Predicting eutrophication status in the North Sea: scenario runs with an ecosystem model

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1. Introduction

Recent assessments of the eutrophic status of European shelf-seas have been carried out under the auspices of OSPAR, a Convention for protection of the marine environment of the North-East Atlantic Ocean [1]. OSPAR recommends a substantial reduction (of the order of 50%) in riverine inputs of phosphorus and nitrogen into areas where eutrophication has been diagnosed [2].

To predict the effectiveness of these recommended management measures in alleviating eutrophication, OSPAR initiated a programme of work to be carried out by the Intersessional Correspondence Group on Eutrophication Modelling (ICG-EMO). This international working group aims to advise OSPAR on the potential application of models to diagnose eutrophication, and in particular to model the outcome of its recommended reduction in riverine nutrient inputs (N & P) for adversely affected marine waters [3].

This poster presents results of the General Estuarine Transport Model (GETM) [4] coupled to the Biogeochemical Flux Model (BFM) [5] applied for the second ICG-EMO workshop held in Lowestoft, UK, in September 2007 [3], and for two additional reduction scenarios.

2. Riverine nutrients

The annual riverine discharges of fresh water into the North Sea and the English Channel by country (Figure 1A) show the dominance of the Rhine and Meuse that enter the North Sea in The Netherlands (although the respective catchments cover several countries), followed by the German rivers, UK rivers, and French rivers. Substantial inter-annual variability was observed. The corresponding nutrient loads (Figure 1B-D) show noticeable reductions, in particular for ammonium and phosphate for the Netherlands and Germany as a result of measures taken after 1985.

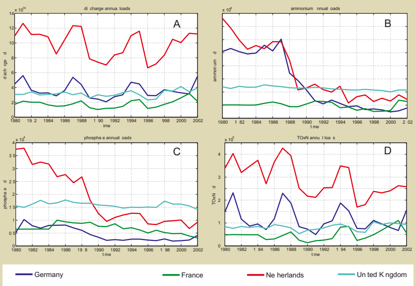

Figure 1 Observed annual river loads discharged into the North Sea and English Channel, by country where the river mouth is located, 1980 to 2002
A fresh water; B ammonium; C phosphate; D total oxidised nitrogen

3. Riverine reduction scenario's

The two model reduction scenario's carried out for the ICG-EMO workshop were set up to reduce the nutrient loads in 2002, per country, to 50% and 70% of the 1985 values (Table 1). Two additional reduction scenario's were carried out: i) reducing all riverine nutrients by 100% ('zero loads'), and ii) reducing all UK riverine nutrients by 100% while keeping continental loads at 2002 levels. In these latter scenarios, all nutrients of natural origin were also removed.

Contracting Party	TOxN (%)	NH_4 (%)	PO_4 (%)
(a) Reductions ach eved between 1985 and 2002			
Ne her ands	0	70	70
Germany	0	90	50
UK	0	20	0
France	0	10	60
(b) Scenario 1: Reduct ons of 2002 national loads necessary to achieve 50% reduction compared to 1985			
Ne her ands	50	0	0
Germany	50	0	0
UK	50	40	50
France	50	40	0
(c) Scenario 2: Reductions of 2002 national loads necessary to achieve 70% reduction compared to 1985			
Ne her ands	70	0	0
Germany	70	0	40
UK	70	60	70
France	70	70	20

Table 1 Achieved riverine nutrient reductions into the North Sea and English Channel per country between 1985 and 2002, and definition of reduction scenario's for model runs

4. Model results

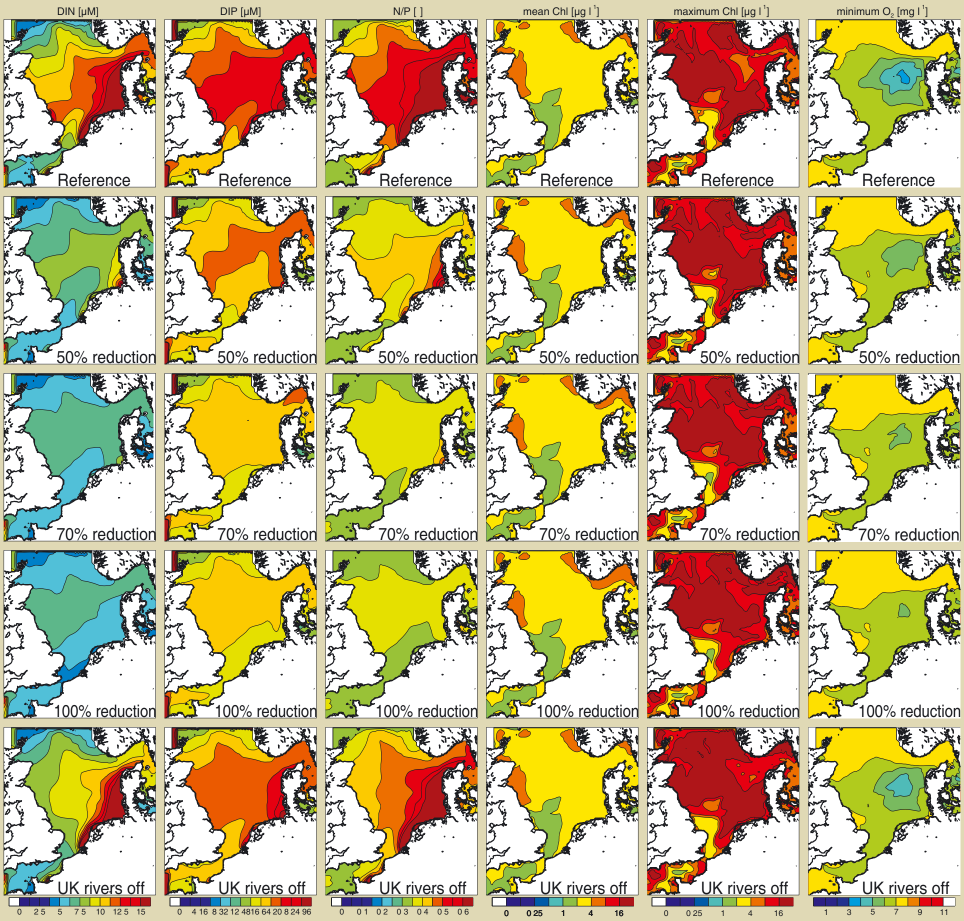

Figure 2 Model results for OSPAR assessment variables for 2002 for each of the reduction scenario's (rows) Nutrients (columns 1 3) were taken at 2 m depth, and averaged over January and February Mean chlorophyll (column 4) was taken at 2 m depth and averaged over March to October Maximum chlorophyll (column 2) was taken at 5 m depth, and taken from the months March to October Minimum oxygen (column 6) was taken at 1 m above the sea bed from the full year

5. OSPAR framework

The OSPAR Common Procedure (CP) is used to assess and classify the eutrophication status of marine waters and was applied to the model results for several target areas (Figure 3). The CP uses a framework of indicators (assessment variables) and thresholds to diagnose eutrophication and to classify water bodies.

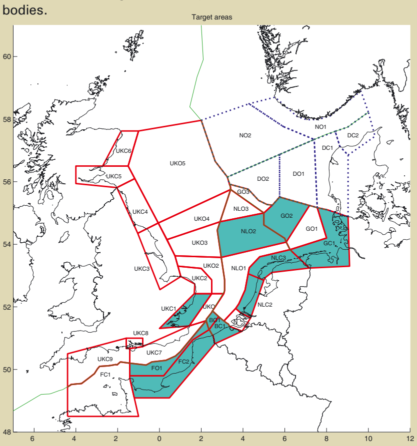

Figure 3 Target areas for the OSPAR Common Procedure assessment (blue)

6. Assessment of model results using OSPAR framework

The results of applying the OSPAR framework to the model outcome (Figure 4) shows a strong decrease of mean winter nutrient concentrations in coastal areas, and an intermediate decrease in offshore areas. Most of the decrease in winter concentrations was achieved with the 50% reduction scenario: further reductions had a relatively small effect. Mean summer chlorophyll concentrations did not change much in response to the nutrient reductions. Maximum summer chlorophyll concentrations showed an intermediate decrease in coastal areas, and small decreases in offshore areas. Annual near-bottom minimum oxygen concentrations showed only a small increase, with the largest response in summer-stratified areas. For all target areas other than UK-C1, there was a small change in concentrations in response to a unilateral reduction of UK riverine loads.

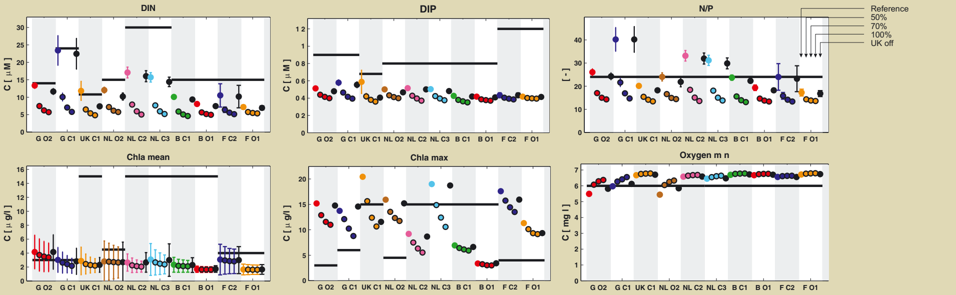

Figure 4 Assessment results per OSPAR assessment variable and per target area Black lines are the threshold values Un circled dots represent the reference run Circled dots represent the 50%, 70% and 100% reduction scenarios Black dots represent the UK 'rivers off' scenario Error bars give the standard deviation of the model results within the target area and assessment period

7. Conclusions

1. 50% Reductions in phosphorus and nitrogen loads were mostly sufficient to reduce the levels of the assessment variables beneath the threshold value (above the threshold for oxygen),
2. Reductions of nutrient loads that exceeded 50% had a minor additional effect on the eutrophication assessment variables,
3. Maximum chlorophyll concentration exceeded the threshold value in many target areas, even for zero nutrient loads,
4. The scenario with unilateral reductions in nutrient loads by the UK did not lead to much improvement in the values of assessment variables for most target areas (in comparison to threshold values).

References

[1] OSPAR publications 140/2001 189/2003 (to appear)/2008
see www ospar org
[2] PARCOM Recommendation 88/2
see www ospar org/v ospar/strategy asp?v0=8&lang=1
[3] ICG EMO 2007 Workshop Users Guide Data Description and Report
see www cefas co uk/eutmod
[4] www getm eu
[5] www bfm cmcc it

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