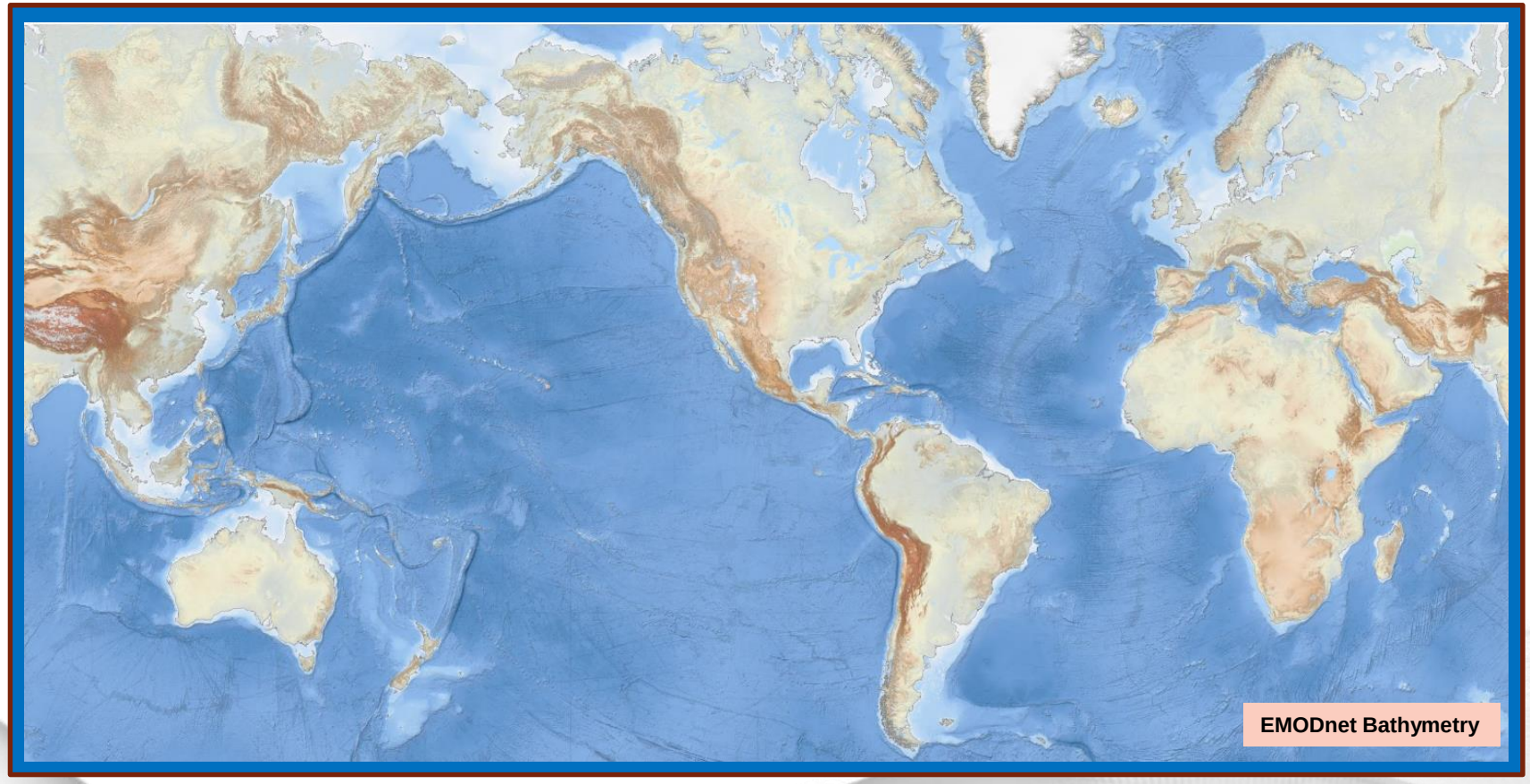
Eurofleets+
An alliance of European marine research infrastructure
to meet the evolving needs of the research and industrial communities

European marine and ocean data management and how to handle data from scientific cruises in Eurofleets+

Dick M.A. Schaap

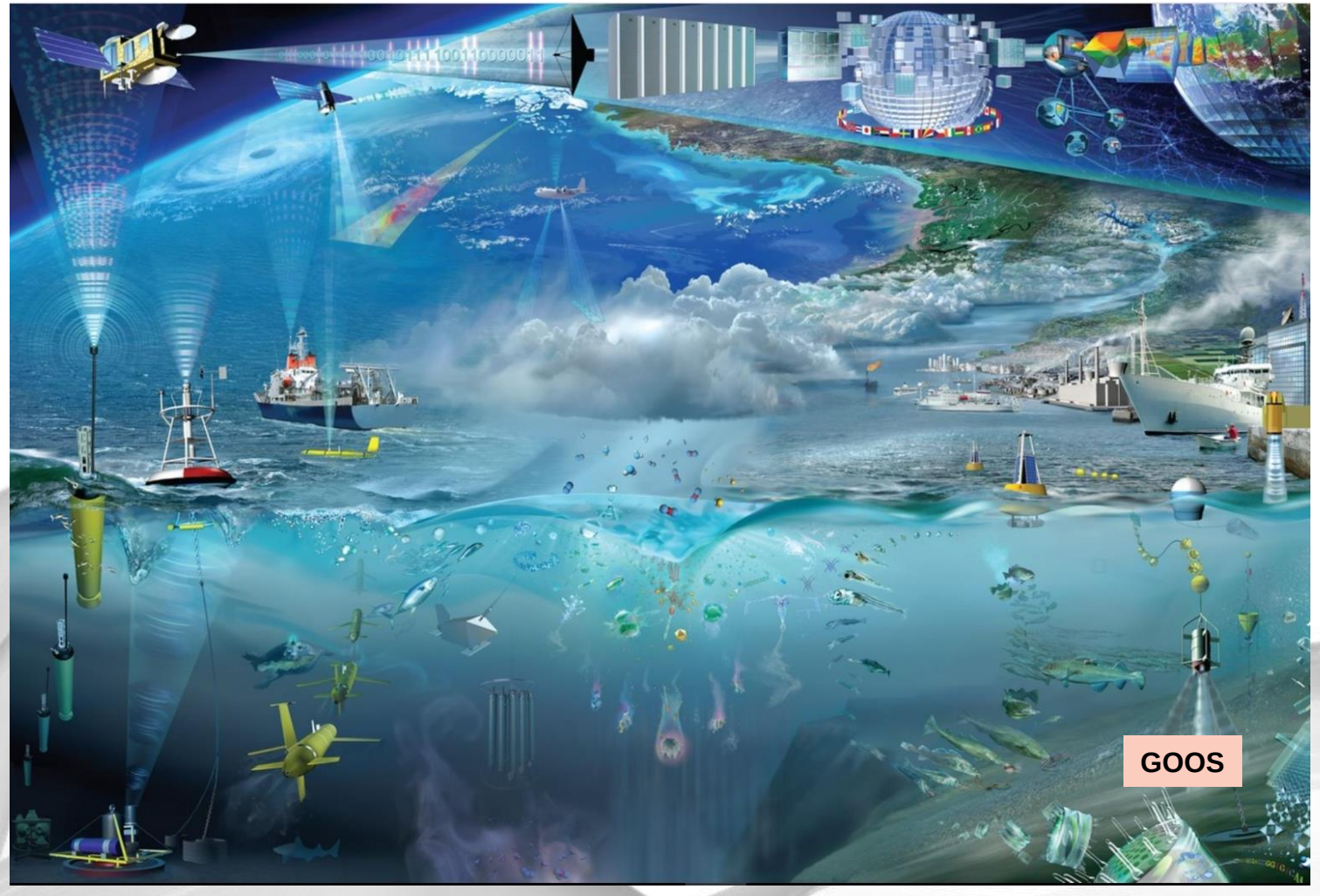
MARIS

Oceans and seas are important



Climate, Energy, Food, Tourism, Trade, Health, ….

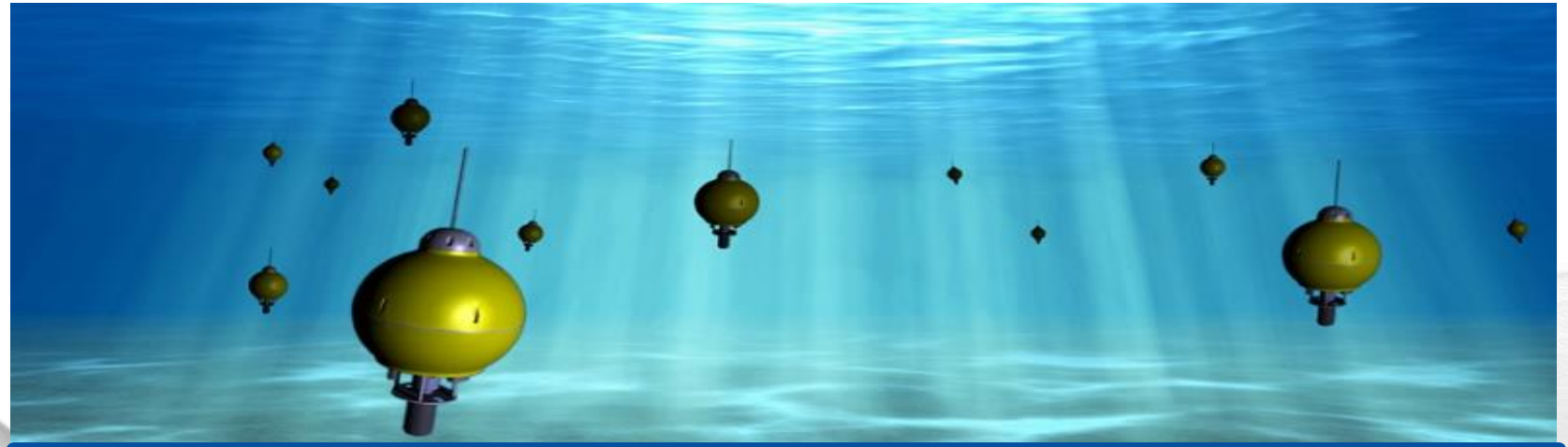
Acquisition of marine and ocean data



- Scientific Research to gain knowledge and insight
- Modelling (including hindcast, nowcast, forecast)
- Economic activities: shipping, offshore industry, dredging industry, fisheries, tourism, engineering ..
- Environmental Management: monitoring and assessment (water quality, climate status, stock assessment)
- Marine Conventions and Directives, in Europe: Water Framework Directive (WFD), Marine Strategy (MSFD), Marine Spatial Planning (MSP), Coastal Zone Management
- EU Strategies, such as Green Deal, Blue Environment, Blue Economy

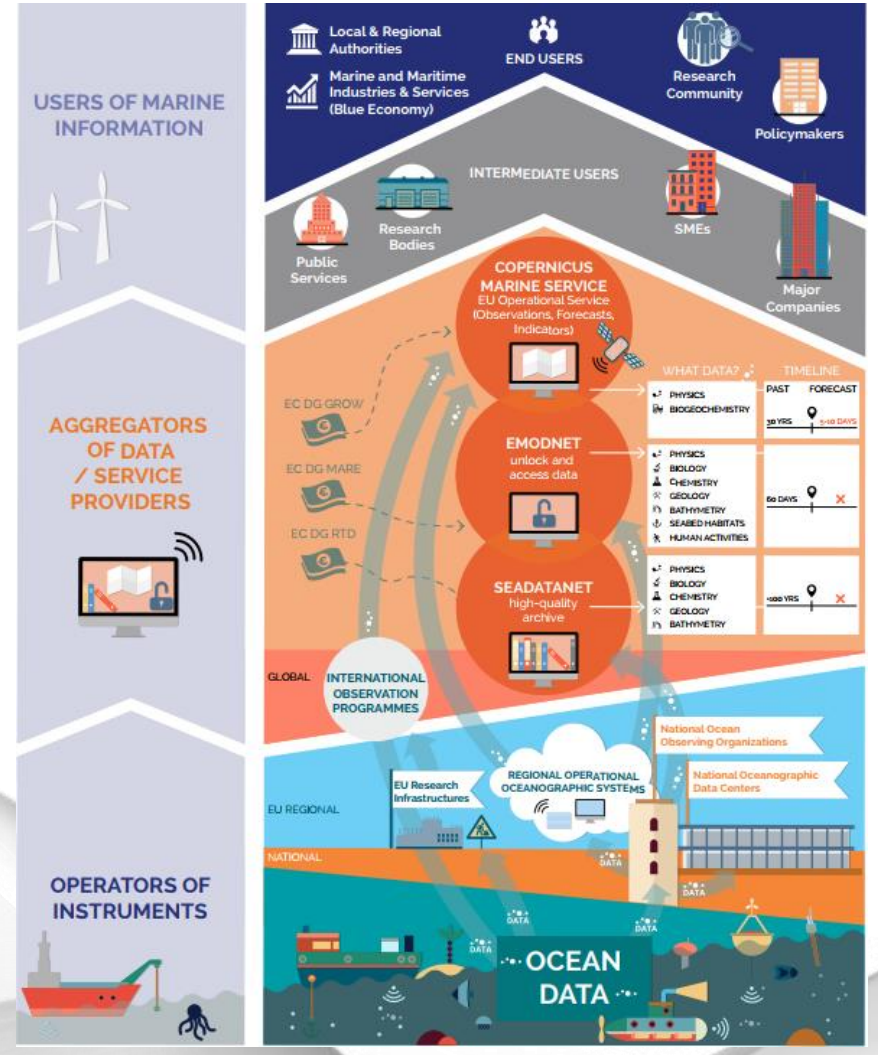
Economy of data acquisition

- Data are collected by governments, research institutes, and private industry: in Europe already more than several thousands of organisations)
- Data for physics, geophysics, meteorology, chemistry, biology, geology, bathymetry
- Acquisition of oceanographic and marine data is expensive; annual costs in Europe estimated at **1.4 Billion Euro** (1.0 = in-situ; 0.4 = satellites)



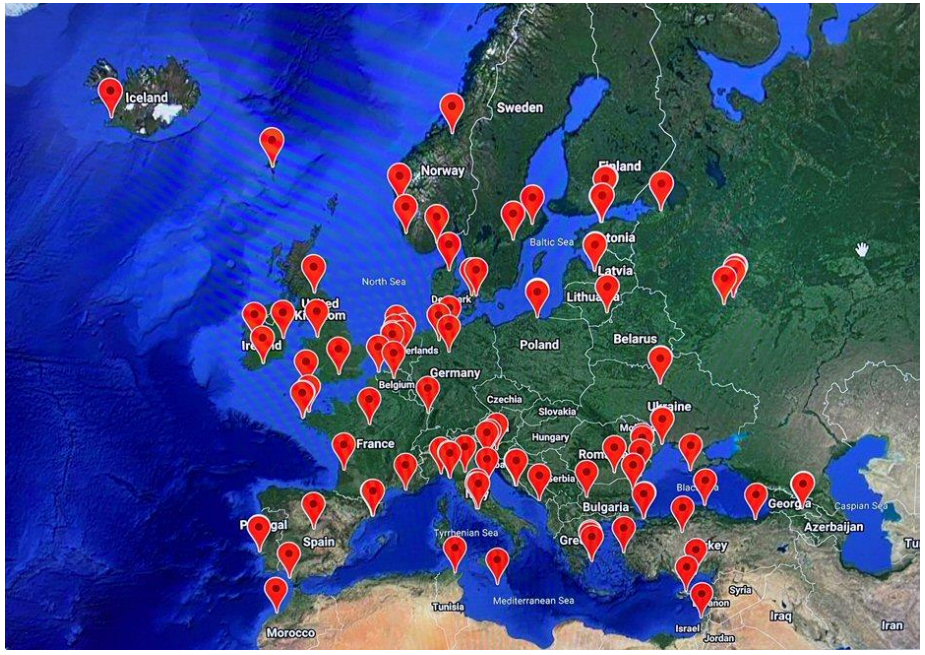
Professional data management is required with agreements on standardisation, quality control protocols, long term archiving, catalogues, and access

European landscape of marine data management



Data aggregators and providers of data products and services

What is SeaDataNet?



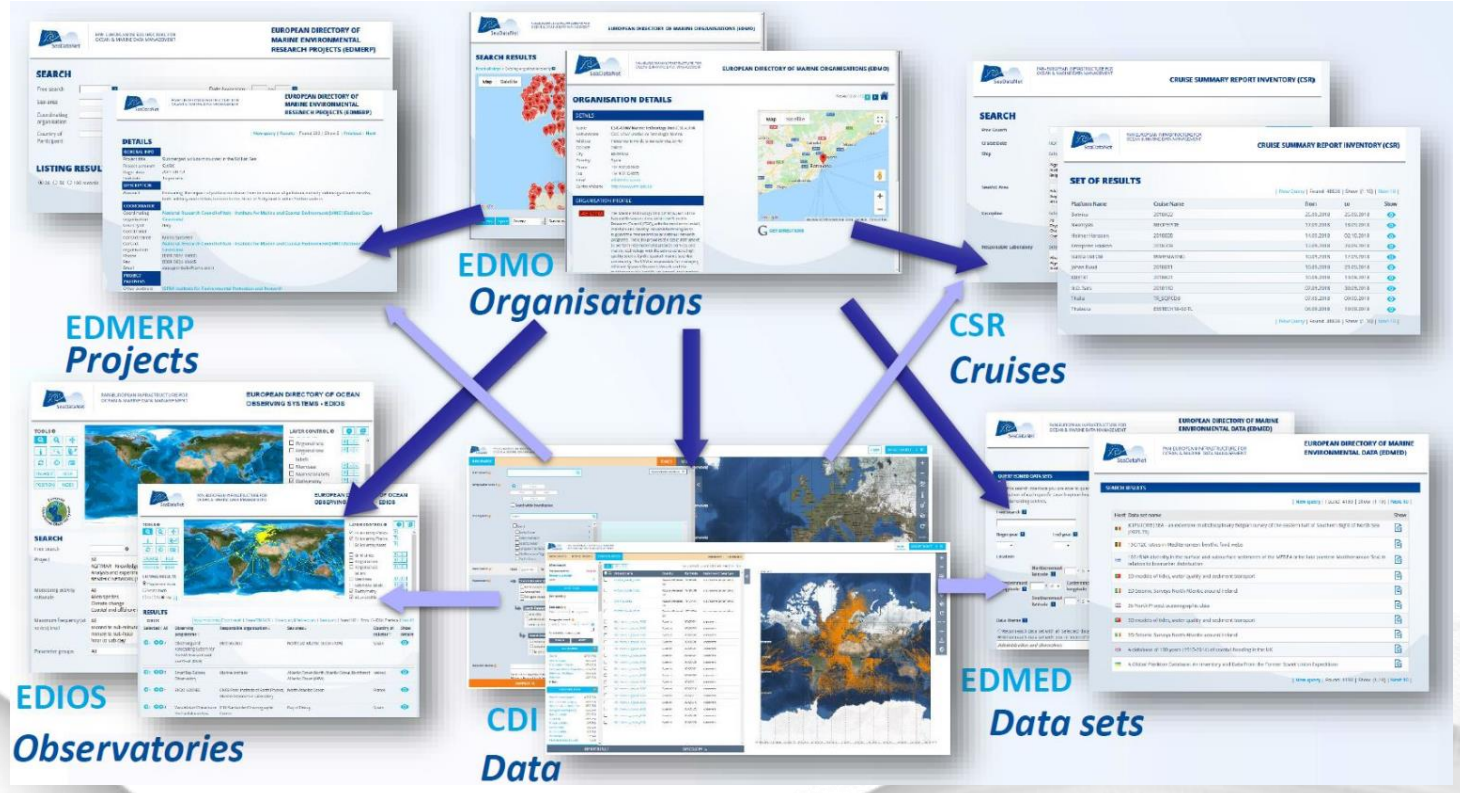
A pan-European infrastructure, initiated and set up by the NODCs and marine data focal points of 34 countries bordering the European seas

90s	Metadata directories Medar/MedAtlas
1998-2001	EuroNODIM (FP3)
2002-2005	Sea-Search (FP5)
2006-2011	SeaDataNet (FP6)
2011-2015	SeaDataNet II (FP7)
2016-2021	SeaDataCloud (H2020)

SeaDataNet AISBL since 2019

- Developing and maintaining of standards and associated tools, services, and guidance for metadata and data formats, and controlled vocabularies for handling many data types and disciplines, deploying FAIR and INSPIRE principles
- Providing training and support to data centres for uptake of standards, tools, and services in their operation
- Developing technological skills for uptake of emerging technologies and principles
- Developing and publishing integrated data products such as T&S climatologies
- Being a major player in the European ocean and marine data management landscape supporting EU initiatives like EMODnet, CMEMS, and EOSC and working together with several Research Infrastructures (RIs), also in the Blue-Cloud

European Directory services



- *User Interfaces*
- *Machine-to-Machine services:*
  - *SparQL*
  - *SOAP web services*
  - *API's*
  - *Linked Data Principle*
  - *Schema.org*

Maintaining and publishing a series of Pan-European directories

SeaDataNet standards

"Making Data and Services:

- *Findable*
- *Accessible*
- *Interoperable*
- *Re-usable*

for machines and people."

- **Common standards for the marine domain**, adapting ISO and OGC standards and achieving INSPIRE compliance:
  - **Metadata formats for data sets, research cruises, monitoring networks, organisations, and research projects**
  - **Standard data exchange formats** : **ODV ASCII and NetCDF (CF),** fully supported by controlled vocabularies
  - **Controlled Vocabularies** for the marine domain (>90.000 terms in 110+ lists), with international governance and web services
- Maintenance and dissemination of standard QA-QC procedures, together with IOC/IODE and ICES

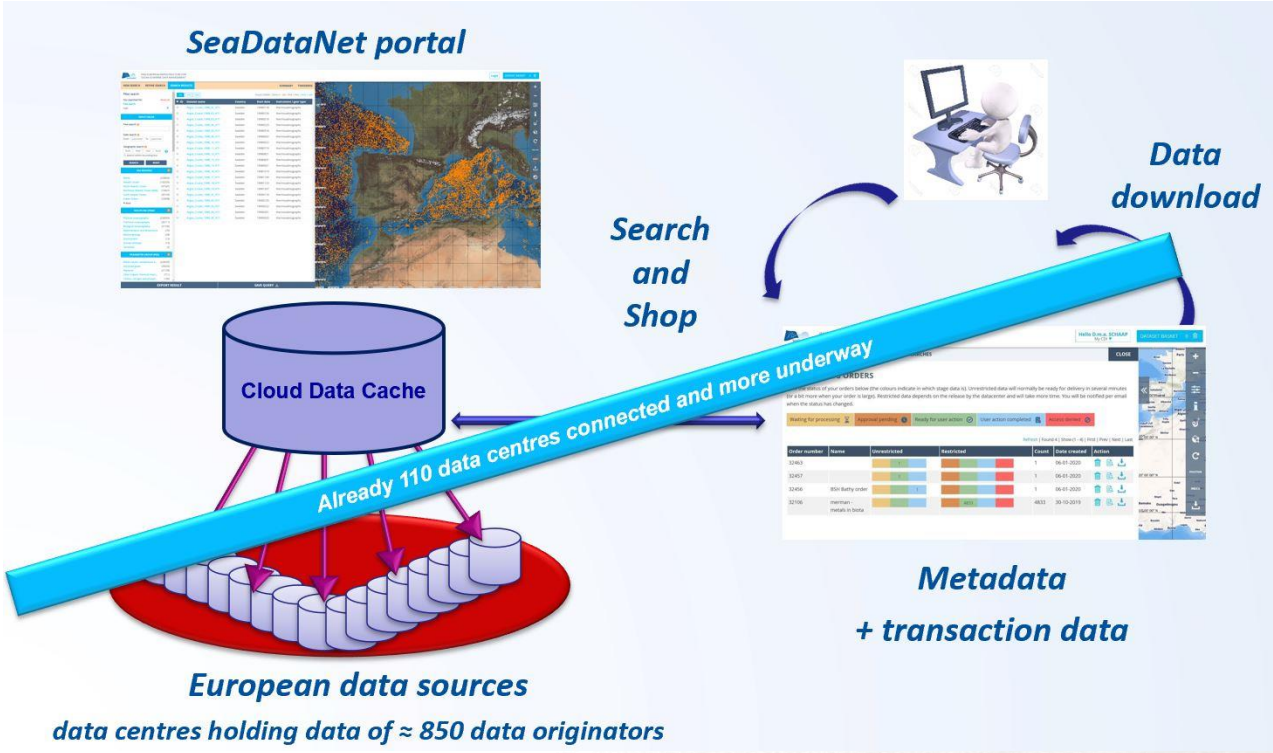
CDI Data Discovery & Access Service

Cooperation with EUDAT, European e-infrastructure of academic computing centres

EUDAT

As part of:

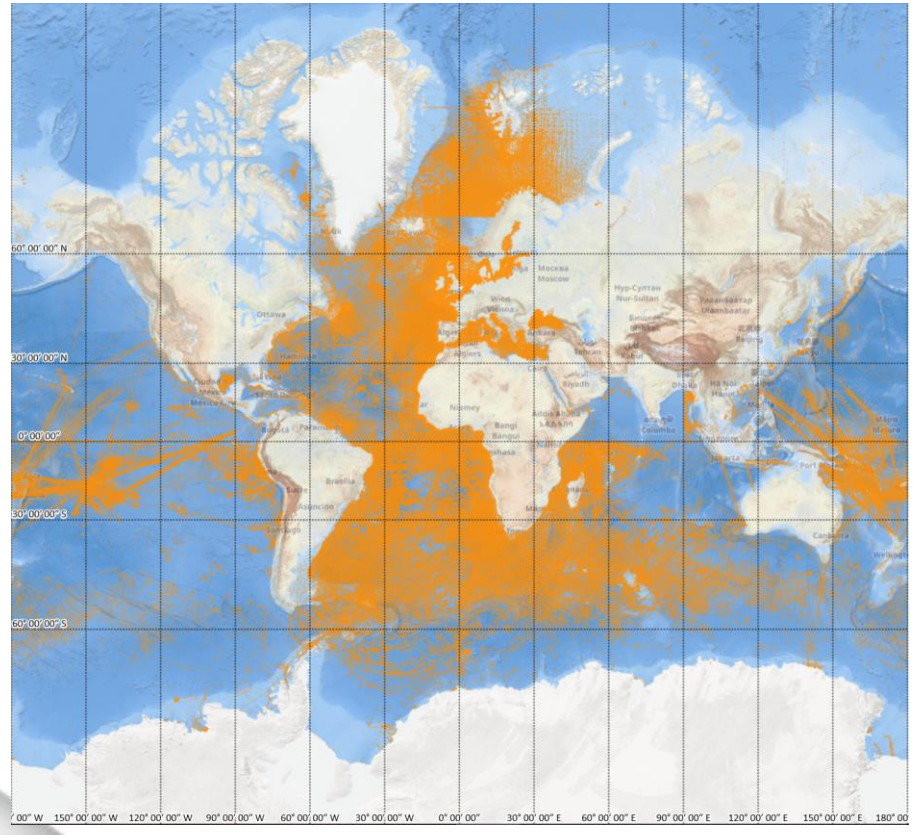
SeaDataCloud

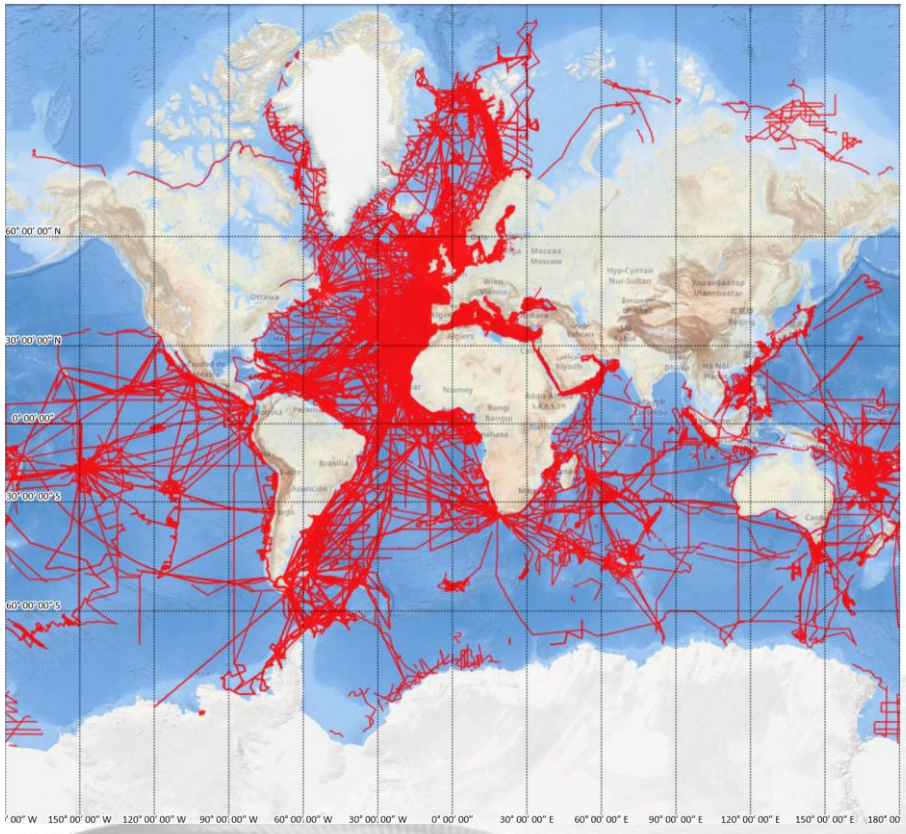


https://cdi.seadatanet.org/search

Providing harmonized discovery and access to marine and ocean data sets for physics, chemistry, geology, bathymetry, biology, and geophysics

CDI Data Discovery & Access Service



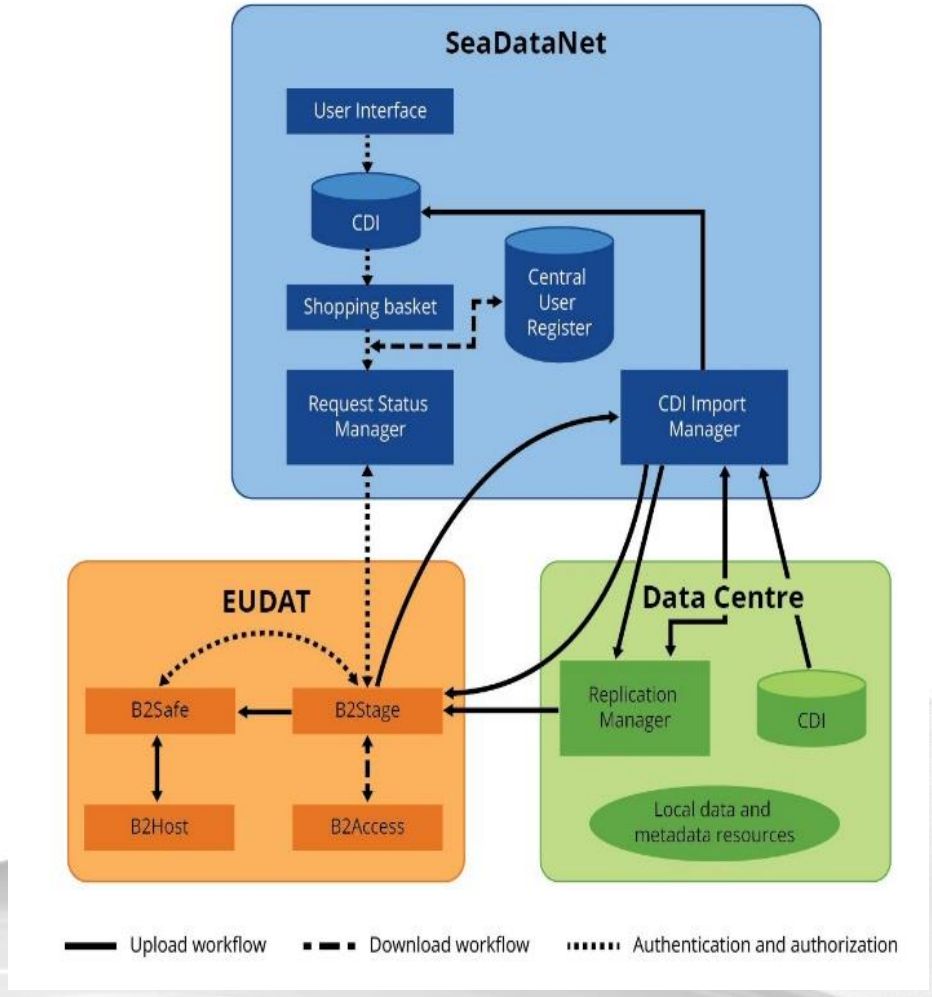


Nov 2022: more than 2.8 million CDI entries for physics, chemistry, biology, geology, bathymetry, and geophysics, from 117 data centres, located around the European seas, and 907 data originators.

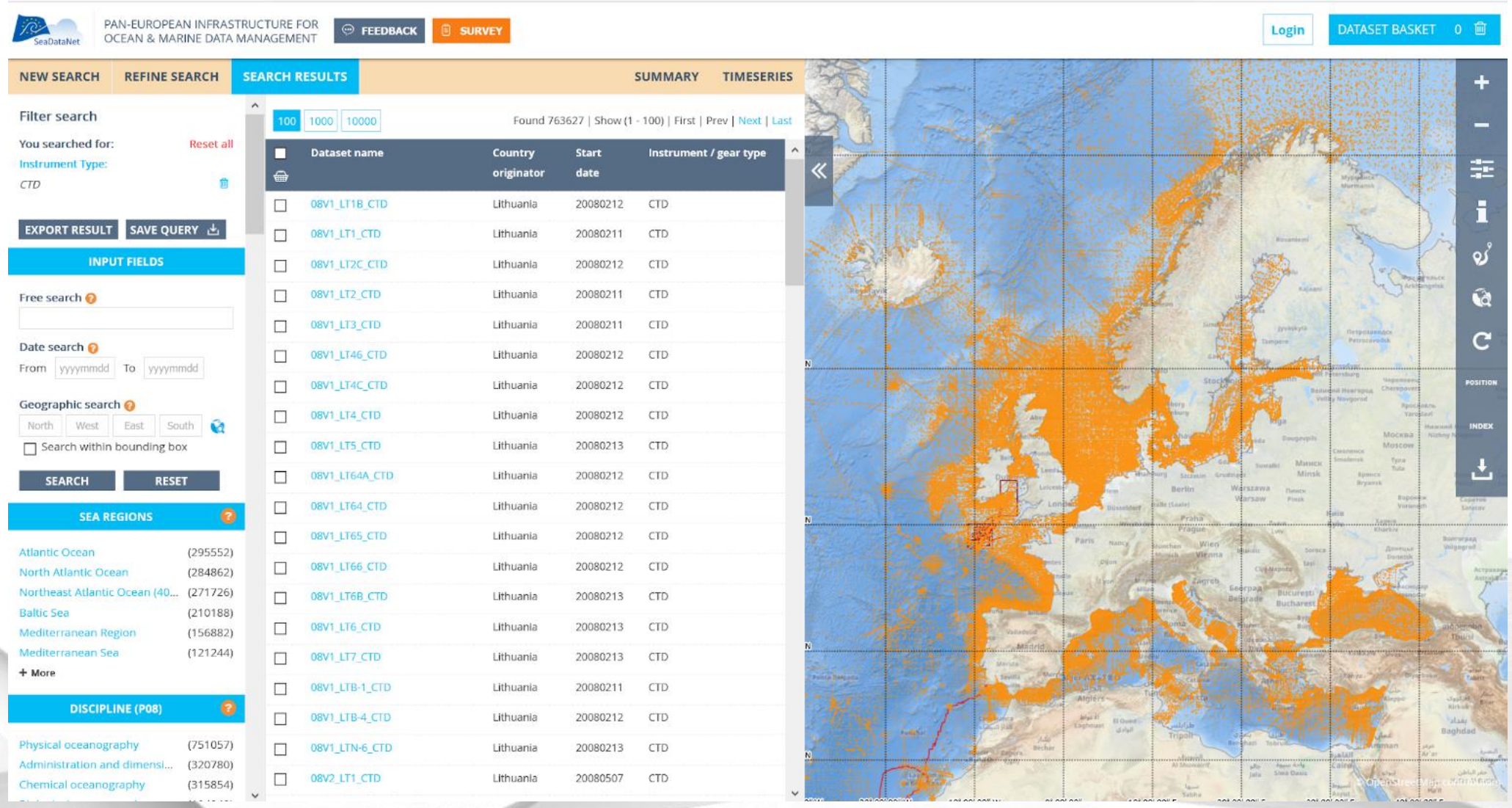
https://cdi.seadatanet.org/search

CDI service architecture

- **Local software tools** at data centres to prepare CDI metadata and data ingestions
- **Replication Manager** (RM) at data centres for transfer entries from data centres to central CDI catalogue and EUDAT data cloud
- **EUDAT cloud** with adapted EUDAT services to store unrestricted data sets
- **CDI User Interface** with central CDI metadata catalogue and facilities for ordering and downloading data sets

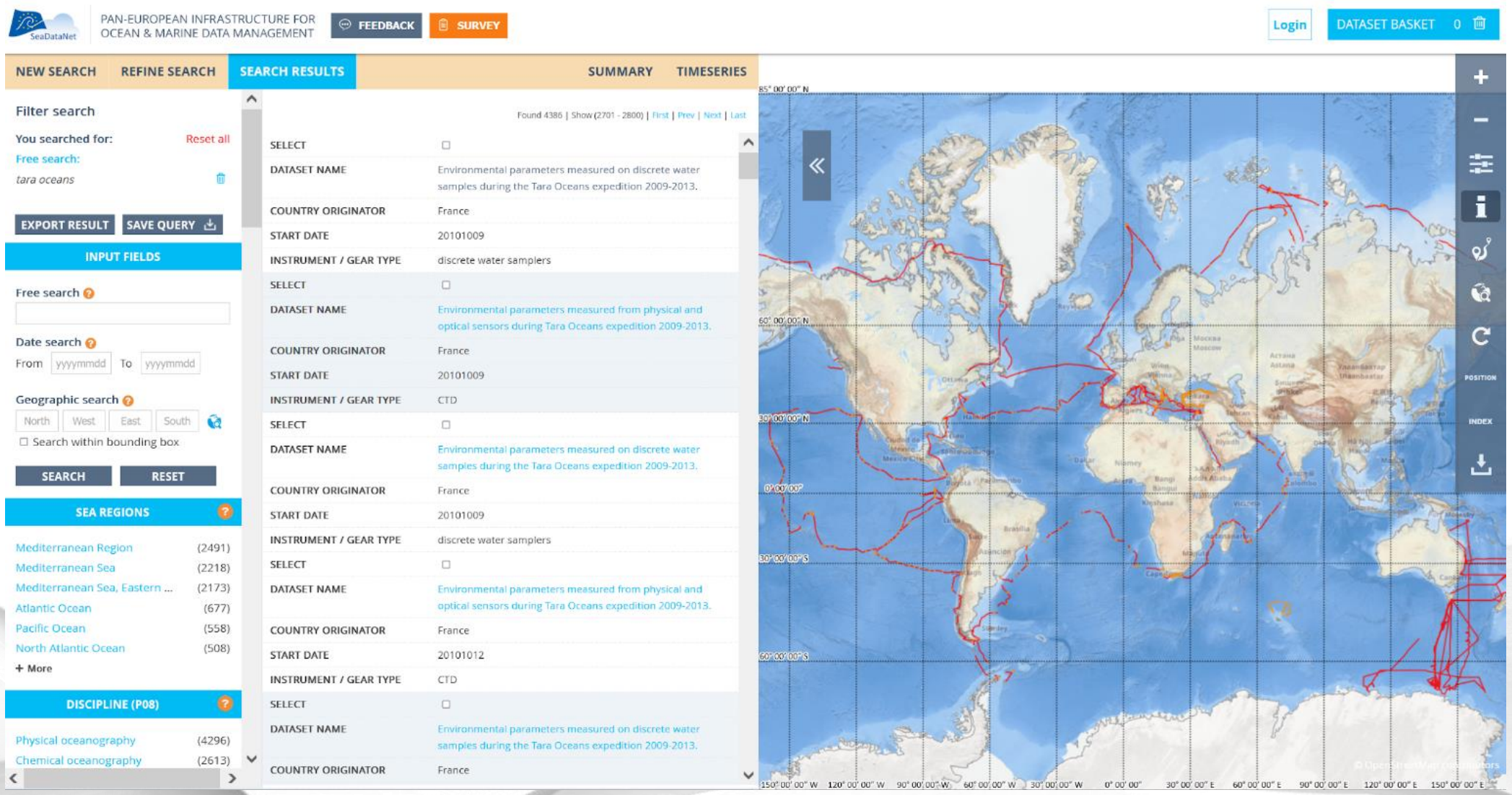


CDI service user interface



CDI search example for CTD measurements

CDI Data Discovery & Access Service



CDI search example for Tara-Oceans cruises

https://cdi.seadatanet.org/search

Fit for handling many data types

- **SeaDataNet metadata and data formats for:**
  - **Physical** data sets, developed with NODCs
  - **Chemistry** datasets, developed with EMODnet Chemistry
  - **Biological** data sets, developed with EurOBIS
  - **Geological and geophysical** data sets, developed with EuroGeoSurveys
  - **Bathymetry** data sets, developed with EMODnet Bathymetry
  - **HF-Radar** data sets, developed with EuroGOOS and EMODnet Physics
  - **Glider** data sets, developed with Ocean Glider network
  - **Flow Cytometry** data together with CNRS and JERICO
  - **Marine Litter** data (beach, seafloor, and micro litter), developed with EMODnet Chemistry and TG ML

- **SeaDataNet Controlled Vocabularies** expanded with new lists and new terms:
  - Currently, 115 lists with > 91000 terms
  - Available as Web Services, SparQL endpoint, User Interfaces, and with P01 Vocabulary builder and decomposer

Tools & services provided

- Software tools for generating XML entries (MIKADO), format conversions and format checking (NEMO and OCTOPUS)
- Software tools for analyses (ODV) and interpolations (DIVA)
- Online versions of ODV (WebODV) and DIVA (DIVAnd) as part of SeaDataNet Virtual Research Environment (VRE)
- Sensor Web Enablement (SWE) toolkit for operational data streams
- SEANOE data publishing and DOI minting service
- Vocabulary and Directories web services
- Brokerage service for discovery and access of several international repositories (NCEI-USA, WOD-USA, AODN-Australia)

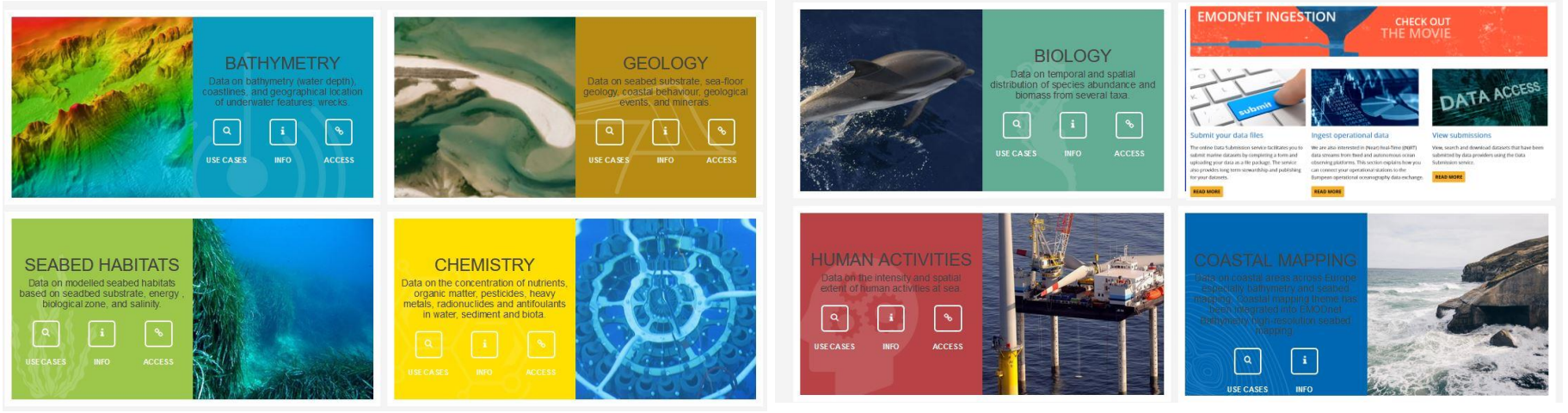
SeaDataNet cooperation

- **Many research projects:** ENVRI-FAIR, MARINET2, PHIDIAS, E-Shape, EOSC-EGI-ACE, EOSC-Future, AtlantOS, ……, adopting and adapting SeaDataNet standards and services, and use cases
- **Large ocean monitoring systems:** EuroGOOS, JERICO-S3, EuroFleets+, Euro-Argo, Gliders, ... adopting standards and services for validation + long-term archiving
- **Blue-Cloud project in G7 Future of the Oceans framework**: pillar under Blue-Cloud Data Discovery & Access service, federating SeaDataNet, EMODnet, ELIXIR-ENA, EurOBIS, EcoTaxa, ICOS, SOCAT, and Euro-Argo
- **GEOSS - EuroGEOSS:** populating the GEOSS portal with SeaDataNet in-situ data collections for global sharing
- **UNESCO IOC – IODE network and Ocean Data Portal:** global data exchange and interoperability solutions
- **Copernicus Marine Services (CMS):** providing standards, and cooperation in T&S climatologies

SeaDataNet is the essential data management link between marine and ocean data collectors (research cruises, operational monitoring, fixed network, autonomous floats, ..) and the overarching infrastructures such as EMODnet, CMS, Blue-Cloud, and EOSC

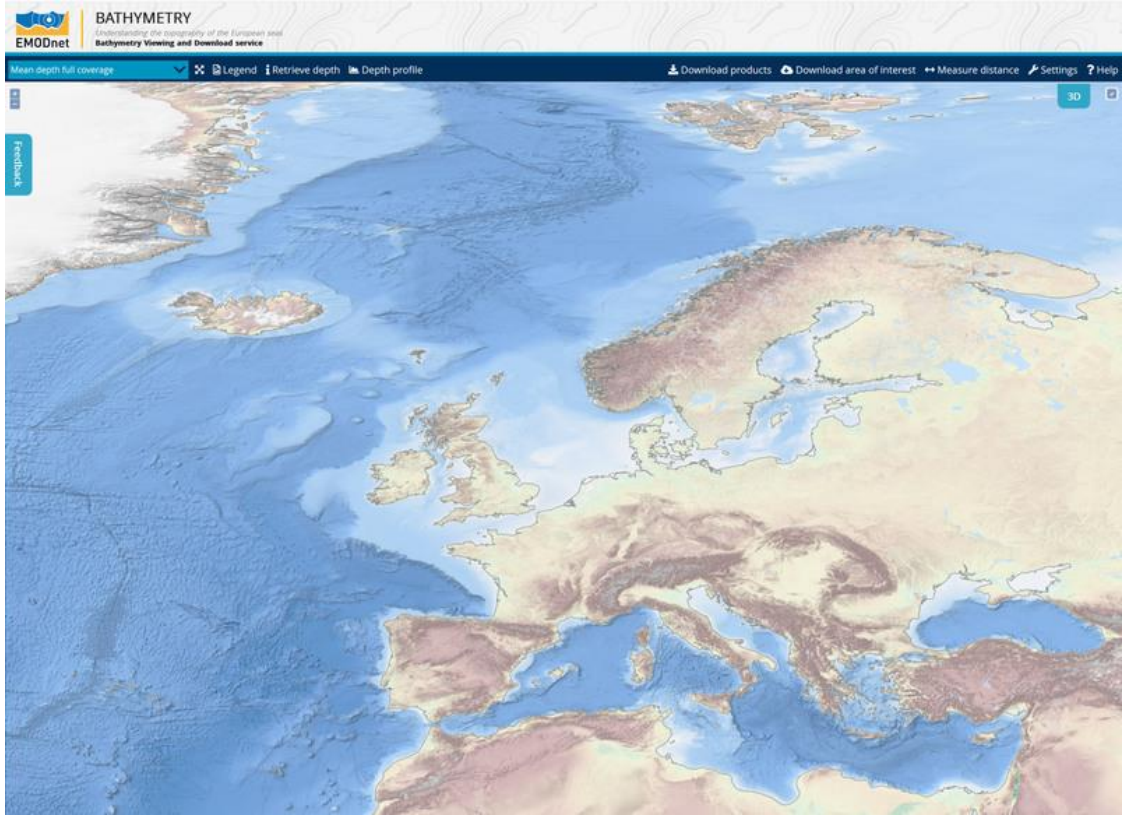
Cooperation with

- The overarching **European Marine Observation and Data Network (EMODnet)** was initiated in 2008 by EU DG MARE



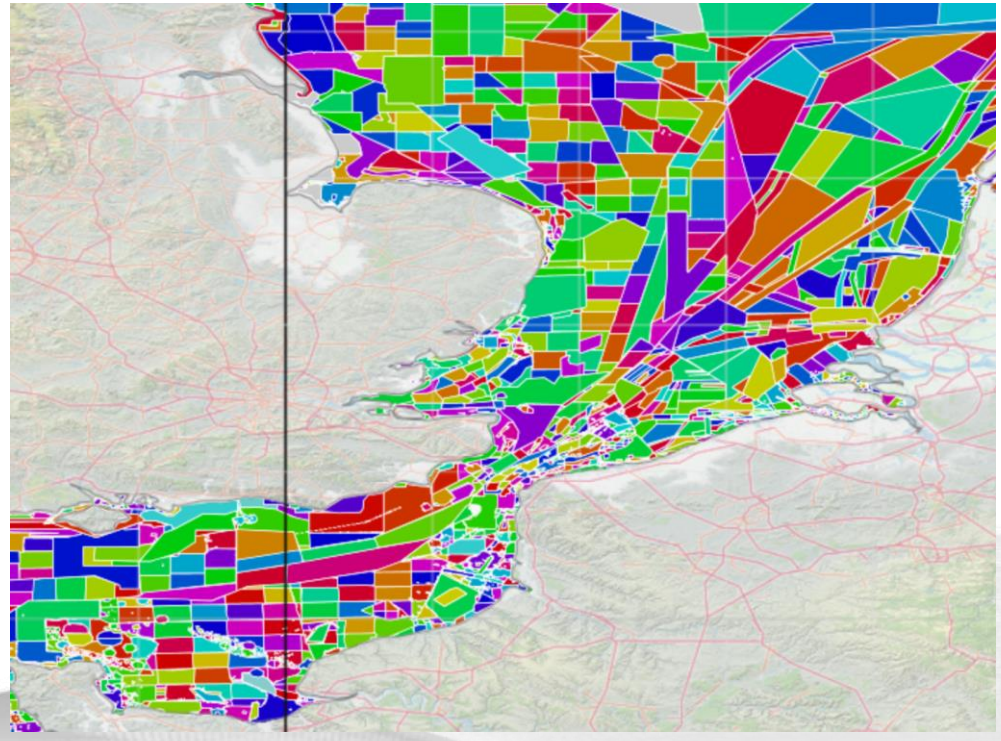
- SeaDataNet qualified as a leading infrastructure for the EMODnet data management component and is driving several thematic portals from the start
- This synergy has resulted in many more data centres adopting SeaDataNet standards and connecting to the CDI Data Discovery and Access service, while it gave a flying start to EMODnet
- EMODnet has a focus on **European data products and services** in support of Blue Economy, Blue Environment and Marine Knowledge 2020 agendas
- The data sets as gathered, harmonised and delivered by SeaDataNet provide essential input for generating and regularly updating EMODnet data products

Example: EMODnet Bathymetry



The best Digital Terrain Model for European seas:

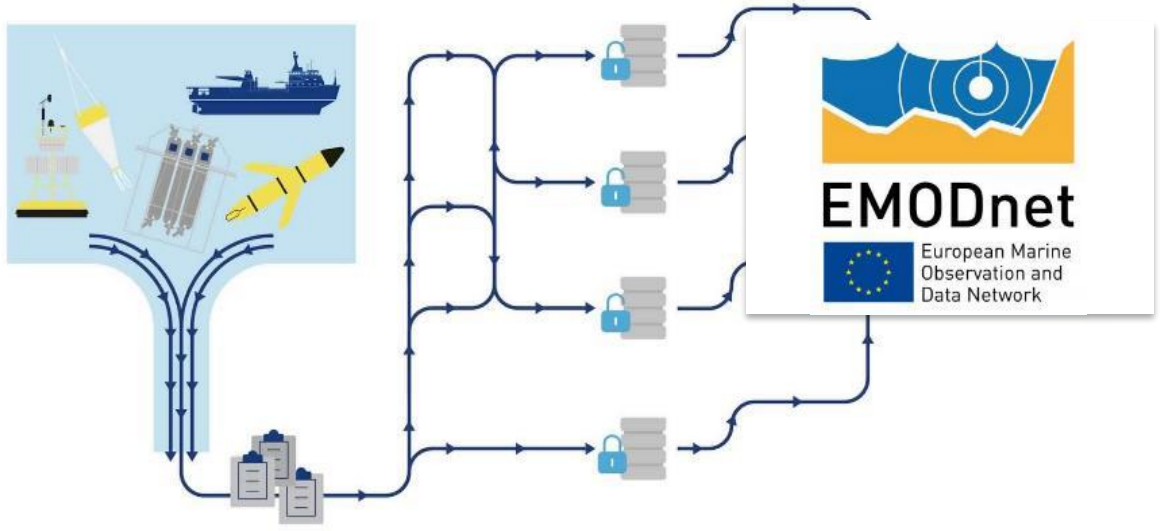
* Resolution 115 * 115 meters
* Based upon > 16.000 survey and SDB data sets



Source reference layer with direct links to CDI service for metadata about used data

Example: EMODnet Bathymetry

Example: EMODnet Chemistry



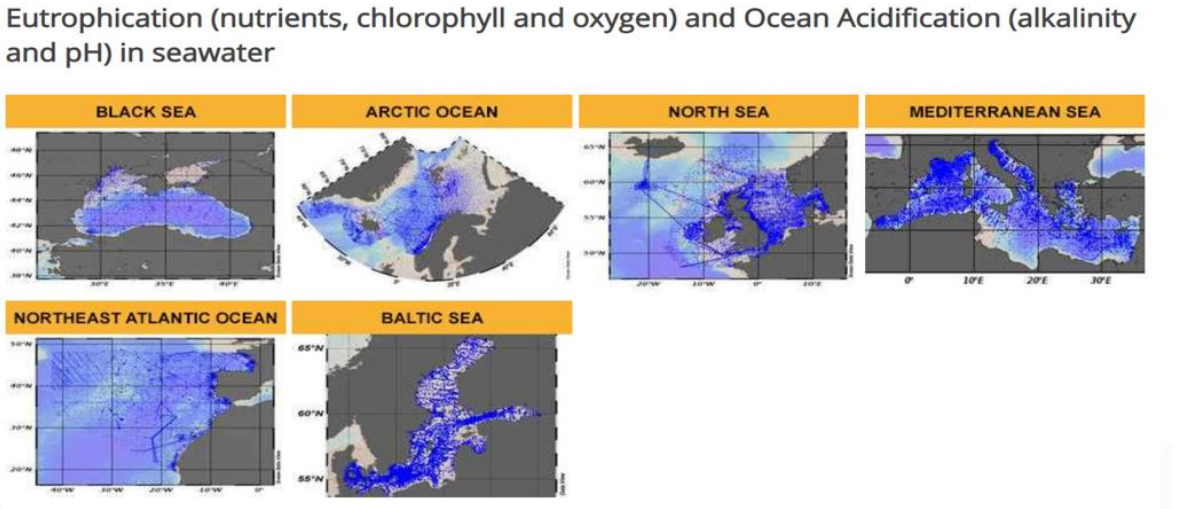
- **C**ollection, **A**ggregation, **S**tandardization, **Q**uality **c**heck of EU marine water quality data relevant to the EU Marine Directives and to global climate change

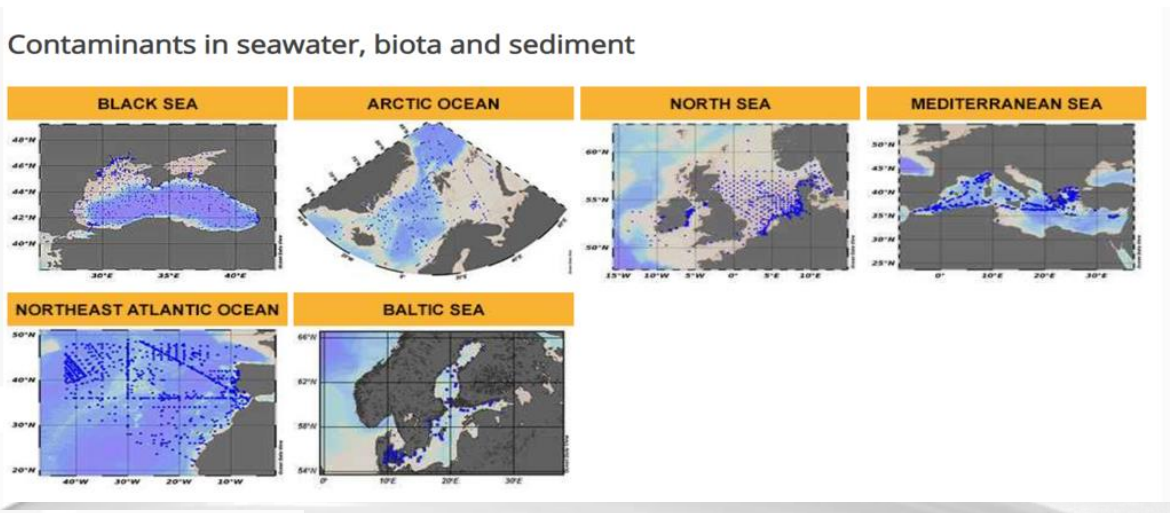
	Group of Parameters	Parameters
Marine Litter	Beach macrolitter, Seafloor macrolitter, Floating microlitter	Composition, Abundance, etc.
Ocean acidification	Acidity	pH, PCO_2, etc.
Contaminants	Antifoulants, Hydrocarbons, Heavy metals, Pesticides, Polychlorobiphenyls (PCBs), Radionuclides	Anthracene, Fluoranthene, Me, Cd, Pb, TBT, DDTs, etc.
Eutrophication	Nutrients, dissolved gases, etc.	N, P, Si, Chl-a, O_2, C, etc.

Example: EMODnet Chemistry

Free and open access to **over 1 million chemistry data sets** in all EU sea basins

QA-QC & Harmonisation by Regional experts

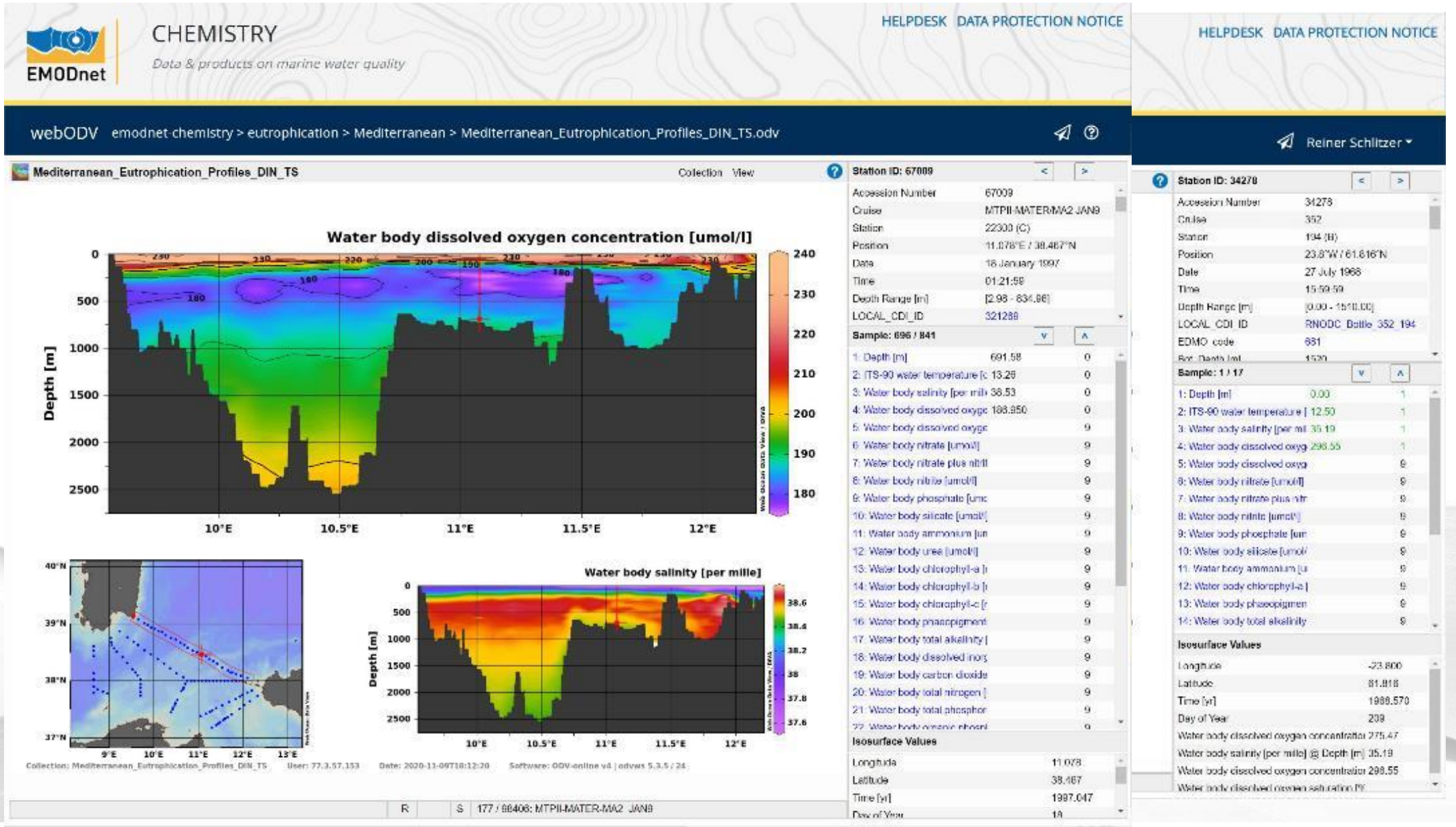




Data collections

Data are harmonized, standardized, validated and made available as regional and global data collections.

Example: EMODnet Chemistry



Blue-Cloud initiative

- To explore and demonstrate the potential of **cloud based open science** supporting research for ocean sustainability, and UN Decade of the Oceans and G7 Future of the Oceans

- To deploy a **cyber platform with smart federation** of multidisciplinary data repositories, analytical tools, and computing facilities

- To develop a **marine thematic European Open Science Cloud (EOSC)** serving the blue economy, marine environment & marine knowledge agendas

EUROPEAN OPEN SCIENCE CLOUD

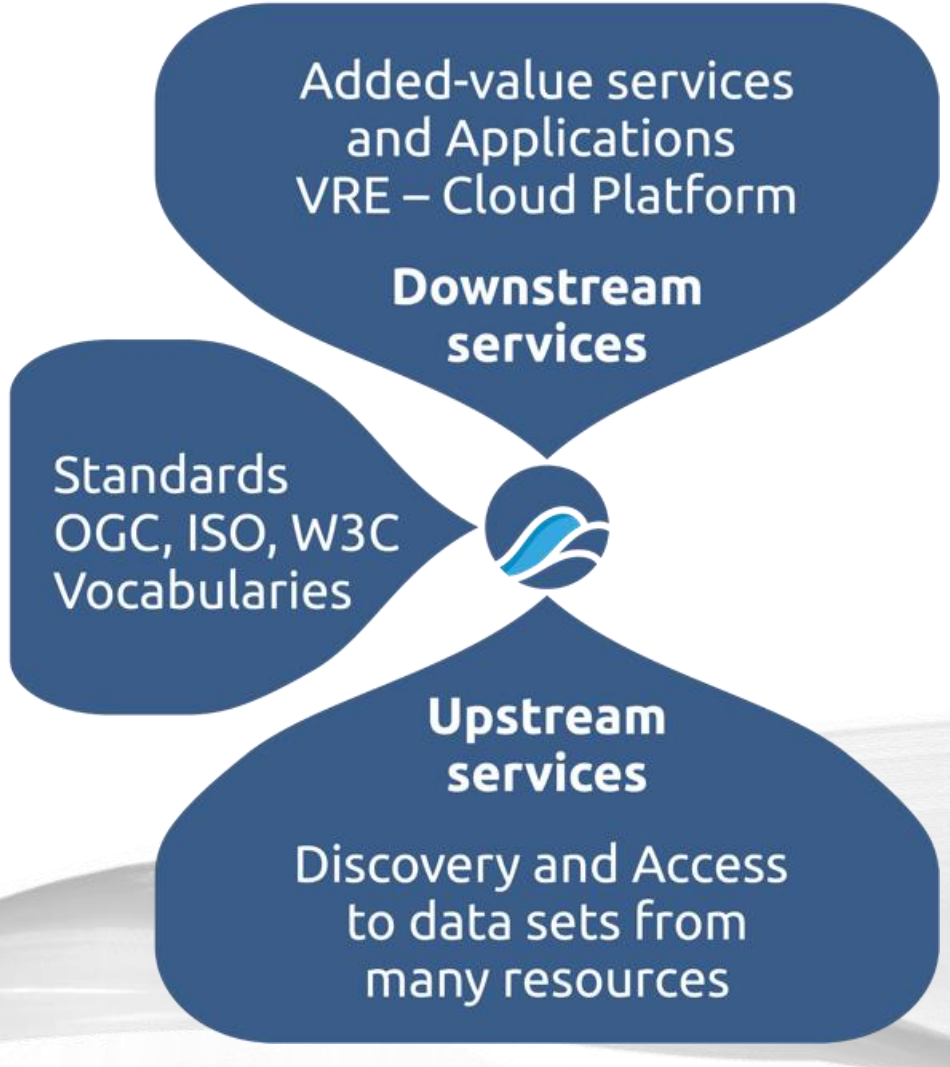
2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Blue-Cloud overarching concept

- Developing and deploying Virtual Research Environment (VRE) with an array of services for configuring and running Virtual Labs for specific analytical workflows, use cases, and demonstrators

- Applying common standards and interoperability solutions for providing harmonized metadata and data

- Developing and deploying harmonized discovery and access to established European marine data management and processing infrastructures

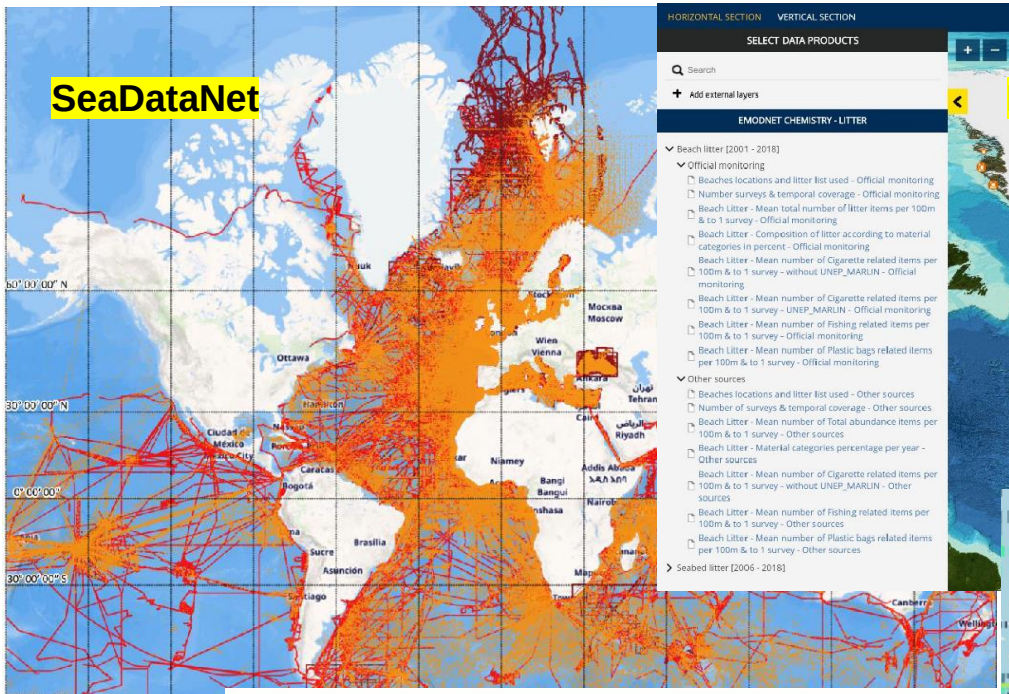


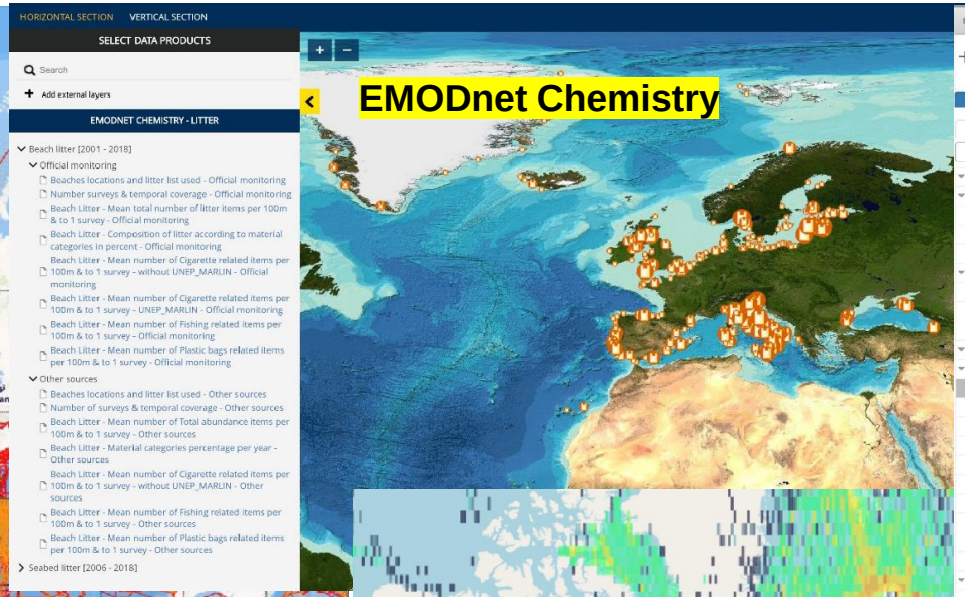
Blue-Cloud federation of major infrastructures

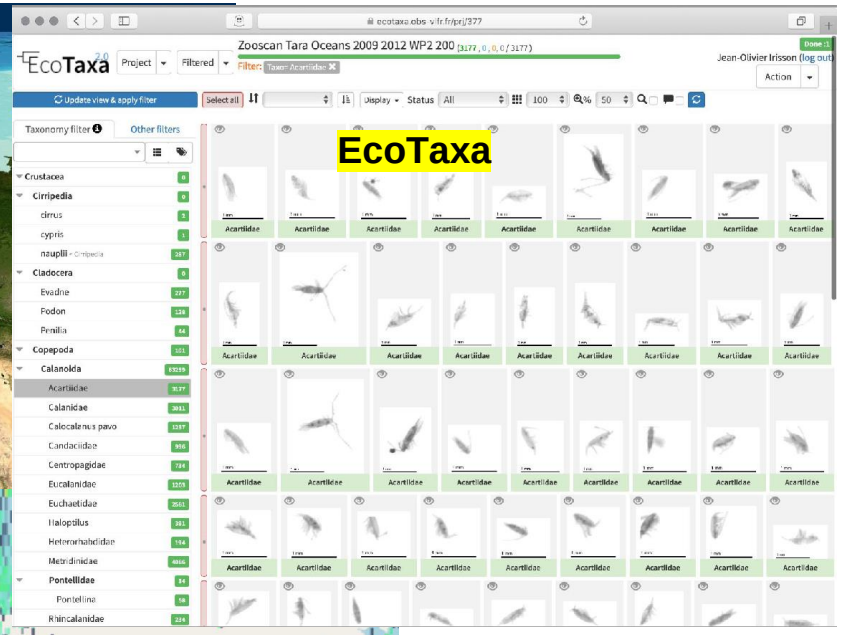
Blue Data infrastructures

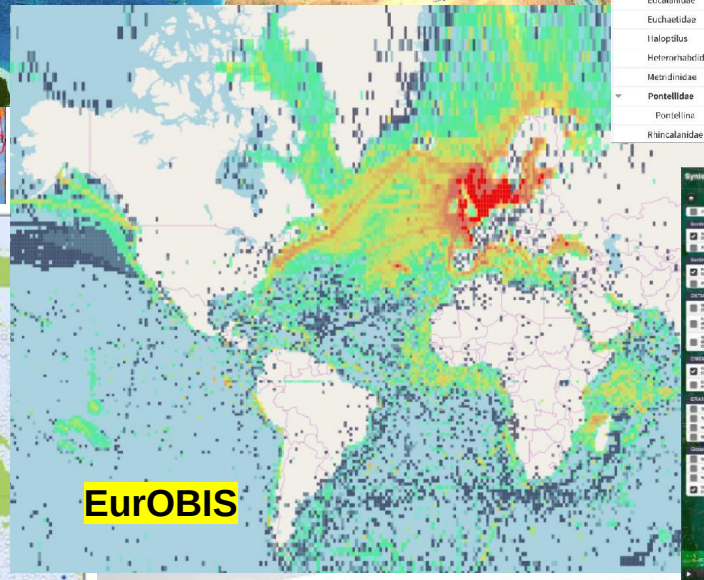
E-infrastructures

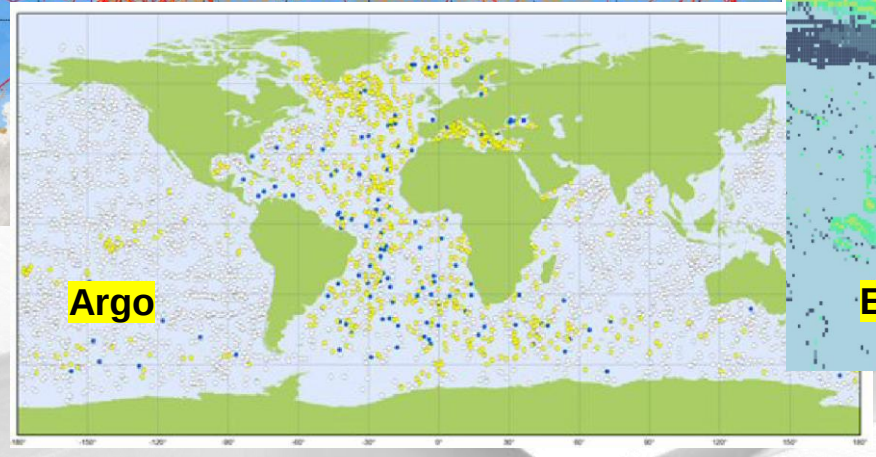
Illustrations of data coverage

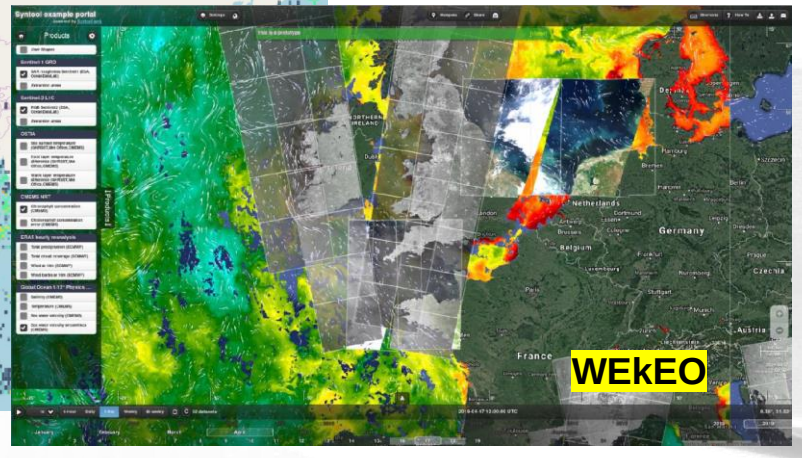






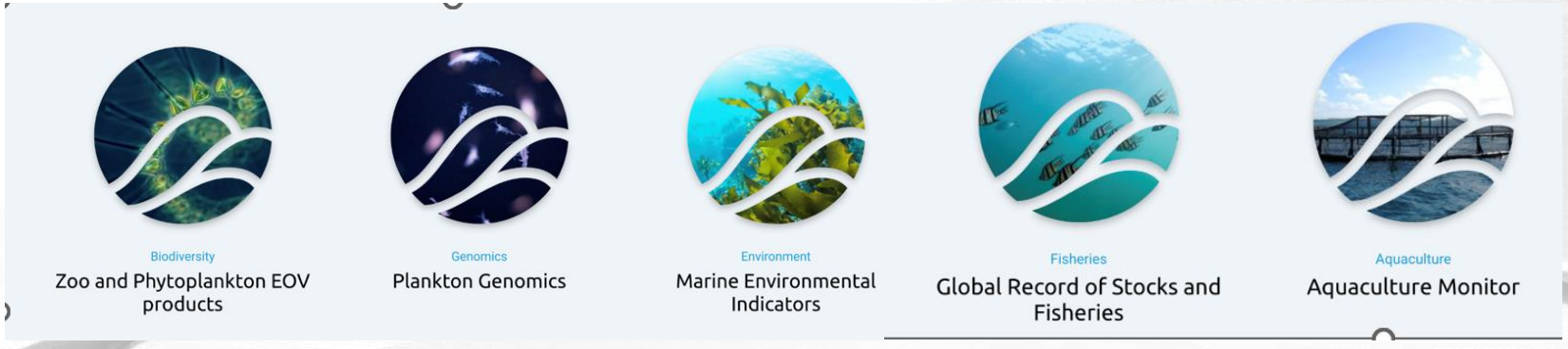






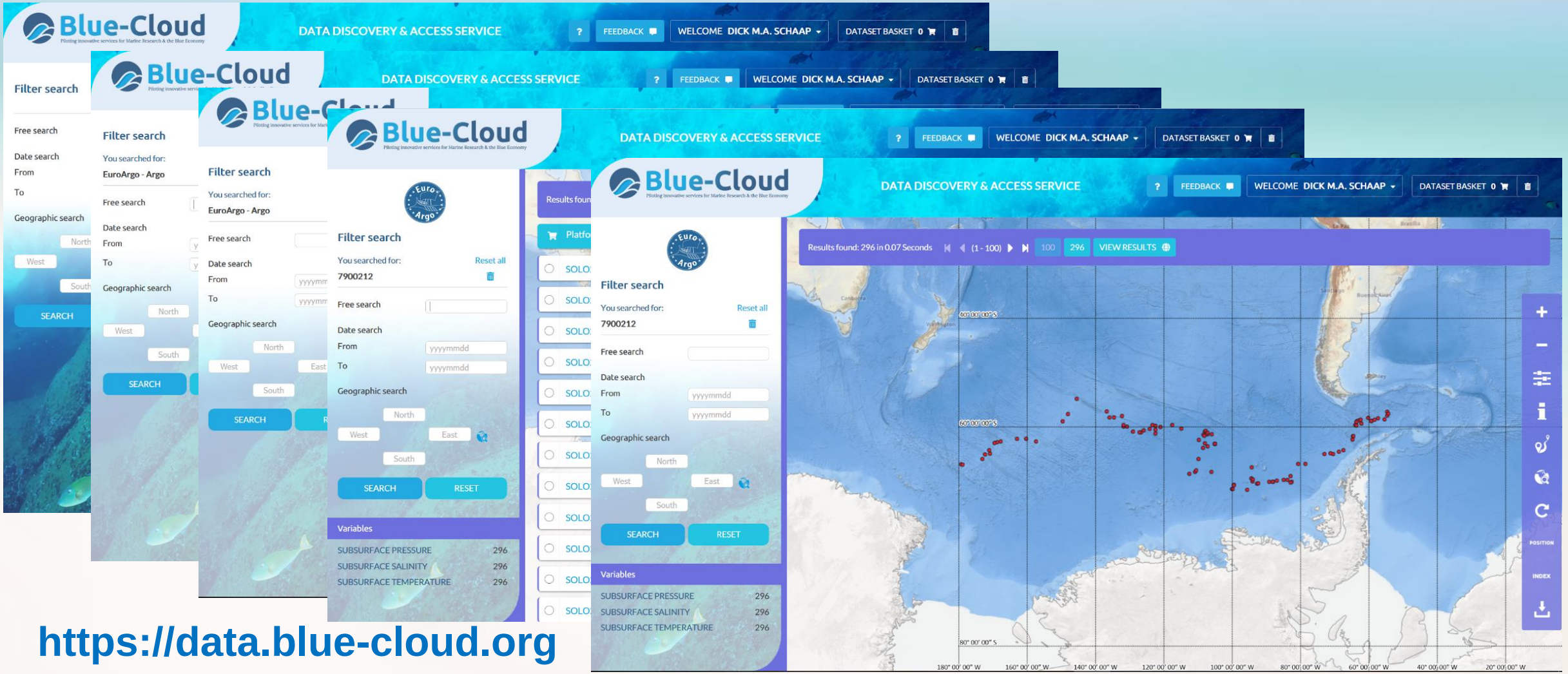
Key products and services

- **Blue-Cloud Data Discovery & Access service**, federating key European data management infrastructures, to facilitate users in finding and retrieving multi-disciplinary datasets from multiple repositories
- **Blue-Cloud Virtual Research Environment infrastructure** to provide a range of services and to facilitate orchestration of computing and analytical services for constructing, hosting and operating Virtual Labs for specific applications
- **Blue-Cloud Virtual Labs**, configured with specific analytical workflows to serve as **Demonstrators,** which can be adopted and adapted for other inputs and analyses



www.blue-cloud.org

DATA DISCOVERY & ACCESS SERVICE



https://data.blue-cloud.org

BLUE-CLOUD VIRTUAL RESEARCH ENVIRONMENT

Collaboration

Sharing

Reuse

Reproducibility

Blue Cloud VRE promotes Open Science

Conclusions

- It is very important that ocean and marine data as collected by science, government, industry, and citizens are shared and become available for wider use in many applications and derived data products

- Europe over time has established an extensive landscape for marine data management, featuring several research data infrastructures for specific data types, complemented with EU initiatives such as EMODnet, Copernicus Marine Service, and European Open Science Cloud.

- There is an ongoing move to more integration between the infrastructures, making data and services more FAIR, and developing more cloud based analytical and visualisation capabilities, supported by powerfull computing and storage resources. This is explored as part of ENVRI-FAIR, Blue-Cloud and EOSC–FUTURE projects.

- SeaDataNet is a major network of NODCs and it handles the data management for many data collectors, including data from most cruises of the European marine research vessel fleet.

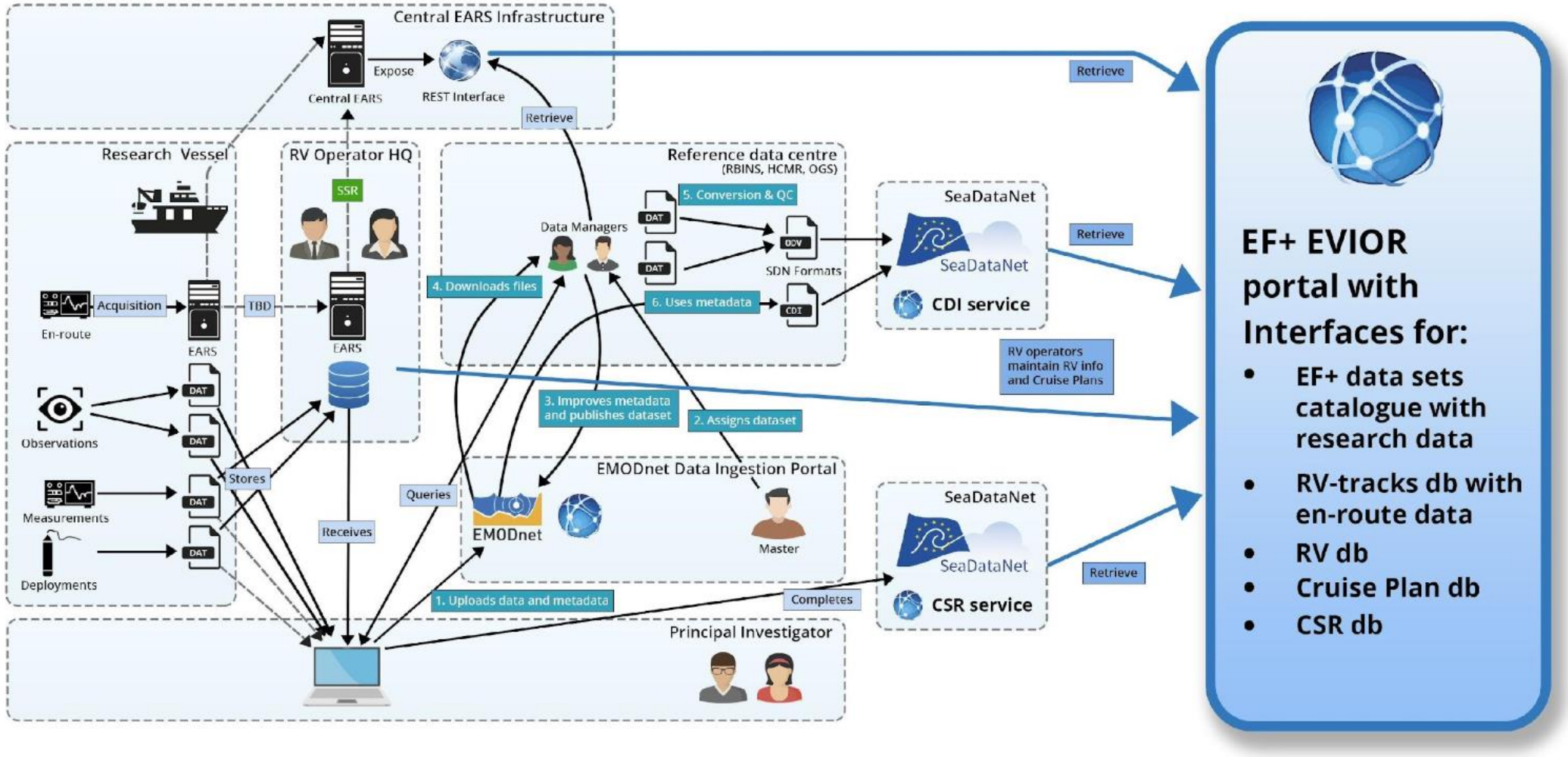
Eurofleets+ open data management strategy

- To ensure that the research data collected during the funded TA cruises, and the en-route data collected by the research vessels are made widely available in line with FAIR and Open Research Data principles

- To make use of existing European standards and services of SeaDataNet for managing and publishing collected cruise data sets, which ensures also distribution towards EMODnet and the wider community of potential users

- To establish and populate also the EVIOR ((European Virtual Infrastructure in Ocean Research) platform, embedded in Eurofleets website, with all information relevant for following the Eurofleets+ cruises and outcomes

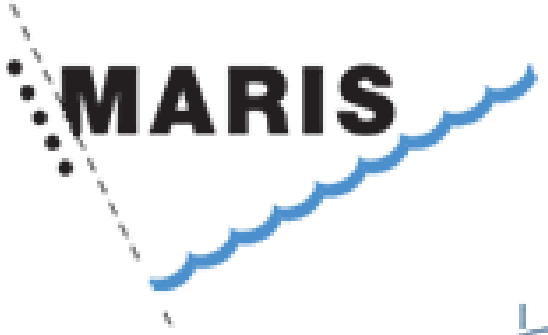
Eurofleets+ data management workflow



Capturing and publishing metadata and data from cruise plan to underway to post cruise

museum
Royal Belgian Institute of Natural Sciences

UTM
CSIC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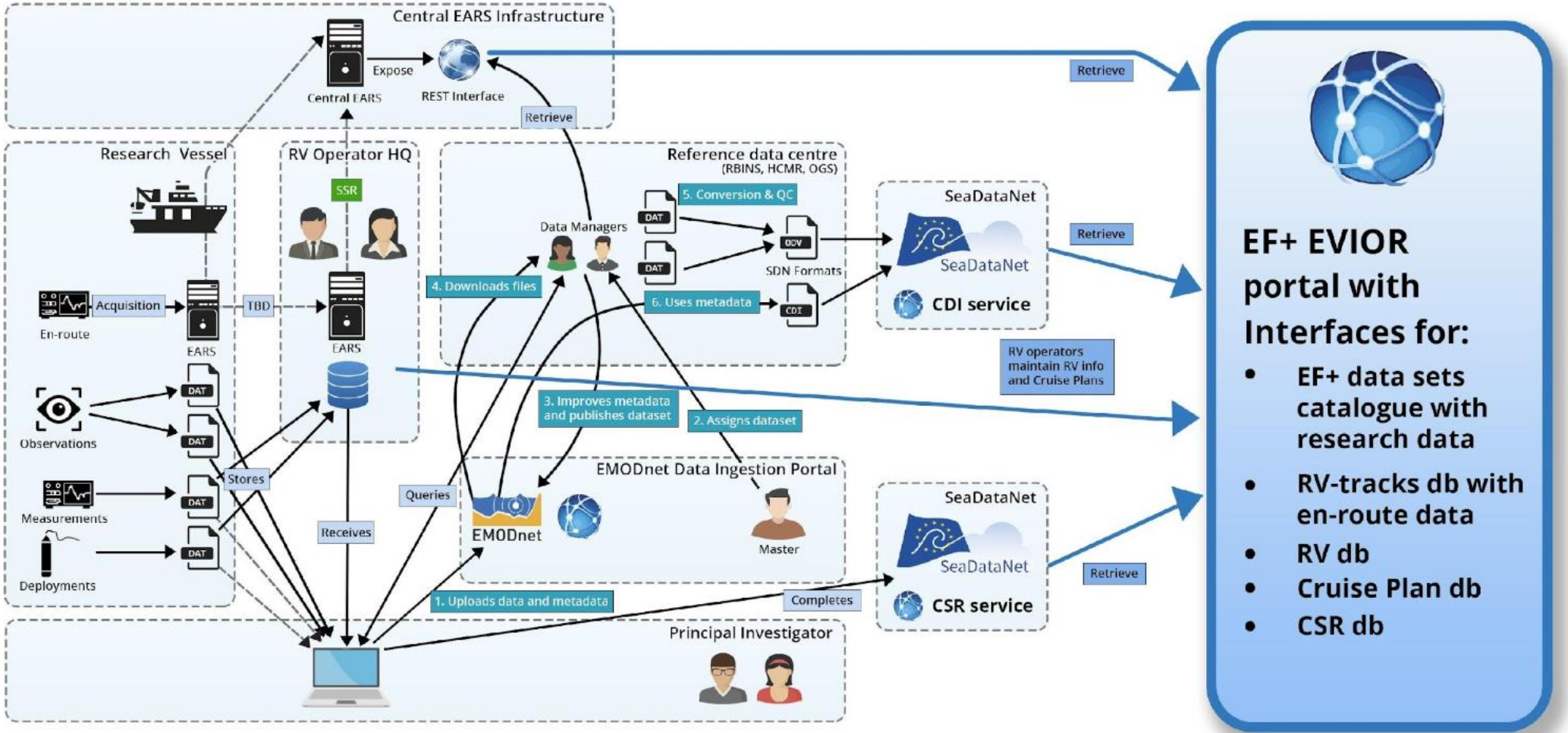
OGS
National Institute
of Oceanography
and Applied
Geophysics

EVIOR (European Virtual Infrastructure in Ocean Research) platform

Dick M.A. Schaap

Data Management Workflow



Capturing and publishing metadata and data from cruise plan to underway to post cruise

EVIOR platform

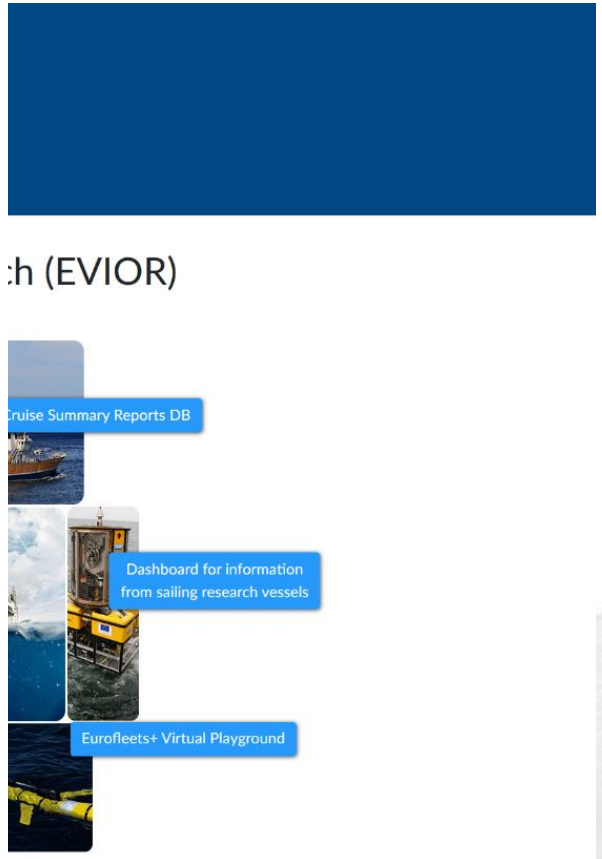
Eurofleets+ Cruise Data Sets Catalogue

RETURN TO EVIOR HOME | BACK

Next

Record No.	1
Cruise ID	iMAR
Cruise Information	Cruise Narrative
Research Vessel	Pelagia
Date start	2021-05-18
Date end	2021-06-02
Cruise Plan	
Cruise Summary Report	Cruise Summary Report
En-route Data	En-route Data
Original Research data in EMODnet Ingestion	1 2 3 4 5
Original Research data in SeaDataNet SEANOE	1 2 3 4 5
Elaborated Research data in SeaDataNet CDI service	1 2 3
Elaborated Research data in EMODnet service	1 2

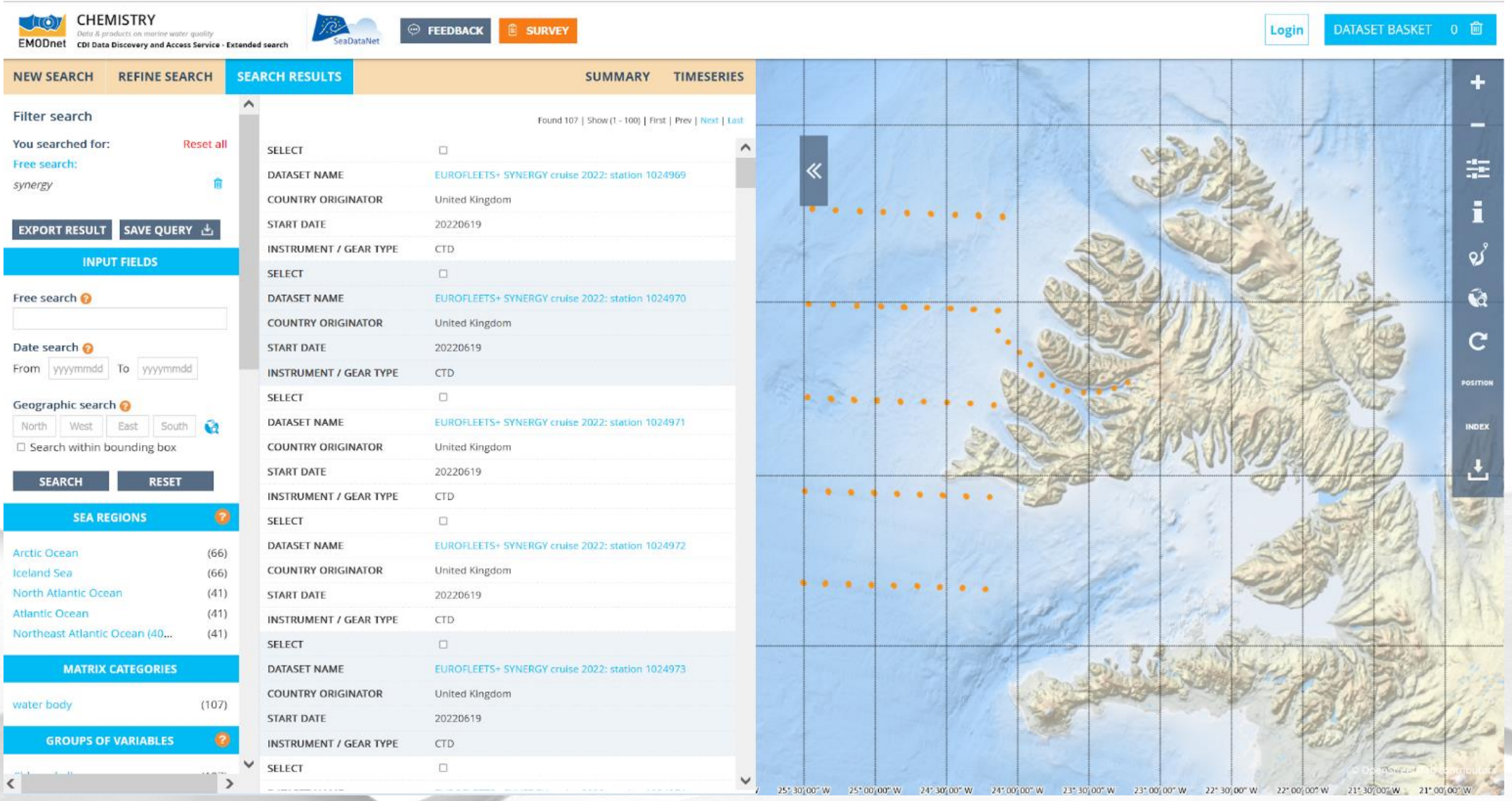
Figure: Virtual Playground system structure



NODCs for Data Management support

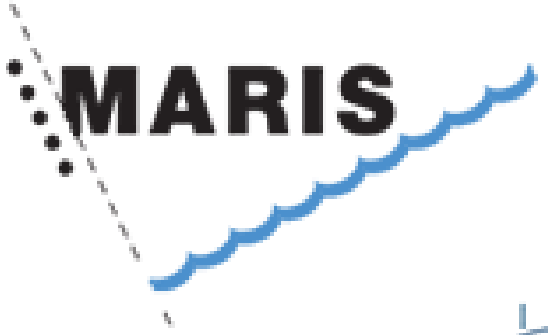
- TA cruise teams make an EF+ Data Management Plan (DMP)
- DMPs are reviewed by 3 NODcs in EF+: HCMR, OGS, RBINS
- One NODC is assigned per TA Cruise
- Guidance and support by NODC to PI and scientific teams:
  - Keeping index of data and sample acquisition during cruise, preferably using the EF+ EARS system on board
  - Preparing a Cruise Summary Report (CSR) after cruise
  - Ensuring transfer of data sets after scientific embargo with sufficient documentation for uptake by NODCs in SeaDataNet, also for wider distribution to EMODnet, CMEMS, and EF+ EVIOR portal

Progress – Example Data Access



museum
Royal Belgian Institute of Natural Sciences

UTM
CSIC


MARIS

Ifremer

52n

hcmr
ΕΛΚΕΘΕ

OGS
National Institute
of Oceanography
and Applied
Geophysics