Interreg NEXT Black Sea Basin

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EfxINNOs

EfxINNOs

Establishing and Operating an Innovative Marine Technology Transfer Network for Enhancing the Transition to a Sustainable Blue Economy in the Black Sea Basin

Share data and project results with the Copernicus Marine Monitoring Network

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https://envrio.eu/efxinnos/

Table of Contents

1. Introduction 3
2. Copernicus Marine Environment Monitoring Service (CMEMS) 4
2.1 Role and Scope of CMEMS 4
2.2 Data Ingestion into CMEMS (CTD Data in ODV Format) 4
Data Transformation and Standardization 4
Quality Control Procedures 4
Submission to CMEMS In Situ Thematic Assembly Centre (INS TAC) 5
Data Dissemination and Access 5
3. European Marine Observation and Data Network (EMODnet) 8
4. Benefits of Data Sharing and Integration 11
4.1 Advancing Scientific Knowledge 11
4.2 Supporting Evidence-Based Policy 11
4.3 Enhancing Local Resilience 11
5. Strategic Collaboration and Long-Term Impact 12

1. Introduction

The sharing of project data and results with major European marine data infrastructures such as the Copernicus Marine Environment Monitoring Service (CMEMS) and the European Marine Observation and Data Network (EMODnet) represents a key element in advancing the monitoring, understanding, and sustainable management of the oceans and coastal areas. This initiative is not only a technical exercise in data exchange but also a strategic step towards fostering stronger international collaboration in marine science, policy, and innovation.

Both CMEMS and EMODnet are cornerstones in Europe's marine knowledge landscape. They provide centralized, interoperable platforms where marine data from diverse sources—satellite observations, in-situ monitoring, and model outputs—are aggregated, quality-checked, and made available to a broad spectrum of stakeholders. By contributing to these platforms, the project ensures its results will have long-term impact, broad accessibility, and the potential to influence decision-making well beyond the project's immediate scope.

2. Copernicus Marine Environment Monitoring Service (CMEMS)

CMEMS is a flagship component of the EU Copernicus Programme, focusing on delivering regular and systematic reference information on the physical and biogeochemical state of the global ocean and European regional seas.

2.1. Role and Scope of CMEMS

The service provides free and open access to high-quality marine data products, including:

- **Real-time observations** from satellites and in-situ instruments.
- **Forecasts** generated through advanced numerical models.
- **Reprocessed datasets** to support long-term trend analysis.

These resources are indispensable for:

- **Climate change research** (e.g., tracking ocean heat content).
- **Marine resource management** (e.g., fisheries planning).
- **Coastal risk assessment** (e.g., storm surge predictions).
- **Marine spatial planning** and policy development.

2.2. Data Ingestion into CMEMS (CTD Data in ODV Format)

Ingesting CTD (Conductivity-Temperature-Depth) data into the Copernicus Marine Environment Monitoring Service (CMEMS) is a multi-step process focused on ensuring data quality, interoperability, and operational relevance. For this project, the raw CTD data will first be transformed into the Ocean Data View (ODV) ASCII format, a widely adopted standard in oceanographic communities, which facilitates data exchange and harmonization with European and global marine data infrastructures.

2.2.1. Data Transformation and Standardization

The transformation into ODV format involves structuring the data into tabular ASCII files with clearly defined columns for parameters such as pressure, temperature, salinity, dissolved oxygen, and other relevant oceanographic variables. Each data file will be accompanied by comprehensive metadata including:

- Precise geolocation (latitude, longitude, depth).
- Time stamps in Coordinated Universal Time (UTC).
- Instrument details and calibration information.
- Data origin and cruise/event identifiers.

This harmonization adheres to the SeaDataNet Common Data Index (CDI) standards and CMEMS metadata requirements, including conformity with ISO 19115/19139 metadata schemas and Climate and Forecast (CF) conventions for parameter naming and units. This standardization ensures that the data can be seamlessly integrated with other datasets from diverse sources.

2.2.2. Quality Control Procedures

Quality control is crucial to maintain the integrity and usability of CTD data within CMEMS. Automated algorithms will first scan for errors such as:

- Physically impossible values (e.g., negative salinity, out-of-range temperature).
- Depth inversions or unrealistic pressure readings.

- Temporal inconsistencies or gaps in data collection.

Subsequently, expert oceanographers will review the flagged data to distinguish between genuine oceanographic anomalies (e.g., thermoclines or salinity fronts) and sensor errors. Quality flags are assigned based on SeaDataNet QF codes, ranging from “good data” to “suspect” or “bad,” providing end-users with confidence metrics.

2.2.3. Submission to CMEMS In Situ Thematic Assembly Centre (INS TAC)

The standardized and quality-controlled CTD datasets will be submitted via the CMEMS In Situ Thematic Assembly Centre (INS TAC), which acts as the official gateway for in situ data ingestion. Typically, submissions are coordinated through recognized National Oceanographic Data Centres (NODCs) or established partners such as the Coriolis Data Centre or SeaDataNet, ensuring compliance with CMEMS operational standards.

Data transmission can be performed through secure FTP or other CMEMS-accepted protocols. Upon receipt, INS TAC further validates metadata completeness and performs integration tasks to register the dataset within the CMEMS catalogue. This catalogue supports advanced search functions, enabling users to locate data by parameter, region, date, and quality level.

2.2.4. Data Dissemination and Access

Once ingested, CTD data become accessible through CMEMS portals and data services, including:

- Interactive web portals that visualize vertical profiles, time series, and spatial distributions.
- Machine-readable APIs such as OPeNDAP, WMS (Web Map Service), and WCS (Web Coverage Service), facilitating automated data retrieval for operational models and research applications.
- Periodic updates reflecting new measurements or improved quality control are incorporated, ensuring the catalogue remains current.

2.2.5. Indicative results of POTI buoy data conversion

This section presents an indicative example of how Poti buoy measurements were processed and converted for the EfxINNOs project, demonstrating the workflow required to transform raw oceanographic telemetry into a standardized, interoperable format. The example focuses on the end-to-end pathway from initial data acquisition to final SeaDataNet-compliant output, illustrating both automated and manual steps that ensure data integrity and long-term usability.

The conversion workflow for the Poti buoy data follows a structured, multi-step process to ensure data integrity, standardization, and compatibility with CMEMS and EMODnet systems:

1. **REST API Data Retrieval** – Raw buoy measurements are accessed programmatically via the Oceancast REST API, allowing automated retrieval of datasets P01, P06, and P09. This ensures timely and reliable access to the most recent observations. The requested datasets are downloaded and organized in a local staging environment. This step includes initial validation of file integrity and format consistency to prevent downstream processing errors.
2. **Data Management** – Retrieved data are structured according to a standardized schema.

This includes harmonizing timestamps, units, and metadata fields, and assigning SeaDataNet-compliant parameter codes. Proper data management ensures traceability and prepares the measurements for quality control and conversion.

3. **Quality Check (QC)** – Automated and manual QC procedures are applied to detect anomalies, missing values, or outliers in the P01, P06, and P09 datasets. QC flags are generated to document data reliability, supporting transparency and reproducibility.
4. **NEMO Conversion** – The cleaned and QC-checked data are ingested into NEMO software. NEMO parses the measurements and metadata to produce fully structured ODV files compliant with SeaDataNet standards, integrating both parameter values and associated QC flags.
5. **EMODnet Ingestion Service** – Finally, the ODV files are prepared for submission to the EMODnet Ingestion Service, enabling long-term archival, interoperability, and visualization in regional and pan-European marine data portals.

The following figure illustrates the workflow for the Poti buoy data conversion, highlighting each key step from data retrieval to EMODnet ingestion.



Figure 1. *Data ingestion workflow*

As mentioned above, the conversion of the Poti buoy time-series into the SeaDataNet Ocean Data View (ODV) format was executed using the NEMO data-processing environment, which supports standardized metadata handling, variable harmonization, and quality-control (QC) workflows aligned with SeaDataNet requirements.

During the transformation, raw buoy data that were retrieved through the Oceancast backend via a REST API, were ingested into the NEMO data-processing environment. Each measurement parameter was carefully mapped to the appropriate SeaDataNet codes, with P01 used for variable identification, P06 for units, and P09 for quality flags, ensuring consistency and interoperability across datasets. NEMO also facilitated the integration of QC flags, temporal normalization, and unit standardization, producing fully structured ODV files that are ready for long-term archival and downstream analysis. The process balances automation with manual validation steps to guarantee data accuracy and traceability. The following figure illustrates the assignment of parameters and SeaDataNet codes, showing how raw buoy data are processed and structured for ODV output.

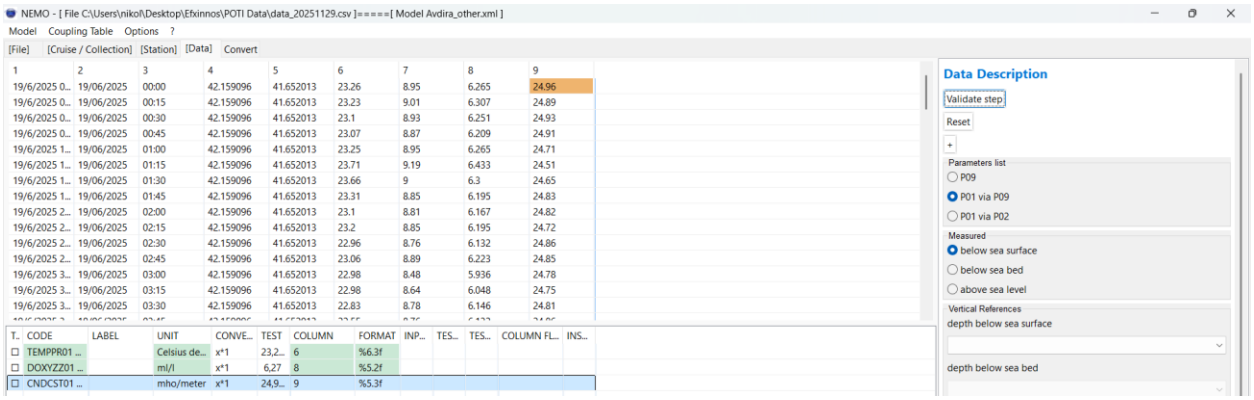


Figure 2. *Parameter and code assignment*

Temporal normalization, unit harmonization, and consistency checks were applied to ensure a coherent and compliant dataset. The final output consisted of a structured ODV spreadsheet integrating measurements, metadata, and QC indicators.

The fully structured ODV file was created in accordance with SeaDataNet conventions, ensuring compliance with the minimum requirements for standardized data exchange. Mandatory metadata fields were included to guarantee traceability and proper identification of the dataset, covering essential information such as *cruise*, *station*, *type*, *geographic coordinates (longitude and latitude)*, *local CDI identifier (Local_CDI_ID)*, and the *EDMO code*. Each measured parameter was assigned the appropriate SeaDataNet parameter code (P01), for example: depth (ADEPZZ01), water temperature (TEMPPR01), dissolved oxygen (DOXYZZ01), conductivity (CNDCST01), and time (TIME). Units were harmonized using the corresponding P06 unit codes, including ULAA for meters, UPAA for °C, UMLL for ml/L, UECA for mS/cm, and TISO for time. All timestamps were formatted according to the ISO-8601 standard to ensure temporal consistency and interoperability across platforms. These steps collectively guarantee that the ODV file is fully compatible with SeaDataNet protocols, enabling reliable archival, sharing, and integration with regional and European marine data infrastructures.

The following figure illustrates the converted Poti buoy dataset in SeaDataNet-compliant ODV format, including the structured measurements, associated metadata (such as timestamps, location, and parameter codes), and quality-control flags that document data reliability.

```
1 //SeaDataNet ODV PHYSICOCHEMICAL timeseries - Generated by Nemo 2.1.1 - 2025-11-29 12:54:22+0200
2 //
3 //<sdn_reference xlink:href="https://cdi.seadatanet.org/report/edmo/5026/POTI_BUOY_00001_D90/xml" xlink:role="isDescribedBy" xlink:type="SDN:L23::CDI"
  sdn:scope="5026:POTI_BUOY_00001_D90"/>
4 //SDN_parameter_mapping
5 //<subject>SDN:LOCAL:time_ISO8601</subject><object>SDN:P01::DTUT8601</object><units>SDN:P06::TISO</units>
6 //<subject>SDN:LOCAL:ADEPZZ01</subject><object>SDN:P01::ADEPZZ01</object><units>SDN:P06::ULAA</units>
7 //<subject>SDN:LOCAL:TEMPPR01</subject><object>SDN:P01::TEMPPR01</object><units>SDN:P06::UPAA</units>
8 //<subject>SDN:LOCAL:DOXYZZ01</subject><object>SDN:P01::DOXYZZ01</object><units>SDN:P06::UMLL</units>
9 //<subject>SDN:LOCAL:CNDCST01</subject><object>SDN:P01::CNDCST01</object><units>SDN:P06::UECA</units>
10 //
11 Cruise  Station Type  YYYY-MM-DDThh:mm  Longitude [degrees_east]  Latitude [degrees_north]  LOCAL_CDI_ID  EDMO_code Bot. Depth [m]  time_ISO8601 [YYYY-MM-DDThh:mm] QV:SEADATANET
   ADEPZZ01 [m]  QV:SEADATANET TEMPPR01 [Celsius degree] QV:SEADATANET DOXYZZ01 [ml/l] QV:SEADATANET CNDCST01 [mho/meter]  QV:SEADATANET
12 POTI_BUOY 1 * 2025-06-19T00:00  41.652013 42.159096 POTI_BUOY_00001_D90 5026    2025-06-19T00:00  0 0.0 B 23.260  0 6.27  0 24.960  0
13                  2025-06-19T00:15  0 0.0 B 23.230  0 6.31  0 24.890  0
14                  2025-06-19T00:30  0 0.0 B 23.100  0 6.25  0 24.930  0
15                  2025-06-19T00:45  0 0.0 B 23.070  0 6.21  0 24.910  0
16                  2025-06-19T01:00  0 0.0 B 23.250  0 6.27  0 24.710  0
17                  2025-06-19T01:15  0 0.0 B 23.710  0 6.43  0 24.510  0
18                  2025-06-19T01:30  0 0.0 B 23.660  0 6.30  0 24.650  0
19                  2025-06-19T01:45  0 0.0 B 23.310  0 6.20  0 24.830  0
20                  2025-06-19T02:00  0 0.0 B 23.100  0 6.17  0 24.820  0
21                  2025-06-19T02:15  0 0.0 B 23.200  0 6.20  0 24.720  0
22                  2025-06-19T02:30  0 0.0 B 22.960  0 6.13  0 24.860  0
23                  2025-06-19T02:45  0 0.0 B 23.060  0 6.22  0 24.850  0
24                  2025-06-19T03:00  0 0.0 B 22.980  0 5.94  0 24.780  0
25                  2025-06-19T03:15  0 0.0 B 22.980  0 6.05  0 24.750  0
26                  2025-06-19T03:30  0 0.0 B 22.830  0 6.15  0 24.810  0
27                  2025-06-19T03:45  0 0.0 B 22.550  0 6.13  0 24.860  0
28                  2025-06-19T04:00  0 0.0 B 22.510  0 6.12  0 24.840  0
29                  2025-06-19T04:15  0 0.0 B 22.620  0 6.13  0 24.800  0
30                  2025-06-19T04:30  0 0.0 B 22.860  0 5.97  0 24.790  0
31                  2025-06-19T04:45  0 0.0 B 22.670  0 6.13  0 24.720  0
32                  2025-06-19T05:00  0 0.0 B 22.850  0 6.03  0 24.540  0
```

Figure 3. *Converted Poti buoy data in SeaDataNet-compliant ODV format, showing measurements, metadata, and QC flags.*

3.European Marine Observation and Data Network (EMODnet)

Except the timeseries data retrieved from the Poti buoy, EfxINNOs project will integrate seagrass data retrieved from the ROV and AUV surveys to the EMODnet platform. Integrating seagrass data into the EMODnet Seabed Habitats portal involves a structured process to ensure data quality, interoperability, and compliance with European marine data standards. This process is crucial for enhancing the understanding and management of seagrass ecosystems across Europe.

3.1. Data Harmonization and Standardization

For EfxINNOs project, seagrass data will be submitted using the OGC-compliant GeoTIFF format, a raster data standard widely recognized for spatial data representation. This choice supports precise spatial referencing and easy integration with other geospatial datasets. The GeoTIFF files will be accompanied by detailed metadata aligned with EMODnet's requirements, including:

- **Geospatial Extent**: Exact geographic coordinates and spatial resolution of seagrass habitat maps.
- **Temporal Information**: Date(s) of data acquisition, ensuring temporal context for dynamic habitats.
- **Methodology**: Description of data collection techniques such as remote sensing or diver surveys.
- **Data Quality**: Information on accuracy, validation procedures, and any uncertainties associated with the habitat classification.
- Seagrass habitat classes will adhere to established standards like EUNIS and MSFD habitat classification, facilitating interoperability and comparability across datasets and European regions.

3.2. Metadata Documentation

Metadata will be prepared following the EMODnet guidelines to provide comprehensive information for data discovery and reuse:

- **Detailed Descriptions** of data provenance, collection methods, and processing workflows.
- **Quality Assurance Documentation**, including validation steps and quality flags where applicable.
- **Licensing and Access Rights** to clarify usage conditions.

All metadata will comply with standards such as **ISO 19115/19139** and be registered within the EMODnet metadata catalogue to ensure transparency and FAIR data principles.

3.3. Submission through the EMODnet Data Ingestion Portal

Our data package—including OGC GeoTIFF files and corresponding metadata—will be submitted via the EMODnet Data Ingestion Portal, where:

- Data providers register and upload their datasets with accompanying documentation.
- Initial automated checks verify file integrity and metadata completeness.

- The submission is assigned to the Seabed Habitats Thematic Assembly Centre (TAC) for further review.

3.4. Validation and Publication

The TAC experts conduct a thorough validation process involving:

- **Technical Validation** to confirm format compliance and metadata accuracy.
- **Scientific Review** ensuring the habitat classifications and spatial data reflect current knowledge.
- After validation, the data is published in the EMODnet Seabed Habitats portal, making it openly accessible through interactive maps and data download services.

3.5. Contribution to European Marine Data Infrastructure

By submitting seagrass data to EMODnet, data providers contribute to the broader European marine data infrastructure:

- **Integration with European Initiatives**: The data becomes part of initiatives like the **Marine Strategy Framework Directive (MSFD)** and the **EU Biodiversity Strategy**, supporting policy development and environmental management.
- **Support for Marine Spatial Planning**: The availability of comprehensive seagrass data aids in the planning and management of marine areas, ensuring the protection and sustainable use of marine resources.
- **Enhancement of Scientific Research**: Researchers gain access to high-quality, standardized seagrass data, facilitating studies on biodiversity, ecosystem services, and climate change impacts.

3.6. Sample Data Processing: AUV-Derived Seagrass Image

As an example from the preliminary survey in the Perama area, data collected with the AUV have been processed to illustrate the conversion of raw observations into the standardized GeoTIFF format.

This example demonstrates how a spatial image of seagrass coverage, captured during the survey, is georeferenced, structured, and accompanied by the required metadata, providing a template for how subsequent datasets will be prepared for integration into the EMODnet Seabed Habitats portal.

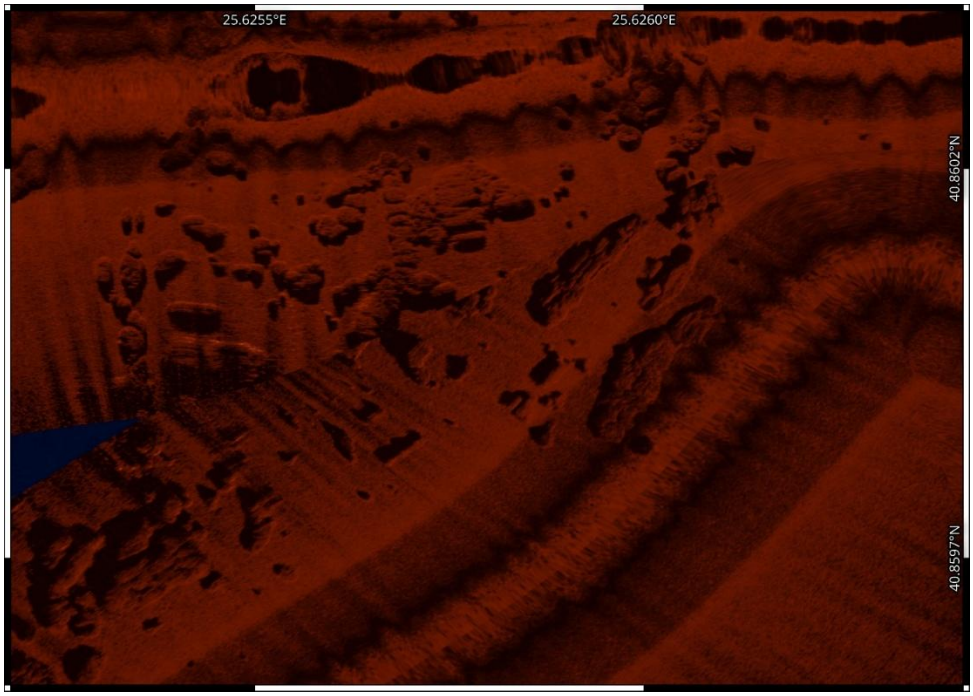


***Figure 4**. Side Scan Sonar recorded data showing seafloor features captured during the preliminary survey visualized using Quantum GIS software.*

4. Benefits of Data Sharing and Integration

4.1. Advancing Scientific Knowledge

Open access to harmonized, quality-controlled datasets promotes **interdisciplinary research** and the development of innovative methods for marine monitoring and modelling. Researchers gain access to complementary datasets from other contributors, enabling richer analysis and broader perspectives.

4.2. Supporting Evidence-Based Policy

By delivering comprehensive and up-to-date assessments of the marine environment, the shared data empower policymakers to make informed decisions on:

- **Marine conservation strategies**.
- **Sustainable fisheries management**.
- **Coastal infrastructure development**.
- **Disaster preparedness and response**.

4.3. Enhancing Local Resilience

For the EfxINNOs project pilot sites, this collaborative data sharing fosters capacity building. Local stakeholders can leverage CMEMS and EMODnet services to design locally relevant, evidence-based policies aimed at enhancing sustainability and resilience in coastal zones.

5. Strategic Collaboration and Long-Term Impact

The integration of project outputs into CMEMS and EMODnet not only reinforces the project's scientific credibility but also ensures that the results continue to generate value after the project's conclusion. The initiative strengthens ties between leading EU knowledge infrastructures and local actors, creating a sustained feedback loop of data provision, analysis, and application.

By actively engaging with these networks, the project positions itself as a contributor to global marine knowledge while ensuring that its findings translate into real-world benefits—ranging from improved environmental stewardship to better-informed socioeconomic planning.