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# Environmental Quality Status in the Danish Wadden Sea – Monitoring and Assessment 2000

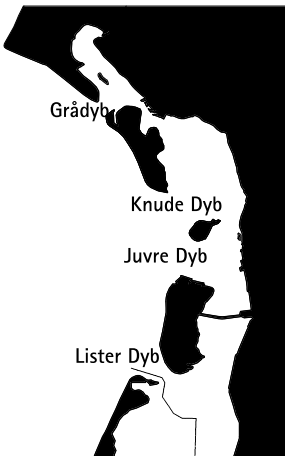


Figure 1: The Danish part of the Wadden Sea.

The environmental status of the Danish part of the Wadden Sea has been assessed in a recent report from the Counties of Sønderjylland and Ribe. It is concluded that the environmental status has been rather unchanged since the beginning of the Danish national monitoring program in 1989. The four tidal areas Lister Dyb, Juvre Dyb, Knude Dyb and Grådyb are still suffering from eutrophication, and xenobiotic substances are found in sediment and marine organisms. Morphological alterations and sterility among a gastropod species is a result of contamination with organic tin compounds used in antifouling agents. Hence the environmental quality criteria are not fulfilled.

## Monitoring Program and Assessment

The two counties carry out the environmental monitoring of the tidal areas in accordance with the Danish national monitoring program for the aquatic environment (NOVA) and with the Danish environmental law, i.e. the regional monitoring program.

The four tidal areas are assigned the highest environmental objective in the regional environmental management plan. This high objective demands an unaffected or only a slightly affected flora and fauna and a good bathing water quality. It is the purpose of the monitoring program to assess the marine water quality in relation to the assigned environmental objective.

The environmental monitoring program for the Danish Wadden Sea consists of the following physical, chemical and biological parameters: CTD-profiles (salinity, temperature, fluorescens, light, oxygen), secchi depth, nutrients (total nitrogen, $NO_x$, $NH_x$, total phosphorus, phosphate ($PO_4^{3-}$) and silicate ($SO_4^{3-}$), chlorophyll-a, phytoplankton (species composition and biomass), macrophytes, macrozoobenthos, xenobiotic substances and heavy metals. Additional evaluations of the climate and the environmental impact from the hydrological catchment area including nutrient load from natural processes and human activities are taken into consideration in the description and assessment of the environmental status.

## The Danish Wadden Sea

The Danish part of the Wadden Sea constitutes about 10% of the total Wadden Sea area of 13,500 $km^2$. The Danish part consists of 4 more and less separate tidal areas beginning in the south with the Lister Dyb tidal area, which is shared with Germany, the Juvre Dyb tidal area, the Knude Dyb tidal area and the Grådyb tidal area (Figure 1). The Lister Dyb tidal area is confined by the Hindenbug Dam in the south and the Rømø Dam in the north, which leaves the water exchange to the sea only through the deep Lister Dyb between Rømø and Sylt. The Juvre Dyb is confined by the Rømø Dam in the south and the Låningsvejen, a low dam in the north. Only on the occasion of high tide and strong wind from the west the water can pass the dam, thus leaving the only connection with the sea to the Juvre Dyb between Manø and Rømø. The Knude Dyb tidal area is connected to the Grådyb tidal area but there is a natural barrier caused by a watershed reducing the water exchange between the two areas. The tidal prism is about 2 m. The retention time of the water in the Lister Dyb tidal area is estimated to about 3 months while it is 17 days in the Juvre Dyb, Knude Dyb and Grådyb tidal areas.

## Results 2000

The four tidal areas are not identical in their physical, chemical and biological characterization but it is not in the scope of this paper to describe the detailed differences. Hence the following descriptions of the results for 2000 will be a generalization for the 4 areas and only a brief summary.

### Physics

The Danish Wadden Sea is an estuarine environ-

ment affected by the rivers. The salinity varied between 22–32 ‰ and is lower during winter due to precipitation and freshwater run-off. The water temperature varied between 3–4 °C in winter and 16–18 °C in late summer. The Secchi depth varied between 0.3–0.5 m in winter and 2.5–4.5 m in autumn. Fluorescence showed maximum values in April and May, and also in some areas in September. Statistical analyses for long-term trends (1989-2000) showed no changes in the physical parameters.

## Water chemistry

The following ranges of nutrient concentration represent the seasonal variation as monthly means: total nitrogen 200–2000 µg/l and in extreme cases up to 5000 µg/l, nitrogen oxides ($NO_x$) 5–1400 µg/l, ammonium and ammonia ($NH_x$) 30–550 µg/l, total phosphorus 20–210 µg/l, orthophosphate ($PO_4^{3-}$) 5–55 µg/l, Silicon oxide ($SiO_3$) 10–35 µg/l, chlorophyll-a 2–35 µg/l.

Potential nutrient limitation of phytoplankton by nitrogen occurred only in a few cases and not in all tidal areas. Potential limitation by phosphorus occurred in all tidal areas and is a regular phenomenon. Silicon was limiting in one tidal area.

Oxygen concentration is always high due to the strong tidal currents and a complete vertical mixing in all tidal areas.

Statistical analyses for long-term trends (1989-2000) in the water chemistry shows few significant changes (Kendall-Tau, $p<0.05$): $NH_x$ and $PO_4$ (summer means) have decreased in two tidal areas, $NO_x$ (winter means) has increased in one tidal area, as well as chlorophyll-a (winter means).

## Biology

In May – June 2000, a bloom of *Phaeocystis pouchetii* occurred and an abundance of $32.7*10^6$ cells/l and a carbon biomass of 820 µg C/l was measured. Other harmful or potential toxic algae species were recorded, e.g. species of the *Pseudonitzschia delicatissima*-group. No harmful effects were recorded in 2000.

Annual green macro algae requiring high nutrient concentration, i.e. *Chaetomorpha linum*, *Ulva* sp. and *Enteromorpha* sp. were widespread and occurred with up to a 100% cover in several places in all tidal areas. Distribution of sea grass was analyzed from aerial photographs and on field surveys. Less than 0.9 % of the total area of the Lister Dyb and the Grådyb tidal areas were covered with *Zostera noltii* or *Rupia cirrhosa*. The latter specie is the most prevalent and occurs with up to 100% cover at specific intertidal locations. *Z. noltii* has a maximum cover of 25%.

The macrozoobenthos consists of relatively few resistant species which can tolerate the fluctuating and harsh environment in the intertidal zone. 8 species are dominating and constitute approx. 90% of the total benthos abundance: Poychaeta: *Arenicola marina, Heteromastus filiformis, Hediste diversicolor, Scoloplos armiger*; Bivalvia: *Cerastoderma edulis, Macoma balthica, Mya arenaria and Crustacea: Corophium volutator*. Abundance, biomass, and species composition vary in time and space. In 2000, abundance and biomass was increasing in some areas or stagnant in others.

## Heavy metals and xenobiotic substances

Heavy metals (Hg, Cd, Cu, Pb, Ni, Zn) were present in low concentrations in the blue mussel, *Mytilus edulis*, in all tidal areas. In sediment, heavy metal concentrations were low but differed between areas. Chlorinated pesticide as polychlorinated biphenyls (PCB), Hexachlorocyclohexane (HCH) and DDT, DDD and DDE in *M. edulis* and sediment were present but in low concentrations. Polycyclic aromatic hydrocarbon (PAH) concentrations were high in *M. edulis* in one tidal area. Tributyltin (TBT) originating from antifouling agents was found in sediment and caused high frequency of intersex (figure 2) resulting in sterility among the gastropod *Littorina littorea*.

## Climate and nutrient load

2000 was climatically a rather normal year. There were no dramatic events like heavy storms or severe winter. The insolation was high in May and that could have been a triggering factor for the algal bloom of *Phaeocystis* in combination with high nutrient concentrations. Summer temperatures were low. The freshwater run off through the rivers is strongly correlated to precipitation

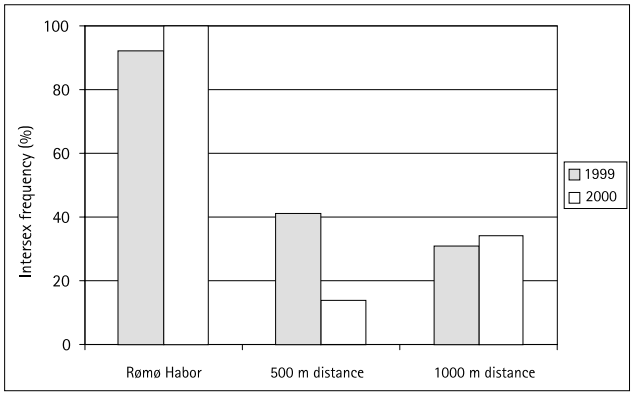


**Figure 2: Intersex caused by TBT in the marine snail Littorina littorea. Frequency (%) at different distances from the supposed source of TBT, Rømø harbour in the Lister Dyb tidal area.**

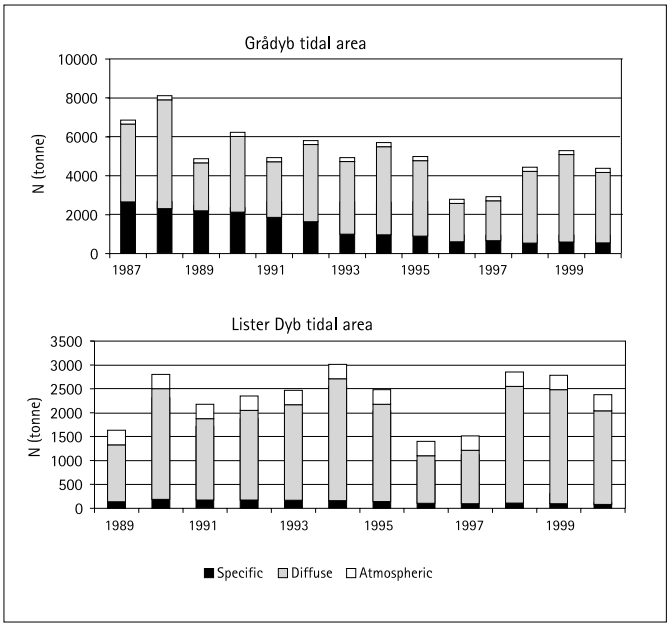


**Figure 3: Nitrogen loads in the Grådyb and the Lister Dyb tidal areas. See text for further explanation.**

and is high in winter and low in summer. The long-term development in the nitrogen load from the catchment areas and direct load to the Grådyb and Lister Dyb tidal areas are shown in figure 2. The total nitrogen load per year is divided into source of origin (Specific sources include wastewater treatment plants, overflow and industrial outlets; diffuse sources include washout from agriculture, drainage from single households and natural erosion; atmospheric deposition is the total of wet and dry deposition). Diffuse sources are the major contributor of nitrogen but differ from year to year depending on precipitation and erosion. Nitrogen from specific sources has declined due to improved treatment for domestic and industrial wastewater. This is most obvious for the Grådyb tidal area, which is a recipient for more sewage than the Lister Dyb tidal area.

## Conclusions

For the Danish Wadden Sea, it was assessed that the objective for the environmental quality is not fulfilled due to the results of the monitoring program in 2000:

- High loads of nitrogen and phosphorus from the catchment area.
- High nutrients concentrations in the seawater.
- No or spare potential nutrient limitation of phytoplankton.
- Periodically high chlorophyll concentration.
- Mass bloom of phytoplankton whereas some species are considered as harmful.
- Mass occurrence of annual green macro algae requiring high nutrient concentration.
- Spare occurrence of *Zostera noltii* and *Rupia cirrhosa*.
- Levels of organic tin composition (TBT) in blue mussels, *Mytilus edulis*, which can cause harmful effects in the organism.
- Levels of organic tin composition (TBT) in sediment, which can cause harmful effects on benthic organisms and plants.
- High level of PAH in mussels.
- Intersex and sterility among the gastropod species *Littorina littorea*.

It is suggested that a considerable reduction in nutrient load, especially nitrogen from diffuse sources in the catchment areas, is needed to achieve an improved water quality and the fulfillment of the environmental objective. Further more the contamination with xenobiotic substances has to be reduced.

More information can be obtained from the technical report "Vadehavet 2000, Vandmiljø overvågning. Amternes Vadehavssamarbejde Ribe Amt og Sønderjyllands Amt 2001" by M. Brozek, G. Bruntse, H. Larsen, P. B. Madsen, T. Thomasen and K. Toudal. The report can be ordered at the 2 counties (in Danish only).

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