

# A comparison of environmental sedimentology in four harbours (Bergen, Göteborg, Ventspils and Port San Luis)

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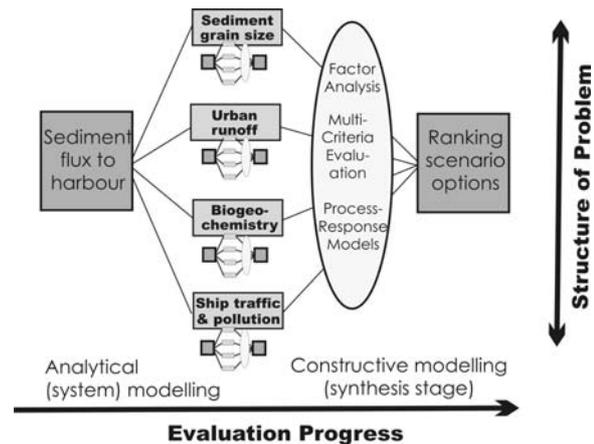
**Introduction:** Understanding the processes and effects in any specific setting is often aided by the comparison with other localities with different conditions. The aim of this presentation is to utilise the differences between four harbour settings to improve the theoretical basis for sustainable sediment management. Since deviations within natural environments are never restricted to just one parameter, an evaluation of the environmental system is necessary. This is a non-trivial task that requires a more sophisticated approach than simple trend observations or parameter correlations. The value of the conceptual model is increasingly apparent with greater environmental complexity.

**Methods:** Three of the harbours were part of an EU project H-SENSE [1] dealing with harbours, silting and environmental sedimentology. The fourth harbour (Port San Luis) has been studied over several years as part of excursions where students cooperated with local port authorities in California.

The main sedimentological observations include grain size, surface texture, mineralogy, geochemistry, sediment colour, and characterization of biological components and effects. When possible, “functional facies” have been classified using the combined sediment features and stressing the process relationships between the components.

Cross-impact matrices and multi-criteria evaluation (MCE) aim to structure the relationships between factors and weight the importance of differences within each environment. These tools also allow the combination of both quantitative and qualitative data in a sequential evaluation that builds upon increasing insight into the system (Fig. 1). There is considerable motivation for separating system modelling, and many similar investigations, into two parts where the first aims to describe and understand the system as a whole, identifying the parts that can be used in model construction in the second, synthetic part.

**Results:** Sandy sediments in Ventspils harbour [2] are much less polluted than the muddy, organic-rich sediments at Bergen. Göteborg harbour has strong river stratification [3,4] and is intermediate between these two. Port San Luis sediments derive from two main sources, the balance of which is important for pollution impact.



**Fig. 1:** The Brunswikian Lens model (figure modified after Scholz & Tietje 2002), illustrating the two, complementary steps in modelling a problem. The small lens figures represent the addition of greater detail and resolution when additional quantitative or qualitative information is available to specify new relationships.

**Discussion:** Environmental sedimentology in these harbours illustrates the important impact of grain size on: 1) mineralogy, 2) organic content, 3) biologic activity, 4) contaminant concentrations, and other sediment features. Since grain size further reflects the site-specific hydrologic conditions, there is also a good connection to flocculation and other sedimentation processes that vary between environmental settings. Therefore, highly polluted environments do not necessarily have highly contaminated sediment. Also, sediment defined trends in contaminant distribution need to be normalized with respect to grain size and related carrier components before contaminant source interpretations are possible. Ship traffic can strongly modify the patterns of natural hydrologic mixing and bottom turbulence. These examples stress the fact that contaminant supply is not equivalent with accumulation.

**References:** [1] Stevens (2003) *Environmental Geology* 43:432-433. [2] Müller-Karulis et al. (2003) *Environmental Geology* 43:445-456. [3] Johannesson et al. (2000) *Estuaries* 23:400-410. [4] Brack et al. (2003) *Environmental Geology* 43: 1232-1241.