Winter Nutrient Concentrations in the Greater North Sea, Kattegat and Skagerrak

MSFD Descriptor: 5 - Eutrophication
MSFD Criterion: 5.1 - Nutrient levels

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Key Message Since 1990, winter concentrations of dissolved inorganic nitrogen (DIN) and phosphorus (DIP) have decreased significantly in the southern North Sea and, for DIN, in the Kattegat, Sound and offshore areas of the Skagerrak. Since 2006, average winter concentrations of DIN and DIP in the area assessed have shown little change

Background

OSPAR's strategic objective with regard to eutrophication is to combat eutrophication in the OSPAR Maritime Area, with the ultimate aim to achieve and maintain a healthy marine environment where anthropogenic eutrophication does not occur. This indicator on winter nutrient concentrations is one of a suite of five eutrophication indicators. When assessed and considered together in the OSPAR Common Procedure in a multi-step method the suite of indicators can diagnose eutrophication.

Nutrients such as nitrogen, phosphorus and silicate enter the marine environment from the atmosphere, rivers, land runoff, or by direct discharges into the sea. Human activities can result in large quantities of nutrients entering the sea from sources that include agriculture, combustion processes (road traffic, shipping, power plants), municipal and industrial waste water treatment and aquaculture. Such nutrient discharges can lead to elevated nutrient concentrations in the marine environment, of which dissolved inorganic winter nutrient concentrations are a good indicator.

Dissolved inorganic nitrogen, phosphorus and silicate concentrations are measured in winter when biological activity and uptake of nutrients by phytoplankton is low. Waters with high nutrient concentrations are not necessarily considered eutrophic because it is the characteristics of these waters (e.g. currents, turbidity) that affect whether those concentrations lead to eutrophication and associated effects.

The present assessment is an intermediate step towards a regionally coherent assessment of winter nutrient concentrations at the level of subregions used in this eutrophication assessment.

Results

For the period 1990–2014, winter DIN and DIP concentrations decreased significantly in the southern North Sea and DIN concentrations decreased significantly in the Kattegat, the Sound and the offshore areas of the Skagerrak. For the shorter period 2006–2014, generally no trends could be detected, except for a limited, but significant increase in DIN concentrations in the coastal areas of the southern North Sea.

In the period 2006–2014, average offshore winter DIN concentrations in the northern North Sea are generally <8 µM except where the typically nutrient-rich inflow from the open Atlantic Ocean enters east of Shetland (**Figure 1**). Average winter DIN concentrations are generally <7 µM in the Sound and Kattegat, and <10 µM in the Skagerrak. The southern North Sea has the highest average DIN concentrations: exceeding 60 µM along the coasts in some eastern areas and 25 µM in some western areas. Concentrations in the central parts of the southern North Sea are 4–6 µM.

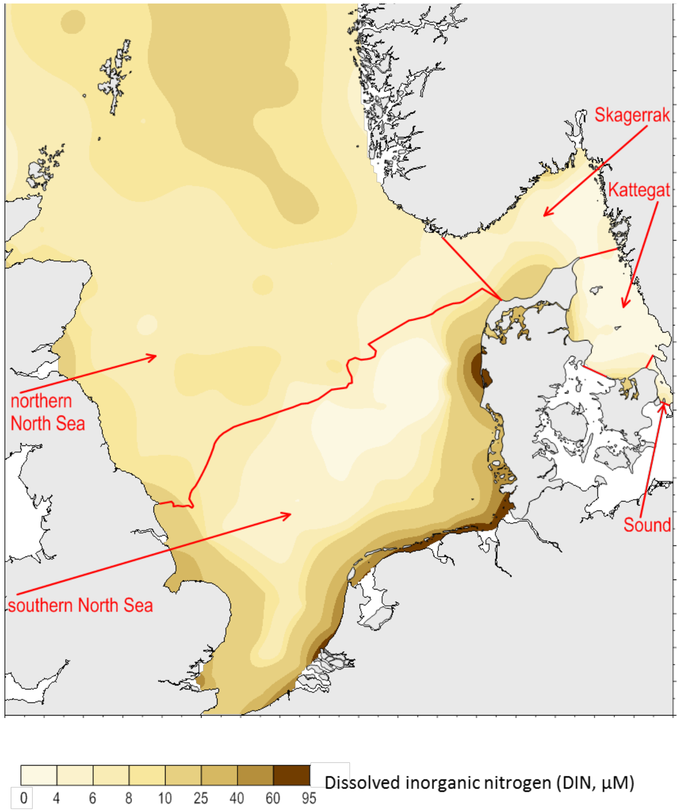

Figure 1: Distribution of average concentrations (2006–2014) of winter DIN (µM) in the northern North Sea, the southern North Sea, the Skagerrak, the Kattegat and the Sound. White areas (marine waters and estuaries) not part of this assessment, according to data availability. The accompanying table shows the results of the trend analysis for the periods 1990–2014 and 2006–2014. Downward arrows indicate a significant decreasing trend, upward arrows indicate a significant increasing trend, and horizontal arrows indicate no statistically significant trend

Area	Trend 1990-2014	Trend 2006-2014
Northern North Sea coastal (S18-30)	⟺	⟺
Northern North Sea offshore (S>30)	⟺	⟺
Southern North Sea coastal (S18-30)	⇩	⇧
Southern North Sea offshore (S>30)	⇩	⟺
Skagerrak coastal (S0-27)	⟺	⟺
Skagerrak offshore (S>27)	⇩	⟺
Kattegat	⇩	⟺
Sound	⇩	⟺

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Results cont...

The distribution pattern for average winter DIP concentrations resembles that for DIN with highest concentrations along the southern North Sea coasts (**Figure 2**). Average annual winter concentrations are around 1.2 µM in coastal waters and around 0.8 µM in offshore waters of the southern North Sea. Average concentrations on the northern North Sea coasts are mostly <0.5 µM and increase up to 0.6 µM offshore, where nutrient-rich waters flow in from the Atlantic. For the Kattegat, Skagerrak and Sound, average concentrations are mostly <0.7 µM. In the east of the Skagerrak average concentrations are around 0.1 µM.

Data coverage varied widely between years, areas and salinity bands assessed. In the southern North Sea for example, the standard deviation of both DIN and DIP was between 40% and 80% across the time series in coastal areas (salinity 18–30) and offshore areas (salinity >30).

The ratio of nitrogen to phosphorus follows the distribution pattern of DIN with the lowest ratios in the offshore areas of the southern North Sea, the eastern Skagerrak, the Kattegat and the Sound. High ratios in coastal areas, namely in the southern North Sea, may link to greater success in reducing phosphorus inputs compared to nitrogen. Ratios have mostly remained stable since 1990 with clear, decreasing trends only in the Kattegat and Skagerrak and increasing trends in estuaries of the southern North Sea.

The distribution pattern of average winter silicate concentrations is similar to winter DIN and DIP concentrations in the areas assessed. Except for an increase in silicate concentrations in the Kattegat and a decrease in the estuaries of the southern North Sea, there are no statistically significant trends in winter silicate concentrations over the period 1990–2014.

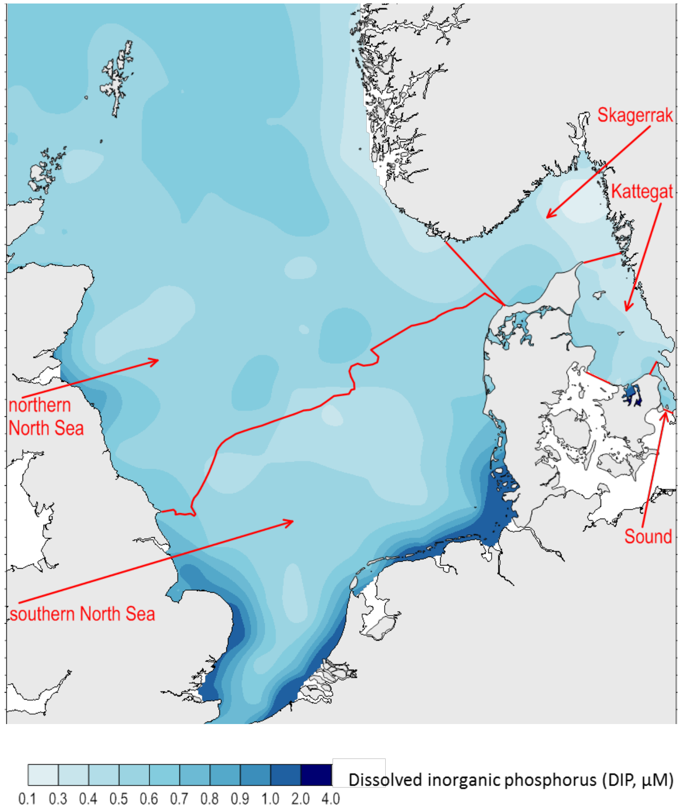

Figure 2: Distribution of average concentrations (2006–2014) of winter DIP (µM) in the northern North Sea, the southern North Sea, the Skagerrak, the Kattegat and the Sound. White areas (marine waters and estuaries) not part of this assessment, according to data availability. The accompanying table shows the results of the trend analysis for the periods 1990–2014 and 2006–2014. Downward arrows indicate a significant decreasing trend, upward arrows indicate a significant increasing trend, and horizontal arrows indicate no statistically significant trend

Area	Trend 1990-2014	Trend 2006-2014
Northern North Sea coastal (S18-30)	↔	↔
Northern North Sea offshore (S>30)	↔	↔
Southern North Sea coastal (S18-30)	↓	↔
Southern North Sea offshore (S>30)	↓	↔
Skagerrak coastal (S0-27)	↔	↔
Skagerrak offshore (S>27)	↔	↔
Kattegat	↔	↔
Sound	↔	↔

Conclusion

Nutrient concentrations in coastal waters are higher than in offshore areas. Concentrations in estuaries and coastal areas in the southern North Sea relate to riverine inputs, which link to human activities such as agriculture, combustion processes and municipal and industrial waste water treatment. The influence of atmospheric nitrogen deposition on the Greater North Sea is not visible due to its more even spatial distribution.

Coastal nutrient concentrations in the southern North Sea and, for dissolved inorganic nitrogen (DIN) only, in offshore areas of the Skagerrak, and in the Kattegat and Sound have declined significantly since 1990. There were generally no statistically significant trends in the areas assessed over the short term (2006–2014); with the exception of a limited but increasing trend in the southern North Sea coastal waters (salinity 18–30). The lack of short term trends may be due to the minor changes in nutrient inputs (especially nitrogen) in the past decade (nutrient inputs indicator assessment) or to variability in the data.

Given that eutrophication is still evident in certain areas (see chlorophyll-a, *Phaeocystis* and oxygen indicator assessments) “a healthy marine environment where anthropogenic eutrophication does not occur” has not yet been achieved (Comprehensive Procedure integrated eutrophication report).

Knowledge Gaps

To obtain an assessment that is not only based on trends but also on the actual status of nutrient concentrations, regionally harmonised assessment values are required in all areas. These could be achieved by applying a common approach. For example, based on historical data, and modelling based on hind-casting in selected areas such as the Greater North Sea. Better informed models are required to estimate long-distance transports of nutrients and their regional effects. There is also a need to better understand the implications of data variability in trend assessment.

This document was published as part of OSPAR’s Intermediate Assessment 2017.
The full assessment can be found at www.ospar.org/assessments