

# Interactive comment on “The role of EMODnet Chemistry in the European challenge for Good Environmental Status” by Matteo Vinci et al.

## Anonymous Referee #1

Received and published: 17 August 2016

Summary: The author presents EMODNet-Chemistry, i.e., a portal that should deliver data and metadata for different chemical groups that are directly related to the Marine Strategy Framework Directive and, in particular, to the definition and monitoring of the Good Environmental Status of marine environments. The paper also provides a good and clear explanations of the main objectives of the EU in addressing maritime issues and describes relationships and roles among different European “structures” such as the MSFD, the DG-MARE, etc.

General Comment: The paper is well structured and it clarifies several “entities”, efforts, and tools that the EC and the EU set in order to bridge the gaps among marine science, data collection and availability, and marine policies. The reader will definitely appreciate the clear explanation of how the EMODNet-Chemistry portal (as well as similar portals) addresses the main environmental protection needs. However, there are several, specific points that make the paper not suitable for a scientific audience: some parts need to be expanded (the authors may not be familiar with some definitions) and most of the figures are not well presented (see specific comments). In particular, most of the figures are not mentioned within the text.

We have considered carefully reviewer #1’s observations and suggestions. The manuscript and the figures were re-organized, integrating the text with more explanations on the concepts presented and providing additional references. As suggested, several parts were expanded, all needed figures and tables were introduced and cited in the text, and figure quality was improved. The detailed answers to the comments are given below, after the Reviewer’s indications. A reviewed version of the manuscript will be included in the reply supplement to clarify the improvements. In red are highlighted the changes done following the comment n.1 while in orange the changes done following the comment n.2.

Specific comments:

Line, 9: The authors should provide a very brief explanation of the GES: : : several non-EU marine scientists will not understand what the Good Environmental Status is.

Line 27: Define here the acronyms GES

Line 28-29: This sentence is good for the abstract. Here, in Intro, the authors should spend some more words for defining and explaining the GES.

*The text has been integrated as follows:*

*The European Union has set the ambitious objective to reach within 2020 the goal of Good Environmental Status (GES) for our oceans and seas. The challenge consists in facing the environmental degradation caused by years of unsustainable and inefficient growth model. The Marine Strategy Framework Directive (MSFD, European Commission 2008) adopted in 2008, with its eleven descriptors and related indicators, represents the legislative framework and the backbone of this work. MSFD defines the GES in Article 3 as: “The environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive”. GES means that the different uses made of the marine resources are conducted at a sustainable level, ensuring their continuity for future generations. Going more in*

*detail for the restoration and the safeguard of this status, the ecosystems (including their hydro-morphological, physical and chemical conditions) should be fully functioning and resilient to human-induced environmental change, the decline of biodiversity caused by human activities should be prevented and biodiversity is protected. The human activities (introducing substances and energy) shouldn't cause pollution effects and noise from human activities should be compatible with the marine environment and its ecosystems.*

Line 35: rephrase as: "Some efforts have already been undertaken by Member States in 2012, which provided initial assessments of: : [explain]"

*We suggest the following improvement:*

*Some efforts have already been undertaken by European Member States which provided in 2012 the initial assessment on the state of the environment of the national marine waters. This assessment reported on environmental status determined in a holistic way, according the 11 descriptors, and on the objectives and targets to reach GES following the articles 8, 9 and 10 of the MSFD.*

*The results of the first phase allowed to recognize gaps and needs in data availability, large heterogeneity of methodological approaches to report information and spatial inconsistency within Member States regarding coastal – offshore data. These outcomes clearly indicated that more efforts are urgently needed if the EU is to reach its goal. More has to be done on the cooperation side and especially on the integration between Member States and Regional Sea Conventions (RSC). The report from the Commission on the first phase of implementation of MSFD indicates a high level of heterogeneity among Member States reports and in several cases poor data availability and accessibility (Dupont et al., 2014; Palialexis et al., 2014)*

Line 40: rephrase as: "As a consequence, evaluation at higher level: : :"

*As a consequence, evaluation at higher level (Regional and EU) is difficult to perform.*

Line 42-43: This sentence is not clear. Please, explain better.

*This first phase of MSFD implementation has somehow brought Europe one step closer to the ecosystem approach. However, the recognized gaps in data and information, the high heterogeneity in assessment approaches should guide the stakeholders involved in MSFD implementation to develop a more homogeneous approach. In view of the revision of the assessment in 2018, several efforts are required to overcome the shortcomings identified in the first reporting phase. Going more in detail, the actions should be focused on different aspects like: revised criteria for GES, methodological standards and standardised methods for monitoring, assessment and data availability, implementation of integrated information systems at regional and EU level.*

Line 50: A reference is needed here.

*In the field of marine research, during the last decades several oceanographic data management initiatives faced the challenge of data availability, interoperability and resilience at Pan-European level. (EU MAST MTP II MATER 1996-1999, EU MAST-INCO MEDAR 1999-2001, FP6 SeaDataNet 2006-2011, FP7 SeaDataNet2 2011-2015).*

Line 65: Please, rephrase as: "Metadata, i.e., all the information needed to describe exhaustively the data, are: : :"

*The simple but efficient idea was the active collection of the EU oceanographic data at national level carried out by a network of National Oceanographic Data Centres (NODCs). The collection of those data was done in direct communication with the data originators to ensure the best set of measured data and related metadata. Metadata, that are all the information needed to describe exhaustively the data, reply to a set of basic but fundamental questions like: who, where, when,*

*what and how about the collected information. For this reason they are key elements to enable efficient browsing and discovering.*

Line 70: Please, rephrase as: "The standardization is done at two main levels by following the interoperability principles provided by INSPIRE: "

*The standardization is done at two main levels by following the interoperability principles provided by INSPIRE: syntactic and semantic. The first is done providing common formats for the files providing metadata and data (XML ISO, ascii).*

Line 72: Replace "thanks to" with "by means of"

*The second is done by means of a set of common vocabularies that let to "use the same language" to describe data and metadata over time, different projects and nationality.*

Line 90: The list should end with a come, such as "seabed habitats, and physical oceanography."

*A pilot project was launched by DG-MARE in 2009 to create the components of the European Marine Observation and Data Network (so called ur-EMODnet), as proposed in the EU Green Paper on Future Maritime Policy (European Commission 2006), consisting in six thematic data portals managing data on bathymetry, marine geology, chemistry, biology, seabed habitats, and physical oceanography.*

Line 100: I would write "Ocean Data View (ODV)". Some readers may not know what ODV is.

- *Standard data transport formats Ocean Data View (ODV) ASCII, MEDATLAS and NetCDF (CF);*

Line 109; Rephrase as "in data collection, data analyses, validation, and creation: : :"

*The partnership involved a subgroup of the SeaDataNet network of National Oceanographic Data Centres (NODCs) with specific experience in data collection, in data analyses, validation, and creation of products and in the technical partners who further developed SDN infrastructure.*

Line 129: Refer here to Fig. 1

*The new phase includes data collection for all European sea-basins: the Baltic Sea, the North-East Atlantic Ocean, the Mediterranean Sea and the Black Sea and involves 46 partners (Fig.1), both from research institutes and national monitoring agencies.*

Figure 1: In general all figures seem to be done in haste. In Figure 1 caption should clearly explain the meaning of colors, logos, and logo positions.

*We suggest as follow:*

*Figure 1: Geographic coverage of EMODnet Chemistry partnership. Logos indicate the nationality of the partner institutes.*

Figure 2: This figure is quite useless. It would be much more interesting to show a density map, or something similar, which might highlight the differences among subbasins in the EMODNet-Chemistry coverage. The figure is note cited within the text.

We suggest the following improvement:

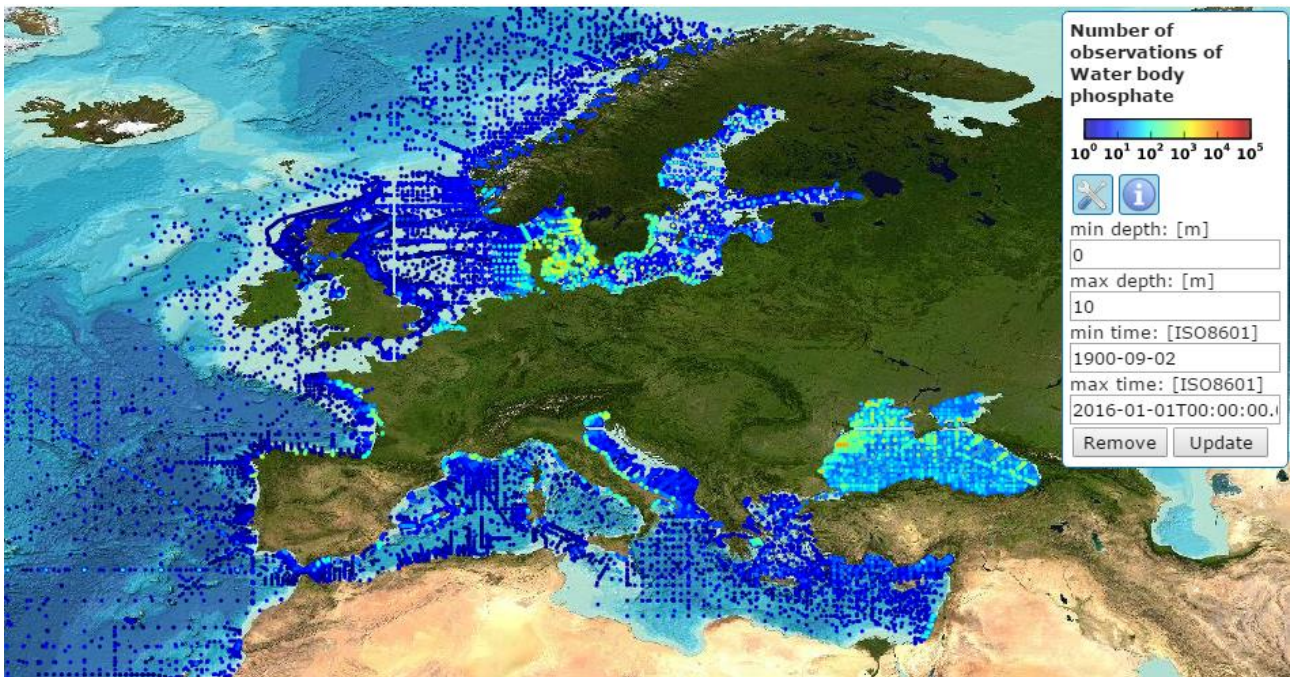
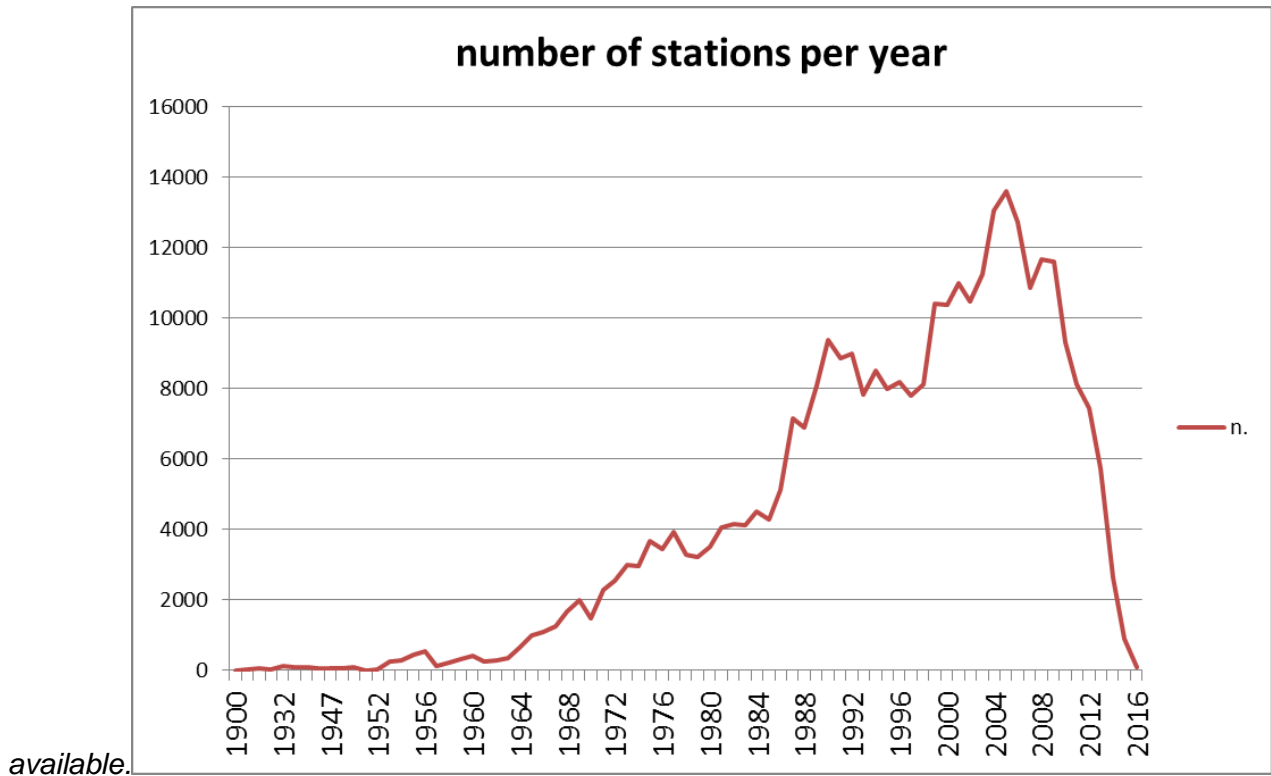


Fig. 2: Density and distribution of water body phosphate harvested stations

Figure 3: The figure is not cited within the text

We suggest to change the position of the figure (now figure 4) and table and cite them as follow:

*By maximizing the availability of data to a larger community, SeaDataNet promotes the use of these data, thereby ensuring that their maximum value can be realized and thus contribute to increase knowledge of the marine environment. Fig. 4 shows temporal distribution of nutrient data, spanning from 1900 to 2016; table 1 shows the number of stations for parameters with more data*



available.

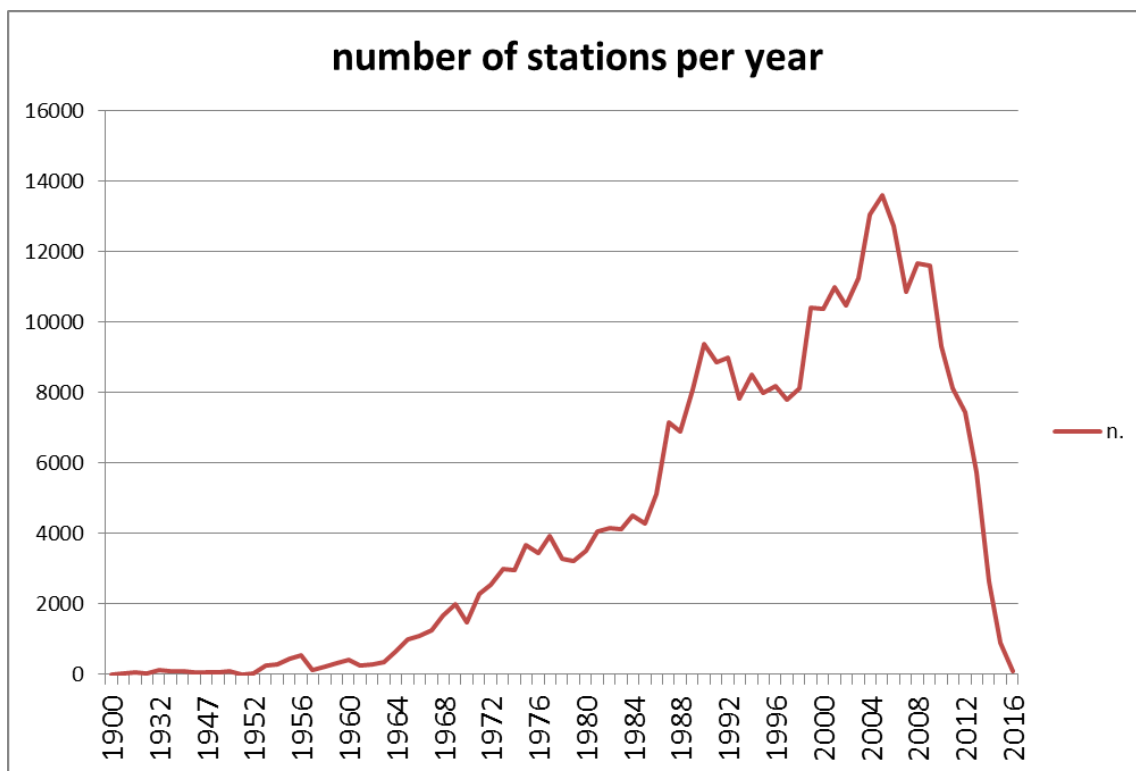
Fig. 4: Temporal distribution of nutrient data, spanning from 1900 to 2016 (counting 90 profiles in the current year; updates May 2016).

Parameter	n.
Phosphate concentration parameters in the water column	305896
Nitrate concentration parameters in the water column	262378
Silicate concentration parameters in the water column	245755
Dissolved oxygen parameters in the water column	198357
Ammonium and ammonia concentration parameters in water bodies	188666
Nitrite concentration parameters in the water column	181642
Salinity of the water column	151969
Chlorophyll pigment concentrations in water bodies	145374

Table 1 number of stations for the parameters with more data available

Table 1 and 2: They are not cited within the text. Moreover, I do not understand the text "With the following: : :." on top of these tables. It looks like that the tables want to be connected to Figure 4. This is unusual and distractive.

*Our suggestions are to eliminate "With the following: : :". Table one has been cited (see the previous point) while Table2 doesn't exist.*



**Fig.4: Temporal distribution of nutrient data, spanning from 1900 to 2016 (counting 90 profiles in the current year; updates May 2016).**

Parameter	n.
Phosphate concentration parameters in the water column	305896
Nitrate concentration parameters in the water column	262378
Silicate concentration parameters in the water column	245755
Dissolved oxygen parameters in the water column	198357
Ammonium and ammonia concentration parameters in water bodies	188666
Nitrite concentration parameters in the water column	181642
Salinity of the water column	151969
Chlorophyll pigment concentrations in water bodies	145374

**Table 1: number of stations for the parameters with more data available**

Line 210-213: It would be better to provide some references here. See Colella et al. (2016) [PloS one 11 (6), e0155756] and references therein.

To improve and harmonize the quality control procedures and standards adopted (at least at regional level), a quality control survey has been carried out within EMODnet Chemistry community, in order to collect the best practices in data validation and highlight gaps of the different institutes involved (Vinci et al., 2015).

See Colella et al. (2016) [PloS one 11 (6), e0155756] and references therein

*Our proposal is the following:*



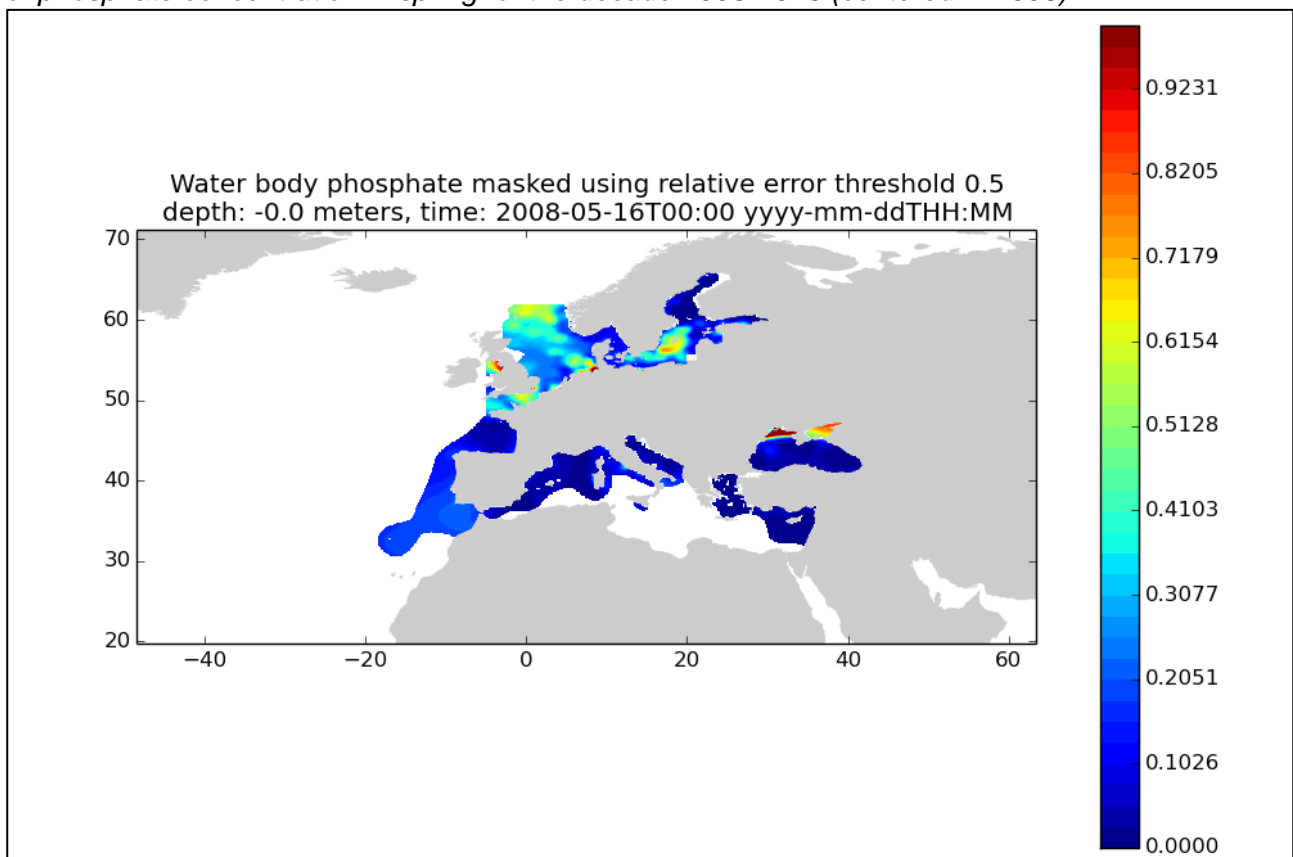
*In order to accomplish the Marine Strategy Framework Directive requirements, EMODnet Chemistry developed products suitable to visualise the time evolution of a selected group of measurements and to calculate spatially distributed data products specifically relevant for MSFD descriptor 5 (eutrophication), 8 (chemical pollution) and 9 (contaminants in seafood) as typically done with satellite data (Colella et al., 2016; Gohin et al., 2008)*

Figure 5: Yet, this is a screen shot from the web. It would be better to show an actual figure that is downloadable from the web and then explain in the caption how that map can be obtain from the portal. The figure is not cited within the text.

The figure will be modified and will be cited in the text as follows:

*Interpolated maps are now generated, mainly for nutrients, with 10 years moving window in order to find a balance between the duration of the environmental evaluation cycle for Member States (to provide maps with a time frame near to the 6 years process of the Member States evaluation) and the number of years that guarantee a sufficient data coverage.*

*An example of a visualization useful for the assessment of eutrophication and in particular of nutrient concentration in the water column is presented in Fig. 6, which displays surface distribution of phosphate concentration in spring for the decade 2003-2013 (centered in 2008)..*



*Fig. 6: 10 years average of water body phosphate concentration ( $\mu\text{mol-P l}^{-1}$ ) in the surface layer for all EU sea basins (years 2003-2013). Interpolated Maps can be selected from the Ocean Browser viewing service interface with the following steps: choose "Select data products" button, scroll and choose in the pop-up window from the list of available products and then select "Add layer" in the lower left corner of the pop-up window. Maps can also be downloaded in different formats obtaining results as in this example (PNG file).*

Figure 6: Is this really useful? The figure is not even cited within the text. If the author believe that Fig. 5 is needed I would strongly recommend not to use a slide from power

point. This is not suitable for a scientific publication.

We suggest the following improvement with improved figure and citation in text:

Figure 6 has been moved up in the “Data quality” section and is now Fig.5. The figure quality has been improved and it is cited in the text as follows:

...

The main goal of this activity is to obtain a harmonized dataset (e.g. a unique dataset of phosphate concentration in the water column starting from different datasets of phosphate concentration expressed with different units) that could be used to generate homogeneous data products. The results of the regional quality control are sent to the data collators (NODCs) to correct errors or anomalies in the original copy of the data available in the EMODnet infrastructure. This feedback loop guarantees data quality upgrade (Fig.5).

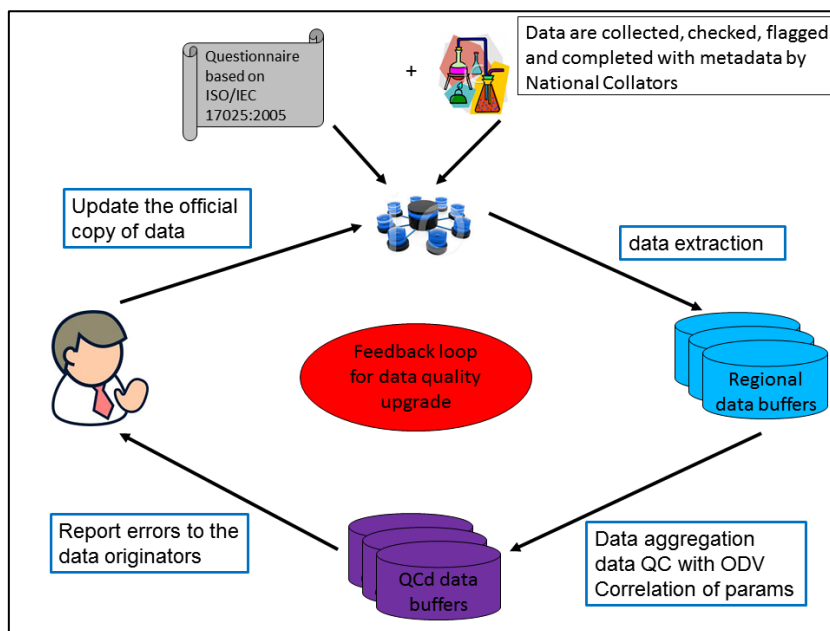


Fig. 5: Data validation loop

To improve and homogenize the quality control procedures and standards adopted (at least at regional level), a quality control survey has been carried out within EMODnet Chemistry community, in order to collect the best practices in data validation and highlight gaps of the different institutes involved (Vinci et al., 2015).

Figure 7: I understand that here it is useful to show a screen shot. However, the caption should state this.

We suggest to improve the caption and cite the figure as follow:

Profiles and time series plots are automatically generated from the Regional aggregated and validated datasets (called Regional buffers), thanks to a service bases on WPS OGC standard, and can be dynamically customized. (Fig.7)



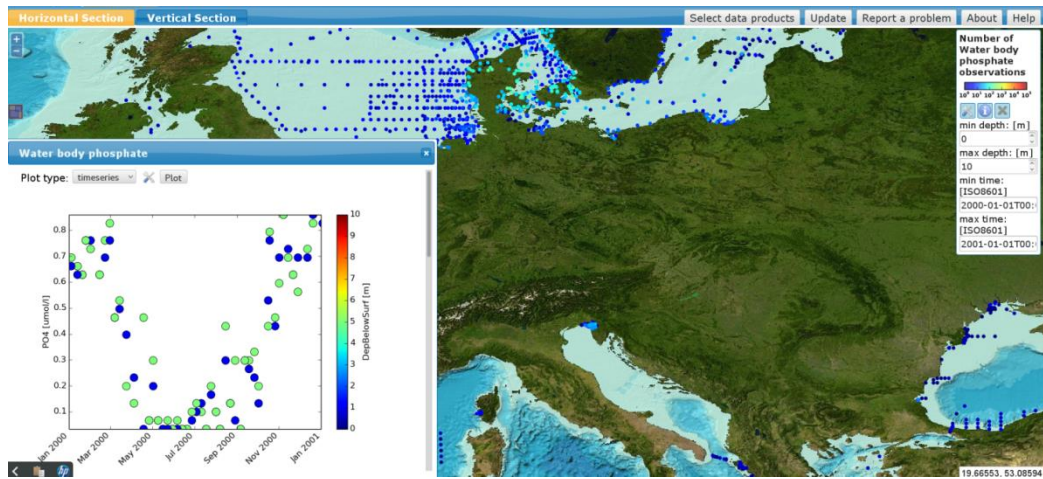


Fig. 7: screenshot from the web portal showing the Time Series dynamically plotted and visualized thanks to the OGC WPS services

# Interactive comment on “The role of EMODnet Chemistry in the European challenge for Good Environmental Status”

by

Matteo Vinci et al.

Anonymous Referee #2

Received and published: 11 September 2016

Review of the manuscript: The role of EMODnet chemistry in the European challenge for good environmental status. M. Vinci, A. Giorgetti, M. Lipizer Submitted to Natural Hazards and Earth System Sciences. REF: NHESS226-2016.

The paper describes the effort carried out by the EMODnet Chemistry community to make available, to the marine sciences audience, a reliable and effectively usable dataset for chemical and biogeochemical properties for the European Seas, aiming to contribute the information and knowledge base necessary for the EU-MSFD objective of “good environmental status” for the European Seas.

It is an important and highly valuable effort. The present manuscript does not attempt to extract scientific information from the data collected, but tries to provide a description of the structure and the quality of the data that EMODnet chemistry is going to make available to the marine scientists communities.

Therefore, the manuscript, even if it cannot precisely be considered as a scientific paper providing original findings, deserves (in principle) publication. Unfortunately due to a series of formal problems it cannot be published in the present form, as it looks like hastily written, without taking much care in clarity and ordered structure.

A revision of the formal structure of the manuscript is absolutely mandatory.

Many concepts and information are taken for granted and a general reader might therefore find the manuscript rather confusing.

Figures (see below) are not correctly referenced in the text and often the relative captions are very, very sloppy.

*The authors acknowledge the comments and suggestions of the reviewer and the need of a revision of the manuscript with the objective to improve the clarity of the described topic. The manuscript has been integrated explaining better the concepts (that sometimes were taken for granted). Presentation of figures and tables were improved following the reviewer's suggestions. Following these actions we believe that the manuscript has already improved and been made clearer.*

*If the editor considers it necessary, we can also reorganize the structure of text, add a glossary to facilitate understanding of several specific terms used in the manuscript and the text can be revised by a native English speaker.*

*Below the replies to the specific comments received.*

Below some specific remarks that I hope might help the Authors to improve the

manuscript.

A reviewed version of the manuscript will be included in the reply supplement to clarify the improvements. In red are highlighted the changes done following the comment n.1 while in orange the changes done following the comment n.2.

Line 50: please explain better how a data management system could achieve interoperability and resilience. The explanations given are still a bit "obscure".

*We suggest the following improvement.*

*In the field of marine research, during the last decades several oceanographic data management initiatives faced the challenge of data availability, interoperability and resilience at Pan-European level. (EU MAST MTP II MATER 1996-1999, EU MAST-INCO MEDAR 1999-2001, FP6 SeaDataNet 2006-2011, FP7 SeaDataNet2 2011-2015).*

*Interoperability is defined as "the ability of a system to work with or use the parts of another system", while resilience is defined as "the ability of a system to cope with change". The translation of these principles in the oceanographic data management consists in the development of a long life system able to easily interact with other systems. As example the adoption of common formats for data and metadata and a system of common vocabularies ensure that the network of involved persons is working in a homogeneous environment from the syntactic and semantic point of view (speaking a common language). The resilience is safeguarded by metadata and quality flags that provide clear knowledge of which kind of information the users are handling even long time after the data measurement (e.g. use of historical data for time series studies).*

Line 111: MSFD and not MSDF

Ok

Line163. explain better the criteria for data restriction

*Following the comment to the manuscript received by the previous reviewer this part has been eliminated. The text describing the data policies is available from line 175 until 186 as follow:*

*Data access is regulated by a data policy (defined in agreement with data originators) which aims to establish a balance between the right of the originator to get proper acknowledgment for data acquisition, and the need for open access through free and unrestricted exchange of data, meta-data and data products. The analysis of data policies Ffor EMODnet Chemistry data shows differences between data access restrictions for nutrients and contaminants (Fig. 3).*

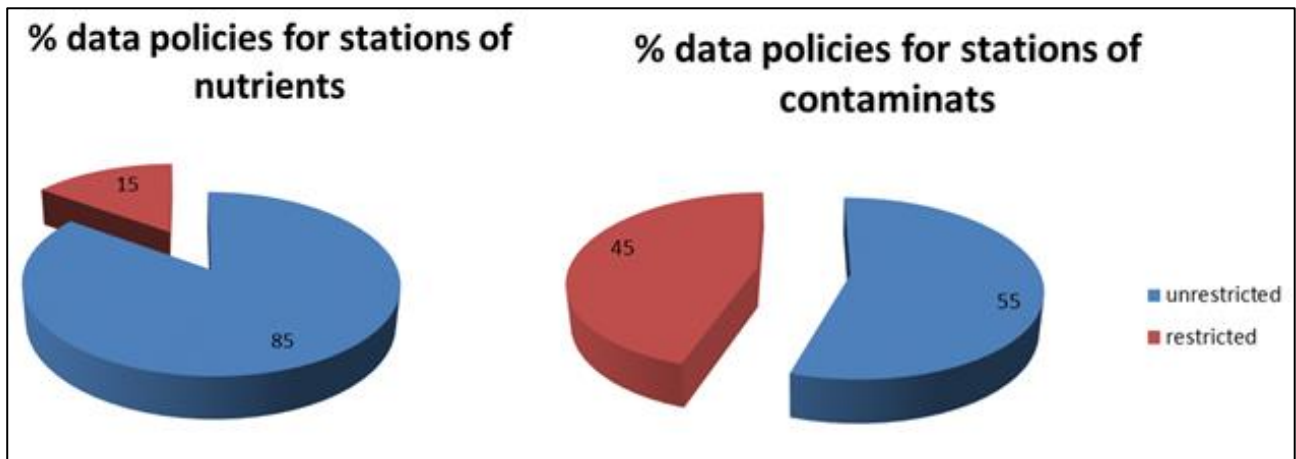


Fig. 3: Data policy for nutrients and contaminant data

*Data requests from registered users are handled by NODCs through a data policy management system. Unrestricted data are freely available while restricted ones need negotiation with data originators. This kind of filter on data access is an effective way to establish contacts and trust between data originators and data management centres, ensuring correct acknowledgement, which ultimately encourages data sharing.*

Line 195 and followings. Explain better (for the general reader) the meaning of codes such as P01 vocabulary and P35 vocabulary.

*We prefer a more general explanation of the vocabularies involved in our workflow to avoid too specific or technical descriptions. Following this we suggest the following improvement.*

...

*Data aggregation is done with the objective to unify the various analytic terms into a unique aggregated term with conversion to a unique measurement unit..*

*The ODV software has a built-in aggregation procedure applying a number of business rules like possible units conversions. (Lowry R. et al., 2013)*

*The main goal of this activity is to obtain a harmonized dataset (e.g. a unique dataset of phosphate concentration in the water column starting from different datasets of phosphate concentration expressed with different units) that could be used to generate homogeneous data products. The results of the regional quality control are sent to the data collators (NODCs) to correct errors or anomalies in the original copy of the data available in the EMODnet infrastructure. This feedback loop guarantees data quality upgrade (Fig.5).*

Section 6. Spend more words to illustrate the procedure for data mapping (DIVA protocol)!!!!

*We suggest the following improvement.*

*The interpolated maps have been produced with the variational inverse method (VIM; Brasseur et al., 1996), using the software DIVA (Data-Interpolating Variational Analysis; Troupin et al., 2010). DIVA is an appropriate numerical implementation of VIM suitable for*

*oceanographic data spatial analysis as it is designed to obtain a gridded field from the availability of non-uniformly distributed observations (Barth et al., 2010; Troupin et al., 2012).*

Section 6 Validation loop must be described better. Just putting a (not referenced) figure with a sloppy caption is not enough!!!!

*Figure 6 has been moved to section “5 Data Quality” where the “Validation loop” was described in a quite detailed way in the text from line 202 to 227, and the figure is now cited in the text. Now the figure is in the correct position and cited to link the description to the image (that in our opinion clarify in a simple but efficient way the workflow).*

## 5. Data Quality

*The quality of the data is a key issue when merging heterogeneous data coming from different sources, periods and geographic areas. Within EMODnet chemistry community, commonly agreed and standardized data quality control (QC) protocols have been defined (Holdsworth, 2010) to guarantee consistency among comprehensive databases which include data from different and/or unknown origin and covering long time periods. As a first step, the data are checked and completed by collators with a standard set of metadata that provide the basic information necessary for their long term use. Afterwards, data undergo a validation loop which consists in several validation steps. The first is done by data collators, prior to the inclusion in the decentralized infrastructure and the second step, which consists in regional quality control, is performed at regional scale on aggregated datasets. The first quality controls (QC) ensure that position and time of data are realistic and compare measurements with broad ranges and specific regional ranges. Whenever available, data are also compared with climatology. As a result of the first QC step, all data are archived with a quality flag value that provides information about their reliability.*

*At this point, data aggregation and regional quality control are performed at regional scale, following a common protocol. Data aggregation is done with the objective to unify the various analytic terms into a unique aggregated term with conversion to a unique measurement unit. The ODV software has a built-in aggregation procedure applying a number of business rules like possible units conversions. (Lowry R. et al., 2013)*

*The main goal of this activity is to obtain a harmonized dataset (e.g. a unique dataset of phosphate concentration in the water column starting from different datasets of phosphate concentration expressed with different units) that could be used to generate homogeneous data products. The results of the regional quality control are sent to the data collators (NODCs) to correct errors or anomalies in the original copy of the data available in the*

EMODnet infrastructure. This feedback loop guarantees data quality upgrade (Fig.5).

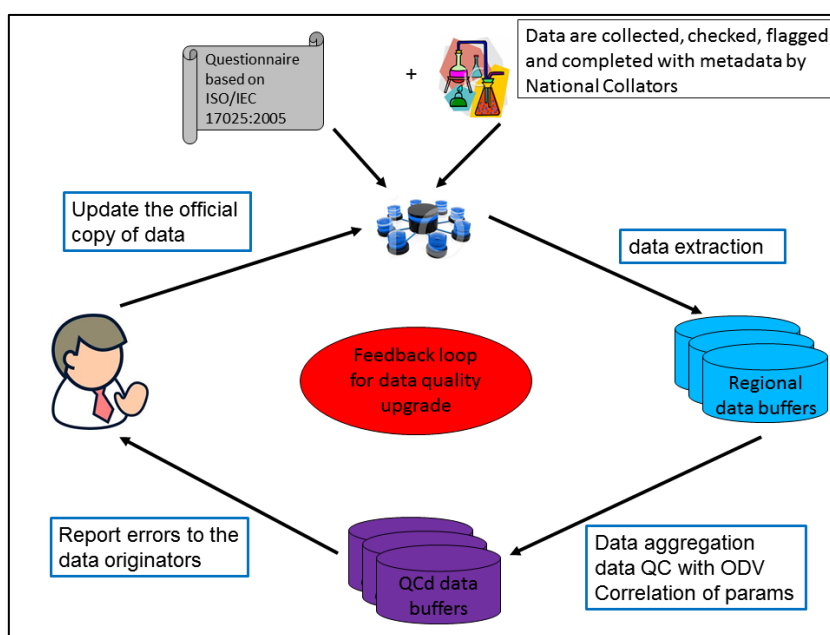


Fig. 5: Data validation loop

To improve and homogenize the quality control procedures and standards adopted (at least at regional level), a quality control survey has been carried out within EMODnet Chemistry community, in order to collect the best practices in data validation and highlight gaps of the different institutes involved (Vinci et al., 2015).

Figures and tables are not correctly referenced in the text. Please reference them correctly. Just writing (for instance) "with the following data policy distribution" and putting below a figure (or a table) is not OK. Moreover figure captions need to be rewritten in order to be more consistent with the pertinent text and with the figures themselves

In particular:

Figs 1, 2, 3, 5, 6, 7 are not referenced in the text Tab 1. Is not referenced in the text and the caption needs rewriting Fig. 4 needs a better caption.

Authors agree on the improvement of figures, tables, captions and references that have been already updated in text.

Fig.1 is cited now at line 150

Fig.2 is cited now at line 168

Fig.3 is cited now at line 178

Fig.4 and Tab.1 are cited now at line 189

Fig.5 is cited now at line 221

Fig.6 is cited now at line 242

Fig.7 is cited now at line 252



# 1 The role of EMODnet Chemistry in the European challenge for 2 Good Environmental Status

3  
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6 (TS) - Italy

7 *Correspondence to: Matteo Vinci mvinci@inogs.it, Alessandra Giorgetti agiorgetti@inogs.it, Marina Lipizer*  
8 *mlipizer@inogs.it*

9 **Abstract:** the European Union set the ambitious objective to reach within 2020 the goal of Good Environmental Status.  
10 The Marine Strategy Framework Directive (2008) represents the legislative framework that drives Member States  
11 efforts to reach it. The Integrated Maritime Policy supported the need to provide a European knowledge base able to  
12 drive sustainable development by launching in 2009 a new European Marine Observation and Data Network  
13 (EMODnet). Through a stepwise approach, EMODnet Chemistry aims to provide high quality marine environmental  
14 data and related products at the scale of regions and sub-regions defined by the Marine Strategy Framework Directive.  
15 The Chemistry Lot takes advantage and further develops the SeaDataNet pan-European infrastructure and the  
16 distributed approach, linking together a network of more than 100 National Oceanographic Data Centres providing data  
17 from more than 500 data originators. The close interaction with EEA, RSCs, ICES and EMODnet-MSFD coordination  
18 group allows to assess the most proper set of information necessary for the MSFD process. EMODnet Chemistry  
19 provides aggregated and validated regional data collections for nutrients, dissolved gasses, chlorophyll and  
20 contaminants, properly visualised with OGC WMS and WPS viewing services. Concentration maps with 10-year  
21 moving window from 1960 to 2014, by season and for selected vertical layers are computed and made available.  
22

23  
24 **Keywords.** Marine chemistry; Europe; Marine Strategy Framework Directive; Good Environmental Status;  
25 Eutrophication; Contaminants;

## 26 1. Introduction

27  
28 The European Union has set the ambitious objective to reach within 2020 the goal of Good Environmental Status (GES)  
29 for our oceans and seas. The challenge consists in facing the environmental degradation caused by years of  
30 unsustainable and inefficient growth model. The Marine Strategy Framework Directive (MSFD, European Commission  
31 2008) adopted in 2008, with its eleven descriptors and related indicators, represents the legislative framework and the  
32 backbone of this work. MSFD defines the GES in Article 3 as: “The environmental status of marine waters where these  
33 provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive”. GES means that  
34 the different uses made of the marine resources are conducted at a sustainable level, ensuring their continuity for future  
35 generations. Going more in detail for the restoration and the safeguard of this status, the ecosystems (including their  
36 hydro-morphological, physical and chemical conditions) should be fully functioning and resilient to human-induced  
37 environmental change, the decline of biodiversity caused by human activities should be prevented and biodiversity is  
38 protected. The human activities (introducing substances and energy) shouldn't cause pollution effects and noise from  
39 human activities should be compatible with the marine environment and its ecosystems.  
40

41 This process is at the moment in the half way between the adoption (2008) and its deadline (2020). The main features of  
42 this strategy are: the ecosystem approach (to provide an integrated evaluation of the activities affecting our seas) and the  
43 common efforts required by the Member States for the cooperation between neighbouring countries.

44 Some efforts have already been undertaken by European Member States which provided in 2012 the initial assessment  
45 on the state of the environment of the national marine waters. This assessment reported on environmental status  
46 determined in a holistic way, according the 11 descriptors, and on the objectives and targets to reach GES following the  
47 articles 8, 9 and 10 of the MSFD.

48 The results of the first phase allowed to recognize gaps and needs in data availability, large heterogeneity of  
49 methodological approaches to report information and spatial inconsistency within Member States regarding coastal –  
50 offshore data. These outcomes clearly indicated that more efforts are urgently needed if the EU is to reach its goal.  
51 More has to be done on the cooperation side and especially on the integration between Member States and Regional Sea  
52 Conventions (RSC). The report from the Commission on the first phase of implementation of MSFD indicates a high  
53 level of heterogeneity among Member States reports and in several cases poor data availability and accessibility  
54 (Dupont et al., 2014; Palialexis et al., 2014)

55 As a consequence, evaluation at higher level (Regional and EU) is difficult to perform. This first phase of MSFD  
56 implementation has somehow brought Europe one step closer to the ecosystem approach. However, the recognized gaps  
57 in data and information, the high heterogeneity in assessment approaches should guide the stakeholders involved in  
58 MSFD implementation to develop a more homogeneous approach. In view of the revision of the assessment in 2018,  
59 several efforts are required to overcome the shortcomings identified in the first reporting phase. Going more in detail,  
60 the actions should be focused on different aspects like: revised criteria for GES, methodological standards and  
61 standardised methods for monitoring, assessment and data availability, implementation of integrated information  
62 systems at regional and EU level.

63 In the field of marine research, during the last decades several oceanographic data management initiatives faced the  
64 challenge of data availability, interoperability and resilience at Pan-European level (EU MAST MTP II MATER 1996-  
65 1999, EU MAST-INCO MEDAR 1999-2001, FP6 SeaDataNet 2006-2011, FP7 SeaDataNet2 2011-2015).

66 Interoperability is defined as “the ability of a system to work with or use the parts of another system”, while resilience  
67 is defined as "the ability of a system to cope with change". The translation of these principles in the oceanographic data  
68 management consists in the development of a long life system able to easily interact with other systems. As example the  
69 adoption of common formats for data and metadata and a system of common vocabularies ensure that the network of  
70 involved persons is working in a homogeneous environment from the syntactic and semantic point of view (speaking a  
71 common language). The resilience is safeguarded by metadata and quality flags that provide clear knowledge of which  
72 kind of information the users are handling even long time after the data measurement (e.g. use of historical data for time  
73 series studies).

74 Since 2007, the Directive establishing an Infrastructure for Spatial Information in the European Community (INSPIRE,  
75 2007/2/EC) has been the driving principle to ensure that the European spatial data infrastructures are compatible and  
76 usable in a transnational context. The Directive requires that common implementing rules are adopted for the  
77 organisation, accessibility and sharing of spatial information with a focus to the implementation of interoperability of  
78 spatial data sets and services. Marine data management communities, developed in the framework of European  
79 initiatives such as the above mentioned MATER (1996-1999) and MEDAR (1999-2001) that converged later in the  
80 SeaDataNet (2006-2015) experience, faced the challenge to provide access to the huge amount of already existing but

81 fragmented and inaccessible data collected by EU oceanographic institutes. This was done developing a system able to  
82 collect, standardise, quality control and share the information, taking into proper account the data policies.

83 **The simple but efficient idea was the active collection of the EU oceanographic data at national level carried out by a**  
84 **network of National Oceanographic Data Centres (NODCs). The collection of those data was done in direct**  
85 **communication with the data originators to ensure the best set of measured data and related metadata. Metadata, that are**  
86 **all the information needed to describe exhaustively the data, reply to a set of basic but fundamental questions like: who,**  
87 **where, when, what and how about the collected information. For this reason they are key elements to enable efficient**  
88 **browsing and discovering.**

89 Between the data collection and sharing, the crucial steps to ensure interoperability and reliability consist in  
90 standardization and quality control.

91 **The standardization is done at two main levels by following the interoperability principles provided by INSPIRE:**  
92 syntactic and semantic. The first is done providing common formats for the files providing metadata and data (XML  
93 ISO, ascii). The second is done **by means of** a set of common vocabularies that let to “use the same language” to  
94 describe data and metadata over time, different projects and nationality.

95 The quality control procedures provide the necessary labelling to complete the harvested information with the  
96 evaluation of their reliability.

97 Finally the registered users can access the needed information according to data access and usage policies defined in  
98 agreement with the originators.

99 In order to extend this approach to different disciplines of the marine environment, at EU level, the Directorate-General  
100 for Maritime Affairs and Fisheries (DG-MARE) launched since 2009 a set of thematic contracts to establish a European  
101 Marine Observation and Data Network (EMODnet).The aim of the initiative was to improve the availability of high  
102 quality marine environmental data at the scale of regions and sub-regions of the Marine Strategy Framework Directive,  
103 to build a knowledge base that can assist in the implementation of marine policies and drive sustainable development.  
104 The EMODnet Lots with their infrastructure could play a central role specifically for countries where the Regional Sea  
105 Conventions are less mature to support the need of qualified and standard information at national, regional and bigger  
106 scale.

## 107 **2. Background**

108 A pilot project was launched by DG-MARE in 2009 to create the components of the European Marine Observation and  
109 Data Network (so called ur-EMODnet), as proposed in the EU Green Paper on Future Maritime Policy (European  
110 Commission 2006), consisting in six thematic data portals managing data on bathymetry, marine geology, chemistry,  
111 biology, seabed habitats, and physical oceanography. Based on the successful experience of the SeaDataNet (SDN)  
112 project (7th Framework Program), EMODnet Chemistry adopted its approach (Vinci et al., 2013). The principle was to  
113 take advantage of its efficient and distributed infrastructure for the management of data deriving from in situ and remote  
114 observation of seas and oceans. This infrastructure can be considered a European de-facto standard, as it already  
115 involves around 100 institutes (nodes) from 35 countries and is adopted and continuously adapted according to specific  
116 requirements for chemical data management.

117 SeaDataNet is actively involved in the development of standards that follow the INSPIRE implementing rules to ensure  
118 interoperability such as:

- 119 • Common metadata standards based on the Extensible Mark-up Language (XML), based on ISO 19115/19139  
120 schema;
- 121 • Standard data transport formats **Ocean Data View** (ODV) ASCII, MEDATLAS and NetCDF (CF);
- 122 • Common quality control methods and quality flag scale;
- 123 • Common Vocabulary Web services, used to mark-up metadata and data, covering a broad spectrum of  
124 disciplines and governed by an international board (SeaVox);
- 125 • SOAP Web services for various communication tasks;
- 126 • Open Geospatial Consortium (OGC) compliant services (Web Map Service, Web Feature Service, Web  
127 Processing Services) for viewing services of data products.

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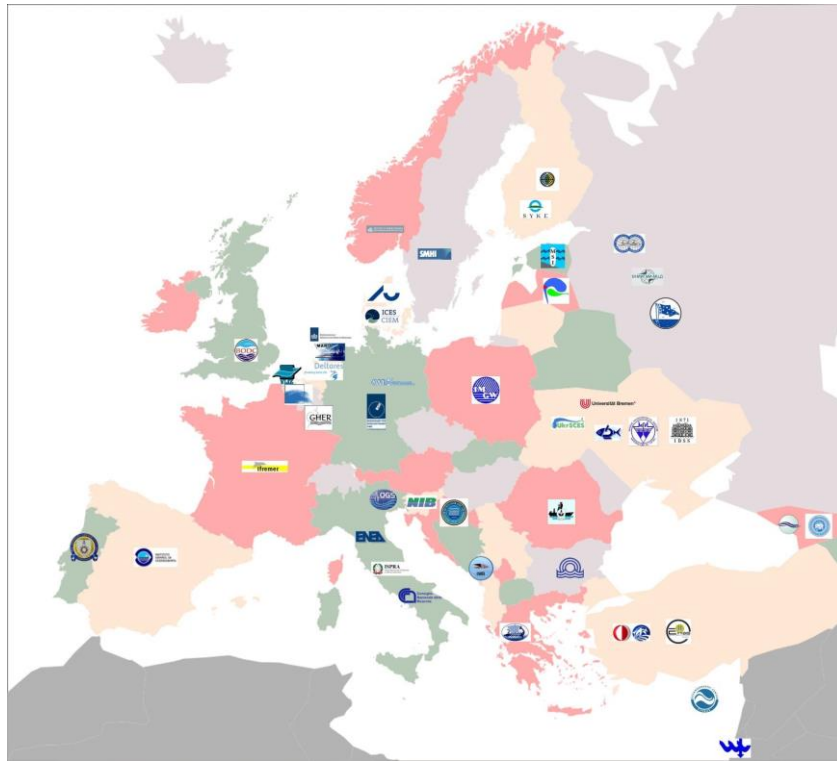
130 The partnership involved a subgroup of the SeaDataNet network of National Oceanographic Data Centres (NODCs)  
131 with specific experience in data collection, in data analyses, validation, and creation of products and in the technical  
132 partners who further developed SDN infrastructure. The Chemistry Pilot project was focused on the collection and  
133 management of data on some chemical parameters relevant for the MSDF (contaminants and fertilisers), in three  
134 matrices (sediment, seawater and biota) and in three areas of interest: the North Sea, the Black Sea and some spots in  
135 the Mediterranean Sea.

136 The comparison of the harvested data between sea basins highlighted a highly heterogeneous situation according to the  
137 different parameters. Data distribution consisted, on one hand, in coastal time series stations monitored at regular  
138 temporal scale, on the other, in data homogeneously distributed at basins level, but discontinuously in time. Furthermore,  
139 high heterogeneity in data managed resulted in the different sampling and analytical protocols adopted, as well as in the  
140 different target species. As a last step of the pilot project data visualizations were provided as interpolated maps when  
141 data were homogeneously distributed in time and space and as time series plots to allow visualization of data with  
142 fragmented spatial coverage. The viewing products were made available on the dedicated web portal in OGC compliant  
143 format (WMS layers).

144

### 145 **3. EMODnet**

146 The positive outcomes from the pilot project confirmed the interest in the further development of a marine observation  
147 infrastructure able to provide data and knowledge required to support the development of marine economy whilst  
148 supporting environmental protection needs, as underlined in the Green Paper Marine Knowledge 2020 (European  
149 Commission 2012). The new phase includes data collection for all European sea-basins: the Baltic Sea, the North-East  
150 Atlantic Ocean, the Mediterranean Sea and the Black Sea and involves 46 partners (**Fig.1**), both from research institutes  
151 and national monitoring agencies.



**Fig. 1: Geographic coverage of EMODnet Chemistry partnership. Logos indicate the nationality of the partner institutes.**

152  
153

154

155 Data managed by EMODnet now include also silicates, chlorophyll, partial pressures of dissolved gases (oxygen and  
156 carbon dioxide), plastics (polyethylene, polypropylene) and acidity (pH, pCO<sub>2</sub>, Total Inorganic Carbon, alkalinity).

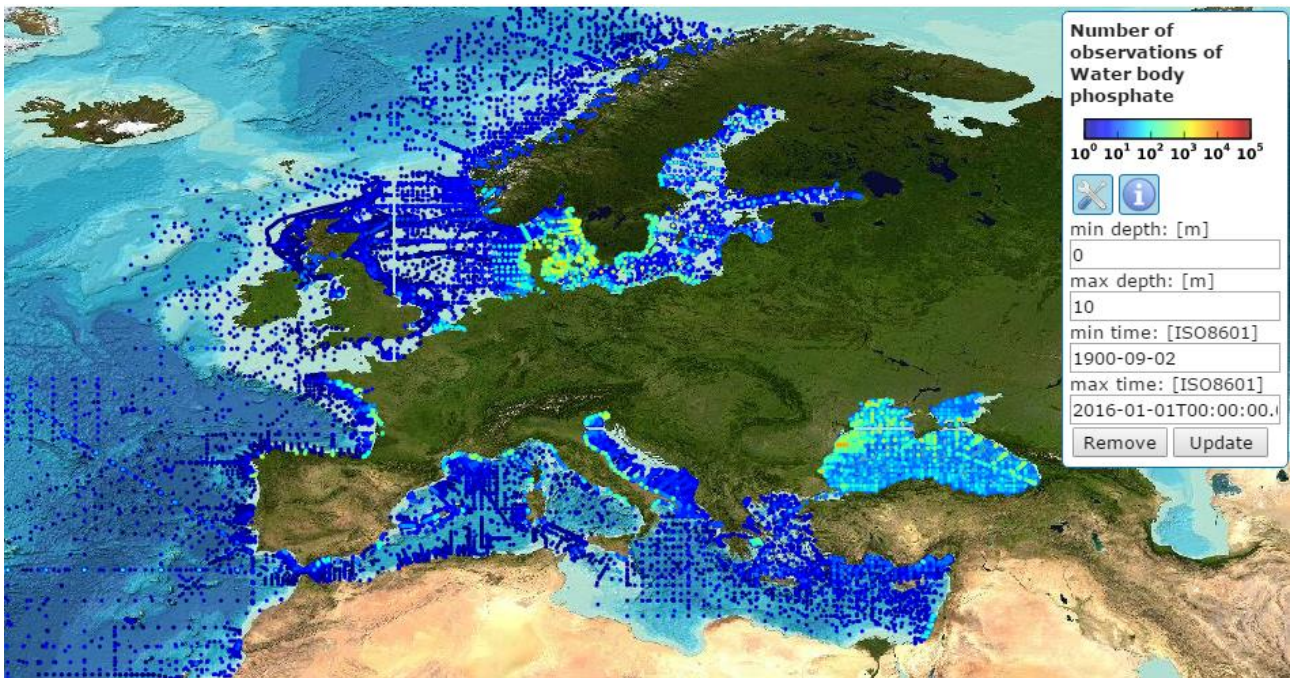
157 Data collection and product generation for all European basins is carried out by 5 Regional leaders, responsible for the  
158 North Sea, the Baltic Sea, the Atlantic, the Mediterranean, and the Black Sea.

159 In order to better tune EMODnet efforts for the requirements of the MSFD, several initiatives have been carried out to  
160 strengthen the dialogue with the Regional Sea Conventions and the Marine Observation and Data Expert Group  
161 (MODEG) and a MSFD – EMODnet coordination group involving Regional Sea conventions, Member States and  
162 relevant stakeholders has been established jointly by DG Mare and DG Environment. Besides, regular meetings with  
163 INSPIRE implementing groups are organized to discuss on the most feasible and useful products and services to  
164 provide.

165 **4. Data collection and Access**

166 Data harvesting is a fundamental activity of EMODnet and it is carried out by the network of NODCs that supervise the  
167 national availability of research and environmental monitoring data, provided respectively by research institutes and  
168 environmental agencies (Fig.2). NODCs maintain regular contact with data originators collecting and enriching data  
169 with the best set of relevant metadata to ensure the reliability of the information. NODCs are also responsible for the  
170 first quality control of data, flagged with quality information.

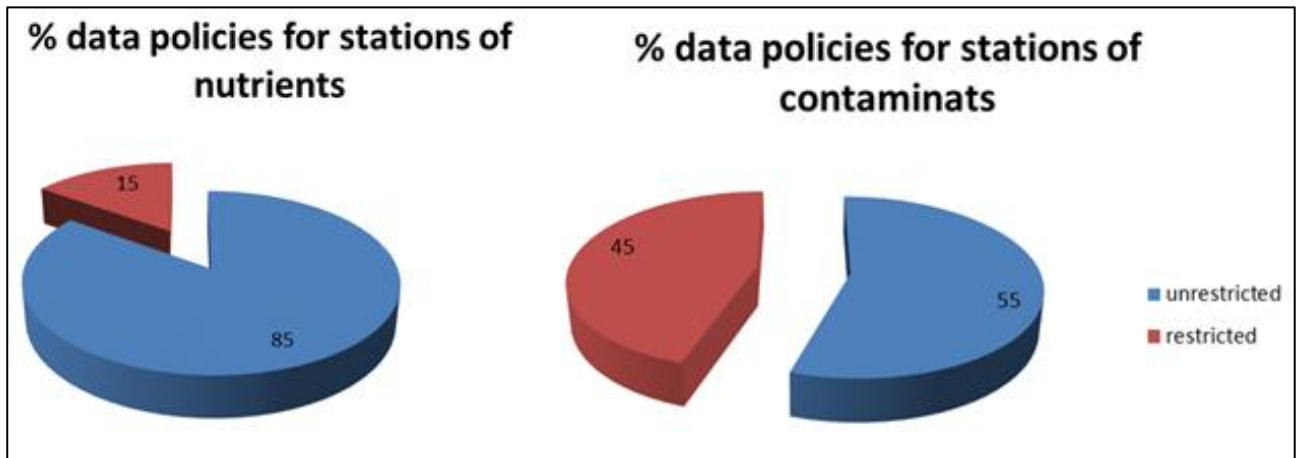




171  
172  
173 **Fig. 2: Density and distribution of water body phosphate harvested stations**

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175  
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Data access is regulated by a data policy (defined in agreement with data originators) which aims to establish a balance between the right of the originator to get proper acknowledgment for data acquisition, and the need for open access through free and unrestricted exchange of data, meta-data and data products. The analysis of data policies for EMODnet Chemistry data shows differences between data access restrictions for nutrients and contaminants (Fig. 3).



180  
181 **Fig. 3: Data policy for nutrients and contaminant data**

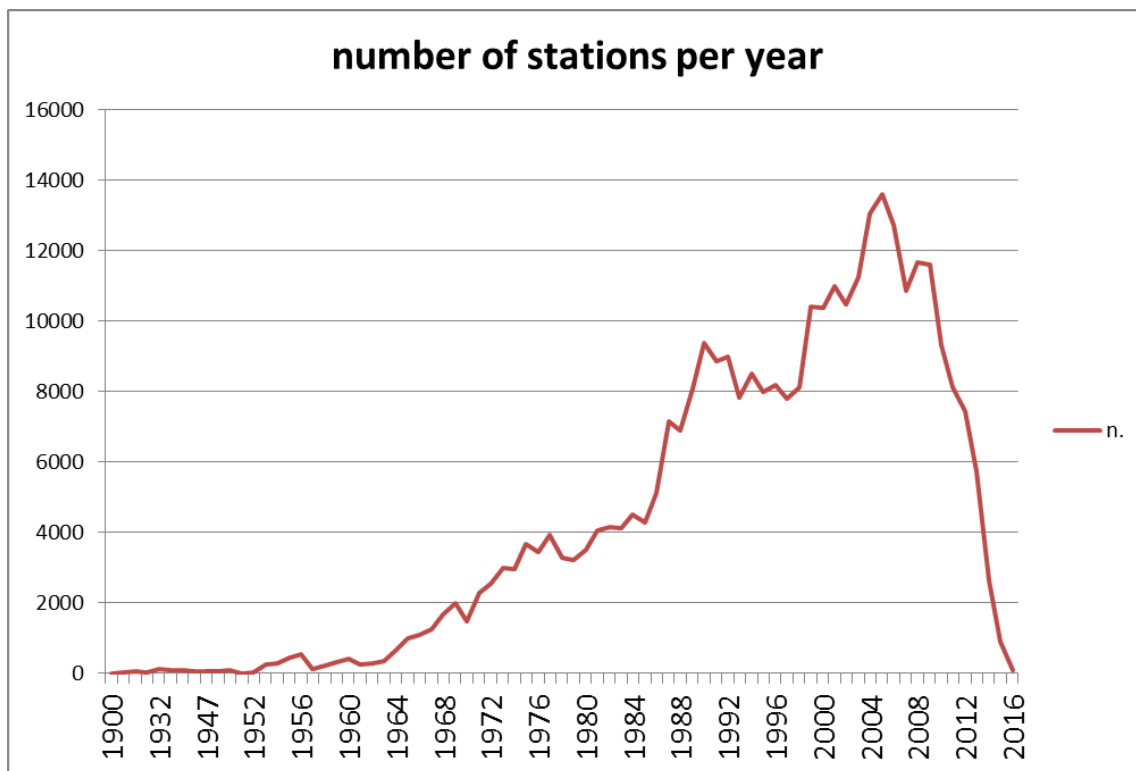
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Data requests from registered users are handled by NODCs through a data policy management system. Unrestricted data are freely available while restricted ones need negotiation with data originators. This kind of filter on data access is an effective way to establish contacts and trust between data originators and data management centres, ensuring correct acknowledgement, which ultimately encourages data sharing.

By maximizing the availability of data to a larger community, SeaDataNet promotes the use of these data, thereby ensuring that their maximum value can be realized and thus contribute to increase knowledge of the marine



189 environment. Fig. 4 shows temporal distribution of nutrient data, spanning from 1900 to 2016; table 1 shows the  
 190 number of stations for parameters with more data available.  
 191



192  
 193 **Fig. 4: Temporal distribution of nutrient data, spanning from 1900 to 2016 (counting 90 profiles in the current year; updates**  
 194 **May 2016).**

195  
 196  
 197

Parameter	n.
Phosphate concentration parameters in the water column	305896
Nitrate concentration parameters in the water column	262378
Silicate concentration parameters in the water column	245755
Dissolved oxygen parameters in the water column	198357
Ammonium and ammonia concentration parameters in water bodies	188666
Nitrite concentration parameters in the water column	181642
Salinity of the water column	151969
Chlorophyll pigment concentrations in water bodies	145374

198  
 199 **Table 1 number of stations for the parameters with more data available**

200

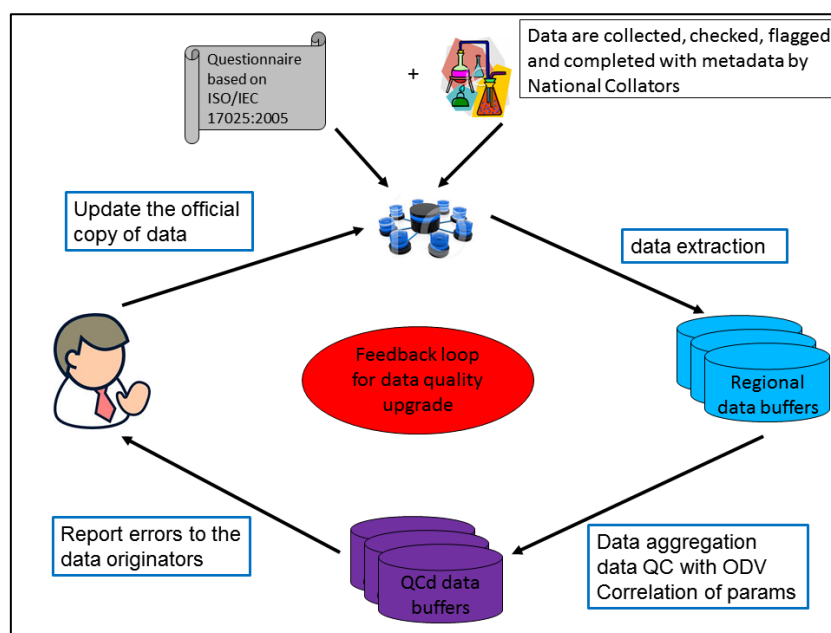
201 **5. Data Quality**

202 The quality of the data is a key issue when merging heterogeneous data coming from different sources, periods and  
 203 geographic areas. Within EMODnet chemistry community, commonly agreed and standardized data quality control  
 204 (QC) protocols have been defined (Holdsworth, 2010) to guarantee consistency among comprehensive databases which

205 include data from different and/or unknown origin and covering long time periods. As a first step, the data are checked  
 206 and completed by collators with a standard set of metadata that provide the basic information necessary for their long  
 207 term use. Afterwards, data undergo a validation loop which consists in several validation steps. The first is done by data  
 208 collators, prior to the inclusion in the decentralized infrastructure and the second step, which consists in regional quality  
 209 control, is performed at regional scale on aggregated datasets. The first quality controls (QC) ensure that position and  
 210 time of data are realistic and compare measurements with broad ranges and specific regional ranges. Whenever  
 211 available, data are also compared with climatology. As a result of the first QC step, all data are archived with a quality  
 212 flag value that provides information about their reliability.

213 At this point, data aggregation and regional quality control are performed at regional scale, following a common  
 214 protocol. **Data aggregation is done with the objective to unify the various analytic terms into a unique aggregated term  
 215 with conversion to a unique measurement unit. The ODV software has a built-in aggregation procedure applying a  
 216 number of business rules like possible units conversions. (Lowry R. et al., 2013)**

217 **The main goal of this activity is to obtain a harmonized dataset (e.g. a unique dataset of phosphate concentration in the  
 218 water column starting from different datasets of phosphate concentration expressed with different units) that could be  
 219 used to generate homogeneous data products. The results of the regional quality control are sent to the data collators  
 220 (NODCs) to correct errors or anomalies in the original copy of the data available in the EMODnet infrastructure. This  
 221 feedback loop guarantees data quality upgrade (Fig.5).**



222  
 223 **Fig. 5: Data validation loop**  
 224

225 To improve and homogenize the quality control procedures and standards adopted (at least at regional level), a quality  
 226 control survey has been carried out within EMODnet Chemistry community, in order to collect the best practices in data  
 227 validation and highlight gaps of the different institutes involved (Vinci et al., 2015).

228 **6. Data products**

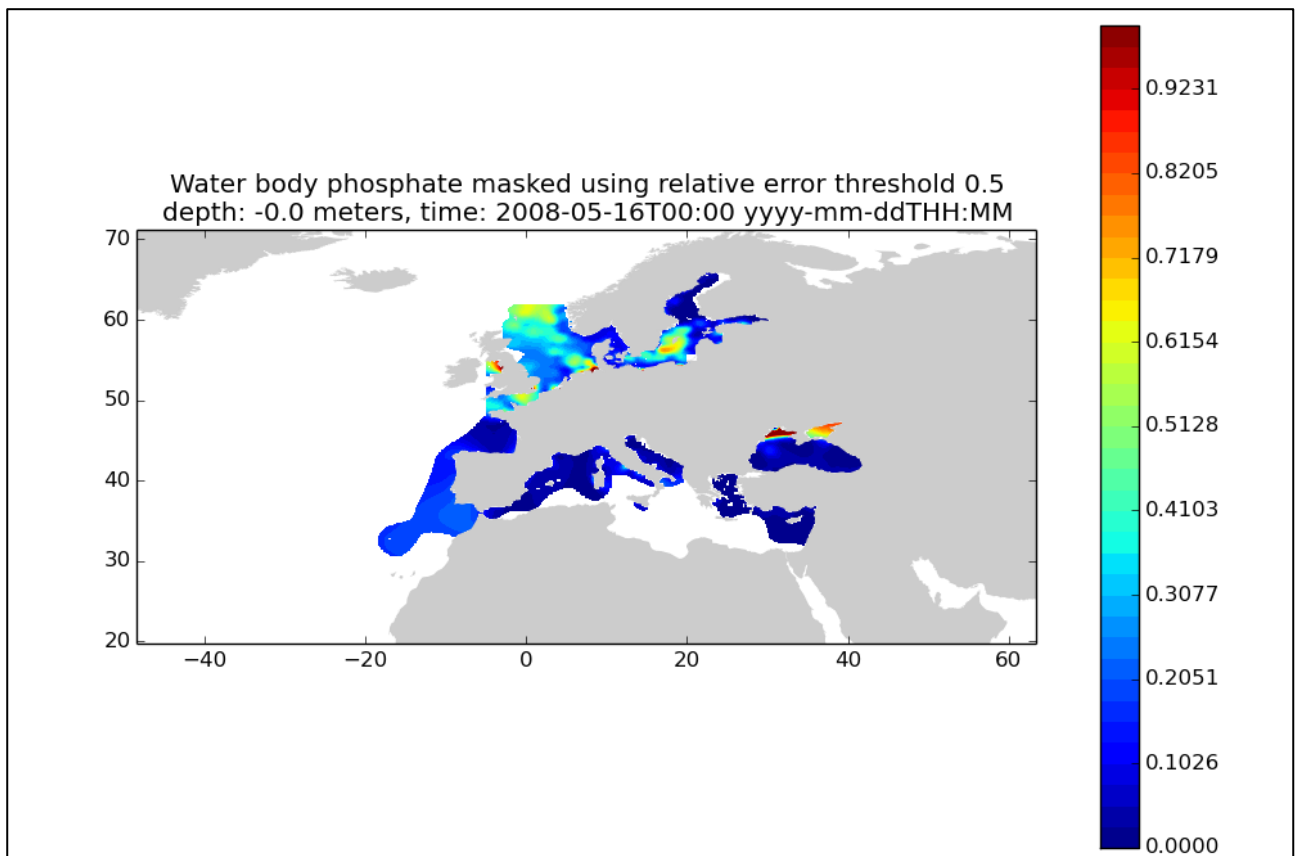
229 In order to accomplish the Marine Strategy Framework Directive requirements, EMODnet Chemistry developed  
 230 products suitable to visualise the time evolution of a selected group of measurements and to calculate spatially

231 distributed data products specifically relevant for MSFD descriptor 5 (eutrophication), 8 (chemical pollution), and 9  
232 (contaminants in seafood) as typically done with satellite data (Colella et al., 2016; Gohin et al., 2008)

233 The interpolated maps have been produced with the Variational Inverse Method (VIM; Brasseur et al., 1996), using the  
234 software DIVA (Data-Interpolating Variational Analysis; Troupin et al., 2010). DIVA is an appropriate numerical  
235 implementation of VIM suitable for oceanographic data spatial analysis as it is designed to obtain a gridded field from  
236 the availability of non-uniformly distributed observations (Barth et al., 2010; Troupin et al., 2012).

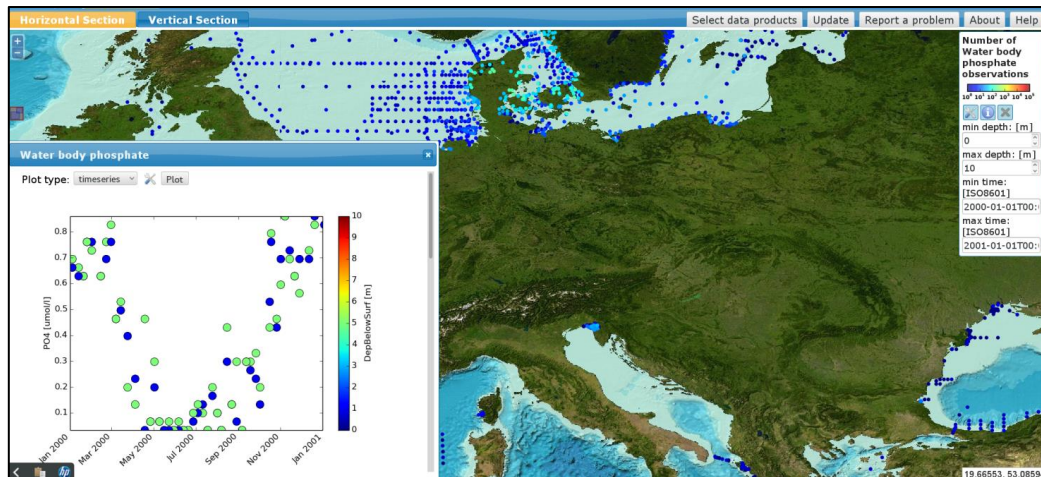
237 Interpolated maps are now generated, mainly for nutrients, with 10 years moving window in order to find a balance  
238 between the duration of the environmental evaluation cycle for Member States (to provide maps with a time frame near  
239 to the 6 years process of the Member States evaluation) and the number of years that guarantee a sufficient data  
240 coverage.

241 An example of a visualization useful for the assessment of eutrophication and in particular of nutrient concentration in  
242 the water column is presented in Fig. 6, which displays surface distribution of phosphate concentration in spring for the  
243 decade 2003-2013 (centered in 2008).



244  
245 **Fig. 6: 10 years average of water body phosphate concentration ( $\mu\text{mol-P l}^{-1}$ ) in the surface layer for all EU sea basins (years**  
246 **2003-2013). Interpolated Maps can be selected from the Ocean Browser viewing service interface with the following steps:**  
247 **choose “Select data products” button, scroll and choose in the pop-up window from the list of available products and then**  
248 **select “Add layer” in the lower left corner of the pop-up window. Maps can also be downloaded in different formats**  
249 **obtaining results as in this example (PNG file).**

250  
251 Profiles and time series plots are automatically generated from the Regional aggregated and validated datasets (called  
252 Regional buffers), thanks to a service bases on WPS OGC standard, and can be dynamically customized. (Fig.7)



253 **Fig. 7: Screenshot from the web portal showing the Time Series dynamically plotted and visualized thanks to the OGC WPS**  
 254 **services**  
 255

256 There are ongoing efforts to develop a more efficient information management thanks to a system of data buffers hosted  
 257 in a cloud system. Data are harvested and validated in buffers and are then used for product generation.  
 258

259 **7. Conclusions and perspectives**

260 EMODnet is a long term marine data initiative developed through a stepwise approach aiming to ensure that European  
 261 marine data will become easily accessible, interoperable and free of restrictions on use. EMODnet Chemistry started in  
 262 2009 to fulfil EU Marine Strategy Framework Directive requirements for the assessment of eutrophication and  
 263 contaminants, following EU INSPIRE Directive rules.

264 With the start of EMODnet phase II, DG MARE and DG ENV started a coordination table to agree on a joint process  
 265 and to identify how EMODnet can best contribute in practical terms to the MSFD. EMODnet Chemistry implemented a  
 266 set of recommendations, in communication with regional sea conventions (RSC) contracting parties. The situation is not  
 267 homogeneous in EU sea basins. While much of the chemistry and contaminant data are well organized within OSPAR  
 268 Commission and Helsinki Convention (HELCOM), namely in the North and Baltic sea respectively, EMODnet  
 269 Chemistry has a more useful role in the Mediterranean where these outputs are less well organized. A Memorandum of  
 270 Understanding with the Commission on the Protection of the Black Sea against Pollution (Bucarest Convention) to  
 271 formalize the cooperation in terms of providing dedicated access to EMODnet Chemistry regional products for  
 272 supporting management of MSFD indicators as well as increasing participation in the Advisory Groups meetings is  
 273 under preparation. A similar step is under discussion with the Information and Communication Regional Activity  
 274 Center (INFO-RAC) through the United Nations Environmental Programme, Coordinating Unit for the Mediterranean  
 275 Action Plan for the Barcelona Convention (UNEP/MAP).

276 These on-going efforts show the importance of EMODnet Chemistry results and the extensions that might be planned in  
 277 view of the last EMODnet implementation phase aiming at a full resolution.

278 In the next years, EMODnet Chemistry could play an important role in the European environmental reporting landscape  
 279 with two main tasks. The first task consists in providing standardized and quality checked buffers of data for specific  
 280 Regions. The second task is to act as an umbrella providing standards, best practices and infrastructure to aggregate at  
 281 Regional level the single member states.  
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