NOURISHING BLUE ECONOMY & SHARING OCEAN KNOWLEDGE

Nourishing Blue Economy and Sharing Ocean Knowledge

Ocean Information for Sustainable Development

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Executive Summary

A sustainable Blue Economy, also known as "marine industrial revolution", allows society to obtain value from the oceans and coastal regions, whilst respecting the long-term capacity of the oceans to regenerate and endure such activities through the implementation of sustainable practices.

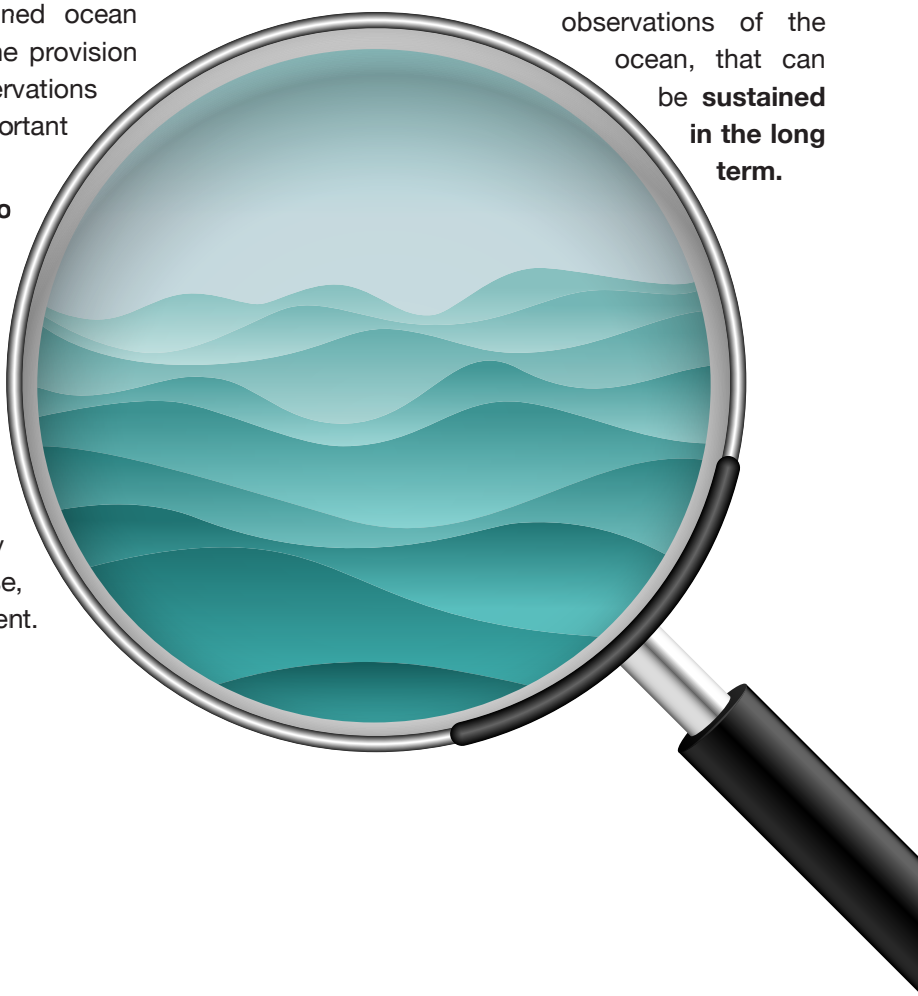
Preserving and increasing the natural capital accumulated in the seas and oceans is critical for society to deliver sustainable ecosystem services and for the EU to achieve the Sustainable Development Goals set by the United Nations for 2030**. There is the responsibility to use the oceans sustainably and to share knowledge, to collaborate across nations, to advance public/private partnerships, while ensuring that professionals working in this sector are adequately educated and following best practices**. As ocean scientific research and sustained ocean information needs have grown in scale, the provision of the means to conduct ocean observations and measurements has become an important economic activity in its own right.

The growth of the Blue Economy added to public and private ocean observations, measurements, and forecasts, that can be tailored for specific end-uses. The ultimate beneficiaries of ocean observations are end-users whose activities or businesses benefit from ocean data and information. Benefits include a better scientific understanding of the ocean, improved safety, economic efficiency gains, more effective regulation of ocean use, and the protection of the ocean environment.

As the ocean is the main driver of climate and weather, the whole of society benefits from improved forecasts based on adequate ocean data.

These insights contribute to society's knowledge pool and are used to develop, for example, forecasts, assessments and recommendations for decision makers. **Policy end-users depend on ocean data and information to help inform the drafting of effective legislation to ensure safety of life or property, protection of the environment and regulation of the use of ocean space or ocean resources**. Ocean data and information are further needed to monitor compliance with the resulting legislation.

Ocean observing is "big science" and cannot be solved by individual nations; it is necessary to ensure high-level integration for coordinated observations of the ocean, that can be **sustained in the long term.**



Ocean Observing for Sustainable Development

The Ocean covers 70% of the Earth's surface and plays a critical role in providing the air we breathe and the freshwater we drink. **The ocean makes our planet habitable as a primary controller of the global climate system**. The Ocean is the pathway for 90% of global trade and provides a wealth of resources supporting human livelihoods, with enormous economic impact. Investors are increasingly looking towards the ocean for economic opportunities. OECD projections suggest that the Blue Economy, evaluated as 2.5% of the world economic value of goods and services produced, is expanding rapidly. By 2030, ocean industries have the potential to double in size (seabed mining, shipping, fishing, tourism, renewable energy systems and aquaculture will intensify). Ocean industries are outperforming the global economy as a whole and making an important contribution to Blue Growth and employment.

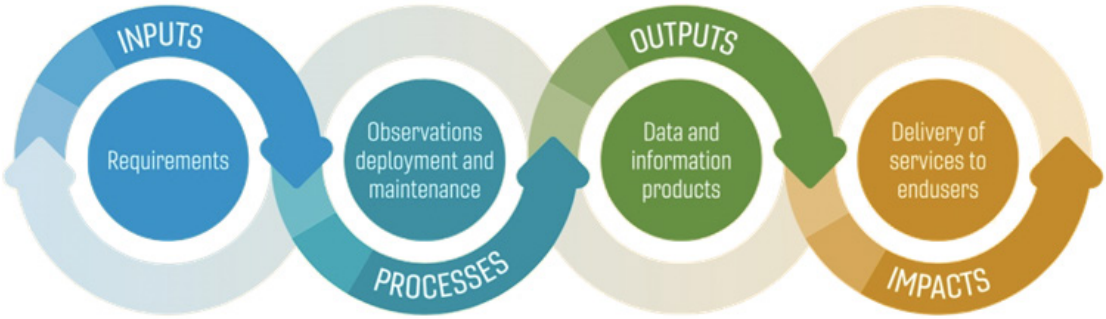
While increased incidences of harmful algae, invasive species, parasites and jellyfish are evident, the overall consequences of intensification of human activities on marine ecosystems and their services are still poorly quantified. The analysis of the overall cost-benefits on short-, mid- and long-term scales are incomplete, even for the North Atlantic Ocean, which has been intensively studied. Consequently, there is a need to develop a framework for more in-depth understanding of marine ecosystems, linking observations, modelling, policy design and implementation.

However, there are fundamental gaps in ocean information delivery to society, limiting the capacity in Europe to sustainably manage the ocean and its resources. These knowledge gaps need to be considered to improve our current knowledge about the ocean. Data plays a key role in addressing knowledge gaps. Improved knowledge is needed, for example, with regard to data on marine biological diversity (especially in the benthic systems), expanded information on fish diversity and its drivers, ecosystem responses in physical and chemical ocean properties, human emissions and socio-economic effects. The impact of the ocean extends well beyond the coastal zone through its role in regulating weather and climate. There is an urgent need to assess human pressures on the ocean, particularly in vulnerable coastal areas. To address those issues, a strong knowledge base and predictive capacities are needed, especially as currently marine data appear fragmented, are inhomogeneous, contain data gaps and are difficult to access. Reliable and timely ocean information is crucial to support evidence-based decisions on the management of the ocean

The information we need to understand the ocean can be divided into four main categories: (a) the morphology of the seafloor; (b) the composition and circulation of ocean water; (c) the biota of the ocean; and (d) the ways in which humans interact with the ocean. An integrated assessment by definition needs to include environmental, social and economic information relevant to human activities and all the components of relevant ecosystems, with input and information from a variety of geographic locations.

The value chain of the ocean consists of four components. First, informed decisions have to be made about the kind, granularity and latency of information needed (input). Second, instruments have to be deployed to make observations (process). Third, data and information products have to be delivered. Fourth, the delivery of services to users has to be assessed (impact). This value chain provides a crucial framework for the sustainable development of the Blue Economy.

The harmonisation and integration of existing and new ocean knowledge will increase the availability of credible scientific evidence to inform industry and help reduce the impact of human activities on the ocean.



Value Chain of Ocean Information

Policy Challenges in Addressing Ocean Observation

There is an equally urgent need to better connect ocean observations to users in governments, communities and industry. They need this information as the base for sound decisions and policies. Sustainable management of the ocean requires an ocean observing system, that delivers fit-for-purpose information and serves governments, societies, the sustainable Blue Economy and citizens. This enables a better assessment of the state of the ocean and better forecasts. Both is crucial for supporting sustained management of the ocean, including exploration, exploitation and protection of the marine environment. Currently, a major fraction of the ocean observing efforts are uncoordinated and funded through short-term science funding, making the observing system fragile and entails uncertain delivery for users and uncertain conditions for implementers.

For the European Union to be able to obtain optimal results for its Common Fisheries Policy, the Blue Economy and the combat of anthropogenic climate change – to name a few – it is of the utmost importance that scientists have access to the exclusive economic zones of European states even if they are not nationals of these states or their research vessels are not registered in these states. Research programmes become increasingly transboundary, something the European Union encourages with its own research funding. Many novel research instruments are technologically very different from the research vessels for which the current rules for the conduct of marine scientific research were written. Such instruments and platforms cannot simply stop at human-made borders in the ocean, since they, for example, go with the currents. The unique organisation of the European Union makes it an ideal set-up for actively diminishing cumbersome rules of access to European waters, something that hampers achieving the best-possible results for not only the Marine Strategy Framework Directive but virtually all European policies relating to the ocean and beyond.

The economic and societal benefits underpinned by ocean observations, measurements and forecasts are large and the cost of obtaining and using ocean observations is almost certainly only a small percentage of the value of the benefits derived. Blue Economy must include social benefits and equity to achieve sustainable development goals. The issue of equitable benefit sharing should be given, at least the same amount of attention as environmental and economic concerns. Policies should take this into account, by including human rights, access to resources, and ensuring an equitable share of benefits and costs.

Recommendations

1. Create a European Policy Framework for Scientific Ocean Observations Long-term Funding

There is a **need to better coordinate and support ocean observing and ocean information delivery efforts across Europe**. As an example, ocean circulation is a dominant controller of the locations and abundances of important marine ecosystem resources. This has a considerable impact on the economy and relations between countries across the Atlantic basin. Climate models do not capture the full range of this variability, **so continued observations and improved biological understanding are both needed to assess oceanographic change and its ecological implications** (general ocean warming, ocean acidification and deoxygenation). **This needs to be seen as research infrastructure, which requires more sustainable and adequate funding to support a growing blue economy through monitoring efforts**.

The usage of research funding so far to sustain ocean observing systems has been creating renewal uncertainty and limiting resources for new research activities and further innovation. Research funding is more volatile and not likely to be able to sustain an observing system over decades. In fact, there are parts of the sustained observing network in decline due to reduced science funding.

The current initiative of the European Commission on ocean observations is a good start to **unify the policies in different member states of the European Union concerning marine scientific research**. By handling access to observations in member states' exclusive economic zones in a unified manner, a more workable situation for the conduct of marine scientific research and ocean observations will be achieved. Ideally, the outcome of the current initiative would be **a framework directive on ocean observations** to unify data-sharing and co-operation between member states. Any guidelines, standards, policies or code of conduct that aims at the same goals would also improve the current situation of different bureaucracies.

2. Support the Professionalisation of the Next Generation of 'Blue Staff'

European **coasts, seas and overall marine sector** have the potential to deliver sustainable growth and jobs in the coming years and **contribute towards the Green Deal objectives.** However, this will only be possible if we invest in new, Blue Skills and career development. A European approach to capacity building in operating marine infrastructures and associated equipment will lead to closer cooperation. This allows for optimal and similar practices across Europe, thus, strengthening the EU's marine infrastructure capabilities. This workforce will be increasingly engaged with more complex equipment and data standards, often in difficult environments, such as in the deep sea and polar regions.

A competitive, resilient and socially fair Blue Economy needs highly qualified and skilled professionals. Yet today, many Blue Economy sectors have difficulties finding the right people, which hampers their growth.

The **Blue Digital Transformation** requires new skills and competencies, educational programs and knowledge**, which will increase employability in the marine sector, both in academia and industry sectors, while the sector better exploits the value of the ocean in a sustainable way.** Policy institutions need to provide support in creating a correct and positive perception of the industry to give the academic institutions the incentive to create programmes for the Blue Economy.

The next generation of "Blue Staff" can be promoted through the targeted training of early stage researchers. Hereby, the EU could increase the participation of less equipped countries, attract more women to science, encourage young people **to consider science careers,** spread good scientific practices, **facilitate exchange of personnel and attract new users to using infrastructures.**

3. Transform Data into Knowledge by Investing in IT Observations

Digital data deluge, cross-disciplinary and multi-modal scientific investigations along with tremendous available computing power will boost science discovery in the Blue Sector. However, it is crucial to develop emerging technologies that study and analyse the ocean in greater detail, to better protect and restore them. Some of the necessary **technologies to assess the deep ocean environment and its ecosystems**, namely to reduce discrepancies between the baseline knowledge of different areas from the same ocean (e.g. North and South Atlantic), are indicated below:

- Advance the integration of modular marine low-cost sensors to existing Earth Observation Systems;
- Promote Internet of Things technologies to collect high quality real time data on multiple parameters, to build digital replicas of the ocean and its processes;
- Exploit existing Artificial Intelligence (AI) analytics and Machine Learning (ML) tools, in combination to thematic or sectorial models, to transform data into knowledge. This facilitates harmonizing databases, algorithms co-creation and interdisciplinary approaches;
- Promote European High Performance Computing emphasizing on cloud data storage to enhance accessibility, Small and Medium Enterprises (SMEs) usability, science-driven decision making, citizen-engagement and transparency in policymaking and implementation.

Thanks to the combination of different technologies, which collect different kinds of data (e.g. microbiome, plastics, ocean circulation), **it will be possible to fill in different gaps in knowledge and understanding of the Blue Sector dynamics** in terms of ecology, biodiversity, sensitivity to climate change and the potential for sustainable exploitation of ocean resources. It is crucial that data is not only collected but also delivered and integrated in a consistent way.

4. Define Global Standards and Interoperability Practices

It is necessary to promote the broad agreement and commitment to adopt a number of standards and best practices related to process in the ocean observing value chain, including ocean observations, ocean data management and ocean data exchange. **T**he oceanographic community is already **developing data interoperability but a more formalised standard framework is required**. Widespread use of standards and interoperability of collected data in the domain of ocean science and technology will **increase data quality levels and ensure more efficient and sustainable use of ocean data and information**. Such standards should ensure that products and services are **comparable in their functional scope** and that they had been qualified in a similar manner. Similarly, there is a need to promote the use of best practices in ocean research, operations and observations to increase efficiency and interoperability.

There are already some good regional examples, namely EMODnet, where community best practices and standards for marine data and metadata are already applied. An example in the context of international standards and efforts is IODE. These, together with other examples from across the Atlantic Ocean basin, can be used as best practices and inspiration for other regions to join the momentum towards a fully interoperable All Atlantic Ocean Data space. To achieve this, **a change in culture is the only way to propagate the use of standards and best practices**. Guidelines for the implementation of global standards and best practices already exist as key components of the FAIR (Findable, Accessible, Interoperable and Reusable) approach towards data management. This goes far beyond data archiving into repositories.

A systemic approach towards interoperability and shared (cross-disciplinary) metadata policy is needed: It should not matter where you submit your data to be able to harvest and multiply its impact globally while keeping provenance tracked. Legal interoperability is part of this.

5. Strengthening Citizen Science for Policy, Equitable Access, Democratization and Critical Data Contributions

Citizen participation in decision-making should be considered as a way to make the policy process more transparent and accessible. By actively supporting **citizen science initiatives, policymakers are able to open up and democratise marine observation science, thus, co-creating a new type of self-driven, sustainable and cost-efficient observatory concept.** This will not only foster scientific education but also appeal to a citizen's natural willingness to contribute to society and offer channels to have their voices heard. Additionally, robust citizen science project data can be a critical element within scientific research and as such have substantial impact on various policies and programmes.

Trust and reciprocity are key to ensuring citizen involvement in science. Mechanisms to provide feedback to citizens need to be put in place to showcase the impact made by their contribution and to further stimulate their engagement. Citizens must also be equipped with easy-to-use systems to upload and download data and encouraged to use cheap sensors to move from pure visual observations to sensor-based ones.

It is recommended that **policy makers should join efforts to create a new generation of evidence-based national, European and transcontinental (All Atlantic) public policies**, given the data originated from the assessment and forecasting of environmental and socio-economic impacts of the interaction between ocean circulation, microbiomes and plastics. It is up to these policies to have an anticipatory and preventive content. This is the only way to predict future impacts and mitigate potential risks, either in the marine environment or in the socioeconomic context of people who depend on the sea for the development of their economic activities.

Project Group

The projects that contributed to this document are indicated below.

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