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The IOC Ocean InfoHub

DEVELOPMENT OF AN IOC CLEARING HOUSE MECHANISM FOR THE TRANSFER OF MARINE TECHNOLOGY POWERED BY A PROOF-OF-CONCEPT ODIS ARCHITECTURE
Version: 10 February 2020

(Summarized version)

A Proposal submitted to the UNESCO/Flanders Fund-in-Trust for the support of UNESCO's activities in the field of Science (FUST)

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1. Project information

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This proposal has been drafted by experts participating in the "ODIS-CHM/TMT PROPOSAL DRAFTING WORKSHOP", 5 - 8 August 2019, Paris, France. They used reports prepared by the IOC Group of Experts on Capacity Development and its task teams, results obtained through the online CD survey, as well as documents prepared for the IOC Assembly and Executive Council related to the development of an IOC Ocean Data and Information System (ODIS).

The current version takes into account recommendations made by the reviewers of the proposal (November 2019)

2. Rationale and background

Project description (including rationale, background and implementation strategy)

2.1 Summary Description

The Ocean InfoHub Project will

1. establish and anchor a network of regional and thematic nodes that will contribute to the transfer of marine technology (TMT) by enhancing shared scientific and technical capacities to render a wide range of data and information products and services
2. develop a proof-of-concept for an underlying Ocean Data and Information System (ODIS) architecture to enable scalable development of the global Ocean InfoHub and interoperability with local, regional and thematic data and information infrastructures.
3. promote and foster awareness and collaboration with established organizations and systems providing enabling support to the marine community, connecting contributors and users with the resources to support their efforts

The Project will create an ecosystem wherein stakeholders can provide, discover and use diverse content

and services in a coherent and easily implementable manner. The Project will thus promote closer interaction across regions and themes, leading to improved mutual understanding and collaboration as well as to strengthening of inter-, multi- and transdisciplinary science, technology and innovation systems and policies.

The proof-of-concept for an underlying Ocean Data and Information System reference architecture (ODIS-Arch[1]) will be applicable for the UN Decade of Ocean Science for Sustainable Development. It will build the foundations for a totally new IOC Ocean Data and Information System (ODIS).

The outcomes, outputs and activities of the project are described in the Results Framework in ANNEX A.

Project Development and Implementation Principles of the Ocean InfoHub

The Project development and implementation principles will be fully based on co-design: the project will seek the participation of the widest possible range of end user communities that are involved in the sustainable use and management of marine areas. This will ensure that the products and services developed through the project are relevant to all user communities including decision makers. The architecture of the project enables a strong focus on national and regional involvement, while also using a global technical and content framework which will enable also inter-regional content sharing.

It is noted that the IOC Ocean InfoHub has been **formally requested by IOCARIBE and IOCAFRICA**:

- Recommendation SC-IOCARIBE-XV.1: IOC New Capacity Development Strategy: Implementation Plan
    o "Urges IOCARIBE Member States to: … (iv) Actively participate in the further development and management of the IOC Clearing- House Mechanism for the Transfer of Marine Technology (CHM/TMT)"
- IOCAFRICA-V/3s (Summary Report IOCAFRICA-V):
    o para 47: "The Sub-Commission recognized the importance of setting-up a regional hub for the Clearing House Mechanism for transfer of marine technology (CHM/TMT) and requested for details on requirements, as this will aid in deciding the appropriate location for the hub."
    o Recommendation IOCAFRICA-V.4: Programme of Work, 2019–2021: Activity 4.2: Setting up a regional hub for CHM/TMT

The Secretariats in the IOCAFRICA and IOCARIBE regions are best placed to organize the co-design of the regionally specific product and service requirements of the regional nodes in the IOCAFRICA and IOCARIBE regions as they are in direct contact with the ocean research institutions as well as various regional organizations and NGOs that represent a wide range of multi-sectoral user communities.

While the IOC does not have a regional subsidiary body for Pacific SIDS, Member States of that region have clearly expressed the need for IOC efforts on Capacity Development in their region and two regional organizations have expressed their interest and commitment to participate in the Project: The Pacific Community (SPC) and SPREP – Pacific Environment. These two organizations represent a large and multi-sectoral number of end user communities and they will be able to organize a bottom-up user requirements analysis for the node in the Pacific SIDS region.

It is noted that the regional workshops planned by the project will be preceded by regional multi-sectoral needs assessments and these will then be discussed during the workshops, with detailed work plans and identified products and services as a result.

Figure 1: Project Development and Implementation Principles of the Ocean InfoHub

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[1] ODIS-Arch: ODIS proof-of-concept reference architecture

2.2 Overall purpose and relevance: needs, issues and baselines

2.2.1 Clearing House Mechanism for the Transfer of Marine Technology (CHM/TMT)

During its 28th Session, IOC adopted ([Resolution XXVIII-2](#)) the IOC Capacity Development Strategy (2015-2021) which was published in 2015 as **IOC/INF-1332**. The IOC Assembly later adopted **Decision IOC-XXIX/10.1** establishing the IOC Group of Experts on Capacity Development. The main objectives of the Group of Experts are:

1. to assist the global and regional programmes with the assessment of their needs in relation to capacity development (CD)
2. the development of work plans to address these needs
3. the mobilization of resources
4. to provide advice on relevant methods and tools to deliver CD.

The Group also advises the Assembly on, and has begun the implementation of, the Transfer of Marine Technology (TMT) Clearing House Mechanism (CHM), as requested by the IOC Criteria and Guidelines on the Transfer of Marine Technology (CGTMT) **IOC/INF-1203**. In line with the philosophy behind ODIS, the CHM is to make use of, to the largest extent possible, existing data and information systems already available at IOC.

According to the IOC CGTMT (2003), the primary objective of the CHM is to transfer marine technology to

> "...developing states, particularly landlocked and geographically disadvantaged states as well as other developing states which have not been able to establish or develop their own capabilities in marine sciences, scientific research, observations of the oceans and coastal areas, and related technology, or to develop the infrastructure needed to achieve such ends".

Following the IOC CGTMT concept, the CHM should:

> "...*provide interested users in Members States with direct and rapid access to relevant sources of information, practical expertise in the transfer of marine technology, as well as facilitate effective scientific, technical and financial cooperation to that end*".

The CHM should therefore become the primary information resource to support the international conventions and agreements and, at the same time, provide a platform to share information, build partnerships and forge collaboration for the growth and transfer of marine technology in developing countries.

The IOC Group of Experts on Capacity Development established 2 task teams:

1. A Task Team on the Implementation of a CHM/TMT portal (TT CHM/TMT) and related activities, with the objectives to:
   a. further seek answers on the questions and issues formulated by the sessional working group on TMT/CHM and taking into account the UN Decade preparations (see [Section 2.3.2](#))
   b. develop the scoping and needs assessment for the CHM, using existing information systems and sources where possible, and (if possible) develop a proof of concept to be demonstrated at IOC-XXX

2. A Task Team to Identify the CD requirements of Member States (TT MSREQ) in relation to the IOC CD strategy and
   a. taking into account the work already done
   b. focusing on SIDS, LDCs and the Member States that are currently not members of any of the three sub-commissions or of IOCINDIO and the Black Sea regional committees
   c. taking into account the UN Decade preparations

All regions reported that a Clearing House Mechanism for the Transfer or Marine Technology would be instrumental to the further development of ocean science capacity in national contexts. Further, all regions expressed their preference for an online, central data and information system integrating the data and information harvested from regional/sectoral CHM portals (need for interoperability). As such the respondents identified the need for a series of regional/thematic nodes rather than only one global central node but using technology that allows interoperability between the nodes.

The development of a Clearing House Mechanism has also been included in the recently published (by UN/DOALOS) "Draft text of an agreement under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction[2]", more specifically in Article 51 (Clearing House Mechanism - see https://undocs.org/en/a/conf.232/2019/6). While the final text has not been agreed upon, the principles are well-matched to the objectives of the Ocean InfoHub this project will deliver.

In particular, the Ocean InfoHub proposed here will provide an openly accessible web-based platform, coordinated by the IOC (Para. 6 of Article 51) and designed to network stakeholders according to their interests, needs and capacities (Para. 2 of Article 51) in a transparent manner (Para. 4.f of Article 51). Thus, it will better match providers of marine technology and know-how with those in need of such capacities (Para. 4.a of Article 51). Through alignment with the ODIS-Arch concept's emphasis on interoperability between distributed resources (see WP2), the project's clearing house technology will natively support interlinkage with existing clearing house mechanisms operating across scales (Principle 4.b) including private sector and NGO resources (Paras 4.c, 4.d, 4.f of Article 51). Collectively, these features are geared to support SIDS and archipelagic developing states and other developing regions/countries to not only provide easy access to the clearing house (Principle 5), but also the ability to establish regional "views" of its content to tailor user experience to local needs.

Through its alignment with the needs specified by UN/DOALOS, this Project directly supports the following rights in the context of marine data, information and science:
- *the right to education;*
- *the right to seek, receive and impact information;*
- *the right to enjoy the benefits of scientific progress and its applications*

Although the project will benefit rights holders regardless of their capacity, the CD-CHM component of the project seeks to provide more pronounced benefits to geographically disadvantaged regions (in terms of financial and technical resources, education/expertise and material assets) supported through IOC regions, focusing initially on:
- IOCAFRICA,
- IOCARIBE,
- Pacific SIDS[3]

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[2] https://undocs.org/en/a/conf.232/2019/6

[3] During the 30th Session of the IOC Assembly Fiji expressed its strong support for the recommendation of the IOC Group of Experts on CD, especially recommendation (iii) to "organize a regional conference on capacity development requirements of the Pacific SIDS involving IOC Member States as well as other stakeholders active in the region;".

In order to test the concept of the CHM/TMT as an entry point to data and information, a first prototype was developed within the framework of the Caribbean Marine Atlas (Phase 2) project by INVEMAR, Colombia and can be seen on http://portete.invemar.org.co/chm/#/. In terms of technology, the product sources records from the IOC OceanExpert database (http://www.oceanexpert.net) (experts, institutions), IODE OceanDocs (http://www.oceandocs.org) (Documents), IOC training events, but also from other sources within Latin America (either through web scraping, API-mediated or manual input).

In contrast to many existing systems for capacity transfer, **the Ocean InfoHub will facilitate the transfer of valuable insight from groups that are typically seen as only recipients of data, information and knowledge products**. The Ocean InfoHub will implement technologies to allow also **indigenous groups** to transfer their local knowledge such that it will impact networked information systems**.** During its course, the project will seek out and welcome partners who can contribute this kind of information, acknowledging and respecting indigenous ownership rights**.**

The project will also focus on **early career scientists**, prioritizing the transfer of content types of special use to them (travel/study grants, training and education opportunities, mentoring) as well as encouraging them to contribute content.

Finally, attention will be given to remedying **gender disparity** by enhanced focus on opportunities for women and girls. Leveraged activities in training, internships and mentoring initiatives will promote and encourage participation of women, particularly in scientific and technical disciplines and careers where women are currently underrepresented. In addition, project governance policy will strive to ensure gender balance and diversity in steering and advisory groups, and all other areas of project management.

Baseline: the baseline of the Ocean InfoHub component of the project consists of the regional prototype which has demonstrated the feasibility of using existing technology to discover and import data and information from existing online data and information sources and to make these available through a regional portal.

Justification: It may be argued that existing commercial search engines are widely used to discover data and information. The main issue with using such tools is that they generate too many non-specific search results, rank the results on unknown algorithms and cannot distinguish between quality-controlled sources and others. Content available through the Ocean InfoHub will be sourced from recognized sources submitted by designated member state experts, international organizations (UN and others) and other sources of which the quality can be demonstrated and provenance is known.

2.2.2 Developing a proof-of-concept for a robust and extensible foundation of the Ocean Data Information System (ODIS)

This project develops from ideas, concepts and pilots developed over the last 2 years, following the initial identification of community need by an External Auditor in 2016. This audit also included the IOC data and information exchange system and recommendation No. 15 of the audit stated:

> "The External Auditor recommends that a draft resolution be submitted to the IOC Assembly calling for Member States to work together, with the support of the IOC, to **construct a universal information system and ocean data portal**, along with a cost-benefit analysis prepared in advance by the IODE project".

The **ODIS concept** can be summarized as follows:

> *"The IOC Ocean Data and Information System (ODIS) will be an e-environment where users can discover and access data, information and associated products or services, provided by Member States, projects and other partners associated with IOC".*

The cost-benefit analysis performed by the second IWG (2019)[4] concluded that the most realistic option for implementing a robust and sustainable ODIS would be the stepwise development strategy (ODIS-Step), focusing on achieving interoperability of existing data and information providers, with sufficient flexibility to support multi-stakeholder interests.

Accordingly, the strategy entails that IODE will work closely with existing stakeholders, associated or not associated to the IOC, to improve the accessibility and interoperability of existing data and information, in a manner aligned to the FAIR (Findable, Accessible, Interoperable and Reusable) data principles[5].

Thus, the ODIS-Step option will build on the existing ODIS Catalogue of Sources (ODISCat: an online, annotated catalogue of online resources serving ocean-related data and information products/services[6]) as a source of online data and information services that are candidates for interoperability products.

The Project will develop the technology and collaborative culture required to allow these - and other - resources to interoperate as components of a collective "e-environment" specified in the ODIS concept (see Figure 2, page 14). Users and developers would thus have the ability to access and build upon the resources of multiple components, through the interfaces of any single component.

The ODIS component of the project will create a "**proof-of-concept reference architecture**" (**ODIS-Arch**) that will enable multiple data systems to interoperate with IOC systems and with each other across a range of information types through machine-to-machine interactions. This will initiate a process to remedy the current lack of automated and scalable communication between the many (hundreds) of marine data and information systems, such that both developers and end users must query and download from each online source, often expending immense resources to contend with a multitude of shifting formats and conventions. The results of this proof-of-concept will also provide valuable perspectives and scoping for the future ODIS Steering Group and contribute substantially to the foundations of ODIS.

ODIS-Arch will be tested through demonstrator projects developed with regional data and information nodes to meet the needs of their users. Technology and capacities developed through these demonstrators will then be shared through the Ocean InfoHub network, as described below.

Baseline: The ODIS component starts with a baseline of 668records (descriptions of online sources of ocean data and information) included in the ODIS Catalogue of Sources (ODISCat).

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[4] Document IOC-XXX/2 Annex 6: IOC Ocean Data and Information System (ODIS): Concept, Implementation Plan and Cost Benefit Analysis

[5]Wilkinson et al. (2016) *Scientific Data*, Volume 3, Article 160018 : https://doi.org/10.1038/sdata.2016.18

[6] ODISCat was launched on 1 February 2019 (see https://catalogue.odis.org), through actions following those of the first IWG coordinated through the IOC Project Office for IODE, with cooperation from the members of the IWG as well as the JCOMM/IODE ETDMP members.

2.3 Contribution of the Project to International Frameworks

2.3.1 Sustainable Development Goals

Due to the far-reaching impact of improved ocean data and information capacity in themes such as climate, food security and terrestrial ecosystem health, the project's objectives will contribute to several SDGs. While the Ocean InfoHub may contribute to a wide range of SDGs, we will list only those to which the project explicitly contributes. The contributions are shown in Table 1 (below).

Example: Advancing the SDG 14 objective on reducing Ocean Acidification (SDG 14.3.1) uses average marine acidity (pH) as an indicator. This indicator is based on observations that constrain the carbon system, which are required to capture the variability in ocean acidity at locations providing ocean services. The carbon system in this context refers mainly to the four measurable parameters: pH (the concentration of hydrogen ions on a logarithmic scale), DIC (total dissolved inorganic carbon), pCO_2 (carbon dioxide partial pressure) and TA (total alkalinity). Ocean acidification is a reduction in the pH of the ocean over an extended period of typically decades or longer, which is caused primarily by uptake of carbon dioxide from the atmosphere. Ocean services are the benefits the ocean provides to people, which may be recreational, economic, environmental (by providing coastal protection) or cultural. A surveying of IODE associated data centres in 2018/2019 revealed that while many data centres manage such data there exists no way to discover data across the data centres so users still need to visit each of the data centres and query the database. As a direct application of ODIS IODE may undertake a survey of identified centres and services known or suspected to house/distribute data on Essential Ocean Variables (EOVs) related to ocean acidification and seeking established partners to collaborating with ODIS to incorporating components related to these EOVs into the ODIS reference architecture. By aligning these sources of ocean acidification EOVs to the prototype reference architecture, the project will build a foundation of interoperable data exchange for application by the broader community.

Table 1: Primary contributions of the Project to SDGs

SDG 4: Quality Education[7]
The Project will leverage interoperation between multiple ocean data and information resources to dramatically enhance the discovery of opportunities in training and education, as well as the data and information to support these. As such, it will contribute to improved education of established and early-career ocean professionals, with special attention to students from developing countries.

SDG 9: Industry, Innovation and Infrastructure[8]

The Project will develop a usable infrastructure (global and regional Ocean InfoHub nodes) which can be tailored to the needs of multiple sectors (including industry) to support innovation through the exchange of technology and expertise. Further, it will provide a proof-of-concept for a technical foundation which can support rapid, global interoperation of new and existing digital products to boost market inclusion of local innovation.

SDG 14: Life below water[9]

The Project's primary focus will be SDG 14.a:

"Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and

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[7] https://sustainabledevelopment.un.org/sdg4

[8] https://sustainabledevelopment.un.org/sdg9

[9] https://sustainabledevelopment.un.org/sdg14

Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries."

Through its contribution to 14.a, the project will explore and test a sustainable and extensible means to support the exchange and use of information between both established and emerging local, national and regional providers. Thus, the Project will contribute to targets dependent on data concerning physicochemical monitoring (14.1, 14.3), the understanding and monitoring of marine biology and ecosystems (14.2), spatial management (14.5), marine resource management (14.4, 14.6, 14.7) and equitable access (14.b).

SDG 17: Partnerships for the Goals[10]

The Project will contribute to multiple targets of this Goal:

- 17.6 (Technology): The Ocean InfoHub will facilitate exchange of technology and know-how both through a central, global coordination mechanism (the global Hub) and through regional views of its content, tailored to users' local needs. It will be built around IOC services, aided by the ODIS proof-of-concept reference architecture and allowing external services to contribute and further exchange.
- 17.8, 17.9 (Capacity Building): Both the Ocean InfoHub and underlying ODIS architecture (WP2) are decidedly enabling technologies, connecting providers and users of digital products and services for science, technology and innovation. They will increase the efficiency with which capacities in these domains are transferred across multiple stakeholders, especially those in least developed countries, with minimal requirements placed upon recipients. It will also support reciprocal exchange of local knowledge across global partners, improving targeted cooperation around disaggregated data and information on global and local challenges.
- 17.16-17.18 (Multi-stakeholder partnerships): The Ocean InfoHub, together with the underlying ODIS architecture, will engage multi-stakeholders to mobilize and share knowledge, expertise and technology.

In particular we highlight the dedicated Goal on Oceans, SDG14[11], which calls on nations to *'conserve and sustainably use the oceans, seas and marine resources for sustainable development'.* This constitutes an essential point of reference for IOC's engagement with its Member States as well as for its programmes at the global, regional and country levels. IOC was identified as the custodian agency for two SDG 14 targets and related indicators:

- 14.a: Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries (*Indicator 14.a.1: Proportion of total research budget allocated to research in the field of marine technology*)
- 14.3: Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels (*Indicator 14.3.1: Average marine acidity (pH) measured at agreed suite of representative sampling stations*).

IOC is also identified as a technical support agency for two additional SDG targets indicators, namely

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[10] https://sustainabledevelopment.un.org/sdg17

[11] https://sustainabledevelopment.un.org/sdg14

Target 14.1 on marine pollution and Target 14.2 on marine and coastal ecosystems, both under UN Environment custodianship.

This project will directly assist IOC in delivering on target 14.a and contribute data and information related to 14.3 as well as other targets under the Goal 14 (see Table 1).

2.3.2 UN Decade of Ocean Science for Sustainable Development

The UN Decade of Ocean Science for Sustainable Development was born out of the recognition that much more needs to be done to reverse the cycle of decline in ocean health and create improved conditions for the sustainable development of the oceans, seas and coasts.

Through its contribution to theme (6), "*A transparent ocean*", this Ocean InfoHub will directly contribute to outcomes (ii), "*comprehensive ocean observing system for all major basins*", (iv), "*data and information portal*" and (vi), "*capacity building and accelerated technology transfer, training and education, Ocean literacy"*.

The project's development of a proof-of-concept architecture for distributed and interoperable data sharing is vital to supporting data exchange across basin-scale observing systems noted in (ii), "*comprehensive ocean observing system for all major basins*". Further, the Ocean InfoHub will substantially contribute to outcomes (iv), "*data and information portal"* and (vi), "*capacity building and accelerated technology transfer, training and education, Ocean literacy*" by empowering local, national, regional and global actors to distribute capacity and information through harmonized portals, fully integratable into other solutions.

2.3.3 The Paris Agreement

The Twenty-first session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (Paris, 30 November to 11 December 2015), decided to adopt the Paris Agreement under the United Nations Framework Convention on Climate Change. The Paris Agreement aims to strengthen the global response to the threat of climate change, in the context of sustainable development and efforts to eradicate poverty.

This project's aim to create a scalable, adaptable and inclusive system to allow multi-stakeholder data, information and knowledge exchange will support the following objectives highlighted by the Paris Agreement:

- Sharing information, good practices, experiences and lessons learned, including, as appropriate, as these relate to science, planning, policies and implementation in relation to adaptation actions
- Strengthening scientific knowledge on climate, including research, systematic observation of the climate system and early warning systems, in a manner that informs climate services and supports decision-making
- Strengthening cooperative action on technology development and transfer
- Enhancing the capacity and ability of developing country Parties, in particular countries with the least capacity, such as the least developed countries, and those that are particularly vulnerable to the adverse effects of climate change, such as small island developing States, to take effective climate change action, including, inter alia, to implement adaptation and mitigation actions
- Facilitating technology development, dissemination and deployment, access to climate finance, relevant aspects of education, training and public awareness, and the transparent, timely and accurate communication of information

2.3.4 Sendai Framework for Disaster Risk Reduction 2015 – 2030

The Sendai Framework for Disaster Risk Reduction 2015–2030 aims to achieve the substantial reduction of disaster risk, in particular to life, livelihoods and health as well as to the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries by 2030. Seven global targets were agreed on to support the assessment of global progress in achieving the outcome and goal of the Sendai Framework:

1. Substantially reduce global disaster mortality by 2030, aiming to lower the average per 100,000 global mortality rate in the decade 2020–2030 compared to the period 2005 - 2015;
2. Substantially reduce the number of affected people globally by 2030, aiming to lower the average global figure per 100,000 in the decade 2020–2030 compared to the period 2005 - 2015;
3. Reduce direct disaster economic loss in relation to global gross domestic product (DP) by 2030;
4. Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030;
5. Substantially increase the number of countries with national and local disaster risk reduction strategies by 2020;
6. Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of the present Framework by 2030;
7. Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people by 2030.

This project will contribute to the achievement of these goals and targets by providing data and information required for disaster risk reduction as well as the information on training opportunities to provide the skills for modeling and forecasting of risk. In particular, the ODIS architecture implemented through Regional Hubs and other relevant data and information systems will increase capacities for situational awareness for disaster preparedness and response by improving discoverability and accessibility of a broader range of high-quality data and information.

2.3.5 Marine Biological Diversity of Areas Beyond National Jurisdiction (BBNJ)

The project will also provide useful data and information on Marine Areas Beyond National Jurisdiction (ABNJ) that could contribute to the implementation of an international legally-binding instrument under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction (BBNJ ILBI) currently under negotiation at the United Nations in New York. The architecture and the different elements of ODIS as well as the pilot Clearing-House Mechanism can directly serve and are built with the flexibility in mind to be further expanded to address the needs of a future ILBI, in particular those needs of least developed countries, landlocked developing countries, geographically disadvantaged States, small island developing States, coastal African States and developing middle-income countries, as well as those needs to support the work of the new bodies to be set up by the instrument (Decision Body and Scientific-Technical Body).

2.4 Project Impact

The main expected impact of the Ocean InfoHub, and the underlying proof-of-concept for an ODIS reference architecture, will be the strengthening of science, technology and innovation systems and policies (*such as Marine Spatial Planning, Integrated Coastal Area Management plans and related policies/legislation*) for the global ocean community, through free, low-threshold and open access to ocean related data and information and contributing towards the achievement of SDG 14, in particular to the targets 14.1-3, 14.5, 14.7, 14.c, with direct focus on 14.a (See section 2.3.1).

The Project will considerably enhance the discovery of, and access to, a wide range of ocean related data and information services and products by a wide range of stakeholders, which will enable them to increase their efficiency and effectiveness related to their actions in and near oceans and coastal areas.

In terms of data and information discovery the Project will:

- Improve system-to-system interoperation (Figure 2), thus allowing custom portals with varied objectives to efficiently harvest and serve distributed global content while presenting unified views of these resources to users;

- Enable searching across multiple data/information types in order to get a better overview of available data/information across the complete ecosystem;

- Enable advanced and complex searches by leveraging semantic technologies, linked data and controlled vocabularies (*e.g. search for a course on marine biodiversity in 2021 taught in Spanish and providing grants for students from developing countries*).

These capacities are especially important in many developing countries (and especially in SIDS), where Internet access is available, but usage time is costly and bandwidth is low. In such conditions it is important to minimize searching time and maximize output.

The Project sets itself apart from many contemporary efforts which attempt to build centralized and "siloed" (i.e. isolated) data and information systems with little interoperability with external efforts. The development of national, regional and global single-point-of-access portals has been a focus during the past two decades, creating solutions which tend to require the centralization of data and services. This practice is not sustainable at a global scale and often marginalizes, rather than empowers, local efforts and innovation. To counter this, technology has been evolving towards federated, web-enabled machine-to-machine communication mediated by standard exchange protocols and conventions. The ODIS related activities of the Project will therefore focus on promoting data access through such technologies, reusing what is already available and suggesting extensions where needed. The Ocean InfoHub will leverage this effort and work with existing data and information systems to deliver the CHM/TMT around a few use cases aligned to the priorities of global development frameworks (Section 2.3).

The ODIS reference architecture aligned to data on the web best practices and supported by recognized semantic resources/framework and technical interoperability, aims at improving the overall discoverability and accessibility of data and information resources contributed by the community. The project will specifically improve the discoverability and accessibility of content related to specific source types (listed in 2.5.2) as a first priority.

2.5 Implementation strategy

2.5.1 Data and information sourcing and related product and services

The ODIS related activities (Section 2.2.2) of the Project will work with IOC and non-IOC data and information systems to prototype an interoperable federation of regional content providers, all contributing to a global e-environment (see the "ODIS concept", Section 2.2.2).   This will allow the Ocean InfoHub component of the Project to constitutively discover, harvest and tailor content to meet the objectives of its stakeholders.

The ODIS related activities will consider the 16 content types (Figure 1) as defined in the ODIS Catalogue of Sources (ODISCat) (http://catalogue.odis.org) as a basis for its activities.

Bibliographic infobases (catalogues and repositories)	Code lists and vocabularies	Data catalogues	Data products (model output, forecasting, climatologies,...)
Data systems/portals (allowing downloading of datasets)	Education and training materials	Information on platforms (buoys, sensors, floats, gliders, satellites,...)	Information on experts and organizations
Information on projects	Information on vessels	Journals (open source and commercial)	Manuals, guidelines, standards and best practices
Maps and atlases (geospatial products)	Multimedia content	Real-time observing systems	Software (ocean related)

Figure 1: content types used in ODISCat

Each of the products and services will be developed in consultation with data resources serving existing stakeholder communities (as representatives of broader user communities), to ensure the relevance of the products and services.

As noted above and in the work package descriptions (Section 2.5.2), systems built upon the proof-of-concept ODIS reference architecture will support distributed access to data and information from global governmental and intergovernmental sources and systems as well as from national, local, NGO and indigenous sources. Information can thus enter the system and be accessed through any participating nodes, which will considerably increase its usefulness and relevance to user communities across scales and disciplines. The number of partners identified in the Project proposal is small but is expected to increase rapidly once the base architecture has been established and regional/thematic nodes are in place and operational.

The Project's primary demonstration of this capacity (of ODIS) will center on the CHM/TMT (Section 2.5.2). The project team will undertake technical, content and product development in support of the needs identified in the surveys undertaken in support of regions for the CHM/TMT.

Example products which can be built upon the ODIS reference architecture and interoperability model include:

- *Interactive visualizations of data and information repositories linked to relevant Ocean InfoHub themes, along with the types of services they provide (e.g. dissemination/sharing,*

archival/hosting, full curation, other services) and enriched to include additional technical metadata beyond that currently available in ODISCat.
objective: enable data and information producers to identify and engage existing centers and services to secure data and information sources, obtaining in-kind support where possible without the need to build a new capability that may not be sustainable.

- *Intelligent search capability to enable the discovery of researchers, institutes, programs seeking and or offering and or facilitating access to opportunities related to project collaboration, training, platform sharing/coordinating field work, technology development and linked to relevant Ocean InfoHub themes and/or regions.*
  objective: support the proactive promotion, coordination and delivery of capacity development and related opportunities to stakeholders in disadvantaged regions.

- *Intelligent search capability to enable the discovery and access to information resources from contributed training and educational source types.*
  objective: provide a user-friendly facility to locate relevant training and education sources employing interoperability connections to contributing sources.

- *Intelligent search capability to enable the discovery and access to information resources from contributed standards source types.*
  objective: provide a user-friendly facility to locate relevant standards and best practice sources employing interoperability connections to contributing sources.

- *Intelligent search capability to enable the discovery and access to information individual vessels from contributed vessel lists.*
  objective: provide a user-friendly facility to locate relevant vessel information employing interoperability connections to contributing sources.

2.5.2 The Ocean InfoHub Network

The project will develop a network of regional and thematic nodes and a global hub to source and expose information prioritized by international frameworks (see Figure 2).
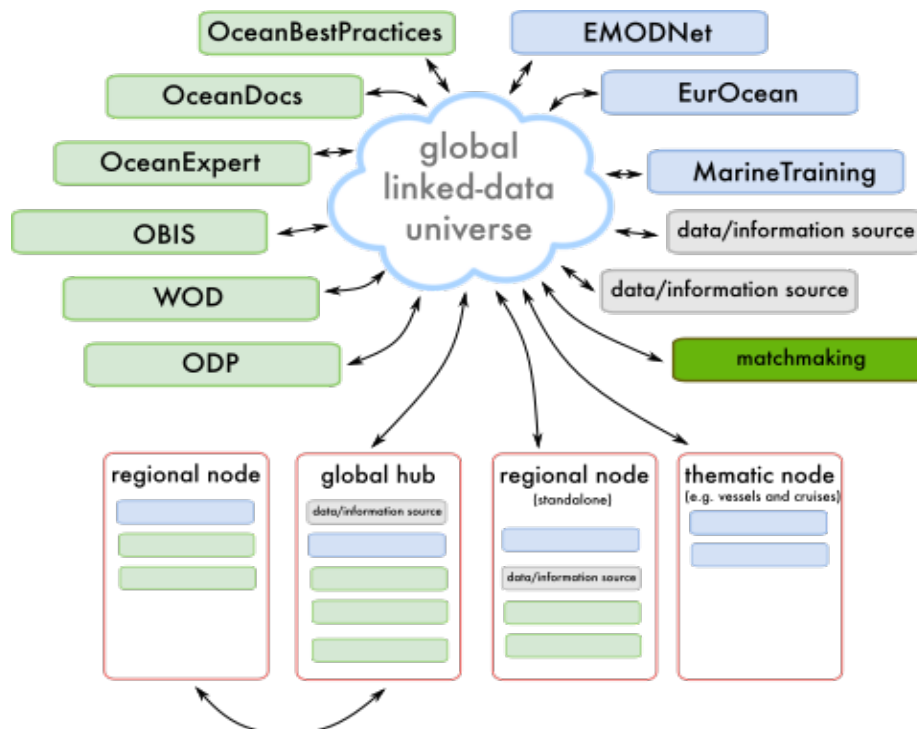

Figure 2: The e-environment underlying the Ocean InfoHub

The Ocean InfoHub will (initially) focus mainly on the following content types:

1. Information on Experts
2. Information on Institutions/Organizations
3. Information on Research Data and Information Infrastructures and their capabilities and services offered (e.g. data curation, data dissemination, etc.)
4. Information on Projects
5. Information on Research Vessels
6. Information on Education and Training opportunities
7. Information on Funding Programs and other opportunities (e.g. access to equipment, etc.)
8. Information on Documents and Publications (e.g. related to ICAM, MSP, …)
9. Information on Manuals, Guidelines, Standards and Best Practices
10. Metadata Catalogue for specific variables
11. Access to Data Sets and/or Data Products relevant to particular program priorities (e.g. SDG 14: Ocean acidification, harmful algae, biogeographic information related to climate change...)

It is noted that all these content types are also covered in ODISCat (see Section 2.5.1).

Much of the required content can already be sourced from existing IOC (and its IODE) products and services such as:
- OceanExpert (global directory of marine and freshwater professionals – http://www.oceanexpert.net),
- OceanDocs (http://www.oceandocs.org),
- Ocean Best Practices (http://www.oceanbestpractices.org),
- Ocean Biogeographic Information System (OBIS) (http://www.iobis.org),
- World Ocean Database (WOD) – (http://wod.iode.org)
- Ocean Data Portal (ODP) – (http://www.oceandataportal.org)

In addition, substantial content will be sourced through the project partners such as:
- EurOcean (Marine Knowledge Gate, Marine Infrastructures Database (including research vessels)…)
- Marinetraining.eu (information on training and education opportunities)
- EMODNET (data portals on bathymetry, geology, seabed habitats, chemistry, biology, physics, human activity, etc.)

It is expected that other regional/global organizations/programmes will join throughout the three years of the project and beyond, when the project becomes operationalized.

These data, information and knowledge stores and services within, and external to, the IOC will be able to interoperably pool and interlink resources through alignment to the ODIS Architecture proof-of-concept. This will allow the Ocean InfoHub to rapidly discover, filter and synthesize content to provide its services, either comprehensively, or tailored to regional/local use cases. Naturally, any other system can also make use of the interoperable elements shared through this e-environment, promoting more rapid innovation and capacity sharing.

As the Project will address three specific regions (Latin America, Africa, Pacific SIDS) it is essential that the Ocean InfoHub is customized to allow users in these regions to quickly and efficiently discover the information that is relevant to their region and with a user interface that allows them to use the language(s) with which they are familiar.

For this reason, the Project will aim to develop three distinct regional "nodes". However, as the Project will need to agree on common standards, protocols and methodologies for the collection, quality control, description and serving of data and information, the Project will initially use a "common" **global hub** infrastructure and provide regional user interfaces that will constitute "virtual" regional nodes. Once the system is up and running and partners within the region have been trained on the data/information management procedures, regions that have the necessary infrastructure (hosting capability, IT staff…) can establish their own regional node infrastructure.

2.5.2.1   Thematic Nodes

For some thematic areas we will identify thematic nodes that may be hosted by IOC programmes, national organizations, NGOs or other regional or international organizations. The thematic nodes will be managed and maintained by their parent project or organization and connected to the global e-environment (and thus the Ocean InfoHub) through the ODIS reference architecture. Examples include nodes handling data and information in support of the GOOS Essential Ocean Variables (EOVs), underrepresented ecosystems (such as those of the deep sea) or specific processes such as the marine impacts of Arctic amplification.

2.5.2.2   Matchmaking Services

While the Ocean InfoHub will provide a wide range of online products and services, users also need a "matchmaking service", which actively connects the needs of individual users with capacities described in the Hub, thereby facilitating the exchange of scientific knowledge, expertise, data, resources, opportunities and technology.

This approach will be particularly valuable for enhancing the capacity of Least Developed Countries (LDCs) and Small Island Developing States (SIDS) and catalyzing marine technology and information transfer across regions and networks. The matchmaking process will be facilitated through a combination of human interaction and the use of open linked data and semantic technology across all ODIS nodes.

1.   Human brokerage

> In order to respond to identified needs, regional node managers will act as focal points, matching online requests for assistance with corresponding resources. This 'human brokerage' approach will initially foster regional partnerships by, for example, enabling access to regionally held infrastructure, facilities and resources. Regional nodes will also work with the global hub to identify and leverage opportunities for collaboration and participation in international projects, study programmes, vessels of opportunity and other initiatives.
>
> In addition to the human brokerage undertaken within the Ocean InfoHub network, the project seeks to promote other organizations (e.g. NODCs) and projects (e.g. data ingestion projects) also providing human brokerage services, leveraging their knowledge to assist in connecting users with the resources they are seeking.
>
> *Example: **Scientist in country x is looking for an opportunity to carry out experiments on-board a research vessel in his/her region during period y**. This requires (i) finding out what RV will be visiting his/her region during period y; and (ii) finding out if there are spare berths on that vessels; and (iii) seeking funds to allow participating in the research cruise. Obtaining answers to (i), (ii) and (iii) requires a combination of information that can be found in the Ocean InfoHub and "human brokerage" to connect the individual scientist with the PI of the research cruise and with possible sources of funding (research grants).*

2. Peer-To-Peer

> Beyond the centralized human brokerage undertaken by the Ocean InfoHub nodes, the project will leverage the Hub's resources to facilitate third party human brokering (i.e. peer-to-peer support) in achieving its goals. Many formal (e.g. registries of repositories) and informal (e.g. web sites, social media platforms) platforms exist in this regard.
>
> *Example:* **Scientist in country x is looking for other experts working on the same topic***. The Ocean InfoHub will assist scientists in finding peers and may also recommend certain social media platforms to share expertise and seek guidance or advice through "peer-to-peer" communication.*

3. Automated/Self-Serve

> A key goal for the project is to leverage the semantic interoperability (i.e. machine-actionable and knowledge-level coordination of data and information) components developed within the ODIS reference architecture as the foundation for automated matchmaking services implemented in the Ocean InfoHub. This will provide a valuable knowledge-level resource to augment the human brokerage support within the system, in discovering and accessing opportunities, even before the raw data and information products are fully harmonized.
>
> The project also seeks to extend the human brokerage function by promoting other organizations (e.g. NODCs) and projects (e.g. data ingestion projects) also providing human brokerage services, leveraging their knowledge to assist in connecting users with the resources they are seeking.
>
> *Example:* **Scientist x is looking for a key expert on marine spatial planning***. Scientist x could search OceanExpert with the subject term "marine spatial planning" but this does not indicate how active that person has been in that topic. Another way would be to search bibliographic databases and associated bibliometric tools which indicate e.g. how many scientific papers someone has written (as 1st or 2nd author) on a topic. The automated/self-serve feature aims at providing such a composite search possibility.*

2.5.2.3 Training and procedures development

In order to ensure that all structural elements of the network provide content of high quality and in a timely fashion, the project will develop and document a set of procedures (which will then be included in the Ocean Best Practices repository) as well as data models (database structures, controlled vocabularies, user interfaces, etc.) that cover all functions performed in the network. Furthermore, to ensure that all individuals involved in the project can perform the required duties it will be necessary to implement a training programme (which will be developed within the Ocean Teacher Global Academy). Similarly, to ensure that users can obtain the best possible use of the Ocean InfoHub self-training modules will be developed.

2.5.3 Work Packages

The Ocean InfoHub and its underlying, proof-of-concept ODIS reference architecture will be implemented through 5 work packages:

- **WP1**: Project management, coordination and evaluation
- **WP2**: Technology development
- **WP3**: Establishment and initial support the global hub and regional nodes
- **WP4**: Training and capacity development of regional nodes
- **WP5**: Communication, user marketing and feedback

Each work package will be implemented by specific teams, headed by a Work Package Leader (except WP 1 which will be under the responsibility of the Project Manager). The overall project will be managed/coordinated by a Steering Group (see below).

2.5.3.1 Work package 1: Project management, coordination and evaluation

Summary:
This work package covers activities related to
- overarching coordination and guidance
- planning and budget management
- monitoring and reporting
- risk and issue management
- project evaluation.

Key Tasks:
As per required practices for projects having a total budget in excess of $500,000 U.S., a project-level advisory group will be established (called the **Steering Group** in this project to align with other IODE projects which have Steering Groups).

The role of the Steering Group will be to:
- monitor and guide the implementation of the Ocean InfoHub
- propose remedial action where necessary
- advise the Project Manager
- ensure that the project serves the needs of the regions
- identify new opportunities and adjust the work plan according to changing needs and circumstances
- prepare annual progress reports

The membership of the Steering Group:
- project manager
- services and technical team leads -
- node managers
- representatives of major stakeholder (user) groups including regional/international organizations
- contacts of other collaborating data/information systems (contributing to Ocean InfoHub and ODIS)

Note: it is recognized that the project is required to serve user needs. Rather than including representatives of the many user groups as well as other collaborating systems, feedback and guidance from these will be obtained through WP4.

Project evaluation:
As is customary for large-scale projects, a project evaluation will be organized at the end of the term of the project. This will be a combination of an external evaluator carrying out an evaluation of the project, combined with a final meeting of the Steering Group to review and discuss the evaluation results. Important: the project will need to develop/establish metrics systems that can track the usage of all products and services by users as defined in 2.6 and referred to in the communication plan .

Deliverables:

D1.1	Annual progress reports
D1.2	Project evaluation report
D1.3	Project final report

Risks:

a. Inadequate monitoring of progress by project manager and Steering Group: low
b. Lack of adequate remedial actions by project manager and Steering Group: low

Cost elements:
- Project manager (consultant) @ 100% x 3 years   (budget item 1.1)
- Administrative assistant @ 50% x 3 years   (budget item 1.2)
- Meetings of the Project Steering Group (year 1 and 2) (budget item 1.3)
- External evaluation (year 3)   (budget item 1.4)
- Project wrap-up/evaluation meeting (year 3)   (budget item 1.5)

2.5.3.2   Work package 2: Technology development

Summary:
This work package covers the technical developments needed to support the implementation of Ocean InfoHub nodes and the proof-of-concept ODIS reference architecture which will allow the nodes to interoperate with each other and external systems.

Key tasks:
In terms of Ocean InfoHub development, this work will include:

- development of a Global Hub (at the IOC Project Office for IODE, Oostende, Belgium)
- development of Regional/Thematic Node application (Virtual nodes part of the Global Hub or as separate software application to be installed at regional/thematic node host)
- continued populating of ODISCat

In terms of ODIS development, this work will include 3 phases (components) that will run concurrently:

Phase 1 - Publish an ODIS reference architecture which outlines the principles and guidelines for composing technologies and methods to network and link data and information systems to enable regional Ocean InfoHub nodes to tap into and contribute to the global data stream of ocean and related scientific data and information.

Phase 2 - Implement modular components from the reference architecture within participating data and information repositories, thereby improving discovery, access and interoperability of these resources around prioritized information products and flows. (*this includes the integration of EurOcean, Marinetraining.eu services provided by the initial partnership as well as, to the extent possible, additional services by partners joining the project during the project*)

Phase 3 - Implement modular components from the reference architecture through development of Ocean InfoHub nodes, testing and iteratively improving the architecture through diverse technology choices within regional contexts.

Deliverables:

Ocean InfoHub
> D2.1   Global hub technology framework developed
> D2.2   Regional node technology developed (virtual and, as possible, as separate application)

ODIS dev Phase 1
> D2.3   Reference architecture towards which any repository wishing to be a part of ODIS can align to and innovate upon
> D2.4   Specifications for automated validation against the ODIS-Arch, for implementation in Phase 2 and/or Phase 3

ODIS dev Phase 2
> D2.5   Cross reference capability in participating repository nodes that exposes the assets from other nodes in context for users
> D2.6   Metrics reporting functionality from repository nodes

ODIS dev Phase 3
> D2.7   At least two working implementations with the ODIS Architecture of regional node information systems that assemble global and local resources, demonstrate cross linking between resources and deliver value tailored to local science and management needs and priorities.
> D2.8   Feedback mechanisms to collect, summarize and report on applications from the Infrastructure that can be shared in the ocean data and information community and used for incremental architectural improvement and solutions development.

Risks:

Ocean InfoHub
> a. Difficulty in finding software engineer with required capacities: moderate
> b. Insufficient time allocated to develop applications: low

ODIS dev Phase 1
> a. Staff recruiting risks: low to moderate
> b. Lack of participation of repositories: low

ODIS dev Phase 2

    c.   There is an inherent risk that repository managers and organizations will not adopt the techniques and methods proposed in the architecture or be willing or be able to invest without an influx of new resources. This will be mitigated through active participation by repository managers (early adopters) in the development of the architecture such that it is compatible with and in line with their own individual development trajectory: low

    d.   There is a risk that implementers may develop information linkages and enhancements to their systems that are not immediately useful to Ocean InfoHub nodes. This will be mitigated through co-development of working technologies, a user feedback-driven design process and intervention from the Project Steering Group as needed: moderate

ODIS dev Phase 3

    e.   While the project will provide supporting investment in developing Regional Nodes through capacity development, training and technical support, Regional Node staff will be required to successfully develop, deploy and sustain a Regional Node. Planning activities will determine the level of support needed, including the potential needs to provide more centralized infrastructure, which may mitigate some challenges: moderate

Cost elements:
- Ocean InfoHub: Staff cost (software engineering)   (budget item 2.1)
  to establish the global hub (year 1)
- Further development and populating of ODISCat   (budget item 2.2)
  (*no cost: in-kind contribution by IODE Project Office*)
- ODIS dev Phase 1,2,3: Staff cost (software engineering) (budget item 2.3)
  (years 1,2,3)
- ODIS dev Phase 1,2,3: Tech meetings (10pax, year 2)   (budget item 2.4)
- ODIS dev Phase 2: initial partner service integration   (budget item 2.5, 2.6)
  (years 1,2,3) (EurOcean, MarineTraining)

2.5.3.3 Work package 3: Establishment and initial support of the global hub and regional nodes

Summary:
This work package will enable the establishment of the global hub and three regional nodes covering Latin America, Africa and Pacific SIDS at the operational level. It is noted that the technical aspects are covered by work package 2. This work package will therefore focus on setting up procedures for the sourcing of content, submission of the content, developing of national and regional networking of content providers and users, and setting up of the matchmaking service to provide in-depth assistance to end users.

Key tasks:
Phase 1: establishment and initial support of the global hub
This work package covers the implementation, testing and support necessary to establish the global Ocean InfoHub node and to support this node to the point where the global node can perform all functions attributed to it.
Note: this will largely be an in-kind contribution, through staff time, by the IOC Project Office for IODE, as well as by (some of) the global partners.

Phase 2: establishment and initial support of the regional nodes

This work package covers implementation, testing and support necessary to establish the regional/thematic[12] Ocean InfoHub nodes and support them to the point where they are self-sustaining (e.g. all day-to-day support provided within the regional nodes, or externally based on formal agreement with the global node/IODE).

Deliverables:

Phase 1

      D3.1   global hub system established at the IOC project office for IODE, Oostende

      D3.2   operational global hub

Phase 2

      D3.3   Installation and startup of regional/thematic Ocean InfoHub portal

      D3.4   Customization of regional/thematic Ocean InfoHub portals

      D3.5   Functional and performance testing to verify integration between the regional/thematic and global node, ensuring acceptable performance by users, along with remediation of any issues encountered

      D3.6   Technical and related support until required support capacity is in place within the node

      D3.7   Establishment of national/regional networks of content providers who will regularly make content available to the regional node

      D3.8   Populating of the regional nodes with content received from the national/regional networks including quality control, reformatting, creating metadata, data entry (Performance indicator: 10,000 content items by the end of the project (global and regional))

      D3.9   "matchmaking" service (human brokering) established and assisting end users with CD related queries

Risks:

Phase 1

    a. Insufficient time allocated to task: moderate

    b. Unforeseen technical difficulties: moderate

Phase 2

    a. Staff recruiting risks: low to moderate

    b. Lack of participation of repositories: low

Cost elements:

    -   Establishment global hub – staff cost   (budget item 3.1)

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[12] in addition to regional nodes that will cover some of the IOC regional bodies (IOCARIBE, IOCAFRICA) the Ocean InfoHub may establish additional regional nodes covering other regions (e.g. North America, Europe, Middle East, IOCINDIO, WESTPAC, etc.) at a later date but also Thematic nodes (e.g. through collaboration with FAO we may have a node focusing on fisheries). This will be especially relevant within the framework of the UN Decade of Ocean Science for Sustainable Development.

(*no cost: in-kind contribution by IODE Project Office*)
- LAC regional node engagement workshop   (budget item 3.2)
  (year 1)
- LAC regional node establishment and operation   (budget item 3.3)
- (years 1,2,3)
- Africa regional node engagement workshop   (budget item 3.4)
  (year 1)
- Africa regional node establishment and operation   (budget item 3.5)
  (years 1,2,3)
- Pacific SIDS node engagement workshop   (budget item 3.6)
  (year 1)
- Pacific SIDS node establishment and operation   (budget item 3.7)
  (years 1,2,3)
- Thematic nodes establishment and operation   (budget item 3.8)
  (no cost: in-kind contribution by node hosts)
- Matchmaking service development and operation   (budget item 3.9)
  (years 1,2,3)

Note: The budget includes allocations for the organization of a regional workshop (to identify regional needs, develop a specific regional work plan to respond to the needs) as well as the development of the regional node (in terms of populating the system with baseline data and information). The regional workshops will allow the co-design of the system (specifically at the regional level). In this regard it is important that the regional workshops include a wide range of stakeholders (international and regional organizations, existing national/regional data/information systems, regional projects, national decision-makers, national experts,…) and take into account needs already identified and documented at various regional as well as national levels.

It is noted that further populating and updating of the system will be done largely on a voluntary basis / in-kind contribution by the participating countries. Nevertheless, a specific allocation ($ 25,000/year) is provided to each region for the operation of the regional nodes. The regions will be able to allocate these funds in accordance to needs and availability of human resources. It is noted however that these funds are intended as "seed funds" as the long-term success and sustainability of the system will depend on the participating countries, organizations and institutions through the provision of in-kind human resources support. This will be driven by the success of the provided services and their ability of fulfil the needs identified by member states. (see also 2.9)

2.5.3.4 Work package 4: Training and capacity development of the nodes

Summary:
This work package covers the training and capacity development needed to support the infrastructure and contributors/users of the global Ocean InfoHub and regional nodes.

Key tasks:
This work package will focus on the development of a series of online training modules and tutorials as well as written documentation such as manuals. The developed training materials can be used through self-paced online sessions or in-class/on-site sessions at regional nodes. Ghent University (partner 6, see Section 3.1), via the OceanTeacher e-Learning Platform, has a lot of experience in the development of both short and more extensive online learning resources and will take the lead in developing learning

materials. IMBRSea/UGent and OTGA have already initiated in the past years some pilot collaborations on the development of online learning materials.

All developed digital learning materials will be hosted on the OceanTeacher e-Learning Platform (Moodle based) which is the backbone of the OceanTeacher Global Academy (OTGA) (http://www.oceanteacher.org). The use of the OceanTeacher e-Learning Platform will avoid the development of a separate training platform and will therefore save resources. Furthermore, by hosting the materials in this dedicated learning environment it will be possible to easily monitor how many learners are using the developed materials. In addition, it will be possible to interact with the users following the online modules and as such get feedback on potential strengths and weaknesses in the Ocean InfoHub or in the available learning materials. If needed the network of OTGA Regional and Specialized Training Centers may organize dedicated face to face training sessions and, if deemed necessary, facilitate the translation of training resources.

The work of this work package will start from year 2 onwards, upon completion of the first functional parts of the Ocean InfoHub (see work packages 2 and 3).

Deliverables:
- D4.1   Operations manuals[13] (administrators, content providers, end users)
- D4.2   Online training courses[14] (for administrators/node managers and content providers and end users)
- D4.3   Coordinated staffing, professional development and other strategies for increasing base of skilled workers to undertake required support activities
- D4.4   Communication skills course (for administrators/node managers)

Risks:
a. Insufficient time allocated to task: moderate
b. Unexpected issues with self-learning modules and training course: moderate

Cost elements:
It is noted that as this work package relies on the hosting of content by the OceanTeacher Global Academy and that class training courses may be funded through OTGA the cost element of this work package is limited to the development of online training modules (6 modules) (budget item 4.1)

2.5.3.5 Work package 5: Communication, user marketing and feedback

This work package covers the communications and engagement activities needed to ensure the relevance and usefulness of the Ocean InfoHub global and regional/thematic nodes, to promote community participation in the Ocean InfoHub as contributors and users, and to solicit input needed to foster ongoing development of the Ocean InfoHub nodes. Under this work package the project will also organize user consultations through online fora, surveys and other two-way communication methods and tools. Extensive use will be made of social media, especially Twitter, to reach a broader, younger audience in a more active way.

Note: it is noted that the project, throughout the implementation, will pro-actively seek collaboration and synergies with other UN agencies and regional organizations that have developed similar

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[13] To be made available in English, French, Spanish (and Portuguese) with the assistance of the regional nodes

[14] To be made available in English, French, Spanish (and Portuguese) with the assistance of the regional nodes

data/information systems, in order to achieve their interoperability with the Ocean InfoHub. This will be especially important during the UN Decade.

<u>Deliverables:</u>

- D5.1 Implementation of the communication plan including linkages between the project and national, regional and global programs and objectives.
- D5.2 Presentations about the Ocean InfoHub at the IOC Governing Bodies, Regional and other subsidiary body meetings and other relevant venues.
- D5.3 News releases, success stories and reusable presentation/communication materials (presentations, posters, flyers, etc.).
- D5.4 Global, regional and thematic mailing lists, social media,…
- D5.5 Contributor and user feedback/satisfaction surveys.
- D5.6 Updated needs assessment and comparison with previous engagement.

<u>Risks:</u>
a. Lack of expertise to implement communication plan: low
b. Insufficient human resources to implement communication plan: moderate

<u>Cost elements:</u>
- Participation in meetings to promote Ocean InfoHub   (budget item 5.1)
- (years 1,2,3)
- Community surveys (online)   (budget item 5.2)
- (*no cost: service provide by Project Office and nodes*)
- Communication services including social media,   (budget item 5.3)
  web site etc. (consultant) -
  part-time 1 person month/year (3 regions + global hub)
- Publications and reports (promo materials)   (budget item 5.4)

2.6 Stakeholders: Beneficiaries and partners

When ODIS and the CHM/TMT initiatives started each initiative identified its user groups (beneficiaries) as shown in Figure 3. It is shown that these are largely identical.

ODIS user groups	CHM/TMT user groups
1. scientists (academic and private sector) 2. government agencies/policy makers 3. IOC global and regional programmes 4. IODE National Oceanographic Data Centres (NODCs), IODE Associate Data Units (ADUs) and IODE Associate Information Units (AIUs) 5. UN agencies, International Governmental Organizations (IGOs) and Non-Governmental Organizations (NGOs) 6. industrial and commercial enterprises	1. research organizations, scientists, academia 2. national government agencies 3. regional organizations 4. International, intergovernmental organizations 5. Non-state actors, including the private sector and international non-governmental organizations

Figure 3: stakeholder communities for ODIS and Ocean InfoHub

It is important to note that the above-mentioned user groups are also those who provide content to the

system. This will enhance the self-driven nature of the system and thus ensure its sustainability beyond the lifespan of the project. Furthermore, the distributed approach will allow further expansion of the "partner network" with new content providers as well as users, thereby further enriching the content ecosystem.

In addition, the project will target early career scientists and aim at mainstreaming initiatives that contribute to UNESCO's global priority on gender equality.

Although many of the beneficiaries and user groups of CHM/TMT and ODIS were defined as being identical both CHM/TMT and ODIS serve a different purpose. CHM/TMT is meant to be a group of end-user portals and products while ODIS will deliver the services needed to make those CHM/TMT portals a success.

2.7 Project timeline

The project will be delivered through a set of integrated work packages. The overall duration of this project will be 36 months and the timeline of the project per key activity is summarized in ANNEX B.

2.8 Risk analysis and preventive mitigation measures

Risk analysis and preventive mitigation measures are described in ANNEX C.

2.9 Sustainability and exit strategy

Sustainability of the results achieved through this project will be impacted by a number of factors:
- Capacity and support at and between the global, regional and thematic Ocean InfoHub nodes;
- Richness and relevance of sources presented through the global, regional and thematic Ocean InfoHub portals;
- Success in leveraging the sources mobilized through the project to address the Ocean InfoHub needs identified through feedback surveys and other tools;
- Commitment by contributors to maintain/enrich their contributions to the Ocean InfoHub and ODIS;
- Evolution of usage (in terms of quantity) of the system.

Although there has been a general culture shift to support increased access to data and information and reducing the barriers to discovery and access, capacity development and other 'working opportunities' require more investment and effort to both establish and maintain.

As mentioned previously, a clear advantage will be that the content providers are also beneficiaries and users of the project output. The distributed architecture of regional nodes will furthermore ensure that member states, institutions and organizations within a region consider the Ocean InfoHub regional node as "their" system which will instil a sense of ownership and responsibility for its continuation beyond the end of the funded project. At the level of the IOC regional offices we will aim at promoting the regional nodes as "authoritative" sources of data and information which will contribute to a wide variety of regional projects and products whereby the region will then self-resource the continued content input and quality control coordination.

A considerable responsibility for the continuation of the regional nodes will be placed at the level of the IOC regional offices to ensure the continued operation of the regional nodes and appropriate promotion and communication will need to be undertaken by the regional offices to ensure the required resources.

Similarly, the global hub will need to continue beyond the duration of the project. IOC has been given responsibility for regular reporting on ocean science capacities in its Member States through the GOSR (Global Ocean Science Report) and within the UN (see 2.3) for the development of the Ocean InfoHub. In addition, data and information will play a key role in the UN Decade of Ocean Science for Sustainable Development. The Ocean InfoHub and ODIS will play a major role in the Decade as a mechanism to collect, share and disseminate ocean data and information as well as promoting the equitable participation of all its Member States in the activities of the IOC and within the Decade, by sharing data and information that facilitate capacity development and sharing of marine technology.

This responsibility will make it essential for IOC to make available the necessary resources for the continued development and maintenance of the Ocean InfoHub beyond the timeframe of the project.

3. Project Management

3.1 Project management and implementation

The initial list of partners is provided in Table 3. It is noted that this list will expand as the project is implemented. As mentioned in 2.5.3 the project will have a Steering Group which will:
- monitor and guide the implementation of the Ocean InfoHub
- propose remedial action where necessary
- advise the Project Manager
- ensure that the project serves user needs
- identify new opportunities and adjust the work plan according to changing needs and circumstances
- prepare annual progress reports

As mentioned in 2.5.3 the membership of the Steering Group will include:
- Project Manager
- Services and Technical team leads
- Node managers

Table 3: Partner List

N°	Name or type of partner	Role
1	IOC Project Office for IODE (IOC, Oostende)	Hosting/management of global node
2	IOCARIBE Secretariat (IOC, Cartagena)	Management of LAC (Latin American Countries) node
3	IOCAFRICA Secretariat (IOC, Nairobi)	Management of Africa node
4	The Pacific Community[15]	Management of P-SIDS (Pacific Small Island Developing States) node

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[15] It is noted that a Letter of Intent was signed in July 2019 between the IOC and SPC in preparation for a Memorandum of Understanding. The Letter of Intent includes references to cooperation on data and information exchange and on capacity development.

5	SPREP – Pacific Environment	Management of P-SIDS node
6	University of Gent (Belgium) (marinetraining.eu)	Development training portal
7	EUROCEAN (Portugal)	Development infrastructures inventory
8	INVEMAR (Colombia)	Development and co-management of the LAC node
9	EMODNET	Contribution to dissemination of data and data products
10	Partnership for Observation of the Global Ocean (POGO)	Contribution to training-related content, human brokering
11	Western Indian Ocean Marine Science Association (WIOMSA)	Management of (East Africa/Indian Ocean) node

Letters of intent are available.

3.2 Monitoring

The detailed Monitoring and Evaluation (M&E) Framework is available.

The performance will be monitored by the Project Steering Group which will meet annually (terms of reference see 2.5.2 and 3.1). Monitoring will focus on whether the key performance indicators (KPIs) have been reached in the observed period (calendar years).

The Project Manager will be responsible for reporting on developing the aggregate view while also identifying systemic (cross-initiative) risks and issues, interdependencies and potential opportunities for collaboration in the delivery of the sub-initiatives.

3.3 Evaluation

The project will be evaluated at two levels:
1. Success in achieving its stated objectives based on planned deliverables and key performance indicators.
2. Overall management of the delivery of the project at both the project and sub-initiative levels.

Although key performance indicators will be established and tracked against each of the work packages as they are developed, a small number of program level indicators will be applied to this proposal as a whole (will also be present at the work package level):
- Number of regional and thematic Ocean InfoHub nodes successfully implemented compared to the original plan
- Number and type of engagement activities delivered, assessment of feedback from participants/users and successfully delivered follow-up activities
- Volume of content registered with the regional/thematic and global Ocean InfoHub nodes and their relevance to the geographic areas and priorities identified at the global and regional levels within the Ocean InfoHub

- Availability and relevance of technical training, equipment and capacity development resources to address gaps identified at the global and regional levels within the Ocean InfoHub
- Number of significant knowledge transfer/collaboration opportunities completed
- Number of "matches" made through the match-making service.

The planned Evaluation is indicated in Work Package 1 .

3.4 Visibility

The purpose of the project communication plan is to:
- facilitate effective and efficient communications and engagement with the various audiences having a major stake in the project;
- attract new users of and contributors to ODIS, with emphasis on early career and female scientist;
- provide visibility to the results of the project;
- reflect how key stakeholders, including beneficiaries, donors and UNESCO, work together to achieve the project results.

The project communication plan is available

Annex A: Results Framework

Impact: All IOC Member States obtaining strengthening of science, technology and innovation systems and policies through free, low-threshold and open access to ocean related data and information and contributing towards the achievement of SDGs, UN Decade of Ocean Science, The Paris Agreement and other international frameworks				
Quantitative and/or qualitative performance indicator (PI) (disaggregated by sex):	**Baseline (B):**	**Source and means of verification (M):**	**Target (T):**	**Assumptions and risks**
PI 1. *Number of ocean products (e.g. policies, MSP, coastal zone management plan, legislation…) developed nationally that used the Ocean InfoHub data/information, disaggregated by country and type of product*	0	Online surveys, bibliographic analysis (WP 5, activity 5.1, 5.2)	10	It is assumed that the enhanced and centralized availability of ocean data and information content will contribute to the development of ocean products. There are risks that decision makers will be unaware of the system or not prepared to use it as a trusted source. These risks will be managed through a combination of project Steering Group, communications and outreach, and training and capacity development to ensure the relevance, community awareness and usability of the Ocean InfoHub.

Outcome N° 1: Number of partners who are contributing and sharing continuously content to the Ocean InfoHub				
Quantitative and/or qualitative performance indicator (PI) (disaggregated by sex):	**Baseline (B):**	**Source and means of verification (M):**	**Target (T):**	**Assumptions and risks**
PI 1. *Number of content items shared through the system*	*0*	System statistics (WP 5, activity 5.2)	1000	It is assumed that national, regional and international potential partners are allowed and willing to share data and information through an open access global system. There is a risk that certain data and information (of commercial and/or military importance) may be restricted. This risk will be mitigated by respecting mandatory organizational controls. This would include promoting the sharing information on the existence of data and instructions for requesting access when direct access is not available. This would also include promoting the sharing of data at levels allowed without contravening operational policies (e.g. providing aggregated data, removal of personally identifying information and other standard practices).
PI 2. *Number of Ocean InfoHub users which have reported collaborative initiatives stimulated by their use of the system*	*0*	Online surveys, bibliographic analysis (WP 5, activity 5.1, 5.2)	10	

				It is assumed that users will keep track of collaborative initiatives promoted through the system. There is a risk that users may not document the origins of collaborative efforts. This risk will be mitigated to the extent possible through outreach channels such as feedback surveys and engagement with other groups providing coordination support.

Output N°1: *Interoperable system of data/information created and available to users (ODIS)*

Quantitative and/or qualitative performance indicator (PI) (disaggregated by sex):	Baseline (B):	Source and means of verification (M):	Target (T):	Assumptions and risks
PI 1. *Number of ODIS integrated products/services developed*	0	Annual report/ web sites	5	It is assumed that national/regional/international data/information systems are willing to develop the integrated interoperability products/services. There is a risk that invited data systems may not be willing to collaborate. In cases where the system is part of a higher-level network, this risk will be mitigated to the extent possible through collaboration at the network level, thus seeking opportunities to limit the incremental effort required on the part of the contributing systems. This risk will also be managed through the development of the specifications for interoperability services, etc. by seeking input from the community in order to create specifications deemed relevant and useful.
PI 2. *Usage of the ODIS (volume of content downloaded)*	*0*	Annual report/System statistics module	1000 items/year/node downloaded	It is assumed that users will discover the ODIS data access modules and consider it sufficiently user friendly. There is a risk that the expertise required to make use of the linked data systems may be too specialized for many users. This risk will be mitigated through development of higher-level APIs and components such that they handle some of the complexity on behalf of the user. Furthermore, as with other outputs from ODIS, APIs will be developed through co-design with the community (users and developers), the work being based on industry standards and taking design and related principles from complementary efforts and user feedback into account.

	Activities:	Assumptions and risks
	1. Sub-projects established for each ODIS product/service involving existing data/information product stakeholders (WP2, activity 2.2, supported by 2.3)	Assumed that existing data/information systems will be able and willing to collaborate. There is a risk that insufficient time/funding will be secured to develop the products. This risk will be managed by taking an iterative approach to development, making small, measurable and useful advances through the project rather than undertaking large-scale and more complex development in a single iteration. Furthermore, as with other outputs from ODIS (e.g. products, web portals, etc.), products and services will be developed through co-design and community (users and experts) engagement, with opportunities for feedback be provided throughout development. There is a risk that existing systems will not be interested in the project/outcomes and may decide to not invest in new development or re-development of existing products and services. This risk will be mitigated in part by undertaking incubator projects to demonstrate specific returns on investment, fostering interest in extending the work.
	2. Integration of ODIS products/services into Ocean InfoHub	Assumed that products/services will be available in a timely fashion. There is a risk that products/services will not be completed in a timely fashion. This risk will be mitigated through iterative development and continuous improvement, delivering products and services which evolve through the project and which provide meaningful value with each iteration.

Output N°2: <mark>Global *Ocean InfoHub node* *established, operated and applied by users and contributors to begin developing ocean products*</mark>

Quantitative and/or qualitative performance indicator (PI) (disaggregated by sex):	Baseline (B):	Source and means of verification (M):	Target (T):	Assumptions and risks
PI 1. *Number of nodes participating in the Ocean InfoHub*	0	Annual report/ web sites	4	It is assumed that the IOC regional offices will be able to host and coordinate the regional nodes in LAC, Africa and Pacific SIDS (regional partner organization). There is a risk that the regional offices and regional partner may not have sufficient human resources to manage the nodes despite support provided by the Project.

		Activities:		Assumptions and risks
		1.Development of global, regional and thematic nodes (WP2, activity 2.1; WP3, activity 3.1, supported by 3.2; WP4, activities 4.2-4.10)		Assumed interest and commitment of regional secretariats and other partners. There is a risk that there will be a lack of commitment to developing the regional and thematic nodes. This risk will be mitigated in part by adopting a virtual node structure to provide remote support where required.
		2.Establishment of Steering Group to build a community of practice (W4, activity 4.1)		Assumed that there will be interest in building a partnership. There is a risk that partners will not be available for meetings. This risk will be mitigated in part by seeking opportunities to leverage meetings already taking place (e.g. back-to-back) and by seeking sponsorship opportunities for some attendees.
		3. Uptake of project by users in using the system for development of ocean policies and coastal/ocean sustainable development (using input from WP5, activities 5.1-5.3)		Assumed interest in available data and information and their relevance to decision makers. There is a risk that products and services are not relevant to decision makers. This risk will be mitigated through active community engagement in order to identify, build and improve products and services based on community input and feedback. Products and services will be co-designed collaboratively with the user community at the onset and developed iteratively to ensure they are relevant and address identified requirements. Tools including surveys and targeted (direct) contact will be used to identify, verify and refine requirements, as well as to solicit feedback.

Above this activities table, the continuation cell reads:

This risk will be managed by evolving the functions undertaken by the nodes over time. This principle of continuous-improvement is intended to not only support nodes with being sustainable, but also to implement change in a manageable way.

Output N°3: ==Capacity in data/information sourcing, quality-control and submission of contributors strengthened, and capacity in system use for data/information discovery and extraction of users strengthened==				
Quantitative and/or qualitative performance indicator (PI)	Baseline (B):	Source and means of verification (M):	Target (T):	Assumptions and risks

(disaggregated by sex):				
PI 1. *Number of trainees trained in content submission*	0	Annual report/ web sites	100	It is assumed that there will be sufficient interest at the level of national, regional and international partners to participate in training There is a risk that there will be insufficient interest or individuals available to take part in training. This risk will be mitigated in part by delivering both on-line (enable remote access and in-class training. Furthermore, the efforts will be made to engage organizations having an operational mandate to support the publication and release of open data in to include them in training opportunities in order to increase available support to contributors.
	Activities:			**Assumptions and risks**
	1. Organization of 2 in-class training courses (WP6, activity 6.1)			It is assumed that there will be sufficient interest at the level of national, regional and international partners to participate in training There is a risk that there will not be sufficient interest in participating in training. This risk will be mitigated in part by seeking opportunities to support sponsorship for some attendees, while offering remote participation where possible for attendees unable to participate in person. There is a risk that training will be provided, but not used in support of contributing content to Ocean InfoHub. This risk will be mitigated in part by ensuring that regional Ocean InfoHub matchmaking support is involved in selecting and providing follow-up support to training participants. This risk will also be mitigated in part by undertaking targeted monitoring and post-training follow-up with participants in order to assess value returned on training sessions, to support participants by identifying post-training support issues and connecting participants with post-training resources to ensure training results in active contributions to Ocean InfoHub.
	2.Development of online training material for self-paced learning (WP6, activity 6.2, supported by 6.3)			It is assumed that there will be sufficient interest at the level of national, regional and international partners to participate in training. There is a risk that there will not be sufficient interest in participating in training.

| | | | | This risk will be mitigated in part through promotion of available self-serve training resources as part of the project communication plan and matchmaking support. This risk will be further mitigated through proactive analysis of web site statistics and execution of community surveys in assess the use of resources and to seek feedback on relevance of the available resources and to targeted users.

There is a risk that training will be provided, but not used in support of contributing content to Ocean InfoHub.

Beyond proactive monitoring of use of training resources, this risk will be mitigated through targeted engagement by the Ocean InfoHub coordination support, soliciting contributions of priority resources by the community. |

Output N°4: <mark>Networking of data/information contributors and users established (forum concept, including coordinated match-making services) leading to improved mutual understanding and collaboration towards strengthening of science, technology and innovation systems and policies.</mark>

Quantitative and/or qualitative performance indicator (PI) (disaggregated by sex):	Baseline (B):	Source and means of verification (M):	Target (T):	Assumptions and risks
PI 1. *Number of data/information providers contributing content*	0	Annual report/ web site statistics	50	It is assumed that national/regional/international data/information systems are willing to participate by providing content There is a risk that existing systems will be unwilling to contribute content (e.g. deem effort duplicative, etc.). This risk will be mitigated in part by seeking opportunities for existing systems to contribute to the foundation of Ocean InfoHub (standards, interoperability, etc.) and to seek opportunities to ensure the project deliverables tangible value back to contributing systems. The strategy for undertaking supporting activities such as the match-making service, along with its deliver, will be established as part of the services work package, considering the differences in circumstances across regions. The goal will be to establish a comprehensive view of match-making opportunities and successes, etc., this will be a federation across regions and it is expected that multiple delivery and oversight models will need to be applied (e.g. in some cases the regions will be able to simply handle the front-line work, in others a multi-regional team approach will be required).

PI2. Number of unique users consulting the system	0	Annual report/ web site statistics	1000/year	It is assumed that the system will obtain visibility in the regions and that number of users will grow throughout the Project. There is a risk that the system will not obtain visibility in the region. This risk will be mitigated through the project communications plan, seeking opportunities to promote Ocean InfoHub at events and through engagement with the user community. This risk will be mitigated in part through regional communication and promotion activities. There is a risk that the system will not provide access to sufficient relevant content in a timely manner necessary to continue attracting new users (e.g. users will not be attracted to the system over other existing discovery/access pathways). This risk will be mitigated by engagement and feedback activities to ensure relevance and usefulness of content available through Ocean InfoHub. Engagement efforts will also be used to identify priority source types and themes and to undertake specific efforts to facilitate ongoing contribution of relevant content to Ocean InfoHub.
		Activities:		**Assumptions and risks**
	1. Detailed statistics of contributors (WP5, activity 5.3)			Assumed that existing data/information systems will be able and willing to collaborate. There is a risk that there will be insufficient time/funding to develop relevant/needed products. This risk will be managed by taking an iterative approach to development, making small, measurable, and useful advances through the project rather than undertaking large-scale and more complex development in a single iteration. As with other community-facing outputs, co-design/specification of critical metrics will be undertaken to ensure tangible value can be demonstrated as a result of contributing to ODIS. There is a risk that there will be insufficient interest from existing systems to contribute. This risk will be mitigated in part by undertaking incubator projects to demonstrate specific returns on investment, fostering interest in extending the work.

Annex B: Timeline

Key Activities	Year 1 (2020)				Year 2 (2021)				Year 3 (2022)			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
WP1: Project Management and Coordination												
1.1 Project manager	X	X	X	X	X	X	X	X	X	X	X	X
1.2 Admin assistant (50%)	X	X	X	X	X	X	X	X	X	X	X	X
1.3 Steering Group meetings	X				X				X			
1.4 External evaluation										X		
1.5 Project wrap-up meeting												X
WP2: Technology development												
2.1 global hub development		X	X	X	X							
2.2 further development of ODISCat	X	X	X	X	X	X	X	X	X	X	X	X
2.3 ODIS development		X	X	X	X	X	X	X	X	X	X	
2.4 ODIS technical meetings					X				X			
2.5 EurOcean service integration			X	X	X	X	X	X	X	X		
2.6 MarineTraining.eu service integration			X	X	X	X	X	X	X	X		
WP3: Establishment and initial support of the nodes												
3.1 Global node establishment and operation				X	X	X	X	X	X	X	X	X
3.2 LAC (IOCARIBE+)node regional meeting	X											
3.3. LAC (IOCARIBE+) node establishment and operation			X	X	X	X	X	X	X	X	X	X
3.4 IOCAFRICA node regional meeting (needs assessment)		X										
3.5 IOCAFRICA node establishment and operation			X	X	X	X	X	X	X	X	X	X
3.6 Pacific SIDS node regional meeting (needs assessment)		X										
3.7 Pacific SIDS node establishment and operation			X	X	X	X	X	X	X	X	X	X
3.8 Thematic nodes establishment and operation			X	X	X	X	X	X	X	X	X	X
3.9 Match-making service development and operation			X	X	X	X	X	X	X	X	X	X
WP4: Training and capacity development of the nodes												
4.1 development of online training modules (6 modules)				X	X	X	X	X	X	X	X	X
4.2 in-class training courses						X			X			
4.3 online hosting of training materials				X	X	X	X	X	X	X	X	X
WP5: Communication, users marketing and feedback:												
5.1 participation in meeting and workshops			X	X	X	X	X	X	X	X	X	X
5.2 community surveys (by global hub and regional nodes)			X	X	X	X	X	X	X	X	X	X
5.3 communication services including social media, web site			X	X	X	X	X	X	X	X	X	X
5.4 publications and reports			X	X	X	X	X	X	X	X	X	X

Annex G.1: Potential Project Concepts Leveraging the ODIS Architecture

Introduction

The ODIS architecture outlined in the proposal is part of a much larger suite of developments in the field of linked open data on the web. Indeed, it sets a robust foundation for future ODIS products and services, and those that will interoperate with them. The concepts can be extended into many other areas to have broader reaching benefits throughout the repositories and data systems of the ODIS network. Annex G presents a number of additional project concepts that were discussed in the writing of the proposal that can be selected in the course of the project as resources are available and priorities set by the Steering Group indicate.

Proposed pilot project topics

1. Data quality assessment and enhancement across distributed systems
Summary: As Regional nodes develop targeted applications to deliver value to end user communities of scientists, managers and others, it is anticipated that a number of issues will arise with metadata content, data formatting and other challenges. These may indicate needs for data and metadata quality assessment and data enhancement, against a global reference to ensure interoperability. The architecture will lend itself to developing modular methods for collaboratively developing software tools and algorithms that can assist human data managers in these tasks.

2. Auditing for alignment to ODIS architecture
Summary: While compliance with the architecture is not a direct aim of the project, a series of tools could be developed to continuously introspect the information flowing through the network from any point of view - Global Ocean InfoHub, Regional nodes, etc. These tools could help to examine the relative completeness of metadata and help to explain phenomena such as metrics showing what items are being discovered and followed on the network.

3. Integrated metrics and reporting
Summary: While each node in the ODIS network can operate independently, loosely coupled with other nodes and information elements in the network, implementation of best practices in collecting user interactions with the system and open sharing of these metrics across the network can help to identify areas of continuous improvement. Many common open source tools exist to aid in this capacity along with standard methods for evaluation and use of the collected information.

4. Accelerating the mainstreaming of new and emerging data resources in ODIS
Summary: The community of users, represented by the Regional nodes, will likely provide new demands for data types and sources needed in local scientific studies and management applications. Particularly as communities continue to tackle sustainability challenges, these demands will include new types of information that need to be integrated and synthesized onto the network through the work of major repositories and/or the Regional nodes themselves. The ODIS architecture will provide technical and method aids to accelerate the process of bringing these data assets online in the most usable and sustainable fashion. It is envisioned that individual data mobilization projects could be sparked through the project, potentially attracting matching funding for topic areas of interest to specific groups within this overall framework.

5. Global inventory of GIS services/layers

Summary: Mappable data layers are a particular area of interest in many communities, as evidenced through the continued growth and popularity of the Integrated Coastal Atlas Network. As Regional and Repository Hubs in the network align with metadata and catalog standards suggested through the ODIS Architecture, a global inventory of GIS services/layers may be desirable and could aid in rapid application to a variety of community data analysis challenges. Tools such as the TerriaJS platform, pioneered in the development of the Australian National Map and made up of open source software, may provide for rapid map application development at very low cost once foundational catalog resources are available.

6. Open-GTS as a data exchange use case

Summary: Both CHM/TMT community members, repository managers and others involved in developing the proposal expressed a strong desire to advance the use of the OpenGTS specification and associated data services for access to real time telemetry data coming from ocean observation and sensor platforms. These emerging technologies offer good opportunities for global collaboration to implement systems following best practices for long term viability and sustainability through alignment with the ODIS Architecture. A project to develop these capabilities through the JCOMM Observations Coordination Group (OCG) could help to implement these technologies across the community and may be attractive to additional investments.

7. Leveraging AI capabilities developed through Ocean Best Practices (OBPS) project

Summary: This work includes tagging facilities being developed to support automatic keyword assignment for resource through text analysis.
Note that the ontologies and vocabularies used are the same as those used to identify EOVs (and soon EBVs) and are well adopted in multiple communities. Can easily be incorporated into ODIS metadata specifications to allow systems like OBPS and ODIS nodes to be semantically consistent.
EurOcean's knowledge products via AquaTT's manual curation of deliverables and other outputs is a good point of possible collaboration with OBPS - they can leverage the NLP and Ontology approach and the community can leverage their manual curation as a resource for AI agent training to improve the automated approaches.

8. Coherent and harmonized data ingestion with ODIS as enabler - combination of proposed concepts

Summary: As noted in the main proposal, harmonized data ingestion process/services hosted by national and regional repositories (e.g. NCEI, EMODnet, IMOS, the NODCs and ADUs) can aid data producers contribute to the global data commons while supporting interoperability between repositories. This pilot will extend this capacity with a particular focus on supporting developing countries with limited capacity - the goal is to create a network of shared capacity for data injection: experts (humans and/or algorithms) who can guide and direct data providers to the repositories, standards and best practices, etc. to support curation and access of data and information.

9. Standardized, yet distributed, access to global research infrastructure

Summary: Global access to research infrastructures from research vessels to computational platforms has been strongly expressed from regional partners and major repositories. This includes both existent infrastructure and campaigns as well as plans for future capacity. Availability of this information in an

integrated way can help in matchmaking between research collaboration opportunities and needs, particularly for researchers from developing countries. There are regional and global sources for this type of information (JCOMMOPS, POGO, EurOcean and others) that provide a model. Regional nodes may have access to other aspects of this information puzzle such as planned permits for work within EEZs that could be contributed.

A project in this area may be of high value across the community. Much of the information exists in various databases, globally, and the project would involve determining the linkage and mapping to enable cross-referencing between these systems. The EurOcean partnership in the project provides a potential starting point for this capacity with a European focus.

10. Standardized access to distributed research project information

Summary: Information about research projects as time bounded events that describe scientific research is another important aspect of the future system described by the Regional Hubs. This will support both cross referencing between systems which often contain information at some level about the projects from which their assets were generated and the goal to aid in research "match-making" described in the proposal. Project information is represented throughout the network in existing infrastructures such as OceanExpert but is not yet a "first order" concept, aligning with established information models from schema.org (http://schema.org) or others. A project to establish adopt a high level, existing schema for project information as an Ocean Best Practice and implement a pilot integration mechanism through partnership EurOcean and EMODNET (ref. to SeaDataNet's EDMERP) may help to demonstrate and begin the process of building this as a robust resource.

Annex G.2: Technical Supplement

This annex includes additional technical details and explanations on the technological developments to be implemented under WP2 and WP3 of the project.

WP2: Technology development

The challenge

One of the greatest challenges facing ocean science and operations - from local to global scales - is the availability of interoperable data and information. Immense effort is still required to discover, assemble and integrate existing data sets in order to further our understanding of the oceans. This is despite the massive investments in regional solutions, which need a sustainable architecture, to allow them to work together and provide users with actionable data.

Objectives:

1. Create a modular global reference architecture (ODIS-Arch) to which stakeholders can align their local and regional implementations and data/information products

2. Align the ODIS-Arch to the informatics needs for the Decade, in particular the GOOS EOVs and the SDGs

3. Publicize and socialize the ODIS-Arch modules, engaging regional and local partners to implement and test interoperability across one or more modules of the global reference architecture.

Overview

The Ocean Data and Information System (ODIS) work plan focuses on proven methods to build a data and information system that will provide coherent insight into the global ocean, in support of science, operations and society. A proof of concept project is described as three distinct project phases operating iteratively to build an ODIS Architecture and implement capacity through development between Ocean Science Repositories and regional Ocean InfoHub nodes. The phases of the project are described in terms of milestones, with aspects of the phases intended to operate in concert with other phases in an iterative fashion where lessons learned can be incorporated quickly to inform current and future work. It is paramount that the work to develop the global data and information system architecture and any supporting technologies not be conducted in isolation from regular involvement and iterative implementation within the international and national information systems and on the ground application at regional hubs.

The foundational principle guiding the proof of concept architecture is that of Five Star Linked (Open[16]) Data posited by Sir Tim Berners-Lee. The principle is simple and elegant by design, and the approach applied to the ODIS concept strives to maintain this simplicity as a deliberate strategy to avoid the pitfalls of overly complex design that can plague already complex processes to build infrastructure in a complex and heterogeneous global environment.

★ Make your stuff available on the web (whatever format)
★★ Make it available as structured data (e.g. Excel instead of image scan of a table)
★★★ Non-proprietary format (e.g. CSV instead of Excel)
★★★★ Use URIs to identify things, so that people can point at your stuff.
★★★★★ Link your data to other people's data to provide context.

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[16] We add the "open" concept here to reflect the fundamental commitment to open science and reduction of barriers inherent in our pursuit as a global infrastructure for the United Nations.

Core Principles for operating as an ODIS node: What is an "ODIS node"?

ODIS relies on a network that rides on the web as its backbone. A node in the ODIS network is any information or data resource which adheres to the core principles below.

1. Align ocean data and information holdings and streams to the ODIS reference architecture (ODIS-Arch).
2. With other nodes and relevant user and standards communities, strive to align and make interoperable information storage and exchange conventions.
3. Design everything as a solution for a real problem, rapidly iterating with solution providers to validate or refute the design.
4. Always look for and use existing information sources that can be augmented or contributed to before building something new.
5. Build robust programmatic interfaces first and then build user interfaces on top of them.
6. Adopt existing standards, adapt to them before adding something new and work within the standards that exist to augment as necessary.
7. Be persistently aware of the holdings of other, related nodes, to maximize reuse.
8. Provide information and data products which support global observing and development agendas

We acknowledge that nodes in the ODIS network will have different levels of capacity. Nodes registered with ODIS will be asked to note how they implement the principles above, noting any deviations. Note that deviation does not mean that the resource cannot be an ODIS node, if an explanation for the deviation's necessity is included as well as a proposal on how it can be remedied. Collectively, the ODIS network can aid nodes with reduced capacities fill gaps and elevate their capabilities through resource sharing and training opportunities.

Phase 1: Reference architecture for networked ocean information

Multiple local and regional stakeholders developing ocean data and information resources (e.g. EMODnet, EurOcean and NCEI) have expressed the need for a reference architecture to guide their products and services towards greater global accessibility and interoperability. This pilot aims to provide this architecture through the evolution of ODIS, sustainably enabling the brokerage and transfer of ocean data and information products between existing and emerging resources.

The tasks in this phase directly contribute to the proposal's key impacts (Section 2.4) in the following ways:

- **Avoid the need to consult multiple online sources:** Any repository implementing the ODIS architecture can broker queries across the ODIS network, augmenting their results with those of other ODIS nodes. The user will thus be able to be presented with the results of multiple nodes, while only accessing one.
- **Enable searching across multiple data/information types:** The ODIS architecture will allow consistent description of multiple data types using aligned semantic resources, thus supporting cross-domain search.
- **Enable advanced and complex searches (e.g. search for a course on marine biodiversity in 2021 taught in Spanish and providing grants for students from developing countries):** Through alignment of ODIS nodes to interoperable semantic resources, search agents will be able to approach complex queries in multiple ways, with local nodes able to tailor interfaces to their users' needs.

Building an architecture which enables distributed interoperability is key: following the schema.org approach and the principles of Linked Data (LD), no highly centralised system should be needed to accomplish this phase's objectives. Instead, implementers of one or more modules of the ODIS-Arch

shall expose their data and information products and streams in a manner discoverable and understandable to all others implementing the global reference architecture, allowing anyone to build tailored solutions drawing from the global "data ocean". To speed discovery, a registry of "ODIS nodes" implementing the ODIS-Arch will guide stakeholders and their data harvesting technologies to endpoints offering 'global reference architecture'-aligned products.

Modules of the ODIS-Arch will include mechanisms for interfacing IOC systems (such as OceanDocs, OceanBestPractices, OceanExpert, OceanTeacher and OBIS) to those external to the IOC by incorporating and (if necessary) extending open, and ideally existing, standards and best practices.

Development of ODIS-Arch will also be guided by the need to better link human capacity to data, information, technology and needs. In its design, it will ensure that cases such as the following are supportable by users of the architecture:
- Matching researchers with opportunities to participate in cruises.
- Matching individuals with training opportunities.
- Matching human capacity by periodically mining OceanExpert and linked profiling systems (e.g. ORCID, Google Scholar), creating up-to-date brokerage between calls for expertise and providers of expertise.

Special focus will be placed on ensuring the ODIS-Arch supports the needs of the GOOS EOVs. A selection of EOV Panels will be approached and their data products aligned to the ODIS-Arch as a guiding example, specifically linked to the Decade. Relation of data and information products exposed through the ODIS-Arch to the indicators of the SDGs will also be demonstrated through semantic interoperability solutions to the emerging UN SIF.

Importantly, this Phase will **not** focus on providing reference implementations such as search and visualization solutions. It will focus on the foundational architecture to allow any stakeholder to build such solutions now and into the future. Implementation only occurs if the reference architecture is compelling enough to attract investment from an operational entity willing and able to commit resources to developing and publicizing an implementation.

[1] For example: EurOcean databases (research infrastructures, knowledge gate for projects, emerging marine science and technology Knowledge Portal etc), SensorWeb implementations, UN Environment WCMC databases (WDBPA, Ocean+, etc.)...)

Key Tasks:
(throughout: ensure that developing country capacity is addressed)

> T2.1 Establish a set of guiding principles for the creation and maintenance of a robust and sustainable ODIS global reference architecture modules
>
> T2.2 Identify and define priority modules in the ODIS-Arch based on the needs of the Decade and stakeholders of the Ocean InfoHub, as well as the capacities of participating data resources
>
> T2.3 Specify how participating nodes can align to the ODIS-Arch modules (providing documents in the OBPS and courses in OceanExpert). This includes:
> - Guidance on the consistent use of, e.g., schema.org templates
> - Guidance on the linkage of data to the EOVs and SDGs using semantic technology
>
> T2.4 Implement open access to schema.org data to external systems, internet search engines, other schema.org aware crawlers

Participants/collaborators & their roles:

Participant	Role	Comments
Data exchange and interoperability experts	Consultation on and drafting of the reference architecture and validation specifications, ensuring fitness-for-purpose, scalability, adaptability and robustness, as well as alignment to existing standards and best practices.	NA
Regional and local repositories	Evaluation of the ODIS-Arch for feasibility of implementation and fitness-for-purpose.	This group will include repositories which have already stated the desire for an ODIS reference architecture, seeding a coalition of the willing
ODIS-Arch staff	An operationally focused graduate student, post-doctoral, or consultant to create the initial ODIS-Arch for review during and between meetings	

Phase 2 - Implementation of the ODIS architecture in ocean data and information repositories

Digital data and information repositories of different size and scope are critical nodes in the data and information network underlying ODIS. These include major existing players representing the World Data System (NCEI, EMODNet, other NODCs/ADUs), the central information systems of the IODE (OceanExpert, OceanDocs, OceanBestPractices, OBIS) and also other repositories.

These systems are already providing interfaces to the web for broad use and application, but can improve their interoperability, transfer of global perspectives and cross linking by collectively aligning to the ODIS-Arch as their representatives help develop it in Phase 1. As they align, repositories can build harmonized and complementary services which can be collectively accessed through any node in the network, greatly reducing demands on the user and adding value to each node's services. The effectiveness of approaches to implementation can be rapidly tested through direct application within regional Ocean InfoHub nodes, with these hubs guiding priorities for data and information exchange.

During this implementation, special focus will be granted to the sharing of repository capacities with developing countries which lack local resources.

Key Tasks:

T2.5 Identify existing (adding as necessary) repositories in the ocean science domain leveraging re3data.org services and augment their records to characterize their capabilities. Curate this registry into a capability complementary to OceanExpert, cross-linking between OceanExpert institutions and re3data repositories.

    T2.5.a Include a semantically consistent and machine-readable representation of the services provided by each repository as well as the data, metadata and the information they provide (e.g., GIS layers, vessels, instruments, other research infrastructure)

T2.6 Clarify the mission parameters of member repositories in terms of the types or sources of data they will accept, providing clear documentation and guidelines on available services (data and metadata curation). Archive these missions and the methodologies used to accomplish them in the OceanBestPracticesSystem, linking them through the ODIS-Arch.

T2.7 Identify repositories which support the specific needs of Ocean InfoHub and engage in the development of context-specific blueprints to build solutions against the architecture.

T2.8 With each participating repository, pool resources to implement cross-linking and distributed search capacity between major repositories such that searches return semantically consistent results of related information from multiple repositories.

T2.9 Develop, implement and begin examining pooled metrics reported from repositories on access and usage of cross links to optimize investment in availability and depth of related information shared across repositories.

T2.10 Continually interface with global policy and observation networking initiatives (Essential Ocean Variables, SDG indicators, etc.) to collaboratively develop data flows into applicable products, providing a feedback mechanism for data providers to participate in and receive credit for data and intellectual contributions.

T2.11 Continually interface with Ocean InfoHub nodes to collaboratively develop data and information capabilities, value-added synthesis and enhancement, and incorporation of appropriate feedback into global data systems.

Leverage gap analyses done by the GOOS Regional Alliances, working with the RAs to find and develop important use cases and incentivise those sitting on data to release it into the global system. Incentives include ODIS contributor status and association to the EOVs in line with FOO 2.0.

Add capacities developed in e.g. SeaDataNet to detect data proximity - the relationship of one data asset to another. Each new node (at EMODNet, NCEI, others) would likely have some (possibly redundant) capacities to contribute and regular meetings will help align and merge duplications of effort.

Participants/collaborators & their roles:

Participant	Role	Comments
Repository Scientists	Develop working implementation of the ODIS architecture within established repository infrastructure	Participants must be able to actively enact change within working systems at a staging or operational level in the course of the workshops.
CHM/TMT Regional Hub Scientists	Articulate use cases for use of working solutions from repositories as applied to regional/local data and information needs, test solutions iteratively and provide immediate targeted feedback	Participants must be able to actively test iteratively developed new capabilities in linked data and information against real world use cases.
Relevant experts	Provide expert assistance, code development, data manipulation and other capacity following linked data principles and techniques	If not represented in one of the other participating groups, outside experts may be sought to accelerate action in workshops to develop working solutions.
Repository Managers	Contribute to sustainability planning to ensure that methods and techniques developed in the project can become part of long-term capacity within the repositories	In the final aspect of this phase (if not before), repository managers with budget and decision-making authority will need to be engaged to ensure that the methods and techniques they have invested in through the project can be sustained over the long run.

Phase 3 - Implementation of the ODIS architecture in regional Ocean InfoHub nodes

Regional information nodes designed to deliver value to local communities from the standpoint of Ocean InfoHub will be developed through time as a direct implementation of the reference architecture they have helped to develop. In this mode, Phase 3 draws from the foundational architecture developed in Phase 1 and the harmonization and connectivity between existing repositories developed in Phase 2. While many of the regional nodes may initially draw information from the long-established repositories focused on in Phase 2, most if not all of them will provide a repository function themselves, serving data and information into the network.

While in some sense it may make more sense, from an engineering standpoint, to build common central infrastructure that implements the Global Reference Architecture, this project will take the approach that it is better to build up local core competency at the regional level in what may be a heterogeneous

mix of technical solutions. The modern web is a mix of many different ways of implementing the same ideas, some of them more or less efficient. With the rapid pace of technology churn, we will also see the mix of solutions evolve over time as well.

Along with capacity development in building and operating technological infrastructure, this phase will invest in local capacity development in data management/preparation and analysis through a couple of key initiatives. Leveraging OpenSeaLab with EMODnet as a partner, at least one regional hackathon event will be planned and executed that will have a dual purpose to rapidly develop potential solutions for local problems using data and stress test the system to identify weaknesses and areas for focus. In addition, the Ocean Teacher Global Academy will be engaged with to develop at least one immersive data science learning experience involving training in scientific software followed by a tiger team approach to local problem solving. Regional nodes will help to conduct the prep work on real issues in data access and application that can be addressed in the immersive sessions.

Key Tasks:
1. Identify willing and ready Ocean InfoHub regional partners starting with in progress or pilot efforts in IOC-CARIBE and IOC-AFRICA.
2. Determine appropriate technologies and implementation partners, building on existing infrastructure where possible, to implement the ODIS architecture and provide a regional interface for science and management users.
3. Implement regional hubs using best available technologies against the ODIS Architecture, leveraging support and consultation services from the ocean data and information community.
4. Develop viable options for local engagement with science and management stakeholders in one or more data hackathons that leverage the infrastructure, address local data priorities and stress test the system.
5. Develop viable options for immersive data science training opportunities within the Ocean Teacher Global Academy context to train local data scientists in new data analysis techniques and apply knowledge to addressing real world problems.

Potential add-on tasks:
1. Co-develop a new data repository infrastructure for operation at Regional Nodes to leverage the OpenGTS and ERDDAP infrastructure for real time data.
2. Develop a new Global Node capability that integrates the best available information on planned research projects and provides this as an additional information element in the network.
3. Develop a targeted global index of geospatial data layers available for mapping services, integrated from across all catalogs in the network and expose through a custom API.

Participants/collaborators & their roles:

Participant	Role	Comments
Ocean InfoHub Regional Nodes	Lead organization and individuals in a Region for implementation of Regional Node	IOC-CARIBE, IOC-AFRICA and IOC-WESTPAC-SIDS have signed on to be part of the initial three year exploration of the concept
Regionally based scientists, managers and interested parties	Participate in regional hackathons and immersive training experiences to learn data analytics techniques and contribute to creative, data-driven problem solving	It is anticipated that Regional Hub managers will develop these networks or already have them in place as the project proceeds
Ocean InfoHub and IODE Project Office	Support and coordination in the implementation of Regional Nodes and use of Global Ocean InfoHub resources	IODE Project Office is providing no-cost support for the Regional implementations
EMODnet	Organizational co-sponsor	EMODnet will provide in-kind contributions by focusing their OpenSeaLab project on at

		least one area of mutual interest in cooperation with ODIS/CHM-TMT to conduct a hackathon challenge

WP3: Establishment and initial support of the global hub and regional nodes

This work package covers the implementation, testing and support necessary to establish the global Ocean InfoHub node and to support this node to the point where the global node can perform all functions attributed to it. The Ocean InfoHub node is essentially a "hypernode" made up of the globally integrating infrastructure components including OceanExpert, OceanDocs, OceanBestPractices and OceanTeacher/MarineTraining. Other nodes in the network include IOC and non-IOC partners, a number of whom have been involved in this proposal and have agreed to be early adopters of the concept. These include data repositories from the National Oceanographic Data Center/Associate Data Unit construct, World Data System and others along with specific content integrators such as MarineSpecies and MarineRegions. Regional nodes are directly a part of the development, focused on the IOC Regional areas leading the effort to develop capacity as part of the Clearing House Mechanism for Transfer of Marine Technology.

The preferred approach to implementation is that all nodes are able to leverage their own existing technology platforms within the ODIS architecture, taking full responsibility for the technology package of the node in terms of hosting and maintenance.

Through early adopters with IOC-AFRICA, IOCARIBE, Pacific SIDS, the project will explore the viability of this approach and may provide infrastructural support for implementation. In this regard it is noted that regional/thematic nodes may actually be of "virtual" nodes whereby the technology is hosted by the global Ocean InfoHub node and where users will access their regional node through a URL that is located at the global Ocean InfoHub node. Alternatively, regional/thematic nodes may be hosted by regional offices/organizations in which case they will take responsibility for the technology package of the node in terms of hosting and maintenance. The global node will then include the necessary software to interact with the regional/thematic nodes.

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