

SPM dynamics measured with an automated tripod in the Belgian nearshore area: natural dynamics and anthropogenic effects

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INTRODUCTION

Many access channels and harbours suffer from sedimentation of fine sediments and formation of fluid mud layers. Conventional dredging methods with trailer suction dredgers, and disposal of the dredged material at designated locations, incur substantial costs.

In May 2009 an experimental study was carried out in the port of Zeebrugge (Albert II dock) to investigate whether the thickness of the mud layer with a density lower than 1200 kg/m^3 , could be reduced by pumping using a cutter dredger. The dredged matter was pumped over the harbour breakwater into the sea at a location closer to the shore and compared to the existing disposal sites (Lauwaert et al., 2009). The investigations performed during the disposal experiment consist of measurements in the water column (e.g. temperature, salinity, SPM concentration, particle size and current velocity) at a fixed location situated about 3 km west of the disposal site to evaluate far field effects. Although the evaluation of the project was negative in terms of efficiently reducing the thickness of the fluid mud layer insight was gained in the monitoring efforts needed to assess the impact on SPM concentration outside the port.

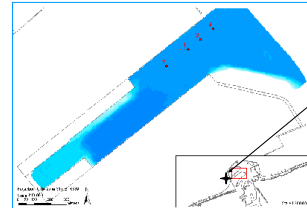


Fluid mud from the port of Zeebrugge

METHOD

A tripod has been deployed for 240 days during 6 measuring periods before, during and after the experiment. SPM concentration was measured at 0.2 m and 2 m above bed.

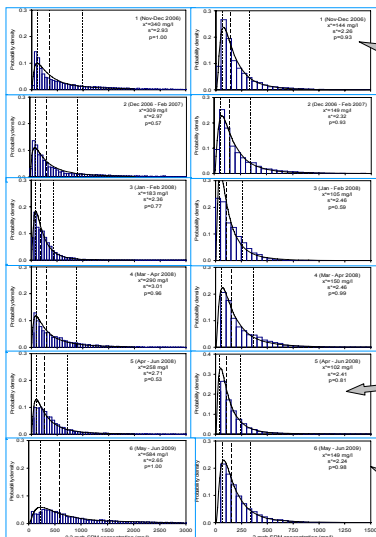
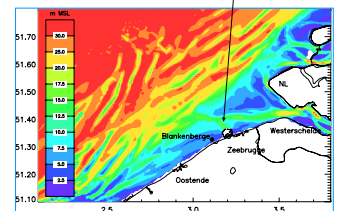
The SPM concentration variability at Blankenberge is the result of various processes related to tides, storms and seasonal changes. In order to identify the effects from dredged material disposal, statistical methods are used. By constructing frequency distributions of different data sets we can calculate using standard statistic tests if two distributions are drawn from the same distribution function. If disposal of dredged material over the western breakwater of the port has an impact on SPM concentration then this should be detected in variations of statistical parameters during the data collected during the field experiment (see Fettweis & Nechad, 2010). Further, changes in SPM concentration due to disposal could result in a shift of the SPM concentration maxima during the tides.



Disposal location of dredged material
Tripod location

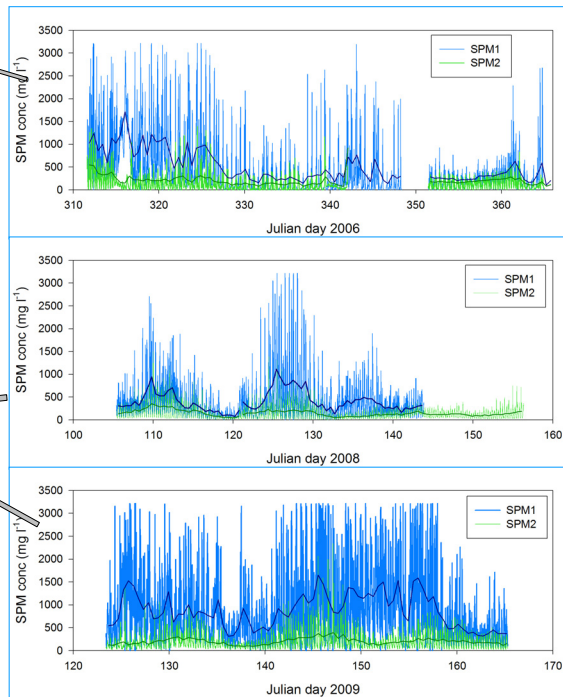
Above: Albert II dock (port of Zeebrugge) and the dredging locations.

Right: Bathymetry in the southern North Sea and the tripod location at Blankenberge

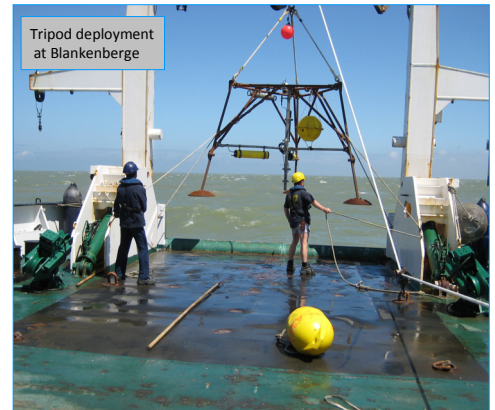


Probability density distribution of the SPM concentration data at 0.2 mab (left) and 2 mab (right) during the 6 measuring periods and the corresponding log-normal probability density functions and χ^2 test probability p. The data are binned in classes of 50 mg l⁻¹, the dashed lines correspond to the median x^* times/over the multiplicative standard deviation s^* .

The field experiment took place during period 6



SPM concentration at 0.2 mab (SPM1) and 2 mab (SPM2) and tide-averaged data during periods 1, 5 and 6 (field experiment)



Numerous morphological, and sedimentological effects result from dredging and disposal works in nearshore areas. The current study focuses on the effects of a continuously disposal of fine-grained dredged material on the increase of SPM concentration and on the possible formation of fluid mud close to the shoreline.

The major conclusion from the data are:

- There is a dominant quarter-diurnal signal in the time-series. The spring-neap tidal signal is clearly visible during calm weather;
- SPM concentrations maxima were sometimes up to 50 times higher than the minima;
- The very high SPM concentrations near the bed during winter and autumn are caused by storms and suggest that high concentrated mud layers or fluid layers are formed (Fettweis et al., 2010);
- During the field experiment (May – June 2009) the near-bed dynamics was mainly influenced by HCBS layers, whereas at 2 mab a spring-neap tidal signal could be identified

CONCLUSION

Harbour authorities world-wide are obliged to dredge their major shipping channels, and subsequently to dispose of the dredge spoil offshore. This study provided a statistical technique to evaluate the effects of disposal operations in a highly turbid area with high natural variability. The following arguments show that the disposal of dredged matter have caused an increase in SPM concentration:

- The SPM concentration near the bed (0.2 mab) was exceptionally high during the field experiment. The median SPM concentration was 240 mg/l higher than during measuring period 1 (high autumn SPM concentration) and about 330 mg/l higher than during the same period in 2008.
- The port and the disposal site are situated in ebb-direction of the measuring location. During the experiment a generally higher SPM concentration near the bed during ebb and at 2 mab during flood was observed, suggesting that disposal of dredged material is mainly transported in the benthic layer.
- The time lag between high wave and high SPM concentration proves that the SPM has been advected towards the measuring location rather than eroded locally.

Further readings:

Fettweis M, Nechad B (2010) Evaluation of in situ and remote sensing sampling methods for SPM concentrations, Belgian continental shelf (southern North Sea). Ocean Dynamics (in revision)
Fettweis M, Francken F, Van den Eynde D, Verwaest T, Janssens J, Van Lancker V (2010) Storm influence on SPM concentrations in a coastal turbidity maximum area with high anthropogenic impact (southern North Sea). Continental Shelf Research (in revision)
Lauwaert B, Berteloot M, De Backer A, Derweduwel J, Dujardin A, Fettweis M, Hillewaert H, Hoffman S, Hostens K, Ides S, Janssens J, Martens C, Michiels T, Parmentier K, Van Hoey G, Verwaest T (2009) Synthesis report on the effects of dredged material disposal on the marine environment (licensing period 2008-2009). Report by MUMM, ILVO, CD, aMT and WL BL/2009/01. 73pp.

