PROPOSAL FOR A SCOR WORKING GROUP

COMMON CHALLENGES IN ESTABLISHING OCEAN OBSERVATORIES

Ver 1.0 – Final Proposal

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BACKGROUND

In a global context, the mission of ocean observatories[1] is to contribute to understand, track and predict the evolution of the world's oceans through continuous time series from the seafloor to the surface. The recent developments of cabled systems in particular, as shared infrastructures with multidisciplinary vocation and unprecedented instrument hosting capacity, have to respond and adapt to the diverse and fast-evolving needs of society. In that respect and in order to make the ocean observatories contribution to earth observation an effective component of the global observing system, as well as to ensure that the resulting infrastructure will deliver as planned, some challenges have yet to be overcome. Coordinating with on-going ocean observations programs, establishing cross-cutting scientific aspects across regions, establishing standard techniques and strategies to optimize sampling and produce more reliable predictions, find out and possibly demonstrate the means of integration of heterogeneous solutions within a global framework, put forward the means of responding to societal needs in a practical fashion, and guarantee the maintenance, sustainability, performance of the overall system, are some of the aspects covered in this proposal.

Keywords: Multidisciplinary ocean observatories, scientific challenges, technological challenges, earth observation, GEOSS, societal benefits, global integration, sensor interoperability, standardization, data interoperability, standard operations, maintenance, sustainability

TIMELINESS AND RELEVANCE

The motivation for the current proposal stems from:

1. The OceanObs conference held in 1999, where it was established that <<Core principles of participation in the sustained observing system include recognition that users require rapid access to all relevant data, free of charge. An integrated system, making use of remotely sensed and in-situ observations is essential. Observations are openly shared in near-real-time when technically feasible. They are collected, analyzed, archived, and distributed to internationally agreed standards with agreed best practices>>

2. The OceanObs conference held in Venice in 2009, where was obtained consensus on the need <<to increase our efforts to achieve the needed level of timely data access, sensor readiness and standards, best practices, data management, uncertainty estimates, and integrated data set availability.>>

3. The expressions of interest received at the EU Maritime Day, held in Gijón (Spain) in May 2010, where a round table was organized with key representatives of some of the most relevant ocean observing systems to date[2]. As a major outcome the need for a better global coordination of research activities in the field of ocean

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[1] Ocean observatories are here defined as multidisciplinary suites of ocean instruments and sensors with long-term power supplies and permanent communications links that can feed data to scientific laboratories and the Internet

[2] See Annex

observatories has been identified. The tool to achieve this could be a Community of Practice Working Group (CoPWG) to discuss and agree upon scientific and technological aspects of global relevance, such as cross-cutting scientific themes, technological harmonization needs and solutions, personnel and instrument sharing, to name a few. Some efforts have already been initiated in order to address such practices.

The European Seas Observatory Network (ESONET (NoE and Vi), see [1-3]) and its infrastructure companion the European Multidisciplinary Seafloor Observatory (EMSO, see [4]) are good recent examples of such requirements and efforts. The perspective is also to meet the milestone of the Global Earth Observing System of Systems (GEOSS, [5-8]), when society should be able to search, access, and fully exploit earth observations for the benefit of society. Standard Development Organizations (SDOs) are already delivering on aspects such as data publication, access, and documentation and sensor interoperability [9-13]. Committees are also trying to tackle data uncertainty [14]. At science level, ocean acidification and ecosystem management are clear examples of a need for a global observation strategy and some actions are already in place to respond to these needs, such as the Global Ocean Observing System (GOOS, [15, 16]). Observatories that produce real-time and continuous data offer an excellent opportunity for these initiatives (Beside ESONET Vi and EMSO, see OOI [17], DONET [18], NEPTUNE Canada [19], MACHO [20], IMOS[3]). Global ocean science would benefit tremendously from utilizing the potential of these observatories. The working group will identify and try to solve the scientific and technological aspects to this aim.

TERMS OF REFERENCE

The primary objective of this group is to discuss and resolve those challenges which have been identified as common to ocean observatory initiatives. As the membership reflects, the involvement of persons directly involved in the scientific, technical and strategic management of ocean observatories will allow for both vertical and horizontal interactions. To achieve the objective, a set of scientific and technological aspects will be addressed, which have been identified by leaders of and key contributors to some of the most important ocean and earth observing initiatives today, spanning from hardware and software infrastructure specialists to large scale stakeholders, and encompassing global integration aspects ranging from the observing system instrument layer up to data products, and the crucial cross-cutting role of ocean observing systems in GEOSS.

There are three terms of reference.

1. Develop a plan for joint action among multidisciplinary ocean observatories to address global cross-cutting scientific issues

- Identify scientific issues that are best addressed through global multidisciplinary observations
- Establish criteria for reference observatories at key locations to evaluate and compare trends
- Identify key scientific and technological cross-cutting demonstration projects

[3] http://imos.org.au/

- Demonstrate the benefit of continuous scientific time-series through specific examples

2. Develop a plan for integration of multidisciplinary ocean observatories into a global system of observatories

- Identify synergies in regard to processes observed and future parameters to be included on relevant platforms between ongoing observation programs like ARGO and OCEANSITES and ocean observatories to be implemented
- Develop requirements and procedures for rapid and free exchange of scientific and technical results. This implies to promote information and technological exchange between permanent ocean stations and coordinate global observing activities on particular processes of interest (e.g. geohazards, ocean acidification, baseline studies – e.g. ecosystem status). This process will imply to define routes to achieve interoperability between the systems i.e. define agreed upon deployment procedures, instrument integration, data exchange, common data policy procedures for standard instruments
- Study and identify the possibilities to implement sensor interoperability concepts, like “plug and work”[4], harmonized timing protocols and software-based open standards in order to enhance the hosting capacity of observatories, optimize and reduce costs of instrument operation and exchange.

3. Identify how long-term sustainability of ocean observatories can be promoted.

- Identify the key stakeholders for ocean observatories and how infrastructures can anticipate or adapt to unforeseen societal needs.
- Define and plan the demonstration of a common long-term traceable Quality of Service[5] criterion, in coordination with GEOSS related tasks and committees
- Identify or define needed protocols that enhance the long-term value and exploitation potential of observations

WORKING GROUP DELIVERABLES

Among other outcomes, we hereby provide a list of tangible products as a result of the group’s terms of reference. A possible time distribution, as a first approach, could be that each of the following items provides the focus of a specific meeting (M[1..3]), some of them will be virtual. This list offers an overview of concrete objectives at the

[4] Plug and work instruments or interfaces require minimal hardware and software configuration needs by embedding all necessary information to avoid generally time-consuming and error-prone processes of connecting an instrument to an observatory infrastructure.

[5] QoS, is here to be interpreted in the context of ocean observatories, thus will cover observatory quality performance, including observation quality assurance and control, uncertainty, measurement time gaps and delays, service cost, and implementing open public standards in this process. Exact criterion shall be defined as a WG activity. Also see [21].

time of submission, i.e. their subject and timing may need to be updated in the course of the working group activities. In order to keep reporting concise, the format of each report will be similar to an executive summary.

M1/T1: Table of global cross-cutting scientific issues

M1/T2: Table of criteria to be addressed for key reference sites

M1/T3: Table of regions of mutual and global scientific and societal interest

M2/R1: Report on synergies with other global ocean observation networks

M2/R2: Report on requirements and plans for ocean observatories scientific and technical integration

M2/R3: Report on key elements and stakeholders for the long-term sustainability of ocean observatories

M3/R4: Report on global data and quality of service criterion with a focus on GEOSS

M3/P1: Review results and prepare for publication as peer-reviewed open-access publication.

Following completion of the group's terms of reference, a SCOR-affiliated group will be formed to implement the group's plans.

MODE OF OPERATION

Each meeting will be preceded by continuous remote discussions and preparation, utilizing web-based platforms, e-mailing and videoconferencing tools. First meeting may either be at the 2012 Ocean Sciences Meeting or the European Geosciences Union General Assembly 2012. At its first meeting, working group members will make short presentations about their activities, followed by agreement on how the terms of reference will be achieved and how to proceed with the planning. Discussion of potential funding sources for WG related activities will be part of the agenda. The final meeting of the group will be held in 2014. As stated above, each meeting will have a tangible deliverable as key product, beside the minutes to be distributed no later than 15 days after the meeting.

THE CASE FOR SCOR SPONSORSHIP OF THE WG

1. The Intergovernmental Oceanographic Commission (IOC), through GOOS, stands ready to co-sponsor and co-fund this joint IOC/SCOR Working Group (Contact: Thomas Gross).

2. The European Commission has expressed interest in the discussions taking place, highlighting that the science incentive, the governance, and the technology for those observatories remain a major challenge for ocean research in the next decades, that the creation of a working group should help in shaping a position from the Ocean Science Community with regard to the implementation of Ocean Observatories and that the results would be quite useful in the context of GEO and GEOSS

3. SCOR has vocation to contribute to the field of Ocean Observing Systems. Relevant past SCOR Working Groups that have studied related topics include:

- WG 16 General Problems of Intercalibration and Standardization
- WG 21 Continuous Current Velocity Measurements
- WG 51 Evaluation of CTD Data
- WG 70 Remote Measurement of the Oceans from Satellites
- WG 88 Intercalibration of Drifting Buoys (formerly WG 66)
- WG 90 Chemical and Biological Oceanographic Sensor Technology
- WG 110 Intercomparison and Validation of Ocean-Atmosphere Flux Fields
- WG 115 Standards for the Survey and Analysis of Plankton
- WG 118 New Technologies for Observing Marine Life
- WG 130 Automatic Visual Plankton Identification
- WG 133 OceanScope (with IAPSO) (on building a vessel-based observatory)

MEMBERSHIP PROPOSAL

	ORGANISATION/ OBSERVATORY	COUNTRY	FULL MEMBERS	ASSOCIATE MEMBERS	OBSERVERS - STAKEHOLDERS
Eric Delory (co-chair) Joaquín Hernández Brito	PLOCAN /Ocean Observatory	Spain	X		
Christoph Waldmann (co-chair)	U. Bremen-MARUM	Germany	X		
Ingrid Puillat Jean-François Rolin	IFREMER /Coord. European Seas Observatory Network	France	X		
Stefano Nativi Monica Cesari	CNR /co-chair - GEO S&T Committee	Italy	X		

	Coord. FP7 EGIDA Project				
Paolo Favali Laura Beranzoli	INGV /Coord. European Multidisciplinary Seafloor Observatory	Italy	X		
Chris Barnes Benoit Pirenne	U. VICTORIA /Coord. NEPTUNE[6] Canada	Canada	X		
Yoshiyuki Kaneda	JAMSTEC /Coord. DONET[7]	Japan		X	
Tim Cowles	Consortium for Ocean Leadership - Director / OOI[8]	United States		X	
Juanjo Dañobeitia Jaume Piera	CSIC-Unidad de Tecnologías Marinas - Director/ OBSEA & CSIC R/V	Spain	X		
Aurea Ciotti Rubens M. Lopes	U. Sao Paulo- CEBIMar – Instituto Oceanografico	Brazil	X		
Tony Haymet	UCSD-SCRIPPS-Director	United States		X	
Bauke Houtman	National Science Foundation	United States	X		
Pinxian Wang	Tongji University, Shanghai	China	X		
Ana Aricha	Ministry of Science and Innovation	Spain			X

[6] NorthEast Pacific Time-Series Undersea Networked Experiments

[7] Dense Oceanfloor Network System for Earthquakes and Tsunamis

[8] Ocean Observatories Initiative

<u>*Table Glossary*</u>

WG full members: Includes WG leaders and most active members. Also viewed as a permanent group, full members meet on a regular basis, validate, initiate, provide guidance and supervise themes of discussion and tasks proposed by the WG members.

WG associate members: Regularly participate to events, forums, and meetings organized by the WG, but not to the level of full members. Participate to WG discussions and projects tasks.

WG observers, **stakeholders**: have a more peripheral role in the activity of the WG. They have a critical role in providing feedback to the WG, particularly on key elements that should be considered within the WG activities.

References

[1] R. Person, "The European deep sea observatories network of excellence ESONET," *OCEANS 2007 - EUROPE, VOLS 1-3,* pp. 247-252, 2007.

[2] I. Priede, "ESONET-European sea floor observatory network," *3RD INTERNATIONAL WORKSHOP ON SCIENTIFIC USE OF SUBMARINE CABLES AND RELATED TECHNOLOGY, PROCEEDINGS,* pp. 263-265, 2003.

[3] I. Puillat, "Standardization prospective in ESONET NoE and a possible implementation on the ANTARES Site," *NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION A-ACCELERATORS SPECTROMETERS DETECTORS AND ASSOCIATED EQUIPMENT,* vol. CCCS CCCT, pp. 240-245, 2009.

[4] P. Favali, "EMSO: European multidisciplinary seafloor observatory," *NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION A-ACCELERATORS SPECTROMETERS DETECTORS AND ASSOCIATED EQUIPMENT,* vol. CCCS CCCT, pp. 21-27, 2009.

[5] "Calibration and validation for GEOSS*," *COSPAR Information Bulletin,* vol. 2006, pp. 88-93, 2006.

[6] E. Christian, "Planning for the Global Earth Observation System of Systems (GEOSS)," *Space Policy,* vol. 21, pp. 105-109, 2005.

[7] C. C. Lautenbacher, "The Global Earth Observation System of Systems: Science Serving Society," *Space Policy,* vol. 22, pp. 8-11, 2006.

[8] S. Nativi, P. Mazzetti, H. Saarenmaa, J. Kerr, and É. Ó. Tuama, "Biodiversity and climate change use scenarios framework for the GEOSS interoperability pilot process," *Ecological Informatics,* vol. 4, pp. 23-33, 2009.

[9] "Open-source Project for a Network Data Access Protocol," OpenDAP.

[10] "Network Common Data Form," Unidata.

[11] "UDDI: Universal Description, Discovery and Integration," OASIS.

[12] M. Botts, G. Percivall, C. Reed, and J. Davidson, "OGC Sensor Web Enablement: Overview and High Level Architecture.," 2007.

[13] E. Y. Song and L. Kang, "Understanding IEEE 1451-Networked smart transducer interface standard - What is a smart transducer?," *Instrumentation & Measurement Magazine, IEEE,* vol. 11, pp. 11-17, 2008.

[14] S. Ungar, P. Campbell, M. Rast, and C. Cao, "Data Quality Guidelines for GEOSS Consideration-The CEOS Working Group on Calibration and Validation (WGCV)." in *IEEE Geoscience and Remote Sensing Symposium, 2007. IGARSS 2007*, 2007.

[15] T. C. Malone, "The coastal module of the Global Ocean Observing System (GOOS): an assessment of current capabilities to detect change," *Marine Policy,* vol. 27, pp. 295-302, 2003.

[16] D. James Baker, N. C. F. K. N. H. Dahlin, and S. E. Petersson, "Global Ocean Observing Systems and the challenges of the 21st century," in *Elsevier Oceanography Series*. vol. Volume 69: Elsevier, 2003, pp. 5-9.

[17] "Ocean observatories Initiative," Consortium for Ocean Leadership, http://www.oceanleadership.org/, 2010.

[18] K. Kawaguchi, Y. Kaneda, and E. Araki, "The DONET: A real-time seafloor research infrastructure for the precise earthquake and tsunami monitoring," in *OCEANS 2008 - MTS/IEEE Kobe Techno-Ocean*, 2008, pp. 1-4.

[19] S. M. Taylor, "Transformative ocean science through the VENUS and NEPTUNE Canada ocean observing systems," *Nuclear Instruments & methods in Physics Research Section A - Accelerators Spectrometers Detectors and Associated Equipment* vol. CCCS CCCT, pp. 63-67, 2009.

[20] S. K. Hsu, C. S. Lee, T. C. Shin, C. S. Liu, B. S. Huang, B. Y. Kuo, C. H. Lin, D. Tang, H. Y. Chang, and C. H. J. Kuo, "Marine Cable Hosted Observatory (MACHO) Project in Taiwan," in *Underwater Technology and Workshop on Scientific Use of Submarine Cables and Related Technologies, 2007. Symposium on*, 2007, pp. 305-307.

[21] R. Onchaga, "Quality of service management framework for dynamic chaining of geographic information services," *International Journal of Applied Earth Observation and Geoinformation,* vol. 8, pp. 137-148, 2006.

ANNEX

COMMON CHALLENGES IN ESTABLISHING OCEAN OBSERVATORIES

ROUND TABLE – GIJÓN, 19 MAY 2010 – *DRAFT TRANSCRIPT*

Were present: Jan Stefan Fritz, Paolo Favali, José Doncel Morales, Gilles Ollier, Jurgen Mienert, José-Joaquín Hernandez-Brito, Christoph Waldmann, Keith Alverson, Stefano Nativi, Eric Delory

Connected through Webex: Benoit Pirenne, Tony Haymet, Roland Person, Jean-François Rolin, Yoshiyudi Kaneda

The following summarizes common and challenging aspects found in establishing ocean observatories, focusing on S&T objectives and global integration, as well as lessons learned, identified during the meeting.

S&T OBJECTIVES

- Provide global observation of ocean processes addressing different disciplines
- Establishing reference stations at key locations to evaluate and compare trends
- Integrate different observational platforms into a system of systems
- Assure rapid and free exchange of scientific and technical results
- Current programs are generally driven by a national or regional priority and despite the global coverage there is still a lack of cross-cutting scientific topics.
  - Example: Impact of Climate Change on the Arctic, Global ocean acidification and carbon uptake

- Make sure that regional specificity does not prevent global integration

- A well-referenced scientific document produced and endorsed by the scientific community that justifies scientific aspects for ocean observatories should be made available in a form which is readable by funding agencies. For example, in Europe this document should be prepared for a so-called "impact assessment" for society.
- Produce the infrastructure "blue print" that will convince funding agencies
- Stabilizing the science needs would prevent unexpected budget changes in the short term and promote more stable cooperation across observatories.
- Guarantee that past and on-going investments in Europe are maintained
- Suggest alternatives medium to long term funding strategies (example: OOI technology research plan as first phase, scientific research as second phase
- The question of continuous collection and archiving of scientific datasets over time is considered as a societal benefit in itself for future generations, despite the possibility that some datasets may not be able to contribute with satisfactory predictions in a short term on certain aspects.

- Identify regions of interest may also be a good driver of global integration rather than scientific aspects only (e.g.: the Arctic).
- Consult with lead scientists and institution representatives to agree on specific cross-cutting aspects
- Clearly identifying who the stakeholders are will be critical to the identification of financial support
- Addressing the question of the choice between ocean observatories and expedition based research may be a key theme between scientific leads.
- Infrastructures and science plans can be addressed independently of the possible financial uncertainties. For example short-term and small projects can contribute to the larger plan right from the beginning (clustering idea).
- The idea of an infrastructure bottom-up approach is worth considering, bearing in mind the strong interest to connect with the broader system.
- Collaborations with non-scientifically driven initiatives may be of interest.
- Geohazards, ocean heat content and circulation, discovery and exploitation of ocean resources, mid-ocean ridge processes (possibly at the origin of early life) are clear cross-cutting aspects. Current misunderstanding of the ocean as the ultimate sink for global carbon is also an important rationale for research. Variability of water masses implies the need for time series.
- Interoperability across disciplines is an important benefit for science, in particular for the discovery of unknown processes and relationships.

<u>Conclusions from the session</u>: identifying cross-cutting topics is a difficult task. Identifying regions of interest may help identifying them. Acidification, geohazards and heat content are some good examples of agreed upon global cross-cutting issue.

ASPECTS FOR PROMOTING THE GLOBAL INTEGRATION OF OCEAN OBSERVING SYSTEMS

- Information exchange on scientific and technical aspects of permanent ocean stations
- Coordinate global observing activities on particular processes of interest (geohazards, ocean acidification etc.)
- Define routes to achieve interoperability between the systems i.e. deployment procedures, instrument integration, data exchange, quality management
- Establish common data policy procedures
- Study and work on the possibilities to implement plug and work concepts.
- Use available GEO portals
- Make sure all observatories are able to share their data like in WMO. Data interoperability is not only a technological issue. Capturing knowledge properly in datasets must be addressed, including uncertainty.
- Sensor exchange is of common interest in the US and in Europe. This must be tested.
- Interoperability is still difficult to evaluate as a deliverable, quality of service as a result may be a good umbrella criterion to this aim
- Quality is important for real-time and to deliver on the operational aspect of observatories. A Quality of service criterion is to be discussed and interoperability to be included as a criterion to assess quality of service if applied.

- GEOSS enables the discovery of data and services. Discovering sensors and environmental models is a key functionality of the overall system.
- Semantic interoperability, taking in account aspects like different languages is also key to the success of information exchange.
- How to provide the right tools to the user to express what they request and how to express as a data provider what it is they are going to get from their request.
- While international standards are currently subsetting mainly regular grids, requests from non-regular grids remains a challenge.
- Defining interoperability needs between existing infrastructures ready to operate and in real need for data exchange (OOI & Neptune are clear examples already at discussion stage in that regard)
- Harmonize sensor quality assurance and quality control practices and documenting
- Plan an Architecture Implementation Pilot project for GEOSS: this is a lacking activity for ocean observatories
- Needs for a common data quality control strategy to be able to respond to models requests.

Lessons learned

- TAO maintenance and data services

Assuring the operation can be maintained (e.g. vandalism issues in TAO)

Business model should be established that includes the clear identification of observatory users and to set services according to user needs to make better predictions (lessons learned from El Niño event and TAO)

- GOOS S&T

Funding can be better justified at component level rather than at global level, despite the fact that synergies can be very rewarding.

- ION Network

Within the Geophysics ION network and IUGG: interoperability has been particularly identified as a main requirement for collaboration on geohazards. A strong community is needed to push in that direction.

- GEOSS/GEOBON

In GEOSS they have been able to manage a network of networks for biodiversity and learning from their experience and implementing some aspects could be an interesting exercise.

Relevant current initiatives

NEPTUNE/Canada - OOI - ESONET/EMSO - DONET - MACHO - PLOCAN - RedICTS Marinas - EUROSITES - HYPOX - GEOSS – GOOS/Global Tropical Moored Buoy Array (TAO and other components)-

POTENTIAL NEXT STEPS (TO BE DISCUSSED IN A FUTURE MEETING)

- Identify interest groups that may support a global integration
- Identify points of contact for each initiative
- Establish an Ocean Community of Practice
- Establish global cross-cutting scientific topics
- Establish a communication platform for exchanging information (Website and physical meetings)
- Establish an international task force on global issues
- Find existing organization to support the objectives (e.g. SCOR)
- Establish a permanent committee (e.g. IODP, InterRidge)
- Create more tools for collaboration and contribution. example: Engage users in a data annotation effort from users which turn into contributors. Bridge the gap between a constant amount of scientist and an increasing amount of data.
- Promoting web communities and data sharing example, like through specific scientific examples across ocean basins.
- Properly coordinate existing infrastructures to comfort the bottom-up approach. A formal agreement between national and international initiatives through MOUs would also be valuable, mainly through the implementation of a coordinated and unique service provided to the users.
- Work towards an agreement between countries to invest in a legal entity for European infrastructures (ERIC).

- Write a proposal to create a working group within the UNESCO/IOC and invite all participants within this group.