Insights into the ocean's emerging digital ecosystem:

The new arena for science and sustainable development

Pier Luigi Buttigieg AWI

unesco
Intergovernmental Oceanographic Commission

IODE International Oceanographic Data and Information Exchange

Flanders State of the Art

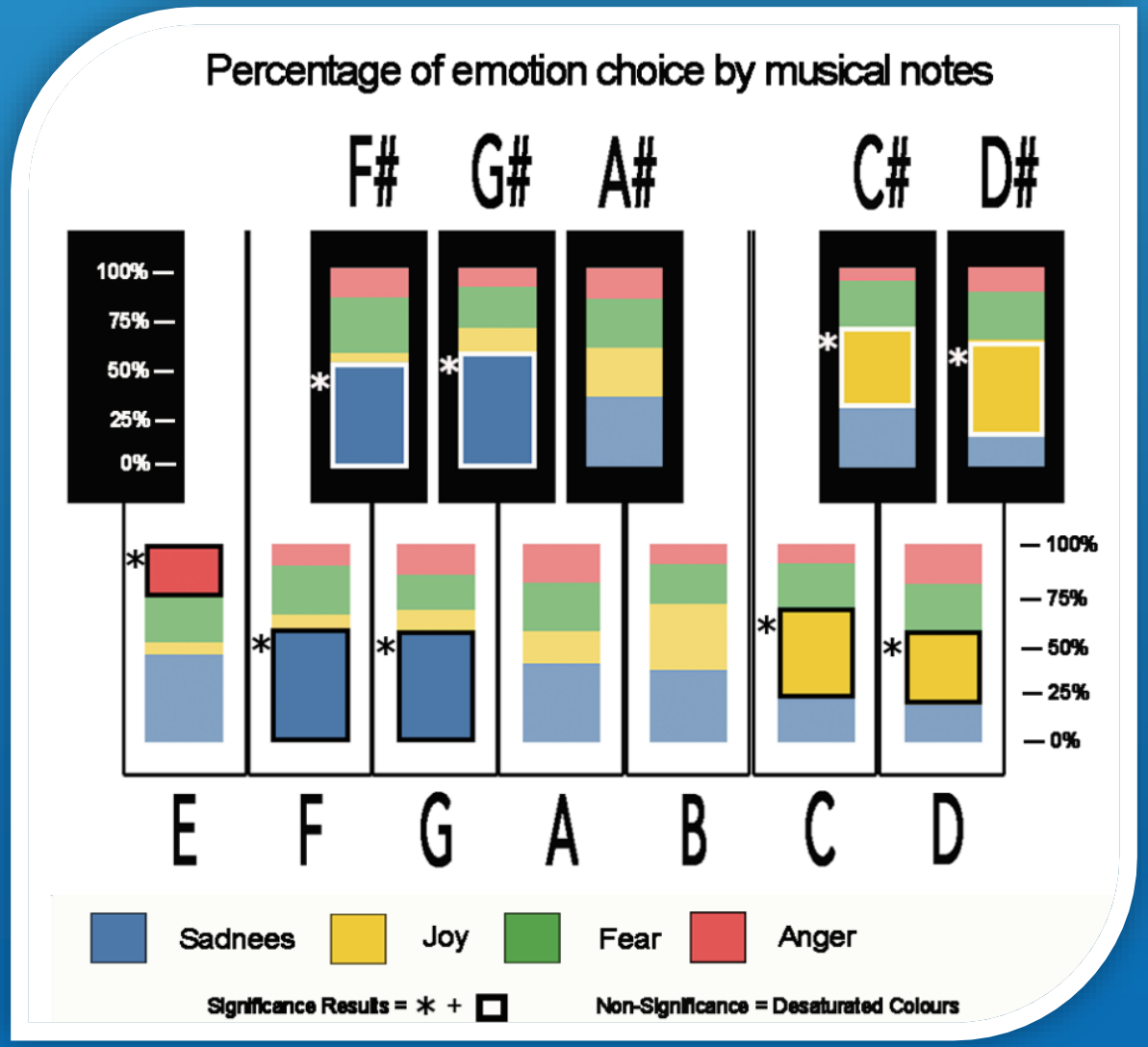
ODIS

IH

WorldFAIR

GA: 101058393

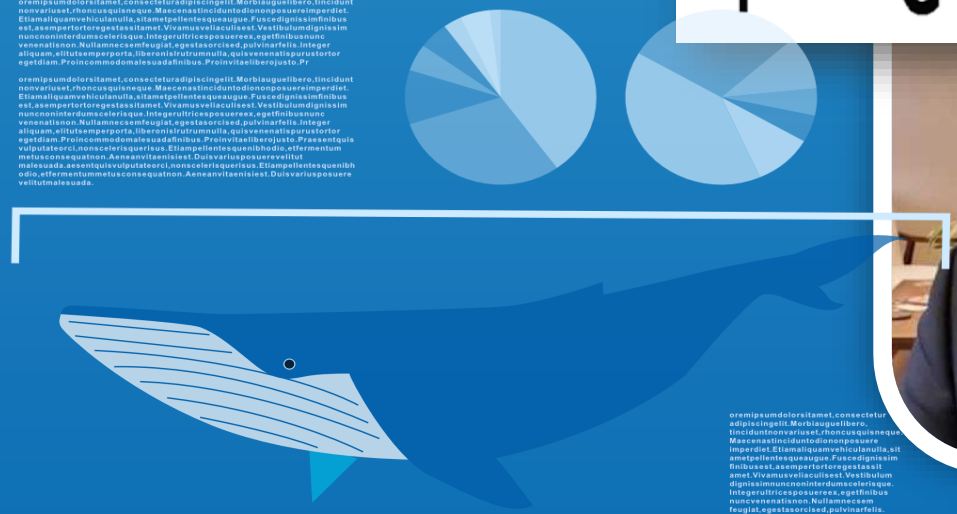
When Emotions are Triggered by Single Musical Notes: Revealing the Underlying Factors of Auditory-Emotion Associations



O'Toole et al. In Companion Publication of the 2021 International Conference on Multimodal Interaction (ICMI '21 Companion), October 18–22, 2021, Montréal, QC, Canada. ACM, New York, NY, USA 8 Pages. https://doi.org/10.1145/3461615.3485419

Could you create a “state of ocean data” report for the IOC?

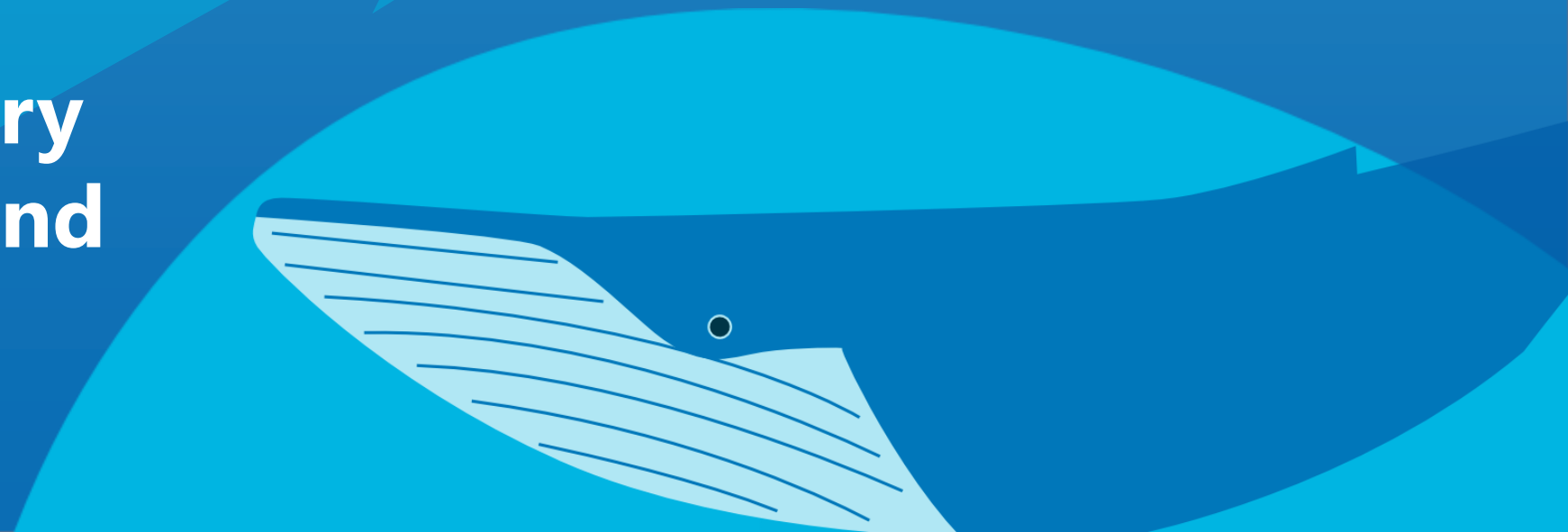
Vladimir Ryabinin



Muggins

- The weakening of global multilateralism
- Increased desire for technological and data sovereignty
- New regulatory frameworks and competition

Splinternet
(cyber-balkanisation)



- Not having FAIR research data costs the European economy at least €10.2bn every year (https://data.europa.eu/doi/10.2777/02999)

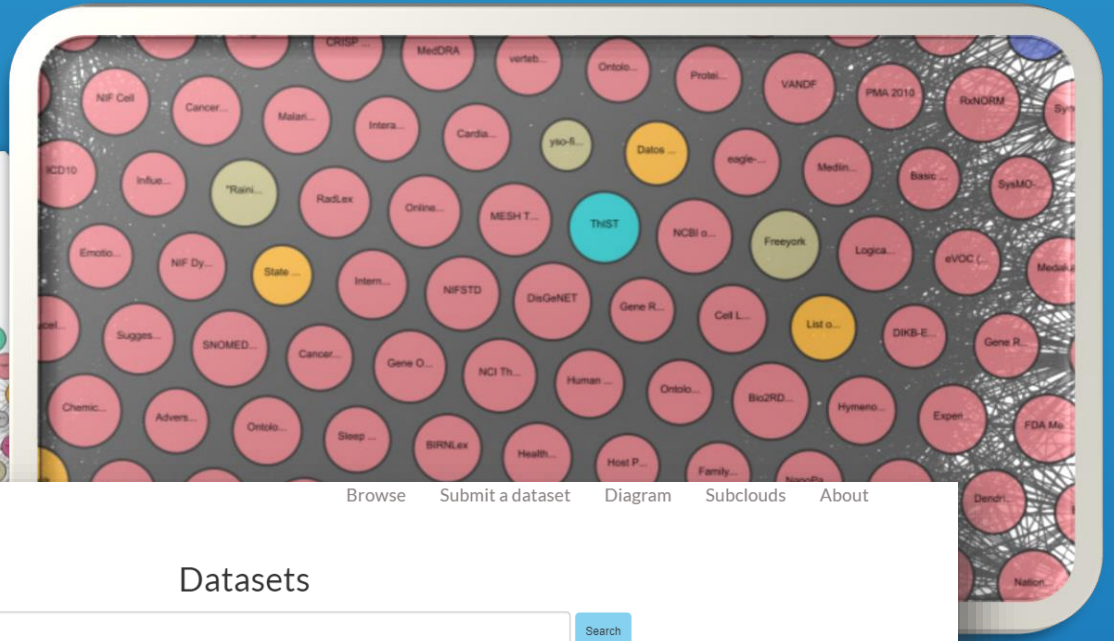
- The Australian Research Data Commons (ARDC) references the “Incentives to Invest in Identifiers” report (https://zenodo.org/records/7100578)
  - Potential savings of up to
    - $24 million per annum through the use of persistent identifiers (PIDs)
    - 38,000 person days, freed from re-keying information that PIDs provide.

Courtesy of Doug Fils

The **Linked Open Data** Cloud https://lod-cloud.net/

Legend

- Cross Domain
- Geography
- Government
- Life Sciences
- Linguistics
- Media
- Publications
- Social Networking
- User Generated



The Linked Open Data Cloud Browse Submit a dataset Diagram Subclouds About

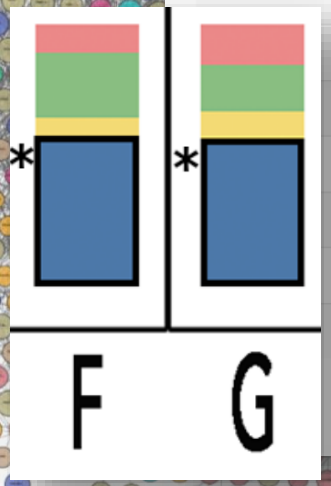
Datasets

Search dataset... Search

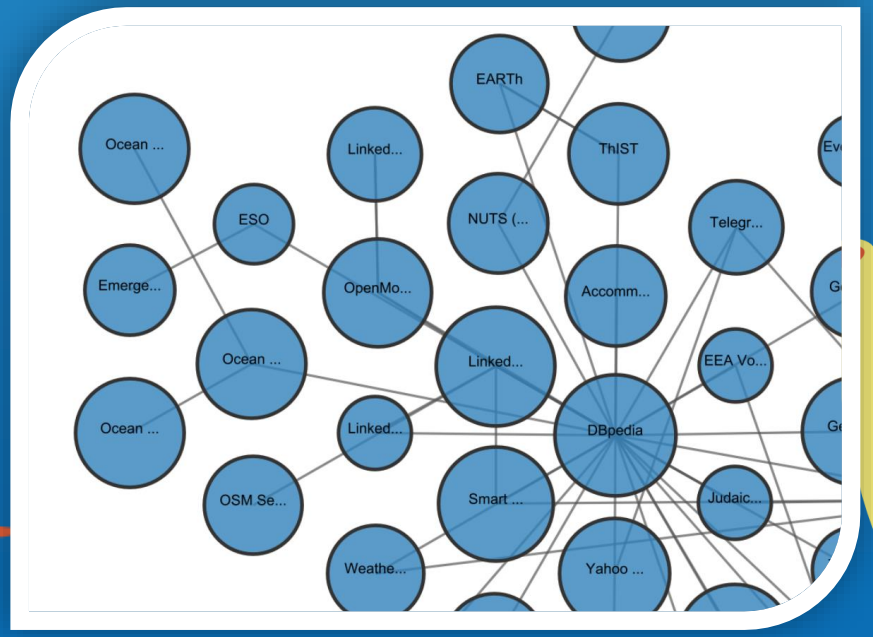
7 / datasets

Title	Identifier	View	Edit
oceandrilling-borehole	oceandrilling-borehole		
Ocean Drilling - Codices	oceandrilling-codices		
Ocean Drilling - dbSEABED	oceandrilling-dbseabed		
Ocean Drilling - Forams	oceandrilling-forams		
Ocean Drilling - Janus LOD	oceandrilling-janus		
Ocean Drilling - Janus Age Models	oceandrilling-janusamp		
Ocean Drilling - LDEO log files as data (TEST leg 218 only)	oceandrilling-ldeo		

First Previous 1 Next Last



The rise of the (FAIR?) Data Swamp



LOD subgraph: Geology

The hard part

A socio-technical system …

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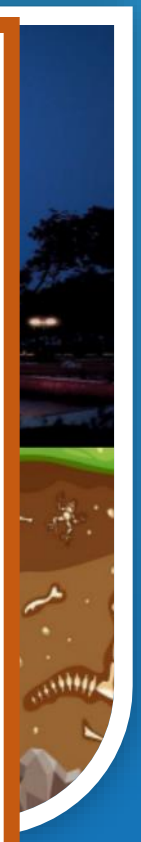


Key issues

- (FAIR) digital implementations are siloed
- Sparkly fountains are prioritised
- Action leads are (typically) not digitally fluent at the implementation level
- Digital/data leads are not networked across actions: they don’t have a home

Where is

Who is ev

What do

What cap
they have

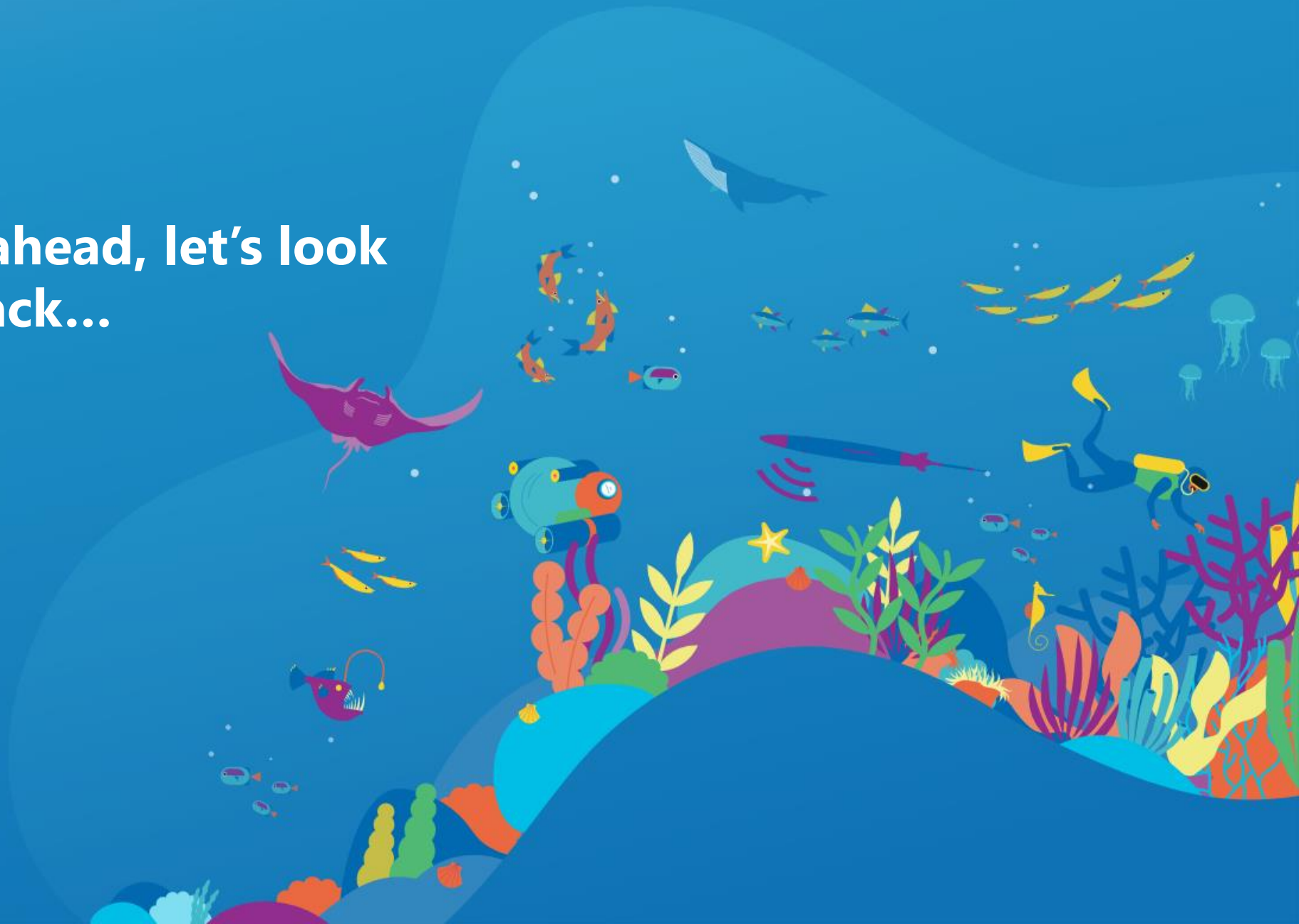
How can
work tog

Glossy documents, handshakes, workshops, high-level events alone don’t cut it:

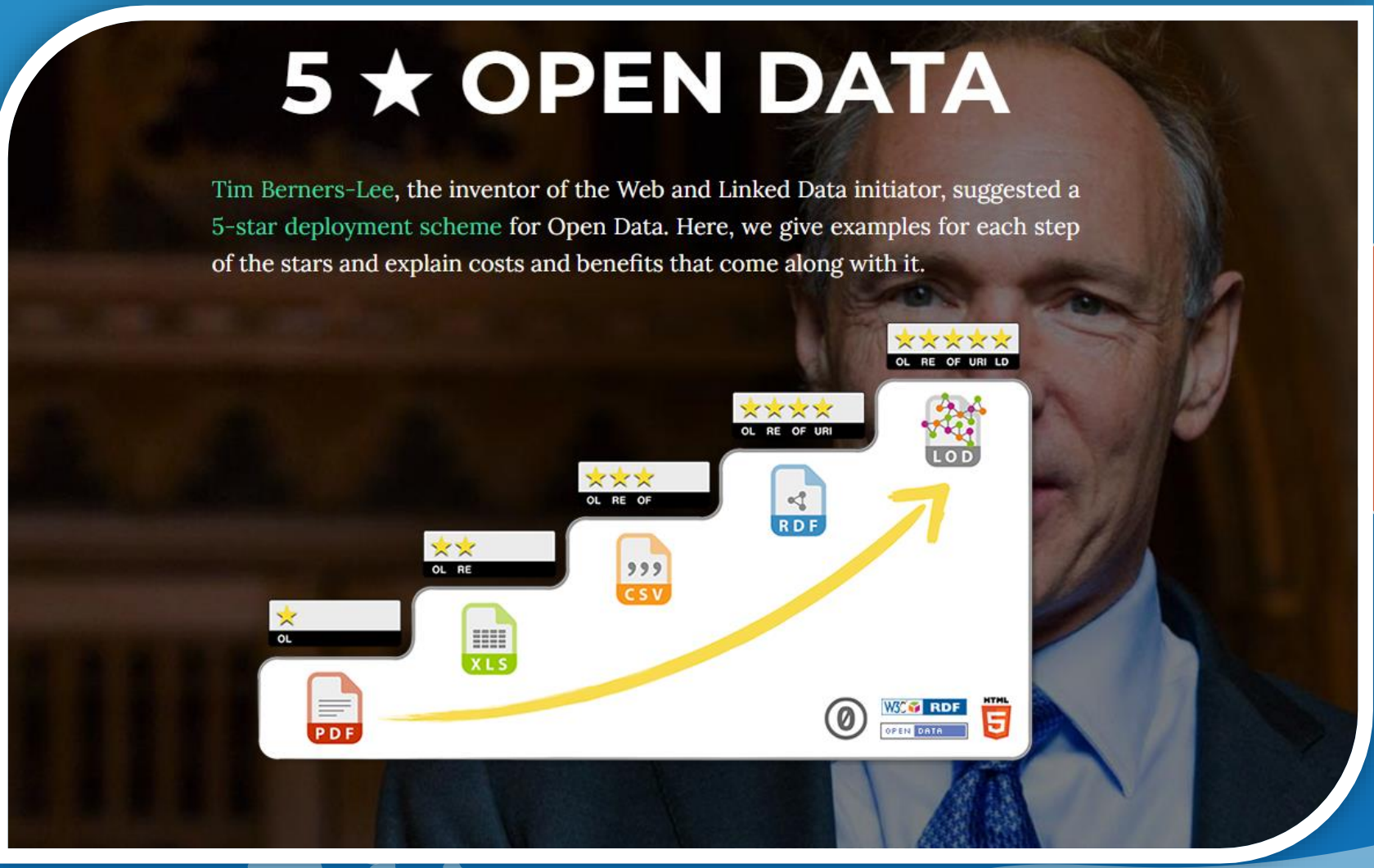
Where are the implementations and cross-validated exchanges?

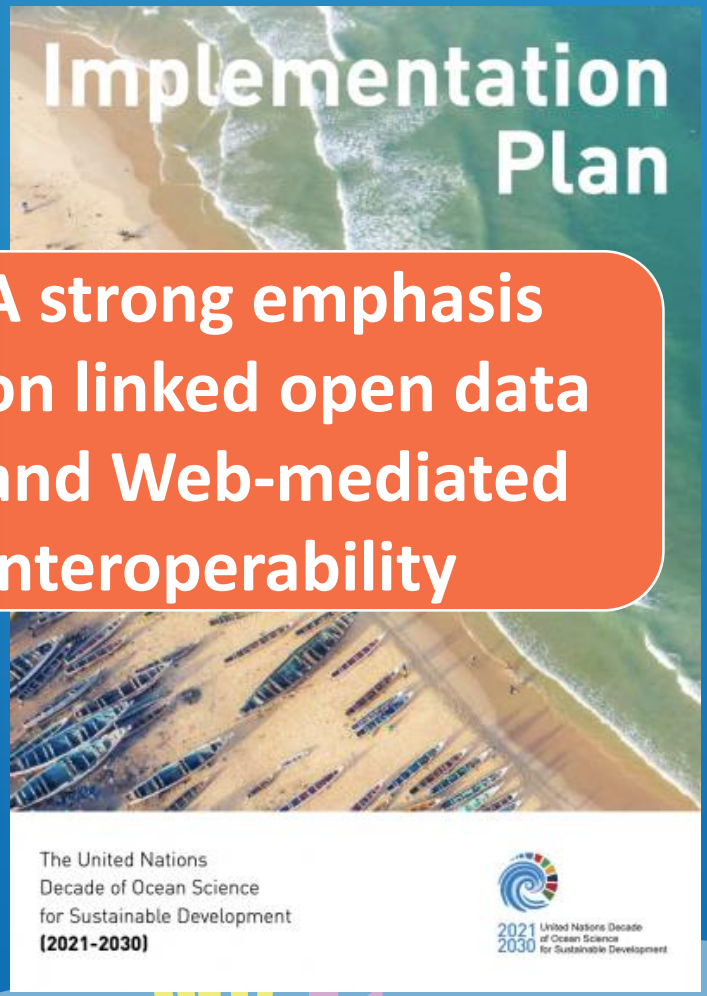
Does the technology *actually* work together?

To look five years ahead, let's look about five years back...



The UN Ocean Decade

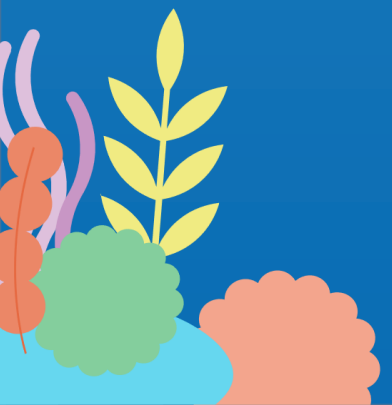




A strong emphasis on linked open data and Web-mediated interoperability

IODE IWG-SODIS (Formed in 2019-2021)

Strategy for Ocean Data and Information Stewardship (SODIS) for the UN Ocean Decade and other key global data initiatives contributing to the Decade data vision and implementation



Towards a Strategy on Ocean Data and Information Stewardship for the UN Decade of Ocean Science for Sustainable Development

Show affiliations | Hide authors

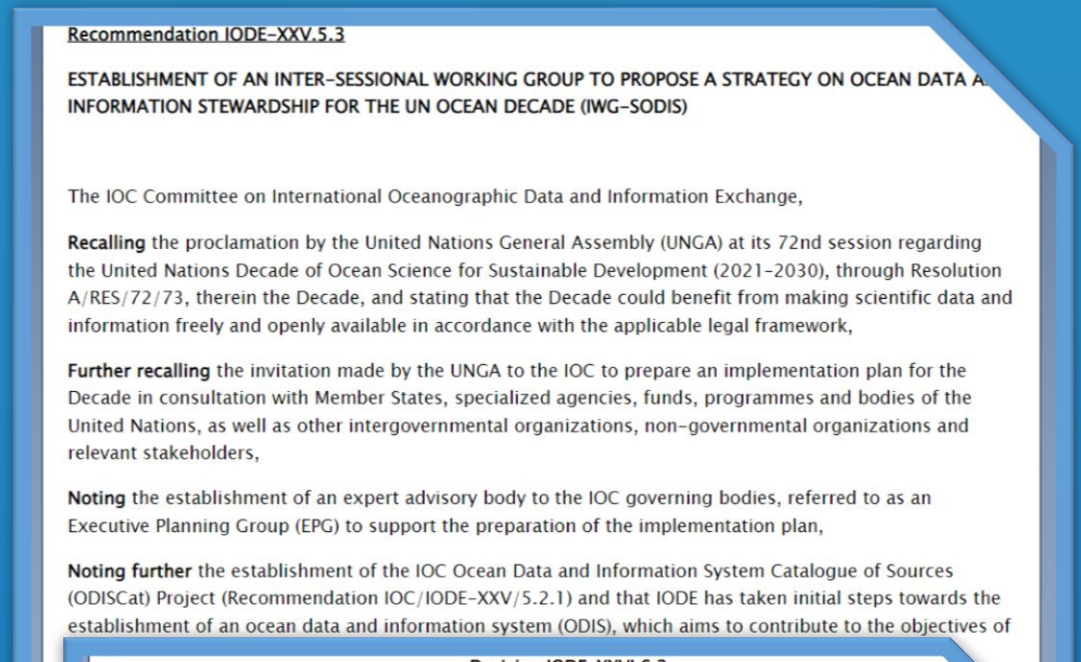
Buttigieg, P. L. ; Appeltans, W. ; Arias, F. ; Bajona, L. ; Belov, S. ; Boyer, T. ; Bristol, S. ; Calewaert, J. B. ; Carter, S. ; Canonico, G. ; Clausen, A. ; De Bruin, T. ; Edmunds, R. ; Gallage, C. ; Geddes, K. ; Genio, L. ; Giorgetti, A. ; Giron, A. ; Holdsworth, N. ; Isensee, K. ; Klein, E. ; Paterson, A. ; Moustahfid, H. ; O'Brien, K. ; Peng, G. ; Pissierssens, P. ; Pfeil, B. ; Scory, S. ; Provoost, P. ; Scott, L. ; Tirpak, E. ; Weatherdon, L. ; Garcia, H. E.

Access to multi-sector marine data and information is one of the top priorities of the UN Decade of Ocean Science for Sustainable Development 2021-2030 (henceforth, "the Decade"). Consequently, the Intergovernmental Oceanographic Commission (IOC) has convened an Inter-sessional Working Group to propose a Strategy on Ocean Data and Information Stewardship for the UN Ocean Decade (IWG-SODIS), managed by the UNESCO-IOC International Oceanographic Data and Information Exchange (IODE) programme.

- IWG-SODIS was established via IOC's Recommendation IODE-XXV.5.3 (2019) & Decision IODE-XXVI.6.2 (2021)

- The IWG-SODIS was charged with releasing recommendations on **shaping global digital stewardship cultures to support an interoperable digital ecosystem** for the Decade, both within the UN System and beyond it.

- The WG was charged to form recommendations around which global digital exchange policies can converge via clear, multilateral agreements.



Recommendation IODE-XXV.5.3

ESTABLISHMENT OF AN INTER-SESSIONAL WORKING GROUP TO PROPOSE A STRATEGY ON OCEAN DATA A… INFORMATION STEWARDSHIP FOR THE UN OCEAN DECADE (IWG-SODIS)

The IOC Committee on International Oceanographic Data and Information Exchange,

Recalling the proclamation by the United Nations General Assembly (UNGA) at its 72nd session regarding the United Nations Decade of Ocean Science for Sustainable Development (2021-2030), through Resolution A/RES/72/73, therein the Decade, and stating that the Decade could benefit from making scientific data and information freely and openly available in accordance with the applicable legal framework,

Further recalling the invitation made by the UNGA to the IOC to prepare an implementation plan for the Decade in consultation with Member States, specialized agencies, funds, programmes and bodies of the United Nations, as well as other intergovernmental organizations, non-governmental organizations and relevant stakeholders,

Noting the establishment of an expert advisory body to the IOC governing bodies, referred to as an Executive Planning Group (EPG) to support the preparation of the implementation plan,

Noting further the establishment of the IOC Ocean Data and Information System Catalogue of Sources (ODISCat) Project (Recommendation IOC/IODE-XXV/5.2.1) and that IODE has taken initial steps towards the establishment of an ocean data and information system (ODIS), which aims to contribute to the objectives of

Decision IODE-XXVI.6.2

IODE CONTRIBUTIONS TO THE UN DECADE OF OCEAN SCIENCE FOR SUSTAINABLE DEVELOPMENT (2021-2030) AND ESTABLISHMENT OF AN IODE INTER-SESSIONAL WORKING GROUP

The IODE Committee,

Recalling the proclamation, by the United Nations General Assembly (UNGA) at its 72nd session regarding the United Nations Decade of Ocean Science for Sustainable Development (2021-2030), through Resolution A/RES/72/73, therein the Ocean Decade, and stating that the Ocean Decade could benefit from making scientific data and information freely and openly available in accordance with the applicable legal framework,

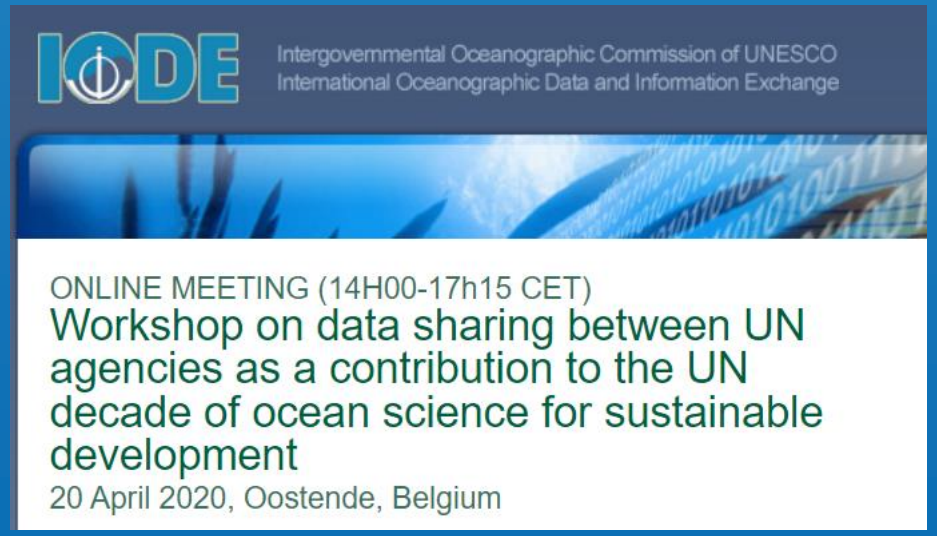
Recognizing the important role that IODE has, and continues to play in timely and unrestricted international exchange of oceanographic data by the countries of the world for a wide variety of purposes including the prediction of weather and climate, the operational forecasting of the marine environment, the preservation of life, the mitigation of human-induced changes in the marine and coastal environment, as well as for the advancement of scientific understanding that makes this possible,

Noting the establishment of the inter-sessional working group to propose a strategy on ocean data and information stewardship for the Ocean Decade (IWG-SODIS) through Recommendation IODE-XXV.5.3,

Decides to register OTGA, OBIS, OIH/ODIS and PacMAN as UN Ocean Decade Action following the procedure established for UN entities in the United Nations Decade of Ocean Science for Sustainable Development (2021-2030) Implementation Plan,

…structs the IODE Secretariat, in close coordination with the IODE MG, to prepare the necessary …mentation to register future IODE Decade Actions during the intersessional period,

Explore, through UN Oceans, the interest of relevant UN bodies to develop a joint data and information system under the Decade and to start assessing respective data and information guidelines and policies and identify relevant data and information access and repositories that may contribute to such a system



Restricted distribution

IOC/IODE-MG-2021/5.1
Oostende, 21 December 2020
English only

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How do we fix it? In a nutshell…

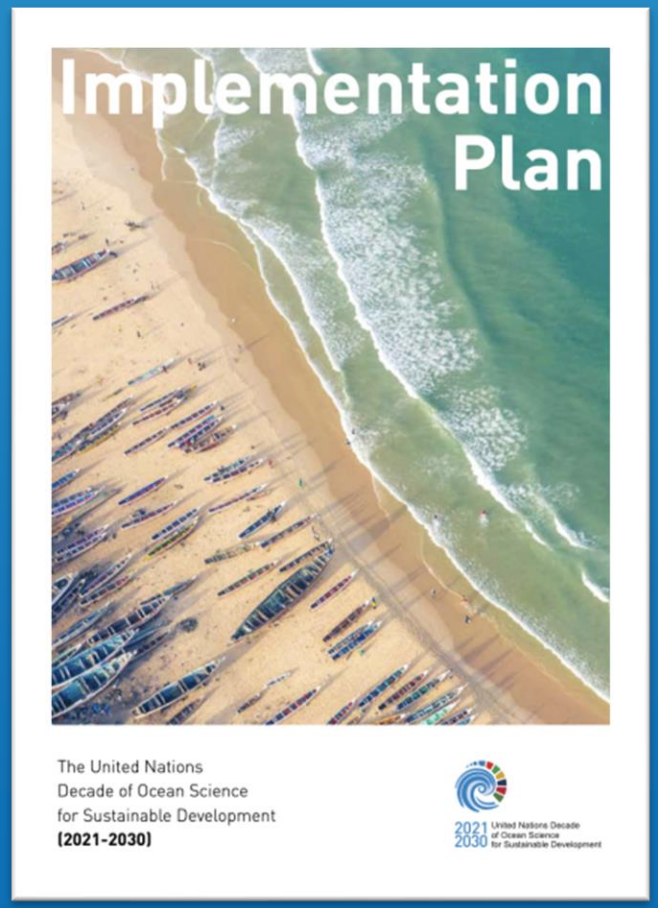
Ocean Decade Data Stewardship should:

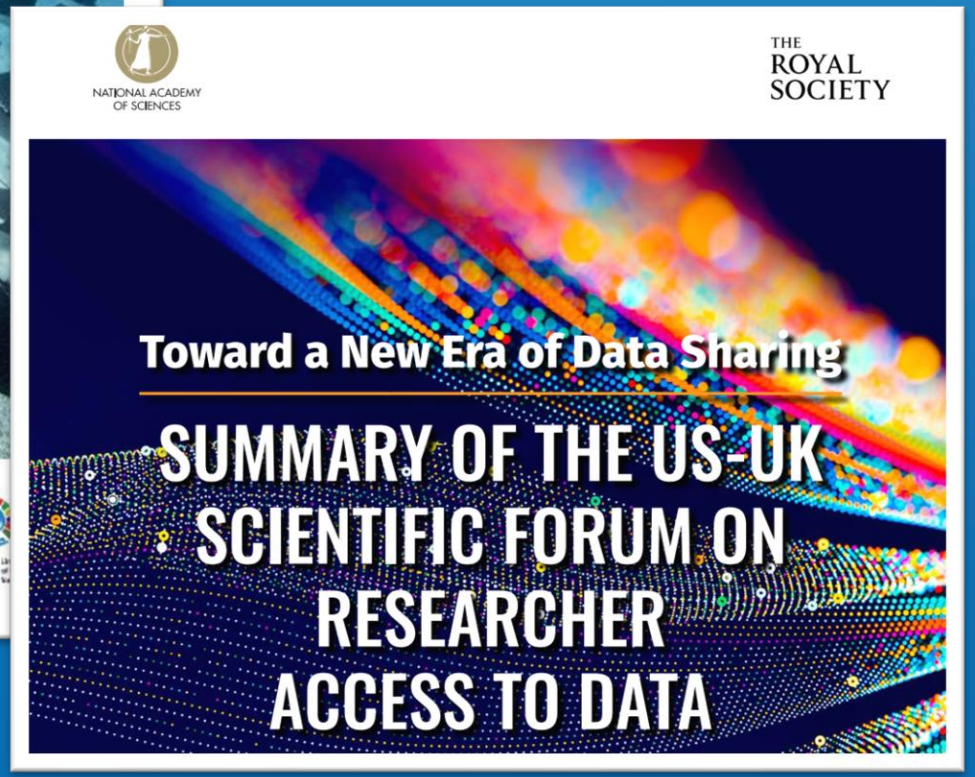
(1) **Get one's own house in order**, using whatever standards and practices make sense to meet local needs challenges and generate quality-controlled (meta)data with full provenance: **fitness for purpose is context dependent**

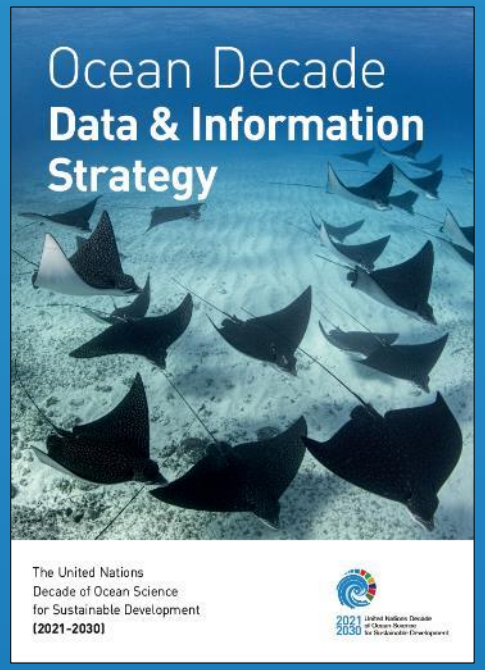
(2) Have a mechanism to **flexibly project (meta)data** into Decade-relevant interoperability layers using regional and/or global conventions/standards (including provenance and quality information)

(3) Build relationships to continuously align and patch gaps in global, regional, and local standards and conventions to meet **real-world needs → develop effective inclusive co-governance/co-development of centralised systems**

Alignment of digital strategy and implementation with global policy and goals







2021 2030 Décennie des Nations Unies pour les sciences océaniques au service du développement durable

unesco
Commission océanographique intergouvernementale

Vision

A trusted, inclusive, and interconnected ocean data and information ecosystem that is actively used for decision making to support sustainable ocean management.

Mission

To catalyse a solution-oriented, global digital transformation for the digital ecosystem we need to overcome the Decade Challenges.

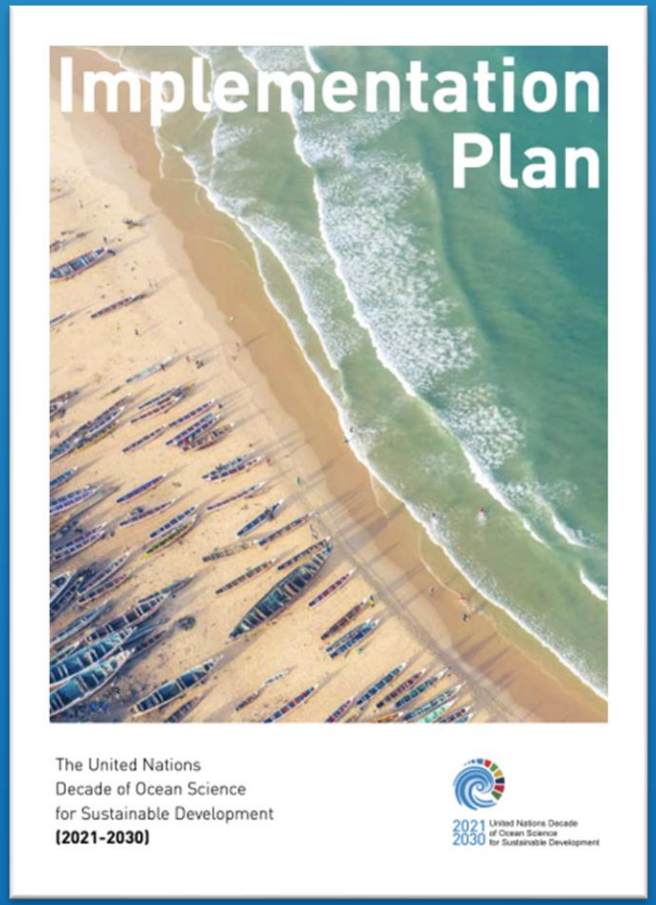
Strategic Objectives

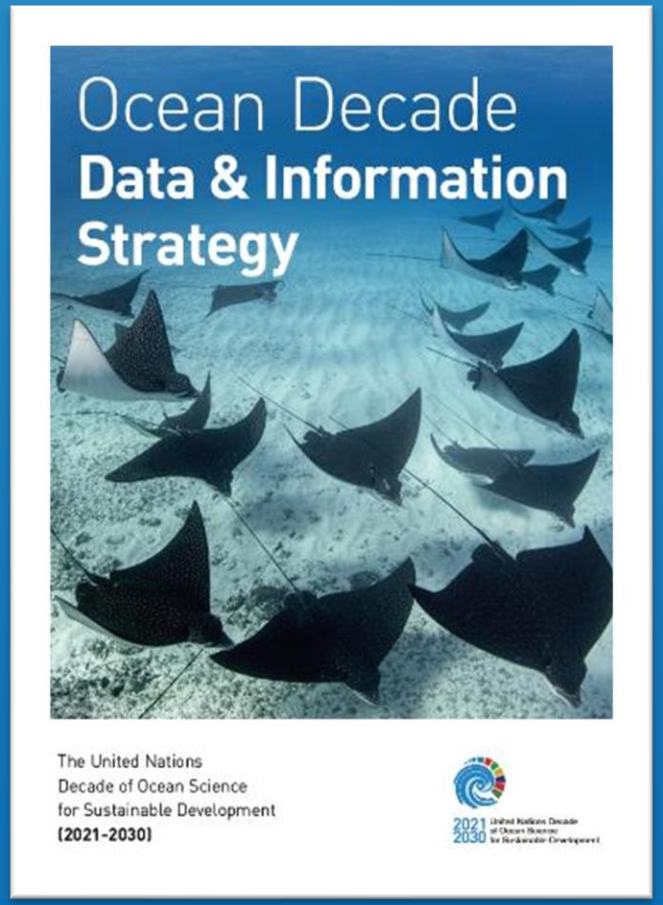
1. **Develop an ocean digital ecosystem** that encourages the sharing and equitable access of multidisciplinary data, information and knowledge by all.
2. **Improve data and information discovery and usability** across the ocean digital ecosystem.
3. **Build trust in data and information** shared across the ocean digital ecosystem.
4. **Prioritise digital solutions** that support decisions for sustainable ocean management.
5. **Expand, empower, and mobilise global communities** to advance and maintain the ocean digital ecosystem.

Enablers

Technological Innovation // Partnerships // Durable Resourcing // Policy & Regulatory Frameworks

Alignment of digital strategy and implementation with global policy and goals





Coming soon

The Data and Information Strategy's Implementation Plan

Data Strategy Implementation Group

Members

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Intergovernmental Oceanographic Commission

Pier Luigi Buttigieg

Kevin O'Brien

Pete Apostle

Corinne Bassin

Pip Bricher

David Currie

Lotta Fyrberg

Hernan Garcia

Aureliano Gentile

Eduardo Klein

Yoav Lehahn

Voahangy Tinah Martin

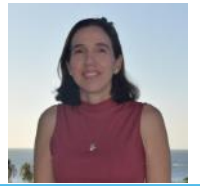
Ana Carol Mazzuco

Aidy Mohamed Muslim

Venkat Shesu Reddem

Greg Reed

Lucy Scott


Paula Sierra Correa

Anna Silyakova

Toru Suzuki

Pramod Thupaki

Sioeli Tonga

Lennert Tyberghein

Marcin Wichorowski

Liu Yulong

Strategy implementation plan – Next steps and timeline

April

- Present Strategy Implementation Plan at Ocean Decade 2024 Conference
- Publish actions on GitHub as they are finalized

4

5

May

- Gather
  partici
- Invite r
  from b

Sign up here to participate in the review and consultation process:

https://www.surveymonkey.com/r/PMF3Q7Z

gust

on and review

tions based on
ub feedback

September / October

- Gather all reviews and comments, including GitHub feedback
- Compile and publish final version

9/10

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2021 2030 Décennie des Nations Unies pour les sciences océaniques au service du développement durable

What's transformative about this strategy and implementation plan?

Data as a first-class, prioritised, and early output of all Actions

Concrete steps to modernise, de-silo, and link data flows across science and sustainable development (ARCO, ACID)

Enhancing capacity to work with data on the web & AI-augmented systems

Operational norms for human and machine agents – data in controlled and ethical action, all the time, everywhere

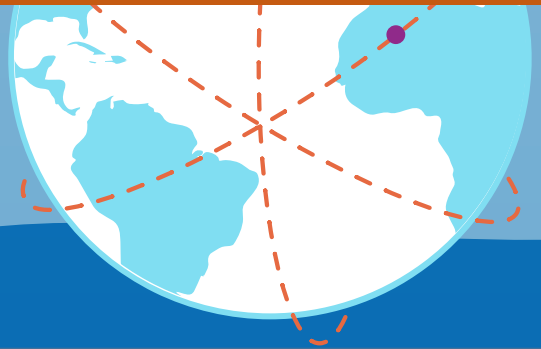
Decoupling data from tooling / software

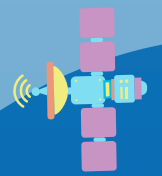
Foundations for new digital economies and marketplaces – new relationships between scientific and societal data

Robust and flexible interoperability is the key

Data swamps →
Data lakes →
Data warehouses / lakehouses →
Data spaces
…and all federated over the Web

One-stop-shops need *global* supply chains





Securing digital supply chains

The Ocean Data and Information System & the Ocean InfoHub project

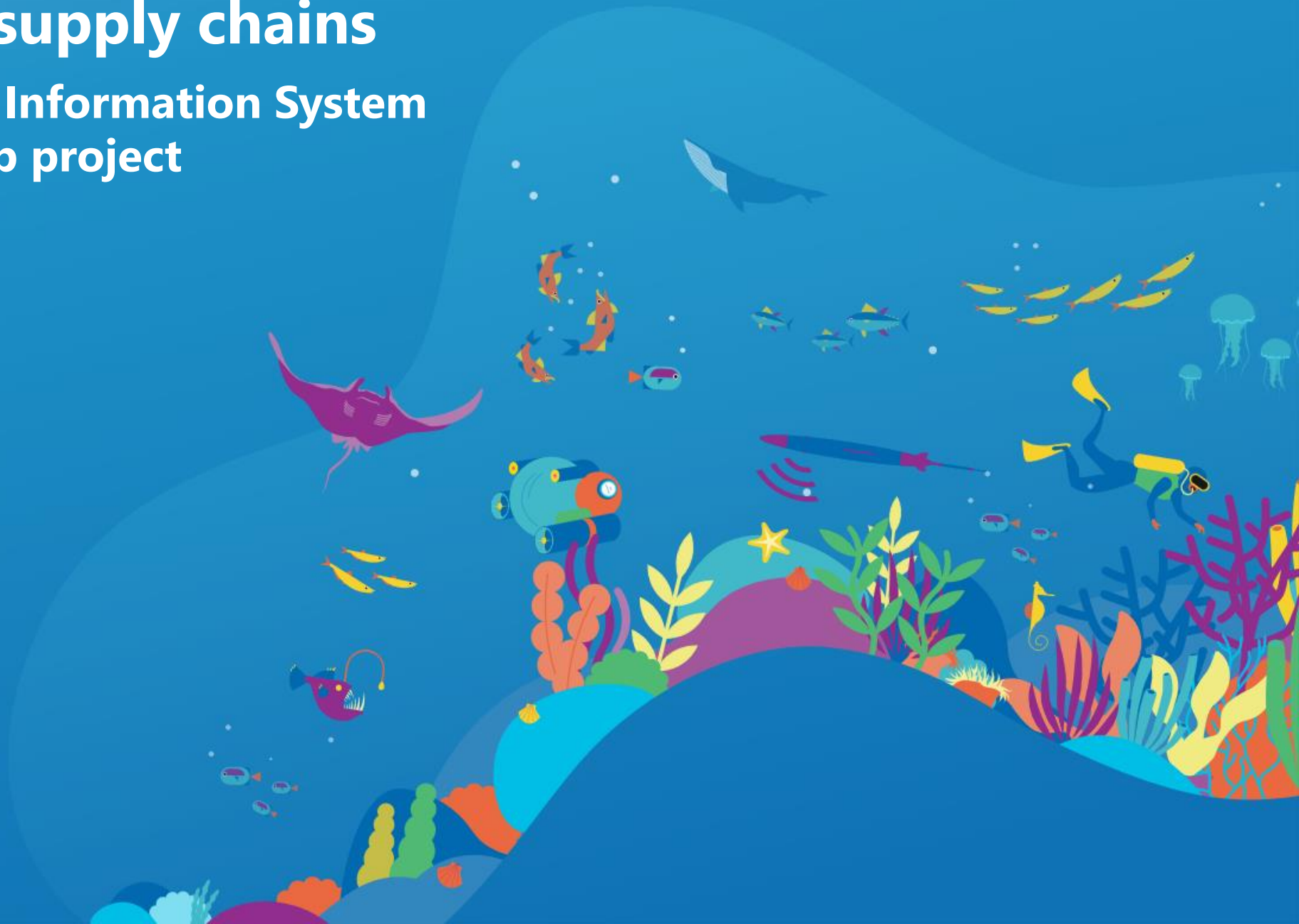
ODIS

OIH

Flanders
State of the Art

IODE International Oceanographic Data and Information Exchange

Full technical documentation at:
https://book.oceaninfohub.org/



The OIH Project & ODIS Federation

- **The Ocean InfoHub (OIH) Project aims to improve equitable access to *global* ocean information, (meta)data and knowledge products for science and sustainable development**
- **Established and expanded a sustainable federation of independent partners: the Ocean Data and Information System (ODIS)**

Pilot regions

Three regions have participated in designing the project and are taking a lead on **pilot projects to test interoperability** between existing information hubs.

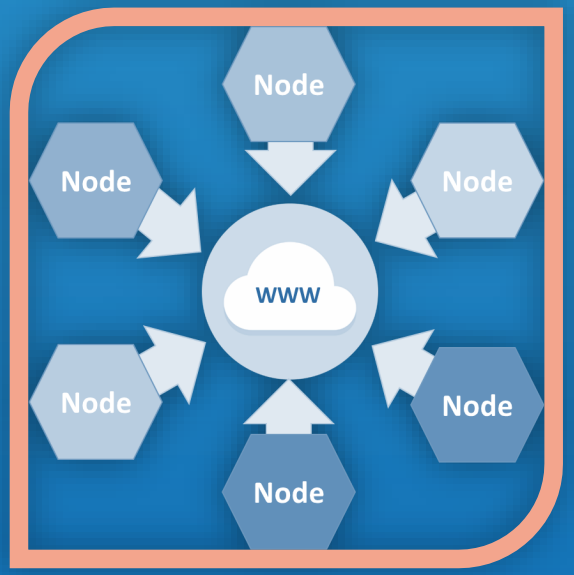
Latin America and the Caribbean

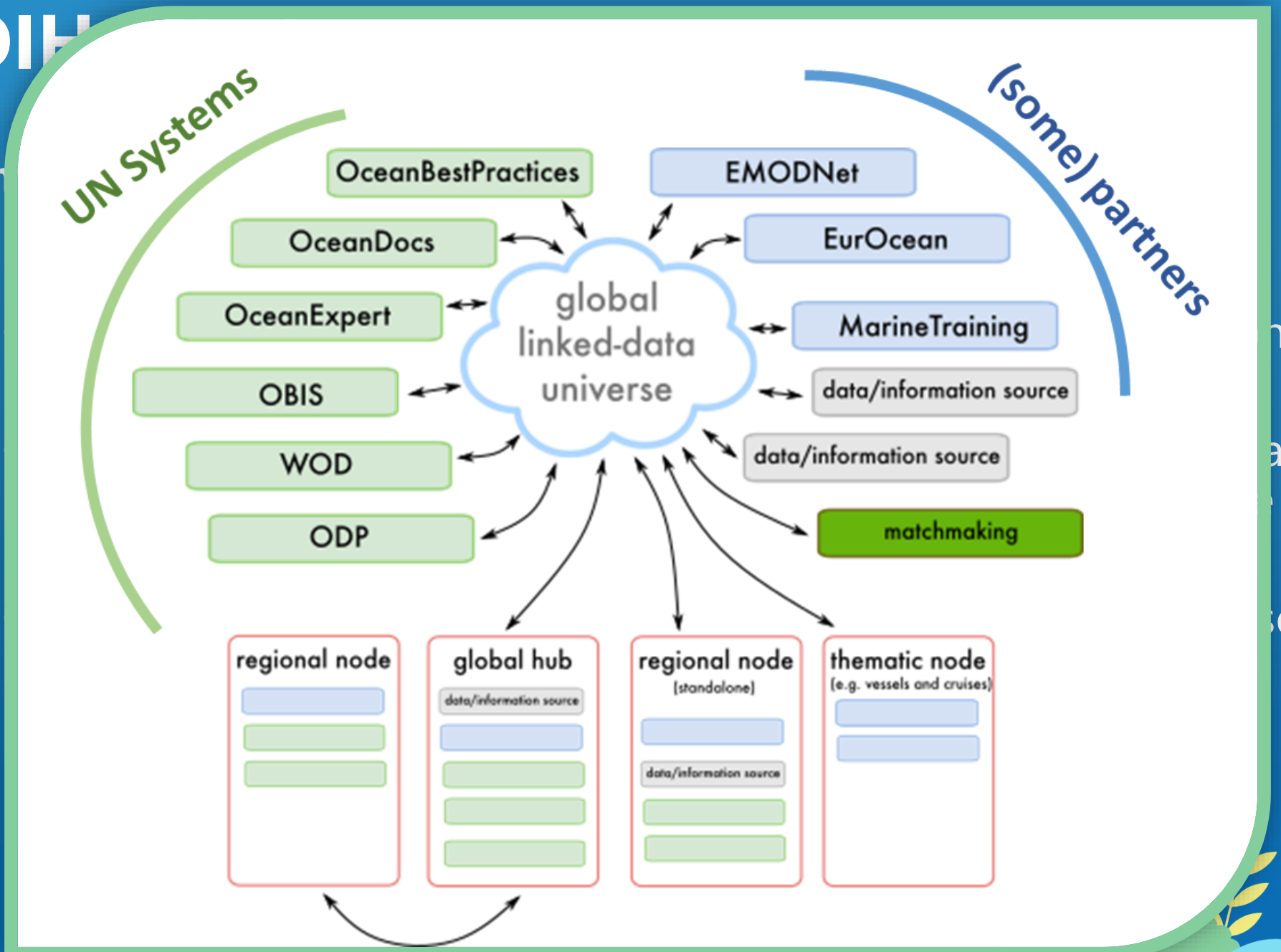
Africa

Pacific Small Island Developing States

The ODIS/OIH

To build a
ecosyste





2021 2030 United Nations Decade of Ocean Science for Sustainable Development

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Digital Twins of the Ocean

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STRENGTHENING BIODIVERSITY OBSERVATION IN SUPPORT OF DECISI

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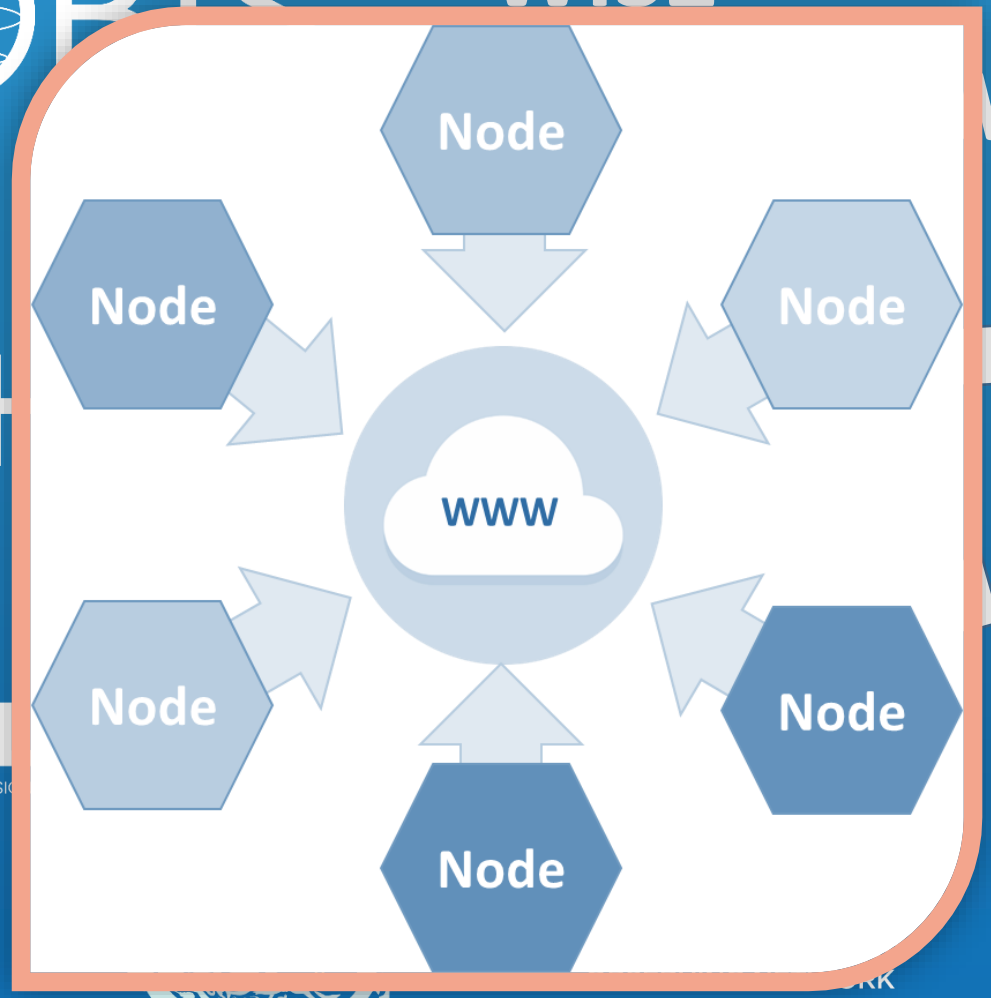
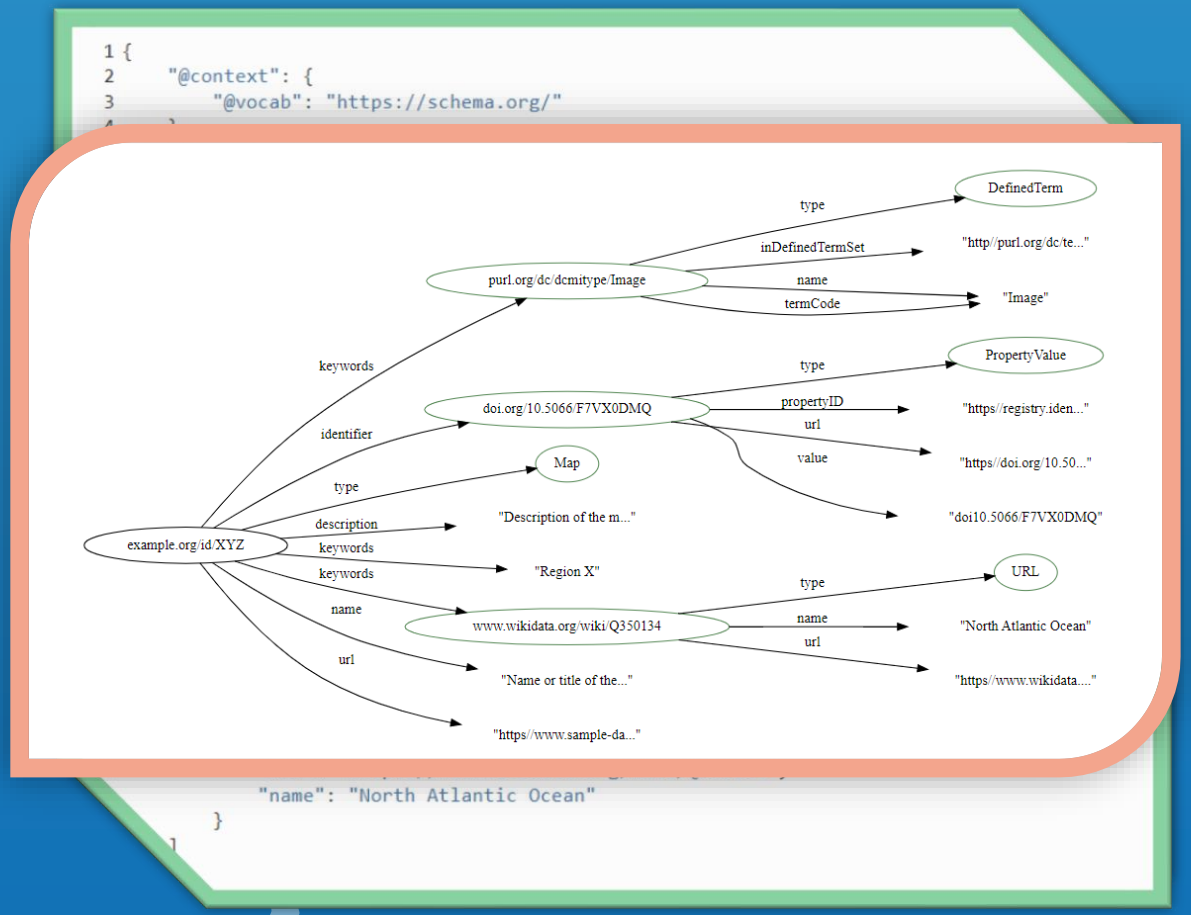


The ODIS-architecture



ODIS links nodes through a JSON-LD+schema.org based, decentralized interoperability architecture (ODIS-Architecture).

Partners aligned to ODIS-Arch are also discoverable by Google, Microsoft, Yahoo, YANDEX, et al.

OIH Dashboard

This dashboard will help monitor the OIH graph, as well as the nodes connected to it.

OIH Graph Summary

Size of OIH graph

12645827 triple

Sitemap s

name
africaioc
aquadocs
bebop
benguela
caribbean
cioos
edmerp
edmo
eurocean
eurocean

OIH Graph Summary

Size of OIH graph

3014339 triples

Keywords

	keywords	count
0	None	258,206
1	Fisheries	14,646
2	Biology	6,946
3	Oceans	4,377
4	Aquaculture	3,950
5	Occurrence	3,623
6	Ecology	3,515
7	GCFI	2,953
8	Température :	2,880
9	Subsurfaceter	2,832

Predicates

Predicate	PredicateCount
http://www.w3.org/1999/02/22-rdf-syntax-ns#type	634,129
https://schema.org/name	229,571
https://schema.org/url	157,230
http://schema.org/name	144,351
https://schema.org/description	111,217
http://schema.org/url	106,276
http://schema.org/keywords	100,168
https://schema.org/knowsAbout	75,084
http://schema.org/description	65,867
https://schema.org/address	53,528

OIH Grap

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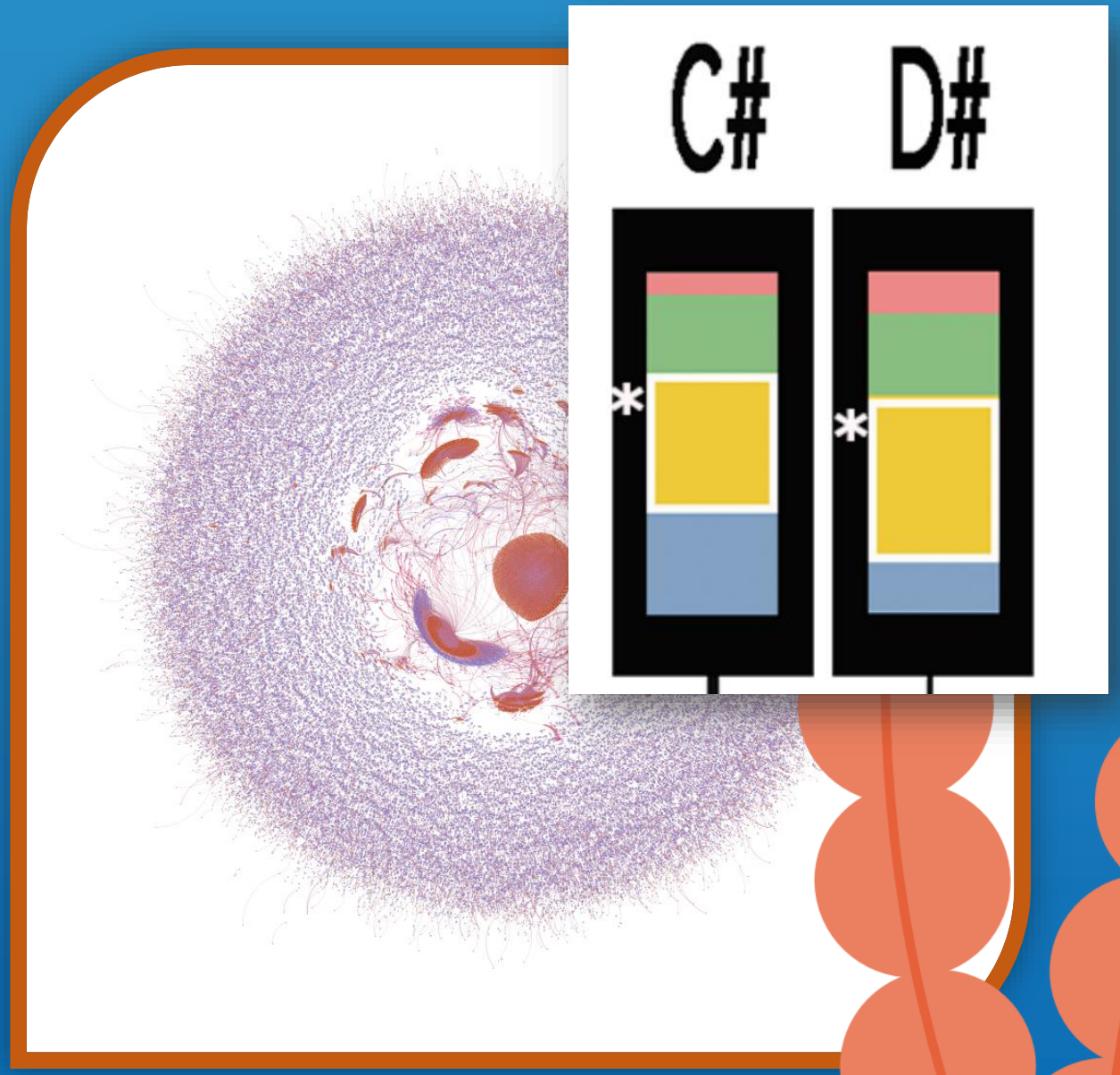
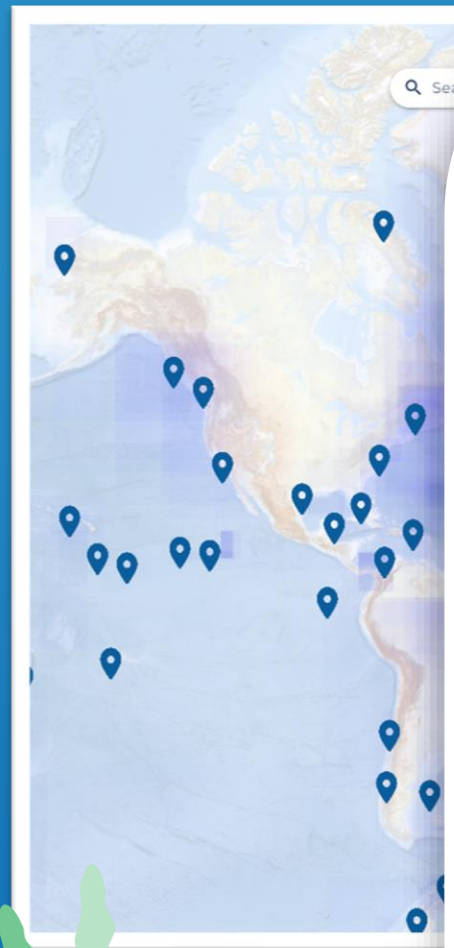
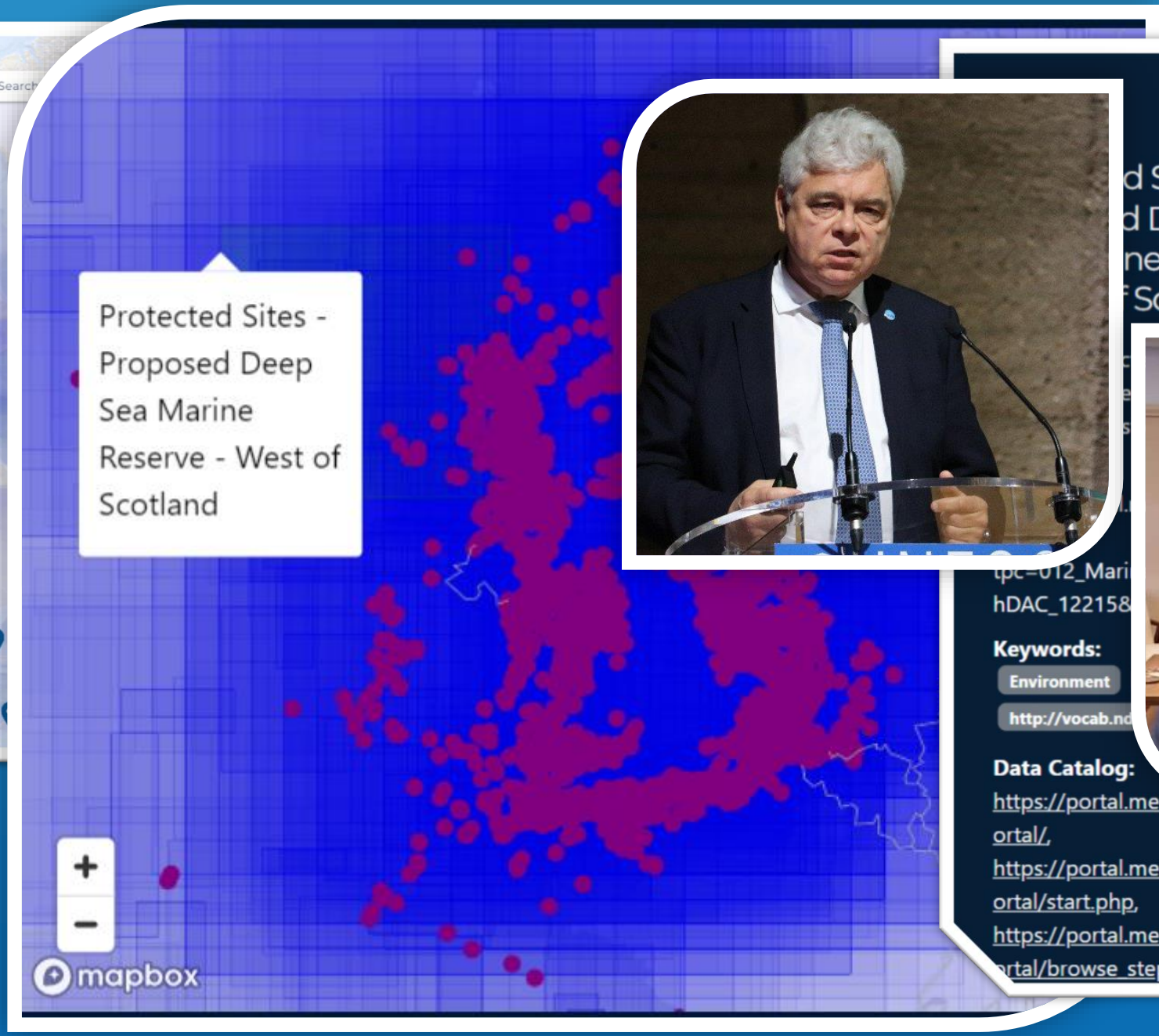
Mapping the ocean's digital ecosystem

Through ODIS, we have better collective intelligence than ever before







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Keywords:

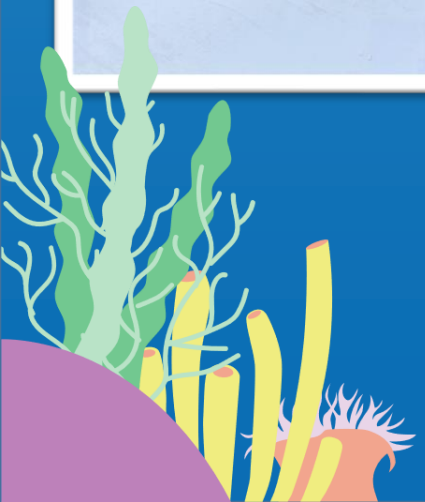
Environment

http://vocab.nc

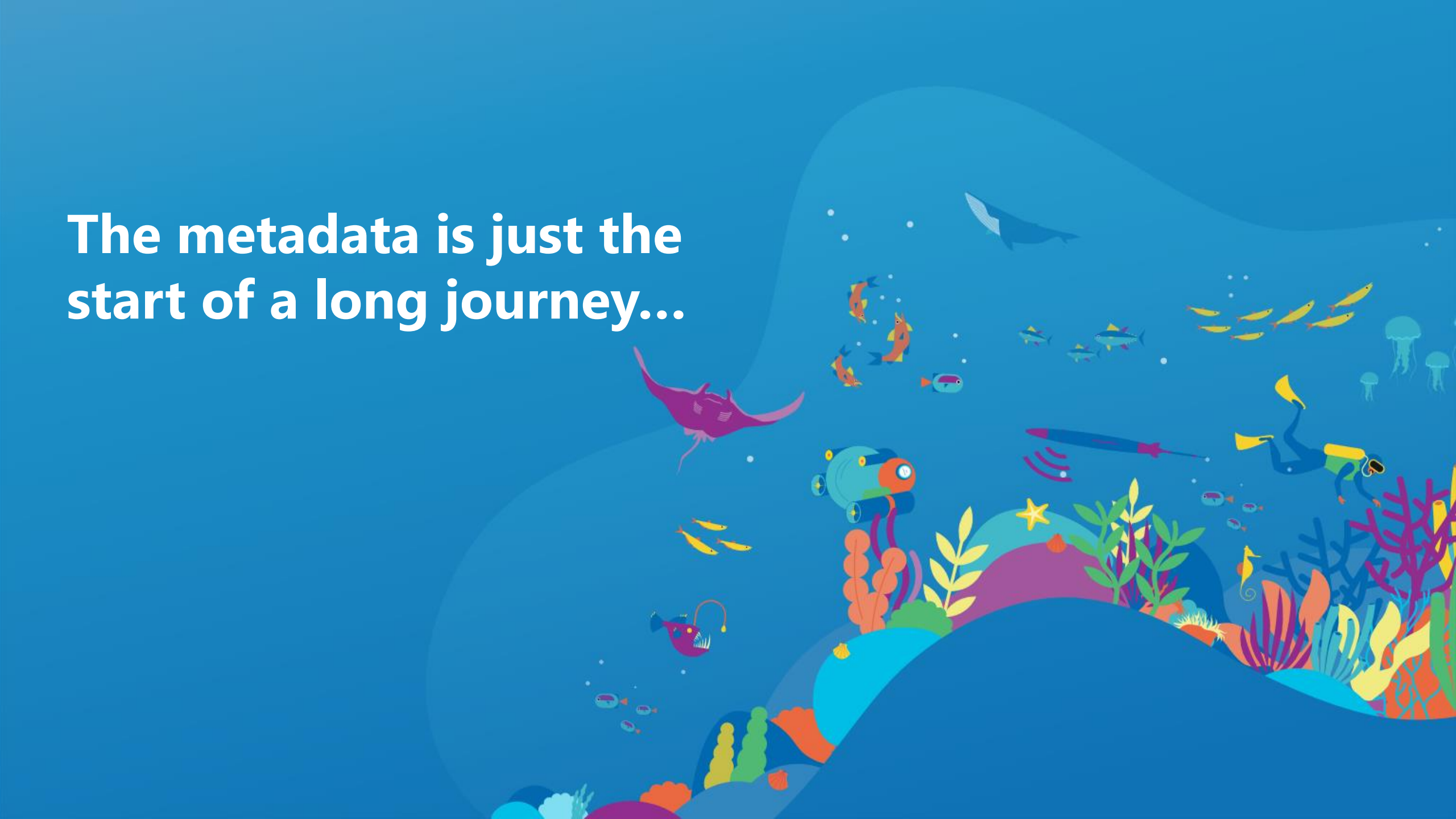
Data Catalog:

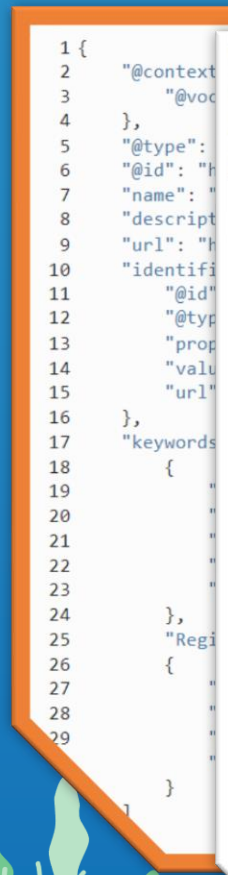
https://portal.medin.org.uk/portal/,
https://portal.medin.org.uk/portal/start.php,
https://portal.medin.org.uk/portal/browse_step.php

We're getting there



The metadata is just the start of a long journey...





Interoperability Architecture for a Digital Ocean (TURTLE)

The "Interoperability Architecture for a Digital Ocean" (TURTLE) project is implemented by SINTEF Ocean, Norway. Its goal is to coordinate ongoing international Digital Twins of the Ocean projects and work towards an interoperability architecture. As initiatives around the globe begin to enhance ocean-oriented digital capacity, there are unprecedented opportunities to power digital twinning.

Currently there are many initiatives that work toward or in support of a Digital Twin of the Ocean, e.g. the EU Digital Twin Ocean system, NOAA's National Centre for Environmental Information, the IOC Ocean Data and Information System ODIS, the IOC Ocean Best Practice System OBPS, the Ocean Data Action Coalition and the UN Data Coordination Group.

DITTO's Priority Activities are

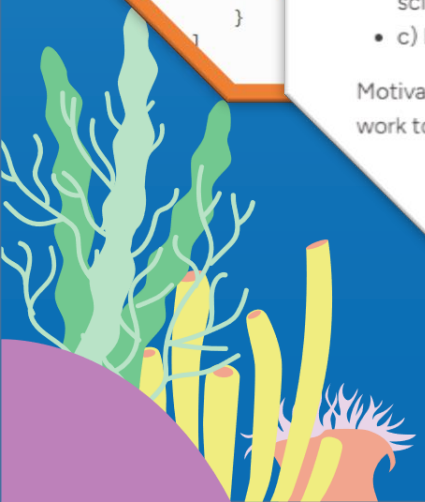
- a) Articulate and advance a common understanding of Digital Twins of the Ocean architecture.
- b) Advance a number of "use case" prototype Digital Twin applications across the spectrum from science, engineering and operations; and
- c) Encourage the formulation of DITTO related Decade Projects.

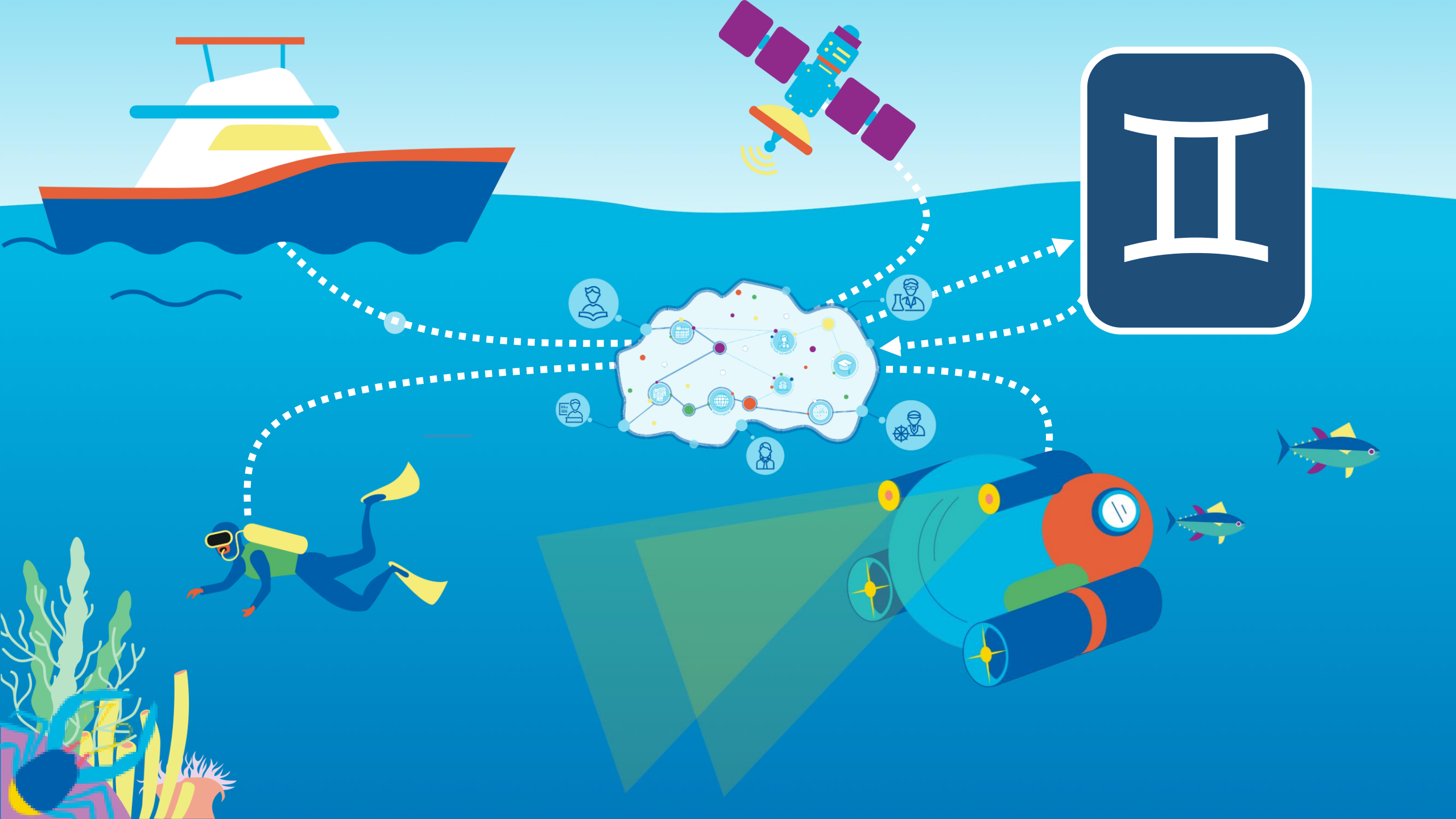
Motivated by this, TURTLE proposes to coordinate ongoing initiatives to address priority activity a) and work towards an interoperability architecture for the Digital Twins of the Ocean.

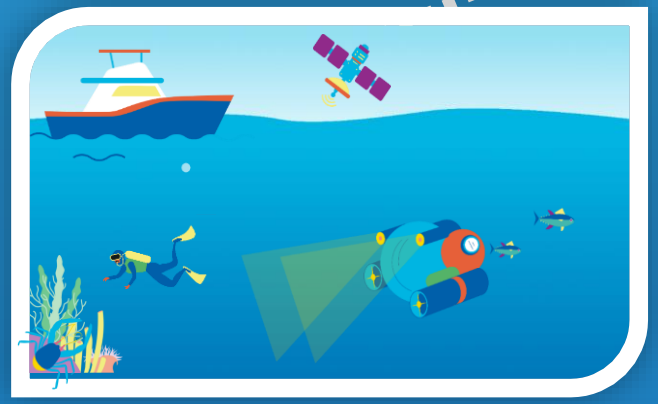
Project date:
01/09/2022 - 31/12/2025

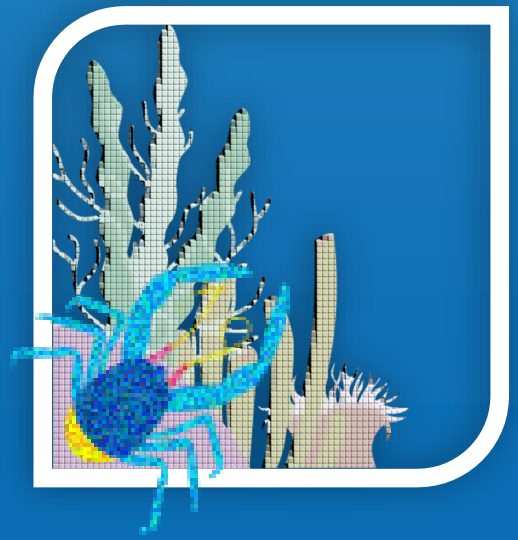
Contact for this project:
Ute Brönner

Project Link:
Interoperability Architecture for a Digital Ocean (TURTLE)









ETL mod

Model & ML stack

Virtualisation/UX modules

What if a new species invades?

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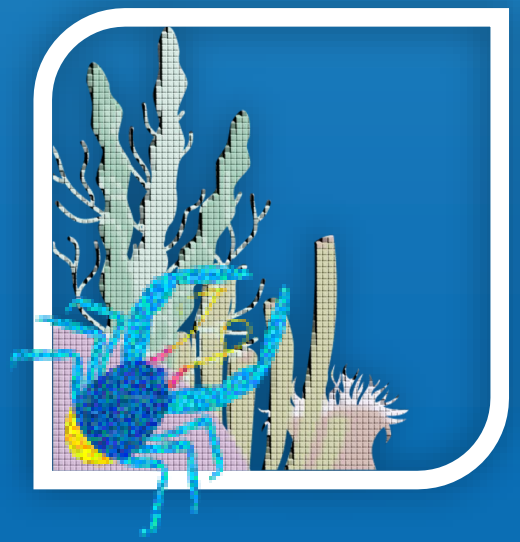
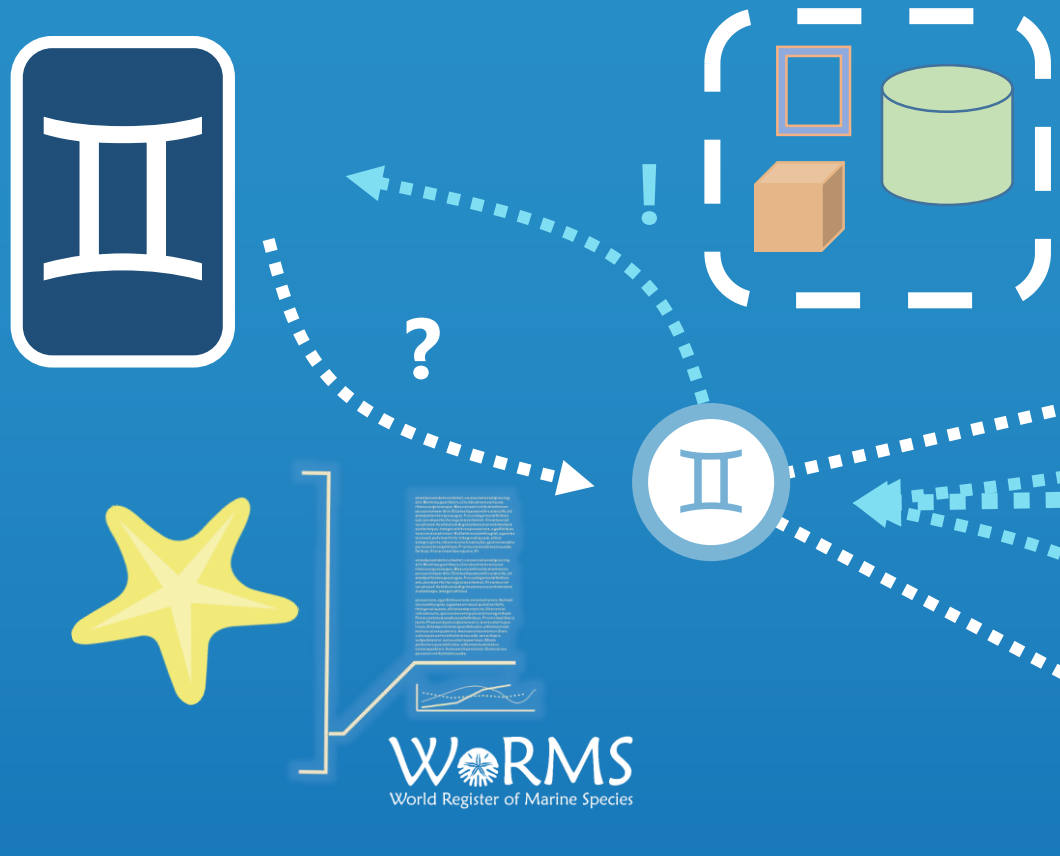


ETL modules

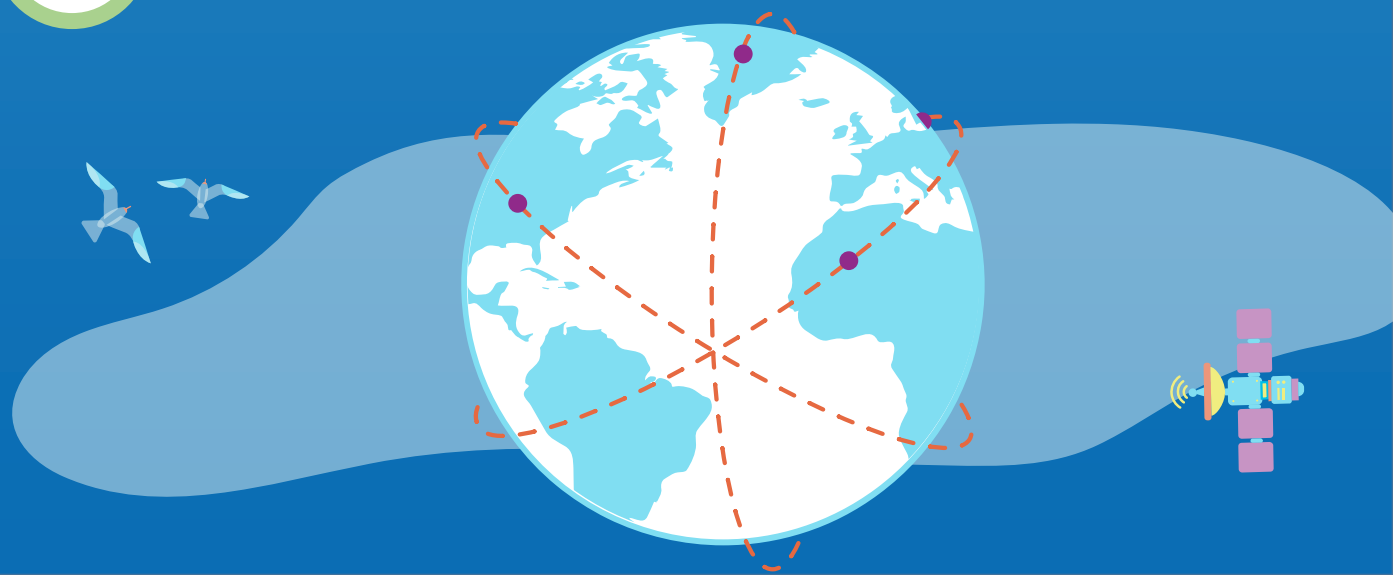
Model & ML stack

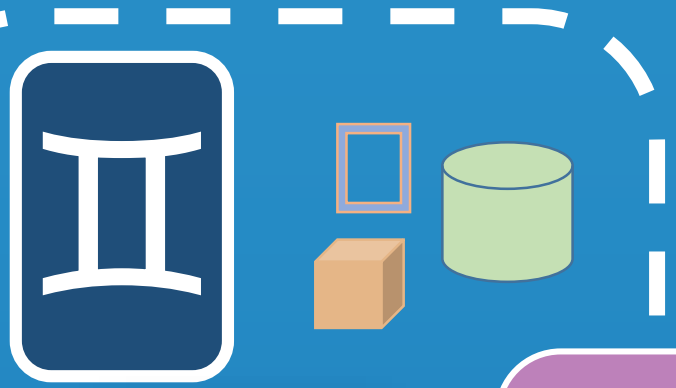
Virtualisation/UX modules

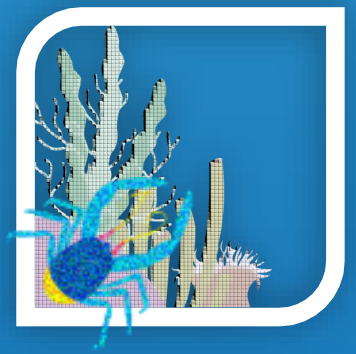
Robust and flexible interoperability is the key



One-stop-shops need *global* supply chains





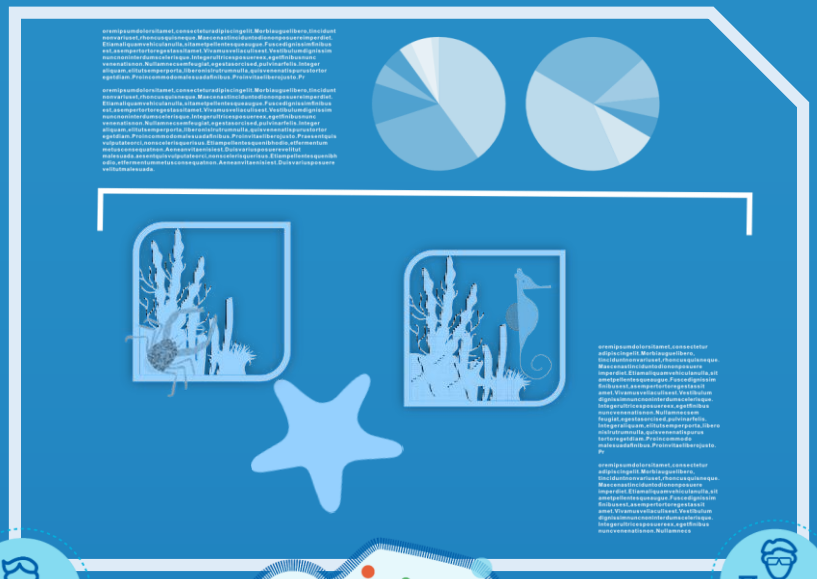


Cost estimation

$¥€£

CO_2

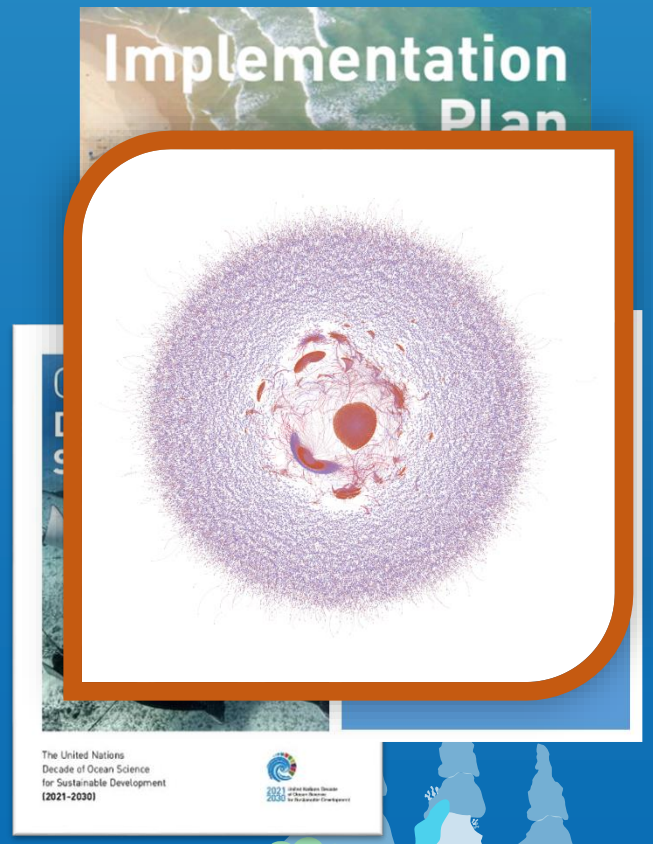
What if a new species invades?



***Rapidly** publish data papers, policy briefs, etc with twin data products*

What if a new species invades?

2021 2030 United Nations Decade of Ocean Science for Sustainable Development



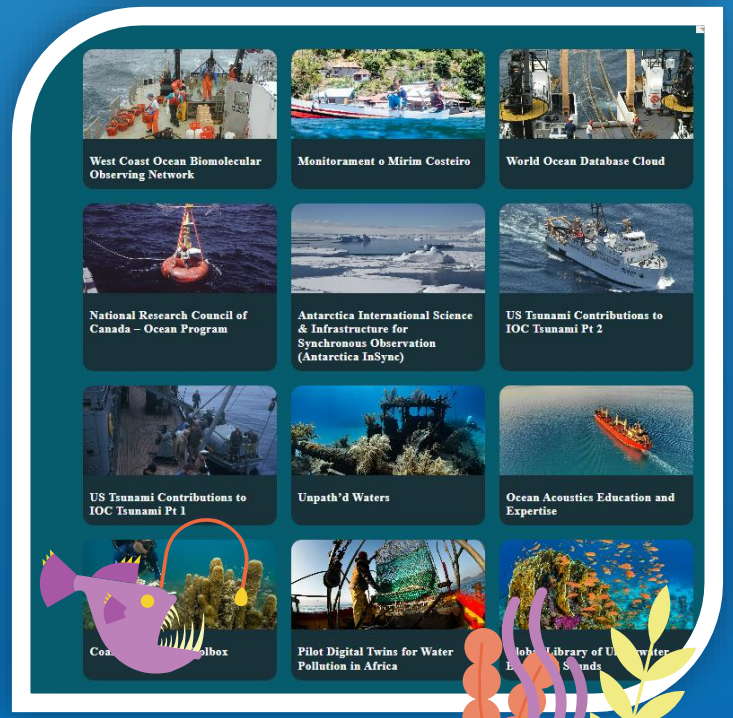
VS

- The weakening of global multilateralism
- Increased desire for technological and data sovereignty
- New regulatory frameworks and competition

Splinternet
(cyber-balkanisation)

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

A programme for data leads in each Action



OceanData2030

DIS

IH

OBIS

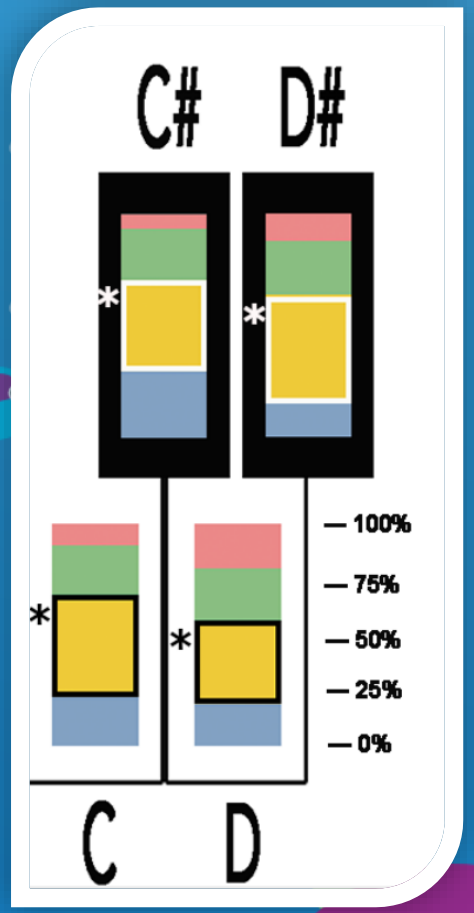
DITTO Digital Twins of the Ocean

OBON OCEAN BIOMOLECULAR OBSERVING NETWORK

Marine Life 2030

Concluding words

- The past five years has seen the vision of ocean data commons taking form
- MEDIN has been a leading example in the foundation of a global map of ocean data and digital resources
- The next five years will be critical:
  - If we – as a global community – can co-implement the UN Ocean Decade Strategy, we will all be able to pool capacities to address the Decade Challenges, SDGs, regional, and national scientific and societal needs



Flanders
State of the Art

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