

# Nitrogen impacts on the Wadden Sea and adjacent Elbe Estuary (Europe): ecosystem degradation, recovery and ongoing impacts

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## Abstract

The Wadden Sea is a shallow tidal sea along the European NW continent. Eutrophication reached a maximum during the 1980s and 1990s. Measures to reduce riverine nutrient loads improved the ecological status of the Wadden Sea. Eutrophication is still a major problem in the adjacent Elbe estuary. Massive phytoplankton blooms from the Elbe river lead to low oxygen concentrations in the dredged part of the tidal Elbe in the vicinity of the Hamburg harbour. An integrated observation platform -currently under construction- will be presented that will allow for improved budgets of nitrogen and other pollutants.

Keywords: Wadden Sea, Elbe estuary, eutrophication, nutrients, partial recovery.

## 1. Eutrophication of the Wadden Sea

Coastal eutrophication has been a scientific and political issue since the 1960s when observations indicated a continuous degradation of many coastal ecosystems (de Jong, 2007) including the Wadden. Negative consequences included anoxia, large phytoplankton blooms, an increase in opportunistic macroalgae and a decrease in seagrass (e.g. van Beusekom et al., 2001).

## 2. Area description

The Wadden Sea is a shallow, intertidal sea along the Dutch, German and Danish North Sea coast. About 50% of the area is exposed during low tide. It is largely protected by barrier island. The Elbe estuary is situated in the central part of the Wadden Sea.

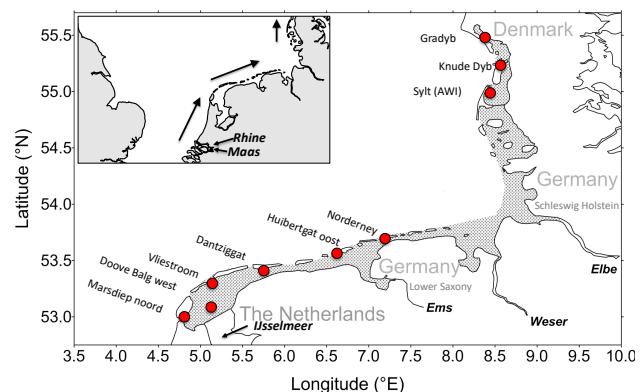


Fig. 1: Map of the Wadden Sea and the Elbe estuary showing the location of the long-term stations (from van Beusekom et al., 2019).

## 3. Eutrophication in the Wadden Sea

First signs of Wadden Sea eutrophication were observed during the 1970s (e.g. de Jong 2007). Several measures including wastewater treatment and a slight decrease in

fertilizer use lead to a decrease in riverine nutrient fluxes and a partial recovery of the Wadden Sea ecosystem including lower phytoplankton biomass and a partial seagrass recovery. Agriculture remains a major nitrogen source (Johannsen et al. 2008).

#### **4. Oxygen deficiency in the Hamburg harbour area**

In contrast to the improvements in the Wadden Sea, import of riverine phytoplankton blooms into the dredged parts of the upper Elbe estuary still lead to suboxic conditions due to an disbalance between production and remineralisation.

#### **5. Outlook**

To improve our understanding of estuaries as a transformation space for nutrients and pollutants, a new, high resolution observation system is under construction that will allow for improved budgets of nitrogen and other pollutants.

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