

THE GERMAN "MORAN" PROJECT

by

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Abstract

The project "MORAN" (Morphological Analyses of the North-Sea-Coast) is an extensive program in order to try and combine all knowledge of the morphologic behaviour of a transitional zone of 5 to 7 km width with weather, tide, current and wave data. The area to be considered is about 9000 km² size. The program started in 1979 and will probably continue until 1984.

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Introduction

One of the supporters of the 16th ICCE was the "German Coastal Engineering Board" (KFKI). This committee is a board which is responsible for the administration of hydraulic engineering tasks on the North Sea coast and which has interested itself in encouraging practical applied research in the coastal area.

Though the German North Sea Coast is relatively short (370 km), its shape varies strongly with estuaries, extended tidal flats, partly protected by sandy islands with deep tidal gullies between them, sometimes with small unprotected islands etc. (fig. 1).

In order to gain more detailed informations and sufficient knowledge about variety and variations in this region, the KFKI (Kuratorium für Forschung im Küsteningenieurwesen) has initiated, supported and coordinated a number of extended projects. One of those was a synoptic survey program of the entire German North Sea Coast in 1974/75, covering an area of about 9.000 km². Moreover, the Board has inspired and promoted a lot of programs in order to sample data and learn about waves, currents, sediments etc. Now the amount of data and knowledge seems to be sufficient to start a demanding and extensive program, i.e. "MORAN".

"MORAN" means "Morphological Analyses of the North-Sea-Coast". The concern and the problems behind this project are manifold. A team of scientists and engineers coming from all German Coastal Engineering Authorities tries to find a way to the roots of morphological changes at the coast. Fundamentals for these investigations are:

- the first quasi-synoptical survey of coastal areas in 1974/75
- a second quasi-synoptical survey of this area in 1979/80
- charts of the changes between both states
- outline of tidal and wind-effected currents
- outline of wave climate
- outline of sediments and geology.

Of course this was already done, for small limited areas, in different parts of the world as case histories, but it will be the first time that this shall be done for an extended, complicated tidal area by synoptical data.

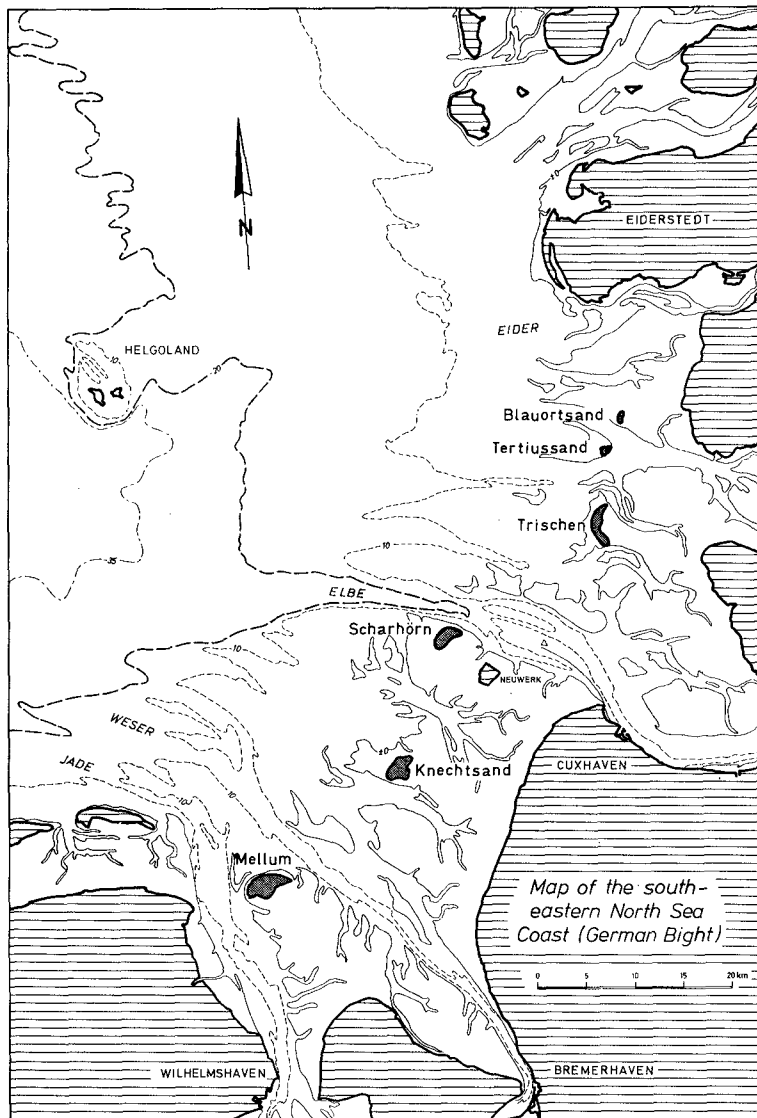


Fig. 1

General Review

The tidal flats and marshes form a transitional zone of an average width of 5 to 7 km in which various tidal flat facies interlock with lagoonal and limnic deposits and peat. These sediments lie on top of an old surface. In the high-lying Pleistocene areas, fluvial erosion and wind-born accretion have formed a rounded wavy relief cut through by separate channels. In the river valleys of the Ems, Weser and Elbe the base of the Holocene has a level surface gently dipping seawards. It corresponds there to the surface of the fluvial Weichselian low Terrace.

The Holocene marine transgression advanced first into these river valleys and channels. At these places there is sometimes a continuous from semi-terrestrial limnic facies to the brackish marine environment, and at other evidence of considerable processes of erosion, reworking and redeposition.

With further rises in sea level the marine influence spread laterally over the low lying regions. In the transitional zone of 5 to 7 km width fine sandy silty tidal flat sediments, mostly rich in lime, were deposited in the seaward part, or silty clayey brackish water deposits with varying lime content. To the landward follow clayey, mainly lime-free sediments with high organic components, and then muds and semi-terrestrial peats. The point of time when marine influenced sedimentation began varies from place to place, according both to its level and how exposed the deposition area was to the sea.

The tides are semidiurnal. The spring tide range lies around 2.6 m with a maximum of 4.1 m. Neap tide range is 1.8 m with a 3.1 m maximum. Mean tidal range in the inner German Bight is about 3 m with possible surges in winter of more than 3 m additional height.

The tidal currents over the flats reach velocities of 30 to 50 cm/s, with a maximum (at storm surges) of 150 cm/s. In smaller channels the current velocities are about 100 cm/s and in large channels sometimes up to 250 cm/s.

Wave movement is a very important factor. Waves procede from various directions and with changing strength. Nevertheless, the predominant movement is from the western sector. The wave movement over the tidal flats is the major factor influencing the distribution of sediments as well as erosion and sedimentation.

Tidal currents and wave movement combine to transport large quantities of suspended load over the tidal flats. Measurements in the Neuwerk flat gave concentrations of sus-

pension of 30 mg/l for a calm tide, and 300 mg/l was reached on a storm flood tide. If account is also taken of the shifting direction and volume with which the tide flows over the flats the transport of sediments during storm surges rises by two to three orders of magnitude.

The water temperature of the body of water which inundates the flats fluctuates greatly and is related to fluctuations in air temperature. In the same way the salt content in the large marine bays also varies, so that in dry summer weather the salt content can rise higher than that in the open sea. In winter the flats cool very much, so that the first ice forms here. When there are strong winds blowing in a landward direction there can be ice pressures which can endanger engineering structures.

Actual Situation

Prototype investigations were intensified during the last two decades. New survey programs have been carried out in the different areas, especially in the mouths of the large estuaries. In the early 1960s current and wave analyses started with concentrations in the areas round the island Norderney and in the Neuwerk/Scharhörn tidal flat complex. Later on a special KFKI project brought intense current investigations along the North Frisian coast, and wave climate measurements were carried out in front of the island Sylt and in the Jade-Weser estuary. Sedimentary and geologic knowledge was gained all over the coastal area with special stress on the region between Weser and Elbe mouths.

All investigations in Germany up to now were not synoptic, but most of them allow general conclusions and can improve our knowledge about the dynamic processes. But till now no attempt was made to include all these in a general survey for the 9.000 km² area in front of the coast.

Of course, we have a lot of examples from all over the world about what is now being done in this MORAN project. Here may be mentioned three of them, standing for others, also from the German coast, that will be incorporated in the actual program:

- One of the tidal channels - the Weser estuary - was presented by Barthel (1977). He investigated the migration of channels and sand banks in the outer Weser estuary from 1910 to 1973. The tendencies are tried to be explained by the predominant current situation.

- Göhren (1975) compared the movement of sand banks in the Elbe estuary (fig. 2), their grain size distributions and their cross sections with recorded currents during storm surges in these exposed tidal flats.
- Stability studies of natural tidal basin systems demand a regime-oriented analysis and a characteristic quantification of the morphological values. Hence Renger (1979) created relative form parameterization dependent on the location by means of a twodimensional system of natural coordinates (elevation and length). The relations derived may prove to be useful in the planning of future constructions and even in understanding and influencing the disadvantageous changes in running systems.

Performance of Project MORAN

Final results will not be available until the second survey will have been evaluated. Because of the vast amount of data this will probably last some years. To get first ideas of how to handle the data most efficiently and how to correlate morphology, topography, hydrology, meteorology and sedimentology, the managing KFKI group decided to select three test regions for a first-step evaluation under the following additional conditions:

- (1) earlier survey results available that can be used as a time series
- (2) no special dredging and depositing areas
- (3) current measurements, wave measurements, and surface sediment investigations during the last decade.

The 3 selected areas are (fig. 3):

- The gully system south of Norderney in a wadden sea area that is protected by an island;
- The unprotected tidal flat of Knechtsand with neighbouring gully systems;
- The wadden sea area west of Büsum, protected only by small islands and sands, in front of a new dike line.

In this first step the choice was influenced by the knowledge that the correlation of morphologic, hydrologic and sedimentologic data surely is simpler there than in breaker areas or in deep estuaries.

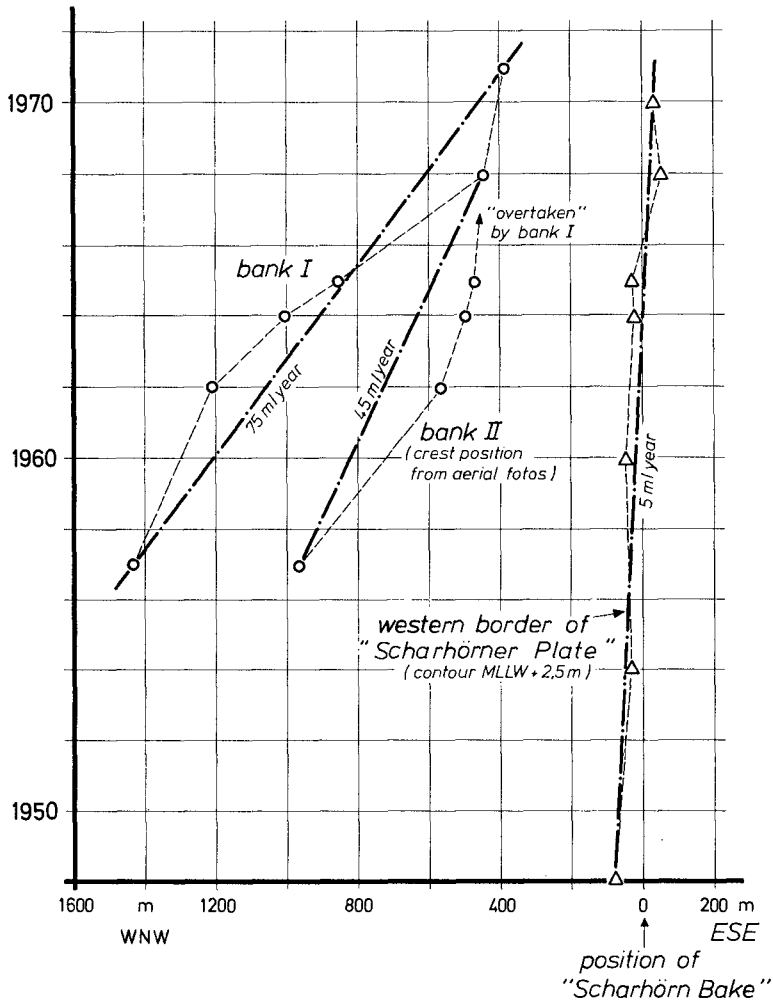


Fig. 2
Movement of sand banks in the Elbe estuary
(GÖHREN, 1975)

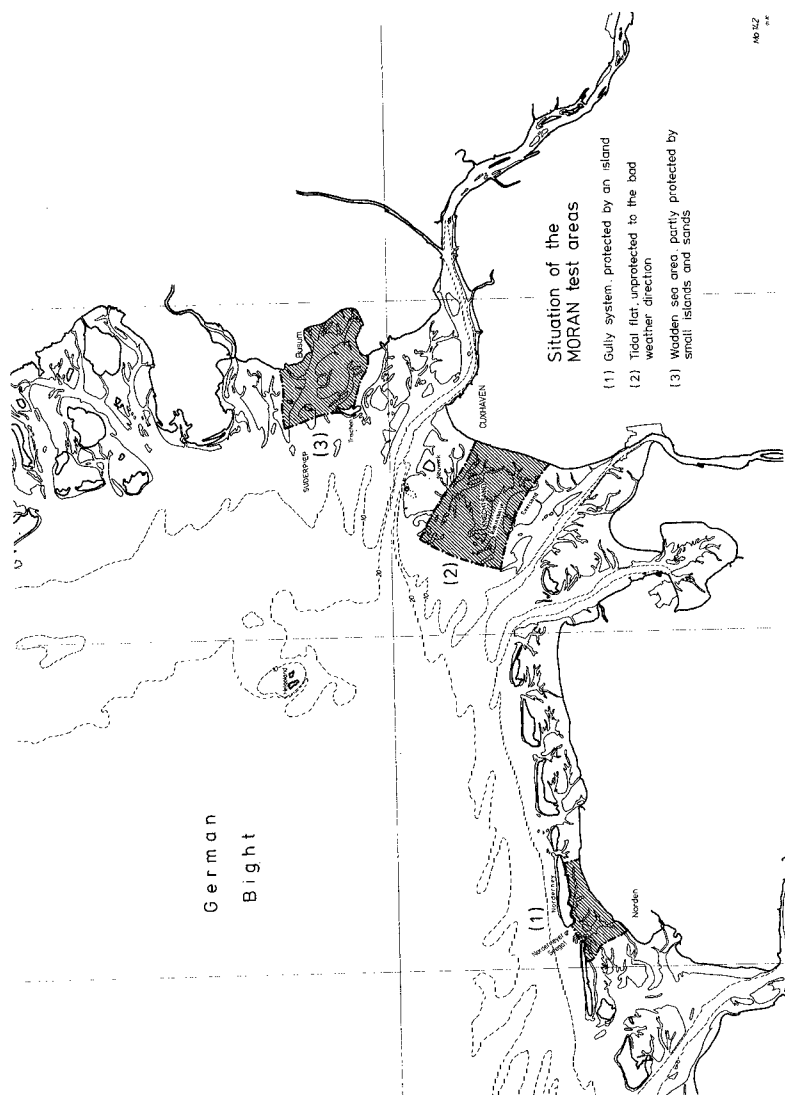
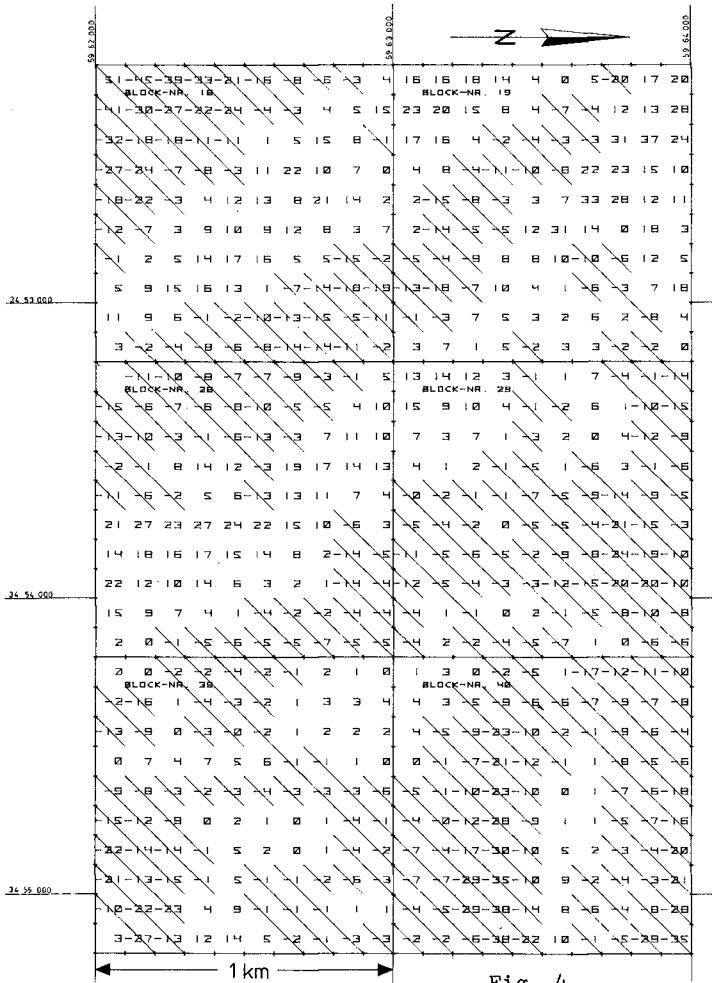


Fig. 3
Southeastern North Sea coast with MORAN test areas

KNECHTSAND AREA

MORPHOLOGIC CHANGES 1974 TO 1979 IN DECIMETERS



The MORAN Project

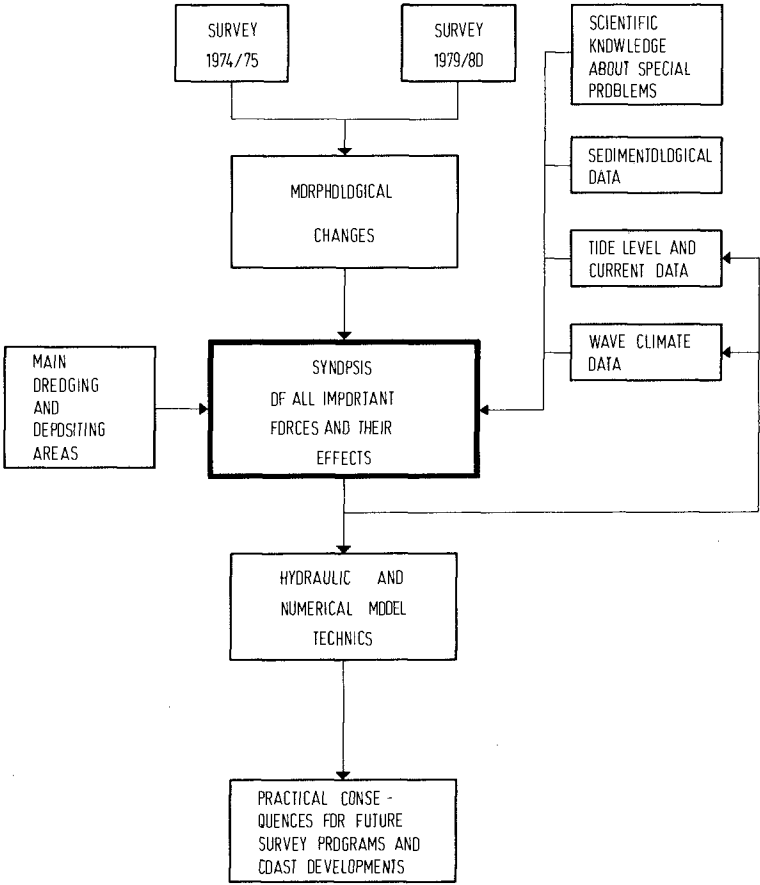


Fig. 5

Pilot Study

The test field is the Knechtsand area. About 1/3 of the survey data of 1974/75 are available in a digitized form. The rest of the data is now being transformed from conventional into digitized form, as is the data of 1979.

We had long discussions about how to evaluate the morphological changes. The result is that we now automatically evaluate mean heights of squares 100 x 100 m out of maps 1:10.000. The grid will be the same for all surveys. The net difference is then evaluated by a computer program and plotted afterwards. First results are shown fig. 4 with max. depth variations in the magnitude of 50 dm within 5 years.

Our Aim

Our aim is to demonstrate in these 3 test fields a synopsis of all available morphologic, hydrologic, sedimentologic and meteorologic informations (fig. 5) in order to find areas of similar morphologic behaviour and by that be able to predict morphological changes during the next decade.

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