EuroGOOS
European Global Ocean Observing System

European operational oceanography:

Delivering services for Blue Growth and ecosystem-based management

EuroGOOS Policy Brief

www.eurogoos.eu

EXECUTIVE SUMMARY

Ocean observing brings various economic and societal benefits. It underpins significant decision and policy making in the marine domain, from weather forecasts, to maritime activities, search and rescue operations, and climate modelling. Furthermore, it is also a critical research area, as until now marine ecosystems remain the least explored natural habitat on Earth. Finally, ocean observing gives the prerequisite information for exploring new ocean technologies for biotechnology, renewable energy or oil, gas and mineral exploitation in the deep sea.

Many economic decisions and the implementation of European Directives (e.g. MSFD, MSPD, WFD[1]), and policies (CFP, MSS[2], etc.) rely on immediate information about the state of the ocean. This information is based on high-quality real-time or near-real-time marine data delivered for management actions at sea and at the coast. However, the current operational observations in Europe represent a strong discrepancy across disciplines (e.g. physical, biological, chemical), and a lack of data standardization which prevents full interoperability (i.e. data from different sources shared seamlessly). Integration of the existing marine data and achieving full interoperability remain a critical challenge and a prerequisite for the creation of the European Digital Single Market[3].

In this paper, EuroGOOS puts forward four critical priority areas for the European oceanography in the coming years. These areas will require not only increased integration and cooperation within the community, but also financial support to coordinate those activities. Addressing these priority areas will support the European advancement in oceanography and derived products and services, and significantly strengthen Europe's contribution to the Global Earth Observations System of Systems (GEOSS) and the Sustainable Development Goals (SDGs).

Operational oceanography needs to build upon existing initiatives at European level. Among others, those initiatives include the Copernicus Marine Environment Monitoring Service (CMEMS), the European Marine Observation and Data Network (EMODnet), Joint Programming Initiative Healthy and Productive Seas and Oceans (JPI Oceans), the European Strategy Forum on Research Infrastructures (ESFRI), as well as strategic research projects such as AtlantOS, JERICO-NEXT, AORA and others. Cognisance of major European capacities and activities in the satellite remote sensing sphere is also critical e.g. Sentinel launches.

[1] Marine Strategy Framework Directive, Marine Spatial Planning Directive, Water Framework Directive
[2] Common Fisheries Policy, Maritime Security Strategy
[3] European Digital Single Market Strategy (May 2015), https://ec.europa.eu/digital-single-market/

Today, ocean observing has an unprecedented potential to help meet societal challenges.

Urgent action is required from both:

- Policy – in recognizing this potential and supporting actions for sustained ocean observing and technology development, and
- Ocean community – in ensuring synergy and collaboration to strengthen the individual states and regional efforts for the common (global) benefit.

KEY SHORT-TERM PRIORITIES FOR THE EUROPEAN OCEANOGRAPHY INCLUDE:

- **Operational ecology service for ecosystem-based management** including a strong network for biogeochemical observations, advanced basic research to fill the gaps in understanding ocean and ecosystems variability, and integration of existing and new knowledge into ecological models capable of informing management decisions.

- **Coastal oceanography integration** ensuring the uptake of all available observation and data products, advanced knowledge of the coastal ocean and fresh water inputs, and strong cooperation between public and private companies in expanding coastal oceanography services and making full use of digital technologies.

- **Improved modelling and forecasting** capable of integrating a broad number of parameters as well as resolving the estuary-coast-ocean continuum, advancing accuracy and uncertainty estimation, and harmonizing a European framework allowing production of tailor-made products for diverse users tied to the uptake of the CMEMS.

- **European Ocean Observing System (EOOS)** providing a focal point and a framework for European research and operational oceanography through cooperation and engagement across all users of ocean data and information, joined by a shared vision driving Europe's leadership in ocean observing and technology.

The port of Hamburg, a living example of multi-sectoral economic activities contributing to blue growth

INTRODUCTION

European and global policy and decision-makers have realized that oceanographic services underpin a wide range of maritime activities and provide an important source of economic prosperity stimulating technology development, innovation and job creation. Economic growth areas requiring oceanographic services include exploitation of marine energy and bio-resources, maritime transport, coastal and offshore engineering and deep-sea exploration among others. Current policy and economic pressures must be addressed by oceanographic community to deliver services satisfying growing user needs, while preserving the marine environmental health.

The implementation of a number of European and global directives and policies (e.g. MSFD, MSPD, WFD, CFP, Agenda 2030, international ocean governance) rely on the ocean observing information and data. In addition, the economic value of the ocean puts a strong emphasis on ocean observing to deliver products and services for various socio-economic sectors contributing to Blue Growth (European Union's strategy for sustainable economic growth in the marine and maritime sectors)[4]. Most of those products and services rely on continuous collection, processing, assimilation and integration of ocean data of a high quality. Operational oceanography is the area of marine sciences which develops tools, routines and services to achieve this.

In past decades, European states have been developing state-of-the-art ocean observing and operational capacities. These efforts have been further strengthened by European and regional projects. The EuroGOOS Regional Operational Oceanographic Systems (ROOS) have played an active role in enhancing collaboration in data exchange, standardization and harmonization, stimulating joint activities. However, integration of the existing data and achieving full interoperability remains a critical challenge. The promotion of open data is an ongoing effort at both community and policy levels.

This paper highlights three specific areas requiring more development and integration as well as funding support to coordinate activities in: (i) Operational ecology; (ii) Coastal oceanography; and (iii) Modelling and forecasting. The fourth area featured in this paper is an overarching framework driven by the research and operational community, to build an end-to-end integrated ocean observing system for Europe. The European Ocean Observing System (EOOS) will help define the landscape of the current European ocean observing capacity and reinforce synergy to fill the existing gaps. The EOOS process will encompass the three priorities mentioned here.

[4] http://ec.europa.eu/maritimeaffairs/policy/blue_growth/index_en.htm

International policy landscape: How can ocean observing make a difference?

Ocean observing is required to provide high-quality information supporting operations and applications in the Societal Benefit Areas defined by the Group on Earth Observations (GEO) for building a Global Earth Observation System of Systems (GEOSS). Furthermore, the GEOSS Societal Benefit Areas process will contribute to achieve the UN's Sustainable Development Goals – the internationally adopted objectives of the UN Agenda 2030.

Most of the Sustainable Development Goals (SDGs) and all of the GEOSS Societal Benefit Areas require oceanographic services and products to reach their objectives. SDG 14[5] is particularly designed to help conserve and sustainably use the oceans, seas and marine resources.

Today, ocean observing has an unprecedented potential to help meet those societal challenges. Urgent action is required from both:

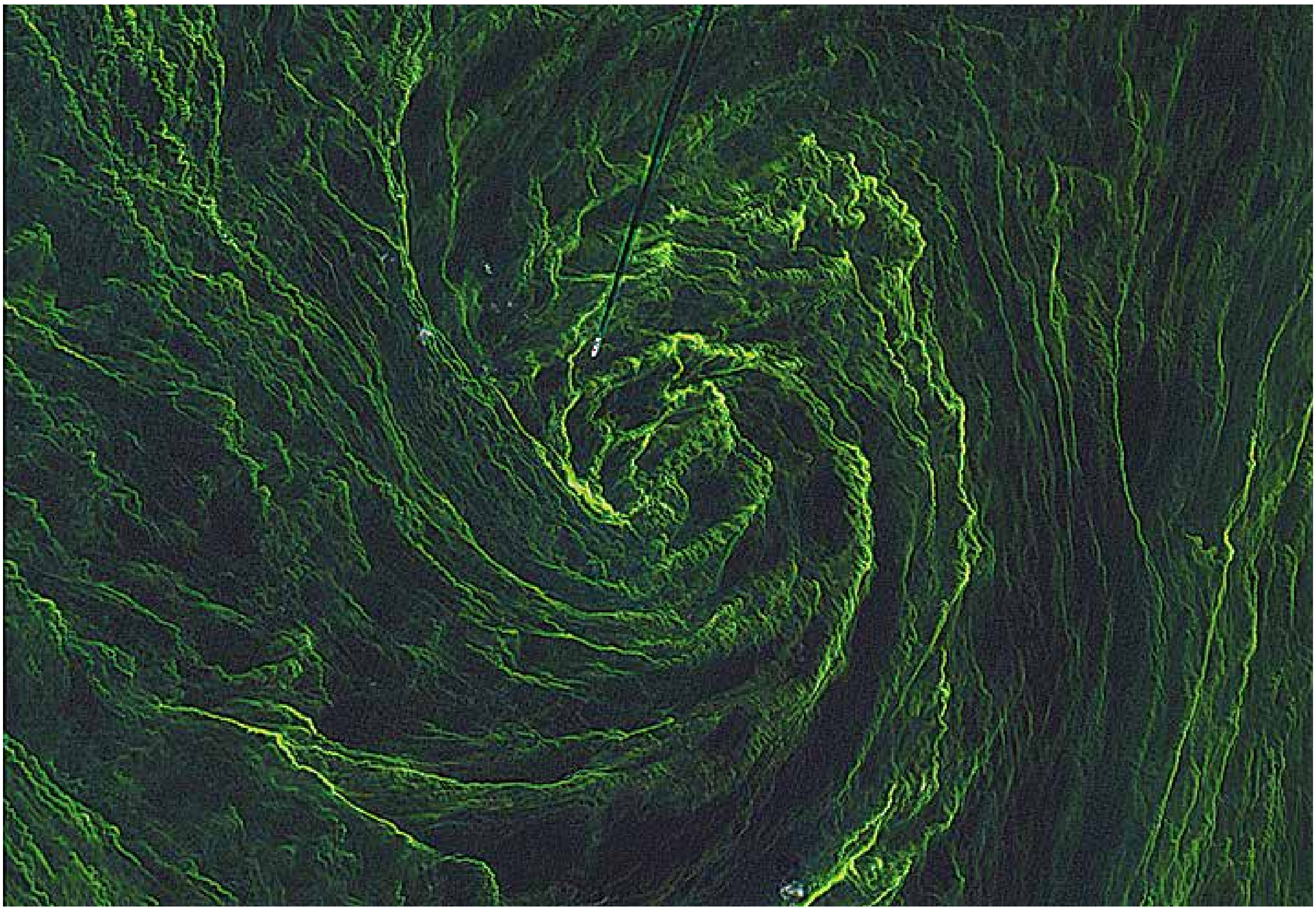
- Policy – in recognizing this potential and supporting actions for sustained ocean observing and technology development, and
- Ocean community – in ensuring synergy and collaboration to strengthen the individual states and regional efforts for the common (global) benefit.

Group on Earth Observations (GEO) Societal Benefit Areas are the environmental fields around which the Global Earth Observation System of Systems is being developed, for the benefit of the world's society and economy.

The Agenda 2030 is a global framework to help eradicate poverty and achieve sustainable development by 2030. It includes 17 Sustainable Development Goals adopted by the United Nations in September 2015.

[5] http://www.un.org/sustainabledevelopment/oceans/

Tagged marine mammals collect data on ocean-atmosphere and physical environment, as well as the ecosystem functioning and dynamics, critical for ecosystem-based management. © C. Guinet (CEBC/CNRS, France)



Algal bloom and a ship in the Baltic Sea captured by Sentinel-2A in August 2015. Large blooms pose serious problems to the ecosystem, aquaculture and tourism. © Copernicus Sentinel data (2015)/ESA

1. OPERATIONAL ECOLOGY SERVICE FOR ECOSYSTEM-BASED MANAGEMENT

Implementation of EU regulations (e.g. Marine Strategy Framework Directive [MSFD], Water Framework Directive, and Common Fisheries Policy) as well as regional conventions, relies on punctual and regular ocean measurements and often rapid provision of data and information. Operational ecology is a branch of oceanography delivering such observations and derived data for operational ecology services (e.g. environmental monitoring, forecast, and scenario projections). These operational ecology services provide information on the status of marine ecosystems and make policy and sustainable management actions possible and efficient.

Operational ecology data products are generated from a combination of remote sensing (satellites), seaborne (in-situ) measurements and models on various time and space scales, from long-term observations (time series), to most recent observations (near-real-time data). Such operational ecology products give us information on the past state of the environment, its current state and allow future predictions (short-term, seasonal, decadal and scenario-based). Derived from these data products is information on the Good Environmental Status (GES) criteria and indicators as well as reports on the marine ecosystem status.

No quality-assured ecological service exists in Europe today, capable of providing daily, weekly, seasonal, annual and decadal forecasting, reanalysis and scenario projections. Pan-European and regional biogeochemical observations and monitoring are essential for ecosystem assessment and monitoring under MSFD. Such collaboration should be based on a data framework and open data sharing among the existing data providers. Furthermore, some new technologies and capabilities have to be further developed.

The gaps in the knowledge, monitoring networks and product quality are interdependent, and are based on the observations. A quality-assured European operational ecology service is needed to fill those gaps and develop modelling and forecasting capacity. Such an operational ecology service will bring together some cutting-edge monitoring infrastructures and traditional ones. Advanced biogeochemical data assimilation techniques are essential for both monitoring programs and modelling.

Ecosystem-based management relies on operational ecology products by providing information on:

- Present state of the ecosystem;
- Ecosystem forecast, e.g. at daily, weekly, seasonal and decadal scales;
- Reliable what/if scenario simulations, e.g. plankton and fish levels;
- Predictions of biohazards, e.g. harmful algal blooms and hypoxia (low oxygen conditions);
- Predictions of future trends, e.g. fluctuation and regime shifts in the marine ecosystem.

IT IS CRITICAL FOR EUROPEAN OPERATIONAL ECOLOGY SERVICE TO:

- Enhance the observing network for biogeochemical parameters in all European regional sea basins;
- Advance basic research to fill gaps in understanding and modelling biogeochemical cycles at regional and local levels, including interactions between low and high trophic levels and benthic ecosystems;
- Integrate the existing and improved knowledge into ecological models.

Coastal ocean laboratories, recovering and processing coastal ocean observation data in real time, are key elements to advance science-based coastal management. © Rijkswaterstaat

High Frequency radars collect real-time data on surface currents and waves © ICTS SOCIB

2. ADVANCING COASTAL OCEANOGRAPHY INTEGRATION

The EU's maritime regions are home to almost half its population and account for almost half its GDP[6]. Therefore, coastal ocean observations and data are of paramount importance for both Blue Growth and environmental monitoring. The growing demand for risk and adaptive management calls for a significant expansion of European coastal oceanography to inform decisions on water pollution, hazards, coastal erosion, and maritime safety among others. However, the current fragmentation of the coastal observing systems and operational services together with inherent limitations of satellite-based remote sensing observations in coastal regions are barriers to this expansion.

Moreover, the use of coastal waters will significantly increase with the widespread use of mobile technology. Cellular networks are now covering very large areas of coastlines, islands and ocean infrastructures, allowing a growing amount of human activities in coastal waters. The coastal ocean is becoming an important part in the European Digital Single Market[7] requiring seamless data and information products available for different users.

The Digital Single Market will provide enabling technologies to develop oceanographic services to coastal infrastructures operators, managers, and the public. A strong cooperation with the private sector and open data and open source software will bring oceanographic products and services to the users.

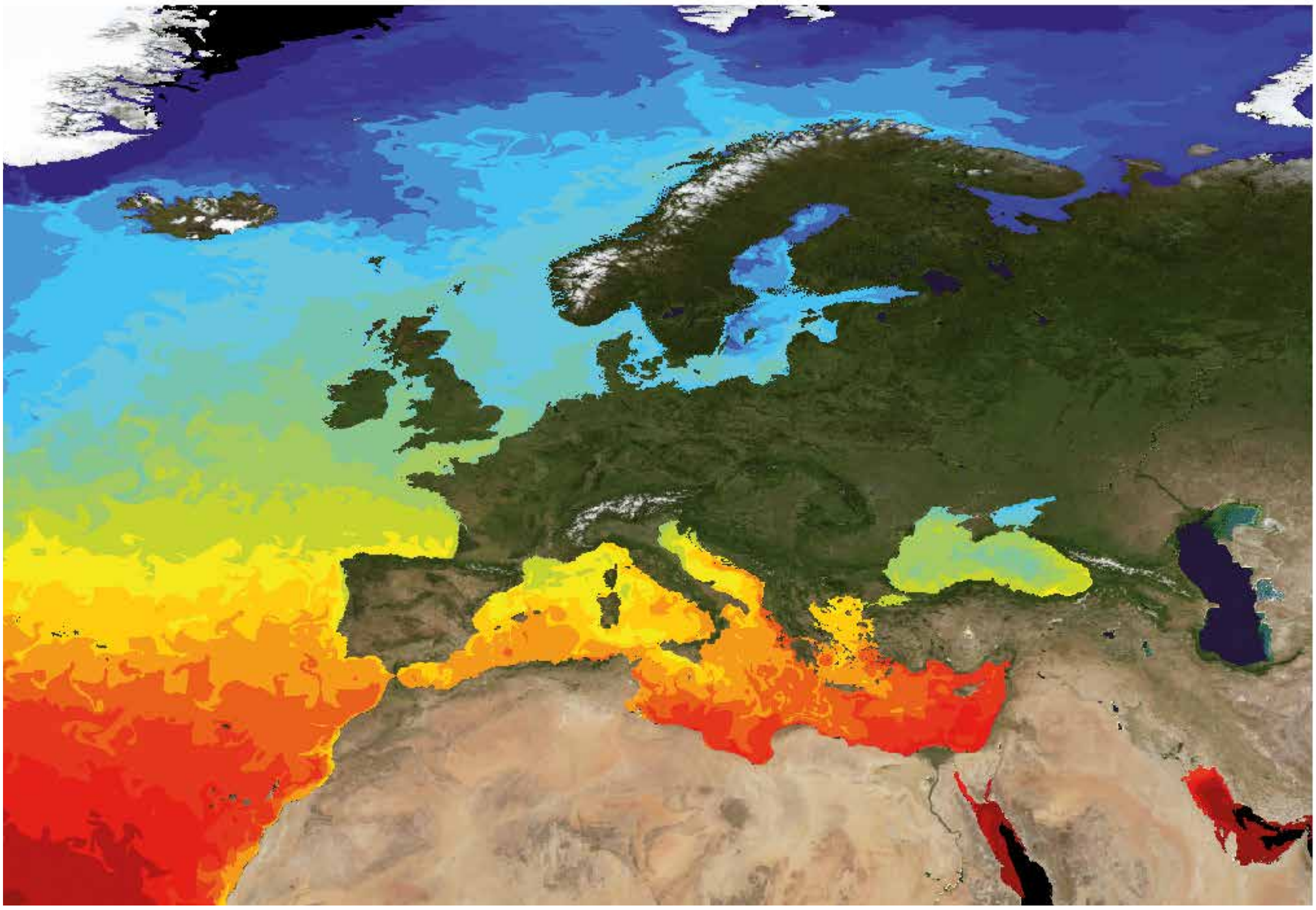
The use of coastal waters will significantly increase with the widespread use of mobile technology.

Integration of the existing marine data and achieving full interoperability is a prerequisite for the creation of the European Digital Single Market.

IT IS CRITICAL FOR EUROPEAN COASTAL OCEANOGRAPHY TO:

- Include new observation variables and data products of higher spatial resolution and quality, delivering information on various time scales;
- Integrate monitoring capacities, underpinned by enhanced internet connectivity and a combination of conventional and low-cost sensors;
- Advance knowledge of coastal processes and the fresh water inputs to the coastal seas, as well as improved data assimilation techniques and high-resolution meteorological data and information;
- Strengthen cooperation between public and private companies as the private sector is a major player in coastal ocean services, a role that will continue to grow with the development of digital technologies.

[6] http://ec.europa.eu/maritimeaffairs/documentation/facts_and_figures/index_en.htm
[7] The European Commission Digital Single Market Strategy (May 2015) https://ec.europa.eu/digital-single-market



Oceanographers make extensive use of satellite images of the ocean in assessing and predicting ocean state. Sea-surface temperature forecast is used for a variety of applications, among others, fisheries, ocean climate, and ocean health. © EU Copernicus Marine Service

3. MODELLING AND FORECASTING

Ocean state and variability are predicted through a combination of ocean observations and ocean modelling. Furthermore, modelling helps scientists and maritime managers make ocean predictions in the areas which cannot be reached with in-situ observations. The accuracy of ocean predictions relies on the quality of the modelling (e.g. numerics, spatial resolution, parameterization of ocean processes) and the observation data, as well as the processing and assimilation of the observations data into the models.

Modelling serves both operational use (e.g. forecasts of ocean currents, sea ice, and harmful algal blooms [HAB]), and long-term projections (e.g. climate change and regime shifts). Running of models often requires large super-computers. Optimization of their use can not only improve the forecasts, but also significantly reduce the time and cost of modelling activities. The numerical outputs of the models need to be interpreted with user-friendly tools and applications producing tailored model products (e.g. HAB forecasts, oil spill/ pollution maps, tourism and leisure applications).

Open source modelling software holds a strong innovation potential, attracting various kinds of users in the international market.

Improved modelling and forecasting capability will:

- Integrate a broad number of parameters;
- Advance accuracy and uncertainty estimation; and
- Allow production of tailor-made products for diverse users.

IT IS CRITICAL FOR EUROPEAN OCEAN MODELLING AND FORECASTING TO:

Improve the models by:

- Integrating a broad number of parameters (e.g. sediments, pollutant drifts, ice, higher trophic levels, etc.) and inclusion of the estuary-coast-ocean continuum;
- Enhancing time and space resolution of the models;
- Advancing the model accuracy, uncertainty estimation and overall quality of the forecast;
- Gaining access to high-quality boundary and forcing data for models including high resolution bathymetry, meteorological forcing and fresh water inputs;
- Developing flexible tools to use common models for new applications.

Ensure the user uptake by:

- Assessing the barriers to uptake of modelling products e.g. model resolution, data format;
- Harmonizing the interface between Member States generating specific user products and services, and the Copernicus Marine Environment Monitoring Service;
- Deliver a common framework capable of providing seamless services at various geographical scales (e.g. local, regional, and pan-European).

EOOS European Ocean Observing System

ALIGNING, INTEGRATING AND PROMOTING EUROPE'S OCEAN OBSERVING CAPACITY

The ocean observing in Europe is done by a multitude of actors at national, regional and pan-European levels. The EOOS process will require openness and collaboration among the ocean observing community to help build a common strategic vision and a framework for Europe.

4. EOOS – EUROPEAN OCEAN OBSERVING SYSTEM

The development of the European Ocean Observing System (EOOS) aims to sustain and enhance European ocean observation and monitoring capacity (remote sensing, in-situ observations, and modelling). Ocean observing is gaining momentum as a critical research and innovation domain underpinning the implementation of a number of European and global policies (e.g. MSFD, WFD, MSPD, CFP, Agenda 2030, international ocean governance). An end-to-end integrated EOOS is needed for Europe to derive maximum value from marine knowledge and information and respond to pressing societal needs. Furthermore, EOOS will play a critical role in Europe's contribution to the global Group on Earth Observations System of Systems (GEOSS).

The European ocean observing community initiated the EOOS process by prioritizing its development in the context of the EU Integrated Maritime Policy (2007). A number of science-policy reports and strategies have included EOOS as a priority area. Since 2014, EOOS development has gained pace after the chairs of both EuroGOOS and European Marine Board called for an urgent action to make EOOS a reality at the EurOCEAN 2014 science-policy conference.

The EurOCEAN 2010 Ostend Declaration placed EOOS as one of three priorities for 2020. The Declaration outlined the EOOS objectives to:

- Re-establish Europe's global leading role in marine science and technology;
- Respond to societal needs by supporting major policy initiatives such as the Integrated Maritime Policy and the Marine Strategy Framework Directive; and
- Support European contributions to global observing systems. This could be achieved through better coordination of national capabilities with appropriate new investments, in coordination with relevant initiatives (e.g. ESFRI, EMODnet, GMES [now Copernicus]) and the engagement of end-users.

IT IS CRITICAL FOR THE EUROPEAN OCEAN OBSERVING SYSTEM (EOOS) TO:

- Provide an overarching strategic framework for European ocean observing encompassing both research and operational oceanography;
- Cooperate with the ongoing European and regional projects and initiatives , e.g. CMEMS, EMODnet, ESFRI, AtlantOS, JERICO-NEXT, AORA, SeaDataNet, Sentinel and other space assets, designed to address ocean observing integration at various geographical scales and for different requirements;
- Form a transparent governance structure and a roadmap to advance the EOOS objectives ensuring the support and involvement of the large variety of users of ocean knowledge and information, spanning science, policy and society;
- Develop a communication strategy helping build EOOS as an open forum and focal point for European ocean observing research and technology.

EuroGOOS, **European Global Ocean Observing System**, is an international non-profit association of governmental agencies, research organisations, and private companies, established in 1994 within the context of the UNESCO Intergovernmental Oceanographic Commission's Global Ocean Observing System (GOOS). Today, EuroGOOS has 40 members from 19 European countries providing operational oceanographic services and carrying out marine research.

The EuroGOOS Regional Operational Oceanographic Systems (ROOS) deliver analysis and forecasts of Europe's regional seas and feed quality-assured data to pan-European data portals. EuroGOOS working groups and networks of marine observing platforms (Task Teams) enhance synergy and deliver strategies, priorities and standards, towards an integrated European Ocean Observing System (EOOS).

Working hand in hand with partners in the European ocean research and observation community, EuroGOOS is promoting the integration of scientific knowledge and innovation for different users spanning science, policy, industry and society. Within the activities of its Science Advisory Working Group EuroGOOS has prepared this policy brief to highlight some key challenges and priorities for European oceanography in the coming years.

www.eurogoos.eu

This policy brief is broadly based on the publication by the EuroGOOS Science Advisory Working Group released in the EuroGOOS Special Issue in the Ocean Sciences Journal of the European Geosciences Union:
She, J., Allen, I., Buch, E., Crise, A., Johannessen, J. A., Le Traon, P. Y., Lips, U., Nolan, G., Pinardi, N., Reißmann, J. H., Siddorn, J., Stanev, E., and Wehde, H.: Developing European operational oceanography for Blue Growth, climate change adaptation and mitigation and ecosystem-based management, Ocean Sci. Discuss., doi:10.5194/os-2015-103, in review, 2016

This policy brief was prepared by:
Jun She, Chair of the EuroGOOS Strategic Advisory Working Group, and
Dina Eparkhina and Glenn Nolan, EuroGOOS Office

Reviewed by EuroGOOS Executive Board

Photography:
Front cover image courtesy of Jens Jakobsen, DMI

To be quoted as follows:
European operational oceanography: Delivering services for Blue Growth and ecosystem-based management. EuroGOOS Policy Brief. 2016. She, J., Eparkhina D., Nolan G. (Eds.). Brussels. Belgium.

This publication is available free of charge on EuroGOOS website: http://eurogoos.eu/publications/

EuroGOOS AISBL

231 Avenue Louise, 1050 Brussels, Belgium
Tel.: +32 2 238 37 90
Email: eurogoos@eurogoos.eu
www.twitter.com/EuroGOOS
www.eurogoos.eu