EMODnet Thematic Lot n° 4

Chemistry

EMODnet Phase 2 – Draft Final Report

Reporting Period: July 2013 – June 2016

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List of abbreviations and acronyms

CDI, Common Data Index, provides a highly detailed description of the data, answering to the questions: where, when, how and who collected the data, and how to get them. One CDI describes a data series which can be a vertical profile on a fixed location, a time series or a trajectory data set.

CR, Contaminant Ratio

CS, Contaminant Score

DIVA, Data-Interpolating Variational Analysis, is a software tool that allows to spatially interpolate (or analyse) observations on a regular grid in an optimal way.

DM, **Download Manager,** is a java component installed by the data centers to process locally the data requests coming from the central data portal.

EQS, Environmental Quality Standards

MSFD is Marine Strategy Framework Directive

NODC, National Oceanographic Data Centre defined within the International Oceanographic Data Exchange (IODE) System of the UNESCO Intergovernmental Oceanographic Commission (IOC).

Ocean Browser is the EMODnet Chemistry data products viewing and downloading service that allows to visualize gridded fields on-line. It is based on open standards from the Open Geospatial Consortium (OGC), in particular Web Map Service (WMS) and Web Feature Service (WFS).

ODV, Ocean Data View, is a freely available software package that provides interactive exploration, analysis and visualization of oceanographic and other geo-referenced profiles or sequence data. ODV and NetCDF data file formats are used as mandatory data exchange format in SeaDataNet/EMODnet Chemistry.

P01 = British Oceanographic Data Centre (BODC) Parameter Usage Vocabulary, is one of SeaDataNet Common Vocabularies based upon a semantic model that is the simple concatenation of three 'themes' (what, where/matrix and how/methods) and used to describe individual measured phenomena in ODV data transport format. P01 are narrower terms of P02. At present P01 already contains more than 30.000 concepts.

P02 = SeaDataNet Parameter Discovery Vocabulary, is one of SeaDataNet Common Vocabularies describing fine-grained related groups of measurement phenomena designed to be used in dataset discovery interfaces (namely CDI metadata records).

P35 = EMODnet chemistry lot aggregated parameter names, is one of SeaDataNet Common Vocabularies used to facilitate data aggregation and data labelling (as in products description).

Robot Harvester is the system used for discovery and gather data from SDN infrastructure of distributed NODCs via the CDI Discovery and Shopping mechanism with an almost full automatic method. It is configured to harvest data on selected sea areas (or MSFD regions) and for specific chemical parameters.

RSC are Regional Sea Conventions

SDN, SeaDataNet is the pan-European infrastructure for ocean & marine data management sponsored within FP7 (grant agreement 283607, 1/10/2011-30/9/2015) linking at the moment more than 100 national oceanographic data centres and marine data centres from 35 countries riparian to all European seas.

Sextant products metadata catalogue is the EMODnet Chemistry data products discovery service used for searching Chemistry data products and linking to the viewing service.

WPS, Web Processing Services

Executive summary

The executive summary that can be read by a non-specialist (15 pages) will be provided as part of the final report to include all results obtained within the project.

1. Introduction

EMODnet Chemistry started in August 2013 and has the overall objective to provide access to marine chemistry data sets and data products related to eutrophication and contaminants, based upon data gathered and collated from national monitoring efforts as well as from research activities as performed by organisations from all European coastal states.

The final output consists of a dedicated infrastructure that provides access to all assembled data related to the chemical composition of all sea basins in European waters in a uniform way and has been specifically implemented to support the Marine Strategy Framework Directive (MSFD) for the five EMODnet regions (Baltic Sea, North Sea, Eastern Atlantic Sea, Black Sea and Mediterranean Sea).

The specific objectives were to:

- Assemble measurements of chemical substances, in particular those relevant for the assessment of Good Environmental Status according to the MSFD (Descriptors 5 – Eutrophication, 8 – Contaminants and 9 – Contaminants in seafood), from heterogeneous data sources and process them into interoperable formats with their appropriate metadata and assess their accuracy and precision;
- Visualise the measurements density in a given time and space window and allow public access to data and metadata;
- Visualise the temporal evolution of the concentration of a selected group of measurements for a given time and space window and also along the coast;
- Calculate spatially distributed data products specifically relevant for MSFD implementation, based on guidance provided by the MSFD Common Implementation Strategy.

The EMODnet Chemistry consortium consists of 46 partners from 35 coastal states bordering the European seas and is built on a network of interconnected National Oceanographic Data Centres (NODCs) and marine information services of the major research institutes and of agencies in charge of environmental assessment. These centres are actively involved in managing, indexing and providing access to ocean and marine data sets, acquired from research cruises and monitoring activities in European marine waters and global oceans.

In order to achieve an harmonized system to manage marine chemistry data for all European Sea basins and to provide visualization products useful for assessment of the marine environment, specific efforts have been dedicated to achieve common, shared and standardized protocols to archive data with suitable accompanying metadata, to define standard Quality Assurance and Quality Control (QA/QC) procedures and to define data products specifically relevant for Marine Strategy Framework Directive implementation. Expert working groups have been defined within EMODnet Chemistry community and EMODnet Chemistry has been involved in several MSFD –

EMODnet coordination meetings, together with members of Regional Sea Conventions (OSPAR, HELCOM, UNEP/MAP, Black Sea Commission).

2. Highlights of the project

- **Improved spatial & temporal coverage** of chemical data (especially eutrophication) for all EU basins (ur-EMODnet vs EMODnet)
- Inclusion of **more chemical species** groups as well as new parameters for climate change (partial pressure of oxygen, carbon dioxide) and acidity (pH);
- Improved **user-friendliness** to **data access** through upgraded and customized quick search by Matrix of chemicals vs Region tool;
- Definition and sharing of practices (QA/QC, DIVA,…) for **increased harmonization** at EU level
- Achievement of **Regional aggregated and validated data buffers** for nutrients (interest by RSC)
- First example of **aggregated and harmonized contaminant** dataset at EU scale
- Improvement in spatial interpolated data products which are now provided as **10-year running averages** to allow rapid visualization of temporal trends;
- **Harmonised Data products** on eutrophication covering all EU basins
- Access to **Dynamic Plots** for time-series data;
- Provision of data layers to **support main actors involved in Marine Strategy Framework Directive (MSFD)** reporting activities including Member States, EEA and Regional Sea Conventions.
- **Increased connections** with MSFD and Marine Conventions (MoU)
- **Raised awareness** of the complexity and need of harmonization at EU level

3. Description of the work done

WP0: Project Management

The coordination activity has been mainly addressed to the following points:

- manage and solve the administrative issues of a wide partnership of 46 participants. Following the EU contract, OGS has drafted and circulated for discussion a Consortium Agreement for all partners and a Subcontract for bilateral contracting of individual subcontractors.
- management activity included payment of the consortium, trying to find solutions for the further involvement of Crimean subcontractors after Crimean crisis, to coordinate and homogenize the inputs from partners requested for the reporting activity and to contact and discuss with possible new partners expressing their interest to join the consortium
- organize the project meetings foreseen in the contract (plenary, steering, MSFD coordination meetings, videoconferences, Expert workshops)
-ensure timely progressing of project activities through the definition of regular (monthly) remote meetings focused on data validation, on products generation, and on tuning the cloud environment hosted at Cineca
-organise ad hoc videoconferences for specific technical issues and developing video tutorials d
- animate the dialogue with the four RSCs, through the participation in EMODnet-MSFD meetings in Brussels with OSPAR, HELCOM and EEA, through the organization of meetings with UNEP MAP and BS Commission secretariat
-keep dialogue with EMODnet Secretariat and with other EMODnet lots through participation in the EMODnet Steering Committee meetings
- implement the survey for feedback from users and analyse them with the steering Committee to derive actions and guidelines for the infrastructure development
-regular reporting activity as foreseen in the contract.

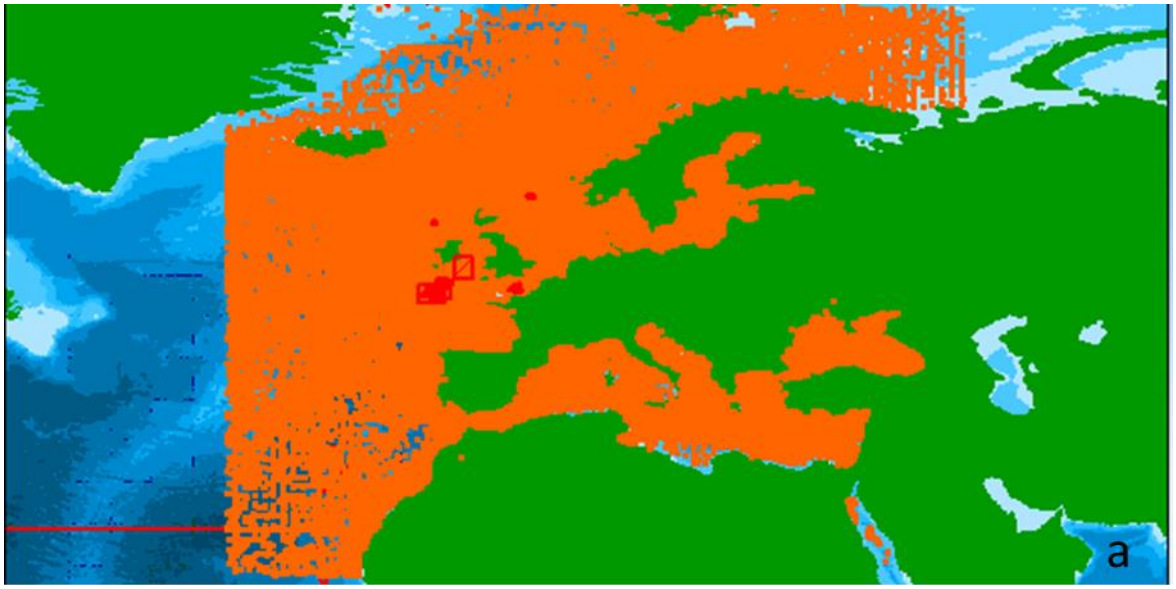
WP1 : Data collection and metadata compilation in sea regions

The objectives of the workpackage consist in gathering relevant chemical data sets from the EMODnet partnership and populating these into the CDI Data Discovery and Access service so that regional data set collections can be compiled and delivered to the EMODnet Chemistry regional groups for producing validated, aggregated and harmonised data collections and data products, that are then made accessable by visualisation services at the portal.

From the start of the project all partners and subcontractors in EMODnet Chemistry were asked to prepare and submit their data to the CDI Data Discovery and Access service, taking into account the

EMODnet Chemistry scope of chemical data, starting with nutrients data and proceeding in the 2nd year with contaminants and other remaining data. All data contributors were tasked to describe their identified and gathered data with metadata in CDI format and to make data available for downloading through the CDI service in the SeaDataNet ODV format. All entries become part of the SeaDataNet CDI collection, but for EMODnet Chemistry a dedicated subset is dynamically generated by filtering on Parameter Discovery Vocabulary (P02) terms that map to the extended scope of chemical substances for EMODnet Chemistry 2. This subset can be queried through the dedicated EMODnet Chemistry CDI User Interfaces (Quick Search and Extended Search) and with the additional CDI User Interface: Search by Chemicals by Regions.

Within the project period (June 2013 – June 2016), the total number of CDIs gathered for chemistry data sets has increased from **382554 to 813309.** These cover the whole globe. Specifically relevant for European waters (defined by Lat Long box**:** N80, W-30; N20, E45) has increased from **312024 to 716062.** These are derived from 64 data providers, from 311 originators and from 32 countries. Data span from 1868 to 2016 and are **84% unrestricted** while 16% require negotiation with data originators through the SDN interface. More details about the increase in population and the division of entries over discovery parameter groups and data providers per country can be found in the Chapter concerning Indicators.



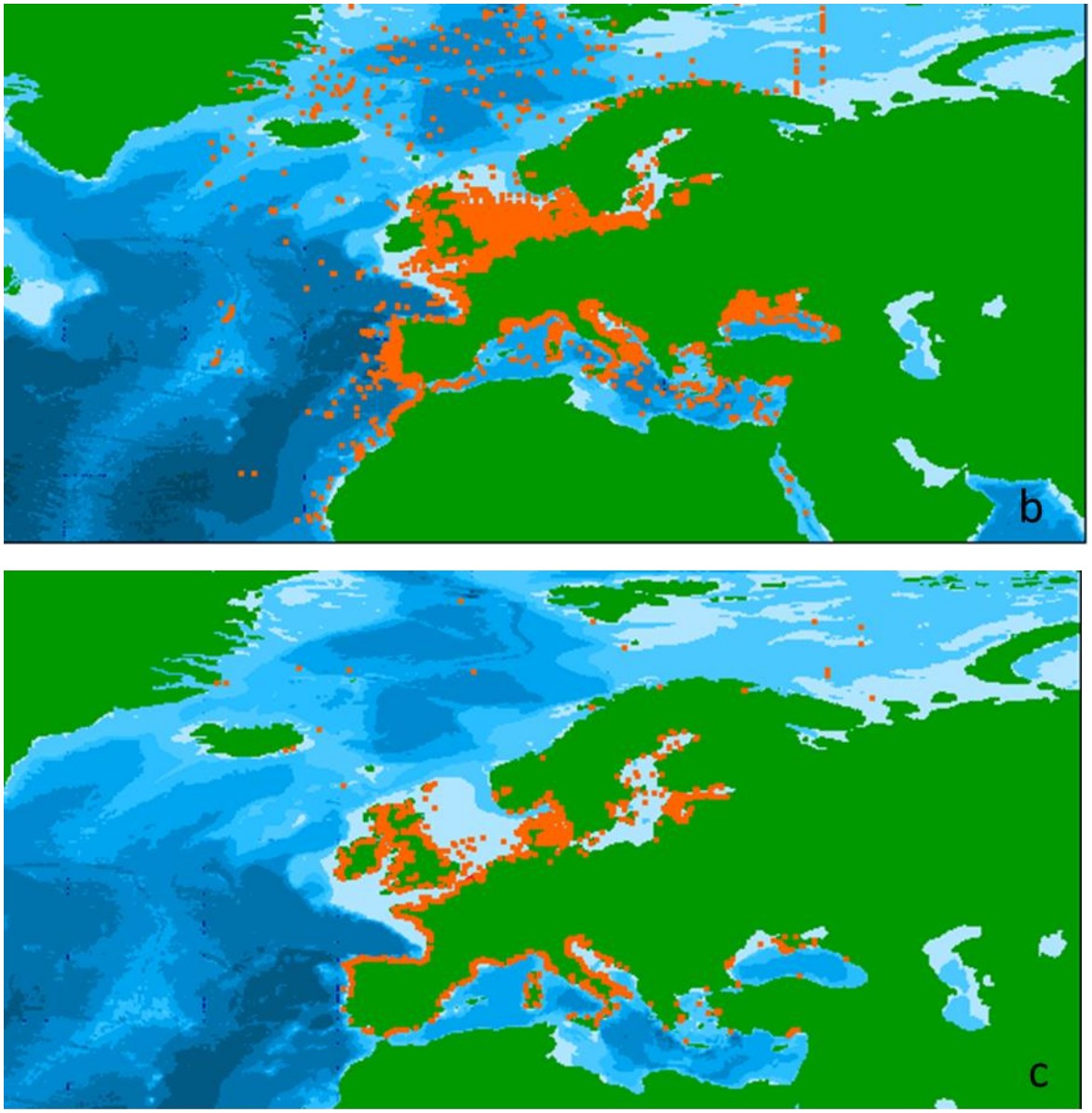


Figure 1. Overview of CDI data locations at the end of 3rd year for European waters, in water body (a), sediment (b) and biota (c).

The EMODnet Chemistry regional groups involved in WP2 have been generating data products based upon the gathered data sets. The harvested data used for data product generation consist of vertical profiles. The harvested data contain measurements made with different instruments and methods. These data products are generated per sea region as approximated as MSFD regions.

As part of WP1, data harvests have been undertaken by MARIS at regular times to deliver regional data sets (CDI metadata and ODV data) to the regional coordinators. Therefore, a dedicated CDI Robot harvester service was set up in the 1st year and further completed in the 2nd year. It facilitates an almost full automatic method to compile and maintain specific aggregate data sets as internal central data

buffers that can be transferred to regional groups for further processing and products generation. This is explained in more technical detail in the chapter of reporting on WP4.

The initial robot harvesting took place for the geofilter of schematised MSFD regions and with a focus on **nutrient** data. In the first round, circa **440.000** CDI records and data sets for nutrients in the given regions were harvested, divided by region and transferred to their regional leaders. To face shortcomings in the datasets indicated by the regional coordinators, a feedback loop with data providers for improvement of the incorrect data sets (metadata and/or data) has been established. The new delivery included circa **480.000** CDI records and data sets for **nutrients** in the given regions.

In April 2015 a new harvesting buffer was initiated for contaminants. These include Antifoulants, Heavy metals, Hydrocarbons, Pesticides and biocides, Pharmaceuticals, Polychlorinated biphenyls, and Radionuclides. End of June 2015 a third harvesting buffer was configured and initiated for the remaining chemicals, consisting of: Acidity, Chlorophyll, Organic matter, and Dissolved gasses. These robot harvesting activities have resulted in delivery of circa **65.000** CDI records and data sets for contaminants and circa **500.000** CDI records and data sets for other parameters (oxygen, chlorophyll, ..) for the given regions, transferred to their regional leaders.

Conclusion and next steps

The data population activities by EMODnet Chemistry partners and subcontractors have been very fruitful and over the 3 years have resulted in a steady and major increase of data in the CDI service, also including more recent data sets. Also an efficient almost fully automatic robot data harvesting system was set up and applied to generate buffers of data on nutrients, contaminants and others (oxygen, chlorophyll, ..) that were made available to the regional coordinators.

As a future step, the regional aggregated data contained in the buffers could be made available to organizations such as EEA, MS and RSC upon request and after agreement with the data providers. This can be arranged by so-called Service Level Agreements. However it should be noted that there are 2 buffer levels: one for the harvested data, and a second one after aggregating, validating and harmonising these harvested data sets at regional scales. For MSFD purposes access to the second level data collections is recommended.

WP2: Data Products generation in the sea regions

The objective of the Work Package was to prepare integrated data products that are provided to users via viewing services to visualize temporal and spatial variability and trends in time of concentration of selected chemical parameters. A special focus was dedicated to calculate data products specifically relevant for Marine Strategy Framework Directive Descriptors 5 (eutrophication), 8 (chemical pollution) and 9 (contaminants in seafood), based on the guidance of the MSFD Common Implementation Strategy.

The activity was articulated in a series of hierarchically linked steps involving:

- regional data aggregation
- regional quality control and data validation
- development of regional data products

In order to obtain data aggregation per sea region from the heterogeneous datasets originating from multiple institutions, an automatic Robot Harvester, properly configured during the first year with predefined criteria of geographical and temporal coverage and parameters, was adopted to retrieve specific data sets from distributed data centers. Regional leaders were in charge of parameter aggregation and data validation according to common and shared protocol, in order to carry out QA/QC control at regional base and to develop visualization products. Parameter aggregation included unit conversions, harmonization of parameter coding and meaning (taking into consideration the possible difference in the collection of new and historical data). The ODV system was suitably enhanced for automate parameter aggregation of data sets from the multiple sources.

In order to face the heterogeneity of sources/instruments/analytical methods to measure chemical parameters, with the zero and LOD values, with the files format error, and to achieve harmonized data validation for all EU basins, detailed procedures for Quality Assurance and Quality Control (QA/QC) have been produced:
http://nodc.ogs.trieste.it/doi/documents/EMD2chem_QCreport_V8-072015.pdf)
Quality control procedures were defined for different parameters and matrices and a validation loop on format error files and qualification of the data has been implemented with the data originators to improve the quality of the EMODnet datasets during the whole project period.

Standard quality control applied to nutrient data in water column consists in: data format checks, broad range control checks to exclude erroneous high values, negatives, identification of zero values, duplication eliminations and comparison of interpolated data with spatially averaged profiles. Regional Quality control procedures for other matrices and parameters mostly consist in position and date checks.

Finally, Diva (Data-Interpolating Variational Analysis) software has been applied to generate spatial interpolated concentrations maps for data with sufficient spatial resolution such as nutrients and dissolved oxygen. In order to allow visualization of temporal variability, concentration maps have been produced at seasonal basis, as 10 years means, with a moving window allowing to visualize time evolution of concentration of chemical parameters. A dynamic visualization service has been implemented to produce plots of observation densities and of temporal evolution of selected observations.

Activities towards harmonization for all EU sea basins:
In order to achieve harmonization of regional quality control, data validation and development of regional data products at EU level, following activities have taken place:

- All regional leaders use common tools (ODV) and methodologies for data processing, aggregations, quality control and preparation of aggregated collections.
- All regional leaders use common analysis tools (DIVA) and methodologies for the preparation of the horizontal maps.
- Usage of common vocabularies for parameters
- Monthly videoconferences between the regional leaders and the TTG key people involved in vocabularies, ODV, and OceanBrowser developments.
- Participation into two Experts Workshops aiming to support the MSFD (1st Chemistry Expert workshop, Split, 19 June, 2014, and 2nd EMODnet Chemistry Expert Workshop, 21 October 2015, Ostende)
- Participation into the project Technical and Steering Committee Meeting, as well as those of SeaDataNet for a common data management approach.
- Participation of regional leaders into the DIVA training courses at STARESO station, Calvi (France), November 2013, November 2014 and October 2015 to practice the new features of DIVA.
- Participation into 2nd SeaDataNet training session in Oostende, Belgium to learn more about the SeaDataNet/EMODnet procedures and software used within the projects
- Organization of dedicated Steering Committee Group and Technical Group meetings on boundaries, vocabularies, standards etc.
- Regular communication between the regional leaders to adapt ODV data processing and DIVA analysis.

3.1.1 Baltic Sea

Overview of the regional data inventory

Before the EMODnet kick-off meeting in Trieste 2013 SMHI/Sweden, as the Regional leader for the Baltic Sea, contacted the project partners (Denmark, Estonia, Finland Germany, Latvia, Poland and Russia) to get information about the datasets (including contaminants) that were going to be available for the project. The information should include a description of the datasets, the parameters measured and the number of records with their temporal coverage.
As the Baltic Sea was not part of the EMODnet Chemistry Pilot Project, no previous DIVA products had been made on the data.
The data distribution was presented during the kick-off meeting. As suggested during the meeting SMHI contacted Baltic Nest Institute, to get information about the data they hold. It turned out that the member states have much more data and that their database was not of interest for the project.
In April 2014, SMHI received the 1st harvested nutrients data for the region which contained 39.372 vertical profiles in SDN ODV Spreadsheet format. Due to unrecognised SDN ODV format an additional 1.717 profiles were not imported correctly and therefore not used. The vertical profiles originated from 8 countries and distributed over 14 organizations, included 208 variables in total. Manual sorting of variables were made in Excel and conversions and merging were made using ODV to create an aggregated data collection. After quality control of the aggregated dataset Diva products were generated on nitrate, phosphate and silicate. These products were created using data from 1990 to 2012 and were considered as a first test for the OceanBrowser. To improve quality of data in the infrastructure format errors and questionable values were documented and passed on to their distributors.

In October 2014, SMHI - received the 2nd nutrient dataset for the Baltic Sea region which had now been expanded to include 57 055 vertical profiles. New improvements in ODV made it possible to merge variables using the link between the P01 and P35 vocabularies. Work now focused on updating the existing aggregated dataset and Diva products for parameters nitrate, phosphate and silicate. Again, quality control was made on the aggregated dataset. As commonly agreed by the Steering Committee Diva products were created, starting with year 1960, for moving ten year periods for four seasons: winter (Dec-Feb), spring (Mar-May), summer (Jun-Aug) and autumn (Sep-Nov). To minimize the potential interpolation differences near the border between the North Sea and the Baltic Sea an overlap dataset from the North Sea was included in the Diva analysis. After the analysis the overlap region was cut off leaving only the Baltic Sea area in the final products. To link metadata to the Diva products xml-files were generated using divadoxml-gui. These were then uploaded to the Sextant catalogue. In addition to the Diva products ODV Spreadsheet files were extracted and sent to Deltares in the Netherlands to be used in the dynamic plots on the OceanBrowser. At this stage the same procedure was carried out on the additional parameters nitrate+nitrite, ammonium, total nitrogen and total phosphorus. Figure 2 shows the spatial and temporal distribution of phosphate. As for most of the parameters the majority of the measurements are made after 1990 and are evenly distributed over the seasons.

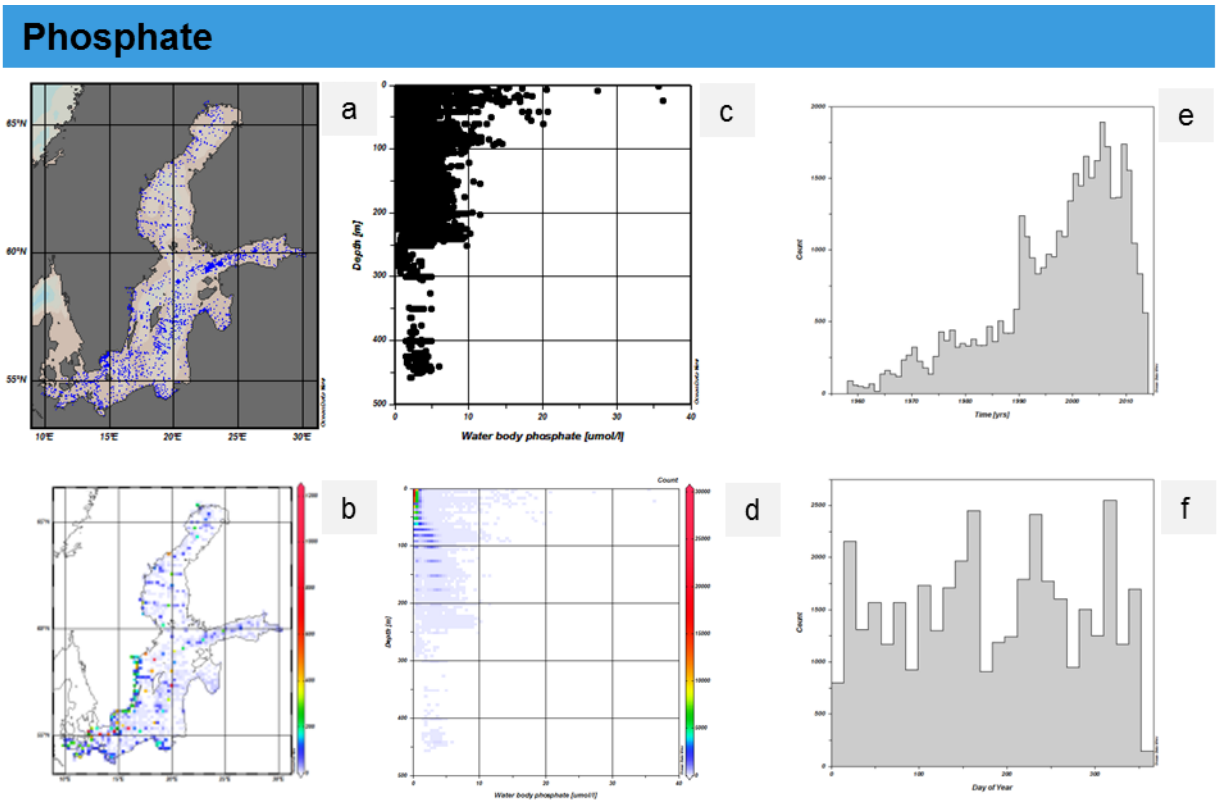


Figure 2. Spatial (a-d) and temporal (e-f) distribution of phosphate.

After numerous testing and evaluation of Diva results the analysis for the final products were setup with a fixed correlation length and signal to noise ratio of 0.7 and 1.0 respectively. Since the Diva tool calculates a “best fit” large gradients in data in combination with values near zero can give negative values in the end result. To eliminate this effect the log option in Diva setting were applied for all nutrients. Figure 3 shows an example of the end products that can be accessed via OceanBrowser.

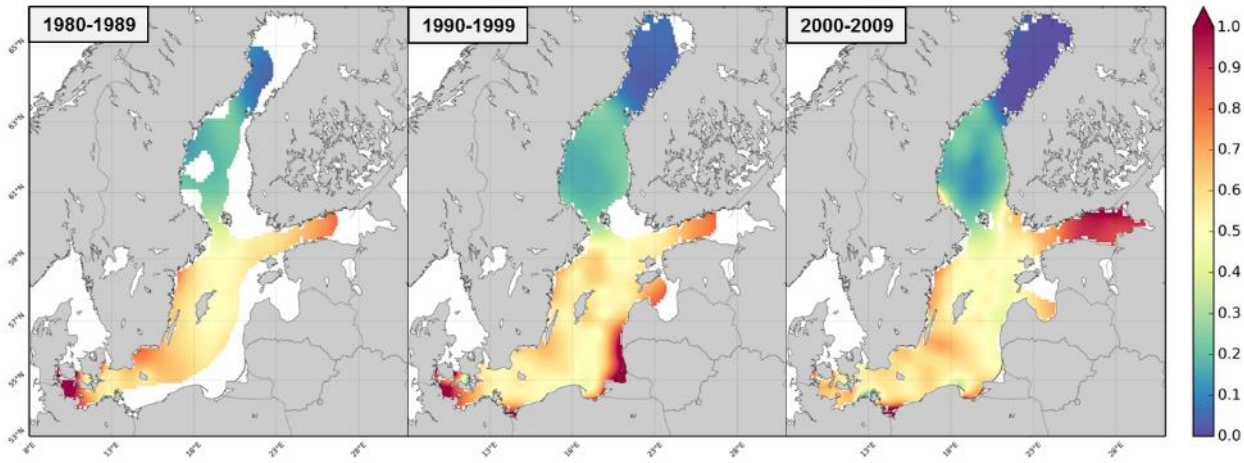


Figure 3. Diva results for winter (Dec-Feb) phosphate concentration (µmol/l) at the surface.

During the 3de year of the work focused on dissolved oxygen, chlorophyll-a, alkalinity, pH and carbon dioxide. SMHI received the dataset containing these parameters in February 2016. The procedures of aggregation and quality control were made and spatial and temporal coverage were checked. Oxygen was well represented in the dataset with more than 51.000 profiles (Figure 4). A large number of negative values, which had been calculated from hydrogen sulphate, were present in the oxygen dataset. Although, this could be helpful in some applications, for the purpose of EMODnet Chemistry these values were set to 0.

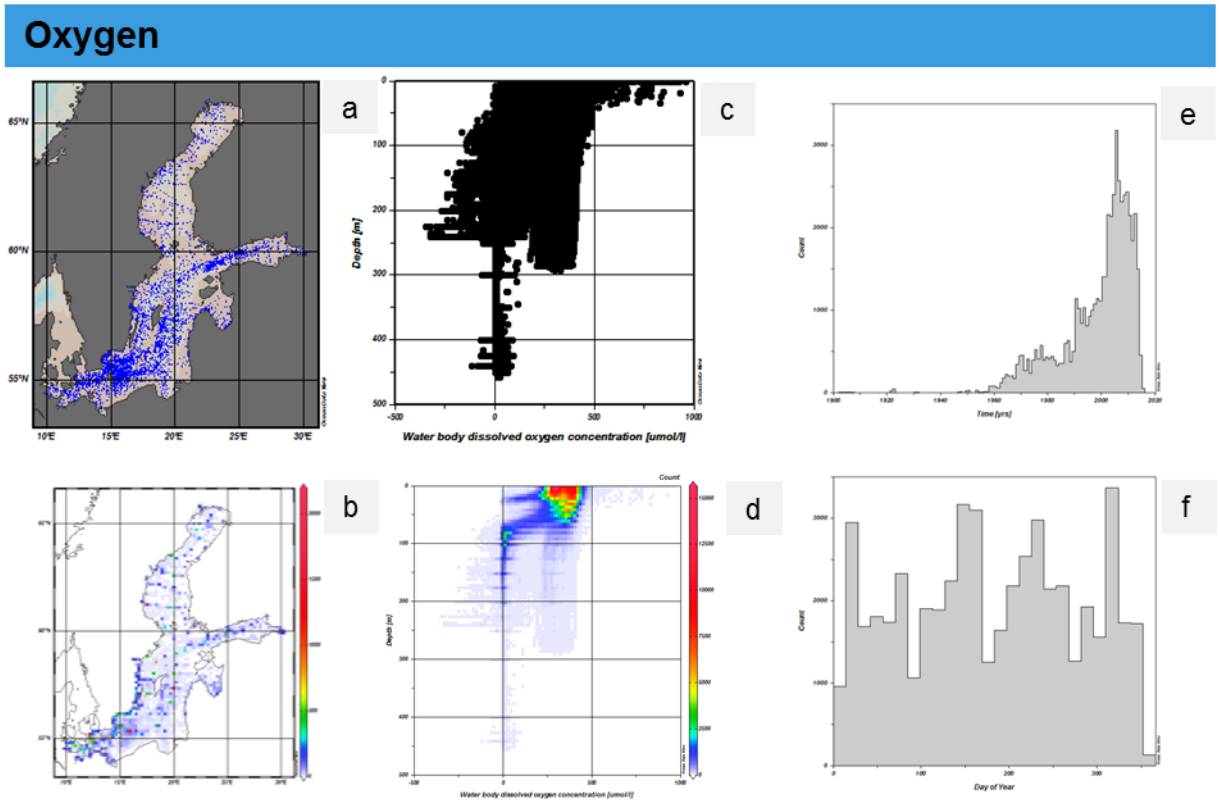


Figure 4. Spatial (a-d) and temporal (e-f) distribution of oxygen. The negative values are calculated from hydrogen sulfate concentration.

The coverage in chlorophyll-a was less with about 18.500 profiles of which most of them were measured after 1980. The number of profiles for Alkalinity and pH was not considered to be sufficient to produce Diva maps. No measurements of carbon dioxides were present in the dataset. Table 1 lists the total number of cdi records and the Diva products available on OceanBrowser.

		Diva products	
Parameter	Nr of profiles	Years	Depth interval
Nitrate	19 400	1960 - 2014	0 – 300
Nitrate + nitrite	34 760	1960 - 2014	0 – 300
Phosphate	39 036	1960 - 2014	0 – 300
Silicate	30 294	1960 - 2014	0 – 300
Ammonium	29 726	1960 - 2014	0 – 300
Total nitrogen	31 630	1960 - 2014	0 – 300
Total phosphorus	33 389	1960 - 2014	0 – 300
Oxygen	51 359	1960 - 2014	0 – 300
Chlorophyll-a	18 472	1980 - 2014	0 - 30
Alkalinity	5 327	n/a	n/a
pH	13 760	n/a	n/a
Carbon dioxide	0	n/a	n/a

Table 1. Number of profiles and diva products currently available for the Baltic Sea. Diva analyses are made for ten year moving average. Available depths are HELCOM standard depths within the interval given in the table. (n/a = no diva products produced).

The third and last year also involved work on contaminants. Late improvements in the P35 vocabulary to aggregate variables have delayed this work and therefore these variables are not yet finished. (however will be finished in the 2nd half of 2016).

Key factors and challenges during the project

The development of the P35 vocabulary to aggregate variables has been essential to the project. Questions regarding what variables to merge within the sediment and biota matrixes show that further work and improvements in this area is crucial.

Close dialogue with the developers of ODV and Diva software has improved both quality of the final products and efficiency of the workflow.

Although there has been some work to find and flag bad and questionable values, in general the quality of the data has been fairly good. The main issues, and the most time consuming work, has been to handle format errors in the ODV files. Most of these errors have been obvious and measures have been taken to correct them. This shows that the feedback loop is very important to improve data quality towards getting a better harmonized workflow.

There have been some questions about how to report certain variables and which primary variable to use in the ODV files. One of these questions regards integrated chlorophyll. To be able to include this

data in the Diva products the integrated value needs to be linked to a depth variable and doing so will in some sense give the wrong information. Further discussions on how to handle this kind of data is needed. Discussions are also needed on how to report contaminants in biota. Often the primary variable is set to be depth even though in many cases this information is not present or valid. This shows that the format for this matrix needs to be standardized.

3.1.2 Atlantic Ocean

Overview of the regional data inventory

For the kick-off meeting on June 2013, Ifremer – the task leader for the Atlantic Ocean area, contacted the project partners (Spain, Portugal, Germany and Russia) to get detailed information (data inventory, spatial and temporal coverages) about the datasets that were going to be available for the project.

In April 2014, Ifremer received the 1st robot harvested collection of nutrients data for the region which included 8 757 CDIs files, plus additional 2 780 CDIs files received from Spain. Manual operations (sorting of the variables, unit conversions, deletion of duplicates, dealing with zero and LOD values) had to be done to create an aggregated data collection with ODV software and to ensure data qualification focusing on Phosphate, Nitrate, Silicate and Ammonium.

During the second year of the project, the coverage of the Atlantic region was extended westward and Ifremer received the second robot harvested collection of nutrients data for the region which included 23 611 CDIs files (23 254 stations – vertical profiles and 357 stations-time series). P35 vocabulary was used to compile an aggregated dataset with ODV and a common methodology for QA/QC and DIVA products was implemented. The coverage of Nitrates in this region was not sufficient to ensure relevant DIVA maps generation; as alternative maps were produced for Nox parameter (named Nitrate_plus_nitrite hereafter) using Nitrate+Nitrite, Nitrate and Nitrite data. Four individual data collections for each parameter were prepared. The resulting Atlantic Ocean aggregated data collections are described in Table 2 and displayed in the following figures.

Nb CDIs	Phosphate	Nitrate_plus_nitrite	Silicate	Ammonium
Total	11319	7472	7110	5001

Table 2. Total number of CDIs/profiles for nutrients in the Atlantic Ocean area

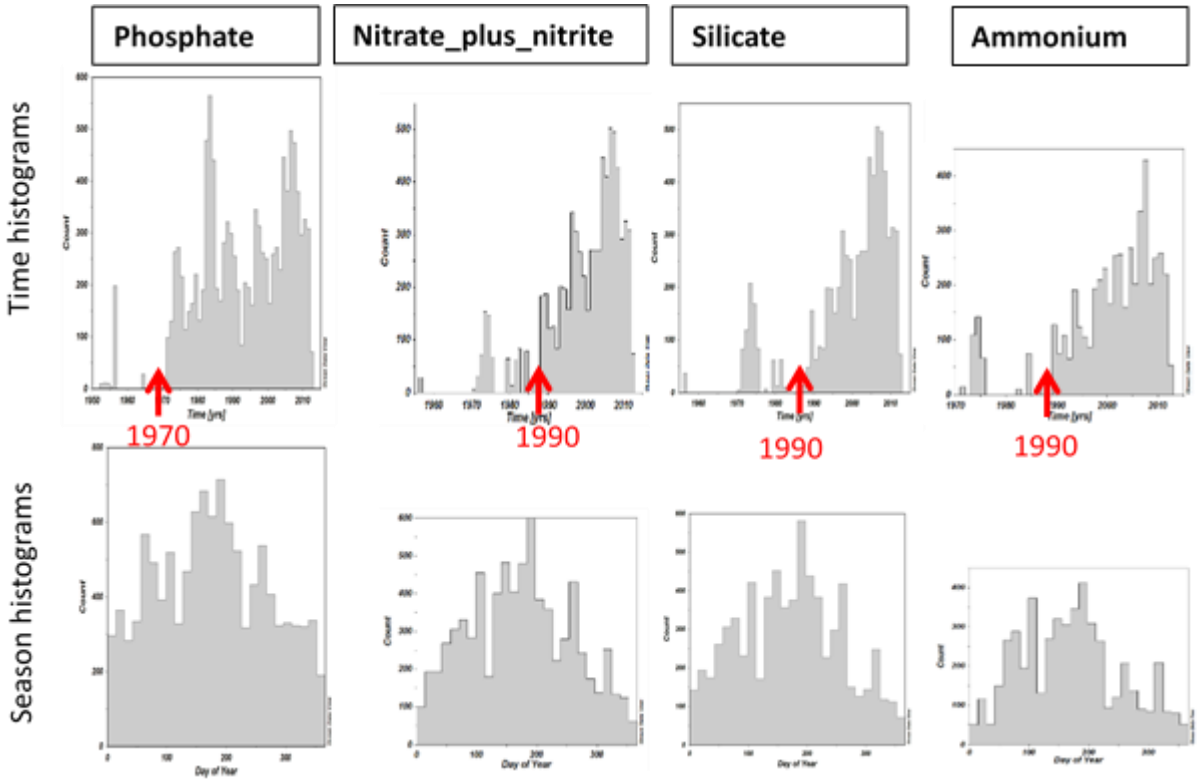


Figure 5. Temporal distribution of nutrients with time histograms (up) and season histograms (down) by nutrients parameters.

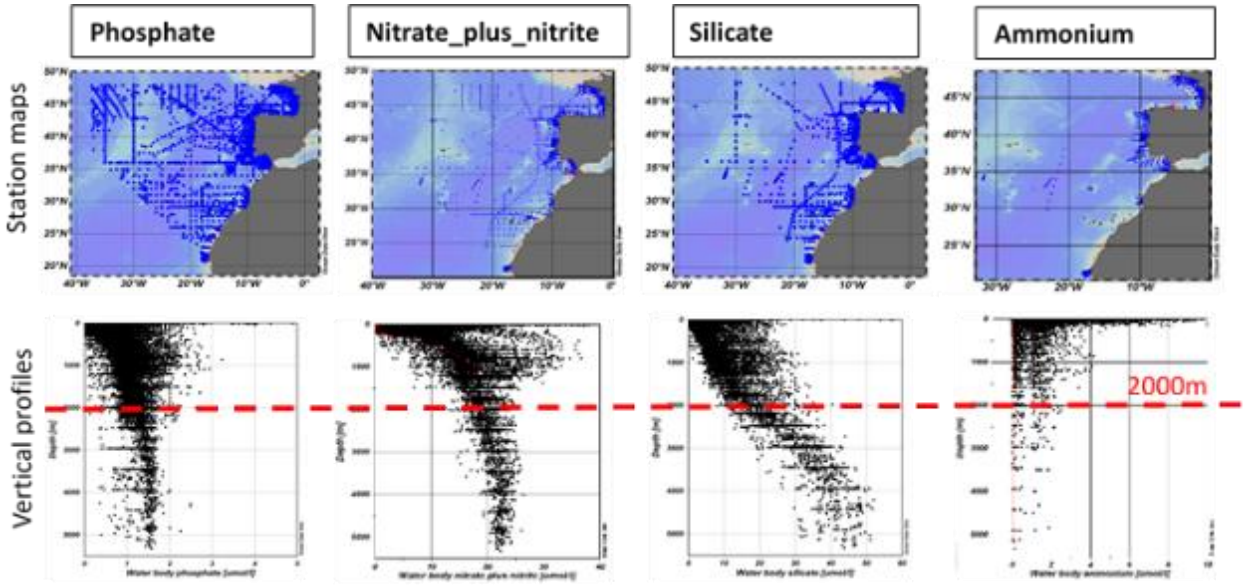


Figure 6. Spatial distribution of nutrients with station maps (up) and vertical plots (bottom) by nutrients parameters. The Phosphate collection has the best coverage in time and space.

The temporal distribution of all parameters becomes statistically relevant from the 1990s with a maximum of measurements during the summer season. A great majority of the data are concentrated at the coast and in the first 2000m.

During the third year of the project (March 2016), Ifremer received the robot harvested collection of other (dissolved oxygen, chlorophyll-a, PH, total alkalinity, DOC) and contaminants data for the region which included respectively 28 584 CDIs and 3 505 CDIs.

Nb CDIs	Oxygen	Chlorophyll-a	PH	Tot. Alkal.	DOC
Total	21098	13357	5048	323	0

Table 3. Total number of CDIs/profiles for other parameters in the Atlantis Ocean area.

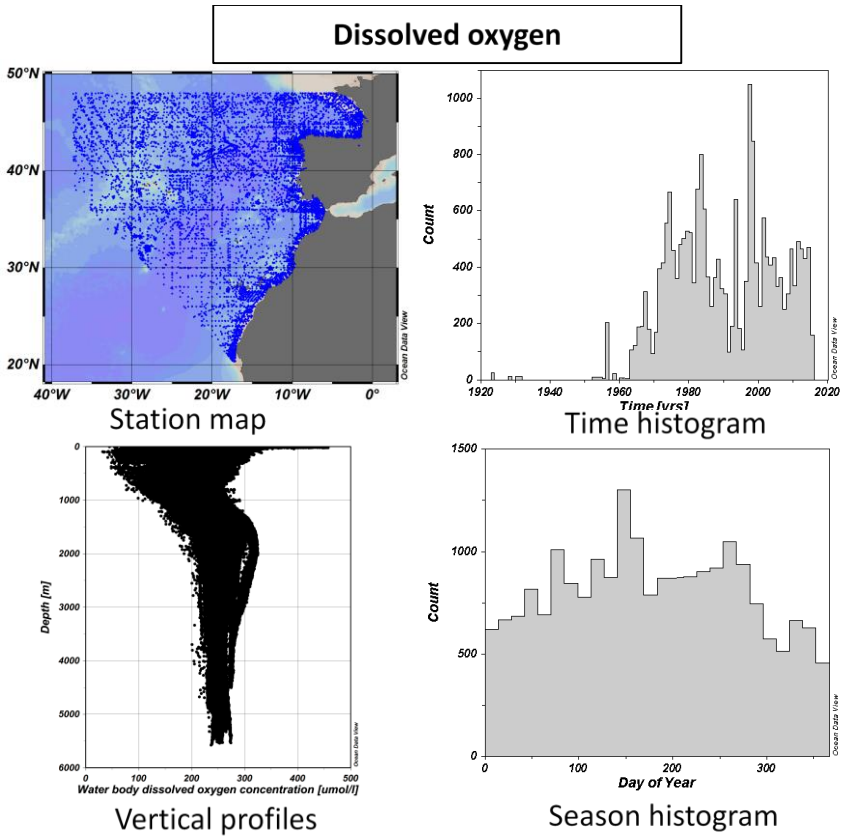


Figure 7. Spatial and temporal distibutions of dissolved oxygen in the Atlantic Ocean area.

Dissolved oxygen has a great spatial coverage and a better time coverage than nutrients parameters with a high number of data from the early 1960s. Chlorophyll-a data are still under analysis and its distribution will be described in the final report in the 2nd half of 2016.

Contaminants data are sparsely represented within the 3 matrices with the best coverage in the sediment matrix (Table 4). Due to the heterogeneity of Contaminants species and sediment grain sizes, it was decided to aggregate variables codes from P01 to P35 only for the most important Contaminants for MSFD. The aggregation will be done later this year after the implementation of Contaminants unit's conversions into ODV software.

Nb CDIs	Water column	biota	sediment
Total	673	268	2564

Table 4. Contaminants inventory (number of profiles and timeseries[1]) by matrices in the Atlantic Ocean area.

DIVA products in the water column, visualisation and catalogue

During the first year, DIVA tests were performed for Phosphate for the period 1998-2013 for spring and summer seasons.

The second year, several DIVA settings have been tried to improve the quality of the resulting products impacted by the lack of coverage of the datasets. For the DIVA parameters optimization phase, it was thus decided to use a seasonally-averaged profile for the correlation length and a constant value for signal to noise ratio. The first DIVA maps with a larger domain (extending westward, up to 36°W) than the initial MSFD definition were made for the NE Atlantic for Phosphate, Nitrate_plus_Nitrite, Silicate and Ammonium. They were created for the period 1962-2014, for all seasons, for 33 IODE standards depths with one-year moving window (Figure 8). No product could be prepared for total phosphorus nor total nitrogen due to the scarcity of these parameters in the dataset.

During the third year, DIVA products are only generated on oxygen (Figure 8) and chlorphyll-a because of the lack of coverage for the other parameters.

[1] From the french coastal monitoring network (Quadrige)

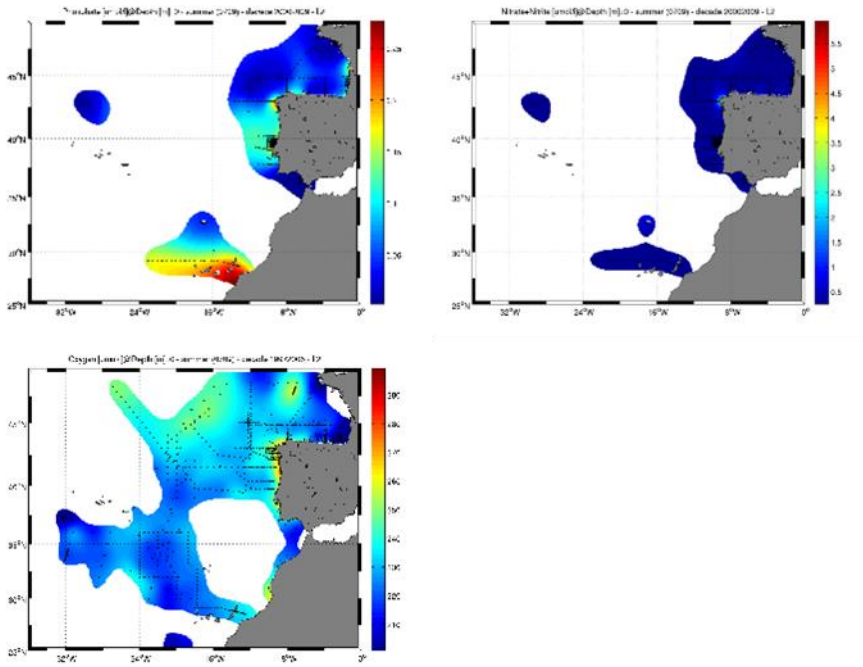


Figure 8. Surface DIVA maps for Phosphate (top left), Nitrate_plus_nitrite (top right) and Oxygen (bottom left) for summer season for 1 decade.

To link metadata to all the DIVA products, xml-files were generated using divadoxml-gui and then uploaded to the Sextant catalogue. DIVA products were also uploaded on the GHER ftp server to be visualized on the EMODnet web portal through Oceanbrowser. In addition to DIVA products, ODV spreadsheet files were generated and sent to Deltares to be used in the dynamic plots on the EMODnet web portal.

Lessons learned

DIVA maps can also be used as a tool/step in the data qualification. Indeed, hot spots highlighted in the resulting products can be investigated more in detail to check whether they are realistic and if not to detect wrong values in the dataset.

Since the beginning of the project, Ifremer has also developed a complete workflow and software chain to stream the data from the French coastal monitoring network (Quadrige database) to EMODnet as time series. These time series can extend over more than 40 years and are regularly updated with the latest data stored in Quadrige. This approach can be a good example for other monitoring agencies in EMODnet to follow.

3.1.3 Black Sea

Overview of the regional data inventory

During the EMODnet kick-off meeting (Trieste, June, 2013), the National Institute for Marine Research and Development "Grigore Antipa" - NIMRD, as Regional leader for the Black Sea, presented a synthesis regarding the datasets available for the Black Sea. Information about datasets description, parameters, number of CDIs, matrix, temporal and spatial coverage was collected from Black Sea data providers (16 partners from Turkey, Georgia, Russia, Ukraine, Romania, Bulgaria, Greece and Germany).

In April 2014, NIMRD received the 1st robot harvested data from MARIS for the region which included 27694 files in ODV Spreadsheet format (from 20 data providers). Several problems (wrong ODV format, wrong parameters labeling, duplicates, etc) appeared during the Black Sea data aggregation. Therefore a specific workflow was adopted for corrections. The chosen parameters (Ammonium, Silicate, Phosphate, Nitrate + Nitrite, Nitrate, and Nitrite) were mapped to the P35 vocabulary and unit' conversions were applied. Six individual data collections for each parameter were prepared. QC check and data validation was done in collaboration with the data originators. Excel and ODV were used for the corrections, parameters aggregation and quality control of the regional data sets. The first DIVA tests were done for the Black Sea, Marmara Sea and Azov Sea as all three seas are included in one MSFD region. DIVA analyses were performed for Nitrates for the period 1955-2013 for spring and summer seasons.

In October 2014, NIMRD received the 2nd harvested nutrients data collection for the region which included 49910 files in ODV Spreadsheet format and the corresponding extended CDI metadata file (data.csv). The datasets originated from 22 CDI-partners and containing data from 35 data originators.

In February 2016 NIMRD received two new harvested data collections. One contained datasets with Oxygen, Chlorophyll a, Acidity parameters which included 41532 files in ODV Spreadsheet format (originated from 24 CDI-partners counting 39 data originators) and the second one contained datasets with Contaminants parameters (Hydrocarbons, Heavy metals, Polychlorinated biphenyls, Pesticides and biocides, Radionuclides) in water, sediment and biota which included 24343 files in ODV Spreadsheet format (originated from 12 CDI-partners counting 18 data originators) and the corresponding extended CDI metadata files (data.csv).

The special version Windows 64Bit ODV 4.6.3.3 was used to merge CDI metadata and ODV data into metadata enriched ODV collections and to export (using the built-in, by AWI, export method) SDN Aggregated ODV Collection with automatically aggregated variables codes from P01 to P35 and units to μmol/l. Further, ODV Software was used for quality control of the regional data sets. The errors / problems occurred at importing in ODV 4.6.3.3 or in parameters units were corrected (using ODV software, Excel and in house developed scripts) in collaboration with partners. Following the document "Methodology for data QA/QC and DIVA product", the metadata enriched aggregated QC ODV collections (vertical profiles) for each parameter were prepared (Water body ammonium (6935 profiles), Water body silicate (19024 profiles), Water body nitrate (8274

profiles), Water body nitrate plus nitrite (9354 profiles), Water body nitrite (11619 profiles), Water body phosphate (22728 profiles), Water body total phosphorus (3186 profiles), Water body total nitrogen (3005 profiles), Water body dissolved oxygen concentration (34383 profiles) and Water body chlorophyll a (1965 profiles)) and send, together with time series data, to MARIS and DELTARES for inclusion in the database related to the Dynamic series plots.

Due to the high variability of data coverage in time (periods of years with no data) it was agreed by the Steering Committee, that Diva analyses to be done on moving ten year period analyses (every year of the time dimension corresponds to the 10-year centered average) for every season.

Black Sea DIVA moving 10-years seasonal analyses of Water body ammonium, silicates, phosphates, nitrates, nitrate plus nitrite, dissolved oxygen concentration for Black Sea were performed. DIVA gridded products (SeaDataNet NetCDF format - Water_body_parameter.4Danl.nc) were uploaded on OceanBrowser for visualization through the Viewing and Downloading service. The corresponding metadata XML files have also been prepared using divadoxml-gui and loaded in SEXTANT discovery catalogue. Due to the low number of data sets available and the poor spatial and temporal coverage for Water body total phosphorus and Water body total nitrogen DIVA analyses for these two parameters could not be performed. For Water body chlorophyll a DIVA analyses will be done only on the regions with good temporal and spatial data coverage (Western and Southern Black Sea).

Due to the high number of Contaminated species, the Steering Committee in collaboration with specialists and Vocabulary Group agreed that the aggregation of variables codes from P01 to P35 and of units should be performed only on the set of contaminants which is the most relevant for the MSFD.

For the Black Sea the errors / problems occurred at importing in ODV 4.6.3.3 were corrected (using ODV software, Excel and in house developed scripts) resulting in 138 profiles in biota, 2305 profiles in sediment, and 21854 profiles in water.

The aggregation from P01 to P35 will be done in the second half of 2016 after the implementation of the rules for Contaminants unit's conversions into ODV software.

Spatial and temporal coverage, stations density distribution, number of vertical profiles and of measurements, as well as some DIVA products are synthetically presented in ANNEX 1.

3.1.4 Mediterranen Sea

Overview of the regional data inventory

For the kick-off meeting on June 2013, the Hellenic Centre of Marine Research - HCMR/HNODC, as task leader for the Mediterranean area, contacted the project partners (18 data providers from 11 countries

- Spain Croatia, Cyprus, France, Greece, Israel, Italy, Montenegro, Slovenia, Spain, Turkey, Ukraine) to get information (data inventory, spatial and temporal coverage) about the datasets that were going to be available for the project.

In April 2014, HCMR received the 1st robot harvested collection of nutrients data for the region which included 29 583 CDIs of vertical profiles and time series in SDN ODV Spreadsheet format, originated from 25 data providers of 12 countries. The data set included in total 231 different parameters that were manually processed to create the first aggregated data collection. All processing steps such as format corrections, units conversions, zero LOD handlings, duplicates deletion, quality control checks, as well as the methodology followed for the preparation of the aggregated data sets, were documented in the Mediterannean report for the QC (*QC_Nutrients_Report_Mediterr-HCMR.doc*) and was sent to originators for confirmation and updating of the local data sets.

The efforts during the second year of the project were focused on expanding and improving the existing nutrients collections and procucts with more data and metadata. In October 2014, HCMR received the 2nd harvested with 34 321 CDIs and additional metadata that were used for the creation of the enriched metadata aggregated collections in support of the dynamic data plots of the visualization services and the products catalogues. The parameters aggregation was done automatically by the new enhanced ODV tool. The QC was done following the methodology that was already defined and documented during the first year of the project. In Table 5 there is an overview of the number of CDIs for phosphates, silicates, nitrates and nitrites, ammonium, total phosphorus and total nitrogen.

During the the third year of the project, in March 2016, HCMR/HNODC received the robot harvested collection with 96 349 CDIs with 74562 oxygen and 23105 chlorophyll-a profiles (See Table 5) and 7433 CDIs with contaminants in water, sediment and biota (see Table 6). In addition the data set included 30 967 PH stations that are still under validation. Other parameters in this last dataset are (not shown in Table 5): total alkalinity (3 423 profiles), DIN (2 513 profiles), POC and DOC (< 1500 profiles) but their coverage is poor and will be used only for the dynamic visualizations and not for horizontal interpolation.

Nb CDIs	Phosphate	Total Phosphorus	Nitrates	Nitrites	Nitrate+nitrite
Total	27 894	7 628	21 875	23 101	5 393

Nb CDIs	Ammonium	Total Nitrogen	Silicate	Oxygen	Chlorophyl
Total	14 563	5 623	23 102	74 562	23 105

Table 5: total number of CDIs for nutrients, Oxygen and Chloropyl in the Mediterranean Region.

Nb CDIs	Water column	biota	sediment
Total	4 483	329	5 380

Table 6: contaminants CDIs (number of profiles and timeseries) by matrices in the Mediterranean Sea.

The spatial, temporal distribution and vertical plots for the nutrients, oxygen and chlorophyll-a profiles are illustrated in Figures 9. As a general comment, oxygen and phosphates have better spatial coverage than the other parameters, while Total P and Total N are limited to the Adriatic Sea only. The seasons are well represented with higher number of stations during summer months (July to September) but the distribution from year to year is not uniform at all. Merging of data overlapping decades with one year step overcomes the lack of data in some periods.

Based on the temporal and vertical distributions of data, the following DIVA horizontal maps have been produced and made available for visualization and downloading at OceanBrowser (Table 7) :

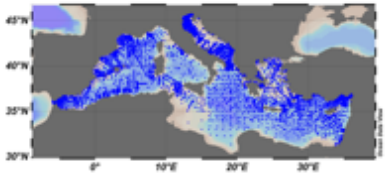
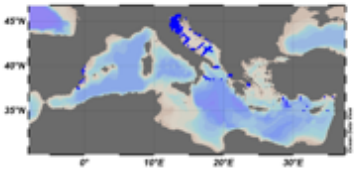
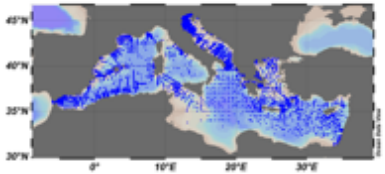
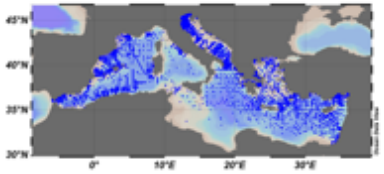
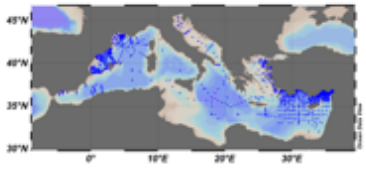
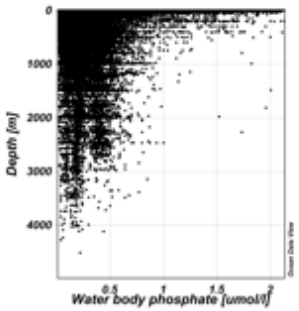
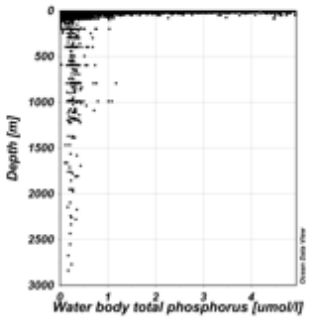
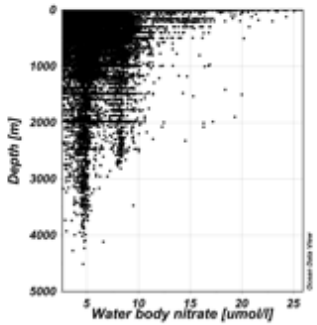
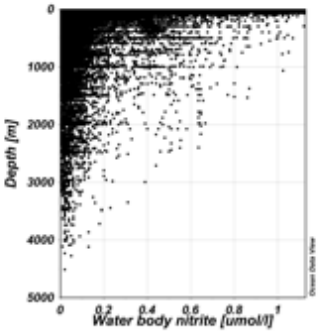
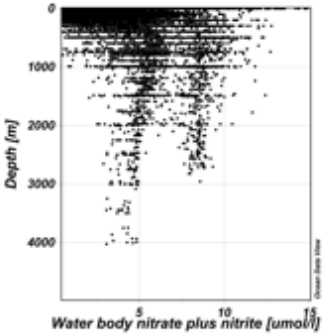
Parameter	From year – to year	Nr seasons	Depth interval
Phosphates	1960 – 2013	4	0 – 1500
Total phosphorus	1984 – 2007	4	0 – 1000
Nitrates	1960 - 2013	4	0 – 1500
Nitrites	1965 - 2013	4	0 – 1500
Nitrate + nitrite	1986 – 2013	4	0 – 1500
Ammonium	1977 – 2013	4	0 – 1000
Total nitrogen	1990 – 2004	4	0 – 1000
Silicate	1960 – 2013	4	0 – 1500

Table 7. Diva products currently available for the Baltic Sea on OceanBrowser

An example of a DIVA horizontal map for phosphates in Mediterranean Sea is given in Figure 10 below.

Key issues

- Inconsistencies were found for the oxygen data derived from instruments such as Argo floats, gliders, ctd profiles, and those from water samples. The history for the instrument calibrations was unknown in most cases, also the flags of the real time quality control needed a lot of corrections and these caused several delays to the validation of the oxygen data.
- New partners who are not yet well experienced in the usage of the SeaDataNet transformation tools (e.g. NEMO) and do not validate the SDN ODV exchange format, introduce format errors with the data sets. The correction of these errors (both at local and regional level) causes considerable time delays until the products is released.
- A high number of usage codes (P01) were found for contaminants which required more than the expected effort for mapping with the project priority parameters.
- The data scarcity is a major issue during DIVA analysis which influence the robustness of the analysis parameters.
- Combining coastal/monitoring and open sea data within DIVA analysis requires higher analysis resolutions and more computational time.

PHOSPHATES	TOTAL PHOSPHORUS	NITRATES	NITRITES	NITRATES PLUS NITRITES
				
Stations Map				
				
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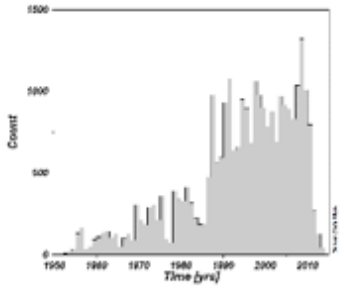
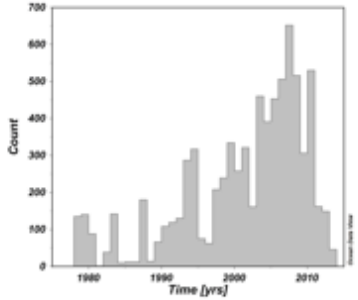
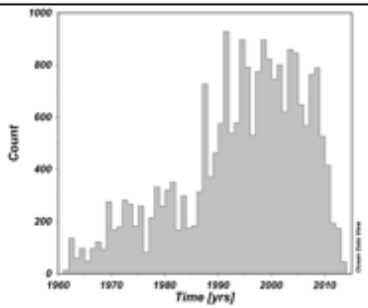
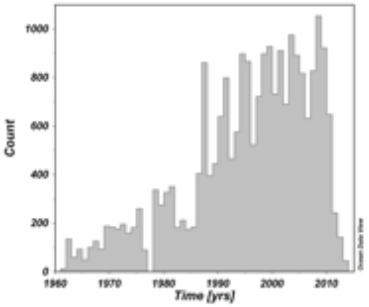
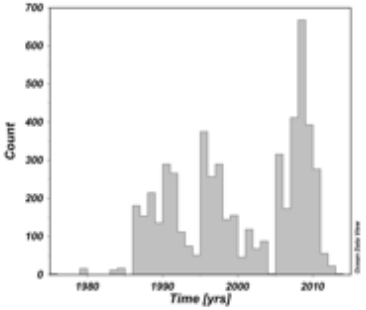
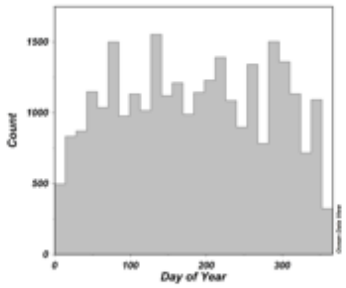
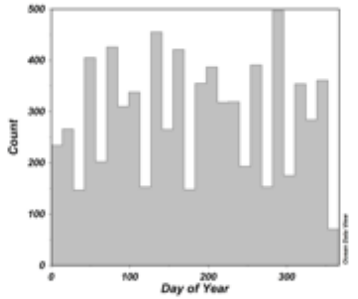
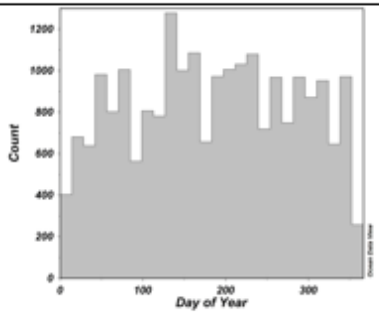
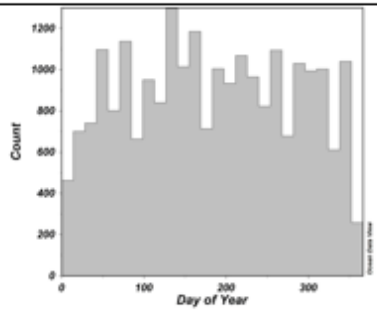
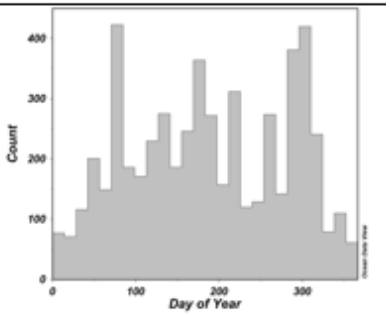
				
Time Histogram				
				
Season Histogram				

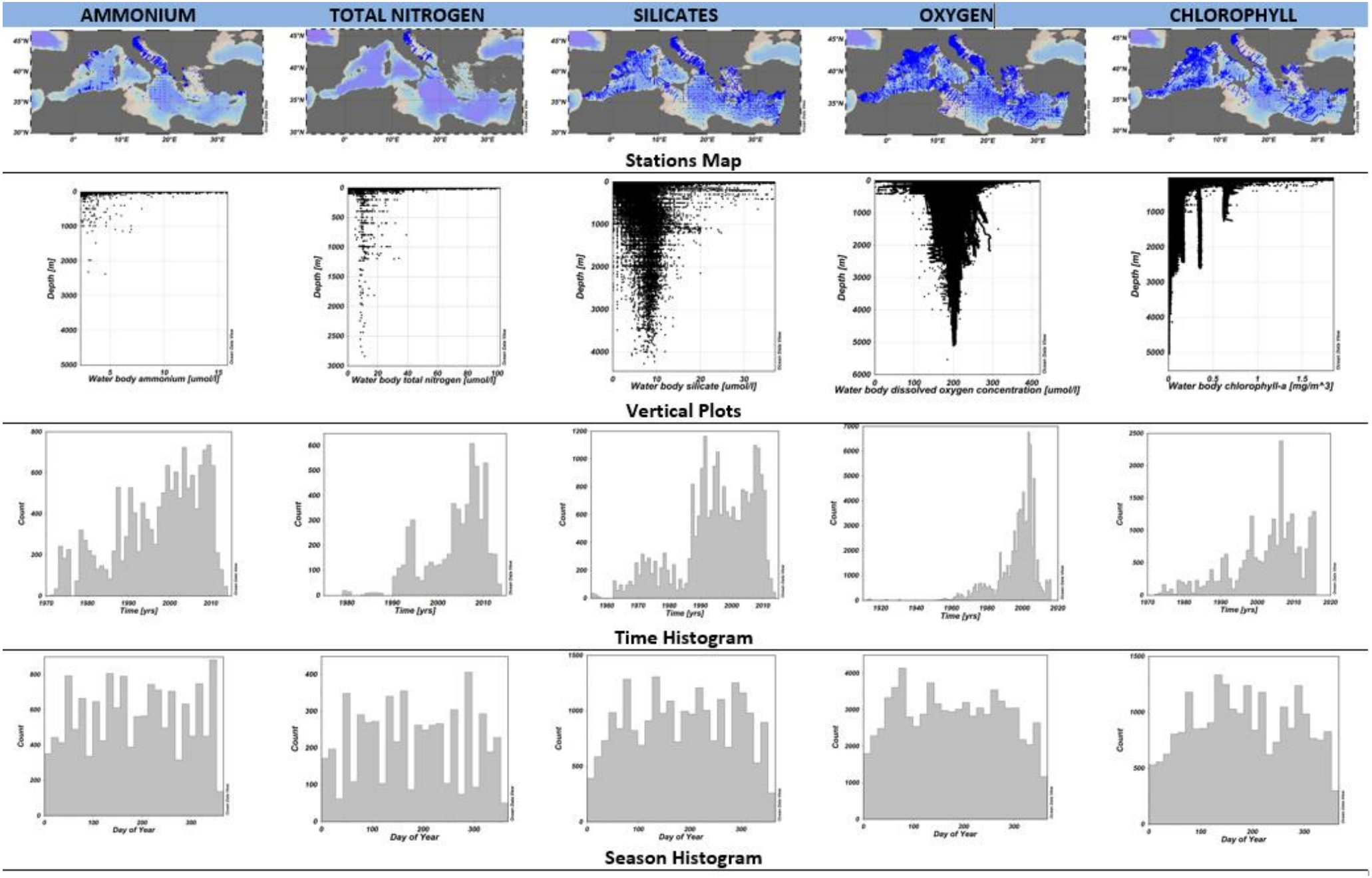


Figure 9. Stations maps, vertical plots and temporal distributions for the available aggregated collections.

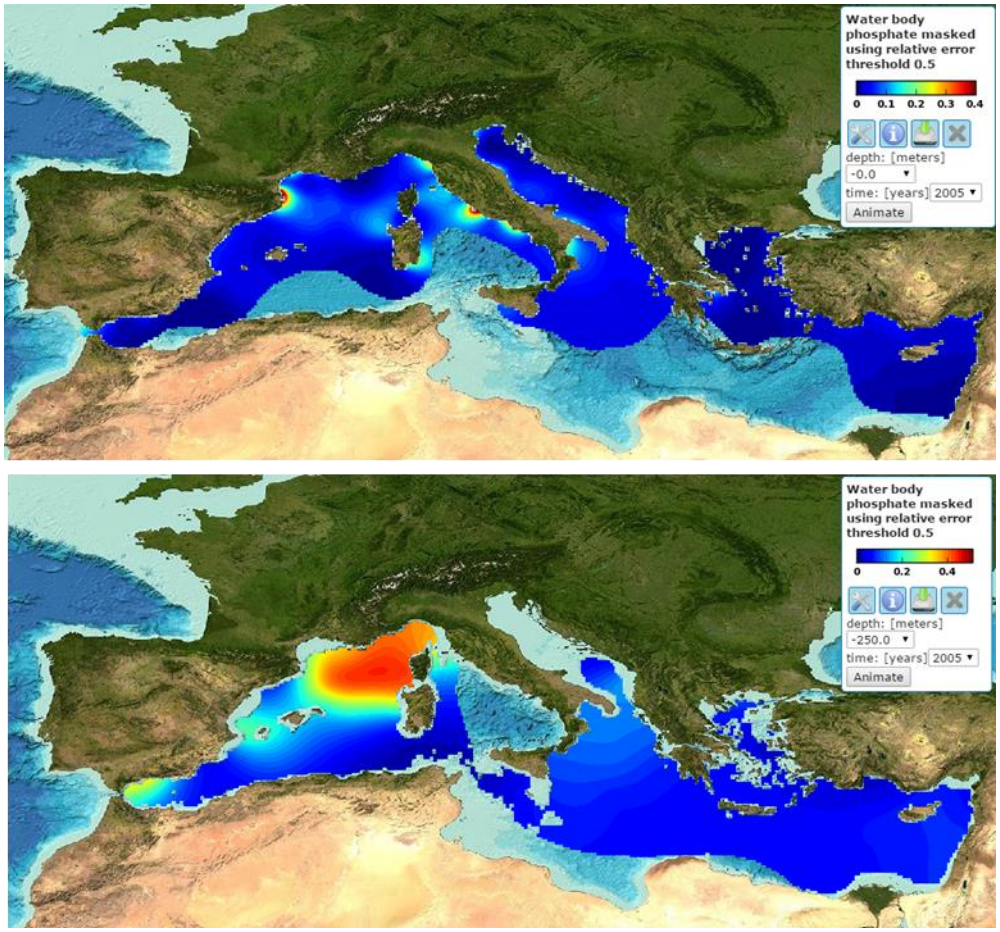


Figure 10. DIVA horizontal map for phosphates in Mediterranean Sea in the surface (upper panel) and at 250 m (lower panel) in the decade 2001-2010.

3.1.5 North Sea

Before the EMODnet kick-off meeting in Trieste 2013 AU-DCE/SE, as the Regional leader for the North Sea, checked with the OSPAR ICES database to have an idea about the expected minimum data availability, and to compare against the EMODnet dataset. As previous partner of the EMODnet Chemistry Pilot Project, some idea of what to expect from the dataset was available, and previous DIVA products had been done.

The data distribution was presented during the kick-off meeting, and the extent of the dataset was by far the largest in the EMODnet regions, but also expected to be in good shape due to most of the partners reporting to ICES and thereby having quality assured the data to a relatively large extent.

In April 2014, AU-DCE received the 1st harvested nutrients data for the region, which contained 939.970 CDIs in SDN ODV Spreadsheet format. Approximately 2% of these where disregarded due to bad quality flag or other data problems. The CDIs originated from 12 organizations. Manual sorting of variables, discovering 20-28 different PO1 terms per variables, were made in Excel and conversions and merging were made using ODV to create

an aggregated data collection. Quality Control was made on the aggregated parameters before creating Diva products focusing on nitrate, phosphate and silicate. These products were created using data from 1990 to 2012 and were considered as a first test for the OceanBrowser. Throughout the workflow format errors in files and questionable values in data were documented and feedback was then given to the data originators to improve the contribution and quality for the next harvest.

At the end of October 2014, AU-DCE - received the 2nd nutrient dataset for the North Sea region which contained 640.189 vertical profiles, and a data size exceeding 2 Gb. Developments made in ODV now made it possible to merge variables using the link between the P01 and P35 vocabularies, which made the aggregation of data much less work intensive. Work now focused on updating the existing aggregated dataset and Diva products for parameters nitrate, phosphate and silicate. Again, quality control was made on the aggregated dataset. As agreed by the Steering Committee, this time Diva products, or ”maps”, were created for moving ten-year periods for four seasons starting with year 1960. Discrepancies between the Baltic Sea and North Sea DIVA products in the Danish straits bordering the two regions was found, and to minimize the differences between Diva products for the North Sea and the Baltic Sea “overlap dataset” from the Baltic Sea out to Bornholm was included in the Diva analysis. Due to much lower data availability at the border to the North Atlantic region, no exchange of data was made with this region. After the analysis the overlap region was cut off leaving only the Baltic Sea area in the final products. To link metadata to the Diva products xml-files were generated using divadoxml-gui and then uploaded to the Sextant catalogue. In addition to the Diva products ODV Spreadsheet files were extracted and sent to Deltares in the Netherlands to be used in the dynamic plots. Due to the large dataset size, it was necessary to divide the dataset into three separate geographical regions for Deltares to be able to accept the data. At this stage the same procedure was carried out on the additional parameters nitrate+nitrite, ammonium, total nitrogen and total phosphorus.

In 20-21st of October AU-DCE participated and presented North Sea nutrient data and an example of using the CHASE aggregation tool for hazardous substances at the Oostende EMODnet expert workshop

During the 3rd year focus was laid on dissolved oxygen, chlorophyll-a, alkalinity, pH and carbon dioxide. Due to problems with one of the main partners CDI’s the dataset was first received on March 23rd 2016, containing 425.212 CDI’s. The procedures of aggregation and quality control were made and spatial and temporal coverage were checked. Oxygen was well represented in the dataset in all than 425.212 profiles (many profiles only contained oxygen. The coverage in chlorophyll-a was less with about 278.228 profiles of which most of them are measured after 1980. For the other parameters the coverage was less (3948 CDIs for pH and nothing for Alkalinity and DOC) and therefore Diva products were only generated for oxygen and chlorophyll-a.

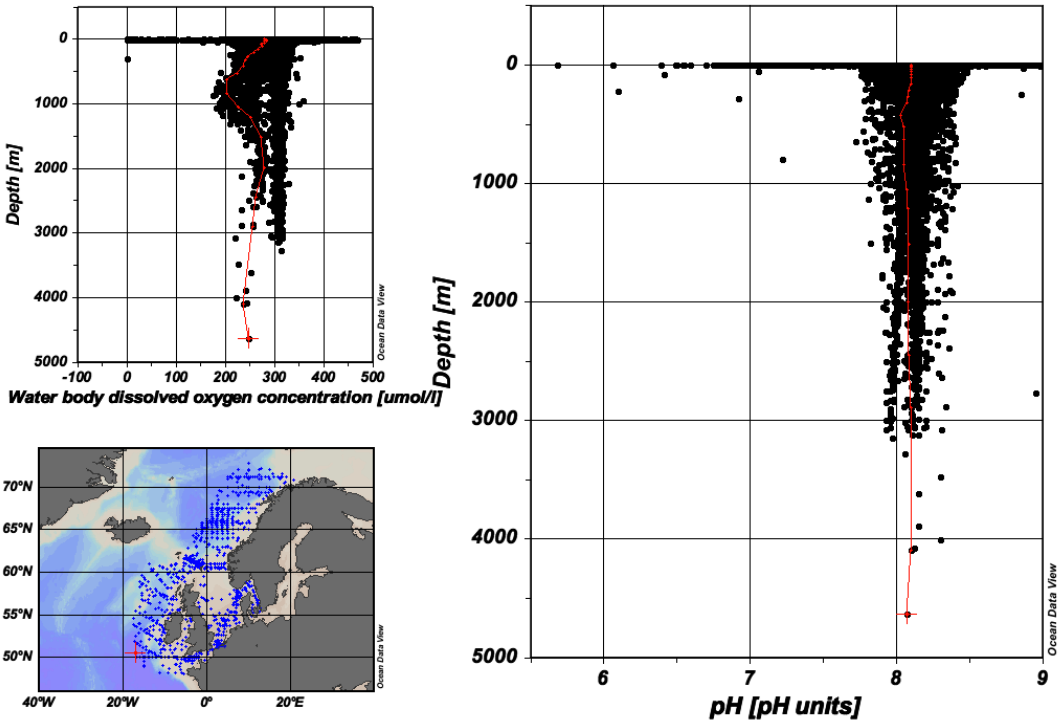


Figure 11. Data extent for O2, Chlorophyll a and pH, with available example of ODV plots for dissolved oxygen and pH after the first rough QA (excluding pH>9).

Parameter	From year – to year	Nr seasons	Depth interval
Nitrate	1960 - 2014	4	0 – 300
Nitrate + nitrite	1960 – 2014	4	0 – 300
Phosphate	1960 – 2014	4	0 – 300
Silicate	1960 – 2014	4	0 – 300
Ammonium	1960 – 2014	4	0 – 300
Total nitrogen	1960 – 2014	4	0 – 300
Total phosphorus	1960 – 2014	4	0 – 300
Oxygen (pending)	1960 – 2014	4	0 – 300
Chlorophyll-a (pending)	1980 - 2014	4	0 - 30
Alkalinity	n/a	n/a	n/a
Carbon dioxide	n/a	n/a	n/a
pH	n/a	n/a	n/a

Table 8. Diva products currently available for the North Sea on OceanBrowser. Analysis made for ten year moving average. Available depths are OSPAR/HELCOM standard depths within the interval given in the table. (n/a = no diva products produced; Pending – ready but awaiting inclusion in sextant at the time of writing)

The third and last year also involved work on hazardous substances in sediment and biota. The guidelines for this work was delayed and is therefore not yet finished which will be done in the second half of 2016.

WP3: QA/QC - Validation - MSFD interaction

A fundamental requirement in collaborative monitoring programmes in marine pollution studies is the intercomparability of data obtained from participating laboratories irrespective of the country of origin.

The production of 'true' data requires that all partners adopt good field and laboratory procedures in order to assure Quality Assurance/Quality Control (QA/QC) of the input data EMODnet Chemical portal.

A specific Questionnaire for the collection of Quality Control (QC) and data Quality Assurance (QA) procedures applied to EMODnet Chemical Parameters by data producers has been proposed, finalised and sent to EMODnet partners for compilation.

A clear distinction has been made between QA/QC used in data production and analytical methods implementation (so called *ex-ante*) and QA/QC for data collection and aggregation (so called *ex-post*). The Questionnaire pertains *ex-ante* QA/QC and its main target are laboratories responsible for chemical analysis.

A special emphasis has been dedicated to application of ISO guide 17025:2005 for laboratory accreditation as requested by Directive 2009/90/EC on Environmental Quality Standard for surface water. Some data providers and partners of EMODnet are not responsible for chemical analysis and, in such cases, *ex-ante* QA/QC are not available. Anyway it has clearly been highlighted that also a negative response is important in order to properly assess data sets available through EMODnet.

The Questionnaire consists of three sections:

a) General questions of laboratory QA/QC **according to ISO Guide 17025:2005** (also requested by EQS EU Directive 2008/105) regarding the level of laboratory staff qualification, maintenance and calibration of equipment, use of published and/or acceptable methods, determination of accuracy, precision and LOD/LOQ and use of certified material

b) For each EMODnet Chemical Lot Theme[2], questions common to all matrices regarding compliant code lists, CAS numbers, station names and coordinates, sampling methods and storage, use of standard analytical methods, determination of LOD/LOQ and

[2] Acidity, Antifoulants, Chlorophyll, Dissolved gasses, Fertilisers, Hydrocarbons, Heavy metals, Organic matter, Polychlorinated biphenyls, Pesticides and biocides, Pharmaceuticals, Plastics, Radionuclides, Silicates

uncertainty and its method of calculation, use of reference materials and participation to intercalibration round

c) For each EMODnet Chemical Lot Theme, questions for seawater (sample type and method of filtration), biota (taxonomic system used for species, number of individuals required to comprise a sample, information on tissue) and sediment (information on grain size of fractionated sample)

The number of partners/subcontractors identified as data provider is **39,** of which **29** responded to QA/QC Questionnaire.

The following tables summarize answers for seawater, sediment and biota, regarding determination of LOQ/LOD, use of reference materials, participation to intercalibration round and determination of uncertainty. For same data provider for a specific issue as for ex. use of reference materials, not for all parameters included in EMODnet Chemical Lot Theme, the answer was positive. In such case if for most parameters the answer was positive, it has been regarded as positive for all of them.

Seawater

Group	(LOD)/LOQ		Reference Materials (ex: NRC-CNRC, etc..)		Intercalibration round (ex: Quasimeme, etc..)		Uncertainty	
	Y	N	Y	N	Y	N	Y	N
Pesticides and biocides	4	0	2	2	4	0	2	0
Antifoulants	2	0	0	2	0	2	0	2
Pharmaceuticals	2	0	0	2	0	2	0	2
Heavy metals	9	0	7	2	7	2	7	2
Hydrocarbons	7	0	2	4	2	4	2	4
Radionuclides	2	0	0	0	0	0	0	2
Fertilisers	22	0	9	13	16	4	11	9
organic matter (e.g. from sewers or mariculture)	16	0	7	9	7	4	7	7
Chlorophyll	20	0	4	16	13	7	9	11
Silicates	20	0	4	16	13	4	11	9
dissolved gases	20	0	0	18	4	11	7	11
Plastics	0	0	0	0	0	0	0	0
Acidity (from pH, pCO_2, Total Inorganic Carbon, alkalinity)	11	0	4	7	2	7	2	9

Sediment

Group	(LOD)/LOQ		Reference Materials (ex: NRC-CNRC, etc..)		Intercalibration round (ex: Quasimeme, etc..)		Uncertainty	
	Y	N	Y	N	Y	N	Y	N
Pesticides and biocides	11	0	9	2	7	4	9	2
Antifoulants	4	0	4	0	4	0	4	0
Pharmaceuticals	0	0	0	0	0	0	0	0
Heavy metals	13	0	11	0	11	2	11	2
Hydrocarbons	13	0	11	2	11	2	11	2
Radionuclides	4	0	2	2	2	2	2	2
Fertilisers	7	2	7	2	7	2	7	2
Organic matter (e.g. from sewers or mariculture)	9	0	9	0	9	0	9	0
Plastics	0	0	0	0	0	0	0	0
Acidity and redox	2	0	2	0	0	2	0	2

Biota

Group	(LOD)/LOQ		Reference Materials (ex: NRC-CNRC, etc..)		Intercalibration round (ex: Quasimeme, etc..)		Uncertainty	
	Y	N	Y	N	Y	N	Y	N
Pesticides and biocides	9	0	4	4	4	4	2	7
Antifoulants	2	0	2	0	2	0	2	0
Pharmaceuticals	0	0	0	0	0	0	0	0
Heavy metals	9	0	7	2	4	4	4	4
Hydrocarbons	4	0	4	0	2	2	2	2
Radionuclides	0	0	0	0	0	0	0	0
Plastics	0	0	0	0	0	0	0	0

Table 9: Summary of results from QA/QC questionnaires for seawater, sediment and biota.

As a general remark, reference materials are poorly used in seawater with respect to sediment and biota, intercalibration rounds are generally rather widespread and uncertainty is not always properly treated in particular for fertilisers, organic matter, chlorophyll and silicates. In particular for chlorophyll, dissolved oxygen also use of reference materials is rare, partially due to use of multi-parametric probe for sampling such parameters.

For what concerns MSFD interactions, ISPRA has actively participated to WG DIKE, TG DATA and also other *ad hoc* meeting organized by EC on using EMODnet for MSFD, in order to promote EMODnet Chemistry as a common platform for implementation of indicators on Descriptor 5 (Eutrophication), 8 and 9 (Contaminants). In last WG DIKE on October 2015, EC has emphasized the role of Regional Sea Conventions (OSPAR, HELCOM, Black Sea and Barcelona Convention for Med Sea) in data aggregation for MSFD reporting by Member States to EC. ISPRA, supporting Italian Ministry of Environment, has urged the necessity for Barcelona Convention to adopt EMODnet platform for data collection and sharing in order to minimize the effort needed by Member States and/or Contracting Parties to be compliant with RSC data collection policy. In this context technical meetings are being settled between EMODnet Chemistry coordinator and INFO/RAC (regional action centre responsible for data management for Barcelona Convention) taking advantage of ISPRA double role as being partner of EMODnet Chemistry and the institute responsible for the implementation and management of INFO/RAC.

WP4: Portal development and operation

Introduction:

The objectives of WP4 have been to develop the EMODnet portal and its services for meeting the new requirements, and to keep the portal services operational, including monitoring and reporting. The EMODnet Chemistry portal makes use of the SeaDataNet services and standards, that have been adapted and further developed for specific EMODnet Chemistry needs. The primary SeaDataNet services used are:

- **CDI Data Discovery and Access Service** giving facilities for searching and retrieving chemistry data sets, but also for further populating new gathered data sets;
- **OceanBrowser Viewing Service** giving facilities for viewing, browsing and downloading of Chemistry data products;
- **Sextant Products metadata catalogue** giving facilities for searching Chemistry data products and linking to the viewing service.

Technical developments:

The technical developments have been undertaken by the EMODnet Chemistry Technical Working Group (TWG) in cooperation and tuning with the SeaDataNet Technical Task Group (TTG). Overall there have been 4 joint TWG-TTG meetings to support the coordination process. The focus of activities has been on:

1) Upgrading the CDI User Interfaces and developing an extra CDI User Interface

The SeaDataNet CDI system (INSPIRE compliant) is used for giving overview and access by means of a shopping mechanism to the distributed data sets that are managed by connected data centres. This is the fundamental atomic entity in the SeaDataNet/EMODNnet Chemistry

data model and is an aggregation of measurements or observations. It is mapped to real world measurement aggregations in different ways such that the dataset is meaningful for a specific type of data, such as a CTD profile or the time series from a single deployment of a data logger. It is described by a CDI record that is permanently associated in the SeaDataNet/EMODnet Chemistry architecture with one or more physical data files. For EMODnet Chemistry a dedicated subset of metadata – data is dynamically generated by filtering on Parameter Discovery Vocabulary (P02) terms that map to the extended scope of chemical substances for EMODnet Chemistry 2. This CDI collection can be queried through the EMODnet Chemistry CDI Quick Search and Extended Search interfaces. These interfaces have been upgraded by MARIS with extra search options for sea regions, data access restrictions, duration of observations, and P02 for discovery parameters. The shopping basket for human users has been extended from 500 to 10.000 CDI's requests per transaction. In the 3rd year also the searching for parameters has been adapted by introducing searching on Matrix Categories (Vocab L04) => Groups of chemical parameters (Vocab P36) => discovery parameters (Vocab P02). These adaptations have been implemented following user suggestions.

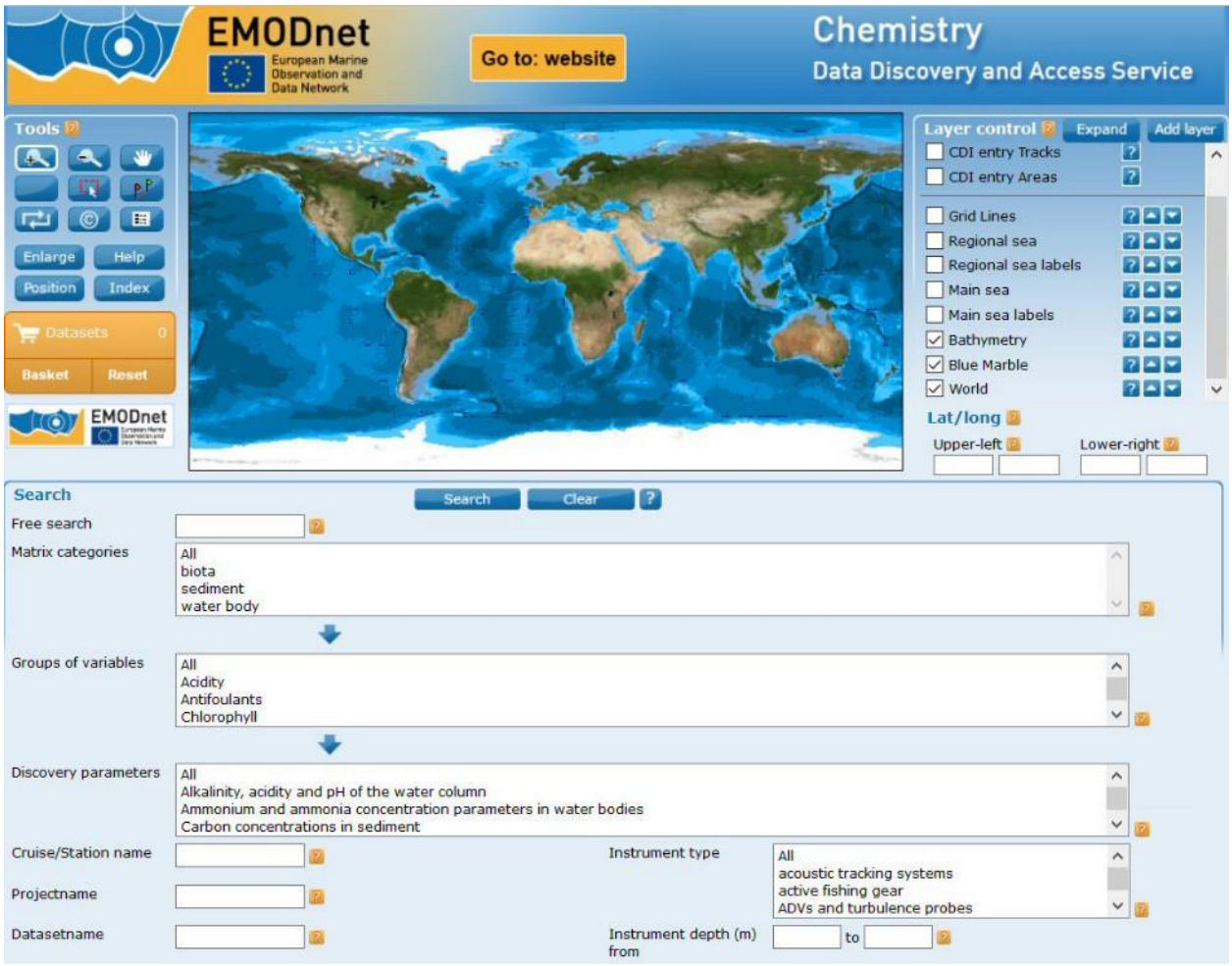


Figure 12. CDI User Interface – Extended Search with dedicated criteria for chemical substances

In order to give visitors of the EMODnet Chemistry a more direct insight in the scope of the EMODnet Chemistry variables and in the availability of associated data sets, MARIS has also developed a third CDI User Interface. This interface 'Search Chemicals by Regions' displays per sea region and per chemicals group by map and table how many measurement data are available. Hovering over a colored square in the table gives the exact number of data sets and a map with their geospatial distribution. Clicking on a colored square triggers a query on the Common Data Index (CDI) Data Discovery and Access service that allows the user to browse the metadata of these data sets in more detail, to narrow down their query and to request access to a selection of data sets. The table also has an (i) button next to each chemicals group to provide details on the P02 terms in each group. This new interface is illustrated with a number of screens. The interface itself is included in the homepage of the EMODnet Chemistry portal to attract immediate attention of visitors.

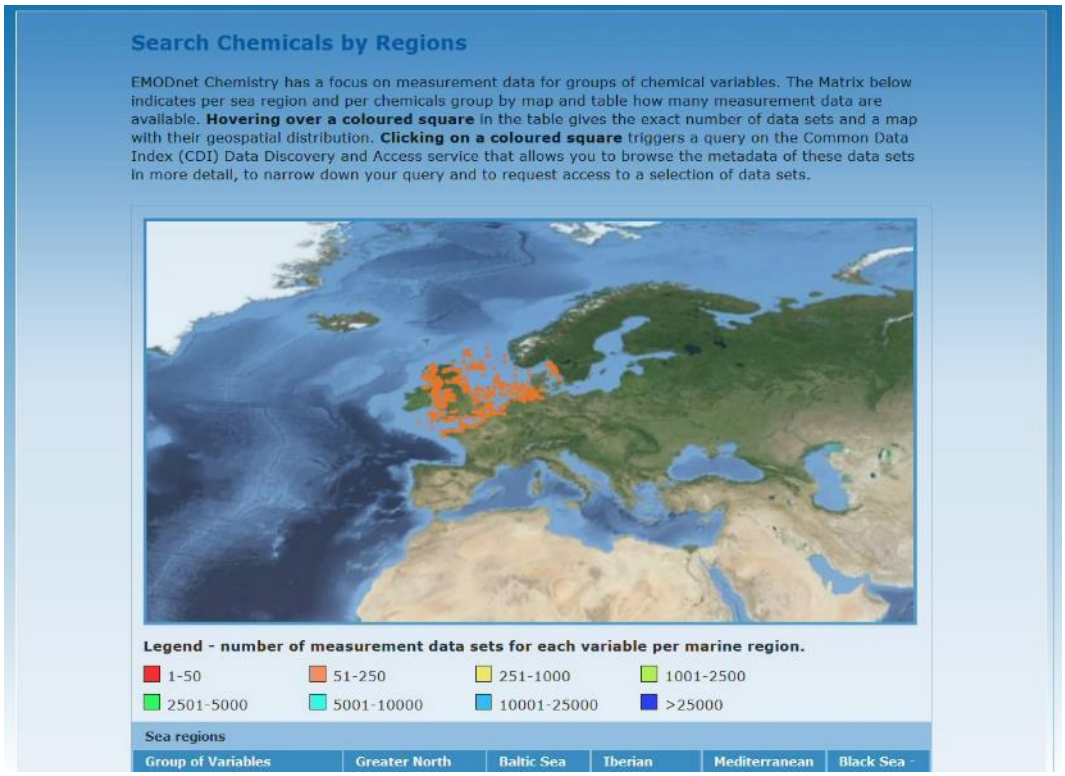


Figure 13. Top half of new CDI User Interface 'Search Chemicals by Regions' with display of a selected chemicals group in a selected region

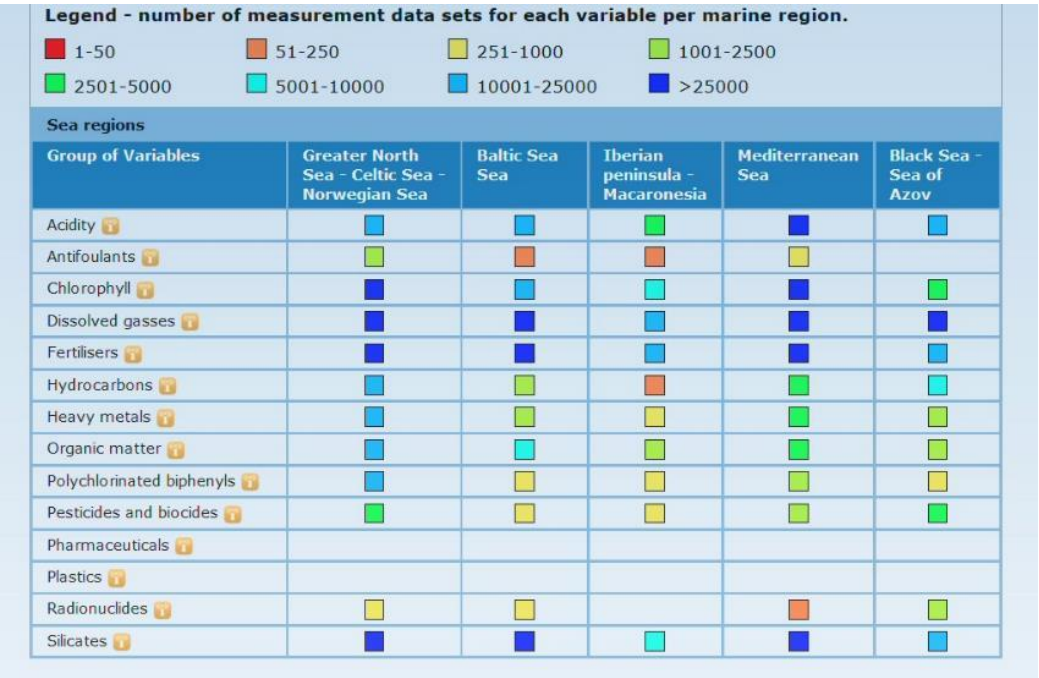


Figure 14. Lower half of new CDI User Interface 'Search Chemicals by Regions' with data intensity

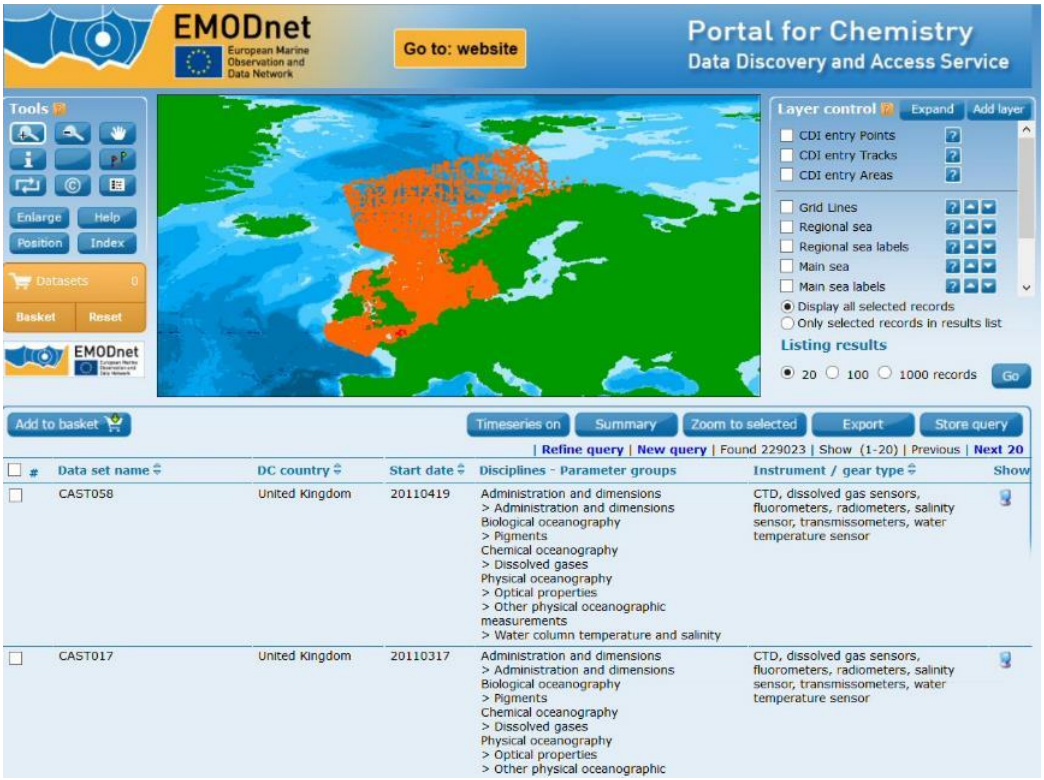


Figure 15. Regular CDI User Interface, dynamically called up by clicking on a cell in the table of chemicals by regions

2) developing machine-to-machine capabilities for the CDI system to ease queries and to support the data harvesting as part of WP1 (data collection and metadata compilation in sea regions)

A robot harvesting system has been developed by MARIS for automatic and more efficient discovery and harvesting of metadata and data sets that are transferred to the regional groups in WP2 for generating EMODnet Chemistry data products. A new online Buffer Content Management System (CMS) has been developed which allows to configure specific group profiles (specify group, involved users, query criteria). The Buffer CMS works together with the upgraded Request Status Manager (RSM) service, an existing component of the CDI shopping mechanism, to perform and administer robot shopping transactions and to store the harvested data sets in central buffers. This also includes maintenance, whereby new and updated CDI entries are identified and used to trigger additional harvesting for the central data buffers. Furthermore the central buffers have been equipped with a Central buffer CDI User Interface and an API (allowing full machine-to-machine interaction), both including shopping mechanism, to facilitate the extraction and delivery of regional data sets for the EMODnet Chemistry regional groups. All central shopping transactions on the central buffers are administered in a new section of the RSM so that data providers can fully oversee all transactions. Remark: this buffering system is exclusive for specific applications and access is secured via AAA service only for authorised users as defined in the buffer CMS. It does not replace the distributed CDI infrastructure and its shopping process for regular users. The image below gives an illustration of the new system.

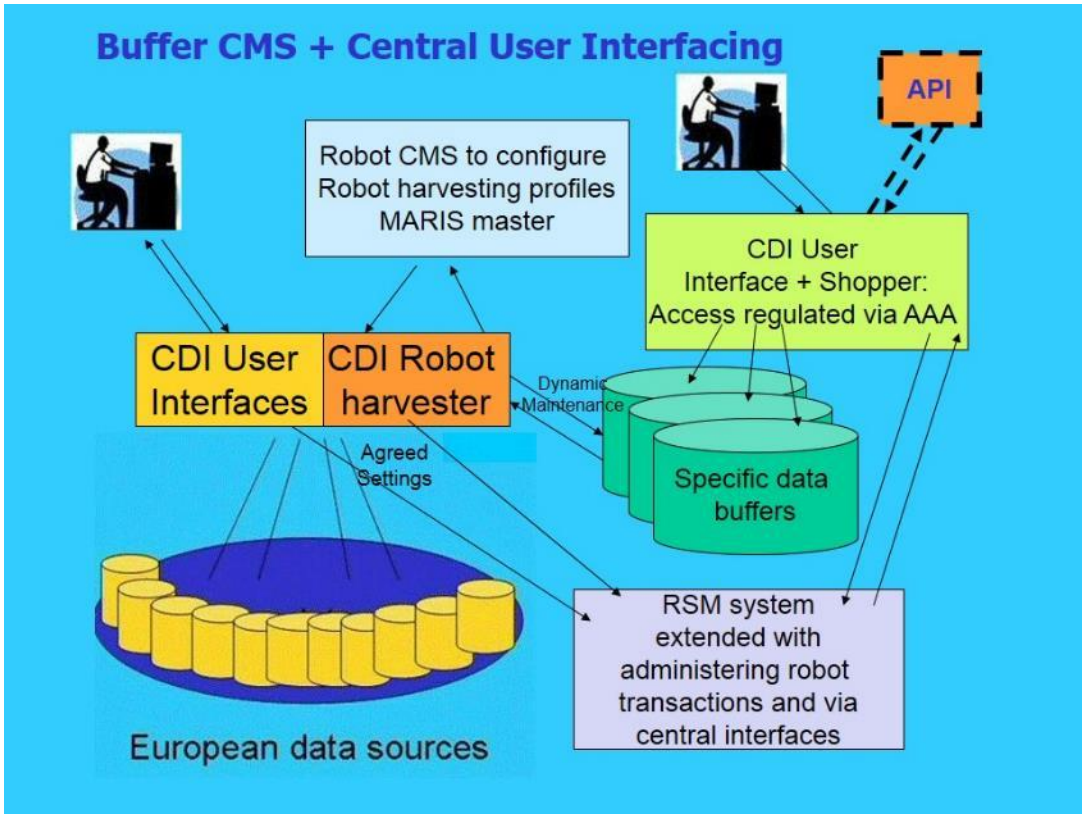


Figure 16. Expansion of the CDI service with buffer CMS, robot harvesting and central buffer access services

Unrestricted and data with SeaDataNet license are harvested in full automatic mode; for restricted data sets, the data providers are requested to give permission in the RSM service for direct harvesting. In most cases data providers have agreed, because the central buffers will be used for generating the EMODnet Chemistry regional data products.

The robot harvesting service has been fully used for the runs of harvesting of nutrients, contaminants and other (oxygen, chlorophyll, ..) data sets for the regional groups as described in WP1.

3) Upgrading the SeaDataNet Common Vocabularies (NVS 2.0) as in use for EMODnet CDI and related data sets and data products to support WP1 (data collection and metadata compilation in sea regions) and WP2 (data products generation in sea regions)

SeaDataNet common vocabularies (NVS 2.0) are maintained and served by NERC BODC as web services for marking up all metadata and data entries. The Parameter Usage vocabulary list P01 is used for data sets while the Parameter Discovery vocabulary P02 is used for the CDI metadata. P01 are narrower terms of P02. At present P01 already contains more than 35.000 concepts. During the project BODC has added many new entries (> 4000) because of the

extended scope of substances in EMODnet Chemistry and following suggestions and requests by data providers. For instance, in the third year 949 biota terms were added to P01 out of 1852 new P01 terms.

Each P01 concept is built up of a number of elements following a model, that is maintained by BODC inside its vocabs database, but was so far largely hidden and not known or understood by many outside BODC. As an implication data providers had to undertake great effort when mapping their internal data holdings and parameters against the P01 vocabulary, especially in case of complex P01 concepts such as for Chemistry. Therefore BODC has been working on exposing the semantic model behind P01 and making it retrievable by components which make mapping to P01 much easier for data providers. Example of P01 term: 'Concentration of tributyltin cation {tributylstannyl TBT+ CAS 36643-28-4} per unit dry weight of biota {Mytilus galloprovincialis (ITIS: 79456: WoRMS 140481) [Subcomponent: flesh]}'. The semantic model is illustrated below.

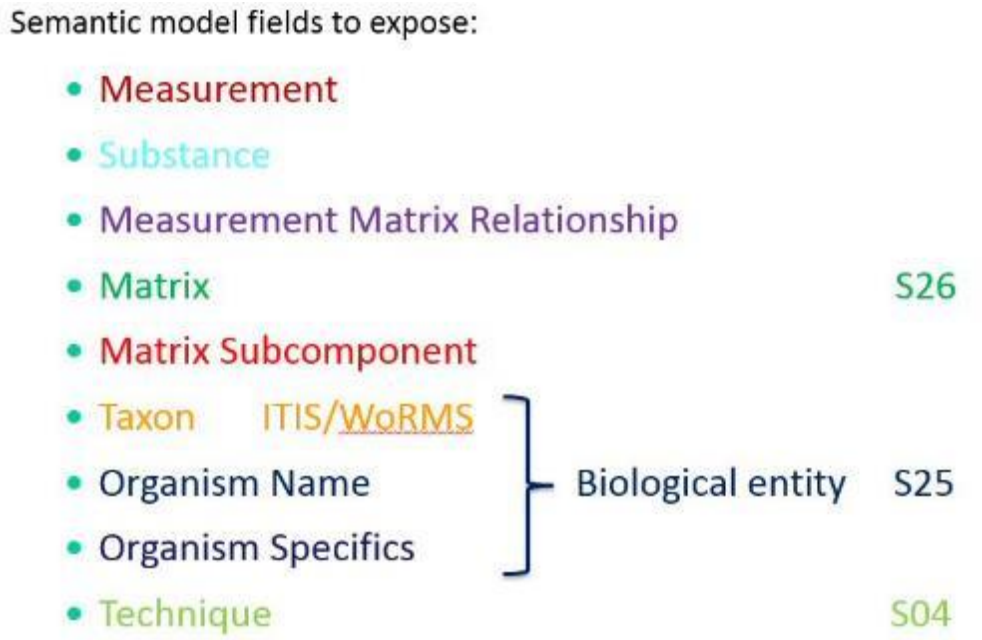


Figure 17. Semantic model of Parameter Usage vocabulary P01

For exposure of the P01 semantic model elements BODC has built and deployed a vocabulary builder tool to facilitate searching and the submission of new terms to three vocabularies: chemical terms from the P01 vocabulary, biological entity terms held in S25 and matrix terms held in S26. The vocabulary builder allows a user to construct the preferred label for a term from the underlying semantic model. As the terms are selected from each subvocabulary they appear in the preferred label box and the number of terms that are relevant to that selection

is displayed. The user can choose to see the results at any stage in the construction of the term.

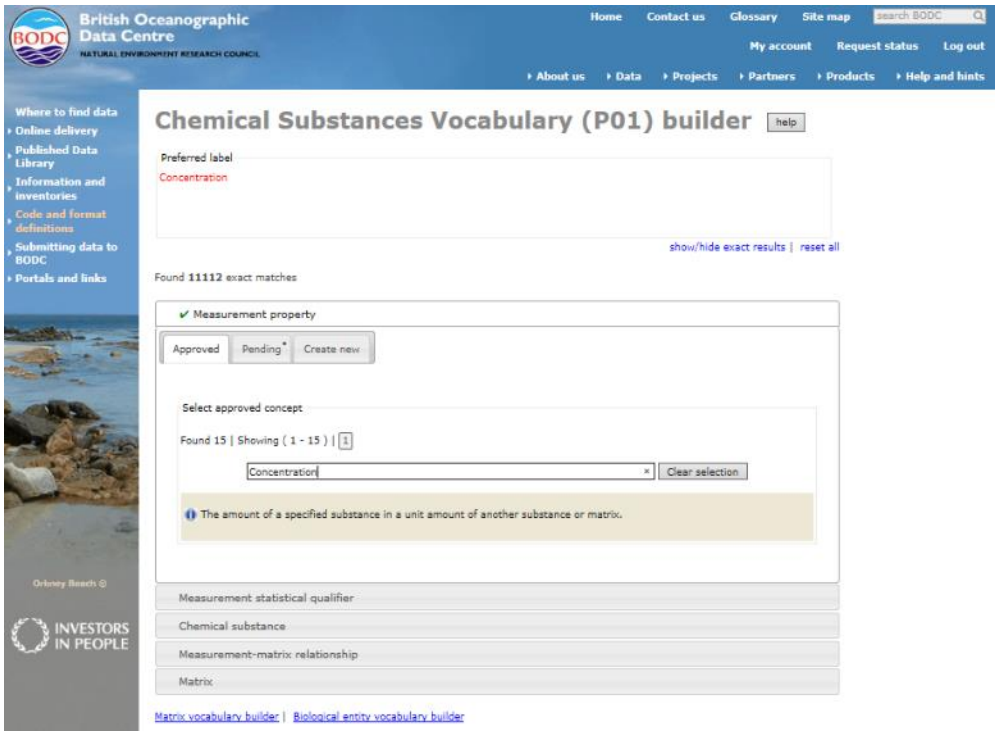


Figure 18. Vocabulary Builder tool user interface – step 1

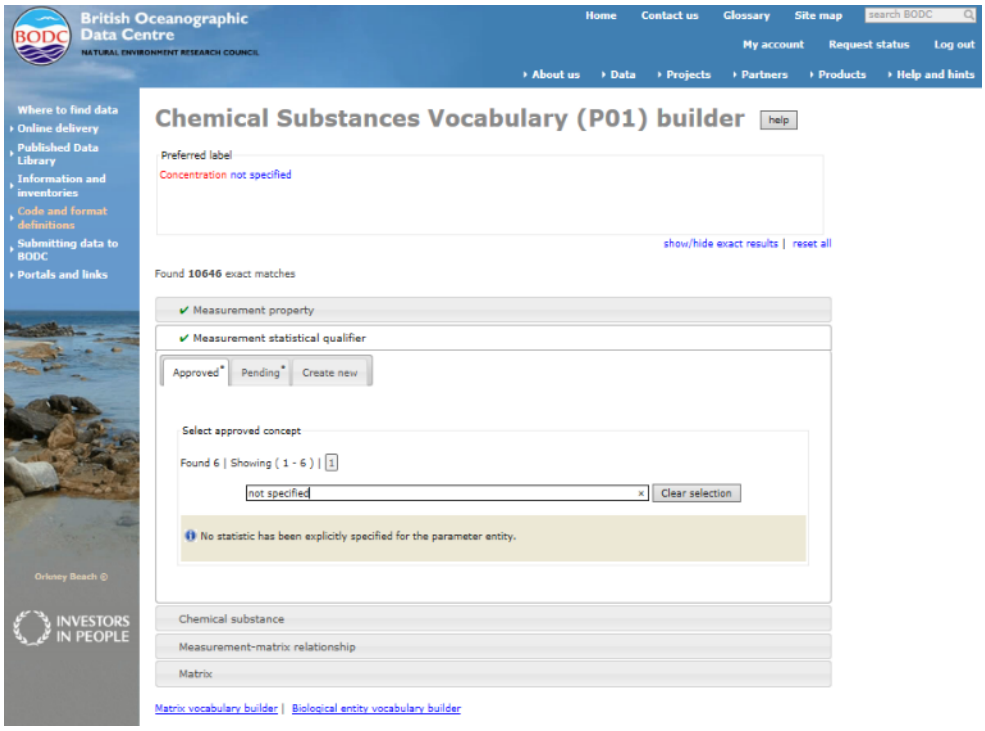


Figure 19. Vocabulary Builder tool user interface – step 2

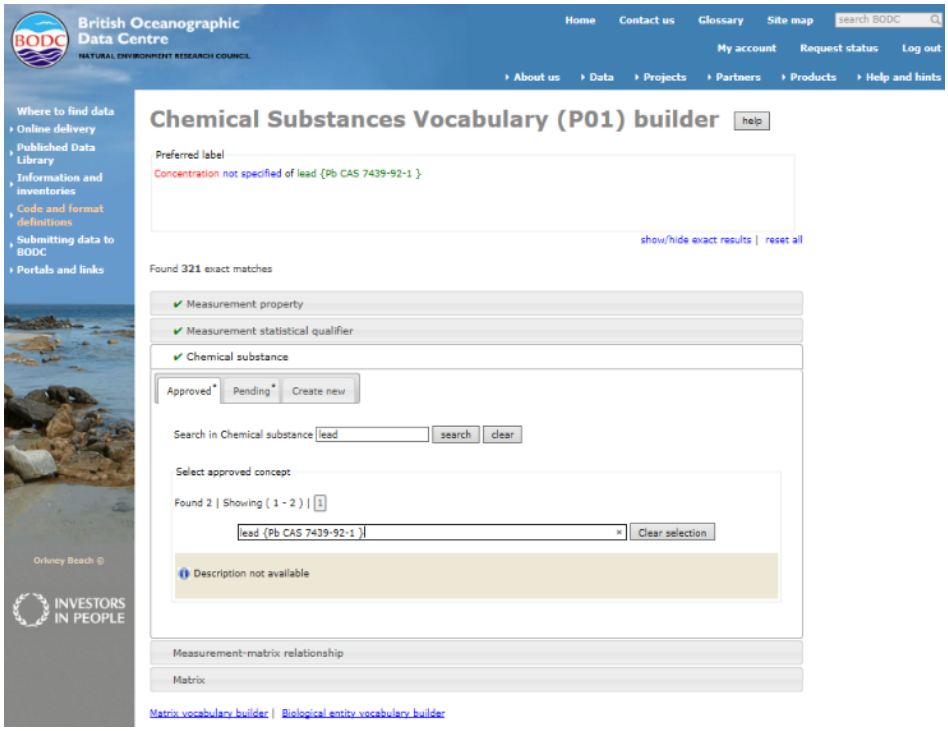


Figure 20. Vocabulary Builder tool user interface – step 3

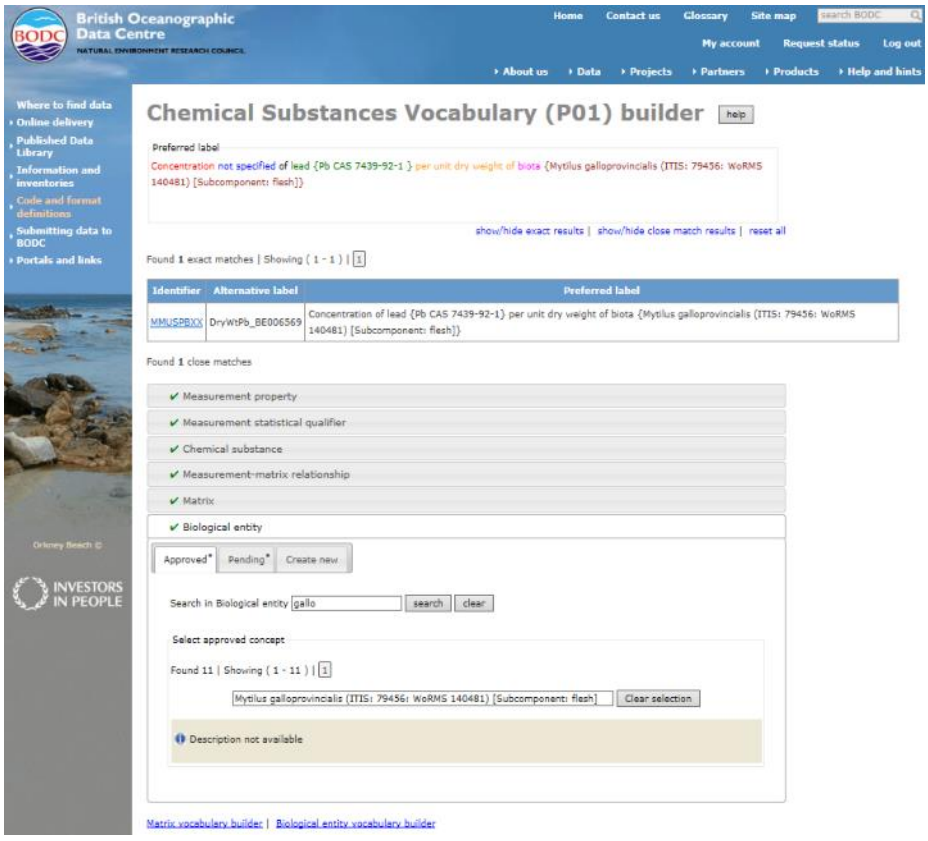


Figure 21. Vocabulary Builder tool user interface – step 4

Once a term has been constructed if it does not already exist a create button is displayed and allows a user to submit their code for consideration. The term is then checked for suitability and if appropriate is published to the NERC Vocabulary Server.

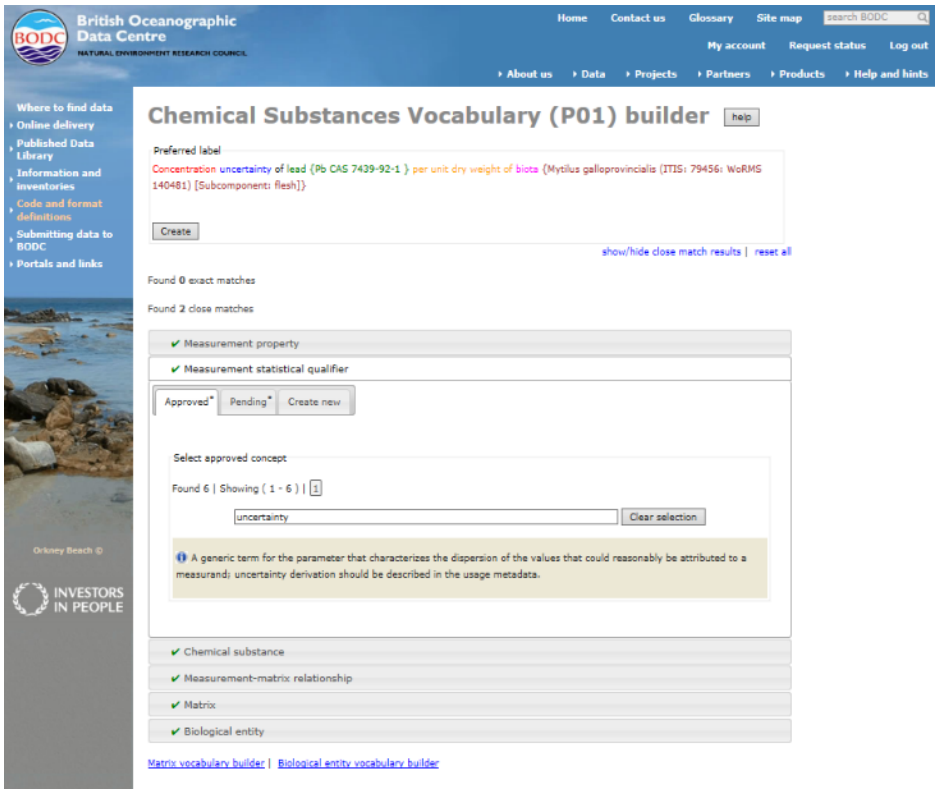


Figure 22. Vocabulary Builder tool user interface – step 5

P01 concepts are used within the data files to indicate parameters. The ODV software has an effective solution for aggregating individual files into so-called multi files for more effective analysis. However data providers in practice make use of many different P01 concepts for scientifically comparable parameters. As a consequence an ODV multi file for parameters such as e.g. temperature or salinity might look like "swiss cheese" because every P01 concept has its own column which then is partially filled over the vertical water column. For that purpose BODC has developed the P35 vocabulary list. P35 is a controlled vocab of aggregated parameters that act as classes, each class bringing together scientifically conform P01 concepts, as well as prefered P06 unit concepts. This solves the "swiss cheese" problem in ODV multi files and allows ODV software to aggregate imported data in a more automated way. There has also been established the P36 vocabulary which groups P35 terms to MSFD chemical groups. P36 has been implemented into the 3 CDI User Interfaces. In the third year of EMODnet Chemistry 86 new aggregation terms added to P35 and 2 new terms added to P36. A further 335 mappings have been added between P01 and P35. During the project many P35 entries have been added following the focus on nutrients and contaminants. P35 now

already contains 222 entries with preferred units (P06). For instance, in the third year 949 biota terms were added to P01 out of 1852 new P01 terms. Also conversion rules have been built up over time that are used in the ODV software to convert parameters to the preferred units.

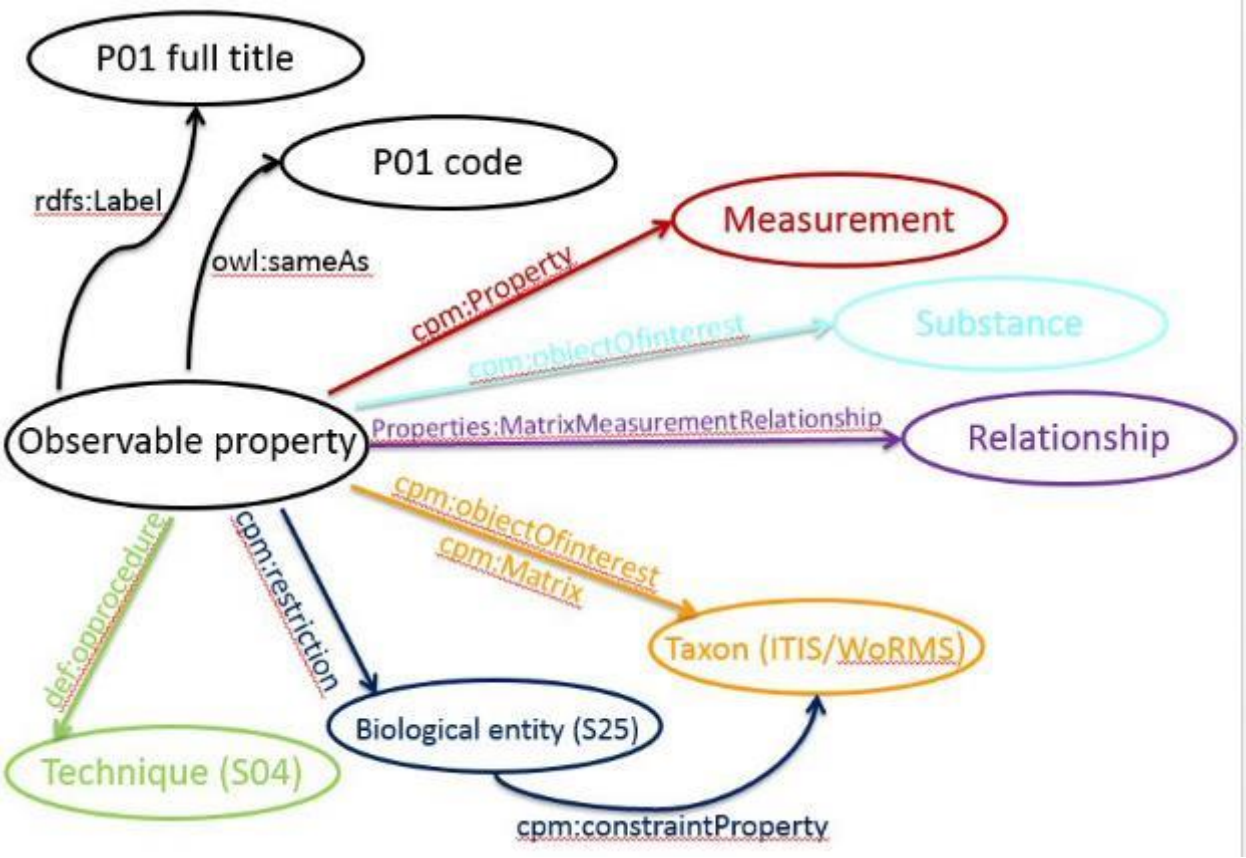


Figure 23. RDF representation of the contaminants in biota semantic model

BODC delivers the P01 vocab with its semantic model by means of JSON (Javascripting) and as SPARQL endpoint with RDF for machine-to-machine interaction.

4) Upgrading the Ocean Data View (ODV) software that is used for validating and aggregating the harvested data sets as part of WP2 (data products generation in sea regions)

The ODV software is used by regional groups in EMODnet Chemistry for quality checking, validation and aggregation of the chemistry data sets as harvested for the MSFD sea regions. The ODV software provides a quite extensive suite of build-in visual and automatic data quality control (QC) procedures and tests. Regularly new versions of the ODV software are developed and published by AWI via the SeaDataNet portal, following requests from users and the EMODnet Chemistry requirements.

For EMODnet Chemistry AWI has developed a number of extra functionalities. The SDN importer in ODV now supports the new SDN netCDF format, in addition to the previous SDN ASCII spreadsheet format. Users select the *Import > SDN Formats* option and select the files to be imported via a file selection dialog. Users may select a combination of SDN ASCII spreadsheet data files, SDN netCDF data files, accompanying .csv files containing CDI metadata, and/or the *readme.txt* file containing the data usage agreement text. When SDN data, metadata and usage agreement files are packaged in .zip archives the user simply selects the respective .zip files. Unpacking is automatically performed by ODV during import. Users may also create files containing lists of import files and identify the list file to start the import.

ODV automatically unzips all selected SDN *.zip* archive files and analyses the contents of all individual extracted spreadsheet or netCDF files. This includes the SDN semantic header lines as well as the column header lines of the input files, testing for SDN spreadsheet format compliance (non-compliant files are excluded), gathering information about available variables and grouping of files according to the primary variables encountered in the files. Warning and error messages are written to log files if problems are encountered. These log files were submitted to the coordinator and passed to the originating data centre with requests to correct the respective data files.

ODV searches for *.csv* metadata files and extracts the contents into a large number of additional meta-variables. This also includes references and instrument information. *LOCAL_CDI_ID*, *EDMO_code* and URL entries in the *Reference* meta variable are clickable, thereby opening documents with more in-depth information in the web-browser. The contents of the *readme.txt* file is extracted and used for the usage agreement dialogs of all created collections. Users need to agree to the usage conditions before access to the data is granted. This results in metadata enriched ODV data collections.

Stability and robustness of the SDN importer in ODV have been improved and the performance has been increased significantly.

Another element is that ODV has been made fit to import both SeaDataNet ODV data files and the CDI metadata that accompany ODV data sets that are downloaded by users through the CDI service. The CDI metadata has been expanded under influence of the migration to ISO 19139 and full INSPIRE compliance. Therefore MARIS has amended the CDI metadata csv structure for the public CDI service, and included this also in the Central Buffer CDI interface so that downloaded ODV data sets are always accompanied by their CDI metadata. AWI has adapted ODV to the new csv export format and on merging both the ODV data and CDI metadata during ODV import, thereby creating metadata enriched ODV multifiles inside the ODV software. This allows for better insight by users. Moreover AWI has arranged that the

so-called ODV collections export files contain the full collection of metadata enriched ODV files.

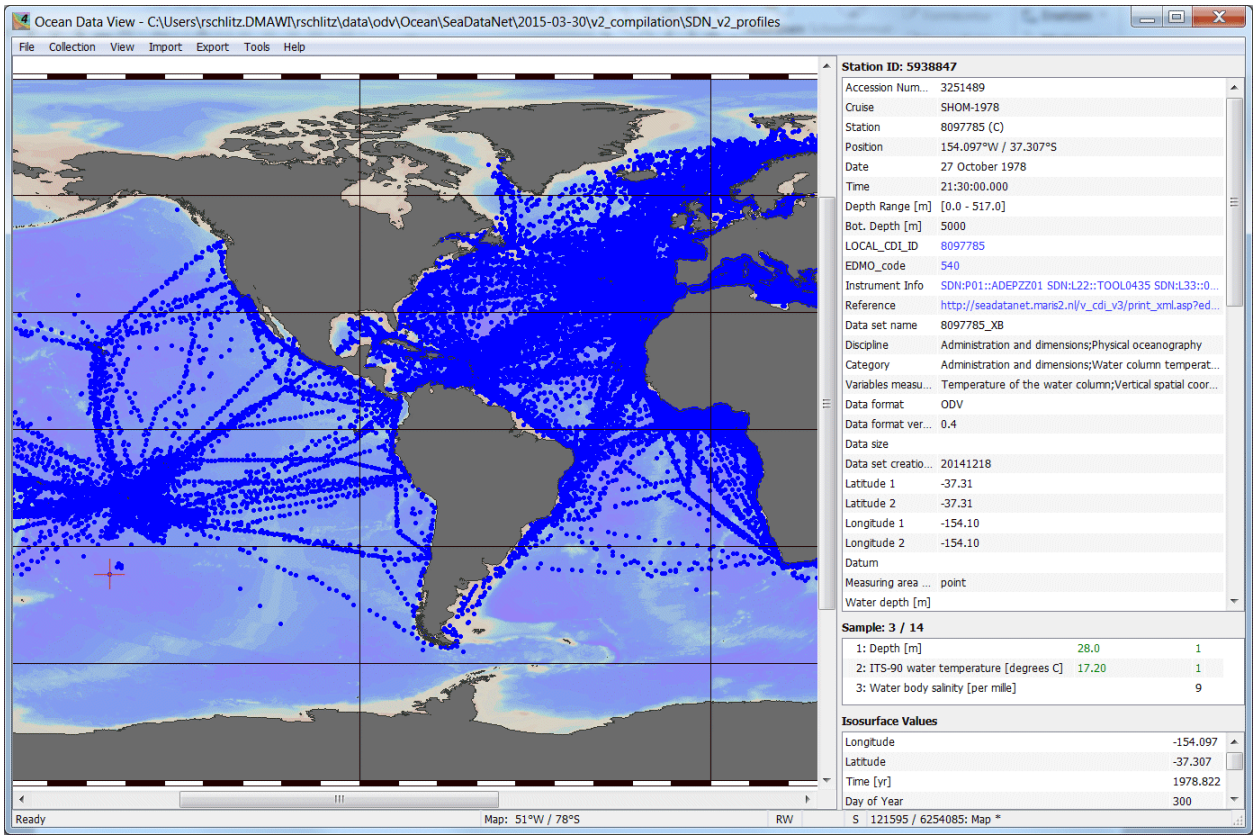


Figure 24. ODV with metadata enriched files

Another major new functionality concerns the integration of the new P35 Vocabulary which facilitates efficient and systematic aggregation of P01 variables in the ODV files, including P06 units. The principle is somewhat straight forward, but the actual implementation required agreement on how to handle issues like unit conversions, multiple columns for the same P01 terms but with possibly different quality flags etc. This has been part of an extensive discussion of which the resulting rules and P35 have been implemented in a new ODV software release.

Aggregation of parameters is performed to combine multiple individual variables for a given quantity into a single variable for easy scientific usage. For instance, there are more than 15 parameter codes for seawater dissolved oxygen in common use in the SDN data files. From a usage perspective this is unfortunate, and an aggregation into a single oxygen variable is desired. The P35 vocabulary maintained by BODC addresses this need and enables parameter aggregation in an automatic way by defining lists of contributing individual parameters for many important oceanographic variables.

Before performing the aggregation ODV first downloads the latest version of the P35 vocabulary. ODV also downloads the latest version of the unit conversion database maintained by AWI. If not connected to the Internet ODV uses the most recent versions of these files available on the system. Required unit conversions are applied automatically during aggregation. P35 aggregated variables use the SeaDataNet quality flag scheme.

The value and quality flag of a P35 aggregated variable are obtained as follows:

- *if only one contributing variable contains data*: use the value and quality flag unchanged,
- *if more than one contributing variable contain data*: use the median of all contributing values; map all quality flags to ODV scheme, take maximum of mapped values and then map back to the SeaDataNet scheme.

If a contributing parameter requires a yet unknown conversion, this input variable is ignored and its data are not used in the aggregation. If users encounter missing conversions they can request inclusion of the new conversion in the ODV conversion database by contacting partner AWI. Once the new conversion is entered into the web-based unit conversion library the user just re-runs the P35 aggregation step.

Unit Conversion Database

```
// ITS-90 water temperature
SDN:P35::WATERTEMP      SDN:P06::UPKA   SDN:P06::UPAA   1.0     -273.15
SDN:P35::WATERTEMP      SDN:P06::DEGE   SDN:P06::UPAA

// Water body salinity
SDN:P35::EPC00001       SDN:P06::UUUU   SDN:P06::UPPT   1.0     0.0
SDN:P35::EPC00001       SDN:P06::UGKG   SDN:P06::UPPT   1.0     0.0
SDN:P35::EPC00001       SDN:P06::UMGL   SDN:P06::UPPT   0.97561e-3      0.0
SDN:P35::EPC00001       SDN:P06::UPPM   SDN:P06::UPPT   1.0e-3  0.0

// Water body dissolved oxygen concentration
SDN:P35::EPC00002       SDN:P06::UMGL   SDN:P06::UPOX   31.25117        0.0
SDN:P35::EPC00002       SDN:P06::UMLL   SDN:P06::UPOX   44.66080        0.0
SDN:P35::EPC00002       SDN:P06::UPPT   SDN:P06::UPOX

// Water body dissolved oxygen saturation
SDN:P35::EPC00003       SDN:P06::UMLL   SDN:P06::UPCT

// Water body nitrate NO3
SDN:P35::EPC00004       SDN:P06::UGPL   SDN:P06::UPOX   0.0713942       0.0
SDN:P35::EPC00004       SDN:P06::UMGL   SDN:P06::UPOX   71.39420        0.0

// Water body nitrate plus nitrite
SDN:P35::EPC00005       SDN:P06::UGPL   SDN:P06::UPOX   0.0713942       0.0
SDN:P35::EPC00005       SDN:P06::UMMC   SDN:P06::UPOX   0.0713942       0.0

// Water body nitrite NO2
SDN:P35::EPC00006       SDN:P06::UGPL   SDN:P06::UPOX   0.0713942       0.0
SDN:P35::EPC00006       SDN:P06::UMGL   SDN:P06::UPOX   71.39420        0.0

// Water body phosphate PO4
SDN:P35::EPC00007       SDN:P06::UGPL   SDN:P06::UPOX   0.03228539      0.0
SDN:P35::EPC00007       SDN:P06::UMMC   SDN:P06::UPOX   0.03228539      0.0
SDN:P35::EPC00007       SDN:P06::UMGL   SDN:P06::UPOX   32.28539        0.0
```

Figure 25. Business rules as used by ODV for converting units for parameters (web service)

These ODV upgrades with P35 and metadata merging allow ODV users and in particular the EMODnet Chemistry regional groups to export from ODV and deliver the results of their regional quality control and aggregation activities as regional collections of validated and aggregated data sets. These collections then provide the input for the data products generation, using the DIVA software for sea basin interpolated maps, and for additional visualisations at data level.

The ODV collection export files are ASCII files in more or less the SeaDataNet ODV format albeit with extra metadata attributes and with P35 concepts. Data collections that have been produced via *Import > SDN Formats* can be further processed by automatically aggregating variables and writing the results to a new collection via *Export > Station Data > SDN Aggregated ODV Collection*.

ODV internally makes use of an ODV binary format, that alternatively could also be exposed to support add-on services. For that purpose AWI has developed the ODV Application Programming Interface (API) that gives its users full access to the data in an ODV data collection and allows development of procedures for all kinds of data processing. The ODV API is in use in SeaDataNet in combination with the Oceanotron server of IFREMER to visualise the SeaDataNet Temperature & Salinity climatology.

5) Upgrading the User Interface of the OceanBrowser Viewing Service for visualising data products and developing and integrating additional services for data visualisation

The workflow of data harvesting and consecutive QA – QC and aggregation by the regional groups using ODV software results in regional aggregated, harmonized and validated ODV data collections. These collections are then used as input for the generation and publication of EMODnet Chemistry data products, such as DIVA interpolated maps, time series graphs of selected stations, and maps of spatial and temporal data distribution. This is illustrated in the image below.

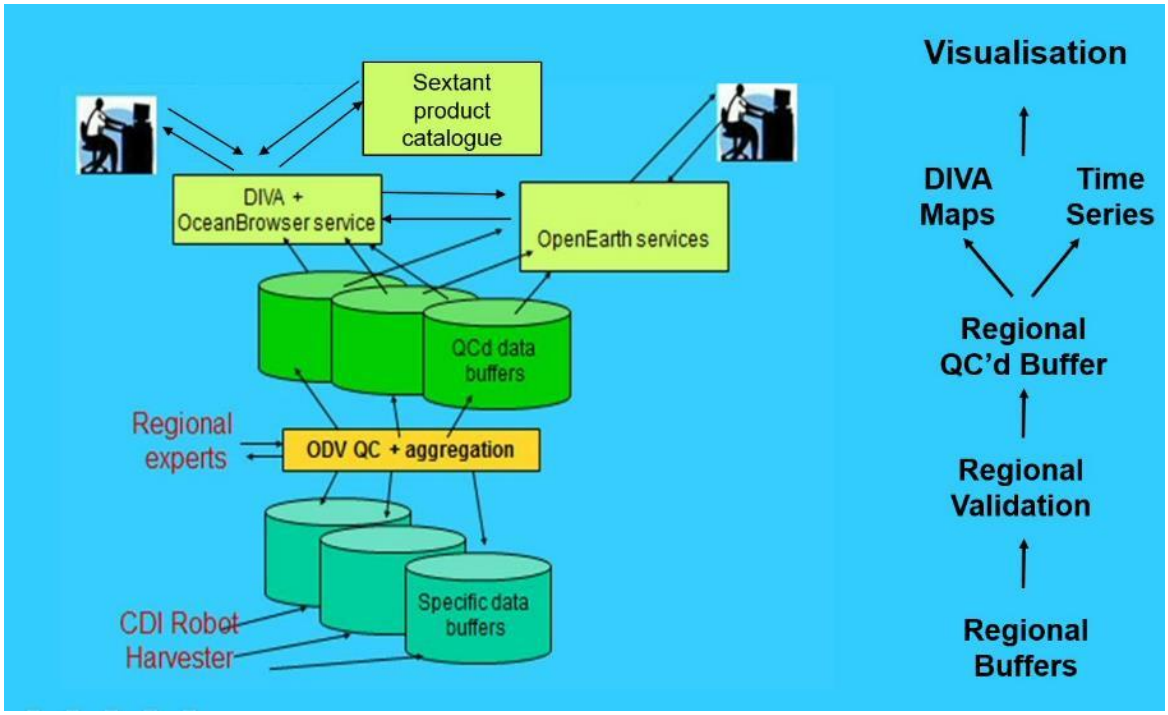


Figure 26. Workflow from data harvesting to advanced viewing services for EMODnet Chemistry data products

The **OceanBrowser Viewing service**, developed and maintained by Ulg, provides access to the DIVA interpolated maps. Output images are available as horizontal sections and vertical sections. The latter can be selected by drawing an appropriate transect. Ulg has included in the interface predefined coastal sections which allow a user to visualise as vertical sections.

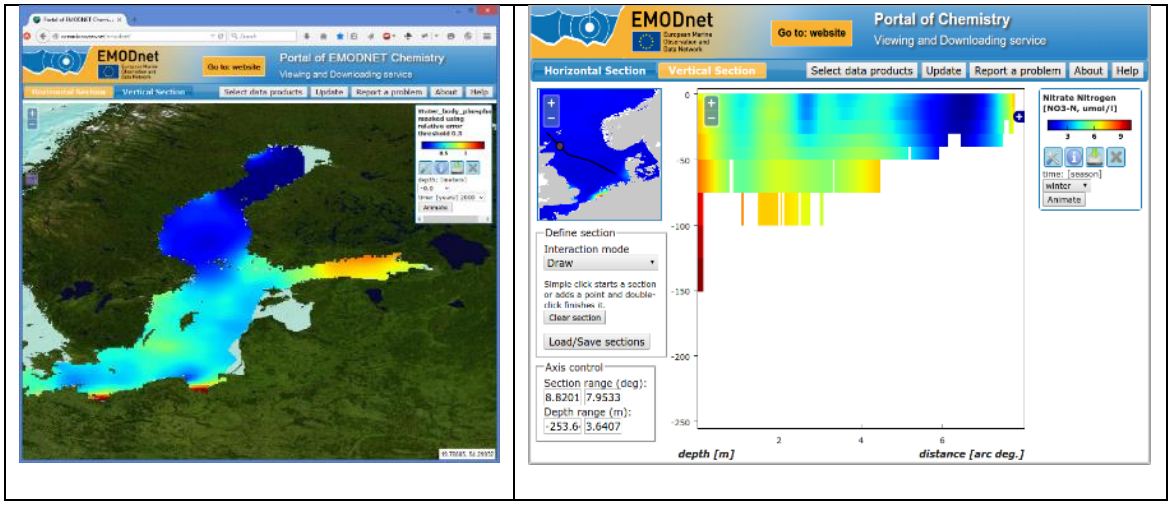


Figure 27. OceanBrowser horizontal and vertical sections viewing

The export of animations has been improved. OceanBrowser now supports HTTP Cache Control headers which significantly improves the responsiveness of OceanBrowser when the

site is revisited and the list of data products did not change in the meantime. Ulg together with IFREMER has integrated the OceanBrowser with the **Sextant data products metadata catalogue**. This now gives users the option to select EMODnet Chemistry data products in the Sextant catalogue and then to visualise and browse those in the OceanBrowser. Alternative to visualise data products in the OceanBrowser and then to look up their description from the Sextant Catalogue. As part of this process Ulg has also developed a DIVA2XML application that facilitates the generation of Sextant XML entries for each data product as generated by the regional groups using the DIVA software for interpolated sea basin maps.

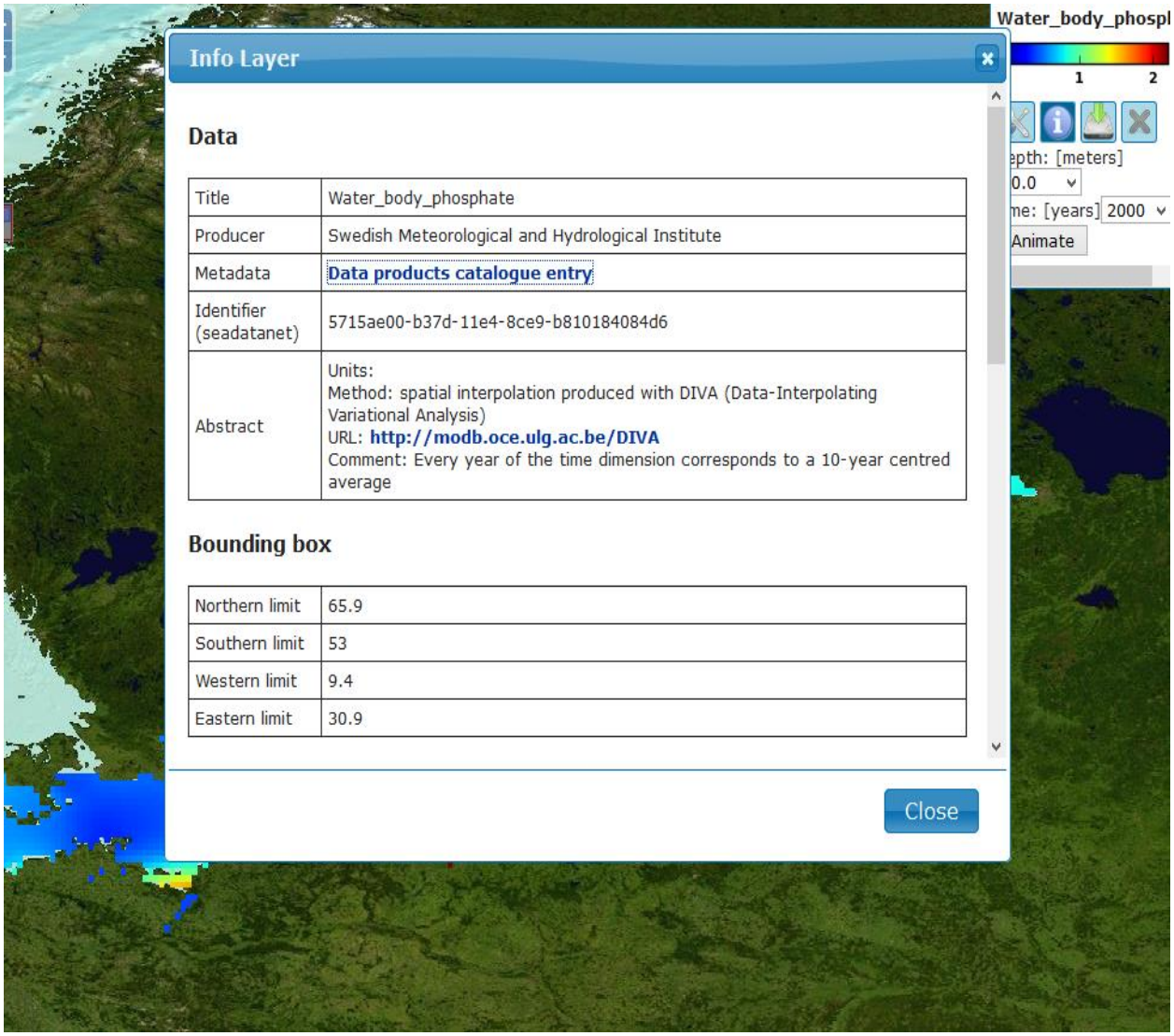


Figure 28. OceanBrowser integration of Sextant product catalogue service

Recently the Sextant entries for data products have been expanded with acknowledgements to the data originators (by means of EDMO and links) that have contributed with their data sets to each product. This has been arranged by a web service from the CDI Data Discovery and Access service, the DIVA product descriptions and the Sextant Catalogue service.

The DIVA maps can not only be viewed but also downloaded as NetCDF (CF) data files. Ulg has also included support for the CDI WMS – WFS services in the OceanBrowser Viewing service so that users can easily see which data sets overall are available in EMODnet Chemistry and their metadata for further information and possible shopping requests.

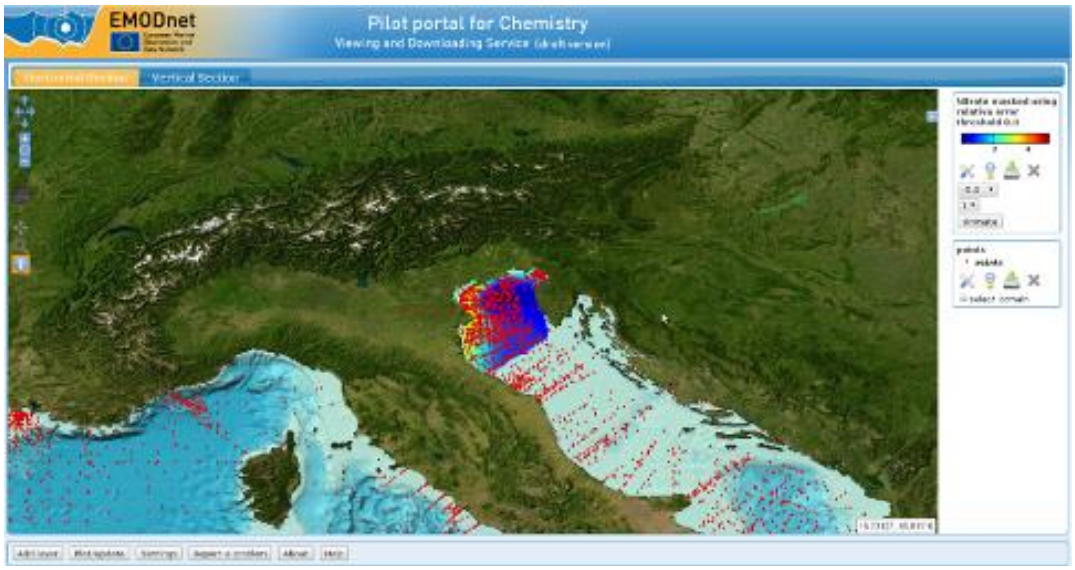


Figure 29. OceanBrowser Viewing service for visualising DIVA interpolated maps and including WMS-WFS overlays of e.g. observation points via CDI service

Ulg has also achieved together with Deltares the integration of additional visualisations for the aggregated and validated data collections (see next). It allows users to visualize the observations of a given parameter and of a selected location. Along with the time series and profile plots, the EDMO codes and CDI identifiers of the displayed data sets are also shown which then can be selected and downloaded from the CDI Data Discovery and Access service.

Finally OceanBrowser now runs on a server at the CINECA data center. The portability of the software was considerably increased by using Linux containers. Further tuning has been undertaken for establishing a fully operational OceanBrowser configuration in the CINECA cloud.

6) Developing advanced viewing services for timeseries and profiles

Deltares has developed additional visualisation services for the aggregated and validated data collections. These visualisations are produced by Web Processing Services (WPS) in a Python framework and generate:

- Plots of time series and profiles of selected parameters from data sets of selected stations
- Maps of regional data collections displaying spatial resolution in time and intensity of data availability for selected parameters

The system has been set-up and upgraded to the latest data model to enable handling of the metadata enriched, harmonised and validated regional data collections, that are produced by the regional coordinators using the harvested data sets, ODV software, the P35 – P06 vocabularies, and their QA-QC expertise. Deltares has worked on the loading of these regional data collections into a PostgreSQL/PostGIS database, followed by WPS services to extract the data.

One service is a WFS service (making use of GeoServer) to calculate and display maps with the locations and data intensity at those locations following a set filter by parameter, date period, and depth interval. This layer is integrated into the OceanBrowser service.

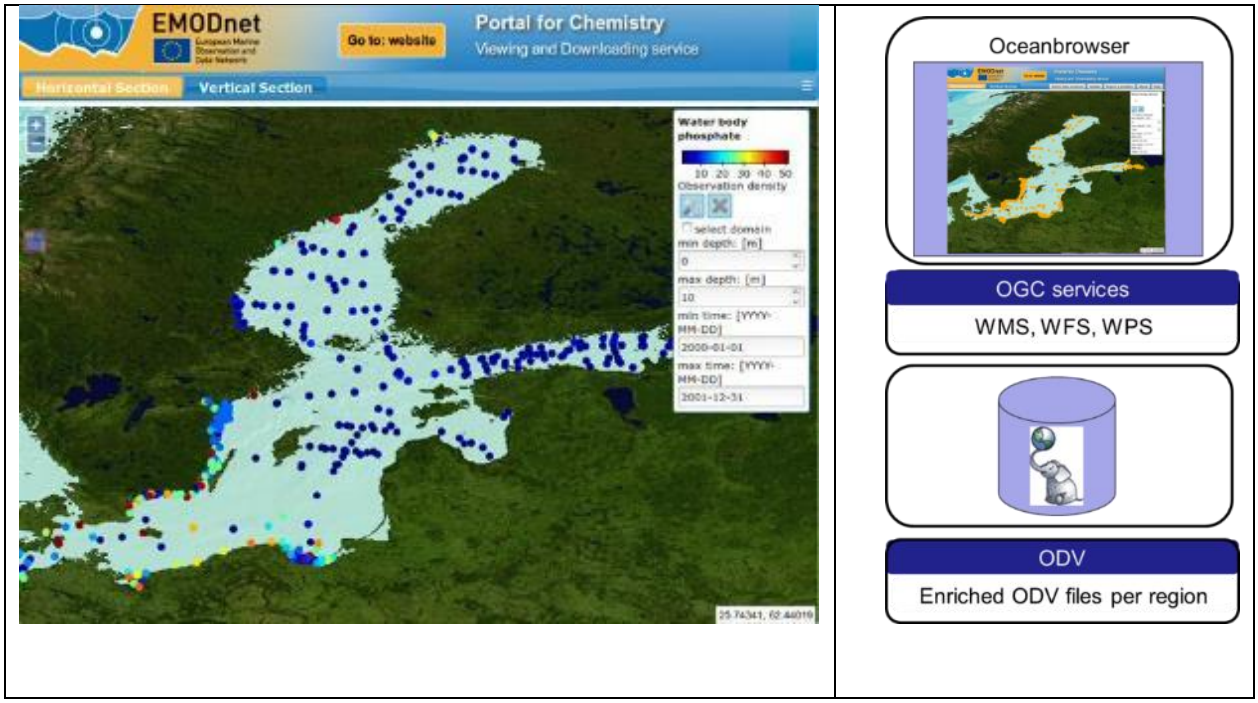


Figure 30. OceanBrowser with map of data locations and data intensity per parameter per location by colour

Furthermore WPS services have been implemented for generating fully dynamic plots of the data at a selected location as time series or as profiles. This includes a second filter to amend the displayed subset of data by date period and depth interval.

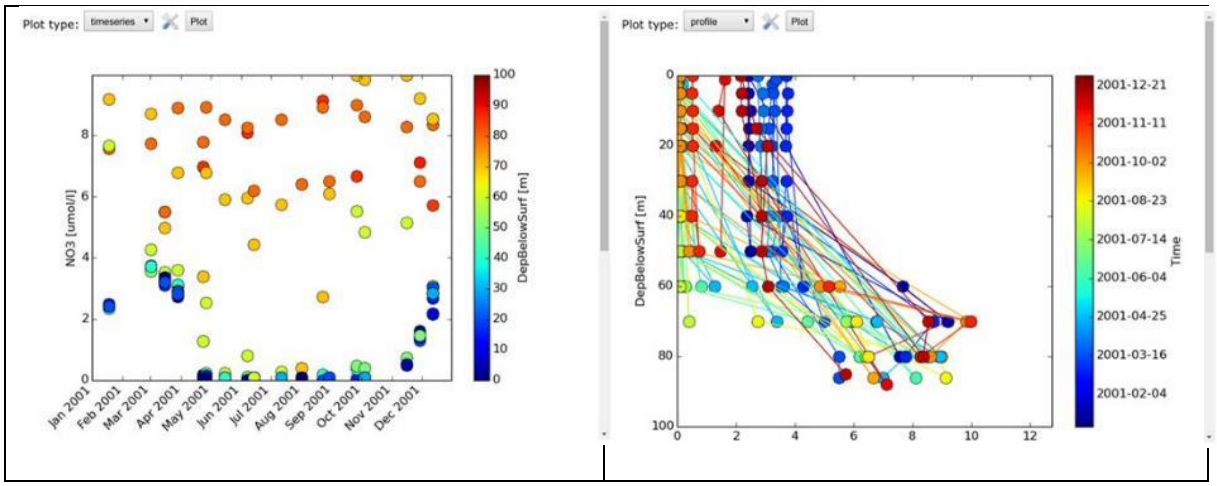


Figure 31. Plots of timeseries and profiles of data at selected location as pop-up on top of the OceanBrowser WFS map.

Furthermore, Deltares has migrated the database and WPS services to the cloud environment at CINECA. This included also the set-up of a GeoServer instance, which has an important role in the exchange to the OceanBrowser web viewer. From early 2015 onwards Deltares has been receiving regional validated data collections from regional leaders and has been loading these into the database. This has been done by python scripting that reads the enriched ODV files and inserts data directly into the database. Several issues on integrity and performance were tackled. Especially, performance was raised by implementing a different way of reading the enriched ODV files. Furthermore, a different implementation in data loading is used whereby a speed improvement of several factors was gained. Deltares has also spent effort in documenting the system for transfer to MARIS that will operate and maintain the services beyond the present EMODnet Chemistry project.

A major investment has been made in enabling Web Processing Services via the cloud. It has been decided to host the regional aggregated and validated datya collections (incl the identified station subsets) in a cloud hosting and computing environment. Therefore OGS and MARIS have explored options and have chosen to work with **Cineca.** Cineca is a non profit Consortium, made up of **69 Italian universities**, **and 3 Institutions,** including OGS and CNR. It is the largest Italian computing centre. Cineca is also partner in **EUDAT**, an FP7 project towards a pan-European Collaborative Data Infrastructure which will allow researchers to share data within and between communities and enable them to carry out their research effectively. OGS-MARIS and CINECA have reached agreement and CINECA has provid a cloud work space for EMODnet Chemistry by September 2014. This gave a challenge for Ulg resp Deltares to install and configure OceanBrowser resp the WPS services on the CINECA cloud. The solution offered by CINECA cloud services and the one presented by Deltares to install WPS services matched after several months only, as the process went through installation

issues, lack of user rights to work with needed software, implementation of several adjustments to the services Deltares already provided on its test server. A matching solution has been found by using so called Linux Docker containers with fully installed WPS services, and the main server acting as a proxy. The investigation, trial and error on how to accomplish this has resulted unfortunately in a considerable time loss. The advantage of a Docker Container is that it can be used on every Linux distribution and on any server, no root access is required and services can be deployed relatively easily.

Also there has been quite some effort for achieving better performance. Deltares has been seeking ways to improve performance of viewing the database by using WFS and more advanced protocols for the proxies used. This implied work done by CINECA and Ulg. In close corporation with both Ulg and MARIS several other improvements were made. These imply a change in the way data is prepared before dissemination by the OceanBrowser. Data is prepared by parameter, so for each parameter there is a separate WFS that is filtered by the OceanBrowser, instead of filtering all data from 1 table. On over 30 million records, this improvement speeds up the query significantly. Most improvements however have made possible by altering some queries and setting proper indices on the columns of the tables.

The advanced visualisation services are now fully operational. However due to the large volume of the database further work might be needed beyond the project to achieve a good performance for all possible queries.

7) Upgrading the DIVA software

DIVA is a software designed by Ulg to deal with discrete in situ data and reconstruct a continuous field from it. Over the project duration several new releases of DIVA have been delivered, the history of the new features and a nearly exhaustive list of changes in DIVA is available on: http://modb.oce.ulg.ac.be/mediawiki/index.php/New_Diva_Features. Among the main new features, there are the possibility of using a variable correlation length depending on the depth, the greater easiness for the user to create its own binary field (advection field, correlation length,...), the continuously upgraded error check (more complete log files, warnings if strange behavior,...), the possibility of using a different reference field for each season, the increased compatibility with Mac OS or some gains of speed in particular cases, upgrading of advection constraint, addition of two new error methods, optimisation of the code performance (see Table 3.1), possibility to extract time series instead of (or with) profiles data, weighting option in order to mitigate the impact of too close observations, either in time or in space.

CPU time (s) for	Diva-4.5.1	diva-4.6.1	diva-4.7.1
Mesh generation	27	2	0.45
Analysis	318	159	127

Table 10. Example of performance gain using divabigtest (test with 1.5 million data points and a very fine mesh).

Furthermore, several strategies were developed to face issues of spatial variability of some variables, and to address the need to produce maps of bottom water properties (eg. bottom oxygen layers). In the last DIVA version (4.7.1), a new feature allows the computation of the layers from several user-defined distances from the bottom surface (see Figure 32).

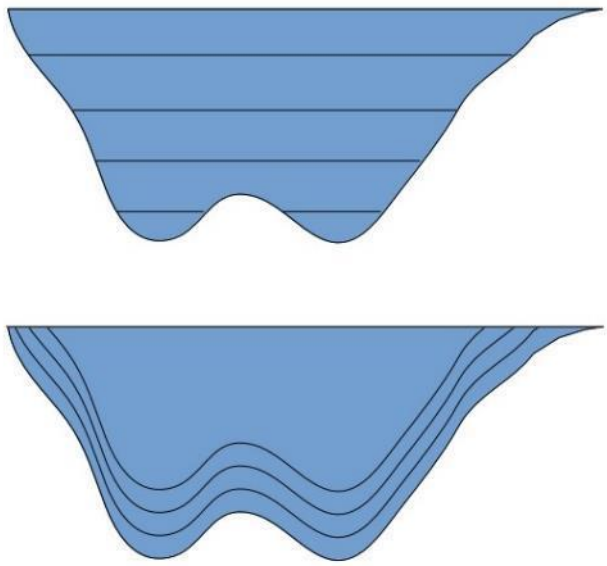


Figure 32. Illustration of both possibilities to analyze data on 2D layers: at a specific distance from the surface (top) and from the ocean bottom (bottom).

Ulg has been very attentive on EMODnet partner's feedback about problems encountered with DIVA or wishes for the next release. For instance, the time series can now be extracted by DIVA if they are provided in a separated ODV file, and their impact on the "over-abundance bias" can be mitigated by a new weighting option, using time and position to decrease the weight of too close measurements. Also, the use of whitespaces in primary variable is now allowed in DIVA, as requested by several users. Another example is the size of the final NETCDF output file, limited to 2 Gb, which will be increased in the next release thanks to users requests. Many small bugs have also been fixed thanks to them, see the link above

(robustness of ODV extraction, topography creation, winter analyse across the new year,...). The documentation is continuously updated accordingly.

8) Upgrading the Sextant Products metadata catalogue and integration with the Ocean Browser Viewing Service

The Sextant Products metadata catalogue as developed by IFREMER is used to describe the Chemistry data products such as DIVA maps. This facilitates searching for specific data products and the exchange and use of the Chemistry data products in other services, such as the Chemistry OceanBrowser, and other portals with OGC WMS support.

During the project the following actions had been performed:

- the description of the products available since the first phase of EMODnet have been migrated to a profile compliant with other European marine services (SeaDataNet, Copernicus) and compliant with INSPIRE directive and are accessible in a web portal : http://sextant.ifremer.fr/en/web/EMODnet_chemistry/catalogue
- A tutorial and web forms have been provided for regional product managers and reviewers (OGS) to edit the product descriptions.
- Efforts have been dedicated to populating the catalogue with the description of products as processed by the regional leaders.
- Also some upgrade and support have been provided by IFREMER in response to feedback from project partners.
- The tool DIVAdoXML developed by Ulg has been upgraded so that the description of a product is automatically templated out of the DIVA processing chain to create the product description for Sextant. The product description now contains P035 parameter terms from the new SeaDataNet P35 vocabulary service. The product description edition forms now enable to select a contact from the EDMO directory and to acknowledge data originators.

Conclusions:

WP4 has achieved very good results. The development and integration of the various services (CDI, OceanBrowser, Sextant, WPS) has been achieved and these have been made fully operational. Further tuning and optimisation might be needed beyond the project for the advanced visualisation services due to the volume of the database. The services are now in use at the EMODnet Chemistry portal and can be populated with additional data, metadata and data products in the future. Moreover, the important tools, ODV, DIVA and Vocabularies, are maintained, operated and upgraded, following user requests. Finally the migration to cloud hosting at CINECA has been successfully achieved.

WP5 : Analyses and Recommendations

Background

This activity focusses on building a continuous dialogue, feedback and iteration loop throughout the lifetime of the project with the stakeholders and users. The main aim of this work is to identify the key users and use cases – focusing particularly on the EU MSFD, and ensure that a dialogue is in place that allows feedback to be collected from these groups and that this feedback is fed into the specific tasks in the project.

During the whole project duration, activities have been dedicated towards convergence of interests and processes focussed around 3 inter-connected areas in relation to the EMODnet Chemistry primary use case and Marine Strategy Framework Directive (MSFD): INSPIRE (the environmental directive on publicly acquired spatial datasets), WISE Marine (web-based portal for sharing information to the marine community on the marine environment in relation to the MSFD) and MSFD indicators.

- INSPIRE, via a marine pilot led by the JRC has started to produce results and feedback
- WISE Marine, the information and knowledge portal for MSFD, has been less prominent in the last phase of the project as there has been less focus at WGDIKE and EEA on this
- The MSFD community, both via the coordination group meetings and dedicated workshops aimed at RSC experts, continues to provide a platform for focussing efforts on how EMODnet can assist in the provision of services to the actors within the MSFD
- The 'portal' user panel community, where two surveys of their use of the EMODnet Chemistry portal have been undertaken, and further challenges for improvements were sought

The feedback mechanisms now in place via a continuous dialogue with partners and stakeholders in the MSFD needs to be capitalized on by ensuring EMODnet Chemistry responds effectively to the specific actions for follow-up and continues to understand better the challenges facing those working within the MSFD. This is heavily reflected in the lessons learned section, where many of the recommendations stem from workshops and coordination meeting between the MSFD community and EMODnet Chemistry.

The emphasis and relationship to RSC's has increased in years 2 and 3, and the draft MoU for the Black Sea Commission Secretariat, which is also being used as a template for the Mediterranean region is a major move forward.

INSPIRE

The environmental directive on publicly acquired spatial datasets is referenced directly in the MSFD and also referenced in the EMODnet contracts. It is therefore important that EMODnet understands INSPIRE, and compliance to it, and also about the interaction in relation to MSFD.

The JRC has now completed phase 1 of a marine pilot with 3 countries (DK, NL, DE) and the work focusses on mapping INSPIRE to MSFD, as well as gaining a better understanding of EMODnet and the implications of INSPIRE on the network. More information on the status can be found on the WGDIKE meeting portal[3]. There is therefore now a continuous contact between INSPIRE and EMODnet steering group, with the JRC also attending the MSFD/EMODnet coordination meeting.

Specifically, EMODnet Chemistry via its SeaDataNet backbone, has made great efforts to ensure the CDI (the dataset discovery meta record) is fully INSPIRE compliant, and also to include the common vocabularies as part of INSPIRE.

WISE Marine

The web-based portal for sharing information to the marine community on the marine environment in relation to the MSFD is seen as a key interaction for the EMODnet Chemistry project. While there was a clear focus on WISE Marine in the MSFD context in the 2nd year of EMODnet Chemistry, this has been difficult to sustain in the final year as DIKE and the EEA have not profiled WISE-Marine. The last meeting of WDIKE, which was scheduled for spring in 2016, was cancelled and this was the final opportunity (in this project phase of EMODnet) to engage with the DIKE and WISE-Marine.

The most relevant area for EMODnet chemistry is Data. Looking at data in Figure 33. WISE Marine level 2: Datagives more detail in how this is expected to be organised. The area in red relates to the reporting from member states according to the articles of the directive, it would be less likely that EMODnet Chemistry would have an immediate role here. In the blue boxes are the data streams and outputs, where both data products and relevant reference data are linked to. EMODnet Chemistry could be seen to provide data streams under 'data services' that can support the overall data and information base for marine assessments and the MSFD. More specifically, EMODnet Chemistry may underpin the evidence base in the indicators component i.e. for D5 and D8. This is however a more difficult challenge as this entails an acceptance by the providers of indicators (Regional Sea Conventions) of a data stream/data product from an EMODnet type approach.

[3] https://circabc.europa.eu/w/browse/0f280812-d150-43c4-9b76-28affb3a7983

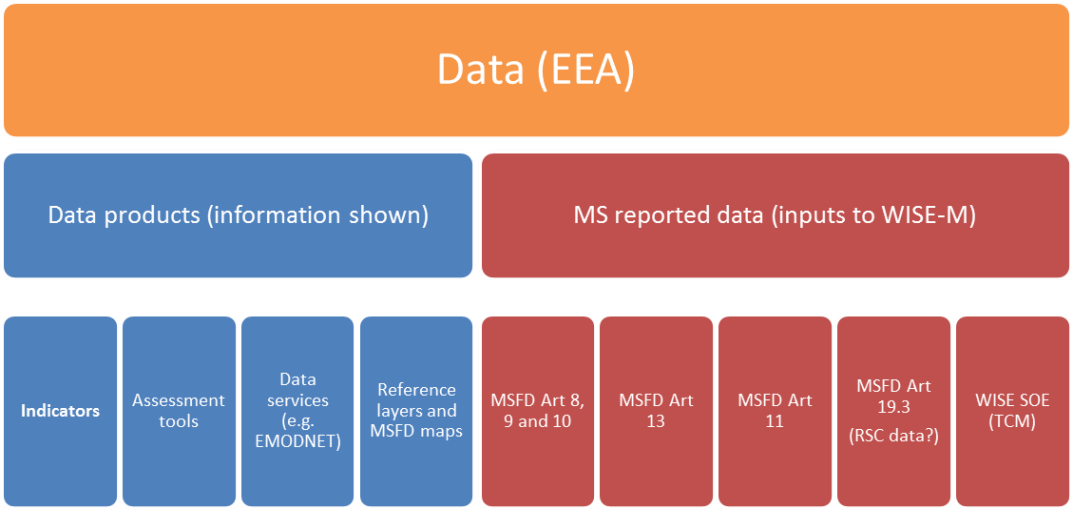


Figure 33. WISE Marine level 2: Data

Key interactions with MSFD

Throughout the project there has been a continued dialogue and interaction with different entry points into the MSFD. While interaction with member states (via WGDIKE), RSC's, EEA and DGENV and other end-user stakeholders have all been attempted, the gravitation has been towards the RSC interaction via the EMODnet- MSFD steering group, and dedicated RSC workshops focussing on products available from EMODnet Chemistry. In September 2014, the first meeting between key members from the EMODnet community – represented by the leads on the portal, DGMARE and EMODnet Secretariat and the MSFD community – represented by the DG ENV, EEA, RSC's and some member states was held. This is now known as the EMODnet-MSFD coordination meeting and is a regular scheduled event, and positive for EMODnet chemistry to have this open channel.

Via WGDIKE, the TGDATA (sub-group) meetings (July 2013, April 2014) had a relation to EMODnet.. A more general discussion was initiated on the way that TGDATA could, going forward, interact with EMODnet Chemistry.

In addition, from the work presented at the workshop in terms of the availability of operational systems/data for the D5 and D8 MSFD indicators it was highlighted that particularly in the Mediterranean and Black Sea that there were opportunities for EMODnet Chemistry to provide infrastructure and products to support the MS/RSC's, which has since been followed up at subsequent meetings and resulted in the draft MoU's for the Black Sea Commission Secretariat and the Mediterranean region

In February 2015 and December 2015 the EMODnet-MSFD coordination meeting met again, this time with a greater focus on the EMODnet Chemistry offering. Once again, there was a general consensus that concentrating on the Mediterranean and Black Sea might bring the greatest benefit. However, OSPAR and HELCOM did elaborate on how EMDODnet Chemistry could be more aligned to their needs, and they suggested to look at appropriate information in the metadata to identify chemistry data suitable for inclusion in MSFD reporting based on QA and QC procedures. As well as pointing to the ICES reporting formats for these information, the suggestion was to look at the indicator specifications as this is where the methodologies are described (including data aggregation, filtering etc.). This resulted in extensive analysis and surveys of the QA/QC procedures of the partners in EMODnet Chemistry, which is further discussed and concluded on in 'lessons learned'.

The EMODnet chemistry workshop in Oostende in October 2015 provided a further opportunity for the RSC's to discuss with the product experts the alignment of the portal and products to their perceived needs. Specific outcomes included the development of video tutorials[4] for using the portal for data access and data products, a better compartmentalisation of the data for assessment needs (putting matrix as an upfront selection criteria), clearer labelling of the data products, investigating the labelling of datasets a regards to their collection purpose (research/monitoring) and a clear direction for MSFD users to access the regional (product) data buffers, rather than go through the portal.

[4] http://www.emodnet-chemistry.eu/videotutorial.html

4. Challenges encountered during the project

The following challenges have been encountered during the project:

Challenges encountered	Short description	Measures to address challenges
Data availability		
Data availability	Difficulties in getting locally identified data from specific organisations	Contact with local data holders trying to convince them to contribute
Delays in receiving data from originators and missindg metadata	Data not appropriately organised in scientists/data holders archives.	Contacts with originators to assist them for delivering their data properly. Metadata were collected and/or completed from data originators.
Import of dataset		
Data received in different formats or errors in formats	Data files not in ODV format and errors at importing in ODV 4.6.3.3	Data files conversion to ODV format
Vocabulary for biota to be implemented	Necessary extensions to the P1 vocabulary to cover all species/substance combinations	Addition of species/substance combinations to the P1 list when all species and substances are known
Not uniform units among datasets of the same chemical compound	Different analysis methods, varying detected quantities of chemical compounds result into different order of magnitude and/or different units of data	Unit conversions upon agreement with EMODnet Chemistry Expert group
Management of zero values	1. The detection limit is not available for old data. 2. Detection limits for same elements/compounds vary according to the method of analysis/laboratory	Contacts with originators/data providers for the identification of the relevant detection limits. The replacement of zero values and their qc flagging is following the decisions of the Steering committee and Plenary meetings.
Mapping datasets and institutes from other data systems	Mapping the ICES contaminants data to the P01 codelist has been a challenge, especially for the biota data due to high heterogeneity. Institutes had to be mapped to EDMO.	Mapping has been done in cooperation with BODC, mainly manually and sometimes in communication with relevant institutes.
Detect duplicate CDI's	Care needs to be taken that CDI's made from other databases do not duplicate effort done by other EMODnet partners.	ICES data submitters has been asked if they prefer submitting to the CDI system on their own or if they would like ICES to create CDI's based on their data.

Data Quality

Validation of the quality of the Mediterranean data set	Inconsistencies between quality flag schemas and observations since obviously "bad" data flagged as "good" e.g. negative values flagged as correct	Preparation of report errors and contacts with the data originators to eliminate wherever possible the detected data errors. The use of ODV tool facilitated the QC processing of the data
Data Quality and management of zero values (WP1&2)	Some data have a zero value and no detection limit is known.	After consultation with the other partners, these data are flagged as 6 “value below detection”.

Products generation

DIVA Products generation	At the beginning of EMODnet the use of DIVA weas not clear enough to ensure a good products definition.	Organization of workshops and training courses on DIVA use and parameters.
Time consuming Manual parameter aggregation	Common parameters (e.g., temperature, oxygen, phosphate, etc.) occur with widely varying names and P01 parameter codes	Overview of needed conversion for dataset collected in Excel spreadsheet and set up of procedures fro automatic mapping.
Data homogenization	the diversity of instruments, analytical methods and units prevented the easy merging of data from different sources.	Visual inspections and grouping of similar data with the use of ODV tool
Data aggregation and unit conversion	Some data were surprisingly high compared to others. A problem of unit conversion during aggregation in ODV was noticed.	Contact with the AWI ODV developers to implement other formulas for unit conversions.
Low spatial and temporal data coverage for DIVA Product and settings	With a low coverage of data running DIVA decades by decades, DIVA parameters optimisation, data binning and data weighting are tested and take too much time.	All aggregated data collections were carefully checked with ODV software for data coverage and DIVA analyses were done on different levels / decades depending on data availability for every parameter and every season
Awareness of product managers and reviewers regarding product cataloguing	Training and awareness of product managers regarding the documentation of their product in the catalogue	No dedicated training session has been organized, however some face to face presentations and discussions have been set up and helped the project to consider the “product catalogue” has an actual tool for product documentation.

Quality Assurance/Quality Control

Collection and selection of relevant QA/QC procedures and technical specifications applied by EMODnet partners at level of data production	Difficulties in collection of relevant QA/QC procedures and technical specifications with a specific questionnaire designed for such purpose submitted for compilation to EMODnet partners	Contact and urge EMODnet partners to fill the questionnaire

Data aggregation

Development of the fully automatic robot harvester system	CDI service has been extended with a Buffer CMS to configure harvesting profiles, that steer a Robot harvester for discovery and retrieving of distributed data sets and storage in a central buffer with central user interface.	Analysis of specifications and gradual development with thorough testing of system components because it is a critical service for making the data harvesting much more efficient and operational
Formulating the geographic filters for MSFD regions	Data products must be generated for MSFD regions according to the contract, but these MSFD regions are not yet officially established	Approximation of MSFD regions, followed by schematising the regions with margings to act as geographic filters for the regional data harvesting
Requesting datasets	Since datasets are more or less confidential, agreement with data provider were necessary	Contacts via technical coordinator ensured sending data in time
Generating harmonised regional data collections as basis for the regional data products.	The harvested data sets consist of sub collections of ODV files and related CDI metadata files from tens of data providers, that make use of many different parameters and units and quality flags.	An approach was implemented to enrich the harvested data collections by merging ODV files with related CDI metadata, by upgrading the ODV software. A new P35 vocabulary was developed for automatic harmonisation of parameters to P35 level and applying business rules for unit conversions and harmonisations.
P35 governance	The data management community requires technical input from the scientific users as to which terms can be aggregated and which terms should not be aggregated.	Governance group has been set up from participants across the EMODnet scientific community.

Conversion from ICES data format to SeaDataNet for contaminants in biota.	Data stored with ICES reference codes which can be applied in may combinations and some combinations were not sensible (e.g. mussels with muscle).	Developed a vocabulary mapping to identify appropriate P01 terms and generate new codes as appropriate depending on the ICES code combinations. Unlikely combinations were identified, queried and then corrected by ICES.

Management of visualization products

Adapt DIVA to specific needs of EMODnet partners	DIVA was adapted to fit EMODnet Chemistry requirements.	The diva-4.6.10 version answers now to all of these requests.
Migrating the advanced viewing services to a Cloud environment	The advanced viewing services comprise the OceanBrowser service for viewing and downloading of DIVA maps in combination with WPS services for interrogating and visualising the underlying harmonised data collections.	Regular dialogue between the service developers Ulg and Deltares together with the coordinating team of OGS and MARIS and with the cloud service provider CINECA (Italy). T

Connection with MSFD

MSFD marine regions and subregions not published	The MSFD marine regions and subregions has not been published for use by EMODnet	Support EEA and Commission in the publication-process of the MSFD regions and subregions
Aligning EMODnet chemistry activities to the MSFD processes	There is a challenge in fitting the timescale and political dimension of the MSFD (the Directive) together with the outputs and infrastructural services that EMODnet Chem (as a project) can offer	Liaison with DG ENV, EEA

Summary of remaining challenges that require attention in the next phase

Since EMODnet Chemistry Pilot Project (2009), several important challenges were recognized and approached, mainly linked to data aggregation and the validation loop, to the viewing and downloading services. Still, a series of issues remains open regarding the following points:

- Improvement of the user-friendliness of the web interfaces (both for data and product access),
- Improvement of the labelling of the harvested data to highlight their origin and distinguish between research and monitoring data,

- Information on QA/QC applied to parameter analysis and monitoring done by source laboratories (“ex ante quality control”) have been collected, syntethised and made available. These metadata need to be linked to the measured data directly,

These challenges will be approached within the next phase to improve the services for data and product access through the portal for EU sea basins.

5. Analysis of performance and lessons learned

EMODnet Chemistry has reached all specific objectives listed in the call for tenders MARE/2012/10 (point 2.2). In particular, the performance in assembling existing data has been periodically reported as evolution of Indicator 1 (Volume of data made available through the portal) and Indicator 2 (Organisations supplying each type of data based on (formal) sharing agreements and broken down into country and organisation type), both showing a continuous increase throughout the three years of the project. EMODnet Chemistry portal allowing public access and viewing of data, metadata and data products has been available during the lifetime of the project. The volume of each type of data and of each data product downloaded from the portal has been reported with Indicator 4, while Indicator 8 reported the list of web-services made available and user organisations connected through these web-services. In addition, two user surveys were circulated to monitor and report on the effectiveness of the system in meeting the needs of users in terms of ease and speed of use, quality of information and fitness for purpose of the data and products delivered. The results are described in Chapter 7 (User Feedback). EMODnet Chemistry has done a consistent step forwards to improve the accuracy, precision, coverage and ease of use of the data setting up a data validation loop at regional scale for the five EU sea basins (see WP2 description for further details). EMODnet Chemistry, being a distributed network of interconnected Data Centers, adopted an automatic Robot Harvester, properly configured with predefined criteria of geographical and temporal coverage and parameters, to retrieve specific data sets and to keep the portal operational.

With reference to the items listed specifically for Lot 4 Chemistry (point 2.4 in the call for tenders MARE/2012/10), the chemical groups delivered by the portal are presented on the main web page by map and table showing chemical parameters by region. The performance per sea region and per chemical group is presented as number of measurement data sets. Clicking on a coloured square triggers a query on the Common Data Index (CDI) Data Discovery and Access service that allows to browse the metadata in more detail. EMODnet Chemistry portal allows to gather all measurements of a particular chemical species with their appropriate metadata within a given space and time window and by the different matrices (water column, sediment and biota). The viewing service allows to visualise the measurement density in a given time and space window, to visualise a time evolution of a selected group of measurements and to show concentration plots for a given time and space window and also along the coast. Inflows of nutrients from rivers are missing from the portal, while spatially distributed data products specifically relevant for Marine Strategy Framework Directive Descriptors 5 (eutrophication), 8 (chemical pollution) and 9

(contaminants in seafood) are made available through the viewing and downloading service as DIVA (Data-Interpolating Variational Analysis) concentration maps, dynamic plots of time series and profiles of selected parameters from data sets of selected stations or maps of regional data collections displaying spatial resolution in time and intensity of data availability for selected parameters.

Lessons learned cover the following items, listed in point 2.5.14 of the tender specifications:

(1) Main barriers to the provision of data

The main barriers to the provision of marine data are well known and transcend just one data type. The data owning institute/organization may have a data policy that prevents or hinders the ability to disseminate data. These constraints can be of a legal nature (protection of intellectual rights or personal privacy) or commercial (commercially sensitive data). Data collected under projects may also have a moratorium that gives the scientists rights to publish their findings before the data are released, these agreements can be varied in how long they withhold the data for. Often cited are two linked issues- the cost of preparing the data and lack of technological infrastructure/resource. While many providers strive to provide data for 'free' via web portals, there is a significant investment needed in infrastructure and technological training to make this happen. This situation is often critically seen in countries where the data are managed in smaller, specialized institutes and where there is no common national framework for managing such data resources. Finally, and also one of the more difficult barriers to understand and overcome, is the general willingness of data providers to provide data. This can be a mixture of cultural reasons, lack of trust, lack of motivation or incentive.

Barriers; Solutions and Recommendations

The EMODnet Chemistry technical infrastructure is based on the well-established SeaDataNet platform. The guiding principles that SeaDataNet and, by default, EMODnet Chemistry follow is to ensure that first and foremost all relevant data are well described and 'discoverable' through the search catalogue. Coupled with this, the data owner is able to apply a defined licence condition[5] to their data. This enables the data provider to make his data known to the marine community, and retain full control over access to the resource. Over time, this approach can lead to a softening of the data restrictions from data owners, as they can oversee the requests and gain trust in the system, as well as subtle 'peer group' pressure from other institutes in the network that have a more open data access licence. The data licence also allows a form of negotiation to take place – where the data owner is able to evaluate each request for use of their data and give rights based on specific uses.

[5] See SeaDataNet vocabulary L08

To address the lack of motivation, or incentive, for data providers to actively supply data into the system there a number of possible means. The most direct way is to engage the data providers in the project – either through their institutional focal point in EMODnet Chemistry or via the sub-contracting approach (data grants) that was successfully used in EMODnet Biology. However, there is a financial and logistical limit to how many potential data providers you can reach via this direct mechanism and so other, more indirect methods, are needed.

The increasing use of the Digital Object Identifier (DOI)[6] to provide a persistent identifier to datasets and data products, allows recognition and credit for the production of data to be duly acknowledged, and also tracks the use and impact of specific datasets. EMODnet Chemistry and SeaDataNet have explored options for applying these identifiers and would view this as an incentive especially for researchers where their data can earn credits as published data papers. In a similar vein, linking the cruise summary report (CSR) – the metadata about a specific research cruise and the Common Data Index (CDI) – the metadata about the resultant dataset(s) from research would allow for a more direct association between the individual researchers and the data they should be credited for collecting. It is important to recognise that in a federated system such as EMODnet, there is a real challenge in ensuring that all links in the data process are sufficiently recognised and acknowledged. It is therefore important that within the institutes that provide data to EMODnet Chemistry, there is sufficient feedback to the researchers that their data are being provided to EMODnet, and what those data are subject to in EMODnet (data licence, data products etc.).

One of the simple tools that EMODnet can provide to data providers is a quality report on the data, this happens arbitrarily in terms of compliance to the data schemas, but also via the regional product leads who routinely evaluate the data in relation to their inclusion in the regional products. This demonstrated to the provider that their data are being utilised, but also highlights potential quality issues that are harder to capture when you are looking at a smaller set of data (i.e. a national vs regional collection).

[6] https://www.datacite.org/services/cite-your-data.html

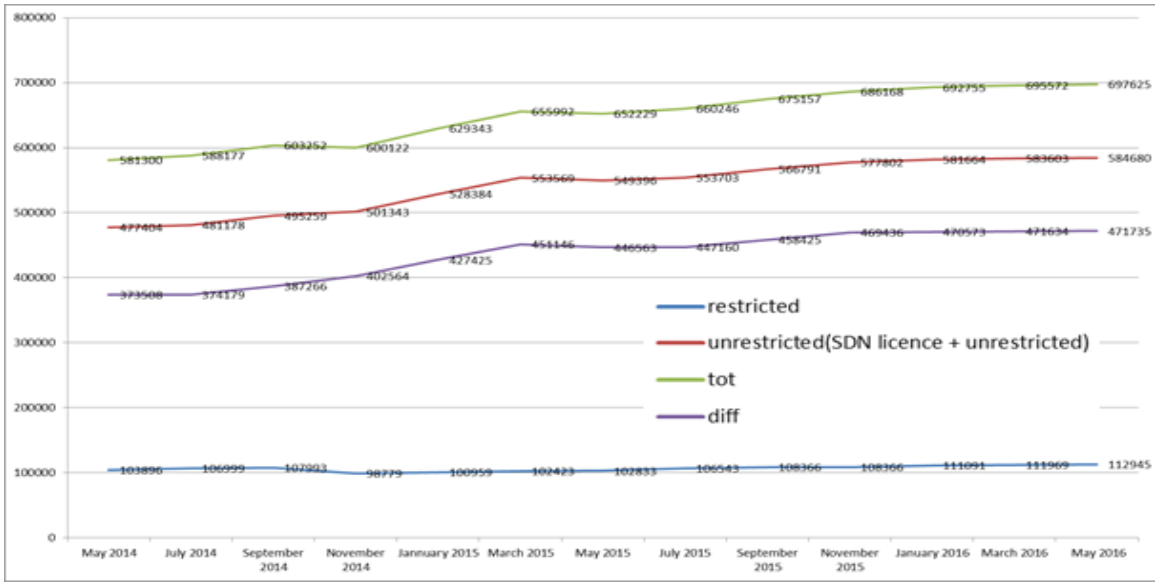


Figure 31. Number of CDIs (dataset identifiers) in EMODnet Chemistry by access licence type from May 2014 to May 2016

A large infrastructure like EMODnet Chemistry is also able to invest in technological standards, such as INSPIRE, which require a high degree of technical understanding and resource. In this way, smaller data providers that do not have the ability/resource to pursue INSPIRE compliance through their own means can use their connection to EMODnet Chemistry to achieve this. In this way, they can leverage the combined effort from EMODnet and ensure their data meet the necessary discovery, catalogue and download capabilities via the EMODnet infrastructure. This would be an incentive for especially the smaller institutes to link-up to EMODnet Chemistry.

Data digitisation, or more generically data archaeology, are considered to be relevant to EMODnet Chemistry especially in regions where resources to transfer data into electronic forms are not readily available or prioritised. This could potentially run along the same lines as the EMODnet Biology work package on data archaeology that provided micro grants in order to provide the needed resources to prepare the data. Considering the relative expense of the collection of such data, the additional small investment could be worthwhile in order to improve the historical collection of chemical data available to EMODnet Chemistry.

Finally, the potential use by Regional Sea Conventions (RSC's) of data derived from EMODnet for assessment and specifically MSFD purposes would be a key perspective in encouraging the provision of data into the EMODnet Chemistry system. This might motivate scientific data providers as their data are used and acknowledged for the MSFD process, while national monitoring agencies will be tasked by their governments to contribute on a structural basis. This will stimulate establishing dynamic updating processes by providers in cooperation with EMODnet leading to operational maintenance of the data provision. A comparable effect can be expected if the EU Commission (DG Env and EEA), which already

recognises EMODnet as an instrument for making marine observation data accessible for MSFD purposes, would provide clarity in how its existing infrastructures (EIONET, SEIS, INSPIRE) will/will not be utilised for the MSFD, its planned MSFD structure (WISE Marine) and how EMODnet can be used to its fullest effect by member states and RSC's.

Barriers - recommendations:

i) Ensure all data are defined by a usage licence;
ii) Ensure adequate metadata for describing data (independent of data access licence);
iii) Respect a data owners right to apply restrictions on data, however use positive examples of how many open datasets are within the system to encourage a change in attitude
iv) Implement DOI's on datasets in EMODnet Chemistry and communicate the benefits to data originators
v) Ensure data quality feedback is delivered to data providers
vi) Use EMODnet Chemistry to provide INSPIRE compliance
vii) Use micro-grants to enable digitisation of desktop data
viii) Official recognition by EEA and DG Env of the potential of EMODnet for MSFD and recommendations to Member States for adoption and population of data for MSFD purposes, also in context of RSCs (see previous bullet point)

(2) Challenges to rendering data interoperable and to producing contiguous data over a maritime basin

The main challenge to interoperability is ensuring all data from all regions are delivered according to the predefined standards, and with all attributes filled. Even with this standardisation, the question remains whether for contaminants it is feasible to have truly interoperable data when the variation in inter-regional concentrations, let alone intra-regional, make it very difficult to draw comparisons.

For EMODnet Chemistry one of the main challenges has been and is the management of the heterogeneity and complexity of parameters addressed. To illustrate the situation:

- 3 matrices (water, sediment, biota) for 14 groups of variables (such as fertilisers, heavy metals, polychlorinated biphenyls, and others) each having multiple parameters, measurement methods, laboratory methods, instruments used etc
- different data distributions in time and space;
- different organisations leading environmental and research data in the different countries;
- heterogeneous data policy.

To deal with this situation the SeaDataNet infrastructure has been adopted and adapted to make use of common standards; a common metadata model (using the INSPIRE compliant CDI – Common Data Index), common vocabularies and a common data format (SeaDataNet ODV ASCII format). Moreover common tools (such as MIKADO XML editor, NEMO data formater, ODV analysis and QA-QC software) are provided to data centres for preparing metadata and data files for their data collections and to populate these to the CDI Data Discovery and Access service infrastructure. The vocabularies are continuously updated lists of standardized terms and during the project many new terms have been added to existing vocabularies and additional vocabularies (such as L04 - Matrices, P36 - groups of variables, P35 - harmonised parameters and others) have been launched for even better capture of the chemistry domain and to anticipate the EMODnet Chemistry products and services. In addition, tools such as ODV and DIVA have been upgraded to include more functionality of particular use for chemistry. For instance, the ODV software makes use of the P35 vocabulary to harmonise multiple P01 parameter terms to unified P35 terms and using agreed units (P06) following conversion rules that are available by web service and regularly expanded. Also ODV during import merges the ODV files with their CDI metadata providing a metadata enriched ODV collection which makes it easier for the regional coordinators in EMODnet Chemistry to undertake their QA-QC at regional level. This also is very beneficial for users of the resulting harmonised validated and aggregated data collections. All these measures and standards contribute to establish interoperability between the data sets from different providers (>60 in EMODnet Chemistry) and also towards other types of data as gathered and made accessible through SeaDataNet - EMODnet for physical oceanography, bathymetry, geology, etc. and these contribute to overcome the large heterogeneity of the data at the basis by regional validation and transformation to a common framework.
However, at a practical level, the regional coordinators found several cases that the data provided to them in the standard format and encapsulated by the CDI as a homogenous means of describing a dataset, were in reality implemented differently by the data providers which gave issues when the data are drawn together for a regional product. For example, there were cases of discrepancies between the CDI-ID in the ODV file and in the CDI record, giving mismatches when merging for metadata enrichment. In practice these issues were identified and reported back by the regional coordinators and taken up by the data providers and the managers of the CDI service for correction as part of the QA-QC cycle. This way the basis collection is improved and made more consistent. However, it also made clear that not all data providers have the same understanding of the common standards. In general, partners have been trained in combination with SeaDataNet Training Workshops, but new staff are coming along and for EMODnet Chemistry very specific guidance applies in addition to general principles. When continuing EMODnet Chemistry it would therefore be wise to invest effort in ensuring updating of the guidance material, learning from the errors and differences in approach as identified, and to arrange another Training Workshop focusing in particular on how to handle chemistry data.

QA/QC information collected by the questionnaires (ex-ante controls) from partners should serve as a basis to propose an integration of EMODnet/SeaDataNet standards in order to include such information along with monitoring data (i.e. Use of Reference Material, Participation to Intercalibration Network,

Methodology used to assess uncertainty). The CDI would be the obvious place, where an extension of the metadata attributes within these to include more QA and QC information relevant to chemical assessment experts would be highly relevant, and also an encapsulated means to tie together the dataset discovery with the supporting quality information. However, it has been noted that some of the QA/QC information, such as a laboratories accreditation to run analysis on specific substances, can only happen at the detail parameter level. To do this the quality information would need to be included at a more detail level – within the datafile itself (ODV format). This implicates that it should be further analysed how quality information can be best integrated into the CDI – ODV model and also how quality information might be added to the search process which is at present primarily implemented by the CDI as a Discovery service. As part of SeaDataNet plans are made to extend the CDI discovery metadata object with use metadata, embedded in linked Sensor ML and Observation & Measurements objects (following OGC Sensor Web Enablement (SWE) standards). These should be supported by additional common vocabularies and upgraded tools for preparing and handling. These extensions will make it possible to include attributes about methods, calibration, etc. Such an extension of the CDI metadata will also have a repercussion, that data providers will be required to gather and provide more metadata which will not be easy in many cases, and the risk of errors / discrepancies might increase. In addition plans are made by SeaDataNet to migrate the CDI service to the cloud introducing options to expand searching from only at metadata level to also at data level. These planned upgrades have been included in the SeaDataCloud proposal that has been submitted to EU DG RTD in March 2016 with an expected decision around September – October 2016. If successful, it will have great benefits for EMODnet Chemistry. Although considerable efforts will be needed from data providers to update their existing CDI and ODV entries with extra attributes, such as the used methodologies and quality assurance. This could be part of the next phase of EMODnet Chemistry.

Related to the search interface, vocabularies still need refinement for expert intended use (P01 too detailed and P02 too aggregated). Very often, an expert works on a single substance regardless of analytical methods, species (for biota), sample technique or analytical instruments. At the moment, it is not so simple to extract all data for a single substance: P01 is a concatenation of substance and other analytical information, P02 is too much general. Such issues are possible to overcome with future implementations to allow searches on components of the P01 concatenation and the right engagement from experts for a proper implementation of vocabularies.

In the process of aggregating data, normalization plays a crucial role. There should be specific tools to extract or show data in a proper way to support expert discussion on normalization. Although QA recommendations and guidelines are in place for normalization[7], there is still a lot of variation between regions on how these methods are applied, and even between institutes within the same region. Generally, OSPAR and HELCOM follow well described guidelines, whereas in the Mediterranean and Black Sea the practice is not so well established regionally. In general, for monitoring data it should be

[7] EMODnet Chemistry QA and QC basic guidelines, 2010 http://www.emodnet-chemistry.eu/QC_Guidelines_EMD-Chemical_version1.2_doi.pdf

expected that normalisation can be applied and therefore in theory could be reported, however the reporting of this to EMODnet is far from complete.

During the lifetime of the phase II project, via the interaction with RSC's, it became clear that the lineage of data is an important factor when making the first filter of data to be used in an assessment. Generally, RSC's use the 'monitoring programme' and 'monitoring purpose' to define this. In principal for EMODnet this boils down to distinguishing between data collected as a part of a monitoring programme, and data collected through a research project or one off exercise. The current metadata setup in EMODnet/SeaDataNet does not fully support this and a survey was undertaken at the data publisher level to determine if this information could be easily gathered and applied to the EMODnet Chemistry data collection. The survey demonstrated that this was not so easy to disentangle, especially as many publishers are not the data owner and they do not have all of the information on the purpose of the dataset data collection. Therefore to do this labelling properly would mean adding the field(s) to the CDI and then undertaking an exercise for each data publisher to review all of their data in EMODnet Chemistry and apply this information in liaison with the data owners. This activity should be included in the plan for Phase III of EMODnet Chemistry.

Relating to the data products, although a standard and defined data product is preferable, this also restricts the user as they have no ability to 'tune' the end product on the fly. The data are prepared according to a prescribed set of criteria, and they are defined by the vocabularies that the data product uses. There are some expert users that would prefer a more flexible visualization that keep some of the decisions about how to merge/standardise data at the viewing level; this would avoid arbitrary decisions on groupings/QC criteria that the user might not agree with. This aspect needs further consideration for Phase III of EMODnet Chemistry.
Recognising that there are many layers of quality control and assurance, particularly for hazardous substances, creates a challenge for EMODnet Chemistry. The approach could be to have different 'layers' of products according to the different quality/aggregation criteria. For example, the top layer product could be a simple map visualization of different species for each substance and their data richness. Whereas the bottom layer could be a regional product of the normalized concentrations of a particular substance for the accepted indicator species/tissue matrix. However, this creates another issue in moving from specific product outputs to more generic products that potentially please no particular audience. The DIVA software is used to produce interpolated maps of specific chemical substances over maritime basins using the earlier produced harmonised and aggregated regional data collections as input. This can only be applied if there is a sufficient coverage in time and space for a specific parameter and region. In the case of contaminants this was not possible as contaminants are mostly collected at fixed locations in the coastal zones as timeseries. For those no DIVA maps are provided but plots of timeseries and profiles. DIVA works with a variational inverse method to derive a continuous field close to the observations and "smooth" enough. It works internally on a finite element mesh which decouples basins based on topography, can take ocean currents into account, can detect trends in the data, detect and remove outliers and provides a consistent error variance estimation. DIVA is a powerful instrument and it gives major benefits above standard interpolations. As part of the SeaDataNet plans for SeaDataCloud it is considered to make DIVA online available in the cloud for users to produce their own

products, using pools of retrieved data (including their own data). This will have benefits for the regional coordinators and it will also allow specific users to make their own products including error indications.

Interoperable and contiguous data - recommendations:

i) Update the guidance material on creating CDI's and related ODV files for chemistry data
ii) Organise a training workshop for data providers to refresh existing and establish new understanding of guidance and tools, and to emphasise how to prevent inconsistencies as observed during the integration and validation process
iii) Explore extending the CDI metadata object with SWE objects to include use metadata
iv) Explore the extension of the search capability to include the QC and QA information and going to the cloud for searching on metadata and data
v) Include labelling of monitoring/research derivation in CDI and undertake revision of entire back catalogue of chemical data
vi) Refine the vocabularies to address even better the needs of a chemical expert
vii) Explore the possibility of tiered products and introducing DIVA in the cloud for user defined products

(3) Fitness for purpose for measuring ecosystem health

According to the Marine Strategy Framework Directive, Good Environmental Status (GES), which can be considered as a measure of marine ecosystem health, is assessed through 11 descriptors and a large number of related indicators. EMODnet Chemistry manages data related to Descriptors 5 (Eutrophication), 8 (Contaminants) and 9 (Contaminants in seafood) and provides visualization products and tools useful to assess GES at regional and sub-regional level according to these descriptors. EMODnet products are particularly fit for assessing Eutrophication issues through the availability of horizontal maps of nutrient (Indicator 5.1.1 Nutrient concentration in the water column), chlorophyll (Indicator 5.2.1 Chlorophyll concentration in the water column) and of dissolved oxygen concentration (Indicator 5.3.2 Dissolved oxygen).

Environmental Quality Standards (EQS) stemming from the EU Water Framework Directive (WFD), national directives, and proposed in some of the RSC targets for their regional assessments relate the relative values of a particular substance/indicator in the environment to the acceptable level. These EQS's, or targets, are currently not available within EMODnet. In order to address ecosystem health it would be critical to have these values in place. It would provide context on how the different EQS's relate

to the regional products, but it would need to be pragmatic and informative (still allowing the largest pool of data to be considered).

Ecosystem health - recommendations:

I. Include/link EQS values as part of the data portal and related specifically to the data products
II. Close cooperation with RSCs to establish links from EMODnet to RSC systems and to tune EMODnet products and services for complimentary use in assessments for MSFD

(4) Priorities and effort required for improving the accuracy, precision and coverage of the data

Quality assurance, how data are collected and prepared prior to transmission, has already been highlighted, where the institutes participating in EMODnet Chemistry were canvassed for their compliance to the ISO Schema 17025:2005, which is referred to in the Water Framework guidance and some RSC's monitoring manuals. Here it was concluded that this information should form part of the 'standard' metadata for data outputs in EMODnet Chemistry.

Quality control, by which we mean the checks we apply after the data have been delivered to the system has proven more challenging to determine a set of standard protocols that can be applied. Generally, checks are made on acceptable ranges, geographic position, spikes/outliers, missing values etc. Figure 32 displays the type of checks that institutes are regularly performing on data, there is a much greater proportion that perform checks on the water column data compared to biota or sediment. This is partially due to the long tradition in data centres in dealing with the 'classic' parameters such as Chlorophyll and nutrients in the water column, where there are many well established guidelines that can be applied generically. For biota and sediment, where sampling is generally for contaminants and biological effects of contaminants, there are fewer standards established and where these standards exist they are only applicable to a particular region, sub-region, species or substance within a specific tissue type. Therefore, it is more challenging to automate such procedures and also to make generalisations.

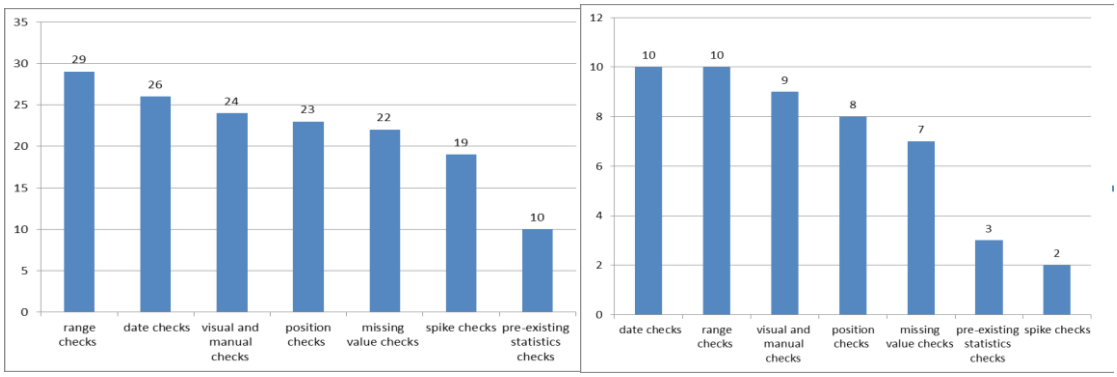


Figure 32. No of institutes responding; type of check on water column matrix (left graph); type of check on biota matrix (right graph)

EMODnet Chemistry has been considering and discussing this over the course of phase II, and there is such heterogeneity in the observations and the acceptable values, that it is not possible to make a system wide range check for hazardous substances. To even do this at a regional scale is very doubtful, as there is still a lot of natural variation which is difficult to make a rule for. The regional product leads undertake a great deal of QC when preparing the regional datasets, it would be an advantage to find ways to ease their burden to help process the datasets. EMODnet Chemistry must therefore seek out the pragmatic solutions, and in year 3 of the project there was a discussion with ICES that offered a way forward.

For the contaminants data, ICES perform a range check comparing against the values already reported in the database. If a reported value is outside ± 2 times standard deviation from the average value in the database (same contaminant, matrix and basis of determination) then they will be given a warning [8] when screening the dataset in the ICES online data screening utility. The check is only performed if there are 50 or more measurements to compare with in the database. As noted, screening for outliers for contaminants is tricky, concentrations may be highly variable even over smaller distances. Also concentrations are highly dependent on matrix (eg. liver in a fish) or species measured. The intention is to identify typical calculation errors resulting in factors of difference (10*, 1000*), while avoiding creating too many warnings/errors so that it gets unmanageable. Our current setup could be improved and we are this year looking into ways to develop a facility to examine the whole database and time series to identify outliers. This should be a tool for the national contacts / data submitters to address national data issues before assessments. This work is supported by OSPAR, but we expect that some of the developments will have more general use.

[8] Warnings are not critical; the data submitter can choose to override these if they believe the measurement value to be correct

This approach was discussed and agreed at the final EMODnet Chemistry meeting as a practical way forward for the project to apply a reasonable QC on the data (within the regional buffers). This would be carried forward to be implemented in the next phase of EMODnet (if funded).

The Copernicus Marine Environmental Monitoring Service (CMEMS) runs large mathematical models for preparing and publishing hindcasts, nowcasts and forecasts for several Essential Ocean Variables for the global oceans and European seas. These products are made freely available through the CMEMS portal. The models are making use of in-situ data and satellite data. As part of the SeaDataCloud project it is planned to work together with CMEMS to explore opportunities for products based upon DIVA in combination with CMEMS basis products. This could also be considered for Phase III of EMODnet Chemistry, integrating for example current patterns and river inflows into the DIVA modelling. Also this will give opportunities for intercalibration.

As regards data coverage, pharmaceuticals data are missing. This is due to the collection for these types of data occurring mainly within specific research projects and studies that may be in the private sector, or outside of the marine domain. There are many studies regarding such substances mainly in freshwater (WFD) and near point of discharge for Urban Waste Water Treatment Plants. The priority for data collection should be based on the watch list defined by Commission Decision 2015/495 (20th March 2015) and for marine waters a survey of projects/research studies is needed in order to target the relevant projects, possibly in liaison with the newly started EMODnet ingestion project. For anti-foulants, the general consensus among the data centres was that these substances were not regularly monitored/included in regional monitoring and therefore the availability of data is relatively low compared to other chemical substances. The Black sea regional product lead would however check with the BSC to confirm that this was the case, as no data have been made available for anti-foulants in this region.

Radionuclides are also another scarce datatype in the EMODnet Chemistry collection, the main reason for this is that the data are restricted and often collected under privately funded studies i.e. for Environmental Impact Assessments. It has therefore proved quite difficult to provide the necessary resources/motivation to the data holders to mobilise these data. Once again, this type of data would be a relevant case for EMODnet Chemistry to join forces with EMODnet ingestion as the main barrier is probably a lack of resource/motivation from the holder of the data to prepare them for another wider use. So EMODnet chemistry and ingestion together could help develop means to ‘lift’ these data from IEA’s and into the public realm more readily.

Precision and coverage - recommendations:

i) Implement 'pragmatic' QC checks across regional data buffer according to ICES suggestion
ii) Gaps; for pharmaceutical data, build an inventory of freshwater and urban waste water studies concerning these data and via EMODnet ingestion target these projects with the necessary tools/support to encourage their provision
iii) Gaps; for radionuclides team up with EMODnet ingestion to help develop means to 'lift' these data from IEA's and into the public realm more readily.
iv) Explore cooperation with Copernicus for integrating CMEMS products in the DIVA modelling and for intercalibrations.

(5) Performance of the portal technology

In general, the portal itself has been subject to a number of improvements brought about by interaction with users from within EMODnet Chemistry (i.e. regional data product leads) and through the interaction and workshops aimed at the MSFD community (i.e. RSC's). However, EMODnet Chemistry reflect that there are still a number of opportunities and challenges to be addressed to make the portal more attractive to end-users.

EMODnet Chemistry has an extensive dashboard of monitoring statistics related to both the download manager and the institutes that are connected through this service. This has enabled a real-time monitoring of the service, and resulted in an almost neglible level of downtime for the service as a whole, and for all the institutes that provide data via the download manager and coupled CDI's. In addition, reports on the status of data requests are managed via the request status manager, where any issues in the non-response of data providers to requests can be monitored and resolved (See Fig. 33).

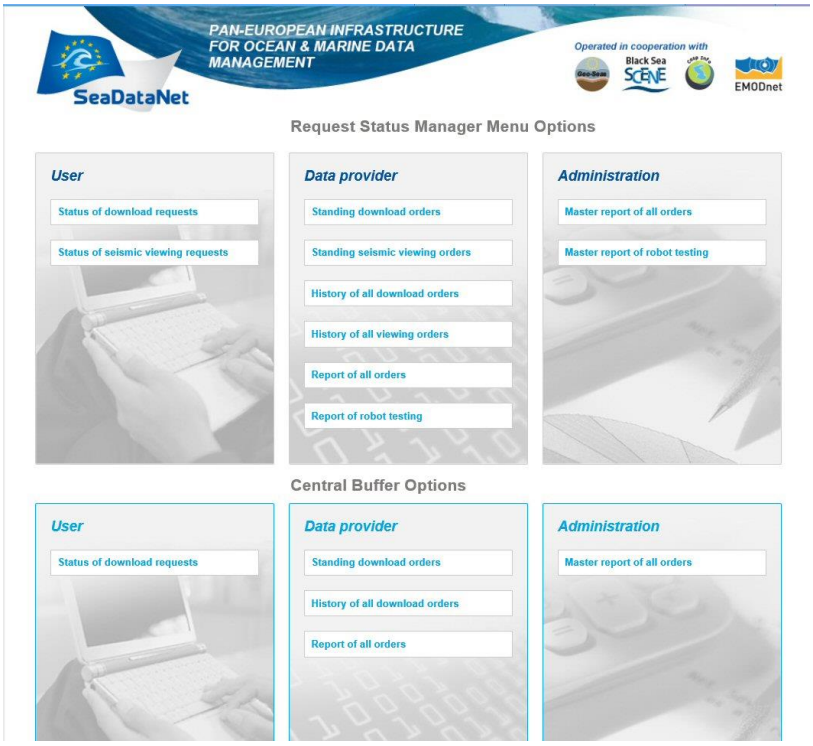


Figure 33. Request Status Management Dashboard

The CDI Data Discovery and Access service is making use of the ISO19115 data model and its ISO19139 XML Schema implementation. The CDI has been defined by SeaDataNet and in the SeaDataNet 2 project a lot of efforts has been undertaken to make the CDI fully INSPIRE compliant and also to include the common vocabularies as part of INSPIRE. This work was undertaken with contributions of experts that are also fully engaged in the ISO, OGC and INSPIRE committees. However lately JRC has upgraded its INSPIRE Validator service and it no longer supports Community Profiles such as SeaDataNet CDI. Therefore, quite some communication has taken place with DG Env (Directorate responsible for INSPIRE) and the JRC INSPIRE implementation team to correct the INSPIRE Validator service and to make it fit again for community profiles, as they otherwise will discourage uptake by communities of the INSPIRE principles. It has been consented that INSPIRE will keep on accepting community profiles, but unfortunately the correction of the Validator service still has not been done which gives EMODnet, not only Chemistry but also Bathymetry, issues in the field when promoting that the CDI is INSPIRE compliant and that providers, adopting CDI, are also serving INSPIRE. It is requested that EU DG MARE urges JRC to make the correction.

Improving the data discovery and access mechanisms has been a key focus of the 2nd phase of EMODnet Chemistry. Specifically, the overview of relevant data available to chemical experts has been tailored to the categories commonly used in relation to chemical assessment, such as MSFD purposes. Much of this work goes on behind the scenes, the refinement and linking of the vocabularies (for parameter discovery

and use) is a keystone of the EMODnet approach and a great deal of effort has been expended on this in phase 2 (See Fig. 34 and 35). The inclusion of matrices (Seawater, sediment and biota) was requested via the EMODnet-MSFD coordination group and the resultant EMODnet Chemistry workshop (Oostende, October 2015). The RSC's and their assessment experts saw this as a fundamental compartmentalisation of the data that would allow them to drill down into the thousands of datasets in a more logical way.

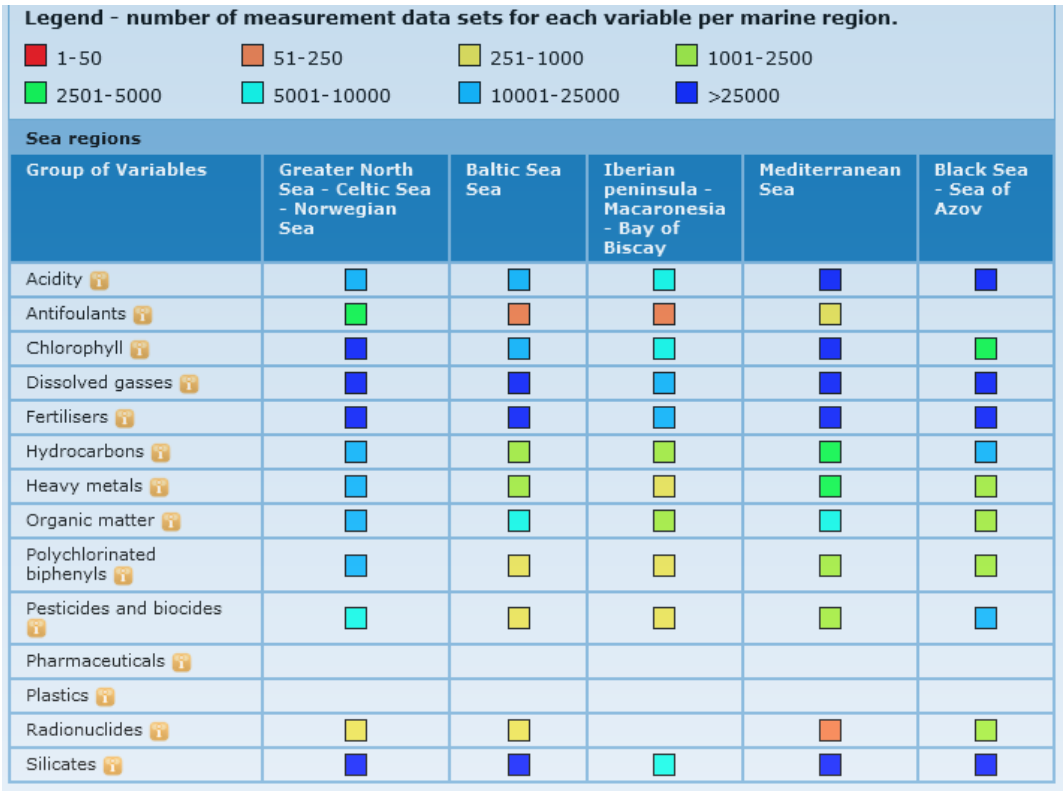


Figure 34. Overview of available data from EMODnet Chemistry web page

Overall, the portal has been responsive and adaptive to the needs of the users, but recognising that the interaction with a growing number of users is essential to the success of the portal, a number of innovative ideas have been identified that may improve this.

The increasing usage of application programming interfaces (APIs) within the research community could be harnessed against specific data collections within EMODnet Chemistry. In principal, services and API's could be tailored for specific communities – these communities could be thematically or technologically focussed i.e. R-scripting for marine statisticians. In this way, EMODnet Chemistry could foster engagement and targeted user feedback around such communities in a less formal way than with its current interactions via questionnaires, workshops and stakeholder engagement.

The logical extension of API's would be to reach out to a wider (and possibly younger) audience via hackathons. The fisheries community is already active in the area, see http://www.fishackathon.co/. This would be a novel way to use the EMODnet chemistry data, and would possibly open up for a new type of user, and some unexpected outcomes. Working via such a process may lead to real products and solution being built into EMODnet Chemistry, and as a positive side-effect increase the profile of EMODnet in this area.

Figure 35. Enhanced search capabilities in phase 2 interface

The H2020 BlueBridge project focuses on providing virtual research environments (VRE's) for its community of practice. Likewise, EMODnet Chemistry possibly in combination with SeaDataNet and its SeaDataCloud proposal, could explore the possibilities to provide such an infrastructure that would give 'super-users' access to a virtual toolbox of data, applications and processing power via the VRE cloud. The obvious test case would be to place the regional product production into such a VRE, ensuring a better control over the data input/output and processing, but also improving the time the processing takes. This may also be the 'playground' to test and share concepts of products with the RSC's and their experts. See also the earlier sections on SeaDataCloud plans.

By its nature, EMODnet Chemistry is a portal aimed at experts rather than the average EU citizen. However the general outreach and impact of the portal could be improved by linking to university communities i.e. including in curricula for undergraduate and masters students and thus educating the coming generation of marine researchers/managers on the availability, use of, and standards associated with chemical marine data. Specifically, the use of DIVA as a product generation tool could be easily applied to a masters course in a marine disclipline.

There is a great potential yet to be realised between the EMODnet portals, and the other portals arising from the latest H2020 and other EU funding mechanisms. The ability to create combined products using the thematic portal products is recognised as an area where with some effort there could be a number of useful standard data layers produced. Already the EMODnet portals share data layers via OGC services, but the real value add would be to work on joint data products that brought together the different thematic expertise to answer questions. A link-up like this is already happening between EMODnet Biology and Habitats, and Biology would also be a logical partner to link some of the chemistry products to (i.e. contaminants in biota linking to distributional ranges of species etc.).

Portal performance - recommendations:

i) Ensure adequate time/priority given to the 'backroom' operations such as vocabulary governance;
ii) Build API's, and target hackathon events to increase engagement
iii) Use of Virtual Research Environments/Clouds to improve data product production cycle
iv) Build links to Universities to include elements of marine chemistry data management and product generation via EMODnet Chemistry

6. Analysis of sustainability

In the following, a set of recommendations describing what would be necessary for the overall EMODnet to remain as a sustained infrastructure are provided, taking into consideration the items indicated in point 2.5.15 of the call for tenders MARE/2012/10.

Sustaining EMODnet as an infrastructure

The EMODnet approach with thematic portals for specific disciplines and communities, a Central EMDnet portal as navigator and high level shop-window for EMODnet thematic portals and their products, and concertation meetings between EMODnet lots is considered as very useful and effective. This way many potential players from a given discipline or theme can be engaged for their own specialism and interest, while the interoperability and cohesion between the thematic portals is achieved by using common standards from OGC for viewing services (WMS, WFS), SeadataNet for data discovery and access services and semantic interoperability, and other standards such as applied by EurOBIS for EMODnet Biology. As part of the SeaDataNet 2 project the SeaDataNet standards have been reviewed and upgraded to make them also fit for handling biological data and as part of EMODnet Biology an interoperability scheme with SeaDataNet API has been established for sharing biological data in EMODnet Biology.

As already indicated in the sections above there are several ideas and plans for improving the common standards and services of SeaDataNet as part of the submitted SeaDataCloud proposal, such as 'going to the cloud' which will greatly benefit the EMODnet portals that are using the SeaDataNet infrastructure at their basis, such as Chemistry, Physics and Bathymetry. As part of the next phase of EMODnet Chemistry these upgrades and improvements must be adopted and adapted for specific use in EMODnet Chemistry, as this domain has specific requirements and constraints as indicated above.

The EMODnet projects must learn from the previous phase and upgrade where needed to come closer to the needs and wishes of users. This will also encourage more data providers to come forward for data sharing and participating in the process of making complete overviews and homogeneous data products. Also this will give wider visibility at the policy and management levels both at EU and Member States that should seek integration of EMODnet output and services in management and policy processes and that will decide upon its future sustained funding. In parallel further RTD work will and must continue on standards and protocols that can be applied as basis for the EMODnet portals. A lot of the future options for the next phase of EMODnet Chemistry will depend on whether the SeaDataCloud will be successfully evaluated by EU DG RTD in September – October 2016. Otherwise only part of these ideas might be undertaken in the next phase of EMODnet Chemistry due to budget limitations but also due to the fact that SeaDataNet is a larger network than EMODnet Chemistry and the plans are fundamental for all connected nodes.

The model for governance by actors in the system

For the longer term a sustained EMODnet operation must be achieved in a cooperation between organisations acquiring and managing data, with structured funding from Member States and EU. In practice EU will fund the tip of the iceberg while most funding for the base of the iceberg will be done by the Member States. This will cover both government organisations as well as research institutions. In this model there should also be roles and contributions from the private sector such as the offshore industry, the windfarm industry and others. The governance model should be flexible enough to cope with the different sectors and their interests. This should be subject of further analysis within the scope of the overall EMODnet development process. Also the relation with EU Directives should be further emphasised, such as the potential of EMODnet Chemistry as structural contributor for the MSFD implementation. Official acknowledgement of this by EU DG Env and EEA would heighten the profile of EMODnet, in particular for Chemistry, Biology and Seabed Habitats, and would demand from Member States to consider contributing to EMODnet as a national structured task for which it has to guarantee a specific performance and operational availability. On the other hand EMODnet will support other societal activities such as e.g. research for which less stringent tasks and guarantees might be posed.

Availability of standard procedures facilitating data flow

The EMODnet Chemistry approach is based upon the SeaDataNet philosophy and standards as explained already in depth in the sections above. The data products are made available via OGC based viewing services, which support interoperability and exchange of the mapping layers to other services. Data providers understand and accept the principles. Standard tools and procedures available from SeaDataNet, which have already been well validated and used, make easier all the activities.

7. User Feedback

During the three years of EMODnet Chemistry, feedback from users were collected mainly through:

- The **thematic portal evaluation** with feedback and recommendations from the Secretariat user-survey started by EMODnet Secretariat in March 2014 and updated in October 2014;

- Input from **EMODnet/MSFD coordination group** meetings;

- Input from **partners** involved in technical working groups like TG DATA, WG DIKE;

- Outputs from **WP3 and WP5** (see Description of the work done);

- **Two users surveys** undertaken by the Chemistry lot consortium focused on having an active communication with users and stakeholders to obtain feedback that were presented and discussed at the steering committees to drive the development of the infrastructure.

In detail, SeaDataNet2 and EMODnet Chemistry Lot decided to join their efforts to set up and circulate a first joint survey circulated between 21/10/2014 and 20/01/2015.

The invited people were selected from the SeaDataNet2 user panel plus a list of participants interested in the Chemistry Lot field of activities. The contacted people were selected from groups with different expertise like: scientific community, policy makers, industry, education, data mangers outside Europe, operational oceanography. A group of 66 people was invited to the joint survey to provide their feedback. The result obtained at the end was of 20 responses (33% of the invited group).

The Joint Survey SeaDataNet2 EMODnet Chemistry 2 was made of 7 topics and 33 questions that have been circulated using the Google form service. The questionnaire was built with one page for each topic, was not necessary to fill all the questions to complete the survey and there were questions with multiple choice and questions with free text.

The invited people were free to provide their personal details in the first page of the survey and 16 of them did this.

Following the summary of the results divided per topic:

Registration

85% (17/17 persons, 3 didn't answer) said that it is quick and easy enough to use. However, from the registration management perspective, one NODC commented that allowing some fields to be non-

mandatory at registration provide insufficient information for the NODC to assign the appropriate role to newly registered users.

Data Discovery and Access

85% (17/20) were able to find the data that met their search criteria, and 85% (17/19) think that metadata are sufficient to describe the data available, which is very positive. 75% of the panelists (15/20) use the Extended Search. Comments highlighted that the metadata are good but the interface search engine is slow, the very long list of parameters and sea area in the small selection window should be more friendly to consult i.e. someone is asking to locate the Lat/Lon in the search section also and not (or not only) in the map section. One respondent had a problem with filtering of the search meta-data, and one respondent stated that the metadata was not extensive enough and required a search against the actual data.

Data Download

45% (9/20) are downloading data often from the SDN2/EMODnet Chemistry infrastructure, 40% (8/20) downloaded once and 15% (3/20) have never downloaded. 9 of the 11 people who replied once or never responded to the follow-on question on the main reason why they had not downloaded data. The main reason stated, 25% (5/9) of responses, was they were just interested in browsing metadata.

50% of the respondents (10/19) are usually requesting from 0 to 500 CDIs, 20% (4/19) more than 10 000 and the 15% (3/19) from 5000-10 000 CDIs.

Overall it appears there are 2 volumes of uses, the lower volumes (0-500) and the high volumes (5000+).The comments highlighted that people dealing with lower volumes had no problems to download the selected data. At the higher volume end, some of the people would like to have an option to download more than 10000 data files at a time and a button for the “choose all" option. When dealing with queries with huge amount of CDIs a lot of steps have to be done to order the selected data and they would like to have a single file per query to deal with.

Post Processing

Most of the people (65%- 13/20) consider the ODV format as the most useful for their purpose; 20% (4/20) think this of NetCDF format. 75% (15/20) are using ODV software to handle the downloaded data. The different software used to handle the downloaded data is: ODV, Excel, Matlab, and DIVA.

The main uses of the downloaded data are: preparing data for national/regional projects (6/19), preparing data for own research (5/19) and checking own data (4/19).

Product discovery and viewing

65% of the people (13/20) who replied had never used the product discovery service based on Sextant; 25% (5/20) had used it once, and only 10% (2/20) often. The most of the people considered this product catalogue interface quick and easy to use and found the products they were interested in.

Product viewing service

A large proportion of the people who replied never used the product viewing service (40% - 8/18). 30 % (6/18) are using it often and 20% (4/18) once. Two didn't answer.

For those using it, they consider it quick and easy enough to use. Some comments highlighted that the labelling is insufficient, and this is confusing the user. Another user found it very good for the functionalities of vertical sections.

Data use, restriction and citation

70% (14/15, 5 didn't answer) replied that data of their interest are mainly unrestricted. The comments on the average negotiation time were that someone never tried negotiation and someone who tried considered it not too long. Other people have a specific project agreement so they don't need to wait for the negotiation.

Regarding citation of data, 65% (13/16, 4 didn't answer) are citing the originators and 70% (14/18, 2 didn't answer) considered the information provided by SDN2/EMODnet system adequate for data citation.

Only 30% (6/16, 4 didn't answer) people are using/referring to permanent digital identifiers for data citation, and 75 %(15/16, 4 didn't answer) aren't using permanent identifiers for scientists. On the comments someone highlighted that until very recently, there was not available a reference for the data extracted and used from SeaDataNet.

A second survey was specifically requested by the Chemistry Lot partnership after the SeaDataNet2 and EMODnet Chemistry Lot joint survey. An updated and revised survey was circulated to all the Chemistry Lot partners encouraging them to share it with their colleagues. Due to the kind of dissemination we are not able to evaluate the total number of invited persons. The survey was made of 7 topics and 31 questions that have been circulated using the Google form service between 18/11/2015 and the end of January 2016. The questionnaire was built with the same principles of the previous one.

Following the summary of the results divided per topic:

The invited people were free to provide their personal details in the first page of the survey and 29 of them did this.

Data Discovery (Data Access Service)

54% (25/46) are using the extended search interface, 67% (31/46) where able to locate data of their interest using the interfaces while 70% (32/46) think that metadata are sufficient to provide a clear idea of the data content.

Comments received were that there are small window for long lists like for Sea Areas selection, drop down menus are not easy to use. For example, for the selection of the sea regions (ex: the North Sea) it would be easier to have a tree with sub-sections that are hidden by default rather than having the complete listing and find your name in all the lines. It would be nice to have a ""waiting/progress bar"" to know that your query is under loading. Someone would like to have information on analyses methods already at this level having information that usually are in P01 parameters. Someone think that the data access is flexible, but restricted data is a nuisance

Data Download

37% (17/46) download often data from Chemistry Lot, 15% (7/46) once and 37% (17/46) never. Reasons for which they didn't download data are mainly that they were only interested in browsing metadata or didn't find the relevant data.

About the volume of data downloaded seems to that 59% (27/46) are downloading from 0-500 CDIs/stations, 7% (3/46) from 500-100 and there is a big percentage that didn't replied 28% (13/46). Most of the people that replied were able to select and download select and download data of their interest (5/46) but sometimes it take some time to understand how the system works.

Comments received were that most of the people who replied were able to easily select and download data but not always the system is considered easy and intuitive. For example someone said that the position of the update button could be next the animate button of the diva maps you are visualizing to be more visible.

Post Processing

Most of the people (59%- 27/46) consider the ODV format as the most useful for their purpose; 7% (3/46) think this of NetCDF format.

61% (28/46) are using ODV software to handle the downloaded data. The different software used to handle the downloaded data is: ODV, Excel, Matlab, Octave, R and Notepad.

The main uses of the downloaded data are: checking own data (16/46), preparing data for own research (7/46) and preparing data for national/regional projects (4/46).

Product Discovery Service

48% of the people (22/46) who replied had never used the product discovery service based on Sextant; 20% (9/46) used it once and 15% (7/46) often. In the questionnaire a link to the service was provided in order to let the people to test it.

The most of the people considered this product catalogue interface quick (21/46) and easy (22/46) to use and found the products they were interested in (20/46).

Comments received were: some links are not working (Eg. Download (link) and Web Map Service (WMS) for several products (Black Sea for ex). Maybe a short user guide is necessary and going from EMODNET Chemistry portal /Data products/ Discovery service directly to the catalogue can be a bit confusing for a new user. Information on format of geographical coordinates would be helpful. Someone suggest that grouping options might be wider, for instance as DIOP and DIN for dissolved nutrients.

Product Download

35% of the people (16/46) who replied had never used the product viewing and download service based on Ocean Browser; 33% (15/46) had used it once, and 17% (8/46) often.

In the questionnaire a link to the service was provided in order to let the people to test it. For those using it, they consider it quick and easy enough to use (21/46).

Some comments highlighted that took quite a lot of time to understand the content and the meaning of the products. A small "dictionary" of terms used and meaning of fields available may help. A user guide is considered necessary. It is already present under the “help” button bringing at the following link but maybe should be better visible (http://modb.oce.ulg.ac.be/mediawiki/index.php/OceanBrowser).

Data use, restriction and citation

Approximatively half of the people who replied used Chemistry Lot data for their work. 41% (19/46) replied that data of their interest are mainly unrestricted, 9% (4/46) replied that more than 30% of the data their interest are restricted, 9% (4/46) replied that more than 50% of the data of their interest are restricted, 5% (2/46) replied that more than 80% of the data of their interest are restricted and 17/46 didn’t reply.

About the average negotiation time people replied that it can take from 1 hour until 2 weeks. 54% (25/46) are usually citing originators while 52% (24/46) considered the information provided Chemistry Lo system adequate for data citation.

Most of the people are not using DOIs for data citation (37% -17/46, 17/46 didn't reply). 46% (21/46) aren't using permanent identifiers (like ORCID, FOAF...) for scientist.

Main comments were that may be helpful to provide a specific "Cite data as" to drive a proper citation. EMODnet chemistry, like SeaDataNet and others groups can provide a ready reference for data citation

Following the results of the two surveys seems that the services provided are in general appreciated. The users are usually accessing data by the "extended search interface". Following the request several improvements has been done like: improvement of performances, the matrix selection was added to the extended search interface, search chemicals by region interface (http://www.EMODnet-chemistry.eu/index.html). About the services for products (catalogue, viewing and downloading) seems that they are considered quick and easy to use but there was the need to improve the visibility, to improve the labelling and to provide better guidelines. The labelling upgrade was already faced and video tutorials have been provided in the web portal (http://www.EMODnet-chemistry.eu/videotutorial.html).

From the other side there is still the need to work on some points such as: the user-friendliness of the long lists of selections, improvements on the categories of selection criteria, the labelling and visibility of the product catalogue viewing services and the provision of a "Cite data as" to drive a proper citation.

Furthermore, feedback and contact buttons and links were added to the Chemistry portal, but these weren't used a lot by the users (Figure 39).

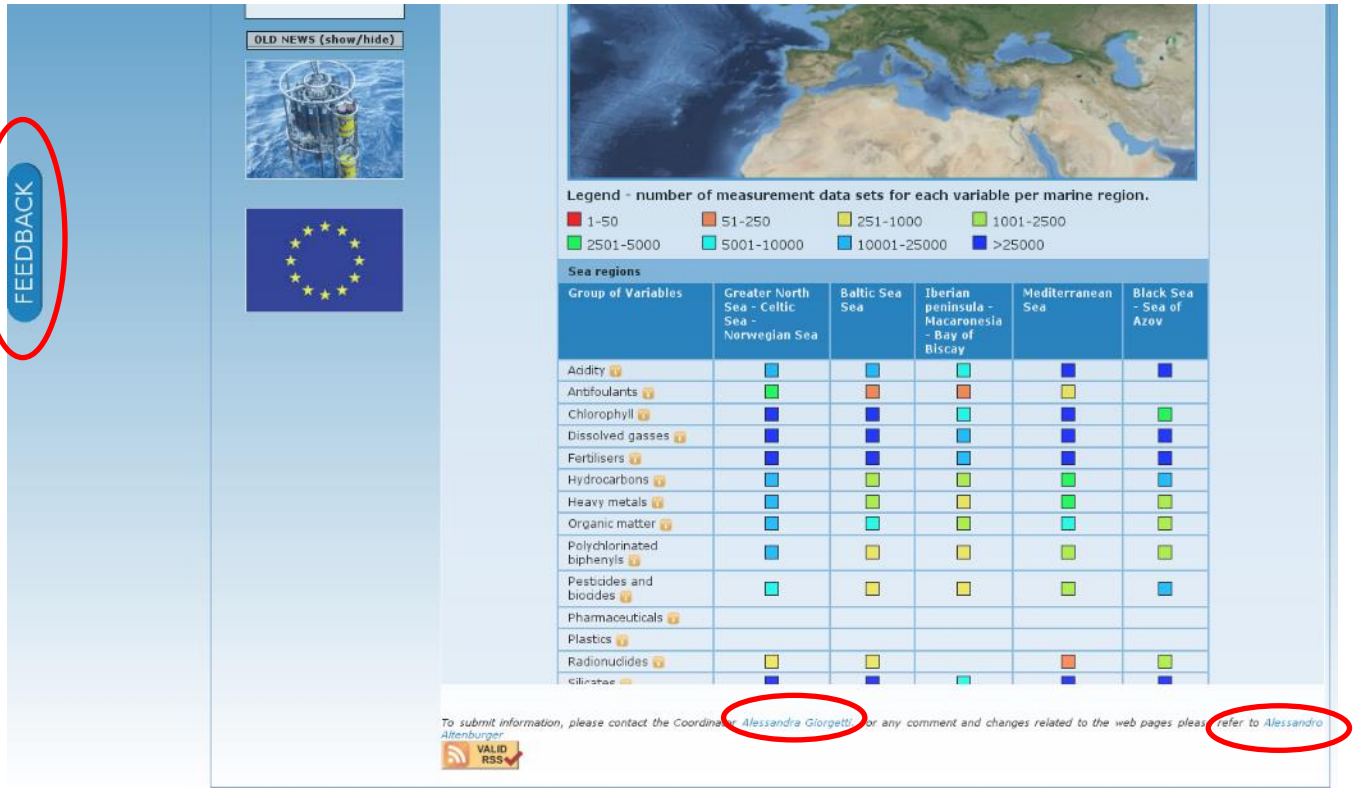


Figure 39. Feedback and contact tools.

8. Allocation of project resources

Estimate of the resource usage (as **percentage** of total project budget) spent during the whole project on the following groups of activities: (i) collecting, harmonising and giving access to data; (ii) creating data products; (iii) developing and maintaining IT; (iv) management and reporting; and (v) answering questions and other communication activities, corresponding to the indicated Work Packages:

(i) collecting, harmonising and giving access to data (WP1: Data collection and metadata compilation);
(ii) (ii) creating data products (WP2: Data Products generation in sea regions);
(iii) (iii) developing and maintaining IT (WP4: Portal development and operation);
(iv) (iv) management and reporting (WP0: Project Management);
(v) (v) answering questions and other communication activities (which includes also activities done within WP5: Analysis and Recommendations);
(vi) Other (WP3: QA/QC - Validation - MSFD interaction).

Partner, Country	(i) collecting, harmonising and giving access to data	(ii) creating data products	(iii) developing and maintaining IT	(iv) management and reporting	(v) answering questions and other communication activities	other
OGS, IT	5.8	9.6	9.6	59.5	9.8	5.8
MARIS, NL	27.8	0	40.7	20.7	5.2	5.6
NERC-BODC, UK	27.3	18.2	18.2	0	18.2	18.2
IFREMER, FR	52.5	24.2	21.2	0	2.0	0
BSH-DOD, DE	75.0	25.0	0	0	0	0
IMR, NO	62.5	25.0	0	0	12.5	0
AU-DCE, DK	40.0	28.6	14.3	0	7.7	9.4
VLIZ, BE	60.0	40.0	0	0	0	0
RBINS-MUMM, BE	33.3	22.2	0	0	11.1	33.3
NIOZ / RWS, NL	50.0	33.3	0	0	0	16.7

SMHI, SE	57.1	35.7	0	0	2.0	5.1
HCMR, GR	50.0	35.7	0	0	9.1	5.1
IO-BAS, BG	60.0	40.0	0	0	0	0
NIMRD, RO	45.5	45.5	0	0	2.0	7.1
ICES, INT	27.3	0	0	0	45.5	27.3
AWI, DE	0	18.2	54.5	0	9.1	18.2
ULg, BE	0	20.0	66.7	0	6.7	6.7
IEO, ES	60.0	20.0	0	0	10.0	10.0
ISPRA, IT	38.5	15.4	0	0	7.7	38.5
OC-UCY, CY	37.5	25.0	0	0	0	37.5
Deltares, NL	0	33.3	66.7	0	0	0
CNR, IT	66.7	33.3	0	0	0	0
IHPT, PT	60.0	40.0	0	0	0	0
IOF, HR	50.0	50.0	0	0	0	0
IMGW, PL	50.0	50.0	0	0	0	0
LHEI, LV	50.0	50.0	0	0	0	0
UniHB, DE	100.0	0	0	0	0	0
MSI, EE	50.0	50.0	0	0	0	0
FMI, FI	40.0	40.0	0	0	0	20.0
IMBK, MN	50.0	50.0	0	0	0	0
NIB, SI	50.0	50.0	0	0	0	0
IOLR, IL	50.0	50.0	0	0	0	0
SYKE, FI	33.3	33.3	0	0	0	33.3
RIHMI-WDC, RU	65.7	33.3	0	0	1.0	0
SIO-RAS, RU	60.0	40.0	0	0	0	0

MHI, UA	40.0	40.0	0	0	0	20.0
TSU-DNA, GE	49.0	50.0	0	0	1.0	0
EU-Consult, NL	100.0	0	0	0	0	0
UkrSCES, UA	50.0	33.3	0	0	0	16.7
SOI, RU	40.0	40.0	0	0	0	20.0
IU, TU	50.0	50.0	0	0	0	0
IBSS, UA	50.0	50.0	0	0	0	0
NEA, GE	50.0	50.0	0	0	0	0
UHI-MB, UA	50.0	50.0	0	0	0	0
IMS-METU, TU	50.0	33.3	0	0	1.0	15.7

9. Outreach and communication activities

All the relevant communication activities or products that we have developed/executed during this period are list up and the 5 most important ones are highlight in purple.

Place & Date	Media	Title	Short description and/or link to the activity
Copenhagen (Denmark), 4-5/07/2013	Short oral presentation	EMODnet Chemistry support to MSFD data reporting. Examples form IT and Black Sea	Presentation at TG DIKE and Marine Data and Observation Export Group (MODEG)
Varna (Bulgaria), 17-19/9/2013	International Congress	How can EMODnet engage in support to the marine environmental assessment	Participation at MARES2020, Varna, September 2013
Lucca (Italy), September 2013	International congress	Modular Information Content for Ocean Data Systems	Presentation at IMDIS Conference
Lucca (Italy), September 2013	International congress	A new API for accessing ODV data collections from C++ and Java	Presentation at IMDIS Conference
Lucca (Italy), September 2013	International congress	Variational data analysis for generating ocean climatologies (DIVA) and web-based distribution of data products (OceanBrowser)	Presentation at IMDIS Conference
Lucca (Italy), September 2013	Poster in IMDIS2013	Near real-time quality data from ships to land	Poster on quality assurance of marine data from automatic dataflow from the research vessel to the land based systems
Lucca (Italy), September 2013	International congress	On-line quality control service of MHI NASU	Poster at IMDIS Conference
Lucca (Italy), September 2013	International congress	Integration of oceanographic databases into the Geographic Information System (GIS) as support for Marine Spatial Planning. Case of Romanian Littoral	Presentation at IMDIS Conference
Lucca (Italy), September 2013	International congress	The Wadden Sea Long Term Ecosystem Research (WaLTER) project: Using the SeaDataNet infrastructure to provide access to integrated environmental and socio-economic data from the Dutch Wadden Sea	Poster at IMDIS Conference
Istanbul (Turkey) 3-4 December 2013	International Black Sea Club	EMODnet Chemistry Presentation	Introduction of EMODNET Chemistry project and EMODNET Chemical portal

January 2014	Journal: Geosci. Model Dev	divand-1.0: n-dimensional variational data analysis for ocean observations	Extension to higher dimensions for DIVA: http://dx.doi.org/10.5194/gmd-7-225-2014
Jan 22, 2014	Presentation slide; discussion	BALSAM work package 2	Discussing how BALSAM project could leverage the work of EMD Chem in relation to Baltic region
February 2014	Journal: Journal of Atmospheric & Oceanic Technology	Approximate and Efficient Methods to Assess Error Fields in Spatial Gridding with Data Interpolating Variational Analysis (DIVA)	New and more efficient methods for computing the error field in DIVA have been derived.
Honolulu (USA) February 2014	International congress	The GEOTRACES Intermediate Data Product	Presentation at AGU Ocean Sciences Meeting
March 4-5, 2014, Istanbul, Turkey.	Seminar to the data holder groups	"The importance of sharing the data to build the whole photograph"	The presentations on the data collection, data production and data quality management were made in the light of EMODnet Chemistry 2 project.
Ukrainian Scientific Centre of Ecology of the Sea Ministry of Ecology and Natural Resources of Ukraine, March 2014	Scientific Council meeting	"Data exchange and sharing" EMODnet Chemistry 2 Project according to EU approaches	UkrSES presented EMODnet Chemistry 2 project within the Scientific Council meeting for the development of the National Strategy for Data collection and exchange in Ukraine
Varna (Bulgaria), 01-02/04/2014	Meeting of Black sea Local and Regional Authorities (Bulgaria, Romania, Georgia)	EMODnet Chemistry Presentation	- To improve the governance of the seas, in particular through the Regional Sea Conventions and effective implementation of the Marine Strategy Framework Directive and other relevant EU environmental legislation;
Odessa (Ukraine) 15-16 April 2014	Black sea Municipalities network meeting	EMODnet Chemistry Presentation	Introduction of EMODNET Chemistry project and EMODNET Chemical portal
April 16 2014, Nantes, France	VALOR'IG days	Time series transmission to EMODnet with a SURVAL product	General information for French marine scientific community on the project
Copenhagen (Denmark), 29-30/04/2014	Short oral presentation	EMODnet Chemistry	Presentation at TG DATA, for presentation of Chemistry Lot for MSFD implementation and cooperation with Regional Sea Conventions
15. April 2014	3d Workshop, Program: "Monitoring and Observation System for an ongoing assessment of the Adriatic Sea"	Presentation of EMODNET project	One hour presentation of objectives and activities performed in the EMODNET Project with special attention on Chemistry Lot
29-30 April, 2014	Presentation slide	EMODnet Chem products workshop	Invititation to TGDATA participants for June workshop
Vienna, 27 April - 2 May 2014	European Geosciences Union General Assembly 2014	Data-Interpolating Variational Analysis (DIVA) software : recent	Presentation of DIVA: http://hdl.handle.net/2268/165681

		development and application	
Vienna, 27 April - 2 May 2014	EGU General Assembly	Using metadata attributes for choice a template of data visualization	http://meetingorganizer.copernicus.org/EGU2014/EGU2014-2543.pdf
Tirana (Albania) 27-28 May 2014	Adriatic-Danube-Black Sea multimodal platform	Introduction of EMODNET Chemistry project and EMODNET Chemical portal.	Protecting environment of South East European area.
May 27, Ankara, MFA, Turkey	2nd meeting of Turkey-EU Maritime Dialogue	Involvement in seabed habitat mapping and marine data networking (EMODNET)	Presentation of IMS-METU activities within the EUSeaMap and EMODNET-Chemistry projects.
June 10 2014, Brest, France	Sextant catalogue and service managers day	SeaDataNet and EMODNET in Sextant (T Loubrieu)	As a Sextant use case, the projects SeaDataNet and EMODNET are presented to the community of catalogue managers.
Las Palmas de Gran Canaria (Spain), 11-13/6/2014	IV Simposio Internacional de Ciencias del Mar.	Recovery and Homogeneization of marine chemical data from IEO systematic monitoring programs. Tel, E., García, M.J., de Armas, D., Bellas, J., Bode, A., Cabanas, J.M., García Martínez, M.C., León, V.M., Campillo, J.A., Rodríguez, M.C., Sánchez Leal, R., Vélez, P., Viñas, L.	Oral Presentation at IV-ISMS (*)
Las Palmas de Gran Canaria (Spain), 11-13/6/2014	XVII Seminario Ibérico de Química Marina	Phytoplankton and nutrient trends in different areas of the western Mediterranean Sea. Garcıa-Martınez, M.C., Moya, F. Vargas-Yanez, M. Lopez-Jurado,J.L. Serra, M. Tel, E.Balbın, R. Aparicio, A. Amengual, B.	Poster at XVII SIQUIMAR (*)
Las Palmas de Gran Canaria (Spain), 11-13/6/2014	XVII Seminario Ibérico de Química Marina	Carbon dioxide. Spatial and seasonal variability in the southwestern Spanish mediterranean	Oral Presentation. at XVII SIQUIMAR (*)
Las Palmas de Gran Canaria (Spain), 11-13/6/2014	IV Simposio Internacional de Ciencias del Mar.	European initiatives to disseminate the Geo-information of marine environment: EMODNET. Marine Knowledge 2020. IEO contributions	Oral Presentation at IV-ISMS (*)
Ministry of Sustainable Development and Tourism, Podgorica, 24 of June 2014	Work shop	"Institutional and legislative framework for integrated coastal zone management in Montenegro"	IBMK presented EMODnet Chemistry 2 project within the consulting meeting for the development of the National Strategy for Integrated Coastal Zone Management (NS ICZM) in Montenegro

August 5-8 2014, (Townsville, Australia)	Presentation	ODIP 3rd meeting	Project meeting
September,3 2014, Paris, France	ODV-DIVA meeting	Methodology for QA/QC and DIVA products	Contribution to the redaction of a methodology manual
9/9/2014 Brussels, DG MARE	Oral presentation	First MSFD - EMODnet Meeting	Aim of the meeting was to consider and discuss EMODnet (Chemistry 2) product development with relevance for MSFD and marine environmental monitoring and reporting.
September 19 2014, Beijing, China	18. World Congress of CIGR	Data Management and Data Sharing	30 minute presentation on activities regarding data management and data sharing at IMR. EMODnet presented as one main portal for data sharing.
October 6–8, 2014	Infrastructure of scientific informational resources and systems. The proceeding of 4 All Russian Symposium. Vol.1. Moscow. Computing center of RAS. pp.52-68.	E. Vyazilov and etc. Metadata – base for automatisation of information production development	It is presenting the questions of effective exploitation of system. They connected with union of information resources; mapping qualifiers; join of historical data; operational data flows and forecasts; calculation of new parameters; search improvement; use metadata attributes at data visualization; standardization of visualization templates of information resources; receiving of interactive production; monitoring of a hydrometeorological situation.
6-9 October	Rome, Italy	EurOcean2014	EMODnet@EurOCEAN2014 pre-event and participation to EurOcean conference.
5th -7 th of November 2014	Oral presentation	EMODnet MedSea Checkpoint plenary meeting	Share information, find synergies and how to contribute to their evaluation activity.
10th of November 2014	Oral presentation	Dedicated meeting with UNEP-MAP	The objective of the meeting was to introduce EMODnet Chemistry infrastructure and results, to find synergies and integration to connect the existing data infrastructures.
17th -20th of November 2014	Oral presentation	EastMed Symposium	The event was focused on the Eastern Mediterranean for fostering new networks and strengthening mutual collaboration.
December, 12, 2014,	Plenary session of UHI's Scientific Conceil	EMODnet Chemistry project: goals and preliminary results	Presentation on the idea and goals of the project and current results obtained by UHI-MB
15 December 2014	Meeting with Black Sea Commission Secretariate in Istanbul - Turkey	To seek adoption and cooperation of BSCS with EMODnet Chemistry	Meeting by MARIS on behalf of EMODnet
January 27 2015, Brest, France	EMODNET information day	EMODNET Chemistry II	General description of the WPs of the project and of the contribution of Ifremer to national partners
09-10 February 2015	Oral presentation		Varna, Bulgaria. EMODnet Chemistry was presented to government and stakeholder meeting.

11-12 February 2015	Oral presentation		Sofia, Bulgaria. EMODnet Chemistry was presented to Ministries and experts of Ministry of transport and marine administration, Ministry of environment and water, Agency of Fishing and Aquaculture, Ministry of Regional Development.
18-20 February 2015	Oral presentation		Tbilisi, Georgia. EMODnet Chemistry was presented to Vice ministries and experts of Ministry of transport, Marine administration, Ministry of environment and water, Agency of Fishing and Aquaculture, Ministry of Regional Development. Stakeholders. Black sea clusters.
23-25 February 2015	Oral presentation		Bucharest, Romania. EMODnet Chemistry was presented to Vice ministries and experts of Ministry of transport, Marine administration, Ministry of environment and water, Agency of Fishing and Aquaculture, Ministry of Regional Development. Stakeholders. Black sea clusters.
26 February 2015	Oral presentation		Constanta, Romania. EMODnet Chemistry was presented to Mayor, vice mayor of Constanta and Stakeholders. Black sea companies.
27 February 2015	Oral presentation		Ankara, Turkey. EMODnet Chemistry was presented to experts of KEY Ministries, stakeholders, private companies, NGOs.
27th of February 2015; Brussel, DG MARE	Oral presentation	2nd MSFD - EMODnet Meeting	Aim of the meeting was to consider and discuss EMODnet (Chemistry 2) product development with relevance for MSFD and marine environmental monitoring and reporting.
March 2-3, 2015, Istanbul, Turkey.	Seminar to the data holder groups	"The importance of Data Quality Control of the Shared Data Sets"	The presentations on the data collection, data production and data quality management were made in the light of EMODnet Chemistry 2 project.
03-05 March 2015	Oral presentation		Kiev, Ukraine. EMODnet Chemistry was presented to experts of KEY Ministries, stakeholders, private companies, NGOs
06 March 2015	Oral presentation		Odessa, Ukraine. EMODnet Chemistry was presented to local and regional Autorities and Stakeholders
09-12 March 2015	Oral presentation		Moskow, Russia. EMODnet Chemistry was presented to experts of KEY Ministries, stakeholders, private companies, NGOs
24.03.2015, Sofia, Bulgaria	conference	Stakeholder conference: Smart and Blue – new opportunities for the blue economy of the Black Sea	IO-BAS organize stand - brochures, leaflets, poster and other printed materials as well as a video/slideshow provided by EMODnet Secretariat
apr-15	European Geosciences Union General Assembly 2015	Web-based visualization of gridded dataset usings OceanBrowser	http://meetingorganizer.copernicus.org/EGU2015/EGU2015-5792.pdf

apr-15	European Geosciences Union General Assembly 2015	Reconstruction of the Gulf Stream since 1900 and correlation with the North Atlantic Oscillation	http://meetingorganizer.copernicus.org/EGU2015/EGU2015-2577-1.pdf
16-apr-15	EGU-2015	Marine Data Management within the EMODnet Chemistry project: data aggregation, quality control and products preparation	Oral presentation of data management activities within the project (http://meetingorganizer.copernicus.org/EGU2015/orals/17164)
20-23 April 2015	Oral presentation	4thWorkshop ODIP	Liverpool, Great Britain. EMODnet Chemistry activities related to the ODIP project
May 2015	Liège Colloquium 2015	Natural variability of the cold intermediate layer on the Romanian Black Sea shelf	Using and acknowledging EMODNET as data source
Kopaonik, Serbia, 2-4 June, 2015	Conference about water use and protection	Castelli, A. Mitric,M. and Kljajic, Z. "Management of the oceanographic data through the networking of European data centers"	Article in Conference Proceedings of the 44th Annual Conference of the Serbian Water Pollution Control Society "Water 2015".
June 2015	Brochure	EMODnet Chemistry Leaflet	http://www.EMODnet-chemistry.eu/EMODnet-Leaflet-2015.pdf
15 – 19 June 2015	10th Baltic Sea Science Congress.	THE EMODnet AND THE SEADATANET INFRASTRUCTURE: A CHALLENGE TOWARDS AN EUROPEAN MULTIDISCIPLINARY INTEROPERABILITY	Poster and leaflets at 10th BSSC Poster session.
EUROFLEET Course "On board course for students in marine sciences" R/V BIOS DVA, Adriatic Sea, (June 16-27, 2015)	Presentation	EMODnet Chemistry - part of EU Marine observation and data network	Presentation of EMODnet Chemistry project
30 June 2015	Meeting with JRC in Ispra - Italy	Tuning INSPIRE Marine Pilot – EMODnet	Meeting of EMODnet SC with INSPIRE team at JRC
03-06/05/2015	Conference	Liege Conference	Chemistry Lot presented
30/06-01/07/2015	Ispra, Italy	EMODnet/INSPIRE meeting	Presentation of EMODnet Lots to the Marine Pilot project
08/10/2015	Istanbul	31st BSC Regular Meeting	EMODnet Chemistry general presentation with focus on the Black Sea
October, 20, 2015, Ostende, Belgium	EMODnet Jamboree		

October, 21, 2015, Ostende, Belgium	Workshop	EMODnet Chemistry expert and stakeholder workshop	Workshop with the Steering Committee, technical partners and invited experts from Marine Conventions, other ongoing thematic projects and stakeholders
12/10/2015	JRC- Ispra	EMODnet-IPCheM team	Technical workshop for the launch of the collaboration between the Information Platform for Chemical Monitoring and EMODnet Portal for Chemistry
19/10/2015	Oostende	MODEG	23rd and Final Meeting of MODEG
25/11/2015	Conference	EMODnet Italian Information Day	EMODnet Information Day, organised by OGS with INGV, Cogea, ETT with the endorsement of ISPRA, the Italian Ministry of Environment, DG MARE
07-08/12/2015	Meeting +videoconference	INSPIRE workshop	INSPIRE workshop with the Marine Pilot experts to evaluate and progress in the compliance between INSPIRE and EMODnet Lots Services
01/04/2016	meeting	ActionMed meeting	Presentation of Chemistry Lot activities and last developements
01/04/2016	European Geosciences Union General Assembly 2016	Data-Interpolating Variational Analysis (DIVA) software : recent development and application	http://meetingorganizer.copernicus.org/EGU2016/EGU2016-6262.pdf
01/04/2016	European Geosciences Union General Assembly 2016	Analysis of ocean in situ observations and web-based visualization	http://meetingorganizer.copernicus.org/EGU2016/EGU2016-7118.pdf
01/04/2016	European Geosciences Union General Assembly 2016	Eutrophication and contaminant data management for EU marine policies: the EMODnet Chemistry infrastructure	http://meetingorganizer.copernicus.org/EGU2016/EGU2016-5985.pdf
May 2016 (acceptance date)	Book chapter in Oceanographic and Marine Cross-Domain Data Management for Sustainable Development	Analysis of Ocean In Situ Observations and Web-Based Visualization, From Individual Measurements to an Integrated View.	http://www.igi-global.com/book/oceanographic-marine-cross-domain-data/148510
May 2016	Video tutorial	EMODnet Chemistry Video tutorial on Data Access & on Data Products	http://www.EMODnet-chemistry.eu/videotutorial.html

10. Evolution of Progress Indicators

Indicator 1. Volume of data made available through the portal

The total number of CDIs for chemistry data sets has increased from: **382554 on 1st June 2013 to 813309 on 30 June 2016.**

This covers the whole globe. Specifically relevant for European waters have increased from: **312024 on 1st June 2013 to 716062 on 30 June 2016.** (Lat Long box**: N80, W-30; N20, E45**)

Of these **601917** are unrestricted (unrestricted and SeaDataNet license), while others (**114145**) require (possible) negotiation due to restrictions.

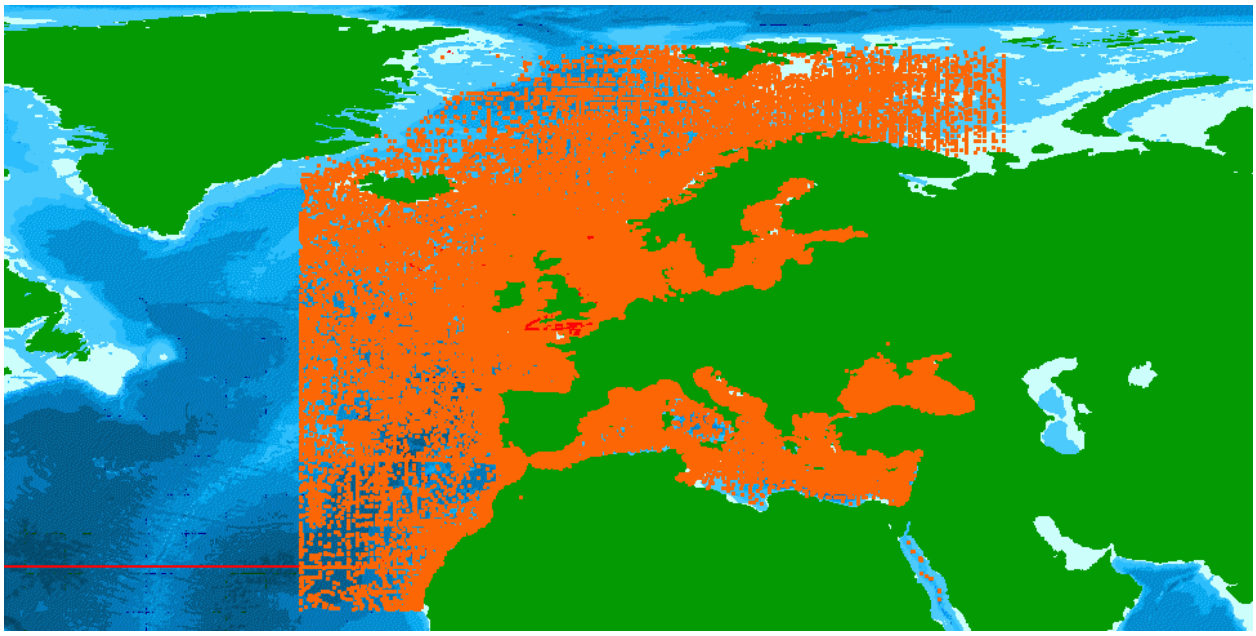


Figure 40. Overview of CDIs in European Lat-Lon box at 30th June 2016

The division per **Discovery Parameter** at 30th June 2016 is as follows:

Parameter	No. of CDI	No restrictions	Restrictions
Dissolved oxygen parameters in the water column	453513	405594	47919
Salinity of the water column	438332	393090	45242
Temperature of the water column	432718	391870	40848
Phosphate concentration parameters in the water column	311255	266170	45085
Nitrate concentration parameters in the water column	267744	226370	41374
Silicate concentration parameters in the water column	251106	211188	39918
Chlorophyll pigment concentrations in water bodies	203772	181141	22631

Ammonium and ammonia concentration parameters in water bodies	188861	157051	31810
Vertical spatial coordinates	186020	139567	46453
Nitrite concentration parameters in the water column	181769	150648	31121
Alkalinity, acidity and pH of the water column	105992	82049	23943
Particulate total and organic nitrogen concentrations in the water column	101370	95008	6362
Particulate total and organic phosphorus concentrations in the water column	91466	87632	3834
Dissolved total or organic phosphorus concentration in the water column	79340	67255	12085
Density of the water column	66884	63432	3452
Dissolved total and organic nitrogen concentrations in the water column	57457	54971	2486
Phaeopigment concentrations in the water column	37358	31131	6227
Concentration of suspended particulate material in the water column	31303	22632	8671
Transmittance and attenuance of the water column	28492	27110	1382
Electrical conductivity of the water column	26145	25135	1010
Raw fluorometer output	22908	14988	7920
Particulate total and organic carbon concentrations in the water column	22275	19353	2922
Concentration of inorganic sulphur species in the water column	22172	20485	1687
Dissolved organic carbon concentration in the water column	18347	12972	5375
Inorganic chemical composition of sediment or rocks	17573	8690	8883
Reference numbers	14586	13217	1369
Concentration of other hydrocarbons in the water column	14326	13561	765
Moored instrument depth	13205	13174	31
Visible waveband radiance and irradiance measurements in the water column	12800	10814	1986
Secchi disk depth	12494	8291	4203
Pesticide concentrations in water bodies	11983	10841	1142
Date and time	11106	10781	325
Concentration of polycyclic aromatic hydrocarbons (PAHs) in sediment samples	11019	5164	5855
Temperature variation in the water column	10988	10988	0
Redox potential in sediment	10204	0	10204
Dissolved metal concentrations in the water column	8708	6723	1985
Metal concentrations in biota	8636	2991	5645

Dissolved inorganic nitrogen concentration in the water column	8520	3703	4817
Concentration of polychlorobiphenyls (PCBs) in sediment samples	8436	3468	4968
Pollution events	8134	8134	0
Carbon concentrations in sediment	8011	1245	6766
Quality control flags	7492	6803	689
Sediment grain size parameters	7049	5258	1791
Concentration of other organic contaminants in the water column	6807	3381	3426
Concentration of polychlorobiphenyls (PCBs) in biota	6413	1307	5106
Nitrogen concentrations in suspended particulate material	6285	2624	3661
Carbon concentrations in suspended particulate material	5941	2037	3904
Raw temperature and/or salinity instrument output	5295	1803	3492
Raw oxygen sensor output	5250	1822	3428
Pesticide concentrations in sediment	5062	3794	1268
Concentration of other organic contaminants in sediment samples	4785	4614	171
Optical backscatter	4532	1954	2578
Pesticide concentrations in biota	4199	1833	2366
Sound velocity and travel time in the water column	4040	3978	62
Raw light meter output	3819	1155	2664
Variable fluorescence parameters	3744	3557	187
Carotenoid and flavenoid pigment concentrations in water bodies	3665	1438	2227
Sea level	3329	696	2633
Metal concentrations in sediment pore waters	3239	2708	531
Nitrogen concentrations in sediment	3198	2155	1043
Metadata parameters	2958	2261	697
Unspecified	2957	2565	392
Concentration of polycyclic aromatic hydrocarbons (PAHs) in the water column	2757	2228	529
Concentration of polycyclic aromatic hydrocarbons (PAHs) in biota	2650	871	1779
Radioactivity in the water column	2592	1358	1234
Unclassified pigment concentrations in the water column	2500	273	2227
Organometallic and organometalloid species concentration parameters in sediments	2265	1941	324
Particulate metal concentrations in the water column	2123	1123	1000
Light absorption in the water column	2111	1477	634
Total metal concentrations in water bodies	2062	724	1338

Raw suspended particulate material concentration sensor output	1979	1849	130
Concentration of organic matter in sediments	1817	915	902
Concentration of other organic contaminants in biota	1797	113	1684
Organometallic species concentration parameters in biota	1673	1607	66
Concentration of carbohydrates, phenols, alkanols (alcohols), ethers, aldehydes and ketones in sediment	1576	664	912
Horizontal spatial co-ordinates	1574	1574	0
Lithology	1572	599	973
Dissolved concentration parameters for other gases in the water column	1336	952	384
Concentration of polychlorobiphenyls (PCBs) in the water column	1315	1041	274
Concentration of polycyclic aromatic hydrocarbons (PAHs) in suspended particulate material	1051	1051	0
Primary production in the water column	1018	648	370
Urea concentration parameters in the water column	1013	704	309
Sedimentary structure	921	0	921
Biota lipid concentrations	884	577	307
Biota properties	759	641	118
Sediment water content, porosity and surface area	695	648	47
Suspended particulate material grain size parameters	669	114	555
Horizontal velocity of the water column (currents)	655	655	0
Concentration of other organic contaminants in suspended particulate material	648	648	0
Light extinction and diffusion coefficients	634	0	634
Geological sample radioactivity	511	447	64
Total dissolved inorganic carbon (TCO2) concentration in the water column	433	319	114
Phosphorus concentrations in suspended particulate material	397	81	316
Stable isotope enrichment in sediment	381	0	381
Dissolved trace metalloid concentrations in the water column	362	113	249
Visible waveband radiance and irradiance measurements in the atmosphere	339	205	134
Bacteria taxonomic abundance in water bodies	333	0	333
Terrestrial detritus in the water column suspended particulate material	322	322	0
Phytoplankton taxonomic abundance in water bodies	317	317	0
Trace metalloid concentrations in biota	294	260	34
Bacteria generic abundance in water bodies	293	257	36

Carbonate chemistry in sediment pore waters	285	120	165
Acoustic backscatter in the water column	283	283	0
Mineralogical composition	252	0	252
Concentration of alkanes in the water column	251	251	0
Phaeopigment concentrations in sediment	244	228	16
Water body redox potential	231	231	0
Concentration of carbohydrates, phenols, alkanols (alcohols), aldehydes and ketones in water bodies	194	194	0
Concentration of proteins in the water column	194	194	0
Zooplankton and zoobenthos morphological parameters	185	185	0
Concentration of inorganic halogens in water bodies	168	168	0
Concentration of polychlorobiphenyls (PCBs) in suspended particulate material	163	163	0
Other halocarbon concentrations in water bodies	156	0	156
Nutrient concentrations in sediment pore waters	151	120	31
Shellfish morphology, age and physiology	148	82	66
Raw in-situ nutrient analyser output	143	143	0
Regenerated production in water bodies	141	141	0
New production in water bodies	139	139	0
Sediment lipid concentrations	137	121	16
Chlorophyll pigment concentrations in sediment	136	120	16
Dissolved organic carbon concentrations in sediment pore waters	136	120	16
Oxygen production and respiration in the water column	136	136	0
Concentration of aliphatic hydrocarbons in sediment samples	133	13	120
Other physical and chemical properties of suspended particulate material	132	132	0
Concentration of inorganic sulphur species in sediment	131	46	85
Colloidal organic carbon concentration in the water column	100	100	0
Geological sample density	80	0	80
Organosulphur and organoselenium species concentration parameters in water bodies	76	76	0
Bacteria non taxonomy-related biomass expressed as carbon per unit volume of the water column	63	0	63
Radioactivity in biota	56	56	0
Excretion rate parameters in the water column	55	55	0
Nitrification rate in the water column	54	54	0
Atmospheric humidity	51	4	47
Stable isotope enrichment in the water column	46	20	26
Concentration of dissolved organic matter in the water column	44	0	44

Phytoplankton generic abundance in water bodies	41	5	36
Concentration of adenlylates in the water column	38	38	0
Fish morphology, age and physiology	38	38	0
Bacterial production in the water column	36	0	36
Phytoplankton generic biomass in water bodies	36	0	36
Geotechnics	32	32	0
Water body lipid concentrations	32	32	0
Air temperature	29	27	2
Air pressure	28	28	0
Plankton biomass expressed as carbon per unit volume of the water column	27	0	27
Wind strength and direction	27	27	0
Concentration of silicon species in the water column	24	9	15
Horizontal platform movement	24	24	0
Wave direction	23	23	0
Wave height and period statistics	23	23	0
Geological sample magnetic, electrical and acoustic properties	22	0	22
Sediment accumulation rate	22	0	22
Phytoplankton taxonomic biomass in water bodies	20	20	0
Chlorofluorocarbon concentrations in the water column	16	16	0
Organometallic and organometalloid species concentration parameters in water bodies	15	2	13
Vertical platform movement	11	11	0
Water body released tracers	11	11	0
Bathymetry and Elevation	10	10	0
Solar Radiation	6	6	0
Concentration of inorganic halogens in sediment pore waters	5	0	5
Concentration of inorganic sulphur species in sediment pore water	5	0	5
Platform or instrument orientation	4	4	0
Dissolved oxygen concentration parameters in sediment pore waters	1	1	0
Engineering parameters	1	1	0
Sediment age	1	0	1

Indicator 2. Organisations supplying each type of data based on (formal) sharing agreements and broken down into country and organisation type (e.g. government, industry, science).

Data Centre	Country	No. of CDI	No restrictions	Restrictions
British Oceanographic Data Centre	United Kingdom	62717	35821	26896
German Oceanographic Datacentre (NODC)	Germany	18045	14238	3807
OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale), Division of Oceanography	Italy	48825	23110	25715
CNR, Institute of Marine Science U.O.S. of Pozzuolo di Lerici (SP)	Italy	484	1	483
Institute of Marine Science (ISMAR) - Ancona	Italy	2974	1	2973
ISAC - Institute of Atmospheric Sciences and Climate (Rome)	Italy	253	253	0
Institute of Fishery Resources (IFR)	Bulgaria	257	257	0
Institute of Meteorology and Water Management, Maritime Branch in Gdynia (IMWM MB)	Poland	2726	0	2726
Hellenic Centre for Marine Research, Hellenic National Oceanographic Data Centre	Greece	9763	6779	2984
IEO/Spanish Oceanographic Institute	Spain	15589	6686	8903
Marine Institute	Ireland	7676	7676	0
Flanders Marine Institute	Belgium	3547	2749	798
IFREMER / IDM / SISMER - Scientific Information Systems for the SEA	France	30354	30133	221
Swedish Meteorological and Hydrological Institute	Sweden	62359	62289	70
IHPT, Hydrographic Institute	Portugal	3974	3037	937
Polish Geological Institute - National Research Institute, Branch of Marine Geology (PGI BMG)	Poland	326	0	326
Institute of Marine Research - Norwegian Marine Data Centre (NMD)	Norway	34578	34578	0
NIOZ Royal Netherlands Institute for Sea Research	Netherlands	3958	3944	14
Netherlands Institute for Ecology, Centre for Estuarine and Marine Ecology	Netherlands	12894	2145	10749
All-Russia Research Institute of Hydrometeorological Information - World Data Centre (RIHMI-WDC) National Oceanographic Data Centre (NODC)	Russian Federation	51474	51474	0
P.P.Shirshov Institute of Oceanology, RAS	Russian Federation	364	364	0
National Institute of Fisheries Research (INRH)	Morocco	552	0	552

Bulgarian National Oceanographic Data Centre(BGODC), Institute of Oceanology	Bulgaria	974	970	4
Iv.Javakhishvili Tbilisi State University, Centre of Relations with UNESCO Oceanological Research Centre and GeoDNA (UNESCO)	Georgia	473	473	0
Institute of Marine Sciences, Middle East Technical University	Turkey	7331	1771	5560
National Institute for Marine Research and Development "Grigore Antipa"	Romania	6851	3000	3851
Latvian Institute of Aquatic Ecology	Latvia	3296	3296	0
Institute of Oceanography and Fisheries	Croatia	2233	2233	0
International Ocean Institute - Malta Operational Centre (University Of Malta) / Physical Oceanography Unit	Malta	128	128	0
Cyprus Oceanography Center	Cyprus	561	561	0
Marine Systems Institute at Tallinn University of Technology	Estonia	17364	17364	0
State Oceanographic Institute (SOI)	Russian Federation	2915	0	2915
Marine Hydrophysical Institute	Ukraine	4652	2058	2594
Aarhus University, Department of Bioscience, Marine Ecology Roskilde	Denmark	185227	185227	0
International Council for the Exploration of the Sea (ICES)	Denmark	11829	11829	0
Karadeniz Technical University, Faculty of Marine Sciences	Turkey	246	29	217
Sinop University, Fisheries Faculty	Turkey	343	343	0
Dokuz Eylul University, Institute of Marine Science and Technology	Turkey	1603	0	1603
Istanbul University, Institute of Marine Science and Management	Turkey	339	171	168
Institute of Biology of the Southern Seas, NAS of Ukraine	Ukraine	998	998	0
Marine branch of Ukrainian Hydrometeorological Institute	Ukraine	26089	26089	0
Russian State Hydrometeorological University, St-Petersburg	Russian Federation	172	172	0
National Institute of Meteorology and Hydrology, Bulgarian Academy of Sciences	Bulgaria	839	602	237

Israel Oceanographic and Limnological Research (IOLR)	Israel	3956	3623	333
BRGM / Office of Geological and Mining Resources	France	1087	0	1087
Finnish Environment Institute	Finland	6207	6207	0
Ukrainian scientific center of Ecology of Sea (UkrSCES)	Ukraine	4800	4800	0
Odessa National I.I.Mechnikov University	Ukraine	889	25	864
National Institute of Biology - NIBMarine Biology Station	Slovenia	7432	3412	4020
Institut National des Sciences et Technologies de la Mer – INSTM	Tunisia	885	21	864
Scientific - Research Firm "GAMMA"	Georgia	1163	1163	0
Rijkswaterstaat Water, Traffic and Environment	Netherlands	13197	13197	0
Institute of Geology and Geography of Nature Research Centre	Lithuania	118	118	0
Management Unit of North Sea and Scheldt Estuary Mathematical Models, Belgian Marine Data Centre	Belgium	9268	9268	0
Geological Survey of Estonia	Estonia	542	542	0
Finnish Meteorological Institute	Finland	7985	7985	0
Ankara University	Turkey	24	24	0
Danube Hydro-meteorological Observatory	Ukraine	44	0	44
Faculty of Geography and Earth Sciences, University of Latvia (LU)	Latvia	721	0	721
National Environmental Agency of the Ministry of Environment Protection and Natural Resources	Georgia	26	26	0
Institute of Marine Biology (IMBK)	Montenegro	644	597	47
ISPRA-Institute for Environmental Protection and Research	Italy	3761	3761	0
PANGAEA - Data Publisher for Earth & Environmental Science	Germany	4242	4242	0
Portuguese Institute of Ocean and Atmosphere	Portugal	919	57	862
TOTALS		**716062**	**601917**	**114145**

Situation 30 June 2016. These centres are government and research institutes. No industry.

Difference between June 2013 and end June 2016:

Data Centre	Country	No. of CDI	No restrictions	Restrictions
British Oceanographic Data Centre	United Kingdom	35752	21182	14570
German Oceanographic Datacentre (NODC)	Germany	4091	3630	461
OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale), Division of Oceanography	Italy	9748	663	9085
CNR, Institute of Marine Science U.O.S. of Pozzuolo di Lerici (SP)	Italy	484	1	483
Institute of Marine Science (ISMAR) - Ancona	Italy	2974	1	2973
ISAC - Institute of Atmospheric Sciences and Climate (Rome)	Italy	253	253	0
Institute of Fishery Resources (IFR)	Bulgaria	0	0	0
Institute of Meteorology and Water Management, Maritime Branch in Gdynia (IMWM MB)	Poland	2726	0	2726
Hellenic Centre for Marine Research, Hellenic National Oceanographic Data Centre	Greece	2963	1843	1120
IEO/Spanish Oceanographic Institute	Spain	4572	159	4413
Marine Institute	Ireland	3159	3159	0
Flanders Marine Institute	Belgium	1943	1145	798
IFREMER / IDM / SISMER - Scientific Information Systems for the SEA	France	14651	14651	0
Swedish Meteorological and Hydrological Institute	Sweden	1496	1496	0
IHPT, Hydrographic Institute	Portugal	3974	3037	937
Polish Geological Institute - National Research Institute, Branch of Marine Geology (PGI BMG)	Poland	0	0	0
Institute of Marine Research - Norwegian Marine Data Centre (NMD)	Norway	34578	34578	0
NIOZ Royal Netherlands Institute for Sea Research	Netherlands	672	672	0
Netherlands Institute for Ecology, Centre for Estuarine and Marine Ecology	Netherlands	0	0	0
All-Russia Research Institute of Hydrometeorological Information - World Data Centre (RIHMI-WDC) National Oceanographic Data Centre (NODC)	Russian Federation	37397	37397	0
P.P.Shirshov Institute of Oceanology, RAS	Russian Federation	-11528	129	-11657
National Institute of Fisheries Research (INRH)	Morocco	552	0	552
Bulgarian National Oceanographic Data Centre(BGODC), Institute of Oceanology	Bulgaria	623	619	4

Iv.Javakhishvili Tbilisi State University, Centre of Relations with UNESCO Oceanological Research Centre and GeoDNA (UNESCO)	Georgia	98	98	0
Institute of Marine Sciences, Middle East Technical University	Turkey	4258	-1302	5560
National Institute for Marine Research and Development "Grigore Antipa"	Romania	2679	551	2128
Latvian Institute of Aquatic Ecology	Latvia	3162	3162	0
Institute of Oceanography and Fisheries	Croatia	689	689	0
International Ocean Institute - Malta Operational Centre (University Of Malta) / Physical Oceanography Unit	Malta	0	0	0
Cyprus Oceanography Center	Cyprus	62	62	0
Marine Systems Institute at Tallinn University of Technology	Estonia	13475	13475	0
State Oceanographic Institute (SOI)	Russian Federation	2915	0	2915
Marine Hydrophysical Institute	Ukraine	1409	4	1405
Aarhus University, Department of Bioscience, Marine Ecology Roskilde	Denmark	185015	185015	0
International Council for the Exploration of the Sea (ICES)	Denmark	10895	10895	0
Karadeniz Technical University, Faculty of Marine Sciences	Turkey	1	0	1
Sinop University, Fisheries Faculty	Turkey	0	0	0
Dokuz Eylul University, Institute of Marine Science and Technology	Turkey	0	0	0
Istanbul University, Institute of Marine Science and Management	Turkey	143	143	0
Institute of Biology of the Southern Seas, NAS of Ukraine	Ukraine	106	106	0
Marine branch of Ukrainian Hydrometeorological Institute	Ukraine	24153	24153	0
Russian State Hydrometeorological University, St-Petersburg	Russian Federation	172	172	0
National Institute of Meteorology and Hydrology, Bulgarian Academy of Sciences	Bulgaria	2	2	0
Israel Oceanographic and Limnological Research (IOLR)	Israel	648	315	333
BRGM / Office of Geological and Mining Resources	France	0	0	0
Finnish Environment Institute	Finland	6207	6207	0

Ukrainian scientific center of Ecology of Sea (UkrSCES)	Ukraine	-1440	-1440	0
Odessa National I.I.Mechnikov University	Ukraine	1	0	1
National Institute of Biology - NIBMarine Biology Station	Slovenia	3445	1501	1944
Institut National des Sciences et Technologies de la Mer – INSTM	Tunisia	885	21	864
Scientific - Research Firm "GAMMA"	Georgia	232	232	0
Rijkswaterstaat Water, Traffic and Environment	Netherlands	0	0	0
Institute of Geology and Geography of Nature Research Centre	Lithuania	0	0	0
Management Unit of North Sea and Scheldt Estuary Mathematical Models, Belgian Marine Data Centre	Belgium	84	84	0
Geological Survey of Estonia	Estonia	0	0	0
Finnish Meteorological Institute	Finland	5883	5883	0
Ankara University	Turkey	0	0	0
Danube Hydro-meteorological Observatory	Ukraine	0	0	0
Faculty of Geography and Earth Sciences, University of Latvia (LU)	Latvia	0	-721	721
National Environmental Agency of the Ministry of Environment Protection and Natural Resources	Georgia	26	26	0
Institute of Marine Biology (IMBK)	Montenegro	631	584	47
ISPRA-Institute for Environmental Protection and Research	Italy	3761	3761	0
PANGAEA - Data Publisher for Earth & Environmental Science	Germany	1648	1648	0
Portuguese Institute of Ocean and Atmosphere	Portugal	919	57	862
National Laboratory of Energy and Geology	Portugal	-919	-48	-871
Taurida V.I. Vernadsky National University	Ukraine	-55	0	-55
Scientific Research Institute of Ecological Problems (USRIEP)	Ukraine	-4	-4	0
Southern Scientific Research Institute of Marine Fisheries and Oceanography	Ukraine	-18228	-18228	0
TOTALS		**404038**	**361718**	**42320**

Note 1: several data centres ceased to exist due to Crimea crisis (Scientific Research Institute of Ecological Problems (USRIEP), Southern Scientific Research Institute of Marine Fisheries and Oceanography) and reorganisation (National Laboratory of Energy and Geology). Where possible their data sets have been taken over by other data centres.

Note 2: From a few data centres with 0 increase or even decrease new data sets are expected on short term.

Note 3: Many of the dat centres with 0 are not part of the EMODnet Chemistry consortium and thus had no project activities for populating new entries. This includes: IFR - Bulgaria, National Institute of Meteorology and Hydrology - Bulgarian Academy of Sciences – Bulgaria, PGI - Poland, Netherlands Institute for Ecology, Centre for Estuarine and Marine Ecology - Netherlands, International Ocean Institute - Malta Operational Centre (University Of Malta) / Physical Oceanography Unit - Malta, Karadeniz Technical University - Faculty of Marine Sciences – Turkey, Sinop University - Fisheries Faculty - Turkey, Dokuz Eylul University - Institute of Marine Science and Technology - Turkey, BRGM / Office of Geological and Mining Resources - France, Odessa National I.I.Mechnikov University - Ukraine, Institute of Geology and Geography of Nature Research Centre - Lithuania, Geological Survey of Estonia - Estonia, Ankara University - Turkey, and Danube Hydro-meteorological Observatory – Romania.

Indicator 3. Organisations that have been approached to supply data with no result, including type of data sought and reason why it has not been supplied.

Nothing to report

Indicator 4. Volume of each type of data and of each data product downloaded from the portal

Time period 1 June 2013 – 30 June 2016:

RSM => EMODnet Chemistry portal

No of CDI basket transactions: 230

No of CDIs requested: 453172

Different users: 57

Different data centres: 52

Access statistics during EMODNET phase 2 (begin June 2013 – end June 2016) of all data products available on Gher webserver

EMODnet-chemistry Dowload of DIVA products	
direct download of the NetCDF files	
North Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body ammonium	123
North Sea->DIVA 4D analysis of water body nitrate (1970-2009)	58
Black Sea->Seasonal distribution->DIVA 4D seasonal analysis of water body nitrate (1920-2011)	58
Mediterranean Sea->Autumn (October-December) - 10-years running averages->DIVA 4D analysis of Water body nitrate	47
Baltic Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body phosphate	39
Baltic Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body ammonium	39
Baltic Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body nitrate	38
Black Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body nitrate	38
Mediterranean Sea->Spring (April-June) - 10-years running averages->DIVA 4D analysis of Water body nitrate	37
Mediterranean Sea->Autumn (October-December) - 10-years running averages->DIVA 4D analysis of Water body silicate	37
Baltic Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body phosphate	36
Mediterranean Sea->Winter (January-March) - 10-years running averages->DIVA 4D analysis of Water body nitrate	35
North Sea->DIVA 4D analysis of water body phosphate (1970-2009)	35
Baltic Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body nitrate	35
Black Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body silicate	35
Black Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body phosphate	34
Baltic Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body phosphate	34
North Sea->DIVA 4D analysis of water body nitrite (1970-2009)	34

Black Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body nitrate	34
Mediterranean Sea->Summer (July-September) - 10-years running averages->DIVA 4D analysis of Water body nitrate	34
Baltic Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body phosphate	33
Mediterranean Sea->Winter (January-March) - 10-years running averages->DIVA 4D analysis of Water body phosphate	33
Baltic Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body silicate	32
Mediterranean Sea->Adriatic->DIVA 4D analysis of water body nitrate	32
Mediterranean Sea->Autumn (October-December) - 10-years running averages->DIVA 4D analysis of Water body phosphate	32
Mediterranean Sea->Summer (July-September) - 10-years running averages->DIVA 4D analysis of Water body silicate	32
Baltic Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body silicate	32
Baltic Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body nitrate	32
North Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body nitrate	31
Baltic Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body silicate	31
Atlantic Sea->Summer (July-September) - 10-years running averages->DIVA 4D analysis of Water body silicate	31
Mediterranean Sea->Summer (July-September) - 10-years running averages->DIVA 4D analysis of Water body phosphate	31
Black Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body phosphate	31
Black Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body nitrate	30
Mediterranean Sea->Winter (January-March) - 10-years running averages->DIVA 4D analysis of Water body silicate	29
Black Sea->Annual distribution->Annual distribution of Alkalinity in the Black Sea for the period of 1957-2011	29

Black Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body silicate	29
Atlantic Sea->Autumn (October-December) - 10-years running averages->DIVA 4D analysis of Water body silicate	29
Black Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body phosphate	28
Mediterranean Sea->Spring (April-June) - 10-years running averages->DIVA 4D analysis of Water body phosphate	28
Mediterranean Sea->Spring (April-June) - 10-years running averages->DIVA 4D analysis of Water body silicate	28
North Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body silicate	28
Black Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body silicate	28
North Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body nitrate	28
Black Sea->Annual distribution->Annual distribution of Zinc in the Kerch strait at the bottom depth for period 2007-2011	28
Black Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body nitrate	27
Atlantic Sea->Spring (April-June) - 10-years running averages->DIVA 4D analysis of Water body phosphate	27
North Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body silicate	27
North Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body phosphate	27
Black Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	26
Black Sea->Annual distribution->Annual distribution of Cuprum in the Kerch strait at the bottom depth for period 2007-2011	26
Black Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body phosphate	26
North Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body nitrate	26
Atlantic Sea->Autumn (October-December) - 10-years running averages->DIVA 4D analysis of Water body phosphate	25

Black Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body silicate	25
North Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body phosphate	25
North Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body silicate	24
Baltic Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body ammonium	24
Mediterranean Sea->Adriatic->DIVA 4D analysis of water body phosphate	24
Atlantic Sea->Winter (January-March) - 10-years running averages->DIVA 4D analysis of Water body phosphate	24
Baltic Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body ammonium	24
Black Sea->Annual distribution->Annual distribution of Ammonium in the Black Sea	24
Atlantic Sea->Summer (July-September) - 10-years running averages->DIVA 4D analysis of Water body phosphate	24
Black Sea->Annual distribution->Annual distribution of Nitrates in the Black Sea for the period of 1957-2011	24
Baltic Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	24
Black Sea->Annual distribution->Annual distribution of Oxygen in the Black Sea for the period 1957-2011	24
Black Sea->Monthly distribution->Monthly distribution of Phosphate concentration in the Black Sea	24
North Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body phosphate	24
Black Sea->Monthly distribution->Monthly distribution of Alkalinity in the Black Sea	23
Baltic Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	23
Baltic Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	23
Black Sea->Annual distribution->Annual distribution of Total nitrogen in the Black Sea for the period of 1957-2011	23
Black Sea->Annual distribution->Annual distribution of Wolfram in the Kerch strait at the bottom depth for period 2007-2011	23

Baltic Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body ammonium	23
Baltic Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	23
Black Sea->Monthly distribution->Monthly distribution of Nitrite concentration in the Black Sea	23
Black Sea->Annual distribution->Annual distribution of CS-137 in the Black Sea	23
North Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body silicate	23
Black Sea->Seasonal distribution->DIVA 4D seasonal analysis of water body ammonium (1920-2011)	23
Mediterranean Sea->Balearic Sea->Winter->DIVA 4D analysis of water body nitrite	23
Black Sea->Annual distribution->Annual distribution of Nickel in the Kerch strait at the bottom depth for period 2007-2011	22
Baltic Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	22
Black Sea->Seasonal distribution->Seasonal distribution of Nitrite in the Black Sea	22
Black Sea->Annual distribution->Annual distribution of Phosphates in the Black Sea for the period of 1957-2011	22
Baltic Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	22
Baltic Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	22
Black Sea->Monthly distribution->Monthly distribution of Oxygen in the Black Sea	22
Black Sea->Annual distribution->Annual distribution of CS-134 in the Black Sea	22
Atlantic Sea->Winter (January-March) - 10-years running averages->DIVA 4D analysis of Water body silicate	22
Baltic Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	22
Black Sea->Seasonal distribution->DIVA 4D seasonal analysis of water body nitrite (1920-2011)	21
Baltic Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	21
Black Sea->Annual distribution->Annual distribution of Nitrites in the Black Sea for the period of 1957-2011	21

Black Sea->Monthly distribution->Monthly distribution of Silicate concentration in the Black Sea	21
Black Sea->Annual distribution->Annual distribution of Chromium in the Kerch strait at the bottom depth for period 2007-2011	21
Black Sea->Seasonal distribution->Seasonal distribution of Ammonium concentration in the Black Sea	21
Black Sea->Seasonal distribution->DIVA 4D seasonal analysis of water body total alkalinity (1920-2011)	21
Baltic Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	21
North Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body nitrate	21
Baltic Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	20
Black Sea->Annual distribution->Annual distribution of Plumbum in the Kerch strait at the bottom depth for period 2007-2011	20
Black Sea->Annual distribution->Annual distribution of Silicates in the Black Sea for the period of 1957-2011	20
North Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body phosphate	20
Black Sea->Annual distribution->Annual distribution of Alkalinity in the Black Sea	19
Black Sea->Seasonal distribution->Seasonal distribution of Total nitrogen concentration in the Black Sea	19
Baltic Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body nitrate	19
Black Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body ammonium	19
Black Sea->Seasonal distribution->DIVA 4D seasonal analysis of pH (1924-2011)	19
Black Sea->Seasonal distribution->Seasonal distribution of Alkalinity in the Black Sea	19
Black Sea->Annual distribution->Annual distribution of Arsenic in the Kerch strait at the bottom depth for period 2007-2011	19
Black Sea->Seasonal distribution->Seasonal distribution of Phosphate in the Black Sea	19
Baltic Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body silicate	19
Black Sea->Seasonal distribution->Seasonal distribution of Silicate in the Black Sea	19

Black Sea->Annual distribution->Annual distribution of Strontium in the Kerch strait at the bottom depth for period 2007-2011	18
Black Sea->Annual distribution->Annual distribution of Cobalt in the Kerch strait at the bottom depth for period 2007-2011	18
Black Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body ammonium	18
Atlantic Sea->Spring (April-June) - 10-years running averages->DIVA 4D analysis of Water body silicate	18
Mediterranean Sea->Levantine Basin->DIVA 4D analysis of water body nitrate	18
Black Sea->Seasonal distribution->Seasonal distribution of PH in the Black Sea	17
Black Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body ammonium	17
Black Sea->Seasonal distribution->DIVA 4D seasonal analysis of water body silicate (1920-2011)	17
Black Sea->Seasonal distribution->DIVA 4D seasonal analysis of water body phosphate (1920-2011)	17
Black Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body ammonium	17
Mediterranean Sea->Gulf of Athens->Annual distribution (1987-1994)->DIVA 4D analysis of water body phosphate	17
Mediterranean Sea->Gulf of Athens->Annual distribution (1987-1994)->DIVA 4D analysis of water body nitrate	17
Black Sea->Seasonal distribution->Seasonal distribution of Nitrate concentration in the Black Sea	17
Baltic Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	17
Mediterranean Sea->Balearic Sea->Fall->DIVA 4D analysis of water body nitrite	17
North Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body ammonium	17
Mediterranean Sea->Levantine Basin->DIVA 4D analysis of water body phosphate	17
Mediterranean Sea->Balearic Sea->Spring->DIVA 4D analysis of water body nitrite	16
Mediterranean Sea->Gulf of Athens->Seasonal distribution (1987-1994)->DIVA 4D analysis of water body phosphate	16
Mediterranean Sea->Gulf of Athens->Mean distribution (2000-2010)->DIVA 4D analysis of water body dissolved cadmium	16

Mediterranean Sea->Gulf of Athens->Mean distribution (1990-1999)->DIVA 4D analysis of water body dissolved cadmium	16
Mediterranean Sea->Gulf of Athens->Annual distribution (1995-2007)->DIVA 4D analysis of water body phosphate	16
Black Sea->Seasonal distribution->DIVA 4D seasonal analysis of water body dissolved oxygen concentration (1920-2011)	16
Mediterranean Sea->Balearic Sea->Summer->DIVA 4D analysis of water body nitrite	16
Mediterranean Sea->Gulf of Athens->Seasonal distribution (1987-1994)->DIVA 4D analysis of water body nitrate	16
Mediterranean Sea->Gulf of Athens->Annual distribution (1995-2007)->DIVA 4D analysis of water body nitrate	15
Mediterranean Sea->Gulf of Athens->Mean distribution (2000-2010)->DIVA 4D analysis of water body dissolved lead	15
Black Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	15
North Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body ammonium	15
Mediterranean Sea->Gulf of Athens->Seasonal distribution (1995-2007)->DIVA 4D analysis of water body phosphate	14
Mediterranean Sea->Gulf of Lions->DIVA 4D analysis of water body phosphate (1971-2003)	13
Mediterranean Sea->Gulf of Athens->Mean distribution (1990-1999)->DIVA 4D analysis of water body dissolved lead	13
Black Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	13
Mediterranean Sea->Summer (July-September) - 10-years running averages->DIVA 4D analysis of Water body ammonium	13
Black Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	12
North Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	12
North Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	12
Mediterranean Sea->Summer (July-September) - 10-years running averages->DIVA 4D analysis of Water body nitrite	12

North Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	12
North Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	11
Mediterranean Sea->Summer (July-September) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	11
Mediterranean Sea->Autumn (October-December) - 10-years running averages->DIVA 4D analysis of Water body ammonium	11
North Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	11
Mediterranean Sea->Autumn (October-December) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	10
North Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	10
Mediterranean Sea->Spring (April-June) - 10-years running averages->DIVA 4D analysis of Water body nitrite	10
Mediterranean Sea->Summer (July-September) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	10
Mediterranean Sea->Autumn (October-December) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	10
North Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body ammonium	10
Mediterranean Sea->Autumn (October-December) - 10-years running averages->DIVA 4D analysis of Water body nitrite	10
North Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	10
Mediterranean Sea->Summer (July-September) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	10
Mediterranean Sea->Spring (April-June) - 10-years running averages->DIVA 4D analysis of Water body ammonium	9
North Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	9
Mediterranean Sea->Spring (April-June) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	8
Mediterranean Sea->Winter (January-March) - 10-years running averages->DIVA 4D analysis of Water body nitrite	8

Mediterranean Sea->Autumn (October-December) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	8
Mediterranean Sea->Spring (April-June) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	8
Mediterranean Sea->Gulf of Athens->Seasonal distribution (1995-2007)->DIVA 4D analysis of water body nitrate	8
Mediterranean Sea->Winter (January-March) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	8
Mediterranean Sea->Winter (January-March) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	7
Mediterranean Sea->Spring (April-June) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	7
Mediterranean Sea->Winter (January-March) - 10-years running averages->DIVA 4D analysis of Water body ammonium	7
Mediterranean Sea->Winter (January-March) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	7
North Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body dissolved oxygen concentration	6
Atlantic Sea->Spring (April-June) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	5
Atlantic Sea->Autumn (October-December) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	5
North Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body dissolved oxygen concentration	5
Black Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body dissolved oxygen concentration	4
North Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body dissolved oxygen concentration	4
North Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body dissolved oxygen concentration	3
Atlantic Sea->Summer (July-September) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	3
Atlantic Sea->Winter (January-March) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	2
Total	**4018**

EMODnet-chemistry Visualization of DIVA products (individual WMS tiles of size 512 x 512 pixels)	
Black Sea->Annual distribution->Annual distribution of Alkalinity in the Black Sea for the period of 1957-2011	329644
Black Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body silicate	140597
North Sea->DIVA 4D analysis of water body nitrate (1970-2009)	72640
Baltic Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body nitrate	44719
North Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body ammonium	41776
Mediterranean Sea->Balearic Sea->Fall->DIVA 4D analysis of water body nitrite	23641
Mediterranean Sea->Gulf of Athens->Annual distribution (1987-1994)->DIVA 4D analysis of water body nitrate	20602
Mediterranean Sea->Spring (April-June) - 10-years running averages->DIVA 4D analysis of Water body nitrate	18540
Mediterranean Sea->Autumn (October-December) - 10-years running averages->DIVA 4D analysis of Water body nitrate	17527
North Sea->DIVA 4D analysis of water body phosphate (1970-2009)	17392
Mediterranean Sea->Spring (April-June) - 10-years running averages->DIVA 4D analysis of Water body phosphate	16939
Atlantic Sea->Autumn (October-December) - 10-years running averages->DIVA 4D analysis of Water body phosphate	15152
Mediterranean Sea->Summer (July-September) - 10-years running averages->DIVA 4D analysis of Water body nitrate	13715
Mediterranean Sea->Adriatic->DIVA 4D analysis of water body nitrate	11639
Atlantic Sea->Spring (April-June) - 10-years running averages->DIVA 4D analysis of Water body phosphate	10446
North Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body phosphate	9505
Atlantic Sea->Summer (July-September) - 10-years running averages->DIVA 4D analysis of Water body phosphate	9053
Mediterranean Sea->Autumn (October-December) - 10-years running averages->DIVA 4D analysis of Water body phosphate	8440
North Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body nitrate	8284

Baltic Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body phosphate	7069
Mediterranean Sea->Winter (January-March) - 10-years running averages->DIVA 4D analysis of Water body nitrate	6611
North Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body ammonium	6240
Mediterranean Sea->Levantine Basin->DIVA 4D analysis of water body nitrate	5100
Mediterranean Sea->Summer (July-September) - 10-years running averages->DIVA 4D analysis of Water body phosphate	4506
North Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body nitrate	4418
Black Sea->Monthly distribution->Monthly distribution of Phosphate concentration in the Black Sea	4259
Black Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body nitrate	3938
Mediterranean Sea->Winter (January-March) - 10-years running averages->DIVA 4D analysis of Water body silicate	3772
Baltic Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body phosphate	3684
Baltic Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body phosphate	3667
Mediterranean Sea->Balearic Sea->Summer->DIVA 4D analysis of water body nitrite	3584
Atlantic Sea->Summer (July-September) - 10-years running averages->DIVA 4D analysis of Water body silicate	3571
North Sea->DIVA 4D analysis of water body nitrite (1970-2009)	3448
Atlantic Sea->Winter (January-March) - 10-years running averages->DIVA 4D analysis of Water body phosphate	3432
Baltic Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body nitrate	3393
Black Sea->Seasonal distribution->DIVA 4D seasonal analysis of water body nitrate (1920-2011)	3391
Mediterranean Sea->Balearic Sea->Spring->DIVA 4D analysis of water body nitrite	3389
Atlantic Sea->Autumn (October-December) - 10-years running averages->DIVA 4D analysis of Water body silicate	3086
Mediterranean Sea->Winter (January-March) - 10-years running averages->DIVA 4D analysis of Water body phosphate	2956

North Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body phosphate	2724
Mediterranean Sea->Gulf of Lions->DIVA 4D analysis of water body phosphate (1971-2003)	2632
Mediterranean Sea->Gulf of Athens->Annual distribution (1995-2007)->DIVA 4D analysis of water body nitrate	2521
Mediterranean Sea->Adriatic->DIVA 4D analysis of water body phosphate	2396
North Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body nitrate	2061
Atlantic Sea->Autumn (October-December) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	2005
Baltic Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	1958
Baltic Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body nitrate	1865
North Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body ammonium	1815
Black Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body phosphate	1804
Atlantic Sea->Winter (January-March) - 10-years running averages->DIVA 4D analysis of Water body silicate	1747
Black Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body silicate	1702
Black Sea->Seasonal distribution->DIVA 4D seasonal analysis of water body total alkalinity (1920-2011)	1641
Baltic Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body ammonium	1552
Black Sea->Seasonal distribution->DIVA 4D seasonal analysis of water body phosphate (1920-2011)	1528
Atlantic Sea->Spring (April-June) - 10-years running averages->DIVA 4D analysis of Water body silicate	1497
Mediterranean Sea->Summer (July-September) - 10-years running averages->DIVA 4D analysis of Water body silicate	1441
Mediterranean Sea->Autumn (October-December) - 10-years running averages->DIVA 4D analysis of Water body silicate	1437

Black Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body dissolved oxygen concentration	1400
Black Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body nitrate	1398
Mediterranean Sea->Winter (January-March) - 10-years running averages->DIVA 4D analysis of Water body ammonium	1342
Black Sea->Monthly distribution->Monthly distribution of Nitrite concentration in the Black Sea	1339
Black Sea->Annual distribution->Annual distribution of CS-134 in the Black Sea	1331
North Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body phosphate	1302
North Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body silicate	1289
North Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body ammonium	1281
Black Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body silicate	1275
Baltic Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body phosphate	1256
North Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body nitrate	1255
Mediterranean Sea->Autumn (October-December) - 10-years running averages->DIVA 4D analysis of Water body ammonium	1239
Black Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body ammonium	1190
Black Sea->Seasonal distribution->DIVA 4D seasonal analysis of water body dissolved oxygen concentration (1920-2011)	1169
North Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body phosphate	1161
Mediterranean Sea->Balearic Sea->Winter->DIVA 4D analysis of water body nitrite	1147
North Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body dissolved oxygen concentration	1022
Baltic Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	958
Baltic Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body ammonium	954

Black Sea->Annual distribution->Annual distribution of CS-137 in the Black Sea	944
Black Sea->Annual distribution->Annual distribution of Nitrites in the Black Sea for the period of 1957-2011	886
Black Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body nitrate	870
Mediterranean Sea->Autumn (October-December) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	853
Mediterranean Sea->Summer (July-September) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	838
Mediterranean Sea->Autumn (October-December) - 10-years running averages->DIVA 4D analysis of Water body nitrite	835
Black Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body ammonium	700
North Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	660
Black Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body nitrate	652
North Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	649
Baltic Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	642
Black Sea->Seasonal distribution->DIVA 4D seasonal analysis of water body ammonium (1920-2011)	622
Baltic Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body ammonium	608
Mediterranean Sea->Gulf of Athens->Annual distribution (1987-1994)->DIVA 4D analysis of water body phosphate	561
Black Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	552
Black Sea->Monthly distribution->Monthly distribution of Oxygen in the Black Sea	551
Mediterranean Sea->Spring (April-June) - 10-years running averages->DIVA 4D analysis of Water body silicate	524
Black Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body phosphate	510
Mediterranean Sea->Summer (July-September) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	504

Mediterranean Sea->Gulf of Athens->Seasonal distribution (1987-1994)->DIVA 4D analysis of water body nitrate	495
Mediterranean Sea->Summer (July-September) - 10-years running averages->DIVA 4D analysis of Water body ammonium	483
Black Sea->Annual distribution->Annual distribution of Nitrates in the Black Sea for the period of 1957-2011	480
Mediterranean Sea->Gulf of Athens->Mean distribution (2000-2010)->DIVA 4D analysis of water body dissolved lead	472
Black Sea->Seasonal distribution->Seasonal distribution of Nitrate concentration in the Black Sea	472
Black Sea->Seasonal distribution->Seasonal distribution of Silicate in the Black Sea	462
Black Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body silicate	449
Mediterranean Sea->Gulf of Athens->Annual distribution (1995-2007)->DIVA 4D analysis of water body phosphate	427
Mediterranean Sea->Levantine Basin->DIVA 4D analysis of water body phosphate	411
Black Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body phosphate	408
Mediterranean Sea->Spring (April-June) - 10-years running averages->DIVA 4D analysis of Water body ammonium	406
Black Sea->Annual distribution->Annual distribution of Oxygen in the Black Sea for the period 1957-2011	397
Mediterranean Sea->Winter (January-March) - 10-years running averages->DIVA 4D analysis of Water body nitrite	376
Mediterranean Sea->Autumn (October-December) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	374
Mediterranean Sea->Spring (April-June) - 10-years running averages->DIVA 4D analysis of Water body nitrite	367
Black Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body ammonium	343
Baltic Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body silicate	332
Mediterranean Sea->Spring (April-June) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	331
Mediterranean Sea->Gulf of Athens->Seasonal distribution (1995-2007)->DIVA 4D analysis of water body nitrate	330

Black Sea->Annual distribution->Annual distribution of Alkalinity in the Black Sea	312
North Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	311
Black Sea->Annual distribution->Annual distribution of Phosphates in the Black Sea for the period of 1957-2011	306
Black Sea->Annual distribution->Annual distribution of Zinc in the Kerch strait at the bottom depth for period 2007-2011	302
Black Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body ammonium	295
Black Sea->Annual distribution->Annual distribution of Total nitrogen in the Black Sea for the period of 1957-2011	289
Black Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body phosphate	287
Baltic Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body silicate	285
Mediterranean Sea->Gulf of Athens->Mean distribution (2000-2010)->DIVA 4D analysis of water body dissolved cadmium	271
Baltic Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body silicate	269
Baltic Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	267
Black Sea->Monthly distribution->Monthly distribution of Alkalinity in the Black Sea	263
Baltic Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	260
Mediterranean Sea->Autumn (October-December) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	260
Black Sea->Annual distribution->Annual distribution of Ammonium in the Black Sea	259
Black Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	259
Black Sea->Seasonal distribution->DIVA 4D seasonal analysis of water body silicate (1920-2011)	249
Mediterranean Sea->Summer (July-September) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	247
Baltic Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	245

North Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	244
Black Sea->Monthly distribution->Monthly distribution of Silicate concentration in the Black Sea	238
Mediterranean Sea->Gulf of Athens->Seasonal distribution (1995-2007)->DIVA 4D analysis of water body phosphate	236
Black Sea->Seasonal distribution->Seasonal distribution of Total nitrogen concentration in the Black Sea	233
Baltic Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body nitrate	223
Black Sea->Annual distribution->Annual distribution of Silicates in the Black Sea for the period of 1957-2011	221
Mediterranean Sea->Winter (January-March) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	221
Baltic Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body ammonium	206
Baltic Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	194
Mediterranean Sea->Summer (July-September) - 10-years running averages->DIVA 4D analysis of Water body nitrite	185
Black Sea->Annual distribution->Annual distribution of Chromium in the Kerch strait at the bottom depth for period 2007-2011	180
Baltic Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body silicate	175
Mediterranean Sea->Gulf of Athens->Mean distribution (1990-1999)->DIVA 4D analysis of water body dissolved cadmium	175
North Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body silicate	169
Black Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	159
Baltic Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	156
Black Sea->Annual distribution->Annual distribution of Arsenic in the Kerch strait at the bottom depth for period 2007-2011	155
Black Sea->Seasonal distribution->DIVA 4D seasonal analysis of pH (1924-2011)	150

North Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body silicate	145
North Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body dissolved oxygen concentration	144
Baltic Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	139
North Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body silicate	133
Black Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	133
North Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body dissolved oxygen concentration	129
Atlantic Sea->Summer (July-September) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	127
Black Sea->Seasonal distribution->Seasonal distribution of Ammonium concentration in the Black Sea	123
Mediterranean Sea->Winter (January-March) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	114
North Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	112
Black Sea->Seasonal distribution->DIVA 4D seasonal analysis of water body nitrite (1920-2011)	111
Baltic Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	110
North Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	108
Mediterranean Sea->Spring (April-June) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	91
Baltic Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	90
Mediterranean Sea->Spring (April-June) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	87
North Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	80
Mediterranean Sea->Winter (January-March) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	75

North Sea->Summer (June-August) - 10-years running averages->DIVA 4D analysis of Water body total phosphorus	67
Black Sea->Annual distribution->Annual distribution of Nickel in the Kerch strait at the bottom depth for period 2007-2011	62
North Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body dissolved oxygen concentration	58
Atlantic Sea->Spring (April-June) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	55
Black Sea->Seasonal distribution->Seasonal distribution of Nitrite in the Black Sea	44
Black Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body dissolved oxygen concentration	40
Mediterranean Sea->Gulf of Athens->Seasonal distribution (1987-1994)->DIVA 4D analysis of water body phosphate	38
Black Sea->Annual distribution->Annual distribution of Wolfram in the Kerch strait at the bottom depth for period 2007-2011	36
Atlantic Sea->Winter (January-March) - 10-years running averages->DIVA 4D analysis of Water body nitrate plus nitrite	34
Black Sea->Annual distribution->Annual distribution of Cuprum in the Kerch strait at the bottom depth for period 2007-2011	33
Black Sea->Seasonal distribution->Seasonal distribution of Alkalinity in the Black Sea	32
Black Sea->Annual distribution->Annual distribution of Plumbum in the Kerch strait at the bottom depth for period 2007-2011	32
Black Sea->Autumn (September-November) - 10-years running averages->DIVA 4D analysis of Water body dissolved oxygen concentration	28
Black Sea->Winter (December-February) - 10-years running averages->DIVA 4D analysis of Water body dissolved oxygen concentration	25
Mediterranean Sea->Gulf of Athens->Mean distribution (1990-1999)->DIVA 4D analysis of water body dissolved lead	24
Baltic Sea->Spring (March-May) - 10-years running averages->DIVA 4D analysis of Water body total nitrogen	22
Black Sea->Annual distribution->Annual distribution of Cobalt in the Kerch strait at the bottom depth for period 2007-2011	15
Black Sea->Annual distribution->Annual distribution of Strontium in the Kerch strait at the bottom depth for period 2007-2011	14
Black Sea->Seasonal distribution->Seasonal distribution of Phosphate in the Black Sea	13
Black Sea->Seasonal distribution->Seasonal distribution of PH in the Black Sea	2
Total	**1.000.000**

Dynamic downloads using WPS via Oceanbrowser until end of June 2016		
P35 description	**P35label**	**Number of requests**
Water body phosphate	EPC00007	10229
Water body nitrate plus nitrite	EPC00005	2645
Water body ammonium	EPC00009	1552
Water body silicate	EPC00008	2482
Water body nitrite	EPC00006	837
Water body total phosphorus	EPC00135	885
Water body total nitrogen	EPC00134	659
Water body nitrate	EPC00004	2123

Indicator 5. Organisations that have downloaded each data type

From CDI service:

Organisation	Country
EMODnet Secretariat	Belgium
Ghent University	Belgium
Seascape	Belgium
VLIZ	Belgium
IO/BAS	Bulgaria
University of Waterloo	Canada
Oceanography Centre, University of Cyprus	Cyprus
Aarhus Universitet BIOS	Denmark
ICES	Denmark
Tallinn University of Technology	Estonia
TTU MSI	Estonia
Finnish Environment Institute SYKE	Finland
IFREMER	France
Bundesamt fur Seeschifffahrt und Hydrographie	Germany
University of Hamburg	Germany
Unknown	Germany
HCMR	Greece
National Technical University of Athens	Greece
Technion University	Israel
CNR	Italy
CNR-ISMAR	Italy
ENEA	Italy

IN-OGS	Italy
ISPRA	Italy
JRC	Italy
National Research Council of Italy	Italy
OGS	Italy
Università Roma Tre	Italy
Institute of Marine Biology	Montenegro
Deltares	Netherlands
MARIS	Netherlands
IMR	Norway
NERSC	Norway
NIVA	Norway
IOCCP	Poland
Instituto Superior Técnico - Technical University of Lisbon	Portugal
University of Algarve	Portugal
NIMRD	Romania
National Institute of Biology	Slovenia
BC3	Spain
CEAB-CSIC	Spain
Spanish Institute of Oceanography	Spain
Lund University, Aquatic Ecology Unit	Sweden
SMHI	Sweden
Swedish Geological Survey	Sweden
IBSS	Ukraine
UkrSCES	Ukraine
BL	United Kingdom
Fugro EMU Limited	United Kingdom
Intertek METOC	United Kingdom
Unknown	United Kingdom
Plymouth University	United Kingdom
RPS	United Kingdom
CEFAS	United Kingdom
University	United Kingdom
University of Southampton	United Kingdom

Indicator 6. Using user statistics to determine the main pages utilized and to identify preferred user navigations routes

Chemistry CDI data discovery and access service:

Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Jun-13	61	79	1,728	3,480	28.36 MB
Jul-13	40	50	1,267	3,419	23.41 MB
Aug-13	58	66	828	2,209	98.95 MB
Sep-13	50	52	425	1,371	12.82 MB
Oct-13	112	160	2,654	10,347	57.58 MB
Nov-13	57	94	2,584	5,965	66.85 MB
Dec-13	88	136	2,853	5,559	95.76 MB
Total	466	637	12339	32350	383.73 MB
Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Jan-14	119	252	15,734	23,892	320.19 MB
Feb-14	100	236	4,185	8,008	104.66 MB
Mar-14	97	209	5,479	11,620	127.09 MB
Apr-14	98	160	3,531	10,093	104.99 MB
May-14	68	109	2,542	5,467	572.57 MB
Jun-14	102	218	4,756	10,415	113.42 MB
Jul-14	22	48	1,491	4,643	51.22 MB
Aug-14	34	83	2,620	3,930	98.47 MB
Sep-14	103	274	3,581	10,044	242.58 MB
Oct-14	198	407	3,053	13,513	129.60 MB
Nov-14	155	249	2,542	7,602	119.85 MB
Dec-14	110	203	2,047	6,862	155.27 MB
Total	1,206	2,448	51,561	116,089	2.09 GB
Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Jan-15	152	245	3,521	8,849	157.93 MB
Feb-15	162	323	3,846	10,607	197.77 MB
Mar-15	188	270	1,897	7,036	102.84 MB
Apr-15	195	364	2,645	7,694	139.40 MB
May-15	203	362	3,799	10,053	291.28 MB
Jun-15	296	704	20,456	45,410	606.31 MB
Jul-15	188	350	3,733	9,912	144.56 MB
Aug-15	121	178	1,595	5,296	104.31 MB
Sep-15	213	467	4,190	11,446	233.10 MB
Oct-15	265	492	5,013	15,949	323.65 MB
Nov-15	219	601	10,272	22,410	449.72 MB
Dec-15	236	357	4,682	13,494	245.71 MB
Total	2,438	4,713	65,649	168,156	2.93 GB
Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth

Jan-16	191	319	4,046	12,594	142.46 MB
Feb-16	227	449	6,140	16,855	276.24 MB
Mar-16	235	411	7,428	19,920	308.22 MB
Apr-16	234	576	12,298	26,193	509.85 MB
May-16	223	515	11,366	22,776	472.76 MB
Jun-16	241	618	9,066	22,660	310.51 MB
Total	1,351	2,888	50,344	120,998	1.97 GB

Statistics of use of Ocean Browser service

Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Jun 2013	47	95	37,321	40,437	281.21 MB
Jul 2013	41	90	15,003	18,076	3.04 GB
Aug 2013	45	96	13,274	16,806	12.04 GB
Sep 2013	59	126	37,954	41,62	872.66 MB
Oct 2013	79	127	14,887	18,925	415.31 MB
Nov-13	59	132	13,835	18,275	347.49 MB
Dec 2013	68	136	34,004	38,379	451.47 MB
Total	583	1,112	250,376	288,621	18.39 GB
Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Jan 2014	76	160	29,327	33,702	354.25 MB
Feb-14	78	153	13,052	18,108	608.02 MB
Mar-14	77	162	38,086	44,153	760.29 MB
Apr-14	73	164	20,507	25,222	897.50 MB
May 2014	64	98	6,144	10,807	183.24 MB
Jun 2014	107	162	20,483	28,974	2.85 GB
Jul 2014	51	90	17,376	21,116	3.06 GB
Aug 2014	57	79	5,024	8,516	166.16 MB
Sep 2014	126	231	16,164	27,695	1.74 GB
Oct 2014	105	194	72,572	82,5	481.51 MB
Nov-14	103	146	13,004	18,843	1.40 GB
Dec 2014	95	159	19,647	28,568	958.79 MB
Total	1,012	1,798	271,386	348,204	13.35 GB

Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Jan 2015	71	108	29,866	34,647	296.82 MB
Feb-15	124	327	47,662	74,613	3.12 GB
Mar-15	109	184	9,661	16,975	3.35 GB
Apr-15	77	124	8,197	13,452	912.16 MB

May 2015	70	124	17,399	21,694	2.83 GB
Jun 2015	120	263	159,772	175,62	5.87 GB
Jul 2015	114	323	10,277	21,481	465.99 MB
Aug 2015	66	170	3,852	6,998	226.31 MB
Sep 2015	93	180	58,942	70,211	903.78 MB
Oct 2015	178	446	61,723	76,993	2.35 GB
Nov-15	125	204	47,322	56,766	1.11 GB
Dec 2015	102	140	35,799	41,749	9.68 GB
Total	1,249	2,593	490,472	611,199	31.05 GB

Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Jan 2016	73	126	22,209	28,08	9.60 GB
Feb-16	101	159	54,997	61,013	5.13 GB
Mar-16	55	103	12,699	17,267	3.15 GB
Apr-16	56	89	4,523	7,374	1.00 GB
May 2016	13	14	155	383	698.48 MB
Jun 2016	8	11	134	517	250.92 MB

Statistics of use of Chemistry Lot web site:

Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Jun 2013	57	104	406	406	1.15 GB
Jul 2013	26	42	70	81	49.73 MB
Aug 2013	20	29	49	49	47.28 MB
Set 2013	35	51	84	84	78.95 MB
Oct 2013	85	136	199	199	98.67 MB
Nov 2013	44	68	109	129	120.90 MB
Dec 2013	37	51	75	75	67.68 MB
Total	304	481	992	1023	1.60 GB

Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Jan 2014	47	85	121	201	222.98 MB
Feb-14	34	46	86	218	82.03 MB
Mar-14	27	54	122	523	44.67 MB
Apr-14	21	35	46	288	46.10 MB
May 2014	21	48	87	503	6.20 MB
Jun 2014	166	251	353	788	44.90 MB
Jul 2014	106	184	451	1,24	8.07 MB

Aug 2014	22	37	61	186	39.83 MB
Sep 2014	15	40	129	134	8.42 MB
Oct 2014	10	12	12	22	7.06 MB
Nov-14	8	8	22	23	427.30 KB
Dec 2014	1	261	1,961	5,177	834.87 MB
Total	478	1,061	3,451	9,303	1.31 GB

Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Jan 2015	16	102	622	1,37	220.52 MB
Feb-15	12	19	22	24	1.95 MB
Mar-15	8	19	81	102	1.30 MB
Apr-15	11	12	13	13	117.45 KB
May 2015	14	20	51	56	3.38 MB
Jun 2015	21	43	53	56	2.14 MB
Jul 2015	25	80	319	323	10.76 MB
Aug 2015	12	28	219	221	2.10 MB
Sep 2015	17	28	95	96	1.06 MB
Oct 2015	16	25	40	40	196.87 KB
Nov-15	10	29	81	93	24.67 MB
Dec 2015	10	20	28	39	26.29 MB
Total	172	425	1,624	2,433	294.46 MB

Month	Unique visitors	Number of visits	Pages	Hits	Bandwidth
Jan 2016	11	26	79	83	12.48 MB
Feb-16	14	21	21	41	58.08 MB
Mar-16	13	22	83	100	60.55 MB
Apr-16	14	25	27	37	31.41 MB
May 2016	18	36	75	89	37.62 MB
Jun 2016	24	37	44	60	56.46 MB

Indicator 7. List of what the downloaded data has been used for (divided into categories e.g. Government planning, pollution assessment and (commercial) environmental assessment, etc.)

Nothing to report

Indicator 8. List of web-services made available and user organisations connected through these web-services

CDI Data Discovery and Access service:
The CDI service has WMS and WFS services which are used primarily internally and by the OceanBrowser service for providing a layer of CDI entries and option for retrieving CDI metadata:

WMS and WFS service: http://geoservice.maris2.nl/wms/seadatanet/EMODnet_chemistry

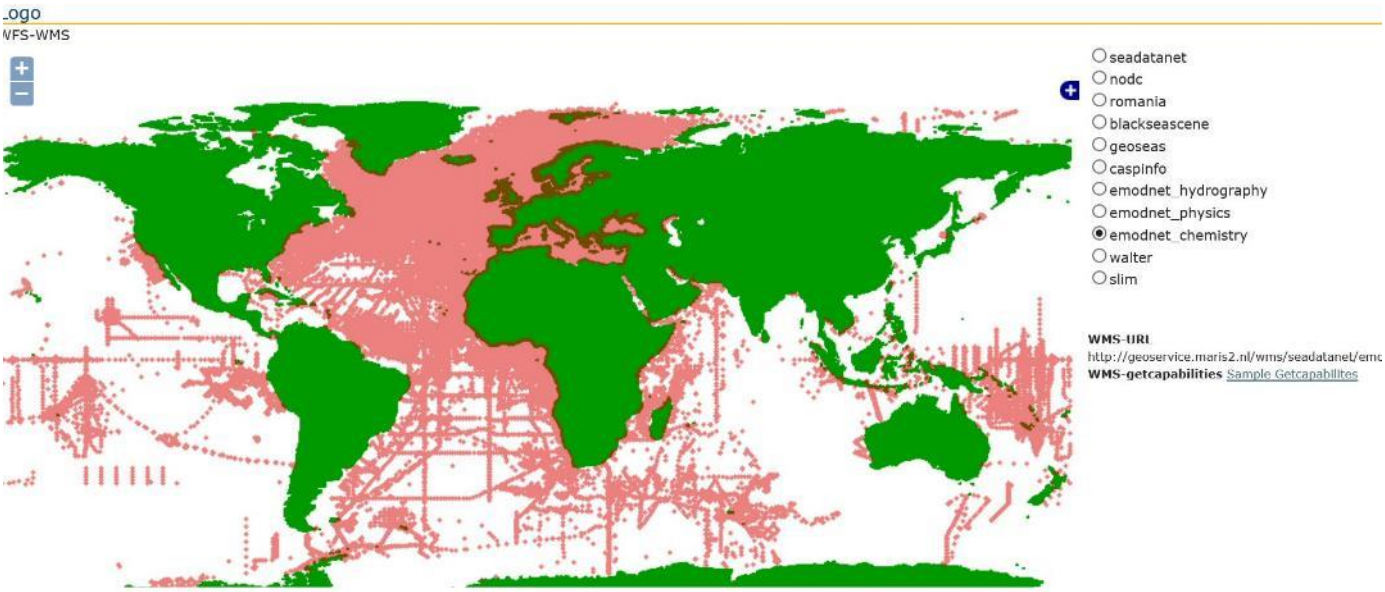


Figure 41. Example of EMODnet Chemistry WMS layer for points

GetCapabilities:

http://geoservice.maris2.nl/wms/seadatanet/EMODnet_chemistry?service=WMS&request=GetCapabilities

Note: Getcapabilites indicates what is available. In CDI case it is both WMS and WFS. Implementing WFS is depending on the client and needs programming. We provide WFS request through WMS:

http://geoservice.maris2.nl/wms/seadatanet/EMODnet_chemistry/?LAYERS=points&QUERY_LAYERS=points&STYLES=&SERVICE=WMS&VERSION=1.1.1&REQUEST=GetFeatureInfo&BBOX=-25.168107%2C39.506018%2C25.808455%2C64.994299&FEATURE_COUNT=10&HEIGHT=290&WIDTH=580&FORMAT=image%2Fpng&INFO_FORMAT=text%2Fhtml&SRS=EPSG%3A4326&X=296&Y=129

with BBox as LON,LAT,LON,LAT for the layer points.

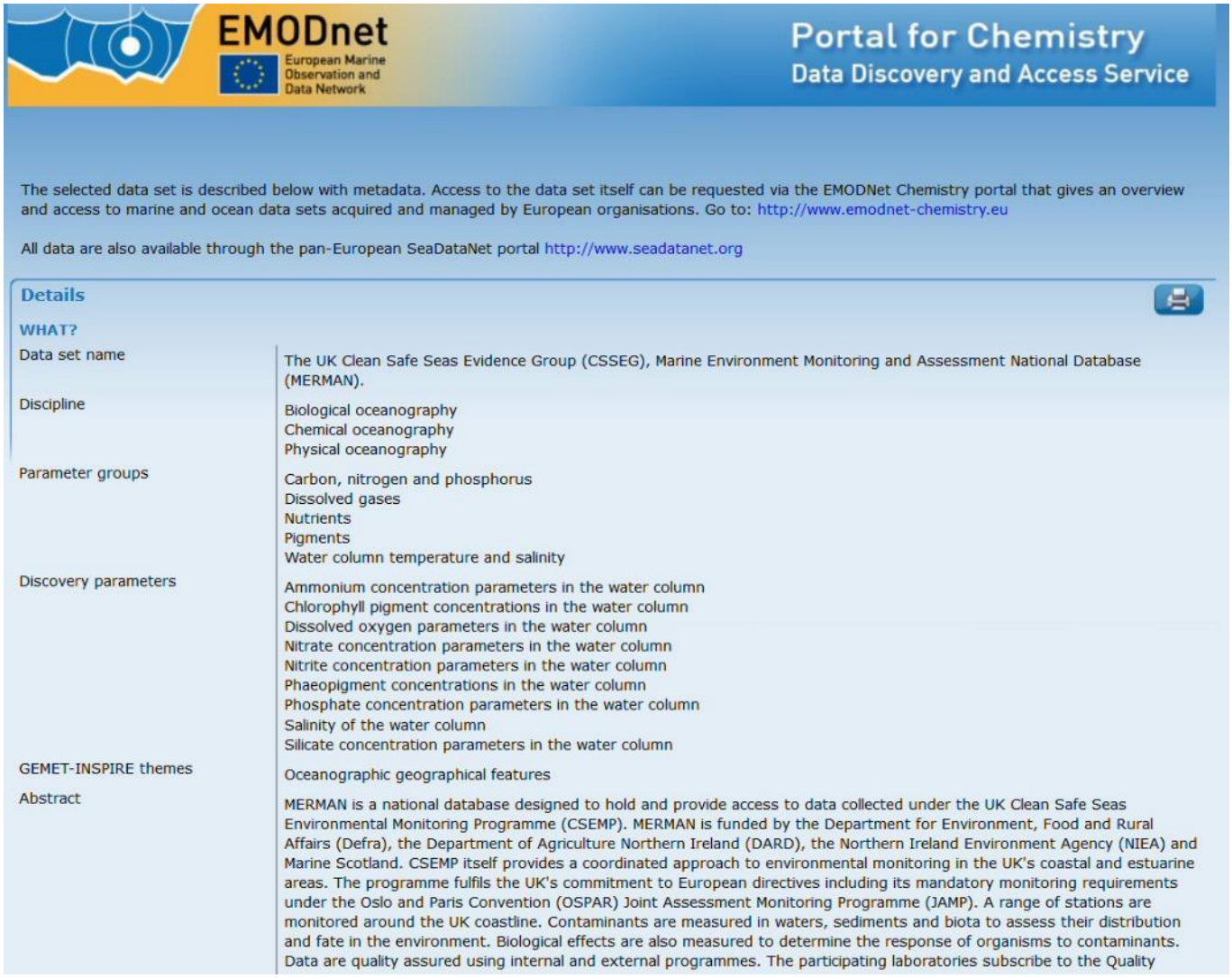
This gives for example:

CDI-record id	Data set name	CDI-partner	Details
292023	RNODC_Bottle_3767	All-Russia Research Institute of Hydrometeorological Information - World Data Centre (RIHMI-WDC) National Oceanographic Data Centre (NODC)	http://EMODnet-chemistry.maris2.nl/v_cdi_v3/print_wfs.asp?n_code=292023
484175	19950030sed_MUDAB	German Oceanographic Datacentre (NODC)	http://EMODnet-chemistry.maris2.nl/v_cdi_v3/print_wfs.asp?n_code=484175
827370	2004040010.bot (00410)	IFREMER / IDM / SISMER - Scientific Information Systems for the SEA	http://EMODnet-chemistry.maris2.nl/v_cdi_v3/print_wfs.asp?n_code=827370
827392	2004040010.bot (00640)	IFREMER / IDM / SISMER - Scientific Information Systems for the SEA	http://EMODnet-chemistry.maris2.nl/v_cdi_v3/print_wfs.asp?n_code=827392
827393	2004040010.bot (00650)	IFREMER / IDM / SISMER - Scientific Information Systems for the SEA	http://EMODnet-chemistry.maris2.nl/v_cdi_v3/print_wfs.asp?n_code=827393
961964	The UK Clean Safe Seas Evidence Group (CSSEG), Marine Environment Monitoring and Assessment National Database (MERMAN).	British Oceanographic Data Centre	http://EMODnet-chemistry.maris2.nl/v_cdi_v3/print_wfs.asp?n_code=961964
961970	The UK Clean Safe Seas Evidence Group (CSSEG), Marine Environment Monitoring and Assessment National Database (MERMAN).	British Oceanographic Data Centre	http://EMODnet-chemistry.maris2.nl/v_cdi_v3/print_wfs.asp?n_code=961970
961971	The UK Clean Safe Seas Evidence Group (CSSEG), Marine Environment Monitoring and Assessment National Database (MERMAN).	British Oceanographic Data Centre	http://EMODnet-chemistry.maris2.nl/v_cdi_v3/print_wfs.asp?n_code=961971
961972	The UK Clean Safe Seas Evidence Group (CSSEG), Marine Environment Monitoring and Assessment National Database (MERMAN).	British Oceanographic Data Centre	http://EMODnet-chemistry.maris2.nl/v_cdi_v3/print_wfs.asp?n_code=961972
961975	The UK Clean Safe Seas Evidence Group (CSSEG), Marine Environment Monitoring and Assessment National Database (MERMAN).	British Oceanographic Data Centre	http://EMODnet-chemistry.maris2.nl/v_cdi_v3/print_wfs.asp?n_code=961975

Table: list of WFS services for the given BBOX for points.

Whereby each link points to a CDI detail page:

http://EMODnet-chemistry.maris2.nl/v_cdi_v3/print_wfs.asp?n_code=961975



EMODnet European Marine Observation and Data Network

Portal for Chemistry
Data Discovery and Access Service

The selected data set is described below with metadata. Access to the data set itself can be requested via the EMODNet Chemistry portal that gives an overview and access to marine and ocean data sets acquired and managed by European organisations. Go to: http://www.emodnet-chemistry.eu

All data are also available through the pan-European SeaDataNet portal http://www.seadatanet.org

Details

WHAT?

Data set name	The UK Clean Safe Seas Evidence Group (CSSEG), Marine Environment Monitoring and Assessment National Database (MERMAN).
Discipline	Biological oceanography Chemical oceanography Physical oceanography
Parameter groups	Carbon, nitrogen and phosphorus Dissolved gases Nutrients Pigments Water column temperature and salinity
Discovery parameters	Ammonium concentration parameters in the water column Chlorophyll pigment concentrations in the water column Dissolved oxygen parameters in the water column Nitrate concentration parameters in the water column Nitrite concentration parameters in the water column Phaeopigment concentrations in the water column Phosphate concentration parameters in the water column Salinity of the water column Silicate concentration parameters in the water column
GEMET-INSPIRE themes	Oceanographic geographical features
Abstract	MERMAN is a national database designed to hold and provide access to data collected under the UK Clean Safe Seas Environmental Monitoring Programme (CSEMP). MERMAN is funded by the Department for Environment, Food and Rural Affairs (Defra), the Department of Agriculture Northern Ireland (DARD), the Northern Ireland Environment Agency (NIEA) and Marine Scotland. CSEMP itself provides a coordinated approach to environmental monitoring in the UK's coastal and estuarine areas. The programme fulfils the UK's commitment to European directives including its mandatory monitoring requirements under the Oslo and Paris Convention (OSPAR) Joint Assessment Monitoring Programme (JAMP). A range of stations are monitored around the UK coastline. Contaminants are measured in waters, sediments and biota to assess their distribution and fate in the environment. Biological effects are also measured to determine the response of organisms to contaminants. Data are quality assured using internal and external programmes. The participating laboratories subscribe to the Quality

Figure 42. Example of CDI record

Data product Viewing and Downloading service:
The analysed field generated by DIVA (Data-Interpolating Variational Analysis) can be visualised using the WMS protocol which supports the following requests:

- GetCapabilities

This request is used to provide all layers of the map server. To every parameter and to every region corresponds a different WMS layer. An example of such a request would be:

http://ec.oceanbrowser.net/EMODnet/Python/web/wms?request=GetCapabilities&service=WMS&version=1.3.0

- GetMap

This request allows to extract a horizontal section of the 4D NetCDF file at the specified depth and time (Example URL). Per default, the axis are not displayed on a map. This can be activated by setting the parameter DECORATED to true (Example URL).

The GetMap can also be used to extract a vertical section (Example URL). The path of the section is encoded in the SECTION parameter: the longitude and latitude are separated by a comma and the coordinates by the pipe-symbol (|). The x-axis corresponds to the distance in arc degrees along the section (the first point is the origin) and the y-axis in the depth in meters. The parameter RATIO defines the aspect ratio of the vertical section.

Images can be returned in raster (PNG) and vector image formats (SVG, EPS, PDF). They can also be saved as a KML file so that the current layer can be visualized in programs like Google Earth and combined with other information imported in such programs.

By providing multiple time instances, the web map server can also return animation in the WebM or MP4 format using this GetMap request (Example URL). As the animation are generated dynamically, it usually takes a couple of minutes to create them. The frame rate of the animation is controlled through the parameter rate.

- GetFeatureInfo

This request returns a simple XML file with the underlying value of the analysed field (Example URL).

However, the WMS standards (in version 1.1.1 and 1.3.0) is not completely adequate for ocean analyses. A WMS allows to represent a data set according a list of different styles. A legend is attributed to each style which for scalar is colorbar. The legend for a given style is represented by a link to an image.

A single legend is used for entire data set (for all depth layers and time instances in particular). However the ocean is strongly stratified and unique legend does not provide sufficient contrast because the ocean properties at depth are often very different from the properties near the surface. The solution is to make the legend dynamic so that it can be adjusted based on a range of value at a specified depth and time

Dynamic Timeseries visualizations and requests for graphs.
Oceanbrowser uses three different services to enable end users to select, display and evaluate time series and profiles of data of a certain kind of parameter. Oceanbrowser uses the OGC web services WFS and WPS for this purpose. These three services are:

1. WFS get parameters request
2. WFS get locations and features
3. WPS get time series and plot in graph

Basic requests

OGC web services WFS consists of various requests, for WFS these are:

- GetCapabilities
- DescribeFeatureType
- GetFeature

http://EMODnet02.cineca.it/geoserver/wfs?service=WFS&request=GetCapabilities yields a capabilities document from the web feature service, or in other words all functionality provided by the services. Below, a part of the yield of this service is provided in a screendump.

```
xmlns:ows="http://www.opengis.net/ows/1.1" xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:fes="http://www.opengis.net/fes/2.0" xmlns:xlink="http://www.w3.org/
xmlns:xs="http://www.w3.org/2001/XMLSchema" xmlns:emodnet="emodnet" version="2.0.0" xsi:schemaLocation="http://www.opengis.net/wfs/2.0
http://localhost:8080/geoserver/schemas/wfs/2.0/wfs.xsd" updateSequence="319">
▼<ows:ServiceIdentification>
    <ows:Title>GeoServer Web Feature Service</ows:Title>
  ▼<ows:Abstract>
      This is the reference implementation of WFS 1.0.0 and WFS 1.1.0, supports all WFS operations including Transaction.
    </ows:Abstract>
  ▼<ows:Keywords>
      <ows:Keyword>WFS</ows:Keyword>
      <ows:Keyword>WMS</ows:Keyword>
      <ows:Keyword>GEOSERVER</ows:Keyword>
    </ows:Keywords>
    <ows:ServiceType>WFS</ows:ServiceType>
    <ows:ServiceTypeVersion>2.0.0</ows:ServiceTypeVersion>
    <ows:Fees>NONE</ows:Fees>
    <ows:AccessConstraints>NONE</ows:AccessConstraints>
  </ows:ServiceIdentification>
▶<ows:ServiceProvider>...</ows:ServiceProvider>
▼<ows:OperationsMetadata>
  ▼<ows:Operation name="GetCapabilities">
    ▼<ows:DCP>
      ▼<ows:HTTP>
          <ows:Get xlink:href="http://localhost:8080/geoserver/wfs"/>
          <ows:Post xlink:href="http://localhost:8080/geoserver/wfs"/>
        </ows:HTTP>
      </ows:DCP>
    ▼<ows:Parameter name="AcceptVersions">
      ▼<ows:AllowedValues>
```


Image: example of result for GetCapabilities request

DescribeFeatureType describes all features described. In this case 2 services are available. The result of http://EMODnet02.cineca.it/geoserver/wfs?service=WFS&request=DescribeFeatureType is displayed in the figure below.


```
▼<xsd:schema xmlns:emodnet="emodnet" xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:wfs="http://www.opengis.net/wfs/2.0" xmlns:xsd="http://www.w3.org
 elementFormDefault="qualified" targetNamespace="emodnet">
   <xsd:import namespace="http://www.opengis.net/gml/3.2" schemaLocation="http://localhost:8080/geoserver/schemas/gml/3.2.1/gml.xsd"/>
 ▼<xsd:complexType name="p35_usedType">
   ▼<xsd:complexContent>
     ▼<xsd:extension base="gml:AbstractFeatureType">
       ▼<xsd:sequence>
          <xsd:element maxOccurs="1" minOccurs="0" name="p35_id" nillable="true" type="xsd:string"/>
          <xsd:element maxOccurs="1" minOccurs="0" name="geom" nillable="true" type="gml:GeometryPropertyType"/>
          <xsd:element maxOccurs="1" minOccurs="0" name="p35" nillable="true" type="xsd:string"/>
          <xsd:element maxOccurs="1" minOccurs="0" name="p36_id" nillable="true" type="xsd:int"/>
          <xsd:element maxOccurs="1" minOccurs="0" name="p36" nillable="true" type="xsd:string"/>
        </xsd:sequence>
      </xsd:extension>
    </xsd:complexContent>
  </xsd:complexType>
  <xsd:element name="p35_used" substitutionGroup="gml:AbstractFeature" type="emodnet:p35_usedType"/>
 ▼<xsd:complexType name="observed_cindexType">
   ▼<xsd:complexContent>
     ▼<xsd:extension base="gml:AbstractFeatureType">
       ▼<xsd:sequence>
          <xsd:element maxOccurs="1" minOccurs="0" name="id" nillable="true" type="xsd:int"/>
          <xsd:element maxOccurs="1" minOccurs="0" name="geom" nillable="true" type="gml:PointPropertyType"/>
          <xsd:element maxOccurs="1" minOccurs="0" name="cdi" nillable="true" type="xsd:string"/>
          <xsd:element maxOccurs="1" minOccurs="0" name="edmo" nillable="true" type="xsd:int"/>
          <xsd:element maxOccurs="1" minOccurs="0" name="p35_id" nillable="true" type="xsd:string"/>
          <xsd:element maxOccurs="1" minOccurs="0" name="p35" nillable="true" type="xsd:string"/>
          <xsd:element maxOccurs="1" minOccurs="0" name="origin" nillable="true" type="xsd:string"/>
```

This information can be used to get a certain feature via the GetFeature statement. This GetFeature statement can be completed with a query to filter on geometry and all other available entities (columns in a database) of the type names available.

For instance http://EMODnet02.cineca.it/geoserver/EMODnet/ows?service=WFS&version=1.0.0&request=GetFeature&typeName=EMODnet:p35_used&filter=<PropertyIsEqualTo><PropertyName>EMODnet:p35_id</PropertyName><Literal>EPC00005</Literal></PropertyIsEqualTo> gives the contents of P35_ID EPC00005 as displayed in the next figure.

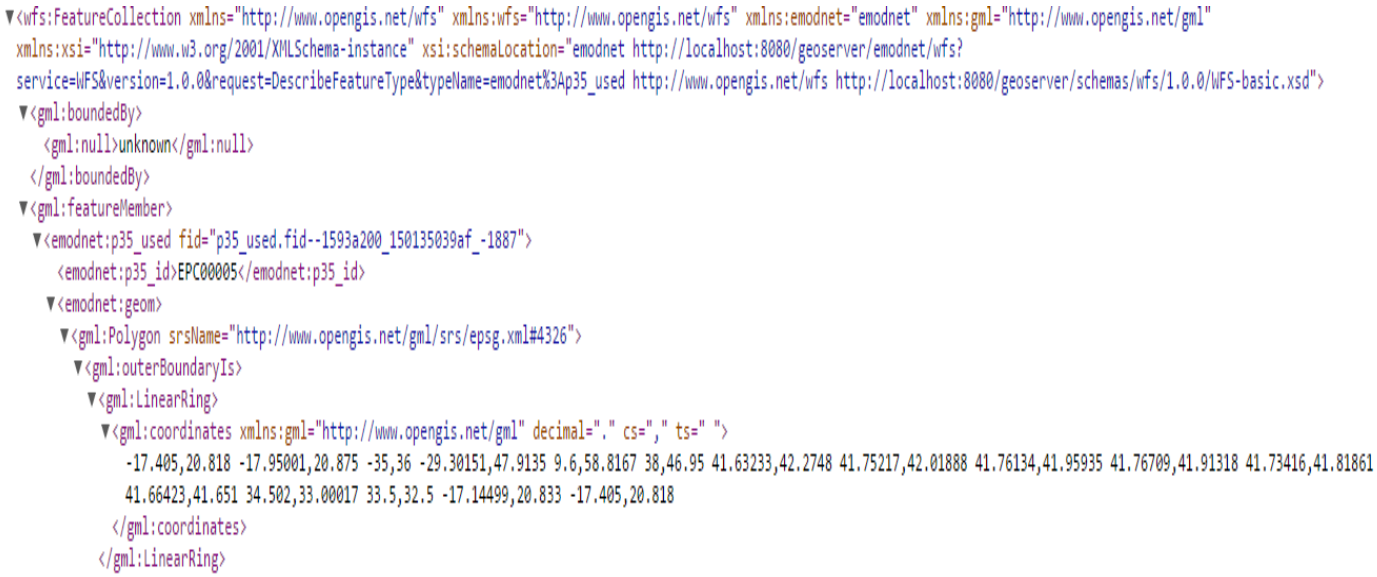
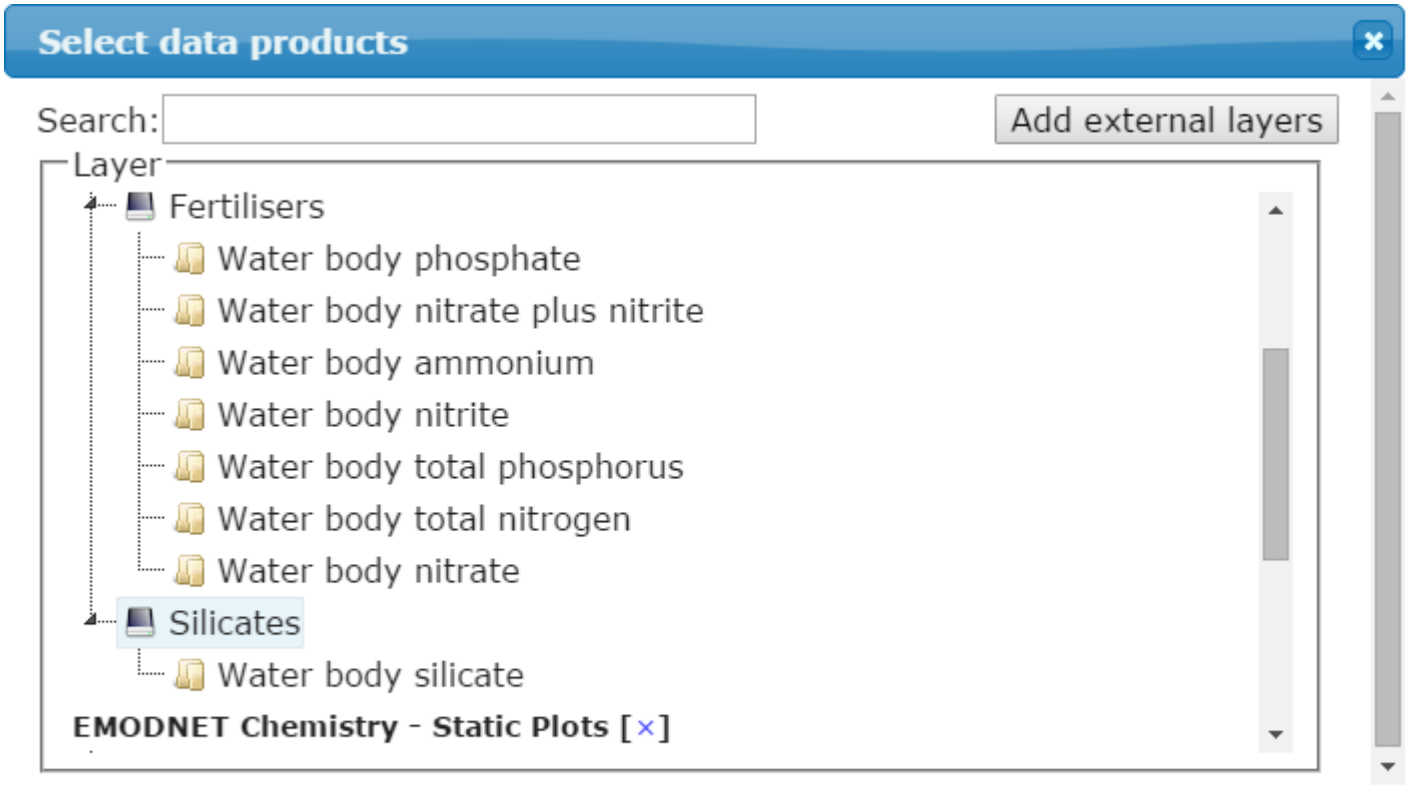


Image: example of result for GetFeature query

Above is used for the first 2 services used by OceanBrowser

1. Getting parameters
   The first WFS is a very basic process that returns a table in xml with the list of available parameters. This table is used by OceanBrowser and displayed as follows:



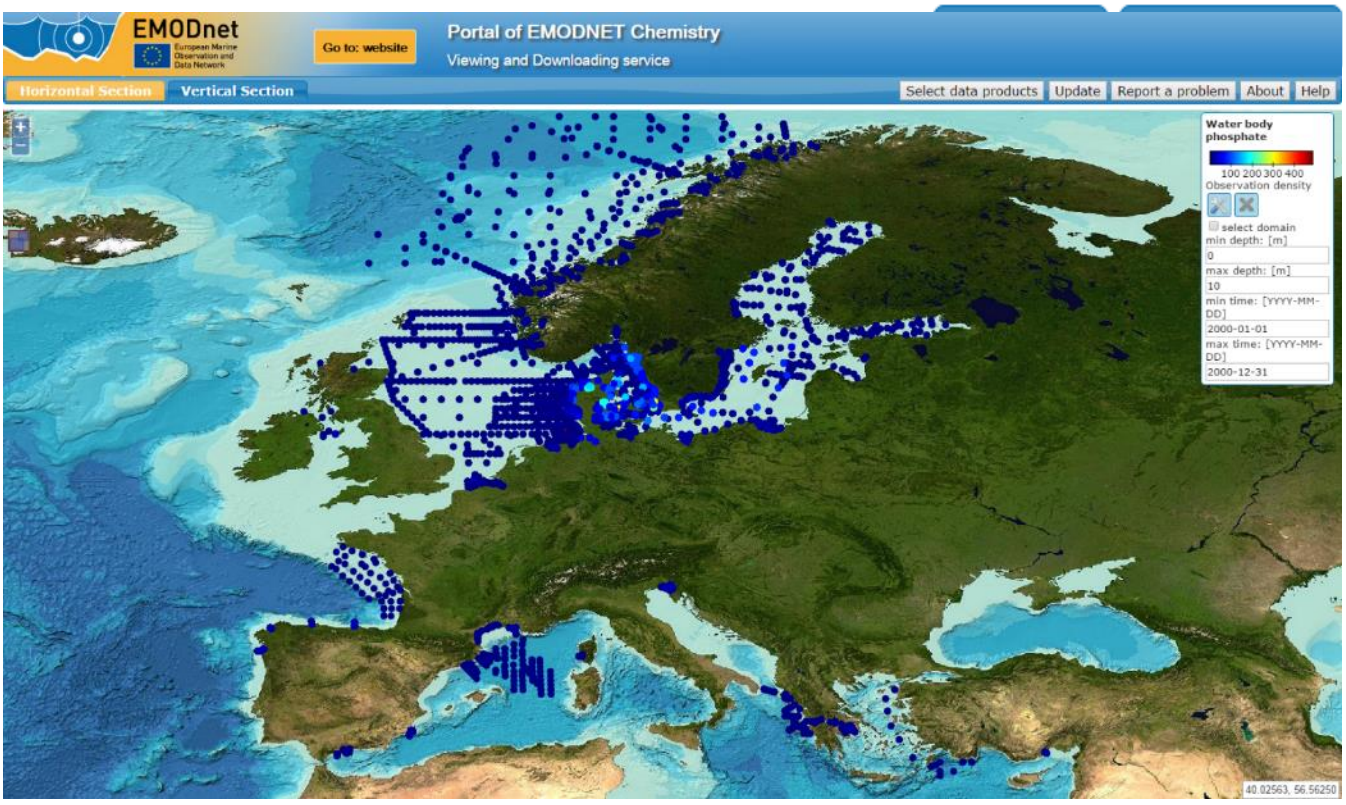


Figure 43. OceanBrowser

2. Get locations and features
   The Add layer button lets Oceanbrowser constructs a GetFeature request on the second WFS (observed_cindex) layer made available as a service.

   OceanBrowser extents the filter with Datetime and BoundingBox. Especially the boundingbox takes care of a limited amount of data transferred. For EMODnet the entire Water body phosphate locations for the link above is visualised through next image.
   Image: OceanBrowser

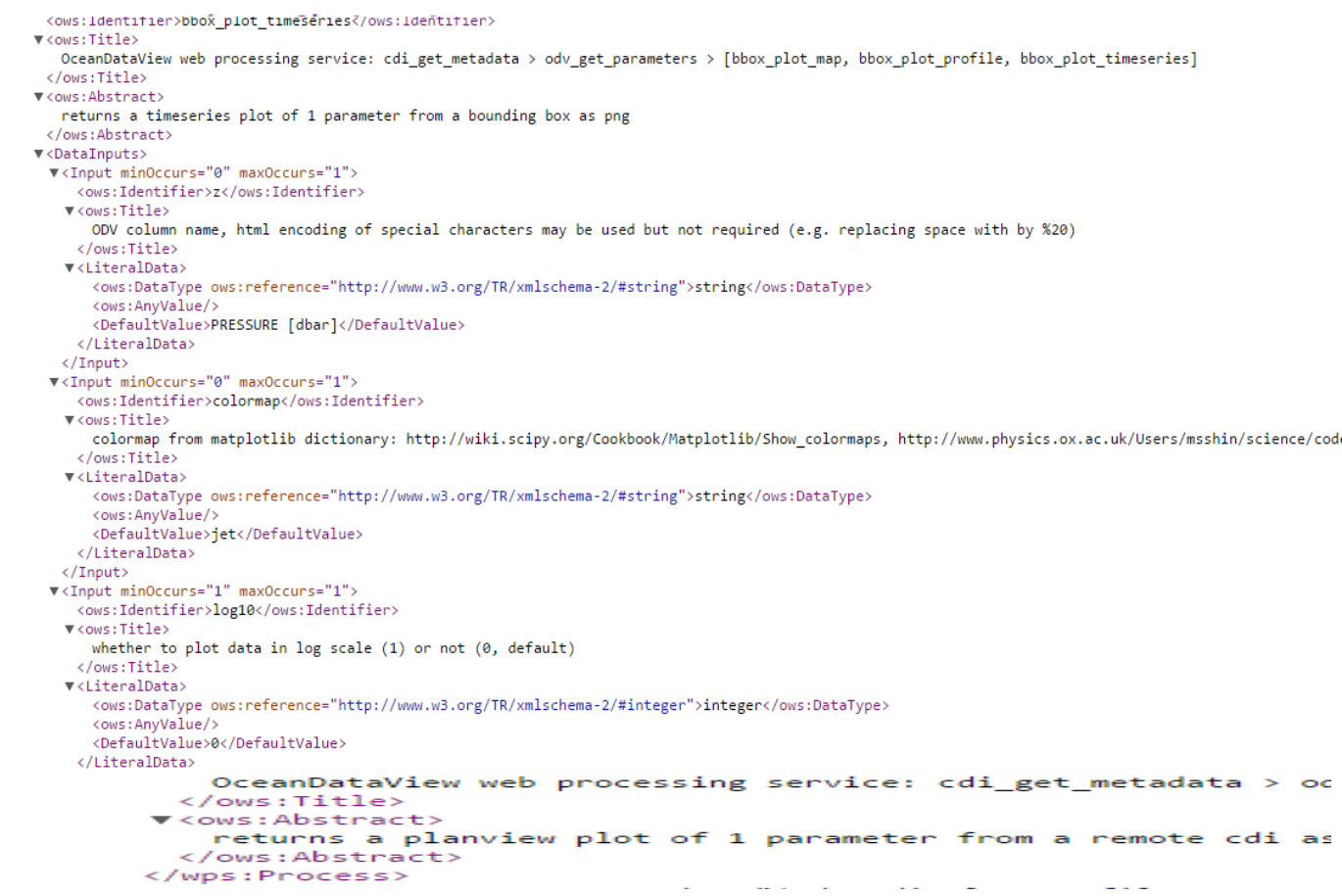
3. Plot time series of certain location
   This is done by the OGC WPS that Deltares created to be able to extract data directly from the database. WPS stands for Web Processing Service and acts as middle ware between client side software and server side software. In this case, WPS acts between OceanBrowser and a database with all observations. The above described WFS processes are used to extract information end-users are interested in. By selecting a location, data and metadata extracted from the database can be visualised in the form of a graph. WPS also makes use of:
   - getCapabilities (what can you do for me, what processes are available)
   - DescribeProcess (how does a process work)
   - Execute (execute a process)

   getCapabilities

   Gives the list of processes available.

   http://EMODnet02.cineca.it/wps?service=wps&version=1.0.0&request=getCapabilities returns

   Image:



DescribeProcess

This describes the available processes of the WPS, including the inputs required, their allowable formats, and the outputs that can be produced.

http://EMODnet02.cineca.it/wps?service=wps&version=1.0.0&request=describeProcess&identifier=bbox_plot_timeseries

Image:

ExecuteProcess

The execute process is build-up on the user choice which can be found on the right hand side of the OceanBrowser portal. OceanBrowser constructs the entire HTML including the ExecuteProcess statement which triggers the WPS.

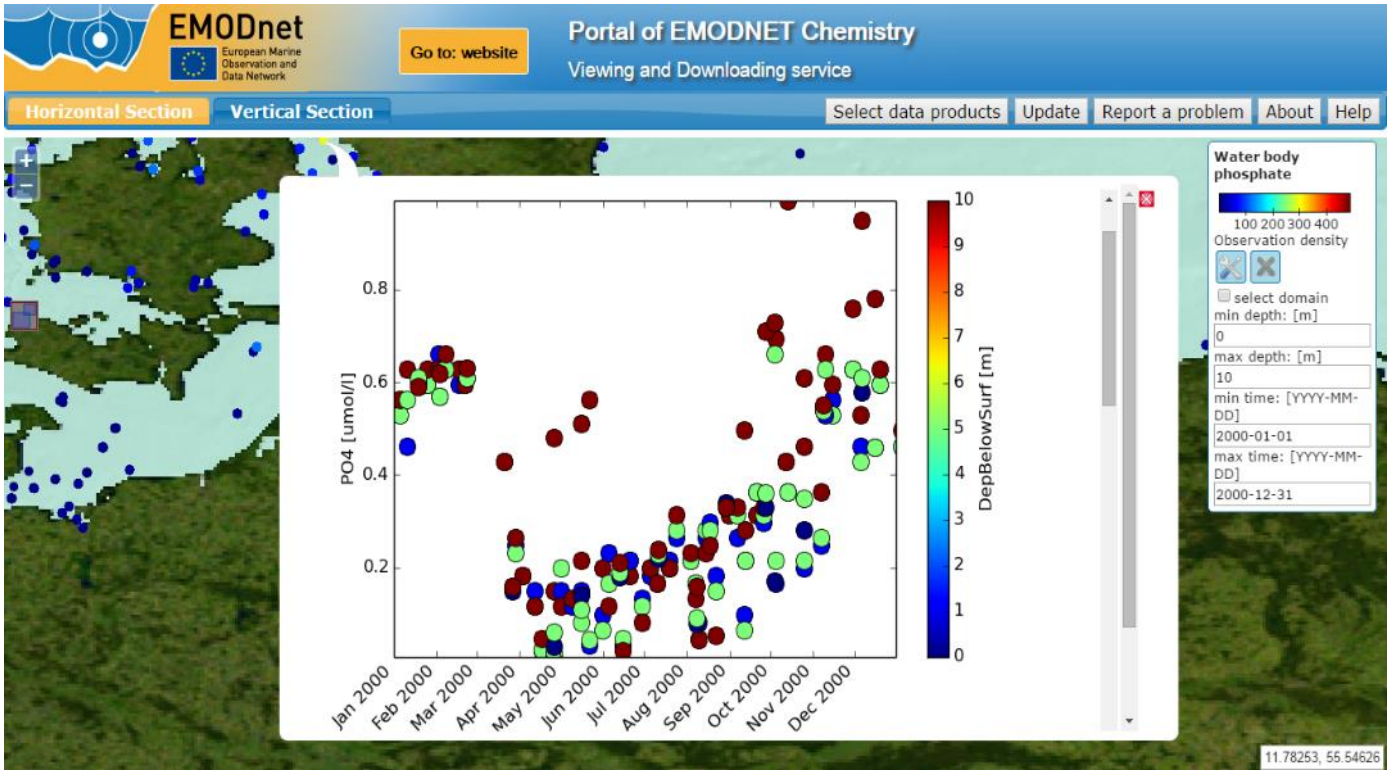


Figure 44. Ocean Browser

http://ec.oceanbrowser.net/EMODnet/proxy?url=http://EMODnet02.cineca.it/wps?DataInputs=[z=ADEPZZ01;zlim1=10;bbox=11.8750340184,11.9848973101,57.6323448275,57.742208087;starttime=2000-01-01T00:00:00Z;endtime=2001-01-01T00:00:00Z;parameter=EPC00007;zlim0=0;log10=0;markersize=12.0;alpha=1]&service=wps&request=Execute&Identifier=bbox_plot_timeseries&version=1.0.0

Eventually, end-users would like to gain insight in observation distribution for a certain location. OceanBrowser executes the process like the above example and retrieves a timeseries like the next picture.

For the same observation, different flavours can be given (from OceanBrowser). The following is a profile call, triggered from the OceanBrowser:

http://ec.oceanbrowser.net/EMODnet/proxy?url=http://EMODnet02.cineca.it/wps?DataInputs=[z=ADEPZZ01;zlim1=10;bbox=11.8750340184,11.9848973101,57.6323448275,57.742208087;starttime=2000-01-01T00:00:00Z;endtime=2001-01-01T00:00:00Z;parameter=EPC00007;zlim0=0;log10=0;markersize=12.0;alpha=1]&service=wps&request=Execute&Identifier=bbox_plot_profile&version=1.0.0

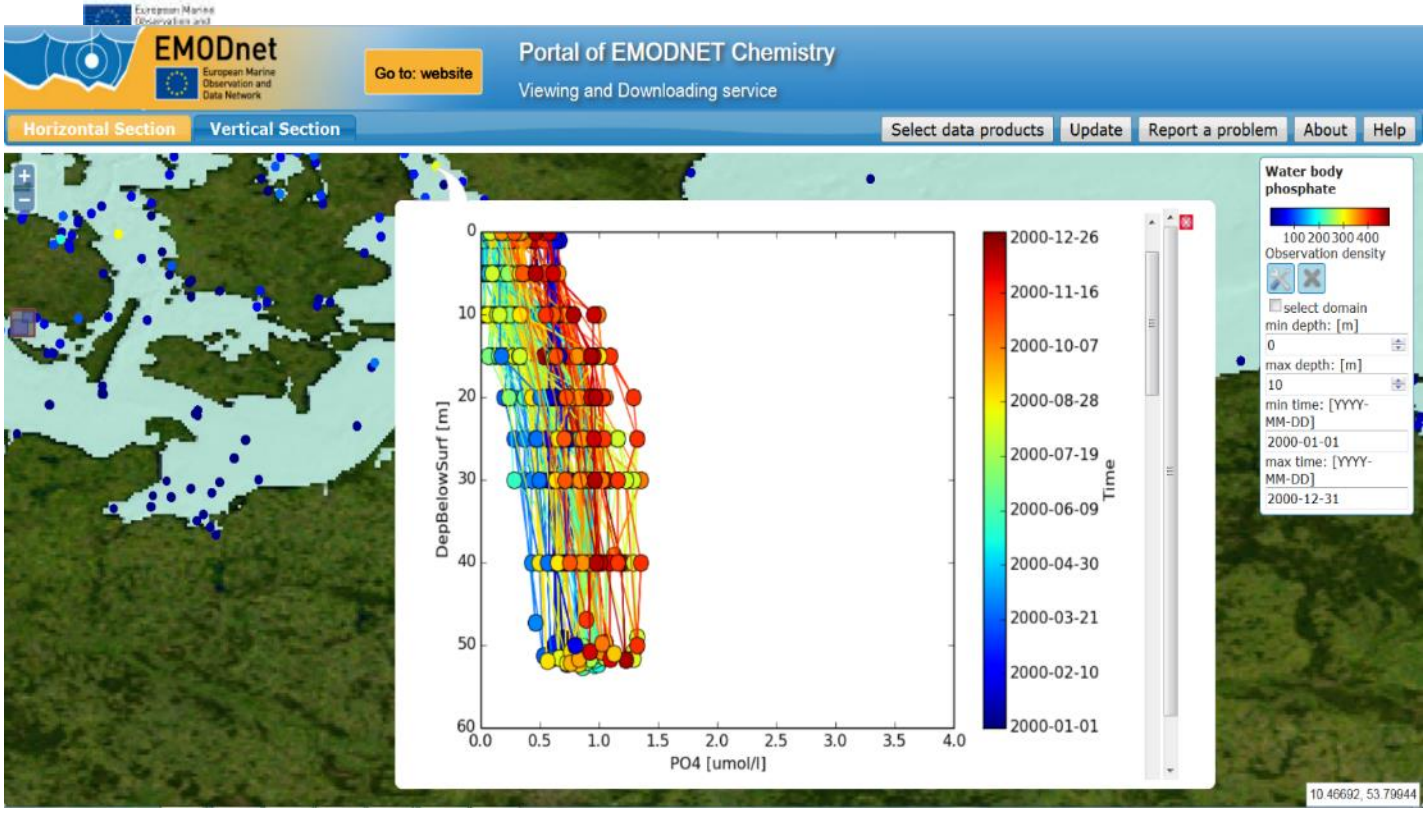


Figure 45. Ocean Browser

The output is:

Together with a picture, a list of EDMO codes, LOCAL_CDI's and links to the data shopping of the used observation is provided. For instance, this is a part of the list generated in OceanBrowser for the profile above:

- EDMO code: 729 - local CDI: Vand_111095
- EDMO code: 729 - local CDI: Vand_111096
- EDMO code: 729 - local CDI: Vand_111097
- …
- EDMO code: 729 - local CDI: Vand_111121
- …

Annex 1 Quality control of nutrients data and DIVA products in the Black Sea