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Deliverable title	Strategic foresight paper on AtlantOS in the European context
Description	This paper looks at the marine science-policy landscape and brings together different policy discussions aimed at the development of a European Ocean Observing System, in the context of AtlantOS and how this relates to wider Atlantic and global policy drivers and existing and emerging wider ocean observation coordination. It has a European focus, looking at proposed mechanisms and components for ocean coordination and governance and the potential contribution of existing organizations and initiatives. The report serves as a reference document for, and contribution to, the European Strategy on Atlantic Ocean Observing and international BluePrint for an integrated Atlantic Ocean Observing System.
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Comments	The final delivery and review of this report (D10.11) was postponed until 31 August 2018 on agreement with the AtlantOS Coordination Office to allow for more input by the AtlantOS partnership. In addition, it enabled more alignment with the European Strategy for Atlantic Ocean Observing which has evolved as a related output to Task 10.6, but is wider looking at the European contribution across all aspects of the future Atlantic Ocean Observing System. EMB was a co-organizer for a foresight workshop on 4-5 June 2018 in Brussels and EMB is a co-author in the resulting Strategy document (<i>in prep</i>), which serves as the European contribution to the BluePrint on Atlantic Ocean Observing. This workshop and subsequent interactions with AtlantOS and wider stakeholders provided important input on future governance and coordination components to D10.11. The slight delay in report delivery also enabled better alignment with the latest <i>draft</i> BluePrint for Atlantic Ocean Observing Vision document and Implementation Plan (<i>in prep</i>), and the developing European Strategy for Atlantic Ocean Observing (<i>in prep</i>).

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Stakeholder engagement relating to this task*

WHO are your most important stakeholders?	X Private company If yes, is it an SME ☐ or a large company ☐? The report could be relevant to both scales of industry X ☐ National governmental body X International organization ☐ NGO X others Please give the name(s) of the stakeholder(s): • Funding agencies at National, Regional e.g. European and International levels. • International and European organizations involved in ocean observation strategy e.g. IOC, UNESCO, the GOOS initiative and GOOS Global Regional Alliances. • Implementers, including coordinators of existing and emerging ocean observation networks and systems in the Atlantic Ocean. This could include the public and private sectors.
WHERE is/are the company(ies) or organization(s) from?	X Your own country X Another country in the EU X Another country outside the EU Please name the country(ies): International (particularly those bordering the Atlantic Ocean), European nations (not exclusively the European Union) and those with leadership roles in ocean observation, particularly in coordination and governance of ocean and ocean observation activities.
Is this deliverable a success story? If yes, why? If not, why?	X Yes The report provides an overview of the marine-science policy interface that largely drives and influences ocean observation at global, Atlantic Ocean and European levels. It provides concrete examples of ongoing initiatives e.g. EOOS, organizations e.g. GOOS, initiatives e.g. AORA and wider stakeholders active in the Atlantic e.g. ICES, OSPAR, that could be built upon, closer aligned, and form new partnerships to realize the future implementation of the BluePrint for Atlantic Ocean Observing, including its coordination and governance. The report is also a contribution to the related process of developing the European Strategy for Atlantic Ocean Observing and the foresight workshop in June 2018 has enabled wider input from AtlantOS community that can be taken forward in the European Strategy.
Will this deliverable be used?	X Yes ☐ No

If yes, who will use it? If not, why will it not be used?	It is intended that this report will serve as a reference for, and contribute to a number of ongoing and emerging initiatives in ocean observation coordination and governance in the Atlantic Ocean (including AtlantOS legacy), but also Europe and beyond. These include: - BluePrint for an integrated Atlantic Ocean Observing System (<i>in prep</i>) - European Strategy for Atlantic Ocean Observing (as a basin-scale contribution to EOOS and as a European contribution to the BluePrint (<i>in prep</i>) (coordinated by AtlantOS partners EuroGOOS, IOC, EMB and GEOMAR); co-authored by EMB); - Contribution of foresight and analysis on ocean observation policy drivers, coordination and governance as input to future developments in the Atlantic Ocean Research Alliance (AORA); - Input to future marine research agendas including European Horizon 2020 project planning 2018-2020 and Horizon Europe (FP9); - OceanObs'19 Community White Papers, including one co-authored by EMB, EuroGOOS and others on stakeholder engagement in ocean observation (MacKenzie <i>et al.</i>) to be published as a special Research Topic in Frontiers journal in 2019; - Future strategies in ocean observing, including the EOOS Strategy and Implementation Plan 2018-2022, the EuroGOOS Strategy (post-2020) and the GOOS 2030 Strategy.
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NOTE: This information is being collected for the following purposes:

1. To make a list of all companies/organizations with which AtlantOS partners have had contact. This is important to demonstrate the extent of industry and public-sector collaboration in the observation community. Please note that we will only publish one aggregated list of companies and not mention specific partnerships.
2. To better report success stories from the AtlantOS community on how observing delivers concrete value to society.

AtlantOS: Optimising and Enhancing the Integrated Atlantic Ocean Observing Systems

Task 10.6, Deliverable 10.11

Strategic foresight paper on AtlantOS in the European context:
Towards strengthened coordination and governance of ocean observing systems

August 2018

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AtlantOS partner interactions and inputs: Jan-Stefan Fritz (KDM; WP10 lead); Anja Reitz and Sandra Ketelhake (GEOMAR, Germany; AtlantOS Project Coordination Office); Neil Holdsworth and Mark Dickey-Collas (ICES); Albert Fischer and Michael Ott (IOC-UNESCO); Pierre-Yves Le Traon (Copernicus Marine Service and Ifremer); Glenn Nolan, Vicente Fernandez, Dina Eparkhina, Erik Buch and George Petihakis (EuroGOOS); Jan-Bart Calewaert and Belén Martín Míguez (Seascope Consultants Ltd, EMODnet); Nadia Pinardi (University of Bologna, Euro-Mediterranean Center on Climate Change (CMCC), Italy), Adrian Martin, Richard Lampitt (NOC, UK), Ann-Katrien Lescrauwet and Hans Pirlet (VLIZ); Isabel Sousa-Pinto (CIIMAR, University of Porto), Sophie Seeyave and Laura Ruffoni (POGO / PML), Sandy Thomalla (CSIR, SAOOC, South Africa).

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EXECUTIVE SUMMARY

The initiation of the Global Ocean Observing System (GOOS) in 1992 was a step change in global ocean observation coordination¹. Over the past 30 years there has been considerable development of ocean observing networks and systems, together with investment to support frameworks and coordination efforts at multiple geographical scales. As a result, the global ocean observation community is better organized than previously. However, in many cases, the ocean observation networks and systems, and stakeholder communities still lack connection. This results in inefficiencies and redundancies together with a lack of sustainability for many systems as a result of a lack of coordination and alignment across nations, systems, networks and stakeholder communities. And yet the societal demand for regular and high quality ocean data, information and products is rising, together with the rise of the ocean on political agendas from G7 to the UN 2030 agenda and the resulting trickle-down impact on regional and national policies. Strengthening coordination and governance is also vital to tackle the geographical scale of marine challenges and finding the synergies/joint costing to do this efficiently as a global community, rather than as individual nations or regions. A new step change in coordination and governance is now required to align and, where relevant, integrate existing initiatives to stream-line existing coordination efforts in ocean observation to optimize knowledge delivery across the ocean observing value chain and maximize the societal benefit, leading to more sustained funding and resource commitments.

The overarching objective of the European H2020 AtlantOS project is to achieve such a transition at a basin-scale in the Atlantic Ocean, from a loosely-coordinated and fragmented set of existing ocean observing activities into a system that is sustainable, efficient, and fit-for-purpose. As a European funded project, AtlantOS also aims to build on existing efforts and further strengthen European leadership in Atlantic Ocean Observing and ensure that European capability and best practice is considered in the future design, coordination and implementation of the Atlantic Ocean Observing System. With these objectives in mind, AtlantOS Task 10.6 is specifically designed to link existing and emerging efforts in European and Atlantic Ocean observing, and contribute to a future European Strategy for Atlantic Ocean observing, drawing from European and wider policy drivers and the latest developments in ocean observation coordination. This report (D10.11) is the first step towards this goal, offering an expert perspective, based on desk study and stakeholder consultation, on how to further connect the European and Atlantic Ocean observing communities. Based on the task description, this report has a focus on coordination frameworks currently in development including the European Ocean Observing System (EOOS), and how AtlantOS can contribute an Atlantic Ocean dimension to EOOS, in the context of the Global Ocean Observing System (GOOS).

The report presents the marine and wider environmental science-policy landscape and how this has shaped (and is shaping) ocean observation. It also looks at current developments in ocean observation coordination and governance, noting the importance of stakeholder engagement and dialogue in the full ocean observing implementation cycle and building on existing organizations and initiatives to assess how a variety of mechanisms could be used in the future governance of an integrated Atlantic Ocean observing system. The report serves as a perspective on ocean observation policy drivers and current coordination and governance developments, to stimulate further discussion within the AtlantOS and wider community. In particular, it serves as input to the developing European Strategy on an Atlantic Ocean Observing System (*in prep.*) and the BluePrint for an integrated Atlantic Ocean Observing System (*in prep.*).

The report is aimed at European and international ocean observation stakeholders both within and beyond the AtlantOS network, in particular those involved in the programming and planning of ocean observing systems but also the wider marine science community. It also aims to inform policy makers of the latest developments in ocean observation coordination and provide input to future planning of research agendas and financing of ocean observation coordination in the Atlantic Ocean and beyond. It is intended that this report can contribute to a number of ongoing and emerging initiatives in ocean observation coordination and governance in the Atlantic Ocean including:

¹ Yves Tourre (Columbia University) keynote at 4th GEO Blue Planet Symposium, July 2-18, Toulouse

- Blueprint for an integrated Atlantic Ocean Observing System (*in prep*);
- European Strategy for Atlantic Ocean Observing (AtlantOS WP9 deliverable as a European contribution to the Blueprint (*in prep*);
- Input to future marine research agendas e.g. European Horizon 2020 and Horizon Europe (FP9);
- OceanObs'19 Community White Papers (*in prep.*) including one co-authored by EMB, EuroGOOS and others on stakeholder engagement in ocean observation (MacKenzie *et al.*);
- Ocean observing Strategies currently in development, including the EOOS Strategy and Implementation Plan 2018-2022, the EuroGOOS Strategy (post-2020) and the GOOS 2030 Strategy.

1 INTRODUCTION

1.1 AtlantOS Task 10.6

AtlantOS Task 10.6 is specifically designed to link existing and emerging efforts in European and Atlantic Ocean observing, drawing from European and wider policy drivers and the latest developments in ocean observation coordination. As a result, this report (D10.11) has a particular focus on ocean observation coordination and governance in the context of European, Atlantic and global science-policy drivers. It presents the marine and wider environmental science-policy landscape and how this has shaped (and is shaping) ocean observation. It also looks at current developments in ocean observation coordination and governance, noting the importance of stakeholder engagement and dialogue in the full ocean observing implementation cycle and building on existing organizations and initiatives to assess how a variety of mechanisms could be used in the future governance of an integrated Atlantic Ocean observing system.

The European Marine Board (EMB) was tasked with leading this report (and Task 10.6) because of its expertise and remit working in the marine science-policy area. EMB is a leading think tank in marine science in Europe, working with experts to produce scientific foresight reports and communications to engage and inform policy makers and wider stakeholders of the state-of-the-art marine scientific knowledge, future advancements and knowledge gaps. These papers can, ultimately, inform marine and wider environmental policy, legislation and research agendas at multiple levels (e.g. Europe and National, in the context of global developments). The development of this report has included interaction with a number of stakeholders within the AtlantOS Consortium and beyond (see Acknowledgements). This has included interactions with ocean observation stakeholders as part of the European Ocean Observing System (EOOS) development process, in EMB's role as co-Chair of the EOOS Steering Group with EuroGOOS, membership of the EOOS events Advisory Committee and co-organizer of the EOOS expert workshop (May 2015), EOOS Forum (8 March 2018) and the EOOS Conference (21-23 November 2018). Other meetings drawn upon were the Ocean Sciences Townhall meeting on ocean observation partnerships and coordination (February 2018), the Copernicus *in situ* coordination workshop in Brussels (April 2018), the 4th GEO Blue Planet Symposium (4-6 July 2018) and a number of interactions with stakeholders by email, telephone and in person to supplement the desk study. As co-organizer and co-author of the European Strategy for Atlantic Ocean Observing workshop on 4-5 June 2018, EMB is working with IOC, EuroGOOS and GEOMAR to identify expert participants, develop the programme and strawman of the European Strategy (*in prep*). Initial highlights of this study (D10.11) were presented and discussed with the 20 Atlantic stakeholders attending the European Strategy workshop. Stakeholder feedback, key messages and recommendations from the workshop, together with interactions stimulated by workshop discussions informed the final development of this report (see Acknowledgements).

1.2 Wider context

In developing a BluePrint for an Atlantic Ocean Observing System, and the coordination and governance aspects, it is important to see how this could fit with existing and emerging policies, legally-binding and voluntary processes and the existing landscape in ocean observation. The ocean is increasingly being recognized at the highest international level, and the value of ocean observing is also rising on political agendas, not least following the G7 Science Ministers meeting in 2015 where the importance of ocean science led to the development of a “Future Seas and Oceans” Working Group initiative, with one priority area on ocean observation and strengthening G7 input to the IOC/UNESCO’s Global Ocean Observing System (GOOS)

UN Agenda 2030 and implementation of the 17 Sustainable Development Goals (SDGs) including, but by no means limited to, SDG 14 “Life Below Water”, will require a systematic and strategic approach to ocean observing, supported by adequate infrastructure and investments but also a coordinated effort by the ocean observation and wider marine research community to provide the knowledge and measuring genuine progress (Biermann *et al.*, 2017). The UN Decade of Ocean Science for Sustainable Development is also a huge opportunity and framework for the marine scientific and ocean observation community to contribute to this. The marine science and wider environmental policy landscape is outlined in section 2 together with the development of ocean observation coordination and governance initiatives.

There are also a number of parallel, yet related, initiatives in ocean observation coordination and governance that have been in development during the time-line of the H2020 AtlantOS project (2015-2019) and have informed the development of this report, including:

AtlantOS-related initiatives:

- AtlantOS project outputs (deliverables²) and the AtlantOS Legacy document (Buch *et al.*, 2018)
- BluePrint for an integrated Atlantic Ocean Observing System³ (Involving AtlantOS and wider stakeholders, *in prep*)
- European Strategy for Atlantic Ocean Observing (AtlantOS WP9 deliverable, *in prep*)

Wider strategies in development 2015-2020 including:

- GOOS 2030 Strategy
- GEOSS e.g. GEO Blue Planet; EuroGEOSS
- EOOS Strategy and Implementation Plan 2018-2022
- EuroGOOS Strategy 2019-2024

Internationally, AtlantOS is a key contributor to a BluePrint for an integrated Atlantic Ocean Observing System (*in prep*) including a vision and implementation plan that will lay out the principles and plans for sustained ocean observations in the North and South Atlantic. All AtlantOS deliverables are relevant to this development, in particular the AtlantOS legacy document (Buch *et al.*, 2018) and the European Strategy on Atlantic Ocean Observing (*in prep*) although the process is much wider, calling upon all interested parties and stakeholders. The final BluePrint will be presented at the upcoming OceanObs’19⁴ conference in September 2019, which includes a specific theme on Ocean Observing System Governance.

In Europe, there has been much progress in the development of the European Ocean Observing System (EOOS)⁵. This is a community-driven regional coordinating framework aimed at aligning, strengthening and integrating Europe’s existing ocean observing capability, thereby adding value and accessing untapped potential in the existing system (see Figure 1 below). This will be achieved by developing a focal point for Europe’s diverse and fragmented ocean observing capability, building on what EuroGOOS already has

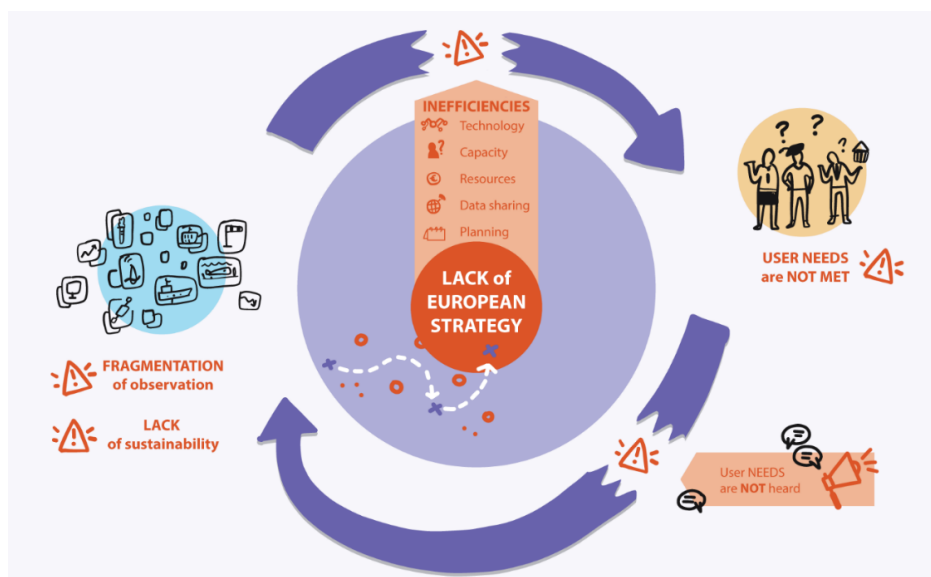
² <https://www.atlantos-h2020.eu/>

³ <http://atlanticblueprint.net/>

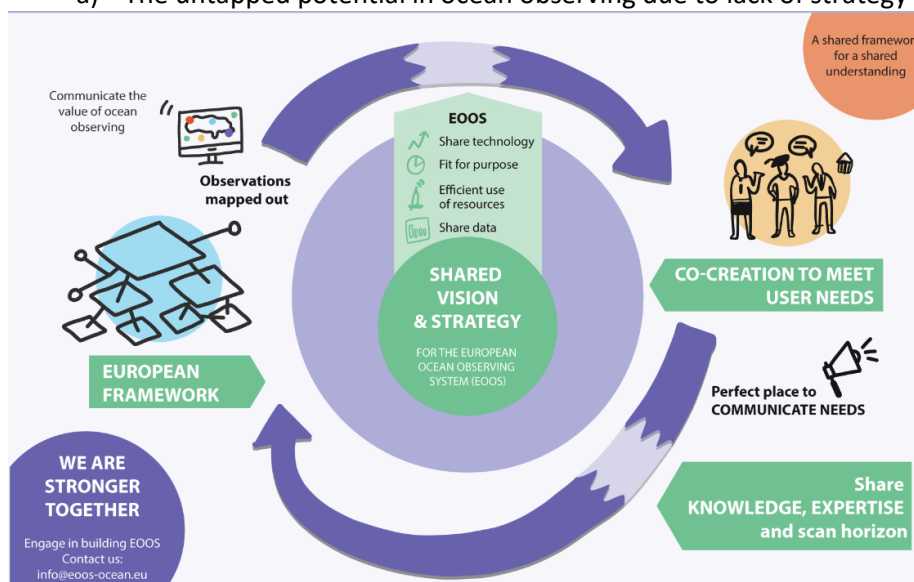
⁴ <http://www.oceanobs19.net/>

⁵ www.eoos-ocean.eu

achieved within the field of operational oceanography, through a common strategy and a living implementation plan for all categories of ocean observations, together with stakeholder consultation and events as a platform to connect disparate groups of stakeholders. This report (D10.11) presents the latest developments towards a European Ocean Observing System as a regional framework to align Europe's existing capacity in ocean observation. It draws from EOOS activities, including stakeholder consultation towards a common EOOS Strategy and Implementation Plan 2018-2022. Related to this, the Global Ocean Observing System (GOOS) which is in the process of drafting its GOOS 2030 Strategy (*in prep*) recognizes the need to diversify ocean observing, strengthening the ocean health component and, particularly, biological ocean observation capability.



a) The untapped potential in ocean observing due to lack of strategy



b) Achieving sustainable ocean observing through a common framework, shared vision and strategy and stakeholder connection, consultation and co-design

Figure 1. The added value of strengthening coordination, vision and strategy in ocean observation. Produced by the European Ocean Observing System (EOOS) Steering Group co-Chairs EuroGOOS and EMB (2018).

This report (D10.11) draws on all of these developments, in addition to wider stakeholder outputs. Specifically, it looks at the BluePrint for Atlantic Ocean Observing Vision and Implementation Plan (*in prep*), to propose potential components for the future coordination and governance of an integrated Atlantic Ocean Observing System. This report also serves as a contribution to the development of a European Strategy for Atlantic Ocean Observing particularly to the sections on policy drivers and ocean observation coordination and governance) (*in prep*) which contributes a European perspective to the international BluePrint for Atlantic Ocean Observing (*in prep*) and informs policy makers, scientists and wider stakeholders of Europe's capability in ocean observation and potential contributions to international efforts in the Atlantic Ocean basin. In turn, this report is intended to serve as a reference and input to the European Strategy and wider BluePrint, particularly in terms of policy drivers, coordination partnerships.

2 THE MARINE SCIENCE-POLICY AND OCEAN OBSERVING LANDSCAPE

2.1 Introduction to the marine science-policy landscape

Section 2 summarizes marine and, where relevant, wider environmental (e.g. climate) science-policy developments at Global, Atlantic and European levels. It also looks at the development and evolution of international, Atlantic and European ocean observation coordination initiatives as a setting for further discussions in sections 3-5 on emerging coordination and governance developments. It is also noted that Section 2 of this report, in particular the European and EOOS components, also serves as a contribution to the EOOS Implementation Plan, specifically pilot action 2.2.2. on the EOOS Policy landscape (EOOS Implementation Plan 2018-2022, *in prep*).

In the past few decades there has been a wealth of policy developments and drivers leading to a very rich, yet complex, marine science-policy landscape. Figure 2 shows a time-line of key science-policy developments (with a focus on marine) and related initiatives in ocean observation coordination from 2007 to 2020. Policies and initiatives are separated by geographical scale and remit, presented in Figure 2 as separate lines for global, Atlantic and European. This allows more information to be presented for specific time-points and allows comparison across geographical scales to see the potential linkages and evolution both in time and across regions. For Europe, an additional line outlines development towards a European Ocean Observing System (EOOS).

The start date of 2007 was chosen since this report is written from the European perspective and 2007 marks the launch of Europe's Integrated Maritime Policy (IMP). The IMP is viewed as a key turning point in Europe, offering a framework for more coherence in marine/maritime policies and after which European marine and ocean observation coordination efforts largely gained momentum (EOOS, 2016). It is noted this date is relatively arbitrary for international developments and there is a much longer history, particularly since the 1980's, in terms of global ocean and wider earth observation initiatives. For this reason, developments in ocean observation preceding 2007 are briefly outlined in the text below but are not the focus of this report. This is because in the last decade alone since the OceanObs 2009 Conference there have been a vast number of relevant policies and ocean observation developments and the decision was made to focus on these as a setting for discussions on future developments post 2020. It is noted that EMB is contributing to a longer time-line on marine and wider environmental science-policy spanning international and European initiatives for the Compendium for Coast and Sea 2018 which will be launched in December 2018 and will be an open access publication with an interactive online time-line application (Flanders Marine Institute, 2018 *in prep*)⁶.

⁶ www.compendiumcoastandsea.be

2.2 International

Historically, the first environmental conventions and legally binding agreements were for climate. In 1992 nations adopted the United Nations Framework Convention on Climate Change (UNFCCC)⁷ and shortly after the Kyoto Protocol (1997)⁸, setting internationally binding emission reduction targets, with a UNFCCC Secretariat as the UN entity tasked to support the global response to the threat of climate change. Internationally, since the 1990s, ocean observation has primarily been coordinated through the **Global Ocean Observing System (GOOS)**, which was formally initiated by the IOC Executive Council in 1992 in cooperation with WMO, UNEP and ICSU (GOOS, 1998). GOOS was set up as a long-term platform for international cooperation for sustained observations of the oceans, generation of oceanographic products and services and interaction between research, operational. GOOS conforms to the methodology of the **Framework for Ocean Observing** (2012), but actions are executed through Global Regional Alliances (GRAs) (see section 3) and wider international collaboration of a diverse collection of scientific experts across the world e.g. working through expert panels. GOOS contributes to the wider Group on Earth Observation (GEO) through the Blue Planet initiative of GEO, developing a Global Earth Observation System of Systems (GEOSS) with its related Data Portal.

The **Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology Observing Programmes (JCOMM OPS) Support Centre**, initiated in 1999, provides technical coordination at the international level for the sustained elements of the Global Ocean Observing System. The Centre monitors, in real-time, the status of the observing networks and provides a toolbox to evaluate their performance and optimize their implementation and data flow.

The **Partnership for Observation of the Global Ocean (POGO)** was also founded in 1999 by directors of oceanographic institutions around the world as a forum to promote and coordinate the observation of the global ocean (POGO Strategy, 2016). Capacity Building and Ocean Literacy in ocean observation are also key components of POGOs ongoing work.

Since the **OceanObs'09 Conference** and its Declaration, there has been stronger impetus on strengthening the capability and coordination of biogeochemical and biological ocean observations. This started just prior to OceanObs'09 with the setting up of **GEO BON** in 2008, followed by a **UN Decade of Biodiversity** (2011-2020) linked to the implementation of the Aichi targets and from which a number of marine observation developments have been started, including the GOOS panel on biology and ecology, the Marine Biodiversity Observation Network (MBON) and the community development of ecology Essential Ocean Variables (eEOVs) and Essential Biodiversity Variables (EBVs).

In terms of wider sustainability policies, the eight Millennium Development Goals⁹, 2000-2015, set out the first international blueprint on societal well-being and development, agreed to by all the world's countries and all the world's leading development institutions. These were followed with the UN 2030 agenda and 17 SDGs adopted in 2015¹⁰. The **UN 2030 Agenda for Sustainable Development**, with its **17 Sustainable Development Goals (SDGs)**, provides a globally significant opportunity to focus scientific effort on delivering the knowledge and expertise required to underpin sustainable development in our seas and ocean. SDG 14 refers specifically to the need to conserve and sustainably use the ocean, seas and marine resources for sustainable development, but it is understood that the marine environment underpins about 60% of all SDGs. Co-ordinated scientific effort is fundamentally important to understanding and tackling these multiple and complex challenges (EMB, 2017).

⁷ <https://unfccc.int/>

⁸ <https://unfccc.int/process/the-kyoto-protocol>

⁹ <http://www.un.org/millenniumgoals/>

¹⁰ <https://www.un.org/sustainabledevelopment/>

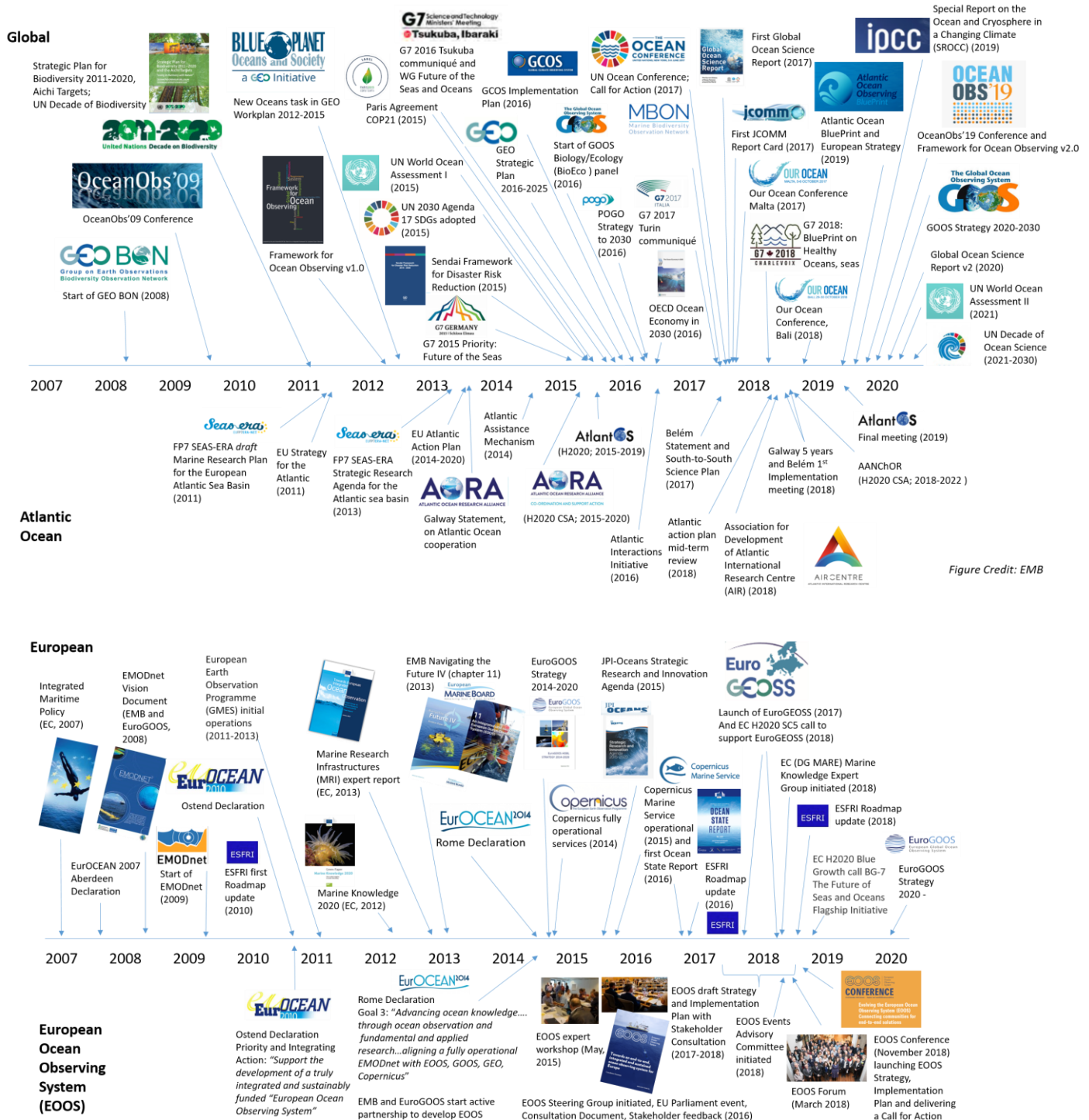


Figure Credit: EMB

Figure 2. A time-line of selected marine science policies and ocean observation initiatives that have shaped ocean observation coordination and governance since 2007 at Global, Atlantic Ocean and European levels, including the community development of the European Ocean Observing System (EOOS). Information on the longer-term history of marine science-policy and ocean observation coordination development is summarized in section 2 and in other AtlantOS outputs e.g. Buch *et al.*, 2018, Liebender *et al.*, 2016). This Figure focuses on presenting global initiatives and those led/promoted by Europe to strengthen ocean observation coordination in Europe and the Atlantic Ocean and the policies that shape them. It does not include National initiatives, platform-specific coordination efforts, or regular cycles of ocean/climate reporting e.g. to UNFCCC. See Glossary in AtlantOS D10.11 (Annex 1) for acronym explanations. (Figure prepared by European Marine Board Secretariat, 2018)

2015 was in fact a pivotal year for international climate, ocean and wider sustainability agreements and policy developments. In addition to the UN 2030 agenda, the **Sendai Framework for Disaster Risk Reduction 2015-2030**¹¹ was adopted, relevant to the more operational aspects of oceanography and early warning. And in December 2015, the 2015 Paris Climate Conference (COP21), delivered the first legally binding and universal agreement on climate, the **Paris Agreement**¹². Notably for ocean observations, the Paris Agreement mentioned ocean ecosystems for the first time and renewed a standing agenda item on sustained observations in the UNFCCC.

The seas and ocean domain has also increased in political awareness within the **Group of Seven (G7)**¹³, in particular since 2015 at the Science and Technology Minister meetings and resulting communiqués and actions. At the G7 Science Ministers meeting in Berlin in 2015, one of the four priorities was the future of the seas and another priority on research infrastructures. This included discussions on how to coordinate G7 efforts for ocean related issues including tackling marine litter and recognized European efforts (e.g. through JPI Oceans) to assess the potential impact of deep-sea mining. The G7 2016 Science and Technology Ministers meeting in Tsukuba and the resulting **Tsukuba communiqué**¹⁴ reaffirmed the future of the oceans as a key priority, and specifically endorsed a number of related actions on ocean observation, namely:

- Support the development of an initiative for enhanced global sea and ocean observation required to monitor *inter alia* climate change and marine biodiversity, e.g. through the Global Argo Network and other observation platforms, while fully sustaining and coordinating with ongoing observation;
- Strengthen collaborative approaches to encourage the development of regional observing capabilities and knowledge networks in a coordinated and coherent way, including supporting the capacity building of developing countries; and
- Promote increased G7 political-cooperation by identifying additional actions needed to enhance future routine ocean observations.

The Ministers also agreed to maintain the seas and oceans expert group as a G7 Working Group Future of Seas and Oceans Initiative, to advance G7 action in this domain¹⁵.

The G7 Science Minister's 2017 **Turin communiqué**¹⁶ and **Annex I** on the Future of the Seas and Oceans¹⁶ initiative on ocean monitoring and observations outlined G7 technical expert recommendations for how to take these actions forward. For ocean observation, relevant actions and recommendations ranged from enhancing G7 contribution to coordination of the global system (Action 1), to strengthening collaborative approaches and regional observing capabilities and knowledge networks (Action 4) and enhancing political cooperation through G7 to enhance future routine ocean observations. Here Action 1 is looked at in more detail in terms of progress to: *"Support the development of a global initiative for an enhanced, global, sustained sea and ocean observing system."* The corresponding technical expert recommendations identified in the Turin communiqué were for:

- The G7 work collectively to establish sustained funding mechanisms that are essential to maintain and extend the existing global ocean monitoring and observing systems in accordance with national research priorities and budgets.
- The G7 members establish a Global Ocean Observing System (GOOS) Implementation group to liaise with and support GOOS whilst coordinating enhancements to G7 observing.

¹¹ https://www.preventionweb.net/files/43291_sendaiframefordrren.pdf

¹² <http://www.cop21paris.org/>

¹³ Informal bloc of industrialized democracies (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States)

¹⁴ http://www8.cao.go.jp/cstp/english/others/communiqué_en.html

¹⁵ Summary provided at: <http://jpi-oceans.eu/news-events/news/g7-science-and-technology-ministers-reaffirm-future-oceans-key-priority>

¹⁶ <http://www.g7italy.it/en/science-ministerial-meeting>

- The G7 develop a strategy for extending observations focussed on high-priority areas and develop associated road maps for the next 5 years.

At a December 2017 workshop of G7 technical experts, a two-year action plan was developed and planning towards a G7 GOOS Implementation group is underway, for delivery in 2018. Options in discussion have ranged from a coordination centre being established for ocean observation platforms that could interface with GOOS and interlink with G7 although in the 5 year action plan it is noted that sustaining G7 GOOS Coordination will very much depend on the ambition of the coordination efforts (*in preparation at time of writing*).

Canada's 2018 G7 presidency¹⁷ has included 'climate change, oceans and clean energy' as one of the 5 key themes. The G7 Leaders' Summit in Charlevoix, Quebec, in June 2018, delivered a **Charlevoix Blueprint for Healthy Oceans, Seas and Resilient Coastal Communities**¹⁸, which will promote sustainable oceans and fisheries, support resilient coasts and coastal communities, and take action on ocean plastic waste and marine litter, including an Oceans Plastics Charter.

There has also been a notable increase in the visibility and development of marine and ocean observation in wider Earth Observation Programmes. For instance, following active lobbying from the oceanographic community (led by POGO) for more emphasis on ocean science and its connectivity to society in **GEO**, the GEO Work Plan 2012-2015 included a new Ocean Task (Oceans and Society: Blue Planet) (POGO, 2016). GOOS contributes to GEO through the **GEO Blue Planet** which is increasingly recognized as a vehicle for collaboration and integration between ocean observation efforts, adding value to existing programmes by engaging with end-users, and highlighting the societal benefits of ocean observations to a variety of stakeholders¹⁹. The GEO Blue Planet initiative has also collaborated with a number of international partners to assess the role of ocean observations, and to identify the requirements and knowledge needs for the implementation and monitoring of the SDGs (e.g. workshop in January 2018²⁰).

The same is true for the rise in reports and assessments and high-level events specifically dedicated to the oceans. This includes the first **World Ocean Assessment** in 2015 (with the second one underway for 2021), the **Global Ocean Science Report** in 2017 (with the second planned in 2020) and the IPCC Special Report on Oceans and Cryosphere in a Changing Climate (SROCC) expected in 2019. In turn, the **UN Ocean Conference**²¹ in 2017 brought together more than 4000 participants from governments, the UN system and other intergovernmental organizations, NGOs, academia, the scientific community and the private sector. In addition, since 2014, the **Our Ocean Conferences**²² have invited ocean leaders to commit to change and the recent Conference in 2017 (Malta) and upcoming in Bali (2018) show just how high oceans are now on political agendas, with almost 1,500 voluntary commitments from Nations and organizations that are actively followed up and tracked.

All of this momentum has led to the UN adopting 2021-2030 as the **United Nations Decade of Ocean Science for Sustainable Development**²³ with the preparatory phase being coordinated by IOC, as mandated by the UN General Assembly. One of the key objectives of the Decade is achieving integrated observations and data sharing and this supports all other objectives including increasing scientific knowledge, informing on sustainable use of ocean and marine resources, and development of the ocean economy.

¹⁷ <https://g7.gc.ca/en/>

¹⁸ <https://g7.gc.ca/en/official-documents/charlevoix-blueprint-healthy-oceans-seas-resilient-coastal-communities/>

¹⁹ See presentations, 4th GEO Blue Planet Symposium: <https://geoblueplanet.org/event/4th-geo-blue-planet-symposium/>

²⁰ http://www.gstss.org/2018_Ocean_SDGs/

²¹ <https://oceanconference.un.org/>

²² <https://oceanconference.un.org>

²³ <https://en.unesco.org/ocean-decade>

In addition, the growing interest in expanding the blue economy and the cost and benefits of ocean observations supporting these, has led to the Organisation for Economic Co-operation and Development (OECD) being internationally recognized for its assessments, publishing a report on the “**Ocean Economy to 2030**” in 2016²⁴. Through interactions with AtlantOS and IOC, OECD is currently working on a related initiative on valuing ocean observations to be published in 2018.

2.3 Atlantic Ocean

Europe has invested significant resources into funding ocean observation and wider marine science initiatives in the Atlantic Ocean and as a result, the marine scientific and ocean observation community contributed greatly to the development of Atlantic Ocean observation capability, coordination and wider marine research agendas. For instance, the European Framework 7 (FP7) project SEAS-ERA European Research Area (ERA) Network (NET) project and Atlantic partnership, sea basin approach (2010 – 2014) contributed to shaping the Atlantic Ocean Strategy through the SEAS-ERA Marine Research Plan for the European Atlantic Sea Basin (Work Package 6; see Marine Institute and EMB, 2011 and 2013). These outputs were timely given the launch of the **Maritime Strategy for the Atlantic Ocean Area**²⁵ (EC, 2011) and the development of an **EU Atlantic Action Plan 2014-2020**²⁶ (EC, 2013b) designed to revitalize the marine and maritime economy of France, Ireland, Portugal, Spain, and the United Kingdom and to put in place national maritime strategies to stimulate sustainable ‘blue growth’ and improve coordination. After 4 years, the 2017 mid-term review of the Atlantic action plan (EC, 2018) noted that EU and national policy developments and funding priorities were found to be largely supportive of and aligned with the priorities of the action plan and that European Horizon 2020 Framework Programme supports EU research policy and funds research in sectors including marine. It also outlined areas that could be built upon including to catalyse intelligent collaboration between research networks, technology platforms and private investors on both sides of the Atlantic with a view to implementing the agreed priorities and actions.

Other networks that SEAS-ERA identified to have contributed to the definition of research priorities in the European Atlantic Sea-Basin include ICES, OSPAR, European Marine Board, JPI OCEANS, EFARO, etc.; sectoral ERA-NETS (e.g. COFASP, Marine Biotech, Climate, etc.), as well as existing Technology Platforms (e.g. EATiP, WATERBORNE, etc.) and large scale cooperative projects (e.g. Euro-BASIN, THOR, etc.) (Marine Institute and European Marine Board, 2011). SEAS-ERA also paved the way for future investment in Atlantic Ocean research, innovation and ocean observation, including the AtlantOS project, as it identified a critical support / infrastructure need to: *“Establish a European Atlantic Ocean Observing and Predictive Capability, based on existing structures, platforms and mechanisms, to support the implementation of EU policies, reduce costs to industry, public authorities and research institutions, stimulate innovation and reduce uncertainty in our understanding of the behaviour of the Atlantic Ocean and the impacts of climate change.”* (SEAS-ERA, 2013).

In 2013, the **Galway Statement**²⁷ on Atlantic Ocean Cooperation that was signed by the European Union (EU), Canada and the United States of America (U.S.A.), launching a Transatlantic Ocean Research Alliance to enhance collaboration to better understand the Atlantic Ocean and sustainably manage and use its resources. Following this political commitment, the European Union has supported marine-related research in the Atlantic and specifically earmarked a total budget of about EUR 140 million, including EUR 40 million for Arctic research, contributing to strengthening maritime industries, developing related economic activities and promoting entrepreneurship in the Atlantic area (EC, 2018). The **Atlantic Ocean Research Alliance** (AORA)²⁸ Coordination and Support Action is a project funded by the European Union from 2015-2020 tasked with the implementation of activities of the Galway Statement which includes a Work Package on Ocean Observation and a high-level cooperation area in seabed mapping. During the course of AtlantOS, a series of

²⁴ <http://www.oecd.org/sti/futures/oceaneconomy.htm>

²⁵ https://ec.europa.eu/maritimeaffairs/policy/sea_basins/atlantic_ocean_en

²⁶ <http://atlanticstrategy.eu/>

²⁷ <https://atlanticresource.org/aora/sites/default/files/GalleryFiles/Default/GalwayStatement.pdf>

²⁸ <https://www.atlanticresource.org/aora>

informal “exchange of ideas” meetings were set up between the AtlantOS project and the wider Atlantic Ocean Research Alliance Coordination and Support Action (AORA-CSA) to discuss the sustainability of ocean observing in the Atlantic Ocean Region. At an exchange in April 2017 it was recognized that work needs to be better coordinated between AtlantOS, BluePrint and G7 Initiatives (as well as GOOS, GEO Blue Planet, POGO) and that foresight and analysis activities could be launched on ocean observation governance, including an analysis of best-practices in observation governance.

In 2017, a related **Belém Statement**²⁹ was signed between the European Union, South Africa and Brazil launching the European Union-Brazil-South Africa Atlantic Ocean Research and Innovation Cooperation to stimulate dialogue within South Atlantic countries and fostering dialogue and cooperation between South- and North Atlantic. Both the Galway and Belém Statements address the challenges put forward in the Atlantic strategy and have been acknowledged as major achievements of the Atlantic strategy and its action plan²⁴

It is noted that a number of other international agreements like the **United Nations Convention on the Law of the Sea** and the **Convention on Biodiversity**, and achieving the goals of the Food and Agricultural Organization and the International Whaling Commission are pertinent to the South-South collaborations as drivers for addressing national and global knowledge gaps towards meeting obligations of these international agreements (South-South Framework / Science Plan, 2017). The **South-South Framework** and integrated science plan contribute to the greater economic, political and diplomatic alignment of South Atlantic nations, positioning South Atlantic Ocean countries as global focal points for regional cooperation through the development of common and joint imperatives for the South and Tropical Atlantic and the Southern Oceans (South-South Framework for Scientific and Technical Cooperation, 2017). The South-South Framework noted *“the importance of working at the science-policy interface to address current global challenges in the Tropical and South Atlantic Ocean, and Southern Ocean. The exchange of ideas between policy officials and scientific researchers is important if national/regional science plans are to be aligned to achieve mutually agreed priorities”* (South-South Framework / Science Plan, 2017). The Framework is intended to promote scientific cooperation and capacity building among South Atlantic countries, and the exchange of expertise in and knowledge of ocean science and technology for the environmental and socio-economic benefits of these countries (South-South Framework for Scientific and Technical Cooperation, 2017).

Europe continues to show leadership building political will and funding cooperation e.g. through Coordination Support Actions to support the Galway Statement (H2020 AORA CSA, 2015-2020) and major international cooperation activities to be launched. These activities will implement the Belém Statement focusing on the South Atlantic Ocean towards an ‘All Atlantic Ocean Research Alliance’ and reinforcing cooperation with partners in other regions such as the Baltic Sea, the North Sea, the Arctic Ocean, the Mediterranean and the Black Sea. In Autumn 2018, this will include the launch of a new Horizon 2020 Coordination and Support Action, **AANCHOR** (All Atlantic Cooperation for Ocean Research and innovation) with a duration of 42 months. In addition, a bilateral agreement to the Belém agreement is in preparation as a Cooperation Arrangement that will be signed by the EU and Cape Verde in November 2018.

The wider importance of scientific and technical cooperation and diplomacy should not be underestimated (Fritz *et al.*, 2016). The Galway Statement has been widely recognised as a model of international cooperation and science diplomacy, and its success has led to the development of a similar approach in other sea basins including the endorsement in 2017 of the BLUEMED Initiative³⁰ for the Mediterranean. The SEAS-ERA Atlantic partnership also recognized from the outset, that the implementation of such a European Atlantic Sea Basin Marine Research Plan needed co-operation, not only between EU and EEA Atlantic Member States, but also with (a) Non-EU eastern Atlantic seaboard countries (e.g. Faroe Islands)³¹.

²⁹ <https://www.atlanticresource.org/aora/belem-statement>

³⁰ <http://www.bluemed-initiative.eu/>

³¹ Note: Norway and Iceland were members of the SEAS-ERA Project, and (b) western Atlantic Ocean seaboard states (USA, Canada, and Greenland).

The South-South Framework is crucial in developing a pan-Atlantic Ocean Observing coordination, particularly with the development of **Atlantic interactions**³², a new intergovernmental initiative on unleash knowledge-driven solutions for the Atlantic Ocean – to be implemented through the **Atlantic international research centre (Air centre)** with the ambition to be a long-term platform for collaboration for research and wider cooperation in the Atlantic (AIR Centre, 2018).

2.4 Europe

In 2007 the **Integrated Maritime Policy** (IMP) outlined a new coherent approach for connecting and increasing coordination between related marine and maritime issues policies (EC, 2007), with the EU Strategy for Marine and Maritime Research (MMRS) (EC, 2008b) adopted as its scientific pillar. In terms of ocean observing, the IMP stated the EC would “*take steps in 2008 towards a European Marine Observation and Data Network (EMODnet)*.” This was followed by a vision document on EMODnet (EMB and EuroGOOS, 2008) as “*A vision for an end-to-end, integrated, inter-operable and user-oriented network of European marine observation and data systems*”, delivered as a collaboration between EuroGOOS and the European Marine Board (EMB). EMODnet started a year later, in 2009.

In 2012, the European Commission released a **Marine Knowledge 2020 Green Paper** (EC, 2012a), which noted that “*Member States and Associated Countries have agreed to pool resources in a Joint Programming Initiative ‘Healthy and Productive Seas and Oceans’ that can provide a framework for coordination of observation programmes.*”

The **EU’s “Blue Growth”** initiative, also launched in 2012 (EC, 2012b), is the maritime contribution to achieving the goals of the Europe 2020 strategy for smart, sustainable and inclusive growth. Marine data, including data from ocean observation and monitoring, is a crucial component of the blue growth value chain producing information, products and services upon which users e.g. industry rely.

The three main EU initiatives in ocean data and product accessibility, interoperability (according to EC, 2017) are:

- the **Copernicus Marine Environment Monitoring Service (CMEMS)** which provides space and In-Situ data and oceanographic forecasts;
- the **Data Collection Framework** which supports the collection and processing of fisheries and aquaculture data and;
- the European Marine Observation and Data Network (**EMODnet**) which assembles, processes and distributes all other marine data and data products.

Other European-wide data management initiatives include **SeaDataNet**³³ and **PANGAEA**³⁴.

In 2016, a Joint Communication on “**International Ocean Governance**” was released by the European Commission and the EU’s High Representative (EC, 2016) which aims to strengthen international research and data as an integral part of the EU’s response to the United Nations’ 2030 Agenda for Sustainable Development, in particular Sustainable Development Goal 14 ‘*to conserve and sustainably use the oceans, seas and marine resources*’, for which coordinated ocean observation will be required.

The need for strengthening European coordination in ocean observation has been driven in part by European policies and legislation, including the **Marine Strategy Framework Directive** (EC, 2008a), adopted in 2008, with the goal of Good Environmental Status (GES) in European waters by 2020. This has led to the

³² <http://www.atlanticinteractions.org/>

³³ <https://www.seadatanet.org/>

³⁴ <https://pangaea.de/>

development of programmes of measures and National monitoring programmes, with regular reporting requirements to the European Union, which since 2017 also takes into account the Commission Decision to revise the set of detailed criteria and methodological standards³⁵. Indeed, the **ICES Implementation Plan** (2014) recognized there are a number of ecosystem-based directives that require countries to develop integrated surveys and observation/monitoring programmes to deliver the data and information to meet these requirements. Benedetti-Cecchi *et al.* (2018) provides more detail on European political drivers for ocean observation and, particularly, current legislation for promoting ocean biological observations and their integration, many of which are relevant to wider ocean observations (see Figure 3 below).

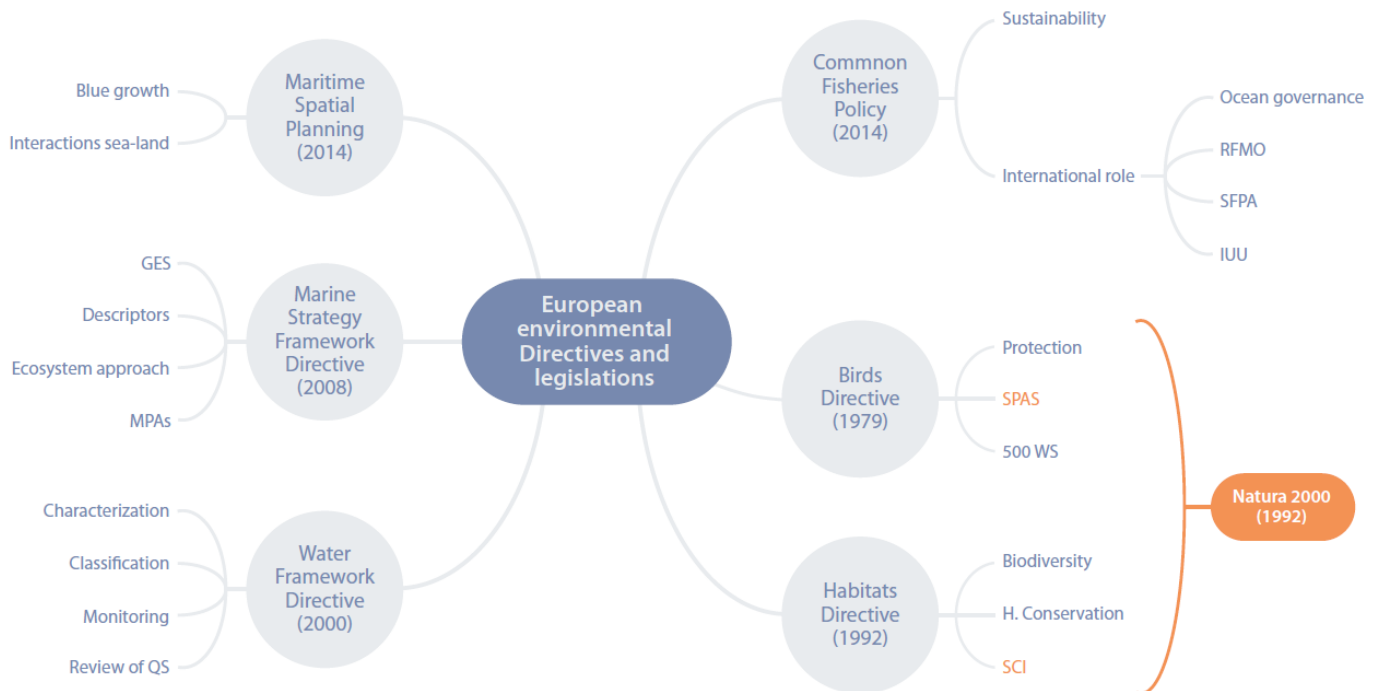


Figure 3. A summary of key EU legislation which requires biological (and wider) observations of seas and ocean (from Benedetti-Cecchi *et al.*, 2018)

European Marine Research Infrastructures and Ocean Observing coordination efforts

The **European Strategy Forum on Research Infrastructures** (ESFRI) was set-up in 2002 with a key role in supporting a coherent and strategy-led approach to policy making on research infrastructures in Europe³⁶. The Operational Oceanography community has been particularly active in the effort to develop key long-term marine research infrastructures (EuroGOOS, 2014), with many networks being added to the ESFRI Roadmap and subsequently developing legal entities as a **European Research Infrastructure Consortium** (ERIC) e.g. Euro-Argo ERIC and EMSO ERIC, requiring national commitments and longer-term resources and sustainability. Roadmap updates started in 2010 with the latest in 2016³⁷ and the 2018 Roadmap Update process still in finalization at the time of writing. ESFRI and the wider European Marine Research Infrastructure (MRI) landscape has also been influenced by an expert group, set up by the European Commission in 2010, to advise on a strategic approach to European MRIs. The final report (EC, 2013a) stated that *“The European landscape of MRIs governance initiatives is too complex and fragmented and this is an obstacle to achieving optimal impact of MRIs and responding to increasing societal needs related to our seas.”* This report recognized the EU Strategy for Marine and Maritime Research (MMRS) that considered *“the Coordinated development of marine research infrastructures at European level in relation to societal needs*

³⁵ <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017D0848&from=EN>

³⁶ <http://ec.europa.eu/research/infrastructures/index.cfm?pg=esfri>

³⁷ <http://www.esfri.eu/roadmap-2016>

identified in the IMP, as an essential objective to be pursued by the Commission in cooperation with Member States (EC, 2008b). The MMRS considers the Marine Research Infrastructures (MRIs) must also be managed at the European scale because marine challenges do not stop at national borders and synergies can be achieved at European level[.....]There are synergies and savings in the coordinated development and utilization of MRIs at European or regional seas' levels and in ensuring shared and free access to the data they produce”.

A number of projects and initiatives have produced mapping exercises of marine research infrastructures. This includes the SEAS-ERA Framework 7 project which included basin-scale mapping of infrastructures e.g. for the Atlantic Ocean³⁸ contributing to basin-scale Strategic Marine Research Plans (Marine Institute and EMB, 2013, see Atlantic policy section above). The Joint Programming Initiative for Healthy Seas and Oceans (**JPI Oceans**) CSA Oceans, a Framework 7 funded Coordination and Support Action to support JPI Oceans in its start-up phase, also produced foresight work on MRIs and ocean observation, including Deliverable 6.1 of CSA Oceans on mapping and preliminary analysis of infrastructures, observation data and human capacity building (Coroner *et al.*, 2014). The publication of the **JPI Oceans Strategic Research and Innovation Agenda** in 2015 also identified a Strategic Area on “*Observing, Modelling and predicting ocean state and processes*”³⁹ (JPI Oceans, 2015). More recently ICES and partners within the Atlantic Ocean Research Alliance Coordination and Support Action have developed a mapping exercise in European marine research and data infrastructures as a European contribution to the building of a wider Knowledge Platform (e.g. ICES, 2018a). The AtlantOS project has also developed mapping and monitoring tools (see section 4.3.2 in this report for more information).

The European Union has financed a number of coordination/cooperation initiatives through Framework Programmes (FPs), ranging from stimulating and strengthening European coordination in specific ocean observing infrastructure platforms e.g. **EuroSITES** and its evolution to **FixO3**⁴⁰ as part of **EMSO ERIC**⁴¹, **Jerico and Jerico-Next**⁴², initiatives for strengthening coordination across marine and wider environmental research infrastructures (e.g. ENVRIPlus⁴³) and basin-scale coordination e.g. AtlantOS⁴⁴ (Atlantic Ocean), INTAROS⁴⁵ (Arctic Ocean) and ODYSSEA⁴⁶ (Mediterranean Sea). The latest FP8, Horizon 2020, includes Blue Growth Calls under Societal Challenge 2. This includes BG-7, - the Future of Seas and Oceans Flagship Initiative which will support major international cooperation activities and pave the way towards an 'All Atlantic Ocean Research Alliance' whilst reinforce cooperation with partners in other regions such as the Arctic Ocean, the Baltic Sea and the North Sea, the Mediterranean and the Black Sea.

EuroGOOS⁴⁷ is a key European coordinating mechanism for Europe’s operational oceanographic community. EuroGOOS is an international non-profit association of national governmental agencies, research organisations, and private companies, committed to European-scale operational oceanography within the context of the inter-governmental Global Ocean Observing System (GOOS). EuroGOOS has today 42 members from 19 European countries providing operational oceanographic services and carrying out marine research.

Five regional sea areas (Fig. 4) where operational systems are being developed have been defined: the Arctic (Arctic ROOS), the Baltic (BOOS), the North West Shelves (NOOS), the Iberia-Biscay-Ireland area (IBI-ROOS) and the Mediterranean (MONGOOS). Additionally, the Organisation cooperates through an MoU with Black

³⁸ <http://www.seas-era.eu/np4/18.html>

³⁹ <http://www.jpi-oceans.eu/observing-modelling-and-predicting-ocean-state-and-processes>

⁴⁰ <http://www.fixo3.eu/>

⁴¹ <http://emso.eu/>

⁴² <http://www.jerico-ri.eu/>

⁴³ <http://www.envriplus.eu/>

⁴⁴ www.atlantos-h2020.eu

⁴⁵ <http://www.intaros.eu/>

⁴⁶ <http://odysseaplatform.eu/>

⁴⁷ <http://eurogoos.eu/>

Sea GOOS which acts as a ROOS in the Black Sea. Strong cooperation within these regions, enabling the involvement of additional regional partners (around 50 organisations) and countries, forms the basis of EuroGOOS work, and is combined with high-level representation at European and Global forums.



Figure 4. EuroGOOS Regional Ocean Observing Systems (ROOSes)

Through its Working Groups, EuroGOOS develops strategies, priorities and standards in order to establish a concerted European approach to the development of operational oceanography. These strategies are actively promoted towards the European and National operational and funding agencies aiming to maximize their impact.

EuroGOOS ocean observing Task Teams (Tide gauges, FerryBox, Gliders, HF-Radars, Fixed stations/EMSO, EuroARGO, Marine Mammals) are operational networks of observing platforms. They promote scientific synergy and technological collaboration among European observing infrastructures. Task Team members exchange open source tools, collaborate in areas of common interest, and jointly make European data available to the EuroGOOS ROOS regional data portals, which in turn are feeding data to pan-European portals, e.g. EMODnet, Copernicus Marine Environment Monitoring Service In-Situ Thematic Assembly Centre and SeaDataNet.

The work is done in close collaboration with the international community of operational oceanography especially through JCOMM and global programs (GODAE, ARGO, OceanSITES, SOOP etc). EuroGOOS is one of the UNESCO-IOC GOOS Regional Alliances (GRA) and works with them for a coordinated approach in the development of regional and coastal operational oceanography.

The **European Marine and Observation Data Network (EMODnet)**⁴⁸ is a long-term marine data initiative of the European Commission's Directorate-General for Maritime Affairs and Fisheries (DG MARE). EMODnet was initiated in 2009 and has been developed through a step-wise approach. Currently the project is in its third and final development phase (running from 2017-2020) and has reached a mature and operational stage. More than 150 organisation work together with EMODnet to observe the sea, process the data according to international standards and make that information freely available as interoperable data layers and data products. This "collect once and use many times" philosophy benefits all marine data users including scientists, policy makers, private industry and the public. The objectives of EMODnet are:

⁴⁸ <http://www.emodnet.eu/>

- to save costs for offshore operator;
- to increase productivity in all tasks involving marine data;
- to stimulate competition and promote innovation;
- and to reduce uncertainty about the behaviour of the sea.

EMODnet provides access to European marine data, data products and information across seven discipline-based themes: Bathymetry, Geology, Seabed habitats, Chemistry, Biology, Physics and Human activities. For each theme, EMODnet has created a gateway (portal) through which users have free access to marine information under the form of:

- data archives and standardised observations
- metadata
- and processed data products, predominantly in the form of basin-scale maps.

The EMODnet Central Portal⁴⁹ is the single access point to these portals. The central portal also contains a number of data services such as a data products catalogue and map viewer as well as a query tool to retrieve summary information from data products from all EMODnet thematic assembly groups.

Since 2018 EMODnet is also the custodian of The European Atlas of the Seas (EAS)⁴⁹, a freely available interactive geographic information system provided by the European Commission, Directorate-General for Maritime Affairs and Fisheries (DG MARE), delivering collections of maps derived from data on Europe's seas and coasts, their environment, related human activities and European policies.

Over the past 15 years, the marine component of European Earth Observation Programmes has also been developed and strengthened. Following a longer-term historical development, the **Global Monitoring for Environment and Security (GMES)** began its initial preparations for a marine service system in 2003 via the project MERSEA which was followed by the MyOcean I and II projects. This evolved via strong support from the EuroGOOS community into the **Copernicus Marine Environment Monitoring Service (CMEMS)**, implemented and operated by a consortium led by Mercator Ocean International, and has been fully operational since 2015, assimilating *in situ* and satellite-derived ocean observation data into forecast models to provide oceanographic products and services for users from domains including maritime safety, coastal and marine environment, climate and weather forecasting and marine resources.

Related to the Copernicus Service activities the **European Environment Agency (EEA)** has the role of cross-cutting coordination of *in situ* data. Concerning environmental *in situ* data (ocean, meteorology and atmospheric composition) EEA has subcontracted a consortium consisting of EuroGOOS, EUMETNET and ICOS/Lund University, who provide guidance on issues such as requirements, sustainability of *in situ* networks, data availability, links to research Infrastructures etc and produces an annual State of Play report⁵⁰.

In 2017, the European GEO Caucus launched the **EuroGEOSS initiative**⁵¹ as Europe's part of the Global Earth Observation System of Systems (GEOSS) supported by more than 30 governments and organizations in Europe. The governance of EuroGEOSS is still to be decided but will be as simple and flexible as possible while allowing for inclusion and leadership. There will be a coordination group jointly chaired by the European Commission and implementation working groups bringing together existing relevant initiatives. Following the European FP7 EuroGEOSS project (2009-2012) there will be a new project starting in 2018 under the Horizon 2020 Societal Challenge 5.

⁴⁹ https://ec.europa.eu/maritimeaffairs/atlas/maritime_atlas/#lang=EN;p=w;bkgd=5;theme=2:0.75;c=undefined;z=undefined

⁵⁰ <https://insitu.copernicus.eu/state-of-play>

⁵¹ https://ec.europa.eu/info/research-and-innovation/knowledge-publications-tools-and-data/knowledge-centres-and-data-portals/eurogeoss_en

Towards a European Ocean Observing System

Building on the IMP and MRI and wider ocean observation and data management developments, the flagship marine science-policy **EuroOCEAN Conference series** provided recommendations and inputs for strengthening pan-European ocean observing coordination. The **2010 Ostend Declaration** included a Priority and Integrating Action to “*Support the development of a truly integrated and sustainably funded ‘European Ocean Observing System’*”. The EMB took this forward in 2013 in the flagship marine scientific foresight publication “**Navigating the Future IV**” (EMB, 2013), with chapter 11 dedicated to the European Ocean Observing System, key components and the need for a cyclical, regular process of implementation. **EuroOCEAN 2014’s Rome Declaration**⁵² included a specific call for “*further development of the European Ocean Observing System (EOOS), integrated at the global level (including GOOS, GEO and Copernicus)*.” Since then, European ocean observing communities have been working together to answer this call and turn EOOS into a reality. Also in 2014, EuroGOOS launched their 2014-2020 Strategy (EuroGOOS, 2014), specifically emphasising EOOS.

Since 2015, the EOOS coordinating framework has been jointly promoted by EuroGOOS⁵³ and the European Marine Board⁵⁴, in a collaboration designed to connect the operational oceanographic and wider marine scientific communities and stimulate the transition of EOOS from a visionary concept into a tangible initiative. Through extensive stakeholder consultation, a community **Strategy and Implementation Plan 2018-2022** will be launched at the EOOS Conference on 21-23 November 2018 (see section 3 for more details on EOOS).

3 TOWARDS STRENGTHENED REGIONAL AND BASIN-SCALE OCEAN OBSERVING

3.1 The Regional approach

The Blue Print for Integrated Atlantic Ocean Observing identifies that ocean observation coordination can be generally separated into networks and systems and that there is a wide range of governance structures ranging from loose coalitions to legal entities with strategic planning, underpinned by national funding (Blue Print for Integrated Atlantic Ocean Observing, *in prep*).

The South-South Framework and integrated science plan for the South Atlantic (2017) recognizes the use of the regional approach to ocean observation and wider marine research “*No single country has the capacity to observe and develop an understanding of the links and climate sensitivities of the coupled ocean-land-atmosphere system in the South Atlantic Ocean on its own. Regional cooperation in this regard will deliver high value and long-lasting regional and global insight into climate and ecosystem sensitivity to global change.*” (South-South Framework, 2017). In addition, AtlantOS Work Package 5 focuses on regional levels, noting the multiple levels and complexity to connect ocean observing across projects, observing systems and across agencies (see AtlantOS Task 5.1 and Blueprint for Atlantic Ocean Observing Implementation Plan, *in prep*, for more information).

From the very beginning GOOS has recognised that the way to successful implementation has to go through regional implementation and therefore established the concept of GOOS Regional Alliances (GRAs) of which the European component is EuroGOOS (see Figure 5). There are today 13 GRA’s while two are in the planning stage – Canadian Integrated Ocean Observing System (C-IOOS) and Arctic GOOS. The primary goal of the individual GRA’s is to coordinate the ocean observing activities within their region. The level of development and maturity varies with IMOS, IOOS and EuroGOOS being the most active and developed. The GRA’s coordinate their activities through bi-monthly teleconferences and bi-annual meetings.

⁵² <http://www.eurooceanconferences.eu/news>

⁵³ <http://eurogoos.eu/>

⁵⁴ <http://marineboard.eu/>

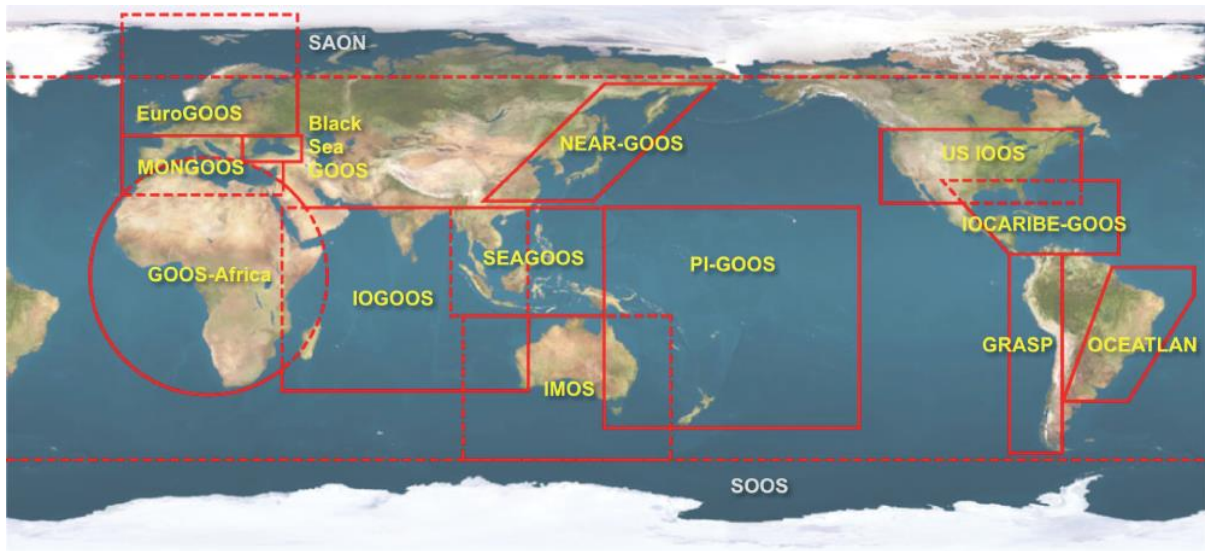


Figure 5. GOOS Regional Alliances.

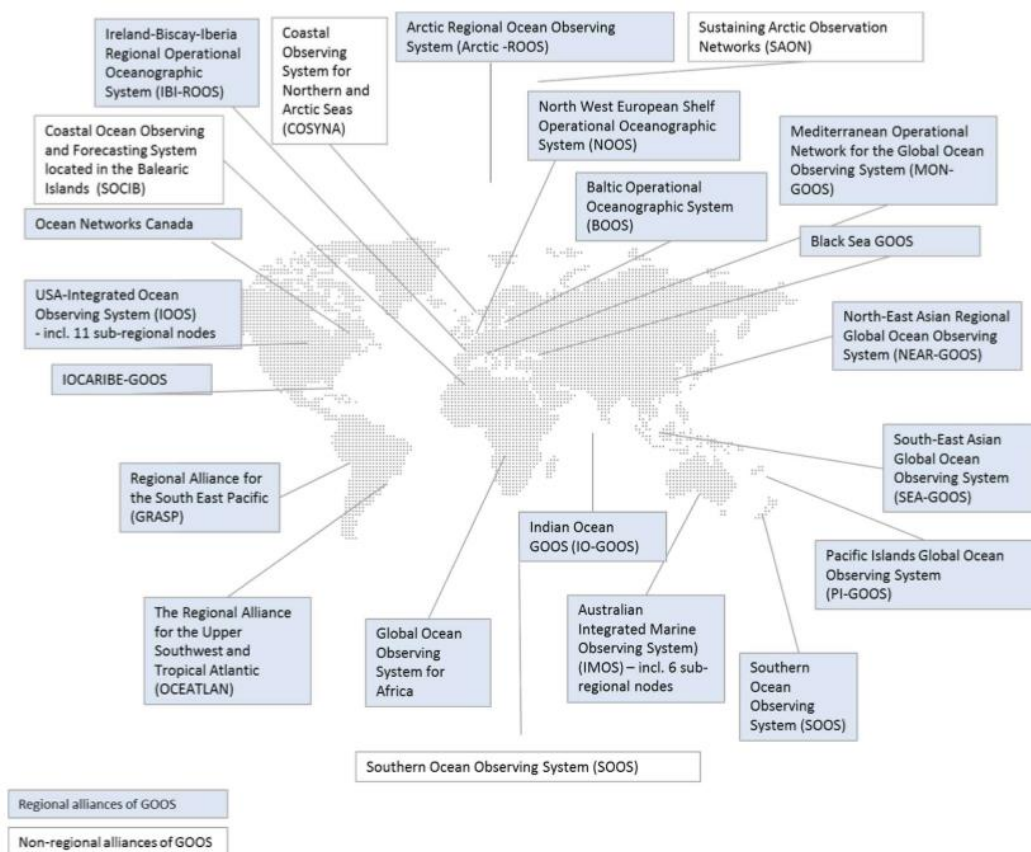


Figure 6. Different regional ocean observation systems (in the context of GOOS and beyond GOOS). It is not a comprehensive list but shows some of the complexity of existing alliances as reviewed by Liebender *et al.*, 2016. EuroGOOS as a GOOS Global Regional Alliance (GRA) is not specifically mentioned, but rather the 5 Regional Ocean Observing Systems (ROOSes), supported by EuroGOOS. Figure Credit: Leibender *et al.*, 2016, AtlantOS WP10 D10.4. Original data source: GOOS⁵⁵, EuroGOOS⁵⁶, HZG⁵⁷, SOCIB⁵⁸.

⁵⁵ http://www.goosocean.org/index.php?option=com_content&view=article&id=43&Itemid=143

⁵⁶ <http://eurogoos.eu/regional-operational-oceanographic-systems/>

⁵⁷ http://www.hzg.de/institutes_platforms/cosyna/research_topics/index.php.en

⁵⁸ http://www.socib.eu/?seccion=textes&id_textotextes=resumenEjecutivo

The AtlantOS Deliverable 10.4 (e.g. Liebender *et al.*, 2016) provides an illustrative list and further information of national, regional (in context and beyond GOOS) and Global ocean observing systems. This includes a Figure of key regional ocean observation systems across the world (presented as Figure 6). In addition, Table 1 presents some key aspects of existing regional (some nationally operated) ocean observing initiatives that can inform best practice on ocean observation coordination and governance.

Table 1. Examples of existing and emerging regional/national ocean observing initiatives that can inform best practice on ocean observation coordination and governance

Ocean Observing System	Key comments
	Integrated Marine Observing System (IMOS) • Nationally operated (Australia) • Collaborative integrated nodes: Large, diverse, dispersed community of scientists, academics, students, users and stakeholders. • Investment and Collaboration: The NCRIS investment and the IMOS collaborative model have provided a quantum leap in the availability of ocean data in Australia, and in the collaborative partnerships between data users across the university, government and industry sectors. http://imos.org.au/
	TPOS Tropical Pacific project to 2020 • U.S., Australia, China lead project office • Governance structure (Steering Committee, Resources Forum, Executive, Project Office) TPOS 2020 will design a modern, sustained tropical Pacific observing system that meets both science and societal needs; • Thematic Task teams (Biogeochemistry, Modelling and Data Assimilation etc) • Partnerships (bi-lateral and multi-lateral) to meteorological, operational centres. • First Report of TPOS 2020 (Cravatte <i>et al.</i>, 2016) www.tpos2020.org
	Southern Ocean Carbon and Climate Observatory (SOCCO) • Nationally operated (South Africa) • Global Change Grand Challenge • Strong scientific research focus: Marine and Antarctic Research Strategy linking carbon and climate • Platform for graduate training and capacity building http://socco.org.za/
	Integrated Ocean Observing System (IOOS) • Nationally operated (United States of America) • 11 Regions (3 Atlantic) • Governed by the Integrated Coastal and Ocean Observation System Act (ICOOS Act) • U.S. IOOS Advisory Committee: scientific institutions, marine technology industries, Coastal & Great Lakes use industries, non-governmental organizations, state, local, and tribal interests, and national and international ocean leadership.

	• National Oceanographic Partnership Program (NOPP) coordinates and develops collaborative ocean research efforts among Federal, state and tribal governments, academia, private industry, NGOs. • QARTOD (Quality Assurance) https://ioos.noaa.gov/
CIOOS	Canadian Integrated Ocean Observing System (CIOOS) Canada, has recently adopted an integrated management framework calling for ecosystem-focused monitoring programmes and just closed (in June 2018) a first call to build the Canadian Integrated Ocean Observing System through public, private and academic partnerships http://meopar.ca/research/cioos-call-for-proposals/ .

3.2 The Atlantic Ocean

The **BluePrint for Atlantic Ocean Observing Implementation Plan** (*in prep*), presents some examples of existing ocean observation networks and systems operating internationally e.g. OceanSITES⁵⁹, and regionally within the Atlantic Ocean e.g. PIRATA⁶⁰, which forms part of the worldwide system of tropical ocean observing buoys (along with TPOS in the tropical Pacific Ocean). This report, D10.11, concentrates on looking at the big picture of a future pan-Atlantic Ocean Observing System that would take into account all existing and emerging initiatives in the Atlantic Basin. AtlantOS Deliverable 9.1 by Belbéoch and Lizé *et al.* (2017) defined a specific polygon for the AtlantOS region (see Figure 7) for the design of a web monitoring tool (see also section 4 of this report).



As stated in the integrated science plan for the South Atlantic (South-South Framework, 2017) understanding many marine processes require a regional, or even basin-scale, cooperation e.g. El Niño–Southern Oscillation (ENSO) predictions (see Tropical Pacific Observing System 2020 project, Table 1 above and Cravatte *et al.* 2016). In addition, studies in the Atlantic Ocean, for example, the EMODnet Atlantic Checkpoint have noted there is a need of a clear governance structure both in Europe (e.g. through EOOS) and the Atlantic Ocean to better define a prioritization of EU data strategy (and monitoring) to address issues related to MFSD, Blue Growth, Climate, etc. and to optimize data quality management system.

Figure 7. AtlantOS region, as determined by Belbéoch and Lizé *et al.* 2017 (AtlantOS Deliverable 9.1)

The **Global Ocean Observing System (GOOS)**⁶¹ is one key framework through which a pan-Atlantic Ocean Observing System could be achieved as there are 5 **GOOS Global Regional Alliances (GRAs)** currently extending into the North and South Atlantic Ocean bordering the Sustaining Arctic Observing Networks (SAON) initiative in the Arctic Ocean and the Southern Ocean Observing System (SOOS) in the Southern Ocean (see Figure 8 below). Many nations collaborate through GRAs to build regional observation programmes that are major contributions to the global system. However, the existing GRAs do not span the full extent of the Atlantic Ocean, leaving much of the Atlantic Ocean without a GRA coordination. In addition, the 5 GRAs are very different in maturity and coordination.

⁵⁹ <http://www.oceansites.org/>

⁶⁰ <https://www.pmel.noaa.gov/gtmba/pirata>

⁶¹ www.goosocean.org

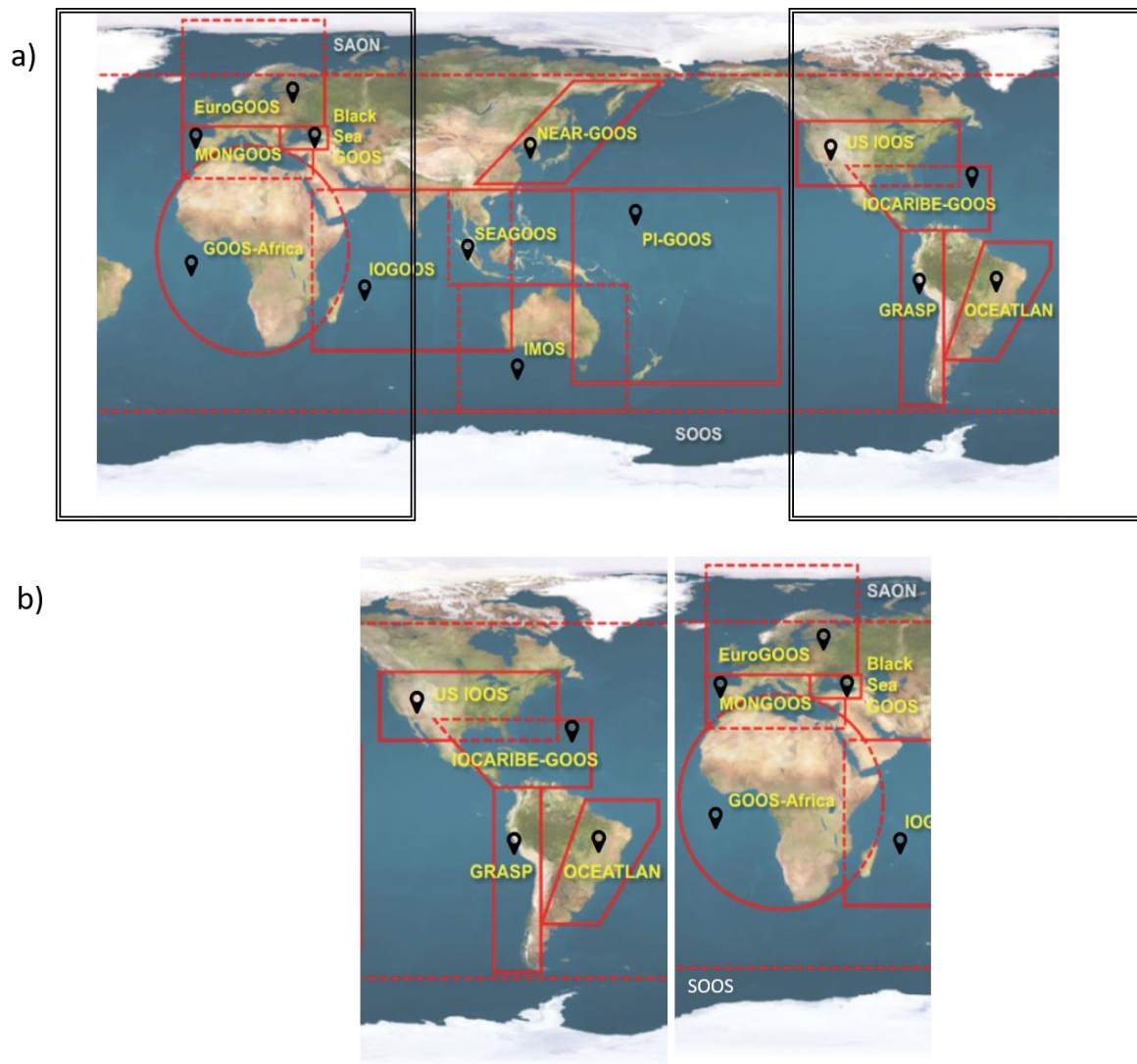


Figure 8. a) GOOS Global Regional Alliances (GRAs) b) GOOS GRAs rearranged to show those with a remit and coordination area in part of the Atlantic Ocean basin. This highlights the areas of the Atlantic Ocean that currently benefit from GOOS coordination through a GRA. It also highlights the large areas that lack a GRA area.

Historically, the Atlantic has never been a GOOS GRA by itself. In the early stages of EuroGOOS it tried to setup an Atlantic ROOS, but the EuroGOOS members was not ready to take the step at the time - building ROOS's for the European Regional Seas had higher priority. In light of the move towards a basin-scale strategy through a BluePrint for Atlantic Ocean Observing (*in prep*), there could be a rationale for GOOS to serve as a framework for developing closer cooperation across its existing GRAs, or even developing a new basin-scale governing framework for the future GOOS.

In a pan-Atlantic integrated ocean observation system, GOOS GRA efforts that are implementing the Framework for Ocean Observing (2012) could link with, and build on, other existing coordination structures in the North Atlantic focused more on observation and monitoring for Integrated Ecosystem Assessment. These include the **International Council for the Exploration of the Sea (ICES)** with 20 members spanning the North Atlantic and the Regional Sea Convention (RSC) for the Protection of the Marine Environment of the North-East Atlantic (**OSPAR**) which has 16 Contracting Parties with a mandate towards protecting and conserving the North-East Atlantic and its resources (see geographical coverage and regions in Figure 9 below).

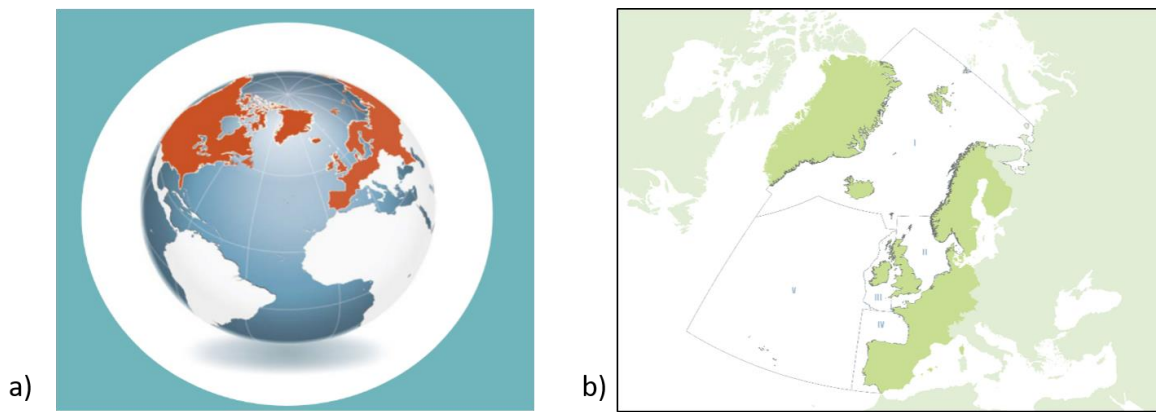


Figure 9. Geographical coverage of a) ICES based on its 20 members focused on the North Atlantic⁶² and b) OSPAR Regions in the North-East Atlantic with 16 Contracting Parties⁶³. Both initiatives offer frameworks and processes for regional ocean observation and monitoring e.g. for Integrated Ecosystem Assessments.

ICES and **OSPAR** both have mechanisms supporting the coordination of ocean observing and monitoring. This includes the ICES **Integrated Ecosystem Observation and Monitoring (IEOM)** Programme to establish integrated ecosystem observation and monitoring systems that enable coordinated data collection in support of scientific and advisory needs, and which have strong links with ICES, National centres and experts (ICES Implementation Plan, 2014).

ICES also has a central ICES Data Centre, based in the ICES Secretariat which manages a number of large dataset collections related to the marine environments of the Northeast Atlantic, Baltic Sea, Greenland Sea, and Norwegian Sea with data mainly originating from the national institutes of ICES Member Countries (ICES Implementation Plan, 2014). OSPAR serves as a crucial regional platform for nations to coordinate their marine and maritime activities, including coordinating actions in the North-East Atlantic and includes OSPAR's Data and Information Management System (OSPAR-ODIMS)⁶⁴ which draws on European Commission services and Research Infrastructures. The role of RSCs in MSFD implementation and interactions with other RSCs is further detailed in studies by Larkin *et al.* (2014) and von Homeyer *et al.* (2013).

In addition, the **Atlantic Ocean Research Alliance (AORA)** and related Coordination efforts, including the AORA CSA with a focus on implementing the Galway Statement for the North Atlantic, and the upcoming AANCHOR CSA to implement the Belém Statement and the South Atlantic, will most likely also play pivotal roles, potentially interacting through High Level Groups set up for each. In the mid-Atlantic, the Atlantic interactions initiative and related **AIR Centre** (AIR, 2018) could offer a role acting as a hub for ocean observing infrastructure coordination and to wider marine research.

3.3 Europe and the European Ocean Observing System

Over the past decade, there has been increased momentum and investment in Europe towards a more coherent and coordinated ocean observing value chain both within Europe and connected to global initiatives. These have been largely driven by marine science-policy developments, (see section 2 of this report) and currently include basin-scale projects to foster international science, innovation and cooperation e.g. H2020 AtlantOS for the Atlantic Ocean. Coordination and alignment in Europe is perhaps particularly needed because the proximity of so many individual nations with coastlines and sea territories has led to the development of numerous national observing and monitoring efforts, some just a few tens of nautical miles

⁶² <http://www.ices.dk/explore-us/who-we-are/Pages/Member-Countries.aspx>

⁶³ <https://www.ospar.org/convention/the-north-east-atlantic>

⁶⁴ <https://odims.ospar.org/>

apart, measuring similar parameters in largely similar oceanographic conditions and yet implemented completely separately by different nations. Such monitoring and observing systems for operational-, climate- and ecosystem health services are still predominantly financed by National funding as part of the **Nations Strategy for National Research Infrastructure Capability**.

The past 15-20 years has seen significant investment from the European Union e.g. through the Framework Programmes but also Interreg⁶⁵ and others, that has fostered the rapid development of coordination networks. These include platform-specific networks (e.g. EuroSITES and FixO3 for fixed-point observatories) and data management initiatives such as SeaDataNet, EMODnet and Copernicus *In situ* Thematic Assembly Centre (TAC), linking National, regional and platform specific marine data centres. Figure 10 shows just some of the complexity in European marine research infrastructure, wider ocean observation and data management efforts. This Figure and further information on European seas infrastructure (data, information and knowledge portals) and Atlantic coastal states marine infrastructure (data and information portals) is presented in ICES (2018a) as a European contribution to the trilateral activity on a cross Atlantic knowledge sharing platform and a deliverable of the AORA-CSA project, work package 11.

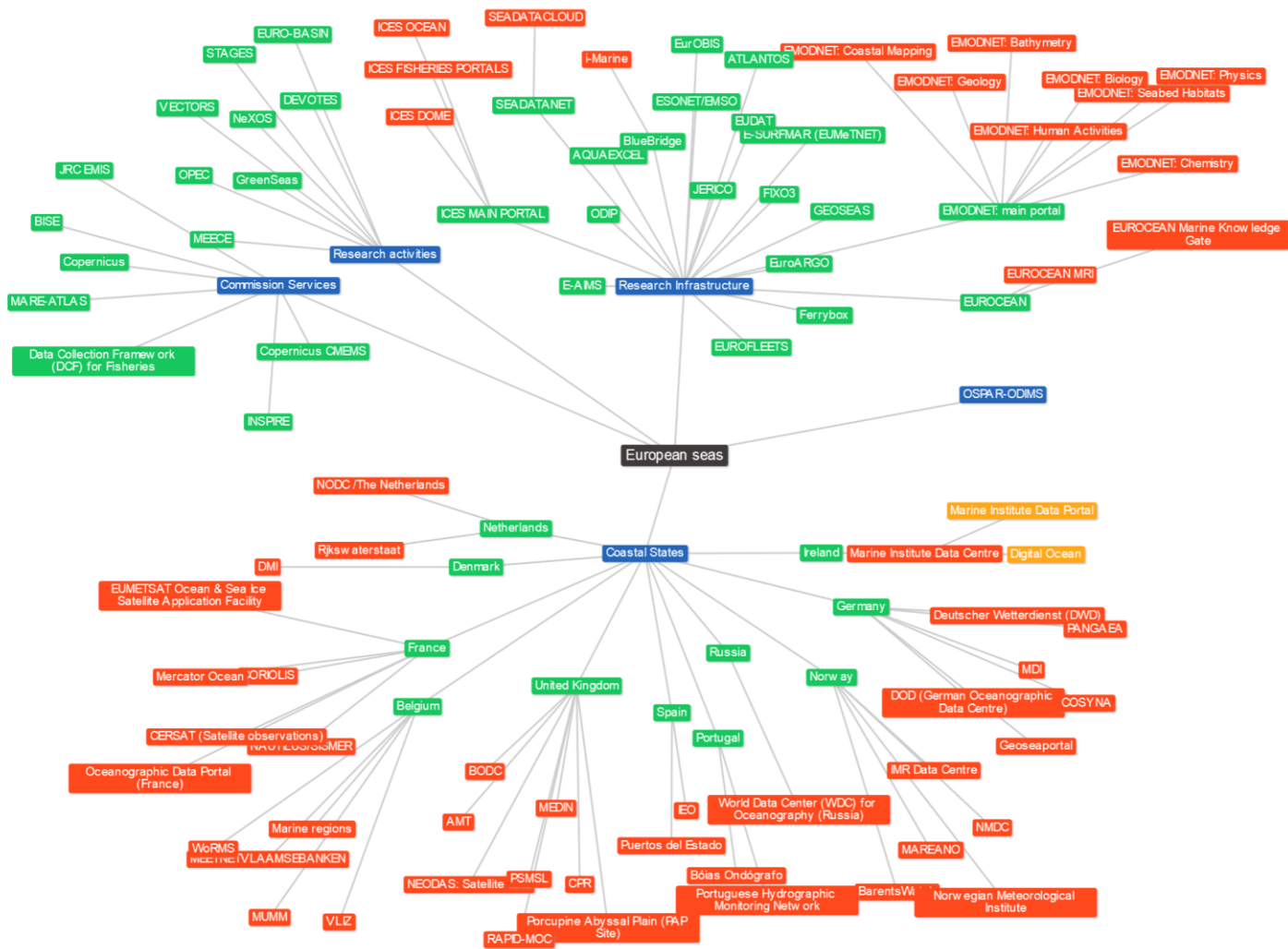


Figure 10. ICES European catalogue mapping the landscape diagram and explanation of European level organizations and platforms. It is noted these data reflect the landscape in May 2018 on publication of ICES (2018a), the data do not reflect current records in the catalogue. For acronyms and abbreviations, see acronym list in this report and in ICES (2018a). (From ICES, 2018a; Credit AORA and the Knowledge Sharing Platform).

⁶⁵ <https://www.interregeurope.eu/>



European
Ocean
Observing
System

The **European Ocean Observing System (EOOS)** is a coordinating framework designed to align and integrate Europe's ocean observing capacity; to promote a systematic and collaborative approach to collecting information on the

state and variability of our seas; and to underpin sustainable management of the marine environment and its resources. EOOS will contribute to the Global Ocean Observing System (GOOS), a contribution to sustained Earth observations and information (GEO).

EOOS is not a new observation network. It will not do what other networks do, but will strengthen coordination and dialogue between systems and networks (EOOS Strategy, *in prep*).

EOOS will focus on the *in situ* European ocean observation capability with observations taken directly in the water, seafloor or by airborne instruments. This includes the infrastructure and people required to deliver ocean observations and encompasses coastal, open ocean, deep sea and seafloor data collection efforts across a multidisciplinary, ecosystem approach.

Since coordination is particularly required within Europe, EOOS will focus on ocean observation efforts in European waters, and the Arctic Ocean and Atlantic Ocean as bordering sea basins of, set in the wider context of European capability worldwide.

EOOS will also take a broad and inclusive perspective in terms of types of observations and stakeholders included in its scope. Essentially, EOOS will take account of all systematic efforts to collect marine environmental data from the ocean. This includes highly automated physical observations, through geological information, bathymetric surveys, ocean chemistry, and biological data collection, most of which is not automated (e.g. fisheries surveys, benthic video footage, etc). It will include both real-time (or near real-time) and delayed modes of data collection and both research-driven and operational data collection (EOOS, 2016).

EOOS aims at adding value by providing a central focal point for strategy, stakeholder engagement and innovation across Europe's diverse ocean observation and monitoring communities. As an inclusive, voluntary federation, EOOS will contribute to global efforts in ocean observing such as GOOS⁶⁶ and GEOSS⁶⁷, and international policies including the UN 2030 Agenda for Sustainable Development and climate change agreements.

EOOS will continue the work of AtlantOS on a European basis, providing a coordination framework to take European Ocean Observing "*from a fragmented array of separate entities conducting routine monitoring to a dynamic "ecosystem" of collaborative, connected stakeholders, sharing best practices, data and ideas for future developments based on the latest societal drivers and technological and scientific advancements.*" (EOOS draft Strategy, *in prep*). The community framework aims to connect wider than GOOS, to include all European ocean observation and monitoring stakeholders from the diverse stakeholder communities including government agencies involved in environmental monitoring for National reporting to European legislation e.g. MSFD, to operational oceanographic implementers, coastal marine stations taking regular yet potentially not automated (e.g. biological ocean) observations, and industry as both a user and producer of ocean observation data. EOOS has developed as a community-driven framework led in the initial stages by EuroGOOS and EMB. Here, the vision, key focus areas, guiding principles and potential future governance are presented, based on stakeholder consultation and feedback.

The EOOS Vision is that, by 2030, "*EOOS will build a coordinated and connected European ocean observation community that puts user needs at its centre, promoting European leadership, driven by stakeholders, and*

⁶⁶ <http://www.goosocean.org/>

⁶⁷ www.earthobservations.org

serving the needs of science, society, and innovation.” (EOOS draft strategy 2018-2022). The EOOS framework is open and inclusive adding value to existing efforts across three focus areas:

- **Better Coordinated and Sustained *in situ* Ocean Observing**
EOOS will connect stakeholders across the ocean observing community with a focus on *in situ* observations, linked to remote sensing and modelling and to ensure full integration and responding to user needs.
- **Ocean Variables Relevant to Society**
EOOS will serve as a European focal point for systematic, long-term observation and monitoring as a forum to discuss, coordinate and implement international standards (e.g. Essential Ocean Variables and Essential Biodiversity Variables) and define European priorities for wider ocean variables. EOOS will promote innovative, adaptable ocean observing that can respond to evolving user needs, apply emerging technology and help invest in observations and big data initiatives.
- **Integrated Ecosystem Approach**
EOOS will promote multi-platform, integrated and thematic observing, which is crucial for sustainable management of the oceans, and to assess ecosystem health and functioning and the interfaces with climate and the wider earth system.

At its core, EOOS is about maximizing the value and benefit of European ocean observation, producing knowledge, goods and services to serve society. To achieve this, EOOS follows 6 guiding principles for its coordination efforts by being:

- **Efficient and fit-for-purpose** as an integral part of the global ocean and wider earth observation system;
- **Connecting communities**, coordinating efforts and engaging diverse stakeholders across ocean observing implementers, funders, and users from public and private sector research, operational oceanography, industry, and public authorities;
- **Inclusive**, promoting community-driven principles of open data, open science and Responsible Research and Innovation (RRI);
- **Innovative and adaptable**, adopting the Essential Ocean variables (EOVs) as part of a wider network of societally-relevant time-series for climate, operational oceanographic and wider ocean health;
- **Stakeholder-driven**, set in the context of a regular status reviews and bringing in the latest advancements in ocean observation and technology, including horizon scanning for future developments and opportunities; and
- **Sustainable**, helping secure long-term financial investment from multiple stakeholders towards sustainable management of the ocean.

At European level there has been substantial stakeholder consultation on strengthening coordination of end-to-end ocean observing and monitoring. Some stakeholders have explicitly named the added value they see from EOOS in their own documentation, including that “*strengthened coordination and stakeholder connection through EOOS can concretely assist countries to develop integrated surveys and observation/monitoring programmes as a result of ecosystem-based directive requirements e.g. MSFD*” (ICES Implementation Plan, 2014).

In extensive consultations between 2015-2018 European ocean observing stakeholders⁶⁸ called for a flexible, inclusive coordinating framework to align and integrate existing initiatives, indicating a preference for a bottom-up, flexible governance model with strong stakeholder involvement across multiple geographical scales, including at national level. They also highlighted the need to drive greater efficiency and value for money and move towards an EOOS that is fit-for-purpose to meet societal and scientific drivers and adaptable to meet evolving end user requirements and technological advancements. In terms of governance options for EOOS, stakeholder feedback has been broad; from a ‘light-touch’ EOOS where a steering group guides the development through the use of fora, implementation groups and advisory boards to the establishment of a secretariat to assist the implementation of EOOS in cooperation with the European

Commission and Member States. (Stakeholder's called for this in the mid to longer-term and this can be done in short-term as a distributed Secretariat).

The EOOS contribution to a future integrated Atlantic Ocean Observing System AtlantOS includes:

- EOOS will connect the whole of Europe with the Atlantic Ocean, including those countries with no Atlantic Ocean border;
- Common focal point for European capability and leadership in Research and Innovation in the Atlantic;
- Strategy and Best Practice;
- Capacity building, and
- Connects many stakeholder communities, place to pilot actions e.g. Technology Forum.

The European Strategy for Atlantic Ocean Observing serves as the European contribution to the international BluePrint for integrated Atlantic Ocean Observing. As it focuses on European capability and vision the European Strategy for Atlantic Ocean Observing can also inform EOOS developments at the Atlantic Ocean basin-scale.

4 TOWARDS EFFECTIVE COORDINATION AND GOVERNANCE FOR ATLANTIC OCEAN OBSERVING

4.1 Stakeholder engagement

There is growing move towards Responsible Research and Innovation⁶⁹ (RRI) engaging stakeholders (including wider citizens) throughout the process to co-define strategy and planning. This will be done through a regular implementation feedback cycle where users and data providers are routinely consulted to evaluate and update the user requirements and bring in the latest scientific and technological advancements, as well as consider evolving policy drivers. This was seen at an International level by the UN2030 agenda. Whilst the earlier Millennium Development Goals (MDGs) were essentially elaborated within the UN Secretariat, the new SDGs were agreed upon in a public and inclusive process that involved input from at least 70 governments as well as numerous representatives of civil society. This stakeholder engagement in co-design of the SDGs, together with the non-binding nature mean that strong stakeholder engagement and dialogue (e.g. with the research community) will be crucial in providing the knowledge for SDG indicators and measuring genuine progress (Biermann *et al.*, 2017).

RRI is promoted by the EOOS Strategy and underpins stakeholder engagement, including regular stakeholder consultations and events to provide a platform for stakeholder connection, sharing of best practice and to collect feedback on the EOOS development from a wide range of ocean observing implementers, funders and networks. Events taking place between 2015 and 2018 have informed the EOOS Strategy and Implementation Plan 2018-2022 (*in prep*). Knowledge transfer is essential to achieve effective dialogue and knowledge exchange across the science-policy-society interface (Larkin *et al.*, 2013)⁷⁰. The use of knowledge brokers for ocean observation will be considered as a mechanism for stakeholder engagement and knowledge exchange in implementing EOOS.

In terms of Atlantic stakeholder engagement, the Atlantic Action Plan (EC, 2013) states that to strengthen governance of the action plan the Atlantic Strategy Group (ASG) should consolidate alliances between members, while leaving enough flexibility and scope for giving a voice to regional or local stakeholders, including regional and local authorities, business and members of civil society. For this reason, an 'ecosystem' of stakeholders and contributing organizations is perhaps the most appropriate to achieve buy-in from the wider community leading to greater use, societal benefit and, ultimately, sustainability. The 2017 mid-term

⁶⁹ MARINA Responsible Research and Innovation (RRI) EU project <https://www.marinaproject.eu/>

⁷⁰ https://www.stagesproject.eu/images/STAGES/deliverables/STAGES_D4.2.pdf

review of the Atlantic Action Plan (EC, 2018) outlined the need to catalyse intelligent collaboration between research networks, technology platforms and private investors on both sides of the Atlantic with a view to implementing the agreed priorities and actions. A number of organizations are working increasingly at the science-industry interface for ocean observation including EuroGOOS (2016) and EMODnet for Business⁷¹ which identify the added value to the blue economy and private sector and how to link closer with wider stakeholders from business to environmental monitoring.

Stakeholder engagement is also a crucial cross-cutting component of the AtlantOS project. Key objectives of the AtlantOS project include developing results-oriented dialogue with key stakeholder communities and engaging a wide range of interested organizations and individuals over the course of AtlantOS. The AtlantOS project has also recognized that creating better synergies among different systems and stakeholders to provide more effective, fit-for-purpose ocean observation has been identified by a number of studies (Fritz *et al.*, 2016a, AtlantOS Stakeholder Engagement Plan v1; Liebender *et al.*, 2016, AtlantOS D10.4). This same report refers to the illustrative value chain of sustained ocean observing systems (see Figure 11). Key stakeholders and users should be re-considered when looking at the key components and most effective coordination and governance.

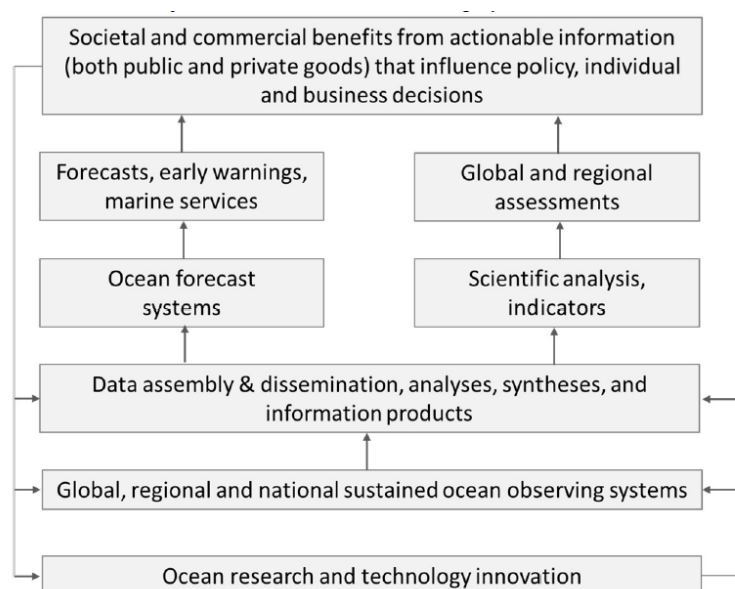


Figure 11. Illustrative value chain of sustained ocean observing systems (from Liebender *et al.*, 2016; adapted from Rayner (2016)).

AtlantOS Deliverable D10.5 (“Best practices in stakeholder engagement, data dissemination and exploitation (Martín Míguez *et al.*, 2016) highlighted the value of online stakeholder engagement platforms, potentially provided by marine data portals. As a result, taking advantage of the links with EMODnet, AtlantOS Task 10.3 explored the possibility of using the EMODnet Central Portal to provide dedicated community information for Atlantic stakeholders to support stakeholder engagement and user uptake of Atlantic marine data and observations. As a result, an Atlantic Community Page⁷² (see Figure 12) within EMODnet Central Portal has been developed as a pilot test phase. It shows the potential for this Atlantic Community Page to serve as a hub for linking and exchanging information with potential users of AtlantOS outputs and could potentially become a support facility for the project and wider stakeholders in the future (Martín Míguez *et al.*, 2016 and Martín Míguez *et al.*, 2018).

⁷¹ <http://www.emodnet.eu/emodnet-business-brochure>

⁷² <http://www.emodnet.eu/atlantic-1>

These could be linked to developments as part of the Atlantic Ocean Research Alliance (AORA) towards a shared, cross-stakeholder Knowledge Platform, which includes a catalogue of European marine research infrastructures (ICES, 2018a) and could be linked with activities developing in the South Atlantic coordination through the AANChOR Coordination Support Action.

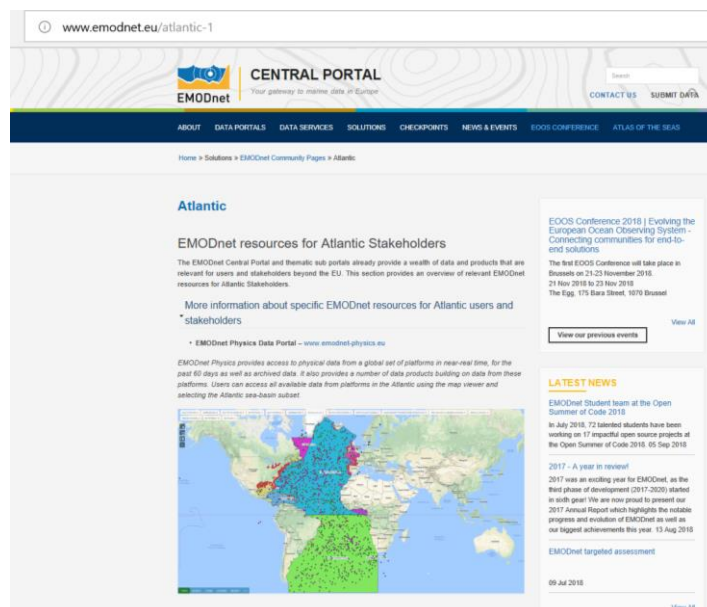


Figure 12. Atlantic Community Page⁷⁷ developed for EMODnet Central Portal as a contribution to AtlantOS (Deliverable 10.8)

4.2 Ocean Observing Implementation Cycle

In Europe, the EOOS Implementation Plan (2018-2022) (*in prep.*) outlines six thematic areas: (i) mapping and stakeholder engagement, (ii) policy context and foresight, (iii) implementation, (iv) funding, (v) communications, and (vi) governance. For each thematic area the plan suggests concrete activities. An EOOS implementation cycle outlines the key steps in the implementation process. This has been adapted to include AtlantOS outputs to show the contribution of AtlantOS to various coordination activities of an Atlantic Ocean Observing System.

The AtlantOS project has delivered an advanced framework for the development of an integrated Atlantic Ocean Observing System that goes beyond the state-of-the-art, and can be sustained and further developed after the lifetime of AtlantOS. Some key AtlantOS deliverables and outputs are mapped in Figure 13 onto the ocean observing implementation cycle to show how AtlantOS has contributed to key components of ocean observation system implementation. To create a functioning ocean observing system implementation cycle it would be important to assess how regular each of these activities should be and which organizations or initiatives could actively contribute in the longer-term.

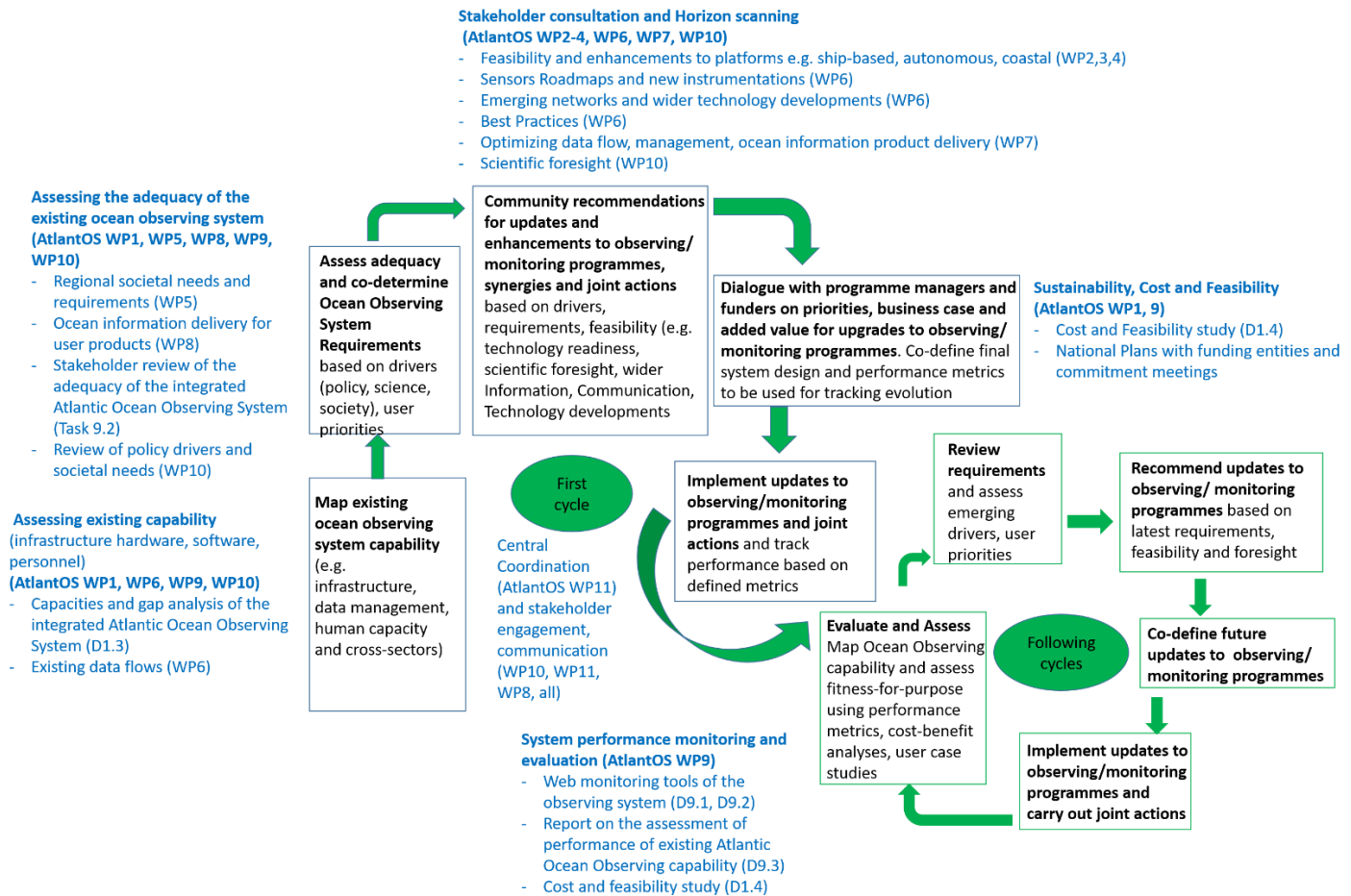


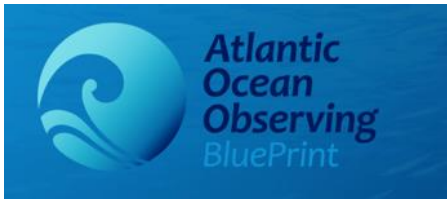
Figure 13. A potential implementation cycle for an Ocean Observing System Implementation, outlining crucial components and steps, with some AtlantOS outputs mapped for each step. This is adapted from a Figure produced for EOOS which proposes a 5-year cycle with key components including mapping existing capability, co-determining ocean observing system requirements, assess community recommendations for updates to the observing/monitoring design, dialogue with programme managers and funders, implementation of agreed updates to observing system design and evaluation including tracking performance using metrics. Cross-cutting and intrinsic to each step are stakeholder engagement, dialogue and co-design; Communication and societal engagement; and Governance and Coordination.

4.3 Atlantic Ocean Observing coordination and governance components

4.3.1 Blueprint for Atlantic Ocean Observing components

As seen in Sections 2 and 3 of this report there is a multitude and diversity of policy drivers, coordination and governance that currently exists internationally and that a future integrated Atlantic Ocean Observing System needs to align with, strengthen and, where possible, develop innovative methods and partnerships.

Just as the Atlantic Action Plan is seen as an overarching frame of reference for policymakers, maritime operators and investors in the Atlantic area (EC, 2018), so could a future Blueprint for Atlantic Ocean Observing provide an overarching framework for Atlantic Ocean Observing stakeholders.



When considering potential components and mechanisms for the future coordination and governance of an Atlantic Ocean Observing System it is important to consider the draft Blueprint for integrated Atlantic Ocean Observing (*in prep.*) which contains a section (6) on coordination and governance. This specifies that “*in approaching governance at the basin scale, spanning the Atlantic, we must*

recognize that there are already many programs with some form of governance.....It is therefore a pragmatic challenge as to how to move forward building upon existing structures so that we do not waste effort by working to ‘reinvent the wheel’ but at the same time ensure that we follow the key principles that are needed to ensure sustainability.” (Blue Print for Atlantic Ocean Observing, *in prep*)

This section looks at potential governance mechanisms, building on those proposed in the Blueprint for Atlantic Ocean Observing (*in prep*), and assessing the roles of existing and emerging networks and initiatives in the future governance and coordination. This is based on the recognition that many good networks already exist with a variety of mandates and geographical scales (see section 3) and that added value can be achieved mainly through defining clear contributions of existing initiatives, leading to better alignment, and fostering stakeholder engagement and new and dynamic connections and partnerships that will, ultimately strengthen both the coordination and governance of Atlantic Ocean Observing, together with its longer-term sustainability.

In stakeholder discussions and consultation, AtlantOS has recognized that successful governance structure for the Atlantic Ocean Observing System should have an appropriate political and legal governance framework and a functional institutional setting⁷³. But what could a future governance system look like and how can we build on existing initiatives? The Blueprint for Atlantic Ocean Observing proposes key components and mechanisms of a future observing system governance as:

- **A coordinating mechanism** that spans three dimensions: the observing system, resource engagement, and ocean information delivery. A single supervisory body with a clear coordination structure of the different subgroups should cover the three dimensions;
- **A Resource Board** to promote long-term funding for the ocean observing community;
- **An Ocean Partnership Panel** to inform the ocean observing community about the role of ocean data and products as well as their societal benefit;
- A regular **review process** of the adequacy of the different ocean observing activities and programmes as well as the requirements needed – perhaps every second year over the coming 6 years while the integrated system is being build, followed by 3 to 5 years’ intervals (this would ensure long-term support and sustainability of the system); and a
- **National Ocean Focal Point** within each of the ocean states, so that oceans could be managed more directly.

It is noted that this report does not comment on the Resource engagement and wider sustainability issues. AtlantOS Work Package 9 is working on a number of mechanisms to develop this, including a review process in Task 9.2. This will inform developments towards a regular review process for the Atlantic Ocean Observing System including:

- Develop a coordinated, more efficient, more integrated, and fit-for-purpose observing system
- Identify long-lasting and sustainable contributions to the societal, economic and scientific benefits
- Develop background material for national authorities to facilitate decision-making processes regarding resource mobilizations for observations in the Atlantic Ocean
- Strengthen pan-Atlantic view on current (and future) national Atlantic Ocean observation activities

⁷³ AtlantOS Town Hall meeting February 2018, Ocean Sciences

In the following section, the coordinating mechanisms of the ocean observing system (see also Figure 12 above) and ocean information delivery are briefly discussed. This includes examples of existing organizations are identified that are already working in these areas that could, potentially, contribute to coordination activities in the future. It is emphasized that these are proposals based on reviews of the literature and some stakeholder consultation but they may not reflect the views of the organizations. In addition, as stated in the Introduction, this report has a focus on European contribution to the Atlantic and therefore includes more European-led initiatives, as a contribution to the European Strategy on Atlantic Ocean Observing.

Coordinating mechanism

The BluePrint for Atlantic Ocean Observing outlines that a single supervisory body could oversee the pan-Atlantic coordination, with sub-groups or activities in the areas of the observing system, resource engagement, and ocean information delivery. This could indeed be a central coordination, building on existing structures such as GOOS (and G7 GOOS coordination developments), JCOMMOPS and AORA coordination efforts. In addition, a distributed Secretariat across North and South Atlantic countries with “hubs” for specific activities could be considered to strengthen cooperation and governance across regions.

In addition, the costs for the coordination and support activities themselves are not often considered but are an important factor if an effective coordination and governance is to be implemented. For example, there have been numerous studies to assess the cost of ocean observing system infrastructure (e.g. capital costs of the initial equipment/infrastructure investment e.g. purchasing sensor, mooring line, ARGO float) and the running costs e.g. maintenance). These all range in scope, with some focusing on particular ocean observing system infrastructure platforms (e.g. Cristini and Lampitt, 2017) or geographical scope (e.g. EC, 2017 for EOOS; Reilly *et al.*, 2018 for the Atlantic).

However, AtlantOS produced a report of ocean observing costs and benefits specific to the Atlantic Ocean (Reilly *et al.*, 2018, AtlantOS D1.4). This provides an overview of the support and coordination costs associated with running the JCOMM *In Situ* Observations Programme Support Centre (JCOMMOPS), which offers a range of coordination support for global ocean observing activities. These costs are not often included in the analysis of ocean observing system costs since these are not tangible costs for the capital investment or running/maintenance costs. As noted in AtlantOS D1.4. coordination and support costs are nonetheless “*a vital component of the ocean observing networks*”. The 2016 JCOMMOPS operational budget was costed at US\$667,000 per year (approx. €574,093 per year). It is noted this is for coordination of a number of ocean observing platform networks at international level. The Atlantic Ocean represents, for a global network such as Argo, 20% of the yearly global effort. It can therefore be approximated that the cost of operating JCOMMOPS in support of Atlantic ocean implementation with 20% of the total, i.e. \$133,400 or ~115,000 Euros (Mathieu Belbeoch, JCOMM-OPS, *pers. comm.*). It is noted that there are other platforms outside of the JCOMM OCG network for which the coordination costs are not included, so this is likely to be an under-estimation of the full coordination costs required but serves as an illustration of some initial studies to cost coordination activities of ocean observing systems.

4.3.2 Observing System

Figure 13 outlines a number of steps in the observing system implementation. Here, a few activities are highlighted that are crucial to inform the evaluation and evolution of an observing system, with examples from the AtlantOS project and wider community. This aims to serve as input to discussions on how to move towards a more regular, cyclical implementation where foresight activities are used as input to setting of requirements and performance tracking and evaluation of the ocean observing system become regular coordination activities. It is also noted that best practices in ocean observing is also a growing field and it will be increasingly important to harness the many important outputs e.g. methodologies and standards from individual projects and initiatives into centralized portals such as the **IOC/IODE Ocean Best Practices Repository**⁷⁴.

⁷⁴ <https://www.oceanbestpractices.org/>

Scientific foresight and the advisory process

For an ocean observing system to be “future-proof” it must remain relevant, evolving to meet new user requirements and needs, but also responding to the latest scientific, technological and wider societal developments. Engaging scientific experts in foresight activities is crucial to provide sound scientific and business advice, perform horizon scanning on future trends in science and technology for ocean observation (e.g. Benedetti-Cecchi *et al.*, 2018) and identify scientific knowledge gaps. A number of organizations work at the marine science-policy interface, notably ICES at an International level and EMB, JPI Oceans and EuroGOOS at a European level⁷⁵. A future coordination activity of an Atlantic Ocean Observing System could foster existing and new partnerships across various organizations, in Europe and beyond, towards a regular process for foresight inputs across different scientific and technological themes.

Performance tracking and evaluation

The mid-term review of the Atlantic Action Plan (2018) identified the lack of a monitoring framework as one of the key weaknesses of the action plan and pointed to the need to establish a set of key performance indicators relevant to the Atlantic coastal regions in order to measure progress in its implementation. Currently each observing system has its own metrics and indicators. Some are extremely well developed e.g. ARGO free-drifting profiling floats⁷⁶, some are at an embryo state (mainly because network have not enough metadata available and no target defined).

The AtlantOS project has progressed web applications and use of performance metrics, developing international (Belbéoch and Lizé, 2017, AtlantOS Deliverable 9.1)⁷⁷ and European (Novellino, *et al.*, 2017, AtlantOS Deliverable 9.2)⁷⁸. These web monitoring tools offer more interactive web experiences to monitor the performance of the ocean observing systems (see Figure 14 below). The European tool is based on the EMODnet Physics dashboard, EuroGOOS ROOSes. and web interfaces Novellino *et al.*, (2017) state that: *“the creation of a monitoring tool for Atlantic Observing is a critical element for Europe to show its ambition to take on a leadership role. European Member States can immediately find out what part of the observing system they are supporting and how their investment is leveraged by similar contributions by other countries and regions”*.

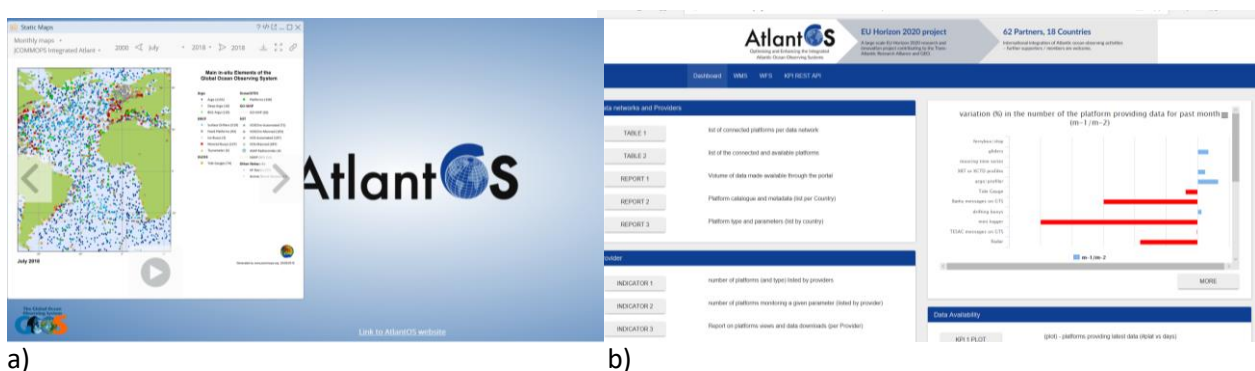


Figure 14. AtlantOS supported ocean observing web monitoring tools a) International tool by JCOMMOPS⁶⁹ b) European tool by EuroGOOS using the EMODnet Physics Dashboard⁷⁰

JCOMMOPS who led the international web monitoring tool identify a number of Key Performance Indicators (KPIs) to assess performance across a number of indicators including: Implementation, Data Flow, Instrumentation, Operations, Data Uptake, and International (Diversity). Through this, JCOMMOPS are building a number of integrated Key Performance Indicators (KPIs) and some are available for AtlantOS. Vocabulary is harmonized but algorithms of calculation can still vary across networks and standardization of

⁷⁵ www.marineboard.eu

⁷⁶ <http://www.jcommops.org/board/wa/KpisModule?t=Argo>

⁷⁷ <http://www.jcommops.org/board/?t=atlantos&contacts=%7B%22query%22%3A%22def%22%7D>

⁷⁸ <http://www.emodnet-physics.eu/atlantos/dashboard/Default.aspx>

metadata is also needed. In the future, performance metrics are also expected to move away from the network perspective and develop EOVI integrated metrics versus specific requirements. (Mathieu Belbeoch, *pers. comm.*). Belbeoch and Lizé *et al.* (2017) also note “It will also be important to engage organizations that can develop and track Performance Metrics to monitor the health of each observing system, detect gaps and weaknesses, and highlight successes, along their evolution from a pilot project to a sustained observing network”.

Towards regular annual reporting on the state and health of the Atlantic Ocean

Better coordination of ocean observation systems, together with open access to data, products and services allows regular assessment of the ocean information available and what it can tell us about the state and health of the Ocean. At a national level, the United Kingdom Marine Climate Change Impacts Partnership (MCCIP)⁷⁹ brings together scientists, government, its agencies and NGOs to provide coordinated advice on climate change impacts and adaptation around the UK coast and in the surrounding seas, including regions in the North Atlantic Ocean and Arctic Ocean. Since 2006 this initiative has produced annual report cards⁸⁰ on the state and health of our seas and oceans and the link between climate change impacts on the oceans.

In the past two years, JCOMM and CMEMS have developed Ocean Report Card (JCOMM) and Ocean State Reports respectively (see Figure 15 below). These initiatives could be extended to produce basin-specific Report Cards e.g. for the Atlantic Ocean Basin, and potentially link with other organizations to include wider observation and monitoring by the private sector.



Figure 15. The JCOMM Ocean Observing System Report Card 2018 (left) and the Copernicus Marine Environment Monitoring Service (CMEMS) Ocean State Report (right). These serve as comprehensive and state-of-the-art assessment of the state of the global ocean (including for CMEMS the European regional seas) for the ocean scientific community as well as for policy and decision-makers.

4.3.3 Ocean information delivery

There are a number of ongoing developments in Atlantic Ocean information portals that could be built upon, and aligned, as part of future Atlantic Ocean observing ocean information delivery and wider stakeholder engagement. In terms of data management, access and delivery, it would also be important for any Atlantic “hub” to further link European initiatives such as EMODnet, other regional efforts e.g. OSPAR-ODIMS and ICES Data Centre (see section 3.2 in this report for more information on both these initiatives). Relevant international developments include GEOSS and the GEOSS data portal built on a Global Common Infrastructure. The CMEMS⁸¹ and the GEO Blue Planet initiative have also built a good connection to the user and wider stakeholder community which could be built upon, together with best practice from regional ocean observing systems e.g. EuroGOOS, IMOS, IOOS. Effective ocean information delivery should link with

⁷⁹ <http://www.mccip.org.uk/>

⁸⁰ <http://www.mccip.org.uk/impacts-report-cards/full-report-cards/>

⁸¹ <https://insitu.copernicus.eu/FactSheets/CMEMS/>

stakeholder engagement mechanisms including the Atlantic Community page being developed by the EMODnet Central Portal, through the AtlantOS project (Martín Míguez, *et al.*, 2018) and the Atlantic Ocean Research Alliance (AORA) developments towards a shared, cross-stakeholder Knowledge Platform (see in sections 3.2 and 4.1 in this report for more information).

An Ocean Partnership Panel, as proposed by the Blue Print for Atlantic Ocean Observing (*in prep.*) could bring all these initiatives together to find the most effective way to inform the ocean observing community about the role of ocean data and products as well as their societal benefit.

5 CONCLUSIONS

Over the course of the AtlantOS project there has been increasing recognition of the need for effective coordination and governance in ocean observing systems both in the Atlantic Ocean and beyond. This is set to continue as the political interest in the ocean increases and the societal need for the ocean as a resource increases along with the need for sustainable management. This report aims to inform and contribute to discussions in Atlantic and wider ocean observation coordination and governance. This report (D10.11) has a particular focus on ocean observation coordination and governance in the context of European, Atlantic and global science-policy drivers. It presents the marine and wider environmental science-policy landscape and how this has shaped (and is shaping) ocean observation. It also looks at current developments in ocean observation coordination and governance, noting the importance of stakeholder engagement and dialogue in the full ocean observing implementation cycle and building on existing organizations and initiatives to assess how a variety of mechanisms could be used in the future governance of an integrated Atlantic Ocean observing system.

This report is aimed at European and international ocean observation stakeholders both within and beyond the AtlantOS network, in particular those involved in the programming and planning of ocean observing systems but also the wider marine science community. It also aims to inform policy makers of the latest developments in ocean observation coordination and provide input to future planning of research agendas and financing of ocean observation coordination in the Atlantic Ocean and beyond.

It shows that any future coordination and governance mechanism will at some level require the developments of a dynamic and dedicated group of actors and activities with a coordinating unit: potentially a combination of a lead single entity and a distributed coordination – potentially across North and South Atlantic – that each lead one of the three components of observing system, resource engagement and ocean information delivery activities. The implementation cycle will require a regular process, considering a number of organizations and actors together with RRI and stakeholder engagement. The report highlights the wealth of activities already ongoing, the best practice that could be drawn from existing organizations e.g. from GOOS, EuroGOOS and projects e.g. AtlantOS, and the various expertise of different existing organizations that could play a role in the future coordination and governance. It will also be important to consider links with wider environmental e.g. climate science through GCOS reporting to the UNFCC to co-plan a climate focus to global ocean observing.

It is intended that this report inform discussions on policy drivers for ocean observation, the marine science-policy interface, and contribute to discussions and planning in ocean observation coordination and governance for the Atlantic Ocean Observing System, most notably the European Strategy for Atlantic Ocean Observing as a basin-scale contribution to EOOS and as a European contribution to the BluePrint (*in prep.*).

ANNEX 1: GLOSSARY OF ACRONYMS AND TERMS

AANCHOR CSA	All AtlaNtic Cooperation for Ocean Research and innovation Coordination Support Action (European H2020 project, starting October 2018 - 2022)
AIR	Atlantic International Research Centre
AORA	Atlantic Ocean Research Alliance
AORA CSA	Atlantic Ocean Research Alliance Coordination Support Action (European H2020 project, 2015-2020)
ASG	Atlantic Strategy Group
BCLME	Benguela Current Large Marine Ecosystem
CFP	Common Fisheries Policy
CMEMS	Copernicus Marine Environment and Monitoring System
COFASP	Cooperation in Fisheries, Aquaculture and seafood processing
CSA Oceans	A European Framework Programme 7 funded Coordination and Support Action to support JPI Oceans in its start-up phase
DFO	Department of Fisheries and Oceans, Canada
DG MARE	European Commission Directorate-General of Maritime Affairs and Fisheries
DG RTD	European Commission Directorate-General for Research and Innovation
EATiP	European Aquaculture Technology and Innovation Platform
EBV	Essential Biodiversity Variable
EC	European Commission
ECMWF	European Centre for Medium-Range Weather Forecasts
EEA	European Environment Agency
EFARO	European Fisheries and Aquaculture Research Organisations
EMB	European Marine Board
EMODnet	European Marine Observation and Data Network
EMSO ERIC	European Multidisciplinary Sea Observatory ERIC
EOOS	European Ocean Observing System
EOV	Essential Ocean Variable

eEOV	Ecology Essential Ocean Variable
ERA-NET	European Research Area Net
ERIC	European Research Infrastructure Consortium
ESFRI	European Strategy Forum on Research Infrastructures
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
Euro-Argo ERIC	European infrastructure for the Argo programme
EuroGOOS	European Global Ocean Observing System
GCOS	Global Climate Observing System
GEOTRACES	An International Study of the Biogeochemical Cycles of Trace Elements and their Isotopes
GES	Good Environmental Status
GEOSS	Global Earth Observation System of Systems
GIS	Geographic Information Service
GOSIC	Global Observing Systems Information Center (GOSIC)
GOOS	Global Ocean Observing System
GRA	Global Regional Alliance (of GOOS)
HLPF	High-level Political Forum on Sustainable Development (HLPF)
IAOOS	Integrated Atlantic Ocean Observing System
ICES	International Council for the Exploration of the Sea
ICEMASA	International Centre for Education, Marine and Atmospheric Sciences over Africa
ICSU	International Council for Science
IEOM	Integrated Ecosystem Observation and Monitoring (IEOM)
IOC	Intergovernmental Oceanographic Commission
IMOS	Integrated Marine Observing System
IMP	Integrated Maritime Policy (European Union)
INSPIRE	INfrastructure for SPatial Information (European Union Directive)
IOC	Intergovernmental Oceanographic Commission (of UNESCO)
IODE	International Oceanographic Data and Information Exchange (of IOC)
IOOS	Integrated Ocean Observing System (U.S.)

IPCC	Intergovernmental Panel on Climate Change
JCOMM	Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology
JPI Oceans	Joint Programming Initiative on Healthy and Productive seas and oceans
MBON	Marine Biodiversity Observation Network
MCCIP	United Kingdom Marine Climate Change Impacts Partnership (MCCIP)
MDG	Millennium Development Goal
MMRS	EU Strategy for Marine and Maritime Research
MSFD	Marine Strategy Framework Directive (European Union Directive)
MSP	Maritime Spatial Planning
MPA	Marine Protected Area
NGO	Non-Governmental Organization
NOAA	National Oceanic and Atmospheric Administration
OECD	Organisation for Economic Co-operation and Development
OGC	Open Geospatial Consortium
ODP	Ocean Data Portal
OSPAR	Oslo and Paris Commission. Regional Sea Convention for the Protection of the Marine Environment of the North-East Atlantic
OSPAR-ODIMS	OSPAR's Data and Information Management System
OTN	Ocean Tracking Network
POGO	Partnership for Observation of the Global Ocean
RSC	Regional Sea Convention
ROOSE	Regional Ocean Observing System (of GOOS)
PIRATA	Prediction and Research Moored Array in the Atlantic
RFM	Regional Fisheries Management
RRI	Responsible Research and Innovation
SAMOC	South Atlantic Meridional Overturning Circulation
SA MRECO	South Atlantic Patterns and Processes of the Ecosystems of the Southern Mid-Atlantic Ridge
SAON	Sustaining Arctic Observing Networks
SCI	Sites of Community Importance (EU Habitats Directive)
SDG	Sustainable Development Goal
SEAS-ERA	Towards integrated European marine research strategy and programmes (European FP7 project 2010-2014)

SFPA	Sea Fisheries Protection Authority
SME	Small and Medium-sized Enterprises
SOCCO	Southern Ocean Carbon and Climate Observatory
SOLAS	Surface Ocean Lower Atmosphere Study
SOOS	Southern Ocean Observing System
SRIA	Strategic Research and Innovation Agenda
TAC	Thematic Assembly Centre
TPOS	Tropical Pacific Observing System
UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCC	UN Framework Convention on Climate Change
WCRP	World Climate Research Programme
WFS	Web Feature Service
WMO	World Meteorological Organization
WMS	Web Map Service
WS	Wild Species
WTP	Waterborne Technology Platform

ANNEX 2: REFERENCES

Adams *et al.* (2000), "The economics of integrated sustained ocean observations (ISOOS): Benefits and rationale for public funding", NOAA/ONR, 53 pp.

AIR Centre Implementation Status v6 (17 August 2018; from José Luiz Moutinho (*pers. comm.*))

Belbéoch and Lizé (2017). Web based monitoring tool of the Atlantic ocean observing system (international). AtlantOS deliverable D9.1. <https://www.atlantos-h2020.eu/project-information/work-packages/deliverables/> Desktop-like application: <http://www.jcommops.org/board/?t=atlantos&contacts=%7B%22query%22%3A%22def%22%7D>

Belbéoch, M., Viola, H., Freeland, H., Clark, C., Meldrum, D., Charpentier, E., Alverson, K., Dexter, P., Fellous J-L (2009). The JCOMM in situ observing programme support centre: A decade of process and remaining challenges. Community White Paper for OceanObs'09. <http://www.oceanobs09.net/proceedings/cwp/Belbeoch-OceanObs09.cwp.04.pdf>

Benedetti-Cecchi, L., Crowe, T., Boehme, L., Boero, F., Christensen, A., Grémare, A., Hernandez, F., Kromkamp, J. C., Nogueira García, E., Petihakis, G., Robidart, J., Sousa Pinto, I. & Zingone, A. (2018) Strengthening Europe's Capability in Biological Ocean Observations. Muñiz Piniella, Á., Kellett, P., Larkin, K., Heymans, J. J. [Eds.] Future Science Brief 3 of the European Marine Board, Ostend, Belgium. 76pp. ISBN: 9789492043559 ISSN: 2593-5232 <http://marineboard.eu/file/871/download?token=kiwyAFQX>

Biermann, F., Kanie, N., Kim, R.E. (2017). Global governance by goal-setting: the novel approach of the UN Sustainable Development Goals. *Current Opinion in Environmental Sustainability* 2017, 26-27:26–3

BluePrint for an Integrated Atlantic Ocean Observing System Vision document and Implementation Plan (*in prep*) Editors: deYoung *et al.* atlanticblueprint.net/

Buch, E. *et al.*, 2018. AtlantOS Legacy document https://www.atlantos-h2020.eu/download/relevant_documents/ATLANTOS-LEGACY_April2018.pdf

Coroner, F., Masset, J-F., Cappelletto, M., de Bernardis, E., Palazzo, N (2014). Mapping and preliminary analysis of infrastructures, observation/data and human capacity building. JPI-Oceans CSA Deliverable D6.1 <http://www.vliz.be/imisdocs/publications/258549.pdf>

Cravatte, S., W. S. Kessler, N. Smith, S. E. Wijffels, and Contributing Authors, 2016: First Report of TPOS 2020. GOOS-215, 200 pp. [Available online at <http://tpos2020.org/first-report/>].

Cristini and Lampitt (2017) Cost-benefit analysis report for the Fixed Point Open Ocean Observatories (FixO3) Network <http://www.fixo3.eu/download/Deliverables/D6.6%20Cost-benefit%20analysis%20report.pdf>

EASME (2018) Study on costs, benefits and nature of an extended European Ocean Observing System <https://publications.europa.eu/en/publication-detail/-/publication/068f4460-1851-11e8-ac73-01aa75ed71a1/language-en/format-PDF/source-66154304>

European Commission (2018). SWD(2018) 49 final. Commission Staff Working Document on the mid-term review of the Atlantic action plan. https://ec.europa.eu/maritimeaffairs/sites/maritimeaffairs/files/swd-2018-49_en.pdf

European Commission (2017) SWD(2017) 128 final. Report on the Blue Growth Strategy: Towards more sustainable growth and jobs in the blue economy. Commission staff working document. https://ec.europa.eu/maritimeaffairs/sites/maritimeaffairs/files/swd-2017-128_en.pdf

European Commission (2016) JOIN(2016) 49 final. International ocean governance: an agenda for the future of our oceans. Joint Communication to the European Parliament, the Council and European economic and social committee and the committee of the regions https://ec.europa.eu/maritimeaffairs/sites/maritimeaffairs/files/join-2016-49_en.pdf

European Commission (2013a) Final report of the expert group on Marine Research Infrastructure <https://webgate.ec.europa.eu/maritimeforum/en/node/3158>

European Commission (2013b). COM (2013)279 final. Action Plan for a Maritime Strategy in the Atlantic Area: delivering smart, sustainable and inclusive growth <http://ec.europa.eu/transparency/regdoc/rep/1/2013/EN/1-2013-279-EN-F1-1.Pdf>

European Commission (2012b). COM(2012) 494 final. Blue Growth opportunities for marine and maritime sustainable growth. <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52012DC0494&from=EN>

European Commission (2012a) COM(2012) 473 final Green Paper on Marine Knowledge 2020: From seabed mapping to ocean forecasting https://ec.europa.eu/maritimeaffairs/sites/maritimeaffairs/files/docs/body/marine-knowledge-2020-green-paper_en.pdf

European Commission (2011). COM(2011) 782 final. Developing a Maritime Strategy for the Atlantic Ocean Area. Communication from the Commission to the European Parliament, the Council, the European Economic and social committee and the committee of the regions. <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0782&from=EN>

European Commission (2007). COM(2007) 575 final. An Integrated Maritime Policy for the European Union https://ec.europa.eu/maritimeaffairs/policy_en

European Commission (2008a). 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) (Text with EEA relevance) <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0056>

European Commission (2008b). Com(2008) 534 final. EU Strategy for Marine and Maritime Research
EU Strategy for Marine and Maritime Research
EOOS (2016) EOOS Consultation Document. http://www.eoos-ocean.eu/download/promotional_materials/EOOS_ConsultationDocument_02.12.2016.pdf

EOOS Strategy 2018-2022 (*in prep*) http://www.eoos-ocean.eu/download/EOOS-Strategy_Dft-v24April.pdf

EOOS Implementation Plan (*in prep*) <http://www.eoos-ocean.eu/download/EOOS-Implementation-Plan-Dft-v-240418.pdf>

EOOS Consultation Document 2016. EuroGOOS-European Marine Board, Brussels http://www.eoos-ocean.eu/download/promotional_materials/EOOS_ConsultationDocument_02.12.2016.pdf

EuroGOOS (2014) EuroGOOS Strategy 2014-2020.

<http://eurogoos.eu/download/publications/EuroGOOS-Strategy-2014-2020.pdf>

European Marine Board (2017). Marine science to support the UN2030 Sustainable Development Goals. 6th Forum Message.

http://www.marineboard.eu/sites/marineboard.eu/files/public/EMB%206th%20Forum/EMB_6th_Forum_Message.pdf

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

<http://www.marineboard.eu/file/18/download?token=QescBTo6>

European Marine Board and EuroGOOS (2008) EMODnet: The European Marine Observation and Data Network. Vision Document by EMB and EuroGOOS. <http://marineboard.eu/file/60/download?token=9-d8m8bh>

European Strategy for Atlantic Ocean Observing (*in prep*). AtlantOS publication as input on European contribution to the Atlantic Ocean Observing Blueprint.

EuroGOOS (2018) Operational Oceanography serving Sustainable Marine Development. Proceedings of the Eight EuroGOOS International Conference. 3-5 October 2017, Bergen, Norway. E. Buch, V. Fernández, D. Eparkhina, P. Gorringe and G. Nolan (Eds.) EuroGOOS. Brussels, Belgium. 2018. ISBN 978-2-9601883-3-2. 516 pp. <http://eurogoos.eu/download/publications/EuroGOOS-2017-Conference-Proceedings.pdf>

EuroGOOS (2016). European Operational Oceanography: Delivering services for Blue Growth and ecosystem-based management. EuroGOOS Policy Brief. She J., Eparkhina D., Nolan G. (Eds). EuroGOOS. Brussels, Belgium. 2016. 14pp. ISBN: 978-2-9601883-0-1 <http://eurogoos.eu/download/publications/EuroGOOS-Policy-Brief-2016.pdf>

Flanders Marine Institute (2018). Compendium for Coast and Sea 2018. An integrated knowledge document about the socio-economic, environmental and institutional aspects of the coast and sea in Flanders and Belgium. www.compendiumcoastandsea.be

Fritz *et al.*, 2016a, AtlantOS D10.1 Engagement Strategy

<https://www.atlantOS-h2020.eu/download/deliverables/10.1%20Engagement%20Strategy.pdf>

Fritz J-S (2016b) Observations, Diplomacy, and the Future of Ocean Governance. *Science & Diplomacy*, Vol. 5, No. 4 (December 2016). <http://www.sciencediplomacy.org/article/2016/observations-diplomacy-and-future-ocean-governance>

Garcia-Soto, C., van der Meeren, G. I., Busch, J. A., Delany, J., Domegan, C., Dubsky, K., Fauville, G., Gorsky, G., von Juterzenka, K., Malfatti, F., Mannaerts, G., McHugh, P., Monestiez, P., Seys, J., Węstawski, J.M. & Zielinski, O. (2017). Advancing Citizen Science for Coastal and Ocean Research. French, V., Kellett, P., Delany, J., McDonough, N. [Eds.] Position Paper 23 of the European Marine Board, Ostend, Belgium. 112pp. ISBN: 978-94-92043-30-6 <http://www.marineboard.eu/file/633/download?token=sMDNN4Xb>

GCOS (2016). The Global Observing System for Climate: Implementation Needs.

GOOS 2030 Strategy (31 May 2018 draft for community review, *in prep*)

- GOOS (1998). Strategic Plan and Principles for the Global Ocean Observing System(GOOS) Version 1.0 January 1998 GOOS Report No. 41
- ICES (2014) Implementing the ICES Strategic Plan 2014-2018. Linking Science, Advice, Data and Information and Secretariat. <http://www.ices.dk/explore-us/what-we-do/Pages/Our-strategy.aspx>
- ICES (2018a) Villamor, A., Holdsworth N. European catalogue of marine data and information portals. European contribution to the trilateral activity on a cross Atlantic knowledge platform *updated version of catalogue: 1 May 2018*
<https://atlanticresource.org/aora/site-area/research-themes/knowledge-sharing/knowledge-sharing-platform>
- ICES (March, 2018b) AORA report for the Working Group on the Ecosystem Approach to Ocean Health and Stressors: Mandates for Ecosystem-based Ocean Governance across Canada, the EU, and the US.
- IPCC Report on the Ocean and Cryosphere in a Changing Climate (SROCC) (*in prep* for 2019)
- IOC (2015) Capacity Development Strategy 2015-2021
http://www.ioc-cd.org/images/3897_15_IOC_E_F_2_langues_WEB.pdf
- JPI Oceans (2015) Strategic Research and Innovation Agenda (2015-2020). Joint Programming Initiative Healthy and Productive Seas and Oceans, Brussels.
- Larkin, K., Wouters, N., McDonough, N *et al.*, (2014). Proposal and Recommendations for a Science-Policy interface (SPi) to support MSFd implementation. Deliverable 4.2 for the European project STAGES (Science and Technology Advancing Governance of Good Environmental Status
http://marineboard.eu/sites/marineboard.eu/files/public/publication/STAGES_D4.2.pdf
- Liebender, A., Jolly, C., Fritz, S. (2016). Report of AtlantOS-OECD Scoping Workshop on the Economic Potential of Data from Ocean Observatories. AtlantOS Deliverable D10.4.
<https://www.atlantos-h2020.eu/download/deliverables/10.4%20Workshop%20Report.pdf>
- Marine Institute and EMB (2013). Towards a Strategic Research Agenda/ Marine Research Plan for the European Atlantic Sea Basin. SEAS-ERA Deliverable N°: D6.1.1 (and its corresponding draft Marine Research Plan for the European Atlantic Sea Basin, published in 2011)
- Martín Míguez, B., Calewaert, J-B., McMeel, O. (2016). Best Practices in Stakeholder Engagement, Data Dissemination and Exploitation. AtlantOS D10.5. <https://www.atlantos-h2020.eu/project-information/work-packages/deliverables/>
- Martín Míguez, B., Calewaert, J-B. (2018). Stakeholder Engagement 'Support Facility' Test Exercise (Demonstrator). AtlantOS D10.8. <https://www.atlantos-h2020.eu/project-information/work-packages/deliverables/> Atlantic community page: <http://www.emodnet.eu/atlantic-1>
- Novellino A., Fernández V., Buch, E. (2017). Web-based monitoring tool of the Atlantic Ocean observing system (Europe). AtlantOS D9.2 <https://www.atlantos-h2020.eu/project-information/work-packages/deliverables/> web-based monitoring tool: <http://www.emodnet-physics.eu/atlantos/dashboard/Default.aspx>
- OECD (2016), *The Ocean Economy in 2030*, OECD Publishing, Paris, <https://doi.org/10.1787/9789264251724-en>. <http://www.oecd.org/sti/futures/the-ocean-economy-in-2030-9789264251724-en.htm>

POGO (2016) Strategy of the Partnership for Observation of the Global Ocean
http://oceanpartners.org/sites/oceanpartners.org/files/public/attachments/article/Products/POGO_strategy_document_Final.pdf

Rayner, R. (2016), "An overview of the expected economic benefits of ocean observations",
Presentation for AtlantOS/OECD workshop, Kiel, June 2016.

Reilly K., Cusack, C., Fernández V., Buch, E., Ott, M. (2018). Atlantic Ocean Observing Networks: Cost and feasibility study. AtlantOS D1.4
https://www.atlantos-h2020.eu/download/deliverables/AtlantOS_D1.4_update.pdf

South-South Framework for Scientific and Technical Cooperation in the South and Tropical Atlantic and Southern Ocean (2017) Developed by South Africa's Department of Science and Technology and Brazil's Ministry of Science, Technology, Innovations and Communications
<https://www.atlanticresource.org/aora/sites/default/files/GalleryFiles/AtlanticFacts/South--South-Framework-for-Scientific-and-Technical-Cooperation-in-the-S....pdf>

Sendai Framework for Disaster Risk Reduction 2015-2030
https://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf

UNESCO (2012). A Framework for Ocean Observing. By the Task Team for an Integrated Framework for Sustained Ocean Observing, UNESCO 2012 (revised in 2017), IOC/INF-1284 rev.2, doi: 10.5270/OceanObs09-FOO

Vincx, M., Antia, A., Deprez, T., Fiksen, O., Koski, M., Mackenzie, B., McGrane, P., O'Carroll, C., Olsen, J., Menezes Pinheiro, L., Ribera d'Alcala, M., Rouillet, G. (2018) Training the 21st Century Marine Professional: A new vision for marine graduate education and training programmes in Europe. Kellett, P., Larkin, K., Heymans, J. J., McDonough, N., Wouters, N., Chu, N-C. [Eds.] Future Science Brief 2 of the European Marine Board, Ostend, Belgium. 47pp. ISBN: 9879492043511. ISSN: 2593-5232
<http://marineboard.eu/file/844/download?token=4iAd6cV7>

Von Homeyer, I., Reins L. and Dupont C. (2013). Analysis of Regional Sea Convention needs ensuring better coherence of approaches under the Marine Strategy Framework Directive. Specific Contract No.07.0307/2013/626367/D2. Implementing Framework Contract ENV.D.2/FRA/2012/0017. Final report, Brussels, 92 pp.
https://webgate.ec.europa.eu/maritimeforum/sites/maritimeforum/files/Final%20Report_RSC%20needs.pdf

UNESCO (2012). A Framework for Ocean Observing. By the Task Team for an Integrated Framework for Sustained Ocean Observing, UNESCO 2012 (revised in 2017), IOC/INF-1284 rev.2, doi: 10.5270/OceanObs09-FOO <http://unesdoc.unesco.org/images/0021/002112/211260e.pdf>