

<b>Project</b>	AtlantOS – 633211
<b>Deliverable number</b>	D11.7
<b>Deliverable title</b>	3 <sup>rd</sup> AtlantOS progress report plus summary of external board meetings
<b>Description</b>	Prior to the 4th annual AtlantOS meeting in month 48 a project progress report for the external project boards (EB and ISTAB) will be prepared to enable them to be as good as possible prepared for the meeting and to ensure consequently that AtlantOS receives as constructive as possible recommendations from the boards. This report, together with the two external summary board meeting reports, which will be requested from the EB and ISTAB, will represent D11.7.
<b>Work Package number</b>	WP11
<b>Work Package title</b>	Management and Exploitation
<b>Lead beneficiary</b>	GEOMAR
<b>Lead authors</b>	Anja Reitz, Brad deYoung
<b>Contributors</b>	The AtlantOS WP leaders and task leaders as well as all ISTAB and ENB members
<b>Submission data</b>	26 April 2019
<b>Due date</b>	May 2019
<b>Comments</b>	



This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement n° 633211.

**Stakeholder engagement relating to this task\***

<b>WHO are your most important stakeholders?</b>	<input type="checkbox"/> Private company If yes, is it an SME <input type="checkbox"/> or a large company <input type="checkbox"/> ? <input type="checkbox"/> National governmental body <input type="checkbox"/> International organization <input type="checkbox"/> NGO <input checked="" type="checkbox"/> others Please give the name(s) of the stakeholder(s): The entire Ocean Observation Community.
<b>WHERE is/are the company(ies) or organization(s) from?</b>	<input checked="" type="checkbox"/> Your own country <input checked="" type="checkbox"/> Another country in the EU <input checked="" type="checkbox"/> Another country outside the EU Please name the country(ies): All countries bordering the Atlantic Ocean and/or are interested in an enhanced and optimised integrated Ocean Observing System.
<b>Is this deliverable a success story? If yes, why? If not, why?</b>	<input type="checkbox"/> Yes, because .....  <input type="checkbox"/> No, because .....
<b>Will this deliverable be used? If yes, who will use it? If not, why will it not be used?</b>	<input checked="" type="checkbox"/> Yes, by the Atlantic Ocean Observing Community, by the external project boards, by the European Commission, by the formal reviewers of AtlantOS  <input type="checkbox"/> No, because .....

**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 obs 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.

\*For ideas about relations with stakeholders you are invited to consult [D10.5](#) Best Practices in Stakeholder Engagement, Data Dissemination and Exploitation.

# AtlantOS

## 3<sup>rd</sup> AtlantOS summary progress report for the external advisory boards March 2019

---

<https://www.atlantos-h2020.eu/>



## Content

1. Introduction	3
2. Abstract of project progress within the time from month 34 to 48	4
3. Work package progress reports	7
WP 1 Observing system requirements and design studies	7
WP 2 Enhancement of ship-based observing networks	10
WP 3 Enhancement of autonomous observing networks	12
WP 4 Interfaces with coastal ocean observing systems	19
WP 5 Integrated regional observing systems	24
WP 6 Cross-cutting issues and emerging networks	30
WP 7 Data flow and data integration	36
WP 8 Societal benefits from observing/information systems	42
WP 9 System evaluation and sustainability	50
WP 10 Engagement, Dissemination, and Communication	54
WP 11 Management and Exploitation	59
4. Science management and governance	64
5. Publications	66

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 633211 (AtlantOS).

## 1. Introduction

**AtlantOS** *Optimising and Enhancing the Integrated Atlantic Ocean Observing Systems* is a large scale EU Horizon 2020 research and innovation project contributing to the Trans-Atlantic Research Alliance, GOOS (Global Ocean Observing System), and GEO (Group on Earth Observations). The project pools the effort of 57 European and 5 non-European partners (research institutes, universities, marine service providers, multi-institutional organisations, and the private sector) from 18 countries to collaborate on optimizing and enhancing Atlantic Ocean observing. It has a budget of € 20.5M for 4 years (April 2015 – June 2019) and is coordinated by GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany (Prof. Dr. Martin Visbeck). The work is organised along work packages on: i) observing system requirements and design studies, ii) enhancement of ship-based and autonomous observing networks, iii) interfaces with coastal ocean observing systems, iv) integration of regional observing systems, v) cross-cutting issues and emerging networks, vi) data flow and data integration, vii) societal benefits from observing /information systems, and viii) system evaluation and resource sustainability. Engagement with wider stakeholders, including end-users of Atlantic Ocean observation products and services, is embedded throughout the project.

Atlantic Ocean observation is currently undertaken through loosely-coordinated, *in-situ* observing networks, satellite observations and data management arrangements of heterogeneous international, national and regional design to support science and a wide range of information products. Thus there is tremendous opportunity to develop the systems towards a fully integrated Atlantic Ocean Observing System (AtlantOS) consistent with the recently developed 'Framework of Ocean Observing' (FOO). The FOO was outlined by a group of experts in charge to develop a strategy for the future to foster progress in sustained ocean observing considering the recognition that more integration across disciplines is needed. The FOO is responsive to user needs and societal drivers.

The **vision of AtlantOS** is to improve and innovate Atlantic observing by using the Framework of Ocean Observing to obtain an international, more sustainable, more efficient, more integrated, and fit-for-purpose system. The AtlantOS initiative aims to have a long-lasting and sustainable contribution to realising societal, economic and scientific benefits arising from this integrated approach, with implementation extending beyond the project's lifetime. Advances will be achieved by improving the value for money, extent, completeness, quality and ease of access to Atlantic Ocean data required by industries, product supplying agencies, scientists and citizens.

The overarching target of the AtlantOS initiative is to deliver 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 after the project's lifetime.

The sustainability will derive from the AtlantOS aims:

- to improve international collaboration in the design, implementation and benefit sharing of ocean observing,
- to promote engagement and innovation in all aspects of ocean observing,
- to facilitate free and open access to ocean data and information,
- to enable and disseminate methods of achieving quality and authority of ocean information,
- to strengthen the Global Ocean Observing System, engage with the Blue Planet initiative of GEO, and to support national and regional efforts to sustain observing systems that are critical for a number of services in Europe and beyond including the Copernicus Marine Environment

Monitoring Service and its strategic alignment with the aims of the Galway Statement and the Belem Statement on Atlantic Ocean Cooperation.

The Galway Statement signed in 2013 by the EU Canada and the US and that of the Belem Statement signed in 2017 by the EU, Brazil and South Africa on Atlantic Ocean Cooperation, launching a Transatlantic Ocean Research Alliances to enhance collaboration to better understand the Atlantic Ocean and sustainably use, protect its resources and govern human activities.

## **2. Abstract of project progress within the time from month 34 to 48**

In this third phase of the action efforts in work package 1 *Observing system requirements* were focused on the refined requirements report (D1.7) as a synergy of the lessons learned from the different work package tasks but also from the input and exchange with other work packages and other initiatives. Furthermore, WP1 produced an Atlantic Ocean Observing Networks Cost and Feasibility Study (D1.4). This is cost estimate for the operation of existing Atlantic Ocean observing activities is the first step towards a consistent cost accounting framework for ocean observing networks in the Atlantic. The estimated total running costs of existing systems accounted for almost €36 million plus roughly €10.3 million staff costs. From the modelling point of view, it can be stated that for the first time a coordinated multi-model OSSE has been carried out, which is a major success towards a robust evaluation of observing systems. Moreover, an increase in technology readiness level from 4 to 6 and from 3 to 7 has been achieved regarding BioGeoChemical models and coordinated physical OSSEs, respectively.

Work package 2 *Enhancement of ship-based observing networks* supported inorganic carbon measurements and transient tracer measurements two GO-SHIP lines, one in the North and one in the South Atlantic. Improvements have been made regarding the EOv carbonate systems including the semi-continuous total alkalinity measurement system. The acoustic fish database that has been developed by WP2, which is running at ICES and currently used for fish assessment purposes will be expanded and additional nation raised interest to share and add their acoustic data. Regarding the bathymetric data collection, there has been a push to increase data sharing and integration of shared data. A gap analysis as been carried out to identify pilot areas for further intensive mapping.

Work package 3 *Enhancement of autonomous observing networks* strengthened the capacities for genomic observations by forming the Global Omics Observatory Network (GLOMICON). Furthermore, in the field of Eulerian ocean observations significant steps towards enhanced collaboration and interaction between Europe and Canada have been made. Activities are ongoing to provide for a free and centralized access to Biogeochemical observations and to extend existing visualisation capacities. WP3 managed to expand the one-stop-shop TMA products; 6 out of 8 TMA time series products are online. A major achievement is the establishment of the European Tracking Network (ETN) as an observational network. The ETN database hosts more than 57 Million detections from more than 50 projects across Europe. The successful application for a COST action will secure the networking activities. Argo expended to deep and BGC measurements in South Atlantic and the first deep float survived 7 months under ice providing unprecedented data in this poorly sampled area.

Work package 4 *Interfaces with coastal ocean observing systems* completed a gap analysis of links between the open ocean and coastal observing systems, the analysis awards recommendations to reconsider strategies. Recommendations for strengthening the links between coastal and open ocean observation communities made a significant contribution to the All-Atlantic Ocean Observing System Strategy. The use of autonomous vehicles in shelf sea monitoring and operational systems, for climate timescales was

initiated by the detailed overview of a series of coordinated glider deployments in the Celtic Sea produced by WP4. Furthermore, a feasibility study of acoustic monitoring from marine noise levels and detection of vocalisation of marine mammals was carried out. A plan was developed to make South Atlantic tide gauge data more discoverable and interoperable, this work led to the production of a community white paper for OceanObs'19 in *Frontiers Marine Science*.

Work package 5 *Integrated regional observing systems* intensified community-building on various stakeholder, discipline and geographic levels. A comprehensive listing of climate and ecosystem related indices was carried out, these included marine ecosystem and the oceans capacity to take up CO<sub>2</sub> via primary productivity and carbon export. Moreover, the operationalisation of the indices as part of CMEMS enables a link with other agencies that are used for advice (e.g. Environmental Agency). In WP5 guidelines have been identified supported by OSSEs to assist the development of the future BGC Argo float network. Statistical OSSEs indicate that a typology of environmental condition as are crucial to determine a network efficiency.

Work package 6 *Cross-cutting issues and emerging networks* established consensus reference materials for trace elements and omics. This will greatly enhance the accuracy of trace elements and omics measurements over the coming years. Within the framework of WP6 the technology of eight separate instruments that address key EOVs has been advanced by a total of 18 TRLs. This enhancement has been achieved in collaboration with other H2020 and previously funded Oceans of Tomorrow projects. The group on best practices in ocean observing engaged across the oceanographic community and established an online repository for Ocean Best Practices. To ensure sustainability of the repository it is hosted by IODE.

Work package 7 *Data flow and data integration* integrated AtlantOS-derived resources in GEOSS and increased visibility in the GEOSS portal. Furthermore, the integrated EU system that involves networks and integrators was improved to consolidate the integrated data system over the coming years in the framework of future projects. The strategy developed in AtlantOS was shared at international level and led to several community papers submitted at OceanObs19. WP7 has been able to show a positive impact of the integration of several AtlantOS observing networks on Copernicus Marine Services ocean analysis and seasonal forecasts. The international carbon database (SOCAT, GLODAP) have been improved and contribution to the QC activities has been made. For the North Atlantic 16 new eco-regional areas have been identified based on the assembly of CPR data. An estimate of global storage of anthropogenic carbon in Ocean between 1994 and 2007 has been carried out by means of GLODAPv2.

Work package 8 *Societal benefits from observing/information systems* made significant progress regarding their task outputs and methodologies discussed. Various webpage applications or links to them are available on the AtlantOS webpage. The applications and exercises are proposed to demonstrate the importance of AtlantOS in generating the selected targeted products of WP8. A major advancement made was in the way WP8 communicated, and developed the downstream products, with a step forward in the area of end-user engagement and the realisation that a stronger future emphasis must be on the co-development of products with end-users to drive the co-creation of new, more accurate downstream products and services. To advance the current ocean observing monitoring system, WP8 partners worked to determine “fitness for use” of available data and “fitness for purpose” of the downstream products developed, to share community “best practice” and avoid duplication of effort.

Work package 9 *System evaluation and sustainability* intensively cooperated with JCOMMOPS resulting in the adaptation of the JCOMMOPS web based monitoring system to the needs of AtlanOS. With respect to this fruitful cooperation WP9 developed the following elements within the course of its deliverable

production (i) real-time monitoring dashboard, (ii) dedicated monthly authoritative monitoring maps, (iii) interactive maps, (iv) performance indicators, (v) various statistic and monitoring tools to support the Atlantic Ocean Observing community. AtlantOS is taking advantage of the monitoring capacities of JCOMMOPS as well as fostering a new generation of information system and web based services which will provide a real-time and persistent monitoring system beyond the lifetime of AtlantOS. For the coastal component of AtlantOS EuroGOOS and EMODnet Physics have developed a web monitoring tool. All these tools represent an easy way to track the AtlantOS impact in terms of data sets which are connected, made available and accessible, furthermore they provide various reports and key performance indicators. Furthermore, an assessment of the adequacy of the performance of Atlantic Ocean Observing was carried out for pilot countries. The online assessment will be used for further review processes. One of the pilot countries directly realized the need to establish a national observing coordination group.

Work package 10 *Engagement, Dissemination, and Communication* co-organised with the H2020 project BlueAction a successful Policy Briefing Event on *The slowing Gulf Stream* at the European Parliament. A special newsletter was produced for this event. A Parallax website has been designed and developed as a visual output of the project. The AtlantOS website has been updated and improved and is currently under intensive improvement regarding the addition of various web base applications to contribute to the steady stream interested stakeholders.

Work package 11 *Management and Exploitation* successfully transformed the Atlantic Ocean Observing Blueprint initiative into an All-Atlantic Ocean Observing System strategy implying two documents the high-level vision document which will be handed over to the European Commission during the AtlantOS Symposium and the All-Atlantic Ocean Observing System implementation document which will be finalized shortly. This is just one example for the successful community building that has been fostered by AtlantOS on various levels. Furthermore, a fruitful town hall meeting on *Partnership building to advance the integrated global in-situ Ocean Observing System* has been conducted with the other basin-scale observing programmes to join forces. Cooperation with AORAC-SA was intensified at various occasions e.g. AORACSA meeting in Brussels. WP11 produced a video animation to explain the strategic approach of AtlantOS aiming to enhance and optimise the integrated Atlantic Ocean Observing System displaying the full value chain of societal, scientific and economic benefit.



### 3. Work package progress reports

#### WP 1 Observing system requirements and design studies

##### Summary

Work in Task 1.1, Requirements for sustained ocean observations of the Atlantic, concentrated on refining the Initial Requirements Report (D1.1, which was submitted in an earlier reporting period) based on input from Ocean Simulation Experiments (Task 1.3) and other Work Packages. Deliverable 1.7 (“Refined Requirements Report”) is scheduled to be delivered by March 31, 2019.

Work in Task 1.2, Capacities, Gaps and feasibility, concentrated on making an initial overview of the running costs related to operating a selection of Ocean Observing Networks in the Atlantic. Such an overview is required to assist funding agencies in making informed decisions on the allocation of future funding for ocean observations. The cost accounting data provided can be used to estimate the cost of filling gaps in the capacities of open ocean observing in the Atlantic. This data is a vital component of an advanced framework for an integrated Atlantic Ocean Observing System, as outlined in the vision of the AtlantOS project.

Work in Task 1.3, Observing System Design Studies, concentrated on carrying out a series of Ocean System Experiments (OSEs) and Ocean System Simulation Experiments (OSSEs) to inform future network plans, which necessitated developing new techniques. The results of these experiments are described in Deliverable 1.5 (“Synthesis of OSSE results”, submitted in August 2018) and the resulting recommendations for networks are summarised in Deliverable 1.6 (“Model guidance for the evolution of the Integrated Atlantic Ocean Observing System”, submitted on December 5, 2018).

##### Progress per Task

###### *Task 1.1: Requirements for sustained ocean observations of the Atlantic*

Task 1.1 hosted a two-day workshop in February 2019 to bring together observing network proponents to consider user needs, OSSE results of network impact, and barriers to integration to discuss future plans and provide recommendations on integration and coordination of efforts.

###### *Task 1.2: Capacities, Gaps and feasibility*

Work in Task 1.2 concentrated on making an initial overview of the running costs related to operating a selection of Ocean Observing Networks in the Atlantic. Such an overview is required to assist funding agencies in making informed decisions on the allocation of future funding for ocean observations. The cost accounting data provided can be used to estimate the cost of filling gaps in the capacities of open ocean observing in the Atlantic. This data is a vital component of an advanced framework for an integrated Atlantic Ocean Observing System, as outlined in the vision of the AtlantOS project.

###### *Task 1.3: Observing System Design Studies*

In response to a input from networks and other AtlantOS partners, including Task 1.1, a plan to use a suite of OSEs and OSSEs to inform future network plans was developed in an earlier Reporting Period. Work in Reporting Period 3 focused on carrying out these numerical simulations, which necessitated the development of a number of new data assimilation techniques. In addition, the results of these experiments were analysed, both individually and collectively to outline relative impact.

##### Additional Activities

In addition to work on the deliverables of WP1, WP1 members promoted AtlantOS in two major conferences and continued the work of developing a long-term implementation plan for a sustained integrated ocean observing system in the Atlantic, the *Blueprint*.

WP1 members hosted two Panel sessions on Harmonization of Ocean Observations and Information at the GEO European Project Workshop 2017 in Helsinki (19-21 June) – the first focused on Governance, Partnerships, Instrumentation and the second focused on Data Types and Programs. WP1 members also hosted a side-event on AtlantOS applications at GEO Plenary in Washington in October 2017, and gave talks and acted as Panel members in a number of other side events, including on costing of measurements, on Sustainable Development Goals, and on marine biodiversity. These sessions and side events provided further opportunity for WP1 members to understand ocean observing requirements and current gaps.

WP1 members are the lead author for one chapter (on Requirements) of the “Atlantic Ocean Observing Blueprint” and were contributing authors for three other chapters.

### **Cooperation and interaction with other AtlantOS WPs**

Observing network proponents from WP2 and WP3, as well as representatives from WP4 (coastal), WP5 (regional), and WP9 (real-time monitoring of the observation network) provided input into the refined user requirements, including at the February 2019 “AtlantOS Quantitative Future Observing Network Design workshop.” (Task 1.1).

Key representatives from AtlantOS WP 2-6 contributed with available cost information on existing Atlantic Ocean observing systems (Task 1.2).

Future plans and technical details from ocean observing networks (WP2 and WP3) were instrumental in developing and running OSEs and OSSEs. These OSEs were also used to initialize seasonal predictions (in Task 7.4) to assess the impact of AtlantOS networks and their improvements for the Copernicus Marine Service (Task 1.3).

### **Cooperation and interaction with other projects and initiatives**

Task 1.1 worked with international groups to understand the need for and impact of ocean information (e.g., OECD) and with ocean networks and aggregators (e.g., NOAA and MBON) to understand how data providers respond to needs and how they situate themselves within the Framework for Ocean Observing (e.g., in relation to Essential Ocean Variables).

Task 1.2 worked with organisations and projects that have also addressed the issue of estimating the cost of ocean observing system - first and foremost NOAA in USA. Representatives from many of the Atlantic Ocean Observing Networks have also been very cooperative.

Task 1.3 worked with numerous scientific and operational colleagues and organisations not directly involved with AtlantOS across Europe to develop, run, and analyse its suite of OSEs and OSSEs.

### **Achieved main results**

Task 1.1: The main output in Reporting Period 3 was the report “Refined Requirement Report” (D1.7). The aim was to update the Initial Requirements Report (D1.1) with the legacy lessons learned from the project, including refinements of understanding of readiness to observe, guidance from models, and input from other work packages on requirements, observation networks, data management, and the generation of useful information. The intended impact of this study is the creation of a coherent framework to optimise the ocean observation system, including regular input and validation from end-users, understanding of

current funding climates, and advice from numerical experiments, all overseen by a European governance structure.

Task 1.2: The main output in Reporting Period 3 was the report “Atlantic Ocean Observing Networks: Cost and feasibility Study” (D1.4). The aim was to provide a cost estimate for the operation of existing Atlantic Ocean observing activities. A significant input from network representatives was required to carry out the exercise. The report represents a first step to develop a consistent cost accounting framework for ocean observing networks in the Atlantic, but due to varying levels of maturity within the networks themselves and a need to further standardise the costing methodology among networks, more work is required to achieve a fully comprehensive report. As a result, the estimated total running cost of the existing system of €35,922,392 plus 137.3 FTE staff (estimated average of €10,297,500) is likely a considerable underestimation of the actual costs.

Task 1.3: The main outputs in Reporting Period 3 were the two reports: “Synthesis of OSSE results” (D1.5) to describe the robust results obtained from across the models and “Model guidance for the evolution of the Integrated Atlantic Ocean Observing System” (D1.6) to look at the optimal observing strategies to capture specific phenomena and to reduce the error in key EOVs. These results will be influential in international thinking about the shape of the future global ocean observing system, both for individual networks and for the governance structure tasked with coordinating the overall ocean observing system.

Important accomplishments include:

- for the first time, a coordinated multi-model OSSE has been carried out to assess the potential of a range of observing elements to better estimate the physical state of the Atlantic Ocean. This represents a major advance in the robust evaluation of observing systems;
- an increase in technology readiness level (TRL) in moving BioGeoChemical OSSEs from TRL 4 to 6 and moving coordinated physical OSSEs from TRL 3 to 7;
- established best practices on the way to run coordinated OSSEs between different centers;
- a number of publications acknowledging AtlantOS (see list below); and
- quantification of impact of observations in ocean analysis and forecasting systems (see results below).

Key results include:

- results for a number of specific networks related to physical variables, including that increased Argo density in western boundary currents and along the equator results in improved estimates of temperature and salinity for the entire Atlantic, and that while the present tropical mooring array provides invaluable data for evaluation of models and assimilation systems, assimilation of the ocean data into current ocean model systems impacts primarily the region of the moorings;
- numerical simulation studies will have significant impact - the results (and resulting publications in the peer-reviewed literature) will be influential in international thinking about the shape of the future global ocean observing system. For example, the results are expected to be an important input to the once-per-decade OceanObs 2019 conference, and in formulating future plans for observation networks. In addition, there is a call for EOOS to take the lead in coordinating, in partnership with the Copernicus Marine Service, a framework for regular OSSE validation of observation plans.

## WP 2 Enhancement of ship-based observing networks

### Summary

WP2 has focused upon improvement, expansion, integration and innovation of ship-based observations undertaken by existing observing networks. The networks include the Global Ocean Ship-Based Hydrographic Investigations Program (GO-SHIP) that provides a globally coordinated network and oversight of repeat hydrography; the Ships-of-Opportunity Program (SOOP) that also includes the Volunteer Observing Ships-Carbon (VOS-Carbon) and Ferrybox Surveys (automated measurement system for determining physical and biogeochemical variables in surface seawater) which collect continuous ocean data from commercial vessels while cruising along regularly scheduled routes; the Continuous Plankton Recorder (CPR) that is towed behind commercial ships and collects plankton; and Acoustic Fisheries Surveys by national institutes primarily under ICES for fisheries assessment purposes. In addition, systematic bathymetric work to map the ocean floor was begun with AtlantOS.

### Progress per Task

#### *Task 2.1. GO-SHIP*

Task 2.1 has helped to improve the Atlantic GO-SHIP program by: 1) supporting their coordination office located at JCOMMOPS in Brest, 2) encouraging and developing the concept of European central laboratories for the observation of not-commonly measured EOVs but that are core in GO-SHIP, and 3) facilitating the observation and delivery of ocean current data from ship-based ADCP systems. The technical coordination of the program has enabled the GO-SHIP program to be visible on the JCOMMOPS network coordination site, facilitating the overall coordination and assessment of the ocean observing system. AtlantOS supported facilities for measuring inorganic carbon and transient tracers on two GO-SHIP lines. The improvement of software for processing ADCP data and support for a data management system for these data has shown large potential, and is now ready to be deployed on a larger scale for the Atlantic GO-SHIP program.

#### *Task 2.2: Ships of Opportunity Programme (SOOP)*

Task 2.2 has supported underway observation of surface  $\Delta p\text{CO}_2$ , T, and S and compared “traditional”  $p\text{CO}_2$  systems and 2  $p\text{CO}_2$  membrane sensors. They outfitted ships with Ferrybox systems measuring T, S, fluorescence, and  $\text{O}_2$ , and developed and tested a new underway automated Total Alkalinity system as well as an Andraea Optode  $p\text{CO}_2$  detector. They improved the coordination, coverage, quality, timeliness and data flow from the existing, formerly uncoordinated ship of opportunity networks (Carbon-VOS, SOOP and FerryBox). They helped to extend the measurements into the South Atlantic and exchanged information on sampling and sampling design.

#### *Task 2.3 Continuous Plankton Recorder (CPR)*

Task 2.3 helped to expand the CPR surveys into the South Atlantic. Also as part of AtlantOS, the CPR survey has been enhanced in several ways including additional sensors on the instrument itself, new water samplers (for flow cytometry and Harmful Algal Bloom (HAB) analysis), enhanced molecular techniques and piloted optical methodologies. The Water and Microplankton Sampler (WaMS) and developing quantitative molecular methods for Harmful Algal Blooms and pathogens has opened new opportunities to identify additional HABs. New automatic visual identification methods are continuing to be developed to speed up components of the traditional taxonomic analysis. As part of AtlantOS, new ecoregions were identified throughout the North Atlantic using physical and biological data from the CPR survey. The CPR survey now plans to monitor each ecoregion in a more systematic and targeted way.

#### *Task 2.4 Fisheries and zooplankton observations*

Task 2.4 on fisheries acoustics led to an international agreement on metadata convention for acoustic fish data and they also developed software to analyze the data and produce zooplankton and fish indices. They led the development of the first acoustic fish database, which is presently located at ICES. They have been spearheading the effort to ensure that all acoustic fish surveys are entered into the database. These data are used in the assessment of fish abundance and distribution and ultimately for fisheries assessment purposes.

#### *Task 2.5 EuroMapApp*

Task 2.5 on bathymetry observations has been encouraging the collection, and ultimately the integration of, bathymetric data and have been pushing to increase bathymetric data sharing. They were able to secure vessels from German and the Netherlands to undertake AtlantOS transit bathymetry lines and to deposit the data into the IHO DCDB. Their work within AtlantOS has significantly contributed to the acceptance of data sharing and the recognition of the IHO DCDB as the global archive for bathymetric data, especially within the European community.

#### **Cooperation and interaction with other AtlantOS WPs**

WP2 has cooperated and interacted with WP3 on coordinating sampling, making scientists aware of ship cruises and availability of on-board space for collecting data, integrating the results from cruises and eliminating duplication of effort. There has been extensive interaction and discussion between WP2 and WP7 over data delivery, quality control, best practices and integration with non-ship related data. Ship-based observations from WP2 have provided data to the pilot studies of the sub-polar gyre (WP6). Some discussion with WP10 has taken place in regards to SMEs in WP2.

#### **Cooperation and interaction with other projects and initiatives**

WP2 has interacted with several networks, groups, institutions, and organizations.

Task 2.1 has worked closely with the GO-SHIP network and its coordinating office. It has helped to bring new groups into the network such as Irish researchers, which led the occupation of GO-SHIP line A2.

Task 2.2 set up and coordinated the Oceans component of the ICOS-RI. This improved network coordination, data availability and integration of other network data as well as liaising with the shipping industry to improve the provision of ships for SOOP operations. A new voluntary organization, SOCONET (surface ocean CO<sub>2</sub> network) was established following network principles modelled on JCOMMOPS Met and Ocean networks to improve integration of CO<sub>2</sub> SOOP operations.

Task 2.3 already has good interlinkage between its observations and other SOOP type activities such as Carbon VOS, for example. It is also active within the Global Alliance of Continuous Plankton Recorder Surveys (GACS).

Task 2.4 has worked closely with the International Commission for the Exploration of the Seas (ICES) and several of their fisheries assessment working groups as well as the ICES Ecosystem Observation Steering Group and the ICES working group on fisheries acoustics, science and technology (WGFAST). It has also interacted and coordinated with the H2020 project Mesopelagic Southern Ocean Prey and Predators (MESOPP).

Task 2.5 has been working closely with the IHO Data Centre for Digital Bathymetry (DCDB), which was established to archive and share, freely and without restrictions, raw unedited single- and multibeam bathymetric data acquired by hydrographic, oceanographic and other vessels and is hosted by the U.S.

National Oceanographic and Atmospheric Administration (NOAA). Within AtlantOS, partner organizations have integrated their national data holdings into the IHO DCDB.

### **Achieved main results**

Task 2.1: AtlantOS supported facilities for measuring inorganic carbon and transient tracers on two GO-SHIP lines, one each in the North and South Atlantic. The improvement of processing software for ADCP data plus support for an ADCP data management system has shown potential, and is ready for deployment on a larger scale for the Atlantic GO-SHIP program.

Task 2.2: The EOVS carbonate systems were improved including the semi-continuous TA measurement system that was tested with satisfactory results. There are now plans to install this permanently on some lines. Detailed assessment of analytical uncertainty and consistency with other carbonate system parameters shows that current standard instrumentation with a precision of 4  $\mu\text{atm}$  can constrain decadal  $\text{pCO}_2$  and OA trends at the basin scale.

Task 2.3: The CPR has documented northward shifts in plankton distributions, which are believed related to regional climate warming. This change is currently considered detrimental because the warmer-water species are not replacing the colder-water species in similar abundances and may negatively impact other trophic levels, including fish larvae. For example, an important zooplankton species has declined by 70% in the North Sea. Seasonal timing, or phenology, is occurring earlier in the North Sea, also related to regional climate warming. The number of micro-plastics collected on CPR samples is increasing and the frequency of occurrence and bloom timing of some Harmful Algal Bloom species are related to regional climate warming.

Task 2.4: This task developed an acoustic fish database at ICES that is presently used for fish assessment purposes. This included the establishment of a metadata convention for acoustic data and software to produce fish and zooplankton indices. This database will be expanded and additional nations are being encouraged to share and add their fish acoustic data into the ICES database.

Task 2.5: Increased collection of bathymetric data has occurred using German and Dutch vessels. There has been a push to increase bathymetric data sharing and to integrate the shared data. The IHO DCDB has been established as the repository for European bathymetric data. A gap analysis has been performed to give suggestions for the Atlantic where to map next. Discussions are underway to form a Working Group with bathymetry experts from different nations, where data integration can be trained and improved and best practices developed.

## **WP 3 Enhancement of autonomous observing networks**

### **Summary**

Euro-Argo have progressed in the last 2 years with the deployment of 7 DEEP and 6 BGC floats deployment in South Atlantic and Southern Ocean in partnership with other networks: and the First DEEP float have been surviving under ice for 7 months. In the North-Atlantic the first success on an automatic releaser of floats (one every 3 months) has been reached and the first deployment of pH sensor on European manufactured floats has been done.

The significant progresses in OceanSITES are the development of capacity for emerging biogeochemical variables, the establishment of a system for developing “Best practice” recording and a transatlantic MOU with Canada. The levels of microplastic contamination on a meridional transect of the Atlantic have also been determined. The determination of the necessary magnitude of an Eulerian array still needs to be

improved. An international overview of oxygen measurements in the TMAs led to the establishment of best practices for oxygen measurements. A significant number of sensors (mostly in the mixed layer with T/C and current sensors) and parameters (with, notably, O<sub>2</sub> and CO<sub>2</sub> biogeochemistry sensors) have been added on the buoys of PIRATA, to better respond to scientific demands. Yearly PIRATA cruises represent also strategic opportunities to build scientific capacity of graduate students and early carrier researchers.

The *OceanGliders* program has been formally approved in October 2017 as an associated program of the GOOS by WMO/IOC JCOMM (World Meteorological Organization / International Oceanographic Commission Joint Commission for Oceanography and Marine Meteorology). Extensive work on software development allowed to improve the monitoring and outreach of the glider activities and glider data management with WP7. All the drifters funded by AtlantOS were deployed in the South Tropical Atlantic and were equipped with barometers. The data collected are available in open access and were assimilated by operational Numerical Weather Prediction centers and benefits to society at a very good cost-benefit ratio. In accordance with the high impact found for the AtlantOS drifters, the EUMETNET members have agreed to continue the legacy of the AtlantOS project, and to fund barometers for upgrade on NOAA drifting buoys, to be deployed in the Tropics, over the coming years. ETN consolidated the launching of the network.

## **Progress per Task**

### *Task 3.1 – Argo*

All AtlantOS floats have been deployed in the Atlantic Ocean, and one deep float deployed in the Austral Ocean with an enhanced controlling system for functioning under Ice – First European Deep float proposing this enhancement – see <https://www.euro-argo.eu/News-Meetings/News/Latest-News/First-deep-ARVOR-profiles-under-the-ice>. The Atlantic Ocean floats are all working as expected, extending the time-series for the AtlantOS timeline and beyond as expected for at least 2 years (up to 2021). Floats have also been deployed in the spatial gaps identified from the JCOMMOPS implementation maps, and participate to the Core Argo program providing Temperature and Salinity measurements from surface to 2000m in areas where core Argo data were lacking. The Austral float has provided data acquired under Ice in the Pacific Austral Ocean, ensuring that the technology is mature enough, and further Ice floats will be deployed in the Atlantic Southern Ocean in potentially Ice-covered areas.

Progress has not been made in this area but an important objective for the future is to generate objective methods to determine the temporal resolution and spatial coverage of a future Eulerian network which is required in order to satisfy certain pre-determined criteria. In the North-Atlantic first success on an automatic releaser of floats (one every 3 months) has been reached and the first deployment of pH sensor on European manufactured floats has been done. Not less than 1400 profiles have been acquired during the entire AtlantOS project's timeline, and the projection towards future based on the average energy available onboard induces an expectation of additional 2 years of functioning at-sea.

The main task carried out to fulfil the related objective was to harmonize the existing procedure for the quality control of auxiliary data (dissolved Oxygen, chlorophyll-a and nitrates concentrations, backscattering, radiometry) and propose a common frame for both calibrations and data analysis.

An assessed procedure for dissolved Oxygen has been proposed, with the hardware and software implementation of in-air measurement at surface in a full saturated environment for all the 13 AtlantOS floats (Bittig et al.).

It is planned that, by 2030, the European component of the Atlantic Ocean Observing System will be fully coordinated and fit-for-purpose. Common strategic priorities have been set out and accompanied by

national and regional implementation plans and voluntary commitments, contributing to the system's sustainability. The European component will be fully integrated in AtlantOS. To achieve this vision, Euro-Argo has prepared its strategy to sustain Argo ocean observation efforts. The planned evolutions as well as the scientific and operational rationales are described in the document "The Euro-Argo Strategy for next decade" <https://doi.org/10.13155/48526>.

The extension to BGC-Argo will require to involve new expertise in the data management teams in particular for the delayed mode processing of the new variables. The extension to Deep ocean will require to enhance the delayed mode QC procedures as the amplitude of the signal at depth is smaller. These two enhancements are already discussed in the relevant working groups, and harmonized procedures have been drafted for final endorsement by the Argo community and operational deployment at Data Assembly Centres.

### *Task 3.2 OceanSites biogeochemistry*

During the last 18 months, capacities for observations of emerging BGC variables have been developed as well as capacities for genomic observation. These were strengthened by method development and testing and by forming the Global Omics Observatory Network (GLOMICON) for omics-based observations. Microplastic contamination observation capacities were further developed and demonstrated during a meridional Atlantic transect.

FixO3 best practices were already recognized as relevant and the manual of best practice has been made available through the Ocean Best Practices (OBP) online platform for efficient dissemination and community review.

A MOU between Canada and EMSO-ERIC has been drafted, following a series of discussions and face to face meetings to enhance collaboration and formalize interactions between Europe and Canada in the field of Eulerian ocean observations. The OceanSITES metadata were integrated into the JCOMMOPS meta-database. Currently 270 moorings (called "platforms" in the JCOMMOPS vocabulary) are classified as "operational" in the system, with 126 in the Atlantic and Arctic (details in D3.8).

In other areas, progress was slower than expected and future efforts are required to work towards an integrated system of Eulerian Observatories. The integration of TMA, PIRATA and BGC networks is not yet optimal. However, as a result of AtlantOS activities, several instances of multi-disciplinary coordination have resulted in the deployment of sensors and sampling in previously mono-disciplinary observatories, a promising trend.

The necessary magnitude of an Eulerian array has not be determined. A full integration of observing networks is essential to implement systematic processes that can be employed to support the planning of the future Atlantic Eulerian observatory array in terms of variables to be observed, spatiotemporal resolution, focus areas, systemic resilience, and other core design features. Observing System Simulation Experiments (OSSEs) can serve as a key tool to inform the observing system design process. During AtlantOS, the development of OSSEs aimed to provide part of this capacity but could not address BGC observations in full depth.

### *Task 3.3 - Ocean Sites Transport*

A review of current developments of deep-sea data telemetry system (capsules, inductive, acoustics) has been done in deliverable 3.7. The implementation of subsea real-time data telemetry systems (DW.SRB) was proposed by one SME (Develogic) and task 3.3 partners contributed with component tests. Furthermore, two other systems that were already under development, the Myrtle-X and the Expendable



trawl-proof bottom temperature loggers, were further tested and refined. A wave glider based acoustic modem solution was also tested. Remarkable progress on the data transmission technology for moored installations during the AtlantOS lifetime can be reported. A demand (market) for such technology has been documented by the institutions involved in developing and testing the systems. These systems that are commercially available (Develogic & the KTH Royal Institute of Technology, Stockholm, Sweden) will ensure more reliable and save data transmission for long term monitoring activities.

Four more TMAs (6 of 8) transport time series have become available in the one-stop web site at OceanSITES (AWI), presenting basic information on the respective TMA arrays as well as making higher level transport data available. A workshop was held on oxygen measurements & observational potential of the TMAs (D3.18). A report is in progress, touching on an overview of oxygen measurements in the TMAs and best practices for oxygen measurements. A wider international involvement beyond the AtlantOS project is contributing to this report, including Canadian scientists from Bedford Institute of Oceanography and Dalhousie University, further leveraging the importance of oxygen observations.

#### *Task 3.4 Glider*

In line with networking activities with teams around the (North and South) Atlantic Ocean and in order to structure and strengthen the Atlantic glider network, the WP3.4 partners (CNRS, GEOMAR, BRUCIN, NERC, PLOCAN, SAMS, UiB) developed efforts that contributed to launch *OceanGliders* during the 7<sup>th</sup> EGO conference (Everyone's Gliding Observatories) organized in September 2016. They have worked with colleagues to make this program formally approved in Oct 2017 as an associated program of the GOOS by WMO/IOC JCOMM (World Meteorological Organization / International Oceanographic Commission Joint Commission for Oceanography and Marine Meteorology) and have been developing it. WP3.4 partners have contributed to the recent opening of a position of a Technical Coordinator at JCOMMOPS (JCOMM Operations and Support) in support of the *OceanGliders* program while a Community White Paper "OceanGliders: a component of the integrated GOOS" has been submitted and accepted to the OceanObs'19 special issue "Ocean Observations" in *Frontiers of Marine Science*. With more than 100 co-authors from all over the world, this paper assesses the progress made since ten years and develops the vision of this program for the next decade. These are major steps forward for the sustainability of the Atlantic glider network since it provides an international and high-level umbrella for their long-term activities, a host for international data management and a leverage for further national commitments.

The review of the AtlantOS eastern boundaries survey performed by WP3.4 partners (D3.12) demonstrated outstanding scientific contributions based on the use of underwater gliders, their role in fisheries assessment and their importance in filling observational gaps in the transition region between the open ocean and the coast. WP3.4 partners have worked (together with WP4) to demonstrate gliders can uniquely connect, but in combination with other observing platforms, coastal and open ocean observing systems and have a significant impact filling the profound gap existing in the current observing continuum of the GOOS today.

WP3.4 partners have also worked on software development (D13.3) to improve the monitoring and outreach of their glider activities and worked (together with WP7) to improve glider data management. They contributed in particular to make progress on metadata management, resulting in a consensus on the development of a unique and international *OceanGliders V1.0* data format.

Finally, during the last months, WP3.4 partners have been working with colleagues in the USA to organize the next and 8<sup>th</sup> EGO conference in Rutgers, New Jersey (20-25<sup>th</sup> May 2019), with a focus on the *OceanGliders* program, best practices and capacity building.

#### *Task 3.5 – PIRATA*

Three cruises (FR, US, BR; 40 days each) were carried out in 2018 for the PIRATA Network servicing (18 buoys serviced and replaced) and additional current (at 5m depth) and T/C (at 3M depth) sensors were added at 6°S-8°E. During the PIRATA FR28 cruise 23 surface drifters were deployed (including 13 SVP-B for Meteo France, as contribution to AtlantOS, and 10 SVP for NOAA/AOML/GDP) and 5 Argo profilers were deployed. For the 1st time in the Tropical Atlantic, 2 Deep-Argo equipped with O2 sensors were deployed; 3 ARVOR were also deployed. The ADCP mooring at 0°N-0°E was, for the 1st time, also successfully serviced and a full 2-year time-series has been registered. Also, continuous acoustic measurements were carried out, Sargassum algae (43 samplings) and fauna samples were collected for taxonomy, biological and microplastic analysis. All French PIRATA cruises data are now with DOI (CTDO2, LADCP, VM-ADCP, ADCP moorings, chemistry). The O2 sensors with and without data transmission were replaced during the PIRATA-PNE cruise (US) in March 2018, as GEOMAR contribution to AtlantOS. Brazilian partners carried out two cruises from the new R/V Vital de Oliveira : the PIRATA-BR XVII and the PIRATA BR-XVIII from October: in addition to 8 PIRATA buoys servicing, these cruises allow to carry out full-depth CTDO2/L-ADCP/nutrients casts, along with radiosoundings and microplastic sampling. US partners conducted the PNE cruise on the R/V Ron Brown with a AOML experiment related to Sargassum studies. This cruise was the first to carry the ESRL/GMD XCO2 air calibration system which will be compared against the pCO2 underway values.

#### *Task 3.6 – Surface Drifters*

The AtlantOS project has funded 52 buoys over a 4-year time-frame using opportunities offered by PIRATA maintenance cruises and other partners such as the Met Office. All the drifters were deployed in the South Tropical Atlantic and were equipped with barometers. The data collected are available in open access from various sources listed in D3.20 and they indicate that the lifetime of drifters is generally shorter in the Tropical Atlantic than when deployed in other regions such as the North Atlantic. However, the value of the data assimilated in global weather forecasts proved to be significant, explaining on average 0.0024 % of the ECMWF total 24-hour forecast reduction. The data were assimilated by operational Numerical Weather Prediction centers and benefits to society at a cost-benefit ratio estimated at 1:138. Based on the results obtained, members of EUMETNET have agreed to continue funding drifters in the Tropical Atlantic beyond the lifetime of the AtlantOS project in collaboration with NOAA, using the barometer upgrade scheme in collaboration with NOAA.

#### *Task 3.7 European Animal Telemetry Network (EATN)*

The emerging European Tracking Network provides researchers with an opportunity to acquire and collate data on the movements of aquatic animals over large spatial and temporal scales, to better understand the spatial ecology of key (ecologically and commercially) aquatic species. This knowledge will enhance their sustainable management and conservation, especially that requiring concerted actions at the trans-national scale. During the last 18 months, ETN consolidated the launching of the network itself (phase 1). This was achieved via an effort in communication including the setting of a webpage and the publication of a peer-reviewed paper to the telemetric community. This effort had the objectives to recruit new members.

The online availability of the central database has been finalized (<http://www.lifewatch.be/etn/>). The expansion of co-deployments of acoustic receivers in other network platforms (e.g. PIRATA, glider network, EMSO) by OTN/U Dalhousie and IMAR has been pursued. Technical standards to be used by the community have been defined (Deliverable D3.10). These technical standards and best practices allow to orientate ETN members when designing new acoustic telemetry studies, carrying out the deployment and

maintenance of acoustic telemetry infrastructures and tagging studies, and implementing the necessary data curation.

The submission of proposals to secure funding for the network functioning during phase 2 has been successful: a COST action will start in March 2019.

### **Cooperation and interaction with other AtlantOS WPs**

A close collaboration with WP6 was key to WP3's success in establishing a system for best practice recording and in building capacities for observations of emerging BGC variables. The framework to collect, review, and disseminate best practices developed in Task 6.4 ('Best practice on observing systems') provides the Eulerian observatory community with the necessary structures to harmonize observation procedures based on the best practices document developed in EU FP7 FixO3. Cooperation with Tasks 6.1 ('Sensors and new instrumentation') and 6.2 ('Common metrology and best practices') provided the means to develop and assess existing and novel methods to observe emerging BGC variables and to test their feasibility. ETN collaborated also in this with task 6.4 for Ocean best practices and participated to the development of a white paper on this topic that has been submitted Frontiers in Science for OceanObs19.

All observing networks worked in cooperation with WP7 to improve the data management system. The developments on surface drifters interacted were conducted hand in hand with WP7 to develop the architecture of a surface drifter Global Data Assembly Centre (GDAC). This collaboration with WP7 has been newly implemented for the ETN in WP7.3: with data provided to the European and international marine and ocean data management infrastructures: IOOS DMAC, OOI Cyber-infrastructure, NEPTUNE Canada, Copernicus/ECOMF in-situ TAC, EMODnet, SeaDataNet NODCs. In WP 7.5 new products were developed (EOV based assessments). PIRATA has been specifically collaborating with WP5 dedicated to Southern Ocean.

Participation to the WP1 workshop in Paris, 5-6 February 2019, provided input for future recommendations; i.e. the network of TMAs should be maintained as several TMAs provide some of the longest time series in the Atlantic.

### **Cooperation and interaction with other projects and initiatives**

A tight connection has been established between TMA and the international program "Arctic and Subarctic Flux studies" (ASOF). ASOF coordinates Arctic Ocean transport arrays and several strategic issues are similar to those of AtlantOS. A next adjustment is planned for the ASOF workshop in May 2019 in Copenhagen.

ETN has continued the close collaboration with the global OTN (co-deployments, database development, technical standards), and developed contacts with other regional aquatic telemetry networks (ATN - US; IMOS – Australia; ATAP – South Africa). ETN developed an industry/ manufacturers working group with the main companies to address common issues and problems, first meeting in November 2018, Olhão; ETN is 'benchmarking' a series of funding proposals being submitted by members in order to develop infrastructures (receiver lines) or tagging (aquatic valuable species) activities. ETN feeds into the EMODnet Central portal and Physics and Biology lots.

Potential enhancements and extensions of PIRATA are proposed, that could be envisaged in the framework of the future Tropical Atlantic Observing System (TAOS). Enhancements priority is given on mixed layer processes, carbon cycle and biogeochemistry, and extensions are required in the south and the northwest regions of the tropical Atlantic, discussed within TAOS.

Furthermore, two relevant cooperation partners for WP3 are OceanSITES and EMSO as the international and European coordinating bodies for fixed point observatories, respectively. There have been continuous efforts by members of WP3 to ensure that cooperation is close, however, OceanSITES has almost zero funding to carry out the coordination and hence relies on research funding and the goodwill of the individual members to achieve sustained observing capability.

The EU CLIVAR and PREFACE projects ended in 2018. However, interaction continues between PIRATA partners (USA & Brazil) with the EU programme PREFACE (FP7) partners. New cooperation are established in the framework of the new H2020 TRIATLAS. PIRATA is developing collaboration with UFPE on pilot programs on capacity building (for PhD & post docs). PIRATA is also collaborating with Benin to develop capacity building with a regional Master 2 dedicated to physical oceanography & PhD, and post docs from Ivory Coast, Senegal).

EUMETNET has entered into agreement with NOAA over the topic of barometer upgrades; this will enable to continue the drifter deployments in the Tropical Atlantic at an effectively lower cost, while reducing the total amount of equipment deployed at sea (and hence, lost there after end-of-life).

### **Achieved main results**

Euro-Argo successfully deployed and maintained BGC- and Deep-Argo floats in South Atlantic and Southern Ocean and the first DEEP float have been surviving under ice for 7 months. In the North-Atlantic the first success on an automatic releaser of floats (one every 3 months) has been reached and the first deployment of pH sensor on European manufactured floats has been done.

For OceanSITES, the capacities for genomic observation were strengthened by forming the Global Omics Observatory Network (GLOMICON) and by tests of methods for omics-based observations including laboratory inter-comparisons carried out with observing programs across the Atlantic. The establishment of a system for developing “Best practice” recording was an important step: The FixO3 manual of best practice for Eulerian observations (<http://www.fixo3.eu/download/Handbook%20of%20best%20practices.pdf>) has been adopted and expanded by AtlantOS. The document has been made available through the Ocean Best Practices (OBP) online platform that was developed in task 6.4 (<https://www.oceanbestpractices.net>). The platform provides the necessary means to make this a living document and ensure a good converge toward community consensus (e.g., version control, user management, cross-indexing, and metadata annotation). The transatlantic integration has been improved with the preparation of a MOU between Canada and EMSO-ERIC.

Task 3.2 has made a significant contribution to enhancing collaboration and formalizing interactions between Europe and Canada in the field of Eulerian ocean observations. After a series of discussions and face to face meetings with key individuals, an MOU between EMSO ERIC and Canada has successfully been drafted. The OceanSITES data management team (DMT) has successfully developed and deployed a distribution strategy for observational data, based on formats compliant with the Climate and Forecast (CF) netCDF format. Two mirrored data centers are in place to ensure that observational data is continuously served via FTP and THREDDS. While the systems effectively handle physical data, BGC data are so far less exposed for a variety of scientific and technical reasons. Activities are ongoing to allow for a full free and centralized access to BGC observations and to extend existing visualization capacities to be fully applicable to BGC data.

The key results are the expansion of the one-stop-shop for TMA products (volume transports of full arrays and subarrays under the hostage of OceanSITES <http://www.oceansites.org/tma/index.html>). 6 out of 8 TMAs time series products are already online and we expect intensive use by the modeler community for

easy model validation. Researchers from the different TMAs identified important long-term effects on the state of moored oxygen measurements and will produce a report, reference toward best practice for moored oxygen measurements.

The key objective of demonstrating value of observations from surface drifters in the Tropical Atlantic has been achieved, so they may continue beyond the project lifetime. This has been secured for the timeframe 2019-2023. This continuation of observation acquisition will enable to sustain the results achieved with regular provision of data for the benefits of numerical weather prediction, which delivers direct societal benefits.

All the PIRATA objectives initially defined in the framework of AtlantOS were successfully achieved (through sensors enhancements: O<sub>2</sub>, CO<sub>2</sub>, T/C, current) and even enlarged (T-Flex systems replacing Atlas; more deep CTDO<sub>2</sub>/LADCP casts; more kinds of measurements during cruise, (e.g. acoustic, and more samplings –Sargassum, microplastics, nutrients, salinity, O<sub>2</sub>, carbon, Chl pigments, plankton... -). All these new efforts will be maintained and contribute to the future PIRATA and TAOS.

The European Tracking Network is now established as an observational network, both amongst users (aquatic bio-telemetrists based in Europe) and the industry (manufacturers). The ETN database already hosts over 57 Million detections from over 50 projects and 120 researchers across Europe; The continuation of networking activities is secured through a successful COST funding scheme.

## **WP 4 Interfaces with coastal ocean observing systems**

### **Summary**

WP4 produced four deliverables during this period (D4.2, D4.3, D4.5, D4.6). Our gap analysis of links between the open ocean and coastal observing systems was completed. D4.5 set out recommendations to re-plan and optimise strategies for continental shelf observing networks and to better complement deep ocean observations. This, along with the recommendations for strengthened links between coastal ocean observing communities, has made a significant contribution to the All Atlantic Ocean Observing System Strategy (the Atlantic BluePrint). D4.3 provided a detailed overview of a series of coordinated glider deployments made in the Celtic Sea. This paves the way for the use of autonomous vehicles in shelf sea monitoring and operational systems, for climate timescale analysis and for policy around health of shelf seas. WP4 also completed a feasibility study of acoustic monitoring from marine autonomous vehicles in typical coastal ocean conditions to investigate capability in measuring marine noise levels and detection of vocalisation of marine mammals (D4.6). A data management plan for all South Atlantic tide gauge data was produced (D4.2); as well as making South Atlantic tide gauge data more discoverable and interoperable, this work has led to a community white paper to the OceanObs'19 conference outlining a forward-looking plan for the GLOSS sea level measurement programme. Finally, progress was made towards a strategy for strengthening pan-Atlantic collaboration identifying a number of actions to improve the sustainability of coastal observations through strengthened alliances.

### **Progress per Task**

#### *Task 4.1 Gap analysis and critical assessment of coastal observing systems)*

This Task completed its gap analysis of the observational links between coastal and open ocean networks. D4.5 is a report setting out recommendations to re-plan and optimise current observational strategies for continental shelf observing networks; and improve their connection with wider ocean observing networks. Gaps in observing networks, data availability, sustainability and technology were all considered, and recommendations were made. The report's main recommendations following identified gaps were:

- The spatial coverage of observing networks need to be improved between the near-coast and open ocean observing systems.
- The general lack of observations over the shelf break and the continental shelf can be improved based on opportunity measurements (*e.g.* Fishery Observing Systems).
- Continuous monitoring of the shelf waters is crucial supporting the continuity and success of active operational numerical forecast models.
- Biogeochemical or biological observations are lacking except near coast where regular sampling are performed.
- Harmonization actions need to be extended to the whole range of observing networks (particularly diverse in coastal area) in coastal and open oceans.
- Coastal data availability remains limited and international initiatives need to be supported.
- Estimations of costs are necessary to show that observing ocean from coast to open ocean has a low cost to society compared with other infrastructures (*e.g.* roads), and how they provide benefits for the society.
- There is a need for standardizing technological modules for continuous, affordable and efficient monitoring systems, particularly for the coastal ocean.

The Task found that the priority overall technological objective in the following years is to improve the harmonization of coastal and open ocean observing networks. The data access remains a limitation in the development of integrated observing systems from the coast to the open ocean. Actions to improve the data availability and access need to be supported.

#### *Task 4.2 Optimised shelf physical and biogeochemical sampling*

The two main developments in Task 4.2 in this period were the full report on the synoptic multi-variable glider study (D4.3) and guidance on acoustic monitoring from marine autonomous systems (D4.6).

D4.3 provided a detailed overview of a series of coordinated glider deployments made in the Celtic Sea. This long-term, multiple vehicle deployment tests the capability of ocean gliders to provide a synoptic study of physical and biogeochemical functioning in a temperate shelf sea, with the longer-term aim of providing a framework for operational coastal oceanography that is globally transferable. The AtlantOS WP4 work extended and complemented an existing project (funded by NERC in the UK). The analysis, carried out under AtlantOS, enabled the broader recommendations for multi-variable glider deployments that are reported here and which was our WP4 objective. In total, 22 autonomous ocean gliders were deployed over a 17-month period. This case study focuses on the on-shelf component of this study, which includes a repeat 120km long transect between the Atlantic shelf break and the inner shelf and a series of short term deployments of specialist gliders that provide additional parameters at fixed station locations. The experiment was highly successful, providing an extensive, high-resolution, multivariable dataset that captures the key components of the seasonal cycle of stratification and associated biogeochemical responses. This report presented useful information on planning strategy, navigation and quality control associated with this long-term series of glider deployments and presents data and analysis of collected data. Finally, recommendations were made for sensor integration, data completeness, an improve piloting of autonomous vehicles.

D4.6 provided guidance on acoustic monitoring from marine autonomous vehicles (*e.g.* for marine mammal detection). It presented results from a feasibility study of acoustic monitoring from marine

autonomous vehicles in typical coastal ocean conditions (i.e. 50-100m depth) to investigate our current capability in measuring marine noise levels and detection of vocalisation of marine mammals and it provided guidance on future use. It is important to effectively measure and monitor natural sound in the marine environment to assess the abundance and location of marine fauna, particularly marine mammals. It is also important to monitor anthropogenic introduction of sound; such as from seismic and underwater drilling activities, largely due to its potential to cause harm to marine life. For this reason, marine noise is listed under the EU Marine Strategy Framework Directive as a potential source of pollution under Descriptor 11: Energy including Underwater Noise and industry spends considerable sums to avoid undertaking high-impact marine noise activities in the vicinity of marine mammals. In total, nine autonomous vehicles were deployed west of Scotland with a variety of acoustic sensors that collected a novel set of data characterising the acoustic environment over several 100kms scale: detailing background noise levels from different marine platforms and identifying marine mammal vocalisations and anthropogenic noise. This work highlighted the capability of marine autonomous vehicles to provide increased coverage at reduced cost compared to traditional ship based or moored acoustic networks. Further experimentation is required to assess the role of autonomous vehicles as effective platforms for marine acoustic monitoring for determining environment status. Before autonomous platforms, such as ocean gliders, can be considered effective platforms for marine acoustic monitoring however, critical limitations in endurance and geolocation need to be addressed.

#### *Task 4.3 Harmonised Sea Level Data Flow*

The South Atlantic tide gauge data management plan (D4.2) had the aim to develop a harmonised data management plan for all South Atlantic tide gauge data building on international data centre activities. Tide gauge stations from the Caribbean, Gulf of Mexico and small section of Antarctica were included as these regions impact on the South Atlantic Ocean and are also data sparse regions, requiring attention. The deliverable builds on several other AtlantOS deliverables including D4.1 Sea level observing site catalogue: Systematic documentation of South Atlantic tide gauge site data and benchmarks, and D11.2. AtlantOS Data Management Plan Framework, together with a number of WP7 deliverables (D7.1, D7.2, D7.3 and D7.4). As became clear at the Task 4.4 Atlantic Coastal Observing Systems workshop held at the AtlantOS GA in November 2017 (Gran Canaria), there are major differences in capability between the NE and NW Atlantic regions, which are well developed, compared with other Atlantic regions. The SWOT analysis for the five key coastal and shelf sea regions in the AtlantOS Atlantic Ocean basin domain, showed common issues of a lack of funding and coordination, and spatial and temporal gaps in observations due to a lack of operational platforms in many countries along the Atlantic coastlines of South America, the Caribbean and west Africa.

AtlantOS, as a Horizon 2020 project, is working on a principle of free and open access to data and also maximising the reuse of data. The AtlantOS Data Management Plan (DMP) Framework (D11.2) suggests that data be output in Network Common Data Form (NetCDF) and that published data formats shall meet accepted international standards. The sea level data relating to this deliverable will be available in NetCDF format and also ASCII files as agreed by the GLOSS community. Task 4.3 also contributed to the GLOSS Group of Experts community white paper abstract to the OceanObs'19 conference which outlined a forward-looking plan for the GLOSS programme.

In order to make the South Atlantic tide gauge data discoverable metadata records are sent to existing AtlantOS integrators such as SeaDataNet. The AtlantOS DMP states that discovery metadata need to be INSPIRE compliant or ISO 19115. There are already existing GLOSS and PSMSL European Directory of Marine Environmental Data (EDMED) records, maintained by SeaDataNet, but we will create a new AtlantOS sea level data EDMED record. We will also create a European Directory of the Ocean Observing

Systems (EDIOS) record, a further SeaDataNet catalogue. Discovery metadata entries can also be provided to other international metadata directories (e.g. NASA's Global Change Master Directory (GCMD)). There is currently a GLOSS entry in the AtlantOS product catalogue, as described in the Data Management Handbook (D7.4); this could be supplemented by a South Atlantic sea level entry. These data will be stored at the GLOSS Delayed Mode Data Centre and all incoming data accessions are assigned a unique identifier.

#### *Task 4.4 Non-EU cooperation and sustainability issues*

This objective of this Task is to build and strengthen transatlantic linkages with coastal observing communities. D4.4 (in progress) is a [“Strategy toward strengthening panAtlantic collaboration between coastal observing communities focused on achieving sustained measurements in the coastal ocean”](#). It will be completed end of March 2019. The deliverable provides an overview of the need for Coastal Ocean Observations (near coast to open ocean) and focuses on existing initiatives that are working to strengthen pan-Atlantic links between coastal ocean observing communities. Results from a Strengths, Weaknesses, Opportunities and Threats analysis of the existing coastal ocean observing system in the Atlantic (S America, N America, Europe and Africa) show a greater requirement for sustained funding, and resources (infrastructure and human). To ensure success, support must start at a national level in all Atlantic countries with developed integrated marine plans with productive regional dialogue. Strategic actions have been identified to guide future efforts to continue to build and strengthen community cooperation in coastal ocean observing.

Planning and Governance Initiatives to strengthen Atlantic alliances include support for the Galway and Belém statements are the EC H2020 Atlantic Ocean Research Alliance – Coordination and Support Action (AORA-CSA) project in the north and its related flagship project in the south, the EC H2020 All Atlantic Cooperation for Ocean Research and innovation – Coordination and Support Action AANChOR, that are coordinating efforts to align research activities in the north and south Atlantic. Research calls are discussed by funders on all sides of the Atlantic before launch in order to facilitate aligned scientific research that can address Atlantic wide issues of importance to society. Emerging transnational implementation initiatives as a result of this Task include The All Atlantic Ocean Observing System Strategy (aka Atlantic Blueprint; de Young *et al.* 2018) outlines an ambitious vision and a new concept for a forward-looking framework and basin-scale partnership to establish a comprehensive ocean observing system for the Atlantic Ocean as a whole that shall be sustainable, multi-disciplinary, efficient, and fit-for-purpose. Regional implementation initiatives resulting from this Task include the [Coastal Working Group](#) (WG) of EuroGOOS, kicked off in May 2018, is one of four EuroGOOS WGs with 16 participating European research and operational centers. The main objective of this group is to provide recommendations for, and facilitate the creation of coastal data-products and services by groups around Europe, using coastal data. The group also documents potential coastal data sources and users requirements of coastal products. The EuroGOOS Coastal WG examines the entire coastal ocean value chain from coastal observations (in-situ and satellite data), ocean forecasts and analysis, to science based products and services (provision of products) for coastal users. The WG examines the sustainability and fitness-for-purpose (upstream datasets) of the existing system and identifies the future steps needed to secure and improve all elements of the coastal value chain. The EuroGOOS Coastal Working Group will build upon initiatives already completed or underway with a focus on coastal observing. These include, but are not limited to, the work of the JERICO and JERICO-NEXT EC projects, activities within EuroGOOS working groups, task teams, and the five regional operational oceanographic systems (ROOS). A key early priority for the Coastal Working Group is to document the existing and planned activities and provide a status of the coastal observing system in Europe at the present time.



The work highlights a number of actions for sustained coastal observations based on strengthened alliances: to build on the number, and empower the Atlantic Coastal Ocean Observing National Focal Points (NFPs; Ketelhake *et al.* 2019) to represent national ocean observing activities and interests; to set up a Funders forum to calculate the amount needed to fund essential resources (personnel and infrastructure) for fit-for-purpose coastal ocean observing systems; to build on existing open access programmes in the Atlantic, and implement the All Atlantic Ocean Observing System Strategy; to ensure implementation activities are carried out in close collaboration with the GOOS GRA.

### **Cooperation and interaction with other AtlantOS WPs**

WP4 Task 4.1 interactions with other work packages focused on discussions around the future observing network (Workshop in February 2019 lead by WP1). The link between coastal (WP4) and regional integrated systems (WP5) are a key component of the future global observing systems. Throughout AtlantOS, WP4 Task 4.2 has worked with WP3 Task 3.4 in delivery of ocean glider data following the recommended EGO format and working with international partners to deliver best practice in marine autonomy. WP4 Task 4.2 worked in tandem with WP6 through the acceleration of Technology Readiness Levels (TRLs) of new glider sensors to address identified gaps in ocean measurement, specifically nutrient sensors to estimate biogeochemical fluxes. Sea level observing work (Task 4.3) contributed to a number of WP7 deliverables (D7.1, D7.2, D7.3 and D7.4). All these activities enhance the optimization of planning for coastal observing systems and lead to improved sharing and integration of data.

### **Cooperation and interaction with other projects and initiatives**

WP4 activities have been driven in close interactions with two other European projects. The project JERICO-NEXT (H2020), focused on coastal observing systems, has driven complementary discussions on targeted observing technologies (e.g. Interoperability Technologies and Best Practices in Environmental Monitoring in October 2018). In the meantime, during the MyCOAST project (Interreg), focused on Arc Atlantic area the link between coastal and open ocean observing systems are discussed. In April 2018, the IBI (Iberia-Biscay-Ireland) week, was the opportunity to exchange on the existing gaps between coastal and open ocean in the IBI region. Concluding remarks from those discussion have been included in the deliverable D4.5 (Gap analysis of links between coastal and open ocean networks). Task 4.3 was conducted in close cooperation with the IOC GLOSS community. Task 4.4 established a coastal working group of EuroGOOS. The Task 4.2 work extended and complemented an existing project, AlterEco (funded by NERC in the UK).

### **Achieved main results**

- Completion of gap analysis of coastal observing systems and final recommendations for improved observing networks, data availability, sustainability and technology (D4.5)
- Successful glider study involving 22 gliders over 17 months to deliver an extensive, high-resolution, multivariable dataset that captured the key components of the seasonal cycle of stratification and associated biogeochemical responses in shelf seas. This work paves the way for the use of autonomous vehicles in shelf sea monitoring and operational systems (D4.3)
- Demonstration of the future capability of ocean autonomous vehicles for marine acoustic monitoring to assess the abundance and location of marine fauna, particularly marine mammals (D4.6)
- Increased discoverability of South Atlantic tide gauge data and white paper in conjunction with GLOSS for OceanObs19 (D4.2)

## WP 5 Integrated regional observing systems

### Summary

During the last reporting period WP5 finalized its activities with respect to the three core themes on regional observing in the North and South Atlantic:

- Analysis of societal requirements connected to climate change and ecosystem management (ultimately linking to sustainable development goals SDGs)
- Assessment of climate change and ecosystem indices that provide state estimates which in turn may assist decision making
- Test concept of ocean observing guidance (observational aspects only) by executing regional Observing System Simulation Experiments (OSSEs) for selected applications related to climate change and ecosystem management

### Progress per Task

#### *Task 5.1 – Assessment and Coordination of Regional Observing:*

For the analysis of societal requirements, we followed a twofold approach: we organized a sequence of in total six meetings in conjunction with other international events related to climate, fisheries, and Atlantic observing (including AtlantOS GA) to connect the various stakeholders from east/west and north/south. We synthesized requirements but also observed the different processes which may be required to better connect ocean observing to stakeholder needs. The outcome of the series of meetings have been synthesized in manuscripts that are under review at the Research Topic “Oceanobs19: An Ocean of Opportunity” of Frontiers magazine.

In Schmidt et al. (submitted) a vision for ocean observing in support of ecosystem-based fisheries management (EBFM) is given. EBFM is a general approach (not only Atlantic) agreed on by the Food and Agriculture Organization (FAO) and individual countries to lead fisheries management and thus closely connected with the WP5 objectives. It is a certain realization of the ocean observing value chain (Figure 5.1). One big challenge in EBFM is that it requires observing across a vast range of scales and disciplines from short-term environmental variability to long-term climate influence and indirect impacts of other anthropogenic activities which alter habitat and ecosystem alike. EBFM is a prime case to clearly spell out the value of observations and link it to society and funding by taxpayers. Depending on the local/national/international implementation the value chain added a “Feedback loop” that is foreseen to enable a co-design element to all components of the value chain (Figure 5.1).

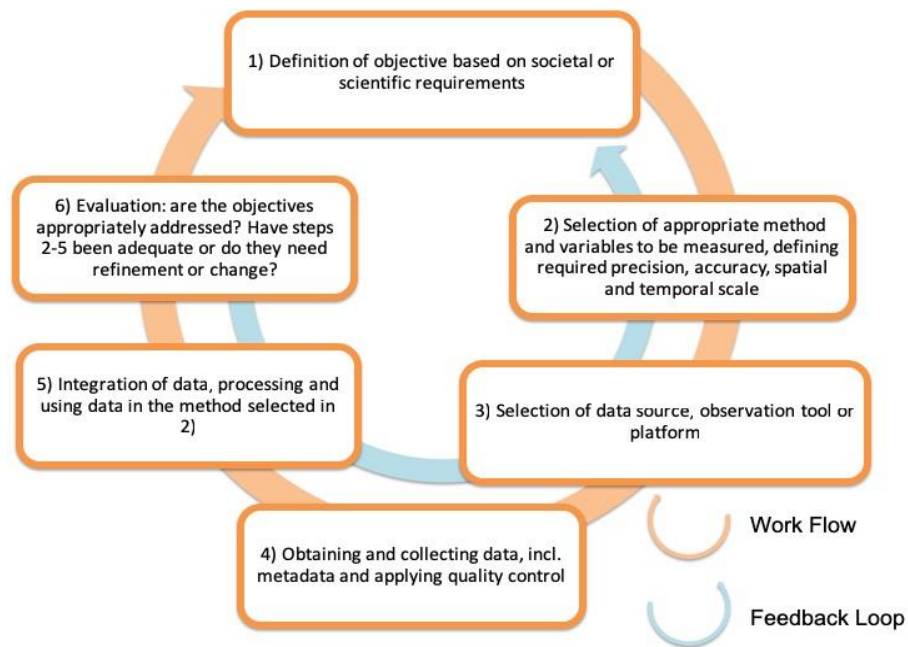


Figure 5.1: The Ocean observing value Chain for with a “feedback loop” that shall enable a stakeholder dialogue and appropriate interaction between ocean data users and observers. (Schmidt et al. submitted).

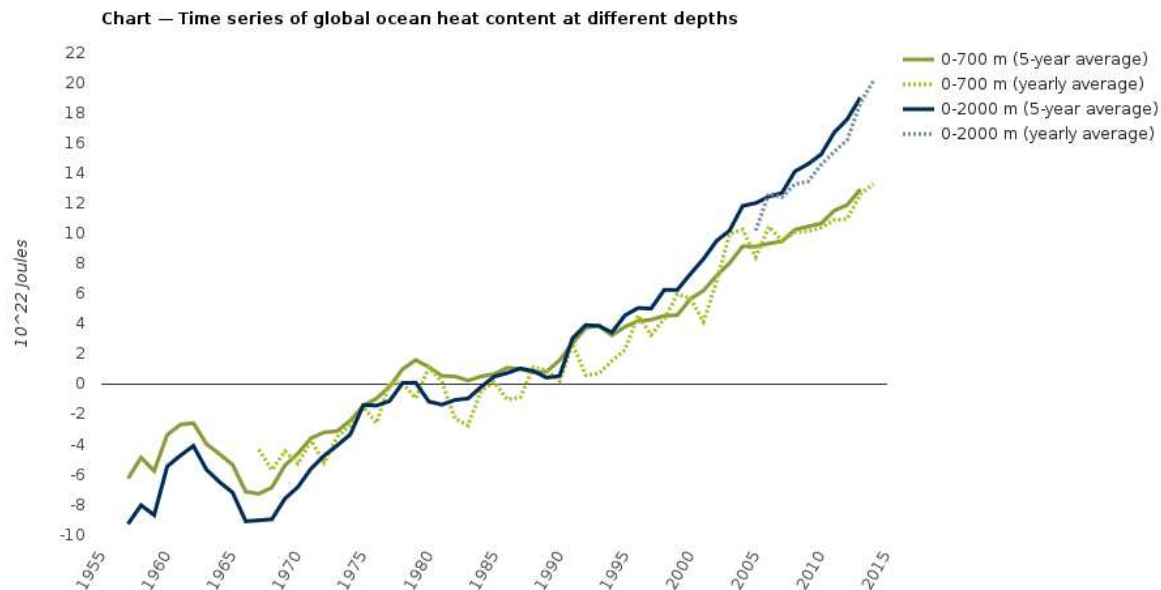
However, Schmidt et al. (submitted) identify:

- A need for “tools” such as ecosystem services analyses, that relate specific observations to societal needs to enable advice on the observing that is needed and which is ultimately a societal decision based on costs, risk, and benefits.
- One important gap in the current ocean observing, not only for EBFM, is the inability to allow a thorough evaluation of the data flow, from generation to end use observing. Observational data is not traceable. The consequences are: (a) the value of observational data cannot be explicitly exposed or even measured; (b) the feedback mechanisms along the ocean observing value chain is missing and the different communities (observation, assessment, modelling) are not able to understand their needs and to evaluate and co-design.
- Another important issue in the context of EBFM, but also evident during the course of AtlantOS in many application areas, is the fragmentation on governance between national and international organizations and programs with different disciplinary communities and institutions leading to a clear lack of harmonization of needs.

In Garcon et al. (submitted) ocean observing related to deoxygenation in connection with oxygen minimum zones is considering societal relevant issues such as the impact on fisheries. The VOICE (Variability of the oxycline and impact on the ecosystems) demonstrates how societal benefits drive the need for integration and optimization of physical, biogeochemical and biological components of regional ocean observing. Building on the Framework for Ocean Observing (FOO), VOICE initiated readiness level (RL) assessments for ocean observing of the oxycline in highly productive and economically important OMZ waters. VOICE determines ocean observing design based on scientific and monitoring activities in selected OMZs including the AtlantOS ones. Regional champions aided in assessing FOO design elements for the respective OMZ, namely: requirements processes, coordination of observational elements, and data management and information products. The RL for FOO elements is derived for each region and points at system bottlenecks which prevent delivering information and products for end users with a goal of motivating consistency across regions. We found that fisheries and ecosystem management are a societal

requirement for all regions, but maturity levels of observational elements and data management and information products differ.

It was recognized in WP5 that knowledge transfer is key and adequate capacity development is needed, in our case to support ocean observations for fisheries, ecosystem, but likewise climate observing and understanding. We initiated selected activities at sea in the South Atlantic (“MyScience cruises” March 2016 M124, Dec 2017 M133; GO-SHIP cruise MSM60; Coastal upwelling cruise RV Meteor M148) and in the subpolar North Atlantic (climate observing cruise Maria S Merian MSM54 & MSM74) that will prevail as “AtlantOS” legacy.



#### Task 5.2 – Application of regional ocean observing: climate and ecosystem:

Regarding climate change and ecosystem indices, we finalized the work on integrating observational data (in-situ and satellite) towards states estimate in the form of indices for the two WP5 focus regions of the Atlantic Ocean (subpolar North Atlantic, subtropical South Atlantic). The indices were addressing the two overarching research and monitoring topics in WP5: climate change and ecosystems evolution.

For climate change indices were overturning strength, and heat and freshwater transports on a regional scale. The current development status on these indices was reviewed from the literature, including efforts that benefited from direct AtlantOS contributions e.g. Overturning in the Subpolar North Atlantic Program (OSNAP). A comprehensive listing of climate indices was provided. These indices augment existing once e.g. from the European Environmental Agency (EEA; Figure 5.2).

Figure 5.2: Example for a climate index (ocean heat content) from the EEA website (<https://www.eea.europa.eu/data-and-maps/indicators/ocean-heat-content-1/assessment>).

For the ecosystem state and evolution recent publications were reviewed and R&D activities executed. The key state indicators of the marine ecosystem and the oceans capacity to take up carbon dioxide

(biological pump) are Primary Productivity (PP) and carbon export. The North Atlantic Subpolar Gyre (NASPG) is one of the key places of the global ocean for carbon drawdown in particular through the most intense spring phytoplankton bloom and subsequent export of organic matter in the mesopelagic (100-1000 m) realm. The South Atlantic subtropical gyre is one of the most oligotrophic zone of the open ocean (together with its South Pacific counterpart) and hence a key experimental zone in the context of increasing stratification and associated extension of oligotrophic areas. The work in WP5 benefited from the enhancement of the observing capabilities of ship based (WP2 and its subtasks) and autonomous (WP3 and its subtasks) observing networks and the enhancement of data access (WP7) and R&D was based on combining data from biogeochemical Argo floats and multidisciplinary moorings with satellite data.

The indices baseline assessments in WP5 facilitates a future operational creation e.g. as part of the Copernicus Marine Environmental Monitoring Service (CMEMS), the Copernicus climate change service ([climate.copernicus.eu](http://climate.copernicus.eu)), and the European Environment Agency ([www.eea.europa.eu/data-and-maps/indicators](http://www.eea.europa.eu/data-and-maps/indicators)). By linking the physical indices with the ecosystem evolution indices support and guidance for advice can be provided e.g. as outlined in the EU report on “Climate Change and European Fisheries” (<https://publications.europa.eu/s/go3l>). Here specific services, such as ecosystem services for fisheries by ICES, are highlighted.

#### *Task 5.3 – Regional Observing System simulation experiments and process modelling:*

Task 5.3 was addressing the optimal design of regional sampling making use of Observing System Simulation Experiments (OSSE). One objective was to estimate the skill in reconstructing quantities (in this case Chlorophyll-a) from different theoretical sampling scenarios (here only profiling float “like” sampling was considered). The results show how the observing system impacts the chlorophyll analysis in a probabilistic ensemble model simulation. By considering two different dates and thus, two different biodynamical states, it was possible to identify guidelines to help in the future development of the biogeochemical Argo float observing network. Those recommendations are presented from the most general and obvious ones to more event-adapted situations. The conclusions should however be considered with some caution as the robustness of the ensemble BGC data assimilation system still needs to be improved.

The other objective was using a statistical optimization approach via OSSEs to estimate an ecosystem module that utilizes multiple in-situ and satellite data to derive predictions for different trophic levels, including fish. The ecosystem module focussed on a key species Micronekton, a group of small organisms able to swim short distances and a key link in the oceanic trophic chain. It constitutes the main forage source for top predators and plays an important role in the biological pump (Figure 5.2). SEAPODYM-MTL is a spatially explicit dynamical model of micronekton. It models six functional groups defined according to their diel vertical migration behavior. As Energy transfer efficiency from primary production to micronekton functional groups is not directly measurable, a data assimilation framework has been developed to estimate these parameters. Several observation networks (Figure 5.2) have been tested regarding energy transfer coefficient estimation using the OSSEs (with perturbed forcing fields). Results indicate that the typology of environmental conditions are crucial to determine a network efficiency. The optimal sampling environment is predicted in warm, quiet to moderately dynamic and productive waters (e.g., eastern equatorial Atlantic Ocean).

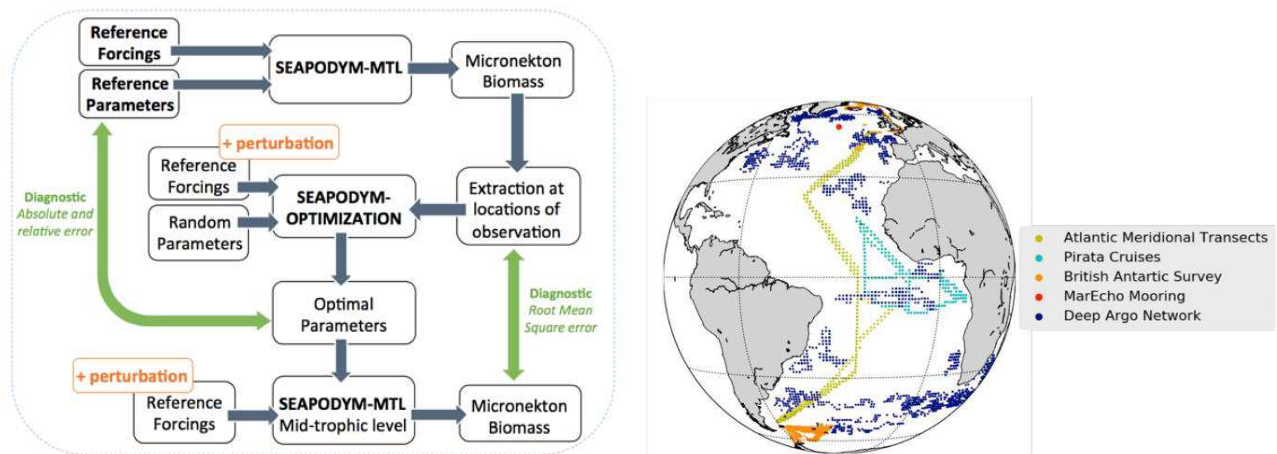


Figure 5.2: (left) Workflow in the statistical OSSE approach applied to the SEAPODYM-MTL. (right) selected observational data used for the test cases and covering the WP5 core regions in the North and South Atlantic.

### Cooperation and interaction with other AtlantOS WPs

All our activities were closely connected to the work in other AtlantOS work packages, specifically WP2 and WP3 (observing network enhancements: coordination, data accessibility, temporal limited enhancement of data acquisition), benefit from new ocean observing technologies (WP6), benefit from improved data accessibility (WP7), WP8 (Societal benefits from observing/information systems, specifically task 8.8).

### Cooperation and interaction with other projects and initiatives

Unlike other projects that define their own, project specific brands and webpages, the base of AtlantOS were in most cases existing established or emerging initiatives. Therefore, with AtlantOS coming to an end the achievements will continue to exist and, if identified as useful elements, will even further developed and matured. One such element is the WMO-IOC Joint Technical Commission for Oceanography and Marine Meteorology in situ Observations Programme Support Centre (JCOMM OPS) that provide an interface to metadata from ocean observing networks. In order to track the changes in the observing components during the AtlantOS lifetime and in the North and South Atlantic the metadata base at the JCOMMOPS was inspected (Table 5.1). In general number are quite fluctuating over the 4 years. What can be said is that in the North Atlantic about double as many observing platforms are operated then in the South Atlantic (average 259 versus 116). In the North Atlantic the average effort by USA & Canada (120) is only little less than what all European countries contribute (139) while in the South Atlantic USA & Brazil (68) contribute significantly more than European countries (48)

Table 5.1: Observing devices (platforms) deployed in the South and North Atlantic during the AtlantOS period 2015 to 2018 according to the JCOMMOPS metadata base. Some countries are color-coded to ease identification in the two regions

YEAR	2015	2016	2017	2018	average
<b>North Atlantic</b>					
<b>United States</b>	69	71	124	117	
<b>France</b>	45	40	45	34	
<b>European Union</b>	33	29	70	72	

<b>United Kingdom</b>	11	5	11	5	
<b>Germany</b>	26	19	20	22	
<b>Canada</b>	19	30	23	21	
<b>Ireland</b>	3	3	3	4	
<b>Spain</b>	0	1	0	11	
<b>USA/European Union</b>	0	9	0	0	
<b>Portugal</b>	1	0	0	0	
<b>Brazil</b>	2	0	0	0	
<b>Italy</b>	0	0	1	0	
<b>- Total -</b>	<u>209</u>	<u>207</u>	<u>297</u>	<u>286</u>	<u>259</u>
<b>South Atlantic</b>					
<b>United States</b>	80	74	50	65	
<b>United Kingdom</b>	19	10	19	22	
<b>Germany</b>	14	15	6	12	
<b>European Union</b>	5	9	26	19	
<b>France</b>	19	4	3	6	
<b>Brazil</b>	4	2	0	0	
<b>Netherlands</b>	1	2	5	2	
<b>Canada</b>	1	0	0	0	
<b>- Total -</b>	<u>143</u>	<u>116</u>	<u>109</u>	<u>126</u>	<u>117</u>

#### Achieved main results

- A series of meetings to “connect” the various stakeholders from east/west and north/south, climate, biodiversity and fisheries, and Atlantic observing were organized to synthesize requirements
- The outcome of the series of meetings have been synthesized in manuscripts that are under review at the Research Topic “Oceanobs19: An Ocean of Opportunity” of Frontiers magazine
- Specific activities for knowledge transfer between East/West and North/South to support ocean observations for fisheries, ecosystem, but likewise climate observing and understanding were initiated and executed
- A comprehensive listing of climate and ecosystem related indices, including marine ecosystem and the oceans capacity to take up carbon dioxide (biological pump) via Primary Productivity (PP) and carbon export
- Operationalizing the creation of indices (e.g. as part of the Copernicus Marine Environmental Monitoring Service, the Copernicus climate change service) will enable a link with other agencies that are used for advice e.g. European Environment Agency
- By linking the physical indices with the ecosystem evolution indices support and guidance for advice can be provided e.g. as outlined in the EU report on “Climate Change and European Fisheries” (<https://publications.europa.eu/s/go3l>)
- Observing System Simulation Experiments identify guidelines to help in the future development of the biogeochemical Argo float observing network.
- Statistical Observing System Simulation Experiments indicate that the typology of environmental conditions are crucial to determine a network efficiency for warm, quiet to moderately dynamic and productive waters

## WP 6 Cross-cutting issues and emerging networks

### Summary




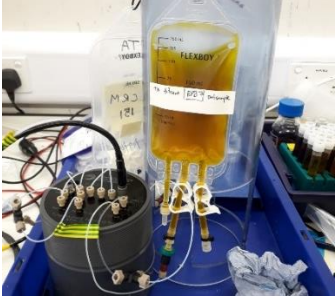
#### Progress per tasks

##### Task 6.1 – Sensors and new instrumentation


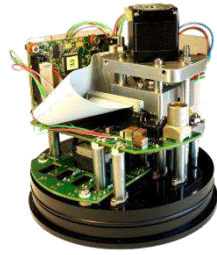
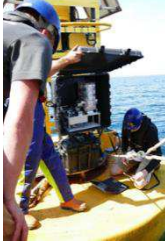
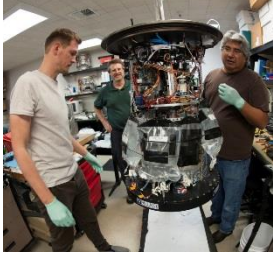
Principal activity during reporting period has been the final validation of sensor and instrumentation innovations that has been the central activity of Task 6.1 since the start of the AtlantOS project. A full description of the work undertaken and the Technology Readiness Levels (TRLs) that have been demonstrated is provided in the AtlantOS deliverable 6.3.

In summary; eight separate technologies that address key Essential Ocean Variables (EOVs) received direct support from AtlantOS and a total of 18 TRLs have been advanced through the AtlantOS project, **Table 1**. Task 6.1 partners also undertook multiple collaborations with previous H2020 EU funded Oceans of Tomorrow projects to further demonstrate and validate technologies that had been developed prior to the start of AtlantOS.

**Table 1** Summary of technology development through Task 6.1

Parameter		EOVs (inc supported variable)	Advancement
pH	 <p>Prototype optode</p>	<ul style="list-style-type: none"> <li>• Inorganic carbon</li> <li>• Phytoplankton biomass and diversity</li> <li>• Hard coral cover and composition</li> </ul>	TRL 5 to 6+
pCO <sub>2</sub>	 <p>Optics electronics board</p>	<ul style="list-style-type: none"> <li>• Inorganic carbon</li> <li>• Phytoplankton biomass and diversity</li> <li>• Stable carbon isotopes</li> </ul>	TRL 5 to 6
O <sub>2</sub>	 <p>Completed optode</p>	<ul style="list-style-type: none"> <li>• Oxygen</li> <li>• Nutrients</li> <li>• Inorganic carbon</li> </ul>	TRL 7 to 9
Total Alkalinity	 <p>Prototype system</p>	<ul style="list-style-type: none"> <li>• Inorganic carbon</li> <li>• Stable carbon isotopes</li> <li>• Phytoplankton biomass and diversity</li> </ul>	TRL 4 to 7



Dissolved inorganic carbon	 <p>Prototype system</p>	<ul style="list-style-type: none"> <li>• Inorganic carbon</li> <li>• Stable carbon isotopes</li> </ul>	TRL 4 to 7
Nutrients	 <p>Completed microfluidic and electronic integration</p>	<ul style="list-style-type: none"> <li>• Nutrients</li> <li>• Dissolved Inorganic Carbon</li> <li>• Phytoplankton biomass and diversity</li> </ul>	TRL 7 to 8+
Marine Autonomous Plankton Sampler	 <p>System trial on buoy</p>	<ul style="list-style-type: none"> <li>• Fish abundance and distribution</li> <li>• Hard coral cover and composition</li> <li>• Phytoplankton biomass and diversity</li> </ul>	TRL 2 to 7
Environmental Sample Processor	 <p>System preparation for trial</p>	<ul style="list-style-type: none"> <li>• Fish abundance and distribution</li> </ul>	TRL 6 to 8

*Task 6.2 – Common metrology and best practices*

In the first reporting period Task 6.2 held a metrology workshop on uncertainty in measurements of trace elements in Plymouth (UK). The meeting was organised by the University of Plymouth. There were 25 – 30 participants, and the meeting consisted of a mix between theoretical and practical applications of uncertainty to analytical measurements of trace elements. In this reporting period a publication on best practices in uncertainty assessments for trace metal measurements in seawater was produced and submitted to *Frontiers in Marine Science*, Topic on Ocean Best Practice. The manuscript is published.

In cooperation with Agriculture and Agri-Food Canada, a three-day genomic workshop was organized by AWI and Ribocon at the Max Planck Institute for Marine Microbiology, Bremen, Germany, in the period 21-23 February 2018. The workshop was on enhancing interoperability and coordination of long-term observing systems capable of observing biodiversity using metagenomic and metatranscriptomic (i.e.

“omic”) techniques. The workshop’s primary outcome was the initialization of a “Global Omics Observatory Network” (GLOMICON), to better coordinate multiregional, long-term, and omically enhanced observation activities. Workshop minutes are currently finalized for upload to the workshop’s page at the AtlantOS website<sup>1</sup>. An online collaborative forum and mailing list have been established to synchronize follow-up activity.

A workshop on ocean observations of oxygen, pH and CO<sub>2</sub> was held during October 10-12, 2018 in Brest (France). The workshop was organised by IFREMER, with a contribution by IOPAN. In addition, a workshop on nutrient and fluorescence observations was held on December 4-6, 2018 in Brest (France). The meetings were successful, and reports and manuscripts for dissemination of the meetings are being produced.

A training workshop organised by IOPAN on carbonate chemistry sensors is scheduled for June 2019. AtlantOS will contribute to this workshop.

The collection and creation of reference seawater materials, in connection with the International GEOTRACES Programme, has been very successful. These materials are distributed free of charge to users and provide a backbone to high quality measurements of trace metals in seawater, allowing data to be comparable and of high quality.

Over 550 samples of 500 ml of deep seawater consensus material (from a depth of 1000 m) for trace metal was collected by GEOMAR on FS Meteor cruise M121 using trace metal clean conditions in the southeast Atlantic Ocean in December 2015. The samples have been assessed for stability, and subsequently shared with international partner laboratories. The samples have been distributed in autumn 2018 to the global community, at no cost to the users other than shipping costs. The exercise forms a collaboration between AtlantOS and the International GEOTRACES Programme.

In the global omics community, a comparison between different protocols by means of standard materials is novel and still an area of research. Discussions on feasible approaches at and following the AtlantOS ‘workshop on enhancing interoperability & coordination of long-term omics observations’ identified the need for a combination of genomic standards (i.e., controlled DNA mixes) and natural samples (i.e., frozen filters). AWI and Ribocon have partnered with the Monterey Bay Aquarium Research Institute (MBARI) to create and exchange genomic standards and natural samples.

The recipes for genomic standards and sampling protocols are made available to the GLOMICON community and all community members are invited to participate in the inter-calibration. The genomic standard materials themselves as well as environmental sample material collected during the summer season of 2018 have been available since mid-August 2018. Extraction and sequencing by AWI, MBARI, and additional participating parties was completed by mid-Autumn 2018. Ribocon is supporting the coordination of these activities by providing the prototype of a dedicated online platform to systematically record and monitor data and information flows (including procedural records) of the GLOMICON community. The platform will provide pre-defined data schemes allowing users to register projects in a fully standardized manner (including support for standardized metadata recording) and will facilitate centralized access to omics raw data and corresponding metadata, as well as analysis results for data intercomparison.

### *Task 6.3 – Shared Infrastructure*

---

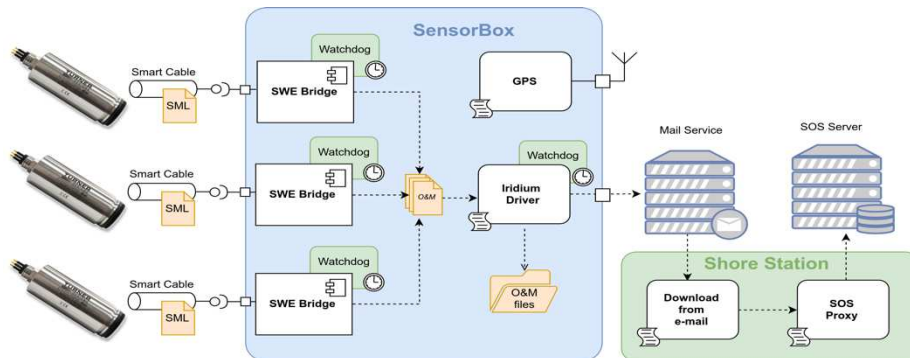
<sup>1</sup> <https://www.atlantos-h2020.eu/events/workshop-on-enhancing-omics-observation/>

Following the first interoperability workshop held in PLOCAN, Gran Canaria (2016), a second one was organized at the Oceanology International '18 convention in London. This second workshop co-sponsored by EMSO ERIC served to engage the community and find synergies between different stakeholders and research groups. Forty attendants attended. Important matters at the workshop related to the different aspects of interoperability including new ocean sensors and real-time data sharing based on OGC standards, were discussed and interesting initiatives and links came up as a result, such as with the JERICO RI, the organization of a training, and field experiment.



**Figure 6.1** Second Interoperability workshop at Oceanology International '18.

One of these initiatives proposed the demonstration of capabilities of the Smart Cable developed under the BRIDGES project. To proceed with this demonstration Ehsan Abdi from Cyprus Subsea and Encoc Martínez from UPC worked on the hardware and software integration of three Turner Cyclops sensors into PLOCAN's Wave Glider SV2.



**Figure 6.2** System Overview

During the experiment three non-PUCK enabled sensors were integrated in the ASV vehicle, and the information gathered by them was transmitted through Iridium and available in real time through a web client.



The AtlantOS deliverable 6.6 corresponding to the shared infrastructure Report has been developed and includes a best practice documentation and a review / inventory of current methods for sharing components, such as ships, fixed and mobile observing systems, calibration facilities and support the use of the infrastructure for innovation testing, validation or demonstration.

**Figure 6.3** Physical integration

#### Task 6.4 – Best practice on observing systems

Activity in this reporting period has focused on wide engagement across the oceanographic community on best practice, the creation of an online repository, methods of discovery and access to best practice, peer review and community forum and relevant training. The AtlantOS D6.7 details all of these activities.

In summary, the themes of the work centered on the derived community needs for an effective Ocean Best Practice System (OBPS);

1. A sustained repository supporting easy discovery and access through semantic technology and natural language processes and machine-to-machine interoperability
2. A process for community peer review and identification of preferred or recognized practices
3. A capability to facilitate capacity building and uptake of best practices
4. A procedure for tracking and monitoring of best practices use and a means of uniquely identifying best practices and provenance

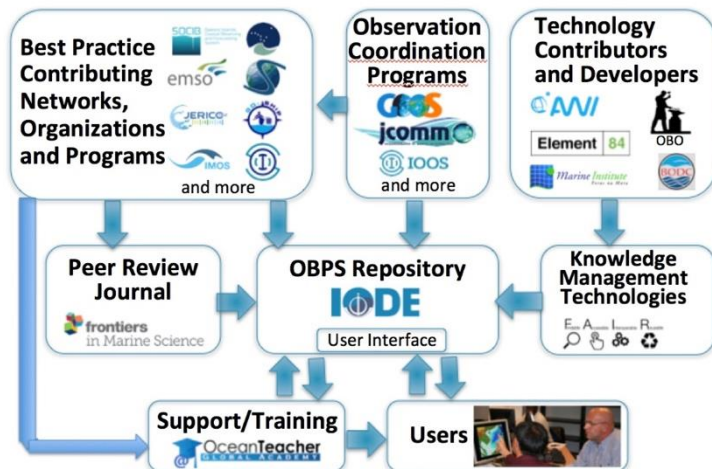


Figure 6.4 Block diagram of Ocean Best Practice elements and their linkages

Once the requirements of the community were known effort was invested in delivering each of the four components. The community engagement has been a consistent thread running through Task 6.4 to both promote the new resources available in the field of best practice but to

also receive essential user feedback to further enhance the contribution towards an integrated ocean observing system.

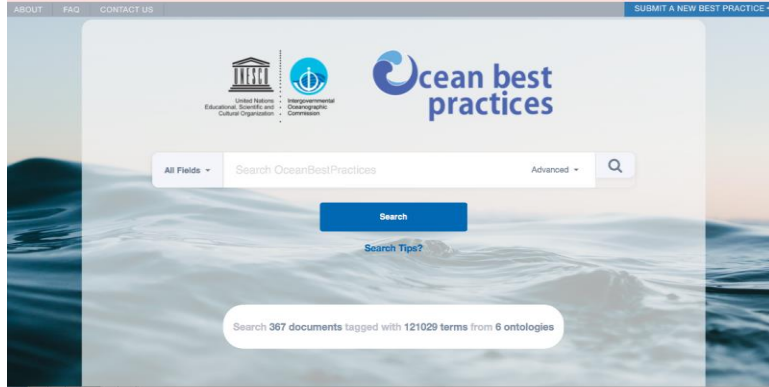
Two workshops of international experts were held in November 2017 and December 2018. The first focused on user requirements which guided the creation of the OceanBestPractice System and pointed to key areas of emphasis such as the use of best practices in Essential Ocean Variables. The second workshop defined recommendations for the next 2 – 5 years. Proceedings of these workshops are available with details of the recommendations.



Figure 6.5 The Best Practices Workshop WP6 brought together international experts to guide the development of the Ocean Best Practices System.

In late 2018, the OBPS transitioned to an operational system. The user portal is available to . The repository is hosted by the International Ocean Data and Information Exchange (IODE) which is part of UNESCO/IOC. During the last year, discussions have been held on a path to sustain the capability after AtlantOS. The approach is to have joint sponsorship by GOOS and IODE under the umbrella of the IOC. In February, the IODE XXV assembly approved a recommendation to IOC for implementation of a two year project. The GOOS Steering Committee will consider a similar motion in May.

There are further developments that will make best practices more widely used and the ocean best



practice system a core contribution to advance in ocean observing. A paper on this subject has been prepared for the OceanObs'19 conference.

**Figure 6.6** User interface for the OBPS allowing BP search and access

### Task 6.5 – New and emerging networks

The roadmap for emerging networks was delivered in a previous reporting period but the deliverable underwent an update during the current reporting period.

The initial submission assessed emerging networks, particularly biogeochemical and biological observing

Sector	Emerging biogeochemical network			
Network	Profiling floats	Gliders	Eulerian Observatories	Ships of opportunity
Organised community (Y/N)	Yes	Yes, in development through EGO and GROOM, see below	Partly through EMSO, RAPID & PIRATA	Yes through the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) through the VOS Panel. The SOOP programme is a key part of the ICOS network for carbon system measurements ( <a href="https://www.icos-ri.eu/home">https://www.icos-ri.eu/home</a> )
Website (link)	<a href="http://www.argo.ucsd.edu/About_Argo.html">http://www.argo.ucsd.edu/About_Argo.html</a>	<a href="https://www.ego-network.org/dokuwiki/doku.php?id=public:gooc/oosgst">https://www.ego-network.org/dokuwiki/doku.php?id=public:gooc/oosgst</a>	<a href="http://www.fixo3.eu/">http://www.fixo3.eu/</a> <a href="http://www.rapid.ac.uk/rapidnetwork">http://www.rapid.ac.uk/rapidnetwork</a> <a href="https://www.pmel.noaa.gov/gtmba/pirata">https://www.pmel.noaa.gov/gtmba/pirata</a>	<a href="http://sot.jcommops.org/vos/">http://sot.jcommops.org/vos/</a>
Organisation document link / attachment		<a href="http://www.groom-fp7.eu/lib/exe/fetch.php?media=public:deliverables:groom_final_report_publishable.pdf">http://www.groom-fp7.eu/lib/exe/fetch.php?media=public:deliverables:groom_final_report_publishable.pdf</a>	N/A	There is a ships of opportunity implementation Panel with details at the following website: <a href="https://www.jcomm.info/index.php?option=com_oe&amp;task=viewGroupRecord&amp;groupID=107">https://www.jcomm.info/index.php?option=com_oe&amp;task=viewGroupRecord&amp;groupID=107</a> There is an updated list of the ships involved in the network on the following pages: <a href="http://www.wmo.int/pages/prog/www/ois/pub47/pub47-home.htm">http://www.wmo.int/pages/prog/www/ois/pub47/pub47-home.htm</a>
Secretariat established? (Y/N)	Yes	No	Previously partly under FixO3. In future under EMSO, RAPID and PIRATA	No but coordinated through JCOMM
	<a href="http://www.argo.ucsd.edu/">http://www.argo.ucsd.edu/</a>		<a href="http://emso.eu/">http://emso.eu/</a>	<a href="https://www.jcomm.info/index.php?option=com_oe&amp;task=viewGroupRecord&amp;groupID=107">https://www.jcomm.info/index.php?option=com_oe&amp;task=viewGroupRecord&amp;groupID=107</a>

systems networks, on their current state and where they could be in three and ten years' time.

**Figure 6.7:** Screen shot of first four rows (24 total) of emerging biogeochemical network assessment

Opportunities for synergies with one another were highlighted and areas in which appropriate funding and resourcing could make a substantive and long-term difference were made.

The update in July 2018 built on this core work by expanding on the key components of the identified networks, which were then further assessed with respect to available observing platforms and the maturity of the network. Invitations for engagement were made across technology, science and program level networks and stakeholders. The results of this work have been summarized in three substantial tables focusing on either biogeochemical, biological observing and industrial infrastructure networks.

### **Cooperation and interaction with other AtlantOS WPs**

WP2 and WP3 collaboration has enabled the deployment of new sensors and instrumentation on fixed and autonomous platforms.

Best Practice approaches and end-to-end implementation have been discussed with WP7 for data and data management as well as user applications within WP8. Dialogs have been initiated with WP2, WP3, WP4 and WP5 for sensor, platforms and networks and it is anticipated that collaboration will expand, as the best practice process is available for user engagement since 2018.

### **Cooperation and interaction with other projects and initiatives**

Interaction with the International GEOTRACES Programme and SCOR for the development of the trace element seawater reference materials. For the development of the omics standards there has been link up with the US Research Institute MBARI, but also with ENA, PANGAEA and German Federation for Biological Data to ensure streamlined metadata protocols, and also data delivery approaches.

### **Achieved main results**

Consensus Reference materials for trace elements and omics. The reference materials will greatly enhance the accuracy of trace element and omics measurements over the coming years.

Publication on uncertainty calculations for trace metals analysis in seawaters. This manuscript provides a clear guidance on how to determine and present uncertainty for trace element measurements in seawater. This open access document will provide key information to enhance uncertainty reporting in future.

Best Practice Report of omics workshop. The report indicates a critical first step towards the use and reporting of consensus materials in omics research. The work provides a step change for omics science.

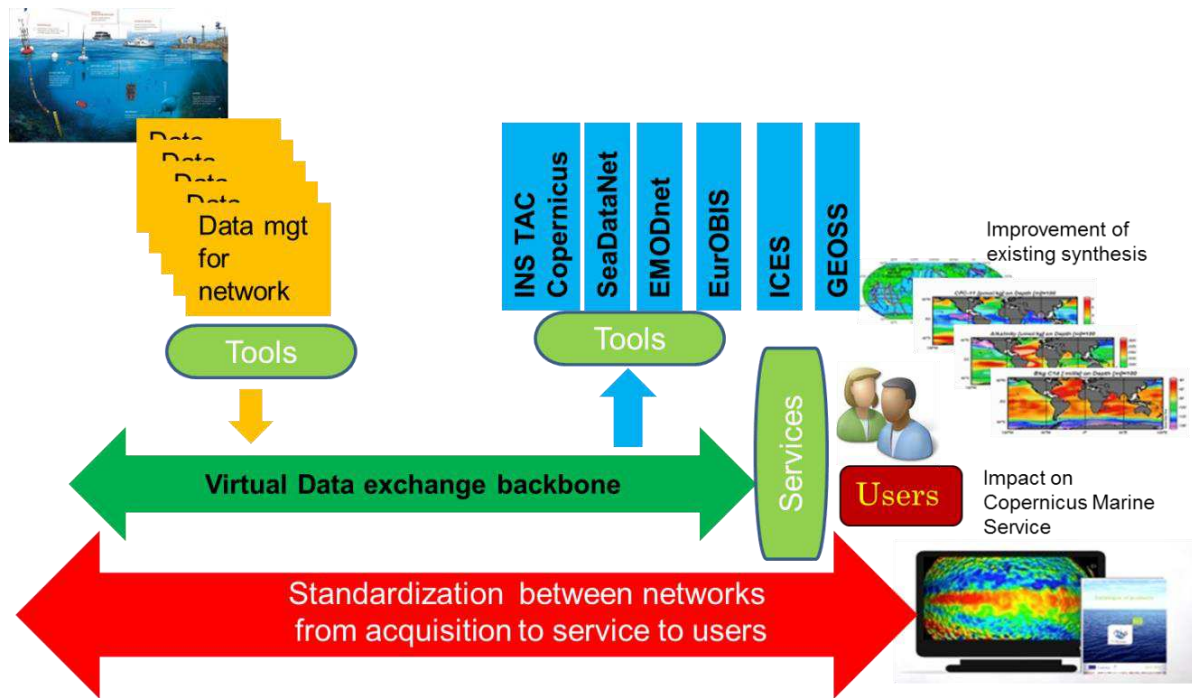
Report on nutrient measurements with in situ sensors, with scientific manuscript in progress and scheduled for submission in May 2019. The report provides a key step forward to improving data quality and inter-comparison of nutrient data.

## **WP 7 Data flow and data integration**

### **Summary**

The targeted European data system within AtlantOS is not a new system but integrates existing data systems. These systems have been enhanced to ingest and deliver more in-situ observation data on the Atlantic Ocean and to better serve the users, in a harmonized way across the systems. The existing data systems participating in WP7 “data harmonization and integration” activities are the WP2-3-4 in-situ observing network systems operating in the Atlantic Ocean and existing European as well as international

data infrastructures and portals, termed integrators (e.g. Copernicus INS TAC, SeaDataNet NODCs, EMODnet, ICES, EurOBIS, GEOSS).



*The integrated European data system for AtlantOS in green and red the interfaces addressed in WP7*

## Progress per tasks

*Task 7.1 Data harmonization of the data management activities and*

*Task 7.2 Data flow and integration of the existing systems*

Within this two tasks, network and integrator representatives have collaborated in the 1<sup>st</sup> and 2<sup>nd</sup> periods of the project to improve harmonization of Atlantic Ocean data and facilitate improved interoperability. In particular, the partners agreed on common standards and procedures, documented in four deliverables ([Data Harmonization Report](#), [Real Time QC Recommendations](#), [Full life cycle Report](#), [Data Management Handbook](#)).

In June 2017, AtlantOS held a successful workshop on Transatlantic Ocean Data Harmonization, which identified key-areas where improved transatlantic collaboration could have a significant impact on data integration. In the 3<sup>rd</sup> period of the project, AtlantOS partners and external participants from this workshop continued collaboration to explore the possibilities for future common efforts. Closer links have been established between AtlantOS and QARTOD and US IOOS that will serve as a sustained transatlantic link in regard to QA/QC harmonization beyond the project lifetime (see [update for 2017-2021 of QARTOD project plan](#)<sup>2</sup>). The mentioned activities led to contributions to three community white papers to be presented at OceanOBS'19 in the fields of (1) Ocean Best Practices and Standards, (2) Ocean FAIR data services, and (3) Ocean data product integration through innovation. These white papers were produced thanks to a truly

<sup>2</sup> [ftp://ftp.library.noaa.gov/noaa\\_documents.lib/NOS/IOOS/QARTOD\\_manuals/qartod\\_project-plan\\_v2.0\\_2017.pdf](ftp://ftp.library.noaa.gov/noaa_documents.lib/NOS/IOOS/QARTOD_manuals/qartod_project-plan_v2.0_2017.pdf)

international collaboration and with a large number of workshop participants as co-authors. Furthermore, the outcome of this collaboration was also used to populate the data section for the AtlantOS blueprint.

The additional tasks of WP7 were designed to demonstrate the operation of the integrated system (7.3), to assess the impact of AtlantOS observations in models through Copernicus (7.4) and to develop and deliver ocean products derived from these observations both for research and for applications (7.5).

### *Task 7.3 Operation demonstration of the integrated data system*

In this task, all the networks and integrators had to enhance their data system according to the WP7 roadmap towards the integrated system. [The 5<sup>th</sup> meeting on 20<sup>th</sup> November 2017](#), a side meeting of the AtlantOS GA, helped to keep progress going on the roadmap, to contribute to the setup of the traceability of use service for data providers, and to get partners involved in the actions identified at the Transatlantic workshop and to contribute to the AtlantOS Blueprint. One challenge for the 3<sup>rd</sup> period of the project was for the network teams to continue implementing recommendations and unlock access to data for the integrators and applications. This was especially true for WP2 networks (more complex datasets, less used to open and free data policy), for OceanSITES moorings where only part of the data is shared and nobody has the mandate to “oblige sharing”, and for biogeochemistry where the link between EMODnet and CMEMS needed to be strengthened.

The partners have all entered a continuous improvement loop that will consolidate the integrated data system over the coming years. The implementation started within the AtlantOS project and it will continue in the framework of future projects. Started in the 2<sup>nd</sup> period of the project and continued in the 3<sup>rd</sup> period, most of the improvements identified within WP7 were implemented or at least are at this point well advanced, although some actions on facilitating network data access for users and integrators will continue beyond the end of March 2019. The major advances for the targeted integrated system are:

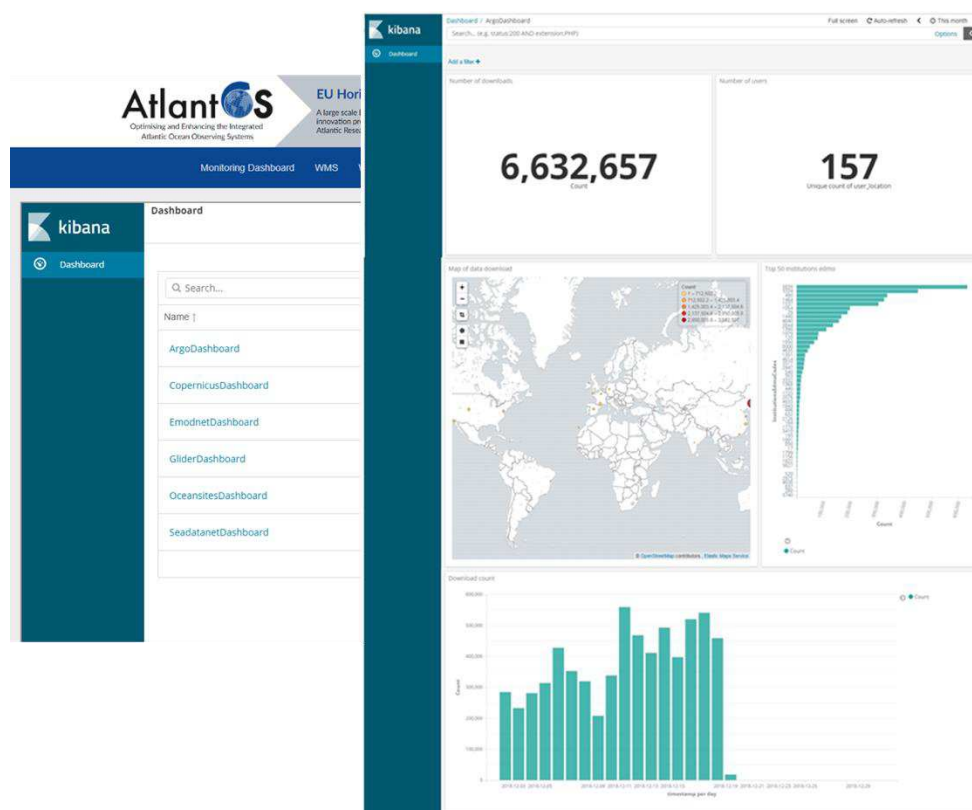
- Enhanced access to network data by setting up a unique entry point to discover and download existing data
  - More data in the existing Global data centres (EGO for gliders, OceanSITES for fixed point platforms and transport arrays, ICOS-Ocean for some VOS and GO-SHIP carbon data)
  - Improved access to ADCP data for GO-SHIP
  - A new GDAC for drifters (endorsed by DBCP/JCOMM) for data access to NRT data and best copy selection of DM data
- On the integrator side, enhanced ingestion by improved network data “connection” and greater data
  - Setting up new nodes (ICOS-Ocean, physical data from CPR) or direct GDAC data flow (ongoing for Argo and to follow for Gliders, Drifters and OceanSITES) in SeaDataNet
  - New marine biological data flow to integrators (Fish Acoustics to ICES, ETN to EMODnet-Biology)
  - More data in Copernicus INS TAC through GDACs harvesting
- Enhanced checking of data integration through monitoring facilities provided by JCOMMOPS

Furthermore, the [deliverable D7.15](#) submitted in December 2018 reports on the data services set up or enhanced within WP7 for AtlantOS observations: AtlantOS traceability of use service, AtlantOS catalogue and new or enhanced data services at the Integrator level.

The setup of the new [traceability of use service](#) during the 3<sup>rd</sup> period of the project was made possible by a joint effort from Ifremer, ETT and JCOMMOPS. This service aims to provide core statistics that give



visibility of data usage to data providers and also to data managers. The statistics are computed upon minimum-shared tracking information across the systems and are presented on a web interactive dashboard.



The first version of this service was up and running at the end of 2018. It shows statistics for data downloads from FTP data services managed at (1) Ifremer for Copernicus INS TAC till May 2018, SeaDataNet products, Argo, Glider and OceanSITES GDACs and (2) at EMODnet physics. Further upgrades of the service (logs from more data services, both from more type of services and from more networks/integrators) are going to be implemented and sustained over the coming months and years within the framework of other projects at a European level.

Concerning the [AtlantOS catalogue](#) tool, its content has been fully completed for the data systems involved in WP7 and further product entries have been added especially in relation to Task 7.5. The Essential Variables filtering facility of the catalogue has also been added. The sustainability at a European level of such a catalogue has been made possible through its integration into GEOOS and through EuroGOOS.

The integration into GEOSS common infrastructure started at the end of 2017 with the joint AtlantOS-COOP+ workshop, which was a side-event to the AtlantOS GA. This workshop introduced the participating AtlantOS partners to GEOSS and provided them with the necessary hands-on skills to register their resources with GEOSS, allowing them to be findable through the GEOSS portal.

GEOSS has recently introduced new features in their portal, allowing for the generation of community sites. AtlantOS was the first marine community to set up a community site in the GEOSS portal (<http://www.geoportal.org/community/atlantos>). The building of the AtlantOS-community site was a technological effort carried out by GEOSS technical staff in a continuous dialog with AtlantOS. AtlantOS was asked to share and discuss our experience setting up a GEOSS community site at the GEOSS 3<sup>rd</sup> data

provider workshop in May 2018, which included both an oral presentation and a panel discussion with the audience. This initiative was followed up at the GEOSS Week in Kyoto, where AtlantOS provided a recorded demonstration of the AtlantOS community site. This was an important outcome of our interaction with GEOSS, providing feedback and thereby improving the workflow for setting up community portals in GEOSS, not just for AtlantOS, but also for future data providers setting up a community site in GEOSS.

Implementing AtlantOS resources in GEOSS also included harvest of content and implementation of the AtlantOS catalogue to make its resources discoverable through the GEOSS portal. This was facilitated through multiple brokering tests conducted in a collaborative effort between GEOSS and AtlantOS. In the future, the harvest will be automatic.

#### *Task 7.4 Integration in models and impact*

Within Task 7.4 that ended in December 2018, the different partners (CLS, ECMWF, MetOffice and Mercator Ocean) assessed the impact of AtlantOS networks and their improvements for the Copernicus Marine Service ocean analysis and seasonal forecasts. This complements Task 1.3 that assessed the improvements for the Copernicus Marine Service expected from the future evolution of AtlantOS networks.

The focus for the assessment was more specifically on the following AtlantOS observations: Argo and deep Argo, surface drifters, tropical moorings, XBT/CTD observations. The impact studies took into account the synergy with satellite observations as they rely on data assimilation systems that merge in situ observations together with satellite observations. The partners used their operational systems and deployed several methods: Observing System Experiments (OSE), Degree of Freedom of the System (DFS) and Canonical-correlation analysis (CCA). For some in situ observing networks, impact analysis was carried out with several systems, allowing inter-comparison of their impact in different systems and context. This was the case for the deep Argo profilers and surface drifters.

In most cases, the analysis and forecasts were improved with the addition of AtlantOS in situ observations. The [deliverable D7.16](#) reports the analysis and synthesis of this impact assessment for Copernicus Marine Service real time monitoring and seasonal forecasts.

#### *Task 7.5 Product Development*

The objective of task 7.5 was to develop EOVS synthesis products from WP2 and WP3 networks and historical data sets for ocean, carbon, ecosystem and climate research. Task 7.5 for AtlantOS started in April 2017 and ended in April 2018. Six deliverables for each of the subtasks of Task 7.5 were prepared and delivered. They are available on the AtlantOS website.

Task 7.5 demonstrated the capability to reconstruct 3D BioGeoChemical fields merging in-situ AtlantOS observations with satellite ocean color observations. A Nature Geoscience paper “Exploitation of merged satellite and (BGC-) Argo fields to provide the first global quantification of an important but overlooked component of the biological carbon pump” illustrates the major impact of such merged products to better understand the biological carbon pump. Task 7.5 activities also led to improvement of international carbon data bases (SOCAT, GLODAP). AtlantOS observations were integrated in these databases and AtlantOS contributed to their QC activities. The capability to reconstruct from AtlantOS surface carbon observations 2D pCO<sub>2</sub> fields using innovative neural network methods was also demonstrated. Based on the assembly of CPR data, 16 new eco-regional areas for the North Atlantic have been defined and monthly means from 1958 to 2016 for all 16 new ecoregions have been calculated for a series of biological EOVS (Phytoplankton Color Index, Total Diatom abundance, Total Dinoflagellate abundance and Total Copepod abundance). Variability and trends for these bio EOVS have been assessed.

### **Cooperation and interaction with other AtlantOS WPs**

- Representatives of networks from WP2, WP3 and WP4 have participated in WP7 activities since the beginning of the project
- Task WP7.4 linked to the activity in WP1.3
- WP9.1 for monitoring and traceability services and WP7.2 collaboration, non-duplication of efforts among partners (Ifremer, ETT, JCOMMOPS) for the development of the traceability of use service
- WP6.4 for Ocean best practices and participation to the white paper on this topic submitted to OceanObs19
- WP8 and WP10: both benefitted from the WP7 deliverables, the AtlantOS catalogue and the work to integrate more data in Copernicus INS TAC, SeaDataNet and EMODnet , and coordinates with Task 7.4 - Task 7.5
- WP7 contributed to the AtlantOS BluePrint process (<http://atlanticblueprint.net/>) for the Data and information section and to the white paper on this topic submitted to OceanObs19.
- For Task 7.4 and Task 7.5, the elements listed above contribute to the AtlantOS high level objective “Increase capacity in ocean observing and information generation”. For the other tasks of WP7 they contribute to the AtlantOS high level objective “Optimize data fusion, sharing and curating, and information delivery”.

#### **Cooperation and interaction with other projects and initiatives**

- Copernicus Marine Service, and it’s In Situ Thematic (INS TAC) centre that builds the necessary in-situ products for the European Copernicus Marine Service
- EMODnet Central portal and Physics and Biology lots
- SeaDataCloud for SeaDataNet Network of National Data Centres that collects, archive and distribute in situ data mainly from research activities
- ENVRI+ that aims at creating a more coherent, interdisciplinary and interoperable cluster of Environmental Research Infrastructures across European projects. Collaboration focuses on the implementation on the European cloud of a “Data delivery service to scientific users” that uses the Copernicus In Situ TAC data.
- ENVRI-FAIR, H2020 INFRAEOSC project that started on the 1<sup>st</sup> January 2019, aims to enhance implementation of FAIR principals within the ESFRI Research Infrastructure. The related activity started in AtlantOS WP7 will continue within the Marine Domain WP of the H2020 ENVRI-FAIR project.
- JERICO-Next project for data integration with regards to WP4 networks and monitoring/dashboard services
- ODIP2 project that is setting the foundation for the harmonization process at the international scale between European, American and Australian partners
- COOP+: the main goal of COOP+ is to strengthen the links and coordination of the ESFRI Research Infrastructures related to marine science, Arctic research and biodiversity with international counterparts creating a common ground for the development of a global network of research infrastructures.

All these elements contribute to the AtlantOS high level objective “Optimize data fusion, sharing and curating, and information delivery”.

#### **Achieved main results**

- For Task 7.2 and 7.3
  - Recommendations coming from the WP7-organized workshop on Transatlantic ocean data harmonization (Brussels on June 7-8, 2017), and the working groups established that have exploited this outcome to provide input to white papers for OceanOBS19 and contribution to the AtlantOS blueprint.
  - Integration of AtlantOS-derived resources in GEOSS, and making the AtlantOS community visible in the GEOSS portal.
  - Improvement of the integrated EU system, involving both networks and integrators, with major advances on facilitating network data access for users and integrators, although some actions will continue beyond the end of AtlantOS. The partners have all entered a continuous improvement loop that will consolidate the integrated data system over the coming years in the framework of future projects.
  - The first version of the traceability of use service that provides visibility of data usage to data providers and to data managers.
- For Task 7.4,
  - The team was able to show a positive impact of the integration of several AtlantOS observing networks on Copernicus Marine Service ocean analysis and seasonal forecasts. Those real-time observation impact experiments complement the design experiments for network evolution conducted within Task 1.3.
- For Task 7.5
  - Demonstration of the added value chain going from AtlantOS networks to EOVs assessment.
  - Demonstration of the capability to reconstruct 3D BGC fields from observations. The techniques demonstrated in AtlantOS will be transferred to the Copernicus Marine Service operational environment.
  - Demonstration of the capability to reconstruct 2D pCO<sub>2</sub> fields using innovative neural network methods. The techniques demonstrated in AtlantOS will be transferred to the Copernicus Marine Service operational environment.
  - Improvement of international carbon databases (SOCAT, GLODAP). Integration of AtlantOS observations in these databases and contribution of AtlantOS to their QC activities.
  - Based on the assembly of CPR data, 16 new eco-regional areas for the North Atlantic have been defined and monthly means from 1958 to 2016 for all 16 new ecoregions have been calculated for a series of biological EOVs. Variability and trends for these bio EOVs have been assessed.
- 8 publications already published or planned.
- GLODAPv2 was used to produce an estimate of global storage of anthropogenic carbon in the Ocean between 1994 and 2007 (Gruber et al., 2019, Science). A paper intended for publication in ESSD is in preparation and will be submitted in April of 2019.

## **WP 8 Societal benefits from observing/information systems**

### **Summary**

WP8 is situated at the very end of a long ocean observing value chain. The applications created in WP8 meet end-user needs under the themes of disaster/hazard risk reduction (coastal flooding risk mapping, maritime transport, efficient ship routing, harmful algal blooms, oil spill hazard mapping), ocean resource assessment and climate descriptors for environmental reporting. The role of WP8 in AtlantOS is to highlight the importance of the *In-Situ* ocean observing system and how data generated is harnessed and used either directly and/or is integrated into marine data products from multiple sources along the ocean value chain to create useful end-user targeted products. The concept of WP8 and how the AtlantOS WP8

downstream products are generated using, often, a combination of Earth Observations, *In-Situ* data systems, model analyses, reanalysis and forecasts, and information on human related activities leading to the creation of beneficial products of value to society is presented in Figure 8.1.

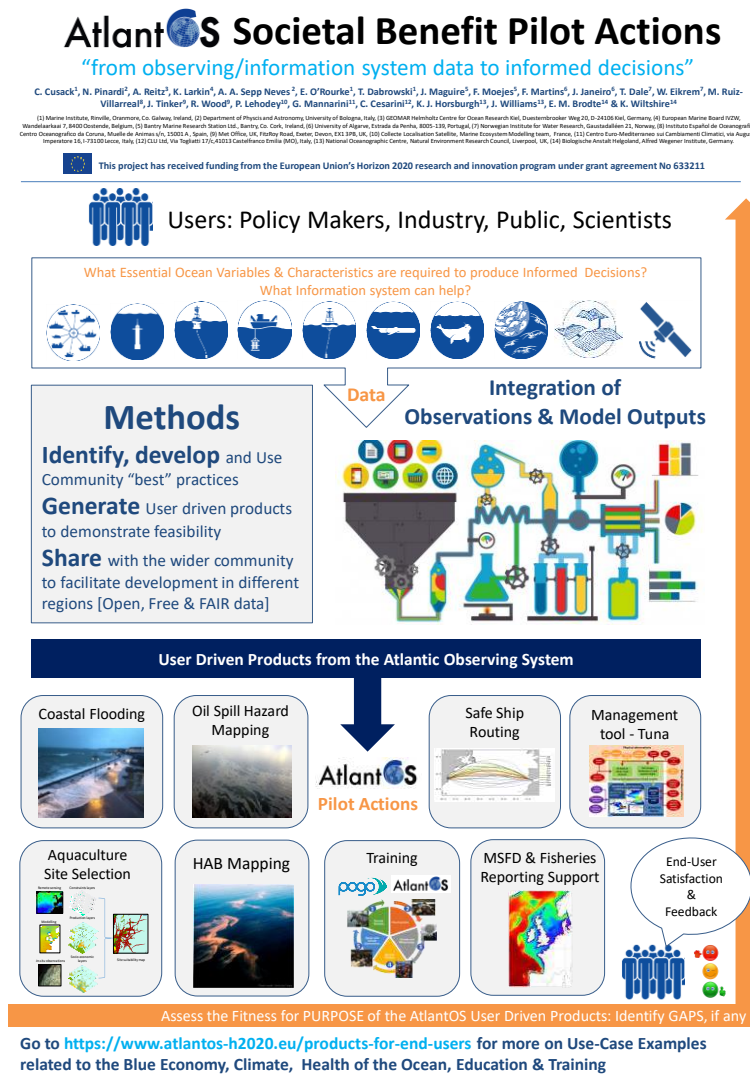


Figure 8.1: Overall concept of WP8 - A poster presentation at the GEO Blue Planet conference 4<sup>th</sup> GEO Blue Planet symposium, 4-6 July 2018, Toulouse – WP8 poster was a collaboration with WP6, WP7 & WP10.

In the third reporting period, WP8 had twelve deliverables; eight submitted (D8.6, D8.7, D8.8, D8.9, D8.10, D8.11, D8.13, D8.16), two under review (D8.14, D8.15) and two deliverables will be completed end of March 2019 (D8.12, D8.17). Five articles were peer reviewed and published and WP8 contributed to the production of three community white papers in preparation for Ocean Obs’19 and submitted to *Frontiers Marine Science*.

The WP8 targeted products cover all three of the broad societal benefit areas identified by GOOS/GCOS: operational ocean services, climate and ocean health as discussed in AtlantOS WP1 reports. WP8 made tangible progress in the final phase of AtlantOs. The methodologies used and developed have resulted in the creation of applications (products for a targeted user) derived from the ocean observing system to give useful information to multiple societal target groups from the super-users at ocean scales (e.g. shipping firms, fisheries managers) to meeting the needs of regional-national end-users (e.g. famers, policy makers, environmental managers). A major advancement made was in the way we communicate, and develop the downstream products, with a step forward in the area of end-user engagement and the realisation that a stronger future emphasis must be on the co-development of products with end-users to drive the co-creation of new, more accurate downstream products and services. The quality and quantity of ocean observing data is critical to the development of downstream products at the end of the value chain that can vary greatly and are highly dependent on end-user needs. To advance the current ocean observing monitoring system, WP8 partners worked to determine “fitness for use” of available data and “fitness for purpose” of the downstream products developed, to share community “best practice” and avoid duplication of effort (Figure 2). WP8 with the assistance of WP6, is the first contributor to submit a Best Practice for an ocean observing societal benefit application to the AtlantOS supported OceanBestPractice (OBP) repository, supported by International Oceanographic Data and Information Exchange (IODE). WP8

**Criteria used for Expert evaluation of the Targeted Products Quality & Gaps in the Input Datasets**

The objective was to provide an expert evaluation of the “fitness for purpose” for each Targeted Product (Pinardi et al., 2017). The methodology helps us to evaluate the quality of the data from current monitoring systems in terms of their accessibility, availability, multiple-use, efficiency, reliability, time consistency, space consistency, as well as the planning of technological advancements, new accessibility, new assembly protocols and observational priorities.

- a) Assign an overall product quality score with respect to scope (fitness for purpose) and explain why, according to the scale in Table 3 below.
- b) Identify the most important characteristic needed for the Targeted Product quality (if all characteristics are important please say so)
- c) Identify the quality element(s) of the most important characteristic(s) that affects the Targeted Product quality.
- d) Identify the limitations on the quality of the Targeted product due to the input data set used.
- e) Explain which characteristics “fails the most” to meet the scope of the Targeted Product.
- f) Provide an expert judgement of the most important gaps in the input data sets for the Targeted Product

Score	Result	"Fitness for purpose and use" of the Targeted Product
1	EXCELLENT	completely meets the scope of the Targeted Product
2	VERY GOOD	meets > 70 % of Targeted Product scope
3	GOOD	meets < 50 % of the Targeted Product scope
4	SUFFICIENT	does not really meet the scope but it is a starting point
5	INADEQUATE	does not really fulfil the scope and is not usable

reports (see below) identified many data gaps that need to be filled to facilitate the development higher numbers of advanced useful quality products and applications e.g. a significant increase in the temporal and spatial availability of biological and biogeochemical variables in coastal and shelf seas (supported by the recent work carried out in WP4, D4.5) are required to create many of the much needed downstream products.

Figure 8.2. EMODnet process used by many

WP8 partners to assess fitness-for-use of observations. Scale used to determine "Fitness for purpose and use" of the Targeted Products.

**Progress per Task**

The seven Pilot Actions/End-Use cases show progress as follows:

### *Task 8.1 Harmful Algal Blooms:*

[marine hazard; food security; environmental management; safe seafood]

Contribution to AtlantOS system:

The bulletins show the value of combined usage of satellite, assimilative models and local observations, development of standards for harmful algal bloom warnings. Assessment of the observing system fitness for HAB warning bulletin in the Atlantic and the TRLs of the existing bulletins was completed with proposed recommendations for future development. Best Practice on HAB bulletin production shared with the wider community to support pilot studies in other Atlantic regions. The harmful algal bloom bulletin is already used by scientists, regulators and the aquaculture industry. WP8 activities have helped to opened dialogue with the end-users and to provide lessons learned to product developers. As European aquaculture expands the co-development information gathered during the AtlantOS project will help considerably to improve future product development.

### *Task 8.2 Coastal Flooding/Storm surges:*

[marine hazards; coastal flooding]

Contribution to AtlantOS system:

Tide gauge standard analysis tools and Atlases were developed. Information on what makes a good sea level measurement and how to interpret the measurements will be explained and documented in a report that will be completed end of March 2019. Advances to coastal flooding products as a result of this task is of great value to all countries impacted by coastal flooding and storm surges.

### *Task 8.3 Ship routing hazard mapping:*

[climate change mitigation, maritime transport, efficient ship routing]

Contribution to AtlantOS system:

This task investigated ways to facilitate efficient and safe routing across the Atlantic and worked to determine the lowest carbon routes. To contribute to the challenges posed by the reduction of GHG emissions by shipping, the VISIR ship routing model (Mannarini *et al.*, 2016) has been further developed by adding new technical capabilities. The results were validated through comparison to both analytical and model benchmarks. Preliminary results are published in Mannarini *et al.* (2018a) and a full-featured documentation provided in two manuscripts submitted for peer review (Mannarini *et al.*, 2018b, Mannarini *et al.* 2019). Ship routing services developed can greatly assist the shipping industry.

### *Task 8.4 Coastal oil spill hazard mapping:*

[marine hazards; oil spill hazard mapping; risk mapping; environmental management; pollution monitoring]

Contribution to AtlantOS system:

Oil Spill hazard risk bulletins can help counties plan for spillages (emergency response to oil spill accidents) and reduce the hazard of oil spill arrival to the coasts from operational releases. The ability to produce oil spill bulletins for all Atlantic coasts is an invaluable tool to any country who want to pre-empt oil spill hazards or need to plan for emergency response to oil spill accidents and/or want to reduce the hazard of oil spill arrival to the coasts from operational releases. Task 8.4 created an [online tool](#) that allows the user to identify risks and vulnerabilities of the target coastal areas of interest. This is done using an online system that helps the user to create a risk bulletin of their choice. Major environmental disasters such as oil spills and maritime accidents can be prevented through access to better risk management, ship-routing, spill modelling and environmental forecast and nowcast products based on a future AtlantOS. The

demonstrators proposed herein lay the foundations for future commercialization of these services by SMEs and public entities.

*Task 8.5 Offshore Aquaculture siting:*

[food security; marine spatial planning; safety at sea]

Contribution to AtlantOS system:

Weather window (sea state conditions) nowcast/forecast Bulletin tools were developed to provide information for safe working conditions at aquaculture sites at target areas in Ireland and Spain; an explanation on how the tools are produced and instructions on how to use the weather window are provided in [D.8.8](#). For Norway, there is already such a tool in place (from May 2017), developed outside AtlantOS. The Norwegian tool can provide forecasts for offshore aquaculture operations and is described in this report. Other work carried out in this task provided a description of the input data sets used in the Use-Case Pilot Action on the “Offshore Aquaculture Siting” and a data adequacy summary, highlighting important gaps in the observing system, based on “expert opinion” for the Offshore Aquaculture suitability maps. The D8.13 report focuses on the ability of the targeted product to ‘sufficiently satisfy a requirement or meet a need’ of the end-users.

*Task 8.6 Reanalysis for MSFD and ICES assessments:*

[shelf sea-ocean interactions; Marine Strategy Framework Directive / MSFD; fisheries management]

Contribution to AtlantOS system:

An estimation of MSFD descriptors from models and an assessment of impact of AtlantOS on North West Shelf state reanalysis. Specific priorities were identified to develop the value chain between CMEMS and end-users. Scientific insights were gained into the possible impact of an improved Atlantic observing system on the quality of analyses of European regional seas (although further research, identified by our work, is needed to establish the full impact). This task assessed the potential impact of the Atlantic Ocean observing system, in support of the Marine Strategy Framework Directive (MSFD) and fisheries planning. Regional reanalyses was used, which assimilate observations into an ocean model to produce a spatially and temporally complete and consistent estimate of the past ocean environmental state, constrained by the assimilated observations. Since the marine observational network is so sparse, such reanalysis are a highly valuable tool to quantify and understand the marine environment in unobserved regions, and to put any variations or trends seen in the actual observations into a wider and longer-term context. The testbed was the Northwest European Shelf (NWS) reanalysis system (Met Office in collaboration with NOC, PML and BSH) and delivered freely through the Copernicus Marine Environment Monitoring Service (CMEMS). This provides ocean state estimates for physical and biogeochemical variables for the NWS region, covering the period 1992 to near present, using a model with a 7km mesh. The study presented an evaluation of user needs for such reanalysis products, based on in-depth discussions with three major European stakeholders, and a scientific study of the extent to which the open ocean Atlantic observing system can constrain reanalysis in the NWS region, by improving the lateral ocean boundary conditions for the NWS regional model. Work from AtlantOS WP1 (Task 1.3, Deliverable 1.5) was used to assess the added value of potential new observing elements in constraining the open ocean state (and hence the open ocean boundary conditions for the NWS model). By analyzing the OSSE experiments of AtlantOS Task 1.3 the impact of additional open ocean observations on the open ocean boundaries of the CO6 regional model was estimated. On short timescales (daily to seasonal) the influence of additional Argo sampling in the western boundary currents and equatorial regions is small at the CO6 boundaries, despite giving an overall improvement in RMS errors over the Atlantic basin (Deliverable 1.5). The development of the value chain from CMEMS production to a vibrant end user community requires continuing work at all points in



the value chain: CMEMS producers, intermediate users and end users. The insights developed in this work will help all parties to focus their future development priorities towards this goal.

*Task 8.7 Operational real-time and forecast modelling of North Atlantic albacore tuna populations:*

[fisheries and ecosystem management; dynamical habitats of protected species]

Contribution to AtlantOS system:

Operational real time and forecast modelling of Atlantic albacore tuna was developed. A model used in the task and called Spatial Ecosystem And Population Dynamics Model (SEAPODYM) estimates stock dynamics (standard stock assessment modelling). It predicts the spatial distribution of fish density (by cohort) and can distinguish between fishing impact and natural variability (environment and climate). Simulation outputs for the historical period of fishing were evaluated based on the current knowledge of this species, the statistical fit to all fishing data and the comparison with other population dynamic model estimates. The downscaling phase to the  $\frac{1}{4}^{\circ}$  resolution operational forcing uses the free run version of the Copernicus reanalysis GLORYS2v4 due to detected biases in the equatorial circulation. The quality, limitation and further needs of AtlantOS data used for this application were documented. There is a need to revise the historical geo-referenced fishing dataset available from ICCAT and to account for the catch (fishing mortality) that has no geo-reference information. The model parameterization previously achieved at coarse resolution needs to be revised and downscaled to the higher resolution used for the operational model. Finally, the chain of automatic production has been developed but needs to be updated with revised parameter values and initial conditions of fish population structure achieved with the downscaling approach.

The new tools and products developed rely on best available operational ocean products and open the way to new governance practices; real time monitoring and control of legal and illegal fishing. Together with the modelling of tuna, the progress in the modelling of their prey, i.e., the micronekton, allowed to propose this new ecosystem variable to the CMEMS catalogue. Since micronekton is prey of many large fish and other oceanic predators (from seabirds to whales), it should provide a useful new key variable to develop applications for the management and conservation of exploited and protected marine species. It also gives useful rapid feedback on the bias and errors in the forcing variables.

*Task 8.8 POGO-AtlantOS collaboration on ocean products:*

[Capacity building; transfer of knowledge; development of methodologies and sampling protocols]

Contribution to AtlantOS system:

Education founded on a well-managed mix of interests and needs in the field of oceanography and marine science is more imperative than ever in order to secure earths' future oceans as a sustainable resource. To strengthen the intercultural competences and general communication skills, an ocean training programme on board large research vessels was set up to provide young researchers hands-on training in the set-up and operation of scientific instrumentation and equipment.

The trainees were taught about the acquisition and processing of samples, sample analysis, and data interpretation, in part with the development of best practice expertise at land based laboratories. The main aim is, training ocean experts to address sustainability issues in our global ocean, by promoting excellence and moral sounding and a good sense for international gender equal facilitation and networking. AtlantOS-POGO Fellowships were provided to Ngozi Ejiofor Oguguah & Edem Mahu, Subrata Sarker and Bruno Sutti with planned scholarships for south american and african students in 2019 (SONOAT2019). To strengthen the collaboration of POGO and AtlantOS and to gain a real synergetic benefit, the funded scholars will train on board the RV Polarstern, embedded in the NoSoAT / SoNoAT

programme in June 2019. Activities in this task were carried out by the AWI. The POGO activities, especially the NF-POGO Centre of Excellence within AtlantOS consisted mainly in the organization of expeditions and workshops for training. These activities include the publishing of the call, reviewing the applications after a proved scheme taking gender balance, regional balance and quality and potential of the applicants into account. In 2019, the scholars of SoNoAT will have a training cruise aboard the RV Polarstern and a pre-cruise workshop in Punta Arenas, Chile.

This task helped to:

- facilitate the interaction between emerging ocean countries along the Atlantic Seaboard and ocean research institutes in Europe
- Expand a network of young researchers
- Implement the scholars' expertise in science and outreach / ocean literacy.
- Provided views in modern ocean science infrastructures to develop “take home” sampling protocols and to the develop assessments of “tool necessities” for specific applications

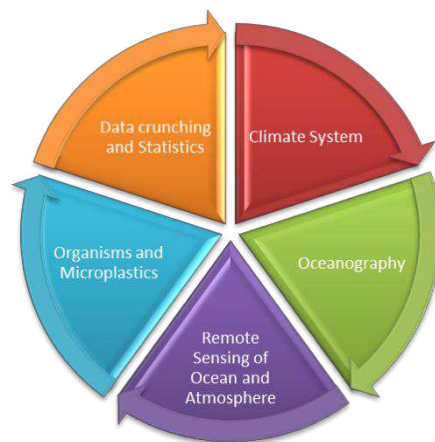


Figure 8.3: Rotation scheme of modules during the expedition

### Cooperation and interaction with other AtlantOS WPs

Cooperated and interacted with AtlantOS WPs 4, 5, 6 & 10

- **WP1 – WP8 interaction:** The major work was to connect the EOVS with targeted products input data sets.
- **WP4 – WP8 interaction:** WP8 partners worked with WP4 to provide information for Deliverable 4.3: Anil, A., Guillaume, C., Cusack, C., Vicente, F. and O'Conchubhair, D. (2018) [Gap analysis of links between coastal and open ocean networks](#). DOI: 10.13155/57443
- **WP5 – WP8 interaction:** WP8 partners in T8.7 Albacore tuna forecasts collaborated with WP5 on the OSE activities e.g. optimal design of ecosystem module [D5.5]. WP8 partners in T8.8 POGO-AtlantOS collaboration on ocean products fellows for the on-board oceanographic expeditions worked with WP5
- **WP6 – WP8 interaction:** WP8 partners worked with WP6 to develop a best practice, on T8.1 HABs application, for the AtlantOS supported [Ocean Best Practices System](#). WP8 also held discussions with WP6 on what BGC and which prototype biological sensors could potentially enhance Targeted products for societal benefit. We are also working with partners in WP6 to document best practices of T8.1 application.
- **WP7 – WP8 interaction:** WP8 relies heavily on the high quality data products developed and enhanced in WP7.

- **WP10 – WP8 interaction:** WP8 in collaboration with WP10 has developed the specific targeted products AtlantOS webpages. WP8 partners worked with WP10 to provide information for Deliverable 10.8: Miguez, B. M. and Calewaert, J. B. (2018) [Stakeholder Engagement ‘Support Facility’ Test Exercise \(Demonstrator\)](#). AtlantOS Deliverable, D10.8 AtlantOS, 28 pp. DOI [10.3289/atlantOS\\_d10.8](https://doi.org/10.3289/atlantOS_d10.8). <http://oceanrep.geomar.de/44732/>
- **WP10 – WP11 – WP8 interaction:** had several discussions related to Stakeholder engagement and end-user needs; product development loop (iterations of the products), importance of community advocates in the co-development loop, identify the specific societal, scientific, and economic benefit.

### **Cooperation and interaction with other projects and initiatives**

**Connected with the EU research projects** PRIMROSE (*Predicting Risk and Impact of Harmful Events on the Aquaculture Sector* funded by Interreg Atlantic Area EAPA\_182/2016), MarRisk (Interreg POCTEP Spain Portugal, 0262\_MARRISK\_1\_E) and CoCLiME (*Co-development of CLimate services for adaption to changing Marine Ecosystems* co-funded by ERA4CS JPI-climate).

WP8 partners worked with PorAtlantic EMODNet Atlantic Checkpoint project to implement the product assessment methodology from EMODnet Checkpoints [to Evaluate “Fitness for Use of Input Data” and “Fitness for Purpose of the Products”].

WP8 partners in T8.8: The Atlantic Training Transect (NoSoAT and SoNoAT) is a biennial training survey that brings together International participants through collaboration between the Alfred Wegener Institute (AWI), Partnership for Observation of the Global Oceans (POGO) and funded through the Nippon Foundation and ATLANTOS. A close cooperation and the main workload was shared between the NF-POGO Centre of Excellence, the Ocean training Portal (OTP) and REKLIM, and home institutes of the teaching faculty during the pre-cruise workshop and the expedition itself: Deutscher Wetterdienst (Germany) , ESSIC-UMD/NASA (USA), Ruđer Bošković Institute (Croatia), MARE-FCUL (Portugal), Max-Planck-Institut für Marine Mikrobiologie (Germany), NUIG, National University of Ireland, MARUM/ Institute of Environmental Physics (IUP) (Germany), Uni Heidelberg (Germany), Pontificia Universidad Católica de Chile (Chile), Universidad Lisboa (Portugal), Universidad de Magallanes (Chile), AAU (Denmark. Additionally, the Training expedition will host participants from the EU Projekt Port WIMS.

**Co-Development of science-based products:** One to one meetings and workshops with relevant stakeholders were organised by the task partners to discuss the science-based products and methodologies used to gather information for development of the products with end-users provided feedback on an ad-hoc basis.

### **Achieved main results**

*Deliverables with contributions from all WP8 task partners:*

1. T8.1 Harmful Algal Bloom Bulletins Production of an early warning bulletin to the aquaculture industry in Spain, Norway and Ireland [D8.6] Submitted.
2. T8.1 AtlantOS fitness for HAB Bulletins [D8.11] Submitted.
3. T8.2 AtlantOS fitness for storm surge [D8.12] will be completed end of March 2019.
4. T8.3 Ship routing hazard maps [8.10] Submitted.
5. T8.3 AtlantOS fitness for ship routing [8.14] will be completed end of March 2019.
6. Oil Spill Hazard Bulletin answers to key relevant questions related to oil spill risk & emergency management [D 8.7] Submitted.

7. T8.4 Assessment of fitness for purpose of the observing system for the Oil spill Hazard Bulletin report [D8.15] Submitted.
8. T8.5 Aquaculture operation Bulletin: Weather window nowcast/forecast Bulletin tool for offshore aquaculture operators [D8.8] Submitted.
9. T8.5 The AtlantOS fitness for purpose for the aquaculture was assessed [D8.13] Submitted.
10. T8.6 Report on AtlantOS fitness to MSFD needs [D8.16] Submitted.
11. T8.7 Report on AtlantOS fitness for Atlantic Albacore: Assessment of the observing system fitness for tuna catch estimates [D8.9] Submitted.
12. T8.8 POGO-AtlantOS collaboration on ocean products Video submitted, POGO-AtlantOS collaboration on ocean products [D8.17] will be completed end of March 2019.

## WP 9 System evaluation and sustainability

### Summary

WP9 objectives were to provide quantitative and near real time information of the state of the in-situ Atlantic Observing System (Task 9.1), to analyze and document for each EOY the adequacy of the current observing and information system (Task 9.2) and to develop a long-term sustainability plan for Atlantic Observing System based on existing plans of international partners, European Member States as well as key European initiatives (task 9.3).

WP9 feeds from WP1 (Design of Atlantic observing system incl. high level requirements, gaps and cost analysis) and WP2&3 (AtlantOS networks will provide inputs on their long-term organization and funding issues). It also feeds from WP7 (the data information system set up in WP7 will feed the monitoring and evaluation system developed in WP9) and WP7/8 (Information products and the societal benefits demonstrations will contribute to the justification of impact of Atlantic Observing System towards the national, international and EU funding agencies).

### Progress per Task

#### *Task 9.1: System monitoring and evaluation*

As planned, the two WWW based monitoring tools were specified and developed for 1) the European (including coastal/regional regions) (EuroGOOS) and 2) the international contributions to the AtlantOS in-situ observing system (IOC/JCOMMOPS). The two monitoring tools are running and they are providing useful inputs for an evaluation of the AtlantOS observing system. These tools offer Key Performance Indicators (KPIs) for most of JCOMM networks and offer a regional perspective for the Atlantic Ocean:

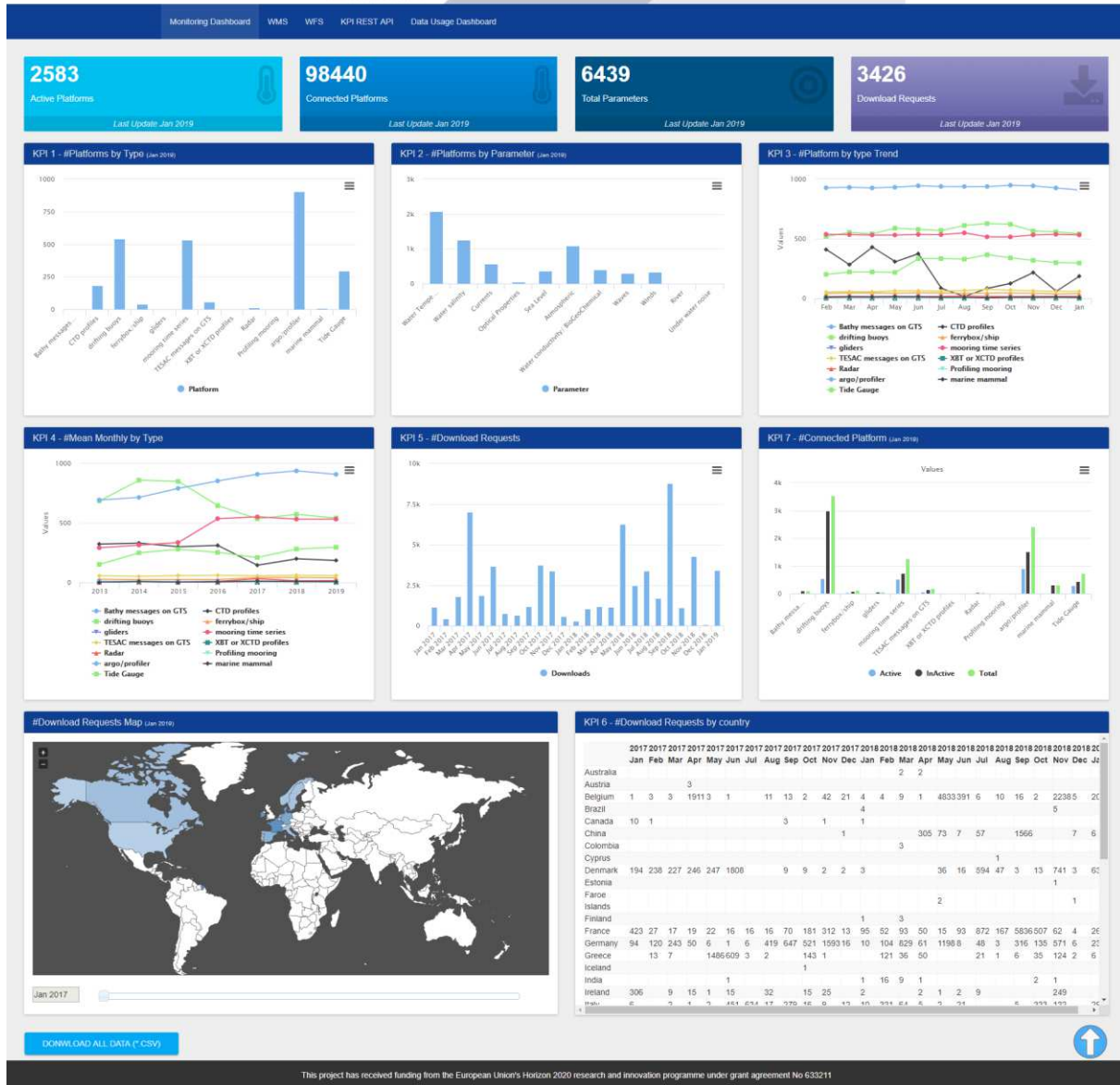
<http://www.jcommops.org/board?t=atlantos>

These KPIs are completed by monitoring of the data flow from European providers (coastal/regional regions) to the AtlantOS observing system (i.e. the EuroGOOS monitoring tool for AtlantOS).

<http://eurogoos.eu/atlantos/atlantos-dashboard/>

As requested by ISTAB and project reviewers, the two monitoring tools are now exchanging information and in particular, the second is feeding the JCOMMOPS tool with supplementary information and have a single point of access for the monitoring and KPIs.

While developing these interoperability and data exchange services between the two monitoring tools, the EuroGOOS one was also re-designed in the scope and layout.



**EuroGOOS monitoring tool for AtlantOS region**

**Task 9.2: Adequacy of the current observing system**

Task 9.2 developed (with input from WP9, WP1, and WP10 partners) and carried out an assessment of the adequacy process in five pilot countries (Brazil, Canada, France, Germany, and Spain) from June 2018 to January 2019 to report on the performance of AtlantOS and its information products (D9.4). From the results and experiences of the AtlantOS assessment of the adequacy process, a number of conclusions and recommendations were made for (1) national and international coordination, the assessment of (2) societal benefit areas, (3) Essential Ocean Variables, (4) data systems, (5) AtlantOS monitoring tools, (6) ocean observing activities, (7) ocean information products, and (8) future ocean observing planning.

The purpose of the assessment process was to give a pan-Atlantic view, evaluate the adequacy of AtlantOS and develop a report – for the first time - that displays the results, experiences, and feedback on which

the ocean observing community can orient towards for further evaluation processes and the implementation of AtlantOS.

#### *Task 9.3 Sustainability issues and long-term national, EU and non-EU Atlantic partner plans*

At the 3<sup>rd</sup> AtlantOS General Assembly in Las Palmas (Gran Canaria, Spain) from 20 – 24 November 2017 it was agreed that Task 9.3 will focus on the formulation of a strategy for a European contribution to the implementation of the AtlantOS Blueprint Vision process. The strategy was formulated during the second half of 2018 and constitutes D9.5 ‘Report on sustainability issues’.

Planned commitment meetings with funders was rescheduled to be part of the two days ‘High level Policy and Stakeholder Segments’ taking place at UNESCO Headquarters in Paris (France) on 27 and 28 March 2019 as an important part of the ‘First International AtlantOS Symposium’.

Task 9.3 partners have actively participated in the AtlantOS BluePrint Process.

#### **Cooperation and interaction with other AtlantOS WPs**

Task 9.1: JCOMMOPS, EuroGOOS and ETT on behalf of EMODnet Physics are interacting with WP7, as its metadata exchange services have to be interoperable and connected to the overall AtlantOS data flow. In addition, to produce some of its KPIs and statistics on data availability, JCOMMOPS maintains synchronization with GDACs. The work done by JCOMMOPS on the harmonization of metadata and vocabulary is also benefitting to WP7. In collaboration with WP7, ETT JCOMMOPS and IFREMER have designed and developed new traceability services that aim to give visibility of data usage to data providers through integrators. JCOMMOPS was tasked by the WMO to distribute all its met-ocean metadata through a WIGOS-compliant API. The targets and design elements clarified by JCOMMOPS within most of the observing systems under its mandate have been filtered on the AtlantOS region to enable AtlantOS KPIs calculation, and provide accurate target numbers to WP1 partners.

JCOMMOPS has been consulted as well on the cost evaluation of each observing system. It advised to calculate the overall cost of each unit (observing platform) through a national or known example and apply it to the intensity targets. E.g.: if we consider that a profiling float costs 25k€ (including hardware, telecommunications, data management, ship time, etc), then  $192 \times 25 = 4.8$  M€ is the yearly cost of maintenance of the Argo/AtlantOS observing system. JCOMMOPS cooperates as well in the WP 2.1 on the GO-SHIP cruises metadata management.

This service (<http://www.emodnet-physics.eu/atlantos/Dashboard/KibanaDashboard.aspx>) aims to provide core statistics that give visibility of data usage to data providers and also to data managers. The statistics are computed upon minimum-shared tracking information across the systems and are presented on a web interactive dashboard (WP7).

Task 9.2: Input from WP1: Design of the Atlantic Observing System incl. high level requirements, cost and feasibility study. Input from WP10: Best Practices in Stakeholder Engagement - better understanding on how to efficiently engage with stakeholders and attract more users (e.g. nations).

Task 9.3: Key representatives from all AtlantOS WP’s contributed to the formulation of the ‘European Strategy for Atlantic Ocean Observing’.

#### **Cooperation and interaction with other projects and initiatives**

As part of Task 9.1, JCOMMOPS, as one of the international coordinating entities for the Global Ocean Observing System, is connected to many national and regional projects. In particular, the work done in AtlantOS will certainly benefit to the TPOS (Tropical Pacific Observing System) initiative. Some connections between both initiatives are being prepared by the JCOMM Observation coordination Group.

As part of Task 9.2, links to GOOS National Focal Points of three pilot countries were established and their connection to ocean observing experts within their nations had been used. The results of the review process will serve as useful information material not only for national authorities; it will be interesting for some international and trans-Atlantic cooperation and initiatives as well:

- Galway Statement on Atlantic Ocean Cooperation (2013),
- Belém Statement on Atlantic Research and Innovation Cooperation (2017),
- Tsukuba Communiqué from the G7 Science and Technology Ministers' (2016) to support an ocean observation initiative,
- United Nation's Decade of Ocean Science for Sustainable Development (2021-2030),
- Global Ocean Observing System, Group on Earth Observations Blue Planet Initiative, and European Ocean Observing System.

Task 9.3 has worked with the EOOS Steering Group (EOOS STG) - EOOS will be an important part of the governance structure for the European contribution of a future Atlantic Ocean Observing System (AtlantOS).

Close contact to the Copernicus Marine Environmental Monitoring System (CMEMS) has been established concerning issues such as requirements for in-situ observations and data management – both important components of the European Strategy.

Close interaction with the European Marine Data and Observation network (EMODnet) and, in particular, with the EMODnet Physics thematic lot have been performed for whole duration of the project for improving data exchange, data dissemination, data flow monitoring, data use traceability etc.

#### **Achieved main results:**

Task 9.1 JCOMMOPS has adapted its web based monitoring system to the needs of the AtlantOS project. Deliverables include the following elements (use links to browse on-line):

- [Real-time monitoring dashboard](#)
- [Dedicated monthly authoritative monitoring maps](#)
- [Interactive maps](#)
- [Performance Indicators](#)
- [Various statistic and monitoring tools \(exportable, customizable, embeddable\)](#)

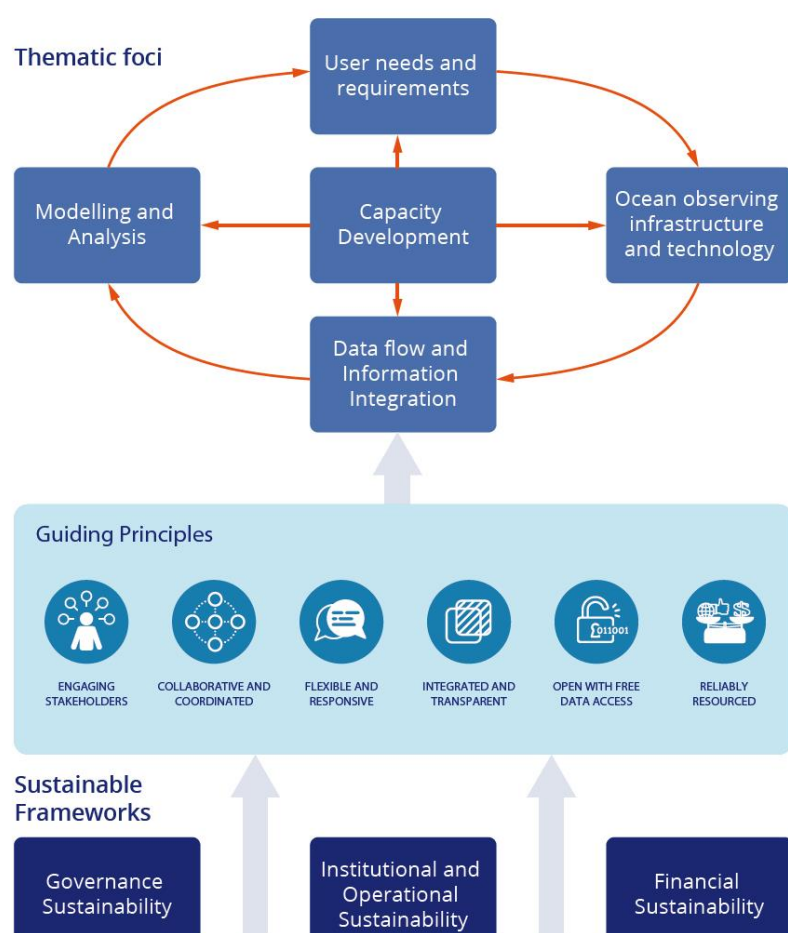
AtlantOS is taking benefit of regional monitoring capacities from JCOMMOPS while building its new generation of Information System and web based services. It will have a real-time and persistent monitoring system that will remain up to date after the AtlantOS project ends. JCOMMOPS is also going to release an improved version of its website that will benefit to AtlantOS and website can be tested at: <http://www.jcommops.org/testboard?t=atlantos>

EuroGOOS and EMODnet Physics have developed web monitoring tools for the coastal component of the AtlantOS project. These tools are operationally working and are going to be maintained under the EuroGOOS umbrella after the end of the AtlantOS project. These tools are offering several reports and KPIs and represent an easy tool to track the AtlantOS impact in terms of connected, made available and accessible datasets as recorded by a variety of platforms.

Tasks 9.2: The main result of Task 9.2 are:

- The formulation of the ‘Report on the performance of AtlantOS observing system’ (D9.4) showing the results and experiences from the AtlantOS assessment of the adequacy process and recommendations for enhancing AtlantOS.
- The development of an online assessment/review questionnaire that can be used for further review processes after updating.
- The decision that the ocean observing community within one pilot country established a national observing coordination group after conducting the assessment process - prior to the AtlantOS review process no coordination group existed.

**Task 9.3:** The main result of Task 9.3 is the formulation of the ‘European Strategy for Atlantic Ocean Observing’ (D9.5) and an active contribution to the planning and implementation of the ‘High level Policy and Stakeholder Segments’ at the ‘First International AtlantOS Symposium’.



## WP 10 Engagement, Dissemination, and Communication

### Summary

### Progress per Task



### *Task 10.3 Stakeholder Engagement ‘Support Facility’*

In the context of developing 10.3., the AtlantOS DoA and consortium composition were first reviewed to explore what the project could offer to potential stakeholders and how this could be taken forward. From this review, it was decided to focus on initiating synergies with WP8 because it specifically focusses on delivering new information products for users and stakeholders in several societal benefit areas. WP8 has a clear need to engage with stakeholders to ensure development of fit-for-purpose products, uptake and impact. D10.8 first describes the process and interactions with WP8 members, which incorporated some of the ideas presented in D10.5 in their workflow with different degrees of accomplishment.

In parallel to the work developed jointly with WP8, another pathway was explored following findings from D10.5 (“Best practices in stakeholder engagement, data dissemination and exploitation“<sup>3</sup>) which highlighted the value of online stakeholder engagement platforms, potentially provided by marine data portals. As a result, taking advantage of the links with EMODnet, in Task 10.3 we explored to possibility of using the EMODnet Central Portal (as an example) to provide dedicated community information for Atlantic stakeholders to support stakeholder engagement and user uptake of Atlantic marine data and observations. EMODnet, the European Marine Observation and Data Network, is one of the so-called integrators of AtlantOS and has established itself as the primary multidisciplinary gateway to in-situ marine data in Europe, encompassing a number of thematic portals that can be accessed through a Central platform. As part of the long-term legacy and BluePrint of AtlantOS, it could in the future also serve beyond users of AtlantOS outputs and become a hub for wider Atlantic Ocean observation implementers and users, providing data resources and connecting to related Atlantic observation and knowledge projects and initiatives such as the AORA Atlantic knowledge platform. EMODNET resources for Atlantic users are available at: <http://www.emodnet.eu/atlantic-1>.

Finally, on the basis of the experience acquired and considering the AtlantOS review in April 2018, we revisited the first list of recommendations from D10.5 and include an update in D10.8., which now offers more definitive actions that can achieve more effective stakeholder engagement once the project has finished.

### *Task 10.4 Science-Policy Briefing Papers and Briefings*

During the reporting period WP10 produced two Science-Policy briefing papers and events (D10.9 and D10.10) as well as one additional report:

#### *Briefing Paper 3: Making Technologies for Ocean Observing accessible (D.10.9)*

This briefing paper summarizes some recent activities of the EU H2020 project AtlantOS to promote the discussion about new technologies, sharing instruments and real-time data, the AtlantOS ‘Sensors an Instrumentation Roadmap’, and ocean best practices in technologies.

*Associated Event:* On 12 March 2018 at Oceanology International 2018 (OI2018) USA-based Maritime Alliance and the global BlueTech Cluster Alliance in collaboration with the European Commission's DG Research and Innovation, Fisheries and Oceans Canada, Marine Institute Ireland, and the National Oceanic and Atmospheric Administration organized a 1<sup>st</sup> Blue Economy Research & Industry Dialogue Workshop. Approximately 70 people attended, including from academia, cluster, industry and government. The aim was to get these different constituencies to discuss options for improving technology development and implementation for ocean observing. Jay Pearlman represented AtlantOS and engaged with the community to discuss options to further demonstrate new interoperability tools.

#### *Briefing Paper 4: Policy Brief and Event "The slowing Gulf Stream? What we know and potential impacts"*

Based on publications by Blue-Action (EU project) and AtlantOS scientists, this briefing paper summarizes the current state of knowledge about what we know about Gulf Stream and its potential slowing as well as the potential impacts thereof.

*Associated Briefing Event:* A Science-policy breakfast discussion entitled "The slowing Gulf Stream? What we know and potential impacts" was held on 4 Sept. 2018 in the European Parliament, Brussels (BE). The Policy Brief and the event were a joint effort of Blue-Action, the AtlantOS project and SEARICA (the EP Intergroup on Seas, Rivers, Islands and Coastal Areas). Over 50 participants attended the event, mainly from the European Parliament, European Commission and interest groups. Yvon Slingenberg, Director in the European Commission's Directorate-General for Climate Action gave a special policy keynote address. Blue-Action and AtlantOS were represented by Steffen M. Olsen (DMI), Tor Eldevik (UiB), Ben Moat (UKRI-NOC), Karin Margretha Larsen (HAV), Marius Årthun (UiB) and Marilena Oltmanns (GEOMAR) and Jan-Stefan Fritz (KDM).

In addition, a *Special Newsletter* was published, entitled "*Strengthening pan-Atlantic Cooperation for Ocean Observing*"

This special newsletter summarizes the discussion of this meeting and provides a platform for key partners from the Southern Atlantic Region to present the work they are currently involved in as well as their contributions and expectations from a pan-Atlantic Ocean observing system.

#### *Task 10.5 Exploring the Economic Potential of Observatories*

In addition to the required deliverables submitted during the second reporting period, Task 10.5 continued to work with the OECD to develop the work initiated by AtlantOS. During this reporting period, an internal working document of the OECD was published under the title "Valuing Ocean Observations in 2018: A OECD Background Paper". This draft OECD paper explores the socio-economic value of ocean observations. Building on OECD work on the ocean economy and an extensive literature review conducted with an original approach, this report was prepared by Julia Hoffmann, economist seconded to the OECD by the University of Kiel's Department of Economics, by the German Cluster of Excellence "The Future Ocean" and by the German Marine Research Consortium (KDM). The contribution of KDM was made through the AtlantOS project. The report was developed under the supervision of Claire Jolly, Head OECD Ocean Economy Group, with inputs from James Jolliffe, OECD Economist, and in cooperation with the UNESCO-IOC. The report includes findings of an expert OECD meeting on "Valuing Ocean Observations", held in Paris on May 14th, 2018.

In March 2019 the OECD then published its second flagship report on the state of the ocean economy, entitled *Rethinking Innovation for a Sustainable Ocean Economy* (OECD Publishing, Paris, <https://doi.org/10.1787/9789264311053-en>). Chapter four of this report highlights new approaches to measuring the ocean economy, notably by exploring the use of satellite accounts for its twin pillars – ocean-based economic activities and marine ecosystem services – and by examining ways to better measure the benefits that important sustained ocean observations provide not only to science, but also to the economy and society more generally. The later section is the result of work proposed, initiated and co-supported by AtlantOS.

#### *Task 10.6 Integrated Atlantic Ocean Observation Systems in the Context of a European Ocean Observing System*

During the reporting period this Task produced a Strategic foresight paper on AtlantOS in the European context (D10.11). 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.

*Task 10.7 Web-based and social media communication and*

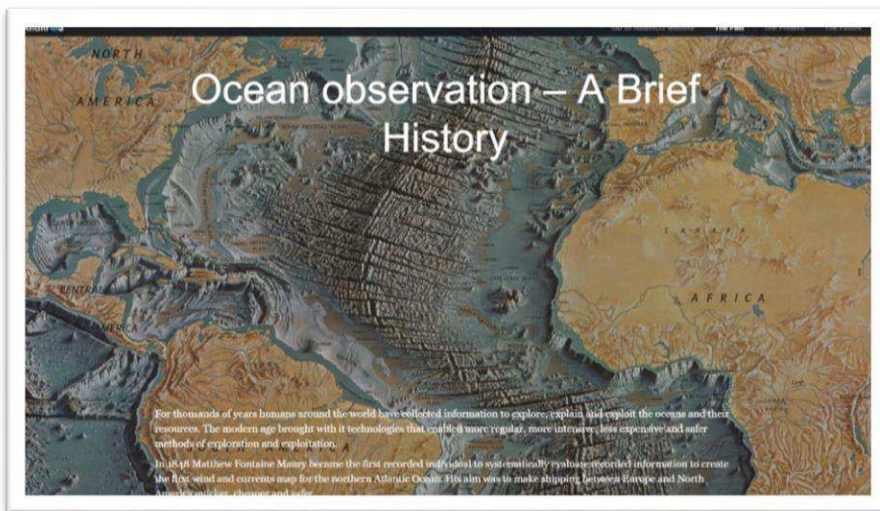
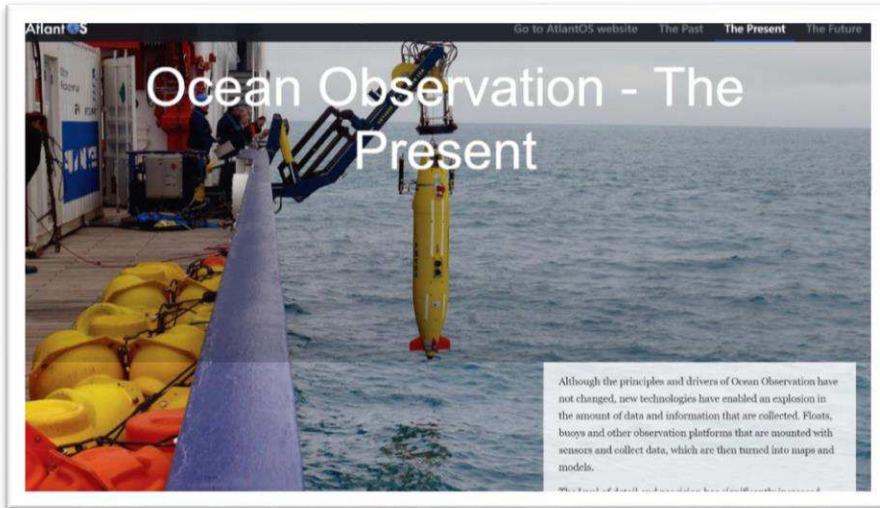
*Task 10.8 Visual and interactive legacy outputs*

These tasks have continued to co-produced, designed and developed a number of products and graphics targeting a range of end-user groups. During the lifetime of the project, this includes:

- 5 themed project newsletters,
- Leaflets and banners for both digital and printed distribution
- Enhanced website structure and functionality for the AtlantOS legacy
- 3 focus AtlantOS briefing papers
- A parallax website providing a visual overview of ocean observation in the past, present and future.
- An interactive infographic providing a visual legacy project of the AtlantOS project structure, outputs and users with links to relevant sections of the website.
- Additional visual products to support the AtlantOS brand and awareness including meeting brochures, logo updates and presentation templates

Specific deliverables during the reporting period: D.10 Legacy Output: Parallax Website

An independent parallax website has been designed and developed as a visual legacy output of the AtlantOS project. Parallax scrolling is a technique in computer graphics where background images move past the camera more slowly than foreground images. This creates an illusion of depth in a 2D scene and a sense of immersion in the virtual experience. The website focusses on ocean observations in the past, present and future and is meant for all observers interested in learning more about ocean observing and the role of AtlantOS in less than 5 minutes. Figures 10.1 – 10.3. give an indication of the layout and content. A demo version is available online at <https://www.atlant0s-h2020.eu/ocean-observation/> .



Figures 10.1. – 10.3. Screenshots of parts of the AtlantOS parallax website

### Also delivered: Interactive AtlantOS Infographic

The AtlantOS infographic has been embedded into a webpage on the project website with full interactive functionality developed. Additional information display in a pop-up window and once finalized, the content will link to relevant sections of the project website. The interactive infographic provides a visual representation of the AtlantOS vision, products, services end-user groups and societal benefits. The interactive infographic will be available for future dissemination as a legacy product for a range of user-groups (<https://www.atlantos-h2020.eu/infographic/>).

### **Cooperation and interaction with other AtlantOS WPs**

Task 10.3 and WP8 regarding resources for Atlantic users on the EMODNet Central Portal

### **Cooperation and interaction with other projects and initiatives**

Task 10.5. and the OECD – cooperation continued leading to a flagship OECD report, which includes a section on ocean observing

Task 10.4. and the Blue-Action H2020 project – joint briefing paper and event

Task 10.6. and EUROGOOS – Strategic foresight on AtlantOS in the European context.

### **Achieved main results**

## **WP 11 Management and Exploitation**

### **Summary**

WP11 provides scientific and administrative management and coordination of the project to ensure all aims of the project are efficiently and effectively met, on time and with the resources budgeted providing that knowledge and innovation are properly managed. The Project Coordination Unit (PCU) effectively reports and communicates within the project, between the partners and stakeholders and between the consortium and the European commission. Furthermore, WP11 supports and provides that AtlantOS achievements and results are discussed and displayed within the context of relevant community events like the Ocean Science meeting in Portland, USA and the EuroGEOSS workshop in Geneva, Switzerland.

### **Progress per task**

#### *Task 11.1 Project management*

The PCU at GEOMAR Helmholtz Centre for Ocean Research Kiel, consisting of the coordinator, its deputy, the manager, its assistance, and a financial assistance is managing the project using effective management procedures.

- The PCU provides administrative, financial, and legal support to all partners involved during the implementation of the action. During the 3<sup>rd</sup> period, AtlantOS conducted 1 amendment to allow beneficiary no 41 to add a third party that provides in-kind contribution against payment. This amendment, was also used to update the Grant Agreement regarding all issues that have changed since the last amendment (autumn 2017) without any need for an amendment for these particular cases. Accordingly, Annex 1 (description of the action) and Annex 2 (estimated budget of the action) have been updated. This amendment had no influence on the total project budget of AtlantOS nor to the scientific work plan.

- The internal communication within AtlantOS is provided via the AtlantOS intranet and via email and telephone calls. External communication, in close cooperation with WP10, is provided via the webpage, the projects newsletter which has always a specific focus and other media like videos. Situational communication, in case the PCU is contacted/informed by one partner or WP regarding a specific issue where a direct link to another partner or WP is realized, the PCU immediately connects these two or more partners or WPs. During the 3<sup>rd</sup> period, an animation video has been developed to illustrate the strategic nature of AtlantOS, including the value chain of ocean observing for societal, scientific, economic benefit. This video has been shown several times by AtlantOS partners and requested by different bodies for high-level events e.g. for the GEO plenary meeting in Kyoto, Japan, the EC for the 'Our Atlantic Ocean for Growth and Well-Being' meeting in Mindelo, the EC for the 'Oceans – The Future of the Blue Planet' meeting in the European Parliament. The newsletters of this period had a specific focus on *Data management, harmonisation and integration across the Atlantic Ocean* (no 3), on *Early Career Scientists in Ocean Observing* (no 4), and a fifth that will be published subsequent to the AtlantOS Symposium will focus on *AtlantOS achievements*. Moreover, the PCU, in cooperation with several WPs, is currently developing and producing a series of short success story videos that will be launched during the AtlantOS Symposium end of March in Paris.
- The PCU prepared the agenda and information material for internal and external board meetings as well as meeting minutes, the project periodic report, reports for the external boards, and the general AtlantOS presentation and is highly involved in high-level communication activities to promote the action and its findings e.g. during the EuroGEOSS workshop in Geneva, Switzerland, the preparation of the *Our Atlantic Ocean for Growth and Well-Being' meeting in Mindelo, the preparation and organization of the First International AtlantOS Symposium in Paris*. This four-day Symposium will celebrate the success of the research and innovation action AtlantOS and simultaneously mark the beginning of the international AtlantOS (All-Atlantic Ocean Observing System) programme. The symposium will bring together scientist, policy makers, users, funders and other stakeholders to define a joint All-Atlantic ambition for ocean observing. Furthermore, the PCU prepares and continuously updates in cooperation with the Steering Committee the general power point presentation, the poster, the terms of reference (the one pager), and the fact sheet of AtlantOS. All this material as well as the logo and some additional material is available for download on the webpage. Internal and external meetings and news are continuously displayed on the project webpage.
- The external project boards, the International Scientific and Technical Advisory Board (ISTAB) and the Engagement Board (ENB) receives a progress report prior to each General Assembly meeting and during the GA meeting a briefing by the Executive Board. Subsequent to the GA meeting, the participating board members will provide the PCU with their written scientific advice. The ISTAB is actively involved in several actions of the project based on the expertise of the experts. Several ISTAB members are part of the so-called BluePrint writing team that developed an All-Atlantic Ocean Observing System high-level Strategy, over the last two years. The vision of this document has been submitted as a community white paper to the OceanObs'19 in Frontiers Marine Science. Brad DeYoung, the chair of the ISTAB was generous enough to take the co-lead together with Martin Visbeck to turn this process into a very successful community-building initiative. The final result of this initiative will be the implementation strategy, which will be finalized subsequent to the AtlantOS Symposium. The ENB is in place since March 2017, it is composed of Kristina Gjerde, Zdenka Willis, Deidre Byrne, Torsten Thiele, and Dawn Wright (see chapter on science management and governance).

These five members have been appointed as core members. The ENB is providing strategic-level advice to the AtlantOS consortium to ensure the vision of a sustained integrated ocean observing system for the Atlantic will be achieved. Zdenka Willis is part of the BluePrint core writing team and greatly supported and steered the development of the stakeholder day of the AtlantOS Symposium. The communication and cooperation with the ENB is conducted in close cooperation to WP10.

- The PCU further provides for regular meetings of the Executive Board (EB) and the Steering Committee (SC) (see chapter on science management and governance). Both internal boards have regular meetings at least at each GA meeting. The SC and EB had an additional face-to-face meeting in October 2018 to prepare for the final AtlantOS GA. Furthermore, the PCU supported WP10 in organising the exchange of ideas between AtlantOS and AORA regarding progress/pitfalls in Atlantic Ocean Observing.
- Support to scientific communication has been provided in the 3<sup>rd</sup> project period by presentation at various conferences and high-level science-policy events e.g. the Ocean Science Meeting 2017 in Portland where 3 AtlantOS town hall meetings have been organised, the Belem Statement Implementation Meeting 2018 in Salvador, the EuroGEOSS workshop 2018 in Geneva where AtlantOS organised a hands-on and a break-out session, the GEO week 2018 in Kyoto, Japan, and the Our Atlantic Ocean for Growth and Well-Being 2018.

#### *Task 11.2 Knowledge and innovation management*

Management of knowledge and innovation in AtlantOS is of high relevance. The focus here is on the role and synergies between beneficiaries' expertise, competence, capabilities, and how partners will protect and share, manage IPR and actual exploitation. During the 3<sup>rd</sup> project period, the PCU, in cooperation with WP10, updated the deliverable template by an stakeholder engagement request per deliverable to get a better idea of the stakeholder engagement on different levels e.g. task level, workpackage level, network level, system level, etc. We will start soon to evaluate the questionnaires.

In cooperation with WP7 the Data Management Plan has been updated based on the extensive experience WP7 has gained during the 2<sup>nd</sup> and 3<sup>rd</sup> project period.

#### **Cooperation and interaction with other AtlantOS WPs**

WP11 is in close contact to all WPs in AtlantOS but has most intensive interaction with WP10 as by nature 'Engagement, Dissemination, and Communication' is part of project management and on the other hand the work on exploitation done in WP11 is also benefiting from the close collaboration to WP10.

#### **Cooperation and interaction with other projects and initiatives**

WP11 together with other AtlantOS WPs e.g. WP10 and others has a close collaboration with AORAC-SA and other EU H2020 projects like Blue Action, INTAROS, ATLAS (the coordinator is a member of the AtlantOS ISTAB), and others. Via the BluePrint network we engage with various international partners from the Ocean Observation community. In the meantime, we have a firm history of international cooperation with various initiatives (e.g. TPOS 2020, GOOS, SCOR, GEO, GEDAE OceanView, GOA-ON, IIOE-2, Copernicus and others) investigating the enhancement and optimisation of ocean observation in various ocean basins to exchange experiences and develop best practices. During the Ocean Science Meeting in February 2018 in Portland we conducted a Town Hall meeting entitled 'Partnership building to advance the integrated global in-situ Ocean Observing Systems' to which we invited initiatives from various ocean basins working on the enhancement and optimisation of ocean observation to evaluate the progress that

has been achieved since 2016 and to identify the main shortcomings. Furthermore, we are also encouraging our cooperation partners to jointly work towards the Sustainable Development Goals defined by the United Nations (mainly goal no 14 ‘life below water’) and to contribute to the OceanObs’2019 discussion.

### Achieved main results

- Successful implementation of the 3<sup>rd</sup> AtlantOS GA meeting which will be combined with the First International AtlantOS Symposium including a high-level policy day as well as a high-level stakeholder day
- Transformation of the Atlantic Ocean Observing BluePrint initiative into an All-Atlantic Ocean Observing System Strategy
- Successful Town Hall meetings at the Ocean Science meeting in Portland, USA as well as successful AtlantOS hands-on meeting and SDG14 break-out session at the EuroGEOSS workshop in Geneva, Switzerland
- Fruitful exchange of ideas with AORA
- Development of an animation video to explain the AtlantOS as a strategic action aiming to enhance and optimise the integrated Atlantic Ocean Observing System
- Very successful community building on all AtlantOS value chain issues to jointly work on an international, integrated, efficient and fit-for-purpose All-Atlantic Ocean Observing System
- Enhanced information on task leader interaction with stakeholders

<b>AtlantOS meetings (November 2018 – March 2019):</b>			
<b>Meeting</b>	<b>Time</b>	<b>Place</b>	<b>Organiser</b>
Side Event ‘Oceans, Climate and the Role of Science I: Marine Observation, Data and Information Systems’ at COP 23	10 November 2017	Bonn	PCU, Copernicus Marine Service
Evolving and Sustaining Ocean Best Practices	15-17 November 2017	Paris	AtlantOS, ODIP, IODE, UNESCO, JCOMM, IEEE, AWI
WP2, WP3, WP4, WP6, WP7, WP8 Meetings	20 November 2017	Gran Canarias	WP2, 3, 4, 6, 7, 8
Joint WP2 & 3, task 6.4, task 4.4, task 9.2 & 9.3, Early Career Scientist, Gender and Diversity Committee, task 3.4, Steering Committee, Executive Board, Intern. Scientific and Technical Advisory Board, Engagement Board Meetings	21 November 2017	Gran Canarias	WP2 and 3, task 4.4, task 6.4, 9.2, 9.3, the GDC, 3 ECS, task 3.4, PCU
3 <sup>rd</sup> AtlantOS General Assembly Meeting including special focus day ‘Sensors, Innovation of Observing Technologies and	21 – 23 November 2017	Gran Canarias	PCU, PLOCAN, WP6



the private sector'			
GEOSS workshop	24 November 2017	Gran Canarias	WP7, UniHB
Ocean Observing System Simulation Experiment (OSSE) meeting	24 November 2017	Gran Canarias	WP1, IFREMER
Mid-term project review of AtlantOS in the North and South Atlantic activities – with focus on ecosystems and climate	24 November 2017	Gran Canarias	WP5
Atlantic Ocean Observing BluePrint Meeting	24-25 November 2017	Gran Canarias	PCU, Brad deYoung
Ocean Science Meeting Town Hall: Ocean Applications for Societal Benefit from Observations and Models	12 February 2018	Portland, USA	WP8
Ocean Science Meeting Town Hall: Managing the Evolution and Sustainability of Best Practices Across Ocean Science	14 February 2018	Portland, USA	WP6
Ocean Science Meeting Town Hall: Partnership building to advance the integrated global in-situ Ocean Observing System	14 February 2018	Portland, USA	WP11
Ocean Science Meeting: Connecting climate, ocean and ecosystem observation – “Ocean observation futures”	15 February 2018	Portland, USA	WP5
Mid-year ETN webex conference	23 February 2018		WP3, ETN task
Genomic workshop	21 – 23 February 2018	Bremen, Germany	WP6, WP3
Interoperability Technologies for Sharing Ocean Instruments and Real-Time Data meeting	15 March 2018	London, UK	WP6
Webinar on Best Practices in Ocean Observing	08 May 2018		WP6
4th ICES/PICES/IOC Symposium on Climate Change and Impacts on the World's Oceans: W8 Workshop, Connecting	03 June 2018	Washington DC, USA	WP5
Perspectives and Plans of German Actors regarding Ocean Observing Activities in the Atlantic Ocean – Meeting	28 June 2019	Hamburg, Germany	WP9, GEOMAR
Behind the Headlines – The Slowing Gulf Stream – What we know and potential impacts – A breakfast science-policy discussion	04 September 2018	European Parliament	WP10, WP11, BlueAction
EuroGEOSS Workshop – AtlantOS hands-on and SDG14 break-out session	12 – 14 September 2018	Geneva, Switzerland	WP11, WP10, GEOMAR, EuroGOOS

Workshop on ocean observations of oxygen, pH and CO <sub>2</sub>	10 – 12 October 2018	Brest, France	WP6, WP2
GEO week – AtlantOS contribution	29 October – 02 November 2018	Kyoto, Japan	WP11, WP6
Reunión de coordinación de la observación oceánica en España	15 – 16 November 2018	Madrid, Spain	WP9, GEOMAR, IEO
Second ETN annual meeting	27-29 November 2018	Olhão, Portugal	WP3, ETN task
Our Atlantic Ocean for Growth and Well-Being with AtlantOS contribution	21 – 23 November 2018	Mindelo, Carbo Verde	WP11
Workshop on interoperability for nutrient and chlorophyll-fluorescence observations	4 – 6 December 2018	Brest, France	WP6
Smart Sensing Interoperability Platforms in the scope of AtlantOS	10 – 11 December 2018	Porto, Portugal	WP6, PLOCAN
AtlantOS Quantitative Future Observing Network Design workshop	5 – 6 February 2019	Paris, France	WP1, WP9
<b>Coming soon</b>			
First International AtlantOS Symposium	25 – 28 March 2019	Paris, France	All WPs
Booth at Ocean Business '19	9 – 11 April 2016	Southampton, UK	WP6
Training course on a suite of biogeochemical sensors	10 – 21 June 2019	Kristineberg, Sweden	IOPAN
Booth at OCEANS '19	17 – 20 June 2019	Marseille, France	WP6

#### 4. Science management and governance

The AtlantOS governance structure is designed to allow fast flow of information between the partners, the stakeholders and the European Commission. It has four different levels i) daily project management, ii) executive, iii) decision making, and, iv) advisory level with specific roles.

*Daily project management:* The Project Coordination Unit (CPU) at GEOMAR will be in charge of the management of the project. The team includes the **coordinator** (Prof. Martin Visbeck), his **deputy** (Johannes Karstensen), the **project manager** (Anja Reitz), **support of the manager** (Sandra Ketelhake) and a **financial assistant** (Anja Wenzel). The work package leaders and co-leaders are in charge of the scientific management of the work on work package level. Each work package has several tasks which are led by the task leaders, they are in charge of the progress of the task and if required interaction with related task leaders / work package leaders.

*Executive level:* The **Executive Board** (EB) is the supervisory body of the execution of the project. It reports to and proposes decisions to the General Assembly and is responsible for their execution. The board comprised of the coordinator and five members of the Steering Committee, plus one expert in biodiversity:

Kate Larkin, Sabrina Speich, Isabel Sousa Pinto, Matthew Mowlem, Albert Fischer, Pierre Yves Le Traon. The EB has in its current composition has a 3 to 4 gender ratio.

The coordinator Martin Visbeck and his deputy Johannes Karstensen have the responsibility of the overall scientific coordination of the project and function together with the manager Anja Reitz as liaison with the European Commission on behalf of the consortium.

*Decision making level:* The **General Assembly** (GA) is the ultimate decision-making body of the consortium. It is responsible for taking key decisions for the project as a whole based on proposals of the EB. It is comprised of one representative of each project partner and is chaired by the coordinator.

*Advisory level:* AtlantOS has internal and external advisory boards. The internal boards are comprised of members of the consortium and the external boards are comprised of external experts and members of the stakeholder communities. They directly advise the EB and indirectly the GA on their specific matters of competence.

The (internal) **Steering Committee** (SC) is comprised of all work package and co-leaders and chaired by the coordinator. It makes propositions for the proper implementation of the project to the EB. The (internal/external) **Gender and Diversity Committee** (GDC) raises gender and diversity awareness within the consortium. It will develop a Gender and Diversity Action Plan and gives advice to the EB on its implementation. The board comprised of Nadia Pinaridi, Albert Fischer, Sandy Thomala, Janice Trotte. The (external) **International Scientific and Technical Advisory Board** (ISTAB) will evaluate and advise on the project's scientific approach and orientation. It will further ensure that the project is properly linked to other programmes. The board is comprised of selected key international experts with a scientific high-profile. The members have been selected considering a good balance regarding disciplines, geography, and gender. The ISTAB comprises of the following 12 members: Maria Paz Chidichimo (AR), Isabelle Ansorge (SA), Moacyr Araujo (BR), Brad DeYoung (CA), Molly O. Baringer (US), Suzanne M. Carbotte (US), Eric Lindstrom (US), Angelika Brandt (DE), Alexandra Giorgetti (IT), Oscar Schofield (US), Peter Croot (IR), Murray Roberts (UK). The (external) **Engagement Board** (ENB) engages industry, government and other relevant stakeholders at a high, strategic level advising on future actions to be implemented by the observatories community. The role of the board is to support the project in gaining new ideas on how to efficiently engage with stakeholders, attract more users, identify ways to improve usage of data and information from society to science and vice versa, and advise on innovation management issues. The consortium was going through a very controversial and iterative procedure to appoint the members for the ENB. The procedure was additionally slowed down due to the fact that several high-level candidates were wished to engage but had problems to yet take any further responsibilities. However, we managed to appoint 5 high-level stakeholders covering diverse fields considering Ocean Observation issues: Deidre Byrne (Dept. of the Environment, South Africa), Kristina Gjerdes (Senior Advisor, Law of the Sea, IUCN World Conservation Union), Thorsten Thiele (Founder – under water technology, Global Ocean Technology), Zdenka Willis (retired Chief Scientist for NOAAs Integrated Ocean Observing Systems), and Dawn Wright (Chief Scientist at ESRI). The ENB members will be invited based on their background and expertise for specific activities and meetings where strategic-level advice is requested e.g. (i) Collaboration with the OECD, (ii) exchange of ideas on sustainable funding, (iii) to support the Blue Print Writing Group, (iv) to support the OceanObs and sustainable development goal 14 (SDG 14) briefings etc.

## 5. Publications

- Abecasis, David, et al. 2018. A review of acoustic telemetry in Europe and the need for a regional aquatic telemetry network. *Animal Biotelemetry* 6.1: 12. <https://doi.org/10.1186/s40317-018-0156-0>.
- Awo, F. M., G. Alory, C.Y. Da-Allada, T. Delcroix, J. Jouanno, E. Kestenare, & E. Baloïtcha, 2018. Sea surface salinity signature of the tropical Atlantic interannual climatic modes. *J. Geophys. Res. Oceans*, 123, 7420–7437, doi:10.1029/2018JC013837.
- Birchill A.J., G. Clinton-Bailey, R. Hanz, E. Mawji, T. Cariou, C. White, S.J. Ussher, P.J. Worsfold, E. P. Achterberg, M. Mowlem, 2019. Realistic measurement uncertainties for marine macronutrient measurements conducted using gas segmented flow and Lab-on-Chip techniques. *Talanta*. In press.
- Bosse, A., Fer, I., Sjøiland, H. and T. Rossby, 2018. Atlantic Water Transformation Along Its Poleward Pathway Across the Nordic Seas. In *J. Geophys. Res. Oceans* 123 (9), pp. 6428–6448. DOI:10.1029/2018JC014147.
- Bourlès, B., M. Araujo, M. J. McPhaden, P. Brandt, G. R. Foltz, R. Lumpkin, H. Giordani, F. Hernandez, N. Lefèvre, P. Nobre, E. Campos, R. Saravanan, J. Trotte-Duhà, M. Dengler, J. Hahn, R. Hummels, J. F. Lübbecke, M. Rouault, L. Cotrim, A. Sutton, M. Jochum, and R. C. Perez. 2019. PIRATA: A Sustained Observing System for Tropical Atlantic Climate Research and Forecasting, submitted to *Earth and Space Sciences*, in revision.
- Bushnell, Mark Bushnell 2018. Quality Control of Real-Time Water Level Data: The U.S. IOOS® QARTOD Project. *Marine Technology Society Journal*, Volume 52, Number 2. (2018). Quality Control of Real-Time Water Level Data: The U.S. IOOS® QARTOD Project. *Marine Technology Society Journal*, Volume 52, Number 2.
- T. Dabrowski, C. Cusack, K. Lyons, J. Silke and E. O’Rourke, 2018. Societal benefits from observing and modelling systems – pilot actions in Ireland in the framework of the AtlantOS project. *Proceedings 8<sup>th</sup> EuroGOOS Conference, October 3rd-5th, 2017, Bergen, Norway*, p. 453-462. <http://eurogoos.eu/download/publications/EuroGOOS-2017-Conference-Proceedings.pdf>
- Denvil-Sommer, A., Gehlen, M., Vrac, M., and Mejia, C. 2018. FFNN-LSCE: A two-step neural network model for the reconstruction of surface ocean pCO<sub>2</sub> over the Global Ocean, *Geosci. Model Dev. Discuss.*, <https://doi.org/10.5194/gmd-2018-247>, in review.
- Evangelista, H., A. Sifeddine, T. Corrège, J. Servain, E. P. Dassié, R. Logato, R. C. Cordeiro, C.-C. Shen, F. Le Cornec, J. Nogueira, B. Segal, A. Castagna, and B. Turcq, 2018. Climatic constraints on growth rate and geochemistry (Sr/Ca and U/Ca) of the coral *Siderastrea stellata* in the Southwest Equatorial Atlantic (Rocas Atoll, Brazil). *Geochem., Geophys., Geosys.*, **19**, 772–786, <https://doi.org/10.1002/2017GC007365>.
- Foltz, G.R., P. Brandt, I. Richter, M. Rodriguez-Fonseca, F. Hernandez, M. Dengler, R.R.Rodrigues, J. Schmidt, L. Yu, N. Lefevre, L. Cotrim, M.J. McPhaden, M. Araujo, J.Karstensen, J. Hahn, M. Martin-Rey, C.M. Patricola, P. Poli, P. Zuidema, R. Hummels, R.C.Perez, V. Hatje, J.F. Lubbecke, I. Polo, R. Lumpkin, B. Bourlès, F.E. Asuquo, P. Lehodey, A.Conchon, P. Chang, P. Dandin, C. Schmid, A. Sutton, H. Giordani, Y. Xue, S. Illig, T.Losada, S.A. Grodsky, F. Gasparin, T. Lee, E. Mohino, P. Nobre, R. Wanninkhof, N.Keenlyside, V. Garcon, E. Sanchez-Gomez, H.C. Nnamchi, M. Drevillon, A. Storto, E. Remy, A. Lazar, S. Speich, M. Goes, T. Dorrington, W.E. Johns, J.N. Moum, C. Robinson, C.Perruche, R.B. de Souza, A. Gaye, J. Lopez-Parages, P.A. Monerie, P. Castellanos, N.U. Benson, M.N. Hounkonnou, J. Trotte-Duha, 2019. The Tropical Atlantic Observing System, Submitted to *Frontiers in Marine Science*, in revision.

- Fujii, Y., Remy, F., Zuo, H., et al. 2018. Observing System Evaluation Based on Ocean Data Assimilation and Prediction Systems: On-going Challenges and Future Vision for Designing/Supporting Ocean Observational Networks, *Frontiers in Marine Science-Ocean observation*, in review.
- Garçon, V., Karstensen, J., et al., Multidisciplinary Observing in the World Ocean's Oxygen Minimum Zone regions: from climate to fish- the VOICE initiative, submitted to *Frontiers in Marine Sciences*, in revision.
- Garry, F. K., McDonagh, E., Blaker, A. T., Roberts, C. D., Desbruyères, D. G., Frajka-Williams, E., King, B. A. 2018. *JGR Oceans*, in review.
- Gary, S. F., Cunningham, S. A., Johnson, C., Houpert, L., Holliday, N. P., Behrens, E., Biastoch, A. and C. W. Böning, 2018, Seasonal Cycles of Oceanic Transports in the Eastern Subpolar North Atlantic. In *J. Geophys. Res. Oceans* 123 (2), pp. 1471–1484. DOI:10.1002/2017JC013350.
- Gasparin, F., Greiner, E., Lellouche, J.-M., Legalloudec, O., Garric, G., Drillet, Y., BourdalleBadie, R., Le Traon, P.-Y., Remy, E., and Drevillon, M. 2018. A large-scale view of oceanic variability from 2007 to 2015 in the global high resolution monitoring and forecasting system at Mercator-Ocean, *J. Marine Syst.*, 187, 260–276, <https://doi.org/10.1016/j.jmarsys.2018.06.015>
- Gasparin F., S. Guinehut C., Mao, I. Mirouze, E. Remy, R. King, M. Hamon, R. Reid., A. Storto, P.Y. Le Traon, M. Martin and S. Masina 2018. Requirements for an integrated in situ Atlantic Ocean Observing System from coordinated Observing System Simulation Experiments, *Frontiers in Marine Sciences*, in review.
- Germineaud C., Brankart J.M. and Brasseur P. 2018. An ensemble-based probabilistic score approach to compare observation scenarios: an application to biogeochemical-Argo deployments, *Monthly Weather Review*, in review.
- Hedemann, C., Mauritsen, T., Jungclaus, J., and Marotzke, J. 2017. The subtle origins of surface-warming hiatuses. *Nature Climate Change*, 7, 336-339, doi:10.1038/nclimate3274
- Herbert G., and B. Bourlès. 2018. Impact of intraseasonal wind bursts on sea surface temperature variability in the far Eastern tropical Atlantic Ocean during boreal spring 2005 and 2006: focus on the mid-May 2005 event, *Ocean Sciences*, 14, 849–869, <https://doi.org/10.5194/os-14-849-2018>.
- Houpert, L., Inall, M. E., Dumont, E., Gary, S., Johnson, C., Porter, M., Johns, W. E. and S. A. Cunningham, 2018. Structure and Transport of the North Atlantic Current in the Eastern Subpolar Gyre From Sustained Glider Observations. In *J. Geophys. Res. Oceans* 123 (8), pp. 6019–6038. DOI:10.1029/2018JC014162.
- Hughes, C. W., Williams, J., Blaker, A., Coward, A., & Stepanov, V. 2018. A window on the deep ocean: The special value of ocean bottom pressure for monitoring the large-scale, deep-ocean circulation. *Prog. Oceanogr.*, 161, 19-46. doi:10.1016/j.pocean.2018.01.011
- Karstensen, J., Schütte, F., Pietri, A., Krahnmann, G., Fiedler, B., Grundle, D., Hauss, H., Körtzinger, A., Löscher, C. R., Testor, P., Vieira, N. and M. Visbeck, 2017. Upwelling and isolation in oxygen-depleted anticyclonic modewater eddies and implications for nitrate cycling. In *Biogeosciences* 14 (8), pp. 2167–2181. DOI:10.5194/bg-14-2167-2017.
- Kolodziejczyk, N., Testor, P., Lazar, A., Echevin, V., Krahnmann, G., Chaigneau, A., Gourcuff, C., Wade, M., Faye, S., Estrade, P., Capet, X., Mortier, L., Brehmer, P., Schütte, F. and J. Karstensen, 2018. Subsurface Fine-Scale Patterns in an Anticyclonic Eddy Off Cap-Vert Peninsula Observed From Glider Measurements. In *J. Geophys. Res. Oceans* 123 (9), pp. 6312–6329. DOI:10.1029/2018JC014135.
- Kounta, L., Capet, X., Jouanno, J., Kolodziejczyk, N., Sow, B., and Gaye, A. T. 2018. A model perspective on the dynamics of the shadow zone of the eastern tropical North Atlantic. Part 1: the poleward slope currents along West Africa, *Ocean Sci. Discuss.*, <https://doi.org/10.5194/os-2018-16>.

- Leadbetter, A., Silke, J., and Cusack, C. 2018. Creating a weekly Harmful Algal Bloom bulletin. Marine Institute, Galway, Ireland. <https://www.oceanbestpractices.net/handle/11329/424>
- Le Quéré, C., R. M. Andrew, P. Friedlingstein, S. Sitch, J. Pongratz, A. C. Manning, et al. 2018. Global Carbon Budget 2017, *Earth Syst. Sci. Data*, 10(1), 405–448, doi:10.5194/essd-10-405-2018.
- Lozier, M. S., Bacon, S., Bower, A. S., Cunningham, S. A., de Jong, M. F., de Steur, L., deYoung, B., Fischer, J., Gary, S. F., Greenan, B. J. W., Heimbach, P., Holliday, N. P., Houpert, L., Inall, M. E., Johns, W. E., Johnson, H. L., Karstensen, J., Li, F., Lin, X., Mackay, N., Marshall, D. P., Mercier, H., Myers, P. G., Pickart, R. S., Pillar, H. R., Straneo, F., Thierry, V., Weller, R. A., Williams, R. G., Wilson, C., Yang, J., Zhao, J. and J. D. Zika, 2017. Overturning in the Subpolar North Atlantic Program: A New International Ocean Observing System. In *Bull. Amer. Meteor. Soc.* 98 (4), pp. 737–752. DOI: 10.1175/BAMS-D-16-0057.1.
- Mannarini, G., Pinardi, N. and Coppini, G. 2018a. Low Carbon Intensity Routes via Ocean Currents and Waves. 19<sup>th</sup> International Conference on Ship & Maritime Research ("NAV18") Technology and Science for the Ships of the Future A. Marinò and V. Bucci (Eds.) IOS Press, 2018 DOI: 10.3233/978-1-61499-870-9-340
- G. Mannarini, D. Subramani, P. Lermusiaux, and N. Pinardi. Graph-search and differential equations for time-optimal vessel route planning in dynamic ocean waves. *IEEE Transactions on Intelligent Transportation Systems*, 2018b, submitted.
- Mannarini, G. and Carelli, L. 2019. VISIR-I.b: waves and ocean currents for energy efficient navigation *Geosci. Model Dev. Discuss.* <https://doi.org/10.5194/gmd-2018-292>
- Mignot, A., Ferrari, R. and Claustre H. 2017. *Floats with bio-optical sensors reveal what processes trigger the North Atlantic bloom.* *Nature Communication*, in press
- Nogueira Neto, A. V., H. Giordani, G. Caniaux, and M. Araujo, 2018. Seasonal and interannual mixed layer heat budget variability in the western tropical Atlantic from Argo floats (2007-2012), *J. Geophys. Res.*, 123, 5298-5322, <http://dx.doi.org/10.1029/2017JC013436>.
- Pearlman, J., M. Bushnell, L. Coppola, P. L. Buttigieg, F. Pearlman, P. Simpson, M. Barbier, J. Karstensen, F. Muller-Karger, C. Munoz-Mas, P. Pissierssens, C. Chandler, J. Hermes, E. Heslop, R. Jenkyns, E. Achterberg, M. Bensi, H. Bittig, J. Blandin, J. Bosch, B. Bourlès, R. Bozzano, J. Buck, E. Burger, D. Cano, V. Cardin, M. C. Llorens, A. Cianca, H. Chen, C. Cusack, E. Delory, R. Garello, G. Giovanetti, V. Harscoat, S. Hartman, R. Heitsenrether, S. Jirka, A. L. Lopez, N. Lanteri, A. Leadbetter, G. Manzella, J. Maso, A. McCurdy, E. Moussat, M. Ntouma, S. Pensieri, G. Petihakis, N. Pinardi, S. Pouliquen, R. Przeslawski, N. Roden, J. Silke, M. Tamburri, H. Tang, T. Tanhua, P. Testor, J. Thomas, C. Waldmann, F. Whoriskey, 2019. Evolving and Sustaining Ocean Best Practices and Standards for the Next Decade, *submitted to Frontier in Marine Science*, in revision.
- Planton, Y., A. Voltaire, H. Giordani, & G. Caniaux, 2018. Main processes of the Atlantic cold tongue interannual variability, *Clim. Dyn.*, 50, 1495-1512, doi: 10.1007/s00382-017-3701-2.
- Poli, Paul. 2018. Note on the impact of meteorological data from PIRATA moorings on global weather forecasts (Version 2). Zenodo. <http://doi.org/10.5281/zenodo.1462649>.
- Porter, M., Inall, M. E., Hopkins, J., Palmer, M. R., Dale, A. C., Aleynik, D., Barth, J. A., Mahaffey, C. and D. A. Smeed, 2016. Glider observations of enhanced deep water upwelling at a shelf break canyon: A mechanism for cross-slope carbon and nutrient exchange. In *J. Geophys. Res. Oceans* 121 (10), pp. 7575–7588. DOI:10.1002/2016JC012087.
- Reubens, J, Verhelst, P., van der Knaap, I., Wydooghe, B., Milotic, T., Deneudt, K., Hernandez F., and Pauwels, I., 2019. The need for aquatic tracking networks: the Permanent Belgian Acoustic Receiver Network. *Animal Biotelemetry*, 7:2

- Rouault, M., S. Illig, J. F. Lübbecke, and R. A. Imbol Koungue, 2018. Origin, development and demise of the 2010-2011 Benguela Niño. *J. Mar. Sys.*, 188, 39-48, <http://dx.doi.org/10.1016/j.jmarsys.2017.07.007>.
- Schauer, U. and M. Losch. 2019. Freshwater in the ocean is not a useful parameter in climate research. In review, *Journal of Physical Oceanography*.
- Schmidt, J., Bograd, S.J., et al., Future ocean observations to connect climate, fisheries and marine ecosystems, submitted to *Frontiers in Marine Sciences*, in revision.
- Steckenreuter, A., Abecasis, D., Fontes, J., Erzini, K., Afonso, P. (2018). Movement ecology on temperate reef fishes: An ATT data collaboration. IODE/OBIS Event. Data Workshop on Animal Tagging and Tracking, Oostende.
- Testor P., B. de Young, K. Hill, D. Rudnick, S. Glenn, D. Hayes, C. M. Lee, C. Pattiaratchi, V. Turpin, P. Alenius, C. Barrera, J. Barth, N. Beaird, G. Bécu, A. Bosse, F. Bourrin, A. Brearley, Y. Chao, S. Chen, J. Chiggiato, L. Coppola, R. Crout, J. Cummings, B. Curry, R. Curry, R. Davis, K. Desai, S. DiMarco, C. Edwards, S. Fielding, I. Fer, E. Frajka-Williams, H. Gildor, G. Goni, D. Gutierrez, S. Hanson, P. Haugan, D. Hebert, J. Heiderich, E. Heslop, K. Heywood, P. Hogan, L. Houpert, S. Huh, M. Inall, M. Ishii, S. Ito, S. Itoh, S. Jan, J. Kaiser, J. Karstensen, B. Kirkpatrick, J. Klymak, J. Kohut, G. Krahnemann, M. Krug, S. McClatchie, E. Mauri, A. Mehra, M. P. Meredith, T. Meunier, T. Miles, J. Morrel, L. Mortier, S. Nicholson, J. O'Callaghan, D. O'Conchubhair, P. Oke, E. Pallas Sanz, M. Palmer, J. Park, L. Perivoliotis, P.-M. Poulain, R. Perry, B. Queste, L. Rainville, E. Rehm, M. Roughan, N. Rome, T. Ross, S. Ruiz, G. Saba, A. Schaeffer, M. Schonau, K. Schroeder, Y. Shimizu, B. Sloyan, D. Smeed, D. Snowden, Y. Song, S. Swart, M. Tenreiro, A. Thompson, J. Tintore, R. Todd, C. Toro, H. Venables, S. Waterman, R. Watlington, D. Wilson, 2019. Ocean gliders: the glider component of the integrated Global Ocean Observing System, *Frontiers in Marine Science, OceanObs'19 Special Issue, accepted*.
- Tinker, J., Krijnen, J., Wood, R., Barciela, R., and Dye, S. R. 2018. What are the prospects for seasonal prediction of the marine environment of the Northwest European shelf?, *Ocean Sci. Ocean Sci.*, 14, 887-909, 2018 <https://doi.org/10.5194/os-14-887-2018>
- Trolliet, M., J. Walawender, B. Bourlès, A. Boilley, J. Trentmann, P. Blanc, M. Lefèvre, and L. Wald, 2018. Downwelling surface solar irradiance in the tropical Atlantic Ocean: a comparison of re-analyses and satellite-derived data sets to PIRATA measurements, *Ocean Sciences*, 14, 1021-1056, <https://doi.org/10.5194/os-14-1021-2018>.
- Trolliet, M., and L. Wald, 2018. Monthly solar radiation in the tropical Atlantic Ocean: Can its spatial variations be captured by the current configuration of the PIRATA moorings? *Advances in Science and Research*, 15, 127-136, <https://doi.org/10.5194/asr-15-127-2018>.
- Wöfl, A.-C., Jencks, J., Johnston, G., Varner, J., and Devey, C. 2017. *Identifying deep sea target areas for a pilot Atlantic seabed mapping project using GIS techniques*. *Journal of Ocean Technology*. In press.
- Worsfold, P.J., Achterberg, E.P., Birchill, A.J., Clough, R., Leito, I., Lohan, M.C., Milne, A., Ussher, S.J. 2019. Estimating Uncertainties in Oceanographic Trace Element Measurements. *Frontiers in Marine Biogeochemistry*, 5, 515, DOI=10.3389/fmars.2018.00515.

Report of the International Scientific Technical and Advisory Board for the Horizons 2020 Project AtlantOS

16.April.2019

This is the final report of the ISTAB at the final meeting of the AtlantOS project in Paris 25-28 March 2019 at the first International AtlantOS Symposium. The following were in attendance for the ISTAB:

1. Moacyr Arajuo- Brazil
2. Molly O. Baringer - USA
3. Maria Paz Chidichimo - Argentina
4. Peter Croot - Ireland
5. Brad deYoung - Canada
6. Alessandra Giorgetti - Italy
7. Eric Lindstrom – USA

Two members of the Engagement Board did attend the meeting and joined in the discussions of the ISTAB:

8. Zdenka Willis - USA
9. Torsten Thiele - Germany

Unfortunately Angelika Brandt (Germany), Murray Roberts (United Kingdom) and Oscar Schofield (USA) were unable to attend. The final report presented here was developed and shared with the full ISTAB and the two representatives of the Engagement Board. The ISTAB was provided with the final summary report of AtlantOS and all those in attendance in Paris heard the first two days of the International meeting at which the results of the AtlantOS project were summarised and presented.

We were impressed with the scale and the scope of the achievements of the AtlantOS project and offer praise to all those who contributed to the outcome, the researchers, the management team and the European Commission which helped to guide the project. As we heard many times, more than 100 deliverables were successfully executed. Clearly much was done. While this measurable success of the program is important to document, and should be praised, it is perhaps in other areas, some of them more difficult to directly gauge today where AtlantOS has had the greatest impact. The project, through support of some observing projects with international partners, has enabled many actors around the Atlantic to envision their own national observing systems and contributions to GOOS AtlantOS assemblies have engaged a wider community in discussion of sustained ocean observing beyond AtlantOS. AtlantOS has successfully demonstrated the value of the Framework for Ocean Observing by building its work packages around the framework and showing that progress in all those dimensions can result in a system greater than the sum of its parts.



We highlight a few key areas, in which AtlantOS has advanced ocean observing:

- The formation of Ocean Gliders and the support for better data management and global coordination of glider activities.
- The encouragement and formalization of a range of Best Practices initiatives. The many meetings held, the publications that have resulted and the formalization of Best Practice as a focus for ocean observation will benefit the community for many years to come, particularly if they have a home with IODE.
- The support and development of data integration standards will benefit the ocean observation community and support many new initiatives that will arise from discussions at OceanObs'19.
- The Observation System Simulation Experiments (OSSEs) were very well organized, will directly benefit the community and will serve as a guide for future such initiatives. Indeed it is hoped that this, and many other such efforts will live on beyond the end of the AtlantOS project.
- The support for increased South Atlantic activities, including the full-depth high resolution hydrographic transect at the 34.5 °S line between Uruguay and South Africa, and the stimulation and support for the Belém Statement were clearly supported by and a result of the AtlantOS project.

Many more achievements could be listed and while it is important that they should be identified and recognized, it is also important that now, at the end of this program, we reflect not only on what has been achieved but also consider what will live on beyond this project and how more might have been possible. We will highlight a few key issues to consider.

1. **The meeting.** We recognize the constraints associated with organizing such a meeting to present the results of five years of work by hundreds of people. And to do it all in two days. We endorse the thematic approach that was taken, sidestepping the trap of following directly along the structure of the project. There was, however, still too much focus on deliverables and too little on achievements. There was also too little mention of legacy and consideration of how legacy will be maintained and supported. A few considered forward looking thoughts in each section would have been helpful.

While there was much diversity at the meeting, we missed hearing from the younger investigators, those who will likely play a greater role in moving forward with the legacy of AtlantOS. Their voices might have helped to provide some of the vision that was missing from the talks.

2. **Assessing the ocean observing activity.** We very much welcome the efforts to gauge the extent of ocean observing. The approach taken was thoughtful and

the results clearly show how much we need such information. We would encourage caution as the results, taken on their own could be misleading. The monetary assessment does not consider capital and coming up with a number (\$36k on page 4 of your report and \$36M on page 9) could certainly lead to confusion. The results should be presented with the caveats laid out so that listeners do not take away the wrong interpretation. These numbers appear to ignore the capital costs and even once rationalized may raise more questions than offer answers.

- 3. AtlantOS the Program.** The shift from a project to a program is a bold step, particularly in the absence of funding for the program. We are impressed with this ambition but note that this leap will require real commitment and support. We recognize that the Paris meeting was a starting point for this new Program but have concerns about how well this new development is planned and supported. Much is promised and to achieve the vision much will be required.
- 4. Engagement.** We commented on challenge of engagement in our very first discussions as an ISTAB. The response at the time was to setup an Engagement Board. We welcomed this response but note that it has not been successful. The members of the Engagement Board who attended the ISTAB indicated the board never met. We recognize the challenge of engagement and note that it takes many different forms from communication to capacity building to partner and stakeholder participation. Some of each of these aspects did happen within AtlantOS but there was no vehicle to grow and expand these developments, particularly in bringing in the private and public sector partners. This is unfortunate. It remains a challenge, now for AtlantOS the program, but also for the wider ocean observation community. We encourage that new approaches be taken, by AtlantOS the Program in the coming year, at OceanObs'19 for example, and in the future by the European Commission when they support programs focused on engagement. Engagement works best when well-integrated from the beginning of the project, adequately resourced and set up in particular to fine tune deliverables in a way to encourage cooperation and partnerships. External input to AtlantOS has suggested linking outputs clearly to SDG indicators, identifying private and public-private partnership approaches and financing strategies for the AtlantOS Program going forward.
- 5. Legacy.** We have noted some of the achievements of AtlantOS the project but wonder about plans for ensuring some of the positive developments such as the OSSE and Best Practices teams and the AtlantOS Program team are adequately supported to ensure that they live on and grow to further support the ocean observation community. We did not hear anything concrete about such plans. Too often we rush from one program to the next without stopping to ensure that we do not lose what has been achieved.

In summary we congratulate the AtlantOS team on their accomplishments but in the closing months of the project encourage the management team, together with the funders – the European Commission – to consider lessons learned, establish best practices for such projects, e.g. around engagement, and seriously review the requirements to support legacy the key results of AtlantOS the Project. Another thought is to consider developing or offering a summary of the AtlantOS achievements, something that weaves together the specific points that we heard in Paris into a fabric that clearly shows the integration of the accomplishments and points towards AtlantOS the Program.

Our best wishes to all and thanks for the opportunity to be involved with this exciting ocean observation initiative.