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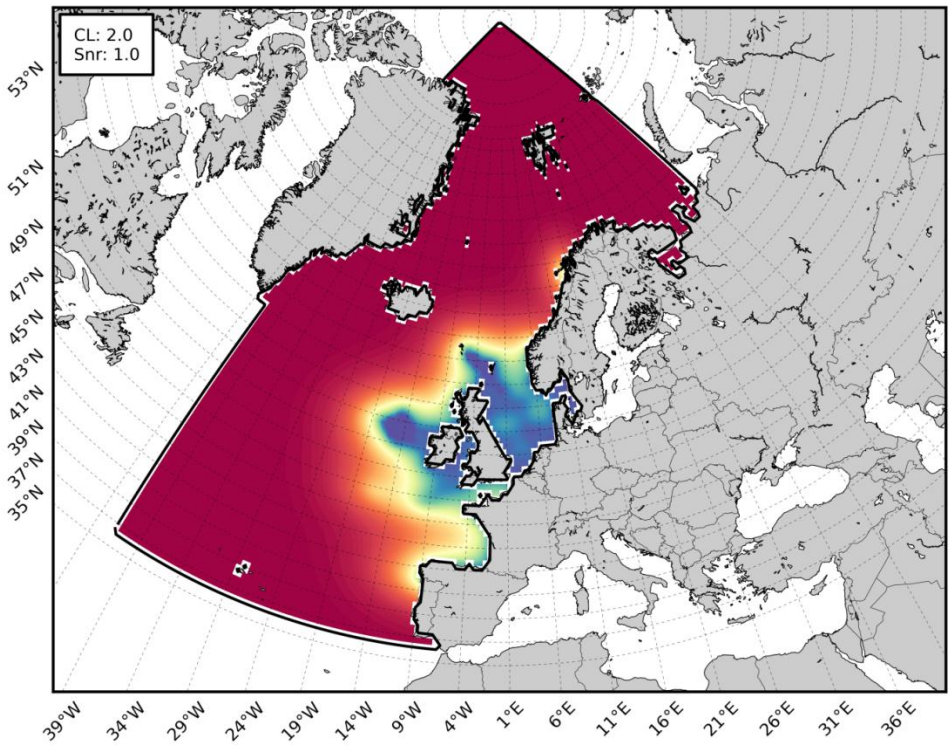
REPORT OCEANOGRAPHY No. 52, 2015

Mapping winter nutrient concentrations in the OSPAR maritime area using Diva

Örjan Bäck & Magnus Wenzer



Front:
Diva error field for dissolved inorganic nitrogen in the OSPAR maritime area.

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Summary

The Diva software (Data Interpolating Variational Analysis) software was used to create interpolated gridded fields for nutrient concentrations in the OSPAR maritime area to support the ongoing process to develop common indicators for the MSFD (Marine Strategy Framework Directive). Data were downloaded from the ICES database and maps created for DIN, DIP and silicate for the winter months (December – February) covering the period 2006-2013. Lack of data in areas I and V shifted focus to regions II, III and IV. The most prominent results from the analysis are the high values of nutrient concentrations found along the southern shore of the North Sea.

The lack of data both at a large scale in OSPAR areas I and V and at a smaller scale near the coast, in particular close to river outlets, is the biggest source of error in the Diva analyses. It is evident that there is a need to increase the data coverage for the future work with indicators and for assessment purposes.

Sammanfattning

Diva (Data Interpolating Variational Analysis) har använts för att skapa interpolerade griddade fält av närsaltskoncentrationer i OSPAR:s maritima område som en del i arbetet med att ta fram gemensamma indikatorer för MSFD (Marine Strategy Framework Directive). Data laddades ner från ICES-databasen och kartor togs fram för DIN, DIP och silikat för vintermånaderna (december-februari) mellan åren 2006 och 2013. På grund av brist på data i områdena I och V lades fokus på regionerna II, III och IV. Mest utmärkande i resultatet av analysen är de höga närsaltskoncentrationerna längs Nordsjöns sydkust.

Brist på data, både i stor skala i OSPAR-regionerna I och V och i mindre skala nära kusten, främst nära flodmynningar, är den största felkällan i Diva-analyserna. Detta visar tydligt att datatäcknigen behöver bli bättre inför framtida arbete med indikatorer och i bedömningsprocesser.

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1 Purpose

The purpose of the investigation is to create interpolated fields of nutrient concentrations with the software Diva that will contribute to OSPAR's work with nutrient indicators for the Marine Strategy Framework Directive in the OSPAR maritime area, see Figure 1.

Associated error fields from the Diva analysis are also of great interest as they indicate areas with too little or no data. The results may be further investigated to determine if a lack of data is due to lack of sampling in these areas, or if sampling exists and the data are missing in the ICES database.

The North East Atlantic

Region I	Arctic Waters
Region II	Greater North Sea
Region III	Celtic Seas
Region IV	Bay of Biscay and Iberian Coast
Region V	Wider Atlantic

Figure 1: OSPAR maritime area.

2 Background

Within OSPAR there is an ongoing process to develop common indicators for the MSFD (Marine Strategy Framework Directive). At the OSPAR ICG-EUT (Intersessional Correspondence Group on Eutrophication) meeting in 2015, Sweden presented the Diva software [Troupin et al., 2012] which is developed by the research group GHER at the University of Liège and used within the European data infrastructures SeaDataNet and EMODnet. As part of the development of common indicators, Sweden was asked to present Diva maps of nutrient winter concentrations for the period 2006-2013.

3 Method

Nutrient data (NO2, NO3, NH4, PO4 and SiO4) from all OSPAR regions were downloaded from the ICES database. Selection was made for winter months (December-February) covering the period 2006-2013 and for the top ten metres of the water column. Dissolved inorganic nitrogen (DIN) was calculated by adding up the contribution of NO3, NO2 (if present) and NH4 (if present). To make sure Diva uses all the data in the interpolation the depths for all measurements from 0-10 metres were all set to 5 metres.

The data were imported into the software Ocean Data View (ODV) [Schlitzer, 2015] and exported as an "ODV Spreadsheet file" which is the format that Diva uses as input. Furthermore, a GEBCO[1] bathymetry with a 1 minute resolution was used to create a coast contour. In this process the resolution was scaled down, using every fifth or fifteenth point depending on area, to save computational time.

Due to the lack of data in large parts of the OSPAR region Diva analyses were made for two areas, one for the whole region and one for a smaller area (North Sea, Celtic Sea and Bay of Biscay) where most of the data can be found. Different values for correlation length and signal to noise ratio were tested to find a "best choice". Correlation length test values were based on information from scientific articles [Radach and Gekeler, 1996; Troupin et al., 2010] and our experience. The unveiling of outliers in the data also justified the use of outlier elimination in the Diva data cleaning process. Altogether, the following settings were used for the two regions, Table 1.

Table 1: Diva Settings.

Diva version: 4.6.9	**Full OSPAR area**	**OSPAR area II, III and IV**
Latitude range	36° N - 90° N	40° N - 65° N
Longitude range	44° W - 51° E	14° W - 14° E
Correlation length in degrees (CL)	2.0	1.0
Signal to noise ratio (Snr)	1.0	1.0
Output grid size in degrees (dx/dy)	0.5/0.5	0.1/0.1
Background field	Mean of data	Mean of data

[1] Gebco gridded global bathymetry data. British Oceanographic Data Centre, Liverpool, United Kingdom, 2009.

4 Results

4.1 OSPAR maritime area

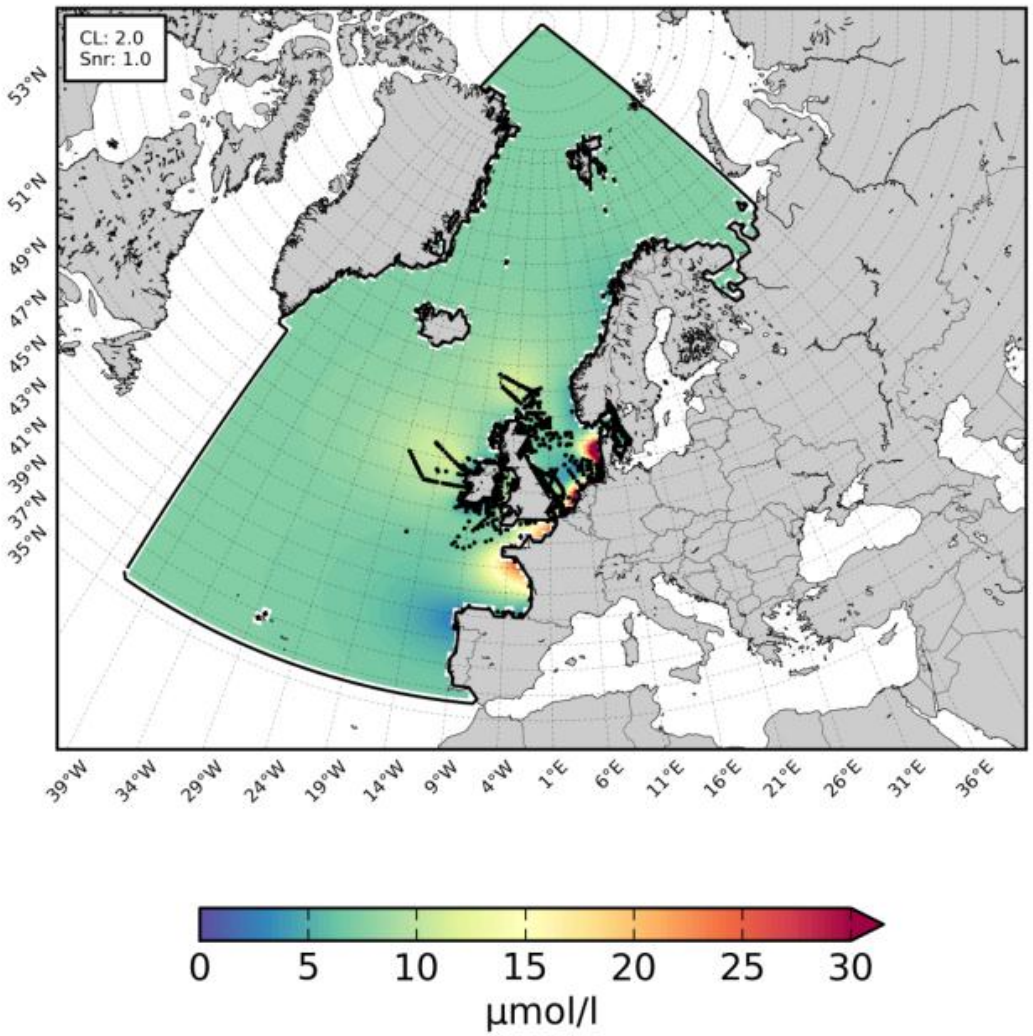

Figure 2: Diva interpolated field for dissolved inorganic nitrogen concentration, DIN, covering the OSPAR maritime area. Sampling points shown as black dots.

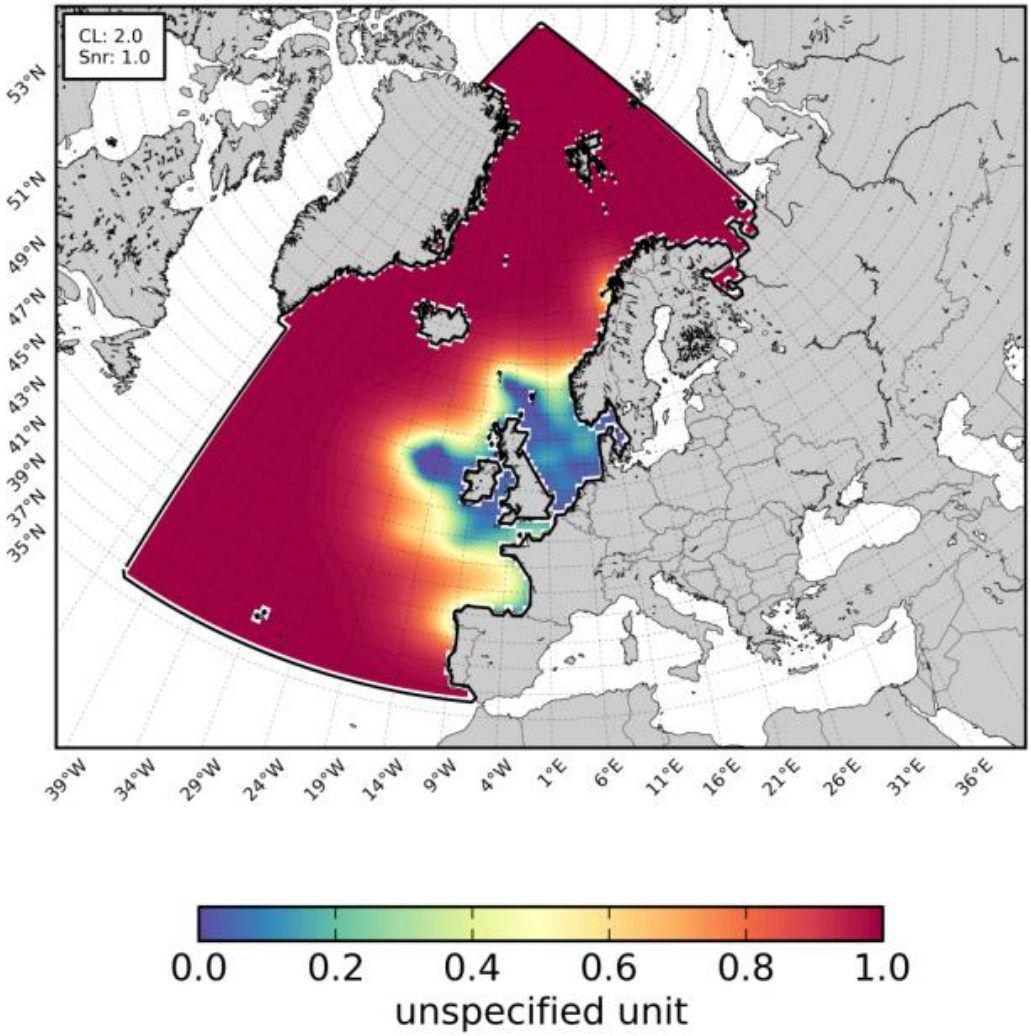

Figure 3: Diva error field for dissolved inorganic nitrogen concentration covering the OSPAR maritime area.

It is clear that the data coverage for DIN during winter is low. Data can be found for the North Sea (including Skagerrak and Kattegat) and the Celtic Seas, also for some coastal measurements outside these two regions. Data coverage for DIP and silicate is similar, see figures in the Appendix. The lack of data results in an error field dominated by high values, ~1, red in Figure 3. By masking the interpolated field where the error field exceeds a threshold value you get a field which only contains data that has a corresponding error below this value. A high threshold value gives a larger areal coverage, but also a higher degree of uncertainty. An error threshold value of 0.5 was used to mask the Diva fields, Figure 4, with the effect that only a portion of the interpolated field remains. This is an important result by itself and it becomes evident that there is a need to increase the data coverage for the work with indicators for assessment purposes.

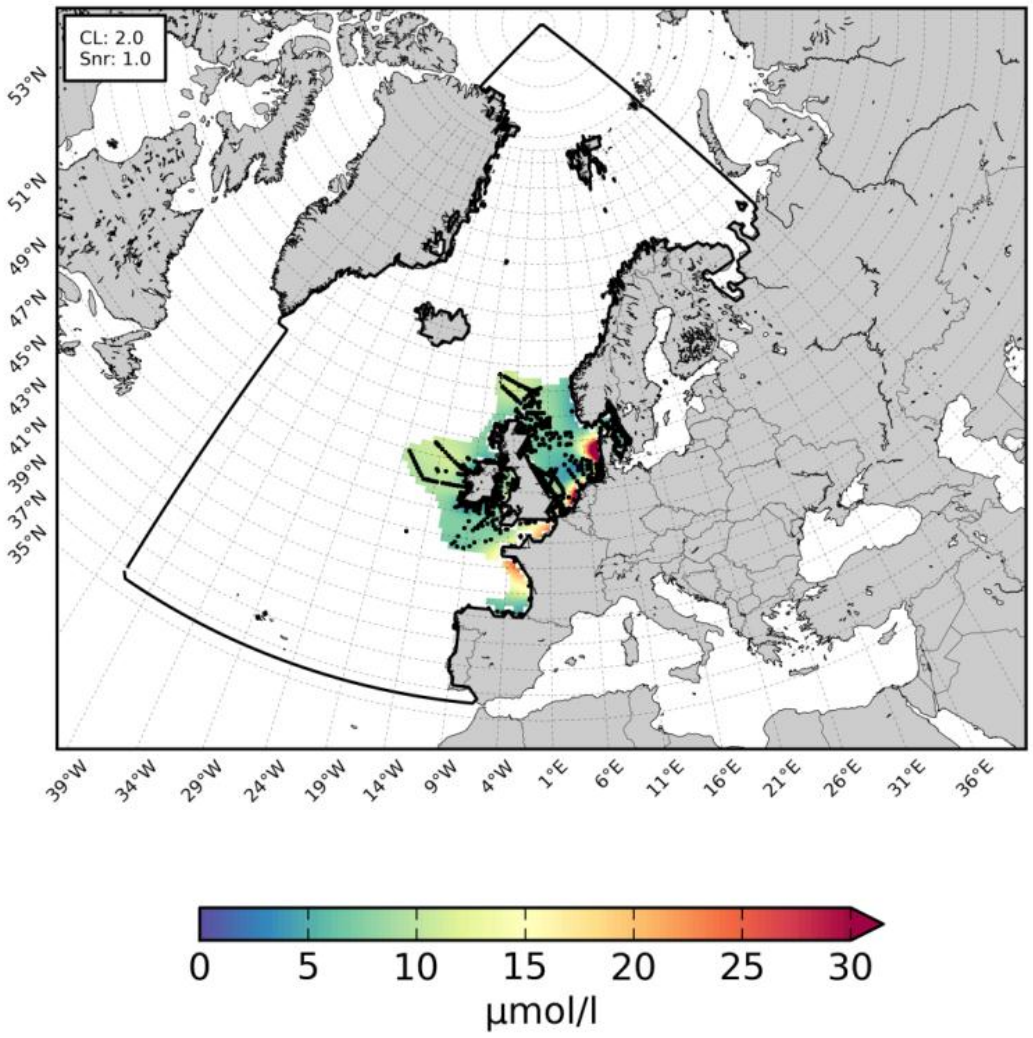

Figure 4: Diva interpolated field masked for DIN with an error threshold of 0.5 (50%). Sampling points shown as black dots.

4.2 OSPAR maritime area II, III and IV

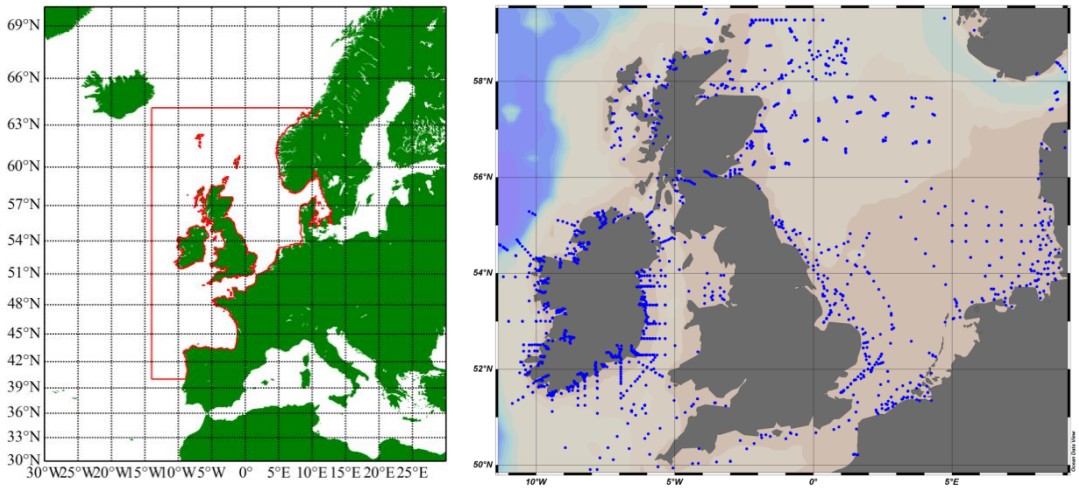

Figure 5: Smaller area covering OSPAR maritime areas II, III and IV (left). Data distribution in the North Sea and Celtic Seas (right).

To better study the results of the Diva interpolated fields, a smaller area was used, see Figure 5 (left), covering almost all of the available data.

All nutrient parameters show a similar distribution with higher concentrations along the south shore of the North Sea and some areas along the coast of Great Britain, Figure 6-Figure 8. For the parameters DIP (dissolved inorganic phosphate) and silicate there is also a hint of higher values in the Kattegat coming from the Baltic Sea through the straits.

In area IV there are only coastal data available which give high error values in Diva far from the coast. Diva analyses were also made for each winter season individually, to investigate annual differences in both concentration and data coverage, see Appendix.

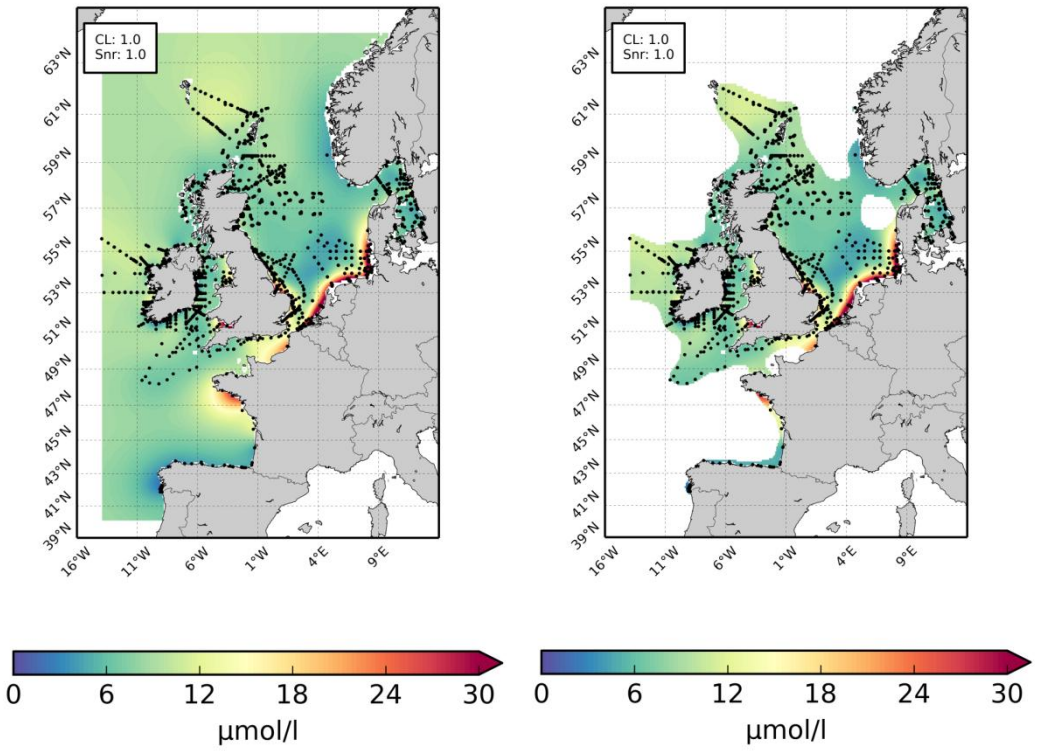

Figure 6: Diva interpolated field for DIN (left), masked with an error threshold of 0.5 (right). Sampling points shown as black dots.

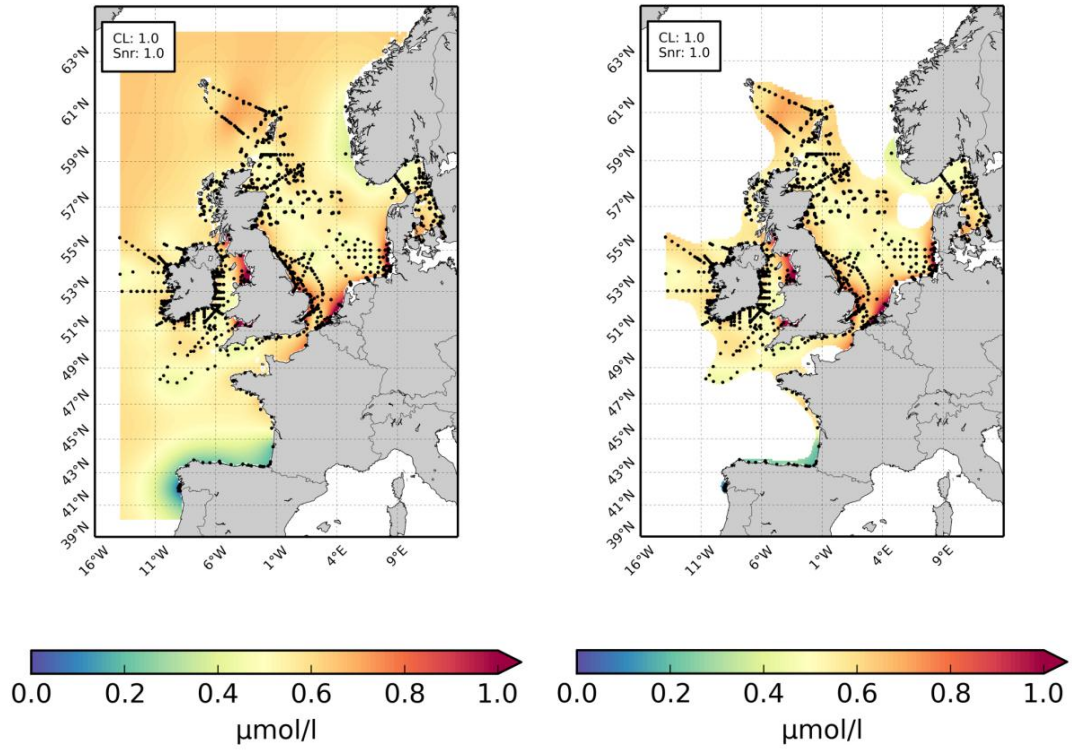

Figure 7: Diva interpolated field for DIP (left), masked with an error threshold of 0.5 (right). Sampling points shown as black dots.

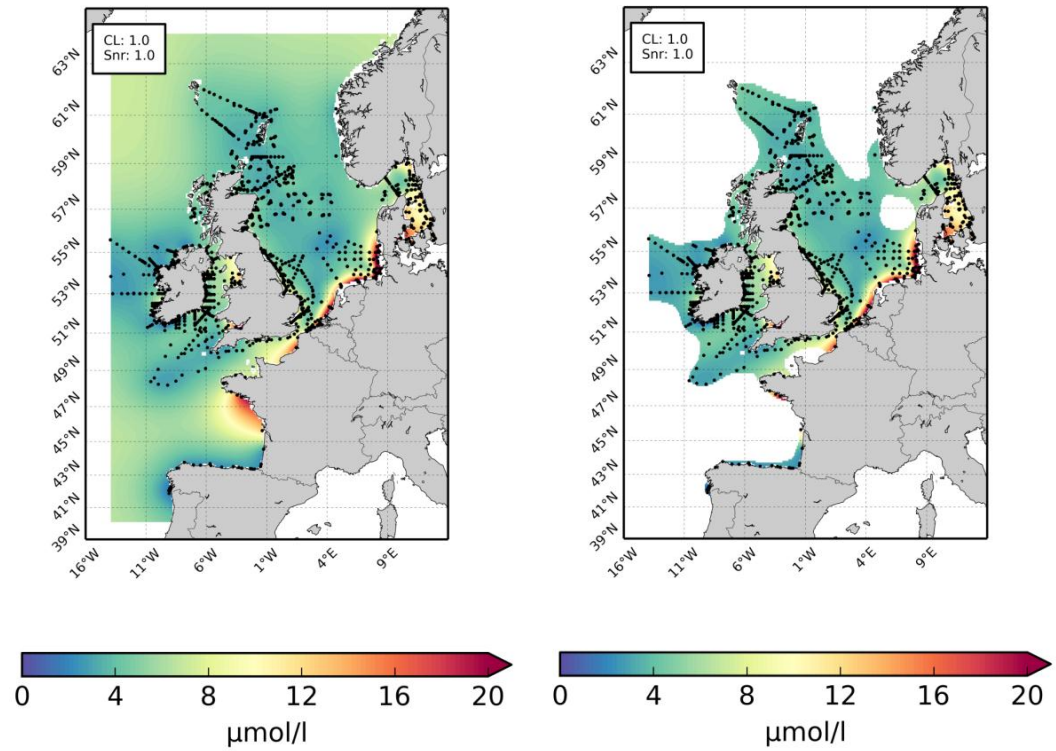

Figure 8: Diva interpolated field for silicate (left), masked with an error threshold of 0.5 (right). Sampling points shown as black dots.

5 Conclusions

Nutrient data available for the winter seasons 2006-2013 in the ICES database roughly covers the North Sea, Celtic Seas, Skagerrak and Kattegat. Some coastal data is available in the Bay of Biscay. Outside these areas there is almost a complete lack of data. Other data sources, such as World Ocean Database and EMODnet Chemistry portal, give an almost identical data coverage.

Areas with high nutrient concentrations, for example close to river outlets, are very prominent in the results. A lack of coastal data in such areas probably results in DIVA underestimating concentrations. The Diva interpolated fields represent data available in the ICES database, and not necessarily the true state. This needs to be considered when interpreting the results. For example, results in areas where near shore data are absent in the dataset might be different when comparing it to coastal areas with better near shore data coverage, such as along the German coast, see Figure 5 (right). The error fields assist in this interpretation. Ideally, monitoring data reported to ICES should be sufficiently detailed to resolve coast to offshore nutrient gradients, particularly around nutrient sources.

For the parameter DIP there was a significant difference for the North Sea region when using outlier elimination, see Figure 9. Some suspiciously high values of DIP in the North Sea far from the coast are removed when using outlier elimination. This suggests that there exist some suspicious values in the ICES database.

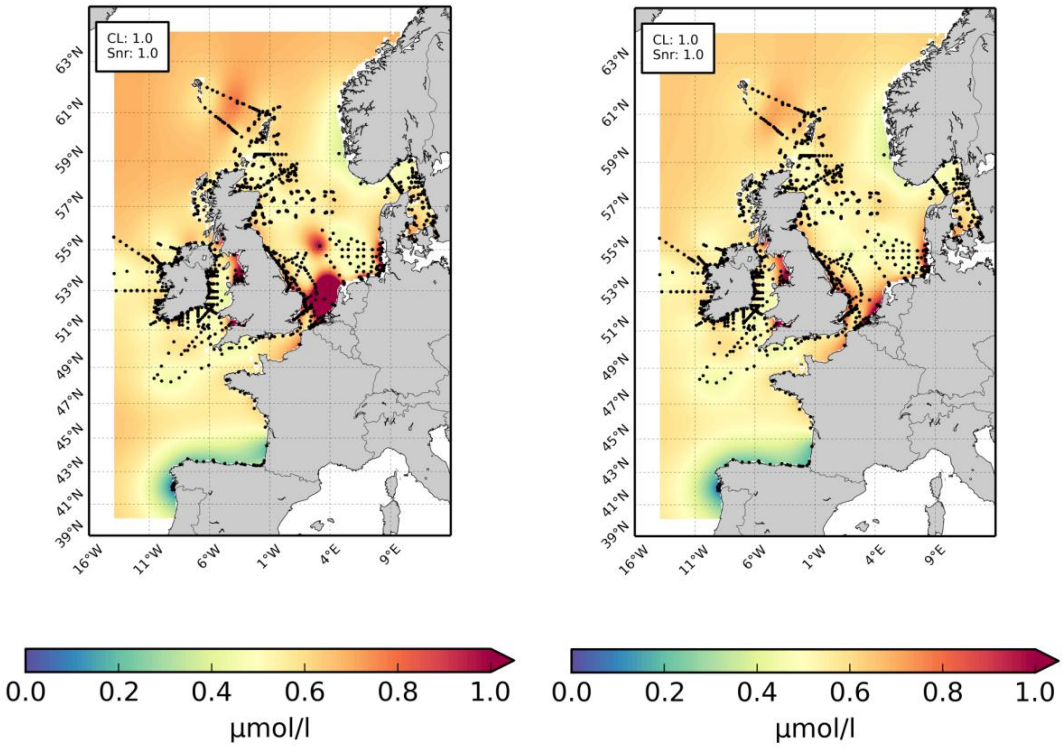

Figure 9: Diva integrated field for DIP, without outlier elimination (left), with outlier elimination (right).

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7 Appendix

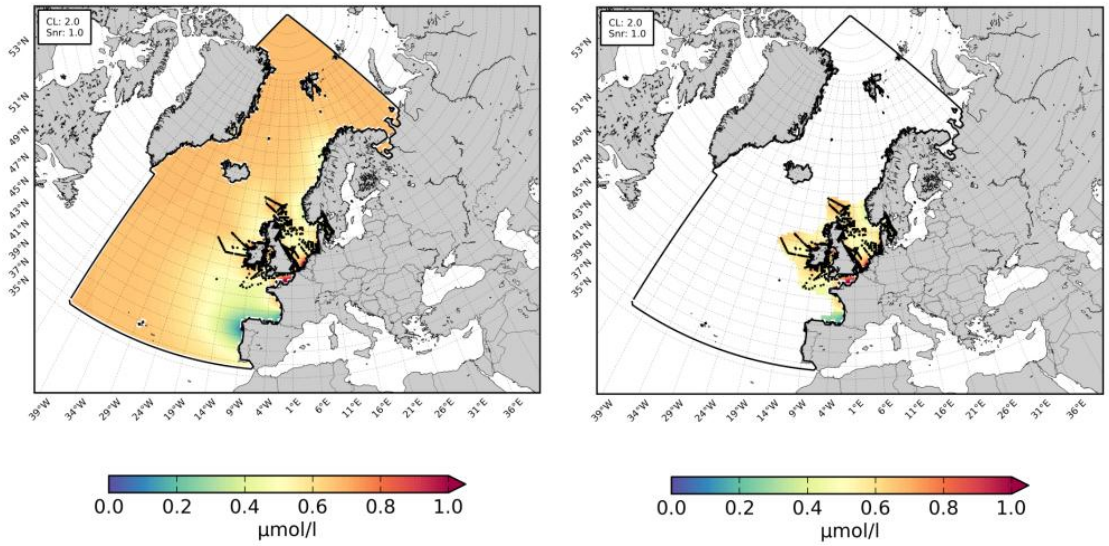

Figure 10: Diva interpolated field for dissolved inorganic phosphate, DIP (left), masked with an error threshold of 0.5 (right). Sampling points shown as black dots.

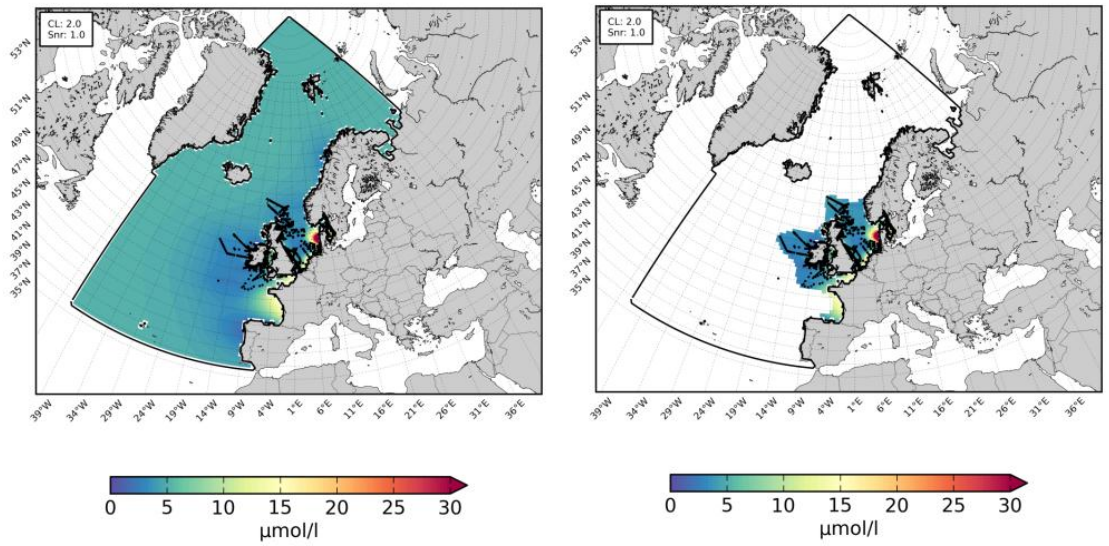

Figure 11: Diva interpolated field for silicate (left), masked with an error threshold of 0.5 (right). Sampling points shown as black dots.

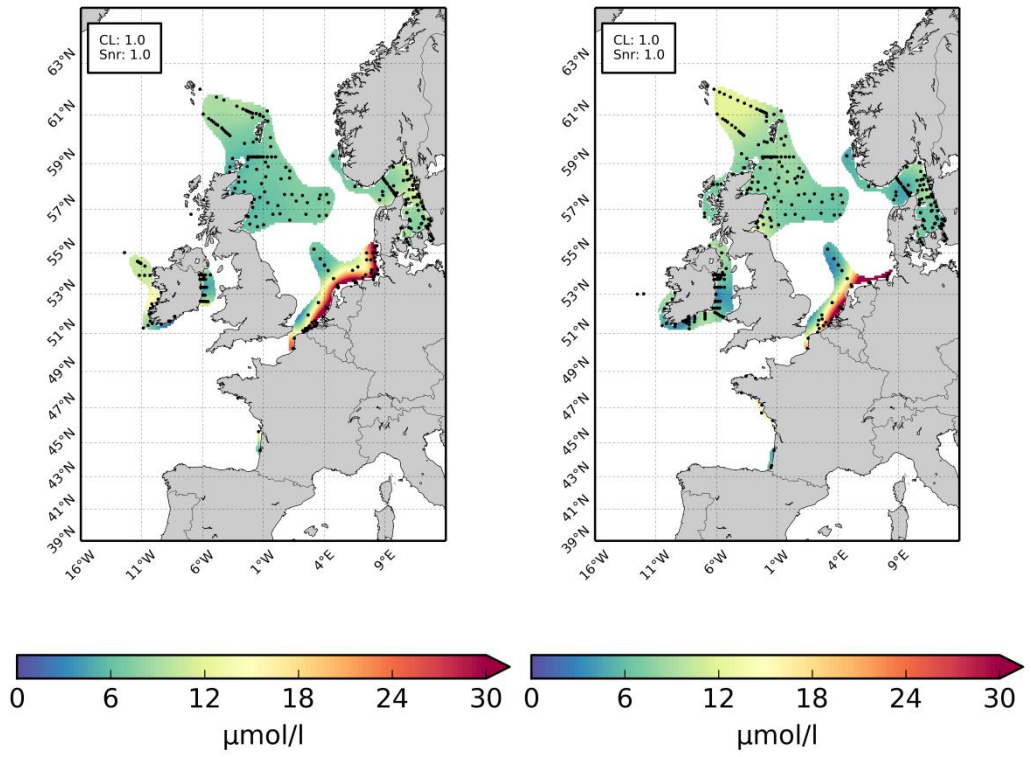

Figure 12: Diva interpolated field for DIN masked with an error threshold of 0.5, winter 2006/2007 (left) and 2007/2008 (right). Sampling points shown as black dots.

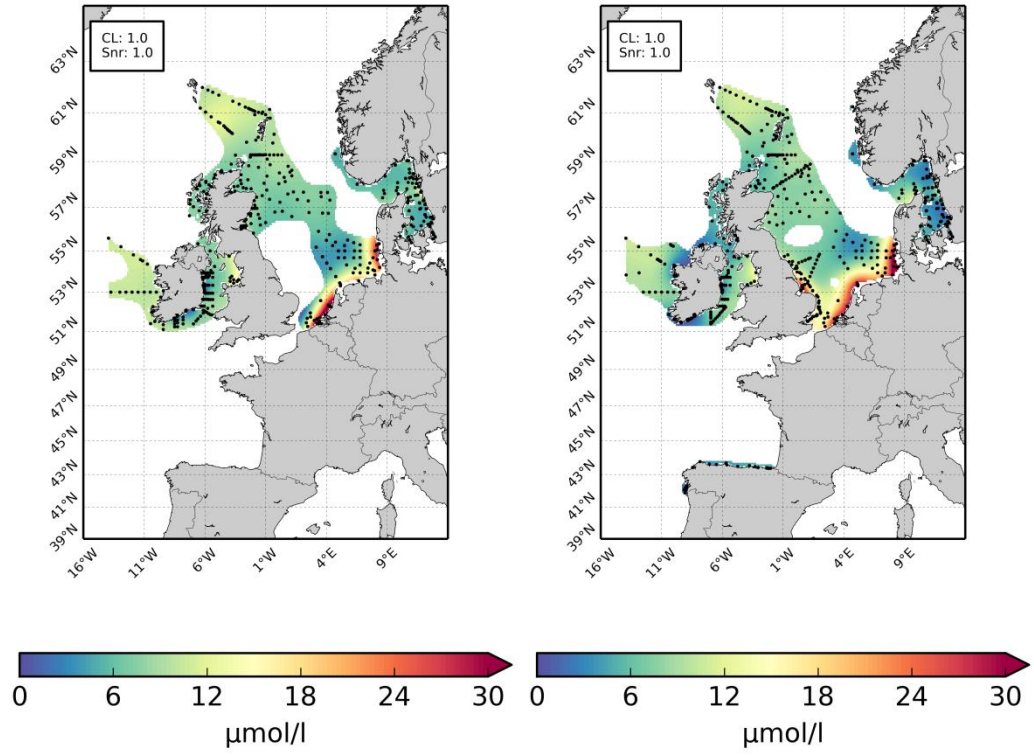

Figure 13: Diva interpolated field for DIN masked with an error threshold of 0.5, winter 2008/2009 (left) and 2009/2010 (right). Sampling points shown as black dots.

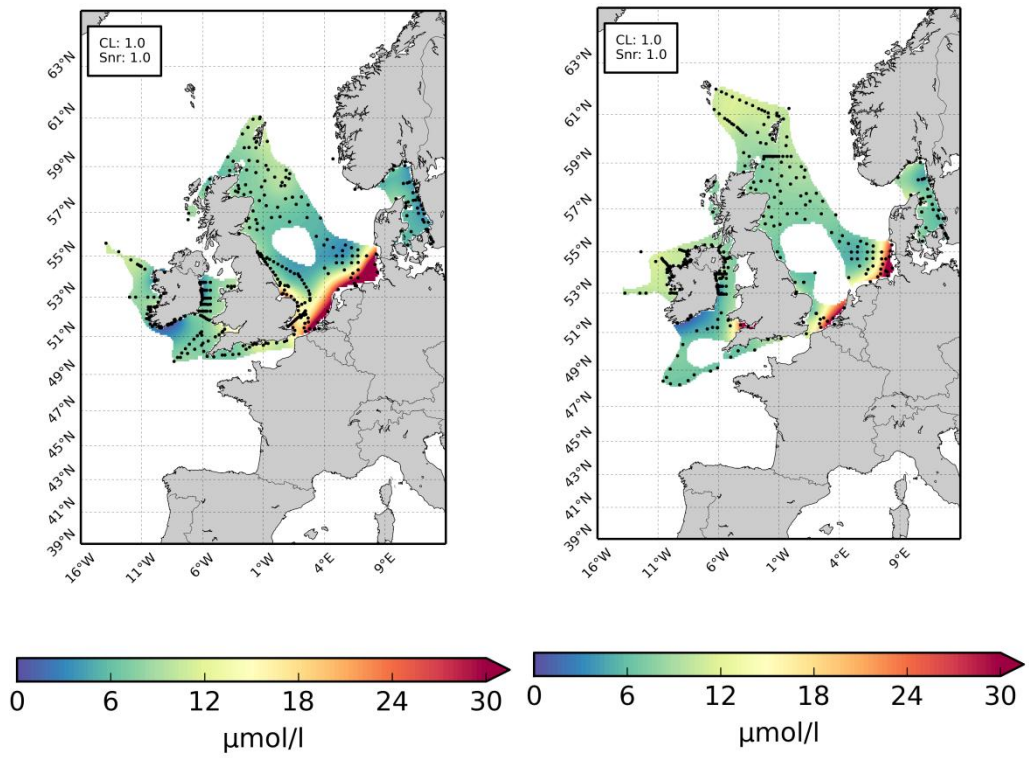

Figure 14: Diva interpolated field for DIN masked with an error threshold of 0.5, winter 2010/2011 (left) and 2011/2012 (right). Sampling points shown as black dots.

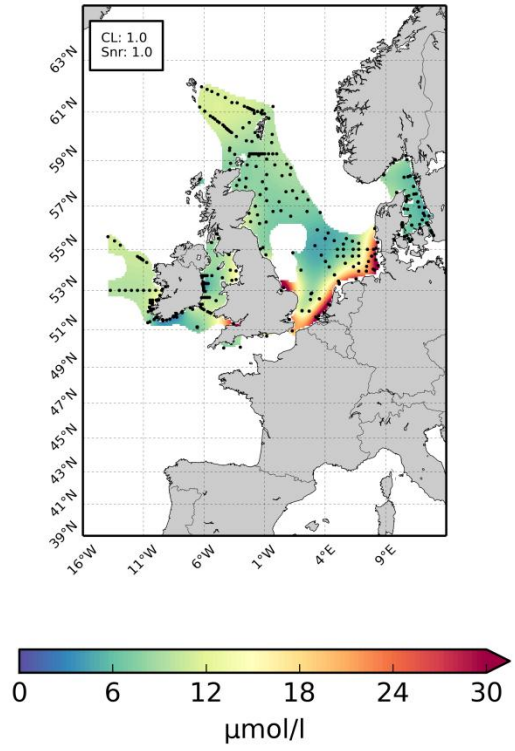

Figure 15: Diva interpolated for with DIN masked with an error threshold of 0.5, winter 2012/2013. Sampling points shown as black dots.

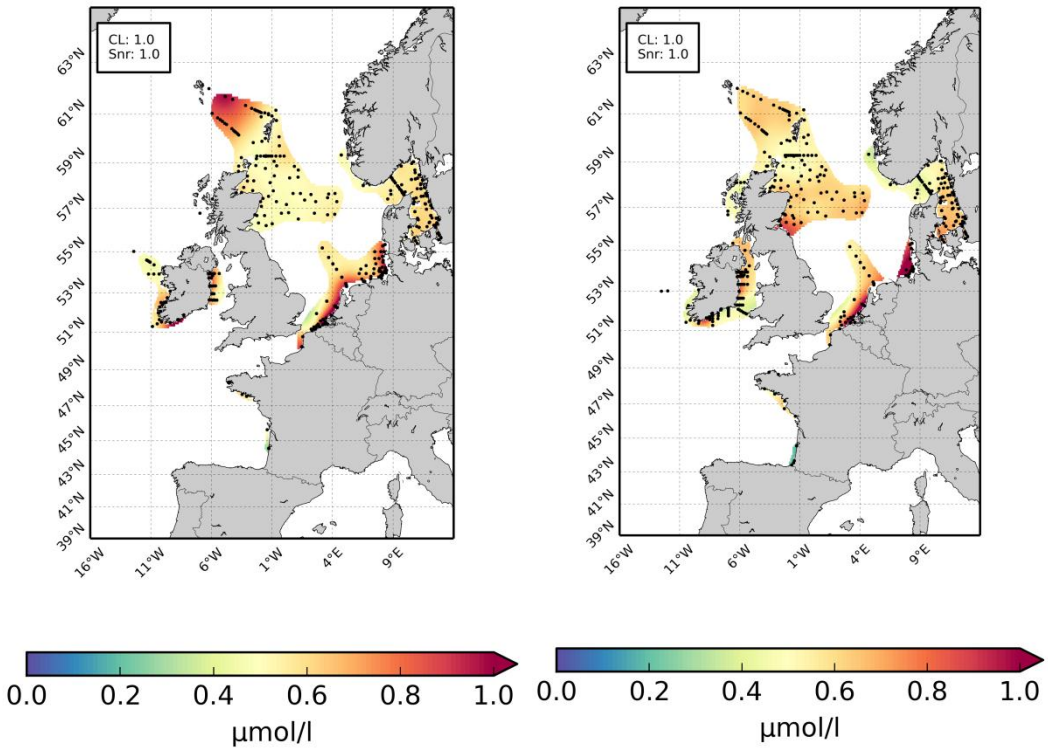

Figure 16: Diva interpolated field for DIP masked with an error threshold of 0.5, winter 2006/2007 (left) and 2007/2008 (right). Sampling points shown as black dots.

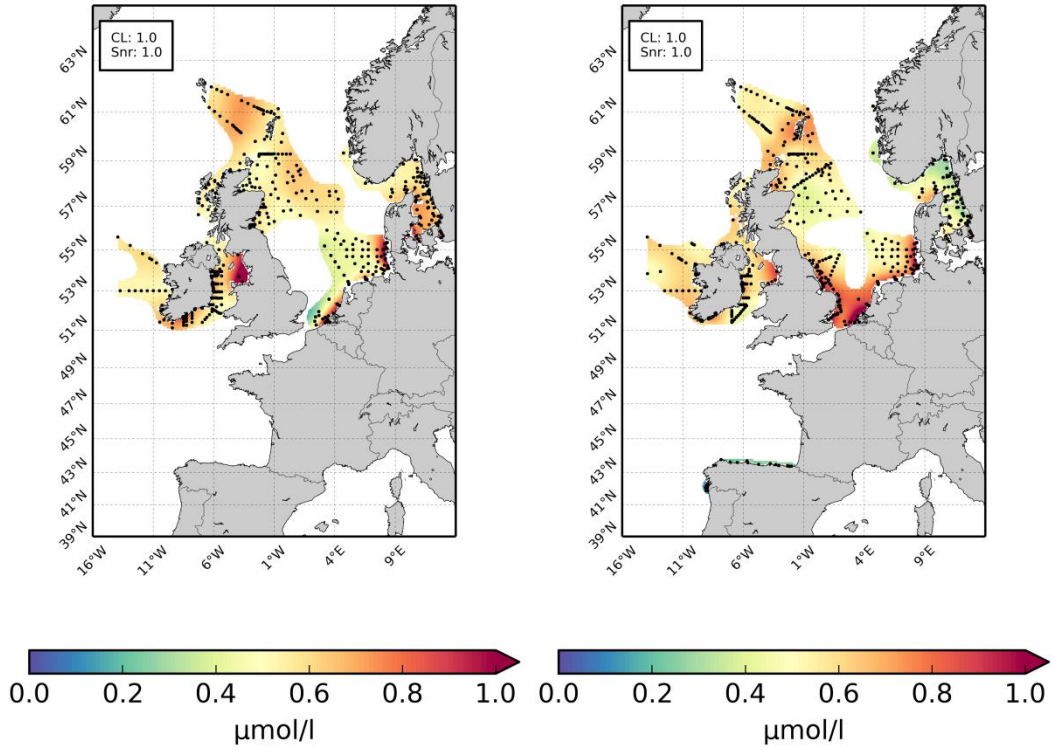

Figure 17: Diva interpolated field for DIP masked with an error threshold of 0.5, winter 2008/2009 (left) and 2009/2010 (right). Sampling points shown as black dots.

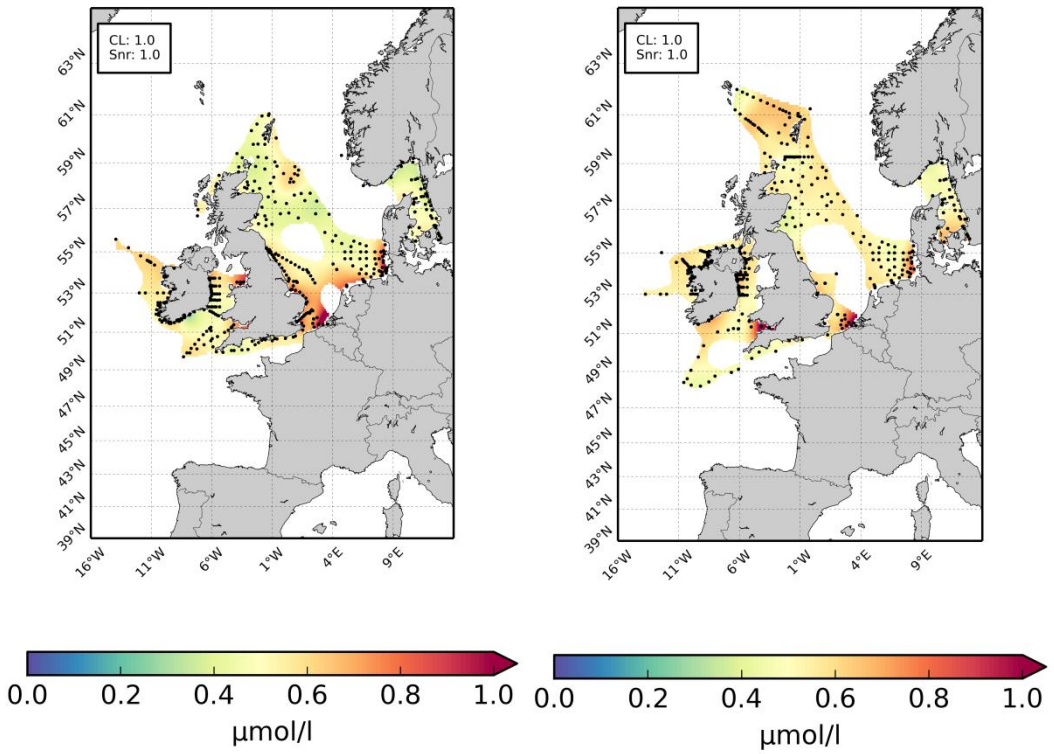

Figure 18: Diva interpolated field for DIP masked with an error threshold of 0.5, winter 2010/2011 (left) and 2011/2012 (right). Sampling points shown as black dots.

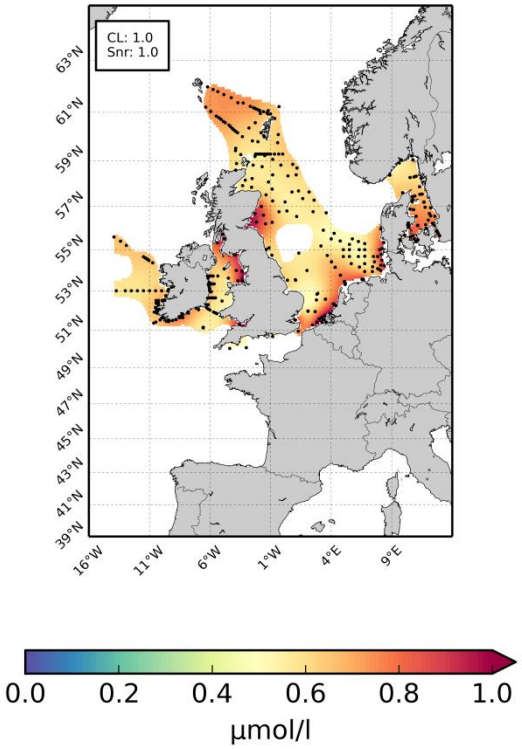

Figure 19: Diva interpolated field for DIP masked with an error threshold of 0.5, winter 2012/2013. Sampling points shown as black dots.

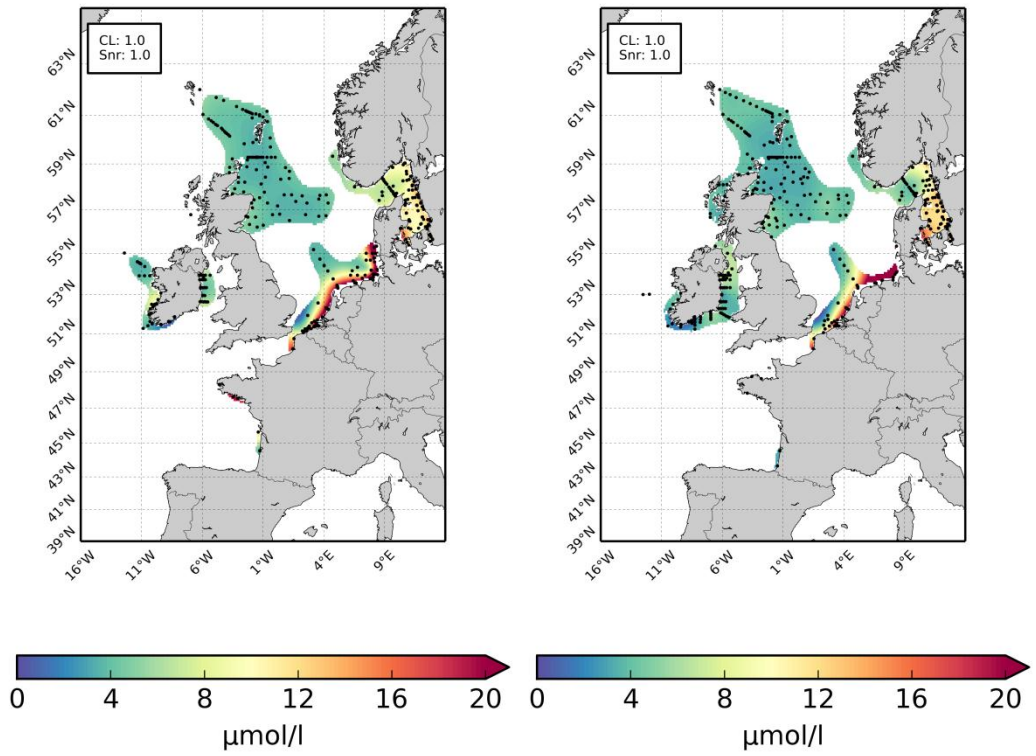

Figure 20: Diva interpolated field for silicate masked with an error threshold of 0.5, winter 2006/2007 (left) and 2007/2008 (right). Sampling points shown as black dots.

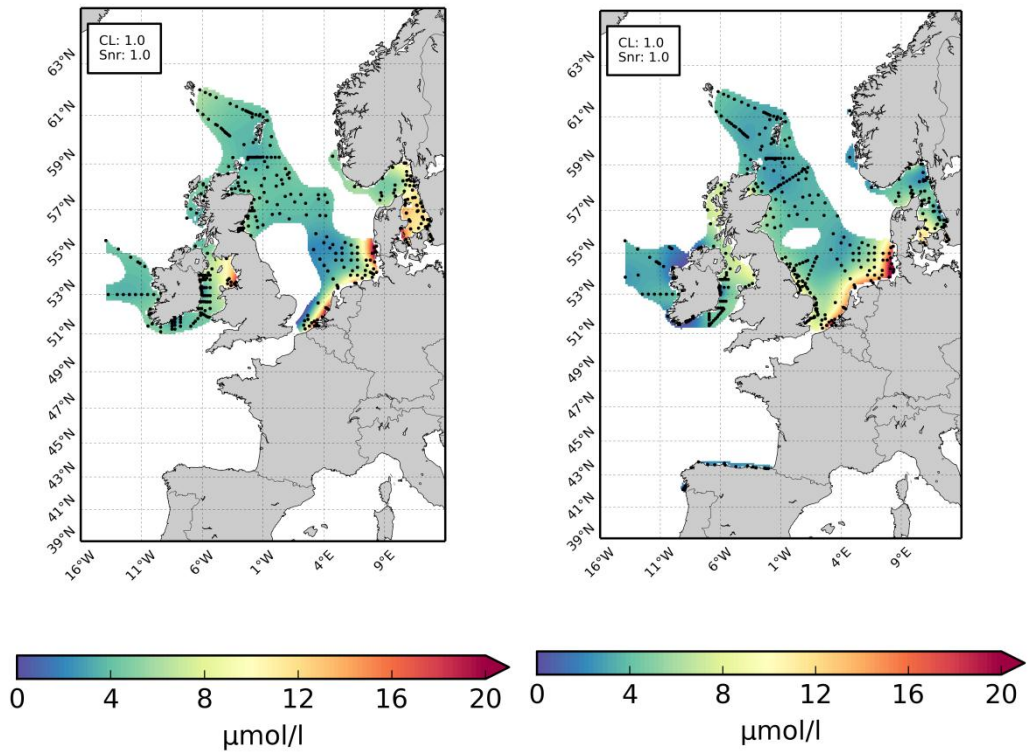

Figure 21: Diva interpolated field for silicate masked with an error threshold of 0.5, winter 2008/2009 (left) and 2009/2010 (right). Sampling points shown as black dots.

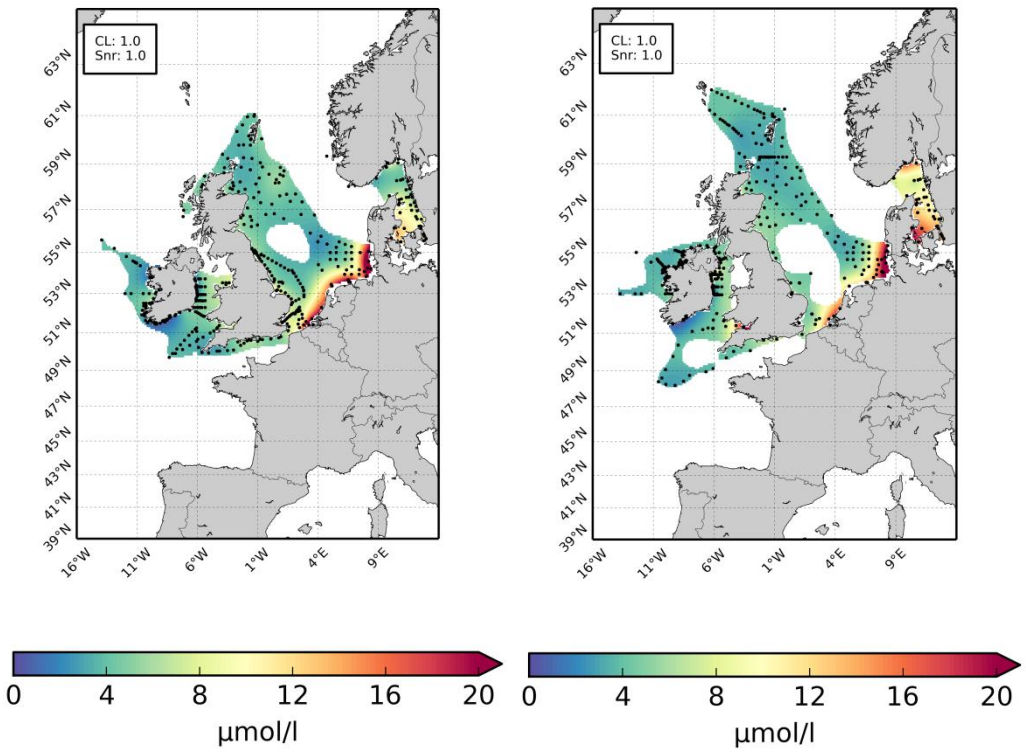

Figure 22: Diva interpolated field for silicate masked with an error threshold of 0.5, winter 2010/2011 (left) and 2011/2012 (right). Sampling points shown as black dots.

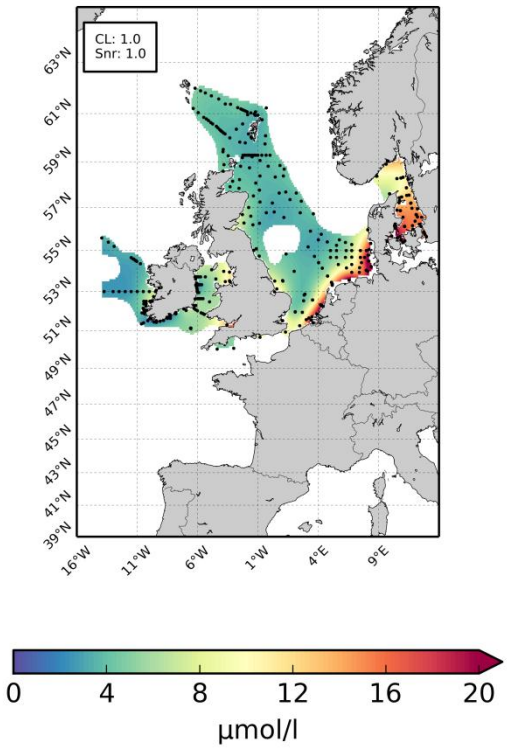

Figure 23: Diva interpolated field for silicate masked with an error threshold of 0.5, winter 2012/2013. Sampling points shown as black dots.

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Swedish Meteorological and Hydrological Institute
SE 601 76 NORRKÖPING
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