Concentrations of Dissolved Oxygen Near the Seafloor

MSFD Descriptor: 5 - Eutrophication
MSFD Criterion: 5.3 - Indirect effects of nutrient enrichment

OSPAR COMMISSION

Key Message Dissolved oxygen is necessary for healthy marine ecosystems. Overall, there is not a problem with dissolved oxygen concentrations near the seafloor in the areas assessed. However, there is oxygen depletion in some localised areas. Improvements in levels of dissolved oxygen concentrations have been observed in the Kattegat

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. Dissolved oxygen 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 can be used to diagnose eutrophication.

Excessive enrichment of marine water with nutrients may lead to algal (phytoplankton) blooms, with the possible consequence of undesirable disturbance to the balance of organisms in the marine ecosystem and overall water quality. Undesirable disturbance includes shifts in the composition and extent of flora and fauna and depletion of oxygen caused by decomposition of accumulated organic material produced by phytoplankton or seaweed communities during their growing seasons. Oxygen depletion may result in behavioural changes or death of fish and other species. Although oxygen depletion can be an indirect effect of nutrient enrichment, other pressures often complicate the identification of causal links between disturbances and nutrient enrichment.

Figure 1: Water samples collected from the Celtic Seas during a *Karenia mikimotoi* bloom (July 2011). With reagents added, surface samples were darker (higher concentrations of dissolved oxygen) than near-bottom samples (lower dissolved oxygen). © Elisa Capuzzo, Cefas

Factors that influence oxygen concentrations include changes in water temperature and salinity and climate change. Seasonal oxygen depletion can be a natural localised process, particularly where the water column stratifies seasonally.

Oxygen concentrations above 6 mg/l are considered to support marine life with minimal problems, while concentrations less than 2 mg/l (hypoxia, i.e. oxygen deficiency) (**Figure 1**) are considered to cause severe problems.

Observations from the Baltic Sea show that when the oxygen content in the bottom water is very low, the only organisms that are able to thrive are the bacteria that live on and in the seafloor (**Figure 2**).

Figure 2: Low oxygen conditions in the Baltic Sea. The patches of white sulphur bacteria form a shroud © Peter Bondo Christensen

Results

Mean near-bed dissolved oxygen concentrations (2006–2014) assessed in large-scale regions of the northern North Sea, southern North Sea, English Channel, Celtic Seas, and Bay of Biscay and Iberian Coast were >6 mg/l. Mean near-bed oxygen concentrations were lower in the Skagerrak (5.25 mg/l), Kattegat (3.98 mg/l) and the Sound (2.80 mg/l). Oxygen concentrations in these three regions are strongly influenced by local eco-hydrodynamic conditions.

No statistically significant temporal trends were observed (1990–2014) in near-bed oxygen concentrations or percentage saturation in most of the large-scale regions (northern North Sea, southern North Sea, Skagerrak, Sound, English Channel, Celtic Seas, and Bay of Biscay and Iberian Coast). The Kattegat was the only exception, with significant upward trends observed in oxygen concentrations and percentage saturation.

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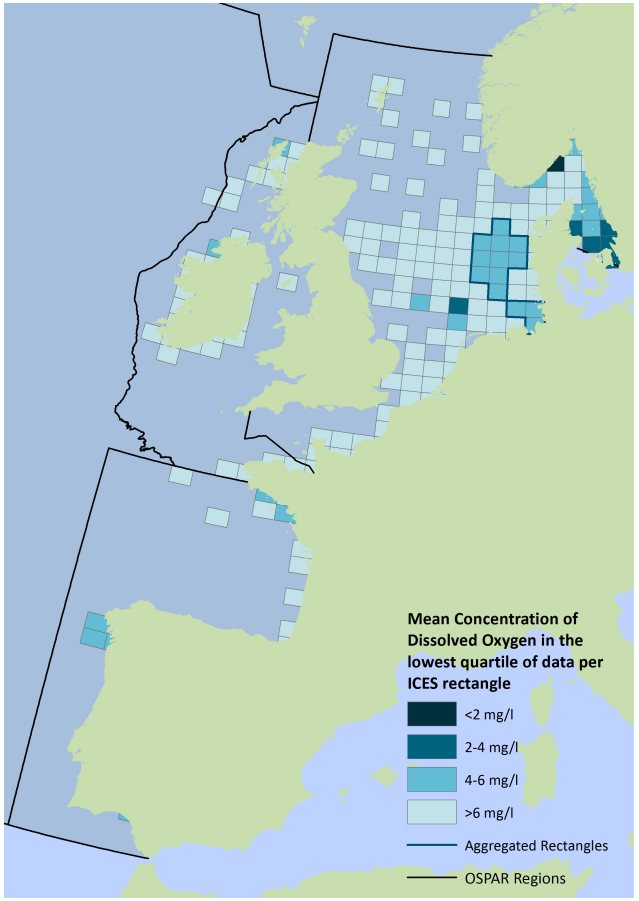
Results cont...

Within the large-scale regions, available data (1990–2014) were analysed at a smaller scale using ICES rectangles. Analyses showed that mean near-bed oxygen concentrations in the lowest quartile of the data during the summer stratification season were >6 mg/l in most ICES rectangles in each region, except in the southern North Sea and the Kattegat (**Figure 3**). For the southern North Sea, rectangles with mean values of <6 mg/l indicate localised areas with lower oxygen concentrations. These rectangles are mostly located in the eastern southern North Sea (outlined in bold in **Figure 3**), a region with a high degree of hydrodynamic variability. No temporal trends were identified in 12 of the 13 individual rectangles in the eastern southern North Sea (i.e. dissolved oxygen concentrations showed no change). A significant downward trend was observed in one rectangle (in the Skagerrak off the southeast coast of Norway). When all the data in these rectangles were aggregated (**Figure 3**) into one dataset, no statistically significant trend was found at the large scale.



In the Skagerrak and Kattegat, ICES rectangles also showed mean near-bed oxygen concentrations of <6 mg/l. However, the specific regional characteristics of this area mean that these levels are not considered to indicate oxygen deficiency. For the Kattegat, analyses of rectangles indicate areas with higher mean near-bed concentrations (4–6 mg/l) than those calculated using the large-scale regional analysis (2–4 mg/l).

In the Bay of Biscay and Iberian Coast, four rectangles showed lower oxygen concentrations (4–6 mg/l) but there were insufficient data for detailed analyses. One rectangle in the Celtic Seas showed a mean near-bed oxygen concentration (5.8 mg/l) towards the upper end of the 4–6 mg/l range, indicating a localised area with low oxygen. Overall, results indicate that oxygen concentrations, when analysed at larger scales, were not depleted during the shorter (2006–2014) and longer (1990–2014) assessment periods.

Confidence ratings in terms of data availability and methodology used are moderate.

Figure 3: Mean concentration of dissolved oxygen in the lowest quartile of the data plotted by ICES rectangles for the period 1990–2014. Rectangles aggregated for analyses are outlined in bold. Data were filtered by season (stratification season 1 July–31 October), depth (within 10 m of the seafloor), and salinity (≥30). Results are shown for rectangles where there were five or more data points. Blank areas indicate where there were no data or insufficient data

Conclusion

Across large-scale assessment regions of the northern North Sea, southern North Sea, English Channel, Celtic Seas, and Iberian Coast and Bay of Biscay, there is no widespread oxygen deficiency. The Skagerrak, Kattegat and Sound have lower mean concentrations, but these are not considered to indicate oxygen deficiency owing to the regional-specific characteristics of this area.

Localised areas of oxygen deficiency are apparent, particularly in the eastern part of the southern North Sea. Oxygen concentrations and percentage saturation are improving in the Kattegat and deteriorating in a very localised area of the eastern southern North Sea.

Assessment outcomes are influenced by the size of the areas assessed and the availability of the data. Assessment at the scale of the southern North Sea, for example, shows a different outcome to assessments based on smaller areas, such as ICES rectangles. However, sufficient data are required to base assessments on smaller areas. In the case of dissolved oxygen, use of only near-bed data during the stratification season limits the amount of data that can be used in assessments.

Knowledge Gaps

Understanding of the relative importance of biological and physical processes (e.g. mixing and currents) in controlling near-bed oxygen dynamics, and the impacts of climate change on physical processes, oxygen deficiency and oxygen consumption is rather poor. This will need to be improved in order to better distinguish between the effects of nutrient enrichment and changes in seawater temperature as a result of climate change. Furthermore, robust assessments of oxygen deficiency require improved availability of suitable data. Since oxygen deficiency is localised and often short-lived, modelling can help in identifying hotspots.

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The full assessment can be found at www.ospar.org/assessments