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The Interreg IVB North Sea Region Programme

WP5 Measures

Basic analysis reports

Measure nr° 19. TIDE pilot project 2: Navigation channel near Ketelplaat – Relocation of dredged sediment to deep areas of the navigation channel

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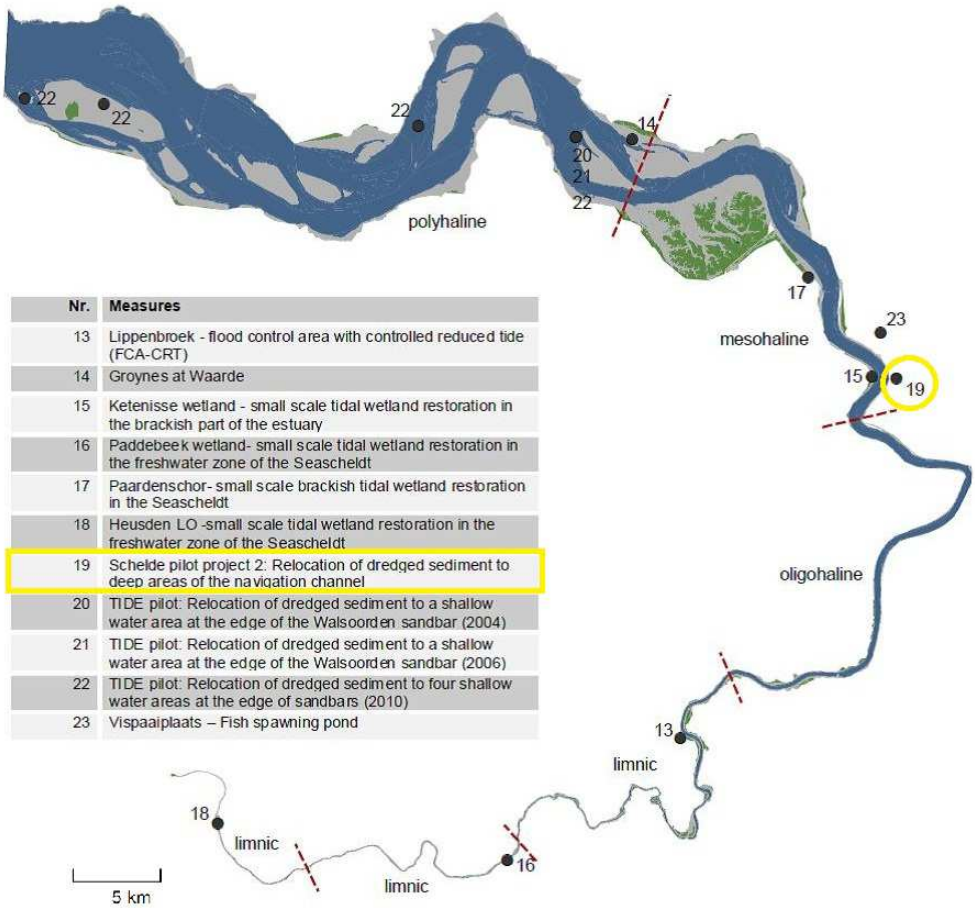
TABLE OF CONTENTS

1 Description of measure

- Measure Category: Hydrology/Morphology
- Estuary: Scheldt
- Salinity zone: Mesohaline
- Pressure: Gross change in morphology and hydrographic regime
- Status: Implemented (in 2010)
- River km: TIDE-km 92
- Country: Belgium
- Specific location: Sea Scheldt, North of Antwerp city (near Liefkenshoektunnel), two disposal areas in the navigation channel between 'Sill Lillo' and 'Sill Parel'
- Responsible authority: Department of Mobility and Public Works (MOW), Maritime Access Division
- Costs: 115,000 €
- Cost category: 50,000 – 250,000 €



Nr.	Measures
13	Lippenbroek - flood control area with controlled reduced tide (FCA-CRT)
14	Groynes at Waarde
15	Ketenisse wetland - small scale tidal wetland restoration in the brackish part of the estuary
16	Paddebeek wetland- small scale tidal wetland restoration in the freshwater zone of the Seascheldt
17	Paardenschor- small scale brackish tidal wetland restoration in the Seascheldt
18	Heusden LO -small scale tidal wetland restoration in the freshwater zone of the Seascheldt
19	Schelde pilot project 2: Relocation of dredged sediment to deep areas of the navigation channel
20	TIDE pilot: Relocation of dredged sediment to a shallow water area at the edge of the Walsoorden sandbar (2004)
21	TIDE pilot: Relocation of dredged sediment to a shallow water area at the edge of the Walsoorden sandbar (2006)
22	TIDE pilot: Relocation of dredged sediment to four shallow water areas at the edge of sandbars (2010)
23	Vispaaiplaats – Fish spawning pond

Figure 1. Location of the relocation measure (near Ketelplaat)

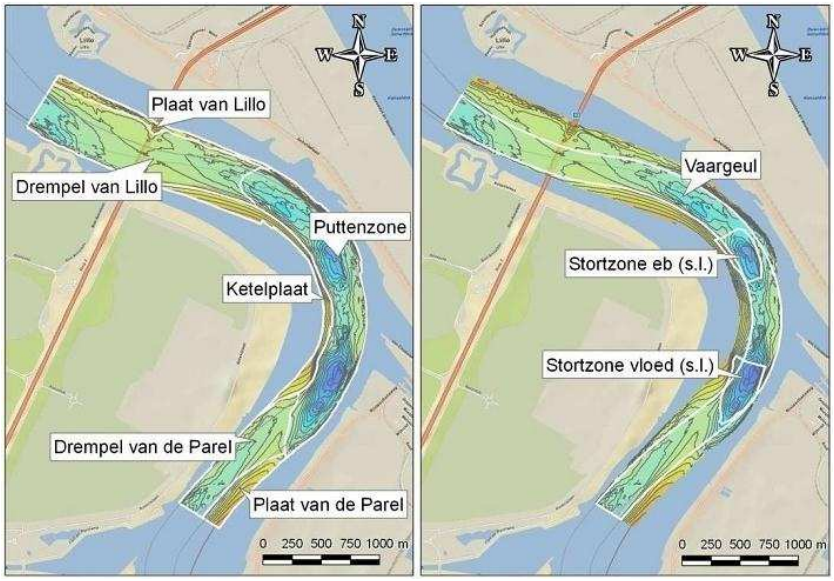


Figure 2. Study area: navigation channel near Ketelplaat with two deep relocation areas (northern site or low tide site 'Stortzone eb' and southern site or high tide site 'stortzone vloed'). The navigation channel that is studied is limited in the north by the 'Plaat van Lillo' and in the south by the 'Drempel van de Parel'. (IMDC 2011)

1.1 Measure description

In several estuaries, including the Scheldt estuary, tidal amplitude and propagation are steadily increasing in the last decades. Climate change could even exacerbate this trend due to elevated sea levels. To ensure safety against flooding in the future, we should find methods to affect tidal currents. One method could be to relocate sediment in such a way that tidal energy dissipation is maximised. The effectiveness of such a method is determined by the timescale that the relocated sediment remains in place. The measure discussed here is a trial to estimate the erosion rate of sediment that was relocated to a deep area in the navigation channel of the Scheldt estuary.

In the Flemish part of the Scheldt estuary 2 locations are available for relocation of sandy dredged material. The first one, 'Schaar Ouden Doel', is in use for more than a century as a site for relocation of sandy dredged material for sand extraction. The second location, two deep areas in the fairway near the 'Ketelplaat', is available since the start of the 3rd deepening programme (February 10th, 2010) and has an area of 88 hectares. At the latter location, a sediment volume of 562.621 m³ (vessel-volume) is relocated from March 8th until March 29th, 2010. The morphological behaviour of the relocated material was assessed as reference for planned numerical morphological modelling for similar relocation on a larger scale. The general aim of the pilot measure consists of three sub-objectives: report on available data on the relocation test; analysis of the bathymetric changes based on historical measurements with special attention to the nearby 'Drempel van Lillo' and 'Drempel van de Parel'; and analysis of the morphologic changes before (10 years), during (3 weeks) and after (7 months) the relocation test (IMDC 2011). The dredging activities took place outside the study area and are therefore of minor importance for this study. However, data on dredged volumes are collected to analyse material fluxes, in particular the behavior of the relocated material in the deeper areas of the navigation channel.

1.2 Monitoring

The monitoring of this measure is completed. The monitoring was based on a wide range of data: week and day reports for dredging and relocation volumes, dredging statistics, data from the Dredging Information System, measures on the relocation areas and GIS shape files. Multibeam surveys were performed with increased frequency and extended area compared to regular surveys.

Historical data were analysed to identify volume changes (net volume change between two historical surveys). This can give an insight in short term and long term 'net' morphological evolutions.

Data from the relocation test were analysed and reported to identify volume changes at the test sites before, during and after the test. 'Depth maps' and 'difference maps' were developed. Net volume changes were analysed between every two consecutive relocation test surveys, between the first and the last survey before the execution of the relocation test (short term natural evolution), between the last survey before and the first survey after the relocation test (evolution during the test), and between the first and the last survey after the test (evolution after the test). The difference maps were also developed in combination with the dredged volumes to show the location, the time and the volume of relocated dredged material. For both relocation sites longitudinal profiles were developed for the periods before, during and after the execution of the relocation test. Finally, the net volume change for the defined erosion and sedimentation areas after the relocation test were calculated to analyse if the disappeared material from the relocation sites could be found in the nearby areas (see Figure 3).

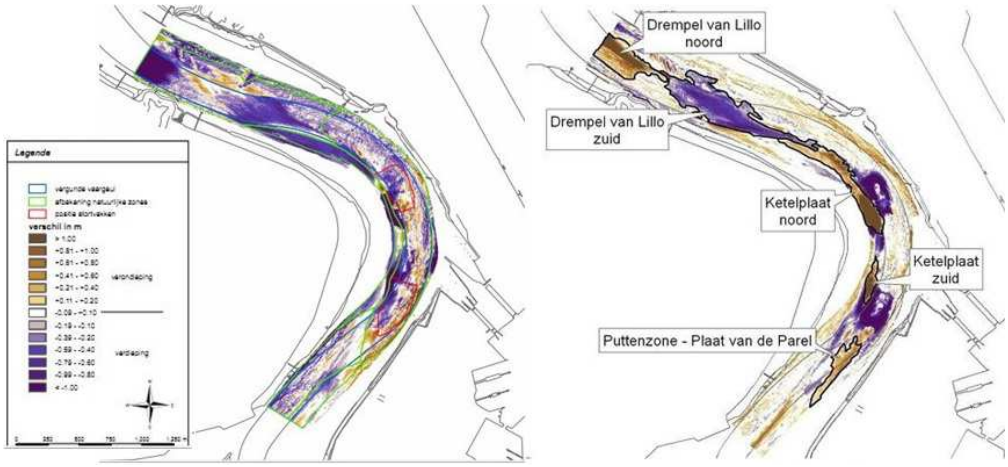


Figure 3. Visualization of the large erosion and sedimentation zones: left: before the relocation test (2008 – 1st March 2010), right: after the relocation test (March-August 2010). Blue area is deepening (erosion) and brown area is sedimentation. (IMDC 2011)

1.3 Monitoring results

First, the long term (1996-2010) and short term (March 1-7 2010) natural evolution of erosion and sedimentation in the study area were analysed. The long term analysis shows a general trend for deepening of the area. This is probably not completely due to natural processes, because many dredging activities occurred at a regular basis in this area between 1996 and 2010. The short period just before the relocation test shows however a sedimentation.

Secondly, the morphological changes during the execution of the relocation test (during three weeks) were analysed. During the relocation (Figure 4), the deep areas of the fairway near Ketelplaat elevated with 1 m (brown area on Figure 5). At the transects through both relocation areas, the changes in bathymetry under influence of the relocation activities are visible: elevation/sedimentation (Figure 6). However, immediately after relocation 20% to 30% of the relocated material had already disappeared out of the relocation site into the immediate surrounding of the relocation site. The downward volume change is also clearly recognizable on Figure 7. The disappeared material is mainly found in the 'Puttenzone', the 'Ketelplaat' and at the 'Drempel van Lillo'.

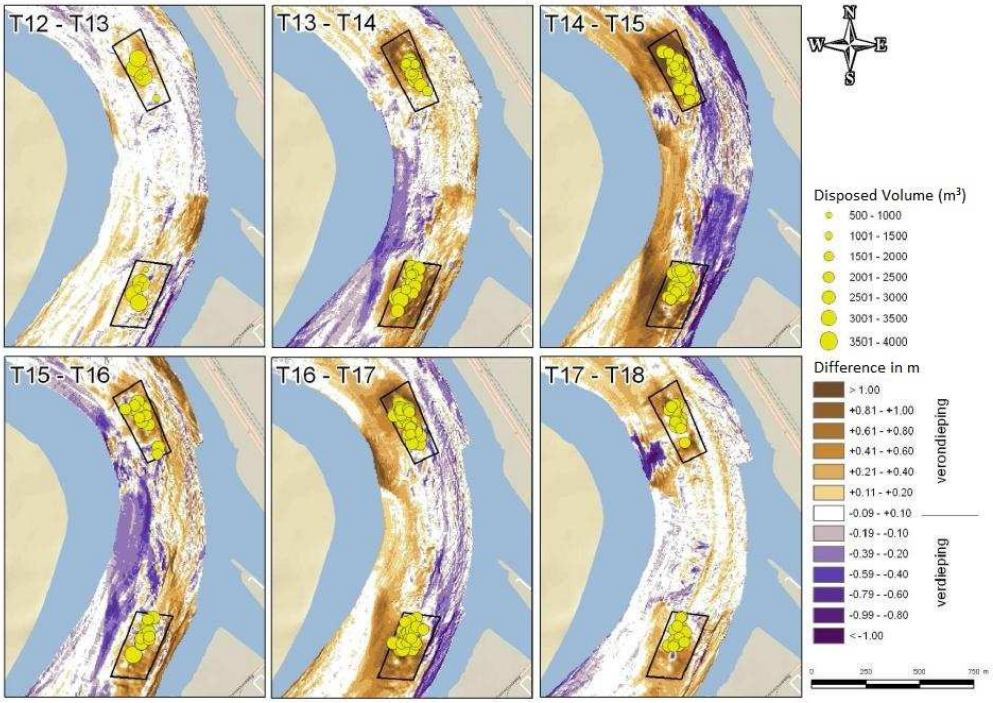


Figure 4. Relocation volumes per time during the relocation test. Also the relocation areas are identified. (IMDC 2011)

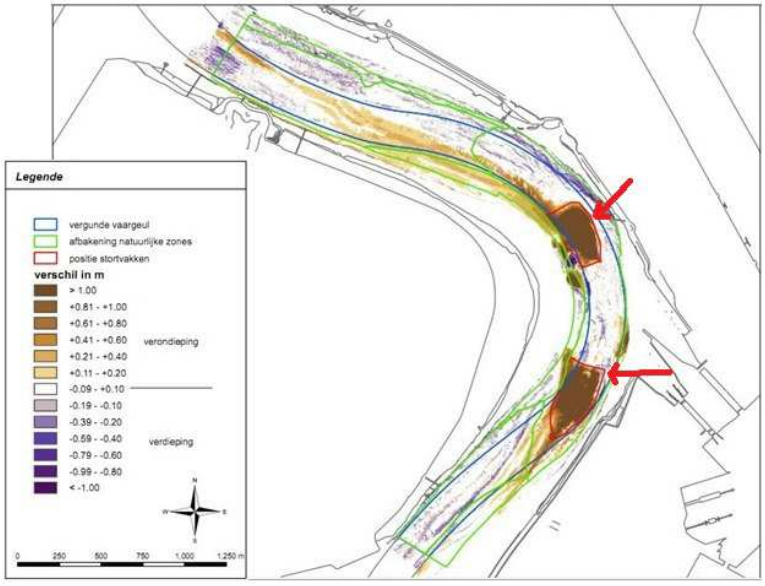


Figure 5. Difference during the relocation period in the deep areas of the Ketelplaat (IMDC 2011)

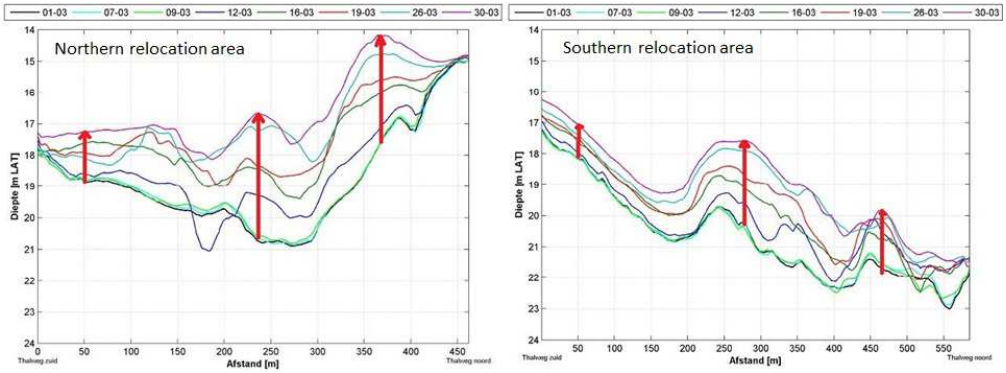


Figure 6. Longitudinal profile through the northern and southern relocation area during the execution of the relocation test (IMDC 2011)

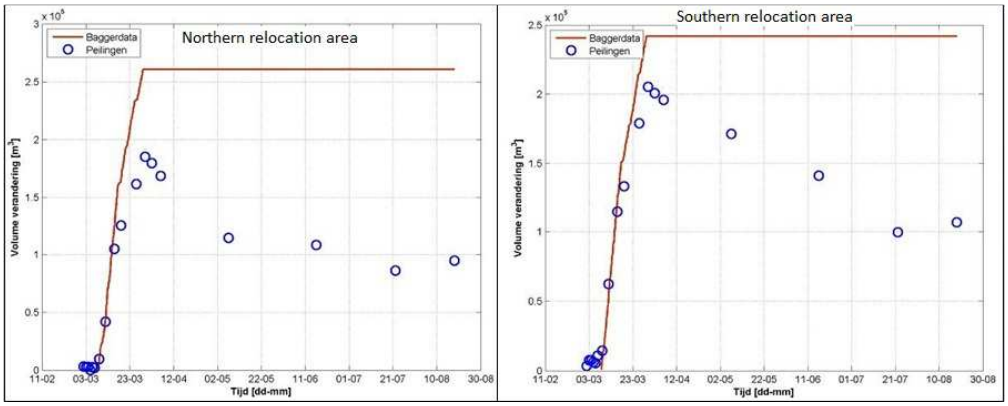


Figure 7. Absolute cumulative volume change (m³) in the northern (left) and southern (right) relocation area, March-August 2010 (IMDC 2011)

Lastly, also the morphological changes after the relocation test (March-August 2010) were analysed. Four to five months after the relocation test, the relocation areas in the navigation channel (near Ketelplaat) were eroded again at most spots (Figure 8), but this stagnated really quickly (Figure 9). Mainly at the edge it deepened again to the original depth (dark blue on Figure 8: *1). Only at some spots, the relocated material was stable four to five months after the relocation test (35% to 40% of the total relocated material) (white on Figure 8: *2). At one edge of the southern site even sedimentation took place and caused elevation (brown on Figure 8: *3). The different trends within both relocation areas are showed by the longitudinal profiles on Figure 10. In general, a large amount of the relocated material disappeared out of the deep relocation areas after the execution of the relocation test. A large amount of this sediment was accumulated at the Ketelplaat and hence did not disappear out of the study area.

In both relocation areas, the bathymetry after the relocation test had flattened. The averaged erosion was 0.8 m for the northern relocation site and 0.9 m for the southern relocation site.

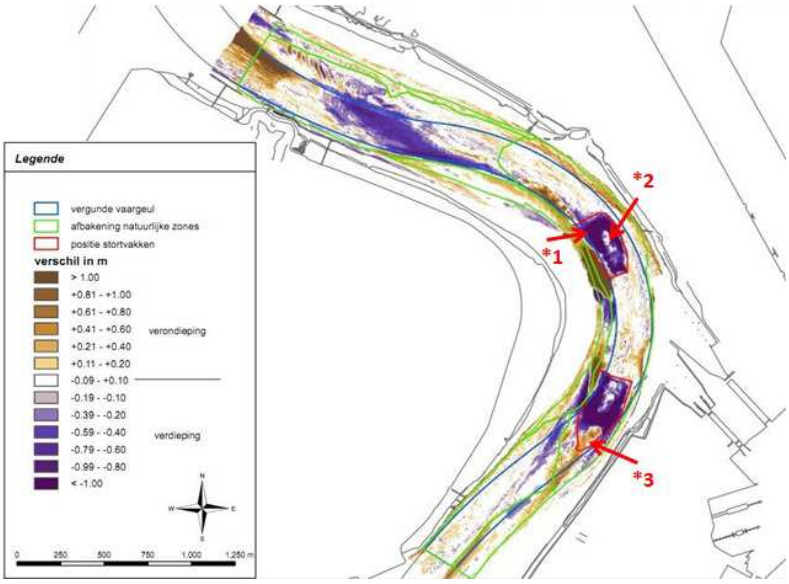


*Figure 8. Difference after the relocation period in the deep areas of the Ketelplaat: deepening (*1), no effect (*2), elevation (*3) (IMDC 2011)*

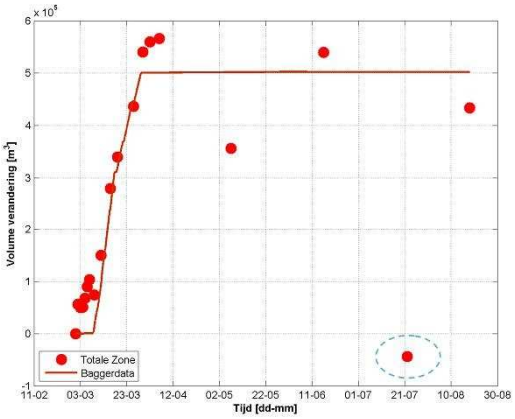


Figure 9. Absolute cumulative volume change (m³) in the total zone (March-August 2010) (IMDC 2011)

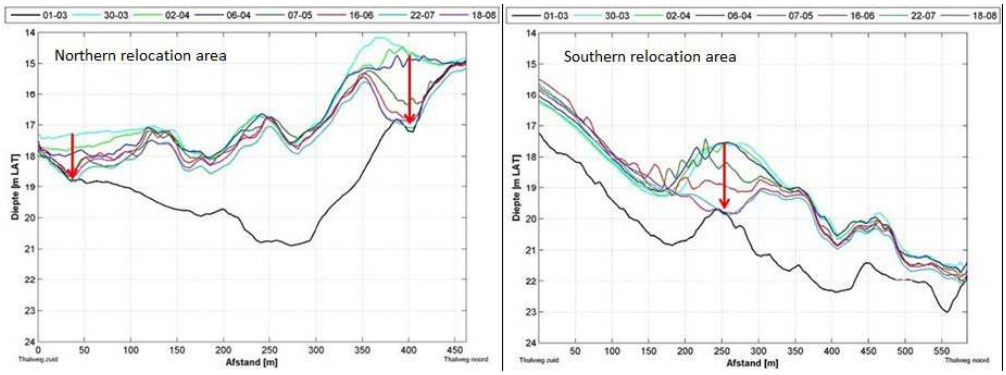


Figure 10. Longitudinal profile through the northern and southern relocation area after the execution of the relocation test. Also the profile before the relocation test (01/03) is showed. (IMDC 2011)

2 Execution of main effectiveness criteria

2.1 Effectiveness according to development targets of measure

Step 1: Definition of development target

This measure is a pilot study with the research objective to assess the morphological behaviour of relocated sediment to deep parts of the navigation channel as a reference for planned numerical morphological modelling. The aim of the monitoring program is to detect the migration pattern of dredged material that is relocated within deep areas of the navigation channel. It was expected that most of the relocated sediment would erode, but time scale and destination were not known. The project is successful if the eroded sediment does not accumulate at the nearby sills (Drempel van Lillo and Drempel van de Parel) and does not create an additional need for maintenance dredging. A small scale pilot was chosen to prevent any irreversible morphological changes.

Step 2: Degree of target achievement

During the relocation test, a substantial volume had disappeared and after four to five months only 35% to 40% of the material remained at the relocation areas within the navigation channel. Almost 80% of the 'disappeared' material was found at the Ketelplaat, adjacent to the navigation channel. The nearby sills in the navigation channel (Drempel van Lillo and Drempel van de Parel) had received almost no additional sediment after the relocation test. However, at these spots dredging activities took place during the study period.

These results were expected. A complete erosion of the relocated material out of the study area or increased sedimentation on the adjacent sills would lead to an unsuccessful evaluation of the pilot project. The aim of the pilot project was to gather data for further investigation.

The relocation test was a pilot project with a larger aim of studying if this type of relocation method could reduce tidal propagation without limiting navigation. However, no significant effects on the tidal propagation were expected, nor observed so far because of the limited scale of the pilot project. The relocation of dredged sediment to deep areas of the navigation channel was helpful to understand the behaviour of relocated sediment.

2.2 Impact on ecosystem services

Step 1: Involved habitats

The measure TIDE pilot project 2 (Scheldt) near Ketelplaat in the mesohaline zone of the Scheldt estuary was about the relocation of dredged sediment to deep areas of the navigation channel, improving the habitat quality of subtidal deep habitat.

Before the implementation of such a measure the quality of this habitat to deliver the service 'dissipation of tidal and river energy' is low because of the presence of deeper areas.
After filling up those deeper areas, the quality of the habitat to deliver the service 'dissipation of tidal and river energy' will be enhanced.

This measure is however only a pilot study at a very small scale with negligible habitat changes.

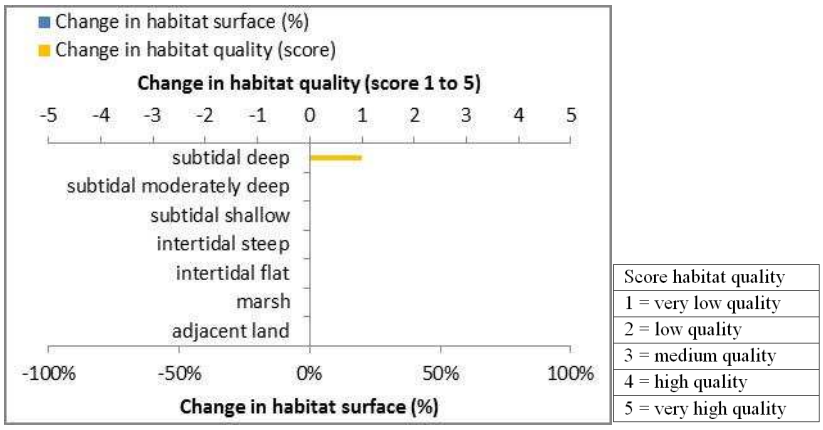


Figure 11. Ecosystem services analysis for TIDE pilot project 2 (Scheldt) near Ketelplaat: Indication of habitat surface and quality change, i.e. situation before versus after measure implementation. The change in habitat quality, i.e. situation after the measure is implemented corrected for the situation before the measure, is '1' in case of a very low quality shift, and '5' in case of a very high quality shift.

Step 2: Expected impact on ecosystem services, compared with targeted ecosystem services, and expected impact on beneficiaries

More information about the methodology and the correct interpretation of the results could be found in the overall measures report (Saathoff et al. 2013).

(1) Overall expected impact on ES:
From the ES assessment it is concluded that this measure generates overall a slightly positive expected impact for many ES, mainly for "biodiversity", Water for navigation; cultural services; and some regulating services (Erosion and sedimentation regulation (by water bodies); Water quality regulation: transport of pollutants and excess nutrients); Water quantity regulation: transportation.

(2) Expected impact on targeted ES
This measure is a pilot project to study the effect of disposing dredged material in deep areas of the navigation channel (ES 'Information for cognitive development'). The expected impact on this ES is slightly positive.

Additionally, the results will be used for a larger project to fill up deeper areas of the navigation channel with the aim of creating current deflecting zones by which tidal energy is dissipated (ES 'Water quantity regulation: dissipation of tidal and river energy'). The expected impact on this ES is nihil (neutral).

(3) Expected impact on beneficiaries
The expected impact for the different beneficiary groups is slightly positive for indirect and future use, and for local and regional use.

Table 1. Ecosystem services analysis for TIDE pilot project 2 (Scheldt) near Ketelplaat: (1) expected impact on ES supply in the measure site and (2) expected impact on different beneficiaries as a consequence of the measure

Cat.	Ecosystem Service	Score
S	"Biodiversity"	1
R1	Erosion and sedimentation regulation by water bodies	1
R2	Water quality regulation: reduction of excess loads coming from the catchment	0
R3	Water quality regulation: transport of pollutants and excess nutrients	1
R4	Water quantity regulation: drainage of river water	0
R5	Erosion and sedimentation regulation by biological mediation	0
R6	Water quantity regulation: transportation	1
R7	Water quantity regulation: landscape maintenance	0
R8	Climate regulation: Carbon sequestration and burial	0
R9	Water quantity regulation: dissipation of tidal and river energy	0
R10	Regulation extreme events or disturbance: Wave reduction	0
R11	Regulation extreme events or disturbance: Water current reduction	0
R12	Regulation extreme events or disturbance: Flood water storage	0
P1	Water for industrial use	0
P2	Water for navigation	1
P3	Food: Animals	0
C1	Aesthetic information	0
C2	Inspiration for culture, art and design	1
C3	Information for cognitive development	1
C4	Opportunities for recreation & tourism	1

Beneficiaries:	
Direct users	0
Indirect users	1
Future users	1
Local users	1
Regional users	1
Global users	0

X Targeted ES

Legend: expected impact*	
3	very positive
2	positive
1	slightly positive
0	neutral
-1	slightly negative
-2	negative
-3	very negative

*: Indicative screening based on ES-supply surveys and estimated impact of measures on habitat quality and quantity. Quantitative socio-economic conclusions require local supply and demand data to complement this assessment.

2.3 Degree of synergistic effects and conflicts according to uses

Planning and implementation were not an issue because it was part of the operational dredging program and because of the scale of the pilot project. No conflicts of interest arose during planning or after implementation. This measure was a relatively small pilot project which can offer information to develop a new relocation strategy. This strategy enables the implementation of morphological management options that strengthen the natural functioning of the estuary, and at the same time relocate this material in an effective way with a possible positive effect on the tide. The latter was however not observed in this study.

3 Additional evaluation criteria in view of EU environmental law

3.1 Degree of synergistic effects and conflicts according to WFD aims

Future projects, based on the findings of this pilot test research project, aims to create current deflecting zones by which tidal energy is dissipated. From the analysis, it seems that the bathymetry changes at a local scale after the relocation of material. The bathymetry of the relocation areas was flattened some months after the relocation test. At a larger scale, this could affect the hydrographic regime (tidal currents) and ensure safety against flooding in the future.

Indicator	code	Main pressures **mesohaline** zone Scheldt	Effect?					Description
			- -	-	0	+	++	
S.I.	1.1	Habitat loss and degradation during the last about 100 years: Intertidal			X			
S.I.	1.5	Gross change of the hydrographic regime during the last about 100 years				X		Changing the bathymetry in the neighbourhood of the relocation areas.
S.I.	3.1/ 3.2	Decrease of water and sediment chemical quality			X			
D.I.	1.3	Land claim during the last about 100 years			X			
D.I.	1.7	Relative Sea Level Rise			X			
D.I.	2.12	Port developments			X			

S.I. = state indicator; D.I. = driver indicator

3.2 Degree of synergistic effects and conflicts according to Natura 2000 aims

The study area is located within a habitat directive area, but not in a bird directive area. More specific this is the **Scheldt part from the border between Belgium and the Netherlands to Gent (side code BE2300006)**. All habitat directive species in this area have a good or excellent preserved protection status. The influence of this measure is rather nihil.

CO	Specification	Effect?					Short explanation
		- -	-	0	+	++	
Protect habitat directive species				X			No effect

4 Crux of the matter

Planning and implementing were not an issue because of the scale of the pilot project. The applicability of this measure to several other locations in the Western Scheldt (Westerschelde) has to be analysed in detail in order to derive sound recommendations. A knowledge gap was revealed regarding the understanding of sediment transport pathways and resulting sedimentation and erosion patterns.

5 References

IMDC. 2011. Monitoringprogramma flexibel storten: Stortproef diepe putten Ketelplaat. Vlaamse Overheid, Departement Mobiliteit en Openbare Werken, Afdeling Maritieme Toegang.

Saathoff, S., J. Knüppel, S. Manson, and A. Boerema. 2013. Management measures analysis and comparison. Investigation of measures planned and implemented at the estuaries of Weser, Elbe, Humber and Scheldt. Study report in the framework of the Interreg IVB project TIDE, Oldenburg, Hamburg, Hull, Antwerp.