MESH metadata standard (www.searchMESH.net/metadata) are the set of metadata elements necessary to fully describe seabed habitat map data.

Monitoring

Continuous or repeated observation, measurement, and evaluation of environmental or technical data, according to prearranged schedules in space and time, using comparable methods for sensing and data collection. Monitoring is used to detect trends over time.

Modelled data

Information created by mathematical representation of data relationships; sometimes used to simulate environments that are difficult to observe reliably or consistently.

Near Real Time

Refers generally to systems that respond almost immediately or synchronously to external events.

Open data

Data is open if anyone is free to access, use, modify, and share it — subject, at most, to measures that preserve provenance and openness.

Ocean Data View (ODV)

A freely available software package that provides interactive exploration, analysis and visualisation of oceanographic and other geo-referenced profiles or sequence data.

Uncertainty

The degree to which the measured value of some quantity is estimated to vary from the true value. Uncertainty can arise from a variety of sources, including limitations on the precision or accuracy of a measuring instrument or system; measurement error; the integration of data that uses different scales or that describe phenomena differently; conflicting representations of the same phenomena; the variable, unquantifiable, or indefinite nature of the phenomena being measured; or the limits of human knowledge. Uncertainty is the opposite of confidence.

Validation

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Comparing data with known information (patterns, ranges, check digits) to verify that the data is correct, includes what is commonly thought of as testing and comparing test results to expected results. Validation occurs at the end of the development process.

WebGIS

A GIS (Geographic Information System) available over the internet.

WFS

Web feature service

Web Map Service (WMS)

A standardised service for delivering georeferenced geographic images over the internet

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ANNEXES

7.4 Annex 1. Inventory of Relevant Portals and Repositories of Marine Data and Information

Country/Region	Name	Website	Geographic Scope	Description	Suggested by COLUMBUS Partner
Global	World Register of Marine Species (WORMS)	http://www.marinespecies.org	Global	The aim of a World Register of Marine Species (WoRMS) is to provide an authoritative and comprehensive list of names of marine organisms, including information on synonymy. While highest priority goes to valid names, other names in use are included so that this register can serve as a guide to interpret taxonomic literature. This register of marine species grew out of the European Register of Marine Species (ERMS), and its combination with several other species registers maintained at the Flanders Marine Institute (VLIZ).	Yes
	Permanent Service for Mean Sea Level (PSMSL)	http://www.psmsl.org/	Global	PSMSL is the global data bank for long term sea level change information from tide gauges and bottom pressure recorders.	Yes

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	Marine Regions	http://www.marineregions.org	Global	Marine Regions is a standard list of marine georeferenced place names and areas. It integrates and serves geographic information from the VLIMAR Gazetteer and the MARBOUND database and proposes a standard of marine georeferenced locations, boundaries and regions.	Yes
	Sea Level Station Monitoring Facility	http://www.ioc-sealevelmonitoring.org/	Global	The objective of this service is to provide information about the operational status of global and regional networks of real time sea level stations to provide a display service for quick inspection of the raw data stream from individual stations	
	JCOMMOPS	http://www.jcommops.org/board	Global	The WMO-IOC Joint Technical Commission for Oceanography and Marine Meteorology in-situ Observing Programmes Support Centre.	Yes
	PANGAEA	https://pangaea.de	Global	The information system PANGAEA is operated as an Open Access repository aimed at archiving, publishing and distributing georeferenced data from earth system research.	Yes
	FishSource™	http://www.fishsource.com/	Global	FishSource™ is a resource about the status of fish stocks and fisheries. The aim being to provide major seafood buyers with up-to date, impartial, actionable information on the sustainability of fisheries and the improvements they need to make to become sustainable.	
	RAM legacy stock assessment database	http://ramlegacy.org/	Global	The RAM Legacy Stock Assessment Database is a compilation of stock assessment results for commercially exploited marine populations from around the world.	
	Fisheries and resources monitoring system	http://firms.fao.org/firms/en	Global	The primary aim of the Fisheries and Resources Monitoring System (FIRMS) is to provide access to a wide range of high-quality information on the global monitoring and management of fishery marine resources.	
	iMarine gateway	https://i-marine.d4science.org/web/guest/virtual-research-environments	Global	iMarine is an open and collaborative initiative that has established a data infrastructure to support the Ecosystem Approach to fisheries management and conservation of marine living resources. This gateway is an access point to a number of Virtual Research Environments deployed and operated in the context of the iMarine project to support the Ecosystem Approach to fisheries management and conservation of marine living resources.	
	AquaMaps	http://www.aquamaps.org	Global	AquaMaps are computer-generated predictions of natural occurrence of marine species, based on the environmental tolerance of a given species with respect to depth, salinity, temperature, primary productivity, and its association with sea ice or coastal areas.	

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	Ocean Biogeographic Information System (OBIS)	http://www.iobis.org/	Global	OBIS allows users to search marine species datasets from all of the world's oceans. The evolving database allows users to identify biodiversity hotspots and large-scale ecological patterns, analyse dispersions of species over time and space, and plot species' locations with temperature, salinity, and depth.	Yes
European	EMODnet	www.emodnet.eu	European	The European Marine Observation and Data Network (EMODnet) consists of approximately 160 organisations assembling marine data, products and metadata to make these fragmented resources more available to public and private users relying on quality-assured, standardised and harmonised marine data which are interoperable and free of restrictions on use.	Yes
	CMEMS	http://marine.copernicus.eu/	Global	The Copernicus Marine Service has been designed to respond to issues emerging in the environmental, business and scientific sectors. Using information from both satellite and in situ observations, it provides state-of-the-art analyses and forecasts daily, which offer an unprecedented capability to observe, understand and anticipate marine environment events.	Yes
	SeaDataNet	http://www.seadatanet.org/	Global	The SeaDataNet infrastructure links national oceanographic data centres and marine data centres from 35 countries riparian to all European seas. The data centres manage large sets of marine and ocean data, originating from their own institutes and from other parties, in a variety of data management systems and configurations. A major objective and challenge in SeaDataNet is to provide an integrated and harmonised overview and access to these data resources, using a distributed network approach.	Yes
	European Atlas of the Seas	http://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/	European	The European Atlas of the Seas is a user friendly portal for professionals, students and the general public to learn more about Europe's seas and coasts, their environment, related human activities and European policies.	
	Marine Operational Ecology Data Portal	http://portal.marineopec.eu/	European	The Marine Operation Ecology data portal provides model simulated ecosystem data for European Regional Seas.	
	EDEN	http://youredenexperience.com/	European	Eden Network is a network of destinations of excellence in sustainable tourism. The EDEN Network promotes a new way to travel in Europe, drawing the value and the diversity of emerging European tourist destinations. Visitors will experience the real country and culture as it is lived every day, not cultural shows and tourism experiences that have been specifically developed for visitors.	Yes
	European Environment Agency (EEA)	http://www.eea.europa.eu/data-and-maps	European	The European Environment Agency makes available a range of datasets, interactive maps, graphs and indices	Yes

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	European Marine Life	http://www.european-marine-life.org/	European	This site is dedicated to the identification of marine flora and fauna from the Atlantic and Mediterranean coasts of Europe.	Yes
	LifeWatch Marine Virtual Research Environment (VRE)	http://marine.lifewatch.eu/	European	A virtual researchy environment bringing together several marine resources, data bases, data systems, web services, tools, etc. In the wider context of the LifeWatch project http://www.lifewatch.eu/Virtual_Research_Environments	
Regional	ICES (International Council for the Exploration of the Sea) Data Centre	http://www.ices.dk/marine-data	Northeast Atlantic, Baltic Sea, Greenland Sea, and Norwegian Sea	ICES Data Centre provides marine data services to ICES member countries, expert groups, world data centres, regional seas conventions (HELCOM and OSPAR), the European Environment Agency (EEA), Eurostat, and various other European projects and biodiversity portals. Dataset collections are organised around specific thematic data portals as well as an overarching data warehouse. The current dataset portals provided by ICES are: Biological community; Contaminants and biological effects; Eggs and larvae; Fish predation (stomach contents); Fish trawl survey (DATRAS); Historical plankton; Ocean physics and chemistry.	Yes
	OSPAR Data and Information System (ODIMS)	http://www.ospar.org/data	North East Atlantic	ODIMS (in development) will be an online tool to improve the discovery, visualisation and accessibility of OSPAR data. Sufficient information is currently available to allow users to access the latest data collected as part of the ongoing monitoring work carried out in the OSPAR Maritime Area	Yes
	HELCOM data and map service	http://maps.helcom.fi/website/mapservice/index.html	Baltic Sea	HELCOM data and map service makes freely available data and maps in the areas of; sea environmental status, sea environmental monitoring, pressures and human activities, biodiversity, monitoring and response, maritime spatial planning	Yes
	Oceanographic Mediterranean and Black Sea Data Management	http://isramar.ocean.org.il/perseus_data/	Mediterranean and Black Sea	Cast Data Base with vertical profiles of physical, chemical and biological data acquired with Bottle casts (Rosette), CTD casts, and Argo floats.	Yes
	DEVOTES project spatial data platform	http://maps.devotes.eu/	All European Regional Seas	The repository for spatial data (and linked files) from DEVOTES	Yes
	The COCONET project WebGIS publishes data for the Mediterranean and Black Sea	http://coconetgis.ismar.cnr.it/	Mediterranean and Black Sea	The COCONET WebGIS publishes data stored in the Geodatabases with all information available for the Mediterranean and Black Sea.	Yes

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	PEGASO project geoportal	http://pegasosdi.uab.es/geoportal/	Mediterranean and Black Sea	The Pegaso Spatial Data Infrastructure has been designed to support the PEGASO Shared Governance Platform for the delivery of Integrated Coastal Zone Management, and the integrated assessments of coastal zones and marine areas in the Mediterranean and the Black Sea.	
	Black sea Marine and Coastal Atlas	http://smartatlas.misisproject.eu/smartatlas/	Black Sea	The Marine and Coastal Atlas was developed in the frame of MISIS project - MSFD GUIDING IMPROVEMENTS IN THE BLACK SEA INTEGRATED MONITORING SYSTEM. The overall goal of the project is to support efforts to protect and restore the environmental quality and sustainability of the Black Sea and also to develop a national integrated monitoring program in line with MSFD standards.	
	Adriplan data portal	http://data.adriplan.eu/	Adriatic Ionian Sea	The Adriplan data portal is available for partners, stakeholders and the general public for searching and sharing knowledge, data, and information related to MSP in the Adriplan project area. The Adriplan (Adriatic Ionian maritime spatial planning) project funded under the "Maritime Spatial Planning (MSP) in the Mediterranean sea and/or the Black sea"	
	Department of Fisheries and Oceans Canada	http://geoportal.gc.ca	Adriatic Ionian	The Northwest Atlantic Fisheries Organisation (NAFO) is a regional fisheries management organisation (RFMO) founded in 1979. NAFO's overall purpose is to help its members work together and share knowledge to effectively manage and conserve the high seas fishery resources of the Northwest Atlantic Ocean.	Yes
	SeaGIS 2 project	http://maps.seagis.org/	Baltic Sea, Gulf of Bothnia	The SeaGIS 2.0 project produce maps via their map portal in relation to the sustainable development of the Gulf of Bothinia.	
	MAPAMED	http://www.medpan.org/	Mediterranean	MAPAMED (Marine Protected Areas in the Mediterranean) is a GIS database that gathers information on marine protected areas of the Mediterranean, and more generally on sites of interest to the conservation of the marine environment	
	Encyclopaedia of Marine Life of Britain and Ireland	http://www.habitas.org.uk/marinelife/	Ireland and Britain	Marine species identification portal. It is intended for divers and marine biologists who need to be able to recognise species in situ and is not an exhaustive identification guide. This photographic guide covers a selection of the larger animals which live round the coasts of Britain and Ireland.	Yes

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Belgian	Marine Information and Data Acquisition System	http://www.vliz.be/vmdcdata/midas/	Belgian Part of the North Sea	MIDAS is developed to plan the cruises of the RV Simon Stevin, to register the research activities during these cruises and to capture navigational, meteorological and oceanographic parameters while underway. Measurements are available online and research activities on the ship can be followed real-time on the Lifewatch portal.	
	Scheldemonitor data portal	http://www.scheldemonitor.be/nl	Scheldt river estuary (Belgium-Netherlands)	The Scheldemonitor is a Dutch-Belgian data, information and knowledge portal which integrates data and information about the Scheldt river estuary stemming from different sources	
	Stranded Seabirds and Marine Mammals database	http://www.mumm.ac.be/EN/Management/Nature/search_strandings.php	Belgian Part of the North Sea	information and data on Stranded Seabirds and Marine Mammals database	
	Database with wrecks information	http://www.vlaamsehydrografie.be/wrakkendatabank.htm	Belgian Part of the North Sea	Information and mapped data on wrecks in the Belgian part of the North Sea	
Bulgarian	Bulgarian National Oceanographic Data Centre	http://www.bgodc.io-bas.bg/	Bulgaria	Bulgarian National Oceanographic Data Center is organised as a local portal for the national and international exchange of oceanographic data for the Black Sea. The main objectives of the centre are: To collect oceanographic data from the Bulgarian institutions and agencies, archive them, and qualify them for use with different levels of access; To carry out the commitments of Bulgaria in the international exchange of data under their obligations to the Intergovernmental Oceanographic Commission (IOC) and European projects SEADATANET, SIBEMA, ASCABOS, ARENA, MyOcean, Geo-Seas, EMODnet etc.	
Cyprus	CYCOFOS	http://www.oceanography.ucy.ac.cy/	Cyprus	The Oceanography Center is the Cyprus institution for ocean research and one of the operational marine core and downstream forecasting and monitoring centres in the Mediterranean	
Denmark	Danish Meteorological Institute	http://www.dmi.dk/en/hav/#danmark	Denmark	Ocean forecasts for Danish waters available from Denmark's Meteorological Institute	
Finland	Baltic Sea Now	http://en.ilmatieteenlaitos.fi/wave-forecast	Baltic Sea	The Finnish Meteorological Institute (FMI) is a research and service agency under the Ministry of Transport and Communications. The main objective of the Finnish Meteorological Institute is to provide the Finnish nation with the best possible information about the atmosphere above and around Finland, for ensuring public safety relating to atmospheric and airborne hazards and for satisfying requirements for specialised meteorological products	

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France	CORIOLIS	http://www.coriolis.eu.org/	France	CORIOLIS contributes to the French operational oceanography program for the in-situ observations. The 7 institutes involved in operational oceanography in France (CNES, CNRS, Ifremer, IPEV, IRD, Météo-France, Shom) decided in 2001 to joint their efforts within Coriolis in order to : organise and maintain data acquisition in real-time and delayed mode of in-situ measurements necessary for operational oceanography, set up an operational in-situ data centre and develop and improve the technology necessary for operational oceanography.	
	Portail des données marines	data.ifremer.fr	France	Oceanographic data portal of the French Research Institute for Exploitation of the Sea	
	Observations Data for the Recognition and Identification of Underwater Fauna and Flora - DORIS (Données d'Observations pour la Reconnaissance et l'Identification de la faune et la flore Subaquatiques)	http://doris.ffessm.fr/	Mediterranean, Atlantic, North Sea, French Indo-Pacific and Caribbean	Open access and interactive data-portal for observations and species identification of underwater freshwater and marine biodiversity.	Yes
Germany	GEOSEAPORTAL	https://www.geoseaportal.de/gdi-bsh-portal/ui	Germany	Germany's Federal Maritime and Hydrographic Agency (BSH) "GeoSeaPortal" provides a central Internet access to comprehensive, multidisciplinary geospatial data, based on international standards	
	COSYNA	http://www.hzg.de/institutes_platforms/cosyna/index.php.en	GERMANY /North Sea and Artic)	The COSYNA Mission is to develop an integrated observing and modelling system suitable for the operational and synoptic description of the environmental status of the North Sea and Arctic coastal waters. COSYNA aims to provide data and knowledge tools to help authorities, industry, and the public to plan and manage routine tasks, respond to emergency situations and to evaluate trends. Scientific products and infrastructure are developed to foster scientific knowledge of the "global coast" and its regional manifestations. COSYNA is financed and coordinated by the Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research GmbH.	
Greece	POSEIDON	http://www.poseidon.hcmr.gr	Greece	Monitoring, forecasting and information system for the Greek seas	

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Ireland	Marine Data Centre	http://marine.ie/Home/site-area/data-services/marine-data-centre	Ireland	Ireland's National Marine Data Centre consists of hosted online data services including descriptive metadata to find data, maps and graphs to view data; and services to download data.	Yes
	Marine Institute Data Portal	http://data.marine.ie/	Ireland	The Marine Institute (MI) Data portal aims to provide simple, self-service access to data available from various MI data holdings in the following broad categories; oceanography, fisheries, ocean energy, food safety, marine environment and meteorology.	Yes
	Marine Atlas	http://atlas.marine.ie/#?c=53.9108:-15.8972:6	Ireland	Ireland's Marine Atlas viewer is funded by the Department of Environment, Community and Local Government and operated by the Marine Institute. The atlas has been developed as part of Ireland's reporting for the Marine Strategy Framework Directive on the condition of the ocean. The Atlas include marine data such as Administrative boundaries, Protected sites, Oil and Gas, Ocean features, Fisheries and Aquaculture, Marine Monitoring, Seabed habitats, Tourism and leisure, Transport, Infrastructure, Discharge point sources, IMO protected areas and Current / Historical dump sites	
	Digital Ocean	http://www.digitalocean.ie/	Ireland	Ireland's Integrated Digital Ocean is a platform providing access to a diverse range of services including online maps, data dashboards, data access, data search and publications	
	INFOMAR	www.infomar.ie	Ireland	The INtegrated Mapping FOr the Sustainable Development of Ireland's MArine Resource (INFOMAR) programme is a joint venture between the Geological Survey of Ireland and the Marine Institute.	Yes
	Irelands Open Data Portal	https://data.gov.ie/data	Ireland	Ireland's Open Data Portal aims to promoting innovation and transparency through the publication of Irish Public Sector data, including marine and maritime data, in open, free and reusable formats	
	Geological Survey of Ireland	www.gsi.ie	Ireland	The GEOLOGICAL SURVEY OF IRELAND (GSI), is the National Earth Science Agency. It is responsible for providing geological advice and information, and for the acquisition of data for this purpose. GSI produces a range of products including maps, reports and databases and acts as a knowledge centre and project partner in all aspects of Irish geology including marine geology	Yes
Italy	GNOO (Gruppo Nazionale di Oceanografia Operativa)	http://gnoo.bo.ingv.it/static/GNOO_Services.htm	Italy	Italy's National Oceanography Data Portal	

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	NODC	http://nodc.ogs.trieste.it/nodc/	Italy	OGS is recognised as the Italian National Oceanographic Data Centre (OGS-NODC) within the International Oceanographic Data Exchange System of the UNESCO Intergovernmental Oceanographic Commission (IOC) since 27/6/2002. OGS is part of the IOC's network of national oceanographic data centres and has designated responsibility for marine data. The oceanographic data base covers the fields of marine physics, chemical, biological, underway geophysics and general information on Italian oceanographic cruises and data sets.	
Malta	Physical Oceanography Institute of the University of Malta	http://ioi.research.um.edu.mt/capemalta/stations@malta/INDEX/	Malta	Real-time Meteo-Marine Observations by the Physical Oceanography Institute of the University of Malta from the University of Malta	
Netherlands	NODC	http://www.nodc.nl/	The Netherlands	The National Oceanographic Data Committee (NODC) of the Netherlands is the national platform for exchange of oceanographic and marine data and information, and for advisory services in the field of ocean and marine data management.	
	Rjkswaterstaat	https://data.overheid.nl//	The Netherlands	Open Data from the Netherlands Ministry of Infrastructure and the Environment	
Norway	Institute Marine Research	http://www.imr.no/forskning/forsknings data/en	Norway	Norway's institute of Marine Research continuously collects large amounts of data from all Norwegian seas. Data are collected using vessels, observation buoys, manual measurements, gliders – amongst others.	
	Norwegian Meteorological Institute	http://www.met.no/English/Ocean_and_Ice/	Norway	Oceanographic information and data for the Nordic Seas and Arctic Ocean from the Norwegian Meteorological Institute.	
	SeaPop (SeaBird Populations)	http://www.seapop.no	Norway	SEAPOP (SEAbird POPulations) is a long-term monitoring and mapping programme for Norwegian seabirds that was established in 2005. The programme covers seabird populations in Norway, Svalbard and adjacent sea areas, and will provide and maintain base-line knowledge of seabirds for an improved management of this marine environment.	Yes
	MAREANO	http://www.mareano.no/en/about_mareano		MAREANO maps of depth and topography, sediment composition, biodiversity, habitats and biotopes as well as pollution in the seabed in Norwegian offshore areas. On MAREANO's web pages, interpreted data are available as maps, WMS-service, and downloadable data. In addition, data is available through "Norge digital" and directly from partners in the project. The Norwegian Mapping Authority, the Geological Survey of Norway (NGU), and the Institute of Marine research, are partners in the project, but they still own and have management responsibility for their own data	

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Portugal	Portugal's Hydrographic Institute	http://www.hidrografico.pt/	Portugal	The Portuguese Hydrographic office has the fundamental task of ensuring activities related to the sciences and techniques of the sea, with a view to their application in the military, and contribute to the country's development in science and protection of the marine environment.	
Spain	PORTUS	http://www.puertos.es/en-us/oceanografia/Pages/portus.aspx	Spain	Puertos del Estado has developed and maintains systems for the measurement and forecasting of the marine environment. Its main customer is the Spanish Port System, but it is open to society and other institutions. Through their PORTUS portal, they provide access to real-time data from their measurement networks (buoys, tidal gauges and high frequency radars), forecasting services (waves, sea level, currents and water temperature) and climatic sets.	
	SOCIB	www.socib.es	Balearic region/Western Mediterranean (for forecasts)	SOCIB Data Centre provides data from SOCIB observation platforms (HF radar, gliders, drifters, buoys), from the operational forecasts produced by the Modelling and Forecasting Facility and from external providers through various collaborations (e.g., Puertos del Estados, CSIC). BUT, they do not have a central portal as such, you can have access to the information in various ways, including apps, but also access for scientists. For more info, consult the webpage http://socib.es/?seccion=dataCenter	Yes
	RAIA	www.marnaraia.org	NW Iberian Coast	An observational network of oceanographic and meteorological data on the Northwest coast of the Iberian Peninsula.	Yes
	Pesca de Galicia	http://www.pescadegalicia.com	Galicia	Statistics of fishes catches landed by species, by port, by year (NW coast of the Iberian Peninsula) in Galicia	Yes
	SIGREMAR	http://ww3.intecmar.org/Sigremar	Galicia	GIS maps focused on the management of specific marine resources from the Galician coast	Yes
	Indamar	http://indamar.ieo.es/		Access to data from IEO networks, including surveys and tide gauges.	
	AZTI	http://www.azti.es/thematic-portals/	Vasque Country	Access to different data resources: from images from beaches, to real-time met-ocean data for one station.	
	IDEE	http://www.idee.es/visualizador/	Spain	The Spatial Data Infrastructure of Spain (IDEE for Infraestructura de Datos Espaciales de España) is an initiative integrating data, metadata and geographical information produced in Spain by a wide set of data producers, which enables data discovering, viewing, and sometimes analyzing and downloading.	
	COO	http://coo.icm.csic.es/es/dataview	Catalunya	The Coastal Ocean Observatory (COO) is dedicated to the acquisition, management and visualisation of oceanographic data, especially along the Mediterranean coast	

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Turkey	National Oceanographic Data Inventory	http://www.ims.metu.edu.tr/Inventory/invsrv.dll/prlist	Turkey	National Oceanographic Data Inventory	
UK	MEDIN	http://www.oceannet.org/	UK	MEDIN is a partnership of UK organisations committed to improving access to marine data.	Yes
	Centre for Environment, Fisheries and Aquaculture Science (CEFAS) Data Hub	http://data.cefas.co.uk/	UK	Cefas Data Hub – an online portal allowing the public and private entities to explore, download and reuse data generated through CEFAS observation and monitoring work (Open Government Licence terms and conditions apply). Datasets available include legacy datasets covering subjects such as fish, shellfish and plankton survey data from the 1980's to the present day, crab tagging data, otolith sample data, records relating to MEDIN Marine Fisheries Data Archive Centre, water temperature, salinity, and sediment data from across the UK continental shelf.	Yes
	Oil and Gas Resources of the United Kingdom 2000	https://www.gov.uk/guidance/oil-and-gas-uk-field-data	UK	ata for oil and gas wells around the UK: production history, income, expenditure on exploration, spills, remaining reserves and approvals	Yes
	European Marine Energy centre	http://www.dbd-data.co.uk/bb2000/book.htm	UK	Department of Trade and Industry's annual report on the development of the oil and gas resources of the United Kingdom	Yes
	The Marine Life Information Network (MARLIN)	http://www.emec.org.uk/facilities/live-data/	UK	The European Marine Energy Centre (EMEC) Ltd is the first and only centre of its kind in the world to provide developers of both wave and tidal energy converters with purpose-built, accredited open-sea testing facilities. In addition EMEC makes available marine data including live wave, tidal, weather and radar data and marine traffic (AIS) data from around the Orkney Islands	
	The Archive for Marine Species and Habitats Data (DASSH)	http://www.marlin.ac.uk/	British Isles	MarLIN provides information to support marine conservation, management and planning. Our resources are based on available scientific evidence and designed for all stakeholders, from government agencies and industry to naturalists and the public. MarLIN hosts the largest review of the effects of human activities and natural events on marine species and habitats yet undertaken.	Yes
	Marine Scotland	http://www.dassh.ac.uk/	British Isles	DASSH is the UK Data Archive Centre for marine biodiversity data for both species and habitats.	
	United Kingdom Hydrographic Organisation INSPIRE Portal and Bathymetry Data Archive Centre	http://marinedata.scotland.gov.uk/	Scotland	Marine Scotland gathers and uses a wide range of data and information as part of its work. The data portal makes available information on; monitoring, oceanography, aquaculture, marine planning, fisheries and modelling code.	Yes

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	Marine Management Organisation	http://aws2.caris.com/ukho/mapViewer/map.action	British Isles	Data Archive Centre for bathymetric surveys	Yes
	National Oceanographic Centre (NOC)	https://www.gov.uk/government/organisations/marine-management-organisation	England and wales	MMO is an executive non-departmental public body, sponsored by the Department for Environment, Food & Rural Affairs who licence, regulate and plan marine activities in the seas around England and Wales so that they're carried out in a sustainable way.	Yes
	Scottish environmental Protection Agency	http://noc.ac.uk/data	British Isles and global (samples)	NOC hosts a variety of national facilities and information and data services including the British Oceanographic Data centre, British Ocean Sediment Core Research Centre, Discovery collections (global benthic and pelagic samples), NERC's data catalogue service and the Permanent Service for Mean Sea level.	Yes
	Scottish National Heritage	http://www.environment.scotland.gov.uk/get-informed/indicators-and-data/	Scotland	Provides access to many datasets that have been used to assess the State of Scotland's environment (SoE) in the fields of air, water, land and people and the environment.	Yes
	JNCC	http://gateway.snh.gov.uk/natural-spaces/index.jsp	Scotland	Scottish National Heritage 'Natural Spaces' allows you to download a wide range of the spatial data held by SNH.	Yes

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7.5 Annex 2 Templates

Template 1A

Name of Portal
Full Name and website
Description
Types of data
Types of products
Services
Geographic Scope
Funding mechanism/Sponsor
Relevant Strategic Documents
Timeline
Operational Structure
Contacts

Template 1B

COLUMBUS Competence Nodes		Details of relevant data, meta-data, information, data products or portal services with potential to address identified gaps and challenges
COLUMBUS Node	Marine Governance and Management	
	Fisheries	
	Aquaculture	

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	Marine biological resources	
	Marine Environment and Futures	
	Marine Physical Resources	
	Maritime transport and logistics	•
	Maritime Tourism	
Marine Strategy Framework Directive Descriptor (Annex 1)		
Marine Spatial Planning Directive Article (Annex 2)		•

Template 1C

Specific data layers, products with high potential for transfer	Potential End-User
	•

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Template 2 Partner Survey Questionnaire

1. Please briefly describe your sector

2. Do you use data or data derived information products (e.g. GIS maps) in your work? If yes, briefly describe below	Yes ☐	No ☐

3. Do you use any portals or repositories to obtain data or data derived products? If yes, please list them below:	Yes ☐	No ☐

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4. Has your work ever been impeded by a lack of data, be this an absence of data, an inability to find relevant data, or the data is there but at a cost? If yes, please describe in as much detail as you can any problems you have had trying to source data or information for your work:	Yes ☐	No ☐

5. Do the activities of your organisation generate data? If yes, please respond to the questions below:	Yes ☐	No ☐
(i) What type(s) of data? (ii) Where do you store your data? (iii) Do you make your data publicly available? If yes, where?		

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If no, why not?

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Template 3 Portal Coordinator Questionnaire

Questions for coordinators	
1.	What is the regional coverage of your portal?
2.	Can data be downloaded from the portal (or is it just the products)?
3.	Where are the biggest gaps in your data - temporal and spatial?
4.	What are the biggest challenges you come across in trying to get data and what could help?
5.	Who is the biggest user-group of your portal? Science/policy etc. What do they use it for?
6.	Do you have any data/products you feel have a lot of potential but which are currently under-utilised for whatever reason? What are the reasons?
7.	Do you have an end-user group you would like to target but can't?
8.	Does your portal contribute to the Marine Strategy Framework Directive, Marine Spatial Planning Directive, specific Blue Growth sector?

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