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## Design of a Mooring System for Waves induced by passing POSTPANMAX Ships

**Client:** Electrabel Deutschland AG, Dr.-Ing. K. Dortmann, +49/30-726153-585

**Location:** Stade-Bützfleth, Elbe Estuary

**Construction:** Jetty at the end of a quay wall

**Scope of Work:** Layout of the mooring system for dynamic mooring forces induced by passing POSTPANMAX ships

**Method:** Measurements of waves (pressure gauges, 10Hz) and currents (ADCP), coupling of a hydrodynamic 2D model with the dynamic mooring force model

### INTRODUCTION

Ship-induced waves and their loads on dikes, revetments and moored ships became a problem in tidal ports of the North Range and their access channels to open sea since POSTPANMAX-ships are operating.

### METHODOLOGY

Intensive measurements of water level variations using pressure gauges, currents (by ADCP) and ship parameters (dimensions, draught, speed over ground, positions during passage) by AIS (Automated Identification System) were done in the Port of Stade-Bützfleth (Fig. 1) during a six week campaign.



Fig. 1: Port of Stade-Bützfleth, Lower Elbe Estuary

These measurements were the basis to setup a suite of models for hydrodynamics (2D, Fig. 2) and mooring forces (Fig. 3), coupled by water levels and currents.

Differences between simulated and measured water levels (Fig. 2) are below 5 cm in peak of the primary wave. The bow wave and the drawdown are calculated with an accuracy of 1.5 cm.

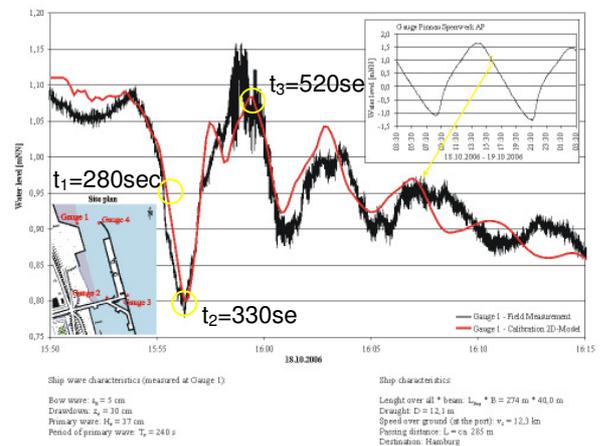


Fig. 2: Ship-Induced Wave System in the Port of Stade-Bützfleth



Fig. 3: Mooring System at Berthing Place K1

Tidal boundary conditions were generated at the upper and lower boundary from a regional 2D model (Fig. 3). The moving boundary condition to describe the passing POSTPANMAX-Ship was generated from measurements.

### CONCLUSIONS

Numerical simulations have shown the capability to model wave systems and currents induced by a passing POSTPANMAX ship.

Accuracy of model results is sufficient to give an input for the design of moorings, fenders and bollards.