SEDIMENT TRANSPORT ALONG THE WEST COAST OF JUTLAND

Erik Damgaard Christensen[1],
Ann Skou[1],
Ida Brøker[1],
Morten Rubjerg[1],
Per Sørensen[2]
[1)]DHI Water and Environment, Agern Allé 11, DK-2970 Hørsholm, Denmark
Email: edc@dhi.dk, ajs@dhi.dk, ibh@dhi.dk, mnr@dhi.dk
[2)]Danish Coastal Authority, Højbovej 1, DK-7620 Lemvig, Denmark

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INTRODUCTION

The west coast of Jutland is exposed to a relatively severe wave climate of the North Sea. From the Wadden Sea in the south to the Skaw in the north, the west coast is several hundred kilometres long. Estimates of the net sediment transport along the coastline range from 500,000 to 1,000,000 m^3/yr. The Danish Coastal Authority has initiated a study of the sediment transport along the coast. This study focuses on three aspects: the wave climates in the nearshore region, the morphology and sediment characteristics and finally a numerical study of the sediment transport.

THE WAVE STUDY

The wave fields have been hindcasted for a period of 6 years by DHI's third generation spectral energy-balance model MIKE21 OSW. This includes energy source terms, energy redistribution terms and energy loss terms, see Kofoed-Hansen et al. (1998) and Komen et al. (1994). The source terms describe the energy transfer from the wind to the waves depending on the local wind, water depth and sea-state. The generation of swell waves from short-crested waves is accounted for through the redistribution terms. Wave breaking on deep water and dissipation of wave energy at the bottom are energy loss terms. The simulated waves were verified against measurements at three locations.

THE SEDIMENT TRANSPORT STUDY

The west coast of Jutland is a sandy, relatively uniform coast. Three "hard points" located at Blåvands Huk, Hanstholm and Hirtshals fix the position of the coastline. Between the hard points, three entrances to the estuaries at Hvide Sande, Thorsminde and Thyborøn break the uniformity.

The general sea currents, driven by tide and meteorological conditions, influence the overall sediment budget. These currents are modelled in a large hydrodynamic model which covers the entire North Sea, the Danish Waters and the Baltic Sea. This current, combined with the effect of the breaking waves in the surf zone, drives the currents along the coast.

The wave-, flow- and sediment transport patterns around the entrances and the hard points are complex and have been studied in detail for selected hydrographic scenarios in two dimensional models. These detailed studies have been used to quantify the bypass of the structures. The Thyborøn study (in Brøker et al. 1996) shows a good example of the detailed studies. Another example of the detailed modelling is shown in Figure 1. Here, MIKE21 modelled the waves, currents and sediment transport around Thorsminde harbour for a characteristic storm.

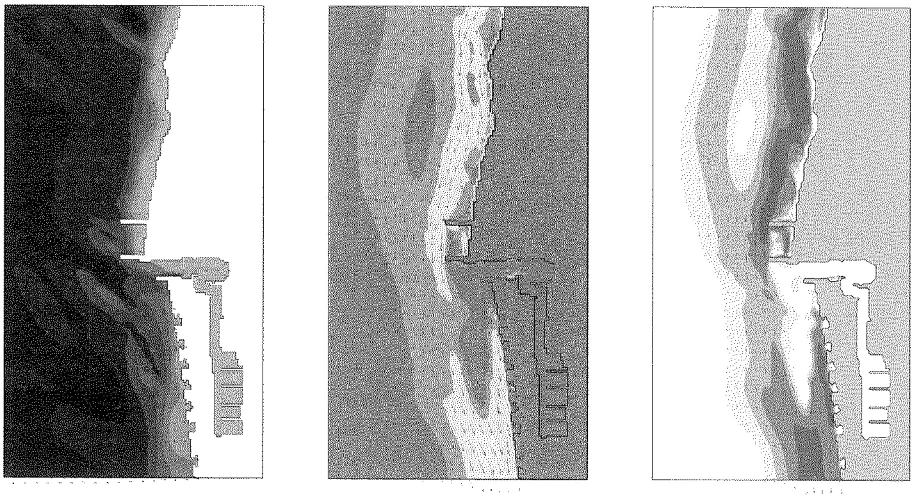

Figure 1 *Wave, current and sediment transport pattern around Thorsminde harbour.*

The long and uniform stretches are suited for modelling under the assumption of nearly uniform conditions along the coast. This approach is the best choice to estimate the sediment transport over long stretches and over a long time, cf. Figure 2. The modelling complex, LITPACK, is based on Deigaard et al. (1986), Deigaard et al. (1991), Deigaard et al (1993) and Elfrink et al. (1996).

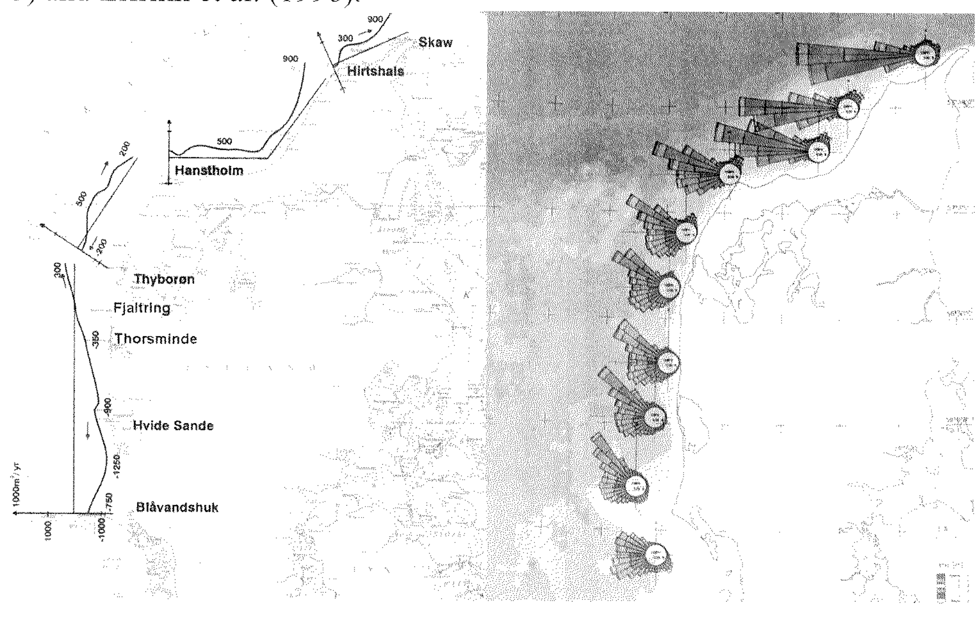

Figure 2 *Overall sediment budget, and an example of wave roses along the west coast of Jutland. The total model area in the wave study covered the entire North Sea, Skagerrak and a part of the Norwegian Sea.*

On deep water, over 12 m, the tidal component dominates the currents, whereas the wave driven currents are strongest on shallower water, less than 8 m. On average the tidal current is north-going. The average direction of the wave-generated current depends on the location along the coast and the shoreline orientation. The net sediment transport can be directed to the north on deep water and to the south in the surf zone. An example of this is shown in Figure 3 at a location between Thorsminde and Thyborøn. The figure shows the sediment transport distribution over a cross-shore profile. It is clear that the net drift (black line) is southward in the surf zone and northward on deep water.

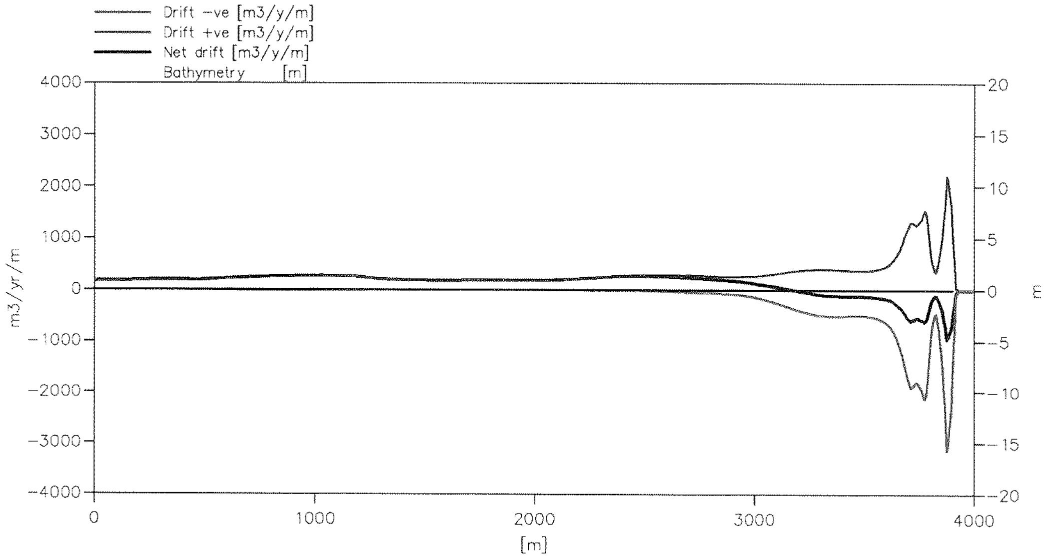

Figure 3 *The distribution of the annual drift over a cross-shore profile located between Thorsminde and Thyborøn. The net drift (black line) is northward on deep water and southward in the surf zone.*

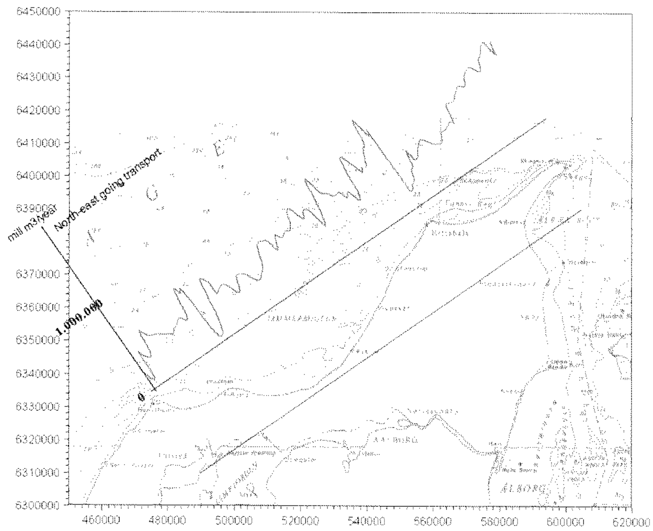

Figure 4 *Modelled net drift on the northern part of the coastline. Positive transport rates are north-eastward.*

On 12 cross-sections the annual drift is found. Between the sections an advanced interpolation technique estimates the transport. The interpolation takes into account variations of wave and current conditions, sediment characteristics and the orientation of the shoreline along the coast. Figure 4 and Figure 5 show the annual drift on the northern and western part of the coast, respectively. Finally, an operational sediment budget system has been established to support the planning of the comprehensive nourishment efforts along the critical stretches, Laustrup et al. (1998).

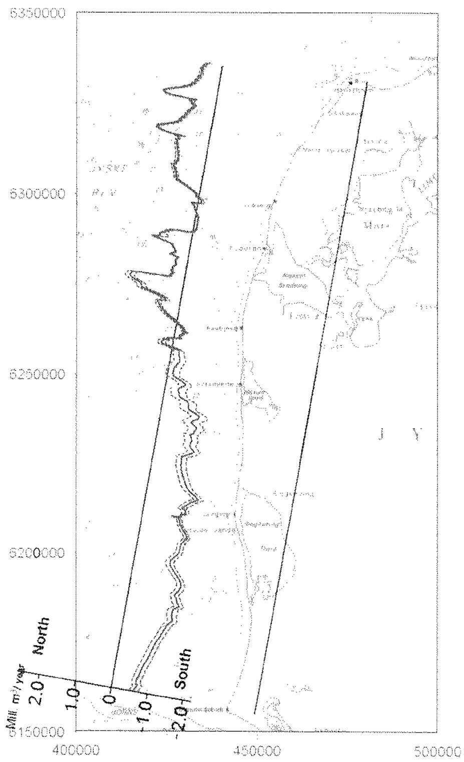

Figure 5 *Modelled net drift on the western part of the coastline. Positive transport rates are northward.*

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