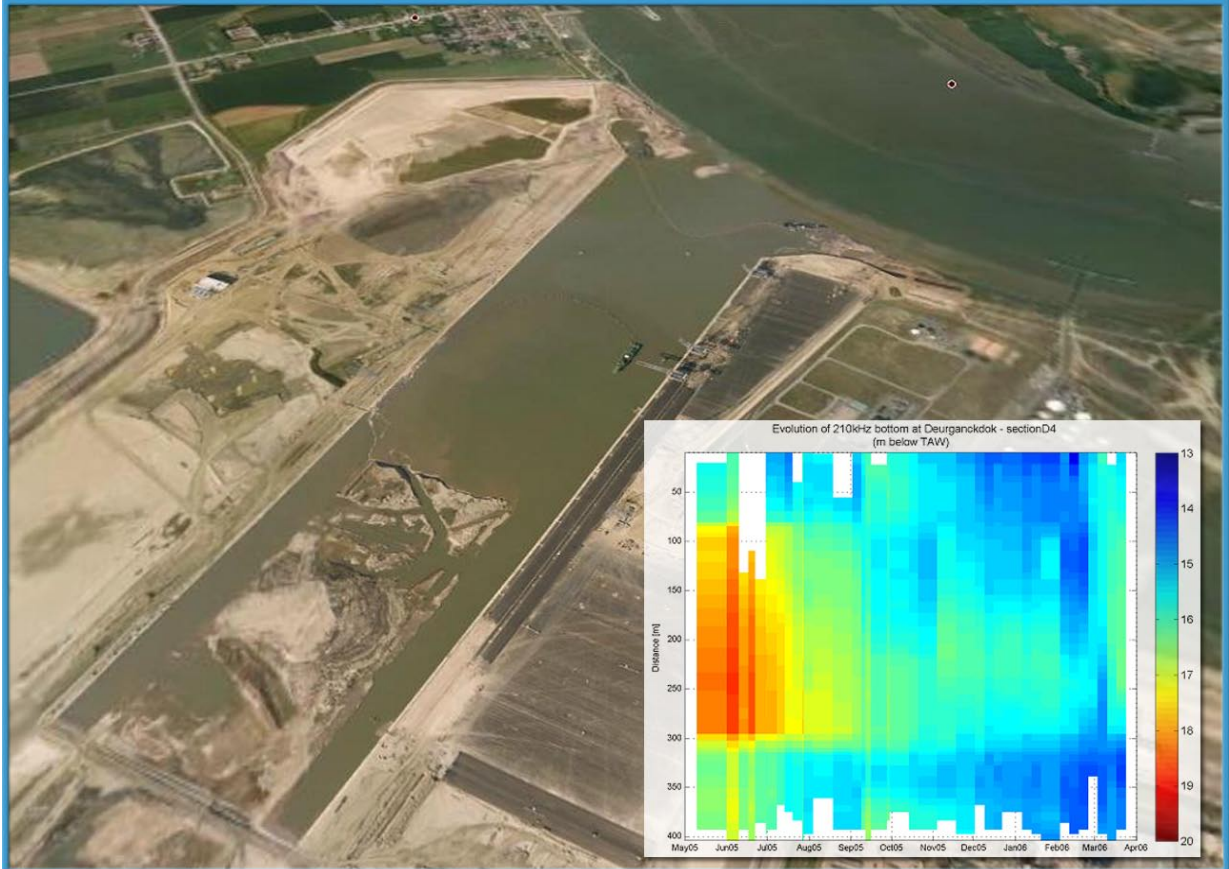


Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing

Bestek 16EB/05/04

Deurganckdok– Evolution of water-bed interface in a cross-section of Deurganckdok



Deelrapport 1.23 : **Sedimentbalans 01/01/2009 – 31/03/2009**

Report 1.23 : **Sediment balance 01/01/2009 – 31/03/2009**



i.s.m.



International Marine and Dredging Consultants (IMDC)
Coveliersstraat 15, 2600 Berchem, Antwerp, Belgium
tel: +32.3.270.92.95 - fax: +32.3.235.67.11
E-mail : info@imdc.be

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| Joris Vanlede | 7 | Waterbouwkundig Laboratorium | Client |
| Frederik Roose | 3 | afdeling Maritieme Toegang | Client |
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GLOSSARY

| | |
|-----------------|---|
| BIS | Dredging Information System used in the Lower Sea Scheldt |
| d | Density of dredged sediment [kg/dm ³] |
| DGD | Deurganckdok |
| HCBS | High Concentration Benthic Suspensions |
| M | mass of dry solids [ton] |
| ρ_s | density of the solid minerals [kg/dm ³] |
| ρ_w | density of clear water [kg/dm ³] |
| t _{0d} | Reference situation for densimetric analysis (empty dock) |
| t _{0e} | Reference situation for volumetric analysis (24 March 2006) |
| TDS | Ton of dry solids [ton] |
| V | volume of dredged sediment [m ³] |

1. INTRODUCTION

1.1. The assignment

This report is part of the set of reports describing the results of the long-term measurements conducted in Deurganckdok aiming at the monitoring and analysis of silt accretion. This measurement campaign is an extension of the study "Extension of the study about density currents in the Beneden Zeeschelde" as part of the Long Term Vision for the Scheldt estuary. It is complementary to the study 'Field measurements high-concentration benthic suspensions (HCBS 2)'.

The terms of reference for this study were prepared by the 'Departement Mobiliteit en Openbare Werken van de Vlaamse Overheid, Afdeling Waterbouwkundig Laboratorium' (16EB/05/04). The repetition of this study was awarded to International Marine and Dredging Consultants NV in association with WL|Delft Hydraulics and Gems International on 10/01/2006. The project term was repeated twice with an extra year from April 2007 till March 2008, and April 2008 till March 2009.

Waterbouwkundig Laboratorium– Cel Hydrometrie Schelde provided data on discharge, tide, salinity and turbidity along the river Scheldt and provided survey vessels for the long term and through tide measurements. Afdeling Maritieme Toegang provided maintenance dredging data. Agentschap voor Maritieme Dienstverlening en Kust – Afdeling Kust and Port of Antwerp provided depth sounding measurements.

The execution of the study involves a twofold assignment:

- Part 1: Setting up a sediment balance of Deurganckdok covering a period of three years
- Part 2: An analysis of the parameters contributing to siltation in Deurganckdok

1.2. Purpose of the study

The Lower Sea Scheldt (Beneden Zeeschelde) is the stretch of the Scheldt estuary between the Belgium-Dutch border and Rupelmonde, where the entrance channels to the Antwerp sea locks are located. The navigation channel has a sandy bed, whereas the shallower areas (intertidal areas, mud flats, salt marshes) consist of sandy clay or even pure mud sometimes. This part of the Scheldt is characterized by large horizontal salinity gradients and the presence of a turbidity maximum with depth-averaged concentrations ranging from 50 to 500 mg/l at grain sizes of 60 - 100 μm . The salinity gradients generate significant density currents between the river and the entrance channels to the locks, causing large siltation rates. It is to be expected that in the near future also the Deurganckdok will suffer from such large siltation rates, which may double the amount of dredging material to be dumped in the Lower Sea Scheldt.

Results from the study may be interpreted by comparison with results from the HCBS and HCBS2 studies covering the whole Lower Sea Scheldt. These studies included through-tide measurement campaigns in the vicinity of Deurganckdok and long term measurements of turbidity and salinity in and near Deurganckdok.

The first part of the study focuses on obtaining a sediment balance of Deurganckdok. Aside from natural sedimentation, the sediment balance is influenced by the maintenance and capital dredging works. This involves sediment influx from capital dredging works in the Deurganckdok, and internal relocation and removal of sediment by maintenance dredging works. To compute a sediment balance an inventory of bathymetric data (depth soundings), density measurements of the deposited material and detailed information of capital and maintenance dredging works will be made up.

The second part of the study is to gain insight in the mechanisms causing siltation in Deurganckdok, it is important to follow the evolution of the parameters involved, and this on a long and short term basis (long term & through-tide measurements). Previous research has shown the importance of water exchange at the entrance of Deurganckdok is essential for understanding sediment transport between the dock and the Scheldt river.

1.3. Overview of the reports

1.3.1. Reports

Reports of the project for the period April 2006 – March 2009 are summarized in Table 1-1.

Table 1-1: Overview of Deurganckdok Reports

| Report | Description |
|---|---|
| Sediment Balance: Bathymetry surveys, Density measurements, Maintenance and construction dredging activities | |
| 1.1 | Sediment Balance: Three monthly report 1/4/2006 – 30/06/2006 (I/RA/11283/06.113/MSA) |
| 1.2 | Sediment Balance: Three monthly report 1/7/2006 – 30/09/2006 (I/RA/11283/06.114/MSA) |
| 1.3 | Sediment Balance: Three monthly report 1/10/2006 – 31/12/2006 (I/RA/11283/06.115/MSA) |
| 1.4 | Sediment Balance: Three monthly report 1/1/2007 – 31/03/2007 (I/RA/11283/06.116/MSA) |
| 1.5 | Annual Sediment Balance (I/RA/11283/06.117/MSA) |
| 1.6 | Sediment balance Bathymetry: 2005 – 3/2006 (I/RA/11283/06.118/MSA) |
| 1.10 | Sediment Balance: Three monthly report 1/4/2007 - 30/06/2007(I/RA/11283/07.081/MSA) |
| 1.11 | Sediment Balance: Two monthly report 1/7/2007 – 31/08/2007 (I/RA/11283/07.082/MSA) |
| 1.12 | Sediment Balance: Four monthly report 1/09/2007 – 31/12/2007 (I/RA/11283/07.083/MSA) |
| 1.13 | Sediment Balance: Three monthly report 1/1/2008 – 31/03/2008 (I/RA/11283/07.084/MSA) |
| 1.14 | Annual Sediment Balance (I/RA/11283/07.085/MSA) |
| 1.20 | Sediment Balance: Three monthly report 1/4/2008 - 30/6/2008 (I/RA/11283/08.076/MSA) |
| 1.21 | Sediment Balance: Three monthly report 1/7/2008 – 30/9/2008 (I/RA/11283/08.077/MSA) |
| 1.22 | Sediment Balance: Three monthly report 1/10/2008 – 31/12/2008 (I/RA/11283/08.078/MSA) |

| Report | Description |
|--|---|
| 1.23 | Sediment Balance: Three monthly report 1/1/2009 – 31/03/2009 (I/RA/11283/08.079/MSA) |
| 1.24 | Annual Sediment Balance (I/RA/11283/08,080/MSA) |
| Factors contributing to salt and sediment distribution in Deurganckdok: Salt-Silt (OBS3A) & Frame measurements, Through tide measurements (SiltProfiling & ADCP) & Calibrations | |
| 2.1 | Through tide measurement Siltprofiler 21/03/2006 Laure Marie (I/RA/11283/06.087/WGO) |
| 2.2 | Through tide measurement Siltprofiler 26/09/2006 Stream (I/RA/11283/06.068/MSA) |
| 2.3 | Through tide measurement Sediview spring tide 22/03/2006 Veremans (I/RA/11283/06.110/BDC) |
| 2.4 | Through tide measurement Sediview spring tide 27/09/2006 Parel 2 (I/RA/11283/06.119/MSA) |
| 2.5 | Through tide measurement Sediview neap tide (to be scheduled) (I/RA/11283/06.120/MSA) |
| 2.6 | Salinity-Silt distribution & Frame Measurements Deurganckdok 13/3/2006 – 31/05/2006 (I/RA/11283/06.121/MSA) |
| 2.7 | Salinity-Silt distribution & Frame Measurements Deurganckdok 15/07/2006 – 31/10/2006 (I/RA/11283/06.122/MSA) |
| 2.8 | Salinity-Silt distribution & Frame Measurements Deurganckdok 15/01/2007 – 15/03/2007 (I/RA/11283/06.123/MSA) |
| 2.9 | Calibration stationary equipment autumn (I/RA/11283/07.095/MSA) |
| 2.10 | Through tide measurement Siltprofiler winter (I/RA/11283/07.086/MSA) |
| 2.11 | Through tide measurement Salinity Profiling winter (I/RA/11283/07.087/MSA) |
| 2.12 | Through tide measurement Sediview winter (I/RA/11283/07.088/MSA) |
| 2.13 | Through tide measurement Sediview winter (I/RA/11283/07.089/MSA) |
| 2.14 | Through tide measurement Sediview winter (I/RA/11283/07.090/MSA) |
| 2.15 | Through tide measurement Siltprofiler (to be scheduled) (I/RA/11283/07.091/MSA) |
| 2.16 | Salinity-Silt distribution Deurganckdok summer (21/6/2007 – 30/07/2007) (I/RA/11283/07.092/MSA) |
| 2.17 | Salinity-Silt distribution & Frame Measurements Deurganckdok autumn (17/09/2007 - 10/12/2007) (I/RA/11283/07.093/MSA) |
| 2.18 | Salinity-Silt distribution & Frame Measurements Deurganckdok winter (18/02/2008 - 31/3/2008) (I/RA/11283/07.094/MSA) |
| 2.19 | Calibration stationary & mobile equipment winter (I/RA/11283/07.096/MSA) |
| 2.20 | Through tide measurement Sediview DGD during neap tide Spring 2008 (I/RA/11283/08.081/MSA) |

| Report | Description |
|---|---|
| 2.21 | Through tide measurement Sediview DGD during spring tide Spring 2008 (I/RA/11283/08.082/MSA) |
| 2.22 | Through tide measurement Sediview DGD during neap tide Summer 2008 (I/RA/11283/08.083/MSA) |
| 2.23 | Through tide measurement Sediview DGD during spring tide Summer 2008 (I/RA/11283/08.084/MSA) |
| 2.24 | Through tide measurement Sediview DGD during neap tide Autumn 2008 (I/RA/11283/08.085/MSA) |
| 2.25 | Through tide measurement Sediview DGD during spring tide Autumn 2008 (I/RA/11283/08.086/MSA) |
| 2.26 | Through tide measurement Sediview DGD during neap tide Winter 2009 (I/RA/11283/08.087/MSA) |
| 2.27 | Through tide measurement Sediview DGD during spring tide Winter 2009 (I/RA/11283/08.088/MSA) |
| 2.28 | Through tide measurement ADCP eddy DGD Summer 2008 (I/RA/11283/08.089/MSA) |
| 2.29 | Through tide measurement Siltprofiler DGD Summer 2008 (I/RA/11283/08.090/MSA) |
| 2.30 | Through tide measurement Siltprofiler DGD Winter 2009 (I/RA/11283/08.091/MSA) |
| 2.31 | Through tide measurement Salinity Profiling DGD Winter 2009 (I/RA/11283/08.092/MSA) |
| 2.32 | Salinity-Silt distribution Deurganckdok: Six monthly report 1/4/2008 - 30/9/2008 (I/RA/11283/08.093/MSA) |
| 2.33 | Salinity-Silt distribution Deurganckdok: Six monthly report 1/10/2008 – 31/3/2009 (I/RA/11283/08.094/MSA) |
| 2.34 | Calibration stationary & mobile equipment Autumn 2008 (I/RA/11283/08.095/MSA) |
| Boundary Conditions: Upriver Discharge, Salt concentration Scheldt, Bathymetric evolution in access channels, dredging activities in Lower Sea Scheldt and access channels | |
| 3.1 | Boundary conditions: Three monthly report 1/1/2007 – 31/03/2007 (I/RA/11283/06.127/MSA) |
| 3.10 | Boundary conditions: Three monthly report 1/4/2007 – 30/06/2007 (I/RA/11283/07.097/MSA) |
| 3.11 | Boundary conditions: Three monthly report 1/7/2007 – 30/09/2007 (I/RA/11283/07.098/MSA) |
| 3.12 | Boundary conditions: Three monthly report 1/10/2007 – 31/12/2007 (I/RA/11283/07.099/MSA) |
| 3.13 | Boundary conditions: Three monthly report 1/1/2008 – 31/03/2008 (I/RA/11283/07.100/MSA) |
| 3.14 | Boundary conditions: Annual report (I/RA/11283/07.101/MSA) |

| Report | Description |
|-----------------|--|
| 3.20 | Boundary conditions: Six monthly report 1/4/2008 – 30/09/2008 (I/RA/11283/08.096/MSA) |
| 3.21 | Boundary conditions: Six monthly report 1/10/2008 – 31/03/2009 (I/RA/11283/08.097/MSA) |
| Analysis | |
| 4.1 | Analysis of Siltation Processes and Factors (I/RA/11283/06.129/MSA) |
| 4.10 | Analysis of Siltation Processes and Factors (I/RA/11283/07.102/MSA) |
| 4.20 | Analysis of Siltation Processes and Factors (I/RA/11283/08.098/MSA) |

1.3.2. Measurement actions

Following measurements have been carried out during the course of this project:

1. Monitoring upstream discharge in the Scheldt river
2. Monitoring Salinity and sediment concentration in the Lower Sea Scheldt taken from on permanent data acquisition sites at Lillo, Oosterweel and up- and downstream of the Deurganckdok.
3. Long term measurement of salinity distribution in Deurganckdok.
4. Long term measurement of sediment concentration in Deurganckdok
5. Monitoring near-bed processes in the central trench in the dock, near the entrance as well as near the landward end: near-bed turbidity, near-bed current velocity and bed elevation variations are measured from a fixed frame placed on the dock's bed.
6. Measurement of current, salinity and sediment transport at the entrance of Deurganckdok for which ADCP backscatter intensity over a full cross section are calibrated with the Sediview procedure and vertical sediment and salt profiles are recorded with the SiltProfiler equipment
7. Through tide measurements of vertical sediment concentration profiles -including near bed highly concentrated suspensions- with the SiltProfiler equipment. Executed over a grid of points near the entrance of Deurganckdok.
8. Monitoring dredging activities at entrance channels towards the Kallo, Zandvliet and Berendrecht locks
9. Monitoring dredging and dumping activities in the Lower Sea Scheldt

In situ calibrations were conducted on several dates to calibrate all turbidity and conductivity sensors (IMDC, 2006f & IMDC, 2007l).

1.4. Structure of the report

This report is the sediment balance of the Deurganckdok for the period of 01/01/2009 to 31/03/2009. The first chapter comprises an introduction. The second chapter describes the project. Chapter 3 describes the methodology. The measurement results and processed data are presented in Chapter 4, whereas chapter 5 gives a preliminary analysis of the data.

2. SEDIMENTATION IN DEURGANCKDOK

2.1. Project Area: Deurganckdok

Deurganckdok is a tidal dock situated at the left bank in the Lower Sea Scheldt, between Liefkenshoek and Doel. Deurganckdok has the following characteristics:

1. The dock has a total length of 2750 m and is 450 m wide at the Scheldt end and 400 m wide at the inward end of the dock
2. The bottom of Deurganckdok is provided at a depth of -17m TAW in the transition zones between the quay walls and the central trench. The bottom in the central trench is designed at -19 m TAW .
3. The quay walls reach up to $+9\text{m TAW}$

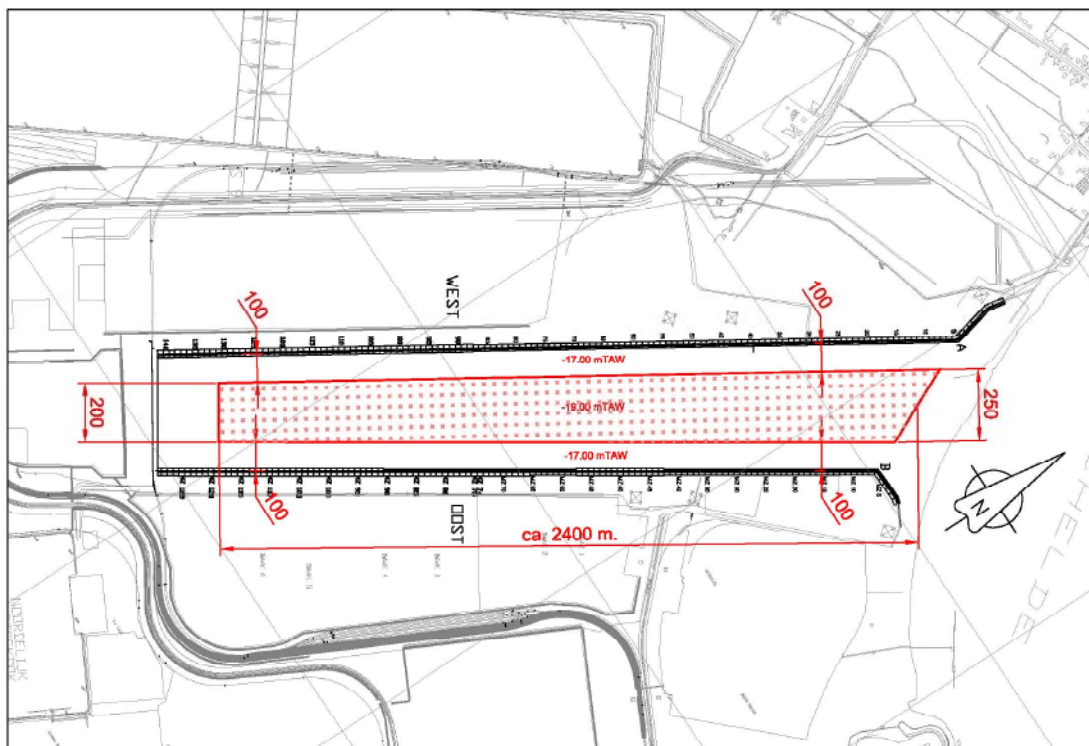


Figure 2-1: Overview of Deurganckdok

The dredging of the dock is performed in 3 phases. On 18 February 2005 the dike between the Scheldt and the Deurganckdok was breached. On 6 July 2005 Deurganckdok was officially opened. The second dredging phase was finalized a few weeks later. The first terminal operations have started since. In February 2007, the third dredging phase started and is finalised by February 2008.

2.2. Overview of the studied parameters

The first part of the study aims at determining a sediment balance of Deurganckdok and the net influx of sediment. The sediment balance comprises a number of sediment transport modes:

deposition, influx from capital dredging works, internal replacement and removal of sediments due to maintenance dredging (Figure 2-2).

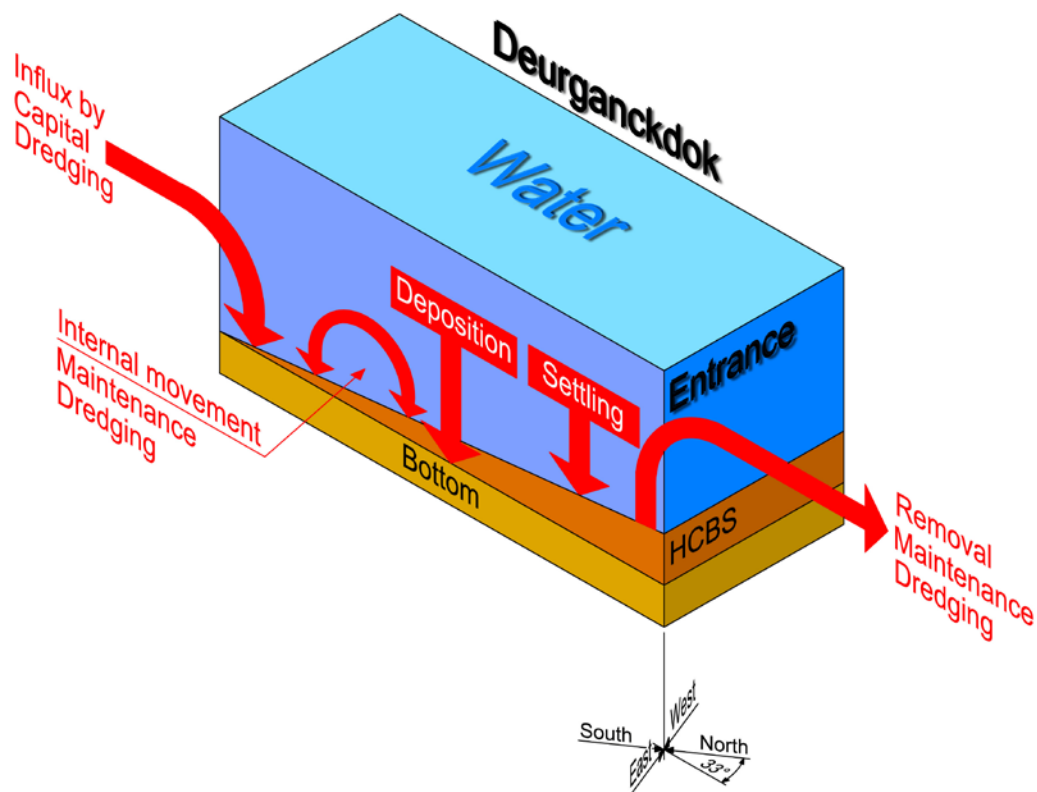


Figure 2-2: Elements of the sediment balance

A net deposition can be calculated from a comparison with a chosen initial condition t_0 (Figure 2-3). The mass of deposited sediment is determined from the integration of bed density profiles recorded at grid points covering the dock. Subtracting bed sediment mass at t_0 leads to the change in mass of sediments present in the dock (mass growth). Adding cumulated dry matter mass of dredged material removed since t_0 and subtracting any sediment influx due to capital dredging works leads to the total cumulated mass entered from the Scheldt river since t_0 .

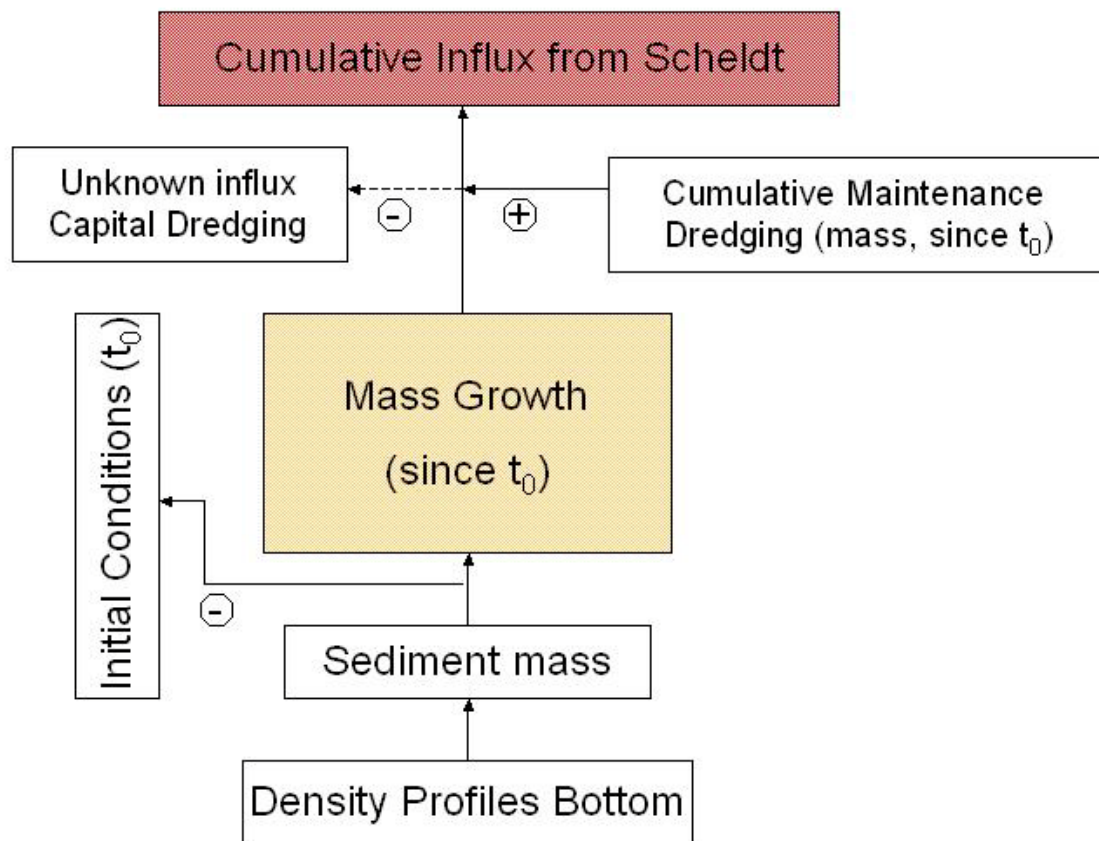


Figure 2-3: Determining a sediment balance

The main purpose of the second part of the study is to gain insight in the mechanisms causing siltation in Deurganckdok. The following mechanisms will be aimed at in this part of the study:

- Tidal prism, i.e. the extra volume in a water body due to high tide
- Vortex patterns due to passing tidal current
- Density currents due to salt gradient between the Scheldt river and the dock
- Density currents due to highly concentrated benthic suspensions

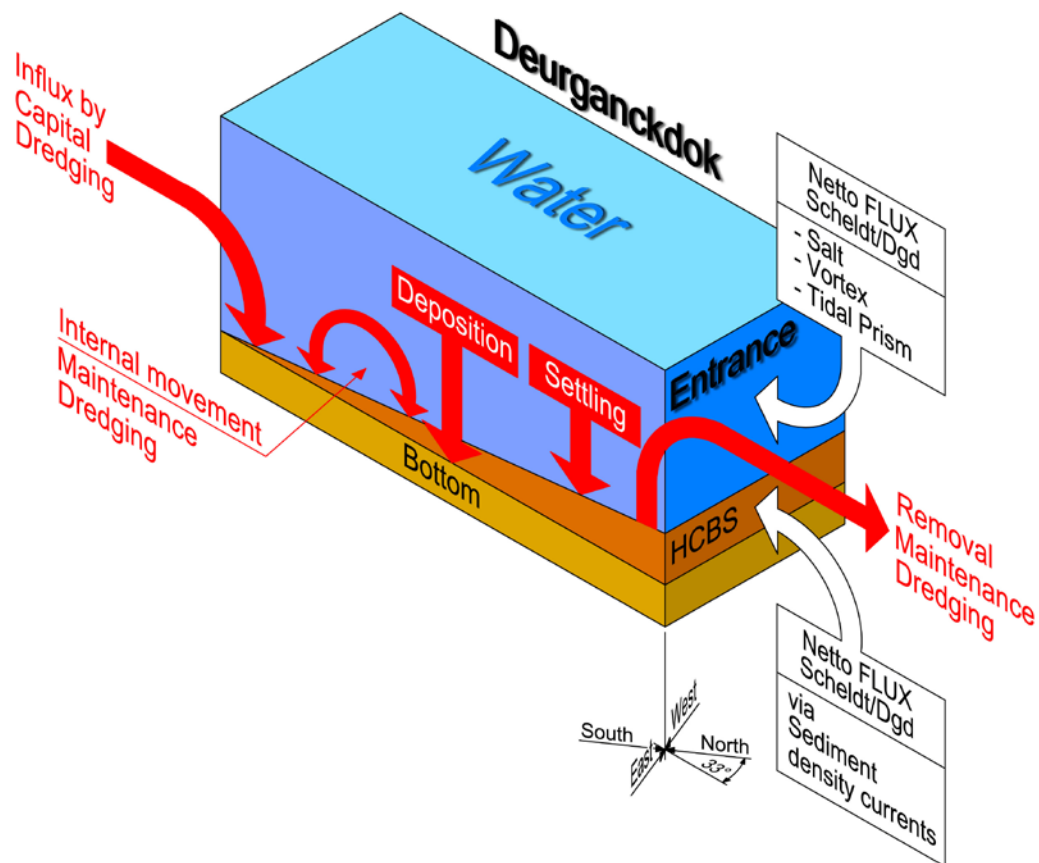


Figure 2-4: Transport mechanisms

These aspects of hydrodynamics and sediment transport have been landmarks in determining the parameters to be measured during the project. Measurements will be focused on three types of timescales: one tidal cycle, one neap-spring cycle and seasonal variation within one year.

Following data are being collected to understand these mechanisms:

- Monitoring upstream discharge in the Scheldt river.
- Monitoring Salt and sediment concentration in the Lower Sea Scheldt at permanent measurement locations at Oosterweel, up- and downstream of the Deurganckdok.
- Long term measurement of salt and suspended sediment distribution in Deurganckdok.
- Monitoring near-bed processes (current velocity, turbidity, and bed elevation variations) in the central trench in the dock, near the entrance as well as near the current deflecting wall location.
- Dynamic measurements of current, salt and sediment transport at the entrance of Deurganckdok.
- Through tide measurements of vertical sediment concentration profiles -including near bed high concentrated benthic suspensions.
- Monitoring dredging activities at entrance channels towards the Kallo, Zandvliet and Berendrecht locks as well as dredging and dumping activities in the Lower Sea Scheldt.
- In situ calibrations were conducted on several dates to calibrate all turbidity and conductivity sensors.

3. MEASUREMENTS

3.1. Depth soundings

The client executes dual-frequency echo-sounder measurements on a frequently basis. F. De Cock (Agentschap voor Maritieme Dienstverlening en Kust – Afdeling Kust) communicated that these measurements are carried out with a 210-33 kC Echo sounder using Qinsy software. The depth sounding measurements are executed in a grid configuration, consisting of sections perpendicular and parallel to the quay wall.

Table 3-1: Overview of the available depth soundings suitable for analysis 01/10/2008 – 31/12/2008

| date | type of measurement | signal | Source |
|-------------|----------------------------|---------------|---------------|
| 13/03/2008* | dual frequency 210-33 kHz | 210 | Afdeling Kust |
| 15/01/2009 | dual frequency 210-33 kHz | 210 | Afdeling Kust |
| 11/02/2009 | dual frequency 210-33 kHz | 210 | Afdeling Kust |
| 03/03/2009 | dual frequency 210-33 kHz | 210 | Afdeling Kust |
| 17/03/2009 | dual frequency 210-33 kHz | 210 | Afdeling Kust |

*= reference situation depth soundings: t_{0e}

To calculate a sediment balance it is necessary to analyse the measurements in stationary situation, with no alteration in boundary conditions being dredging operations. Every period is characterized by a depth sounding measurement before ('inpeiling') and one after ('uitpeiling').

A number of analyses were done using the depth soundings in Table 3-1. The raw depth sounding data was processed in ESRI ArcGIS. The 210 kC signal is used in the following analyses as it gives an indication of the water-bed interface.

A reference level was chosen from all depth sounding measurements. Previous reports used the earliest measurement as reference level, i.e. 24 March 2006. In February 2008, the capital dredging of the dock was finalized such that a significant larger measurement area became applicable. A new reference situation, initial condition t_{0e} , therefore seemed plausible for which the depth sounding of 13 March 2008 was selected.

A number of analyses were performed in ArcGIS 9 and a Matlab environment to produce maps, figures and tables with relevant information concerning elevation, elevation changes and volumetric growth (§4.2 to §4.4).

3.2. Density measurements

Density measurements are necessary to calculate a sediment balance of dry weight of sediment per surface unit.

The DensiTune is a patented system to determine the internal density of liquid silt layers. The measurement system is based on the "tuning fork" principles. One of the legs vibrates with a specific frequency, and the other leg responds with a frequency which depends on the density of the medium in which the DensiTune is inserted. The system measures vertical density profiles in liquid silt layers while lowered.

The resulting density profiles were processed in a Matlab environment and visualized in Matlab and ESRI ArcGIS. Equal density layers were computed. Volume and density information was used to calculate masses of silt. All masses are given in ton of dry solids (TDS) characterized by a density of 2.65 kg/dm³. The water-bed interface is defined as the layer with a density of 1.03 kg/dm³.

To calculate the local sediment mass in the dock, or zones of it, each measured density profile was integrated over its depth. The unmeasured part of the water column, covering the distance between the deepest sampling point and the design depth, needed to be estimated (if not measured). This sediment concentration was estimated as being constant for the unmeasured depth range and being proportional to the deepest measured concentration. As proportionality, a value of 1.02 was applied which was determined from a preliminary analyses of the density profiles near the bottom (measured by Navitracker). A horizontal distribution of the sediment mass was subsequently obtained by cubic interpolation between the profiling locations onto a grid with a resolution of 5 m.

In this measurement campaign, DensiTune measurements were performed on 30 January and 12 March 2009.

As a reference situation the empty dock will be used at the design depth. The design depths for the different zones are shown in Table 3-2. The different zones are described in §4.1.

Table 3-2: Reference Situation Density Measurements (t_{0d})

| Zone | Design Depth (mTAW) |
|---|----------------------------|
| Central trench | -19 |
| Berthing zones and transition zones to central trench | -17 |
| Sill | -13.5 |
| Transition sill to navigation channel | Not applicable |

3.3. Maintenance Dredging Data

All maintenance dredging (except sweep beam) activities in Deurganckdok were collected in the BIS-system. This system gives a standardised output per week, that states the weight, volume and V^1 removed/dumped in every 5*5m grid cell in the area. In case the density of the dredged sediment in the hopper bin is larger or equal to 1.6 kg/dm³, V' is equal to the volume in the bin. In case the density is smaller than 1.6 kg/dm³, V' is equal to the reduced volume which is defined as the volume the dredged sediment would have in case the density would be equal to 2 kg/dm³ (AWZ 2000). These dredged volumes are important to have an overall view on the sediment balance. Maintenance dredging occurred between 11 February and 2 March 2009.

The available data on sweep beam activity is not collected in the BIS-system. However, the mode of operation of the sweep beam is explained:

- On the sill (zone 1 & 2): the sediment is swept into the Lower Sea Scheldt
- Inside the dock: the sweep beam sweeps the berthing zones next to the quay walls and moves sediment into the central trench

Therefore, an overview is given of where and when sweep beam dredger was working in Deurganckdok (DGD) or on the sill of Deurganckdok (sill DGD).

¹ V' = Reduced Volume

Table 3-3: Sweep beam maintenance dredging activities in Deurganckdok and on the sill of Deurganckdok between January and March 2009 (source: Afdeling Maritieme Toegang)

| From | Till | Duration (days) | Location |
|-------------|-------------|------------------------|-----------------|
| 5/01/2009 | 5/01/2009 | 1 | sill DGD |
| 12/01/2009 | 12/01/2009 | 1 | sill DGD |
| 19/01/2009 | 19/01/2009 | 1 | sill DGD |
| 28/01/2009 | 29/01/2009 | 2 | sill DGD |
| 2/02/2009 | 3/02/2009 | 2 | sill DGD |
| 9/02/2009 | 10/02/2009 | 2 | sill DGD |
| 16/02/2009 | 17/02/2009 | 2 | sill DGD |
| 23/02/2009 | 24/02/2009 | 2 | sill DGD |
| 2/03/2009 | 3/03/2009 | 2 | sill DGD |
| 10/03/2009 | 11/03/2009 | 2 | sill DGD |
| 16/03/2009 | 16/03/2009 | 1 | sill DGD |
| 23/03/2009 | 24/03/2009 | 2 | sill DGD |
| 30/03/2009 | 31/03/2009 | 2 | sill DGD |

An overview of the total dredged mass in all zones (BIS data) is provided in APPENDIX I. The sweep beam tracks are shown in APPENDIX J. The loggings of the sweep beam tracks show the position and depth of the rake. From the up-down position of the rake and the ship's direction, it is possible to identify whether the ship is sweeping sediment into the Scheldt or not.

4. SEDIMENT BALANCE ANALYSES

4.1. Project Area: (Sub)Zones and Sections

To calculate volumes and masses for the sediment balance of Deurganckdok it is necessary to subdivide it into 5 zones:

- Zone 1: Between the sill and the navigation channel in the Lower Sea Scheldt.
- Zone 2: Sill at entrance DGD designed at -13.5 m TAW.
- Zone 3: Central trench in DGD with a design depth at -19 m TAW (including slope to -17 m TAW)
- Zone 4: Transition between central trench and berthing zones with a design depth at -17.00 m TAW: on both (North (N) and South (Z)) sides of DGD (55 m wide).
- Zone 5: Berthing zones next to quay walls on both (North (N) and South (Z)) sides of DGD (40 m wide)

Zones 3, 4 and 5 are subdivided into subzones A, B, C, D and E. This is shown in Figure 4-1.

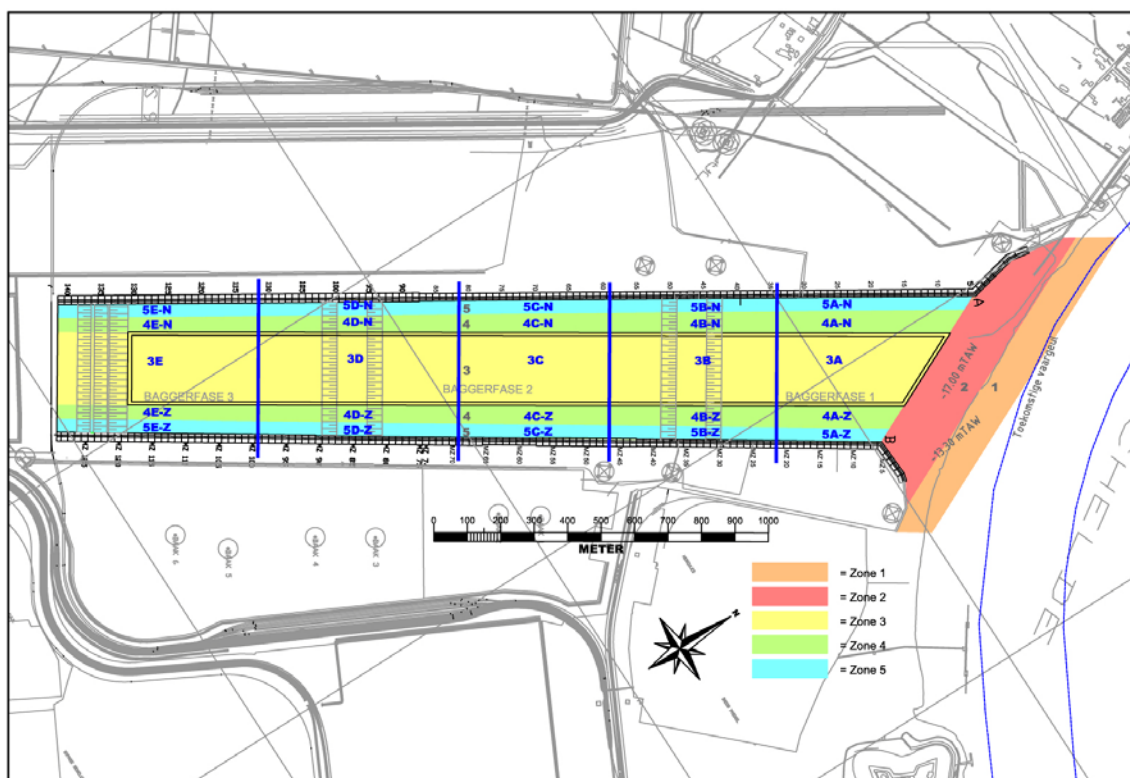


Figure 4-1: Deurganckdok: Zones and Subzones

Sections are defined for this whole area (Figure 4-2):

- D sections are oriented perpendicular to the quay walls inside the dock and parallel to the navigation channel outside the dock (sill and Scheldt). The origin of the sections is taken on the quay wall at the left bank (West side) looking outwards.
- L Sections are oriented along the centerline of the dock and run from the navigation channel towards the inland end of the dock, in anticipation of the realisation of the third phase of Deurganckdok. The origin is situated on the intersection between each L section and section D10.

The coordinates of these sections are given in Table 4-1.



Figure 4-2: Deurganckdok: D and L Sections

Table 4-1: Coordinates of Sections [UTM ED50]

| Name | Origin | | End | |
|-------------------|---------|----------|---------|----------|
| | Easting | Northing | Easting | Northing |
| D Sections | | | | |
| D1 | 587773 | 5683253 | 588123 | 5683037 |
| D2 | 587929 | 5683510 | 588283 | 5683290 |
| D3 | 588084 | 5683767 | 588444 | 5683544 |
| D4 | 588239 | 5684023 | 588604 | 5683797 |
| D5 | 588394 | 5684280 | 588765 | 5684051 |
| D6 | 588542 | 5684526 | 588772 | 5684062 |
| D7 | 588521 | 5684761 | 588864 | 5684068 |
| D8 | 588552 | 5684875 | 588972 | 5684027 |
| D9 | 588585 | 5684930 | 589047 | 5683994 |
| D10 | 588617 | 5684984 | 589081 | 5684047 |
| D11 | 587615 | 5682997 | 587962 | 5682783 |
| D12 | 587459 | 5682742 | 587802 | 5682529 |
| D13 | 587300 | 5682487 | 587642 | 5682276 |
| D14 | 587143 | 5682232 | 587482 | 5682023 |
| L Sections | | | | |
| L1 | 588748 | 5684720 | 587180 | 5682151 |
| L2 | 588825 | 5684565 | 587290 | 5682082 |
| L3 | 588901 | 5684410 | 587409 | 5682007 |

4.2. Depth of the water-bed interface (210 kC)

This is shown as a GIS grid map generated directly from the depth sounding data and is shown in APPENDIX A. An example is shown in Figure 4-3.

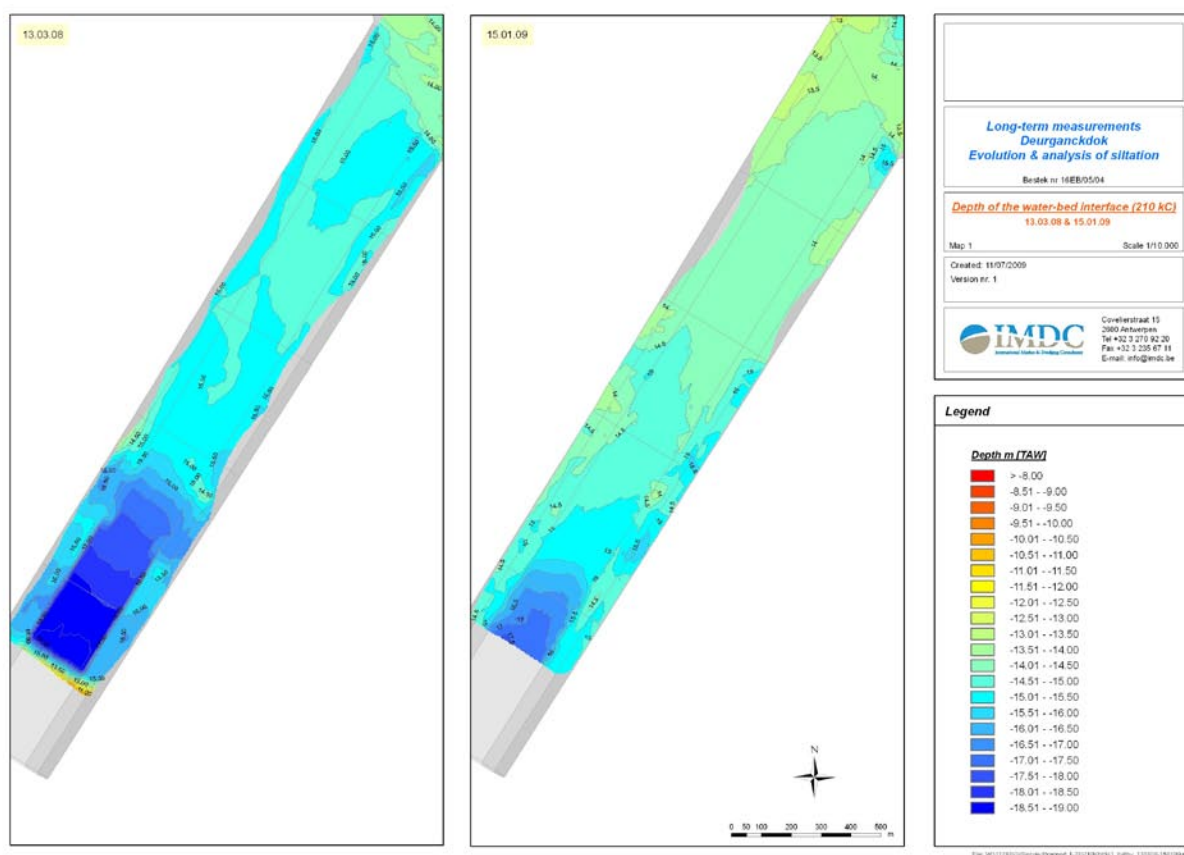


Figure 4-3: Example of a map showing depth of water-bed interface (210 kC) for 13/03/08 and 15/01/09

4.3. Evolution of water-bed interface (210 kC)

GIS grid maps show the difference charts for every depth sounding in relation to the reference situation (t_{0e}) and to the previous depth sounding (right). An example is shown in Figure 4-4.

The difference in depth between subsequent depth soundings for 210 kC measurements is also shown for all predefined sections. Graphs show a colour plot with Time in the X-axis, Distance to origin of section in the Y-axis and the depth of the top layer [m TAW] as a colour plot.

The origin for the D sections is the northern quay wall. The origin of the L sections is the intersection between the L section with the Scheldt edge of zone 1. An example for sections is shown in Figure 4-5. The description of the sections is given in § 4.1.

Maps and graphs are shown in APPENDIX B.

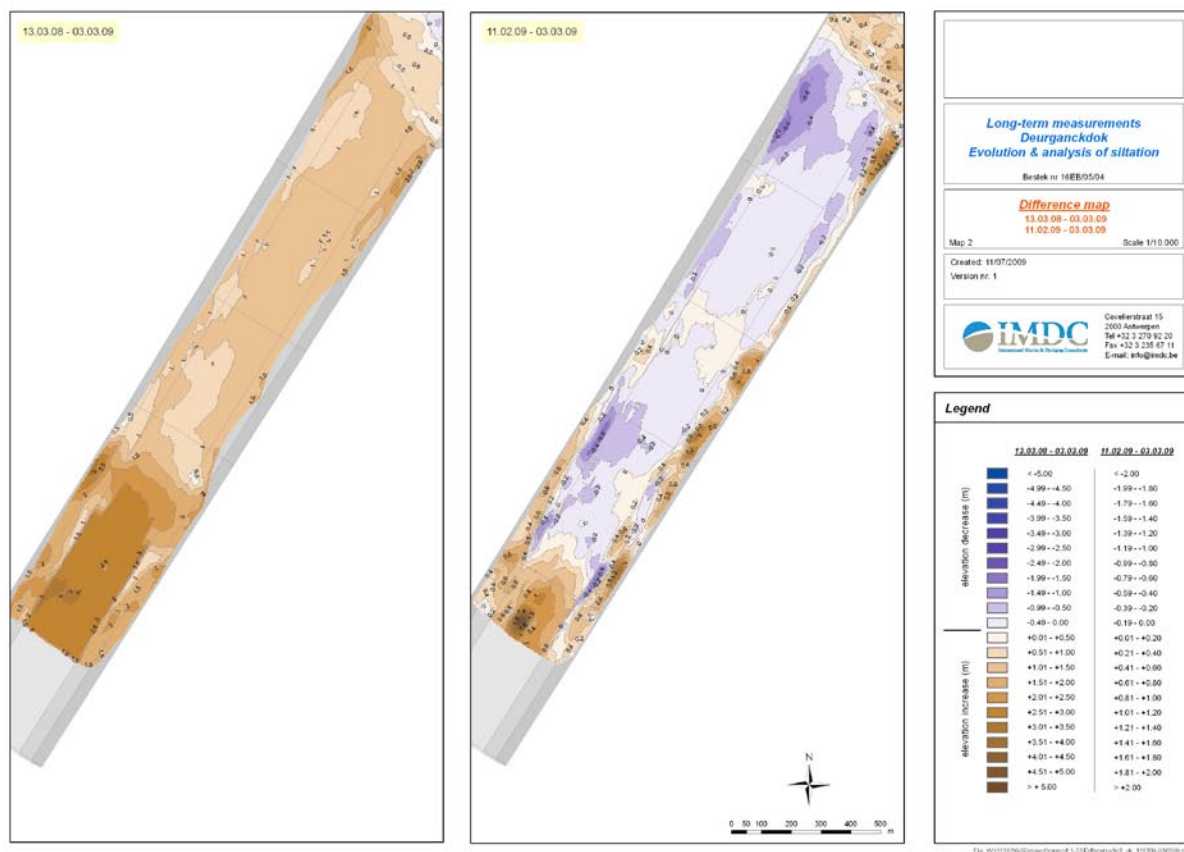


Figure 4-4: Difference charts of the depth sounding on 3/03/09: in reference to t_{0e} (left), and to the previous measurement (right) on 11/02/09

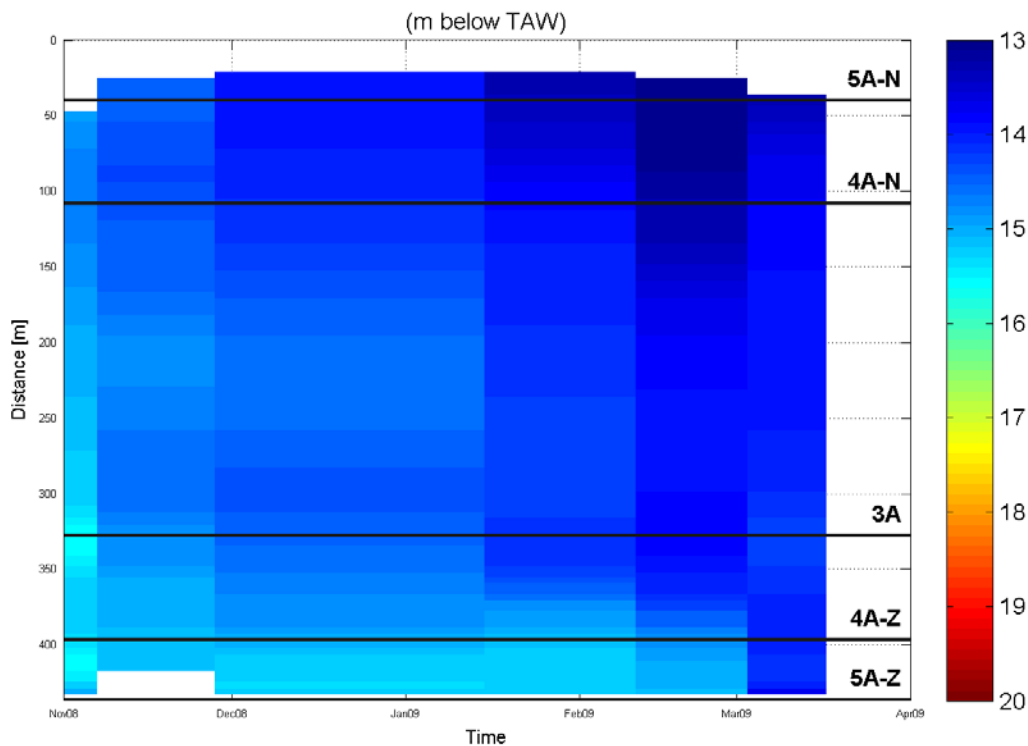


Figure 4-5: Graph of Evolution of the water-bed interface (210 kC) for section D5

4.4. Volumetric siltation rates [cm/day] in different zones and sections

A table with monthly average siltation rates for all (sub)zones is also given in APPENDIX C.

Graphs in APPENDIX C show two parameters:

- Average siltation rates [cm/day]: The average siltation rate is the difference in the depth of the water-bed interface and is calculated only for those zones and subzones that have at least a 50% surface area overlap between two subsequent depth soundings. This is done for all successive depth soundings. It is shown in the plots as a bar and is positive for sedimentation and negative for erosion or removal.
- Cumulative bed level change [m]: an initial situation (t_0) is used as baseline. Starting from this reference level the evolution of the average bed level elevation is shown for the particular (sub)zone.

Dredging events from the BIS system are marked on each of these graphs. This is computed for all zones, subzones, sections and Deurganckdok as a whole. As an example we show siltation rate and cumulative bed level change for zone 3a in Figure 4-6.

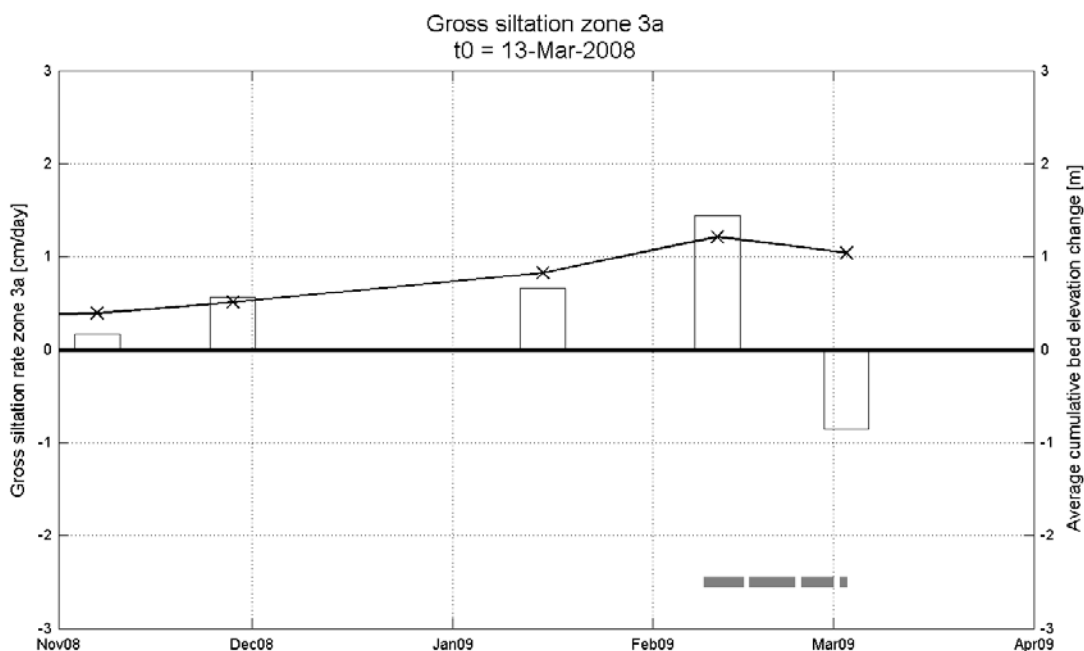


Figure 4-6: Volumetric siltation rate for zone 3a

4.5. Depth of water-bed interface (1.03 kg/dm³) and equal density layers

This analysis is based on density profile measurements from the Navitracker. Maps show the depth of water-bed interface and equal density layers (1.1, 1.2, 1.3 kg/dm³). The elevation of the water-bed interface is here defined as the depth at which the equipment encounters a density of 1.03 kg/dm³. This threshold is chosen since the maximum weight of salt and suspended sediment in the water column is estimated at 30 g/l, corresponding with a bulk density of about 1.03 kg/dm³. When the density passes this value, the equipment is assumed to reach the water-bed interface. The depth of the layers of constant density can be found in APPENDIX D, whereas APPENDIX E gives the density profiles for the different sections in Deurganckdok. An example for equal density layers in section D1 is given in Figure 4-7. An example of a map is given in Figure 4-8. The description of the sections is given in § 4.1.

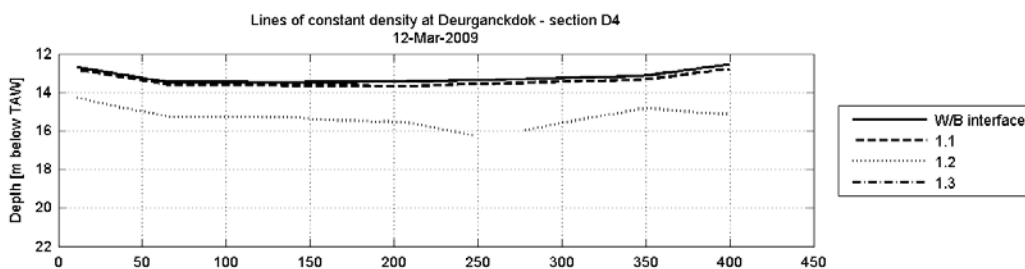


Figure 4-7: Depth of water-bed interface and equal density layers in section D4 on 12 March 2009

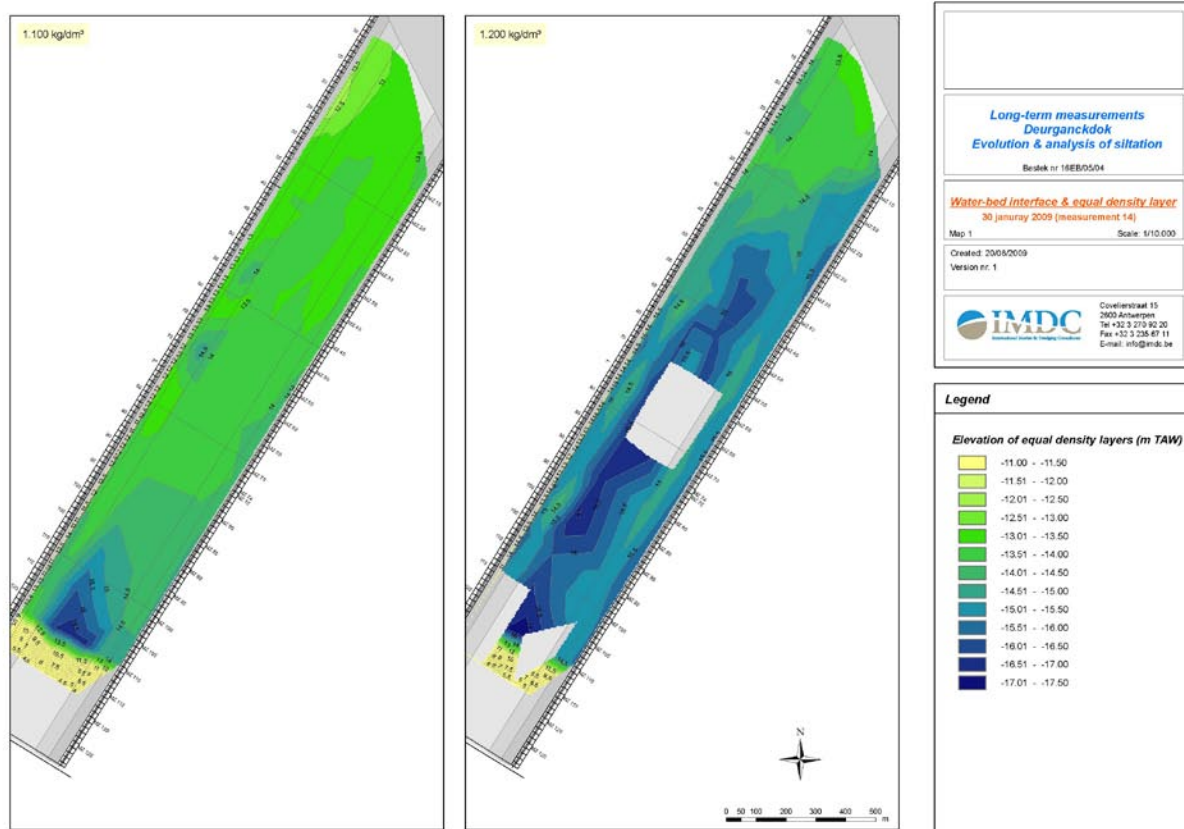


Figure 4-8: Map of the depth of the water-bed interface and equal density layers for 30/01/09

4.6. Evolution of water-bed interface and equal density layers elevation

The evolution of water-bed interface and equal density layers (1.1, 1.2 en 1.3 kg/dm³) are shown for all sections in APPENDIX F. The description of the sections is given in § 4.1. Note that the last measurement of the previous measurement campaign, i.e. 6 November 2008, is added to the present data series in order to have a good view on the density evolution. This makes 3 density measurements in total being used for this comparison. Sections of four different planes of constant density are determined. These planes are determined by mapping the depths at which the specified densities have been encountered. For every measurement campaign the elevation of these planes across the sections has been plotted. An example is shown in Figure 4-9.

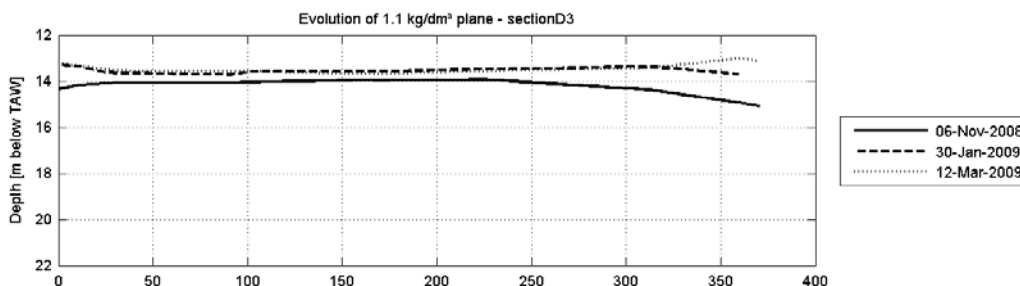


Figure 4-9: Graph of the evolution of 1.1 kg/dm³ plane in section D3

4.7. Measured mass maps

The measured mass in [TDS/m²] is calculated and visualized in maps for every measurement in reference to the empty dock at design depth (reference situation t_{0d}) (see §3.2). Every map is based on a density measurement.

These maps are shown in APPENDIX G.

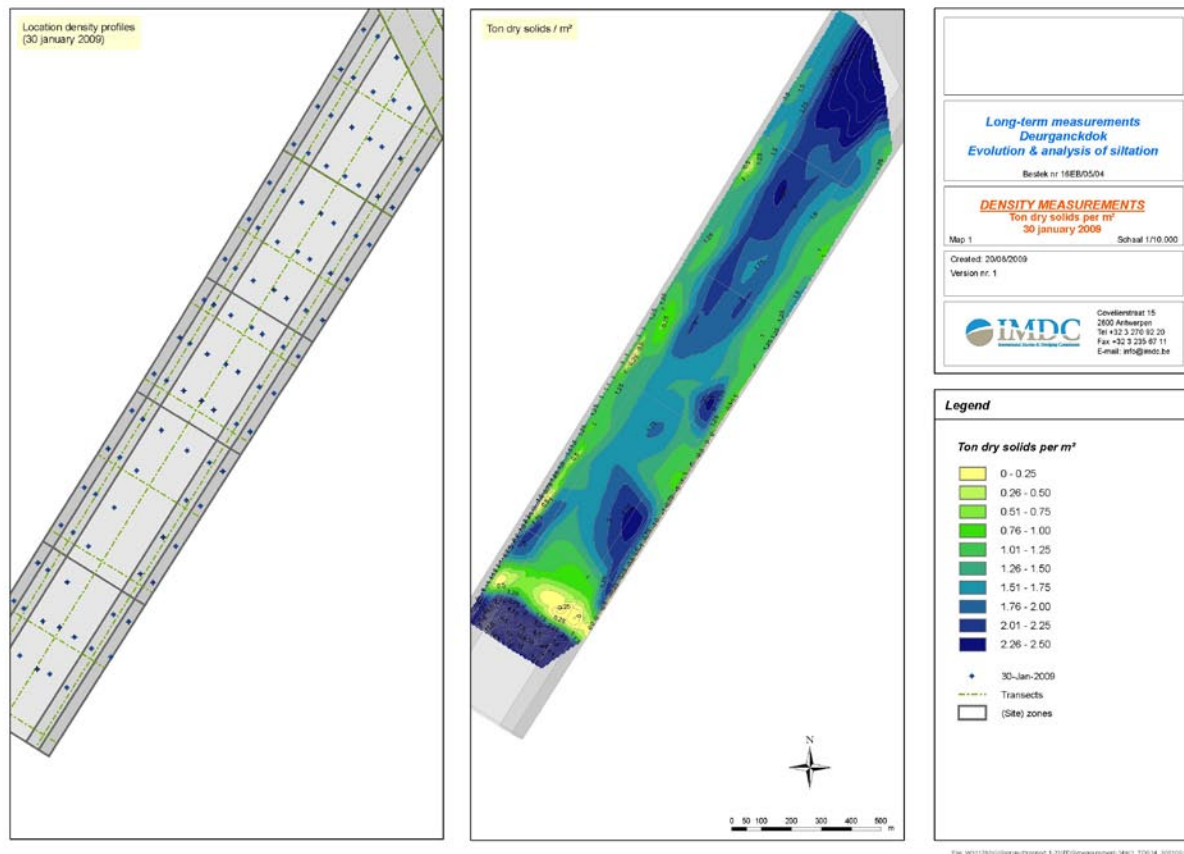


Figure 4-10: Map showing the location of the density profiles (left) and the calculation of TDS (right) on 30/01/09

4.8. Average net mass evolution

The average net mass growth [TDS/m²] in all zones and subzones is based on density profile measurements (measured sediment mass). The actual sediment mass present in the dock and measured by density profiling does not take the removed dredged material into account. The mass removed by dredging can be computed from BIS data (dredged material mass). Only zones spatially covered for 50% and more by density measurements are considered for sediment mass calculations. Unmeasured parts of these zones retrieve a value for the calculations (in order to close the mass balance of the zone), being the average mass per square meter based on the actual density measurements of the considered zone.

By adding measured mass to dredged material mass, the total accumulated mass and hence the growth can be shown (see Figure 4-11). In case this *total mass* can be computed for the complete dock (or a zone) for two subsequent measurements, an estimation of the net sediment flux into the dock (or zone) during the intermediate period is given by the difference of both total mass values. The net sediment flux into an area can also be defined as the net mass growth (kg/m² or Ton Dry

Solids/m²). Division of the net mass growth of a zone by the number of days in between measurements leads to the averaged net mass growth rate. Note that the last measurement of the previous measurement campaign, i.e. 6 November 2008, is added to the present data series in order to have a good view on the net mass evolution.

Averaged net mass growth rate [kg/m²/day] is computed for each zone and subzone and is shown in APPENDIX H. An example is shown for zone 3C in Figure 4-12.

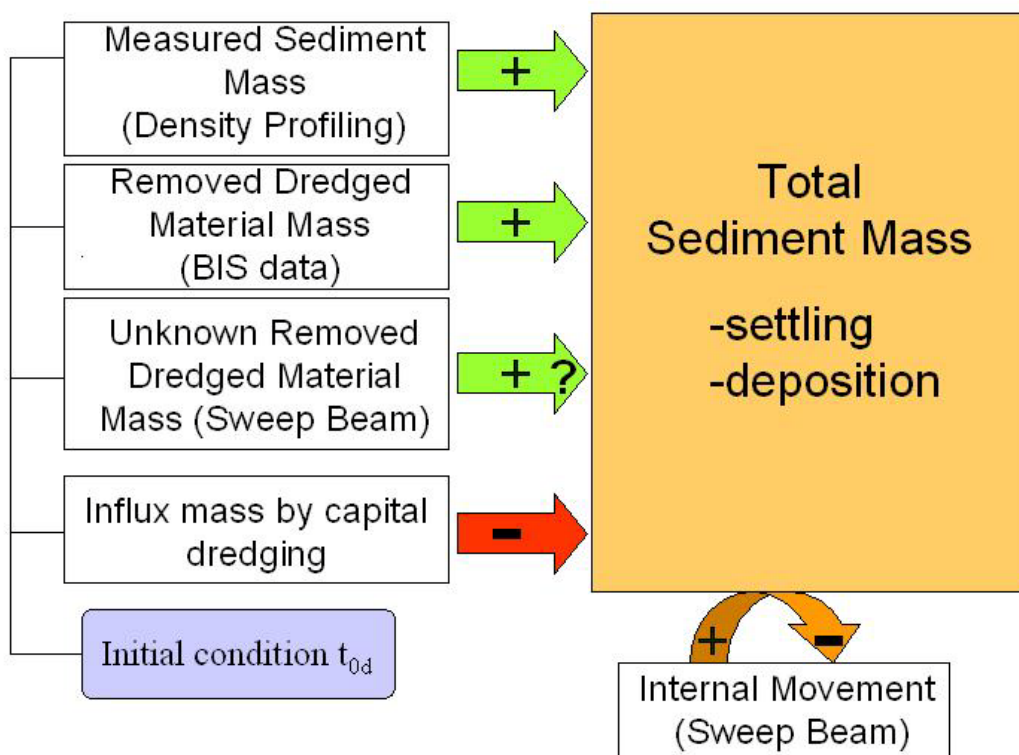


Figure 4-11: Flow chart with different elements contributing to total sediment mass for (sub)zones and total area

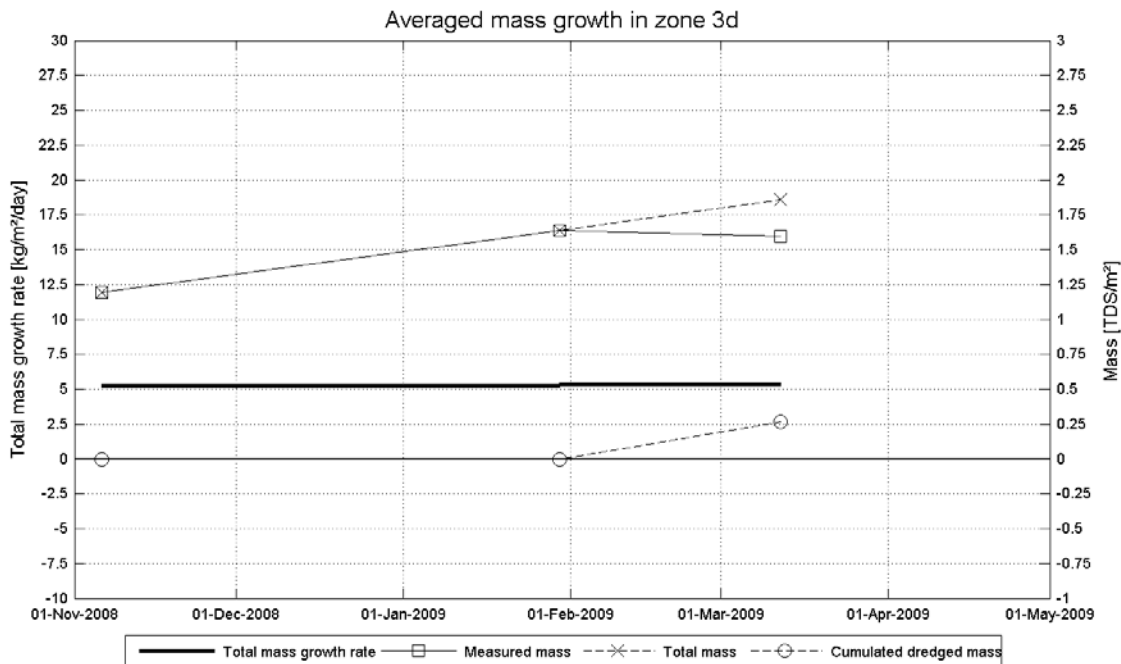


Figure 4-12: Example of averaged mass growth and mass evolution for subzone 3D

Clearly, the sediment mass balance is incomplete because sediment fluxes cannot be derived from the sweep beam data (of which no mass or volume information is available). Internal movements of sediment by the sweep beam (berthing zones to central trench) and removal of sediments from the sill into the Lower Sea Scheldt definitely influence the mass balance for (sub)zones and the total dock.

A table in APPENDIX H gives an overview for all zones and subzones for the following parameters, and this only if data is available for at least 50 % of this (sub)zone:

- Measured Sediment mass [TDS/m²]
- Dredged Material mass (absolute) [TDS]
- Total Sediment mass [TDS/m²]
- Growth rate [kg/m²/day]
- Total area [ha]
- Covered area [ha]: area covered by density profiles
- Percent of zone covered [%]

5. PRELIMINARY ANALYSIS OF THE DATA

5.1. Volumetric analysis

Depth sounding data is processed to show the evolution of the average sediment volume per unit of surface, i.e. the average evolution of bed level as detected by a 210 kHz sounder. If more than 50% of the area of a (sub)zone is covered, an average siltation rate is calculated. For the period of January - March 2009, depth soundings were performed on 15 January, 11 February, and 3 and 17 March 2009. The depth soundings covered almost all zones; an exception was zone E.

The bathymetric measurements in APPENDIX A and the corresponding bathymetric difference maps in APPENDIX B show that the bed interface increases in the period January – mid-February 2009 due to the absence of maintenance dredging. The difference maps indeed show a general increase of more than 40 cm in the central trench zones A-C. Due to dredging on 11 February and 2 March, the bed interface lowers again with maximally 40 cm in the zones 3A-D.

These bed level evolutions are reflected by the siltation rates in APPENDIX C. Due to the undisturbed siltation between January and mid-February 2009, positive siltation rates occur in the dock. Siltation rates are smaller than 1 cm/day in for the period December 2008 – January 2009, whereas rates are larger than 1 cm/day between mid-January and mid-February 2009. Negative siltation rates can be observed in the dock after 3 March 2009 due to maintenance dredging. A decrease in siltation rate when going further inside the dock is clearly seen in the period December 2008 – mid-February 2009. This was however not so clear for the subsequent and undisturbed period of mid-January – mid-February 2009.

5.2. Densimetric analysis

Hopper maintenance dredging occurred on several days as shown in Table 5-1. BIS data revealed that more than 257×10^3 TDS was dredged in the period 11 February and 2 March 2009. The majority of dredged mass originated from the central trench and covered almost 64% of the total dredged mass. Near the northern quays, 21.4% of the dredged mass could be found, whereas the southern quays covered 14.1%.

From the measured vertical density profiles, the temporal evolution of planes of constant density can be investigated. The results can be found in APPENDIX F. For the first half of the dock, it is observed that the water-bed interface and 1.1 kg/dm³ density interface increased between November 2008 and the end of January 2009, after which it stayed at the same level even with maintenance dredging occurring. The effect of dredging is only seen by a lowering of the 1.2 tons/m³ density interface. This indicates that the sediment bed does not 'collapse' when dredging below the water-bed interface, at least not immediately. In the second half of the dock, dredging has an effect on all sediment bed layers though.

The vertical density profiles have also been numerically integrated to calculate the mass of dry solids above a reference plane for each zone (i.e. the design depth of Deurganckdok t_{0d} (see §2.1)). This data availability also enables the use of the densimetric dredging data, cf. BIS data, in the mass balance calculations. Total sediment mass is only calculated for locations where 50% and more of the zone area is covered by density measurements. Adding up the measured and dredged masses leads to the total sediment mass as shown in APPENDIX H. Results show mass growth rates in the central trench (zones 3A-D) in the range of 1.9 and 6.45 kg/m²/day. These numbers are at the lower-end of the range of growth rates measured in the previous measurement period, i.e. 1.9 – 16.9 kg/m²/day for the period October -December 2008.

Table 5-1: Dredged sediment mass (TDS)

| | 09-Feb-09 | 16-Feb-09 | 24-Feb-09 | 02-Mar-09 | |
|----------------|-----------|-----------|-----------|-----------|---------|
| | 15-Feb-09 | 23-Feb-09 | 01-Mar-09 | 02-Mar-09 | % Total |
| 1 | 28 | 0 | 0 | 0 | 0.0 |
| 2 | 115 | 673 | 623 | 0 | 0.5 |
| 3a | 7478 | 12311 | 35768 | 2122 | 22.4 |
| 3b | 2268 | 9991 | 25328 | 1597 | 15.2 |
| 3c | 2341 | 7773 | 18303 | 1151 | 11.5 |
| 3d | 3608 | 12843 | 17634 | 779 | 13.5 |
| 3e | 283 | 499 | 1987 | 0 | 1.1 |
| 4Na | 5137 | 9582 | 1789 | 0 | 6.4 |
| 4Nb | 4629 | 12123 | 629 | 0 | 6.8 |
| 4Nc | 3763 | 7966 | 537 | 0 | 4.8 |
| 4Nd | 2700 | 6081 | 281 | 0 | 3.5 |
| 4Ne | 65 | 9 | 16 | 0 | 0.0 |
| 4Za | 1930 | 6477 | 1438 | 0 | 3.8 |
| 4Zb | 3055 | 7731 | 749 | 0 | 4.5 |
| 4Zc | 2500 | 5327 | 217 | 0 | 3.1 |
| 4Zd | 1514 | 5288 | 217 | 0 | 2.7 |
| 4Ze | 56 | 22 | 15 | 0 | 0.0 |
| 5Na | 0 | 0 | 0 | 0 | 0.0 |
| 5Nb | 0 | 0 | 0 | 0 | 0.0 |
| 5Nc | 0 | 4 | 0 | 0 | 0.0 |
| 5Nd | 0 | 0 | 0 | 0 | 0.0 |
| 5Ne | 0 | 0 | 0 | 0 | 0.0 |
| 5Za | 0 | 0 | 0 | 0 | 0.0 |
| 5Zb | 0 | 0 | 0 | 0 | 0.0 |
| 5Zc | 0 | 0 | 0 | 0 | 0.0 |
| 5Zd | 0 | 0 | 0 | 0 | 0.0 |
| 5Ze | 0 | 0 | 0 | 0 | 0.0 |
| Total | 41468 | 104701 | 105533 | 5649 | 257350 |
| % Total | 16.1 | 40.7 | 41.0 | 2.2 | |

An overview of the total sediment mass settled over time, for all zones that have been covered for 100%, is shown in Table 5-2 and Table 5-3. From these figures, it is concluded that between 6 November 2008 and 30 January 2009 200×10^3 tons of dry solids have settled in zones 3 and 4, subzones A-D. Instead, the subsequent six-weeks period showed 168×10^3 tons of settled dry solids.

Table 5-2: Total sediment mass (measured + dredged, in 10³ TDS) in some zones

| zone | 30-Jan-09 | 12-Mar-09 |
|------------|-----------|-----------|
| 3a | 230 | 250 |
| 3b | 159 | 167 |
| 3c | 185 | 220 |
| 3d | 165 | 188 |
| 4Na | 42 | 46 |
| 4Nb | 28 | 37 |
| 4Nc | 28 | 44 |
| 4Nd | 28 | 35 |
| 4Za | 38 | 49 |
| 4Zb | 25 | 35 |
| 4Zc | 35 | 50 |
| 4Zd | 35 | 44 |

Table 5-3: Mass settled per subzone in zones 3 and 4 (measured + dredged, in 10³ TDS)

| | 6-Nov-2008 / 30-Jan-2009 | 30-Jan-2009 / 12-Mar-2009 |
|------------------|-----------------------------|------------------------------|
| subzone A | 66 | 34 |
| subzone B | 34 | 27 |
| subzone C | 34 | 66 |
| subzone D | 66 | 41 |

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- IMDC (2006b) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.1 Through tide measurement SiltProfiler 21/03/2006 Laure Marie (I/RA/11283/06.087/WGO).
- IMDC (2006c) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.3 Through tide measurement Sediview spring tide 22/03/2006 Veremans (I/RA/11283/06.110/BDC)
- IMDC (2006d) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.4 Through tide measurement Sediview spring tide 27/09/2006 Parel 2 (I/RA/11283/06.119/MSA).
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- IMDC (2007b) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 1.2 Sediment Balance: Three monthly report 1/7/2006 – 30/09/2006 (I/RA/11283/06.114/MSA)
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- IMDC (2007f) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.2 Through tide measurement SiltProfiler 26/09/2006 Stream (I/RA/11283/06.068/MSA)
- IMDC (2007g) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.5 Through tide measurement Sediview neap tide (to be scheduled) (I/RA/11283/06.120/MSA)
- IMDC (2007h) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.7 Salt-Silt distribution & Frame Measurements Deurganckdok 15/07/2006 – 31/10/2006 (I/RA/11283/06.122/MSA)

IMDC (2007i) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.8 Salt-Silt distribution & Frame Measurements Deurganckdok 15/01/2007 – 15/03/2007 (I/RA/11283/06.123/MSA)

IMDC (2007j) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 3.1 Boundary conditions: Three monthly report 1/1/2007 – 31/03/2007 (I/RA/11283/06.127/MSA)

IMDC (2007k) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 3.2 Boundary conditions: Annual report (I/RA/11283/06.128/MSA)

IMDC (2007l) Uitbreiding studie dichtheitsstromingen in de Beneden Zeeschelde in het kader van LTV Meetcampagne naar hooggeconcentreerde slib suspensies Deelrapport 6.2 Summer Calibration and Final Report (I/RA/11291/06.093/MSA)

IMDC (2007m). Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 1.11 Sediment Balance: Two monthly report 1/7/2007 – 31/08/2007 (I/RA/11283/07.082/MSA).

IMDC (2007n). Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 1.14 Annual sediment balance (I/RA/11283/07.085/MSA).

IMDC (2007o). Calibration stationary & mobile equipment winter (I/RA/11283/07.096/MSA).

IMDC (2008a). Feasibility study of echo sounding to determine fluid mud density profiles (I/NO/11283/08.001/BOB).

IMDC (2008b). Comparison Navitracker-DensiTune (I/NO/08.275/ABR)

APPENDIX A.

DEPTH OF THE WATER-BED INTERFACE (210 KC)

APPENDIX B.

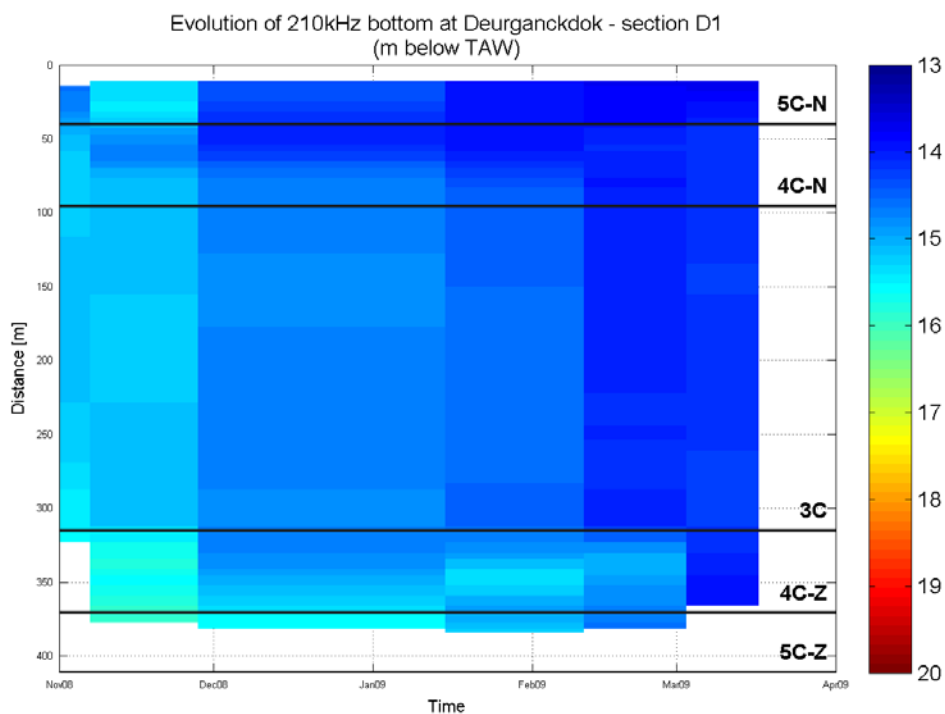
EVOLUTION OF DEPTH OF WATER-BED INTERFACE



(210 KC)

B.1 Difference maps

B.2 Bed elevation evolution per section

| | |
|--|---------------------------------------|
| Long-term monitoring siltation Deurganckdok | |
| Evolution 210kHz bottom | Equipment(s): 210kHz depth sounder |
| | Location: DGD |



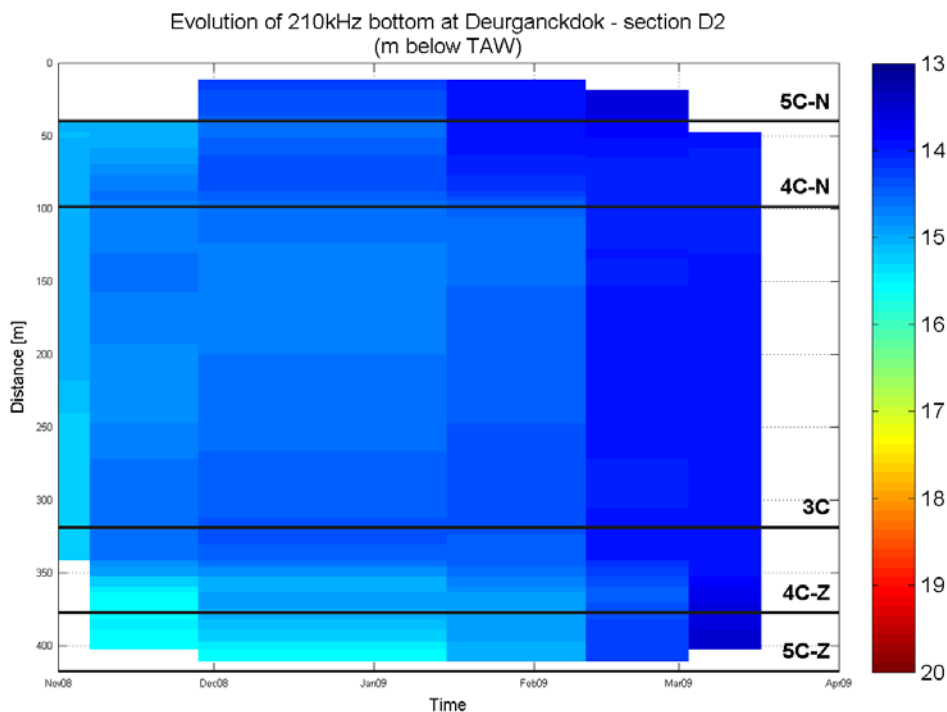
Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom

Equipment(s):
 210kHz depth sounder

Location:
 DGD



Data Processed by:



In association with:



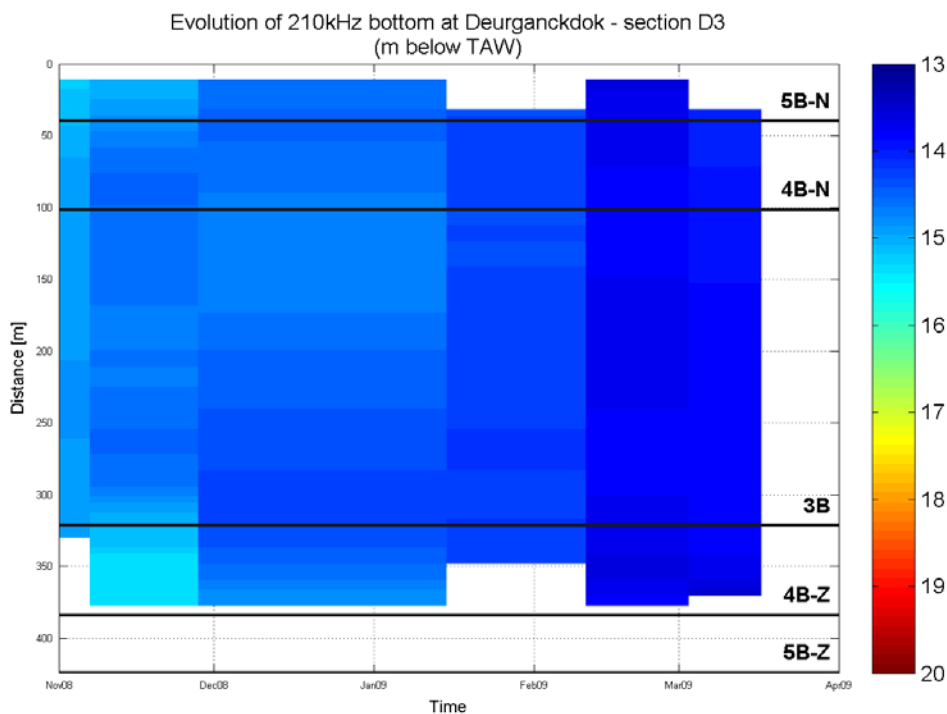
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom

Equipment(s):
 210kHz depth sounder

Location:
 DGD



Data Processed by: 
 In association with: 

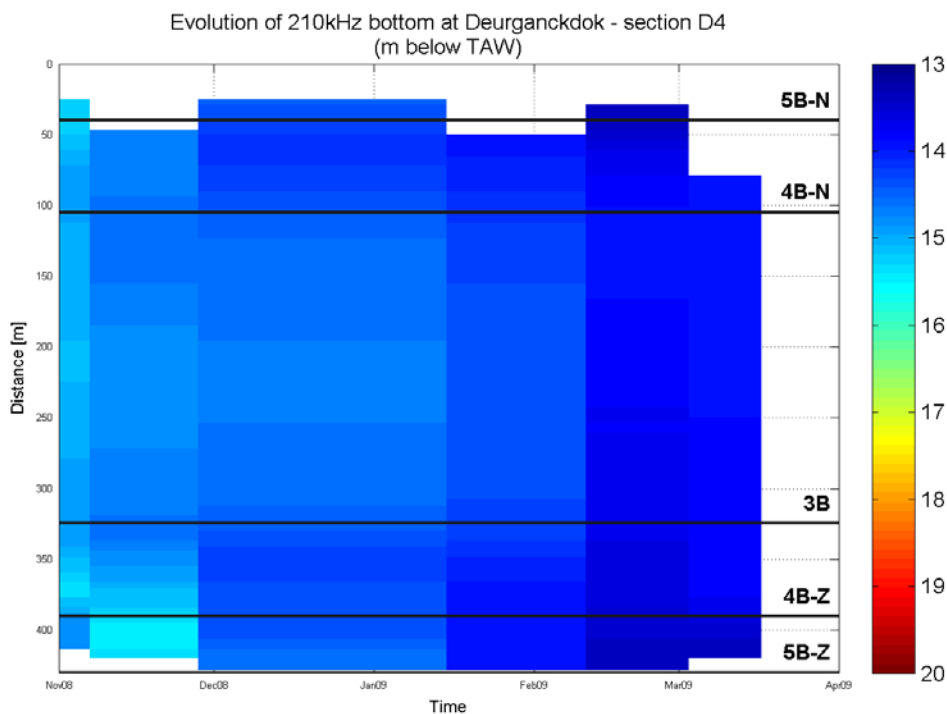
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom

Equipment(s):
 210kHz depth sounder

Location:
 DGD



Data Processed by: 
 In association with: 

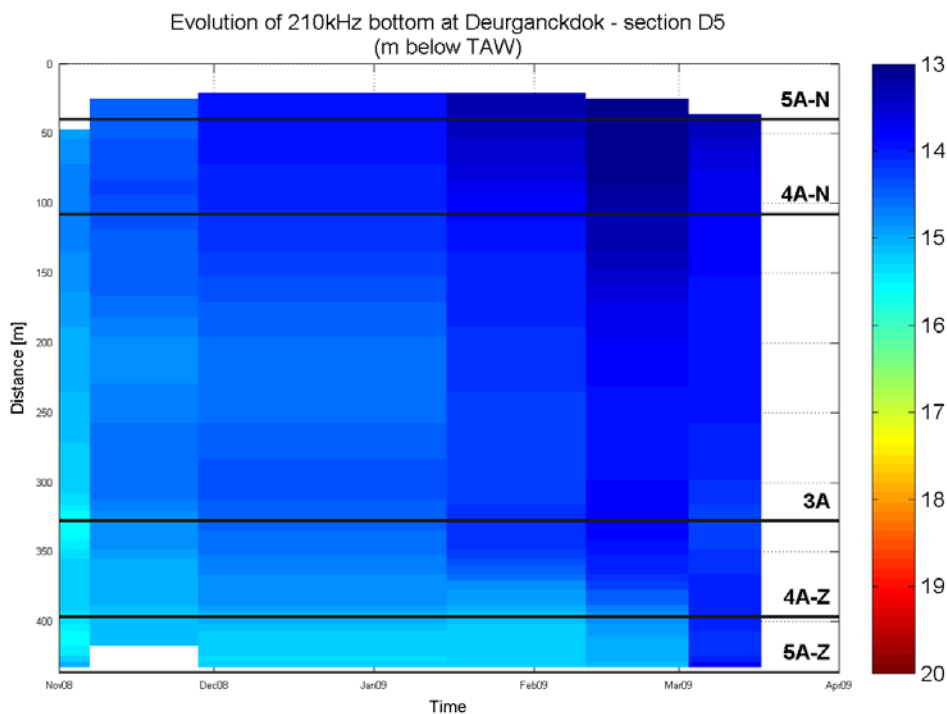
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom

Equipment(s):
 210kHz depth sounder

Location:
 DGD



Data Processed by: 
 In association with: 

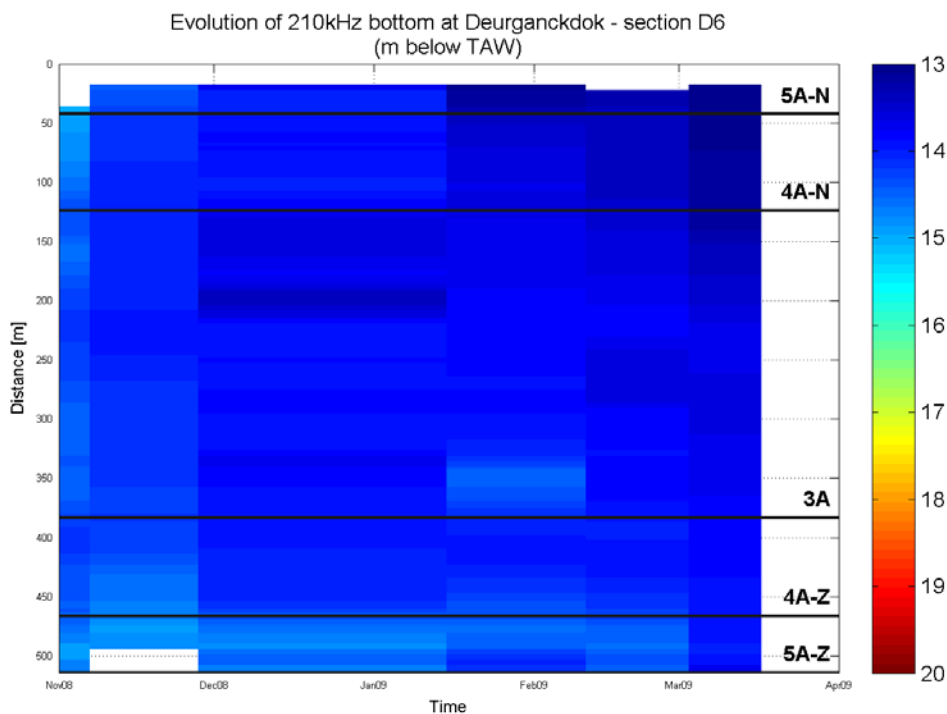
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom

Equipment(s):
 210kHz depth sounder

Location:
 DGD



Data Processed by: 
 In association with: 

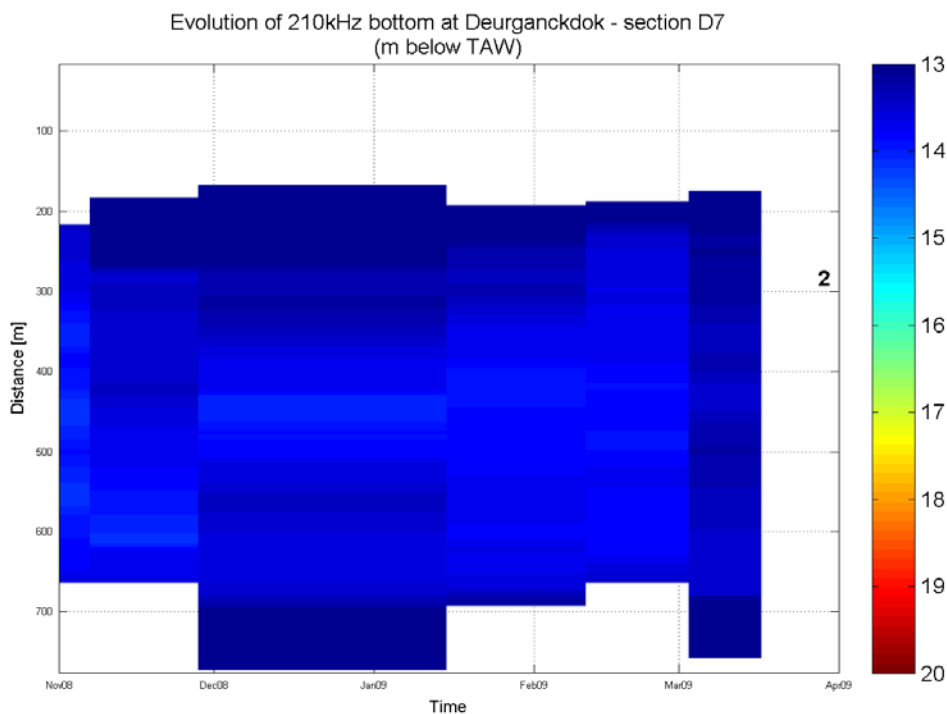
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom

Equipment(s):
 210kHz depth sounder

Location:
 DGD



Data Processed by:



In association with:



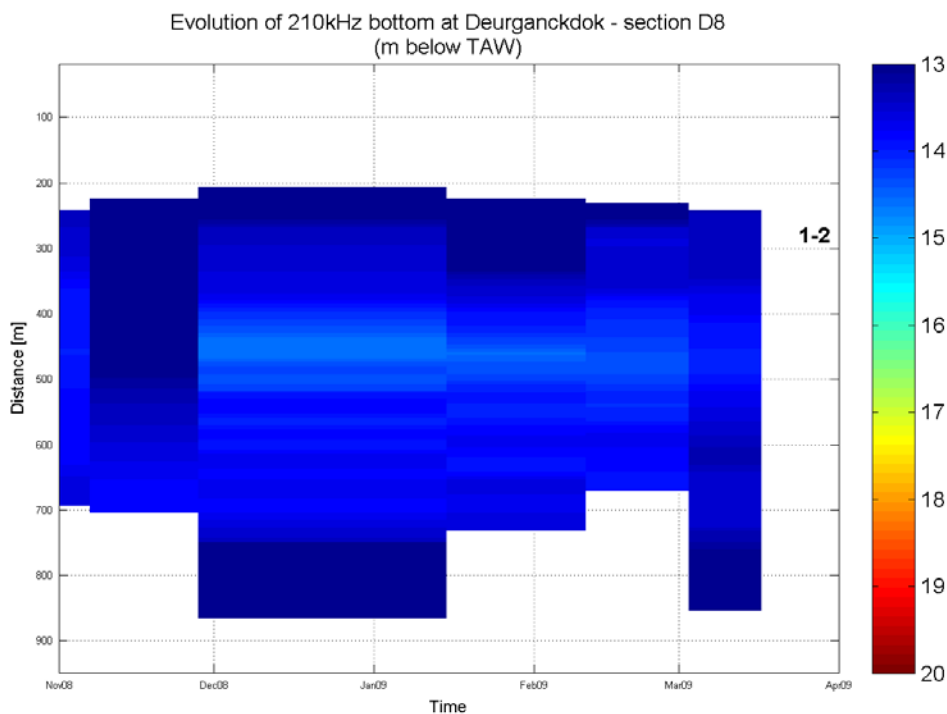
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom

Equipment(s):
 210kHz depth sounder

Location:
 DGD



Data Processed by:



In association with:



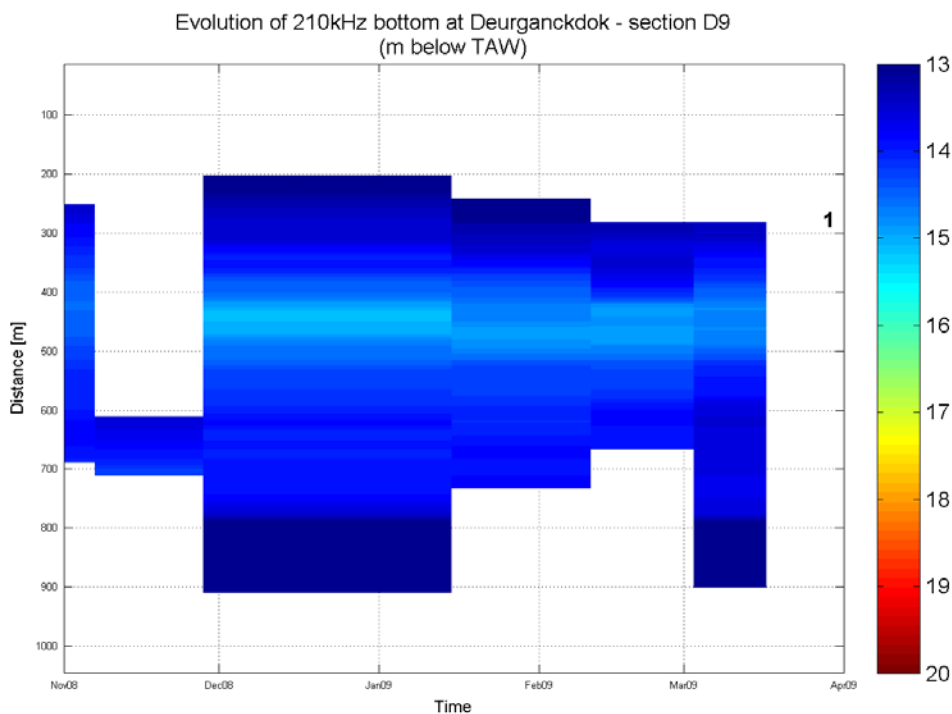
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom

Equipment(s):
 210kHz depth sounder

Location:
 DGD



Data Processed by:



In association with:



I/RA/11283/08.079/MSA

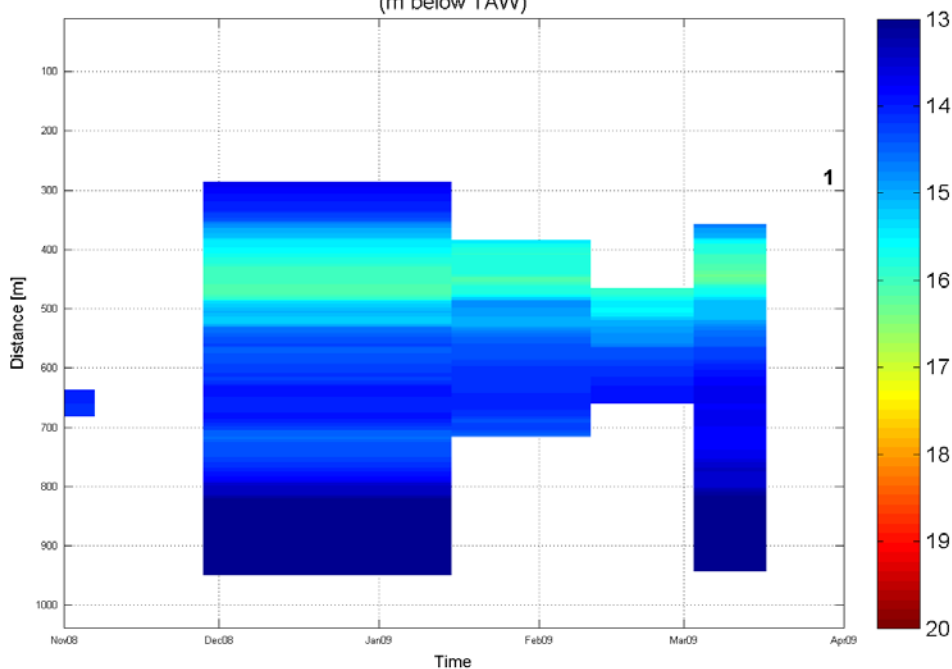
Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom

Equipment(s):
 210kHz depth sounder

Location:
 DGD

Evolution of 210kHz bottom at Deurganckdok - section D10
 (m below TAW)



Data Processed by:



In association with:



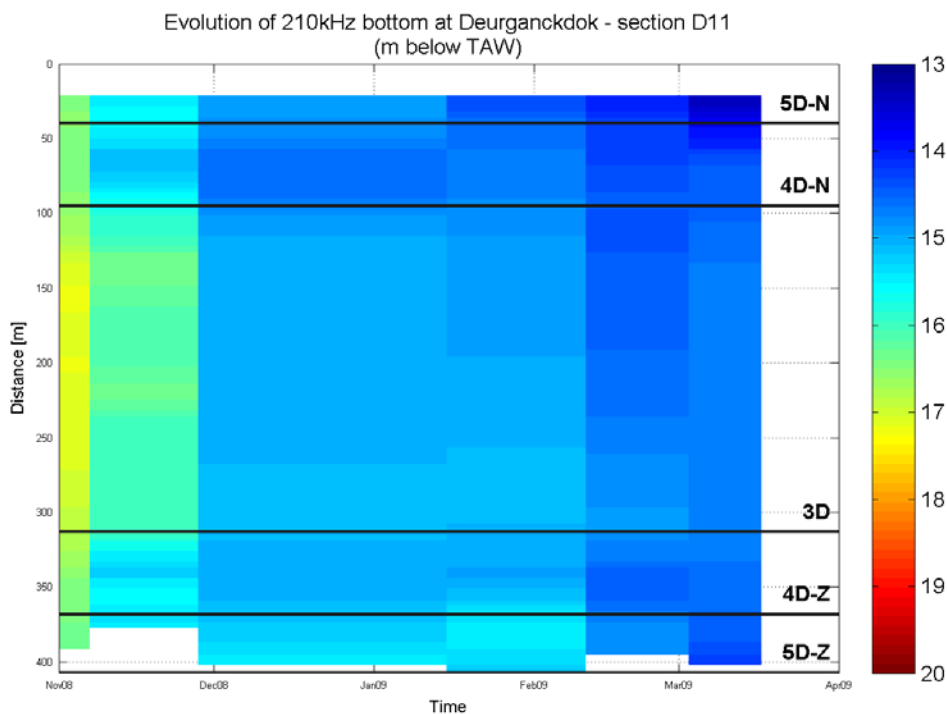
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom

Equipment(s):
 210kHz depth sounder

Location:
 DGD



Data Processed by:



In association with:



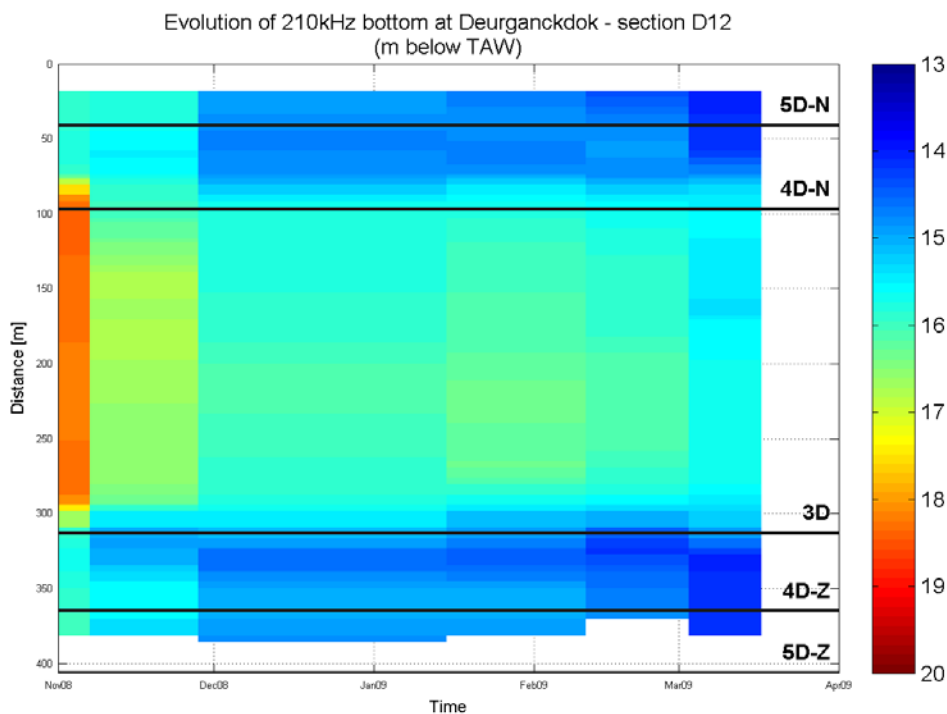
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom

Equipment(s):
 210kHz depth sounder

Location:
 DGD



Data Processed by:



In association with:



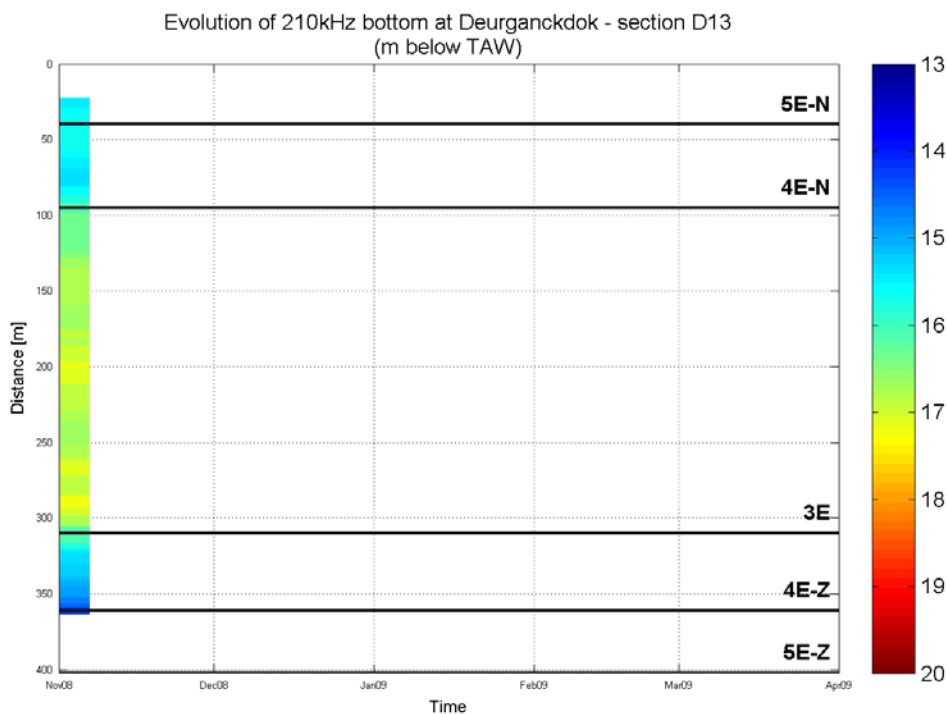
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom

Equipment(s):
 210kHz depth sounder

Location:
 DGD



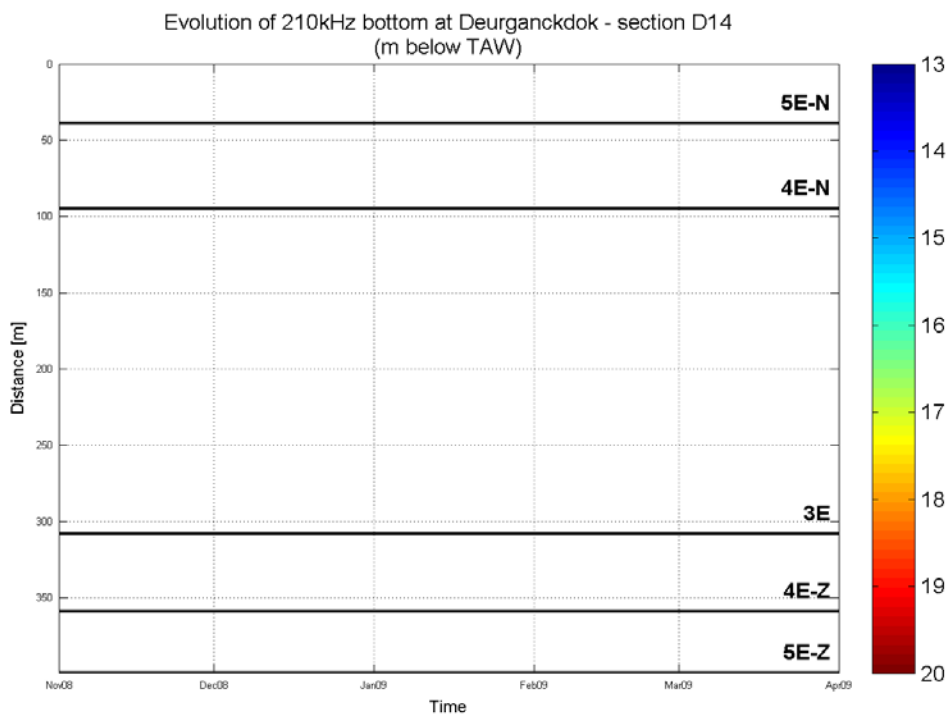
Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom

Equipment(s):
 210kHz depth sounder

Location:
 DGD



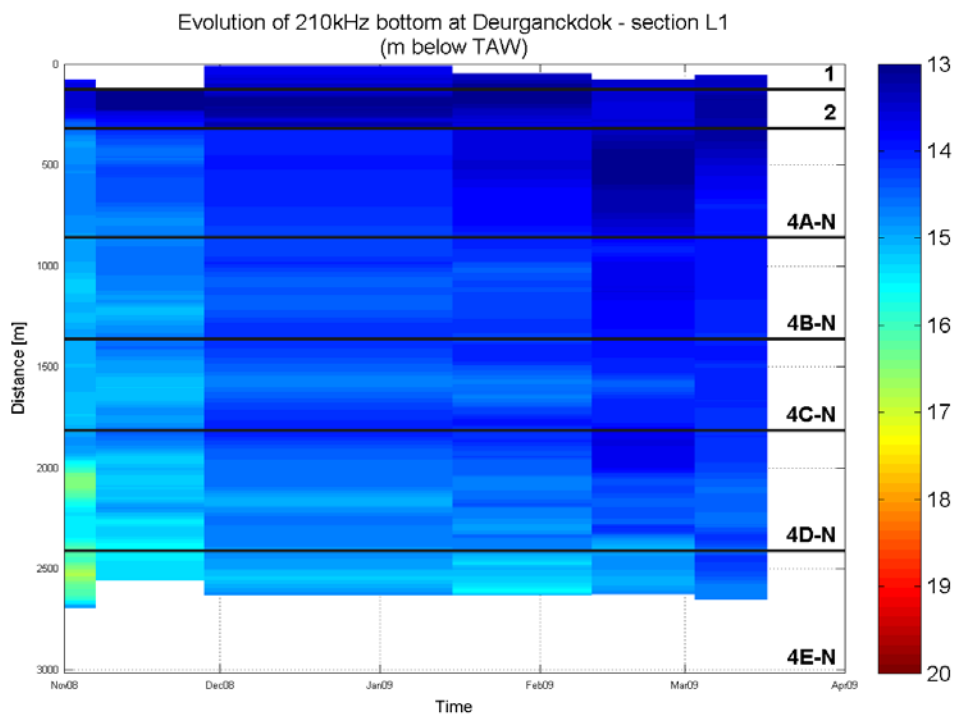
Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom

Equipment(s):
 210kHz depth sounder

Location:
 DGD



Data Processed by: 
 In association with: 

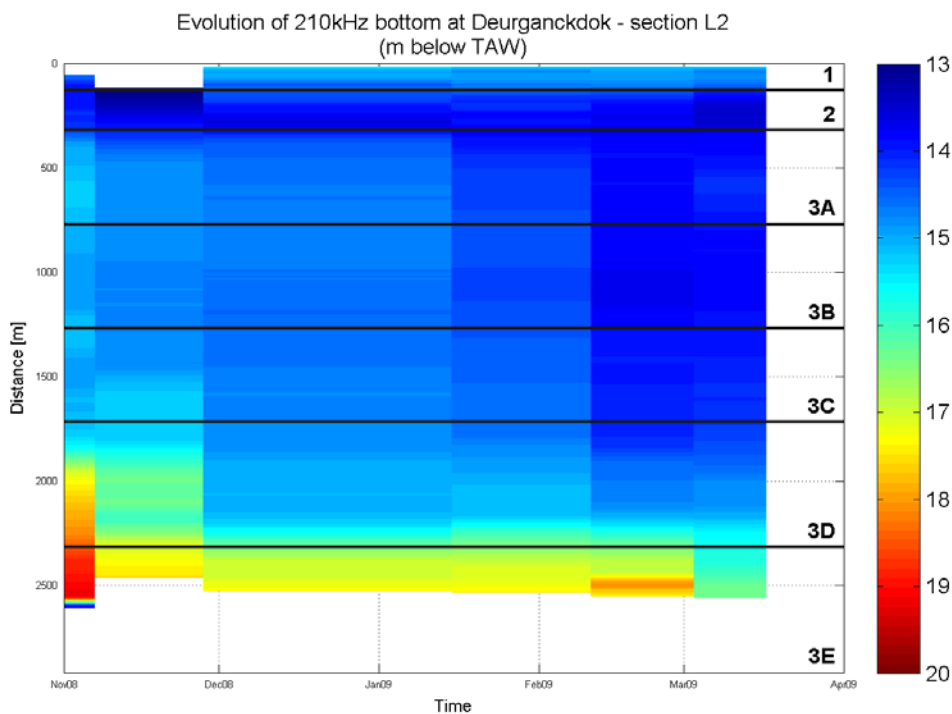
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom

Equipment(s):
 210kHz depth sounder

Location:
 DGD



Data Processed by: 
 In association with: 

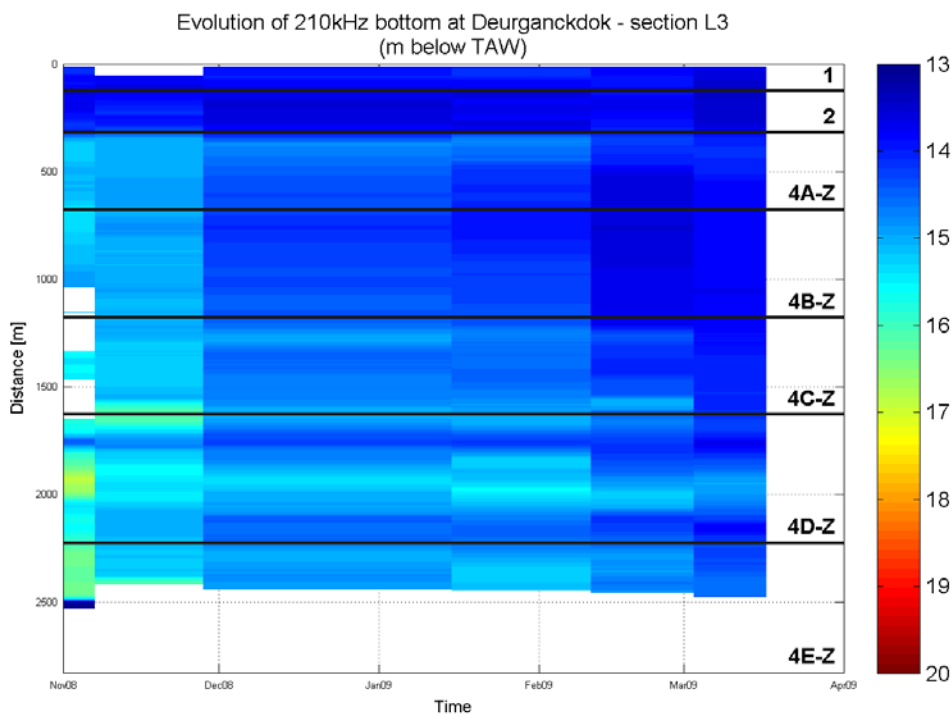
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom

Equipment(s):
 210kHz depth sounder

Location:
 DGD



Data Processed by:



In association with:



I/RA/11283/08.079/MSA

APPENDIX C.

**VOLUMETRIC SILTATION RATES IN DIFFERENT
ZONES AND SECTIONS**

C.1 Siltation rates (tabular)*1/ Per zone (cm/day)*

| | 15-Jan-09 | 11-Feb-09 | 3-Mar-09 |
|------------|------------------|------------------|-----------------|
| 1 | - | - | 0.00 |
| 2 | -1.85 | -0.47 | 4.31 |
| 3a | 0.66 | 1.44 | -0.86 |
| 3b | 0.52 | 1.88 | -0.33 |
| 3c | 0.31 | 1.91 | -0.24 |
| 3d | 0.00 | 1.22 | -0.14 |
| 3e | - | - | - |
| 4Na | 0.74 | 1.70 | -1.78 |
| 4Nb | 0.31 | 1.68 | -0.98 |
| 4Nc | 0.22 | 1.23 | -0.08 |
| 4Nd | 0.09 | 1.47 | -0.20 |
| 4Ne | - | - | - |
| 4Za | 0.42 | 1.42 | 0.04 |
| 4Zb | 0.32 | 1.93 | -0.69 |
| 4Zc | 0.04 | 1.50 | 1.39 |
| 4Zd | -0.18 | 1.01 | 0.88 |
| 4Ze | - | - | - |
| 5Na | 1.05 | 1.76 | - |
| 5Nb | - | 1.05 | - |
| 5Nc | 0.62 | 1.73 | - |
| 5Nd | 0.65 | 1.74 | 2.17 |
| 5Ne | - | - | - |
| 5Za | 0.67 | 1.45 | 3.64 |
| 5Zb | 1.34 | 1.79 | 0.76 |
| 5Zc | 0.27 | 2.07 | 3.65 |
| 5Zd | -0.20 | 1.05 | 2.85 |
| 5Ze | - | - | - |

2/ Per section (cm/day)

| | 15-Jan-09 | 11-Feb-09 | 3-Mar-09 |
|------------|------------------|------------------|-----------------|
| D1 | 0.39 | 1.34 | 0.19 |
| D2 | 0.42 | 1.57 | 0.46 |
| D3 | 0.57 | 1.90 | -0.52 |
| D4 | 0.60 | 1.83 | -0.63 |
| D5 | 0.61 | 1.47 | -0.62 |
| D6 | 0.12 | 0.38 | 1.24 |
| D7 | -2.04 | -0.54 | 5.31 |
| D8 | -2.49 | - | 1.65 |
| D9 | - | - | -0.05 |
| D10 | - | - | 0.27 |
| D11 | 0.09 | 1.54 | 0.22 |
| D12 | -0.20 | 0.61 | 1.63 |
| D13 | - | - | - |
| D14 | - | - | - |
| L1 | 0.20 | 1.08 | -0.39 |
| L2 | 0.28 | 1.21 | 0.42 |
| L3 | 0.04 | 1.22 | 0.63 |

C.2 Water-bed interface evolution for all zones

Long-term monitoring siltation Deurganckdok

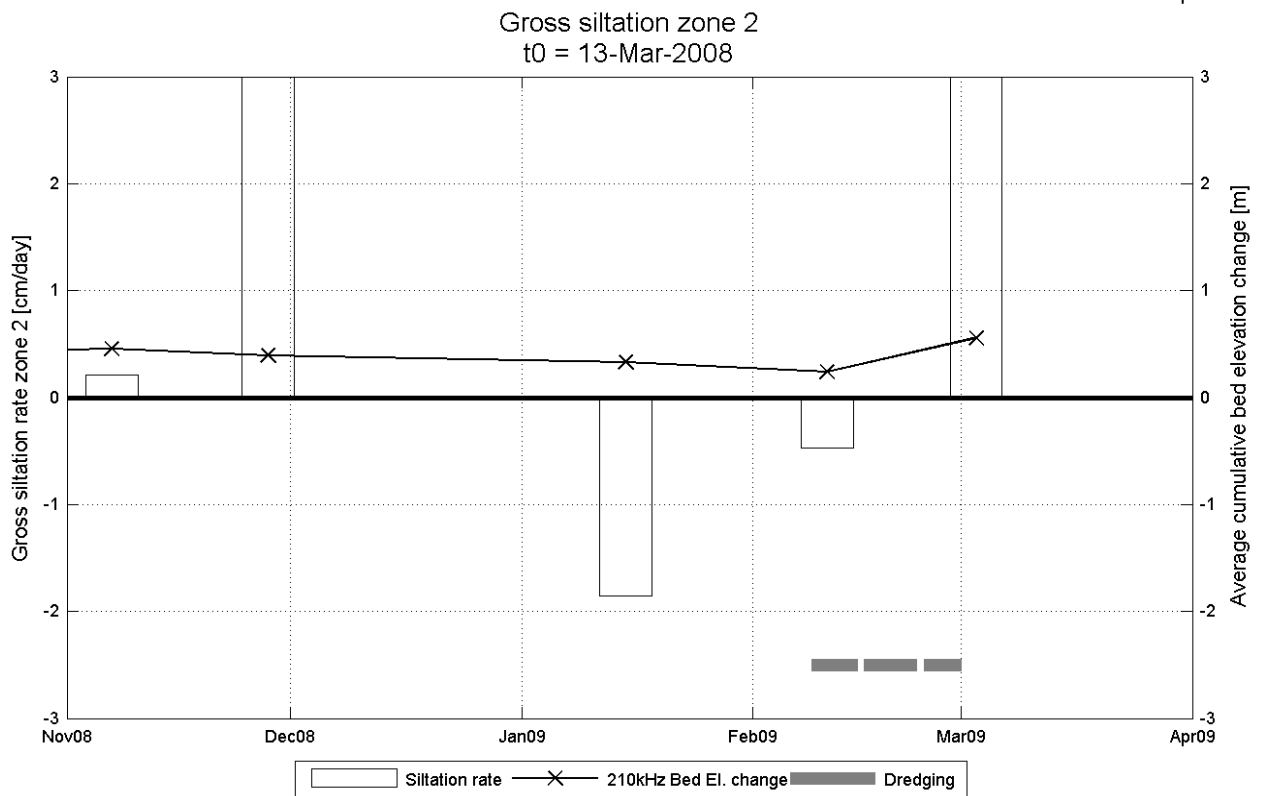
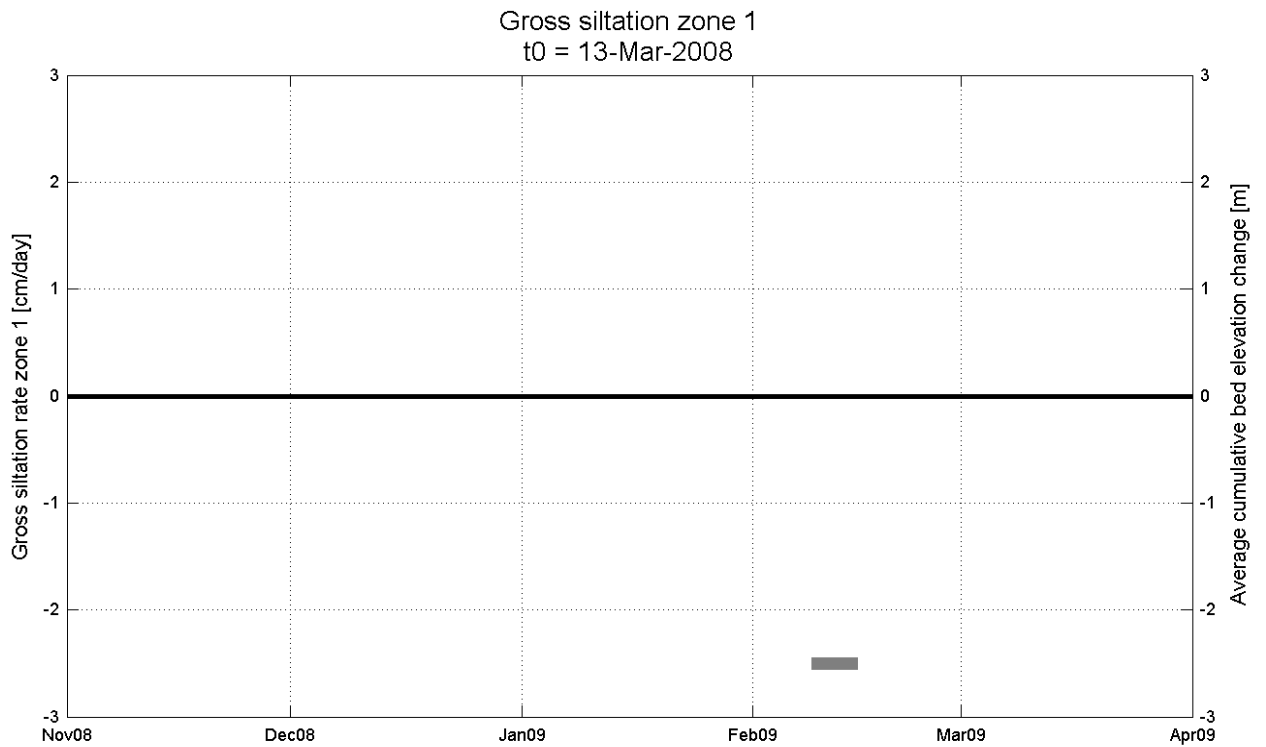
Siltation height / gross siltation rate

Equipment(s):

210kHz depth sounder

Location:

DGD



Reference level: depth sounding 13-Mar-2008

Data Processed by:



In association with:



I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

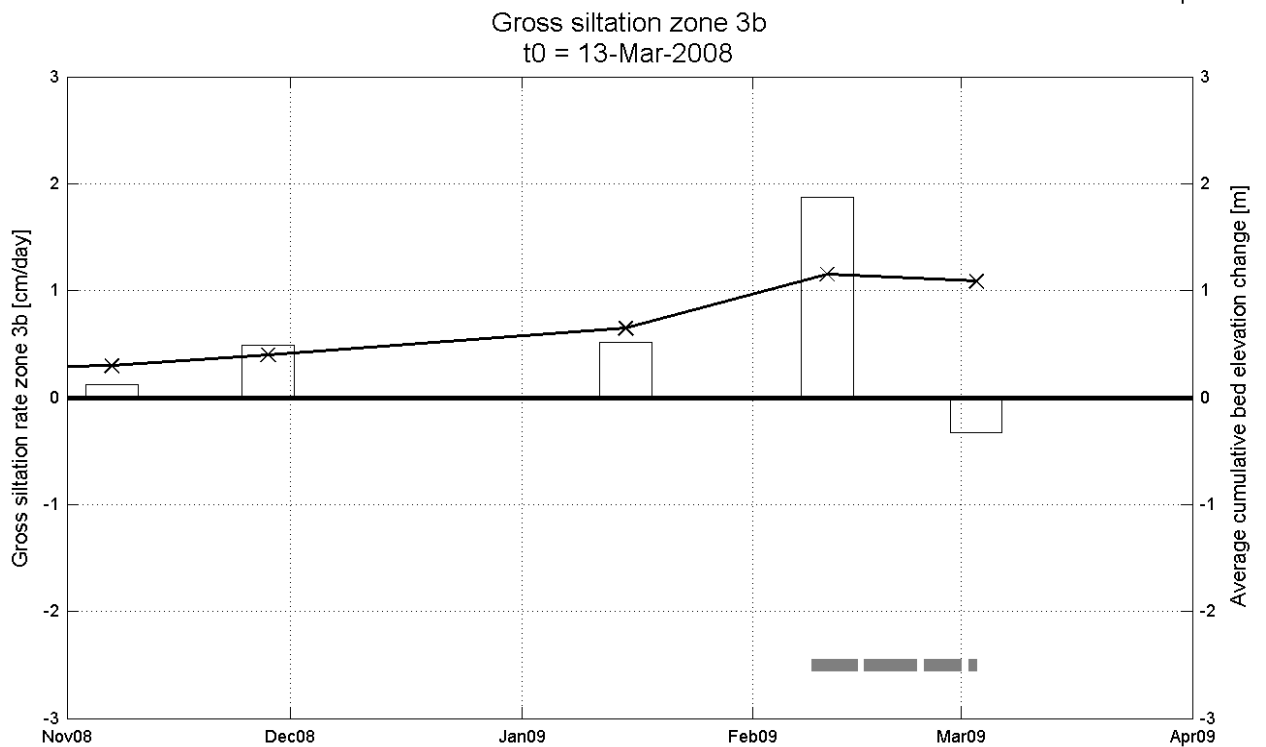
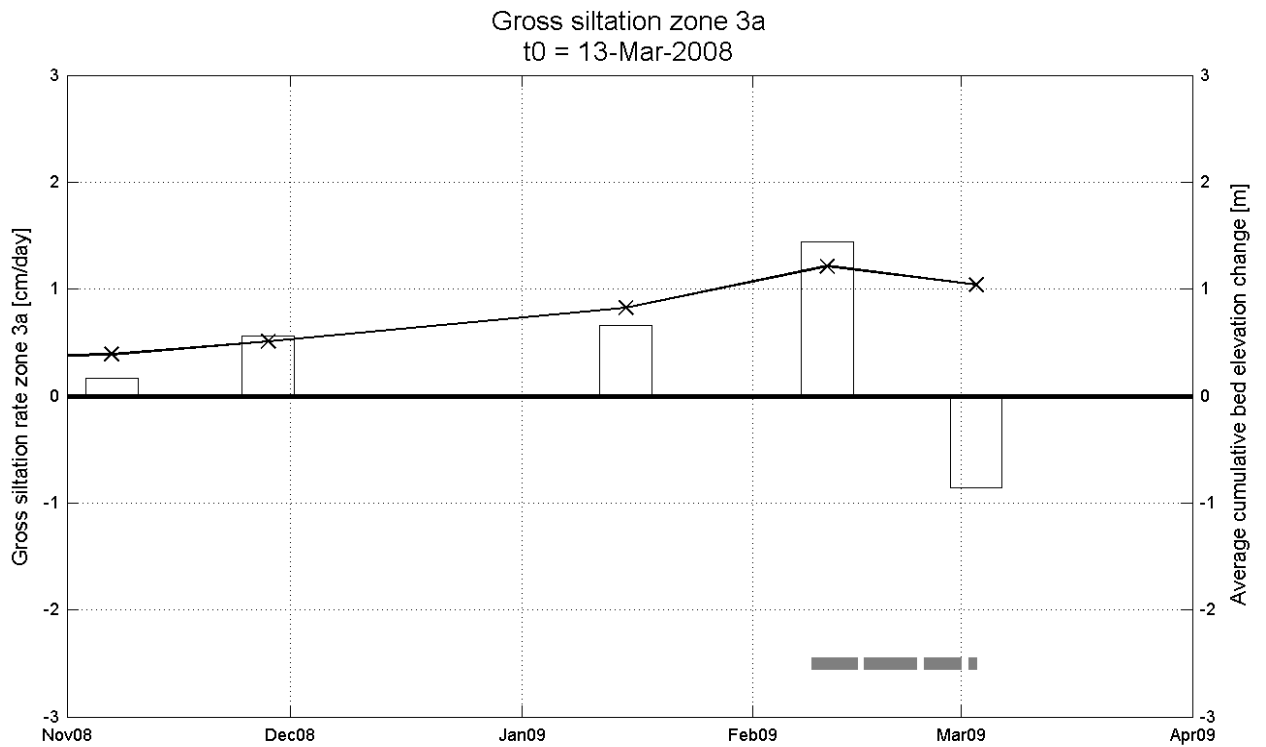
Siltation height / gross siltation rate

Equipment(s):

210kHz depth sounder

Location:

DGD



Siltation rate
 —x— 210kHz Bed El. change
█ Dredging

Reference level: depth sounding 13-Mar-2008

Data Processed by:



In association with:



I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

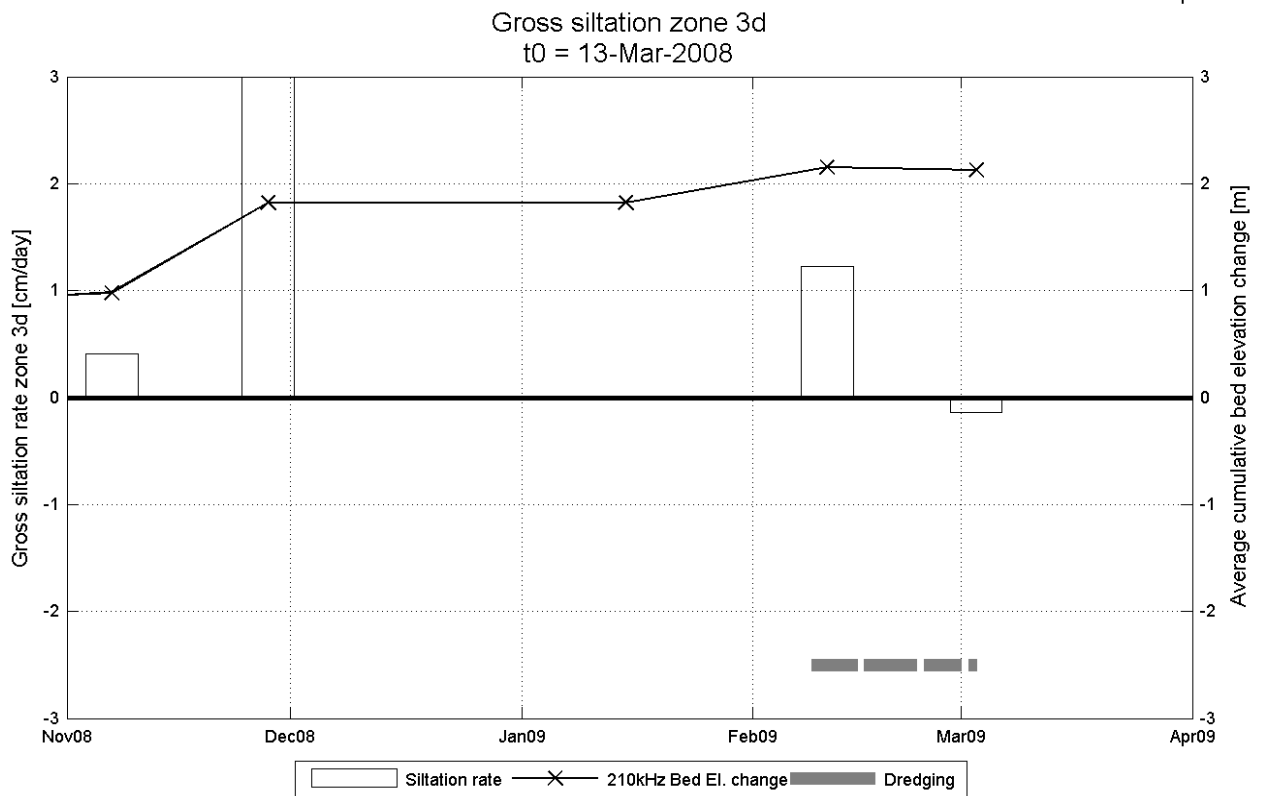
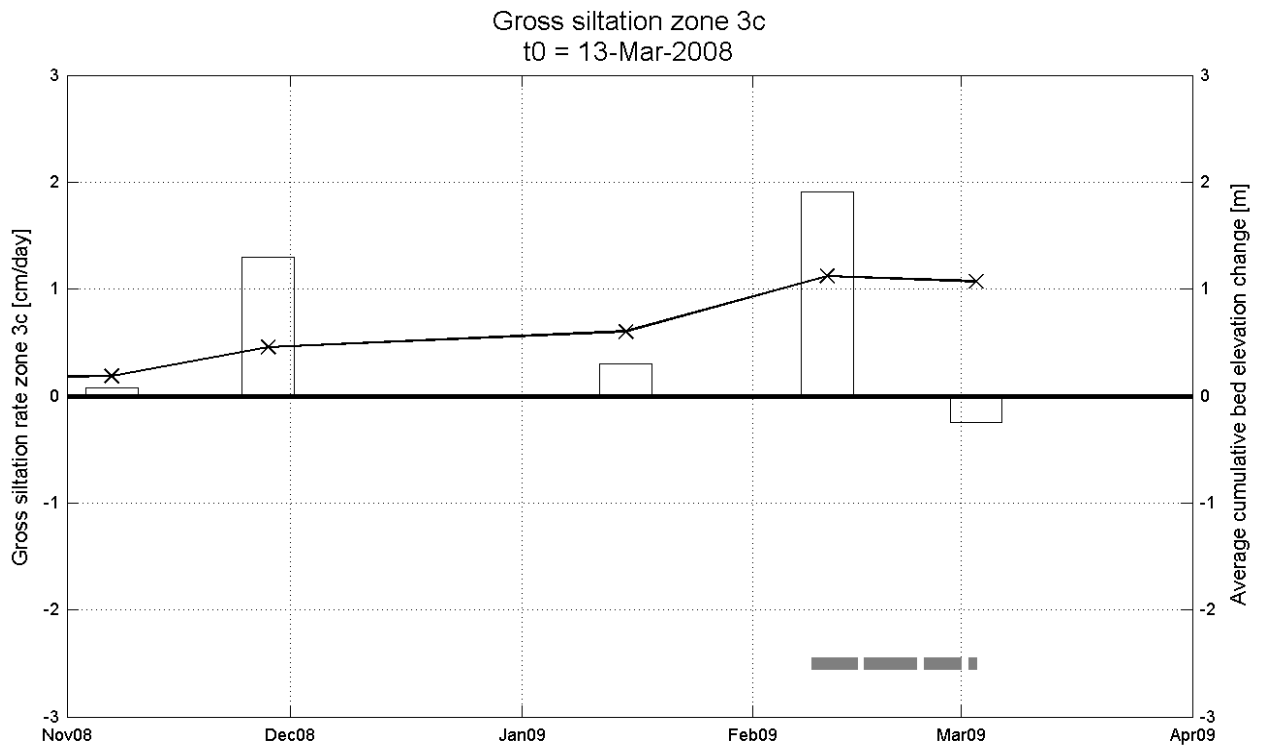
Siltation height / gross siltation rate

Equipment(s):

210kHz depth sounder

Location:

DGD



Reference level: depth sounding 13-Mar-2008

Data Processed by:



In association with:



I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

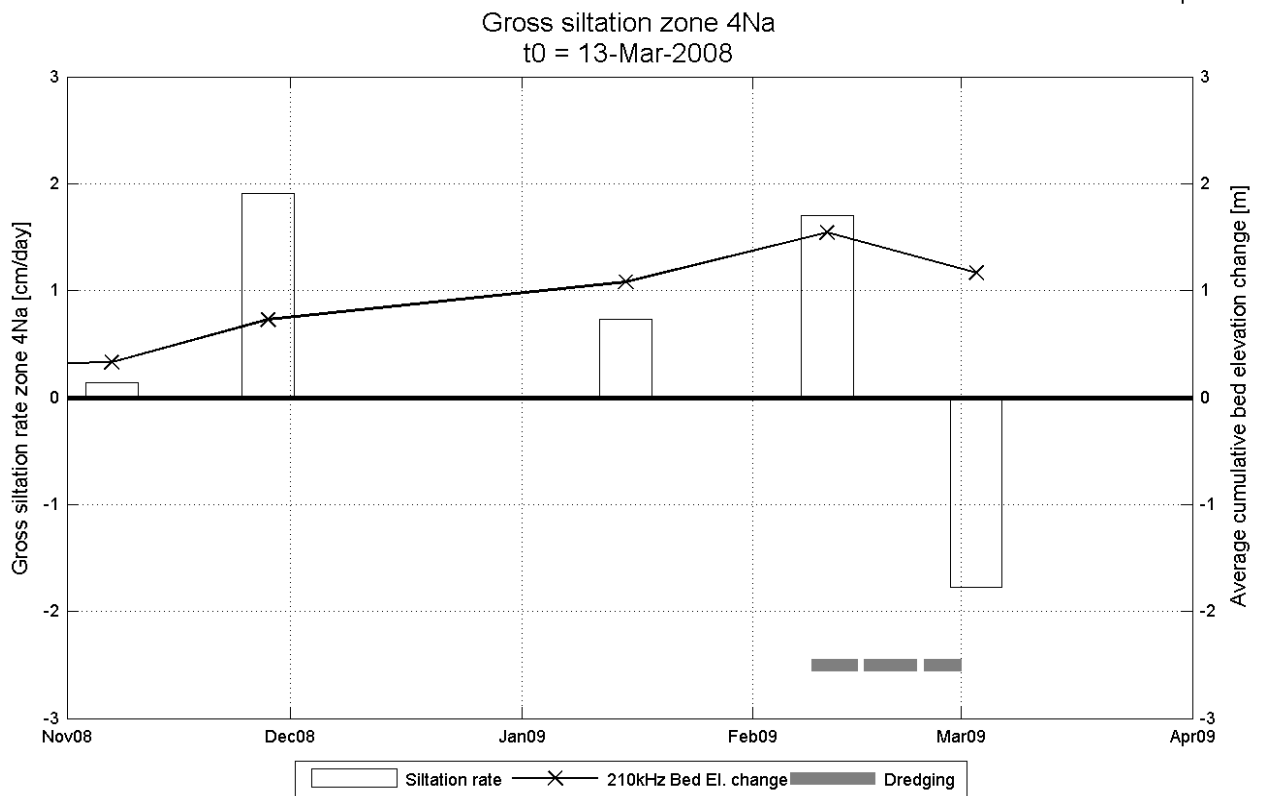
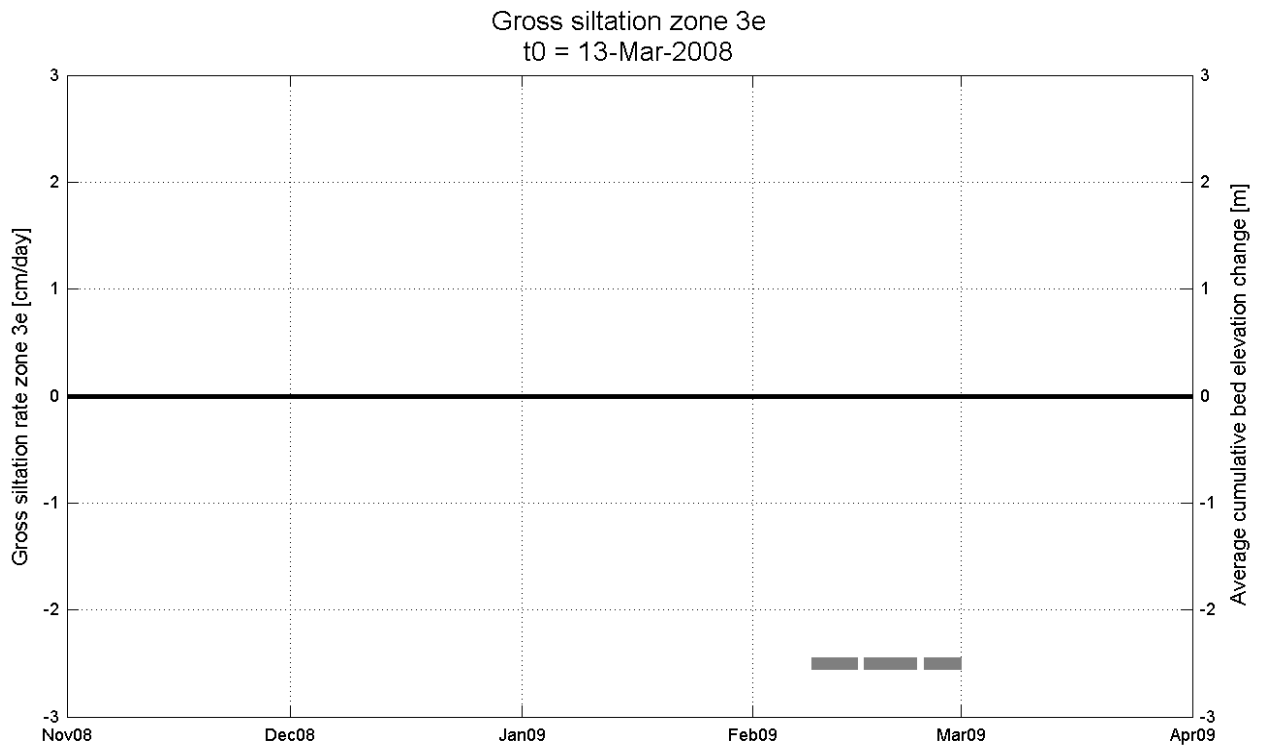
Siltation height / gross siltation rate

Equipment(s):

210kHz depth sounder

Location:

DGD



Reference level: depth sounding 13-Mar-2008

Data Processed by:



In association with:



I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

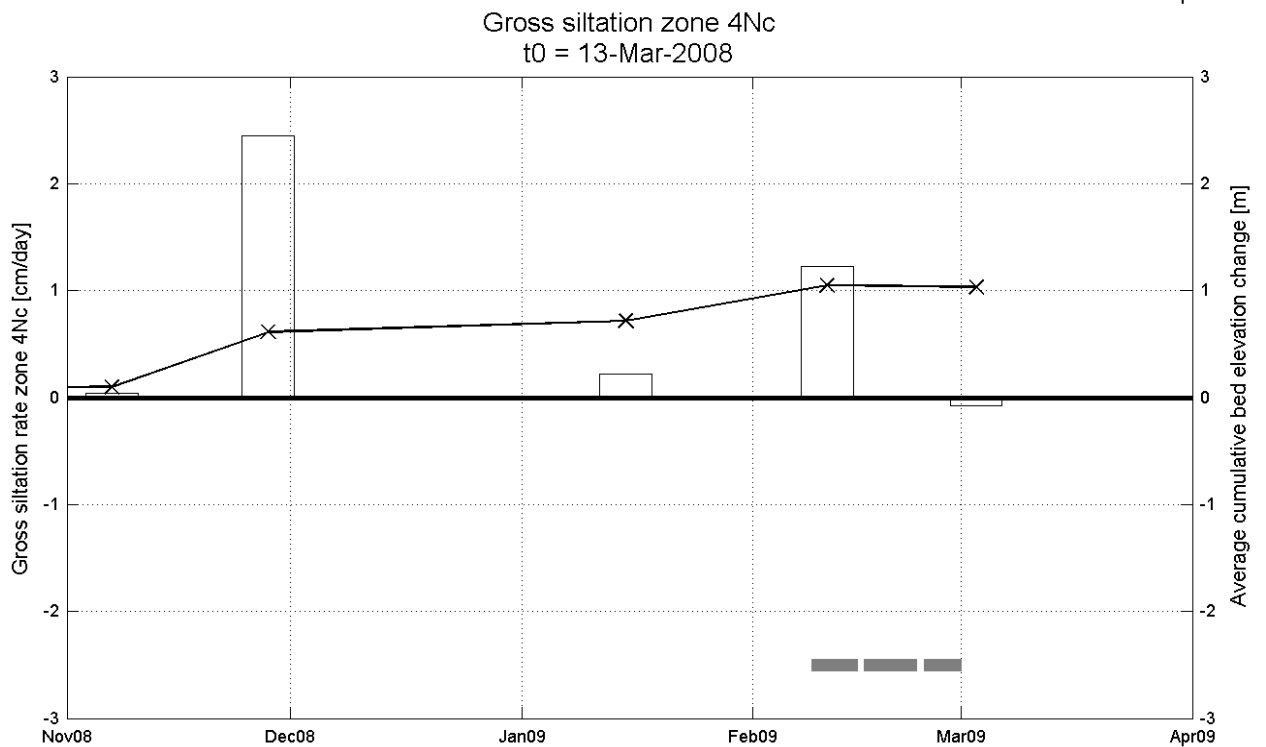
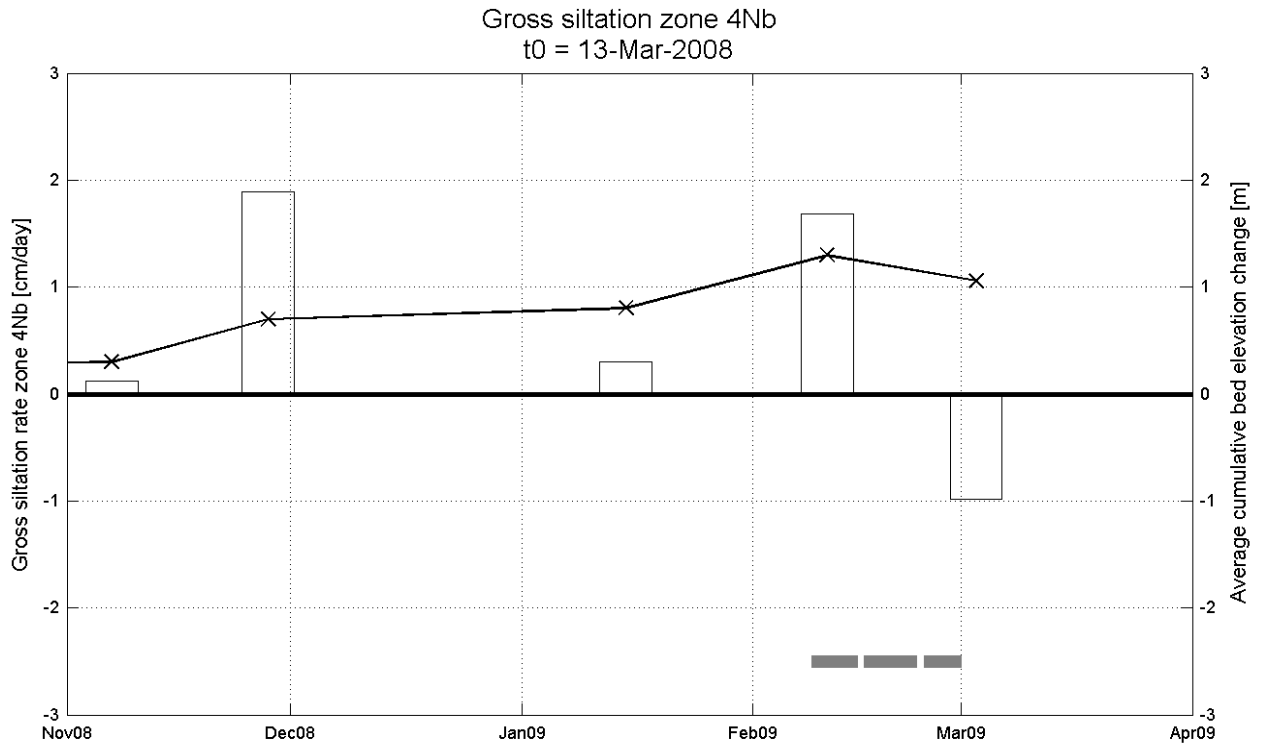
Siltation height / gross siltation rate

Equipment(s):

210kHz depth sounder

Location:

DGD



Siltation rate
 —x— 210kHz Bed El. change
■ Dredging

Reference level: depth sounding 13-Mar-2008

Data Processed by:



In association with:



I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

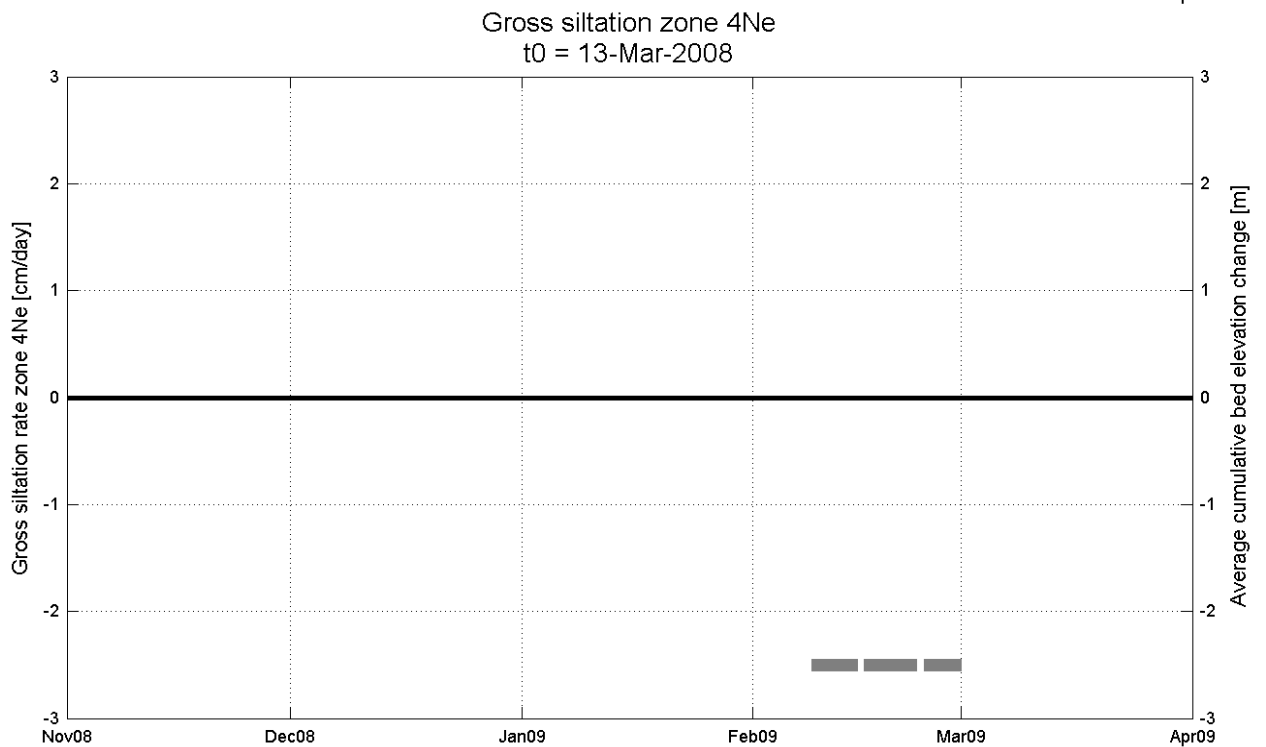
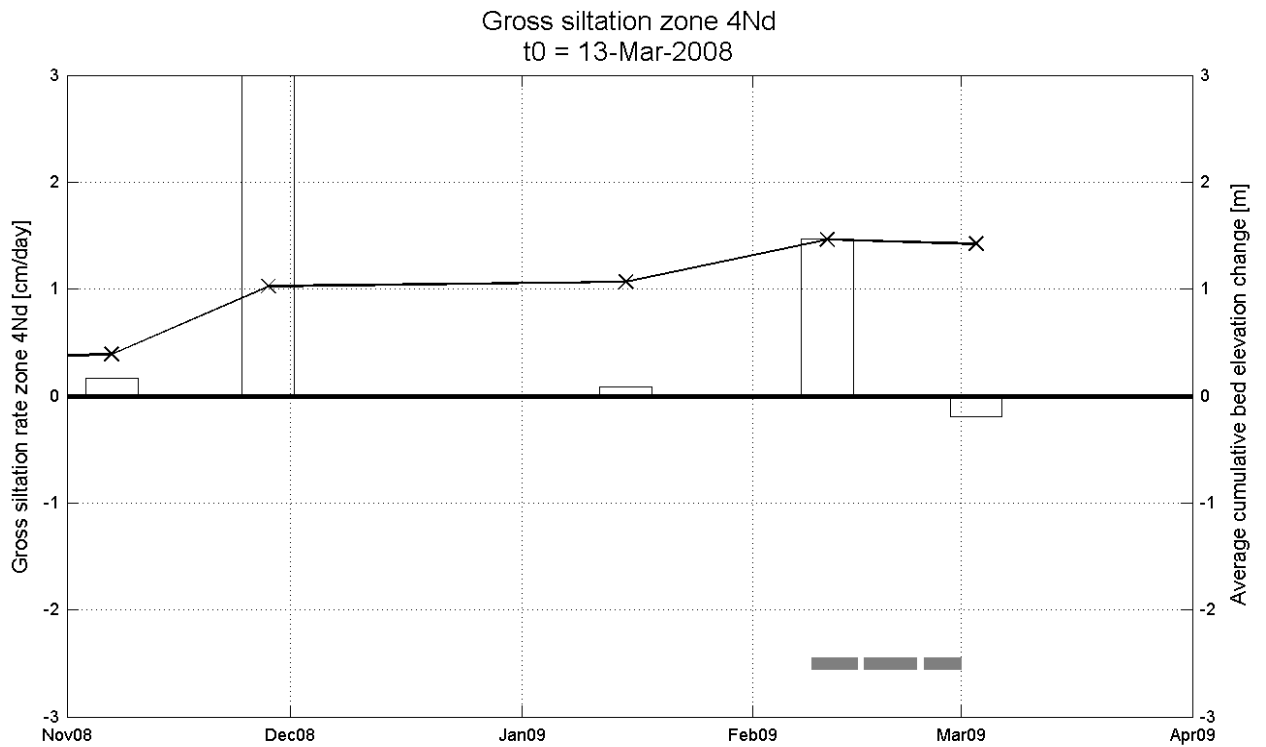
Siltation height / gross siltation rate

Equipment(s):

210kHz depth sounder

Location:

DGD



Siltation rate
 —x— 210kHz Bed El. change
■ Dredging

Reference level: depth sounding 13-Mar-2008

Data Processed by:



In association with:



I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

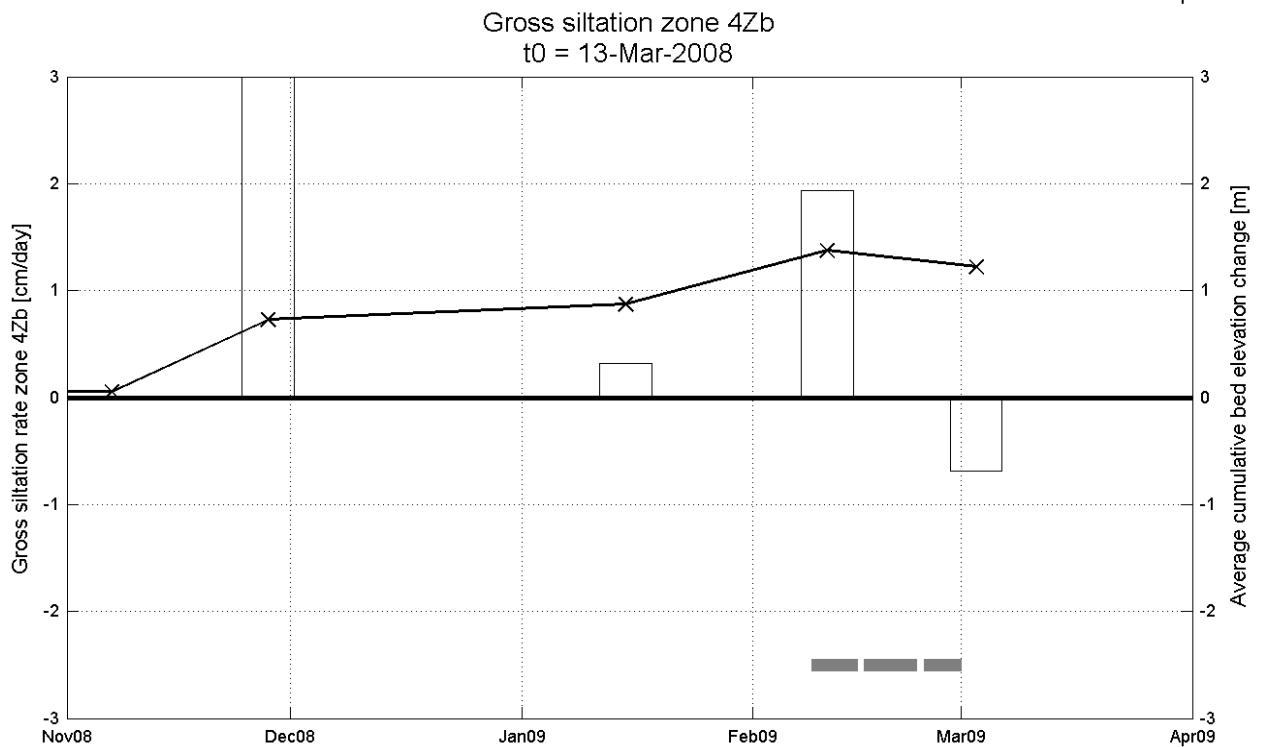
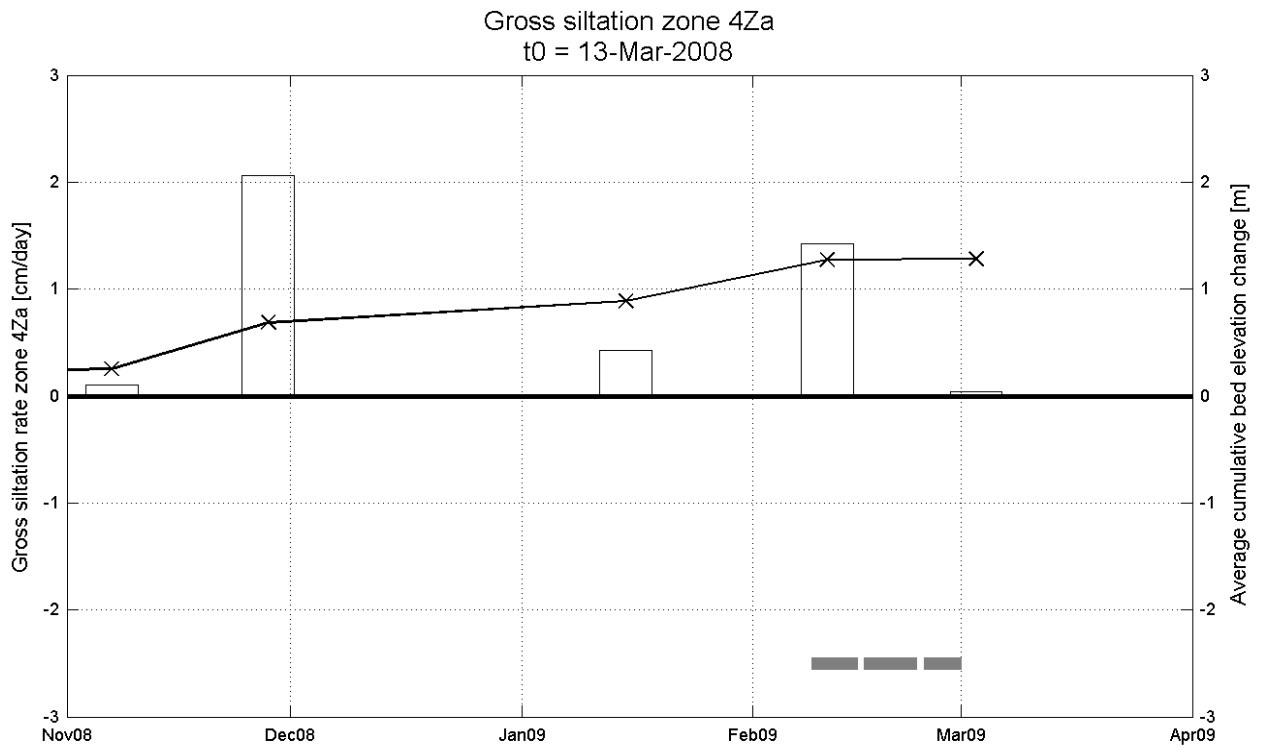
Siltation height / gross siltation rate

Equipment(s):

210kHz depth sounder

Location:

DGD



Siltation rate
 —x— 210kHz Bed El. change
■ Dredging

Reference level: depth sounding 13-Mar-2008

Data Processed by:



In association with:



I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

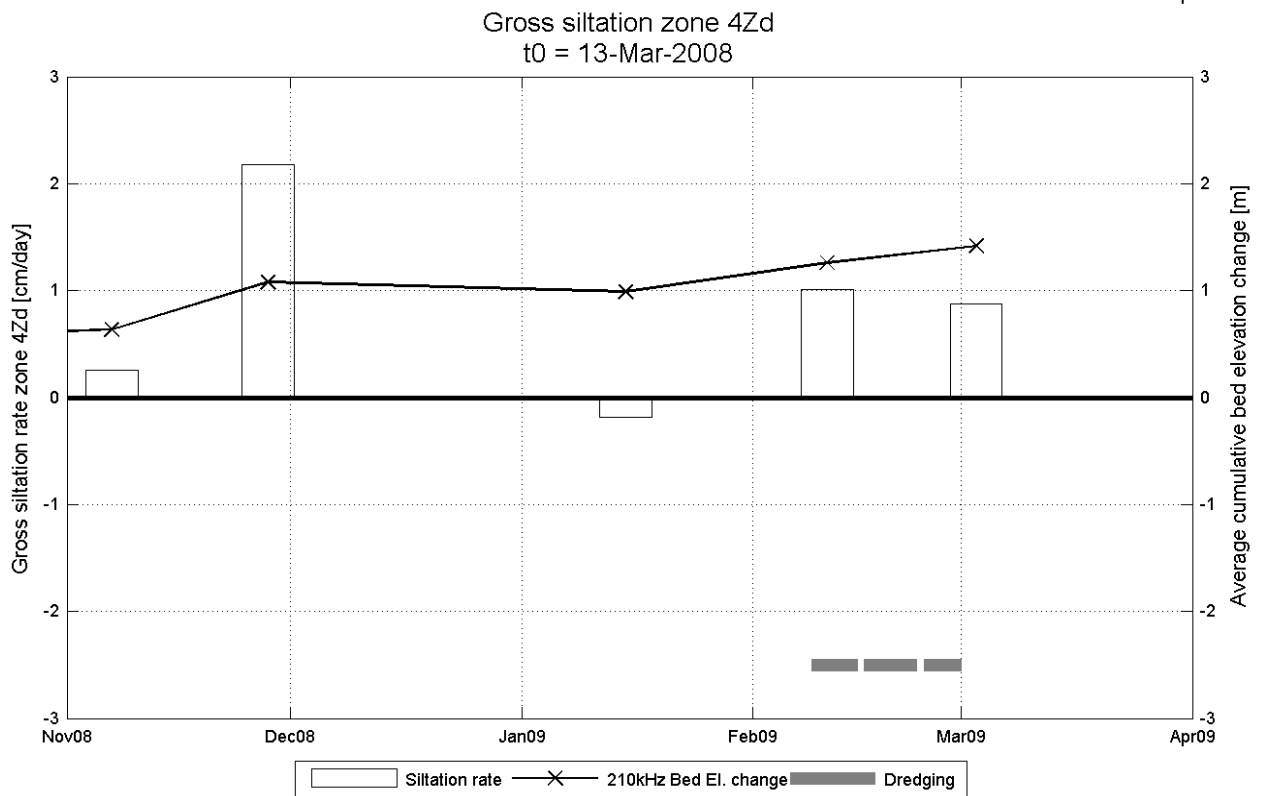
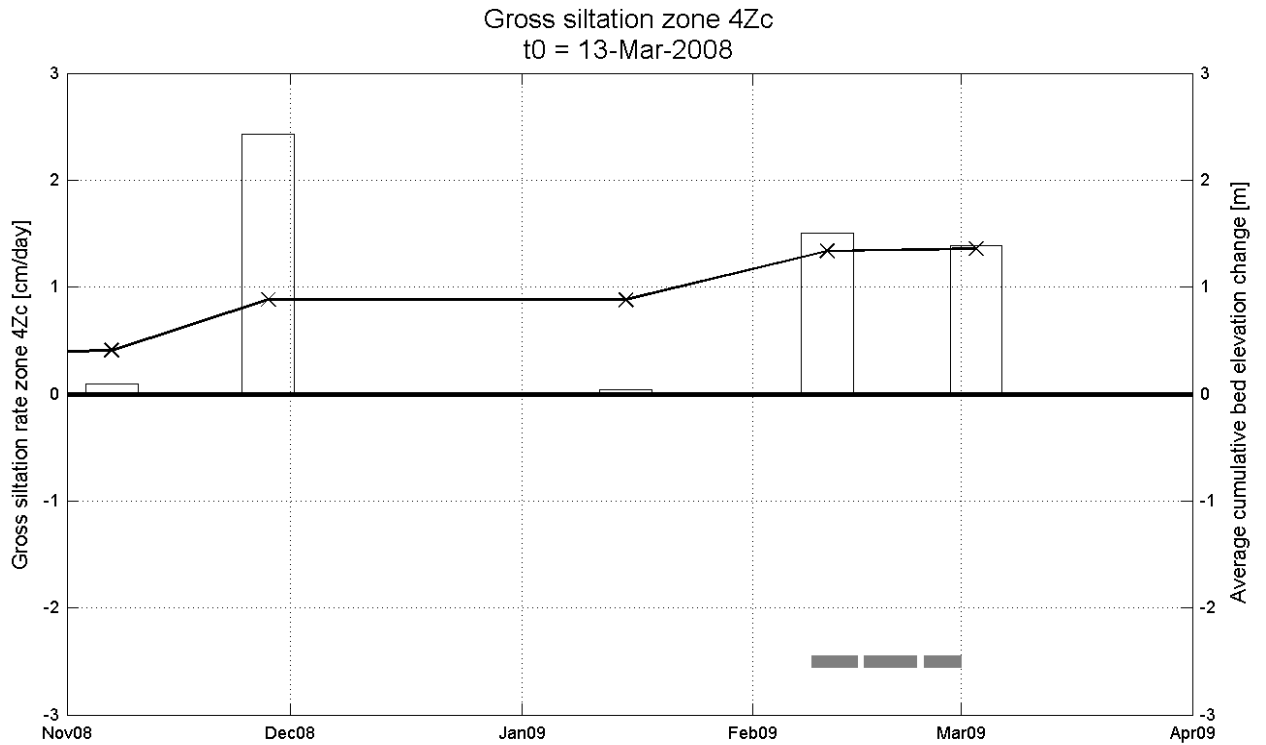
Siltation height / gross siltation rate

Equipment(s):

210kHz depth sounder

Location:

DGD



Reference level: depth sounding 13-Mar-2008

Data Processed by:



In association with:



I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

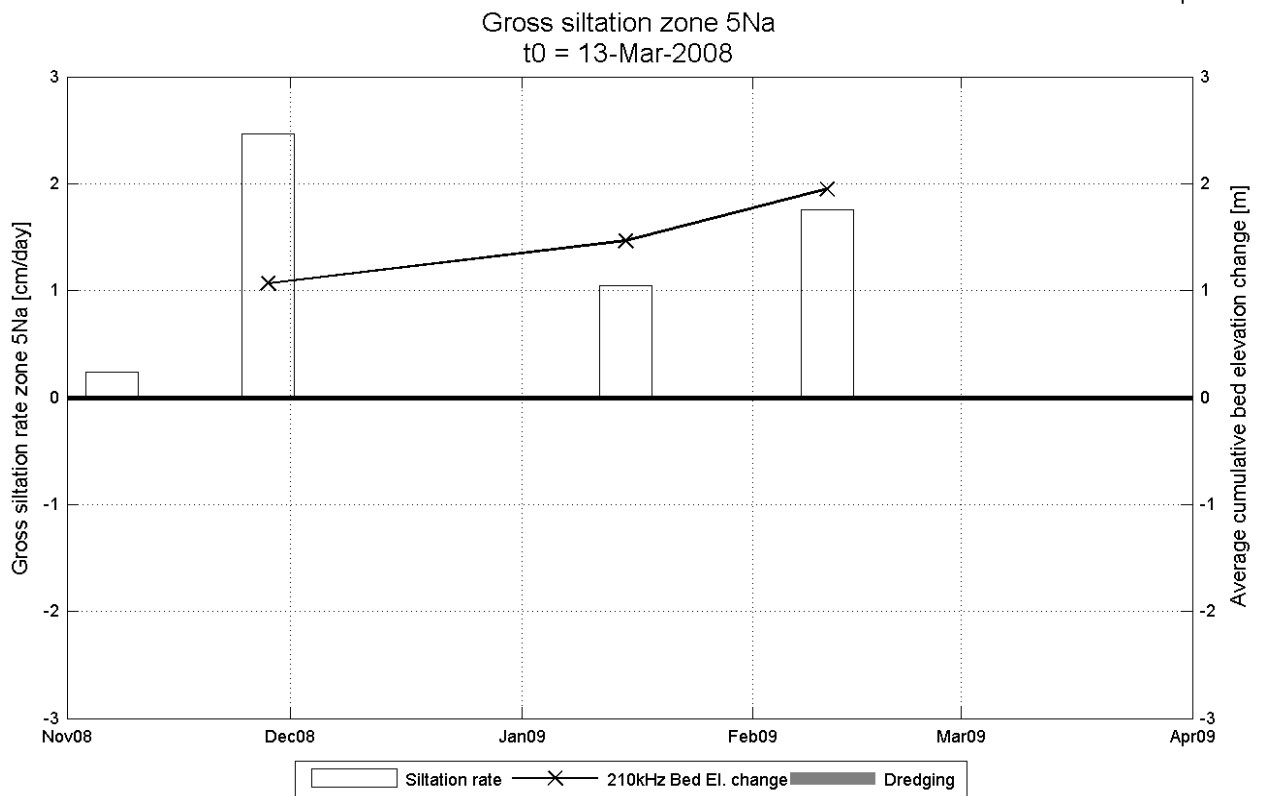
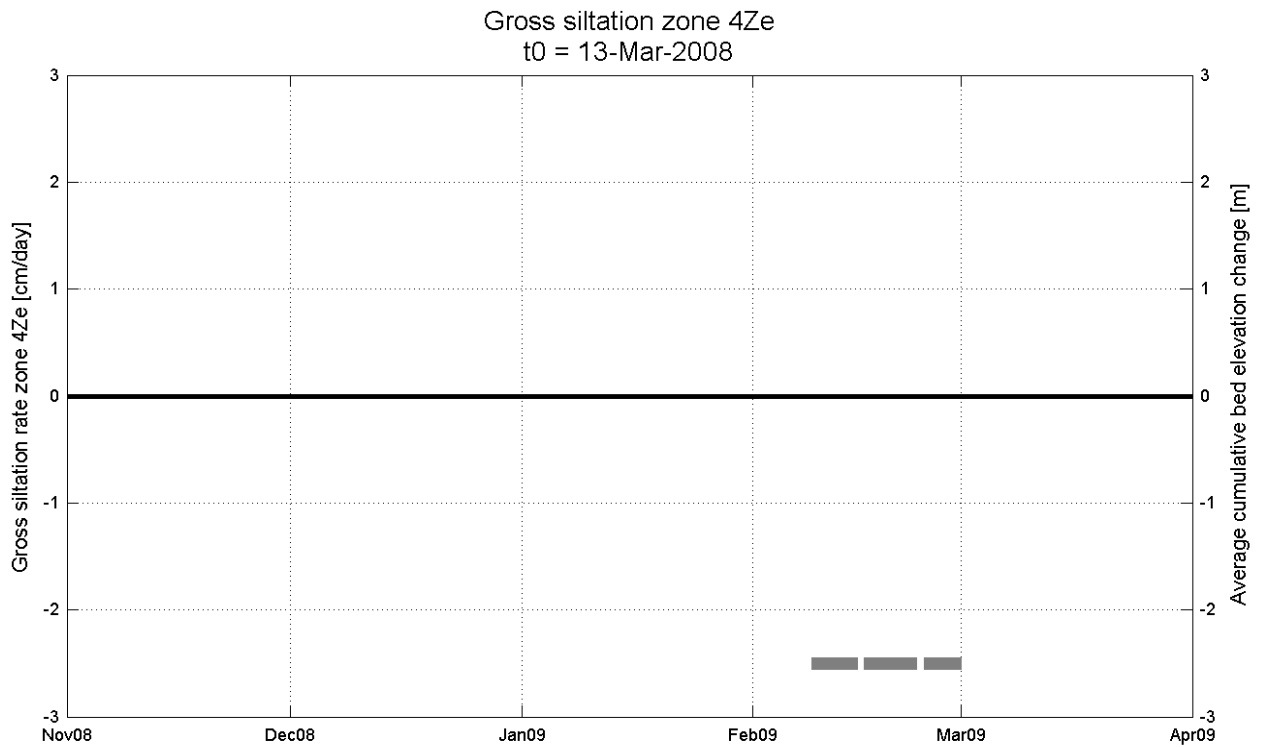
Siltation height / gross siltation rate

Equipment(s):

210kHz depth sounder

Location:

DGD



Reference level: depth sounding 13-Mar-2008

Data Processed by:



In association with:



I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

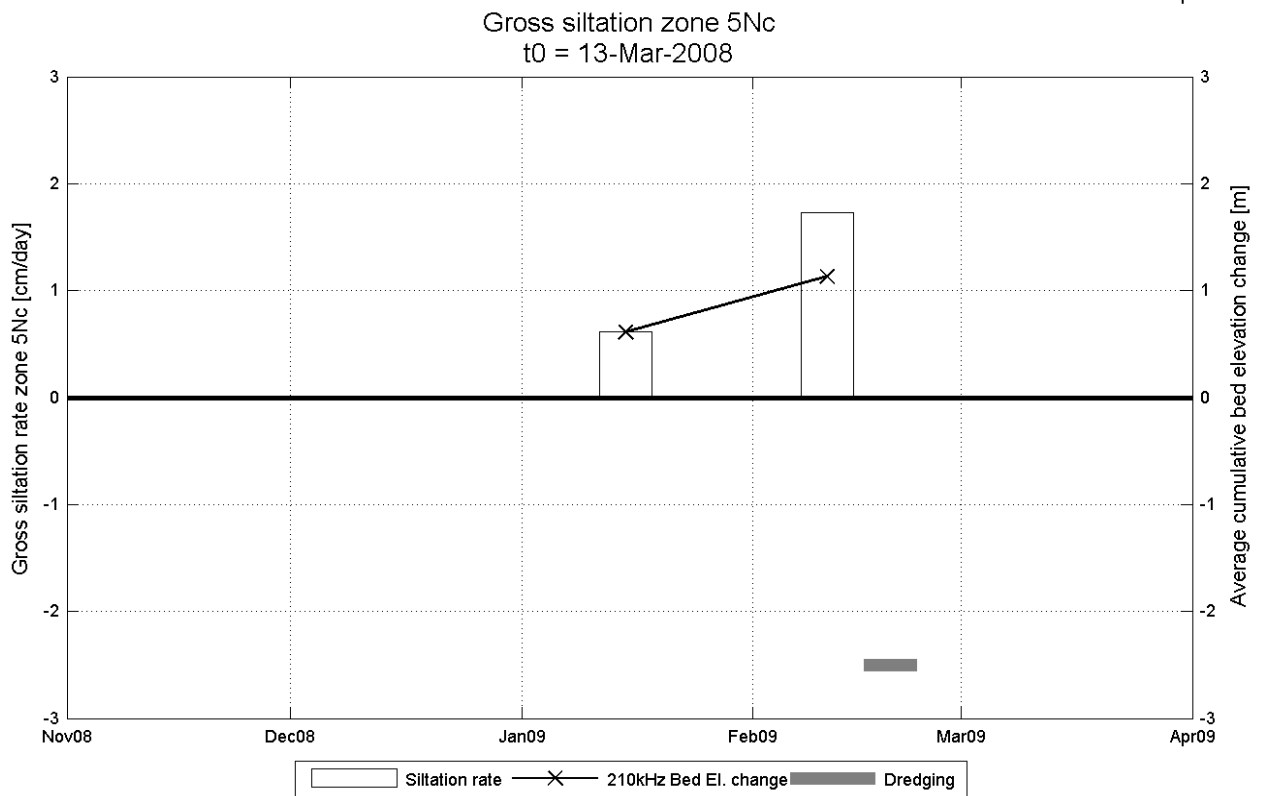
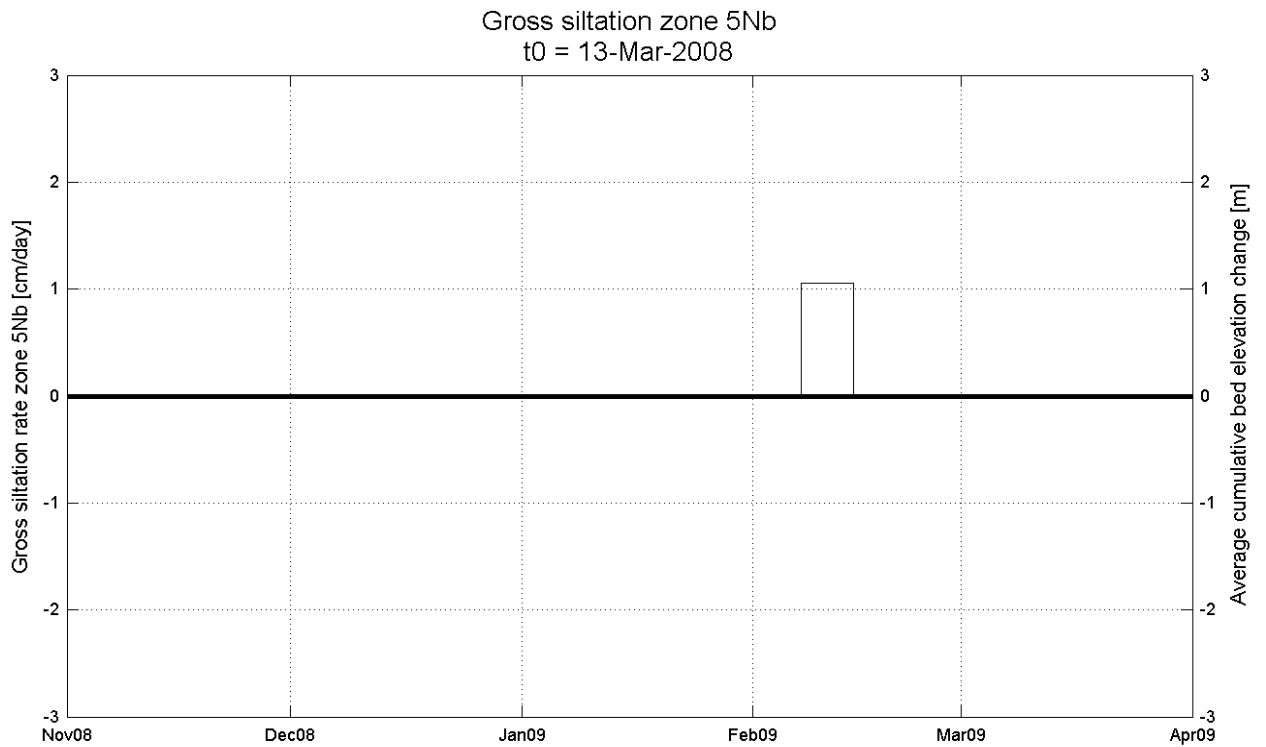
Siltation height / gross siltation rate

Equipment(s):

210kHz depth sounder

Location:

DGD



Reference level: depth sounding 13-Mar-2008

Data Processed by:



In association with:



I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

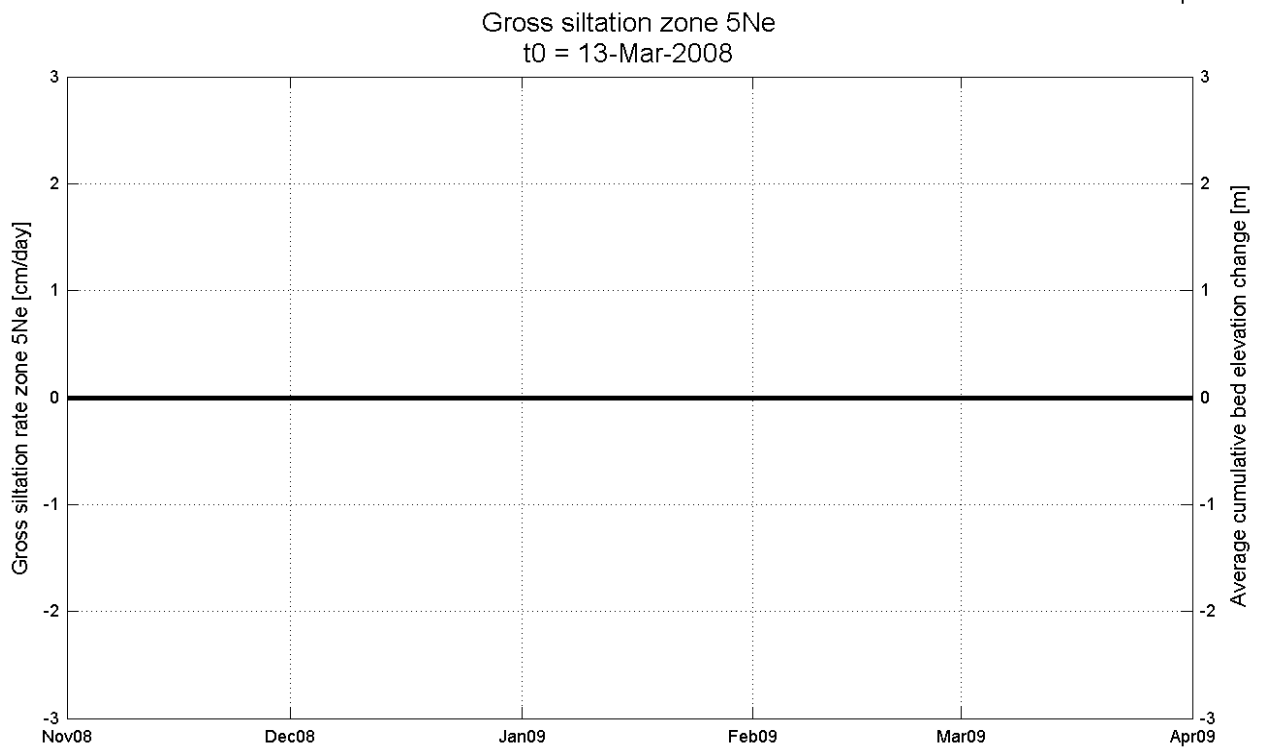
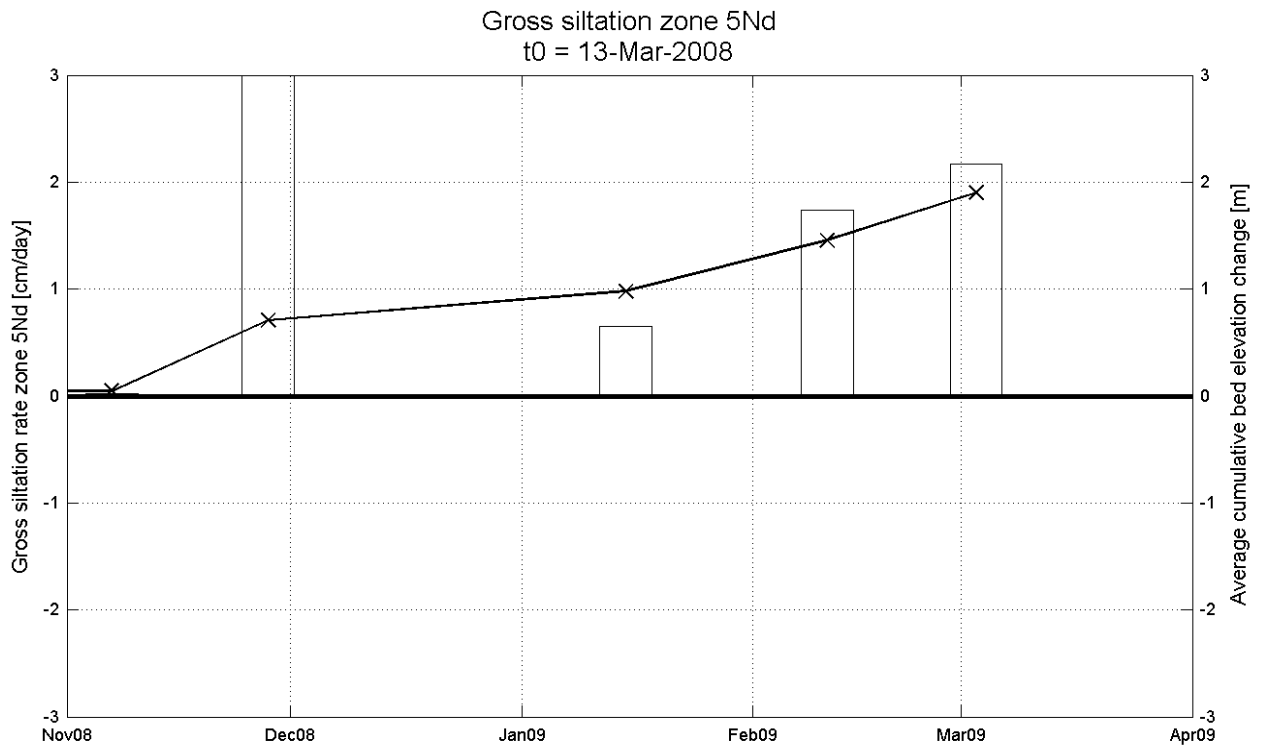
Siltation height / gross siltation rate

Equipment(s):

210kHz depth sounder

Location:

DGD



Siltation rate
 —x— 210kHz Bed El. change
█ Dredging

Reference level: depth sounding 13-Mar-2008

Data Processed by:



In association with:



I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

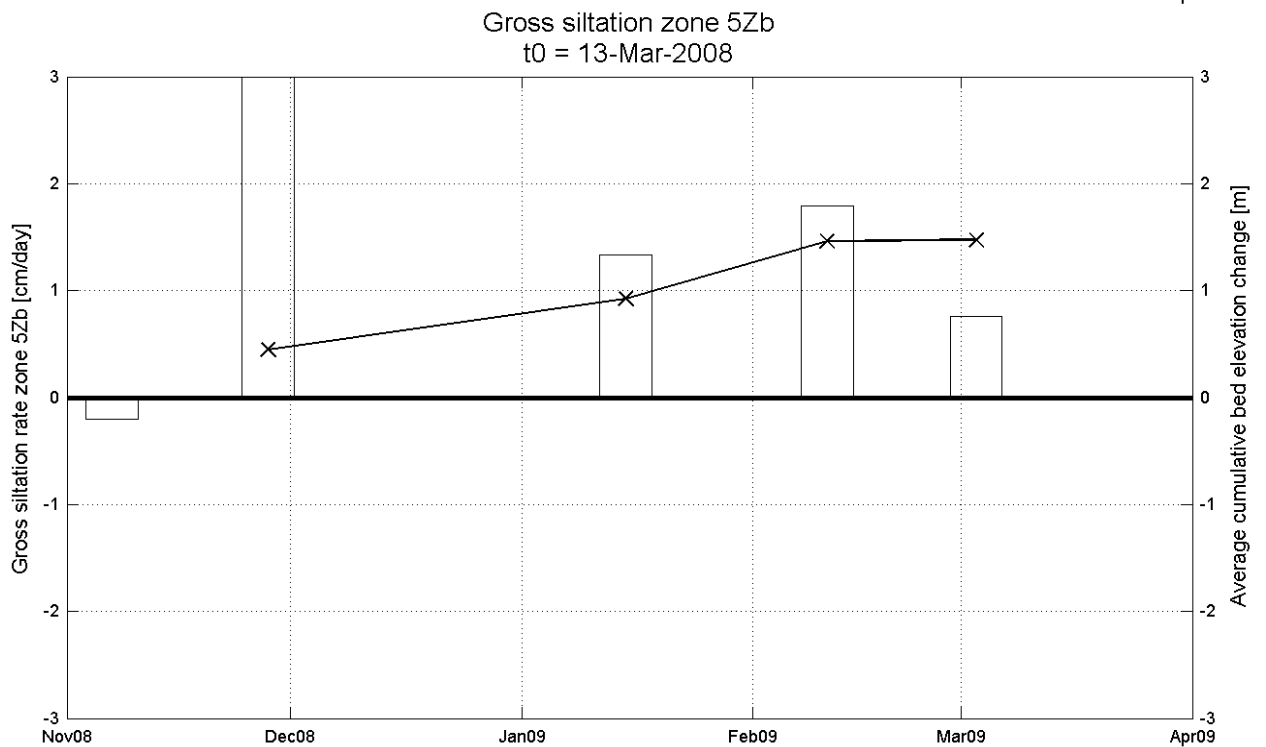
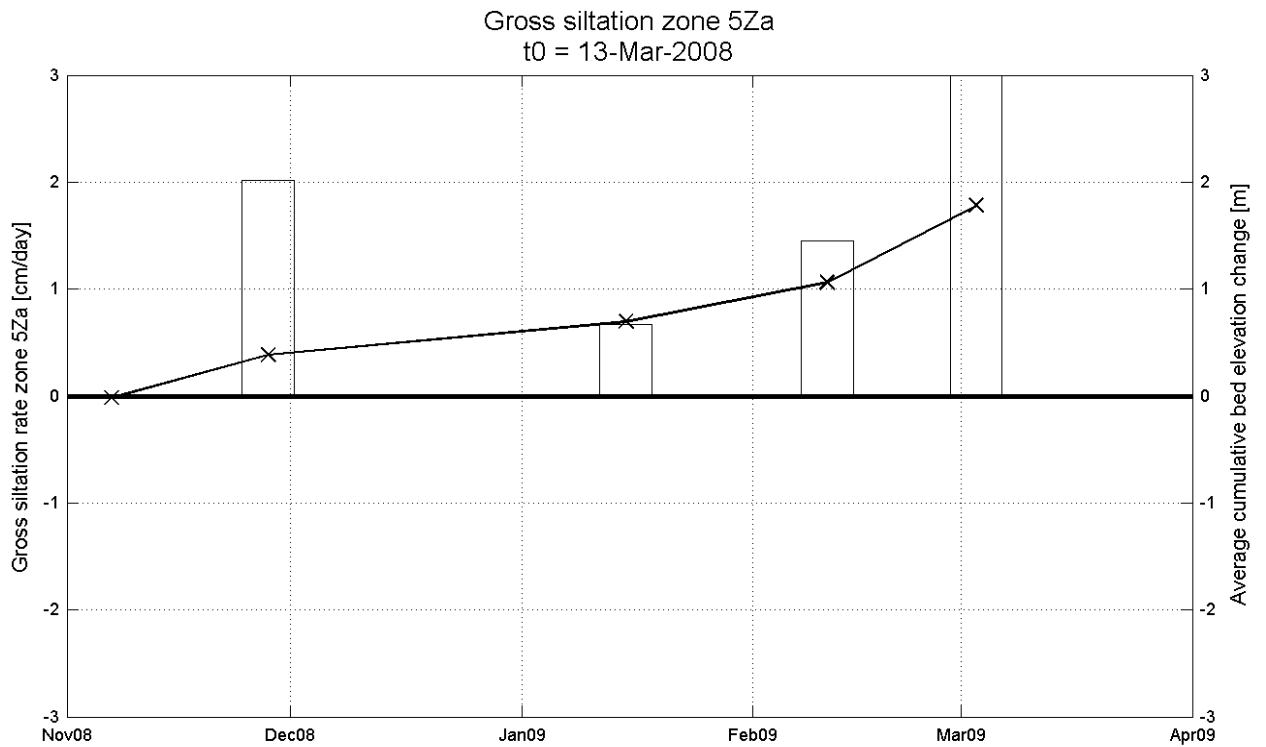
Siltation height / gross siltation rate

Equipment(s):

210kHz depth sounder

Location:

DGD



Siltation rate
 —x— 210kHz Bed El. change
█ Dredging

Reference level: depth sounding 13-Mar-2008

Data Processed by:



In association with:



I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

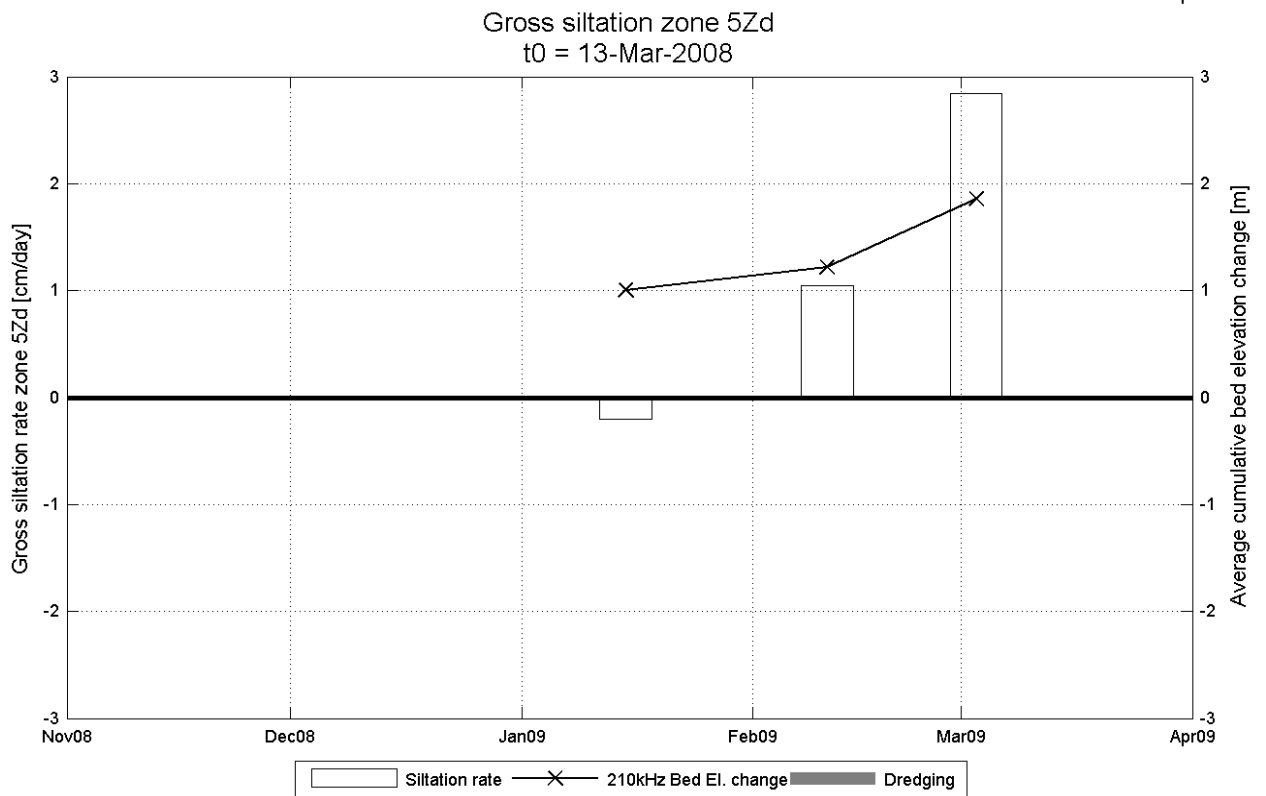
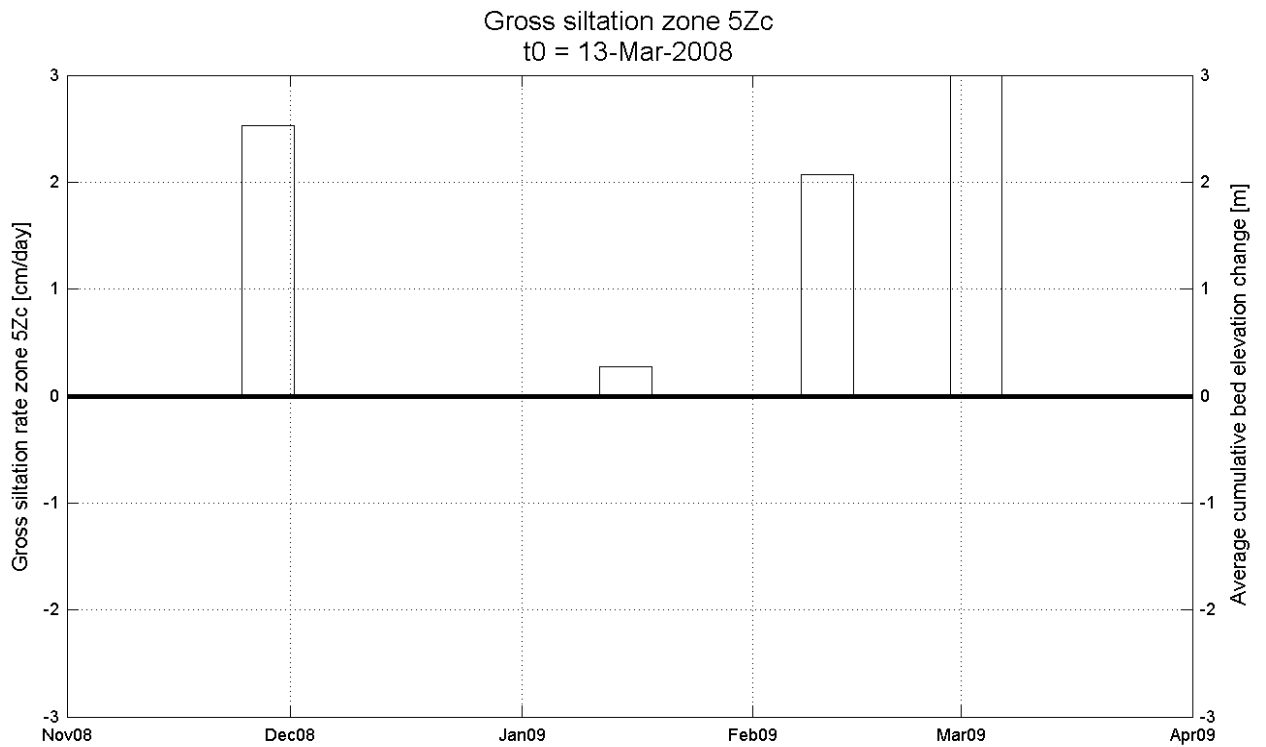
Siltation height / gross siltation rate

Equipment(s):

210kHz depth sounder

Location:

DGD



Reference level: depth sounding 13-Mar-2008

Data Processed by:



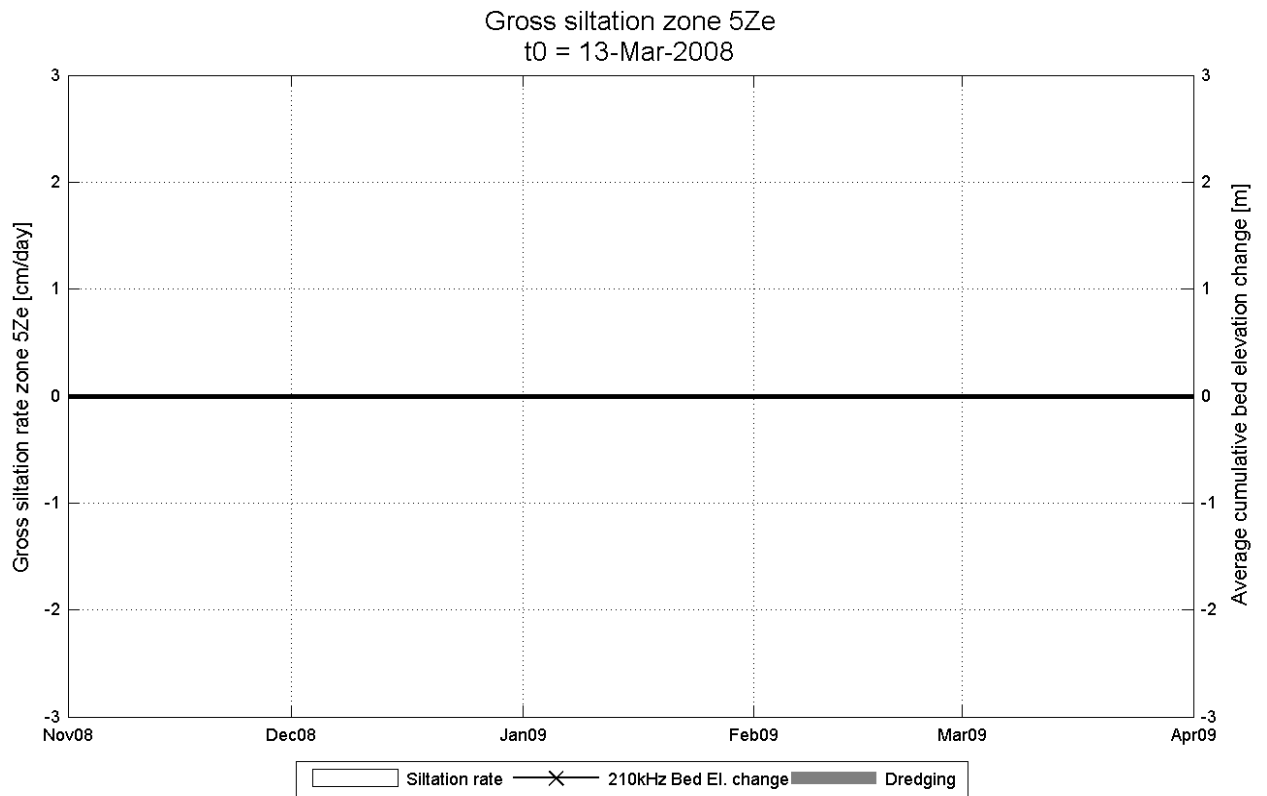
In association with:



I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

| | |
|---|---------------------------------------|
| Siltation height / gross siltation rate | Equipment(s): 210kHz depth sounder |
| | Location: DGD |



Reference level: depth sounding 13-Mar-2008

Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

C.3 Water-bed interface evolution for all sections

Long-term monitoring siltation Deurganckdok

Siltation height / gross siltation rate

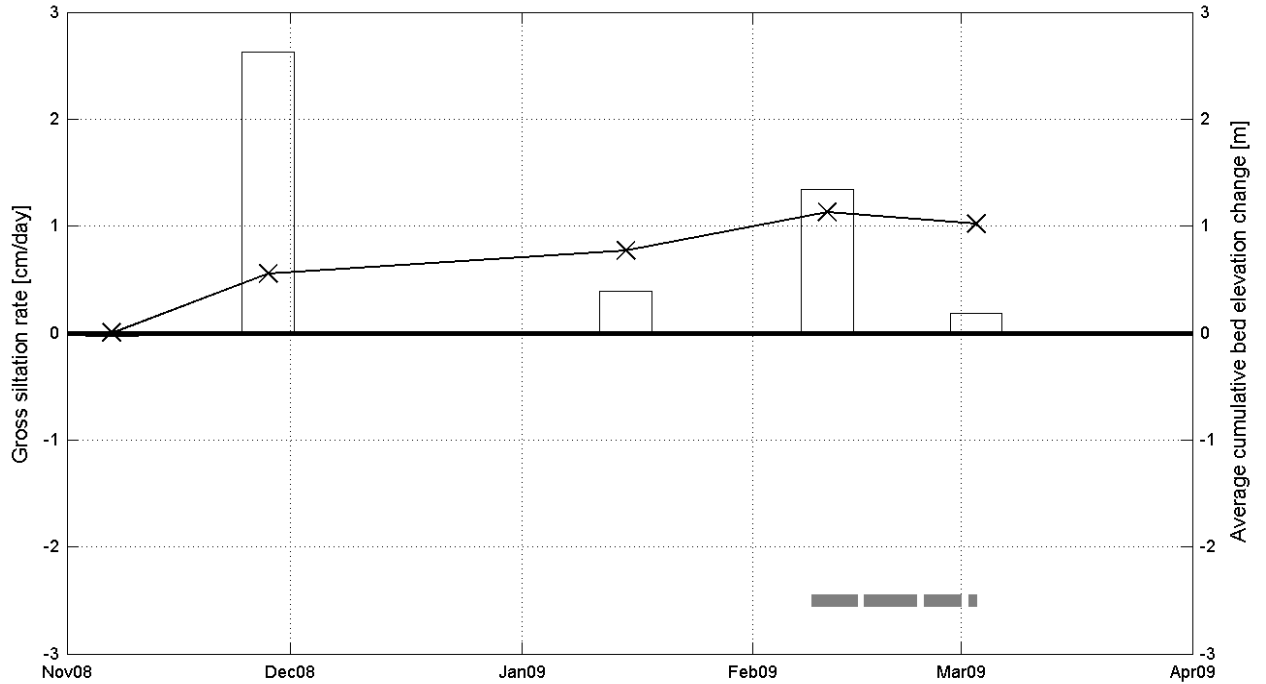
Equipment(s):

210kHz depth sounder

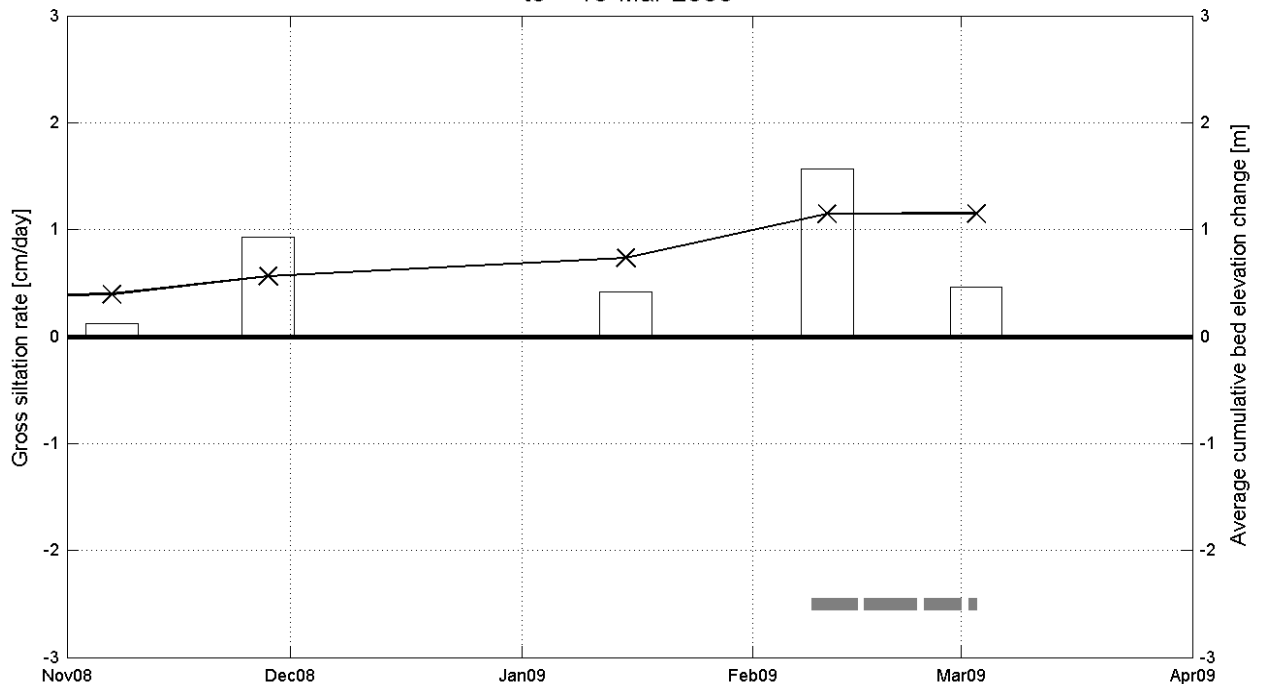
Location:

DGD

Gross siltation over section D1
t0 = 13-Mar-2008



Gross siltation over section D2
t0 = 13-Mar-2008



Siltation rate
 —x— 210kHz Bed El. change
■ Dredging

Reference level: depth sounding 13-Mar-2008

Data Processed by:



In association with:



I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Siltation height / gross siltation rate

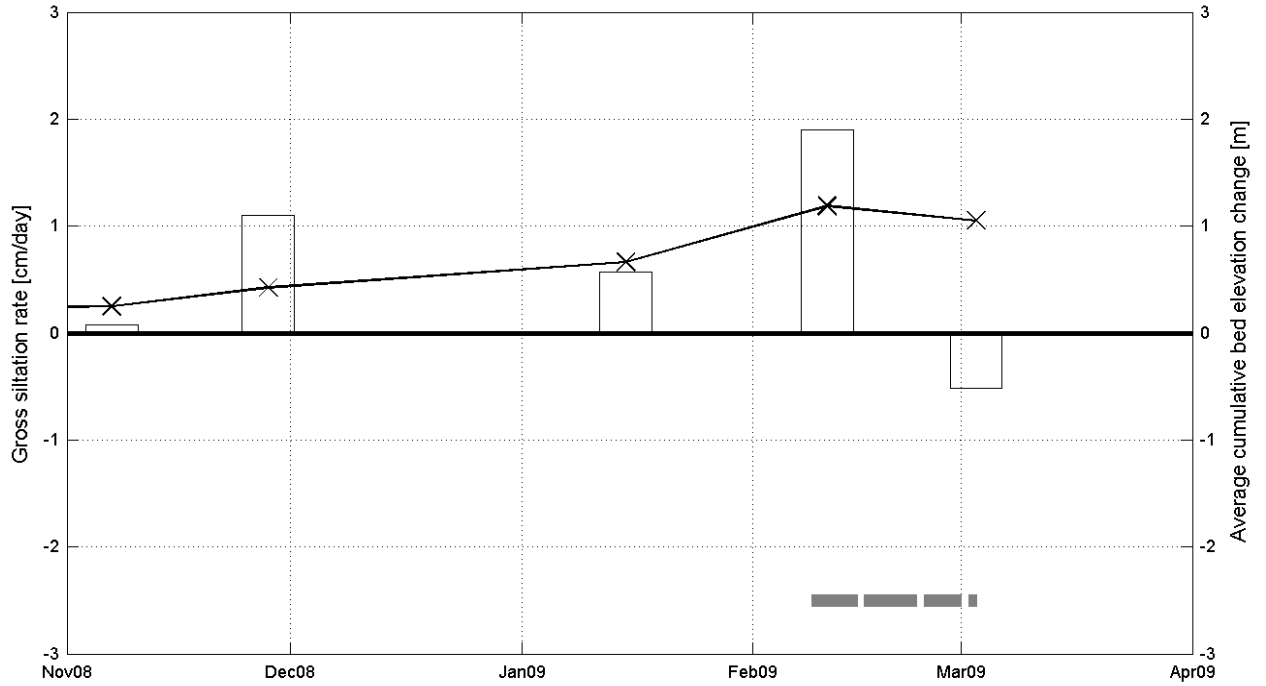
Equipment(s):

210kHz depth sounder

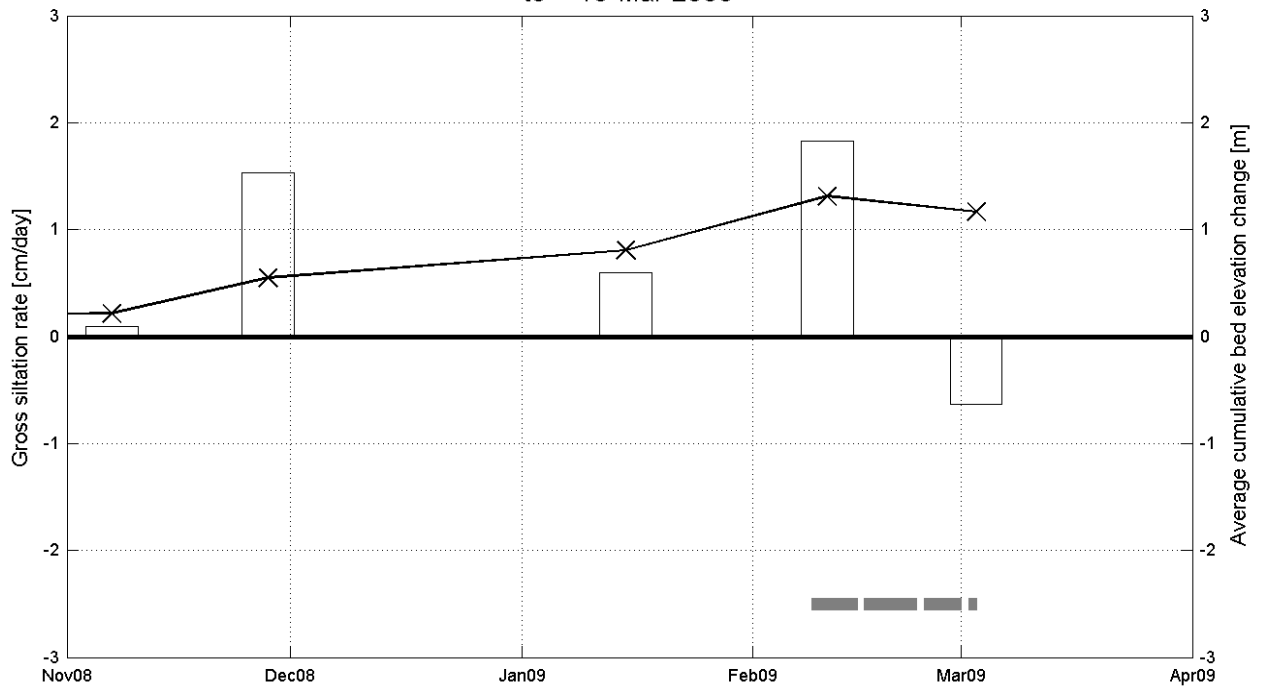
Location:

DGD

Gross siltation over section D3
t0 = 13-Mar-2008



Gross siltation over section D4
t0 = 13-Mar-2008



Siltation rate
 —x— 210kHz Bed El. change
█ Dredging

Reference level: depth sounding 13-Mar-2008

Data Processed by:



In association with:



I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Siltation height / gross siltation rate

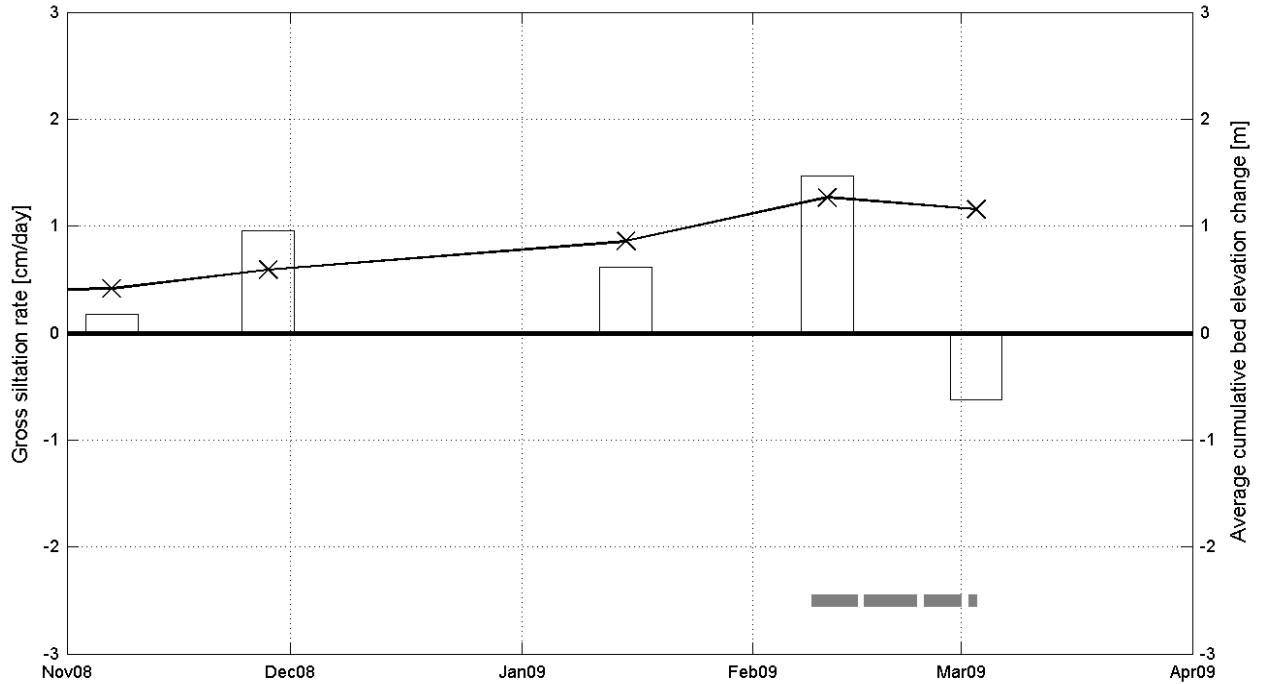
Equipment(s):

210kHz depth sounder

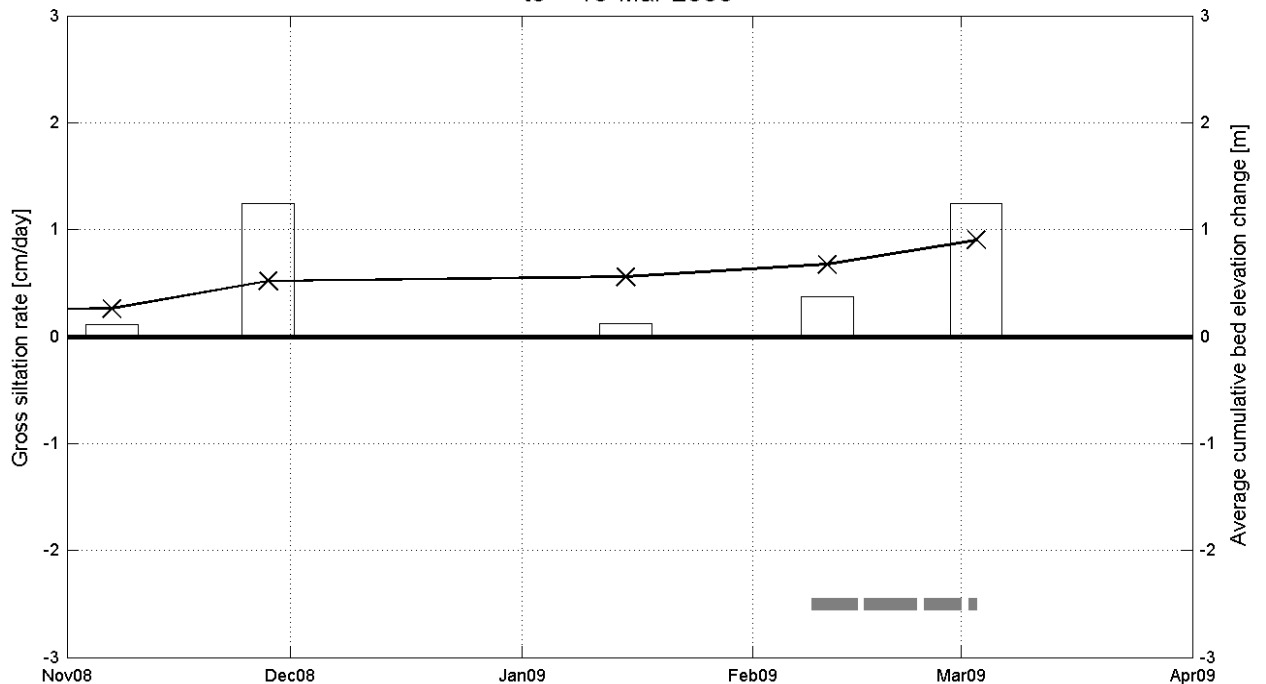
Location:

DGD

Gross siltation over section D5
t0 = 13-Mar-2008



Gross siltation over section D6
t0 = 13-Mar-2008



Siltation rate
 —X— 210kHz Bed El. change
█ Dredging

Reference level: depth sounding 13-Mar-2008

Data Processed by:



In association with:



I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Siltation height / gross siltation rate

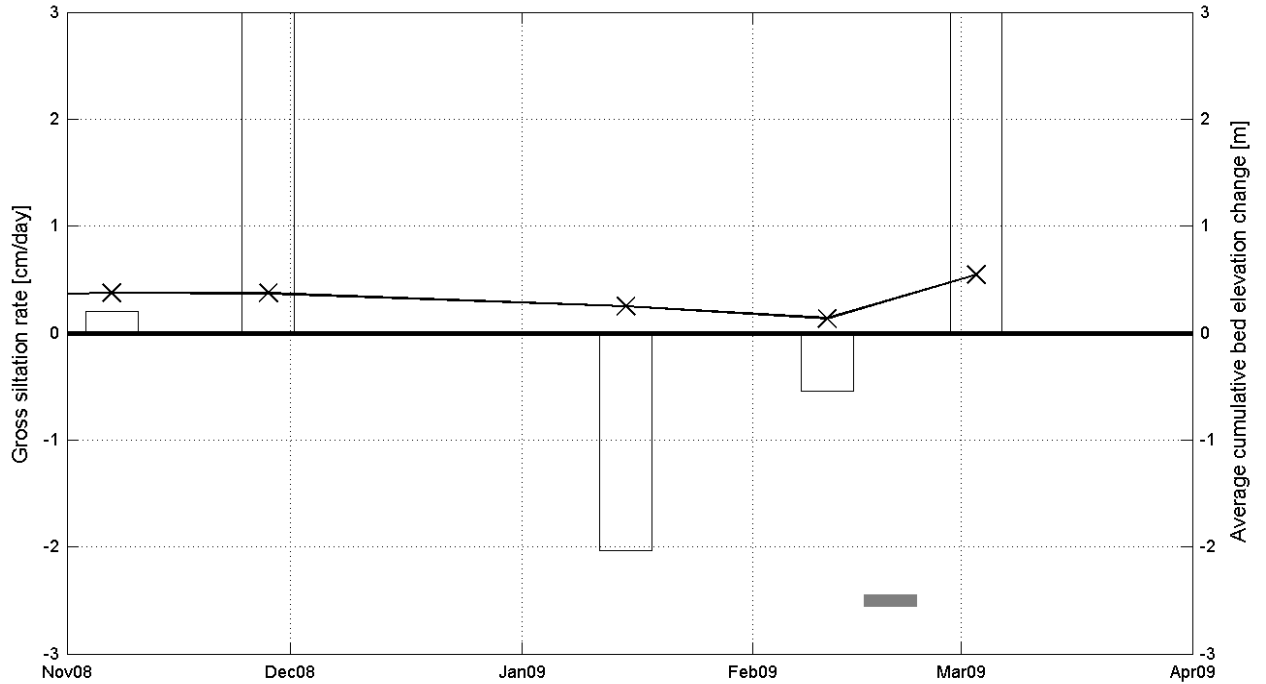
Equipment(s):

210kHz depth sounder

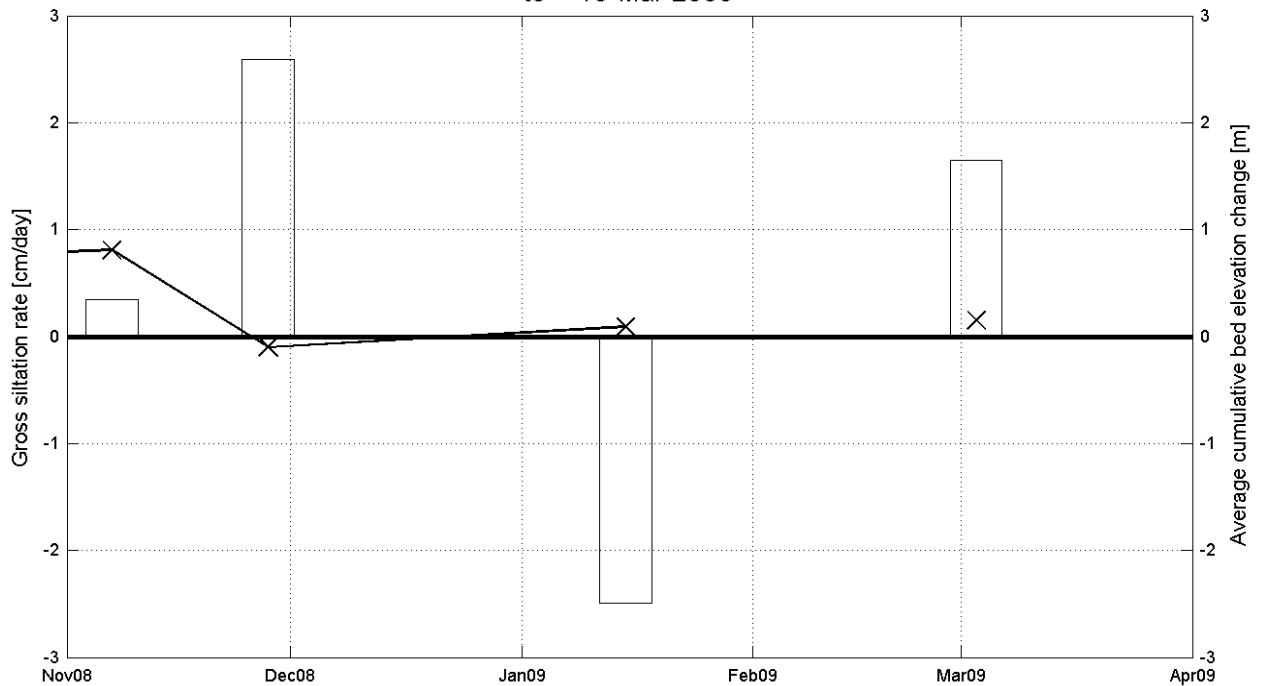
Location:

DGD

Gross siltation over section D7
t0 = 13-Mar-2008



Gross siltation over section D8
t0 = 13-Mar-2008



Siltation rate
 —x— 210kHz Bed El. change
■ Dredging

Reference level: depth sounding 13-Mar-2008

Data Processed by:



In association with:



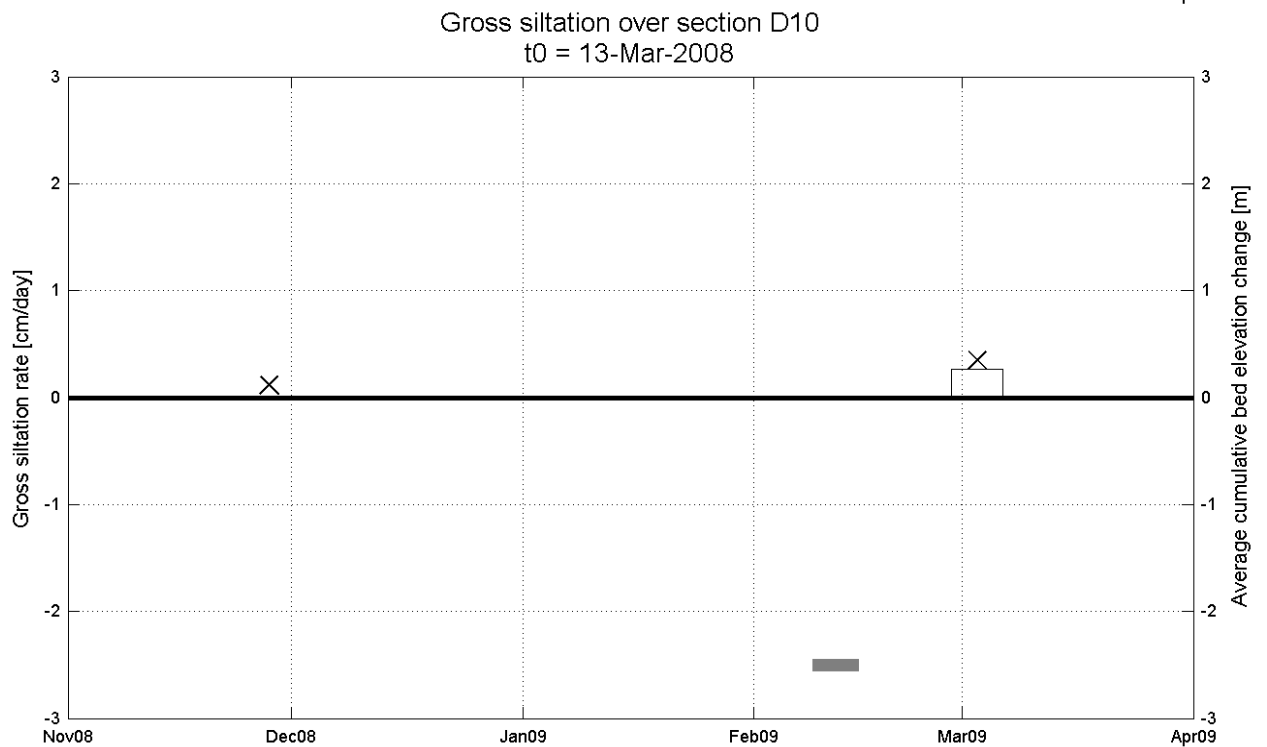
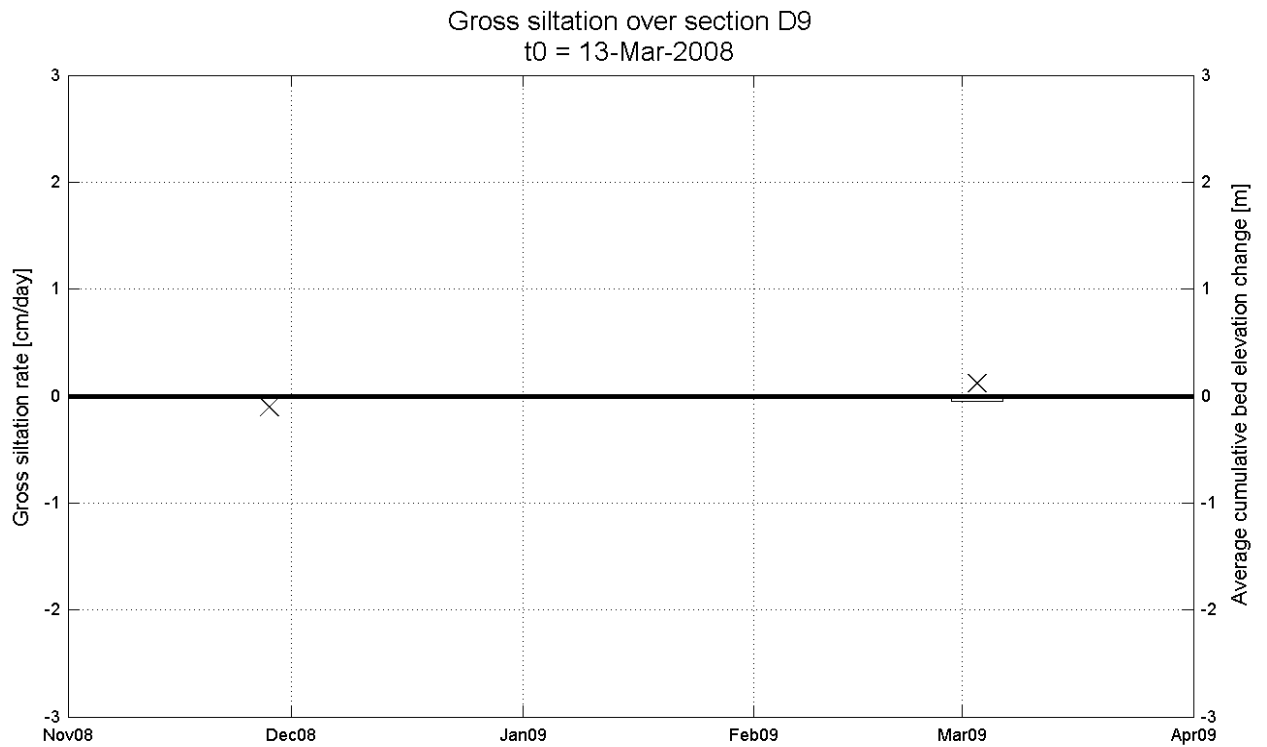
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Siltation height / gross siltation rate

Equipment(s):
210kHz depth sounder

Location:
DGD



Siltation rate
 X 210kHz Bed El. change
 Dredging

Reference level: depth sounding 13-Mar-2008

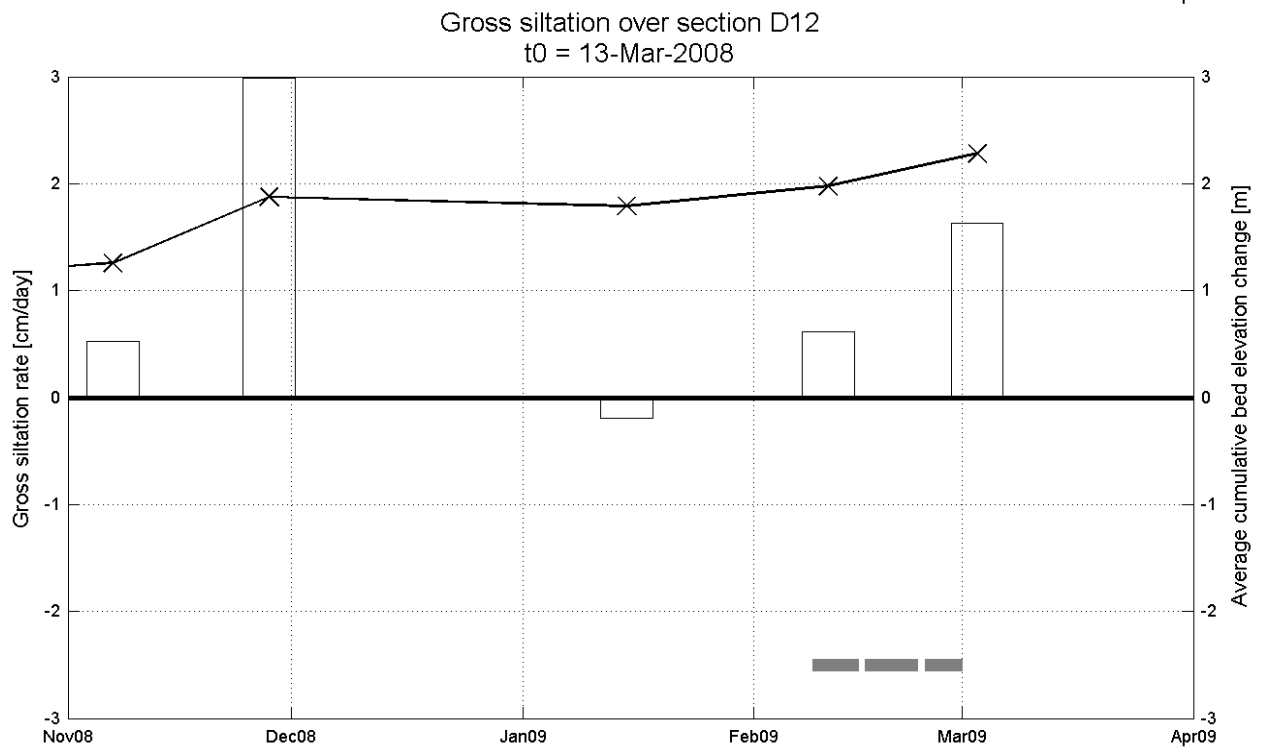
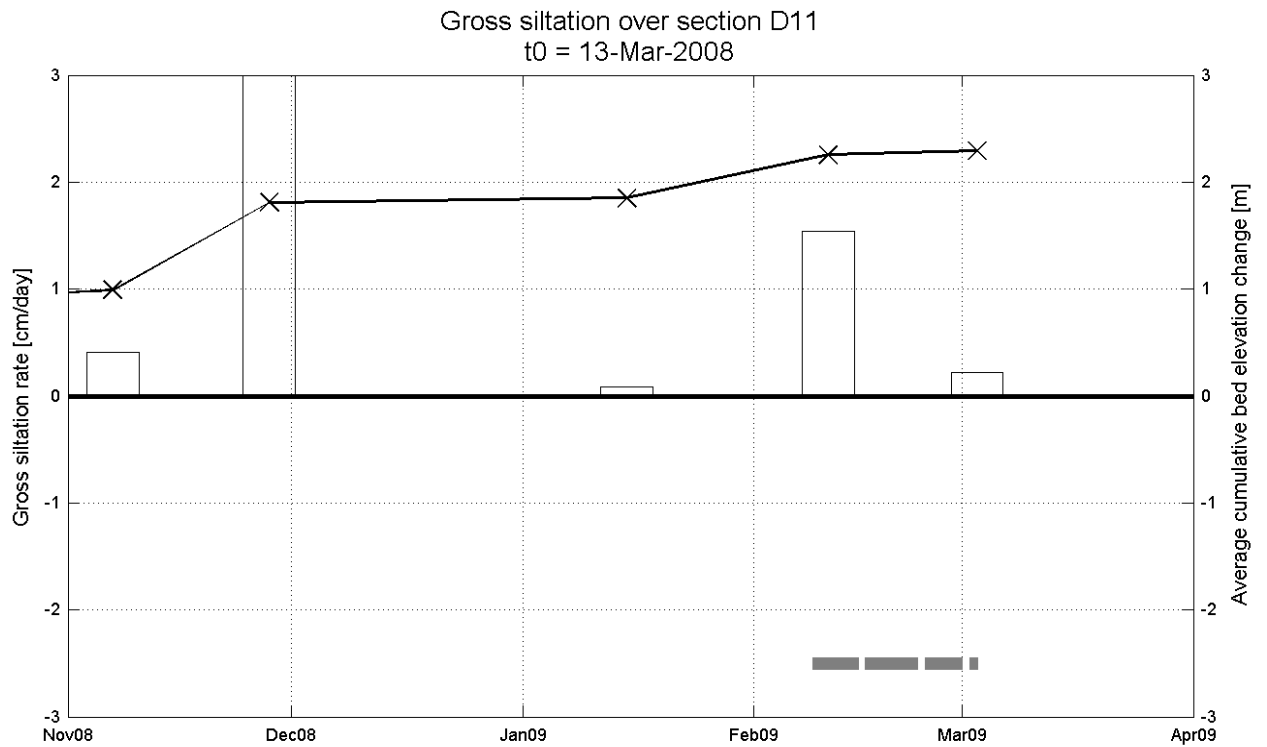
Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Siltation height / gross siltation rate

Equipment(s):
210kHz depth sounder

Location:
DGD



Siltation rate
 —x— 210kHz Bed El. change
■ Dredging

Reference level: depth sounding 13-Mar-2008

Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Siltation height / gross siltation rate

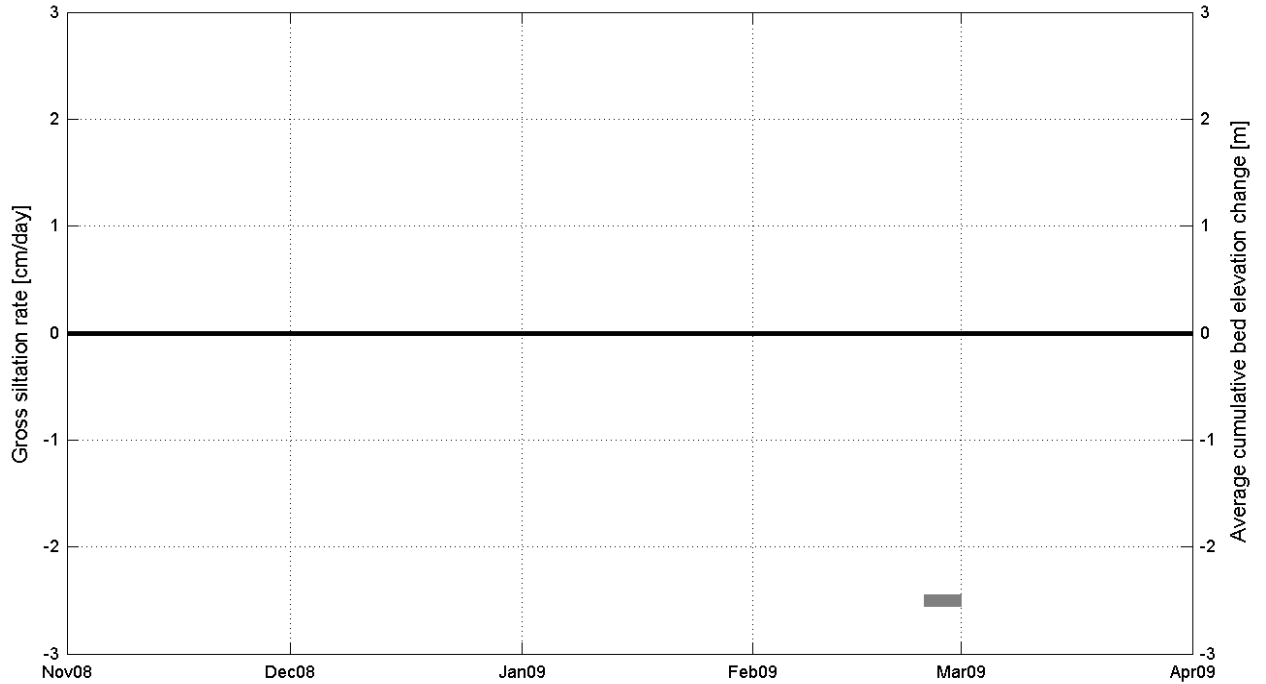
Equipment(s):

210kHz depth sounder

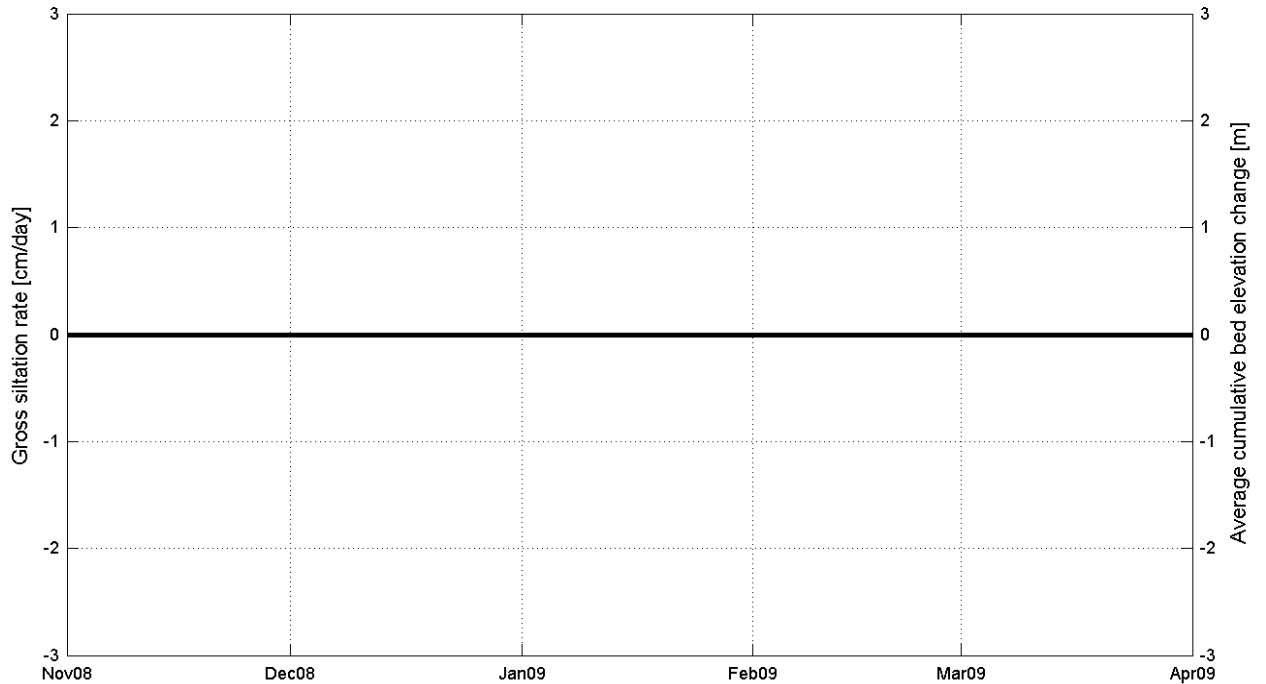
Location:

DGD

Gross siltation over section D13
t0 = 13-Mar-2008



Gross siltation over section D14
t0 = 13-Mar-2008



Siltation rate
 X 210kHz Bed El. change
 Dredging

Reference level: depth sounding 13-Mar-2008

Data Processed by:



In association with:



I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Siltation height / gross siltation rate

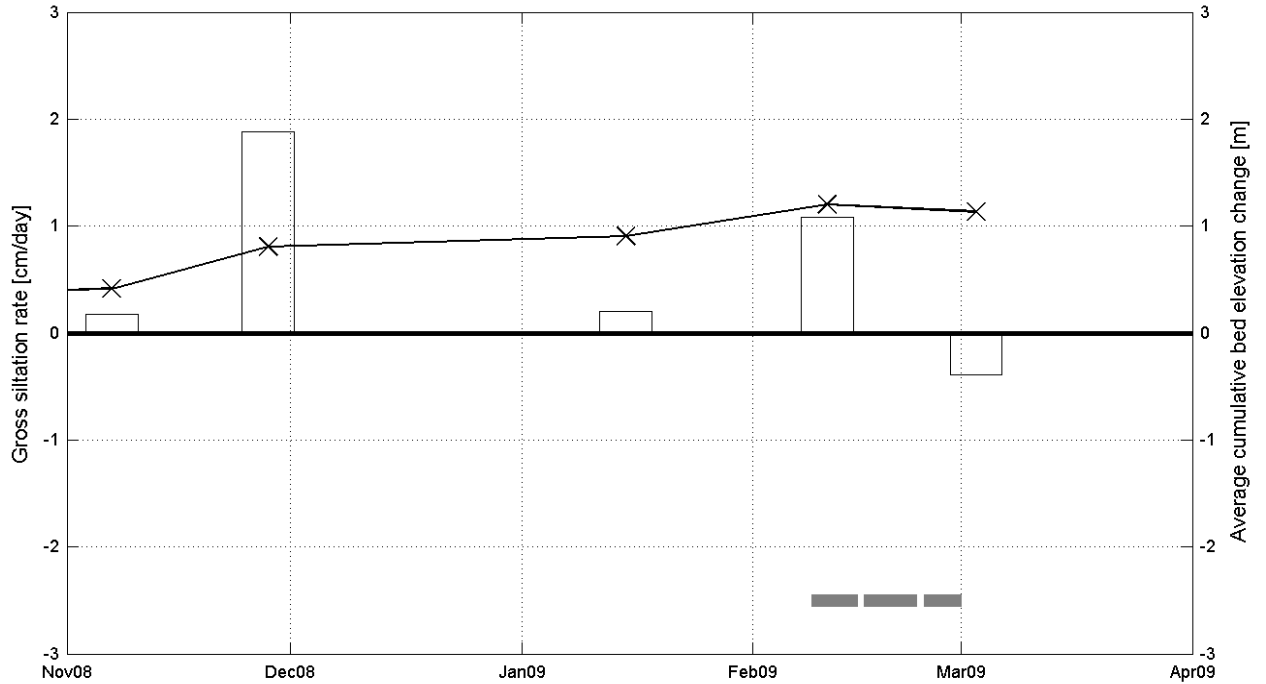
Equipment(s):

210kHz depth sounder

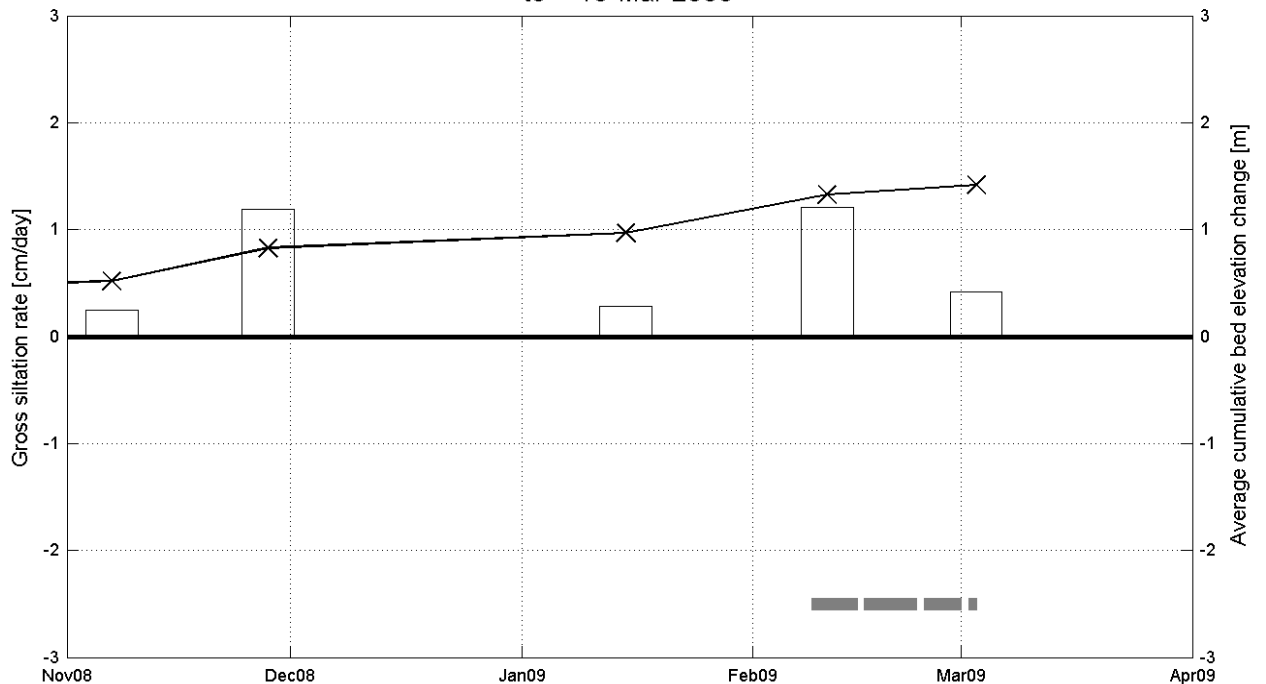
Location:

DGD

Gross siltation over section L1
t0 = 13-Mar-2008



Gross siltation over section L2
t0 = 13-Mar-2008



Siltation rate
 —x— 210kHz Bed El. change
█ Dredging

Reference level: depth sounding 13-Mar-2008

Data Processed by:



In association with:



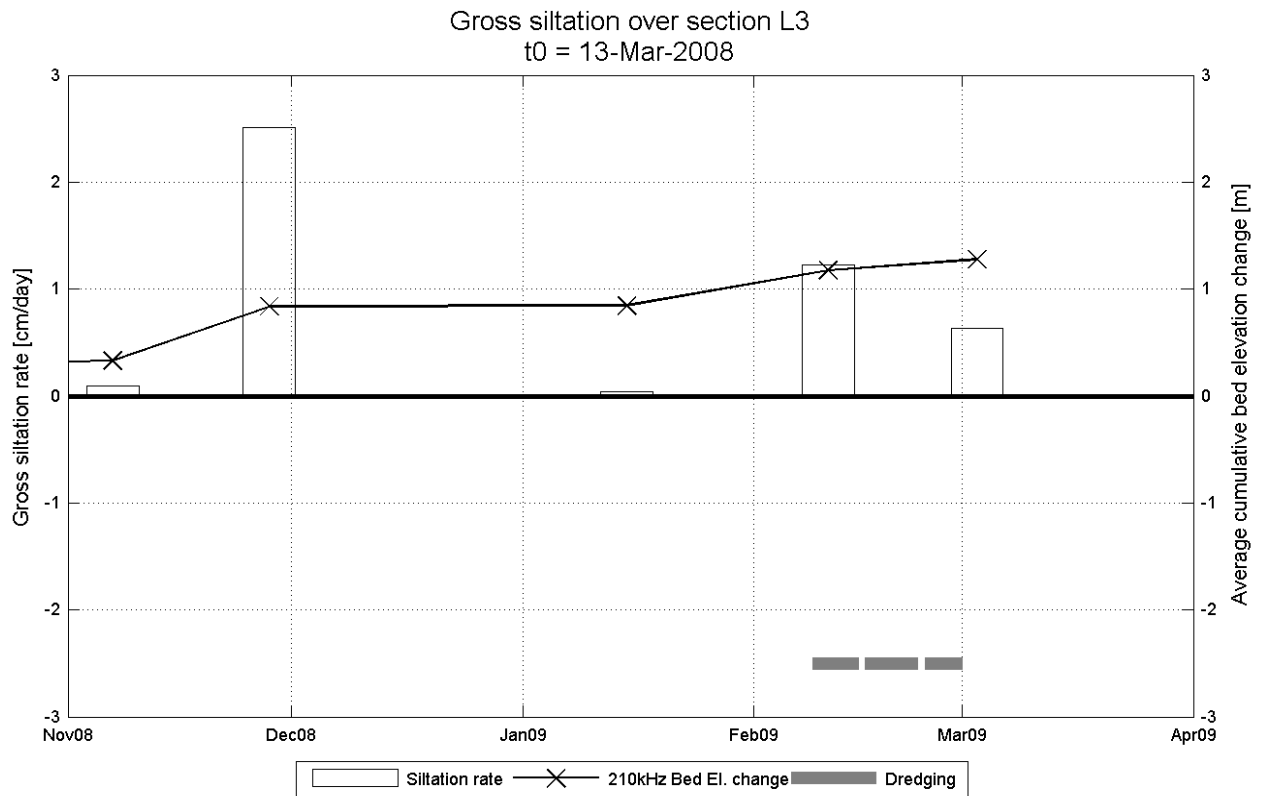
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Siltation height / gross siltation rate

Equipment(s):
210kHz depth sounder

Location:
DGD



Reference level: depth sounding 13-Mar-2008

Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

C.4 Siltation rate complete Deurganckdok

Long-term monitoring siltation Deurganckdok

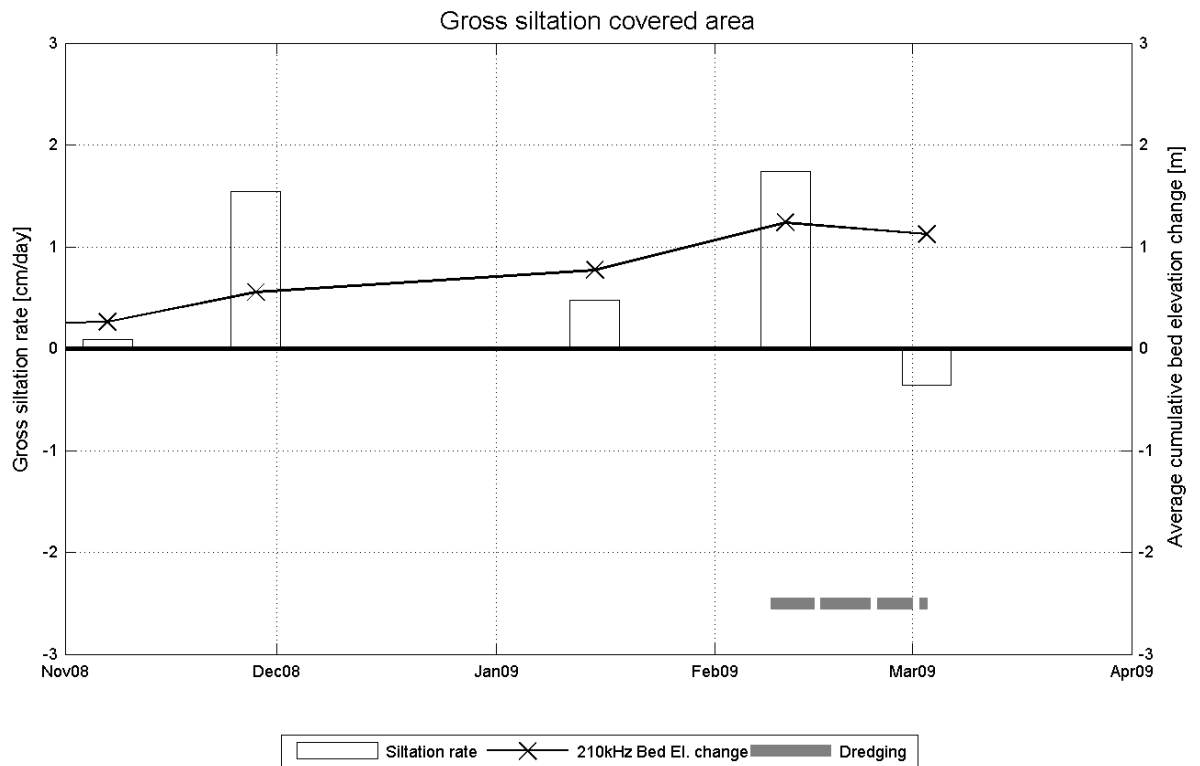
Siltation height / gross siltation rate

Equipment(s):

210kHz depth sounder

Location:

DGD



Reference level: depth sounding 13-Mar-2008

Data Processed by:



In association with:



I/RA/11283/08.079/MSA

APPENDIX D.

DEPTH OF WATER-BED INTERFACE AND EQUAL

DENSITY LAYERS

APPENDIX E.

DEPTH OF PLANES OF CONSTANT DENSITY

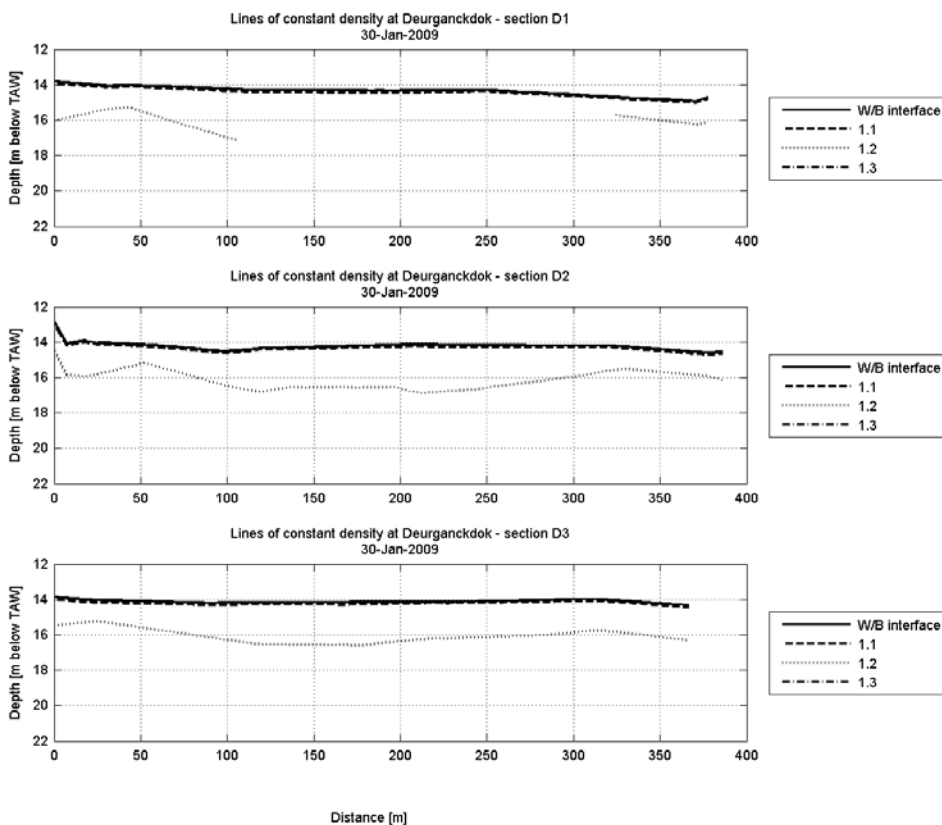
E.1 Measurements January 30th, 2009

Long-term monitoring siltation Deurganckdok

Cross sections planes constant density

Equipment(s):
 NaviTracker

Location:
 DGD



Data Processed by:



In association with:



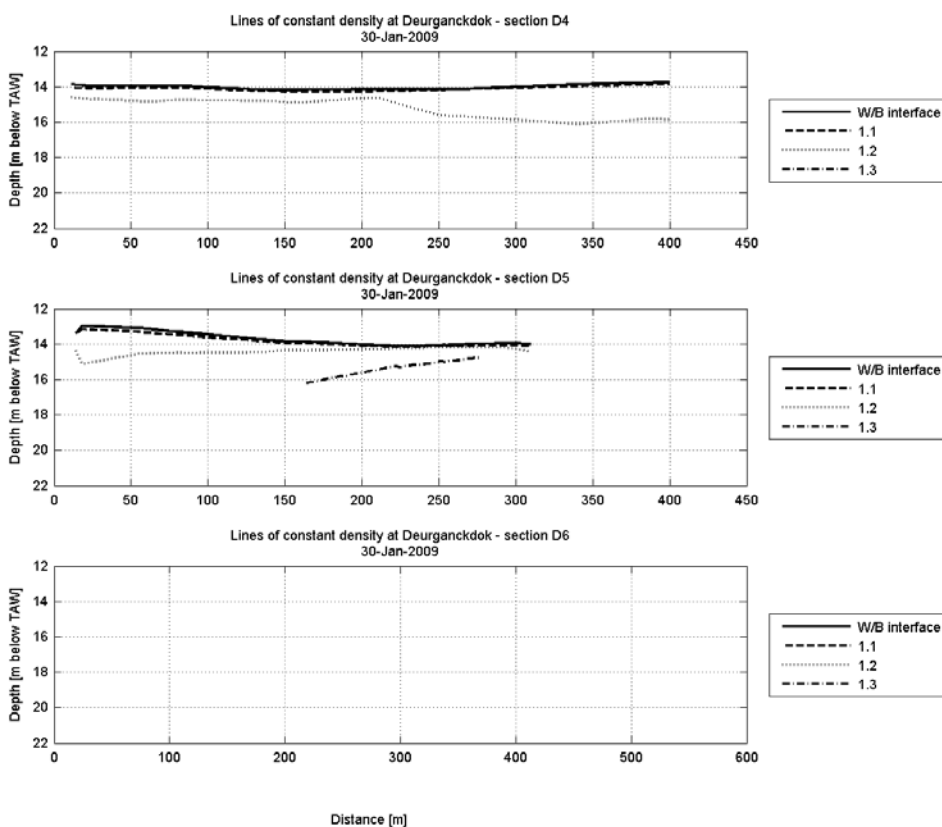
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Cross sections planes constant density

Equipment(s):
 NaviTracker

Location:
 DGD



Data Processed by:



In association with:



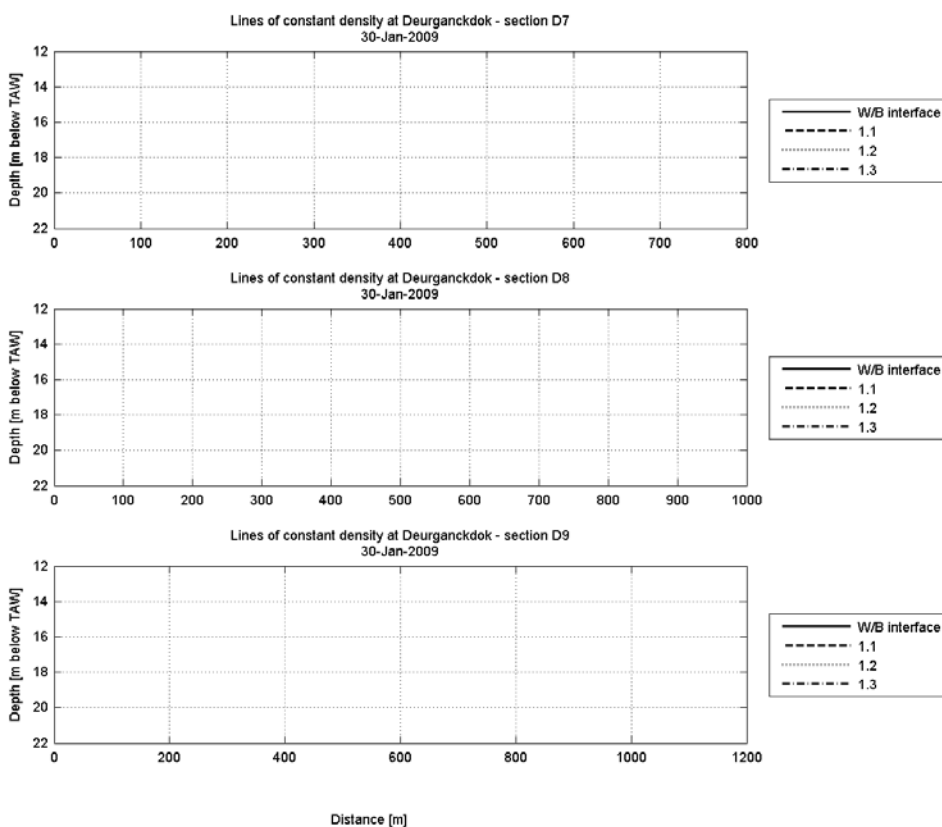
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Cross sections planes constant density

Equipment(s):
 NaviTracker

Location:
 DGD



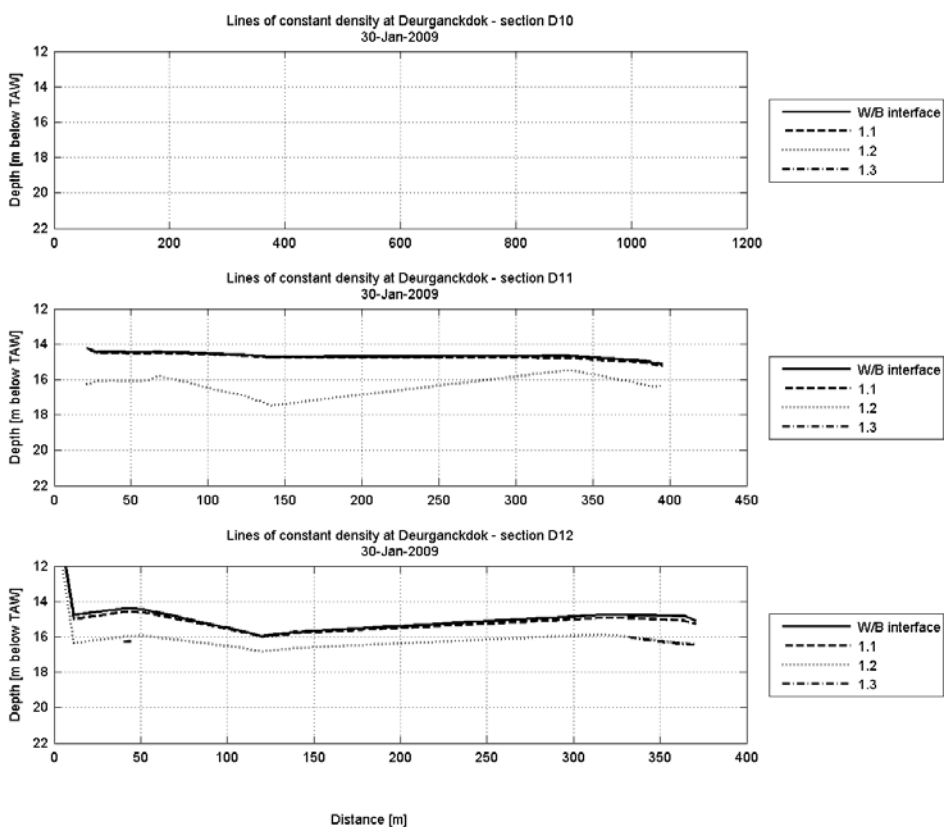
Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Cross sections planes constant density

Equipment(s):
 NaviTracker

Location:
 DGD



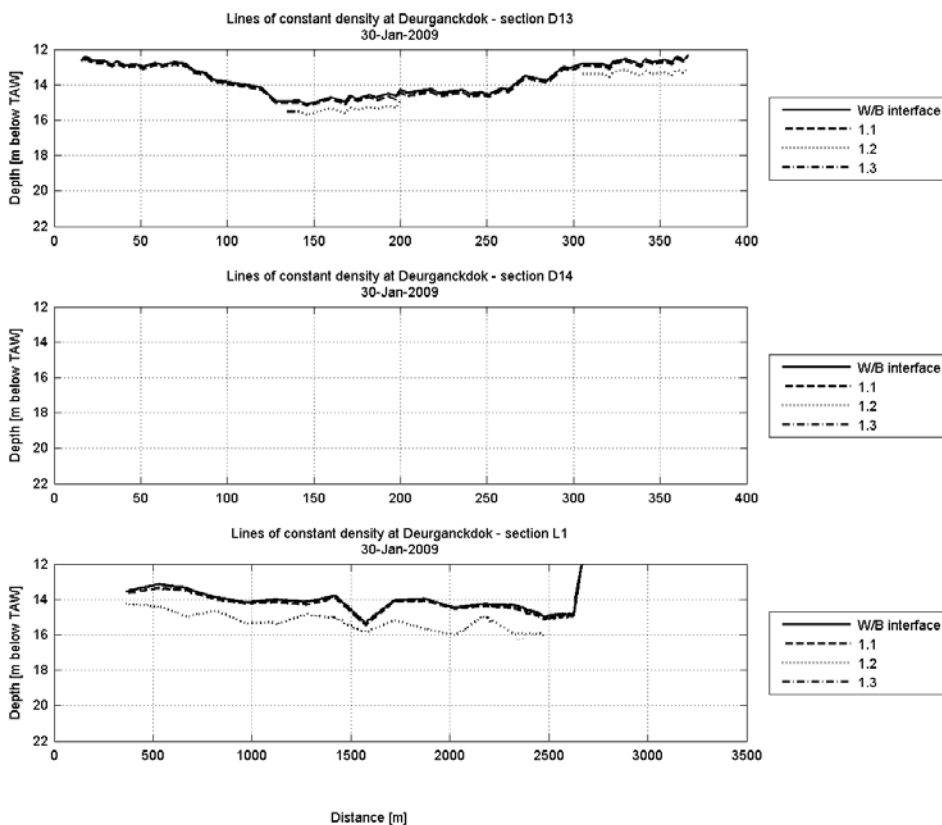
Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Cross sections planes constant density

Equipment(s):
 NaviTracker

Location:
 DGD



Data Processed by:



In association with:



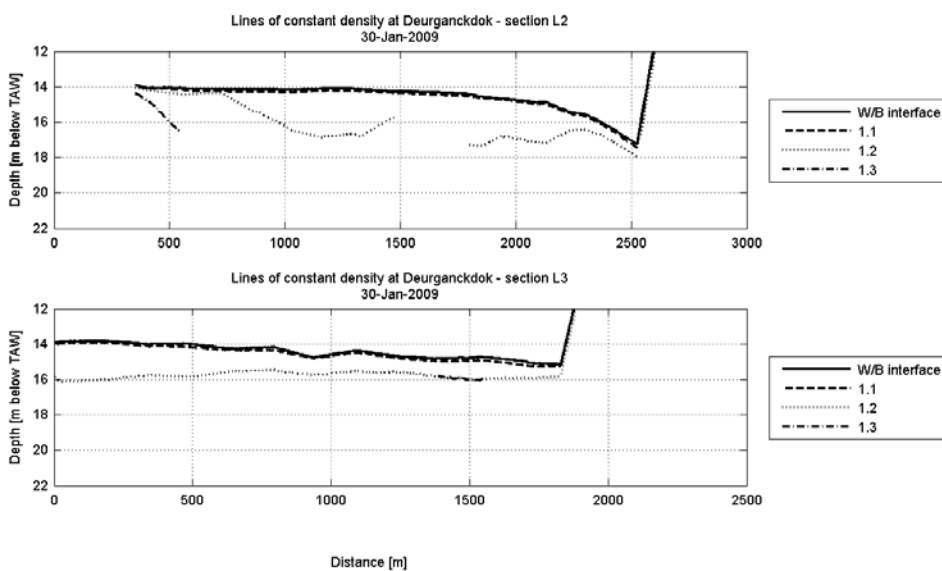
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Cross sections planes constant density

Equipment(s):
 NaviTracker

Location:
 DGD



Data Processed by:



In association with:



I/RA/11283/08.079/MSA

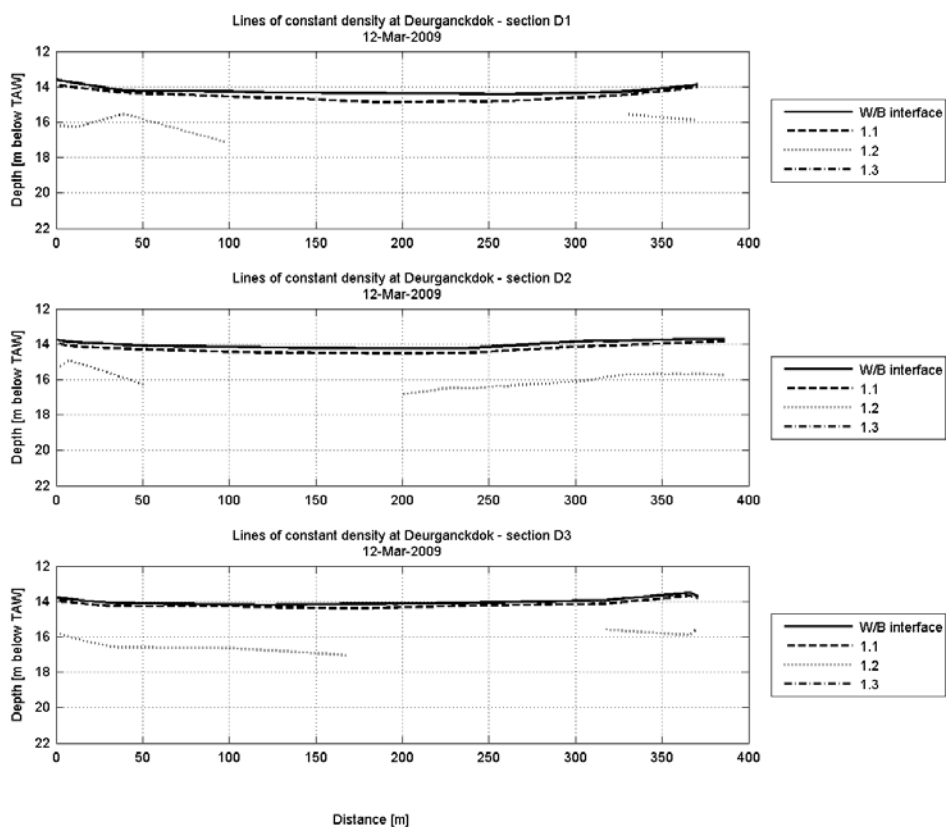
E.2 Measurements March 12th, 2009

Long-term monitoring siltation Deurganckdok

Cross sections planes constant density

Equipment(s):
 NaviTracker

Location:
 DGD



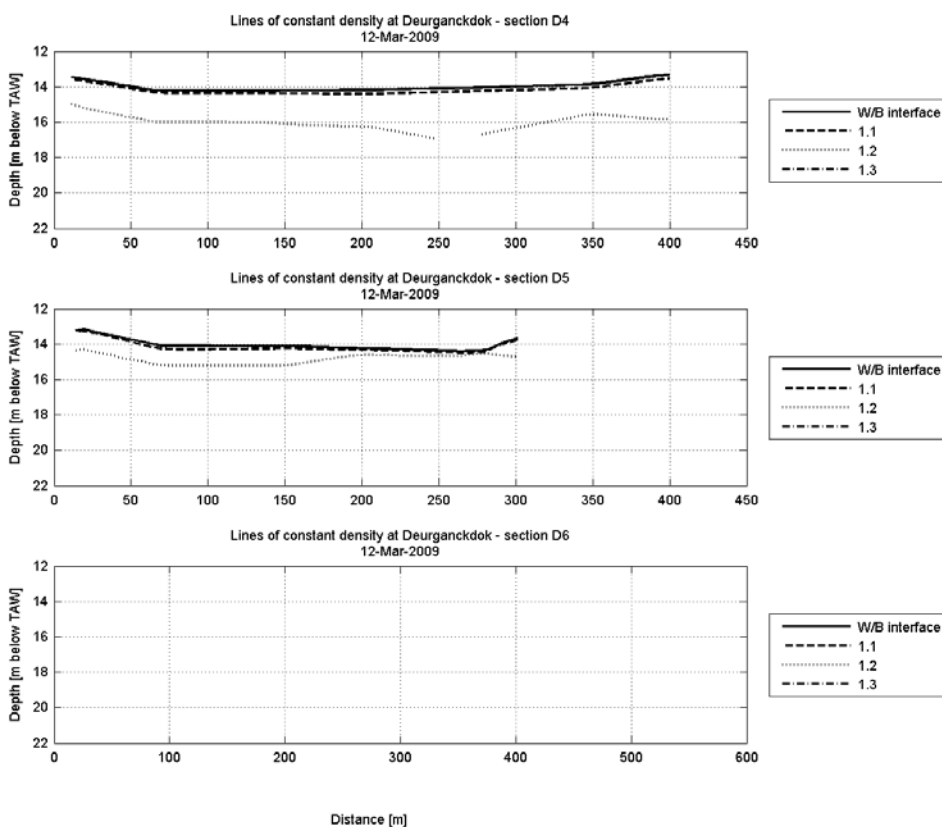
Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Cross sections planes constant density

Equipment(s):
 NaviTracker

Location:
 DGD



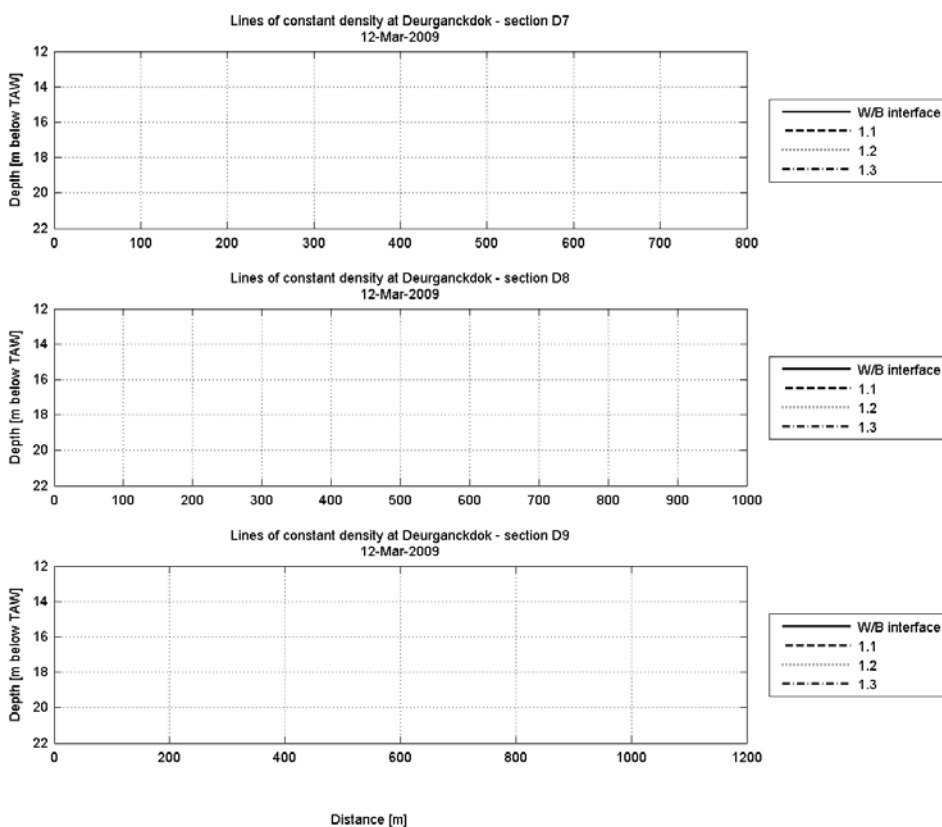
Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Cross sections planes constant density

Equipment(s):
 NaviTracker

Location:
 DGD



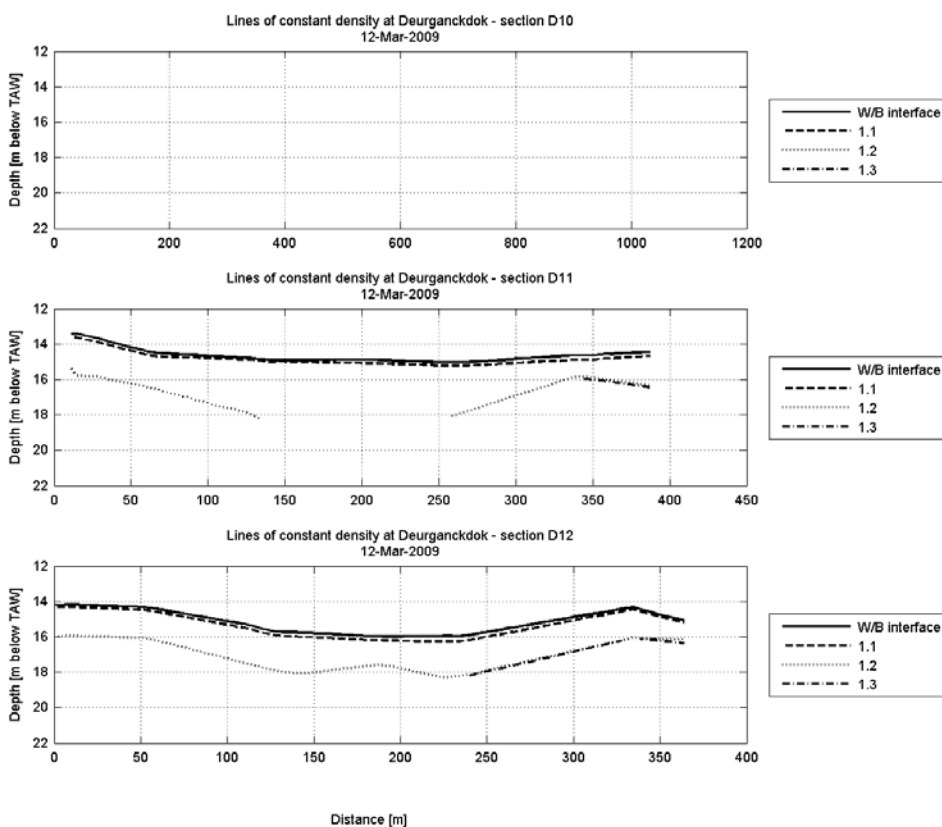
Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Cross sections planes constant density

Equipment(s):
 NaviTracker

Location:
 DGD



Data Processed by: 
 In association with: 

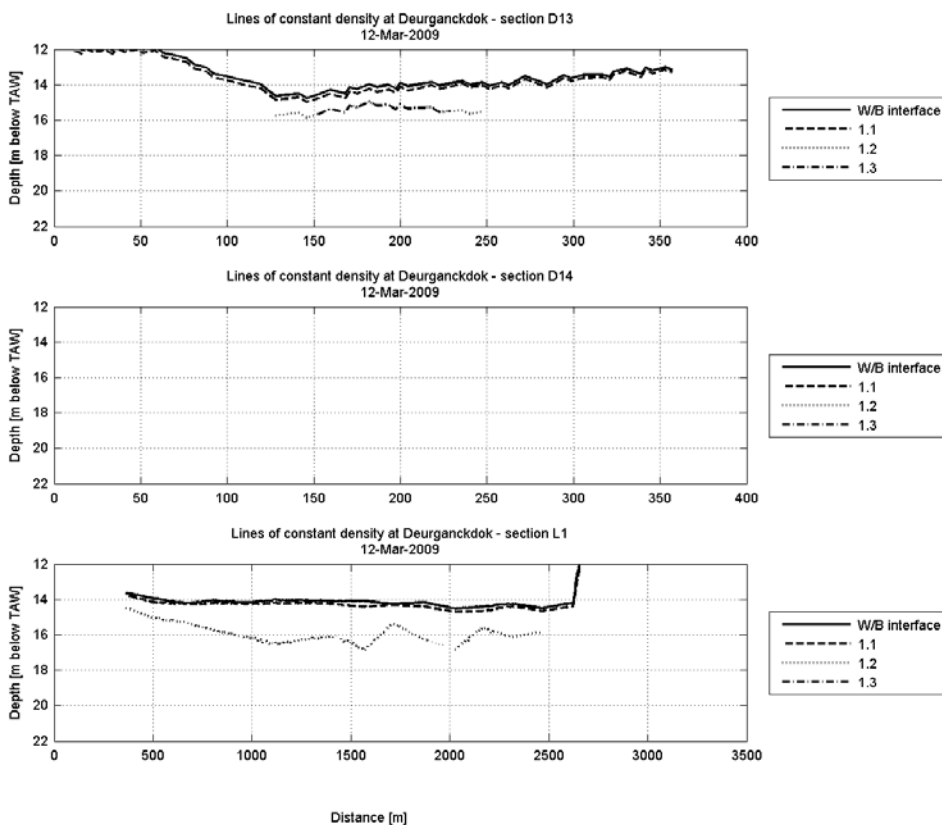
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Cross sections planes constant density

Equipment(s):
 NaviTracker

Location:
 DGD



Data Processed by: 
 In association with: 

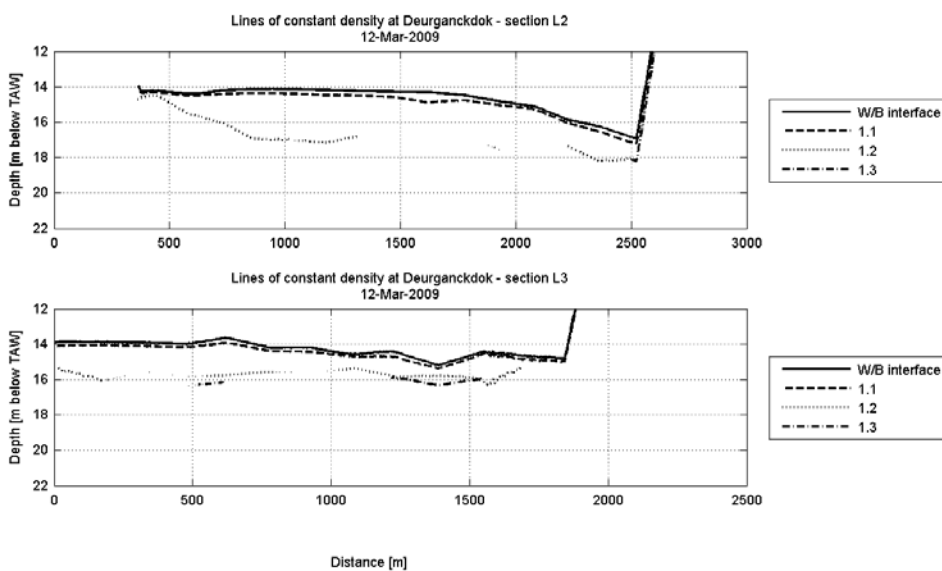
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Cross sections planes constant density

Equipment(s):
 NaviTracker

Location:
 DGD



Data Processed by:



In association with:



I/RA/11283/08.079/MSA

APPENDIX F.

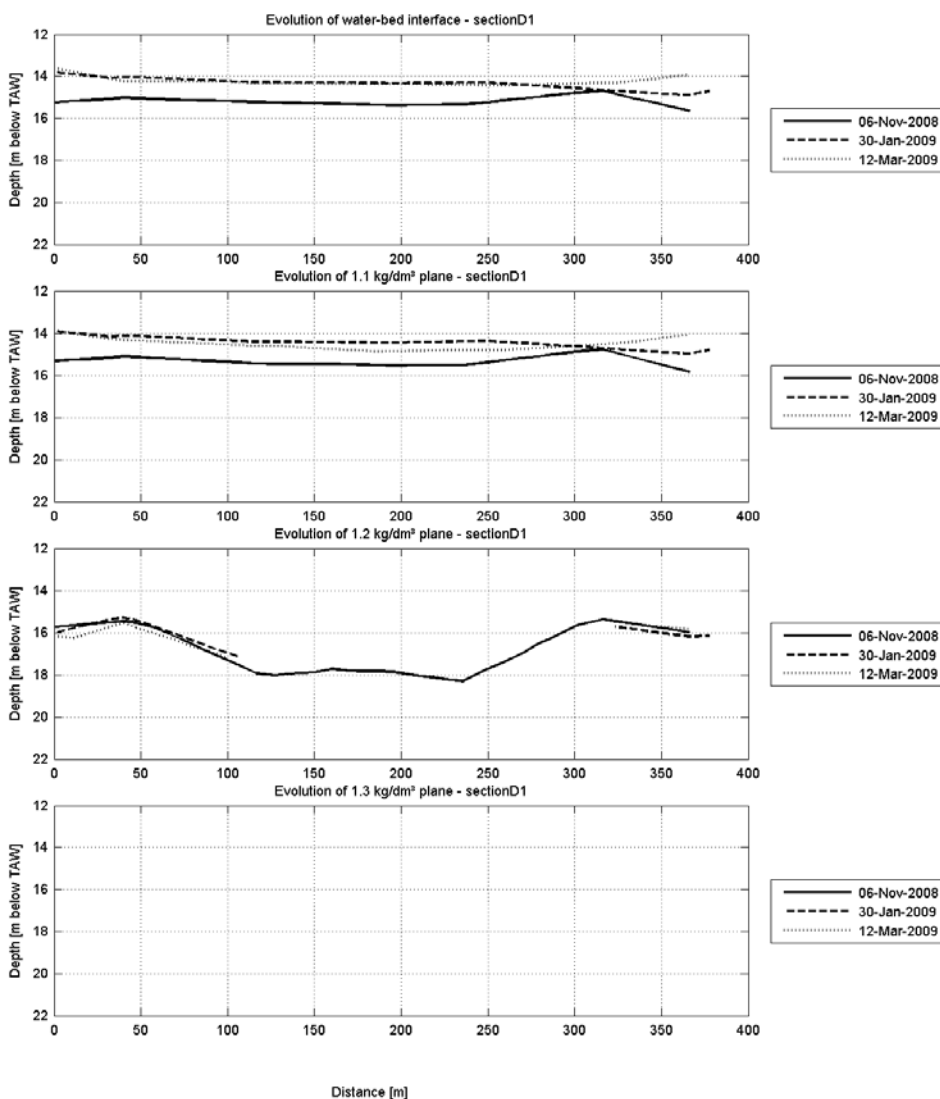
**DEPTH EVOLUTION OF PLANES OF CONSTANT
DENSITY**

Long-term monitoring siltation Deurganckdok

Evolution of planes of constant density

Equipment(s):
 NaviTracker

Location:
 DGD



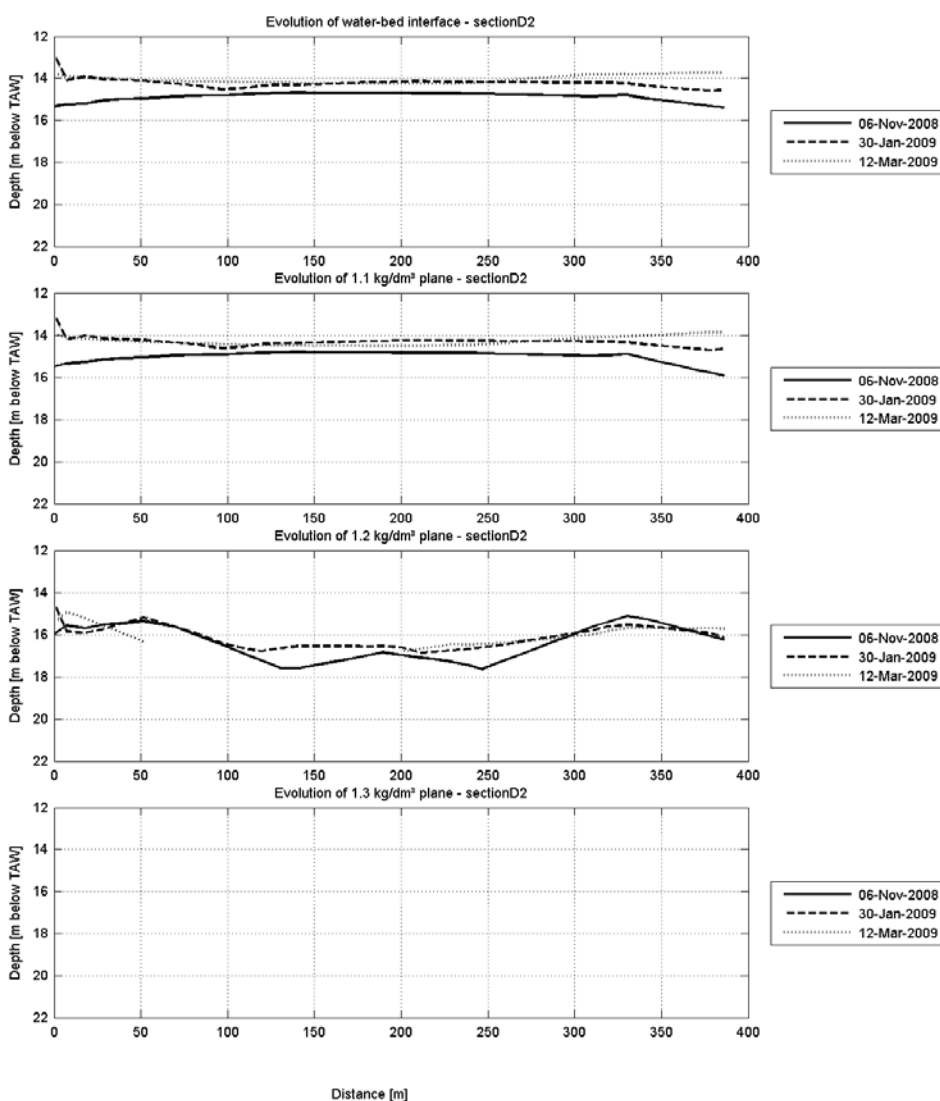
Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution of planes of constant density

Equipment(s):
 NaviTracker

Location:
 DGD



Data Processed by: 
 In association with: 

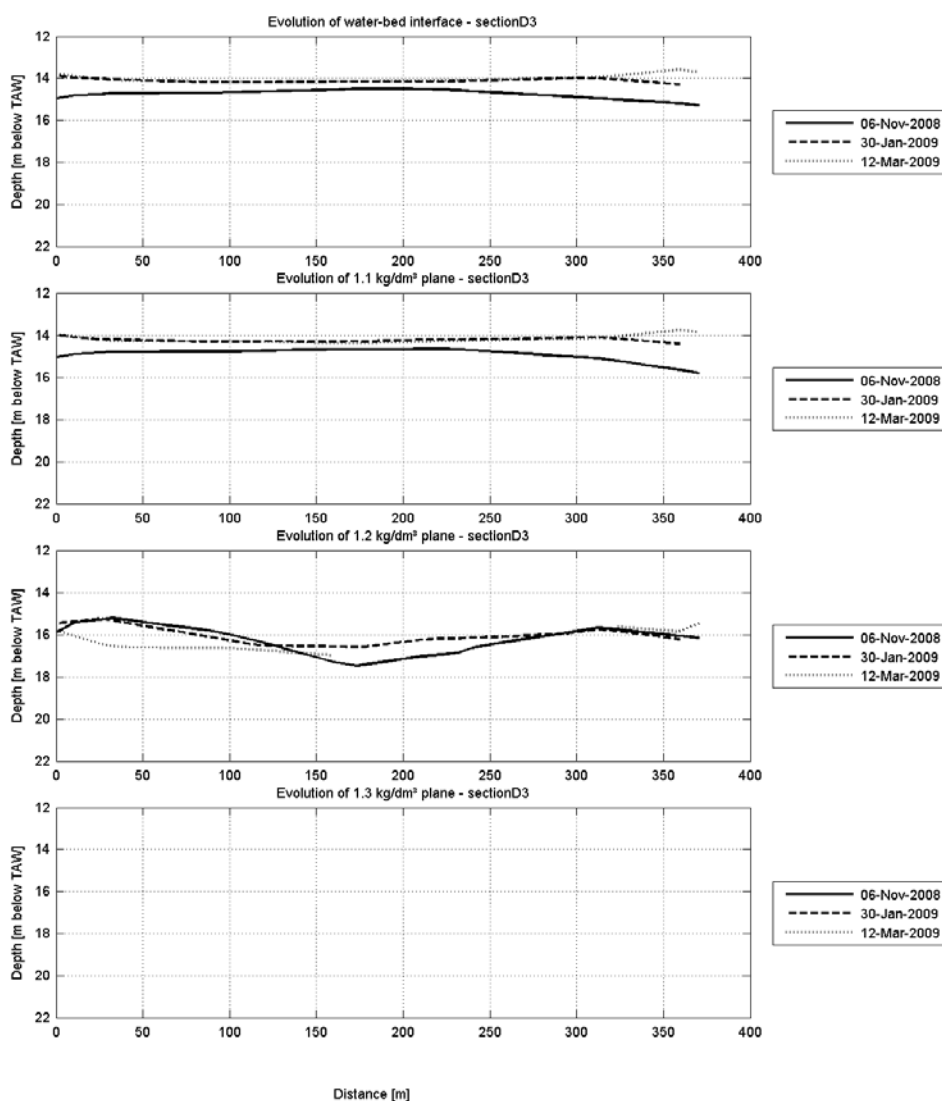
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution of planes of constant density

Equipment(s):
 NaviTracker

Location:
 DGD



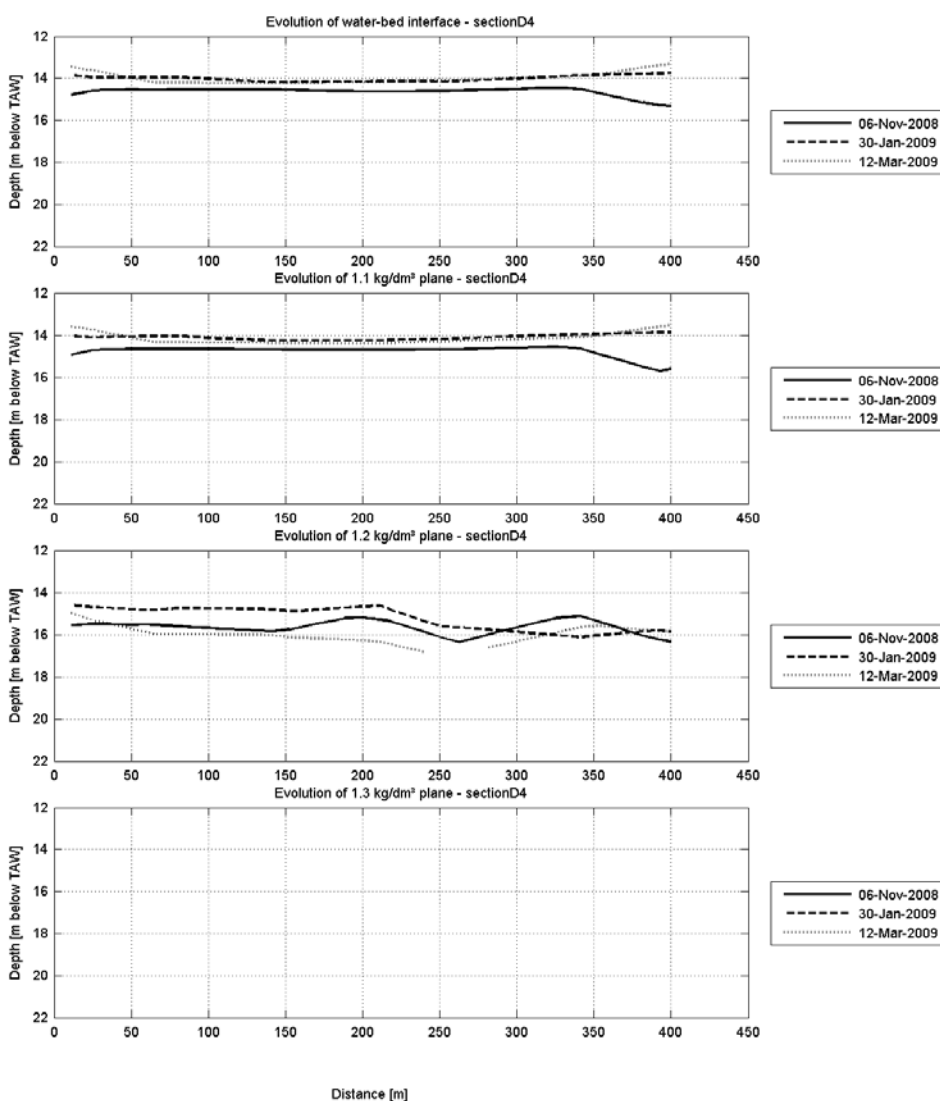
Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution of planes of constant density

Equipment(s):
 NaviTracker

Location:
 DGD



Data Processed by:



In association with:



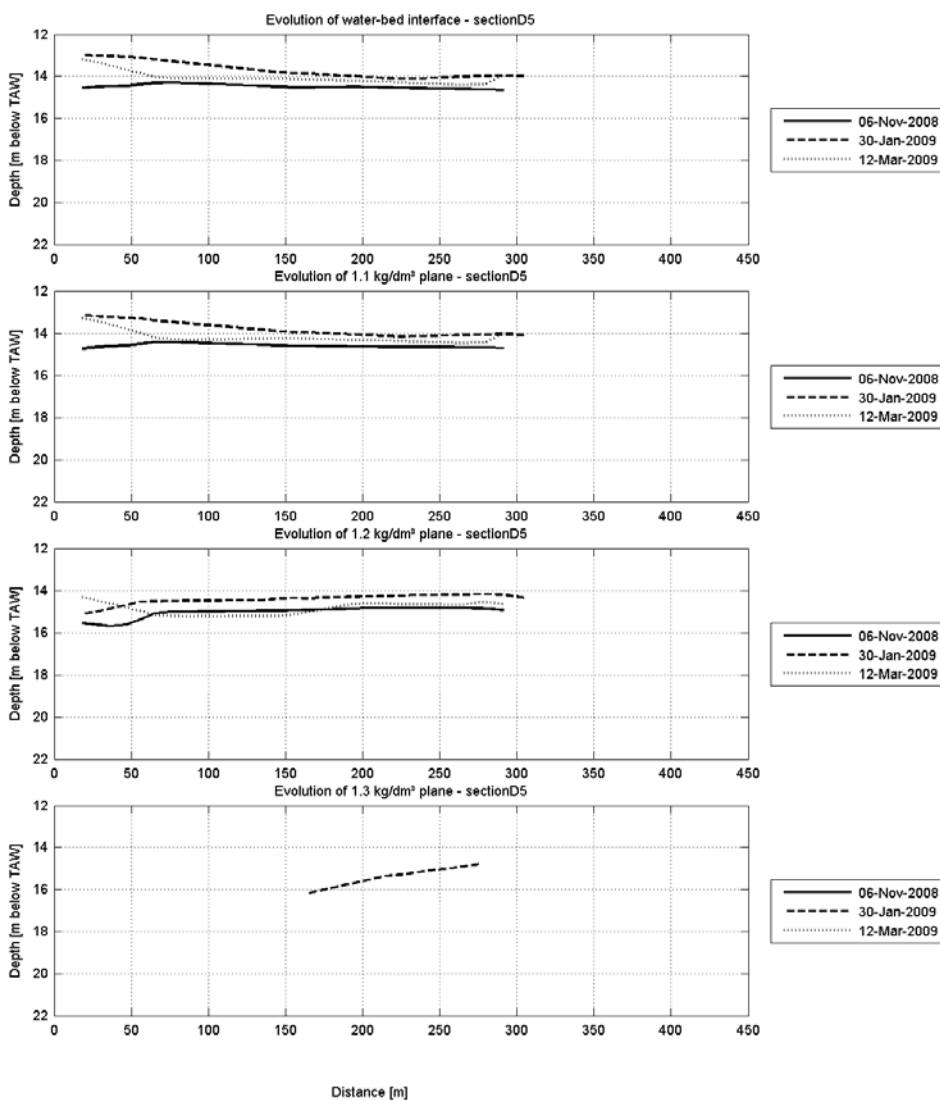
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution of planes of constant density

Equipment(s):
 NaviTracker

Location:
 DGD



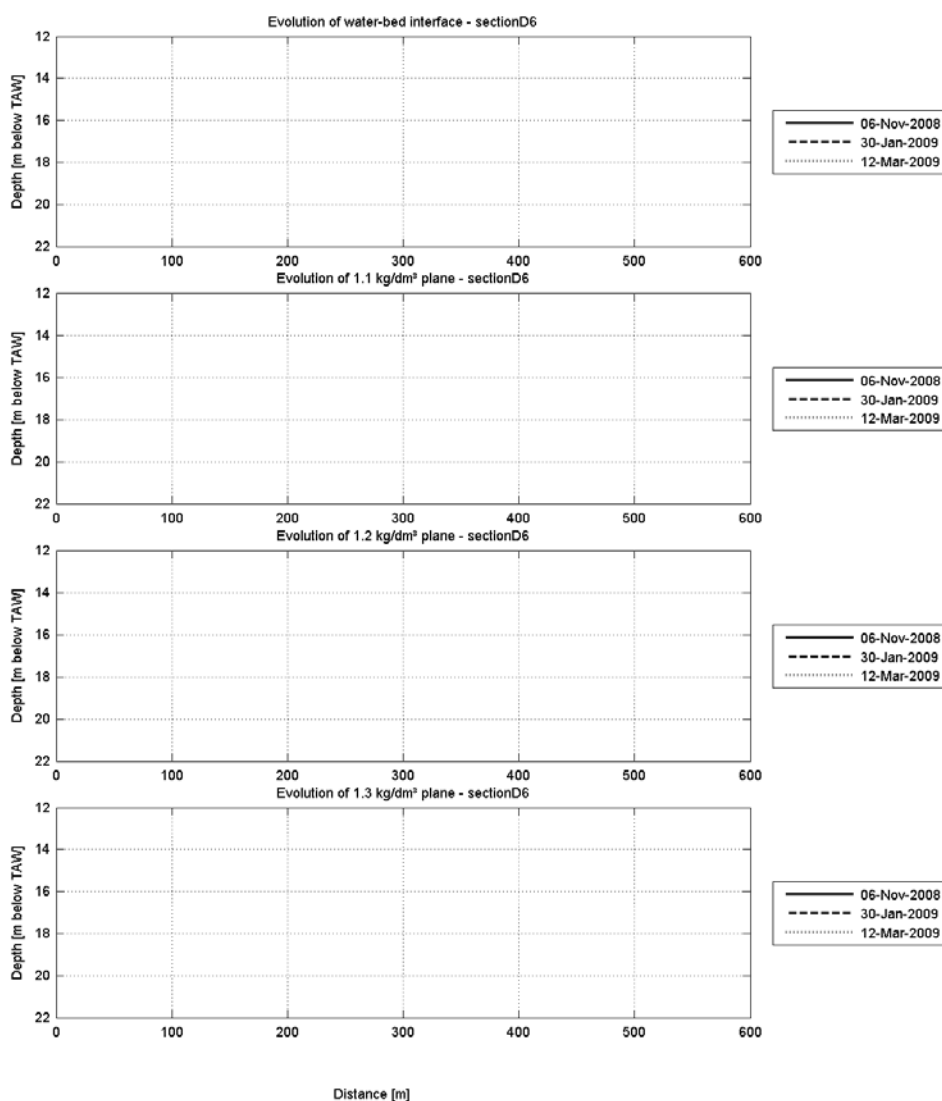
Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution of planes of constant density

Equipment(s):
 NaviTracker

Location:
 DGD



Data Processed by:



In association with:



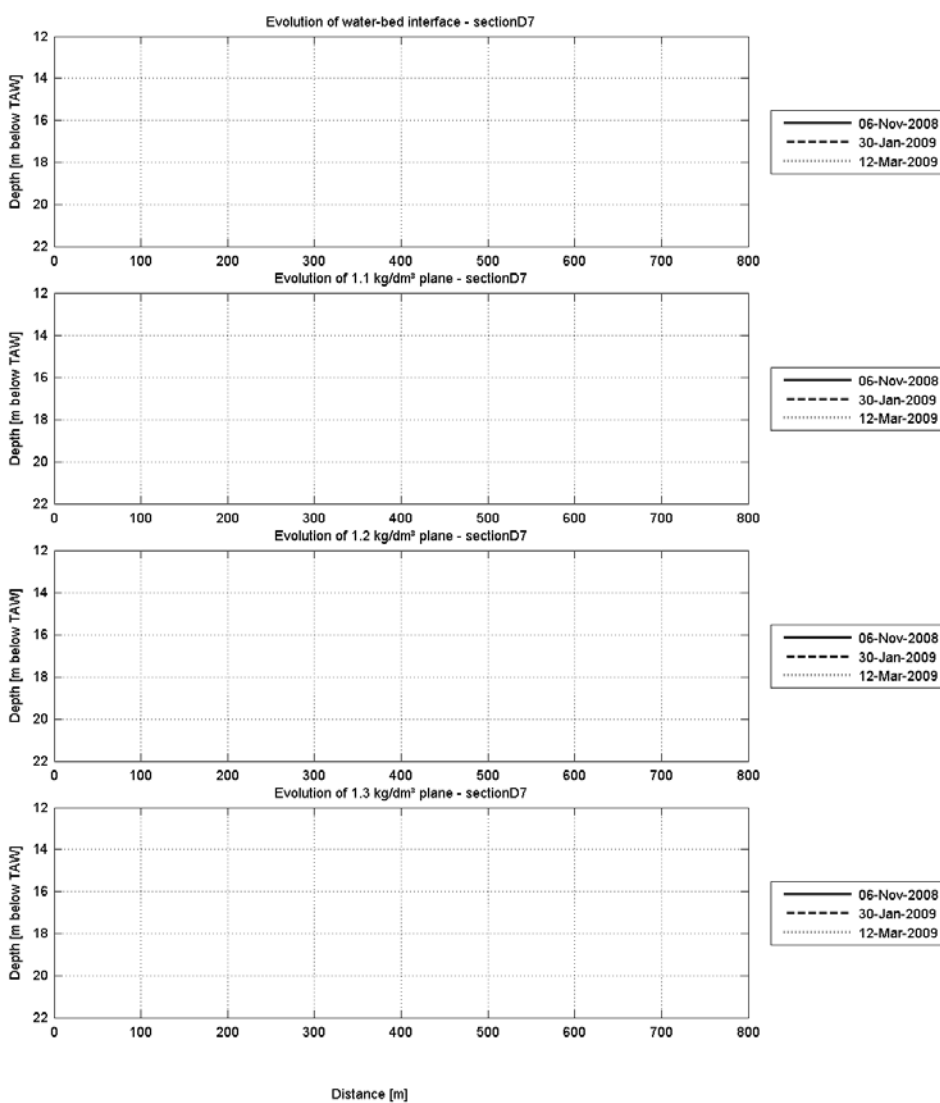
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution of planes of constant density

Equipment(s):
 NaviTracker

Location:
 DGD



Data Processed by:



In association with:



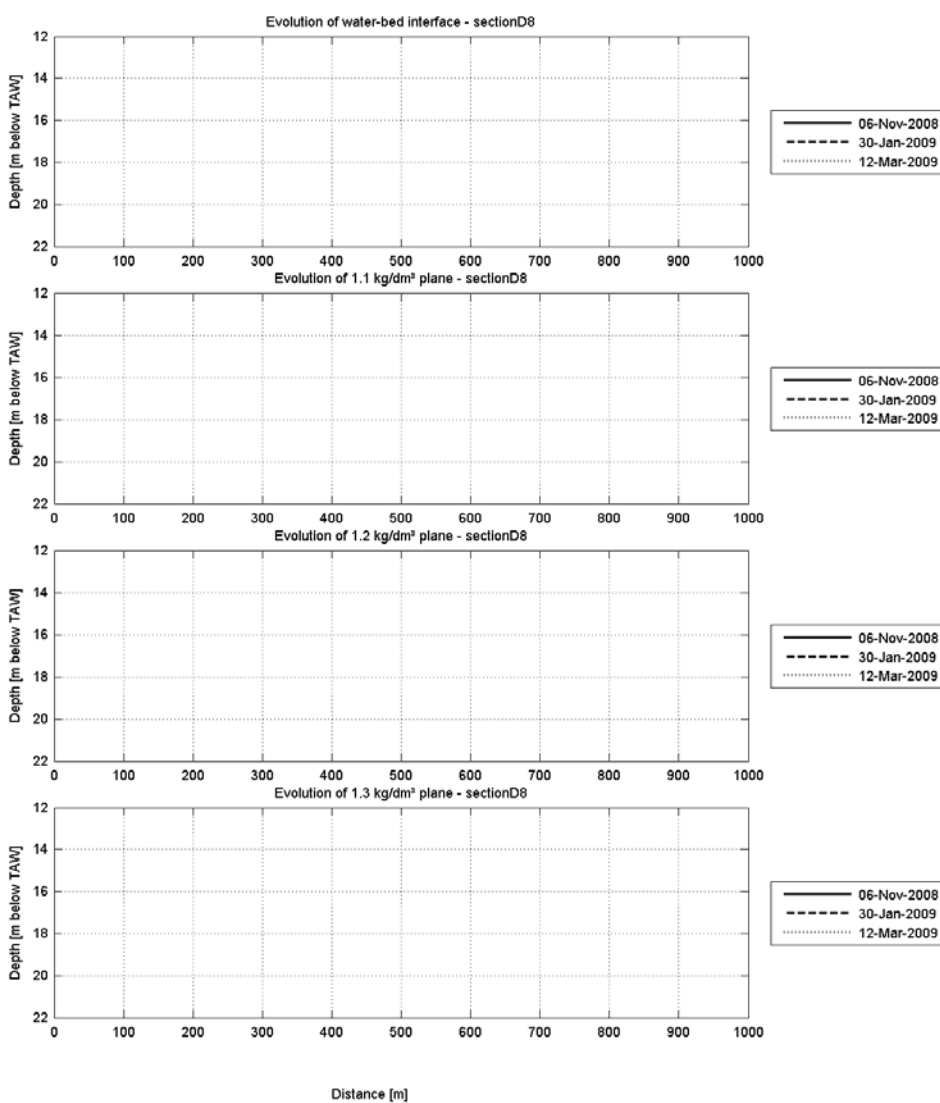
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution of planes of constant density

Equipment(s):
 NaviTracker

Location:
 DGD



Data Processed by: 
 In association with: 

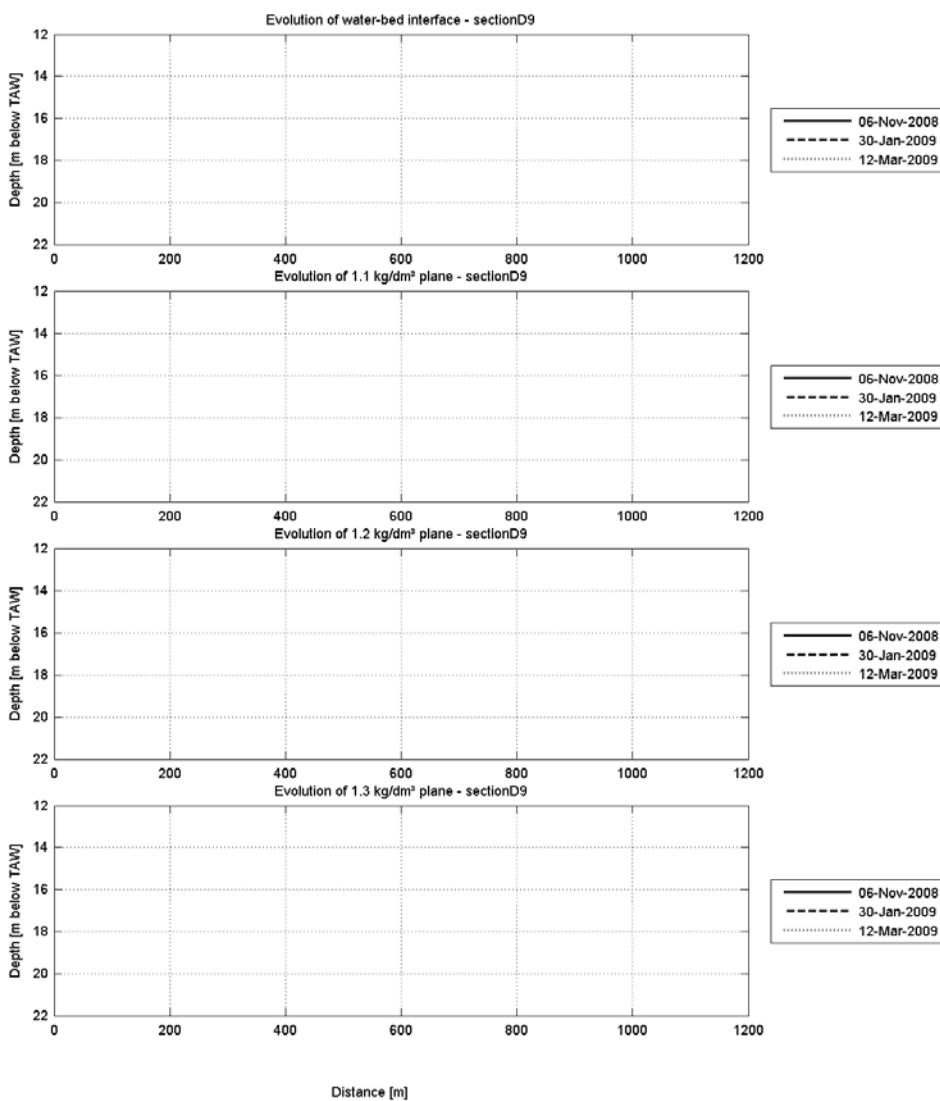
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution of planes of constant density

Equipment(s):
 NaviTracker

Location:
 DGD



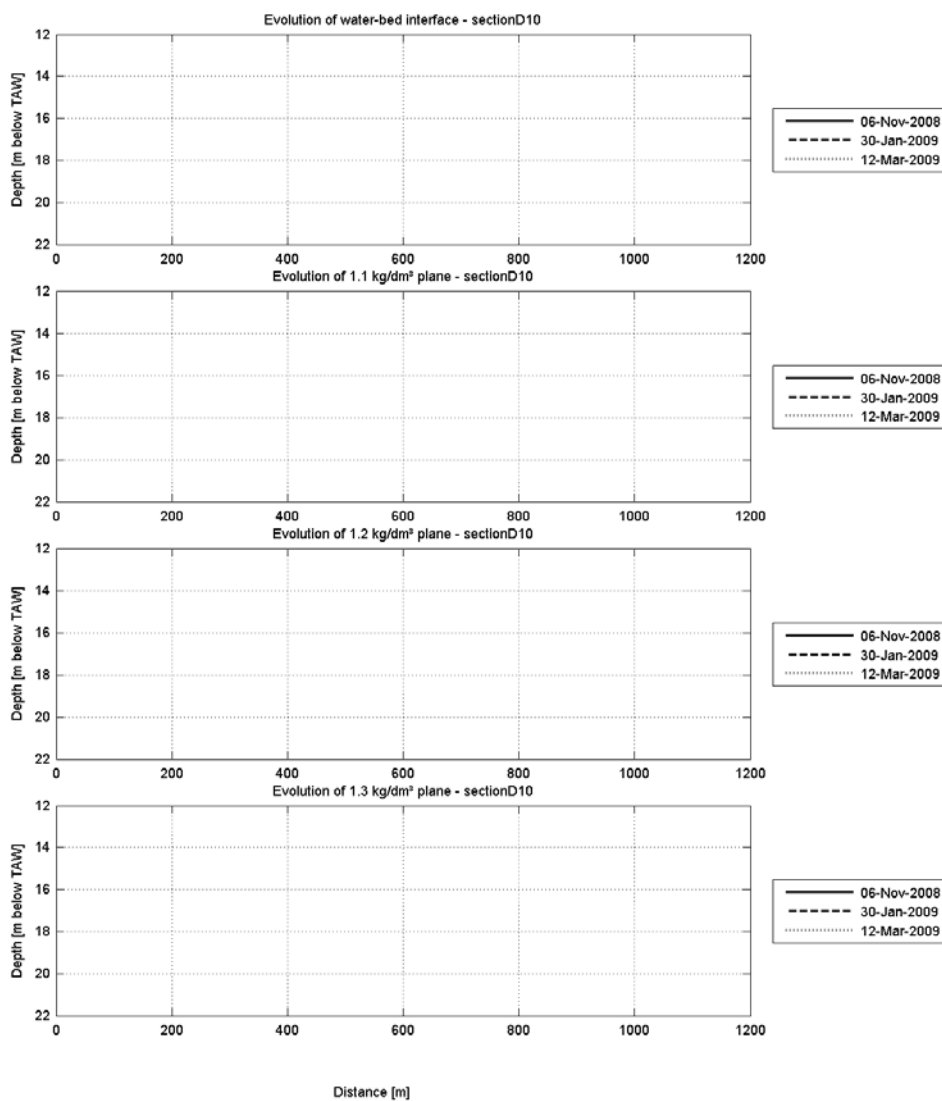
Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution of planes of constant density

Equipment(s):
 NaviTracker

Location:
 DGD



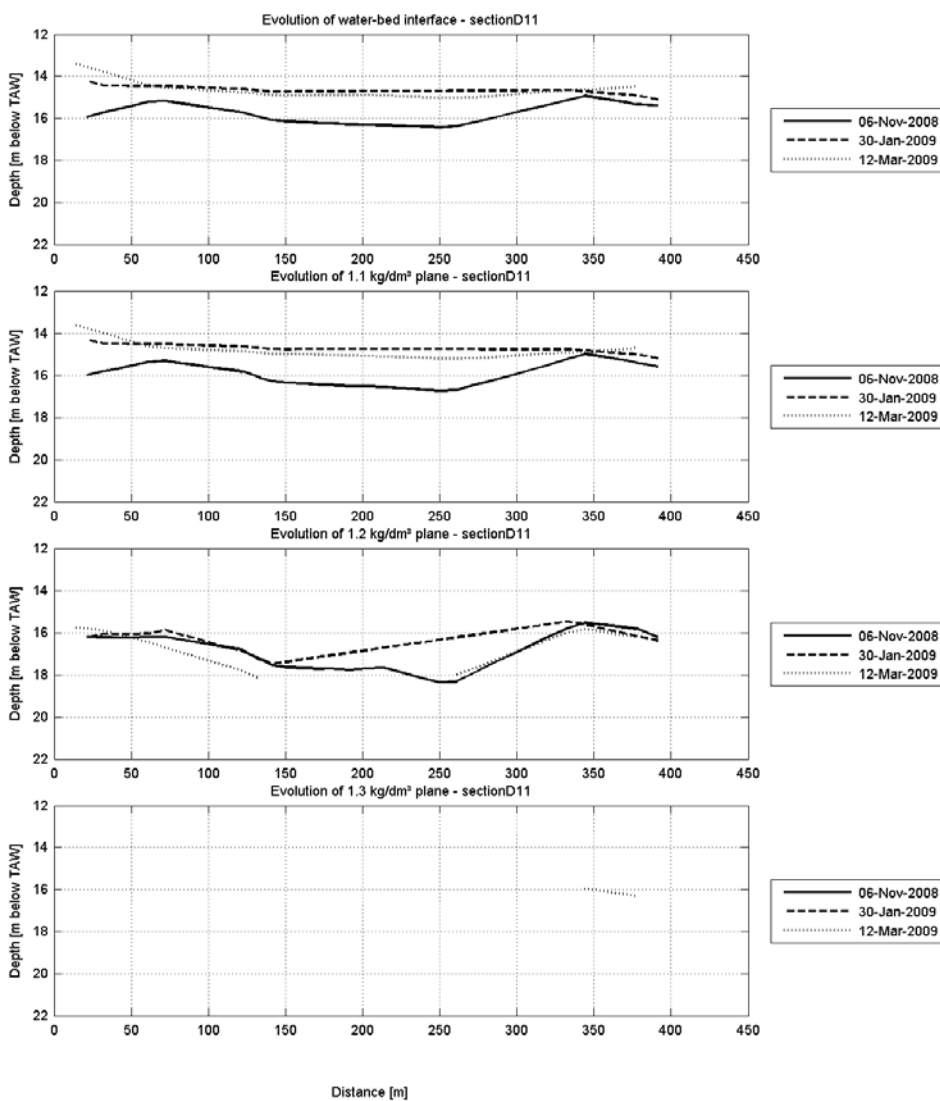
Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution of planes of constant density

Equipment(s):
 NaviTracker

Location:
 DGD



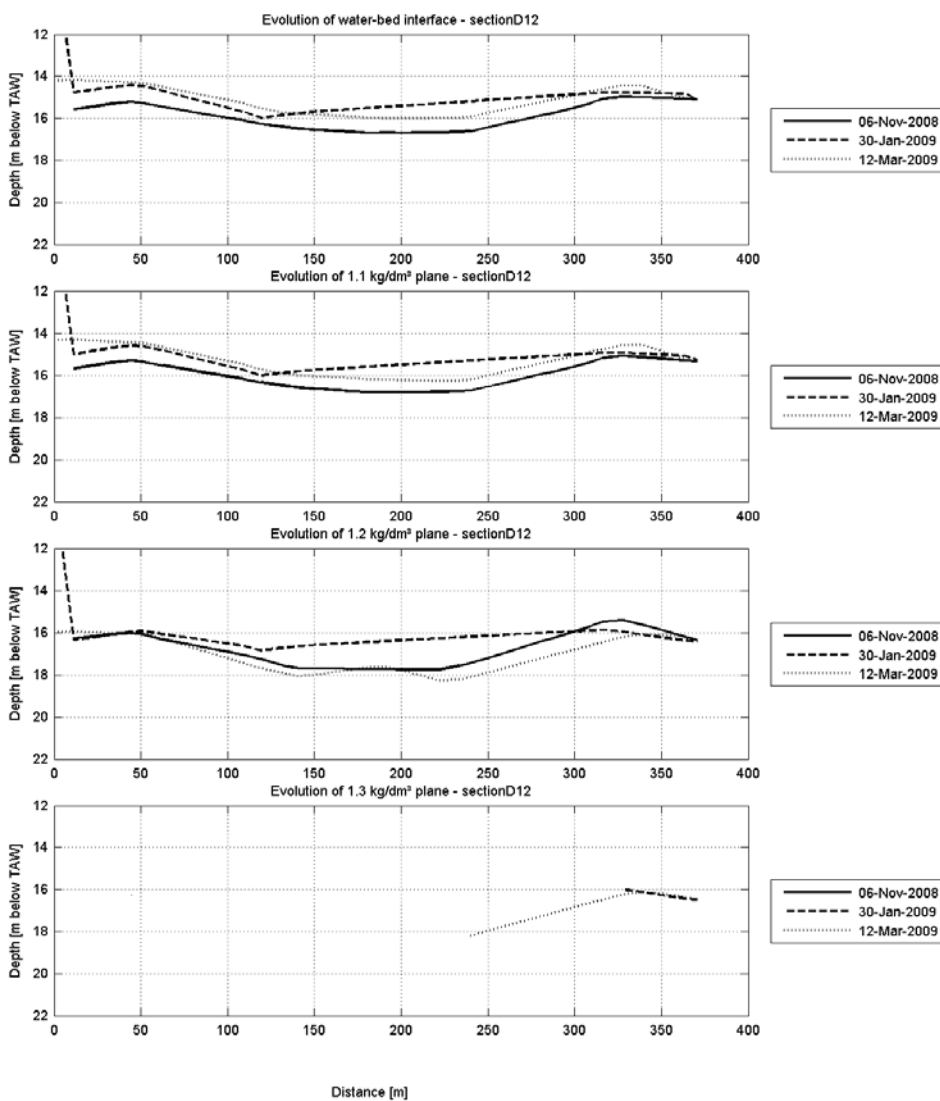
Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution of planes of constant density

Equipment(s):
 NaviTracker

Location:
 DGD



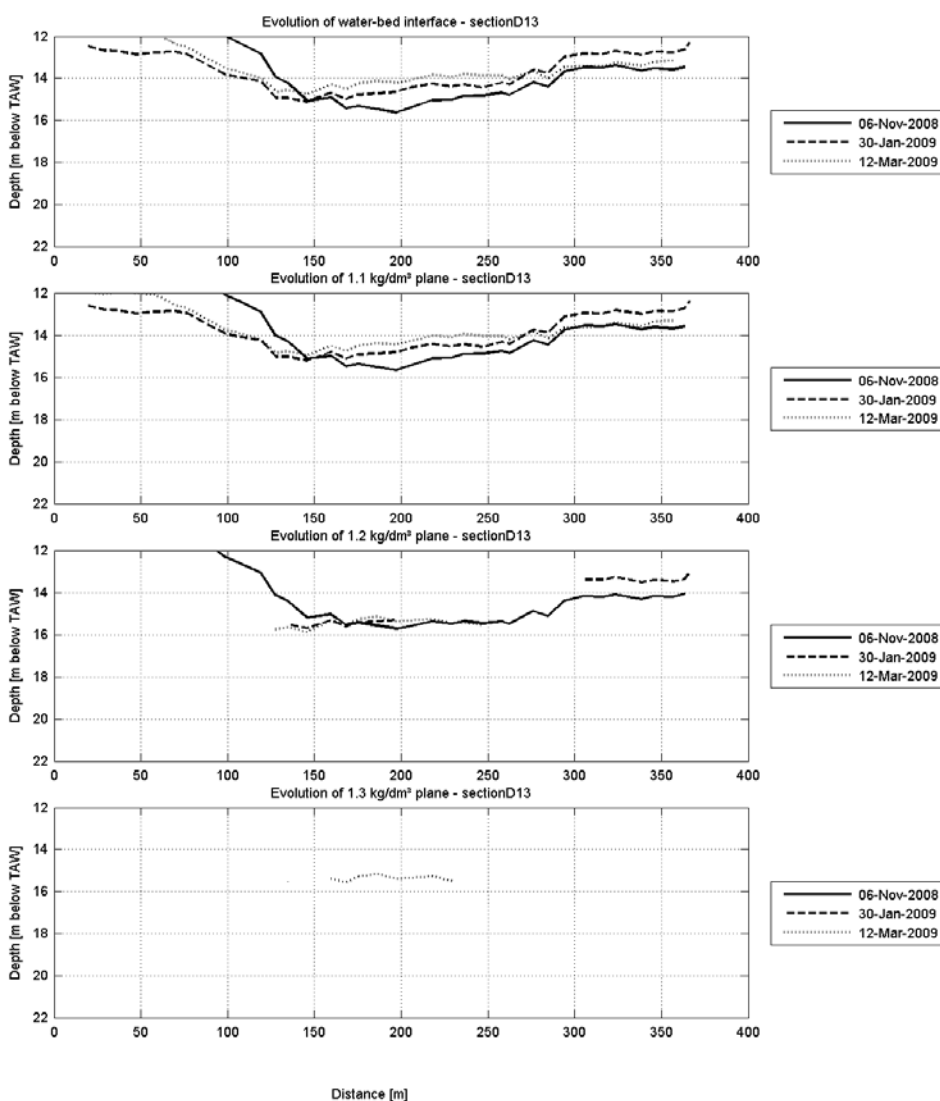
Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution of planes of constant density

Equipment(s):
 NaviTracker

Location:
 DGD



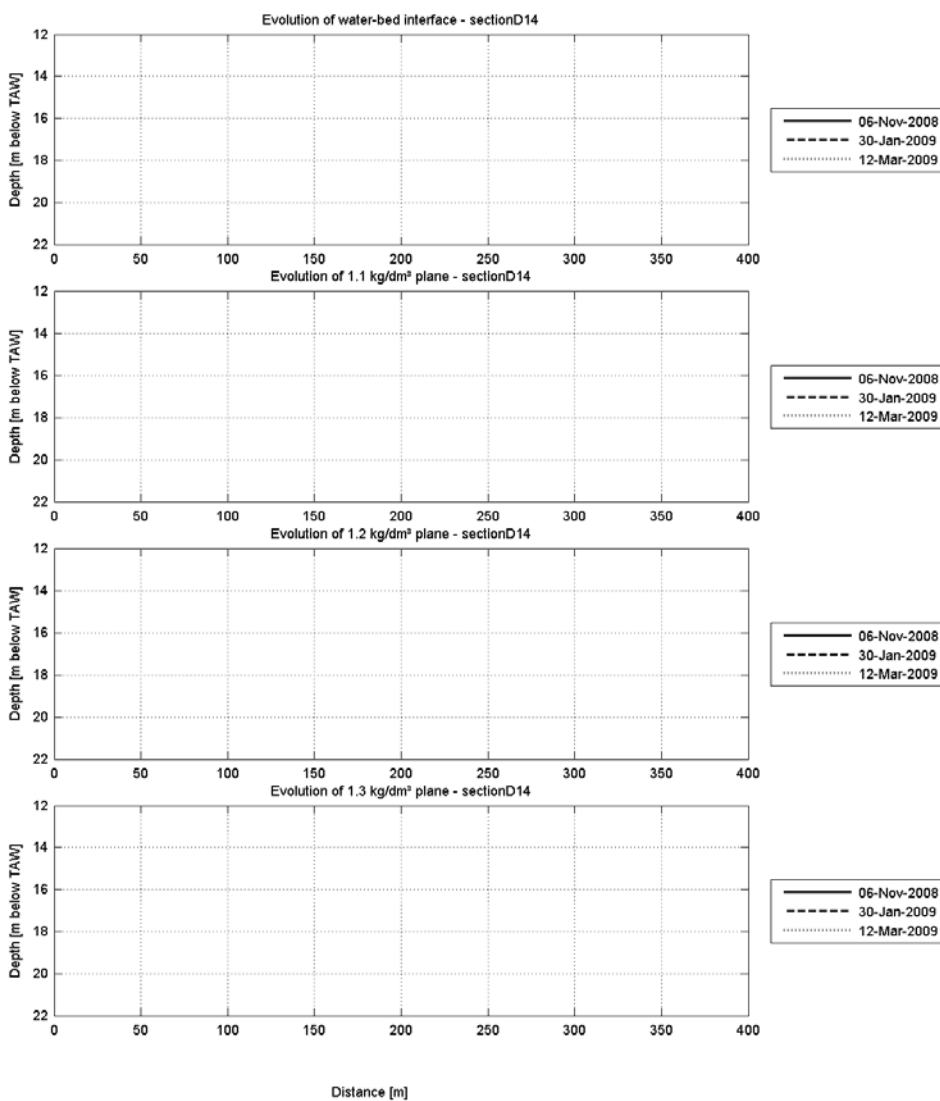
Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution of planes of constant density

Equipment(s):
 NaviTracker

Location:
 DGD



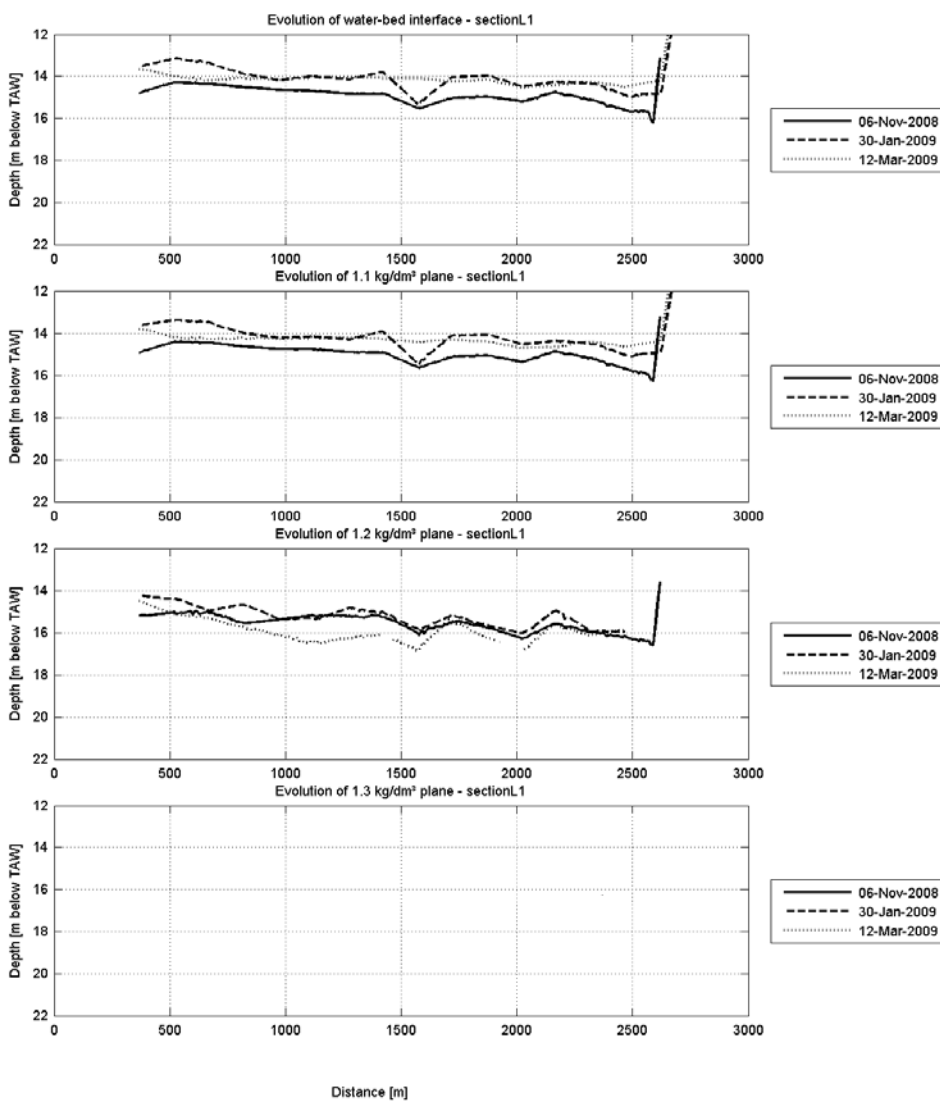
Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution of planes of constant density

Equipment(s):
 NaviTracker

Location:
 DGD



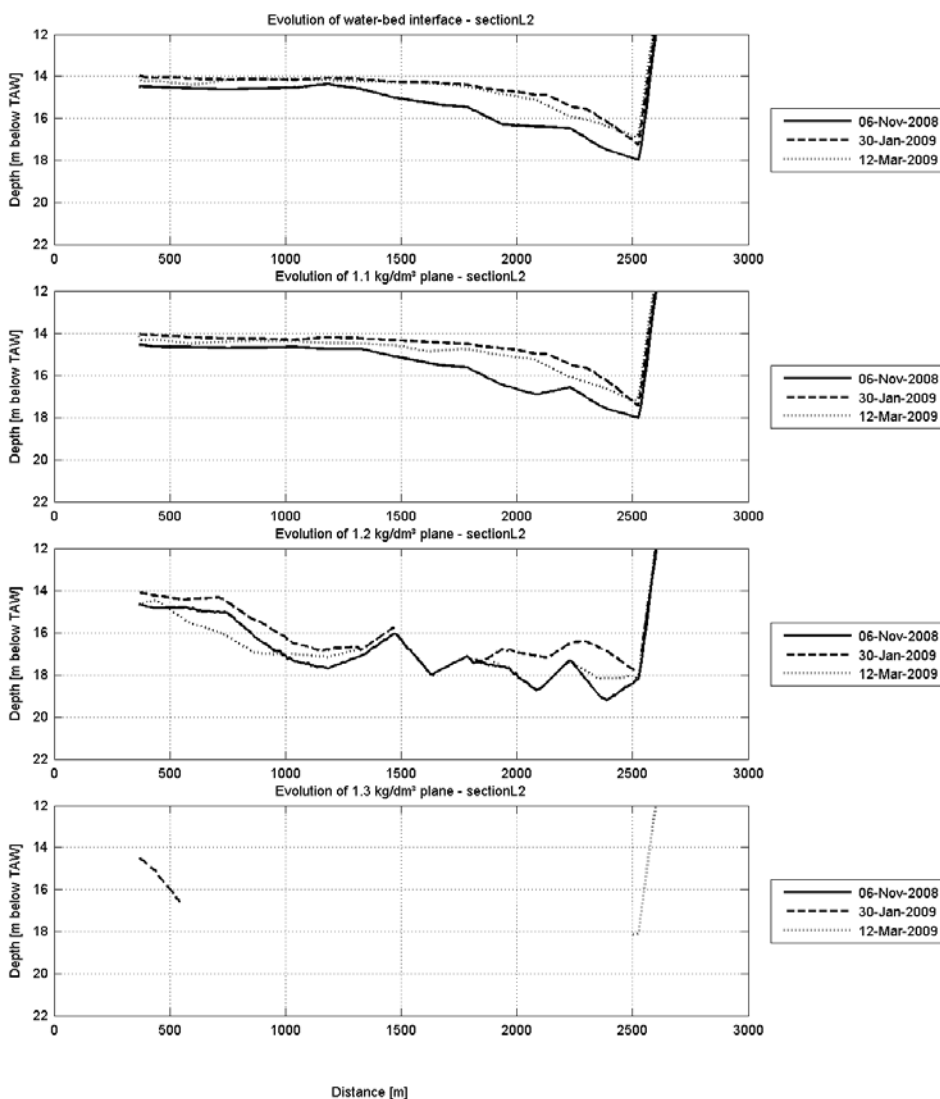
Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution of planes of constant density

Equipment(s):
 NaviTracker

Location:
 DGD



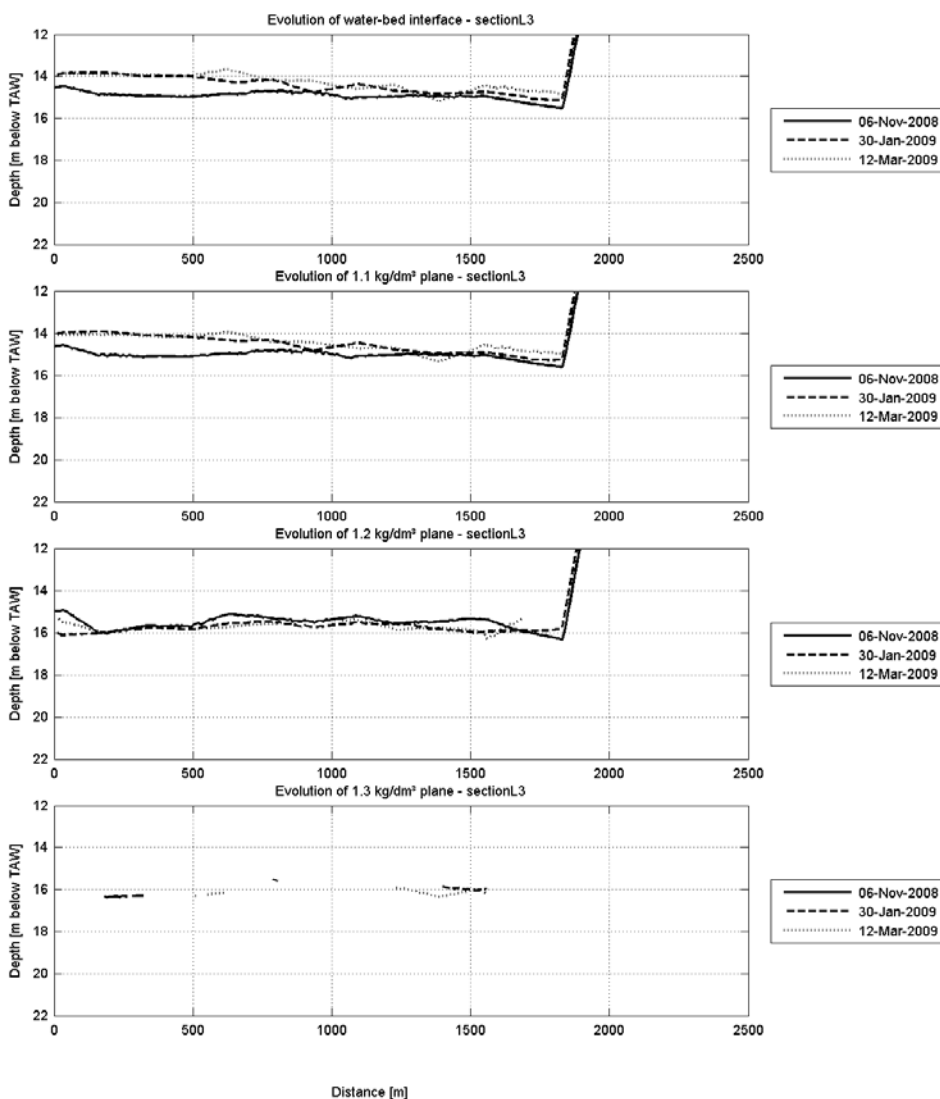
Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Evolution of planes of constant density

Equipment(s):
 NaviTracker

Location:
 DGD



Data Processed by:



In association with:



I/RA/11283/08.079/MSA

APPENDIX G.

SEDIMENT MASS DISTRIBUTION IN

DEURGANCKDOK

APPENDIX H.

AVERAGE MASS GROWTH AND GROWTH RATE

H.1 Tabular results

****Measured Mass (TDS/m²)**

| | 30-Jan-09 | 12-Mar-09 |
|-------------------------|------------------|------------------|
| 1 | - | - |
| 2 | - | - |
| 3a | 2.10 | 1.69 |
| 3b | 1.60 | 1.33 |
| 3c | 1.42 | 1.38 |
| 3d | 1.27 | 1.19 |
| 3e | 3.22 | 2.18 |
| 4Na | 1.34 | 1.02 |
| 4Nb | 1.09 | 0.89 |
| 4Nc | 0.85 | 0.87 |
| 4Nd | 0.86 | 0.80 |
| 4Ne | 1.75 | 2.37 |
| 4Za | 1.22 | 1.16 |
| 4Zb | 0.96 | 0.98 |
| 4Zc | 1.07 | 1.24 |
| 4Zd | 1.13 | 1.22 |
| 4Ze | 2.31 | 1.42 |
| 5Na | - | - |
| 5Nb | 0.90 | 1.08 |
| 5Nc | 0.69 | 1.05 |
| 5Nd | 0.67 | 0.91 |
| 5Ne | - | - |
| 5Za | - | - |
| 5Zb | 0.85 | 1.10 |
| 5Zc | 0.70 | 1.08 |
| 5Zd | 0.43 | 1.10 |
| 5Ze | - | - |
| Trench area mean | 1.57 | 1.38 |

****Cumulative dredged mass in covered area (TDS)**

| | 30-Jan-09 | 12-Mar-09 |
|--------------|------------------|------------------|
| 1 | 0 | 28 |
| 2 | 0 | 1410 |
| 3a | 0 | 57679 |
| 3b | 0 | 39184 |
| 3c | 0 | 29567 |
| 3d | 0 | 34863 |
| 3e | 0 | 2770 |
| 4Na | 0 | 16509 |
| 4Nb | 0 | 17381 |
| 4Nc | 0 | 12267 |
| 4Nd | 0 | 9062 |
| 4Ne | 0 | 90 |
| 4Za | 0 | 9845 |
| 4Zb | 0 | 11535 |
| 4Zc | 0 | 8045 |
| 4Zd | 0 | 7019 |
| 4Ze | 0 | 92 |
| 5Na | 0 | 0 |
| 5Nb | 0 | 0 |
| 5Nc | 0 | 4 |
| 5Nd | 0 | 0 |
| 5Ne | 0 | 0 |
| 5Za | 0 | 0 |
| 5Zb | 0 | 0 |
| 5Zc | 0 | 0 |
| 5Zd | 0 | 0 |
| 5Ze | 0 | 0 |
| Total | 0 | 257350 |

****Total cumulative mass(TDS/m²)**

| | 30-Jan-09 | 12-Mar-09 |
|-------------------------|------------------|------------------|
| 1 | - | - |
| 2 | - | - |
| 3a | 2.10 | 2.27 |
| 3b | 1.60 | 1.68 |
| 3c | 1.42 | 1.68 |
| 3d | 1.27 | 1.46 |
| 3e | 3.22 | 2.21 |
| 4Na | 1.34 | 1.47 |
| 4Nb | 1.09 | 1.44 |
| 4Nc | 0.85 | 1.35 |
| 4Nd | 0.86 | 1.08 |
| 4Ne | 1.75 | 2.37 |
| 4Za | 1.22 | 1.56 |
| 4Zb | 0.96 | 1.35 |
| 4Zc | 1.07 | 1.55 |
| 4Zd | 1.13 | 1.44 |
| 4Ze | 2.31 | 1.42 |
| 5Na | - | - |
| 5Nb | 0.90 | 1.08 |
| 5Nc | 0.69 | 1.05 |
| 5Nd | 0.67 | 0.91 |
| 5Ne | - | - |
| 5Za | - | - |
| 5Zb | 0.85 | 1.10 |
| 5Zc | 0.70 | 1.08 |
| 5Zd | 0.43 | 1.10 |
| 5Ze | - | - |
| Trench area mean | 1.57 | 1.75 |

****Growth rate (kg/m²/day)**

| | 6-Nov-2008 / 30-Jan-2009 | 30-Jan-2009 / 12-Mar-2009 |
|-------------------------|-------------------------------------|--------------------------------------|
| 1 | - | - |
| 2 | - | - |
| 3a | 4.74 | 4.24 |
| 3b | 2.75 | 1.92 |
| 3c | 2.51 | 6.45 |
| 3d | 4.43 | 4.56 |
| 3e | 23.34 | -24.65 |
| 4Na | 3.87 | 3.35 |
| 4Nb | 2.36 | 8.61 |
| 4Nc | 0.75 | 12.23 |
| 4Nd | 2.63 | 5.49 |
| 4Ne | - | 15.19 |
| 4Za | 4.31 | 8.43 |
| 4Zb | 2.46 | 9.56 |
| 4Zc | 1.61 | 11.56 |
| 4Zd | 3.79 | 7.39 |
| 4Ze | 11.88 | -21.58 |
| 5Na | - | - |
| 5Nb | 2.44 | 4.31 |
| 5Nc | 1.06 | 8.73 |
| 5Nd | 3.34 | 6.05 |
| 5Ne | - | - |
| 5Za | - | - |
| 5Zb | 4.29 | 6.13 |
| 5Zc | -0.43 | 9.18 |
| 5Zd | -1.22 | 16.48 |
| 5Ze | - | - |
| Trench area mean | 3.64 | 4.25 |

****Covered Area (ha)**

| | 30-Jan-09 | | 12-Mar-09 | |
|--------------|-----------|-----|-----------|-----|
| | (ha) | (%) | (ha) | (%) |
| 1 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 |
| 3a | 8.93 | 90 | 8.62 | 87 |
| 3b | 10.99 | 100 | 10.99 | 100 |
| 3c | 9.91 | 100 | 9.91 | 100 |
| 3d | 13.06 | 100 | 13.06 | 100 |
| 3e | 8.06 | 62 | 8.01 | 62 |
| 4Na | 3.29 | 90 | 3.3 | 91 |
| 4Nb | 3.12 | 100 | 3.12 | 100 |
| 4Nc | 2.57 | 100 | 2.57 | 100 |
| 4Nd | 3.28 | 100 | 3.28 | 100 |
| 4Ne | 2.04 | 62 | 2 | 61 |
| 4Za | 1.69 | 70 | 1.6 | 66 |
| 4Zb | 3.12 | 100 | 3.12 | 100 |
| 4Zc | 2.59 | 100 | 2.59 | 100 |
| 4Zd | 3.23 | 100 | 3.23 | 100 |
| 4Ze | 1.8 | 58 | 1.76 | 57 |
| 5Na | 0.96 | 42 | 0.94 | 41 |
| 5Nb | 1.08 | 54 | 1.2 | 60 |
| 5Nc | 1.04 | 58 | 1.26 | 70 |
| 5Nd | 1.28 | 54 | 1.73 | 73 |
| 5Ne | 0.67 | 28 | 0.91 | 38 |
| 5Za | 0.51 | 39 | 0.53 | 40 |
| 5Zb | 1.42 | 71 | 1.46 | 73 |
| 5Zc | 1.42 | 79 | 1.37 | 76 |
| 5Zd | 2.04 | 85 | 1.5 | 62 |
| 5Ze | 0.91 | 38 | 0.5 | 21 |
| Total | 89 | 70 | 88.5 | 70 |

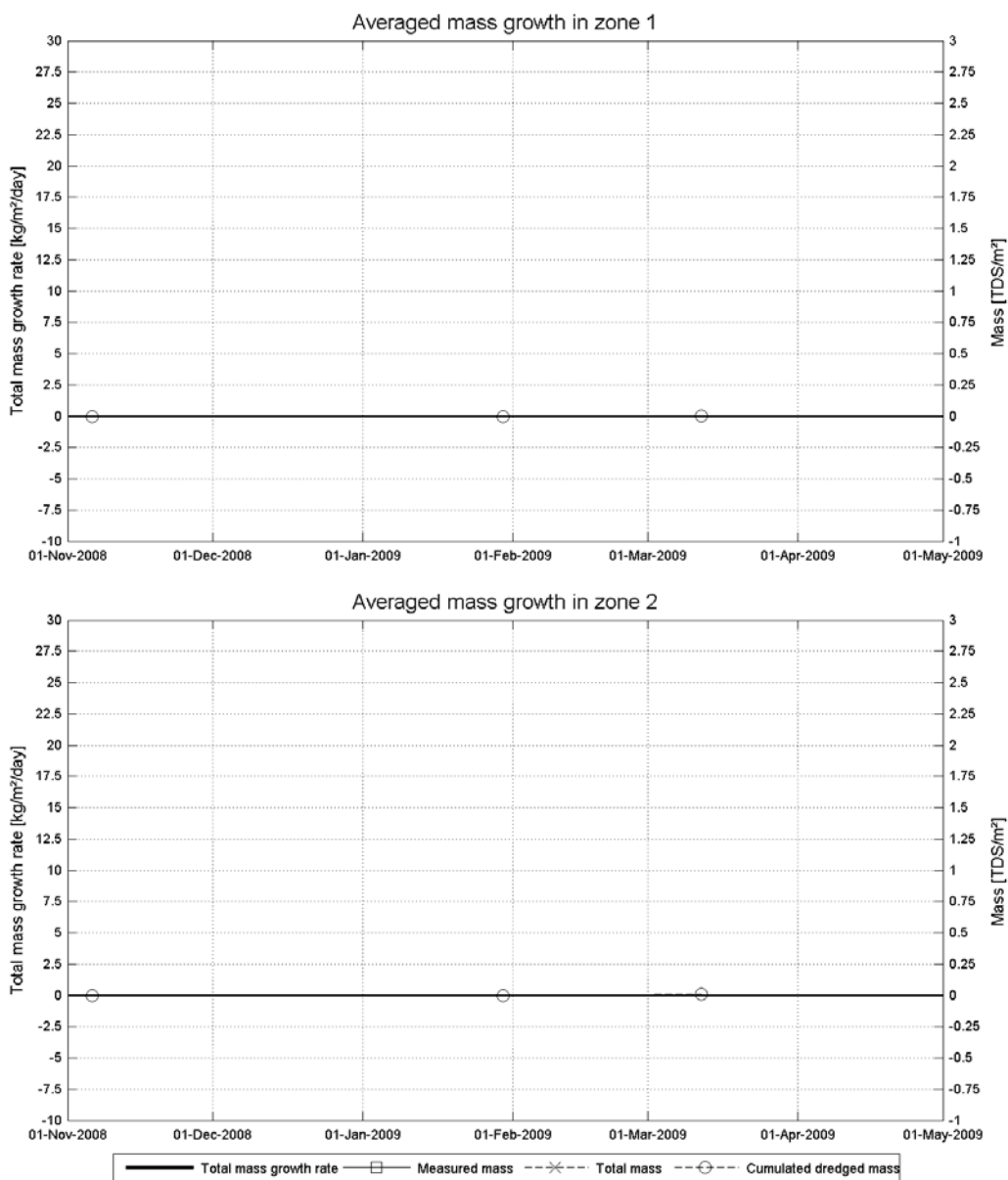
H.2 For each zone

Long-term monitoring siltation Deurganckdok

Measured/Dredged/Total Mass

Equipment(s):
 NaviTracker

Location:
 DGD



Data Processed by:



In association with:



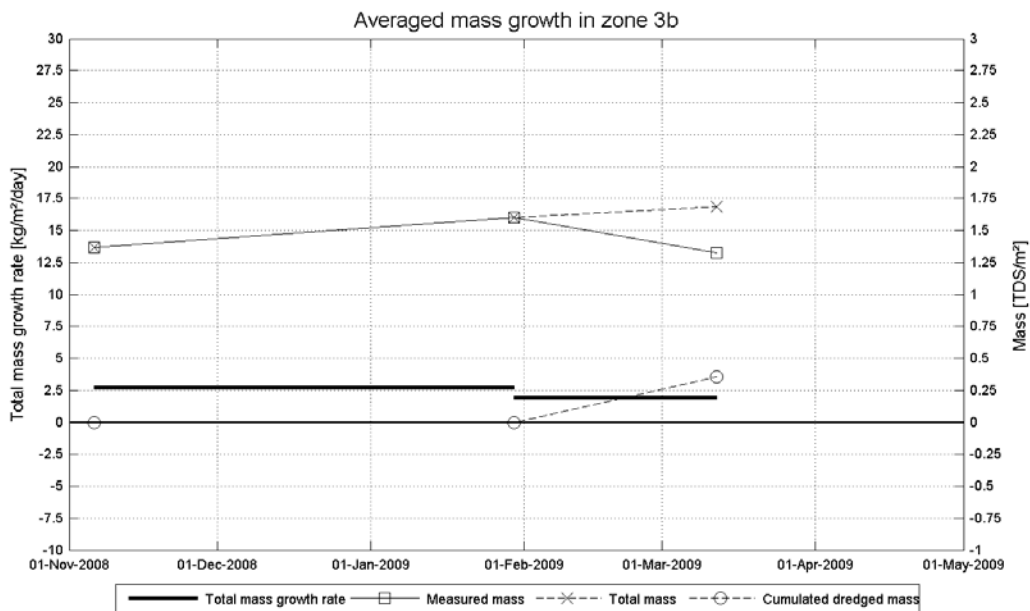
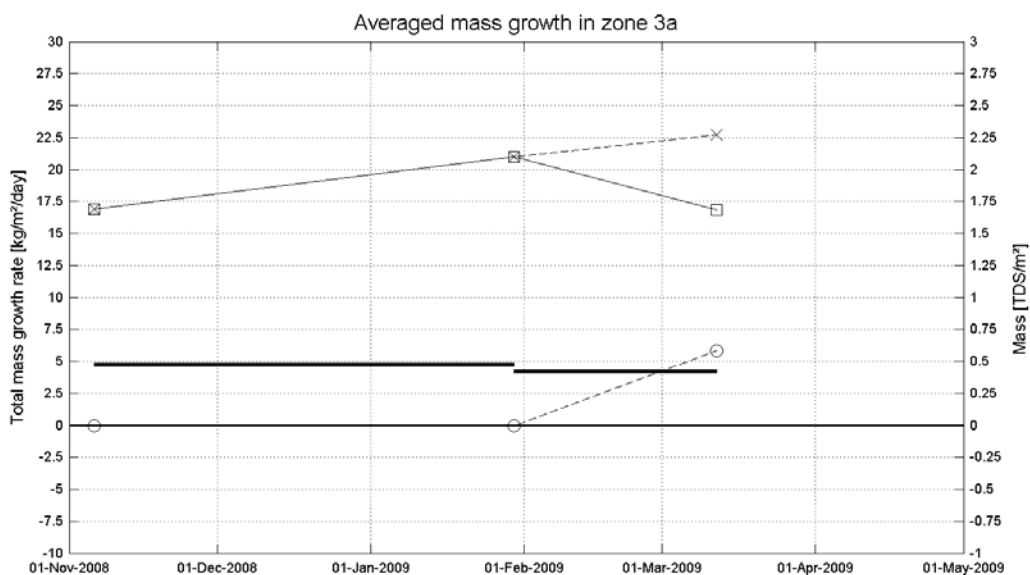
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Measured/Dredged/Total Mass

Equipment(s):
 NaviTracker

Location:
 DGD



Total mass growth rate
 Measured mass
 Total mass
 Cumulated dredged mass

Data Processed by:



In association with:



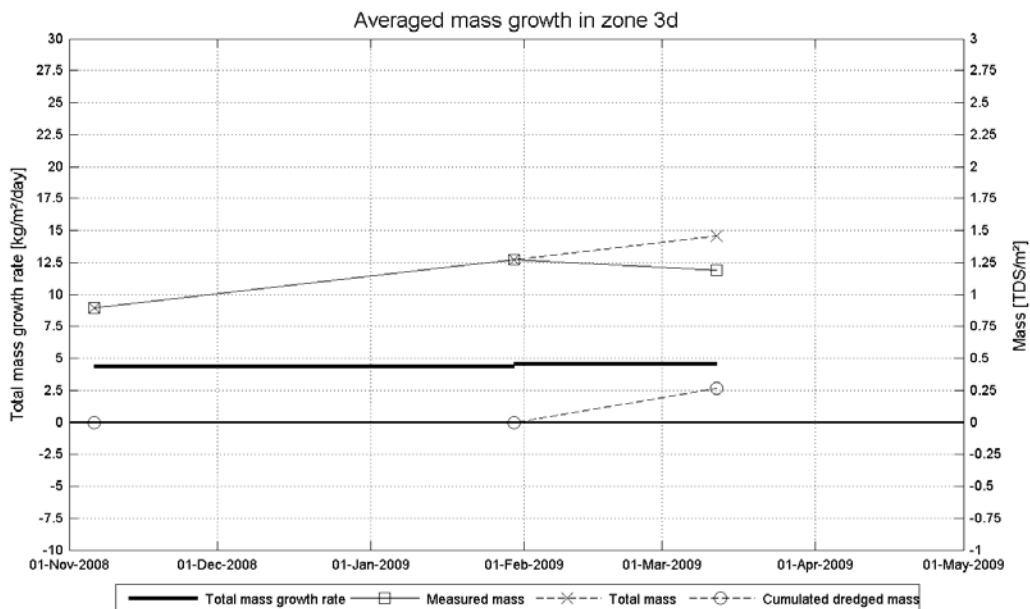
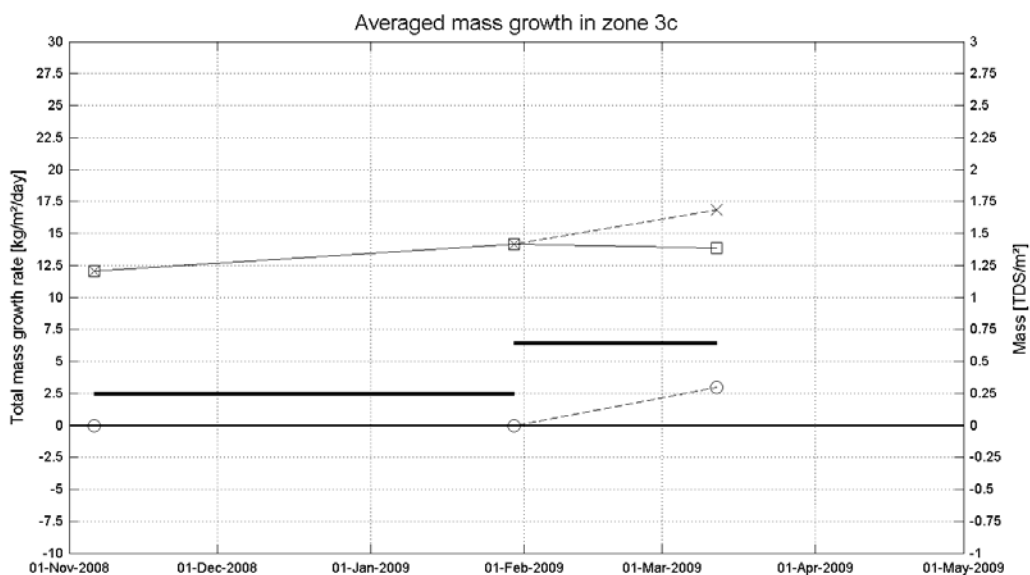
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Measured/Dredged/Total Mass

Equipment(s):
 NaviTracker

Location:
 DGD



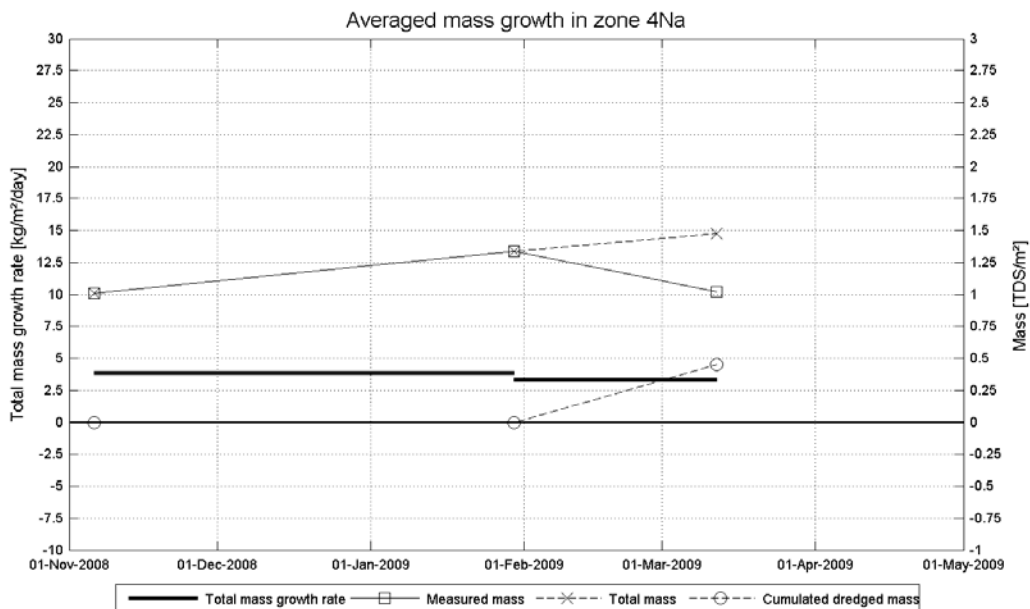
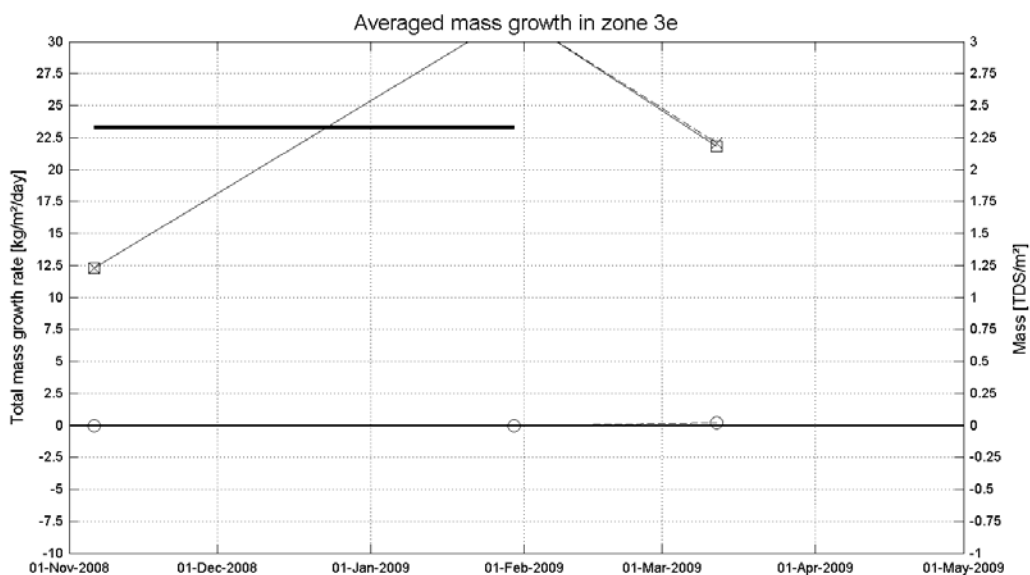
Data Processed by: 
 In association with: 
 I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Measured/Dredged/Total Mass

Equipment(s):
 NaviTracker

Location:
 DGD



Data Processed by:



In association with:



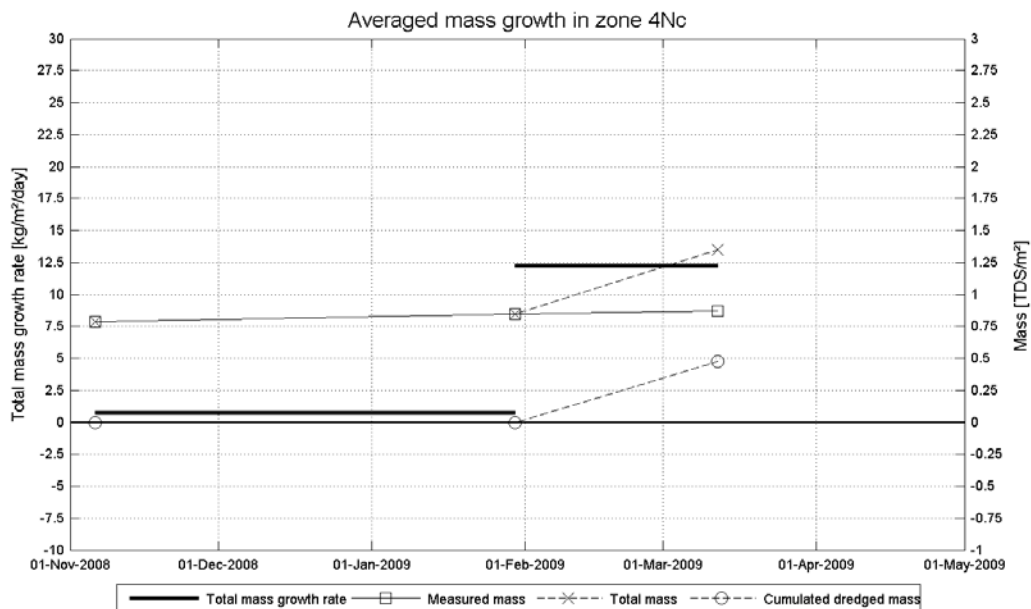
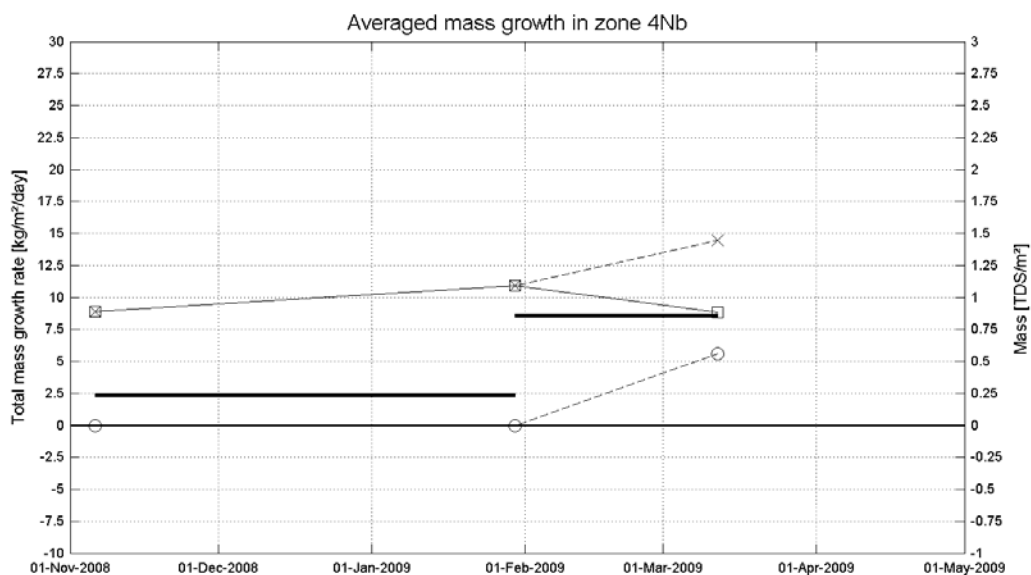
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Measured/Dredged/Total Mass

Equipment(s):
NaviTracker

Location:
DGD



Data Processed by:



In association with:



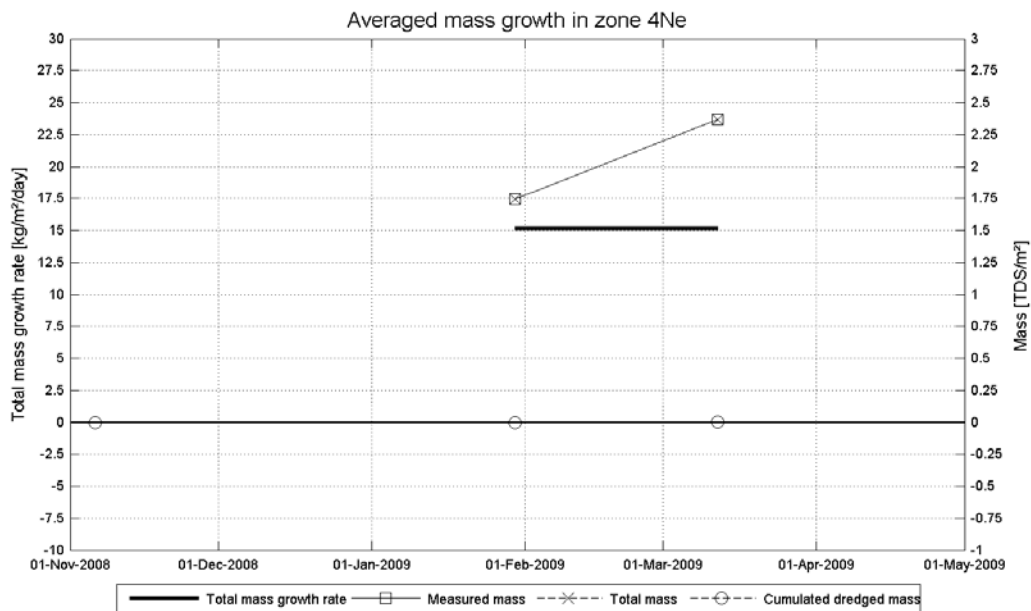
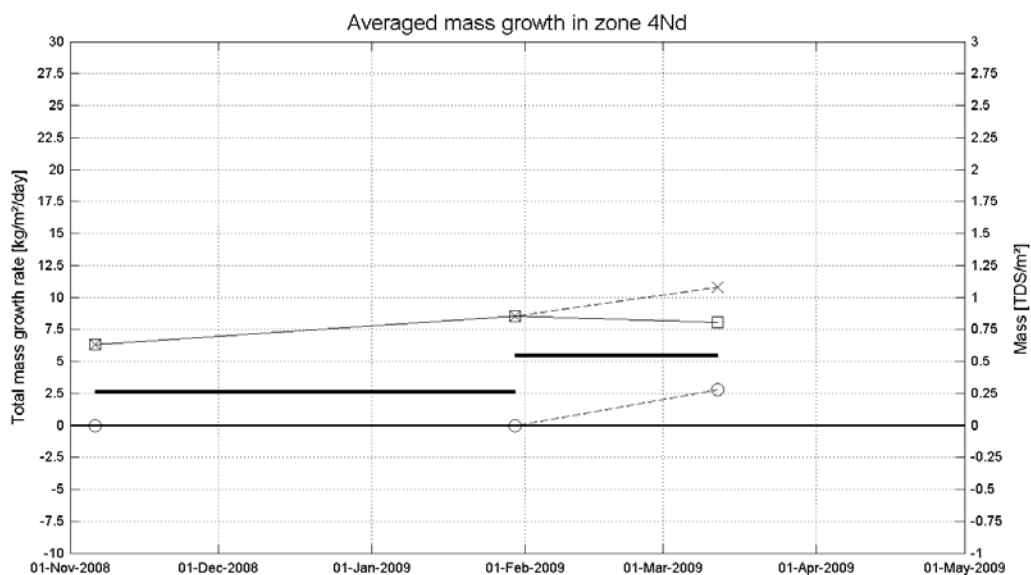
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Measured/Dredged/Total Mass

Equipment(s):
 NaviTracker

Location:
 DGD



Total mass growth rate
 Measured mass
 Total mass
 Cumulated dredged mass

Data Processed by:



In association with:



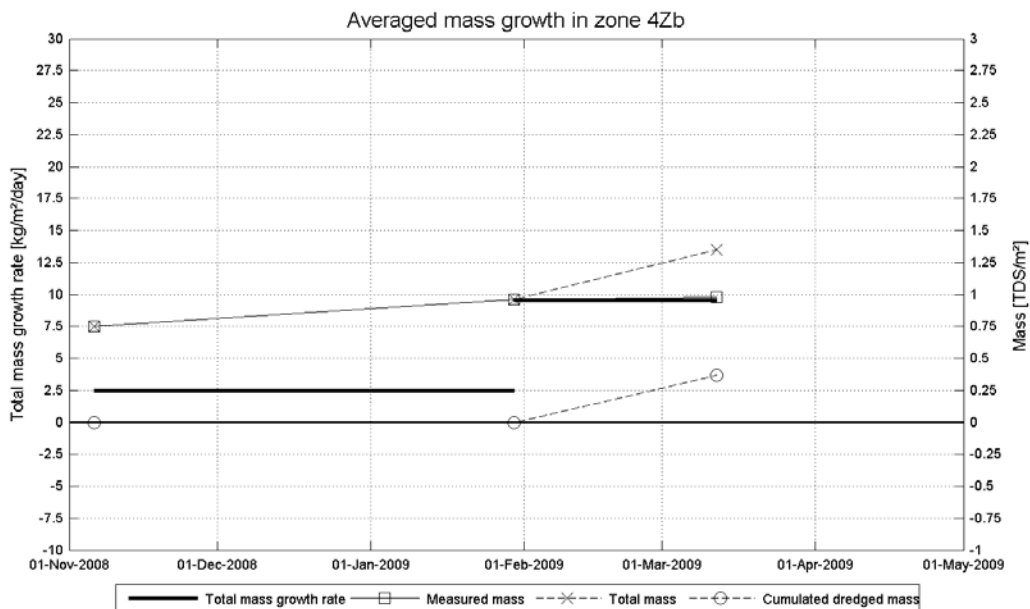
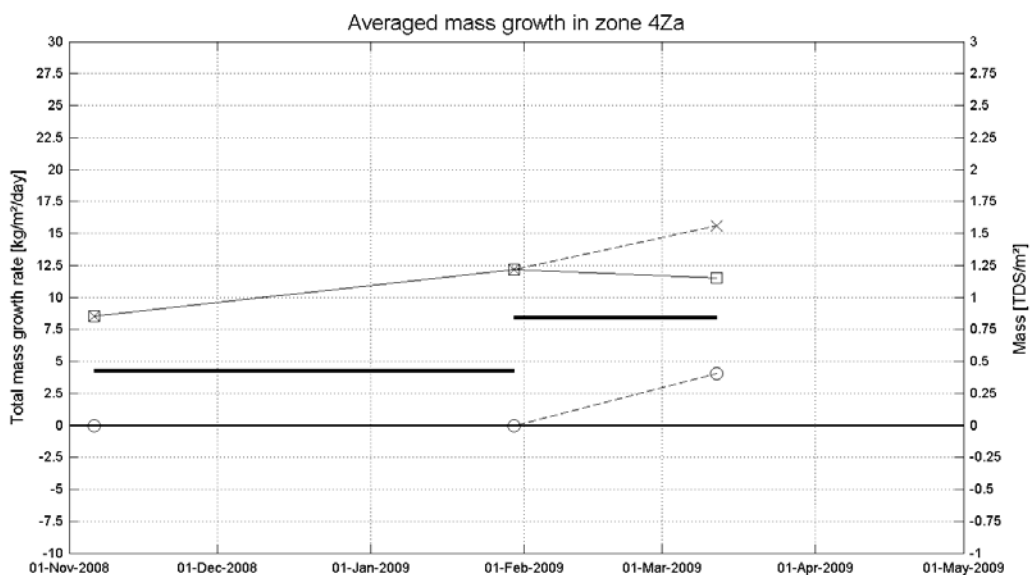
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Measured/Dredged/Total Mass

Equipment(s):
NaviTracker

Location:
DGD



Data Processed by:



In association with:



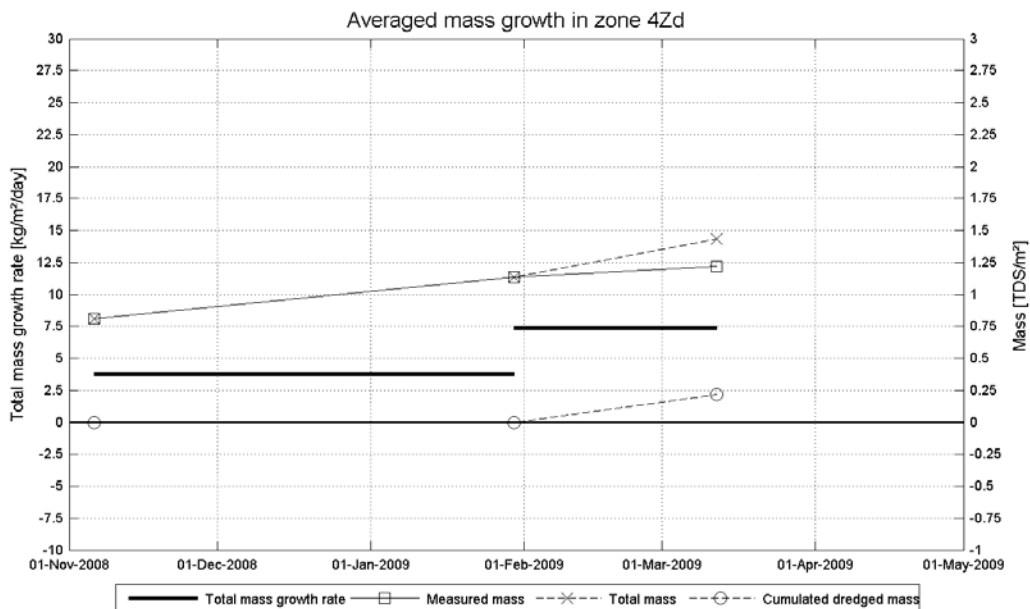
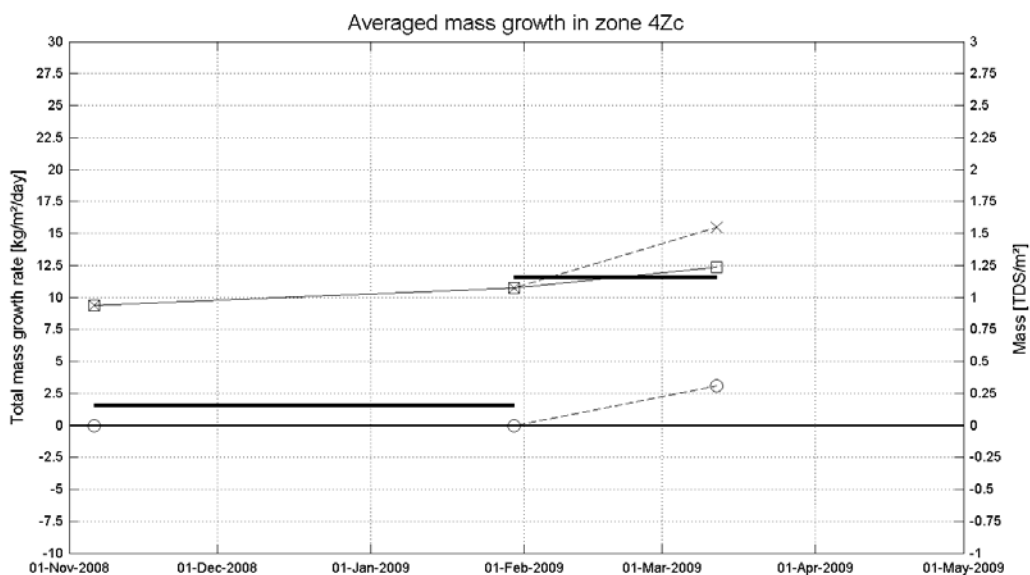
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Measured/Dredged/Total Mass

Equipment(s):
 NaviTracker

Location:
 DGD



Data Processed by:



In association with:



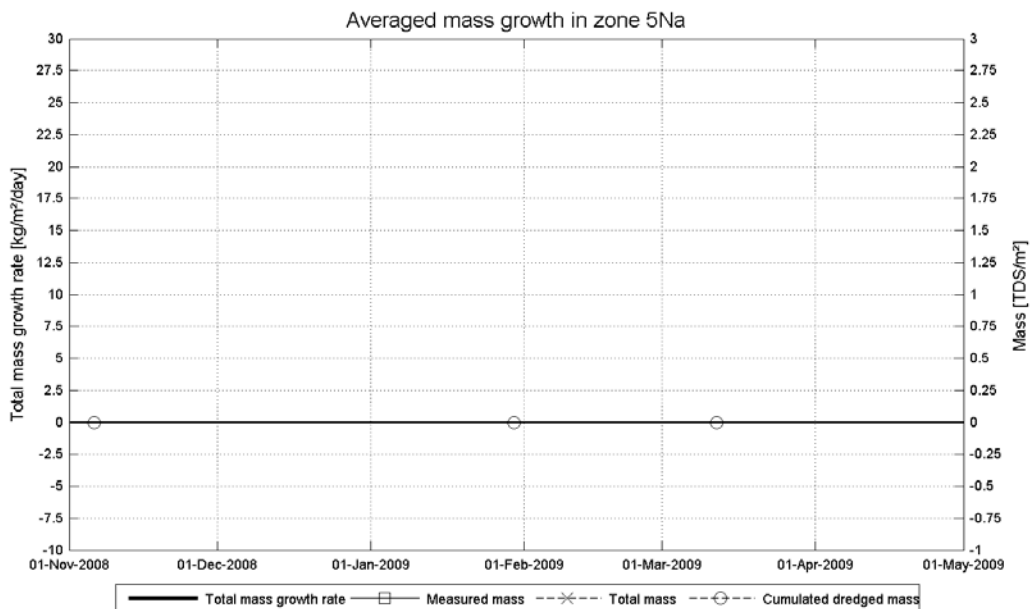
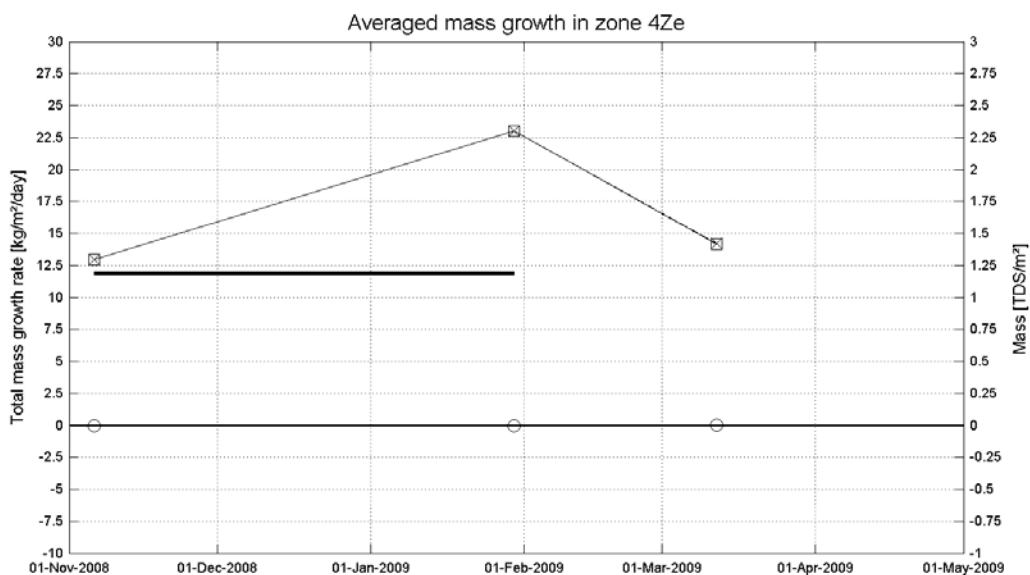
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Measured/Dredged/Total Mass

Equipment(s):
 NaviTracker

Location:
 DGD



Data Processed by:



In association with:



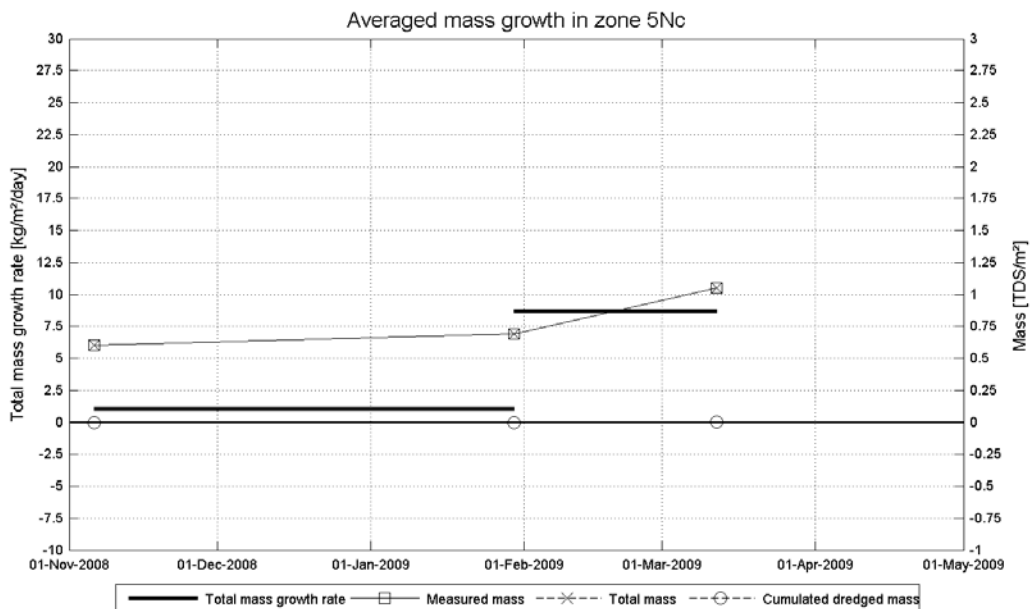
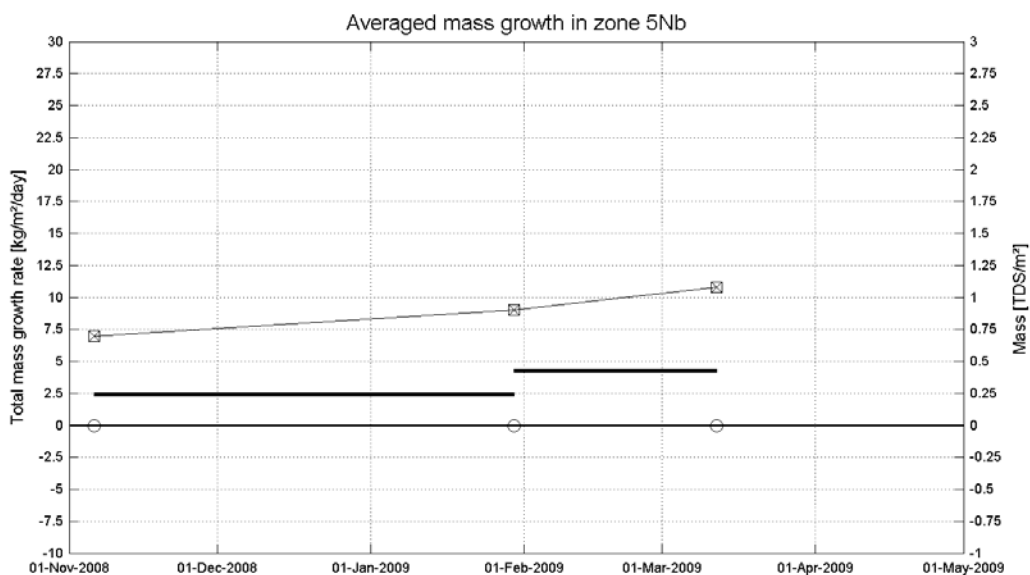
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Measured/Dredged/Total Mass

Equipment(s):
 NaviTracker

Location:
 DGD



Total mass growth rate
 □ Measured mass
 - - x - - Total mass
 - - o - - Cumulated dredged mass

Data Processed by:



In association with:



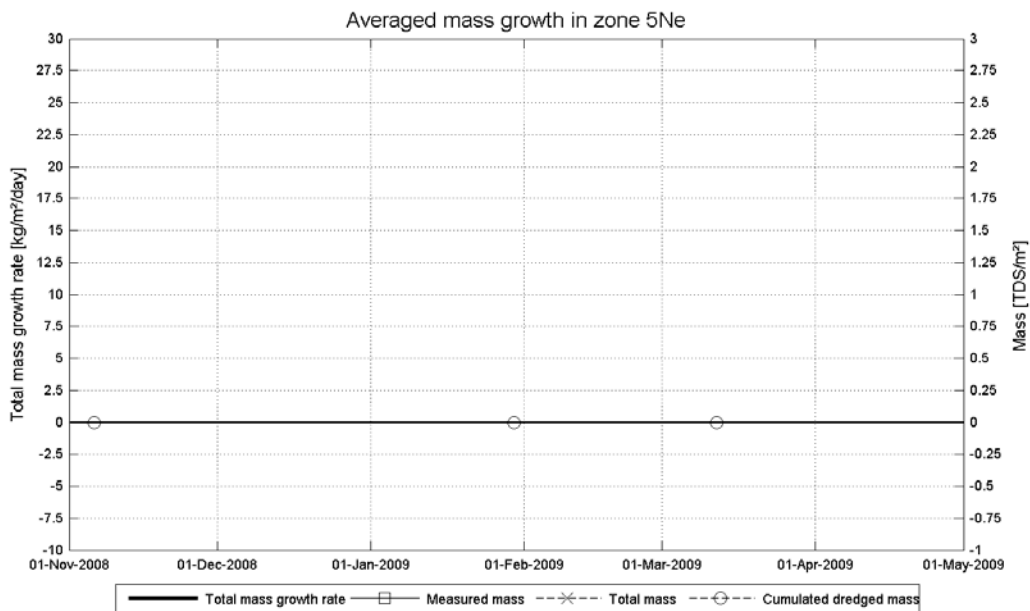
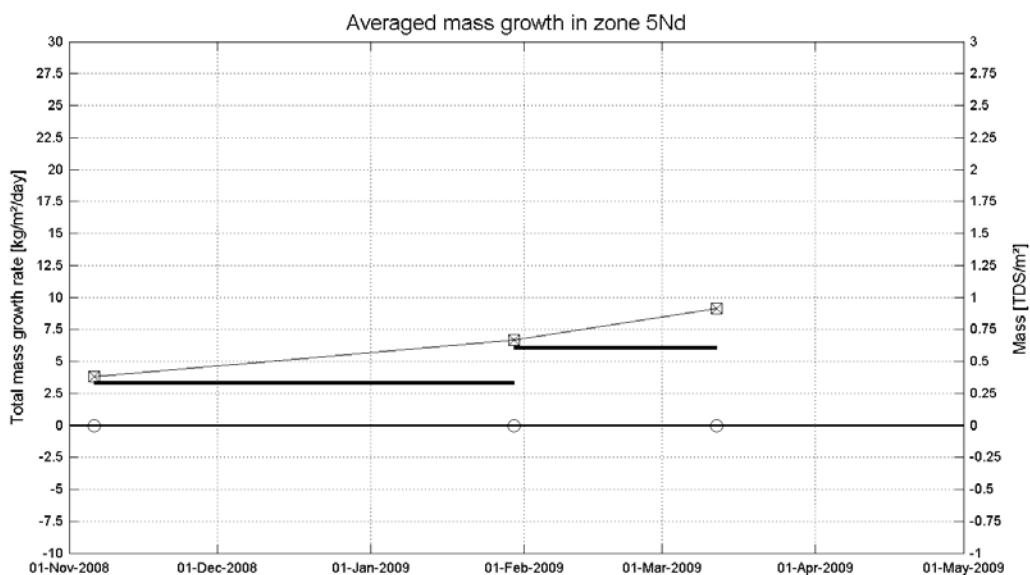
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Measured/Dredged/Total Mass

Equipment(s):
 NaviTracker

Location:
 DGD



Total mass growth rate
 □ Measured mass
 Total mass
 ○ Cumulated dredged mass

Data Processed by:



In association with:



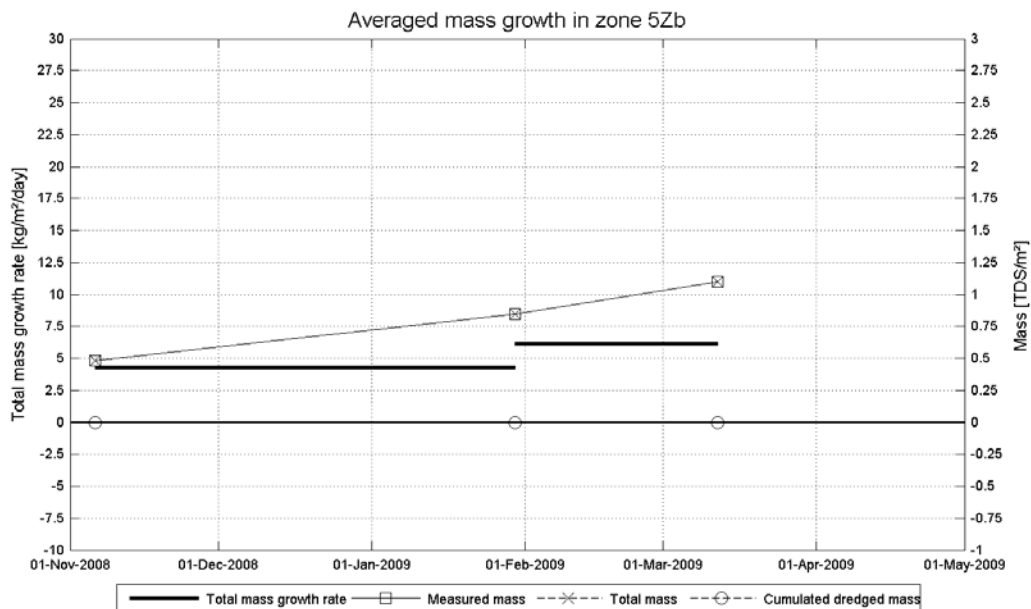
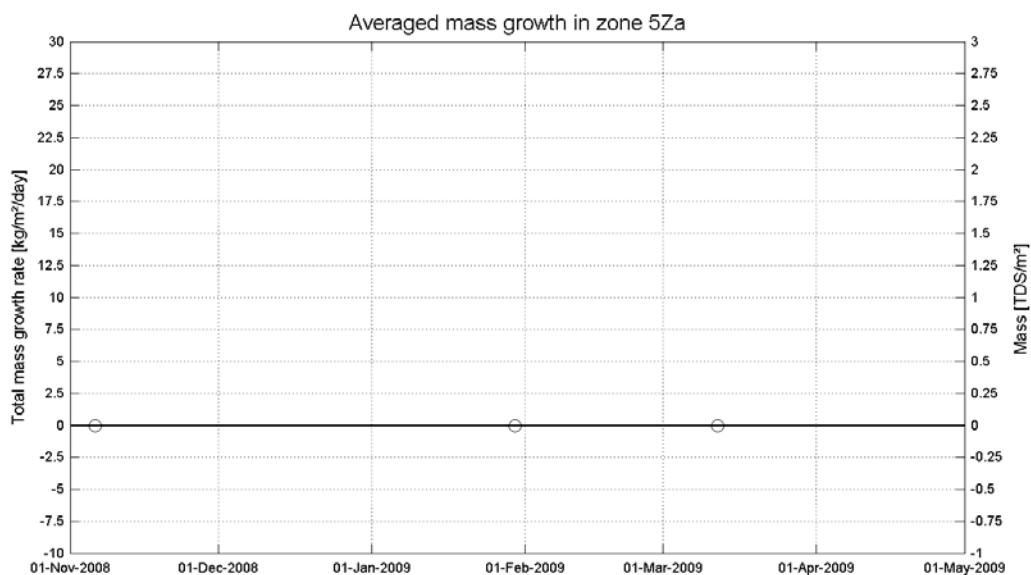
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Measured/Dredged/Total Mass

Equipment(s):
 NaviTracker

Location:
 DGD



Data Processed by:



In association with:



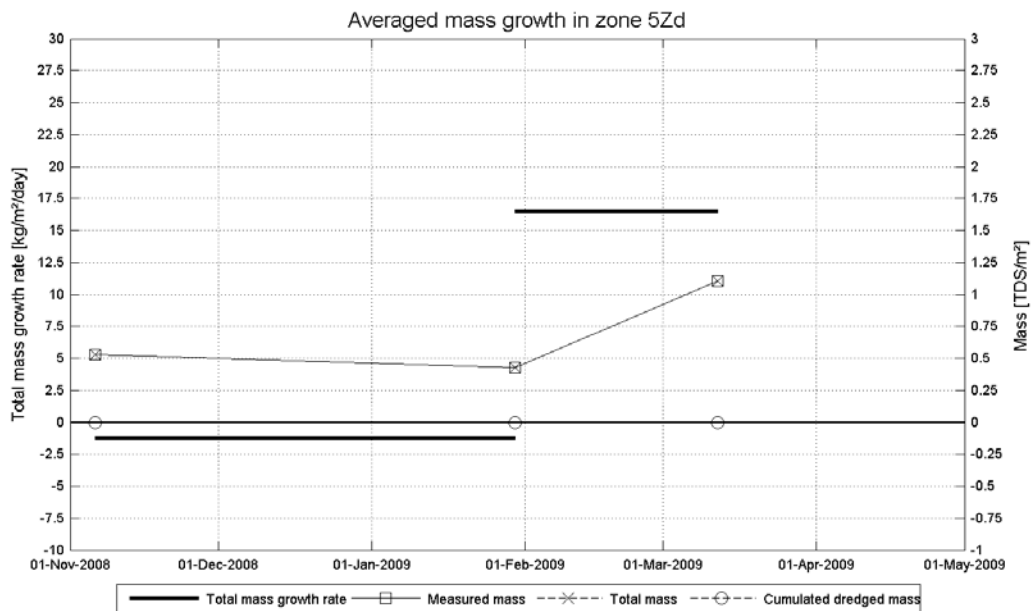
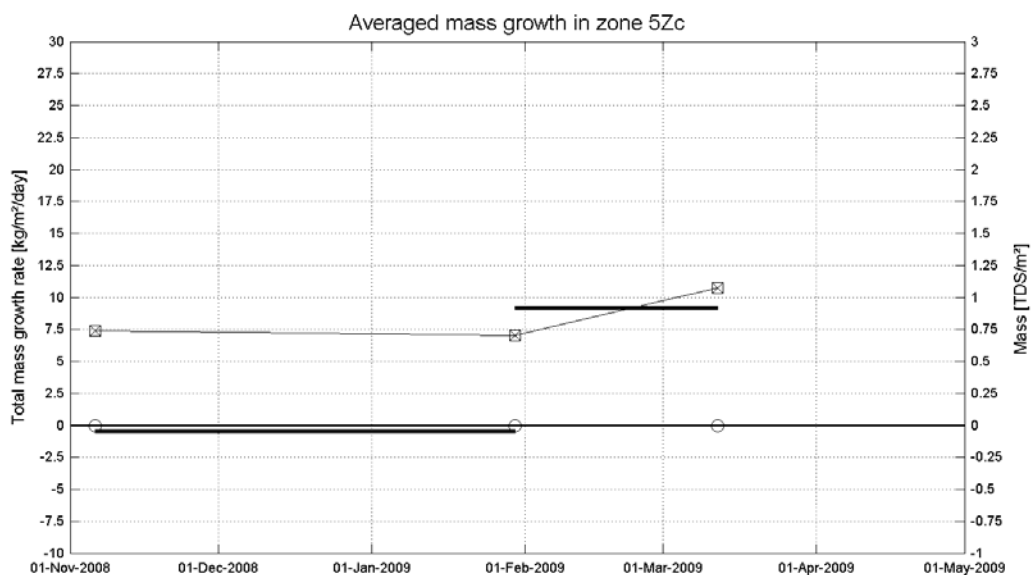
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Measured/Dredged/Total Mass

Equipment(s):
 NaviTracker

Location:
 DGD



Data Processed by:



In association with:



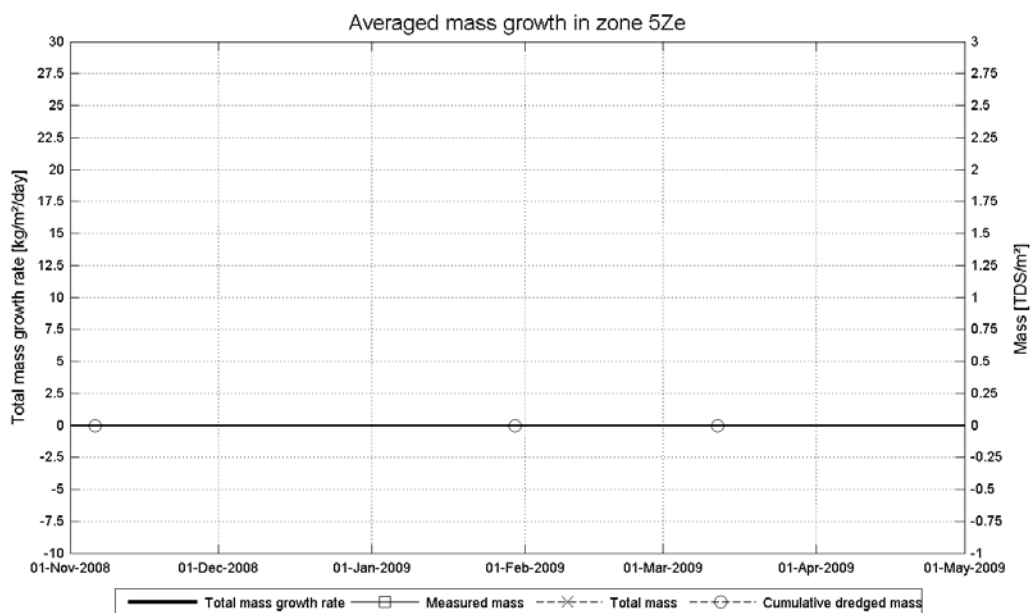
I/RA/11283/08.079/MSA

Long-term monitoring siltation Deurganckdok

Measured/Dredged/Total Mass

Equipment(s):
 NaviTracker

Location:
 DGD



Data Processed by:



In association with:



I/RA/11283/08.079/MSA

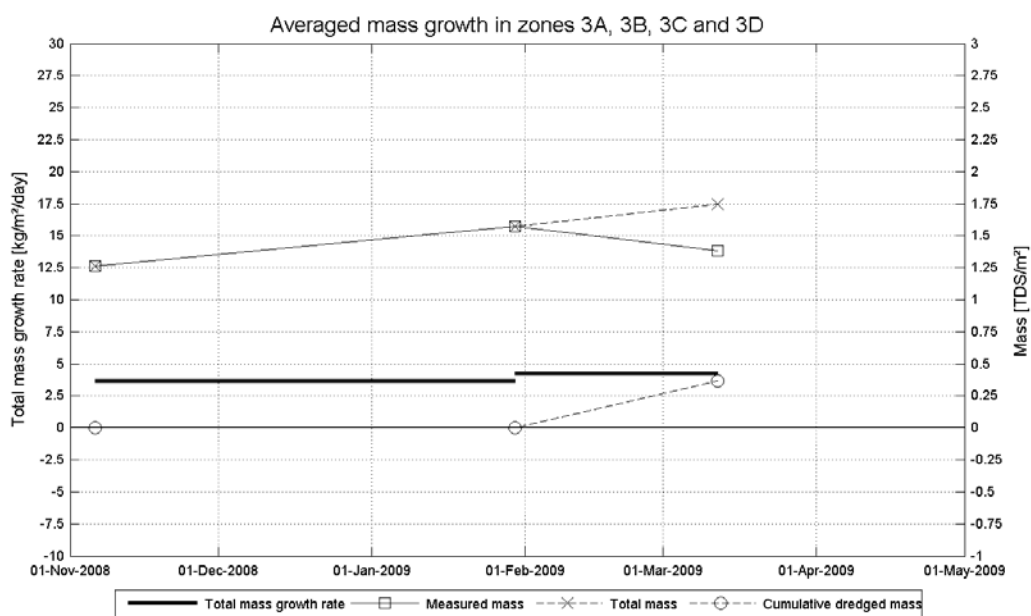
H.3 For complete Deurganckdok

Long-term monitoring siltation Deurganckdok

Measured/Dredged/Total Mass

Equipment(s):
 NaviTracker

Location:
 DGD



Data Processed by:



In association with:



I/RA/11283/08.079/MSA

APPENDIX I.

DREDGING DATA

**Dredged mass in covered area (TDS)

| | 09-Feb-09 | 16-Feb-09 | 24-Feb-09 | 02-Mar-09 |
|--------------|-----------|-----------|-----------|-----------|
| | 15-Feb-09 | 23-Feb-09 | 01-Mar-09 | 02-Mar-09 |
| 1 | 28 | 0 | 0 | 0 |
| 2 | 115 | 673 | 623 | 0 |
| 3a | 7478 | 12311 | 35768 | 2122 |
| 3b | 2268 | 9991 | 25328 | 1597 |
| 3c | 2341 | 7773 | 18303 | 1151 |
| 3d | 3608 | 12843 | 17634 | 779 |
| 3e | 283 | 499 | 1987 | 0 |
| 4Na | 5137 | 9582 | 1789 | 0 |
| 4Nb | 4629 | 12123 | 629 | 0 |
| 4Nc | 3763 | 7966 | 537 | 0 |
| 4Nd | 2700 | 6081 | 281 | 0 |
| 4Ne | 65 | 9 | 16 | 0 |
| 4Za | 1930 | 6477 | 1438 | 0 |
| 4Zb | 3055 | 7731 | 749 | 0 |
| 4Zc | 2500 | 5327 | 217 | 0 |
| 4Zd | 1514 | 5288 | 217 | 0 |
| 4Ze | 56 | 22 | 15 | 0 |
| 5Na | 0 | 0 | 0 | 0 |
| 5Nb | 0 | 0 | 0 | 0 |
| 5Nc | 0 | 4 | 0 | 0 |
| 5Nd | 0 | 0 | 0 | 0 |
| 5Ne | 0 | 0 | 0 | 0 |
| 5Za | 0 | 0 | 0 | 0 |
| 5Zb | 0 | 0 | 0 | 0 |
| 5Zc | 0 | 0 | 0 | 0 |
| 5Zd | 0 | 0 | 0 | 0 |
| 5Ze | 0 | 0 | 0 | 0 |
| Total | 41468 | 104701 | 105533 | 5649 |

APPENDIX J.

SWEEP BEAM DREDGING DATA

