

A 5-Step Succession Model for the Baltic – A Future Management Tool?

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The semi-enclosed, brackish Baltic Sea is characterized by steep horizontal and vertical, environmental and biological gradients. The present Baltic Sea is only about 8000 years old, and can be classified as a transitory successional stage between the more marine southern parts, and the almost limnic inner areas. The Baltic is still recovering from the „glacial trauma“.

The Baltic is a series of basins divided by sills. It has a strong salinity gradient from almost marine conditions to limnic waters. The Baltic needs inflows of marine water to maintain its integrity. This is hampered by the sills.

Eutrophication and hypoxia/anoxia are acute threats to Baltic biota, and the benthic communities registered are products of the short time available for succession, the sharp environmental gradients and the increasing anthropogenic influence.

Zoobenthos is a good indicator of environmental health. The Baltic biota are low in species diversity and the ecosystem is vulnerable to additional stress. Differences in successional sequences between basins and vertical zones (supra- and sub-halocline) are documented by Rumohr *et al.* (1996), and the changes in functional group diversity were published by (Rumohr *et al.*, 1996; Bonsdorff & Pearson, 1999).

Based on the experience we have today, it can be concluded that the combined use of sediment imaging techniques and routine benthic sampling will give a valid large-scale representation of the state of the benthic communities. It also provides a certain amount of predictivity, in that the spatially occurring clines of successional stages can represent temporal changes just as well (Pearson & Rosenberg, 1978; Bonsdorff & Pearson, 1999).

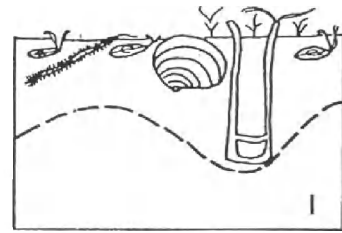
A conceptual model to analyze Baltic benthic successional stages was developed (Rumohr 1993; Rumohr *et al.*, 1996; similar to the Pearson-Rosenberg Model, 1978). The model was designed to evaluate monitoring data and as a management tool, and is a step forward in combining traditional data with modern imaging techniques (Rumohr, 1995).

The scientific basis for the model is traditional benthos data (since 1913) including HELCOM Monitoring data since 1986 and reports of fishers about anoxia and other peculiar events. Routine video and REMOTS/SPI recordings together with surface stills images were made since 1986 and formed the basis for this model.

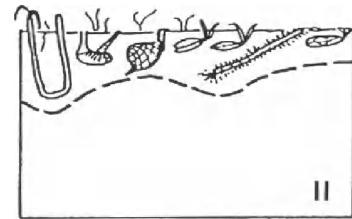
The conceptual model presented here divides the Baltic benthos into five successional stages (*sensu* Rumohr, 1993; the stages are virtually the same as in Nilsson & Rosenberg 1997 with opposite numbers) ranging from diverse communities to dead bottoms along the continuum from natural, diverse communities (stage I) to sediments completely devoid of macrofauna (stage V). The successional sequence is reversible at any point in time or space, and changes can be rapid, and stages in the development can be lost, coming further north in the Baltic.

The model based on the Baltic Sea benthos suggests 5 successional stages (Fig. 1):

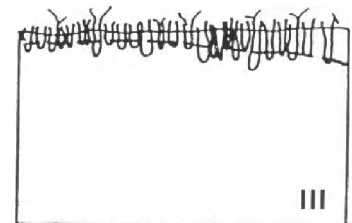
Stage I: a "climax-community" dominated by deep-burrowing species (Echinoderms, bivalves), and a deep (several cm's) RPD-layer (nowadays rare in the Baltic Sea),



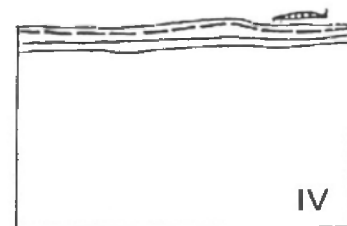
Stage II: first signs of stress, strong fluctuations, disappearance of echinoderms, decreasing species richness, increased productivity and biomass, and elevated RPD-layer (due to a natural lack of burrowers in much the Baltic Sea, this stage can be considered close to a natural "climax community"; Bonsdorff & Pearson, 1999),



Stage III: dominated by small polychaete worms (or their ecological equivalents, such as oligochaetes, insect larvae, or even small molluscs), and the RPD-layer close to the sediment/water boundary layer. At this stage limited, more or less regular events of hypoxia may occur,



Stage IV: long periods of hypoxia and formation of bacterial mats (Beggiatoa) at the sediment surface, with no permanent benthic macrofauna (very common in the central Baltic Sea proper below the permanent halocline) but sometimes with vagile epifauna (Harmothoe spec.),



Stage V: complete absence of benthic communities due to long-term anoxia. Increased sedimentation rates and lack of bio-turbation leads to lamination of sediments, and accumulation of organic material, nutrients and also pollutants. Sometimes vagile epifauna (Polyniods), when the bottom water is oxic.

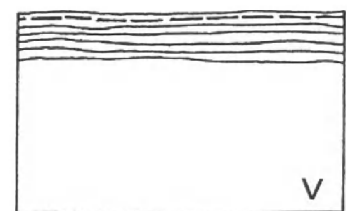


Figure 1. Baltic succession model

Differences in successional sequences between the Baltic basins and vertical zones (supra- and sub-halocline) are documented (Rumohr *et al.*, 1996), and the changes in functional group diversity is also exemplified (Rumohr *et al.*, 1996; Bonsdorff & Pearson, 1999).

Based on the experience we have today, it can be concluded that the combined use of sediment imaging techniques and routine benthic sampling will give a valid large-scale representation of the state of the benthic communities that can be used for management purposes. It also provides a certain amount of predictivity, in that the spatially occurring clines of successional stages can represent temporal changes just as well (Pearson & Rosenberg, 1978; Bonsdorff & Pearson, 1999).

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