Ocean Data Interoperability Platform

Deliverable D3.4: Results and conclusions from Prototype Analyses

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Contents

Executive Summary

The three ODIP prototype development tasks were formulated following an analysis of the outcomes of the 1st ODIP workshop (February 2013) and through further consultation within the project consortium. The formulation of the three prototype development tasks was subsequently finalized and fully accepted by the ODIP community in September 2013 (M12), and documented in deliverable *D3.1 ODIP Prototypes.* As a follow-up, the deliverable *D3.2 Results and conclusions from prototype analyses* was drafted in the second year which provides a full analyses and the agreed work plans for the development and implementation of the three ODIP prototype interoperability solutions.

The three ODIP prototype development tasks consist of:

- **ODIP 1**: Establishing interoperability between SeaDataNet CDI, US NODC, and IMOS MCP data discovery and access services using a brokerage service, and moving towards interacting with the global IODE-ODP and GEOSS portals, led by SeaDataNet (Europe);
- **ODIP 2**: Establishing a common deployment and interoperability between cruise summary reporting (CSR) systems in Europe, the USA and Australia by making use of GeoNetwork, and moving towards interaction with the global POGO portal, led by R2R (USA);
- **ODIP 3**: Establishing a prototype for a Sensor Observation Service (SOS) and formulating common O&M and SensorML profiles for selected sensors (SWE), installed on research vessels and in real-time monitoring systems, led by AODN (Australia).

The activities in WP3 have resulted in a number of highly significant results:

- the GEOSS portal and the IODE-ODP portal have been populated with data collection entries as harvested and brokered from the three regional SeaDataNet (Europe), US NODC (USA) and AODN (Australia) data discovery and access services as a result of ODIP 1;
- the SeaDataNet Cruise Summary Report (CSR) metadata profile and schema have been adopted by R2R (USA) and NMF (Australia) within the framework of ODIP 2, leading to the population of the POGO CSR catalogue with an initial set of CSRs for US Research Vessels and a first CSR entry for Australia;
- ODIP 3 has resulted in a closer cooperation and alignment between multiple European and USA projects on SWE for the marine domain, leading to synergies, initiation and adoption of common vocabularies, and a basis for continued activity in the ODIP II follow-on project.

This deliverable, *D3.4 Results and conclusions from Prototype Analyses,* reports in detail, and with illustrations where relevant, the activities and results of the three ODIP prototype development tasks.

1 Introduction

The Ocean Data Interoperability Platform (ODIP) project manages an EU / USA / Australia/ IOC-IODE coordination platform, the objective of which is achieving the interoperability of ocean and marine data management infrastructures, and to demonstrate this coordination through several joint EU-USA-Australia-IOC/IODE prototypes that ensure persistent availability and effective sharing of data across scientific domains, organisations and national boundaries.

The ODIP workshops organized by WP2, have been instrumental in reviewing and comparing existing marine data infrastructures and the associated standards in order to identify major differences between them, and propose how to overcome these through the development of interoperability solutions and/or common standards.

Three ODIP prototype development tasks were formulated following an analysis of the outcomes of the 1st ODIP Workshop (February 2013) and through further consultation within the project consortium. The formulation of the three prototype development tasks was subsequently finalized and fully accepted by the ODIP community in September 2013 (M12), and fully documented in deliverable *D3.1 ODIP Prototypes.* As a follow-up, the deliverable *D3.2 Results and conclusions from prototype analyses* was subsequently drafted and published which provides the agreed work plans for developing and implementing the three ODIP prototype development tasks. This document gives a further details for the formulation of the three ODIP prototype interoperability solutions, combining actions from the list compiled during workshop, and leveraging on activities in ongoing regional projects and initiatives, such as SeaDataNet, JERICO and Eurofleets in Europe, R2R, US NODC and US IOOS in USA, and IMOS and AODN in Australia as well as making use of global activities in the framework of the GEOSS portal and IODE's Ocean Data Portal (ODP) developments.

The three ODIP prototype development tasks consist of:

- **ODIP 1**: Establishing interoperability between SeaDataNet CDI, US NODC, and IMOS MCP data discovery and access services using a brokerage service, and moving towards interacting with the global IODE-ODP and GEOSS portals, led by SeaDataNet (Europe);

- **ODIP 2**: Establishing a common deployment and interoperability between Cruise Summary Reporting systems in Europe, US and Australia by making use of GeoNetwork, and moving towards interaction with the global POGO portal, led by R2R (USA);

- **ODIP 3**: Establishing a prototype for a Sensor Observation Service (SOS) and formulating common O&M and SensorML profiles for selected sensors (SWE), installed on research vessels and in real-time monitoring systems, led by AODN (Australia).

The actual implementation of the three ODIP prototype developments has in effect taken place since the second ODIP workshop, where the implementation plans were formulated, resulting in deliverable *D3.2 Results and conclusions from prototype analyses*. ODIP is an international project including partners from Europe, the USA and Australia. Moreover, a number of the international partners are participating in the project on a voluntary basis. This has implied that communication between partners and with the wider ODIP community

concerning the prototype development activities and progress monitoring has taken place at consecutive ODIP Workshops with 9 month intervals, through 'get togethers' of a number of partners at the EGU 2014 and EGU 2015 conferences, and by e-mail correspondence. Despite these challenges considerable results have been achieved by the three ODIP prototype development tasks.

2 ODIP 1 prototype development task: results

Objective
To establish interoperability between SeaDataNet CDI, US NODC, and IMOS MCP data discovery and access services using a brokerage service, and moving towards interacting with the global IODE-ODP and GEOSS portals.

Context
Europe, USA and Australia each operate and manage their own data discovery and access services, including their own metadata formats, vocabularies, access control, data formats and data policies. As part of the ODIP 1 prototype developments tasks partners have agreed to contribute datasets to the global IODE Ocean Data Portal (ODP) and the GEOSS portal by making use of the GEO-DAB brokerage service. Following is a short description of each of the three regional systems and two global target services as well as of the GEO-DAB brokerage service:

- **SeaDataNet CDI service in Europe**:

The Common Data Index (CDI) service is part of the services for the SeaDataNet pan-European infrastructure for marine and ocean data management and which currently includes more than 100 connected data centres from 34 countries riparian to European seas. At present it covers more than 1.78 million data sets at granule level with global coverage for a wide range of marine disciplines. Further development and population takes place through engagement in multiple European projects. The CDI is a marine profile of the ISO 19115 content model and XML encoding following ISO 19139 making it fully INSPIRE compliant. Use is made of controlled vocabularies where possible. Services includes discovery and access of data sets that are managed by the distributed data centres. Two types of user interfaces are provided: an extended search with various search fields in combinations and a faceted search. Data access is arranged by means of a shopping basket mechanism with logon and tracking and tracing system of request processing and downloading. Various interoperability services are available on the metadata, such as WMS, WFS, CS-W and service bindings in CDI for supporting SWE and visualisations.

- **US NODC service in USA**:

The US NODC service covers in-situ, satellite and model data. Its volume is more than 150 terabytes. All collections have metadata as FGDC, and ISO 19115-2 - 19139. Distinction is made in granules (comparable to CDI) and collections (groups of granules). These are linked by identifiers. US NODC provides discovery and access to more than 28,000 collections with a global coverage for a wide range of marine disciplines which relate to >1.3 million granule data sets via its user interface. There are CSW, OAI-PMH and OpenSearch endpoints for discovery at collection level. All metadata contain at least FTP and HTTP links to the data, and many also have OPeNDAP Hyrax, THREDDS Data Server, ArcGIS server and Live Access Server (LAS) links. There is also a CSW service at granule level. There is currently no user authentication/ registration system. US NODC maintains and makes use of a range of vocabularies, and it is also experimenting with using SKOS.

- **AODN MCP service in Australia**:

The Australian Ocean Data Network (AODN) is a network of organisations (government and science) in Australia and New Zealand. The AODN web portal provides overview and access to the data sets as collected and managed. The Marine Community Profile (MCP) metadata format is based upon ISO 19115 - 19139. GeoNetwork is used for the discovery (CSW) and mapping (WMS) services, while WFS and OpenDAP (TDS) are used for downloading. GeoNetwork is also used for harvesting between the data providers and AODN portal. There is open access and no registration. The discovery service worked originally at the granule level and has been upgraded to collections level by means of a faceted search for ease of use. The AODN 123 portal has a download cart for data retrieval. AODN originally made use of its own vocabularies, but under the influence of ODIP discussions is moving towards adopting several lists from the NERC Vocabulary Server (NVS 2.0) as used in SeaDataNet. AODN has CSW, OAI-PMH and OpenSearch endpoints for discovery of collections (circa 110 at present).

- **Global GEOSS portal:**

The GEO initiative (2002 G8) is charged with developing the Global Earth Observation System of Systems (GEOSS) for the nine societal benefit areas. GEO states that '*Earth Observation Systems should be coordinated and shared internationally to answer Society's need for informed decision making'*. GEO can be seen as a framework to promote international cooperation. It currently has 11 Communities of Practice, including the Ocean and Coastal Zone, but there are also other COPs which have relevance for the marine domain. GEO is not a funding mechanism but its global cooperation inspires research programmes. The GEOSS portal makes use of the GEO Common Infrastructure (GCI) which gives Discovery and Access Broker and Resource Registration for Earth observation data, information and services for the nine societal areas. GEOSS has more than 20 major data provider infrastructures connected, and gives an overview and potential access to around 7 million collections and 65 million granules. Access to additional collections and granules is underway. GEOSS started out by demanding a common input and delivery by all potential contributing systems, but this approach has been replaced by a brokerage service solution. Since then the number of connected infrastructures and volume of data resources has increased in a spectacular way because the broker provides a much lower threshold for those wanting to contribute data resources. The underlying services can continue their normal operation while the broker takes care of the exchange with GEOSS.

- **Global IODE Ocean Data Portal (ODP):**

The International Oceanographic Data and Information Exchange (IODE) of UNESCO-IOC was established in 1961 and strives to enhance marine research, exploitation, and development through exchange of data and information between member states. The Ocean Data Portal (ODP) initiative started in 2007 to facilitate discovery, evaluation and access to marine data. It is not only aimed at data users, but also provides capacities and facilities for data providers. Discovery makes use of GeoNetwork and dedicated ODP services. Supported protocols are: CSW 2, OAI-PMH, SRU, OGC WxS, WebDav, THREDDS (GeoNetwork based), HTTP REST, SOAP, JSON, RSS/ATOM. The ODP vocabulary is based on the SeaDataNet vocabularies with some extensions for climatology and other fields. Data access comprises both pull and push services. Data pull by HTTP REST and SOAP (online mode) and data push by FTP and email (online, delayed).The metadata follows the ISO19x family. From the ODIP 1 perspective the three regional services from Europe, USA and Australia could be considered as IODE ODP Associated Data Units (ADU) which includes metadata exchange and then data access through the metadata (URI-based via portal or direct).

For the implementation of the ODIP Prototype 1 use has been made of the brokerage service concept (at the metadata level).

- **GEO-DAB brokerage service:**

The aim of GEOSS is to realise a community of communities by the systems of systems approach. Despite the large heterogeneity, this can be achieved by building on the autonomous infrastructures and using two main interoperability implementations: 1) standardisation by means of federation and 2) intermediation by means of brokerage. The brokerage approach has many benefits, such as it lowers barriers for acceptance by existing repositories, it accelerates interconnection and it removes the need to impose common specifications. This concept was further developed in the EU FP7 EURO-GEOSS project and then adopted for GEOSS with great success. The concept has been further developed in the USA NSF Advanced Cooperative Arctic Data and Information Service (ACADIS) project, the USA NSF Brokering Building Blocks for Earth Cube (BCUBE) project, and the EU FP7 GEO-WOW project. The present broker framework is called GEO-DAB brokerage service and is largely based upon the GI-Cat software as maintained by CNR. The GEO-DAB Brokerage Service at CNR harvests XML entries and converts these following a Generic Brokerage Reference Schema, adopting prevailing vocabularies.

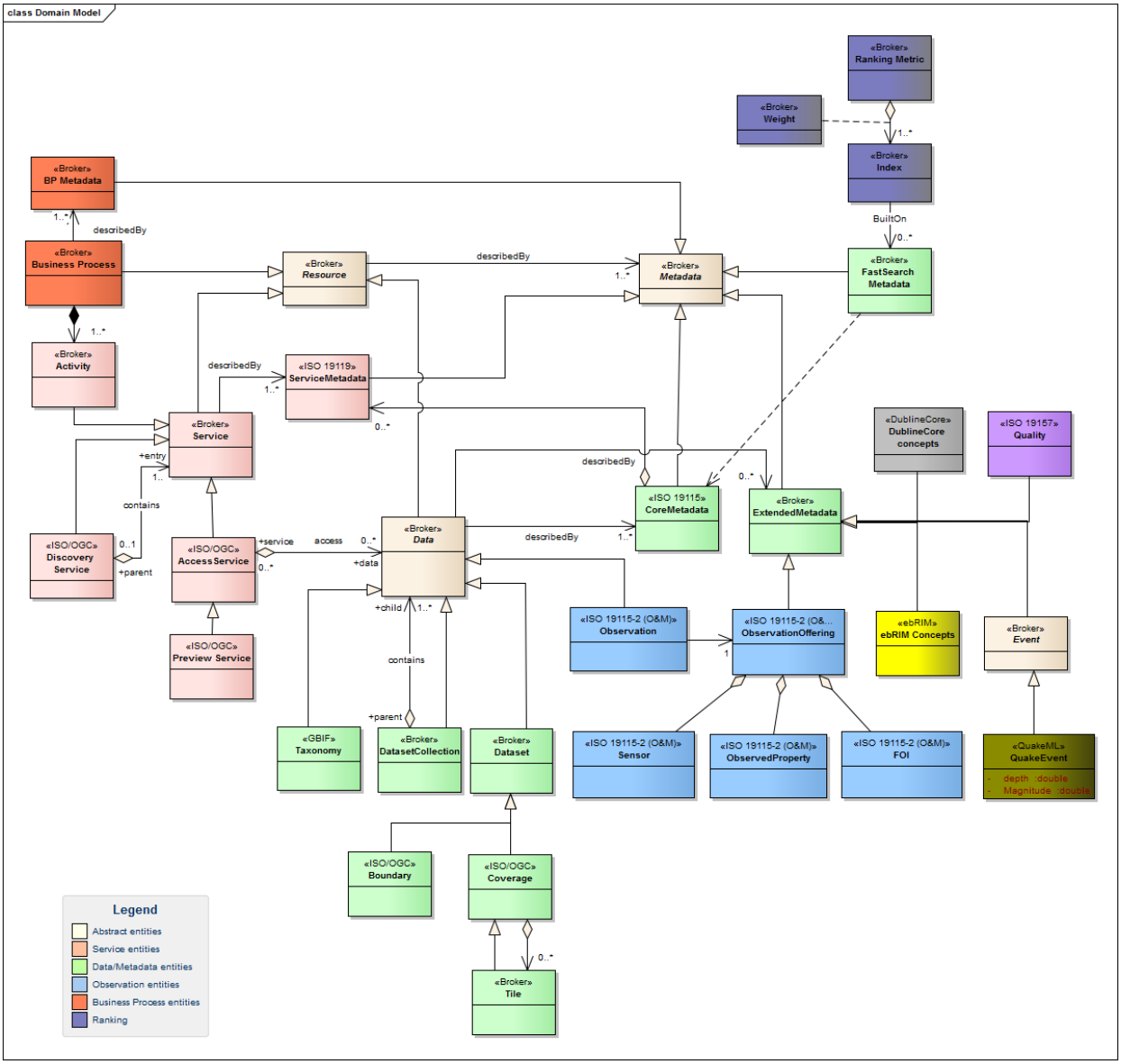


Figure 1: Generic Brokerage Reference Scheme

Partners directly involved:
Led by MARIS on behalf of SeaDataNet (Europe)
Partners: MARIS on behalf of SeaDataNet consortium, US NODC, UTAS on behalf of AODN consortium, CNR and IEEE on behalf of GEO-DAB brokerage service development team, and RIHMI-WDC and DFO-BIO on behalf of IODE ODP development team.

Activities that have been undertaken:
Considering the function of the two international portals as global guides and also taking into account performance issues it has been decided to establish the vertical interoperability from the three regional infrastructures towards the global portals (IODE-ODP and GEOSS) at **collections** level.

A start was made with establishing interoperability between SeaDataNet on one side and GEOSS and ODP on the other side, between December 2013 and June 2014. The activities undertaken were:

- setting-up an XML output service by REST / CS-W for the SeaDataNet portal at the collections level, following the CDI ISO 19139 schema and supporting vocabularies; aggregating existing granule entries following a specific filter, in order to reduce the approximately 1.78 million granules entries to a meaningful and more reasonable number of collection entries (MARIS); this has been done by aggregating CDI granules into CDI collections by data centre (EDMO-code), discipline (P08 terms) and by geometry (points / tracks / polygons). This has resulted in around 480 CDI collections, each with an URL to the CDI service for details on the CDIs within one collection;
- setting up of a REST web service (IP – IP protected) by MARIS to provide these collections in ISO 19139 XML and using SeaDataNet vocabularies. This aggregation is dynamic, which means that the collections are maintained for each update of the CDI granules database;
- the SeaDataNet XML output from the REST web service is taken up by CNR for the GEO-DAB brokerage and its XML is converted to the Brokerage Common Reference Model, thereby sustaining use of specific SeaDataNet vocabulary terms next to ISO standard terms;
- the GEO-DAB brokerage service provides the SeaDataNet collections as common XML by OAI-PMH service:

  http://seadatanet.essi-lab.eu/gi-cat/services/oaipmh?verb=ListIdentifiers&metadataPrefix=ISO19139&set=SEADATANET

  and by CS-W service Version 2.0.2 Service – HTTP POST method:

  http://seadatanet.essi-lab.eu/gi-cat/services/cswiso

  with SEADATANET as parameter for retrieving the SeaDataNet output.

  GetRecords of a CSW works by POST method. Therefore an XML is uploaded to the CSW service:

  Example XML:

```
<csw:GetRecords xmlns:csw="http://www.opengis.net/cat/csw/2.0.2"
xmlns:ogc="http://www.opengis.net/ogc" service="CSW" version="2.0.2" resultType="results"
startPosition="1" maxRecords="15" outputFormat="application/xml"
outputSchema="http://www.opengis.net/cat/csw/2.0.2"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.opengis.net/cat/csw/2.0.2
http://schemas.opengis.net/csw/2.0.2/CSW-discovery.xsd">
<csw:Query typeNames="csw:Record">
<csw:ElementSetName>brief</csw:ElementSetName>
</csw:Query>
</csw:GetRecords>
```

  This gives:

Figure 2: XML output of Geo Brokerage CS-W service

To request the XML records per 'Provider' use must be made of the 'apiso:parentIdentifier', which is SEADATANET for SeaDataNet.

Example of request:

Post URL: http://seadatanet.essi-lab.eu/gi-cat/services/cswiso

Request body must be posted with header "Content-Type: application/xml":

```
<csw:GetRecords xmlns:csw="http://www.opengis.net/cat/csw/2.0.2"
xmlns:ogc="http://www.opengis.net/ogc" service="CSW" version="2.0.2" resultType="results"
startPosition="1" maxRecords="15" outputFormat="application/xml"
outputSchema="http://www.opengis.net/cat/csw/2.0.2"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.opengis.net/cat/csw/2.0.2
http://schemas.opengis.net/csw/2.0.2/CSW-discovery.xsd">
  <csw:Query typeNames="csw:Record">
    <csw:ElementSetName>brief</csw:ElementSetName>
    <csw:Constraint version="1.1.0">
      <ogc:Filter>
        <ogc:PropertyIsLike>
          <ogc:PropertyName>apiso:parentIdentifier</ogc:PropertyName>
          <ogc:Literal> SEADATANET </ogc:Literal>
        </ogc:PropertyIsLike>
      </ogc:Filter>
    </csw:Constraint>
  </csw:Query>
</csw:GetRecords>
```

This will return the full list of SeaDataNet collections in XML.

- The GEO-DAB brokerage output of SeaDataNet collections has been harvested and imported into the GEOSS portal with support from CNR using the CS-W service;
- The SeaDataNet output has also been harvested and loaded into the IODE-ODP portal, but with support of RIHMI-WDC and using the OAI-PMH service and the jOAI harvester which ODP also uses for harvesting records from the WIS (WMO) service;
- The import into the GEOSS and ODP portals has been checked and fine-tuned in dialogue between MARIS, CNR and RIHMI-WDC, and triggers have been configured for fully automatic and the most efficient synchronisation between the different services in the chain;

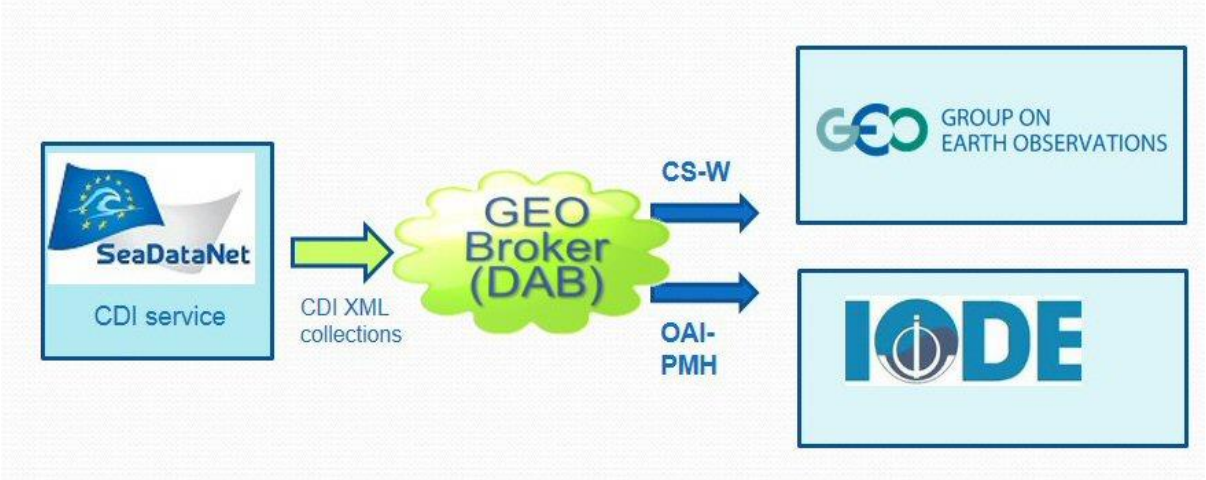


Figure 3: Established metadata interoperability between SeaDataNet and GEOSS and IODE–ODP portals

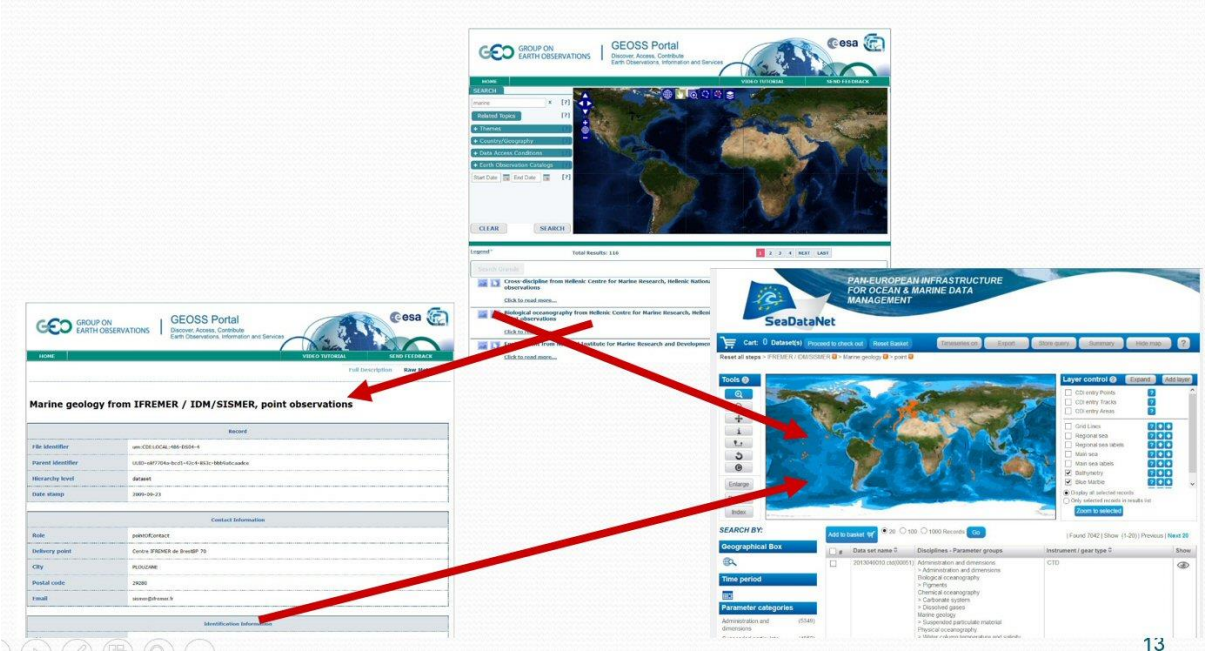


Figure 4: searching and retrieving in GEOSS and linking to the SeaDataNet portal with detailed CDI granules within the selected collection and options for requesting access to the related data sets

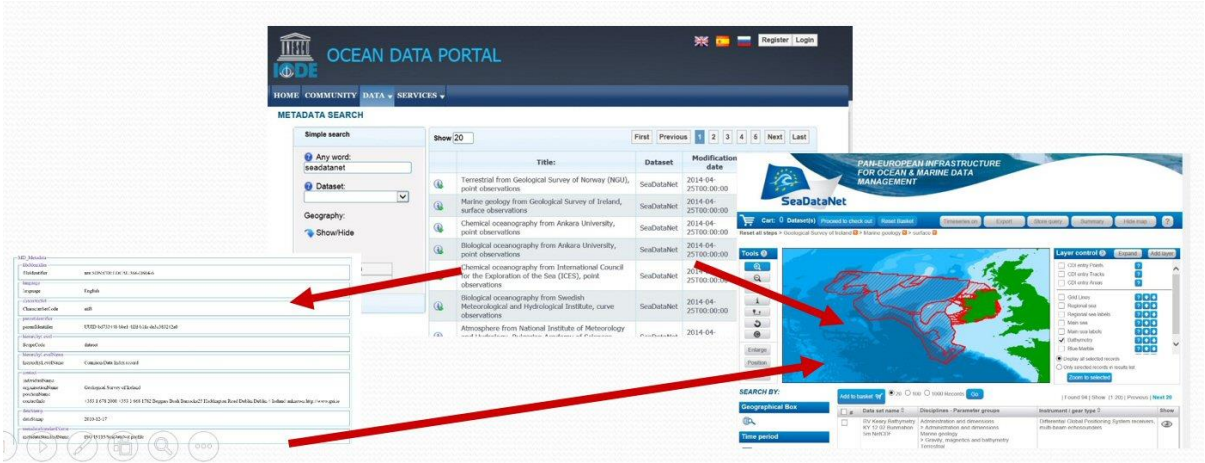


Figure 5: searching and retrieving in ODP and linkage to SeaDataNet portal with detailed CDI granules within the selected collection and options for requesting access to the related data sets

Following the approach for SeaDataNet a comparable analysis and procedure has been applied by MARIS and CNR for the US NODC portal service in dialogue with US NODC and for the Australian AODN portal service in dialogue with UTAS:

- US NODC provides CSW and OAI-PMH services at collection level as follows:

  OAI-PMH:

  http://data.nodc.noaa.gov/cgi-bin/oai-pmh?verb=ListIdentifiers&metadataPrefix=iso19139

  CSW:

  http://data.nodc.noaa.gov/geoportal/csw/discovery?Request=GetCapabilities&Service=CSW&Version=2.0.2

- An example US NODC Collection XML can be retrieved at:

  http://data.nodc.noaa.gov/geoportal/rest/document?id={3A86074D-38C4-4664-83D8-DA0522812AF3}

  The XML contains a Lat – Lon box which can be used to display the collection geo coverage at the receiving portal and also a URL to the Collection web page with title: '*Navigate directly to the URL for a descriptive web page with download links'*

  Example of such a URL to a collection detail page:

  http://data.nodc.noaa.gov/cgi-bin/iso?id=gov.noaa.nodc:0000217

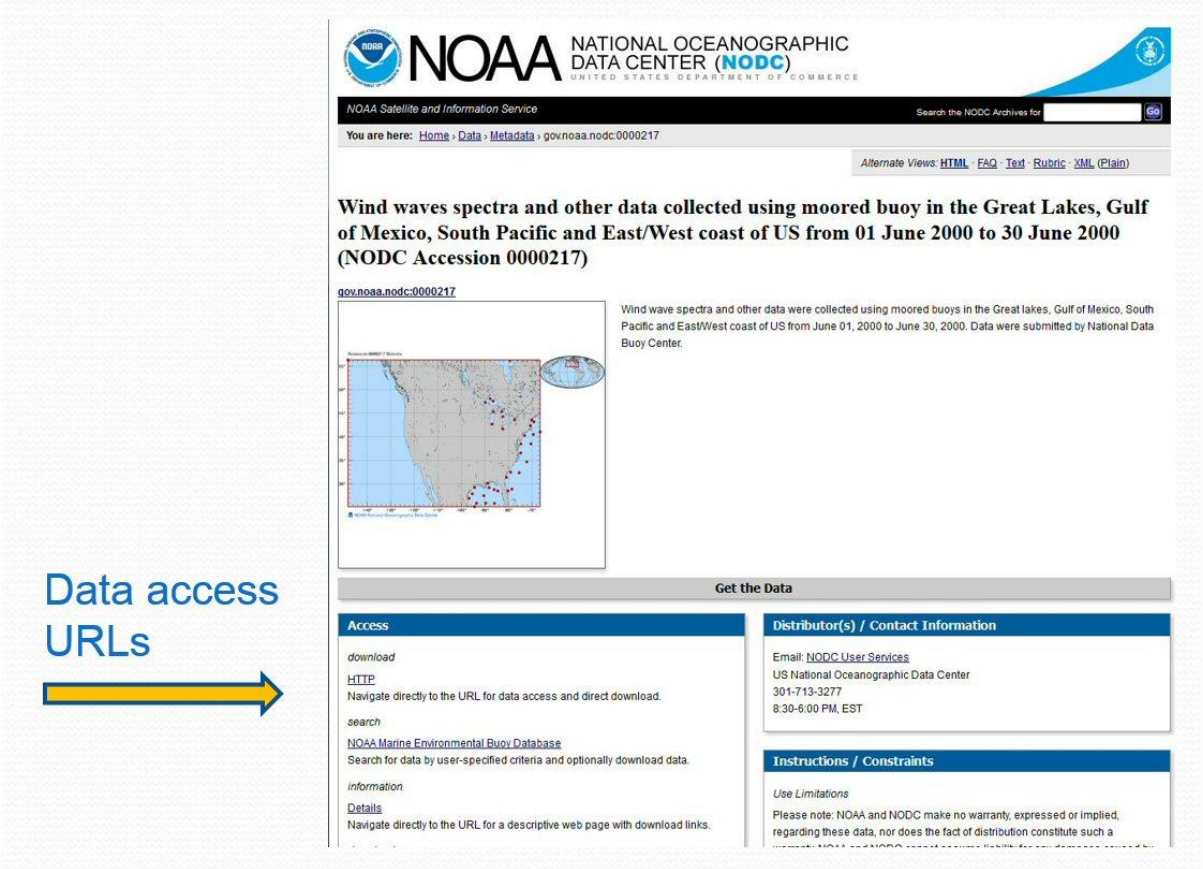


Figure 6: collection detail page at US NODC portal with data access URLs via different protocols

- The GEO-DAB Brokerage Service provided by CNR has harvested the US NODC CSW for collections (approx. 28,000 entries) and converted the XML to the Generic Brokerage Reference Schema, adopting US NODC vocabs, for supplying harmonised CSW and OAI-PMH towards GEOSS and ODP:

  OAI-PMH interface, at:

  http://seadatanet.essi-lab.eu/gi-cat/services/oaipmh?verb=ListIdentifiers&metadataPrefix=ISO19139&set=NODC

  OGC Catalogue Service for the Web (CSW) Version 2.0.2 Service – HTTP POST method:

  http://seadatanet.essi-lab.eu/gi-cat/services/cswiso

  with 'apiso:parentIdentifier' = NODC

  An individual collection record of US NODC after brokerage can be seen at:

  http://seadatanet.essi-lab.eu/gi-cat/services/cswisogeo?service=CSW&request=GetRecordById&id=gov.noaa.nodc:0069000&outputschema=http://www.isotc211.org/2005/gmi&elementSetName=full

- The US NODC collections have been harvested and loaded into the GEOSS and IODE-ODP portals in a comparable way to that used for the SeaDataNet collections.

- Last step has been connecting the AODN service. AODN makes use of GeoNetwork and provides web services at collections level as CSW and OAI-PMH. The collections are defined somewhat differently from SeaDataNet and US NODC, and defined by IMOS facilities (similar to data originator), geometric object, and timeliness (real-time or delayed mode).
- AODN provides CSW and OAI-PMH services at collection level as follows:

  OAI-PMH:

  https://catalogue-123.aodn.org.au/GeoNetwork/srv/eng/oaipmh?verb=Identify

  CSW:
  https://catalogue-123.aodn.org.au/GeoNetwork/srv/eng/csw?REQUEST=GetCapabilities&service=CSW
- An example AODN Collection page can be retrieved at:

  https://catalogue-123.aodn.org.au/GeoNetwork/srv/eng/metadata.show?uuid=c13451a9-7cfe-091c-e044-00144f7bc0f4

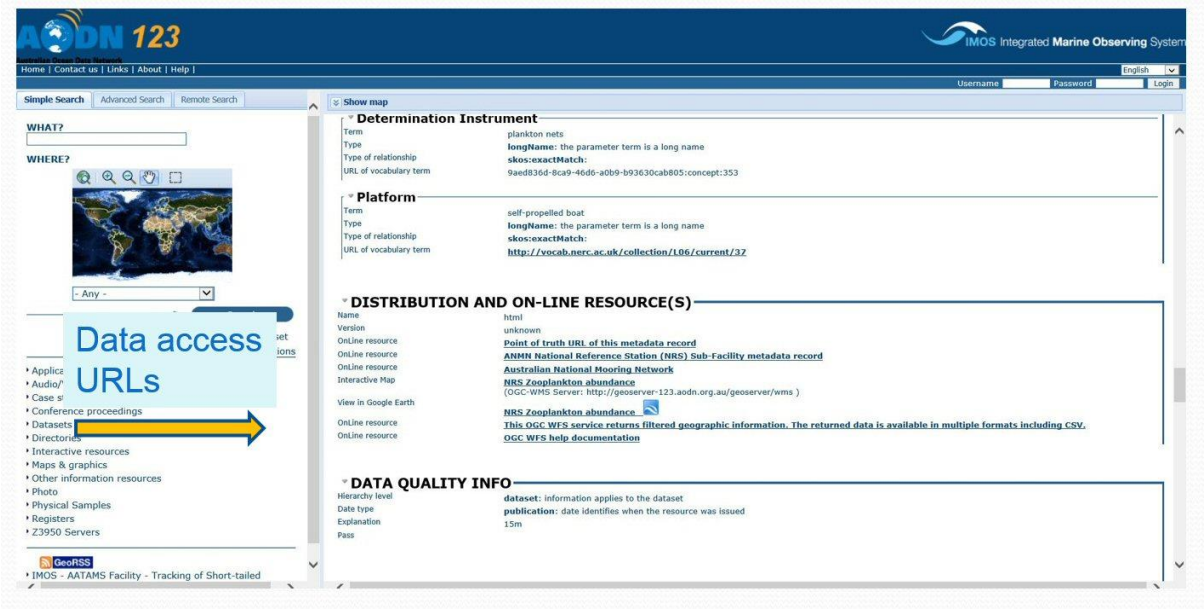


Figure 7: collection detail page at AODN portal with data access URLs via different protocols

The XML contains a Lat – Lon box which can be used to display the collection geo coverage at the receiving portal and also a URL to the Collection web page with title: '*Point of truth URL of this metadata record'*

- AODN collections are now available via public web services as provided by the GEO-DAB Brokerage service. However in this instance the GEO brokerage had to make use of the Dublin Core metadata profile in order to ensure that all links were included in the exchange:

OAI-PMH interface, at:

http://seadatanet.essi-lab.eu/gi-cat/services/oaipmh?verb=ListIdentifiers&metadataPrefix=ISO19139&set=AODNCSWCORE

OGC Catalogue Service for the Web (CSW) Version 2.0.2 Service – HTTP POST method:

http://seadatanet.essi-lab.eu/gi-cat/services/cswiso

with 'apiso:parentIdentifier' = AODNCSWCORE

An individual collection record of AODN after brokerage can be seen at:

http://seadatanet.essi-lab.eu/gi-cat/services/cswisogeo?service=CSW&request=GetRecordById&id=63db5801-cc19-40ef-83b3-85ccba884cf7&outputschema=http://www.isotc211.org/2005/gmi&elementSetName=full

- The AODN collections have also been harvested and loaded into the GEOSS and IODE-ODP portals in comparable ways to those used for the SeaDataNet collections.

Figure 8: SeaDataNet, AODN and US NODC collections included in the GEOSS portal at http://www.geoportal.org

Figure 9: US NODC collection entries found in the GEOSS

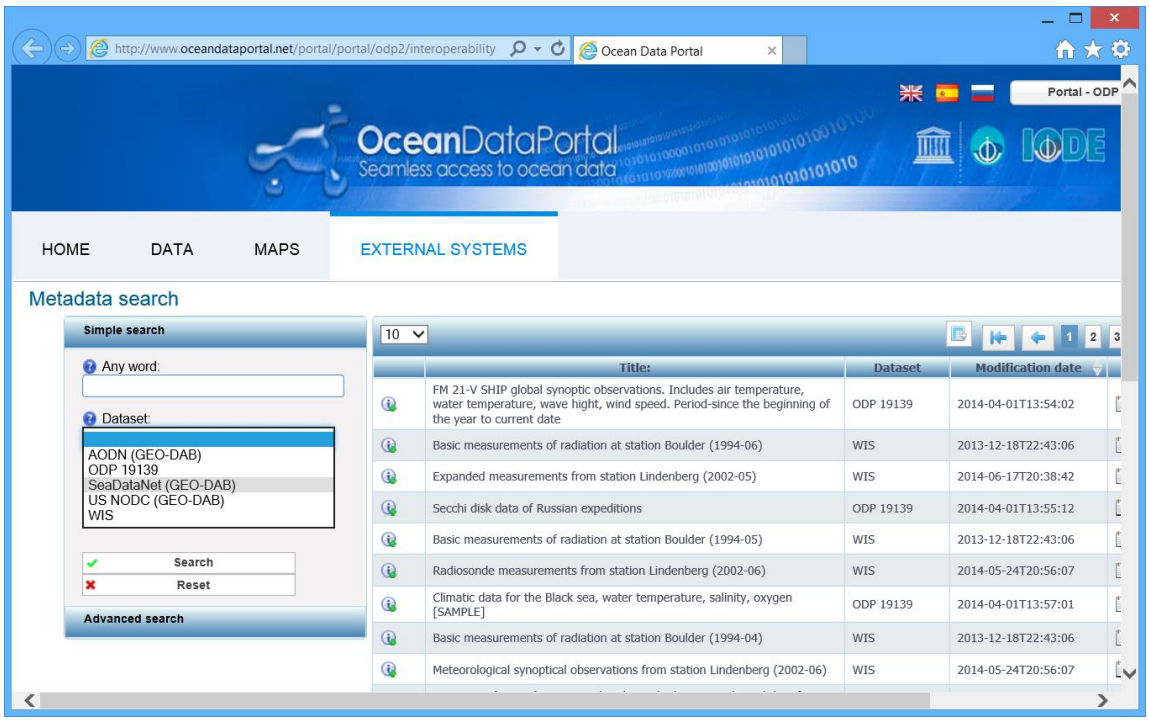


Figure 10: SeaDataNet, AODN and US NODC collections included in the IODE-ODP portal at: http://www.oceandataportal.net/portal/portal/odp2/interoperability

It can be concluded that the ODIP1 prototype development task has been successfully implemented and all three regional systems are now included at collection level with metadata in the two global portals, GEOSS and IODE-ODP, with return links to detailed pages at the respective regional portals for more details and access to related data sets.

During the planning of the ODIP 1 prototype development the following additional activities were considered:

- establishing horizontal interoperability at granule level between the three regional portals by means of OGC WMS – WFS;
- analysing how the interoperability can be extended to direct data level by making use of a data brokerage service, interacting remotely with the regional data request and delivery services, thereby also taking into account the complications of AAA services as operated by SeaDataNet
- analysing semantic harmonisation because the three regional systems make use of different vocabularies from which terms are propagated to the global portals.

In practice there has been not enough time to undertake these additional activities and it has therefore been decided to push these forward to the ODIP II follow-on project.

3 ODIP 2 prototype development task: results

Objective

To establish a common deployment and interoperability between cruise summary reporting (CSR) systems in Europe, the USA and Australia by making use of GeoNetwork, and moving towards interaction with the global POGO portal.

Context

Europe, the USA and Australia are undertaking efforts for administering the cruises and related data acquisition activities undertaken by their research vessels, as well as for innovating their related information systems. In addition all three regions are participating in the Partnership for Observation of the Global Oceans (POGO). As part of POGO a portal (http://www.pogo-oceancruises.org) is maintained by BODC, BSH and MARIS which aims to share information on planned, current and past cruises to enhance awareness of opportunities, and to improve the cost-effectiveness of cruises.

- **European and POGO services:**

The Cruise Summary Report (CSR) gives a low level inventory of cruises with reference to observations and also provides a tool for tracking. CSR is part of the SeaDataNet metadata infrastructure and at present it contains more than 46,000 entries from more than 2000 research vessels for cruises since 1873. It also includes historic CSRs from European countries included in the ICES database from 1960 onwards. At the end of 2013 the CSR format and schema were upgraded to ISO 19139 and to make use of the SeaDataNet vocabularies which have been extended for several attributes such as ports (C38) and platforms (C17). It is based upon the ISO 19115 and 19115-2 (for measurements and samples part) content models. The format and interface also supports linking to track charts (image / WMS) and station lists. The CSR WMS service is operational and displays CSRs that have been supplied with their navigation tracks in GML. Moreover CSR XML entries are provided as web services and used as such in the SeaDataNet CDI service. This will facilitate retrieving data sets from specific cruises.

CSR is also in use for the POGO research vessel portal. EurOcean (Portugal and Eurofleets partner) maintains a global directory of research vessels, which are linked by ICES Shipcodes (C17) to CSR. The POGO portal has a focus on ocean-going research vessels (length >60 metres) and is managed by SeaDataNet partners (BODC, MARIS and BSH). It gives the research vessel directory, the CSR directory and a directory of Cruise Programmes (CP). These planned cruises are gathered by BODC through dialogue with global research vessel operators and using a simple CP format. In the latter case BODC also collects input from non-European fleets such as those in the USA and Australia, but this takes a lot of effort and there is no steady flow of information. MARIS manages the user interface for the Cruise Programmes database and has also developed an online CMS that allows vessel operators to enter their planned cruises online. Alternatively it can be done by csv or as XML using the SeaDataNet MIKADO XML editor. The Cruise Programme format is also supported by the SeaDataNet Common Vocabularies.

As part of Eurofleets project progress is being made with establishing a streamlined flow of cruise data information directly from the shipboard systems, such as the navigation tracks, events and later on a Ship Summary Report (SSR) which should provide the basis for CSRs. The Eurofleets portal gives access to the directory of European research vessels, CSRs and CPs of all European research vessels. In addition it features a prototype for a Dynamic Vessel Tracking & Events System, using the onboard system. SeaDataNet partner BSH from Germany manages the central SeaDataNet CSR directory and services, which can be

queried through the SeaDataNet portal. MARIS takes care of the POGO and Eurofleets EVIOR portals and services.

Every data centre includes its Local_CSR_ID as a unique identifier in the CSR XML. The central master (BSH) then uses the combination of Local_CSR_ID and EDMO_code of CSR author to manage unique CSR entries at the central portal and it adds a Central_CSR_ID for its public output services. The Central portal provides web services for internal use with Local_CSR_IDs and for external use with Central_CSR_IDs. These IDs are sustained and used for recognising updates and new CSR additions. BSH also provides the CSRs for Europe to ICES. However ICES maintains its own CSR ID numbering and various countries outside Europe also report to the ICES CSR database but not on a full scale. Therefore BSH and ICES have regular contact and exchange to preserve the integrity of the CSR databases. However, there is a need for the user to be aware of potential duplicates when bringing together the CSR collections from Europe, USA and Australia, because of research vessels sailing through international waters and global scale charter/barter arrangements.

- **R2R Cruise Information in USA:**

The mission of the Rolling Deck to Repository (R2R) project is to provide uniform stewardship of routinely-collected environmental sensor data from the US academic research fleet. As of October 2015 it covers 5749 Cruise IDs from 38 research vessels with 30 Device Classes from 60 manufacturers and 173 Device Make and Models. Furthermore this covers >3000 Person IDs from >400 organisations, >200 Portals and >25 Programmes. It publishes Cruise records in multiple formats: ISO 19115-2 Metadata records; OGC Web Services; W3C “Linked Open Data” with a SPARQL endpoint; DOI-DataCite Metadata records, all using controlled vocabularies and best practices where available. For ISO 19115-2 it uses the vanilla schema, as provided by the NOAA/R2R Template. The NOAA/R2R records are published in a GeoNetwork (GN) 2.8 based web portal.

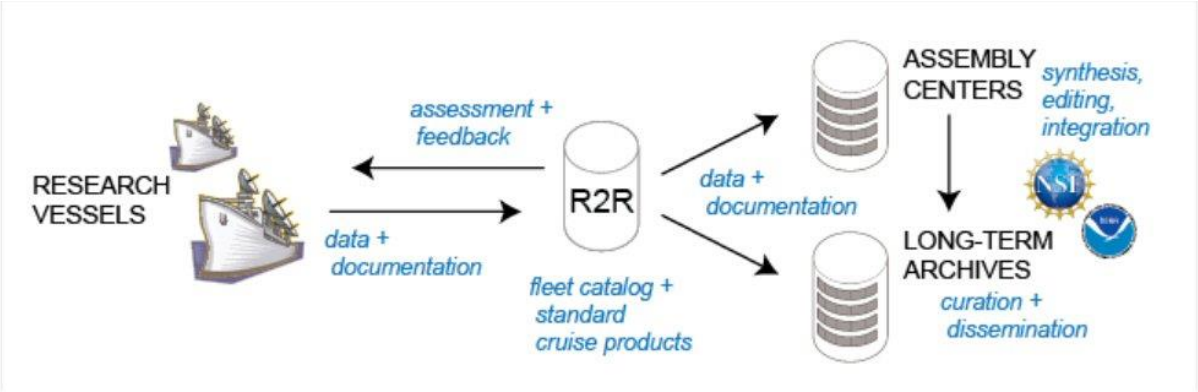


Figure 11: Overview of the US R2R system for research vessels

- **MNF Cruise metadata in Australia:**

The research vessels voyage metadata in Australia is stored in the CSIRO Marine and Atmospheric Research metadata system, MarLIN, along with metadata on datasets from the Marine National Facility (MNF) and other sources. For each research vessel it provides the survey details, voyage plan, voyage track and voyage data. The plans are loosely structured.

There is a now a new Australian research vessel ("RV Investigator"), which gives the opportunity for possible innovation in the cruise reporting systems in Australia. There are also separate systems in operation for other research vessels.

Directly involved partners:
Led by R2R partners (USA) (LDEO – lead, SIO, FSU, WHOI);
Partners: R2R consortium partners; BSH, BODC, IFREMER, RBINS, CSIC, and MARIS on behalf of SeaDataNet, Eurofleets and POGO consortia; CSIRO and UTAS on behalf of Australian MNF consortium.

Activities that have been undertaken:
The aim for the ODIP 2 prototype development task has been to strengthen the cruise data and information management in each of the three regions by sharing, where possible, common formats and vocabularies, and to streamline and considerably improve the contributions of the three regions to the POGO portal. The priority has been set as the exchange of Cruise Summary Reports of completed cruises.

Early on in the prototype development it was decided that the global POGO portal will run on the SeaDataNet CSR 3.0 Schema, which implied that the regional systems for USA and Australia should also adopt or achieve interoperability with this schema and its vocabularies. Moreover it has been decided that GeoNetwork will be used for exchanging the CSR XML entries between the regions and with POGO. In principle each region has been, and is, autonomous in building and managing its own portal while GeoNetwork harvesting is applied by SeaDataNet partners (BSH, BODC, and MARIS) for feeding the POGO portal. USA R2R decided at an early stage to adopt the SeaDataNet CSR 3.0 schema and to work on making its existing format and database fit for that purpose, which among other things s required a large amount of mapping between its local vocabularies and those used by SeaDataNet. R2R has also decided to develop a new search interface for its R2R portal using GeoNetwork.

In practice most of the activities in the ODIP 2 prototype development task have been undertaken by European and US partners, while those in Australia have worked on preparatory mappings. This is largely due to the fact that Australia does not manage a comparable cruise summary catalogue service at present, and the MNF is not a direct partner in ODIP.

The ODIP 2 activities have focused on the following three main activities:

- Publish ISO Cruise Summary Reports following SeaDataNet CSR 3.0 Schema and Vocabularies at each of the regional nodes (BSH on behalf of SeaDataNet consortium for Europe and R2R consortium for US cruises)

- Deploy a GeoNetwork catalog at each of the regional nodes, providing both a GUI (Web portal) and API (CSW service) (BSH on behalf of SeaDataNet consortium and R2R consortium for US cruises)

- Harvest GeoNetwork nodes into the POGO global catalogue to provide an integrated search (BSH, BODC and MARIS on behalf of POGO and SeaDataNet portals)

IFREMER has finalised the adaptation of the GeoNetwork software for supporting the SeaDataNet CSR schema and to facilitate harvesting of CSR XML entries. This software is freely available at:

ftp://ftp.ifremer.fr/ifremer/sismer/donnees/SeaDataNet_Software/CSW/GeoNetwork-sdn.war

This version requires Java (7 or 8, openjdk or Oracle JDK should be supported) and Java container (eg. Apache Tomcat 7 or 8). Java 6 and Tomcat 6 are no longer supported.

Documentation is available at:

ftp://ftp.ifremer.fr/ifremer/sismer/donnees/SeaDataNet_Software/CSW/SDN2_D92_WP9_CSW_harvesting.docx

The GeoNetwork includes both an API for harvesting CSR XML and a user interface for discovery and browsing of CSR XML entries.

This software solution has been evaluated by SeaDataNet for CSR harvesting between a number of national nodes and BSH as the CSR manager. BSH has upgraded its staging process for validating, importing and publishing CSRs by adding harvesting as another option next to online CMS and import of CSR XML as provided by email or FTP. The evaluation and testing have been successful and this method has been used operationally in SeaDataNet for several months. BSH has also arranged that, after validation, harvested CSR entries are published in both the SeaDataNet CSR Catalogue service for all research vessels and the CSR Catalogue service in the POGO portal for larger ocean-going research vessels.

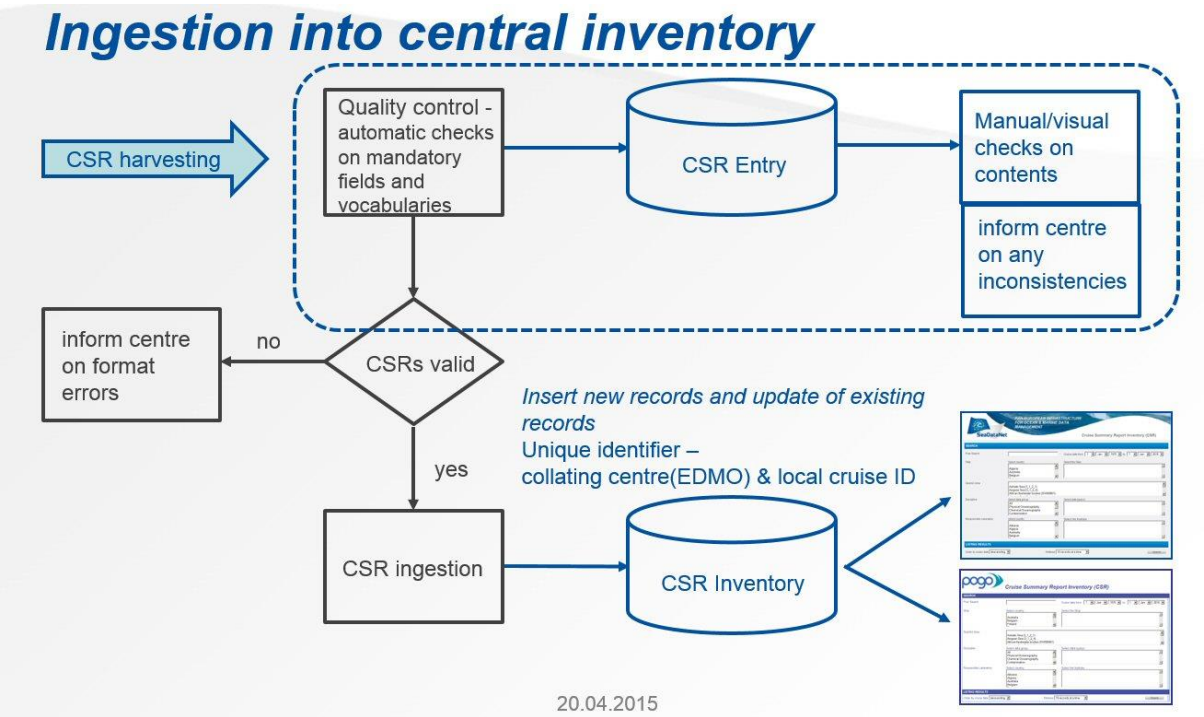


Figure 12: ingestion of CSR entries at BSH

R2R in USA has also analysed the software solution and the implications of converting their USA cruise entries to the SeaDataNet CSR schema. USA and Australian partners have undertaken considerable effort with mapping between local and SeaDataNet vocabularies and the further population of these vocabularies with additional terms in case of missing terms with support of NERC-BODC as manager of the SeaDataNet vocabularies. In addition, the EDMO directory for organisations and their addresses has been extended with more than 400 entries for USA institutes which are relevant in the context of the R2R system and with more than 228 entries for Australian institutes. Accounts have been set-up in the EDMO CMS system for USA and Australian colleagues to maintain their national collection. MARIS has also upgraded the EDMO user interface to make the USA and Australian entries accessible.

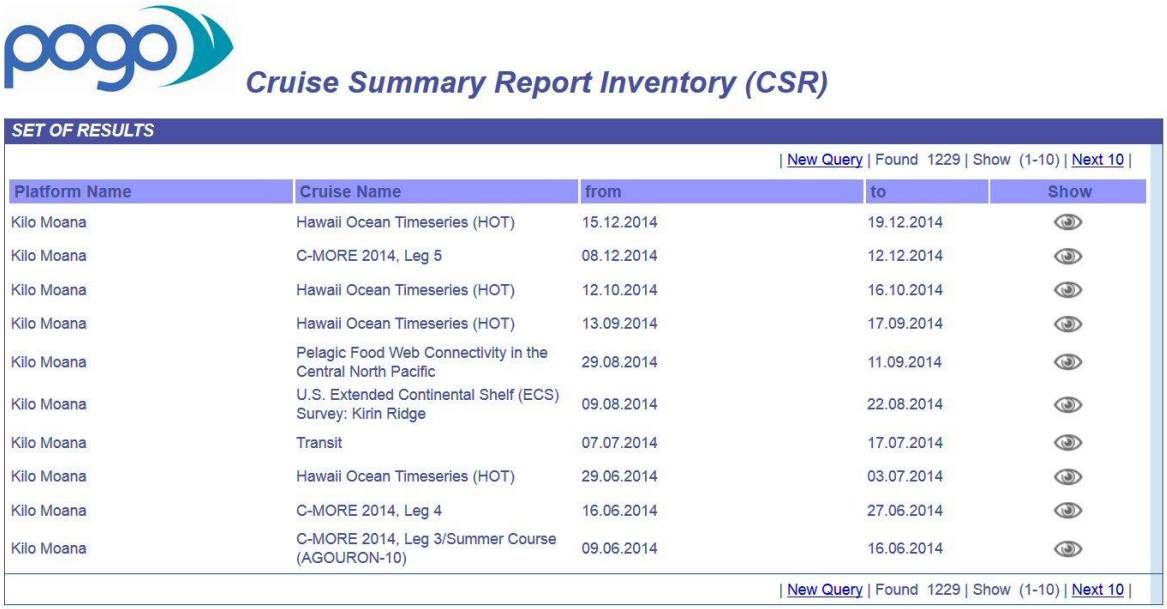
Further analysis has been dedicated to Cruise ID governance, handling of cruise tracks in GML, and potential use of linked data services. The R2R partners have engaged and managed a number of student projects which have supported the ODIP2 prototype development task and also worked on publishing Linked Data for the following topics:

- Embed URIs in CSR ISO records *http://data.rvdata.us/*
- Deploy Linked Data API
- Provide GeoSPARQL advanced query support
- Publish SAMOS Terms+Data
- Ontology-based Matching
- Align with EarthCube-OceanLink

The R2R team has extensively upgraded its Cruise Catalogue with the established mappings between USA and SeaDataNet controlled vocabularies, leveraging the NERC Vocabulary Server (NVS 2.0). These mappings include SeaDataNet platform categories (L06), ICES platforms (C17), SeaDataNet CSR data categories (C77), SeaVoX ports (C38), SeaVoX water bodies (C19), SeaDataNet device categories (L05), SeaVoX device make/models (L22), BODC usage parameters (P01), SeaDataNet discovery parameters (P02), and BODC data units (P06). Further vocabulary work included mapping R2R persons to Open Researcher and Contributor IDs (ORCIDs), mapping R2R organizations to the European Directory of Marine Organisations (EDMO), and publishing Digital Object Identifiers (DOIs) for R2R cruises. In the case of C17, C38, L22, and EDMO, additional work was required to add USA terms to the existing vocabularies managed by NERC BODC.

BSH participated in the 4th ODIP Workshop and presented their progress on the CSR harvesting mechanism. They also made further arrangements with the R2R team for delivering and including CSR entries from USA research vessels. Following the 4th ODIP workshop the R2R team has prepared and published an initial set of 130 CSRs for the USA research vessels *Kilo Moana* and *Falkor* via its GeoNetwork node, which were harvested and successfully integrated by BSH into the POGO CSR Catalogue service. This initial submission marks a successful completion of the ODIP2 prototype development task.

The R2R team has agreed to continue making further submissions in the ODIP II project, in an effort to have a larger number of US CSRs in the POGO portal. Only one CSR entry was achieved for Australia. However it has been agreed that the Australian partners will pursue further CSR implementation in the framework of the ODIP II project, especially as Australia is fully engaged with POGO through its Blue Planet initiative.



pogo Cruise Summary Report Inventory (CSR)

SET OF RESULTS

| New Query | Found 1229 | Show (1-10) | Next 10 |

Platform Name	Cruise Name	from	to	Show
Kilo Moana	Hawaii Ocean Timeseries (HOT)	15.12.2014	19.12.2014	
Kilo Moana	C-MORE 2014, Leg 5	08.12.2014	12.12.2014	
Kilo Moana	Hawaii Ocean Timeseries (HOT)	12.10.2014	16.10.2014	
Kilo Moana	Hawaii Ocean Timeseries (HOT)	13.09.2014	17.09.2014	
Kilo Moana	Pelagic Food Web Connectivity in the Central North Pacific	29.08.2014	11.09.2014	
Kilo Moana	U.S. Extended Continental Shelf (ECS) Survey: Kirin Ridge	09.08.2014	22.08.2014	
Kilo Moana	Transit	07.07.2014	17.07.2014	
Kilo Moana	Hawaii Ocean Timeseries (HOT)	29.06.2014	03.07.2014	
Kilo Moana	C-MORE 2014, Leg 4	16.06.2014	27.06.2014	
Kilo Moana	C-MORE 2014, Leg 3/Summer Course (AGOURON-10)	09.06.2014	16.06.2014	

| New Query | Found 1229 | Show (1-10) | Next 10 |

Figure 13: USA CSR entries in the POGO portal (www.pogo-oceancruises.org)

4. ODIP 3 prototype development task: results

Objective:

To establish a prototype for a Sensor Observation Service (SOS) and formulate common O&M and SensorML profiles for selected sensors (SWE), installed on research vessels and in real-time monitoring systems.

Context:

OGC provides a family of standards specifications called 'Sensor Web Enablement' (SWE) which includes detailed information about the sensors making measurements and the platforms that carry the sensors using the Sensor Model Language (SensorML), general models and XML encodings for sensor Observations and Measurements (O&M), and a protocol to provide access to observations from sensors and sensor systems in a standard way (Sensor Observation Service (SOS)).

Europe, the USA and Australia have an interest SOS and are taking steps towards adopting SWE and developing standards that can be applied by operators of operational marine observation systems to describe in more detail their observations, and to provide standardised access to these observations using the SOS service protocol. This can provide a way for direct access to the related data streams from operational sensor systems, such as real-time ocean monitoring networks and underway data from systems on board research vessels.

The SWE architecture comprises two major blocks: the information consists of the underlying conceptual models and encodings; the service model is the specification of services. SWE comprises SensorML profiles, O&M profiles and SOS services. SOS supports a number of key operations, such as Core, Transactional and Enhanced profiles. The Core profile comprises GetCapabilities, DescribeSensor and GetObservation. The latter works with the O&M profile: *An Observation is an action whose result is an estimate of the value of some property of the* feature-*of-interest, obtained using a specified procedure.*

For SOS there are only a few applications currently available in the marine domain and there is a lot of scope for ODIP to set practical standards going beyond the present applications.

Directly involved partners:
Led by UTAS on behalf of AODN (Australia);
Partners: UTAS, CSIRO, AIMS and BOM on behalf of AODN; CSIC, OGS, IFREMER, MARIS, CNR, BODC, and AWI on behalf of SeaDataNet – Eurofleets and RITMARE projects; NOAA on behalf of US-IOOS; 52North.

Activities that have been undertaken:
Originally this prototype development task had aimed to establish a set of common standards for Sensor Web Enablement (SWE) concerning a sensor observation service (SOS) for selected sensors (SWE) installed on research vessels and in real-time monitoring systems. However during the lifetime of the ODIP project it has appeared not to be feasible to derive common SWE standards. There are multiple SWE initiatives in the marine domain in Europe in several EU research projects for observing systems (EuroFleets 1 and 2, JERICO and JERICO-NEXT, FixO3, AtlantOS, GROOM), data management (SeaDataNet 2), and instruments and sensors (Sense OCEAN, NEXOS, and SCHeMA), and also in USA with major implementations of SWE as part of the US-IOOS programme, and several initiatives with SWE in Australia. Therefore over time it has been decided to amend the aims of the ODIP 3 prototype development task to following these SWE developments in the projects mentioned above, which the ODIP partners are involved in, by means of presentations and discussions at the ODIP workshops. This in itself has led to synergy and cross-fertilisation, but as mentioned not to common SWE standards. Specific topics of interest have been dedicated to SensorML and O&M profiles, SOS services (52North SOS service, ncSOS), vocabulary mappings (instruments, manufacturers, etc.), SWE editors, and performance of SOS services. The presentations are summarized below with a link to the original presentations to provide a good overview of ongoing initiatives and experiences.

The following presentations on SWE topics were given at the ODIP Workshops:

- **SWE developments in Australia – Roger Proctor (UTAS), Sebastien Mancini (UTAS) and Scott Bainbridge (AIMS) (2nd ODIP Workshop)**

http://www.iode.org/index.php?option=com_oe&task=viewDocumentRecord&docID=12228

A Virtual Machine (VM) with the latest version of 52North SOS has been set up by AIMS. This allows for easy setting up of new instances of the 52North SOS on the same VM or to easily set up new VM's. The current SOS has real time data from IMOS via the Davies Reef Sensor network (every 10 minutes). The SOS is currently accepting requests so anyone can post/query to this (code available on request). Currently it uses minimal sensorML and O&M templates as a starting point for future development. There is also minimal security at the service level so fewer road-blocks for other people to use these systems. It is open for anyone to test/try, can be quickly re-built, cloned or used as software test beds.

There are also other groups in Australia working on SWE. This includes Bureau of Meteorology (BOM) for implementation of a 52North SOS service as a component of the National Environmental Information Infrastructure. Their objective is to deliver historical data from large datasets using SOS. A problem encountered is that SOS 52North v3.5 could not handle this amount of data. As a result a set of improvements were developed that have recently been included in the V3.6 release of 52North. V3.6 has also been set up on the same platform as V4.0 and is available for testing. SWE activity also takes place in a number of projects at CSIRO.

- **SWE developments in Europe for SeaDataNet and EuroFleets – Jordi Sorribas (CSIC) (2nd ODIP Workshop)**

http://www.iode.org/index.php?option=com_oe&task=viewDocumentRecord&docID=12577

There are several ongoing marine SWE activities in Europe. The SeaDataNet 2 and EuroFleets 2 projects each have a work package on SWE, led by CSIC with contributions from MARIS and these are combined where possible. They are aimed at streamlining the flow of data from research vessels and fixed monitoring stations. In EuroFleets the focus is on software and tools for underway Ship Summary Reports, onboard data acquisition and remote e-access, while SeaDataNet is focusing on defining SensorML and O&M profiles for a range of instruments, sensors, and observation types. The motivation is to increase the level of information provided of instrumentation, use a common way to access Real Time data and instrument descriptions, and to enhance existing SeaDataNet metadata descriptors (CDI and EDIOS (describing monitoring networks and stations)). The first steps in SWE have been made for seismic data sets by OGS as part of the Geo-Seas project. As a result specific SensorML and O&M profiles have been defined as extensions to the CDI format. These are supported by SeaDataNet vocabularies and can be generated with the MIKADO XML editor. These extensions provide the means to describe seismic instrumentation and use metadata. Moreover the seismic visualisation services can be reached from the O&M object. This has been integrated into the operational SeaDataNet and Geo-Seas CDI service for several thousands of CDI entries for seismic data sets. This development has continued in the SeaDataNet 2 and EuroFleets 2 projects. A roadmap has therefore been established with three phases: specifications of requirements; implementation of descriptions, and implementation of services. The activities are now at the start of phase three. The present state including definition of SensorML and O&M profiles for a number of instruments has been reported in a SeaDataNet Report, which is publicly available. So far this concerns time series, profiles and trajectories. Further work is needed for gridded data and instruments such as radar and swath. Forthoming activities in SeaDataNet and EuroFleets will focus on review and refinement of the SensorML and O&M profiles to Version 2.0, how to adopt MIKADO for generating the new profiles, and setting up services to test over SOS implementation and for Real Time data access, Ship Summary Report and Real Time data from buoys. Comparable work on SWE is also taking place at CSIC in the new EU FP7 NEXOS project which will have synergy with the SeaDataNet - EuroFleets activities and also the ODIP 3 prototype development task. SWE activities including SensorML and O&M profiles and SOS services are also undertaken by CNR within the framework of the RITMARE flagship project. This relates to virtual machines with 52North SOS implementations for a number of monitoring stations. Also OGS is testing SOS services for two monitoring sites. In addition AWI is considering SOS services for its research vessels and is studying the results from SeaDataNet and Eurofleets, while IFREMER is also looking at implementing the SOS protocol for its *oceanotron server* as used in the Copernicus Marine Environment Monitoring Service. In addition, IFREMER is working together with

CSIC to fine tune the SensorML and O&M profiles and developing an online XML editor. BODC has started the implementation of a prototype ncSOS for glider and animal tag data.

- **SWE developments in US-IOOS – Derrick Snowden (US IOOS) (2nd ODIP Workshop)**

http://www.iode.org/index.php?option=com_oe&task=viewDocumentRecord&docID=12576

The US-IOOS Program has 6 - 7 years' experience with SWE in the context of 11 portals for exposing ocean information at regional scales. With SOS US-IOOS aims to provide a uniform service level on top of the heterogeneous regional systems. The SWE family of standards can be applied to time series, profiles and trajectories data from buoys, tide gauges, ADCPs, gliders, and other common oceanographic data collection platforms. Several templates have been developed (V1.0) based on the 1.0 version of the relevant SWE standards, while developments are ongoing for migrating to the newly released 2.0 version. These are published in the public domain. US-IOOS has implemented these templates in two types of server: 52North (SOS) 4.0 and the ncSOS plugin for the THREDDS data server. A number of additions have been made to the 52North server and use is made of an SOS-injector between the data sources and the 52North server. This server supports *GetCapabilities, DescribeSensor (sensor + station), GetObservation (O&M, NetCDF, CSV, KML, JSON).* For the ncSOS server, an ncSOS THREDDS plugin is used to convert between CF 1.6 and O&M/SensorML. There are a number of clients and graphics utilities. There are also a number of SOS testing tools such as a NetCDF compliance tester.

- **SOS and 52North – Simon Jirka (52North) (2nd ODIP Workshop)**

http://www.iode.org/index.php?option=com_oe&task=viewDocumentRecord&docID=12578

52North is a major developer and provider of SOS servers. Recent version is SOS 3.6 a full SOS 1.0 implementation with elements from SOS 2.0. This also includes the contributions of BOM to give a performance boost, support streaming XML encoding, and more efficient Capabilities cache. Furthermore version 4.0 has recently been released. This has SOS 2.0 reference implementation of key value pairing (KVP), full SOS 2.0 and core elements of SOS 1.0. It also includes a lightweight SOS profile and SOS 2.0 Hydrology profile / WaterML 2.0. Extensions have been included for US-IOOS SOS. 52North is also developing a 52North Sensor Web Client and a Mobile Sensor Web Client. The outlook is for SensorML 2.0, and client development for a REST-API and a Javascript API.

- **2 SOS installations, pressure test – Scott Bainbridge (AIMS) (3rd ODIP Workshop)**

http://www.iode.org/index.php?option=com_oe&task=viewDocumentRecord&docID=13814

AIMS has been stress testing the 52North SOS services, V4.0 and V3.6. These were set up at the Github site for ODIP (https://github.com/aodn/ODIP) and loaded with real data from AIMS/IMOS. V3.6 was much better at dealing with large numbers of records but the limited support for SWE V2.0 makes it less fit for use. V4.0 has improved scalability and very good support for SensorML-2.0 which is really useful. Also it is much easier to program and interact with. However there is no clear winner. The best way forward would be to go with V4.0 and hope that 52North will keep improving the scalability and maybe roll in the changes done to V3.6 even though V4.0 was a re-write. Or find another server / software / solution. The two servers are accessible for everybody at the URLs given in the presentation. Simon Cox (CSIRO) adds that if you could use the RESTful bindings to SOS, then you could overcome the issue of dealing with large data volumes efficiently. This could be arranged by

having a RESTful SOS on a Database, which would make use of the Database qualities. This solution is nearby but efforts are needed to coordinate a number of persons working on this.

- **O&M and SensorML update – Simon Cox (CSIRO) (3rd ODIP Workshop)**

http://www.iode.org/index.php?option=com_oe&task=viewDocumentRecord&docID=14076
A star system can be used to describe the functionalities, increasing stars indicates increasing complexity of information:
* GetCapabilities
* GetObservation (feature, property, procedure, time, *space*)
** GetObservation - by ID
** GetResult
** GetFeatureOfInterest
** DescribeSensor
*** InsertSensor/DeleteSensor
*** InsertObservation/InsertResult
**** GetDataAvailability ?
The OGC SOS for observation data access presents the getObservation, getResult, describeSensor and getFeatureOfInterest operations. The O&M vocabulary comprises: Observation, Procedure, Observed property, Result, Feature of interest, Phenomenon time, Result time, and Valid time. Using these neutral terminologies supports cross-domain data discovery & fusion. SensorML 2.0 is making good progress and several examples of templates are available. Not everything has to be solved with XML. There are other solutions such as Starfish Fungus Language (*FL) a lightweight alternative.

- **SensorML and O&M profiles – Kim Finney (IMOS/AODN) (3rd ODIP Workshop)**

http://www.iode.org/index.php?option=com_oe&task=viewDocumentRecord&docID=13808

Current IMOS activities on SensorML developments include an IMOS review of the SeaDataNet O&M template (see presentation of Jordi Sorribas (CSIC)) for fixed station data. This review revealed several minor data mapping issues such as the possible need for a more complex “procedure” description and questions concerning the inclusion of QC flags.

AODN/IMOS also has been testing SOS services and analysing the approach as formulated by CSIC for Eurofleets and SeaDataNet. Sample files have been created using the SeaDataNet profiles for fixed stations. The pattern fitted fine, but linking back from O&M to SensorML raised an issue. In O&M the *om:Procedure* is not considered expressive enough. It is suggested to introduce into the O&M SeaDataNet schema a customised ‘ProcedurePackage’ with a number of GML members containing *xLinks* to relevant SensorML files and *xlink:role*’(s) defining the type of resource found at the end of the *xlinks*. This would enable more direct (and granular) links back to relevant SensorML data files.

Another issue is how we should include Quality Flags in the SOS service output? Scott Bainbridge (AIMS) commented on the lack of guidance about how to mark-up QC flags. Simon Cox (CSIRO) noted that QC information was not neglected from the metadata model and that there is ISO guidance on ‘Quality’ metadata. When the model was designed the target was the ISO community that requires the quality approach and if someone starts with the raw data, then the QC becomes part of the provenance of the data. Scott noted that QC flags are included at the different processing levels of data (level 0, 1, etc), and then the QC flags become a data processing flag.

- **SOS Services and endpoints, SMG; sensorCloud; visualisation – Jonathan Hodge (CSIRO) (4th ODIP Workshop)**

http://www.iode.org/index.php?option=com_oe&task=viewDocumentRecord&docID=15123

Jonathan Hodge demonstrated a portal for Water Quality on the Logan River. It works with XML and JSON data and tables. Observation timeseries from stations can be plugged in and provide input for a Decision Support System. For instance floods in the Logan River are monitored and scenarios can be run for assessing impacts and solutions. The portal combines different services. It has a Java layer on top and works with a Mongo Database (Mongo DB is a new start-up in USA). Another interesting project with WPS for processes is the www.zoo-project.org. It is an open WPS platform. Furthermore CSIRO is working on a SensorCloud project. It makes use of a Sensor Message Gateway (SMG) protocol which has been defined by CSIRO. It is used in connection with MongoDB for large ingestions and output. They have developed also a way to plug in the Sensor Cloud into an SOS service. This makes the building of SOS Client interfaces much easier.

Simon Cox (CSIRO) suggests an alternative architectural approach: make use of SOS as traffic cop to manage traffic through WCS (data) and WFS (metadata). And then bundle these to the users.

Jonathan also presented how some of the time series services integrated into SOS can perform. It is an activity within the framework of the eReefs project. The main issue was the performance of SOS and it was found that SOS can give all standards and all compliance that is needed. There are many use cases well beyond the scientific world (real computing or financial) which use a huge amount of time series data but when standards are to be used then data are lost. In an example of a weather station data, where performance was measured with a SOS v4.0, we get 50,000 results back in about 5 seconds which is reasonable but if we try to get back huge amounts of data (1 or more millions) for pre-processing or other usage then the performance is insufficient. So InfluxDB (replacing Sensor CRUD (create, read, update and delete)) was considered, its main feature is to easily get data in or out. InfluxDB uses SQL plain language, it is easy to install and use and retrieves 50 Million values between 9 and 14 seconds. Jonathan then explained the Hybrid Architecture and the SOS PROXY noting that the concept of such hybrid systems for times series data is similar with the Hybrid OGC Services. Advantages and disadvantages of such an approach were discussed and it is concluded that a python proxy to either 52North SOS or an InfluxDB service was faster than 52North SOS alone in the CSIRO case, and that Hybrid services offer advantages in speed without sacrificing functionality.

- **SOS at IFREMER – Thomas Loubrieu (IFREMER) (3rd ODIP Workshop)**

http://www.iode.org/index.php?option=com_oe&task=viewDocumentRecord&docID=14061

IFREMER undertakes activities for implementing a module providing SOS services in the *Oceanotron* server. *Oceanotron* manages and gives access to aggregated data sets in NetCDF (from CORIOLIS, for Copernicus Marine Environment Monitoring Service and OceanSites) and ODV (Ocean Data View) binary formats (for SeaDataNet). The SOS service of *Oceanotron* allows subsetting. *Oceanotron* also provides OpenDAP and ncWMS services. SOS Version 2 with getObservation of SeaDataNet profiles has just been implemented. It enables subsetting of the data collections and gives output as NetCDF, O&M XML and JSON results. IFREMER also started a new development for sensorNanny / SOS-T services. This will be adopted for SeaDataNet to generate and manage SensorML

and O&M descriptions for specific observation platforms and instruments. It will thus act as back-end for the editor and registry to be instrumental in SeaDataNet for SWE. Sensor models are being formulated for Argo floats, Research Vessels (as part of Eurofleets project), and fixed platforms (as part of JERICO project). A challenge is how to deal with deletions of entries. The 52North SOS service is being tested.
There follows a discussion on JSON, GeoJSON, and XML formats: what is the most efficient and how can they be converted to each other? Simon Cox (CSIRO) comments that there is no delete operation in SOS. A status flag would be the common way to manage the requirement in a system that does not permit data to be deleted. In an operational service we should not delete anything. In relation with JSON encoding in OGC, we are in the stage of standardization of JSON, there is an existing project (geoJSON-LD) dealing with this.

- **Update on Eurofleets SensorML 2.0 - Jordi Sorribas (CSIC) (3rd ODIP Workshop)**

http://www.iode.org/index.php?option=com_oe&task=viewDocumentRecord&docID=13805

CSIC is active with SWE as part of Eurofleets and SeaDataNet. An overview is given of the benefits of using sensorML and O&M (Observation and Measurements) for instruments and their data transfer. Detailed examples of vessel system, gravimeters description in sensorML and CTD and gravity observation in O&M are presented. The latest profiles are based upon SWE Version 2.0. The earlier draft SeaDataNet SWE profiles have been improved by strengthening the integration with the SeaDataNet common vocabularies (P06 for units of measure, L22 for devices, C17 for vessels) and reference directories (EDMO for points of contact). This makes the formats much more concise. RelaxNG schema language is used to describe the SeaDataNet profiles for SWE. This schema language can embed schematron rules (which are commonly used for other SeaDataNet XML standards). RelaxNG is easy to apply in a JAVA application (JING or JAVA XML API). The SOS protocol is used for registration and consultation of SensorML or O&M records on a server. The SOS protocol is intended to be deployed at every data transmission level, from the sensor onwards. This aims to streamline the data flow (acquisition system description and observations) up to the data centres. At the moment, either specific or on-the-shelf implementation can be considered. The most popular implementation for now is 52North but it still has some limitations. CSIC has developed their own SOS service for a demonstration but of course is open for other packages that will support the SWE Version 2.0 profiles of Eurofleets and SeaDataNet. The SWE profiles will be finalised soon for selected instruments. Thereafter further work is planned for an SWE editor and an implementation of SOS services for selected observation platforms in connection with the CDI and EDIOS services in SeaDataNet. See also the presentation of Thomas Loubrieu (IFREMER) on sensorNanny.

- **BODC activities and ncSOS - Justin Buck (BODC) (3rd ODIP Workshop)**

http://www.iode.org/index.php?option=com_oe&task=viewDocumentRecord&docID=13807

BODC is interested in SWE for gliders, AUVs, tagged animals, and floats to transfer in real-time and in delayed mode observation data in netCDF. There are multiple platforms deployed and therefore consistent and interoperable formats are needed. SOS has a dual role within BODC.

1. Real time data streams with netCDF are made available via OpenDAP Thredds + ncSOS for delivery to users by means of web services.
2. The ncSOS is also used to deliver the observed data towards the BODC delayed mode system for validation, archiving and delivery to users.

Therefore BODC is evaluating ncSOS because it is a natural choice for handling netCDF files. There are a few limitations, e.g. for gliders because of limited support in THREDDS for trajectories. So far the implementation is based upon SWE Version 1. BODC is involved in several projects (SenseOCEAN, AtlantOS, BRIDGES) that will bring this work further. There is also cooperation with manufacturers of instruments which requires good business cases. The Oil & Gas industry and Defence communities should be interested in order to make a business impact for manufacturers. The cooperation in ODIP and with several projects has impacts such as reduced costs for development and testing because of shared development. SWE opens data up to be accessed remotely in near-real-time which increases user base, data uptake and data impact. And the introduction of OGC standards enables interoperability which reduces efforts required to assemble datasets.

- **RITMARE starter kit – Paolo Tagliota (CNR) and Alessandr Oggione (CNR) (4th ODIP Workshop)**

http://www.iode.org/index.php?option=com_oe&task=viewDocumentRecord&docID=15125

CNR has developed the Starter Kit has been developed as an open tool as part of the Italian RITMARE project to facilitate the generation and publishing of metadata and data by any data provider. This way quality differences will come to light and might be solved by community efforts.
SP7 is the 7th sub-project of RITMARE, with the objective to create the interoperable infrastructure interconnecting the whole marine research community. A bottom-up strategy was chosen enabling researchers to autonomously contribute to the infrastructure. The Geographic Enabled Toolkit (GET-IT) Starter Kit was developed for both geo and sensor data and is a suite of software and services integrating GeoNode, GeoServer, PyCSW the SOS implementation by 52North in v4.1, and among other tools a Metadata Editor (EDI) – an online editor for sensor metadata in v4.1. Twelve registered nodes use the Get-IT Starter Kit solution and have installed the SOS server but only six use SOS for distributing the observations and the sensor metadata. The SensorML editor has been completely integrated in the GET-IT software. All parts of SensorML are reproduced in a EDI SensorML template, for each item there are tooltips, and when user finishes with the filling on the form, the interface creates the SensorML XML in v4.1.0. The editor has many functions and multiple fields can be generated for each item. The generation of dropdown lists is based on codelists such as keywords. Autocompletion is also possible for manufacturers. The autocompletion is used also for other metadata fields whose values shall be taken from SeaDataNet controlled vocabularies stored in the RDF triple store. The data model underlying template creation is encoded as an XML. A user oriented sensor description has been also integrated where the user can visualize the information about the sensor. The next update concerns the development of a sensors prototype, in collaboration with IMOS. The prototype is developed for different types of sensors and allows the autocompletion of the SensorML. The last update is the autocompletion of FOAF RDF profiles for RITMARE users and institutes and sensor manufacturers. The tool is completely open and a Github has been developed for RITMARE and its group. Dick Schaap (MARIS) suggested making the list of manufacturers part of EDMO and since EDMO is available as web service and used by CSR, USA and AUS, this list could be populated and used by a larger community as a basic vocabulary like P01. For the collection of the information of the sensor profiles one should speak directly with the manufacturers instead of collecting information from web sites or existing directories (FixO3). This is done in Eurofleets and FixO3 projects and as more manufacturers are being involved, more tuning can be achieved. CNR used SensorML v1

because at the time of creation of the first template the 52N was using v1, but CNR has started to create v2 for physical components for example.

- **Updates on 52North SOS testing – Jonathan Hodge (CSIRO) (4th ODIP Workshop)**

http://www.iode.org/index.php?option=com_oe&task=viewDocumentRecord&docID=15122

CSIRO has continued its testing of SOS. The 52North Version 4.0 had huge memory growth and investigation found that all record identifiers from all tables were being loaded into cache. Version 4.1 drops a lot of memory issues but Postgres appeared to not be making the best use of available DB indexes. Retrieving 1 observation from 13.7million took about 2.5 minutes, which was not functional. Removal of several tables left out joins to observation types which were not required (e.g. text time series, blobs, Boolean, etc), resulted in joins to only 4 data types instead of 7. Retrieving 1 observation now took ~30ms, which is a huge improvement. Some other experimental settings in v4.1 such as settings that stop sequential table scans and false indexes used to find data and found that with all 7 data types: retrieving 1 observation took ~1.6s which is good but not a sensible solution for small tables. Discussions with the developers of 52North provided more reliable ways to remove outer joins without forcing index use. Results match the second situation but with a more sustainable solution.

- **SOS for grain-size distribution – Rob van Ede (TNO) (4th ODIP Workshop)**

http://www.iode.org/index.php?option=com_oe&task=viewDocumentRecord&docID=15142
Recently the TNO database has been extended through digitisation of the archives of measured grain-size distributions from land and water samples, mostly on Dutch territory. A number of techniques were used to get these distributions: sieving, laser diffraction and optical methods. Local (Dutch) vocabularies are used. Currently the quality controlled data are available free of charge through a web-shop (DinoLoket.nl) that will be soon translated in English. In parallel work has started to make these data available through an SOS. A Lab environment has been set up, not yet publicly available, that uses 52North 4.2.0 SOS and the local vocabularies are mapped to the SeaDataNet-BODC vocabularies P01 (for grain-size classes), S04 (for procedures), P02 (for offerings). The big challenge during mapping is the grain size min-max. In the database there are not well defined classes and some match exactly with the P01 while others not. The question is: should we start to generalize the data and make these more usable for people, or extend P01. Discussion with Roy Lowry (BODC) is ongoing about that. The next actions include: complete the mapping and extension of the vocabularies where needed; load data into SOS straight from database or through transactional request; test for usability; move to production and release; and for the future to serve subsidence measurements from oil-gas industry with SOS (time-series of GPS elevation).

- **Updates on BODC activity – Justin Buck (BODC) (4th ODIP Workshop)**

http://www.iode.org/index.php?option=com_oe&task=viewDocumentRecord&docID=15126

Justin Buck presented the BODC activities within several ongoing and future projects. He first explained what are the goals and the SOS role in the context of BODC. There are many types of data, glider data, AUV data, animal tag data, profiling floats and we want these data in the systems quickly and in consistent formats. There is also the requirement to transfer these real time data into a delayed mode infrastructure for calibration and most of these

communities need the data primarily in CF compliant NetCDF. Within several projects multiple types of platforms being deployed simultaneously so formats and protocols need to be consistent for interoperability. SOS has a dual role within BODC. Real time data streams with NetCDF exchange format are made available through THREDDS and ncSOS or 52North implementation according to the initial plans. Also, SOS service is used to deliver the observed data towards web services and the BODC delayed mode system for validation, archiving and web delivery to users. BODC is involved in two on-going Sensor Web Enablement projects and funding prospects to continue work are good with multiple EU Horizons 2020 proposals submitted/funded with SOS/O&M/SensorML central to the data management:

- SenseOCEAN (working at sensor level for getting biogeochemical data in a standard format);
- BRIDGES (working at platform level for Introducing OGC standards in the communication between the base station and platform and delivering data in standards based formats directly from base station);
- AtlantOS (working on data delivery for standardization of data between diverse networks and from acquisition to services and users), and
- ODIP2.

Roger Proctor (UTAS) asked if standard vocabulary services (BODC NVS) are used in these projects. Justin Buck (BODC) replied that FixO3 and Argo use their own vocabularies. New bio Argo data will be mapped to NVS. They are trying to convince the glider community to use NVS. Dick Schaap (MARIS) noted that the same happens in AtlantOS where there are different networks which try to converge the output while effort should be given also to the input and suggested to keep pushing observing networks to use common standards.

- **Progresses on SeaDataNet, JERICO-NEXT and Eurofleet projects – Thomas Loubrieu (IFREMER) (4th ODIP Workshop)**

http://www.iode.org/index.php?option=com_oe&task=viewDocumentRecord&docID=15128

Thomas Loubrieu presented the status of development in different EU projects. SWE is used in two different perspectives. First, between the data providers and data centres where there is a lot of heterogeneity in the data source, different platforms, acquisition systems and a unified conceptual model is needed to manage the provenance of observations. The relevant EU projects that are managing observation systems are JERICO, Eurofleets, FixO3. Secondly, SWE is used to provide homogeneous collection of observations to scientists for gridded analysis and time series analysis and they need less metadata about observations and observing systems because the data centres have already homogenized data collections. In these cases the SOS protocol is used to ease the access to these collections and comply with the INSPIRE directive which is mandatory at EU level. These projects are EMODnet/SeaDataNet and Copernicus. The progress is presented at the downstream part (between data centres and users) concerning the SOS protocol at the *Oceanotron* in situ data server for dissemination of profiles, time series and trajectories (up to 100 thousand features in a single collection) towards SeaDataNet, EMODnet and Copernicus. The native dissemination format is netCDF, ODV binary collections or local databases and enable coordinates, phenomenon subsetting criteria. The results can be accessed by an O&M data model in JSON or XML encoding or netCDF4. For big volumes, users send requests with subsetting criteria and get URLs from where the datasets can be downloaded offline. Issues related with the implementation of SOS for big data collections have been solved (GetCapabilities, DescribeSensor, GetFeatureOfInterest) or are to be solved (GetFeatureOfInterest + extension parameter to only get unique sampling features per

platform for “readable” map). Front-end clients will be developed internally at Ifremer and connected with OceanBrowser and Sextant. For data dissemination ncSOS and 52North are also looked at. NcSOS did not succeed with netCDF. The RESTful API from 52North for time series is a serious competitor to the SOS XML implementation. On the other side between the data providers or systems operators at data centres, there are different actions. IFREMER is developing SensorML editors with traditional web-forms for 'standard' templated systems in order to describe JERICO moorings. A “Draw my observation system” application is being developed to describe complex experimental deep sea systems, like MOMAR. The basic principle is that the data provider can describe the system by doing drag and drop of pre-defined sensors and export the result in SensorML. Within the Eurofleets project, Ifremer is working with CSIC on the real time data transmission from research vessels to databases for the management of events, CSR and CDI automated creation, and real time data flow to on-shore databases. There is a module on board that creates the system configuration by sending SensorML records to the shore system. When the system starts an observation it sends O&M records and triggers an on-shore database that harvests by a grabber in real time the data stream provided by the vessel. When the observation is completed the system on board sends an updated O&M record and the stream is stopped. Within SeaDataNet, Ifremer is working with OGS for the management of monitoring stations in the Adriatic Sea and a 52North implementation with new tests for SOS v4.2 to enable a Restful API on top of SOS 4.2.0. A SOS web client is installed at OGS (http://nodc.ogs.trieste.it/SOSclient/). Finally, within SeaDataNet, a SWE demonstration is being set up to combine research vessel navigation and thermosalinographs, Argo data, monitoring data from moorings (poseidon/pylos, E2M3A, MAMBO1) and deep sea observatories (MAMOR) and define a common profile in SensorML 2.0 and O&M. Data will be available in separate services (http, ftp, NetCDF or ASCII) for the moment and not in O&M or getResult request. A portal will cross link these observation interfaces with CDI portal.

- **SenseOCEAN – Justin Buck (BODC) (4th ODIP Workshop)**

http://www.iode.org/index.php?option=com_oe&task=viewDocumentRecord&docID=15129

The difficulties in delivering data using standards and the proposed solution are explained. Autonomous ocean observation is massively increasing the number of sensors in the ocean. Each platform is equivalent to a small vessel. Data practices need to evolve to ensure: key metadata and technical data from novel sensors are never lost; efficient data processing, efficient data archival and seamless data delivery. The solution is that data standards are needed from sensor through to delivery. OGC standards are becoming a common practice and the applicable OGC SWE standards to this work are: Observations & Measurements (O&M), PUCK Protocol Standard Sensor Model Language (SensorML), Sensor Observation Service for delivery (SOS). W3C Linked Data is also being explored for serving data from a SOS and a linked data server. However it became quickly apparent that legacy hardware and cost of data transmission is constraining implementation. For legacy systems (such as gliders, autonomous platforms, ARGO) there were bandwidth limitations between sensor and control board and limited processing power on control board. Existing base stations were not OGC SWE compliant. The cost competes with the scientists desire to get maximum data back: using XML based syntax e.g. SensorML significantly increases the cost of transmission. The high volume data from new sensors brings back highly compressed data e.g. passive acoustic monitoring. Given the above difficulties, the proposed solution creates minimal extra transmission costs. It uses the NERC linked data service to serve sensor metadata in a variety of formats. Collection data service implementation allows delivery of data by both W3C Linked Data and OGC SWE standards. Implementation of SWE standards is not precluded at earlier levels of processing. Thomas Loubrieu (Ifremer) asked

if there are already any feedback on how those who are working on the development of sensors are reacting to the SWE standards; Justin replied that this is difficult. The effort is to minimize the process, transmission and duration cost. The binary implementation of XML will solve some of the problems.

- **Oceans of Tomorrow 2013.2 Projects – Jay Pearlman (IEEE) (4th ODIP Workshop)**

http://www.iode.org/index.php?option=com_oe&task=viewDocumentRecord&docID=15130

The work within three EU FP7-OCEAN-2013.2 projects, NeXOS, Common Sense, Schema, is presented with their commonalities and collaborative activities. The projects were awarded in September, October and November 2014. The motivation for these projects came from the fact that there is increased interest for new sensors which will expand the observations, lower their cost and make them more pervasive. By reducing the cost of observations more sensors will be bought, more sensors will be built and their cost will be reduced (chicken and egg situation).To stimulate this process, EU in the FP7 programme, has two classes of projects, the 2013.1 and 2013.2. The first (2013.1) is for sensors (for biogeochemistry, chemical and other biological elements of observations) and the second (2013.2) is for sensors and systems. The increasing need for ocean information is balanced by the budget limitations and the challenges of comprehensive observations. This was approached by incorporating new technologies in the sensors side. Part of this balance then is how detailed the real time data should be, how to deal with what data is essential and how to do the compression. A very important issue was the transition of research to production and operations, identifying new markets for instrumentation.
NeXOS: is a four year Project, about 6 million Euros budget (EU contribution) and is focused on the next generation ocean sensors. In terms of cost-effectiveness of ocean observations the project is looking at:

- Development of compact optic and acoustic sensors with web enablement
- Data interoperability "out of the box" with "sensor web enablement for interoperability: "plug and work"
- Multifunctional sensing: do more with instruments without increasing their price
- Smart antifouling system: less maintenance
- Multiplatform: increase the sampling resolution using low-cost and platforms of opportunity
- Addressing the full life cycle from design to operations

Two types of sensors are being examined: optical and acoustic. The optical sensors are fluorometers and interferometers. In terms of measurements they focus on carbon and carbon cycle, and some organic and suspended matter. For the acoustic sensors, the emphasis is to increase sensitivity and a much larger dynamic range. The third class of measurements is from sensors on fishing nets to look at the environment conditions and help the fishing fleet to manage the catch. Ifremer has a very effective cooperation with the fishing fleet. For the different types of platform types such as gliders, drifters, cabled observatories, ferry boxes, trawlers, etc, a series of user scenarios (use cases) have been identified to test, validate and demonstrate the new sensors developments. The optical sensors for example can be tested at the majority of the platforms. The application areas of NeXOS are science research, marine management and supporting of industry and particularly the off shore industry and measurements of chemicals in the water.
Common Sense: is a project co-ordinated by LEITAT a Technological Centre in Spain, about 6 million Euros budget (4.6 million is the EU contribution), the consortium consists of 15 partners from 7 countries. The project is dealing with Temperature and Pressure innovative sensors for water monitoring and the use of microcomposite and nanocomposite

films for partial pressure of carbon dioxide (pCO2) measurements. Other areas of study are the chemical environment, litter, plastics, small particles, chemistry for phosphate, ammonia, nitrate and nitrite. Of particular interest is the examination of heavy metals (GEOTRACES) as different types of metals become important parts of the water cycle. For the implementation, there will be first functional prototypes but the ultimate goal is the production systems so as to move from early experimentation into demonstration adapted to different users monitoring requirements and deployment platforms. The project also will use Sensor Web Enablement standards.

SCHeMA: is a four-year project with a budget of 5.2 million Euros, led by Univ. of Geneva and is focused mainly on chemistry. Its objective is the development of an array of novel chemical sensors taking advantage of various innovative analytical solutions for the measurement of CO2 and bio-toxins. It focuses in two classes of marine hazardous substances and organisms. The one is related to natural origin such as toxins coming from toxic jellyfish, microalgae, cyanobacteria, harmful algal blooms, etc. and pathogenic agents (viruses, bacteria). The second class is of anthropogenic origin such as marine pollution. It is a product-based project for developing a suite of sensors for the assessment of the water quality and from the scientific view point to support the analysis of the coastal environment.

The projects together with SenseOcean coordinate and share activities on sensors systems, information systems and platforms implementation. The collaboration areas are divided in three core subjects: standards and best practices, cross-system exchanges and collaborative facilities. Through a joint agreement, certain standards, access to test areas and interfaces for the information systems are commonly used. These activities are being routinely tracked for efficient coordination. In the area of standards and best practices and on the sensors side the activities are:

- compile a list of definitions to support comparison of testing
- technical specialists interchange to address common interface standards (a case examined in NeXOS)
- approach manufacturers for glider implementation of interface standards
- create a template for, and populate, a compilation of standards and best practices (AtlantOS is checking that)

Reasonable sensor calibration between the four projects is done by:

- trade samples of toxins (Topics 1 and 2) and hydrocarbons (Topic 2)
- compilation of a table of chemicals and methods for each project
- approach the teams working on biofouling and determine whether cooperation is possible
- where possible, exchange approaches to assessing cost-benefit.

Finally, the third collaborative area is:

- create and maintain a list of calibration facilities for projects
- create and maintain a list of ship and other platforms that could be available
- look for facilities that solicit testing and allow in-water comparisons
- examine opportunities in AtlantOS for project measurements.

SUMMARY by Roger Proctor (UTAS) as coordinator of ODIP 3 prototype developments (4th ODIP Workshop)

http://www.iode.org/index.php?option=com_oe&task=viewDocumentRecord&docID=15117

The objectives of the ODIP 3 prototype have been to explore opportunities and encourage people to pick up and test different technologies and establish prototypes for SWE for vessels and real time monitoring systems, and coordinating regional initiatives' progress

towards the adoption of SWE, allowing direct standardised access to the data from operational sensor systems. Two categories of data dissemination architecture have been considered. First, the atomic data services which provide a dataset with small granularity and little discoverability capacity and rely on a "central" catalogue to discover the services such as ncSOS and THREDDS Data Server based in-situ observation dissemination as used at IOOS, at IMOS or at IMEDEA, and SeaDataNet. The second category is the collection of data services which use extensive OGC components to directly access the data sets.
Steps that have been undertaken include:

- setting up a testbed for different SOS services, and adding additional services to it
- establishment of a collaboration tool Github (https://github.com/aodn/ODIP) for compiling an inventory of services and endpoints, vocabularies and registries
- setting up working groups to:
    - access the performance of services (BODC, AIMS)
    - examine how these services should be constructed using SensorML or StarFl, which are different ways of formatting the data model of the O&M profiles (OGS, NCI, IFREMER, CNR)
- examine how to use vocabularies services for potential mappings from one group to another (UTAS, CNR)

Different initiatives of RESTful API and JSON encoding have popped up (52North, CSIRO, CSIC, IFREMER, RITMARE) because these are more commonly used in web developments. But none of them has been standardized at OGC yet. There is a requirement to merge these initiatives into one standard. It has been seen that the RESTful API proposed by 52North is a good candidate while some standardization of SensorML and O&M implementation in JSON is currently in discussion at OGC (e.g. using JSON-LD for linked data and geoJSON for geospatial information).

Activities will continue in the successor ODIP II project in order to make further progress towards SWE implementations in the marine domain and possible common standards. In ODIP II this will be strengthened by participation of 52North as a new EU project partner; 52North is a leading organisation for developing and implementing SOS services.

Annex A. Terminology

Term	Definition
CDI	Common Data Index metadata schema and catalogue developed by the SeaDataNet project
CSR	Cruise Summary Reports is a directory of research cruises.
CSW	OGC standard – Catalogue Service for the Web
GeoNetwork	An open source catalogue application for managing spatially referenced resources. It provides a metadata editing tool and search functions as well as providing embedded interactive web map viewer
GEOSS	Global Earth Observation System of Systems
IOC	Intergovernmental Oceanographic Commission of UNESCO (IOC/UNESCO).
IODE	International Oceanographic Data and Information Exchange (part of IOC)
IMOS	Integrated Marine Observing System: Australian monitoring system; providing open access to marine research data
MCP	Marine Community Profile
OAI-PMH	Open Archives Initiative - Protocol for Metadata Harvesting
ODP	Ocean Data Portal: data discovery and access service, part of the IODE network
ODV	Ocean Data View (ODV) data-analysis and visualisation software tool.
O&M	Observations and Measurements: OGC standard defining XML schemas for observations, and for features involved in sampling when making observations
OGC	Open Geospatial Consortium: an international industry consortium to develop community adopted standards to “geo-enable” the Web
R2R	Rolling Deck to Repository: a US project responsible for the cataloguing and delivery of data acquired by the US research fleet.
SeaDataNet	SeaDataNet: EU-funded pan-European e-infrastructure for the management and delivery of marine and oceanographic data
SensorML	OGC standard providing models and an XML encoding for describing sensors and process lineage

SOS	Sensor Observation Service: a web service to query real-time sensor data and sensor data time series. Part of the Sensor Web
SPARQL	a query language for databases, able to retrieve and manipulate data stored in a Resource Description Framework (RDF) format
SWE	Sensor Web Enablement: OGC standards enabling developers to make all types of sensors, transducers and sensor data repositories discoverable, accessible and useable via the web
US-IOOS	US Integrated Ocean Observing System
WebEx	On-line web conferencing and collaboration tool
WCS	OGC standard – Web Coverage Service
WFS	OGC standard – Web Feature Service
WMS	OGC standard – Web Mapping Service