Project	AtlantOS – 633211
Deliverable number	D11.6
Deliverable title	2nd AtlantOS progress report plus International Scientific and Technical Advisory Board minutes and AtlantOS Legacy document
Description	Prior to the 3rd annual meeting in month 32 a project progress report for the external project boards will be prepared to enable them to as good as possible prepared for the meeting and to ensure consequently that AtlantOS receives as constructive as possible recommendations from the board. The report together with the external summary board meeting report will be part of D11.6
Work Package number	11
Work Package title	Management and Exploitation
Lead beneficiary	GEOMAR
Lead authors	Anja Reitz, Brad DeYoung, Erik Buch
Contributors	The AtlantOS WP leaders and task leaders as well as all ISTAB and ENB members
Submission data	2 May 2018
Due date	January 2018
Comments	This deliverable is delayed because the AtlantOS Executive Board wanted to finalize an AtlantOS Legacy document be for publication of D11.6.

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*

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

2nd AtlantOS summary progress report for the external advisory boards November 2017

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

Content

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

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 2016 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 16 to 33

In this second phase of the action efforts in work package 1 *Observing system requirements* were focused on the capacities and gap analysis (D1.3) for the Atlantic Ocean observation. Current capacities and gaps were analysed for all three disciplinary components (i) physical, (ii) biogeochemical, and (iii) biological. The report outlined the strategy for performing a comprehensive capacity and gap analysis of the ocean observation value chain in the context of an Integrated Atlantic Ocean Observing System. Furthermore, WP1 collected material, made valuable contacts, and considerable worked on tasks to foster good progress for its refined Integrated Atlantic Ocean Observing System requirements report, the cost and feasibility study, and the Model Guidance for Integrated Atlantic Ocean Observing System Evolution.

Work package 2 *Enhancement of ship-based observing networks* improved the coordination between the GO-SHIP network and other hydrographic surveys. In this context they co-organised, planned and supported two GO-SHIP transects (Ireland - Canada and South Africa – Brazil). The new autonomous titration system for total alkalinity (TA) has been tested and 2 pCO2 membrane sensors, a CTD and Turner Fluorometer, and Aanderra sensors (O2, T, S) have been developed. Comprehensive work has been carried out and published based on the Continuous Plankton Recorder (CPR) data that includes biological EOV's. For the North-East Atlantic and the Baltic Sea an open access acoustic fish database has been developed within ICES. The Seafloor mapping task group is part of the international Seabed Mapping working Group that developed out as a consequence of the Galway Process. The group identified three potential pilot areas within the North Atlantic suitable for future mapping surveys regarding coverage and various application fields.

Work package 3 *Enhancement of autonomous observing networks* Argo has ordered Deep Argo Floats for Argo and new biogeochemical sensor implementation is on-going, data management procedures for biogeochemical variables have been strengthened. Biogeochemical sensors have begun to be implemented on moorings either PIRATA (O2 and CO2) or on Transport Mooring Array (O2). Fixed biogeochemistry observatories are also extending the measurements, in particular to microbial community based on DNA sequencing of particle trap samples. Recent successful deployments of automated moored water samplers allow extending investigations to microbial communities of specific water depths. Drifters with barometers have been deployed in the Tropic Atlantic, and the novel low-cost SST and SSS sensors developed in the project has been successfully tested at sea on a drifter. Regarding the glider work, a new partnership with Brazil has been developed and a Glider Steering Team and a Glider Data Management Team within JCOMMOPS as well as a glider Task Team within EuroGOOS have been established. Additionally, the European Aquatic Animal Telemetric Network has been launched. The online survey provides a useful overview of the European-based acoustic telemetric research community and their expectations towards an organised network.

Work package 4 *Interfaces with coastal ocean observing systems* made significant progress towards the use of autonomous vehicles for the routine monitoring of a wider range of key variables. To do so WP4 engaged among others with a number of pan-Atlantic partners. It investigated and supported the joint analysis for the Fishery Observing Systems (RECOPECA) over the continental shelf and the Argo profiles in the Bay of Biscay. Furthermore, WP4 made explicit connection to the G7 Future Seas and Oceans Initiative.

Work package 5 *Integrated regional observing systems* initiated and executed a series of meetings to join forces of the climate and ecosystem observing communities in the two regions of the North and South Atlantic Ocean to assess and promote integration. These meetings provided a comprehensive overview about the observing efforts, motivations and approaches which will serve as a base for an optimisation of the regional observing systems considered in WP5. Significant work has been started regarding the development of climate and ecosystem indices. This work is based on the enhancement in observing in the South Atlantic initiated by AtlantOS and the leveraging from on-going enhancement by activities in the North Atlantic subpolar gyre region. The work on OSSEs and process models, which are of great interest for observing in the entire Atlantic, have been generated in close collaboration with WP1.

Work package 6 *Cross-cutting issues and emerging networks* has seen good progress in this reporting period including the development of samplers and instruments including: the sea trial of a shipborne prototype of an autonomous particle sampler; and prototyping of new pH and pCO_2 optodes by industrial partners KMCON. It has seen improved collaboration between work packages including with respect to shared infrastructure (WP3) road-mapping (WP2&3) demonstration of new nutrient sensors on autonomous submersible gliders (WP3&4) as well as improved links between WPs 7, 8 and its coordination of best practices. WP6 has continued to provide community leadership and didactic best practice activity. This includes: the submission of a publication documenting metrology best practice for trace element measurement; and maturation of roadmaps for both sensors and instrumentation and for emerging networks.

Work package 7 *Data flow and data integration* completed the design of the integrated EU data system during the 2nd project phase of AtlantOS involving networks as well as integrators. This approach implicates major advances regarding the facilitation of better access to data for users and integrators as well as networks due to data management enhancement. The web portal and AtlantOS catalogue is in operation since early 2017 and is continuously updated and advanced. Together with WP9 a coordinated action for monitoring the traceability of the use of services will be conducted considering a shared strategy and complementary developments avoiding duplication of effort. Furthermore, the AtlantOS transatlantic data harmonisation workshop (June 2017) was a major success with representations from all bordering continents. As a result, new initiatives will clear the way for an improved and integrated approach to manage data harmonisation challenges at transatlantic level.

Work package 8 *Societal benefits form 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 or will become available within the next weeks. The applications and exercises are proposed to demonstrate the importance of AtlantOS in generating the selected targeted products of WP8. Potential actions on stakeholder engagement have been discussed in cooperation with WP10 and WP11. Regarding an improved understanding on how the targeted products for societal benefit can show the adequacy of the ocean observing system, WP8 is in close cooperation with WP1 and 6. Furthermore, WP8 is cooperating with WP6 to present an overview of recent developments for ocean observing sensors and best practices in this field.

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 date sets which are connected, made available and accessible, furthermore they provide various reports and key performance indicators.

Work package 10 *Engagement, Dissemination, and Communication* completed a comprehensive overview on 'Best Practices in Stakeholder Engagement, Data Dissemination and Exploitation'. Furthermore, two policy briefing papers have been produced and launched at high level policy events (the UN Preparatory Meeting to 'The Ocean Conference' in February in New York and the actual conference in June in New York) during the 2nd project phase. Besides, WP10 paved the way for discussion with funding agencies in North America. Based on this well-received exercise a similar informal exchange of ideas is planned for the EU (including EU Member States and European institutions). 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 organised and implemented the process of the Atlantic Ocean BluePrint initiative including the first draft of the short version of the document. This action was a follow up of the 2nd AtlantOS GA meeting based on the advice given by the ISTAB and was led by Brad DeYoung supported by the PCU and Sandra Ketelkake. Furthermore, two fruitful side events at high-level UN conferences (The Ocean Conference and the Preparatory meeting to this conference both in New York) have been organised and conducted. Cooperation with AORAC-SA was intensified at various occasions e.g. the UN conference in New York and high-level EU meeting accompanying the signing of the Belem Statement as well as a joint workshop on emerging technologies on Gran Canarias. A cooperation with the Volvo Ocean Race team to take Ocean Observing technology on board has been developed

3. Work package progress reports

WP 1 Observing system requirements and design studies

Summary

(Task 1.1) to define the high-level requirements of the integrated Atlantic Ocean observing system based on the GEO societal benefits and other international initiatives, providing a direct link to societal challenges related to the Atlantic basin and the European Blue Growth strategy. These requirements will be translated into strategic recommendations about sustained monitoring of EOVs;

(Task 1.2) to analyse the present capacities for ocean observing in the Atlantic in order to identify the critical gaps that need to be filled. This analysis shall a) take into account both scientific and operational gaps, (b) focus on the observing networks, data systems, and the delivery of actionable information, (c) be performed at different levels including the whole range of observations from physics, to biogeochemistry and living resources, and (d) cover all national and international initiatives in the Atlantic as well as a dedicated analysis for the European capacities and gaps. Task 1.2 will also estimate the cost of existing observing networks as well as the needed investments in regard to the identified gaps, and an evaluation of the readiness and feasibility of implementation of different observing technologies as guidance in systems design; and

(Task 1.3) to deliver guidance to improve existing elements and/or implement new components of the integrated Atlantic Ocean observing system using OSSEs and data assimilation to optimally merge in-situ and satellite observations with models.

Progress per Task

Task 1.1: Requirements for sustained ocean observations of the Atlantic

Deliverable 1.1 (the Initial Integrated Atlantic Ocean observing system Requirements Report was delivered in Reporting Period 1. The other deliverable in this Task (Deliverable 1.7, the Refined Integrated Atlantic Ocean observing system requirements Report) is due in Project Month 45, near the end of Reporting Period 3, taking into account the results of the entire AtlantOS project, and in particular Task 1.3. While work on writing this update to the initial report (Deliverable 1.1) has not formally begun, consultations with other tasks within WP1 (e.g., Task 1.3 – Observing System Design Studies, to better understand the potential roles of various platforms to fill current gaps) and other work packages (e.g., WP5 – Integrated Regional Observing Systems, to better understand regional needs) are continuing. The work done in these components of AtlantOS will inform the updates and refinements needed for Deliverable 1.7. We expect to begin writing the report itself in mid-2018.

Task 1.2: Capacities, Gaps and feasibility

Deliverable 1.3 (the Capacities and Gap Analysis) was delivered in Project Month 24 (i.e., Reporting Period 2). It analysed the current capacities and gaps of all three disciplinary components of the Atlantic Ocean Observing System (OOS): physical, biogeochemical and biological. Expert meetings within the work package, and with leading international expert groups under IOC, such as the GOOS disciplinary expert panels, were conducted. Following the earlier integrated look at the societal requirements across the three disciplines (D1.1 of Task 1), the report outlines the strategy for performing a comprehensive

capacity and gap analysis of the ocean observing value chain, in the context of an integrated Atlantic Ocean observing system. Based on the work carried out in preparing this report, the following “lessons learned” and conclusions can be drawn:

- A key concept in the *Framework for Ocean Observing* is "readiness" and the path from concept, to pilot, to mature elements of the observing system. We are increasingly aware that this is also evident in defining and understanding phenomena and Essential Ocean Variables (EOVs) - and the requirements for observing for: 1. climate mitigation, adaptation and services; 2. operational oceanography services such as coastal early warning and ocean forecasting products for industry; and 3. safeguarding ocean health, whether in the domain of the EU Marine Strategy Framework Directive (MSFD) or the global Sustainable Development Goals. This means that the resulting definition of applications, the need to capture certain ocean phenomena, and the space and timescales needed of observation of the associated EOVs, vary significantly in maturity. This is particularly evident across the three disciplines of physics, biogeochemistry, and biology and ecosystems. This in turn impacts the establishment of solid requirements and subsequently the capacity as well as gap analysis of the system
- Analysing the existing observing capacity in sampling appropriate EOV’s in sufficient space/time resolution in the Atlantic Ocean can only be done in reference to each of the multiple observing objectives individually – and considering requirement (input) and observing products (output), informing society about ocean state
- The report provides examples of “generic” gaps identified in the system (e.g. missing baseline data)
- A grouping of gaps for future gap analysis according to subjects is proposed:
    - Gaps in the observing networks
    - Gaps in data availability
    - Gaps in sustainability
    - Gaps in technology

The other deliverable in this Task (Deliverable 1.4 Cost and Feasibility Study) is due in Project Month 36, in March 2018, early in Reporting Period 3. Consultations were held with the National Oceanic and Atmospheric Administration (NOAA, of the U.S.) which has recently conducted a similar study. Their recommendations were helpful in developing the methodology and constructing the templates for requesting data from the various networks. Data collection for the first network (GO-SHIP) has been completed, the Argo, Ocean Glider, and PIRATA network templates are under review, and other Atlantic OOS networks are being approached. The plan is to have all data collected by December 2017, leaving three months for analysis and writing; this is in line with the NOAA experience.

Task 1.3: Observing System Design Studies

Deliverable 1.2 (the Design of OSSE Experiments report) was delivered in Project Month 12 (i.e., in Reporting Period 1). It described the Observing System Simulation Experiments (OSSEs), including the scenarios to be tested, the role of each individual partner, and how the results will be synthesized into guidance for observing networks. Deliverable 1.5 (Synthesis of OSSE Results) is due in Project Month 36 (March 2018, Reporting Period 3) and Deliverable 1.6 (Model Guidance for integrated Atlantic Ocean observing system Evolution) is due in Project Month 42 (September 2018, Reporting Period 3). Preparation for the OSSEs, the focus until December 2017, included setting up the models, description and validation of the nature run simulation to produce the observations, data files, observation and

model errors, and improvement and adaption of the different assimilation schemes. The analysis of the model runs will begin in 2018.

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

WP1 attended to workshops that have been organized by WP5 to reach out to stakeholders outside AtlantOS (Assessment and Coordination of Regional Observing) and provided input regarding ocean observation requirements. Joint work with WP8 is planned to harmonize the approach taken to identifying observing requirements for the various more coastally-focused demonstration applications, with the overall approach of the *Framework for Ocean Observing* and WP1.

WP 2 and WP 3 leaders were contacted to inform them on the cost accounting activity progress to date and to request assistance. A list of WP2 and WP3 Network representatives, along with key contacts for Atlantic shelf seas, was compiled. Closer cooperation between WP1 and WPs 2 and 3 is anticipated in the next couple of months.

Cooperation with WP9 is established regarding assessment on the existing observation network and, more importantly, on the providing background information for contact to national and international funding mechanisms on sustainable funding of a future Atlantic Ocean observing system.

Cooperation and interaction with other projects and initiatives

Contacts to relevant H2020 projects such as INTAROS, ODYSSEA, Blue Action and Jerico Next, as well as the Copernicus Marine Service and Copernicus In-Situ programme and the JPI-Climate/Belmont Forum project INTERDEC, have been established regarding exchange of experience on requirements, gap analysis and cost estimates.

WP1 regularly engages with GEO (including its different initiatives like Blue Planet and MBON) and GOOS members. A parallel effort for integration of disparate observing networks in the tropical Pacific Ocean, the *Tropical Pacific Observing System in 2020 project*, is taking a different approach to a similar problem as AtlantOS. GOOS has started a discussion of best practices in approaches to these regional observing system projects, and will ensure that the lessons learned from AtlantOS apply to other projects, and vice versa.

Discussions with NOAA have been held regarding a cost study that NOAA conducted into its own observation activities and programmes in order to streamline the process of developing a questionnaire to collect data, and a procedure to engage networks for information. In the next few months, this task will draw on results from the shelf sea initiatives, including the MRAG report, the costing exercise Iain Shepherd commissioned through EASME, and the IOOS reports which NOAA has provided.

Development of the assimilation system of biogeochemical observations at CNRS/IGE is achieved within the French Green-Global Reanalysis of Ocean biogeochemistry (Green-GROG) consortium (LSCE, LOCEAN, LOV, LEGOS, IGE, MARBEC, Mercator Ocean, CLS, Ifremer and ACRI-ST), which aims to improve the BGC products delivered by CMEMS. Interactions with the Overturning in the Subpolar North Atlantic Program (OSNAP) are also considered through discussions at the Irminger Sea regional science workshop held at the National Oceanography Centre, Southampton, November 8-9, 2017.

Configuration of the physical and biogeochemical models being used by the Met Office has been coordinated with those developing the UK Earth System Model (UKESM1) which will be used for submissions to the 6th Coupled Model Intercomparison Project (CMIP6). The model and assimilation framework is a development of the method recently used to assess satellite ocean colour observations as part of the European Space Agency's Climate Change Initiative (ESA CCI), thereby linking the assessment of satellite and in situ biogeochemistry for assimilation.

Development of the assimilation is also being coordinated with planned developments to forecast and reanalysis products delivered to CMEMS, so that BGC-Argo data can be included in future.

Achieved main results

Task 1.1 had no deliverables for Reporting Period 2; while they have begun collecting raw information for their RP3 deliverables, no results are yet complete.

Task 1.2 delivered the "Capacities and Gap Analysis" report (D1.3) in Project Month 24. In addition, in preparation for the Cost and Feasibility Study due in RP3, procedures and templates have been developed, observing networks are being contacted, and some of the information has already been collected.

Task 1.3 had no deliverables for Reporting Period 2; while they have carried out a considerable amount of work (as noted above) for Deliverables due in Reporting Period 3 (D1.5 – Synthesis of OSSE Results and D1.6 – Model Guidance for integrated Atlantic Ocean observing system Evolution), results are not yet complete.

WP 2 Enhancement of ship-based observing networks

Summary

WP2 is focusing on improving, expanding, and integrating ship-based observations undertaken by existing observing networks. It includes oceanographic research vessels through the GO-SHIP network (Task 2.1) and the Ships of Opportunity Program (SOOP) (including Carbon-VOS, SOOP, and Ferryboxes; Task 2.2), both of which provide physical and chemical EOVs. It also includes the continuous plankton recorder measurements (CPR; Task 2.3) by the Sir Alistair Hardy Foundation for Ocean Sciences (SAHFOS), acoustic fish data on abundance, distribution and community structure collected during national surveys and coordinated by ICES (Task 2.4), and finally, sea floor mapping (Task 2.5) undertaken by various nations for various purposes, including as a measure of habitat potential for biological organisms.

Progress towards the WP2 objectives is being achieved in key areas. The various WP2 Task Teams have been implementing improvements that is increasing cooperation and improving monitoring efficiency.

Progress per Task

Task 2.1. GO-SHIP

To help improve coordination between GO-SHIP repeat hydrography and other relevant hydrographic surveys in the Atlantic (GEOMAR, IOC-UNESCO, IO PAN), a tracking system for GO-SHIP lines has been set up at JCOMMOPS, http://www.jcommops.org/board. Interaction between the AtlantOS task 2.1 lead, the GO-SHIP community and JCOMMOPS is ongoing through the GO-SHIP coordination office.

Based on the above consultations, Task 2.1 identified two lines where the support laboratory service will have the largest impact, both scientifically (filling observational gaps) and by expanding the network to nations and groups that to date have participated little in the GO-SHIP network. The first is the A02 section, running from Ireland to Canada, which is a core line in the international GO-SHIP plan but has not been occupied in its entirety for more than a decade. Task 2.1 engaged with the Irish partners to organize an occupation of this line that was carried out in April-May of 2017 on the Irish RV Celtic Explorer, with a mix of scientists from the Canadian and Irish partners and the support labs from AtlantOS. The second line was carried out on the German RV Maria S. Merian that left Cape Town and followed 34.5 degrees South across the Atlantic on a modified A10 GO-SHIP line, joining boundary Brazil and South African Samba and SAMOC sections, respectively. It was a multinational cruise A10.5 in the South Atlantic with, among others, participation of Brazilian and South African scientists and the AtlantOS support labs. AtlantOS provided support for transient tracer and inorganic carbon measurements, and additional general support for the cruise planning and organization.

Task 2.1 is continuing with setting up processing facilities for ship-board ADCPs. A portal for SADCP data is being created under the umbrella of GOSUD (Global Ocean Surface Underway Data). The format of the data was examined. A new format, more compatible with OceanSite, will be proposed, knowing that a Python toolbox was written to easily convert files that were processed from the two most used software systems (Codas and Cascade). In addition, SCIC has been developing software to support efforts to enhance quality assurance, timely data delivery, and inclusion of interior ocean biogeochemical data into a data product (CSIC, IOC-UNESCO).

Task 2.2: Ships of Opportunity Programme (SOOP)

D2.4: SOOP Network Enhancement

Extension of carbon VOS, SOOP and Ferrybox network coverage into the South Atlantic Ocean by adding and supporting routes: NERC (participant no. 2) are in negotiations with Maersk Shipping Company and hope to have a system running by the end of 2017 from Europe to the Falklands. Maersk Raleigh will be making voyages to the Falklands at least twice per annum. There have been some delays as Maersk changed the ship operating on the Falklands route and were initially unsure if it was the best route to offer us. The tanker is on charter to MoD and has traditionally sailed to the Falklands via Ascension four times per annum. They are investigating other possible shipping routes on container vessels by Maersk. Routes sail to Brazil—Argentina-Uruguay on an 8-week round trip. These ships would sail from Gibraltar to Santos, then hug the South American coast down to BA / Montevideo and then back up the coast to Pecem, before returning to Gibraltar. CNRS (participant no. 6) and IRD (participant no. 25) are currently in the process of identifying a ship in the Gulf of Guinea towards South Africa. Line AX01: Denmark to West Greenland will be interrupted early 2018 with chartered ships afterwards. Line AX02: Iceland to Newfoundland/Maine. The ship was discontinued in January 2017 and will be replaced in November

2017. PLOCAN (participant no. 15): The QUIMA VOS line has recently moved from the North America - Montevideo route to a new line from the Mediterranean Sea to Central America (Mexico and South of USA) from 35°N leaving Gibraltar to Gulf of Mexico. Discussions are in place with the United Arab Shipping Company and with the Marine Shipping Company in trying to get a ship to join the North Atlantic with South Africa. There are difficulties in finding a ship that will run for longer than 6 months. IRD (participant no. 25) coordinates 2 VOS lines (France-Brazil, France-French Guiana) in the Atlantic to collect underway fCO2, temperature and salinity data. The data is submitted and used for the estimate of the annual global carbon budget. The 2017 data are still being processed and will be sent to SOCAT. A collaboration with Brazilian colleagues has allowed the extension of the CO2 observations in the tropical Atlantic.

Evaluation of improved EOV carbonate system: GEOMAR (participant no. 1), CONTROS (participant no. 50) and PLOCAN (participant no. 15) have completed in-situ testing and assessment exercises with the HydroFIA TA analysers during expedition FS Meteor 133, South Africa to Falkland Islands during Dec-Jan 2017. They aim to install it on a VOS line that stops at the Canary Islands. Discreet reference samples were taken for TA and DIC measurements for comparison. They have developed an HPLC purification method for the indicator Bromocresol Green (BCG), application on BCG from different vendors and evaluation of its effect on the measurement performance is in progress. Further, comparison of the CONTROS HydroFIA TA underway measurements on the M133 cruise, with reference samples to evaluate the accuracy of the system is now completed. The 2nd evaluation cruise will commence 3rd Nov - 14th Nov 2017 (MSM68/2) from Emden, Germany to Mendel, Cape Verde.

Improving the network instrumentation by re-assessing instrument design: PML (participant no. 43) have deployed the Andrea Opcode pCO2 detector on two Atlantic Meridional Transect cruises (AMT26/27) alongside established pCO2 technologies. These are 6-week cruises from the UK to the Falkland Islands, and take observations in the poorly sampled parts of the South Atlantic Ocean. The impact of changing to Optode technology is that it will achieve cost and size savings, allowing more of these instruments to be deployed worldwide. PML have been processing data from a Cavity Ring Down Spectrometer (CRDS) for CO2 and CH4. Deployment was during the DY040 and AMT26 cruises. They are currently processing data from an Aanderaa optode, deployed on DY040 cruise. The CDRS, Optode and their standard, non-dispersive infrared system (PML Dartcom Live pCO2) are all deployed onboard the RRS Discovery, AMT27 cruise

D2.5: SOOP Network Coordination - Report on network coordination, documenting steps taken to coordinate network and make it robust against data gaps, delivering regular seamless data, integrated with Pan Atlantic partners. U. Exeter (participant no. 24) and UiB (participant no. 12) are working towards good Pan Atlantic connections through ICOS RI (https://www.icos-cp.eu/). ICOS is a pan European research infrastructure of which UiB hosts the Ocean Thematic Centre (OTC). U. Exeter is a member of ICOS and hopes to join the OTC in early 2018. ICOS RI provides long term, high quality observations, and quality controlled observational data that can be submitted via the OTC carbon portal or via SOCAT (https://www.socat.info/). SOCAT version 6 will be released during summer 2018.missing

Task 2.3 Continuous Plankton Recorder (CPR)

SAHFOS has been involved in optimizing the Continuous Plankton Recorder (CPR) surveys including using new technology. New remote CTDF units have been deployed with the CPRs and are now operational on numerous Northern European Shelf routes which include the major European ecoregions such as the North Sea, Celtic Sea, Irish Sea and the English Channel. The new CTDF units transmit data back to SAHFOS upon haul out of the CPR, which facilitates more rapid processing and analysis of the data.

To more rapidly determine zooplankton abundance from the CPR samples, a Macrocam is being tested in its ability to automatically count zooplankton and through comparison to standard methods to determine the reliability of the Macrocam. In addition, faster quantitative molecular assays of key harmful plankton and pathogens using molecular techniques is being carried out in the English Channel using the Water and Microplankton Sampler (WaMS) that fits within the Continuous Plankton Recorder (CPR) device.

Essential Ocean/Biological Variables (EOV/EBV) for monitoring the assessment of marine biodiversity and ecosystem health for the North Atlantic have been developed. These have been reported in the AtlantOS Plankton Report based on observations from the CPR survey that was published in 2017. In addition, comparisons are being made between hydrographic data on the CPR surveys with other instrumentation, such as Ferrybox data.

Task 2.4 Fisheries and zooplankton observations

The aim of this task was to assemble national fisheries acoustic data on pelagic fish stocks into a common database, which will be held by ICES and accessible to all. It has completed all its deliverables and milestones. The specification of the ICES acoustic database, and of missing functionality of DATRAS were completed (Milestone 2.4.1) and an update in the ICES metadata standard for acoustic data was published through ICES in January 2017. This work was undertaken by ICES with input from IMR, HAV, IFREMER and ICES expert groups. ICES implemented the core acoustic component of the data model e.g. upload, download of XML and CSV data including XSD validation. The Schematron validation and the acoustic vocabularies were completed, and the acoustic metadata was added following the revised acoustic metadata standard.

IMR modified the StoX software for use in several ICES acoustic surveys. The software system was aligned with the data model at the ICES data centre and has been implemented. The software is released under GNU open source licence and can be downloaded from http://www.imr.no/forskning/prosjekter/stox/nb-no.

Processed Acoustic and Biotic collected on acoustic trawl surveys in the Northeast Atlantic and Baltic seas are now available on the ICES website. This database hosts information on fisheries observations collected from various pelagic surveys coordinated by ICES and falls into two categories: acoustic data, derived from readings taken on vessels, and those obtained through trawls in the open ocean – pelagic – zone. Combined, this provides key biological data on fish stocks such as herring, mackerel and blue whiting as well as krill and other prey species.

Task 2.5 EuroMapApp

The aim of this task is to collect available seafloor data, make the raw data freely available, and combine the data to produce high resolution bottom charts of the seafloor over as much of the Atlantic as possible, making them available online. Since the beginning of AtlantOS, it has become clear that the work within Task 2.5 and the work at an intergovernmental level within the Galway Process are intricately intertwined. Within the Galway Process, an Atlantic Seabed Mapping International Working Group (ASMIWG) has been formed, whose work directly links into the AtlantOS mandate. The deliverables include D2.3 Bathymetric Integration: Integration of High Seas bathymetry holdings of partner organisations into EuroMapApp which involves making an inventory of the data, determining freedom of access (quality controlling the data and integration into a Multi-Resolution Topography). The second deliverable is D2.10 Bathymetry Visualization: Integration of data from at least two additional European repositories into the EuroMapApp system as pilot project to make Europe´s bathymetric data visible and usable by all.

A task meeting was held in Paris during July. They reviewed national Multibeam Data Management to determine what bathymetric data are available and how best to organize and develop them into an open international database and a portal for all Atlantic bathymetry data from partner countries. Reports were provided by the Netherlands, the UK, France, and Germany. As part of the work of the ASMIWG, three potential pilot areas within the North Atlantic suitable for future mapping surveys with regard to data coverage and various fields of application are being selected. This includes defining the parameters to be mapped (bathymetry is taken as a given, but to what extent is habitat mapping, oceanographic parameters etc. necessary). The Pilot Project itself will be resourced and performed outside the ASMIWG. It was concluded that the AtlantOS bathymetry data catalogue being developed should only contain data from the Atlantic Ocean for now. The boundaries selected are between latitudes 60° 0' 0" S and 68° 37' 24.9" N and longitudes 83° 0' 29" W and 20° 0' 0" E, excluding the EEZ and ECS zones. A review of online data archives and interactive maps including the Global Multi-Resolution Topography and NCEI platform and the GMRT Map Tool; NOAA's Bathymetric Data Viewer; and the EMODnet platform and the Mikado software from Ifremer for creating XML files. Through 2017 and into next year this task is preparing a GIS layer that includes multibeam data track lines from each participating country that should be finalized by April 2018, preparing an associated multibeam data catalogue containing metadata including data accessibility (e.g. publicly available, available on request, not available) and a link to the data or data holder. They are also exploring options for publication and maintenance of the GIS layer and data catalogue such as the International Hydrographic Organization (IHO). The task is also actively soliciting other countries to be involved in the mapping activities, e.g. Spain and Portugal, Italy, Norway, Sweden, Iceland, etc. The task has also continued to encourage ships of opportunity to collect bathymetric data.

Cooperation and interaction with other AtlantOS WPs

WP2 has links to WP6 through the testing of the membrane sensors (PRO-CO2) with the underway equilibrator systems on different sea voyages and on the Bio-Argo effort. It has had discussions with WP3 regarding improved coordination of ship-based and in situ and autonomous instrumentation and will meet in November to further this. It has been involved with WP7 on data integration, models and product development.

Cooperation and interaction with other projects and initiatives

WP has strong ties to the GO-SHIP community and the GO-SHIP coordination office as well as with JCOMMOPS and the JCOMM Observations Coordination group. It is involved with the Natural Environmental Research Council of the UK for missions from the UK to the Falklands; interaction with the US project TAACT regarding the establishment of automated TA measurements for (coastal) carbonate chemistry studies, including applicability in the context of shellfish aquaculture; and work with ICOS RI.

Furthermore, there are links to the Global Ocean Observing System (GOOS), the Scientific Commission on Oceanic Research (SCOR), the Partnership for Observation of the Global Oceans (POGO), the North Pacific Marine Science Organization (PICES), and to the Atlantic Seabed Mapping International Working Group (ASMIWG).

Achieved main results

Task 2.1 helped organize, plan and support two GO-SHIP transects, one between Ireland and Canada and another in the South Atlantic between Brazil and South Africa.

Task 2.2 have developed a flow-through system with 2 pCO2 membrane sensors, a CTD and Turner Fluorometer, and Aanderra sensors (O2, T and S).

Task 2.3 have published an AtlantOS Plankton Report based on the CPR data that includes biological EOVs.

Task 2.4 has developed an acoustical fish database for the Northeast Atlantic and the Baltic Sea within ICES that is open access.

Task 2.5 is developing an online bathymetry database including 3-D visualization of the data.

WP 3 Enhancement of autonomous observing networks

Summary

For Argo, additional Biogeochemical (BGC) floats and Deep floats have been purchased and go under intensive testing procedure. The spatio-temporal coverage is extended for BGC-Argo floats to the equatorial and southern Atlantic. pH sensors have been implemented on BGC-Argo floats and will be tested for developing global and long-term monitoring of ocean acidification. Fixed biogeochemistry observatories are also extending their measurements, in particular to microbial community based on DNA sequencing of particle trap samples. Recent successful deployments of automated moored water samplers allow extending investigations to microbial communities of specific water depths. For the PIRATA network, Buoys have been updated to next generation and equipped with additional sensors: 3 current meters, 2 T/S, 1 CO2 as well as O2 sensors. O2 measurements are now transmitted in real time. Oxygen sensors have also been integrated on the fixed physical mooring (TMA). Transport estimates and original data in appropriate format are now available for 3 TMAs: Fram, GSR and NOAC. The glider network has developed new partnership with Brazil and a Glider Steering Team and a Glider Data Management Team within JCOMMOPS as well as a glider Task Team within EuroGOOS have been established. A website dedicated to the OceanGliders program is almost available as well as the glider App'. Regarding drifters, observations of air/sea exchanges in the Atlantic has been extended with 36 additional drifters equipped with barometers deployed so far in the Tropical Atlantic, the novel SST & SSS sensors was successfully tested, and long-term plans to continue regular deployment of drifters in the Tropical Atlantic have been made.

Finally, cooperation across observation networks (OceanSites, Rapid Mooring Array, ONSAP buoy network, PIRATA buoys, Everyone's Gliding Observatories) allow the expansion of the acoustic receiving network to support Animal tracking.

Progress per Task

Task 3.1 – Argo

The main objectives are to Implement pH sensors on floats and to integrate Biogeochemical & Deep Argo measurements in the Data Centers. So far, 6 Biogeochemical floats and 7 Deep floats have been purchased

<u>Deep floats.</u>

The deployment of similar floats as those purchased within AtlantOS during RREX cruise are showing an early failure on 1 over 5 floats. In order to continue the investigation on technical issues, the best float among the AtlantOS available ones (as a result of the intensive testing procedure at their acceptance) has been sent for a deployment from RV Investigator in the Austral Ocean – Ice detection software has been included. The 6 remaining floats are kept for later deployment in 2018, once the technical issues would have been understood and floats upgraded. Deployment plans are updated:

- 1 float Austral Ocean RV Investigator (2017)

- 1 float off Canaria Island (2018)
- 3 floats on ORCHESTRA UK GO-SHIP JC159 cruise in the south-Eastern Atlantic (24°S) (2018)
- 2 floats on RREX Islandic Basin (2018)

BGC floats. All floats have been delivered and acceptance tests successfully carried-on in September 2017.

Deployment plans are updated:

- 4 floats in the equatorial and southern Atlantic (deployed October 2017) from RV Discovery AMT27 cruise
- 2 floats to be deployed during ORCHESTRA JC159 cruise in the south-Eastern Atlantic (24°S) (2018)

Task 3.2 OceanSites biogeochemistry

Plans are in development for community wide workshop in Spring 2018 to integrate with TMA and PIRATA including accepted protocols. The Molecular / 'omic technique development is well progressing with the demonstration of microbial community time-series observations thru data analysis of the Legacy Fram Strait trap sample (manuscript in preparation), thru Microbial (bacteria, phytoplankton) DNA extraction and sequencing from the 1-year time-series samples obtained with moored particle and water autosamplers in the Arctic in different water layers. Progress towards best practice for omics sampling, sequencing and bioinformatics analyses are made. The best-suited bacteria / microalgae primers are identified, and a manuscript is in preparation. The time series experiment to evaluate potential bias from storage-conditions- on 18S sequence data are continued, and samples from first time points are analyzed. The development of bioinformatics pipelines and genomic data management are underway thanks to a collaboration with SME ('RiboCon') and are applied to selected data sets from the FRAM 'Microbial Observatory'. Finally, continued engagement with the scientific community and stakeholders aim to raise awareness of 'omics-based observations, to harvest and disseminate best practices, and to establish standardized channels for the dissemination and archiving of genomics-based biodiversity data to relevant e-facilities (e.g., OBIS, GBIF) with reduced human interaction. Regarding the analyses of pollutants, after major procurement problems the appropriate analytical equipment (FTIR) will be delivered before the end of 2017 with novel and extremely powerful data anticipated within 3 months. However, regarding the measures of all EOVs at all observatories, no significant developments are observed due to continuing harsh financial realities. This will however be a major focus of the workshop in 2018.

Task 3.3 - Ocean Sites Transport

The Overarching goal is the development of a sustainable, efficient and comprehensive network of TMAs and to review, perform and demonstrate developments of deep sea data telemetry systems.

OSNAP TMA: 2 SBE37-ODO (Microcat with optical dissolved O2 sensor) are deployed on an OSNAP mooring in the Rockall Trough. Part of a larger deployment of biogeochemistry sensors under EU ATLAS project. Deployment in May 2017 – Recovery Sept 2018.

The website texts for 3 out of 8 TMAs are finalized: Fram, GSR and NOAC. Data (transport estimates and original data in OceanSites format or with a DOI) of 3 TMAs are available (see example of Fram Strait: http://www.oceansites.org/tma/fram.html). For the other 5 TMAs, correspondence on details of the web text and transfer of the data is ongoing between task leader and TMA partners.

D3.18: Report on the observational potential of TMAs: Assessment of the impact of upper-ocean measurements and of coherent integration of O2 measurements (as example for non-phyisical EOVs) for transports and fluxes in the Atlantic TMAs and synergies with the wider Atlantic Observing System (Workshop PM45).

Task 3.4 Glider

A website for OceanGliders program (1st release due by the end of October, public release by the end of the year) has been designed and the glider App' has been released. A Data Management Working Group on 4 topics: New teams, Delayed mode data management, Integration of SeaExplorer, Technical data management have been initiated. One of the objective is to develop and simplify the metadata management system for the EGO community, the agenda with glider Data Assembly Center (Norwegian Data Marine Center, British Ocean Data Center) to collect their past and real-time data in expected EGO format has been set up with a deadline for the dataset delivery by the end of the year. A New version of EGO data format is under progress with Coriolis and the validation and implementation of a DOI strategy for the Glider Network are on-going

The network has answered the H2020 call for GROOM II project to set up a European Glider Infrastructure. The GROOMII proposal has been rejected but was 1st in the "waiting list". A position paper to be signed by connected Marine Research Infrastructure and send to ministries is under progress.

Task 3.5 – PIRATA

The main objectives are to progressively replace all ATLAS buoys by T-Flex systems on the PIRATA network and the deployment of new additional sensors (TC, current, O2, CO2).

PIRATA FR27 cruise was achieved in Feb-April 2017. One additional new T-Flex system installed at 6S-8E, replacing an ATLAS system, equipped with a new CO2 sensor (as IRD/LOCEAN contribution to AtlantOS). No additional T-Flex implementation is anticipated in 2018 (due to funding constraints in US, extending on a longer time frame the T-Flex implementation plans). During PIRATA FR27: 21 SVP-B drifters deployed (including 11 for AtlantOS). The PIRATA FR28 cruise is under preparation (Feb 25th-April 4th, 2018).

2 new ARGO profilers equipped with O2 sensor were deployed around 6S-8E. O2 sensors with data transmission deployed at 4N-23W & 12-23W during the PIRATA-PNE cruise (US), as GEOMAR contribution to AtlantOS. The next round of O2 sensors deployment at 23W is planned during PIRATA NE (PNE) cruise in Dec. 2017/Jan. 2018

PIRATA 22 / PREFACE meeting is currently organized in Fortaleza (Nov 5-10, 2017) celebrating the 20th anniversary of PIRATA & dedicated Summer School (Nov 2-5, 2017). PIRATA-BR 2017 cruise has been delayed in Oct-Nov 2017 (instead April, due to vessel problem). The Pirata-Fr website is actualized: new data sets, documents, links, reports and DOI for PIRATA FR cruises & some data sets are set up.

Task 3.6 – Surface Drifters

Draft specifications of sustained EUMETNET activities for upcoming years now include the deployment of drifters in the Tropical Atlantic. However, this draft is yet to be approved. If confirmed, this will continue for the long-term the legacy of AtlantOS enhancement of the drifter component.

In addition, the novel SST & SSS sensor for drifting buoys, developed by NKE, has been deployed at sea during campaign PEACETIME, thereby upgrading the technical readiness level of this development (to TRL7). Furthermore, two units of the drifter with novel SST & SSS sensor are being deployed during

campaign SPURS2 in the Pacific Ocean. One is the prototype already tested at sea during PEACETIME, and the other is the first commercial demonstrator unit. If successful, this will upgrade the technical readiness level of this development to TRL8.

Task 3.7 European Animal Telemetry Network (EATN)

The main objective is to formalize the ETN as a multistakeholder network and contributor to biological ocean observation. A joint proposal has been prepared and submitted for a COST action to fund ETN networking activities for the next 4 years;

ETN has been presented at the 6th Biologging Conference, Germany

A Program initiation for WMO MetOcean drifter buoys configuration to contain acoustic receivers has been implemented. This program will provide cost-effective new capabilities to the drifters, to the benefit of all. An automated routine for multi-source acoustic telemetric data assembly into the ETN database has been developed. Discussions are on-going with European investigators on loans of OTN equipment for new projects, including flagship projects identified on D3.2 on Valued species report. The open ocean (Eurosites) and costal acoustic receiving network is under expansion. And various national-level applications for funding of projects using ETN 'label' are submitted.

Cooperation and interaction with other AtlantOS WPs

- Interactions within WP3 : PIRATA, ETN, ARGO, drifters, FixO3…. (sensors on platforms)
- Cooperation with AtlantOS WP3- WP5 (Southern Ocean)
- Cooperation with AtlantOS WP3-WP7 (data)
- The TMA SAMBA-SAMOC along 34.5°S is included in the TMA network.
- Cooperation with AtlantOS WP6 (best practice repository)
- Cooperation with AtlantOS WP1 (cost-benefit analysis)

Cooperation and interaction with other projects and initiatives

- Cooperation with Biogeochemical-Argo programme (Argo)
- Cooperation with CLIVAR (PIRATA)
- Cooperation with EU programmes Eurosites and project FixO3 (ETN)
- Cooperation with EU programme ATLAS (TMA)
- Cooperation with Copernicus Marine Service to take CMEMS need in the Euro-Argo implementation plan
- Cooperation with OceanSites: OceanSites hosts the TMA website and they will archive and make accessible the data products.
- Cooperation with FRAM: Cooperation OceanSites, FixO3, FRAM (Arctic long-term observatory) (microbial observatories)
- Cooperation with PREFACE: Cooperation & interactions between PIRATA partners (USA & Brazil) and with the EU programme PREFACE (FP7);
- Cooperation with UFPE, Brazil (PIRATA, UFPE: PILOTE program, capacity building: PhD & post docs)
- Cooperation with institutions engaged in multi-omic observations in the framework of the Biodiversity Information Standards / Taxonomic Databases Working Group (TDWG) and the Genomic Standards Consortium (GSC) (BGC fixed point)

Cooperation for materials deployment:

- cruise PEACETIME, cruise SPURS2 (for novel SST & SSS sensor on drifters)
- cruise RREX (Argo floats)
- PIRATA-PNE cruise (US) (O2 sensors)
- PIRATA FR27: for T Flex including SVP-B drifters, Argo floats with O2 sensors

Cooperation in preparation:

- Cooperation AtlantOS WP2-WP3: preparation joint meeting
- South Atlantic: AMT 27 cruise (September 2017) and on Polarstern (Spring 2018) (BGC-Argo flaots)
- North Atlantic: UK GO-SHIP line (March 2018) & R/V Investigator cruise January 2018 (Deep Argo floats)
- Eastern North Atlantic: cruise IOS, October 2017 / march 2018 (Deep Argo floats)

Achieved main results

- For Argo, additional Biogeochemical floats and Deep floats have been purchased and goes under intensive testing procedure. The spatio-temporal coverage is extended for BGC-Argo floats to the equatorial and southern Atlantic/south Eastern Atlantic. pH sensors have been implemented and will be further tested on NKE BGC-Argo floats for developing global and long-term monitoring of ocean acidification
- Fixed biogeochemistry observatories are also extending the measurements, in particular to microbial community based on DNA sequencing of particle trap samples. Recent successful deployments of automated moored water samplers allow extending investigations to microbial communities of specific water depths. Best practices for omics sampling, sequencing and bioinformatics analyses are under drafting
- For the PIRATA network, buoys have been updated to next generation and equipped with additional sensors: 3 current meters, 2 T/S, 1 CO2 as well as O2 sensors. O2 measurements are now transmitted in real time.
- Oxygen sensors have also been integrated on the fixed physical mooring (TMA). Transport estimates and original data in appropriate format are now available for 3 TMAs: Fram, GSR and NOAC.
- Regarding the glider work, a new partnership with Brazil has been developed and a Glider Steering Team and a Glider Data Management Team within JCOMMOPS as well as a glider Task Team within EuroGOOS have been established. A website dedicated to the OceanGliders program is almost available as well as the glider App'.
- Regarding drifters, observations of air/sea exchanges in the Atlantic have been extended with 36 additional drifters equipped with barometers deployed so far in the Tropical Atlantic, the novel SST & SSS sensor was successfully tested, and long-term plans to continue regular deployment of drifters in the Tropical Atlantic have been made.
- Finally, cooperation across observation networks (OceanSites, Rapid Mooring Array, ONSAP buoy network, PIRATA buoys, Everyone's Gliding Observatories) allow the expansion of the acoustic receiving network to support Animal tracking.
- Many cooperation within AtlantOS have been developed, specifically with WP6 to organize the AtlantOS workshop on strategies, methods and new technologies for a sustained and integrated autonomous in-situ observing system for the Atlantic Ocean, supported by the AORA-CSA. The

workshop was finalized by Synthetic remarks from autonomous observing platforms and Recommendations for the BluePrint, WP3 as well as a Report of the AtlantOS workshop on strategies, methods and new technologies for a sustained and integrated autonomous in-situ observing system for the Atlantic Ocean, supported by AORA-CSA.

WP 4 Interfaces with coastal ocean observing systems

Summary

Data and deliverables from WP4 will feed into the already growing database of continental shelf studies using autonomous vehicles that will help provide the links between open ocean and continental shelf observing systems. Within Task 4.1, progress has been made towards understanding the basis of measurements of cross-shelf exchange (in the Bay of Biscay). New observational campaigns under Task 4.2 have taken place in 2017-2018 and the results will ensure the delivery of significant outputs under D4.3 and D4.6. During 2017 the sea level effort concentrated on recovering and quality controlling tide gauge data from the Caribbean and south and central America. The data represents a significant addition to the Atlantic dataset, and will be added to the GLOSS-managed sea level extremes dataset (GESLA) for coastal protection. The work under "Non-EU cooperation and sustainability issues", has been widened in response to the significant development of the G7 Future Seas and Oceans Initiative, and to give WP4 the agility to respond to and contribute to this important global driver.

Progress per Task

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

The overall aim of this task is to perform a mapping and gap analysis of the relevant existing European Systems following targeted EOVs, targeted processes, and targeted sensors and platforms. The Task team are investigating whether Argo and Arvor (coastal profiler) data can be combined to give seamless observations from the open ocean to the shelf seas, thus establishing a methodology to quantify open ocean/shelf sea exchanges. Cross-shelf exchanges in the Bay of Biscay are being explored and will be combined with numerical models to investigate the key observation gaps in the analysis.

First steps have focused on the joint analysis of the Fishery Observing Systems (RECOPECA programme) over the continental shelf and the Argo profiles in the Bay of Biscay. The first exploration was based on In-situ vertical profiles of temperature and salinity acquired from the Coriolis Ocean Dataset for Reanalysis for the Ireland-Biscay-Iberia region (CORA-IBI, Szekely et al., 2017). CORA-IBI dataset contains observations from a variety of platforms including research/opportunity vessels (CTD, XBT, Ferrybox) and autonomous platforms (Argo floats, moorings, gliders, drifters and fishery observing system - RECOPESCA program). CORA-IBI product supplies quality flags, which are assigned through statistical tests and visual quality controls (Szekely et al., 2017). In this first study, we focus on the northern part of Bay of Biscay, particularly in two rectangular areas (first area bounded by 46^{o}N-48^{o}N and 4^{o}W-8^{o}W and second area by 45^{o}N-47^{o}N and 3^{o}W-7^{o}W). Selection of these areas were done considering the lack of knowledge in literature for this region (north of 45^{o}N), the availability of in-situ measurements and the observed (sub)mesoscale features (with possible role in cross-shelf exchanges) observed along the shelf-break in the region (from satellite images). The area was further divided into 3 regions (Figure 1), following a simple bathymetry criterion, as shelf waters (R3: water depth<150m), shelf-break region (R2: 150<water depth< 2500m) and open waters (R1: water depth >2500m). In-situ data were used to construct the monthly distribution of temperature and salinity in these 3 sub-regions. After obtaining these background states of temperature/salinity for the sub-regions, anomalies (not shown here) were obtained by simply subtracting the climatological means of each month (average of 2007-2014 for each

month) from the corresponding month (e.g: Anomaly of March 2008= March 2008- March mean (2007-2014)).

In order to understand the general thermohaline characteristics in the region of interest, in-situ temperature and salinity profiles were used to construct the background state. Figure 4.1 represents the distribution of profiles in the domain of investigation. Here, temporal distribution of temperature (Figure 4.2) is presented only for the first region (R1-open ocean) as an example. For all the regions, temperature fields represent the seasonal cycle and interannual variations clearly, whereas for salinity it was rather unclear due to high variability. Some of the observed temperature anomalies were associated with eddy activity (as seen by satellite images), whereas for salinity anomalies no direct link was found. Despite the high uncertainty (due to alternating number of observations over time), in-situ profiles of temperature/salinity provided the climatological state of the region fairly well, constructing background knowledge for the numerical simulations.

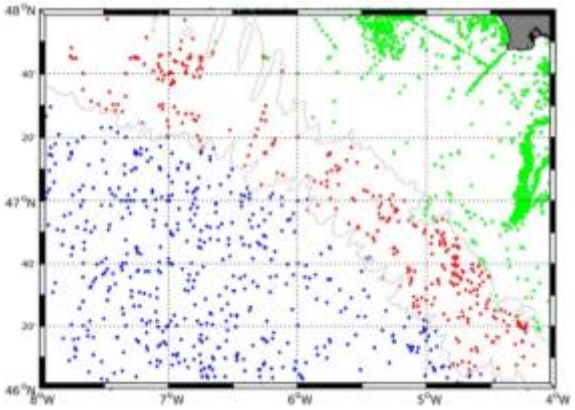


Figure 4.1 Distribution of temperature/salinity profiles in the first rectangular area (2007-2014). Blue, red and green dots represent profiles in the open-ocean(R1), shelf-break (R2) and coastal (R3) regions respectively.

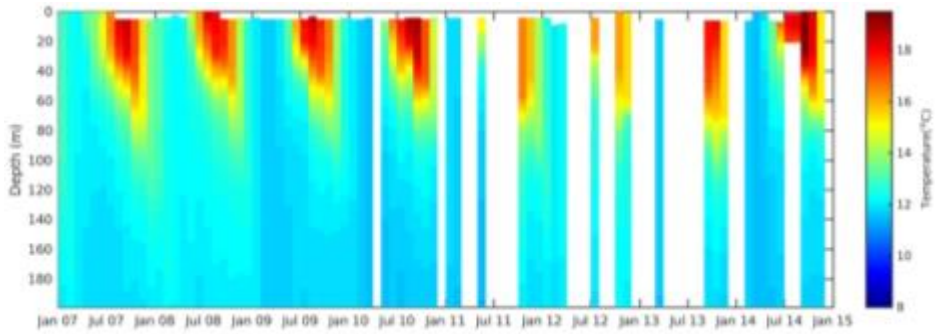


Figure 4.2 Temporal evolution of temperature in region R1.

In-situ measurements were used to detect possible imprints of cross-shelf exchanges, simply by investigating data clusters over the shelf-break region, and through individual Argo float transects which cross the shelf break. However, no clear sign of cross-shelf exchange was found.

This first exploration in the task highlights the limitations of the observations between shelf and open ocean regions. Results, presented at the EuroGOOS conference in October 2017, will be extended to other dataset (e.g. thermosalinograph, glider) and European regions in 2018. A dedicated workshop was planned in 2017 but, due to unforeseen issues, it will now be organised in 2018.

Task 4.2 Optimised shelf physical and biogeochemical sampling

Progress has been made on biogeochemical analysis, and the planning of further shelf-wide cruises has made significant progress towards D4.3. Two scientific papers are submitted and two further papers are in preparation. There are strong synergies with a new observational campaign led by the Task leader

under NERC: Research Grant “An Alternative Framework to Assess Marine Ecosystem Functioning in Shelf Seas (AlterEco)”. A new observational campaign will take place in 2017-2018 and the results will provide the basis for D4.3 and D4.6.

The two main developments in Task 4.2 this year were two new multiple glider deployments that strongly leveraged additional project funding:

1) a short (3 week) but intensive series of measurements that included 10 surface and submarine gliders deployed from the Orkney Islands and from the CMRE (NATO) ship NRV Alliance. The mission included a range of oceanographic data collection, with a particular focus on passive acoustic monitoring of marine mammals and oceanographic features, in support of WP4.2 objectives.

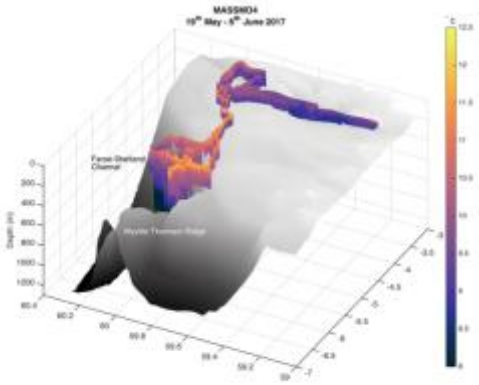


Figure 4.3. Observations of conservative temperature [˚C] collected by four submarine gliders on the Scottish shelf and in the Faroe-Shetland Channel in summer 2017.”

2) sustained observations of a region of the North Sea with the objective of testing autonomous capability in providing long-term marine measurement for both scientific and statutory monitoring purposes. The work includes both submarine and surface gliders covering physics, through biogeochemistry, to fish through implementation of the latest available technologies. This campaign over the next two years will call on new sensor technologies and will strengthen the links between AtlantOS WP4 and WP6.

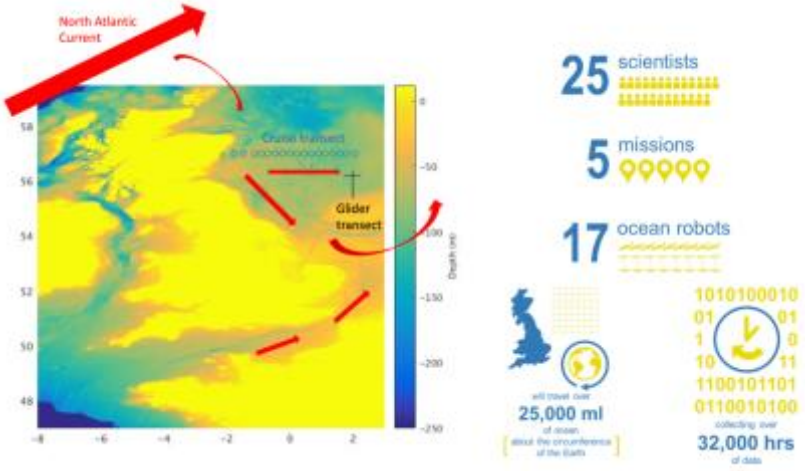


Figure 4.4. Schematic of the North Sea glider deployments planned in support of AlterEco and AtlantOS Task 4.2

Task 4.3 Harmonised Sea Level Data Flow

Deliverable D4.1 was submitted by the due date of 31st March 2017. The title was "Sea level observing site catalogue: Systematic documentation of South Atlantic tide gauge site data and benchmarks". The main aim of the deliverable was to produce a comprehensive catalogue of sea level observing sites, including information on instrumentation and benchmark histories. Though the deliverable description initially included just the South Atlantic, the catalogue also lists tide gauges in the Caribbean, Gulf of Mexico and a small section of Antarctica. These other regions were included as they impact on the South Atlantic Ocean and are also data sparse, requiring attention.

Dr Lesley Rickards attended the Fifteenth session of the Group of Experts for the Global Sea Level Observing System (GLOSS), 8th to 9th July 2017, in New York, which was held before the WCRP/IOC Regional Sea Level Changes and Coastal Impacts conference. There were representatives from several South Atlantic countries and reports were submitted to GLOSS for Brazil, Costa Rica, Mexico and Trinidad and Tobago. These reports will be used to update the station catalogue if necessary and will also be used to feed in to deliverable D4.2, the South Atlantic data management plan, which is due in PM36. The contact information included in the country reports will be used to help obtain tide gauge data from South Atlantic tide gauges, which will then be quality controlled, documented, archived and made available.

Elizabeth Bradshaw participated in the EuroGOOS tide gauge task team, including attending a Skype meeting on 5th May to discuss GLOSS recommendations for metadata, as well as being in the discussion group to provide EuroGOOS recommendations for a tide gauge data format. These recommendations on data and metadata format will feed in to deliverable D4.2.

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. The task team met in Brussels, June 2017, to Lay to the framework for T4.4 "Transatlantic cooperation and sustainability" and to develop a work plan for the months ahead. Background information was gathered on existing initiatives e.g. JERICO, G7, SDG and the Atlantic Blueprint. Gap and options analysis, Key stakeholders, recommendations and implementation and initial report structure were key focus areas discussed at the meeting. Implementation options (Roadmap) will develop later with involvement of key stakeholders. An initial SWOT analysis (Strengths, Weaknesses, Opportunities and Threats) was carried out by the task team to assess the Existing Atlantic Coastal Ocean Observing Systems (Figure 5 below). A wider environmental scan is planned at the AtlantOS General Assembly to include pan-Atlantic representatives from the coastal observing communities. Five regions/zones will be examined including 1. West Africa (Atlantic), 2. South America (Atlantic), 3. Caribbean, (Atlantic), 4. Northwest Atlantic (USA IOOS and Canada) and 5. Northeast Atlantic (Europe). The workshop output will feed into the strategy document on sustained transatlantic coastal observations. If time allows, information gathered will feed into the Atlantic Blueprint as 'best practice' for coastal observing systems. Recommendations for coastal ocean observing systems should inform future activity of the G7 Future Seas and Oceans initiative.

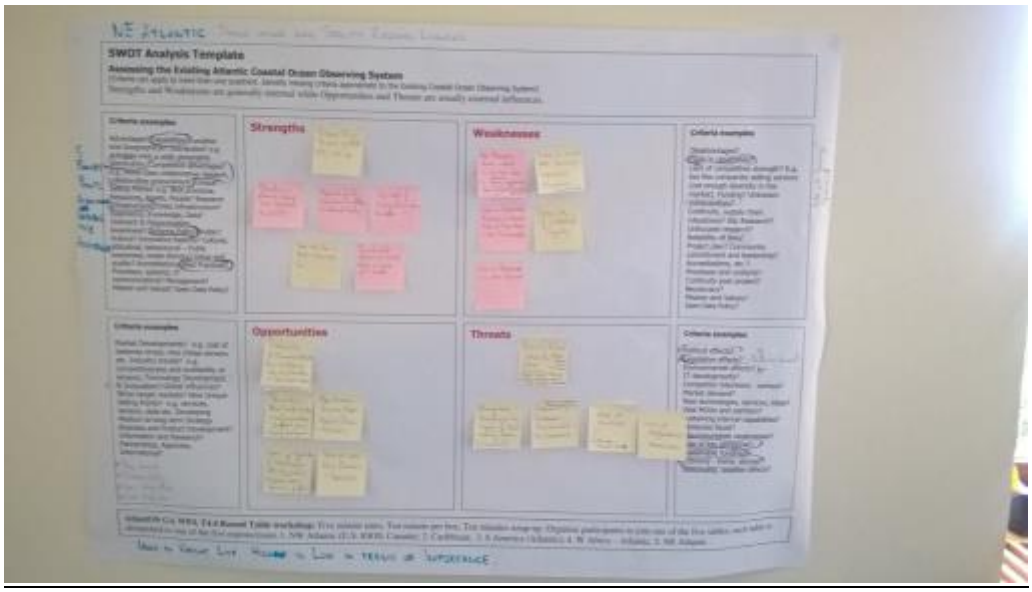


Figure 4.5. Initial environmental scan (SWOT) from one of the partners for the NE Atlantic region.

By gathering a diverse range of stakeholders our primary goal is to identify user needs (particularly in developing countries). Current capabilities of coastal ocean observing systems will be reviewed. We plan to follow up our analysis by working with International and regional organisations to develop wider support and potentially co-funding for gap-filling coastal observing systems. A key future milestone of this activity will be a Symposium on observing system requirements, best practices, tools and technologies for coastal management issues.

Cooperation and interaction with other AtlantOS WPs

WP4 Task 4.2 is working 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 is also working with WP6 through the acceleration of Technology Readiness Levels (TRLs) of new glider sensors to address WP4 identified gaps in ocean measurement, specifically linking fine-scale, microstructure and turbulence measurements with newly developed nutrient sensors to estimate biogeochemical fluxes. There is interaction between WP4 Task 4.1 with WP7 on the mapping of coastal observing systems, mainly Ferrybox but also tides gauges, RECOPESCA, coastal profilers and coastal fixed moorings.

Cooperation and interaction with other projects and initiatives

The analysis of cross-shelf exchanges in the Bay of Biscay performed in the frame of AtlantOS under Task 4.1 are also discussed in the COCTO (Coastal Ocean Continuum in surface Topography Observations) project funded by the CNES/NASA spatial agencies for the SWOT programme. In this project, they are interested in understanding the potential surface signature of coastal (sub)mesoscale processes. Furthermore, obtained results concerning the link between coastal and open-ocean observing systems are discussed in the H2020 JERICO-NEXT project and in Operational Oceanography groups as IBI-ROOS (Ireland-Biscay-Iberia Regional Operational Oceanographic System) for the considered region.

The work under Task 4.2 is interconnected with two major UK research projects: MASSMO4 (intensive series of measurements with10 surface and submarine gliders) which is demonstrating the full coverage attainable with multiple AUV and ASVs; and AlterEco (sustained coverage of a region of the North Sea)

with the objective of testing autonomous capability in providing long-term marine measurement for both scientific and statutory monitoring purposes, and the feasibility of linking autonomous measurements with operational numerical models of shelf sea and ecosystem function.

The sea level data cataloguing and quality control is directly contributing to GLOSS (under WMO/IOC JCOMM). This Task also interacts with the EuroGOOS tide gauge task team leading to improved standards for metadata and tide gauge data formats.

WP4 Task 4.4 has connected with a number of key experts, whose work relates to Atlantic coastal ocean observing systems, from Canada, USA, Brazil, Argentina, Angola and the EU and who have agreed to collaborate and make a valuable contribution to developing a strategy document for sustained transatlantic coastal observations

Achieved main results

WP 4 investigated and supported the joint analysis of the Fishery Observing Systems (RECOPECA programme) over the continental shelf and the Argo profiles in the Bay of Biscay. This has led to a method for detection of possible imprints of cross-shelf exchanges.

Further progress has been made on biogeochemical analysis from glider data at the shelf-ocean interface and on shelf sea. The deployments in 2017 also improve WP4s capability to design comprehensive autonomous sampling programmes using multiple platforms.

Additionally, WP 4 is engaging a number of pan-Atlantic partners as part of its deliverables. Working with African partners initially but ultimately wider international partners from developing countries (under G7) WP4 have promoted three linked activities: (1) initial stakeholder engagement and identification of user needs; (2) co-design, implementation and delivery of site-specific coastal ocean observing systems; and (3) capacity development and system sustainability.

WP 5 Integrated regional observing systems

Summary

The core objective of WP5 is to assess and promote integration of ocean observing activities in two focus regions, the subpolar North Atlantic and the subtropical South Atlantic, and related to two overarching research and monitoring topics: climate change and ecosystems evolution. Our detailed objectives concern the assessment of observing requirements, scientific approaches to be used to derive information, observing instrumentation and networks, preparation and dissemination of information from ocean observing in the two focus regions. Very good progress can be reported towards all objectives, as detailed in the next section progress report per task. In brief, in task 5.1 a series of meetings have been organized to assess the requirement and status of the regional observing. The analysis of historical/recent data in the context of Observing System Design in task 5.2 has produced a critical data set and analysis to derive climate and ecosystem indices for the two regions. Likewise, the Observing System Simulation Experiments in task 5.3 have now been performed and the results are presented to the community in the coming months. Both tasks (5.2 and 5.3) will provide recommendations for optimized sampling of the relevant spatial and temporal scales and the parameter space to deliver the critical EOVs via the observing networks.

Progress per Task

Task 5.1 – Assessment and Coordination of Regional Observing:

Requirements and scientific approaches have been investigated via emerging and existing partnerships represented in, and associated with, AtlantOS (observing networks, stakeholders, scientists). An important approach for the assessment and integration were dedicated and *ad-hoc* meetings (Kiel AtlantOS GA June 2016; Lisbon/Belem meeting July 2017; IAPSO Meeting Cape Town Sept. 2017; planned meetings: PLOCAN AtlantOS GA Nov. 2017; IOC/ICES/PICES meeting June 2018). These meeting activities will be the base for deliverable D5.1 ("Status report on regional climate and ecosystems [36]").

The meetings revealed that integration of climate and ecosystem observations (resp. fisheries) is well advanced in many of the South Atlantic bordering countries (east and west) what may also reflect the close linkage with the economically important fishery industry. Along the West African coastline, the observing activities are/have been in many cases closely linked to the FAO fisheries program, and in particular the FV FRITJOF NANSEN project. The NANSEN can be considered a key observing elements for research and monitoring in coastal/open ocean transition region for the whole West African coast. In addition, substantial national investments in observing is seen e.g. the new Angolan Fisheries Research Vessel or the moored systems off Senegal and Namibia. Recent R & D activities within the EU FP7 PREFACE project, national collaborative programs (French IRD), and other efforts such as the Eastern Boundary Upwelling Systems multidisciplinary observing initiative "Variability in the Oxycline and its ImpaCts on the Ecosystem (VOICE)", all contribute to improvement and optimization of climate and fisheries/ecosystem ocean observing in these regions. However, when it comes to observing the South Atlantic open ocean, currently, in-situ observing activities are sparse. AtlantOS sponsored/is sponsoring enhancement in South Atlantic observing via dedicated activities linked to deliverables in other WPs (e.g. SOOP extension [UEXETER]; surface drifter deployments [EUMET]; Tuna modelling [CLS]; CPR surveys [SAFOS]; Animal telemetry [IMAR]; Sea Level catalogue [NERC]; South Atlantic EOV based product development [IFREMER]; and POGO fellowships [AWI]) – most of them are due in May 2018. At the PLOCAN AtlantOS GA Nov. 2017 workshop organised by WP5 ("Mid-term project review of integrated regional observing") we aim to review these activities in the regional context. Moreover, AtlantOS partners in WP5 also performed individual South Atlantic observing activities (Maria S Merian Expedition MSM60; planned UK/NERC expedition along 26°S) contributing to a short term enhancement.

In the North Atlantic subpolar gyre the observing activities on climate and ecosystems are strong and supported by a series of national and international projects. Not only is the region well covered by all standard Argo floats, also Deep Argo and biogeochemical Argo are present in a significant number that allow conclusions on observing design to be taken. Moreover, long-term moored installations, a critical component in climate monitoring, such as the US Ocean Observation Initiative (OOI) global node "Irminger Sea", the German "53°N array" and the "K1" in Labrador Sea, the long term observing system at the Greenland Scotland Ridges by the Faroese, Icelandic, German, and Norwegian moorings. Likewise, long term and frequent observations by ship and gliders e.g. in the framework of the UK Extended Ellett Line, the French OVIDE program, the CPR surveys (see also WP2 report) or the Canadian AR7W and AZMP expeditions contribute to climate and ecosystem observations. For the climate topic various aspects are routinely monitored as well as process studies being executed that have a focus on the warm to cold water transformation and its link to the overturning circulation and the various science questions associated with it: carbon sequestration, air/sea gas exchange, Spring bloom onset and duration, heat and freshwater transport, and of course the connection with/export to the Arctic (e.g. via the Nordic Seas/Barents Sea link) as well as the import across the Greenland Scotland Ridges and the Baffin Bay. It is observed in WP5 that linkages between observing efforts in the Subpolar region still have room for improvement, for example the link with the sustained ecosystem observations performed in the context of the Intergovernmental Organization ICES, one of the leading ecosystem management/fisheries organizations, is not as well developed as it could. Communication with ICES, via WP5 initiated meetings

but also in the context of WP2 (plankton acoustic surveys) and WP1 (requirements) exists. WP5 is a co-organizer of a session at the IOC-ICES-PICES Symposium on the Effects of Climate Change on the World's Oceans (4-8 June 2018), and we are confident that it will strengthen the collaboration between ICES and the Atlantic Observing from an AtlantOS point of view.

We continued the effort to reinforce the regional integration via capacity-building actions dedicated to Atlantic undergraduate, master and PhD students. In terms of an integration of pan-Atlantic research teams and stakeholders, we organized dedicated oceanographic cruises which have been opened for participation to partners from the South Atlantic. The first GO-SHIP cruise over the SAMBA-SAMOC project line at 34.5°S was executed as a truly pan-Atlantic activity.

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

The current intensification of observing activities in the North Atlantic subpolar gyre, but likewise (at a different level though) in the South Atlantic, with Argo floats and ships expeditions, provide a baseline dataset to be used for observing design studies as well as OSSEs (link to task 5.3) related to selected climate and ecosystem problems and as a contribution to deliverable D5.2 ("Indices associated with climate variability [36]") and deliverable D5.3 ("Indices associated with primary productivity and carbon export [36]"). These deliverables evaluate indices, which can be routinely produced based on sustained observing (satellite, in-situ), may rely on certain "transfer function" determined from intense campaigns. For example, deliverable D5.3 will be based on combining various sources of in situ data (largely relying on Argo floats and on Biogeochemical-Argo floats deployed in the Atlantic as part of the ERC remOcean project) and/or satellite data, sometimes combined with models. New biogeochemical and ecosystem status products are developed in order to better address phytoplankton dynamics and its impact on primary production and export in both the North Atlantic Sub-polar Gyre (NASPG) and the South Atlantic Subtropical Gyre (SASTG). Very recent complementary investigations have taken benefit of availability of large (Atlantic subsets) databases to develop more systematic analysis over the whole Atlantic basin with respect, in particular, to deep phytoplankton layers of production or of regional bio-optical specificities. Overturning volume and heat transport time series in the subpolar gyre were derived from standard Argo and satellite altimetry data and referenced to individual, directly observed transport across e.g. across the Greenland-Portugal OVIDE section from 1993 to 2016. The high correlation between this heat transport time series and the MOC is in agreement with results derived from repeat hydrography. However, we observed that the heat transport by the lower branch of the Atlantic Meridional Overturning Circulation (AMOC) is too large compared to repeat hydrography. Pursuing its work on the carbon budget in the Atlantic, the quantitative role of the AMOC in dissolved organic carbon (DOC) export by combining DOC measurements with observed water mass transports was done.

Applications of technological enhancements of the two WP5 regions and themes have been executed via collaborating with WP3 (Biogeochemcial Argo floats) but also through the many national and international financed activities (ERC remOcean project; UK NERC financed South Atlantic cruise, ESFRI Euro-Argo). Some examples include: recovery a Bio-Argo floats (during the AtlantOS MSM60 cruise) or the optimization of the SPG observing by using a self-calibrating Infrared radiometer for SST retrievals for Copernicus satellite Cal/Val efforts (enhancement of WP3 SOOT). Other new technology for ship based observations in the SOOT context were the coordinated acquisition of underway hydrographic data using conventional one-way XBT probes (provide by NOAA/US) and reusable probes (GEOMAR owned OceanScience underway CTD and RapidCast systems). The systems were operated in parallel on recent South Atlantic AtlantOS cruises (M133, M124).

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

In the OSSE task 5.3 suitable guidelines to define the optimal sampling for biogeochemistry variables using OSSEs are developed. This activity is closely linked to WP1 (Task 1.3; Subtask 1.3.2) where more information of methodologies is provided. The CNRS/IGE team has developed the assimilation of biogeochemistry observations from satellite ocean colour data and vertical profiles of Chl-a, nutrient and oxygen observations in a 1/4° North Atlantic NEMO-PISCES configuration. The North Atlantic subpolar gyre has been chosen under Task 5.3 to conduct regional OSSEs. The impact of the assimilated observations will be assessed depending on defined scenarios, and are expected to be achieved on time and deliver against D5.4 ("Optimal design of regional sampling based on OSSE [42]" and "Optimal design of ecosystem module [42]").

Cooperation and interaction with other AtlantOS WPs

WP1: Regional ensemble-based OSSE approach follows strategy outlined under task 1.3.2.

WP2: The different ship based observing efforts are aligned/follow recommendations in task 2.1 (GO-SHIP) protocols (OVIDE occupation in 2018, MSM60, M124/M133). ISAR installation on commercial vessel to be linked to task 2.2 (SOOP).

WP3: Argo/BGC-Argo data is used for analysis and indices (D5.2. & D5.3.). Dedicated ship expeditions are used to deploy Argo and Deep-Argo floats. The BGC-Argo data is quality-controlled (procedures are linked to task 3.1).

WP6: The ISAR instrument activities are linked to task 6.1. They enhance the readiness of ship-based and autonomous platform observing networks so they become sufficiently mature for long-term sustainability.

WP7: Open access to a new data stream (task 7.1) via task 5.2 ISAR instrument Cal/Val. The BGC-Argo data is delivered to end-users in collaboration with task 7.2. New products are developed through the merging of in situ and satellite data and contribute special applications to task 7.5. (Time series along 24°S, along OVIDE and biogeochemistry from floats).

WP8: Capacity building and Knowledge Transfer via the ship expeditions (including sharing of laboratory and use of products – SOCAT v2).

WP10: We also continuously interact with WP10 to engage with pan-Atlantic stakeholders during the various meetings. A briefing paper is currently edited within this context.

Cooperation and interaction with other projects and initiatives

Partners in WP5 engaged with a wide range of research initiatives and communities including the regional Atlantic Overturning observational programs (OSNAP in the subpolar North Atlantic; SAMOC in the South Atlantic). We also strongly engaged with the international dimension of the South-South Science Plan that is the science backbone of the Belem Statement.

The radiometer observations are integrated in the ESA project Fiducial Reference Measurements for satellite derived Surface Temperature Measurements (FRM4STS, frm4sts.org). A global radiometer network has been established within the Group for High Resolution SST (GHRSST). In addition, participation in the Sentinel 3 Cal/Val team and the Copernicus CMEMS OSI-TAC projects ensure the results are used to improve satellite-based services.

Observing activities contribute to and analysis activities benefit from the data available via the JCOMM coordinated global ocean observing networks (GO-SHIP; SOT; Argo; OceanSites; GLOSS).

Model data used in the probabilistic analysis of sea surface height were produced within the framework of the French ANR project OCCIPUT (*OceaniC Chaos – ImPacts, strUcture, predicTability* e.g. Penduff et al. 2014) and will contribute to ongoing interactions within the follow-on CNES/OST-ST PIRATE (*Probabilistic*

InteRpretation of Altimeter & in-siTu obsErvations) project, which aims to isolate and attenuate the influence of low frequency chaotic variability in the observational record.

The development of the assimilation system of biogeochemical observations (satellite and in-situ profiles) under Task 5.3 aims to improve the biogeochemical products delivered by the Copernicus Marine Service (CMEMS). In term of the subpolar MOC, interactions with the Overturning in the Subpolar North Atlantic Program (OSNAP) are considered through discussions at the Irminger Sea regional science workshop (Nov. 2017).

The MSM60 expedition was executed as a full international North/South expedition. The expedition was a milestone in the context of the SAMOC initiative and had PIs from all participating countries on board. The current step is the joint analysis of the data which is expected to further strengthen the linkages between North/South and East/West.

Achieved main results

A series of meetings was initiated and executed to bring the climate and ecosystem observing communities together, including representatives from national agencies such as fisheries organizations, in order to assess and promote integration of ocean observing activities in two focus regions, the subpolar North Atlantic and the subtropical South Atlantic, and related to two overarching research and monitoring topics: climate change and ecosystems evolution. A rather detailed overview about the observing efforts, motivations and approaches was acquired, the base for an optimization of the regional observing systems considered in WP5 and which is the preparatory work for D5.1 'Status report on regional climate and ecosystems'.

Based on enhancement in observing, in particular for the South Atlantic via AtlantOS initiated activities, and leveraging from the on-going observing enhancement by recently launched activities (namely OSNAP, Ocean Frontiers Institution etc.) in the North Atlantic subpolar gyre region, significant work towards the development of climate and ecosystem indices has started. These indicies will ultimately be used to derive information for the various stakeholders about the status climate change and ecosystems evolution in the two focus regions and for selected science questions (e.g. overturning variability, carbon export).

Different approaches for space/time sampling have been analysed using Observing system design as well as Observing system simulation experiments related to climate and ecosystem functioning in the two focus regions. The OSSE activities have been generated in close collaboration with WP1 (task 1.3) and are of great interest for all observing in the Atlantic. In the coming months (starting with the AtlantOS GA) a dissemination and discussed of the results and the reflection against scientific approaches for individual requirements will take place.

WP 6 Cross-cutting issues and emerging networks

Summary

New autonomous plankton / particle sampler supported by AtlantOS has been developed from concept to now delivering science on a recent cruise. Novel nutrient sensor technology currently on deployment on fixed and autonomous platforms though collaboration with WP2+3, Task 6.1.

Milestone 9 (online publication of sensors and instrumentation and emerging networks roadmaps) successfully submitted, Task 6.1 and 6.5.

Sensors and instrumentation roadmap underwent two updates in this reporting period, now more than twice its original size. Task 6.1.

Successful workshop into trace element measurement has resulted in a submitted publication on the measurement of uncertainty for oceanographic measurements, Task 6.2.

Workshop into sustained cost-effective observing systems for the Atlantic Ocean was held with support from across AtlantOS and colleagues from AORA-CSA. Outcome is directing subsequent planned deployments that will demonstrate efficiencies of implementing best practice for shared infrastructure, Task 6.3.

Creation of a best practices (BP) system for significantly improved discovery and access was initiated including coordination with IOC/IODE as the preferred long-term repository. For interoperability, BP templates have been defined and beta tested with the observing community. A demonstration of BP content tagging was completed. A workshop with the international observing and data management community was held to obtain community inputs and review. Task 6.4.

Deliverable 6.2 (emerging networks roadmap) successfully submitted, Task 6.5.

Progress per tasks

Task 6.1 – Sensors and new instrumentation

This reporting period begun with the online publication of the sensors and instrumentation roadmap (NERC lead). The roadmap continues to be updated, growing from an initial 61 submissions to over 140 (link). The roadmap has enjoyed greater exposure than ever before, not least through presentations at Ocean Business '17 and the 2017 EuroGOOS AGM.

In August a high-throughput Marine Autonomous Plankton Sampler (MAPS, Figure 6.3) underwent its first field trials, connected to an underway seawater supply in the west Atlantic (NERC lead). The MAPS performed independently as expected outside of minor interactions, for 10 days. It collected over 200 samples of varying biomass, and is currently being upgraded for *in situ* sampling at Station L4 in the Western Channel Observatory. MAPS is an example of a new capability that has grown from concept to delivering science at sea due to the AtlantOS project. The concept has generated significant interest within the community with requests for duplicate systems. Development of the concept is being explored with work package partners (TELABS).

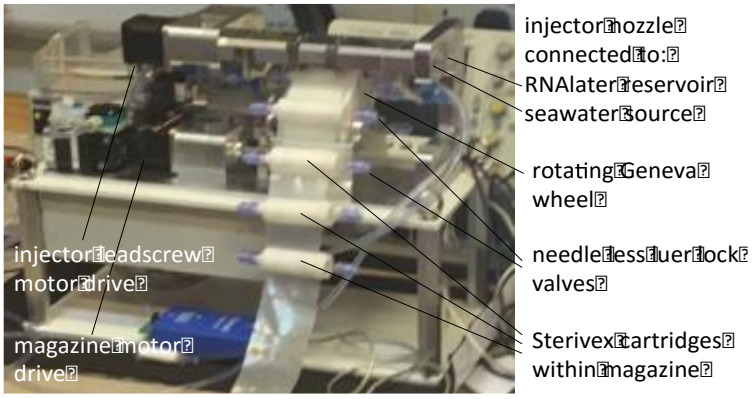


Figure 6.3 Marine Autonomous Plankton Sampler (MAPS, TRL4) collects cells from ≤5L seawater on 0.22um filters, then preserves with RNAlater. It can collect >300 samples per deployment.

AtlantOS project supported nutrient sensors (NERC) are currently on deployment in the Atlantic and North Sea on both fixed observatories and autonomous gliding platforms. These deployments demonstrate high accuracy measurements over short timescales and even a high precision year long

deployment. Such undertakings provide valuable evidence of ever increasing technology readiness levels; this has only been possible through collaboration with colleagues in work packages 2 and 3.

New optode measuring technologies have been developed (GEOMAR, KMCON) that monitor O_2, pH and pCO_2. The fast O_2 testing has been conducted with a dozen units with samples taken from air, CTD profiles, laboratory calibrations and underway sampling on four trans- Tropical North and South Atlantic cruises. Initial tests have been undertaken on floats and Wave Glider platforms. Fast time response has been verified (t_{63} = 3-4 s). The pH and CO_2 technologies are part way through their next development iteration with optical and mechanical (housing, flow through head) aspects of the designs being optimized. Next steps for both pathways of optode being developed are further characterization and under controlled conditions and validation in the field.

Task 6.2 – Common metrology and best practices

Following the successful workshop held last year on trace element measurement (UOP, GEOMAR, IEEE)a best practice manual has been written as an overview paper and submitted to L&O Methods, pending publication. The abstract is included below:

"A realistic estimation of uncertainty is an essential requirement for all analytical measurements. It is common practice, however, for the uncertainty estimate of a chemical measurement to be based on the instrumental precision associated with the analysis of a single sample, which can lead to a significant underestimation. Within the context of chemical oceanography such an underestimation of uncertainty could lead to an over interpretation of the significance of the result and hence impact on, e.g. studies of biogeochemical cycles, and the outputs from oceanographic models. This paper describes and compares two recommended approaches that can give a more holistic assessment of the uncertainty associated with such measurements. These are known as the "bottom up" or modelling approach and the "top down" or empirical approach. The determination of iron (and other trace elements) in seawater presents a significant analytical challenge and is used as a case study for the implementation of both approaches using real oceanographic data. Recommendations for the practical implementation of these strategies are provided. The "top down" approach combines the uncertainties associated with day to day reproducibility and possible bias in the complete data set and is easy to use. For analytical methods that are routinely used, laboratories will have access to the information required to calculate the uncertainty from archived quality assurance data."

Further workshops include genomic observatories (RIBOCON lead), nutrients and oxygen sensor observations (IFREMER lead) and carbonate chemistry sensors measurements (IO-PAN lead). The production of best practice manuals will follow each of these individual workshops and will be made available for free on-line dissemination. This will also be accessible through the D6.7 compendium of best practices (led by IEEE).

Task 6.3 – Shared Infrastructure

As planned and prepared during the first reporting period, the task team (PLOCAN, IEEE, Ifremer) finalised the preparation, organised and hosted the joint AtlantOS workshop with contribution from several AtlantOS work packages and the AORA CSA project (Figure 6.4). The workshop: "AtlantOS workshop on strategies, methods and new technologies for a sustained and integrated autonomous *in situ* observing system for the Atlantic Ocean, supported by AORA-CSA" was held between the 2nd – 4th of November and has a website (http://atlanticworkshop.plocan.eu) with the full report available here.

The focus of this 3-day scientific and technical workshop was the enhancement of integration of cross-cutting issues regarding in-situ Ocean observing within AtlantOS and the involved networks as well as better involvement of international participants.

It was attended by several international researchers who gave their perspective from the other side of the Atlantic Ocean, and also by a number of participants in the Atlantic Ocean Research Alliance Co-ordination and Support Action (AORA-CSA) in order to provide scientific, technical and logistical support to the EC in the development and implementation of transatlantic marine research between the European Union, the United States of America and Canada.

Figure 6.4 Images from shared infrastructure workshop

The workshop participants agreed to:

1) Propose an AORA strategic action to compare sharing modes and recommend more Atlantic wide solutions
2) Consider a 'policy statement' for the Atlantic Observing community
3) Encourage full meta data delivery with all data sets and to establish and promote the use standard descriptors to allow best data harvesting
4) Include to the EOVs discussion issues such as metrology, data compression, comparison of performance and establish review criteria
   A follow-up event will address the preparation of a field experiment (PLOCAN, NERC, CONTROS) aimed at demonstrating the potential of new technologies in enabling the sharing of observing infrastructures.

Task 6.4 – Best practice on observing systems

The near-term objectives are to 1) formulate the infrastructure and processes for optimum collaboration and dissemination of best practice in the long term and 2) engage the ocean observation community in the evaluation of these processes and infrastructure prior to implementation of an Initial Operating Capacity (IOC). This work is being done with AtlantOS partners and other members of the international observing community, addressing the end-to-end flow of information from sensors and data to data management and users. All disciplines are engaged including physical oceanography, biology and biogeochemistry.

A major objective is the definition and implementation of a sustainable repository, leveraging existing capabilities whenever possible, both in the repository infrastructure and its content of best practices. The preferred repository in the IODE facility recently renamed as the OceanBestPractices repository. The

BP system is not to create best practices – those will come from the ocean observing experts – but to improve interoperability across ocean disciplines through improved discovery and access of existing and new BP. Thus, while existing best practice documents will be included in their native formats, it will likely be necessary to add metadata elements to the BP documents. In addition, a series of BP templates with crucial metadata information have been created and beta tested. As a strategy, the best practice repository will identify three levels of document processing to indicate the completeness of the documentation to users. At the highest level, the best practices will have comprehensive metadata and have been peer reviewed by the community or through a repository expert panel. To support peer review, a new Research Topic in the Ocean Observations Section of the Frontiers in Science Journal of Marine Science has been approved and has just started with Johannes Karstensen as Lead Editor. Figure 6.5 below shows the institutional interfaces.

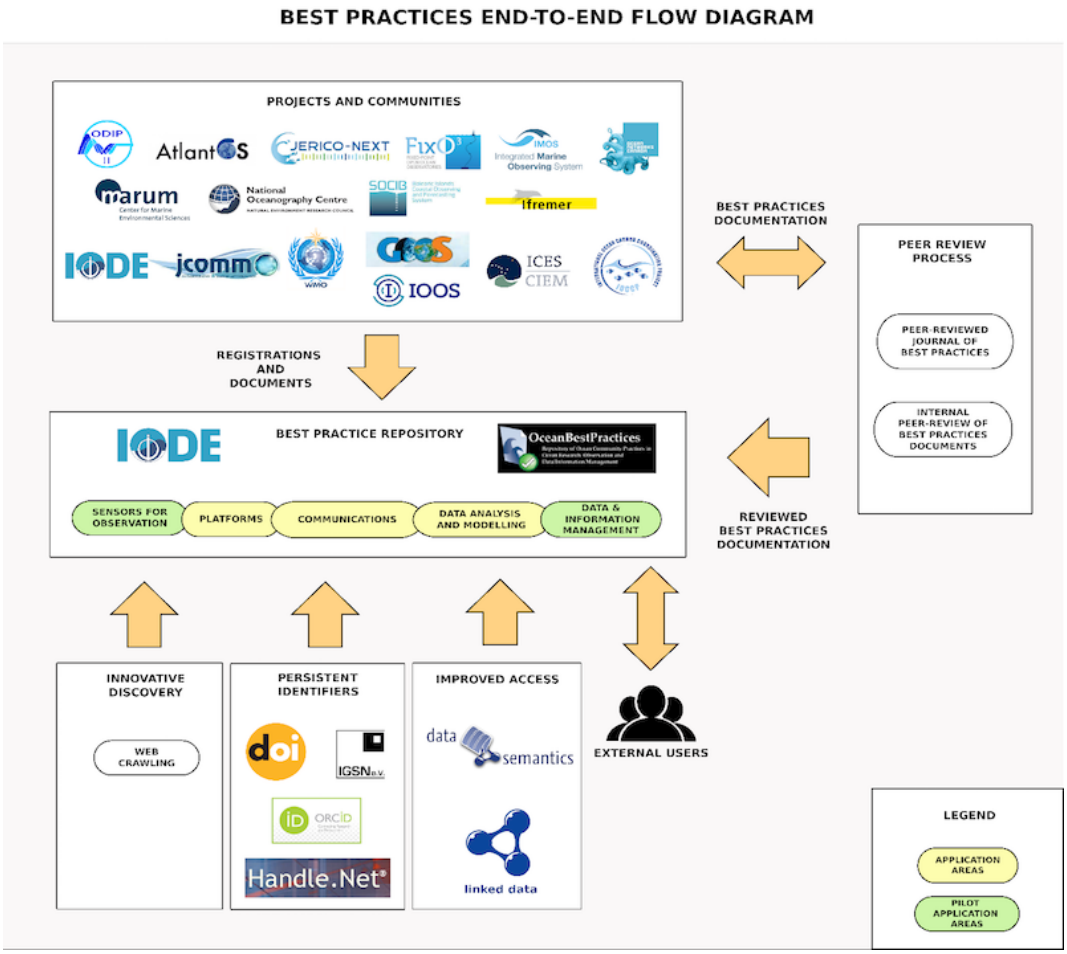


Figure 6.5 Best practices end-to-end flow diagram

While the figure above shows the institutional relations in supporting users access to best practices, the flow process itself is described in the Figure 6.6.

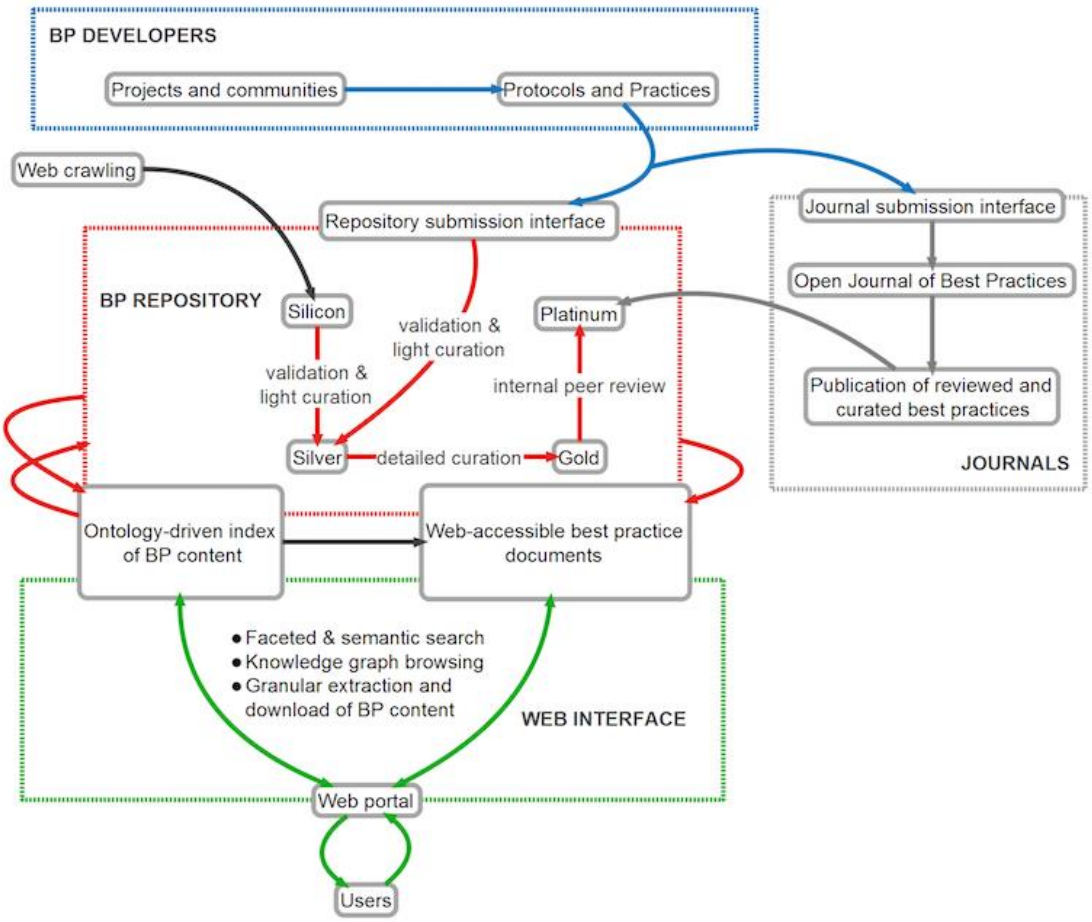


Figure 6.6 Best practice flow process diagram

The flow works as follows: documents created by expert groups, agencies, or other stakeholders are to be deposited in the OceanBestPractices Repository of IODE where they will be allocated a persistent URI. A methods description of the best practice can then be submitted to a companion peer review open access journal, Frontiers in Science Marine Science. The journal, which is an initiative of Task 6.4 in collaboration with the Ocean Data Interoperability Platform (ODIP) project, serves as a dissemination platform with the full best practice document archived in the Repository. In both cases, the submitters would include metadata descriptors, sourced from a continually updated ontology. Within the repository, the document may be at one of several levels depending on the levels of metadata, completeness of information and peer review.

An outcome of the task is the transition of best practice documents to web page formats, with each section of the BP document indexed by the assigned metadata descriptors, and assigned its own persistent URI or Handle, as mentioned above. Users may access a web portal that would automatically convert their search requests into semantic queries that would be processed using the ontology. Access to the documents through the OceanBestPractices repository will be available in native (the authoritative version) or web-based formats. There is also an ongoing effort to facilitate submission of current and new best practices in formats that are interoperable across ocean observation communities. This may include the availability of templates and recommendations. A workshop to review this process and the planned infrastructures was held in Paris in Novemer.

Task 6.5 – New and emerging networks

The emerging networks roadmap (NERC, AWI, RIBOCON, CIIMAR) was successfully submitted last November and formed part of AtlantOS Milestone 9 alongside the online publication of the sensors and instrumentation roadmap (link). Following the initial publication of the emerging networks roadmap new material from WP7 has become available, an update is in preparation that will incorporate this information into the emerging networks roadmap.

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.

WP3 helped organize the Task 6.3 workshop "AtlantOS workshop on strategies, methods and new technologies for a sustained and integrated autonomous *in situ* observing system for the Atlantic Ocean, supported by AORA-CSA". All autonomous observing networks from WP3 were represented at the workshop. WP7 also participated, representing data management objectives and interests for the AtlantOS strategy.

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 in 2018.

WP7 material and partners are contributing to the update of the WP6 emerging networks roadmap.

Cooperation and interaction with other projects and initiatives

Sensors and instrumentation roadmap presented at 2017 EuroGOOS AGM.

AORA-CSA, AtlantOS coordination and the European Commission participated in the selection of the international panel of participants for the AtlantOS workshop organized by task 6.3.

Results of the Ocean of Tomorrow projects on the development of new sensor technologies (SenseOcean and NeXOS) were presented, the objective being the assessment of new technologies maturity level for the measurement of essential variables.

The core Task 6.4 working group (called the BPWG) includes representatives of multiple institutions including JCOMM, IODE, SAEON (South Africa), SOCIB (Spain), AWI (Germany) and IOOS (US) that address a broad range of applications and user needs. These activities are co-sponsored by The H2020 project ODIP. There has also been initial discussion and collaboration with FixO3, JERICO, NeXOS projects and regional organizations such as SeaDataNet, EMSO and EuroGOOS. Some are partners in Task 6.4 but all will be part of discussions moving forward.

Achieved main results

Objectives set out in proposal	Results towards objective in reporting period
Step change in the number of sensors and instruments addressing priority EOVs that are proven on ocean observing systems	A novel plankton filtering system has been supported from concept through to delivering science, significant interest from community generated. Demonstration of increased technology readiness levels of novel nutrient sensors. Continuous update of sensors and instrumentation

	roadmap enables increasing exposure to the community of technology undergoing development that address priority EOVs.
Create a roadmap for the development of priority sensors and instrumentation	D6.1 changed from static to 'living document'. Has already undergone two updates and is freely available online. Has achieved ever greater exposure to the oceanographic community having been presented at multiple international events and submissions have more than doubled in size from the initial submission
Lead the development of metrology standards and best practice for ocean observing	The first international workshop on metrology standards has Trace Element Metrology has been completed. Collation of best practices arising from workshop now submitted publication. Best practice process defined following wide consultation with community in cluding an international workshop on Ocean Best Practices (November 2017). Repository for best practice identified and infrastructure for peer review process and semantic search. Journal has been created and a sustainable repository has been identified for legacy beyond AtlantOS project.
Reduce the cost of IAOOS by efficiency gains delivered through networks and nations sharing resources and infrastructure during the creation, operation and maintenance of IAOOS	Successful workshop held with partners across AtlantOS project and AORA-CSA. Workshop summary distributed widely with follow-up deployments to show case benefits of sharing resources being organised. Workshop specified communities needs with a thorough analysis of methods, interests and requirements. • Focus on significant assets that are either unique or costly • Enhance technical interoperability to make it easier to share and exchange sensors and observation system components • Is there scope to build an Atlantic wide sharing mechanism? OFEG-Atlantic? • Propose an AORA strategic action to compare sharing modes and recommend more Atlantic wide solutions.
Address the chronic under-sampling of biogeochemical and biological variables (including (meta)genomics) and to address other observational / coordination gaps by supporting existing activities and the creation of new networks, observation technologies and	Deployment of new water and filter sampler technology (MAPS) in the Atlantic. Technology development of concept being pursued with industrial partners.

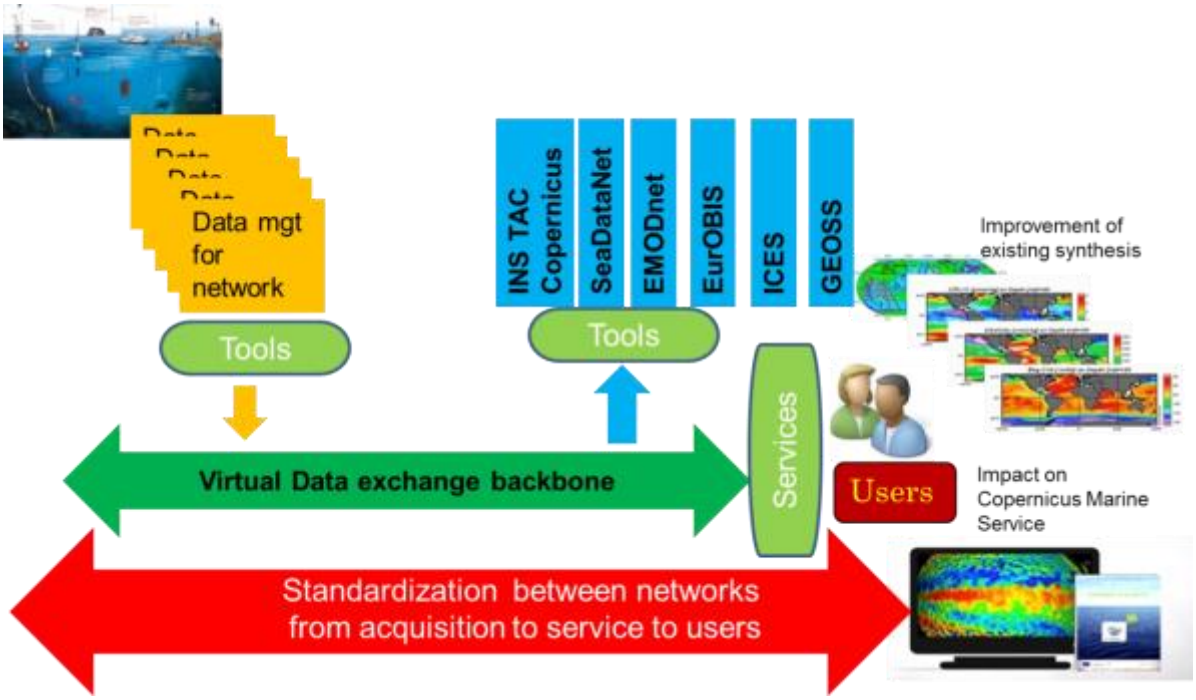
programmes	

WP 7 Data flow and data integration

Summary

The overall objective of WP7 within AtlantOS project is to ensure that data from different and diverse in-situ observing networks operating in the Atlantic Ocean are readily accessible and useable to the wider community, international ocean science community and other stakeholders in this field.

To achieve that, the strategy in WP7 is to move towards improved integration of existing systems within AtlantOS by [Task WP7.1] harmonising work flows, data processing and distribution across the in-situ observing network systems from WP2-3-4, and [Task WP7.2] by integrating in-situ observations in existing European and 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

The actors, integrators and networks, of the targeted system are overall mature systems with long-term experience and established procedures for data collection and management. In this context, trying to implement a sovereign and rigid set of rules for all the actors to comply with, would be highly challenging and not in the best interest of AtlantOS**.** Thus the Integrated European data system is not a new system but integrates existing systems, these being enhanced to ingest and deliver more in-situ observation data on Atlantic Ocean and to better serve the users, in a harmonized way across the systems.

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 and

Task 7.3 Operation demonstration of the integrated data system

In the past 2 years within task 7.1 (data harmonization of the data management activities) and 7.2 (data flow and integration of the existing systems), networks and integrators representatives have collaborated to improve harmonization of Atlantic Ocean data and facilitate improved interoperability. The partners achieved to agree on common standards and procedures. This was documented in 4 deliverables submitted during fall 2016:

- *Data Harmonization Report* identifying gaps and providing recommendations to be implemented by all networks and integrators in Europe and also within an international landscape.
- *Real Time QC Recommendations* for 7 selected EOVs acquired by more than one network and further used with the task WP7.4 and WP7.5 (Temperature, Salinity, Current, Oxygen, Chlorophyll, Nitrate, Sea Level and Carbon).
- *Full life cycle Report*: assessment of the full data lifecycle of observing data and information from data acquisition to long-term archiving to detect fields for improvement that may be common for a data provider in AtlantOS.
- *Data Management Handbook* for Data Management activities regarding data flow and data integration.

To further expand our data harmonization activities, WP7 has been invited to participate mid-November 2017 to the workshop on *Evolving and Sustaining Ocean Best Practices Workshop* hold by AtlantOS (WP6.4) and ODIP projects, JCOMM-OGC and IODE.

The partners involved in tasks 7.1 and 7.2 made significant progress. The work was coordinated through two meetings organized in June 2016 and in December 2016. The second one was organized as small splinter-meetings where a group of network representatives were working with representatives from an integrator or monitoring activities (in link with WP9.1) on in order to facilitate, define and initiate concrete actions. The meeting report describes the detailed work plan for the partners, and most of the improvements are currently being implemented in most networks, although some actions on facilitating data access for users and integrators will probably last after the end of the project. The major advances from WP7 activities on data management for networks from WP2-WP3 are:

- Setting up two GDACs (Global Data Assembly Centres) for Drifters, one in Europe and one in Canada, as central points of data access in Near Real Time and for the best Delayed Mode version.
- UK data integration in the GDAC for Gliders, improve access to ADCP data for GO-SHIP (with the long term goal to set up a GDAC).
- Setting up nodes in the SeaDataNet infrastructure: done for SOCAT carbon data from VOS/SOOP and GO-SHIP networks, underway for physical data from CPR network, planned direct GDAC data flow connection to SeaDataNet for Argo, Gliders, Drifters and OceanSites networks (will be investigated first for Argo).
- Integration of data from EATN in EMODnet Biology.

In 2017, another step was taken in order to involve countries from all continents bordering the Atlantic Ocean in AtlantOS harmonization and integration efforts. A first step was the organization of a workshop on “AtlantOS Transatlantic Ocean Data Harmonization” held 7-8 June 2017 in Brussels, where key organizations for Atlantic Ocean data management from all continents bordering the Atlantic (Europe, USA, Canada, South America, Africa, AORAC) shared their best practices (curation, handling and

dissemination) and identified key issues for long-term and lasting improvements of transatlantic data exchange across continents. In particular, transcontinental harmonization of best practices is an obvious next step for a better interoperability on Atlantic Ocean data. As an outcome, post-workshop activities seek to establish three working groups, continuing the work initiated at this workshop, with the goal of presenting 3 white papers on selected topics at the OceanOBS19-conference: (1) Ocean data - Quality assurance and quality control, (2) Data standardization (in an initiative with IEEE), (3) Interoperability, semantics and machine learning from a user community perspective including new services that could emerge from big data technologies. The working groups and production of white papers shall be a community driven effort by the international ocean data community, hence it is encouraged to develop diverse working groups with representation from all continents bordering the Atlantic Ocean as well as the inclusion of essential current projects and initiatives, such as AtlantOS, ODIP, RDA and IEEE. The outcome from this workshop will also be used to populate the data section for the AtlantOS blueprint.

Task 7.3 that started in April 2017 aims to demonstrate the operation of the integrated system. All the actors of the targeted integrated system have to enhance their data system according to the roadmap set up during the 4th WP7 meeting held in December 2016. One challenge is to keep momentum with the networks and continue implementing recommendations and unlock access to data for the integrators and applications, especially 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 also for bio-geochemistry were the link between EMODnet and CMEMS needs to be strengthened.

AtlantOS WP7 is closely following the evolution of the GEOSS Common infrastructure, and some WP7 data providers are already experienced in the use of GEOSS for data integration purposes. However, there is a task ahead making sure all data providers get the necessary information and guidance in the use of the GEOSS GCI. WP7 has initiated a dialogue with GEOSS in order to explore how AtlantOS as a community can contribute and make best use of GEOSS services for technical solutions to improve harmonization as well as for dissemination of AtlantOS data. The outcome will be presented in a workshop arranged for WP7 and also open to the larger AtlantOS community. The workshop is planned in collaboration with the project Envri+ and COOP+. It has goal of making sure that all individual data providers in AtlantOS to be registered within the GEOSS GCI. This will lay the foundation for making AtlantOS resources available through GEOSS in a sustainable way that goes beyond the life-time of the project. Furthermore, the workshop will provide guidelines for making resources available and it will be possible for the individual data providers to get answers to specific individual questions. It will also focus how to make use of the brokering services provided through the GEOSS GCI explaining necessary requirements and how to initiate brokering processes. Additionally, the workshop shall initiate the making of an AtlantOS Hub within GEOSS making the AtlantOS entries, including the AtlantOS catalog, more discoverable. The workshop is set for November 24th 2017 in connection with the AtlantOS general assembly.

Setting up the AtlantOS data portal is underway since the beginning of 2017. On the one hand, it gives access to the AtlantOS catalogue that provides a discovery service and facilitates the access to existing services (viewing, downloading and monitoring) of the data systems. Significant progress has been made on populating the catalogue: mid-October 2017 network and integrator entries were mostly completed (99%) together with some products entries relevant for Atlantic Ocean from Copernicus and SeaDataNet. Further product entries are going to be added especially in link with Task WP7.5. The Essential Variables filtering facility of the catalogue will be set up before end of November 2017, except for biology that

needs further definition work in agreement with the GOOS level. The sustainability at European level of such catalogue will be studied with EuroGOOS.

AtlantOS catalogue

On the other hand, the portal gives access to monitoring services designed under the JCOMMOPS and EuroGOOS umbrellas (link with WP9.1, see WP9 second periodic report) and the traceability services that aim to provide statistics on data usage to data providers. Collaborative work between partners is underway on common data service log information that could be shared between the integrated system actors and processed to produce harmonized statistics dashboards using common tools.

Next milestone for WP7 activities is the 5th meeting on 20th November 2017, side to the AtlantOS GA. It aims to keep the momentum with partners to progress on the WP7 roadmap towards the integrated system, to contribute to the setup of traceability of use services for data providers and to get involved in the actions identified at the Transatlantic workshop and contribution to the AtlantOS Blueprint.

Task 7.4 Integration in models and impact and

Task 7.5 Product Development

These tasks of WP7 started in April 2017. They aim to demonstrate the operation of the integrated system (WP7.3), to assess the impact of AtlantOS observations in models through Copernicus (WP7.4) and to develop and deliver ocean products derived from these observations both for research and for applications (7.5).

From the discussions conducted with WP2 and WP3, the precise design of the impact studies that will be carried out within task 7.4 have been defined. The details of the different planned experiments and analysis with the different systems (Mercator, CLS, MetOffice and ECMWF) are documented in the deliverable D7.6 issued October 2017. The impact analysis will be done with the same analysis systems that are being used within the Task 1.3 for observing system simulation experiments (OSSEs) designed to investigate the potential impact of extensions to the existing Atlantic observing network. The use of different systems will allow having an AtlantOS observation impact analysis for different applications.

Task 7.5 for AtlantOS officially started in April 2017 (T0+24 months) and will end in April 2018 (T0+36 months). The objective of this task is to develop EOV synthesis products from WP2 and WP3 networks and historical data sets for ocean, carbon, ecosystem and climate research. Over the first 6 months of the task, work to be carried out for each of the six subtasks addressing different EOV synthesis products has been precisely defined and development of processing techniques has started. The Biogeochemical EOVs from satellite and BioGeoChemical Argo measurements will use statistical techniques to estimate 3D fields of Chl-a and backscatter coefficients. Surface carbon EOV syntheses will provide surface ocean carbon synthesis products, specifically by contributing to the international community effort Surface Ocean CO2 Atlas (SOCAT) and use statistical techniques to produce a proof-of-concept of the feasibility of ocean carbon system estimates resolving seasonal and inter-annual variability. Ocean carbon interior synthesis subtask objective is to release an updated version of GLODAPv2 (GLODAPv2.2018). This new product will contain AtlantOS funded, and coordinated, interior ocean observations. The impact of the AtlantOS observations on interior ocean biogeochemistry will be assessed. Temperature, Salinity and Oxygen synthesis subtask will use the ISAS objective analysis tool to produce temperature, salinity and oxygen syntheses of the Atlantic Ocean over the last 10 years. Ecological EOVs subtask will provide ecological EOVs from Continuous Plankton Recorder CPR rich biodiversity data. Processed EOVs will target specific areas relevant to observing change and will directly deliver key information of significant societal relevance such as human health climate change impacts on ecosystems, ocean acidification, biodiversity and fisheries. Merged satellite/in-situ surface current products will use past and AtlantOS ADCP data to validate and enhance merged satellite/in-situ (sub) surface current products.

Cooperation and interaction with other AtlantOS WPs

- Task WP7.4 linked to the activity in WP1.3
- WP9.1 for monitoring services and WP7.2 collaboration, non-duplication of efforts
- WP6.4 for Ocean best practices: participation of WP7 to the **«** Evolving and Sustaining Ocean Best Practices**»** Workshop 15-16 November 2017 and
- WP8 and WP10: benefits from the WP7 deliverables, the setup of the AtlantOS catalogue and the work in progress to integrate more data in Copernicus INS TAC, SeaDataNet and EMODnet , and coordinates with Task 7.4 - Task 7.5

Cooperation and interaction with other projects and initiatives

- Copernicus Marine Service, and its' In Situ Thematic (INS TAC) center that build 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 Europe projects. Collaboration is on the implementation on the European cloud of a "Data delivery service to scientific users' using the Copernicus In-Situ TAC data. A joint technical workshop between ENVRI+, Euro-Argo and SeaDataNet took place in Ifremer/Brest on 6-7 April 2017.
- JERICO-Next project for data integration concerning WP4 networks and monitoring/dashboard services
- ODIP2 project that is setting the foundation for the harmonization process at 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.

Achieved main results

- Completion of the design of the integrated EU data system along with four major deliverables
- Improvement of the integrated EU system, involving both networks and integrators, with major advances on Network side for data management enhancements facilitating better access to data for users and integrators. An on-going process involving Integrators and Networks
- Setup of a web portal and AtlantOS catalogue
- A coordinated action for monitoring and traceability of use of services, involving ETT, JCOMMOPS and Ifremer. The action includes a shared strategy and complementary developments without duplication of efforts with WP9.1.
- Organization of an AtlantOS transatlantic data harmonization workshop on 7-8 June 2017 with representation from all bordering continents. The outcome includes new initiatives that will pave the way for a better integrated approach to handle data harmonization challenges at a trans-continent level

WP 8 Societal benefits from observing/information systems

Summary

WP8 activities have progressed steadily with outputs and methodologies discussed in details between the partners. A preliminary assessment of WP8 main deliverables and products took place at the 2nd WP8 Technical meeting held in Dublin, in July 2017. At the meeting, AtlantOS targeted products were technically described and assessed. In addition, applications and exercises proposed to demonstrate the importance of AtlantOS generated data used in the targeted products were selected. Several Tasks (Task 8.2, 8.4, 8.5, 8.6, 8.7) submitted deliverables that are reachable at the project web page (https://www.atlantos-h2020.eu/project-information/work-packages/deliverables/). Several web sub-pages have been developed and implemented at the project web site to disseminate the WP8 products to a large community.

Possible actions on stakeholder engagement were also discussed and a preliminary stakeholder investigation was carried out under the leadership of WPs 10 & 11. AtlantOS partners will continue to work on the WP8-WP10-WP11-Blue-Print Interaction in the third year related to Stakeholder

engagement; product development loop (iterations of the products), importance of community advocates in the co-development loop, identify the specific societal, scientific, and economic benefits. At the last technical meeting, WP6 also presented an overview of recent developments for ocean observing sensors and best practices in the field. WP8 is now working with WP6 to develop best practices on ocean applications with T8.1 as the example application.

Progress per Task

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

Task 8.1 Harmful Algal Blooms:

Information and data product exchange continued between partners with the publication of the Norwegian and Irish bulletins in 2017. Publication of the Spanish bulletin is expected in spring 2018. Some of the partners are also working with WP6 on documenting the Best Practices for this application.

Task 8.2 Coastal Flooding/Storm surges:

The novel analysis of storm surge distributions has now been published in a high impact factor journal (Geophysical Research Letters); we show that on observational evidence, the tide has no role in modulating skew surge - an important proof that has not previously been systematically explained, despite its importance for coastal extreme sea levels. There are seasonal dependencies between tides and storm surges which form the basis of new work. The methodology of Williams et al. (2016) has also been applied to the global extreme sea level data set (GESLA). A new version of a global tide-surge model with improved bathymetry and global tidal behaviour has been produced and this will be used to generate a new global tide-surge hindcast. This work will lead to a scientific paper in the next reporting period. During this reporting period, D8.1 “Storm surge probability climatology” was delivered.

Task 8.3 Ship routing hazard mapping:

Progress has been made to validate the numerical solution of the routing code vs. an exact method developed at the Massachussets Institute of Technology. Furthermore, the CMCC model has been extended with the functionality to use ocean currents data for computing optimal routes.

Task 8.4 Coastal oil spill hazard mapping:

Progress has been made in the production of the ensemble simulations for the North Eastern Atlantic coastlines and a prototype web decision support system portal has been developed (https://glamor.sincem.unibo.it/) with these initial results. The D8.4 “Oil spill Hazard maps” was delivered.

Task 8.5 Offshore Aquaculture siting:

Partners worked on the development of a number of products reported on in D8.2 and have continued to document product specifications for the next phase of work to evaluate the products based on the Expert Opinion and use of the EMODnet Sextant system.

Task 8.6 Reanalysis for MSFD and ICES assessments:

Potential target users have been identified for hands-on assessment and training in the use of CMEMS products.

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

Progress has been made in the understanding of different input environmental marine condition data sources (reanalyses) and prepare the historical geo-referenced fishing datasets for the study.

Task 8.8 POGO-AtlantOS collaboration on ocean products:

The POGO activities consisted mainly in the organization of Cruises and Workshops for Training of young researcher. Scholarships were given from AtlantOS for the NoSoAT training cruise 2015 & 2016 and the RV Maria S. Merian (MSM60) cruise in 2017.

Cooperation and interaction with other AtlantOS WPs

The cooperation and interaction with other AtlantOS WPs has also progressed steadily and in particular:

- WP1-WP8 interaction: the major work was to connect the EOVs with Targeted products input data sets.
- WP6-WP8 interaction: this involved discussions 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.
- WP8-WP10 interaction: WP8 in collaboration with WP10 is working to have specific WP8 Tasks Webpages. The connection with the EOVs in WP1 will be displayed on each webpage. In the 3rd year the products should all be displayed on the website.

WP8-WP10-WP11 interaction: interacting more on Stakeholder engagement 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

Cooperation with other initiatives is on-going, in particular:

Pinardi entered the scientific steering committee of GEO Blue Planet and participated to the third Blue Planet workshop in Maryland, USA, May 31-June 2, 2017 where the interface between AtlantOS WP8 products and the activities of GEO Blue Planet has been planned.

WP8 partners agreed to implement the product assessment methodology from EMODnet Checkpoints [to Evaluate “Fitness for Use of Input Data” and “Fitness for Purpose of the Products”]. There were developments on the EMODNet Atlantic Checkpoint who have agreed to add the AtlantOS product data to their catalogue. There are two assessment methodologies: Expert opinions and Appropriateness indicators. Tutorials were provided at the WP8 2nd Technical meeting in Dublin, in year 3 partners will enter the required information to do the gap analyses.

WP8 in collaboration with U.S. IOOS and the GEO Blue Planet submitted a proposal for Joint Town Hall Meeting at Ocean Sciences 2018 and it has now been accepted. Nadia Pinardi as part of the GEO Blue Planet steering committee is disseminating and connecting the Blue Planet initiative with WP8 application areas.

WP8 has submitted a number of abstracts for consideration for the Blue Planet Supplemental Issue on Ocean Observing for Societal Benefit for the Journal of Operational Oceanography. The focus is on end-to-end case studies of ocean observations being used to benefit various sectors of society.

Achieved main results

Two types of results were achieved by WP8 in the second reporting period:

1) the first is related to the targeted products, each task further developed their products and started to disseminate them;

2) the second is connected to the coordination of WP8 with internal and external relevant activities.

All the targeted products, using several observational and integrated input data sets have advanced toward the release to the public. In particular the web Bulletins for HABs were published (http://www.niva.no/atlantos, http://www.marine.ie/Home/site-area/data-services/interactive-maps/weekly-hab-bulletin) as well as the oil spill hazard maps Bulletin (https://glamor.sincem.unibo.it/). Other products are on their way to develop the appropriate web page for display.

The second result concern the continuous interaction with WP1 and WP6 in order to advance toward the understanding on how the targeted products for societal benefit can show the adequacy of the observing system. Stakeholder engagement will be undertaken in the 3rd year after consultation with WP10 and WP11.

WP 9 System evaluation and sustainability

Summary

WP9 objectives are to provide quantitative and near real time information of the state of the in-situ Atlantic Observing System (Task 9.1), to analyse and document for each EOV 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 and 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 report for the three tasks of WP9 is summarized below. Note that main activities for Task 9.2 and 9.3 are just starting (mid 2017).

Progress per Task

Task 9.1: System monitoring and evaluation

Two WWW based monitoring tools were specified and developed for (i) the European (including coastal/regional regions) (EuroGOOS) and (ii) the international contributions to the AtlantOS in-situ observing system (IOC/JCOMMOPS). These two monitoring tools are now running and they provide useful inputs for an evaluation of the AtlantOS observing system. The data flow (real time and delayed mode/climate) monitoring is organized in relation to WP7.

Key Performance Indicators (KPIs) have been developed for most of JCOMM networks. They have been adapted for regional perspectives, including Atlantic Ocean. A dedicated AtlantOS dashboard was set up (including Atlantic and AtlantOS perspectives) (see http://www.jcommops.org/board?t=atlantos).

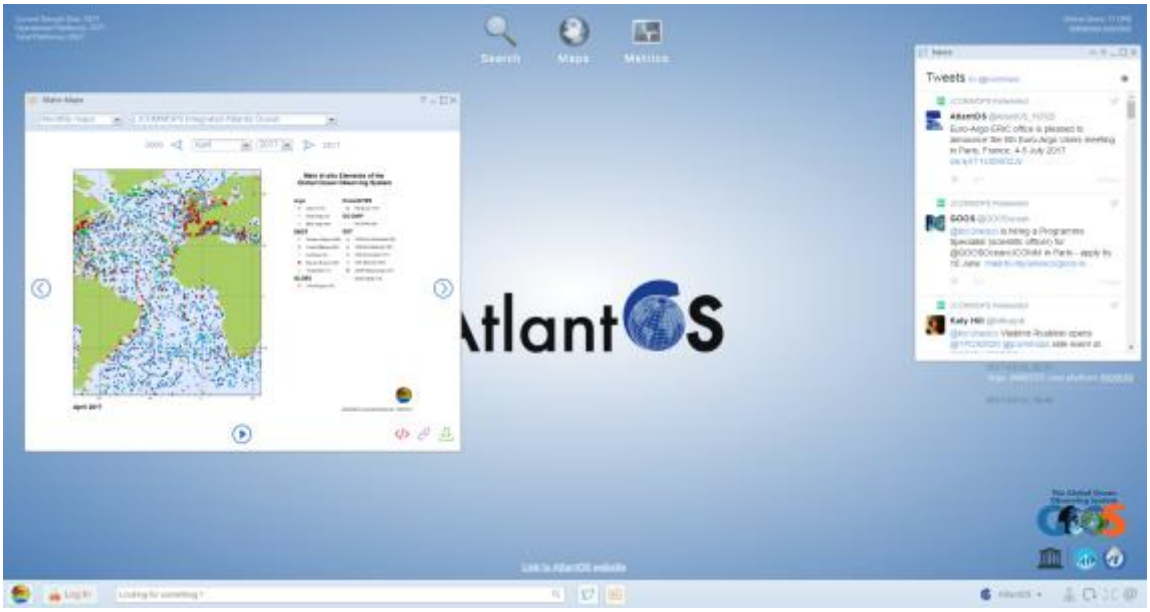
Next steps include developing further KPIs for some networks (OceanSites, GO-SHIP in particular) and adding additional in-situ observing systems in the database (gliders, marine mammals, etc). Remaining challenges include developing KPIs for emerging networks (not mature enough to do so) and developing integrated KPIs (EOV oriented, GOOS strategical mapping context).

KPIs were also developed for European providers (coastal/regional regions) based on EMODnet integrator. A dedicated AtlantOS dashboard embedded into EuroGOOS webpage

(http://eurogoos.eu/atlantos/atlantos-dashboard/) was developed (monitoring web tool for the Atlantic Ocean). It monitors data flow and KPI of the AtlantOS ocean observing system.

The two deliverables planned for Task 9.1 at T0+24 months have been submitted on time and are available on the AtlantOS WWW site (https://www.atlantos-h2020.eu/project-information/work-packages/deliverables/):

- Web based monitoring tool of the Atlantic ocean observing system (international) (D.9.1 IOC/JCOMMOPS).
- Web based monitoring tool of the Atlantic ocean observing system (Europe) (D.9.2, EuroGOOS, ETT).



The AtlantOS web based dashboard homepage, including monthly maps produced routinely by for Atlantic Ocean observing system status (see http://www.jcommops.org/board/?t=atlantos)

	Argo				DBCP	SOT
	Argo Core	Argo Global	Argo BioGeoChemical	AtlantOS	Global Drifter Program	VOS
Implementation						
Activity Atlantic Ocean	103.67% 6/2017	112.26% 6/2017		116.1% 6/2017	142.63% 6/2017	
Coverage (Monthly) Atlantic Ocean		55.61% 6/2017		58.53% 6/2017	50.32% 6/2017	2.34% 6/2017
Coverage (Monthly, sum) Atlantic Ocean		64.4% 6/2017		67.65% 6/2017	68.64% 6/2017	
Coverage (Yearly) Atlantic Ocean	65.87% 2016	71.05% 2016				
Density (Monthly) Atlantic Ocean	91.42% 6/2017	92.94% 6/2017	46.98% 6/2017		90% 7/2017	
Intensity Atlantic Ocean	115.63% 6/2017	121.88% 6/2017		133.53% 6/2017	119.99% 6/2017	
Instrumentation						
Life Expectancy Atlantic Ocean		4.49 2016				
Mortality Rate Atlantic Ocean		26.01% 2016				

Example of KPIs (Key Performance Indicators) produced routinely by JCOMMOPS for the Atlantic Ocean and AtlantOS region

EuroGOOS monitoring tool for AtlantOS region

Task 9.2: Adequacy of the current observing system

Task 9.2 just began the process of developing a questionnaire that invites national representatives and other experts to assess the adequacy of the current observing system and its information products (D9.4, PM42). The outcome of the assessment of adequacy enables AtlantOS to evaluate the nations and experts' perspective on the relevance of the information products. The questionnaire will comprise two parts: The first part will ask for feedback on the adequacy of the ocean observation networks and the information delivery against EOVs (based on D1.1 and D9.2) and the requirements which are needed by the nations and experts. The second part will allow us to provide information about the current engagement in ocean observing activities as well as information about future engagement activities within the next 5 years.

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

In the planning of WP9, the activities of task 9.3 have been scheduled to start in month 30 (1 October 2017), so this task is in its initial phase. However, some activities have already been initiated during 2017:

- Task 9.3 partner are active in formulation of a "Blueprint for an Atlantic Ocean Observing System" which will constitute a substantial part of the Task 9.3 deliverable (D9.5).
- In close cooperation with WP10 a joint meeting between Atlantic Ocean Research Alliance (AORA) and AtlantOS was organised and attended in Washington DC April 2017.
- EOOS (European Ocean Observing system) planning and implementation is in progress. EOOS framework will gather European efforts to set up a sustained long term multidisciplinary observing system covering European coastal seas and European contributions to the global and regional ocean observing systems.

The work in Task 9.3 will in the coming months concentrate on establishing contact with national funding agencies and observing system operators (Europe and aboard) and engage with EOOS.

Cooperation and interaction with other AtlantOS WPs

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. 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 cooperate as well in the WP 2.1 on the GO-SHIP cruises metadata management and with WP2 and WP3 to get a consolidated view of the different network long-term plans.

WP9 appreciated the input from WP1 to the design of the Atlantic Observing System inclusive high level requirements, gaps and analysis. Further cooperation with WP1 is taking place concerning costs of a future Atlantic Observing System. Input from WP10 was provided by the best practices in Stakeholder Engagement – better understanding on how to efficiently engage with stakeholders and attract more users. Together with WP10 and 11, WP9 supports the dialog with a AORAC-SA consortium.

Cooperation and interaction with other projects and initiatives

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 TPOS2020 (Tropical Pacific Observing System) initiative. Some connections between both initiatives are being prepared by the JCOMM Observation coordination group. WP9 cooperates with the EOOS Steering Group and will participate in the EOOS Forum planned to take place March 2018, since the intended focus group for this meeting fits very well with the scheduled task 9.3 commitment meetings. Globally, the operational ocean observations are coordinated within the Global Ocean Observing System (GOOS) which is implemented via activities within 13 GOOS Regional Alliances (GRAs). EuroGOOS is one of the GRA of relevance for the Atlantic Ocean (together with IOOS, IOCARIBE GOOS, OCEATLAN and GOOS Africa). EuroGOOS is strongly engaged in getting all European ocean observing data made freely available to marine users to support a good and sound decision making. The data are made available via central European portals such as Copernicus Maritime Environmental System (CMEMS), EMODnet or SeaDataNet; but a central component in the data flow from originator to these databases is the EuroGOOS ROOSes cooperation and data exchange system.

Achieved main results:

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.

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.

WP 10 Engagement, Dissemination, and Communication

Summary

With a view to the objectives identified in the DOA, during the 2nd reporting period, WP10 has organised activities relating to the following:

- Encourage interested actors to consider the future of observatories and their place in the Atlantic area in order to cultivate and further develop a dynamic 'ecosystem' of actors and activities around an Integrated Atlantic Ocean Observing System
- Take a proactive role to structure the exchange between the observatory communities in Europe, the US and Canada as well as other user groups
- Disseminate the concrete results of work completed in WP1-9 as well as actively engage the potential users of data and information from observatories in both commercial and public sectors

- Implement communication activities

Progress per Task

Task 10.2 Best Practices in Stakeholder Engagement, Data Dissemination and Exploitation

- The report "Best Practices in Stakeholder Engagement, Data Dissemination and Exploitation" (D10.5) was submitted on 30th September 2016. Before submission, the report received feedback from colleagues from inside and outside AtlantOS community. The report can be now accessed via the project AtlantOS website.
- In July 2017, Seascape launched a survey to gather information about the experiences of consortium partners in engaging with stakeholders. Exactly 89 responses were received and analysed. The results of the survey were included in D10.5.
- Some of the findings of D10.5 were presented at the International Conference on Marine Data and Information Systems (IMDIS) 11-13 October 2016 in Gdansk, Poland. The poster is available on the IMDIS website.

Task 10.3 Stakeholder Engagement 'Support Facility'

Task 10.3 aims to investigate options to embed engagement tools and practices into a durable stakeholder engagement support facility able to serve the needs of the envisaged Integrated Atlantic Ocean Observing System. As it was not clear what the requirements for these tools and practices were before the onset of the project, the Task description was kept deliberately broad at the time of proposal submission, to allow to define the focus more specifically during the project taking into account the activities, suggestions and needs arising from other AtlantOS activities. This also allowed to fully take into account the findings of the work carried out in Task 10.2 and presented in D10.5 to feed into Task 10.3. D10.5, providing more concrete suggestions and specific recommendations for AtlantOS to consider in terms of stakeholder engagement that could be taken on-board and tested as part of Task 10.3. It was envisaged that Task 10.3 is transversal to the project and could encourage cross-WP interactions.

Following actions have been undertaken during the reporting period, to narrow down the scope and focus the activities:

- The AtlantOS DoA and consortium were reviewed to explore what the project could offer to stakeholders and who should be taking this forward.
- So far, most effort has been focused on synergies/collaboration with WP8 which aims to provide new information products in several societal benefit areas (i.e. climate, disasters, ecosystems) through Use Cases.

In spring 2017, seascape started to explore activities within WP8 to consider options to collaborate and develop a stakeholder engagement demonstration exercise. For example, WP10 through Task 10.3 could help WP8 by proposing a step-by-step process to structure the dialogue with their users, in particular from the private sector, and improve the impact of their pilot actions. WP8 colleagues were ready to collaborate as they recognised that a better stakeholder (user) engagement would help them develop more fit for use products and hence would contribute to their impact. WP8 technical documents describing the Use Cases were consulted to assess the potential of the different WP8 teams to implement a stakeholder engagement test exercise. On 18-20 July 2017, Belén Martín Míguez (WP10) participated in 2nd Technical WP8 Meeting which took place in Dublin. There she presented the Stakeholder Engagement Test Exercise, consisting on a number of steps/instructions which could be adapted to each Use Case. Together with WP8 leaders and with the other members of WP10/WP11

present in Dublin (Anja Reitz and Kristin Hamman) a workshop was organised during the same meeting. This allowed learning more about WP8 teams and Use cases, the most important stakeholders for their task, the kind of information exchange/contact they have with them etc. Despite the promising interactions with WP8 in Dublin and several follow-up emails after that, this has not yet resulted into a clearly identified demonstrator exercise to show user-uptake and stakeholder interactions which would require more time to be pursued.

Currently Task 10.3 is being reviewed in view of the above experiences and wider strategic developments, to refine and clarify its focus, among others to align the activities and outputs of the Task with the Internationalisation Strategy for EMODnet from DG Mare and the possible contribution of EMODnet Atlantic Checkpoint.

Task 10.4 Science-Policy Briefing Papers and Briefings

The first AtlantOS Briefing Paper entitled *The AtlantOS Vision – A long-term observing system in the Atlantic Ocean*, was completed in January 2017 and presented at the UN Preparatory Conference for the UN Oceans Conference in February 2017. (D10.6)

The second AtlantOS Briefing Paper entitled *Ocean Observing for Society – AtlantOS products and services* was completed in June 2017 and presented at the UN Conference on the Oceans in New York on June 8th. (D10.7)

In addition, a briefing event was organized as part of the *AAAS Conference on Science Diplomacy* in Washington, D.C. on 29 March 2017. This was specifically aimed at the science-policy community in Washington that is involved in decisions related to ocean development and management, but not necessarily directly working with observatories.

A further Briefing Paper is in preparation as follow-up to the July 2017 Blue Enlightement Conference held in Lisbon, Portugal.

Task 10.5 Exploring the Economic Potential of Observatories

OECD cooperation – during the reporting period no concrete tasks were carried out. Preparatory work in underway to begin writing a final research report on the economic potential of ocean observing beginning in January 2018.

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

Task 10.6 is focusing on the governance and coordination of ocean observing systems, with a specific focus on the links between the current and future coordinating frameworks for the Atlantic Ocean Observing System (AtlantOS) and the European Ocean Observing System (EOOS). The main rationale for this work is that a number of related ocean observation initiatives are currently developing across multiple geographical scales, e.g. Basin scale, regional seas and European. The landscape remains fragmented and there is a real need to assess these parallel developments and to see where exchange of information and interaction could be further strengthened to make these coordination initiatives as complimentary and efficient as possible. This is also set in the context of new strategies being developed in 2017/2018 for GOOS (for public consultation end 2017/early 2018), and EOOS, including short-term implementation actions (Spring-Summer 2018). The resulting deliverable (D10.11, due M40), will provide an overview of these development at Atlantic Ocean, European and International levels and it will include recommendations for strengthening the dialogue between related coordination efforts into the future.

In the reporting period, EMB have undertaken preparatory work for this analysis. Some specific activities have included:

- Continuing and regular interactions with EuroGOOS in the context of developing the coordination framework for the European Ocean Observing System, specifically, as co-Chair of the EOOS Steering Group. This includes the joint organization of two EOOS stakeholder events in 2018 (a 1 day Forum on 8 March and a multi-day conference on 21-23 November 2018).
- Attending AtlantOS meetings, specifically the "*Connecting to better observe the Atlantic Ocean*" on 12 July 2017 in Lisbon and the subsequent Blue Enlightenment meeting 13-14 July and the AtlantOS Steering Committee meeting on 21 September 2017 in Brussels which included discussions on the Blue Print status and development. Here EMB was also invited to present options for future funding through Horizon 2020, Work Programme 2018-2020.
- Participating in AtlantOS Work Package 10 meetings (in person and tele-meetings) with WP10 lead KDM, partner Seascape and AtlantOS Coordination to discuss Task 10.6, WP10 and wider AtlantOS activities, including stakeholder engagement.
- External events and interaction: EMB presented AtlantOS work (focus on WP10, Task 20.6) at the European Ocean Observing System (EOOS) Steering Group meeting on 20 September 2017 and at the EuroGOOS international conference 3-5 October 2017 in Bergen. EMB also connected via web stream to the launch of EuroGEOSS during GEO Week in Washington on 24 October 2017. EuroGEOSS provides a framework for European earth system science and observation. EMB have also increased interactions with EMODnet since the start of Phase III (started 19 September 2017), since this includes a new Task to support the development of EOOS. EMB will provide options for structured dialogue between EMODnet and EOOS development (led by the EOOS Steering Group).

EMB have also followed policy discussions and developments e.g. G7 Future of the Seas and Oceans Working Group, Ocean conference, Our Ocean meeting, surrounding European ocean observation and this will feed into Task 10.6 (D10.11) development.

Task 10.7 Web-based and social media communication

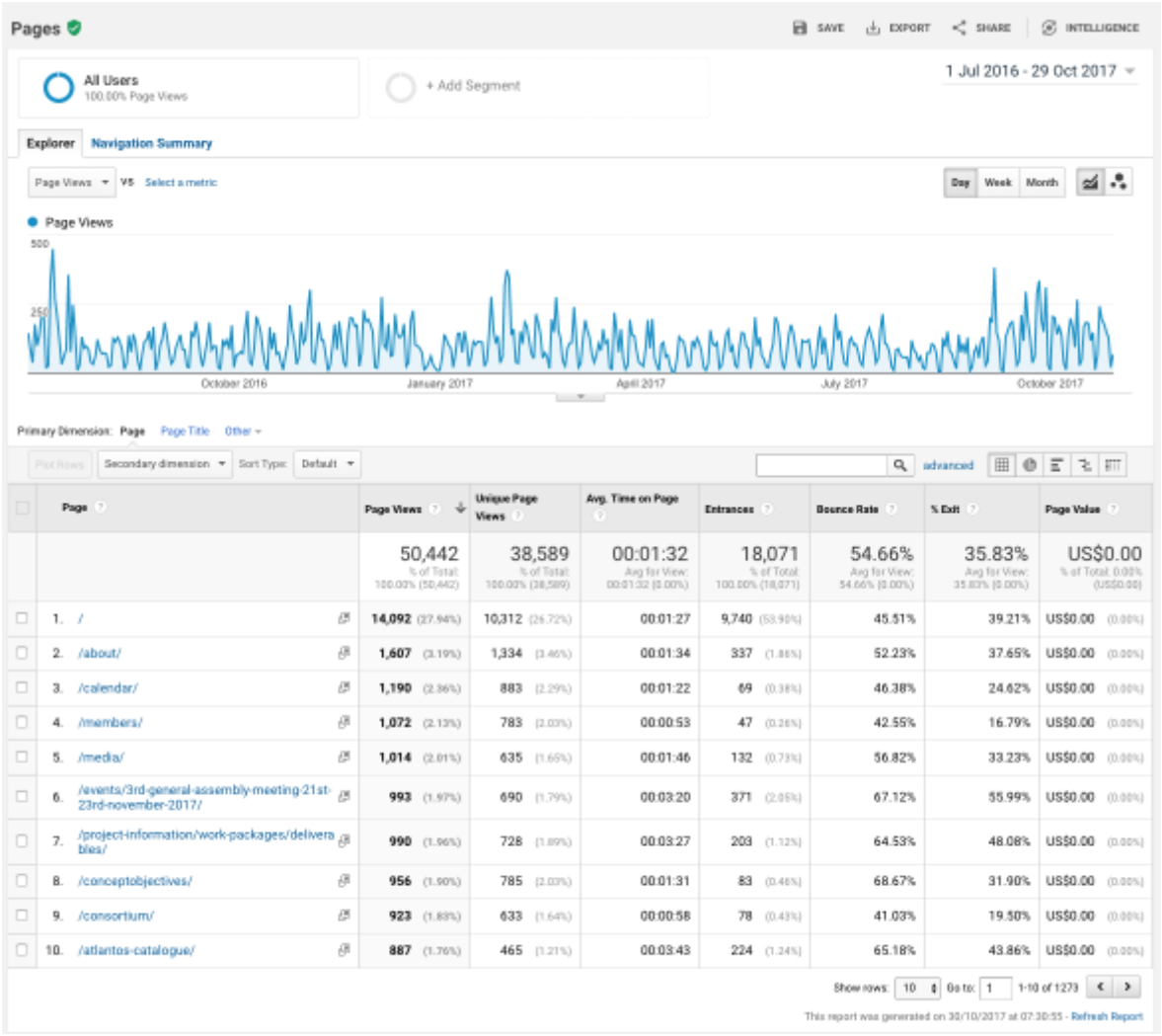
A considerable amount of content has been added to the website during the period, including news articles, events, deliverables, AtlantOS products. The website now contains more than 500 pages / documents and has 424 registered users.

Further products continue to be added to the website regularly and the project pictograms / value chain are currently being integrated as an interactive infographic of the project.

The project Twitter account has 2,260 followers (30th October 2017). This is an increase from 1,110 in the first period. The followers were gained both organically and through 'community building' and represent a very focussed set of 'quality' followers. This ensures that messages sent through the Twitter account receive significant retweet / distribution through networks. The Facebook page has only 43 followers and does not perform as well as the Twitter account. This is expected.

During the period, the website received just over 18k visits.

Top 10 countries, UK, Germany, France, UK, Russia, Belgium, Spain, Italy, Ireland, Portugal. Device: Desktop: 93.5% Mobile / Tablet: 6.5%



Google Analytics data for the atlantos-h2020.eu website, 30th October 2017

Screen print of the atlantos-h2020.eu website homepage in December 2015.

Cooperation and interaction with other AtlantOS WPs

Together with WP1 and 11, WP10 organized on 6 April 2017 in the State Dept. in Washington D.C. a first informal Exchange of Ideas between AtlantOS and the Partners in the Atlantic Ocean Research Alliance. Participants included Craig Mclean (Chief Scientist, NOAA, USA), Trevor Schwerdfager (Asst. Dept. Minister, Dept. of Fisheries and Oceans, Canada) as well as approx. 20 other individuals from the USA, Canada and Europe. This is the first of a series of meetings to exchange ideas concerning long-term sustainability issues related to development of a comprehensive observing system in the Atlantic Ocean region. This meeting agreed to a number of general action items, including:

1. Further exchanges would be useful to discuss progress in ocean observing and the potential of more systematic funding

2. AtlantOS needs to increase appeal factor and be more concrete, focusing on illustrative examples to highlight the real-world relevance of ocean observing

3. Pool resources and allocate responsibilities between the different ocean observing initiatives, including GOOS, GEO Blue Planet and POGO.

4. Speed-up delivery time of Blue Print to mid 2018

5. Structure relations with user needs more precisely, for example related to Ocean health (e.g. Ecosystem-based management regimes, World Oceans Assessment); Operational products – AtlantOS WP8 Societal Benefit Areas, generally support to early warning systems and Blue Economy / industry decision-making processes; Climate projection and services; and, Illustrative case studies such as storm surges and plastics.

6. Foresight/Analysis activities, including on the following topics: ocean observation governance (e.g. analysis of best-practices in the governance of observations), innovative finance for ocean observing (with Engagement Board and possibly OECD project), next generation technologies (possibly with JPI Oceans) and EOVs and user requirements (e.g. innovative linkages and best-practice examples).

7. Future governance/management of the observing system in the Galway area

Cooperation and interaction with other projects and initiatives

WP10 partner EMB have ongoing interactions with EuroGOOS in developing the strategy and coordination of the European Ocean Observing System (EOOS). In addition, EMB attended and presented at the EuroGOOS international conference on 3-5 October 2017. EMB also acts as a key link across the science-policy interface for ocean observation. This includes links, to the wider marine scientific network (33 organizations, 19 countries). But also, to the European Commission since EMB has regular interaction with multiple DGs (e.g. DG RTD, DG MARE, DG ENV, DG GROW) including development of the EOOS coordination framework and planning for EurOCEAN 2019.

Achieved main results

- AtlantOS now has an overview of “Best Practices in Stakeholder Engagement, Data Dissemination and Exploitation”
- WP10 has played the lead in seeking the discussion with funding agencies in North America. Based on this experience a similar informal exchange of ideas is planned for the EU; that is, with the EU Member States and the European Institutions.
- The AtlantOS website has been updated and improved, contributing to a steady stream of interested visitors.

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 high-level events like the United Nations – *The Ocean Conference* in New York, the UN conference on Climate Change (COP23) in Bonn or the GEO plenary meeting in Washington.

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, it's 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 2nd period, AtlantOS conducted 2 amendments, the first one in July 2016 was requested by the EC to integrate the updated version (3.0) of the Model Grant Agreement (MGA), the second amendment was a change of beneficiary due to partial takeover requested by AtlantOS beneficiary ESF-EMB which became EMB-IVZW. This latter amendment, was also used to update the Grant Agreement regarding all issues that have changed since the first amendment (summer 2016) 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 budge of AtlantOS nor to the scientific work plan.
- The internal communication within AtlantOS is provided via the AtlantOS intranet, via the projects newsletter which has always a specific focus, and via email and telephone calls. It is conducted in close cooperation with WP10. 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.
- The PCU prepares the agenda and information material for internal and external board meetings as well as meeting minutes, the project periodic reports, reports for the external boards, and the general AtlantOS presentation (ppt, poster, flyer, newsletter etc.) and is highly involved in high-level communication activities to promote the action and its findings e.g. during the preparatory conference to the UN *The Ocean Conference* (Feb 2017) and the UN *The Ocean Conference* (June 2017) both in New York. The two side events that had been organises (i. *Building partnerships for Integrated Ocean Observing and Information in support of the implementation of SDG 14,* ii. *Alliances for Integrated Ocean Observing and Information Services Supporting the Implementation of Sustainable Development Goal 14*) were very well received by the audience. 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. Moreover, the PCU is currently, preparing for the development and production of a short (2 – 2.5 minutes) whiteboard graphic animation to feature the project and its added value to the scientific and stakeholder community of Atlantic Ocean Observation. Due to the fact that AtlantOS is not a pure research project but a structural project to enhance and optimise integrated Atlantic Ocean Observation it seems appropriate to explain the project and its main goals as simple but impressive as possible. To ensure smooth administrative procedures and best possible information flux between the EC and AtlantOS for mutual benefit we are in regular contact with our project officer Gaelle Le Bouler in Brussels.

- 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. One major advice that was given during the last GA meeting, namely to ensure that the planned Atlantic Ocean Observing BluePrint document should develop as an action starting from AtlantOS but growing out of it to ensure highest level engagement of all experts in Atlantic Ocean Observing to produce a comprehensive high-level document, had a great impact. Subsequent to the last GA meeting, AtlantOS, with great support by Brad DeYoung, was intensively working to (i) open an international application procedure to develop a writing team, (ii) to select experts considering good balance regarding discipline, geography and gender, (iii) to develop a good document structure, (iv) to retrieve the required high-level input, and (v) finally to produce the first draft document. Beginning 2017 the BluePrint team had an initial telephone conference and since than 4 face-to-face meetings (see table of AtlantOS meetings). Soon after the writing team had been adopted, Brad DeYoung had been so kind to accept the lead of the team, supported by Martin Visbeck as coordinator of AtlantOS and by Sandra Ketelkake. The first version of the BluePrint document will be provided to the AtlantOS community shortly before the 3rd GA meeting. The BluePrint team expects to retrieve feedback to the report during a dedicated break-out session during the 3rd GA meeting. Subsequent to the GA the BluePrint team will meet for 1.5 days to discuss the feedback they received on the first version and to discuss last steps to ensure finalisation by spring/early summer 2018.
  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, this number might rise as further individuals with relevant expertise are identified by the project. The ENB will provide strategic-level advice to the AtlantOS consortium to ensure the vision of a sustained integrated ocean observing system for the Atlantic will be achieved. The ENB is invited to participate to the GA meetings, however, most substantial work will take place over the course of smaller meetings to support e.g. (i) the collaboration with the OECD, (ii) the exchange of ideas on sustainable funding of Atlantic Ocean Observing, (iii) the Blue Print Writing group, and (iv) Ocean Observing and Sustainable Development Goal (SDG) briefings which was for example already twice done by Kristina Gjerdes. 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 EB had an additional face-to-face

meeting in February 2017, the Steering Committee had an additional face-to-face meeting in September 2017. This latter meeting was following individual telephone/skype/webex meetings of the PCU with all WPs to discuss individual WP issues, which were summarized during the SC meeting in September. The SC meetings main focus was the 3rd GA, evaluation of WP cooperation as well as the representation of the added value of AtlantOS particularly featuring why AtlantOS as a project was important to make progress regarding integrated Atlantic Ocean Observing. The 3rd AtlatnOS GA meeting and the board meeting at the GA are considered extremely relevant to join forces regarding this issues and to define the next steps for the final phase of AtlantOS. 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 2nd project period by presentation at various conferences and high-level science-policy events e.g. EGU 207 meeting in Vienna, the GEO XIII 2016 and GEO XIV 2017 Plenary Meeting in St. Petersburg and Washington, respectively, the ICRI meeting in Cape Town in October 2016, the EU Project Blue Action Kick off Meeting, the EU Action Blue Cloud workshop, the EU high-level meeting 'An Era of Blue Enlightenment' in July 2017 in Lisbon, the GEO European Project Workshop in Helsinki, the UN Preparatory meeting for the UN The Ocean conference in February and the UN The Ocean Conference in June 2017 in New York (see as well table of AtlantOS events – showing events that have been organised or co-organised by AtlantOS). Additionally, the PCU and WP10 supported WP2 scientist Toste Tanhua to convince the Volvo Ocean Race organisers to take ocean observing technology on-board for Ocean Race Yachts CP1756. This initiative can be followed on the AtlantOS webpage.

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 2nd project period, the PCU, in cooperation with WP10, WP8 and a GEOMAR colleague, Kristin Hamann, who is currently conducting a secondary study on 'science marketing', had a various fruitful discussion on issues regarding stakeholder engagement and impact gained by project findings and results. It had been realized that there is a strong need to go back to the task leaders, which are closest to the stakeholders in their field of expertise, to request their experience on various issues regarding stakeholder engagement and impact e.g. which stakeholder groups they are in contact with, by which means of communication or information exchange, why do they consider these stakeholders important and what are the expectations from these stakeholders. According to the evaluation of the questionnaire and various communications with task leaders the Exploitation Plan for AtlantOS will be updated towards the end of 2017.

In cooperation with WP7 we will consider to update the Data Management Plan based on the extensive experience WP7 has gained during the 2nd project period. The DMP will be updated towards the end of 2017.

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 profiting 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 basis to exchange experiences and develop best practices. For the upcoming Ocean Science Meeting in February 2018 in Portland we applied successfully for 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 2nd AtlantOS GA meeting with a special focus on biodiversity
- Implementation of the Atlantic Ocean BluePrint initiative including finalisation of the first draft (short version)
- Two very successful side events at the UN The Ocean Conference and the Preparatory meeting to The Ocean Conferene
- Fruitful exchange of ideas with AORA
- The cooperation with the Volvo Ocean Race organisers to take Ocean Observation technology on-board
- Enhanced information on task leader interaction with stakeholders

AtlantOS meetings (July 2016 – Nov 2017):

Meeting	Time	Place	Organiser
Best Practice workshop on trace element measurements in oceanography	18-20 July 2016	Plymouth University	Task 6.2
AtlantOS joint workshop on strategies, methods and new technologies for a sustained and integrated autonomous in-situ observing system for the Atlantic Ocean, supported by the AORA-CSA.	2-4 November 2016	Gran Canarias	WP6, PLOCAN
4th WP7 task 7.1 and 7.2 meeting	14-15 December 2016 and 11 January 2017	Brest and videoconference	WP7, IFREMER

Atlantic Ocean Observing BluePrint Small Writing Team Meeting	27 January 2017	Webex conference	PCU
Side event ,Building partnerships for Integrated Ocean Observing and Information in support of the implementation of SDG 14' at Preparatory UN conference ,The Ocean Conference'	15 February 2017	New York	PCU, UNESCO
Webex meeting inter-WP cooperation between WP8-WP10-WP7	22 February 2017		WP8
Executive Board Meeting	24 February 2017	Brussels	PCU
1st Atlantic Ocean Observing BluePrint Meeting	24 February 2017	Brussels	PCU
Exchange of Ideas with AORA	7 April 2017	Washington	KDM
2nd Atlantic Ocean Observing BluePrint Meeting	23 April 2017	Paris	PCU
3 Preparatory webex meetings to organise Transatlantic Data Harmonization workshop	14 December2016 10 January 2017 22 February 2017		WP7, UniHB
AtlantOS Transatlantic Ocean Data Harmonization workshop	7-8 June 2017	Brussels	WP7, UniHB
Side Event ,Alliances for Integrated Ocean Observing and Information Services Supporting the Implementation of Sustainable Development Goal 14' at UN ,The Ocean Conference'	8 June 2017	New York	PCU
3rd Atlantic Ocean Observing BluePrint Meeting	9-10 June 2017	New York	PCU
Side Event 'Harmnonisation of Ocean Observation and Information' at the GEO week	20 June 2017	Helsinki	UNESCO, WP1, IEEE
Side event 'Connecting to better observe the Atlantic Ocean' at EU event 'A New Era of Blue Enlightenment'	12 July 2017	Lisbon	Ecole Normale Superieure, GEOMAR
4th Atlantic Ocean Observing BluePrint Meeting	14 July 2017	Lisbon	PCU
WP8 2nd Technical Meeting	18-20 July 2017	Dublin	WP8, MI
3 webex meetings on usage log monitoring	22 May 2017 3 July 2017		WP7, Ifremer

	20 September 2017		
WP specific Skype and Telephone conferences between all WPs and PCU	July – Sep 2017		PCU
Steering Committee Meeting	21 September 2017	Brussels	PCU
Side Event 'Ocean Applications from the AtlantOS project' at GEO week	24 October 2017	Washington	WP1
Upcoming meetings			
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
3rd AtlantOS General Assembly Meeting including special focus day 'Sensors, Innovation of Observing Technologies and the private sector'	21 – 23 November 2017	Gran Canarias	PCU, PLOCAN, WP6
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

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: Kate Larkin, Sabrina Speich, Matthew Mowlem, Albert Fischer, Pierre Yves Le Traon. From January 2016 to April 2017 we had to replace Kate Larkin due her maternity leave. She was replaced by Isabel Sousa Pinto who has great expertise in biodiversity which was so far underrepresented in the EB. Since April 2017 Kate Larkin is back as a member and the Isabel Sousa Pinto remained in the EB. Accordingly, the EB has in its current composition 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 liaise 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 Pinardi, 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 divers 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. Follow-up of recommendations and comments received by ISTAB in June/July 2016

In the following we briefly describe how we responded to the recommendation (written and oral) you have given to the AtlantOS consortium in summer 2016.

- 'The Work Packages could be better integrated and could work together more effectively than they appear to be':
  In this reporting period the cross work package fertilization practiced in AtlantOS was intensified and more explicitly highlighted in the report. For example, we added for all WP reports sub-chapters on 'cooperation and interaction with other AtlantOS WPs' to shade some more light on the different levels of cross WP cooperation. Obviously, the cross WP cooperation varies between the different work packages, some were cooperating actively since the start and others started later. Recently, various cross WP meetings have been taken place e.g. (i) all WP7 meeting are since the start cross WP meeting, (ii) the AtlantOS – AORAC-SA joint meeting on strategies, methods and technologies for a sustained autonomous in-situ observing system in November 2016, (iii) the WP8 technical meeting in January 2016 and in July 2017, (iv) the AtlantOS observing network enhancement meeting in July 2016, (v) the EOVs meeting in July 2016, (vi) the OSSE (Task1.3 & Task 5.3) meeting in September 2016, and (vii) the Meeting on Advances in observing technologies in December 2016.

- 'Developing an Atlantic Ocean Observing BluePrint initiative inviting the entire and diverse community to participate':
  As described in the WP11 report, this advice was very well received by the AtantOS community. We started the procedure to develop a high-level expert group reflecting expertise far beyond the AtlantOS consortium right after the last GA meeting. Beginning 2017 we organised a kick-off webex meeting to plan (i) an international application procedure to develop a writing team, (ii) to discuss the procedures to select experts considering good balance regarding discipline, geography and gender, (iii) to discuss the development of a good document structure, (iv) to discuss retrieval procedures of the required high-level input. Since this final webex meeting the established BluePrint team had 4 face-to-face meetings (see table of AtlantOS meetings). The

product of this meetings and various cross-expert communications is the first comprehensive draft of a short version of the 'Atlantic Ocean Observing BluePrint' document. Feedback to this draft will be retrieved during the 3rd GA meeting and evaluated during the 5th BluePrint meeting on Gran Canarias subsequent to the GA meeting.

1. 'Develop a summary roadmap identifying (i) the links between the different participants and OOS considered under AtlantOS and (ii) the different modes of AtlantOS' contributions to the development and integration of OOS in the Atlantic Ocean:
   During the 2nd project period A. Reitz, A. Fischer and M. Visbeck contributed an introduction chapter entitled 'Opportunities, challenges and requirements of ocean observing' for a book edited by E. Delory and J. Pearlman entitled 'Challenges and innovations in ocean in-situ sensors – Measuring inner ocean processes and health in the digital age'. This introductory book chapter summarises the history of Ocean Observation as well as the links between the different main initiatives in Ocean Observation Systems considered under AtlantOS. Moreover, the BluePrint lays out the need for, and suggests ways to accomplish, cooperation between different participants in improving and maintaining an integrated Atlantic Ocean Observing System. More specifically within the AtlantOS project, Deliverable 1.7 (the Refined Integrated Atlantic Ocean observing system requirements Report) will consider how AtlantOS partners can create further links to meet the needs in societal benefit areas including climate, operational services, and ocean health.
2. Enhance cooperation of WPs:
   As described above cooperation between WPs has increased a lot during the 2nd project period and will be even more intensified during the upcoming GA meeting with several cross cutting activities e.g. all meetings on Friday but also some task meetings (e.g. task 4.4, 6.4).
3. Opportunities to encourage South Atlantic engagement as done in WP5:
   WP5 is intensively engaging with scientists from the South Atlantic (see 'Essential Ocean Variables' workshop in June/July 2016 with participants from AO, BR, NG, UY, AR, MA, NA, ZA, and CV and the work shop 'Connecting to better observe the Atlantic Ocean' aligned to the EU high-level event in conjunction to the signing of the Belem Statement. As displayed by the cooperation WP5 has within AtlantOS to other WPs the engagement with colleagues in the South Atlantic is ignited by WP5 and spread through cooperation to almost all WPs.
4. Gaps
   (a) benthic activities: IOC and the GOOS Biology / Ecosystem Panel are working to formalise EOVs and their measurements, primarily in the coastal areas. In the benthic zone, these include live coral, seagrass cover, macro-algal canopy, and mangrove cover. An implementation plan for the coral EOV, for example, is being developed for February 2018 and will include (GOOS, MBON, and UNEP) requirements, best practices, and current capabilities. While these efforts are focussed globally, there will be impacts in the Atlantic Ocean.
   (b) marine spatial planning: WP8 task 8.6 develops innovative 'Good Environmental Status' indicators for the MSFD from reanalyses. To ensure progress in this regards they will further intensify their cooperation with WP4 and WP5. Further, WP8 partners made a concerted effort to include Legal/Administrative GIS layered in D8.2. Additional GIS layers used included those related to Marine Protected Areas, Oil & Gas fields, Offshore Windfarms, Other Aquaculture areas relevant to MSP. Furthermore, the seafloor mapping group in WP2 implemented GIS-based pilot areas for detailed mapping. The definition of this pilot area was conducted with a recently established international seafloor mapping group.

(c) ocean acidification: The recently established "Global Ocean Acidification Observing Network (GOA-ON)" (www.goa-on.org) is the hub to align the various acidification related observing efforts in the individual observing networks (ships, moorings, autonomous) into a global context. If possible we always aim in AtlantOS to integrate into the global coordination (in particular JCOMM and GOOS/GCOS).
All the above issues are as well co-discussed during the high-level side events we organised (e.g. Town Hall at OSM 2016, side events at UN The Ocean Conference, upcoming side event at the OSM 2018.

5. Encourage engagement between individual WPs and stakeholders:
As described in WP10 and 11 we had various discussions about engagement and impact in AtlantOS and approached the task leaders with a questionnaire regarding their engagement with stakeholder to break this issue down to the base where more direct engagement is conduced. We do recognize that this challenge still exists and will be called out for during the GA. However, we see good steps taken in various parts of the consortium.
6. Emerging Networks – clarify the desired legacy of this effort:
The deliverable D6.2 describes where emerging networks that started to gain importance and consider critical EOVs could be within three and ten years. These networks are currently small scale programs or communities that, with focus, could become more important in the future. The intention for the roadmap is to highlight these opportunities to the community to enhance early adoption and collaboration. By design the emerging networks roadmap is made freely available alongside the sensors and instrumentation roadmap. Emerging networks can be limited by the availability of appropriate technology, as highlighted in the deliverable, and placing the two roadmaps alongside one another will foster coordination of what the scientific community wishes to observe and the development of the instrumentation to do so. The emerging networks roadmap is also undergoing an update that will include new insights and material from elsewhere within the AtlantOS project. This will enhance the relevance of the roadmap and strengthen the links across the community. The desired legacy is that the highlighted emerging networks reach maturity earlier than they otherwise would have.
7. Data Flow and Integration plan – develop specific priorities, actions, and outcomes:
A work plan with specific priorities, actions, and outcomes was established by WP7 partners during the 4th WP7 meeting held mid-December 2016. It is detailed in the meeting report (http://doi.org/10.13155/51745). There are two specific issues on which actions are specifically undertaken: (1) standardization for biological EVs that is not achieved, and the action is on-going in collaboration with GOOS and (2) on data policy the need to push for sharing of *biogeochemical observations* via the integrators. Also, to ensure the endorsement at European level on the recommendations setup within AtlantOS WP7, a close collaboration is established with EUROGOOS DATAMEQ working group. For the convergence at transcontinental level, the mid-2017 workshop was a first step, building on continent expertise and existing projects such as ODIP projects. Transcontinental activities will be carried out on three identified subjects by dedicated working groups, with the goal of presenting 3 white papers on selected topics at the OceanOBS19-conference. The importance of initiatives such as IQUOD or ODIP was highlighted and their sustainability recommended. The outcome from this workshop will also be used to populate the data section for the Atlantic Ocean Observing BluePrint.
8. The precise target of WP8:
WP8 has documented downstream service capacities for several societal benefit areas. WP8 plans in the third project phase to become actively engaged with stakeholders and to use the

EMODnet Checkpoint framework to assess the impact of ocean observations on the Targeted products. It will further produce 7 Data Adequacy Reports (see for a definition http://www.emodnet-mediterranean.eu/checkpoint_information/) that will show the "fitness for use" of the observational, modelling and forecasting data in the Use Case products. This will in turn feedback on the data providers and potentially improve the observing, modelling and forecasting systems. Regarding the identification of observing gaps, WP8 is cooperating with WP1.

6. Publications

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Second Report of the International Scientific Technical and Advisory Board (ISTAB) to AtlantOS

8.Dec.2017

In Las Palmas - Brad deYoung and Eric Lindstrom (co-chairs), Maria Paz Chidichimo, Moacyr Araujo, Angelika Brandt, Alexandra Giorgetti, Peter Croot, Murray Roberts. By invitation Zdenka Willis.

Absent from Las Palmas – Isabelle Ansorge, Molly Baringer, Suzanne Carbotte, Oscar Schofield.

The ISTAB committee was given the 2nd AtlantOS summary progress report for the external advisory boards November 2017 (63 pp.) in advance of the General Assembly(GA) that was held in Las Palmas 22-23 November. The ISTAB met with the Executive Board (EB) on Tuesday afternoon 21 November before the GA and attended the presentations from the Work Packages on Wednesday 22 November. The ISTAB attended sessions on Thursday morning and then met on Thursday afternoon 23 November to discuss its concerns and organize its response. The ISTAB then met with Martin Visbeck and Anja Reitz to provide them with verbal feedback on the primary concerns noted by the ISTAB.

Summary

The ISTAB found it difficult to understand how well the WPs were performing based solely on the written report. While the report for the 2017 GA was clearer and more useful than the report at the last review, the ISTAB still found it difficult to distinguish between activities and real progress. The presentations by the WP leaders helped to fill in some of the gaps and in the end the ISTAB believes that it formed a clear impression of the progress and results of the various WPs.

On the whole the ISTAB is impressed by the progress of AtlantOS. We found strong evidence that in many areas AtlantOS is significantly contributing to the improvement of ocean observation. The support of the Galway and Belem accords by AtlantOS is a benefit to the wider Atlantic community.

The reports provided lists indicating collaboration between the different WPs however there was little documentation to support the assertions. For example some of the connections seemed to be uni-directional and some collaborations were not reported by the other WP. We did get the impression at the Las Palmas meeting, in particular in the two days before the GA of growing connections and collaborations between the WPs. The ISTAB has some concerns, however, and also sees opportunities for improvement. The concerns noted by the ISTAB include

issues of process, e.g. how the network is operating or communicating, while others are of substance on what the WPs are, or are not, doing.

As AtlantOS moves forward to its completion in 2019 we encourage attention to addressing the question of how success would look like and what should be the AtlantOS legacy. AtlantOS should clearly outline and communicate its successes and how it has contributed to the improvement of sustained ocean observing within the Atlantic Ocean basin, both so that network participants can recognize their achievements but also so that the wider community can see how sustained ocean observing is envisioned to evolve.

Our general concerns can be organized around two fundamental uses: communication, synthesis and legacy.

Communication:

(1) The summary report: We found the written report awkward and challenging to digest. While there were many lists, e.g. statements about collaborations, there was not enough information to judge the work being described. This report may satisfy funding agencies but we wonder whether the information provided is sufficient to enable effective management by the EB. It is insufficient for the ISTAB to be clear where performance is falling below the mark. We think that improved assessment and communication of progress would benefit the network in several ways. Most importantly, we think that the present communication strategy makes it difficult for network participants to identify opportunities for collaboration. We also think that the present report structure makes it difficult for the participants or the WPs to see how they are contributing to the network or are partners with others in the network.

We suggest that future requests for information ask for identifiable, tangible evidence of progress. We also suggest that the management team work to develop summaries that demonstrate the real progress of the network. One thought would be to develop figures that demonstrate connectedness of the network, both internally and externally, both thematically and structurally. We believe that such figures could make a stronger case for where they fit and the progress and influence of the network and help guide participants to see how they could further contribute to ocean observing developments, not only within AtlantOS but also in the wider European and Atlantic context.

(2) Presentations – As noted above, we did find the presentations to be useful but they often failed to deliver a clear and compelling message. While the format could be improved, the key issue was the lack of any overview. Even where the progress of the WP was significant there were clear opportunities to improve the communication of the WP. We suggest that the WPs focus

less on checking off the milestones and more on the stories that demonstrate clear impact, significant results and connectivity with other WPs. It would also be expected as the WPs continue to develop that they should address the issue of legacy, what AtlantOS will leave behind after it ends. It will be difficult to cover all aspects of the WP activities but better to focus on descriptions of significant results that are clear and compelling than summaries that are wordy and fulsome but rather un-compelling.

(3) External communications - Some of the WPs have a direct responsibility for external communications but at some level this is a responsibility for all the WPs. The management team should take overall responsibility for development of a communications strategy, identifying the message and the audience, but each of the investigators and WPs could contribute to the implementation of the strategy. Working towards the end of the program, and the focus on legacy, it will be important to communicate not only to the funding agencies, but also to the other partners in ocean observing what AtlantOS has contributed. AtlantOS may also identify key messages to deliver based upon the work that has been done and the AtlantOS perspective on the present state of ocean observation programs and activities.

(4) Engagement – At the June 2016 meeting in Kiel, the EB offered that it would form an Engagement Board to enhance communication and coordination with ocean observing partners. The Board exists but has not met nor has it been effective. We encourage the EB to reevaluate the utility of the Engagement Board and explore other opportunities for Engagement. The connection to users, either through the Board or the WPs, is a weakness, in particular the limited engagement and communication with the end user communities. Greater involvement of and connection with users is an inescapable ingredient to achieving a fit-for-purpose AOS. We agree that it is difficult and there is no simple answer to the challenge, but it is worth more attention and renewed effort. Perhaps holding sectoral workshops, or attending relevant partner meetings?

Synthesis and legacy:

(1) Legacy – While some of the WPs have clearly begun to think about legacy issues (e.g. the best practices in data handling in WP7) most have not. While the management team is aware of the need to support legacy initiatives, this challenge is one that requires more attention and focus. Of course most of this work should take place at the WP level but perhaps there is cross-cutting activity that has to be managed above the level of the WPs. We recommend that there be explicit attention to identify goals for legacy development and that future reporting address this issue. What is valuable and what should be preserved?

(2) Bridging across the WPs – The written reports and the presentations identify much more collaboration between the WPs but we wonder about the gaps between the WPs that are being missed where no single WP is taking

responsibility for a task. The focus on the 2030 vision is an example of an activity that clearly spans most, if not all of the WPs but we wonder if there are others that we have missed.

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Second Report of the International Scientific Technical and Advisory Board (ISTAB) to AtlantOS

8.Dec.2017

In Las Palmas - Brad deYoung and Eric Lindstrom (co-chairs), Maria Paz Chidichimo, Moacyr Araujo, Angelika Brandt, Alexandra Giorgetti, Peter Croot, Murray Roberts. By invitation Zdenka Willis.

Absent from Las Palmas – Isabelle Ansorge, Molly Baringer, Suzanne Carbotte, Oscar Schofield.

The ISTAB committee was given the 2nd AtlantOS summary progress report for the external advisory boards November 2017 (63 pp.) in advance of the General Assembly(GA) that was held in Las Palmas 22-23 November. The ISTAB met with the Executive Board (EB) on Tuesday afternoon 21 November before the GA and attended the presentations from the Work Packages on Wednesday 22 November. The ISTAB attended sessions on Thursday morning and then met on Thursday afternoon 23 November to discuss its concerns and organize its response. The ISTAB then met with Martin Visbeck and Anja Reitz to provide them with verbal feedback on the primary concerns noted by the ISTAB.

Summary

The ISTAB found it difficult to understand how well the WPs were performing based solely on the written report. While the report for the 2017 GA was clearer and more useful than the report at the last review, the ISTAB still found it difficult to distinguish between activities and real progress. The presentations by the WP leaders helped to fill in some of the gaps and in the end the ISTAB believes that it formed a clear impression of the progress and results of the various WPs.

On the whole the ISTAB is impressed by the progress of AtlantOS. We found strong evidence that in many areas AtlantOS is significantly contributing to the improvement of ocean observation. The support of the Galway and Belem accords by AtlantOS is a benefit to the wider Atlantic community.

The reports provided lists indicating collaboration between the different WPs however there was little documentation to support the assertions. For example some of the connections seemed to be uni-directional and some collaborations were not reported by the other WP. We did get the impression at the Las Palmas meeting, in particular in the two days before the GA of growing connections and collaborations between the WPs. The ISTAB has some concerns, however, and also sees opportunities for improvement. The concerns noted by the ISTAB include

issues of process, e.g. how the network is operating or communicating, while others are of substance on what the WPs are, or are not, doing.

As AtlantOS moves forward to its completion in 2019 we encourage attention to addressing the question of how success would look like and what should be the AtlantOS legacy. AtlantOS should clearly outline and communicate its successes and how it has contributed to the improvement of sustained ocean observing within the Atlantic Ocean basin, both so that network participants can recognize their achievements but also so that the wider community can see how sustained ocean observing is envisioned to evolve.

Our general concerns can be organized around two fundamental uses: communication, synthesis and legacy.

Communication:

(1) The summary report: We found the written report awkward and challenging to digest. While there were many lists, e.g. statements about collaborations, there was not enough information to judge the work being described. This report may satisfy funding agencies but we wonder whether the information provided is sufficient to enable effective management by the EB. It is insufficient for the ISTAB to be clear where performance is falling below the mark. We think that improved assessment and communication of progress would benefit the network in several ways. Most importantly, we think that the present communication strategy makes it difficult for network participants to identify opportunities for collaboration. We also think that the present report structure makes it difficult for the participants or the WPs to see how they are contributing to the network or are partners with others in the network.

We suggest that future requests for information ask for identifiable, tangible evidence of progress. We also suggest that the management team work to develop summaries that demonstrate the real progress of the network. One thought would be to develop figures that demonstrate connectedness of the network, both internally and externally, both thematically and structurally. We believe that such figures could make a stronger case for where they fit and the progress and influence of the network and help guide participants to see how they could further contribute to ocean observing developments, not only within AtlantOS but also in the wider European and Atlantic context.

(2) Presentations – As noted above, we did find the presentations to be useful but they often failed to deliver a clear and compelling message. While the format could be improved, the key issue was the lack of any overview. Even where the progress of the WP was significant there were clear opportunities to improve the communication of the WP. We suggest that the WPs focus

less on checking off the milestones and more on the stories that demonstrate clear impact, significant results and connectivity with other WPs. It would also be expected as the WPs continue to develop that they should address the issue of legacy, what AtlantOS will leave behind after it ends. It will be difficult to cover all aspects of the WP activities but better to focus on descriptions of significant results that are clear and compelling than summaries that are wordy and fulsome but rather un-compelling.

(3) External communications - Some of the WPs have a direct responsibility for external communications but at some level this is a responsibility for all the WPs. The management team should take overall responsibility for development of a communications strategy, identifying the message and the audience, but each of the investigators and WPs could contribute to the implementation of the strategy. Working towards the end of the program, and the focus on legacy, it will be important to communicate not only to the funding agencies, but also to the other partners in ocean observing what AtlantOS has contributed. AtlantOS may also identify key messages to deliver based upon the work that has been done and the AtlantOS perspective on the present state of ocean observation programs and activities.

(4) Engagement – At the June 2016 meeting in Kiel, the EB offered that it would form an Engagement Board to enhance communication and coordination with ocean observing partners. The Board exists but has not met nor has it been effective. We encourage the EB to reevaluate the utility of the Engagement Board and explore other opportunities for Engagement. The connection to users, either through the Board or the WPs, is a weakness, in particular the limited engagement and communication with the end user communities. Greater involvement of and connection with users is an inescapable ingredient to achieving a fit-for-purpose AOS. We agree that it is difficult and there is no simple answer to the challenge, but it is worth more attention and renewed effort. Perhaps holding sectoral workshops, or attending relevant partner meetings?

Synthesis and legacy:

(1) Legacy – While some of the WPs have clearly begun to think about legacy issues (e.g. the best practices in data handling in WP7) most have not. While the management team is aware of the need to support legacy initiatives, this challenge is one that requires more attention and focus. Of course most of this work should take place at the WP level but perhaps there is cross-cutting activity that has to be managed above the level of the WPs. We recommend that there be explicit attention to identify goals for legacy development and that future reporting address this issue. What is valuable and what should be preserved?

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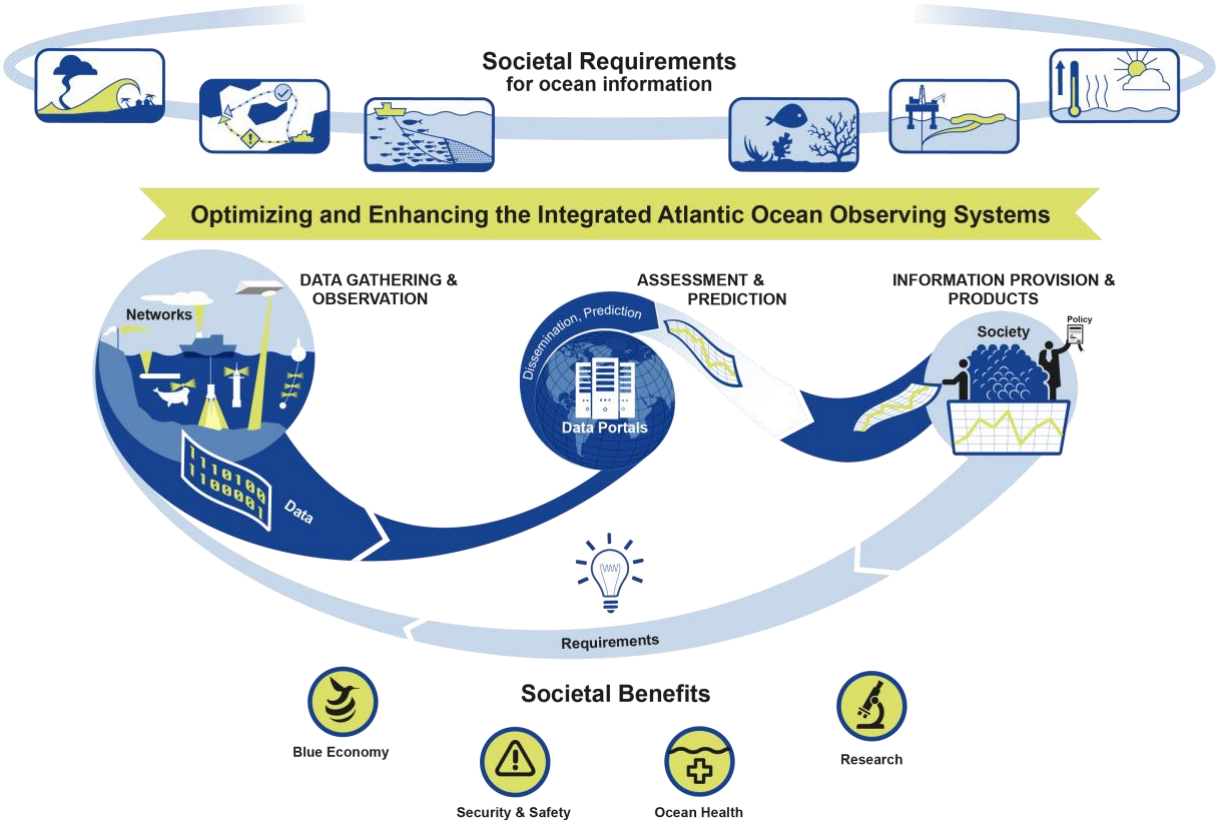
ATLANTOS LEGACY



April 2018

Introduction

The vision of AtlantOS is to improve and innovate Atlantic Ocean 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 information required by industries, product supplying agencies, scientists and citizens.

The overarching target of the AtlantOS initiative has been to advance ocean observing in the Atlantic and articulate an advanced framework for evolving and sustaining an integrated Atlantic Ocean Observing System that goes beyond the state-of–the-art for the next decade.

Specific objectives of AtlantOS are:

- to improve international collaboration in the design, shared implementation, data delivery and benefit sharing of (in-situ) ocean observing,
- to promote engagement and innovation in all aspects of ocean observing,
- to develop, share and use best practices,
- to facilitate equitable and open access to ocean data and information,
- to enable and disseminate methods of achieving quality and authority of ocean information, and
- to strengthen the Global Ocean Observing System, engage with the Blue Planet initiative of GEO, and 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.

AtlantOS is a 4-year H2020 Research and Innovation project that began in April 2015. The work carried out to meet the aforementioned ambitious objective will deliver a long-lasting and sustainable contribution to realising societal, economic and scientific benefits arising from the integrated approach. The ambition of the present document is to briefly outline the legacy of AtlantOS for the benefit of the Atlantic Community and to inform on the preparation of the ***BluePrint for an Atlantic Ocean Observing System*** and its related European vision document. It is believed that the AtlantOS Legacy will act as an inspiration to other communities engaged in regional ocean observing systems.

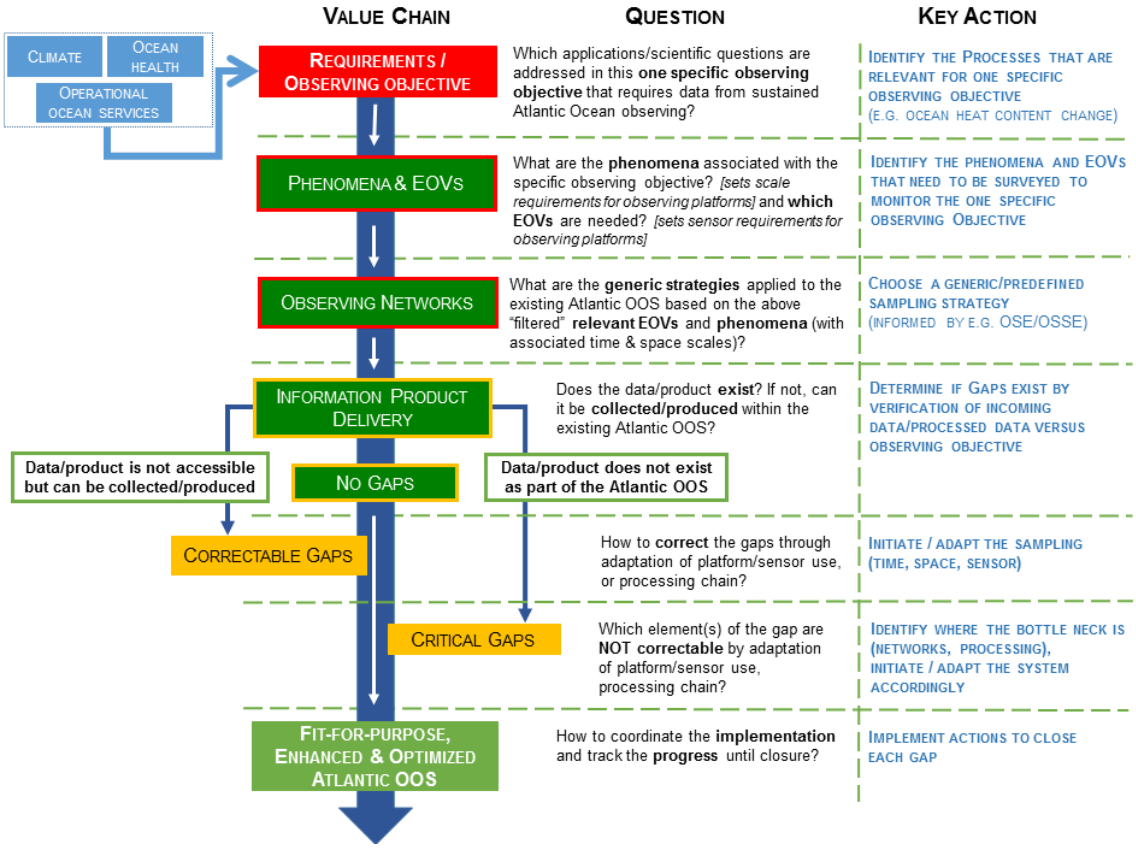
Where has AtlantOS brought us since 2015

Societal needs and requirements

To determine an adequate observing strategy, the observing objective needs to be defined first (Figure 1). Observing objectives for sustained observing should address one or more societally-relevant needs, which, for example, could be a routine product that informs society about the status of a part of the ocean but which may ultimately ask for a decision to be taken.

After defining the observing objective for sustained ocean observing, a set of relevant phenomena such as fronts and eddies, upwelling air-sea fluxes etc., and essential ocean variables (EOV), will emerge with considerations of the regional context. The phenomena assist in determining time and space scales over which the observing must be executed. The phenomena also narrow down the EOVs that belong to the observing objective. From the combination of phenomena and EOVs, the set of suitable observing platforms

and sensors can be determined. This "selection" is, *per-se,* a predefined process because each observing platform has its own limited/known time/space/sensor potential.



Stages of the value chain for design of a fit-for -purpose observation network

The focus of AtlantOS is to design a multiplatform, multidisciplinary Atlantic-wide system, which requires that data collected by the observing platforms be used for many different observing objectives. On the one side, this is the beauty of a truly integrated system, but on the other hand the capacity and gap analysis then has to be done along the full value chain. The capacity of the sustained observing system defines the ability to deliver information that can serve additional observing objectives.

The AtlantOS work on requirements identified the following challenges:

- The climate, operational ocean services, and ocean ecosystem health communities need to explicitly work towards a more integrated and efficient observing system instead of focussing on their individual priorities.
- The optimal mix of observing platforms to measure the required space and time scales for the needed applications and scientific challenges require a more methodical and systematic approach, keeping in mind the common framework, so that recommendations are both traceable to source and reasoning, as well as compatible to avoid duplication of observing systems.

Observing system evaluation and gap analysis

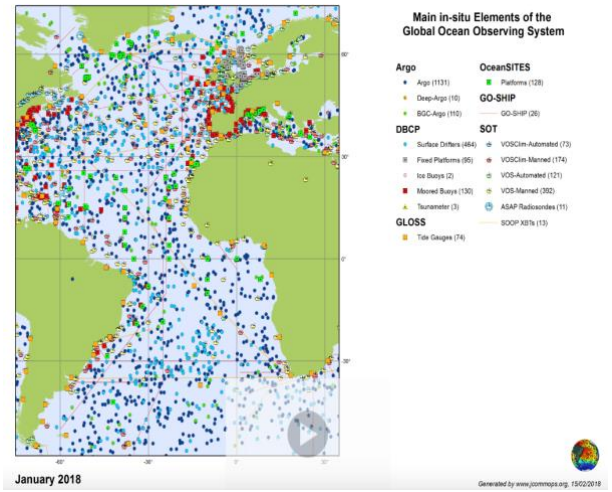
In general, the readiness of the integrated ocean observing system is measured across three components:

1) an understanding of the requirements for data from the integrated observing system (i.e., the EOVs needed to meet the observing objectives);

2) the ability to make observations with sufficient accuracy on the required time and spatial scales (which depends on technology, funding, and cooperation among observing networks); and
3) data analysis, data management, and the provision of ocean information to users in timely fashion (which includes common standards, as well as free and open access to data).

Along each of these three dimensions, the readiness of the observing system evolves from concept through pilot to mature, with rigorous review, vetting, and approval by the community to allow for innovation while protecting against inadequate or duplicative solutions.

Constant monitoring of ocean observing capacity, as well as the gaps in the system, is a core activity to ensure an optimized, and thus cost efficient, sustainable and purposeful observing system. In this respect, sustained ocean observing is different from ocean observing for fundamental research performed only for a defined period only. However, both, the sustained and research-driven observing efforts should benefit from each other. The most obvious link is via data exchange - while observing in the sustained system must provide open-access data, the fundamental researchers should make their data open-access as well, to ensure the data is integrated into the ocean observing value chain.



AtlantOS has, via close cooperation with JCOMMOPS and EuroGOOS/EMODnet, fostered the next generation of a web-based information system providing real-time and persistent monitoring of existing Atlantic Ocean observation capacity. The system consists of two components:

- A full Atlantic system - based on the JCOMMOPS web-based monitoring system
- The European component of the Atlantic Ocean Observation System - via a web monitoring tool developed by EuroGOOS/EMODnet.

The AtlantOS impact in terms of connection, availability, and accessibility of data sets is easily represented by these tools.

The gaps in the sustained observing system are defined by the observations (time/space/sensor) that are not available to inform society sufficiently in respect to defined observing objectives. It is not yet possibly to perform a detailed gap analysis due to the very different levels of "maturity" in setting societal requirements for designing and carrying out sustained measurements of physical, biogeochemical and biological phenomena and EOV's needed to observe key ocean processes. However, an AtlantOS-funded study suggests that future gap analyses consider four categories of gaps:

- Gaps in the observing networks
- Gaps in data availability
- Gaps in sustainability
- Gaps in technology

Facilitating the analysis of gaps and an optimal design of a future Atlantic Ocean Observing System, AtlantOS has performed intensive *"Observing System Simulation Experiments- OSSE's"* using state of the art ocean models and assimilation technology. Focus has been on improving design of the in-situ observing system for ocean reanalysis, analysis and forecasting of physical, biogeochemical and ocean carbon variables as well as to support climate prediction and detection of change.

AtlantOS has, in close cooperation with observation network operators, examined the costs associated with the existing observation programmes. From the analysis, the annual estimated total running cost of the existing networks is estimated at €48,098,032 plus 162.3 Full Time Equivalent staff (estimated at €12,172,500). This is likely an underestimate, as only the major networks (GO-SHIP, ARGO, CPR, OceanSITES, Gliders, PIRATA, SOOP, Surface Drifters, Ocean Tracking Networks and Animal telemetry Networks) are included in the study and not all of them were able/willing to provide exact numbers. The analysis additionally noted that the majority of the networks are currently funded through project and ad-hoc funding; a lack of sustained funding, for example is preventing the Glider Network from exploiting the full observing capacity of its current fleet. Ocean Observation Networks would benefit greatly if nations could commit to an increase in contributions of staff time to facilitate internal network co-ordination activities.

Advances in existing observation networks, sensor and platform technology

A substantial part of the AtlantOS work has been devoted to optimise existing observation networks as well as improve and further develop the sensors and platforms used. Remarkable results have been obtained in the relatively short timeframe of AtlantOS – the most important are:

- Ship-based observations
  - Improved coordination between GO-SHIP and other oceanographic surveys
  - Testing and introduction of several new sensors to be used on routine cruises
  - Enhanced focus on biological EOV's
  - Identification of three pilot areas for seafloor mapping (linked to the Galway process)
- Autonomous observing networks
  - Tested and started implementation of Deep Argo Floats (6000 m) and Argo floats with biogeochemical sensor.
  - Introduction of biogeochemical sensors on moorings
  - Deployment of automated moored water samplers
  - Testing of low-cost SST, SSS and barometers on drifters
  - Increased coordination of the glider community between continents
  - Launch of European Aquatic Animal Telemetry Network
  - Significant progress on linking open ocean to coastal observing systems

Additionally, strong efforts have been made to join the forces of the climate and ecosystem observing communities in the North and South Atlantic Ocean to assess and promote integration. These efforts have provided a comprehensive overview of the observing efforts, motivations and approaches which will serve as a base for an optimisation of the regional observing systems, and have started the development of climate and ecosystem indices. This work is based on the enhancement in observing in the South Atlantic initiated by AtlantOS and the leveraging from on-going enhancement by activities in the North Atlantic subpolar gyre region.

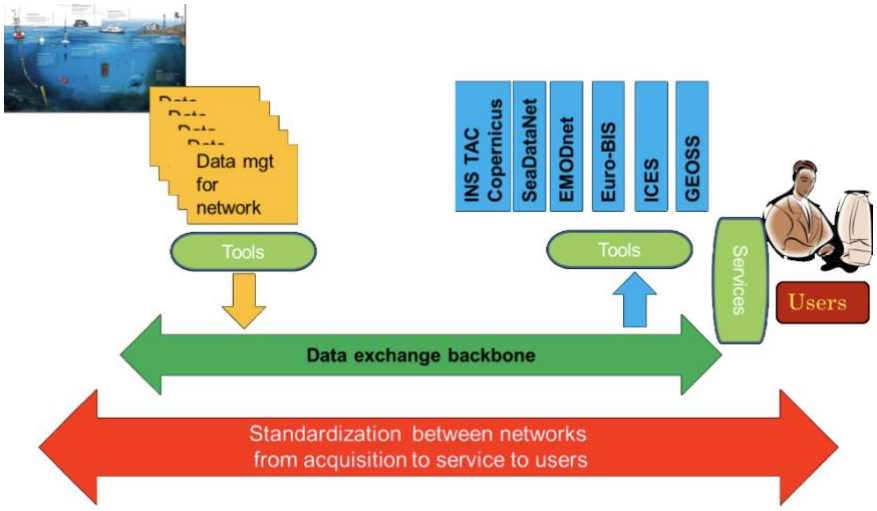
Optimizing the observation system for the Atlantic Ocean includes the development of and improvements in observing sensors and instruments. This will enable multiple observing networks to produce more data that are better targeted at stakeholder, user and customer requirements, to address identified gaps, and not least, to reduce the overall cost. AtlantOS has collected detailed information on global progress in sensor and instrument development, and has built a roadmap that constitutes a tool from which the oceanographic community can learn of current and upcoming technology to better inform grant proposals, improve engagement with technology providers and help focus integrated effort on to the most important science questions. The roadmap monitors these developments and their Technology Readiness Level (TRL) and displays it at the following link, which is updated on a regular basis:

http://noc.ac.uk/files/documents/science/WP6_Roadmaps_(S%2BI_and_Emerging_networks)V4.xlsx

Closely linked to the development of new technology, is the establishment of best practices in operating the individual systems, and ensuring that these practices are well-documented and easily accessible to all operators. An important outcome of AtlantOS is an initiative to collect and publishes the relevant, internationally agreed best practices on an easily accessible webpage under UNESCO/IOC-IODE.

Data Management

AtlantOS has designed and developed a modern data management system aiming to ensure that data from different and diverse in-situ observing networks operating in the Atlantic are readily accessible and useable to the wider community, the international ocean science community, and other stakeholders in the field, as well as to demonstrate the potential impact of models and products.



Schematics of the target ocean data flow from observations to users Source: AtlantOS

Progressively, the systems are advanced towards interoperability to serve both the routine data exchanges within and between the observation networks, as well as user-friendly tools for data/products discovery viewing and access. Key components of the system are:

- Agreed-up on common standards for metadata and data description, which rely on existing international standards and protocols
- Mandatory metadata to guarantee a continuum between data-platform-institution in an unambiguous way across the Networks
- Common vocabularies for metadata and data description
- Minimum Near Real Time (24 hours to several days) Quality Control procedures
- Integrated access to the best copy of Network Data
- Data citation: support network to develop a DOI (Data Object Identifier) strategy for their Network
- Synchronization with the Network portals to integrate the highest quality data
- Customised Services to provide additional viewing and downloading facilities on Network data

User benefits and engagement

Society demands many products and services from our oceans. However, the value chain from observation to the products and services delivered to the end user is long, complex, and far from transparent to the user, whose involvement is often restricted to a dialogue with the service provider with a direct focus on the

required product or service. The AtlantOS consortium has therefore actively worked on a broad range of topics showcasing the societal benefits obtained from observing/information systems in support of system evaluation and sustainability to broad community engagement, dissemination and communication. A stronger user engagement needs to be secured via stronger engagement in the future governance structure of the Atlantic Ocean Observing System.

How to exploit AtlantOS towards an Atlantic Ocean Observing System

AtlantOS has delivered an advanced framework for the development of an integrated Atlantic Ocean Observing System that goes beyond the state-of–the-art, and can be sustained and further developed after the lifetime of AtlantOS.

Optimised design of observation systems

Based on the AtlantOS mapping of important phenomena and EOV's to monitor in an Atlantic Ocean Observing System, a more detailed specification of requirements (time and space resolution, quality, timelines) has to be defined; see an example in table below. It is, however, important when defining requirements on this detailed level to engage the various stakeholders in the process to secure that the designed observation system meets the various wishes from the different user communities . An integral part of this process is close interaction with the modelling community, since ocean observing and modelling are complementary and intrinsically linked activities. Models generate internally consistent and comprehensive estimates of ocean state that can be used to understand events that cannot be observed directly. They can also be used to guide observational strategies to support a comprehensive (physical, biogeochemical, biological) observing capability.

The next step in the design process is then to find the optimal combination of observation platforms (ARGO floats, fixed platforms, ship observations, gliders, animal-borne instruments etc.) to establish a fit-for-purpose observation system meeting requirements, but also minimizing the costs of the total system.

Name	Dissemination	Quality Control Procedure	Group	Uncertainty	Update Frequency	Timeliness	Horizontal resolution	Vertical resolution
Subsurface salinity	NRT Service	Automatic	TBD	0,1psu 0,07psu 0,05psu	12h 3h 1h	1d 6h 3h	30km 5km 1km	100m 10m 1m
sea surface salinity	NRT Service	Automatic	TBD	0,1psu 0,07psu 0,05psu	72d 24d 6d	3d 2d 1d	25km 10km 5km	
Sea state	NRT Service	Automatic	TBD	0,25m 0,25m 0,1m	24h 3h 6min	6h 1h 5min	60km 10km 5km	N/A N/A N/A
Sea state	Offline	Automatic	TBD	0,25m 0,25m 0,1m	24h 3h 6min	6h 1h 5min	60km 10km N/A	N/A N/A N/A
Sea surface temperature	NRT Service	Automatic	TBD	0,5K 0,2K 0,1K	3d 1d 6h	3h 2h 1h	25km 10km 5km	
subsurface temperature	NRT Service	Automatic	TBD	1k 0,5k 0,1k	24d 3d 1d	3d 1d 12h	50km 10km 2km	50m 10m 1m
subsurface temperature	Offline	Manual	TBD	1k 0,5k 0,1k	24d 3d 1d	3d 1d 12h	50km 10km 2km	50m 10m 1m
HRL VALCAL	View and Download Service	TBD	Land cover			N/A N/A N/A		
Settlement_Building_Footprint	View and Download	Manual	Settlements	25%	6 months	2 Week	5 m	N/A

Example of a detailed requirement definition for selected EOV's (Copernicus In situ Component Information System)

International and European Initiatives

The importance of ocean observations has, in recent years, attracted great political attention, especially after the G7 Ministers agreed in 2015 on the importance of ocean science and to support an ocean observation initiative. Additionally, UN member nations in June 2017 agreed to support the implementation of SDG 14 to *"Conserve and sustainably use the oceans, seas and marine resources for sustainable development".*

Moreover, political promotion of trans- and pan- Atlantic cooperation has resulted in the signing of two separate, but related, international cooperative agreements reflecting the growing recognition of the key role that oceans play in developing national and regional economies. The Galway Statement was signed by the European Union (EU), Canada and United States of America (U.S.) in 2013, and the Belem Accord was signed between the European Union, South Africa and Brazil in 2017.

The AtlantOS project achievements forms an excellent framework for the international marine society to address the many challenges associated with implementing this global agenda. AtlantOS thereby directly supports the implementation of the Global Ocean Observing System (GOOS) operated by IOC/UNESCO and contributes to the Blue Planet Initiative of GEO.

In Europe, work performed within the AtlantOS project has inspired several programmes and projects that focus on the design and implementation of effective ocean observing capacities, and improving their efficiency and their timely and high-quality delivery of ocean information for climate, health of the ocean, operational services, security and science. Up to 2030, Europe is building an end-to-end, integrated and sustained European Ocean Observing System (EOOS) under the leadership of EuroGOOS and the European Marine Board, which is a coordinating framework designed to:

- align and integrate Europe's ocean observing capacity;
- promote a systematic and collaborative approach to collecting information on the state and variability of our seas;
- underpin sustainable management of the marine environment and its resources

Over the past year, AtlantOS has successfully initiated the formulation of an Atlantic Ocean Blueprint. The goal was to develop an advanced, international elaborated framework for the formation of an integrated Atlantic Ocean Observing System that goes beyond the state-of–the-art and leaves a legacy of sustainability. The Blueprint will integrate existing ocean observing activities into a sustainable, efficient, and fit-for-purpose Integrated Atlantic Ocean Observing System which shall be integrative, ambitious, multi-national, multi-sectoral and purposeful, but not prescriptive. The system shall support and enhance new partnerships between science, service, private sector and civil society. The Blueprint is split into a Vision document and an Implementation Plan. Additionally, AtlantOS has initiated a process to define a European Vision 2030 in support of the Atlantic Ocean Blueprint Vision.

Future Governance

The weakness of the existing in-situ observing and data management systems for the Atlantic Ocean is its loose coordination with arrangements of heterogeneous international, national and regional design to support science and a wide range of information products. These weaknesses limit the potential for Atlantic observing systems to become even more fit-for-purpose and thus guarantee sustainability in the long run. AtlantOS, therefore intensively aims to develop an improved governance system, enhanced partnerships, and the stimulation of capacity building. the Blueprint suggests that the following mechanisms be included in a future observing governance system:

- **A coordinating mechanism** that spans three dimensions: the observing system, resource engagement, and ocean information delivery. A single supervisory body with a clear coordination structure of the different subgroups should cover the three dimensions.
- **A Resource Board** to promote long-term funding for the ocean observing community
- **An Ocean Partnership Panel** to inform the ocean observing community about the role of ocean data and products as well as their societal benefit

- A regular **review process** of the adequacy of the different ocean observing activities and programmes as well as the requirements needed – perhaps every second year over the coming 6 years while the integrated system is being build, followed by 3 to 5 years' intervals; this would ensure long-term support and sustainability of the system.
- **National Ocean Focal Point** within each of the ocean states, so that oceans could be managed more directly.

The discussion of a suitable governance structure is still in its infancy and further high-level consideration and discussion are needed.

Inspiration to other ocean regions

The achievements and the legacy of AtlantOS has great potential to serve as inspiration for designing and implementing integrated ocean observing systems in other parts of the world's oceans. The AtlantOS team are therefore very engaged and focussed on promoting the outcome of the project at the upcoming **Ocean Obs'19 Conference** which has as its prime goal to further develop effective strategies for a sustained, multidisciplinary and integrated ocean observing system, and to better connect user communities and observers.