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D11.3 Ocean Science and Sustainable Development Demonstration

Work Package	WP11 - Ocean Science and Sustainable Development
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Contributing Author(s) (Org)	NA
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X	PU: Public
	PP: Restricted to other programme participants (including the Commission)
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Abbreviations and Acronyms

Acronym	Expansion	URL
API	Application Programming Interface	–
AquaDocs	UNESCO Document Resources (IODE & IAMSLIC)	https://aquadocs.org/
BCC	Benguela Current Convention GeoData Portal	https://geodata.benguelacc.org /
BiOcean5D	Marine biodiversity assessment and prediction across spatial, temporal and human scale	https://cordis.europa.eu/project/id/101059915
CDIF	Cross-domain interoperability framework	https://github.com/Cross-Domain-Interoperability-Framework
BioEcoOcean	Co-Creating Transformative Pathways to Biological and Ecosystem Ocean Observations	https://cordis.europa.eu/project/id/101136748
CHEBI	Chemical Entities of Biological Interest	https://www.ebi.ac.uk/chebi/
CIOOS	Canadian Integrated Ocean Observing System	https://www.cioos.ca/
CORDIS	Community Research and Development Information Service	https://cordis.europa.eu/about
DCMI	Dublin Core Metadata Initiative	https://www.dublincore.org/specifications/dublin-core/dcmi-terms/
DWC	Darwin Core	https://dwc.tdwg.org/
EBV	Essential Biodiversity Variable	https://geobon.org/ebvs/what-are-ebvs/
EMODnet	European Marine Observation and Data Network	https://emodnet.ec.europa.eu/en
EOV	Essential Ocean Variable	https://goosocean.org/what-we-do/framework/essential-ocean-variables/

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EnvO	Environment Ontology	http://www.environmentontology.org
ESIP	Earth Science Information Partners	https://www.esipfed.org/
FIP	FAIR Implementation Profile	https://www.go-fair.org/how-to-go-fair/fair-implementation-profile/
GBIF	Global Biodiversity Information Facility	https://www.gbif.org/
GEO	Group on Earth Observations	https://earthobservations.org/
GEO BON	Group on Earth Observations Biodiversity Observation Network	https://geobon.org/
GLAM	Galleries, Libraries, Archives and Museums	–
GOOS	Global Ocean Observing System	https://goosocean.org/
GSC	Genomic Standards Consortium	https://www.gensc.org/
IIIF	International Image Interoperability Framework	https://iiif.io/
IOC	Intergovernmental Oceanographic Commission	https://www.ioc.unesco.org/
IODE	International Oceanographic Data and Information Exchange	https://iode.org/
ISO	International Organization for Standardization	https://www.iso.org/
IUPAC	International Union of Pure and Applied Chemistry	https://iupac.org/
JSON(-LD)	JavaScript Object Notation (for Linked Data)	https://www.w3.org/TR/json-ld11/
L(O)D	Linked (Open) Data	https://www.w3.org/wiki/LinkedData
MARCO-BOLO	MARine COastal BiOdiversity Long-term Observations	https://cordis.europa.eu/project/id/101082021
MASPAWIO	Marine Spatial Atlas for the Western Indian Ocean	http://maspawio.net/

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MEDIN	Marine Environmental Data and Information Network	https://medin.org.uk/
ODIN	Ocean Data and Information Network	–
ODIS	Ocean Data and Information System	https://odis.org/
ODIS-Arch	ODIS Architecture	https://github.com/iodepo/odis-arch
ODISCat	ODIS Catalogue of Sources	https://catalogue.odis.org/
OIH	Ocean InfoHub	https://oceaninfohub.org/
Omic BON	Omic Biodiversity Observation Network	https://geobon.org/bons/thematic-bon/omic-bon/
OTGA	Ocean Teacher Global Academy	https://classroom.oceanteacher.org/
OWL	Web Ontology Language	https://www.w3.org/OWL/
PDH	Pacific Data Hub	https://pacificdata.org/
PID	Permanent Identifier	–
REST	REpresentational State Transfer	–
RDA	Research Data Australia[1]	https://researchdata.edu.au/
RDF(S)	Resource Description Framework (Schema)	https://www.w3.org/RDF/
SKOS	Simple Knowledge Organization System	https://www.w3.org/2004/02/skos/specs
SNRCN	Sampling Nature Research Collaboration Network	https://samplingnature.github.io/
SPREP PROE	Pacific Environment Data Portal	https://pacific-data.sprep.org/
TDWG	Biodiversity Information Standards	https://www.tdwg.org/
UNDRR	United Nations Office for Disaster Risk Reduction	https://www.undrr.org/
UNEP	United Nations Environment Programme	https://www.unep.org

[1] Note, that the Research Data Alliance is also abbreviated RDA. This organisation is not noted in this document.

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UNESCO	United Nations Educational, Scientific, and Cultural Organization	https://www.unesco.org/
UNSPIDER	United Nations Platform for Space-based Information for Disaster Management and Emergency Response	https://www.un-spider.org/
UN Ocean Decade	United Nations Decade of Ocean Science for Sustainable Development	https://oceandecade.org/
WOD	World Ocean Database	https://www.ncei.noaa.gov/products/world-ocean-database
WMO	World Meteorological Organisation	https://wmo.int/
XML(S)	eXtensible Markup Language (Schema)	–

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Executive summary

In close succession of WorldFAIR deliverables 11.1 and 11.2, this deliverable briefly reports on demonstrations of verified, FAIR (meta)data exchanges with selected, independent partners through the Ocean Data and Information System (ODIS). These exchanges are facilitated through Web architectural approaches and linked open data (LOD) norms, which the ODIS Architecture (ODIS-Arch) has used to create digital supply chains between highly diverse data systems around the world. With WorldFAIR's support, ODIS-Arch has been extended with new (meta)data profiles to support cross-domain interoperability, in alignment with the principles of the emerging Cross-Domain Interoperability Framework (CDIF). Due to its success, the ODIS approach to domain-independent, interoperable data and information flow is being used as a guiding reference implementation for CDIF (described further in D11.2), aligned to its core principles.

While primarily concerned with Work Package (WP) 11, this deliverable also has bearing on the thematic areas of WP03 (Chemistry), WP05 (Geochemistry), WP09 (Biodiversity), WP10 (Agricultural Biodiversity), WP12 (Disaster Risk Reduction), and WP13 (Cultural Heritage). This document focuses on WP03, WP09, WP12, and WP13, but the demonstrations and new specifications noted are relevant to WP05 and WP10 due to their thematic proximity to the former WPs. As described in Section 2, (meta)data from each domain represented in these WPs is now flowing across the ODIS Federation, and is - to varying degrees - FAIR within and beyond it. Due to alignments in LOD implementation, direct interoperation between ODIS (WP11) and GBIF (WP9) is now being implemented, which has far-reaching implications for marine biodiversity data flow and the strengthening of Essential Ocean Variable (EOV) data systems. Presently, interoperation potential with other WPs is less technically direct; however, clear avenues to mature the status quo are present and discussed in Section 2, based on insights from WorldFAIR case studies.

In terms of the wider datascape, this deliverable shows that cross-domain digital interoperability can be straightforward, should 1) a trusted, regionally and domain-neutral entity provide coordination and conflict resolution (in the case of WP11, the International Oceanographic Data and Information Exchange of IOC-UNESCO, the Intergovernmental Oceanographic Commission), 2) the will to collaborate, rather than compete, exists across partners, 3) global perspective and multilateralism inform highly competent technical leadership, and 4) clear implementation and operational concerns are ranked above untested innovation and bureaucratic convenience.

The overall conclusion of this deliverable is one of great optimism: the demonstrations presented here, and the trend across the other WorldFAIR case studies discussed, indicate a strong convergence towards domain-neutral (meta)data exchange over the Web, where domain-specific conventions are either translated to or embedded within generic serialisations and semantics to allow rapid and accurate communication across highly diverse implementation and operational scenarios. Work to secure the progress made in WorldFAIR will continue and seek further resourcing to fulfil the great promise co-developed during the project.

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1. Background

1.1. Context

This deliverable builds upon WorldFAIR deliverables 11.1[2] and 11.2[3], which contain contextualising background and are prerequisite reading to fully understand the present document. In brief, WP11 has enhanced the cross-domain interoperability of the IOC-UNESCO Ocean Data and Information System (ODIS) and its user-facing discovery system, the Ocean InfoHub (https://oceaninfohub.org). ODIS is a Web-based 'system of systems' comprising a global federation of partner organisations - representing single working groups as well as entire continents - which interlink their digital holdings using linked open data principles (https://5stardata.info/en/) and Web architectural principles. Currently, ODIS has federated partner metadata catalogues describing their assets; however, this will progressively and steadily be extended to data products and services. The UNESCO Intergovernmental Oceanographic Commission (IOC)'s International Oceanographic Data and Information Exchange coordinates ODIS, and aims to deepen its functionality through partner-led initiatives as well as mechanisms of the UN Decade of Ocean Science for Sustainable Development ('the Ocean Decade'). The latter include the Ocean Decade's Data and Information Strategy and its soon-to-be-released Implementation Plan[4], as well as programmes such as Ocean Data 2030[5]. Living documentation of the system is available (https://book.oceaninfohub.org/) and its active collaborative codebase is version controlled in a publicly-accessible GitHub repository (https://github.com/iodepo/odis-arch).

The aim of the current document is to highlight and briefly describe examples of ODIS' capacities for and demonstrations of cross-domain interoperability. In several cases, these are tuned to the outcomes of WorldFAIR's other domain-focused WPs, where those align with feasible implementation paths and good practice. Other cases are driven by the progress and initiative of ODIS' partner nodes, many of whom are handling cross-domain data flows as a matter of course.

1.2. Alignment with the Cross-Domain Interoperability Framework (CDIF)

As described in Deliverable 11.2, ODIS specifications were used as a driving reference implementation for components of the emerging CDIF specifications, particularly for data discovery

2 Buttegieg, P. L. (2023). WorldFAIR Project (D11.1) An assessment of the Ocean Data priority areas for development and implementation roadmap (Version 1). Zenodo. https://doi.org/10.5281/zenodo.7682399

3 Buttigieg, P. L. (2023). WorldFAIR (D11.2) New interoperability specifications and policy recommendations (Version 1). Zenodo. https://doi.org/10.5281/zenodo.10219933

4 https://github.com/iodepo/OceanDecade-dsig

5 https://oceaninfohub.org/26-may-2022-oceandata-2030-is-a-registered-programme-of-the-un-decade-for-ocean-science-for-sustainable-development/ the official website is due to launch in Q3, 2024, at https://oceandata2030.org .

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and with some bearing on how to handle varying semantics across diverse digital ecosystems. Further development of CDIF has generally maintained interoperability with the approach adopted by ODIS[6], however, with some technical variations and governance concerns that preclude wholesale adoption and recommendation of CDIF as a norm across the ODIS Federation.

To illustrate, the serialisations of JSON-LD currently recommended by CDIF drafts use literalist typing of metadata files[7]. That is, metadata stored in a JSON-LD file must encapsulate metadata about the subject of the JSON-LD file (e.g. a dataset, vehicle, etc) in metadata about the JSON-LD file itself. This is counter to more direct entity representation as widely used on the Web and described in the JSON-LD Specification[8], which ODIS adheres to for simplicity and accuracy. To quote the draft CDIF specifications[9]:

> *A metadata record has two parts; one part is about the metadata record itself, the other part is the content about the resource that the metadata documents. The part about the record specifies the identifier for the metadata record, agents with responsibility for the record, when it was last updated, what specification or profiles the metadata serialisation conforms to, and other optional properties of the metadata that are deemed useful. The metadata about the resource has properties about the resource like title, description, responsible parties, spatial or temporal extent (as outlined in the Metadata Content Requirements section).*[10]

As noted in the draft CDIF specification itself, encapsulating metadata of the subject entity in metadata about the JSON-LD file, is extraneous when using JSON-LD to express schema.org:

> *Schema.org includes several properties that can be used to embed information about the metadata record in the resource metadata: sdDatePublished, sdLicense, sdPublisher, but lacks a way to provide an identifier for the metadata record distinct from the resource it describes, to specify other agents responsible for the metadata except the publisher, or to assert specification or profile conformance for the metadata record itself.*[11]

While schema.org does not have a property to provide an identifier for the metadata record, it does not require one, as node identifiers (`@id`) in JSON-LD documents may serve this purpose, as shown in the W3C JSON-LD specification[12]. Further, if a dedicated schema.org property is deemed

[6] Which aims at conformance with existing conventions (JSON-LD for serialisation, and schema.org for primary semantics) and simplicity of implementation: https://book.oceaninfohub.org/content.html

[7] "Serialization of CDIF metadata", https://github.com/Cross-Domain-Interoperability-Framework/Discovery/blob/main/discoverability.md#serialization-of-cdif-metadata (Retrieved 2024-04-24)

[8] https://www.w3.org/TR/2014/REC-json-ld-20140116/#specifying-the-type (Retrieved 2024-04-24)

[9] WorldFAIR D2.3, https://doi.org/10.5281/zenodo.11236871

[10] WorldFAIR D2.3, p. 116, para. 3.

[11] WorldFAIR D2.3, p. 116, para. 4.

[12] https://www.w3.org/2018/jsonld-cg-reports/json-ld/#node-identifiers (Retrieved 2024-04-24), Note that the URL in the @id value space in the example (http://me.markus-lanthaler.com/) resolves to a JSON-LD document, effectively

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absolutely necessary, a request should be made to the schema.org community, rather than creating a new convention that contradicts/adds questionable complexity to this globally adopted standard's norms. Potential users of CDIF, such as ODIS, are placed in a difficult position: do they align with CDIF, risking less interoperability with their global partners? Or do they maintain more normative use of JSON-LD/schema.org but diverge from CDIF?

Naturally, remedies are possible, especially as CDIF is still in an early phase and the majority if its recommendations are supportable. The issue identified above (and others, such as the overly loose usage of terms like "controlled vocabulary") have been raised in CDIF Working Group sessions and in the internal review of WorldFAIR deliverables related to CDIF. However, a more formal and transparent process to raise and deliberate over such issues, and come to a resolution, must be created (ideally over the CDIF GitHub Organization) such that stakeholders from communities like ODIS can make their case and evaluate whether CDIF is fit for purpose.

1.3. Notes for readers

As a description of demonstrations, the bulk of this deliverable will tersely describe and then provide actionable links to Web portals showing live (meta)data exchange across ODIS partners. Below, some general clarifying notes on reading this document are provided.

1.3.1. Insets, figures, and code elements

In this report, multiple screen captures and their associated code will be presented. All content is derived from the current public release of Ocean InfoHub, which provides one (of many possible) interfaces to interoperable content shared by ODIS Nodes. Unless otherwise stated, these are all sourced from https://oceaninfohub.org/ and have been verified as accurate on 2024-05–01. The JSON-LD used to construct each record shown can be retrieved from the search interface by clicking the "View JSON-LD source" link, below each record, which is retrievable via the URLs in each caption's footnotes.

As ODIS nodes are able to update the data holdings they federate at any time they choose, note that links to code resources may lead to different instances of the code, or may be obsolete in the future. ODIS will soon implement a system of 'release graphs', whereby snapshots of its federated content will be archived - with record level identifiers - to allow retrospective analysis.

serving as the identifier of the metadata document. This is the approach used by ODIS to maintain simplicity of the knowledge graph and other downstream products generated from JSON-LD records.

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1.3.2. User interface and experience updates

The majority of the screen captures (*Figures* and *Record examples*) included in this document are extracted from the current version of Ocean InfoHub (OIH). However, due to the high degree of adoption and success that ODIS and OIH have achieved, a new user interface was needed to handle the growing corpus and is near completion. This will include general enhancements to the user experience (Figures 1 and 2), the inclusion of an advanced search interface to better utilise the properties present in the JSON-LD files shared by ODIS nodes (Figure 3), map-based layers to avoid congestion (Figure 4, e.g. using H3 grids: https://h3geo.org/), and numerous other UI/UX optimisations. Progress may be tracked here: https://github.com/iodepo/oih-ui.

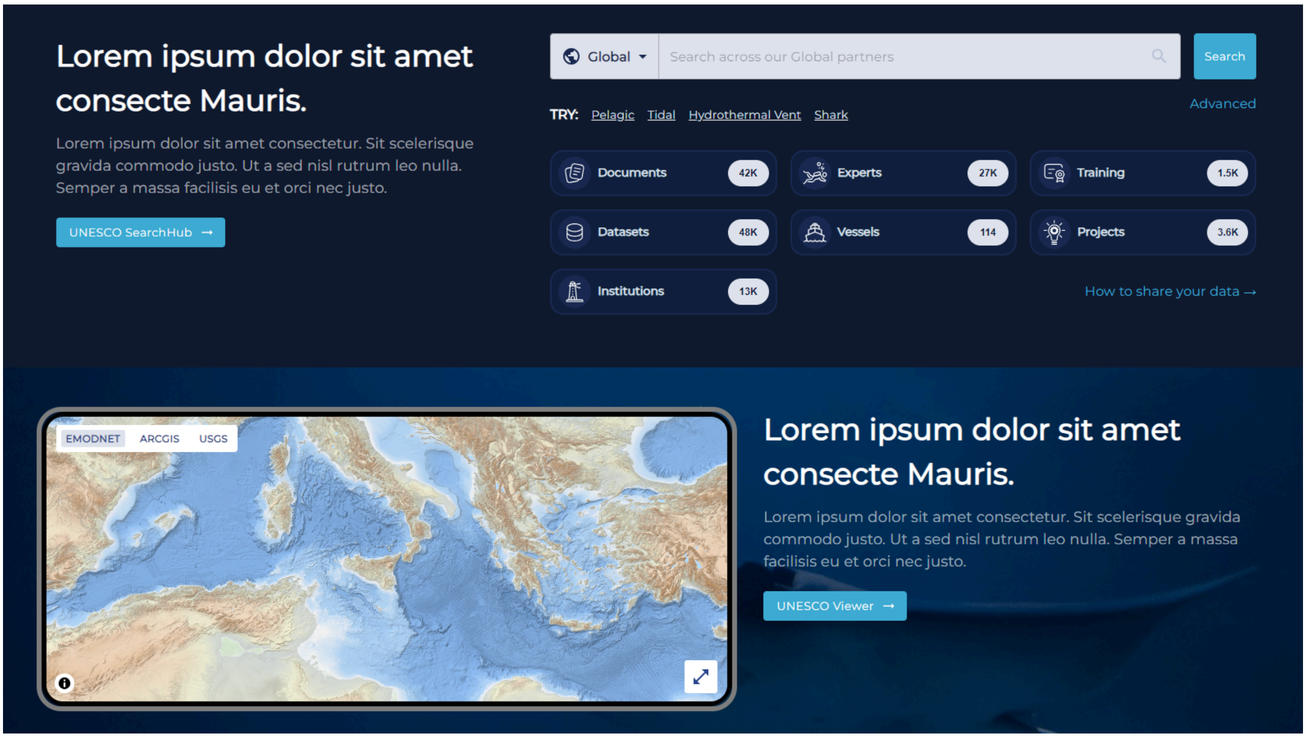

Figure 1: A screen capture of the impending UI/UX updates. The updated landing page, emphasising the global reach of ODIS and allowing for facets representing the data types handled by the ODIS Federation to be updated dynamically. (Screen capture from the development release, https://oih.trust-it.it/, retrieved 2024-04-21.)

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Figure 2: A screen capture of the impending UI/UX updates. A result page, showing the dynamically populated, per facet result counts in the left sidebar, as well as filtering interface elements. A selection of values in each JSON-LD object shared by ODIS nodes is displayed, with the full records available via the "View JSON-LD source" option. The new UI supports visual elements reflecting the degree of data completion, evaluated against recommendation from IODE's ODIS coordination group. (Screen capture from the development release, https://oih.trust-it.it/, retrieved 2024-04-21.)

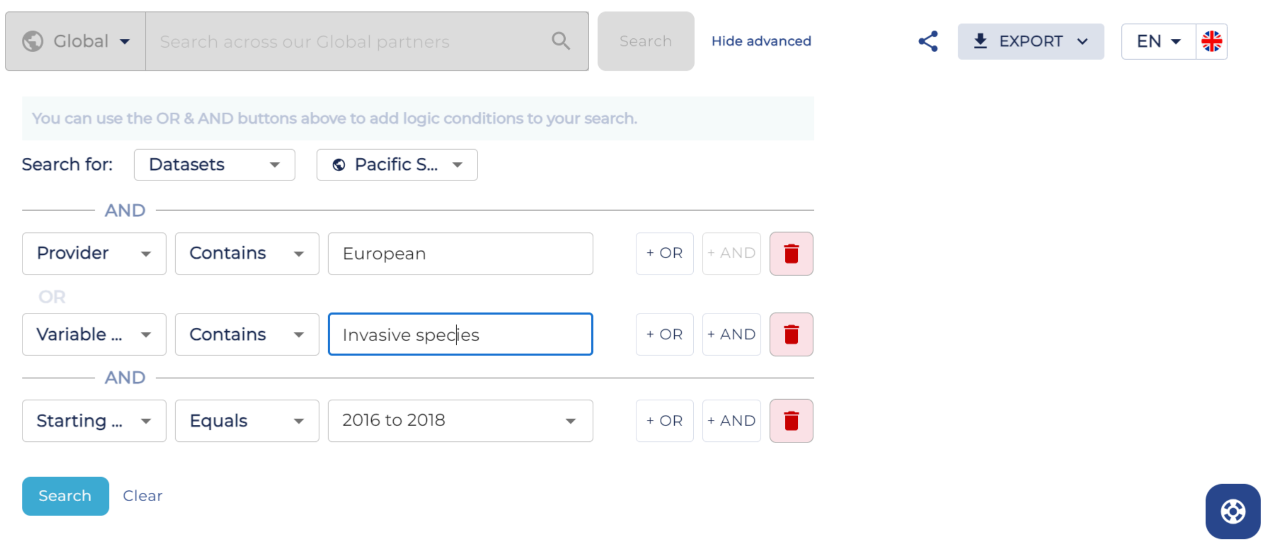

Figure 3: A screen capture of the impending UI/UX updates. A new Advanced Search UI allowing Boolean combinations of matching constraints for search keys across properties in JSON-LD/schema.org records harvested from the entire ODIS Federation. (Screen capture from the development release, https://oih.trust-it.it/, retrieved 2024-04-21.)

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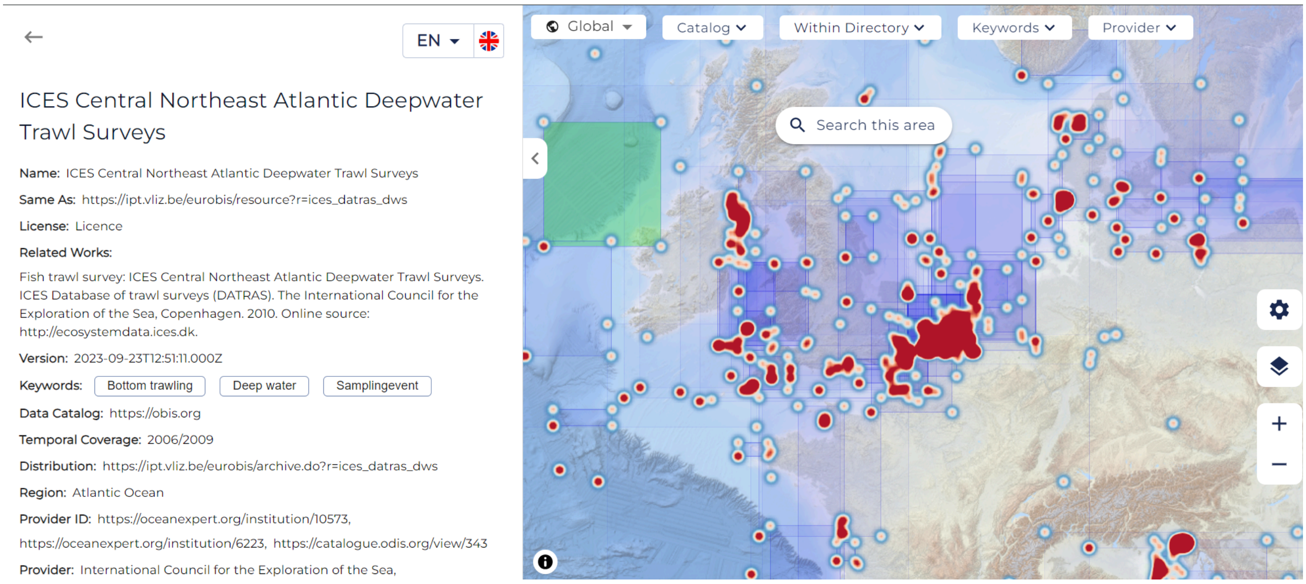

Figure 4: A screen capture of the impending UI/UX updates. A new spatial search interface allows map-based browsing of all geospatially qualified records shared by ODIS nodes. Concentration of data records can also be visualised in H3 grid cells (not shown). (Screen capture from the development release, https://oih.trust-it.it/, retrieved 2024-04-21.)

1.3.3. Programmatic interfaces and bulk access

Naturally, programmatic interfaces to the ODIS Knowledge Graph and its downstream products (e.g. Apache Parquet files for each partner node[13]) are available for more technically fluent users. This is the most powerful way to access and use the ODIS Federation's collection of digital assets, and build new services and software on top of them.

A SPARQL endpoint to a Blazegraph instance is available[14] and any Web-based interface to such endpoints may access it[15] (Figure 5). A migration to OxiGraph[16] is underway in order to increase performance over the rapidly growing ODIS corpus. Updates to the available endpoints and programmatic interfaces will be posted in the ODIS documentation[17].

A collection of SPARQL queries[18] are available to provide examples and to run diagnostics which power the ODIS Dashboard and other downstream services. As the automation and architecture of the Ocean InfoHub system is completed, we aim to export products to support other programmatic

[13] http://ossapi.oceaninfohub.org/public/ - This XML file lists parquet assets which may be downloaded by appending their Key values to the root URL. For example, to access the parquet file for the Canadian Integrated Ocean Observing System (CIOOS; https://www.cioos.ca/), one would target http://ossapi.oceaninfohub.org/public/assets/cioos.parquet.
[14] http://graph.oceaninfohub.org/blazegraph/namespace/oih/sparql (Validated 2024-04-26)
[15] https://yasgui.triply.cc/# (Retrieved 2024-04-26)
[16] https://github.com/oxigraph (Retrieved 2024-04-25
[17] https://book.oceaninfohub.org/ (Retrieved 2024-04-24)
[18] https://github.com/iodepo/odis-in/tree/master/SPARQL/ (Retrieved 2024-04-28)

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interfaces, such as the Spatio-Temporal Asset Catalog (STAC)[19] and the Open Geospatial Consortium (OGC) API[20]. This exercise will also reveal where risks of drift (i.e. where the data standards used by one access system include semantics or value space specifications that are not exact matches to another, to the detriment of interoperability) occur. While somewhat inevitable, it is important that standards organisations (such as schema.org and OGC) are made more aware that they are effectively competing, rather than reusing or efficiently mapping to one another.

In the logic of WorldFAIR, these interfaces may be used to detect and harvest records which correspond to search keys (in any property) of any domain. Note, these interfaces to International Oceanographic Data and Information Exchange (IODE) servers and cloud services are intended for diagnostic and basic discovery. For more computationally-intensive processing, a series of release graphs including the entire ODIS Knowledge Graph, ODIS partner-specific graphs, and other subgraphs will be archived on Zenodo. These may be downloaded locally or rehosted on other cloud services as needed for more computationally intensive operations.

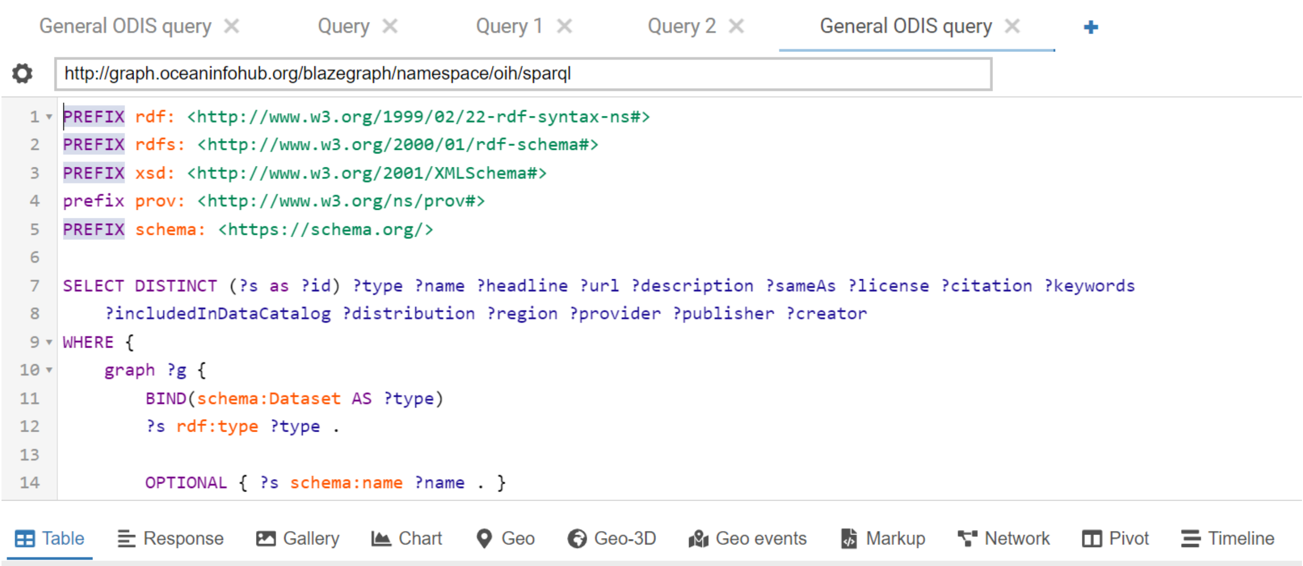

Figure 5: A screen capture of a Yasgui interface to the ODIS Knowledge graph (Retrieved 2024-04-21), preloaded with a query to retrieve a selection of properties from schema.org Dataset types. On 2024-05-01, 53144 results were returned in 6.27 seconds. The query can be run and modified here: https://api.triplydb.com/s/mua0UJLnK.

[19] https://stacspec.org/en/ (Retrieved 2024-04-26)
[20] https://www.ogc.org/standard/ogcapi-features/ ; https://ogcapi.ogc.org/features/ (Retrieved 2024-04-24)

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1.3.4. Data federation and sourcing

Throughout Section 2 of this document, examples will be drawn from across the ODIS Federation[21]; however, certain nations or regional nodes will be highlighted due to their relatively advanced alignment to the ODIS Architecture and operational norms. For example, the United Kingdom's Marine Environmental Data and Information Network (MEDIN, https://medin.org.uk/) has created a nationally coordinated sub-system of ODIS - itself federating a diverse array of partners (of over 600 organisations) and harmonising their data into standards which are fit for national standards and strategic objectives, before projecting the metadata describing them into the JSON-LD/schema.org model used by ODIS for global interoperability (Figure 6).

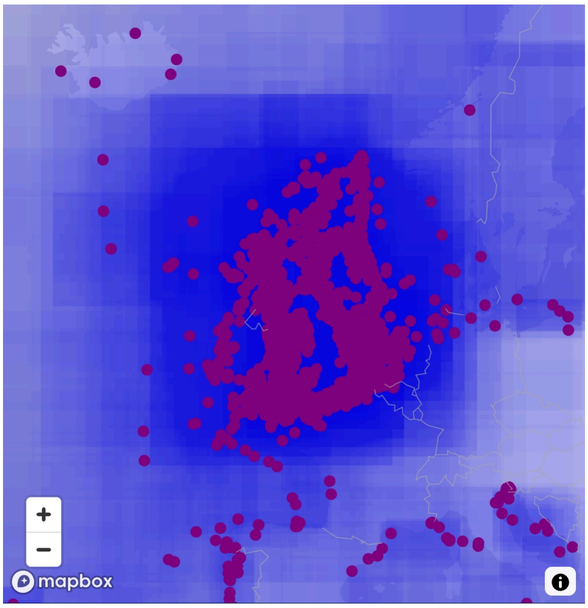

Figure 6: A screenshot of the area around the United Kingdom, where MEDIN and other ODIS partners have cross-indexed their metadata catalogues of some 34,467 entities (17,466 of which are from MEDIN directly).

Similar examples exist across ODIS, including the national/continental-scale coordination and federation of systems by Research Data Australia (RDA, https://researchdata.edu.au/, a link forged during a WorldFAIR workshop at Schloss Dagstuhl[22]; see Figure 7).

[21] The state of the ODIS data flows - integrated into the ODIS Knowledge Graph - are summarised here: http://dashboard.oceaninfohub.org/. Individual partner nodes can be assessed using the "ODIS Node Summary" module below the general graph updates. (Retrieved 2024-04-25)

[22] https://www.dagstuhl.de/en/seminars/seminar-calendar/seminar-details/19413

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Like MEDIN, RDA harvests data from numerous Australian research and governmental repositories, and relays ocean-relevant data[23] to the ODIS Federation. It assists these organisations - many of which lack technical experts on staff - by curating, harmonising, and converting their (meta)data holdings into more professionalised forms which ODIS and other stakeholders may use. For a smaller number of data products - rather than their component datasets - the European Marine Observation and Data Network (EMODnet)[24] performs a similar function, while discussions with projects such as BlueCloud 2026[25] are underway to extend Europe's regional impact.

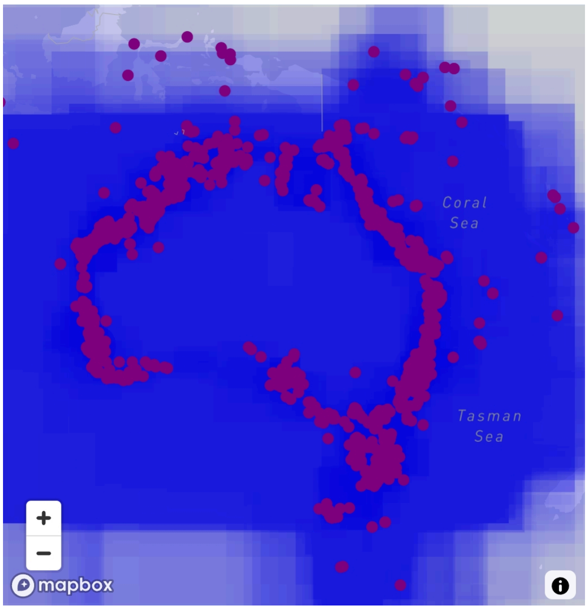

Figure 7: A screenshot of the area around Australia, showing 8,683 records from Research Data Australia.

2. Demonstrations of cross-domain interoperability

In this section, illustrative examples of cross-domain (meta)data exchange across the ODIS Federation[26] will be presented, aligned to the focal areas noted in D11.2. These demonstrate the viability of the underlying approach and architecture. These examples comprise records built from the JSON-LD/schema.org files shared by ODIS partners, as exposed through the Ocean InfoHub interface (see Section 1.3.1). Each example includes a caption with a footnote to reproduce the search to retrieve the record via OIH, as well as a URL to the resource as served by the ODIS partner. Following these examples, a concise reflection on opportunities to expand interoperability based on

[23] Primarily from the Australian Ocean Data Network (AODN, https://portal.aodn.org.au/)
[24] https://emodnet.ec.europa.eu/en
[25] https://cordis.europa.eu/project/id/101094227
[26] currently handling ~665,305 records, decomposed into 3,014,339 atomic statements/triples

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the outputs of the WorldFAIR partners are included, often with links to ongoing work to bring them into operation.

2.1. Oceans and Cultural Heritage

Multiple ODIS Nodes maintain collections of cultural heritage data. Most of these assets are currently represented as Dataset or Document types, although work with sample and specimen (meta)data communities (via the Sampling Nature Research Collaboration Network, https://samplingnature.github.io/) is helping forge new profiles for physical objects in collections[27].

Examples of such records in ODIS are shown below, demonstrating interoperability between UNESCO document resources (AquaDocs), the Pacific Environment Data Portal[28], the Benguela Current Convention Data Portal[29], and the Ocean Biodiversity Information System[30] (OBIS;, also demonstrating cross-domain value of cultural heritage and biodiversity). ODIS Federation partners have largely[31] normalised their (meta)data projections to JSON-LD/schema.org along the ODIS Architecture specifications, coordinated and moderated by IODE[32].

[27] https://github.com/iodepo/odis-arch/issues/376
[28] https://pacific-data.sprep.org/
[29] https://geodata.benguelacc.org/
[30] https://obis.org/
[31] Variations and deviations from the IODE specifications are still present, often due to capacity gaps and additional resourcing needed to modify native exports from software implementations with varying interpretations of fit-for-purpose JSON-LD/schema.org. ODIS will continue to assist such partners in alignment, but we note that interoperation is, nonetheless, greatly furthered by approximations of the expected (meta)data patterns.
[32] https://iode.org/

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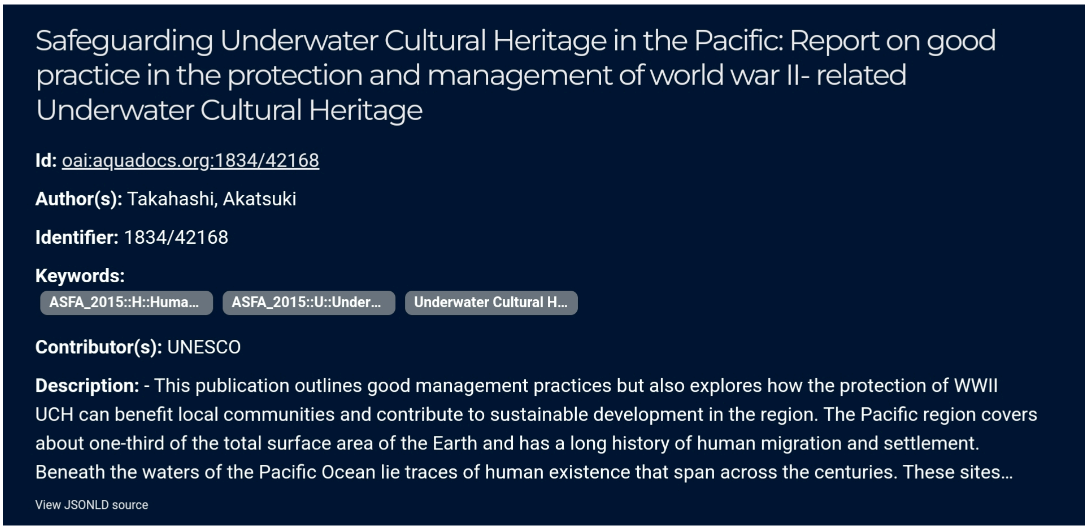
Safeguarding Underwater Cultural Heritage in the Pacific: Report on good practice in the protection and management of world war II- related Underwater Cultural Heritage

Id: oai:aquadocs.org:1834/42168

Author(s): Takahashi, Akatsuki

Identifier: 1834/42168

Keywords:
ASFA_2015::H::Huma... ASFA_2015::U::Under... Underwater Cultural H...

Contributor(s): UNESCO

Description: - This publication outlines good management practices but also explores how the protection of WWII UCH can benefit local communities and contribute to sustainable development in the region. The Pacific region covers about one-third of the total surface area of the Earth and has a long history of human migration and settlement. Beneath the waters of the Pacific Ocean lie traces of human existence that span across the centuries. These sites...

View JSONLD source

Record example 1: Safeguarding Underwater Cultural Heritage in the Pacific: Report on good practice in the protection and management of World War II- related Underwater Cultural Heritage[33], directing to https://aquadocs.org/handle/1834/42168.


Traditional and Cultural Heritage Sites_Nauru

Name: Traditional and Cultural Heritage Sites_Nauru

License: https://pacific-data.sprep.org/dataset/data-portal-license-agreements/resource/de2a56f5-a565-481a-8589-406dc40b5588

Keywords:
environment r2r

Data Catalog: https://pacific-data.sprep.org/index.php/search

Provider ID: https://oceaninfohub.org/.well-known/org/pedp

Provider: Pacific Environment Data Portal

Description: Ridge to Reef data on the locations of Traditional and Cultural Heritage Sites on Nauru, limited metadata, compiled in 2018

View JSONLD source

Record example 2: Traditional and Cultural Heritage Sites_Nauru[34], directing to https://pacificdata.org/data/dataset/traditional-and-cultural-heritage-sites_naurubb94e379-b7dc-4201-8d3b-5b2a8fecf2a1.

[33] https://oceaninfohub.org/results/?search_text=Safeguarding+Underwater+Cultural+Heritage+in+the+Pacific%3A+Report+on+good+practice+in+the+protection+and+management+of+world+war+II-+related+Underwater+Cultural+Heritage&page=0

[34] https://oceaninfohub.org/results/Dataset?search_text=Traditional+and+Cultural+Heritage+Sites_Nauru

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BEWREMABI dataset: Belgian Shipwreck - hotspots for Marine Biodiversity: Macrofauna in vicinity of shipwrecks

Name: BEWREMABI dataset: Belgian Shipwreck - hotspots for Marine Biodiversity: Macrofauna in vicinity of shipwrecks

Same As: http://ipt.vliz.be/eurobis/resource?r=bewremabi_macrofauna

License: This work is licensed under a Creative Commons Attribution (CC-BY) 4.0 License

Version: 2023-09-23T12:15:19.000Z

Keywords:
Biodiversity Observation Occurrence Shipwrecks Wrecks diver

Data Catalog: https://obis.org

Temporal Coverage: 2004/2006

Distribution: https://ipt.vliz.be/eurobis/archive.do?r=bewremabi_macrofauna

Region: Atlantic Ocean

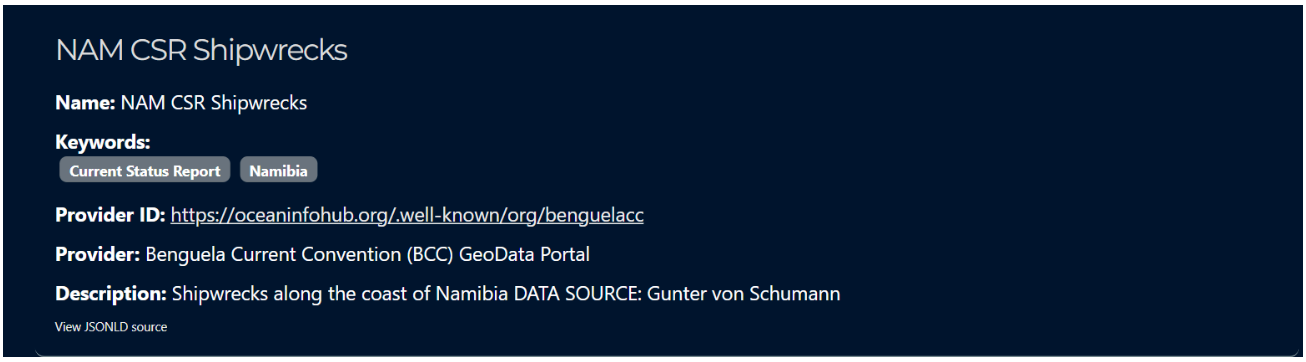
Provider ID: https://oceanexpert.org/institution/10708, https://oceanexpert.org/institution/11235, https://oceanexpert.org/institution/6223, https://catalogue.odis.org/view/343

Provider: POD Federaal Wetenschapsbeleid, Universiteit Gent, Marine Biology research group, Vlaams Instituut voor de Zee, Ocean Biodiversity Information System

Description: Data was gathered during BEWREMABI project (part of SPSD-II federal science policy programme) sampling campaigns. Macrofauna was sampled in the vicinity of shipwrecks using macrofauna core + scuba.

View JSONLD source

Record example 3: BEWREMABI dataset: Belgian Shipwrecks [35], directing to https://obis.org/dataset/1d198847-58cf-4350-9d2c-8c8f611083c4.



NAM CSR Shipwrecks

Name: NAM CSR Shipwrecks

Keywords:
Current Status Report Namibia

Provider ID: https://oceaninfohub.org/.well-known/org/benguelacc

Provider: Benguela Current Convention (BCC) GeoData Portal

Description: Shipwrecks along the coast of Namibia DATA SOURCE: Gunter von Schumann

View JSONLD source

Record example 4: NAM CSR, Shipwrecks along the coast of Namibia [36], directing to https://geodata.benguelacc.org/layers/geonode_deploy_data:geonode:NAM_CSR_HER_shipwreck.

[35] https://oceaninfohub.org/results/Dataset?search_text=BEWREMABI+dataset%3A+Belgian+Shipwrecks&page=0
[36] https://oceaninfohub.org/results/Dataset?search_text=NAM+CSR+Shipwrecks

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ODIS partners - such as the Pacific Data Hub[37] - have noted that much of their cultural heritage data is stored in formats such as PDFs (e.g. scanned tables, images, or other records in physical documents), underscoring the diversity of assets which need representation and the volume of work to be done to move data along the 5-star linked open data spectrum[38].

WorldFAIR's Cultural Heritage (WP13) activities and outputs - particularly workshops describing the International Image Interoperability Framework (IIIF, https://iiif.io/) and Gallery, Library, Archive and Museum (GLAM) collections - were of key value in preparing ODIS for broader interoperability with cultural heritage data sources. Recognising that federated access to image-based (meta)data (including video, 3D objects, etc) will be key to deeper interoperability with cultural data hubs, a new set of metadata patterns for media objects[39], including image objects[40], has been created in the ODIS-Architecture. As described in D11.2, this will allow the embedding of links to data distributions (i.e. downloadable subject data via IIIF API[41] calls) within generic metadata about the media objects themselves to maximise discovery and subsequent access to image collections and individual records or their parts. ODIS is now better poised to pursue deeper interoperability with cultural heritage data resources on the Web.

Further WorldFAIR D13.1[42] and D13.2[43] have highlighted that many data archives in WP13's analysis (e.g. D13.1, Figure 1) are "metadata only" and thus well-aligned to the current, first-order[44] implementation of ODIS. This is even more promising as these deliverables report that local/implementation-specific semantic standards are being mapped to more generic, inter-domain standards such as Dublin Core[45], which is closer to the schema.org semantics used in ODIS (D13.2, Appendix C). As described in D11.2, embedding such metadata in JSON-LD/schema.org records is already possible, but authoritative mappings provided by organisations such as Getty will go much further, more sustainably, particularly if these are encoded in machine-actionable forms such as Simple Standard for Sharing Ontology Mappings[46] (SSSOM). A number of findings also align to

[37] https://pacificdata.org/
[38] https://5stardata.info/en/
[39] https://github.com/iodepo/odis-in/blob/master/dataGraphs/thematics/MediaObject/graphs/MediaObject.json
[40] https://github.com/iodepo/odis-in/blob/master/dataGraphs/thematics/ImageObject/graphs/ImageObject.json
[41] https://iiif.io/api/index.html
[42] Knazook, B., Murphy, J. (2023). WorldFAIR Project (D13.1) Cultural Heritage Mapping Report: Practices and policies supporting Cultural Heritage image sharing platforms (Version 1). Zenodo. https://doi.org/10.5281/zenodo.7659002
[43] Knazook, B., Murphy, J., Barner, K., Cassidy, K., Claeyssens, S., Cortese, C., Manchester, E. J., Padilla, T., Reijerkerk, D., Robson, G., Schmidt, A., Sherratt, T., Warren, M. (2023). WorldFAIR Project (D13.2) Cultural Heritage Image Sharing Recommendations Report (Version 1). Zenodo. https://doi.org/10.5281/zenodo.7897244
[44] The first-order implementation of ODIS is also focused on metadata sharing, as an anchor to link partners and a means to progressively deepen interoperability through shared intelligence.
[45] https://www.dublincore.org/specifications/dublin-core/dcmi-terms/
[46] https://mapping-commons.github.io/sssom/spec/

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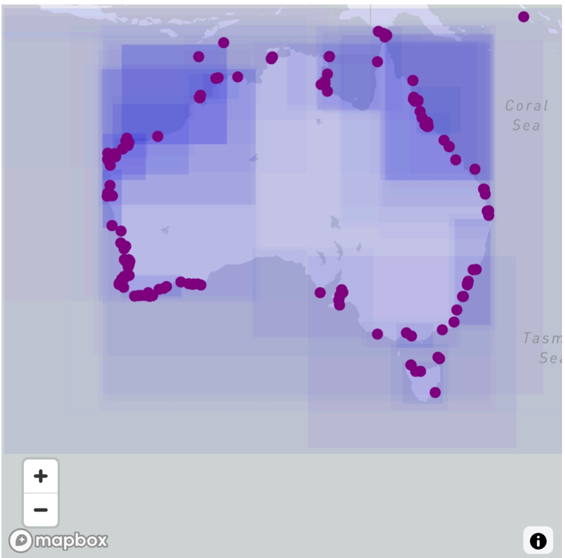
recommendations in D11.2, particularly support for policy-level commitment to making metadata open (D11.2, Section 2.1.1.), even when subject data may be under a restricted access model. However, we note that some digital holdings are so sensitive that even metadata access may be restricted (e.g. due to personal privacy regulations, security concerns, and the protection of endangered species).

2.2. Oceans and Biodiversity (WP09)

In 2023, ODIS became a programme component of the International Oceanographic Data and Information Exchange (IODE), alongside the Ocean Biodiversity Information System (OBIS) and the Ocean Teacher Global Academy[47] (OTGA). OBIS federates data from a global network of organisations, and - through alignment to the Darwin Core[48] (DwC) standards and co-implementation of technologies with the Global Biodiversity Information Facility (GBIF, lead organisation of WorldFAIR WP09 Biodiversity) - provides broadly interoperable data in the biodiversity community.

As OBIS is already an ODIS Node, its holdings go far in representing the biodiversity domain in the ODIS Federation. However, ODIS allows OBIS assets to be complemented by those of other systems. This complementarity is key: as we build new biodiversity data hubs for national and international reporting, we can no longer afford to build and maintain (potentially hundreds of) bilateral data exchanges with hundreds of partners. This allows more comprehensive discovery of distributed biodiversity data assets for national and regional applications and awareness (e.g. Figure 8), while diversifying participation and avoiding monopolies.



To illustrate, consider the assets described in *Record example 5* and *Record example 6.* Both these assets are housed in regional archives (Research Data Australia and EMODnet, respectively), rather than aggregation hubs such as GBIF and OBIS. There are of course justifications for this (e.g. the EMODnet asset is a data layer product, rather than an occurrence), but ODIS has ensured they are more rapidly co-discoverable through metadata interoperation.

Figure 8: Datasets retrieved through a search for "seagrass" in the Ocean InfoHub portal and constrained to the geographical area displayed in the figure (2024-04-20, n = 485). Note, only datasets with valid geospatial metadata are shown.

[47] https://classroom.oceanteacher.org/
[48] https://dwc.tdwg.org/

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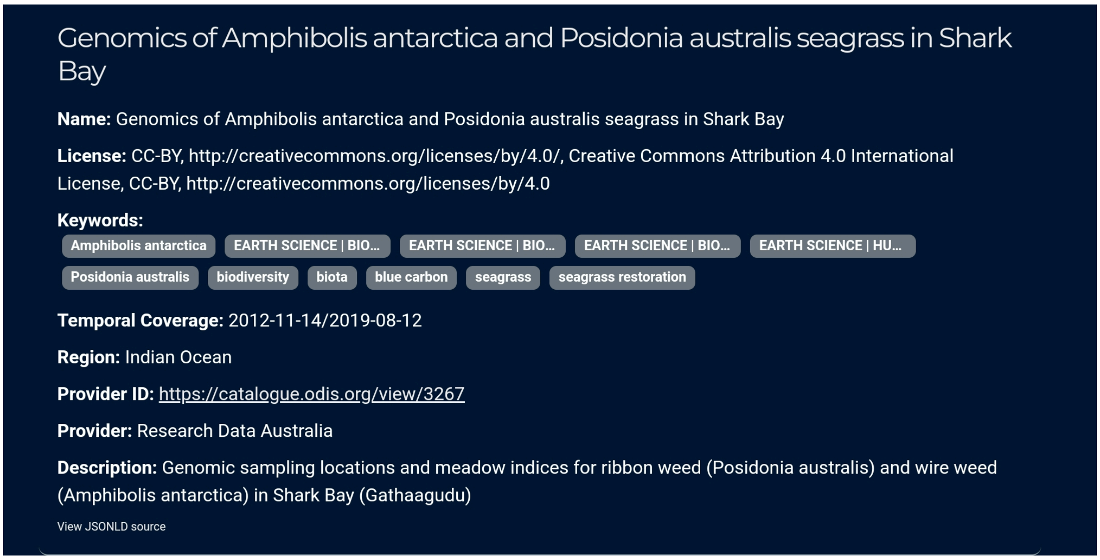

Record example 5: Genomics of Amphibolis antarctica and Posidonia australis seagrass in Shark Bay[49], directing to: https://researchdata.edu.au/genomics-amphibolis-antarctica-shark-bay/1712019.

Within WorldFAIR and globally, GBIF (WP09) is a premier source of biodiversity data. Its work with global standards agencies such as the Biodiversity Information Standards[50] organisation (TDWG) and the Genomic Standards Consortium[51] to generate stable domain-specific standards is itself a multiplier of interoperability (see D9.1[52]). As reported in D9.1, an "Event" is now being placed at the centre of GBIF models structuring biodiversity (meta)data in GBIF. ODIS's new Event and EventSeries[53] patterns (based on the schema.org types of the same names) stand ready to interface with this model, and multiply the interoperability of GBIF's holdings.

There is high, deliberate overlap between the holdings of OBIS and GBIF; however, there are marine records in GBIF that are not visible in OBIS[54]. Through WorldFAIR, GBIF has now registered in the ODIS Catalogue of Sources[55] (ODISCat; Figure 9), and linked ODIS to metadata catalogues in JSON-LD/schema.org describing its holdings.

49 https://oceaninfohub.org/results/Dataset?search_text=Genomics+of+Amphibolis+antarctica+and+Posidonia+australis+seagrass+in+Shark+Bay
50 https://www.tdwg.org/
51 https://www.gensc.org/
52 Miller, J., Robertson, T., Wieczorek, J. (2023). WorldFAIR Project (D9.1) Data standard for sharing ecological and environmental monitoring data documented for community review (Version 1). Zenodo. https://doi.org/10.5281/zenodo.7849241
53 https://github.com/iodepo/odis-in/tree/master/dataGraphs/thematics/events/graphs
54 This is largely due to the submission system used by GBIF, which presents users with an option to cross-archive their submission in OBIS; however, not all users with marine data notice or use this option.
55 https://catalogue.odis.org/

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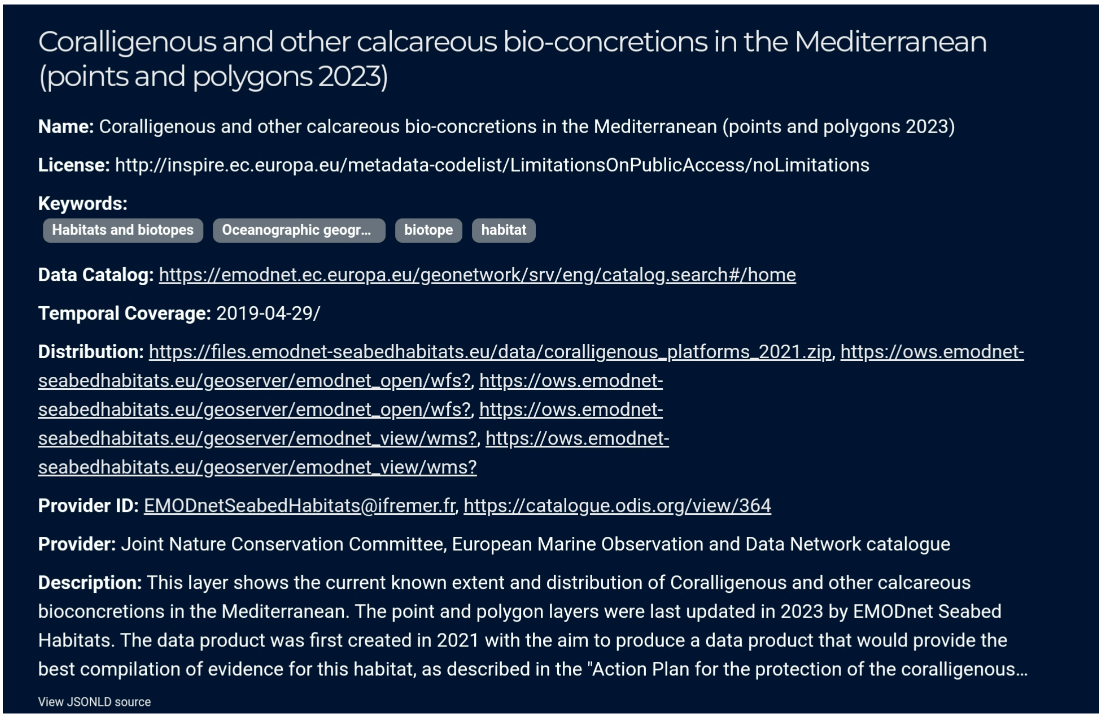

Corralligenous and other calcareous bio-concretions in the Mediterranean (points and polygons 2023)

Name: Coralligenous and other calcareous bio-concretions in the Mediterranean (points and polygons 2023)

License: http://inspire.ec.europa.eu/metadata-codelist/LimitationsOnPublicAccess/noLimitations

Keywords:
Habitats and biotopes | Oceanographic geogr... | biotope | habitat

Data Catalog: https://emodnet.ec.europa.eu/geonetwork/srv/eng/catalog.search#/home

Temporal Coverage: 2019-04-29/

Distribution: https://files.emodnet-seabedhabitats.eu/data/coralligenous_platforms_2021.zip, https://ows.emodnet-seabedhabitats.eu/geoserver/emodnet_open/wfs?, https://ows.emodnet-seabedhabitats.eu/geoserver/emodnet_open/wfs?, https://ows.emodnet-seabedhabitats.eu/geoserver/emodnet_view/wms?, https://ows.emodnet-seabedhabitats.eu/geoserver/emodnet_view/wms?

Provider ID: EMODnetSeabedHabitats@ifremer.fr, https://catalogue.odis.org/view/364

Provider: Joint Nature Conservation Committee, European Marine Observation and Data Network catalogue

Description: This layer shows the current known extent and distribution of Coralligenous and other calcareous bioconcretions in the Mediterranean. The point and polygon layers were last updated in 2023 by EMODnet Seabed Habitats. The data product was first created in 2021 with the aim to produce a data product that would provide the best compilation of evidence for this habitat, as described in the "Action Plan for the protection of the coralligenous...

View JSONLD source

Record example 6: Coralligenous and other calcareous bio-concretions in the Mediterranean (points and polygons last updated in 2023) [56]*, directing to:*
https://emodnet.ec.europa.eu/geonetwork/srv/api/records/c94bdb30-4a72-4cf2-a990-fb5778104ce7.

While there are minor issues to resolve[57], this action allows ODIS to harvest and integrate these records into the development and testing module of the ODIS Knowledge Graph. In turn, this allows OBIS (and other systems) to discover them, fill extant gaps, and generate new technology on top of these federated holdings. Due to resource constraints and implementation schedules, GBIF may not be able to create an independent linked open data presence in ODIS; however, OBIS has proposed a data brokerage model where they will leverage familiarity with GBIF's holdings and generate a sitemap with valid JSON-LD/schema.org for them[58]. In terms of digital ecosystems, this is an excellent example of interoperating entities assisting each other in expanding more global interoperability.

GBIF also provides XML sitemaps dedicated to linking to pages containing Dataset[59] and Species[60] descriptions. The Dataset sitemap links to HTML pages with JSON-LD/schema.org embedded within

56 https://oceaninfohub.org/results/Dataset?search_text=Coralligenous+and+other+calcareous+bio-concretions+in+the+Mediterranean+%28points+and+polygons+2023%29
57 https://github.com/iodepo/odis-arch/issues/426
58 https://github.com/iodepo/odis-arch/issues/426#issuecomment-2117078186
59 https://www.gbif.org/sitemap-dataset.xml
60 https://www.gbif.org/sitemap-species.xml

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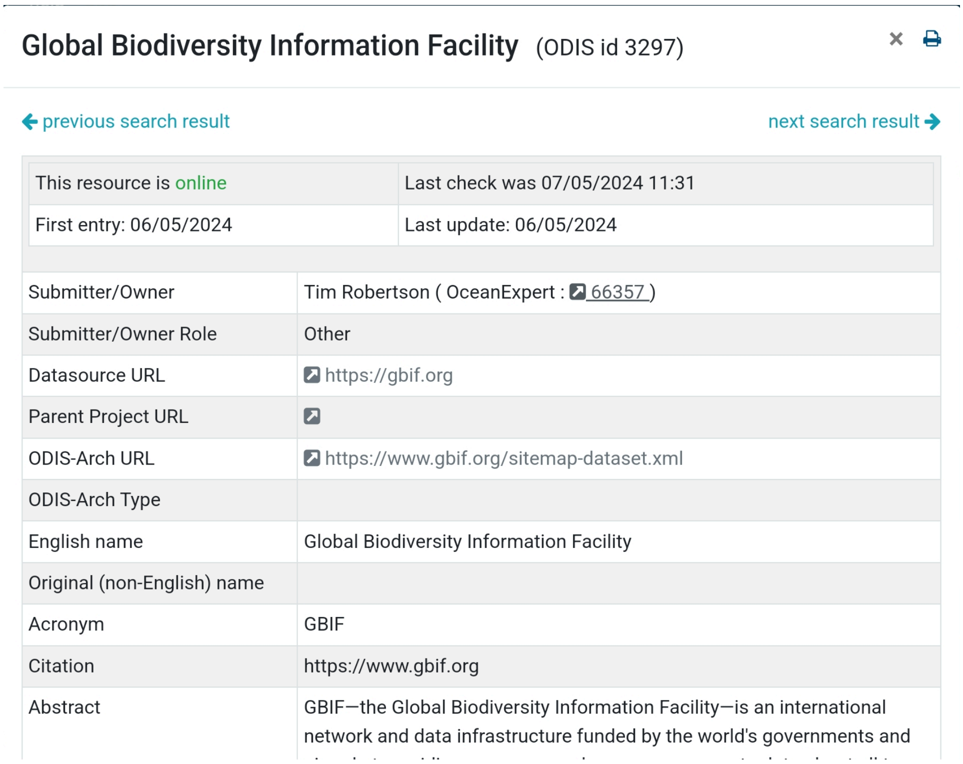
them (as described above). However, the Species sitemap links to HTML pages without such embedded data. The latter pages are prime targets for future development: embedding the schema.org/Bioschemas Taxon type[61] in taxon-centric pages will support new discovery vectors, and ODIS has created new specifications to support this for GBIF, and several other stakeholders[62].


Global Biodiversity Information Facility (ODIS id 3297)

previous search result | next search result

This resource is online	Last check was 07/05/2024 11:31
First entry: 06/05/2024	Last update: 06/05/2024

Submitter/Owner	Tim Robertson (OceanExpert : 66357)
Submitter/Owner Role	Other
Datasource URL	https://gbif.org
Parent Project URL	
ODIS-Arch URL	https://www.gbif.org/sitemap-dataset.xml
ODIS-Arch Type	
English name	Global Biodiversity Information Facility
Original (non-English) name	
Acronym	GBIF
Citation	https://www.gbif.org
Abstract	GBIF—the Global Biodiversity Information Facility—is an international network and data infrastructure funded by the world's governments and

Figure 9: The ODIS Catalogue of Sources (ODISCat) entry for GBIF's data portal. Note the ODIS-Arch URL, which links to a sitemap.xml which, in turn, links to HTML pages with embedded JSON-LD/schema.org harvestable by ODIS.

The potentials and new interoperability bridges for oceans and biodiversity supported by WorldFAIR will be further exploited by MARCO-BOLO[63], BiOcean5D[64], and BioEcoOcean[65] in pursuit of enhanced, *global* FAIR implementation for Europe and the global community via the UN Ocean Decade. This will be of particular importance to creating a coordinated regional and global system to serve Essential Ocean Variable data to the Global Ocean Observing System's[66] stakeholders, and synchronising these with the Essential Biodiversity Variable (EBV) framework[67].

61 https://schema.org/Taxon
62 https://github.com/iodepo/odis-arch/issues/391
63 https://cordis.europa.eu/project/id/101082021
64 https://cordis.europa.eu/project/id/101059915
65 https://cordis.europa.eu/project/id/101136748
66 https://goosocean.org/
67 https://geobon.org/ebvs/what-are-ebvs/

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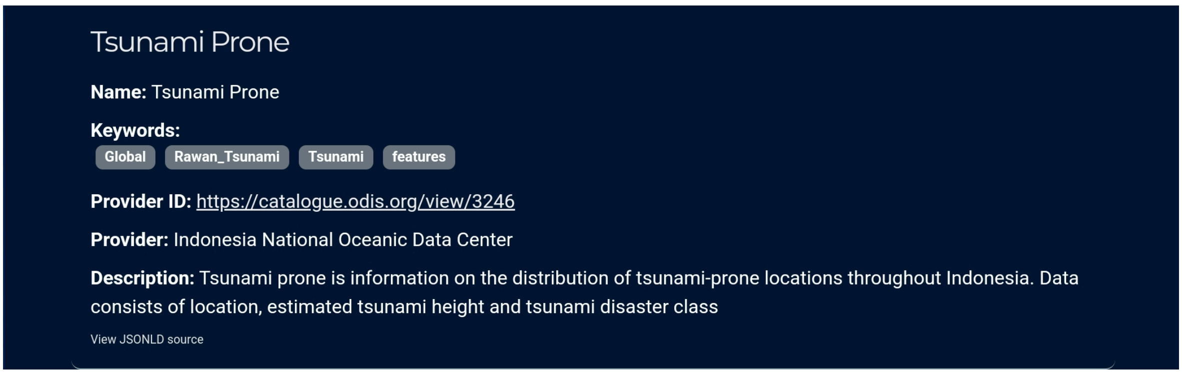
2.3. Oceans and Disaster Risk Reduction (WP12)

Growing populations and infrastructure along coastlines present new exposures to risk from hazards and disasters. This is particularly so in regions prone to seismic activity, tsunamis, volcanism, and high-energy storms, as well as from biological hazards such as red tides (of relevance to Section 2.2).

Below, ODIS-mediated interoperation between asset catalogues from the Indonesian National Oceanographic Data Centre, the Pacific Environment Data Portal, the Italian National Institute for Environmental Protection and Research (served through the EMODnet catalogue), and the Marine Spatial Atlas for the Western Indian Ocean[68] (MASPAWIO) are shown in *Record examples 7-10*. These examples demonstrate the operation of first-order (i.e. metadata-level), globally-coordinated FAIR resources linking the ocean and disaster risk reduction domains. With the ODIS Programme Component of the IODE now in effect, paced and strategic efforts to deepen this interoperability in conjunction with other agencies (e.g. WMO[69], UNEP[70],[71]) and services (e.g. United Nations Platform for Space-based Information for Disaster Management and Emergency Response, UNSPIDER[72]) are being explored to extend this layer.


Tsunami Prone

Name: Tsunami Prone

Keywords:
Global Rawan_Tsunami Tsunami features

Provider ID: https://catalogue.odis.org/view/3246

Provider: Indonesia National Oceanic Data Center

Description: Tsunami prone is information on the distribution of tsunami-prone locations throughout Indonesia. Data consists of location, estimated tsunami height and tsunami disaster class

View JSONLD source

Record example 7: Tsunami Prone [73], directing to:
https://geonode.nodc.id/layers/geonode_data:geonode:Rawan_Tsunami.

[68] http://maspawio.net/
[69] https://wmo.int/
[70] https://www.unep.org/
[71] https://github.com/iodepo/odis-arch/tree/master/archinterfaces
[72] https://www.un-spider.org/
[73] https://oceaninfohub.org/results/Dataset?search_text=Tsunami+prone

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Marine Turtles stranded on Land after the 2009 Tsunami

Name: Marine Turtles stranded on Land after the 2009 Tsunami

License: https://pacific-data.sprep.org/dataset/data-portal-license-agreements/resource/de2a56f5-a565-481a-8589-406dc40b5588

Keywords:
2009-tsunami marine-turtles

Data Catalog: https://pacific-data.sprep.org/index.php/search

Distribution: Marine turtles stranded on land after the 2009 Tsunami in Samoa

Provider ID: https://oceaninfohub.org/.well-known/org/pedp

Provider: Pacific Environment Data Portal

Description: The 2009 tsunami waves that swept through parts of the Samoa Islands brought a lot of marine life with them, portions of which were stranded on land when the waves subsided. In addition to the reef fishes of varying sizes, marine turtles, a few sharks and dolphins were also stranded. This report focuses on marine turtles and attempts to give an account on the number and fate of marine turtles that were stranded on land after the tsunami...

View JSONLD source

Record example 8: Tsunami Prone[74], directing to: *https://pacificdata.org/data/dataset/marine-turtles-stranded-on-land-after-the-2009-tsunamic57365b3-00c7-43c7-b449-83b461bd38e0*.

Submarine Volcanoes Polygons (100k)

Name: Submarine Volcanoes Polygons (100k)

Keywords:
features volcanic_center_pol_...

Data Catalog: https://emodnet.ec.europa.eu/geonetwork/srv/eng/catalog.search#/home

Distribution: http://drive.emodnet-geology.eu/geoserver/ispra/ows?SERVICE=WMS&, http://drive.emodnet-geology.eu/geoserver/ispra/ows?service=WMS&version=1.3.0&request=GetLegendGraphic&format=image%2Fpng&width=20&height=20&layer=volcanic_center_pol_100k, https://www.emodnet-geology.eu/products/wp6/metadata/EMODNet4_WP6_volcanic_center_pol_100k_metadata_2021.xml

Provider ID: andrea.fiorentino@isprambiente.it, https://catalogue.odis.org/view/364

Provider: ISPRA - Italian National Institute for Environmental Protection and Research, European Marine Observation and Data Network catalogue

Description: Submarine volcanic structures and eruption centers including hydrothermal activity, mapped by various national and regional mapping projects and recovered in the literature. Locally polygons are extended on land to include the emerged portions of the volcanoes. Polygons represent areas larger than 4 hectares. (for smaller areas, see volcanoes points layer) Note: blank areas do not necessarily correspond to no occurrence.

View JSONLD source

Record example 9: Submarine Volcanoes Polygons (100k)[75], directing to: *https://emodnet.ec.europa.eu/geonetwork/srv/api/records/f18ede89e5093e5c4c12babc96446487014b4624*.

[74] https://oceaninfohub.org/results/Dataset?search_text=Marine+Turtles+stranded+on+Land+after+the+2009+Tsunami
[75] https://oceaninfohub.org/results/Dataset?search_text=Submarine+Volcanoes+Polygons+%28100k%29&page=0

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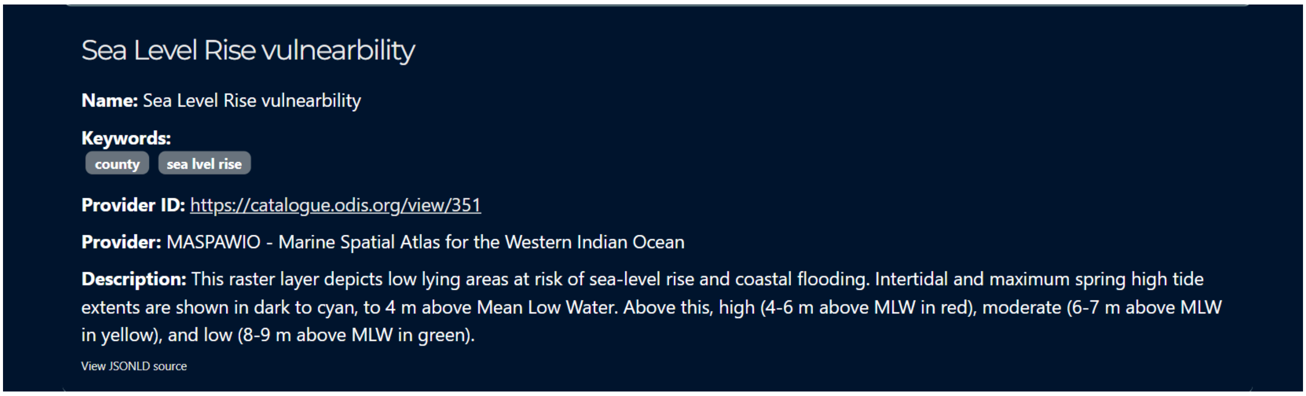

Sea Level Rise vulnearbility

Name: Sea Level Rise vulnearbility

Keywords:
county
sea lvel rise

Provider ID: https://catalogue.odis.org/view/351

Provider: MASPAWIO - Marine Spatial Atlas for the Western Indian Ocean

Description: This raster layer depicts low lying areas at risk of sea-level rise and coastal flooding. Intertidal and maximum spring high tide extents are shown in dark to cyan, to 4 m above Mean Low Water. Above this, high (4-6 m above MLW in red), moderate (6-7 m above MLW in yellow), and low (8-9 m above MLW in green).

View JSONLD source

Record example 10: Sea Level Rise vulnearbility [sic][76], directing to: *http://maspawio.net/layers/geonode%3Akwale_kilifi_mombasa_slr_vulnearbility*.

[76] https://oceaninfohub.org/results/Dataset?search_text=Sea+Level+Rise+vulnearbility&page=0

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Within the WorldFAIR project, WP12 (Disaster Risk Reduction) has provided key insight into further interoperability avenues for the Ocean-DRR domain interface through the case studies explored in D12.1[77] - particularly that in Fiji. We note that the South Pacific Commission (SPC) Pacific Data Hub (PDH), the Secretariat of the Pacific Regional Environment Programme (SPREP) and the ~14 national resources they integrate (mentioned in D12.1) are already ODIS Nodes, and interoperability bridges are being built between ODIS and the World Meteorological Organization's Information System (WIS2[78]). Thus, cross-domain interoperability at the metadata level is already in effect. However, as noted in D12.1's conclusions, there is high heterogeneity in the content and level of completeness/richness across (meta)data assets (evident in *Record example 7* vs *8*). In addition, there are valuable stores of metadata that are gathered, but not necessarily shared in a FAIR manner (e.g. D12.1, Figure 6).

Further, the importance of remotely-sensed data products was underscored by WP12. While several ODIS partners do project interoperable metadata describing such assets[79], there has been no dedicated effort to federate specialised remote sensing data hubs[80] into the Federation. This, and the need to promote the sharing of model metadata (corresponding to, e.g., the Flood Damage Model: HEC-RAS 1D hydraulic - model metadata in D12.1, Table A.13) are prime areas for future work.

WP12's Deliverable 12.2[81] - which focused on semantic resources and interoperability - provides another instructive resource for WP11 and ODIS. The JSON-LD serialisation used by ODIS Nodes is a graph format: it can be processed as a mathematical "graph" or a network of nodes and the edges that connect them (as required for advanced 5-star linked open data conformance). Most FAIR vocabularies encoded in the Simple Knowledge Organization System (SKOS)[82] or Web Ontology Language (OWL)[83] are also compatible with graph formats, through deeper Resource Description Framework (RDF) compatibility. The United Nations Office for Disaster Risk Reduction (UNDRR) Hazard Implementation Profiles (HIPs)[84] are now available on the web, and - while they are not yet serialised in a FAIR form - they allow other semantic resources to align to an authoritative reference.

[77] Bolland, J., Fakhruddin, B., Reinen-Hamill, R. (2023). WorldFAIR Project (D12.1) Disaster Risk Reduction Case study report (Version 1). Zenodo. https://doi.org/10.5281/zenodo.7887557
[78] https://wmo.int/activities/wmo-information-system-wis
[79] https://oceaninfohub.org/results/Dataset?search_text=Surface+Water+Temperature+by+Satellite+Remote+Sensing&page=0
[80] Examples noted in D12.1 and 12.2 include the Global Disaster Alert and Coordination System (GDACS), ReliefWeb, SentinelAsia, and the Copernicus Emergency Management Service(CEMS)
[81] Bolland, J., Shanker, N., Reinen-Hamill, R., Fakhruddin, B. (2023). WorldFAIR Project (D12.2) Disaster Risk Reduction Domain-specific FAIR vocabularies (Version 1). Zenodo. https://doi.org/10.5281/zenodo.8110630
[82] https://www.w3.org/2004/02/skos/specs
[83] https://www.w3.org/TR/owl2-syntax/
[84] https://www.preventionweb.net/drr-glossary/hips

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Following discussions with UNDRR representatives at the US-UK Scientific Forum on Researcher Access to Data (Washington D.C., 12-13 September 2023[85]), efforts will be directed towards creating an OWL instance of UNDRR HIPs in the Environment Ontology (ENVO)[86], leveraging insights on semantic harmonisation gleaned from working groups in the Earth Science Information Partners (ESIP)[87].

As this proceeds, ENVO's semantic graphs may be cross-linked to data graphs such as those used by ODIS as shown in *Code block 1*. This will provide immense interoperability growth (at the semantic level, at least) as more resources adopt linked open data models. Potentially, CDIF's semantic harmonisation approach (e.g. using SSSOM to map ENVO classes, HIP terms, and other resources) may extend this interoperability further. Promisingly, this is also a bridge to leverate Large Language Models (LLMs) and similar advancements in artificial intelligence, through providing semantic qualification and neighbourhoods for entities mined from natural text (Figure 10).

[85] https://www.nasonline.org/programs/scientific-forum/researcher-access.html

[86] www.environmentontology.org

[87] Duerr, R., Buttigieg, P. L., Cross, G. B., Blumberg, K. L., Whitehead, B., Wiegand, N., Rose, K. (2024). Harmonizing GCW Cryosphere Vocabularies with ENVO and SWEET. Towards a General Model for Semantic Harmonization. Data Science Journal, 23(1), 26. https://doi.org/10.5334/dsj-2024-026. Note: This paper demonstrates that semantic mapping and harmonisation is not a trivial task, and - to be of high quality - requires a moderated exchange between semantic experts, domain experts, and the maintainers of trusted semantic resources. This is an important counter argument to a common attitude of "we'll build our own vocabulary for now, we can always map later": Mapping is an expensive and laborious process, if it is to be of good quality.

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Code block 1: A demonstration of how to use a class or term from a semantic resource in any ODIS JSON-LD/schema.org file to interlink the ODIS Knowledge Graph to the semantic graph in, e.g., a well-crafted ontology. See also Figure 10.

```
"keywords":
        {
            "@type": "DefinedTerm",
            "inDefinedTermSet": "http://purl.obolibrary.org/obo/envo.owl",
            "Identifier": "http://purl.obolibrary.org/obo/ENVO_01000678",
            "termCode": "ENVO:01000678",
            "name": "tectonic earthquake"
        }
```

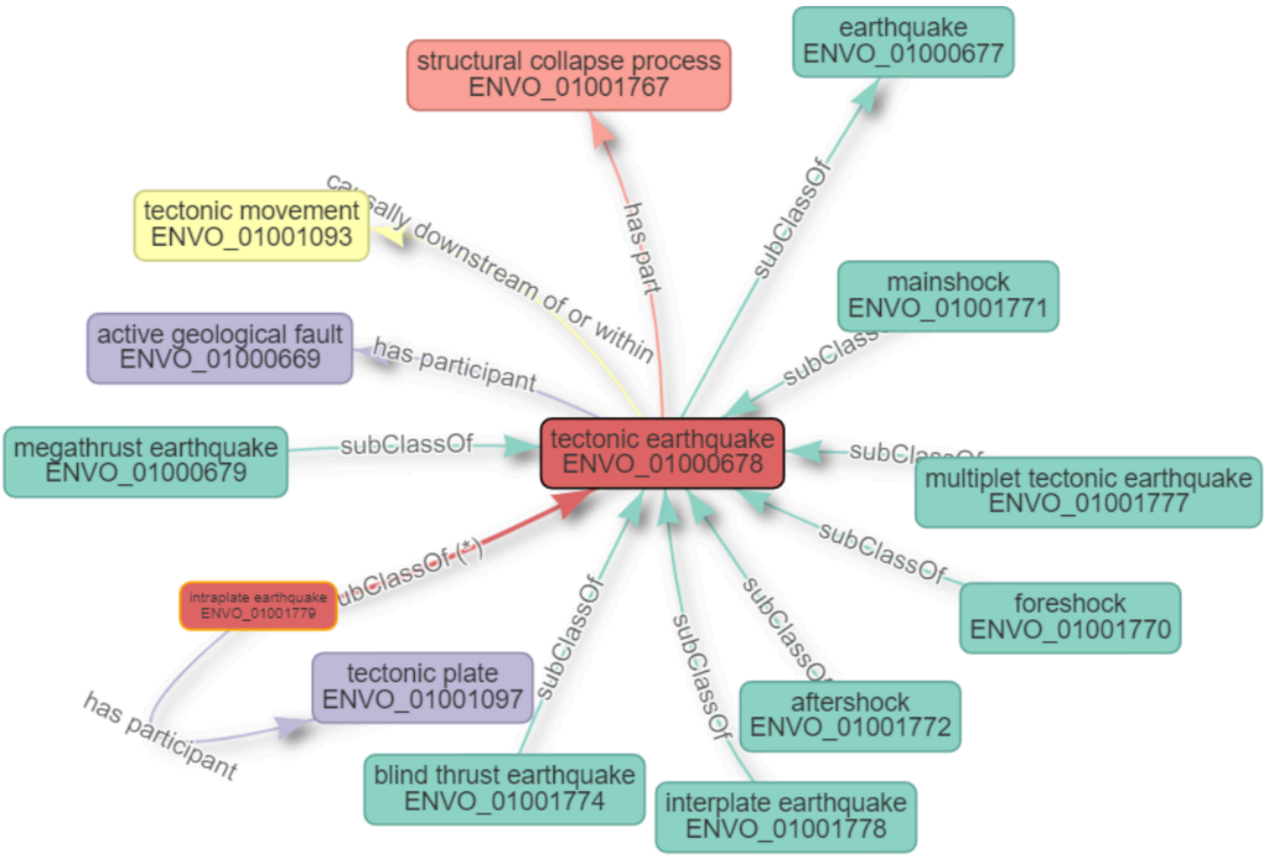

Figure 10: The semantic graph neighbourhood of the ENVO class "tectonic earthquake" (http://purl.obolibrary.org/obo/ENVO_01000678) as viewed through the European Bioinformatics Institute's Ontology Lookup Service (https://www.ebi.ac.uk/ols4/).

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2.4. Oceans and Chemistry (WP03)

Ocean chemistry is of central concern across virtually all branches of oceanography. ODIS Federation partners are actively sharing (meta)data about or related to a diverse array of chemical phenomena, including ocean acidification[88], pollutants[89], nutrients[90], and toxins[91]. These phenomena are affecting marine life (including human populations) and many oceanographic communities (such as Biogeochemical Argo[92]) are generating (meta)data to describe them. Indeed, a Global Ocean Observing System (GOOS) Essential Ocean Variable (EOV) Panel on Biochemistry is aligning global observations to provide more planetary-scale harmonisation of such phenomena[93].

Below, we provide one example derived from the Ocean Biodiversity Information System (OBIS), itself showing that multi-domain data flow is inherent in ocean observation. This relatively rich record now allows discovery of this data via ODIS (and other generic systems such as Google Dataset Search) by those in the chemistry domains who may never have thought to explore OBIS for chemical data.

Further, as EMODnet is an ODIS Node, its EMODnet Chemistry data products are also discoverable and linked through the ODIS Federation[94] (*Record example 11*), although the data underpinning them is not yet fully transparent.

[88] https://oceaninfohub.org/results/?search_text=ocean+acidification&page=0
[89] https://oceaninfohub.org/results/?search_text=pollutants&page=0
[90] https://oceaninfohub.org/results/?search_text=nutrients&page=0
[91] https://oceaninfohub.org/results/?search_text=toxins&page=0
[92] https://biogeochemical-argo.org/
[93] https://goosocean.org/what-we-do/framework/essential-ocean-variables/
[94] https://oceaninfohub.org/results/Dataset?page=0&facet_query=facetType%3Dtxt_provider%26facetName%3DEMODnet%2BChemistry

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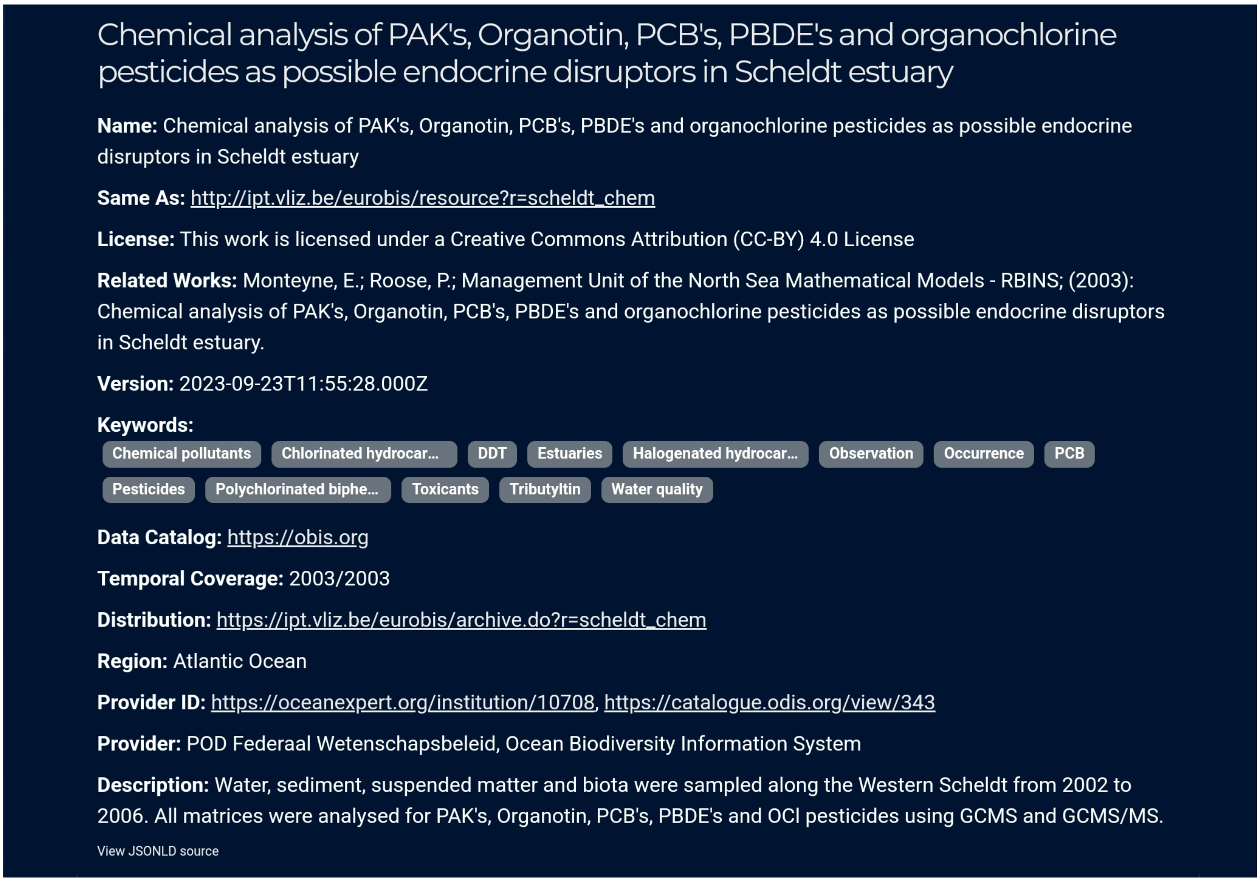

Chemical analysis of PAK's, Organotin, PCB's, PBDE's and organochlorine pesticides as possible endocrine disruptors in Scheldt estuary

Name: Chemical analysis of PAK's, Organotin, PCB's, PBDE's and organochlorine pesticides as possible endocrine disruptors in Scheldt estuary

Same As: http://ipt.vliz.be/eurobis/resource?r=scheldt_chem

License: This work is licensed under a Creative Commons Attribution (CC-BY) 4.0 License

Related Works: Monteyne, E.; Roose, P.; Management Unit of the North Sea Mathematical Models - RBINS; (2003): Chemical analysis of PAK's, Organotin, PCB's, PBDE's and organochlorine pesticides as possible endocrine disruptors in Scheldt estuary.

Version: 2023-09-23T11:55:28.000Z

Keywords:
Chemical pollutants | Chlorinated hydrocar... | DDT | Estuaries | Halogenated hydrocar... | Observation | Occurrence | PCB | Pesticides | Polychlorinated biphe... | Toxicants | Tributyltin | Water quality

Data Catalog: https://obis.org

Temporal Coverage: 2003/2003

Distribution: https://ipt.vliz.be/eurobis/archive.do?r=scheldt_chem

Region: Atlantic Ocean

Provider ID: https://oceanexpert.org/institution/10708, https://catalogue.odis.org/view/343

Provider: POD Federaal Wetenschapsbeleid, Ocean Biodiversity Information System

Description: Water, sediment, suspended matter and biota were sampled along the Western Scheldt from 2002 to 2006. All matrices were analysed for PAK's, Organotin, PCB's, PBDE's and OCl pesticides using GCMS and GCMS/MS.

View JSONLD source

Record example 11: Chemical analysis of PAK's, Organotin, PCB's, PBDE's and organochlorine pesticides as possible endocrine disruptors in Scheldt estuary[95], directing to: *https://obis.org/dataset/beee292b-d8b5-43b5-a836-906b92486908*.

[95] https://oceaninfohub.org/results/Dataset?search_text=chemical+analysis+of+PAKS

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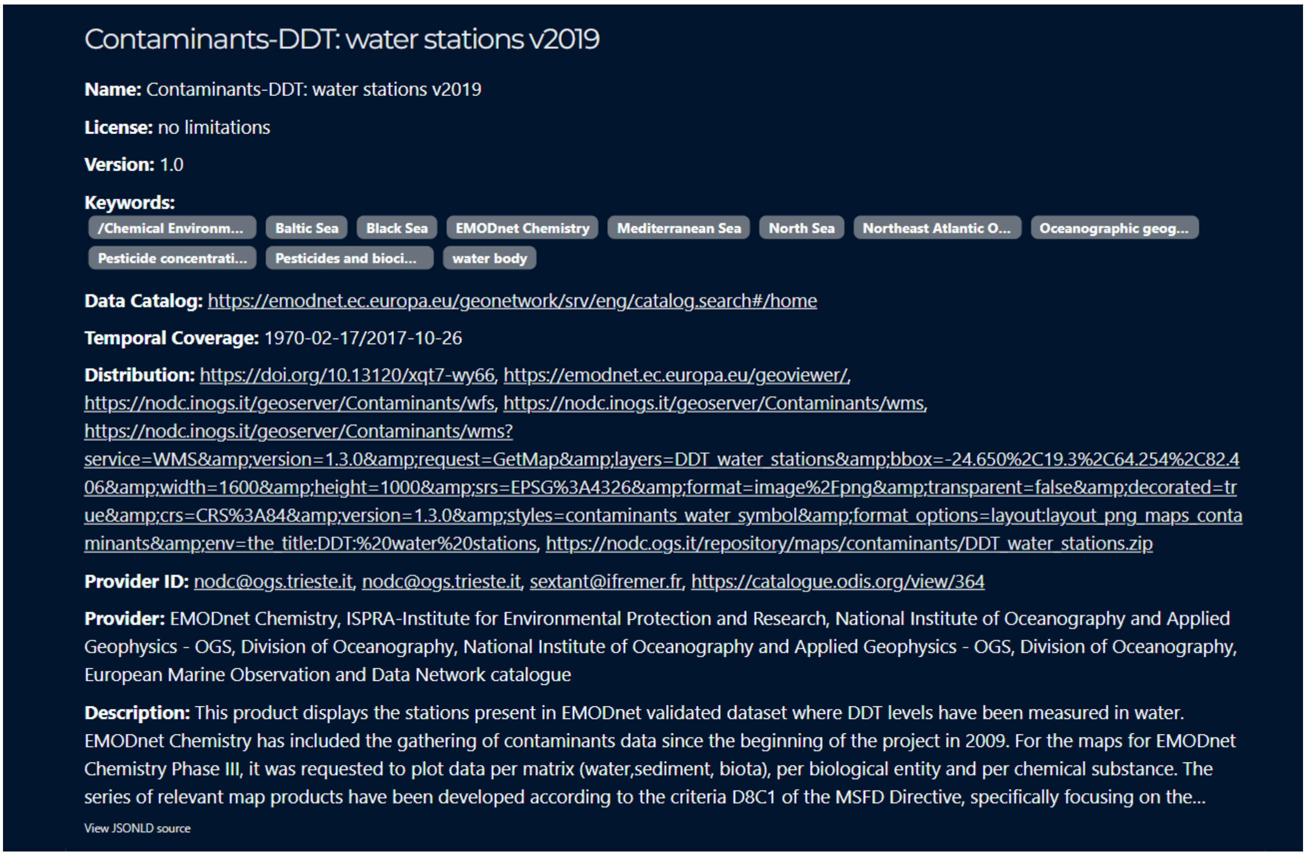

Contaminants-DDT: water stations v2019

Name: Contaminants-DDT: water stations v2019

License: no limitations

Version: 1.0

Keywords:
/Chemical Environm... | Baltic Sea | Black Sea | EMODnet Chemistry | Mediterranean Sea | North Sea | Northeast Atlantic O... | Oceanographic geog... | Pesticide concentrati... | Pesticides and bioci... | water body

Data Catalog: https://emodnet.ec.europa.eu/geonetwork/srv/eng/catalog.search#/home

Temporal Coverage: 1970-02-17/2017-10-26

Distribution: https://doi.org/10.13120/xqt7-wy66, https://emodnet.ec.europa.eu/geoviewer/, https://nodc.inogs.it/geoserver/Contaminants/wfs, https://nodc.inogs.it/geoserver/Contaminants/wms, https://nodc.inogs.it/geoserver/Contaminants/wms?service=WMS&version=1.3.0&request=GetMap&layers=DDT_water_stations&bbox=-24.650%2C19.3%2C64.254%2C82.406&width=1600&height=1000&srs=EPSG%3A4326&format=image%2Fpng&transparent=false&decorated=true&crs=CRS%3A84&version=1.3.0&styles=contaminants_water_symbol&format_options=layout:layout_png_maps_contaminants&env=the_title:DDT:%20water%20stations, https://nodc.ogs.it/repository/maps/contaminants/DDT_water_stations.zip

Provider ID: nodc@ogs.trieste.it, nodc@ogs.trieste.it, sextant@ifremer.fr, https://catalogue.odis.org/view/364

Provider: EMODnet Chemistry, ISPRA-Institute for Environmental Protection and Research, National Institute of Oceanography and Applied Geophysics - OGS, Division of Oceanography, National Institute of Oceanography and Applied Geophysics - OGS, Division of Oceanography, European Marine Observation and Data Network catalogue

Description: This product displays the stations present in EMODnet validated dataset where DDT levels have been measured in water. EMODnet Chemistry has included the gathering of contaminants data since the beginning of the project in 2009. For the maps for EMODnet Chemistry Phase III, it was requested to plot data per matrix (water,sediment, biota), per biological entity and per chemical substance. The series of relevant map products have been developed according to the criteria D8C1 of the MSFD Directive, specifically focusing on the...

View JSONLD source

Record example 11: Contaminants-DDT: water stations v2019[96], directing to: *https://emodnet.ec.europa.eu/geonetwork/srv/api/records/ec92ad82-5c5b-4fed-b210-c9f4dc57d6c5*.

WorldFAIR Chemistry Work Package 3, Deliverable 3.1[97] notes several key considerations to expand ODIS' current capacity to interoperate with chemical (meta)data. The sample-centric nature of Earth chemistry data (as described and defined in D3.1, Section 2.2.3) is clear from the records shown above, as well as many other chemically-focused datasets present across ODIS. The JSON-LD/schema.org specifications for samples[98] being developed in collaboration with the Sampling Nature Research Coordination Network (RCN)[99] is a natural cross-domain interface, bolstered by the specifications for tracking events (including sampling and processing events, also highly relevant for WP09 ins Section 2.3 of this document),[100] co-developed in collaboration with the

[96] https://oceaninfohub.org/results/Dataset?search_text=Contaminants-DDT%3A+water+stations+v2019
[97] McEwen, L., Bruno, I. (2023). WorldFAIR Project (D3.1) Digital recommendations for Chemistry FAIR data policy and practice (Version 1). Zenodo. https://doi.org/10.5281/zenodo.7887283
[98] https://github.com/iodepo/odis-arch/issues/376
[99] https://samplingnature.github.io/
[100] https://github.com/iodepo/odis-in/blob/master/dataGraphs/thematics/events/graphs/timeSeries.json

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Marine Ecological Time Series RCN[101]. The metadata to populate such specifications is native to the Laboratory/Field Information Management Systems (L/FIMS) and electronic laboratory notebooks (ELNs) that are noted in D3.1's desired end state (Section 2.4.2). The regulatory concerns alluded to in this document are also of key importance - while these were only supplementary to the technical focus of most work conducted in WorldFAIR, subsequent initiatives will inevitably be confronted with understanding and creating technology to handle these.

At this stage, the most readily implementable means to strengthen cross-domain interoperability between ODIS holdings and the primary resources in WP03 is similar to the semantic resource link described in Section 2.4 of this document. In WorldFAIR D3.1, Section 3.1.3.3 describes several resources which are suited to this action.

As shown below (Code Block 2, Figure 11) with the Chemical Entities of Biological Interest (CHEBI) ontology[102], this simple, IRI-based link has a profound effect: it links knowledge graphs like those generated by harvesting and processing ODIS Node records, to a semantic graph, allowing knowledge representation (KR) resources to augment human knowledge and enable AI-powered applications. If such simple bridges can be extended by FAIR representations of chemical mixtures and impurities (D3.1, Section 2.2.8), far more accurate representations of natural phenomena will enable precision data science in ocean chemistry.

Further, WP03's Deliverable 3.3[103] (Section 4.2) provides illustrative JSON code blocks that foreshadow sub-specifications for ODIS patterns, which may be embedded in the generic schema.org code described in D11.2. These would be a rapidly deployable means to link ODIS with the (meta)data resources in focus across WP03, particularly those converting community and domain-specific conventions into generic forms. Indeed, in D3.3 (Section 4.1.1), deliberations on whether to adopt JSON or XML in common data models becomes more an internal concern, if - as recommended in D11.2 - systems gathering and harmonising (meta)data are able to project JSON(-LD) with well-qualified and structured generic and domain specific semantics. The ability for the utility services proposed to broker between commonly-used identifiers (e.g. as described in D3.3, section 4.1) and serve coherent responses is very much in line with the data space behaviour ODIS aims to achieve: local or regional conventions (of sufficient quality and stability) may be used to query a global system, with translations occurring across systems using different conventions, but capable of serving an accurate response in the form requested by the original user.

In sum, the work to stabilise and harmonise FAIR chemical data exchange by organisations such as the International Union of Pure and Applied Chemistry[104] (IUPAC) is likely to create a stable domain interface with ODIS. It is feasible that in the near future, ODIS and the services described in D3.3 will be able to broker and enhance each other's content and operations, supported by training material

[101] https://www2.whoi.edu/site/mets-rcn/
[102] https://www.ebi.ac.uk/chebi/
[103] Thiessen, P., Bolton, E., Williams, A., McEwen, L. R. (2023). WorldFAIR (D3.3) Utility services for Chemistry Standards (Version 1). Zenodo. https://doi.org/10.5281/zenodo.10289786
[104] https://iupac.org/

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such as the Cookbook described in Deliverable 3.2[105] and the ODIS Book[106], and training courses[107]. As with coordination with IIIF, described above (Section 2.1), deferring to IUPAC services and models encapsulated in generic schema.org types (e.g. https://schema.org/ChemicalSubstance) will provide far greater impact through interoperation with appropriate, FAIR-enabled, and authoritative organisations. The only criterion for this link is that such services reuse generic standards as far as possible to prevent idiosyncratic, exclusive (to those that understand one domain's conventions) and brittle[108] interoperability requirements (e.g. bespoke mappings, new formats, etc).

The urgency of building this digital bridge was underscored by a recent workshop for developing enhanced data exchanges for ocean carbon and acidification data (Venice, 7-8 May 2024[109]), to inform both science and society through direct data exchange with UN Sustainable Development Goal (SDG) Indicator 14.3's[110] custodian agency, UNESCO's IOC (with potential interoperability with UNDRR through the corresponding HIP[111], see Section 2.3).

[105] Chalk, S., Munday, S., Kroenlein, K., McEwen, L., Mustafa, F. (2024). WorldFAIR (D3.2) Training Package: FAIR Chemistry Cookbook (Version 1). Zenodo. https://doi.org/10.5281/zenodo.10711950
[106] https://book.oceaninfohub.org/
[107] https://classroom.oceanteacher.org/mod/forum/discuss.php?d=4081
[108] https://en.wikipedia.org/wiki/Brittle_system
[109] https://webhost.essic.umd.edu/first-international-workshop-to-advance-ocean-carbon-and-acidification-data-management-and-interoperability/
[110] https://www.globalgoals.org/goals/14-life-below-water/
[111] https://www.preventionweb.net/understanding-disaster-risk/terminology/hips/mh0021

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Code block 2: A demonstration of how to use a class or term from a semantic resource in any ODIS JSON-LD/schema.org file to interlink the ODIS Knowledge Graph to the semantic graph in, e.g., a well-crafted ontology. See also Figure 11.

```
"keywords":
        {
            "@type": "DefinedTerm",
            "inDefinedTermSet": "http://purl.obolibrary.org/obo/chebi.owl",
            "Identifier": "http://purl.obolibrary.org/obo/CHEBI_77853",
            "termCode": "CHEBI:77853",
            "name": "persistent organic pollutant"
        }
```

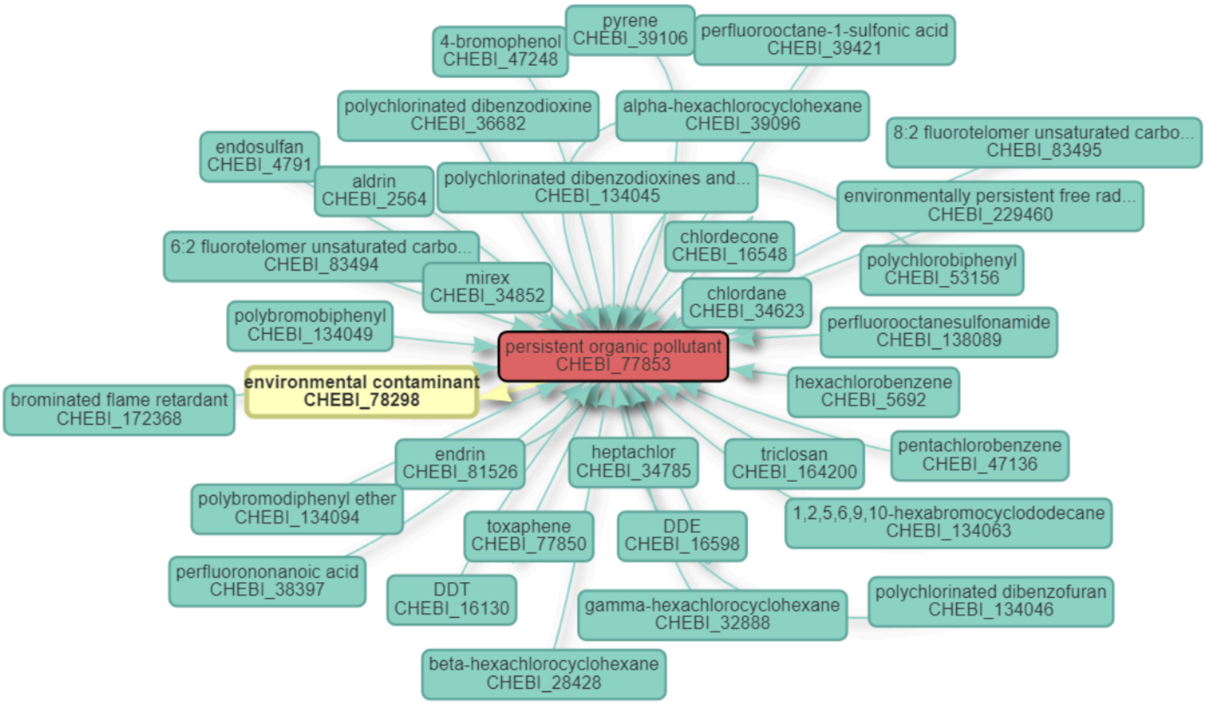

Figure 11: The semantic graph neighbourhood of the CHEBI class "persistent organic pollutant" (http://purl.obolibrary.org/obo/CHEBI_77853) as viewed through the European Bioinformatics Institute's Ontology Lookup Service (https://www.ebi.ac.uk/ols4/). CHEBI's modelling of this class as a "role" follows from alignment to the Basic Formal Ontology and the best practices of the Open Biological and Biomedical Ontologies (OBO) Foundry. The various chemical compounds known to have this role are interlinked, allowing human and machine agents (such as reasoners) to leverage digitised knowledge about chemistry to enhance their operations.

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3. Conclusions

This deliverable has demonstrated current, cross-domain (meta)data exchanges across the ODIS Federation, representing digital assets from hundreds of organisations and communities worldwide and laying a foundation to deepen interoperability from metadata to data products and services. It has also noted where new interoperability specifications within the ODIS Architecture have been developed to support further and deeper interoperability, guided by case studies within WorldFAIR and leveraging/conforming to the prevalent JSON-LD/schema.org approach to sharing linked open data over the Web. The domains described in Section 2 describe a few cases of ODIS's existing cross-domain operations, which represent significant progress towards the vision of both WorldFAIR and the Cross-Domain Interoperability Framework (CDIF).

Across all case studies and domains, the trend to embrace the original vision of the Web[112] and to use generic, domain- and community-neutral conventions which are 1) progressing along the five-star linked open data model and 2) natively understood by millions of machines and software applications on the Web, is key to the future of cross-domain interoperability.

In relation to ODIS's immediate future, WorldFAIR has catalysed practical, tangible, and technically sound interoperability efforts with significant actors in Cultural Heritage (WP13), Biodiversity (WP09), Disaster Risk Reduction (WP12), and Chemistry (WP03). As these concrete avenues to sustainable interoperation develop and are tested for their operational fitness, the embedding of ODIS in a multi-domain and diverse global digital ecosystem is poised to achieve unprecedented impact, and better interface with the sustained digital revolution now providing artificial intelligence solutions with quality insight. ODIS looks forward to further collaboration with the domains and actors across WorldFAIR case studies in the future, to build on the progress described here and in Deliverables 11.1 and 11.2.

[112] The history of the Web is extensive, but the original vision of the Web was to create a universal linked data system built on top of the Internet, with user and developer friendliness in mind. The key is to embrace data exchange over packet switched / connectionless networks, prioritising globally standardised data flows over any given local or domain-specific software (i.e. many software implementations should be able to understand data flows generically, such as how different browsers on different operating systems can similarly process HTML pages). From https://home.cern/science/computing/birth-web/short-history-web : "The basic idea of the WWW was to merge the evolving technologies of computers, data networks and hypertext into a powerful and easy to use global information system."

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