Waves and current monitoring in the context with macrophytes investigations on the river Elbe 2015

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Abstract

Measurements of ship inducted wave impacts on estuaries and waterways are always of interest. This project was focused on the impact of ship inducted waves on macrophytes and the enclose environment. Macrophytes build a natural protection zone regarding erosion processes on river banks and marshes. The plant belt builds a natural barrier and the roots hold the soil. Unregulated ship traffic and the appearance of big container ships in the last years increase the impact on these resources. Ship traffic must be controlled regarding the speed and draft. The river Elbe carries the most ship movements in Germany and the impact is noticeable already.

The Project had been realized in a partnership with Ramboll IMS, Dr.-Ing. Karsten Peters for the Waterways And Shipping Office, Hamburg (WSA). Other institutes in charge are the Federal Office Of Hydrology (BFG) and the Federal Institute For Waterways Engineering, Hamburg (BAW), Germany. Ramboll IMS was responsible for post processing wave data and rendering the opinion.

Introduction

The river Elbe is one of the three major shipways at the German cost and feeds the harbor of Hamburg. The port of Hamburg is located in land and approx. 110 km off the Elbe estuary. Ships pass many human settlements while going up and down the river and induct waves showing impact on macrophytes and other protective vegetation and buildings.

This project was developed to relate wave and current impact on macrophytes and the visible damage on the vegetation. The maximum water depth at high tides is approx. 2m above the area of interest in a field of macrophytes. The possible interference of debris disturbances on the wave detector was decisive to use a pressure transducer. As the point of interest was the area just above the bottom (approx..10cm) a fail save current meter must be used. At low tide the locations falls dry for approx.. 12 hours per day. No data could be detected at this moment. The instruments and parts must be UV resistive and must survive permanent submergence. Power generation like solar or wind was not possible. Therefore a self contained power system must have been developed. The systems where located on river beaches used by humans as recreation areas and on an island (***fig.1***). Vandalism had to be taken care off. All system components are mounted on a steel frame covered with solid steel fence sheets (**fig. 6**).

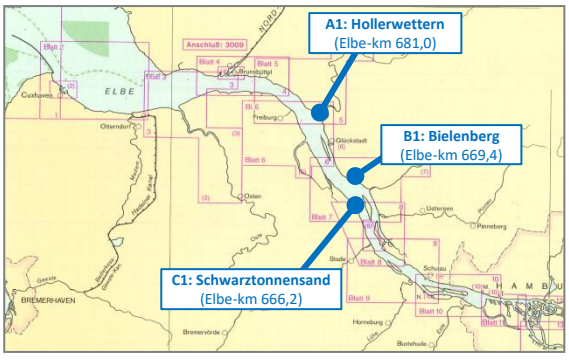

Figure 1 Map of the river Elbe estuary. A1 and B1 are located on the east river banks. C1 is located on the east beach of the island of Schwarztonnensand.

Measurement procedures

To process wave spectra from raw data 10Hz sampling rates have been implemented. The waves had been detected by a pressure transducer. Using a pressure transducer for dynamic wave detection the hydraulic filter (low pass filter) in relation to water depth and measuring frequency has to be taken in charge. As this application had been installed in low waters (10…200cm) the filter could be ignored. The scope of interest was the depth range between 10 and 100 cm. Wave spectra had been post processed. Definition can be found below (***fig. 2, 3, 4***). The transducer was combined with a MAVS4, 3-D current meter from Nobska using the physical principle of acoustic travel time differences. The measuring system was exposed to a grass and reeds flat where possible debris had to be taken care off. Compared to a Doppler current meter the MAVS measures 10 cm above the bottom.

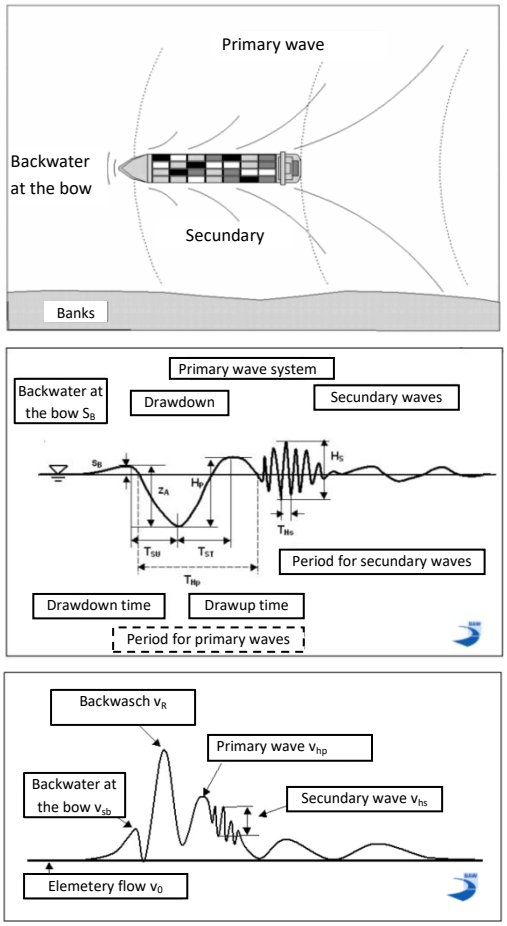

Figure 2, 3 and 4 Definition for relevant parameters of ship inducted waves (BAW Germany)

The difference between the "macrophytes" application and the AWGS system is the sensor priciple. As the "macrophytes" system contains a pressure transducer which is suitable only for very low water applications, the ASM (Argus Wave Gauge) gives accurate data between 0…10m of water depths. All three stations (A1, B1 and C1) had been time synchronized.

Instrumentation

The MAVS current meter is detecting currents between two frames in a distance of 10 cm measuring the travel time differences of two ultrasonic signals sent between two transducers. The moving water creates a delay between both signals. This is a measure of flow velocity.
The pressure transducer used was a gage type as it was submerged completely. Metrologic air pressure must be subtracted from the value detected.

Data logging and telemetry as well as the batteries are mounted in a Delrin pressure container (DAC, PSC) (**fig 5**). A Campbell CR1000 data logger had been installed in combination with a GSM data modem. The telemetry antenna was installed inside the Delrin container as well. Replaceable standard D-cell batteries had been used. High efficient, low impedance DC/DC converters provides stabilized voltages converted from the 24V battery pack for the different consumers. Batteries last for about 3 weeks under permanent discharge conditions und low temperature conditions.

Data sampling:
10Hz permanent, no burst

Power source:
48 x Alkaline D-Cell at approx. 1 kwh.

Data telemetry:
Every 12 hours during low tides

All components had been installed on a 1x1x1 m steel frame cage (**fig. 6**). Beside vandalism protection, the makeup serves as a cage of faraday as well to prevent damage on lightning discharges.

Figure 5 Pressure container for battery, data logger, controls, modem and antenna (PSC and DAC)

Figure 6 System cage rammed into the sediment at low tides

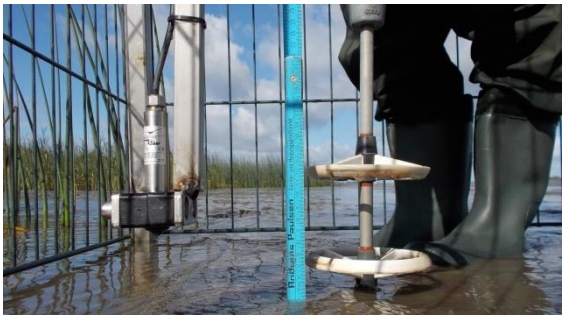

Figure 7 Undisturbed measurements of velocity for 3 directions 10cm above the ground

The installation took approx. 4 hours because the locations where not easy to reach and all equipment had be hand carried (**fig. 8**) or supplied by a small inflatable boat (**fig. 9**).

Figure 8 System cage carried for the location

Figure 9 A small dingy needed for installation and maintenance work

Results

The data quality was 100%. No data loss was recognized. Battery replacements had been carried out while the system was power bypassed. Wave spectra calculation was post processed using MATLAB algorithms.

Evaluation concept

1.

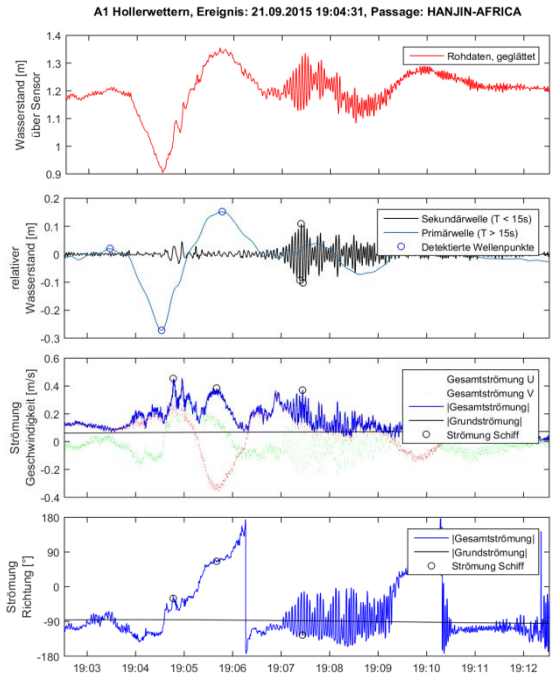

Figure 10 The graphics show the wave and current induction for the container ship Hanjin Africa.

2.

Hong Kong Bridge: SOG 17.9 kn
Length 336
Width: 46 m
Draft: 12.8 m

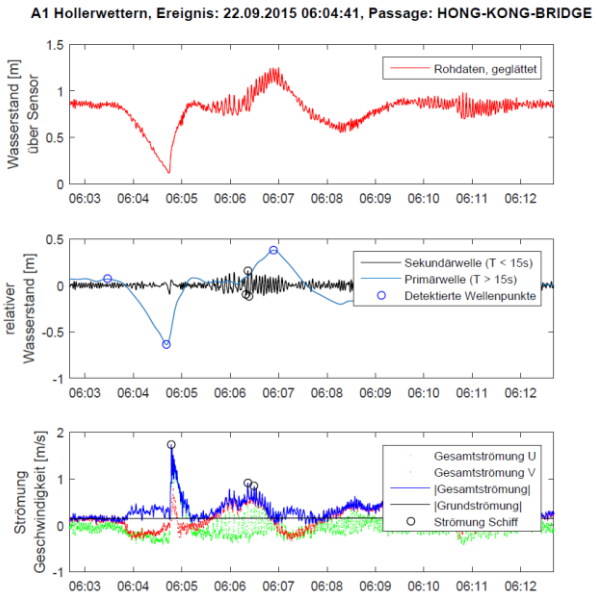

Figure 11 Example Hong Kong Bridge

Some reasonable ship inducted wave impacts on the macrophytes could be detected. The big container ships can erode the river banks and plant roots will loose the contact to the sediment. The natural belt of macrophytes could be sustainably damaged.

The report provided by Ramboll IMS will be used as a database for investigations of biologists form the office of hydrology in Germany.

It is planned to repeat the monitoring intermittently during the next years. Some modifications on the instrument setup have to be discussed draw more information for the processes of the impacts.