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Reducing Nitrogen loadings to estuaries in Denmark, 1990-2010. Results and costs of measures applied in catchments to 10 Danish estuaries

J. Windolf, G. Blicher-Mathiesen, N.J. Carstensen, and B. Kronvang
Department of Bioscience, Aarhus University, P.O. Box 314, Vejlsøvej 25, DK-8600 Silkeborg. Denmark

The Nitrogen loading to 10 Danish estuaries has since 1990 been reduced by on average 42%. Thirty percent of this reduction is due to a reduction in Nitrogen loss from diffuse sources. Nitrogen surplus and the change in this surplus is shown to be a strong overall indicator for the trends in Nitrogen loading to most estuaries. The Nitrogen surplus has been reduced due to general national regulations and mitigation measures applied leading to an increased efficiency of Nitrogen use in cattle slurry (30%) and in pig slurry (ca. 40%). These improvements are paralleled by a reduced application of commercial N-fertilizer. Mean flow-weighted total Nitrogen concentrations in inlet fresh waters to estuaries have been reduced by 18-56% resulting in reductions of total Nitrogen concentrations (24-62%) in the inner and middle parts of the estuaries. The large variations in total Nitrogen loadings and concentrations in estuaries are due to both attenuation and time delays of Nitrogen in groundwater aquifers depending on catchment soil type and geology. This also implies varying costs of reducing the Nitrogen loadings from agricultural land (24-94 Euro/kg N reduced). Knowledge of the outcome of responses in the form of national regulations of agricultural N management for the N cycling from field to estuaries is important for decision makers and catchment managers working with the implementation of EU Directives such as the Water Framework Directive. Based on our findings we suggest that further reductions of Nitrogen loadings from agricultural land should be based on targeted and catchment specific measures leading to the most cost efficient way to achieve good ecological quality in the individual estuaries.