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## Wadden Sea Specific Eutrophication Criteria

### Framework

In 1994, at the 7<sup>th</sup> Wadden Sea Conference in Leeuwarden, the trilateral Targets were adopted. With regard to eutrophication a formulation was agreed upon which was consistent with the development of a procedure regarding the strategy to combat eutrophication within the framework of OSPAR. Part of this strategy is to classify the Convention Area in terms of Eutrophication Problem Areas, Non-Problem Areas and Potential Problem Areas. It was recognized that criteria for the classification would differ between different sea areas of the Convention Areas, given the large hydrological differences. This was the reason why it was decided that Wadden Sea specific criteria should be developed within the trilateral framework (Wadden Sea Plan Project 2.2.1).

In the period December 1998–December 2000 a trilateral project was carried out with financial support of the three countries and logistic support of the Alfred Wegener Institute (AWI, Wattenmeerstation Sylt) and the Wadden Sea Secretariat. The work consisted of a literature study, analyses of long-time data series from the three countries, and an expert workshop.

### Outcome

The main starting point for the analysis is the assumption that the Wadden Sea is a system which imports organic material from the adjacent North Sea (compare van Beusekom, 2000). This material is broken down (remineralized) in the Wadden Sea and the resulting products, amongst which nutrients, are used again for primary production in the Wadden Sea itself and in the adjacent coastal zone.

An important implication of this concept is that changes in the growth of phytoplankton (primary production) in the coastal zone will result in changes in the remineralization rate in the Wadden Sea. Consequently, remineralization products in the Wadden Sea can be used as an indicator of the eutrophication status of the Wadden Sea and the North Sea coastal zone. The main proposal from the study is to use ammonium + nitrite concentrations in autumn as such indicators.

The choice for the general concept and for the mentioned indicator could be substantiated by the

analyses of long-term data series. Several other indicator parameters were evaluated for their usefulness as eutrophication indicator. The general problem that arose was that none of the so-called eutrophication effect parameters (for example growth of macroalgae and mussels) could be directly linked to nutrient concentrations. Several other factors, such as weather and climate, also strongly influenced these parameters.

In the final phase of the project, a model was developed which would allow for the classification of the Wadden Sea into the three OSPAR categories. One of the principal problems that had to be faced was that the definition of „Eutrophication problem area“<sup>1</sup> contains a substantial normative aspect. It was recognized that the Wadden Sea is, also in a pristine state, a eutrophic area, where, under certain circumstances, eutrophication effects, such as large algal blooms, may occur. The question when such events must be regarded as undesirable can hardly be answered on the basis of scientific facts. Therefore, the choice was made to apply a model in which nutrient concentrations instead of eutrophication events are used, assuming that the frequency of eutrophication events will (statistically) increase with increasing nutrient concentrations.

On the basis of scientific literature it could be made plausible that during the 1970s a general increase in eutrophication events had occurred (e.g. a doubling of the primary production). This increase coincided with a doubling of wintery nitrate concentrations between 1970 and 1980. It was, therefore, decided, to regard these changes as indicative of the transition from potential-problem area conditions to problem area conditions.

Although autumnal ammonium + nitrite values for the early 1970s are available, these could not be applied directly as transition concentrations. That is because in the early 1970s the supply of riverine ammonium was very high because

<sup>1</sup> Eutrophication Problem Area: Problem Areas with regard to eutrophication are those areas for which there is evidence of an undesirable disturbance to the marine ecosystem due to anthropogenic enrichment by nutrients.

Table 1: Classification of the Wadden Sea into Non-Problem, Potential Problem and Problem areas based on autumn concentrations of  $\text{NH}_4 + \text{NO}_2$  ( $\mu\text{M}$ ). The division in subregions is based on the availability of seasonal data. The present autumn values refer to values during the 1990s.

	Non-Problem conditions	Potential Problem conditions	Problem conditons	"Present" values (1990s)
Western Dutch Wadden Sea	<3.0 $\mu\text{M}$	3.0 $\mu\text{M}$ - 8.3 $\mu\text{M}$	> 8.3 $\mu\text{M}$	12.3 $\mu\text{M}$
Eastern Dutch Wadden Sea	<4.0 $\mu\text{M}$	4.0 $\mu\text{M}$ - 10.2 $\mu\text{M}$	> 10.2 $\mu\text{M}$	16.7 $\mu\text{M}$
Lower Saxony Wadden Sea	<3.2 $\mu\text{M}$	3.2 $\mu\text{M}$ - 8.2 $\mu\text{M}$	> 8.2 $\mu\text{M}$	13.0 $\mu\text{M}$
Sylt Rømø Bight	<3.1 $\mu\text{M}$	3.1 $\mu\text{M}$ - 7.4 $\mu\text{M}$	> 7.4 $\mu\text{M}$	11.8 $\mu\text{M}$
Danish Wadden Sea	<2.5 $\mu\text{M}$	2.5 $\mu\text{M}$ - 6.5 $\mu\text{M}$	> 6.5 $\mu\text{M}$	10.3 $\mu\text{M}$

of the relatively low level of biological treatment in sewage treatment plants in the Wadden Sea catchment area. For this reason the concentrations of ammonium+nitrite demarcating potential-problem and problem area conditions were based on the values from after 1980, that is, after the large-scale introduction of secondary treatment in most of the Wadden Sea catchment area. The transition values, reflecting the early 1970 values shortly before the increase that occurred in the course of the 1970s, are assumed to be half of the post-1980 values.

All ranges were developed for the western Dutch Wadden Sea and adapted for five different subregions of the Wadden Sea on the basis of recent differences in autumn concentrations of ammonium + nitrite. In all these subregions, concentrations are such that they must be regarded as eutrophication problem areas (see Table 1). On the basis of a comparison of the different input sources of nutrients it was concluded that riverine inputs are the major source, but that, in order to arrive at non-problem area conditions, also atmospheric nitrogen inputs will have to be reduced.

The Final Report of the project (van Beusekom et al., 2001), will be published in the Wadden Sea Ecosystem series.

## References

- Van Beusekom, J.E.E. 2000. Eutrophication of the Wadden Sea. Wadden Sea Newsletter 2000-1: 6-8
- Van Beusekom, J.E.E., Fock, H., De Jong, F., Diel-Christiansen, S., Christiansen, B. 2001. Wadden Sea Specific Eutrophication Criteria. In press.

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