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FerryBox

From On-line Oceanographic Observations to Environmental Information

Report and Draft of Scientific Papers on Sediment Transport

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Document Reference Sheet

This document has been elaborated and issued by the European FerryBox Consortium.

P 1	GKSS	**GKSS Research Centre** **Institute for Coastal Research**	**Coordinator**
P 2	NERC.NOC	**NERC.NOC – National Oceanography Centre** **Southampton University and National Environment Res. Council** formerly NERC.SOC – Southampton Oceanography Centre	
P 3	NIOZ	**Royal Netherlands Institute of Sea Research**	
P 4	FIMR	**Finnish Institute of Marine Research**	
P 5	HCMR (formerly NCMR)	**Hellenic Centre for Marine Research** (formerly National Centre for Marine Research)	
P 6	NERC.POL	**Proudman Oceanographic Laboratory**	
P 7	NIVA	**Norwegian Institute for Water Research**	
P 8	HYDROMOD	**HYDROMOD Scientific Consulting**	
P 9	CTG **(formerly CIL)**	**Chelsea Technology Group** **(formerly Chelsea Instruments Ltd.)**	
P 10	IEO	**Spanish Institute of Oceanography**	
P 11	EMI	**Estonian Marine Institute** (in cooperation with the Estonian Maritime Academy)	

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1 Objectives

Overview

The key project objectives in WP4 were to provide a scientific support for the principle that FerryBoxes can deliver information of immediate scientific value, based on a coordinated approach which can quantify environmental variability on a European scale. It concentrated on 3 scientific areas relevant to issues of water quality, eco-system stability and climate variability and change. (1) Eutrophication including plankton productivity and variability in productivity in relation to physical and biogeochemical constraints. (2) Transport of sediments (and associated contaminants) over long and short spatial and temporal scales. (3) Determination of the stability and transport of water masses. It implemented and tested the procedures and software developed in WP-2 and WP-3. The work was structured to provide a basis for the calibration and validation of the associated models developed in WP-5.

1.1 Task 4-4 – Analysis of Data with Respect to Sediment Transport

The hypotheses to be tested were that FerryBoxes could accurately and precisely determine the temporal and spatial variations in suspended sediment concentrations. Specifically (1) sediment transport is dominated by sporadic meteorological events (storms) (2) the backscatter-intensity from an ADCP can be used to estimate suspended sediment concentrations and (3) ADCP observations can be used to quantify the relationship between current flows and sediment transport.

2 Results and Achievements

Most of the scientific work done in this task was carried out by NIOZ. This group are the only FerryBox project partners working on the application of ADCP (Acoustic Doppler Current Profiler) based methods to determine controls of sediment transport. The Texel to Den Helder ferry across the Marsdiep tidal inlet is equipped with a vessel-mounted ADCP measures the current field below the ferry.

Observations on currents and backscatter are used to obtain insight in the current field and suspended sediment concentration in the tidal inlet that forms the connection between the western most tidal basin of the Wadden Sea and the adjacent North Sea. The long duration and, especially, the high frequency of the observations (the ferry crosses the inlet each 30 minutes every day between 06.00 and 22.00 hrs) make the observations in principle suitable for such studies.

The results obtained by the NIOZ FerryBox give an excellent demonstration of what SOO systems can achieve in terms of the precision in the data delivered by the continuous repetition of their tracks by ferries. Figure 2-1, shows typical examples of the depth-averaged currents around maximum flood, maximum ebb and of the tidally averaged currents. The precision of the data allows both peaks and troughs in flow to be identified bothy in time and location. Tidal currents reach maximum values of around 1.5 m/s, with strongest currents in the deepest central part of the inlet.

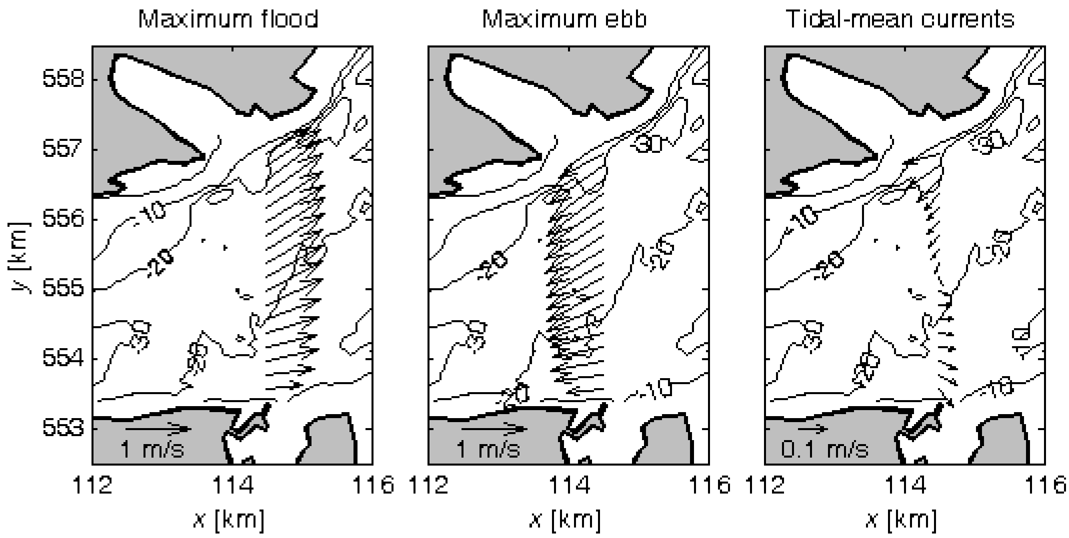

Figure 2-1: Typical examples of the depth-averaged tidal and mean currents in the Marsdiep inlet as observed with the ferry-ADCP on the route Den Helder – Texel.

The strength of the tidal mean currents is about 10% of the tidal currents and has a large spatial variability even over the relatively short distance of the inlet (about 4 km). At the northern site of the inlet the mean currents are outward (towards the adjacent North Sea), at the southern site the currents are inward. The influence of wind or river inflow on these tidal mean currents appears to be relatively weak because they are mainly caused by the interaction between the tidal currents and the topography.

By integrating the measured vertical profiles over each transect (that takes some 12-15 minutes) a more or less synoptic dataset on the water transport through the entire inlet was obtained.

A harmonic fit, using 67 tidal components was applied to analyse this data set. Figure 2-2 shows the results for a period of 5 years (1998 – 2002) of observations. The top of the figure shows the harmonic fit of the data and the bottom shows the original data (black dots), the harmonic fit (blue line) and the difference between both (red dots) for a representative number of days. Further analyses showed that the variability in the remaining signal (red dots) can largely be explained from variability in the wind speed and direction. For such a type of analyses of the variability in the water transport it is essential that the data set has a high frequency and a long duration enabling the determination of relatively high- and low-frequency tidal components. Here the period of the tidal components that was used in the analysis varied between some hours and about one year.

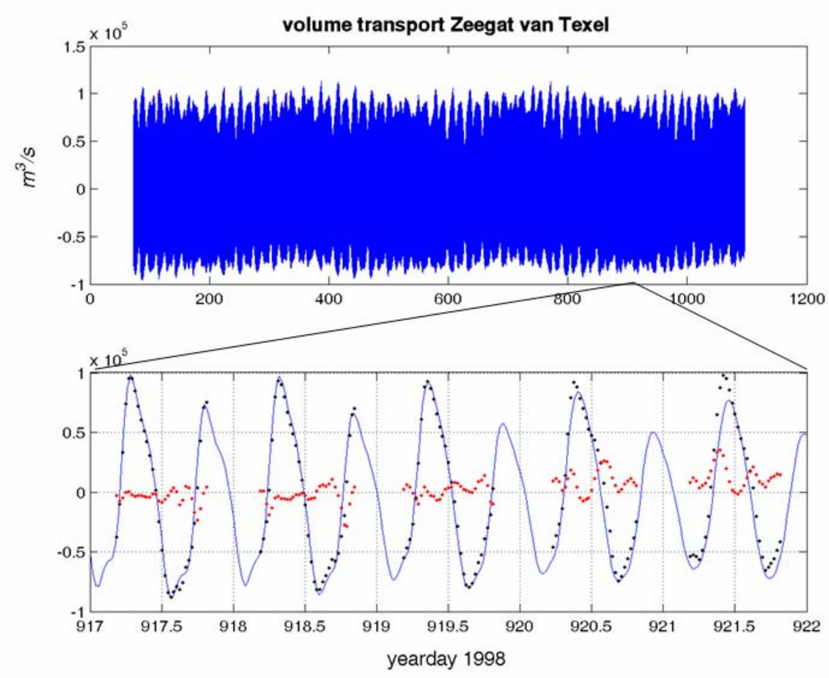

Figure 2-2: Water transport through the Marsdiep tidal inlet between the North Sea and Wadden Sea as determined from the long term ADCP observations. The top panel shows the harmonic fit to the data for a period of about 4 years, the bottom panel shows a typical example of the original data (black dots), the harmonic fit (blue line) and the difference between both for a period of 6 days..

This information of transport is essential for identifying the forces transporting suspended sediment. The ADCP data also provides information on sediment loads. The NIOZ studies found problems with the model commonly used to relate backscatter to suspended sediment concentration. A new model was developed that takes account of acoustic backscatter enhanced by coherence in the particles' spatial distribution as a result of turbulence-induced sediment fluctuations. This is based on a theoretically derived relationship (Merckelbach, 2005, paper 1a) which has been tested against field surveys to used calibrate the ferry observations (Merckelbach & Ridderinkhof, 2005 paper 1b).

The calibrated data has identified that the greatest fluxes of sediment occur in spring and early summer. This suggests that biological processes may influence the magnitude of this net flux (Ridderinkhof & Merckelbach, paper 1c).

Please find the drafts of the scientific papers as Annex to the Final Report.