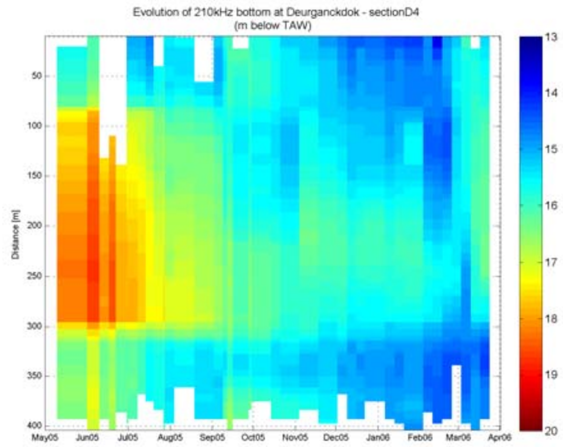
VLAAMSE OVERHEID

DEPARTEMENT MOBILITEIT EN OPENBARE WERKEN
WATERBOUWKUNDIG LABORATORIUM

Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing

Bestek 16EB/05/04

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



Deelrapport 1.6: Sediment balans 7/2005 – 3/2006
Report 1.6: Sediment Balance: 7/2005-3/2006

7 februari 2007

I/RA/11283/06.118/MSA

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GLOSSARY

BIS	Dredging Information System used in the Lower Sea Scheldt
d	Density of dredged sediment [kg/dm³]
DGD	Deurganckdok
HCBS	High Concentration Benthic Suspensions
M	mass of dry solids [ton]
ρ_s	density of the solid minerals [kg/dm³]
ρ_w	density of clear water [kg/dm³]
t_{0d}	Reference situation for densimetric analysis (empty dock)
t_{0e}	Reference situation for volumetric analysis (28 July 2006)
TDS	Ton of dry solids [ton]
V	volume of dredged sediment [m³]

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)'[1].

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.

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 one year
- 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

[1] Uitbreiding studie densiteitsstromingen in de Beneden Zeeschelde in het kader van LTV Meetcampagne naar hooggeconcentreerde slibsuspensies

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 ‘Opvolging aanslibbing Deurganckdok’ are summarized in Table 1-1.

Reports of the measurement campaign HCBS2 for which the winter campaign has been carried out simultaneously with the trough tide measurements in this project are listed in APPENDIX H.

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)
Factors contributing to salt and sediment distribution in Deurganckdok: Salt-Silt (OBS3A) & Frame measurements, Through tide measurements (SiltProfiling & ADCP)	
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	Salt-Silt distribution & Frame Measurements Deurganckdok 13/3/2006 – 31/05/2006

Report	Description
	(I/RA/11283/06.121/MSA)
2.7	Salt-Silt distribution & Frame Measurements Deurganckdok 15/07/2006 – 31/10/2006 (I/RA/11283/06.122/MSA)
2.8	Salt-Silt distribution & Frame Measurements Deurganckdok 15/01/2007 – 15/03/2007 (I/RA/11283/06.123/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)
3.2	Boundary condtions: Annual report (I/RA/11283/06.128/MSA)
Analysis	
4	Analysis of Siltation Processes and Factors (I/RA/11283/06.129/MSA)
Calibration	
6.1	Winter Calibration (I/RA/11291/06.092/MSA)
6.2	Summer Calibration and Final Report (I/RA/11291/06.093/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 Salt 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 salt 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, salt 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, Zanvliet 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.

1.4. Structure of the report

This report is the sediment balance of the Deurganckdok for the period of 07/2005 to 03/2006. 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 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
3. The quay walls reach up to +9m TAW

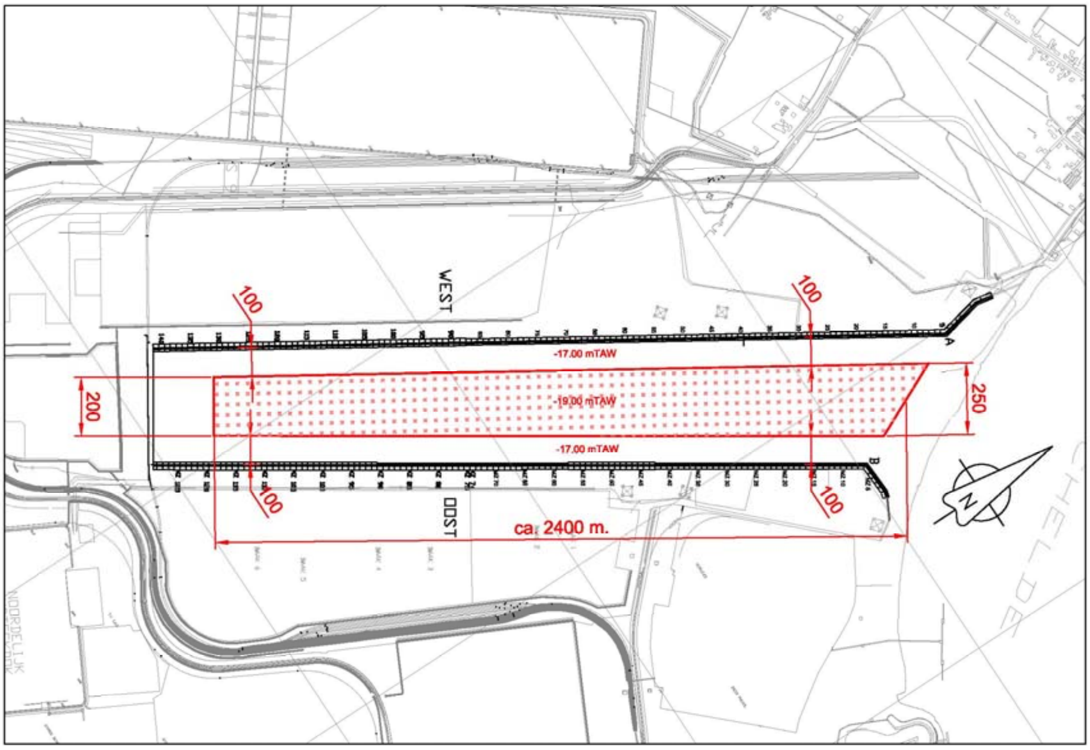


Figure 2-1: Overview of Deurganckdok

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.

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).

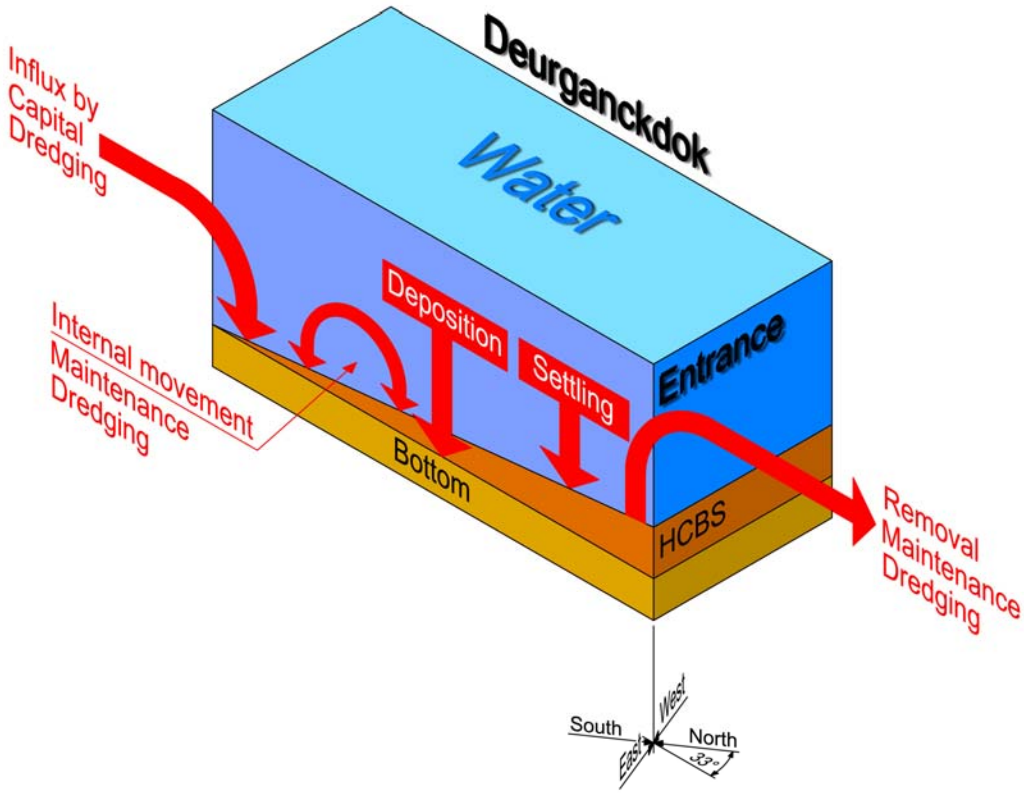


Figure 2-2: Elements of the sediment balance

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.

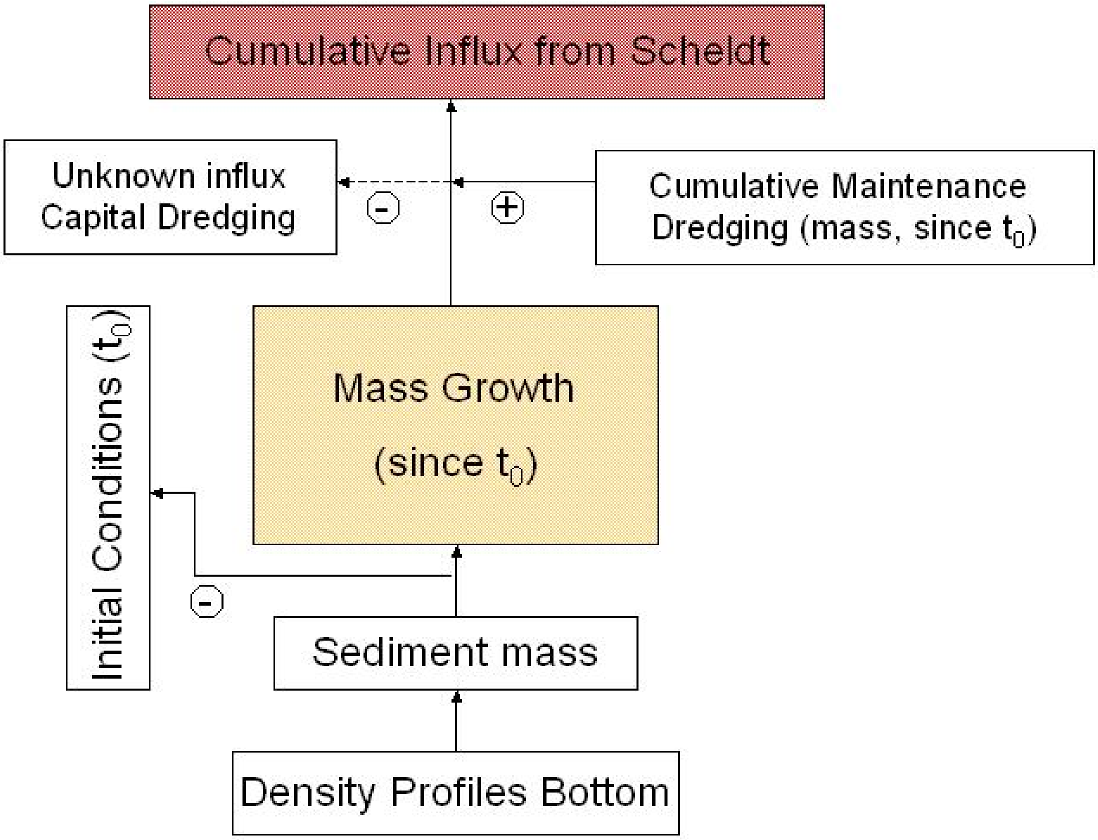


Figure 2-3: Determining a sediment balance

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

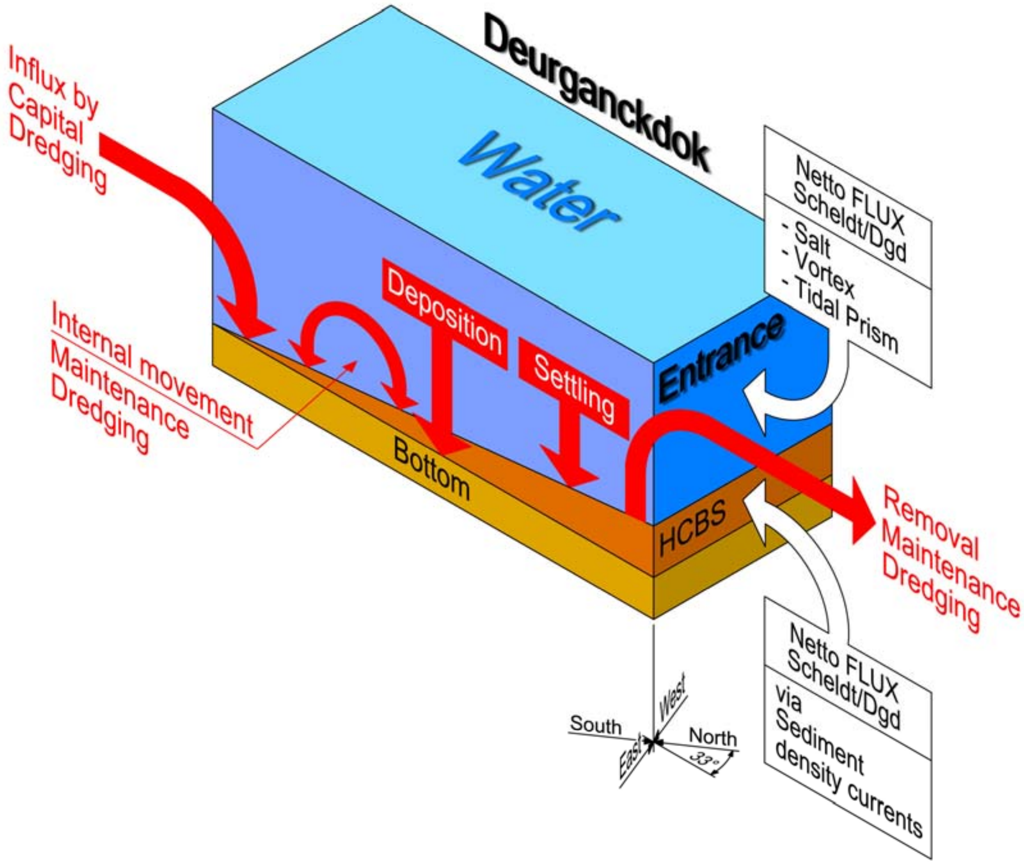


Figure 2-4: Transport mechanisms

These aspects of hydrodynamics and sediment transport have been landmark 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 weekly dual-frequency echo-sounder measurements, with complementary multibeam measurements. 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 and a 300 kC Multibeam using Qinsy software. Additional Multibeam measurements were carried out by the Port of Antwerp. 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 7/2005 – 3/2006

date	***type of measurement***	***signal***	***Source***
4/08/2005*	dual frequency 210-33 kHz	210	Afdeling Kust
19/08/2005	dual frequency 210-33 kHz	210	Afdeling Kust
2/09/2005	dual frequency 210-33 kHz	210	Afdeling Kust
9/09/2005	dual frequency 210-33 kHz	210	Afdeling Kust
12/09/2005	multibeam	-	Port of Antwerp
16/09/2005	dual frequency 210-33 kHz	210	Afdeling Kust
28/09/2005	multibeam	-	Port of Antwerp
30/09/2005	dual frequency 210-33 kHz	210	Afdeling Kust
14/10/2005	dual frequency 210-33 kHz	210	Afdeling Kust
21/10/2005	dual frequency 210-33 kHz	210	Afdeling Kust
4/11/2005	dual frequency 210-33 kHz	210	Afdeling Kust
18/11/2005	dual frequency 210-33 kHz	210	Afdeling Kust
2/12/2005	dual frequency 210-33 kHz	210	Afdeling Kust
9/12/2005	dual frequency 210-33 kHz	210	Afdeling Kust
16/12/2005	dual frequency 210-33 kHz	210	Afdeling Kust
22/12/2005	dual frequency 210-33 kHz	210	Afdeling Kust
6/01/2006	dual frequency 210-33 kHz	210	Afdeling Kust
13/01/2006	dual frequency 210-33 kHz	210	Afdeling Kust
20/01/2006	dual frequency 210-33 kHz	210	Afdeling Kust
3/02/2006	dual frequency 210-33 kHz	210	Afdeling Kust
10/02/2006	dual frequency 210-33 kHz	210	Afdeling Kust
17/02/2006	dual frequency 210-33 kHz	210	Afdeling Kust
24/02/2006	dual frequency 210-33 kHz	210	Afdeling Kust
3/03/2006	dual frequency 210-33 kHz	210	Afdeling Kust
10/03/2006	dual frequency 210-33 kHz	210	Afdeling Kust
17/03/2006	dual frequency 210-33 kHz	210	Afdeling Kust
24/03/2006	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. Only the 210 kC/Multibeam 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, effectively the earliest most complete measurement. This turned out to be the measurement on 28 July 2005. This will be considered as a reference situation, initial condition t_{0e}.

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 (§0 to §4.4).

Additional depth soundings were only used to visualize the evolution of the water-bed interface in all sections (APPENDIX B). These depth soundings contained insufficient covering to be used for other analyses. These depth soundings are listed in Table 3-2

Table 3-2: Additional depth soundings only used for visualization of water-bed interface in all sections

date	***type of measurement***	***signal***	***source***
10/05/2005	dual frequency 210-33 kHz	210	Afdeling Kust
27/05/2005	dual frequency 210-33 kHz	210	Afdeling Kust
01/06/2005	multibeam	-	Port of Antwerp
10/06/2005	dual frequency 210-33 kHz	210	Afdeling Kust
17/06/2005	multibeam	-	Port of Antwerp
22/06/2005	dual frequency 210-33 kHz	210	Afdeling Kust
30/06/2005	multibeam	-	Afdeling Kust
01/07/2005	dual frequency 210-33 kHz	210	Afdeling Kust
08/07/2005	dual frequency 210-33 kHz	210	Afdeling Kust
14/07/2005	dual frequency 210-33 kHz	210	Afdeling Kust
20/07/2005	dual frequency 210-33 kHz	210	Afdeling Kust
27/07/2005	multibeam	-	Port of Antwerp
28/07/2005	multibeam	-	Afdeling Kust

3.2. Density measurements

Navitracker was used to perform density measurements Density measurements are necessary to calculate a sediment balance of dry weight of sediment per surface unit.

The Navitracker is a patented system to measure the density of fluid mud suspensions, by means of a gamma-density meter. It has been used by the Flemish authorities over 20 years to determine the nautical bed for the port of Zeebrugge.

The Navitracker system can be operated by a computer controlled winch to tow it through the mud (horizontal mode). The Navitracker is equipped with the following sensors:

- The Gamma ray density sensor, mounted on a fork-like tow fish, gives density information
- The depth sensor gives information of the depth of the sensor
- The position of the fish is calculated out of the length of the winch cable. Together with the position of the tow fish, following the density level, a dual frequency echo sounder is used to map the hard bottom and the top of the mud. With a speed of 2 to 3 knots, large areas can be covered.

For these measurements the Navitracker was used in a vertical profiling mode, with the probe in vertical position in order to penetrate the soft bottom. The vertical density profiler is used to measure density in thick mud layers with high densities.

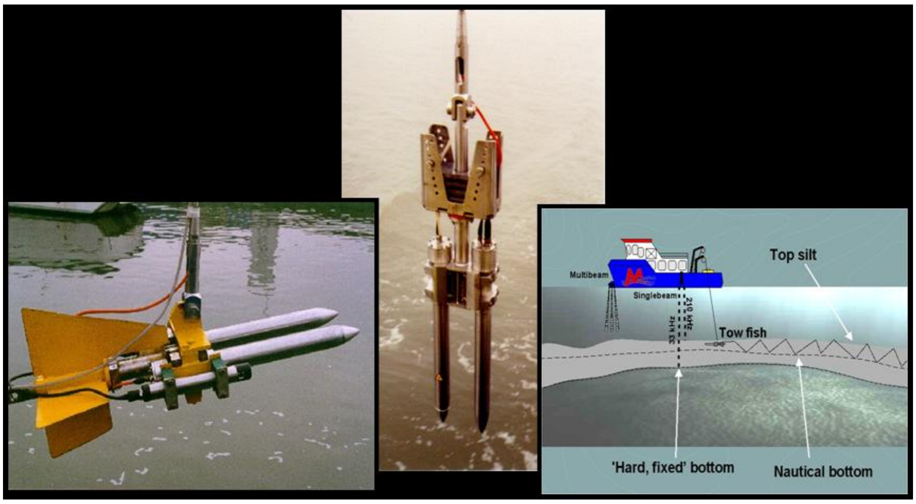


Figure 3-1: Navitracker

The Navitracker was calibrated in the laboratory for measuring high densities, formed by very dense water-mud mixtures. For this reason the Navitracker did not detect subtle variations in density caused by changes in salinity. The density deviated from 1.000 ton/m³ only in the presence of a high concentration of sediments.

The Navitracker has a sampling frequency of 10 measurements per second.

Table 3-3: Overview of available Density Profiles 7/2005 – 3/2006

date	***type of measurement***
24/08/05	Density profiles
04/10/05	Density profiles
03/12/05	Density profiles

As a reference situation for the empty dock will be used at the design depth. The design depths for the different zones are shown in Table 3-4. The different zones are described in §4.1.

Table 3-4: 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

The resulting 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. Output information can be found in §4.5 to §4.8.

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'[2] 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.

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). Sweep beam data was only available starting from January 2006.

Table 3-5: Sweep beam Maintenance dredging activities in Deurganckdok en on the sill of Deurganckdok between October 2005 and April 2006 (source: Afdeling Maritieme Toegang)

From	Till	Duration (days)	Location
16/1/2006	21/1/2006	6	Sill DGD+ Plaat van Lillo
30/1/2006	3/2/2006	5	DGD
6/2/2006	11/2/2006	6	Sill DGD+DGD
13/2/2006	18/2/2006	6	Sill DGD+ DGD
6/3/2006	6/3/2006	1	Sill DGD
27/3/2006	27/3/2006	1	Sill DGD

[2] V' = Reduced Volume

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 and C. This is shown in Figure 4-1.

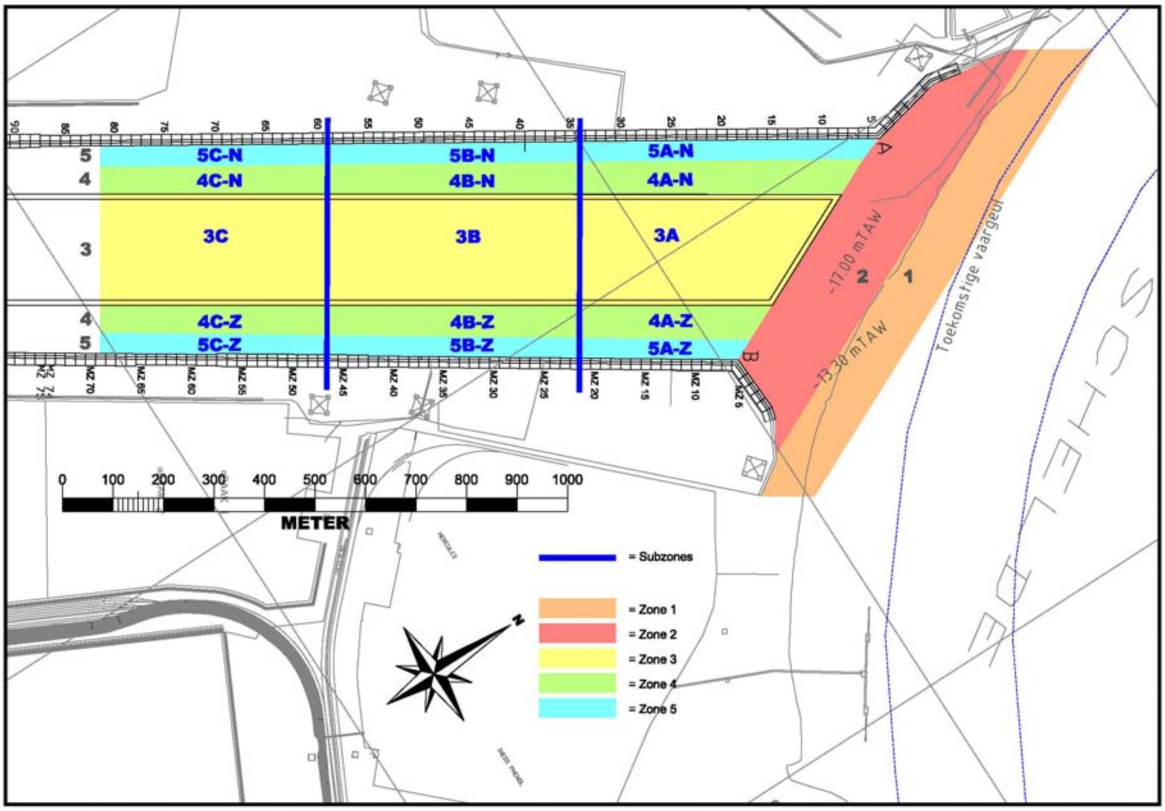


Figure 4-1: Deurganckdok: Zones and Subzones

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.

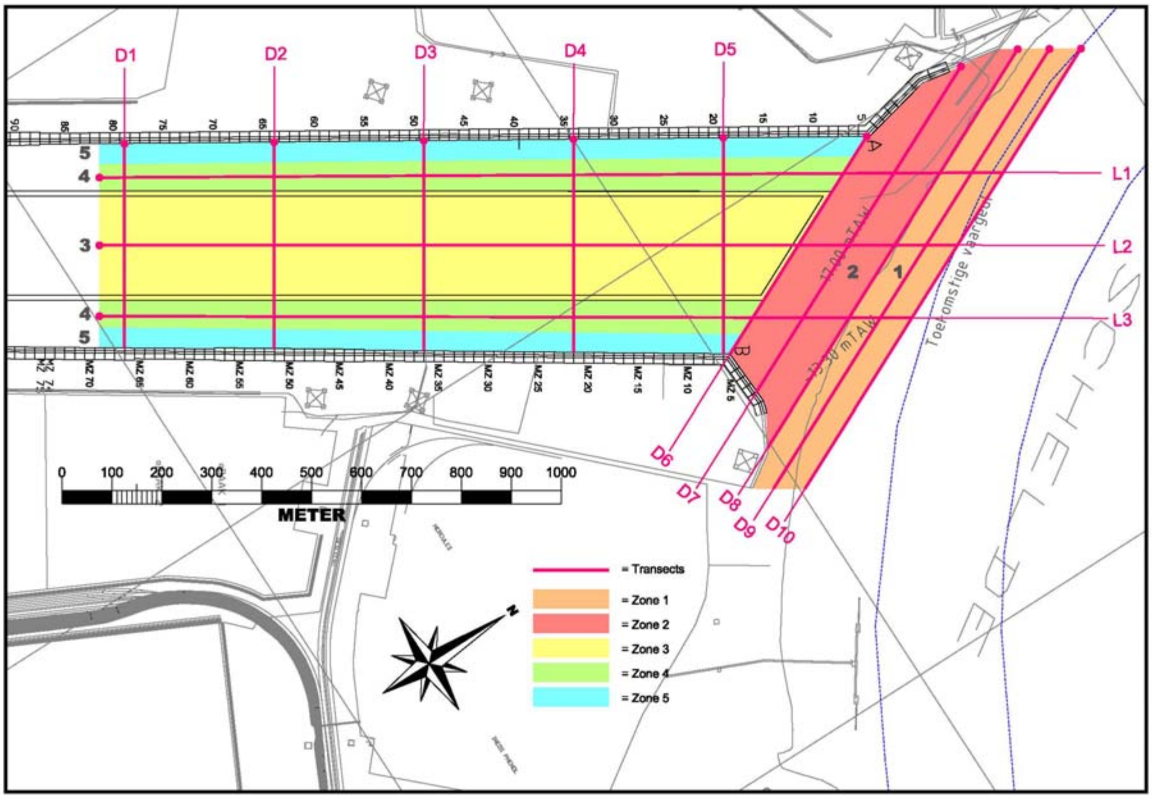


Figure 4-2: Deurganckdok: D and L Sections

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

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
L Sections				
L1	588748	5684720	587805	5683175
L2	588825	5684565	587921	5683103
L3	588901	5684410	588043	5683028

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.

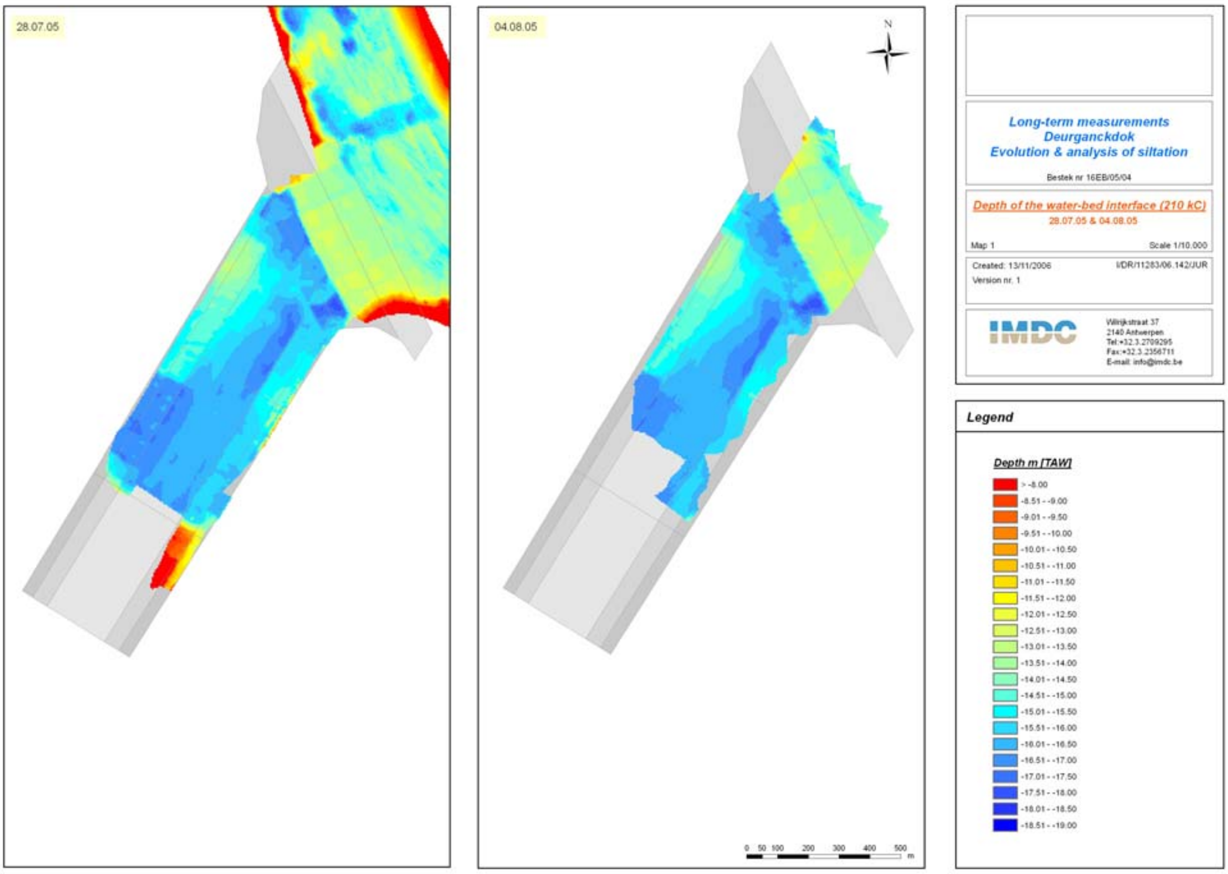


Figure 4-3: Example of a map showing depth of water-bed interface (210 kC) for 28/07/05 and 04/08/05

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. An example for sections is shown in Figure 4-5. For this analysis 12 additional depth soundings were used as shown in Table 3-2. The description of the sections is given in § 4.1.

Maps and graphs are shown in APPENDIX B.

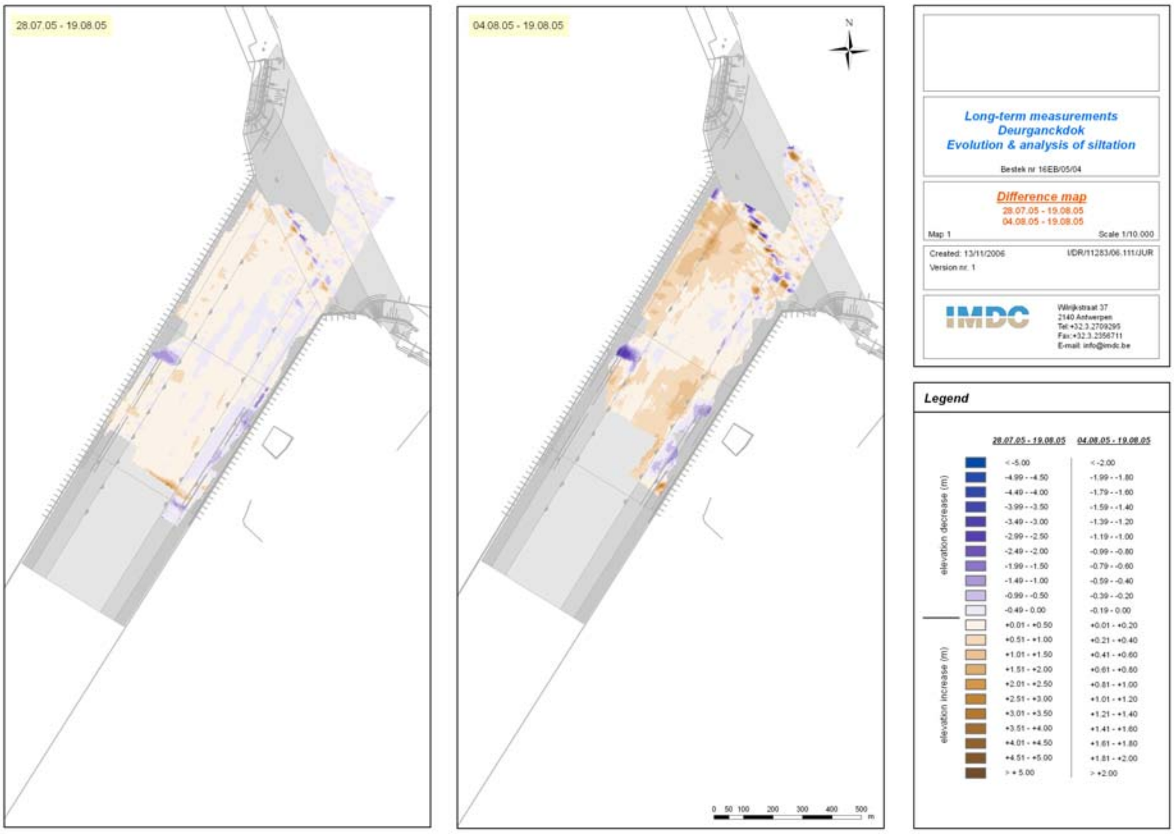


Figure 4-4: Difference charts of the depth sounding on 19/08/06: in reference to t_{0e} (left), and to the previous measurement (right) on 04/08/06

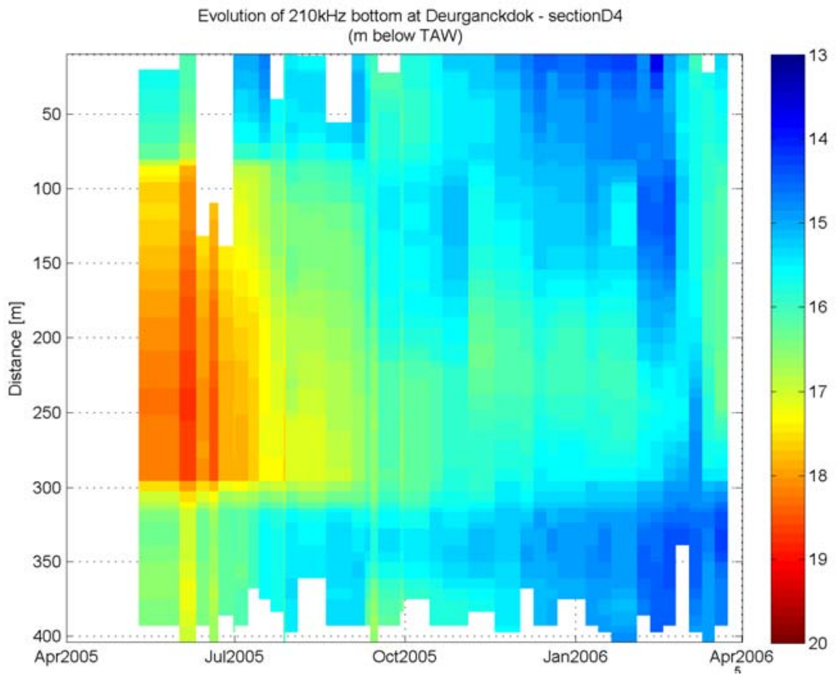


Figure 4-5: Graph of Evolution of the water-bed interface (210 kC) for section D4

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. For each month an average siltation rate is calculated this way. 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 section D4 in Figure 4-6.

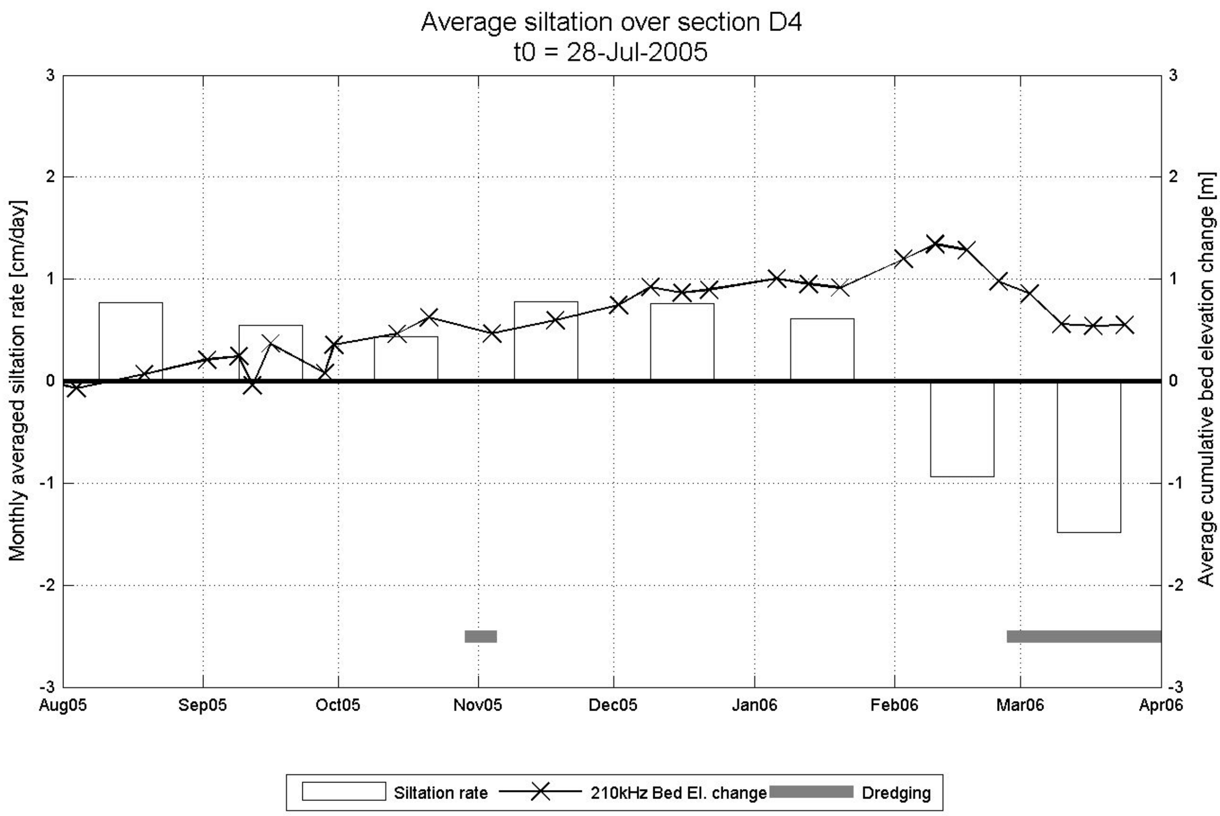


Figure 4-6: Volumetric siltation rate for section D4

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

This analysis is based on density profile measurements. 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 30g/l, corresponding with a density of about 1.03 kg/dm³, whenever the density passes this value we assume the equipment has reached the water-bed interface. The depth of the layers of constant density is also shown for all sections in APPENDIX D. An example for equal density layers in section D4 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.

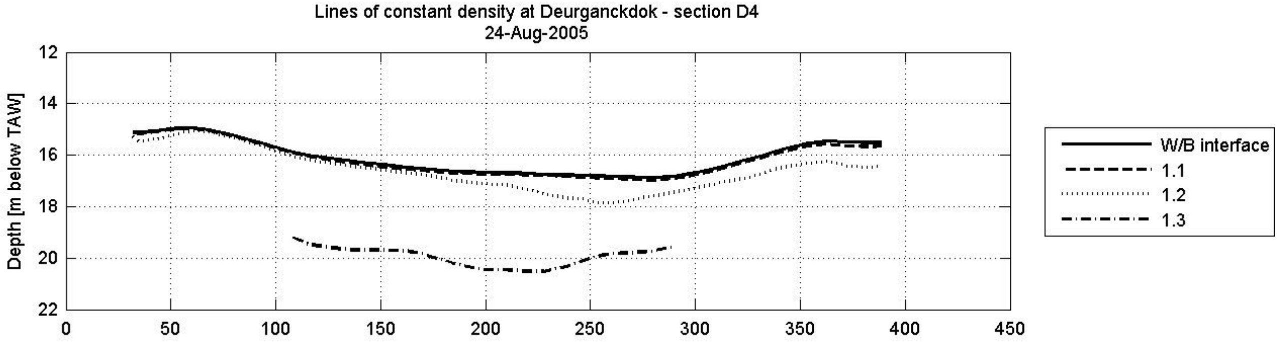


Figure 4-7: Depth of water-bed interface and equal density layers in section D4 on 3 December 2005

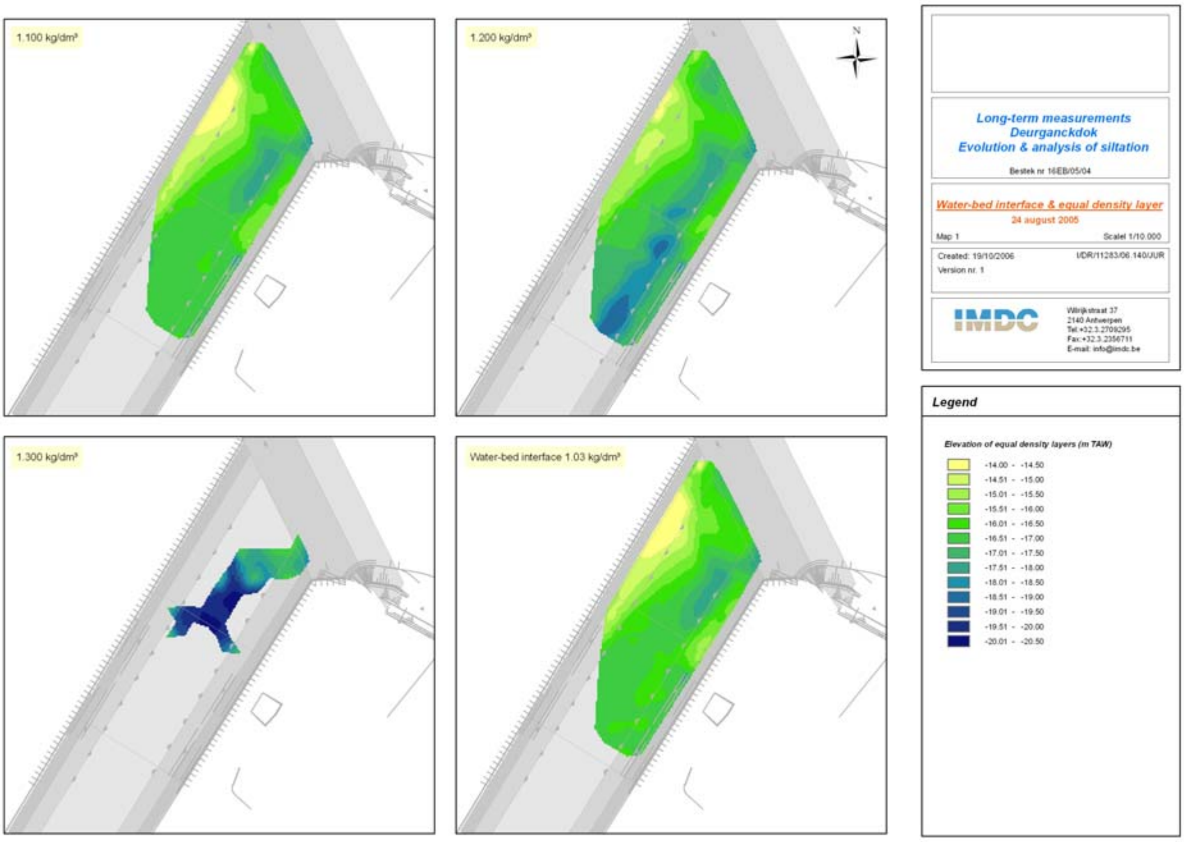


Figure 4-8: Map of the depth of the water-bed interface and equal density layers for 24/08/06

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 E. The description of the sections is given in § 4.1.

All 3 density measurements are used for this comparison. Sections of three 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.

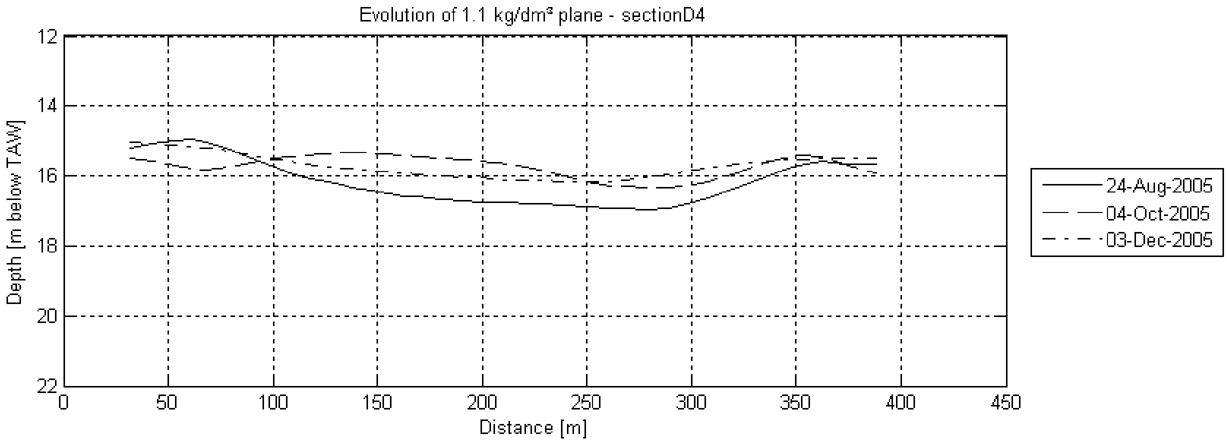


Figure 4-9: Graph of the evolution of 1.1 kg/dm³ plane in section D4

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 F.

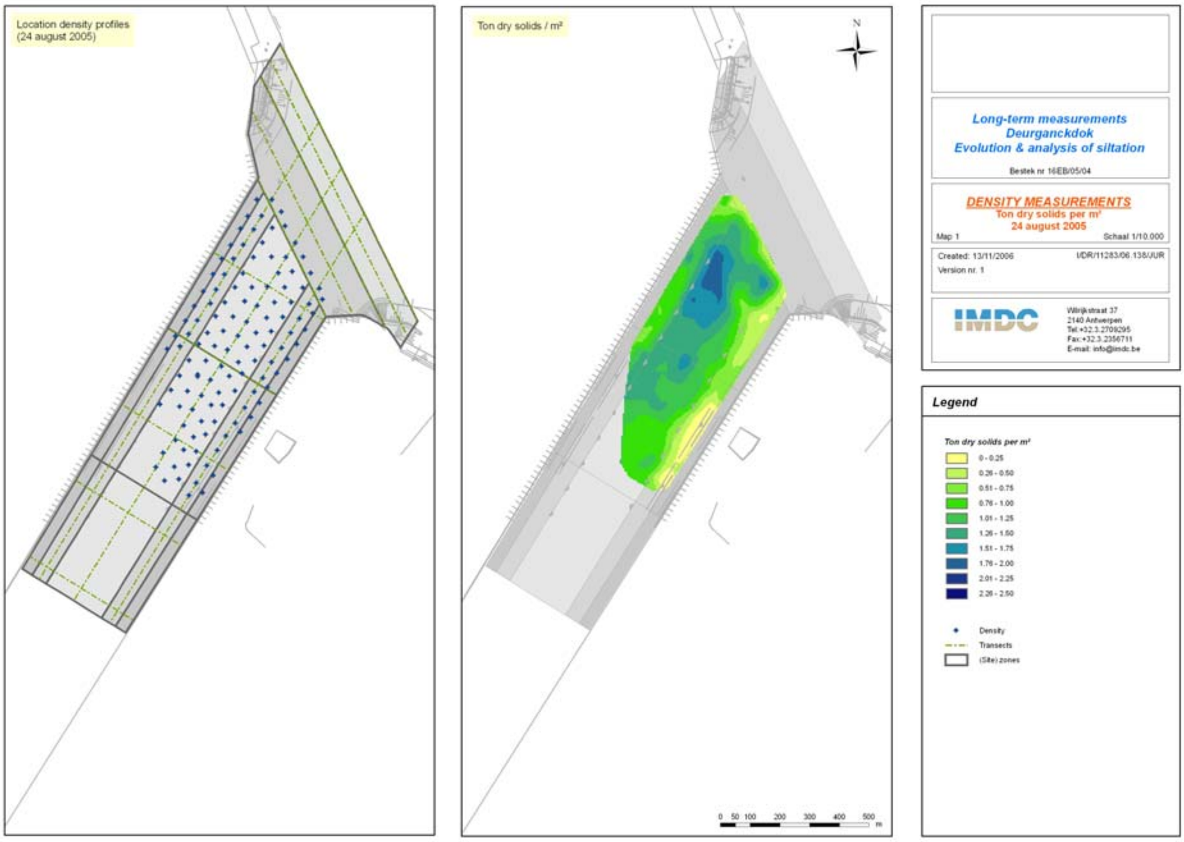


Figure 4-10: Map showing the location of the density profiles (left) and the calculation of TDS (right) on 24/08/06

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 the sediment dredged on locations for which the mass present in the bed could be measured is taken into account.

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.

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

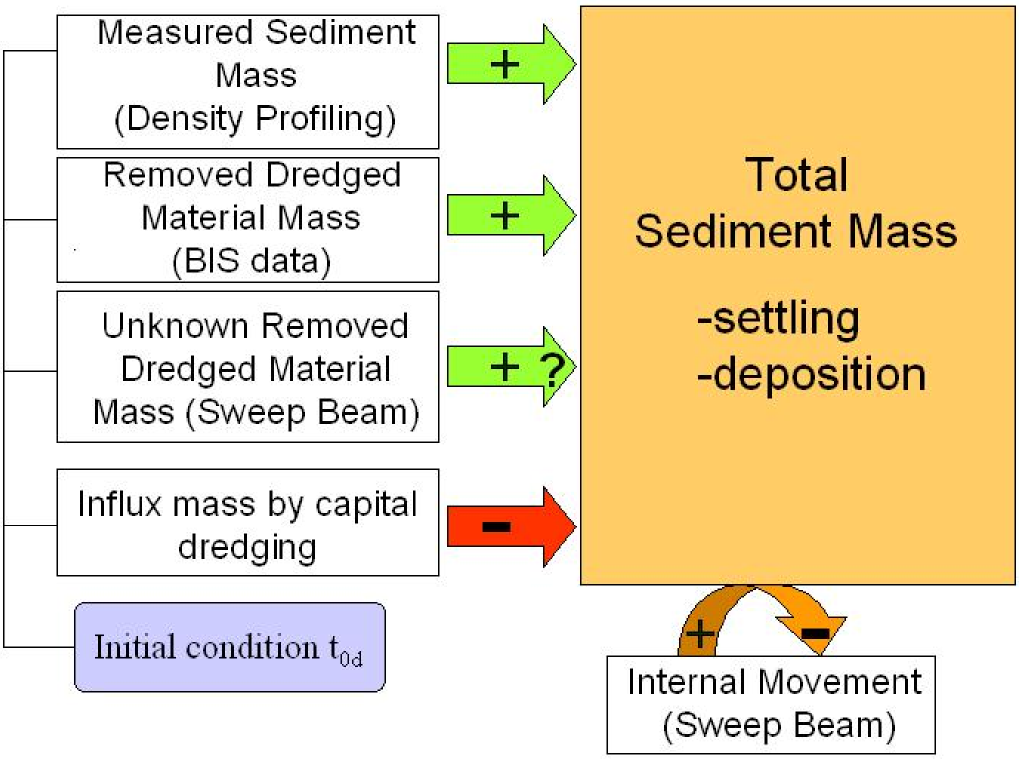


Figure 4-11: Flow chart with different elements contributing to total sediment mass for (sub)zones and total area

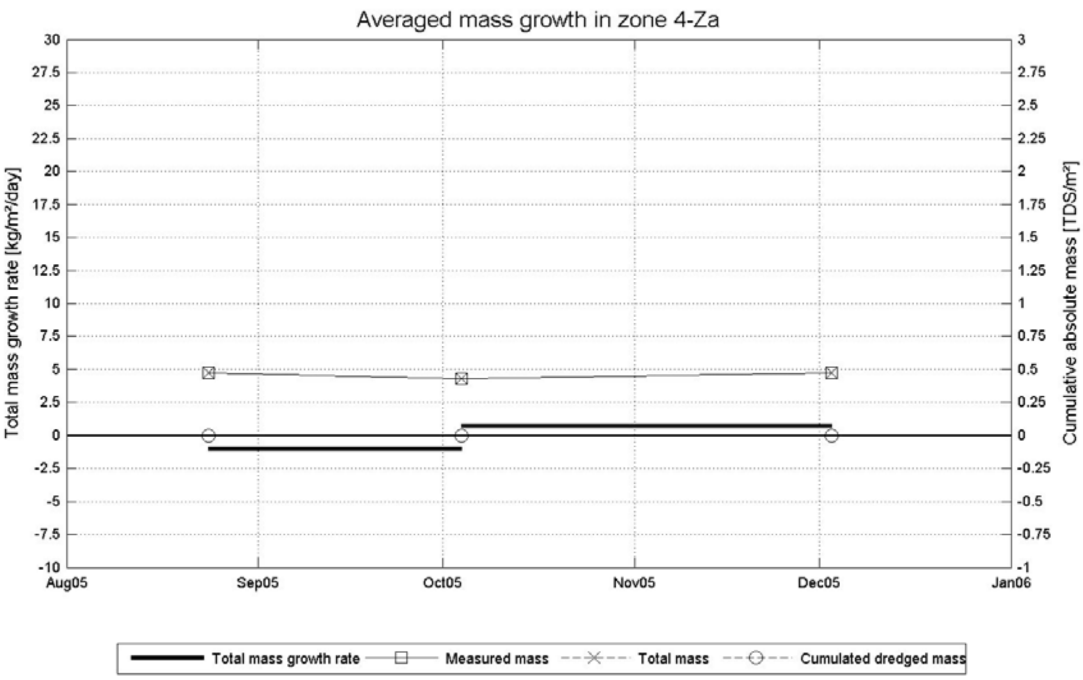


Figure 4-12: Example of Averaged mass growth and mass evolution for subzone 4-Za

The sweep beam data (of which no mass or volume information is available) is missing in this mass balance. As discussed in §3.3, It should be mentioned that this mass balance is incomplete without sweep beam information and should be looked at carefully. 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 influence the mass balance for (sub)zones and the total dock.

A table in APPENDIX G 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

Since depth sounder data can only give information about volume change, it is processed to show evolution of average volume per unit of surface, i.e. the average evolution of bed evolution as detected by a 210kHz sounder. For the period August 2005 to October 2005 depth sounding data is still affected by capital dredging works, mainly in the south end of the dock and at the downstream corner of the entrance, as seen in the difference maps in APPENDIX B.

Coverage of depth sounding data is largely variable over time, therefore no time evolution of directly measured volume can be presented per zone. If more than 50% of the area of a (sub)zone is covered an average siltation rate can be calculated.

The first type of bed evolution plots show a siltation rate for zones 3A and 3B (which have the best coverage in the data) of about 1 cm per day in periods of undisturbed bed (no dredging). The highest siltation rates are observed for zone 4A-N and 5A-N, on the northwest end of the dock. Here we see volumetric siltation rates of about 1.5 to 2 cm per day. For corresponding zones on the south end (4A-Z and 5A-Z) data is not as continuous as for the northwest part (coverage smaller than 50% in some cases) but a typical siltation rate can be seen, being 0.5 cm per day. Sweep beam activities are clearly influencing the results for all zones 4 and 5. In the first week of September there is a very sharp decrease in bed level in these zones while no hopper dredging activities have been reported. The sweep beam redistribution of sediment can clearly be seen in difference map number 3 (APPENDIX B), where in the same period bed levels close to the quay walls have decreased and bed levels in the central trench have increased.

All subzones C have not been measured with sufficient coverage so far, these zones were still under construction until early November 2005.

Zones 1 and 2 show smaller siltation rates, due to their location closer to the navigation channel and thus more under influence of tidal currents. Zone 2 shows siltation rates of less than 0.5 cm per day, zone 1 was covered more than 50% only in very limited cases. Frequent sweep beam activities must be taken into account in evaluating these zones.

A table with siltation rates per month and for all cross sections, longitudinal sections and subzones are given in a table in APPENDIX C.

5.2. Densimetric analysis

Density profiles have 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 §3.2)). The availability of mass dry solids distributions gives the opportunity to add the weight of dry solids taken out of the system by dredging. Total sediment mass is only calculated for locations where both density profile and dredging information are available. Adding up both leads to the total sediment mass. Results show a mass growth rate in the central trench (zones 3A and 3B) in the range of 3 to 7 kg/m²/day (APPENDIX G).

Zone 4A-N shows a negative growth rate between the first two density measurements, probably due to sweep beam activity in this subzone. In the second period a growth rate of 5 kg/m²/day has been calculated for subzone 4A-N. In the southern equivalent of this subzone (4A-Z) slightly lower growth rates have been found: in the range 2 to 4 kg/m²/day. An overview of total mass settled over time for all zones that have been covered completely is shown in Table 5-1.

*Table 5-1: Total sediment mass (measured + dredged, in 1000 TDS) in some zones (***: coverage smaller than 50%)*

	24-aug-05	**04-oct-2005**	**03-dec-05**
3a	132	156	201
3b	111	113	138
4Na	37	29	39
4Nb	***	17	19
4Za	27	29	34
4Zb	10	15	20

From these figures we can conclude that between the end of August and early October 2005 (41 days) about 25,000 tons dry solids have settled in zones 3 and 4, subzones A and B. Between early October and early December (60 days) about 90,000 tons of dry solids have settled in this area. The decrease in zone 4N-A during September is probably due to sweep beam activity, replacing sediment from zone 4 towards zone 3 with some sediment possibly being resuspended.

Subdividing per subzone we see roughly that the settled mass in subzones A (nearest to river) is double the settled mass in subzones B (Table 5-2), confirming the hypothesis of a gradual decrease in siltation with distance from the Scheldt river.

Table 5-2: Mass settled per subzone in zones 3 and 4 (in 1000 TDS)

	Aug 24th – Oct 4th	**Oct 4th – Dec 3rd**
Subzone A	18	60
Subzone B	8	31

From BIS data an average density has been determined of 1.28 kg/dm³ in hopper bin. Combining this result with the determined settled mass leads to a corresponding volume of dredged sediment of between 55,000 and 100,000 m³ per month for zones A and B, depending on the season (1).

$$V = M \frac{(\rho_s - \rho_w)}{\rho_s (d - \rho_w)} \tag{1}$$

Where: V is the volume of dredged sediment, M is the mass of dry solids, d is the average density derived from BIS, ρ_s is the density of the solid minerals and ρ_w is the density of water.

Future measurements will result in a better understanding of the seasonal variations of above results.

6. REFERENCES

AWZ (2000): Baggerwerken 2000, Westerschelde en Zeeschelde

IMDC(2006a) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.1 Opmeting stroming en zout- en sedimentbeweging aan de ingang van het Deurganckdok (SiltProfiler) (I/RA/11283/06.087/WGO).

IMDC(2006b) Langdurige metingen Deurganckdok: Opvolging en analyse aanslibbing. Deelrapport 2.3. Opmeting stroming en zout-en sedimentbeweging aan de ingang van het Deurganckdok (ADCP) (I/RA/11283/06.110/BDC)

APPENDIX A. DEPTH OF THE WATER-BED INTERFACE (210 KC)

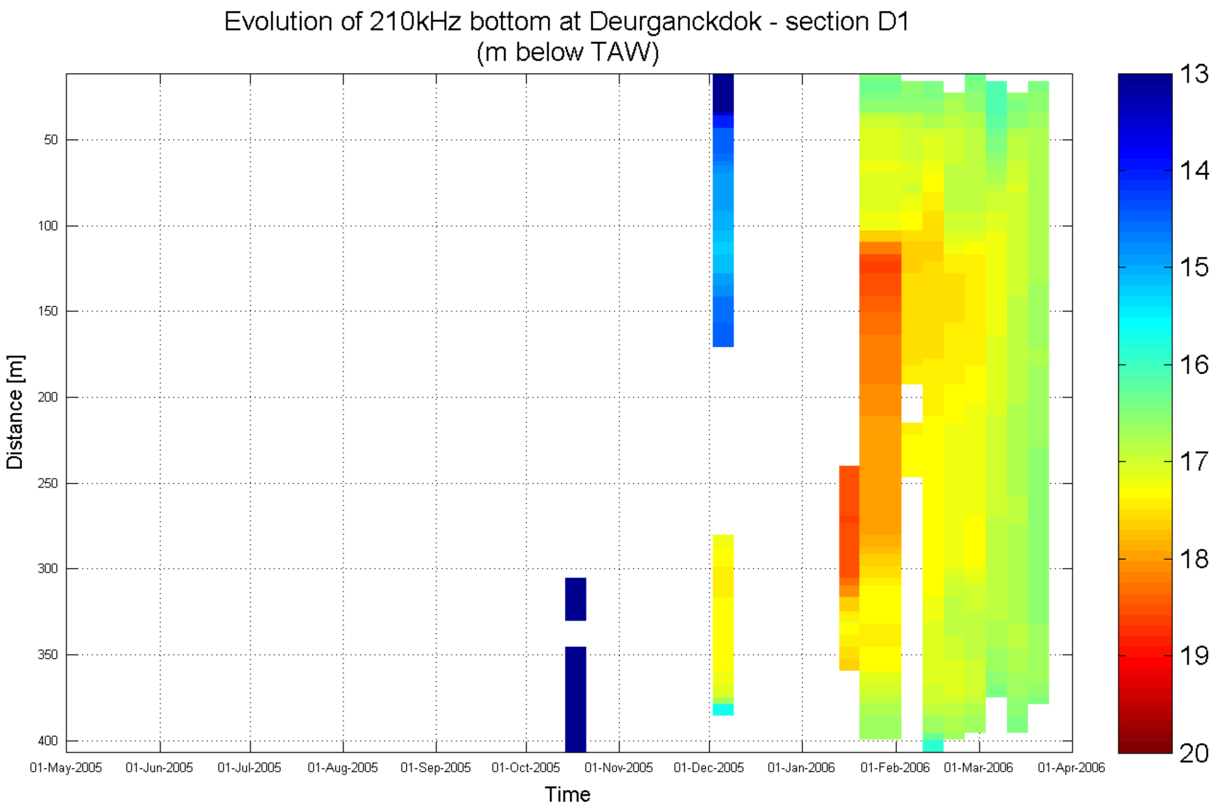
APPENDIX B. EVOLUTION OF DEPTH OF WATER-BED INTERFACE (210 KC)

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



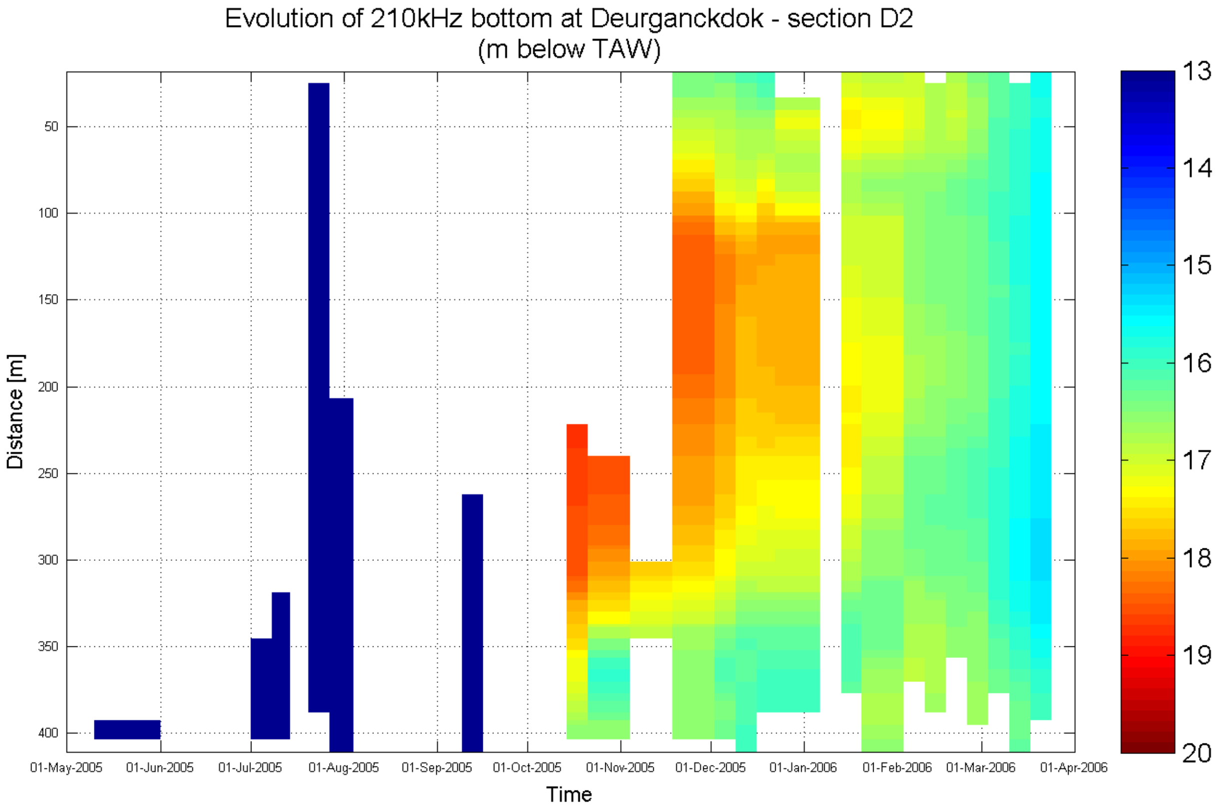
Data Processed by:

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom	Equipment(s): 210kHz depth sounder
	Location: DGD



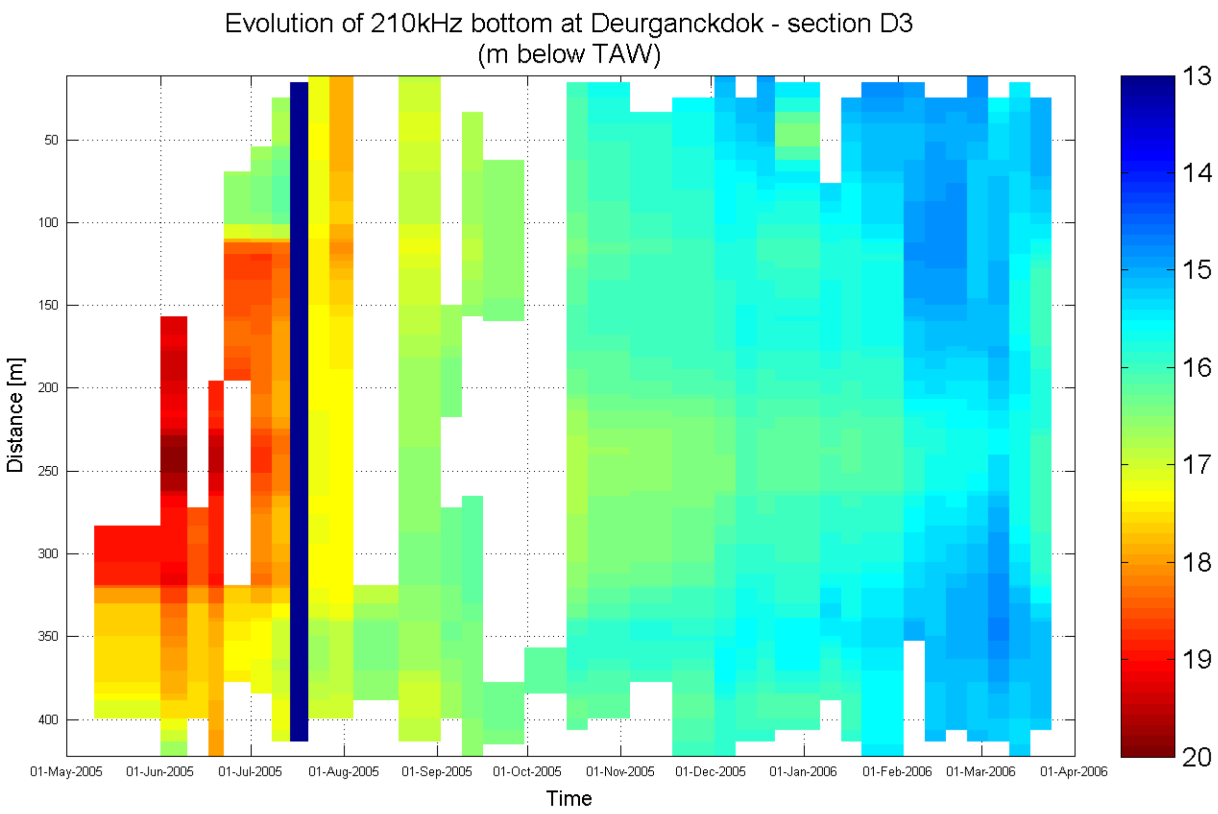
Data Processed by:

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom	Equipment(s): 210kHz depth sounder
	Location: DGD

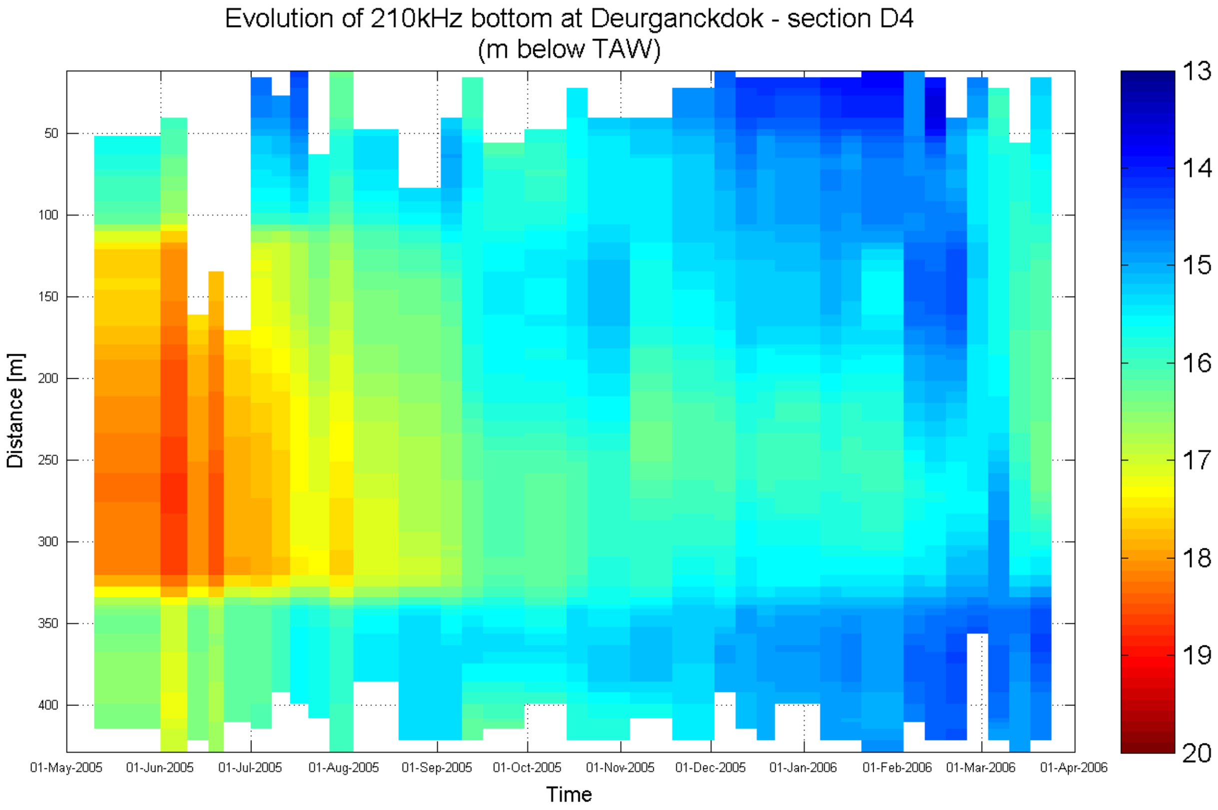


Data Processed by:

In association with :

I/RA/11283/06.118/MSA

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



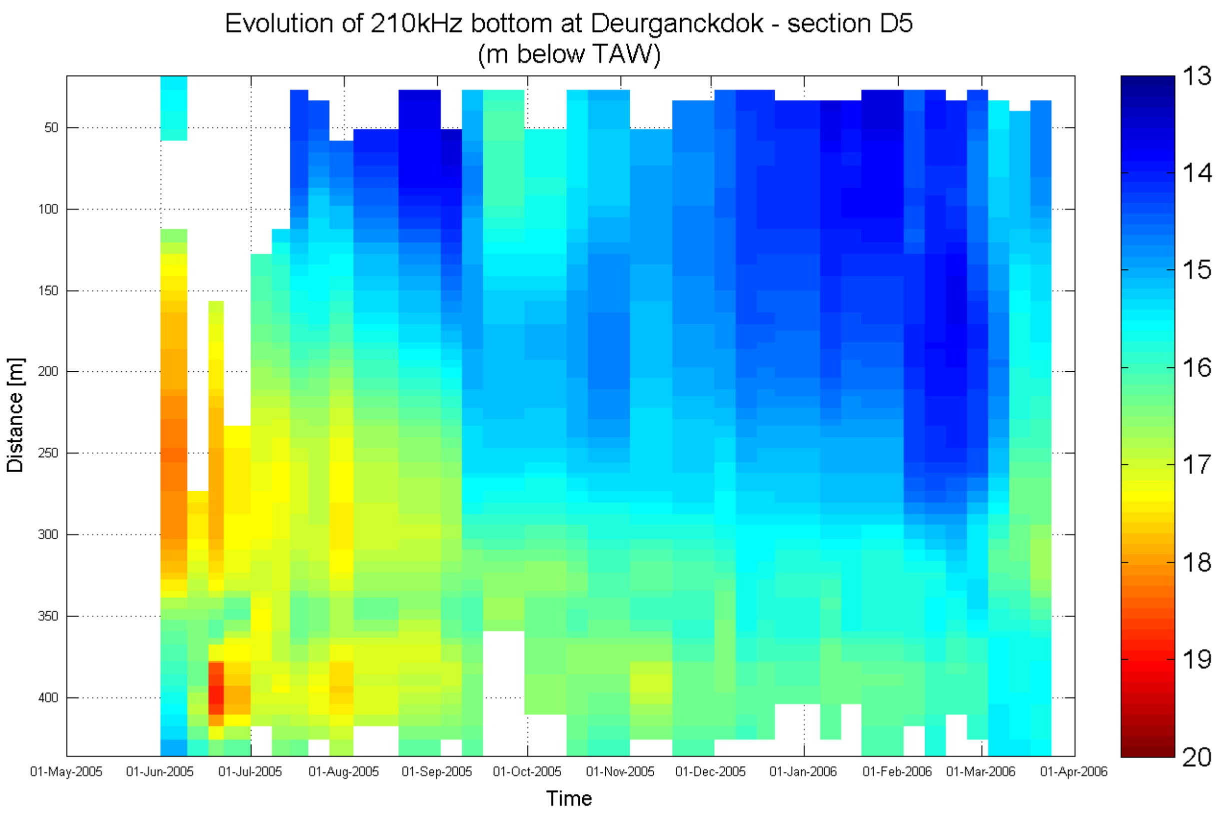
Data Processed by: IMDC

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom	Equipment(s): 210kHz depth sounder
	Location: DGD



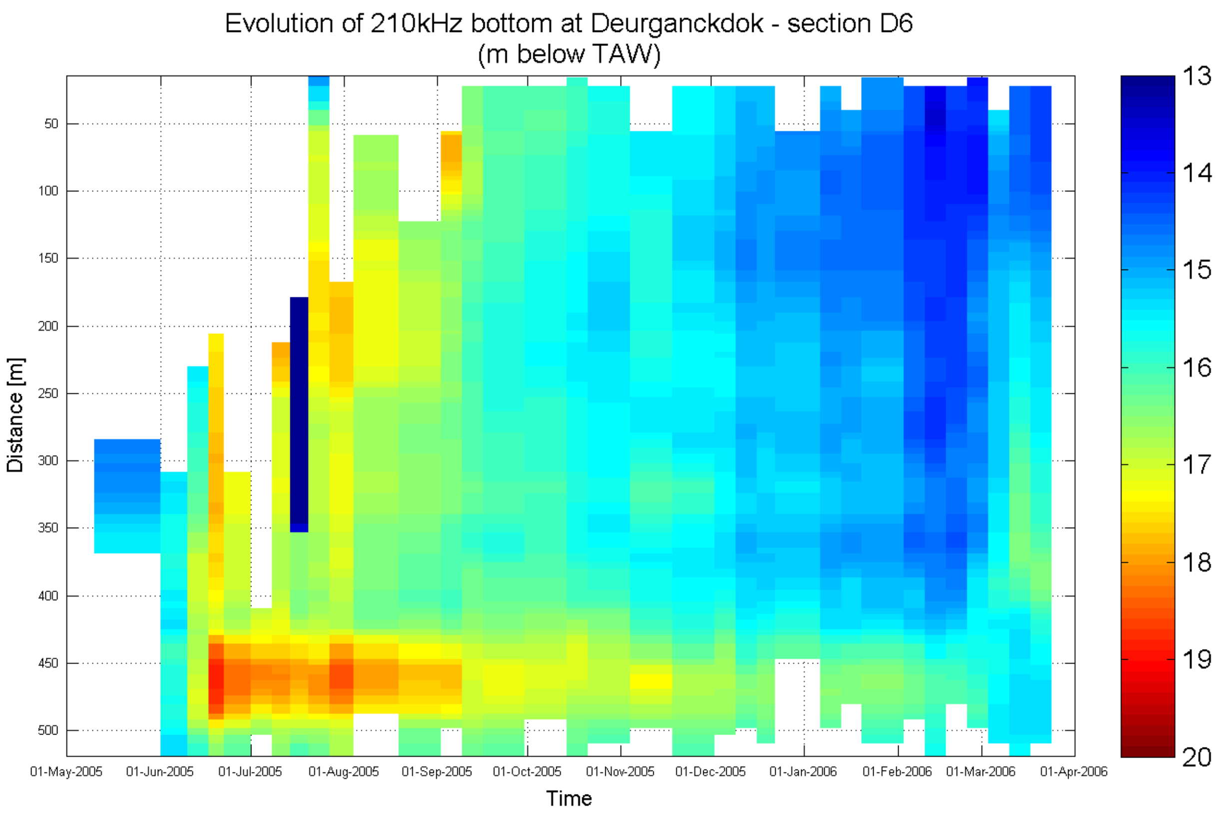
Data Processed by:

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom	Equipment(s): 210kHz depth sounder
	Location: DGD



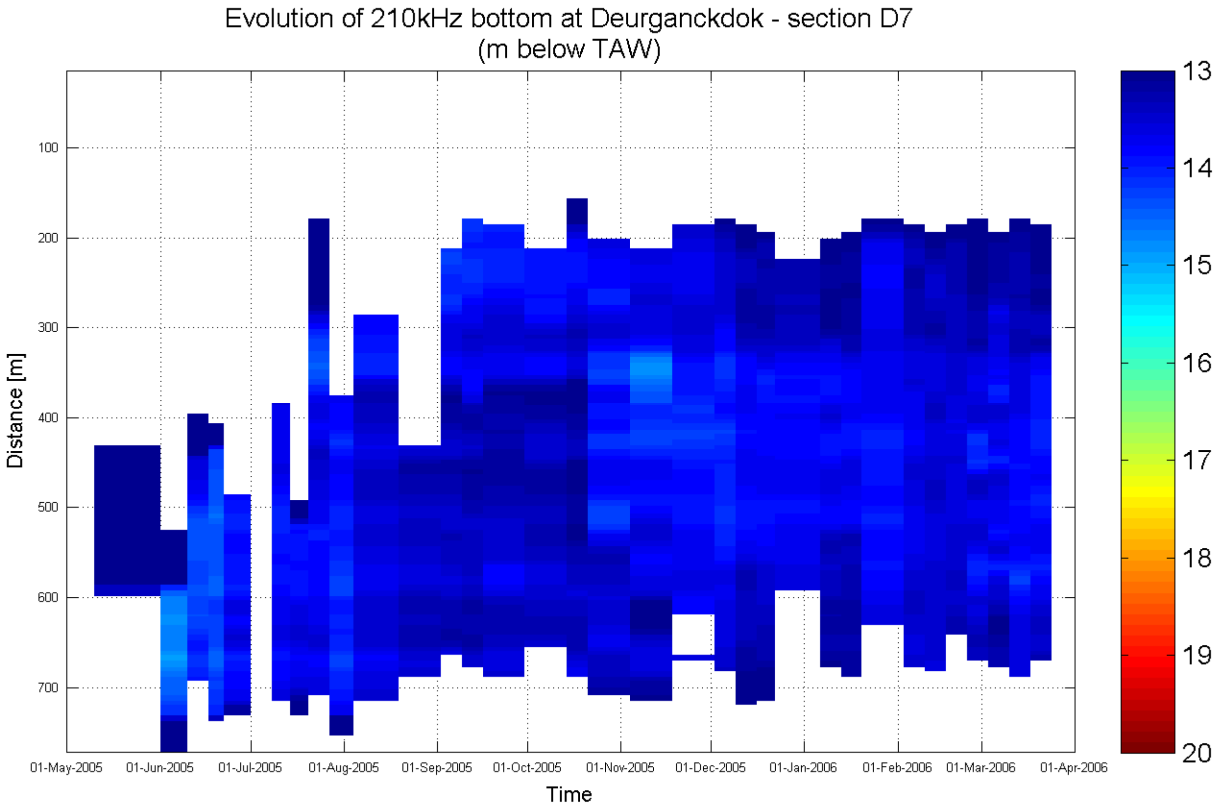
Data Processed by:

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom	Equipment(s): 210kHz depth sounder
	Location: DGD



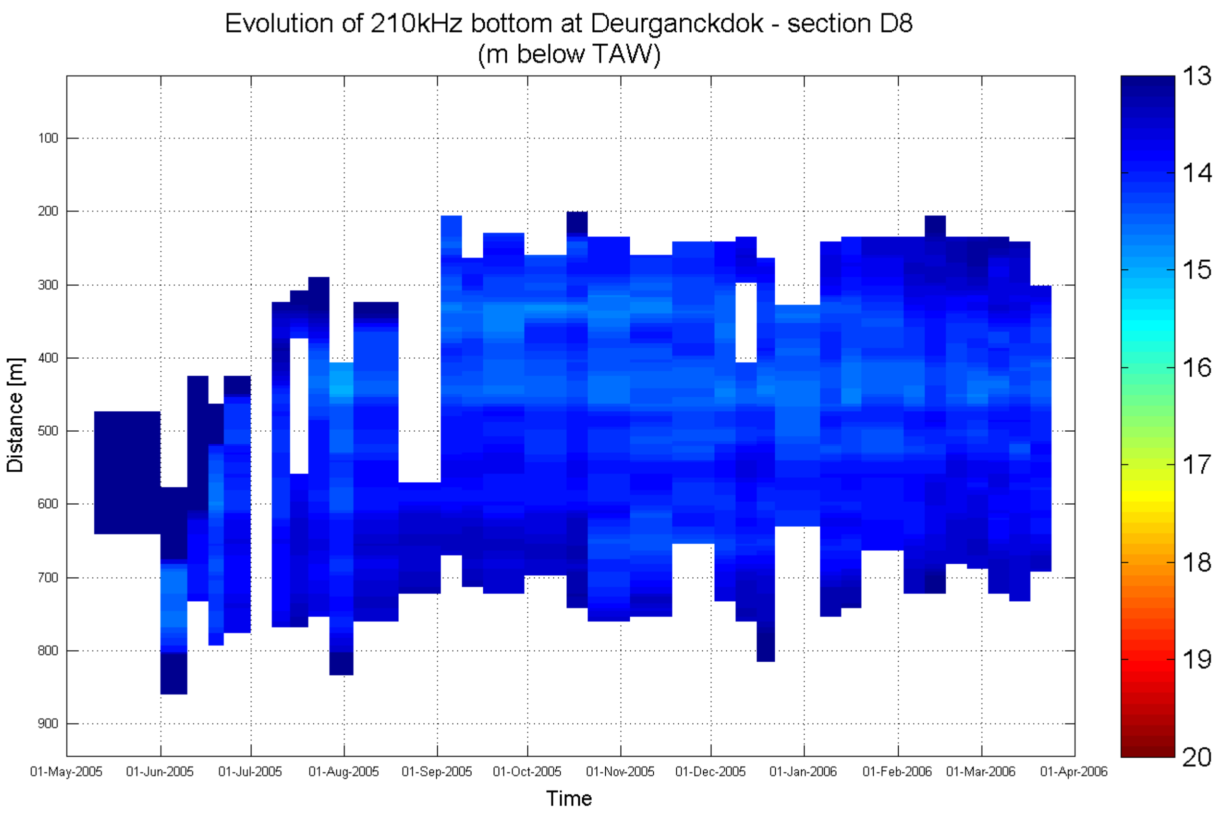
Data Processed by: IMDC

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom	Equipment(s): 210kHz depth sounder
	Location: DGD



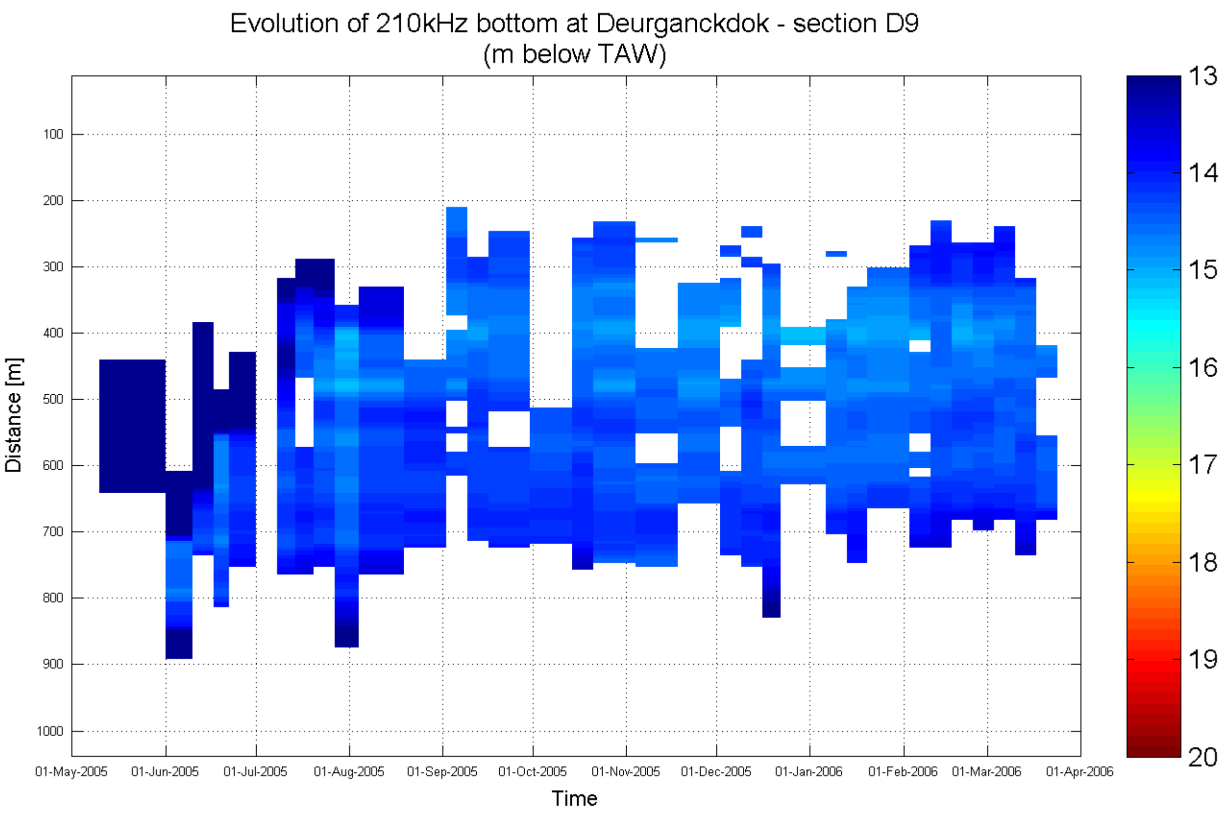
Data Processed by:

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom	Equipment(s): 210kHz depth sounder
	Location: DGD



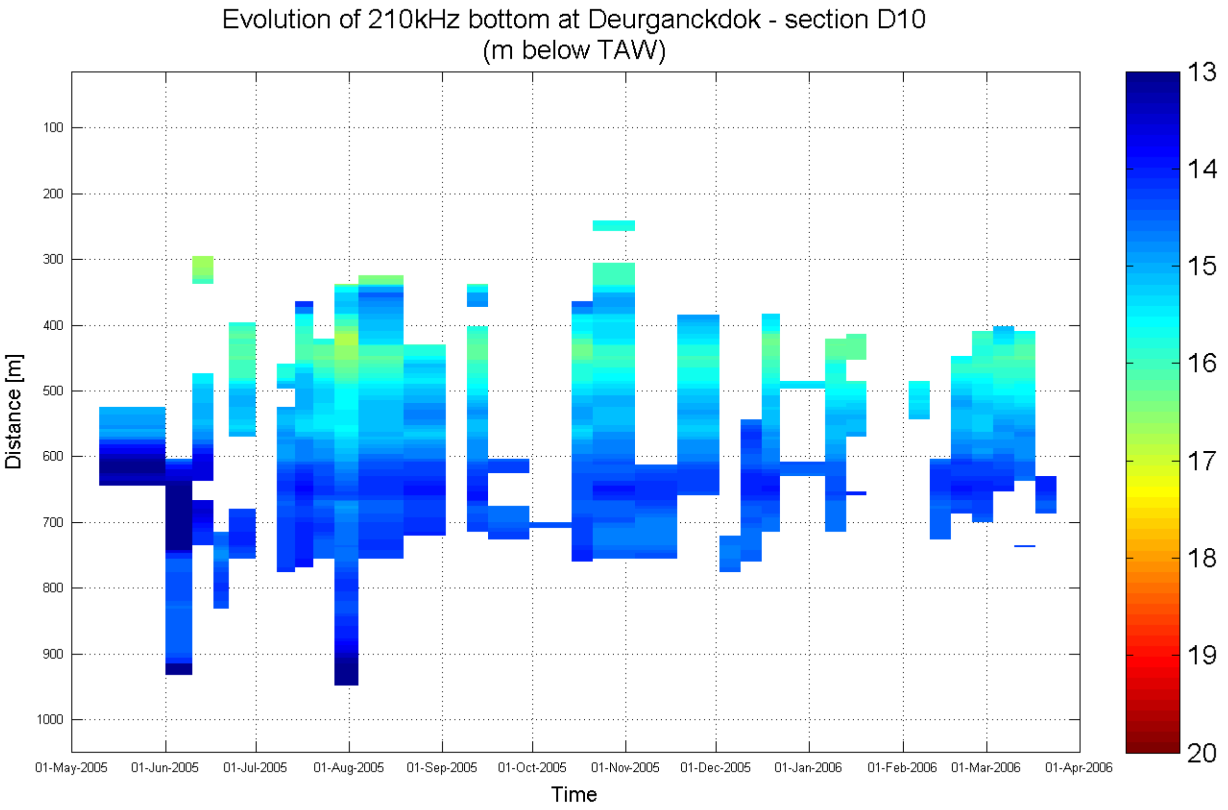
Data Processed by:

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom	Equipment(s): 210kHz depth sounder
	Location: DGD



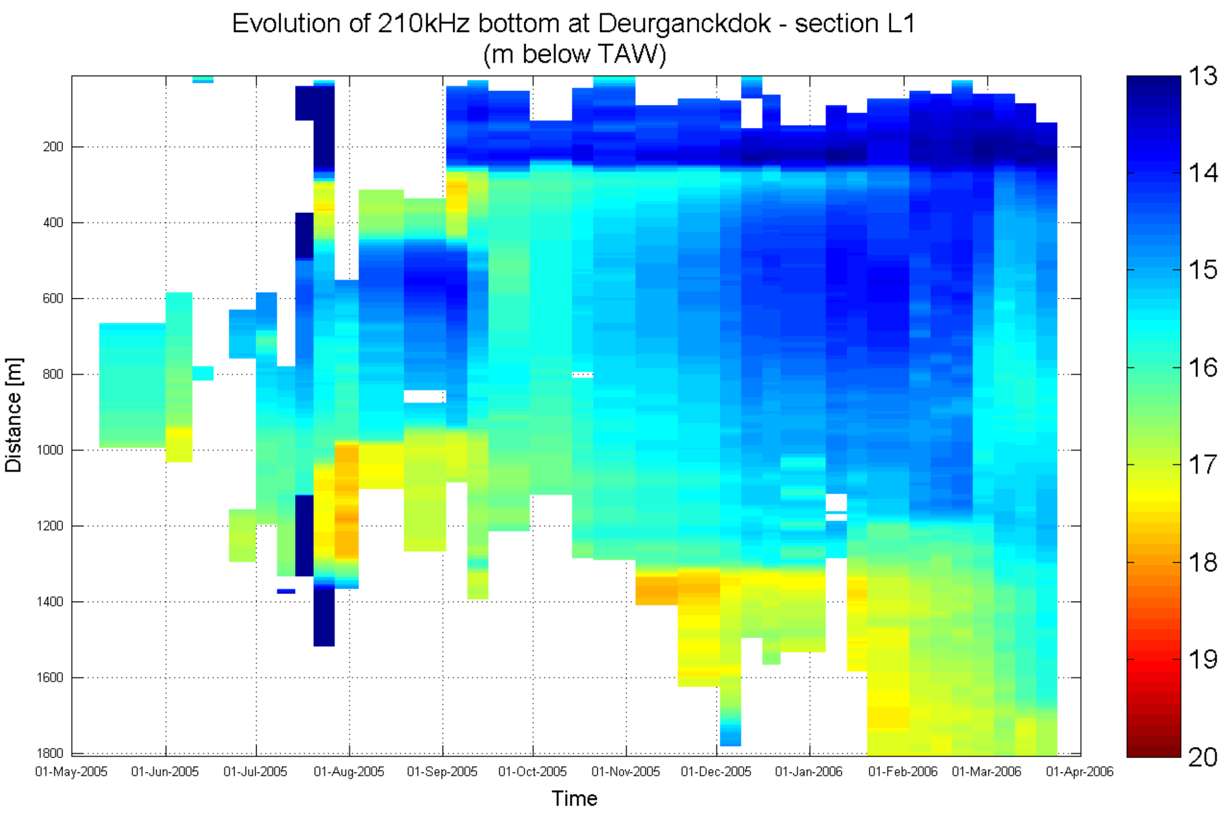
Data Processed by:

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom	Equipment(s): 210kHz depth sounder
	Location: DGD



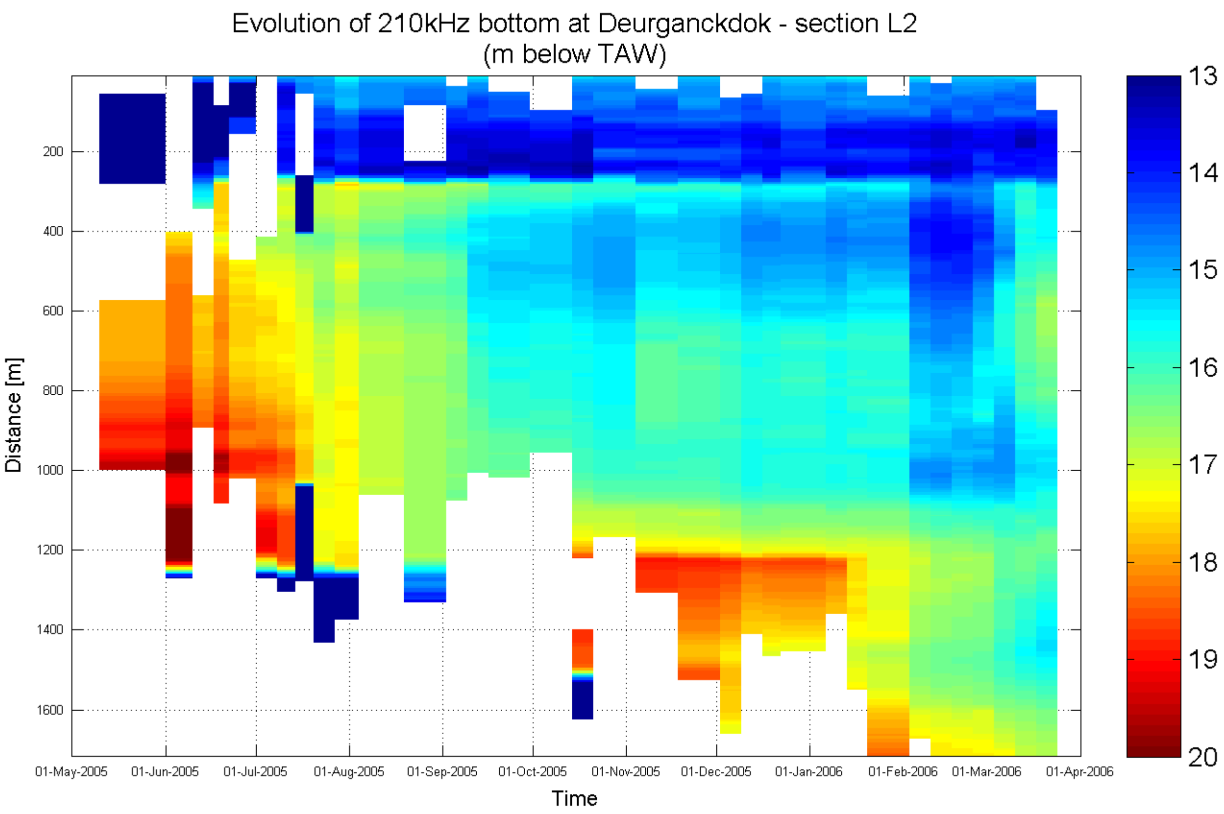
Data Processed by:

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom	Equipment(s): 210kHz depth sounder
	Location: DGD



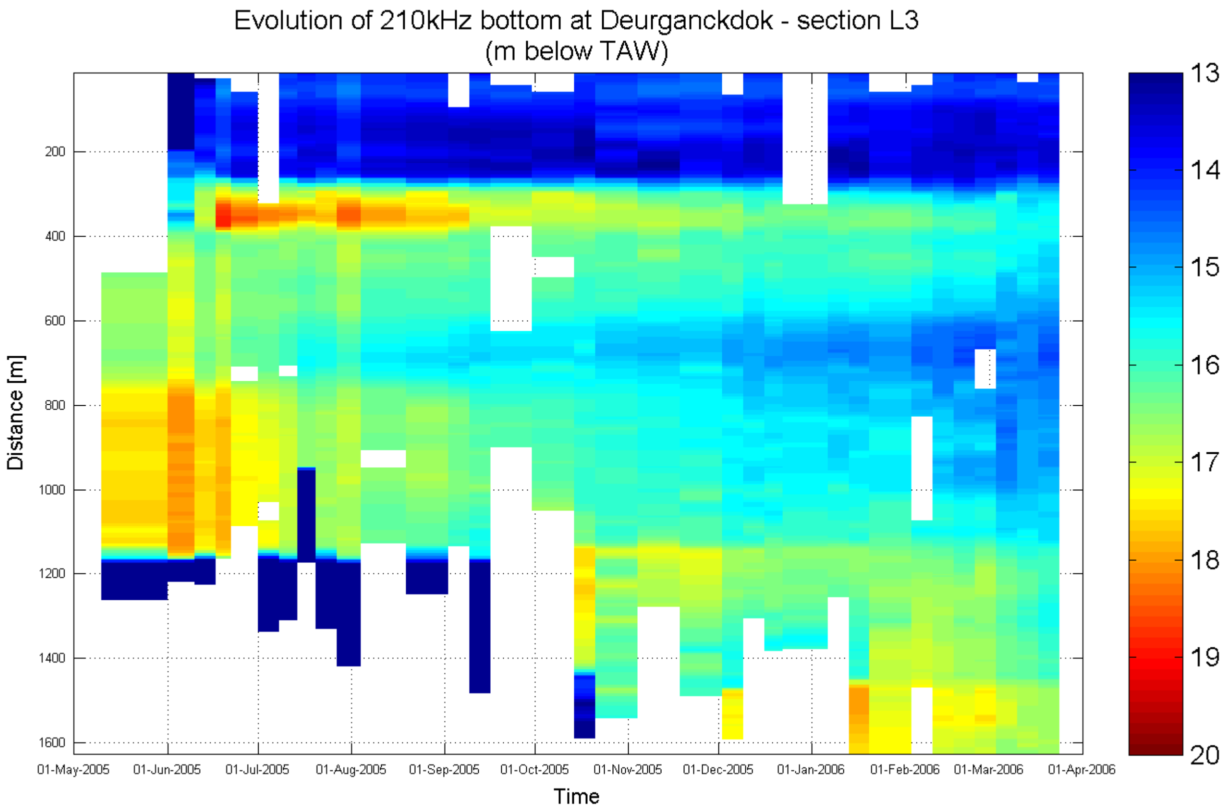
Data Processed by:

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Evolution 210kHz bottom	Equipment(s): 210kHz depth sounder
	Location: DGD



Data Processed by:

In association with :

I/RA/11283/06.118/MSA

APPENDIX C.

VOLUMETRIC SILTATION RATES IN DIFFERENT ZONES AND SECTIONS

C.1 Siltation rates (tabular)

Siltation rates in cm/day

1/ Per zone

	May05	jun/05	jul/05	aug/05	sep/05	Oct05	nov/05	dec/05	jan/06	feb/06	Mar06
1	***	***	***	***	***	***	***	***	***	***	***
2	***	***	***	0.44	0.542	-0.423	0.146	0.983	0.355	-0.125	-0.409
3a	0	2.633	1.679	1.717	1.614	0.284	0.454	0.864	1.237	-1.571	-2.624
3b	0	3.359	3.643	1.933	1.173	0.371	0.513	0.653	1.351	0.552	-3.061
3c	***	***	***	***	***	***	***	***	***	***	***
4Na	0	2.756	0.223	1.589	-2.142	1.626	1.521	1.585	-0.357	-3.001	0.943
4Nb	***	***	-1.859	1.287	0.801	1.319	1.195	0.915	0.505	-2.369	0.568
4Nc	***	***	***	***	***	***	***	***	***	***	***
4Za	1.036	0.227	0.441	0.844	0.303	0.286	0.466	0.763	0.359	0.955	-0.081
4Zb	-2.432	2.652	1.98	0.949	0.324	0.901	0.665	0.501	0.542	1.198	-0.662
4Zc	***	***	***	***	***	***	***	***	***	***	***
5Na	***	***	***	***	***	***	***	***	***	***	***
5Nb	***	***	***	***	***	***	***	***	***	***	***
5Nc	***	***	***	***	***	***	***	***	***	***	***
5Za	***	***	***	***	***	***	***	***	***	***	***
5Zb	***	***	***	***	***	***	***	***	***	***	***
5Zc	***	***	***	***	***	***	***	***	***	***	***
AVG	*******	*******	**1.722**	**1.55**	**0.577**	**0.714**	**0.709**	**0.9**	**0.852**	**-0.92**	**-1.538**

1/ Per section

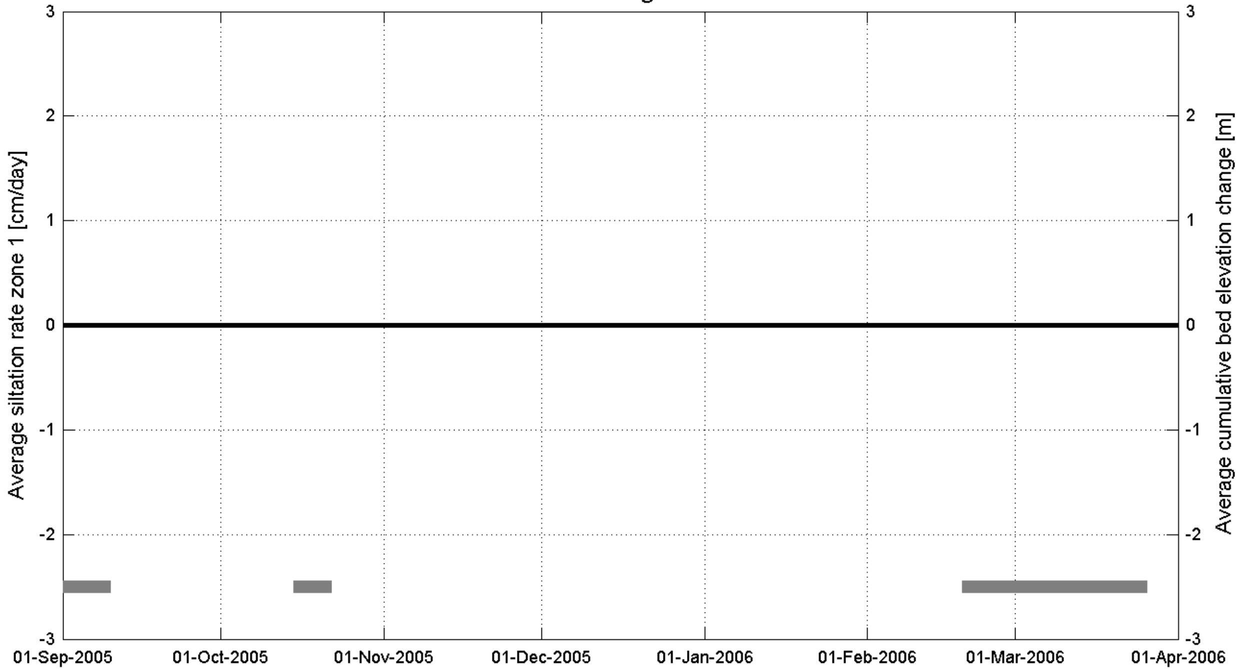
	May05	jun/05	jul/05	aug/05	sep/05	Oct05	nov/05	dec/05	jan/06	feb/06	Mar06
D1	***	***	***	***	***	***	***	***	***	***	***
D2	***	***	***	***	***	***	***	***	***	***	***
D3	0	2.36	1.678	1.476	0.861	0.799	0.7	0.225	1.765	0.888	-1.401
D4	-2.148	2.986	1.375	1.447	0.671	0.426	0.59	0.759	0.755	-0.884	-1.727
D5	0	1.716	0.898	1.758	-0.387	0.656	0.625	1.22	0.388	-1.077	-1.463
D6	***	***	1.199	1.148	2.188	0.671	0.958	1.419	1.078	-1.192	-0.113
D7	***	***	***	0.676	0.089	-1.114	-0.353	1.091	-0.295	0.015	-0.761
D8	***	***	***	-0.157	0.223	-0.848	-0.024	0.595	0.114	0.436	-0.188
D9	***	***	***	***	***	***	***	***	***	***	***
D10	***	***	***	***	***	***	***	***	***	***	***
L1	***	***	***	0.862	-1.372	1.761	1.423	1.473	-0.158	-2.79	1.054
L2	0	4.281	1.595	1.431	1.747	-0.473	0.221	0.494	1.386	-0.726	-2.186
L3	0	-0.518	1.184	0.88	0.263	0.412	0.565	0.556	0.054	0.933	-0.252

C.2 Water-bed interface evolution for all zones

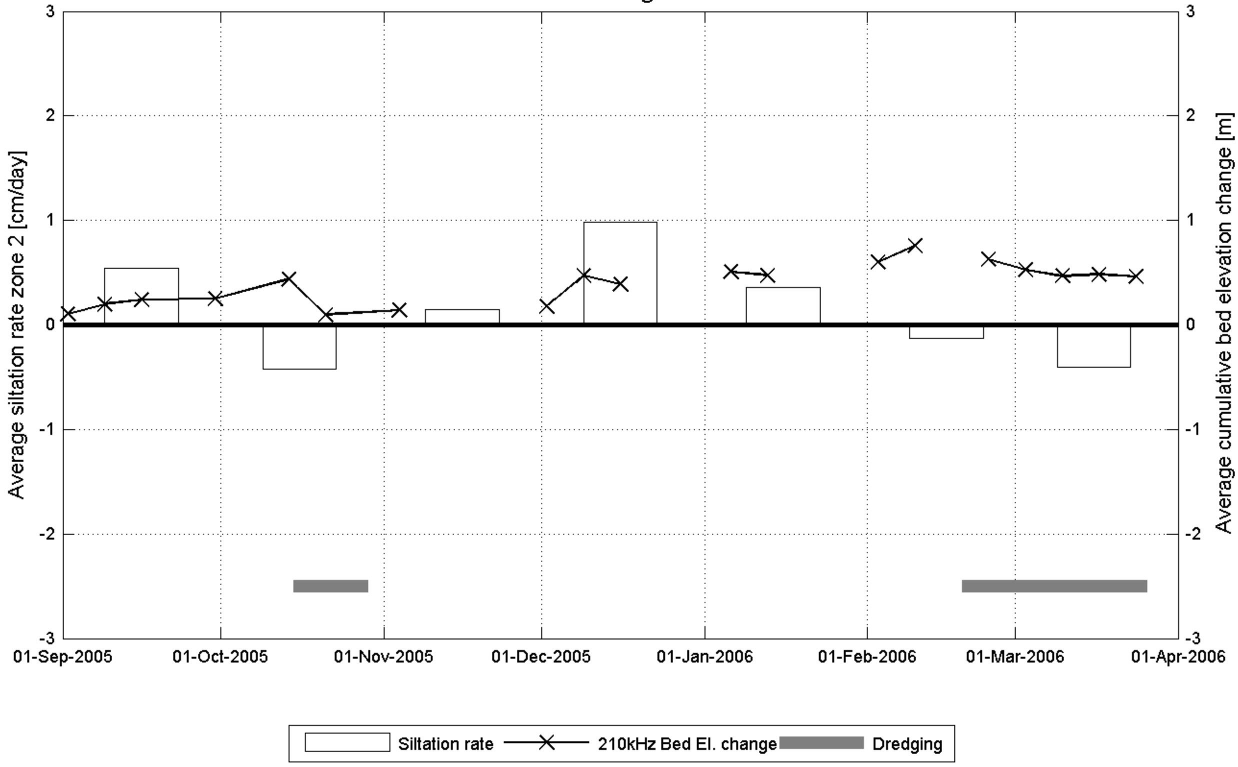
Long-term monitoring siltation Deurganckdok

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

Average siltation zone 1
t0 = 04-Aug-2005



Average siltation zone 2
t0 = 04-Aug-2005



Reference level: depth sounding 04-Aug-2005

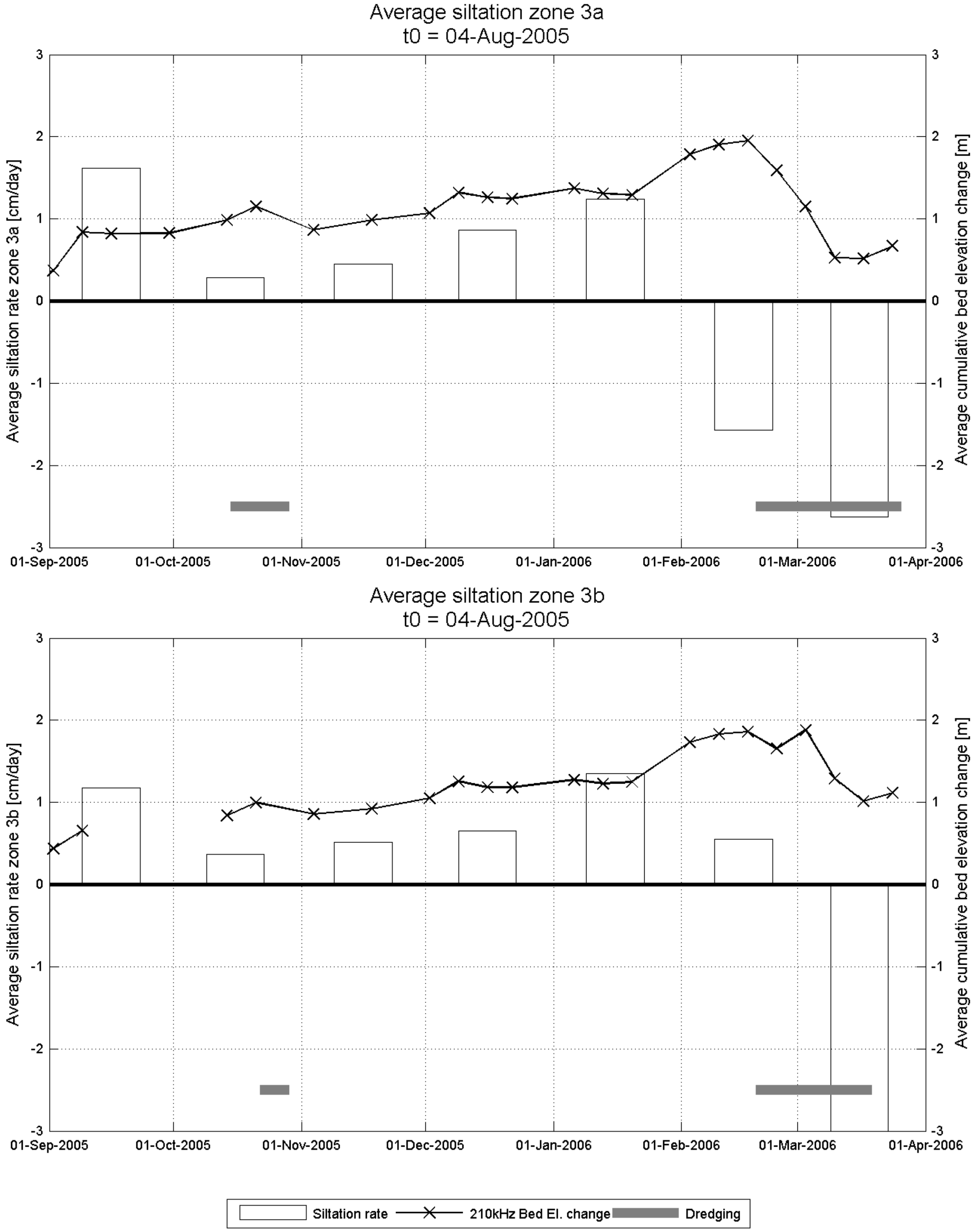
Data Processed by: IMDC

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

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



Reference level: depth sounding 04-Aug-2005

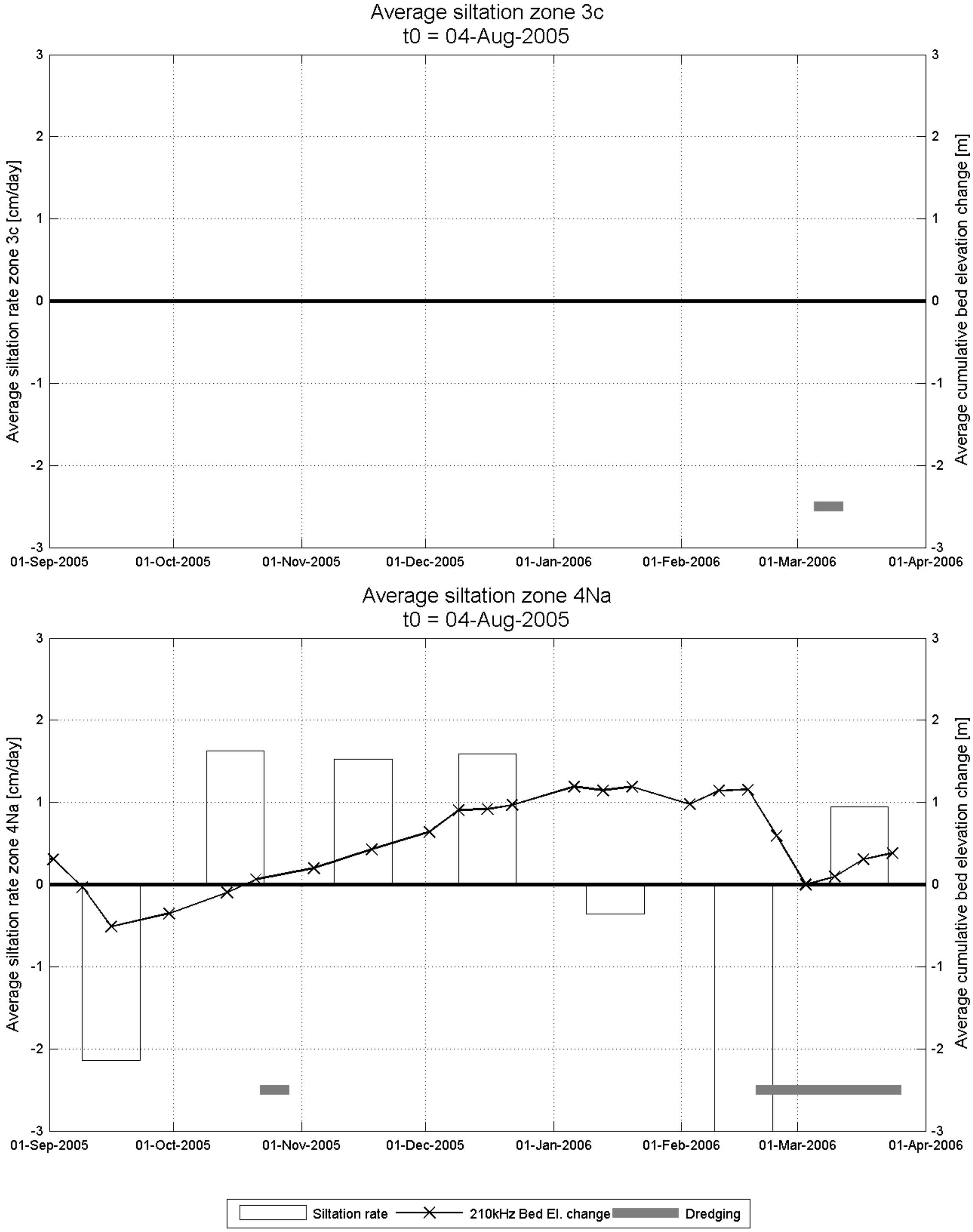
Data Processed by:

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

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



Reference level: depth sounding 04-Aug-2005

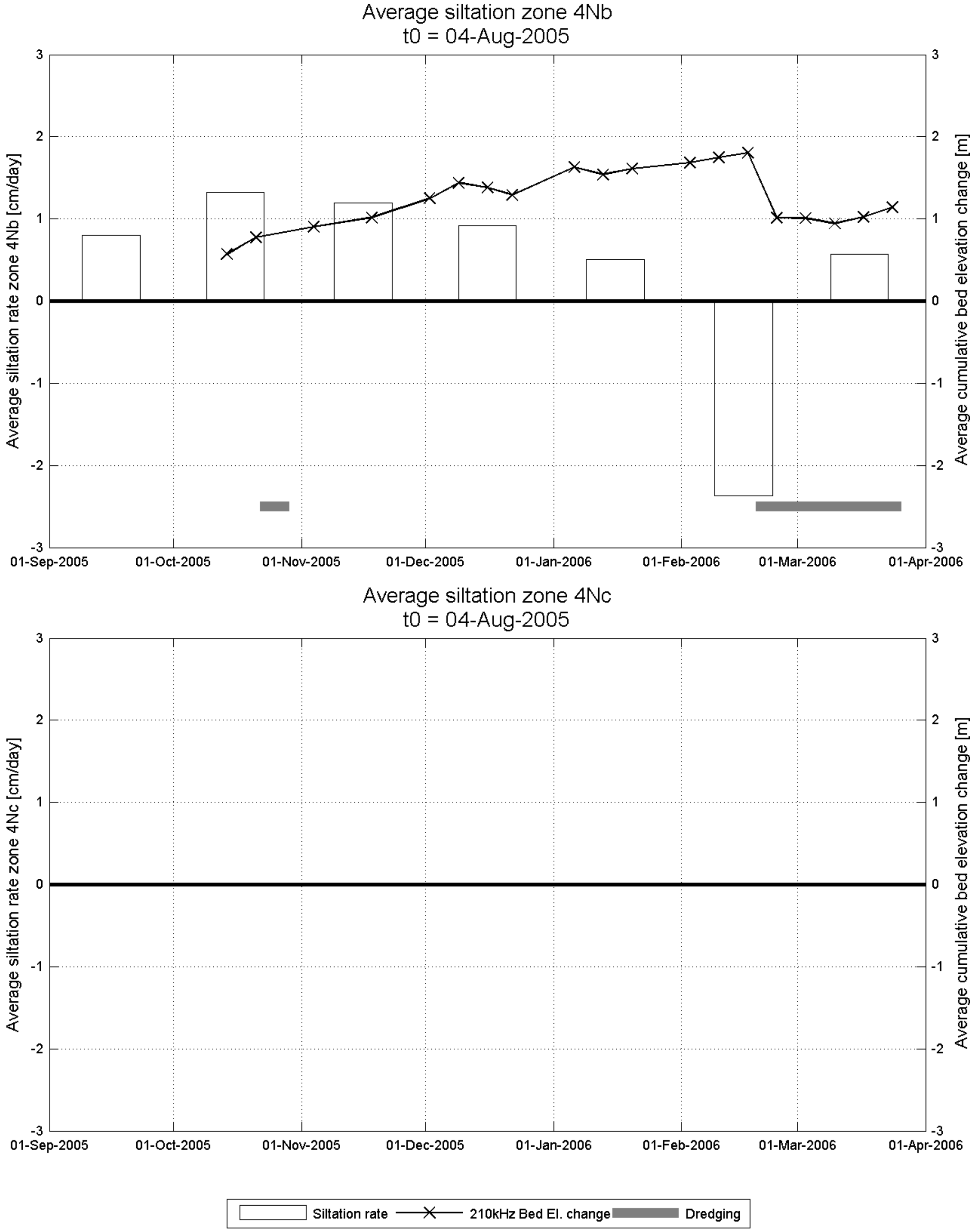
Data Processed by:

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

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



Reference level: depth sounding 04-Aug-2005

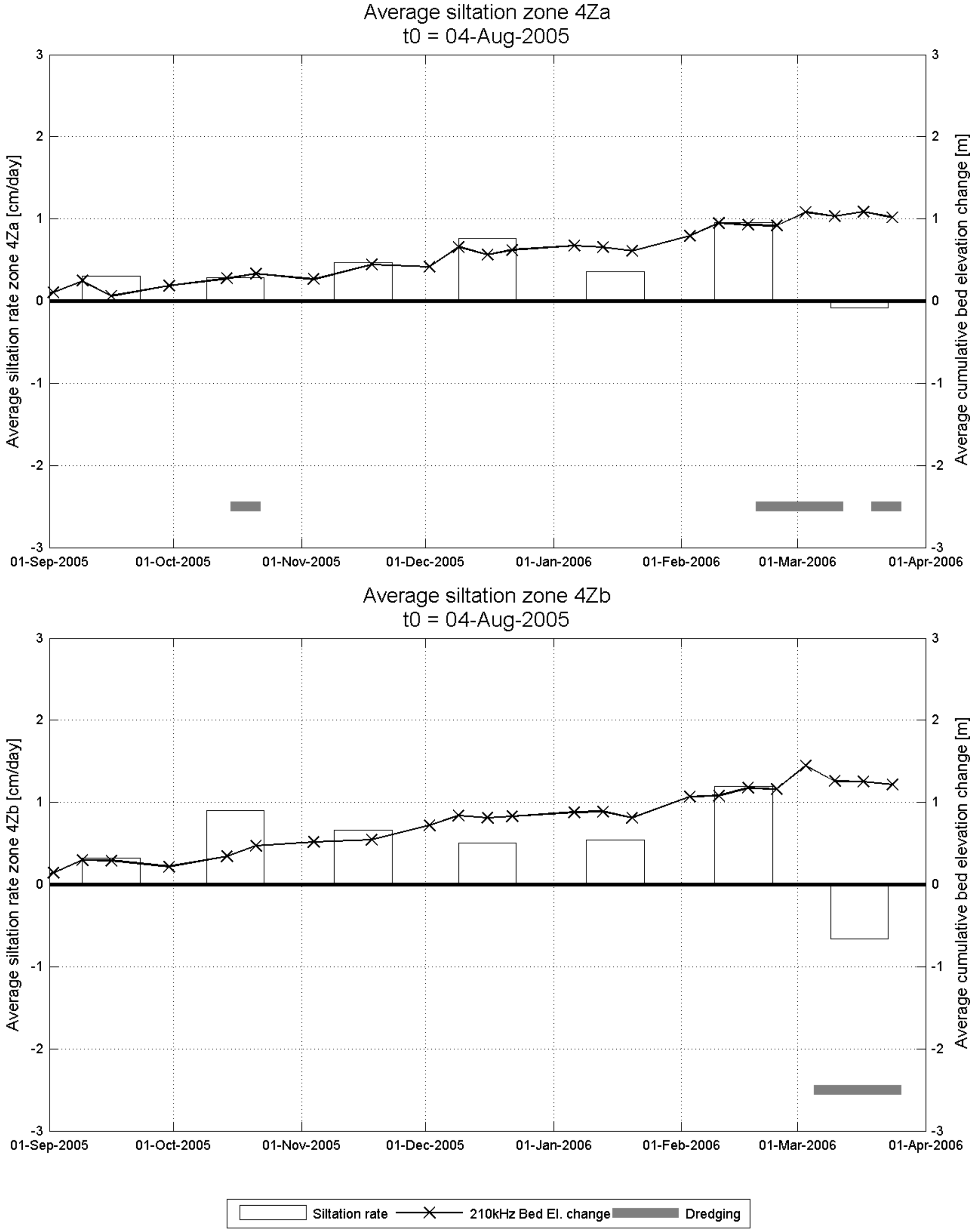
Data Processed by: IMDC

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

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



Reference level: depth sounding 04-Aug-2005

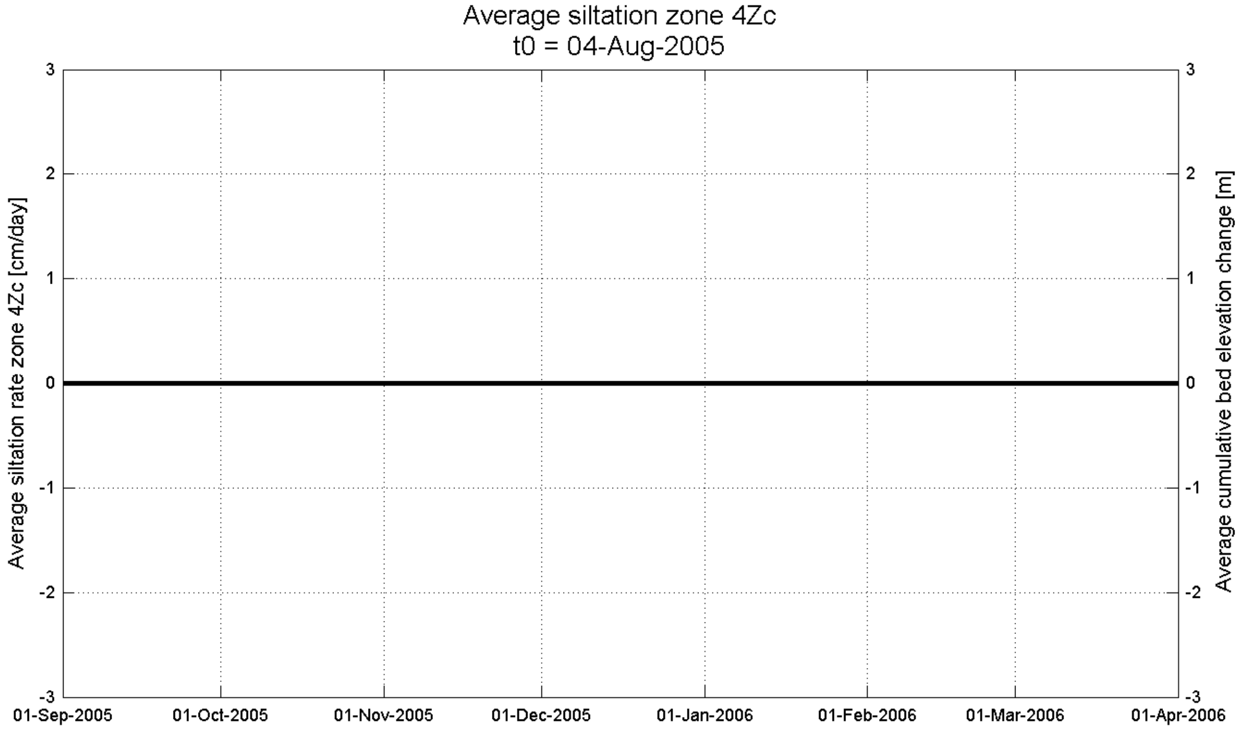
Data Processed by: IMDC

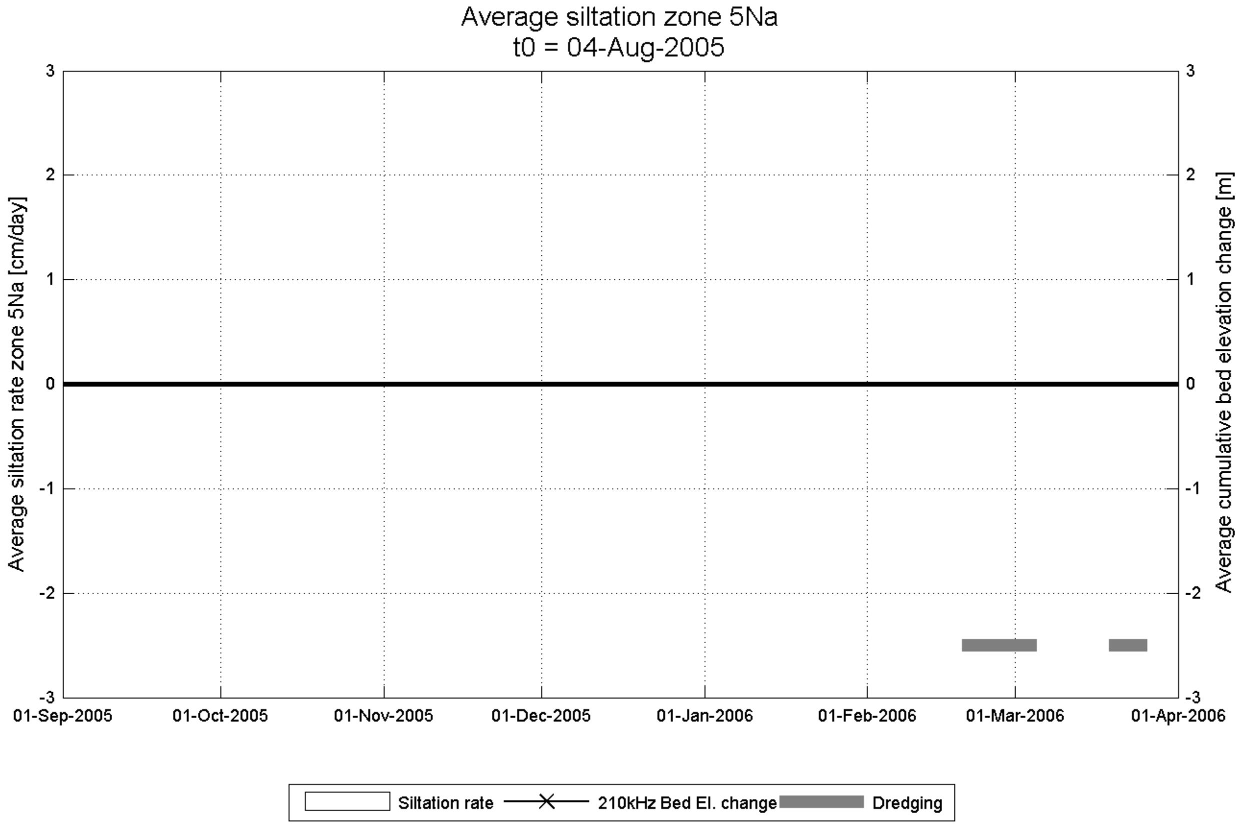
In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

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





Reference level: depth sounding 04-Aug-2005

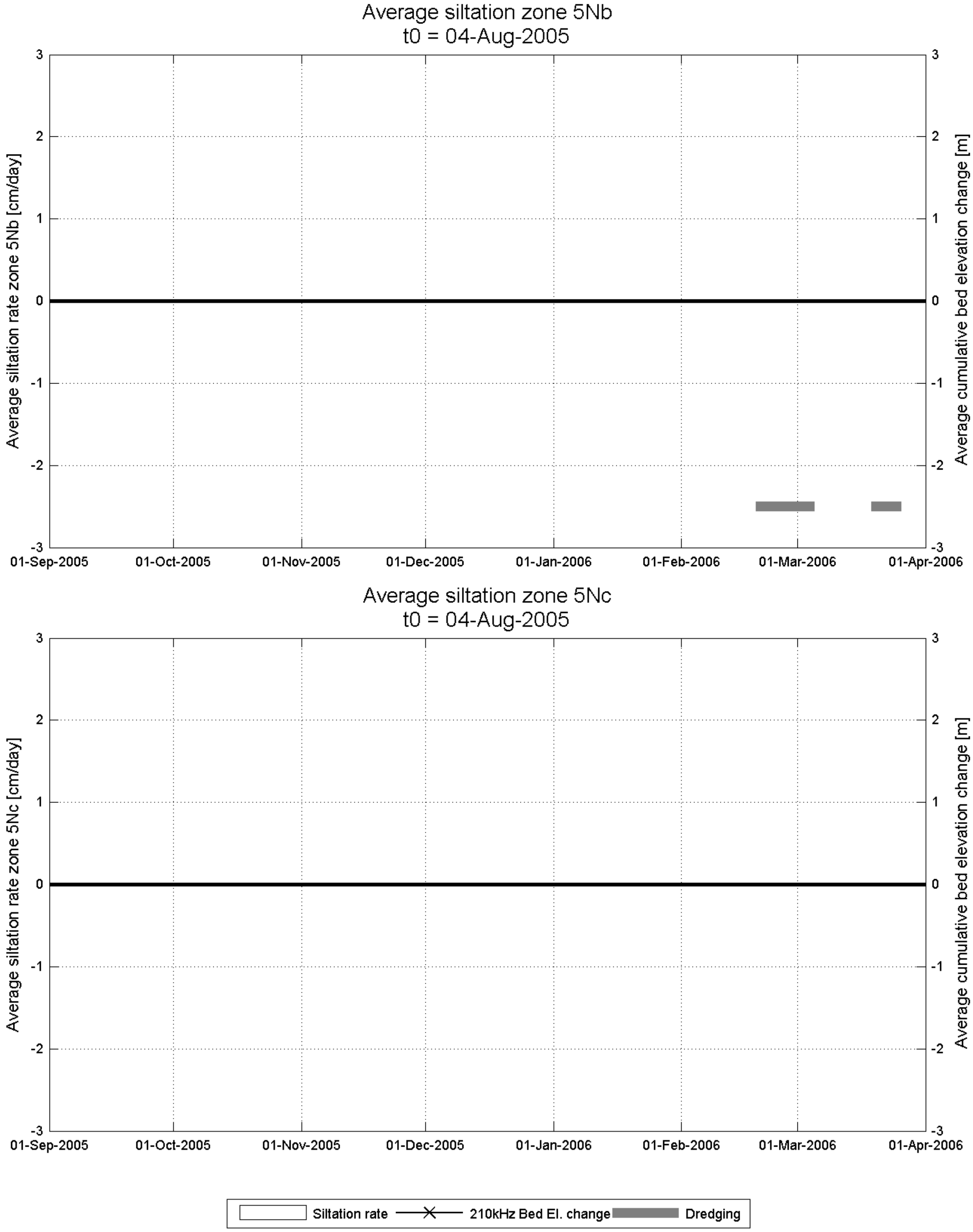
Data Processed by: IMDC

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

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



Reference level: depth sounding 04-Aug-2005

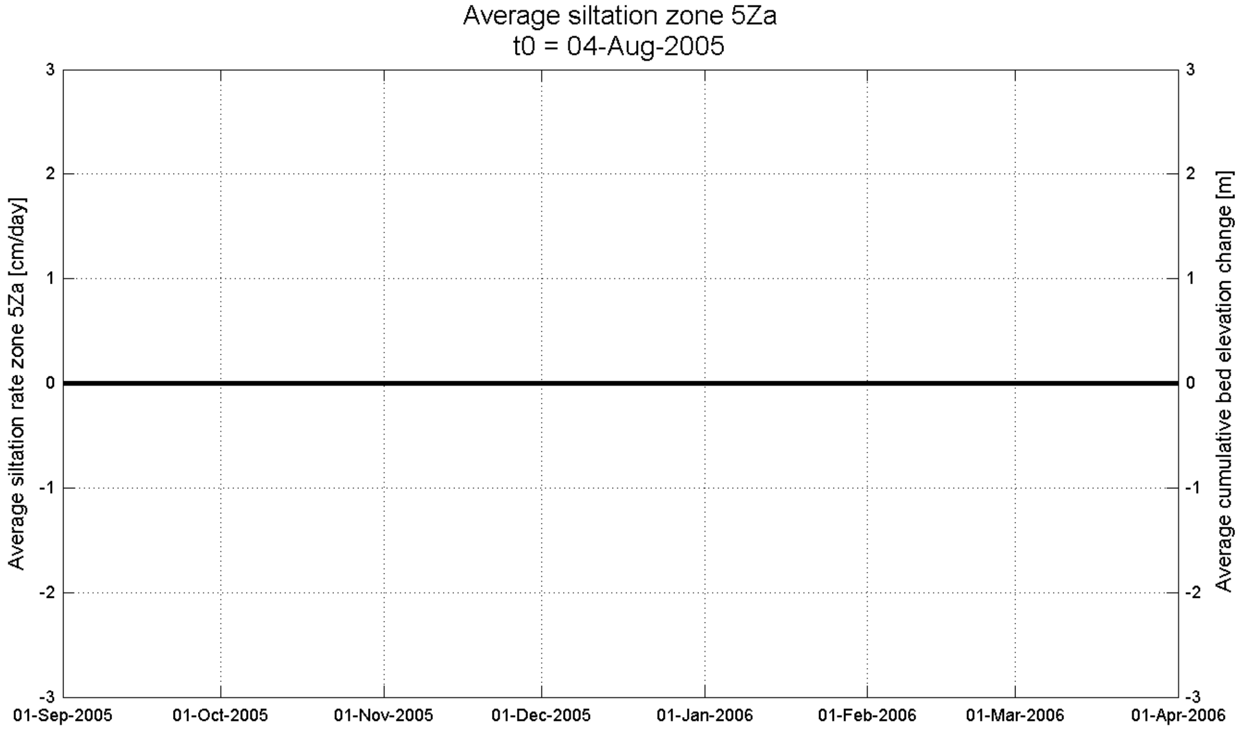
Data Processed by: IMDC

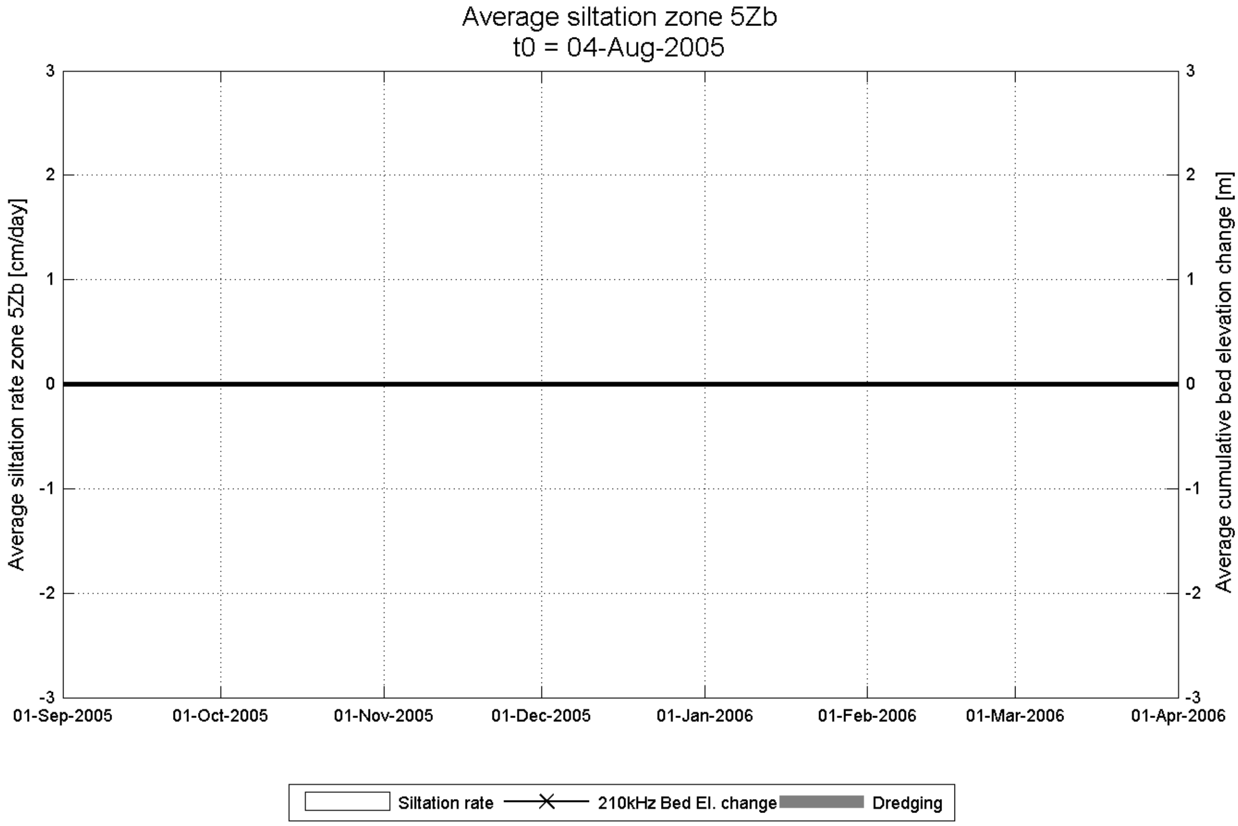
In association with : wl | delft hydraulics, GEMS International

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

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





Reference level: depth sounding 04-Aug-2005

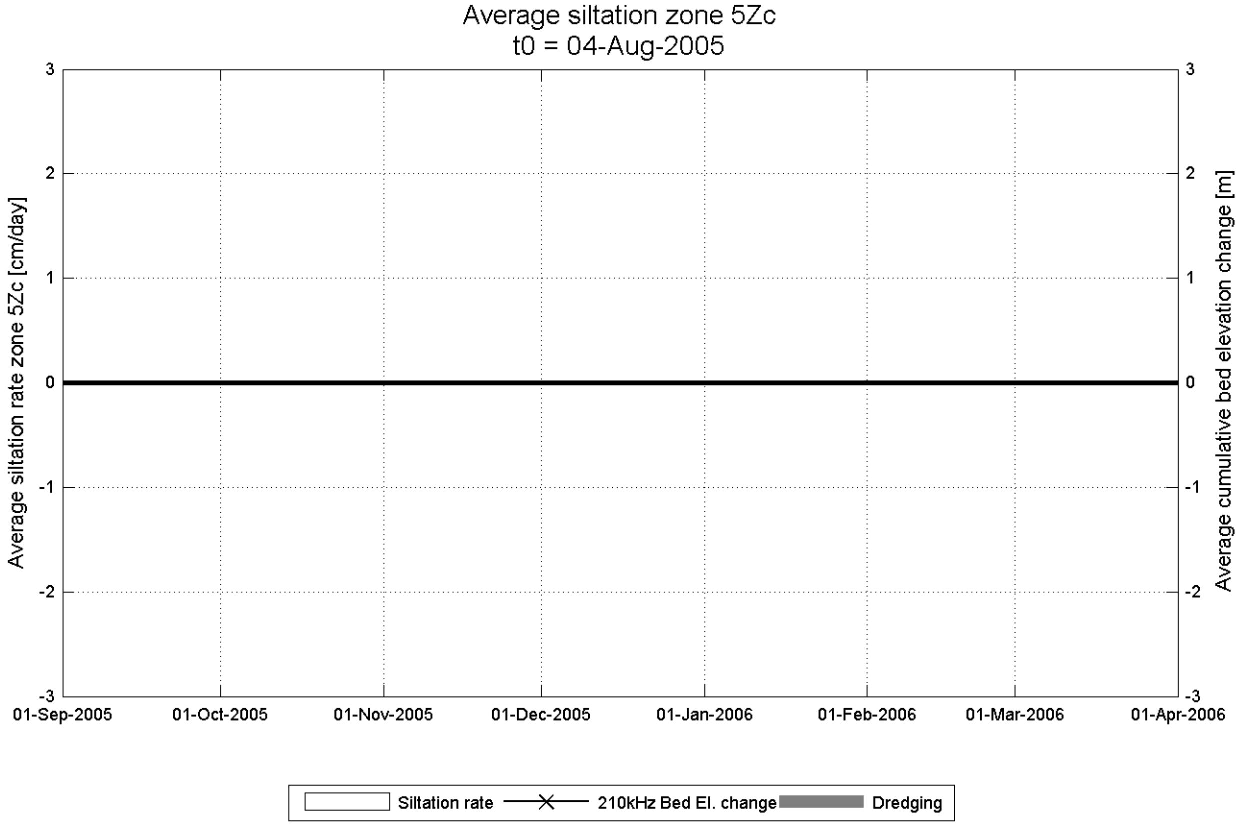
Data Processed by:

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

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



Reference level: depth sounding 04-Aug-2005

Data Processed by: IMDC

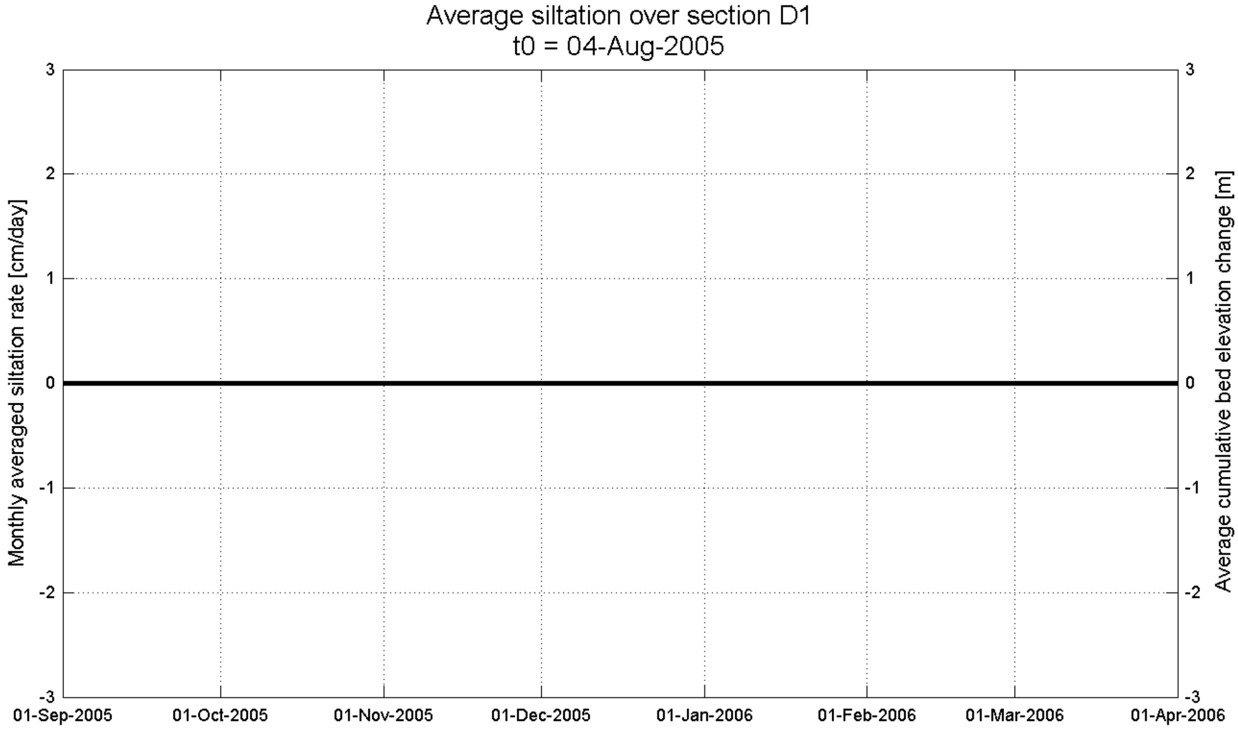
In association with :

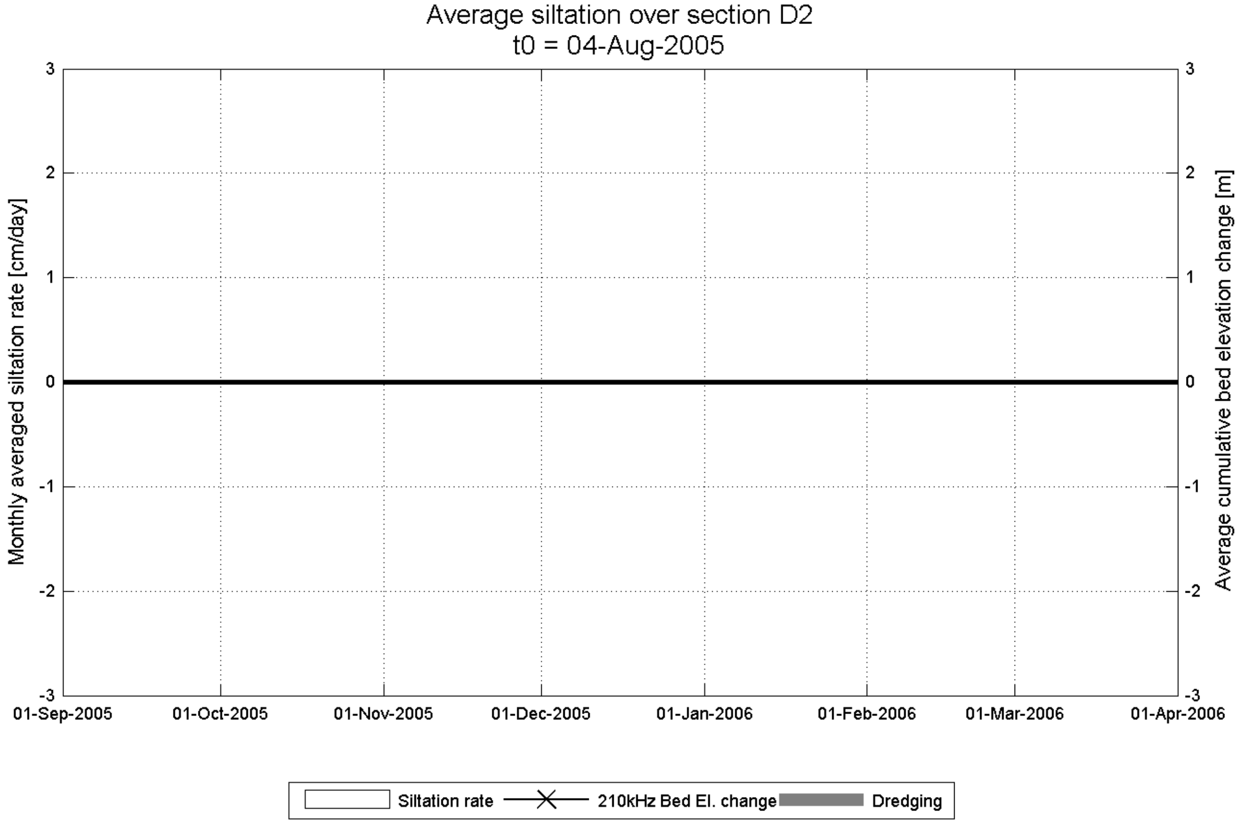
I/RA/11283/06.118/MSA

C.3 Water-bed interface evolution for all sections

Long-term monitoring siltation Deurganckdok

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



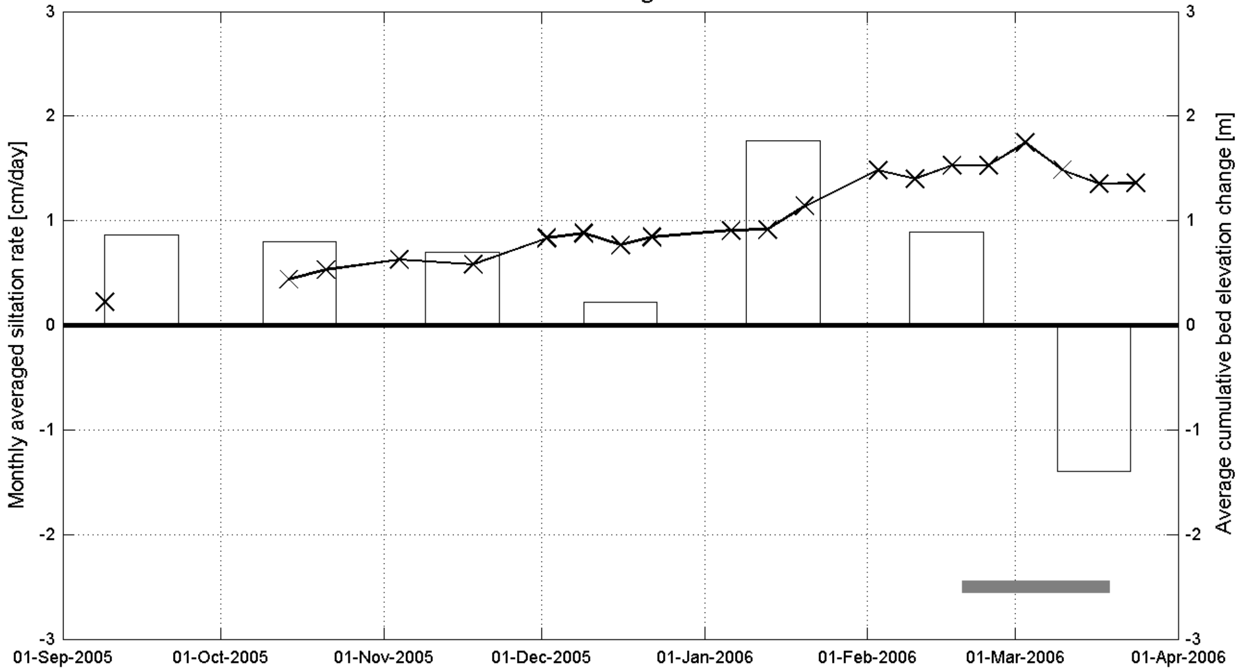


Reference level: depth sounding 04-Aug-2005	Data Processed by: IMDC In association with : I/RA/11283/06.118/MSA

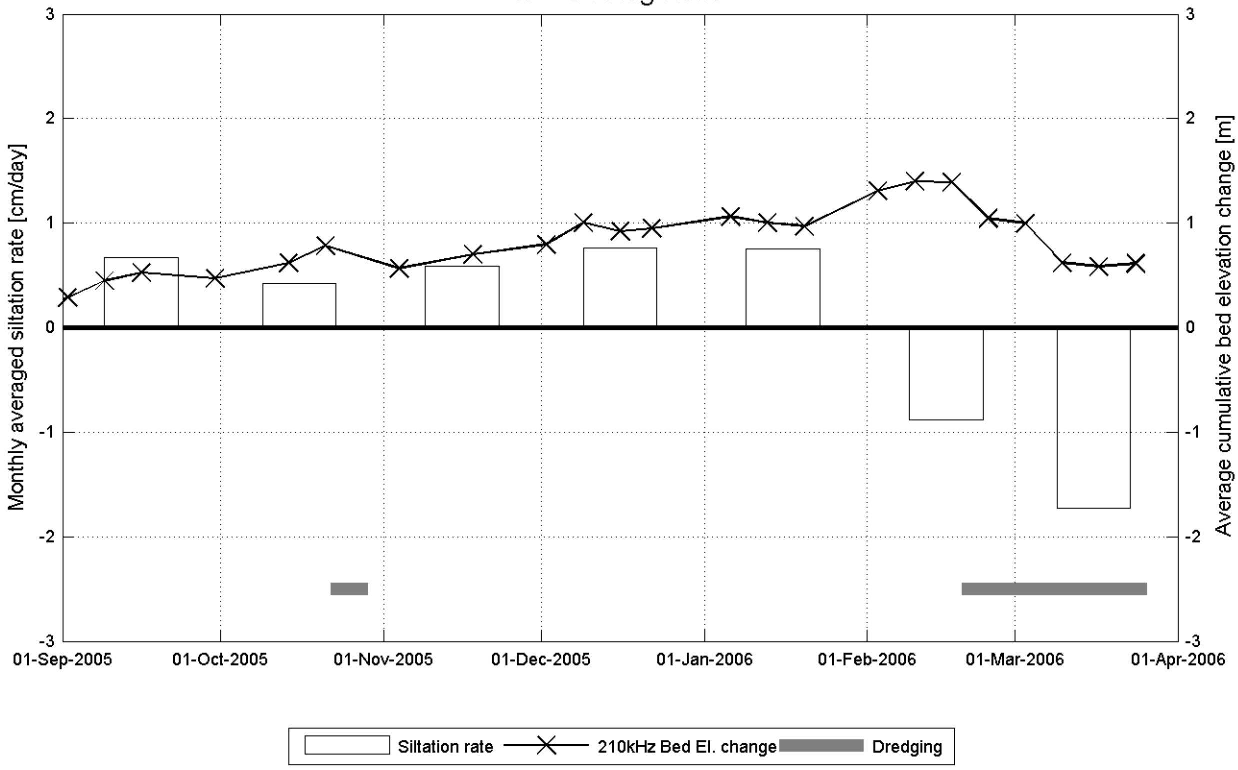
Long-term monitoring siltation Deurganckdok

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

Average siltation over section D3
t0 = 04-Aug-2005



Average siltation over section D4
t0 = 04-Aug-2005



Reference level: depth sounding 04-Aug-2005

Data Processed by: IMDC

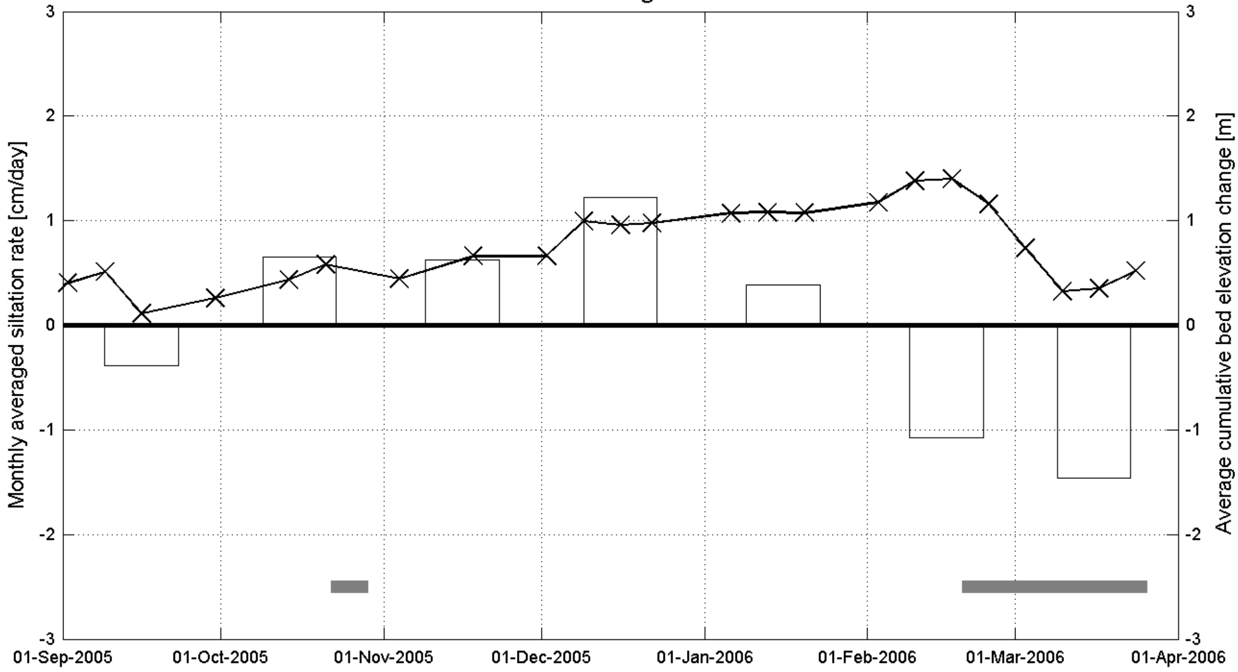
In association with :

I/RA/11283/06.118/MSA

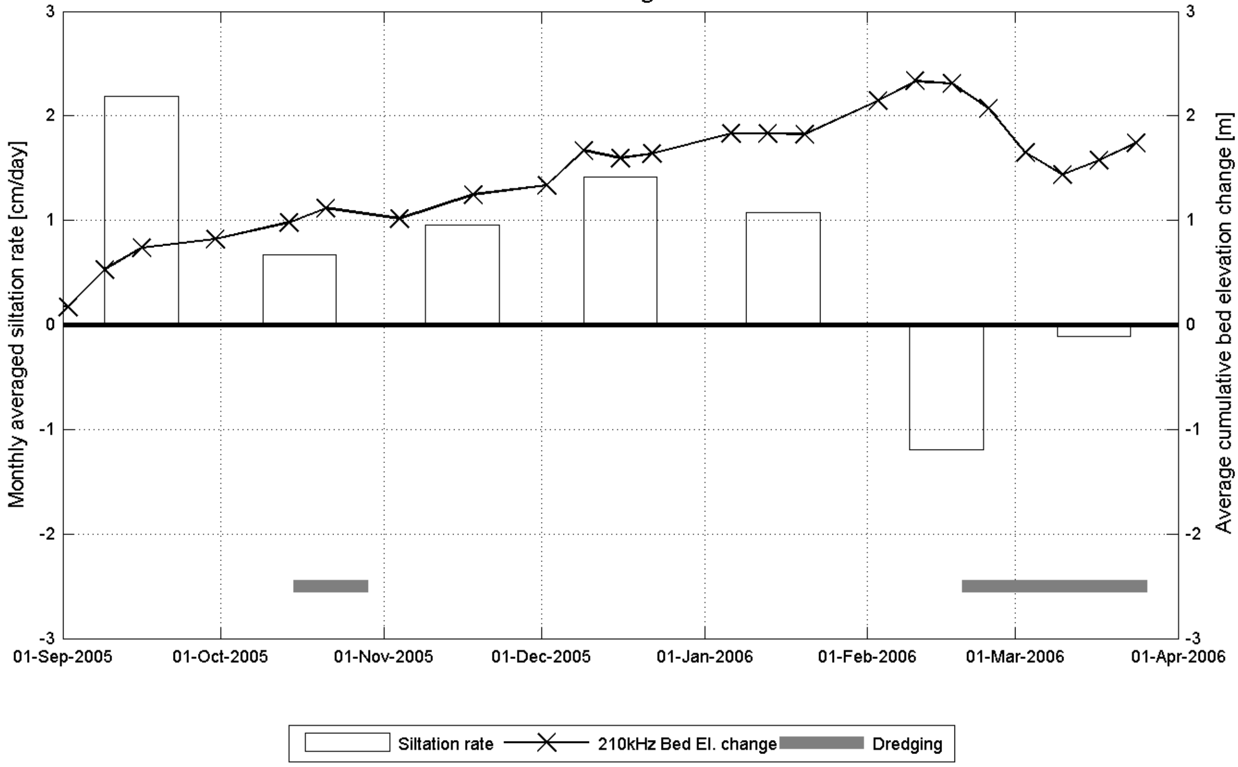
Long-term monitoring siltation Deurganckdok

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

Average siltation over section D5
t0 = 04-Aug-2005



Average siltation over section D6
t0 = 04-Aug-2005



Reference level: depth sounding 04-Aug-2005

Data Processed by: IMDC

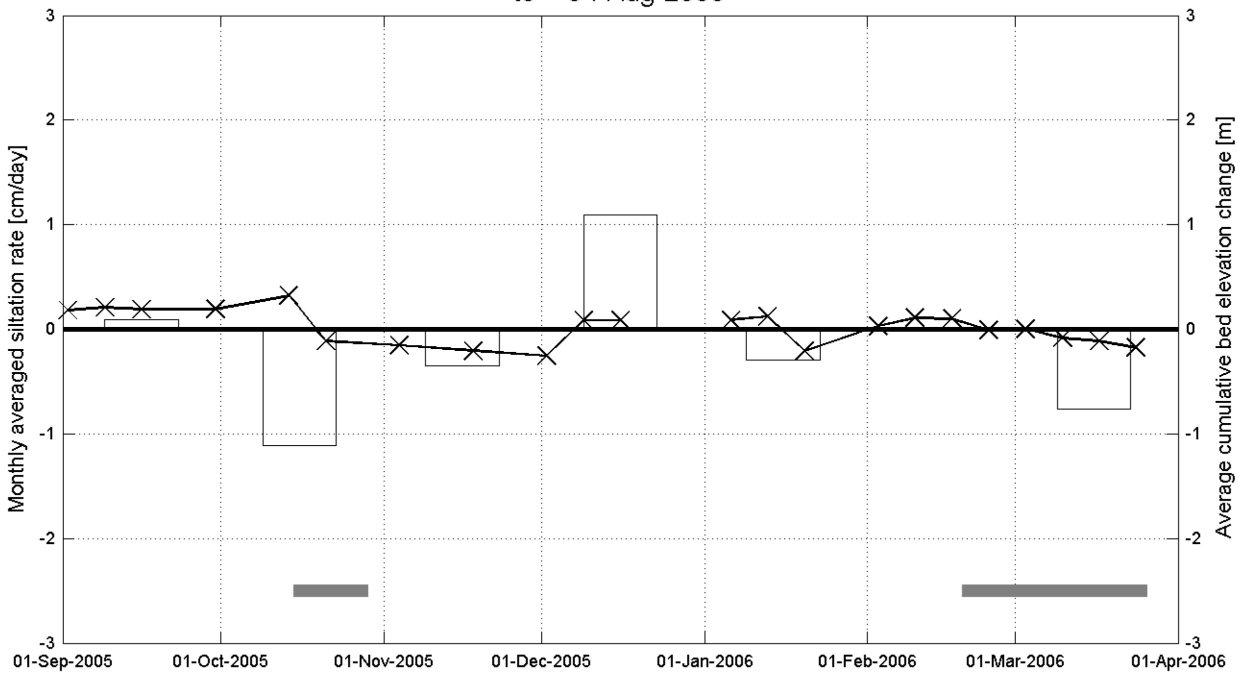
In association with :

I/RA/11283/06.118/MSA

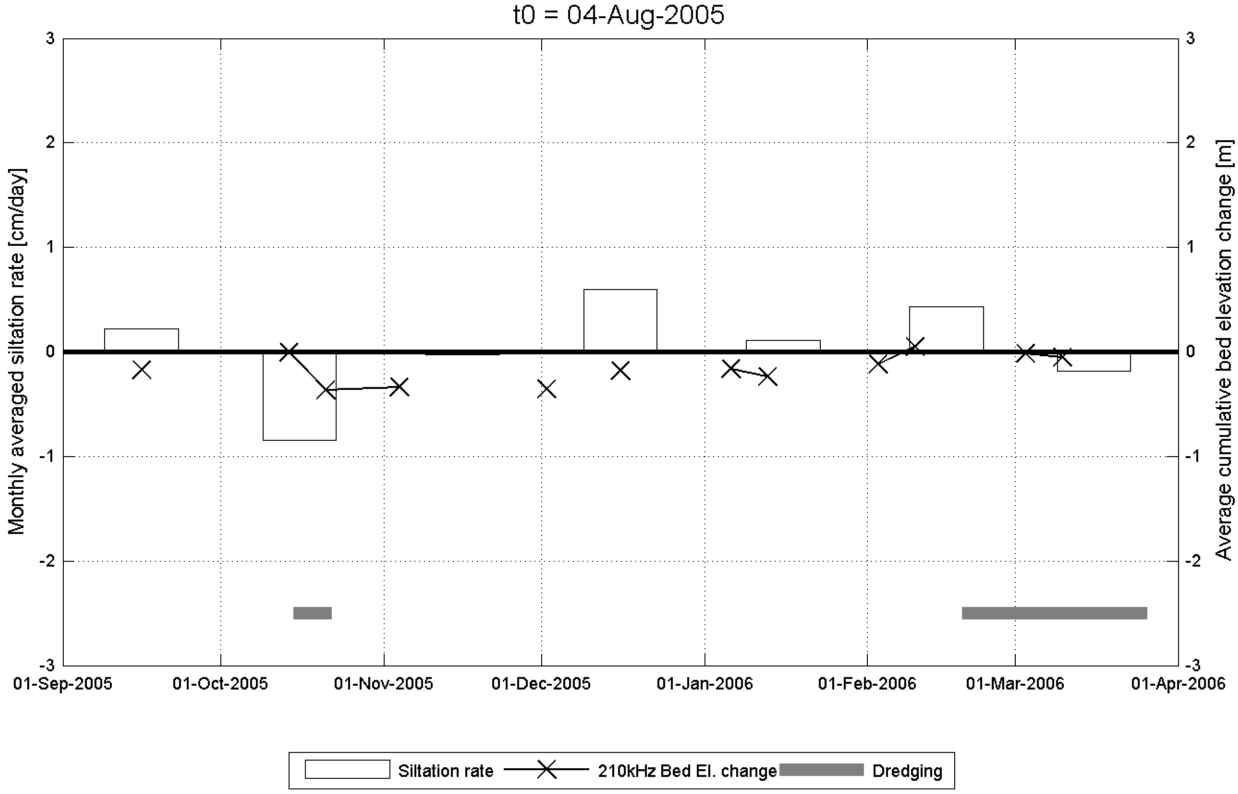
Long-term monitoring siltation Deurganckdok

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

Average siltation over section D7
t0 = 04-Aug-2005



Average siltation over section D8
t0 = 04-Aug-2005



Reference level: depth sounding 04-Aug-2005

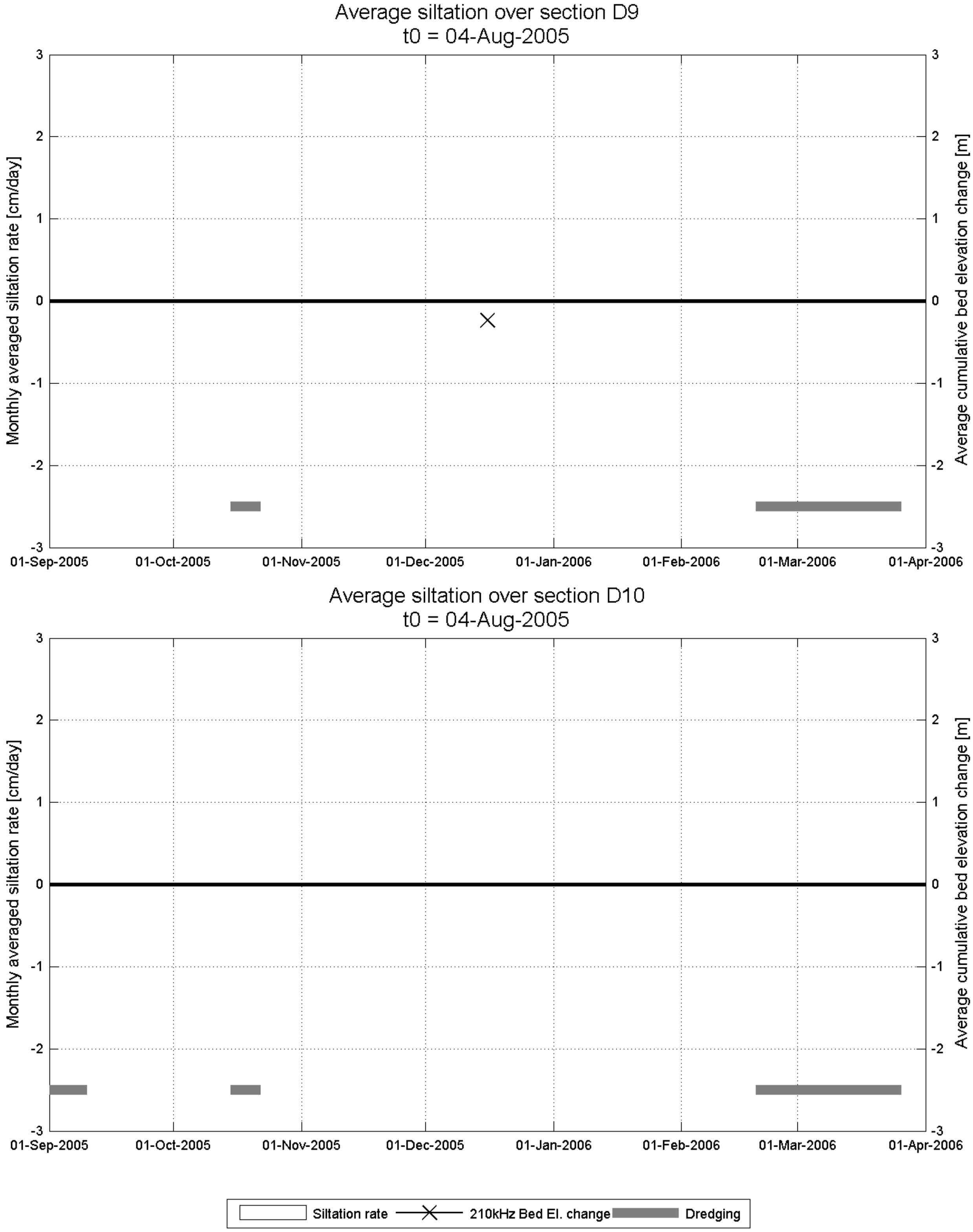
Data Processed by: IMDC

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

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



Reference level: depth sounding 04-Aug-2005

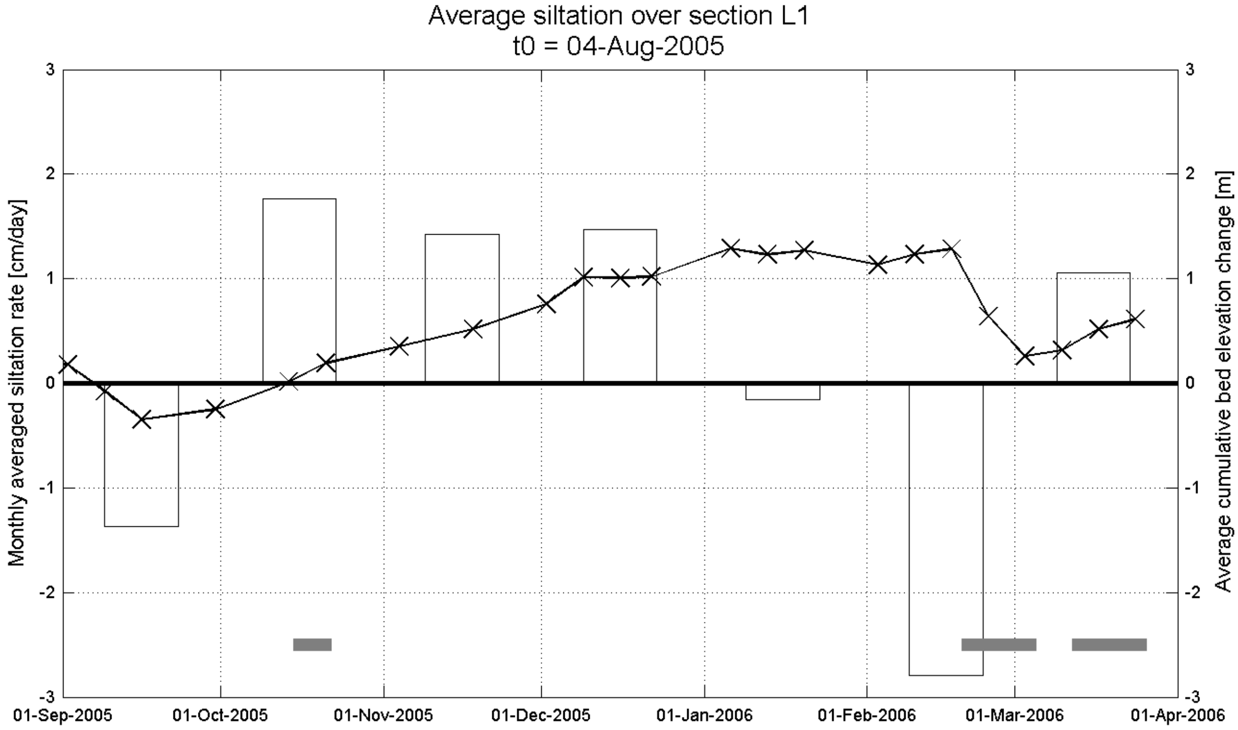
Data Processed by: IMDC

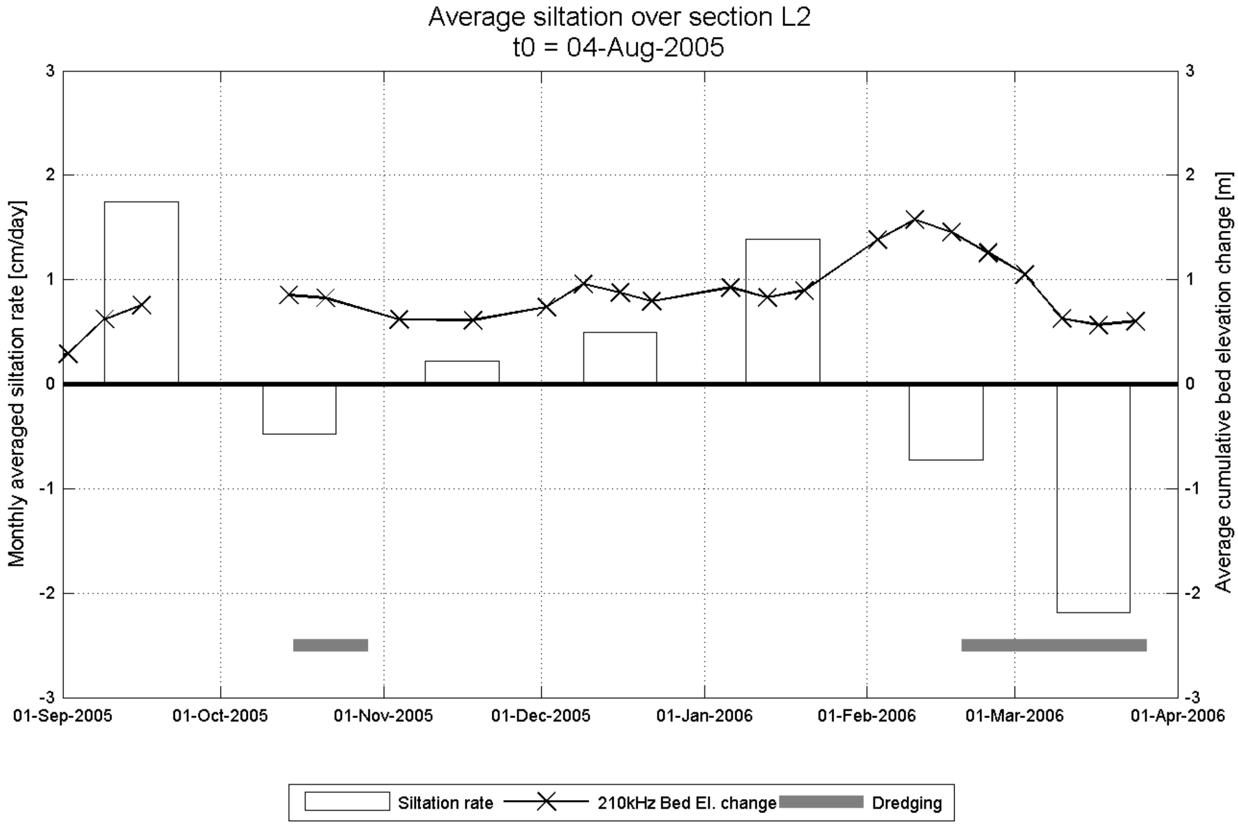
In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

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





Reference level: depth sounding 04-Aug-2005

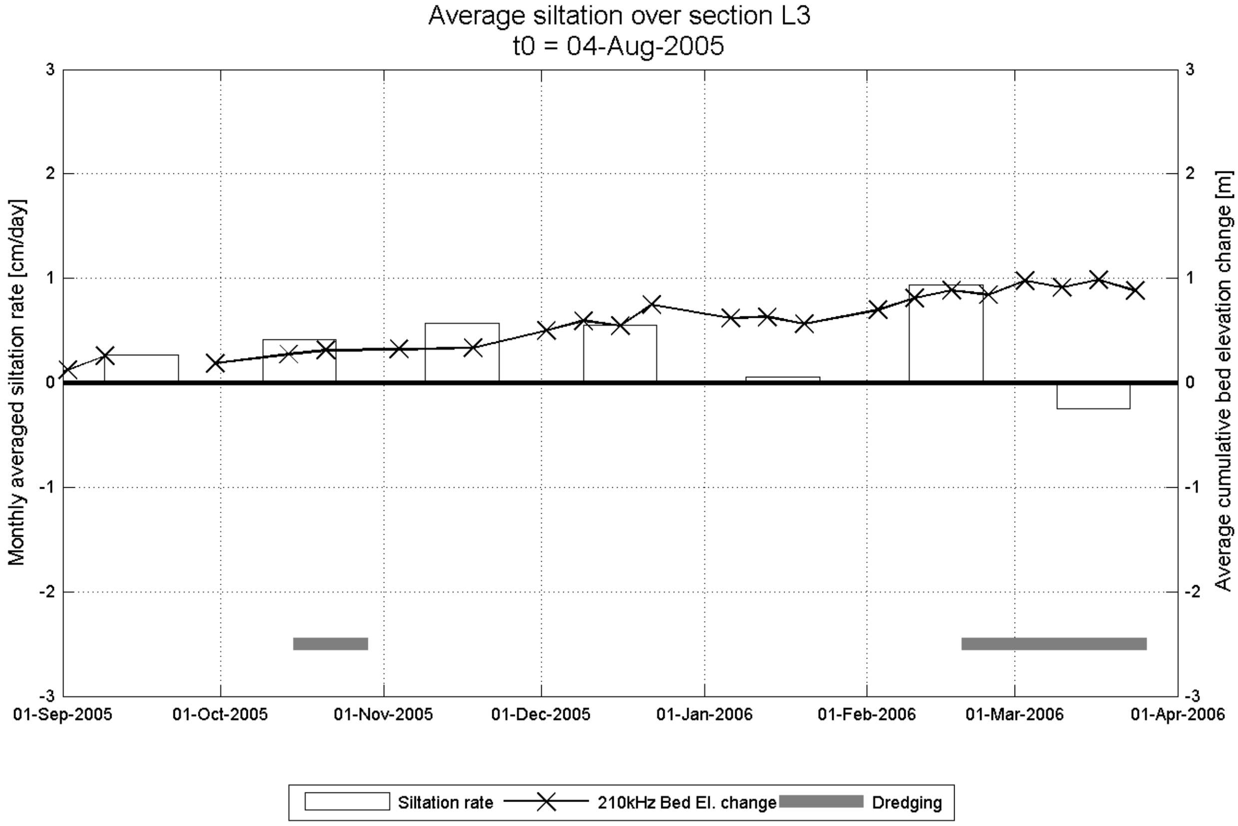
Data Processed by: IMDC

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

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



Reference level: depth sounding 04-Aug-2005

Data Processed by:

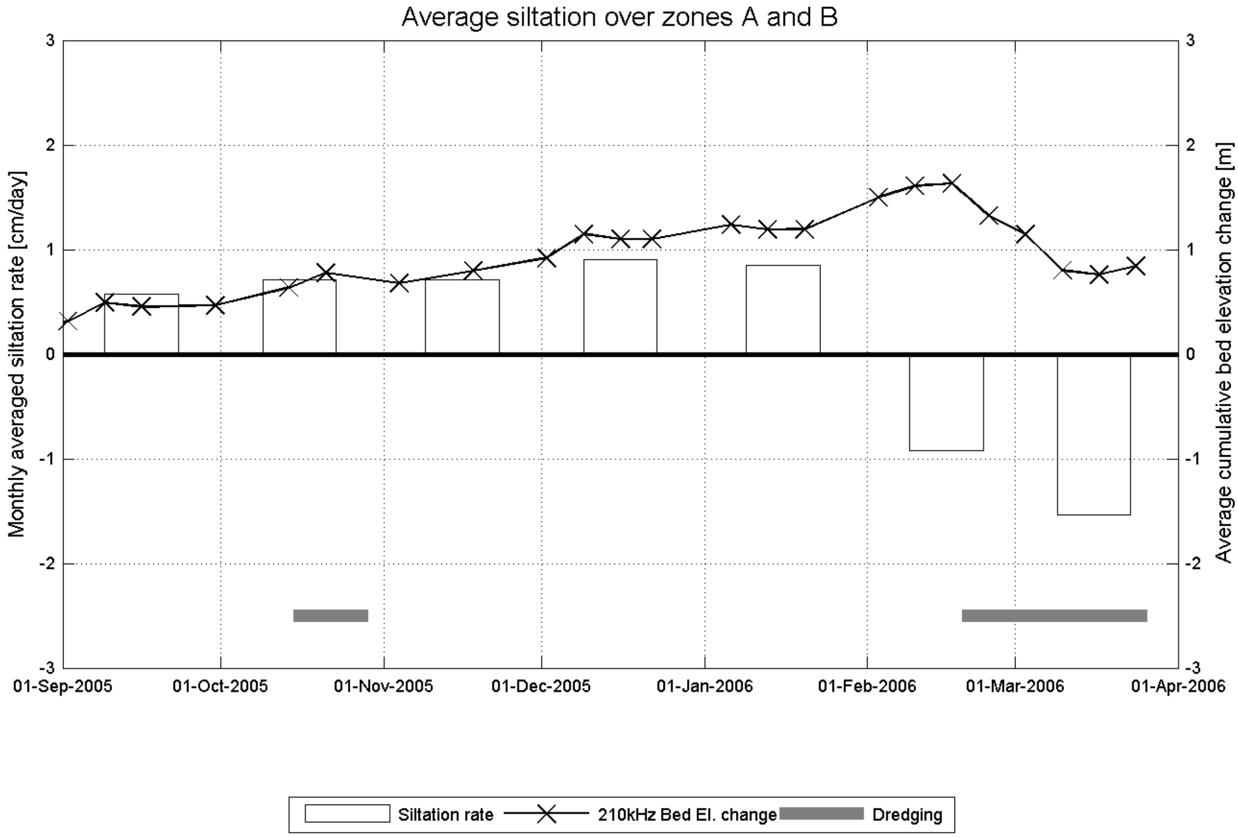
In association with :

I/RA/11283/06.118/MSA

C.4 Siltation rate complete Deurganckdok

Long-term monitoring siltation Deurganckdok

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



Average siltation for zones 3A/3B/4A/4B/5A/5B
Reference level: depth sounding 04-Aug-2005

Data Processed by:
In association with :

I/RA/11283/06.118/MSA

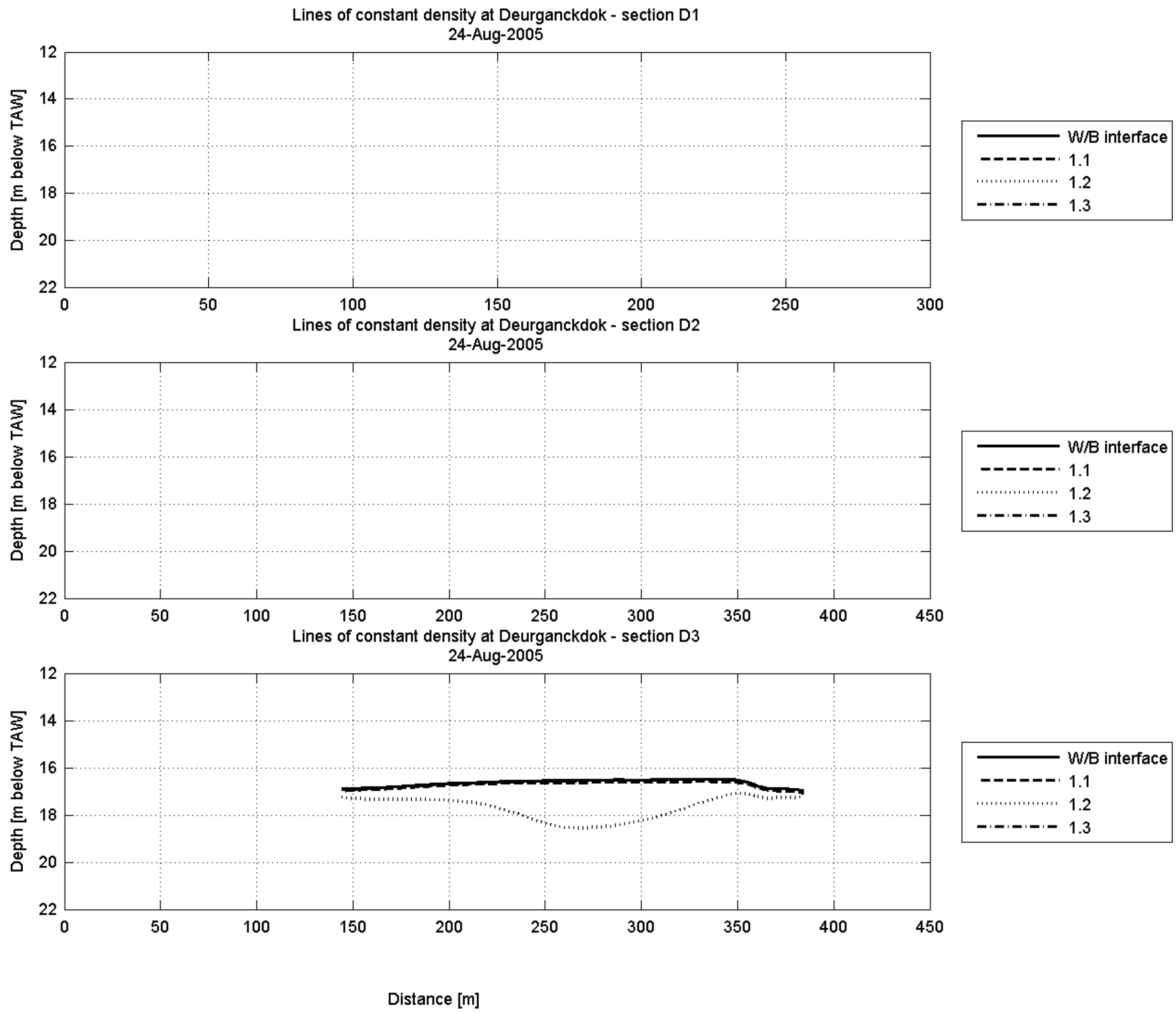
APPENDIX D.

DEPTH OF WATER-BED INTERFACE AND EQUAL DENSITY LAYERS

D.1 Measurements August 24th 2005

Long-term monitoring siltation Deurganckdok

Cross sections planes constant density	Equipment(s): NaviTracker
	Location: DGD



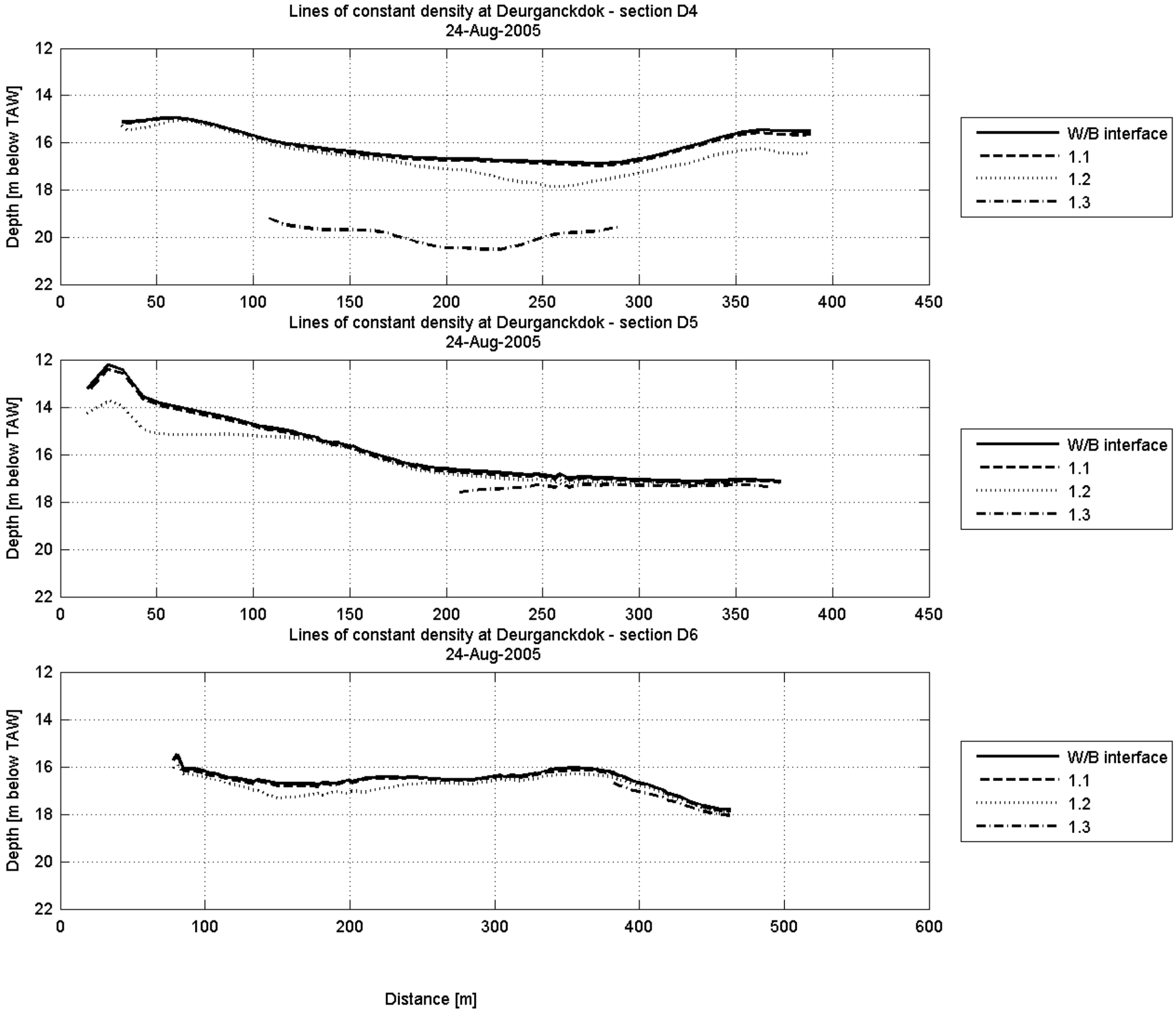
Data Processed by:

In association with :

I/RA/11283/06.118/MSA

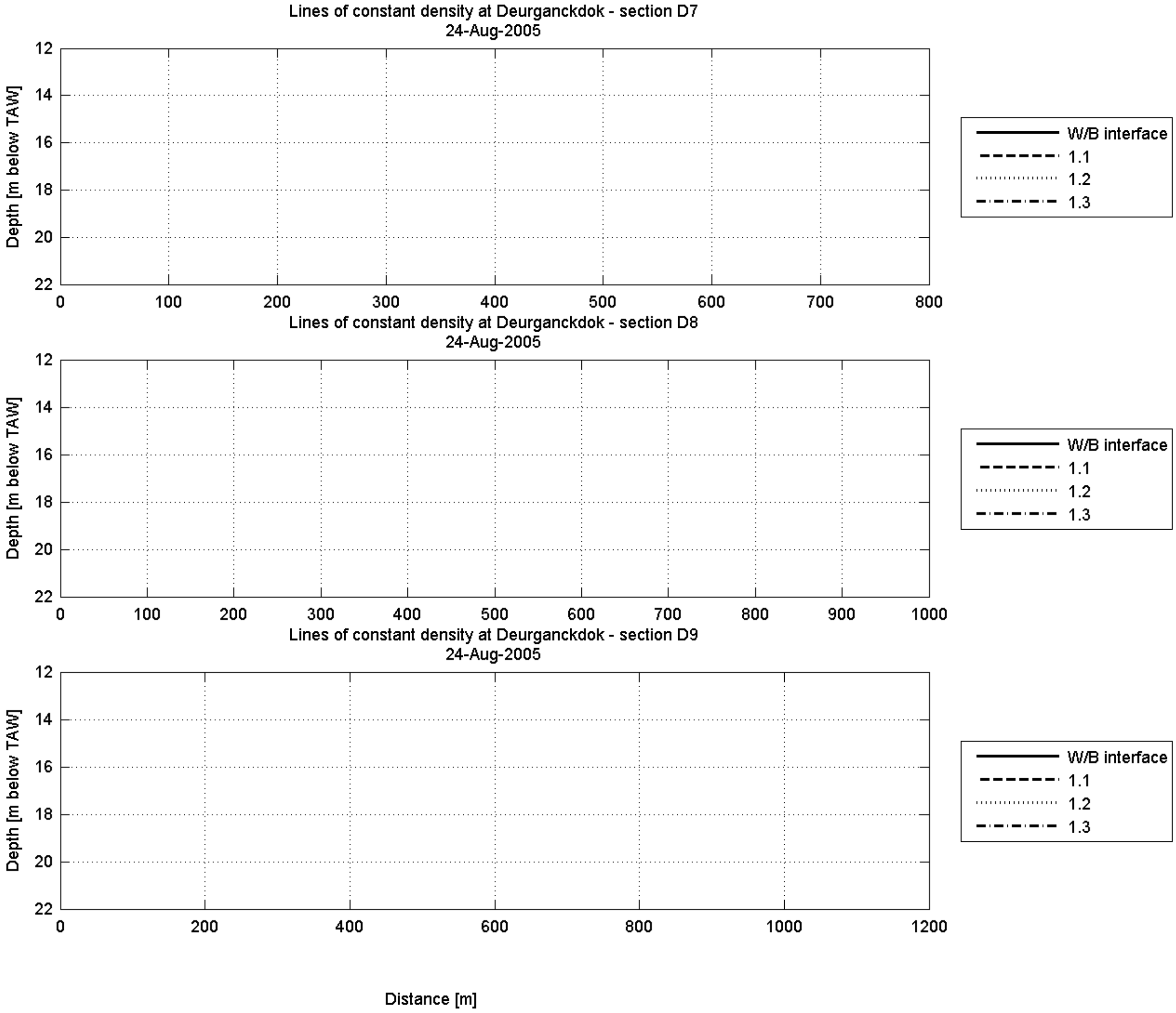
Long-term monitoring siltation Deurganckdok

Cross sections planes constant density	Equipment(s): NaviTracker
	Location: DGD



Long-term monitoring siltation Deurganckdok

Cross sections planes constant density	Equipment(s): NaviTracker
	Location: DGD

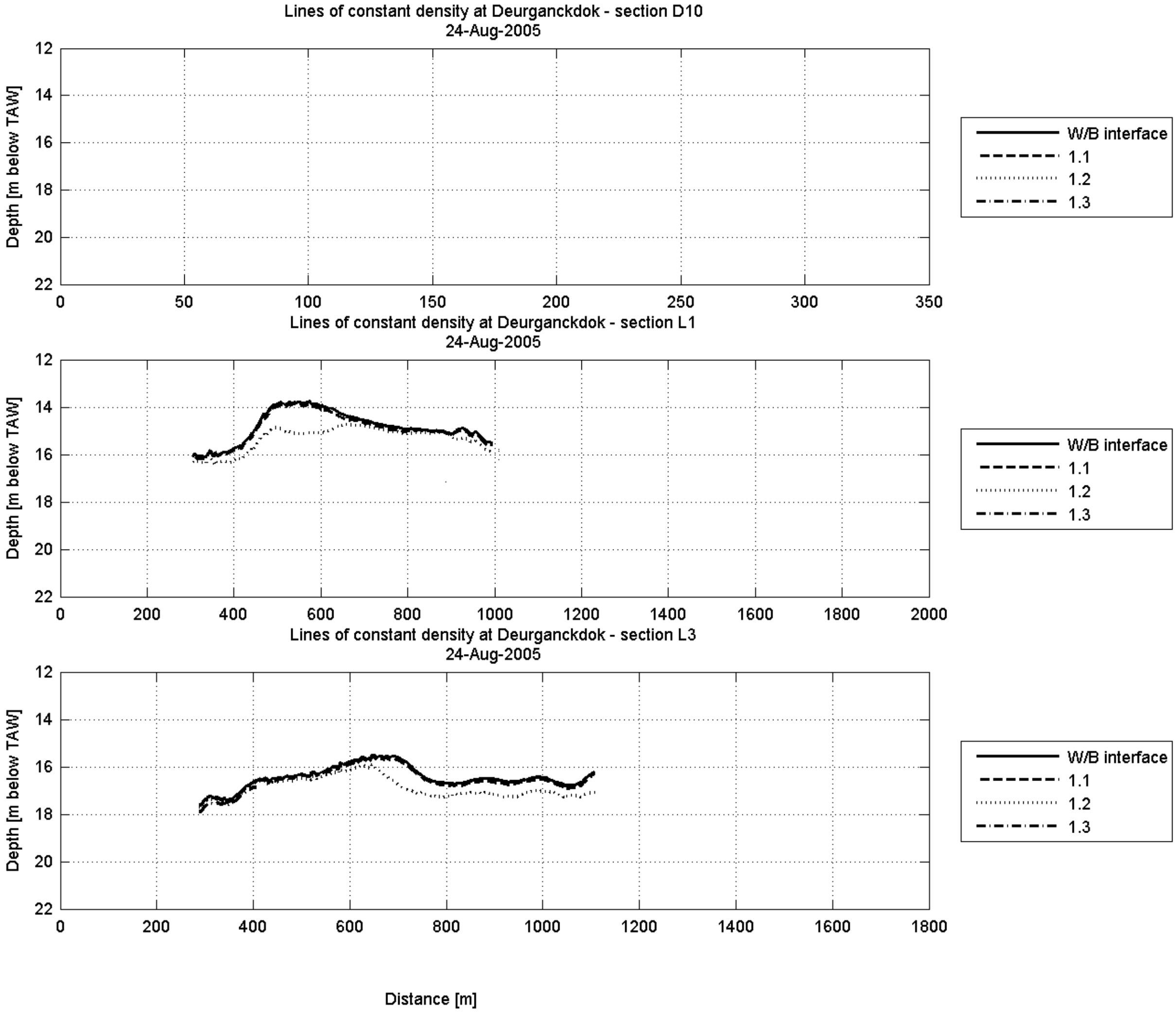


Data Processed by:

In association with :

Long-term monitoring siltation Deurganckdok

Cross sections planes constant density	Equipment(s): NaviTracker
	Location: DGD



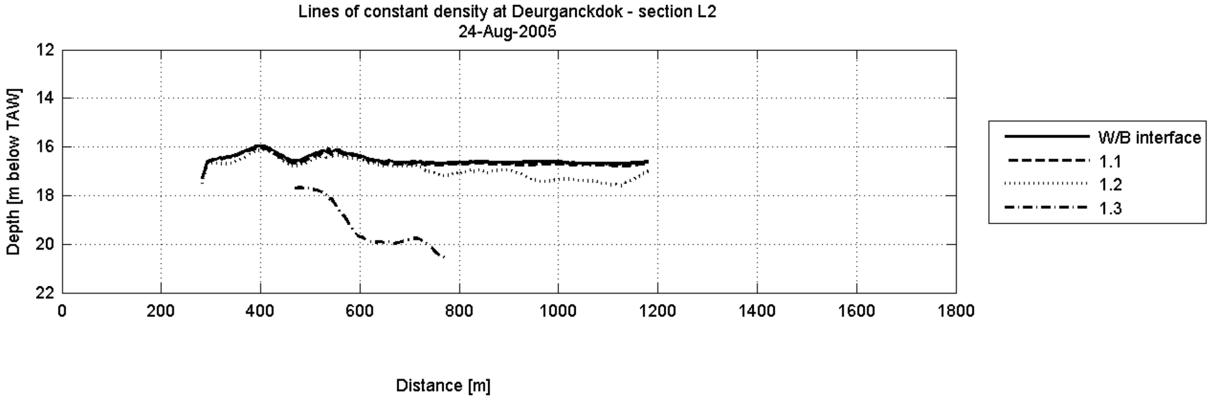
Data Processed by:

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Cross sections planes constant density	Equipment(s): NaviTracker
	Location: DGD



Data Processed by:

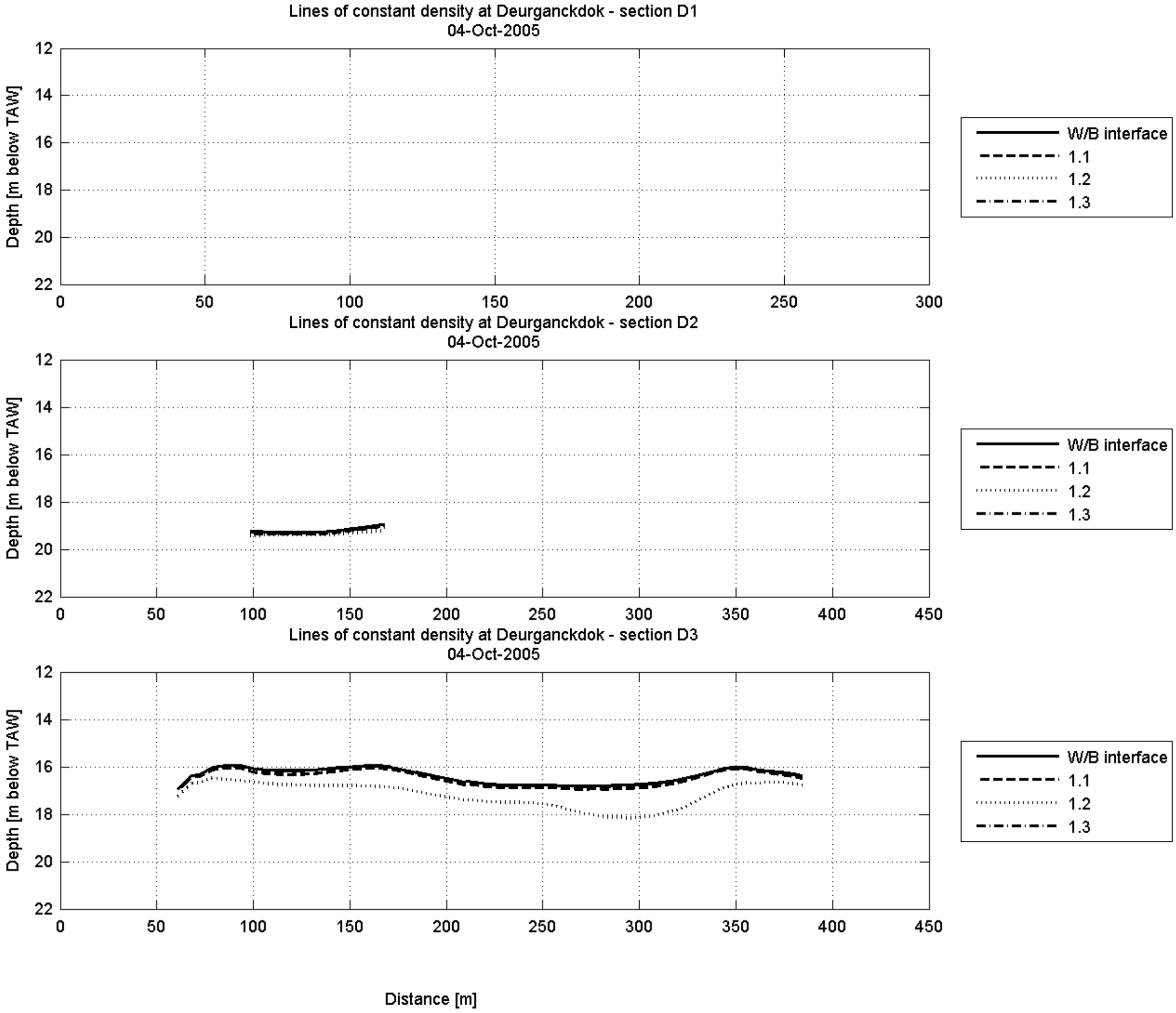
In association with :

I/RA/11283/06.118/MSA

D.2 Measurements October 4th 2005

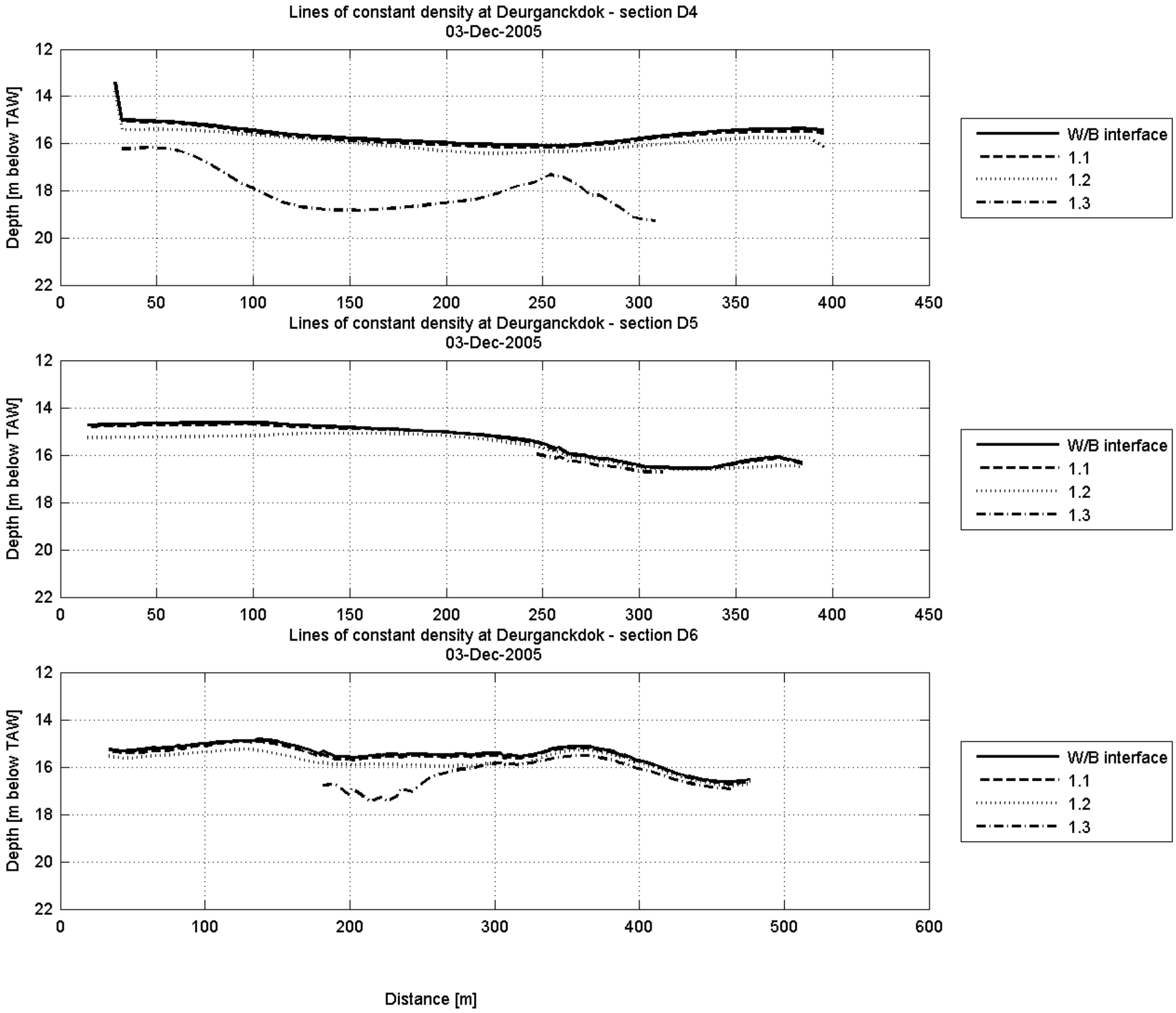
Long-term monitoring siltation Deurganckdok

Cross sections planes constant density	Equipment(s): NaviTracker
	Location: DGD



Long-term monitoring siltation Deurganckdok

Cross sections planes constant density	Equipment(s): NaviTracker
	Location: DGD



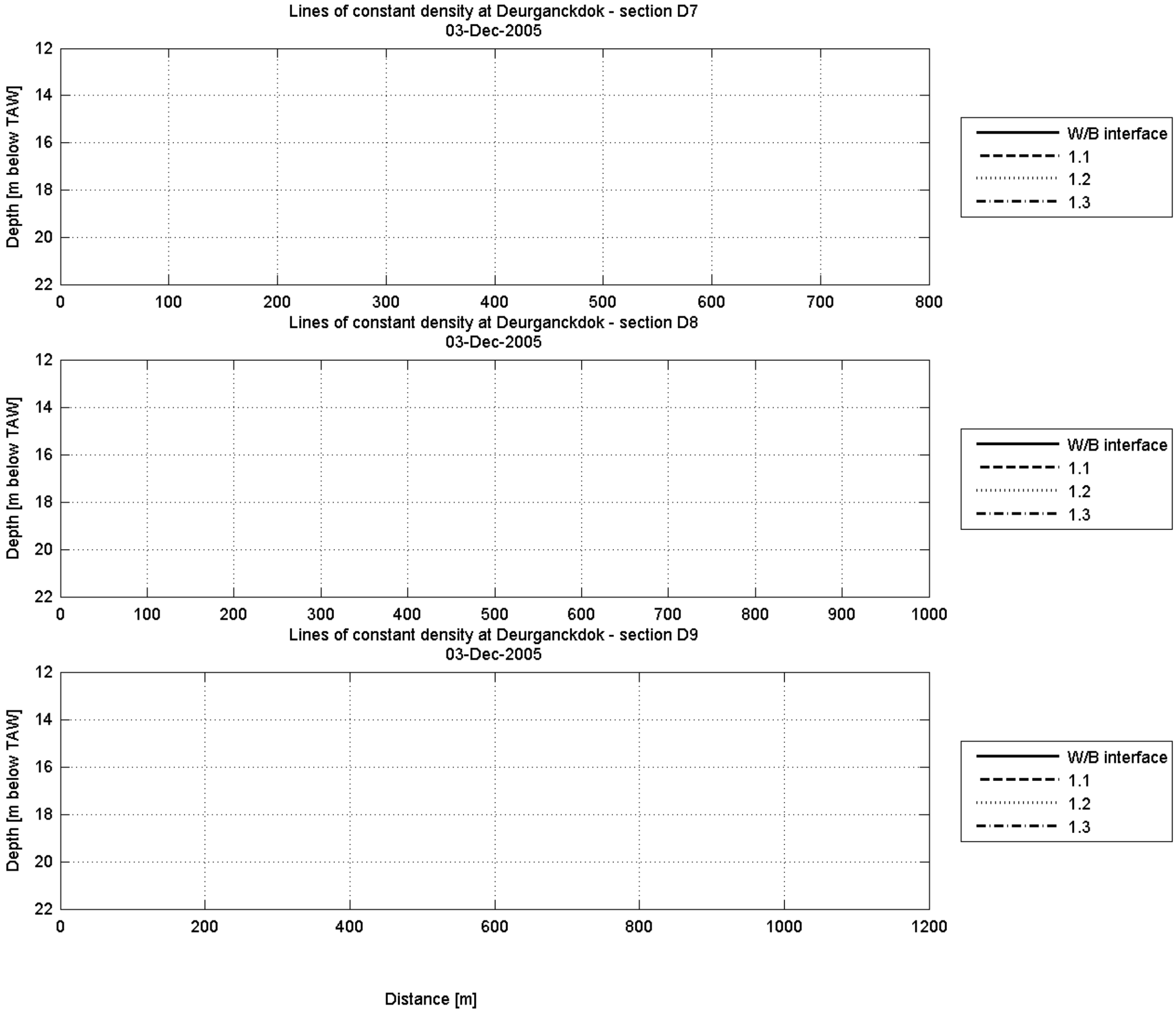
Data Processed by:

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Cross sections planes constant density	Equipment(s): NaviTracker
	Location: DGD



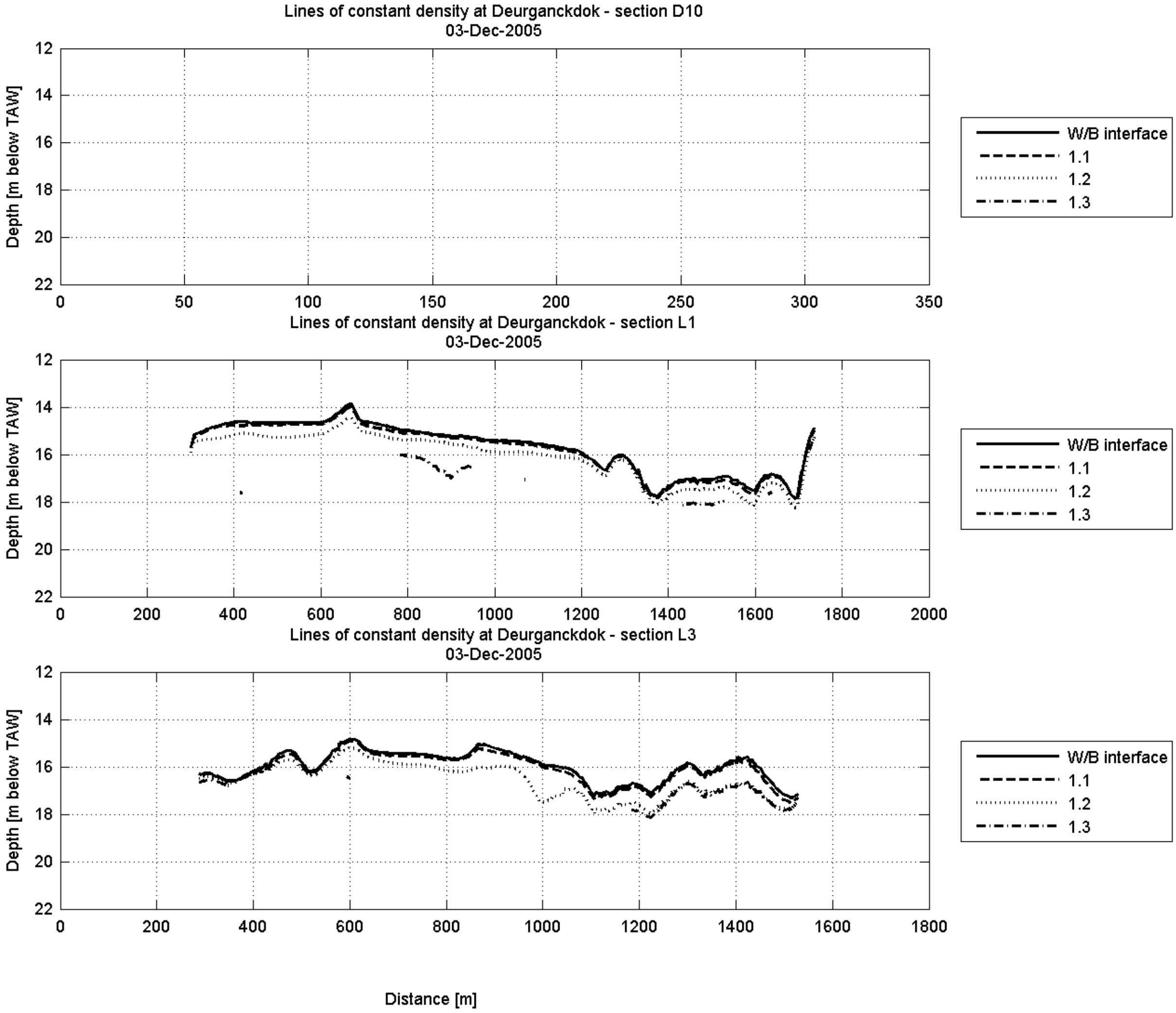
Data Processed by:

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Cross sections planes constant density	Equipment(s): NaviTracker
	Location: DGD



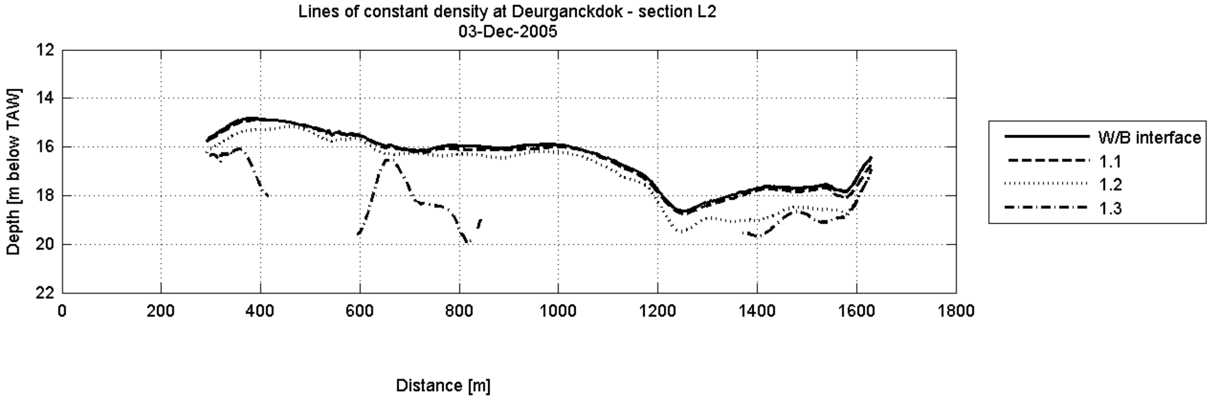
Data Processed by: IMDC

In association with : wl | delft hydraulics, GEMS International

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Cross sections planes constant density	Equipment(s): NaviTracker
	Location: DGD



Data Processed by:

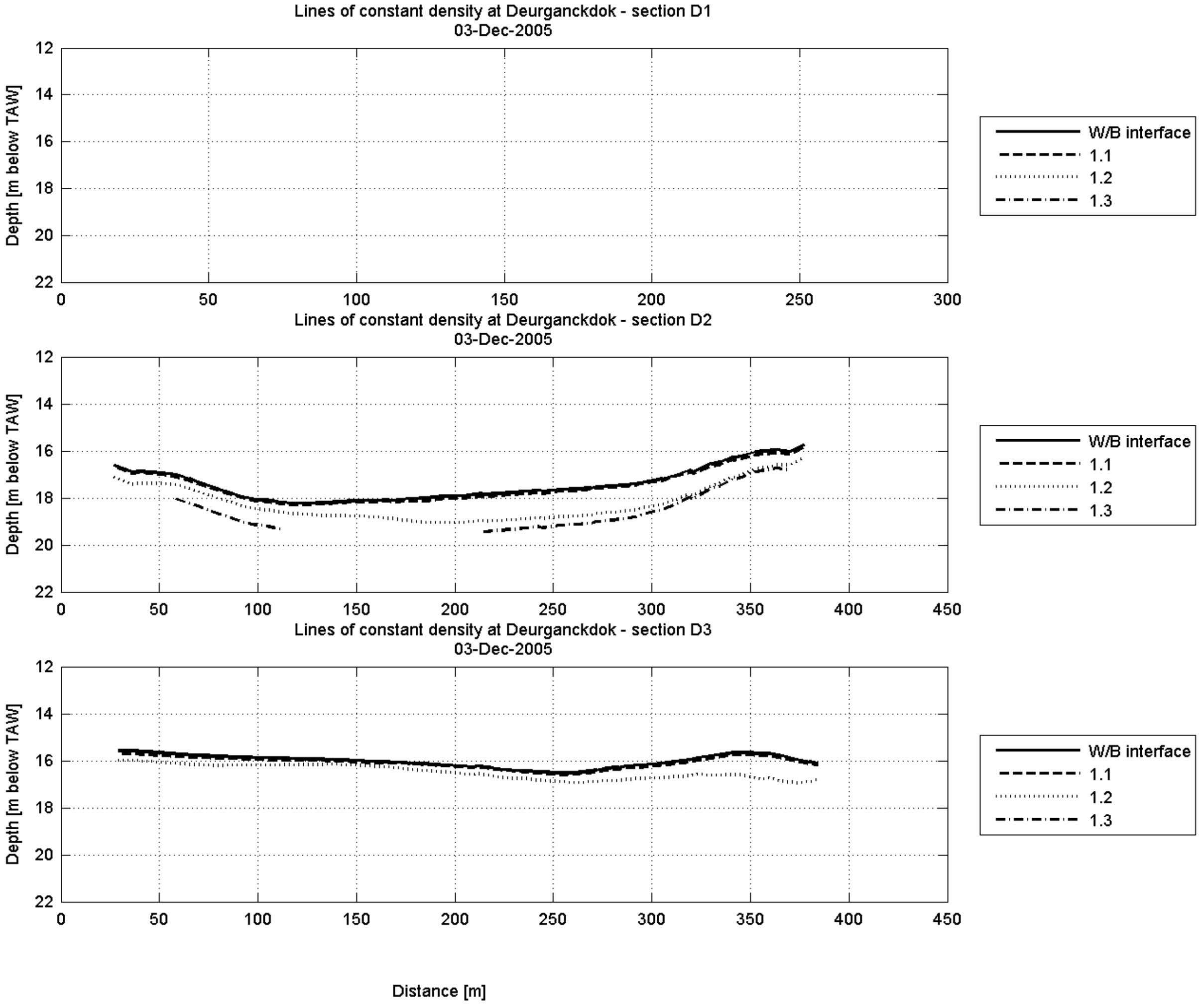
In association with :

I/RA/11283/06.118/MSA

D.3 Measurements December 3rd 2005

Long-term monitoring siltation Deurganckdok

Cross sections planes constant density	Equipment(s): NaviTracker
	Location: DGD



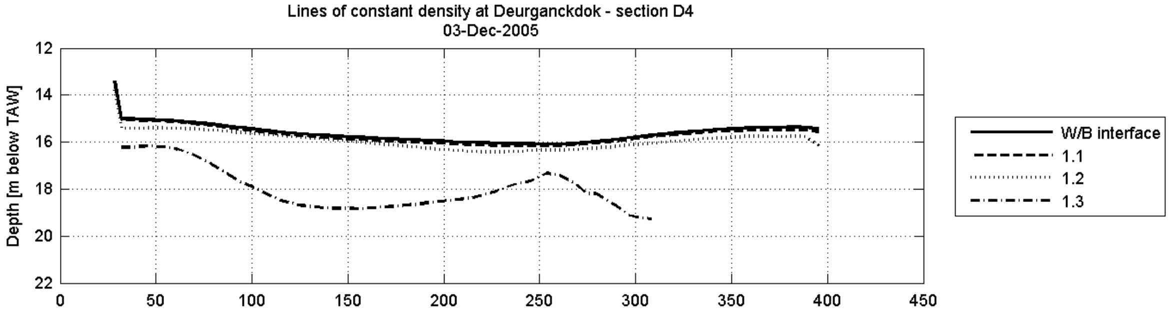
Data Processed by: IMDC

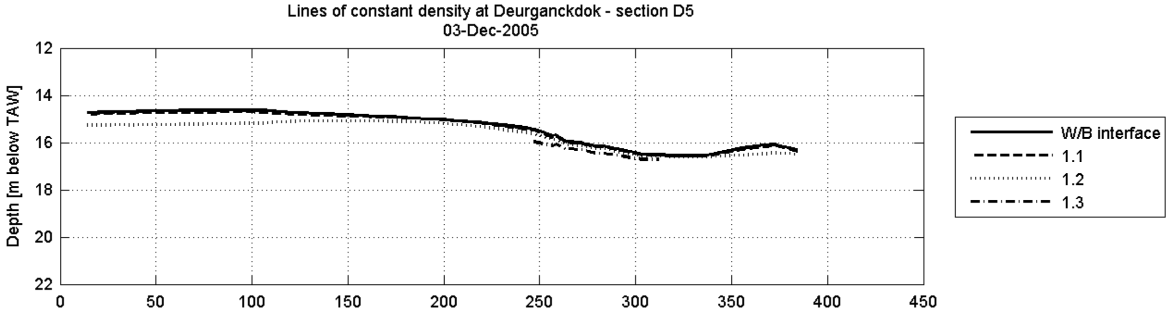
In association with :

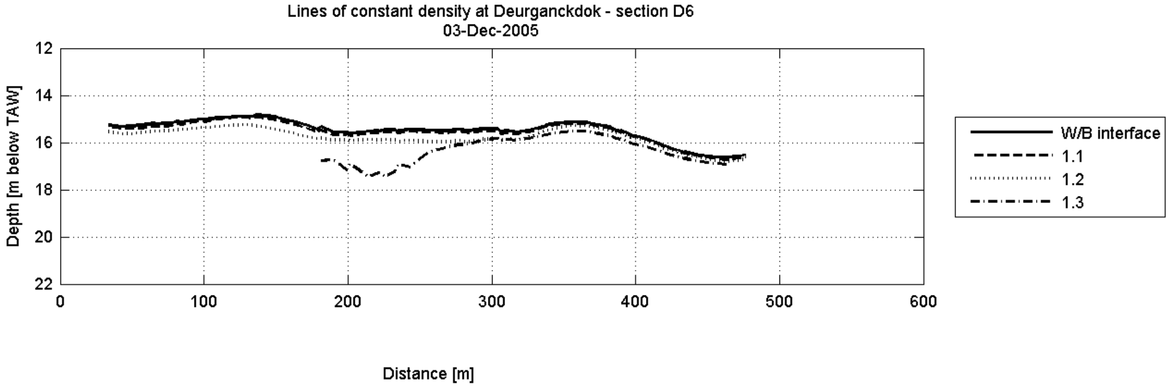
I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Cross sections planes constant density	Equipment(s): NaviTracker
	Location: DGD







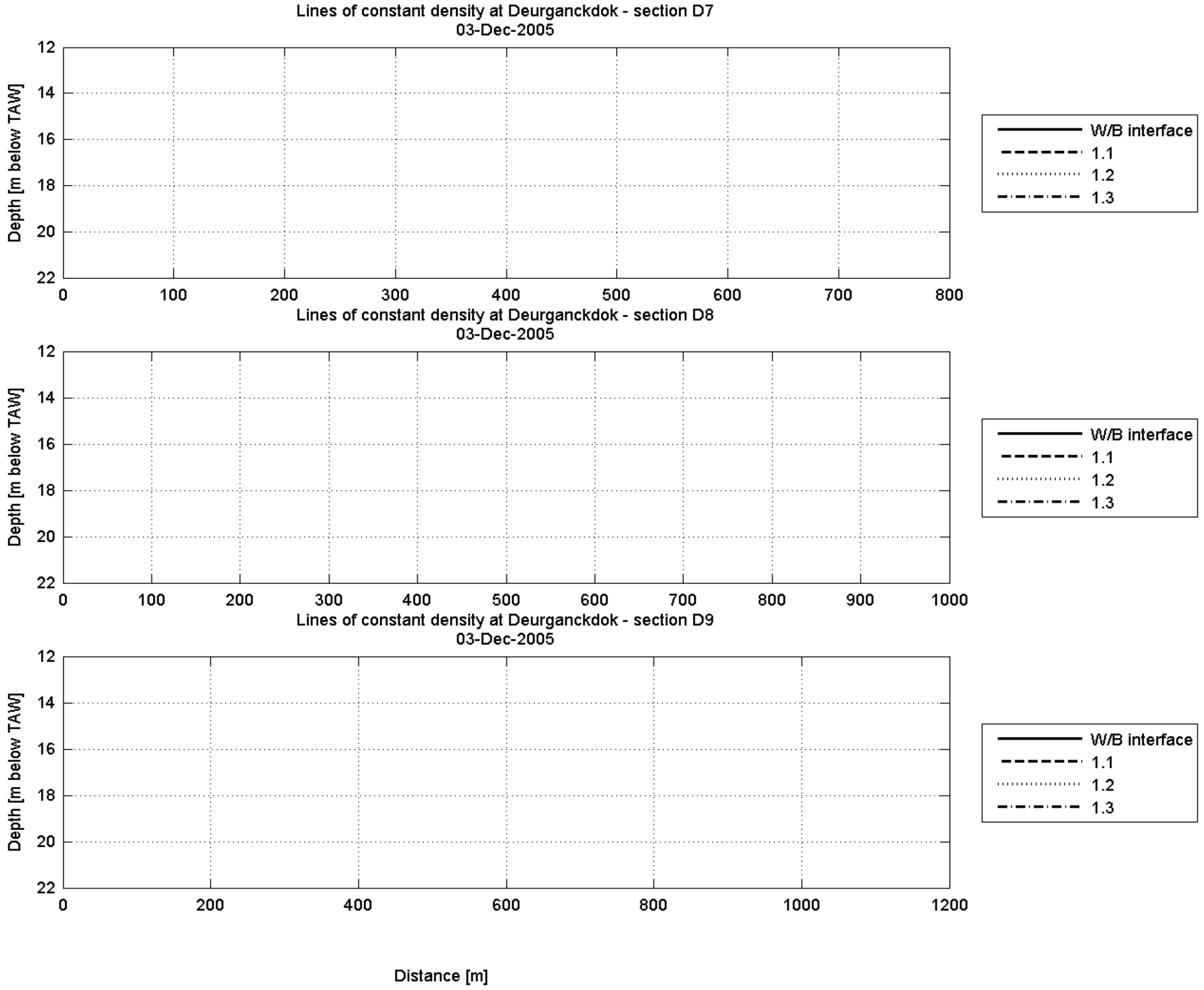
Data Processed by:

In association with :

I/RA/11283/06.118/MSA

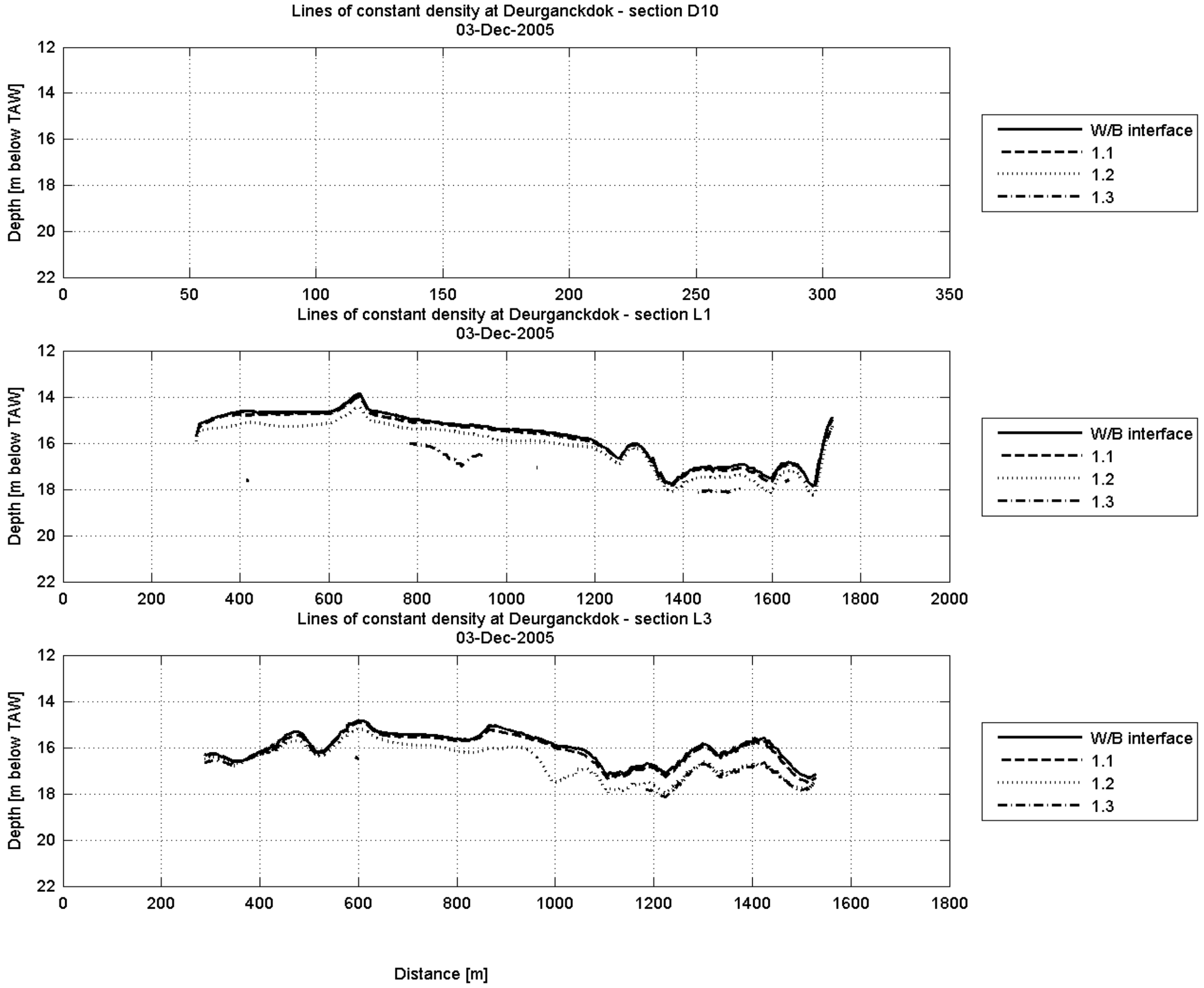
Long-term monitoring siltation Deurganckdok

Cross sections planes constant density	Equipment(s): NaviTracker
	Location: DGD



Long-term monitoring siltation Deurganckdok

Cross sections planes constant density	Equipment(s): NaviTracker
	Location: DGD



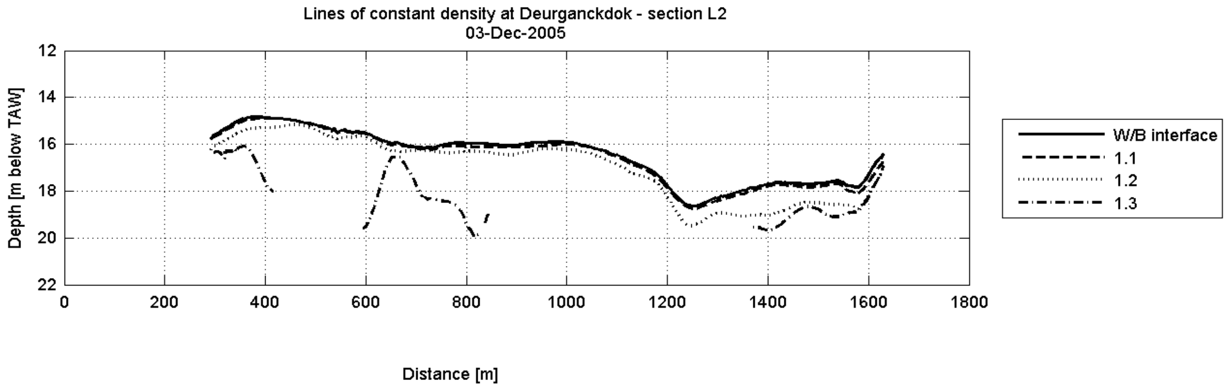
Data Processed by:

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Cross sections planes constant density	Equipment(s): NaviTracker
	Location: DGD



Data Processed by:

In association with :

I/RA/11283/06.118/MSA

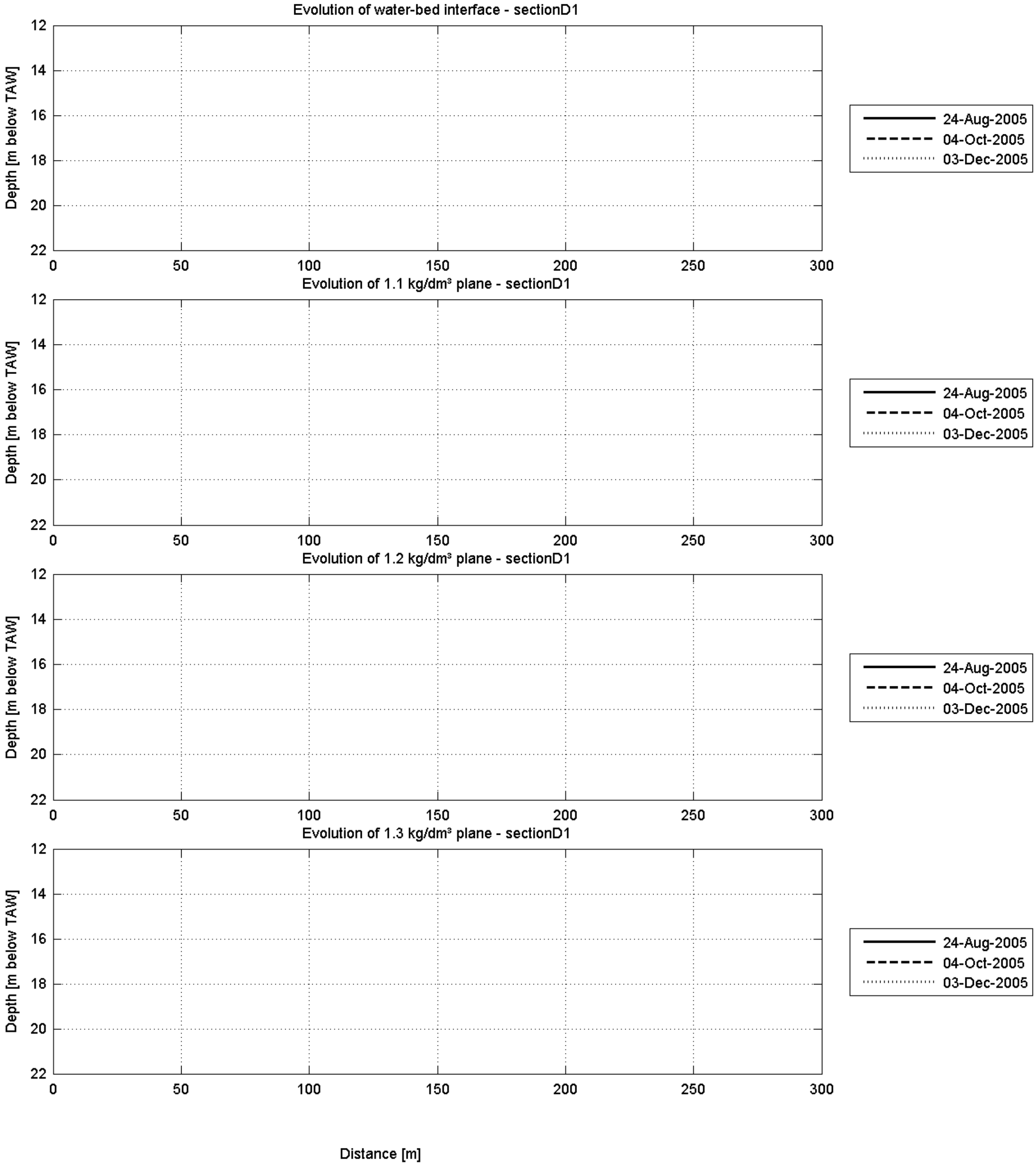
D.4 Maps Water-bed interface & equal density layer

APPENDIX E.

EVOLUTION OF WATER-BED INTERFACE AND PLANES OF CONSTANT DENSITY

Long-term monitoring siltation Deurganckdok

Evolution of planes of constant density	Equipment(s): NaviTracker
	Location: DGD



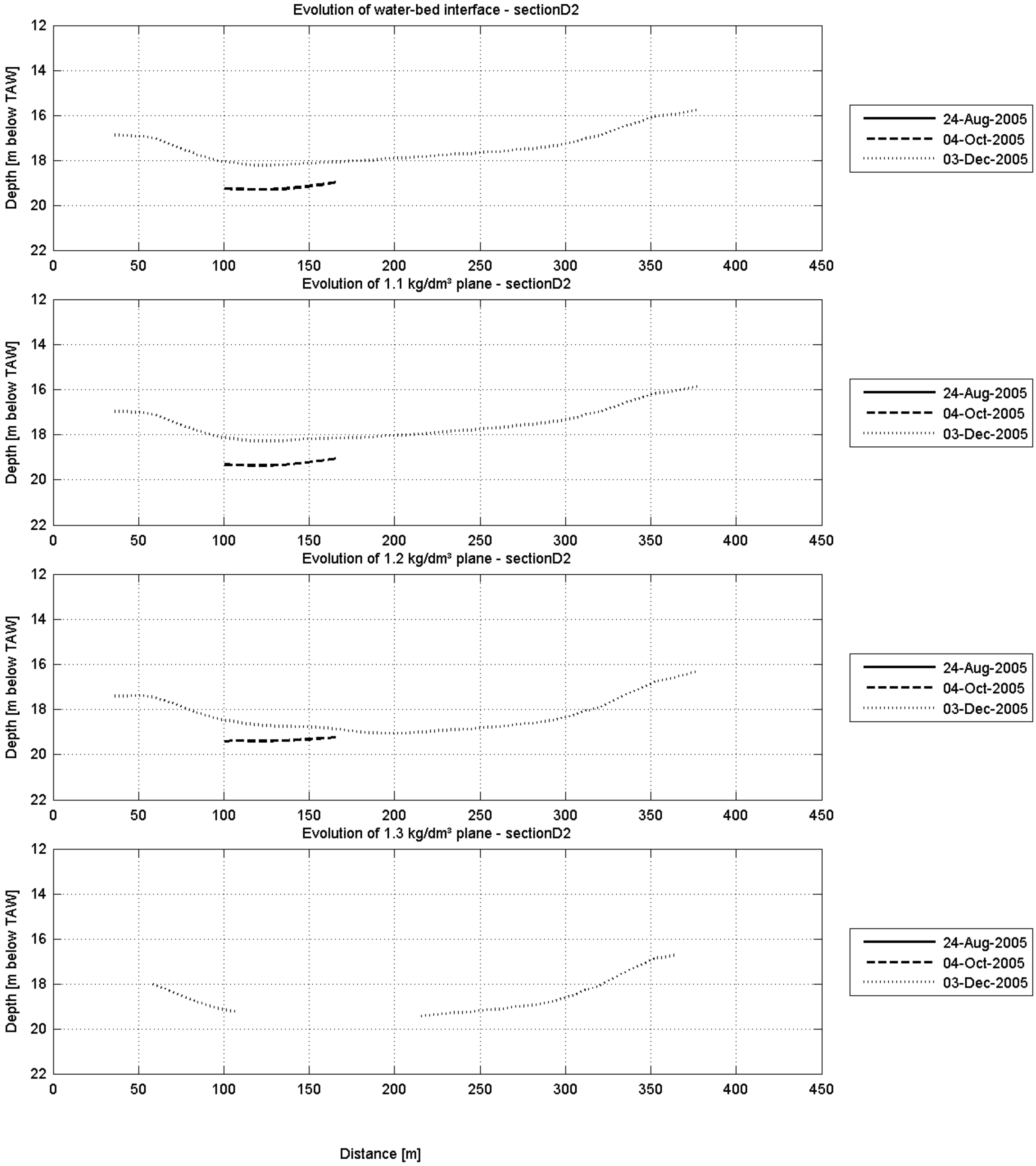
Data Processed by:

In association with :

I/RA/11283/06.118/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/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

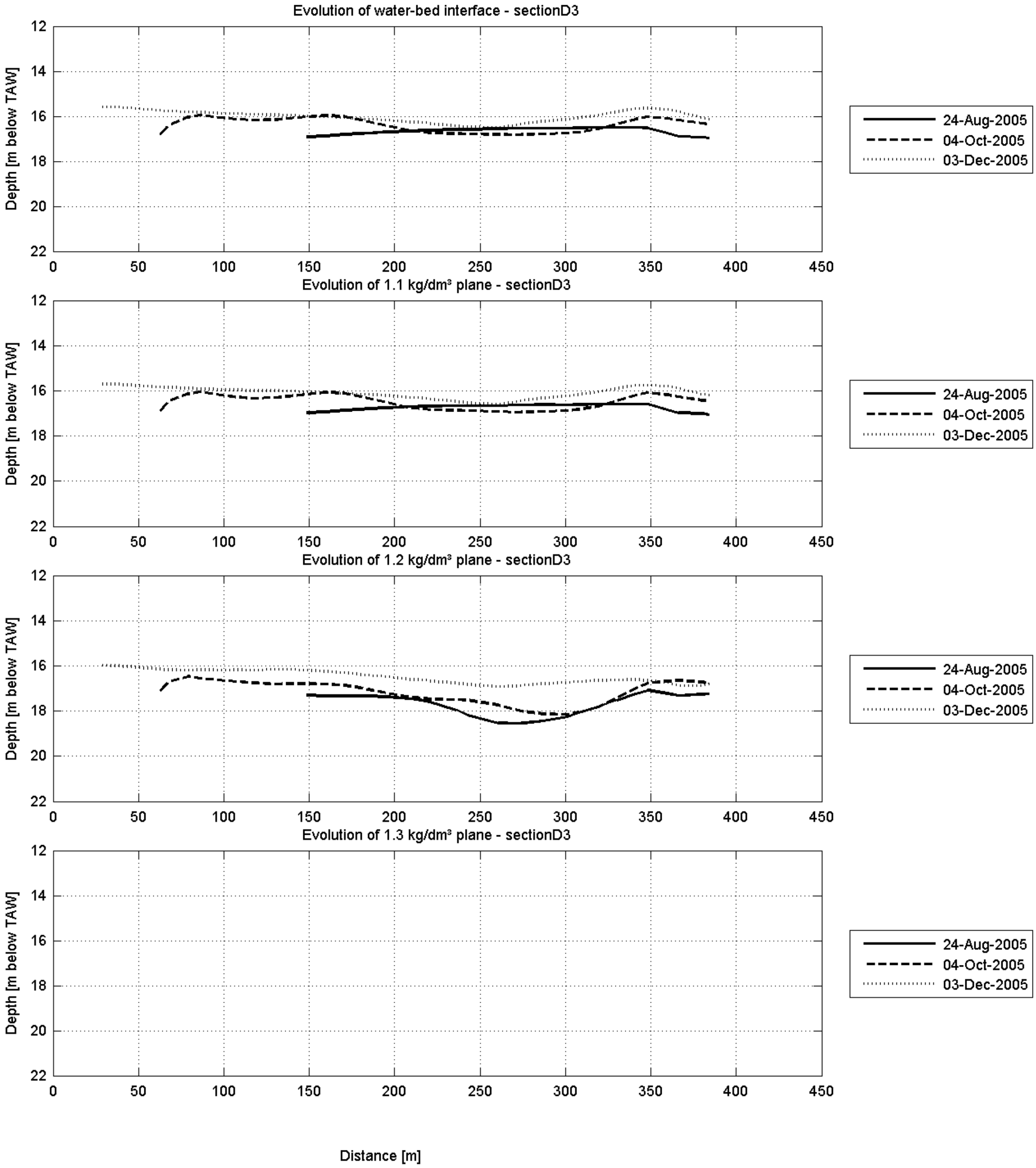
Evolution of planes of constant density

Equipment(s):

NaviTracker

Location:

DGD



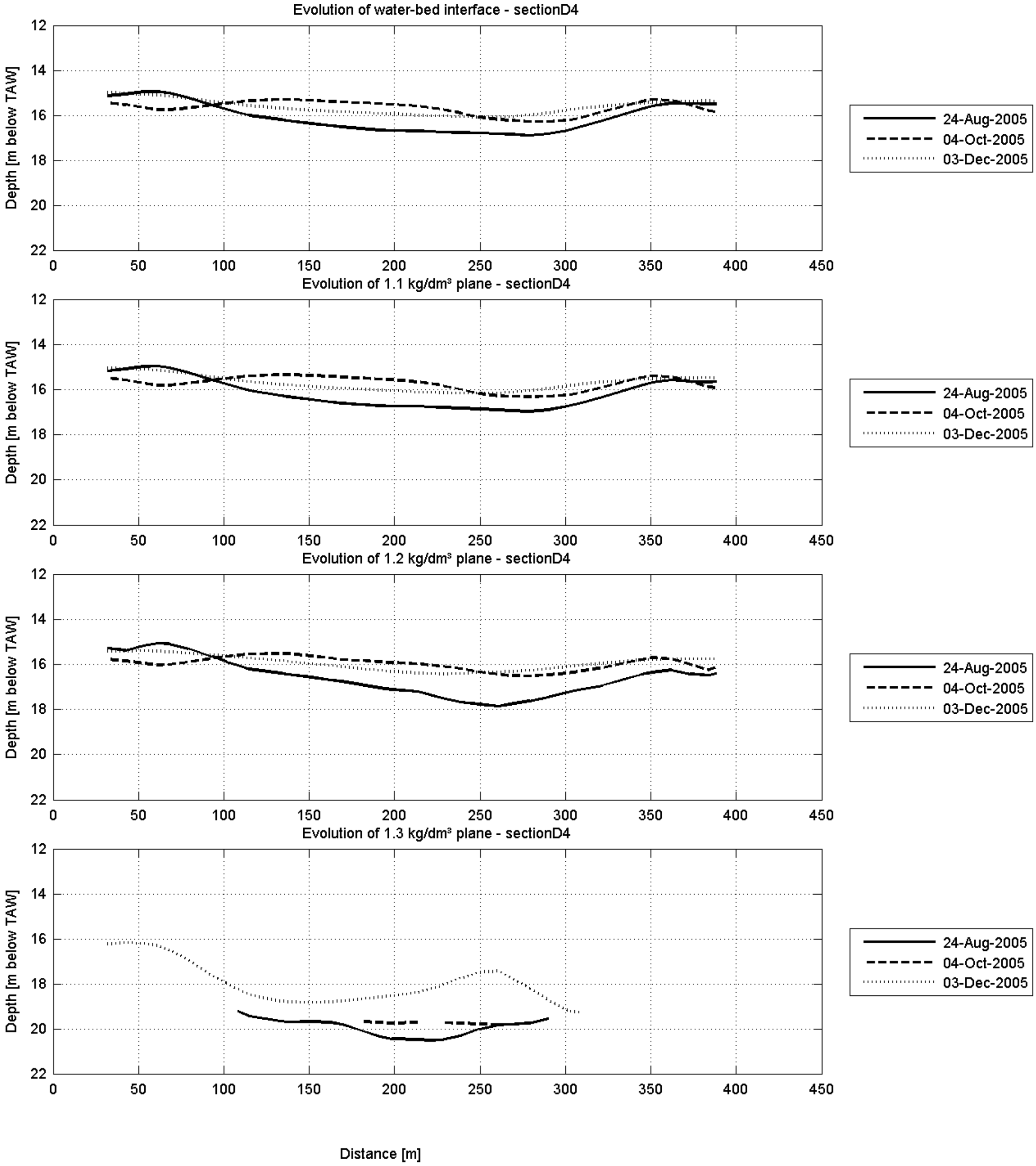
Data Processed by:

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Evolution of planes of constant density	Equipment(s): NaviTracker
	Location: DGD



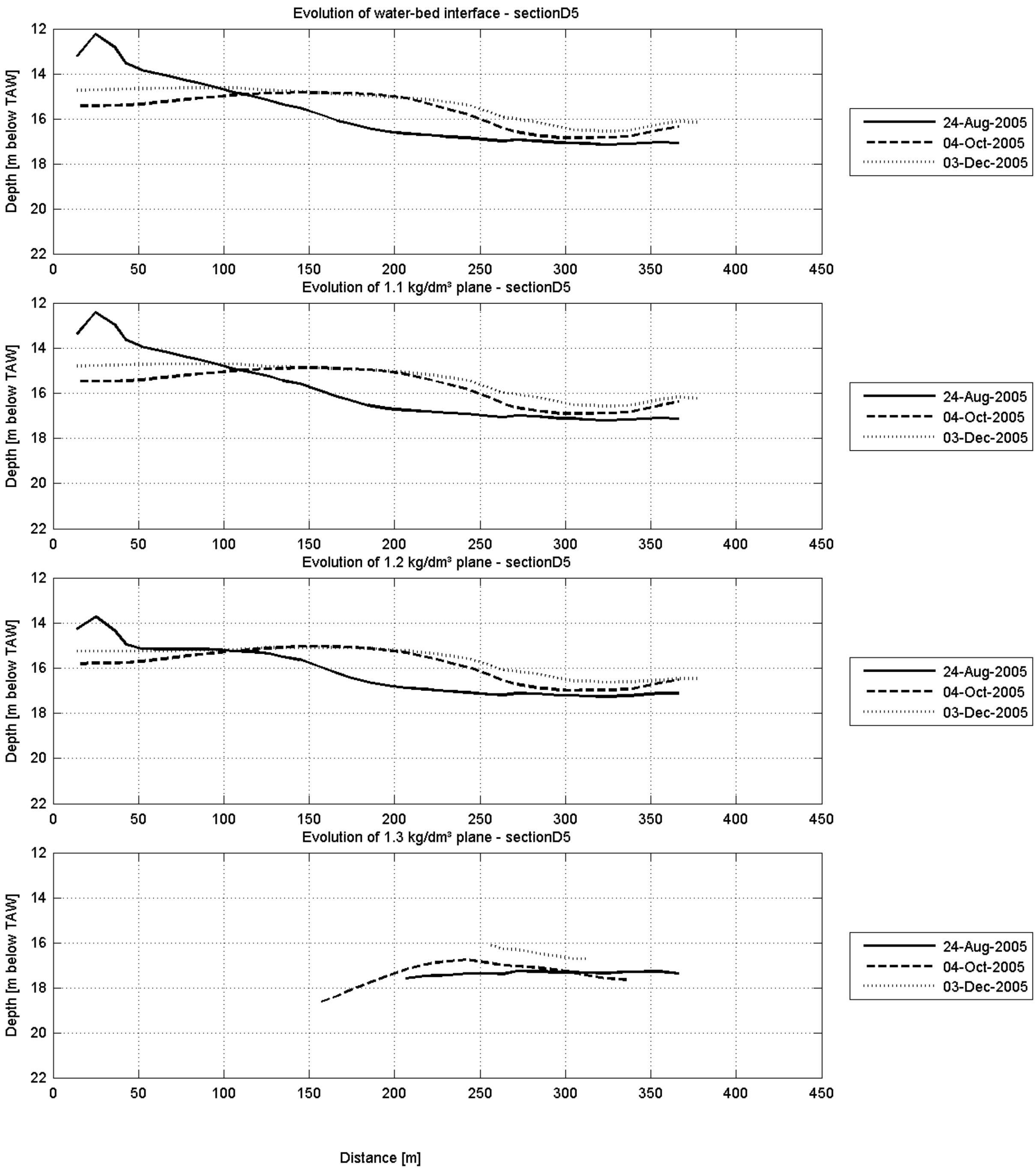
Data Processed by: IMDC

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Evolution of planes of constant density	Equipment(s): NaviTracker
	Location: DGD



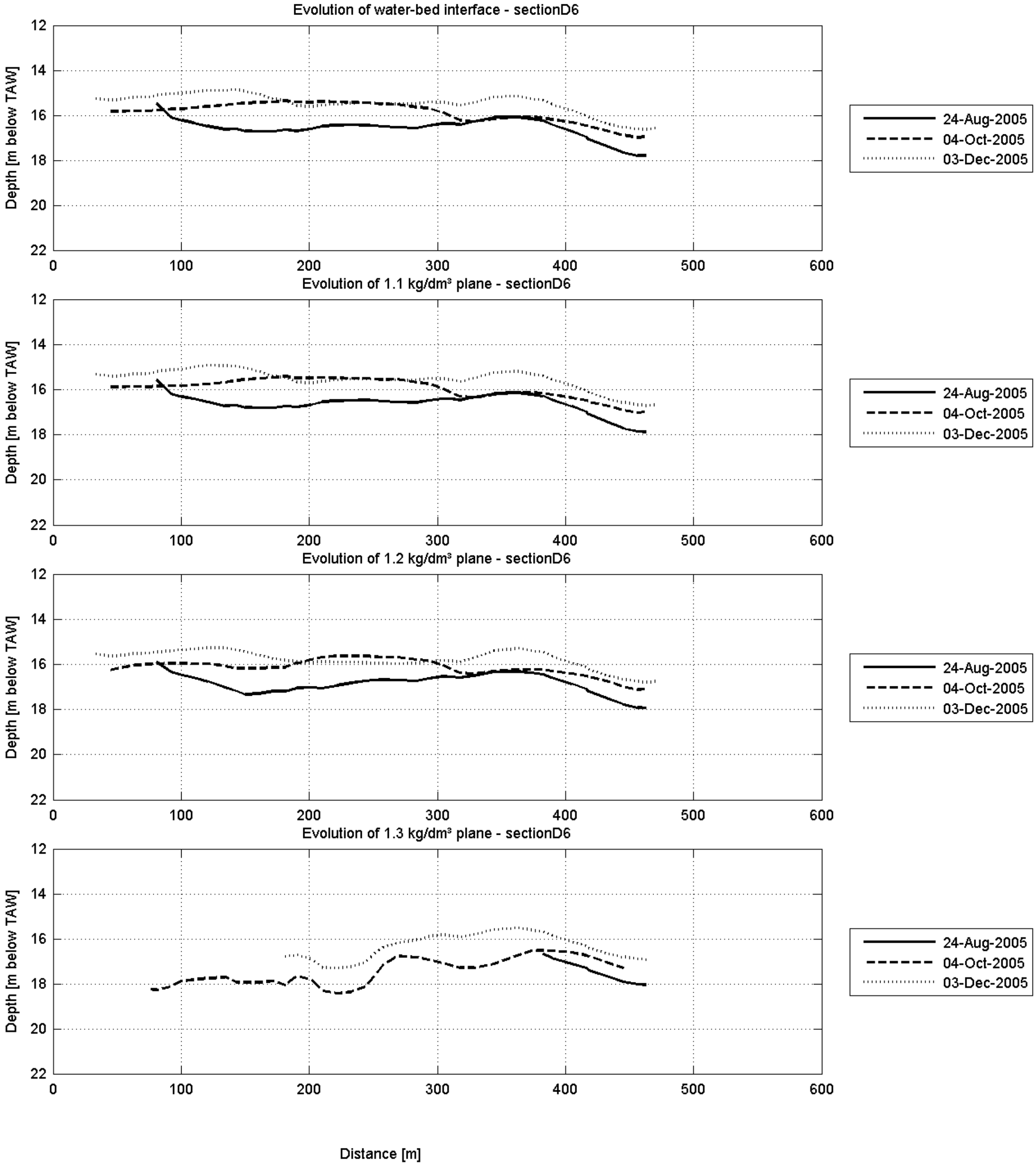
Data Processed by: IMDC

In association with :

I/RA/11283/06.118/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/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

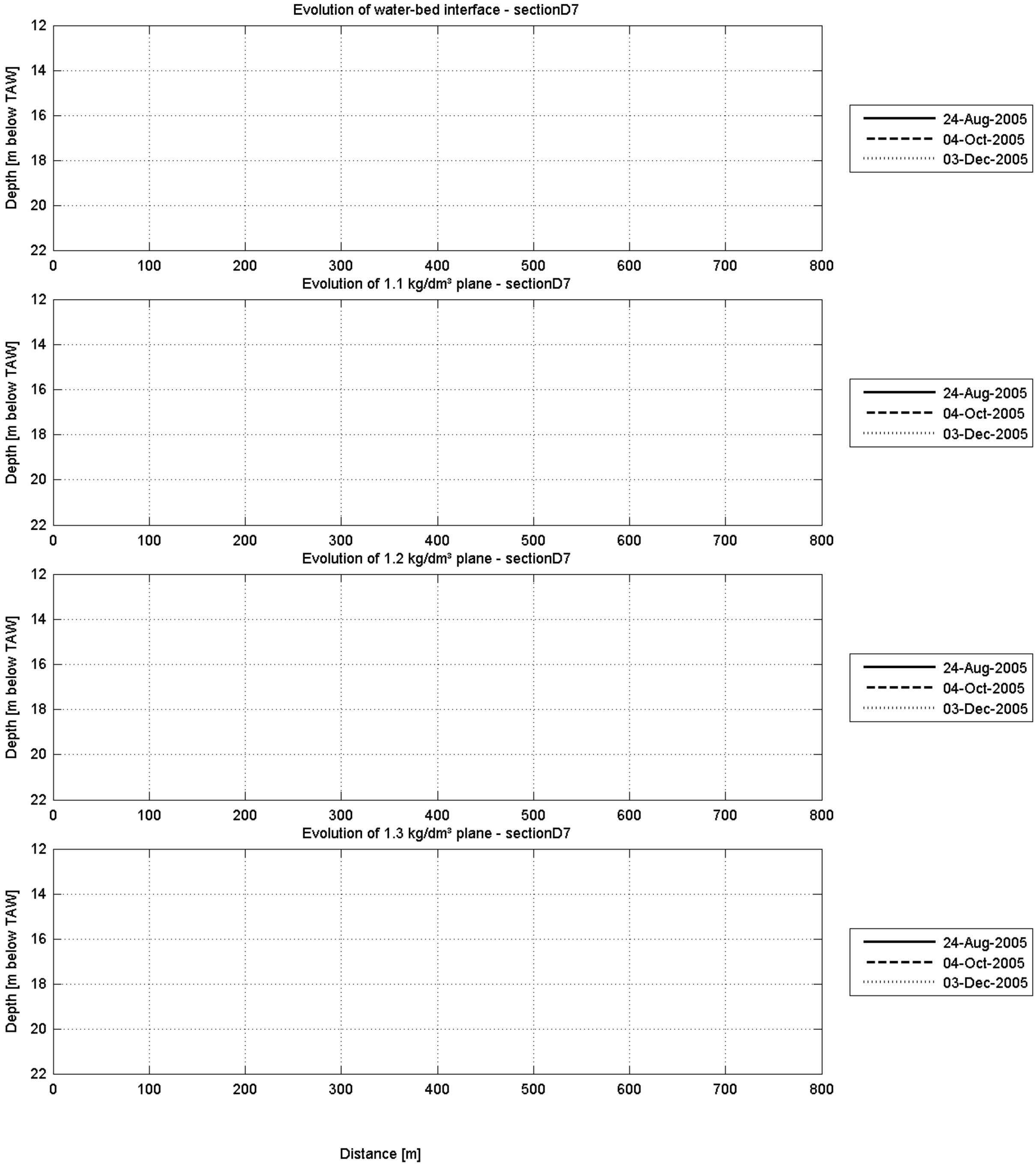
Evolution of planes of constant density

Equipment(s):

NaviTracker

Location:

DGD



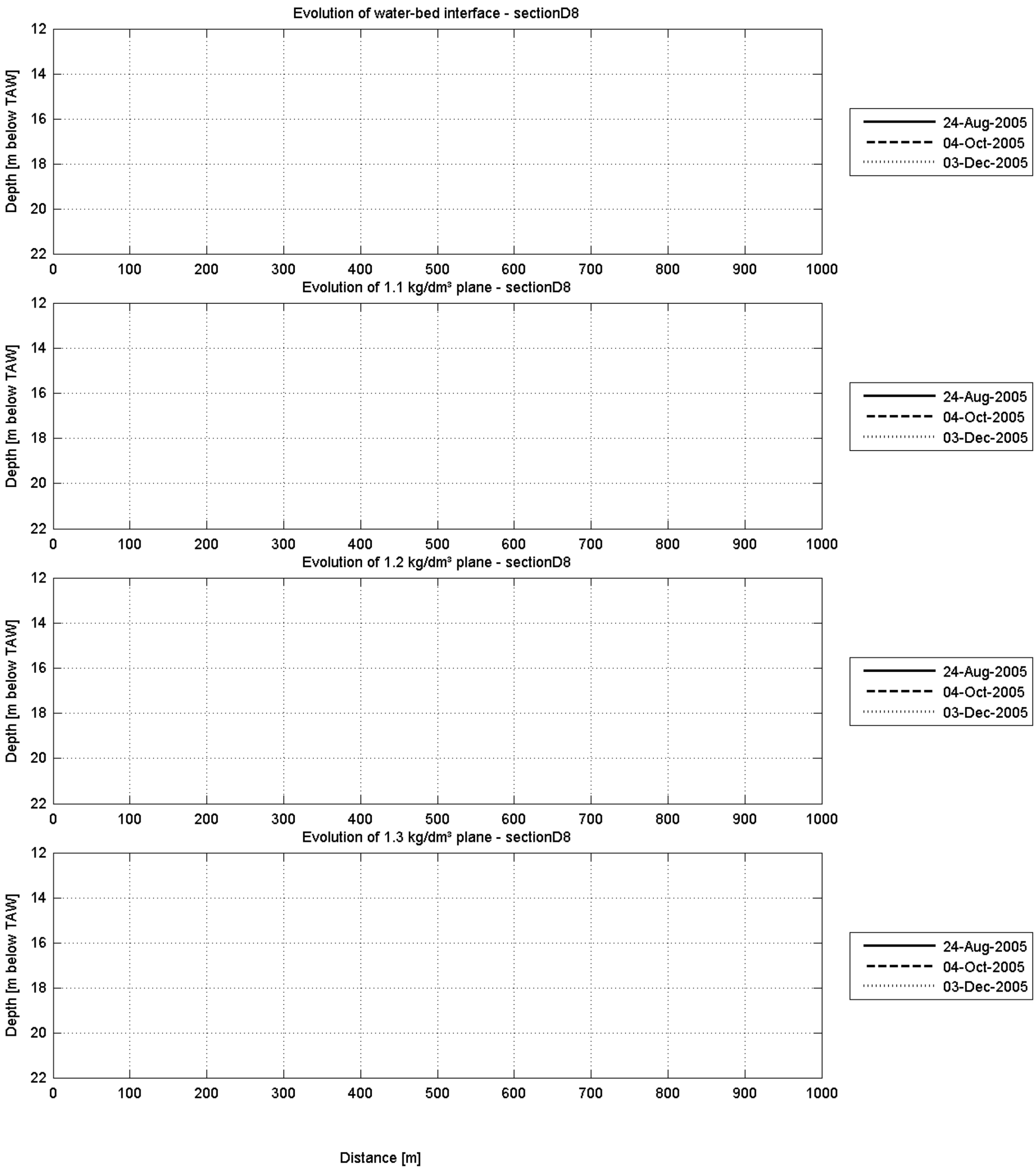
Data Processed by:

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Evolution of planes of constant density	Equipment(s): NaviTracker
	Location: DGD



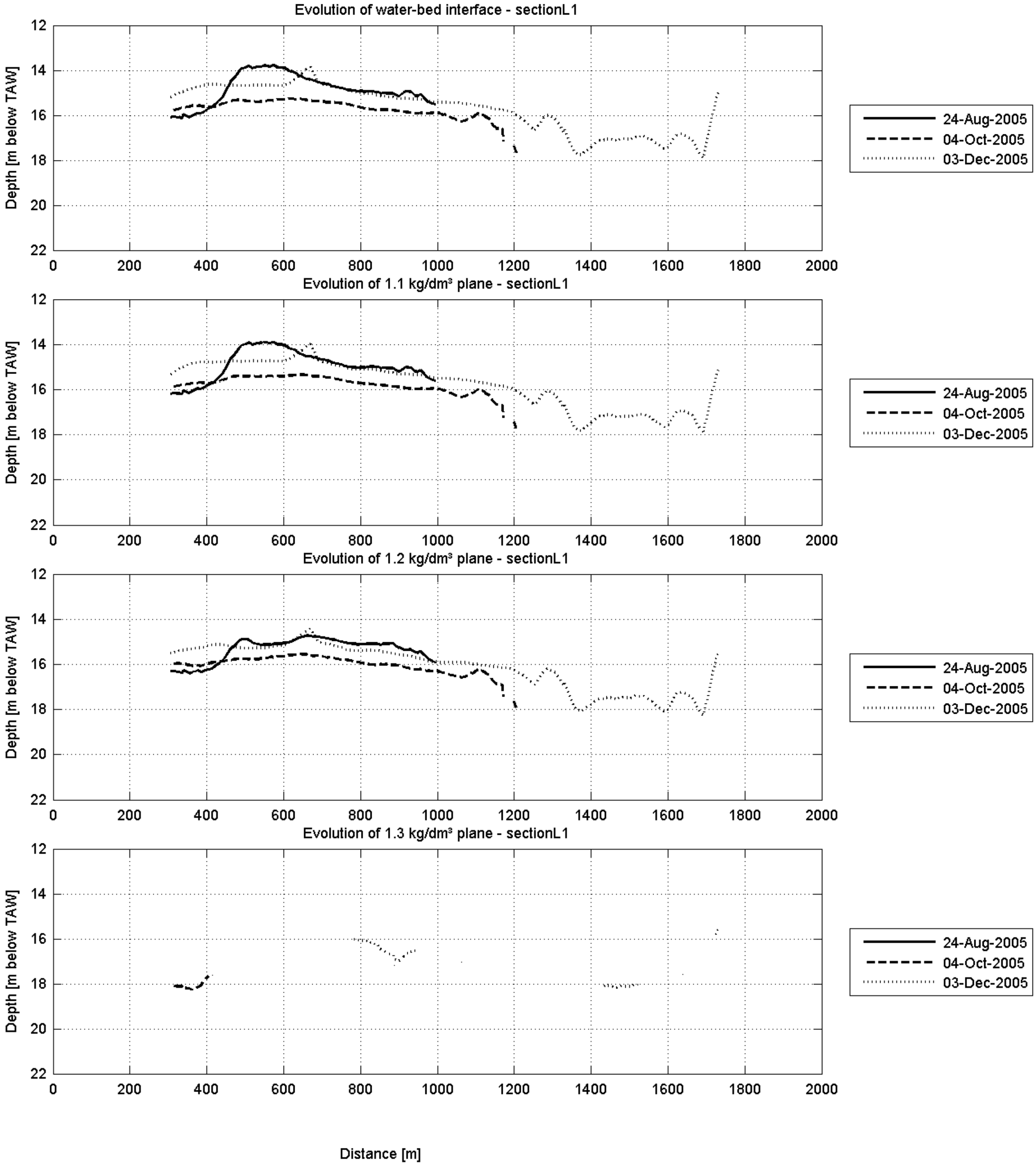
Data Processed by:

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Evolution of planes of constant density	Equipment(s): NaviTracker
	Location: DGD

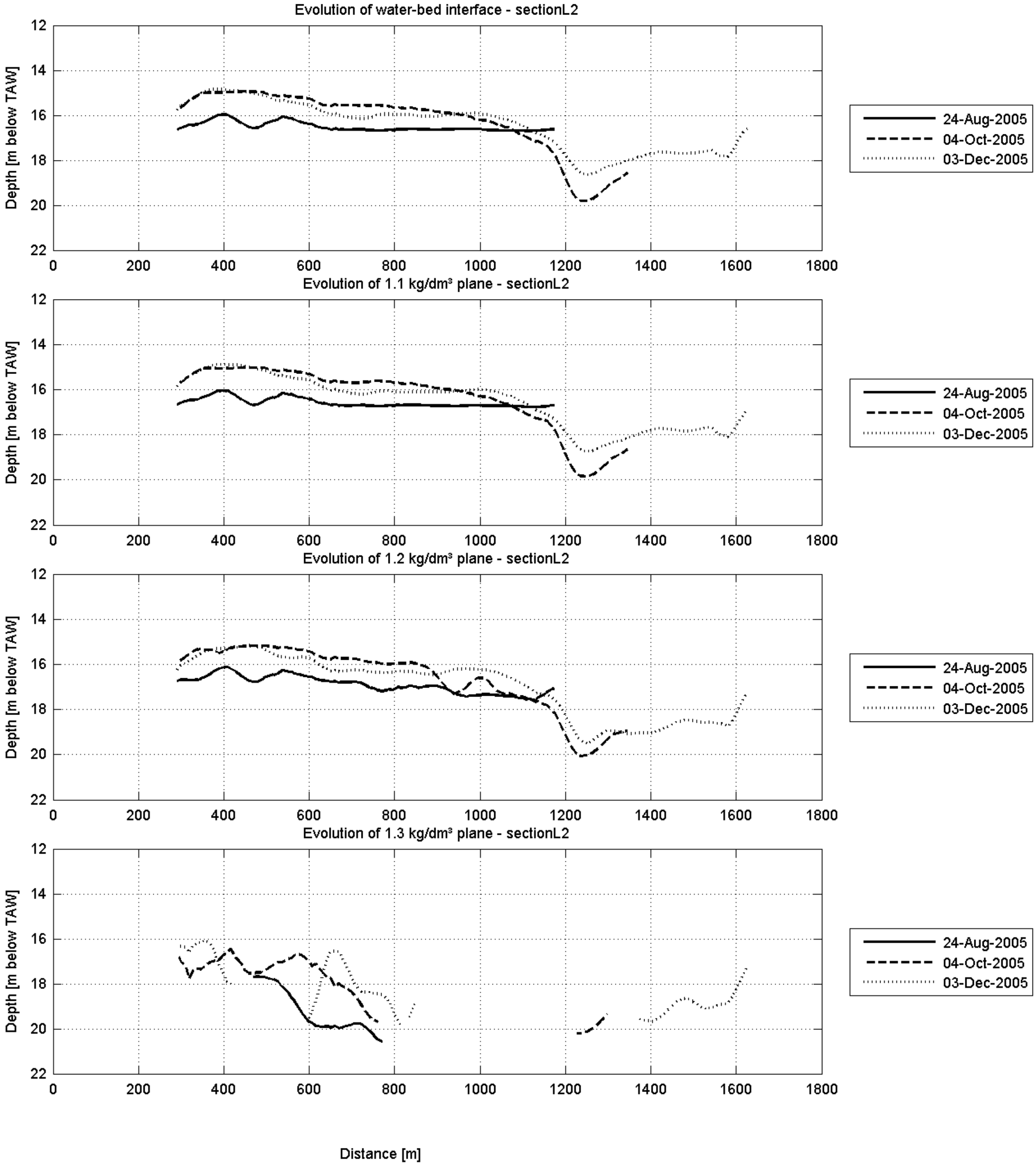


Data Processed by: IMDC

In association with :

I/RA/11283/06.118/MSA

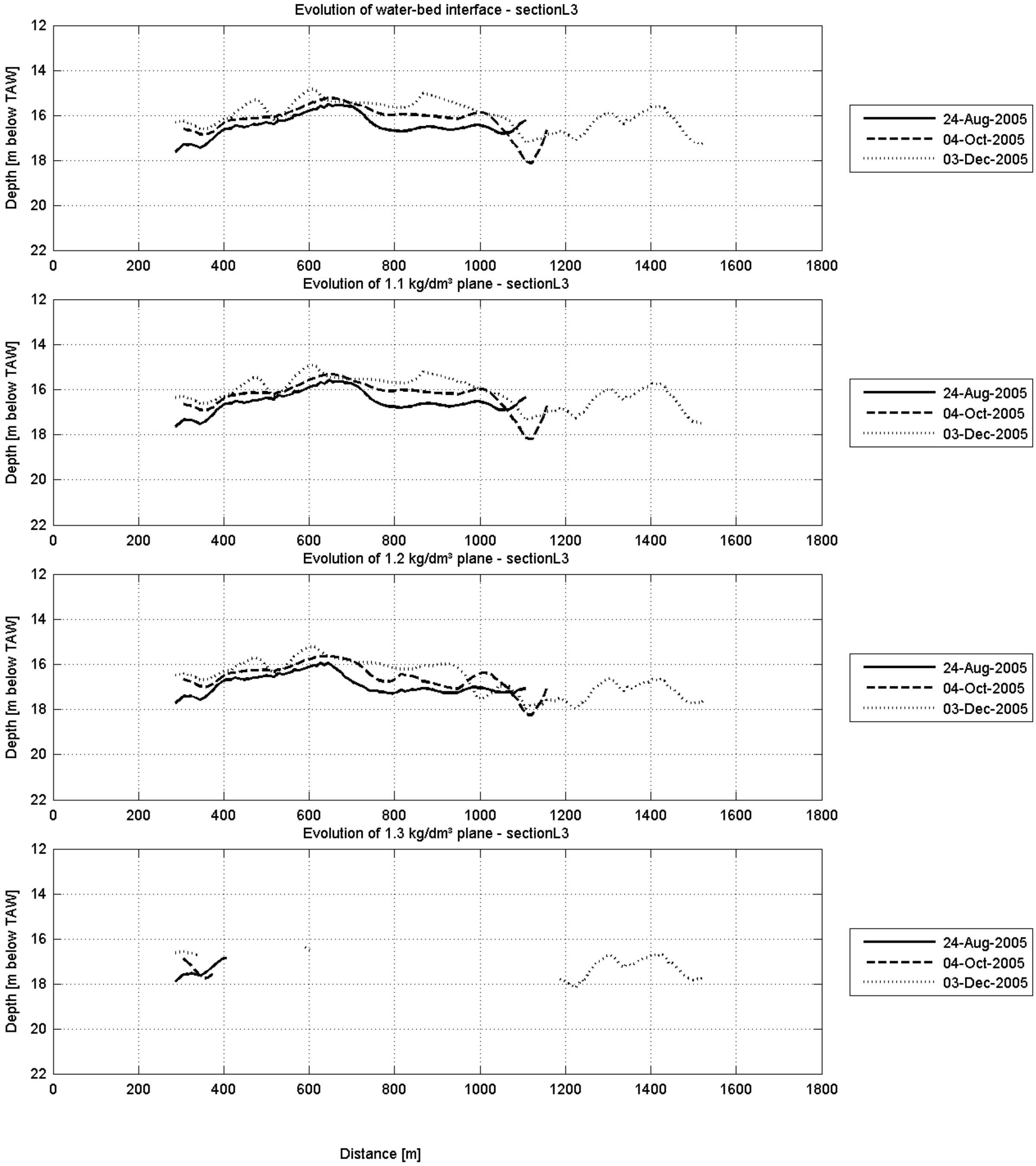
Long-term monitoring siltation Deurganckdok	
Evolution of planes of constant density	Equipment(s): NaviTracker
	Location: DGD



	Data Processed by: IMDC In association with : wl | delft hydraulics, GEMS International I/RA/11283/06.118/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/11283/06.118/MSA

APPENDIX F.

MEASURED MASS MAPS

APPENDIX G.

AVERAGE MASS GROWTH AND GROWTH RATE

G.1 Tabular results

Measured Mass (TDS/m²)			
------------	***24/aug/05***	***04-Oct-2005***	***3/dec/05***
1	***	***	***
2	***	***	***
3a	1.338	1.582	1.626
3b	1.084	1.091	1.213
3c	***	***	0.67
4Na	1.03	0.814	1.069
4Nb	***	0.604	0.668
4Nc	***	***	0.492
4Za	0.524	0.597	0.855
4Zb	0.337	0.485	0.67
4Zc	***	***	0.62
5Na	***	***	***
5Nb	***	***	***
5Nc	***	***	***
5Za	***	***	***
5Zb	***	***	***
5Zc	***	***	***
Area mean	1.017	1.026	1.009

Dredged Material mass in covered area (TDS, Cumulative from March ’05))			
------------	***24/aug/05***	***04-Oct-2005***	***3/dec/05***
1	8273.406	9805.764	65339.43
2	0	0	83229.75
3a	0	0	40251.31
3b	0	0	12978.62
3c	0	0	0
4Na	0	0	391.678
4Nb	0	0	111.065
4Nc	0	0	0
4Za	0	0	47.116
4Zb	0	0	0
4Zc	0	0	0
5Na	0	0	0
5Nb	0	0	0
5Nc	0	0	0
5Za	0	0	0
5Zb	0	0	0

5Zc	0	0	0
Total	8273.406	9805.764	202349

*****Total sediment mass(TDS/m²)***

	24/aug/05	*04-Oct-2005*	*3/dec/05*
1	***	***	***
2	***	***	***
3a	1.338	1.582	2.034
3b	1.084	1.091	1.332
3c	***	***	0.67
4Na	1.03	0.814	1.08
4Nb	***	0.604	0.671
4Nc	***	***	0.492
4Za	0.524	0.597	0.857
4Zb	0.337	0.485	0.67
4Zc	***	***	0.62
5Na	***	***	***
5Nb	***	***	***
5Nc	***	***	***
5Za	***	***	***
5Zb	***	***	***
5Zc	***	***	***
Mean	1.017	1.026	1.122

*****Growth rate (kg/m²/day)***

	24-Aug-2005-04-Oct-2005	*04-Oct-2005-03-Dec-2005*
1	***	***
2	***	***
3a	5.93	7.537
3b	0.19	4.004
3c	***	***
4Na	-5.282	4.432
4Nb	***	1.114
4Nc	***	***
4Za	1.781	4.332
4Zb	3.596	3.093
4Zc	***	***
5Na	***	***

5Nb	***	***
5Nc	***	***
5Za	***	***
5Zb	***	***
5Zc	***	***
Mean	0.223	1.591

***Covered Area (ha)**

	24/aug/05	04-Oct-2005	3/dec/05	Total zone
1	0	0	0	10.5
2	0.88	0.83	0.96	12.00
3a	9.87	9.87	9.87	9.87
3b	8.34	10.99	10.99	10.99
3c	0	1.82	8.23	9.92
4Na	3.6	3.64	3.64	3.64
4Nb	0.92	2.15	3.12	3.12
4Nc	0	0.02	2.19	2.58
4Za	2.42	2.42	2.42	2.42
4Zb	2.75	3.08	3.12	3.12
4Zc	0	0.03	2.12	2.59
5Na	0.3	0.42	0.55	2.29
5Nb	0.03	0.04	0.43	2.05
5Nc	0	0	0.26	1.86
5Za	0.19	0.22	0.43	1.30
5Zb	0.32	0.67	0.67	2.03
5Zc	0	0	0.33	1.83
All zones	29.62	36.17	49.32	82.10

***Percent of zone covered**

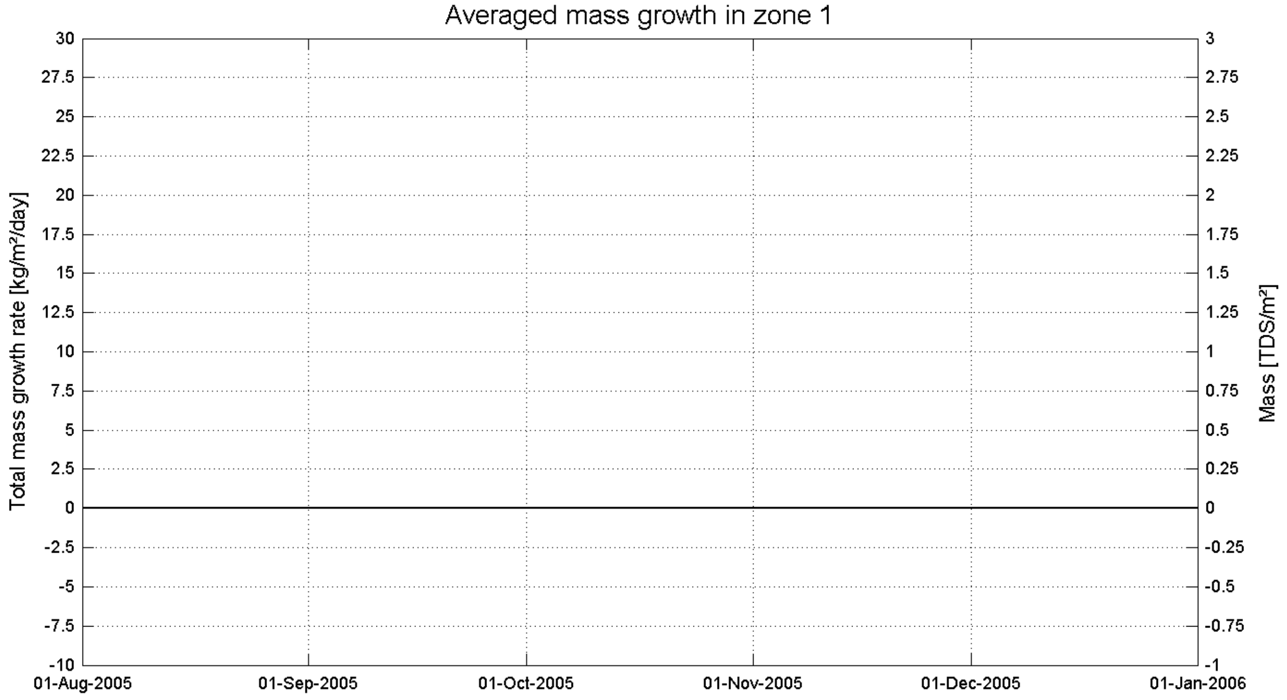
	24/aug/05	04-Oct-2005	3/dec/05
1	0	0	0
2	7	7	8
3a	100	100	100
3b	76	100	100
3c	0	18	83
4Na	99	100	100
4Nb	29	69	100
4Nc	0	1	85
4Za	100	100	100
4Zb	88	98	100

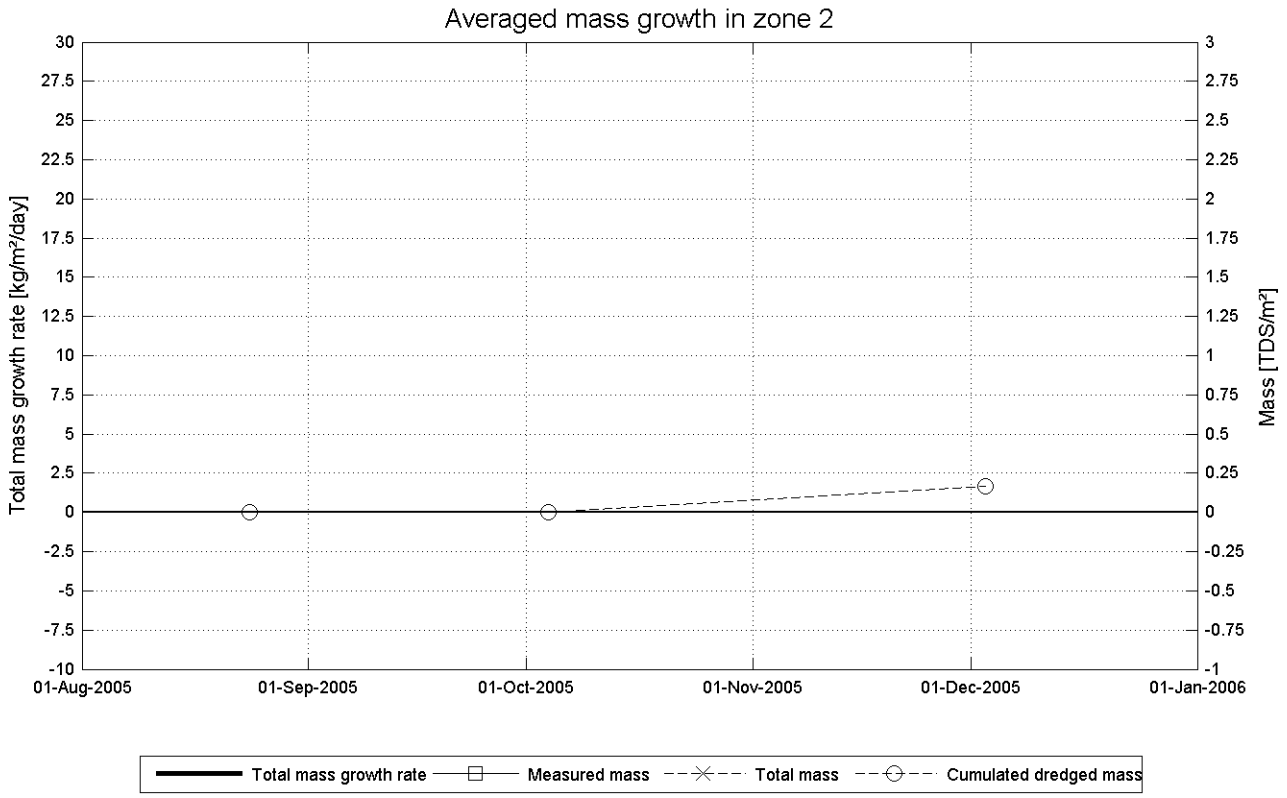
4Zc	0	1	82
5Na	13	18	24
5Nb	2	2	21
5Nc	0	0	14
5Za	15	17	33
5Zb	16	33	33
5Zc	0	0	18
All zones	32	39	59

G.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/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

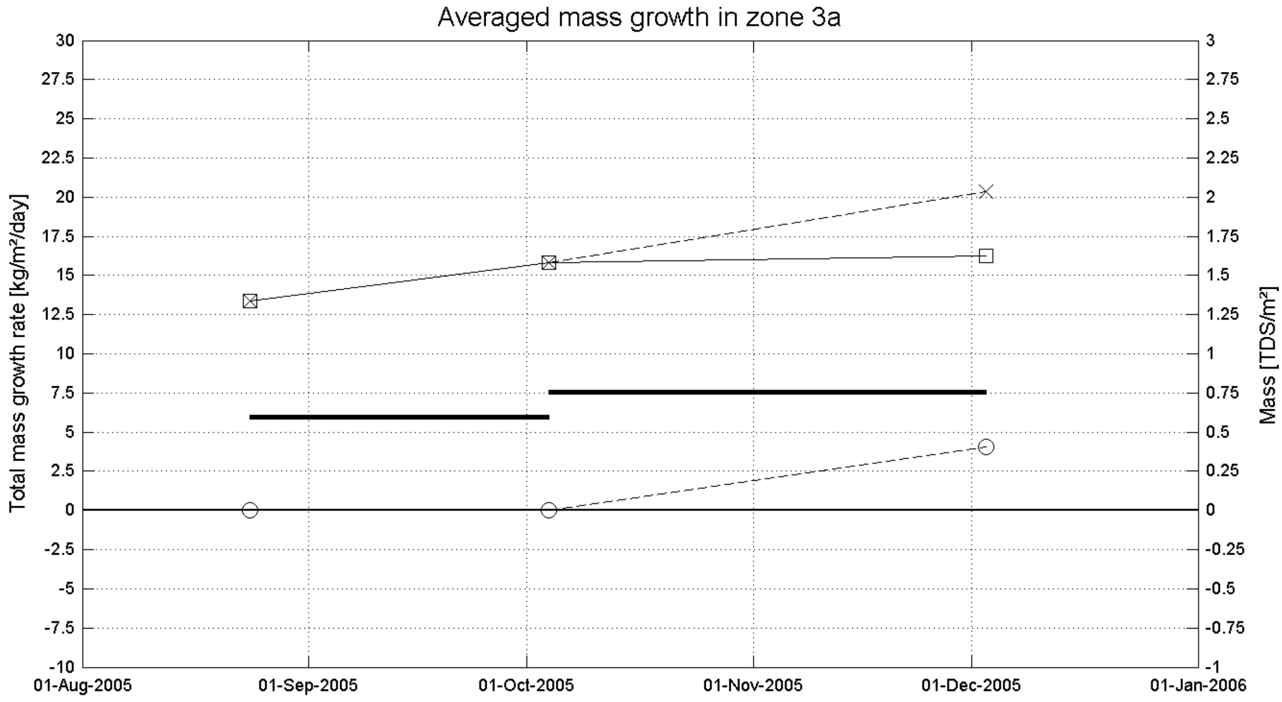
Measured/Dredged/Total Mass

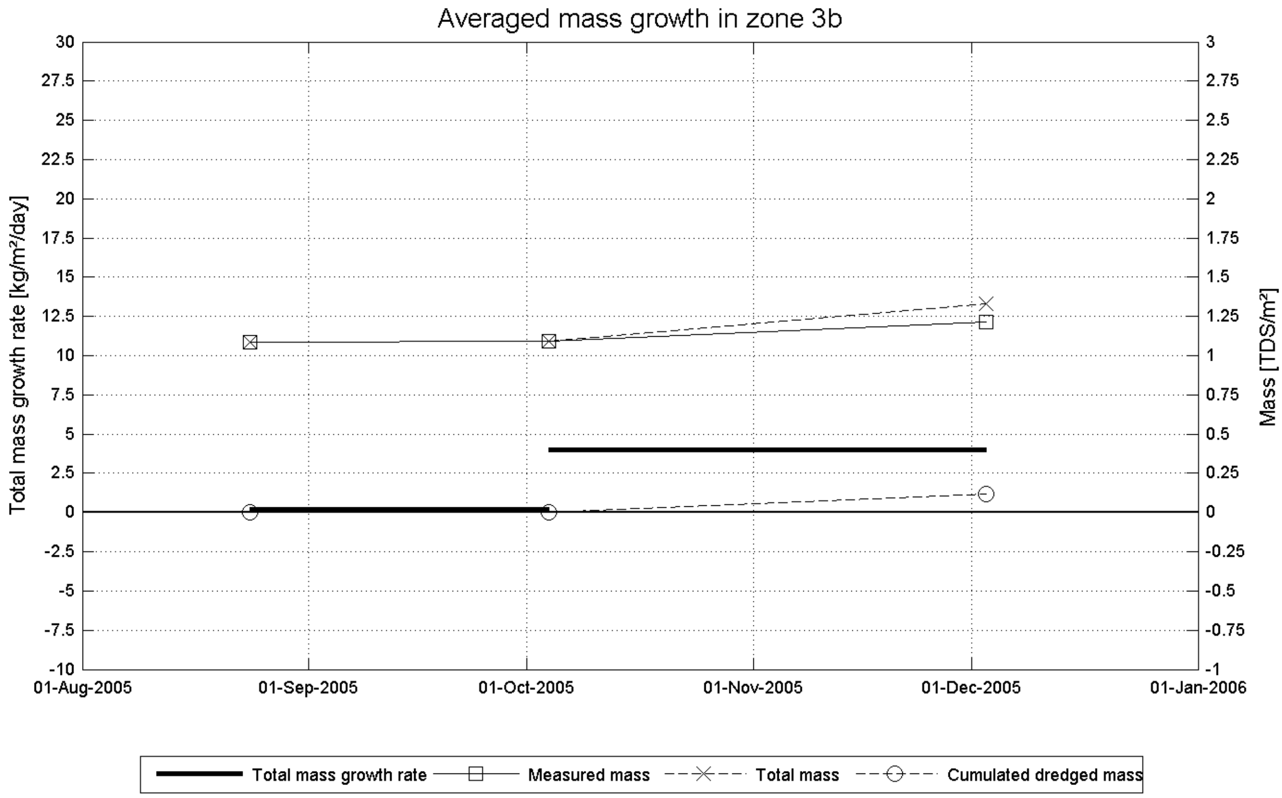
Equipment(s):

NaviTracker

Location:

DGD





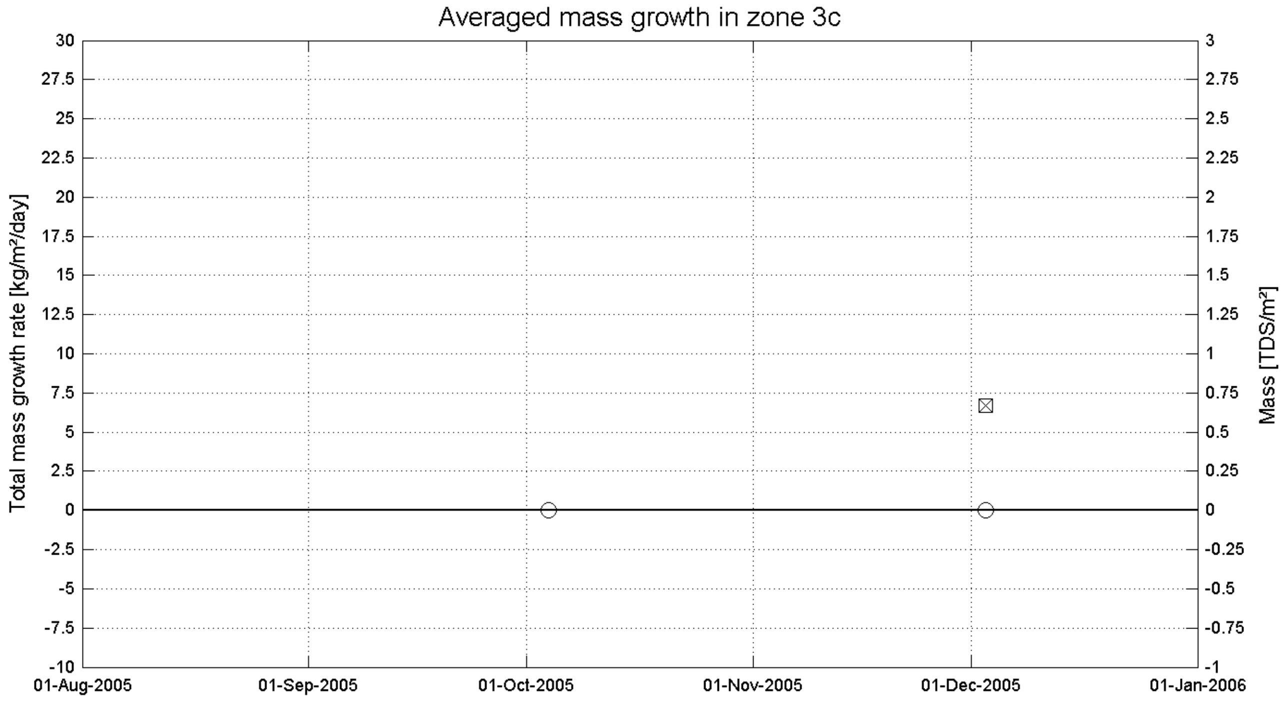
Data Processed by:

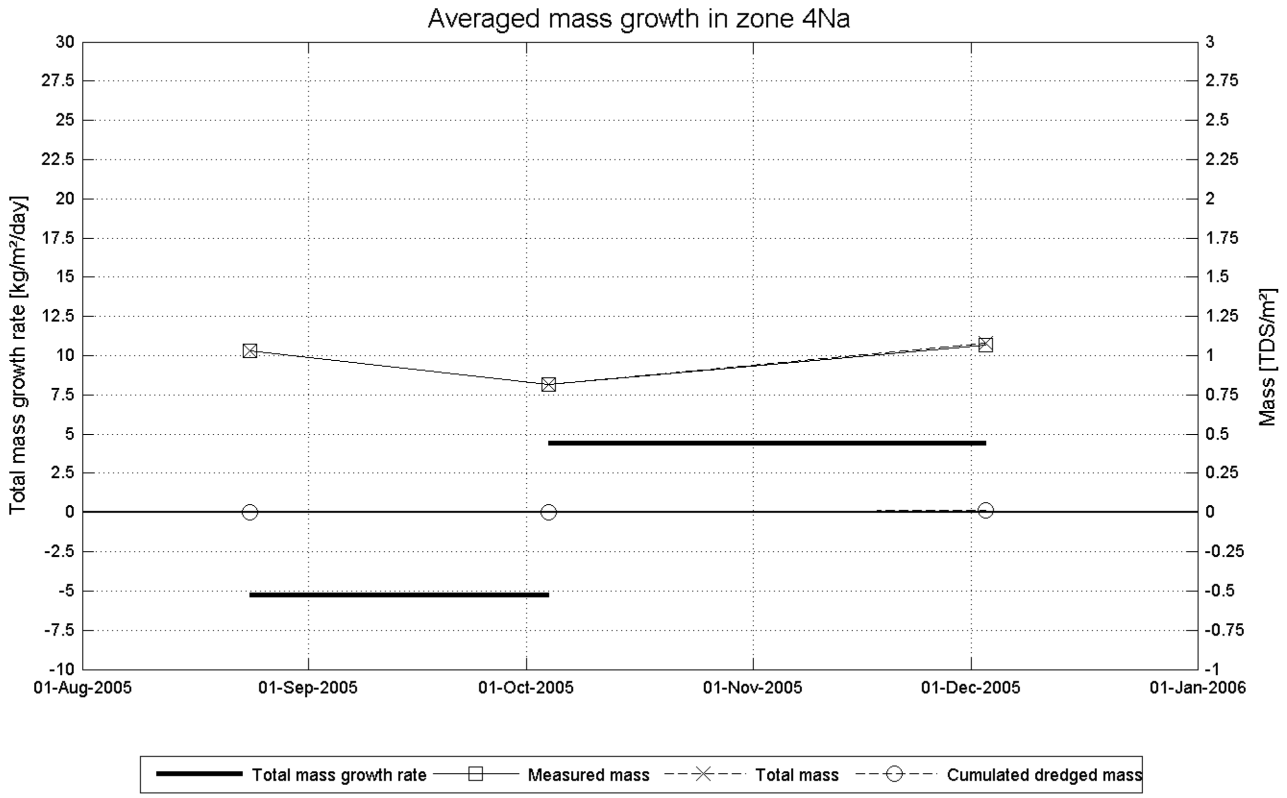
In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Measured/Dredged/Total Mass	Equipment(s): NaviTracker
	Location: DGD





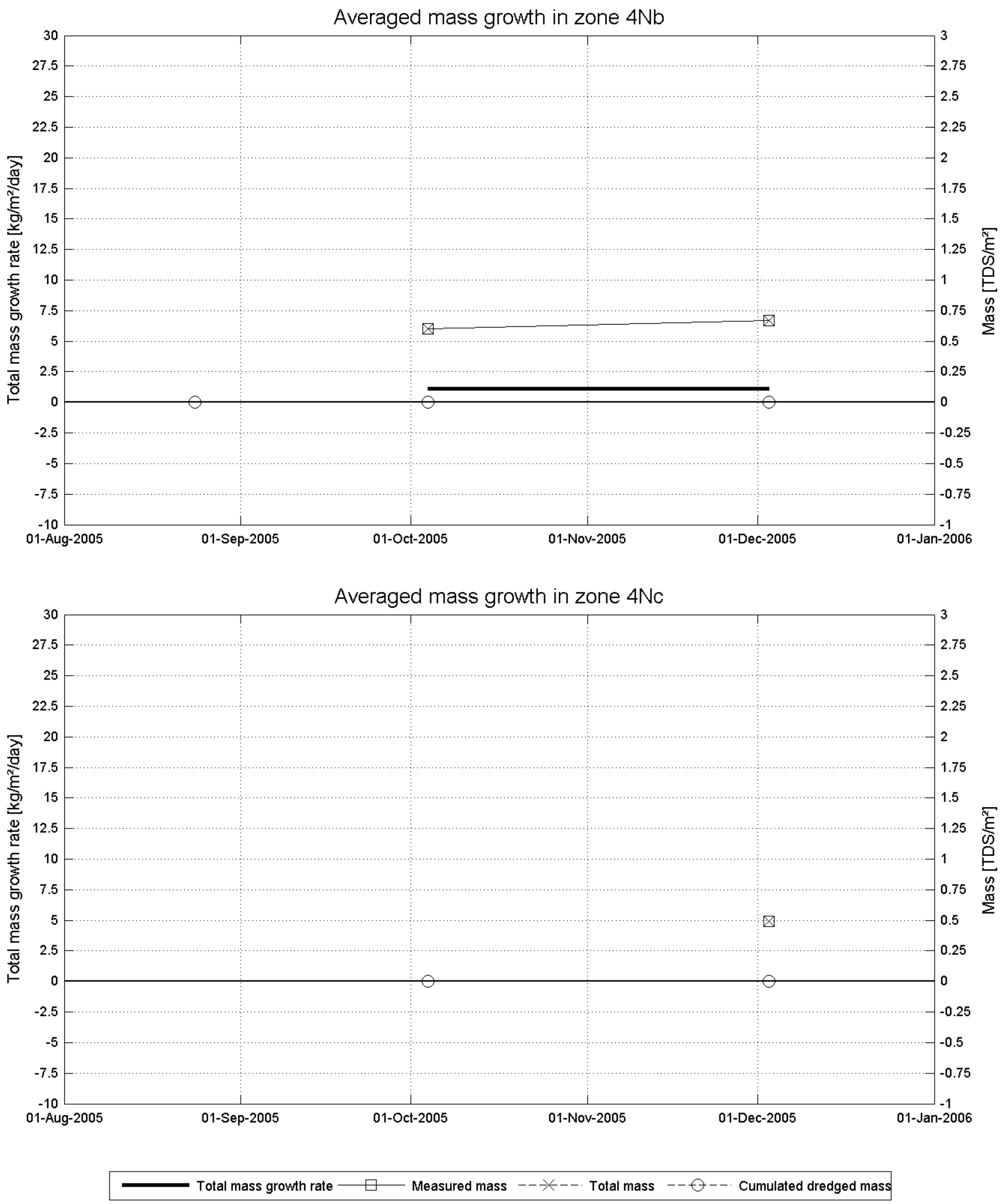
Data Processed by:

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Measured/Dredged/Total Mass	Equipment(s): NaviTracker
	Location: DGD



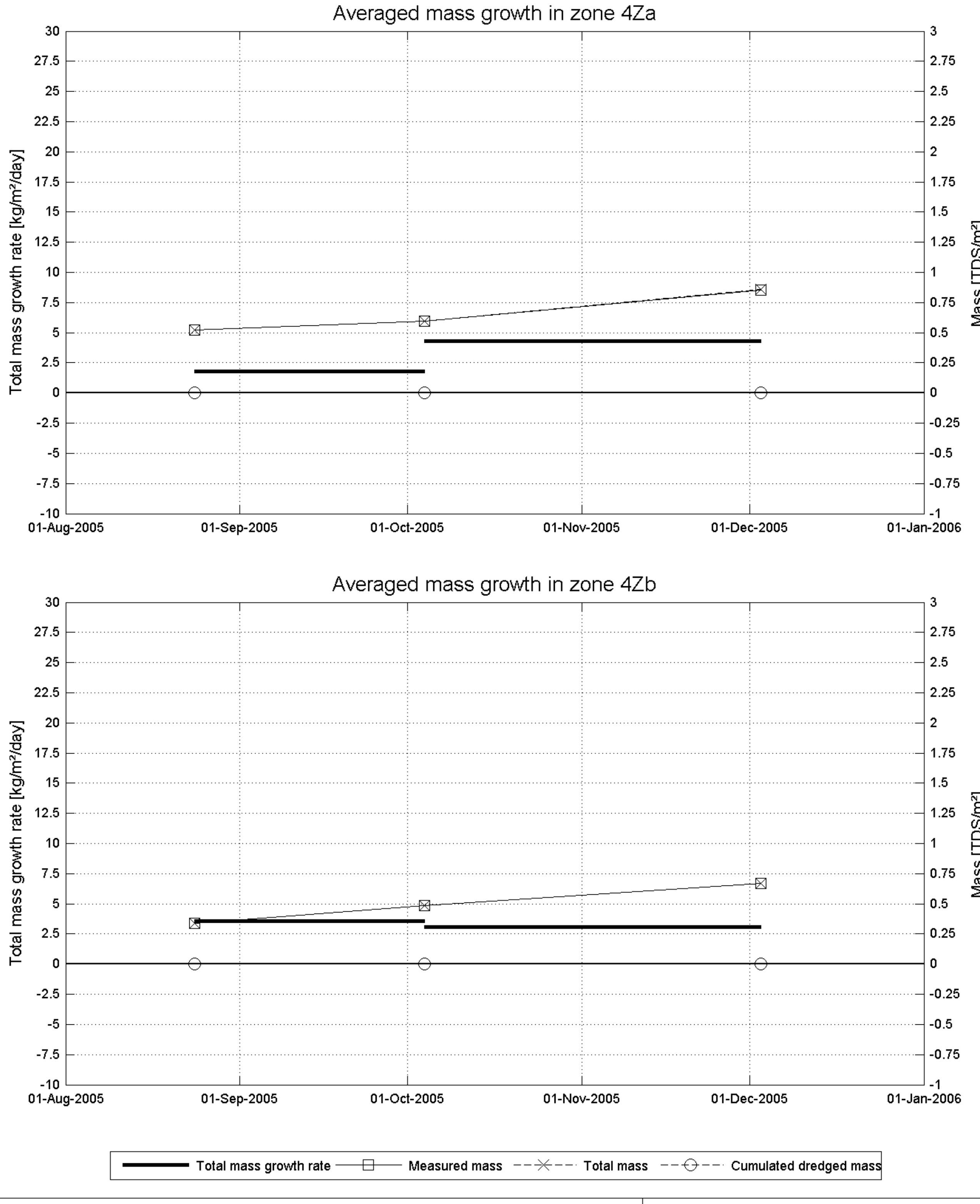
Data Processed by:

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Measured/Dredged/Total Mass	Equipment(s): NaviTracker
	Location: DGD



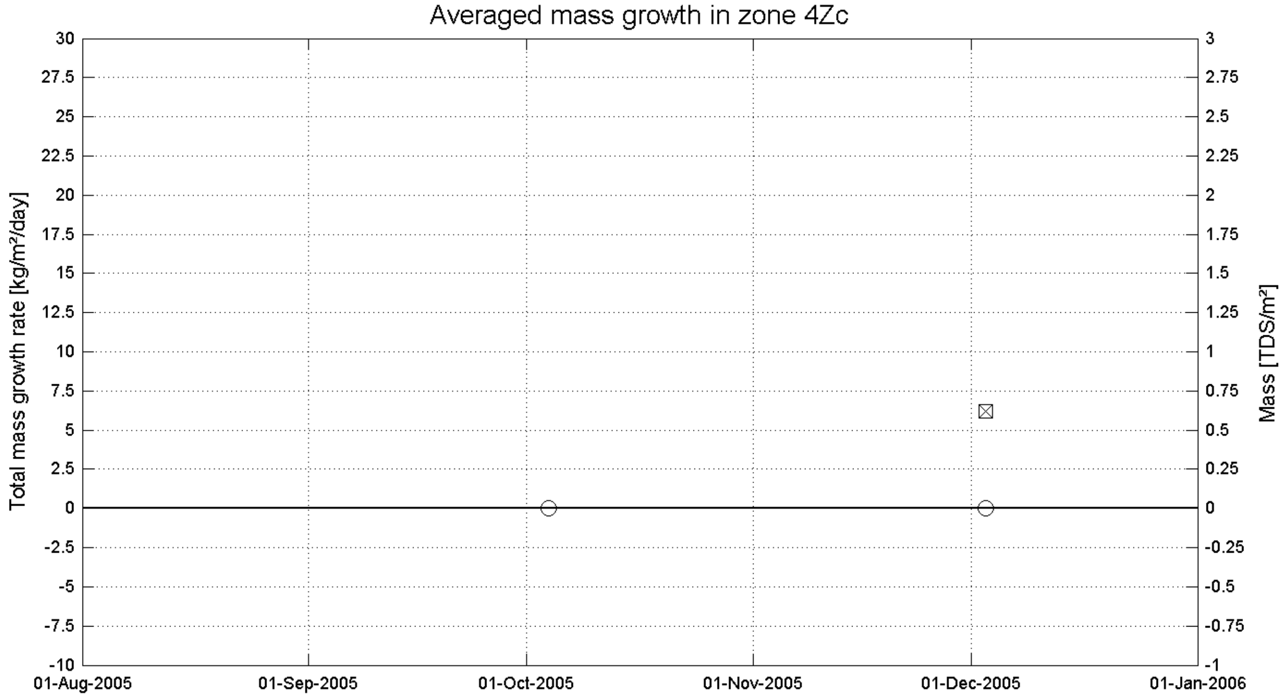
Data Processed by: IMDC

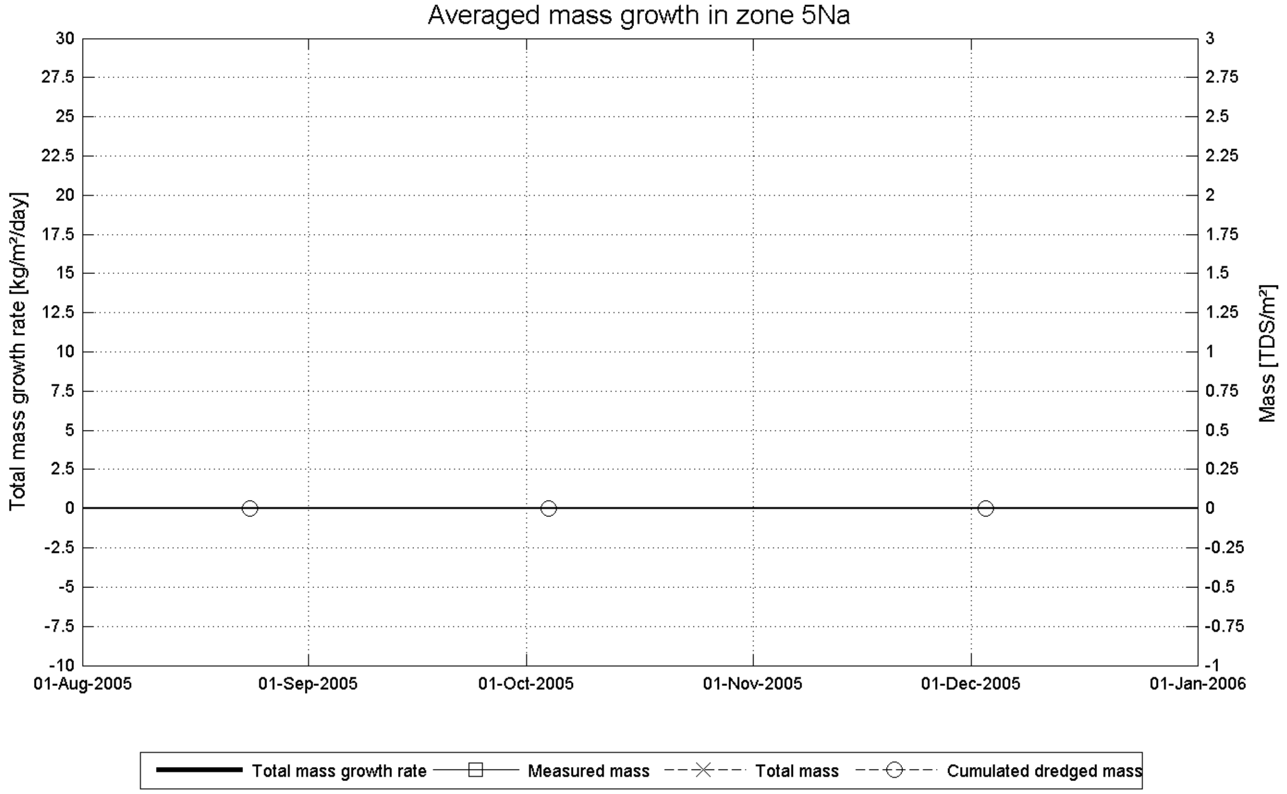
In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Measured/Dredged/Total Mass	Equipment(s): NaviTracker
	Location: DGD





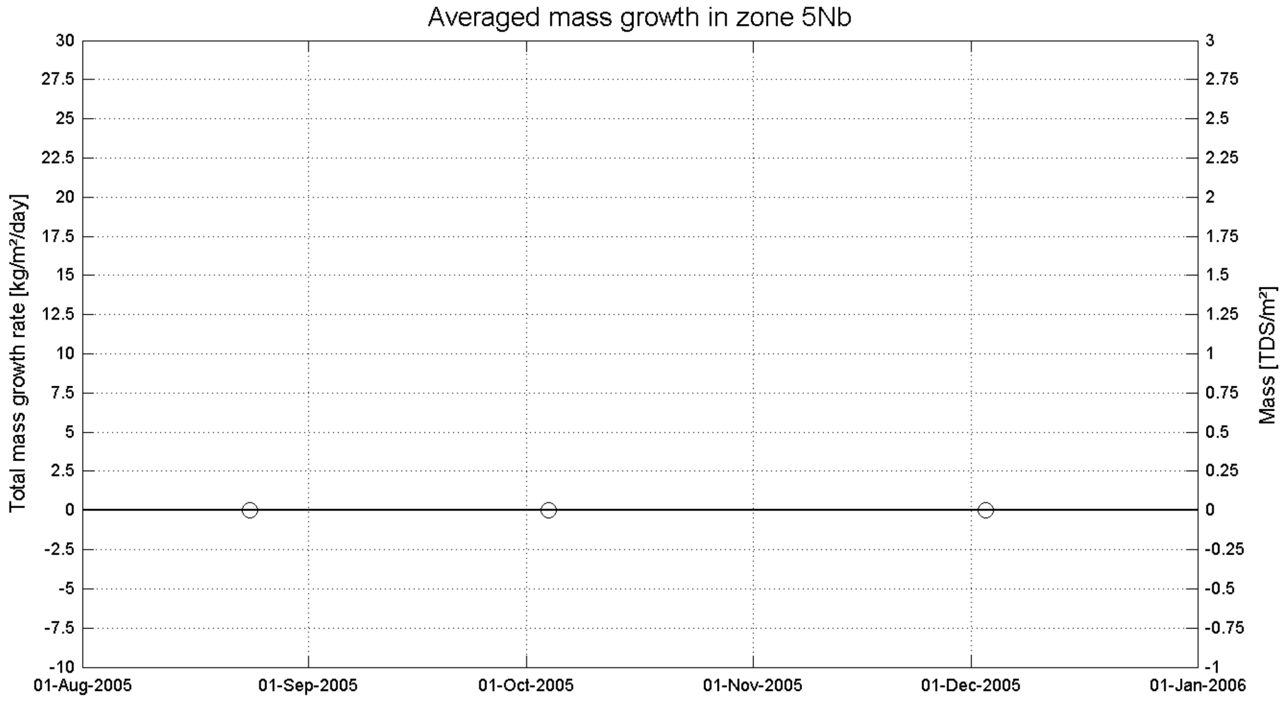
Data Processed by:

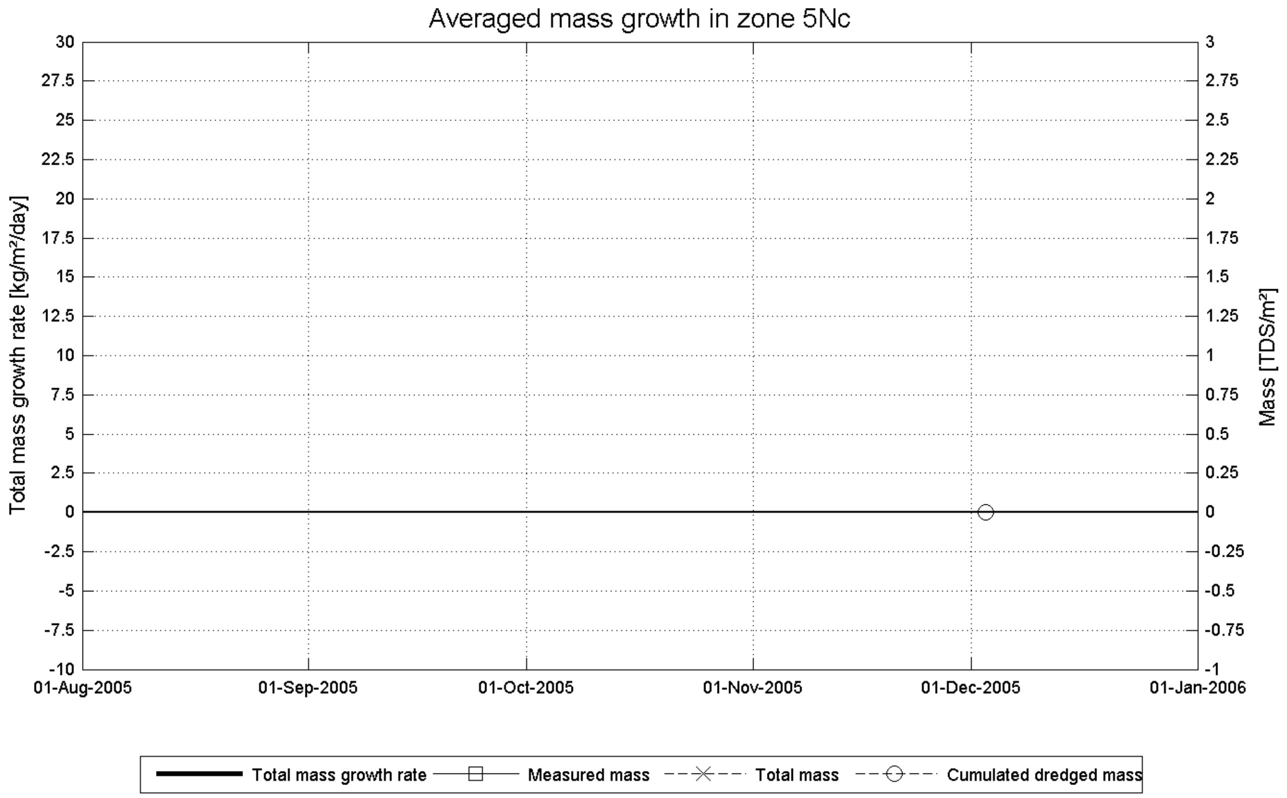
In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Measured/Dredged/Total Mass	Equipment(s): NaviTracker
	Location: DGD





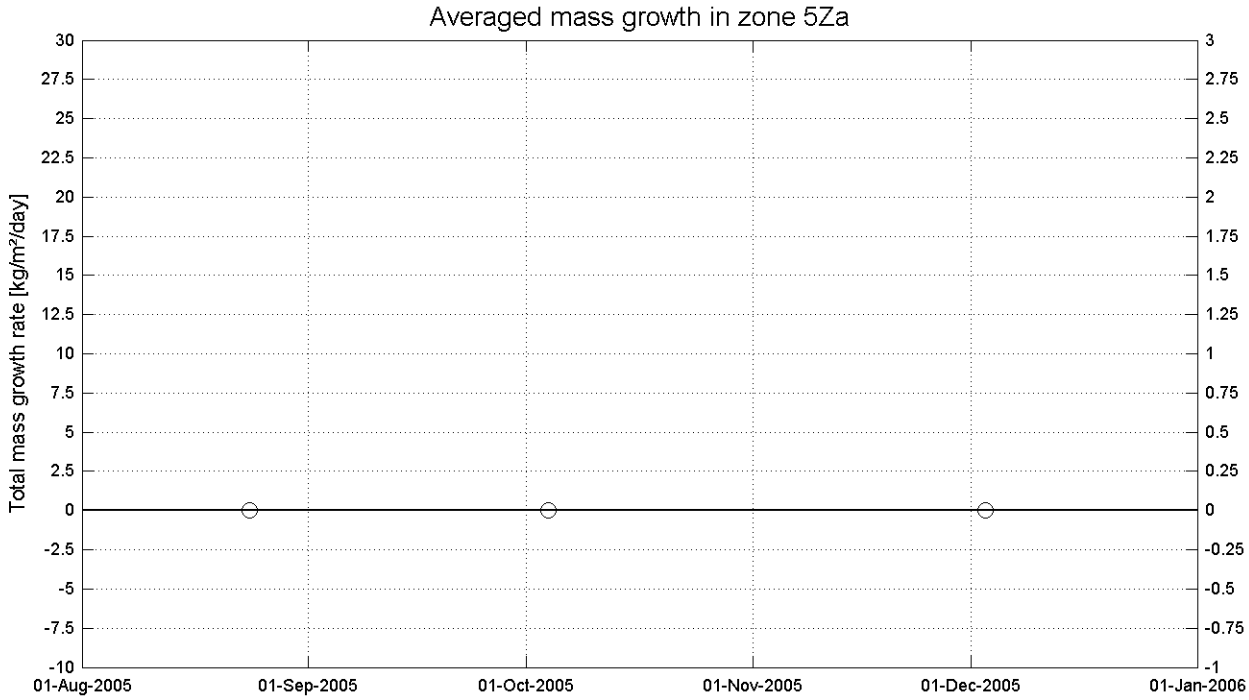
Data Processed by:

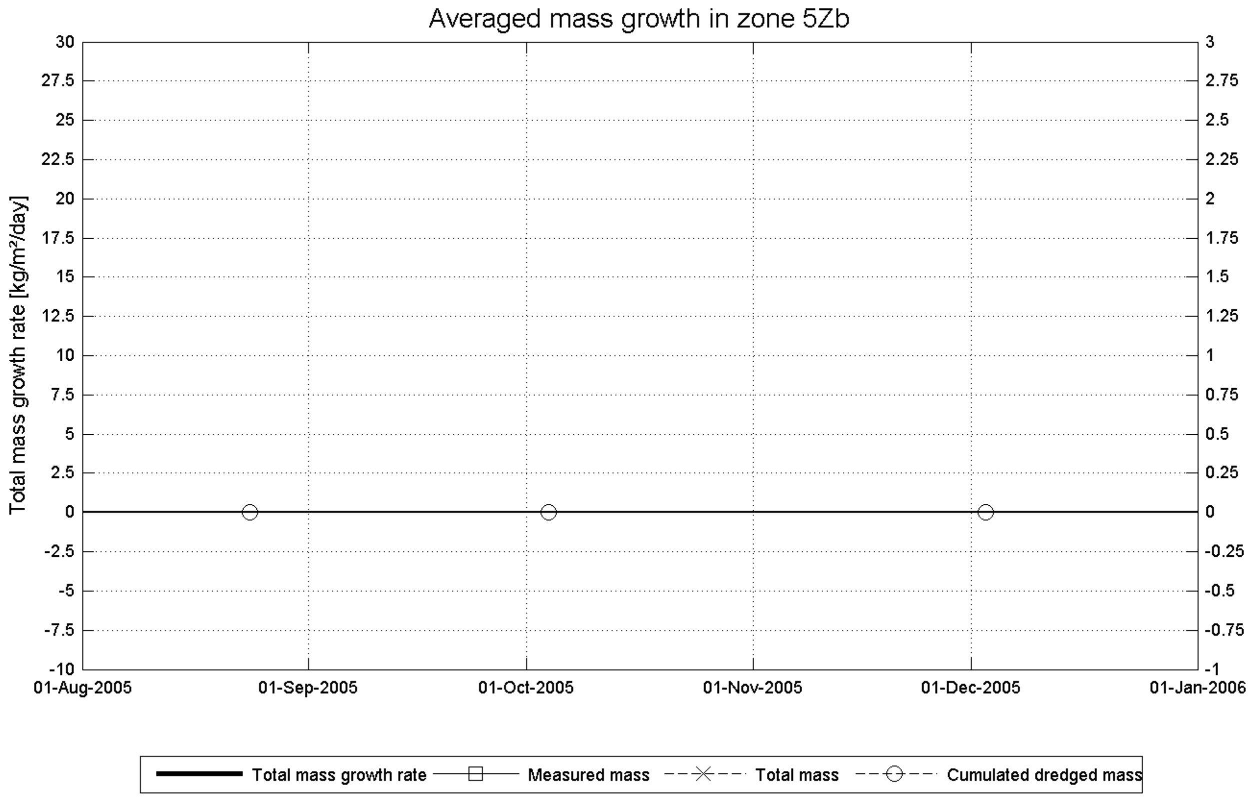
In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Measured/Dredged/Total Mass	Equipment(s): NaviTracker
	Location: DGD





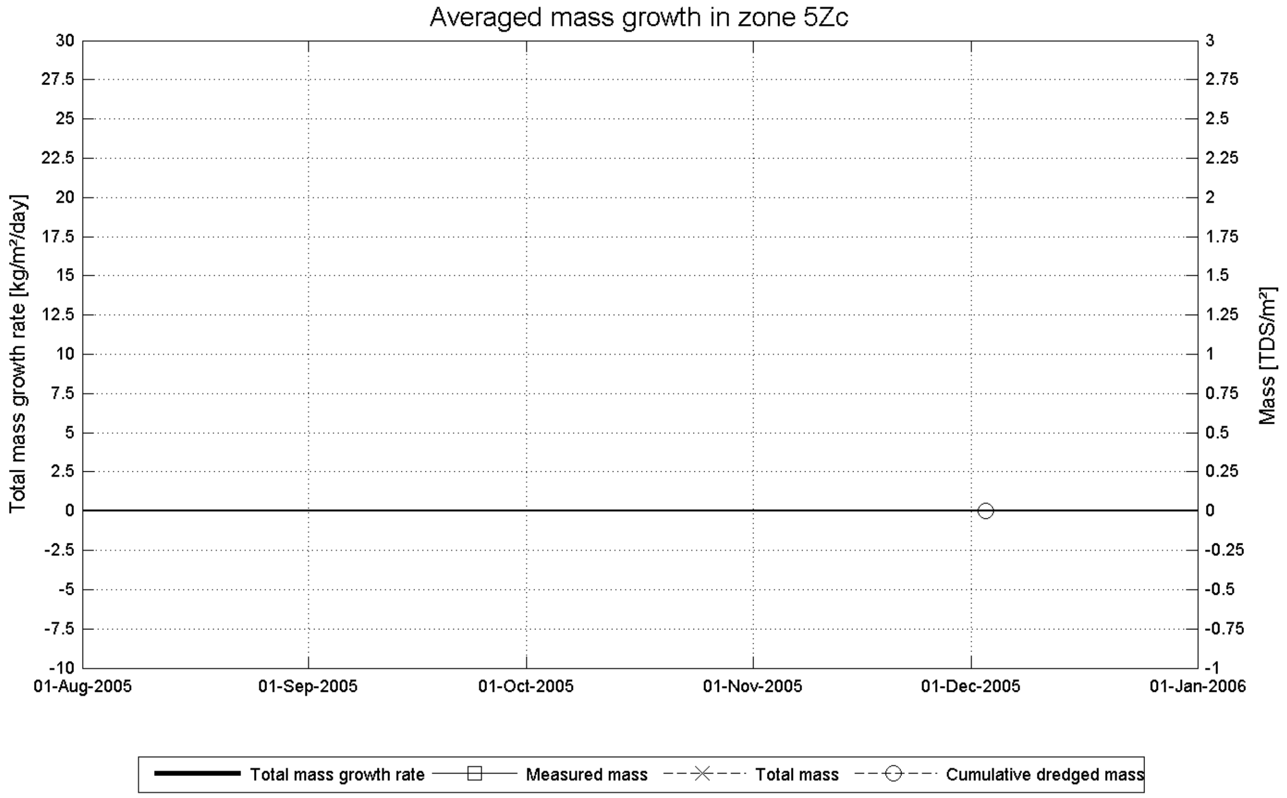
Data Processed by: IMDC

In association with :

I/RA/11283/06.118/MSA

Long-term monitoring siltation Deurganckdok

Measured/Dredged/Total Mass	Equipment(s): NaviTracker
	Location: DGD



Data Processed by:

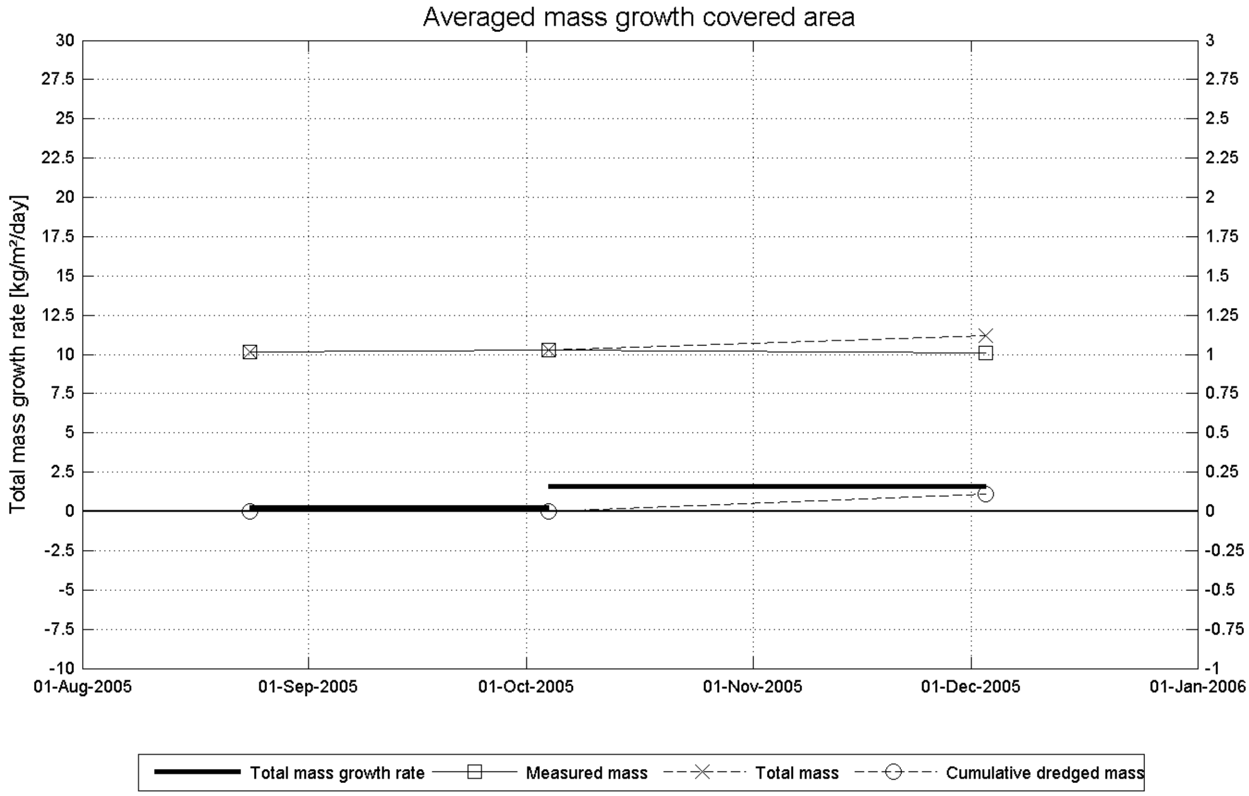
In association with :

I/RA/11283/06.118/MSA

G.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/11283/06.118/MSA

APPENDIX H.

HCBS2 REPORTS WINTER CAMPAIGN

Report	Description
Ambient Conditions Lower Sea Scheldt	
5.3	Overview of ambient conditions in the river Scheldt – January-June 2006 (I/RA/11291/06.088/MSA)
5.4	Overview of ambient conditions in the river Scheldt – July-December 2006 (I/RA/11291/06.089/MSA)
5.5	Overview of ambient conditions in the river Scheldt : RCM-9 buoy 84 & 97 (1/1/2007 - 31/3/2007) (I/RA/11291/06.090/MSA)
5.6	Analysis of ambient conditions during 2006 (I/RA/11291/06.091/MSA)
Calibration	
6.1	Winter Calibration (I/RA/11291/06.092/MSA)
6.2	Summer Calibration and Final Report (I/RA/11291/06.093/MSA)
Through tide Measurements Winter 2006	
7.1	21/3 Scheldewacht – Deurganckdok – Salinity Distribution (I/RA/11291/06.094/MSA)
7.2	22/3 Parel 2 – Deurganckdok (I/RA/11291/06.095/MSA)
7.3	22/3 Laure Marie – Liefkenshoek (I/RA/11291/06.096/MSA)
7.4	23/3 Parel 2 – Schelle (I/RA/11291/06.097/MSA)
7.5	23/3 Laure Marie – Deurganckdok (I/RA/11291/06.098/MSA)
7.6	23/3 Veremans Waarde (I/RA/11291/06.099/MSA)
HCBS Near bed continuous monitoring (Frames)	
8.1	Near bed continuous monitoring winter 2006 (I/RA/11291/06.100/MSA)
8.2	Near bed continuous monitoring summer 2006 (I/RA/11291/06.101/MSA)
INSSEV	
9	Settling Velocity - INSSEV summer 2006 (I/RA/11291/06.102/MSA)
Cohesive Sediment	
10	Cohesive sediment properties summer 2006 (I/RA/11291/06.103/MSA)
Through tide Measurements Summer	
11.1	Measurement Day 27/9 Vessel 1 (I/RA/11291/06.104/MSA)
11.2	Measurement Day 27/9 vessel 2 (I/RA/11291/06.105/MSA)
11.3	Measurement Day 28/9 vessel 1 (I/RA/11291/06.106/MSA)
11.4	Measurement Day 28/9 vessel 2 (I/RA/11291/06.107/MSA)
11.5	Measurement Day 28/9 vessel 3 (I/RA/11291/06.108/MSA)
Analysis	
12	Report concerning the presence of HCBS layers in the Scheldt river (I/RA/11291/06.109/MSA)